BUREAU OF RECLAMATION

Glen Canyon Monthly Operations Call

Basin Hydrology and Operations

December 21, 2021

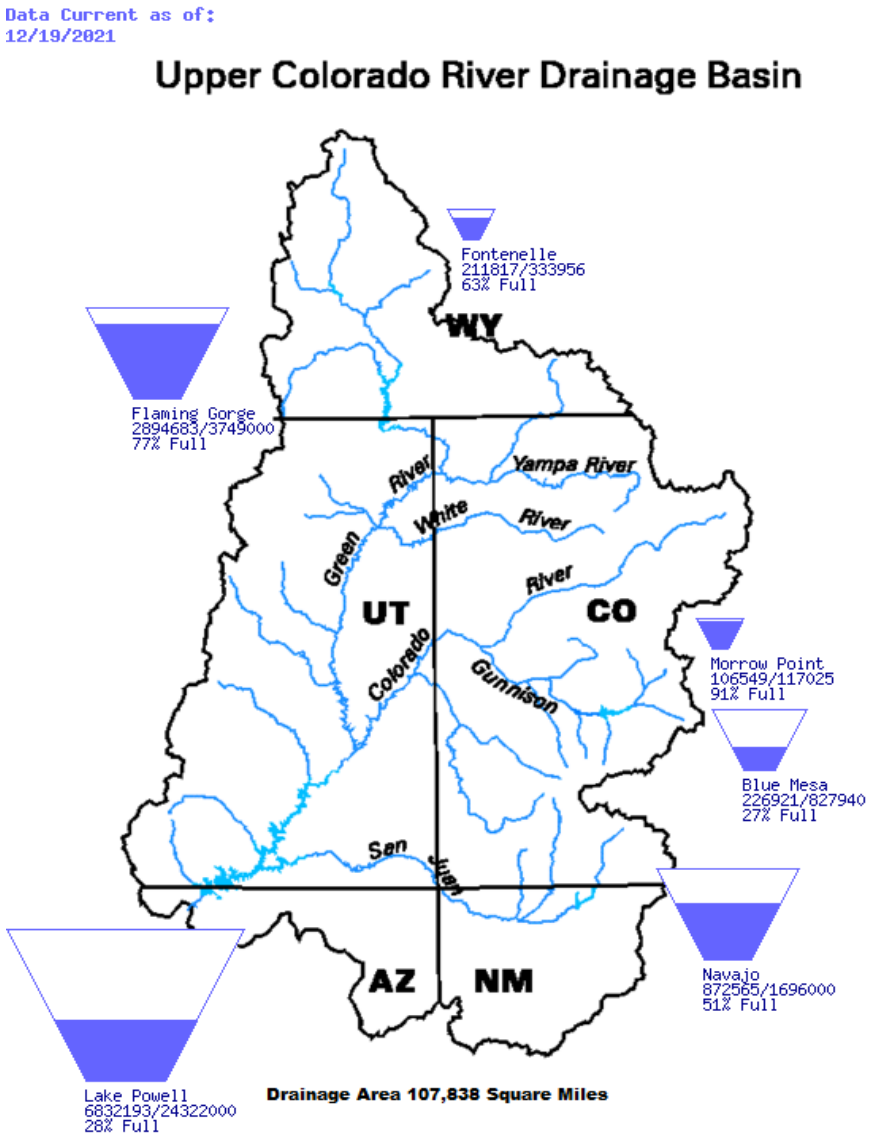
Background

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

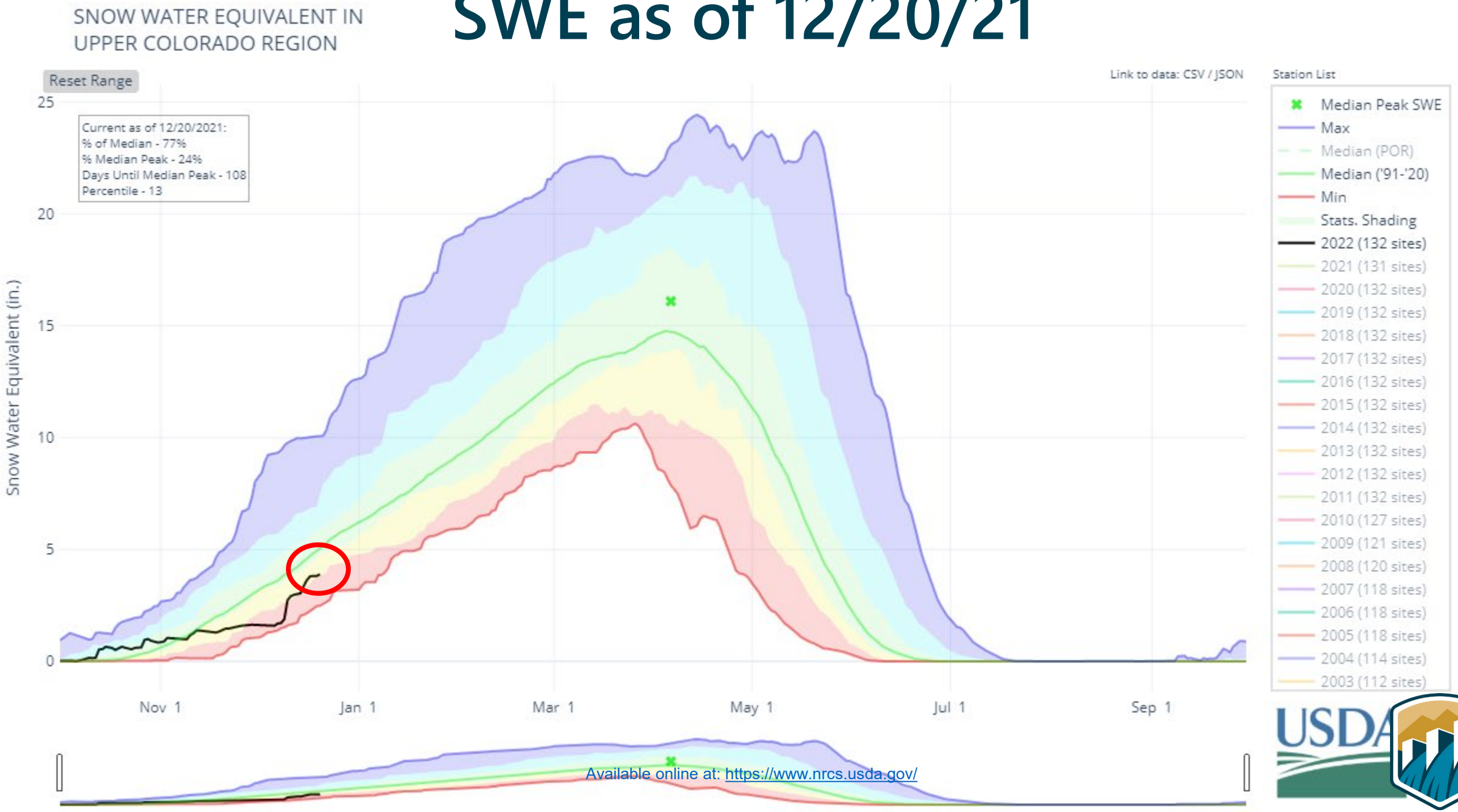
"Annually, Reclamation will develop a hydrograph based on the characteristics above. Reclamation will seek consensus on the annual hydrograph through monthly operational coordination calls with governmental entities, and regular meetings of the GCDAMP Technical Working Group (TWG) and AMWG. Reclamation 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 December 19, 2021)

Reservoir	Percent Current Live Storage	Current Live Storage (maf)	Live Storage Capacity (maf)	Elevation (feet)
Fontenelle	63	0.21	0.33	6,489.01
Flaming Gorge	77	2.90	3.75	6,017.57
Blue Mesa	27	0.23	0.83	7,433.54
Navajo	51	0.87	1.70	6,020.71
Lake Powell	28	6.83	24.32	3,539.12
UC System Storage	36	11.16	30.93	

