Features and Planned Updates for IWFM in Support of SGMA

CWEMF Annual Meeting

Folsom, California

April 11 – 13, 2016

Can Dogrul

California Department of Water Resources

SGMA Draft GSP Emergency Regulations (February 18, 2016)

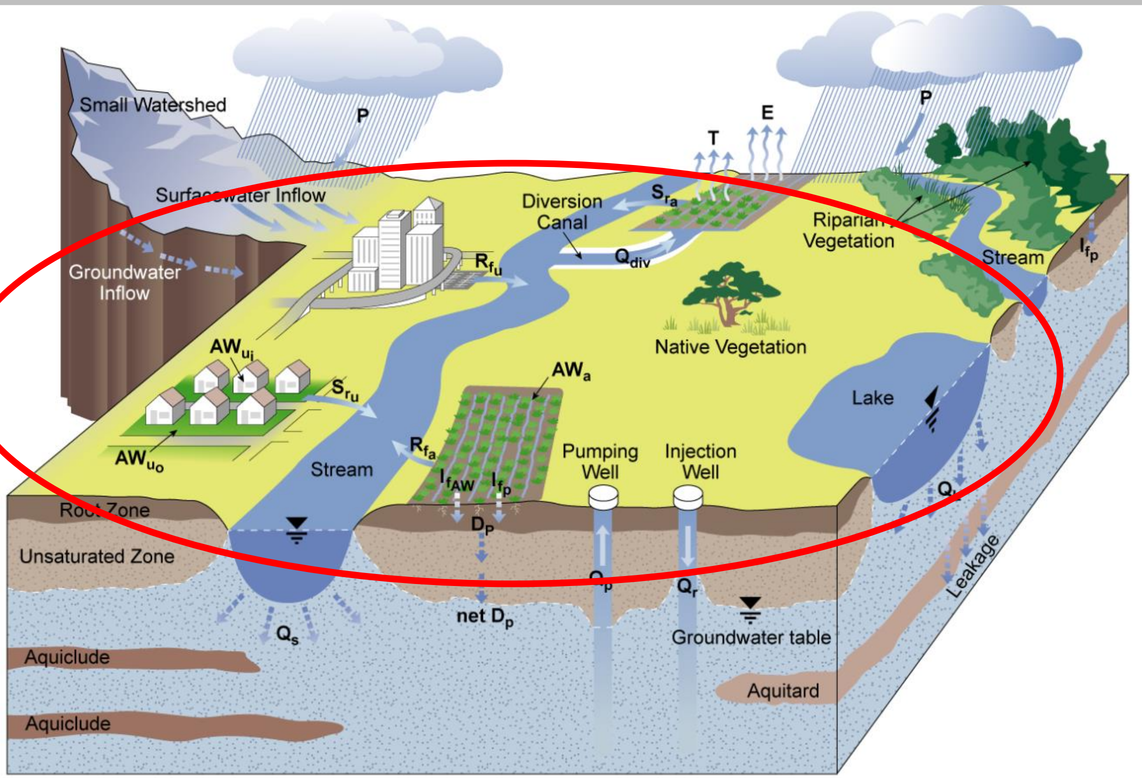
§ 354.18. Water Budget

- "*The Plan shall include a water budget for the basin … annual amount of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions …*"

- *" … water budget shall quantify …"*
  - ✓ All inflows (infiltration of precipitation, infiltration of applied water and from surface water system; subsurface groundwater inflow, etc.)
  - ✓ All outflows (ET, groundwater extraction, losses to streams, subsurface groundwater outflow, etc.)
  - ✓ Change in annual volume of groundwater storage

- *"The Department shall provide C2VSim and IWFM for use by Agencies in developing the water budget. Agencies may choose to use a different flow model."*

Integrated Water Flow Model (IWFM)



LEGEND

- **P**........... *Precipitation*
- **AW_a**..... *Water applied to agricultural lands*
- **AW_{u_i}**.... *Water applied to indoor urban lands*
- **AW_{u_o}**... *Water applied to outdoor urban lands*
- **E**........... *Evaporation*
- **T**........... *Transpiration*
- **I_{f_p}**......... *Infiltration of precipitation*
- **I_{fAW}**..... *Infiltration of applied water*
- **Q_{div}**...... *Surface water diversion*
- **S_{r_a}**........ *Agricultural runoff*
- **S_{r_u}**........ *Urban runoff*
- **R_{f_a}**........ *Agricultural return flow*
- **R_{f_u}**........ *Urban return flow*
- **D_P**......... *Deep percolation of water to the unsaturated zone*
- **net D_p**... *Recharge to the groundwater aquifer*
- **Q_p**......... *Pumping from groundwater aquifer*
- **Q_r**......... *Recharge to groundwater aquifer*
- **Q_s**......... *Stream-groundwater interaction*
- **Q_L**......... *Lake-groundwater interaction*

