Appendix C

CRMMS Model Documentation

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Appendix C. CRMMS Model Documentation

C.1 Introduction

The Bureau of Reclamation's (Reclamation's) Colorado River Mid-term Modeling System (CRMMS) for the Colorado River Basin (Basin) is a Basin-wide operations model utilized to evaluate future system conditions for out to five years into the future. Specifically, the September 2022 CRMMS version is used for hydrology modeling for this Supplemental Environmental Impact Statement (SEIS). This appendix provides a detailed overview of the model and its components, as well as the reservoir operations simulated in the model.

Reclamation uses two primary Basin-wide modeling and decision support tools. These are (1) CRMMS and (2) the Colorado River Simulation System (CRSS). The CRMMS is run in two modes, the 24-Month Study Mode and Ensemble Mode. CRMMS 24-Month Study Mode is used to produce the 24-Month Study and the Annual Operating Plan. The 24-Month Study is an operational model with a two-year outlook that uses a single most probable inflow forecast (updated monthly) provided by the National Weather Service's Colorado Basin River Forecast Center (CBRFC). The 24-Month Study is limited in its ability to incorporate hydrologic uncertainty because future reservoir operations must be input manually. Additionally, CRMMS can be run in Ensemble Mode to produce 1- to 5-year probabilistic projections of Basin conditions. CRMMS uses the CBRFC's Ensemble Streamflow Prediction (ESP) forecast (updated monthly) to provide more information about risk and uncertainty for operations. CRSS, which is used in long-term planning studies (for example, the 2007 Interim Guidelines Final EIS [2007 FEIS]), and Colorado River Basin Water Supply and Demand Study), is a planning model that simulates Basin conditions decades into the future. Although CRSS accounts for hydrologic uncertainty in its ability to simulate hundreds of future hydrologic scenarios, it is limited in its ability to incorporate real-time forecasts and operations.

The CRMMS Ensemble Mode (referred to as CRMMS for the remainder of the appendix) provides probabilistic information about the uncertainty associated with Basin reservoir operations and future states of the system in the 1- to 5-year timeframe. By supplementing the most probable projection of Basin conditions developed in the 24-Month Study, the CRMMS provides a wider range of information for planning, risk analysis, and operational decision-making in the short- to mid-term planning horizons.

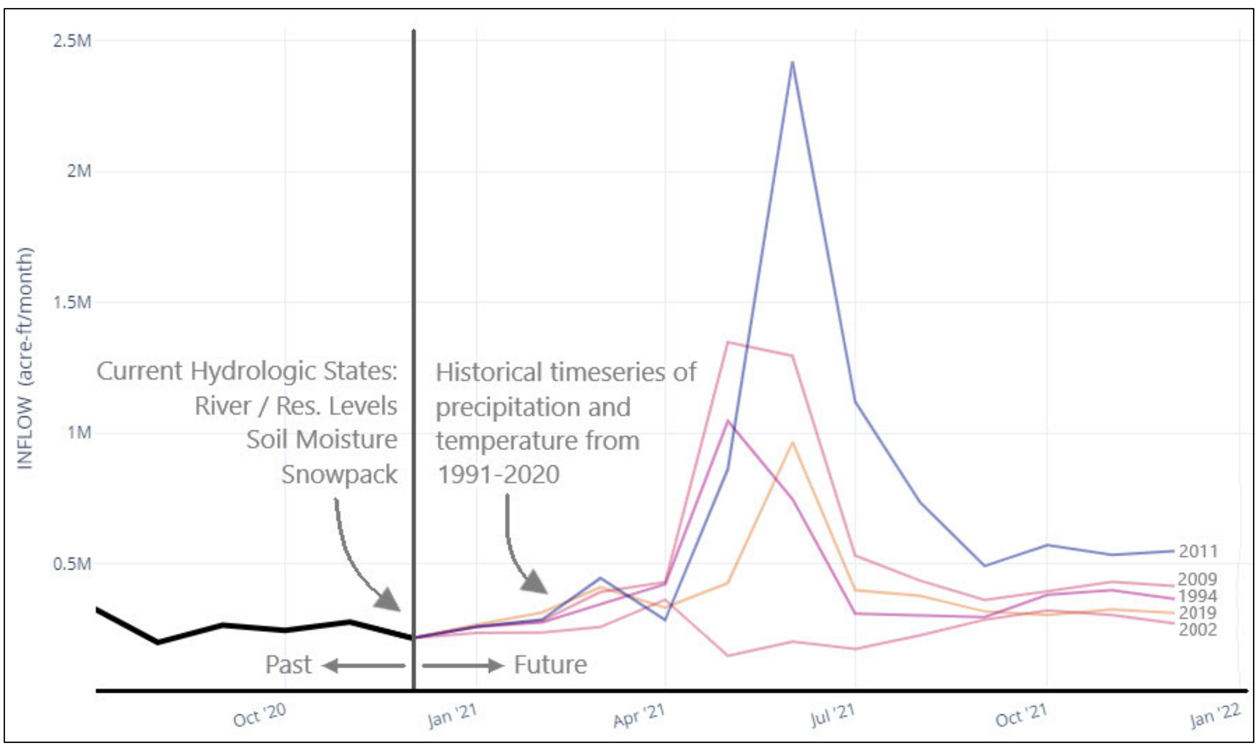
C.2 Overview

CRMMS is implemented in the commercial river modeling software called RiverWare™ developed by the Center for Advanced Decision Support for Water and Environmental Systems at the University of Colorado Boulder. The models are updated and maintained continually by Reclamation's Upper and Lower Basin Regions.

The Basin-wide model simulates the operation of the major reservoirs on the Colorado River system and provides information regarding the projected future state of the system on a monthly basis. Output variables include the volume of water in storage, reservoir elevations, releases from the dams, energy generation, streamflow, and diversions to and return flows from water users throughout the system. Input data includes physical parameters (e.g., individual reservoir storage capacity, evaporation rates, and reservoir release capabilities), initial reservoir conditions, and the depletion schedules for entities in the Lower Division States and for the United Mexican States (Mexico). Upper Basin depletion schedules are not explicitly modeled in CRMMS as the unregulated streamflow forecasts provided by the CBRFC include the impact of most Upper Basin depletions except for three diversions: Gunnison Tunnel, the Azotea Tunnel, and the Navajo Indian Irrigation Project (NIIP), which are individually input. These simulations use a mass balance (or water budget) calculation, which accounts for all water entering, stored in, and leaving the system. CRMMS contains a modeling "rule set", which simulates how water is released and delivered under various hydrologic conditions with the aim of simulating actual operations.

CRMMS provides information about risk and uncertainty for operations within a one- to five-year planning horizon. CRMMS uses an ensemble of unregulated streamflow forecasts developed by the CBRFC using ESP forecasts. **Figure C-1** depicts an example of ESP forecasts of future potential hydrologic inflows.

Figure C-1
Process for Developing ESP Forecasts



Source: Reclamation 2022

C.2.1 Model Simulations

CRMMS simulates the operations of nine reservoirs in the Upper Basin, three reservoirs in the Lower Basin, river flows, energy generation, and diversions throughout the Basin. A description of each reservoir, the drivers of operation, and how reservoir operations are modeled in CRMMS are discussed in Sections C.5 through C.8.

In understanding how CRMMS simulates operations, it is helpful to first understand the modeling process used in production of the 24-Month Study, which CRMMS attempts to replicate. In production of the 24-Month Study, Reclamation modelers first manually set releases for the reservoirs at the Upper Basin headwaters (**Table 3**). Once operations are set for reservoirs furthest upstream, operations for the next downstream reservoirs can be entered. Information about upstream reservoir operations is required before operations can be set for the downstream reservoirs because a full year of projected regulated inflow is needed for planning reservoir releases at those downstream reservoirs. Additionally, operations for Lake Powell and Lake Mead are frequently set in an iterative manner, as Lake Powell and Lake Mead operations are coordinated based on their respective releases and resulting elevations/storages.

In order to simulate operations in CRMMS in a manner similar to the manual process used in production of the 24-Month Study, CRMMS takes advantage of a RiverWare feature called "run cycles." By using run cycles, RiverWare has the capability of cycling through the simulation (from the first timestep to the last timestep) multiple times during the run. With the aid of rule logic, CRMMS uses four run cycles to solve or "operate" the reservoirs from the Upper Basin headwaters downstream through the Lower Basin. **Table C-1** shows which reservoirs and outflows are solved within each run cycle. To initiate the model run for each year of the model run duration, Lower Basin depletion schedules are set with a default assumption of "normal condition" so that the entire Basin will solve when the rule logic solves for Lake Powell. Lower Basin Shortage and Surplus are assessed and applied in later run cycles, similar to the iterative process completed manually in the production of the 24-Month Study.

Table C-1
How Run Cycles Solve Reservoir Operations in CRMMS

Run Cycle	Operations Solved
1	Upper Basin Headwater Reservoirs – Taylor Park, Vallecito, and Fontenelle; Initial Lower Basin Diversions and Lake Mead Outflow
2	Additional Upper Basin Reservoirs – Flaming Gorge, the Aspinall Unit, and Navajo
3	Lake Powell, Lake Mead, and the remainder of the Lower Basin (Initial Lake Mead Outflow was solved in Run Cycle 1; Flood Control, Surplus, Shortage, and hydrologic demand variability first solve in Run Cycle 3)
4	Lake Powell, Lake Mead, and the remainder of the Lower Basin may resolve again (Lake Powell releases are fine-tuned to achieve balancing when appropriate, and Lower Basin operations are adjusted, if necessary, after Lake Powell releases have been modified)

An additional feature of CRMMS is that the model run duration period changes depending on the model run's initial time step. The model run duration ranges from 60 to 68 months in an ensemble run. Extending the length of the model run is required in the months of February through September in order to complete Lake Powell operations for the entire operating year (October through September) in the last year of the model run. The duration of each model run is specified in **Table C-2**. The modeling analysis for the SEIS uses the September 2022 version of CRMMS but limits the analysis period to September 2022 – December 2026.

Table C-2
Model Run Duration for Ensemble Model Runs

Initial Time Step (Month)	Ensemble Run Duration (Months)
January	60
February	68
March	67
April	66
May	65
June	64
July	63
August	62
September	61
October	60
November	60
December	60

C.2.2 Model Uncertainty

CRMMS projections are subject to multiple sources of uncertainty. One source is the model, which is a simplified representation of a complex system. Another component of uncertainty is the need to estimate physical processes such as reservoir evaporation and transpiration from plants. The most impactful source of uncertainty is the future itself - models rely on assumptions about how hydrology, water demand, and policy/operations will unfold. Reclamation works with stakeholders and scientists to develop the best modeling practices and most appropriate assumptions in light of the purpose of the model. It is important to understand the purpose, approach, and assumptions associated with projections and their inherent uncertainty to properly interpret the information they provide.

Projections are most sensitive to assumptions about future hydrology, and future flows are highly uncertain. Assumptions about future hydrology can produce very different pictures of risk. Using ESP, CRMMS generates a wide range of hydrologic possibilities based on an assumption that the future precipitation and temperature will be similar to those experienced during the recent thirty years (i.e., 1991-2020), allowing evaluation of the proposed action under a wide range of future flows.

The further out projections look, the more uncertainty exists. This is apparent when comparing the different ranges of possible conditions in the next 1-5 years. As time horizons extend and uncertainty increases, projections of statistics-based measures such as risks of certain system conditions become less reliable as representations of the true probabilities that specific events may occur. All statistics calculated are reflective of the hydrology scenarios and other assumptions used in modeling for this SEIS and are not intended to suggest actual probabilities of any events occurring. However, it is meaningful to compare statistics across alternatives to differentiate performance.

C.3 Hydrology

In order to simulate reservoir operations for up to 5 years, a hydrologic forecast of 60-68 months at twelve Upper Basin forecast points and seven Lower Basin forecast points must be input into the model. The Upper Basin hydrology inputs are unregulated inflow forecasts for each forecast point. Unregulated flow is the forecasted flow that would arrive at a specific point if there were no dams located upstream of that point. The total unregulated inflow for each forecast point includes the entire flow from the Basin upstream from that point. In other words, each downstream forecast point reflects the sum of the unregulated inflows from all forecast points above it in the Upper Basin.

Lower Basin hydrology inputs are developed by Reclamation and are generated using 30 years of calculated historical intervening flows. The 30-year period of historical flows matches the CBRFC's 30-year calibration period (currently 1991 through 2020) to provide consistency in the periods of record used to produce flow assumptions for the Upper and Lower Basin portions of the model. Historical intervening flows in the Lower Basin are calculated based on a mass balance approach as discussed in **Section C.3.2**. Intervening flows for this purpose are defined as the amount of flow entering the system between the upstream point and the downstream point.

C.3.1 Upper Basin Hydrology

The CBRFC provides ESP forecasts at 12 Upper Basin forecast points (**Table C-3**). The ESP method generates multiple time series, i.e., traces, of forecasted streamflow. Forecasts are created using the Sacramento Soil Moisture Accounting hydrologic model, which is initialized with current Basin conditions for soil moisture and snowpack and forced with a set of historical time series of precipitation and temperature that matches the model calibration period (currently 1991 through 2020). This process results in a 30-member ensemble for monthly streamflow forecasts based on current Basin conditions and temperature and precipitation that match the 1991-2020 climatological period.

Table C-3
Upper Basin Forecast Points

Fontenelle Inflow
Flaming Gorge Unregulated Inflow
Yampa River Inflow
Taylor Park Inflow
Blue Mesa Unregulated Inflow
Crystal Unregulated Inflow
Morrow Point Unregulated Inflow
Gains Crystal to Grand Junction
Vallecito Unregulated Inflow
Animas River Inflow
Navajo Unregulated Inflow
Powell Unregulated Inflow

C.3.2 Lower Basin Hydrology

For modeling purposes in CRMMS, the Lower Basin is the portion of the model below the Lees Ferry Gage. Although the intervening flows between Glen Canyon Dam and the Lees Ferry Gage are physically located in the Upper Basin above the Lee Ferry Compact Point, the methodology used to project these flows matches the methodology used to project the Lower Basin inflows; therefore, flows at Lees Ferry Gage are included in this section. The hydrology inputs for the Lower Basin are intervening flows (**Table C-4**) which may be positive, representing a gain in the reach, or negative, representing a loss in the reach.

Table C-4
Lower Basin Intervening Flow Points

Glen Canyon Dam to Lees Ferry
Lees Ferry to USGS gage at Grand Canyon
USGS gage at Grand Canyon to Hoover Dam
Hoover Dam to Davis Dam
Davis Dam to Parker Dam
Parker Dam to Imperial Dam
Imperial Dam to Northerly International Boundary with Mexico

The intervening inflows are the estimated volumes calculated by Reclamation's Lower Colorado Gain-Loss Model. This method calculates the intervening inflows using a mass balance approach. CRMMS uses the calculated intervening inflow values from the same 30-year period for which the CBRFC produces forecast traces (1991 through 2020).

Just as the model rotates through Upper Basin inflow traces corresponding to a particular year in the 30-year calibration period, the model also rotates through intervening flows in the Lower Basin corresponding to the same year. For example, the Upper Basin inflow forecast corresponding to the

1991 trace is generated from the temperature and precipitation from 1991 through 1995. In this 1991 trace, the intervening inflows for all seven reaches below Glen Canyon Dam is the historical calculated intervening inflows from 1991 through 1995.