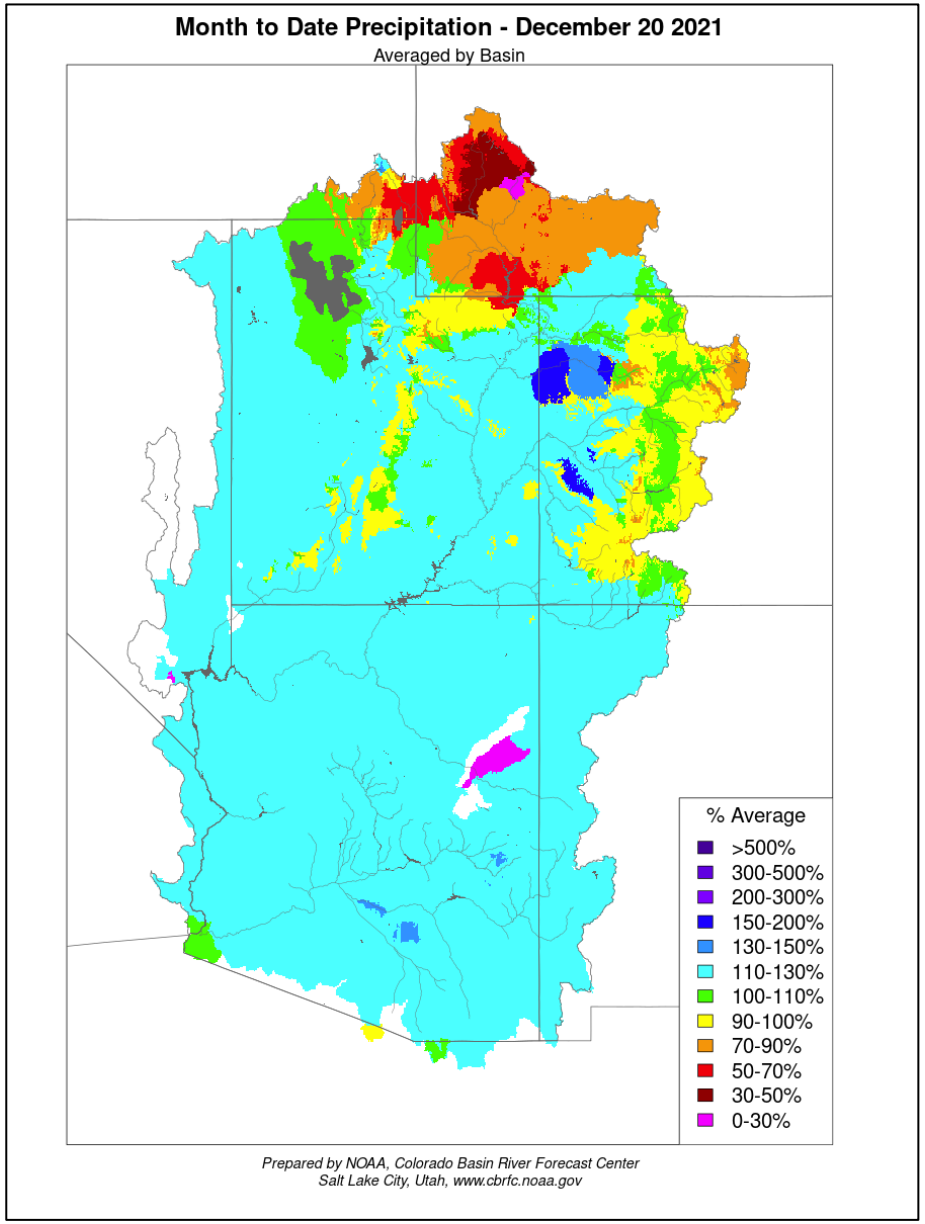


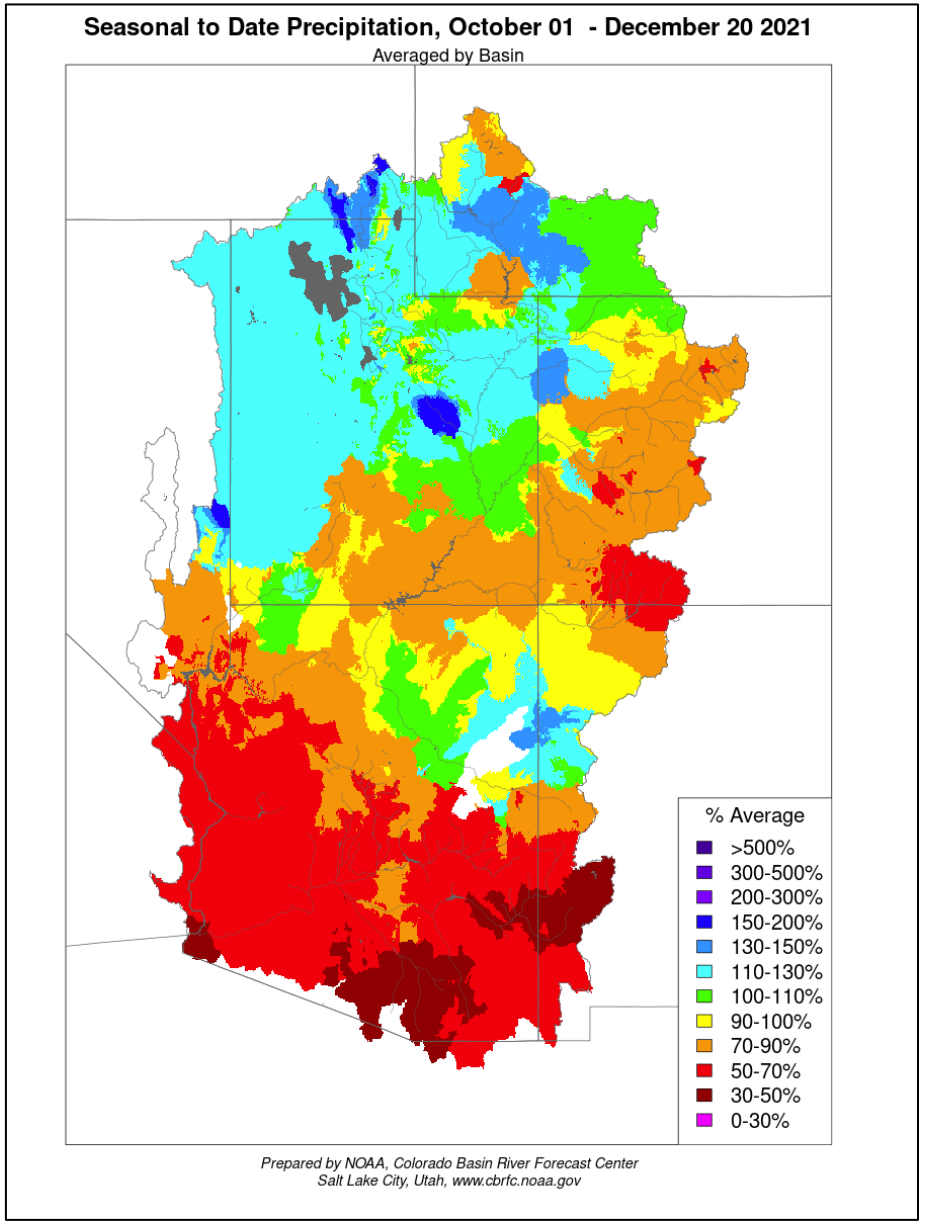
SWE as of 12/20/21



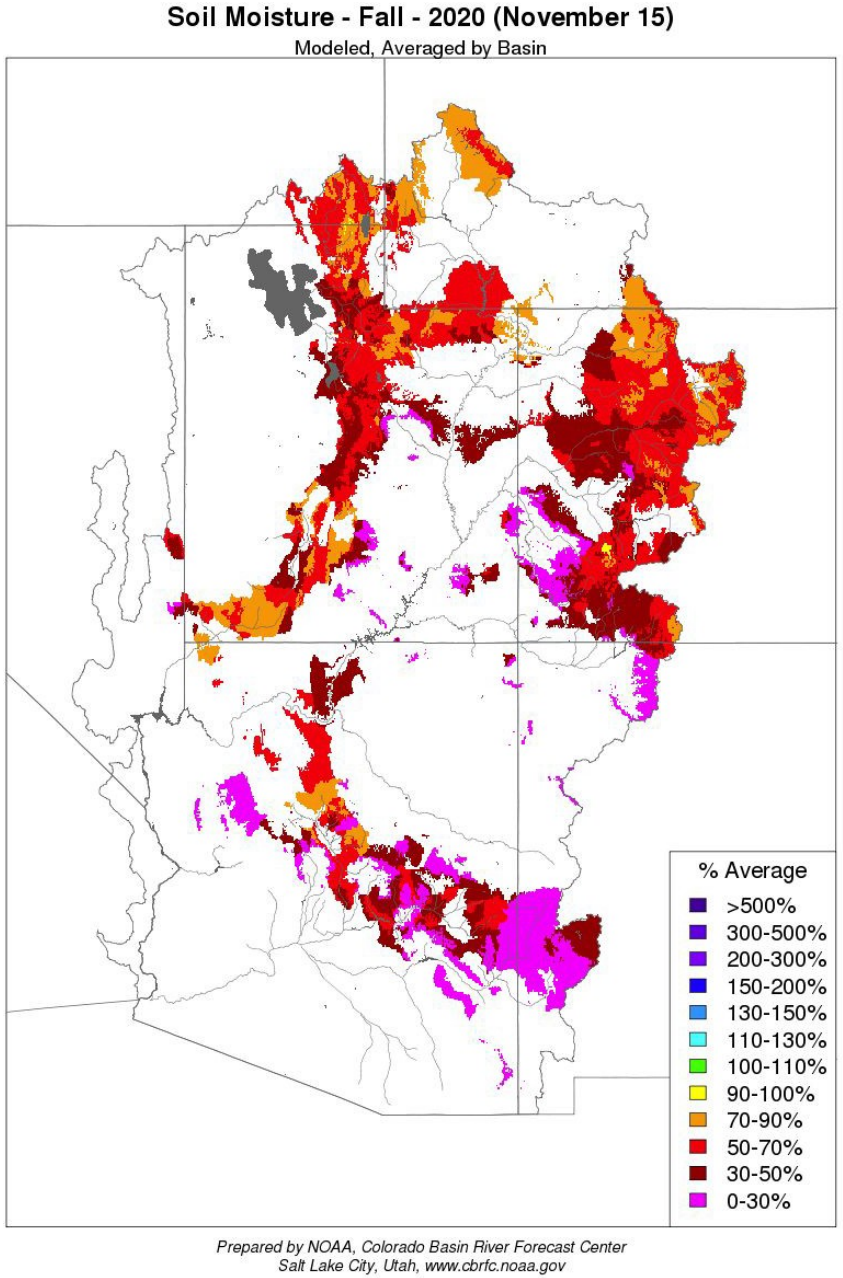
Available online at: https://www.nrcs.usda.gov/

2022 Precipitation: October and November



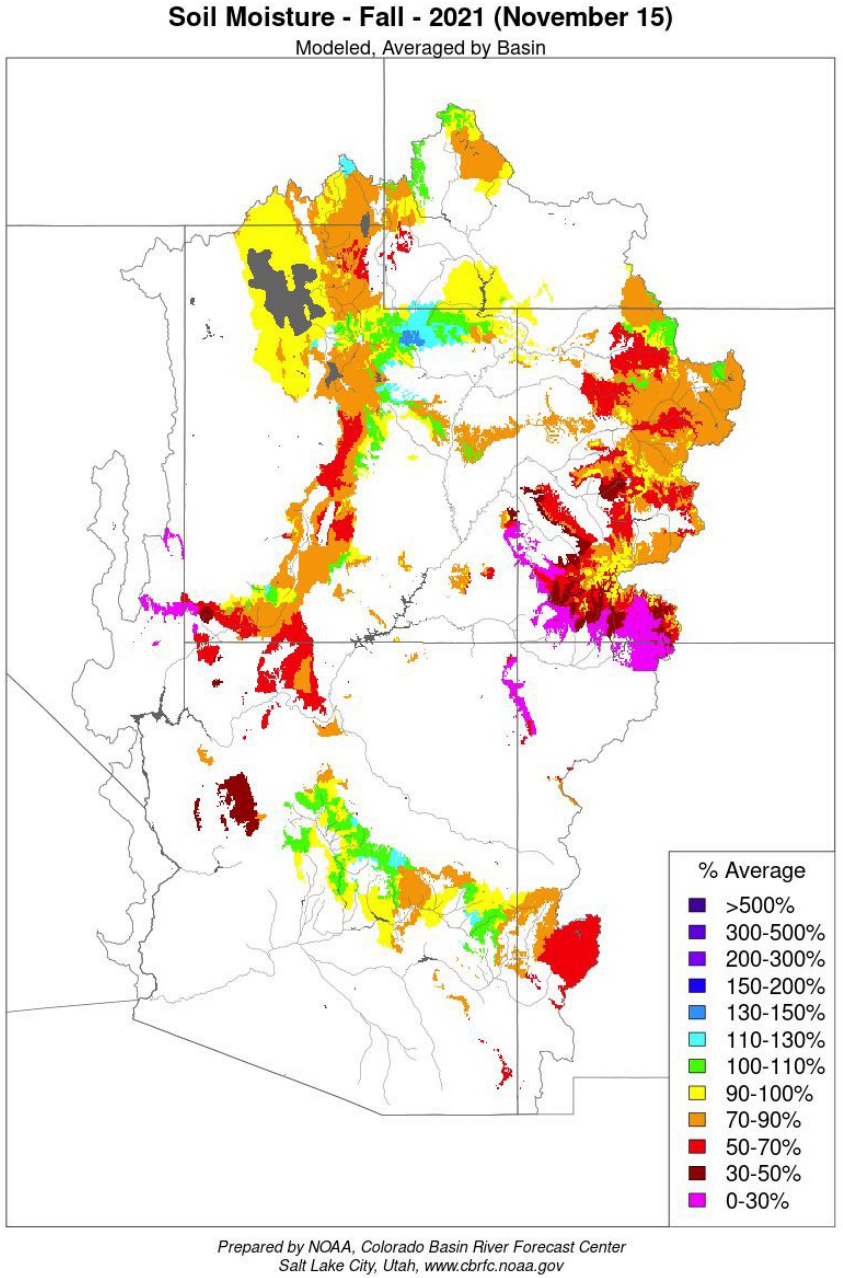


Fall Model Soil Moisture Conditions: 2020 vs. 2021



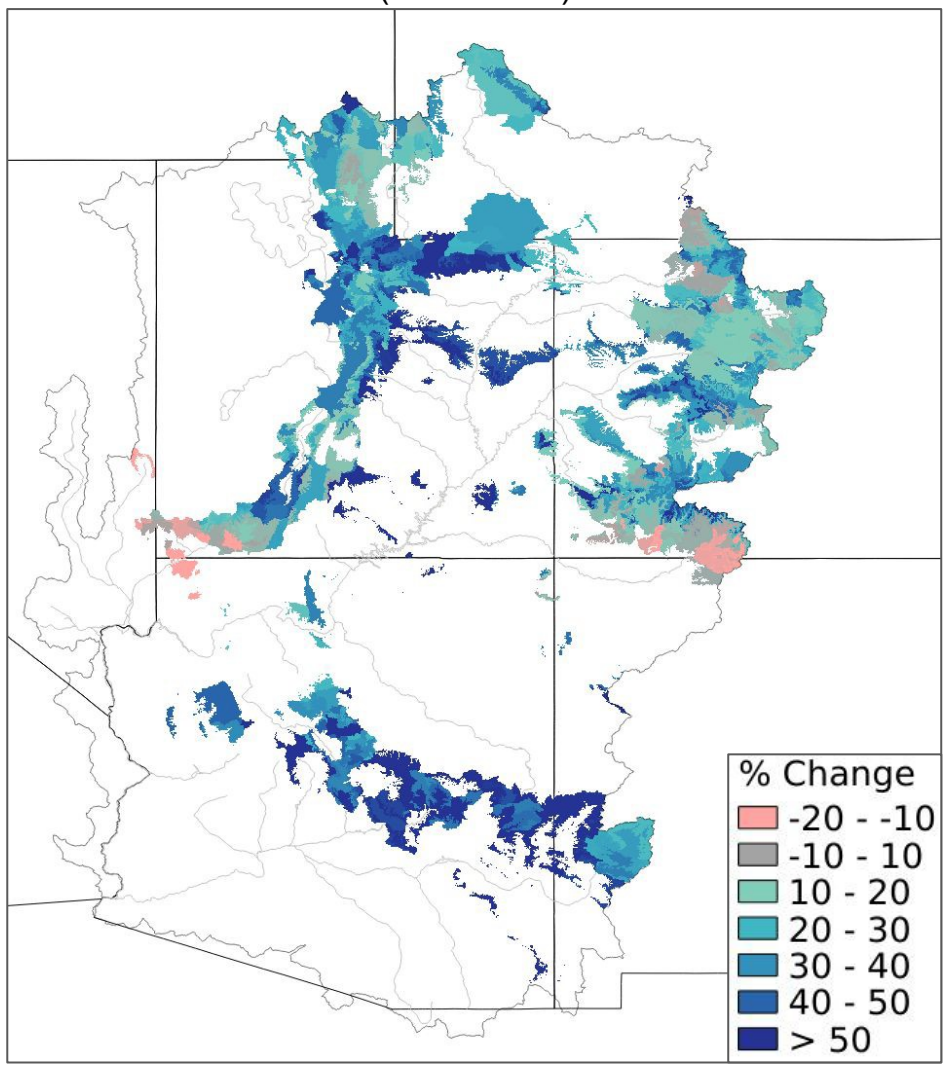
CBRFC model soil moisture conditions are improved from their record/near record dry levels a year ago but remain below to well below normal across many of the major runoff producing areas.

Above normal winter/spring precipitation will be needed to improve soil moisture deficits.



