BUREAU OF RECLAMATION

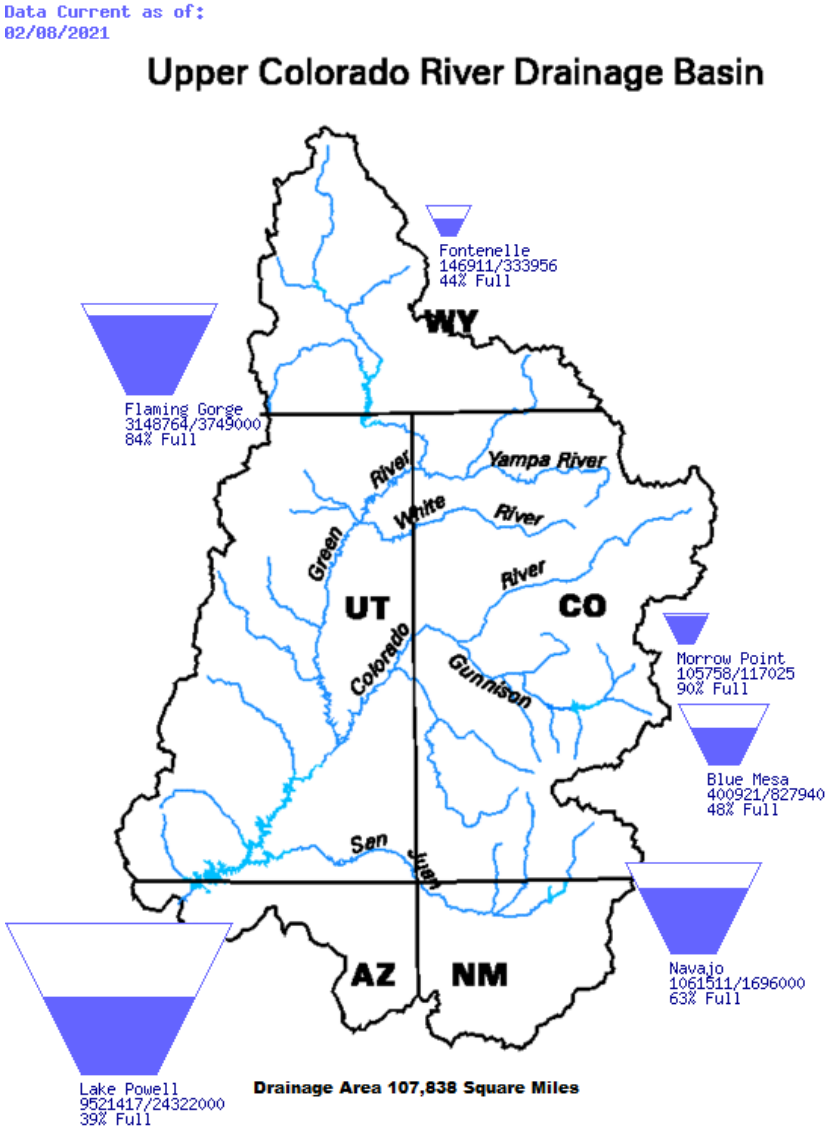
GCDAMP Adaptive Management Work Group

Basin Hydrology and Operations

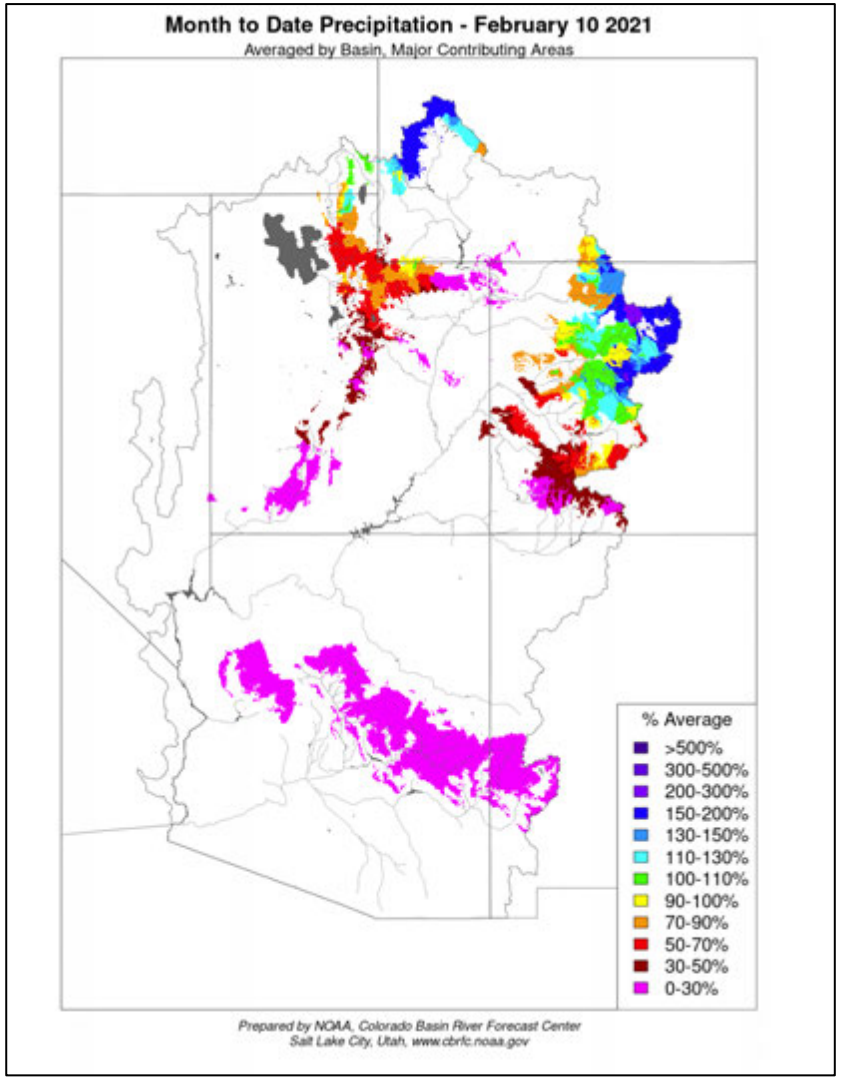
February 10, 2021

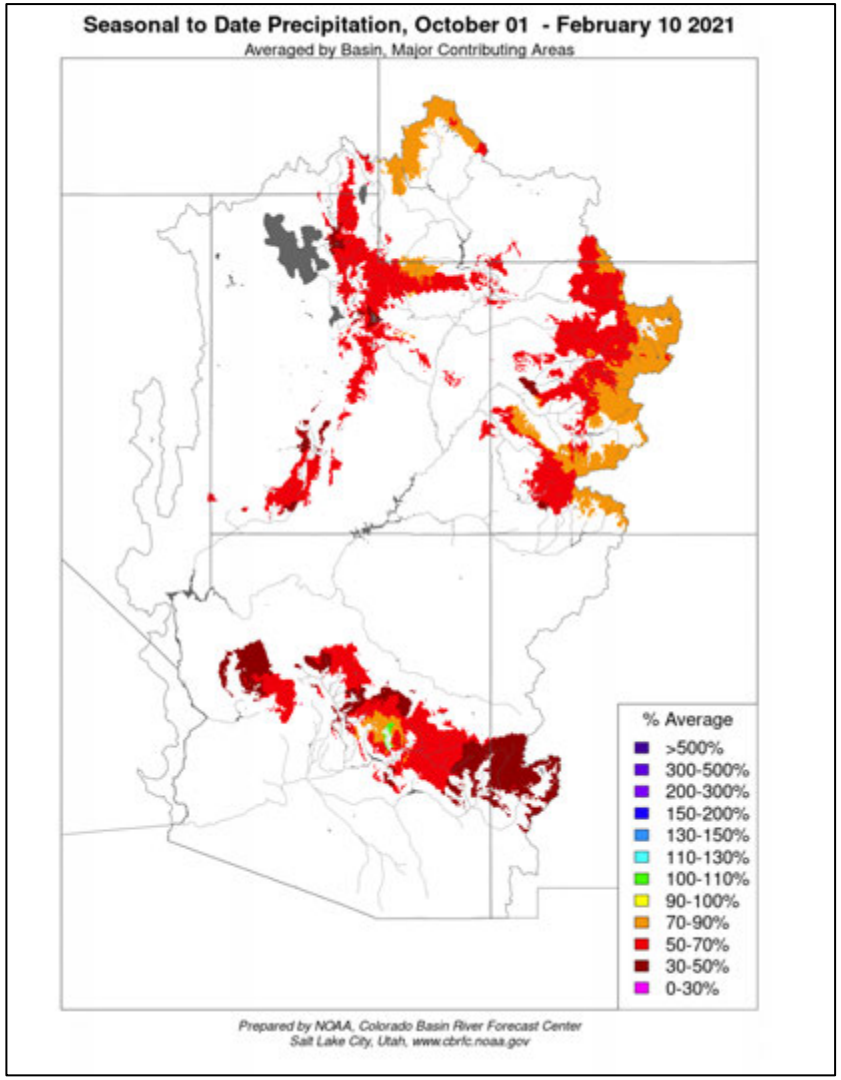
Upper Basin Storage (as of February 9, 2021)

Reservoir	Percent Current Live Storage	Current Live Storage (maf)	Live Storage Capacity (maf)	Elevation (feet)
Fontenelle	44	.146	.334	6,477.57
Flaming Gorge	84	3.15	3.75	6,024.67
Blue Mesa	48	0.400	.828	7,465.38
Navajo	63	1.06	1.70	6,035.11
Lake Powell	39	9.51	24.32	3,574.89
UC System Storage	46	14.40	31.09	

