Potential Central Arizona Project water shortages as influenced by climate and Upper Basin delivery schedules

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Introduction

The Decision Center for a Desert City (DCDC) supports and conducts climate, water, and decision research. We also develop innovative tools to bridge the boundary between scientists and decision makers in order to put our work into the hands of those whose concern is for the sustainable future of Greater Phoenix.

Most, by now, are familiar with our WaterSim water policy and management model. However, few are familiar with the types of simulations and analyses that we can now do using WaterSim 5.0. In this contribution, we examined the probabilities of future water shortages on the Colorado River as influenced by likely changes in river flow and by potential Upper Basin water deliveries.

WaterSim is a hierarchical water policy and management model for the Phoenix Active Management Area (AMA). We model surface water availability and water use (and re-use). We use population projections, land-use change, and current and projected trends in per capita water consumption to estimate water demand for residential, commercial, and industrial water users.

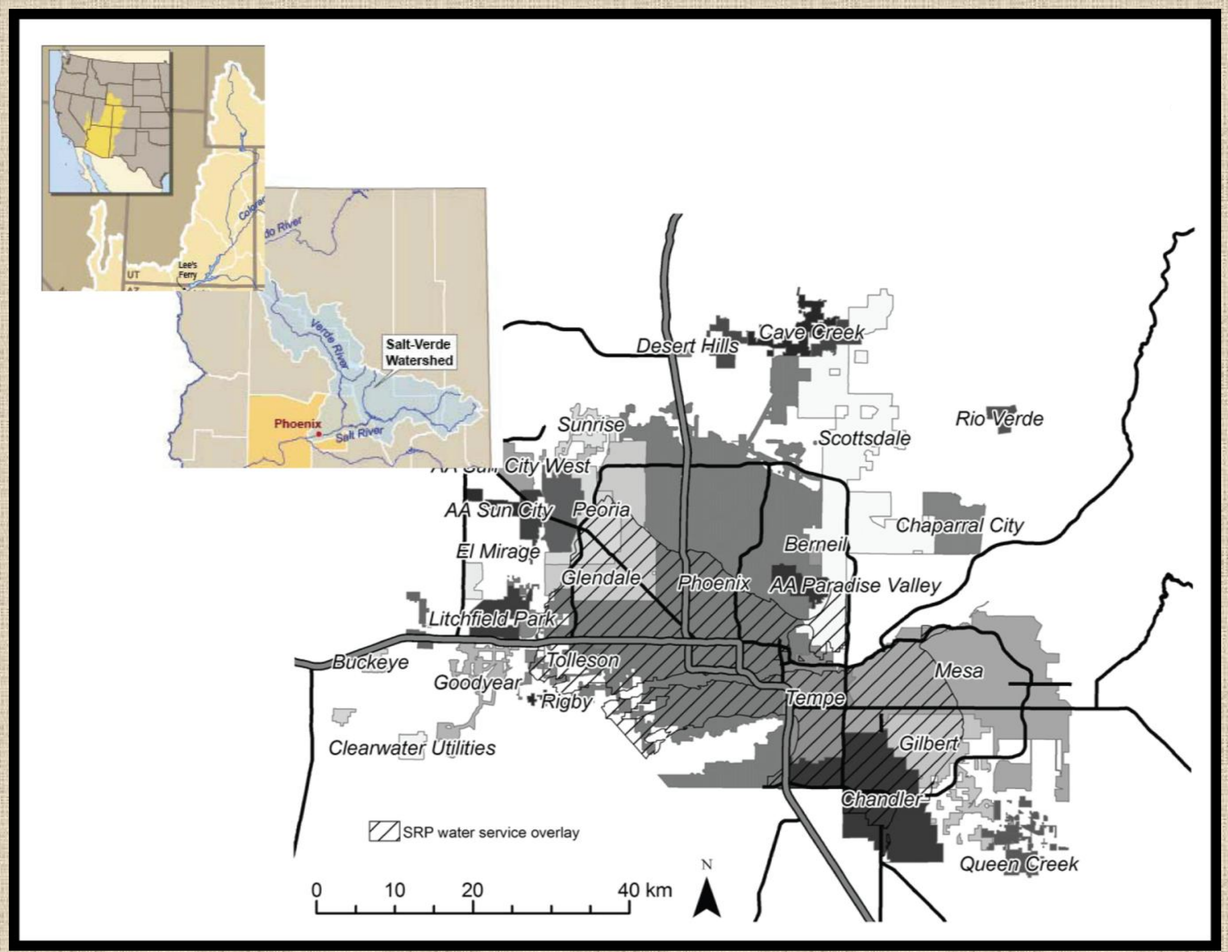


Figure 1. The spatial extent (modeling area) of the current generation of the WaterSim Modeling platform.

