BUREAU OF RECLAMATION

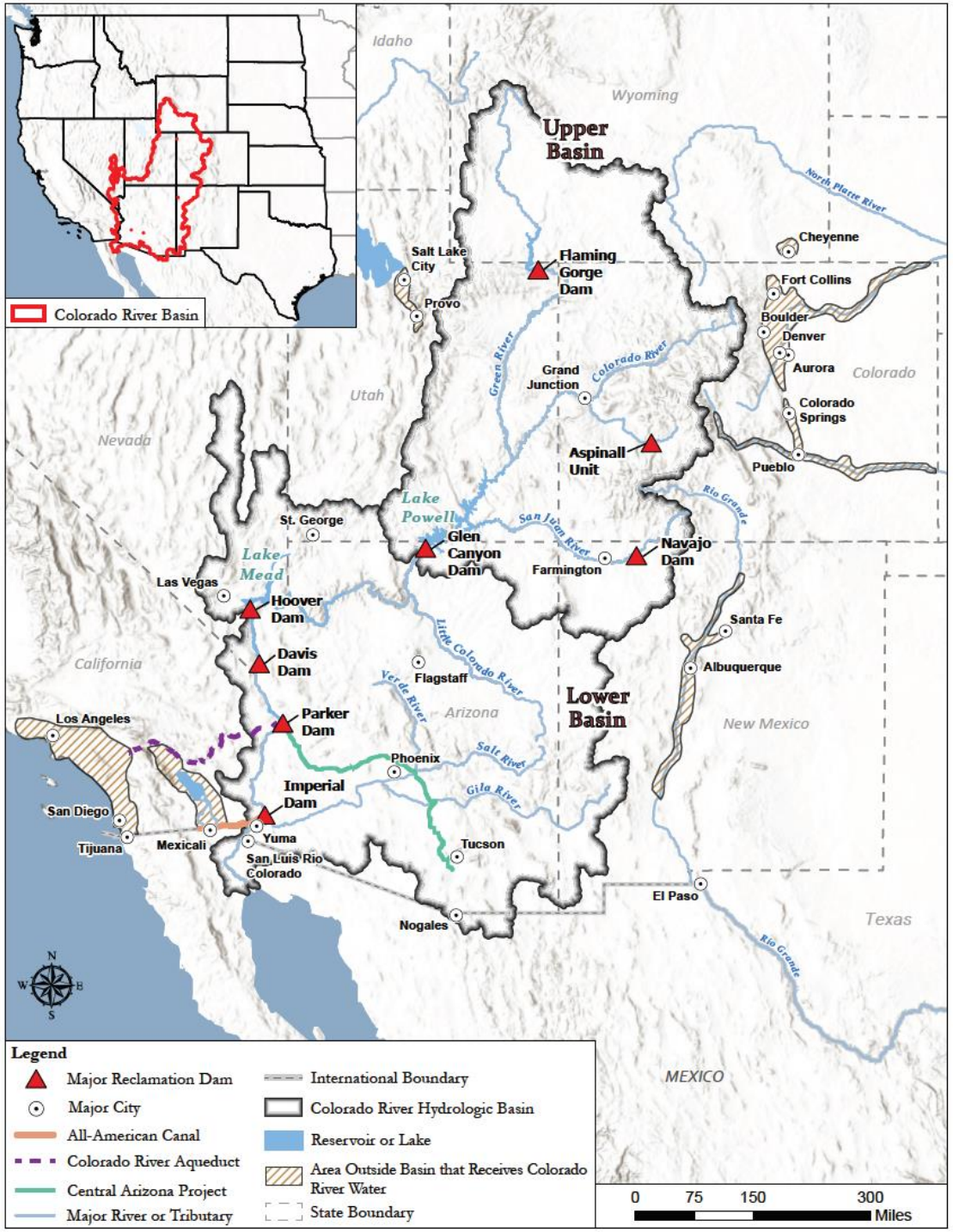
Colorado River Basin

Western Water Forecast Concerns and Research Priorities

CIROH, Salt Lake City, UT

May 27, 2025

Colorado River Basin Setting



U.S. States

Arizona, California, Colorado, Nevada, New Mexico, Utah, Wyoming

Major U.S. Cities:

- Albuquerque
- Denver
- Las Vegas
- Los Angeles
- Phoenix
- Salt Lake City
- San Diego

Areas Outside the Basin Receiving Colorado River Water:

- Albuquerque and Santa Fe, New Mexico (San Juan Chama Project)
- Cheyenne, Wyoming
- Colorado Front Range (Colorado-Big Thompson and Fryingpan-Arkansas Projects)
- Southern California (Colorado River Aqueduct/All-American Canal)
- Wasatch Front Range (Central Utah Project and Strawberry Valley Project)

International: Mexico

River Basin Area: 246,000 square miles

River Length: 1,450 miles

Major Water Uses:

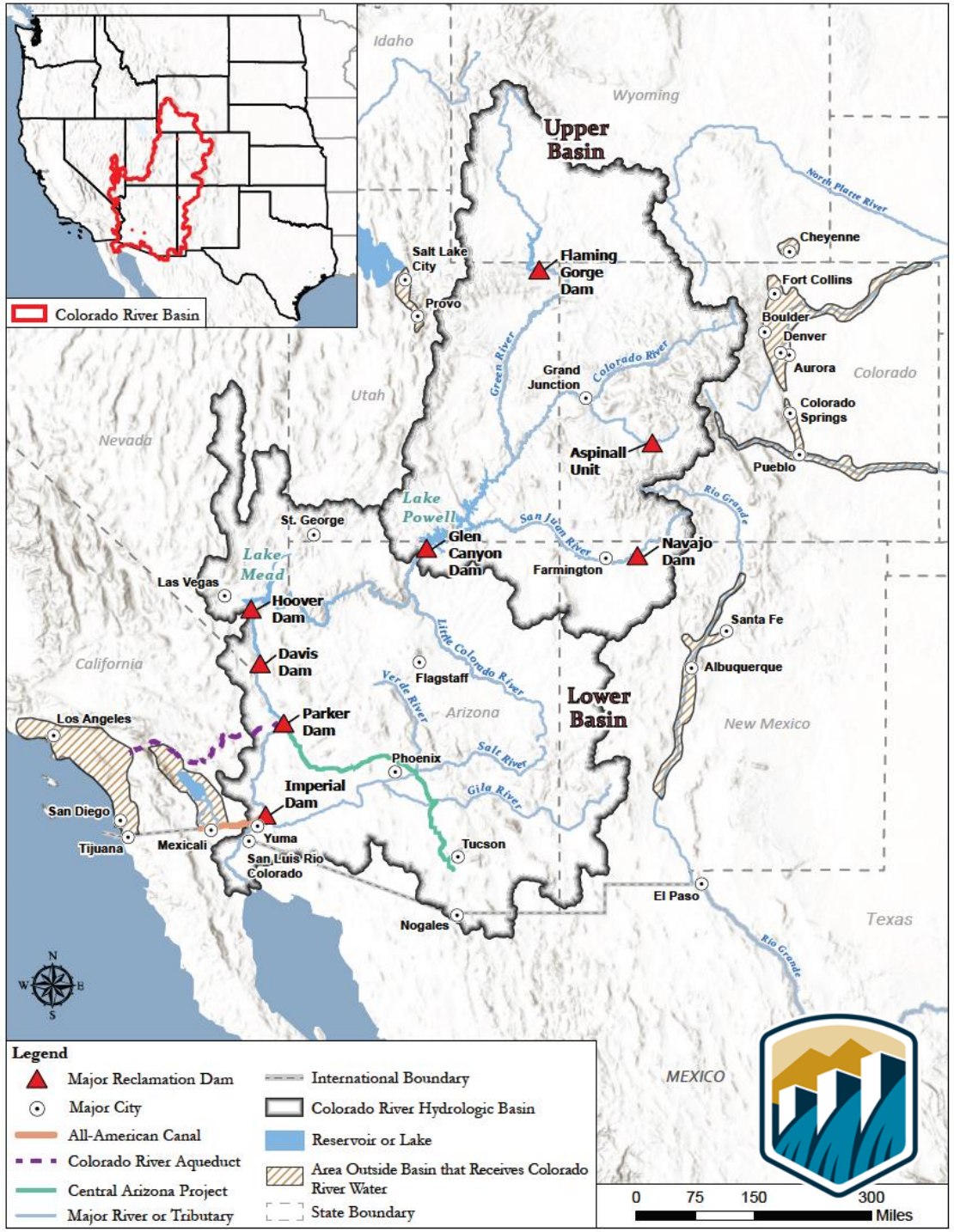
- Agriculture (4.5 million acres)
- Municipal (40 million people)
- Hydropower (4,200 megawatts)
- Recreation
- Fish and Wildife Habitat