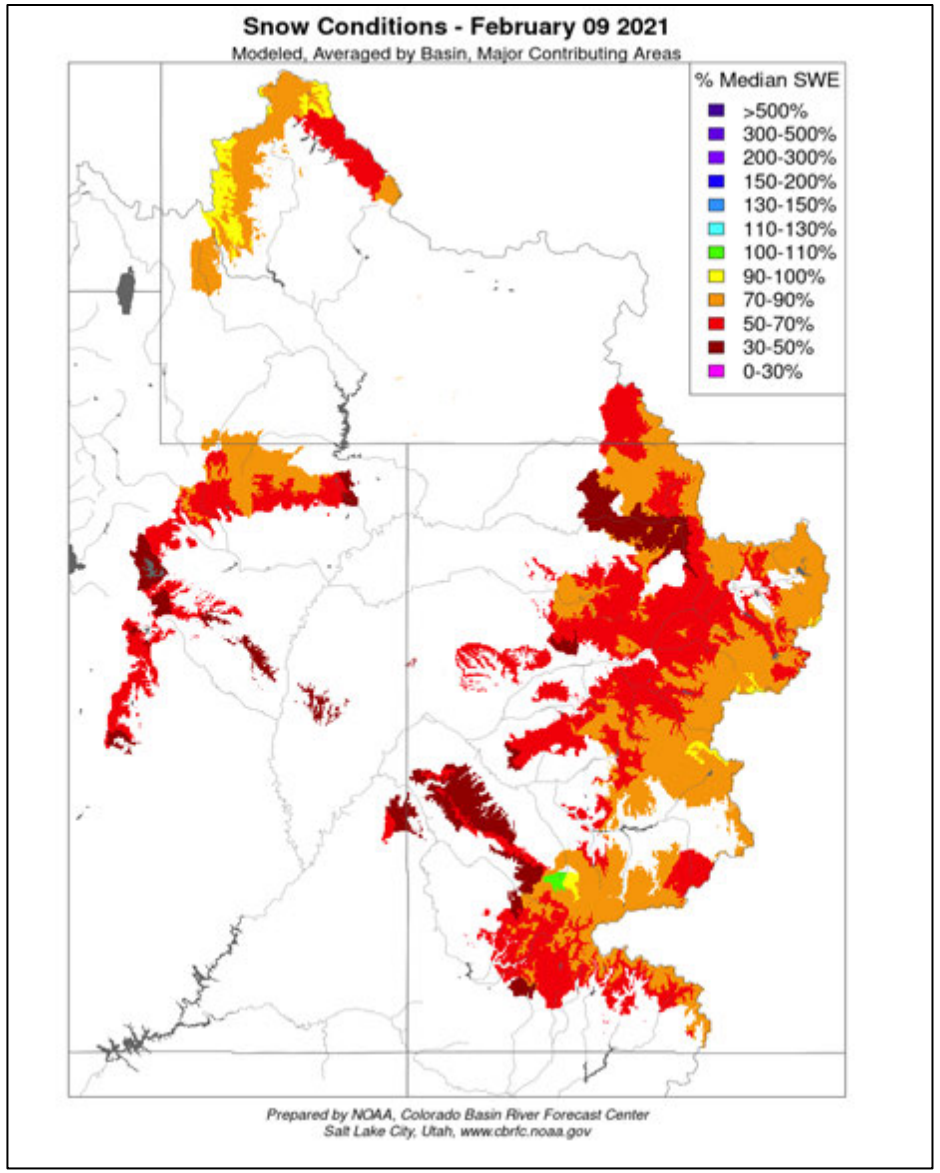


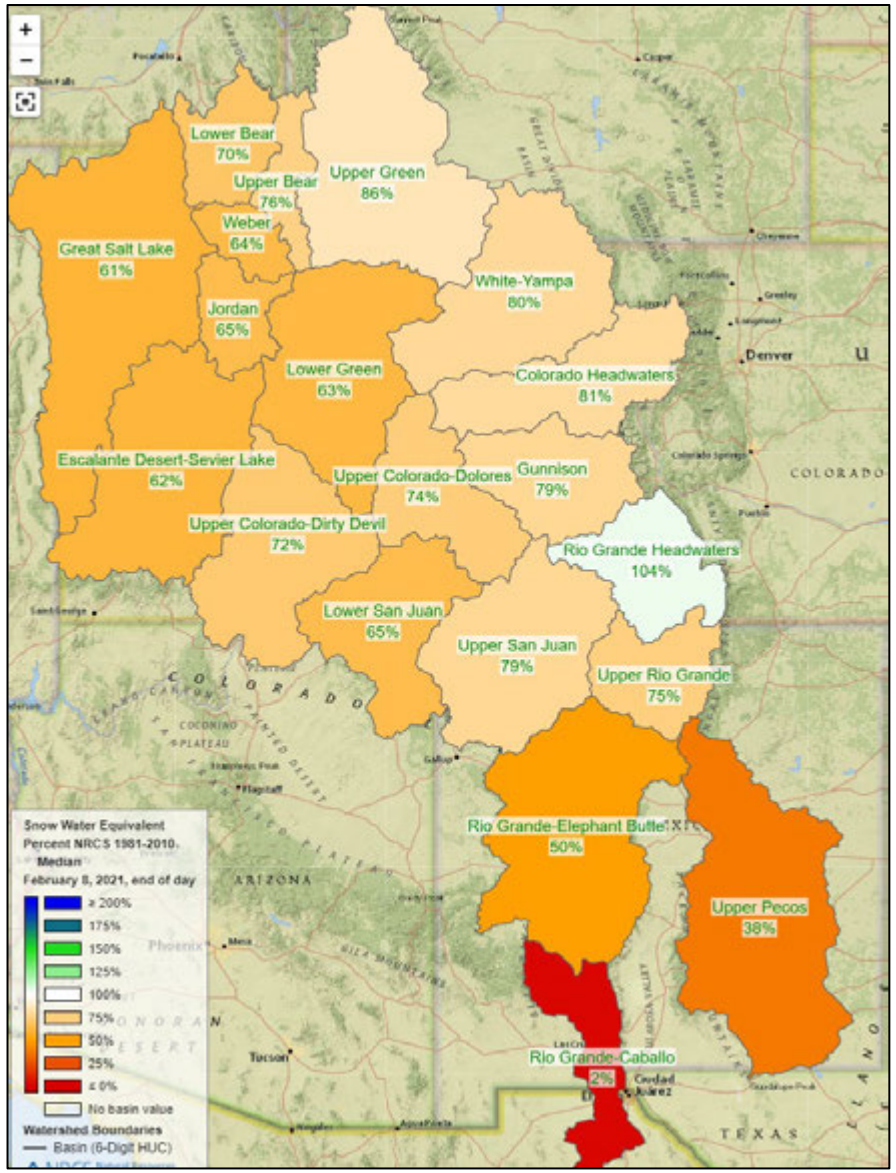
Seasonal and Monthly Precipitation



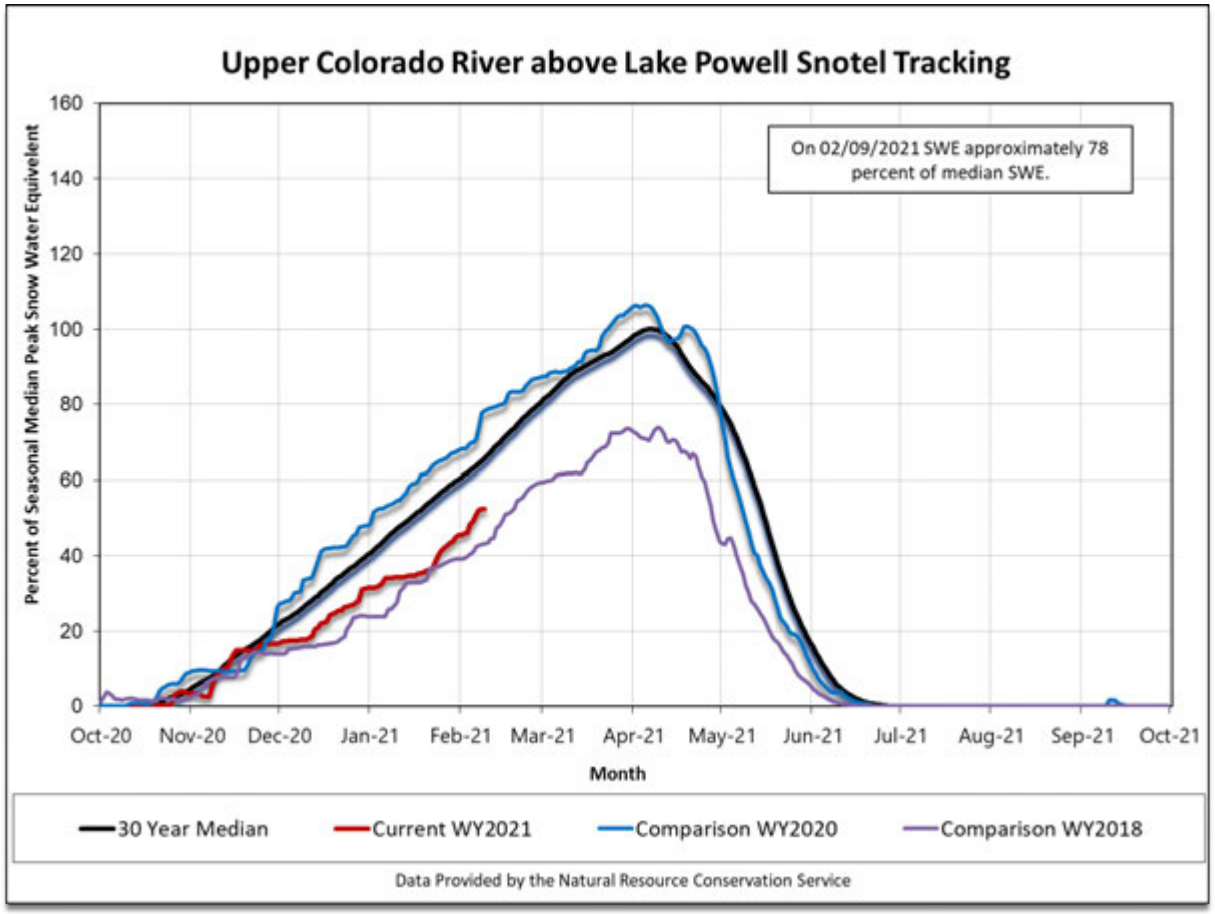


Seasonal Snow Conditions and Basin SWE





Current SWE and February WY2021 Forecast

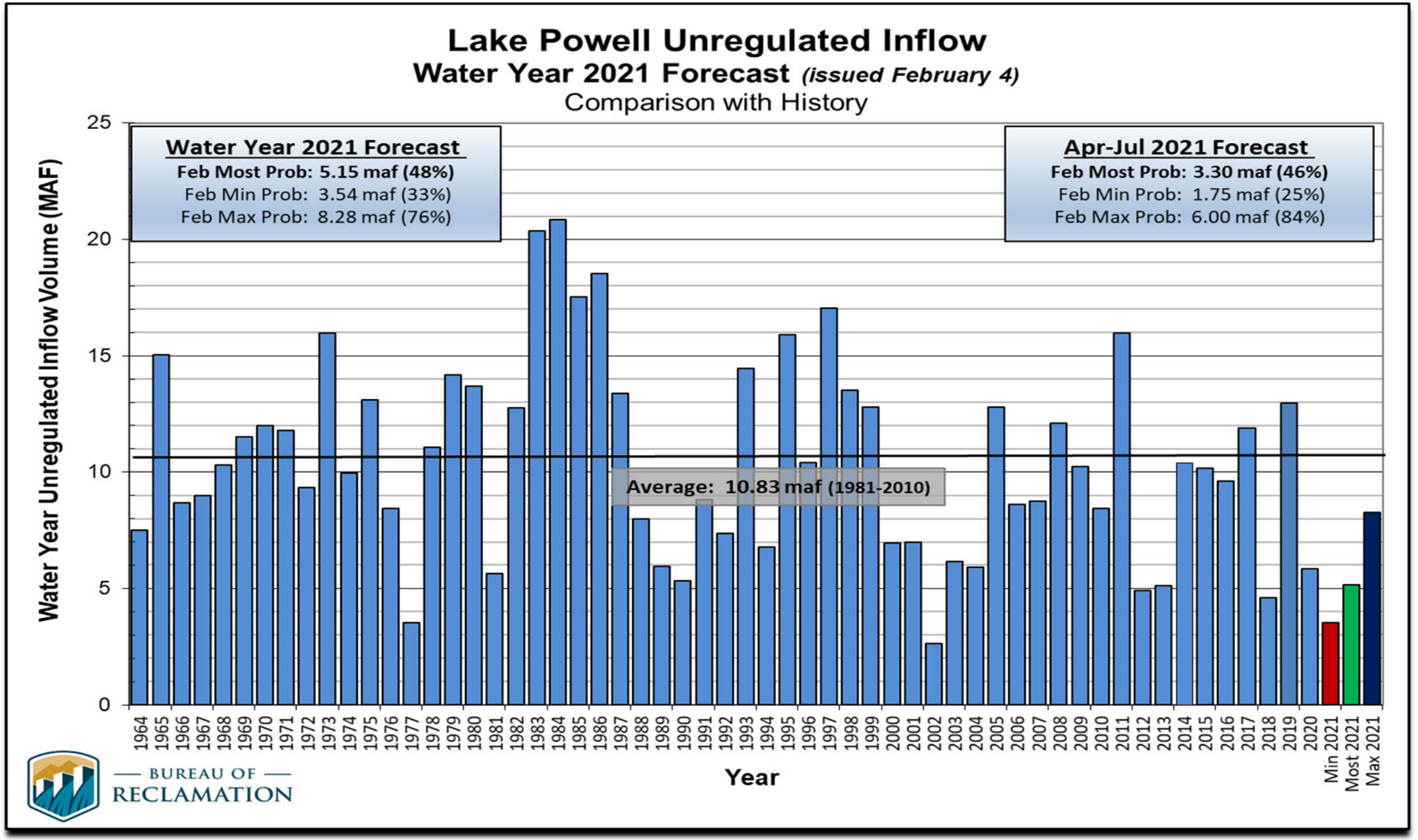


Water Year 2021 Forecasted Unregulated Inflow

as of February 1, 2021

Reservoir	Unregulated Inflow (kaf)	Percent of Average[1]
Fontenelle	659	64
Flaming Gorge	814	56
Blue Mesa	674	71
Navajo	605	56
Powell	5,149	48

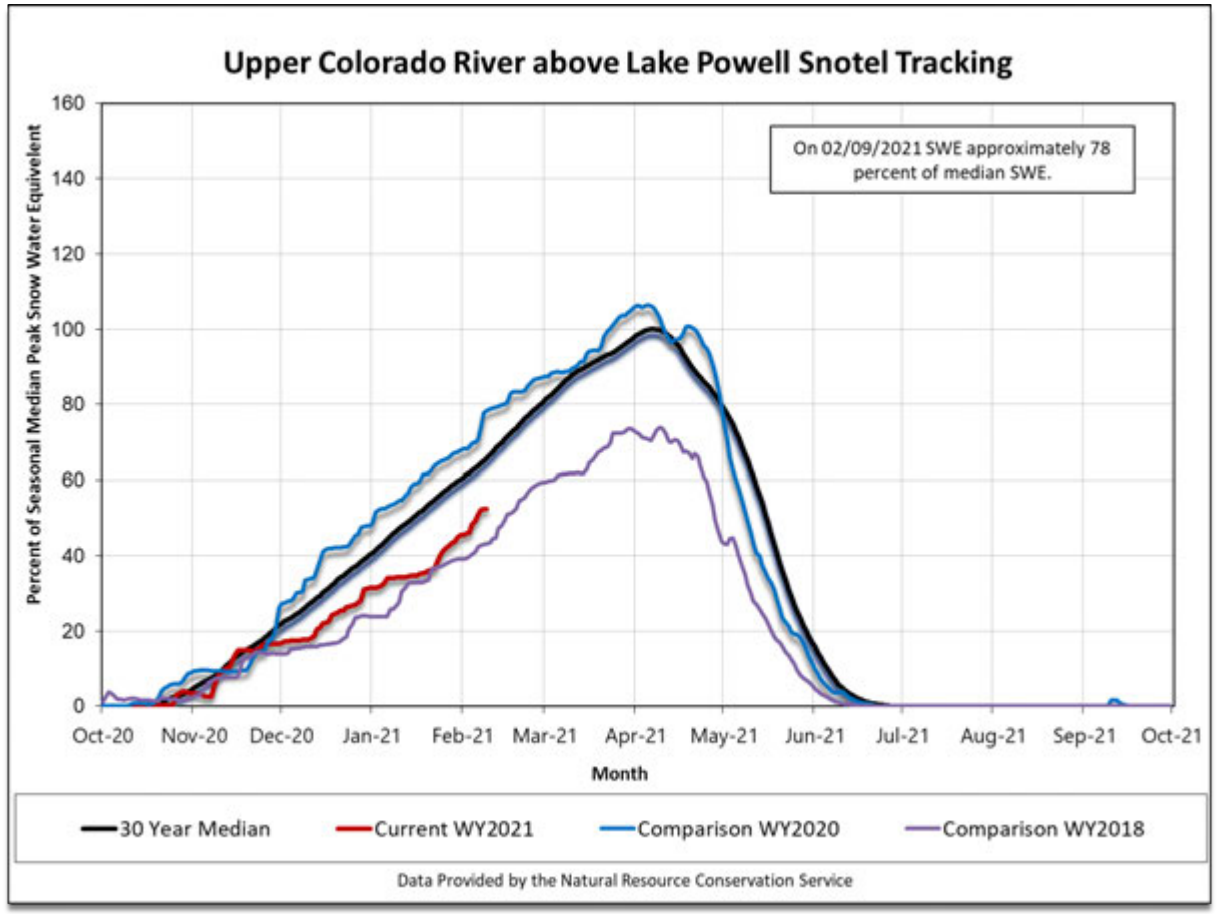
[1] Percent of average based on the period of record from 1981-2010.


