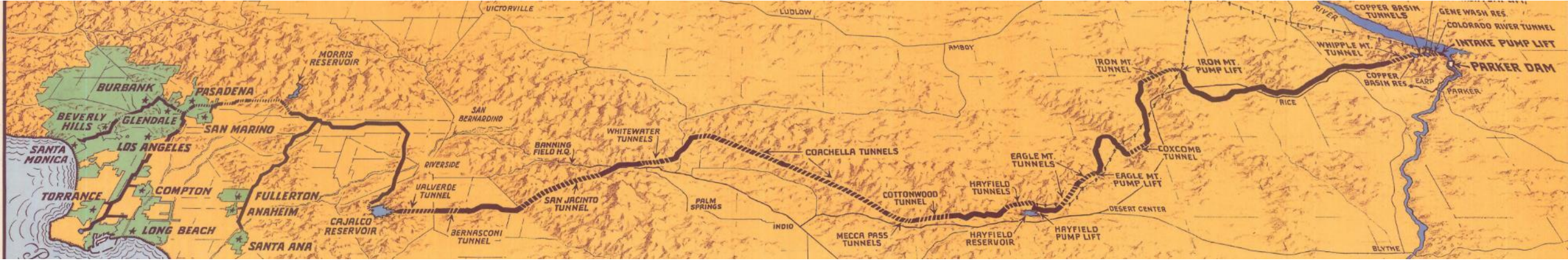


The Role of Modeling in Planning and Management of the Colorado River for California in a Changing World

David Rheinheimer and Angela Rashid

Colorado River Board of California

Colorado River Board of California

September 23, 2024

California Water and Environment Modeling Forum

Outline

- Background
- Modeling in the basin
- Example: post-2026 operations
  - Collaboration
- Modeling for in-state resource allocation for MWD

The Colorado River Basin

- Critical for California
  - Water for **19 million people**
  - **600,000 acres** of irrigated agriculture
  - **Power, habitat**, **recreation**, etc.
  - 4.4 MAF of 12+ MAF supply

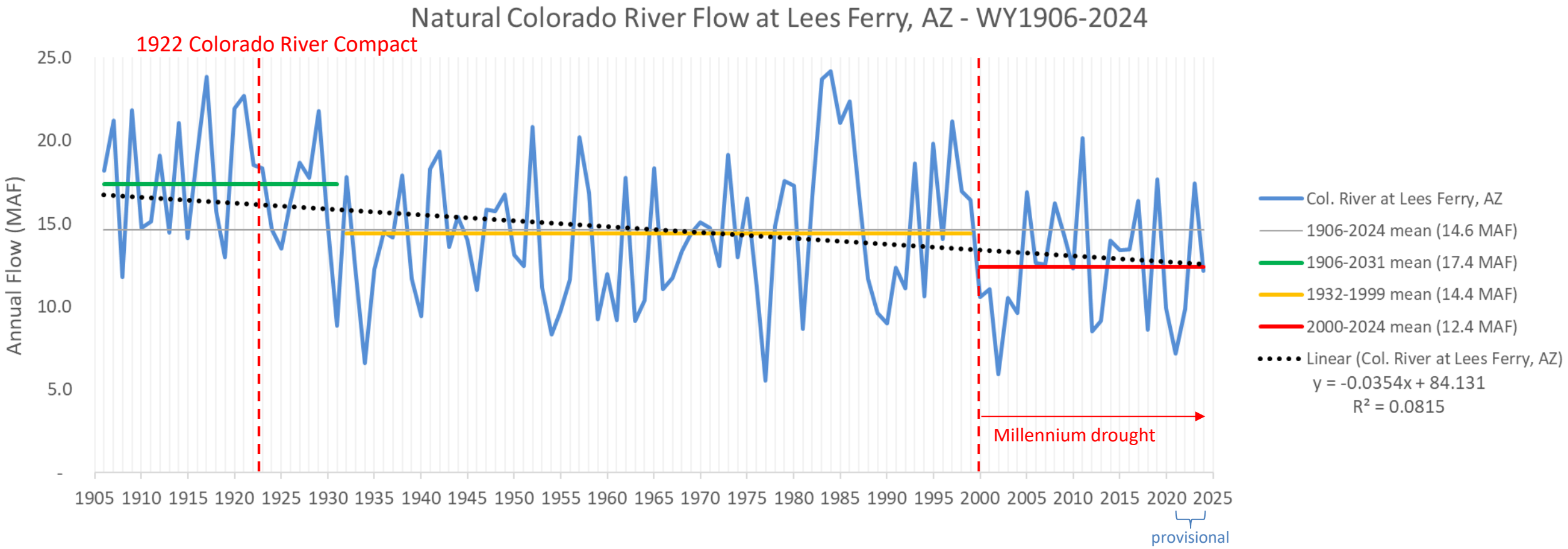
- Colorado River management involves many, **many players**

- **Planning and management** of the river **relies heavily on modeling** over different time horizons

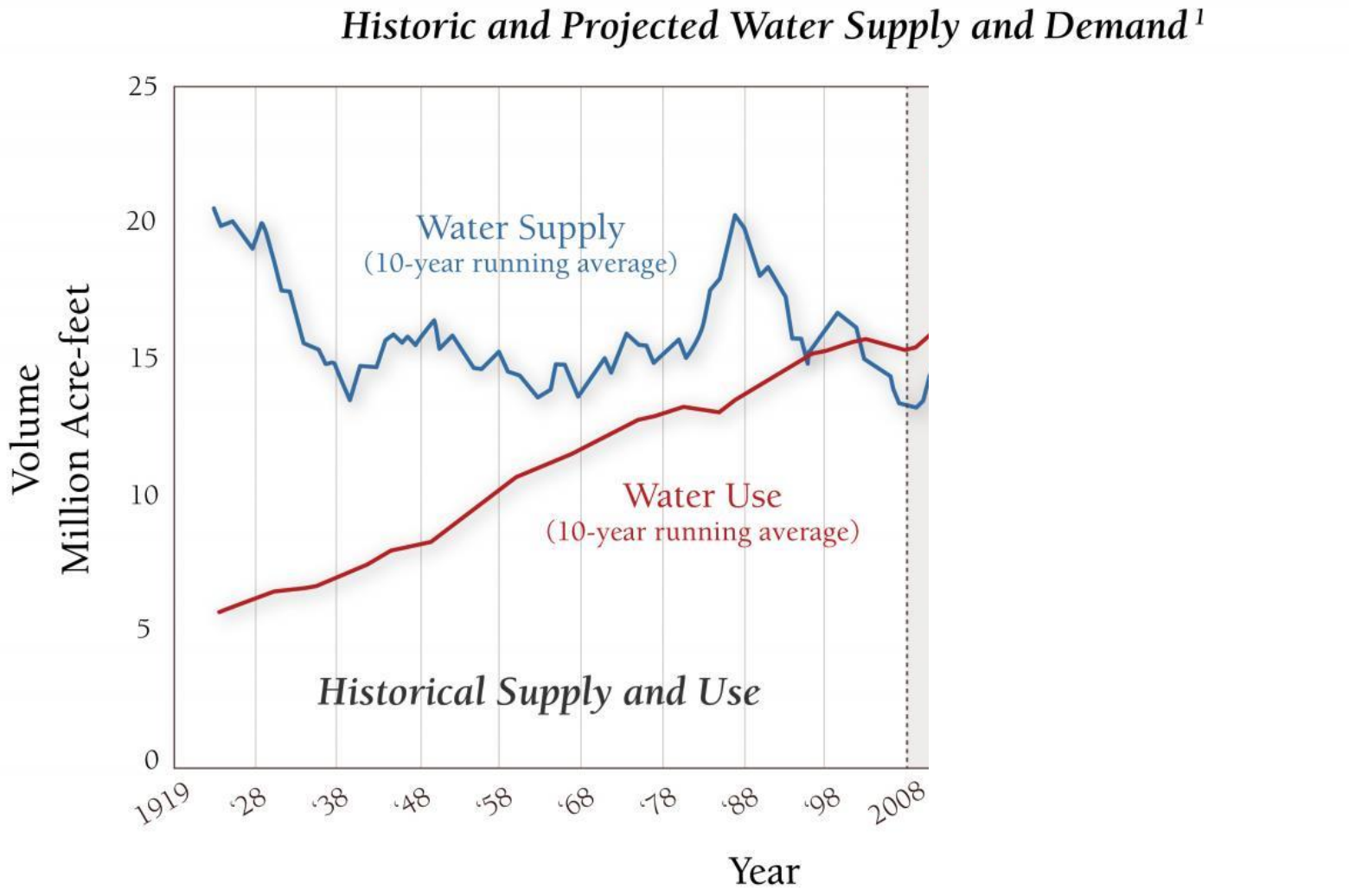
- **Water supply and demand are changing:**
  - What is the role of modeling in planning for change?
  - What is California's role in this modeling?

