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RECLAMATION

Colorado River Forecasting Service Lake Powell Operations

November 24, 2020





Upper Colorado Basin

24-MS/MTOM Integration and Statistical Out-Year Update to 24-Month Study



Integrated Mid-term Modeling System

	24-Month Study Mode	MTOM Mode
Primary Use	AOP tier determinations and projections of current conditions	Risk-based operational planning and analysis
Probabilistic or Deterministic	Deterministic – single hydrologic trace	Probabilistic 35 (or more) hydrologic traces
Simulated Reservoir Operations	Operations input manually	Rule-driven operations
Time Horizon (years)		
Frequency of Publication	Monthly	Monthly

WY 2021 Source of Monthly Unregulated Inflow for Upper Colorado Reservoirs in the 24 Month Study

Most Probable

Month Issued	April-July Unregulated Inflow																																					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov			
Jan	RFC	RFC	RFC	Official A-J	Official A-J	Official A-J	Official A-J	ESP Jan	ESP Jan	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med															
Feb		RFC	RFC	RFC	Official A-J	Official A-J	Official A-J	ESP Feb	ESP Feb	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	
Mar			RFC	RFC	RFC	Official A-J	Official A-J	ESP Mar	ESP Mar	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	
Apr				RFC	RFC	RFC	Official A-J	ESP Apr	ESP Apr	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	
May					RFC	RFC	RFC	ESP May	ESP May	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	
Jun						RFC	RFC	RFC	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	ESP Jun	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med
Jul							RFC	RFC	RFC	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	ESP Jul	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med
Aug								RFC	RFC	RFC	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	ESP Aug	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med
Sep									RFC	RFC	RFC	ESP Sep	ESP Sep	ESP Sep	ESP Sep	ESP Sep	ESP Sep	ESP Sep	ESP Sep	ESP Sep	ESP Sep	ESP Sep	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	
Oct										RFC	RFC	RFC	ESP Oct	ESP Oct	ESP Oct	ESP Oct	ESP Oct	ESP Oct	ESP Oct	ESP Oct	ESP Oct	ESP Oct	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	
Nov											RFC	RFC	RFC	ESP Nov	ESP Nov	ESP Nov	ESP Nov	ESP Nov	ESP Nov	ESP Nov	ESP Nov	ESP Nov	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med
Dec												RFC	RFC	RFC	ESP Dec	ESP Dec	ESP Dec	ESP Dec	ESP Dec	ESP Dec	ESP Dec	ESP Dec	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med

RFC values are issued by the Colorado Basin River Forecast Center (RFC) as the official forecast values for the next three-month period of time. The values are calculated using Ensemble Streamflow Predictions (ESP) modeling. This official forecast has the least amount of error associated with it.

Official A-J values are official forecast values issued by the RFC for the April-July runoff period using ESP. Apr-Jul water supply forecast volume is disaggregated by the RFC.

81-15 Med values are the monthly median inflow values generated from water years 1981-2015 calculated using the database maintained by the Bureau of Reclamation Upper Colorado Region (UCBOR). A water year begins October 1 and ends September 30.

Interpolated values are calculated by UCBOR and are based on percent of the 81-15 median. The method takes the percent of median of the previous month's forecast value and interpolates over two months to the percent of median for the month following the interpolation period. This is done to smoothly transition between the end of the current water year and the next water year.

ESP monthly values are generated using the RFC ESP forecasted volume for the water year using the current month's initial hydrological conditions. The RFC provides monthly volumes consistent with the 3-month forecast and the water year ESP volume.

* Light grey text indicates that the model is run in this month, however, only results for the first 24 months of the model run (black text) are published in the 24 Month Study report

WY 2021 Source of Monthly Unregulated Inflow for Upper Colorado Reservoirs in the 24 Month Study

Minimum Probable

Month Issued				April-July Unregulated Inflow																																	
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov		
Jan	RFC	RFC	RFC	Coord A-J 10th %ile	Coord A-J 10th %ile	Coord A-J 10th %ile	Coord A-J 10th %ile	interpolate	interpolate	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	interpolate	interpolate	81-15 Med													
Feb																																					
Mar																																					
Apr				Coord A-J 10th %ile	Coord A-J 10th %ile	Coord A-J 10th %ile	Coord A-J 10th %ile	interpolate	interpolate	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	interpolate	interpolate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med		
May																																					
Jun																																					
Jul																																					
Aug								RFC	RFC	RFC	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	10th %ile Aug ESP	interpolate	interpolate	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	
Sep																																					
Oct										RFC	RFC	RFC	10th %ile Oct ESP	10th %ile Oct ESP	10th %ile Oct ESP	10th %ile Oct ESP	10th %ile Oct ESP	10th %ile Oct ESP	10th %ile Oct ESP	10th %ile Oct ESP	10th %ile Oct ESP	interpolate	interpolate	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	25th %ile of 81-15	
Nov																																					
Dec																																					

RFC values are issued by the Colorado Basin River Forecast Center (RFC) as the official forecast values for the next three-month period of time. The values are calculated using Ensemble Streamflow Predictions (ESP) modeling. This official forecast has the least amount of error associated with it.

