BUREAU OF RECLAMATION

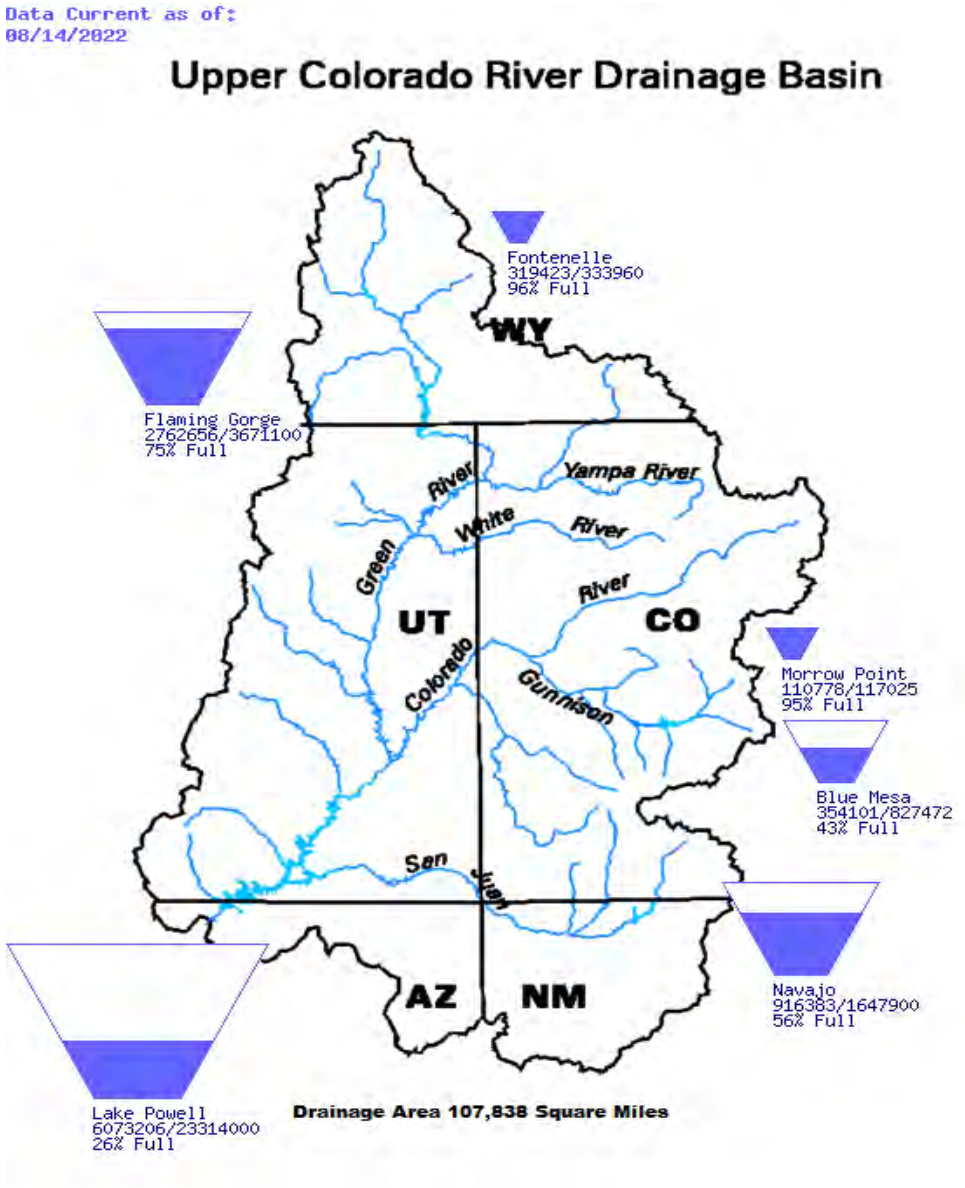
GCDAMP Adaptive Management Work Group

Basin Hydrology, Operations and Water Quality

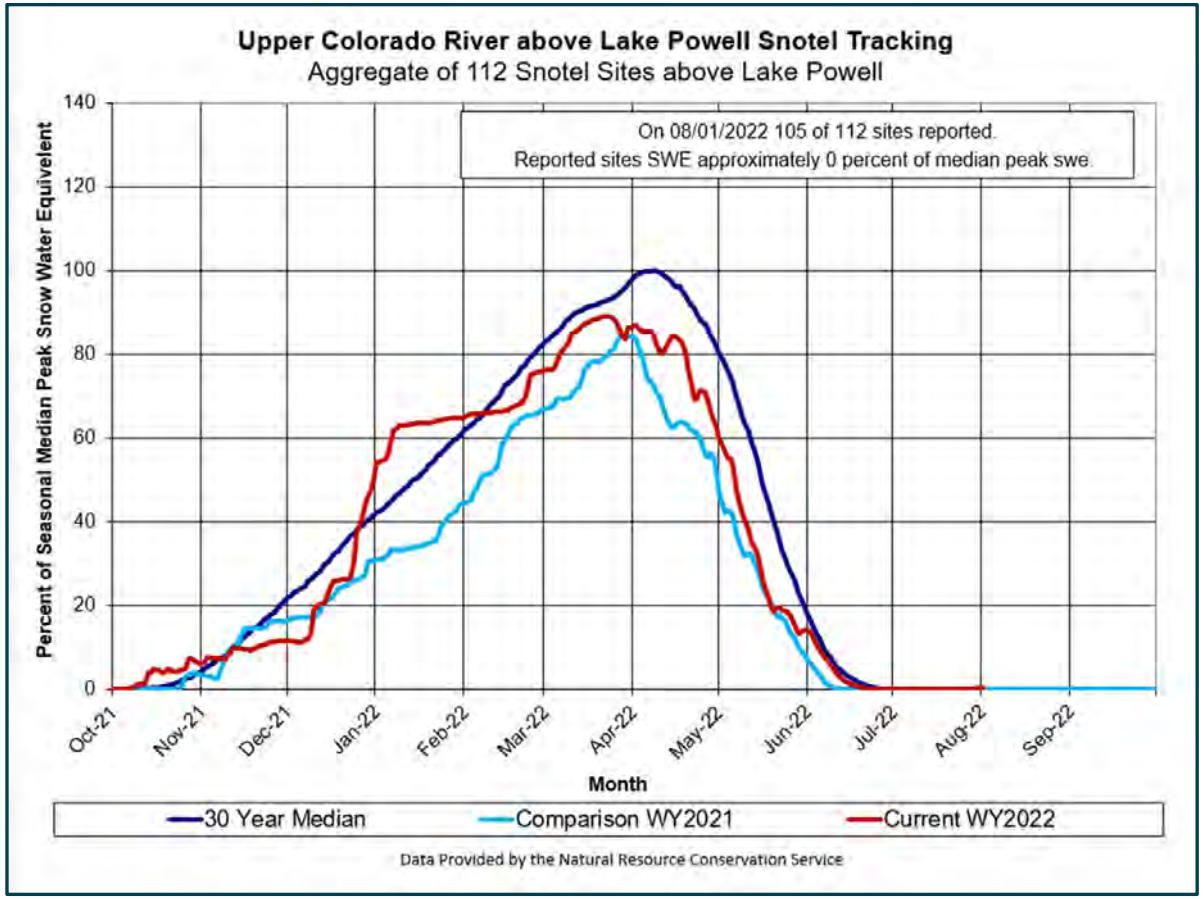
August 17, 2022

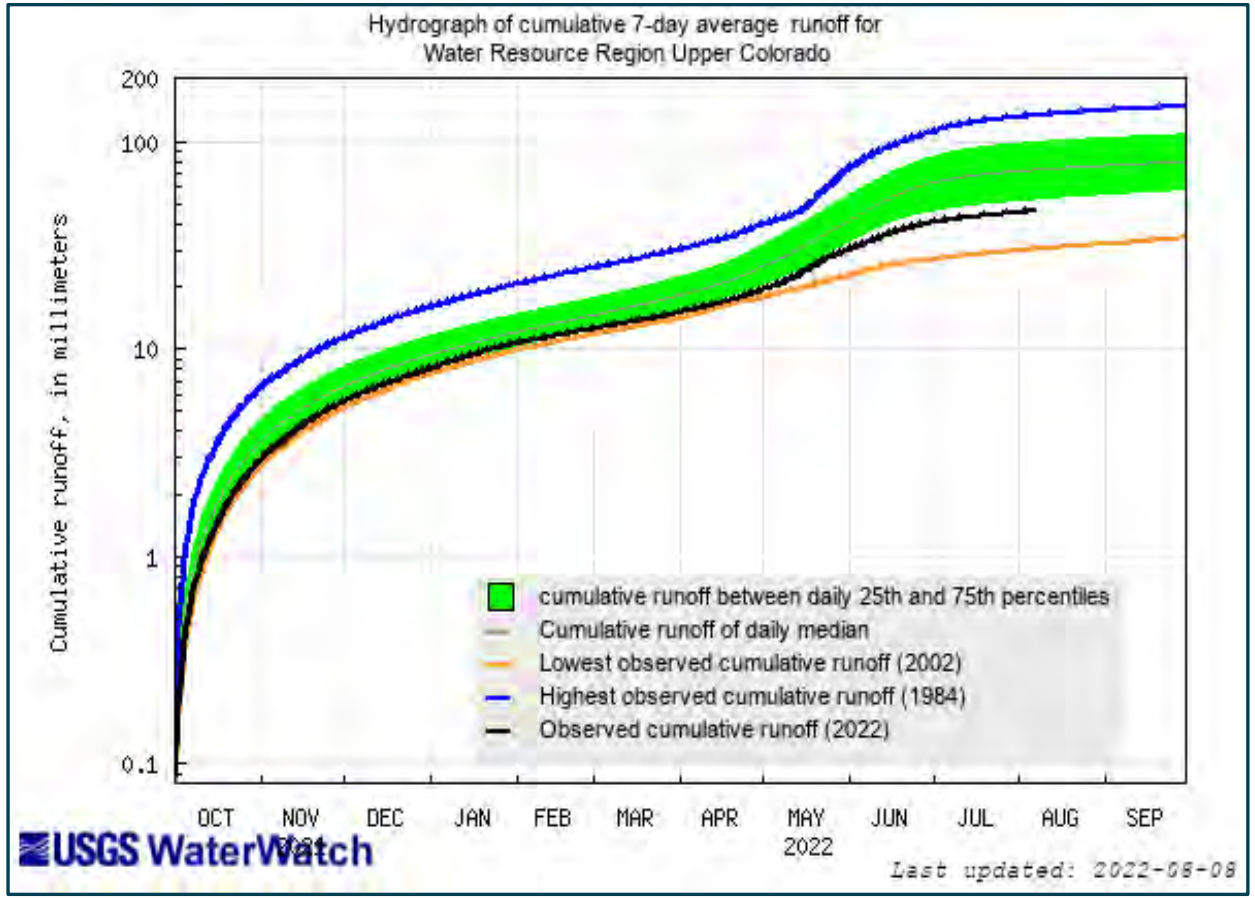
Upper Basin Storage (as of August 14, 2022)

