Data and Tools

Committee on Long term Analytical Tool and Data Development *(California Water and Environment Modeling Forum)* 3

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Draft Interim Report

Committee on Long-term Analytical Tool and Data Development California Water and Environment Modeling Forum

22 April 2004

Committee Charge

"The Committee will draft a "white paper" on strategic planning for analytical tool and data development and use for the management of California's water supply system. The contents of the white paper will range from a proposed statement of common principles to a proposed strategic vision for development and use of analytical tools and data for the coming 10 years. An interim progress report will be submitted to the CWEMF Steering Committee and the California Water Plan staff and Advisory Committee by April 15th, 2004. A more substantial draft report will be presented to the Steering Committee by June 20, 2004, to allow submission as a comment on the public review draft of the California Water Plan Update."

- resolved at the CWEMF Steering Committee meeting on March 19, 2004

Problem Statement

In the past, California's water problems were those of water resource development – locating and sizing of dams, canals, and pipelines and establishing water delivery contracts for major water projects, usually under the control of a single agency. Inexpensive water supplies were being developed for a growing agricultural economy and increasingly prosperous and populous urban areas. Water was seen as being available in streams, but was merely in the wrong place at the wrong times to satisfy these growing water demands. Many of our major analytical tools and data sets are based on of analytical methods designed to address such water resource development problems.

California's water problems have evolved substantially in recent decades. As most of the inexpensive water supplies have become developed, remaining locations for reservoirs or reservoir expansions are typically less economical or more controversial in terms of environmental impacts and area-of-origin concerns. At the same time water demands and regulations for urban and environmental water uses continue to grow, and substantial water scarcity for agriculture remains.

Responding to the decreasing cost-effectiveness and increasing controversy of traditional water resource development, local, regional, state, and federal agencies have sought to develop additional water management options such as improvements in water use efficiency, conjunctive use of surface and ground waters, coordinated operation of reservoirs and pumping facilities, water markets, transfers, and exchanges, and wastewater reuse. *[There is a suggestion to begin the problem statement here.]* Effective water system management to meet California's increasingly diverse and geographically dispersed water management objectives requires careful coordination of these new options with traditional water management strategies. The technical aspects of water policy, planning, and operations have become much more complex.

The institutional aspects of water management also have become more complex in recent decades. Water projects rarely operate in isolation, and must increasingly operate in coordination with environmental regulations, water contractor decisions, and the operation of other water projects. Local water management activities such as water use efficiency, wastewater reclamation, water purchases and sales, local conjunctive use must be increasingly coordinated with other local agencies (which are buying or selling water or water storage) and the large water project operations to provide deliveries of water. In recent years, local and statewide water management institutions have shown increasing flexibility to coordinate their water planning and operations decisions.

The involvement of an increasing number of parties and interests in water management has raised the level of scrutiny and expectations regarding quality, accuracy, and reliability of technical information supporting these types of water management decisions and institutional interactions. The increasingly pluralistic, complex, and flexible nature of water management in California also poses challenging demands for technical analysis needed to support such increasingly desirable operations. Recent legislation has resulted in modeling results taking on an accounting function for assurances of local water supplies required for new urban developments that requires invites greater scrutiny of modeling results.

All these issues indicate a need to develop some sort of strategic analysis framework to guide and coordinate the future development of analytical tools and data to support water resources management planning and policy. What analytical and data analysis framework should we strive towards to be most effective in helping to address California's long-term water problems? How should such technical analysis be developed and performed to support the increasingly difficult and controversial policy, planning, and operational decisions at local, regional, and statewide levels for California's water system and its component sub-systems?

CWEMF Effort

In response to recognition of a need to develop a strategic analysis framework to guide and coordinate the development of analytical tools to address a future of increasingly complex water management issues, the members of the California Water and Environmental Modeling Forum (CWEMF) have embarked on a reflective study to identify the major future issues that the California water community will need to address in the next to10 years and what the types of analytical tools and data that will be needed to support water policy, planning, and operations decisions 10 years into the future. A 10 year time frame was felt necessary to 1) concentrate our thinking on the kind of technical environment which would be of the greatest long-term value (rather than the current problems du jour) and 2) reduce adherence to existing technical tools which are unavoidably somewhat legacies of past problems. While the results of this work might be informative and useful for current planning and policy deliberations, we are expressly focused on developing a long term vision of the future. The purpose of this effort is to prepare a vision of how our work might be more effective and efficient in providing a stable and constantly improving information basis for making water management decisions and policies. As such, we would like to provide a structure for long-term thinking about technical analysis of California's water problems, and perhaps an objective to strive towards in the coming years.

The process of this CWEMF effort began with a wide-ranging discussion at the February 2004 annual meeting of CWEMF at Asilomar. This plenary session led to the solicitation of input on strategic modeling directions from the CWEMF membership and others, based on four open-ended questions and the formation of a Committee on Long-term Analytical Tool and Data Development. This committee will

continue with its solicitations of ideas from the water community, will sponsor one or more workshops and otherwise consult broadly on these issues, and prepare written products which constitute a future vision of the technical analysis capability desirable for addressing California's long-term water problems.

