BUREAU OF RECLAMATION

The Colorado River Basin Post-2026 Operations Exploration Tool: A Web-Based Modeling Interface and Interactive DMDU Analysis

2025 RiverWare User Group Meeting

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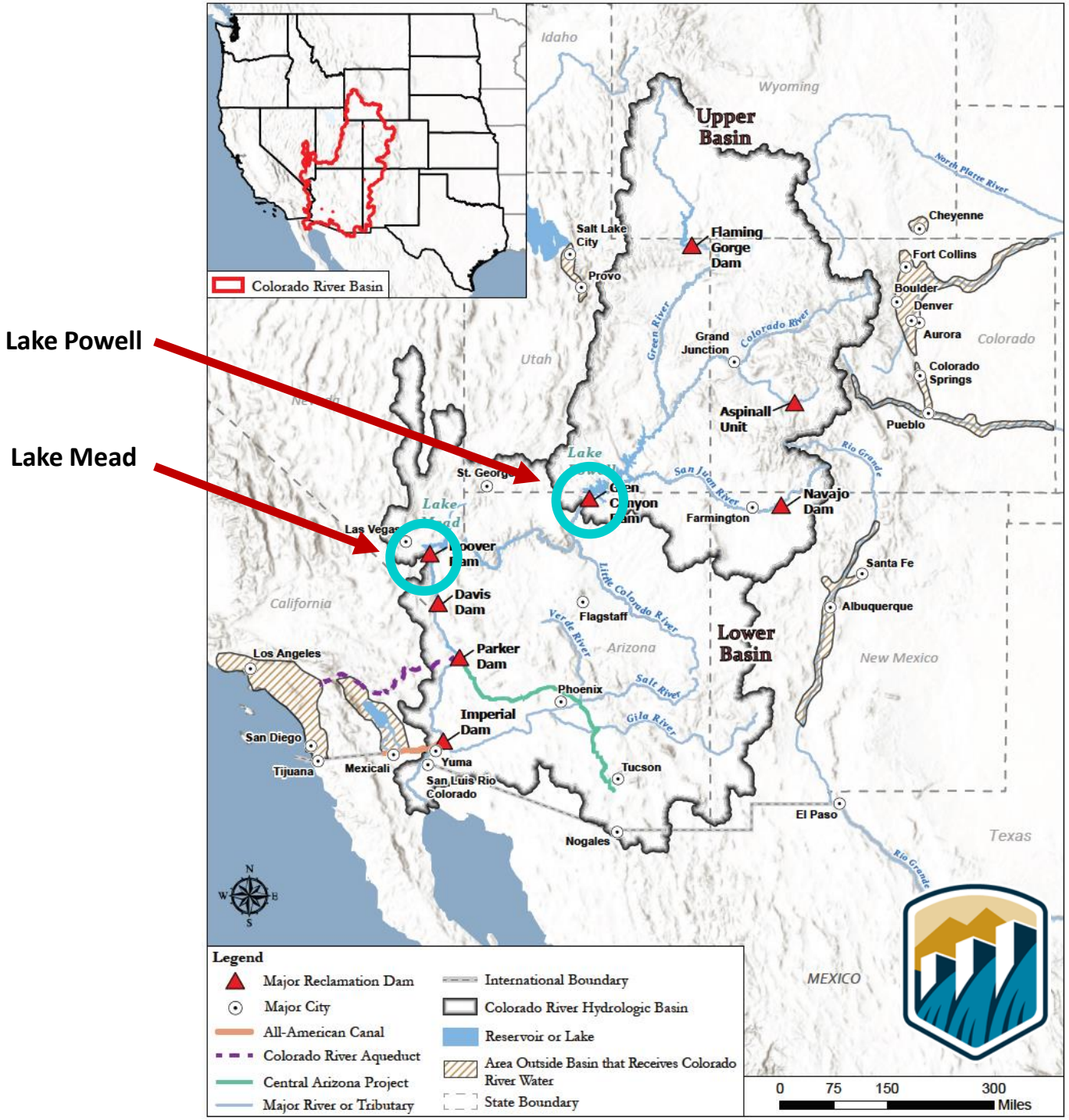
Outline