Coord A-J 10th %ile values are the official forecast of the total April-July volume issued by the RFC for the April-July runoff period using SWS and ESP. Monthly values are disaggregated using the 81-15 average monthly distribution.

25th %ile of 81-15 values are the monthly 25th percentile (75% exceedance) inflow values generated from water years 1981-2015 calculated using the database maintained by the Bureau of Reclamation Upper Colorado Region (UCBOR). A water year begins October 1 and ends September 30.

Interpolated values are calculated by UCBOR and are based on percent of the 81-15 median. The method takes the percent of average of the previous month's forecast value and interpolates over two months to the percent of median for the month following the interpolation period. This is done to smoothly transition between the end of the current water year and the next water year.

10th %ile Jan/Apr/Aug/Oct ESP values are generated using the RFC ESP forecasted volume for the water year using the monthly initial hydrological conditions. Monthly values are disaggregated from the total water year ESP volume using the median 81-15 statistical monthly distribution, consistent with the 3-month forecast. ESP forecasts are issued for each month of the base flow period to the end of the current water year for the 24-month study.

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Maximum Probable

Month Issued	April-July Unregulated Inflow																																					
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov			
Jan	RFC	RFC	RFC	A-J Coord 90th %ile	A-J Coord 90th %ile	A-J Coord 90th %ile	A-J Coord 90th %ile	inter-polate	inter-polate	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	inter-polate	inter-polate	81-15 Med															
Feb																																						
Mar																																						
Apr				A-J Coord 90th %ile	A-J Coord 90th %ile	A-J Coord 90th %ile	A-J Coord 90th %ile	inter-polate	inter-polate	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	inter-polate	inter-polate	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	81-15 Med	
May																																						
Jun																																						
Jul																																						
Aug								RFC	RFC	RFC	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	90th %ile Aug ESP	inter-polate	inter-polate	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	
Sep																																						
Oct										RFC	RFC	RFC	90th %ile Oct ESP	90th %ile Oct ESP	90th %ile Oct ESP	90th %ile Oct ESP	90th %ile Oct ESP	90th %ile Oct ESP	90th %ile Oct ESP	90th %ile Oct ESP	inter-polate	inter-polate	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	75th %ile of 81-15	
Nov																																						
Dec																																						

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Coord A-J 90th %ile are the official forecast of the total April-July volume issued by the RFC for the April-July runoff period using ESP. Monthly values are disaggregated using the 81-15 median monthly distribution.

75th %ile of 81-15 values are the monthly 75th percentile (25% exceedance) inflow values generated from water years 1981-2015 calculated using the database maintained by the Bureau of Reclamation Upper Colorado Region (UCBOR). A water year begins October 1 and ends September 30.

Interpolated values are calculated by UCBOR and are based on percent of the 81-15 median. The method takes the percent of average of the previous month's forecast value and interpolates over two months to the percent of median for the month following the interpolation period. This is done to smoothly transition between the end of the current water year and the next water year.

90th %ile Jan/Apr/Aug/Oct ESP values are generated using the RFC ESP forecasted volume for the water year using the monthly initial hydrological conditions. Monthly values are disaggregated from the total water year ESP volume using the median 81-15 statistical monthly distribution, consistent with the 3-month forecast. ESP forecasts are issued for each month of the base flow period to the end of the current water year for the 24-month study.