Center for Colorado River Studies, Utah State University

Changing hydrology – past

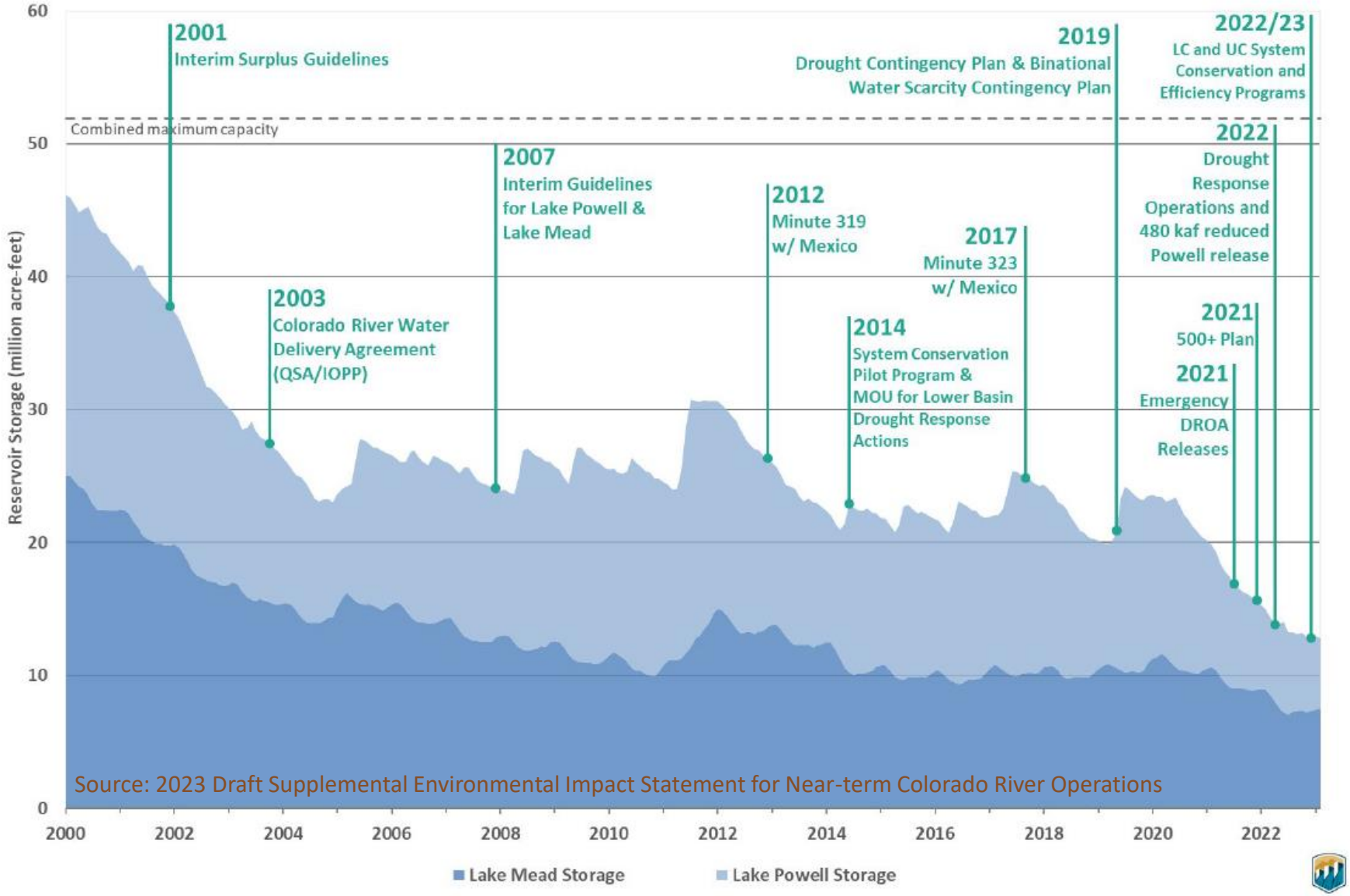


Water supply vs. demand



[1] U.S. Department of the Interior. Bureau of Reclamation. "Reclamation Managing Water in the West: Colorado River Basin Water Supply and Demand Study." (Executive Summary). Dec 2012

Major agreements since 2000



Source: 2023 Draft Supplemental Environmental Impact Statement for Near-term Colorado River Operations

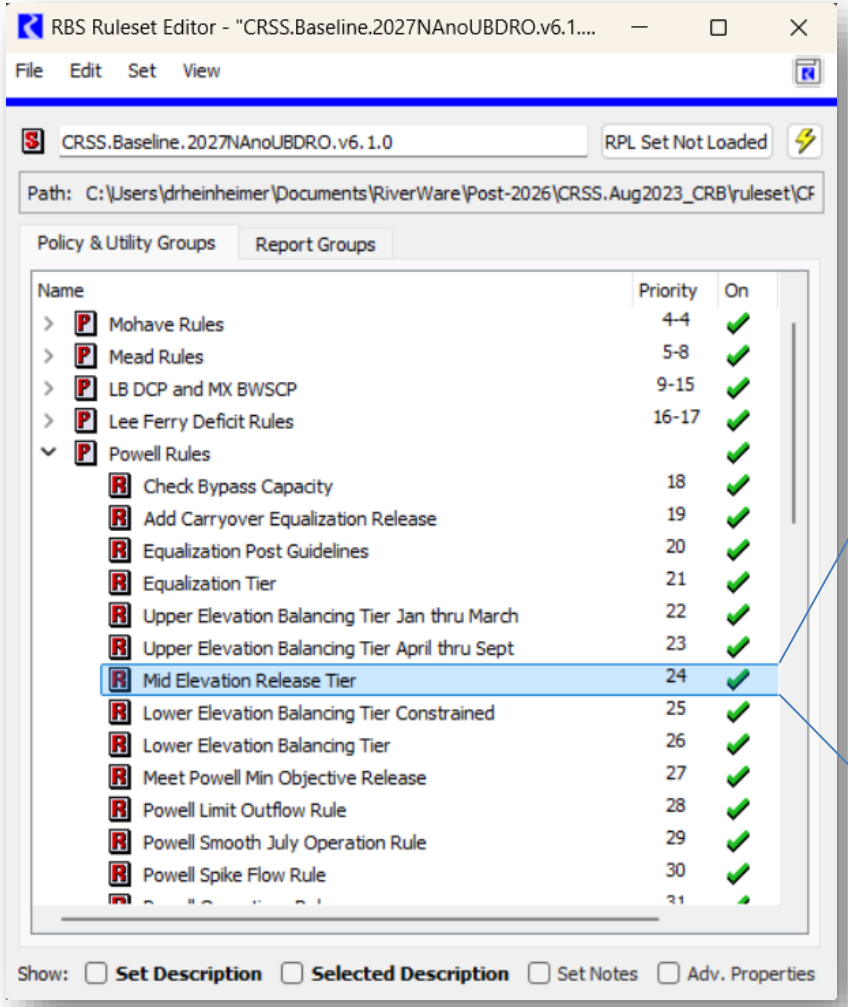
And now:

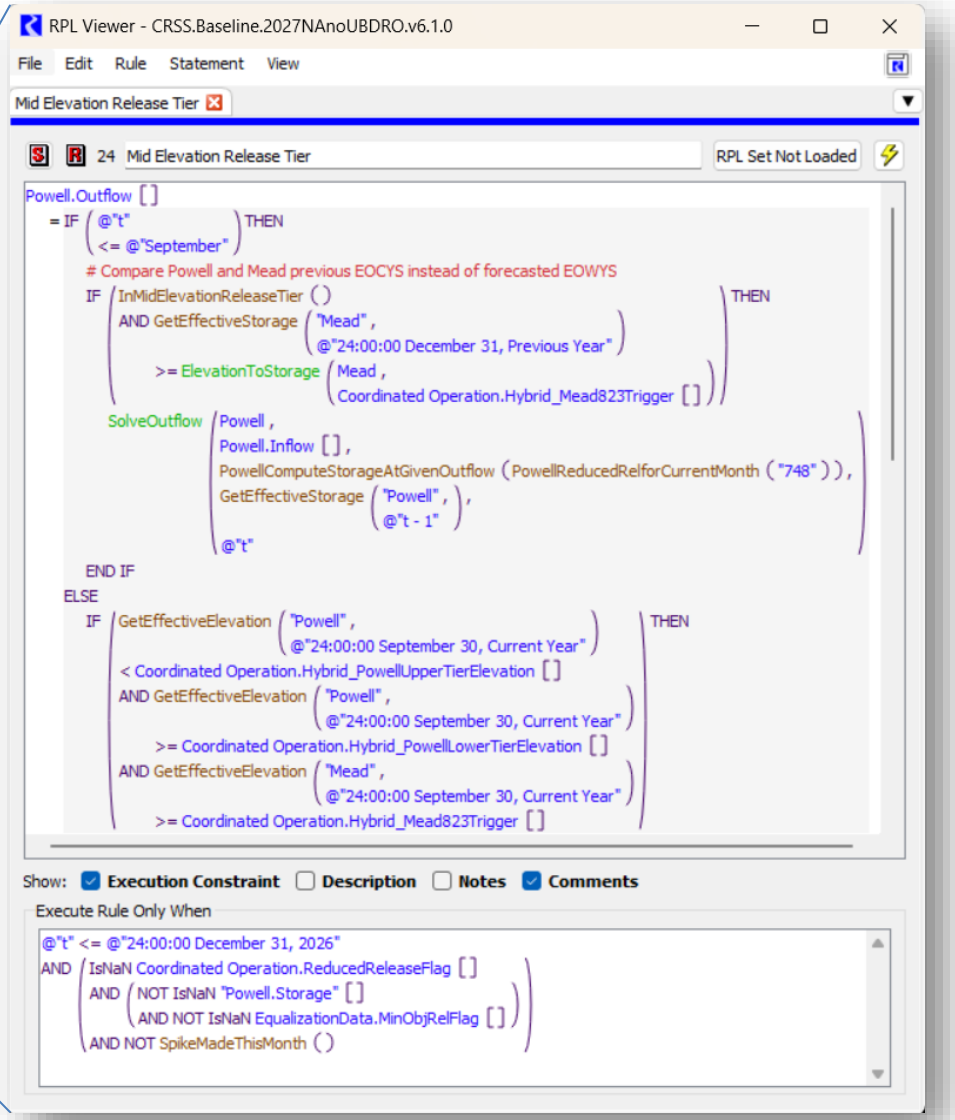
- Supplemental Environmental Impact Statement for 2024-2026 (3 MAF of further reductions in use)
- Ongoing development of post-2026 operations of Lakes Powell & Mead