Model Application

We examined the shortage probabilities for the Central Arizona Project (CAP) as influenced by a potential (likely) range in runoff conditions for the Colorado River Basin, and three estimates of Upper Basin water deliveries. We varied Colorado River runoff by:

1. 80% to 110% of historical, in 1 % increments

Two Upper Basin delivery schedules (and one simulation estimate):

1. The 2007 Colorado River Commission schedule[A]
2. The Arizona schedule for deliveries (ADWR) [A]
3. Original algorithm (Dr. Tim Lant)

We simulated Lake Mead elevation for 2010 to 2041; used the Colorado River flow record for the period 1906 to 2010 using a 30-year indexed sequential method (simulations from 2000 to 2041 with actual estimates of river flow for 2000-2010).

We used the 3D smoothing functions in Sigma-Plot (Negative Exponential; sampling 0.1 proportion; 1st degree polynomial) to create the 3D plots (236,652 total records).

Results (1)

Minor differences between the 2007 Colorado River Commission (CRC) Upper Basin delivery schedule (red) and the ADWR Arizona schedule (orange) were observed (Fig. 2). Note that the previous formulations within WaterSim (light green) were substantially lower than current algorithms (dark green), although both were lower than the two schedule estimates.

CAP shortages are likely to occur (Fig. 3). The shortage realized will depend on the actual runoff received and the schedule followed. Near-term level one shortage (Lake Mead reaches 1075 feet msl) probabilities for the most likely runoff projections (up to a 10% reduction) were:

1. 0.0 to 0.45 for the CRC schedule (panel A).
2. 0.0 to ~ 0.35 for the Arizona schedule (panel B).
3. 0.0 to ~ 0.25 for the model estimate (using new inflow data and revised parameterization)(panel C).