This interim report is an initial step in this study, posing a set of common principles for analytical tool and data development and use that should apply across all major analytical tool and data developments and applications. It is felt that having a set of common principles for major developments and applications will provide a common foundation for both technical activities and decision-maker use of information provided by technical activities. A set of common principles should provide conceptual expectations for technical work which technical analysts, water managers, and policy-makers can all understand.

Common Principles for Long-Term Analytical Tool and Data Development and Use

Similar to the "Principals for California Water Planning Analysis," found in the California Water Plan Update Bulletin 160-03 DRAFT (Appendix A of this document), we suggest XX principals of near-universal applicability for long-term technical analysis tool and data development and use for California water problems. These principles fall into 5 areas and are summarized in Table 1. While the exact vision of desirable technical analysis capability is as yet unclear to us, we feel such principles can help structure our long-term technical thinking, provide linkages between our technical work and water managers, policy-makers, and stakeholders, and provide some direction to help move our data and tools from what we have today to what we would like to have in the future.

Strategy

1. Analytical tools and data should be developed based on expected long-term water problems and the decision-making processes they are expected to inform.
2. Frequently amended strategic documents should identify the technical objectives, roles, and responsibilities of major data collection efforts and analytical tools.
3. A frequently updated implementation document should outline short-term and long-term efforts, budgets, and responsibilities for continuous improvement of analytical tools and data with policy for continued user, local agency, and stakeholder involvement.
4. DWR, in discussion with other major stakeholders, should maintain a strategic analysis framework that should undergo periodic internal and external review to identify needs for additional analytical tool and data development.

Analytical tools and data are expensive to create and maintain. Such tools are more likely to be successful if they are designed to respond to a defined set of problems and decision-making processes perceived to be of long-term importance. Strategic planning documents for analytical tools provide evidence and documentation of such thinking, as well as a measure of transparency of the intent of analytical tools for the non-technical community. However, since problems, data, understanding, and analytical techniques change with time, so it is best for strategic thinking to be adaptive and amended from time to time.

Aside from the value of informing policy-makers and managers of the intent of particular analytical tools, such documents and thinking provide a basis for better long-term convergence between the expectations of modelers and model result users. Another important aspect of strategic documentation is to educate

newcomers to the technical community, so that they might more quickly understand the tools, their limitations, and , the context of their application.

Someone must be responsible for strategy, or it will not happen. Strategic responsibility also seems ill-fitted to a grass-roots volunteer organization, such as CWEMF. The California Department of Water Resources, through its responsibilities for statewide water planning and accounting, seems the most logical agency for maintaining a strategic analysis framework, although it would probably be wise for DWR to accomplish this function in broad collaboration.

Transparency

5. All data and models should have significant documentation.
6. Known limitations and appropriate applications should be documented.
7. Model applications should have explanatory and self-critical discussions of results.
8. All data, models, and major reports should be in the public domain and available on the web.
9. A common glossary of key terms should be maintained.

Analysis of water systems as complex and extensive as California's will never be wholly transparent. No one person can understand this entire system, so it seems unrealistic for any one person to understand a set of analytical tools and data which might reasonably represent such a system. Nevertheless, greater and more systematic efforts at transparency in technical activities are needed to:

a. **Enhance quality**. Transparency allows analytical methods better understood, allows limitations to be more readily identified and addressed, and facilitates broader input into improvements.
b. **Enhance credibility**. Technical credibility rests on the notion that each step in the analytical process has an empirical or derived basis and that each of these steps is discoverable, testable, and replicable.
c. **Enhance sustainability**. Personnel in technical positions frequently change positions, and the most experienced eventually retire from service. Analytical tools and their data sets are often very long-lived. Without systematic and detailed documentation, the basis for analytical capability can be lost, detracting from the ability of new personnel to understand what they are doing technically, resulting in an inability to improve or adapt analytical tools and data for current or future conditions, and deteriorating the empirical and derived basis for the model's results.

Self-critical discussion of a model or model results is essential to making useful and credible insights from unavoidably imperfect model results

Technical Sustainability

10. Modularity: Major analytical tools should be designed and implemented to fit modularly, which allows models to be tested, refined, updated, and replaced without major adjustments to other components, in the larger strategic analysis framework
11. Adaptive information management framework: Major data and information efforts should fall within a larger information management framework, including protocols for data documentation and updating, and documentation of limitations.

The complexity and ever-changing nature of California's water problems calls for a long-term approach where major tool and data developments can remain integrated but adaptable over long periods of time. In a strategic modeling framework, individual models are modular in that they are explicitly (and painfully) designed to have consistent assumptions and data structures (time-steps and spatial

aggregation). Within each model, spatial components are also modular, allowing models to be run as detailed and spatially extensive representations, regionally detailed representations, or extensive simplified representations for different purposes. Modularity allows one element of an analytical framework to be improved significantly without attempting to revolutionize all aspects of modeling such a complex system. Modularity also should facilitate creation of analytical capability that can be applied at coarser or finer spatial, temporal, or topical scales.