Modeling in the basin

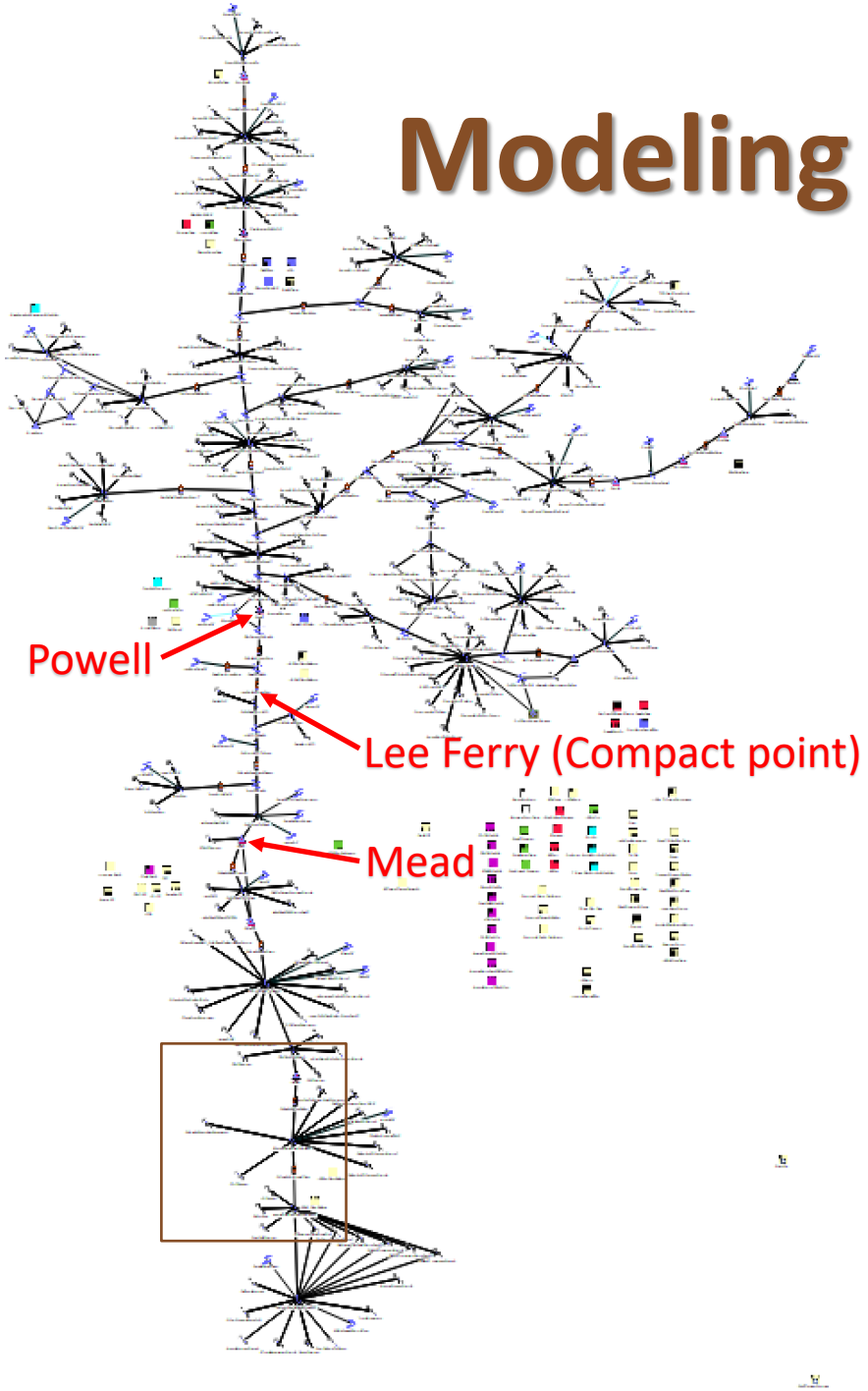
- Reclamation has two major models:
  - **Mid-term: operational, 1-2 years – CRMMS (24-Month Study)**
  - **Long-term: strategic, decades – CRSS**
- Both models built in RiverWare, which is:
  - Developed by CADSWES at Univ. of Colorado, Boulder
  - Rule-based
- Both models are **monthly time step**
- Stakeholders use Reclamation's models