IWFM Features in Support of SGMA

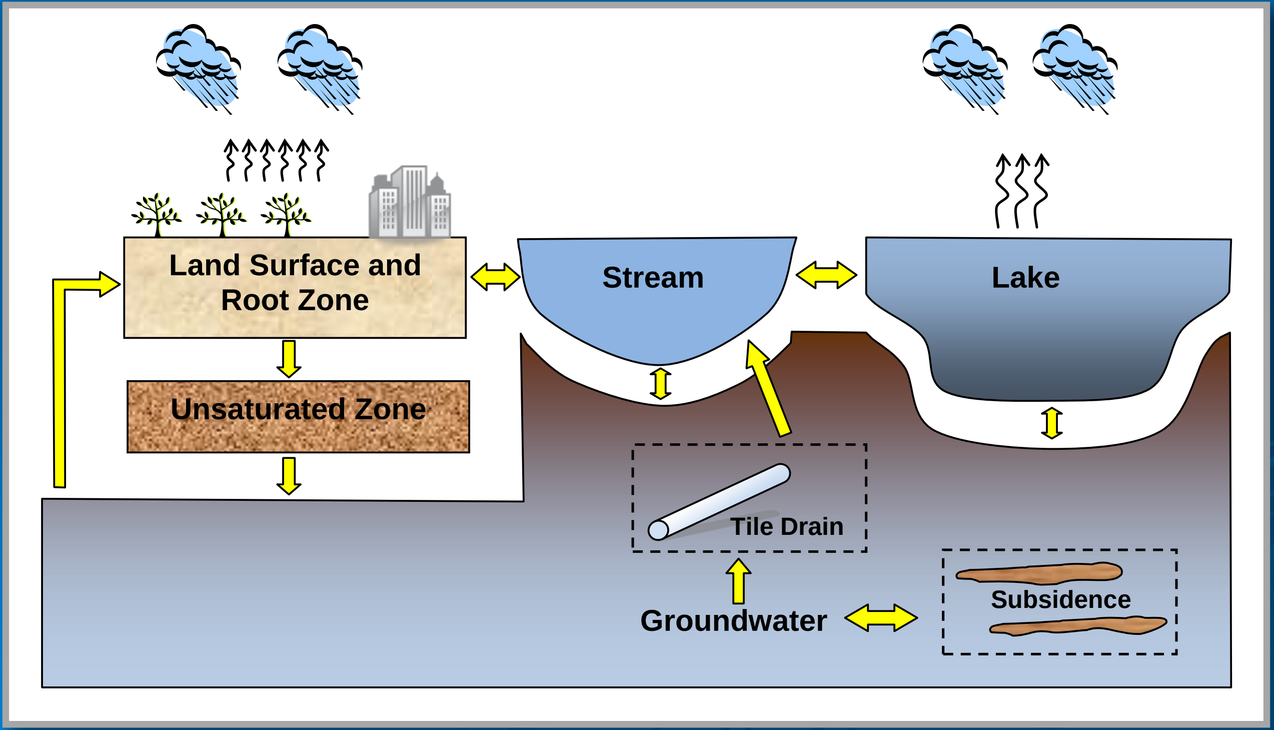
- Computation of agricultural water demand as a function of crop types and areas, climate (precipitation and ET), soil parameters, and farm water management parameters
- Computation of urban water demand as a function of population and per-capita water use; indoor and outdoor water demand separation
- Link between groundwater and root zone and land surface processes through percolation (eventual recharge to groundwater) and groundwater pumping as all or part of water supply
- Automatic adjustment of water supply to meet water demand

IWFM Features in Support of SGMA

- Extensive water budget output for all simulated hydrologic components:
  - Groundwater budget
  - Stream flow budget
  - Root zone budget
  - Land and water use budget (comparison of water demand and supply)
  - Unsaturated zone budget
  - Small watershed budget (ungauged watersheds contributing surface and subsurface boundary inflows)

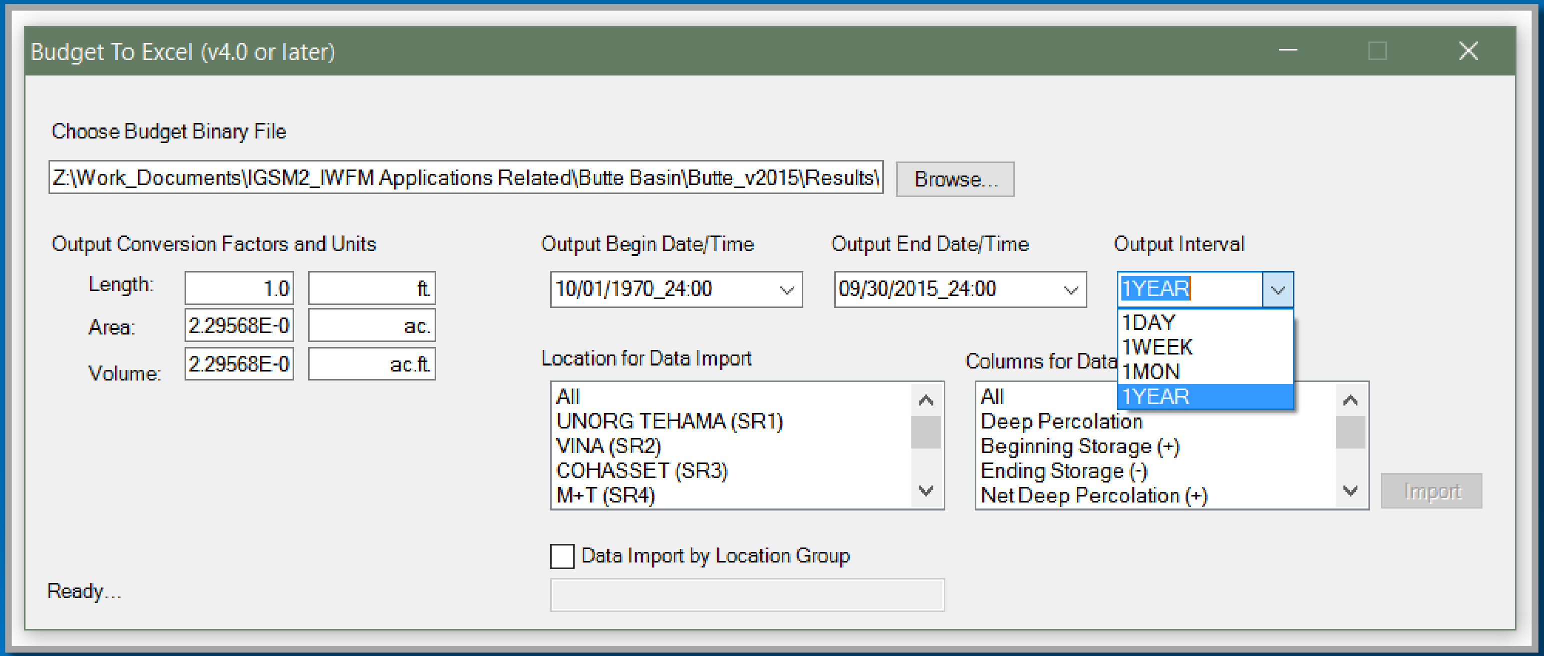
IWFM Features in Support of SGMA

- Cross-flow terms in water budget outputs to easily track water within the system (e.g. stream-aquifer flow exchange appearing in groundwater and stream budgets; deep percolation appearing in root zone and groundwater budgets; pumping appearing in land & water use and groundwater budgets)



