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# Glen Canyon Monthly Operations Call

## Basin Hydrology and Operations

January 19, 2022

# Background

This briefing is being provided consistent with the provision in Section 1.1 of the LTEMP ROD which states:

“Annually, Reclamation will develop a hydrograph based on the characteristics above. Reclamation will seek consensus on the annual hydrograph through monthly operational coordination calls with governmental entities, and regular meetings of the GCDAMP Technical Working Group (TWG) and AMWG.

Reclamation will conduct monthly Glen Canyon Dam operational coordination meetings or calls with the DOI bureaus (USGS, NPS, FWS, and BIA), WAPA, and representatives from the Basin States and UCRC. The purpose of these meetings or calls is for the participants to share and seek information on Glen Canyon Dam operations. One liaison from each Basin State and from the UCRC may participate in the monthly operational coordination meetings or calls.”

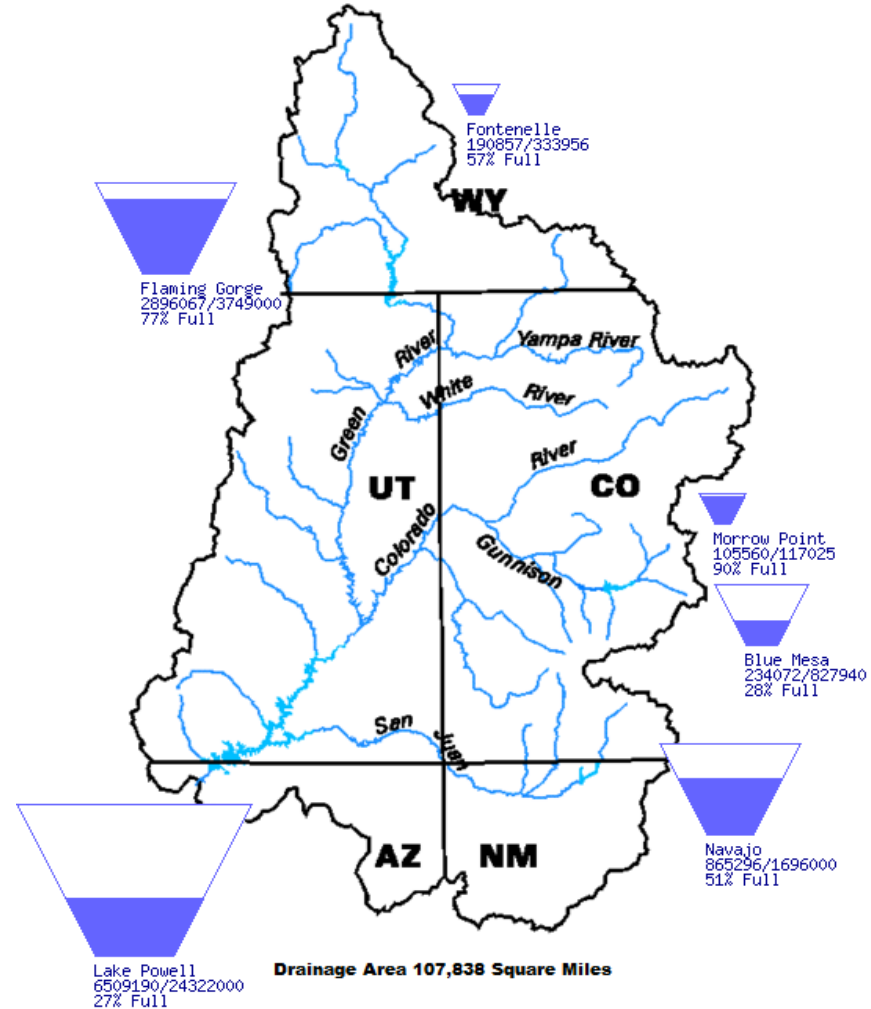


# Upper Basin Storage (as of January 17, 2022)

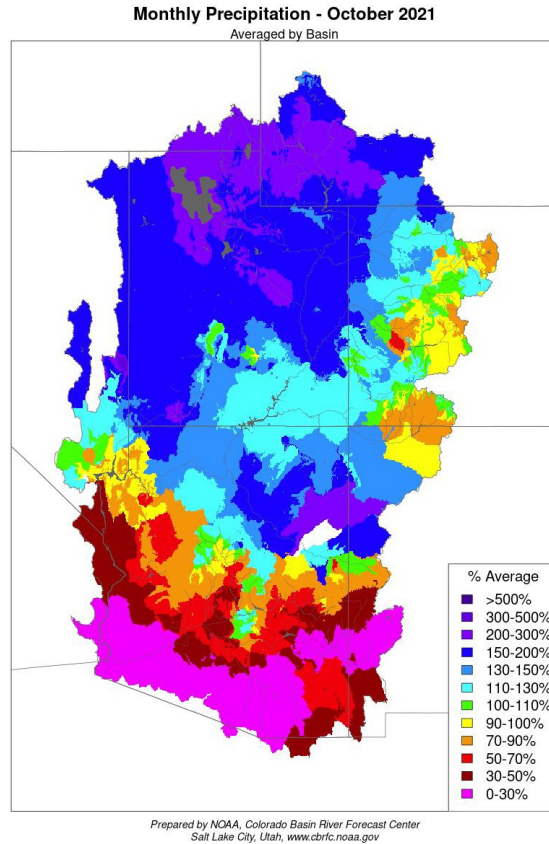
Data Current as of:  
01/17/2022

## Upper Colorado River Drainage Basin

Reservoir	Percent Current Live Storage	Current Live Storage (maf)	Live Storage Capacity (maf)	Elevation (feet)
Fontenelle	57	0.19	0.33	6,485.68
Flaming Gorge	77	2.90	3.75	6,017.61
Blue Mesa	28	0.23	0.83	7,435.09
Navajo	51	0.87	1.70	6,019.90
Lake Powell	27	6.51	24.32	3,534.22
UC System Storage	35	10.82	30.93	

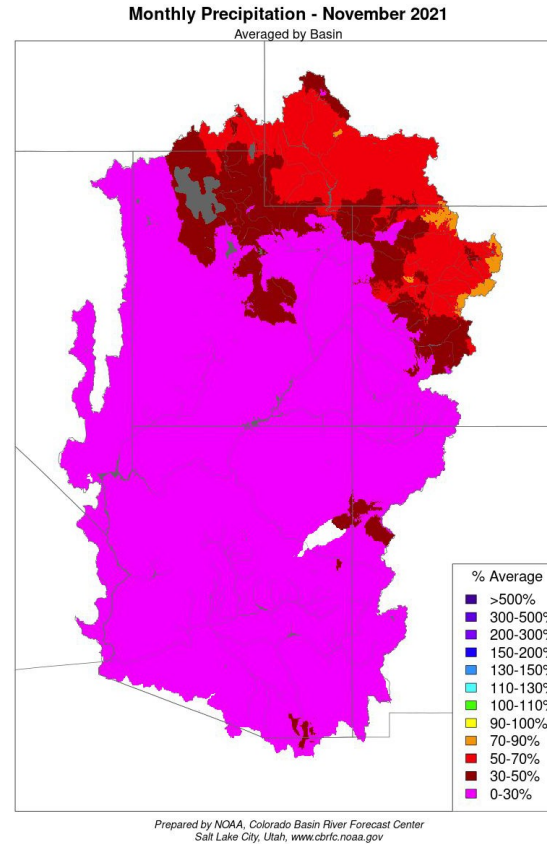


# Water Year 2022 (October - December) Monthly Precipitation Summary



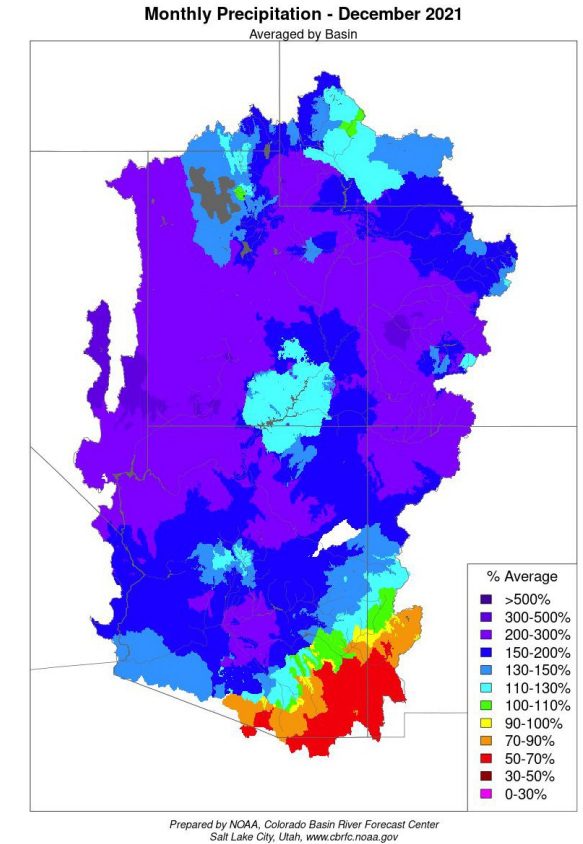
October precipitation was well above average across much of the region including southwest Wyoming, most of Utah, and northern Arizona.

Western Colorado had near average October precipitation while southern Arizona had below average precipitation during the month.



November's weather pattern was mostly very warm and dry with much below average monthly precipitation across most of the region.

November precipitation fell in the bottom five at numerous SNOTEL stations across Utah, southwest Colorado, and central Arizona.



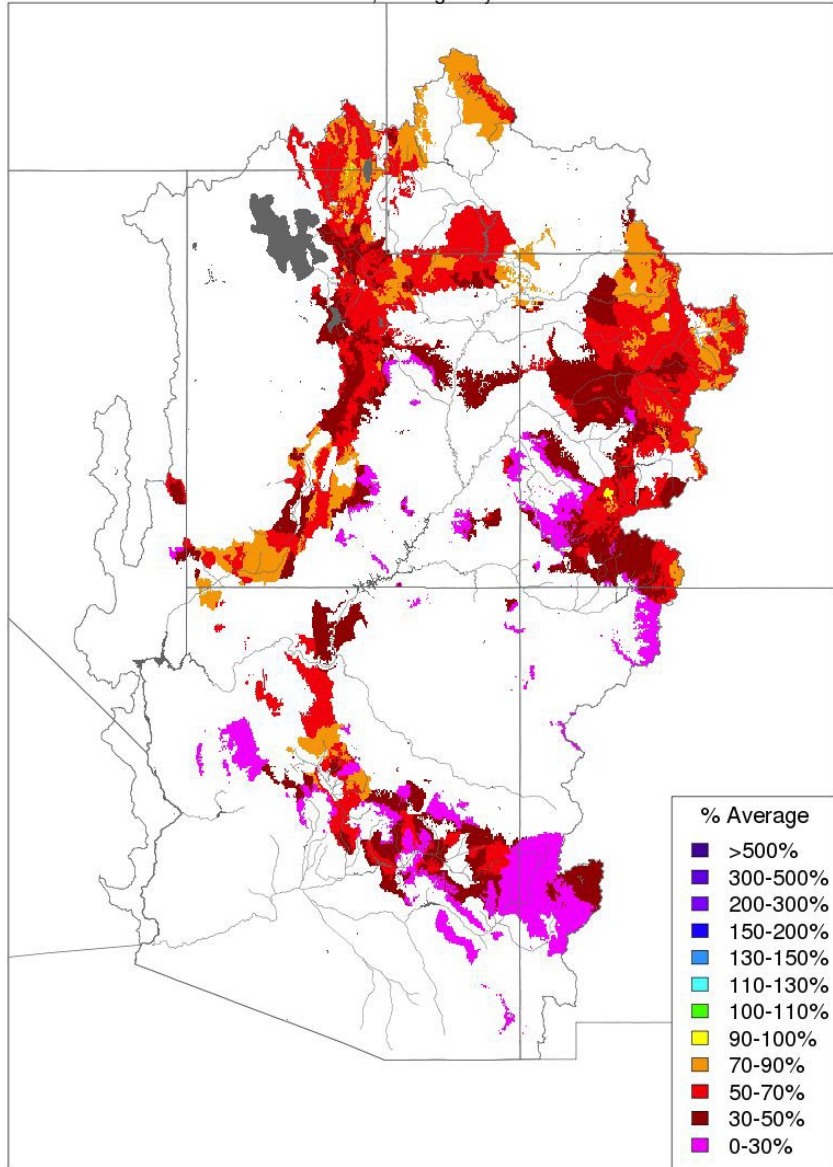
The weather pattern shifted during the second week of December towards colder and wetter conditions and featured multiple storm systems that brought widespread precipitation to most of the region during the last three weeks of the month.

The majority of SNOTEL sites across Utah and western Colorado and a few sites across central Arizona reported December precipitation values that ranked in the wettest five on record.

# Fall Model Soil Moisture Conditions: 2020 vs. 2021

Soil Moisture - Fall - 2020 (November 15)

Modeled, Averaged by Basin

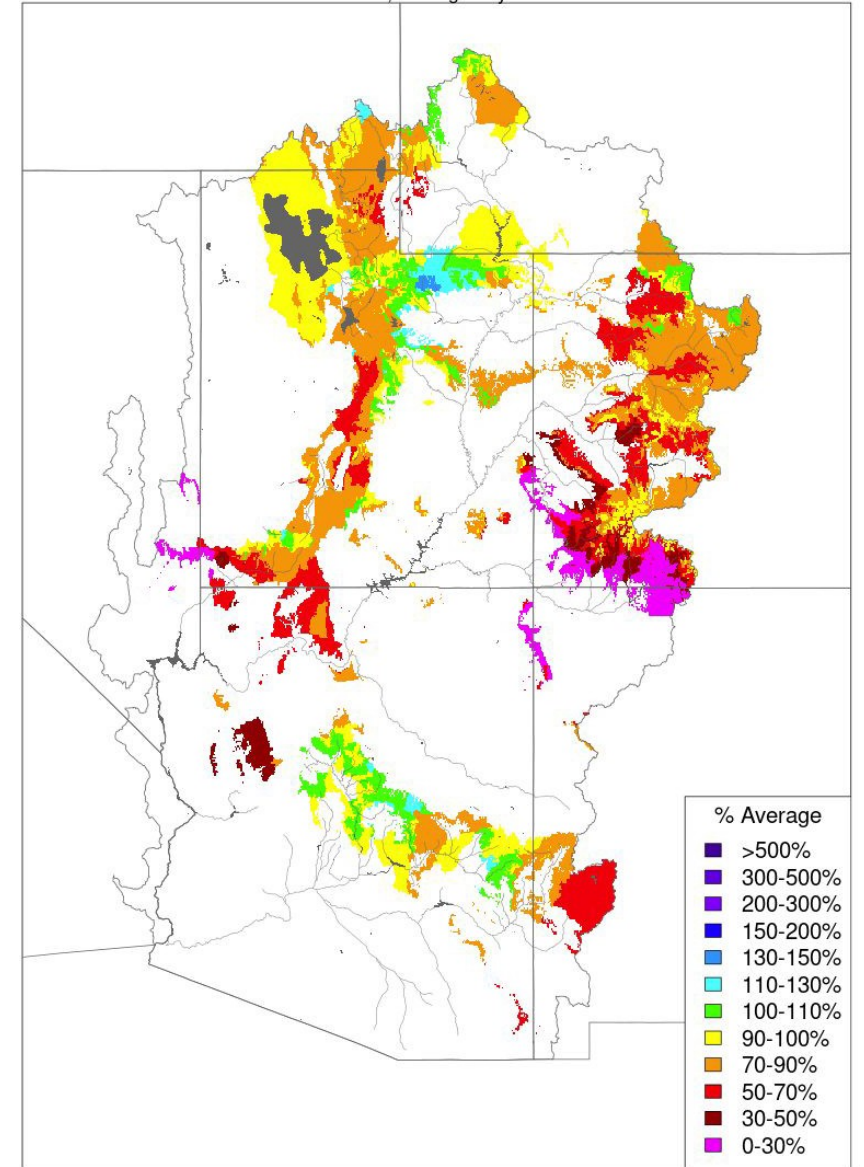


Prepared by NOAA, Colorado Basin River Forecast Center  
Salt Lake City, Utah, [www.cbrfc.noaa.gov](http://www.cbrfc.noaa.gov)

CBRFC model soil moisture conditions are improved from their record/near record dry levels a year ago but remain below to well below normal across many of the major runoff producing areas, notably western Colorado.