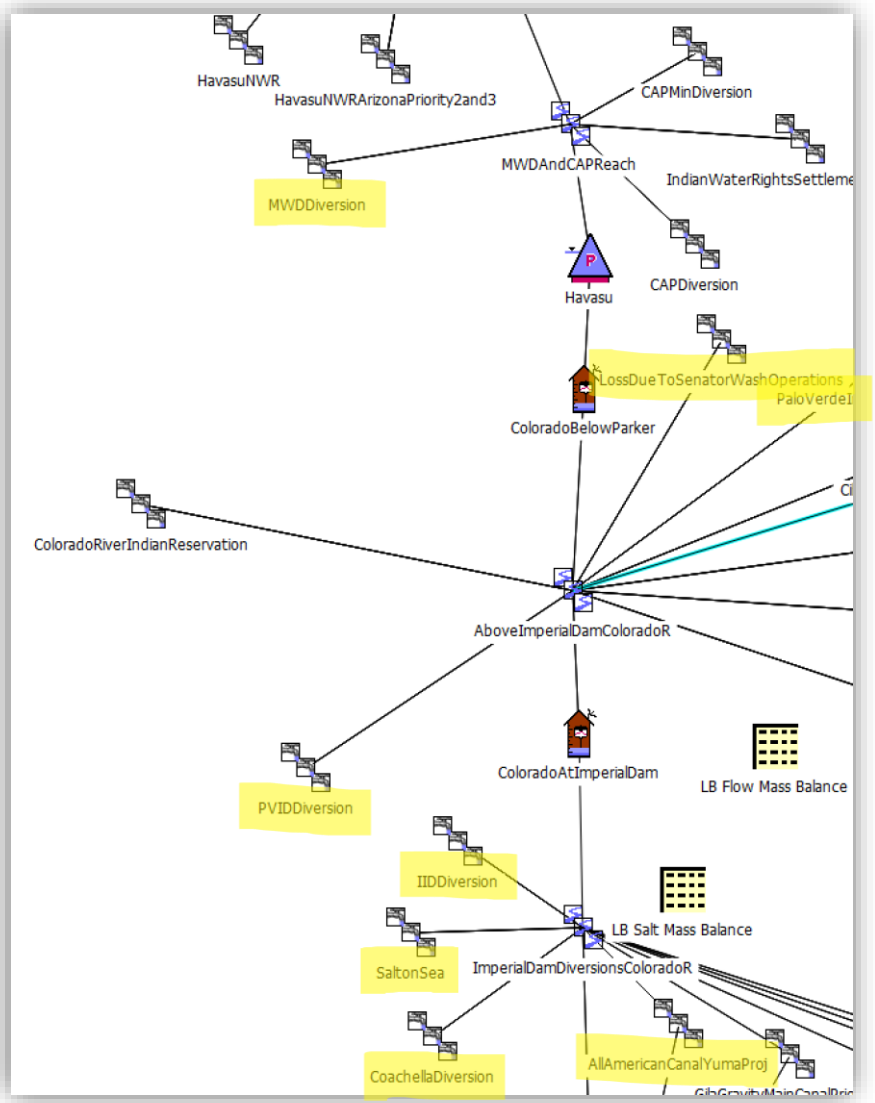
Modeling with RiverWare





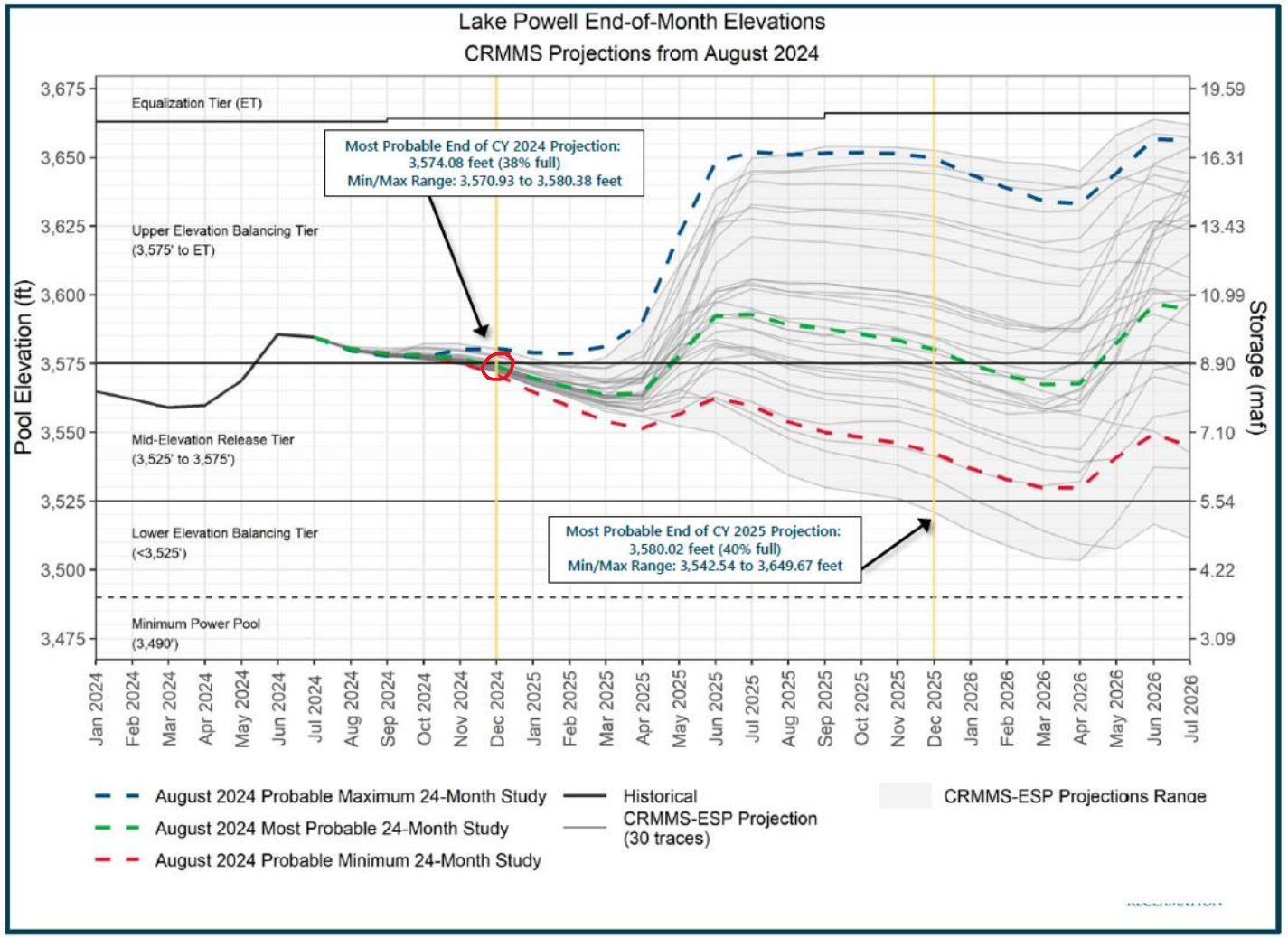
Modeling with RiverWare





24-Month Study – Lake Powell

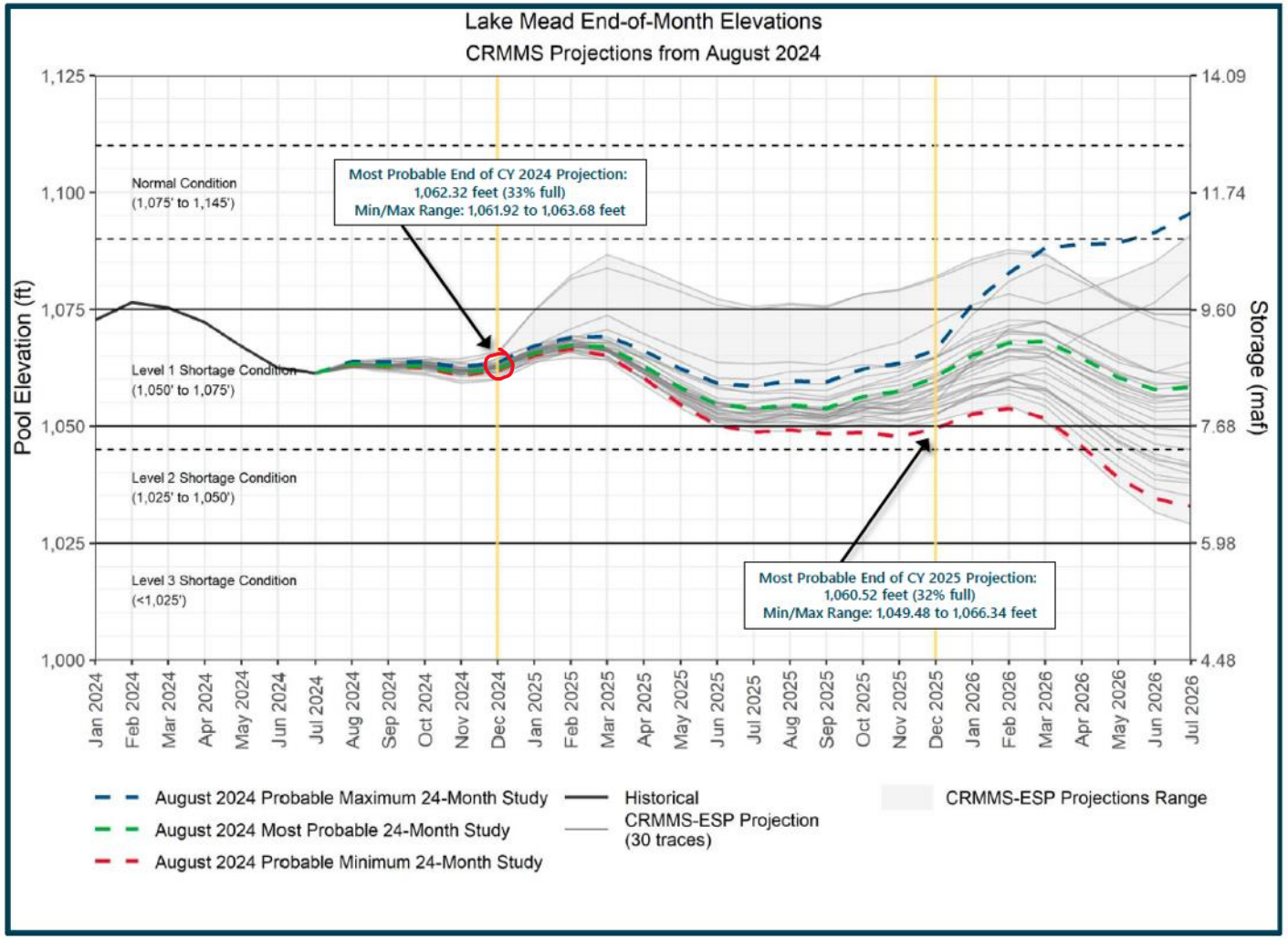
WY-2024:
Mid-Elevation Release Tier
(3,525’ to 3,575’)



20

24-Month Study – Lake Mead

WY-2024:
Level 1 Shortage Condition
(1,050’ to 1,075’)



26

2007 Interim Guidelines, Minute 323, Lower Basin Drought Contingency Plan, and Binational Water Scarcity Contingency Plan

Total Volumes (kaf)