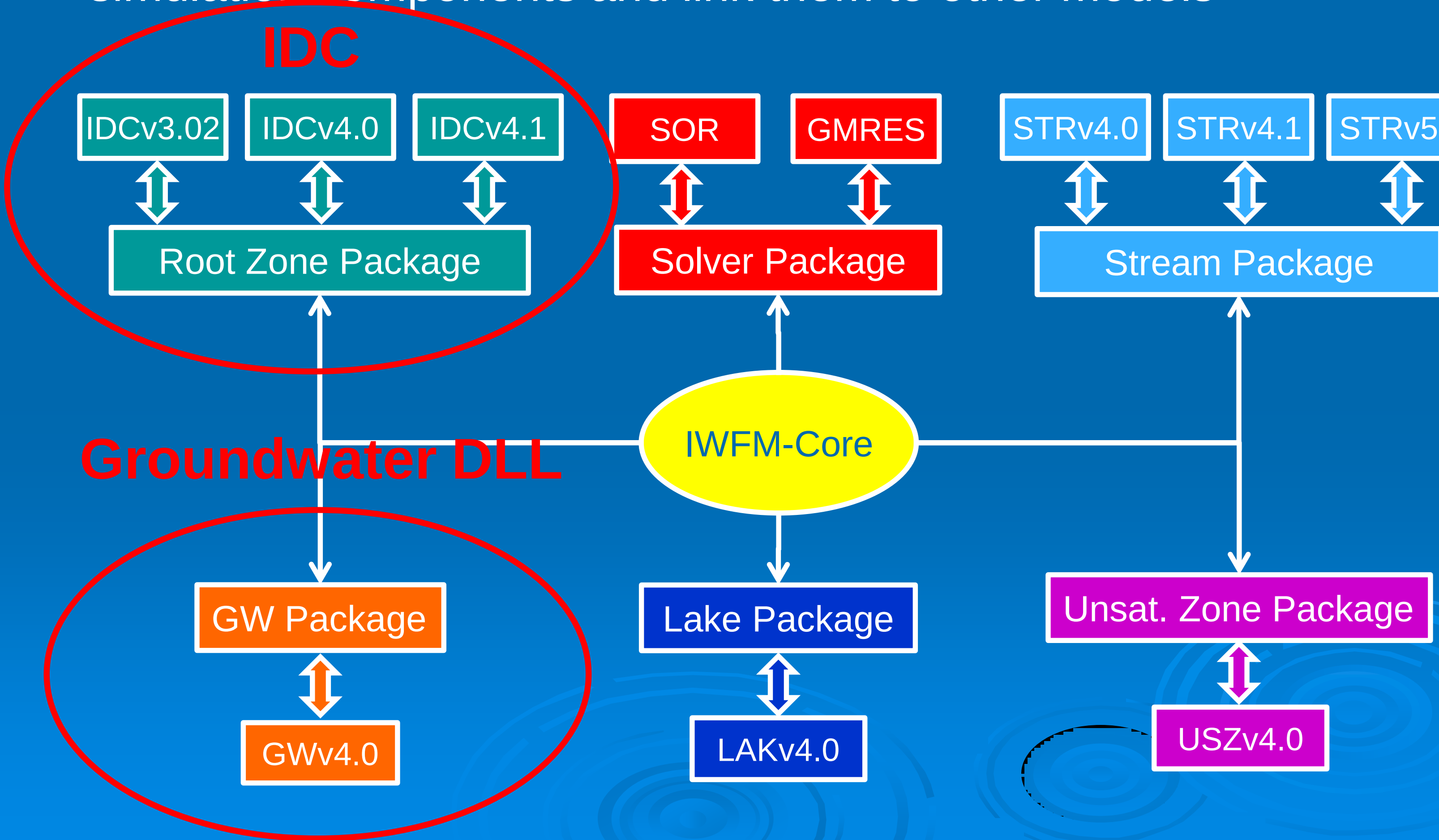
IWFM Features in Support of SGMA

- Post-processor utilities for ease of accessibility to model results



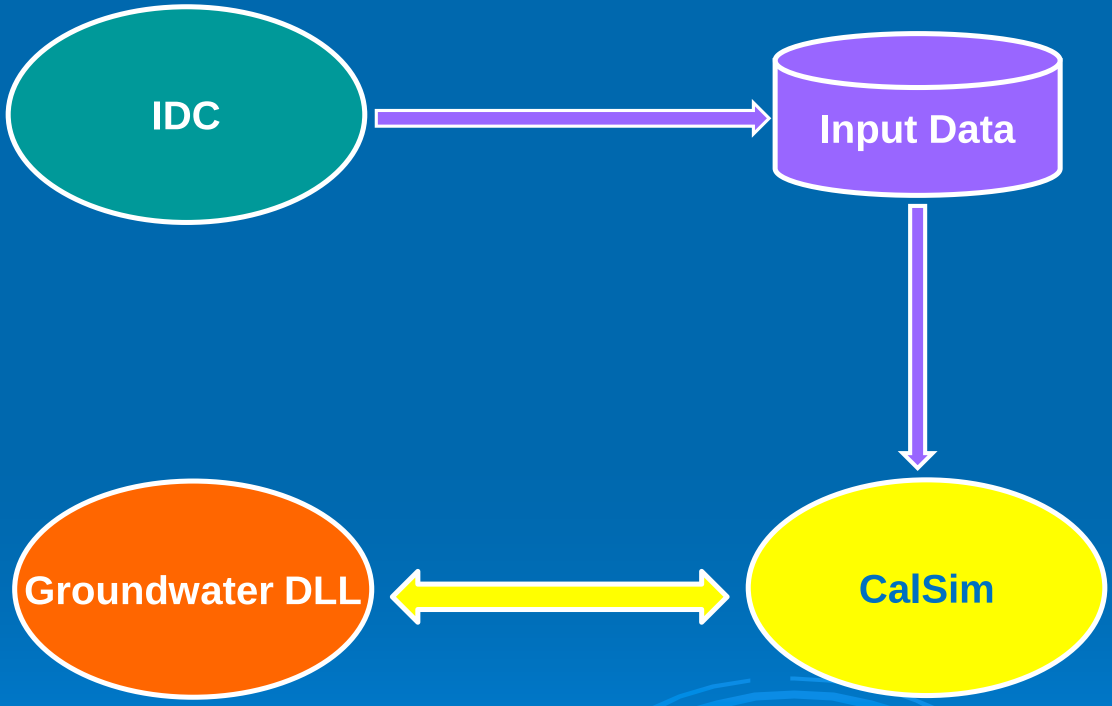
IWFM Features in Support of SGMA

- Software design that makes it easy to “pick apart” IWFM hydrologic simulation components and link them to other models



