SacWAM Independent Science Review Panel

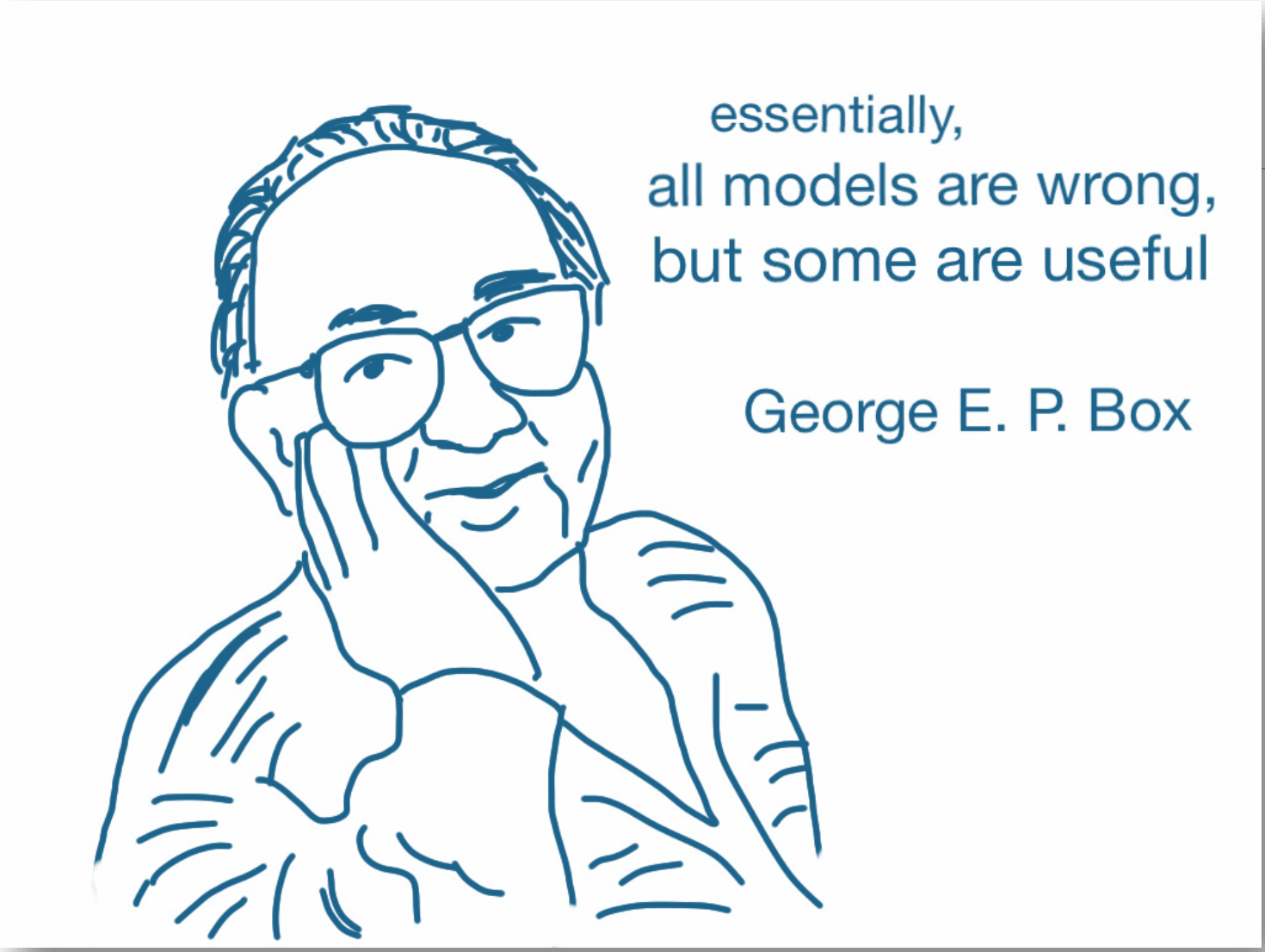
INITIAL FINDINGS & RECOMMENDATIONS

19TH OCTOBER 2016

CONDON, FLEENOR, SANDOVAL-SOLIS, SERENO, & VIERS

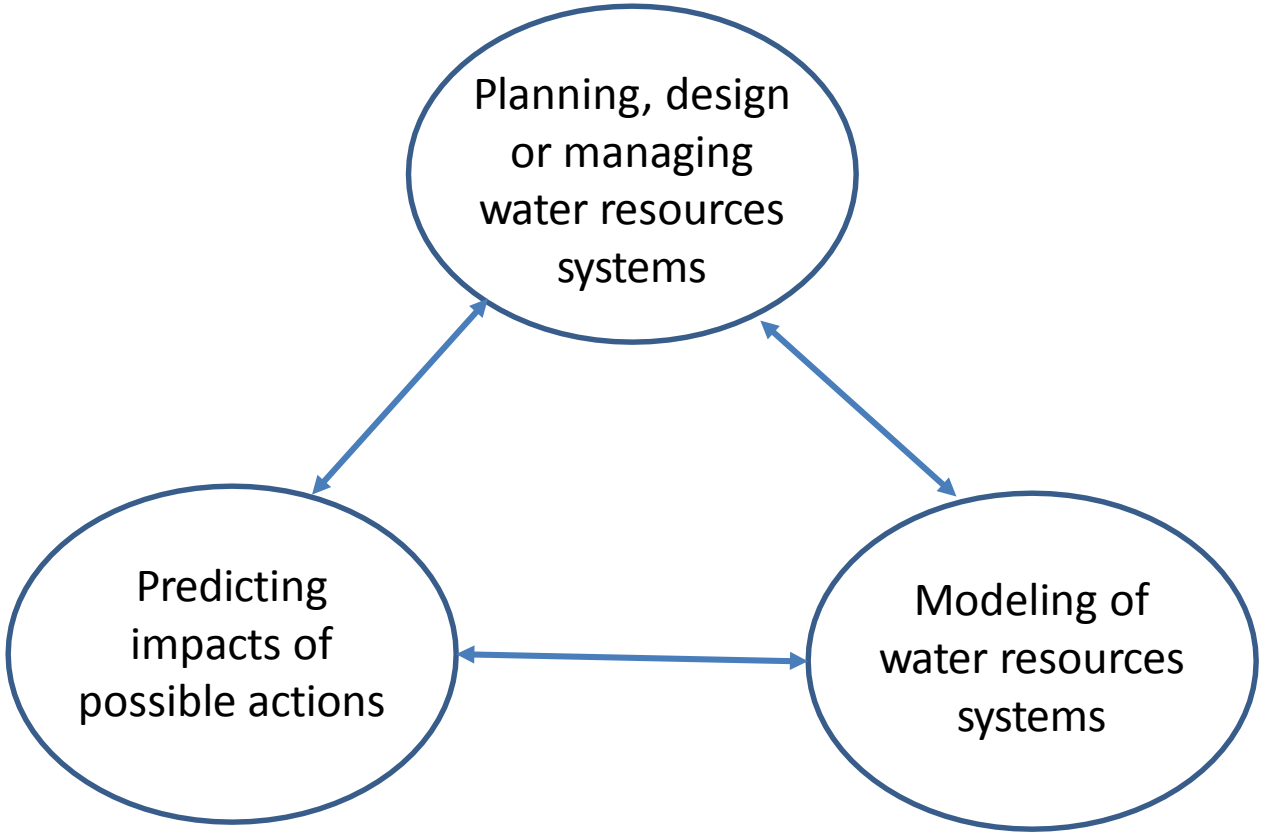
Our Charge

The model will be reviewed by an Independent Review Panel in a public forum in order to assure transparency and confirm the adequacy of SacWAM to simulate water balance for comparative purposes for applications related to updates to the Bay-Delta Plan.