Fall Model Soil Moisture Conditions: 2020 vs. 2021

Soil Moisture - Fall (November 15)
Modeled, %Change
(2021-2020)



Prepared by NOAA, Colorado Basin River Forecast Center
Salt Lake City, Utah, www.cbrfc.noaa.gov

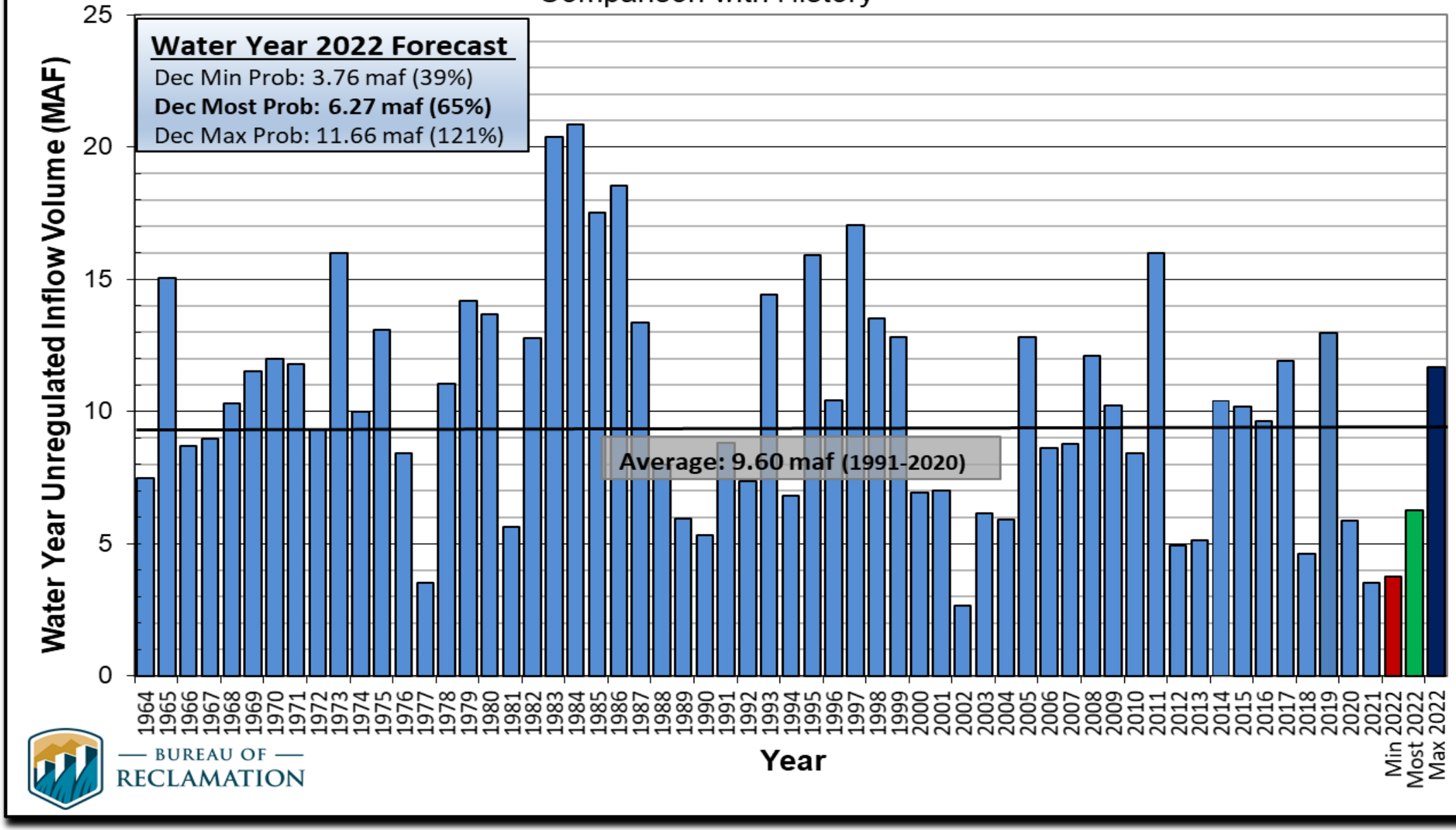
This is an experimental CBRFC soil moisture graphic.

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

Lake Powell Unregulated Inflow

Water Year 2022 Forecast *(issued December 1)*

Comparison with History



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Most Probable December Forecast Water Year 2022

Water Year 2022 Forecasted Unregulated Inflow
as of December 1, 2021

Reservoir	Unregulated Inflow (kaf)	1991-2020 Percent of Avg
Fontenelle	865	81
Flaming Gorge	1,096	78
Blue Mesa	689	76
Navajo	572	63
Powell	6,272	65

April – July 2022 Forecasted Unregulated Inflow
as of December 1, 2021

Reservoir	Unregulated Inflow (kaf)	1991-2020 Percent of Avg
Fontenelle	580	79
Flaming Gorge	720	75
Blue Mesa	480	75
Navajo	400	64
Powell	4,120	64

Upper Colorado Basin

Projected Operations for Water Year 2022 Based on December 2021 Modeling

Upper Basin DROA Initial Unit Drought Response Releases started in July 2021 and finished October 2021

- July WY2021 forecast decreased 140 kaf from the June forecast
- Continued drought conditions exacerbated already parched soil moisture conditions
- Prospects of future monsoon events unknown
- December 2021 forecast decreased 1.5 maf from November 2021

DROA Releases for the July 24MS Model Run

	Jul (kaf)	Aug (kaf)	Sep (kaf)	Oct (kaf)	Nov (kaf)	Dec (kaf)	Sum
Flaming Gorge	13	42	43	27	0	0	125
Blue Mesa	0	14	18	4	0	0	36
Navajo	0	0	0	0	10	10	20
Sum:	13	56	61	31	10	10	181

DROA Releases for the December 24MS Model Run

	Jul (kaf)	Aug (kaf)	Sep (kaf)	Oct (kaf)	Nov (kaf)	Dec (kaf)	Sum
Flaming Gorge	12	45	44	24	0	0	125
Blue Mesa	0	17	16	3	0	0	36
Navajo	0	0	0	0	0	0	0
Sum:	12	62	60	27	0	0	161

Lake Powell & Lake Mead Operational Table

Operating Determinations for Water Year/Calendar Year 2022

Lake Powell		
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
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)
3,575	**Mid-Elevation Release Tier** Release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	9.5
3,535.40 ft Jan 1, 2022 Projection		
3,525	**Lower Elevation Balancing Tier** Balance contents with a min/max release of 7.0 and 9.5 maf	5.9
3,490		4.0
3,370		0

Lake Mead		
Elevation (feet)	**Operation According to the Interim Guidelines**	**Live Storage (maf)[1]**
1,220	**Flood Control Surplus or Quantified Surplus Condition** Deliver > 7.5 maf	25.9
1,200 (approx.)[2]	**Domestic Surplus or ICS Surplus Condition** Deliver > 7.5 maf	22.9 (approx.)[2]
1,145	**Normal or ICS Surplus Condition** Deliver ≥ 7.5 maf	15.9
1,105		11.9
1,075		9.4
1,065.85 ft Jan 1, 2022 Projection		
1,050	**Shortage Condition** Deliver 7.167[4] maf	7.5
1,025	**Shortage Condition** Deliver 7.083[5] maf	5.8
1,000	**Shortage Condition** Deliver 7.0[6] maf Further measures may be undertaken[7]	4.3
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

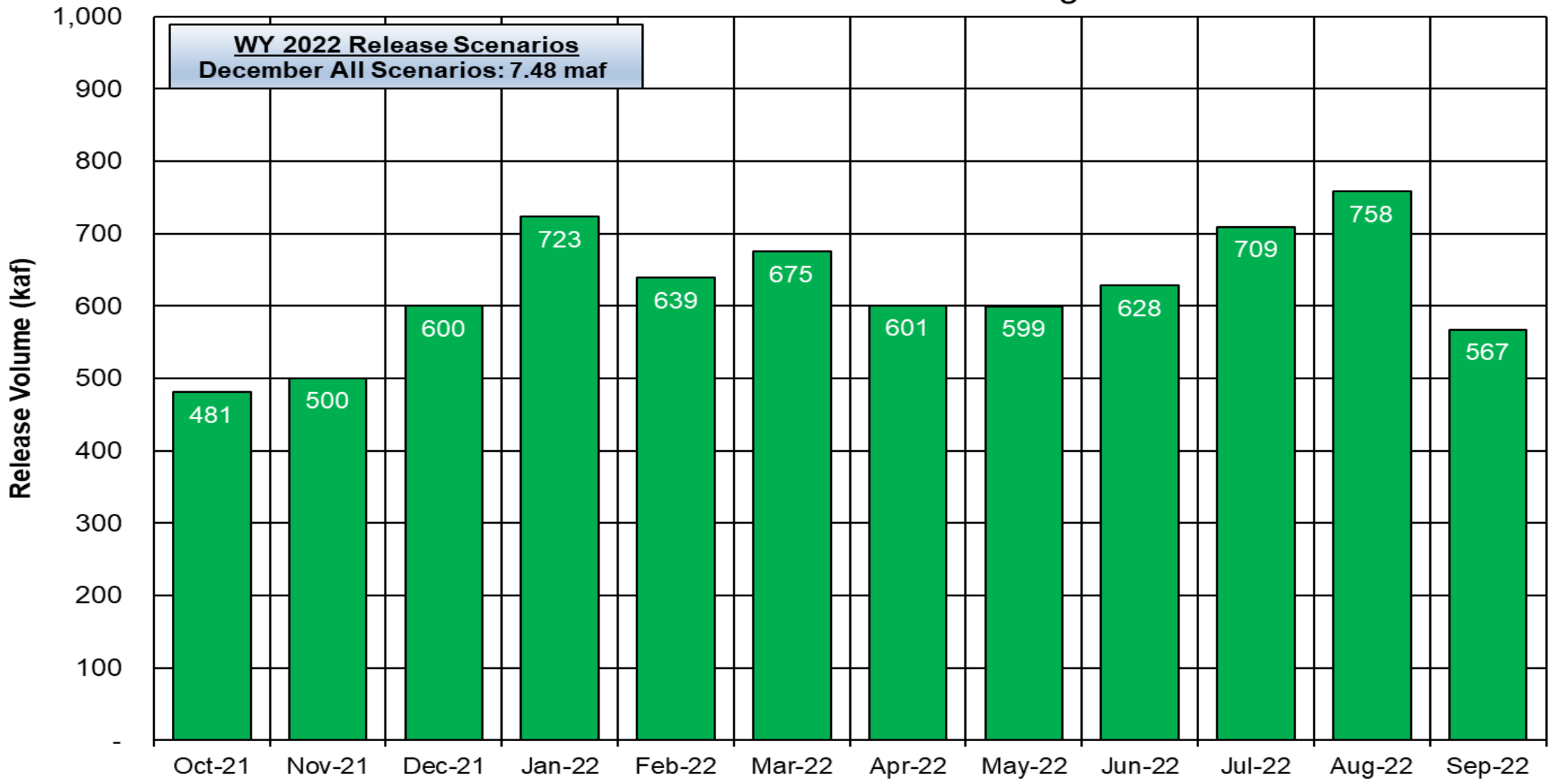
[6] Of which 2.32 maf is apportioned to Arizona, 4.4 maf to California, and 0.280 maf to Nevada

[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 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.

Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2022
Based on December 2021 Modeling