Just as models need to adapt over time, so does the data used for modeling. This is more easily and reasonably done if data is developed within a larger systematic framework for system analysis. Because data is expensive, current modeling is limited by the data remaining from historical technical activities. Some effort and investment is needed to develop and document the kinds of data needed for long-term future analytical activities.

Many of the transparency principles are also related to technical sustainability. The coverage principles below also would facilitate greater job flexibility of personnel statewide.

Coverage:

12. The spatial coverage of the basic data and analytical framework should be statewide and encompass a wide variety of water management options and processes.
13. Local and regional water management and resources should be explicitly represented to allow consistency of local, regional, and statewide studies.

Water management problems in California have become highly interconnected, and are likely to become increasingly so. Conjunctive use and water conservation efforts in one end of the state are increasingly tied to water use decisions in another, with potential implications for many water management components in between. For detailed analysis, a statewide framework of analysis is desirable.

Development of statewide coverage must be a cooperative enterprise. If each local, regional, and statewide agency employs a consistent data and modeling framework and set of modeling protocols, an entire analytical system can be constructed without major funding and expertise from statewide agencies beyond developing the framework and protocols. Having a statewide framework also provides a standardized and more credible basis for water management studies for local and regional projects as well as opportunities for local agencies and concerns to become involved with improving representation of their areas for regional and statewide analysis.

Accountability and Quality Control:

14. Explicit model testing should be undertaken, documented, and made available for major analytical tools.
15. Major analytical products should undergo review by external unaffiliated experts and local agencies whose systems are included in the model(s).
16. Protocols and guidelines for model use should be developed and adhered to.
17. In developing and maintaining analytical tools, significant efforts should be made to involve local agencies and stakeholders, including users groups or other cooperation mechanisms for widely used analytical tools.

Quality control is an essential part of good technical work. And much of how the public and policy-makers come to understand the presence of quality control in technical work is through formal testing, documentation, application, and review procedures. Such formalities may not always be needed (or required), but they are likely to be especially desirable for studies of controversial subjects, where there is a significant probability of serious questioning of analytical results and tools.

Table 1:
Suggested Principles for Development and Use of Analytical Tools and Data for California Water Problems and Solutions

Strategy:

1. Analytical tools and data should be based on expected long-term water problems and the decision-making processes they are expected to inform.
2. Frequently amended strategic documents should identify the technical objectives, roles, and responsibilities of major data collection efforts and analytical tools.
3. DWR, in discussion with other major stakeholders, should maintain a strategic analysis framework that should undergo periodic internal and external review to identify needs for additional analytical tool and data development.

Transparency:

4. All data and models should have significant documentation.
5. Known limitations and appropriate applications should be documented.
6. Model applications should have explanatory and self-critical discussions of results.
7. All data, models, and major reports should be in the public domain and available on the web.
8. A common glossary of key terms should be maintained.

Technical Sustainability:

9. Modularity: Major analytical tools should be designed and implemented to fit modularly, which allows models to be tested, refined, updated, and replaced without major adjustments to other components, in the larger strategic analysis framework
10. Adaptive information management framework: Major data and information efforts should fall within a larger information management framework, including protocols for data documentation and updating, and documentation of limitations.
11. A frequently updated document should outline short-term and long-term efforts, budgets, and responsibilities for continuous improvement of analytical tools and data with policy for continued user, local agency, and stakeholder involvement.

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Implementation of Common Principles

Long-term adherence to such principles will require long-term focused and planned investments beyond project-specific studies. Adherence to these principles will also require management commitment from the major agencies involved in analytical studies of California's water, especially, but not exclusively, the California Department of Water Resources and the US Bureau of Reclamation.

Why might the diverse agencies and consultants involved in technical analysis of California's diverse water problems for diverse stakeholders and purposes abide by such a set of common principles?

Several reasons to cooperate and mechanisms for cooperation seem plausible:

- *Improvements in internal modeling effectiveness and efficiency by agencies and consulting firms* – Many of the principles above are simply sound ideas for improving the sustainability and effectiveness of technical activities in the current California water management environment. The principles are good business practices, made all the more effective and efficient as more modeling activities abide by them.
- *Predefined rules and procedures* – Having predefined rules and mechanisms for addressing technical conflicts will increase the ability of agencies to perform consistent analysis. This will save staff resources in the long term by allowing more efficient resolution of technical differences.
- *Common professional expectations* – Adhering to broadly useful norms and facilitates cooperation among agencies.
- *"Peer pressure"* – It is more difficult and expensive to cooperate with agencies not employing a common analytical framework.
- *Common agreement* – Common agreement could be informal or might be a formal agreement, perhaps similar to the MOU on urban water conservation BMPs that are the basis for the California Urban Water conservation Council.
- *Legal or regulatory requirements* –Adherence to such common principles can have a legal or regulatory basis if they become the expectations of judges ruling on the adequacy of EIS/EIR documents or are mandated in SWRCB water right regulations, DWR requirements for use of SWP facilities, legislated for access to State funding. SWRCB already requires peer review of some technical products [Rich S., Can you help here?].

Not all of these mechanisms would be available, appropriate, or even perhaps productive to pursue at this time.