Lake Powell Unregulated Inflow
Water Year 2021 Forecast (issued February 4)
Comparison with History
Water Year 2021 Forecast
Feb Most Prob: 5.15 maf (48%)
Feb Min Prob: 3.54 maf (33%)
Feb Max Prob: 8.28 maf (76%)
Apr-Jul 2021 Forecast
Feb Most Prob: 3.30 maf (46%)
Feb Min Prob: 1.75 maf (25%)
Feb Max Prob: 6.00 maf (84%)
Average: 10.83 maf (1981-2010)
Water Year Unregulated Inflow Volume (MAF)
Year
Min 2021
Most 2021
Max 2021
BUREAU OF RECLAMATION

Upper Colorado Basin

Projected Operations for Water Year 2021 Based on January 2021 Modeling

Current SWE and January WY2021 Forecast



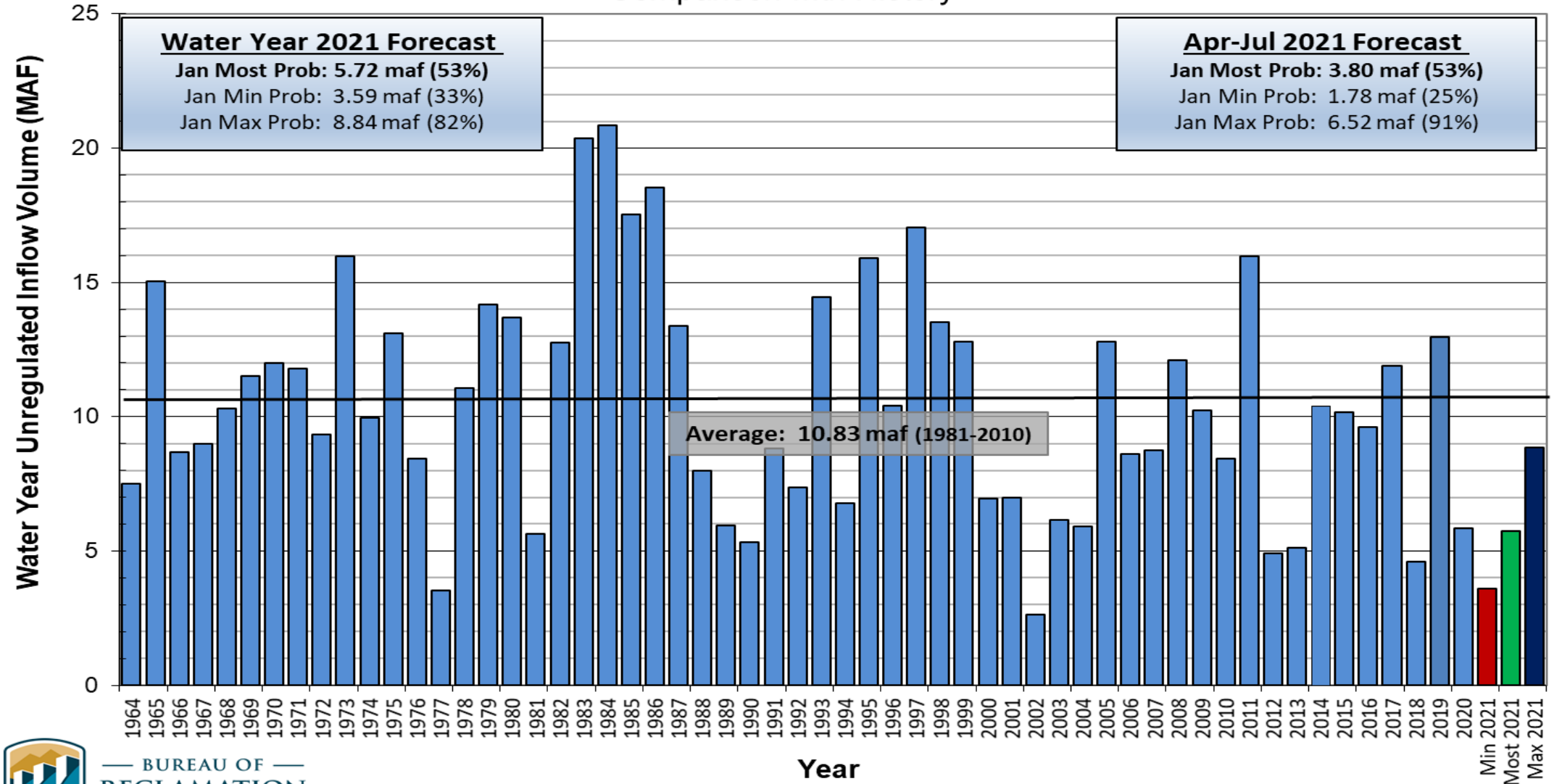
Water Year 2021 Forecasted Unregulated Inflow

as of January 1, 2021

Reservoir	Unregulated Inflow (kaf)	Percent of Average[1]
Fontenelle	727	67
Flaming Gorge	900	62
Blue Mesa	670	70
Navajo	609	57
Powell	5,723	53

[1] Percent of average based on the period of record from 1981-2010.

Lake Powell Unregulated Inflow
Water Year 2021 Forecast *(issued January 6)*
Comparison with History



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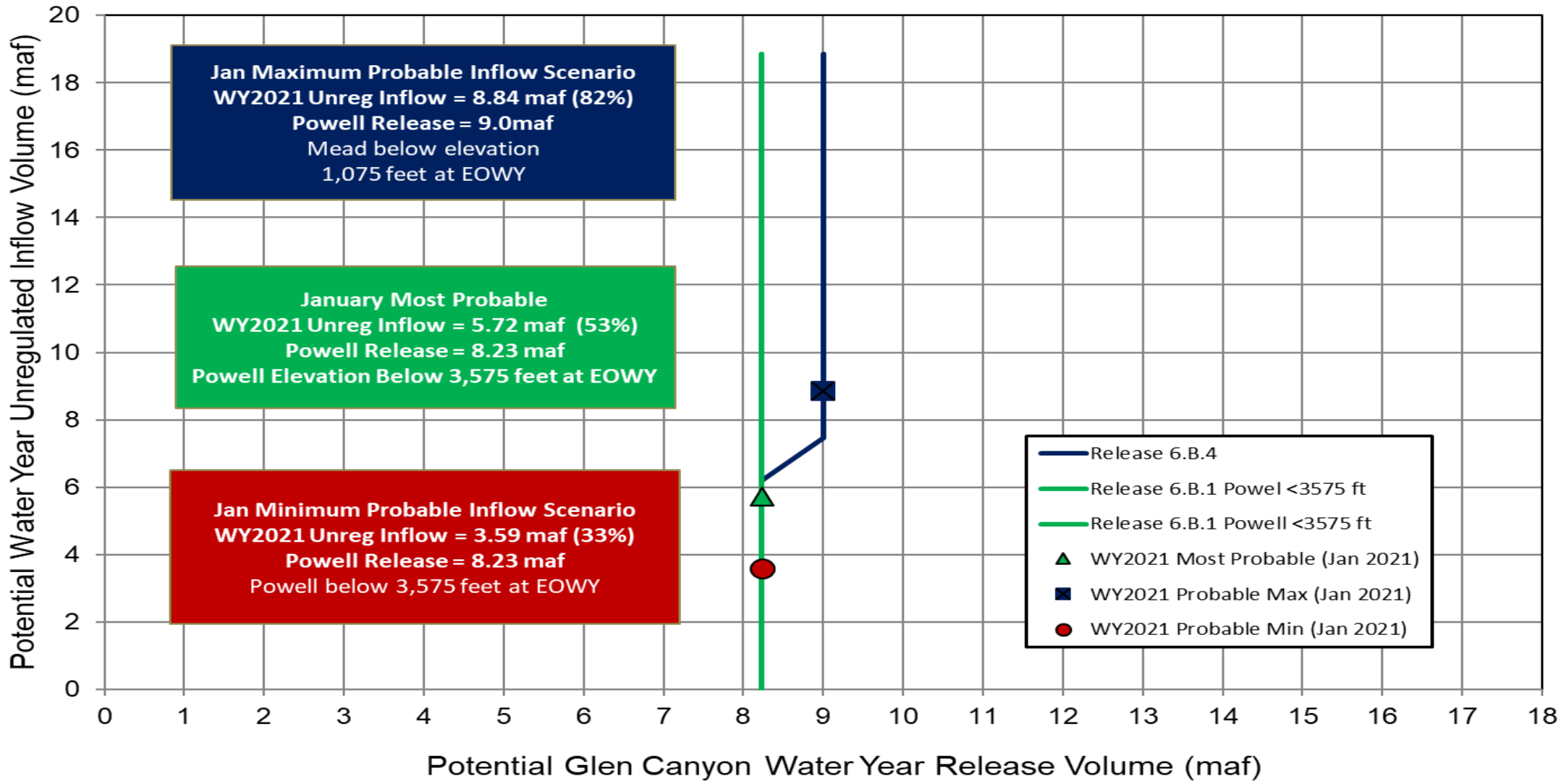
Lake Powell Release Scenarios under Section 6.B

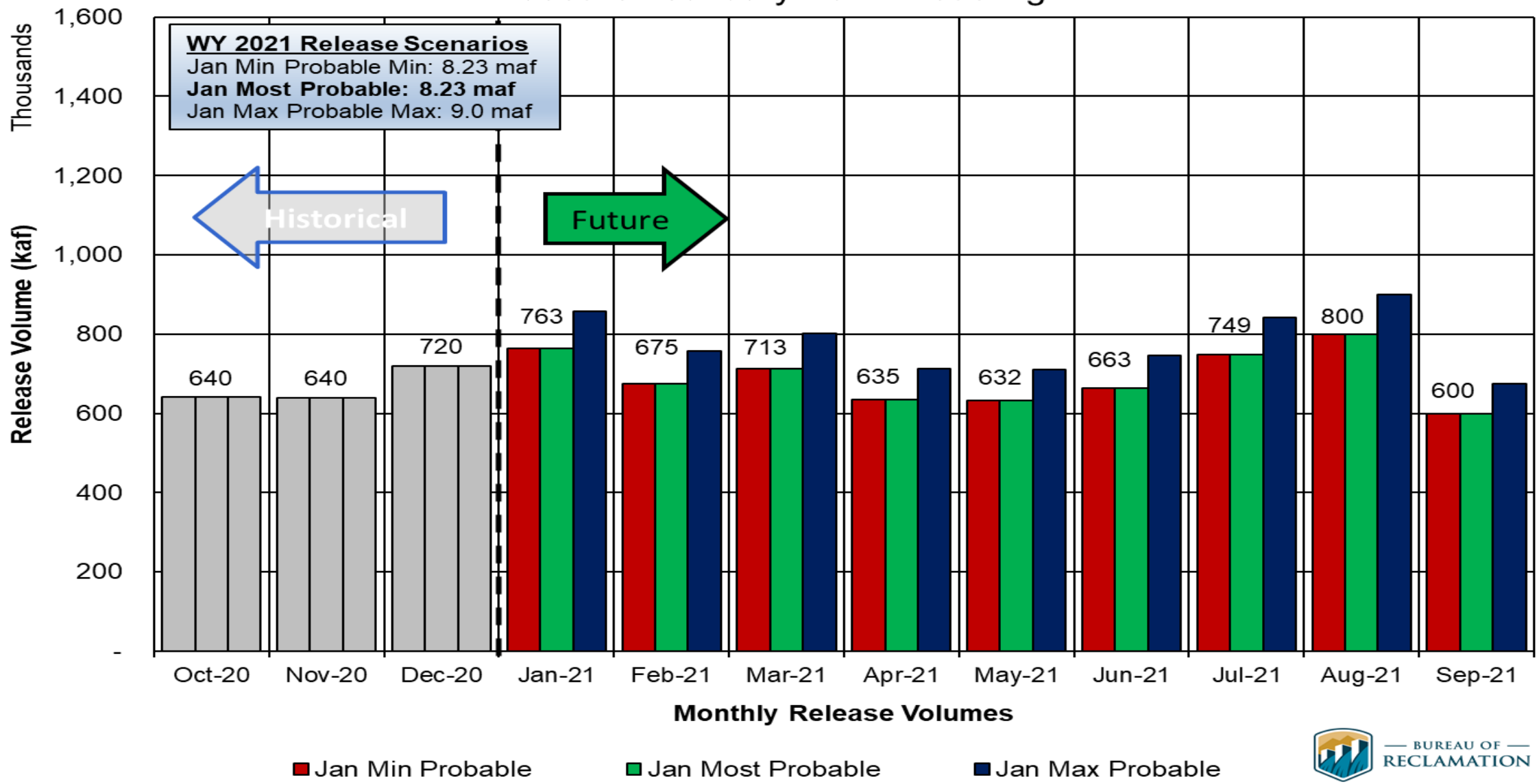
Water Year 2021 Release Volume as a Function of Upper Elevation Balancing Tier
based on January 2021 24-Month Study Conditions



Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2021

Based on January 2021 Modeling



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LTEMP Operational Flexibility

1.2 OPERATIONAL FLEXIBILITY UNDER ALTERNATIVE D

Reclamation retains the authority to utilize operational flexibility at Glen Canyon Dam because hydrologic conditions of the Colorado River Basin (or the operational conditions of Colorado River reservoirs) cannot be completely known in advance. Consistent with current operations, Reclamation, in consultation with WAPA, will make specific adjustments to daily and monthly release volumes during the water year. Monthly release volumes may be rounded for practical implementation or for maintenance needs. In addition, when releases are actually implemented, minor variations may occur regularly for a number of operational reasons that cannot be projected in advance.