C.3.3 Hydrology used in CRMMS SEIS Modeling

The hydrologies used in the SEIS are derived from the September 2022 ESP Upper Basin forecast and associated Lower Basin intervening flows. Three sets of ESPs are used in the SEIS modeling:

- 100-percent ESP: no adjustment to the streamflow forecasts
- 90-percent ESP: streamflow forecasts are reduced by 10 percent
- 80-percent ESP: streamflow forecasts are reduced by 20 percent

ESP forecasts are adjusted at each forecast location by reducing the monthly streamflow forecast by the desired percentage. The following equation was used to reduce each month's streamflow forecast:

$$AdjustedMonthlyStreamflow_i = MonthlyStreamflow_i - |MonthlyStreamflow_i| \times PercentReduction$$

where, *PercentReduction* is the percent reduction (i.e., 0.1 or 0.2 for 90-percent ESP and 80-percent ESP, respectively), and *i* is a single forecast location for all locations described in Sections C.3.1 and C.3.2.

The equation allows for the adjustment of both negative and positive forecasts.

The three sets of ESPs, 100-percent ESP, 90-percent ESP, and 80-percent ESP, are combined into a 90-member hydrology scenario for SEIS analysis purposes. The three sets of ESPs allow for analysis of a wider range of low flow hydrologic scenarios beyond those experienced during the recent thirty years (1991-2020). It is possible; however, that future flows may include periods of wet or dry conditions that are outside the 90-member scenario sequences analyzed.

C.4 Initial Reservoir Conditions

CRMMS was initialized with observed August 2022 end-of-month reservoir conditions shown in **Table C-5**.

Table C-5
End-of-Month Reservoir Conditions used as Initial Conditions

Reservoir	Elevation (feet above mean sea level [msl])	Storage (af)
Fontenelle	6,502.43	306,420
Flaming Gorge	6,014.73	2,735,239
Taylor Park	9,310.33	70,421
Blue Mesa	7,455.69	341,476
Morrow Point	7,152.25	110,833

Reservoir	Elevation (feet above mean sea level [msl])	Storage (af)
Crystal	6,751.42	16,524
Vallecito	7,637.64	59,556
Navajo	6,023.95	902,138
Powell	3,531.69	5,937,930
Mead	1,044.28	7,275,375
Mohave	642.87	1,695,022
Havasu	448.16	582,945

C.5 Reservoirs Upstream of Lake Powell

Nine Upper Basin reservoirs are simulated in CRMMS. Each of the nine Upper Basin reservoirs included in the model has an individual operation plan. Some facilities are operated to meet storage or elevation targets, while others feature environmentally regulated, controlled, consistent releases. Within the model, each reservoir has a set of rules to guide the specific operations and the model solves by using the logic in those operating rules. The following briefly describes the various Upper Basin reservoirs along with a high-level description of the logic in RiverWare for simulating operations within the Upper Basin.

In a rule-based model such as CRMMS in Ensemble Mode, general assumptions must be made for the model to solve. The rules developed for CRMMS are, ideally, the best representation of operations that can be projected. In practice, however, there are sometimes differences between the projected operations produced by the model and actual operations. For example, many reservoirs in the Upper Basin are operated following the principles of Adaptive Management. As such, operations may be altered to meet various objectives of the reservoirs' Adaptive Management Work Groups on an ad-hoc or experimental basis. Such ad-hoc or experimental operations cannot be known in advance, within the 5-year model outlook. As such, CRMMS Ensemble Mode projections may differ from actual operations, even under similar hydrologic conditions.

The operations of the Upper Basin reservoirs above Lake Powell are modeled the same in the No Action Alternative and Action Alternative 1. Action Alternative 2 includes modeling assumptions regarding contributions from the Upper Initial Units for releases from zero to 500,000 af per Drought Response Operations Agreement (DROA) Year (May 1 – April 30), which will conform to the DROA and its implementing documents and will be made only to help protect Lake Powell elevation 3,500 feet. The analysis refers to these as "potential DROA contributions." Section C.5.8 details about the potential DROA contributions modeling assumptions and how they may affect modeled operations of Flaming Gorge, Aspinall, and Navajo.

C.5.1 Fontenelle Reservoir

Fontenelle Reservoir is located on the Green River about 24 miles southeast of La Barge, Wyoming. Fontenelle Reservoir is operated to meet various target elevations throughout the year while staying within practical and authorized limits.

C.5.2 Flaming Gorge Reservoir

Flaming Gorge Reservoir is located on the Green River about 32 miles downstream of the Utah-Wyoming border and upstream of the confluence with the Yampa River. The operations of Flaming Gorge Reservoir meet the requirements detailed in the 2006 Record of Decision for the Operation of Flaming Gorge Dam Final Environmental Impact Statement (2006 Flaming Gorge ROD; Reclamation 2006a) that were designed to achieve the authorized purposes of the Colorado River Storage Project Act while addressing environmental requirements. The 2006 Flaming Gorge ROD outlines the operational guidelines of Flaming Gorge and implements, to the extent possible, recommendations to assist in the recovery of four endangered fish species, outlined in the 2000 Flow and Temperature Recommendations for Endangered Fish in the Green River Downstream of Flaming Gorge Dam (Muth 2000).

Flaming Gorge operations are governed by the April through July unregulated inflow into the reservoir, which determines the corresponding hydrologic classification, spring peak and base flow targets from the 2006 Flaming Gorge ROD (Reclamation 2006a) for the year. April – July releases are modeled at the daily time step in CRMMS to approximate the sub-monthly component of the spring peak targets. The model logic determines typical daily operations from April through July before summing to a monthly release. During the March to April transition period, Flaming Gorge operations try to achieve a May 1st storage target. Actual annual operations at Flaming Gorge are determined in a consultation process with other agencies; CRMMS Ensemble Mode cannot model these adaptive management decisions; therefore, model results do not include possible future adaptive management decision changes to the logic described above.

C.5.3 Taylor Park Reservoir

Taylor Park Reservoir is located on the Taylor River, a tributary of the Gunnison River on the western slope of Colorado's Rocky Mountains. Taylor Park Reservoir is operated with a rule curve to meet various target elevations throughout the year while staying within practical and authorized limits.

C.5.4 Aspinall Reservoirs – Blue Mesa, Morrow Point, and Crystal

The Aspinall Unit consists of three reservoirs: Blue Mesa, Morrow Point, and Crystal, in series along the Gunnison River in western Colorado. The operations of the Aspinall Unit meet the requirements detailed in the April 2012 Record of Decision for the Aspinall Unit Operations Final Environmental Impact Statement (2012 Aspinall ROD; Reclamation 2012) and the decree quantifying the Federal Reserved Water Right for the Black Canyon of the Gunnison, which specify the spring peak outflow hydrographs and base flows for the rest of the year based on the hydrologic conditions upstream of Blue Mesa Reservoir. The 2012 Aspinall ROD provides specifications to avoid jeopardizing the continued existence of fish listed under the Endangered Species Act and to ensure the dam's operations do not result in the destruction or adverse modification of critical habitat in the Gunnison River.

Aspinall Unit operations are governed by the April through July unregulated inflow into the reservoir, which determines spring peak and base flow targets for the rest of the year based on the hydrologic conditions above Blue Mesa Reservoir. CRMMS approximates daily flow targets in the 2012 Aspinall ROD and Federal Reserved Water Right for the Black Canyon of the Gunnison by first modeling typical daily operations for both the spring and baseflow periods and then summing to a monthly release. Morrow Point and Crystal Reservoirs are modeled to maintain elevation targets 7,153.73 feet and 6,753.04 feet, respectively.

C.5.5 Vallecito Reservoir

Vallecito Reservoir is on the Pine River which flows into the San Juan River. The reservoir is located 18 miles northeast of Durango, Colorado. Vallecito Reservoir is operated with a rule curve to meet various target elevations throughout the year while staying within practical and authorized limits.

C.5.6 Navajo Reservoir

Navajo Reservoir is located on the San Juan River above the confluence with the Animas River. The reservoir is operated to meet environmental requirements outlined in the July 2006 Record of Decision for the Navajo Reservoir Operations, Navajo Unit- San Juan River New Mexico, Colorado, Utah Final Environmental Impact Statement. (Reclamation 2006b). Navajo Reservoir also provides for the diversion of NIIP water from Navajo Reservoir, and other municipal and industrial uses throughout the San Juan Basin. The minimum active storage at Navajo Reservoir is at 5,990 feet, at which point the NIIP can no longer divert water.

Navajo Reservoir operations are modeled to first meet environmental baseflow requirements at downstream gages stated in the July 2006 Record of Decision for the Navajo Reservoir Operations, Navajo Unit- San Juan River New Mexico, Colorado, Utah Final Environmental Impact Statement (Reclamation 2006b); because of the CRMMS spatial scale, it is assumed that all flow targets are for the San Juan River near Farmington, New Mexico. If available additional water is released as a spring peak, a spring release pattern is selected to bring Navajo Reservoir closest to the September 30th storage target while staying within practical and authorized limits including maintaining NIIP diversions. If the reservoir pool elevation is projected to go below 5,990 feet, the minimum elevation for NIIP diversions, the outflow, and NIIP diversions are proportionally reduced.

C.5.7 DROA Year 2022 Contribution Assumptions

The CRMMS modeling assumes Flaming Gorge DROA releases consistent with the September 2022 CRMMS simulation for DROA Year 2022 (i.e., May 2022 through April 2023). The DROA releases from Flaming Gorge are a projected 500,000 af for May 2022 through April 2023[1] and are added to the Flaming Gorge releases solved for CRMMS using the operations described in **Section C.5.2**. At the end of run cycle 2, CRMMS has completely solved for reservoir operations above Lake Powell, including Flaming Gorge. At the beginning of run cycle 3, the input DROA releases, which are populated from the September 2022 24-Month Study, are added to Flaming Gorge releases for September 2022 through May 2023, resulting in an increased release from Flaming Gorge. This assumption is included in modeling of all SEIS alternatives.

C.5.8 Potential DROA Contribution Assumptions in Action Alternative 2

Action Alternative 2 includes modeling assumptions for potential DROA contributions to Lake Powell for DROA Years 2024 through 2026 (i.e., May 2024 through the end of the simulation).

[1] The projected 500,0000af DROA release was reduced in March 2023 but is not reflected in the modeling assumptions. It may be updated for the Final SEIS.

Potential DROA contributions range from zero to 500,000 af per DROA Year when Lake Powell is projected to be below 3,525 feet at the end of the operating year, depending on water available for potential DROA contributions from Flaming Gorge, Navajo, and Blue Mesa Reservoirs. Potential DROA contributions are distributed proportionally across Flaming Gorge, Navajo, and Blue Mesa Reservoirs based on each reservoir's storage above key reservoir elevation targets.

In CRMMS, the potential DROA contribution is calculated in August of run cycle 4. The rules are higher priority than the Lake Powell operations and therefore solve after the Lake Powell operating tier and operating year releases have been calculated. The potential DROA contributions are only assumed to occur if Lake Powell is projected to be below 3,525 feet during Lake Powell's initial calculation in the Lower Elevation Release Tier (see **Section C.6.3** for more details); this also results in a modeled 6.0 million acre-feet (maf) or less release from Lake Powell. The potential DROA contributions rules then distribute up to an additional 500,000-af release from Flaming Gorge, Blue Mesa, and Navajo Reservoirs.

To determine the portion of the 500,000-af additional release applied to Flaming Gorge, Blue Mesa, and Navajo Reservoirs, the available storage that can be released from all three reservoirs is calculated. For Flaming Gorge, the storage available for a DROA contribution is calculated by taking the difference between the projected storage at end of the DROA year (i.e., April in the following operating year) and the storage at 5,890 feet (19 feet above minimum power pool). For Blue Mesa Reservoir, the storage available for DROA contribution is calculate by taking the difference between the storage at the end of December of the following year and the storage at 7,412 feet (19 feet above minimum power pool). For Navajo, the storage available for DROA contribution is calculated by taking the difference between the projected storage at the end of September of the following year and the storage at 6,050 feet (60 feet above the NIIP diversion intake). The total available storage for DROA contribution is calculated as the sum of each reservoir's available storage volume. If the total available storage for DROA contribution is less than 500,000 af, then the potential DROA contribution is set to the volume of available storage. Each reservoir's storage available for a DROA contribution is constrained to be non-negative.

The percent of the potential DROA contributions from Flaming Gorge, Blue Mesa, and Navajo Reservoirs are calculated as:

$$PotentialContributionPercent_i = \frac{AvailableStorage_i}{\sum_i AvailableStorage_i}$$

where i is each reservoir (Flaming Gorge, Blue Mesa, and Navajo).

The potential DROA contributions are released over the DROA Year using the monthly proportions in **Table C-6**. These monthly distributions are based off the monthly distribution of DROA releases in past planned DROA releases (i.e., DROA Year 2022 for Flaming Gorge Reservoir and 2021 for Blue Mesa and Navajo Reservoirs).

Table C-6
Monthly Distribution of Potential DROA Contributions

Month	Flaming Gorge Reservoir	Blue Mesa Reservoir	Navajo Reservoir
	percent	percent	percent
January	8.58	0.00	0.00
February	7.78	0.00	0.00
March	8.58	0.00	0.00
April	4.79	0.00	0.00
May	21.56	0.00	0.00
June	2.40	0.00	0.00
July	3.59	0.00	0.00
August	9.78	38.89	0.00
September	9.58	50.00	0.00
October	7.58	11.11	0.00
November	7.19	0.00	50.00
December	8.59	0.00	50.00

In the calculation of monthly release for the DROA Year, the additional DROA contribution is added to the reservoir's current release. The new projected release is then constrained to ensure it would not cause the reservoir to drop below dead pool or below the NIIP diversion at Navajo. Morrow Point and Crystal Reservoirs are then resolved for the DROA Year since their inflow has been adjusted due to the potential DROA contributions. These reservoirs adjust their outflow to ensure they stay at their storage targets, passing the DROA contribution from Blue Mesa Reservoir.

C.6 Lake Powell Operation

Lake Powell is the most downstream reservoir in the Upper Basin and is impounded by Glen Canyon Dam. Glen Canyon Dam is near Page, Arizona and is located 17 miles upstream of Lee Ferry, the delineation point between the Upper and Lower Basins.

In CRMMS, Lake Powell operations logic calculates the annual operating year release, followed by disaggregating the annual release to monthly releases. These operations are summarized in the sections below. **Section C.6.1** describes modeling assumptions common to all alternatives. **Section C.6.2** describes model assumptions for Lake Powell operating tiers used only in the No Action Alternative, and **Section C.6.3** includes model assumptions for operating tiers used in Action Alternative 1 and Action Alternative 2.

C.6.1 Assumptions Common to All Alternatives

CRMMS solves for Lake Powell operating tiers in CRMMS run cycles 3 and 4. The following rules are solved for in run cycles 3 and 4. In August, operations of Lake Powell are set for the entire following operating year (i.e., October through September). An initial operating year release of 8.23 maf is used to solve for the end-of-calendar year (EOCY) pool elevation, which is used to determine the operating tier and annual operating year release volume. The annual release is then disaggregated into monthly releases using the Long-term Experimental and Management Plan release patterns. The Lake Powell assumed monthly releases for CRMMS are in **Attachment C-1**.

The monthly releases solved using **Table Attachment C-1** can be constrained due to physical limitations at Glen Canyon Dam. Water can be released through the power plant turbines until the pool elevation drops below 3,490 feet. Once Powell is below 3,490 feet, releases are made through the river outlet works. There are four river outlet works at Glen Canyon Dam. The capacity of the river outlet works varies with the elevation of Lake Powell; the higher the pool elevation, the higher the potential release through the river outlet works. CRMMS computes the maximum monthly release based on the Lake Powell elevation using **Table C-7** and interpolates for the capacity between elevations list in **Table C-7**. For the SEIS modeling, three out of four river outlet works are assumed available for use at any given time because of the need for periodic inspections and any associated maintenance activities. Reclamation believes this is a conservative and prudent estimation given the historical and future operations and maintenance requirements for the river outlet works.