Lake Mead Elevation (feet msl)	2007 Interim Guidelines Shortages		Minute 323 Delivery Reductions	Total Combined Reductions	DCP Water Savings Contributions			Binational Water Scarcity Contingency Plan Savings	Combined Volumes by Country *US: (2007 Interim Guidelines Shortages + DCP Contributions)* *Mexico: (Minute 323 Delivery Reductions + Binational Water Scarcity Contingency Plan Savings)*					Total Combined Volumes
	AZ	NV	Mexico	***Lower Basin States + Mexico***	AZ	NV	CA	Mexico	*AZ Total*	*NV Total*	*CA Total*	*Lower Basin States Total*	*Mexico Total*	***Lower Basin States + Mexico***
1,090 - 1,075	0	0	0	***0***	192	8	0	41	192	8	0	*200*	*41*	***241***
1,075 - 1050	320	13	50	***383***	192	8	0	30	512	21	0	*533*	*80*	***613***
1,050 - 1,045	400	17	70	***487***	192	8	0	34	592	25	0	*617*	*104*	***721***
1,045 - 1,040	400	17	70	***487***	240	10	200	76	640	27	200	*867*	*146*	***1,013***
1,040 - 1,035	400	17	70	***487***	240	10	250	84	640	27	250	*917*	*154*	***1,071***
1,035 - 1,030	400	17	70	***487***	240	10	300	92	640	27	300	*967*	*162*	***1,129***
1,030 - 1,025	400	17	70	***487***	240	10	350	101	640	27	350	*1,017*	*171*	***1,188***
<1,025	480	20	125	***625***	240	10	350	150	720	30	350	*1,100*	*275*	***1,375***

2024 & 2025 Reductions + Contributions →

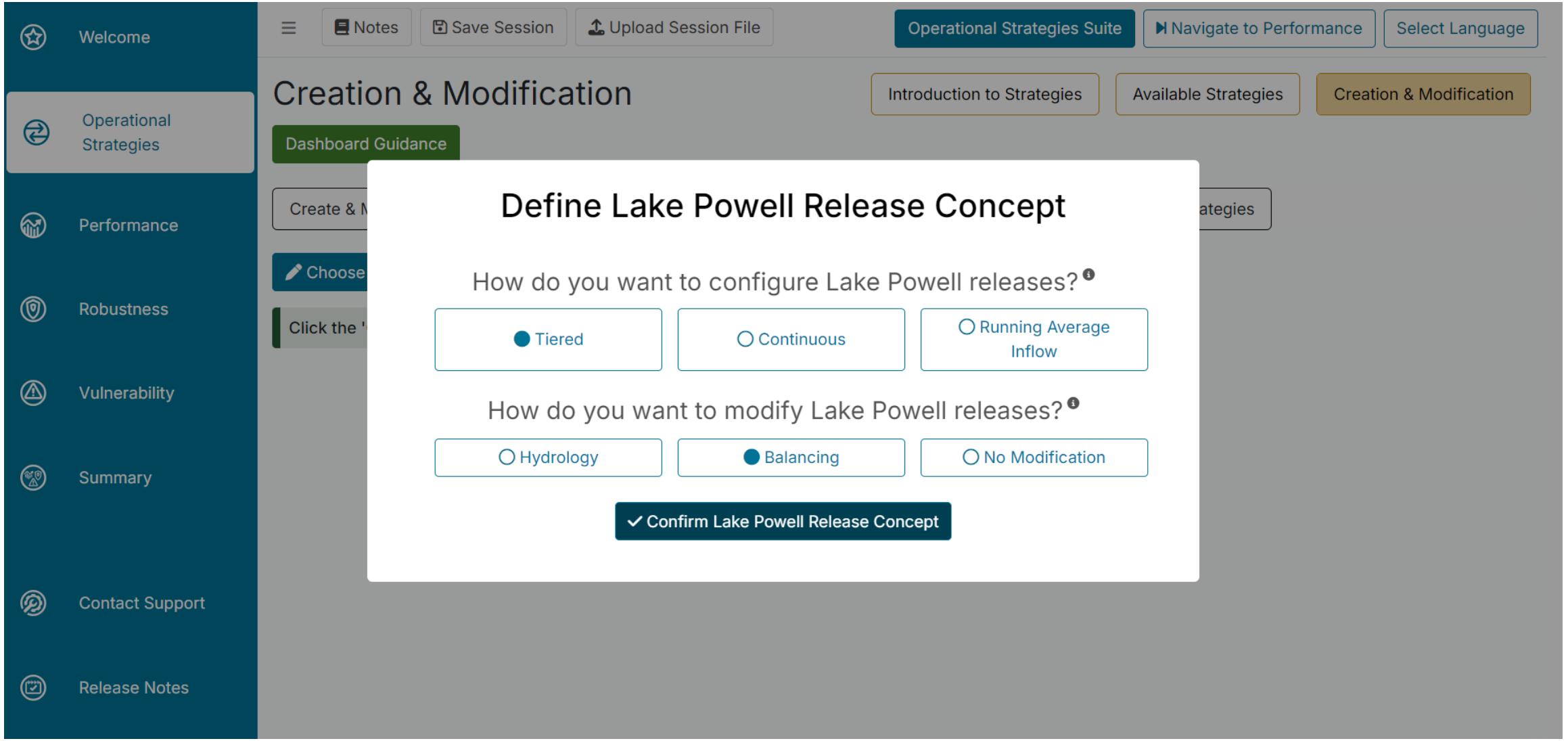
← 2024 & 2025 Reductions + Contributions

The Secretary of the Interior will take affirmative actions to implement programs designed to create or conserve 100,000 acre-ft per annum or more of Colorado River System water to contribute to conservation of water supplies in Lake Mead and other Colorado River reservoirs in the lower basin. All actions taken by the United States shall be subject to applicable law, including availability of appropriations.

Modeling for post-2026

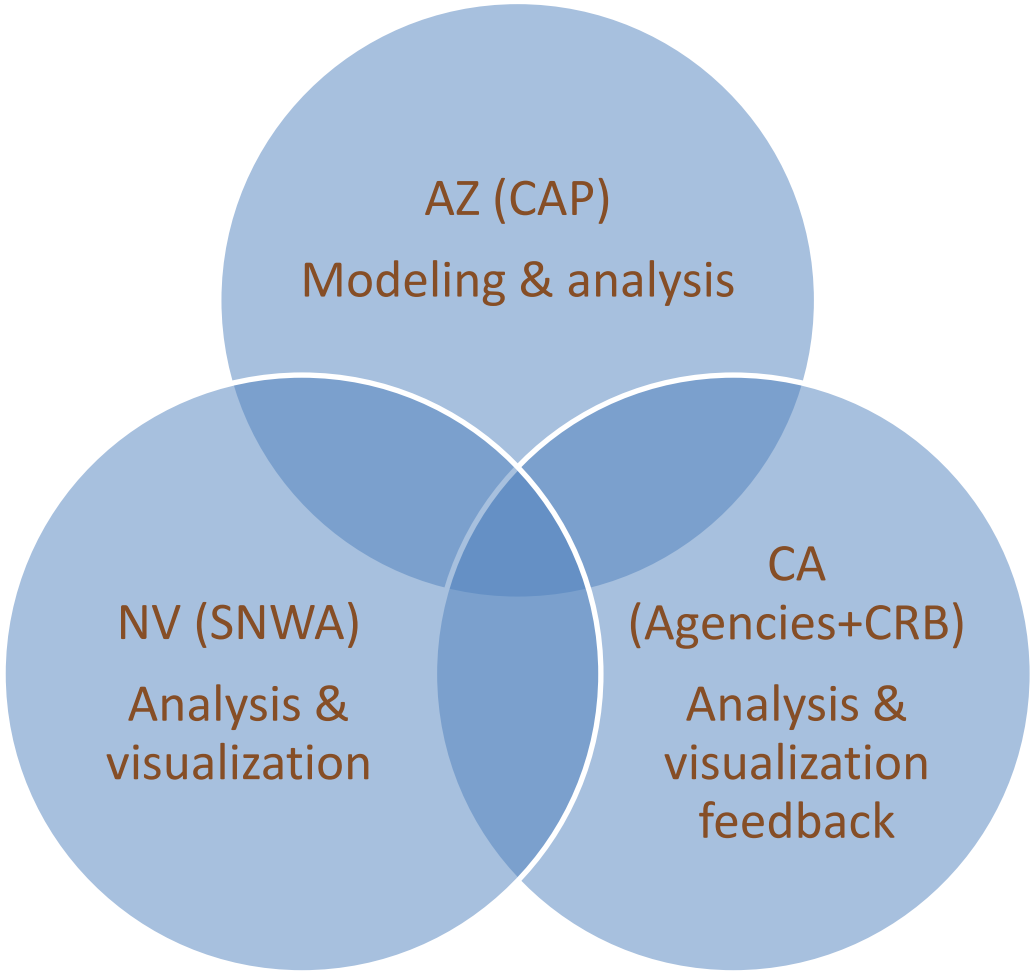
- 2007 Interim Guidelines are set to expire at end of 2026
- Basin stakeholders are currently developing post-2026 policy
- **Modeling plays a key role**
  - Reclamation: DMDU-style analysis using CRSS w/ (optional) public web tool + help
- States are negotiating to develop a consensus-based, model-informed operational policy

Post-2026 “web tool”