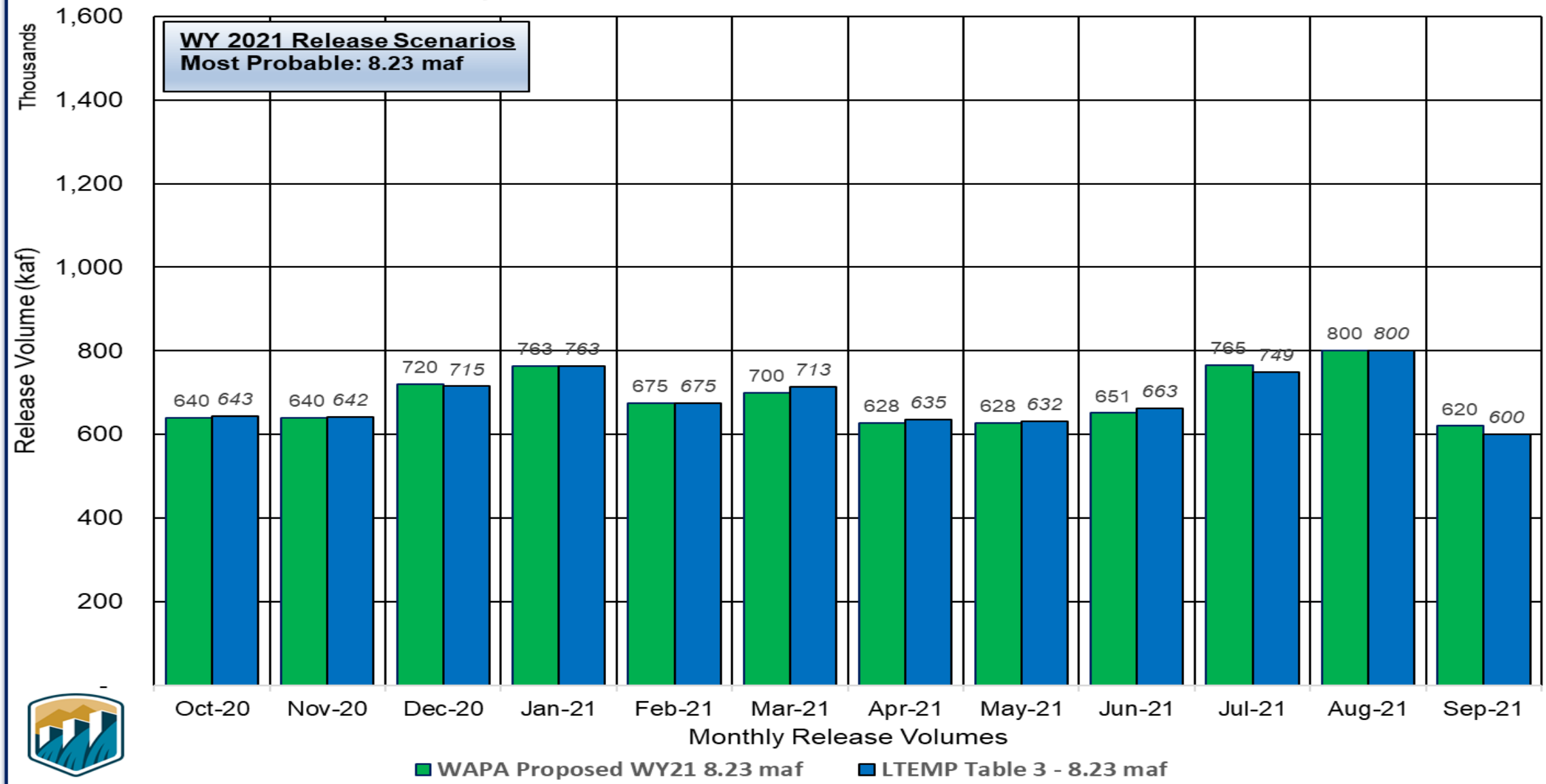
Reclamation also will make specific adjustments to daily and monthly release volumes, in consultation with other entities as appropriate, for a number of reasons, including operational, resource-related, and hydropower-related issues. Examples of these adjustments may include, but are not limited to, the following:

- For water distribution purposes, volumes may be adjusted to allocate water between the Upper and Lower Basins consistent with the Law of the River as a result of changing hydrology;
- For resource-related issues that may occur uniquely in a given year, release adjustments may be made to accommodate nonnative species removal, to assist with aerial photography, or to accommodate other resource considerations separate from experimental treatments under the LTEMP;
- For hydropower-related issues, adjustments may occur to address issues such as electrical grid reliability, actual or forecasted prices for purchased power, transmission outages, and experimental releases from other Colorado River Storage Project dams.

In addition, Reclamation may make modifications under circumstances that may include operations that are prudent or necessary for the safety of dams, public health and safety, other emergency situations, or other unanticipated or unforeseen activities arising from actual operating experience (including, in coordination with the Basin States, actions to respond to low reservoir conditions as a result of drought in the Colorado River Basin). In addition, the Emergency Exception Criteria established for Glen Canyon Dam will continue under this alternative. (See, e.g., Section 3 of the Glen Canyon Operating Criteria at 62 FR 9448, March 3, 1997.)

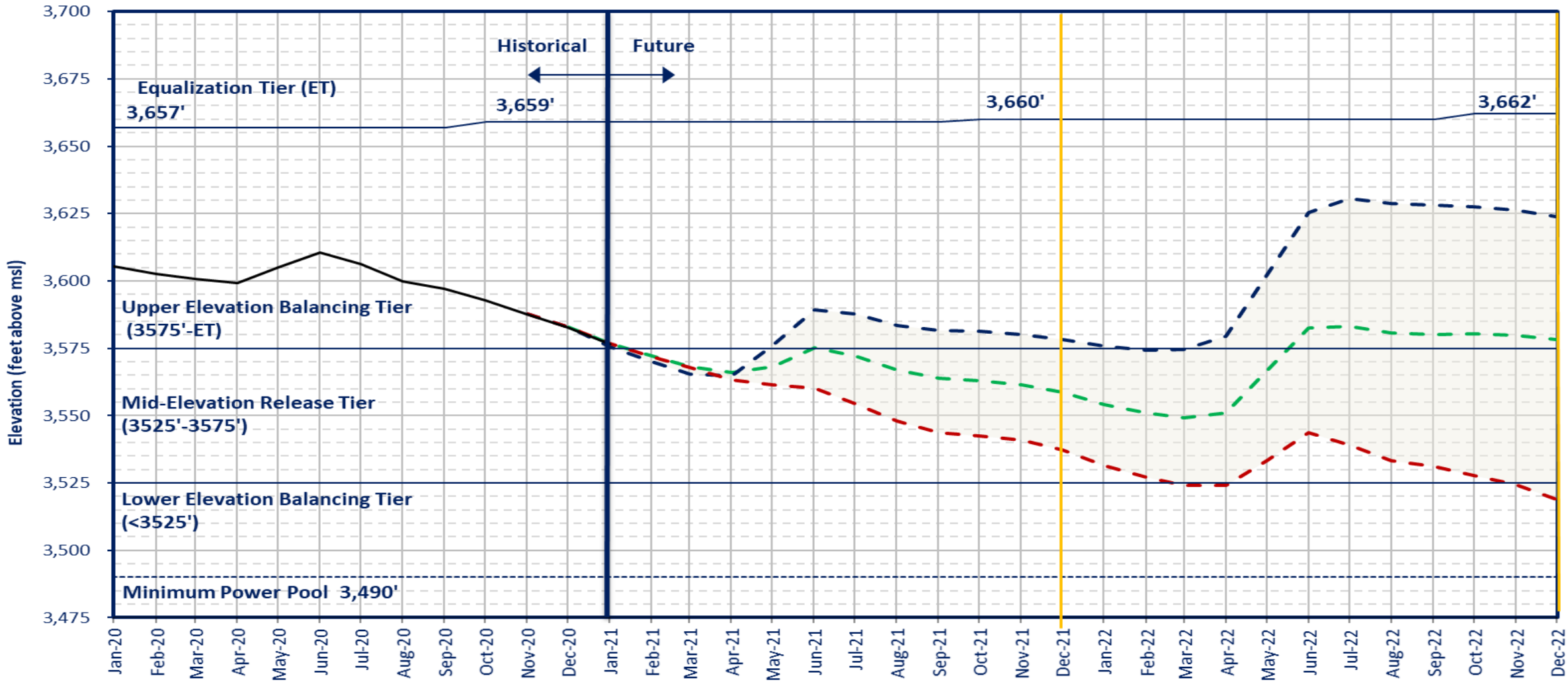
Lake Powell Monthly Release Volume Distribution

WAPA Proposed 8.23 maf Pattern for Water Year 2021



Lake Powell End of Month Elevations

Historical and Projected based on January 2021 24-Month Study Inflow Scenarios



Jan 2021 Most Probable - Lake Powell release of 8.23 maf in WY2021, 7.48 maf in WY2022 and 7.48 maf in WY2023

Jan 2021 Max Probable - Lake Powell release of 9.0 maf in WY2021, 8.23 maf in WY2022 and 8.23 maf in WY2023

Jan 2021 Min Probable - Lake Powell release of 8.23 maf in WY2021, 7.48 maf in WY2022, and 8.23 maf (LEBT) in WY2023

Historical Elevations

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Drought Operations

Attachment A1 to the Agreement Concerning Colorado River Drought Contingency Management and Operations ("Companion Agreement")

AGREEMENT FOR DROUGHT RESPONSE OPERATIONS AT THE INITIAL UNITS OF THE COLORADO RIVER STORAGE PROJECT ACT

This Agreement for Drought Response Operations ("Drought Response Operations Agreement") at the Glen Canyon Dam, Flaming Gorge Dam, Curecanti (the "Aspinall Unit"), and Navajo Dam authorized by the Colorado River Storage Project Act (collectively referred to as the "CRSPA Initial Units" and individually as "CRSPA Initial Unit"), an element of the Upper Colorado River Basin's Drought Contingency Plan, is hereby made and entered into this 20th day of May, 2019 by and among the Upper Colorado River Division States of Colorado, New Mexico, Utah, and Wyoming ("Upper Division States"), through the Upper Colorado River Commission ("Commission"), and the Secretary of the Interior ("Secretary") hereinafter collectively referred to as the "Parties." The Secretary may delegate his or her duties under this Drought Response Operations Agreement to the Bureau of Reclamation ("Reclamation").

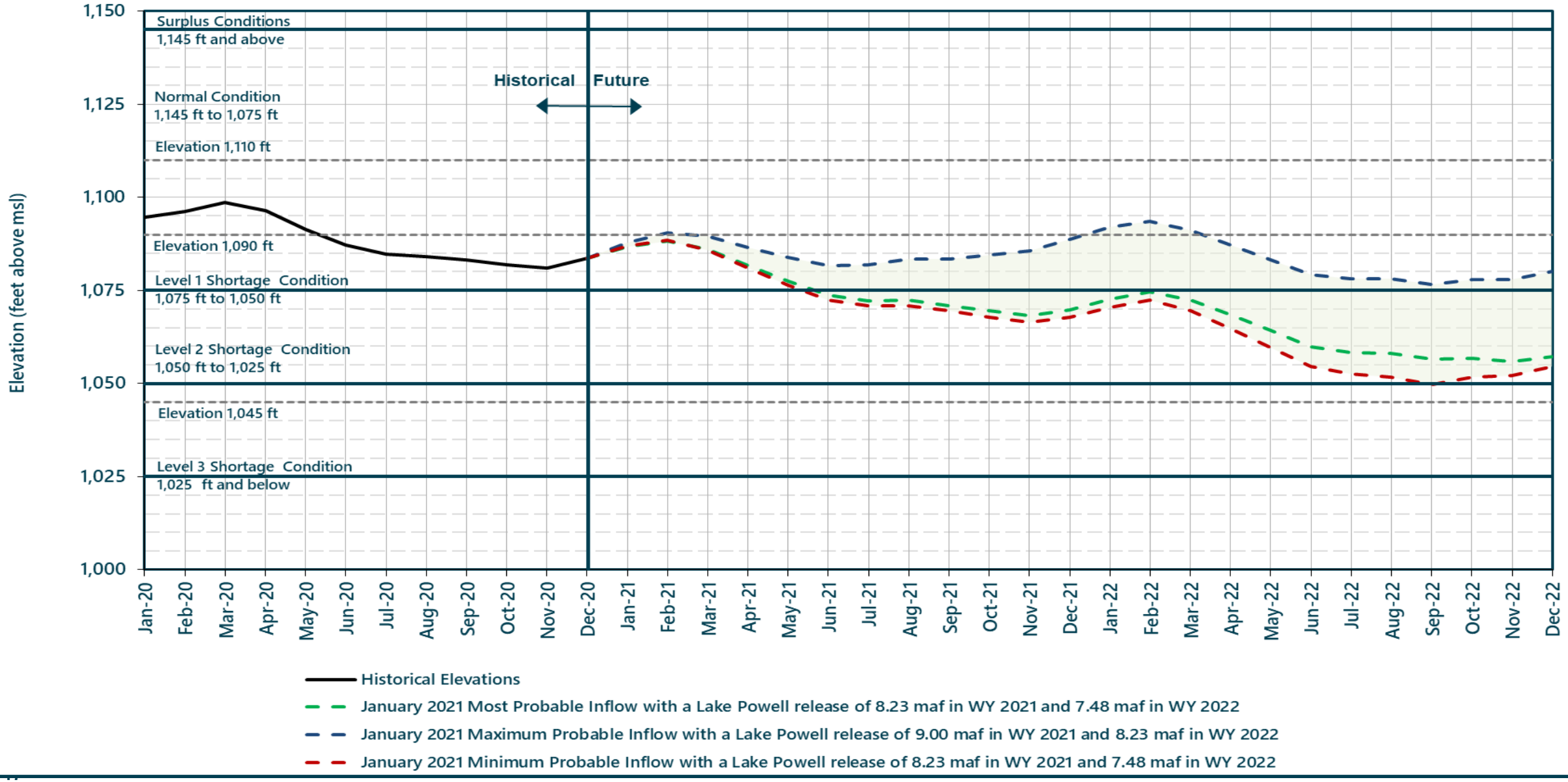
4. Drought Response Process: In an effort to achieve the primary goals of this Drought Response Operations Agreement, and to implement the "Principles" outlined in Section II.A.3, the Parties agree that, subject to Section II.A.3.j "Emergency Action", they will work to minimize the risk of Lake Powell declining below the Target Elevation by:
    a. *Initiating drought response process*: The Parties will initiate a drought response process, which will include at a minimum:
        i. *Notice*: The Secretary will notify the Commission and the Lower Division States when Reclamation's 24-Month Study model, using Minimum Probable hydrology based upon the inflow forecast provided by the Colorado Basin River Forecast Center, projects Lake Powell's elevation at or below the Target Elevation at any time during the subsequent 24-month period, or when emergency action becomes necessary as set forth in Section II.A.3.j.
        ii. *Modeling:* The Secretary will commence monthly modeling of Minimum Probable, Maximum Probable and Most Probable hydrology for the subsequent 24-month period until the Minimum Probable 24-Month Study projects that Lake Powell will consistently remain above the Target Elevation for a 24-month period. Reclamation will report such modeling results to the Upper Division States and the Commission during monthly calls, *see* Section II.A.4.a.iii.

