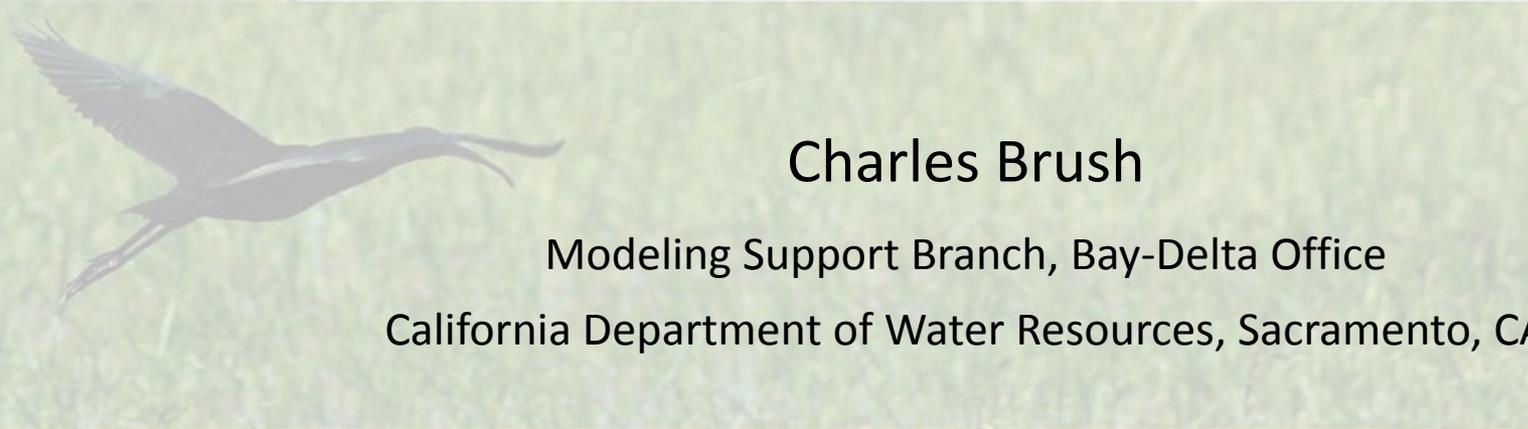




# Public Release of C2VSim The California Central Valley Groundwater-Surface Water Simulation Model

Groundwater Resources Association of California  
2012 Annual Conference and Meeting  
October 4-5, 2012



Charles Brush

Modeling Support Branch, Bay-Delta Office  
California Department of Water Resources, Sacramento, CA





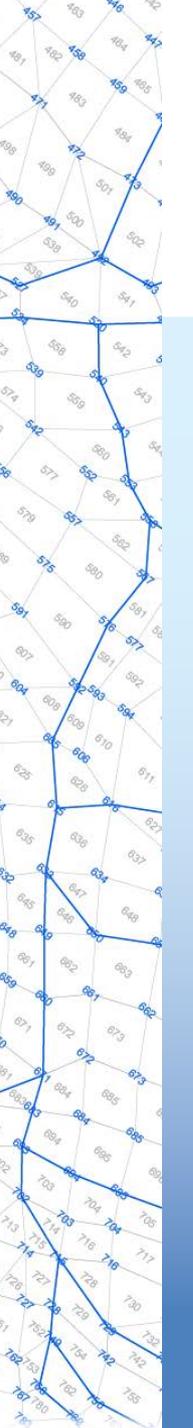
# Outline

Integrated Water Flow Model (IWFM)