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Upper Colorado Basin

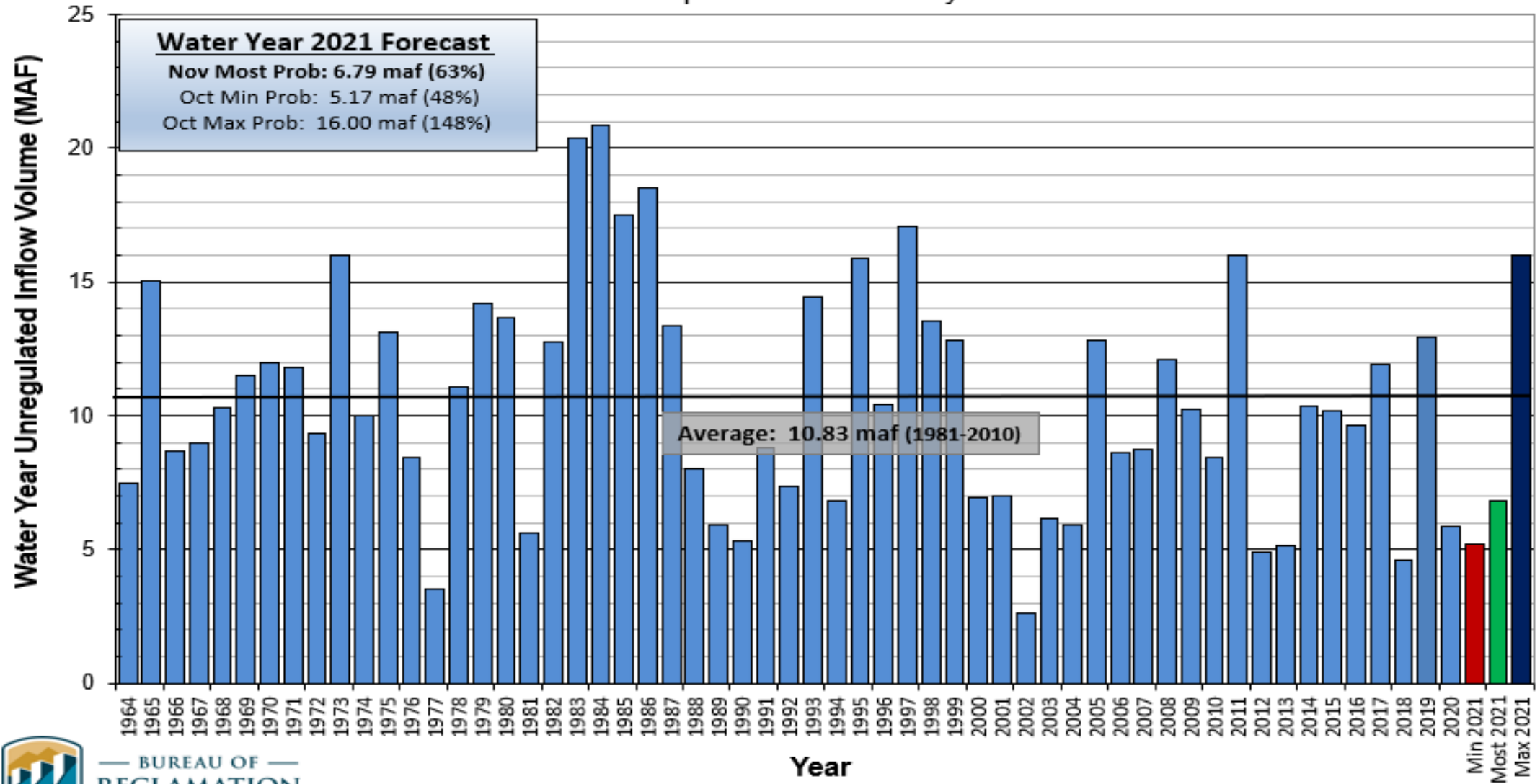
Projected Operations for Water Year 2021 Based on November 2020 Modeling



