Evaluating Response Packages: A Proof-of-Concept Analysis for the 2013 Water Plan

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Outline

- Current capabilities
- Proposed methodology
- Proof-of-Concept analysis
- Questions / discussion

DWR has been building capacity to evaluate response packages under future scenarios

- 2005 CWP
  - Shift to scenario-based planning
  - Developed water demand scenarios by hydrologic region
- 2009 CWP
  - Incorporated climate information into demand scenarios
  - Developed PA-scale WEAP model for SR and SJ hydrological regions
  - Calibrated PA model to historical conditions
- *2013 CWP*
  - *Expanding PA-scale WEAP model to TL HR (in conjunction with CVP IRP)*
  - *To evaluate response packages under uncertainty*

Water Plan analysis to address long-term planning uncertainties

- Future uncertainties are "*deep*"
  - Inability to agree on probabilities for future factors
  - Difficulty defining a single value function to use to rank options
- Optimal solutions contentious
  - Rely on non-credible point or probabilistic forecasts
  - Contingent upon a single or aggregate world-view

Robust decision methods offer approach to identify robust management strategies

- Robust strategies perform adequately across:
  - Different characterizations of the future (e.g. scenarios)
  - Divergent values
- Methods do not require *a priori* assignment of likelihoods of future conditions
- Reflect broad range of values
- Support substantial stakeholder and decision maker participation

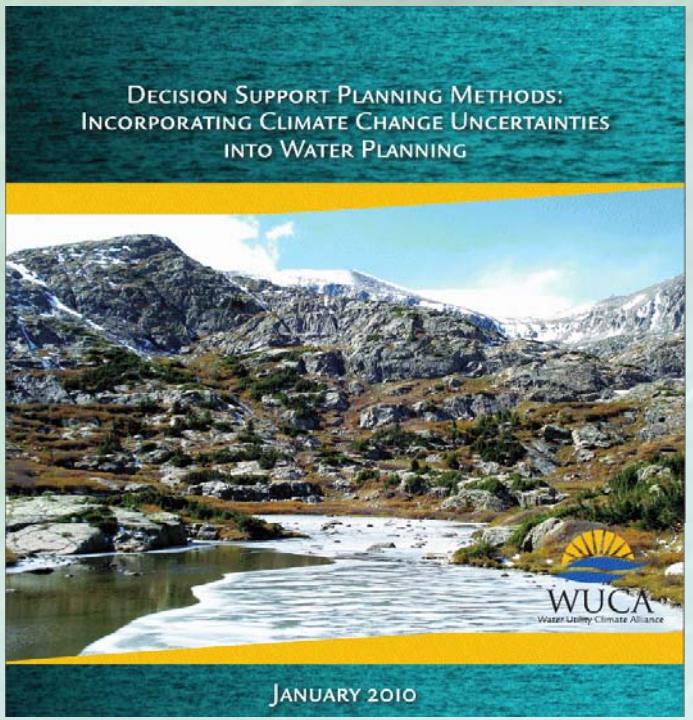
Robust Decision Making (RDM) is a structured approach for defining robust strategies

RDM structures analyses around key uncertainties, options, metrics, and models

Uncertain Factors (X) and Scenarios	**Management Strategies (L) and Response Packages**
Uncertain factors outside of the control of water managers — Basis for "Scenarios"	Water management options — "Response Packages"
Model (R)	**Performance Metrics (M)**
Model(s) that estimate outcomes (M) for strategies (L) under specific scenarios (X) $X, L \xrightarrow{R} M$	Water-related outcomes of interest — "Evaluation Criteria"

RDM being applied to long-term water planning across California and the west

- Metropolitan Water District's IRP
- El Dorado Irrigation District's UWMP (w/ CEC funding)
- Denver Water's IRP
- Featured in January 2009 Water Utility Climate Alliance (WUCA) Report



RDM well documented in the literature

- **Robust Decision Making Concepts and Methods**
  - Lempert, R. J., Popper, S. W., and Bankes, S. C. (2003). *Shaping the Next One Hundred Years: New methods for quantitative, long-term policy analysis*, RAND, Santa Monica, CA.
  - Lempert, R. J., Groves, D. G., Popper, S. W., and Bankes, S. C. (2006). "A General, Analytic Method for Generating Robust Strategies and Narrative Scenarios." *Management Science*, 52(4), 514-528.
  - Lempert, R., and Collins, M. (2007). "Managing the Risk of Uncertain Threshold Responses: Comparison of Robust, Optimum, and Precautionary Approaches." *Risk Analysis*, 27(4).
  - Groves, D. G., and Lempert, R. J. (2007). "A New Analytic Method for Finding Policy-Relevant Scenarios." Global Environmental Change 17, 73-85.
  - Bryant, B. P., and Lempert, R. J. (2010). "Thinking inside the box: A participatory, computer-assisted approach to scenario discovery." Technological Forecasting and Social Change, 77(1), 34-49.