Soil Moisture - Fall - 2021 (November 15)

Modeled, Averaged by Basin

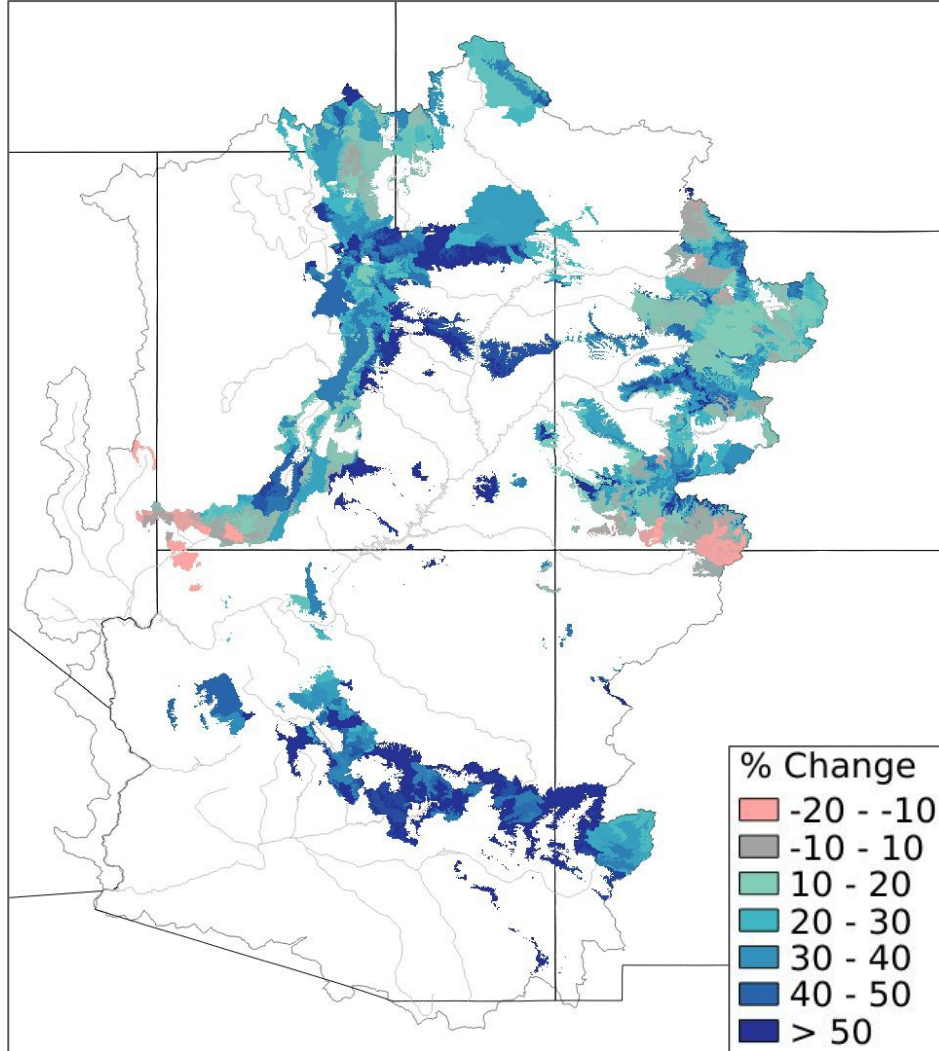


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# Fall Model Soil Moisture Conditions: 2020 vs. 2021

## Soil Moisture - Fall (November 15)

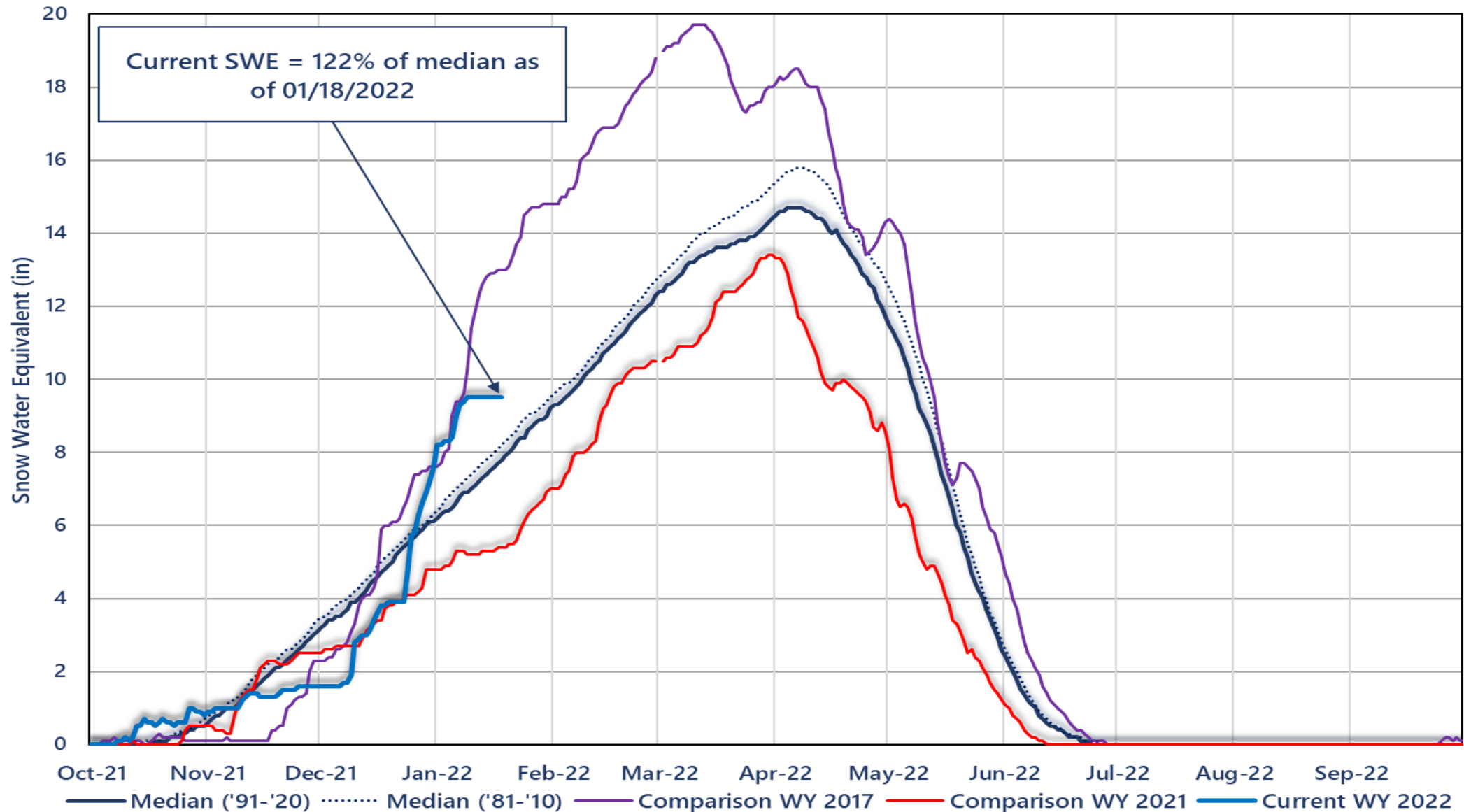
Modeled, %Change  
(2021-2020)



This is an experimental CBRFC soil moisture graphic.

Utah & Arizona model soil moisture conditions improved more compared to southwest Wyoming & western Colorado.

# Colorado River Basin Above Lake Powell Snow Water Equivalent



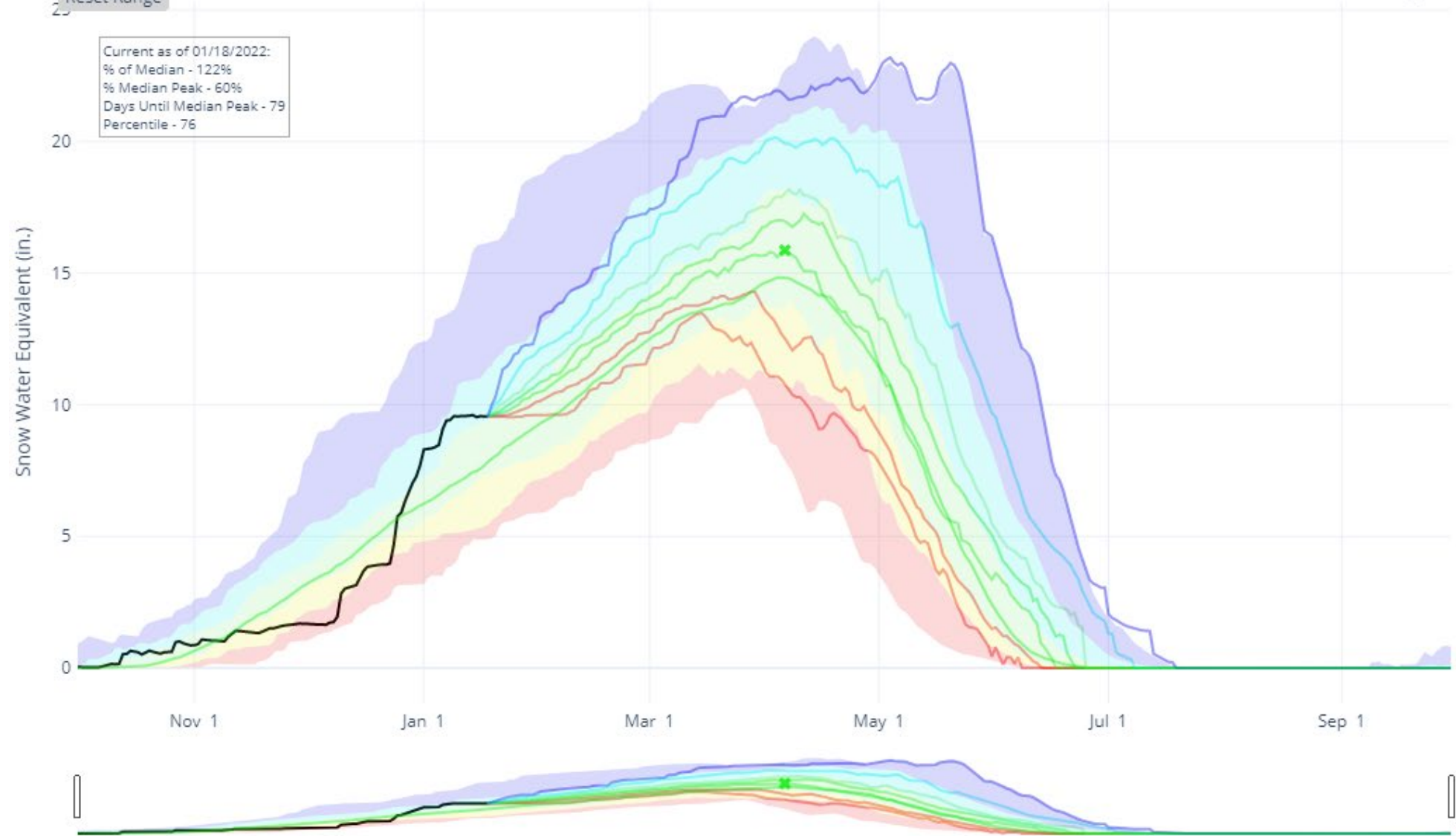
# SNOW WATER EQUIVALENT PROJECTIONS IN UPPER COLORADO REGION

Reset Range

Link to data: CSV / JSON

Station List

Current as of 01/18/2022:  
 % of Median - 122%  
 % Median Peak - 60%  
 Days Until Median Peak - 79  
 Percentile - 76



- ✕ Median Peak SWE
- Median (POR)
- Median ('91-'20)
- Stats. Shading
- Max Proj
- 90% Proj
- 70% Proj
- 50% Proj
- 30% Proj
- 10% Proj
- Min Proj
- 2022 (116 sites)
- 2021 (115 sites)
- 2020 (116 sites)
- 2019 (116 sites)
- 2018 (116 sites)
- 2017 (116 sites)
- 2016 (116 sites)
- 2015 (116 sites)
- 2014 (116 sites)
- 2013 (116 sites)
- 2012 (116 sites)
- 2011 (116 sites)
- 2010 (112 sites)
- 2009 (106 sites)
- 2008 (106 sites)