Lake Powell Unregulated Inflow

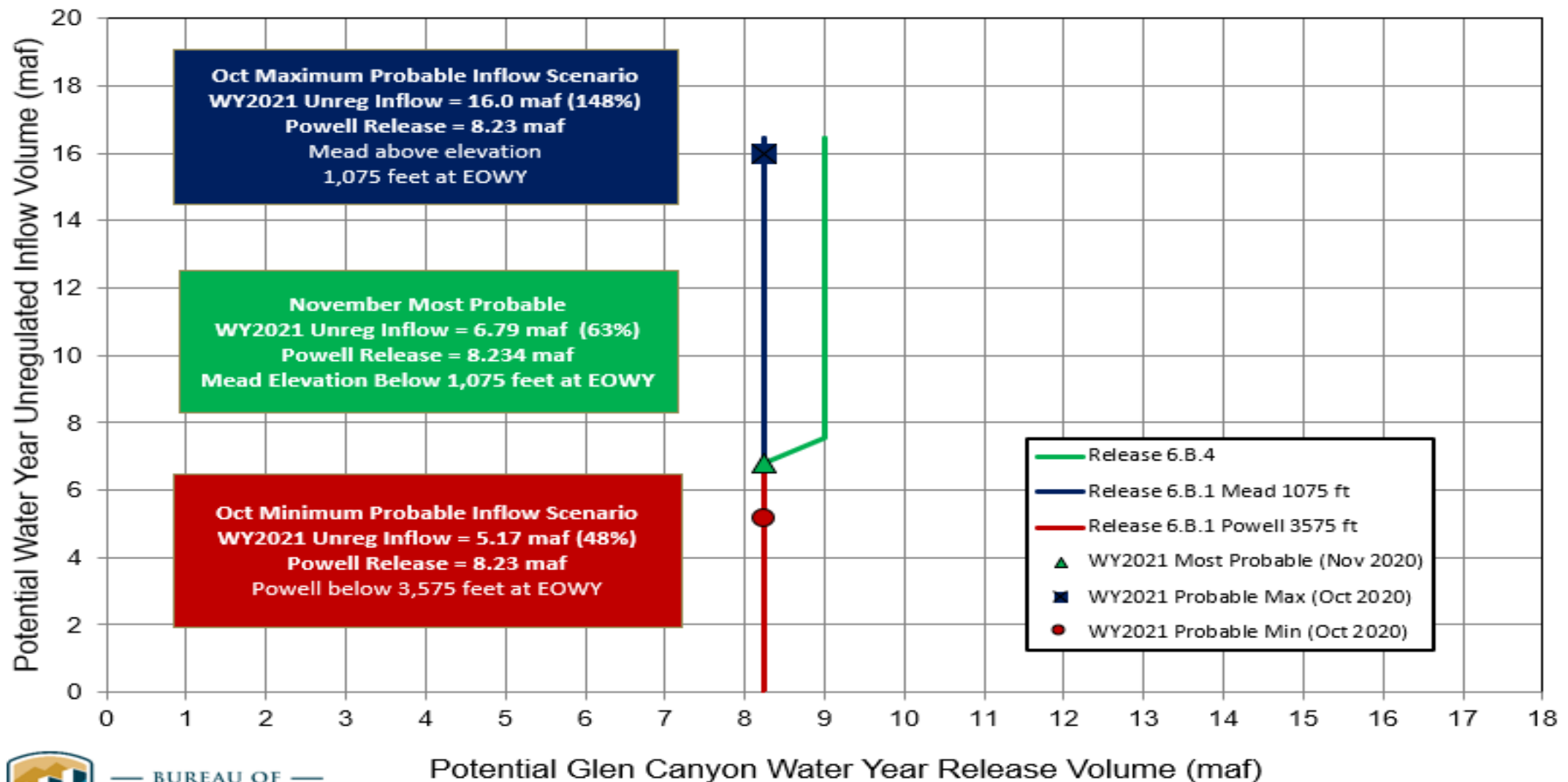
Water Year 2021 Forecast (issued November 2)