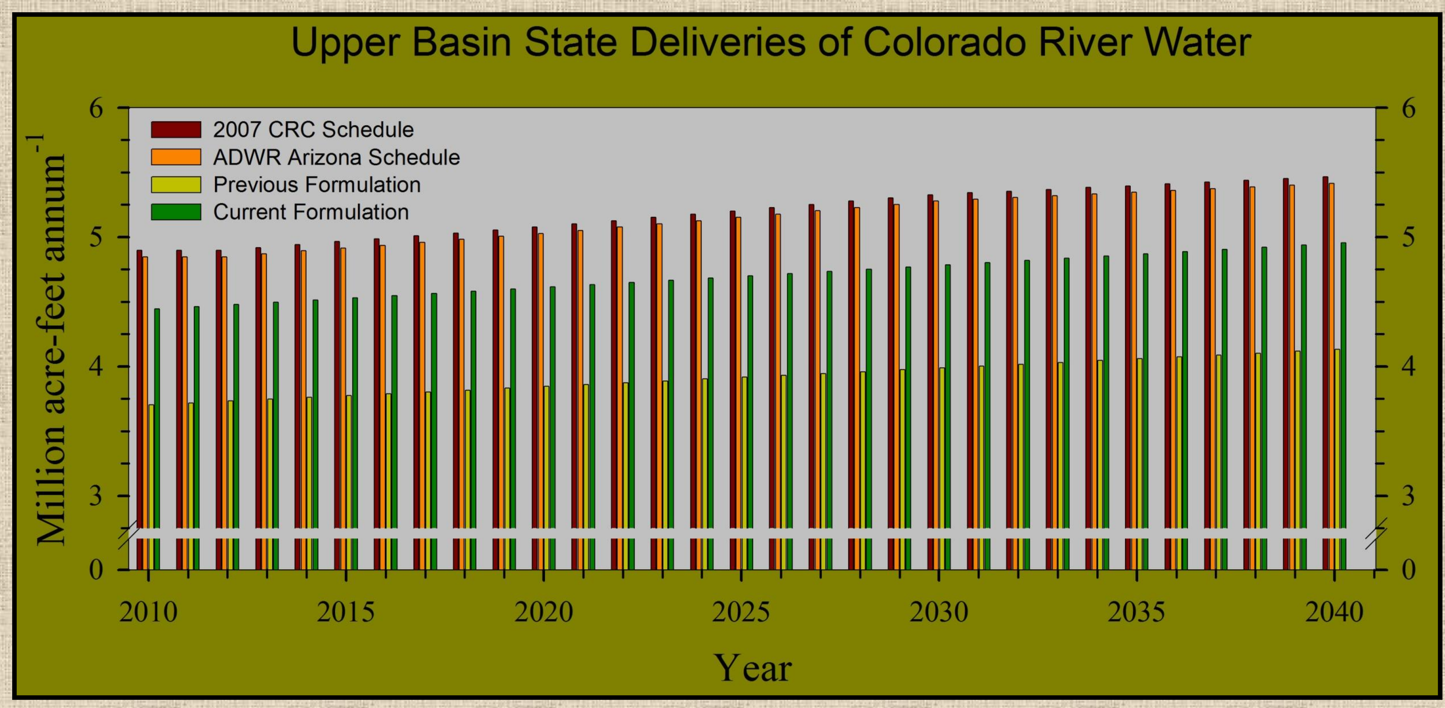
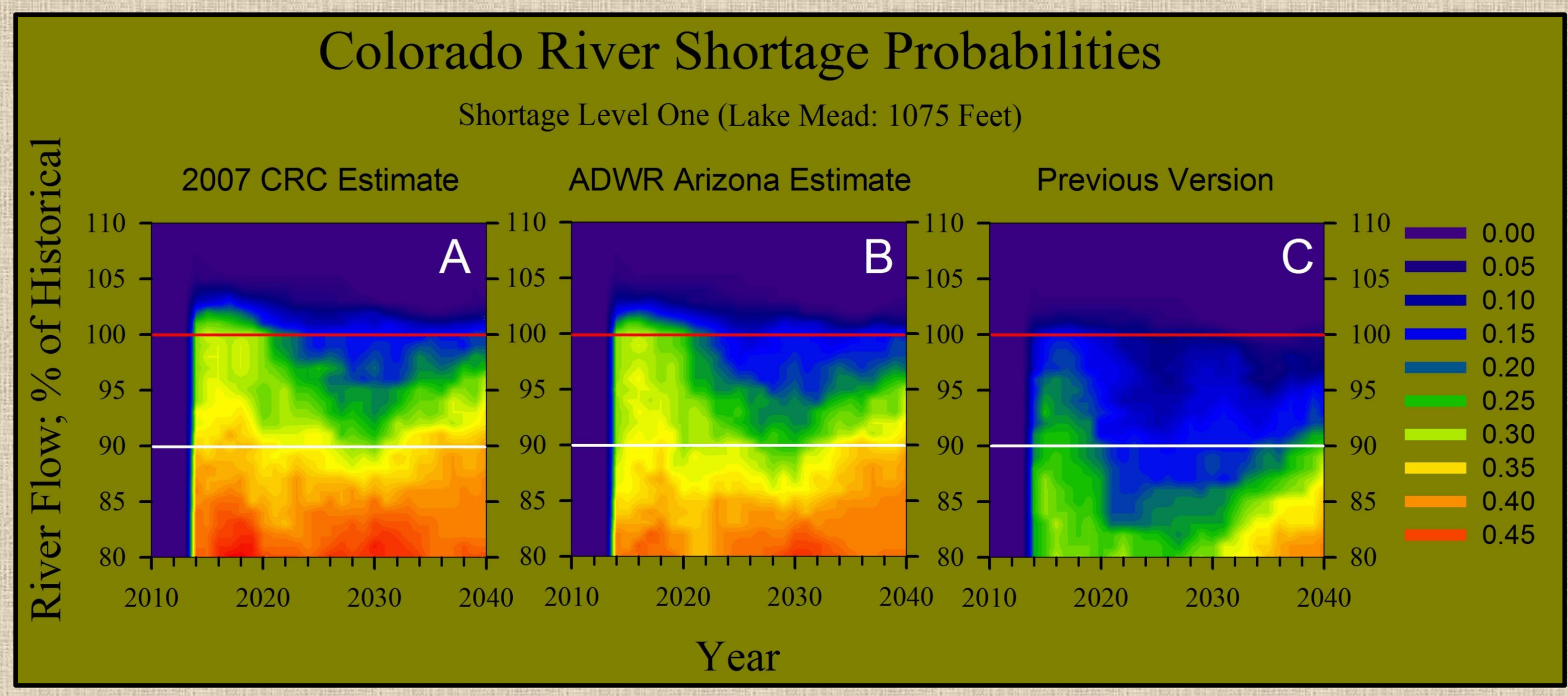


Figure 2. Upper Basin Deliveries of CO River water for two scheduled deliveries and two simulation estimates (one no longer considered).

