

Water Management Lessons for California from Statewide Hydro-economic Modeling Using the CALVIN Model

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<http://cee.engr.ucdavis.edu/CALVIN/>

California’s complex water management system often defies comprehensive analysis. We summarize the results of a decade of quantification and analysis of this system from a hydro-economic perspective using the CALVIN Model. The general approach taken dates back to Roman times, when Frontinus (97 AD) began his oversight of Rome’s water system with a systematic inventory and quantification of its water system. This approach has been formalized and expanded in the modern era as economists, planners, and engineers have sought to grapple with complex water management systems and problems.

In California water supply and demands are inconvenient in space and time. Most water availability is in northern California from winter precipitation and spring snow-melt; whereas water demands are more in the south during the dry summer. Consequently, major floods and seasonal and multiyear droughts characterize water resources in California. The Sacramento-San Joaquin Delta is the major north-south hub for this water network. Population growth, climate change, a vulnerable Delta, and decentralized water governance pose opportunities and challenges to water management in California. Portfolios of water management activities, including diverse general policy tools, demand management, and operations and supply expansion options, are available to manage competing demands in complex situations. Exploring promising portfolios of actions is the main intent of the CALVIN model.

The CALVIN model

CALVIN is an economic-engineering optimization model of California developed at the University of California – Davis (Figure 1). CALVIN’s major innovations are its statewide (rather than project) scale, representation of a broad range of water management options, explicit integration of broad economic objectives, and its consequent applicability to a wide variety of policy, operations, and planning problems.

The CALVIN model uses a 72-year monthly time series of hydrology (1921-1993) to represent system variability. CALVIN manages water infrastructure and demands throughout California’s intertidal water network to minimize net scarcity and operating costs statewide. The model employs HEC-PRM with a network flow optimization solver developed by the US Army Corps of Engineers (Draper et al., 2003).

Model applications, summarized in Table 1, have been wide-ranging and provide a variety of insights.

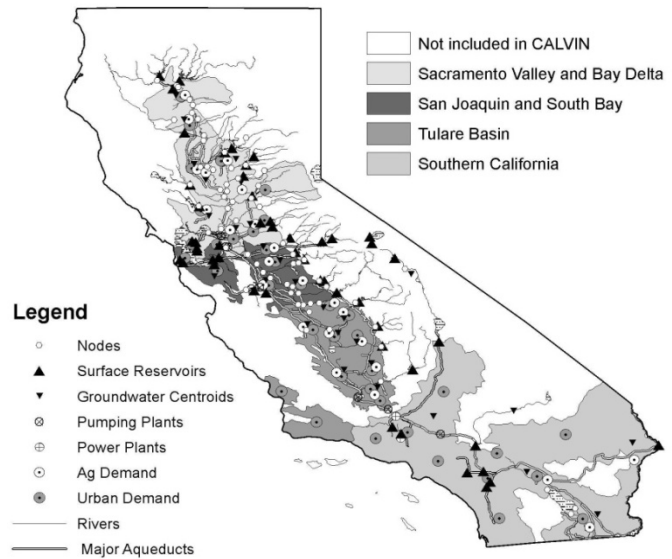


Figure 1 CALVIN, a hydro-economic representation of California’s water resources

Table 1. CALVIN Model Applications

Application	References
Integrated water management, water markets, capacity expansion	Draper et al. (2003); Jenkins et al. (2001; 2004)
Perfect and Limited Foresight	Draper 2001; Draper and Lund (2004)
Conjunctive use and Southern California	Pulido et al. (2004); Newlin et al. (2002)
Hetch Hetchy restoration	Null (2004); Null and Lund (2006)
Climate Change, wet and dry	Lund et al. (2003); Tanaka et al.(2006; 2008); Medellín et al.(2008a; 2009); Connell (2009)
Severe sustained drought impacts and adaptation (paleodrought)	Harou et al. (In Press)
Colorado River delta and Baja California water management	Medellin-Azuara et al. (2006; 2007; 2008b; 2009)
Ending overdraft in the Tulare Basin	Harou and Lund (2008)
Cosumnes River restoration and Sacramento area water management	Hersh-Burdick (2008)
Reducing Delta exports and increasing Delta outflows	Tanaka and Lund (2003); Tanaka et al. (2006; 2008); Lund et al. (2007; 2008, in press)

Hydro-Economic Model Development Lessons

1. Begin with a broad integrated and workable technical plan with ambitious, but limited objectives.
2. Organize input data in databases
3. Document data in databases
4. We need better data, and better documentation of data
5. What few features should better statewide water planning and policy models have?
6. Need policy discussion and decision-making frameworks that can better employ quantitative information

Water Management Lessons for California

1. It is possible to represent and greatly improve statewide integrated water management and policy studies in California using hydro-economic modeling.
2. CALVIN results demonstrate the significant physical and economic flexibility of California's water system and its adaptability to a wide range of potential changes.
3. The Sacramento-San Joaquin Delta is the weakest link in California's water supply system.
4. There is rarely a shortage of water, only a shortage of cheap water.
5. Integrated portfolio solutions of traditional and new options tend to be the most cost effective and robust. Portfolios including water markets, groundwater banking, conservation, reuse, and improvements in conveyance and recharge show great promise for a wide range of climate and population conditions.
6. Of traditional infrastructure, expansions of selected conveyance and aquifer recharge are typically much more beneficial if water operations are well managed.
7. We should have higher expectations for quantitative information for water policy and management.

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