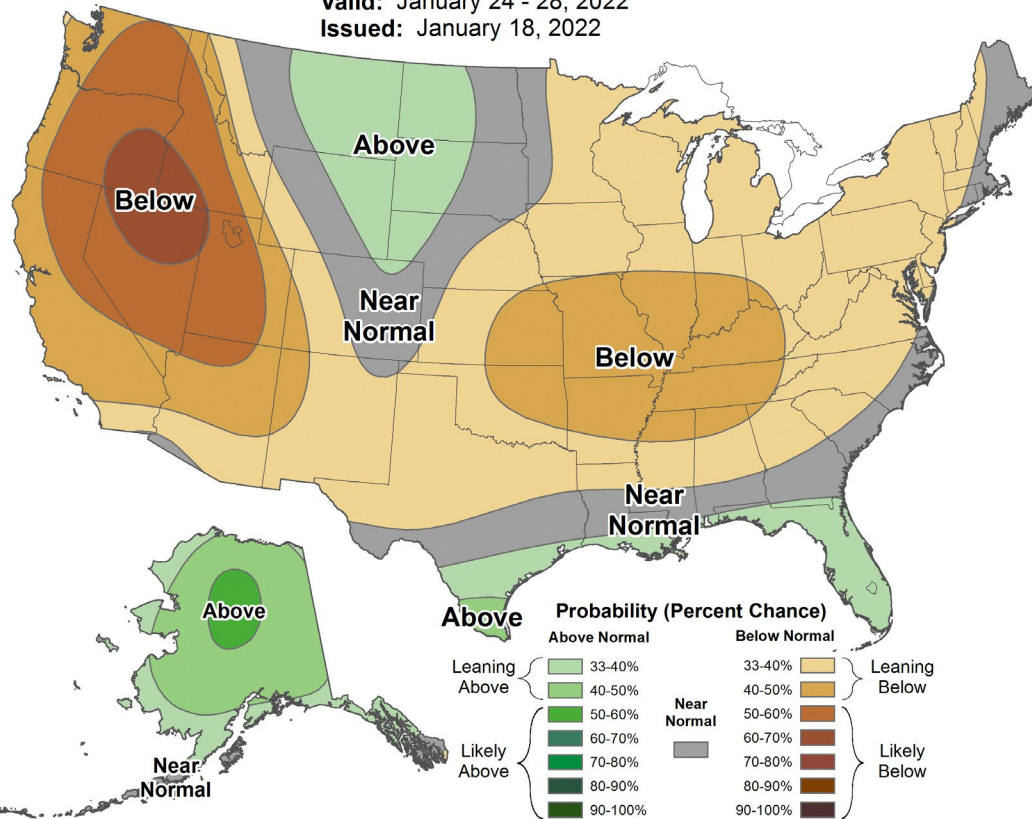
# NOAA Precipitation Outlook Comparison



## 6-10 Day Precipitation Outlook



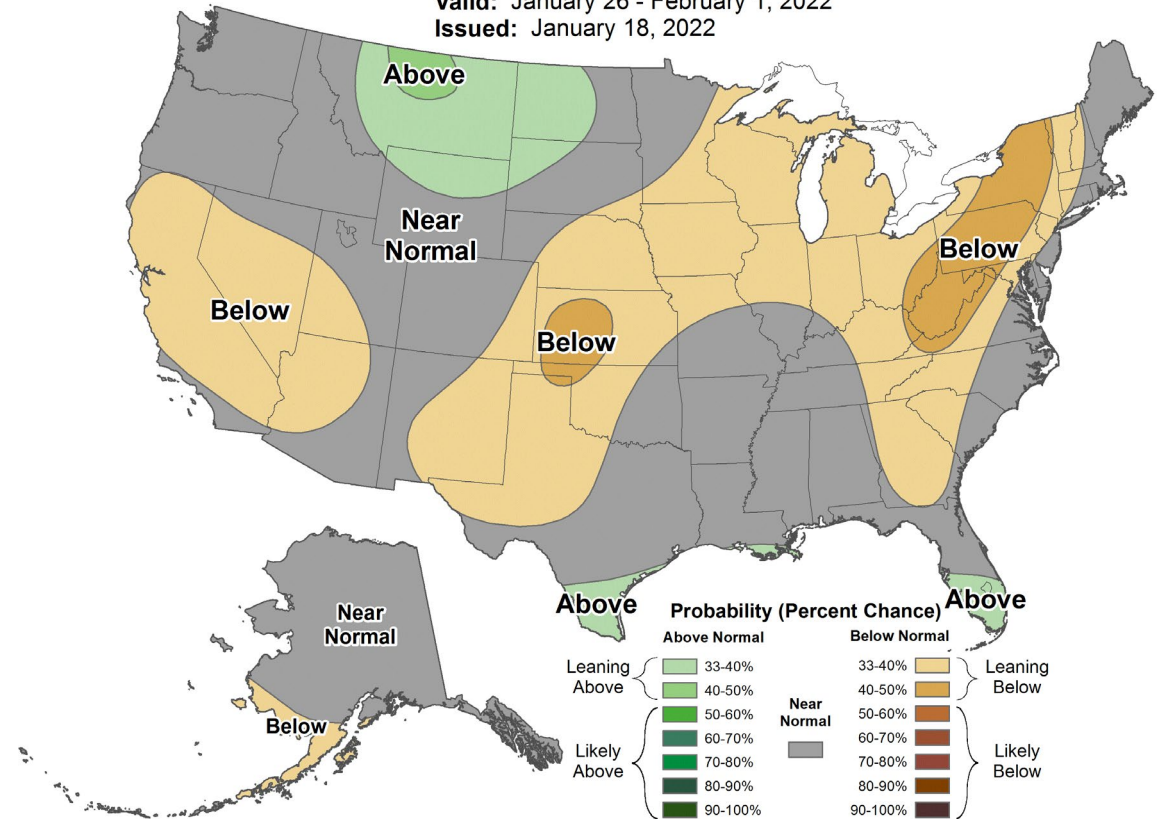
Valid: January 24 - 28, 2022  
 Issued: January 18, 2022



## 8-14 Day Precipitation Outlook



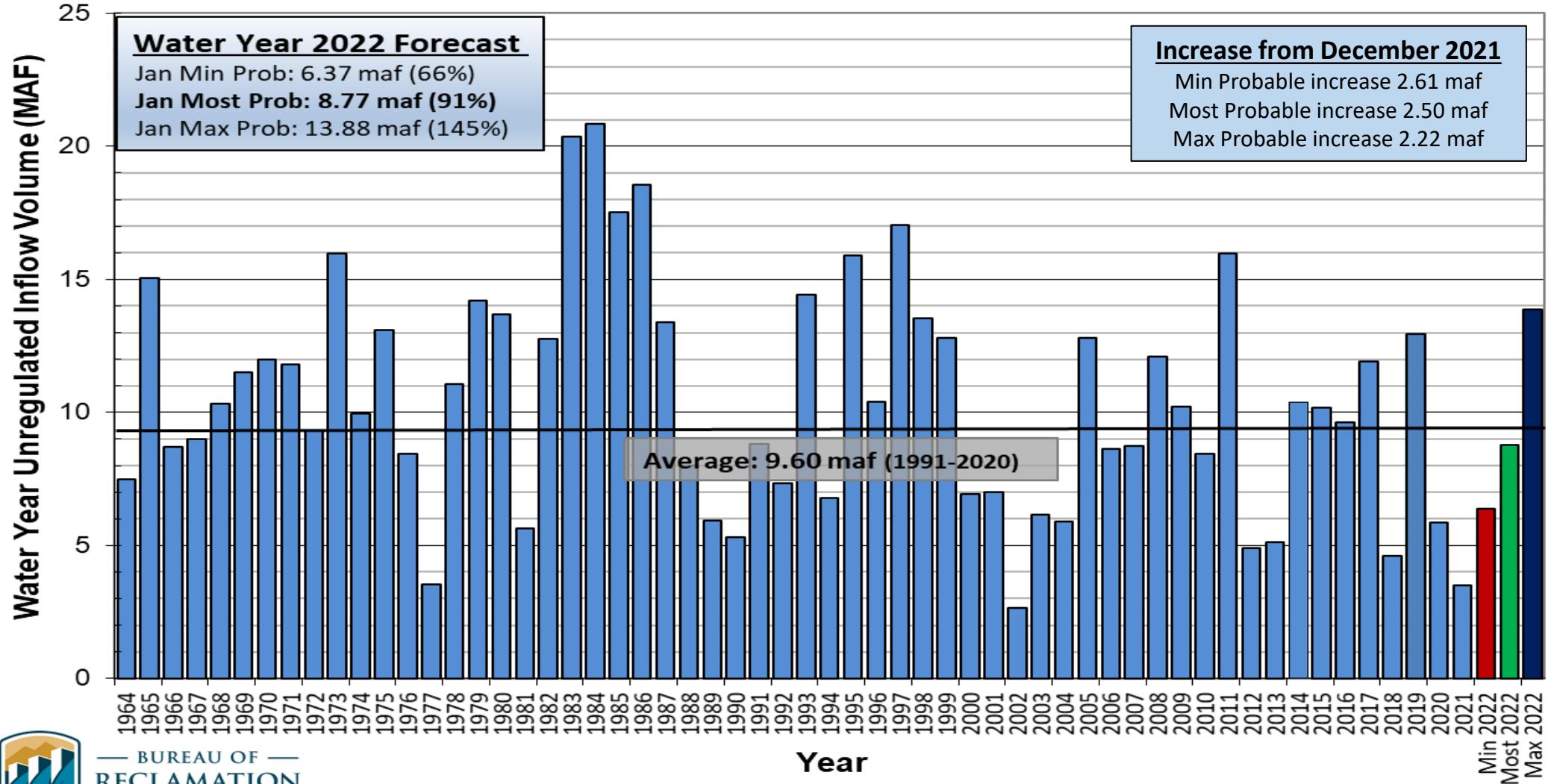
Valid: January 26 - February 1, 2022  
 Issued: January 18, 2022



# Lake Powell Unregulated Inflow

## Water Year 2022 Forecast (issued January 5)

### Comparison with History



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# Most Probable December Forecast Water Year 2022

Water Year 2022  
Forecasted Unregulated Inflow  
as of January 5, 2022

Reservoir	Unregulated Inflow (kaf)	1991-2020 Percent of Avg
Fontenelle	942	88
Flaming Gorge	1,216	86
Blue Mesa	880	97
Navajo	725	80
Powell	8,767	91

April – July 2022  
Forecasted Unregulated Inflow  
as of January 5, 2022

Reservoir	Unregulated Inflow (kaf)	1991-2020 Percent of Avg
Fontenelle	650	88
Flaming Gorge	840	87
Blue Mesa	650	102
Navajo	550	88
Powell	6,300	99

Powell January midmonth = 6.1 maf (95%)



# Current Upper Colorado Drought Response Activities

## Drought Response Operations Agreement

- Effective May 2019
- Continues through 2026 (except recovery)
- 2021 DROA release volumes of 161 kaf completed in October 2021
- Glen Canyon Dam release adjustments under LTEMP flexibility beginning in January 2022

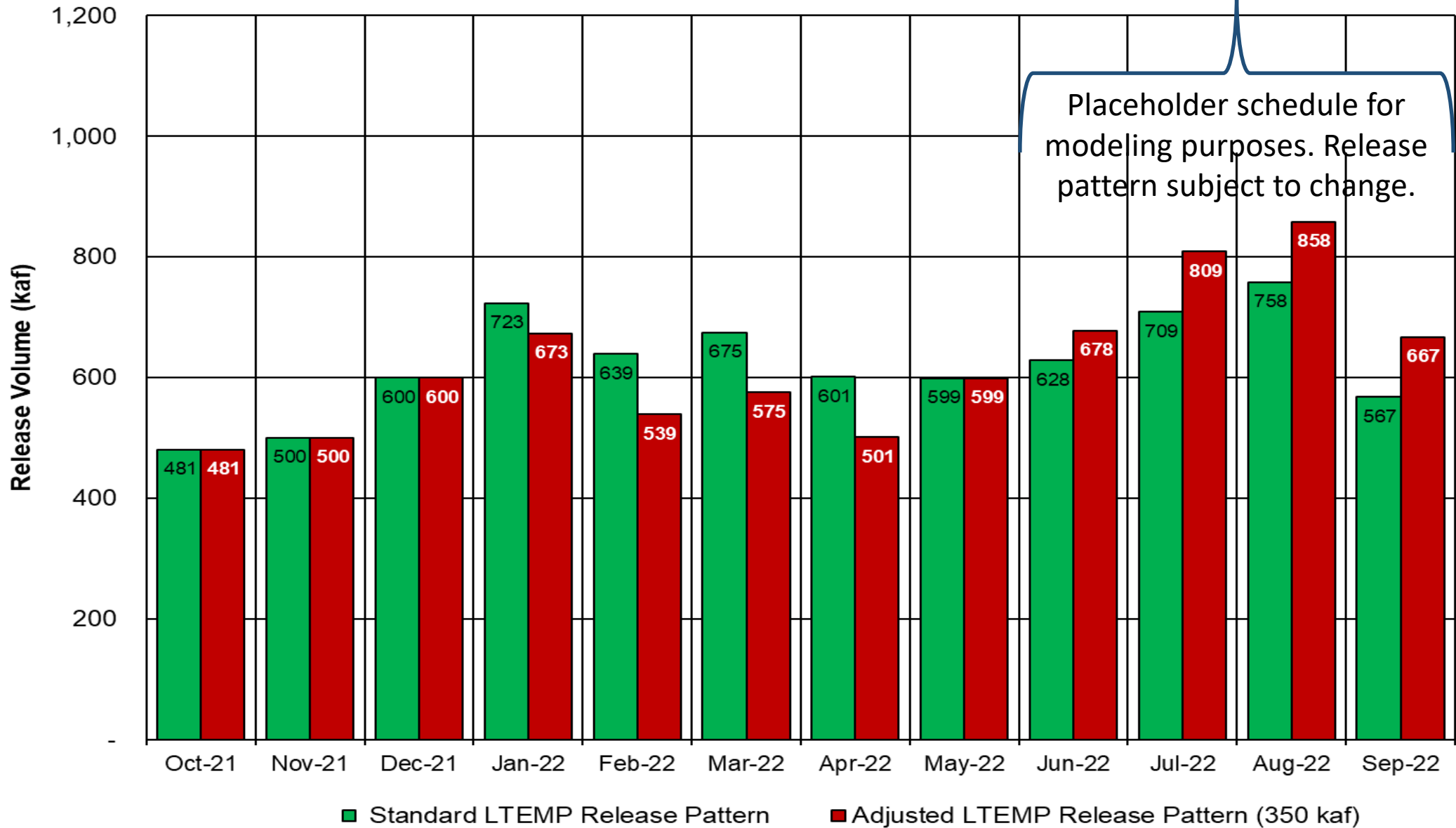
## Drought Response Operations Plan

- Scheduled to be finalized in April 2022
- Draft framework document circulating for review
- Webinar in late January to be followed by comment period
- 2022 operational plans based on actual hydrology to be developed February through April



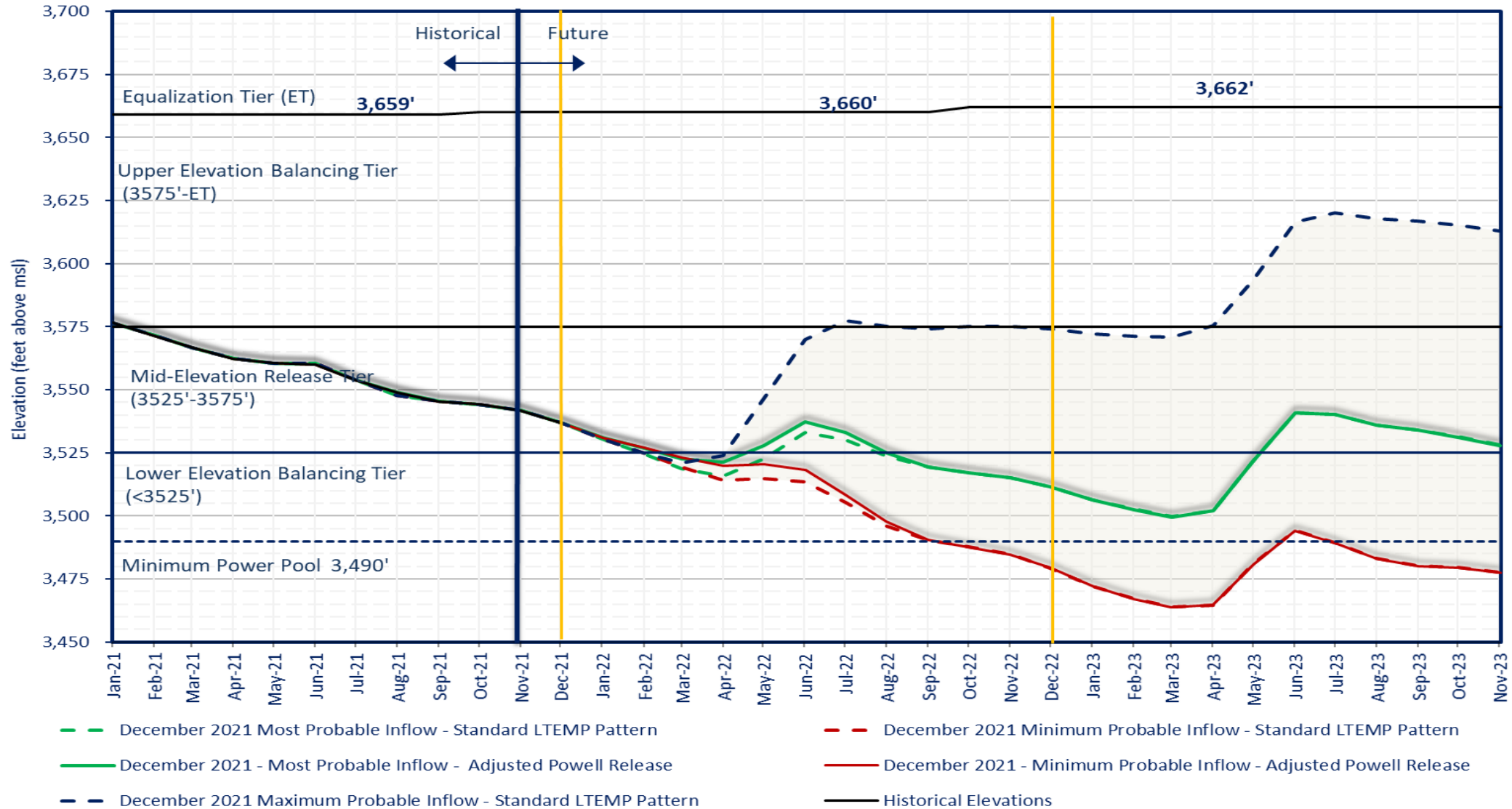
# Potential Lake Powell Monthly Release Volume Distribution