Notable Reclamation Facilities:

- Hoover Dam
- Glen Canyon Dam
- Flaming Gorge Dam
- Aspinall Unit
- Navajo Dam
- Davis Dam
- Parker Dam
- Imperial Dam

Operational Setting

- Colorado River system provides water for over 40 million people in 7 U.S. States, 30 Basin Tribes, and Mexico
- Snowpack contributes 80% of total inflow
- System reservoirs can store ~4 years avg. inflow (~60 maf)
- Two largest reservoirs store ~85% system storage
  - Lake Powell – formed by Glen Canyon Dam
  - Lake Mead – formed by Hoover Dam
- Current system storage is 35% full
- Current operations are based on the 2007 Interim Guidelines and subsequent agreements that expire in 2026



Legal Setting ("Law of the River")

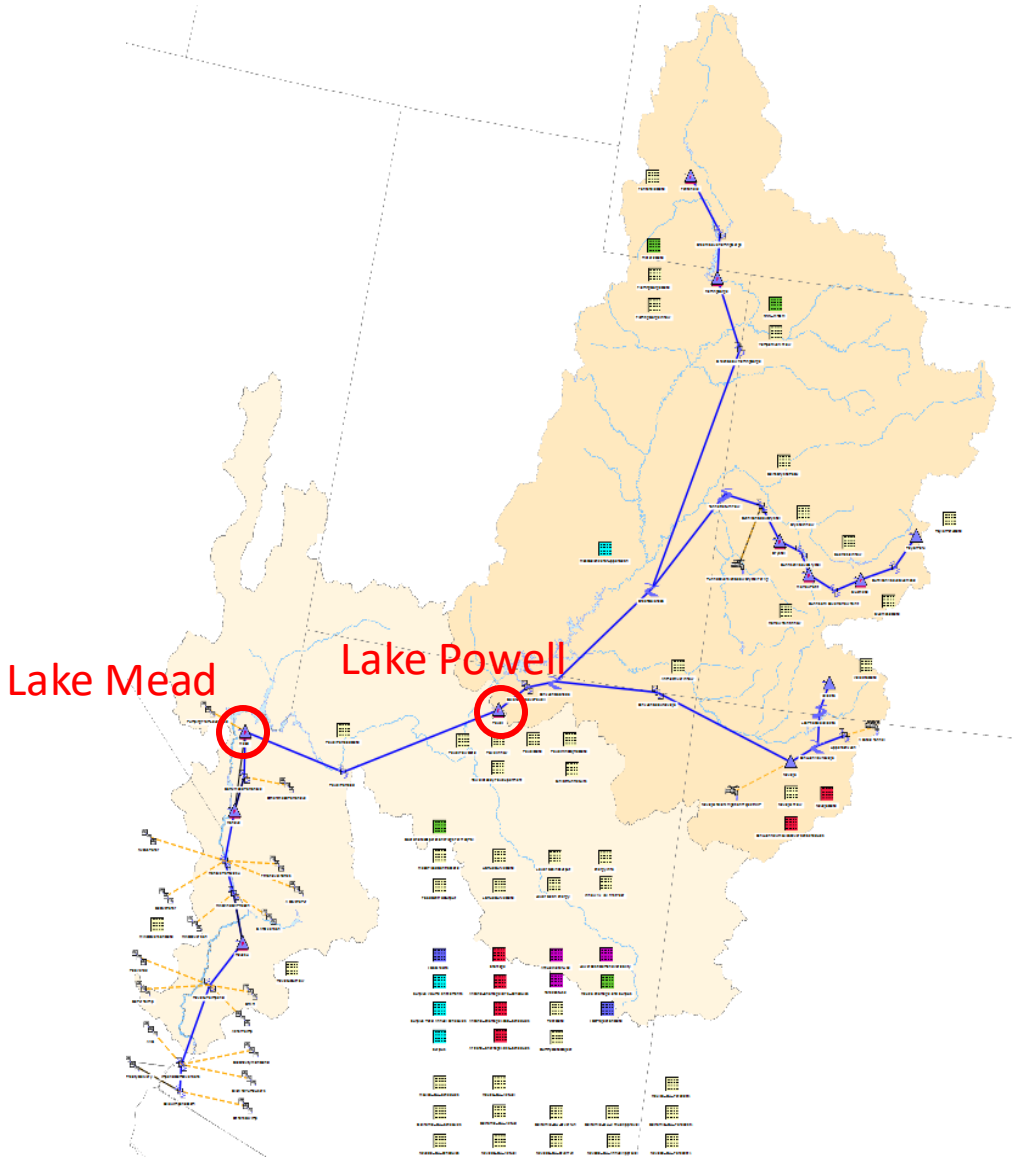
- Longstanding and complex body of legal agreements governing the Colorado River
- Foundational elements of the "Law of the River"
  - 1922 Colorado River Compact
    - Established two basins apportioning 7.5 maf to each; includes an Upper Basin "non-deplete" *obligation* to the Lower Basin
  - 1944 Treaty between the U.S. and Mexico (Colorado, Rio Grande, and Tijuana rivers)
    - Framework for sharing Colorado River water between countries; allots 1.5 maf; Minutes to the Treaty specify implementation details
  - 1948 Upper Basin Compact
    - Allocated the Upper Basin apportionment: CO 51.75%, UT 23%, WY 14%, NM 11.25%; AZ <1%
  - 1964 Supreme Court Decree in *Arizona v. California* (Lower Basin)
    - Upheld the allocation of water in the Lower Basin: CA 4.4 maf, AZ 2.8 maf, NV 0.3 maf; established the role of the Secretary as the "Water Master" in the Lower Basin
  - 1968 Colorado River Basin Project Act
    - Mandated the coordinated operation of Glen Canyon Dam (Lake Powell) and Hoover Dam (Lake Mead)
    - Implementing agreements
      - 1970 Long-Range Operating Criteria
      - 2007 Interim Guidelines, expires in 2026
      - 2017 Minute 323 to the 1944 Treaty, expires in 2026
      - 2019 Drought Contingency Plan, expires in 2026
  - Upper Basin water use and deliveries administered by individual states
  - Numerous inter- and intrastate agreements that implement Compact apportionments