Comparison with History



Lake Powell Release Scenarios under Section 6.B

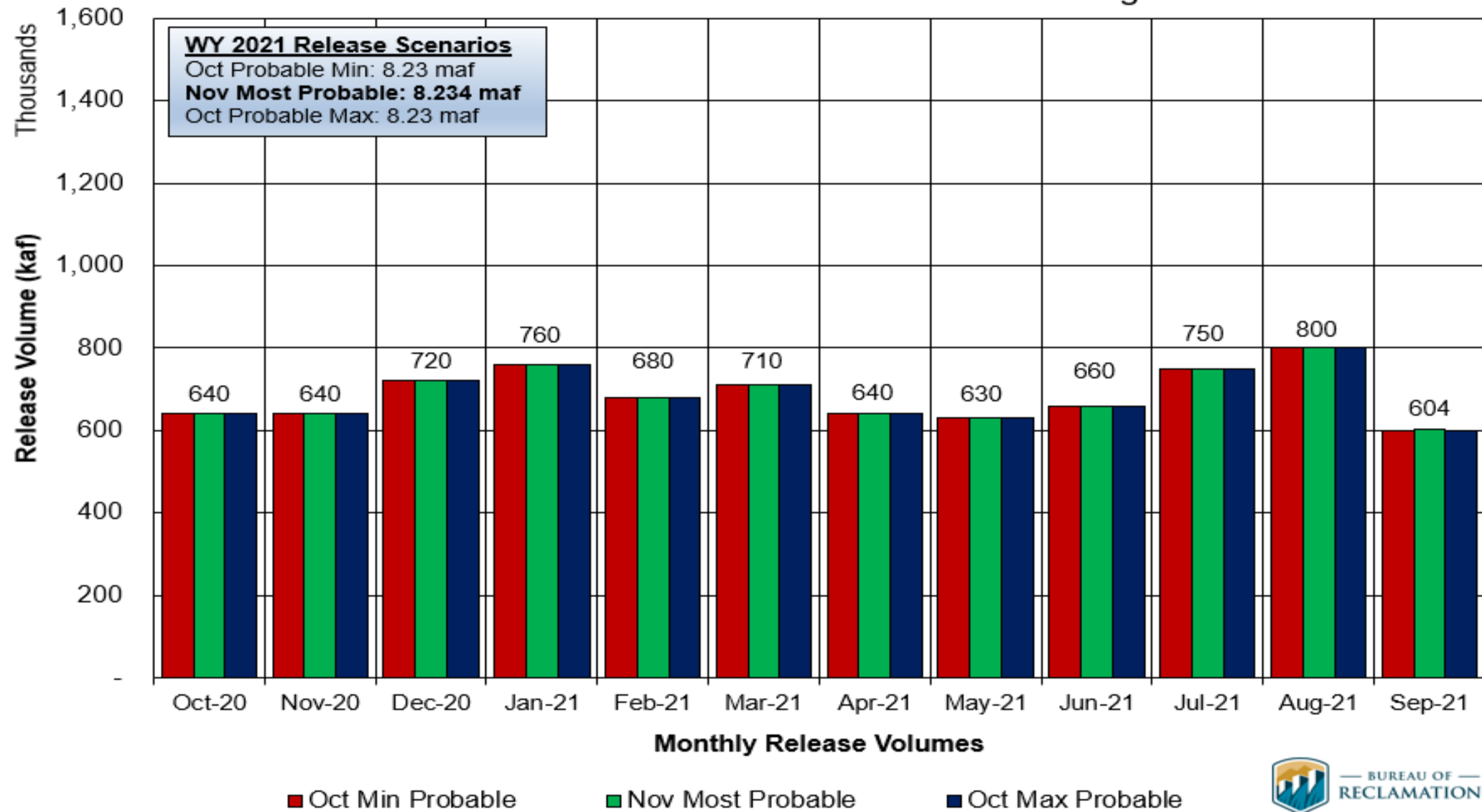
Water Year 2021 Release Volume as a Function of Upper Elevation Balancing Tier based on October and November 2020 24-Month Study Conditions