7.48 MAF Release Pattern for Water Year 2022



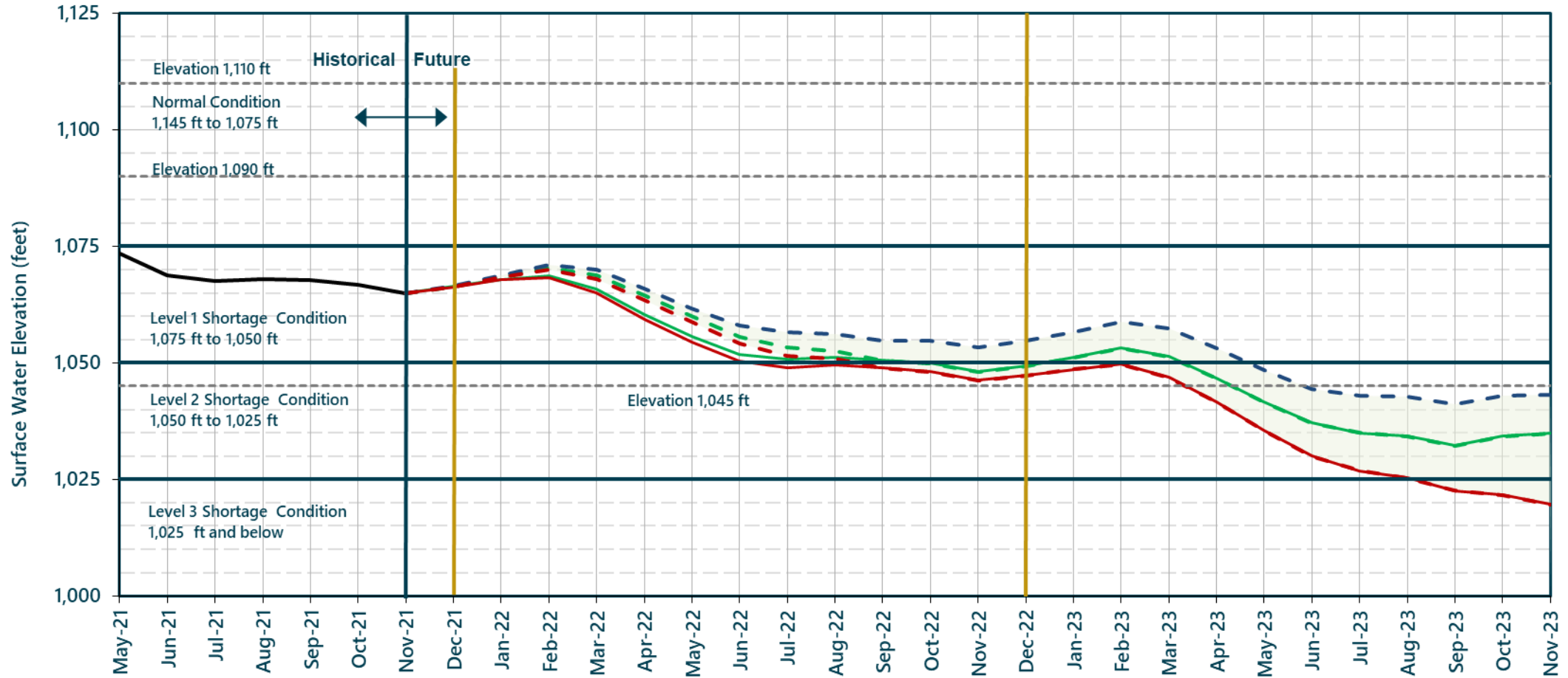
# Lake Powell End of Month Elevations

Projections from the December 2021 24-Month Study Inflow Scenarios



# Lake Mead End of Month Elevations

Projections from the December 2021 24-Month Study Inflow Scenarios



- Historical Elevations
- December 2021 Most Probable Inflow - Standard LTEMP Pattern
- December 2021 Most Probable Inflow - Adjusted Powell Release
- - December 2021 DROA Maximum Probable Inflow - Standard LTEMP Pattern
- - December 2021 DROA Minimum Probable Inflow - Standard LTEMP Pattern
- December 2021 Min Probable Inflow - Adjusted Powell Release

The Drought Response Operations Agreement (DROA) is available online at: <https://www.usbr.gov/dcp/finaldocs.html>.





# Upper Colorado Basin

## Projected Operations for Water Year 2022 Based on January 2022 Modeling





# Lake Powell & Lake Mead Operational Table

## Operating Determinations for Water Year/Calendar Year 2022

Lake Powell			Lake Mead		
Elevation (feet)	Operation According to the Interim Guidelines	Live Storage (maf) <sup>1</sup>	Elevation (feet)	Operation According to the Interim Guidelines	Live Storage (maf) <sup>1</sup>
3,700	Equalization Tier Equalize, avoid spills or release 8.23 maf	24.3	1,220	Flood Control Surplus or Quantified Surplus Condition Deliver > 7.5 maf	25.9
3,636 - 3,666 (2008-2026)	Upper Elevation Balancing Tier <sup>3</sup> Release 8.23 maf; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	15.5 - 19.3 (2008-2026)	1,200 (approx.) <sup>2</sup>	Domestic Surplus or ICS Surplus Condition Deliver > 7.5 maf	22.9 (approx.) <sup>2</sup>
3,575	Mid-Elevation Release Tier Release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	9.5	1,145	Normal or ICS Surplus Condition Deliver ≥ 7.5 maf	15.9
	<b>3,535.40 ft</b>		1,105		11.9
			1,075	<b>1,065.85 ft</b>	9.4
	<b>Jan 1, 2022 Projection</b>			Shortage Condition Deliver 7.167 <sup>4</sup> maf	<b>Jan 1, 2022 Projection</b>
3,525		5.9	1,050		7.5
	Lower Elevation Balancing Tier Balance contents with a min/max release of 7.0 and 9.5 maf		1,025	Shortage Condition Deliver 7.083 <sup>5</sup> maf	5.8
3,490		4.0	1,000	Shortage Condition Deliver 7.0 <sup>6</sup> maf Further measures may be undertaken <sup>7</sup>	4.3
3,370		0	895		0

Diagram not to scale

<sup>1</sup> Acronym for million acre-feet

<sup>2</sup> This elevation is shown as approximate as it is determined each year by considering several factors including Lake Powell and Lake Mead storage, projected Upper Basin and Lower Basin demands, and an assumed inflow.

<sup>3</sup> Subject to April adjustments which may result in a release according to the Equalization Tier

<sup>4</sup> Of which 2.48 maf is apportioned to Arizona, 4.4 maf to California, and 0.287 maf to Nevada

<sup>5</sup> Of which 2.40 maf is apportioned to Arizona, 4.4 maf to California, and 0.283 maf to Nevada

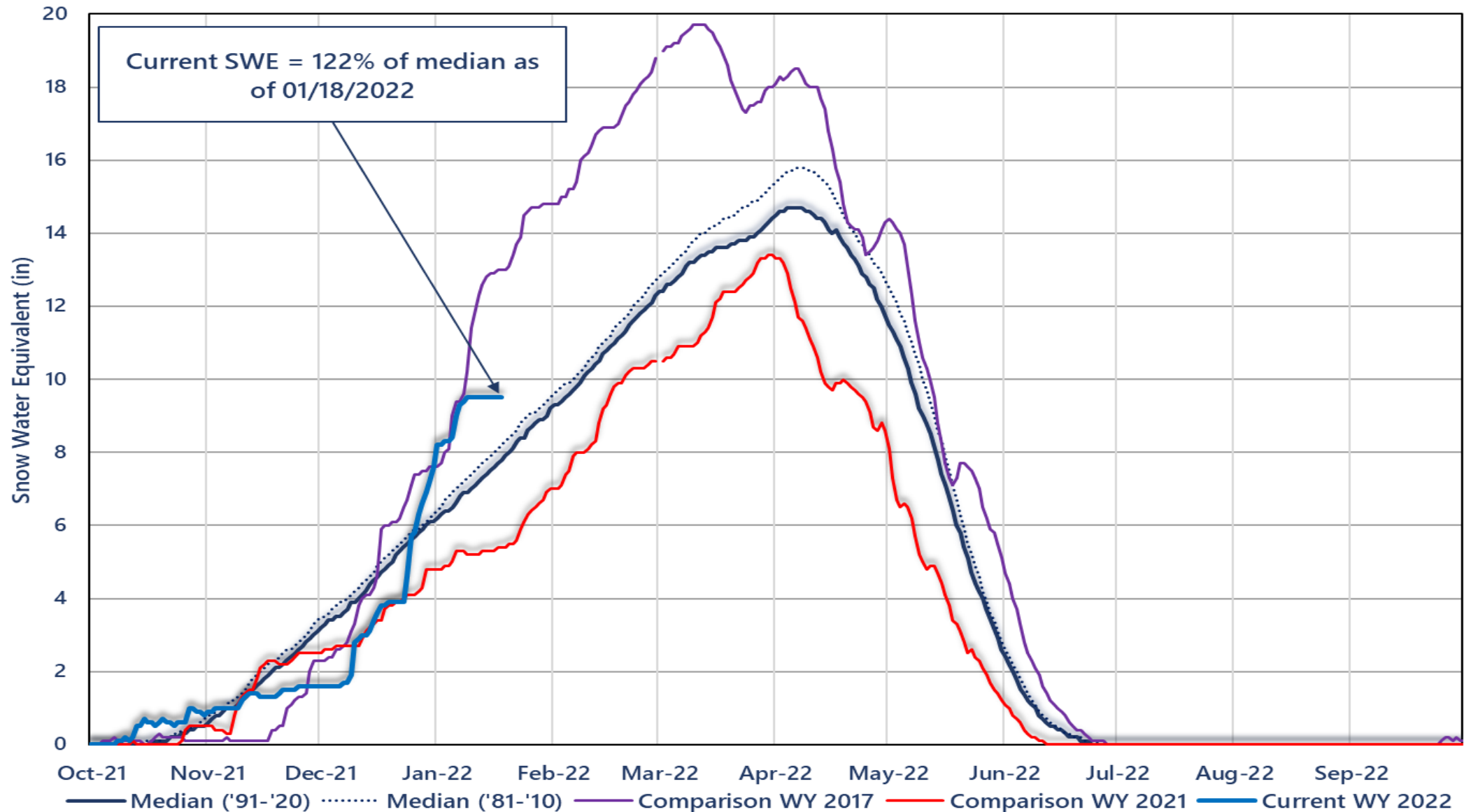
<sup>6</sup> Of which 2.32 maf is apportioned to Arizona, 4.4 maf to California, and 0.280 maf to Nevada

<sup>7</sup> Whenever Lake Mead is below elevation 1,025 feet, the Secretary shall consider whether hydrologic conditions together with anticipated deliveries to the Lower Division States and Mexico is likely to cause the elevation at Lake Mead to fall below 1,000 feet. Such consideration, in consultation with the Basin States, may result in the undertaking of further measures, consistent with applicable Federal law.

<sup>1</sup> Lake Powell and Lake Mead operating determinations are based on August 2021 24-Month Study projections consistent with the 2007 Interim Guidelines and 2019 Drought Contingency Plans. These determinations will be documented in the 2022 Annual Operating Plan for Colorado River Reservoirs.



# Colorado River Basin Above Lake Powell Snow Water Equivalent



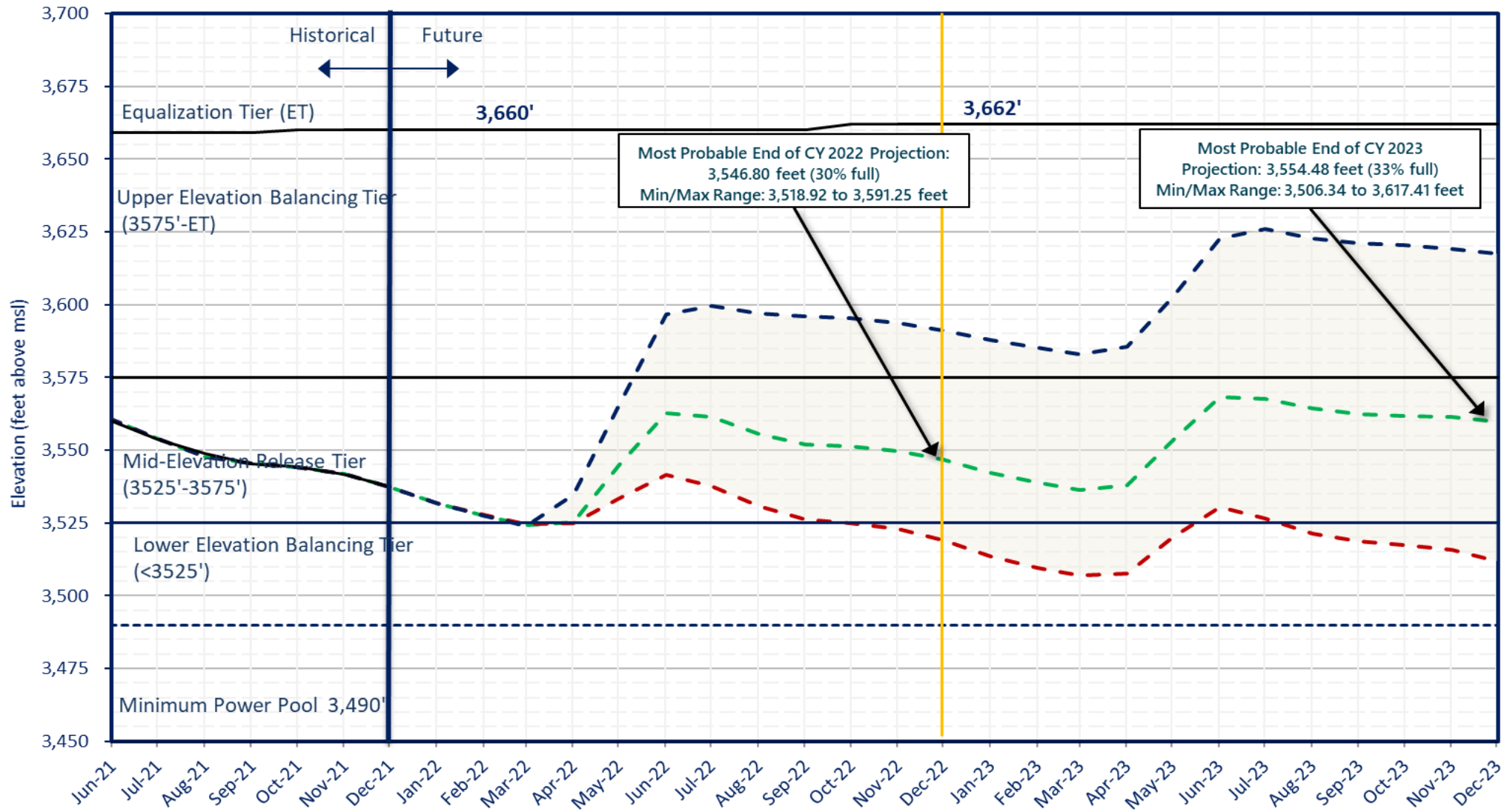
# Reclamation Operational Modeling Model Comparison