- Intro to the Post-2026 Planning Process and the Operations Exploration Tool (Web Tool) context
- Key Web Tool Components
- Demo
- Borg-RiverWare and the Web Tool
- Stakeholder Engagement and Partnerships

Operational Setting

- Colorado River system provides water for 7 States, 30 Basin Tribes, and Mexico
- Dams and reservoirs on the river can store nearly 4 years' water supply and generate 4,200 megawatts of hydropower
- Two largest reservoirs in the system have the capacity to store 50 million acre-feet of water
  - Lake Powell – formed by Glen Canyon Dam
  - Lake Mead – formed by Hoover Dam
- Several operating agreements that govern the operation of Lake Powell and Lake Mead expire at the end of 2026
- The "Post-2026" process is intended to develop successor domestic agreements prior to preparation of the 2027 Annual Operating Plan (anticipated mid-2026)



2007 Interim Guidelines - Operational Elements and Diagram

Operational Elements

- **Shortage Guidelines** – Prescribed volumes of Lower Basin Shortages at specific Lake Mead elevations
- **Coordinated Reservoir Operations** – Guidelines for coordinated operations between Lake Powell and Lake Mead
- **Storage and Delivery of Conserved Water** – Mechanism for storage and delivery of conserved water in Lake Mead
- **Surplus Guidelines** – Guidelines to identify Surplus Conditions