Colorado River Reclamation Operational Modeling
Model Comparison

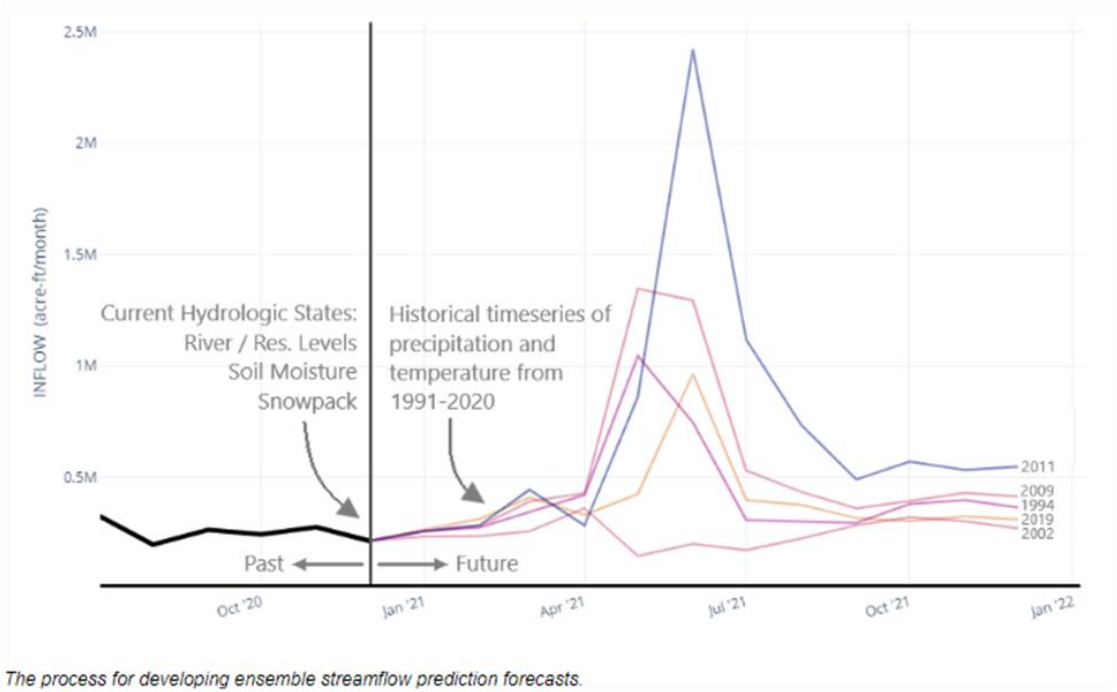
	Colorado River Mid-term Modeling System (CRMMS)		*CRSS*
	24-Month Study Mode *(Manual Mode)*	Ensemble Mode *(Rule-based Mode)*	
Primary Use	AOP tier determinations and projections of current conditions	Risk-based operational planning and analysis	Long-term planning, comparison of alternatives
Simulated Reservoir Operations	Operations input manually	Rule-driven operations	
Probabilistic or Deterministic	Deterministic – single hydrologic trace	Deterministic OR Probabilistic 30 (or more) hydrologic traces	Probabilistic – 100+ traces
Time Horizon (years)	1 - 2	1 - 5	1 - 50
Upper Basin Inflow	Unregulated forecast, 1 trace	Unregulated ESP forecast, 30 traces	Natural flow; historical, paleo, or climate change hydrology
Upper Basin Demands	Implicit, in unregulated inflow forecast		Explicit, 2016 UCRC assumptions
Lower Basin Demands	Official approved or operational		Developed with LB users

CRMMS: Colorado River Mid-term Modeling System

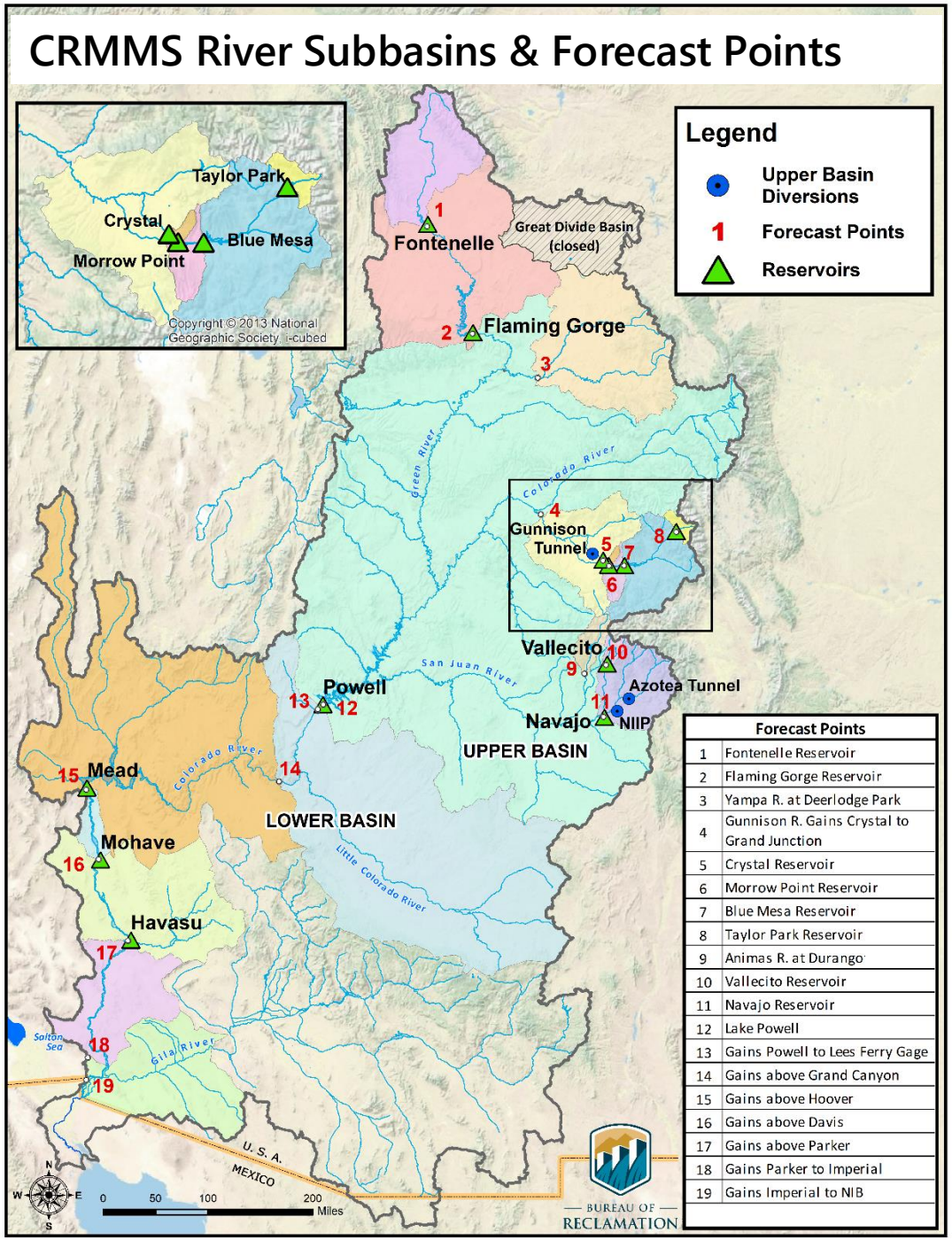
- RiverWare™ model that simulates operations at 12 reservoirs in the basin
- Monthly rule-driven operations of the 2007 Interim Guidelines and other treaties, plans, minutes and agreements
- Upper Basin streamflow forecasts are provided by the Colorado Basin River Forecasting Center (CBRFC)