Table C-7
CRMMS modeled river outlet work capacity by Lake Powell Elevation

Lake Powell Elevation	Capacity (1 river outlet work)		Capacity (3 river outlet works)	
feet	cubic feet/ second (cfs)	af/month*	cfs	af/month*
3,490	3,660	225,045	10,980	675,134
3,480	3,620	222,585	10,860	667,755
3,470	3,520	216,436	10,560	649,309
3,460	3,380	207,828	10,140	623,484
3,450	3,140	193,071	9,420	579,213
3,440	2,860	175,855	8,580	527,564
3,430	2,560	157,408	7,680	472,225
3,420	2,200	135,273	6,600	405,818
3,410	1,760	108,218	5,280	324,655
3,400	1,200	73,785	3,600	221,355
3,390	800	49,190	2,400	147,570
3,380	400	24,595	1,200	73,785
3,370	0	0	0	0

* Computed using 31 days/month.

C.6.2 No Action Alternative

Lake Powell operating tiers are determined based on projected EOCY pool elevation at Lake Powell. In operating year 2022, the Lake Powell annual release was reduced from 7.48 maf to 7.00 maf, resulting in a reduced release volume of 0.480 maf that normally would have been released from Glen Canyon Dam to Lake Mead as part of the 7.48 maf annual release volume, consistent with routine operations under the 2007 Colorado River Interim Guidelines for Lower Basin Shortages and the Coordinated Operations for Lake Powell and Lake Mead (2007 Interim Guidelines). The reduction of releases from Glen Canyon Dam in operating year 2022 (resulting in increased storage in Lake Powell) is accounted for "as if" this volume of water had been delivered to

Lake Mead. Therefore, operating tiers in the No Action Alternative are determined based on an 'effective' EOCY pool elevation. The effective pool elevation at Lake Powell is determined by subtracting 0.480 maf to the EOCY storage, then determining the pool elevation associated with the effective storage.

For operating year 2023, the August 2022 24-Month Study projected the January 1, 2023, effective pool elevation to be less than 3,525 feet, which results in 2023 operations being governed by the Lower Elevation Balancing Tier. CRMMS rules are then used to solve for the 2023 annual release in the Lower Elevation Balancing Tier.

For operating years beyond 2023, CRMMS will solve for the Lake Powell operating tier and annual release for the entire operating year in August. The first step of solving for the Lake Powell operating tier is to set the annual release to 8.23 maf. This allows for Lake Powell to solve for the releases for the entire operating year and allows Lake Powell to solve for storage and other parameters since inflow is solved for in run cycle 2. This includes the EOCY pool elevation, which is used to set the Lake Powell operating tier.

The effective EOCY pool elevation is calculated by subtracting 480,000 af from the EOCY storage. Then, the Lake Powell operating tier is solved for as follows using the projected effective EOCY pool elevation:

- If the effective Lake Powell EOCY pool elevation is greater than or equal to the Equalization Level (**Table C-8**), the operating year releases are governed by Equalization Tier operations.
- If the effective Lake Powell EOCY pool elevation is less than the Equalization Level and greater than or equal to 3,575 feet, the operating year releases are governed by the Upper Elevation Balancing Tier.
- If the effective Lake Powell EOCY pool elevation is less than 3,575 feet and greater than or equal to 3,525 feet, the operating year releases are governed by the Mid-Elevation Release Tier.
- If the effective Lake Powell EOCY pool elevation is less than the 3,525 feet, the operating year releases are governed by the Lower Elevation Balancing Tier.

The annual release for each tier is described below for the No Action Alternative. The last section describes how Lake Powell operating year releases are disaggregated to a monthly scale.

Table C-8
Lake Powell Equalization Level Table

Year	Equalization Elevation (feet msl)
2023	3,662
2024	3,663
2025	3,664
2026	3,666

In the following sections for the No Action Alternative, references to Lake Powell or Lake Mead pool elevation or storage are assumed to be the effective pool elevation or storage. This includes balancing volume calculations and end of year elevations.

C.6.2.1 Equalization Tier

Under the No Action Alternative, the equalization of storage between Lake Powell and Lake Mead is modeled with a rule that first calculates how much water would be released to equalized Lakes Powell and Mead. The release for equalization is computed by taking half of the difference between the predicted End of Water Year (EOWY) volumes of Lake Powell and Lake Mead. Evaporation and bank storage losses at Lake Powell and Lake Mead are estimated in the calculation. The equalization release is then constrained by choosing the minimum of the equalization release, the release to take Lake Mead to 1,105 feet and the release to take Lake Powell to 20 feet below the Equalization Level. The rule then sets the Lake Powell operating year release to the maximum of the constrained equalization volume and an 8.23-maf release. Monthly releases from Powell are then calculated for the operating year using **Table Attachment C-1**.

After Lake Powell and Lake Mead have both resolved, a higher priority rule refines the equalization release. This rule is also used to refine Upper Elevation Balancing equalization releases. The rule calculates the volume deviation of the EOWY storage at Lake Powell and Lake Mead from target levels (i.e., equalization, to achieve Lake Mead at 1,105 feet, or to achieve Lake Powell 20 feet below the Equalization Level). The deviation volume then adjusts Lake Powell's release to achieve the EOWY target, subject to a minimum release of 8.23 maf. This rule is allowed to iterate so that EOWY target elevations are achieved to within a specified tolerance.

C.6.2.2 Upper Elevation Balancing Tier

Once it is determined that Lake Powell is starting the year in the Upper Elevation Balancing Tier, the projected EOWY pool elevation at the end of the next operating year, e.g., September 30, 2024, when the model has set the operating tier in August 2023, is used to determine how much water is released.

If the projected Lake Powell EOWY pool elevation is above the Equalization Level, then an April switch to Equalization is modeled and the operating year release is set based on Equalization logic (described in the previous section) and is constrained to a minimum of 8.23 maf.

Otherwise, (Lake Powell's projected EOWY pool elevation is less than or equal to the Equalization Level) Lake Powell's releases are modeled consistent with the Upper Elevation Balancing constraints and are dependent on Lake Mead's EOWY pool elevation:

- If the Lake Mead EOCY pool elevation is greater than or equal to 1,075 feet, the operating year release necessary to balance Lake Powell and Lake Mead's EOWY storage is calculated but constrained to be within the range of 8.23 maf to 9.0 maf.
- If Lake Mead EOCY pool elevation is greater than 1,075 feet and the Lake Powell EOWY pool elevation is less than or equal to 3,575 feet, the operating year release is 8.23 maf.

- If the Lake Mead EOCY pool elevation is less than 1,075 feet, the operating year release necessary to balance Lake Powell and Lake Mead EOWY storage is calculated but constrained to be within the range of 7.0 maf to 9.0 maf.

C.6.2.4 Mid-Elevation Release Tier

The Mid-Elevation Release Tier modeled by first checking Lake Mead's projected EOCY pool elevation. If the Lake Mead EOCY pool elevation is greater than or equal to 1,025 feet, Lake Powell's operating year release is set to 7.48 maf, otherwise the operating year release is set to 8.23 maf.

C.6.2.4 Lower Elevation Balancing Tier

For operating year 2023 and 2024, the Lower Elevation Balancing Tier operations are modeled in a way that protects critical elevations at Lake Powell. This is done by assessing potential balancing releases in April 2023 and limiting any balancing releases (with a minimum of 7.00 maf) to protect Lake Powell from declining below elevation 3,525 feet at the end of December of the following year. For operating years 2025 and 2026, balancing releases are not limited to protect Lake Powell from declining below critical elevations.

In CRMMS, the Lower Elevation Balancing Tier is modeled by first setting the Lake Powell operating year release to 7.0 maf, which causes Lake Powell to resolve for monthly releases and pool elevations. Next, Lower Elevation Balancing releases are calculated with different constraints dependent on the operating year, as previously described:

- In operating years 2023-2024
  - If the Lake Powell EOWY pool elevation is greater than the protection threshold of 3,535 feet[2], two potential annual releases are calculated: (1) the operating year release necessary to balance Lake Powell and Lake Mead's EOWY storage is calculated but constrained to be within the range of 7.0 maf to 9.5 maf. and (2) the release needed so that Lake Powell's EOWY pool elevation is 3,535 feet. The minimum of these two releases is used to set Lake Powell's annual release. If the EOWY Lake Powell pool elevation is less than the protection threshold of 3,535 feet with a 7.0 maf release, the release is not adjusted.
- In operating years 2025 and beyond
  - The operating year release necessary to balance Lake Powell and Lake Mead's EOWY storage is calculated but constrained to be within the range of 7.0 maf to 9.5 maf.

C.6.2.4 Disaggregation from Annual to Monthly Release

Lake Powell operating year releases are disaggregated to monthly releases anytime the operating year release volume is set for Lake Powell. The operating year volume is used to select the closest operating year release pattern from the **Table Attachment C-1**; for operating year releases between

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[2] The protection threshold of 3,535 feet was used for modeling purposes since it is the EOWY elevation needed during an average year to achieve an EOCY elevation of 3,525 feet (or higher).

set values, the monthly releases are interpolated between the two columns with the closest operating year release.

There are a few special cases where the monthly releases are not interpolated directly from **Table Attachment C-1**. If there is an equalization outflow in the Upper Elevation Balancing Tier, then the outflows from the October until March follow a path of a 9.0-maf release and then will be either the maximum power plant release or the remaining amount of volume to meet the equalization annual release volume. The April through September releases are calculated to attempt to release the remainder operating year release volume while constraining releases to power plant capacity. If the operating year release volume is less than 8.23 maf, the release pattern is set to the 7.48-maf pattern for October through December. For January through September, the remainder of the operating year release volume is released proportional to **Table Attachment C-1**.

The disaggregated monthly releases are further constrained so that the monthly releases to do not exceed what can be moved through the river outlet works. If a monthly release is constrained, the volume is tracked and is attempted to be released later in the operating year to maintain the desired operating year release, if possible.

C.6.3 Action Alternatives

The Lake Powell operations for Action Alternatives 1 and 2 are the same. For operating year 2023, Lake Powell operations are solved for as described in the No Action Alternative, where effective pool elevation is used to calculate the annual release. For operating years 2024 to 2026, the Lake Powell operating tier and operating year release are assumed to use the physical elevations at Lake Powell and Lake Mead. The Lake Powell operating tier is solved for as follows using the projected physical pool elevation:

- If the projected Lake Powell EOCY pool elevation is greater than or equal to the Equalization Level (**Table C-8**), the operating year releases are governed by Equalization Tier operations (see **Section C.6.3.1**).
- If the Lake Powell EOCY pool elevation is less than the Equalization Level and greater than or equal to 3,575 feet, the operating year releases are governed by the Upper Elevation Balancing Tier (see **Section C.6.3.2**).
- If the Lake Powell EOCY pool elevation is less than 3,575 feet, the operating year releases are governed by the new Lower Elevation Release Tier (see **Section C.6.3.3**).

The operating year release calculation for each tier is described below for the action alternatives.

C.6.3.1 Equalization Tier

The Equalization Tier method for Lake Powell under the action alternatives is identical to that of the No Action Alternative.

C.6.3.2 Upper Elevation Balancing Tier

The Upper Elevation Balancing Tier method for Lake Powell under the action alternatives is identical to that of the No Action Alternative.

C.6.3.3 Lower Elevation Release Tier

Operating year 2023 is in the Lower Elevation Balancing Tier, as set by the August 2022 24-Month Study. The calculation of the Lake Powell annual release for operating year 2023 is identical to the No Action Alternative.

For operating years beyond 2023, the Lower Elevation Release Tier is modeled by first setting the annual release volume to 8.23 maf. Lake Powell resolves with the 8.23-maf annual release for monthly releases and pool elevations. Next, a rule checks if the projected Lake Powell EOWY pool elevation (e.g., September 30, 2024, when the model is executing in August 2023) and sets the operating year release as follows:

- If the projected Lake Powell EOWY pool elevation is greater than or equal to 3,575 feet, set the operating year release to 8.23 maf.
- If the projected Lake Powell EOWY pool elevation is less than 3,575 feet and greater than or equal to 3,550 feet, set the operating year release to 7.48 maf.
- If the projected Lake Powell EOWY pool elevation is less than 3,550 feet and greater than or equal to 3,525 feet, set the operating year release to 7.00 maf.
- If the Lake Powell EOWY pool elevation is less than 3,525 feet, set the operating year release to 6.00 maf.

C.6.3.4 Protection Level

The action alternatives specify a protection level at Lake Powell such that if, in any month, Lake Powell's elevation is below 3,500 feet, the Lake Powell release would be set to maintain or increase the elevation with a maximum release of 6.0 maf; the goal would be to maintain Long-term Experimental and Management Plan minimum flows subject to run-of-the-river conditions, operational constraints, and prudent operations as determined by Reclamation.

In CRMMS, this is modeled by constraining monthly releases to ensure the pool elevation does not drop below 3,500 feet. If the operating year starts with Lake Powell below 3,500 feet. and if the monthly release will cause the elevation to decrease, then the monthly release is decreased to maintain the current elevation and is also constrained by river outlet works capacity[3]. If the monthly outflow results in an increase in pool elevation, the method will try to release any constrained volume from earlier in the operating year while staying above the protection elevation of 3,500 feet.

If Lake Powell is greater than or equal to 3,500 feet at the beginning of the operating year, then all monthly releases are constrained such that the end-of-month pool elevation does not fall below 3,500 feet. The constrained release volume is tracked throughout the operating year. If a release for a given month is above 3,500 feet, then the method will try to release previously constrained volume such that Lake Powell remains at or above 3,500 feet at the end of the month.

[3] This is possible because the action alternatives are assumed to not begin until October 2023, so there are traces analyzed that drop below elevation 3,500 feet before this protection level logic is modeled.

C.6.3.5 Disaggregation from Annual to Monthly Release

Lake Powell operating year releases are disaggregated to monthly releases using the same method as the No Action Alternative. To assist in the solution of monthly releases, an additional column was added to **Table Attachment C-1** for a 6.0-maf annual release (**Table C-9**). This monthly distribution is used for modeling purposes only.

Table C-9
Monthly distribution of Lake Powell releases for a 6.0 maf annual release (af)

Annual Total	**6,000,000**
October	410,000
November	430,000
December	510,000
January	570,000
February	500,000
March	530,000
April	470,000
May	470,000
June	500,000
July	560,000
August	600,000
September	450,000

C.7 Lake Mead Operation

Lake Mead is the upper-most reservoir in the Lower Basin. Located 35 miles southeast of Las Vegas, the 726-foot-high Hoover Dam impounds Lake Mead. In CRMMS, Lake Mead operations are modeled by solving for the Lower Basin condition, Lower Basin and Mexico diversions, and intentionally created surplus (ICS) and other conservation activity. **Section C.7.1** describes modeling assumptions common to all alternatives. **Sections C.7.2, C.7.3, and C.7.4** describe Lake Mead operations for the No Action Alternative, Action Alternative 1, and Action Alternative 2, respectively.