Reservoir	Percent Current Live Storage	Current Live Storage (maf)	Live Storage Capacity (maf)	Elevation (feet)
Fontenelle	96	0.32	0.33	6,504.13
Flaming Gorge	75	2.76	3.67	6,015.57
Blue Mesa	43	0.35	0.83	7,457.84
Navajo	56	0.92	1.65	6,025.48
Lake Powell	26	6.07	23.31	3533.93
UC System Storage	35	10.55	29.79	
Total System Storage	34	19.99	58.48	



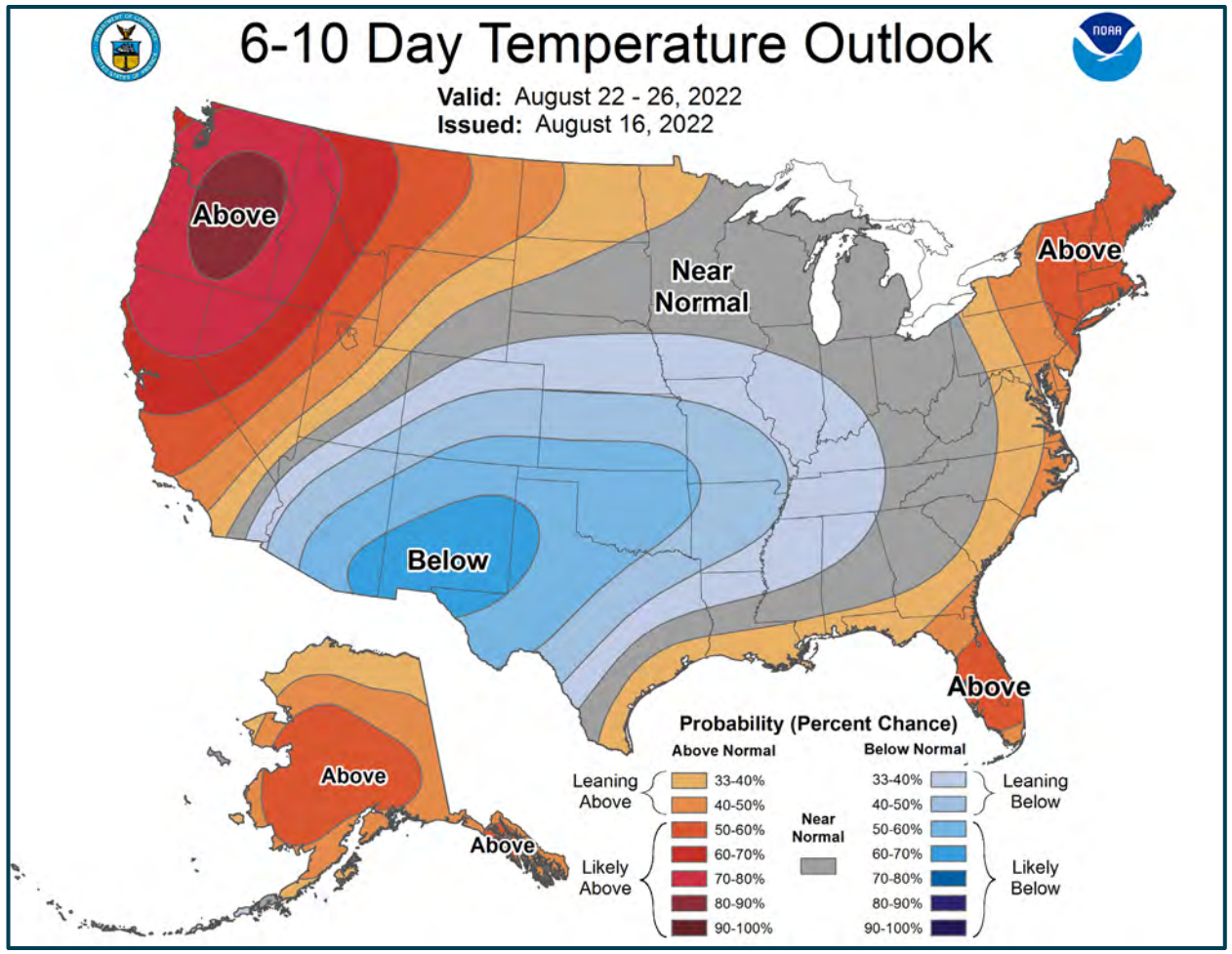
Upper Colorado SWE and Observed Inflows

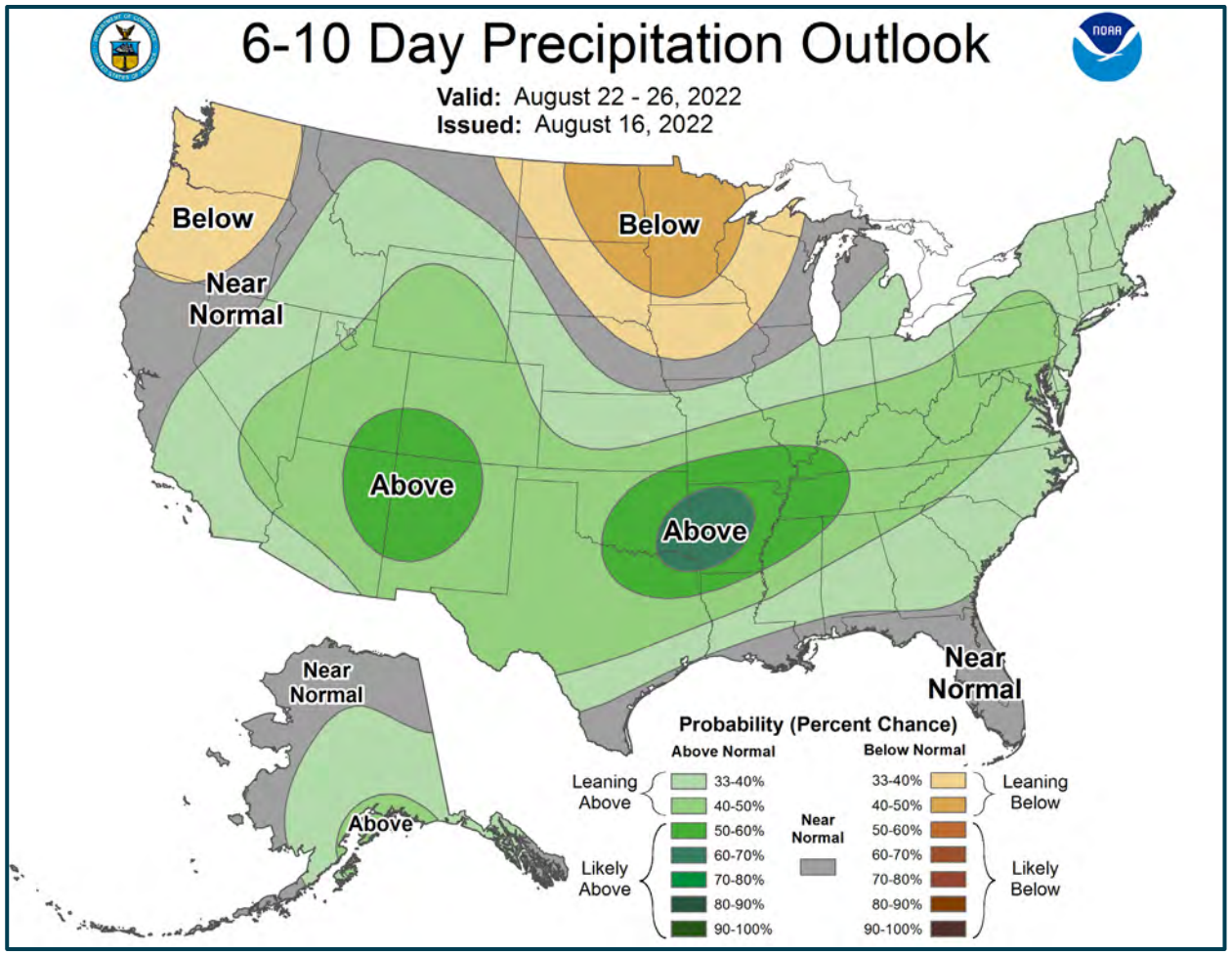




Available online at: https://waterwatch.usgs.gov/index.php?id=wwdur_cumrunoff

Precipitation and Temperature Outlook





Most Probable Forecast – August Final
Water Years 2022 and 2023

April – July 2022 Preliminary Observed Unregulated Inflow

Reservoir	Inflow (kaf)	Percent of Avg[1]
Fontenelle	456	62
Flaming Gorge	552	57
Blue Mesa	431	68
Navajo	381	60
Powell	3,750	59

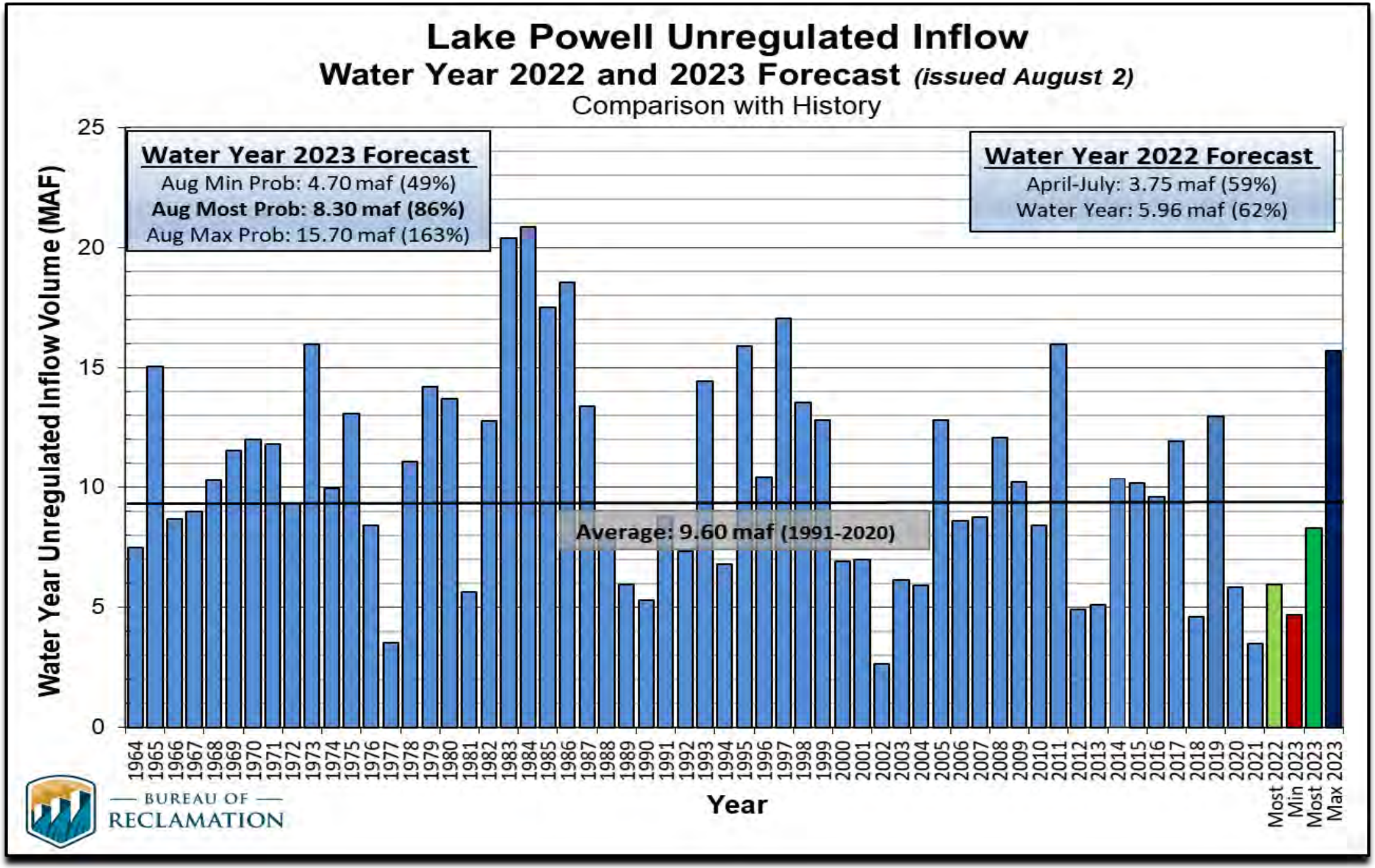
Water Year 2022 Unregulated Inflow Forecast
as of August 2, 2022