essentially,
all models are wrong,
but some are useful
George E. P. Box

Role of models and modeling

Using mental models for prediction

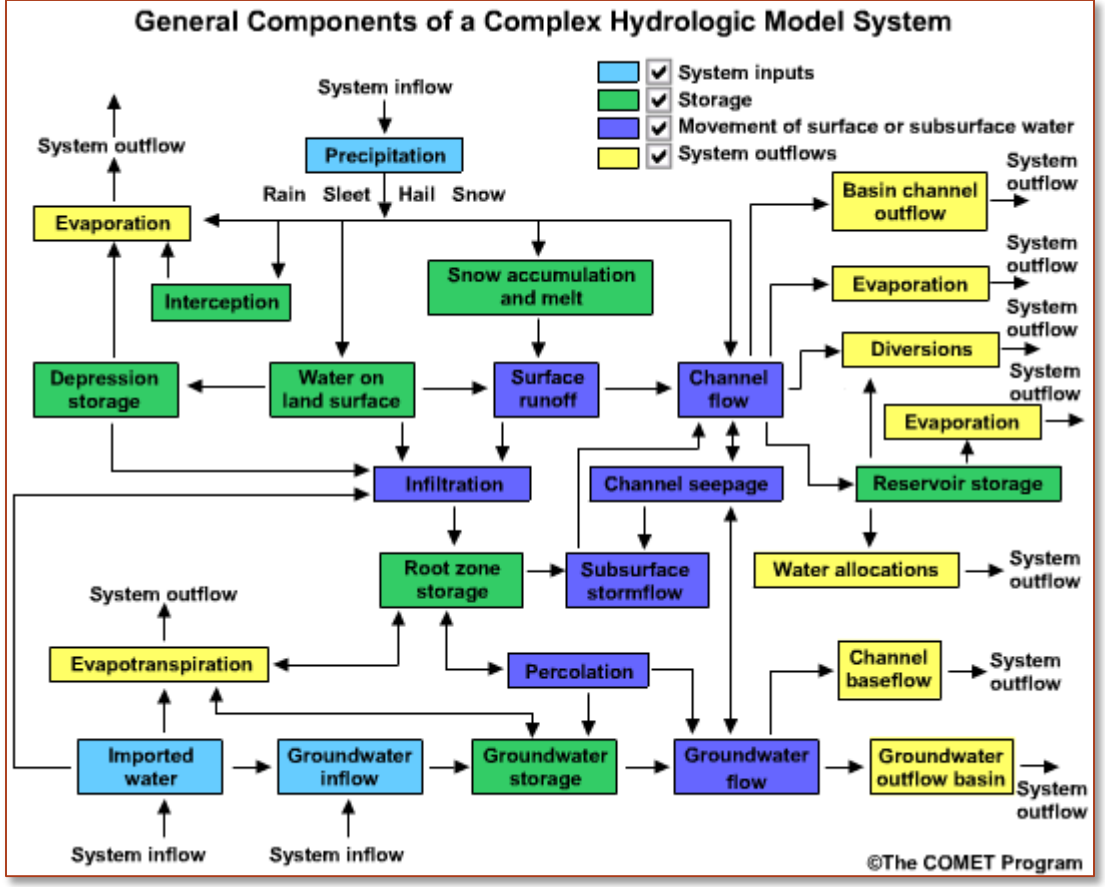


Planning, design and management decisions are based on what the decision-makers believe, or hope, will take place as a result of their decisions

Computer-based modelling is used to enhance, but not fully replace, mental models

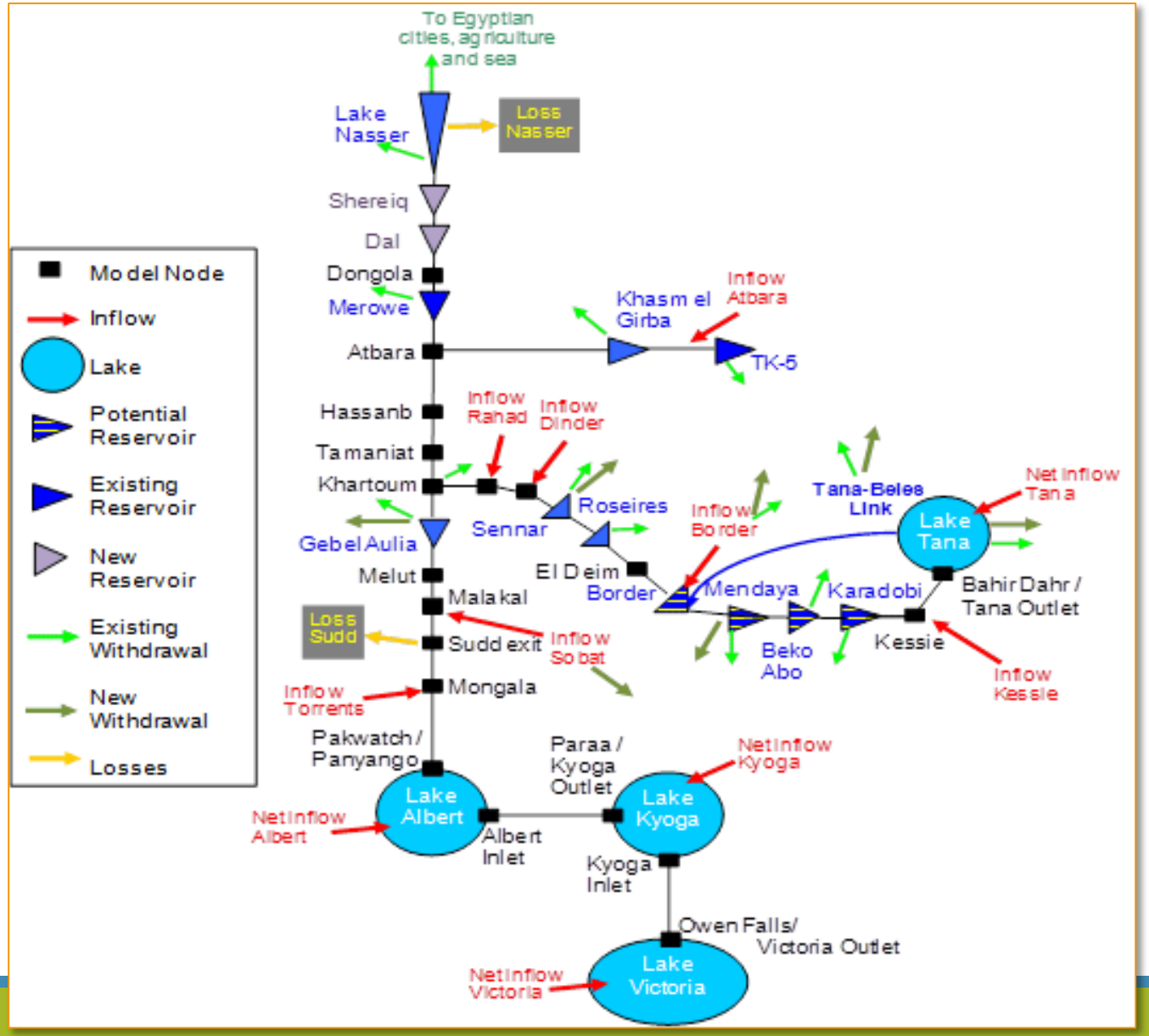
Limitations of modeling

- Water resources systems are far more complex than anything analysts have been, or perhaps ever will be, able to model and solve.
- This <u>not simply a computational limit</u> on the number of model variables, constraints, subroutines or executable statements
- Rather it is because <u>we do not understand sufficiently the multiple interdependent processes</u> (physical, biochemical, ecological, social, legal and political (human)) that govern the behavior of water resources systems
- Processes are affected by uncertainties in measurements
- There are also unpredictable actions of multiple (human) actors



Loucks ch 2

Developing models is an art

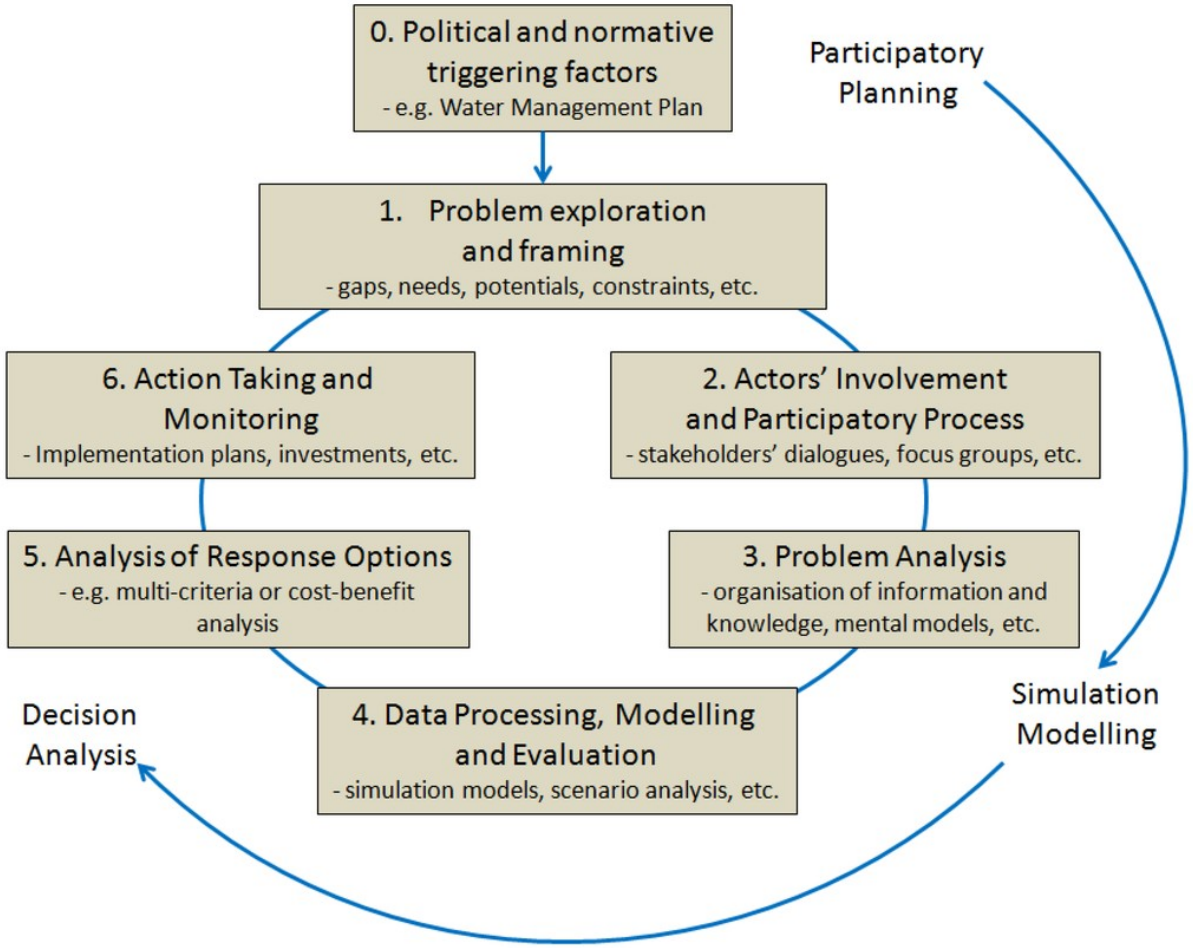


- Requires knowledge of the system being modeled, objectives, goals and information needs
- Always based on numerous assumptions or approximations
- Applying approximations of reality in ways that improve understanding requires not only modelling skills but also an ability to communicate effectively