C2VSim Overview

C2VSim Results

Public Release & Future Directions



# Outline

## **Integrated Water Flow Model (IWFM)**

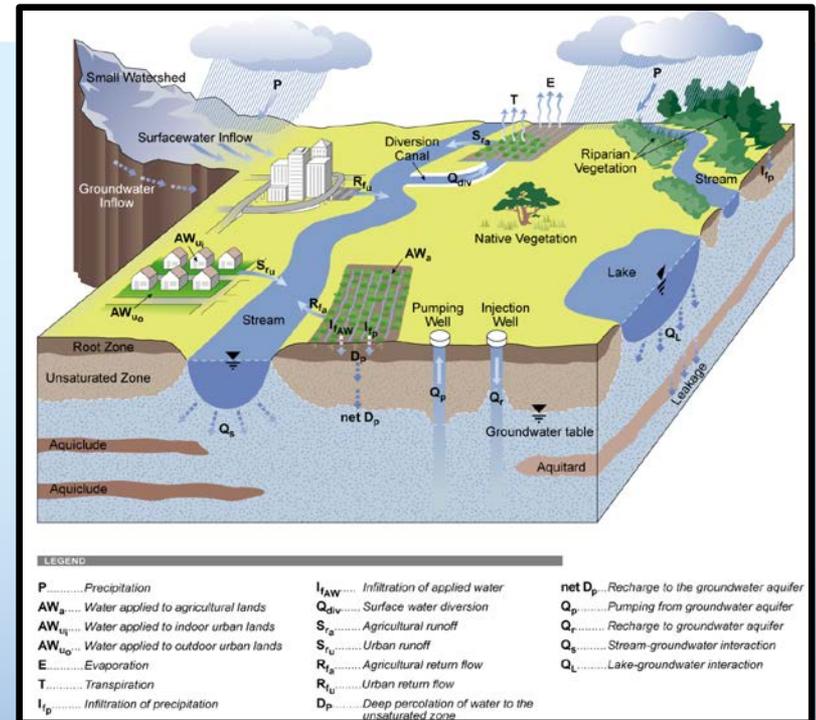
C2VSim Overview

C2VSim Results

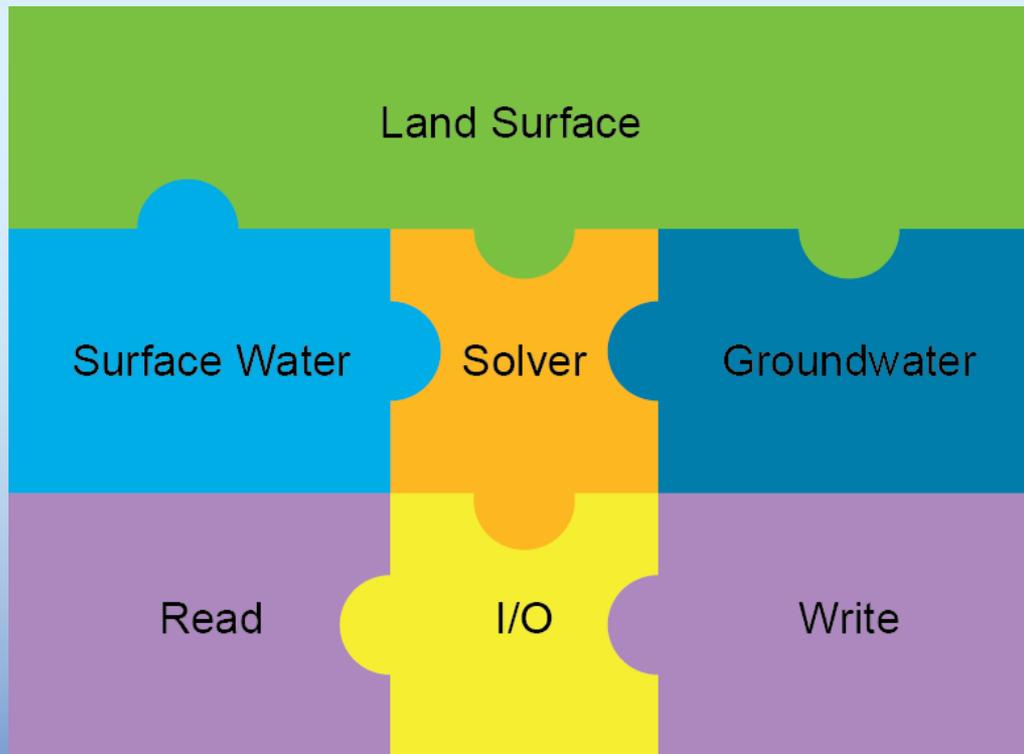
Public Release & Future Directions

# Integrated Water Flow Model (IWFM)

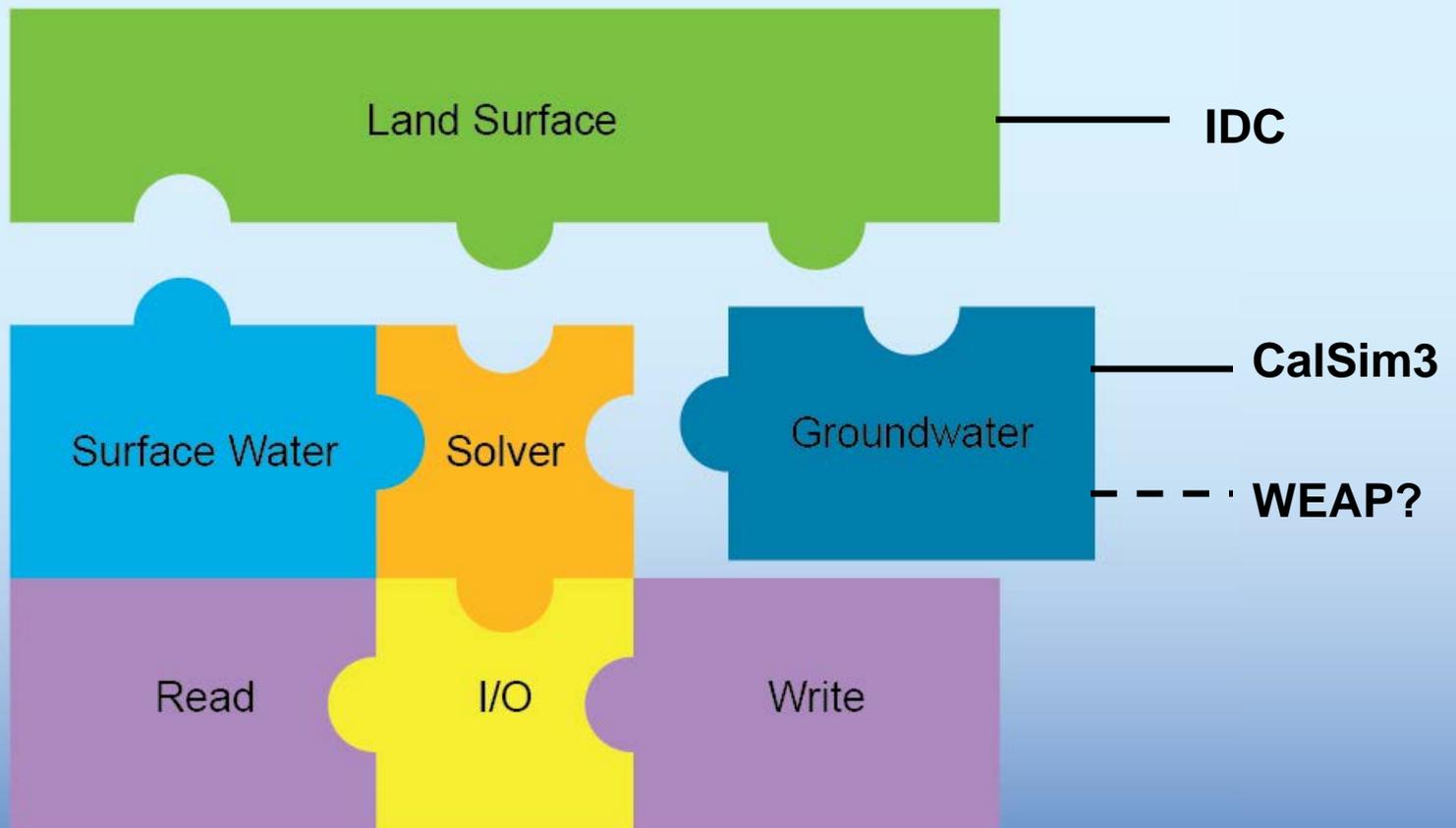
- Open-source, regional-scale integrated hydrologic model
- Simulates land surface, groundwater, surface water, and surface-groundwater interactions
- Represent agricultural and urban water management practices, and their effects on the water system
- A planning and analysis tool as it computes agricultural and urban water demands based on climatic, soil, land-use and agronomic parameters, and tries to meet this demand with pumping and stream diversions



# Object-Oriented Design

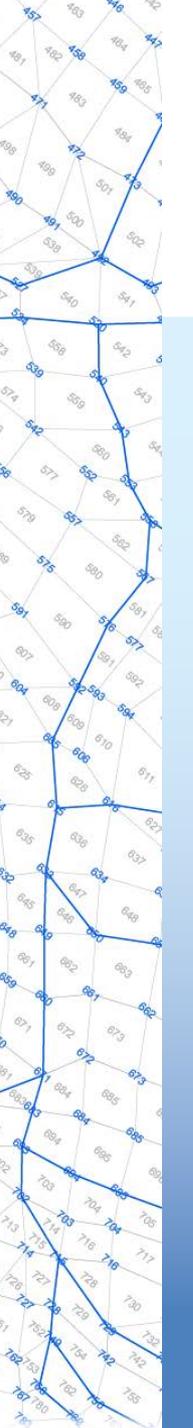


# Linked with Other Models



# IWFM Applications

- California Central Valley Groundwater-Surface Water Model (C2VSim)
- Butte County Groundwater Model (Heywood, CDM)
- Walla Walla River Basin Model (Petrides, OSU)
- Yolo County Integrated Model



