BUREAU OF RECLAMATION

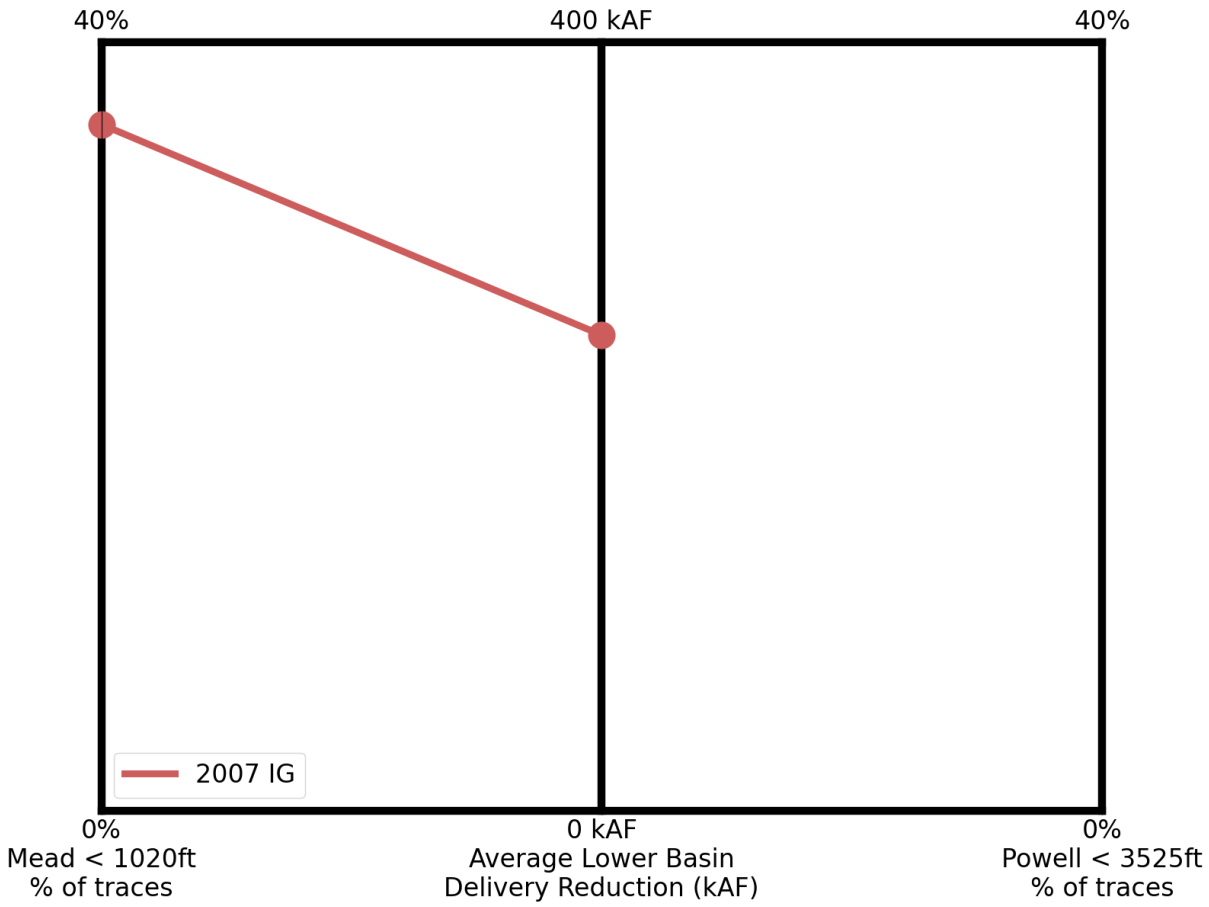
Using RiverSMART and Cloud Computing to Support Long-Term Policy Exploration in the Colorado River Basin

RiverWare User Group Meeting
August 29, 2023

What sort of future conditions should drive the design of Colorado River Post-2026 Operations?