C.7.1 Assumptions Common to All Alternatives

CRMMS solves for the Lower Basin operating condition in CRMMS run cycles 3 and 4. In August, operations of Lake Powell are set for the entire following operating year (i.e., October through September). Once Lake Powell releases are set for the entire operating year, the Lower Basin condition can be solved, which occurs in the January timestep. After the condition is set, depletion schedules for the Lower Division States and Mexico may be modified in accordance with the requirements of the operating condition for the entire calendar year based on the 2007 Interim Guidelines, 2019 Drought Contingency Plans (DCPs), and Minute 323. Assumed ICS activity may also affect the water user depletions. Once demands below Lake Mead are calculated, Lake Mead's release is set to meet downstream demands.

For Lower Division States and Mexico use, in the first year of the model run, depletion schedules use water orders that reflect shortage conditions, Lower Basin DCP contributions, reductions under low elevation reservoir conditions, Binational Water Scarcity Contingency Plan (BWSCP) contributions per Minute 323, and signed system conservation agreements. For the remaining years in the model run, depletion schedules reflect "normal" schedules, and represent near-term historical trends in water use. All additional reductions (2007 Interim Guidelines shortages, DCP reductions, reductions under low elevation reservoir conditions and BWSCP contributions per Minute 323, and/or additional shortages in the action alternatives) reduce these "baseline/normal" depletion schedules. Depletion schedules for CRMMS water users that were used in the September 2022 CRMMS modeling are summarized in **Attachment C-2**.

C.7.1.1 Lake Mead/Hoover Dam Flood Control

The Lake Mead flood control logic in CRMMS is based on the 1984 Field Working Agreement between Reclamation and the United States Army Corps of Engineers. There are three flood control procedures in effect for different times of the year. The first procedure is in effect throughout the year. Its objective is to maintain a minimum space of 1.5 maf in Lake Mead, primarily for extreme storm events. This space is referred to as exclusive flood control space and is represented by the space above elevation 1,219.6 feet. The second procedure is used during the period from January to July. The objective during this period is to route the maximum inflow forecast through the reservoir system using specific rates of Hoover Dam outflow, assuming that Lake Mead will fill to elevation 1,219.6 feet at the end of July. The third procedure is used during the space building or drawdown period of August through December. The objective during this period is to gradually draw down the reservoir system, to meet the total system space requirements in each month in anticipation of the next year's runoff.

This logic matches the logic used in the 2007 FEIS. Given the September 2022 conditions and inflow forecast ensemble, there were no instances of simulating flood control operations in the SEIS modeling through 2026.

C.7.2 No Action Alternative

Lake Mead operations and Lower Basin conditions are modeled based on projected EOCY pool elevation at Lake Mead. In operating year 2022, the Lake Powell annual release was reduced from 7.48 maf to 7.00 maf, resulting in a reduced release volume of 0.480 maf that normally would have been released from Glen Canyon Dam to Lake Mead as part of the 7.48-maf annual release volume, consistent with routine operations under the 2007 Interim Guidelines.

The operating year 2022 reduced release from Glen Canyon Dam (discussed in **Section C.6.2**) resulted in decreased storage in Lake Mead. For Lower Basin condition determination, the 2022 release adjustment is accounted for "as if" this volume of water had been delivered to Lake Mead. Therefore, Lower Basin operating conditions in the No Action Alternative are determined based on an 'effective' EOCY pool elevation. The effective pool elevation at Lake Mead is determined by adding 0.480 maf to the EOCY storage, then determining the pool elevation associated with the effective storage.

In the following sections for the No Action Alternative, references to Lake Mead pool elevation or storage are assumed to be the effective pool elevation or storage.

C.7.2.1 Surplus

The Lower Basin operates in a Surplus Condition if the Lake Mead elevation is above elevation 1,145 feet and below an elevation that would trigger space-building or flood control releases pursuant to the 1984 Field Working Agreement between Reclamation and the Army Corps of Engineers (described in **Section C.7.1.1**).

The 2007 Interim Guidelines define two levels of Surplus. A Domestic Surplus is determined if the Lake Mead elevation is above 1,145 feet and below the elevation that triggers a Quantified Surplus. Under a Domestic Surplus, depletion schedules are modified in the Lower Division States consistent with the 2007 Interim Guidelines Section 2.B.2. A Quantified Surplus is determined if water needs to be delivered to reduce the risk of potential reservoir spills based on the 70R Strategy (see 2007 FEIS, Appendix A, Section A.6.2.4). Under a Quantified Surplus, depletion schedules are modified in the Lower Division States consistent with the 2007 Interim Guidelines Section 2.B.3.

C.7.2.2 Normal Conditions

The Lower Basin operates in a Normal Condition if the Lake Mead elevation is above elevation 1,075 feet and below elevation 1,145 feet. If the model determines that a Normal Condition exists, the model retains the default Normal schedules initially assigned in run cycle 1. Depletion schedules might be modified due to ICS creation or delivery logic or for DCP contributions. An ICS Surplus Condition is a type of Normal Condition that is determined when Lake Mead's elevation is in the range above and there is an ICS Creation Plan in place for at least one Lower Basin entity.

C.7.2.3 Shortage Conditions

A Lower Basin Shortage Condition is modeled if the Lake Mead elevation is less than or equal to 1,075 feet. A rule solves for the Shortage Condition in January by comparing Lake Mead's EOCY pool elevation to defined pool elevations as shown in **Table C-10**.

Once the Shortage Condition is set, shortage volumes (**Table C-10**) are assigned to users proportionally to a user's monthly and annual scheduled water user:

$$MonthlyShortage_i = AnnualShortage_i * \left(\frac{MonthlyWaterUse_i}{AnnualWaterUse_i} \right)$$

where *i* is an individual water user.

Diversions for water users are then adjusted with the user's monthly shortage. In Nevada, the entire shortage volume is incurred by Southern Nevada Water Project (SNWP) users (Nevada), and in Arizona, the entire shortage volume is modeled to be incurred by Central Arizona Water Conservation District (CAWCD).

Table C-10
Lower Division State Shortage Volumes

Lake Mead Elevation (feet)	AZ Shortage (af)	NV Shortage (af)	Total Shortage (af)
> 1,075	0	0	0
1,075 to 1,050	320,000	13,000	333,000
< 1,050 to 1,025	400,000	17,000	417,000
< 1,025	480,000	20,000	500,000

C.7.2.4 Minute 323 High and Low Elevation Reservoir Conditions

The Minute 323 defines reductions to Mexico under low elevation reservoir conditions based on projected Lake Mead EOCY pool elevation. Mexico's reductions are shown in **Table C-11**. Adjustments to Mexico's delivery assume the same method to disaggregate the annual reduction to a monthly reduction as the adjustments due to shortage in the Lower Division States (**Section C.7.2.3**).

Table C-11
Mexico Minute 323 Reductions

Lake Mead Elevation (feet)	Mexico Reduction (af)
> 1,075	0
1,075 to 1,050	50,000
< 1,050 to 1,025	70,000
< 1,025	125,000

Distribution of flows to Mexico under high elevation reservoir conditions are modeled in accordance with Minute 323 Section II, when Lake Mead EOCY is at or above elevation 1,145 feet.

C.7.2.5 2019 DCPs and Binational Water Scarcity Contingency Plan

The CRMMS models 2019 DCP contributions in accordance with Exhibit 1 to the Lower Basin DCP Agreement and the Minute 323 BWSCP. The contribution volumes (**Table C-12**) are based on the projected Lake Mead EOCY pool elevation, similar to the Shortage Condition. For modeling purposes, DCP contributions can be made through conversion of existing ICS, simultaneous ICS creation and conversion to DCP-ICS, and/or reducing depletions to create system water. Additional CRMMS ICS assumptions are described in **Section C.7.2.6**.

As previously mentioned, in the first year of the model run, depletion schedules use water orders that reflect shortage conditions, Lower Basin DCP contributions, Minute 323 reductions and contributions. These first-year depletion schedules reflect more guidance and input from states, water users, and Mexico than exist for the subsequent modeled years. In the subsequent years, model assumptions are developed with states, water users, and Mexico to provide a reasonable assumption for how DCP and BWSCP contributions might be made, as described below.

Table C-12
2019 DCP and Minute 322 BWSCP Contribution Volumes

Lake Mead Elevation (feet msl)	DCP (1,000 af) Arizona	Nevada	California	Minute 323 BWSCP (1,000 af)
>1,090	0	0	0	0
1,075 – 1,050	192	8	0	41
<1,050 – >1,045	192	8	0	30
1,045 – >1,040	192	8	0	34
1,040 – >1,035	240	10	200	76
1,035 – >1,030	240	10	250	84
1,030 – 1,025	240	10	300	92
1,075 – 1,050	240	10	350	101
<1,025	240	10	350	150

In Nevada, the DCP contribution is generally made by converting extraordinary conservation (EC)-ICS to DCP-ICS. If there is not enough EC-ICS available to meet the full DCP contribution, Nevada simultaneously creates EC-ICS and converts it to DCP-ICS in the year it is required. If insufficient ICS bank space exists to create DCP-ICS, then contributions are made via system water.

In California, the agreement between Metropolitan Water District of Southern California (MWD) and Coachella Valley Water District (Coachella) is modeled in CRMMS; however, the entire DCP-ICS balance in the CRMMS is tracked in the MWD's ICS account. This means that CRMMS decreases Coachella's water use schedule by 7 percent of California's DCP contribution. Then the MWD makes 100 percent of the DCP contribution by converting EC-ICS to DCP-ICS and can then take delivery of the unused water created by Coachella. If the MWD's EC-ICS balance is insufficient to meet the full DCP contribution, the MWD simultaneously creates EC-ICS and converts it to DCP-ICS in the year it is required. If the ICS bank is full, and/or there is insufficient EC-ICS to meet the entire DCP contribution, then the MWD creates non-ICS water (i.e., system water) to meet the DCP contribution.

In Arizona, the DCP contributions are assumed to be made through simultaneous creation of EC-ICS and conversion to DCP-ICS in the year it is required, and through non-ICS water. If the ICS bank is full, then CAWCD makes the entire DCP contribution through non-ICS water.

In Mexico, BWSCP contributions are assumed to be made through reductions to Mexico's delivery (i.e., via system water), unless other input and assumptions are provided by Mexico.

C.7.2.6 ICS Assumptions

ICS may be created through various mechanisms, including EC, tributary conservation, system efficiency projects, importation of non-Colorado River water, and transfer of Mexico's Water Reserve to Binational ICS. For modeling purposes in CRMMS, ICS creation and delivery is a combination of inputs and logic.

In CRMMS, ICS is modeled in multiple steps. First, non-junior priority ICS accounts are solved. Second, the preliminary ICS for junior priority accounts is solved. Preliminary ICS represents the

ICS creation or delivery volumes that each junior priority entity would like under their ideal scenario. Using the preliminary ICS values, CRMMS then solves the ICS bank sharing. Bank sharing, per the agreements signed in 2020 and 2021, allows Lower Division States to take advantage of the full 2.7 maf of ICS storage through a sharing mechanism. Following the ICS bank sharing, the model then adjusts the preliminary ICS accounts appropriately to finalize ICS creation, deliveries, and balances. Finally, water users' diversions are adjusted to reflect ICS creation and deliveries.

C.7.2.6.1 Constants

Table C-13 list the ICS related assumptions used in CRMMS.

Table C-13
Annual Creation and Delivery Limits

State	Max Annual Creation (1,000 af)	Max Annual Delivery (1,000 af)
Arizona	100	300
California	400	400
Nevada	125	300

CRMMS models the ICS bank sharing agreements from 2020 and 2021. Therefore, the accumulation limits (**Table C-14**) reflect volumes that differ somewhat from those specified in the 2007 Interim Guidelines and Lower Basin DCP. Additionally, there is logic in CRMMS that allows one or more states to exceed their maximum accumulation limit as long as the total Lower Basin ICS accumulation as defined in the Lower Basin DCP (i.e., sum of EC-ICS, DCP-ICS, and Binational ICS) is less than or equal to 2.7 maf. Annual ICS assessments for evaporation are entity and year dependent (**Table C-15**).

Table C-14
Accumulation Limits by Entity in CRMMS

Bank Size (af)	Arizona			California			Nevada
	CAWCD	Tribal	Total	IID	MWD	Total	Total
	300,000	300,000	**600,000**	50,000	1,600,000	**1,650,000**	**450,000**

Table C-15
Annual ICS Assessments (percentages)

Entity	Year 1	Year 2	Year 3
Arizona	10	-	-
IID[1]	5	3	3
MWD	10	-	-
Nevada	10	-	-

[1] After the year of creation, a 3-percent evaporation assessment is applied in all non-shortage years.

C.7.2.6.2 Arizona ICS Assumptions

In general, information about the ICS creation is provided to Reclamation by the state, and CRMMS logic is used to model future ICS delivery and type of ICS created.

ICS creation volumes for all entities in Arizona are generally input based on existing and anticipated ICS Creation Plans (**Table C-16**). The CRMMS allows CAWCD's DCP contribution to be made through creation of ICS and non-ICS water. A default creation volume is input, and rule logic determines if CAWCD's ICS creation is EC-ICS or DCP ICS based on the operating condition of the current year.

Assumed ICS delivery volumes for all entities in Arizona except CAWCD and Gila River Indian Community (GRIC) are also input. Delivery volumes for CAWCD include a default assumption provided by CAWCD plus an assumed delivery for mitigation water. Starting in 2026, CAWCD is modeled to try to take delivery of their remaining ICS by 2036, based on the operating condition. Assumed ICS delivery volumes for GRIC are based on the Arizona Firming Agreement and are assumed to start in 2027. There are no ICS deliveries when Lake Mead is projected to decline below elevation 1025 feet on January 1.

Table C-16
Assumed ICS Creation and Delivery Volumes in Arizona based on the September 2022 CRMMS

		2022	2023	2024	2025	2026
CAWCD	EC/DCP Creation (af)	100,000	60,000	60,000	0	0
	Binational Creation (af)	0	9,092	0	0	9,092
	System Efficiency Creation (af)	0	0	0	0	0
	Default Delivery [1] (af)	49,496	27,500	30,000	0	0
GRIC	EC Creation (af)	78,565	0	0	0	0
	Delivery (af)	0	0	0	0	0

[1]CAWCD delivers an additional 60,000 af when the operating condition is a between 1,075 and 1,025 feet for mitigation purposes. Starting in 2026, CAWCD will also try to take delivery of their remaining ICS by 2036, based on the operating condition.

C.7.2.6.3 California ICS Assumptions

CRMMS includes ICS assumptions in California for the Imperial Irrigation District (IID) and MWD (**Table C-17**). Creation volumes of Binational ICS (assumed conversion from Mexico's Water Reserve pursuant to Minute 323) for the IID and MWD, and System Efficiency ICS for the MWD are input into CRMMS.

Table C-17
Assumed ICS creation volumes by IID and MWD (af)

		2022	2023	2024	2025	2026
MWD	Binational ICS Creation (af)	0	9,092	0	0	9,092
	System Efficiency ICS Creation (af)	0	0	0	0	0
IID	Binational ICS Creation (af)	0	9,092	0	0	9,092

In general, IID tries to keep their ICS bank full (50,000 af). As such, approximately 1,500 af of EC-ICS can be created in normal, ICS surplus, and domestic surplus years. This volume is enough to keep the EC bank at capacity and cover the annual evaporative assessment (**Table C-15**).

There is no logic to create additional EC-ICS by IID above the 1,500 af lost to evaporation during normal and surplus years. Therefore, if the EC-ICS balance decreases more than 1,500 af due to the assumed behavior in flood control surplus conditions, that ICS balance is not currently replenished in the year(s) following the flood control release.

There is currently no assumed delivery of Binational ICS or EC-ICS by IID.