Lower Basin collaboration in post-2026 modeling

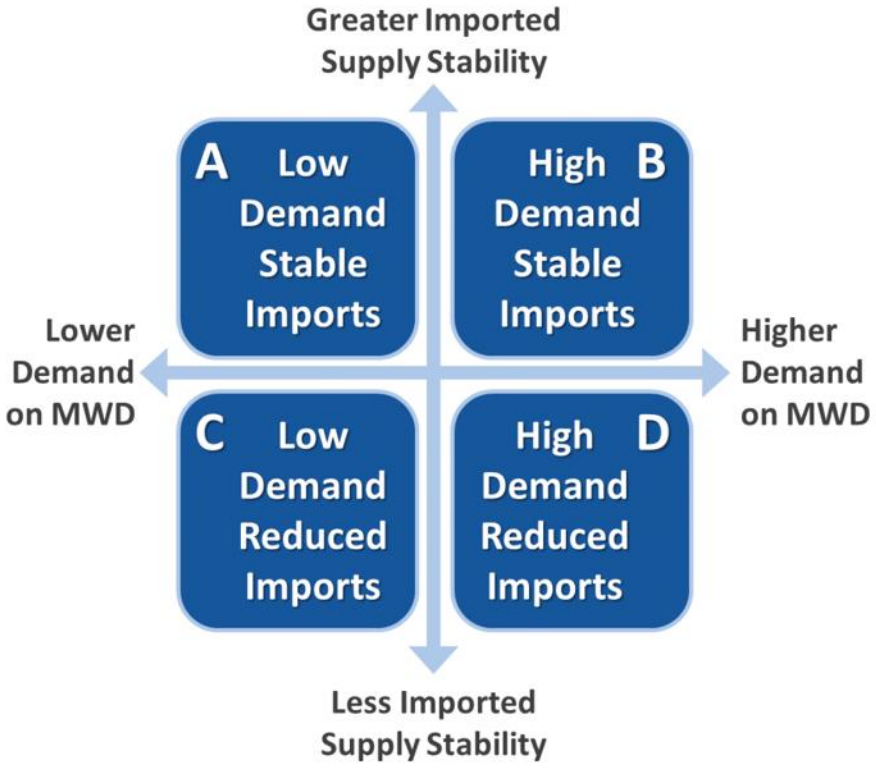
- Regular technical policy discussions
- …supported by modeling by Arizona & analysis by all
- …visualized in a Power BI app developed by Nevada
- States are co-equals in discussions & technical work



Modeling for Urban Water

MWD – long term
Integrated Water Resources Plan (IRP)

Figure ES-1: 2020 IRP Scenario Framework



The Integrated Water Resources Plan (IRP)

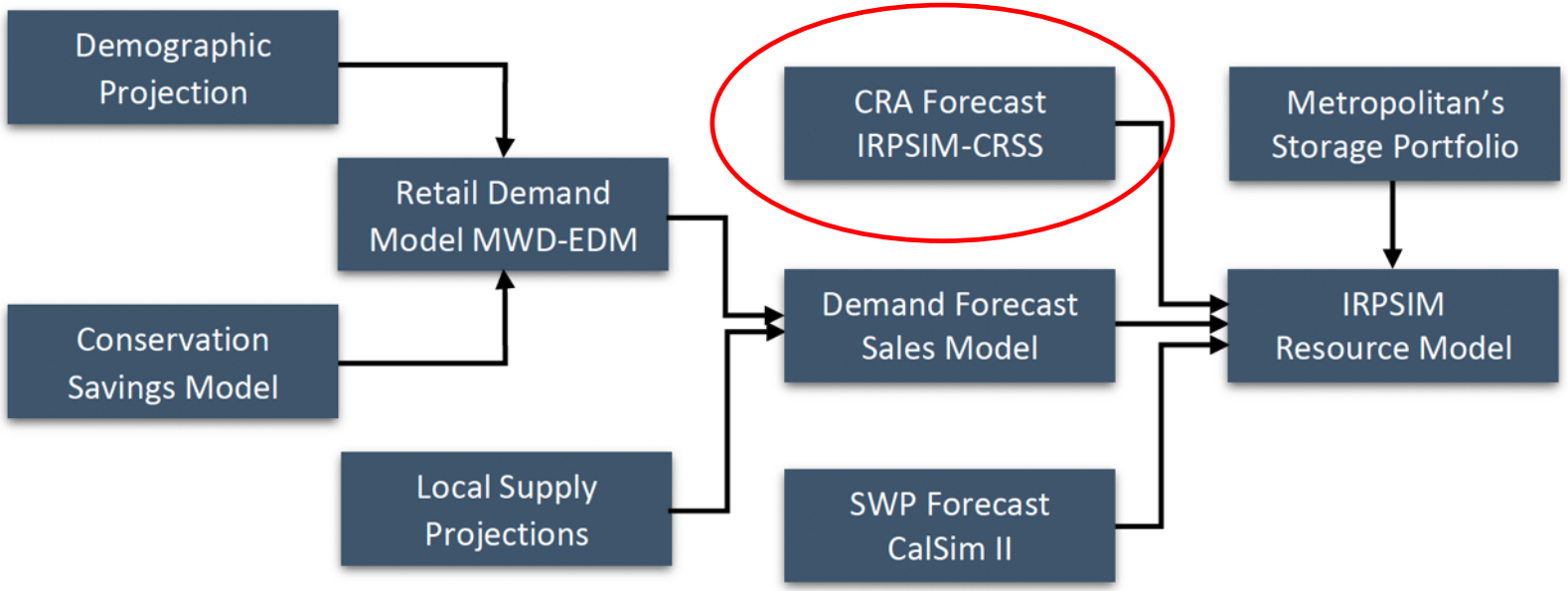
- Long-term planning needs
- Investment prioritization
- For reliability & affordability

IRPSIM

- For IRP development
- Strategic planning considering broader water supply portfolio
- Uses assumptions about Colorado River operations from CRSS

MWD – long term
Integrated Water Resources Plan (IRP)

Figure 3-2: *Metropolitan's modeling framework for quantifying uncertainties.*



Key points

- Change is accounted for through irregular, negotiated policy changes
  …supported by model-based analyses (CRSS)
  …which California contributes to & benefits from

- California provides feedback for model improvements

- Democratization and collaboration drive modeling efforts for post-2026 planning

- MWD includes Colorado River as an imported supply for its IRP

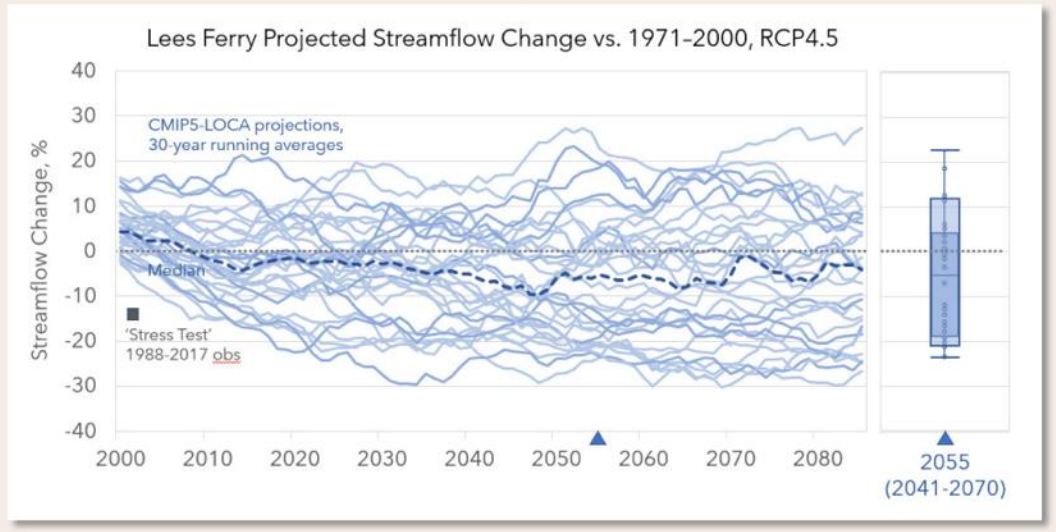
Thank you!

drheinheimer@crb.ca.gov


Colorado River Basin
WY
FONTENELLE RESERVOIR
FLAMING GORGE RESERVOIR
UT
NV
CO
BLUE MESA, MORROW POINT, CRYSTAL RESERVOIRS
UPPER BASIN
LAKE POWELL
NAVAJO RESERVOIR
California Aqueduct
CA
Los Angeles Aqueduct
LAKE MEAD
LEE FERRY
LOWER BASIN
LAKE MOHAVE
LAKE HAVASU
Colorado River Aqueduct
NM
AZ
MWD
LADWP
CVWD
PVID
Yuma Project
SDCWA
IID
All-American Canal
COLORADO RIVER DELTA
GULF OF CALIFORNIA
MEXICO