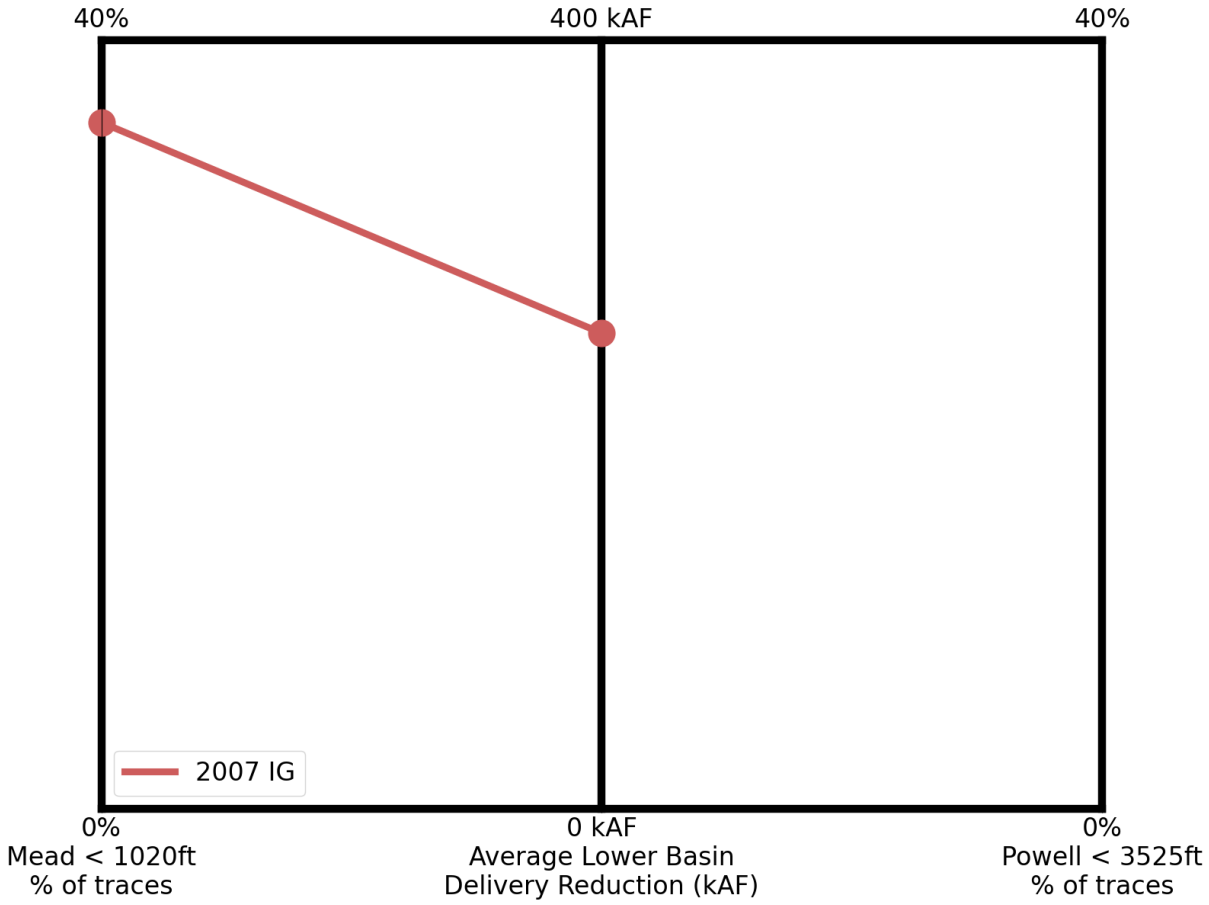
- Uncertainty about future water supply within the Colorado River Basin
  - Long-term average flow?
  - Drought persistence? Periods of high flows?
- Uncertainty about demand growth in the Upper Basin and shortage magnitudes in the Lower Basin
  - Overall demand levels + rates of growth
- Currently in the middle of unprecedented drought and declining reservoir storage – what will conditions be when new agreements are made?
  - Does this impact policy evaluation?
- How do we incorporate many potential futures into a decision-making framework that includes more stakeholder involvement?

Exploring CRSS policies in multiple dimensions

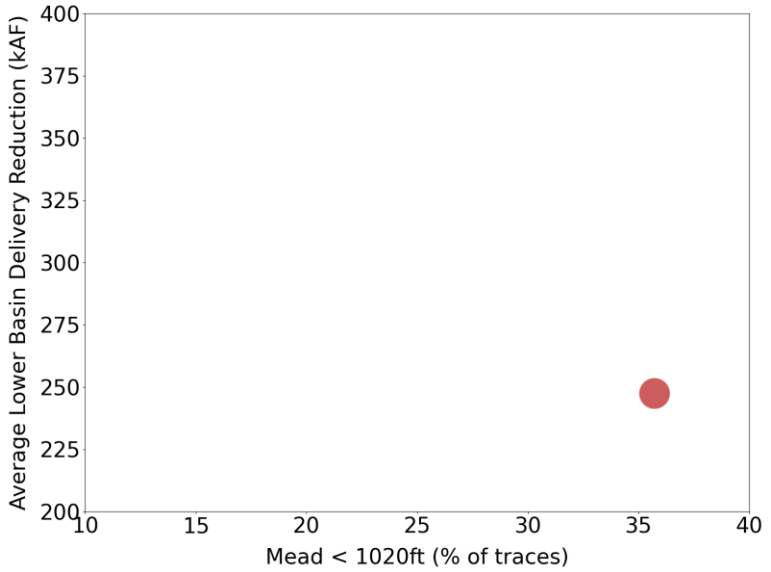


- Multi-objective measures compare policy tradeoffs using one value per performance objective