Background Readings and References

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Appendix A: Principles for California Water Planning Analysis Development and Application of Tools and Data (from Bulletin 160-03 DRAFT)

Strategy:

1. Emphasize the approach "First what, then how."
2. A frequently amended strategic document will lay out DWR's strategic analysis framework and identify the technical objectives, roles, and responsibilities of major DWR data collection efforts and analytical tools and their interactions and their responsible managers.

Transparency:

3. Develop and maintain a glossary of key terms.
4. All data and models should be in the public domain and available on the web.
5. All data and models should have significant documentation.
6. Known limitations should be documented.

Long-Term Viability:

7. Modularity: Major analytical tools will be designed and implemented to fit modularly, which allows models to be tested, refined, updated, and replaced without major adjustments to other components, in the larger strategic analysis framework
8. Adaptive information management framework: Major data and information efforts will fall within a larger information management framework, including protocols for data documentation and updating, and documentation of limitations.
9. A frequently updated document will outline short-term and long-term efforts, budgets, and responsibilities for continuous improvement of analytical tools and data with policy for continued user, local agency, and stakeholder involvement.

Coverage:

10. The spatial coverage of the basic data and analytical framework will be statewide.
11. Local and regional water management and resources will be explicitly represented.

Accountability and Quality Control:

12. In developing analytical tools, significant efforts should be made to involve local agencies and stakeholders. Users groups will exist for major analytical tools.
13. Major analytical products will undergo review by external unaffiliated experts and local agencies whose systems are included in the model(s).
14. DWR's strategic analysis framework will undergo periodic internal and external review to identify needs for additional analytical tool and data development.

Future Quantitative Analysis for California Water Planning

Background and Context

Past California Water Plan updates were intended for water managers and those involved in making state water infrastructure decisions. However, as various resource issues become more interconnected, and land use and resource planners consider water management in their analyses and decisions, requests are increasing for the Water Plan to address questions broader than traditional water needs.

Analytical tool and data development for California has not kept pace with the growing public awareness of the complexity and interaction between water-related issues. Deficits exist in current analytical capability related to supply reliability and systems issues. A critical issue facing California is the need for better data and tools to produce useful information about *environmental objectives, water quality, economic issues, equity issues, and ground and surface water interaction*. Also, there is a need to better integrate details associated with regional and local planning into the studies being conducted from a statewide perspective. For planning purposes, these tools and data must help planners predict a range of plausible future conditions and interactions on the statewide level and compare outcomes of potential management actions. Many of the current tools have been developed and applied in a comparative role, and their suitability for a predictive role can vary widely. Even so, planners rely on the state to provide data and outputs that help to describe and analyze plausible future scenarios, which they can use for planning purposes.

The State must play a leadership role in developing the overall strategy for California water management from a system-wide perspective. No tools currently exist that can be used for both predictive and comparative modes integrating all of the interactions described above. Local land use planners also rely on water management information for which the State can provide insights. Work on the Water Plan is converging with the CALFED Integrated Storage Investigation's Common Assumptions and Water Use Efficiency Comprehensive Analysis studies. Staff from these planning processes have been meeting to coordinate information management and discuss study assumptions and quantitative methodologies.

Advisory Committee members, stakeholders interested in modeling, technical consultants for other planning processes, California Bay Delta Authority and State Water Project staff, and DWR staff have met more than 16 times as the "Modeling Work Group" to discuss the roles, validation, and confidence in available tools and data and the ability to perform studies and analyses envisioned for Update 2003. To address concerns, a series of workshops were convened that focused on the fundamental questions the Water Plan should address in general and the technical information that the tools are expected to provide in particular. Many of the issues discussed are responded to in the work plan, including quality assurance, transparency, accessibility of information, external review processes and integrating issues like water quality, economics, the environment, groundwater, and land use.

Principles for California Water Planning Analysis
Development and Application of Tools and Data

Strategy:

1. Emphasize the approach "First what, then how."
2. A frequently amended strategic document will lay out DWR's strategic analysis framework and identify the technical objectives, roles, and responsibilities of major DWR data collection efforts and analytical tools and their interactions and their responsible managers.

Transparency:

3. Develop and maintain a glossary of key terms.
4. All data and models should be in the public domain and available on the web.
5. All data and models should have significant documentation.
6. Known limitations should be documented.

Long-Term Viability:

7. Modularity: Major analytical tools will be designed and implemented to fit modularly, which allows models to be tested, refined, updated, and replaced without major adjustments to other components, in the larger strategic analysis framework
8. Adaptive information management framework: Major data and information efforts will fall within a larger information management framework, including protocols for data documentation and updating, and documentation of limitations.
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Coverage:

10. The spatial coverage of the basic data and analytical framework will be statewide.
11. Local and regional water management and resources will be explicitly represented.

Accountability and Quality Control:

12. In developing analytical tools, significant efforts should be made to involve local agencies and stakeholders. Users groups will exist for major analytical tools.
13. Major analytical products will undergo review by external unaffiliated experts and local agencies whose systems are included in the model(s).
14. DWR's strategic analysis framework will undergo periodic internal and external review to identify needs for additional analytical tool and data development.