Loucks ch 2

Models produce information, not decisions

- Decisions may not be influenced by planning and management model results
- Managers know that not everyone will benefit from a preferred action, and those who lose will likely scream louder than those who gain
- Decision-makers may feel safer in inaction than action,
  - In many cultures and legal systems the failure to act (nonfeasance) is more acceptable than acts that fail (misfeasance or malfeasance)
  - We all feel greater responsibility for what we do than for what we do not do

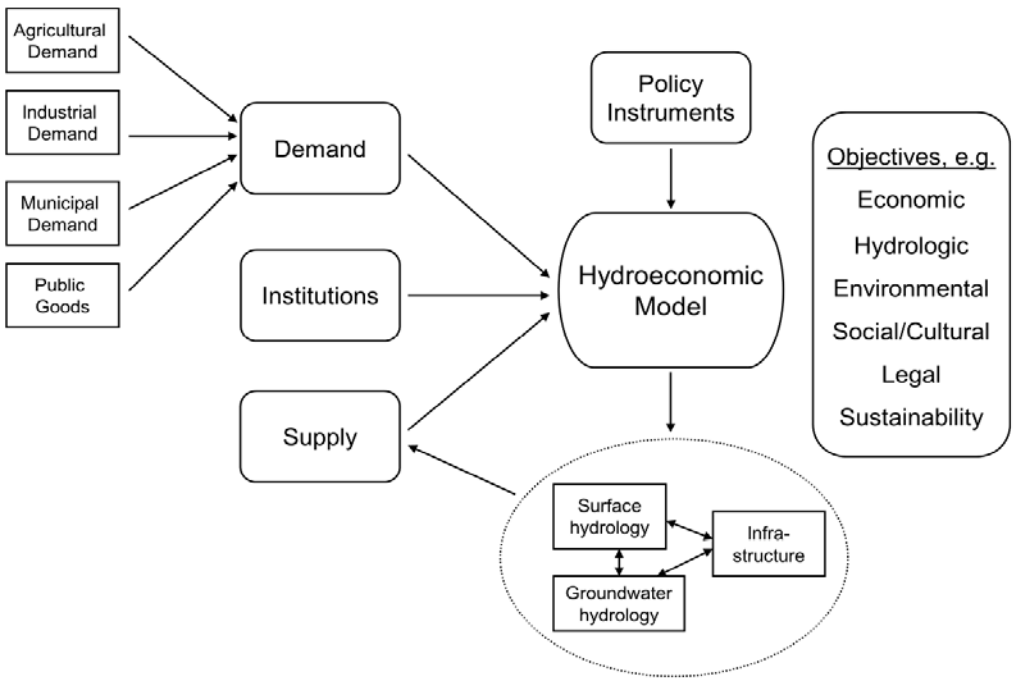


Giupponi, Water 2013
Loucks ch 2

Characteristics of problems to be modeled

Modeling is most appropriate when

- Planning and management objectives are well defined, as are users of results
- There are alternative decisions that may satisfy the stated objectives, and the best decision is not obvious
- System and the objectives being analyzed are describable by reasonably tractable mathematical representations
- Information needed, such as the hydrologic, economic, environmental and ecological impacts, can be better estimated through the use of models
- Model parameters are estimable from readily obtainable data



Basic conceptual structure of integrated hydroeconomic models

Booker 2011

Loucks ch 2

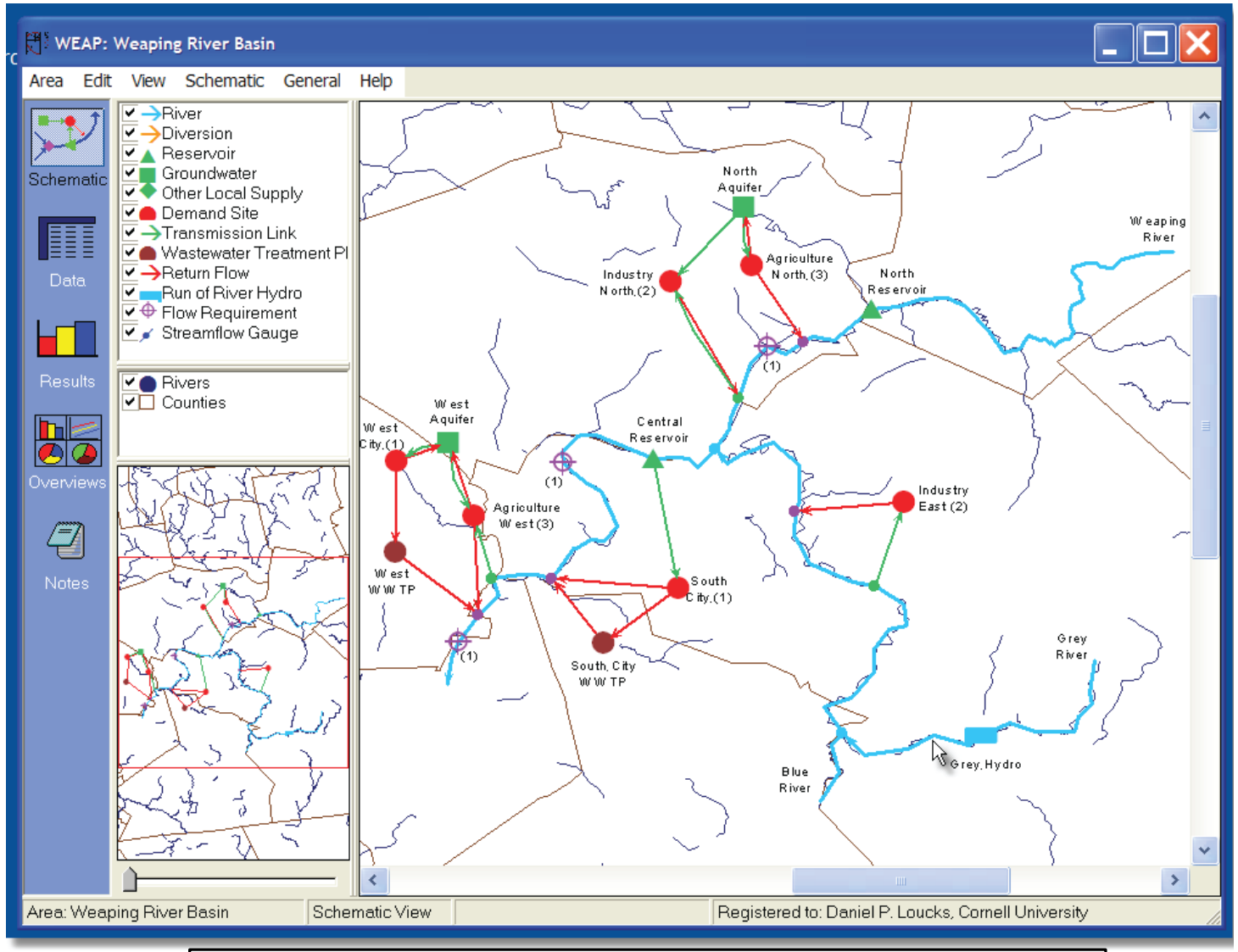
Advances in decision support systems

It is said that decision-makers don't know what they want until they know what they can get

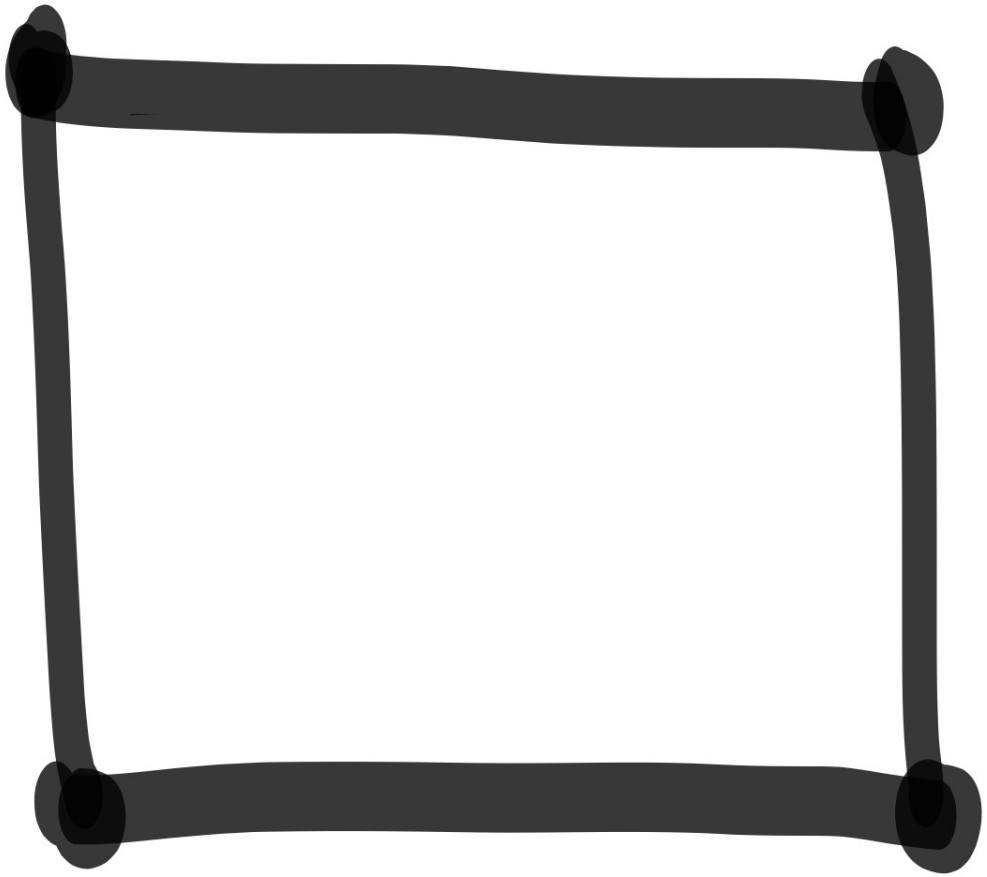
Stakeholders involved in river basin planning and management, each having different goals and information needs

