Uncertainties in Forecasting, Implications for Managing Colorado River Water Supplies

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NOAA NWS Climate Prediction Center Skill Scores

Seasonal (Lead 0.5 Months) Precipitation Heidke Skill Score
DJF Manual Forecasts From 1995 to 2018

Average = 7.9
I. Introduction

The Colorado River Basin (Basin) is in the eighth year of drought – the worst eight year period in over a century of continuous recordkeeping. Reservoir elevations have declined over this period and the duration of this ongoing, historic drought is unknown. This is the first long-term drought in the modern history of the Colorado River, although climate experts and scientists suggest droughts of this severity have occurred in the past and are likely to occur in the future.
## Lakes Powell & Mead Operations

(USBR)

<table>
<thead>
<tr>
<th>Lake Powell</th>
<th>Lake Mead</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Elevation (feet)</strong></td>
<td><strong>Live Storage (maf)</strong></td>
</tr>
<tr>
<td>3,700</td>
<td>24.3</td>
</tr>
<tr>
<td>3,636 - 3,686 (2008-2026)</td>
<td>15.5 - 19.3 (approx.)</td>
</tr>
<tr>
<td>3,575</td>
<td>9.5</td>
</tr>
<tr>
<td>3,525</td>
<td>5.9</td>
</tr>
<tr>
<td>3,490</td>
<td>4.0</td>
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<tr>
<td>3,370</td>
<td>0</td>
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<tr>
<td></td>
<td>895</td>
</tr>
</tbody>
</table>

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 and Lower 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 0.263 maf to Nevada
⁶ Of which 2.32 maf is apportioned to Arizona, 4.4 maf to California, and 0.260 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 Division States and Mexico is 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.
Interim Guidelines for the Operation of Lake Powell and Lake Mead

Section 2. Determination of Lake Mead Operation During the Interim Period

In the development of the AOP, the Secretary shall use the August 24-Month Study projections for the following January 1 system storage and reservoir water surface elevations to determine the Lake Mead operation for the following Calendar Year as described in this Section 2.
Dear Members of Congress,

The designated representatives of the seven States of the Colorado River Basin collectively seek your support in promptly securing legislation to implement necessary actions in the Colorado River Basin in order to respond to the historic drought and ongoing dry conditions in the Basin.

The Colorado River provides water to approximately 40 million people and 5.5 million acres of irrigated agriculture in the Upper Basin (Colorado, New Mexico, Utah and Wyoming) and Lower Basin (Arizona, California and Nevada). Since 2000, the Basin has experienced historically dry conditions and combined storage in Lakes Powell and Mead has reached its lowest level since Lake Powell initially began filling in the 1960s. Last year’s runoff into the Colorado River was the second lowest since 2000, and there is no sign that the trend of extended dry conditions will end any time soon even if 2019 provides above average runoff. Lakes Powell and Mead could reach critically low levels as early as 2021 if conditions do not significantly improve. Declining reservoirs threaten water supplies that are essential to the economy, environment, and health of the Southwestern United States.

Working together, the seven Basin States have developed drought contingency plans (DCPs) that are reflected in the agreements attached to this letter. We hereby request passage of federal legislation that would authorize and direct the Secretary of the Interior to sign and implement the agreements upon execution by the non-federal parties.

We look forward to working with you on legislation directing the Secretary of the Interior to implement the DCPs upon their execution by the Basin States and without granting any additional authority to the Secretary. Furthermore, the DCP agreements themselves reserve and recognize each party’s existing rights and do not disturb the rights of other water users or stakeholders with interests in the Colorado River.

Federal legislation and subsequent implementation of the agreements will enable prompt action to enhance conservation of Colorado River water and provide us with water management tools necessary to address a looming crisis. These tools will assist us in reducing the probability that Lakes Powell and Mead will decline to critically low elevations. Our goal is
j. **Emergency Action:** In light of the potential uncertainty associated with modeling projections, the Parties agree that notwithstanding the principles for implementing a drought response operation set forth in this subsection 3, the Secretary retains all applicable authority to make releases from the CRSPA Initial Units and perform subsequent recovery of storage operations if actual hydrology or actual operating experience demonstrate an imminent need to protect the Target Elevation at Lake Powell. Such action shall be performed, to the greatest extent practicable, with advance consultation and coordination with the Upper Division States, through the Commission, and following consultation with the Governors’ Representatives of the Colorado River Basin States consistent with the Agreement Concerning Colorado River Drought Contingency Management and Operations (“Companion Agreement”).

4. **Drought Response Process:** In an effort to achieve the primary goals of this Drought Response Operations Agreement, and to implement the “Principles” outlined in Section II.A.3, the Parties agree that, subject to Section II.A.3.j “Emergency Action”, they will work to minimize the risk of Lake Powell declining below the Target Elevation by:

   a. **Initiating drought response process:** The Parties will initiate a drought response process, which will include at a minimum:

      i. **Notice:** The Secretary will notify the Commission and the Lower Division States when Reclamation’s 24-Month Study model, using Minimum Probable hydrology based upon the inflow forecast provided by the Colorado Basin River Forecast Center, projects Lake Powell’s elevation at or below the Target Elevation at any time during the subsequent 24-month period, or when emergency action becomes necessary as set forth in Section II.A.3.j.

      ii. **Modeling:** The Secretary will commence monthly modeling of Minimum Probable, Maximum Probable and Most Probable hydrology for the subsequent 24-month period until the Minimum Probable 24-Month Study projects that Lake Powell will consistently remain above the Target Elevation for a 24-month period. Reclamation will report such modeling results to the Upper Division States and the Commission during monthly calls, see Section II.A.4.a.iii.