The short and long-term work plan prepared for Update 2003 aims to improve the quantitative understanding of California water and of how to employ analytical tools to aid in developing and comparing solutions to California's water problems and decision making. This work plan for data and tools is consistent with the three-phased approach for producing California Water Plan Update 2003, outlined in Chapter 1. The work on tools and data in the three-phased approach include:

- Phase 1: Recommend the short- and long-term work plans.
- Phase 2: Select appropriate analytical tools, data, and assumptions to provide technical analyses needed to evaluate the four plausible future scenarios (described in the prior section).
- Phase 3: Apply the analytical tools selected in Phase 2 and interpret results to evaluate performance of several response strategies on a regional basis given the four plausible future scenarios.

Technical Information Needs

The desire to address various crosscutting issues such as environmental objectives, land-use planning, and economics in different scenarios in this Water Plan and other ongoing planning efforts requires more technical and quantitative information than for previous Water Plans. Many discussions with the Modeling Work Group and the Advisory Committee have focused on the specific information needed to satisfy the broad objectives of the Water Plan's new planning framework (see Chapter 1) and disclosure of all technical assumptions.

In addition to developing the new planning framework, the Advisory Committee and DWR invited land use and resource planners, academics, policy analysts, and technical experts to build on and affirm Advisory Committee understanding about issues critical for the Water Plan to address. These conversations have been captured in mind maps that represent a web of relationships and ideas. The mind maps are in the Technical Guide (Volume 4). In addition to traditional needs related to projecting water supply and demand, Water Plan users seek good information related to ecosystem wants and demands; economic issues, such as tiered water pricing and the effect on demand or economic effects of transfers; water quality, such as reusing wastewater and matching water quality to use; equity issues, such as public trust and environmental justice concerns; water use efficiency; and ground and surface water interaction. Further, the Water Plan could play a critical role linking water and land use management decision making. Land use planners need useful information about water demand as it relates to compact development and growth.

Types of technical information needs that have been identified can be described as:

- ***Data*** – factual (or observed) information, such as measurements or statistics (e.g., gauged flows in a river, population as measured by census, and salinity of a water sample). Sets of data can be *raw* (as taken from measurement device) or *elaborated* (modified slightly as part of quality assessment and quality control measures, or supplemented to address missing measurements).
- ***Relationships*** (or system interactions) – descriptions of how the social, physical, and environmental systems affect or are affected by the status of water supply and water use in California (e.g., how releases from a reservoir affect water temperature at a point in a river downstream, the crop mix in a region and the expected market conditions for each crop, and snow pack conditions in February and the delivery of SWP water).
- ***Estimates*** – inferred, derived and/or forecasted quantities based on available data, defined relationships, and other assumptions (e.g., population forecasts for the Los Angeles area in 2030, groundwater flows between sub basins, future available water deliveries, and the cost to implement water conservation best management practices).

Organizing Information

Given the large quantity and complexity of data, relationships, and estimates desired, the update team has organized the requested information according to their potential interactions. Figure 3.X illustrates a high-level conceptual model (framework) of the interactions. The three light blue boxes across the top represent information set by the user and does not change during the analyses, such as population, population density, and hydrology. (These can be called *static* estimates.) The three green boxes contain information that will be quantified using analytical tool(s) that explicitly consider the inter-relationships with other data, relationships, or estimates (or *dynamic* estimates). Examples of dynamic estimates include: demand for agricultural water supply, the economic costs of drought management, etc. The orange box in the center represents where most of the decisions are made within the analytical tools (often called decision variables). This box would contain most of the information contained in a response package. A priority list of technical information needs is in Volume 5 the Technical Guide.