Potential Lake Powell Monthly Release Volume Distribution

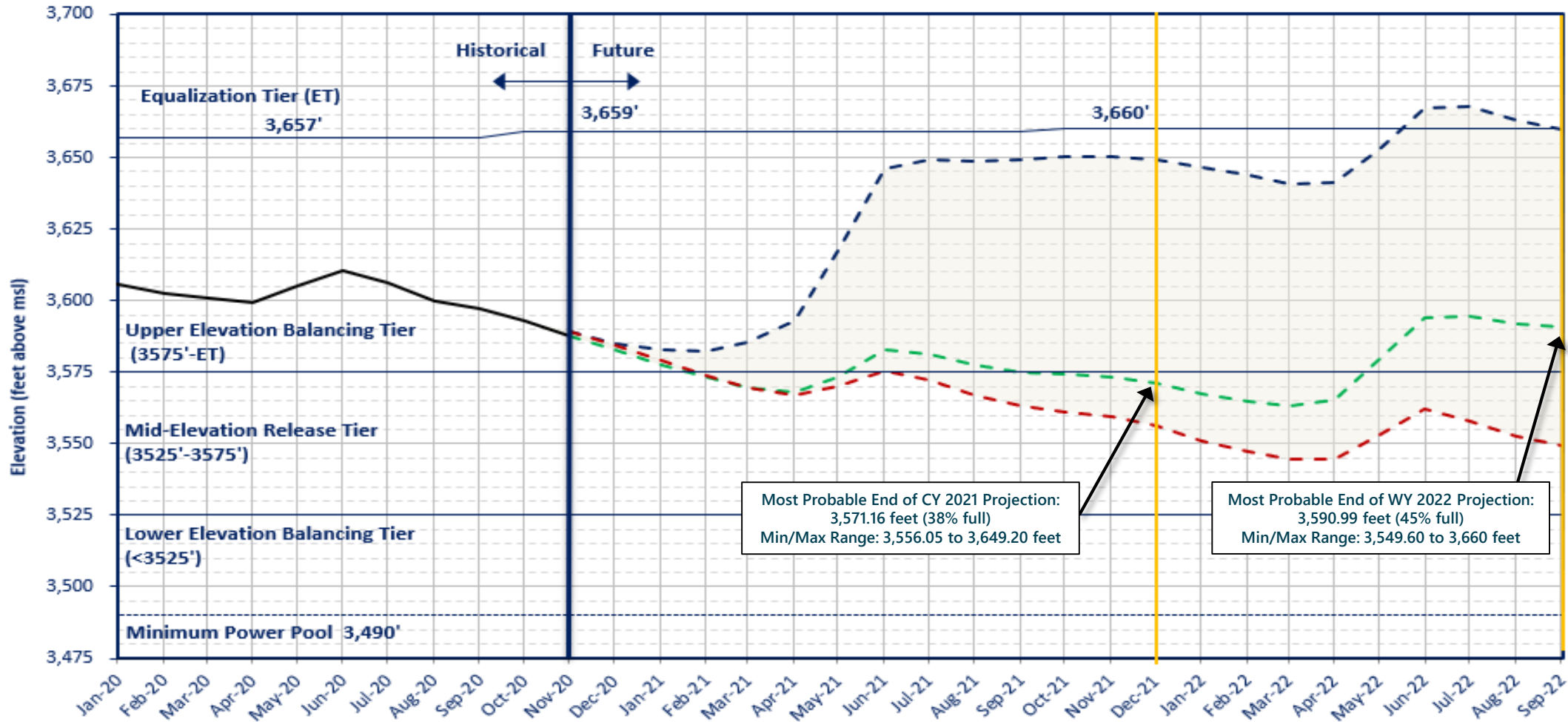
Release Scenarios for Water Year 2021

Based on October and November 2020 Modeling



Lake Powell End of Month Elevations

Historic and Projected based on October and November 2020 24-Month Study Inflow Scenarios



Most Probable End of CY 2021 Projection:
3,571.16 feet (38% full)
Min/Max Range: 3,556.05 to 3,649.20 feet

Most Probable End of WY 2022 Projection:
3,590.99 feet (45% full)
Min/Max Range: 3,549.60 to 3,660 feet

- - - Nov 2020 Most Probable - Lake Powell release of 8.234 maf in WY2021 and 7.48 maf in WY2022
- - - Oct 2020 Max Probable - Lake Powell release of 8.23 maf in WY2021 and 11.67 maf in WY2022
- - - Oct 2020 Min Probable - Lake Powell release of 8.23 maf in WY2021 and 7.48 maf in WY2022
- Historical Elevations



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	[Outage]											[Outage]
2	[Outage]											[Outage]
3	[Outage]							[Outage]				
4		[Outage]						[Outage]				
5			[Outage]								[Outage]	
6	[Outage]		[Outage]								[Outage]	
7			[Outage]									
8			[Outage]									
Units Available	5	5/4	6	6	6	6	6	6	6	6	6	6/4
Capacity (cfs)	16,400	16,300 / 12,400	19,800	19,700	19,500	19,400	19,400	19,500	19,900	19,800	19,700	19,600 / 12,400
Capacity (kaf/month)	1,040	1,140	1,250	1,220	1,100	1,220	1,220	1,270	1,260	1,310	1,340	1,100
Max (kaf) ²	640	640	720	760	680	710	640	630	660	750	800	600
Most (kaf) ¹	640	640	720	860	750	800	710	710	740	870	890	690
Min (kaf) ²	640	640	720	760	680	710	640	630	660	750	800	600
										(updated 10-20-2020)		

OCT MOST³
 OCT MAX
 8.23
 9.0
 8.23

1 Projected release, based on October 2020 Most Probable Inflow Projections and 24-Month Study model runs.
 2 Projected release, based on October 2020 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.



