Excerpts:
Review of Water Supply Reliability Estimation Related to the Sacramento-San Joaquin Delta
DRAFT – Please Do Not Cite

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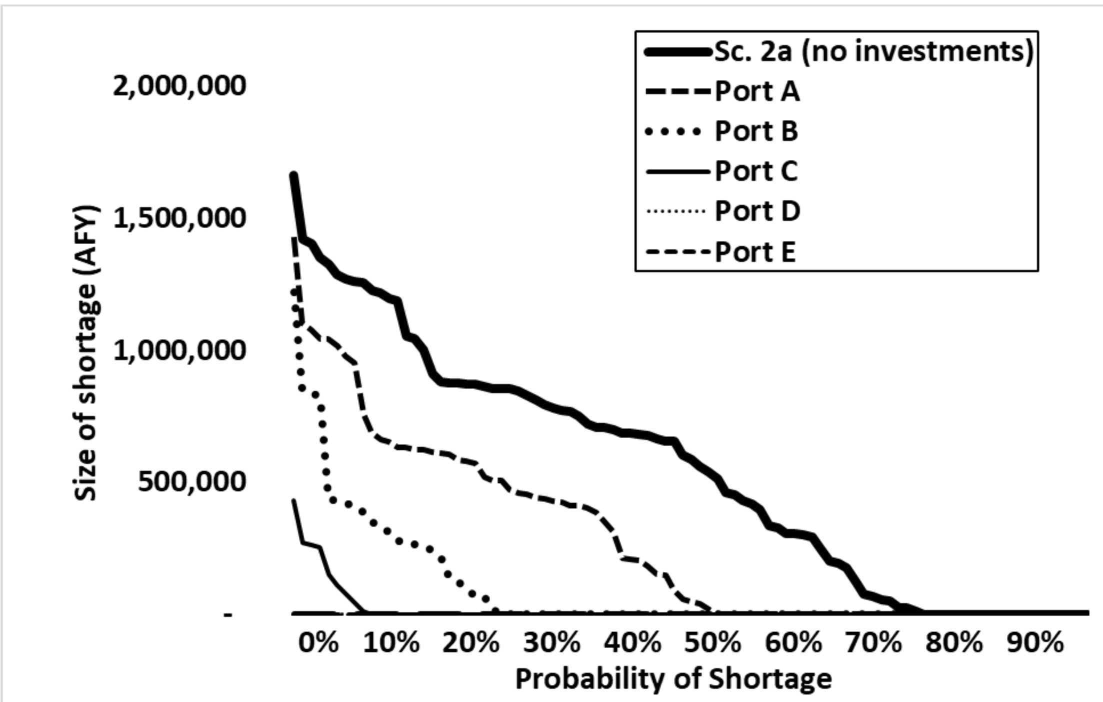

Report Cover Figure. Metropolitan Water District of Southern California Delivery Shortage Probabilities for Different Regional Portfolios in Year 2040, in acre-feet per year (modified for accessibility from MWDOC, *Orange County Water Reliability Study*, 2016)

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Sacramento, California

Report Outline

Table of Figures, Tables, and Boxes

Acknowledgements

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Executive Summary

The Sacramento-San Joaquin Delta Reform Act of 2009 mandates the balancing of two goals for the Delta: (1) providing a reliable water supply for both the Delta and California and (2) protecting, restoring, and enhancing the Delta ecosystem and Delta as an evolving place. This review by the Delta Independent Science Board (Delta ISB) provides findings and recommendations on the science and practice of water supply reliability estimation with a focus on the Delta.

This report responds to the Delta ISB's legislative mandate to review the adequacy of science supporting adaptive management for the Delta. Accordingly, the Delta ISB undertook this review of scientific and formal methods to estimate water supply reliability. The review sought perspectives from stakeholders, managers, and experts by formal presentations and questionnaires, a workshop, and interviews. It draws heavily from these three forums and the scientific literature.