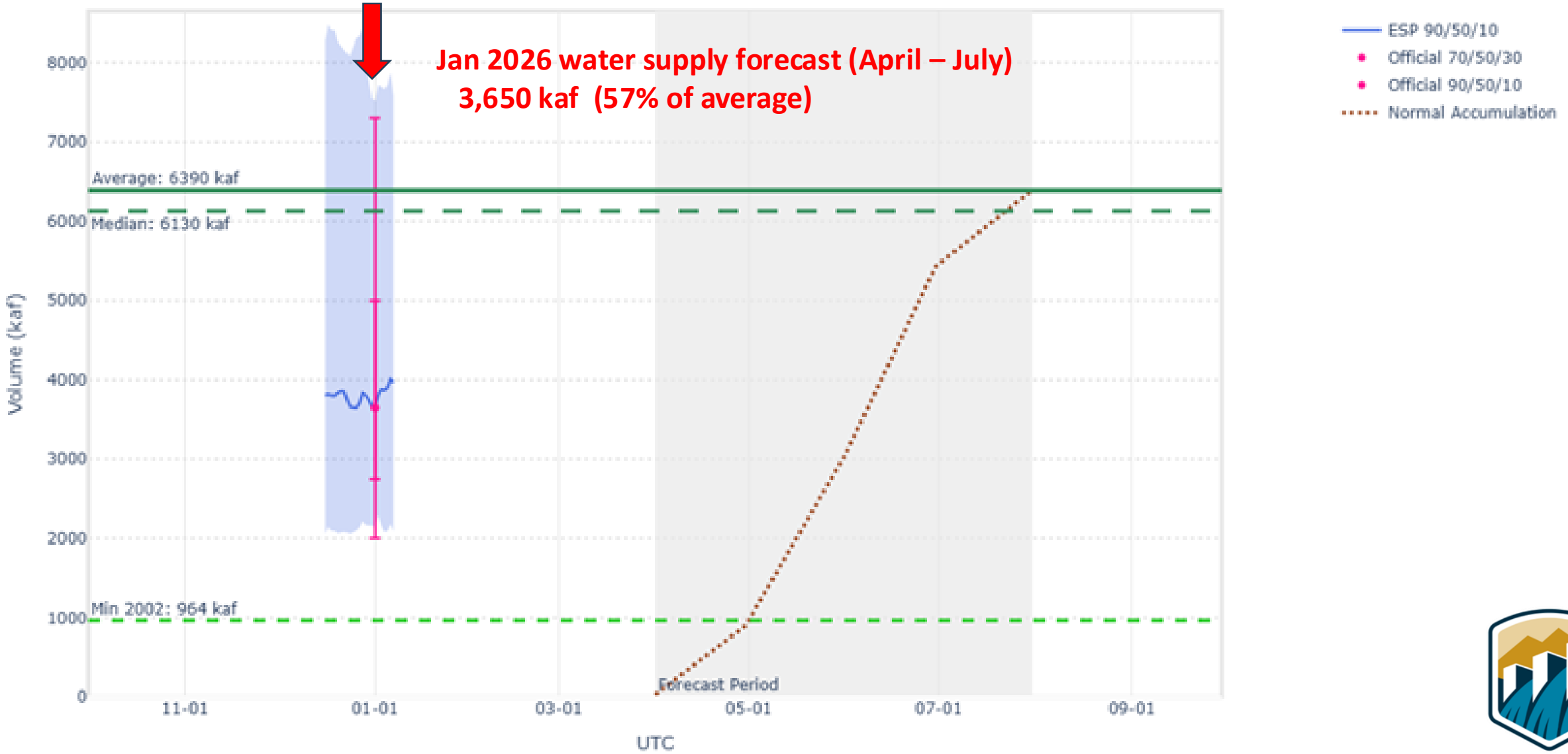
Unregulated Inflow Forecast Points



The process for developing ensemble streamflow prediction forecasts.



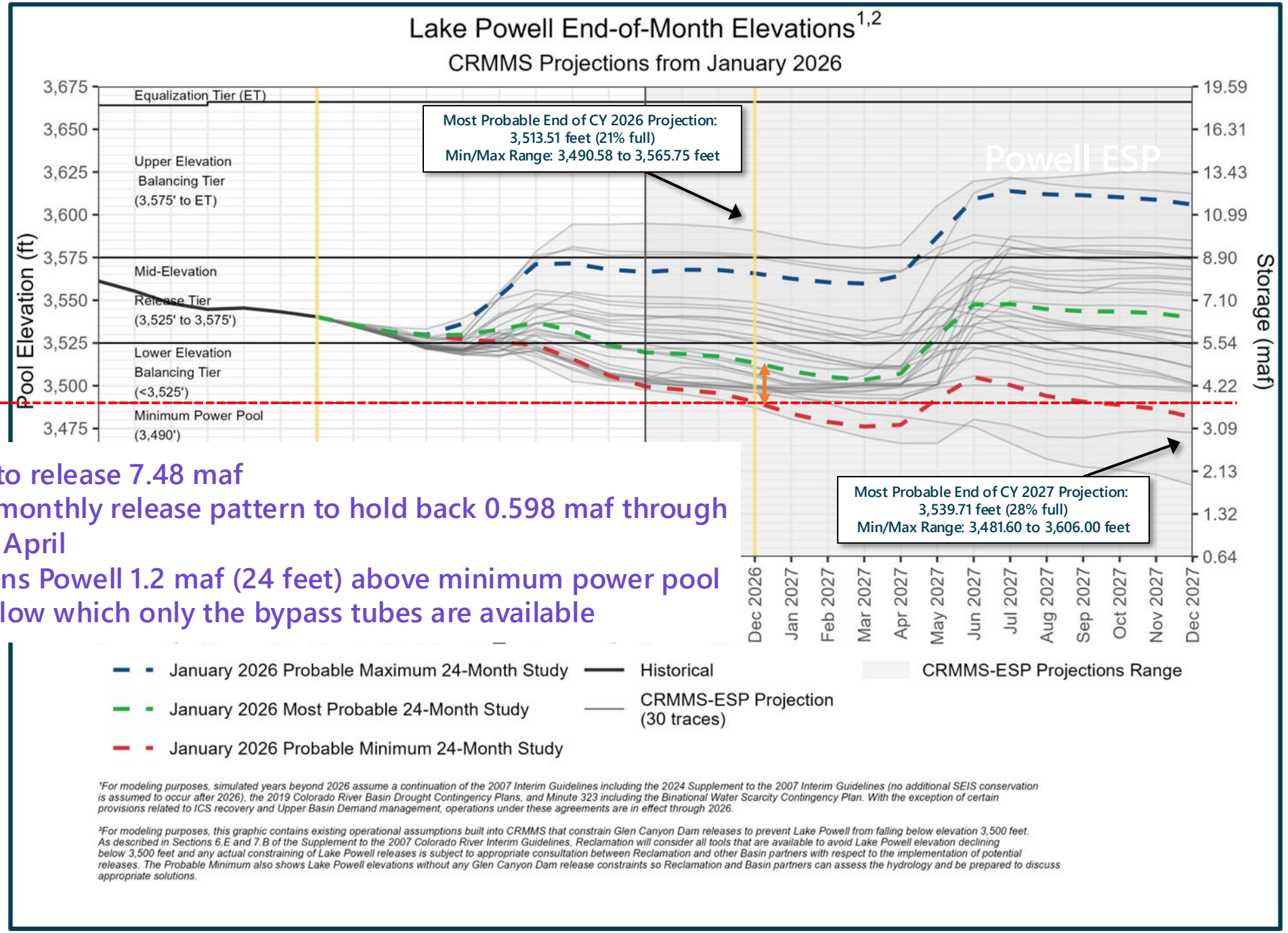
2026 Lake Powell Water Supply Forecast Evolution Plot



Lake Powell Water Supply Forecast

CBRFC probabilistic water supply forecasts are produced using current model soil moisture and snow states in addition to 30 years of observed weather (1991-2020).

The resulting 30 hydrographs provide information about the probability of certain volumes being exceeded.