# Outline

Integrated Water Flow Model (IWFM)

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# C2VSim Coarse-Grid

## Finite Element Grid

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

## Surface Water System

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

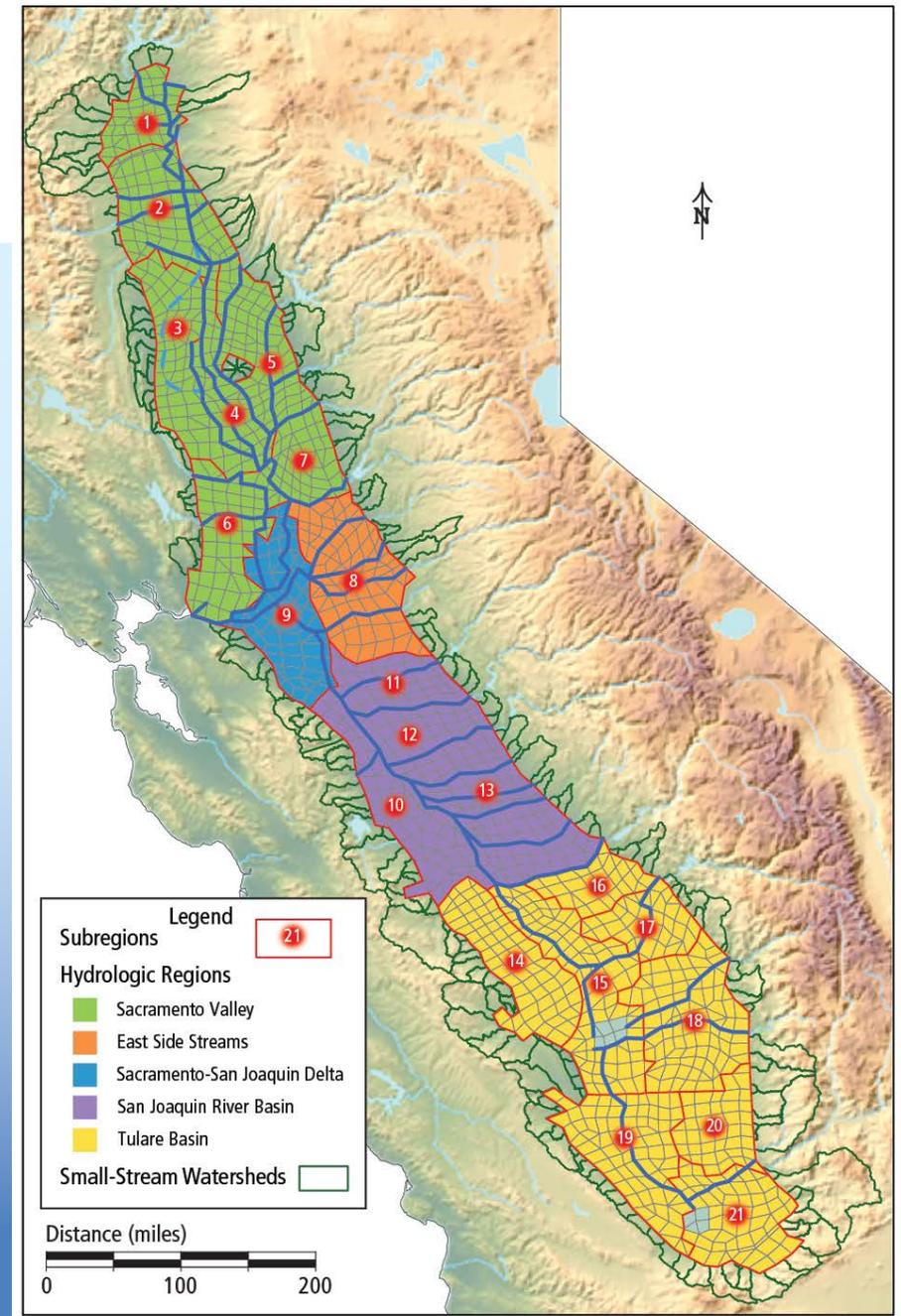
## Land Use Process

- 21 Subregions (DSAs)
- 4 Land Use Types

## Simulation periods

- 10/1921-9/2009 (88 yrs)
- runs in 4 min

## IWFM version 3.02



# C2VSim Development

## Derived from the CVGSM model

- WY 1922-1980 Boyle & JM Montgomery (1990)
- WY 1981-1998 CH<sub>2</sub>M Hill

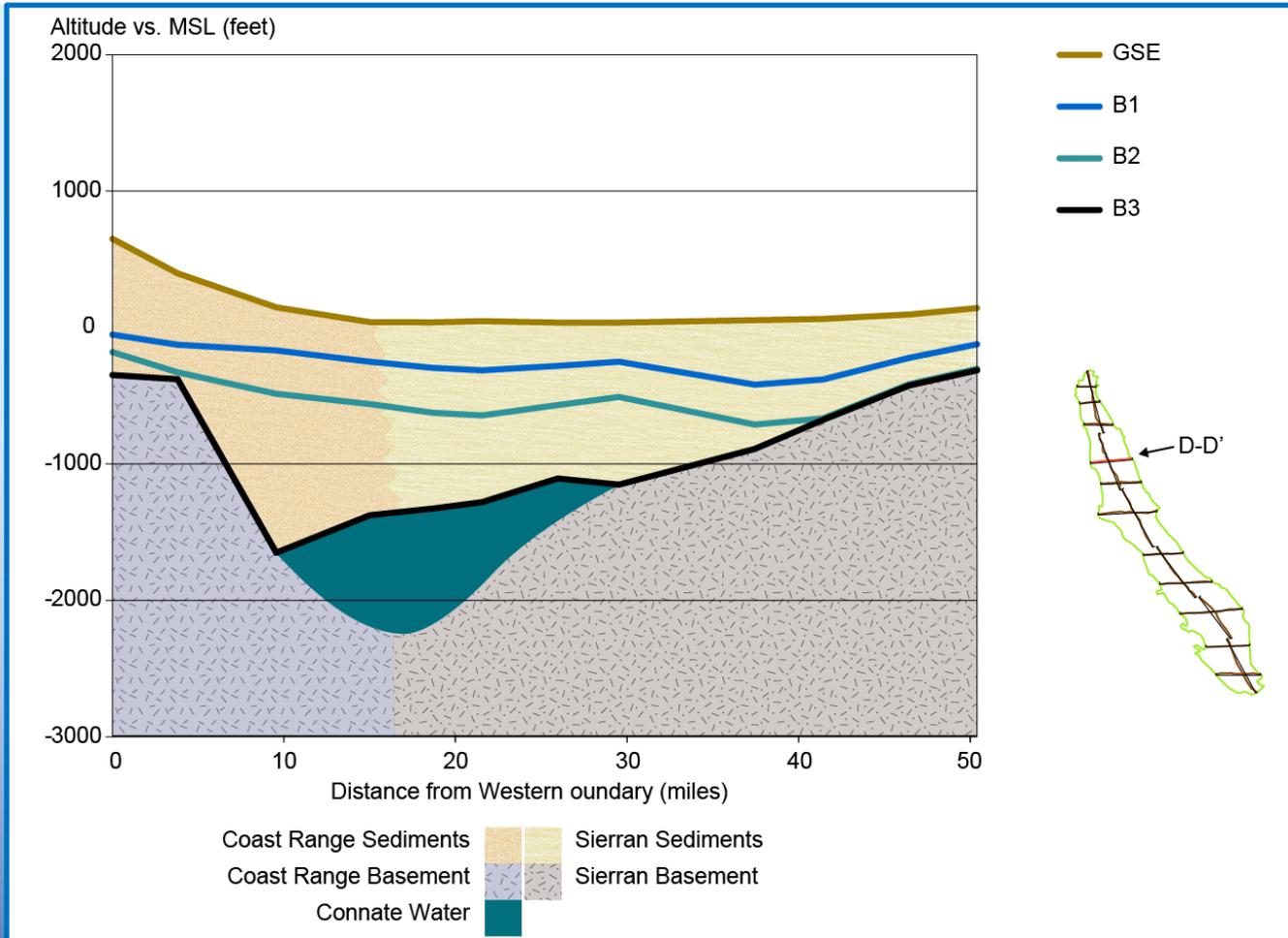
## Steady modification

- 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 Aquifer Layers



# 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       |
| <b>TOTAL</b>                      | <b>1,620</b>          | <b>75,367</b>    |           |

| Observation Type                  | Root Mean Squared Error | Residual | <u>RMSE</u> Range | <u>Residual</u> 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



# Outline

Integrated Water Flow Model (IWFM)