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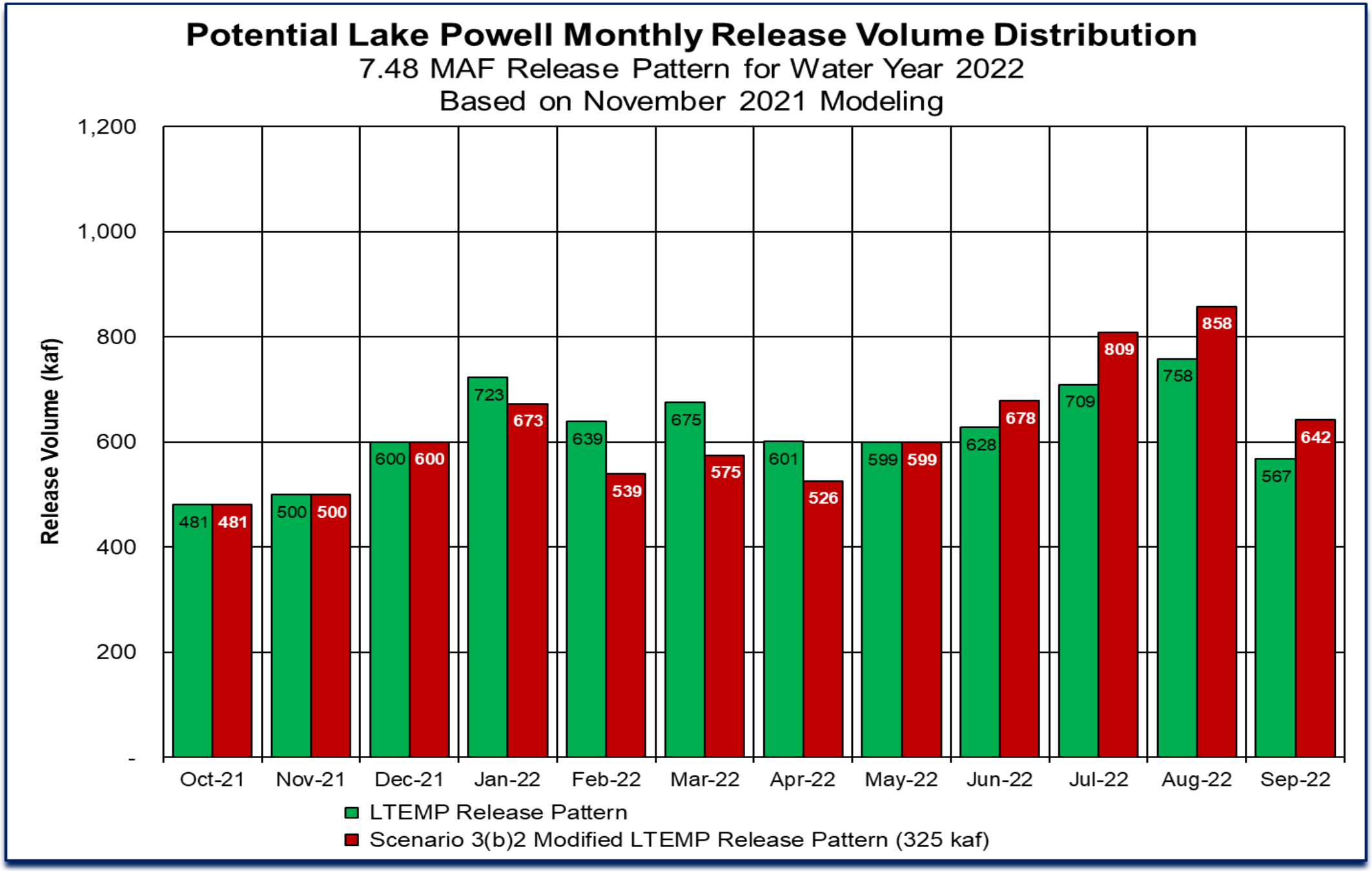
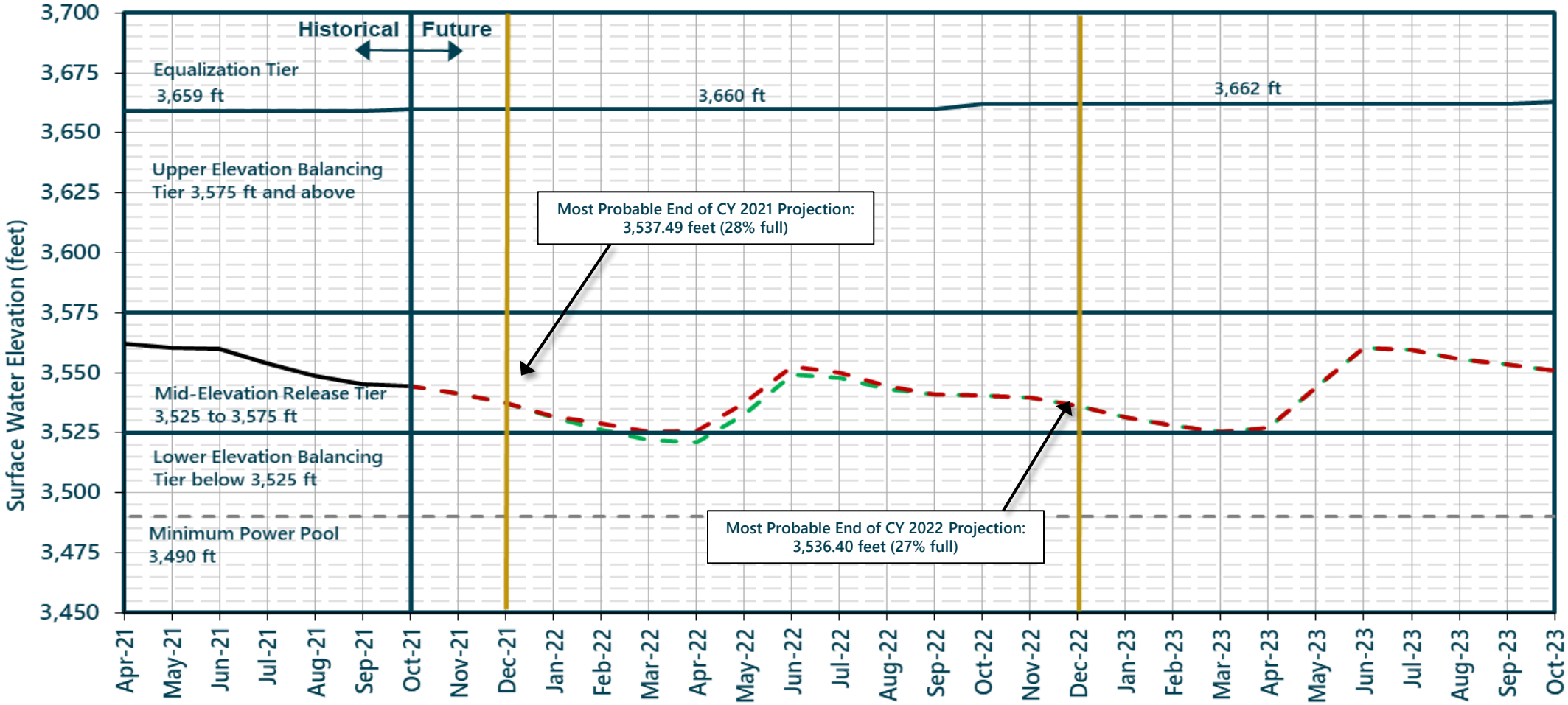
The Drought Response Operations Agreement (DROA) can be found here: https://www.usbr.gov/dcp/finaldocs.html

Preliminary data – do not cite or distribute



Lake Powell End of Month Elevations

Projections from the Most Probable November 2021 24-Month Study Inflow Scenario



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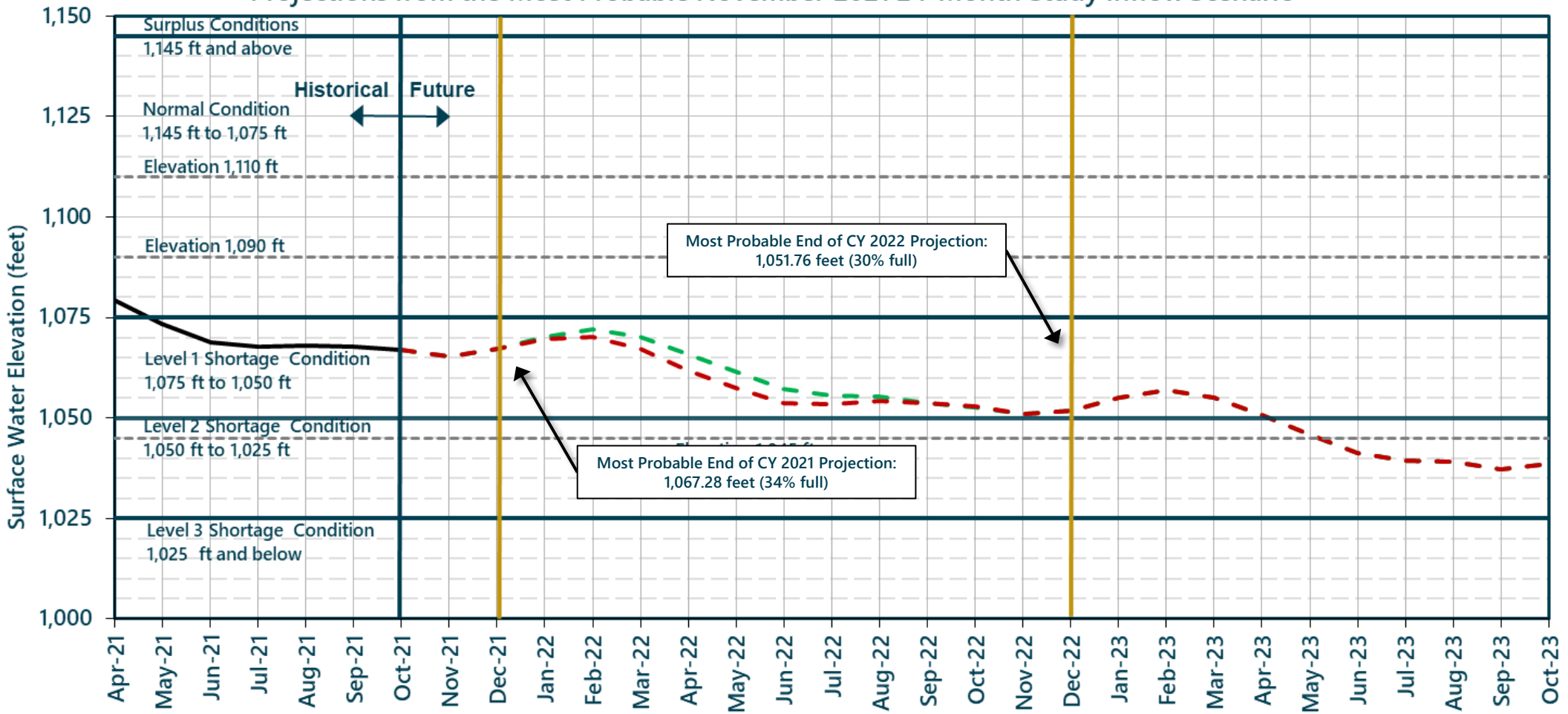
Lake Mead End of Month Elevations

Projections from the Most Probable November 2021 24-Month Study Inflow Scenario



Historical Elevations

LTEMP Release Pattern - Lake Powell release of 7.48 maf in WY 2022 and WY 2023

Scenario 3(b)2 Modified LTEMP Release Pattern - Lake Powell release of 7.48 maf in WY 2022 and WY 2023

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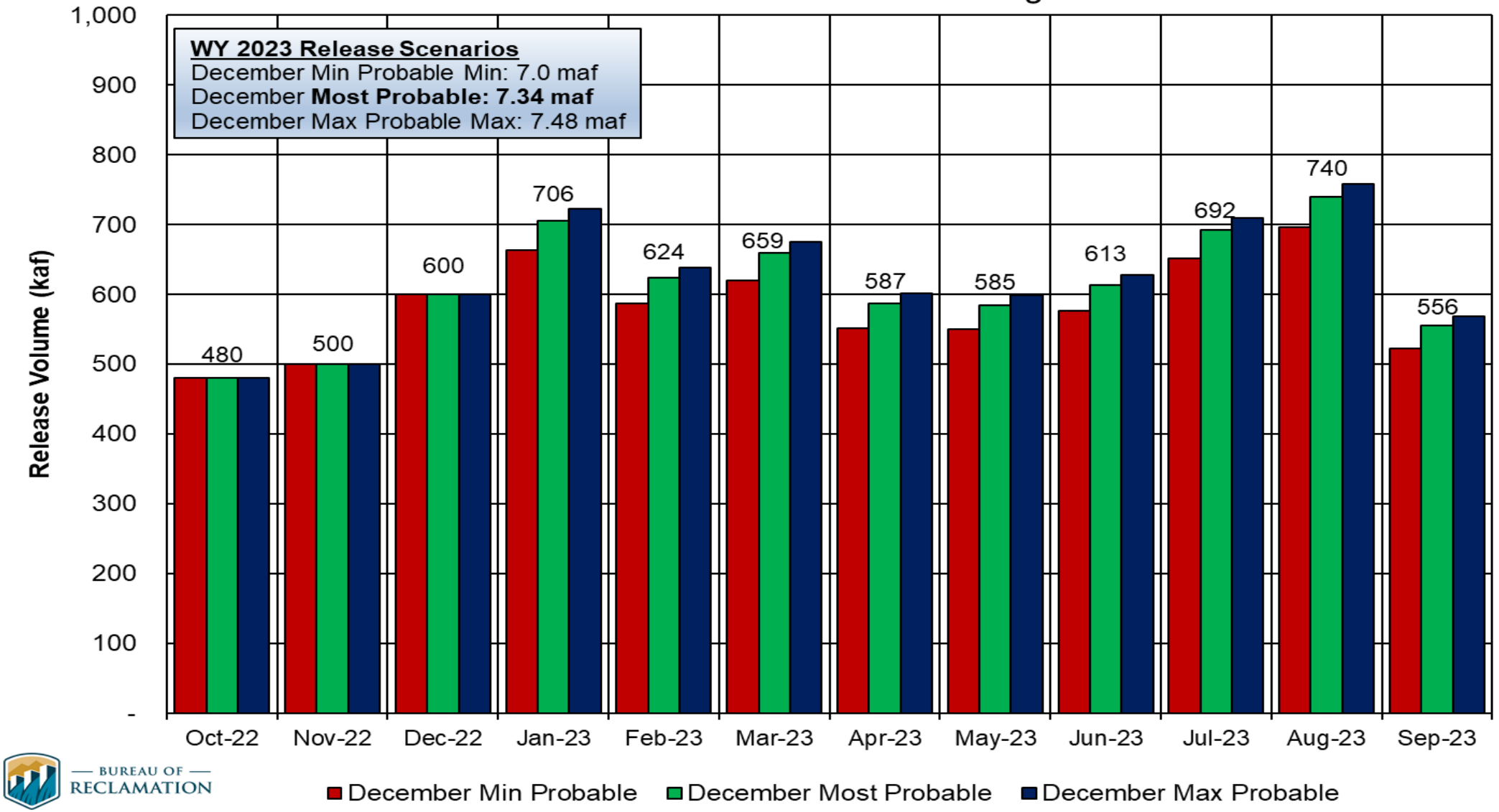
Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2023
Based on December 2021 Modeling