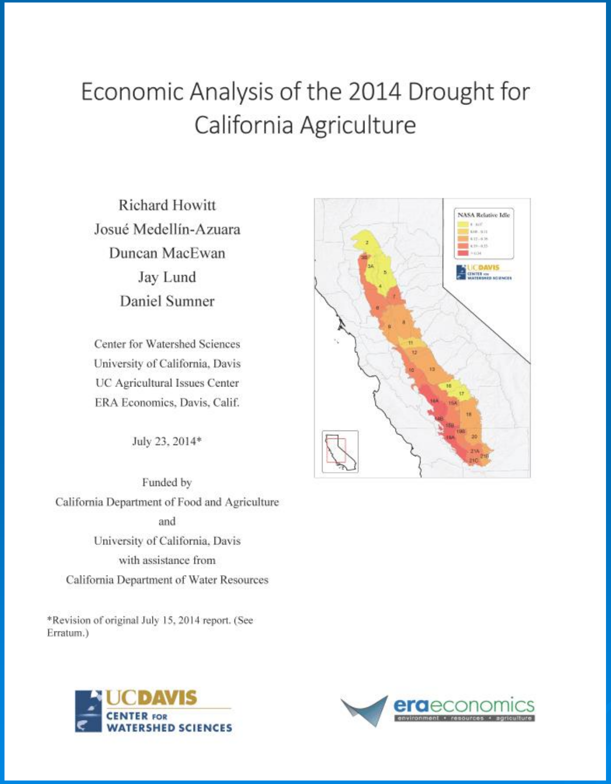
IWFM Features in Support of SGMA

- SGMA Draft GSP Emergency Regulations mention surface water supply and reliability for projected water budgets
- Surface water supply in California depends on the upstream reservoir operations and downstream regulations
- Need for linkage to CalSim
- Already established through C2VSim-CalSim 3.0 linkage



IWFM Features in Support of SGMA

- Ability to analyze economic impact of GSPs (not required by SGMA) through linkage of IWFM to agricultural economics models (e.g. C2VSim-SWAP linkage)


Economic Analysis of the 2014 Drought for California Agriculture

Richard Howitt
Josué Medellín-Azuara
Duncan MacEwan
Jay Lund
Daniel Sumner

Center for Watershed Sciences
University of California, Davis
UC Agricultural Issues Center
ERA Economics, Davis, Calif.

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*Revision of original July 15, 2014 report. (See Erratum.)

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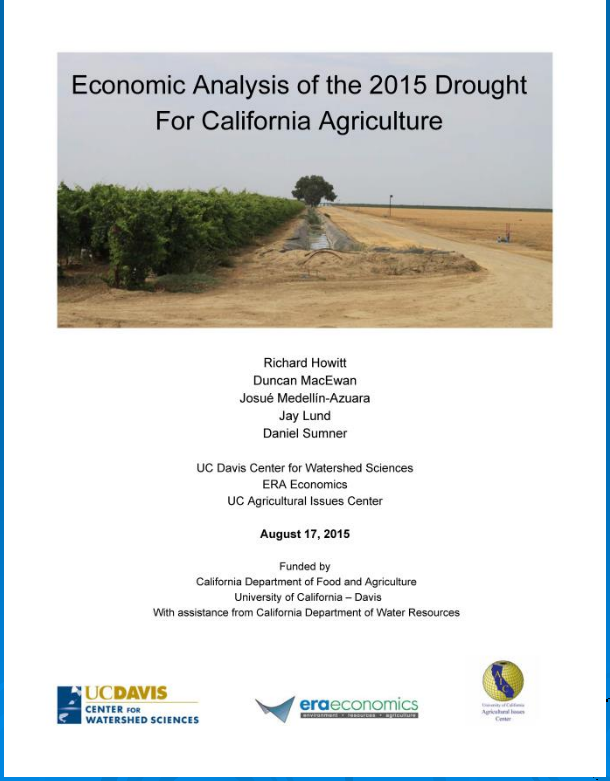
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Hydro-economic analysis of groundwater pumping for irrigated agriculture in California's Central Valley, USA

Josué Medellín-Azuara · Duncan MacEwan · Richard E. Howitt · George Koruakos · Emin C. Dogrul · Charles F. Brush · Tariq N. Kadir · Thomas Harter · Forrest Melton · Jay R. Lund

Abstract As in many places, groundwater in California (USA) is the major alternative water source for agriculture during drought, so groundwater's availability will drive some inevitable changes in the state's water management. Currently, agricultural, environmental, and urban uses compete for groundwater, resulting in substantial overdraft in dry years with lowering of water tables, which in turn increases pumping costs and reduces groundwater pumping capacity. In this study, SWAP (an economic model of agricultural production and water use in California) and C2VISim (the California Department of Water Resources groundwater model for California's Central Valley) are connected. This paper examines the economic costs of pumping replacement groundwater during drought and the potential loss of pumping capacity as groundwater levels drop. A scenario of three additional drought years continuing from 2014 show lower water tables in California's Central Valley and loss of pumping capacity. Places without access to groundwater and with uncertain surface-water deliveries during drought are the most economically vulnerable in terms of crop revenues, employment and household income. This is particularly true for Tulare Lake Basin, which relies heavily on water imported from the Sacramento-San Joaquin Delta. Remote-sensing estimates of idle agricultural land between 2012 and 2014 confirm this finding. Results also point to the potential of a portfolio approach for agriculture, in which crop mixing and conservation practices have substantial roles.