RDM well documented in the literature

- **Applications of RDM to Water Management**
  - Groves, D. G., Matyac, S., and Hawkins, T. (2005). "Quantified Scenarios of 2030 California Water Demand." California Water Plan Update 2005, California Department of Water Resources, Sacramento, CA.
  - Groves, D. G., Knopman, D., Lempert, R., Berry, S., and Wainfan, L. (2008a). *Presenting Uncertainty About Climate Change to Water Resource Managers - Summary of Workshops with the Inland Empire Utilities Agency*. RAND, Santa Monica, CA.
  - Groves, D. G., Lempert, R., Knopman, D., and Berry, S. (2008b). *Preparing for an Uncertain Future Climate in the Inland Empire – Identifying Robust Water Management Strategies.* RAND Corporation, Santa Monica, CA.
  - Groves, D. G., Davis, M., Wilkinson, R., and Lempert, R. (2008c). "Planning for Climate Change in the Inland Empire: Southern California." *Water Resources IMPACT*, July.
  - Groves, D. G., Yates, D., and Tebaldi, C. (2008d). Developing and Applying Uncertain Global Climate Change Projections for Regional Water Management Planning. *Water Resources Research*, 44(W12413).
  - Lempert, R. J., and Groves, D. G. (2010). "Identifying and Evaluating Robust Adaptive Policy Responses to Climate Change for Water Management Agencies in the American West." *Technological Forecasting and Social Change*, 77.

DWR proposes to support Proof-of-Concept application of RDM using WEAP PA models

- Purpose of POC
  - demonstrate the application of RDM and educate stakeholders
  - identify critical methodological issues to be resolved
  - help prioritize WEAP modeling enhancements
  - define application of RDM to the CWP Update 2013
- Illustrative questions to address
  - What is the range of future management outcomes under no new management?
  - Which response packages lead to acceptable outcomes?
  - In which conditions do promising response packages perform poorly?
  - How could adaptivity improve the robustness of response packages?

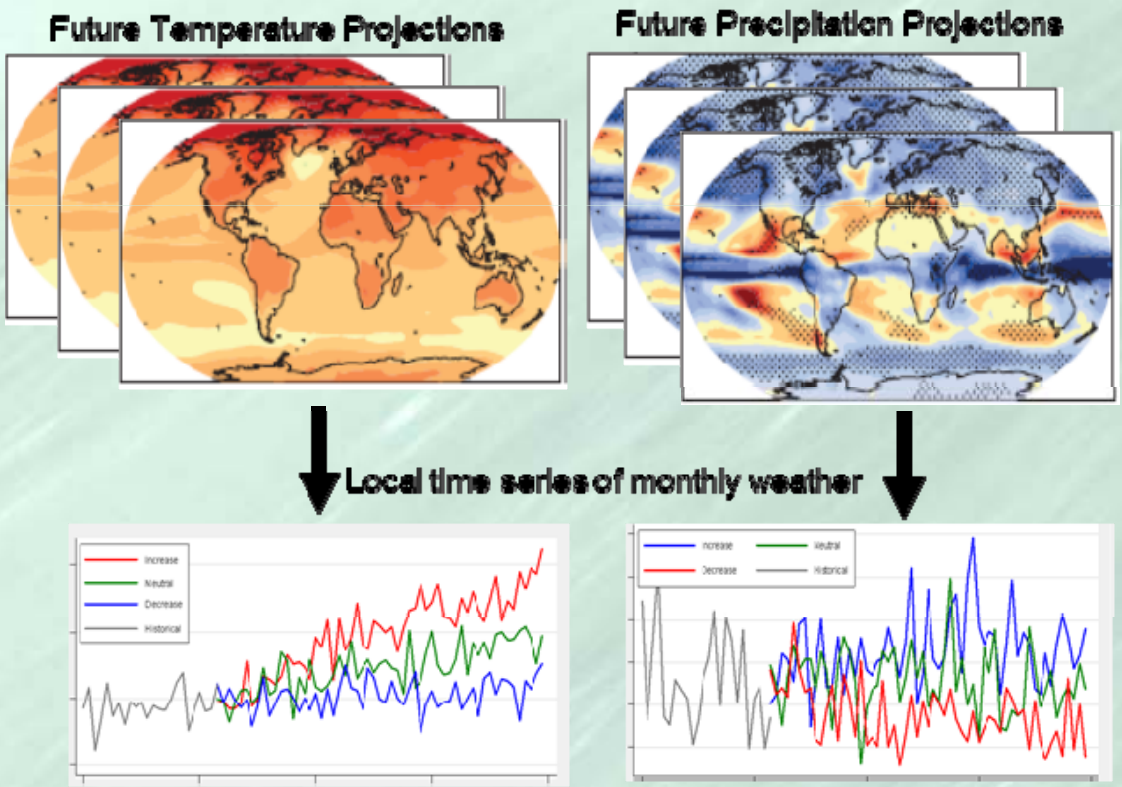
POC analysis to build on CWP 2009 scenarios