Reservoir	Inflow (kaf)	Percent of Avg[1]
Fontenelle	736	69
Flaming Gorge	890	63
Blue Mesa	573	71
Navajo	561	62
Powell	5,961	62

Water Year 2023 Unregulated Inflow Forecast
as of August 2, 2022

Reservoir	Inflow (kaf)	Percent of Avg[1]
Fontenelle	925	86
Flaming Gorge	1,210	86
Blue Mesa	820	91
Navajo	810	89
Powell	8,300	86

[1]Averages are based on the 1991 through 2020 period of record.


Lake Powell Unregulated Inflow
Water Year 2022 and 2023 Forecast (issued August 2)
Comparison with History
Water Year 2023 Forecast
Aug Min Prob: 4.70 maf (49%)
Aug Most Prob: 8.30 maf (86%)
Aug Max Prob: 15.70 maf (163%)
Water Year 2022 Forecast
April-July: 3.75 maf (59%)
Water Year: 5.96 maf (62%)
Average: 9.60 maf (1991-2020)
Water Year Unregulated Inflow Volume (MAF)
0
5
10
15
20
25
1964 1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021 Most 2022 Min 2023 Most 2023 Max 2023
Year
BUREAU OF RECLAMATION

Upper Basin Drought Response Actions

- The Bureau of Reclamation announced on May 3, 2022, two separate urgent drought response actions that will help prop up Lake Powell by nearly 1 million acre-feet (maf) of water over the next 12 months (May 2022 through April 2023). To protect Lake Powell, more water will flow into the lake from upstream reservoirs and less water will be released downstream:

  - Under a Drought Contingency Plan adopted in 2022, approximately 500 thousand acre-feet (kaf) of water will come from Flaming Gorge Reservoir, located approximately 455 river miles upstream of Lake Powell (2022 Plan).
    - For more information: https://www.usbr.gov/uc/DocLibrary/Plans/20220429-2022DroughtResponseOperationsPlan-ApprovalMemo-508-DOI.pdf.

  - Another 480 kaf will be left in Lake Powell by reducing Glen Canyon Dam's annual release volume from 7.48 maf to 7.00 maf (GC Operational Adjustment), in accordance with Sections 6 and 7.D of the 2007 Interim Guidelines.
    - For more information: https://www.usbr.gov/uc/DocLibrary/Plans/20220503-2022DROA-GlenCanyonDamOperationsDecisionLetter-508-DOI.pdf

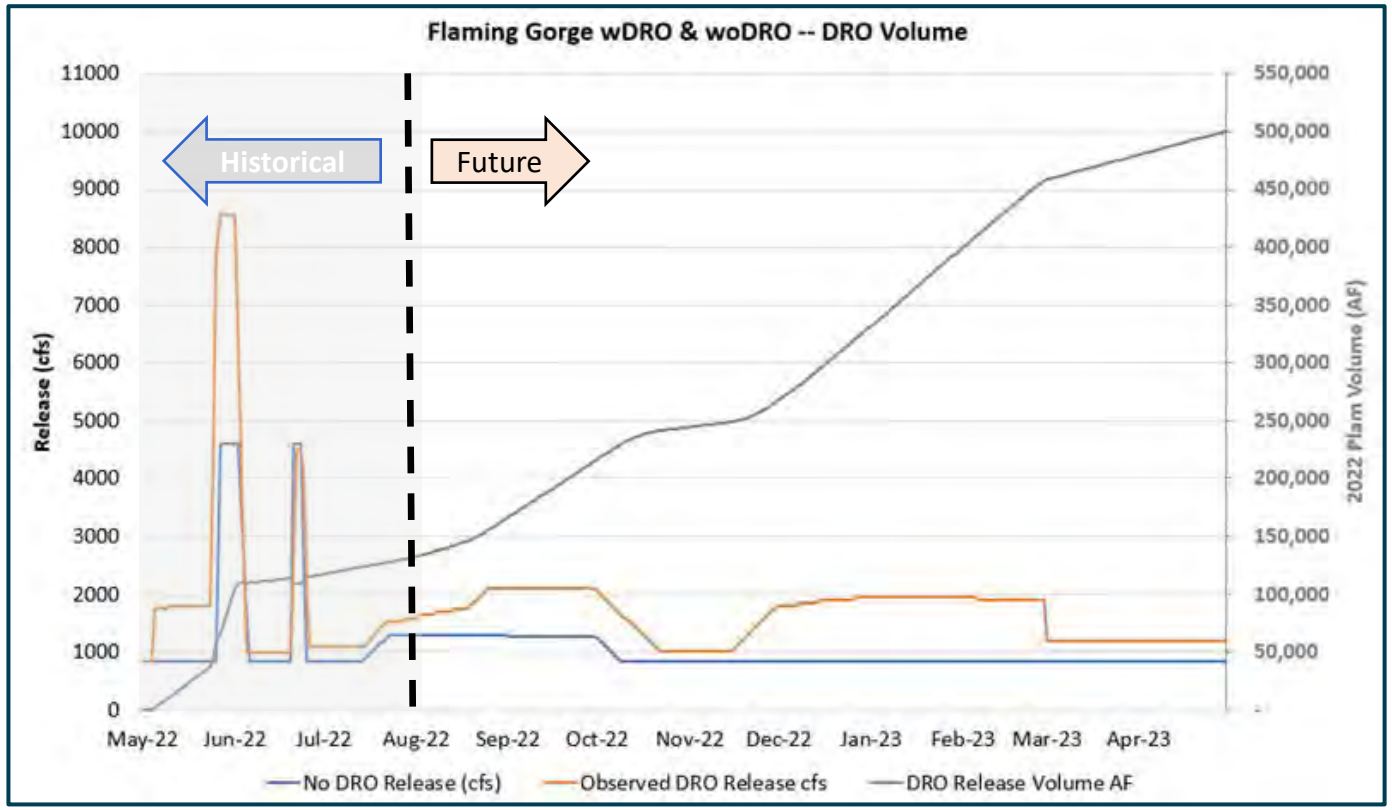
Drought Response Operations Agreement (DROA)

DROA Volumes Released[1]

Reservoir	2021 DROA Volume (kaf)	2022 DROA Volume (kaf)	Total DROA Volume (kaf)
Flaming Gorge	125	500	625
Blue Mesa	36	0	36
Navajo	0	0	0
Volume in Powell	161	500	661

[1]DROA operational year is from May through April.

Flaming Gorge 2022 Plan



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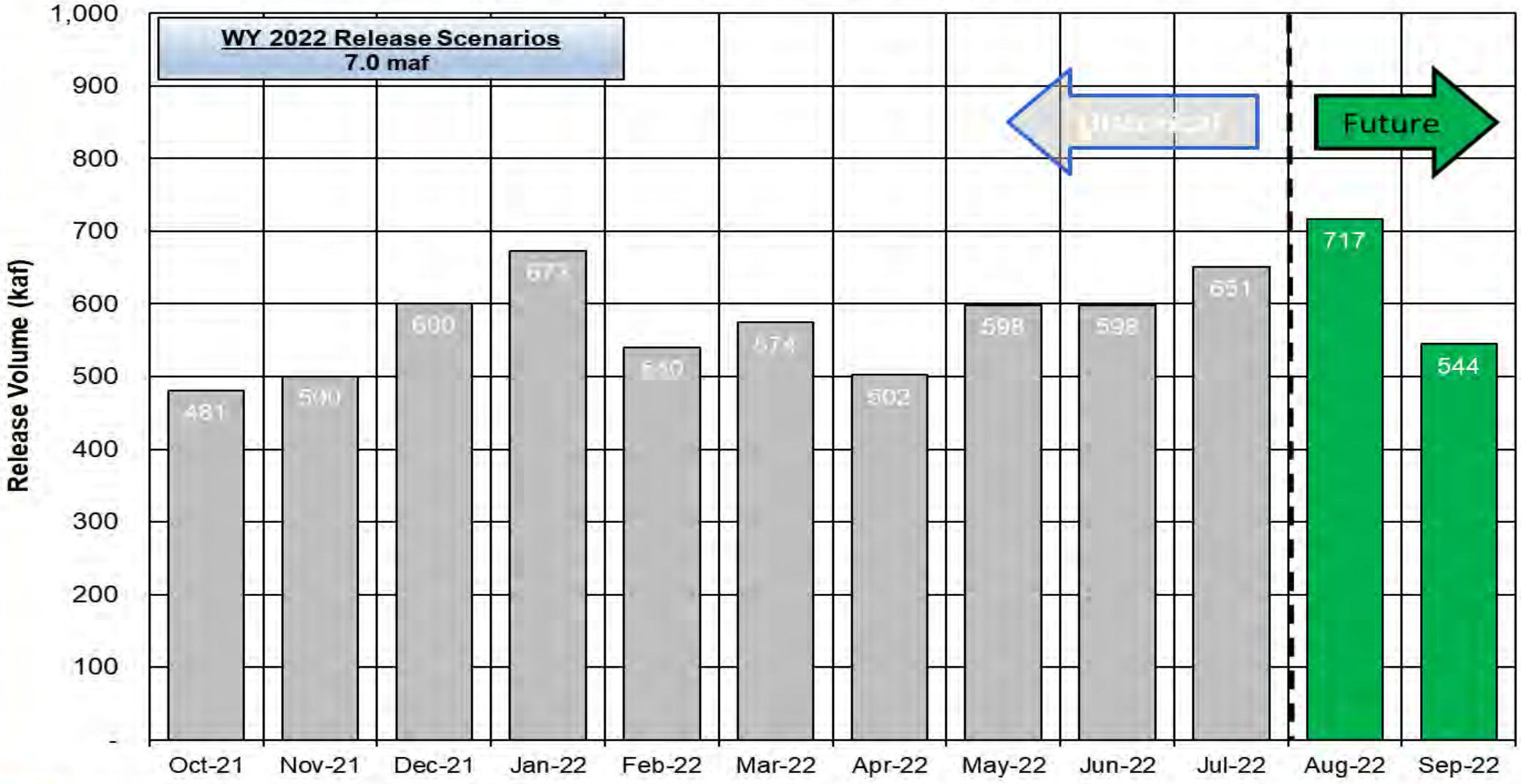
Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2022