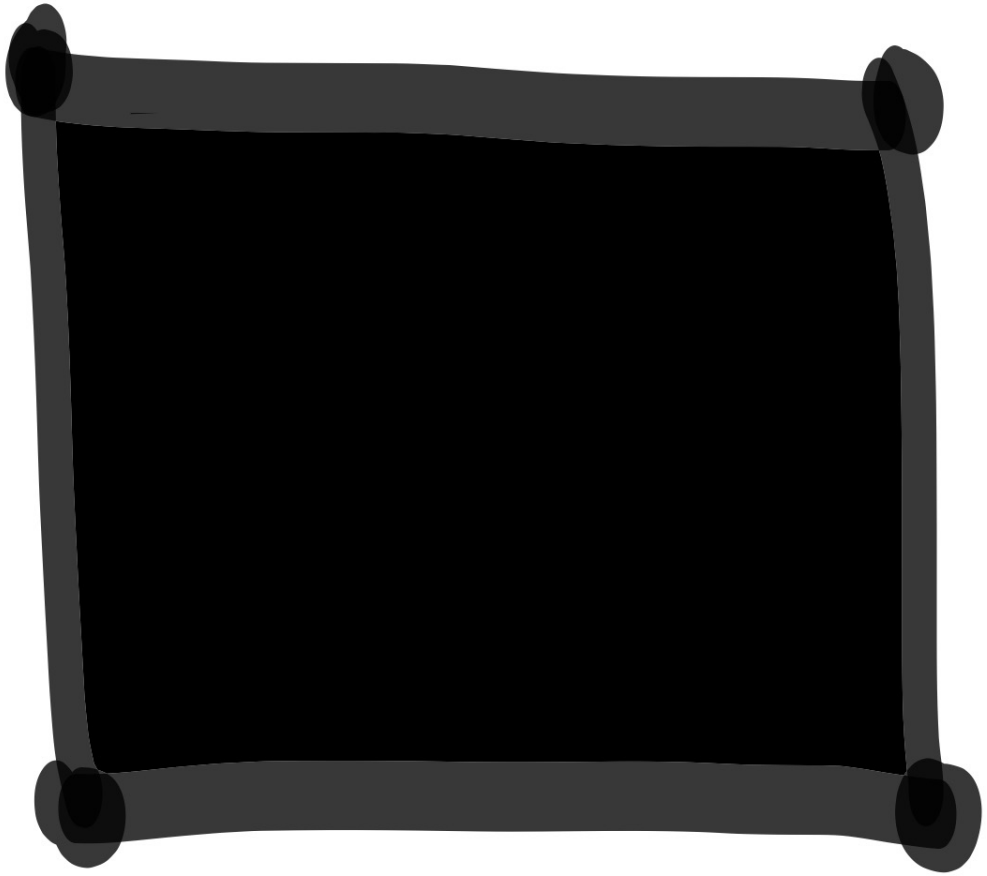
Advances in modeling and decision support

- Shared vision modeling
- Open modeling systems



Main interface of WEAP, which is typical of a variety of generic river basin models that are able to simulate any river system





CalSim II

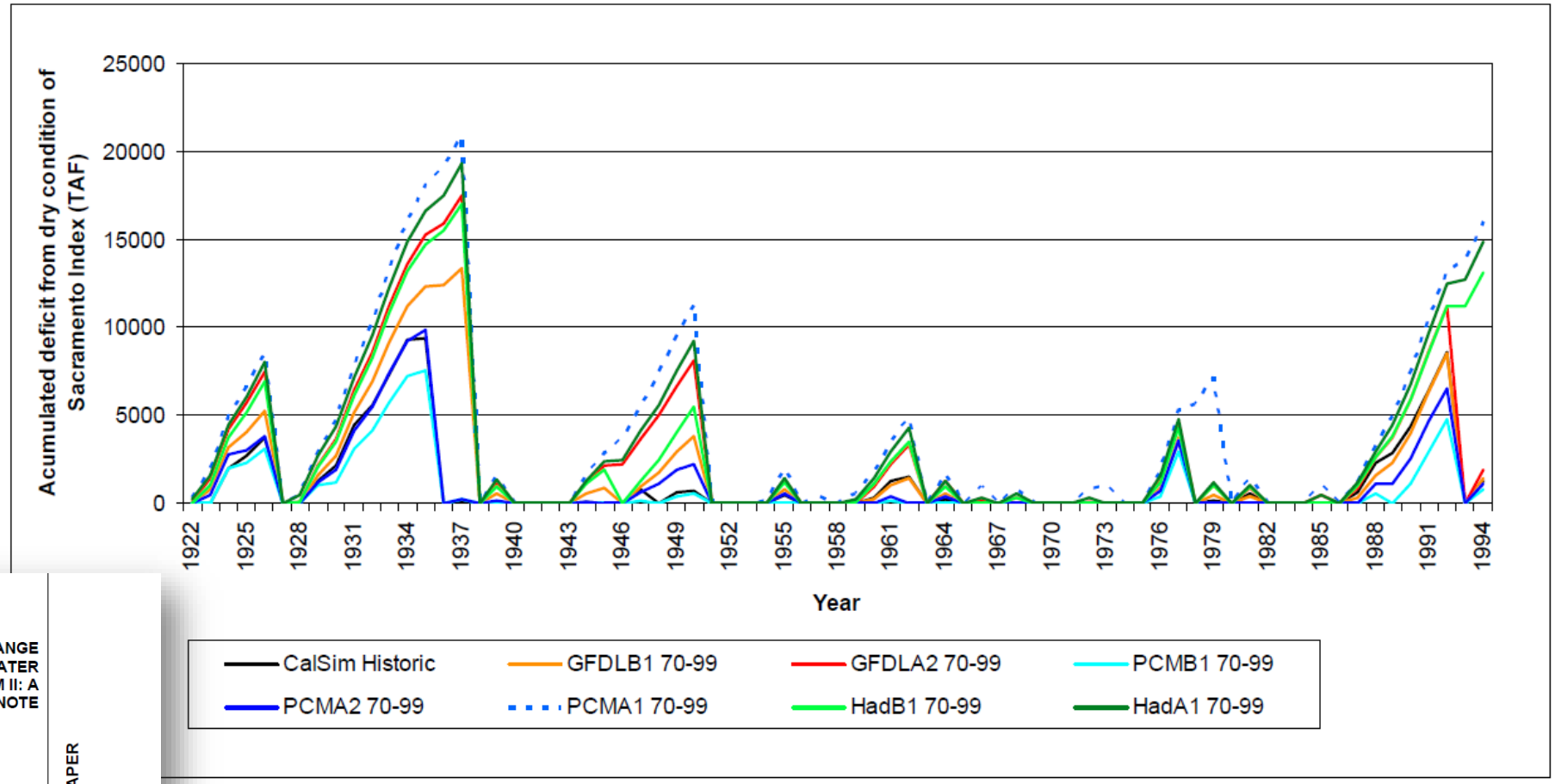
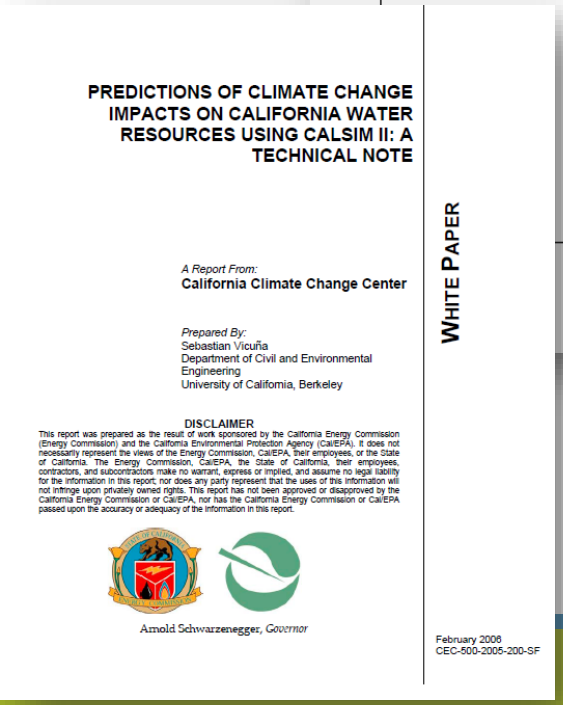


Figure 2. Changes in drought conditions for all climate scenarios



PREDICTIONS OF CLIMATE CHANGE IMPACTS ON CALIFORNIA WATER RESOURCES USING CALSIM II: A TECHNICAL NOTE

WHITE PAPER

A Report From:
California Climate Change Center

Prepared By:
Sebastian Vicuña
Department of Civil and Environmental Engineering
University of California, Berkeley