Keywords Agriculture · USA · Hydro-economics · Groundwater management · Remote sensing · Optimization

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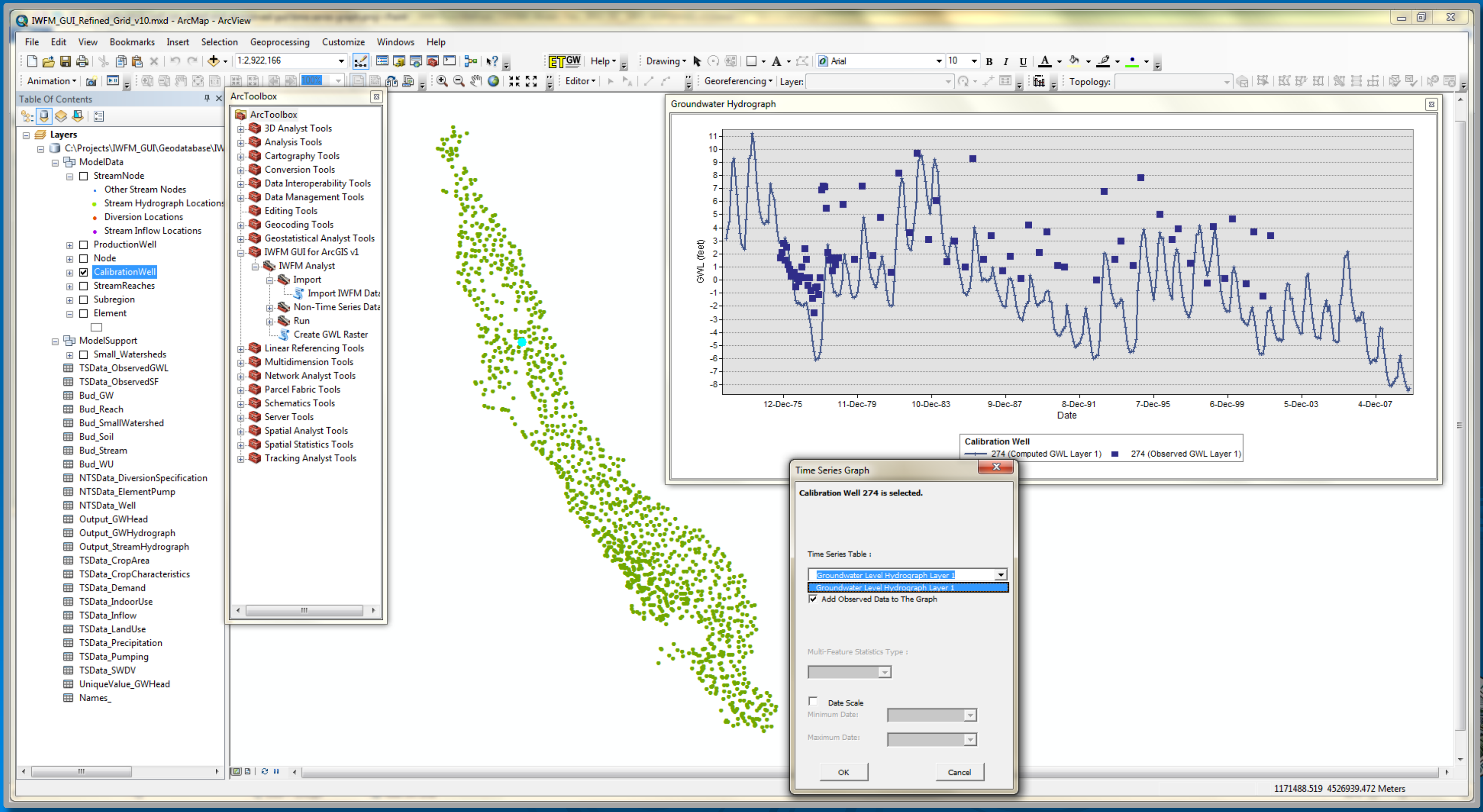
Introduction

Groundwater serves as the primary buffer against drought for irrigated agriculture worldwide, particularly in places like California (USA) that have both highly developed agriculture and water infrastructure. However, groundwater is often overexploited, threatening its availability during future droughts and for use in other human and environmental needs. California's recent Sustainable Groundwater Management Act, passed in 2014, requires and empowers local agencies to design and adopt basin-scale groundwater management plans. Given the complicated nature of integrated water management in California, it will likely take many years for overdrafted groundwater basins to re-equilibrate to long-term sustainable levels.

This paper explores the dynamic link between surface water and groundwater use in agriculture using a case study on the 2014 California drought. The analysis shows that replacing surface water with groundwater during drought can significantly mitigate the economic cost of drought. However, this additional groundwater pumping draws down the aquifer and imposes long-term costs including energy, pumping and well capital replacement costs, in addition to the standard long-term risks to water supply reliability.