Drought Operations

- The January 2021 minimum probable forecast projects Powell to fall below 3525 feet in 2022.
- The Basin States, UCRC, and WAPA were notified on January 22 informing them of this event.
- Model results *do not* initiate immediate operational changes to Reclamation facilities.
- Model results *do* initiate enhanced monitoring and coordination under the DROA.
- Model results *do* initiate monthly analysis of min/most/max with the Upper Division States, the UCRC, and other parties.
- The DROA enhanced monitoring and coordination will continue until either:
  - (i) The minimum probable projected elevation remains above 3525' for 24 months; or
  - (ii) the process moves to the next step when the most probable projected elevation indicates Powell elevations below 3,525 feet and a specific Drought Response Operations Plan is developed. (Section II.A.4.b)

Lake Mead End of Month Elevations

Projections from the January 2021 24-Month Study Inflow Scenarios



Glen Canyon Power Plant Planned Unit Outage Schedule for Water Year 2021

Unit Number	Oct 2020	Nov 2020	Dec 2020	Jan 2021	Feb 2021	Mar 2021	Apr 2021	May 2021	Jun 2021	Jul 2021	Aug 2021	Sep 2021	
1													
2													
3													
4													
5													
6													
7													
8													
Units Available	5	5/4	6	6	6	6	6	5	6	6	6	8/6	
Capacity (cfs)	16,400	16,400/ 12,200	19,800	19,600	19,500	19,400	19,300	15,800	19,600	19,500	19,300	26,300/ 19,300	JAN MOST[3]
Capacity (kaf/month)	1,040	1,140	1,250	1,220	1,210	1,080	1,280	1,190	1,160	1,200	1,340	1,410	JAN MOST
Max (kaf)[2]	640	640	720	857	758	801	713	710	745	842	900	674	9.0
Most (kaf)[1]	640	640	720	763	675	700	628	628	651	765	800	620	8.23
Min (kaf)[2]	640	640	720	760	680	710	640	630	660	750	800	600	8.23
										(updated 01-26-2021)			

1 Projected release, based on January 2021 Most Probable Inflow Projections and 24-Month Study model runs.
2 Projected release, based on January 2021 Min and Max Probable Inflow Projections and 24-Month Study model runs.
3 Dependent upon availability to shift contingency reserves, which will increase capacity by 30-40MW (3%) at current efficiency.

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Glen Canyon Power Plant Planned Unit Outage Schedule for Water Year 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	6/5	5/6	6	4	6	8	7	6	6	6	4	
Capacity (cfs)	19,200	19,200/ 15,700	15,600/ 19,100	19,000	12,000	18,800	25,800	23,000	19,800	19,800	19,700	12,500	JAN MOST[3]
Capacity (kaf/month)	1,170	1,030	1,110	1,150	730	1,240	1,540	1,440	1,250	1,220	1,210	800	JAN MOST
Max (kaf)[2]	643	642	715	763	675	713	635	632	663	749	800	600	8.23
Most (kaf)[1]	480	500	600	723	639	675	601	599	628	709	758	568	7.48
Min (kaf)[2]	480	500	600	723	639	675	601	599	628	709	758	548	7.48
										(updated 01-26-2021)			

1 Projected release, based on January 2021 Most Probable Inflow Projections and 24-Month Study model runs.
2 Projected release, based on January 2021 Min and Max Probable Inflow Projections and 24-Month Study model runs.
3 Dependent upon availability to shift contingency reserves, which will increase capacity by 30-40MW (3%) at current efficiency.

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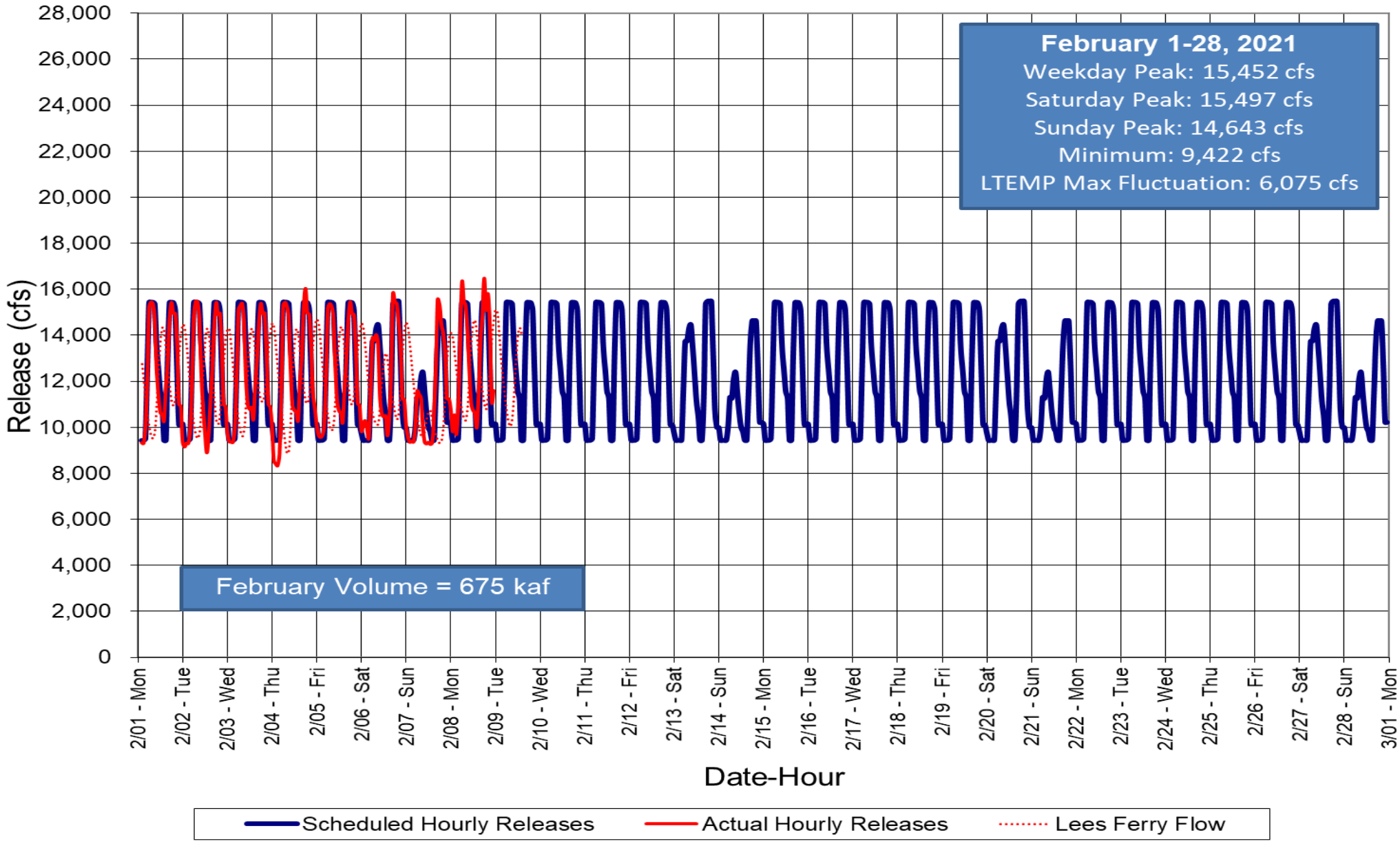
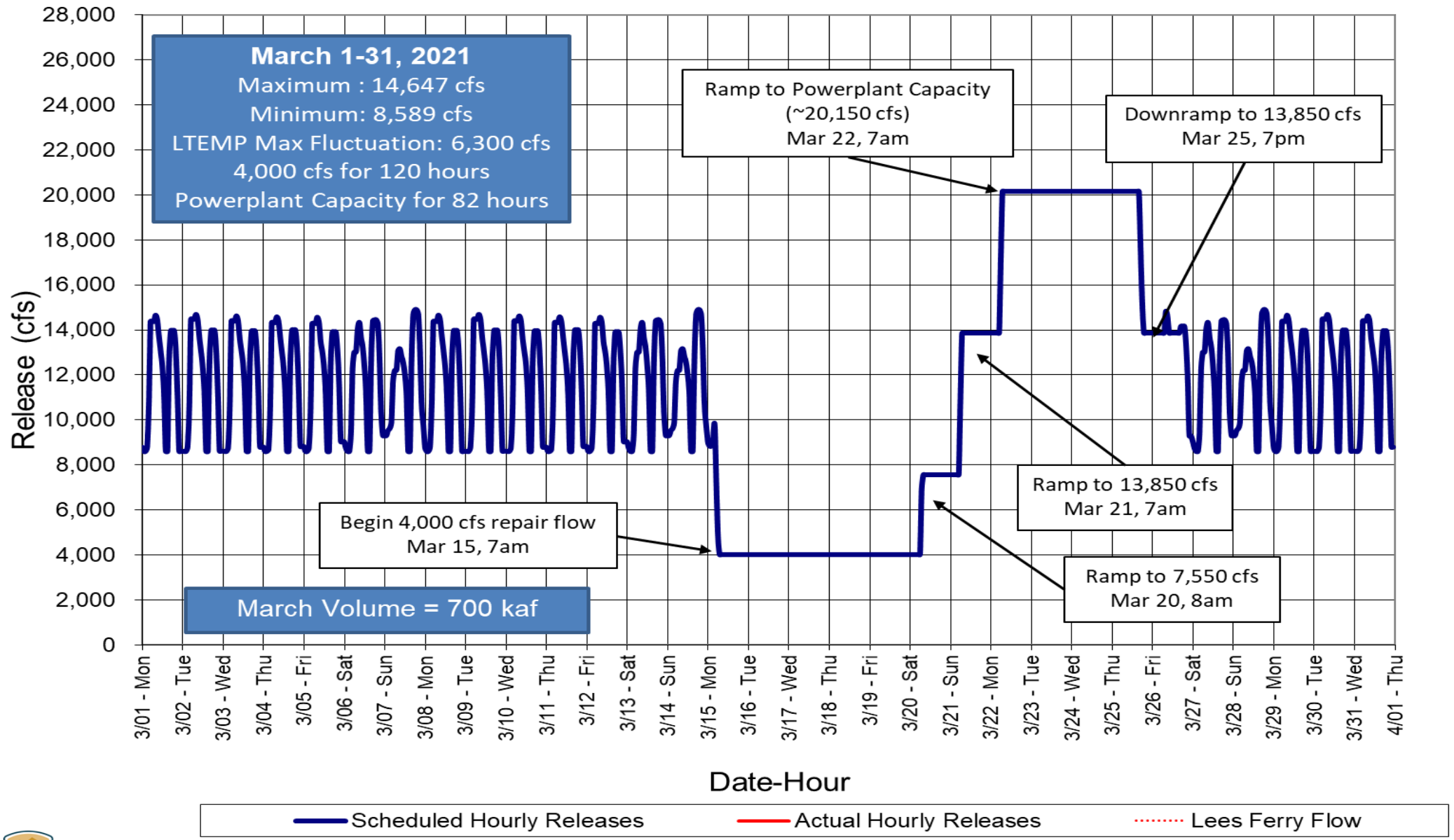
Glen Canyon Dam Hourly Release Pattern February 2021