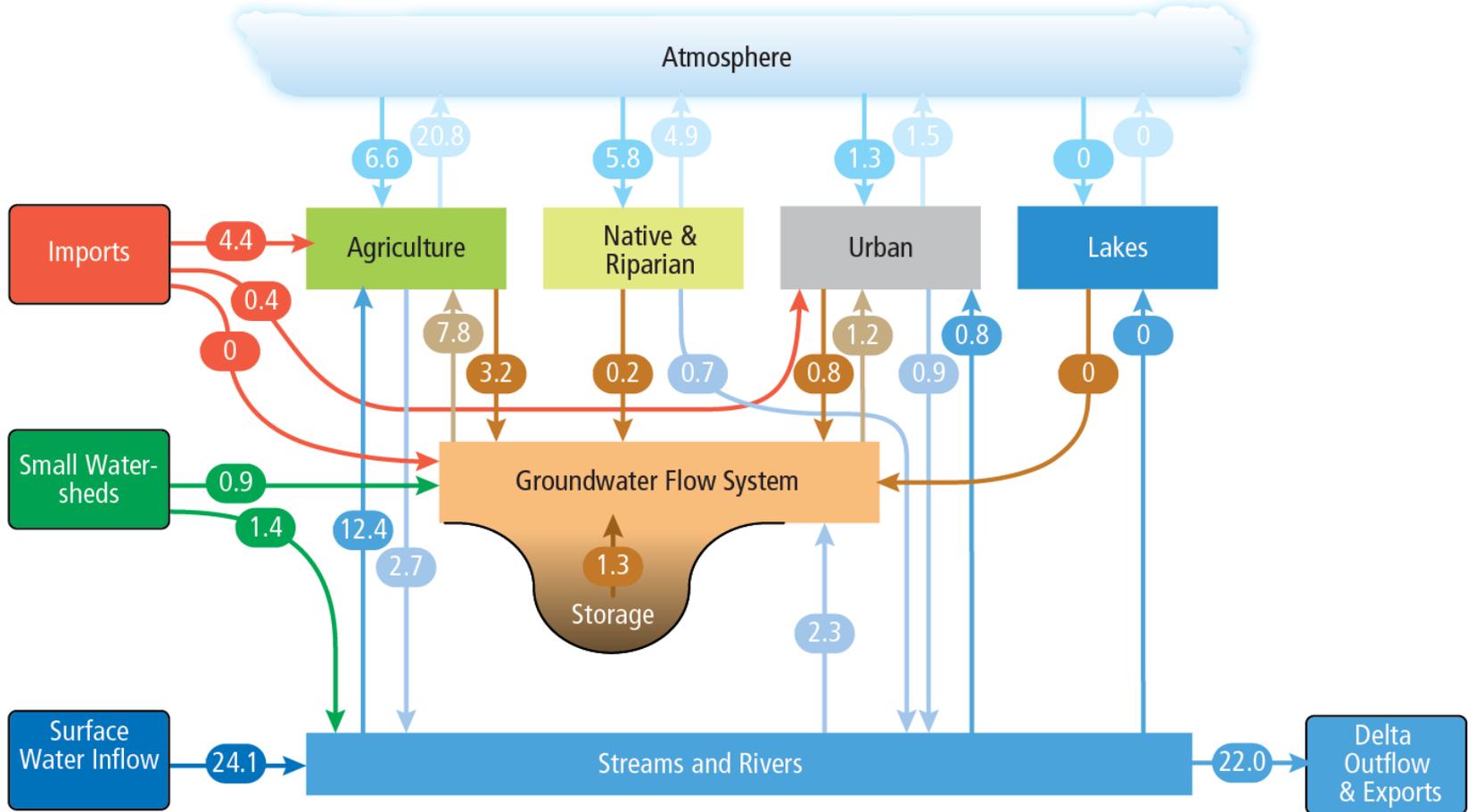
C2VSim Overview

**C2VSim Results**

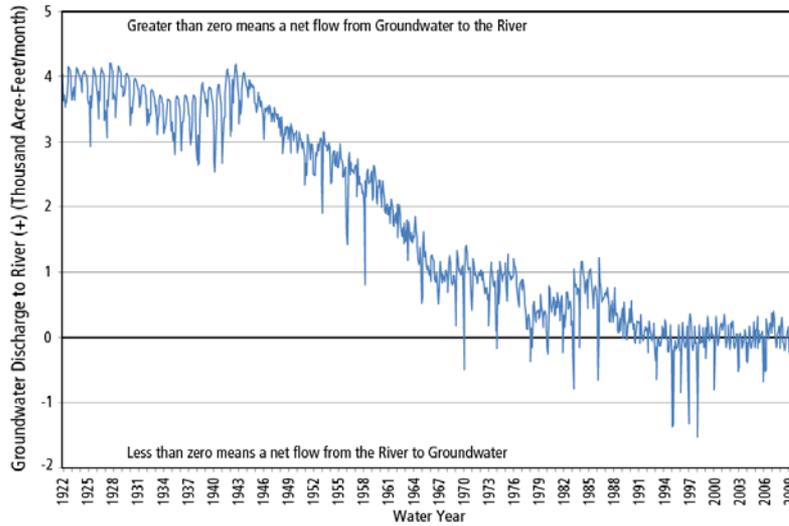
Public Release & Future Directions

# Simulated Annual Water Budget

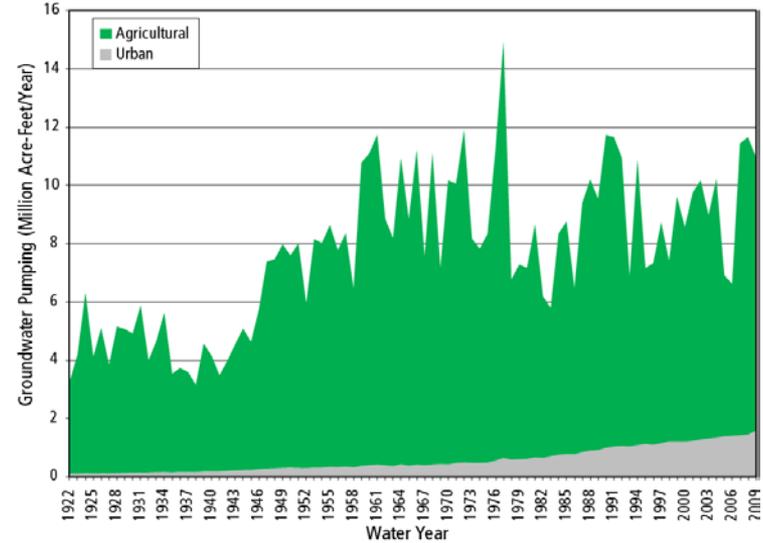
Average Flows for water years 2000-2009  
[Million Acre-Feet/Year]