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

Drought Response Operations Agreement (DROA)

DROA Volumes Released[1]

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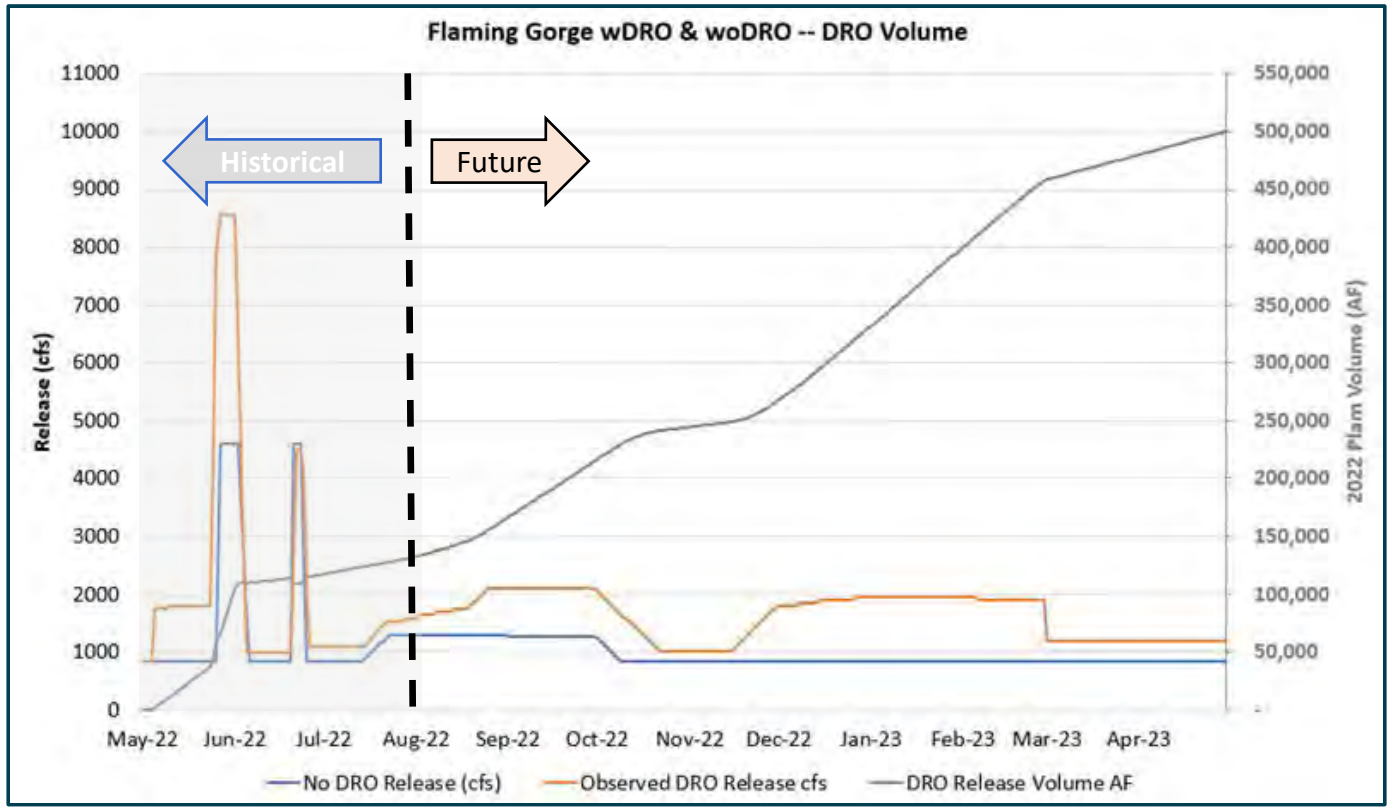
[1]DROA operational year is from May through April.

Flaming Gorge 2022 Plan



August 24-Month Study Projections

Upper Colorado Basin Region Operations

Timing of Operational Decisions

- August 24-Month Study projections of January 1 elevations sets the operating tiers for Lake Powell and Lake Mead

Lake Powell & Lake Mead Operational Table

Lake Powell Operational Tier Determination Run (aka "Exhibit Run") with an 8.23 maf Release[1,2]

3,505.66 ft
Jan 1, 2023
Projection

1,047.61 ft
Jan 1, 2023
Projection

Lake Powell			Lake Mead		
Elevation (feet)	Operation According to the Interim Guidelines	Live Storage (maf)[1]	Elevation (feet)	Operation According to the Interim Guidelines	Live Storage (maf)[1]
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**[3] 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.)[2]	**Domestic Surplus or ICS Surplus Condition** Deliver > 7.5 maf	22.9 (approx.)[2]
			1,145		15.9
			1,105	**Normal or ICS Surplus Condition** Deliver ≥ 7.5 maf	11.9
3,575		9.5	1,075		9.4
	Mid-Elevation Release Tier Release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf			**Shortage Condition** Deliver 7.167[4] maf	
			1,050		7.5
3,525		5.9		**Shortage Condition** Deliver 7.083[5] maf	
			1,025		5.8
3,490	**Lower Elevation Balancing Tier** Balance contents with a min/max release of 7.0 and 9.5 maf	4.0	1,000	**Shortage Condition** Deliver 7.0[6] maf Further measures may be undertaken[7]	4.3
3,370		0	895		0

Diagram not to scale

[1] Acronym for million acre-feet

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

[3] Subject to April adjustments which may result in a release according to the Equalization Tier

[4] Of which 2.48 maf is apportioned to Arizona, 4.4 maf to California, and 0.287 maf to Nevada

[5] Of which 2.40 maf is apportioned to Arizona, 4.4 maf to California, and 0.283 maf to Nevada

[6] Of which 2.32 maf is apportioned to Arizona, 4.4 maf to California, and 0.280 maf to Nevada

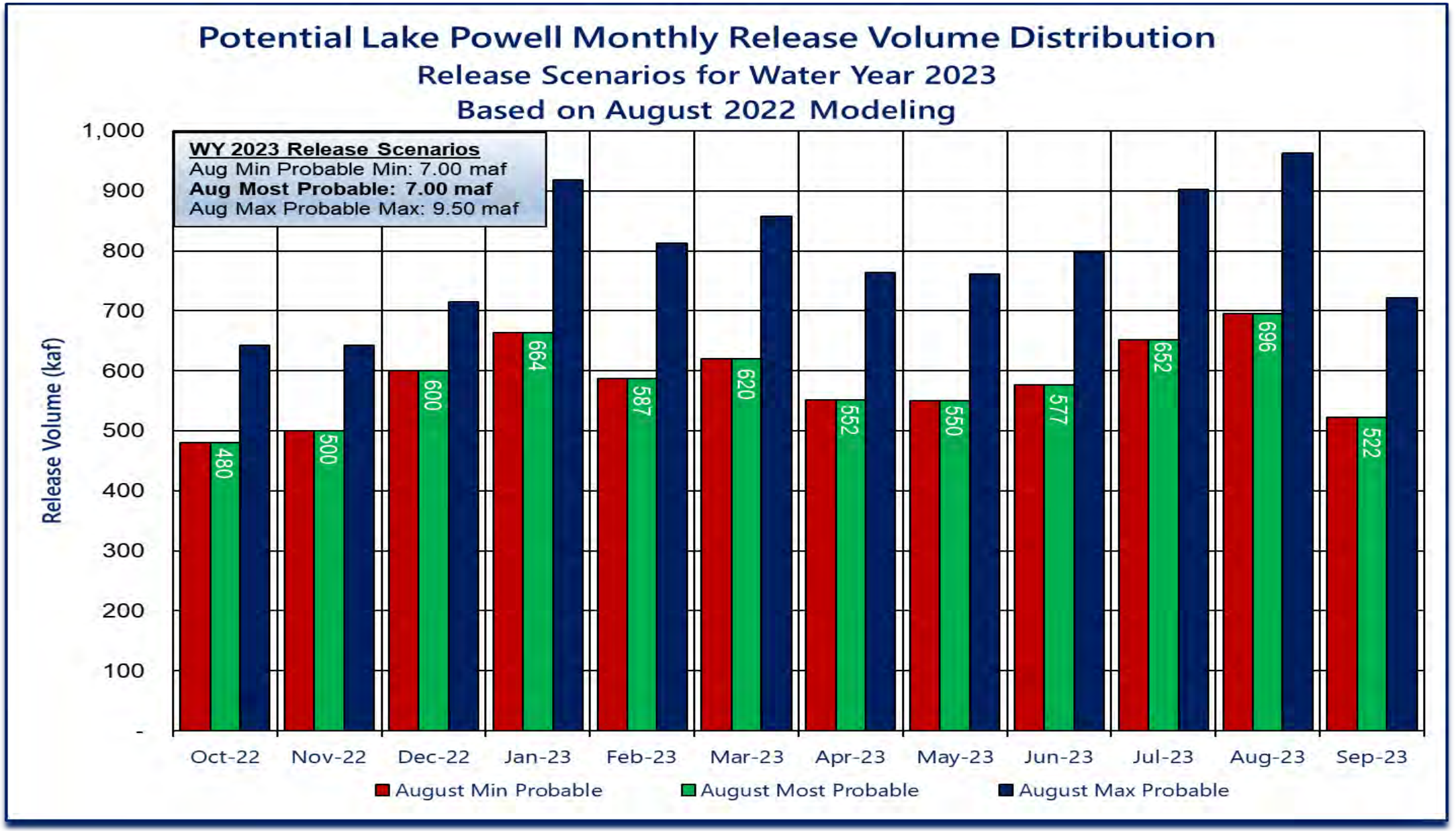
[7] Whenever Lake Mead is below elevation 1,025 feet, the Secretary shall consider whether hydrologic conditions together with anticipated deliveries to the Lower Division States and Mexico is likely to cause the elevation at Lake Mead to fall below 1,000 feet. Such consideration, in consultation with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

[1] Lake Powell and Lake Mead operational tier determinations are based on August 2021 24-Month Study projections will be documented in the draft 2023 AOP.

[2] The operating determination for WY 2023 is based on a projected elevation "as if" the 0.48 maf were delivered to Lake Mead with a Glen Canyon Dam release pattern of 8.23 maf.

Upper Basin Reservoir Operations in Water Year 2023

- Lake Powell will be operated consistent with the 2007 Interim Guidelines, the Upper Basin Drought Response Operations Agreement and Upper Basin Records of Decision
- Lake Powell's projected end of calendar year (CY) 2022 "tier determination" elevation in the August 2022 24-Month Study determines Lake Powell's operating tier in CY 2023
  - Lake Powell will operate in the Lower Elevation Balancing Tier where Lake Powell and Lake Mead will balance contents with Glen Canyon Dam release volumes no less than 7.0 maf and no more than 9.5 maf
- Consistent with the provisions of the 2007 Interim Guidelines, and to preserve the benefits to Glen Canyon Dam facilities from 2022 Operations into 2023 and 2024, Reclamation will consult with the Basin States on monthly and annual operations. Reclamation will also ensure all appropriate consultation with Basin Tribes, the Republic of Mexico, other federal agencies, water users and non-governmental organizations with respect to implementation of these monthly and annual operations.
  - The Glen Canyon Dam annual release has initially been set to 7.00 maf, and in April 2023 Reclamation will evaluate hydrologic conditions to determine if balancing releases may be appropriate under the conditions established in the 2007 Interim Guidelines;
  - Balancing releases will be limited (with a minimum of 7.00 maf) to protect Lake Powell from declining below elevation 3,525 feet at the end of December 2023;
  - Balancing releases will take into account operational neutrality of the 0.480 maf that was retained in Lake Powell under the May 2022 action1. Any Lake Powell balancing release volume will be calculated as if the 0.480 maf had been delivered to Lake Mead in WY 2022; and
  - The modeling approach for WY 2023 will apply to 2024.



