

## Multi-Objective Robust Decision Making: IWRM Transferability from a Colorado Municipality to Colorado River Basin Level Planning

Most water providers in the west are faced with increasing competition for finite resources as well as increasing supply uncertainty due to complex external factors. These factors, which include climate change, the legal and regulatory environment, infrastructure failures, demand uncertainty, wildfires, etc., can be interrelated and influence planning decisions. We present examples to address these planning challenges, first for a recently completed municipal planning study and then describe the approach at a regional level under for a NOAA Sectoral Applications Research Program (SARP) for the Colorado River Basin headwaters (CRB).

Due to the complex external uncertainties described above and the desire for sustainable water resources, Colorado Springs Utilities (CSU) transitioned to a risk tolerance based planning approach. This transition was accomplished by developing a robust, long-term planning framework as part of their Integrated Water Resource Plan (IWRP) process. This process included Multi-Objective Robust Decision Making (MORDM), which allows users to interactively discover promising alternatives and potential vulnerabilities while examining conflicting management objectives. The MORDM methods help users avoid pre-decisional assumptions and make use of objective modeling, data analysis, and data visualization combined with subject matter experts that drive the study and draw conclusions. The major elements of the framework will be presented, such as “bottom up” climate change impact analysis, complex risk identification and analysis, multi-objective optimization (MOEA), and adaptive pathways. These tools support more quantitative analyses, giving end users the ability to evaluate competing management and stakeholder objectives.

The CSU IWRP planning approach is being leveraged for the NOAA SARP CRB study. We will demonstrate the transition from vulnerability assessments to actionable decision triggers that holistically consider changing hydrology, endangered species, water leasing, hydropower production, and regionally coordinated demand management within the CRB. Our ultimate goal is to demonstrate that we can transfer the MORDM example with transparent tradeoff analysis, to address the relevant questions and concerns of CRB stakeholders, and allow them to explore the impacts and significance of alternative management actions and concepts of robustness.

Water managers need more powerful tools and approaches to robustly plan for their future, incorporate greater resilience, and justify their plans to their stakeholders and constituents. These innovative tools and techniques can be used to compare numerous interrelated variables, evaluate thousands of potential scenarios, and inform risk, risk tolerance and resiliency decisions so that a water manager can select and adapt a plan even in the face of great uncertainty. Our multi-objective, bottom up decision support framework can serve as an example to other river basins in the west.

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