For the MWD, EC-ICS creation and ICS delivery volumes are based on the annual Sacramento River Water Year Classification (SRWYC). The SRWYC index is obtained at http://cdec.water.cC.gov/cgi-progs/iodir/WSIHIST and then resampled using the index sequential method, for use with each inflow trace scenario, consistent with the year the Lower Basin hydrology input is from. Other constraints are described below.

EC-ICS will be created per **Table C-18** in Normal and Shortage conditions, subject to bank space and annual creation limits. ICS creation is also limited to make sure the MWD's annual diversion does not fall below their specified annual minimum diversion of 500,000 af. No creation occurs during surplus or flood control conditions.

Table C-18
EC- ICS creation and delivery volumes by SRWYC

SRWYC	Creation (af)	Delivery (af)
Wet	300,000	0
Above Normal	150,000	0
Below Normal	0	0
Dry	0	100,000
Critical	0	200,000

If a DCP contribution is needed, the MWD converts EC-ICS to meet their contribution. If there is not enough EC-ICS is available to meet the full DCP contribution, the MWD simultaneously creates EC-ICS and converts it to DCP-ICS in the year it is required. If insufficient ICS bank space exists to create DCP-ICS, then contributions are made via system water.

C.7.2.6.4 Nevada ICS Assumptions

Creation of tributary conservation, imported ICS, and Binational ICS are all inputs in CRMMS (**Table C-19**).

If a DCP contribution is needed, the SNWP converts EC-ICS to meet their contribution. If there is not enough EC-ICS available to meet the full DCP contribution, the SNWP simultaneously creates EC-ICS and converts it to DCP-ICS in the year it is required. If insufficient ICS bank space exists to create DCP-ICS, then contributions are made via system water.

Table C-19
Assumed ICS creation volumes by the SNWP

	2022	2023	2024	2025	2026
Tributary Conservation (af)	30,000	30,000	30,000	30,000	30,000
Imported ICS Creation (af)	0	0	0	0	0
Bination ICS Creation (af)	0	9,092	0	0	9,092

EC-ICS is assumed to be created from Nevada's unused apportionment as long as there is bank space available. The SNWP's unused apportionment equals the SNWP's apportionment minus shortages and DCP contributions if EC-ICS was not converted in that year, minus their annual normal demand.

ICS can be used to meet the SNWP's water demands; however, it is typically only used when the demands exceed apportionment, or to offset delivery reductions resulting from shortages. In the 5-year modeling period of the September 2022 CRMMS run, the demands do not exceed the SNWP's apportionment.

C.7.3 Action Alternative 1

The Lake Mead operations and Lower Basin conditions for Action Alternative 1 are similar to the No Action Alternative, i.e., shortage and DCP contribution volumes are based on Lake Mead elevations. For operating year 2023, Lake Mead operations are solved for as described in the No Action Alternative, where effective pool elevation is used to calculate Lake Mead operations and the Lower Basin condition. For operating years 2024 to 2026, the Lake Mead operations and Lower Basin conditions are solved for using the physical elevations at Lake Mead.

C.7.3.1 Surplus

The Surplus model assumptions for the Lower Basin under the Action Alternative 1 is identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.2 Normal Conditions

The Normal Condition model assumptions for the Lower Basin under the Action Alternative 1 is identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.3 Shortage Condition

Under Action Alternative 1 for operating years 2024 through 2026, the Lower Basin is modeled to operate in a Shortage Condition when projected Lake Mead EOCY pool elevation is at or below 1,090 feet. For 2023, operations are identical with the No Action Alterative. In CRMMS, a rule solves for the Shortage Condition in January by comparing Lake Mead's previous EOCY pool elevation to defined pool elevations in the **Table C-20**; the total Lower Division States shortage volumes correspond to the Shortage Condition and operating year in **Table C-20**. The total shortage is then distributed by priority among the Lower Division States and water users by following the method used in the Shortage Allocation Model for Action Alternative 1 (see **Appendix D**).

Table C-20
Lower Division States' Shortages and DCP Contributions

Lake Mead Elevation (feet)	Shortages	DCP Contributions	Additional Shortages in Action Alternatives		Total Combined (Shortages + DCP Contributions)	
	2007 Interim Guidelines	2019 DCPs	Additional Shortage in 2024	Additional Shortage in 2025-2026	Action Alts 2024	Action Alts 2025-2026
1,090 to > 1,075	0	200	200	200	400	400
1,075 to 1050	333	200	533	533	1,066	1,066
< 1,050 to > 1,045	417	200	617	617	1,234	1,234
1,045 to > 1,040	417	450	867	867	1,734	1,734
1,040 to > 1,035	417	500	1,166	1,166	2,083	2,083
1,035 to > 1,030	417	550	1,116	1,283	2,083	2,250
1,030 to 1,025	417	600	1,066	1,483	2,083	2,500
< 1,025 to 1,000	500	600	983	1,900	2,083	3,000
< 1,000 to 975	500	600	983	2,233	2,083	3,333
< 975 to 950	500	600	983	2,567	2,083	3,667
< 950	500	600	983	2,900	2,083	4,000

The distribution of shortages among water users was computed outside of CRMMS and is applied in two stages. When distributing shortage volumes by priority using the Shortage Allocation Model method, total reductions are inclusive of reductions specified by the 2007 ROD and 2019 DCPs. In Stage 1, Nevada and Arizona users are shorted. Nevada is assigned 4 percent of the total reduction, which is Nevada's apportionment divided by the total Lower Division States' apportionment (i.e., 300 kaf/7,500 kaf). The remainder of the total reduction is assigned to Arizona, which is 96 percent of the total reduction. Once Arizona Priority 4 entitlements are fully shorted (i.e., water use is set to zero), Stage 2 is entered.

In Stage 2, all Lower Division States' uses are reduced proportional to the remaining consumptive uses scheduled in CRMMS. Reductions taken by Nevada and Arizona in Stage 1 are subtracted from each state's annual scheduled consumptive use when determining state reductions.

$$Stage2Reduction_n = Stage2Reduction * \left(\frac{ScheduledUse_n - Stage1Reduction_n}{LDSTotalUse - Stage1Reduction}\right)$$

where *n* is an individual state.

Once the total state reductions are calculated for each Lower Basin Shortage Condition, total reductions are split into reduction types (i.e., 2007 ROD shortage, Action Alternative 1 shortage, and 2019 DCP contributions). The 2019 DCP contributions can be larger than the specified additional shortage based on the modeled application of Action Alternative 1. In this case the larger volume is applied, which causes larger total reductions than the volumes based on a given elevation range. A summary of modeled shortage by state and priority for Action Alternative 1 is in **Attachment C-4, Table Attachments C-6**, **C-7**, and **C-8**. Tables are provided for 2024, 2025, and

2026 separately because CRMMS depletion schedules vary slightly each year, which results in slightly different distributions of shortage.

Within each state, reductions are distrusted by priority, where the lowest priority users are shorted completely before shorting any higher priority user. The assumed priorities of CRMMS users are summarized in **Attachment C-3**. Shortages that are assigned to a specific priority are distributed proportionally across users in a priority group based on CRMMS input annual water depletion schedules.

$$MonthlyShortage_i = AnnualShortage_P * \left(\frac{AnnualWaterUse_i}{AnnualWaterUse_P}\right) * \left(\frac{MonthlyWaterUse_i}{AnnualWaterUse_i}\right)$$

where *P* is a group of water users in the same priority within a state, and *i* is the specific water user within the priority group.

In **Appendix D**, an alternative method to the Action Alternative 1 Shortage Allocation Model is analyzed. The proposed revision adjusts how the Lower Division States' shortage is distributed. This revised method was applied to CRMMS and is analyzed in **Attachment C-5**.

C.7.3.4 Minute 323 High and Low Elevation Reservoir Conditions

The Minute 323 model assumptions for the Lower Basin under the Action Alternative 1 are identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.5 DCP and BWSCP

The DCP and BWSCP model assumptions for the Lower Basin under the Action Alternative 1 are identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.3.6 ICS Assumptions

The ICS model assumptions for the Lower Basin under the Action Alternative 1 are identical to that of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4 Action Alternative 2

The Lake Mead operations and Lower Basin conditions for Action Alternative 2 are similar to the No Action Alternative, i.e., shortage and DCP contribution volumes are based on Lake Mead elevations. For operating year 2023, Lake Mead operations are solved for as described in the No Action Alternative, where effective pool elevation is used to calculate Lake Mead Operations and Lower Basin condition. For operating years 2024 to 2026, the Lake Mead operations and Lower Basin conditions are solved for using the physical elevations at Lake Mead.

C.7.4.1 Surplus

The Surplus model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.2 Normal Conditions

The Normal Condition model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.3 Shortage Condition

Under Action Alternative 2, the Lower Division States' total shortage volumes are the same as Action Alternative 1 (**Table C-20**) but the shortage distribution between states and water users is different. For Action Alternative 2, shortages in addition to the 2007 ROD and 2019 DCPs are distributed in the same percentage across all Lower Basin water users based on 2021 adjusted consumptive use for CRMMS water users. The total shortage distributed among the Lower Division States and water users follows the method used in the Shortage Allocation Model for Action Alternative 2 (see **Appendix D**).

The distribution of shortage to individual water users in performed outside of the CRMMS. Specific shortage volumes for each water user and Shortage Conditions are input into the CRMMS. These shortages are computed by determining the percentage reduction for each water user based on the additional shortage's percentage of the total Lower Division States' consumptive use:

$$UserAdditionalShortage_i = \frac{TotalLDSShortage}{7{,}500{,}000} * UserDepletionScheduleUse_i$$

where i is each Lower Division States' water user modeled in the CRMMS.

In applying shortages and DCP contributions under Action Alternative 2, first, the 2007 ROD shortages and 2019 DCP contributions are applied to the users identified in these CRMMS modeling assumptions. Then, the additional shortages are applied using the above equation. A rule applies the shortage to each water user by spreading the annual shortage out over all months proportional to the users' monthly depletion schedules.

$$MonthlyShortage_i = AnnualShortage_i * \left(\frac{MonthlyWaterUse_i}{AnnualWaterUse_i}\right)$$

where i is an individual water user.

A summary of modeled shortage by state for Action Alternative 2 is in **Attachment C-4, Table Attachments C-9** and **C-10**.

C.7.4.4 Minute 323 High and Low Elevation Reservoir Conditions

The Minute 323 model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.5 DCP and BWSCP

The DCP and BWSCP model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.7.4.6 ICS Assumptions

The ICS model assumptions for the Lower Basin under Action Alternative 2 are identical to those of the No Action Alternative except pool elevations references are physical pool elevations, not effective pool elevations, for 2024 through 2026.

C.8 Lake Mohave and Lake Havasu Operations

Lake Mohave and Lake Havasu are operated to meet user-specified target storages at the end of each month. These operations remained consistent for all alternatives. The storage targets and the corresponding elevations for Lake Mohave and Lake Havasu are presented in the following sections.

C.8.1 Lake Mohave/Davis Dam

Lake Mohave is operated to meet monthly elevation targets (**Table C-21**). These elevation targets are based on effective storage space targets set by the Army Corps of Engineers for Lower Basin flood control purposes, as well as endangered species operations developed in conjunction with the Fish and Wildlife Service.

Table C-21
Lake Mohave Monthly Elevation/Storage Targets

Month	Lake Mohave Target Elevation (feet msl)	Lake Mohave Target Storage (1,000 af)
January	641.8	1,666
February	641.8	1,666
March	642.5	1,685
April	643.0	1,699
May	643.0	1,699
June	643.0	1,671
July	642.0	1,658
August	642.0	1,658
September	640.0	1,617
October	630.5	1,371
November	635.0	1,486
December	638.7	1,583

C.8.2 Lake Havasu/Parker Dam

Lake Havasu is operated to meet monthly elevation targets (**Table C-22**). These elevation targets are based on effective storage space targets set by the Army Corps of Engineers for Lower Basin flood control purposes, as well as seasonal needs to meet downstream water demands.

Table C-22
Lake Havasu Monthly Elevation/Storage Targets

Month	Lake Havasu Target Elevation (feet msl)	Lake Havasu Target Storage (1,000 af)
January	446.5	552
February	446.5	552
March	446.7	555
April	448.7	593
May	448.7	593
June	448.7	593
July	448.0	580
August	447.5	571
September	447.5	571
October	447.5	571
November	447.5	571
December	446.5	552

C.9 Energy Generation

RiverWare™ includes a variety of methods that can be chosen to compute electrical power generation and estimate generation capacity. All methods compute power and energy on a monthly basis. These results can be used to estimate revenue and total economic value. The following sections describe the methods used to compute power at Glen Canyon Dam, Hoover Dam, Davis Dam, and Parker Dam.

C.9.1 Glen Canyon Dam

While CRMMS includes a RiverWare™ method to compute electrical power generated from Glen Canyon Dam, the power generation data used in **Section 3.15** are computed using Generation Transmission Maximization Model (GTMax) Lite.

If the previous month's elevation is less than 3,490 feet msl, there is no power or energy generated for the current month. This elevation reflects the minimum power pool elevation at Lake Powell.

C.9.2 Hoover Dam

The method that computes power and energy generated at the Hoover Dam, which is the same method used in the CRSS for the 2007 FEIS, assumes two levels of power generation. The lower level of generation occurs at base flow while the upper level occurs at peak flow. The method computes the fraction of the month that the powerplant is operated at peak flow and base flow. The peaking flow is the most efficient flow through the turbines for the current operating head while the baseflow represents the minimum flow through the turbines to produce energy.

The base flow and corresponding power generation is based on the outflow for the current month. The peak flow must be computed through an iterative procedure using operating head, tailwater elevation and turbine release. The initial turbine release is assumed to be that corresponding to maximum power production. Tailwater elevation at Hoover Dam is computed as a function of Lake Mohave elevation and Hoover Dam release.

The monthly Hoover Dam release volume at base flow is computed by applying the base flow over the month. The monthly release volume at peak flow is computed as

$$PeakFlowVolume = TurbineReleaseVolume - BaseFlowVolume$$

Next, the number of hours required for operation at base and peak flows are then computed as

$$PeakHours = \frac{PeakFlowVolume}{(PeakFlow - BaseFlow) * 3600}$$

$$BaseHours = \frac{SecondsInMonth}{3600} - PeakHours$$

where 3600 is the amount of seconds per hour.

If the peak hours are greater than the length of the month, the peak hours value is set equal to the length of the month and base hours value is set to zero. The peak and base hours are then multiplied by the powerplant capacity at each level and added together to obtain the total energy produced for the month. Power is computed as the energy divided by the length of the month in hours.

The algorithm described above allows generation at elevations below approximately 950 feet msl, the minimum power pool at Lake Mead. According to the algorithm, power is generated as long as the minimum operating head of 304 feet is available, corresponding to an elevation of about 950 feet msl. Because there is no operating experience at these elevations, it is impossible to verify if CRMMS mimics the actual turbine performance at such low heads. It is therefore critical to view energy results from CRMMS in a relative manner and not in a strict numeric sense.

Power capacity is the power that could be generated if the flow is directed through the penstock turbine(s) given an operating head. This is computed to distinguish between actual power production and the power that could be produced.

C.9.3 Davis Dam

The method that computes power and energy generations at Davis Dam uses an empirical relationship as a function of flow, operating head, plant efficiency, and user-specified power coefficients. This empirical relationship is estimated by Reclamation and was last updated in 2019. Energy is computed using this empirical relationship as:

$$Energy\ (MWH) = \left(C_1 * \frac{62.4}{737.5} * Outflow\ (1000\ cfs) * HoursInMonth * \frac{OperatingHead\ (ft)}{1000} - C_2\right) * eff * 1000$$

where 62.4 is the unit weight of water in pounds per cubic foot; 737.5 represents foot-pounds per second per kilowatt; C_1 is estimated to be 0.88 based on historical data; C_2 is estimated to be 0; and eff is typically set to 1.0.