Summarized from the 2007 Interim Guidelines Record of Decision

On February 2nd, Powell and Mead were each ~35% full

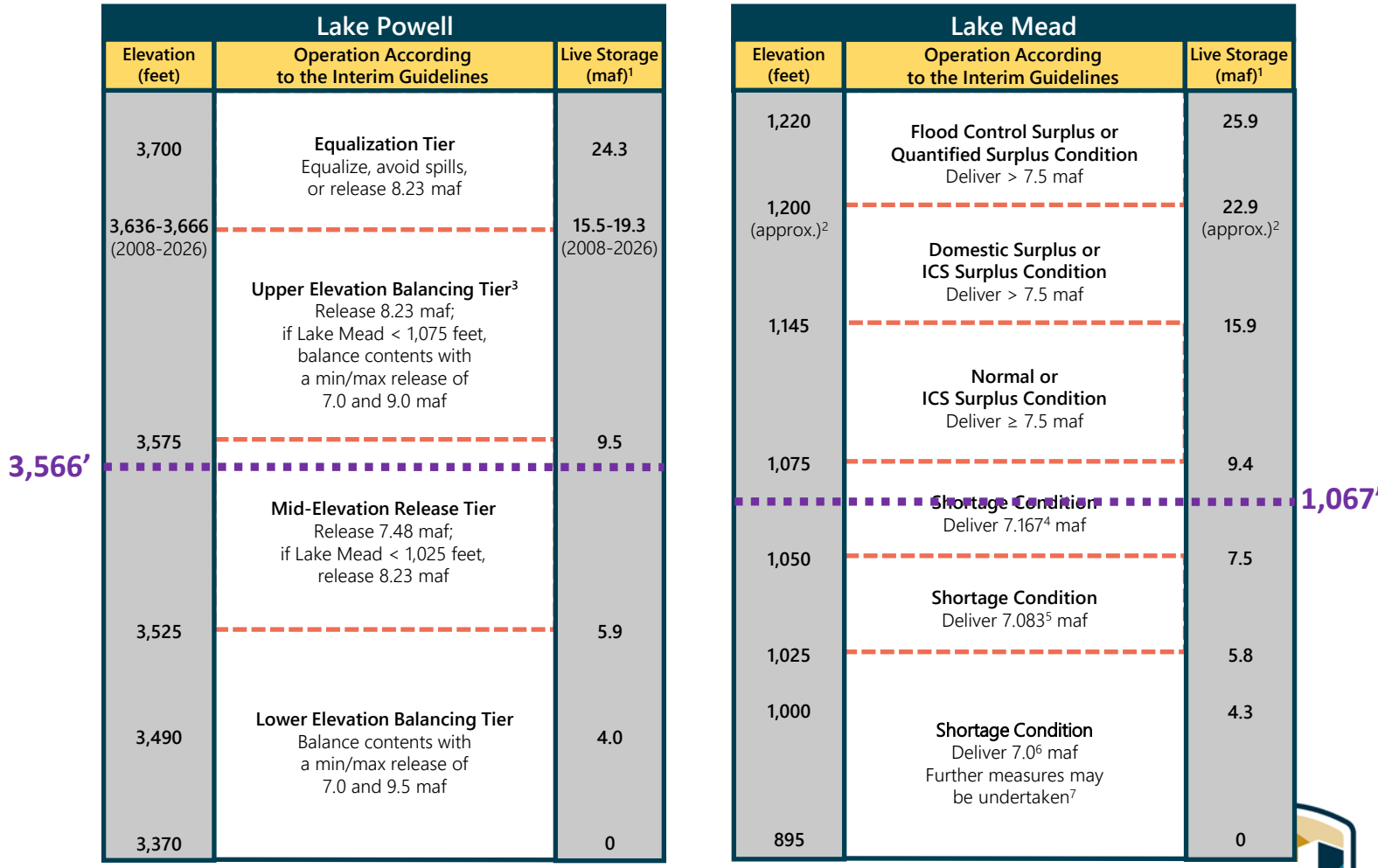


Diagram not to scale; [1] Acronym for million acre-feet; [2] This elevation is shown as approximate as it is determined each year by considering several factors including Lake Powell and Lake Mead storage, projected Upper Basin demands, and an assumed inflow; [3] Subject to April adjustments which may result in a release according to the Equalization Tier; [4] Of which 2.48 maf is apportioned to Arizona, 4.4 maf to California, and 0.287 maf to Nevada; [5] Of which 2.40 maf is apportioned to Arizona, 4.4 maf to California, and 0.283 maf to Nevada; [6] Of which 2.32 maf is apportioned to Arizona, 4.4 maf to California, and 0.280 maf to Nevada; [7] Whenever Lake Mead is below elevation 1,025 feet, the Secretary shall consider whether hydrologic conditions together with anticipated deliveries to the Lower Divison States and Mexico are likely to cause the elevation at Lake Mead to fall below 1,000 feet. Such consideration, in consultation with the Basin States, may result in the undertaking of further measures, consistent with applicable Federal law.

Changed Circumstances Since Adoption of the 2007 Interim Guidelines

- Unprecedented drought, exacerbated by climate change, and declining reservoir storage
- Increasing uncertainty about future water supply and demand
- Need to explore a wide range of creative solutions
- Advances in technical methods and tools
- Increased need for expanded partner-stakeholder engagement in Colorado River decision-making

These factors are described in the June 2022 Federal Register Notice requesting input on the development of Post-2026 Colorado River Reservoir operational strategies for Lake Powell and Lake Mead

Web Tool Objectives

The Post-2026 Operations Exploration Tool is designed to meet three main objectives:

1. Enable the exploration of a wide range of potential operational strategies for Lake Powell and Lake Mead;

2. Provide a common technical platform that is accessible to all Basin stakeholders and interested parties, enabling everyone to explore strategies on an equal basis;