California's public health, economic prosperity, ecosystem health, and social well-being require a reliable water supply. However, estimating supply reliability is challenging with California's diverse landscape and climate, unequally distributed and variable precipitation, complex infrastructure, decentralized institutions, and competing water demands from agriculture, cities, and the environment. Formal methods to estimate supply system reliability are essential for managers, stakeholders, and agency leaders.

Water supply reliability estimation has a long history of use in California. It formally originated in civil engineering in the late-19thth century to size new reservoirs to supply water with 100% reliability based on historical streamflow records. By the 1980's, this approach was replaced in California by a more realistic and probabilistic understanding of relationships between variable streamflow, water storage capacity, and water deliveries considering fluctuating water supplies and demands.

Extreme events like droughts test water management systems and require public and political authorities to adapt and invest in new solutions and approaches. Improvements in California's water reliability has always been a benefit of droughts (Pinter et al. 2019). This second year of the current drought is likely to be the third driest year in more than 100 years of precipitation records. The extremity of this test will reveal areas needing improvement.

The current drought demonstrates the timeliness of this review and need for it. Already, the drought has shown the increase in water reliability afforded to communities and regions that have made effective preparations and investments. The need to improve runoff predictions with a warmer climate, as well as flows and water temperatures for fish is also clear. The drought is another example of how reliability estimation is fundamental for reasoned design of investments and preparations across the wide range of water management events, actions, and purposes.

The review identified three broad challenges for water supply reliability modeling and analyses: environmental concerns, technical and management issues, and modeling and managing uncertainties.

Environmental concerns include the impacts on water supply from climate change, incorporating a more sophisticated methodology for estimating reliability of flows for ecological systems and species, and accounting for water quality such as salinity and temperature. Of the three, the transition to a nonstationary climate may be the most vexing because California's future climate depends on the unknowable extent to which global society addresses the drivers of climate change. This unknown is a major determinant of water supplies and demands. As environmental flows are receiving increasing attention there is a great need to estimate and manage water for environmental water supply reliability, in quantity and quality, and more explicitly represent environmental water demands in water supply reliability overall.

Technical and management issues include representing broader and more realistic water management portfolios (multiple water sources, operations, and demand management) in water supply reliability modeling with adaptive decision making. Better representation and design of water management portfolios is critical statewide and for the Delta. Using these methods for more adaptive management is central to meeting all goals of the 2009 Reform Act.

Modeling and managing uncertainties include various formal methods to represent, quantify, and apply uncertainties for decision-making. These include more formal multiple objective analysis, broadening forecast-informed reservoir operations (FIRO) to include multiple reservoirs and support for environmental flow management, adopting new technologies to process and share data and models, improving estimates of uncertainty and risk, and increasing awareness of extraordinary natural and anthropogenic catastrophes.

Effective water supply reliability analysis and estimates are fundamental to managing water in California. Unfortunately, water supply reliability analysis is often done in non-reproducible ways without sufficient testing, interpretation, and documentation for public dissemination and decisions, due to time pressures and inadequate human resources.

Findings and Recommendations

This report supports several findings and recommendations on the science and practice of water supply reliability estimation. Implementing these recommendations will make such estimates more informative for policy and management discussions and decisions.

Findings

Broad Importance of Water Supply Reliability and Estimations

1. Most major water suppliers employ some formal reliability analysis for water operations, planning, and policy decision-making in California and the Delta. Water supply reliability estimation is common for major urban water utilities and large Federal and State water delivery projects, such as the Central Valley Project (CVP) and State Water Project (SWP).
2. Ecological and other environmental purposes also need reliable water supplies, especially when water shortages to urban and agricultural uses tend to be partially recouped from environmental flows. However, there is less agreement on how to quantify or understand environmental water supply reliability.
3. Reliability analysis is increasingly being applied to support state, regional and local water managers faced with climate change, reduced groundwater availability, regulated environmental flows, and extreme events. Preparing human and ecological systems for drought and changing future conditions is a major motivation.