This energy method is different from the method used in CRSS for the 2007 FEIS because analysis of energy methods in RiverWare indicated that the new method simulates historical energy generation better than the method previously used in CRSS. This method does not currently estimate the power capacity at Davis Dam, which was computed by the method used for the 2007 FEIS.

C.9.4 Parker Dam

The method that computes power and energy generation at Parker Dam is the same method used for Davis Dam, except C_1 is estimated to be 1.0; C_2 is estimated to be 0; and eff varies by month as shown in **Table C-23**. The monthly efficiency coefficients are based on analysis of historical data from PO&M reports.

Table C-23
Parker Dam Monthly Efficiency Coefficients

Month	Coefficient
January	0.8192
February	0.8583
March	0.8645
April	0.8732
May	0.8705
June	0.8703
July	0.8658
August	0.8631
September	0.8588
October	0.8636
November	0.8369
December	0.7710

This energy method was implemented in CRMMS for Parker Dam in June 2022 after performing analysis of different methods in RiverWare and comparing the simulated energy to actual energy as reported in historical reports. The new method was shown to out-perform the previous method (used in the 2007 FEIS), particularly at higher flow/generation levels.

C.10 References

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Attachment C-1

CRMMS Lake Powell Assumed Monthly Releases

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Attachment C-1. CRMMS Lake Powell Assumed Monthly Releases

Table Attachment C-1
CRMMS Lake Powell Assumed Monthly Releases
(Values in af)

Annual Total	October	November	December	January	February	March	April	May	June	July	August	September
0	0	0	0	0	0	0	0	0	0	0	0	0
7,000,000	480,000	500,000	600,000	664,000	587,000	620,000	552,000	550,000	577,000	652,000	696,000	522,000
7,480,000	480,000	500,000	600,000	723,000	639,000	675,000	601,000	599,000	628,000	709,000	758,000	568,000
8,230,000	643,000	642,000	715,000	763,000	675,000	713,000	635,000	632,000	663,000	749,000	800,000	600,000
9,000,000	643,000	642,000	715,000	857,000	758,000	801,000	713,000	710,000	745,000	842,000	900,000	674,000
9,500,000	643,000	642,000	715,000	919,000	813,000	858,000	764,000	761,000	798,000	902,000	963,000	722,000
10,000,000	643,000	642,000	715,000	980,000	870,000	920,000	810,000	810,000	850,000	960,000	1,030,000	770,000
10,500,000	643,000	642,000	715,000	1,041,000	921,000	973,000	866,000	862,000	905,000	1,022,000	1,091,000	819,000
11,000,000	643,000	642,000	715,000	1,102,000	975,000	1,030,000	917,000	913,000	958,000	1,082,000	1,156,000	867,000
11,500,000	643,000	642,000	715,000	1,160,000	1,030,000	1,090,000	970,000	960,000	1,010,000	1,140,000	1,220,000	920,000
12,000,000	643,000	642,000	715,000	1,225,000	1,083,000	1,145,000	1,020,000	1,014,000	1,064,000	1,202,000	1,284,000	963,000
12,500,000	643,000	642,000	715,000	1,290,000	1,140,000	1,200,000	1,070,000	1,060,000	1,120,000	1,260,000	1,350,000	1,010,000
13,000,000	643,000	642,000	715,000	1,347,000	1,192,000	1,259,000	1,121,000	1,116,000	1,171,000	1,322,000	1,413,000	1,059,000
13,500,000	643,000	642,000	715,000	1,410,000	1,250,000	1,320,000	1,170,000	1,170,000	1,220,000	1,380,000	1,480,000	1,100,000
14,000,000	643,000	642,000	715,000	1,470,000	1,300,000	1,373,000	1,223,000	1,217,000	1,277,000	1,443,000	1,537,000	1,160,000
14,500,000	643,000	642,000	715,000	1,530,000	1,350,000	1,430,000	1,270,000	1,270,000	1,330,000	1,500,000	1,600,000	1,220,000
15,000,000	643,000	642,000	715,000	1,590,000	1,410,000	1,490,000	1,320,000	1,320,000	1,380,000	1,560,000	1,670,000	1,260,000
15,500,000	650,000	650,000	750,000	1,650,000	1,450,000	1,540,000	1,370,000	1,370,000	1,420,000	1,620,000	1,730,000	1,300,000
16,000,000	650,000	650,000	800,000	1,720,000	1,490,000	1,590,000	1,410,000	1,420,000	1,480,000	1,670,000	1,780,000	1,340,000
16,500,000	650,000	650,000	800,000	1,770,000	1,550,000	1,650,000	1,470,000	1,460,000	1,530,000	1,730,000	1,850,000	1,390,000
17,000,000	650,000	650,000	800,000	1,840,000	1,600,000	1,700,000	1,510,000	1,510,000	1,590,000	1,790,000	1,920,000	1,440,000
17,500,000	650,000	650,000	800,000	1,900,000	1,650,000	1,760,000	1,560,000	1,570,000	1,640,000	1,850,000	1,980,000	1,490,000
18,000,000	650,000	650,000	800,000	1,960,000	1,710,000	1,820,000	1,620,000	1,620,000	1,690,000	1,910,000	2,040,000	1,530,000
20,000,000	800,000	800,000	1,000,000	2,000,000	1,760,000	1,880,000	1,980,000	2,040,000	1,980,000	2,040,000	2,040,000	1,680,000
30,000,000	1,600,000	1,600,000	1,900,000	2,500,000	1,900,000	2,500,000	2,500,000	2,800,000	3,100,000	3,400,000	3,400,000	2,800,000
50,000,000	2,666,667	2,666,667	3,166,667	4,166,667	3,166,667	4,166,667	4,166,667	4,666,667	5,166,667	5,666,667	5,666,667	4,666,667
75,000,000	4,000,000	4,000,000	4,750,000	6,250,000	4,750,000	6,250,000	6,250,000	7,000,000	7,750,000	8,500,000	8,500,000	7,000,000

Footnote:
Releases from 7.0 to 14.0 maf are from LTEMP; releases outside of this range are interpolated from LTEMP patterns for modeling purposes.

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Attachment C-2

CRMMS Lower Basin Water User Depletion Schedules

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Attachment C-2. CRMMS Lower Basin Water User Depletion Schedules

Table Attachment C-2
CRMMS Input Annual Lower Basin Water User Depletion Schedules (Values in af)

State	CRMMS Water User	2023	2024	2025	2026
Arizona	AzPumpersAbvImp	5,237	5,237	5,237	5,237
	AzPumpersBlwImp	9,240	9,240	9,240	9,240
	AzPumpersDvsToPkr	896	896	896	896
	BrookeWater	324	324	324	324
	BullheadCity	8,799	8,799	8,799	8,799
	CAP	1,547,318	1,545,964	1,547,318	1,547,318
	CibolaNWR	14,264	14,264	14,264	14,264
	CibolaValleyIID	13,637	13,637	13,637	13,637
	City of Parker	424	424	424	424
	City of Yuma	15,833	15,833	15,833	15,833
	Cocopah Indian Res	1,725	1,725	1,725	1,725
	CRIRAz	335,969	335,969	335,969	335,969
	DavisDamProject	2	2	2	2
	DesertLawnMemorial	26	26	26	26
	Ehrenberg	252	252	252	252
	Ft Yuma	1,553	1,553	1,553	1,553
	FtMohaveAz	44,550	44,550	44,550	44,550
	Gila Monster Farms	4,888	4,888	4,888	4,888
	GoldenShores	286	286	286	286
	HavasuNWR	3,564	3,564	3,564	3,564
	ImperialNWR	3,799	3,799	3,799	3,799
	LakeHavasuCity	9,052	9,052	9,052	9,052
	LMNRA Az Mead	63	63	63	63
	LMNRA Az Mohave	214	214	214	214
	MCAirStation	1,300	1,300	1,300	1,300
	MohaveValleyIID	21,464	22,818	21,464	21,464
	MohaveWaterConsDist	692	692	692	692
	NGVIDD	10,674	10,674	10,674	10,674
	SouthernPacific	29	29	29	29
	UnitB	13,129	13,129	13,129	13,129
	UofA	852	852	852	852
	WMIDD	278,000	278,000	278,000	278,000
	YAO	195	195	195	195
	YCWUA	275,560	275,560	275,560	275,560
	YID	39,569	39,569	39,569	39,569
	YMIDD	110,859	110,859	110,859	110,859
	YumaProvingGround	517	517	517	517
	YumaUnionHighScl	150	150	150	150

State	CRMMS Water User	2023	2024	2025	2026
Nevada	LMNRA Mead	182,623	182,624	182,625	182,626
	BasicManagement	229,579	229,580	229,581	229,582
	City of Henderson	283,269	283,270	283,271	283,272
	NvDeptFishGame	172,207	172,208	172,209	172,210
	BoulderCanyonProject	174,223	174,224	174,225	174,226
	PacificCoastBuilding	178,619	178,620	178,621	178,622
	FtMohaveNv	204,484	204,485	204,486	204,487
	SCE	172,123	172,124	172,125	172,126
	BigBend	205,478	205,479	205,480	205,481
	LMNRA Mohave	175,623	175,624	175,625	175,626
	SNWADiversion	3,538,116	3,538,117	3,538,118	3,538,119
	LVWashReturns	1,734,239	1,734,240	1,734,241	1,734,242
	SNWP	1,873,545	1,873,546	1,873,547	1,873,548
California	CaPumpersAbvImp	47	47	47	47
	CaPumpersDvsToPkr	407	407	407	407
	Chemehuevi	183	183	183	183
	Coachella	384,000	394,000	419,000	409,000
	CRIRCa	5,014	5,014	5,014	5,014
	FtMohaveCa	8,996	8,996	8,996	8,996
	FYIR_Ranches	2,224	2,224	2,224	2,224
	IID	2,617,800	2,612,800	2,612,800	2,622,800
	MWD	1,092,328	1,092,328	797,400	797,400
	MWDDiversion	1,094,928	1,094,928	800,000	800,000
	MWDReturns	2,600	2,600	2,600	2,600
	Needles	1,605	1,605	1,605	1,605
	PaloVerde	362,104	386,321	362,104	362,104
	SaltonSea	0	0	0	0
	Winterhaven	61	61	61	61
	YumaIsland	1,629	1,629	1,629	1,629
	YumaProject	48,606	48,606	48,606	48,606
Mexico	MexicoSched	1,500,000	1,500,000	1,500,000	1,500,000
	MexicoBypass	116,633	116,633	116,633	116,633
	MexicoExcess	25,039	25,039	25,039	25,039
	MexicoTJ	1,154	1,154	1,154	1,154

Footnotes:
Water user names in the table reflect the water user names in the September 2022 CRMMS. Water user names may have been updated in and/or not match the Lower Basin Water Accounting Reports.

Attachment C-3

CRMMS Lower Basin Water User Priorities

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Attachment C-3. CRMMS Lower Basin Water User Priorities

Table Attachments C-3 through C-5 list the CRMMS users and the corresponding assumed priorities that are used for purposes of distributing shortages in Action Alternative 1. The water user names are provided exactly as they show up in CRMMS and abbreviations are not defined.

Table Attachment C-3
CRMMS Water Users by Priority for Arizona

Arizona		
Priority 1 (P1)	**Priority 2, 3 (P2,3)**	**Priority 4 (P4)**
AzPumpersBlwImp P1	CibolaNWR	AzPumpersAbvImp
BrookeWater P1	City of Yuma P3	AzPumpersBlwImp P4
City of Parker P1	DavisDamProject	AzPumpersDvsToPkr
City of Yuma P1	DesertLawnMemorial	BrookeWater P4
Cocopah Indian Res	Gila Monster Farms P2,3	BullheadCity
CRIRAz	HavasuNWR	CAP P4
Ft Yuma	ImperialNWR	CibolaValleyIID
FtMohaveAz	LMNRA Az Mead	City of Parker P4
Gila Monster Farms P1	LMNRA Az Mohave	Ehrenberg
MohaveValleyIID P1	MCAirStation	Gila Monster Farms P4
NGVIDD P1	NGVIDD P 2,3	GoldenShores
UnitB P1	SouthernPacific	LakeHavasuCity
YCWUA P1	UnitB P2,3	MohaveValleyIID P4
	UofA	MohaveWaterConsDist
	WMIDD	
	YAO	
	YCWUA P2,3	
	YID	
	YMIDD	
	YumaProvingGround	
	YumaUnionHighScl	
	CAP P3	

Table Attachment C-4
CRMMS Water Users by Priority for Nevada

Nevada		
Present Perfected Rights (PPR)	**SNWP non-Present Perfected Rights**	**Non-Present Perfected Rights, Non-SNWP**
FtMohaveNv	BasicManagement	BigBend
LMNRA Mead PPR	BoulderCanyonProject	LMNRA Mohave P2
LMNRA Mohave PPR	City of Henderson	SCE
	LMNRA Mead P2	
	LVWashReturns	
	NvDeptFishGame	
	PacificCoastBuilding	
	SNWADiversion	
	SNWP	

Table Attachment C-5
CRMMS Water Users by Priority for California

California					
Present Perfected Rights (PPR)	**Priority 1 (P1)**	**Priority 2 (P2)**	**Priority 3 (P3)**	**Priority 4 (P4)**	**No Priority (Pnone)**
CaPumpersDvsToPkr - PPR	PaloVerde P1	YumaProject	Coachella	MWD	CaPumpersAbvImp
Chemehuevi			IID – P3		CaPumpersDvsToPkr-Pnone
CRIRCa					SaltonSea
FtMohaveCa					YumaIsland
FYIR_Ranches					
IID – PPR					
Needles					
PaloVerde PPR					
Winterhaven					
YumaProject					

Attachment C-4

CRMMS Action Alternatives Shortages and DCP Contributions

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Attachment C-4. CRMMS Action Alternatives Shortages and DCP Contributions

Table Attachments C-6 through C-11 include the assumed shortages and DCP contributions by state and priority (for Action Alternative 1) that were computed using the methods described in **Sections C.7.3.3 and C.7.4.3**. These shortage volumes are imported to CRMMS to model the action alternatives.