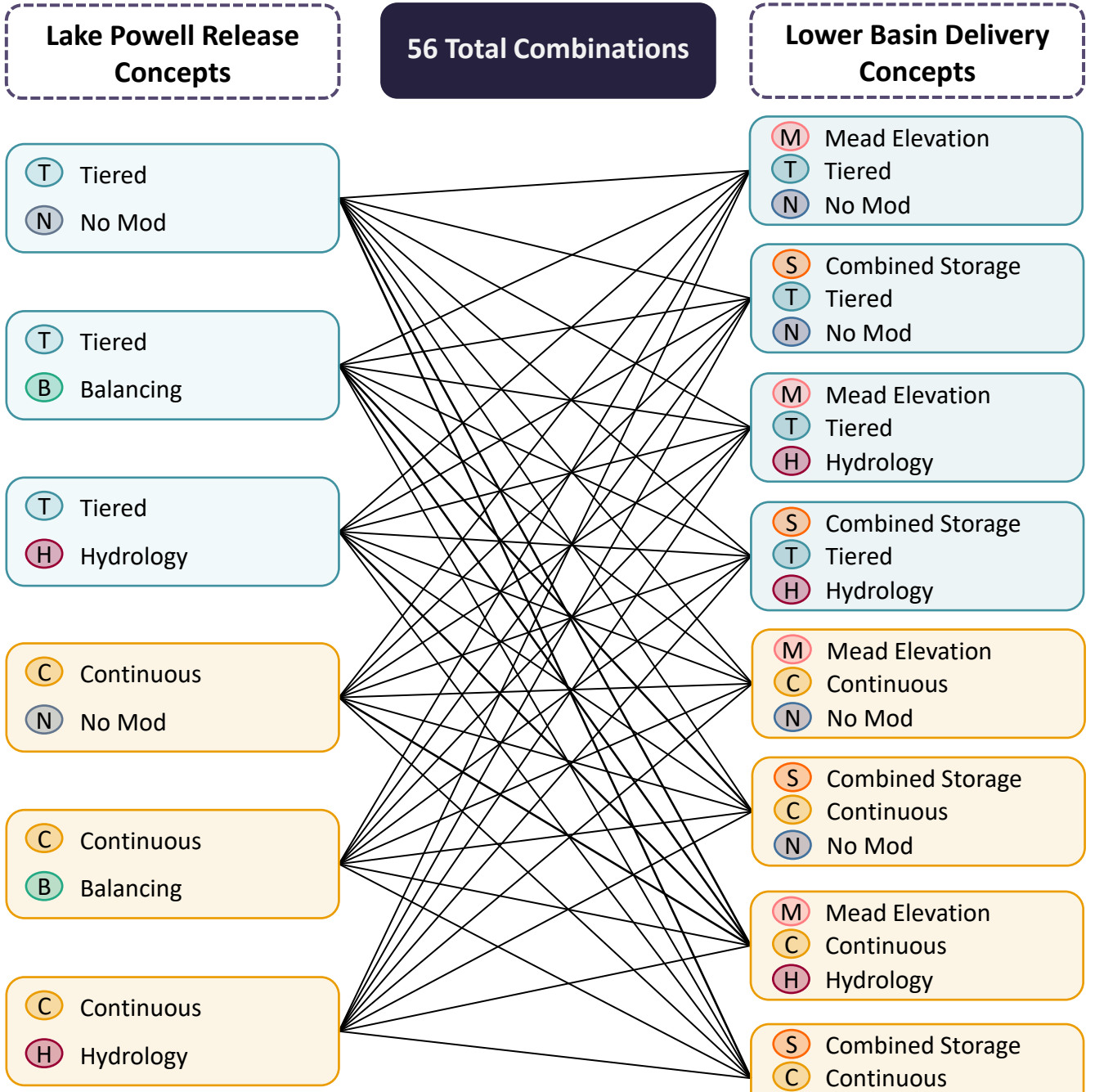
3. Facilitate the development of robust future strategies through the use of Decision Making under Deep Uncertainty (DMDU).