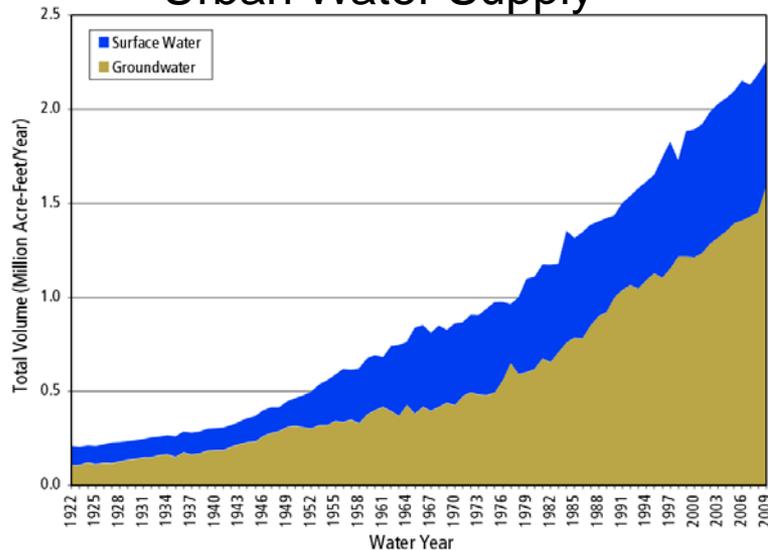
### River-Groundwater Flows



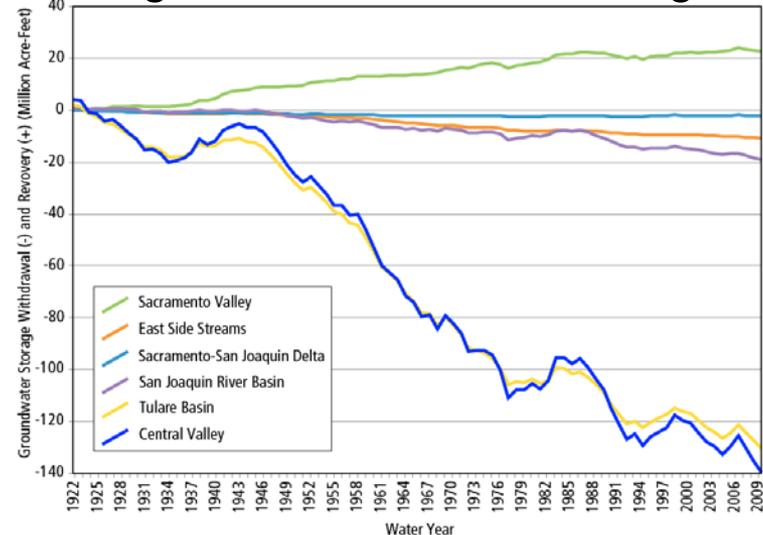
### Groundwater Pumping



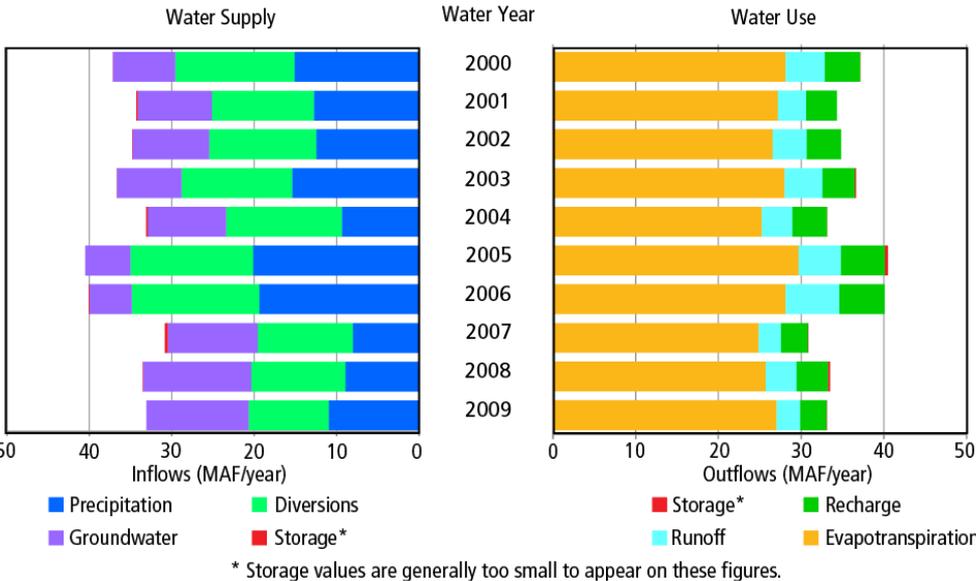