Figure 3. Level one shortage probabilities for Lake Mead for three different estimates of Upper Basin deliveries.



Results (2)

Probabilities for level two and level three shortages for the Arizona estimate of Upper Basin water deliveries (Figure 4, panels B and C) decreased dramatically from those observed for level one (panel A).

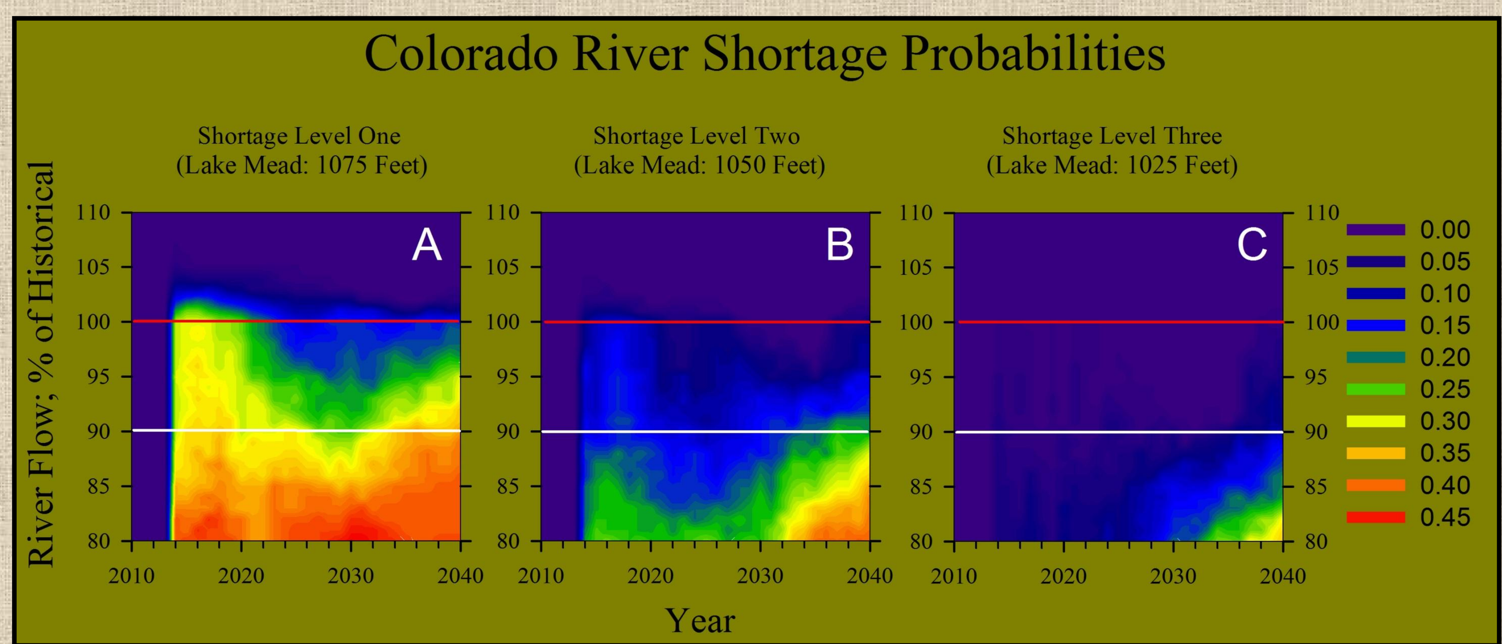


Figure 4. Level one, two, and three shortage probabilities for Lake Mead using the Arizona estimate (ADWR) for Upper Basin deliveries.

Results (3)

Both the annual flow and the inter-annual variability in the flow will strongly affect reservoir management and, thus, probable reductions on the CAP system (Fig. 5). These paleo-climate traces depict four distinct, possible, patterns (wet, low variance to dry, high variance).