Key Web Tool Components:

Flexible Modeling
DMDU Analysis
Dynamic Web Interface + Cloud + RiverWare

Flexible RiverWare Modeling

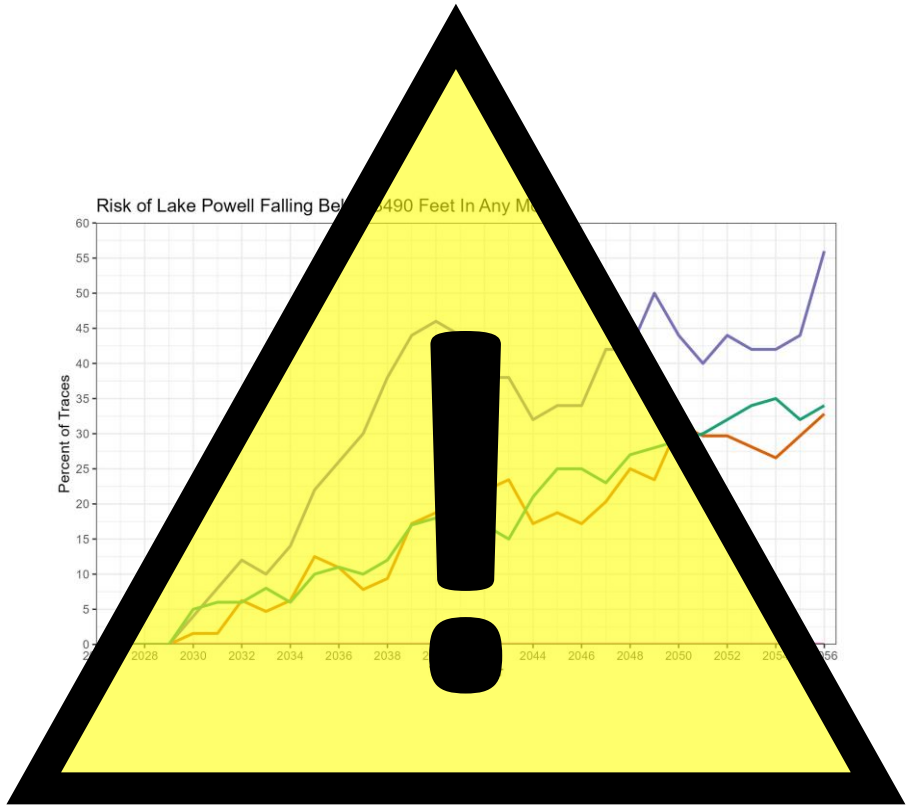
- Modified our long-term planning model to support operational paradigms that would allow users to explore various strategies for Lake Powell and Lake Mead operations
- Flexibility is focused on Lake Powell releases and Lower Basin deliveries*
  - 7 Lake Powell Release Concepts
  - 8 Lower Basin Delivery Concepts
  - 56 customizable paradigms
- Each paradigm is comprised of dozens of levers which can take different values to produce different operations and performance
- Models developed to work with either simulation-optimization (Borg-RiverWare) routines or web interface inputs



*Web Tool modeling does not include operations at other reservoirs, voluntary conservation activities, distribution of shortages by user, or other implementation details

Decision Making under Deep Uncertainty (DMDU) Analysis

Under deep uncertainty, risk-based analysis is not reliable as the sole basis for decision making