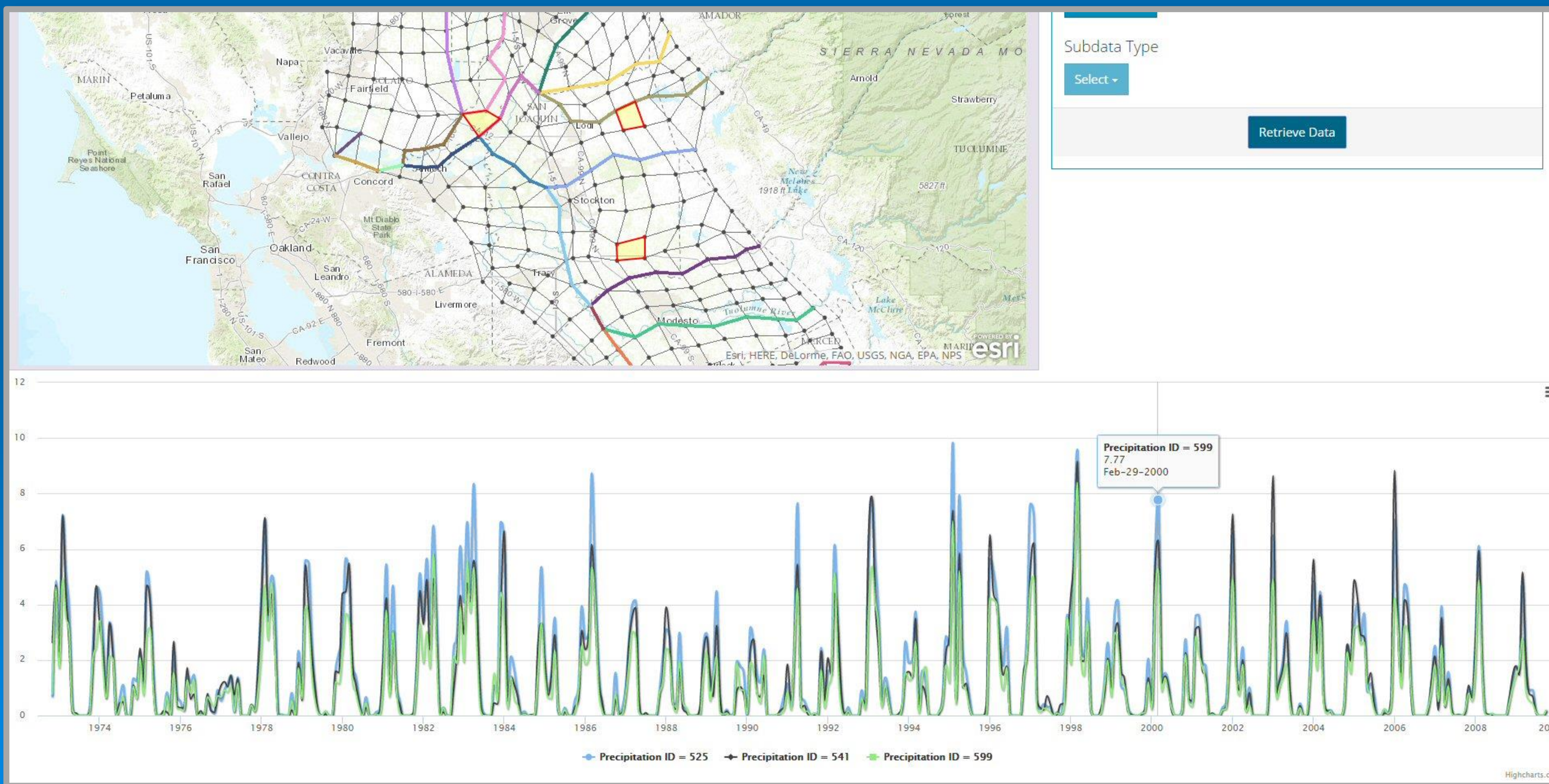
Planned Updates to IWFM

- Convert C2VSim ArcGIS GUI to generic IWFM model GUI



Planned Updates to IWFM

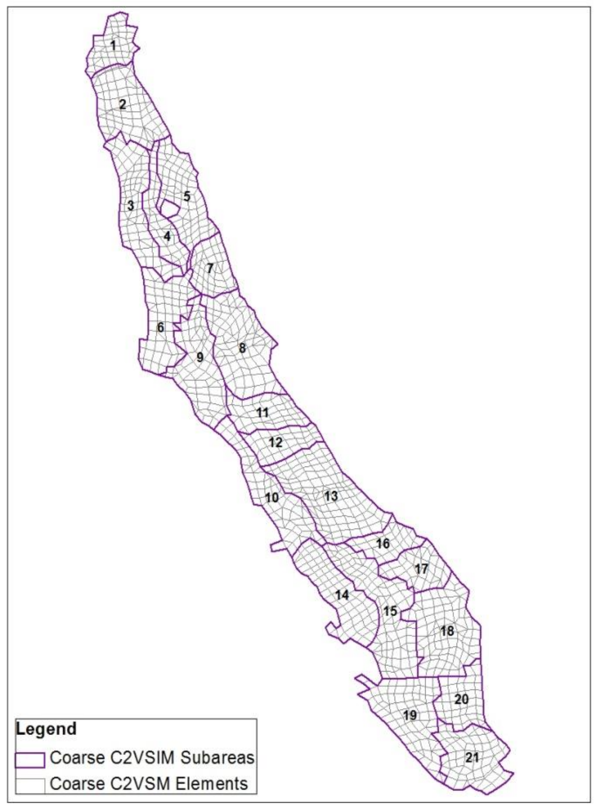
- Convert current C2VSim ArcGIS GUI to a web application for effective data distribution, increased accessibility, and to avoid ArcGIS version incompatibilities



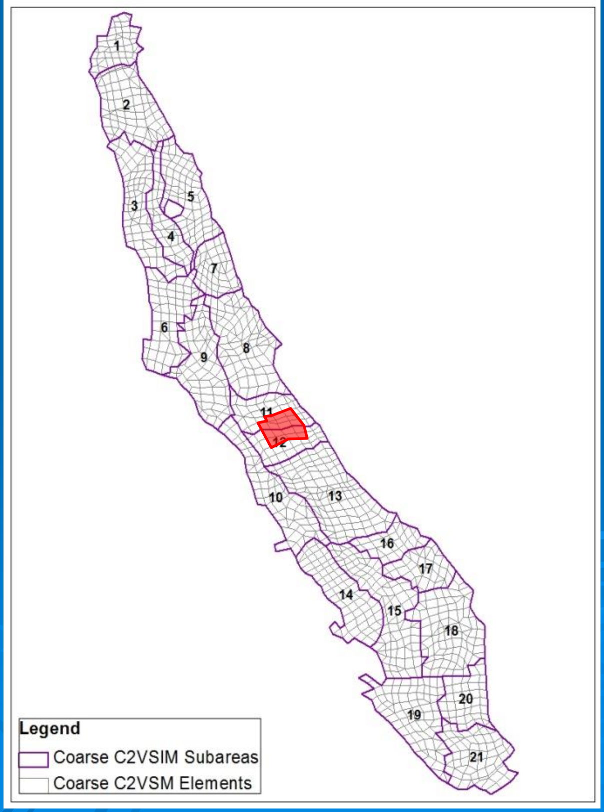
Planned Updates to IWFM

- Implement Z-Budget outputs for hydrologic processes other than groundwater

Budget
(for pre-defined subregions)



Z-Budget
(for arbitrary cell collections)



Planned Updates to C2VSim

- Migrate C2VSim-CG and C2VSim-FG to the latest IWFM simulation engine (IWFM-2015)
- Extend C2VSim (both CG and FG versions) simulation period to September 2015 (currently working on development of historical land-use data)
- Recalibrate C2VSim (both CG and FG versions)