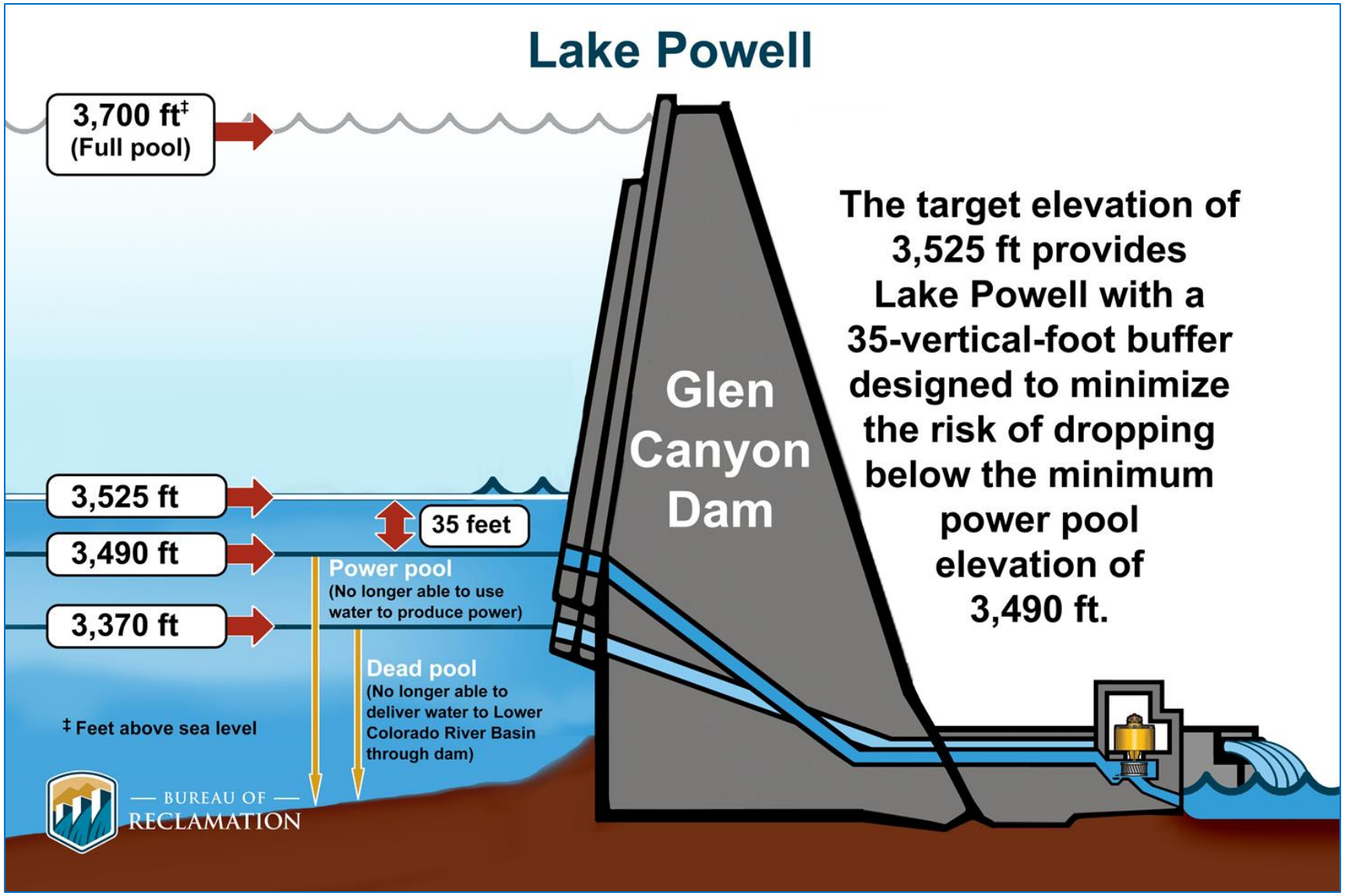


- Powell to release 7.48 maf
- Adjust monthly release pattern to hold back 0.598 maf through at least April
- Maintains Powell 1.2 maf (24 feet) above minimum power pool
  - below which only the bypass tubes are available

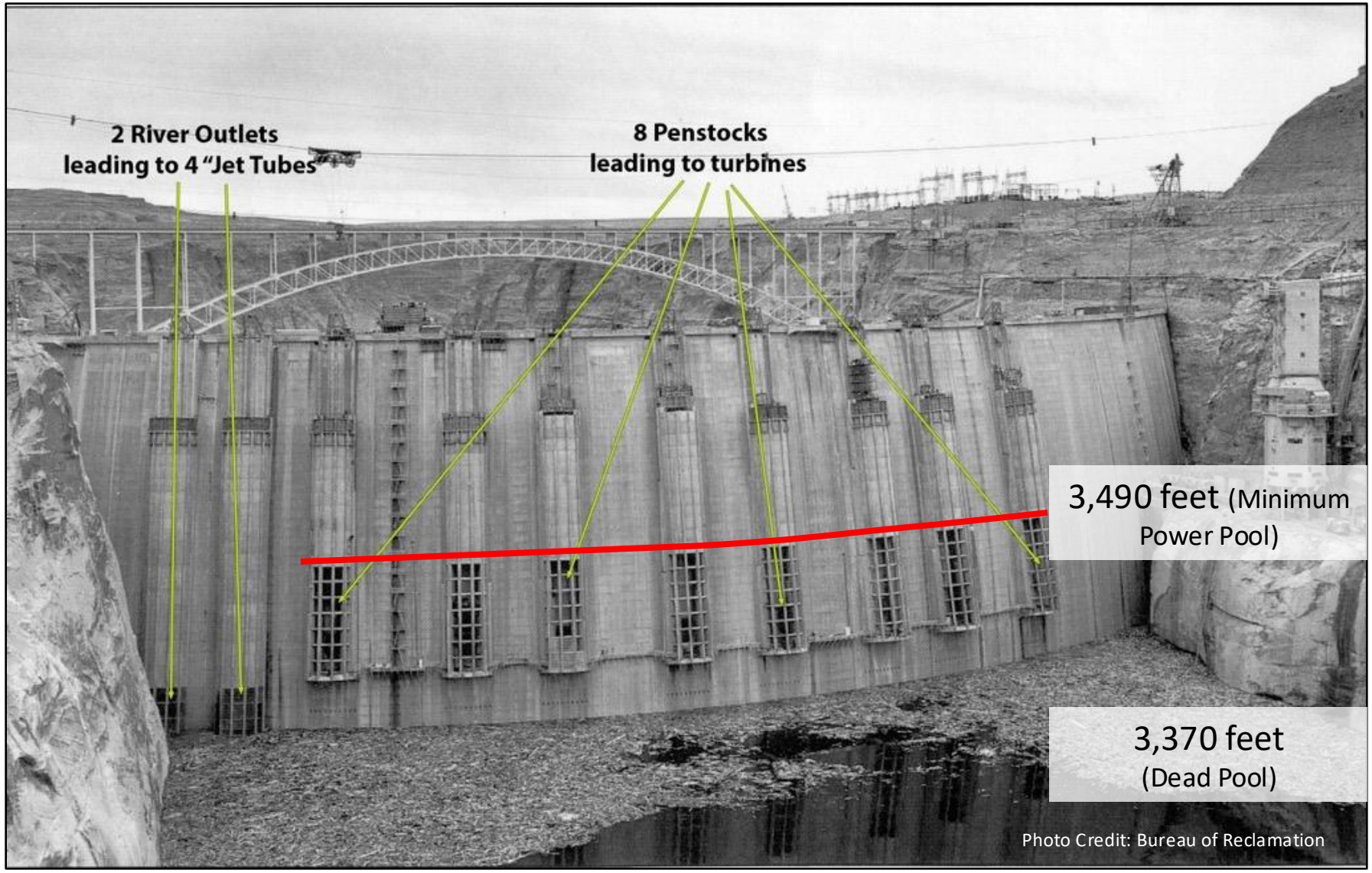
[1]For modeling purposes, simulated years beyond 2026 assume a continuation of the 2007 Interim Guidelines including the 2024 Supplement to the 2007 Interim Guidelines (no additional SEIS conservation is assumed to occur after 2026), the 2019 Colorado River Basin Drought Contingency Plans, and Minute 323 including the Binational Water Scarcity Contingency Plan. With the exception of certain provisions related to ICS recovery and Upper Basin Demand management, operations under these agreements are in effect through 2026.

[2]For modeling purposes, this graphic contains existing operational assumptions built into CRMMS that constrain Glen Canyon Dam releases to prevent Lake Powell from falling below elevation 3,500 feet. As described in Sections 6.E and 7.B of the Supplement to the 2007 Colorado River Interim Guidelines, Reclamation will consider all tools that are available to avoid Lake Powell elevation declining below 3,500 feet and any actual constraining of Lake Powell releases is subject to appropriate consultation between Reclamation and other Basin partners with respect to the implementation of potential releases. The Probable Minimum also shows Lake Powell elevations without any Glen Canyon Dam release constraints so Reclamation and Basin partners can assess the hydrology and be prepared to discuss appropriate solutions.