Glen Canyon Dam Hourly Release Pattern March 2021



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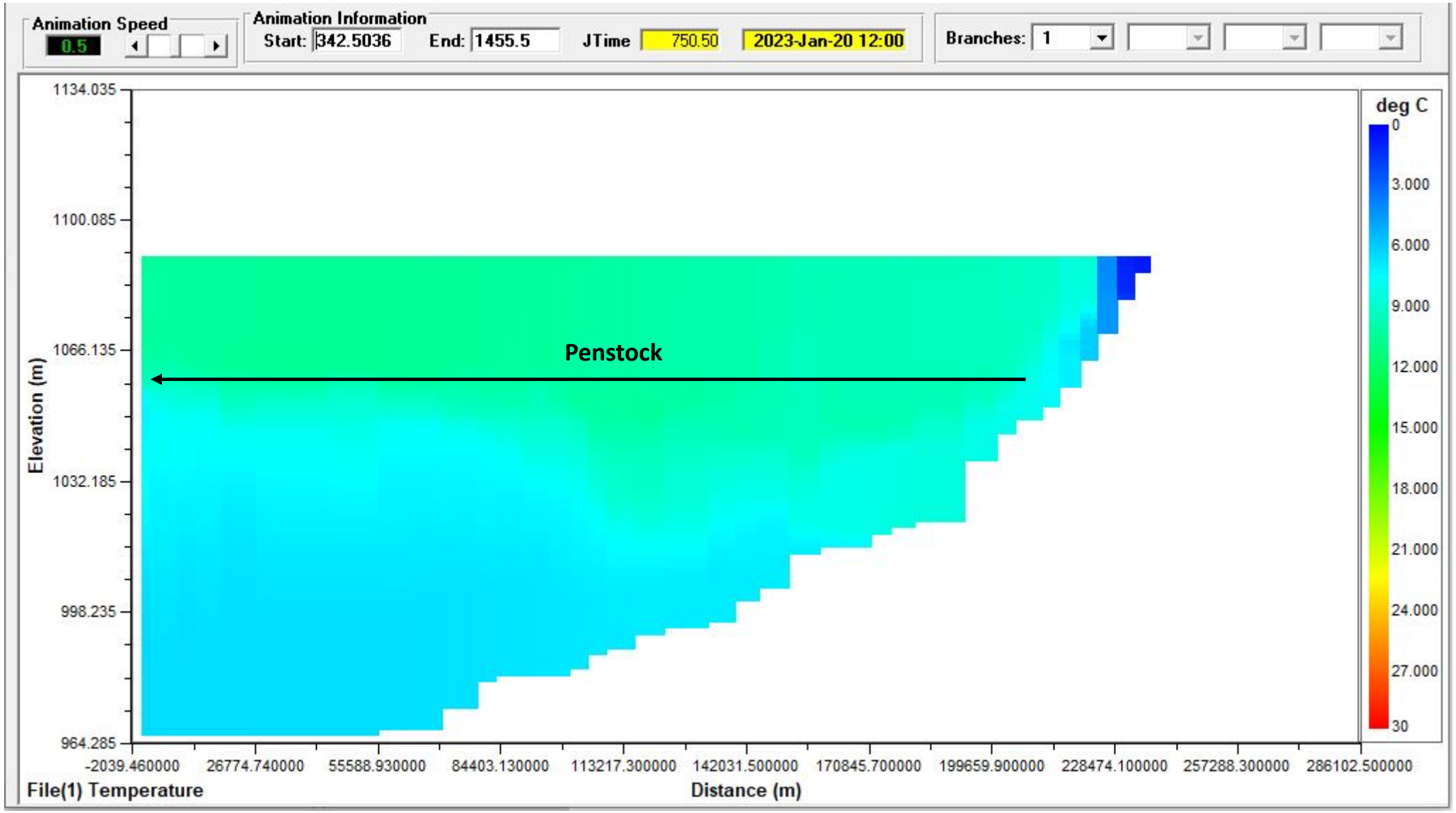
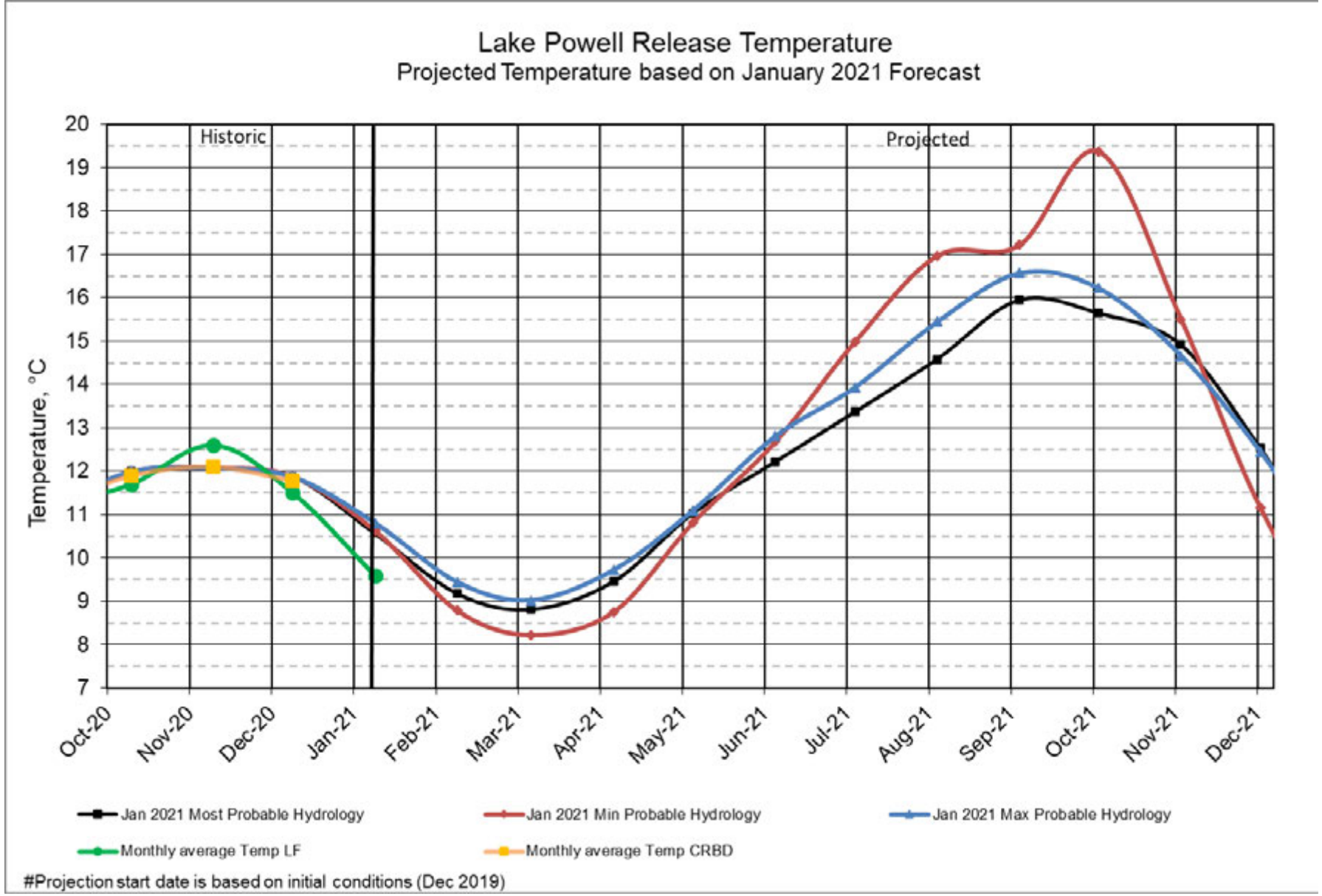
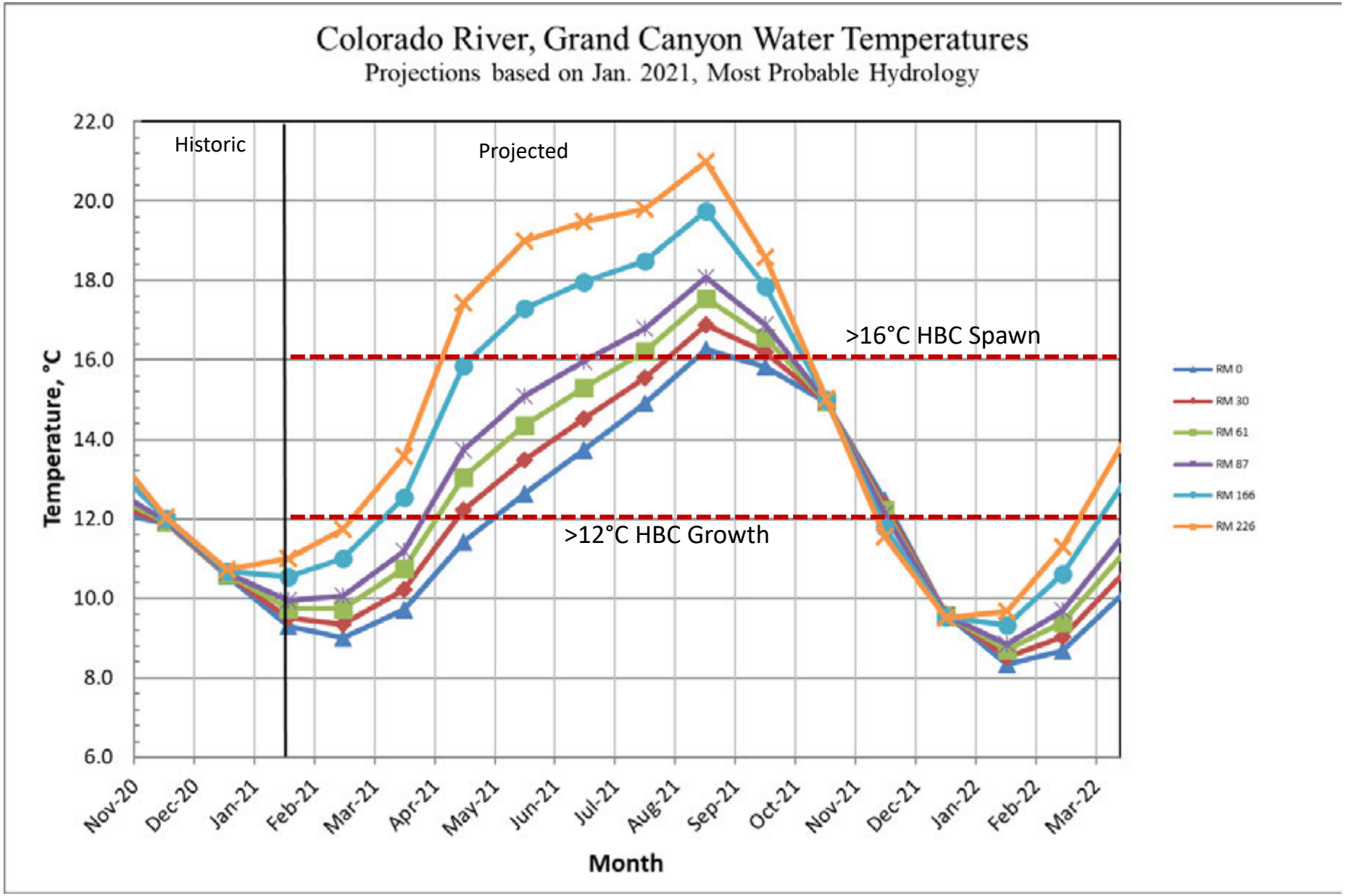
Water Quality

Cross Sectional Temperature Profile of Lake Powell

1/20/2021




Lake Powell Release Temperature
Projected Temperature based on January 2021 Forecast
Historic
Projected
Temperature, °C
20
19
18
17
16
15
14
13
12
11
10
9
8
7
Oct-20
Nov-20
Dec-20
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan 2021 Most Probable Hydrology
Jan 2021 Min Probable Hydrology
Jan 2021 Max Probable Hydrology
Monthly average Temp LF
Monthly average Temp CRBD
#Projection start date is based on initial conditions (Dec 2019)

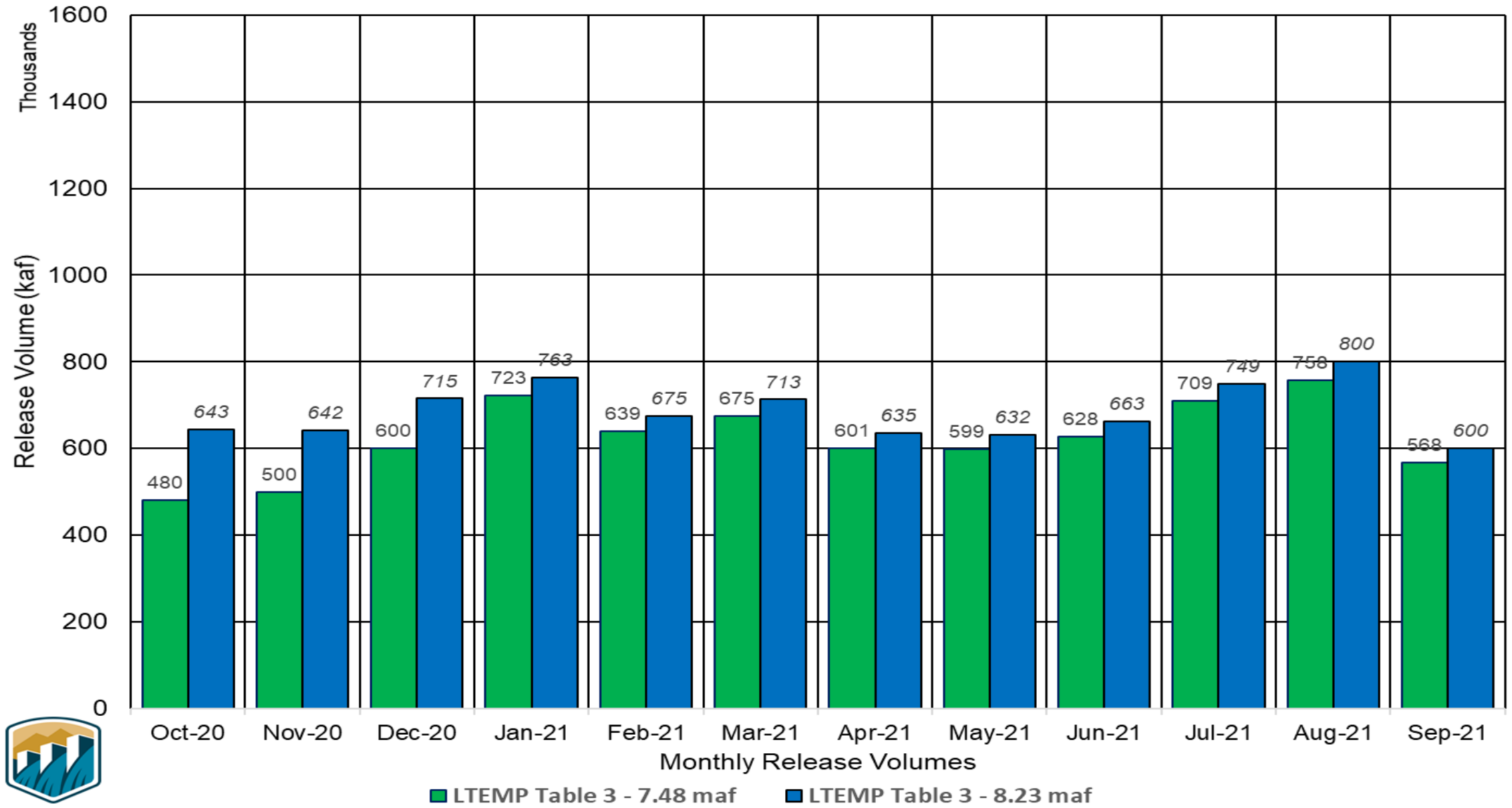

Colorado River, Grand Canyon Water Temperatures
Projections based on Jan. 2021, Most Probable Hydrology
Historic
Projected
>16°C HBC Spawn
>12°C HBC Growth
Temperature, °C
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
Nov-20
Dec-20
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22
Mar-22
Month
RM 0
RM 30
RM 61
RM 87
RM 166
RM 226