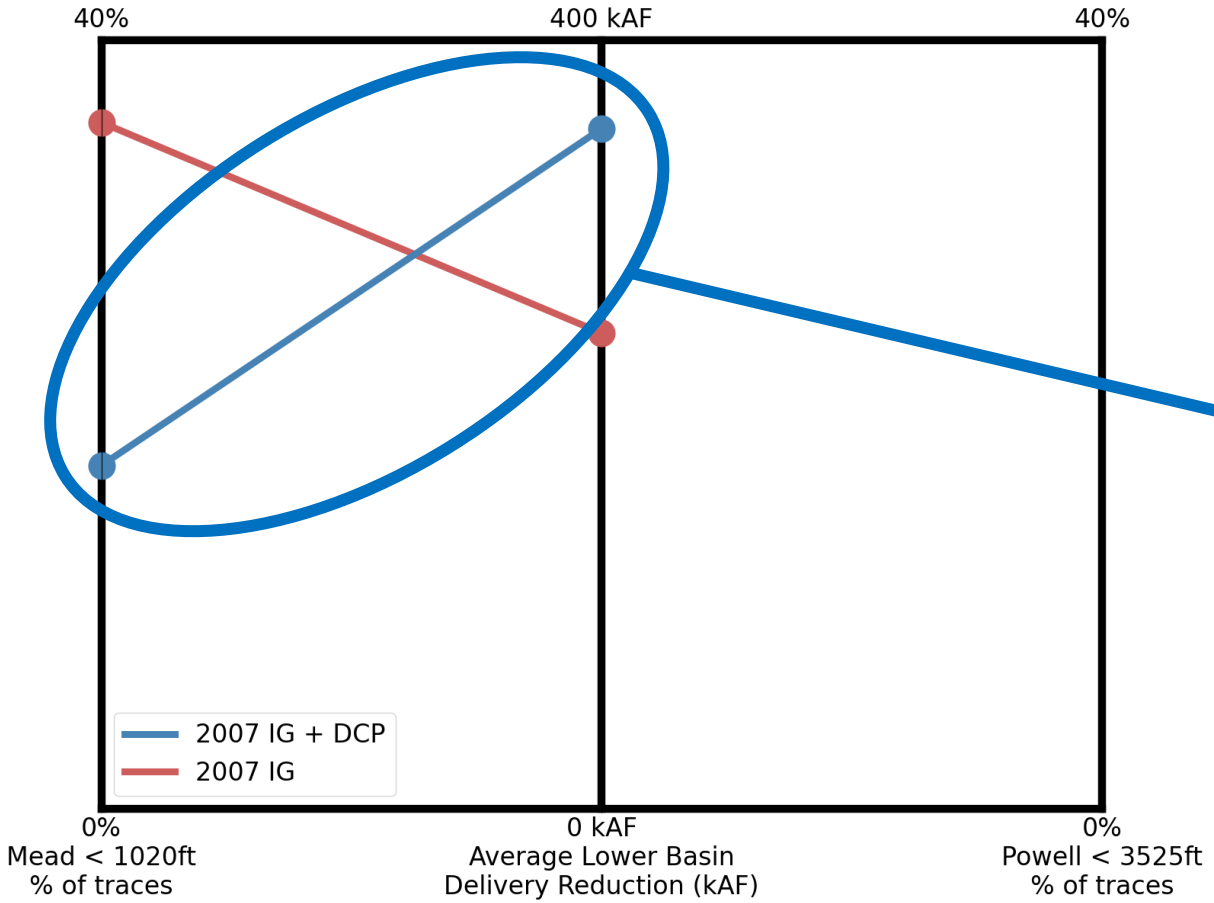
Exploring CRSS policies in multiple dimensions



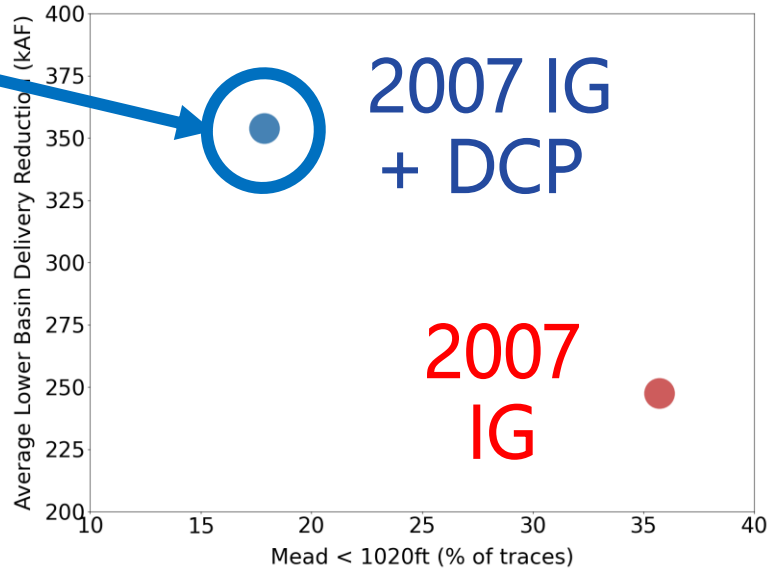
- Multi-objective measures compare policy tradeoffs using one value per performance objective