Demographic and Land Use Factors

Factors of Uncertainty	Current Trends	Strategic Growth	Expansive Growth
	Recent trends are assumed to continue into the future. The state faces lawsuits on a regular basis, from flood damages to water quality and endangered species protections. Regulations are not coordinated or comprehensive, creating uncertainty for planners and water managers.	Private, public, and governmental institutions form alliances to provide for efficient planning and development that is less resources intensive than current conditions. State government implements comprehensive and coordinated regulatory programs to improve water quality, protect fish and wildlife, and protect communities from flooding.	Future conditions are more resource intensive than existing conditions. Protection of water quality and endangered species is driven mostly by lawsuits. State government has responded on a case-by-case basis, creating a patchwork of regulations and uncertainty for planners and water managers.
Population	**60** million	**45** million	**70** million
Land Use	Continued development	Compact development	Sprawling development
Irrigated Crop Area	**8.5** million acres	**9** million acres	**8.2** million acres
Environmental Water	**1.0** additional MAF	**1.5** additional MAF	**0.6** additional MAF
Background Water Conservation	**10%** increase	**15%** increase	**5%** increase

POC analysis to build on CWP 2009 scenarios

Downscaled AOGCM climate sequences



- 6 AOCGMs
  - CNRM-CM3
  - GFDL-CM21
  - Micro32med
  - MPI-ECHAM5
  - NCAR-CCSM3
  - NCAR-PCM1
- Two emissions scenarios
  - A2
  - B1

POC analysis to build on CWP 2009 scenarios

- Other factors
  - Costs and/or limits to groundwater pumping
  - Costs of resource management strategies

Scope of POC Analysis

Uncertain Factors (X) and Scenarios	**Management Strategies (L) and Response Packages**
Population Household factors Employment factors } Land use / demographic scenarios (3) Climatic conditions } Temperature / precipitation scenarios (12) Groundwater limits/costs Costs of management strategies	Water management options — "Response Packages"
Model (R)	**Performance Metrics (M)**
WEAP PA model for Central Valley	Water-related outcomes of interest — "Evaluation Criteria"