	Colorado River Mid-term Modeling System (CRMMS)		CRSS
	24-Month Study Mode (Manual Mode)	Ensemble Mode (Rule-based Mode)	
Primary Use	AOP tier determinations and projections of current conditions	Risk-based operational planning and analysis	Long-term planning, comparison of alternatives
Simulated Reservoir Operations	Operations input manually	Rule-driven operations	
Probabilistic or Deterministic	Deterministic – single hydrologic trace	Deterministic OR Probabilistic 35 (or more) hydrologic traces	Probabilistic – 100+ traces
Time Horizon (years)	1 - 2	1 - 5	1 - 50
Upper Basin Inflow	Unregulated forecast, 1 trace	Unregulated ESP forecast, 35 traces	Natural flow; historical, paleo, or climate change hydrology
Upper Basin Demands	Implicit, in unregulated inflow forecast		Explicit, 2016 UCRC assumptions
Lower Basin Demands	Official approved or operational		Developed with LB users



# Lake Powell End of Month Elevations

Projections from the January 2022 24-Month Study Inflow Scenarios



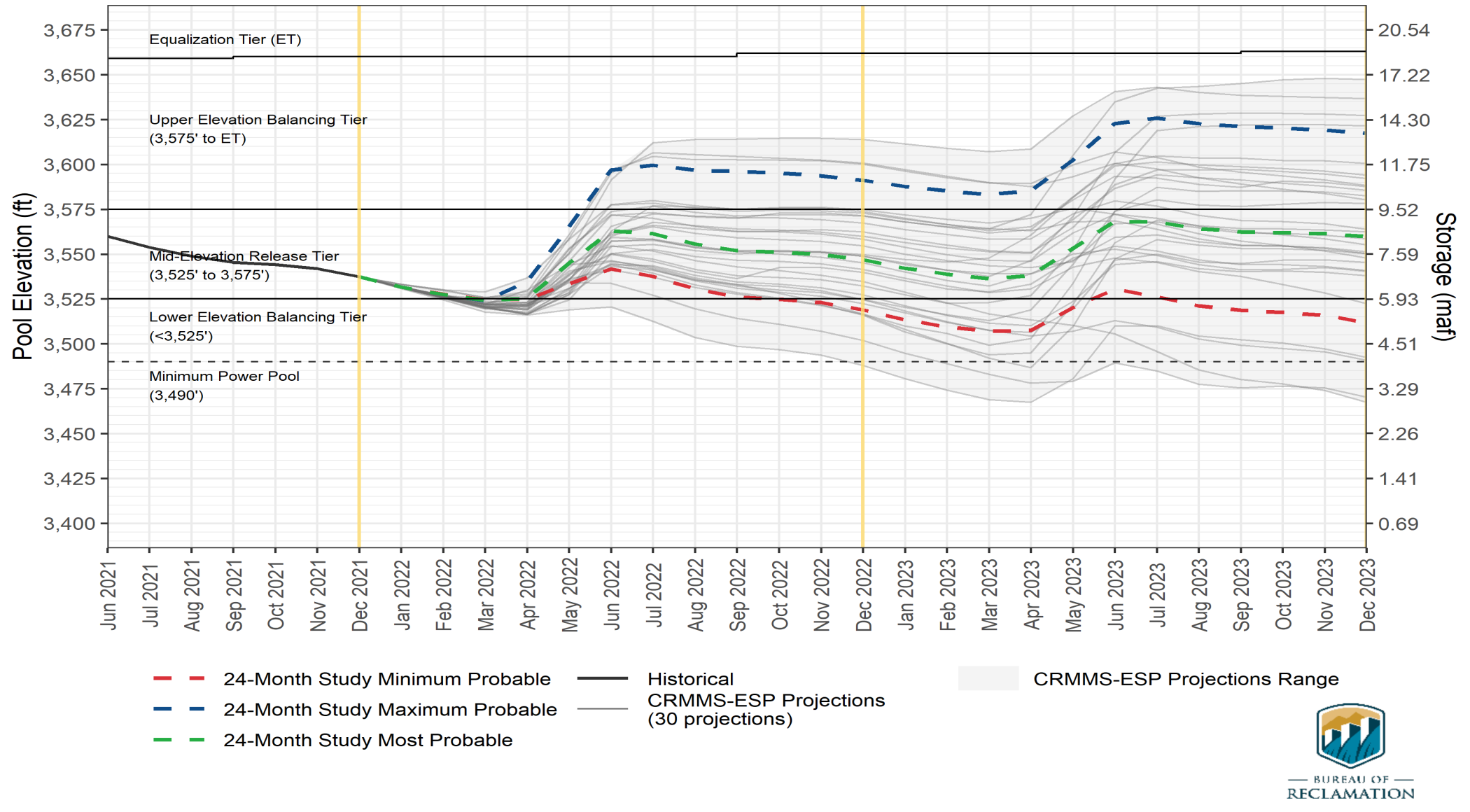
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- January 2022 Most Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 7.48 maf in WY2023
- - - January 2022 Minimum Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 7.0 maf in WY2023
- - - January 2022 Maximum Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 9.0 maf in WY2023
- Historical Elevations

\*The Drought Response Operations Agreement (DROA) can be found here: <https://www.usbr.gov/dcp/finaldocs.html>

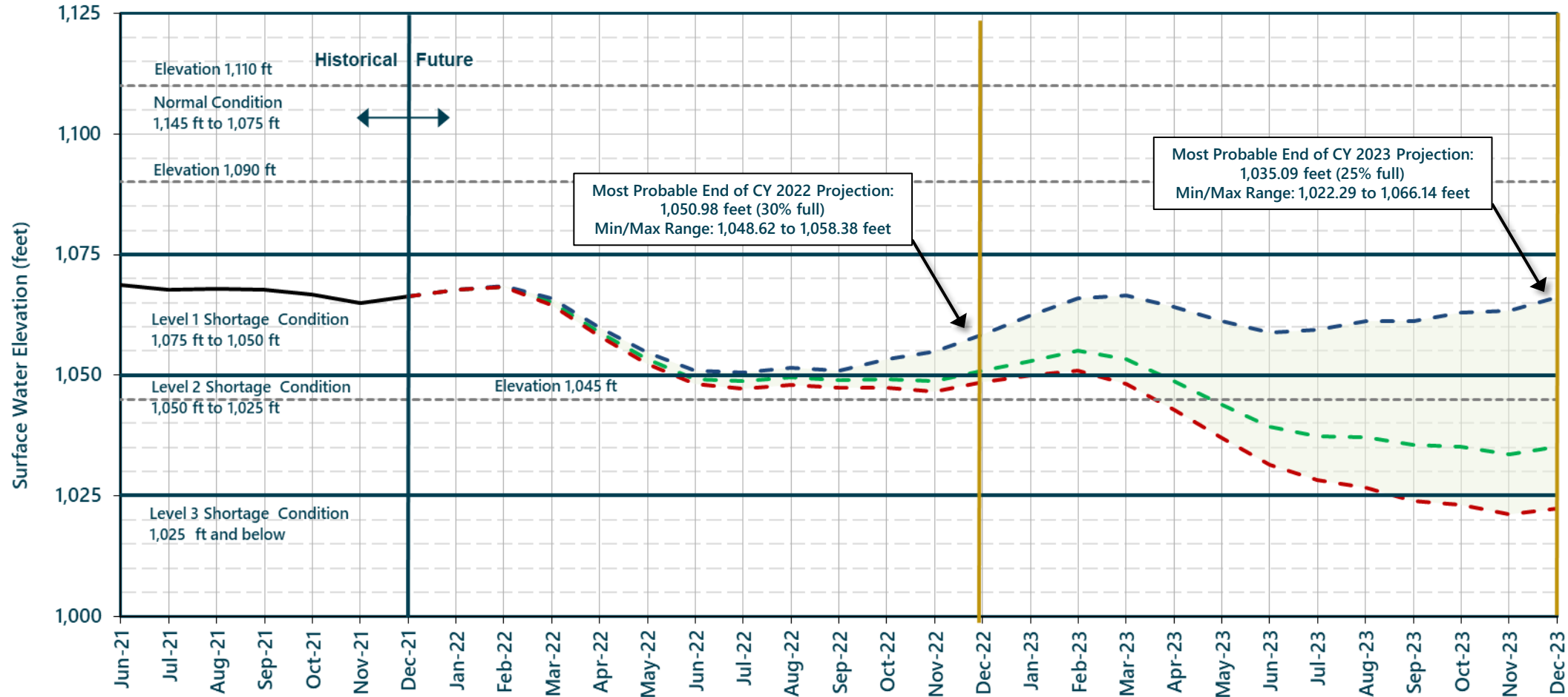


## Lake Powell End-of-Month Elevations CRMMS Projections from January 2022



# Lake Mead End of Month Elevations

Projections from the January 2022 24-Month Study Inflow Scenarios

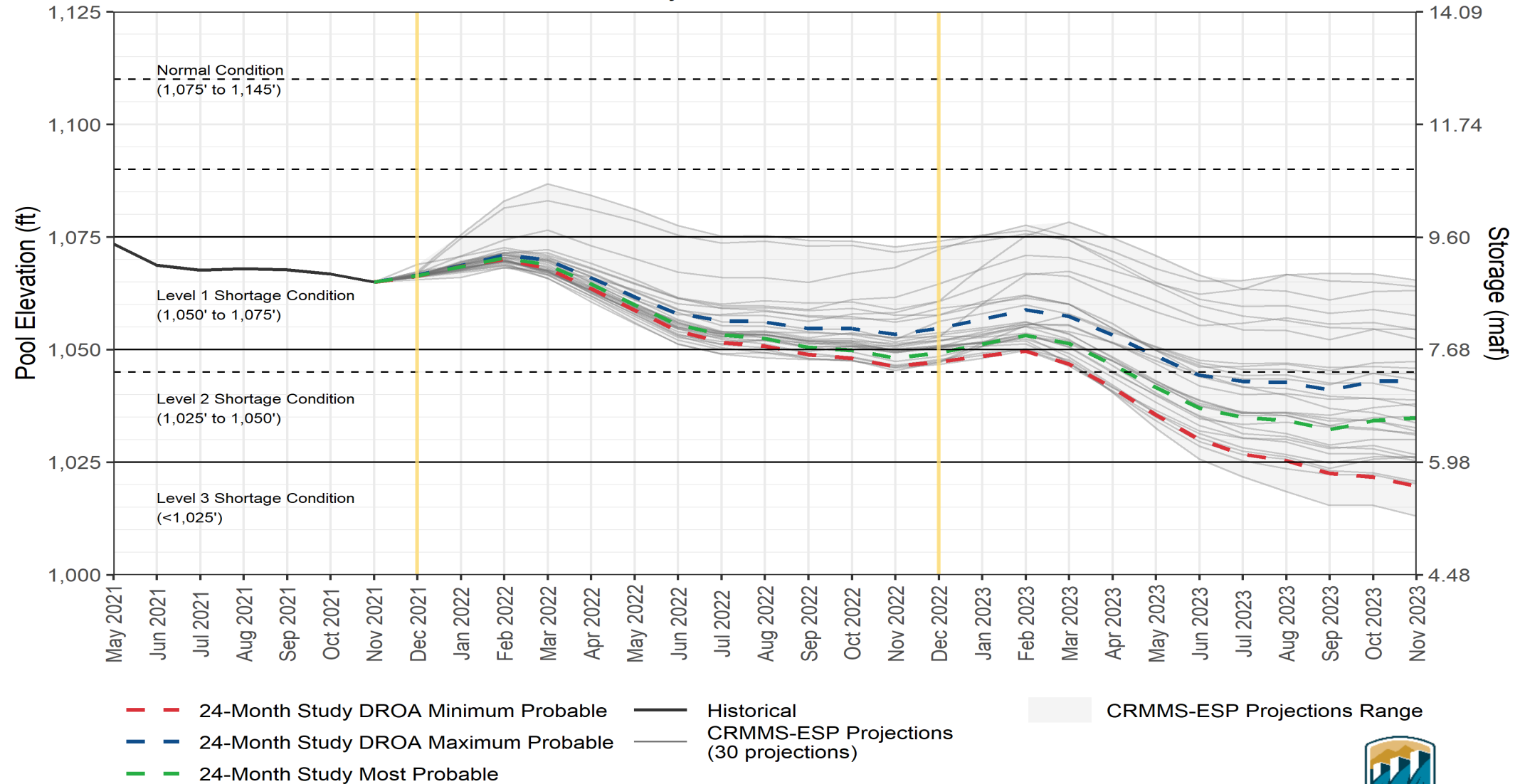


- Historical Elevations
- January 2022 Most Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 7.48 maf in WY 2023
- January 2022 Maximum Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 9.00 maf in WY 2023
- January 2022 Minimum Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 7.00 maf in WY 2023

The Drought Response Operations Agreement (DROA) is available online at: <https://www.usbr.gov/dcp/finaldocs.html>.



## Lake Mead End-of-Month Elevations CRMMS Projections from December 2021





# Upper Colorado Basin

## Hydropower Maintenance





# Glen Canyon Dam Power Plant Unit Outage Schedule for 2022

Unit Number	Oct 2021	Nov 2021	Dec 2021	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022
1					■							■
2						■						■
3												
4												
5						■						
6						■						
7	■							■				
8	■											
Units Available	6	6	6	6	5	4	6	5	6	6	6	4
Capacity (cfs)	18,700	18,600	11,700	18,700	14,800	11,350	18,000	15,300	19,200	19,200	19,000	12,000
Capacity (kaf/month)	1,150	1,110	1,110	1,160	890	1,050	1,070	970	1,100	1,180	1,150	750
Max (kaf) <sup>1</sup>	481	500	600	673	539	575	501	599	678	809	858	667
Most (kaf) <sup>1</sup>	481	500	600	673	539	575	501	599	678	809	858	667
Min (kaf) <sup>1</sup>	481	500	600	673	539	575	501	599	678	809	858	667

JAN MOST<sup>2</sup>

JAN MOST

7.48 maf

7.48 maf

7.48 maf

(updated 01-19-2022)

1 Projected release, based on January 2022 minimum, most and maximum probable inflow projections and 24-Month Study model runs.  
 2 Dependent upon availability to shift contingency reserves, which will increase capacity by 30-40MW (3%) at current efficiency.