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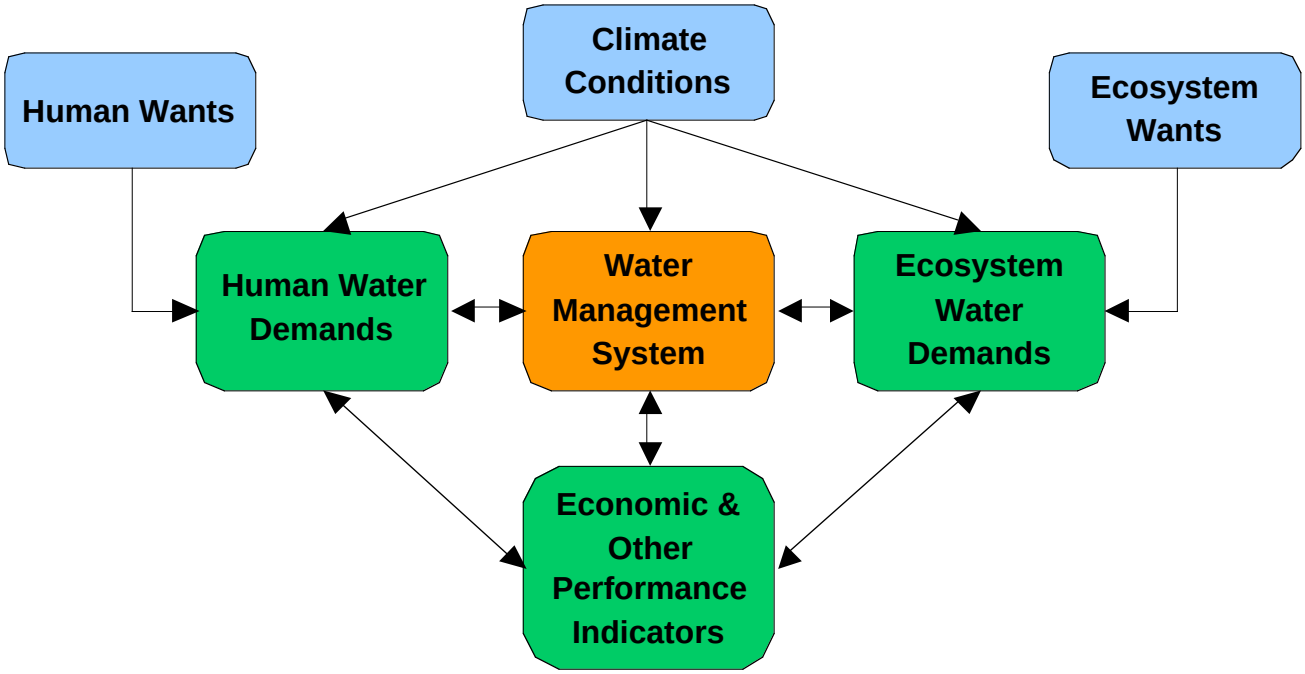
Conceptual Framework for Data and Estimate Interactions



Planned Analyses

For Update 2003, the phased work plan includes three groups of analyses:

1. ***Water Portfolios*** that describe the available water sources, movement and uses by region, under several recent hydrologic conditions using actual data for 1998, 2000, and 2001. The portfolios present historic *data* and the *relationships* between sources and uses of water as it moves in California.
2. ***Future Scenarios*** that describe plausible conditions of water use, supply, and demand throughout California in 2030. The scenarios are intended to provide quantitative *estimates* of future water conditions based on existing *data* and defined *relationships*.
3. ***Performance Comparison*** of different water resource management strategies combined to form response packages applied to the future scenarios. A list of evaluation criteria (*estimates*) that must be generated to compare the performance of different water management strategies is shown in Volume 3.

Water Portfolios

The *water portfolios* provide comprehensive water balance and flow diagrams for 10 hydrologic regions covering the entire state. The flow diagram characterizes the hydrologic cycle and documents sources of water, such as precipitation and inflows into the state, and tracks the water as it flows (through many different uses) to its ultimate destination. Since data for some categories are not measured for many

regions of the state, the current water portfolios show gaps. Identifying additional data collection and management activities in Update 2003 is an important step in improving the water portfolios for future water plan updates.

There are a number of categories in the flow diagram where data are simply not available or very resource intensive to compile. Significant data gaps include:

- state wide land use data (e.g., native vegetation, urban footprints, non-irrigated agriculture, and irrigated agriculture)
- total groundwater natural recharge,
- groundwater subsurface inflow and outflow,
- groundwater extractions and recharge,
- evaporation from land surfaces,
- evapotranspiration from native vegetation and non-irrigated agriculture,
- total stream flow,
- total direct diversions,
- natural and incidental runoff,
- return flows and
- conveyance losses.

There are a number of data items necessary to calculate or estimate these categories. Some of the major data items needed to complete the flow diagram and water balances consist of more detailed and accessible land and water use information including information to separate out applied water use versus consumptive water use. The major data items are:

- water source of supply information,
- outflow data,
- groundwater level data,
- groundwater recharge rates,
- natural riparian water requirements,
- evapotranspiration rates for all types of vegetation,
- detailed return flow information and
- more detailed physical information about all watersheds, water systems and groundwater basins in the state.

Data are currently available for some regions and not for others. For example, methodologies and data to estimate natural runoff are available for regions like the Sacramento River and the San Francisco Bay Region where the Delta is a control point, but in areas like the South Coast Region with no control point and substantial groundwater, the natural runoff is nearly impossible to estimate. In addition to natural obstacles, existing data are not easily aggregated or disaggregated to provide convenient access for all areas of interest, and resource constraints limit extensive data collection and management necessary to quantify and track all the water in the state.

The state should guide California in expanding data collection and management programs that already exist. Data needs are characterized by the need for detail (data monitoring in more geographic locations and for particular categories), to digitize (common electronic methods), and for a comprehensive database.

Future Scenarios

Developing quantitative estimates for four *future scenarios* requires using available data and presumed relationships. A list of key factors affecting future use and supply scenarios in 2030 is shown in the Technical Guide (Table 1). Some examples of these factors include total population, population density, agricultural water use efficiency, and energy costs. Each of these factors must be predicted or quantified, and like the data needed for the water portfolios, the availability and resolution of data needed for the future scenarios varies widely. While the key factors have been identified, much work still exists to reach agreement on the relationships between the factors and the methods that will be used to quantify the factors as described in Table 1. Some examples of the significant complexities in predicting factors such as groundwater storage or surface water storage conditions in 2030 are shown in the Factor Complexity Diagrams in the Technical Guide.