### Urban Water Supply



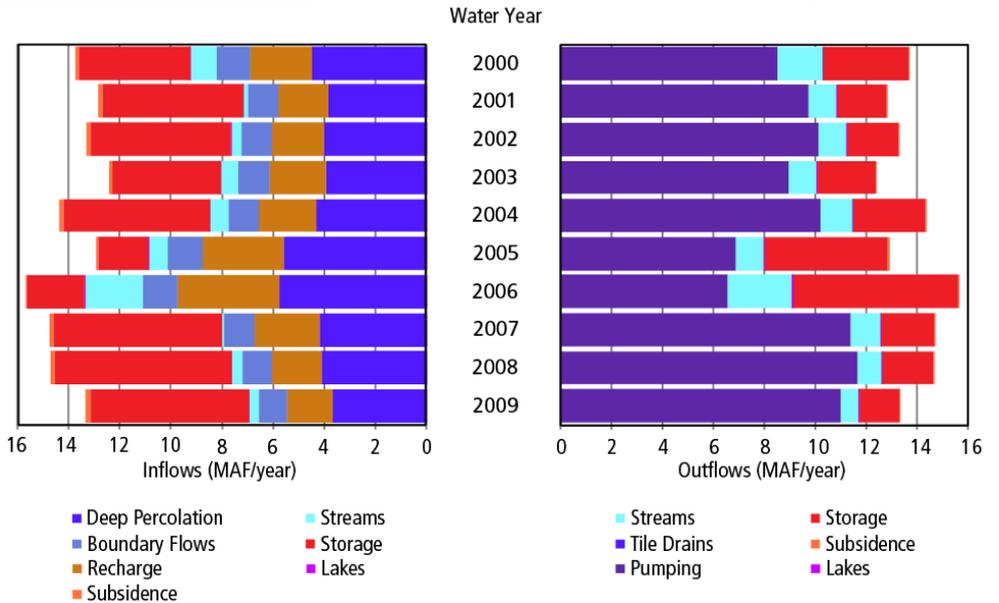
### Change in Groundwater Storage



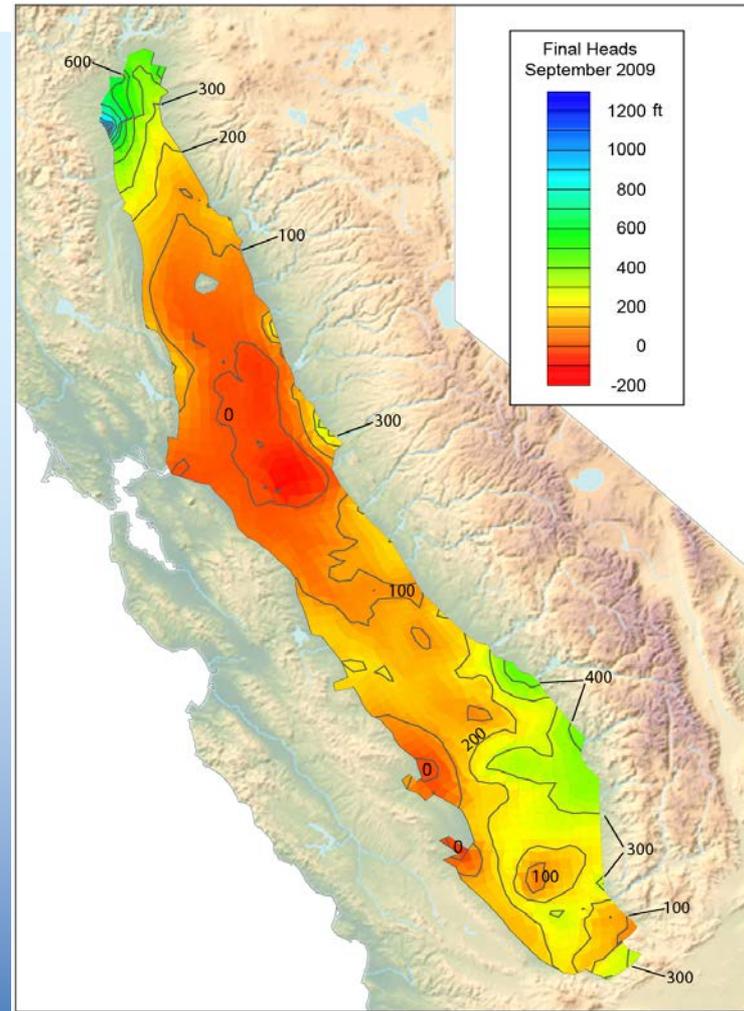
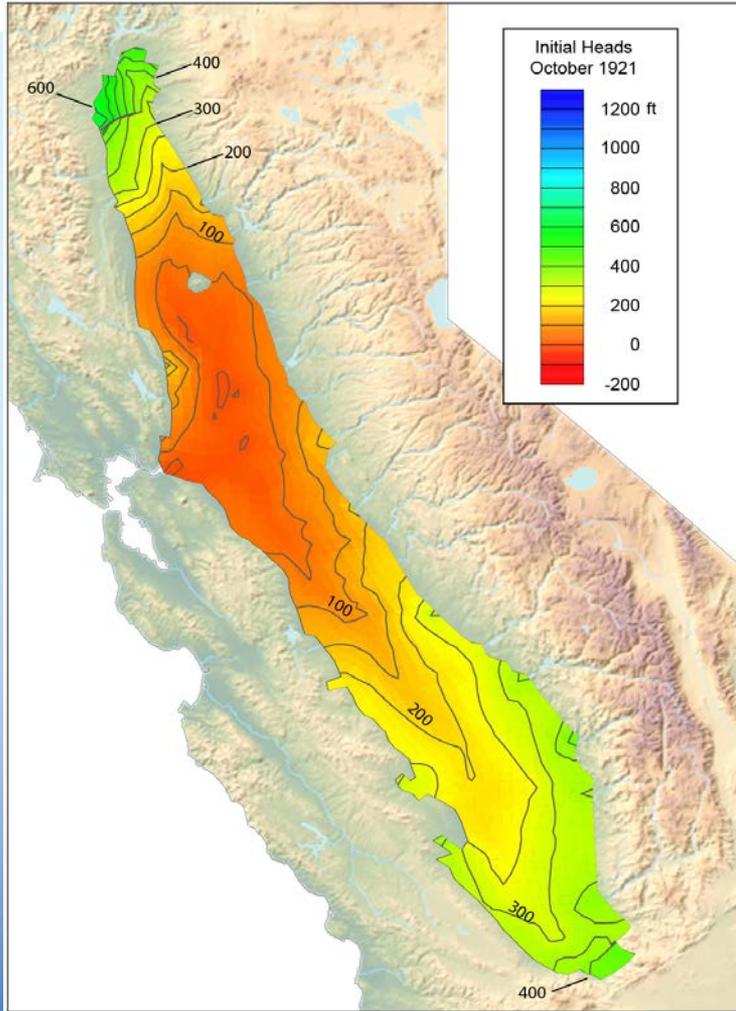
## Land Surface Budget