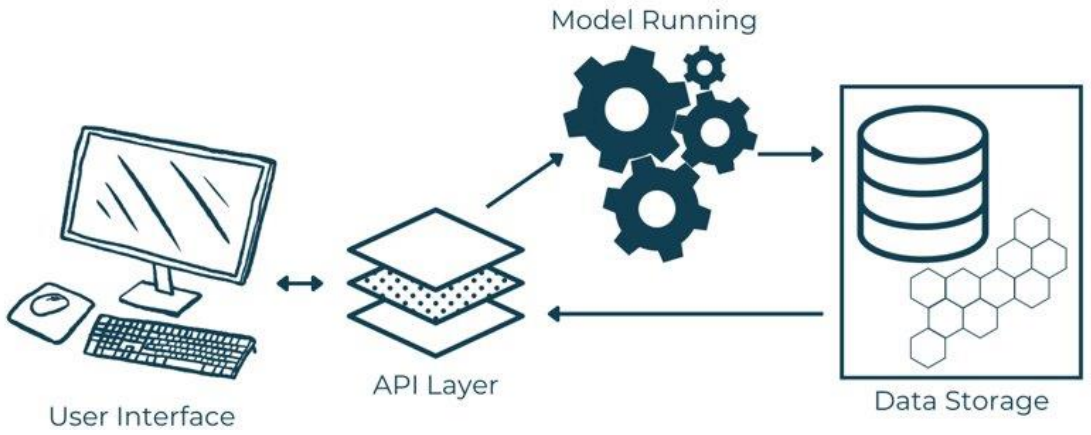
Core DMDU Analytical Steps

- Simulate operational strategies under a *wide range* of future conditions without assigning likelihood beforehand
- Investigate *tradeoffs* among operational strategies that balance performance metrics differently
- Prioritize *robustness*, or the ability of an operational strategy to perform acceptably well in a wide range of conditions
- Assess the *vulnerability* of the system under an operational strategy: what uncertain future conditions might cause the system to have unacceptable performance?

Dynamic Web Interface + Cloud + RiverWare

- Dynamic interface supports:
  - Designing custom strategies
  - >100 different performance metrics
  - Vast range of robustness and vulnerability definitions
- Run custom strategies in Reclamation's long-term planning model in the cloud
- Store and serve data from the cloud

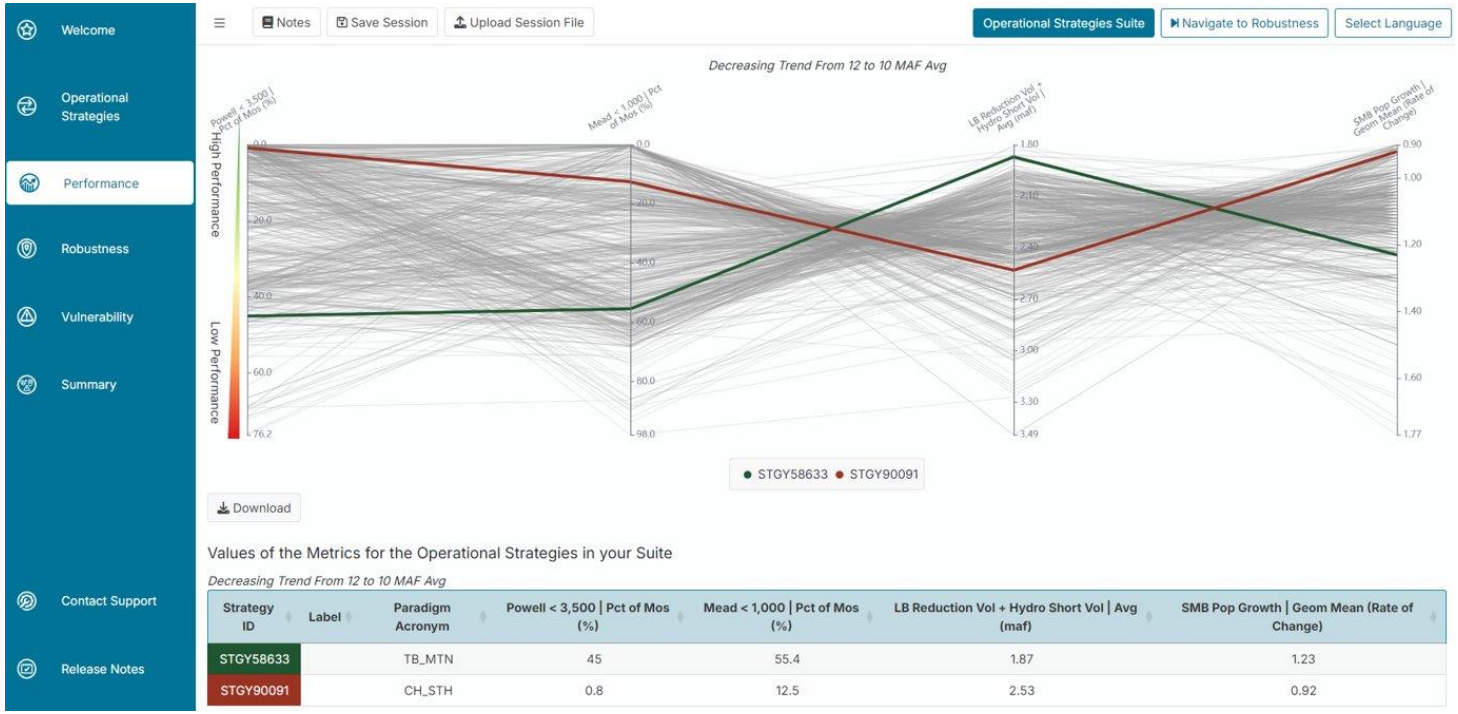
Anyone can register to use the Web Tool and access Reclamation's modeling & DMDU analysis in a browser