# Glen Canyon Dam Power Plant Unit Outage Schedule for 2023

Unit Number	Oct 2022	Nov 2022	Dec 2022	Jan 2023	Feb 2023	Mar 2023	Apr 2023	May 2023	Jun 2023	Jul 2023	Aug 2023	Sep 2023
1												
2												
3												
4												
5												
6												
7												
8												
Units Available	4	4	6	6	4	4	6	7	6	6	6	6
Capacity (cfs)	11,900	11,900	18,800	18,600	11,400	11,400	18,500	19,000	19,400	19,400	19,300	19,200
Capacity (kaf/month)	1,140	1,100	1,240	1,510	940	1,300	1,480	1,390	1,560	1,610	1,600	1,200
Max (kaf) <sup>1</sup>	643	642	715	857	758	801	713	710	745	842	900	674
Most (kaf) <sup>1</sup>	480	500	600	723	639	675	601	599	628	709	758	568
Min (kaf) <sup>1</sup>	480	500	600	664	587	620	552	550	577	670	720	550

JAN MOST<sup>2</sup>

JAN MOST

9.0 maf

7.48 maf

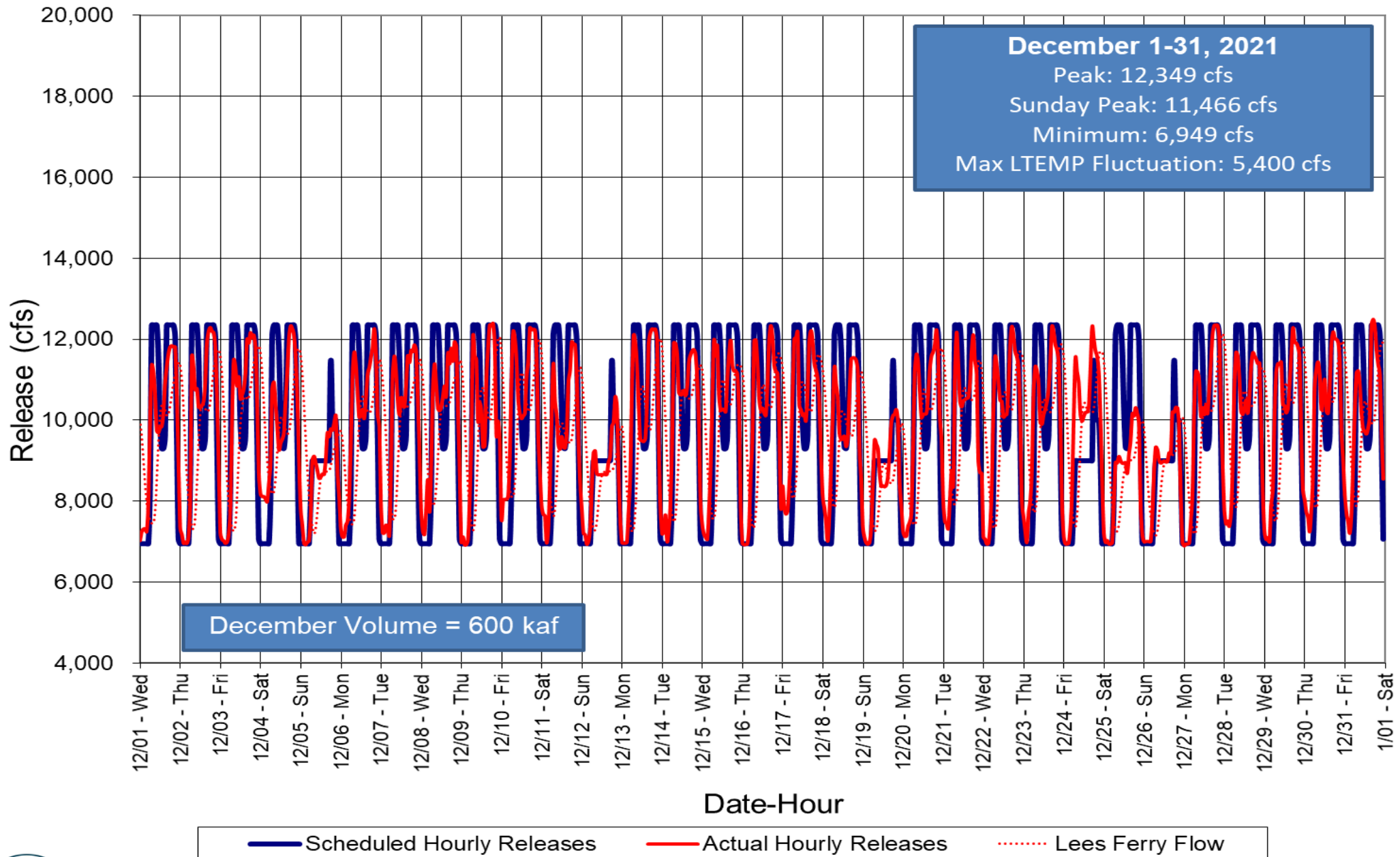
7.0 maf

(updated 01-19-2022)

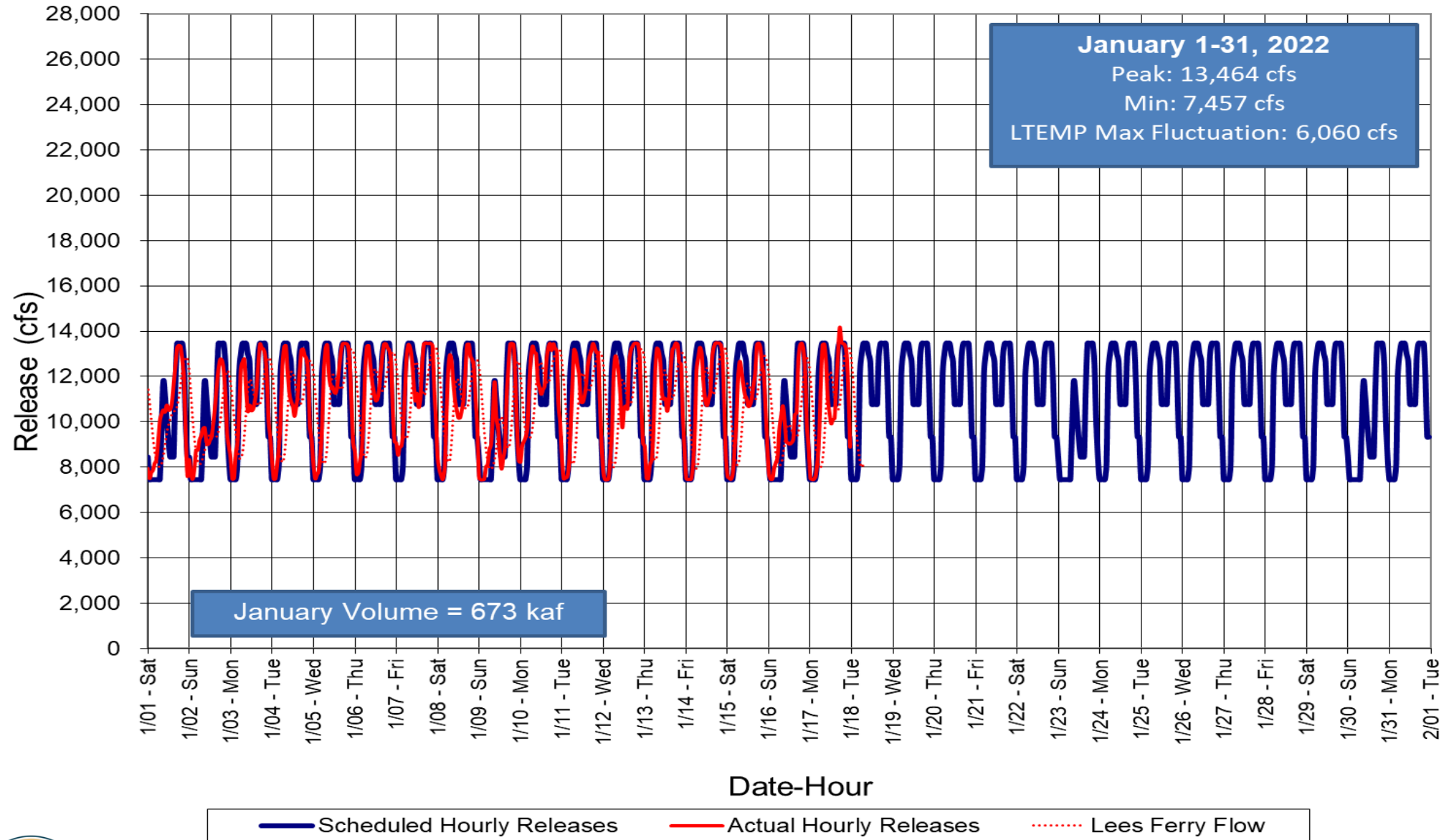
1 Projected release, based on January 2022 minimum, most and maximum probable Inflow Projections and 24-Month Study model runs.  
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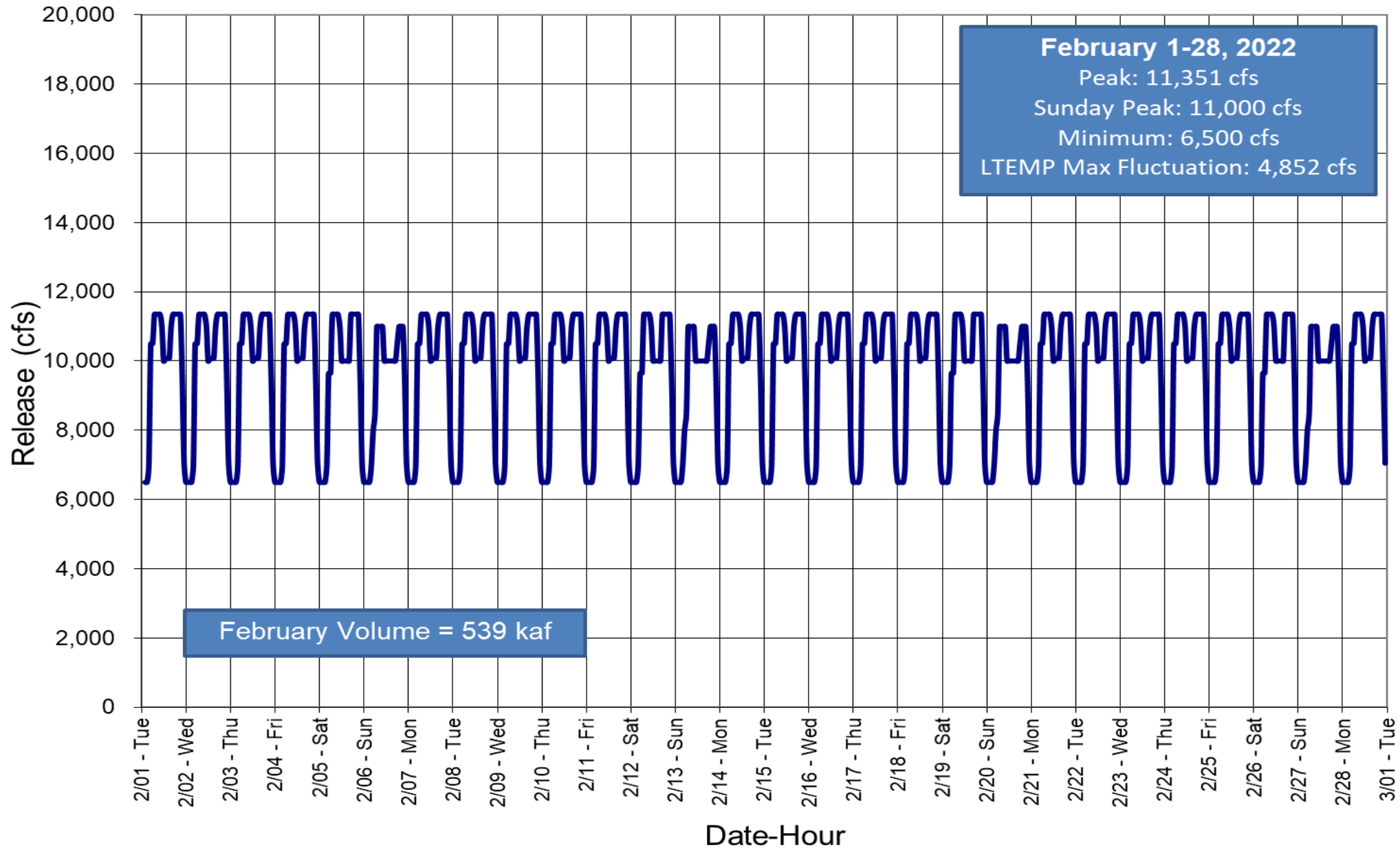
# Glen Canyon Dam Hourly Release Pattern December 2021



# Glen Canyon Dam Hourly Release Pattern January 2022



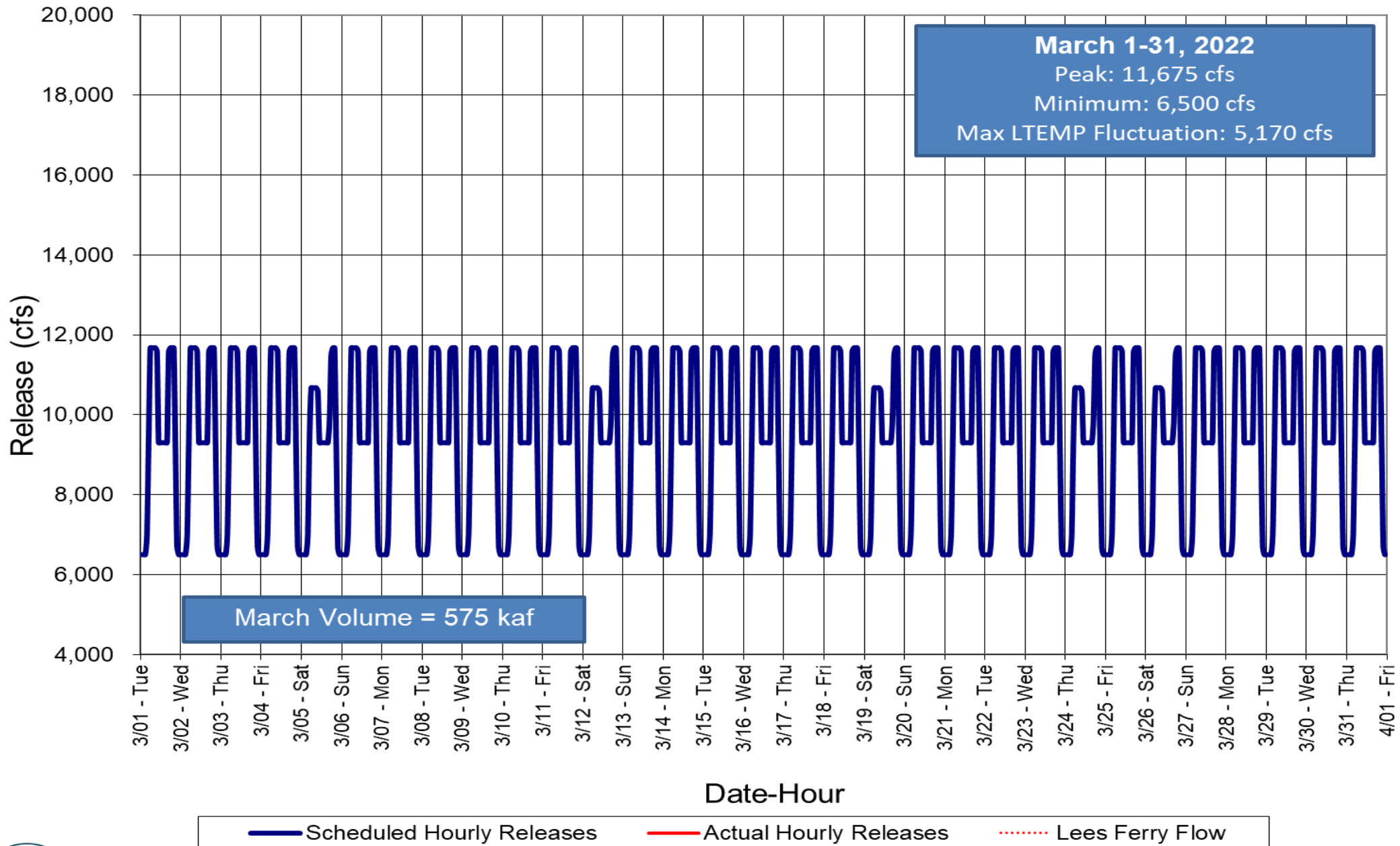
# Glen Canyon Dam Hourly Release Pattern February 2022