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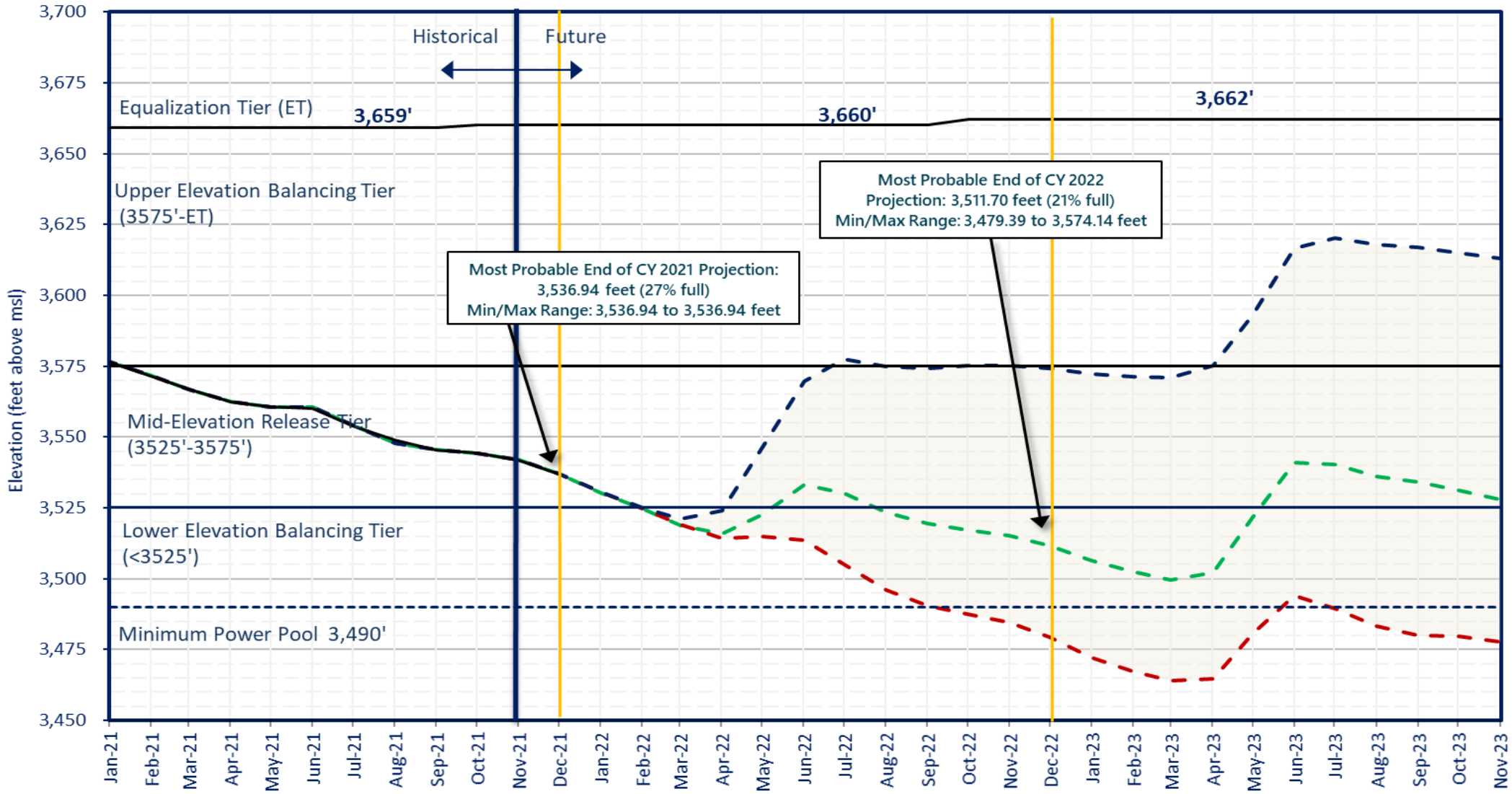
Reclamation Operational Modeling
Model Comparison

	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 December 2021 24-Month Study Inflow Scenarios



December 2021 Most Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 7.34 maf in WY2023

December 2021 Minimum Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 7.0 maf in WY2023

December 2021 Maximum Probable Inflow - Lake Powell release of 7.48 maf in WY2022 and 7.48 maf in WY2023

Historical Elevations

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

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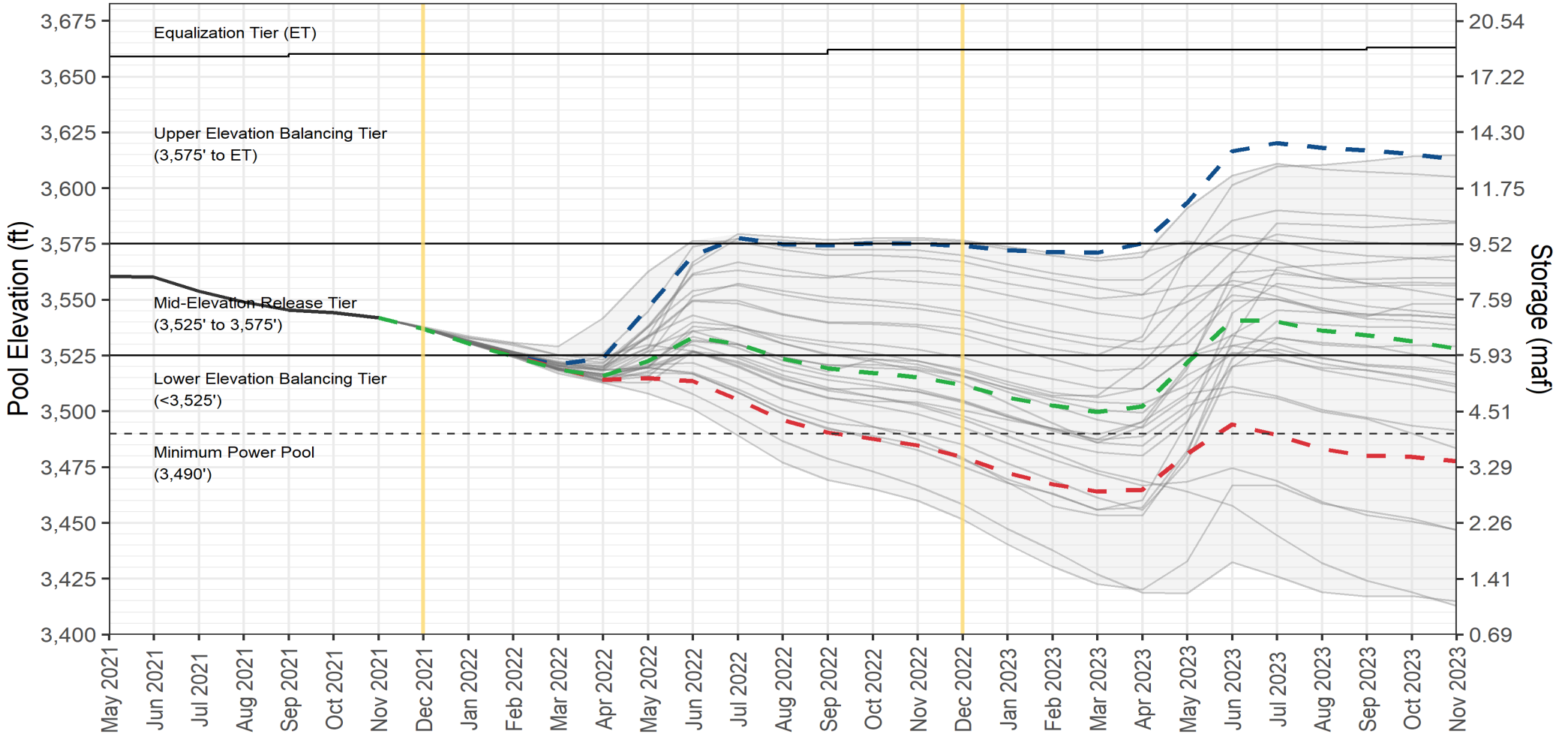
Lake Powell End-of-Month Elevations

CRMMS Projections from December 2021



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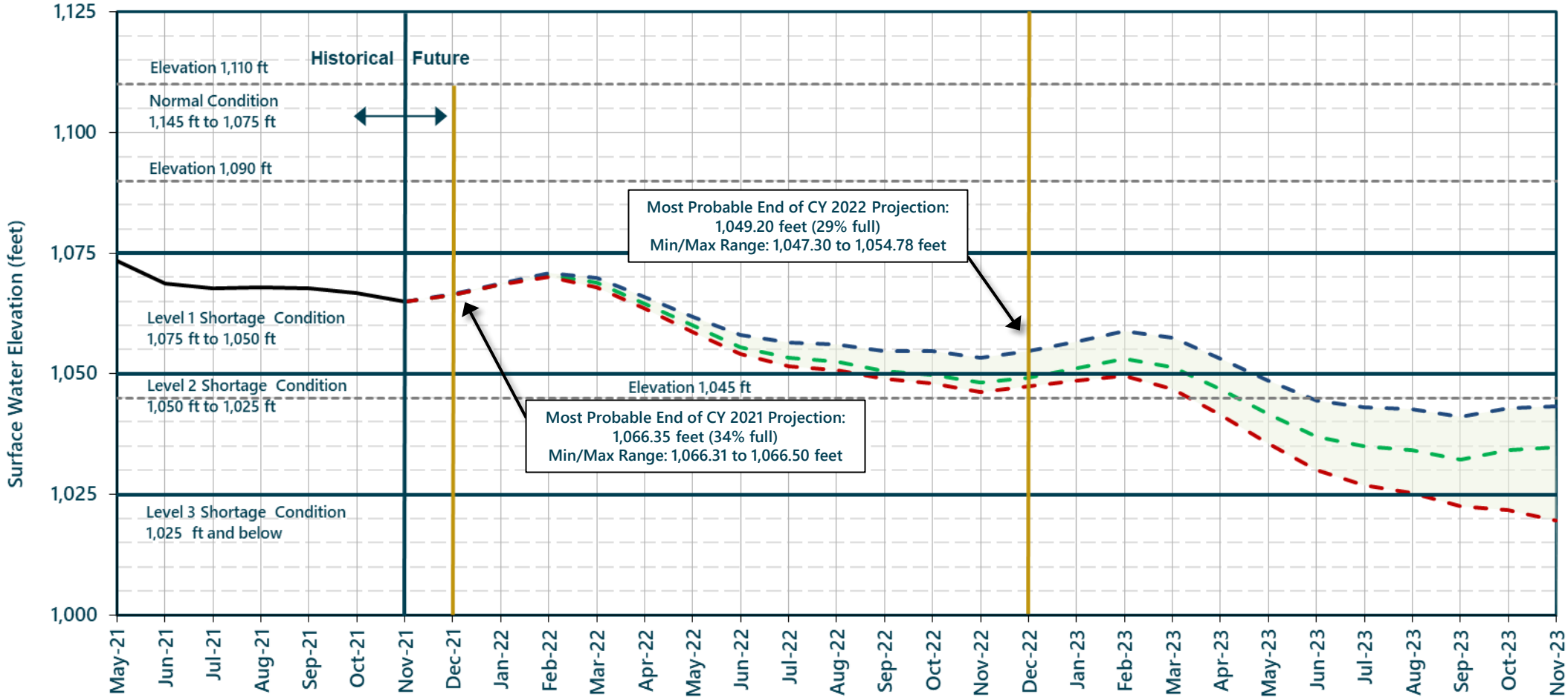
Lake Mead End of Month Elevations

Projections from the December 2021 24-Month Study Inflow Scenarios



Historical Elevations

December 2021 Most Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 7.34 maf in WY 2023

December 2021 DROA Maximum Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and WY 2023

December 2021 DROA Minimum Probable Inflow with a Lake Powell release of 7.48 maf in WY 2022 and 7.00 maf in WY 2023

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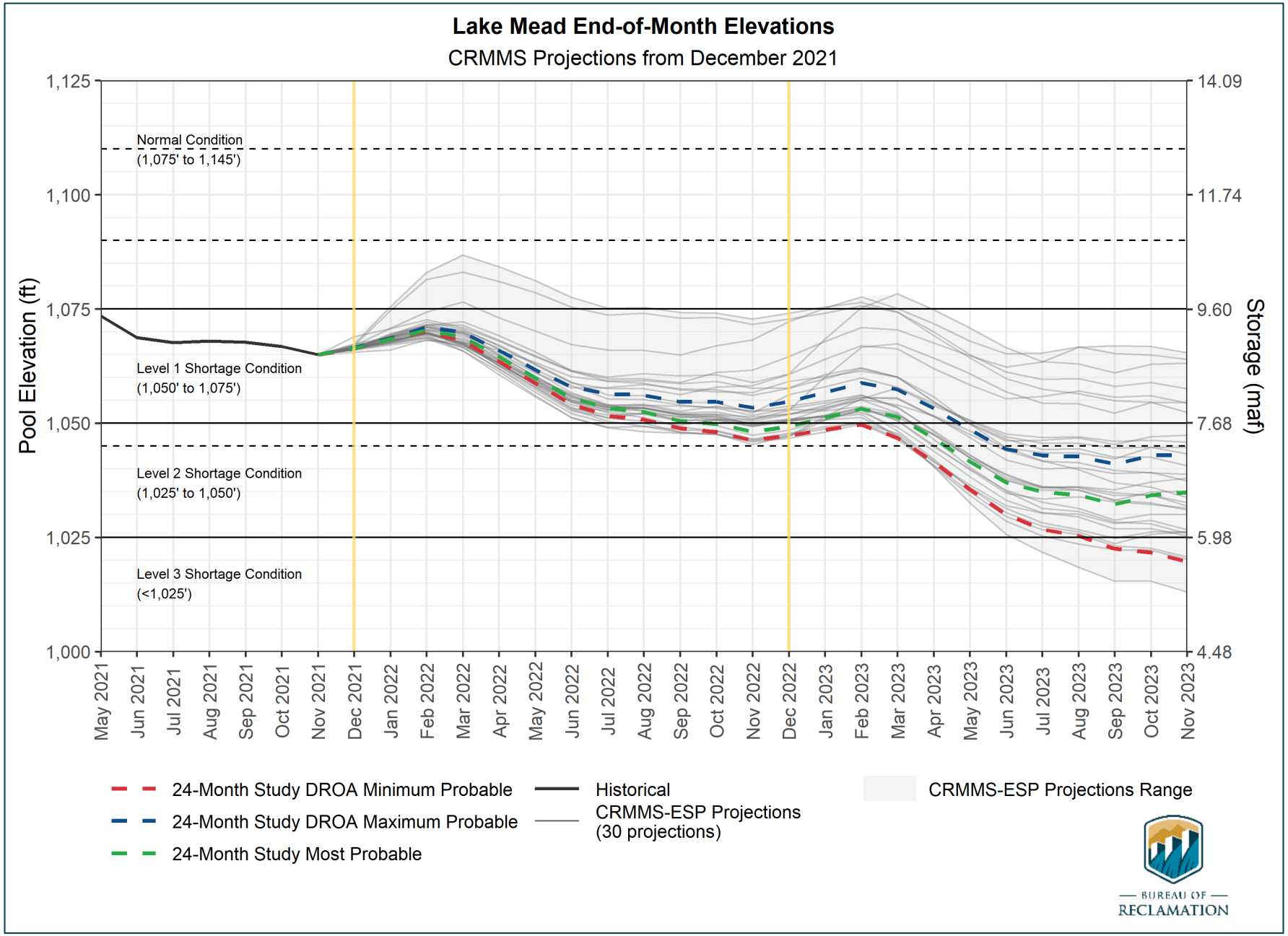