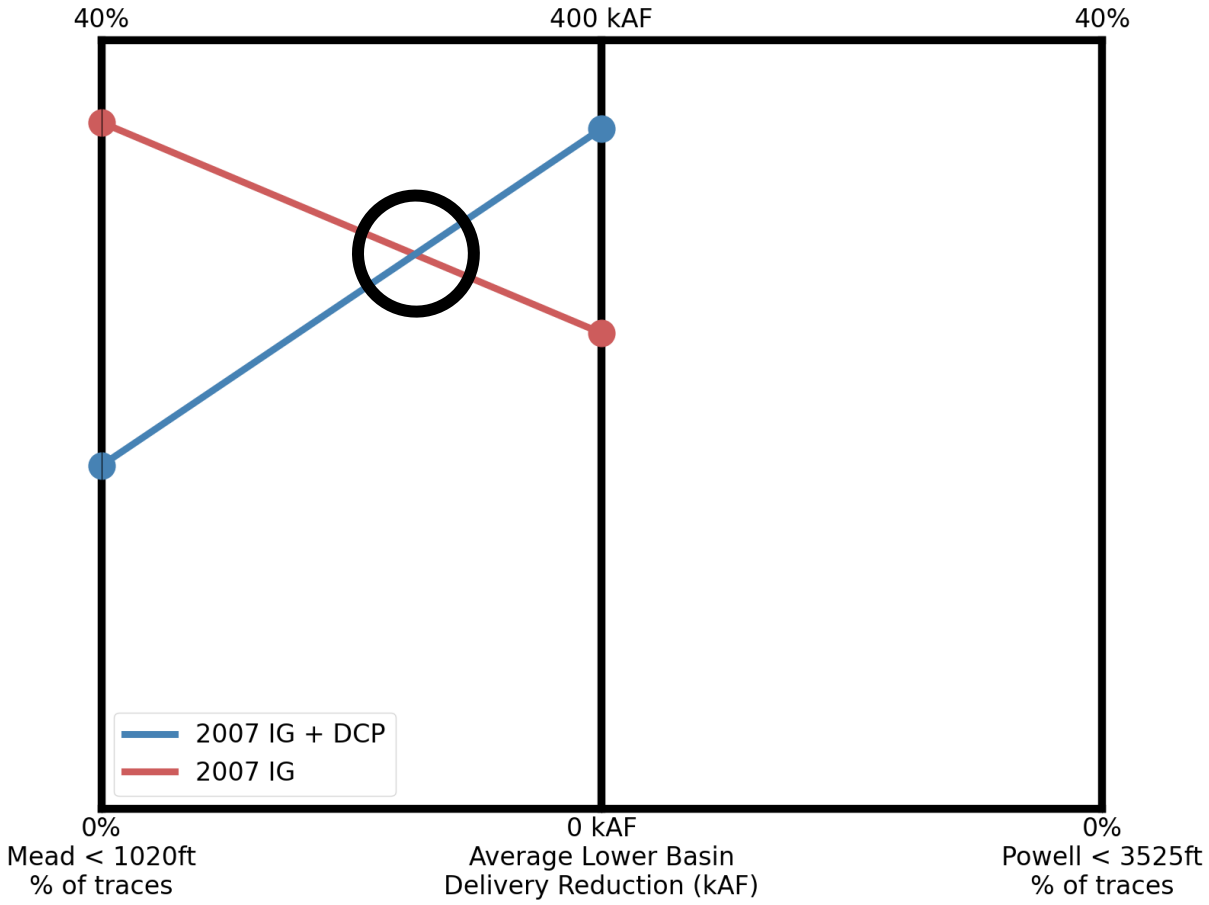
Exploring CRSS policies in multiple dimensions



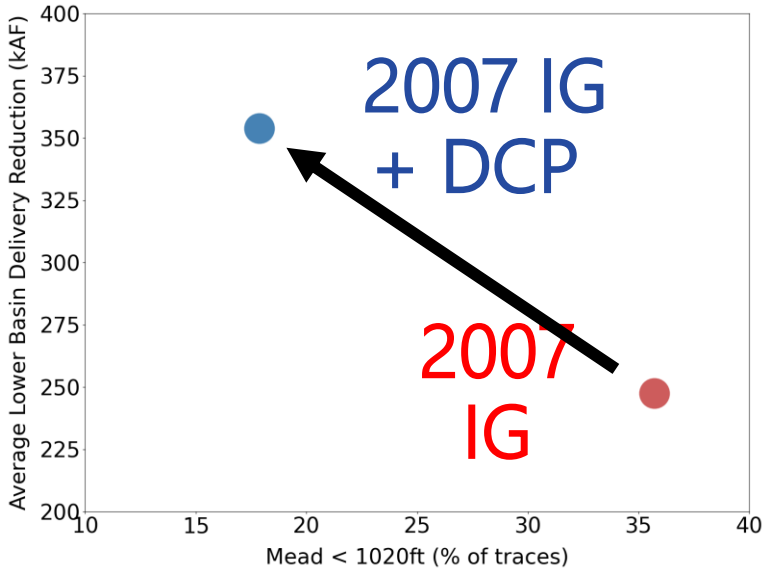
- Multi-objective measures compare policy tradeoffs using one value per performance objective