A report addressing some of the challenges and possible approaches for forecasting urban water demand was presented in July 2003 entitled *Water Demand Forecast Methodology for California Planning Areas: Work Plan and Model Review*. (See Technical Guide.) The authors of the report offer recommendations for:

- near-term analyses given available data, and
- future development for long-term analyses.

The recommendations for future development identify additional data needs such as:

- water and sewer rate data for the utilities and time frames for data contained in DWR's Public Water Supply Survey database,
- correlate local/regional demographic information with per unit water use rates by area, and
- correlate climate conditions with per unit use rates over time.

This new information will allow DWR to update their statistical explanatory demand models by region based on some of these key factors. DWR will have to examine other factors and determine the best way to quantify those factors. DWR predicts that other data gaps will emerge leading to better understanding of the type of data collection and analysis needed to support the new planning framework.

Performance Comparison

A significant difference in the new Water Plan framework is the addition of quantitative comparisons for thematic response packages of water resource management strategies (as identified in Volume ?). This *performance comparison* of various mixes of water management strategies under plausible future scenarios will provide planners unprecedented access to relevant technical information and new insights. This quantitative insight can be used to help guide investments in statewide water management actions. To help focus the quantitative analyses, a list of evaluation criteria have been identified with the Advisory Committee and Modeling Work Group that represents the technical information required to compare the response packages. A full list of the evaluation criteria are included in the Technical Guide. These evaluation criteria include information such as:

- percent of years agriculture receives all of its desired water supply
- change in economic benefits or losses
- statistical water supply reliability by location
- change in regional imports and exports

While this information is expected to be extremely valuable, developing the capability to complete these performance comparisons presents a significant challenge for DWR over the next several years. Conducting quantitative performance comparisons that the Advisory Committee and public want will require considerable resources (staff, time, and money) to develop and implement.

Analytical Tools

Generating quantitative estimates for most of the information contained in the water portfolios, future scenarios, and performance comparison requires the use of one or more analytical tools. The term *analytical tool* is defined to mean "something used to study or determine the nature and relationship of the component parts of a whole". Given the broad range and scale of quantitative information desired, many analytical tools will be needed. No single analytical tool could be developed to provide all of the desired information, but rather a hierarchy of tools must be employed.

The role of an analytical tool and the method for using it varies significantly depending on the specifics of the information being generated. Given the desire to promote understanding and transparency of analysis, the Update team has developed and will apply a systematic method to identify potential analytical tools, determine their proper use, and validate their application to generate all of the quantitative information needed for the Water Plan.

Initially, this effort will focus heavily on the need, availability, and adequacy of technical tools to perform the integrated analyses. Given the high degree of interest expressed by several members of the Advisory Committee and the Modeling Work Group, DWR proposes a systematic, step-by-step approach to develop acceptable methods to complete the quantitative analyses for both the short-term (Update 2008) and long-term efforts. This step-by-step approach is outlined below, and will require extensive participation from the Modeling Work Group.

Once the methods have been defined and agreed upon, DWR will need to set up and conduct the modeling studies, perform quality control reviews of modeling results, and interpret and communicate the meanings of the analytical tool outputs.

Framework to Assess an Analytical Tool

Evaluating the appropriateness of an analytical tool to produce quantitative estimates can be extremely complicated. To help make the process as effective and transparent as possible, the team will apply the following framework, described using a series of questions, for each item on the comprehensive list of technical information needs.

- What is the job at hand?
  - Describe by task if needed, highlighting the quantitative results that would assist in accomplishing the task
- If the ideal tool to assist with the task were available, what capabilities would it have?
- Which tools are available that could produce the desired quantitative results?
- Which tool represents the best fit?
  - Evaluate the potential tools according to the desired capabilities
  - Consider limitations
  - Consider practical ability to improve each tool
- What are the remaining limitations of the selected tool likely to be?

This process can be improved by using common, objective evaluation criteria to the extent possible for each piece of technical information being generated. The criteria used to answer the question "Which tool represents the best fit?" will be discussed and documented before making any judgments about the suitability of the analytical tools in question.

Parts of an Analytical Tool

To understand the capabilities of an analytical tool, or to assess the validity of using an analytical tool for a specific purpose, it is helpful to consider the tool in terms of its parts:

- Conceptual model: a description or analogy used to visualize something that cannot be directly observed (e.g., a road map).
- Theoretical model: a system of postulates, data, and inferences presented as a description of an entity or state of affairs (e.g., the law of gravity).
- Numerical model: an analytical tool that employs quantitative approximations to the solutions of mathematical problems.
- Data
- Data management system
- Software
- Administrative aspects: intellectual property (proprietary vs. public domain, user support, expertise available in community to use or improve model, etc.

Describing an analytical tool using these categories promotes more precise discussions regarding the capabilities and appropriate use of analytical tools.

Information Management System

The quantitative elements of the water plan require tremendous amounts of data and information. As such, effective management of this information is a key component to the long-term success of the technical efforts. Currently available information management system technologies could be used to provide efficient, secure, and transparent access to this critical component of the ongoing state wide planning efforts.