CRMMS 2-Year Probabilistic Projections are available online at: https://www.usbr.gov/lc/region/g4000/riverops/crmms-2year-projections.html

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	6	6	5	6	6	6	4	
Capacity (cfs)	18,700	18,600	11,700	18,300	11,400	11,300	17,900	14,900	15,400	18,800	18,700	11,700	DEC MOST[2]
Capacity (kaf/month)	1,150	1,110	1,110	1,160	890	1,050	1,070	970	1,100	1,180	1,150	750	DEC MOST
Max (kaf) [1]	481	500	600	723	639	675	601	599	628	709	758	567	7.48 maf
Most (kaf) [1]	481	500	600	723	639	675	601	599	628	709	758	567	7.48 maf
Min (kaf) [1]	481	500	600	723	639	675	601	599	628	709	758	567	7.48 maf
										(updated 12-14-2021)			

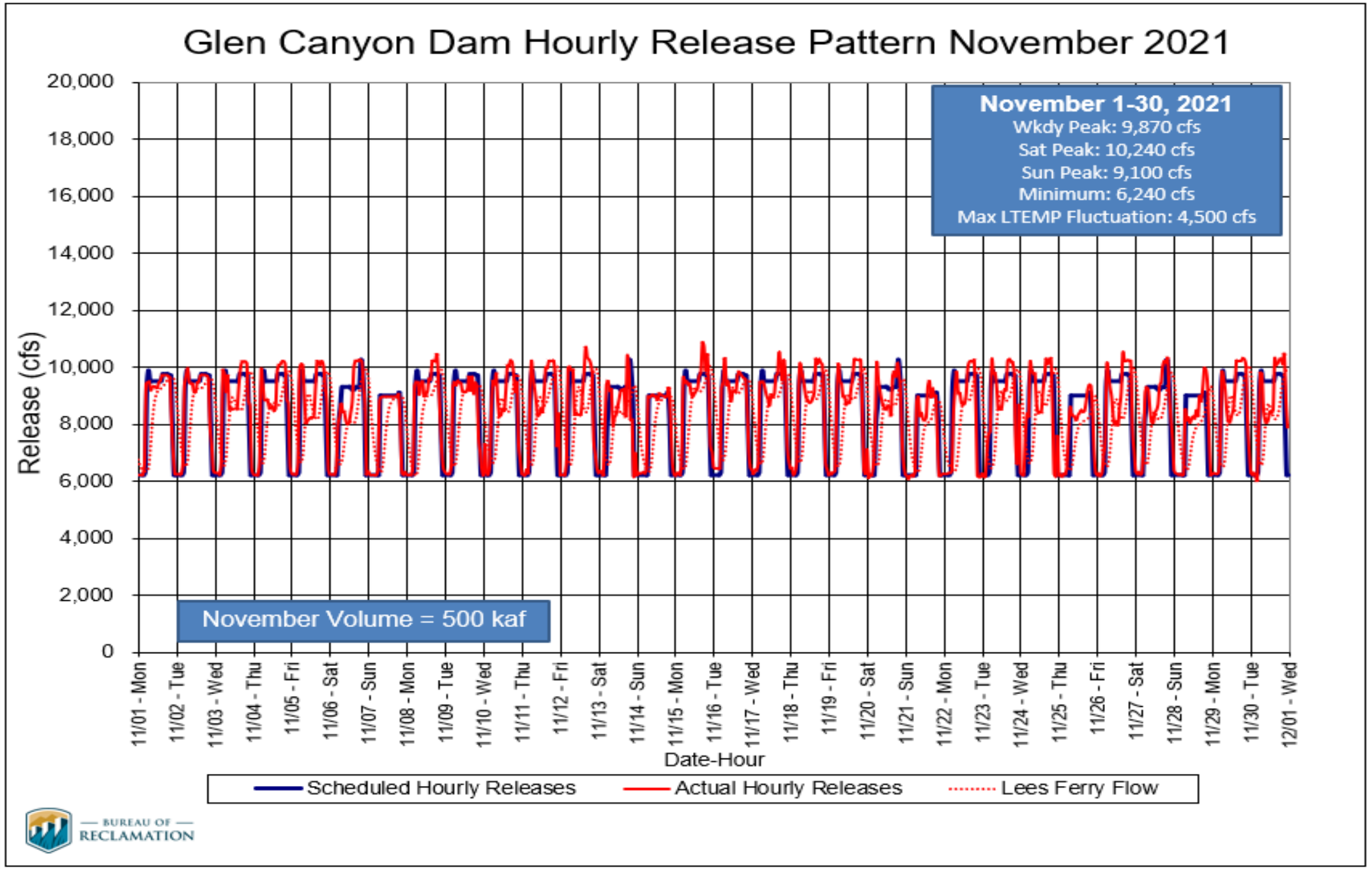
1 Projected release, based on December 2021 minimum, most and maximum probable inflow projections and 24-Month Study model runs.

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	7	8	6	7	8	7	8	8	8	6	
Capacity (cfs)	18,600	18,500	18,400	18,300	11,400	18,100	24,800	22,100	26,200	26,200	26,000	19,000	DEC MOST[2]
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	DEC MOST
Max (kaf) [1]	480	500	600	723	639	675	601	599	628	709	758	568	7.48 maf
Most (kaf) [1]	480	500	600	706	624	659	587	585	613	692	740	556	7.34 maf
Min (kaf) [1]	480	500	600	664	587	620	552	550	577	652	696	522	7.0 maf
										(updated 12-14-2021)			

1 Projected release, based on December 2021 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 Hourly Release Pattern November 2021
November 1-30, 2021
Wkdy Peak: 9,870 cfs
Sat Peak: 10,240 cfs
Sun Peak: 9,100 cfs
Minimum: 6,240 cfs
Max LTEMP Fluctuation: 4,500 cfs
November Volume = 500 kaf
Release (cfs)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
11/01 - Mon
11/02 - Tue
11/03 - Wed
11/04 - Thu
11/05 - Fri
11/06 - Sat
11/07 - Sun
11/08 - Mon
11/09 - Tue
11/10 - Wed
11/11 - Thu
11/12 - Fri
11/13 - Sat
11/14 - Sun
11/15 - Mon
11/16 - Tue
11/17 - Wed
11/18 - Thu
11/19 - Fri
11/20 - Sat
11/21 - Sun
11/22 - Mon
11/23 - Tue
11/24 - Wed
11/25 - Thu
11/26 - Fri
11/27 - Sat
11/28 - Sun
11/29 - Mon
11/30 - Tue
12/01 - Wed
Date-Hour
Scheduled Hourly Releases
Actual Hourly Releases
Lees Ferry Flow
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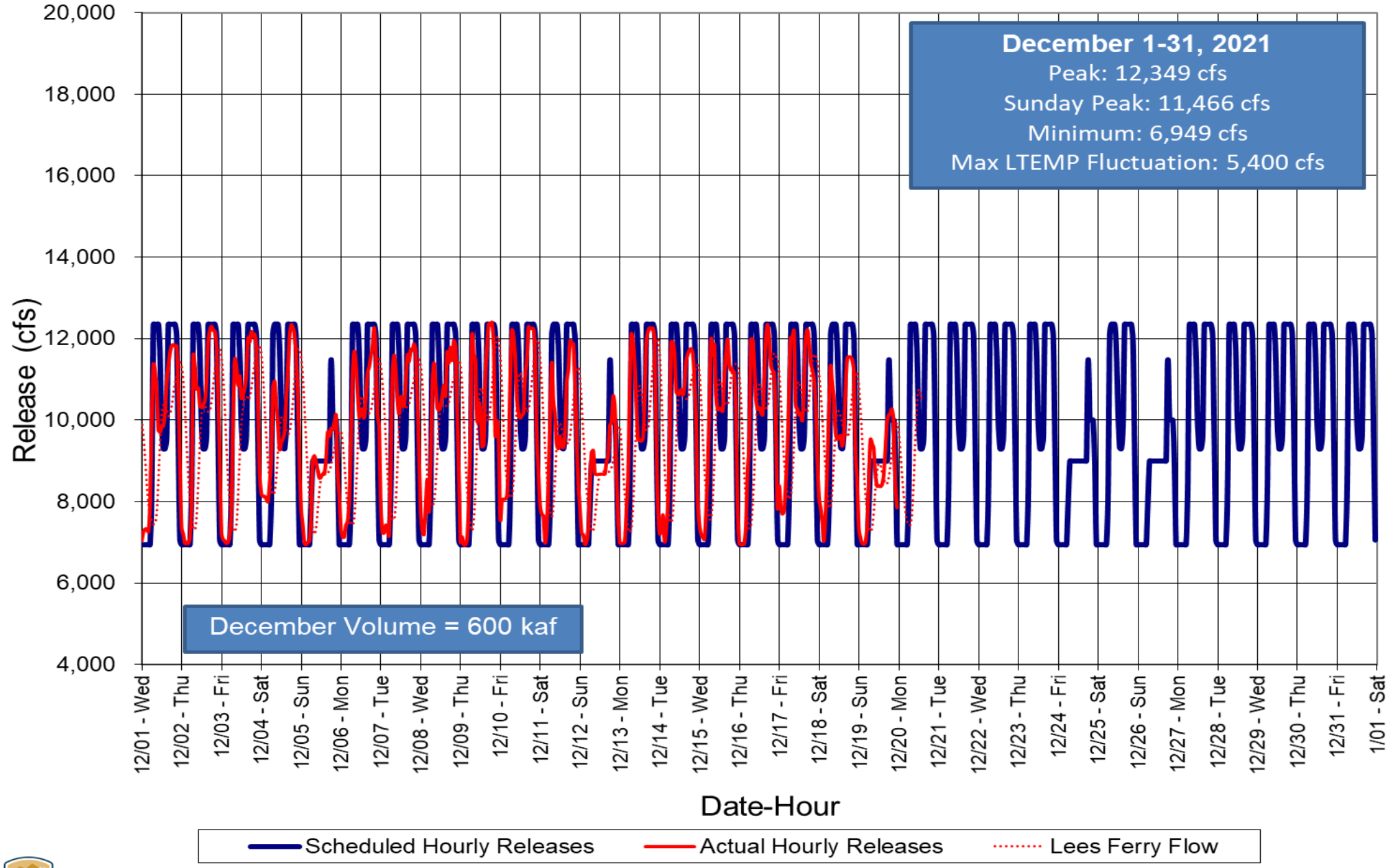
Glen Canyon Dam Hourly Release Pattern December 2021