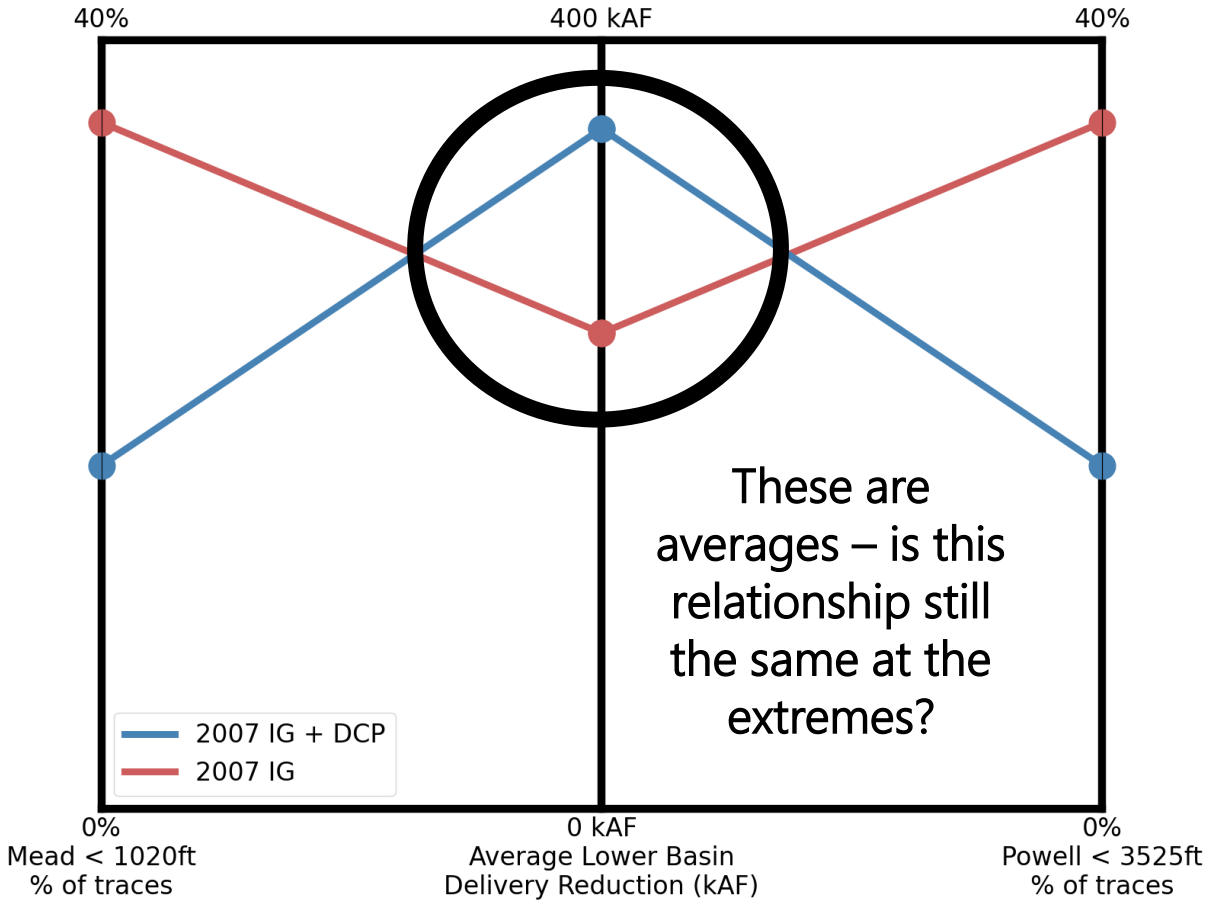
Exploring CRSS policies in multiple dimensions



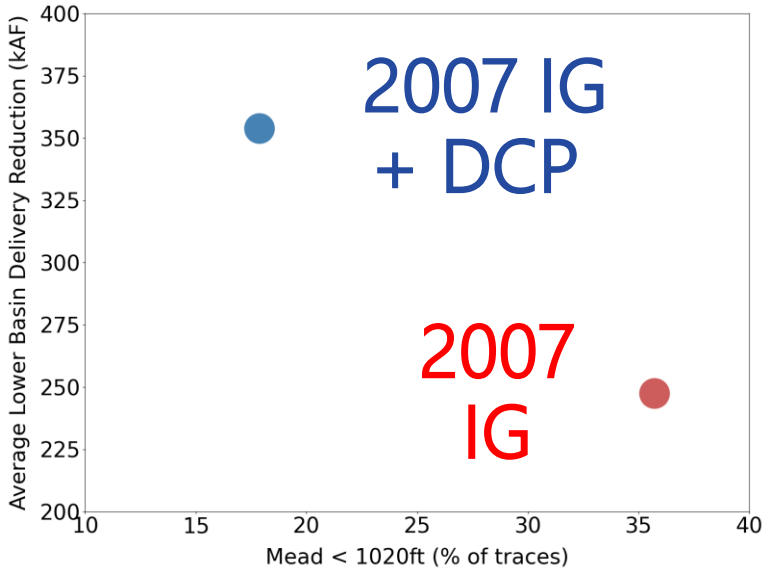
- Multi-objective measures compare policy tradeoffs using one value per performance objective