Glen Canyon Power Plant Planned Unit Outage Schedule for Water Year 2022

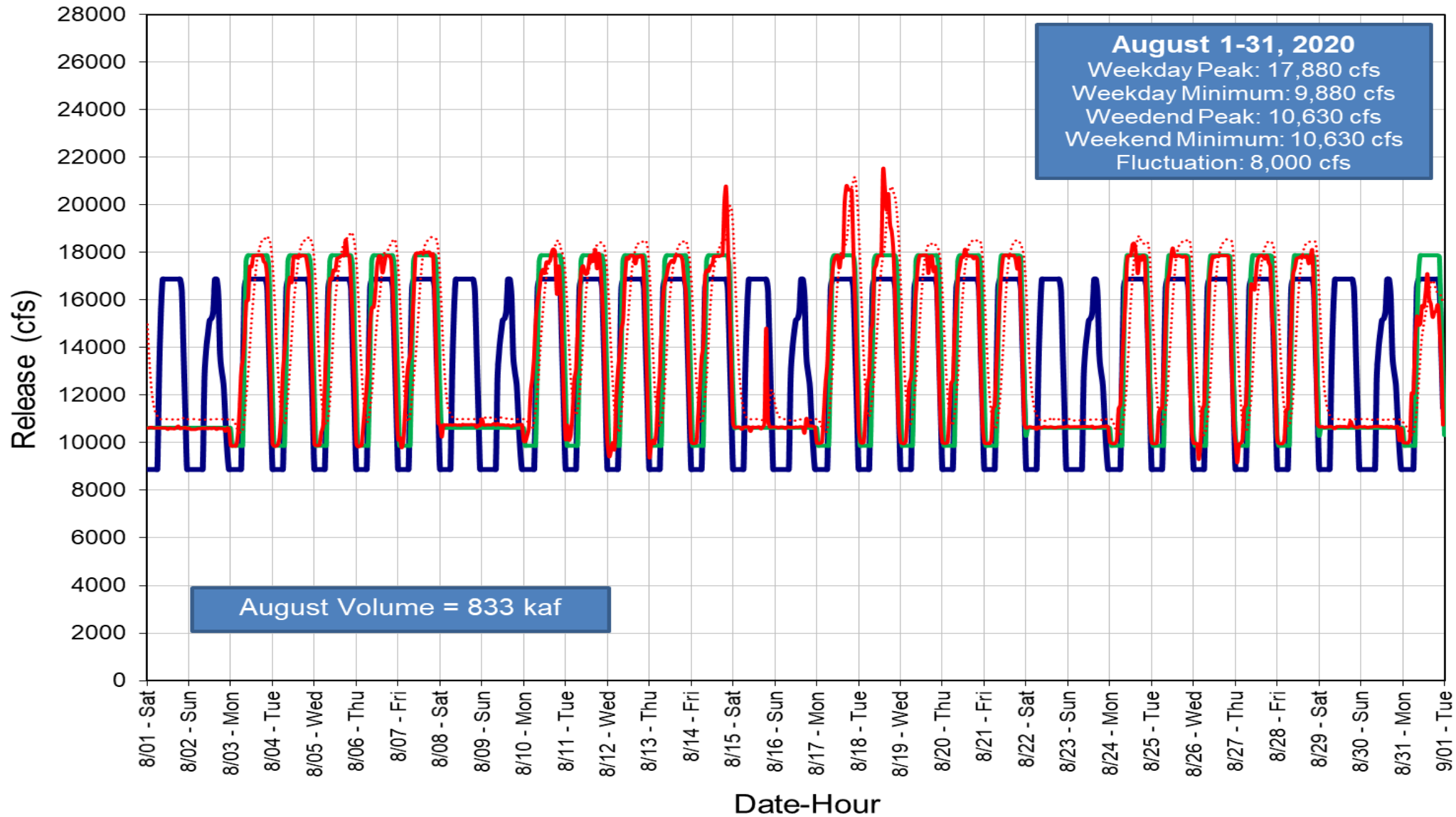
Unit Number	Oct 2021	Nov 2021	Dec 2021	Jan 2022	Feb 2022	Mar 2022	Apr 2022	May 2022	Jun 2022	Jul 2022	Aug 2022	Sep 2022
1	■											■
2	■											■
3	■					■						
4	■					■		■				
5	■	■	■									
6	■	■	■									
7		■			■							
8					■							
Units Available	4	4/5	5/8	8	6	6/8	8	7	8	8	8	8/6
Capacity (cfs)	12,400	12,400 /16,000	16,000/ 26,700	26,500	19,400	19,300/ 26,400	26,500	23,400	27,600	27,600	27,500	27,500 /20,100
Capacity (kaf/month)	870	970	1,350	1,770	1,210	1,390	1,720	1,600	1,760	1,820	1,810	1,340
Max (kaf) ²	640	640	720	950	950	1,100	1,050	1,050	1,075	1,250	1,280	968
Most (kaf) ¹	480	500	600	720	640	675	600	600	630	710	760	565
Min (kaf) ²	480	500	600	720	640	675	600	600	630	710	760	565
										(updated 10-20-2020)		

OCT MOST³
 OCT MAX
 11.67
 7.48
 7.48

1 Projected release, based on October 2020 Most Probable Inflow Projections and 24-Month Study model runs.
 2 Projected release, based on October 2020 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.