Analysis will evaluate several water management strategies

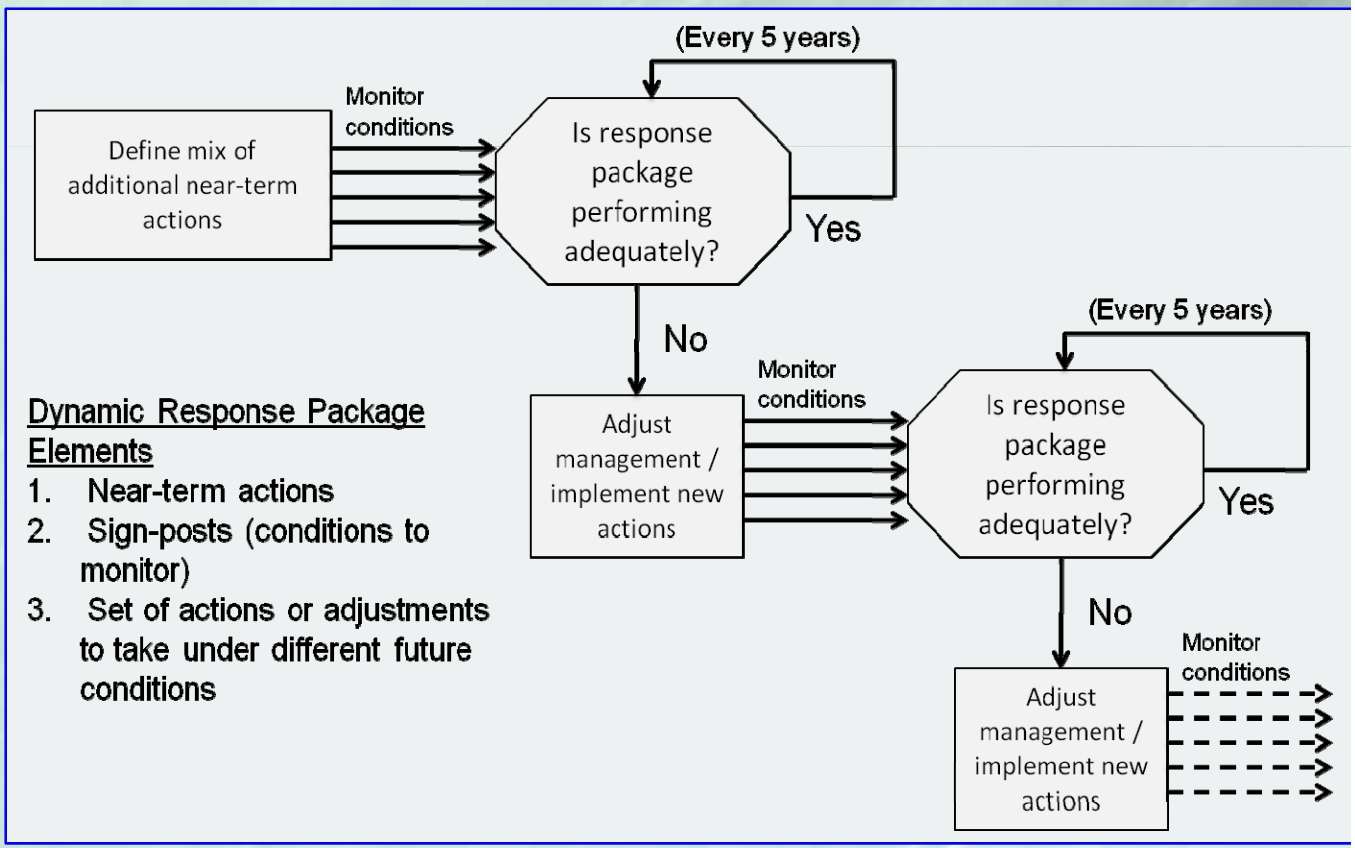
WATER PLAN STRATEGIES	SIMULATE IN WEAP?	IMPLEMENATION IN PA Model
STRATEGIES TO REDUCE WATER DEMAND		
* Agricultural Water Use Efficiency	YES	Adjust crop/irrigation coefficients
* Urban Water Use Efficiency	YES	Adjust water use rates through efficiency parameter
STRATEGIES TO IMPROVE OPERATIONAL EFFICIENCY		
† Conveyance - Delta	YES	Modify schematic to reflect any structural changes. Adjust constraints on existing facilities to reflect any capacity expansions.
† Conveyance - Regional/Local	YES	
* System Reoperation	YES	Modify operational logic. May include adjusting reservoir rule curves, adjusting priorities of demands and/or storages, adjusting supply preferences
Water Transfers	YES	Adjust constraints as needed to permit contractual transfer of water. Adjust demands (as needed) by decreasing the sellers demand (presumably due to land retirement or efficiency improvement). Update supply preferences as needed.
STRATEGIES TO INCREASE WATER SUPPLY		
* Conjunctive Management & Groundwater Storage	YES	Adjust supply preferences to reflect a shift to relying more on groundwater in dry periods. Modify schematic to include groundwater recharge areas (using WEAP's reservoir object)
Desalination - Brackish & Seawater	YES	Modify schematic to include new sources. Specify capacity/production
Precipitation Enhancement	YES	Adjust precipitation time series to reflect expected increases.
* Recycled Municipal Water	YES	Allow return flows from waste water treatment plants to be used as a water supply source
† Surface Storage -- CALFED/State	YES	Modify schematic to include new facilities. Modify operational logic to reflect changes in water storage priorities for reservoirs and/or changes in supply preferences for demands
Surface Storage -- Regional/Local	YES	

Water management strategies will be evaluated as *Response Packages*

"Static" Response Packages

- Level of implementation for each strategy
- Year of implementation –or- time schedule for various levels of implementation

"Dynamic" Response Packages



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Model (R)	**Performance Metrics (M)**
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Analysis will evaluate key trade-offs among different performance metrics

Performance Metric Category	Performance Metric
Demand	- Monthly and annual demand by node (irrigated agriculture, indoor urban, outdoor urban)
Supply	- Surface supply delivered - Groundwater supply delivered
Reliability	- Unmet demand by node - % of years with unmet demands
Environmental Objectives	- Anadromous Fish Restoration Programs flows (4) - Delta inflow - Delta outflow - X2 position - Water quality (temperature)
System Operations	- Flows into major reservoirs - Storage volume for major dams (5) - Delta exports - Groundwater levels
Financial	- Capital costs - Fixed costs - Variable costs
Hydropower	- Annual hydropower generation
Economic impacts	- Economic impacts of shortages

Analysis plan designed to provide quick results to inform remaining 2013 Water Plan work

1. Finalize scope of POC (August 2010)
2. Implement uncertainties & response packages in WEAP model (September 2010)
3. Evaluate static response packages against scenarios (October 2010)
4. Vulnerability analysis (November 2010)
5. Trade-off analysis (December 2010)
6. Results workshop (January 2011)

Questions and Discussion