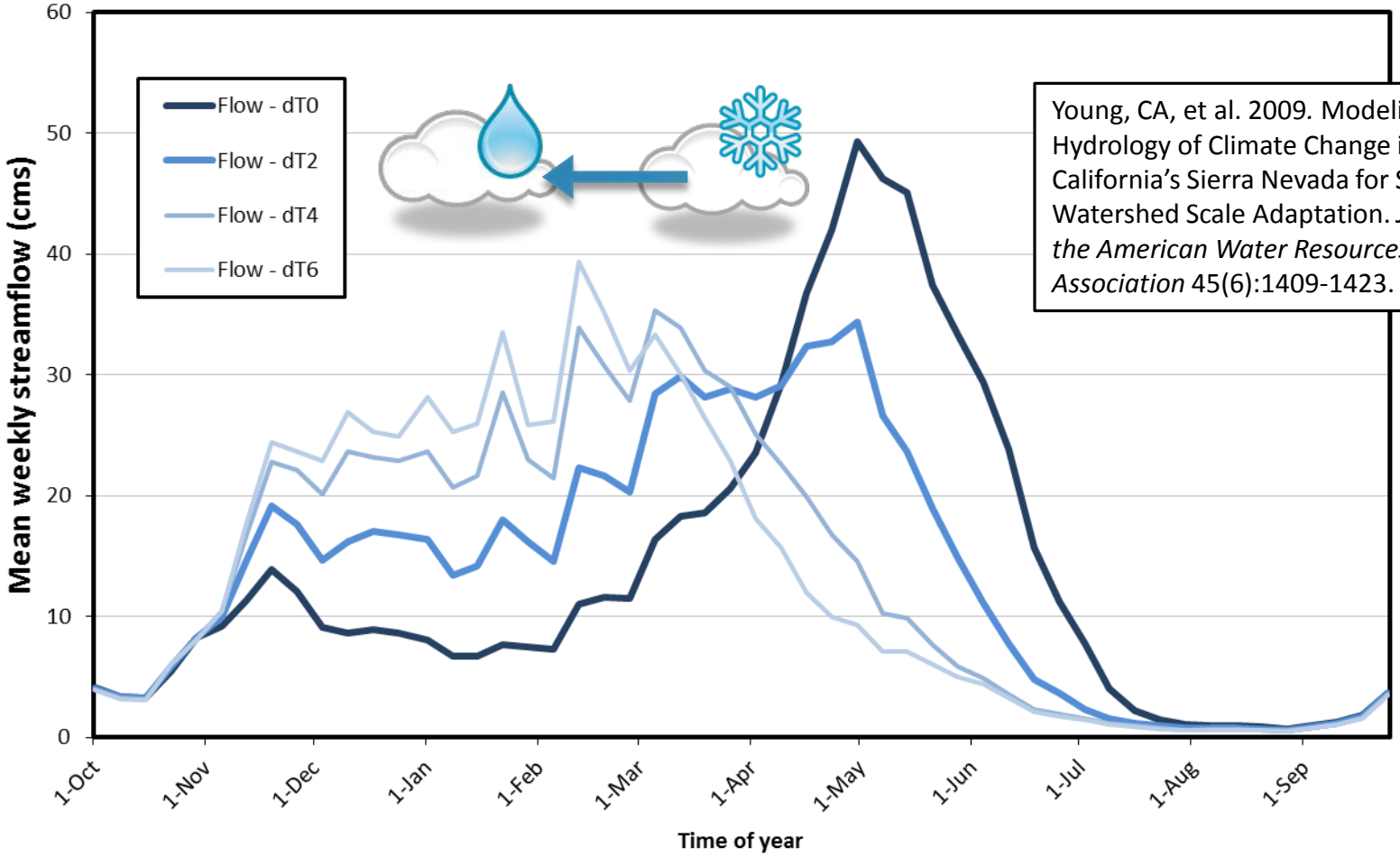
DISCLAIMER
This report was prepared as the result of work sponsored by the California Energy Commission (Energy Commission) and the California Environmental Protection Agency (Cal/EPA). It does not necessarily represent the views of the Energy Commission, Cal/EPA, their employees, or the State of California. The Energy Commission, Cal/EPA, the State of California, their employees, contractors, and subcontractors make no warrant, express or implied, and assume no legal liability for the information in this report; nor does any party represent that the uses of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the California Energy Commission or Cal/EPA, nor has the California Energy Commission or Cal/EPA passed upon the accuracy or adequacy of the information in this report.