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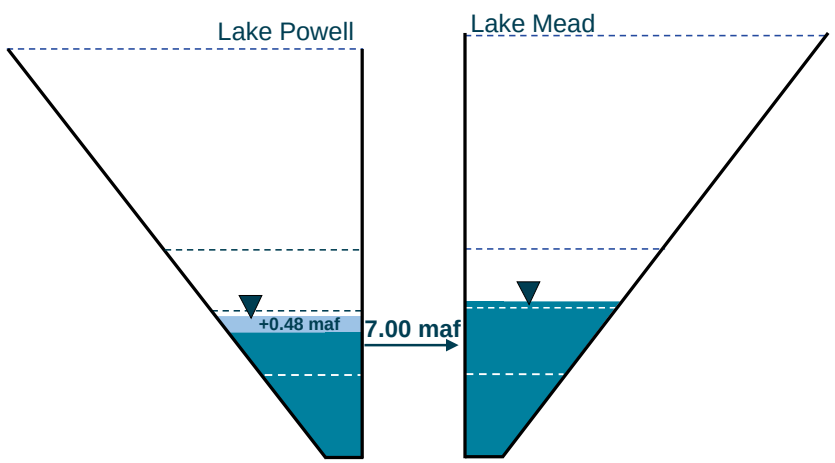
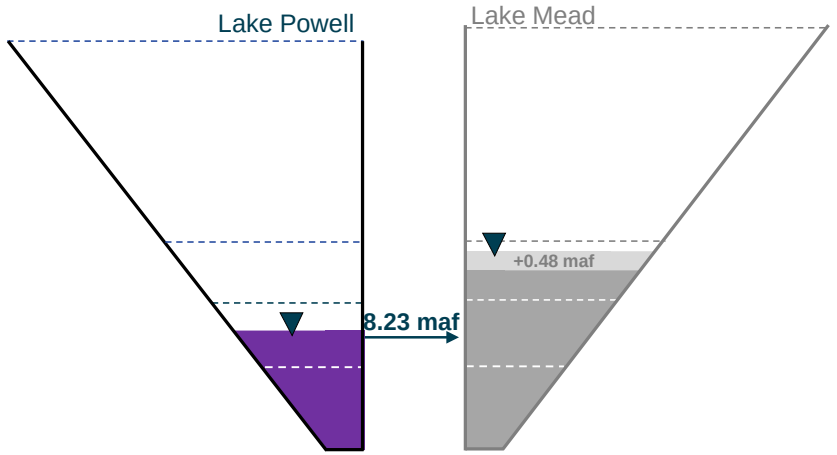
End of Calendar Year 2022 Lake Powell and Lake Mead Elevations Based on August 2022 24-Month Study[1,2,3]

Physical Elevations: Real-time or projected elevations based on a 7.00 maf release from Lake Powell in WY 2022 and 7.00 maf in WY 2023.



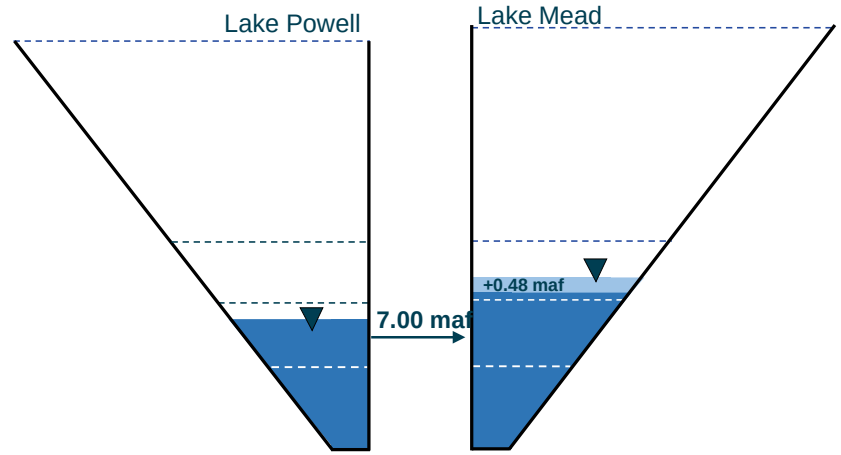
Reservoir	End of Calendar Year 2022 **Physical Elevation**
Lake Powell	3,521.84
Lake Mead	1,040.47

Powell Tier Determination: Projected elevation "as if" the additional 0.48 maf were released from Powell in WY 2022 and with an 8.23 maf WY 2023 Powell release.



Reservoir	End of Calendar Year 2022 **Powell Tier Determination Elevation**
Lake Powell	3,505.66
Lake Mead	NA

Effective Elevation & Mead Operating Condition Determination: Projected elevation "as if" the additional 0.48 maf were released from Powell in WY 2022, with an adjusted WY 2023 Powell release of 7.00 maf.

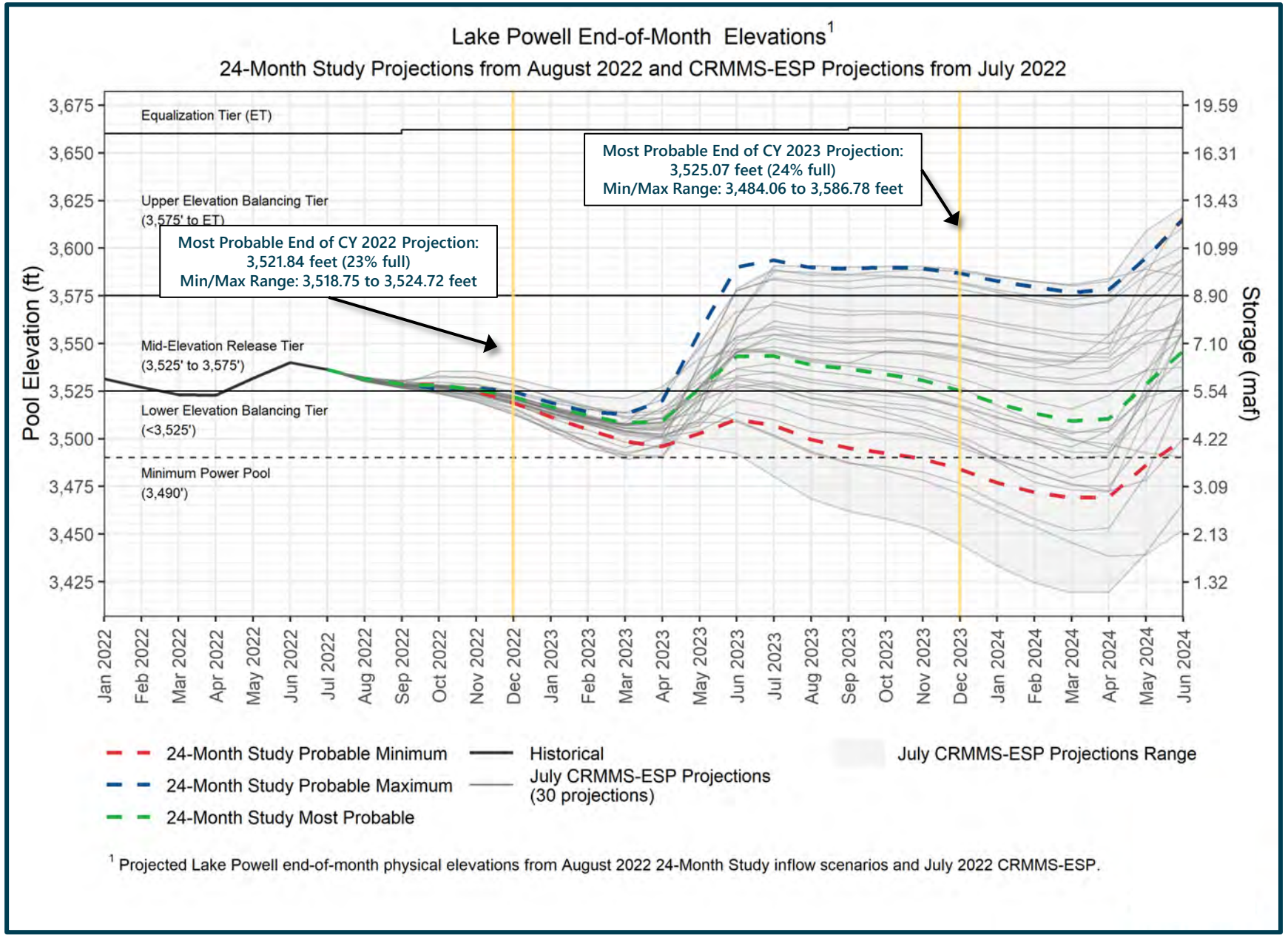


Reservoir	End of Calendar Year 2022 **Effective Elevation**
Lake Powell	3,513..10
Lake Mead	1,047.61

[1] For more information: https://www.usbr.gov/uc/DocLibrary/Plans/20220503-2022DROA-GlenCanyonDamOperationsDecisionLetter-508-DOI.pdf.
[2] Both the Powell Tier Determination and Effective Elevations are "as if" the additional 0.48 maf were delivered to Mead in WY 2022. Powell's Tier Determination elevation is used to set the WY 2023 operating tier. For Mead, the Effective Elevation is used to set the CY 2023 operating condition. The Department of Interior and Reclamation will work to determine the manner in which to operate Glen Canyon Dam to ensure the benefits of these actions are preserved.
[3] Images are **not** to scale.