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1 The term “emergency” as used in this Drought Response Operations Agreement does not identify, describe or otherwise define what constitutes a general emergency under federal or state laws or other emergency situation at a Reclamation reservoir, a deficiency in the system under the Colorado River Compact, or an extraordinary drought under the 1944 Water Treaty between the United States and Mexico regarding the Colorado River.
Lower Basin DCP

- Simultaneous creation and conversion of Extraordinary Conservation, System Efficiency, or Binational ICS to DCP ICS
- Creation of Non-ICS Water

“DCP ICS” shall mean Intentionally Created Surplus converted from Extraordinary Conservation ICS, System Efficiency ICS, or Binational ICS as set forth in these LBOps. Reductions in Colorado River water available to a State pursuant to Section XI.G.2.D of the 2007 Interim Guidelines shall not constitute DCP ICS.

“DCP ICS Account” shall mean records established by the Secretary regarding DCP ICS.

“Effective Date” means the date first set forth in the Lower Basin Drought Contingency Agreement.

“Intra-State DCP Agreements” means agreements among, as appropriate, the United States, a Lower Division State, Contractors, Tribes and local government entities within such state setting forth the relative rights and obligations among Contractors within the state regarding DCP Contributions.

III. Operational Provisions

A. Reservoir Elevation Projections

In making projections of Lake Mead water surface elevations as required throughout these LBOps, the Secretary shall use the Bureau of Reclamation's August 24-Month Study for the most probable inflows unless expressly provided otherwise herein.

B. DCP Contributions

In addition to any reductions provided in Section XI.G.2.D. of the 2007 Interim Guidelines, from the Effective Date of these LBOps through December 31, 2025 (through preparation of the 2026 AOP), and consistent with applicable Intra-State DCP Agreements, the States of Arizona, California, and Nevada, shall make DCP Contributions as follows:

1. Arizona
   a. Lake Mead January 1 elevation projected to be above 1,045 feet and at or below 1,090 feet

      In Years when Lake Mead elevation is projected to be above 1,045 feet and at or below 1,090 feet on January 1, the State of Arizona shall make annual DCP Contributions in the total amount of 192,000 acre-feet.

   b. Lake Mead January 1 elevation projected to be at or below 1,045 feet
USBR’s Operations Modeling

- **Observed Reservoir Elevations**
  - Initial Reservoir Conditions
  - December 31, 2019 observed reservoir elevations

- **MTOM Projected Reservoir Elevations**
  - Initial Reservoir Conditions
  - 35 projections of December 2019 reservoir elevations

- **Mid-Term Operations Model (MTOM)**
  - Simulates reservoir operations in 2019

- **Colorado River Simulation System (CRSS)**
  - Simulates reservoir operations from 2020 to 2026

- **Streamflow Forecast**
  - Future Hydrology
  - 35 unregulated inflow forecasts dated January 4, 2019 provided by the Colorado Basin River Forecast Center

- **Natural Flow Record**
  - Future Hydrology
  - 111 hydrologic sequences from resampled natural flow record of 1906-2016

- **January 2019 Colorado River System 5-Year Projected Future Conditions**
  - 35 MTOM traces for 2019 and 3,885 CRSS traces (35 initial conditions x 111 hydrologic sequences = 3,885 traces) for 2020-2026
Experience to Date

- Lead time too short
- Lower Basin shortage forecast has flipped in several years between the April and August 24-month study runs.
- At current reservoir levels, relative balance between demand & supply translates to high sensitivity at trigger elevation.
- Intentionally Created Surplus water developed through forbearance agreements pursuant to the IGs has “propped up” Mead elevations.
- Additional pilot system conservation programs have been used to further “prop up” reservoir elevations.
Percent of Average Precipitation (%)
10/1/2018 - 3/24/2019

Map showing precipitation percentage across the United States from October 1, 2018, to March 24, 2019.
Example Existing Investments to Mitigate Risk

- Capital investments -- SNWA third intake, $817M
- Individual local agencies’ Intentionally Created Surplus projects
- Pilot system conservation programs (including in UB), 2014-17, ~$19M
New Actions to Implement DCP, Upper Basin

• Demand management actions TBD, such as temporary fallowing programs, system conservation programs, forbearance agreements, etc

• Lessons learned/questions raised from pilot system conservation program:
  6. What would be the source of financial support for measurable demand management volumes, recognizing current unit costs? For example, is it feasible to secure roughly $40 million to conserve approximately 200,000 acre-feet based on the 2017 SCPP unit costs? 7. How do we manage risk and determine an appropriate level of conservation given hydrologic variability? For example, how do we minimize large investments in conservation rendered unnecessary by a wet year—are there opportunities for using surplus conserved water in the Upper Basin (e.g., water banking)?
Managing with Uncertainty in Forecasts

• Lead time required for making decisions!
• Uncertainty costs money, agencies want to manage financial risk
  – Irretrievable impacts
  – Avoided costs, opportunity costs
Seasonal Precipitation Forecasting

- Skillful forecasting would be very valuable for risk management, especially for cost management
- Supports longer lead times for risk management actions
- No clear pathway for forecasting improvements