— Scheduled Hourly Releases   
 — Actual Hourly Releases   
 ⋯ Lees Ferry Flow



# Glen Canyon Dam Hourly Release Pattern March 2022



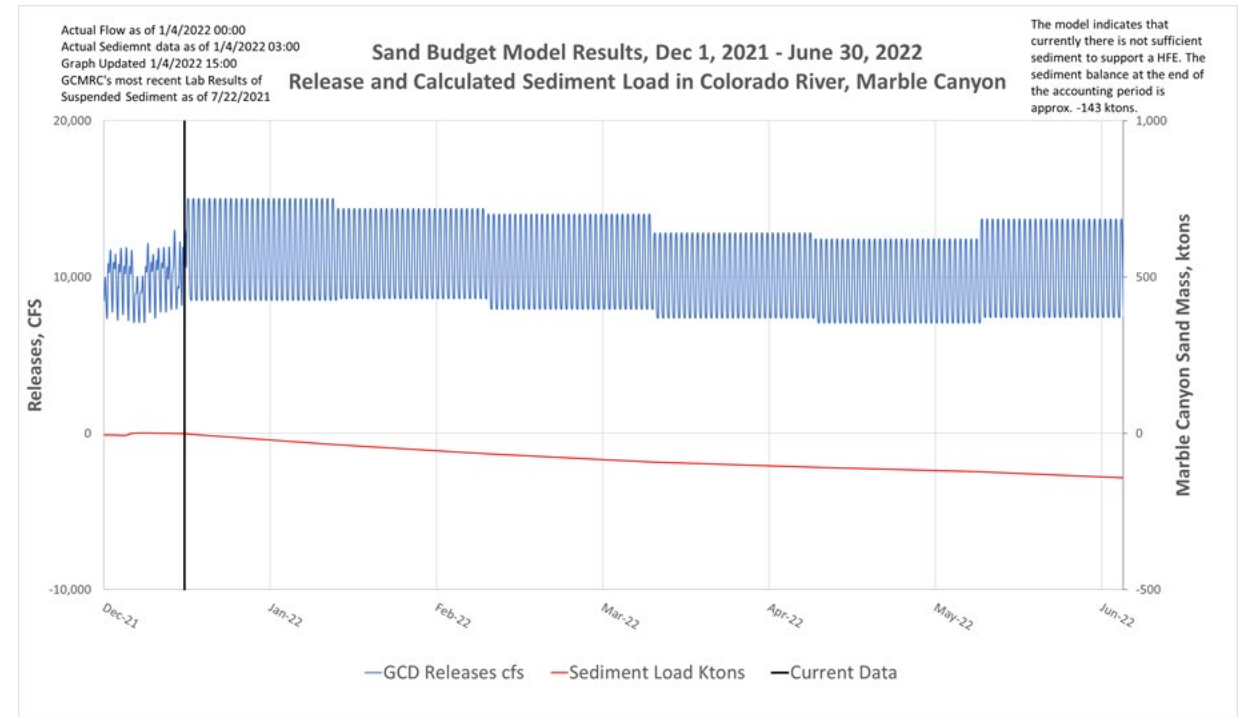
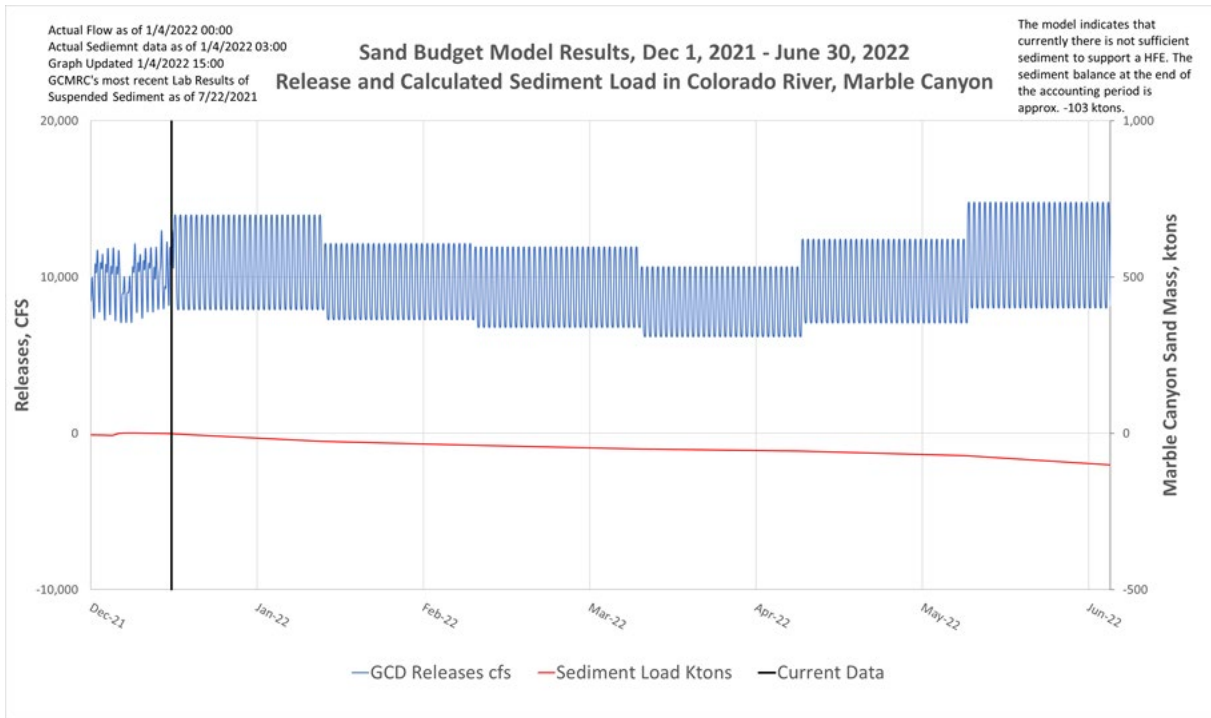
# Water Quality



# Spring 2022 HFE Modeling

## GCD Adjusted LTEMP Pattern (-103 kton)

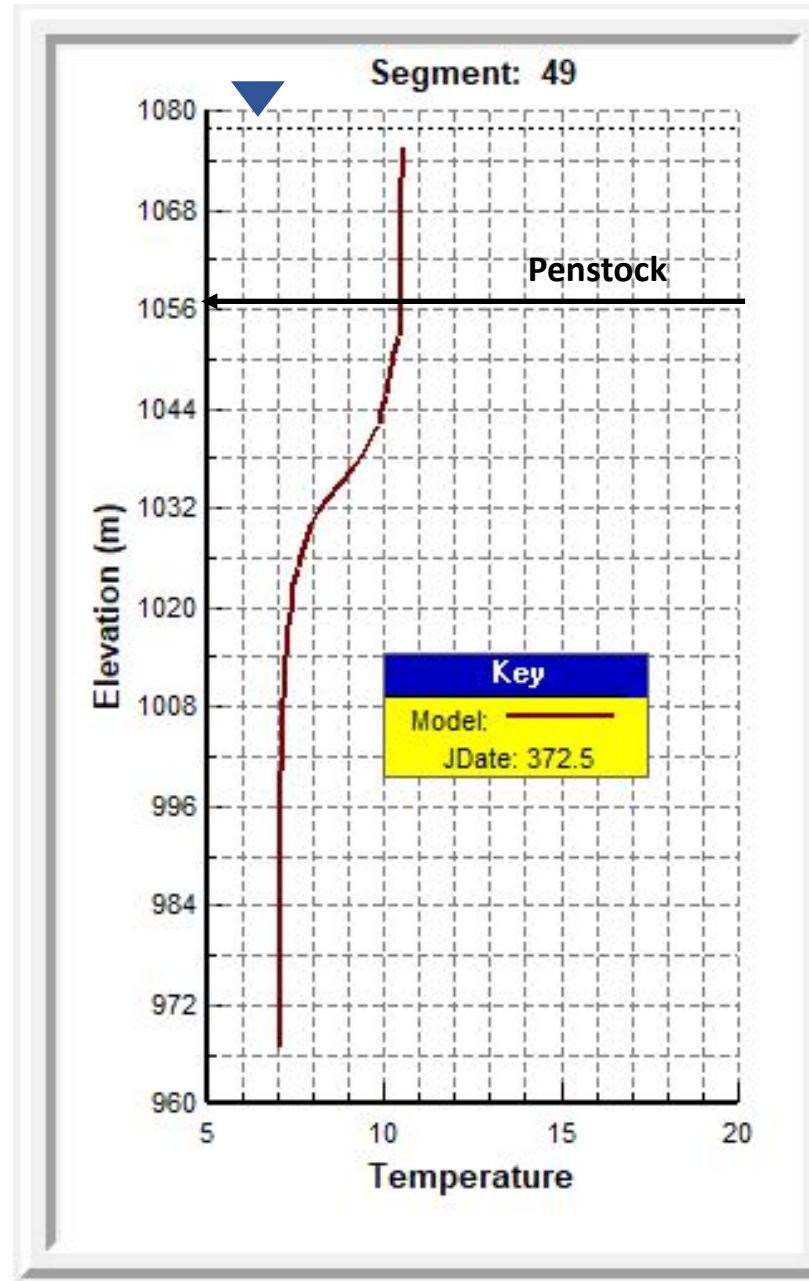
## GCD Standard LTEMP Pattern (-143 ktons)





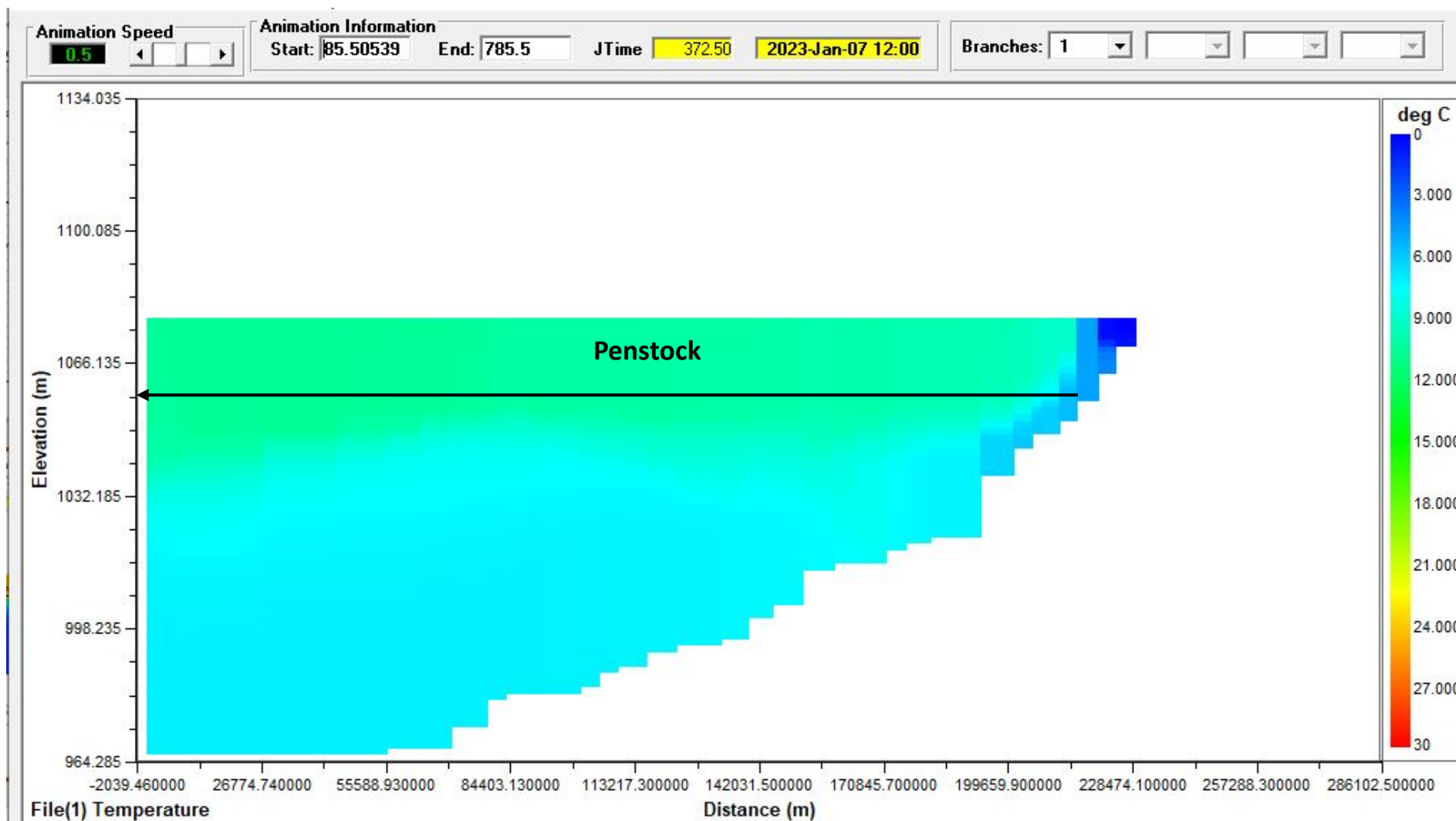
# Temperature Profile of Lake Powell near Glen Canyon Dam