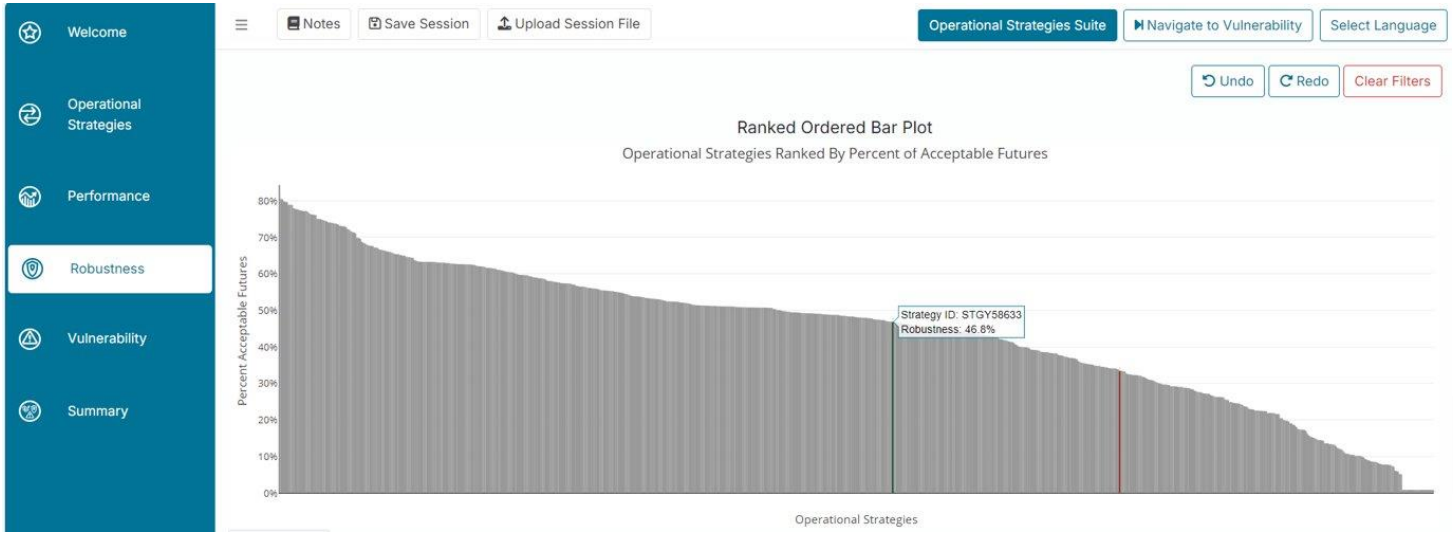


Demo

Borg-RiverWare and the Web Tool

- Used Borg-RW to automate the search for high quality strategies for the starting Web Tool population
  - Provide “cover” for anonymous custom runs
  - Provide context for tradeoffs and robustness
- Running 40 optimization problems at once on cloud
- Iterated through multiple sets of objectives and used different random seeds