Analysis of Water Supply Reliability

4. Unreliability in water supplies has many sources. In addition to drought, these sources include natural catastrophes (such as floods, wildfires, and earthquakes), mechanical breakdowns and deferred maintenance, chemical contamination, environmental regulations, and various forms of system mismanagement.
5. A portfolio approach that integrates management of both demands and supplies has a long history of effectiveness in California. Urban water systems, particularly in southern California, are international leaders in combining portfolio management and reliability analysis.
6. Climate change is challenging water supply reliability for all purposes and locations in California. Reliability depends on early and effective preparations by local and regional water agencies. Climate change is motivating and accelerating improvements and adaptations to California's

water systems. Sea level rise in the Delta (and its effects on encroaching salinity, flooding, and water quality) and increased water temperatures affecting species and ecosystems will have wide-ranging implications on the reliability of water supplies in California for all water uses.

7. Many approaches have been used in California to estimate water-supply reliability. Each approach has advantages and limitations. Methods developed for narrower applications tend to be more rigorous.
8. Probabilistic approaches to water supply reliability are the most rigorous and support development of balanced water management portfolios. However, it is prudent to further explore the stability, economy, and adaptability of balanced water management solutions using robustness and sensitivity analyses.

Reliability Analyses for Management and Policy

9. Water supply reliability estimates vary with underlying assumptions. Managers and stakeholders often do not appreciate the implications of these assumptions and resulting variability in reliability results.
10. Water supply reliability analyses could be better integrated into water operation, planning, and policy decision-making to improve and focus deliberations on performance and trade-offs among water management and environmental objectives.
11. State, regional, and local agency expertise in water supply reliability estimation is scarce and often not current with the state of the science and escalating challenges. This staffing problem seems likely to worsen as demands on agencies increase and senior staff retire.

Recommendations

1. *Environmental water supply reliability should be further developed and employed to improve ecosystem management portfolios.* Environmental flows should be considered in context and timing for specific habitats, ecosystems, and species. Including reliability analyses would improve ecosystem management and better inform policies that support the Delta's co-equal goals. (Findings 2,3,5,6)
2. *Most water supply reliability analyses should reflect the complex portfolio-based water management common in California,* including interacting surface-water and groundwater sources, infrastructure operations, and water demand management in multiple sectors. This would improve local portfolio development within agencies and support regional water management among diverse entities. (Findings 3,4,5,6,10)

3. Performance of water systems generally should be evaluated in terms of fundamental public health, economic, ecological, and social objectives, rather than technical reliability objectives alone. (Findings 1,2,10)
4. *Climate change should be included in analyses for longer-term planning and policy decisions*. , Long-term forecasting is a major challenge, but it can be accomplished by combining scenario-based and probabilistic analyses, uncertainty quantification and managing the system adaptively to identify adaptable and resilient management strategies. (Findings 3,6,7)
5. *Agencies and stakeholders should improve reliability analyses.* A common State water accounting system, as well as better documentation, interpretation, testing, and standardization would improve technical quality, comparability, and communication for both technical and non-technical audiences. (Findings 1,2,5,8,9,10,11)
6. The next generation of state-sponsored water supply system models used for reliability estimation should be built, updated, and evaluated by a broader consortium of state and federal project and regulatory agencies and experts. Collaboration promotes compatible approaches and facilitates the sharing and documentation of input data, assumptions, parameters, and technical expertise, all of which help lower the costs of model development while improving model utility. Having coordinated coarse, intermediate, and detailed system models and establishing standards would increase model comparability and accelerate model upgrades for a broader range of analyses. (Findings 5,8,9,10,11)
7. Research and education should be supported by state, regional, and local water agencies to develop and improve water supply reliability science and practice. Some areas of emphasis include: a) climate change and adaptation, b) environmental water supply reliability, c) water management portfolios, d) nexus of water quality and water supply reliability, e) regional water operations, f) planning and policy decisions under uncertainty, and g) education of staff in State agencies to promote more rigorous, advanced, and insightful analyses. (Findings 2,3,4,5,6,9,10,11)