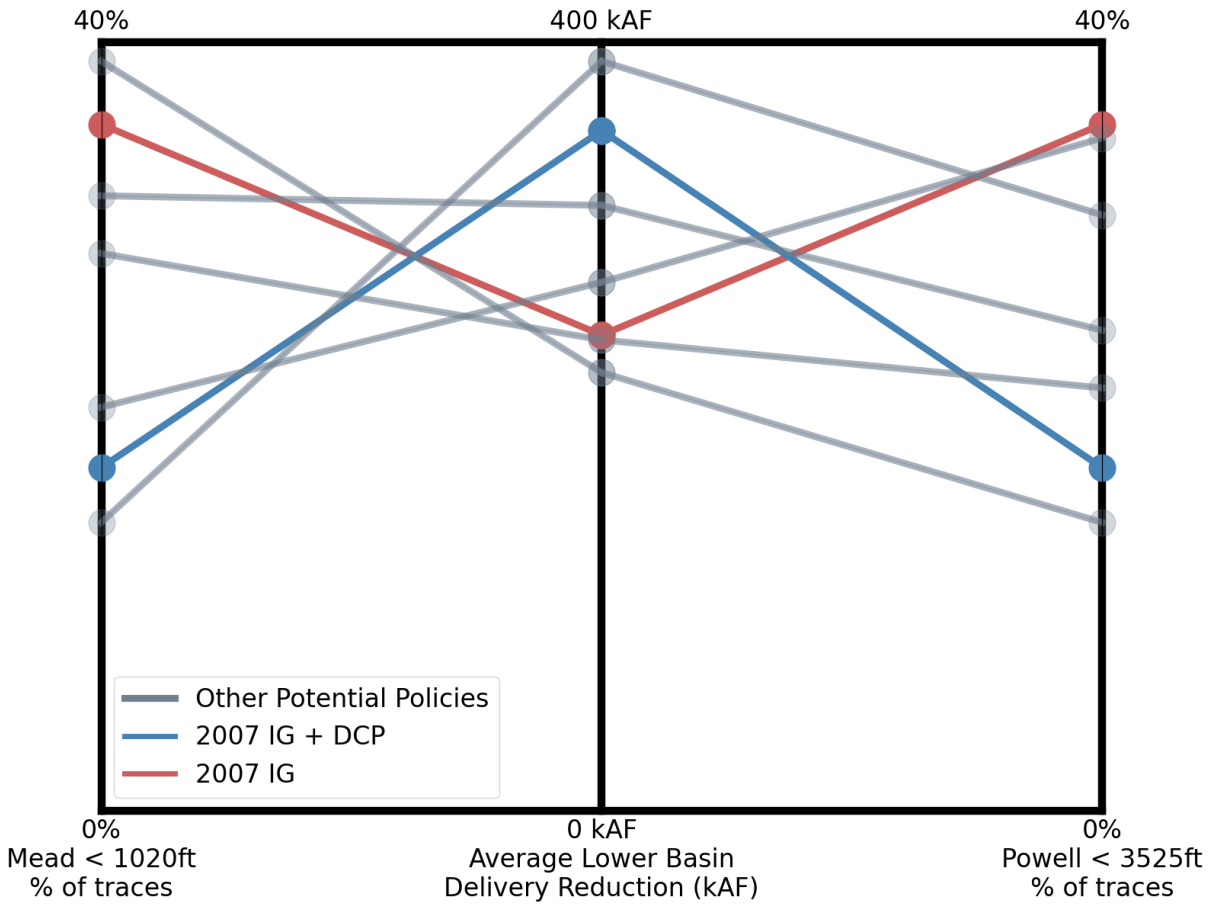
Exploring CRSS policies in multiple dimensions



- Multi-objective measures compare policy tradeoffs using one value per performance objective
  - single values do not summarize performance across large ensembles