Sky Valley
Joshua Tree National Park
Eagle Mountain
Midland
Inca
COLORADO RIVER RESERVATION
Palm Springs
Cathedral City
Palm Desert
Indio
La Quinta
Desert Center
Chiriaco Summit
Blythe
Ripley
Palo Verde
North Shore
Desert Shores
Salton Sea
Salton City
Cibola
Paymaster Landing
Borrego Springs
Mundo
Niland
Ocotillo Wells SVRA
Estelle
Calipatria
Anza-Borrego Desert State Park
Julian
Westmorland
Brawley
Martinez Lake
Imperial
Seeley
Bard
Ocotillo
Live Oak Springs
Calexico
Yuma
Fortuna Foothills
Jacumba Hot Springs
Campo
Mexicali
Ciudad Morelos
Somerton
Puebla
Google

Changing hydrology – future



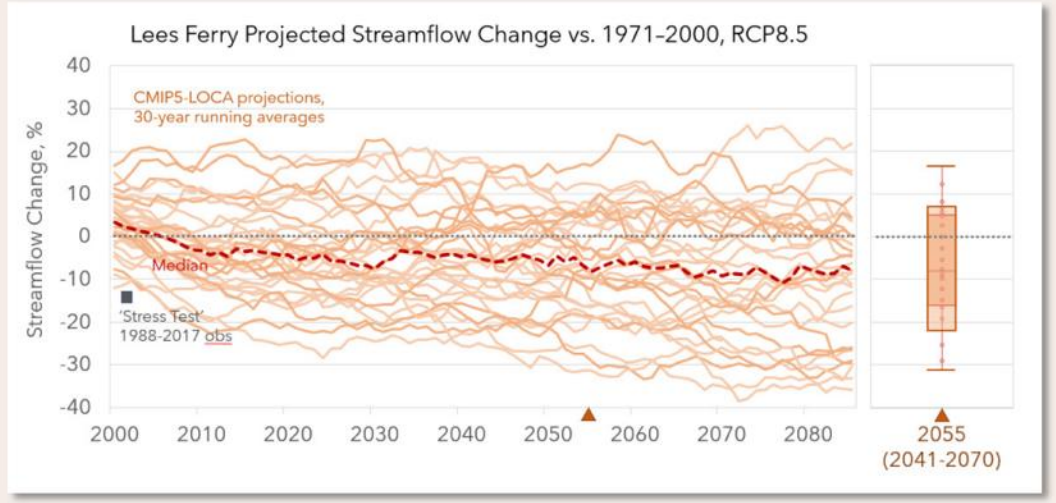


Figure 11.12

Figure 11.12

Projected future streamflow change at Lees Ferry compared to the 1971–2000 baseline, from two ensembles of 32 CMIP5 projections under two emissions scenarios (top: RCP4.5; bottom: RCP8.5) downscaled with LOCA and run through the VIC model to simulate hydrology. The lighter traces on both time-series plots are the 30-year running averages, plotted on the middle (15th) year, of the projected annual streamflows, with the median trace shown as the dark dashed line. The 30-year average of the 1988–2017 'Stress Test" observed natural streamflow is shown as a black square. The box-whiskers plots show the distribution of the 30-year average values at 2055 (2041–2070); the outer boxes show the 10th and 90th percentiles; the inner boxes show the 25th, 50th, and 75th percentiles, and the max/min are shown at the ends of the whiskers. (Data: N. Mizukami, NCAR)

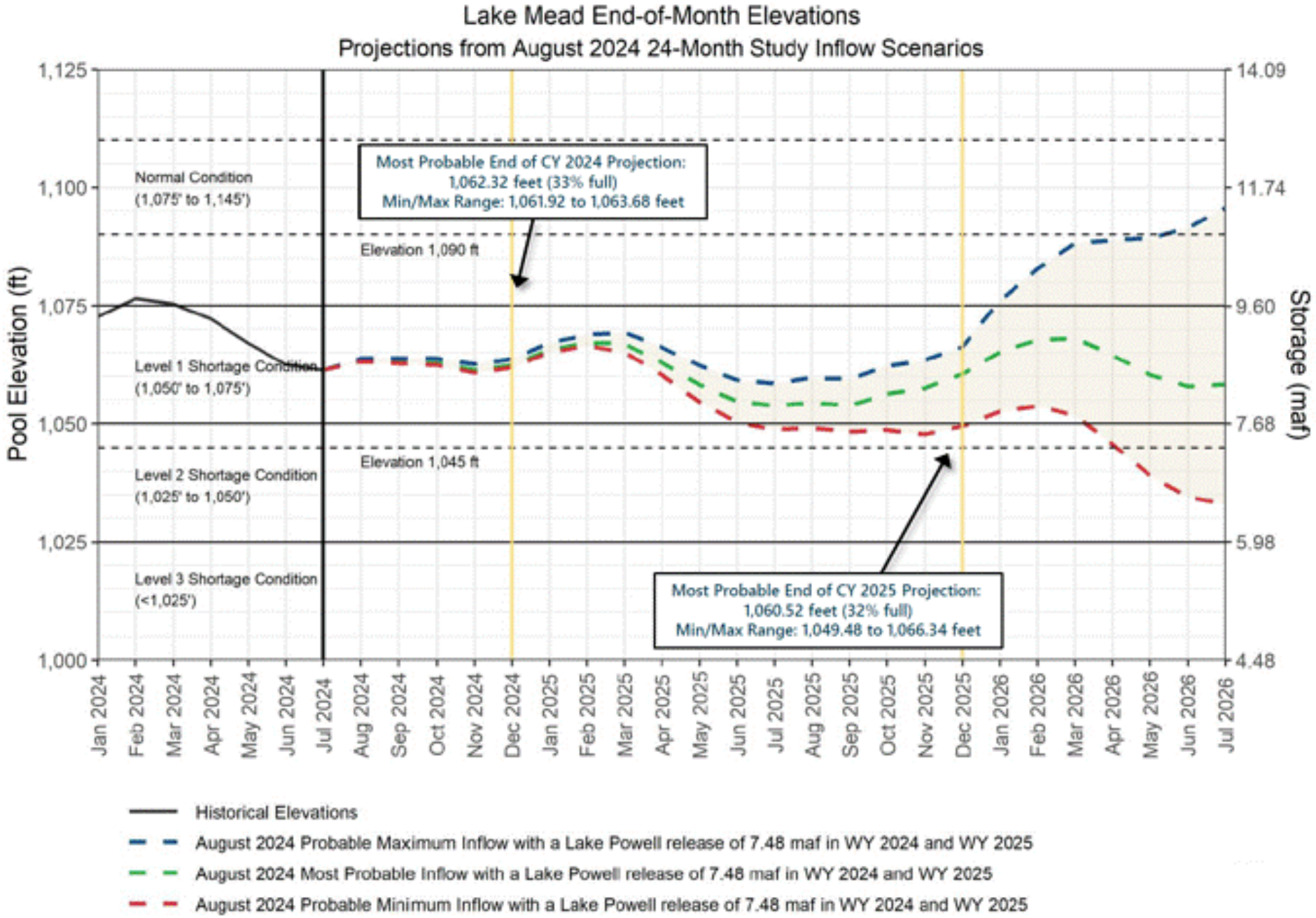
Western Water Assessment (2020): Colorado River Basin Climate and Hydrology: State of the Science

Mid-term modeling w/ CRMMS

- Reclamation operates system reservoirs according to its **Annual Operating Plan (AOP)**
- The AOP is supported with Reclamation's **CRMMS**, for the **24-Month Study**
- California's water agencies plan their water use around the AOP
  - How much water will be released from Lake Powell to Lake Mead?
  - How much water will be available for use from Lake Mead?
- In addition, we work with basin partners around knowledge of their AOP-driven shortages