Arnold Schwarzenegger, *Governor*

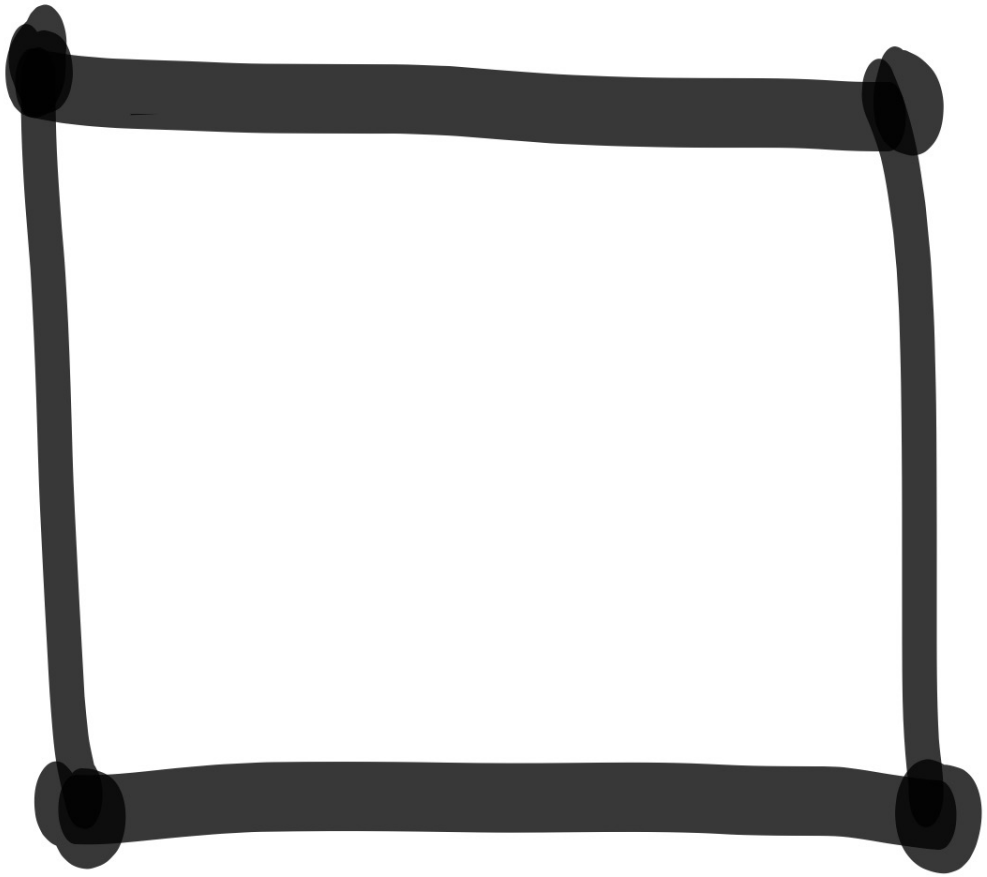
February 2006
CEC-500-2005-200-SF

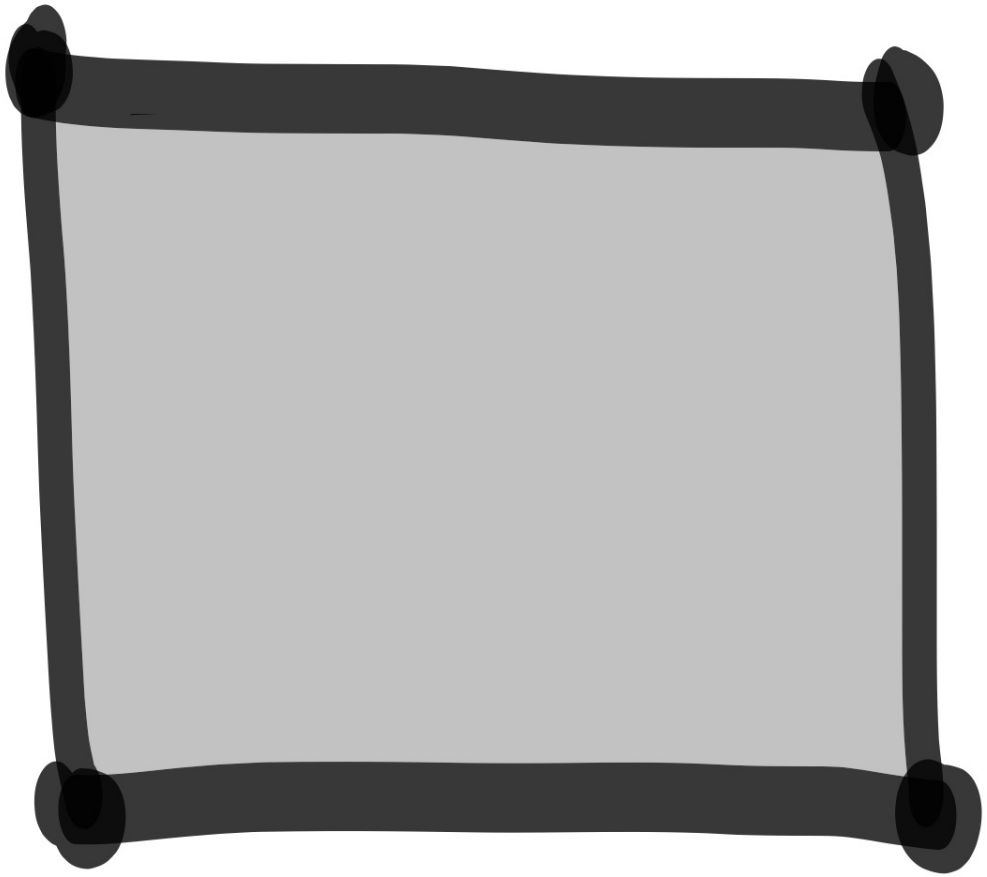
S. Vicuna 2006

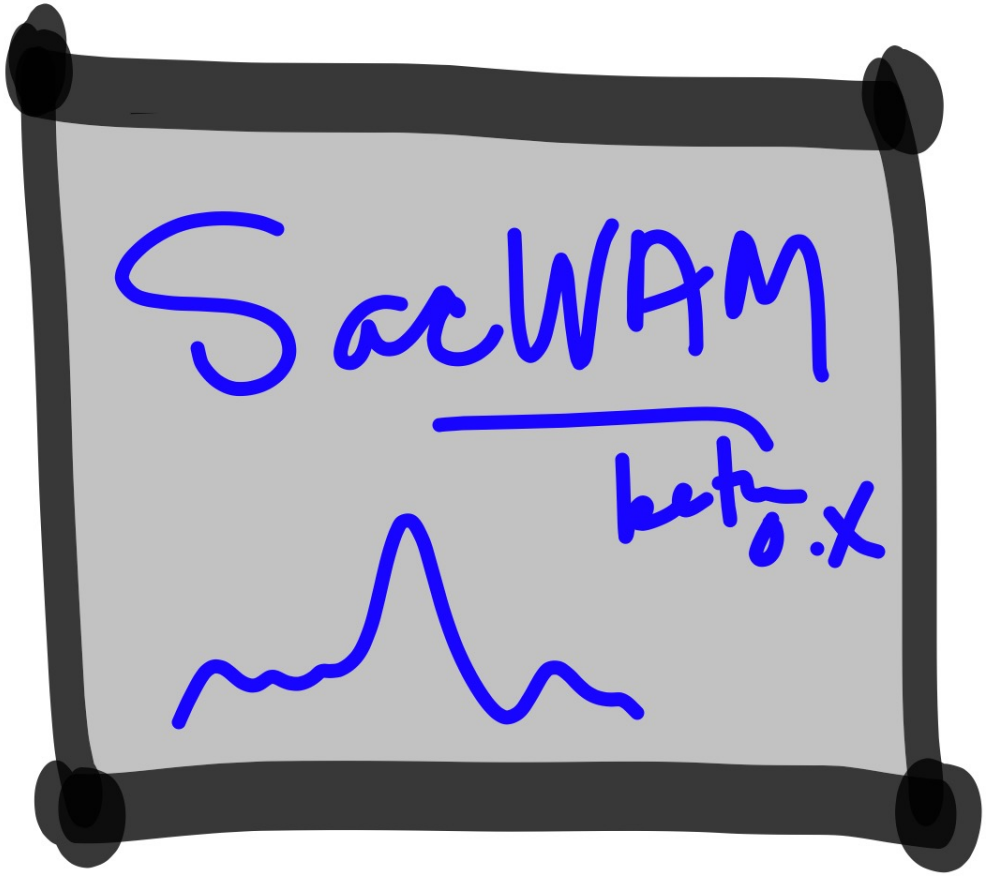
The Sierra is losing its Nevada.

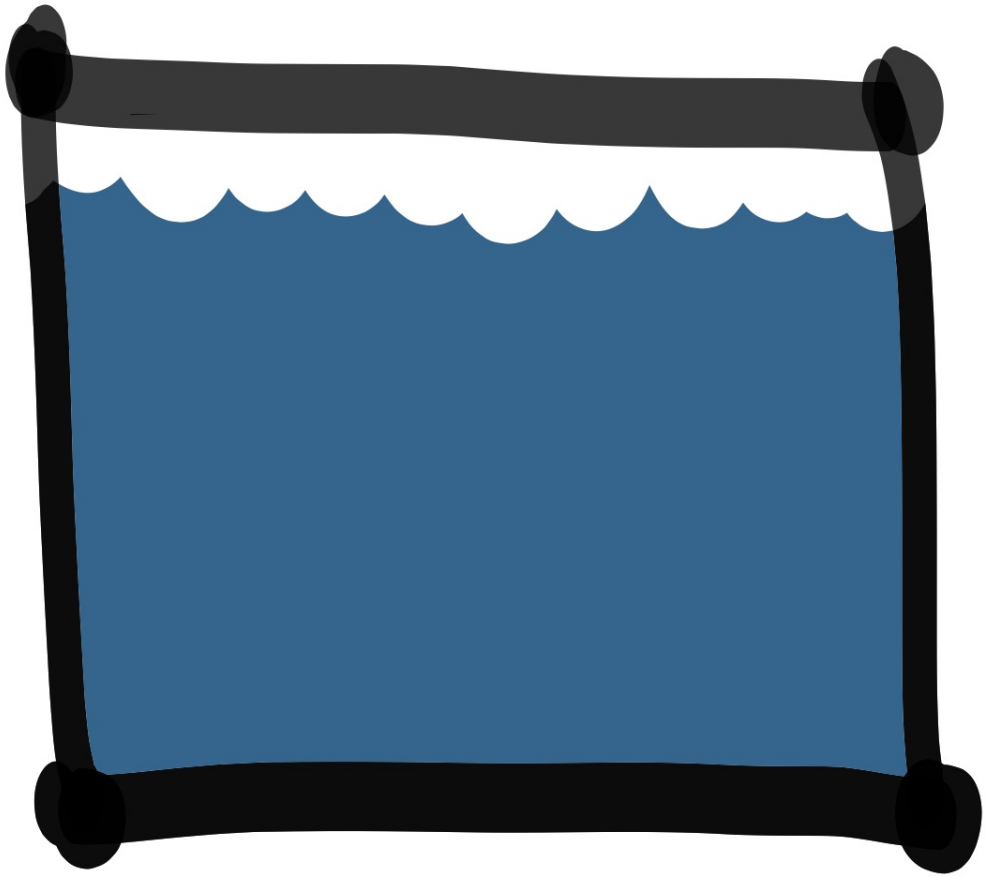


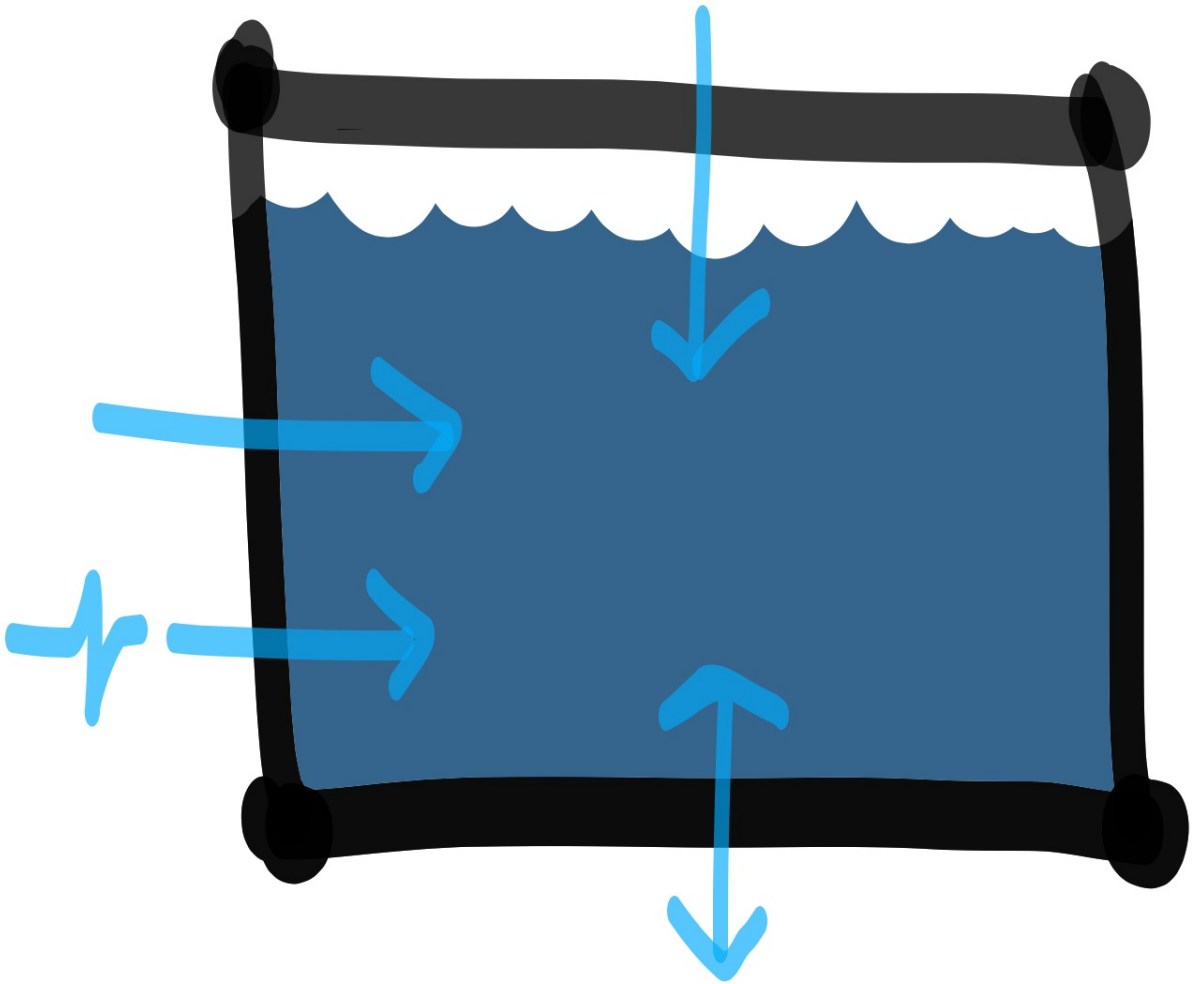
Young, CA, et al. 2009. Modeling the Hydrology of Climate Change in California's Sierra Nevada for Sub-Watershed Scale Adaptation. *Journal of the American Water Resources Association* 45(6):1409-1423.