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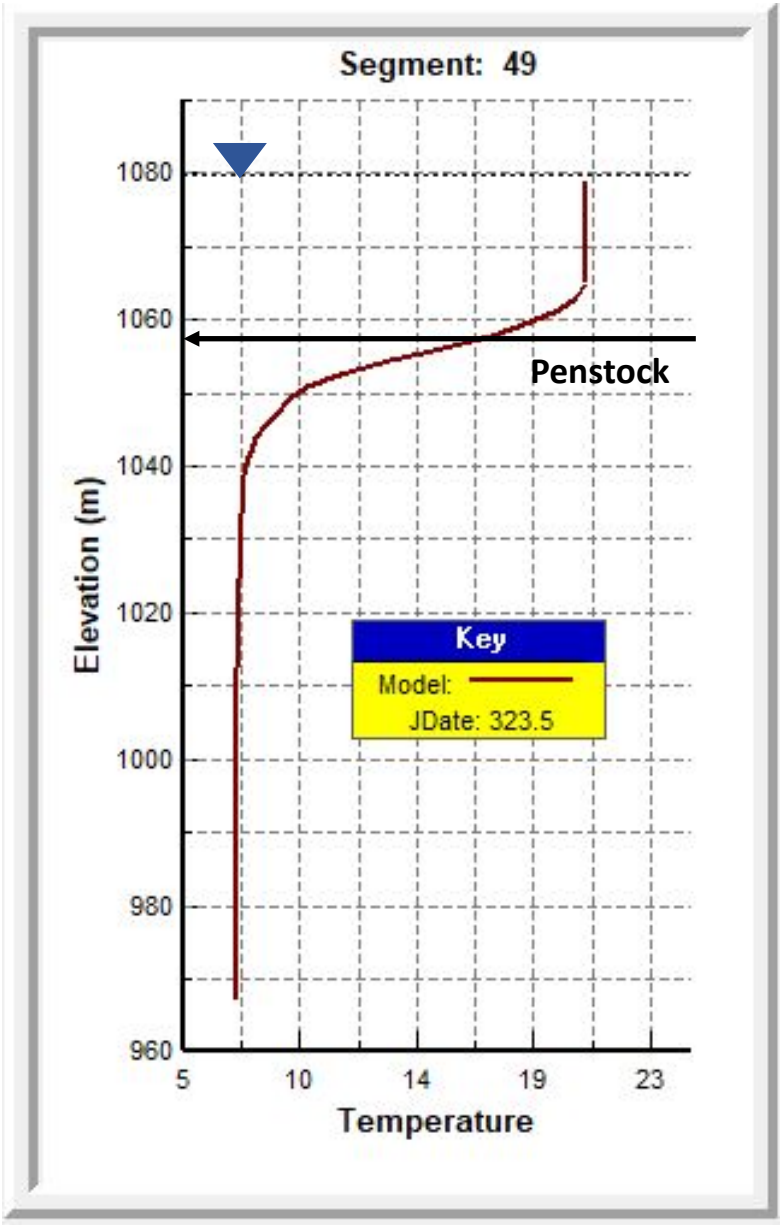
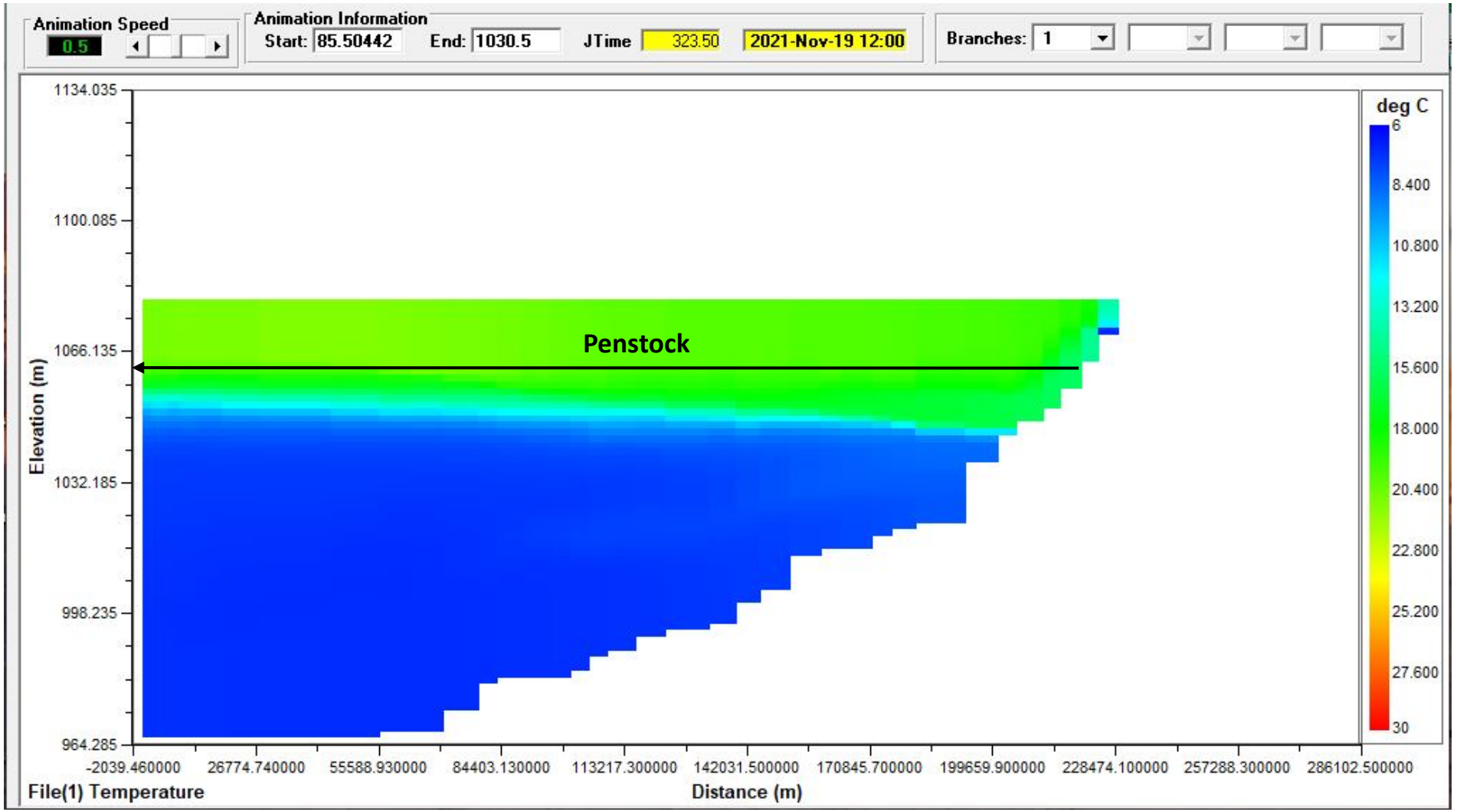
Water Quality

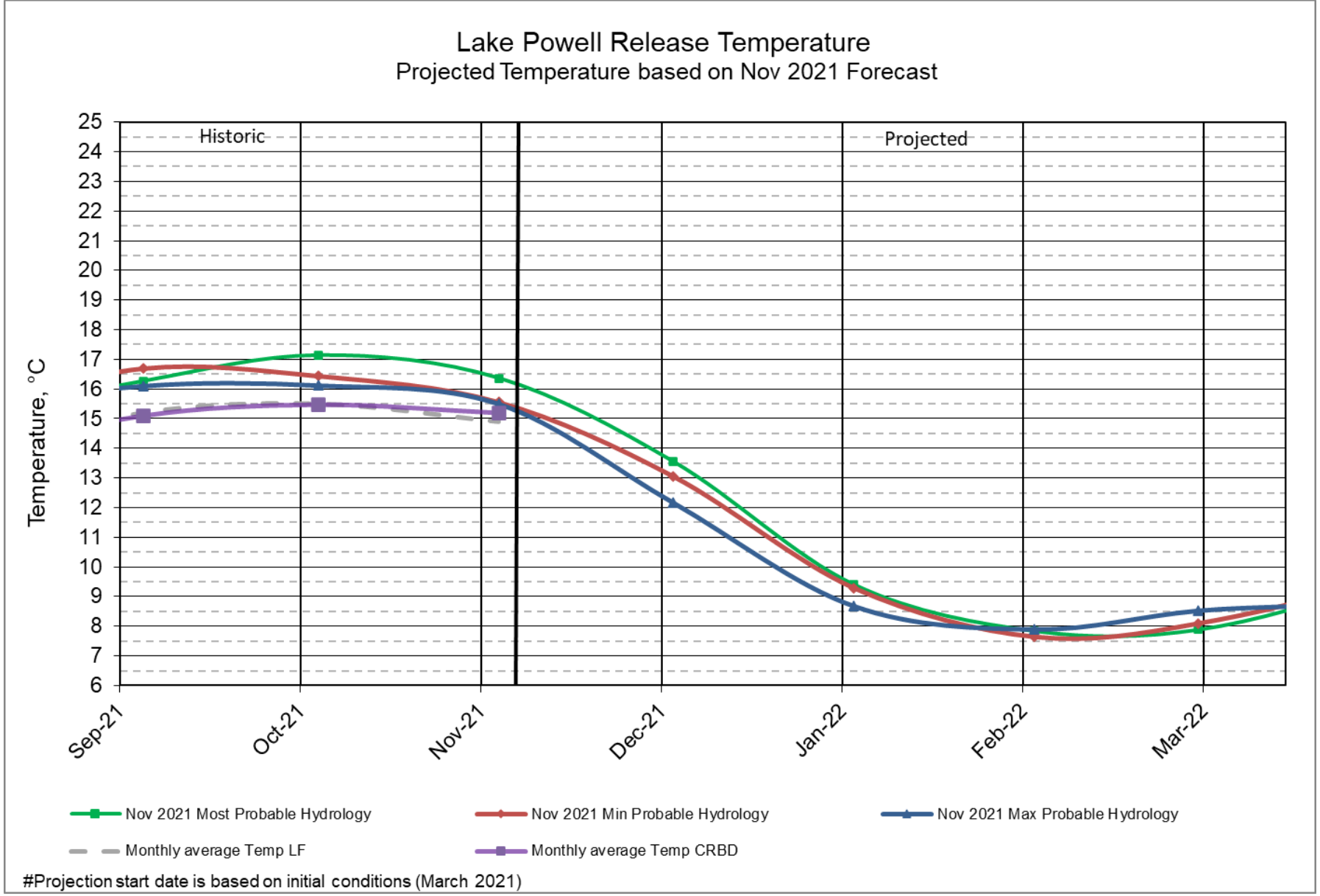
Temperature Profile of Lake Powell near Glen Canyon Dam
11/19/2021

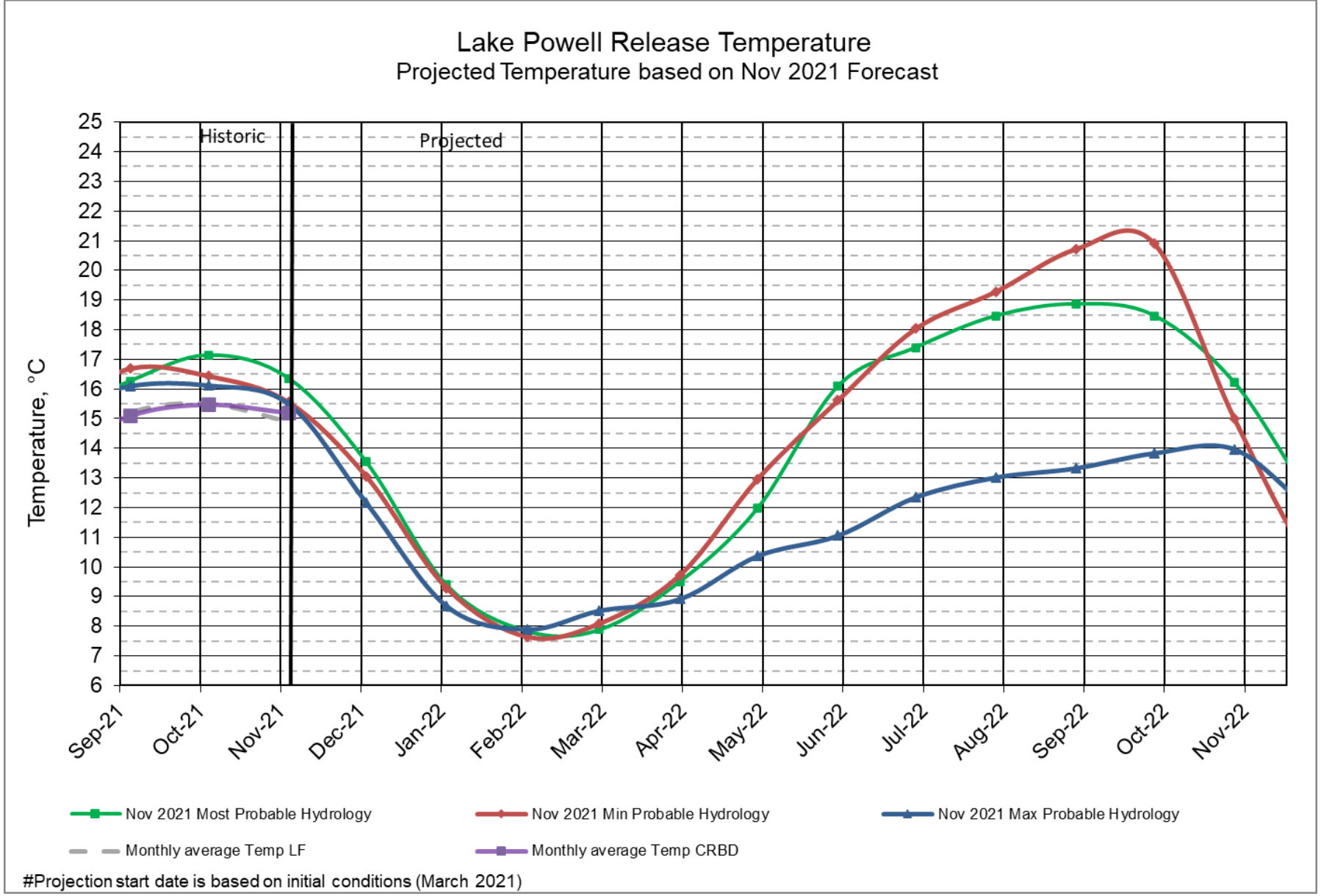


Cross Sectional Temperature Profile of Lake Powell

11/19/2021




Lake Powell Release Temperature
Projected Temperature based on Nov 2021 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
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22
Mar-22
Nov 2021 Most Probable Hydrology
Nov 2021 Min Probable Hydrology
Nov 2021 Max Probable Hydrology
Monthly average Temp LF
Monthly average Temp CRBD
#Projection start date is based on initial conditions (March 2021)


