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# Preparing for an Uncertain Future Climate in the Inland Empire

## Identifying Robust Water- Management Strategies

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Sponsored by the National Science Foundation



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The research described in this report was sponsored by the National Science Foundation and was conducted under the auspices of the Environment, Energy, and Economic Development Program (EEED) within RAND Infrastructure, Safety, and Environment (ISE), in partnership with the RAND Frederick S. Pardee Center for Longer Range Global Policy and the Future Human Condition.

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Published 2008 by the RAND Corporation  
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## Summary

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Water-resource managers have long strived to meet their goals of system reliability and environmental protection in the face of many uncertainties, including demographic and economic forecasts, intrinsic weather variability, and short-term climate change induced by El Niño and other naturally occurring cycles. Now water managers face a new uncertainty—the potential for longer-term and more persistent climate change, which, in coming years, may significantly affect the availability of supply and patterns of water demand. Information about the future effects of climate change is deeply uncertain and likely to remain so for the foreseeable future. Thus, the scientific community is debating how to most usefully characterize this important yet uncertain information for decisionmakers.

The RAND Corporation is conducting a large, multiyear study under a grant from the National Science Foundation (NSF) on climate-change decisionmaking under uncertainty (see ISE, 2007). As part of that project, we are working with water agencies in California to help them better understand how climate change might affect their systems and what actions, if any, they need to take to address this challenge. As a key component of this effort, we have conducted four workshops in cooperation with the Inland Empire Utilities Agency (IEUA), whose service area overlies Southern California's Chino Groundwater Basin. We chose to work with IEUA because of its forward-leaning management team and articulation of strategies intended to improve the long-term water outlook for its service area. The first three workshops are described in detail in Groves, Knopman, et al. (2008). This document describes the analysis developed for the fourth workshop, held in September 2007.

The workshop described here was developed to help water managers, technical staff, elected officials, and other planners from the IEUA region consider the significance of potential climate change relative to other key planning uncertainties and evaluate options for reducing their vulnerability to supply shortfalls under a wide range of plausible future conditions. We also administered surveys to the participants before and after the workshop to assess how the participants' views about the climate-change challenge and their possible responses changed, as well as how well various aspects of our presentation informed them about these issues.

We used an integrated decision framework to evaluate the performance of IEUA plans over a wide range of uncertain planning assumptions. The framework centers around a water-management model developed using the Water Evaluation and Planning (WEAP) modeling environment (see SEI, undated). The WEAP model incorporates temperature and precipitation time series reflective of historical weather and plausible ranges of climate change. Each set of assumptions and specifications of IEUA plans is evaluated using a set of outcome measures, including the cost of providing supply to IEUA's retail customers and the cost of incurring shortages.

We considered nine adaptive management strategies. Each assumed that the management actions described in IEUA's *2005 Regional Urban Water Management Plan* (IEUA, 2005) would be enacted. Some strategies included near-term commitment to implementing additional water-management strategies. Others required adaptation by implementing additional management actions if conditions deteriorated over time. The specific augmenting actions were chosen in consultation with IEUA staff members. They included actions that either are under active consideration or have been identified as potential strategies for promoting water-supply reliability and addressing climate change.

We evaluated these various plans under a wide range of planning assumptions and possible weather sequences. Following the scenario-discovery procedure outlined in Groves and Lempert (2007) and Lempert, Groves, et al. (2006), we then use a cluster-finding algorithm called the patient rule induction method (PRIM) (Friedman and Fisher, 1999) to find and characterize clusters in the database of simulations that represent management conditions under which the plans perform poorly.

In some climate-change scenarios, we found that the actions described in the *2005 Regional Urban Water Management Plan* (IEUA, 2005) would lead to significant shortages and high-cost outcomes. We identified the key risk factors leading to costs that are above a specific cost-impact threshold—namely, declining precipitation, strong effects of climate change on imports, and greater than anticipated declines in Chino basin percolation. When the *2005 Regional Urban Water Management Plan* (the 2005 UWMP) is specified to adapt to changing conditions over time, there are fewer high-cost outcomes across the various futures, and those futures that lead to high-cost outcomes are characterized by slightly different factors. We evaluated other strategies as well. In general, strategies that increased the development of local resources in the near term lead to lower overall costs, regardless of the scenario for which the plan was evaluated. The key risk factors are different for the different plans.

We presented the ensembles of results using two types of visualizations—histograms of performance and scatter plots that disaggregate supply-provisioning costs and shortage costs. The scatter plots, which show the results of the individual simulations as single points on a graph, provide more useful information but are more complex and difficult to understand. These scatter plots revealed that not all high-cost cases can be explained by the key risk factors identified and that some cases classified by the risk factors do not result in costs that exceed the threshold. For the former case, one may also seek to develop an additional characterization of results that exceeds the cost threshold but does not arise from the first set of key risk factors.

In summary, the findings suggest that the IEUA region can reduce its exposure to adverse climate-change effects by taking advantage of the favorable economics of local resource development in the region. As long as the local resource-development activities (including increasing efficiency) are less costly than imports and precipitation trends under climate change are flat to strongly decreasing, there is little risk in overinvestment. The results also indicate that, if current IEUA regional leadership expects that future water managers and city planners will respond to decreasing reliability, some actions may be deferred. However, if the region were to implement only the 2005 UWMP now and wait before augmenting its plans, the region would remain vulnerable to scenarios in which there are significant precipitation declines, reductions in basin percolation, and strong reductions in imports due to climate change.

The results of the surveys that were administered before and after the workshop suggested that the survey respondents slightly increased their support for additional near-term water-management actions. They reported that they felt that robust decisionmaking (RDM) was a

useful methodology for presenting climate-related risks and presenting information in a useful way that was helpful for planning. Most notably, the comparison of the before- and after-workshop responses suggests that the RDM analysis provided information that increased the participants' concerns about the effect of climate change—both the likelihood of significant effects and the severity of the effects. At the same time, water planners increased their belief that they could mitigate or manage these effects. This is a noteworthy finding, as a primary objective of an RDM analysis is to illustrate possible threats and then identify strategies that can be taken to address these threats without having a clear understanding of exactly how the future may evolve. In this case, the survey results suggest that this objective was met.