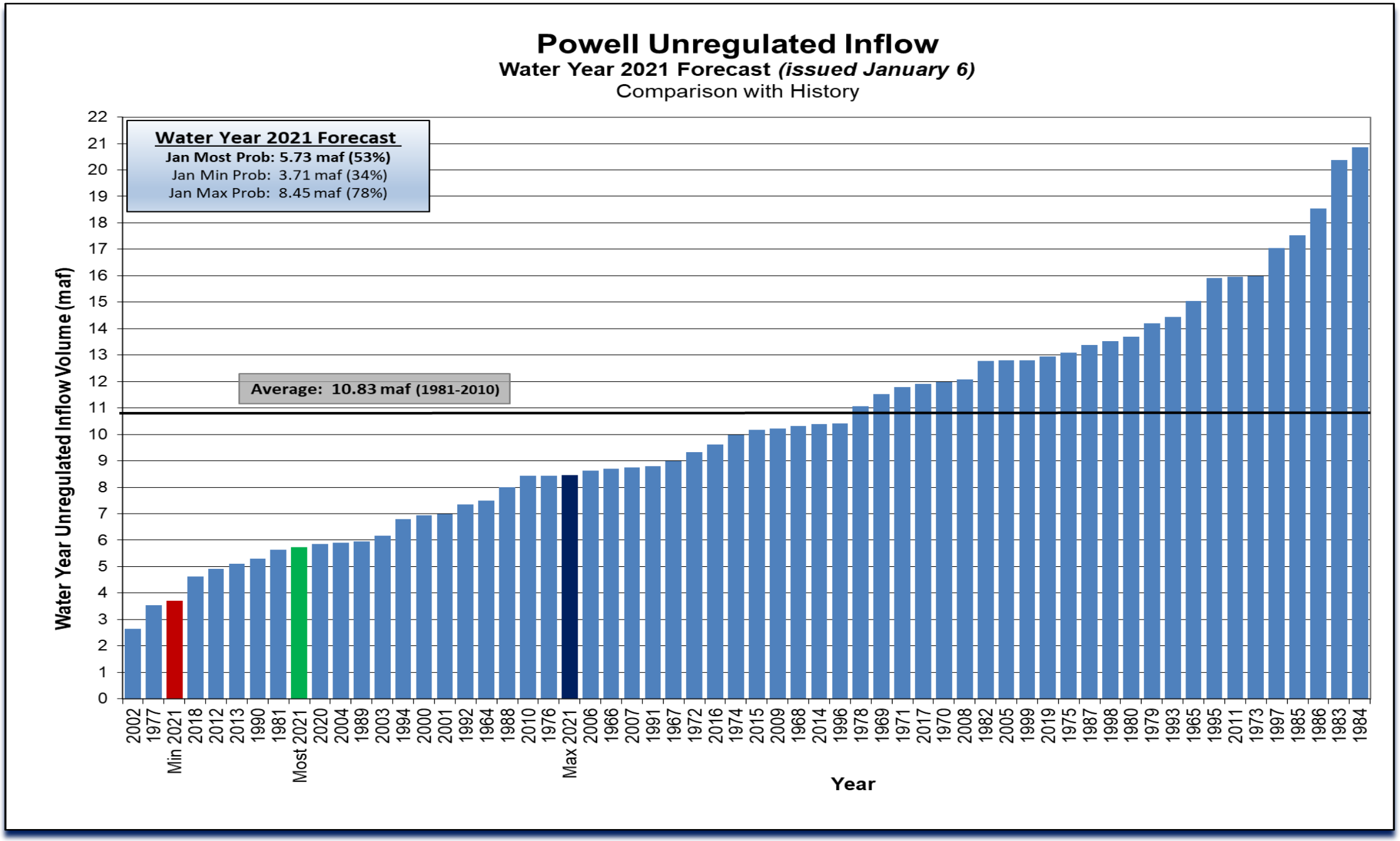
Upper Colorado Basin

Operational and WQ Historical Analysis of 7.48 maf Releases

Lake Powell Monthly Release Volume Distribution

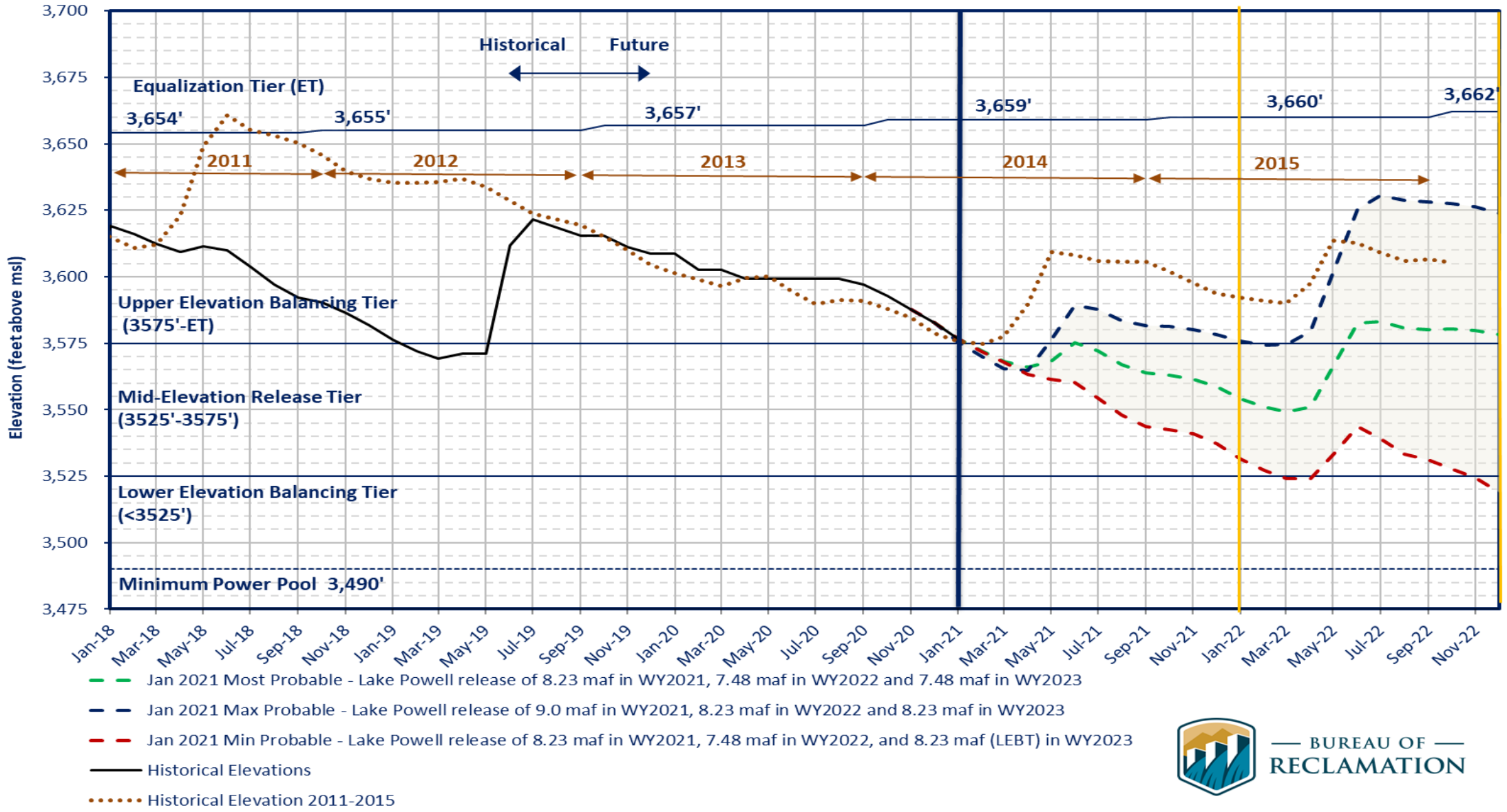
Annual Release Patterns from LTEMP Table 3



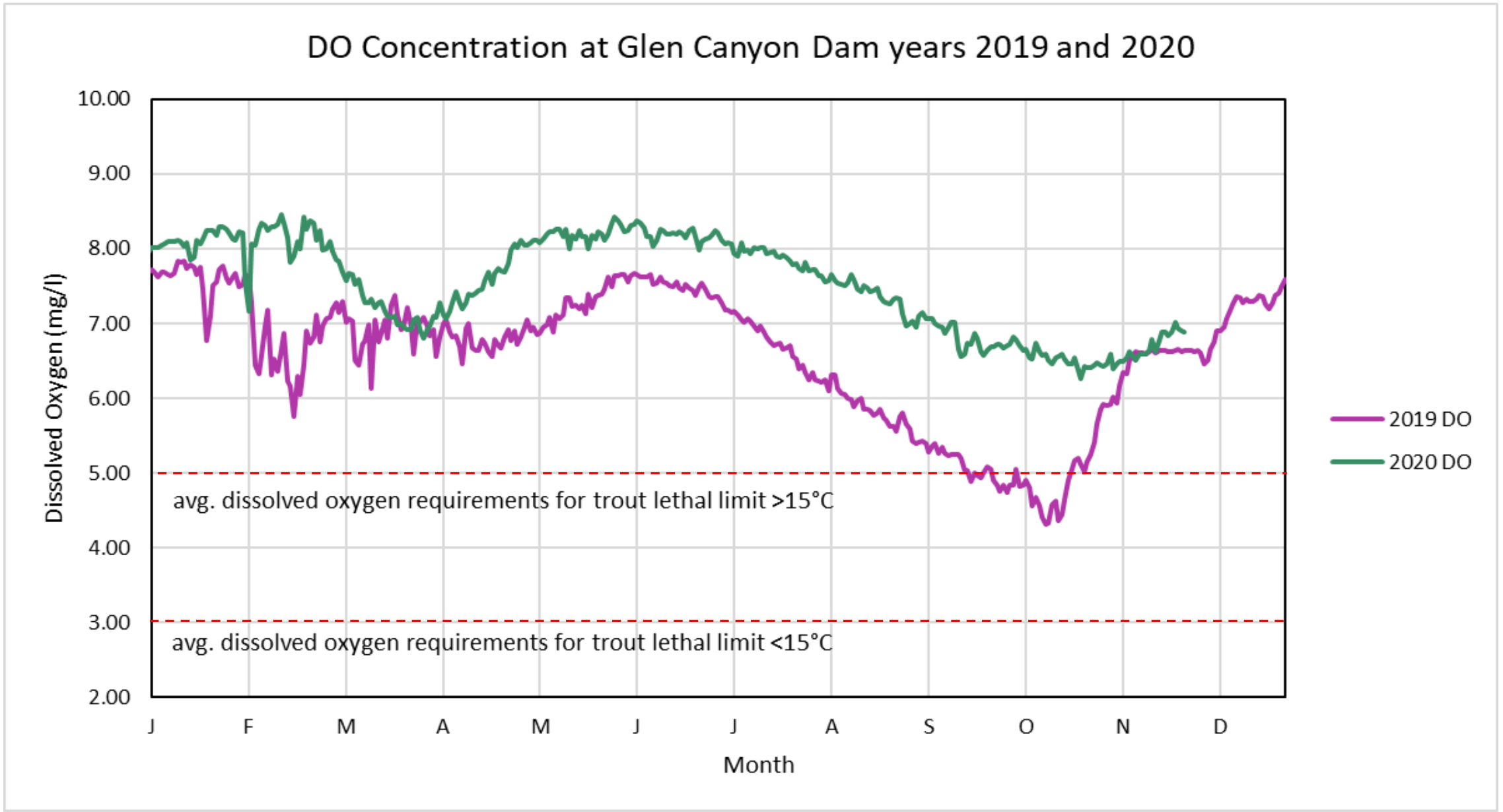

Powell Unregulated Inflow
Water Year 2021 Forecast (issued January 6)
Comparison with History
Water Year 2021 Forecast
Jan Most Prob: 5.73 maf (53%)
Jan Min Prob: 3.71 maf (34%)
Jan Max Prob: 8.45 maf (78%)
Average: 10.83 maf (1981-2010)
Water Year Unregulated Inflow Volume (maf)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
2002
1977
Min 2021
2018
2012
2013
1990
1981
Most 2021
2020
2004
1989
2003
1994
2000
2001
1992
1964
1988
2010
1976
Max 2021
2006
1966
2007
1991
1967
1972
2016
1974
2015
2009
1968
2014
1996
1978
1969
1971
2017
1970
2008
1982
2005
1999
2019
1975
1987
1998
1980
1979
1993
1965
1995
2011
1973
1997
1985
1986
1983
1984
Year