Planned Updates to C2VSim

- Develop a GIS web application to serve C2VSim data in conjunction with Z-Budget feature in support of SGMA

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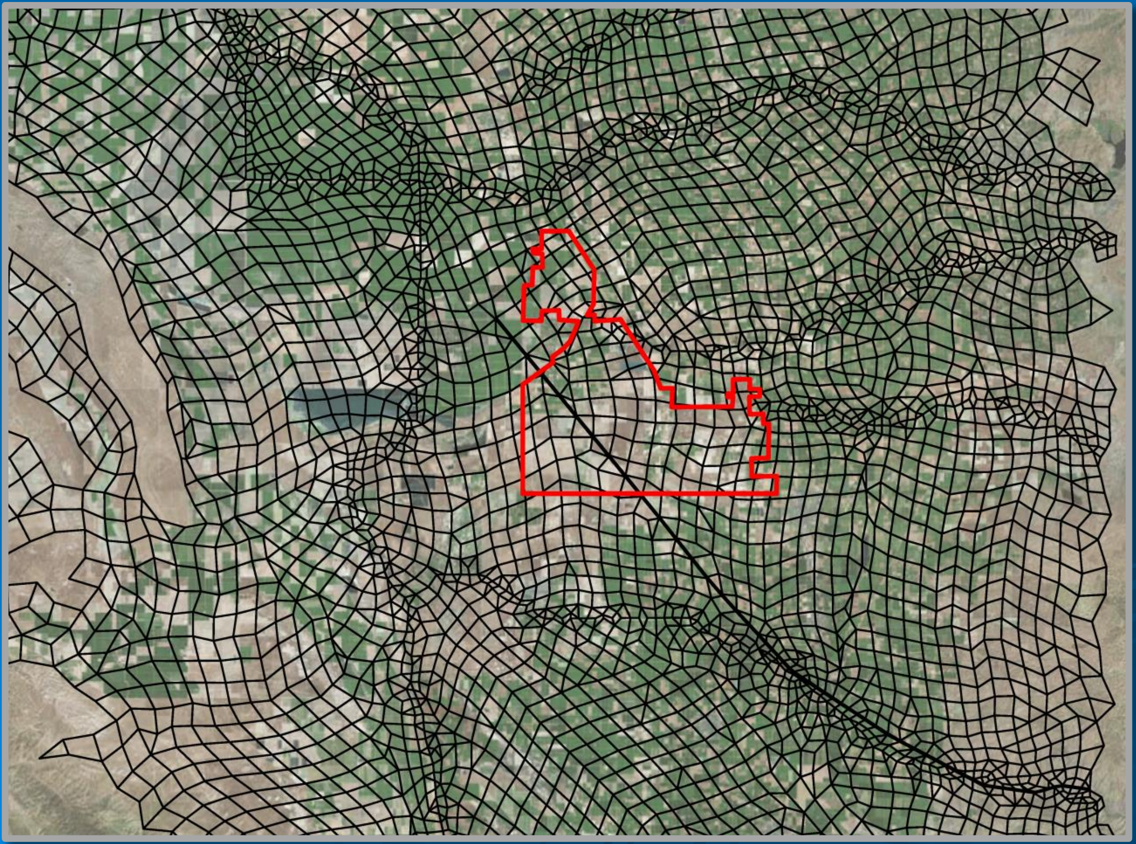
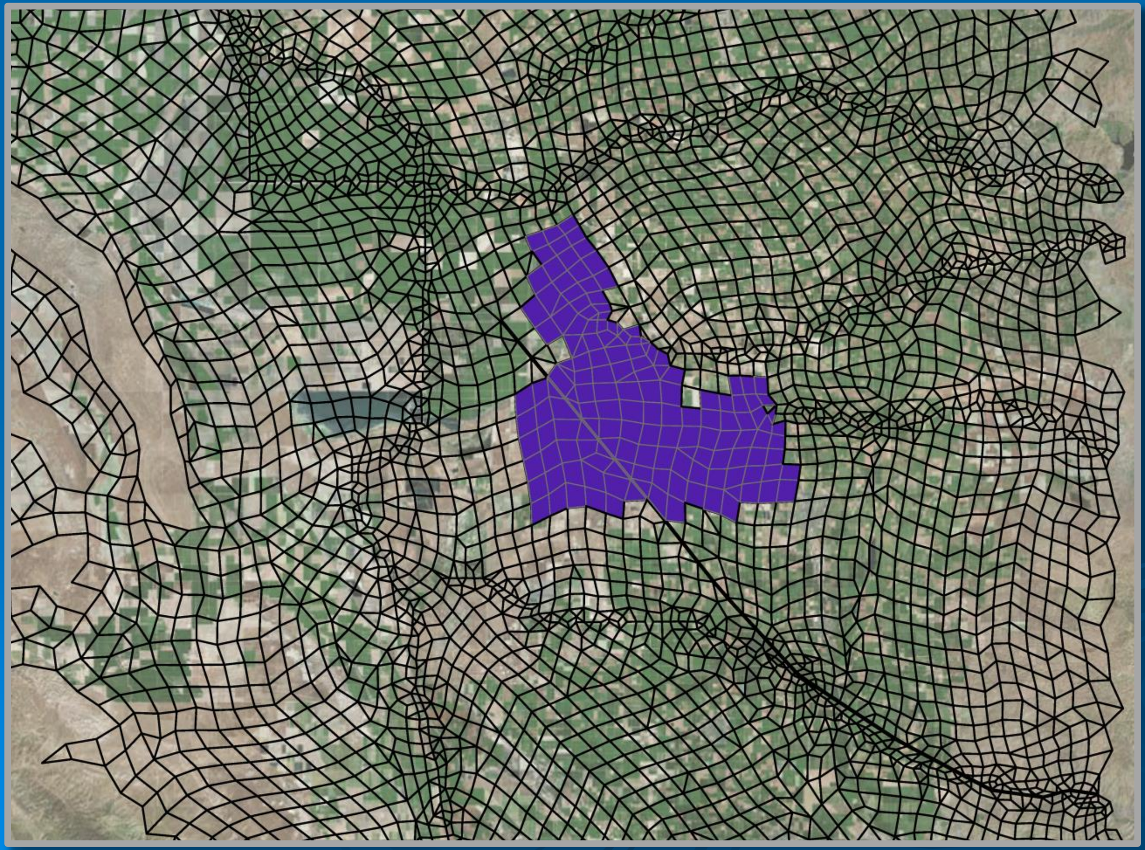