Table Attachment C-6
2024 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,090 - 1,075	0	0	192,000	8,000	0	192,000	0	8,000	0	0	0	0	0	384,000	16,000	0	400,000
1,075 - 1050	320,000	13,000	192,000	8,000	0	511,360	0	21,640	0	0	0	0	0	1,023,360	42,640	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	592,640	0	24,360	0	0	0	0	0	1,184,640	49,360	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	26,779	42,385	0	0	0	0	0	1,569,008	69,385	200,000	1,838,393
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	100,073	56,413	107,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	100,073	56,413	57,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	100,073	56,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
975-950	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	100,073	53,413	7,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000

Footnotes:

[1]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

[2]AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Pnone (California users with no priority); CA-P3 (California Priority 3); CA-P2 (California Priority 2); CA-P1 (California Priority 1); CA-PPR (California Priority Perfected Right)

[3]CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

Disclaimer: These modeling inputs (for Action Alternative 1) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-7
2025 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,090 - 1,075	0	0	192,000	8,000	0	192,000	0	8,000	0	0	0	0	0	384,000	16,000	0	400,000
1,075 - 1050	320,000	13,000	192,000	8,000	0	511,360	0	21,640	0	0	0	0	0	1,023,360	42,640	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	592,640	0	24,360	0	0	0	0	0	1,184,640	49,360	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	26,779	42,385	0	0	0	0	0	1,569,008	69,385	200,000	1,838,393
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	100,073	56,413	107,285	0	0	0	0	1,642,302	83,413	357,285	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	135,145	63,125	182,501	0	0	0	0	1,677,374	90,125	482,501	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	187,648	73,174	319,949	0	0	0	0	1,729,877	100,174	669,949	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	292,654	90,271	613,713	81,133	0	0	0	1,834,883	120,271	1,044,846	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	362,588	103,656	613,713	330,815	0	0	0	1,904,817	133,656	1,294,527	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	822,229	432,732	117,081	613,713	407,300	30,375	143,570	0	1,974,961	147,081	1,544,958	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	502,666	130,466	613,713	407,300	30,375	262,083	131,169	2,044,895	160,466	1,794,640	4,000,000

Footnotes:

[1]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

[2]AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Pnone (California users with no priority); CA-P3 (California Priority 3); CA-P2 (California Priority 2); CA-P1 (California Priority 1); CA-PPR (California Priority Perfected Right)

[3]CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

[4]Different tables are provided for 2025 and 2026 because CRMMS depletion schedules vary slightly between 2025 and 2026 which cause slightly different distributions of shortage.

Disclaimer: These modeling inputs (for Action Alternative 1) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-8
2026 Action Alternative 1 CRMMS Shortages and DCP Contributions Table by State and Priority (values in acre-ft)

Interim Guidelines Shortages		DCP Contributions			Additional Shortages								Total Reductions			Lower Division States Total
AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	192,000	8,000	0	192,000	0	8,000	0	0	0	0	0	384,000	16,000	0	400,000
320,000	13,000	192,000	8,000	0	511,360	0	21,640	0	0	0	0	0	1,023,360	42,640	0	1,066,000
400,000	17,000	192,000	8,000	0	592,640	0	24,360	0	0	0	0	0	1,184,640	49,360	0	1,234,000
400,000	17,000	240,000	10,000	200,000	902,229	27,213	42,360	0	0	0	0	0	1,569,442	69,360	200,000	1,838,802
400,000	17,000	240,000	10,000	250,000	902,229	101,695	56,320	105,756	0	0	0	0	1,643,924	83,320	355,756	2,083,000
400,000	17,000	240,000	10,000	300,000	902,229	137,336	63,000	180,435	0	0	0	0	1,679,565	90,000	480,435	2,250,000
400,000	17,000	240,000	10,000	350,000	902,229	190,690	73,000	317,081	0	0	0	0	1,732,919	100,000	667,081	2,500,000
480,000	20,000	240,000	10,000	350,000	822,229	297,398	90,000	612,134	78,239	0	0	0	1,839,627	120,000	1,040,373	3,000,000
480,000	20,000	240,000	10,000	350,000	822,229	368,466	103,320	612,134	326,852	0	0	0	1,910,694	133,320	1,288,986	3,333,000
480,000	20,000	240,000	10,000	350,000	822,229	439,747	116,680	612,134	407,300	30,375	138,535	0	1,981,975	146,680	1,538,345	3,667,000
480,000	20,000	240,000	10,000	350,000	822,229	510,814	130,000	612,134	407,300	30,375	262,083	125,065	2,053,043	160,000	1,786,957	4,000,000

Footnotes:

[1]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

[2]AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Pnone (California users with no priority); CA-P3 (California Priority 3); CA-P2 (California Priority 2); CA-P1 (California Priority 1); CA-PPR (California Priority Perfected Right)

[3]CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

[4]Different tables are provided for 2025 and 2026 because CRMMS depletion schedules vary slightly between 2025 and 2026 which cause slightly different distributions of shortage.

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Table Attachment C-9
2024 Action Alternative 2 CRMMS Shortage Volume Table (values in acre-ft)

Lake Mead Pool Elevation (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages			Total Shortages			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ	NV	CA	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0
1,090 - 1,075	0	0	192,000	8,000	0	74,666	8,001	117,333	266,666	16,001	117,333	400,000
1,075 - 1050	320,000	13,000	192,000	8,000	0	198,986	21,321	312,693	710,986	42,321	312,693	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	230,349	24,680	361,971	822,349	49,680	361,971	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	323,677	34,681	508,642	963,677	61,681	708,642	1,734,000
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	435,307	46,640	684,053	1,075,307	73,640	934,053	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	416,640	44,639	654,721	1,056,640	71,639	954,721	2,083,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	397,974	42,640	625,386	1,037,974	69,640	975,386	2,083,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	366,988	39,319	576,693	1,086,988	69,319	926,693	2,083,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	366,988	39,319	576,693	1,086,988	69,319	926,693	2,083,000
975-950	480,000	20,000	240,000	10,000	350,000	366,988	39,319	576,693	1,086,988	69,319	926,693	2,083,000
< 950	480,000	20,000	240,000	10,000	350,000	366,988	39,319	576,693	1,086,988	69,319	926,693	2,083,000

Disclaimer: These modeling inputs (for Action Alternative 2) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-10
2025-2026 Action Alternative 2 CRMMS Shortage Volume Table (values in acre-ft)

Lake Mead Pool Elevation (feet)	Interim Guidelines Shortages		DCP Contributions			Additional Shortages			Total Shortages			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ	NV	CA	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0
1,090 - 1,075	0	0	192,000	8,000	0	74,666	8,001	117,333	266,666	16,001	117,333	400,000
1,075 - 1050	320,000	13,000	192,000	8,000	0	198,986	21,321	312,693	710,986	42,321	312,693	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	230,349	24,680	361,971	822,349	49,680	361,971	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	323,677	34,681	508,642	963,677	61,681	708,642	1,734,000
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	435,307	46,640	684,053	1,075,307	73,640	934,053	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	478,986	51,320	752,694	1,118,986	78,320	1,052,694	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	553,654	59,320	870,026	1,193,654	86,320	1,220,026	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	709,330	76,002	1,114,668	1,429,330	106,002	1,464,668	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	833,652	89,321	1,310,027	1,553,652	119,321	1,660,027	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	958,346	102,681	1,505,973	1,678,346	132,681	1,855,973	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	1,082,666	116,000	1,701,334	1,802,666	146,000	2,051,334	4,000,000

Disclaimer: These modeling inputs (for Action Alternative 2) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Attachment C-5

Comparison of Action Alternative 1 Shortage Distribution Methods

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Attachment C-5. Comparison of Action Alternative 1 Shortage Distribution Methods

In the Shortage Allocation Model Appendix (**Appendix D**), an alternative approach for distributing shortage was analyzed for Action Alternative 1 (see **Section D.4.4**). This attachment compares the hydrologic modeling results from different methods for distributing shortage in Action Alternative 1. First, the method for translating shortage volumes to CRMMS inputs is described. Then, the differences in Lake Mead operations and Lower Division States use and shortage volumes are explored for 2024, 2025, and 2026. Refer to **Section C.7.3.3** for a description of how shortages are modeled in Action Alternative 1.

C-5.1 CRMMS Shortage Assumptions for the Alternative Approach to Action Alternative 1

The Action Alternative 1 Shortage Allocation Model that was used in **Chapter 3** of the SEIS resulted in shortages being applied to California PPR entitlements before Arizona or Nevada's non-PPR entitlements were fully shorted. This also occurred when translating the Shortage Allocation Model method to CRMMS inputs (e.g., **Attachment Tables C-6**, **C-7**, and **C-8**). The alternative approach to the Action Alternative 1 Shortage Allocation Model treats each state's non-PPR entitlements as co-equal. Therefore, all non-PPR entitlements will be completely shorted before any PPR entitlements are shorted.

The distribution of shortage volumes among water users in CRMMS for the alternative approach to the Action Alternative 1 method was computed outside of CRMMS and uses the same approach as the alternative approach to the Shortage Allocation Model. In developing the Stage 1 and Stage 2 percentages for the sharing of shortages among the Lower Division States, the CRMMS depletion schedules of PPR entities were removed from each state's total depletion schedule volumes.

The distribution of shortages among water users was computed outside of CRMMS and was applied in two stages. When distributing shortage volumes by priority using the Shortage Allocation Model method, total shortages and DCP contributions are inclusive of the 2007 ROD and 2019 DCP. As in Action Alternative 1, Stage 1 reductions are applied to Nevada and Arizona.

- Nevada: The Nevada Stage 1 shortage volume is total Nevada non-PPR depletion schedule divided by the total Lower Division States' non-PPR depletion schedule:

$$Stage1ShortagePercent = \frac{NevadaNonPPRVolume}{LDSNonPPRVolume} = 7.1\%$$

- Arizona: The remainder of the total shortage is assigned to Arizona, which is 92.9% of the total shortage.

Once Arizona Priority 4 entitlements are fully shorted (i.e., water use is set to zero), Stage 2 begins.

In Stage 2, all Lower Division States are shorted proportional to the remaining depletion scheduled in CRMMS. Shortages taken by Nevada and Arizona in Stage 1 are subtracted from each state's annual scheduled depletion when determining state level reductions.

$$Stage2SReduction_n = Stage2Reduction * \left(\frac{ScheduledUse_n - Stage1Reduction_n - ScheduledPPRUse_n}{LDSTotalUse - Stage1Reduction - LDSScheduledPPRUse}\right)$$

where n is an individual state.

Once the total state reductions are calculated for each Lower Basin Shortage Condition, total reductions are split into reduction types (i.e., 2007 ROD shortage, Action Alternative 1 shortage, and 2019 DCP contributions). The 2019 DCP contributions can be larger than the specified additional shortage based on the modeled application of Action Alternative 1. In this case the larger volume is applied, which causes larger total reductions than the volumes based on a given elevation range. A summary of modeled shortage by state and priority for the alternative approach to Action Alternative 1 is in **Table Attachments C-11**, **C-12**, and **C-13**. Tables are provided for 2024, 2025, and 2026 because CRMMS depletion schedules vary slightly each year, which causes slightly different distributions of shortage.

Table Attachment C-11
2024 Action Alternative 1 CRMMS Shortage Volume Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortage		DCP Contributions			Additional Shortage								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,090 - 1,075	0	0	192,000	8,000	0	179,571	0	20,429	0	0	0	0	0	371,571	28,429	0	400,000
1,075 - 1050	320,000	13,000	192,000	8,000	0	478,237	0	54,763	0	0	0	0	0	990,237	75,763	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	554,297	0	62,703	0	0	0	0	0	1,146,297	87,703	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	19,312	96,239	0	0	0	0	0	1,561,541	123,239	200,000	1,884,779
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	110,668	121,043	32,061	0	0	0	0	1,652,896	148,043	282,061	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	110,668	121,043	0	0	0	0	0	1,652,896	148,043	300,000	2,100,939
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	110,668	121,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
975-950	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939
< 950	480,000	20,000	240,000	10,000	350,000	822,229	110,668	118,043	0	0	0	0	0	1,652,896	148,043	350,000	2,150,939

Footnotes:

[1]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

[2]AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Pnone (California users with no priority); CA-P3 (California Priority 3); CA-P2 (California Priority 2); CA-P1 (California Priority 1); CA-PPR (California Priority Perfected Right)

[3]CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

Disclaimer: These modeling inputs (for alternative approach to Action Alternative 1) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-12
2025 Action Alternative 1 CRMMS Shortage Volume Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortage		DCP Contributions			Additional Shortage								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,090 - 1,075	0	0	192,000	8,000	0	179,571	0	20,429	0	0	0	0	0	371,571	28,429	0	400,000
1,075 - 1050	320,000	13,000	192,000	8,000	0	478,237	0	54,763	0	0	0	0	0	990,237	75,763	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	554,297	0	62,703	0	0	0	0	0	1,146,297	87,703	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	19,312	96,239	0	0	0	0	0	1,561,541	123,239	200,000	1,884,779
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	110,668	121,043	32,061	0	0	0	0	1,652,896	148,043	282,061	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	154,382	132,912	93,477	0	0	0	0	1,696,611	159,912	393,477	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	219,823	150,680	210,268	0	0	0	0	1,762,052	177,680	560,268	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	350,705	183,216	543,851	0	0	0	0	1,892,934	213,216	893,851	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	437,872	206,883	613,713	152,303	0	0	0	1,980,101	236,883	1,116,016	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	822,229	525,302	230,621	613,713	375,136	0	0	0	2,067,530	260,621	1,338,849	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	612,469	254,288	613,713	407,300	30,375	159,627	0	2,154,698	284,288	1,561,015	4,000,000

Footnotes:

[1]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

[2]AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Pnone (California users with no priority); CA-P3 (California Priority 3); CA-P2 (California Priority 2); CA-P1 (California Priority 1); CA-PPR (California Priority Perfected Right)

[3]CRMMS users are categorized by priority in **Table Attachments C-2, C-3, and C-4**.

Disclaimer: These modeling inputs (for alternative approach to Action Alternative 1) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

Table Attachment C-13
2026 Action Alternative 1 CRMMS Shortage Volume Table by State and Priority (values in acre-ft)

Lake Mead (feet)	Interim Guidelines Shortage		DCP Contributions			Additional Shortage								Total Reductions			Lower Division States Total
	AZ	NV	AZ	NV	CA	AZ-P4	AZ-P2,3	NV	CA-P4 and CA-Pnone	CA-P3	CA-P2	CA-P1	CA-PPR	AZ	NV	CA	
>1,090	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1,090 - 1,075	0	0	192,000	8,000	0	179,560	0	20,440	0	0	0	0	0	371,560	28,440	0	400,000
1,075 - 1050	320,000	13,000	192,000	8,000	0	478,209	0	54,791	0	0	0	0	0	990,209	75,791	0	1,066,000
1,050 - 1,045	400,000	17,000	192,000	8,000	0	554,264	0	62,736	0	0	0	0	0	1,146,264	87,736	0	1,234,000
1,045 - 1,040	400,000	17,000	240,000	10,000	200,000	902,229	19,312	96,286	0	0	0	0	0	1,561,541	123,286	200,000	1,884,826
1,040 - 1,035	400,000	17,000	240,000	10,000	250,000	902,229	110,727	121,099	31,945	0	0	0	0	1,652,956	148,099	281,945	2,083,000
1,035 - 1,030	400,000	17,000	240,000	10,000	300,000	902,229	154,470	132,973	93,328	0	0	0	0	1,696,699	159,973	393,328	2,250,000
1,030 - 1,025	400,000	17,000	240,000	10,000	350,000	902,229	219,954	150,747	210,070	0	0	0	0	1,762,183	177,747	560,070	2,500,000
1,025 - 1,000	480,000	20,000	240,000	10,000	350,000	822,229	350,921	183,297	543,553	0	0	0	0	1,893,150	213,297	893,553	3,000,000
1,000 - 975	480,000	20,000	240,000	10,000	350,000	822,229	438,146	206,973	612,134	153,519	0	0	0	1,980,375	236,973	1,115,653	3,333,000
975-950	480,000	20,000	240,000	10,000	350,000	822,229	525,632	230,720	612,134	376,286	0	0	0	2,067,861	260,720	1,338,420	3,667,000
< 950	480,000	20,000	240,000	10,000	350,000	822,229	612,856	254,396	612,134	407,300	30,375	160,710	0	2,155,085	284,396	1,560,519	4,000,000

Footnotes:

[1]In this elevation tier, the 2019 DCP contributions for California exceed what would be required under the Action Alternative 1. As a result, no additional shortage is required in this elevation tier for California.