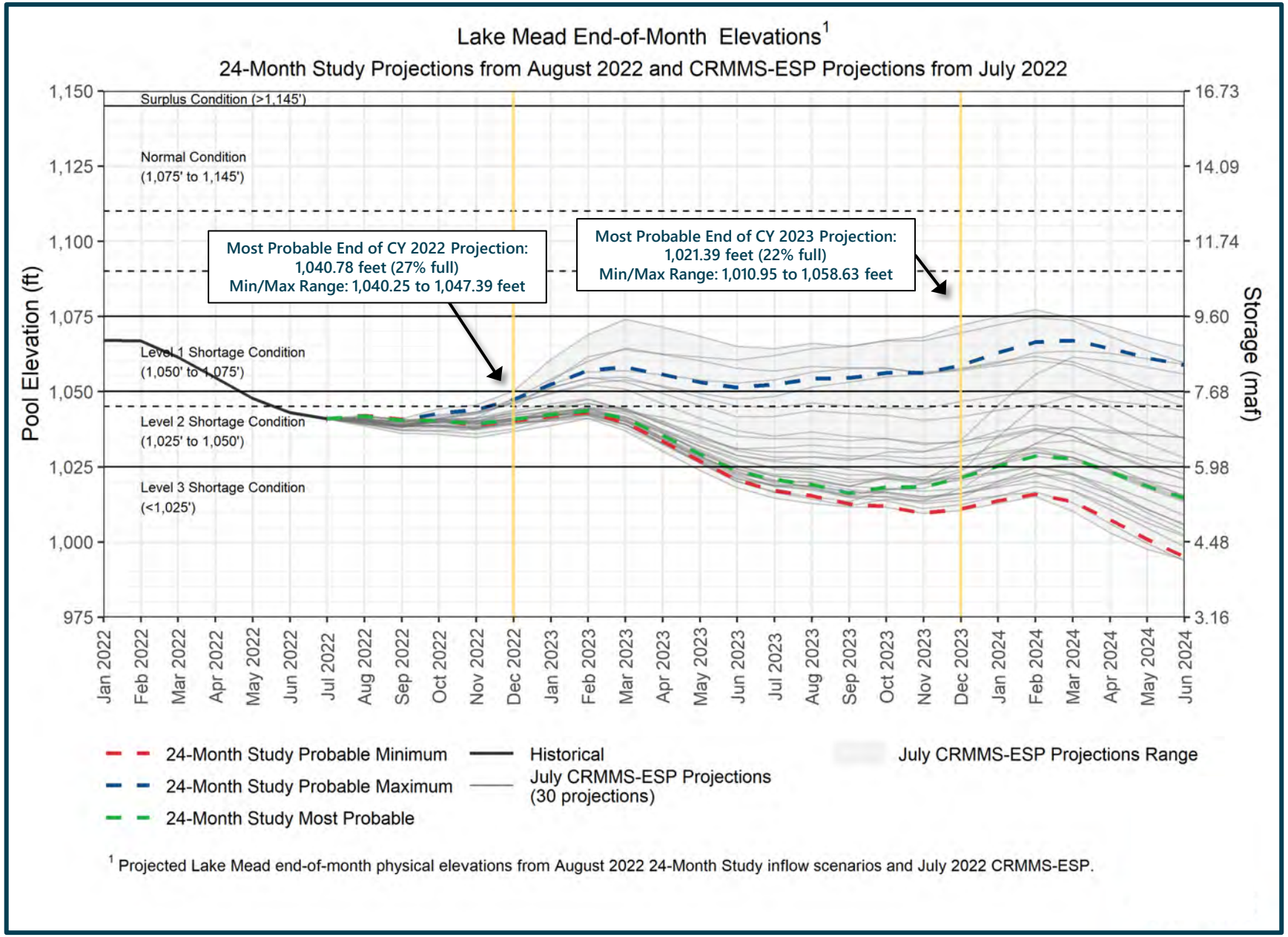
Reclamation Operational Modeling
Model Comparison

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



[1] Projected Lake Powell end-of-month physical elevations from August 2022 24-Month Study inflow scenarios and July 2022 CRMMS-ESP.

The chart above displays projected "physical" elevations for Lake Powell. Based on August 2022 24-Month Study modeling, Lake Powell's elevation is projected to be less than 3,525 feet and the operating tier for water year 2023 is the Lower Elevation Balancing Tier.



The chart above displays projected "physical" elevations for Lake Mead. Based on August 2022 24-Month Study modeling, Lake Mead's operating condition for calendar year 2023 is the Level 2 Shortage Condition within the 1,045 – 1,050 elevation band.

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	6	6	6	6	6	
Capacity (cfs)	18,700	18,600	11,700	18,700	14,800	11,300	17,900	14,900	18,500	18,400	18,400	18,200	JUL MOST[2]
Capacity (kaf/month)	1,150	1,110	1,110	1,160	810	980	1,000	1,050	1,110	1,130	1,120	1,080	JUL MOST
Max (kaf) [1]	481	500	600	673	540	575	502	598	598	673	717	543	7.0 maf
Most (kaf) [1]	481	500	600	673	540	575	502	598	598	673	717	543	7.0 maf
Min (kaf) [1]	481	500	600	673	540	575	502	598	598	673	717	542	7.0 maf
										(updated 08-04-2022)			

1 Projected release, based on July 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	6	6/6	6	6	6	4	6	8	7	8	8	6	
Capacity (cfs)	18,100	24,700/ 16,000	17,900	17,700	17,500	10,900	17,400	21,350	22,000	25,500	25,300	18,400	JUL MOST[2]
Capacity (kaf/month)	940	1,070	1,100	1,090	950	990	1,020	1,100	1,100	1,140	1,130	750	JUL MOST
Max (kaf)[1]	643	642	715	919	813	858	764	761	798	902	963	722	9.5 maf
Most (kaf)[1]	480	500	600	664	587	620	552	550	577	652	696	522	7.0 maf
Min (kaf)[1]	480	500	600	664	587	620	552	550	577	652	696	522	7.0 maf
										(updated 08-04-2022)			

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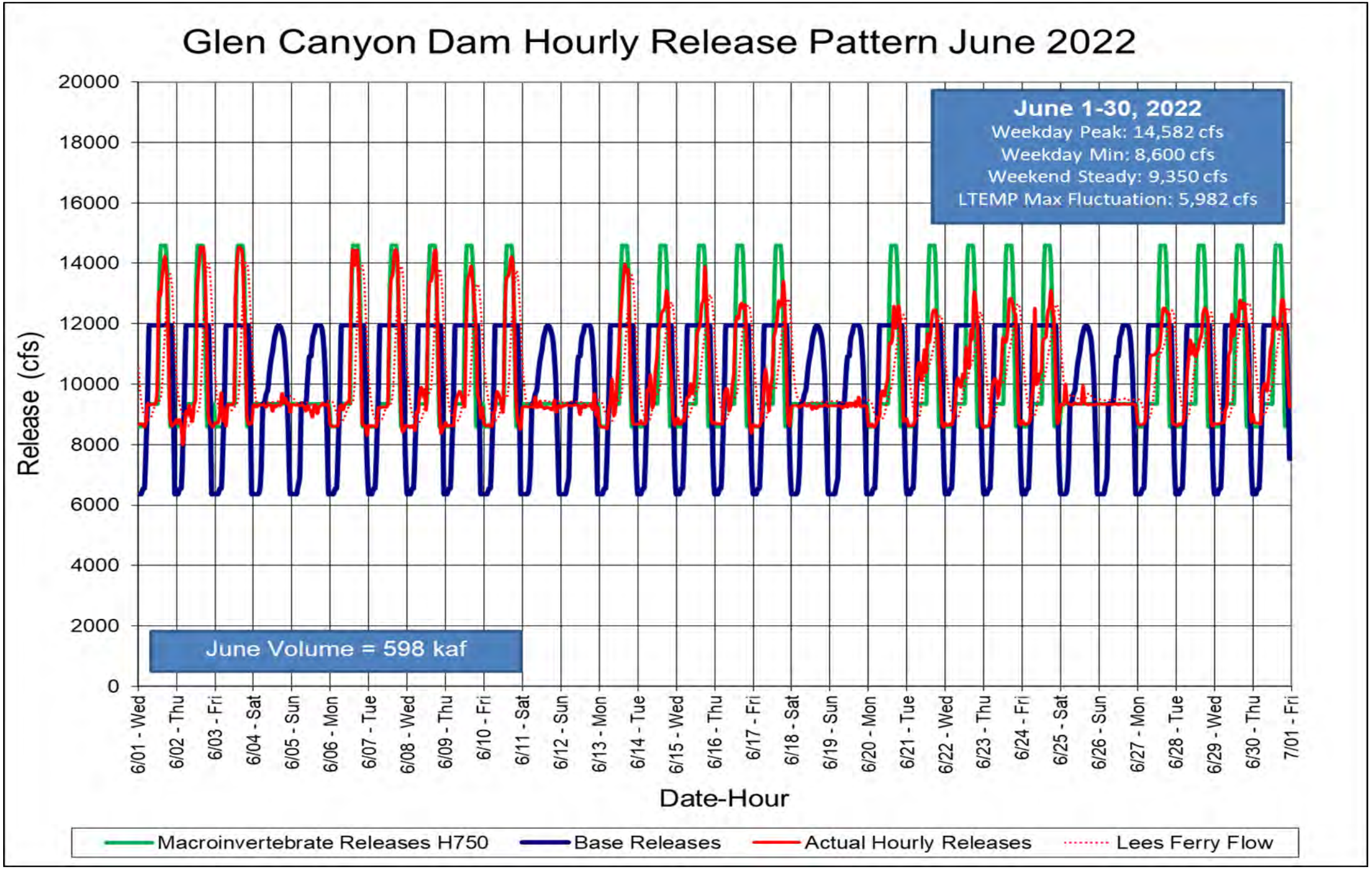
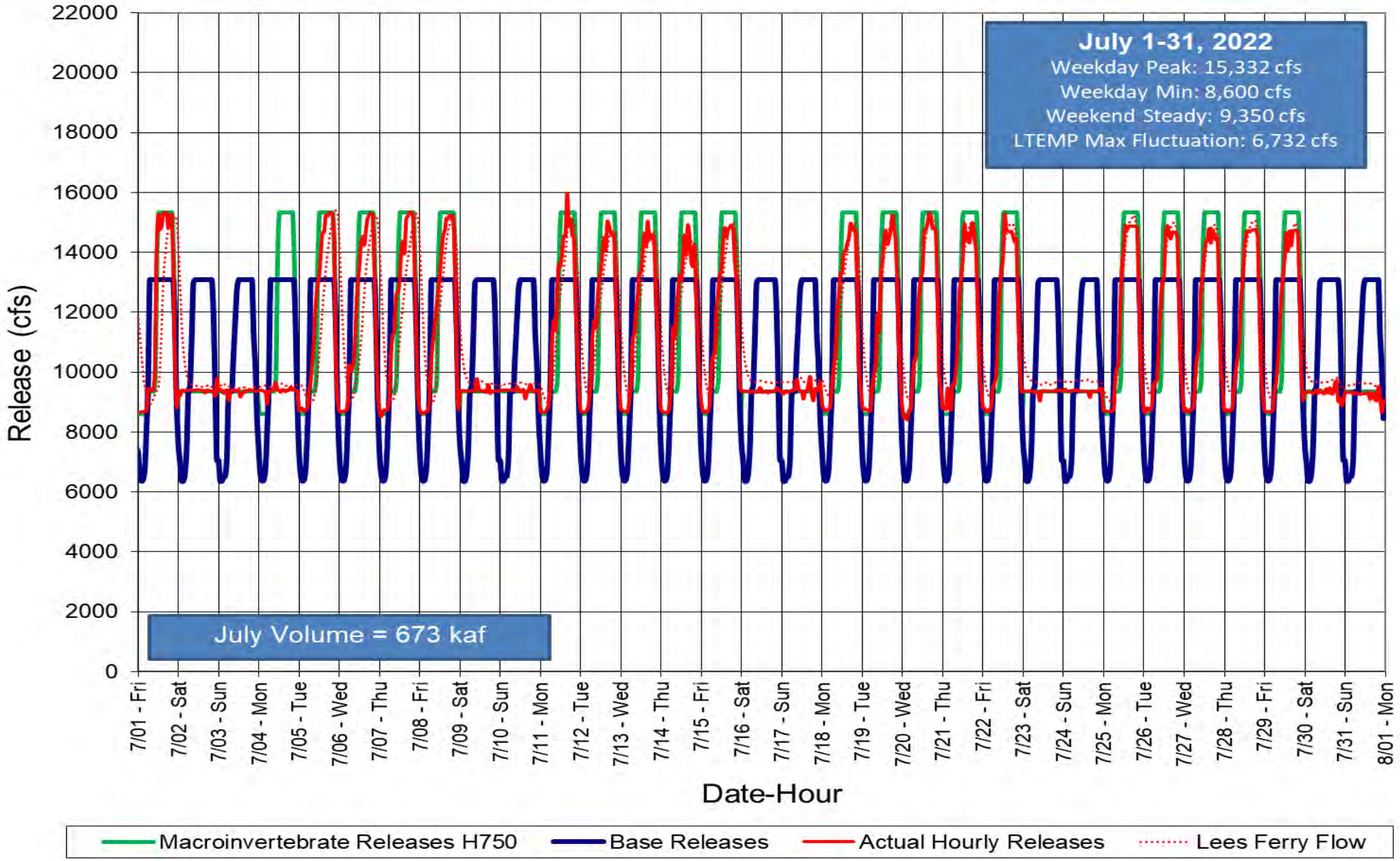
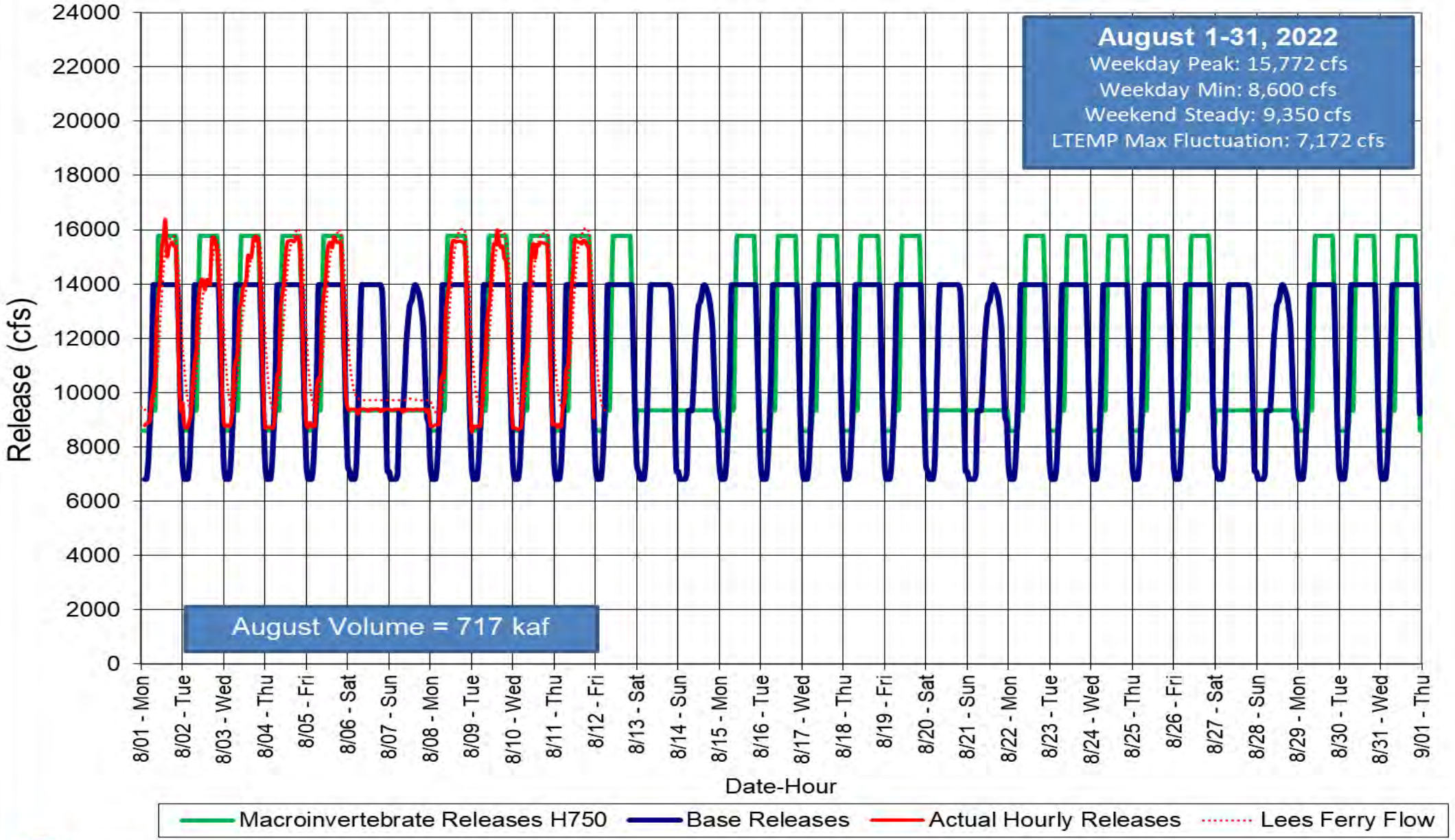
Glen Canyon Dam Hourly Release Pattern June 2022