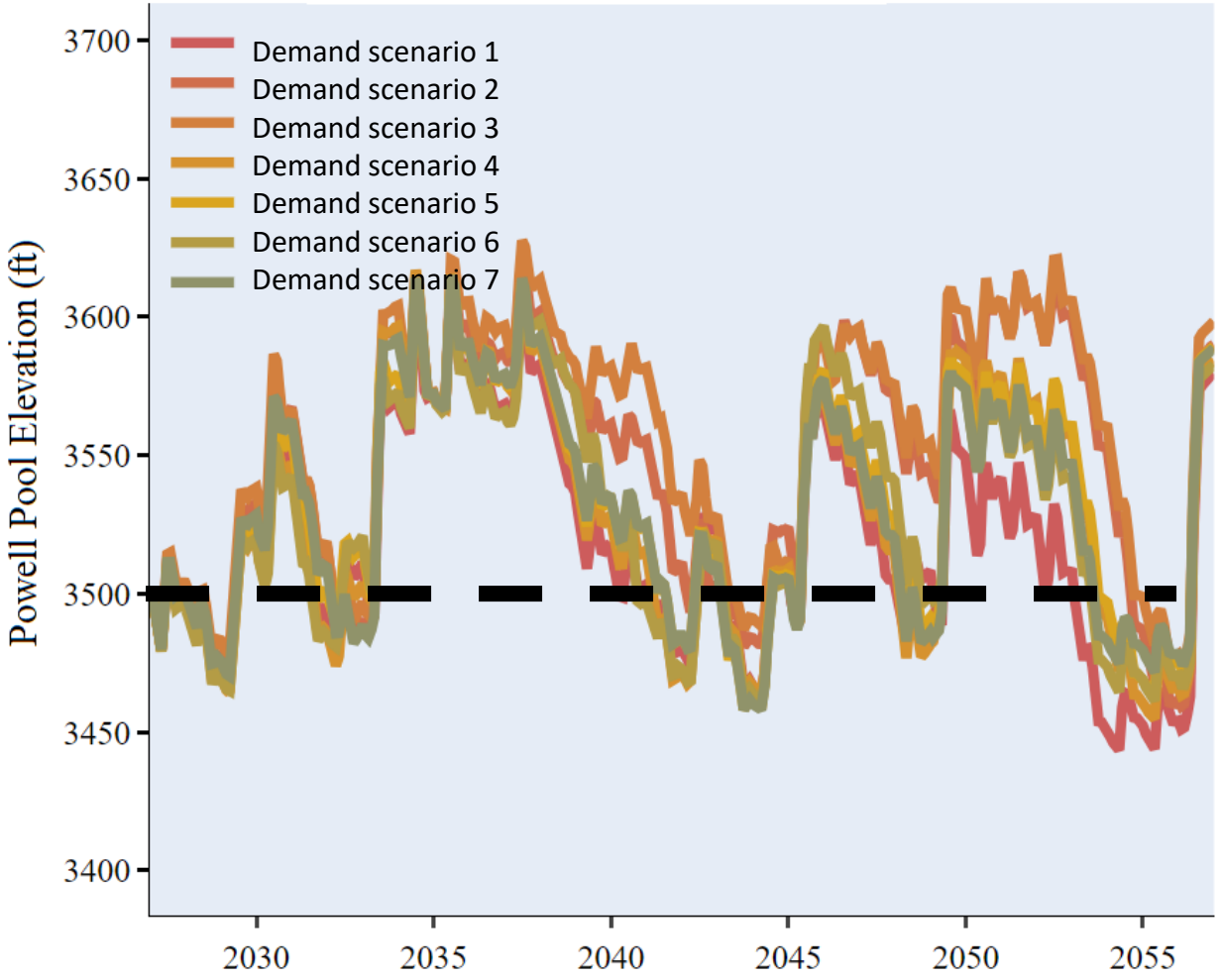


Exploring CRSS policies in multiple dimensions



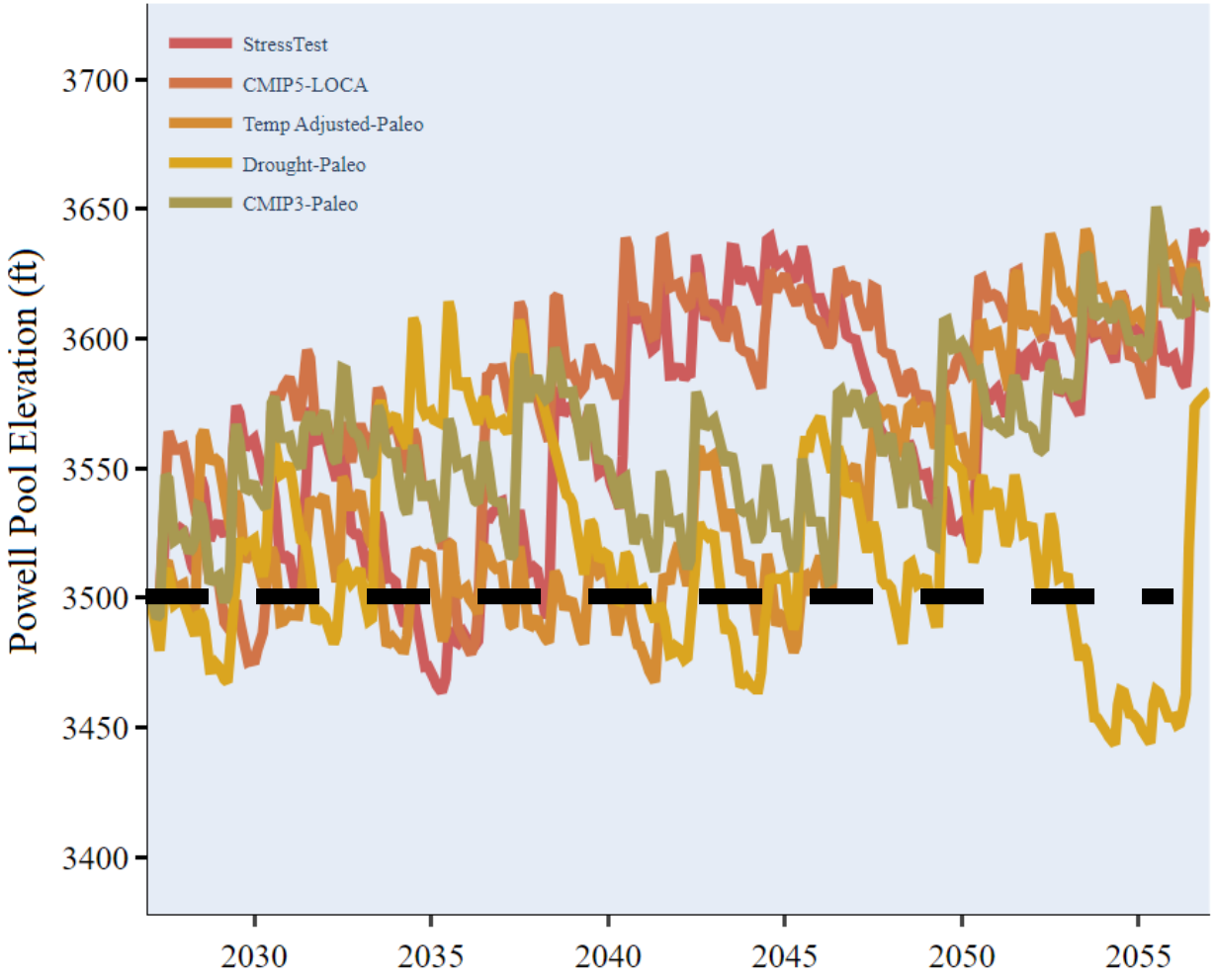
- Multi-objective measures compare policy tradeoffs using one value per performance objective
  - single values do not summarize performance across large ensembles
- Tradeoffs are only valid across a specific set of assumptions – what if those assumptions change?