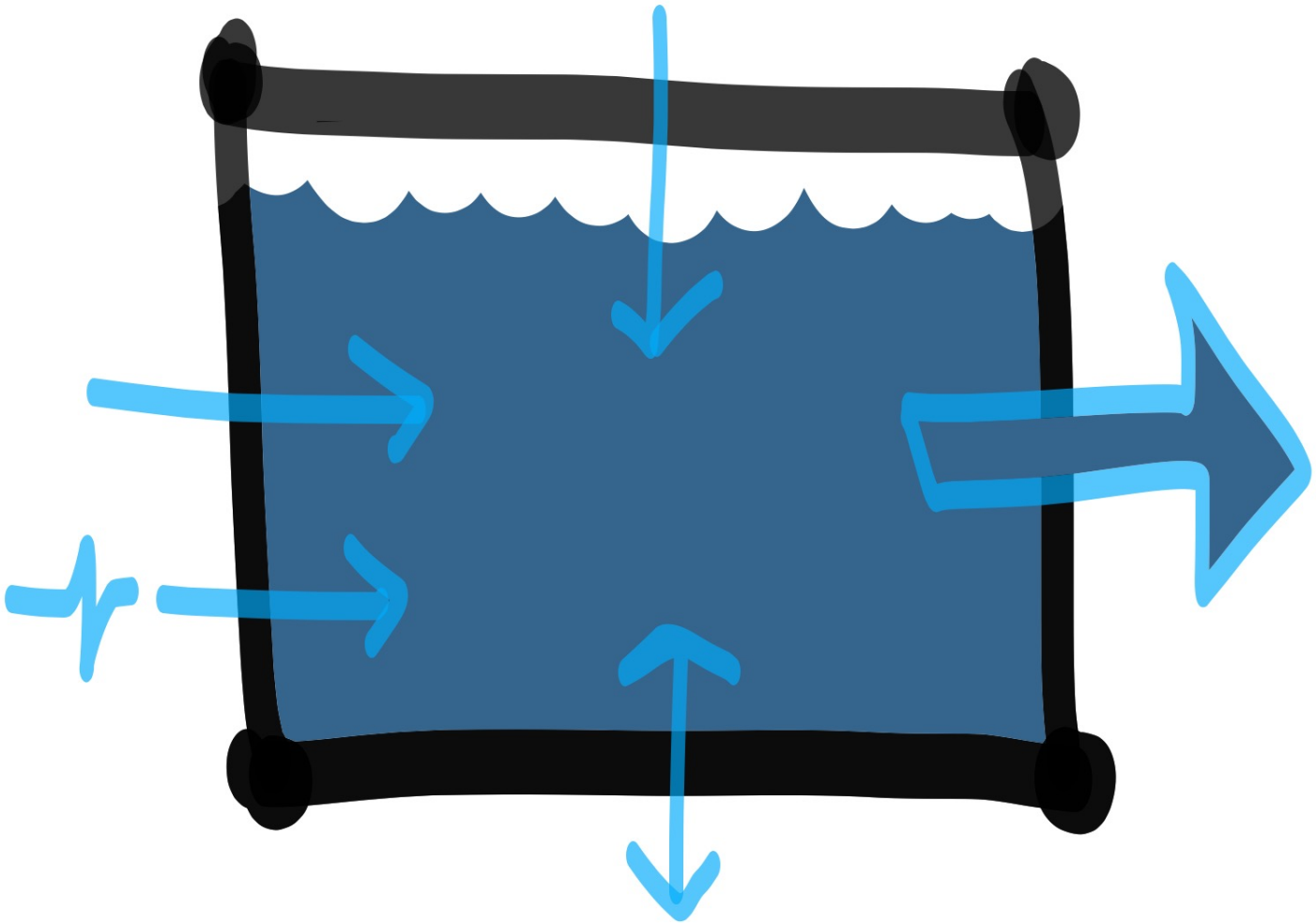


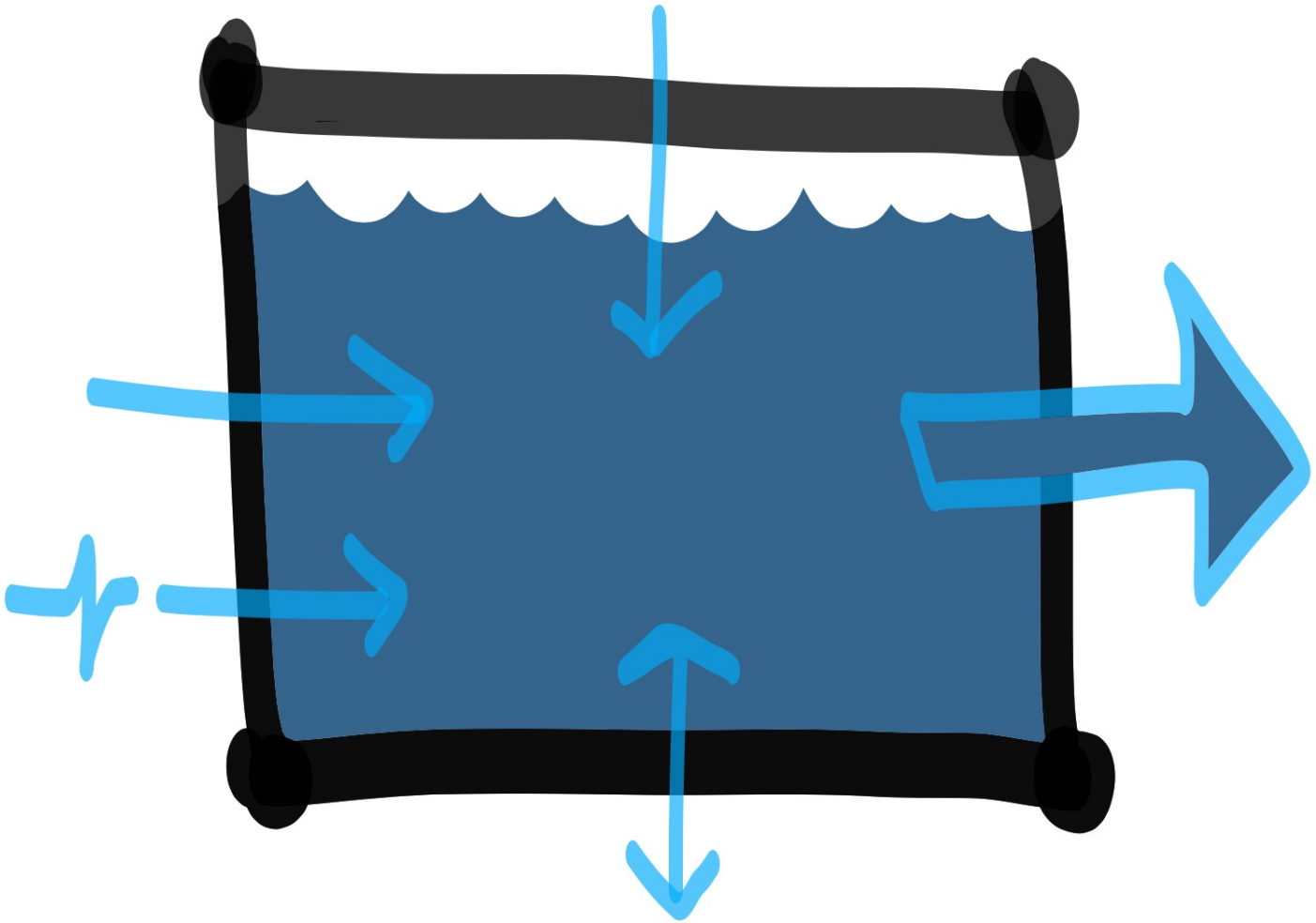



SacWAM
beta.x









$$\Delta \text{storage} = \text{Ins} - \text{Outs}$$

Desired Benefits of SacWAM

The Board needs additional modeling capabilities that are not part of CalSim II's functionality:

1. the ability to predict flows at the mouths of tributaries to the Delta;
2. ability to simulate water diversions on non-mainstem tributaries and creeks; and
3. ability to simulate the operation of local agency reservoirs that are not part of the SWP or CVP.
4. Rapid assessment of alternative water development and management strategies
5. Evaluate a wide range of water development and management options taking into account multiple and competing uses of water

Needs to be a flexible, user-friendly simulation tool to assess the impacts of various regulatory scenarios on flows into the Delta, within the Delta, and flows exported from the Delta.

1. Is SacWAM an appropriate tool to assist the State Water Board with the analyses associated with the Bay-Delta Plan update?

- **Advantages**
  - highly complex model developed with proven software tools
  - inclusion of features (infrastructure, inflows) not previously available
  - relative ease in creating new scenarios to ask ‘what-if’ questions
  - fidelity to existing data representations
- **Disadvantages**
  - fidelity to existing data representations
    - (i.e., model forcing via boundary conditions and bias correction)
  - not fully transparent, though documented and supported
    - guidance would be improved with Bay
  - reliance on commercial numerical solver will limit adoption by public

Other Key Questions:

2. What are the limitations, uncertainties, and impediments associated with the use of the SacWAM model? Can you suggest ways to improve SacWAM to address those concerns?
3. Under what circumstance(s) would SacWAM or CALSIM II be more scientifically justified?
4. What additional information or capabilities could be added to the SacWAM model, post-run processing, or documentation to improve its usefulness to State Water Board?
5. Is SacWAM's calibration and/or validation appropriate and sufficient for the intended use to evaluate potential changes in flows, and environmental and economic impacts under different regulatory requirements?
6. What, if any, additional sensitivity analysis, calibration and/or validation is recommended for SacWAM?
7. Are SacWAM's temporal and geographic scales and resolutions appropriate for the intended use?