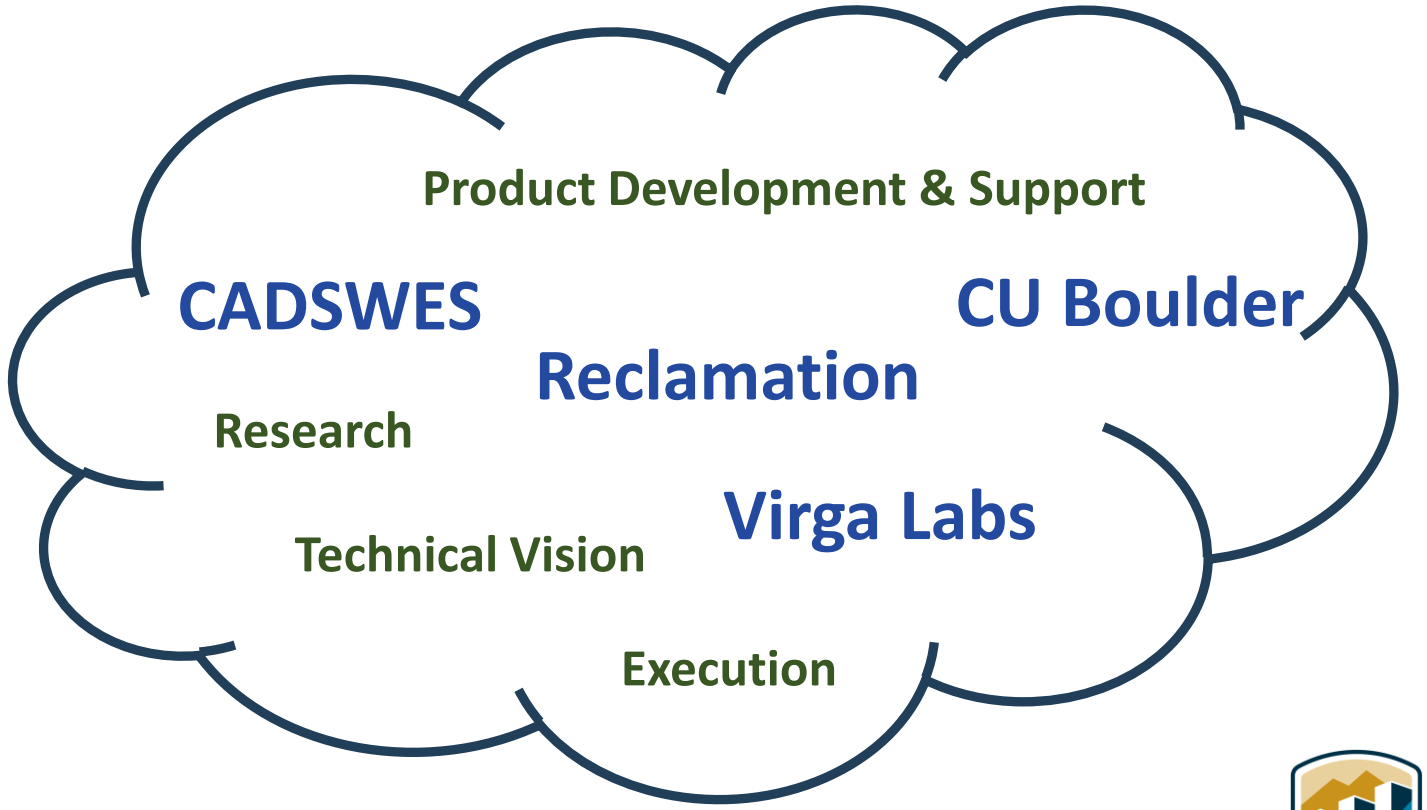


Stakeholder Engagement and Partnerships

Stakeholder Engagement

- 6 education sessions and 2 training sessions with wide range of stakeholders
- Small group working sessions
- NGOs, National Park Service, and US Fish and Wildlife Service explicitly used Web Tool to develop NEPA input

Partnerships




Thank You
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