Planned Updates to C2VSim

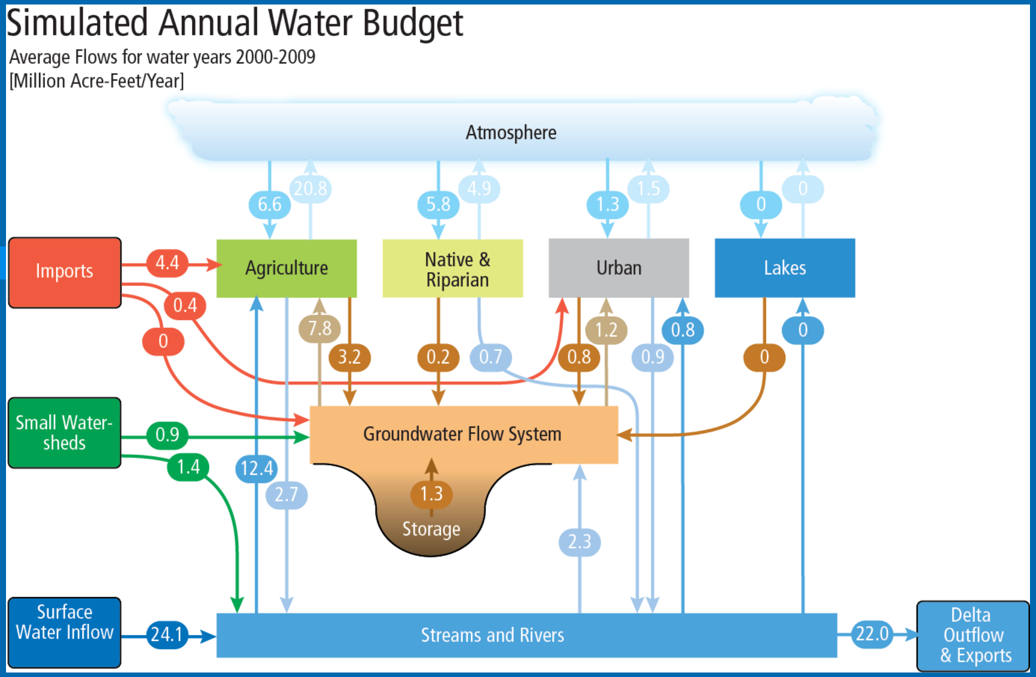
- Develop a GIS web application to serve C2VSim data in conjunction with Z-Budget feature in support of SGMA (calculate boundary flows, water budget terms)

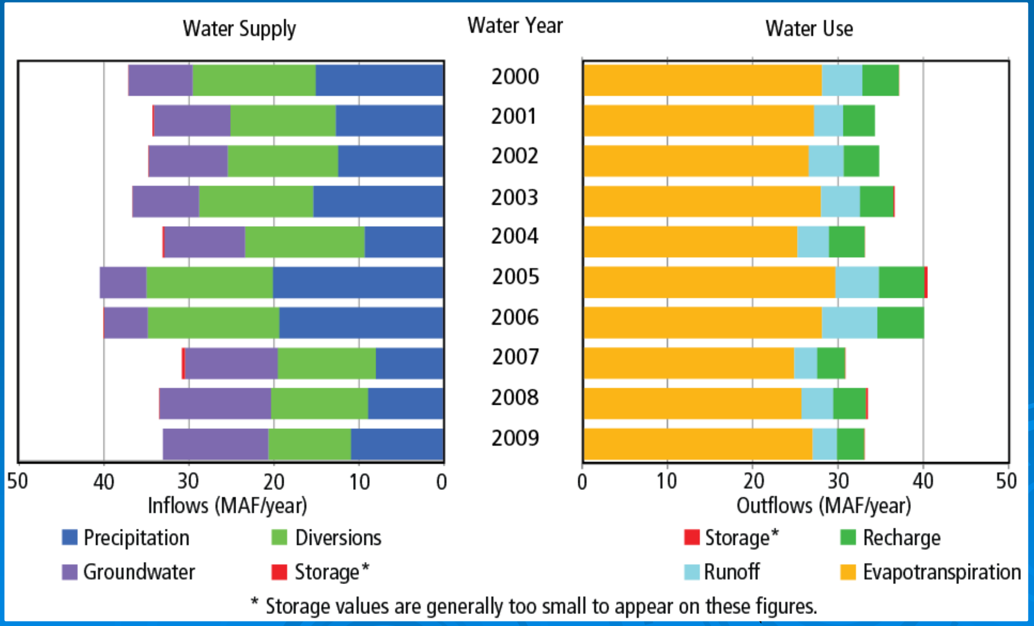


Additional Updates

- Move Z-Budget output to HDF5 file format for I/O efficiency and built-in file compression capabilities
- Develop automated visual tools for easy analysis of system behavior
- Implement water quality simulation both for groundwater and surface water systems
- Still exploring parallel processing
- Continue providing technical support and workshops (next IWFM workshop is April 25-27)

Questions?


Simulated Annual Water Budget
Average Flows for water years 2000-2009
[Million Acre-Feet/Year]
Atmosphere
6.6
20.8
5.8
4.9
1.3
1.5
0
0
Imports
4.4
Agriculture
Native & Riparian
Urban
Lakes
0.4
0
7.8
3.2
0.2
0.7
0.8
1.2
0.9
0.8
0
0
Small Water-sheds
0.9
Groundwater Flow System
1.4
12.4
2.7
1.3
Storage
2.3
Surface Water Inflow
24.1
Streams and Rivers
22.0
Delta Outflow & Exports


Water Supply
Water Year
Water Use
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
50
40
30
20
10
0
Inflows (MAF/year)
0
10
20
30
40
50
Outflows (MAF/year)
Precipitation
Diversions
Groundwater
Storage*
Storage*
Recharge
Runoff
Evapotranspiration
* Storage values are generally too small to appear on these figures.