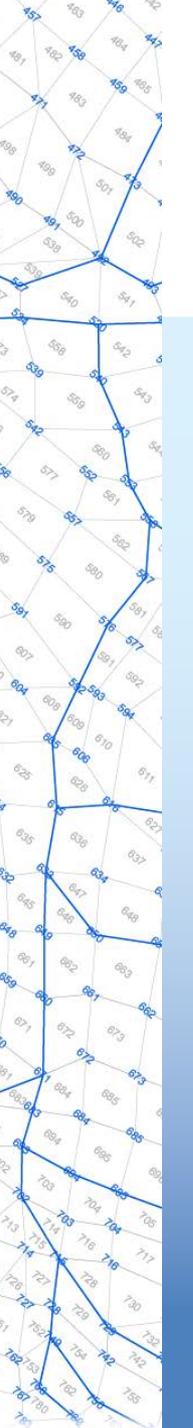


## Groundwater Budget



# Water Table Altitude





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# C2VSim Coarse Grid

## 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

The screenshot shows the C2VSim web site interface. At the top, there is a navigation bar with links for California Home, Governor Home, and Amber Alert, along with the date Friday, September 21, 2012. Below this is a "Welcome to California" banner with various scenic images. The main content area is divided into several sections:

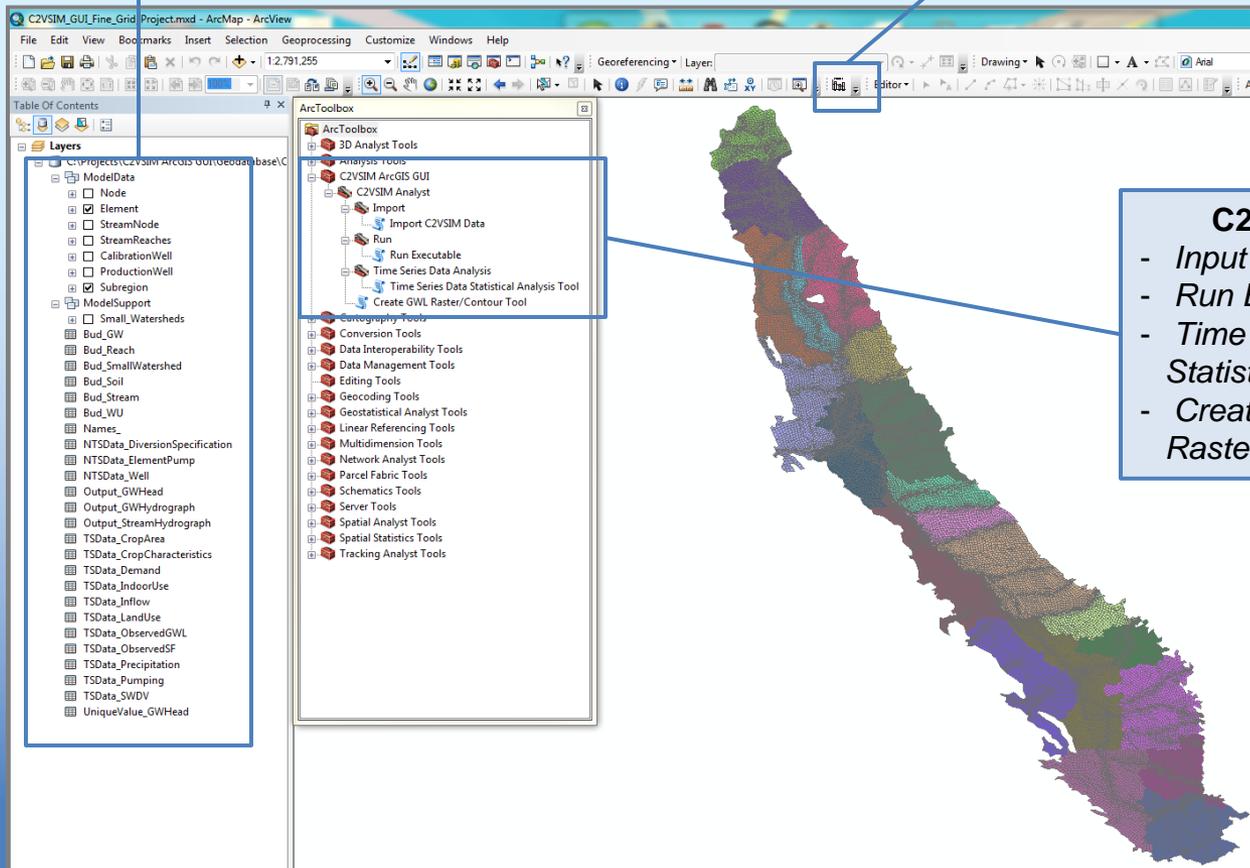
- Left Navigation Menu:** Includes links for DWR Home, BDO Home, Organization (Administration & Program Control, Delta Conveyance, Modeling Support, South Delta), DWR Computers Only, BDO Currents, DWR Forms, Organization Charts, SAP ESS, BDO Computer Support Request, and Training.
- Header Section:** Features the Department of Water Resources logo and the text "BAY-DELTA".
- Main Content:** Titled "C2VSim: California Central Valley Groundwater-Surface Water Simulation Model". It includes a description of the model, its history, and its applications. A "Summer" banner image is also present.
- Right Side:** Contains a search bar, "Section Pages" (Central Valley Water Resources System, Modeling, Delta Modeling, Computer Assistance), and "Quick Hits" (WRIMS/CalSim, CalLite, DSM2, IWFM, IDC).
- Footer:** Provides contact information for the Bay-Delta Office, Department of Water Resources, including the address (1416 9th Street, Sacramento, Ca 95814) and mailing address (P. O. Box 942836, Sacramento, Ca 94236-0001).