Lake Powell Key Elevations

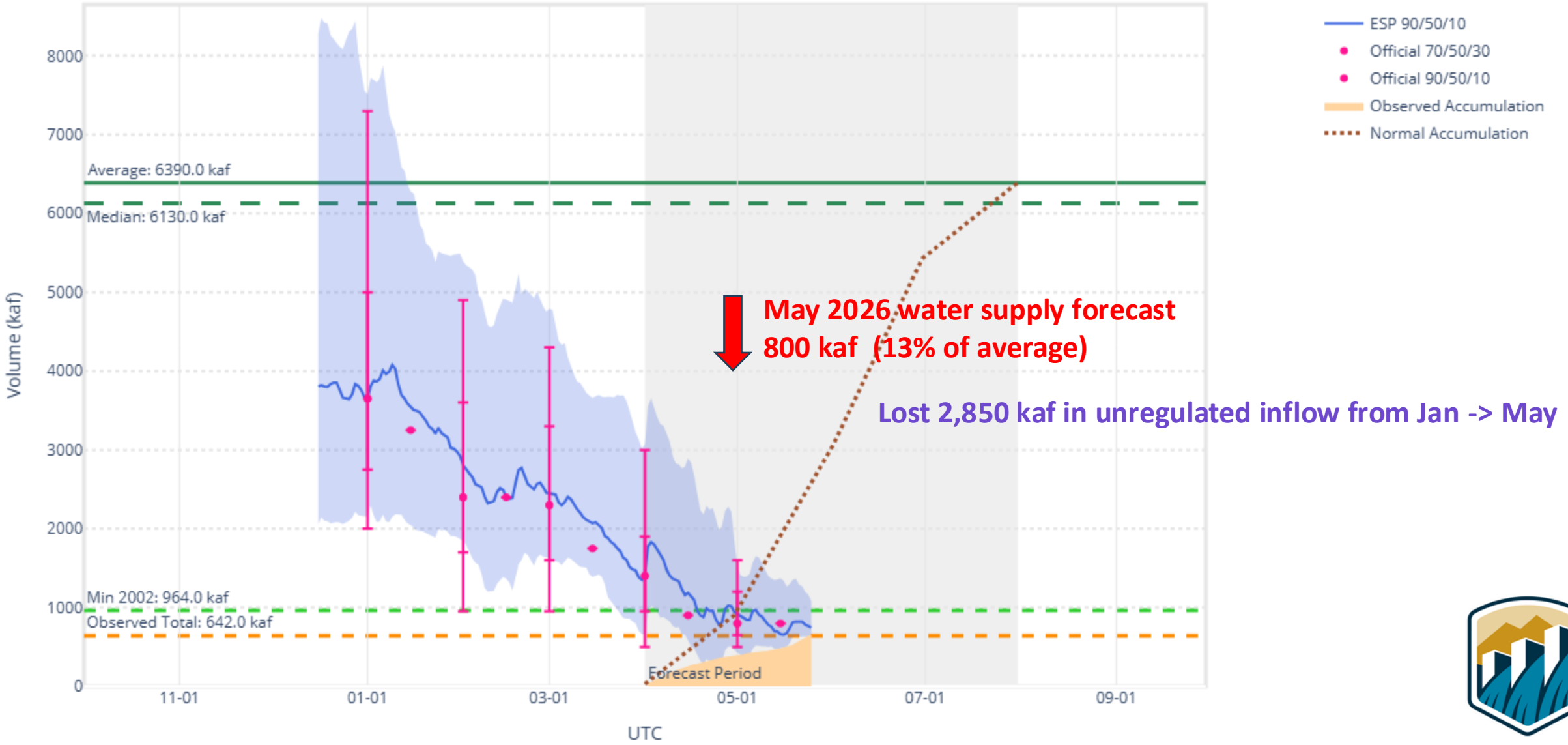


Glen Canyon Dam - November 21, 1963



2026 Water Supply Forecast - Colorado - Lake Powell, Glen Cyn Dam, At (GLDA3)

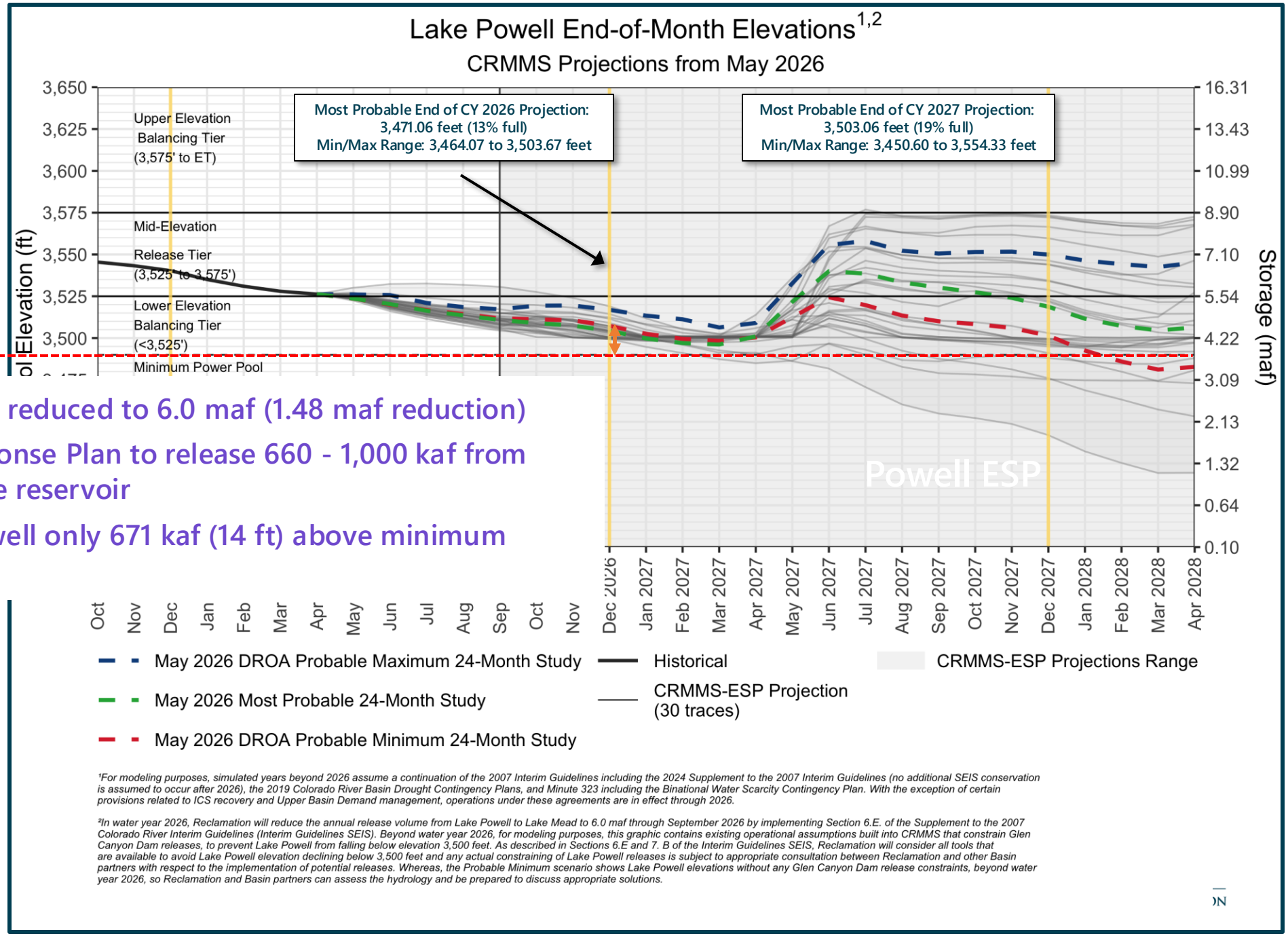
ESP is Unregulated and No Precipitation Forecast Included
Official 50% Fcst (2026-05-15): 800 kaf (13% Avg, 13% Med), (0% of Yrs Below Fcst, 63 Highest Flow / 62 Tot Yrs)
ESP 50% Fcst (2026-05-25): 745 kaf (12% Avg, 12% Med), (0% of Yrs Below Fcst, 63 Highest Flow / 62 Tot Yrs)
Observed Volume: 642 kaf (10% Average, 10% Median)



May 2026 water supply forecast
800 kaf (13% of average)

Lost 2,850 kaf in unregulated inflow from Jan -> May

- Powell release reduced to 6.0 maf (1.48 maf reduction)
- Drought Response Plan to release 660 - 1,000 kaf from Flaming Gorge reservoir
- Maintains Powell only 671 kaf (14 ft) above minimum power pool



[1]For modeling purposes, simulated years beyond 2026 assume a continuation of the 2007 Interim Guidelines including the 2024 Supplement to the 2007 Interim Guidelines (no additional SEIS conservation is assumed to occur after 2026), the 2019 Colorado River Basin Drought Contingency Plans, and Minute 323 including the Binational Water Scarcity Contingency Plan. With the exception of certain provisions related to ICS recovery and Upper Basin Demand management, operations under these agreements are in effect through 2026.