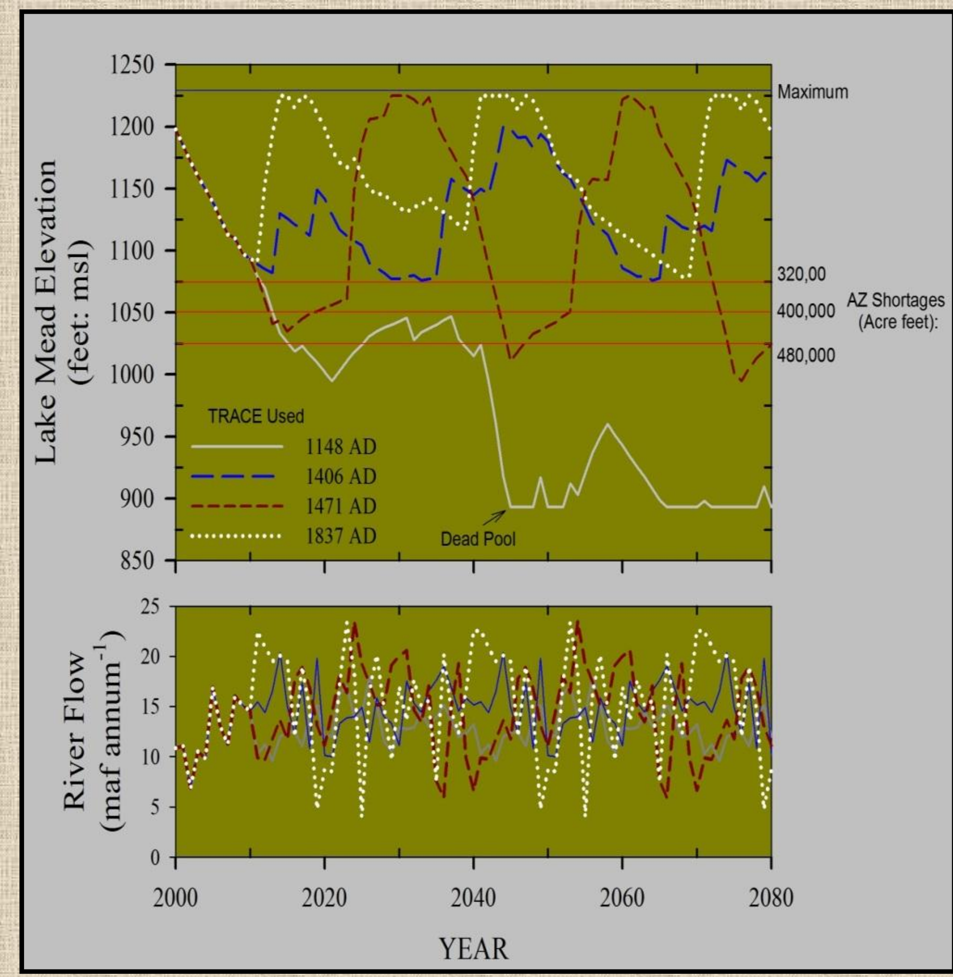


Figure 5. Four river traces and Lake Mead elevation (top panel). River flow for each trace (bottom panel).

Discussion

Shortages on the CAP system are very likely, with level one shortages a very real possibility in the near future. Level two or level three appear less likely. CAP deliveries will likely soon be reduced by 320,000 acre-feet per annum (water for about 500,000 households).

Future Upper Basin water deliveries are unknown. Current trends in them empirical estimates of Upper Basin water use suggest future use will be less than current projections (data not presented).

Non-stationarity in the climate system would impact our observed results. Namely, increased inter-annual variation in precipitation and, thus, runoff, would tend to exacerbate the trends observed in the response for the 1471 AD data record (Fig. 5, dashed red line).

NOTE: Probabilities were truncated at 2013. Re-verification and validation are planned [new code].

CAP LTER 2013 ANNUAL SYMPOSIUM

More Information

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Additional information on the WaterSim model can be obtained at http://dcdc.asu.edu/watersim.

Acknowledgments

This material is based upon work supported by the National Science Foundation under Grant No. SES-0951366 Decision Center for a Desert City II: Urban Climate Adaptation (DCDC). Any opinions, findings and conclusions or recommendation expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation (NSF).

[A]We thank Don Gross for the Upper Basin delivery schedules.