However, the technology alone is not sufficient. A necessary part of a successful information management system is an intelligent information management framework and scheme. Ideas for a viable information management framework can be developed as the needed data, relationships, and estimates for the quantitative analyses are further described.

Resources Needed

Generating and interpreting the quantitative information described above will require persistent dedication of significant resources. The technical scope and magnitude of the desired analyses is unprecedented in California water planning. While several parts of the desired analyses have been done before, no previous quantitative study has ever been conducted so comprehensively and with such intensive stakeholder interaction. Needless to say, a large team of technical experts with diverse skills will need to be engaged over a lengthy period of time. Technical experts will be needed who can understand the complex interaction between policy-making and technical analyses, organize technical information needs, identify and qualify subject-matter data, manage extensive data, interface with diverse stakeholders

and programs like the California Bay Delta Authority, and demonstrate leadership to inspire confidence within policy and technical communities. In addition to the broad array of technical expertise required, a large number of experts will need to be assembled to accomplish the goals set forth in the given timeframe. Nonetheless, DWR is committed to leading the way in developing the methods, analytical tools, and conducting the analyses to provide the information the public of California needs in a transparent and responsive manner. Some examples of existing analytical tools and data systems that incorporate some aspects of the vision for desired quantitative capability include Metropolitan Water District's IRPSIM, CALVIN, Aquatool (Spain), and SCADA systems (common for most major urban water distribution systems).

Major Tasks and Schedule

The following tasks and associated schedule chart outline the major steps DWR plans to take to provide the desired technical information in a timely manner. As shown on the associated schedule chart, DWR plans to perform these activities with frequent and detailed interactions with interested parties through the Modeling Work Group. This framework requires that DWR receive assistance from others to complete the tasks. The rate of progress will depend on available resources and the level of cooperative participation by other agencies and institutions. This systematic approach will allow DWR and others to address concerns raised about validity of existing tools and questions raised about the appropriateness of quantitative methods used for previous technical studies. A related item, the peer review of the CALSIM II model being conducted in cooperation with the California Bay-Delta Authority is shown on the schedule.

1. Generate a priority list of required technical information.
2. Organize the technical information needed using the relationships of the information similar to the conceptual framework illustrated in Figure 3.X.
3. Circulate the priority list of required technical information to the Modeling Work Group for review. Meet with the MWG to discuss.
4. Incorporate comments and finalize priority list of required technical information.
5. Propose a conceptual model (or models) for each piece of information needed to complete the:
    a. Water Portfolios
    b. Future Scenarios for 2030
    c. Performance Comparisons
6. Distribute documents containing the proposed conceptual models to the Modeling Work Group and conduct workshops to adopt preferred conceptual models used to compute each piece of technical information
7. Propose a theoretical model for each piece of required technical information including: postulates, data, and inferences
8. Establish, to the extent possible, objective criteria for evaluating the suitability of potential analytical tools for generating each piece of required technical information.
9. Distribute documents containing the proposed theoretical models to the Modeling Work Group and conduct workshops to adopt preferred theoretical models used to compute each piece of technical information
10. Compare preferred theoretical models with those implemented in currently available analytical tools
    a. Review existing analytical tools to determine if they incorporate some or all of the preferred theoretical models
    b. As needed, determine if existing analytical tools can be modified for short-term use

11. Modify tools as needed and as possible for short-term use
    a. Make changes to existing analytical tools to better incorporate preferred theoretical model implementation that can be accomplished by the end of Q1 2005
    b. Acknowledge and document where existing tools and data that will be used for Update 2008 fall short of the desired theoretical implementation and cannot be suitably modified by end of 2007
    c. Prepare a document that describes how analyses for Update 2008 will be implemented in the short-term
12. Develop a document that outlines requirements for new analytical tools and data to perform the preferred quantitative analyses for future updates
    a. Describe likely approach to obtain or develop tools that can fulfill the requirements
    b. Develop a schedule for development and testing
    c. Develop budget for development and testing
13. Apply existing analytical tools to quantify all required technical information for Update 2008
    a. Future Scenarios
    b. Performance Comparison
14. Interpret and describe quantitative results for
    a. Future Scenarios
    b. Performance Comparison

Update 2008 and Beyond

The tasks described above are focused towards identifying and developing trusted and acceptable quantitative methods over the next two years that can be applied as completely as possible in the short-term for update 2008, and as close to the preferred methods as possible for updates beyond 2008. As these requirements, data gaps, and preferred conceptual and theoretical models are adopted, DWR will also identify the requirements for a viable information management system. Given the magnitude and complexity of information, and the desire to coordinate and share this information at various levels of detail throughout the state, DWR likely will need to implement an enterprise-level information management system accessible via the World Wide Web.

Furthermore, as progress is made in developing better, more comprehensive data and analytical tools to analyze the water movement and interactions, DWR plans to foster development of decision support tools that increase planners' ability to fully utilize the new and improved technical information being provided in future Updates.

Irrigation Survey

This article is still pending.