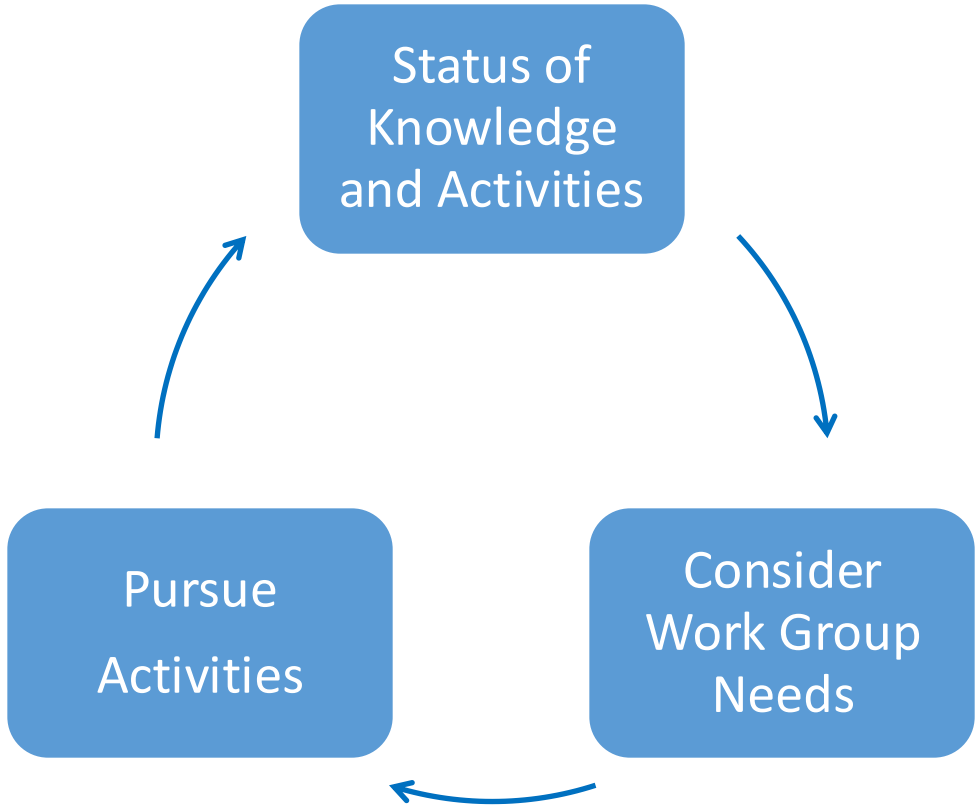
[2]In water year 2026, Reclamation will reduce the annual release volume from Lake Powell to Lake Mead to 6.0 maf through September 2026 by implementing Section 6.E. of the Supplement to the 2007 Colorado River Interim Guidelines (Interim Guidelines SEIS). Beyond water year 2026, for modeling purposes, this graphic contains existing operational assumptions built into CRMMS that constrain Glen Canyon Dam releases, to prevent Lake Powell from falling below elevation 3,500 feet. As described in Sections 6.E and 7. B of the Interim Guidelines SEIS, Reclamation will consider all tools that are available to avoid Lake Powell elevation declining below 3,500 feet and any actual constraining of Lake Powell releases is subject to appropriate consultation between Reclamation and other Basin partners with respect to the implementation of potential releases. Whereas, the Probable Minimum scenario shows Lake Powell elevations without any Glen Canyon Dam release constraints, beyond water year 2026, so Reclamation and Basin partners can assess the hydrology and be prepared to discuss appropriate solutions.

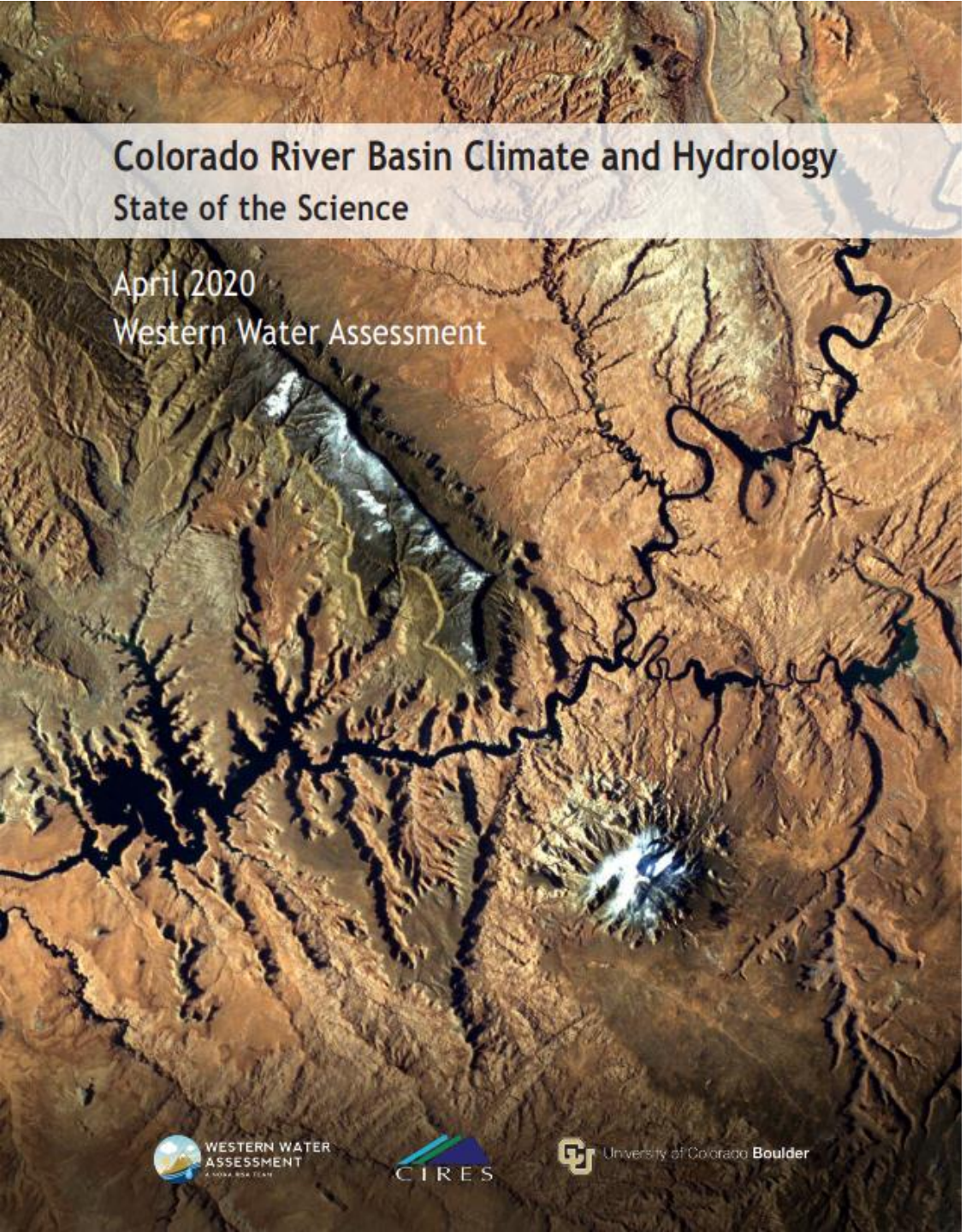
R2O Research to Operations
Colorado River Climate and Hydrology Workgroup

- Formed in 2017
- Informal and voluntary group
- Water user/manager need and consensus driven
- Improve data and methods within operational modeling tools
  - Community Hydrologic Prediction System (CHPS)
  - Colorado River Midterm Modeling System (CRMMS)
  - Colorado River Simulation System (CRSS)

Colorado River Climate and Hydrology Workgroup Goal

- Advance scientific understanding to improve the accuracy of hydrological forecasts and projections, to enhance the performance of predictive tools, and to better understand the uncertainty related to future supply and demand conditions in the Colorado River Basin.