1/7/2022

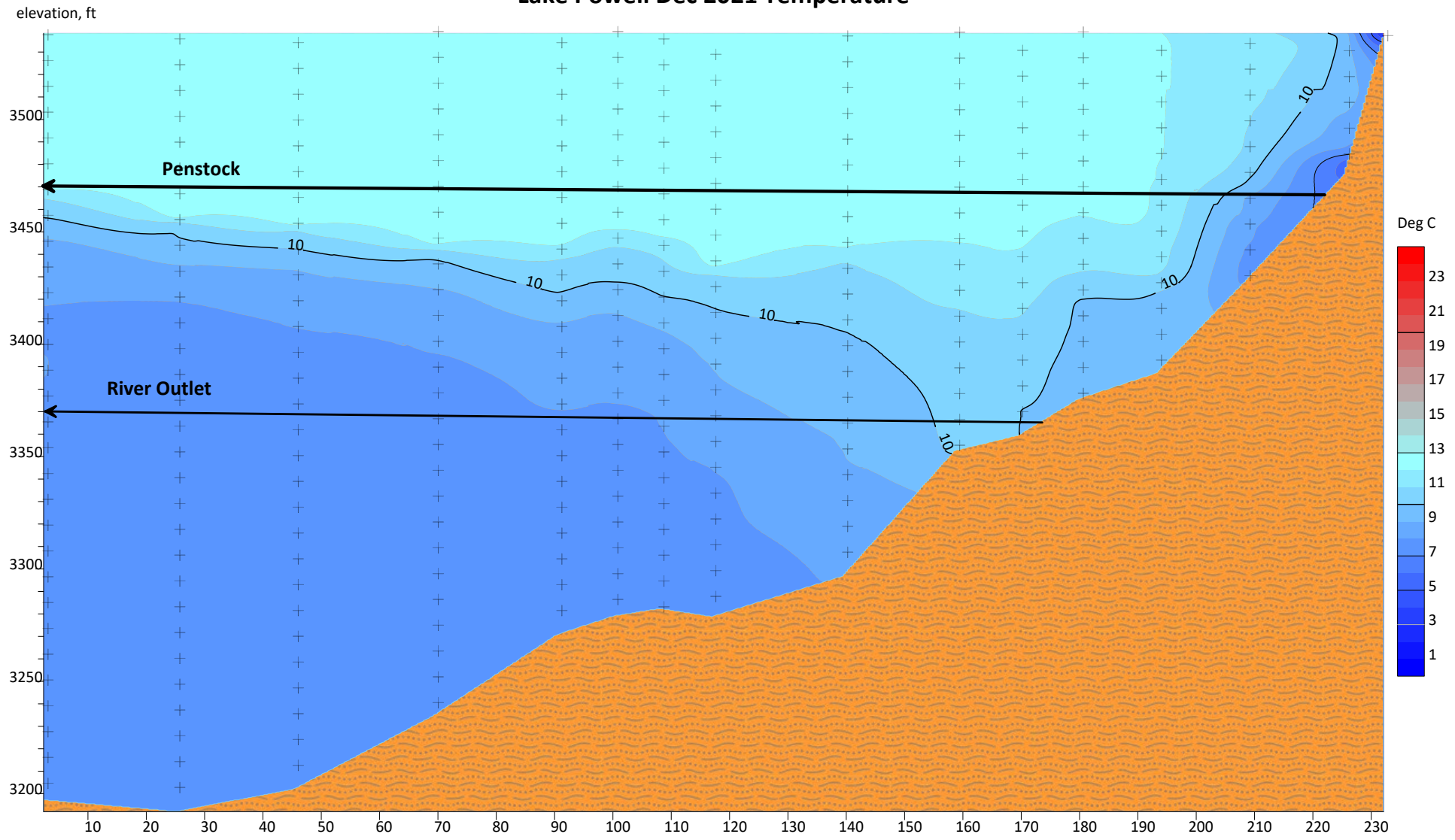


# Cross Sectional Temperature Profile of Lake Powell

1/7/2022

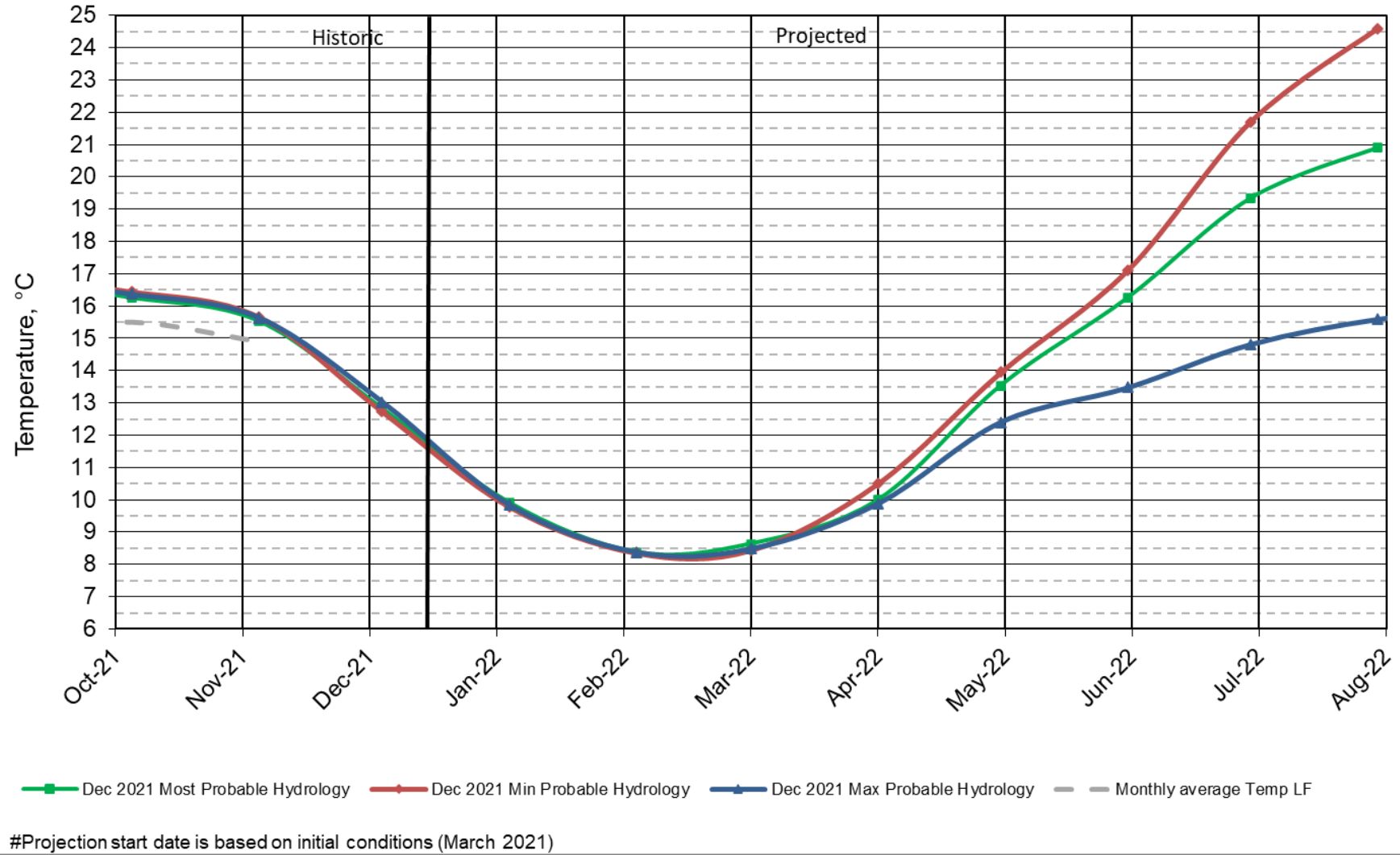


# Lake Powell Dec 2021 Temperature

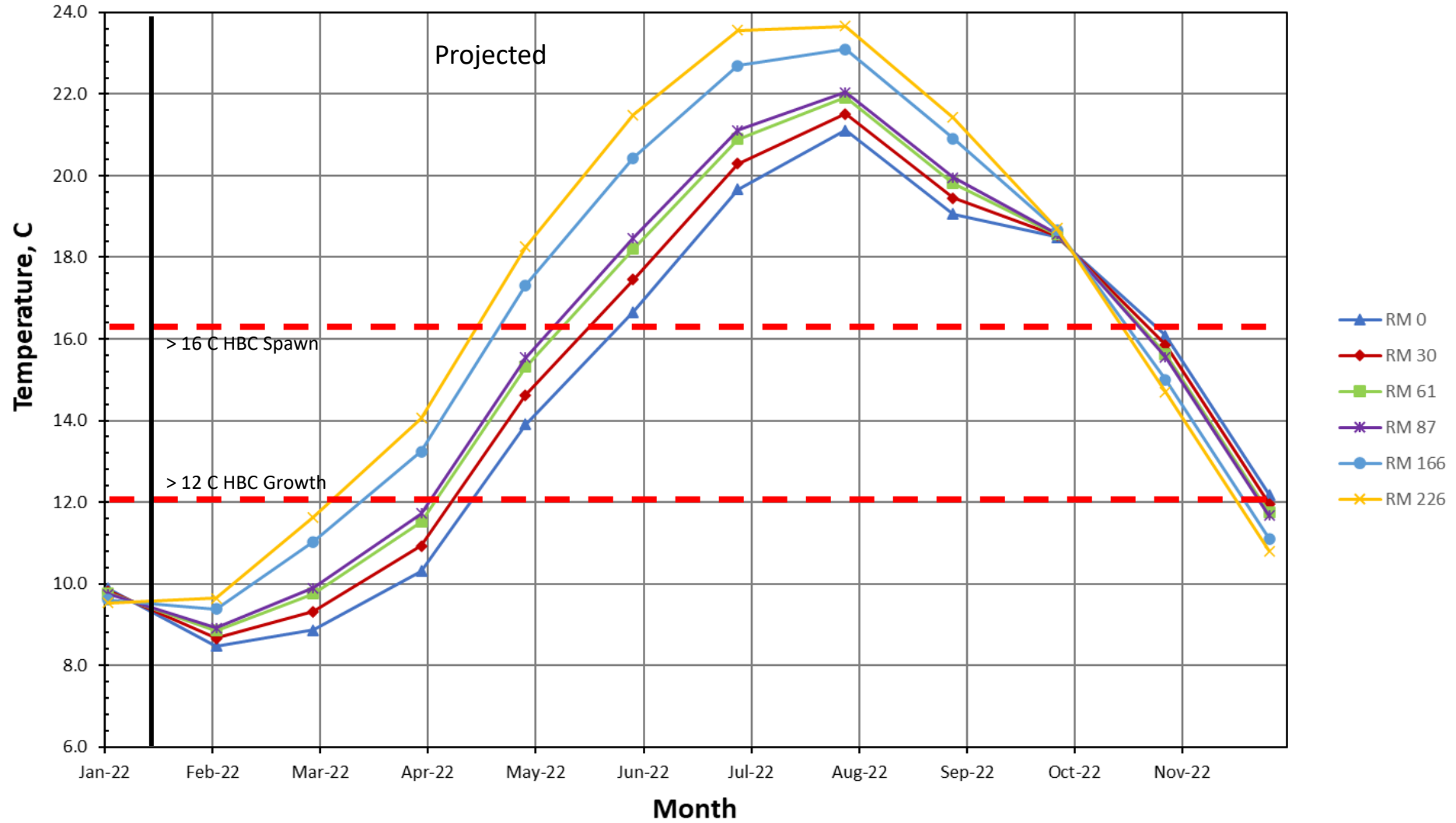


# Lake Powell Release Temperature

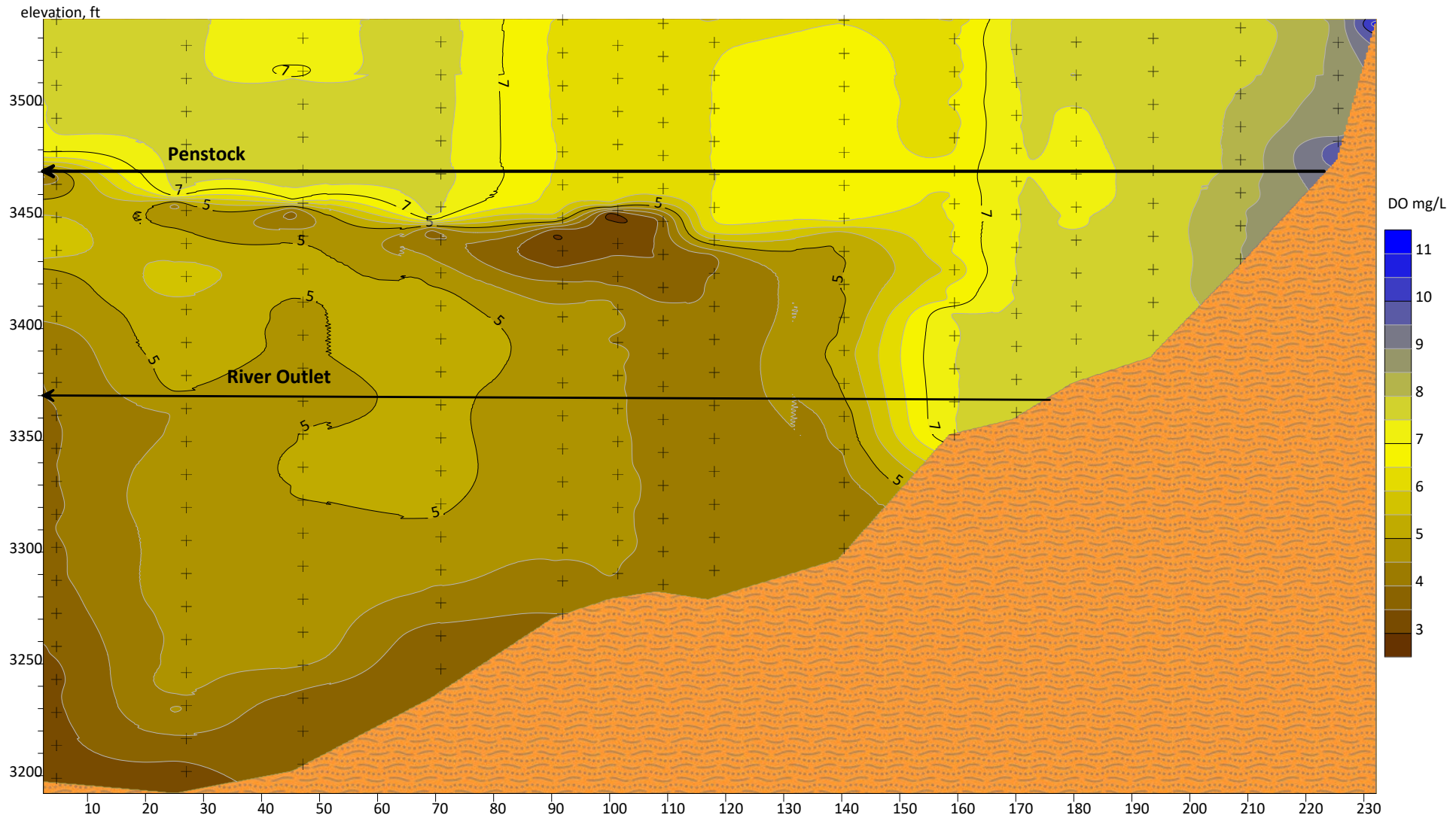
## Projected Temperature based on Dec 2021 Forecast



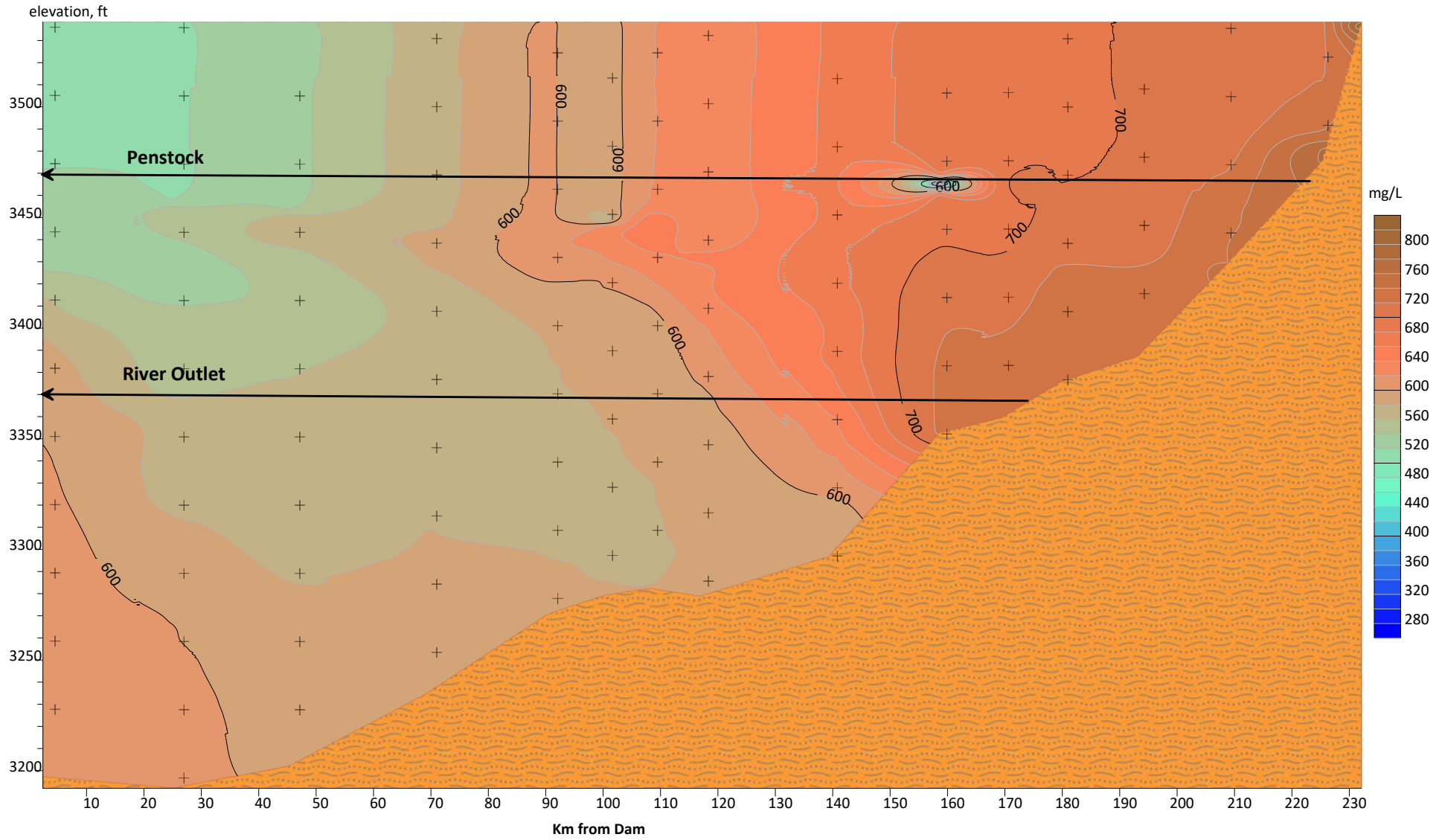
Colorado River, Grand Canyon Water Temperatures  
Projections based on December 2021 24MS, Most Probable Hydrology (Dibble 2020)



# Lake Powell Dec 2021 Dissolved Oxygen



# Lake Powell Dec 2021 TDS



# Questions?



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