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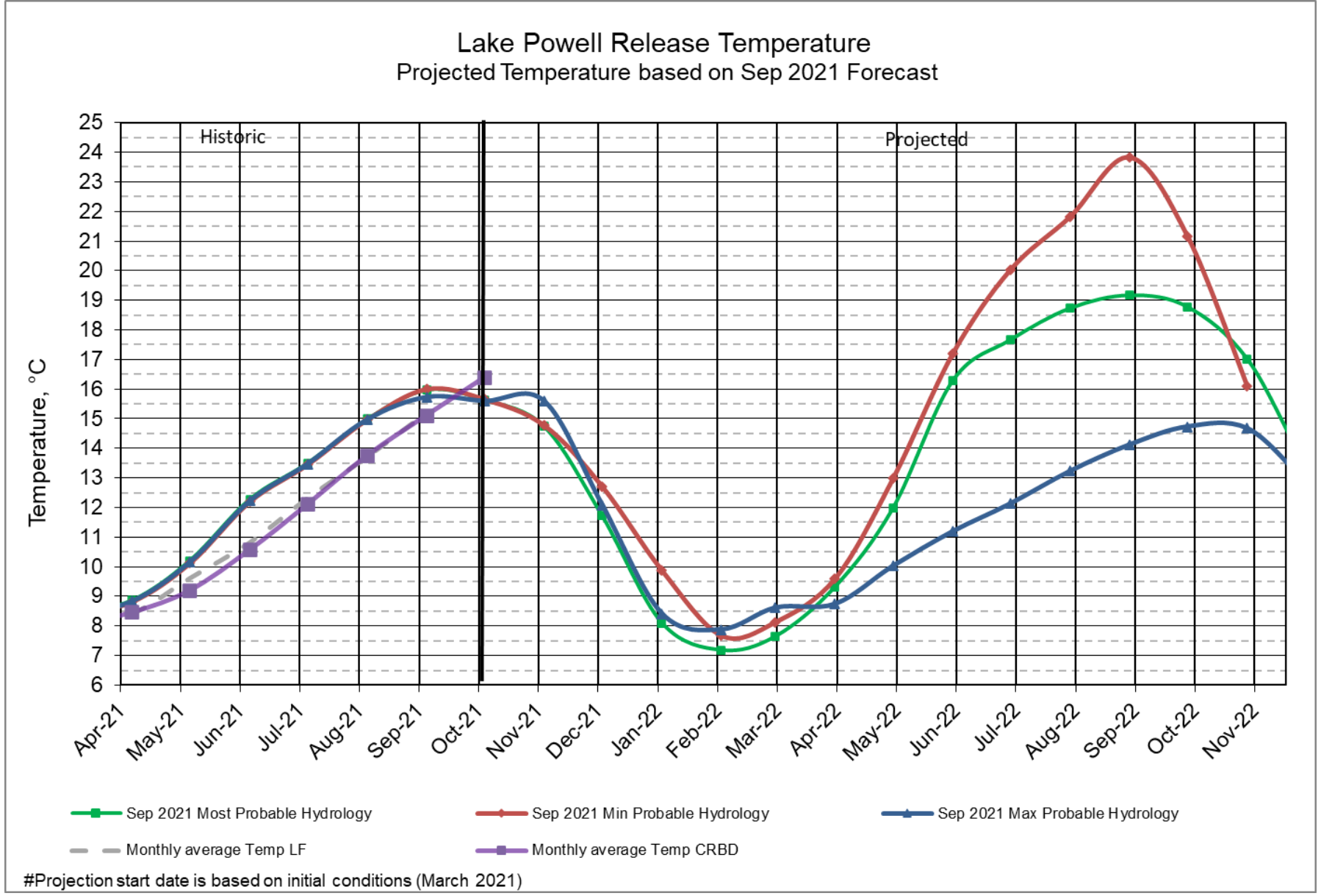
19
18
17
16
15
14
13
12
11
10
9
8
7
6
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Nov 2021 Most Probable Hydrology
Nov 2021 Min Probable Hydrology
Nov 2021 Max Probable Hydrology
Monthly average Temp LF
Monthly average Temp CRBD
#Projection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


Lake Powell Release Temperature
Projected Temperature based on Sep 2021 Forecast
Historic
Projected
Temperature, °C
25
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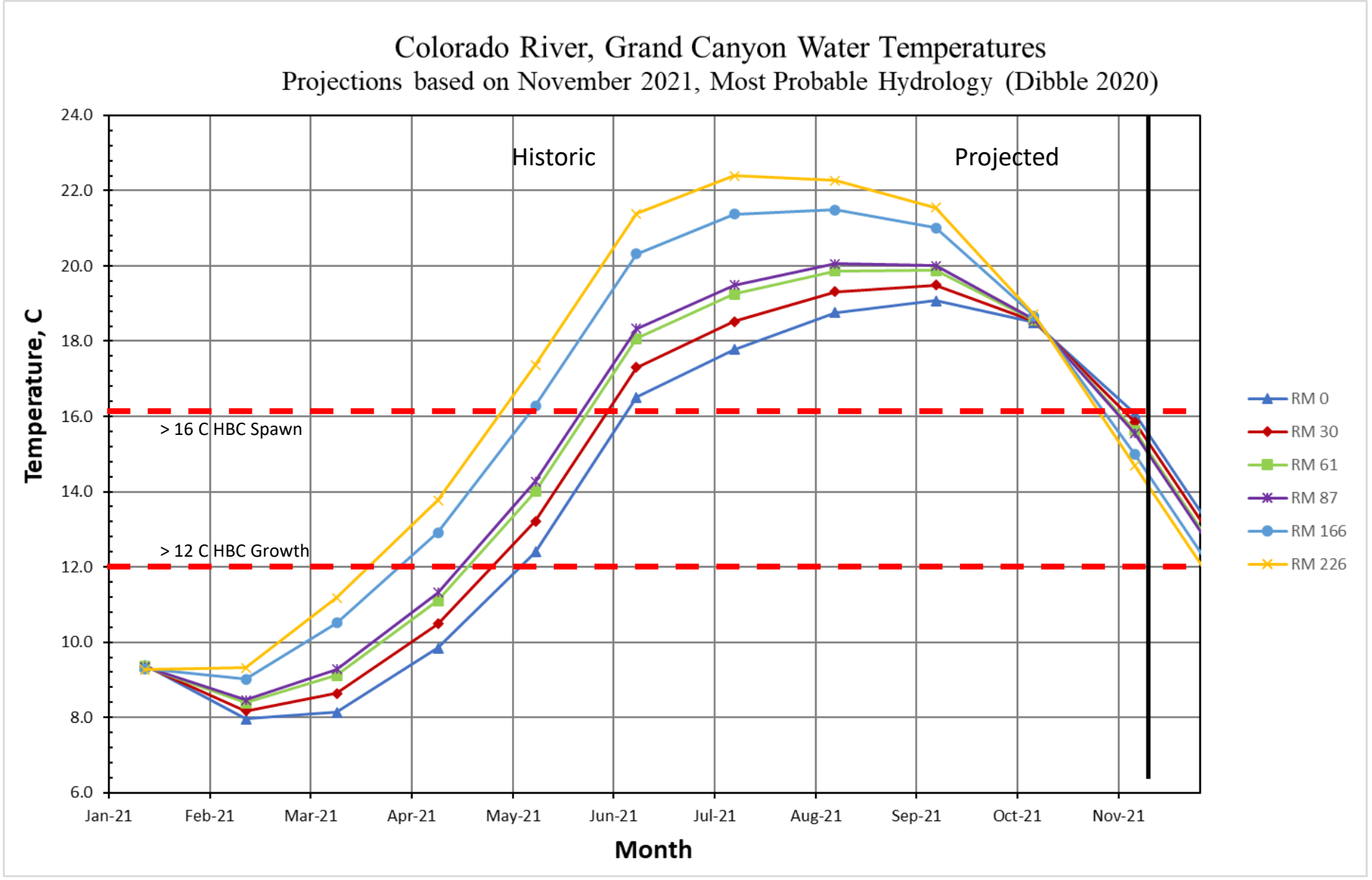
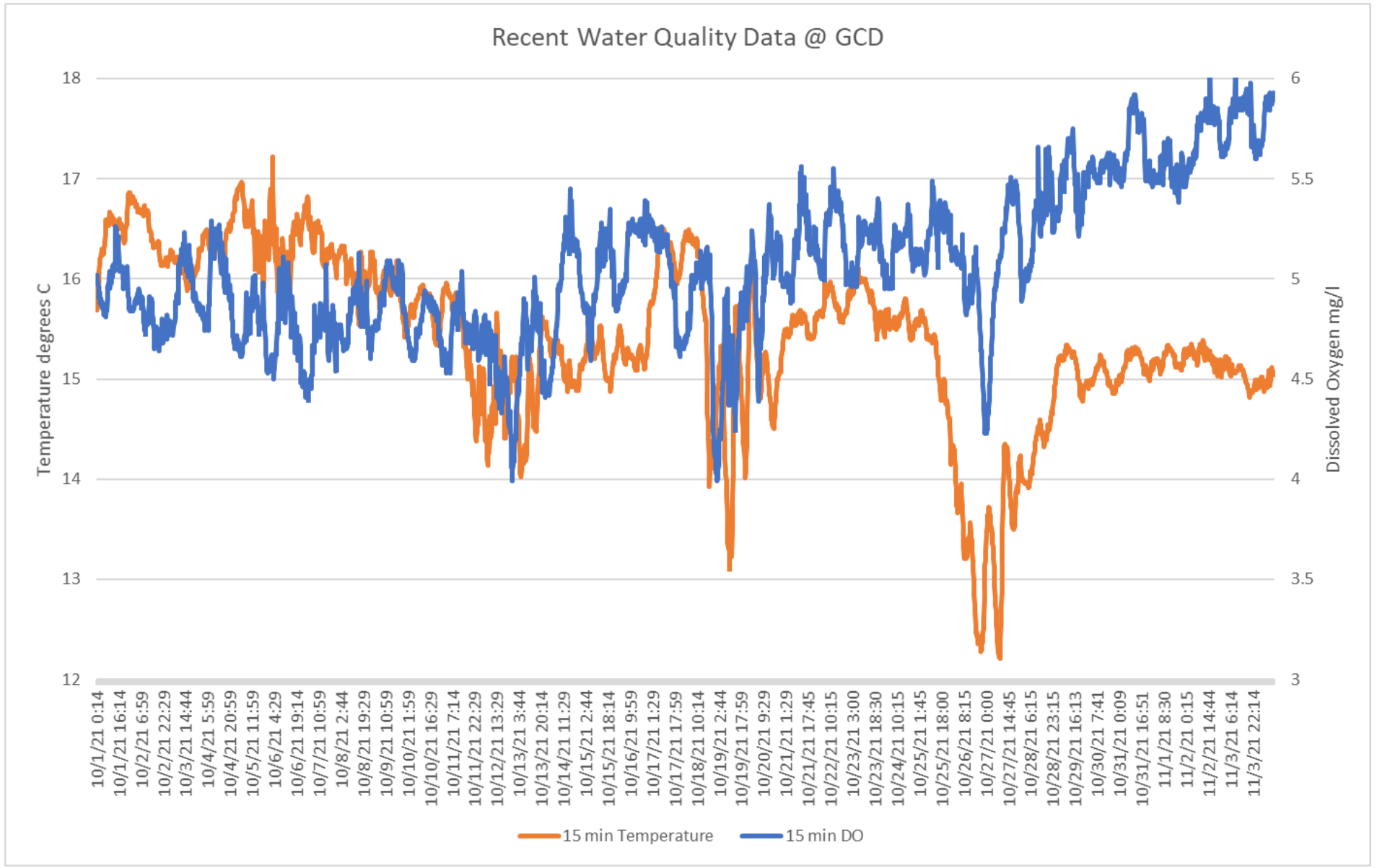
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21
Jan-22
Feb-22
Mar-22
Apr-22
May-22
Jun-22
Jul-22
Aug-22
Sep-22
Oct-22
Nov-22
Sep 2021 Most Probable Hydrology
Sep 2021 Min Probable Hydrology
Sep 2021 Max Probable Hydrology
Monthly average Temp LF
Monthly average Temp CRBD
#Projection start date is based on initial conditions (March 2021)


Colorado River, Grand Canyon Water Temperatures
Projections based on November 2021, Most Probable Hydrology (Dibble 2020)
Historic
Projected
> 16 C HBC Spawn
> 12 C HBC Growth
Temperature, C
Month
24.0
22.0
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
RM 0
RM 30
RM 61
RM 87
RM 166
RM 226


Recent Water Quality Data @ GCD
Temperature degrees C
Dissolved Oxygen mg/l
18
17
16
15
14
13
12
6
5.5
5
4.5
4
3.5
3
10/1/21 0:14
10/1/21 16:14
10/2/21 6:59
10/2/21 22:29
10/3/21 14:44
10/4/21 5:59
10/4/21 20:59
10/5/21 11:59
10/6/21 4:29
10/6/21 19:14
10/7/21 10:59
10/8/21 2:44
10/8/21 19:29
10/9/21 10:59
10/10/21 1:59
10/10/21 16:29
10/11/21 7:14
10/11/21 22:29
10/12/21 13:29
10/13/21 3:44
10/13/21 20:14
10/14/21 11:29
10/15/21 2:44
10/15/21 18:14
10/16/21 9:59
10/17/21 1:29
10/17/21 17:59
10/18/21 10:14
10/19/21 2:44
10/19/21 17:59
10/20/21 9:29
10/21/21 1:29
10/21/21 17:45
10/22/21 10:15
10/23/21 3:00
10/23/21 18:30
10/24/21 10:15
10/25/21 1:45
10/25/21 18:00
10/26/21 8:15
10/27/21 0:00
10/27/21 14:45
10/28/21 6:15
10/28/21 23:15
10/29/21 16:13
10/30/21 7:41
10/31/21 0:09
10/31/21 16:51
11/1/21 8:30
11/2/21 0:15
11/2/21 14:44
11/3/21 6:14
11/3/21 22:14
15 min Temperature
15 min DO


Questions?
BUREAU OF
RECLAMATION