Tension between exploring policy tradeoffs and performance in different futures



- Single-objective measures can be evaluated across many futures – how often do we ***fall below a threshold*** measure?
  - Same policy for many different demands

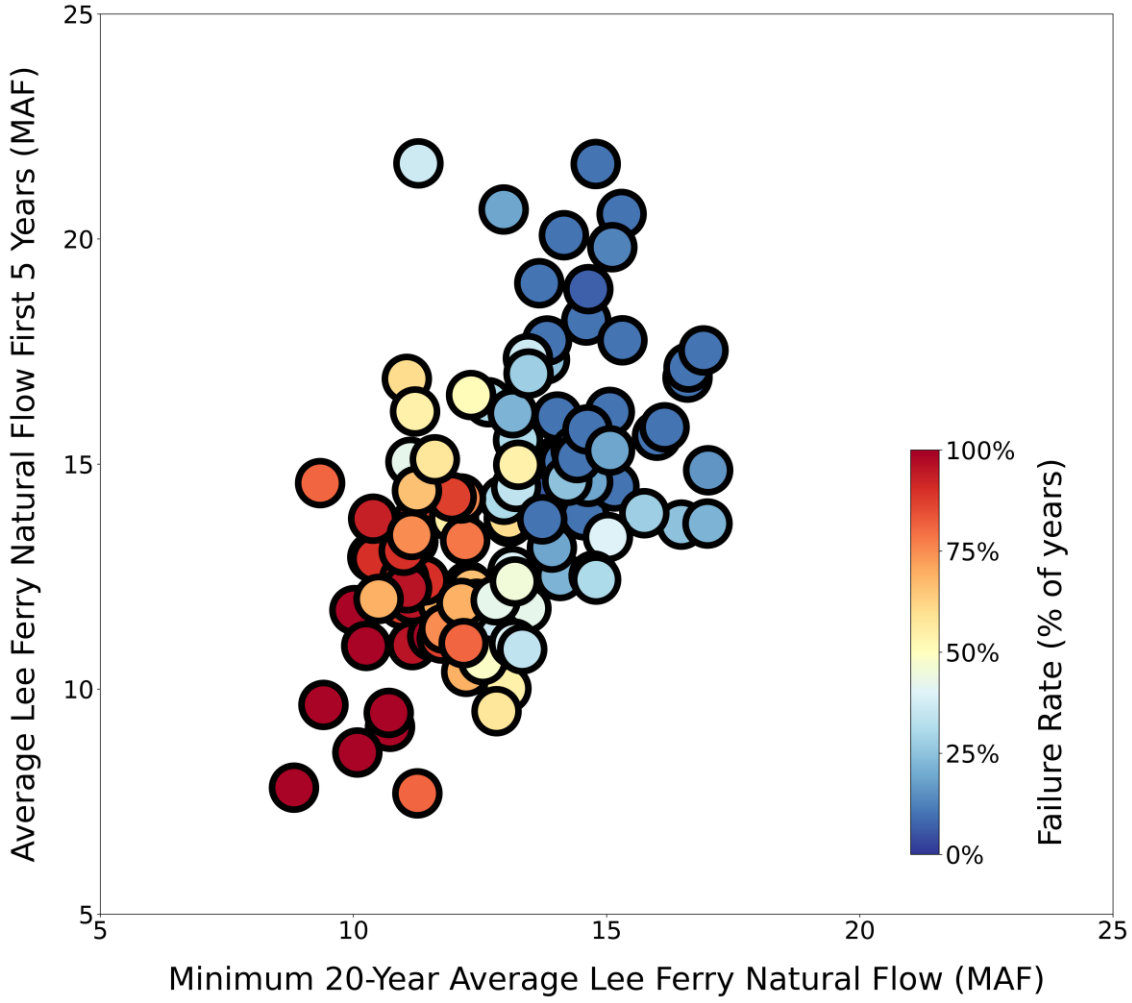
Tension between exploring policy tradeoffs and performance in different futures



- Single-objective measures can be evaluated across many futures – how often do we ***fall below a threshold*** measure?
  - Same policy for many different demands
  - Same policy for many different hydrology traces

Instead of looking for the ‘best’ policy – we find vulnerable conditions in every policy

- Does not require projection of ‘most likely’ future conditions
- Instead focused on finding undesirable outcomes across all potential conditions
  - How do we simulate all potential conditions? (we don’t)
  - Identify important characteristics & sample using different methods
- How should we categorize future conditions – for sampling & visualization
  - Input from other models (CRMMS)
  - Scenarios/ensembles
  - Statistical/pattern grouping methods



Balance between considering many policies + evaluating many futures

- Policy choices:
  - Ex: Are reservoir-based triggers (e.g., LB shortage) continuous or tiered? Elevation- or volume-based?
  - Ex: evaluate 200 different policies
- Scenarios:
  - ~400 hydrology traces (30 years, 2027 - 2056)
  - ~7 Upper Basin demand scenarios (steady and growing scenarios)
  - ~3 Initial conditions (imported from CRMMS)
- ~200 policies * 400 traces * 7 demands * 3 ICs = *1.68 million* RiverWare evaluations
- 1,750 days of computing time = not helpful for a process that finishes in 2026
- 4 Microsoft Azure VMs w/ 100 processing cores = 4.3 days

Faster computation enables iterative model development

- Multiple rounds of optimization/scenario exploration provided feedback for the creation of policy levers, demand, hydrology, and IC scenarios as well as metric and objective slots
  - Scenario exploration and model operational concepts were developed together
- Web tool enables iterative policy design by stakeholders
  - Interactive web interface makes it simple to design new policies
  - Stakeholder input can be translated to RiverWare policies and run on the cloud
  - Full sensitivity results returned within 4.5 hours – computational resources that are not readily available to most of stakeholders
  - Policies generated through optimization are available for benchmarking/comparison


Questions?
HB Zeff
hzeff@usbr.gov
BUREAU OF
RECLAMATION