2. What are the limitations, uncertainties, and impediments associated with the use of the SacWAM model? Can you suggest ways to improve SacWAM to address those concerns?

- **Limitations**:
  - model to model corroboration (i.e., we know that CalSim II has problems)
  - exclusion of most recent water years (2009-2016, better understood & relevant)
  - monthly time step (e.g., snowmelt and environmental flows)
  - surface water / groundwater interaction (linear approx., MABIA perc. / baseflow)
- **Uncertainty**:
  - not quantified, unclear boundary conditions & lack of dynamic feedback
- **Impediments**:
  - commercial numerical solver
  - complex graphical user interface & interpretation of results
  - overall transparency to system logic limited and difficult to adjust, if you know how

2. What are the limitations, uncertainties, and impediments associated with the use of the SacWAM model? Can you suggest ways to improve SacWAM to address those concerns?

- **A few suggested improvements**:
  - extend through 2016 Water Year
    - sensitivity analysis of dry/critically dry years
  - calibration and validation against historical hydrology
    - groundwater to include seasonal fluxes; validate to in river flows
  - formalize uncertainty around boundary conditions (specified vs. catchment)
  - formal sensitivity analysis of demand priority allocations and bias correction
  - address lack of dynamic feedback at SJR inflows
  - provide better mechanism to interpret results that allow users intuitively examine results numerically, graphically, and geographically (add DSS!!) >> MWH post-processor is a good first start, but need mechanism to better investigate driving mechanisms to understand underlying processes (i.e., tracing)

3. Under what circumstance(s) would SacWAM or CALSIM II be more scientifically justified?

- Fallacy to think it is one model vs. the other model, but as models in sync, which will require coordination across agencies.
- It is also a fallacy to think that since one model is good then two models are better (e.g., ensemble approach), because it can create confusion, or become out of phase (CalSim III) [*Versioning Needed*].
- SacWAM was built to mimic CalSim II where CalSim II has input (non-independence). Therefore:
  - The answer depends on how models will be used in practice, and given design requirements, SacWAM will likely excel at scenario development, and will be used to estimate flow in tributaries and non-project outflows, etc.

4. What additional information or capabilities could be added to the SacWAM model, post-run processing, or documentation to improve its usefulness to State Water Board?

- SacWAM is one of the most complex implementations of WEAP, but WEAP has some inherent software limitations:
  - While visual object oriented, the GUI can be cumbersome for analysis
  - While access to logic is available, it can be difficult to find, edit, and run;
  - Even if operational system understood (e.g., Project operations), the priority ranking, object relationships, and rule sets can be difficult to decipher
  - Model result presentations are not often intuitive (and occasionally buggy)
  - Need to readily identify all differences between scenarios (not just results, e.g., logic, priority, and other assumptions)
- Ultimate use will depend on the sophistication of the user, level of expertise in California water operations, and questions driving the inquiry

5. Is SacWAM's calibration and/or validation appropriate and sufficient for the intended use to evaluate potential changes in flows, and environmental and economic impacts under different regulatory requirements?

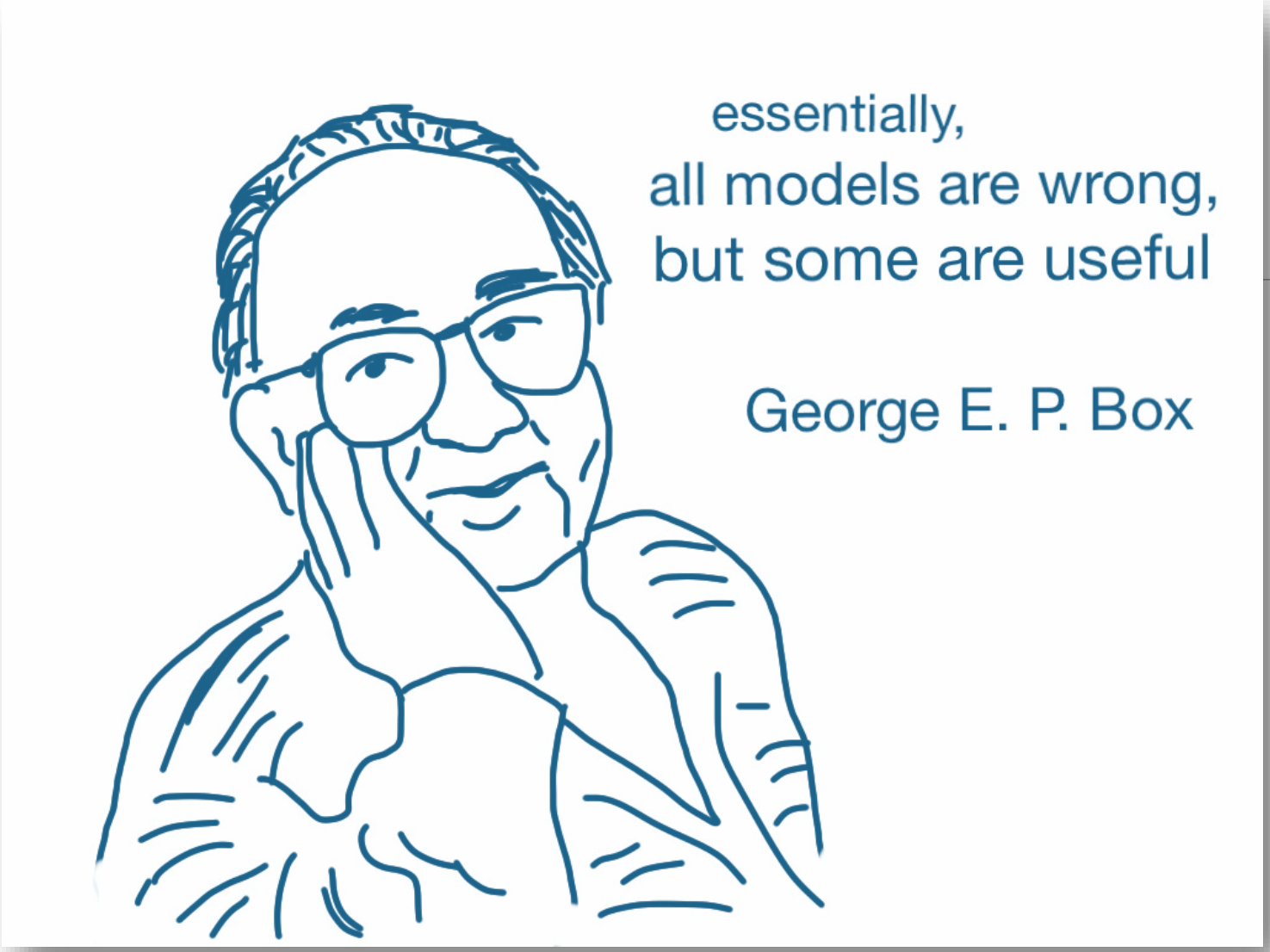
- SacWAM isn't really calibrated *per se* but compared and readjusted
- SacWAM is not validated for locations that CalSim isn't represented
- For Delta outflows, SacWAM is wet in dry years and dry in wet years; while this averages out over the long term, it limits ability to manage water
- Calibration and validation should be for extreme events (i.e., droughts)
  - Needs to include seasonal groundwater component
  - Needs to include most recent time series with different regulatory environment (2009-2016)
- Model to model comparison, can only do scenario to base case
- Scenario to scenario comparisons limited by lack of sensitivity (direction, not magnitude)
- Unimpaired flows or natural flows? Where, when, and why.

6. What, if any, additional sensitivity analysis, calibration and/or validation is recommended for SacWAM?

- **Sensitivity analyses**
  - examination of priority allocation aggregation
  - SVI 4 River Index and distribution of WYTs
  - antecedent conditions and reservoir carryover
  - accretion/depletion trends at Freeport
  - Seasonal groundwater dynamics
- **Validation**
  - historical conditions for tribs & in river recent years
  - Inflows/outflows from non-project facilities
  - Validate against current drought & seasonal dynamics

7. Are SacWAM's temporal and geographic scales and resolutions appropriate for the intended use?

- Assuming that geographic scale and boundary conditions remain constant, the geographic scale is limited:
  - missing dynamic feedback between DMC and SJR operations
  - Not using upstream catchments, or not clear when will be used
- Assuming that land use and facilities remain constant, the temporal scale is currently limited by:
  - 2009-2016 WY exclusion limits understanding of regulatory env.
  - monthly time step has limitations for water planning around drought, low flow conditions, environmental flow development, snow melt (climate change), and salinity dynamics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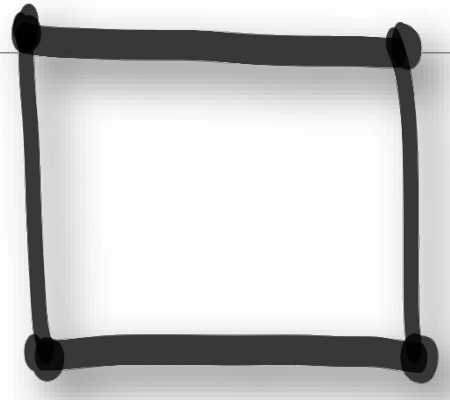

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