Glen Canyon Dam Hourly Release Pattern July 2022



Glen Canyon Dam Hourly Release Pattern August 2022



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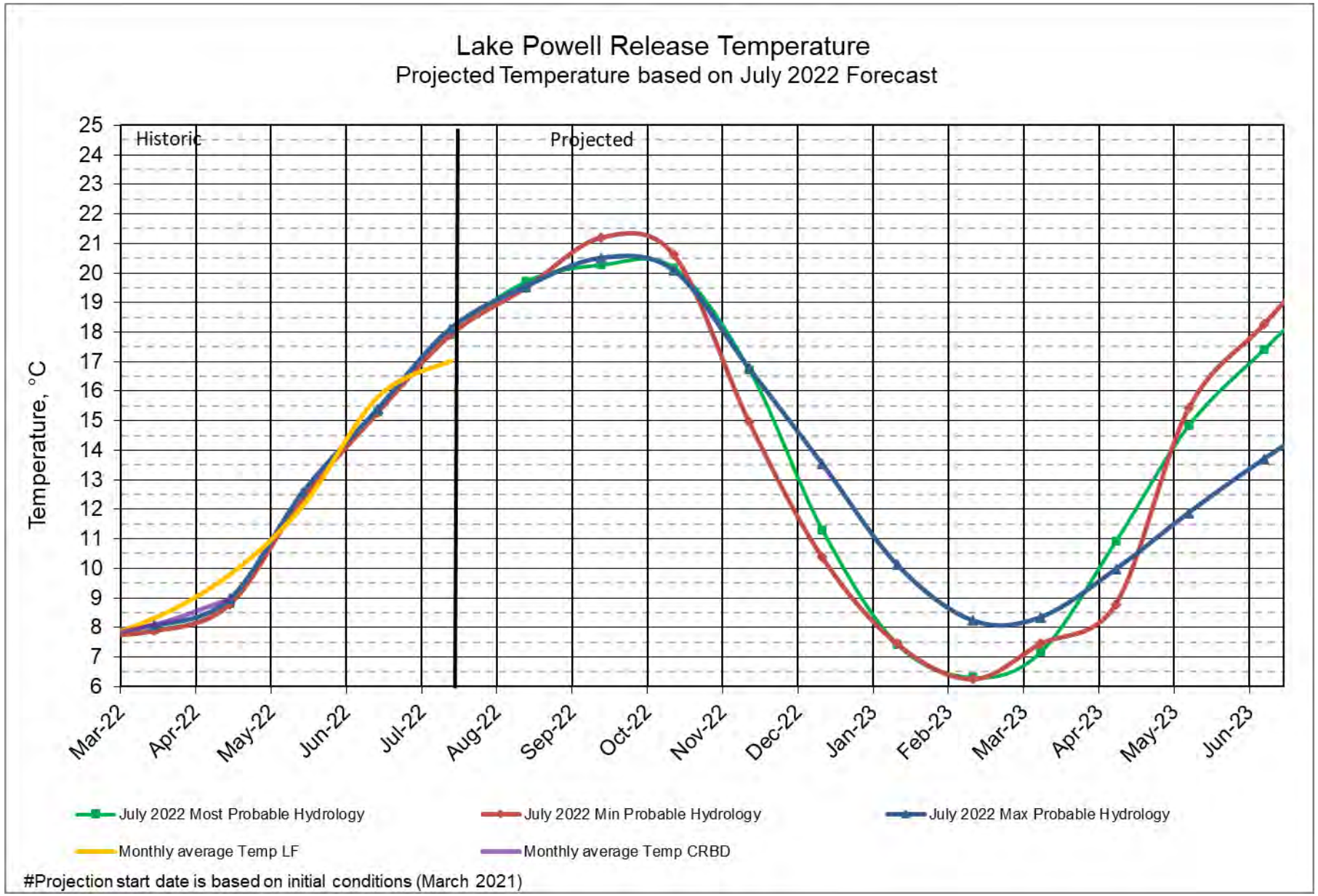
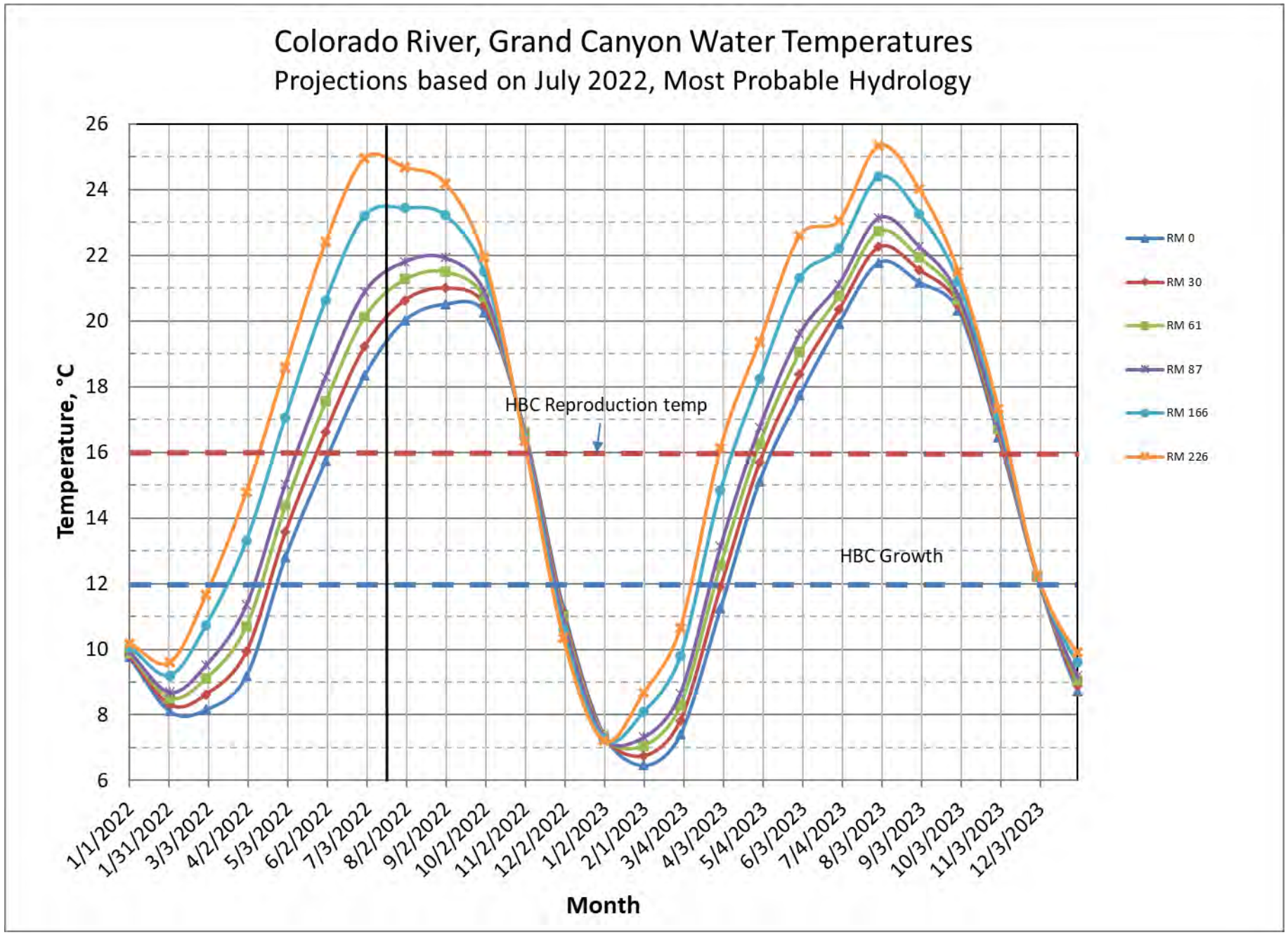
Water Quality