[2]AZ-P4 (Arizona Priority 4); AZ-P2,3 (Arizona Priority 2 and Priority 3); CA-P4 (California Priority 4); CA-Pnone (California users with no priority); CA-P3 (California Priority 3); CA-P2 (California Priority 2); CA-P1 (California Priority 1); CA-PPR (California Priority Perfected Right)

[3]CRMMS users are categorized by priority in Table Attachments C-3, C-4, and C-5.

Disclaimer: These modeling inputs (for alternative approach to Action Alternative 1) should only be used to compare the relative magnitude of effects reasonably expected to occur under the alternatives evaluated in this SEIS. Modeling assumptions should not be taken as agency position with respect to contract or statutory interpretation, and they are not intended to limit Secretarial discretion with respect to current or future policy. This modeled methodology is not a substitute for the annual process of reviewing water orders and determining which can be filled and cannot replicate the precision required of that process.

C-5.1.1 CRMMS Modeling Results

The Action Alternative 1 shortage distribution methods are compared using the following metrics:

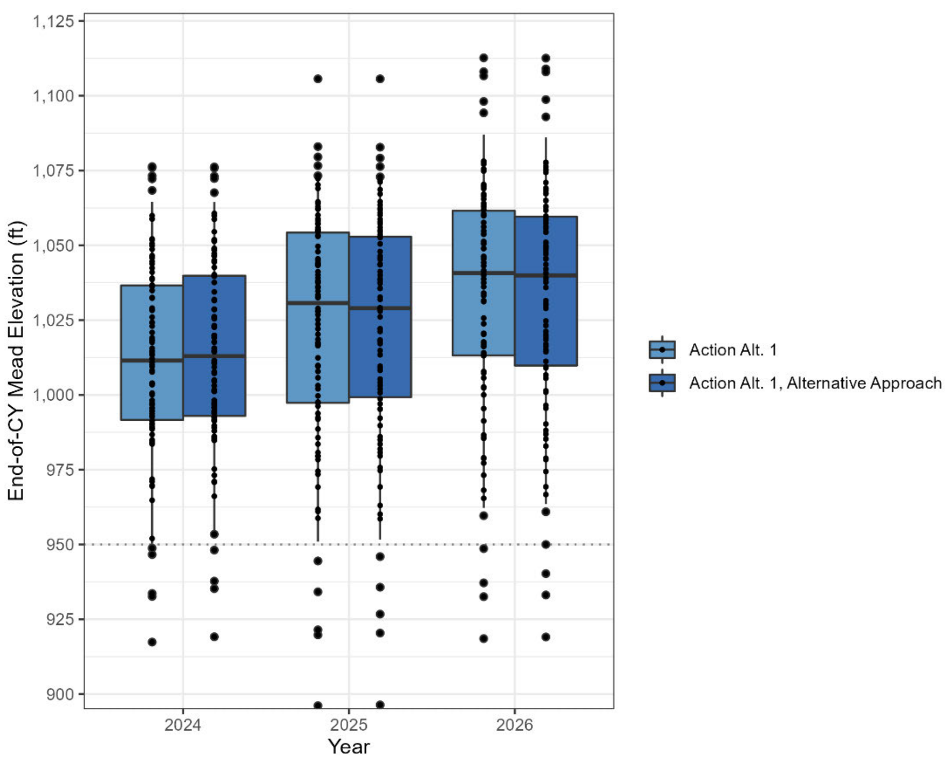
- Lake Mead end-of-calendar year (EOCY) pool elevation
- Lower Division States modeled depletions (without system shortage)
- Lower Division States shortage and DCP contributions

This truncated set of metrics and is focused on those that differ the most when comparing the Action Alternative 1 shortage distribution methods. There are other metrics, e.g., Lake Powell pool elevation, that may be indirectly affected by these different methods and/or may have smaller differences than these highlighted metrics.

Lake Mead

Figure Attachment C-1 shows the distributions of modeled EOCY Lake Mead pool elevations in 2024, 2025, and 2026. Each dot is the end-of-calendar year elevation produced by a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines.

Figure Attachment C-1
Mead End-of-Calendar Year Pool Elevations

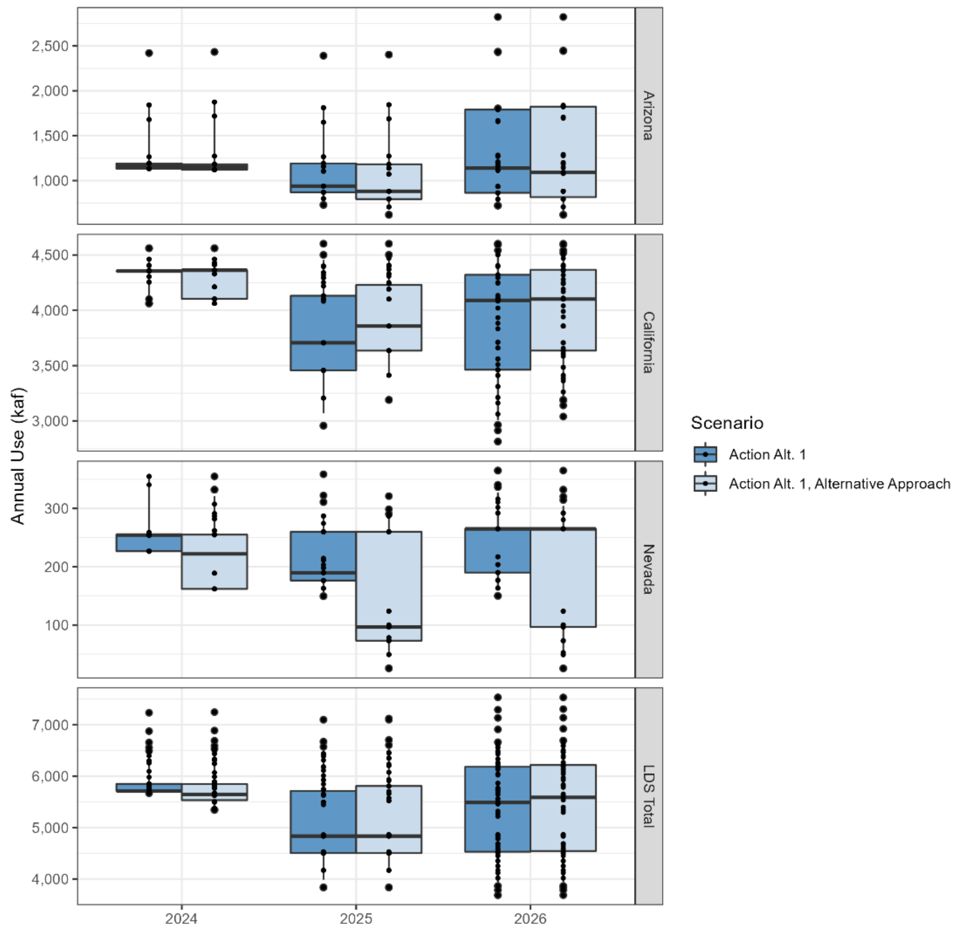


The distributions of modeled EOCY Lake Mead elevations for Action Alternative 1 and the alternative approach to Action Alternative 1 which uses state apportionments less PPR entitlements (labeled Action Alt. 1, Alternative Approach) shown in **Figure Attachment C-1** are very similar. The median and 25th to 75th percentiles of the distributions change only slightly. In 2024, the alternative approach to Action Alternative 1 has a slightly higher median than Action Alternative 1, and in 2025 and 2026 the median for the alternative approach to Action Alternative 1 is slightly lower. The minor differences in EOCY pool elevation are due to slightly different demands downstream of Lake Mead caused by the differences in shortage distribution. These minor differences cause a few hydrologic traces to be in a different Lower Basin Shortage Condition, which also affects reduction volumes in the following years.

Shortage Sharing and Water Delivery

Figure Attachment C-2 shows the distributions of modeled Lower Division States depletions in 2024, 2025, and 2026. Each dot is the volume of water requested during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines. Panels one through four display depletions for Arizona, California, Nevada, and Lower Division States total, respectively, that include ICS creation/delivery and other assumptions related to meeting the required DCP contributions. This figure is oriented to facilitate the comparison of a single state's modeled depletions across each alternative over the period of analysis.

Figure Attachment C-2
Lower Division States' Modeled Depletions



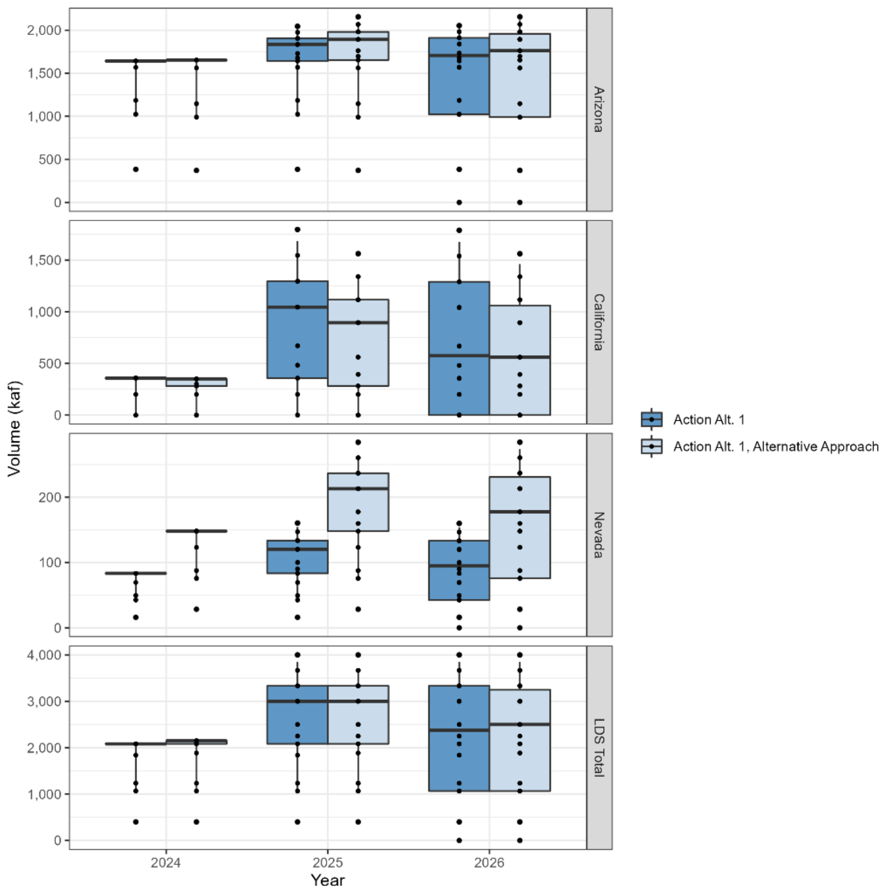
In the top panel of **Figure Attachment C-2**, Arizona's modeled annual depletion is similar across the two Action Alternative 1 shortage distribution methods. The alternative approach to Action Alternative 1 has slightly lower annual use for Arizona. In the second panel, modeled annual depletions for California for both scenarios similar. In 2025 and 2026, the alternative approach to Action Alternative 1 has a slightly higher annual depletion and higher minimum annual depletion than Action Alternative 1. The modeled annual depletions for Nevada in the third panel have lower annual depletion with the alternative approach to Action Alternative 1. Since Nevada has a lower proportion of PPR entitlements compared to Arizona and California, Nevada has a higher percentage of the required reductions with the alternative approach to Action Alternative 1. This causes lower use across most of the distribution. In 2025 and 2026, the lowest 50th and 25th percent of projections, respectively, show Nevada's annual depletion at or below 100,000 af.

The total modeled Lower Division States annual depletions are compared in the bottom panel of **Figure Attachment C-2**. The median and range of both scenarios are very similar. This is expected since the scenarios have the similar shortage volumes applied at each Lake Mead elevation. The minor differences in total Lower Division States' annual depletion are due to slightly different distributions of shortage which can have minor difference in water use due to ICS activity and the way users meet their DCP contributions. Additionally, due to the shortage distribution methods certain shortage conditions may have slightly higher required shortages with the alternative shortage distribution approach because California has a required DCP contribution that are greater than the shortage that would have been required in a strict priority system.

The modeled Lower Division States annual depletions in **Figure Attachment C-2** are the requested depletions before any system shortages occur. These are not reported in this attachment because only 1.1 percent of traces have a system shortage in Action Alternative 1 in 2025 and 2026 (**Section 3.7.2**) and because **Figure Attachment C-2** indicate there is very little difference in Lake Mead elevations. This indicates little to no difference in system shortages due to the different Action Alternative 1 shortage distribution methods.

Figure Attachment C-3 shows the distributions of modeled shortages and DCP contributions for Lower Division States in 2024, 2025, and 2026. Each dot is the volume of shortages and DCP contributions modeled during that year under a single hydrologic trace. Dots may be plotted on top of one another. The top and bottom of each box captures the 25th to 75th percentile of the modeled elevations, the whiskers extend to the 5th and 95th percentiles, and the outliers are represented as dots beyond these lines. Panels one through four display modeled shortages and DCP contributions for Arizona, California, Nevada, and Lower Division States total, respectively.

Figure Attachment C-3
Lower Division States Modeled Delivery Reduction Volumes



In the top panel of **Figure Attachment C-3**, Arizona's modeled shortages and DCP contributions are similar across the two Action Alternative 1 shortage distribution methods. The alternative approach to Action Alternative 1 has slightly higher reduction at the median in 2025 and 2026. In the second panel, modeled shortages and DCP contributions for California are generally lower in the alternative approach to Action Alternative 1. In 2024, both scenarios have similar reductions. In 2025 and 2026, the alternative approach to Action Alternative 1 reductions are lower for the top 90% of reductions. For 2026, the top 25th percent of reductions are lower in the alternative approach to Action Alternative 1. The modeled shortages and DCP contributions for Nevada in the third panel show higher annual shortages and DCP contributions in the alternative approach to Action Alternative 1 in all years due to Nevada's lower proportion of PPR entitlements compared to the other Lower Division States. Reductions in **Figure Attachment C-3** do not translate directly to annual depletion in **Figure Attachment C-2** because of ICS activity and how states meet their DCP contribution (which can be met through conversion of EC-ICS to DCP-ICS).

The total modeled Lower Division States' reductions are compared in the bottom panel of **Figure Attachment C-3**. The median and range of both scenarios are very similar. The minor differences in total Lower Division States' shortages and DCP contributions are due to minor differences in Lower Basin Shortage Conditions and slightly different reduction volumes between Action Alternative 1 and the alternative approach to Action Alternative 1. The slight differences in reaction volumes are due to how California's required DCP contribution is modeled, which causes higher shortage volumes than would have been required in Action Alternative 1 and the alternative approach to Action Alternative 1.

C-5.1.2 Summary

Overall, the different Action Alternative 1 shortage distribution methods compared in this attachment result in only small modeled differences in Lake Mead elevations. The alternative approach results in higher modeled shortages and DCP contributions and lower modeled depletions for Nevada and Arizona, and lower modeled shortages and DCP contributions with higher modeled depletions for California than the method used for Action Alternative 1. This is mostly due to the relative proportion of each state's total modeled depletions that are from PPR entitlements. Because Nevada and Arizona have a lower proportion of PPR entitlements, the alternative approach to Action Alternative 1 models a higher proportion of shortage to Arizona and Nevada than the original Action Alternative 1 method. Conversely, because California has higher proportion of PPR entitlements, the alternative approach to Action Alternative 1 models a lower proportion shortage to California than the original Action Alternative 1 method.

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