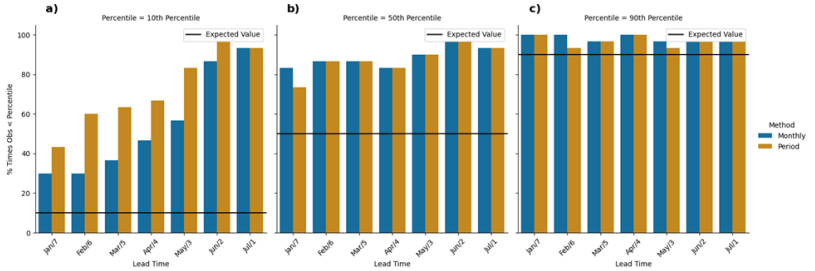
- Documented state of knowledge and practice – released April 2020
- Identified key challenges and opportunities
- Jointly funded by Reclamation, state, and local water management agencies
- Led by Western Water Assessment, authored and reviewed by dozens of scientists
- Foundational Science Resource for parties interested in the Colorado River Basin: Reclamation, stakeholders, and scientists
- Tool for engaging researchers

https://wwa.colorado.edu/resources/colorado-river-resources/CRBreport

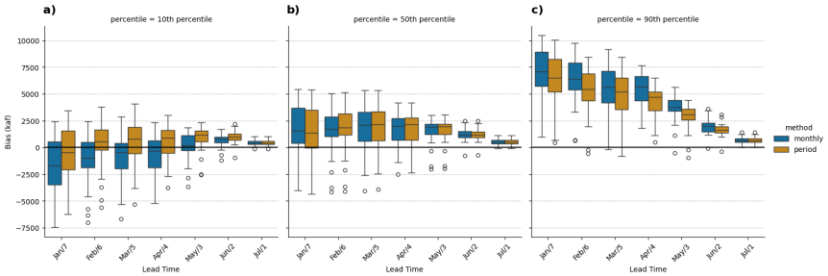
Recent Research Activities

- Funded FTE stationed at the CBRFC
- Develop tools to prioritize product testing
  - Colorado River Basin Operations Testbed
  - Developing a CHPS Forecast Testbed at CBRFC
  - CHPS autocalibration
  - Web based forecast dashboard
- Products awaiting CHPS testing
  - Detrended temperature
  - Dynamic ET
  - Consumptive use model improvements

Reliability



Bias



Work Group Participants

BUREAU OF RECLAMATION

CENTRAL UTAH WATER CONSERVANCY DISTRICT

THE COLORADO RIVER AUTHORITY OF UTAH

COLORADO
Colorado Water Conservation Board
Department of Natural Resources

DENVER WATER

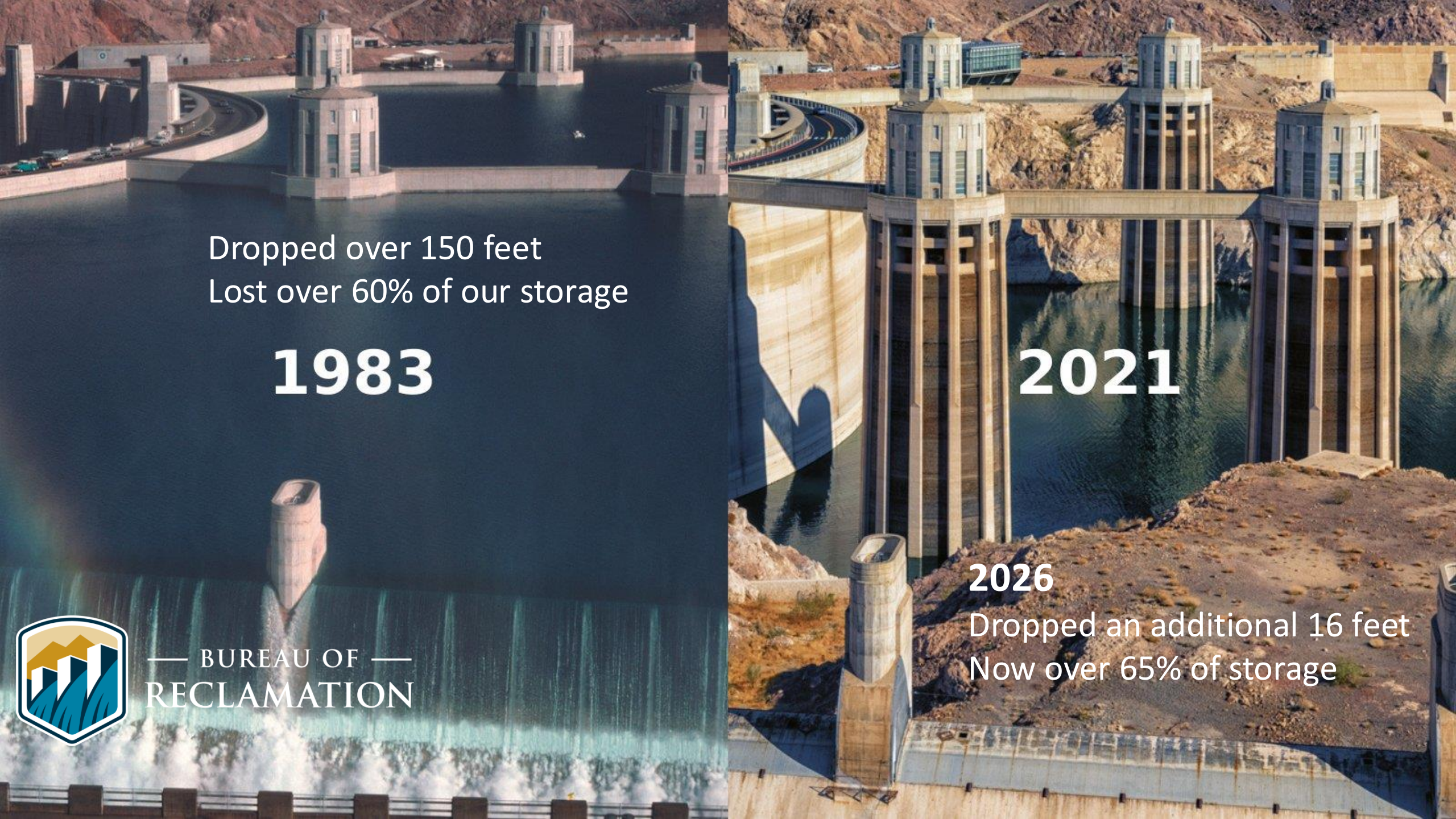
CALIFORNIA DEPARTMENT OF WATER RESOURCES

SOUTHERN NEVADA WATER AUTHORITY

Colorado Basin River Forecast Center
National Weather Service

Key Questions for Future Forecast Improvement

- Forecast Skill
  - Can we improve 5-month lead forecast skill?
  - How do we communicate rare-but-plausible risks in extended droughts?
  - Can we integrate skillful long-lead temperature & precipitation forecasts?
- Evaluation & Engagement
  - Develop and apply experimental forecast evaluation tools
  - Use testbeds linking forecast performance to operations
  - Engage stakeholders early when exploring research needs
  - Ensure strong participation from local river forecast centers


Dropped over 150 feet
Lost over 60% of our storage
1983
BUREAU OF
RECLAMATION
2021
2026
Dropped an additional 16 feet
Now over 65% of storage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