Lake Powell Release Temperature
Projected Temperature based on July 2022 Forecast
Historic
Projected
Temperature, °C
25
24
23
22
21
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Dec-22
Jan-23
Feb-23
Mar-23
Apr-23
May-23
Jun-23
July 2022 Most Probable Hydrology
July 2022 Min Probable Hydrology
July 2022 Max Probable Hydrology
Monthly average Temp LF
Monthly average Temp CRBD
#Projection start date is based on initial conditions (March 2021)


Colorado River, Grand Canyon Water Temperatures
Projections based on July 2022, Most Probable Hydrology
Temperature, °C
26
24
22
20
18
16
14
12
10
8
6
HBC Reproduction temp
HBC Growth
1/1/2022
1/31/2022
3/3/2022
4/2/2022
5/3/2022
6/2/2022
7/3/2022
8/2/2022
9/2/2022
10/2/2022
11/2/2022
12/2/2022
1/2/2023
2/1/2023
3/4/2023
4/3/2023
5/4/2023
6/3/2023
7/4/2023
8/3/2023
9/3/2023
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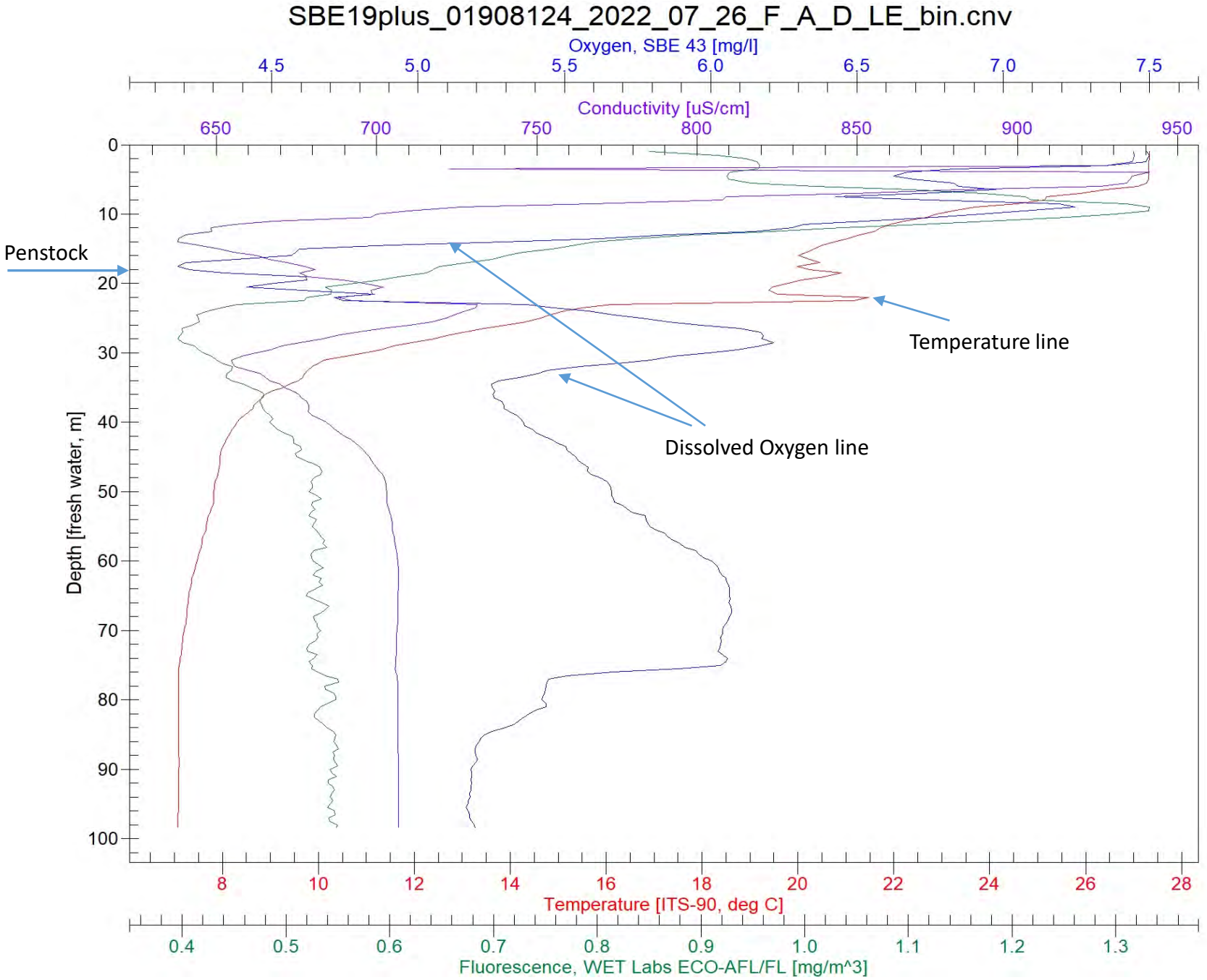
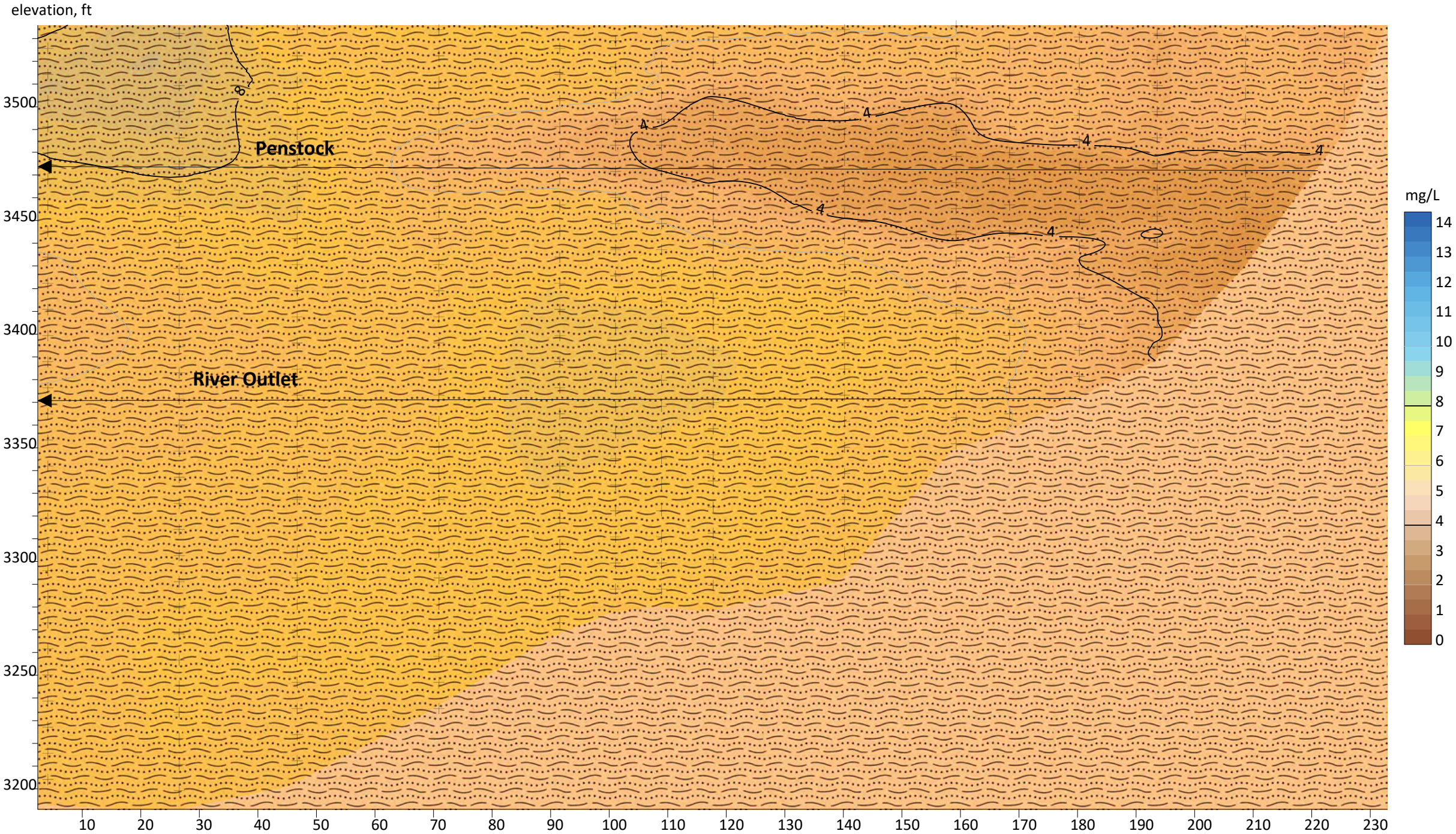
Month
RM 0
RM 30
RM 61
RM 87
RM 166
RM 226


SBE19plus_01908124_2022_07_26_F_A_D_LE_bin.cnv
Oxygen, SBE 43 [mg/l]
4.5
5.0
5.5
6.0
6.5
7.0
7.5
Conductivity [uS/cm]
650
700
750
800
850
900
950
Penstock
Temperature line
Dissolved Oxygen line
Depth [fresh water, m]
0
10
20
30
40
50
60
70
80
90
100
8
10
12
14
16
18
20
22
24
26
28
Temperature [ITS-90, deg C]
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
Fluorescence, WET Labs ECO-AFL/FL [mg/m^3]

Lake Powell Dissolved Oxygen June 2022




Questions?
BUREAU OF
RECLAMATION