# C2VSim ArcGIS Tool

- ArcGIS tool to display model output (developed by RMC-WRIME)

## C2VSim Feature Shapefiles and Data Tables

## Time Series Graphing



## C2VSim Toolbox

- *Input C2VSim Data tool*
- *Run Executables tool*
- *Time Series Data Statistical Analysis tool*
- *Create GW Level Raster/Contour tool*

# IWFM Tools

- Import model output tables to MS Excel

The screenshot displays the IWFM Tools application window with the 'Budget To Excel (v3.02)' dialog box open. The dialog box has two main sections: 'Choose Budget Input File' and 'Choose Budget Table'. The 'Choose Budget Input File' section shows a file path 'D:\Work\_Documents\CV2\SIM\Model\R358\1921-2009\Budget\CV' and buttons for 'Browse...' and 'Import'. The 'Choose Budget Table' section has a dropdown menu with four options: 'Land and water use budget', 'Stream budget', 'Root zone budget' (which is selected), and 'Groundwater budget'. A 'Transfer to Excel' button is also present. The background shows an Excel spreadsheet with the following data:

| Time                | Ag. Area (AC) | Ag. Precipitation | Ag. Runoff | Ag. Prime Applied Water | Ag. Reused Water | Ag. Total Applied Water | Ag. Return Flow | Ag. Beginning Storage | Ag. Net Gain from Land Expansion |
|---------------------|---------------|-------------------|------------|-------------------------|------------------|-------------------------|-----------------|-----------------------|----------------------------------|
| 10/31/1921 12:00 AM | 146552.02     | 1405.91           | 0.00       | 6231.72                 | 0.00             | 6231.72                 | 0.00            | 82280.58              | 0.00                             |
| 11/30/1921 12:00 AM | 146552.02     | 4036.19           | 0.00       | 16031.33                | 0.00             | 16031.33                | 0.00            | 51387.45              | 0.00                             |
| 12/31/1921 12:00 AM | 146552.02     | 17370.27          | 0.00       | 0.00                    | 0.00             | 0.00                    | 0.00            | 52400.47              | 0.00                             |
| 01/31/1922 12:00 AM | 146552.02     | 20308.99          | 4.33       | 1763.64                 | 0.00             | 1763.64                 | 0.00            | 58127.27              | 0.00                             |
| 02/28/1922 12:00 AM | 146552.02     | 20563.55          | 5.80       | 958.91                  | 0.00             | 958.91                  | 0.00            | 64685.49              | 0.00                             |

- Import IWFM model to ArcGIS and create shapefiles
- Finite Element Mesh Generator in ArcGIS
- PEST linkages for model calibration
- IWFM Executables for MS Windows and Linux

# C2VSim Fine Grid

## Nodal Spacing:

- 0.5 mi on rivers
- 1.5 mi on edge
- Average 0.6 mi<sup>2</sup>

## Model grid

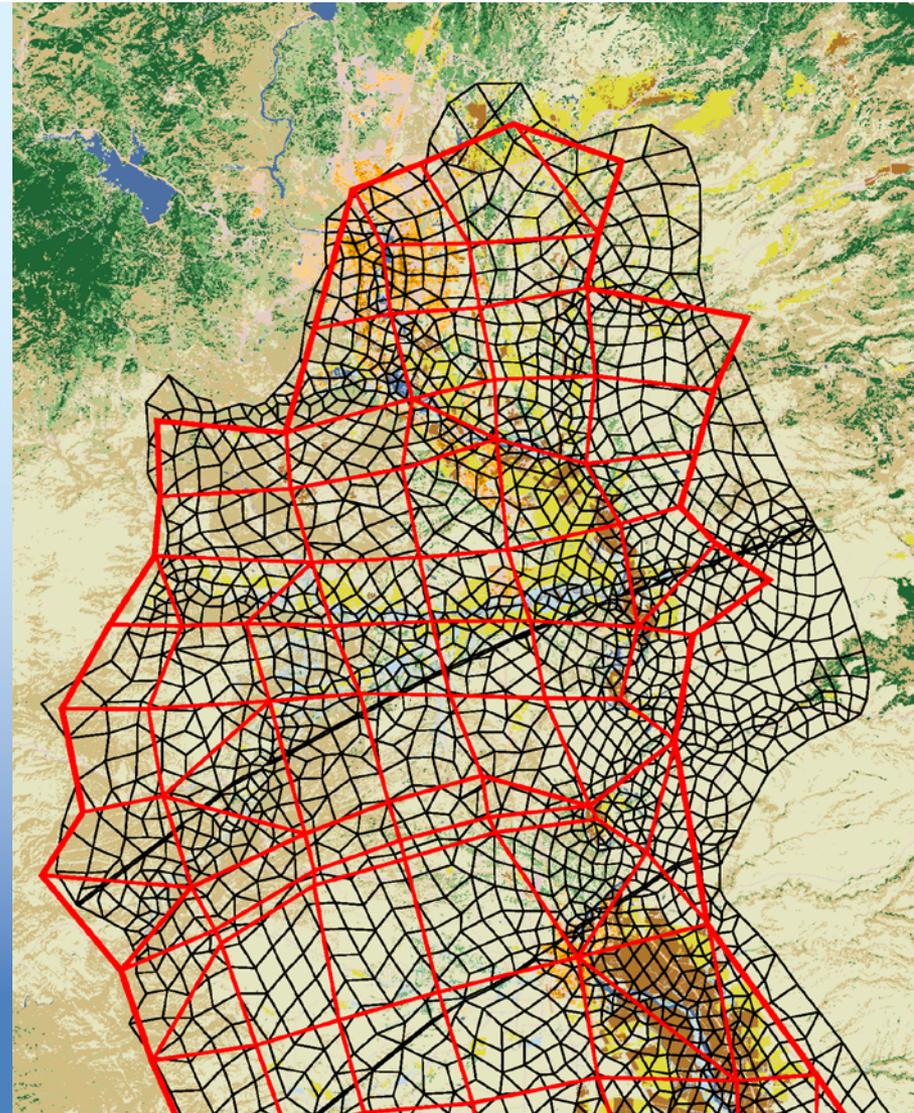
- 32,537 elements
- 30,179 nodes
- 4,529 river nodes

## Run times:

- CG 88 yrs in 6 min
- FG 88 yrs in appx 6 hrs

## Suggested uses:

- CG region-scale analyses
- FG local-scale analyses



# C2VSim Applications

- CalSim 3 groundwater component
- Integrated regional water management plans
- Climate change assessments
- Planning studies
- Ecosystem enhancement scenarios
- Stream-groundwater flows for fish passage
- Infrastructure improvements
- Groundwater storage investigations
- Impacts of operations on Delta flows

# Acknowledgements

Tariq Kadir, Can Dogrul, Francis Chung, Michael Moncrief<sup>1</sup>, Guobiao Huang, Jane Shafer-Kramer, Messele Ejeta, Liheng Zhong, Linda Bond, Chris Bonds, Dong Chen, Jeff Galef, Todd Hillaire, Abdul Khan, Seth Lawrence, Dan McManus, Paul Mendoza, Chris Montoya, Bob Niblack, Scott Olling, Eric Senter, Steven Springhorn, Jean Woods and Brett Wyckoff

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Andy Draper and Jafar Faghieh, MWH Global

Ali Taghavi, Reza Namvar and Mesut Cayar, RMC-WRIME

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