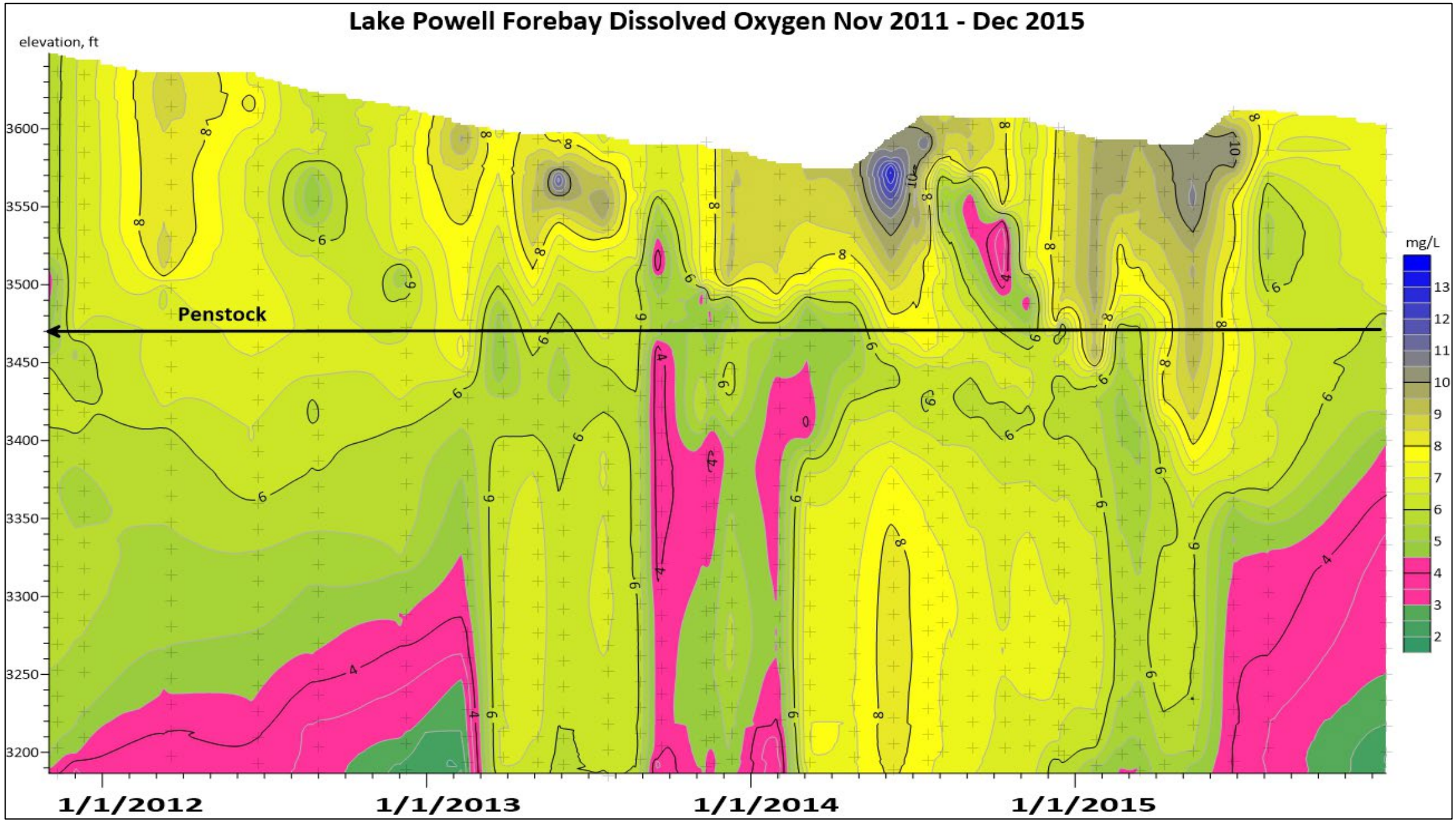
Lake Powell End of Month Elevations

Historical and Projected based on January 2021 24-Month Study Inflow Scenarios



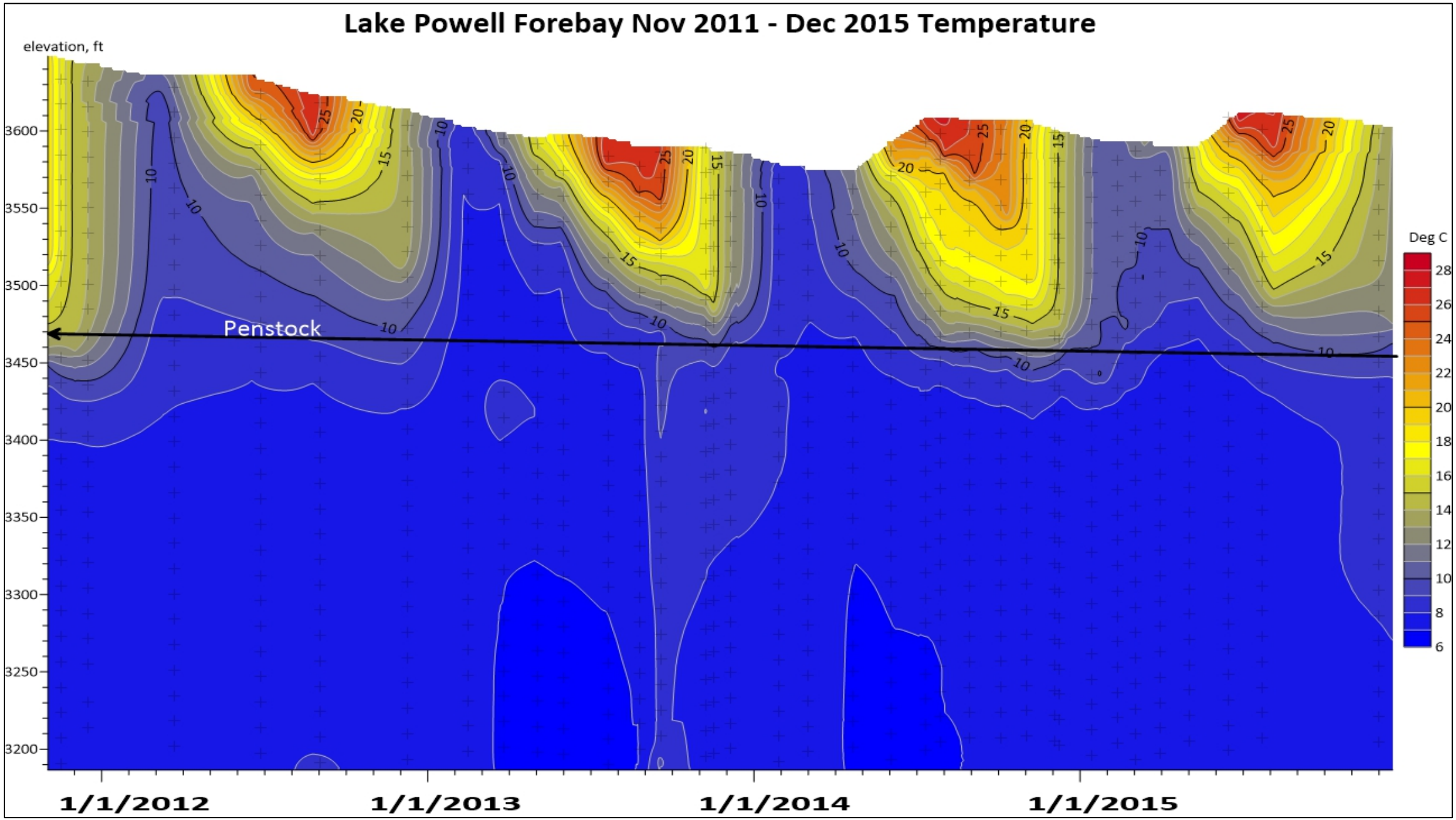
BUREAU OF RECLAMATION

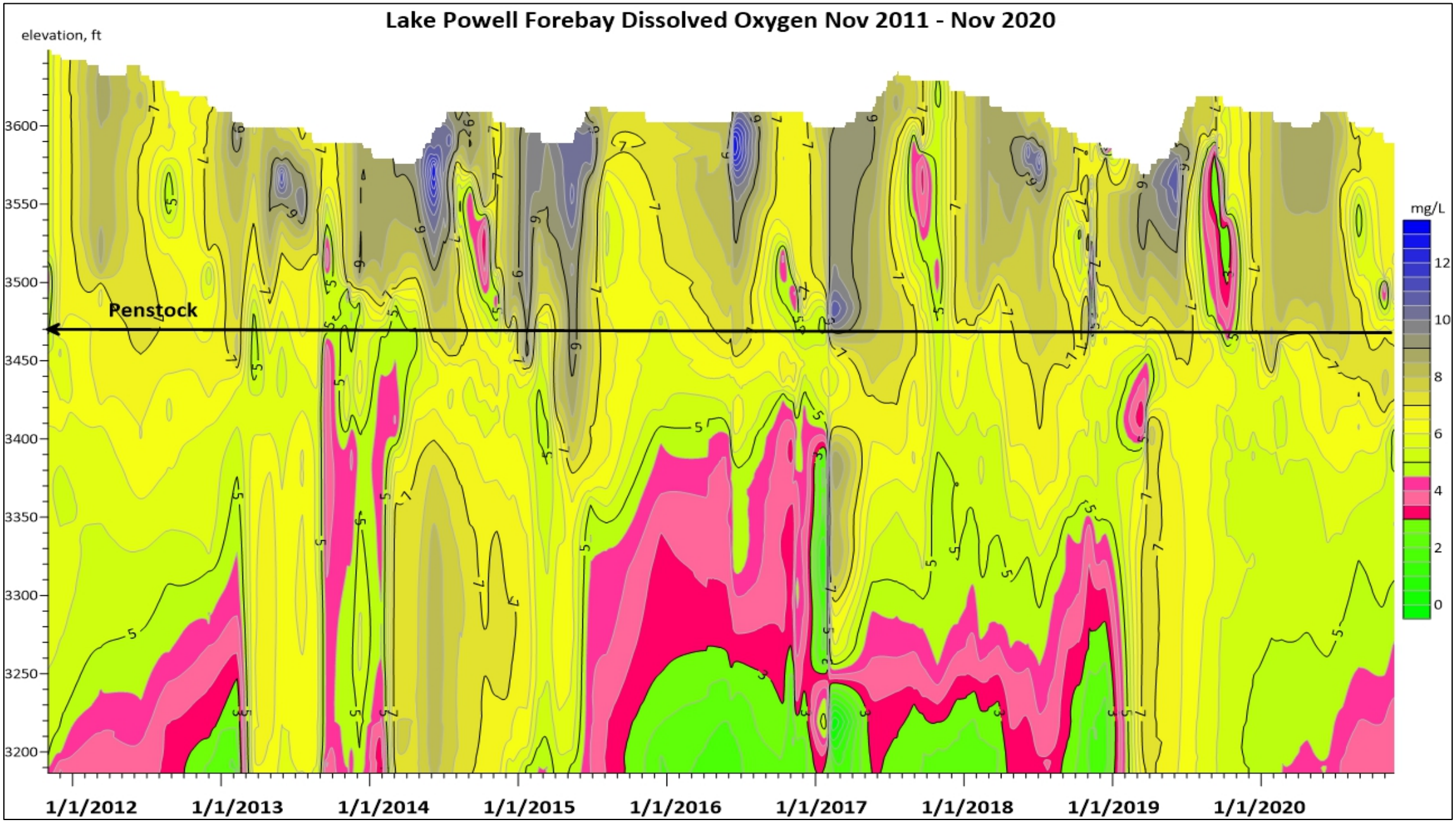

DO Concentration at Glen Canyon Dam years 2019 and 2020
Dissolved Oxygen (mg/l)
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
avg. dissolved oxygen requirements for trout lethal limit >15°C
avg. dissolved oxygen requirements for trout lethal limit <15°C
J
F
M
A
M
J
J
A
S
O
N
D
Month
2019 DO
2020 DO


Lake Powell Forebay Dissolved Oxygen Nov 2011 - Dec 2015
elevation, ft
3600
3550
3500
3450
3400
3350
3300
3250
3200
Penstock
1/1/2012
1/1/2013
1/1/2014
1/1/2015
mg/L
13
12
11
10
9
8
7
6
5
4
3
2

Questions/Discussion

BUREAU OF RECLAMATION


Lake Powell Forebay Nov 2011 - Dec 2015 Temperature
elevation, ft
3600
3550
3500
3450
3400
3350
3300
3250
3200
Penstock
1/1/2012
1/1/2013
1/1/2014
1/1/2015
Deg C
28
26
24
22
20
18
16
14
12
10
8
6


Lake Powell Forebay Dissolved Oxygen Nov 2011 - Nov 2020
elevation, ft
3600
3550
3500
3450
3400
3350
3300
3250
3200
Penstock
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
1/1/2018
1/1/2019
1/1/2020
mg/L
12
10
8
6
4
2
0