Long-term modeling w/ CRSS

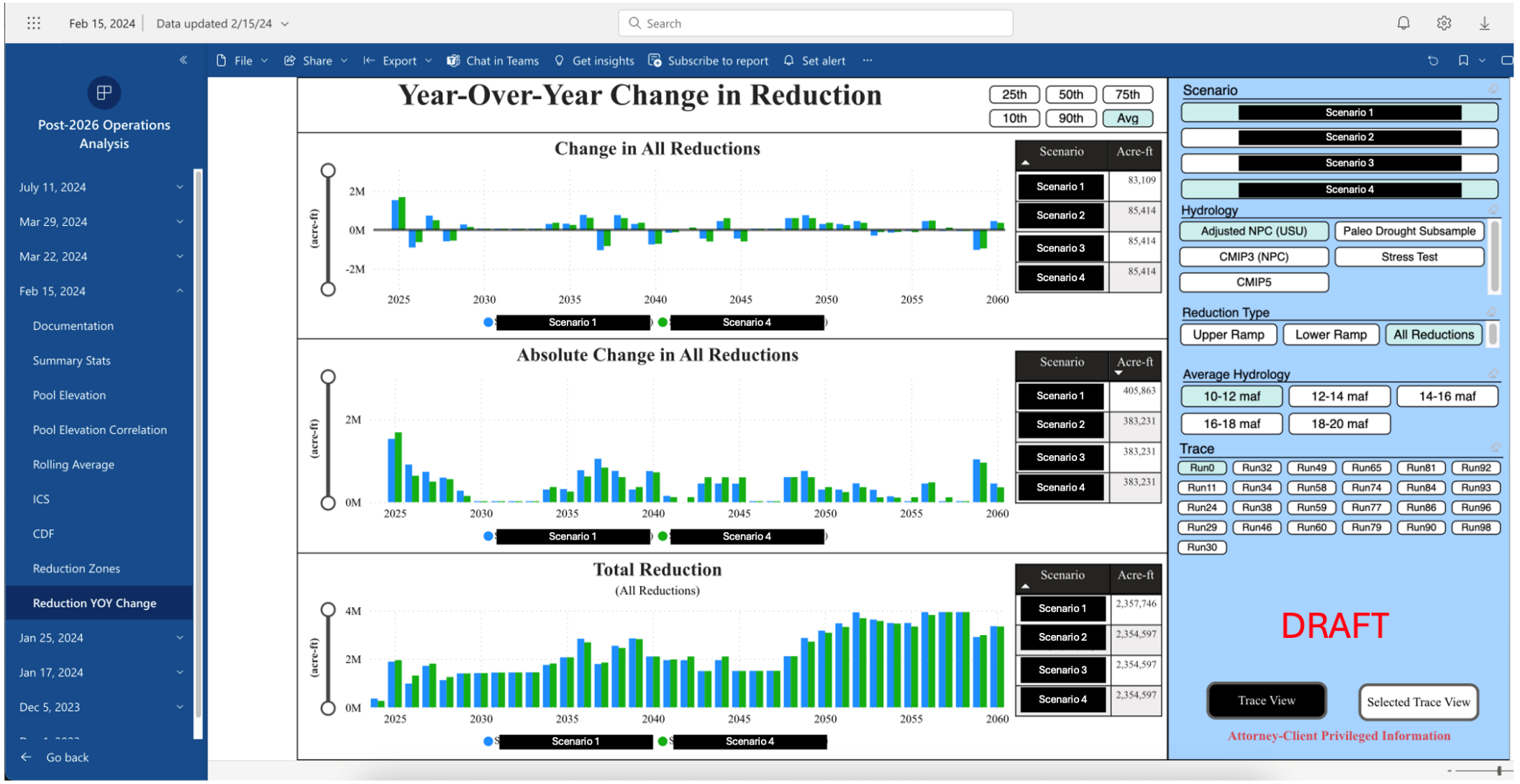
- **CRSS** developed by Reclamation for long-term strategic planning
  - Monthly model through 2060
  - Includes **water** (delivery, storage, flood control objectives) **and salinity**
- CRSS regularly reviewed & improved
- Stakeholders can & do use CRSS for their own studies
  - Some modeling capacity in California
  - Significant modeling capacity basin-wide
- CRSS main modeling tool for developing post-2026 operations of Lakes Powell and Mead


Lake Mead End-of-Month Elevations
Projections from August 2024 24-Month Study Inflow Scenarios
Pool Elevation (ft)
Storage (maf)
1,125
1,100
1,075
1,050
1,025
1,000
14.09
11.74
9.60
7.68
5.98
4.48
Normal Condition
(1,075' to 1,145')
Level 1 Shortage Condition
(1,050' to 1,075')
Level 2 Shortage Condition
(1,025' to 1,050')
Level 3 Shortage Condition
(<1,025')
Elevation 1,090 ft
Elevation 1,045 ft
Most Probable End of CY 2024 Projection:
1,062.32 feet (33% full)
Min/Max Range: 1,061.92 to 1,063.68 feet
Most Probable End of CY 2025 Projection:
1,060.52 feet (32% full)
Min/Max Range: 1,049.48 to 1,066.34 feet
Jan 2024
Feb 2024
Mar 2024
Apr 2024
May 2024
Jun 2024
Jul 2024
Aug 2024
Sep 2024
Oct 2024
Nov 2024
Dec 2024
Jan 2025
Feb 2025
Mar 2025
Apr 2025
May 2025
Jun 2025
Jul 2025
Aug 2025
Sep 2025
Oct 2025
Nov 2025
Dec 2025
Jan 2026
Feb 2026
Mar 2026
Apr 2026
May 2026
Jun 2026
Jul 2026
Historical Elevations
August 2024 Probable Maximum Inflow with a Lake Powell release of 7.48 maf in WY 2024 and WY 2025
August 2024 Most Probable Inflow with a Lake Powell release of 7.48 maf in WY 2024 and WY 2025
August 2024 Probable Minimum Inflow with a Lake Powell release of 7.48 maf in WY 2024 and WY 2025

Power BI app


Feb 15, 2024
Data updated 2/15/24
Search
File
Share
Export
Chat in Teams
Get insights
Subscribe to report
Set alert
Post-2026 Operations Analysis
July 11, 2024
Mar 29, 2024
Mar 22, 2024
Feb 15, 2024
Documentation
Summary Stats
Pool Elevation
Pool Elevation Correlati...
Rolling Average
ICS
CDF
Reduction Zones
Reduction YOY Change
Jan 25, 2024
Jan 17, 2024
Dec 5, 2023
Go back
EOCY Pool Elevation (ft)
Powell Equalization
MEAD BELOW CRITICAL ELEVATION
POWELL & MEAD BELOW CRITICAL ELEVATION
POWELL BELOW CRITICAL ELEVATION
Lake Powell
Lake Mead
3,700
3,650
3,600
3,550
3,500
3,450
3,400
3,350
850
900
950
1,000
1,050
1,100
1,150
1,200
Scenario
Scenario 1
Scenario 4
Average Upper Basin Depletions
Parameter
Reductions (CY)
Powell Rel. (WY)
Nat. Flow (CY)
UB Depletions (CY)
(acre-ft)
5M
0M
2025
2030
2035
2040
2045
2050
2055
2060
Scenario
Scenario 1
Scenario 4
Scenario
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Hydrology
Adjusted NPC (USU)
CMIP3 (NPC)
CMIP5
Paleo Drought Subsample
Stress Test
DRAFT
Note: Select a point on the Powell vs. Mead chart to highlight the selected parameter value on the bottom panel.
Scenario
Average Reductions (MAF)
Scenario 1
1.31
Scenario 2
1.36
Scenario 3
1.36
Scenario 4
1.36

Power BI app


Feb 15, 2024 | Data updated 2/15/24
Search
File
Share
Export
Chat in Teams
Get insights
Subscribe to report
Set alert
Post-2026 Operations Analysis
July 11, 2024
Mar 29, 2024
Mar 22, 2024
Feb 15, 2024
Documentation
Summary Stats
Pool Elevation
Pool Elevation Correlation
Rolling Average
ICS
CDF
Reduction Zones
Reduction YOY Change
Jan 25, 2024
Jan 17, 2024
Dec 5, 2023
Go back
Year-Over-Year Change in Reduction
25th
50th
75th
10th
90th
Avg
Change in All Reductions
(acre-ft)
2M
0M
-2M
2025
2030
2035
2040
2045
2050
2055
2060
Scenario 1
Scenario 4
Scenario
Acre-ft
Scenario 1
83,109
Scenario 2
85,414
Scenario 3
85,414
Scenario 4
85,414
Absolute Change in All Reductions
(acre-ft)
2M
0M
2025
2030
2035
2040
2045
2050
2055
2060
Scenario 1
Scenario 4
Scenario
Acre-ft
Scenario 1
405,863
Scenario 2
383,231
Scenario 3
383,231
Scenario 4
383,231
Total Reduction
(All Reductions)
(acre-ft)
4M
2M
0M
2025
2030
2035
2040
2045
2050
2055
2060
Scenario 1
Scenario 4
Scenario
Acre-ft
Scenario 1
2,357,746
Scenario 2
2,354,597
Scenario 3
2,354,597
Scenario 4
2,354,597
Scenario
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Hydrology
Adjusted NPC (USU)
Paleo Drought Subsample
CMIP3 (NPC)
Stress Test
CMIP5
Reduction Type
Upper Ramp
Lower Ramp
All Reductions
Average Hydrology
10-12 maf
12-14 maf
14-16 maf
16-18 maf
18-20 maf
Trace
Run0
Run32
Run49
Run65
Run81
Run92
Run11
Run34
Run58
Run74
Run84
Run93
Run24
Run38
Run59
Run77
Run86
Run96
Run29
Run46
Run60
Run79
Run90
Run98
Run30
DRAFT
Trace View
Selected Trace View
Attorney-Client Privileged Information

MWD – near term

- **Spreadsheet model** w/ ag adjustment (sub-annual planning)
  - Ag: higher priority users
  - Extra water if CVWD, IID underrun
- **Short-term distribution model**
  - No real restriction on CR imports
  - Disconnected from CR modeling