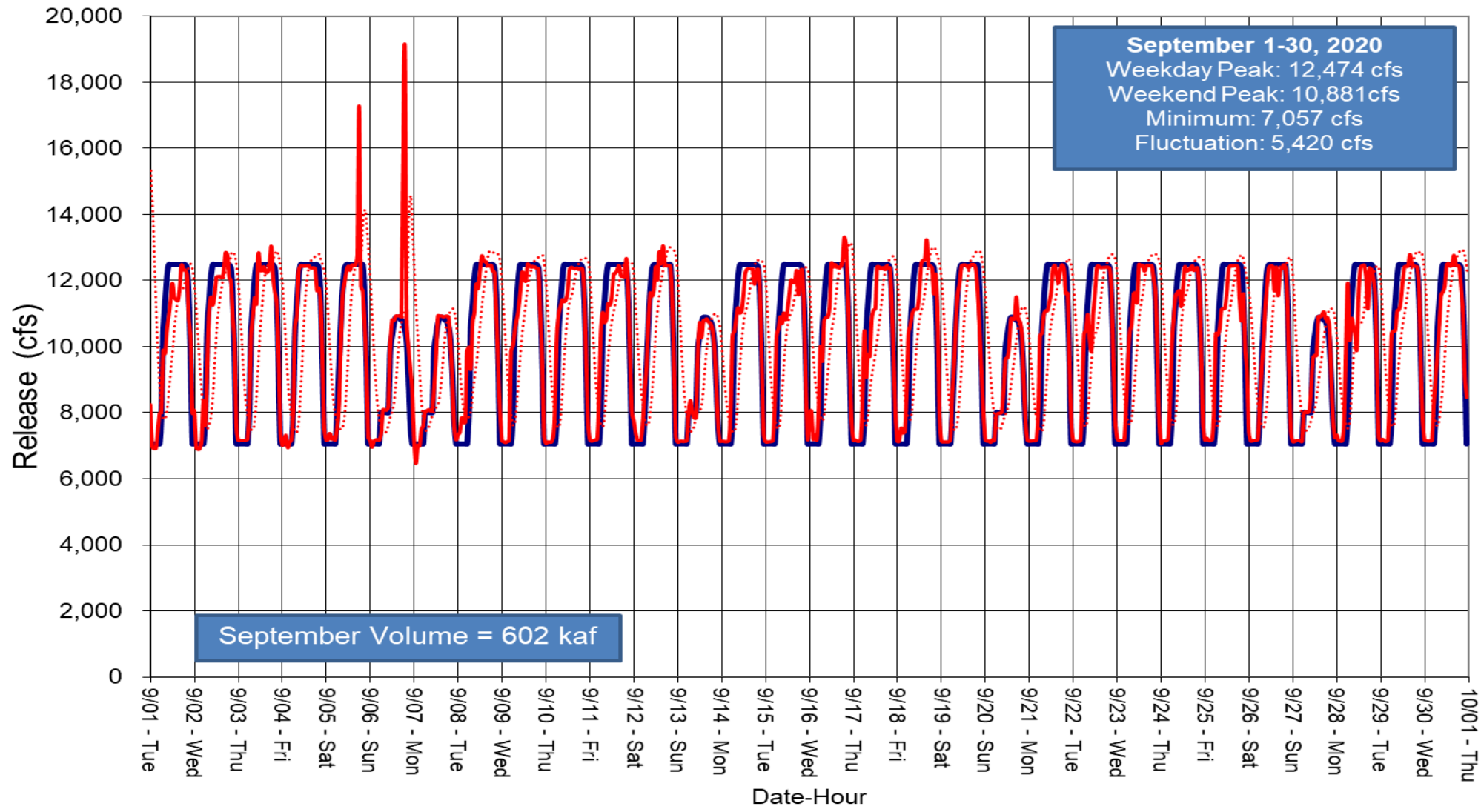
Glen Canyon Dam Hourly Release Pattern August 2020



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



Glen Canyon Dam Hourly Release Pattern September 2020



September Volume = 602 kaf

September 1-30, 2020
 Weekday Peak: 12,474 cfs
 Weekend Peak: 10,881 cfs
 Minimum: 7,057 cfs
 Fluctuation: 5,420 cfs

— Scheduled Hourly Releases — Actual Hourly Releases Lees Ferry Flow

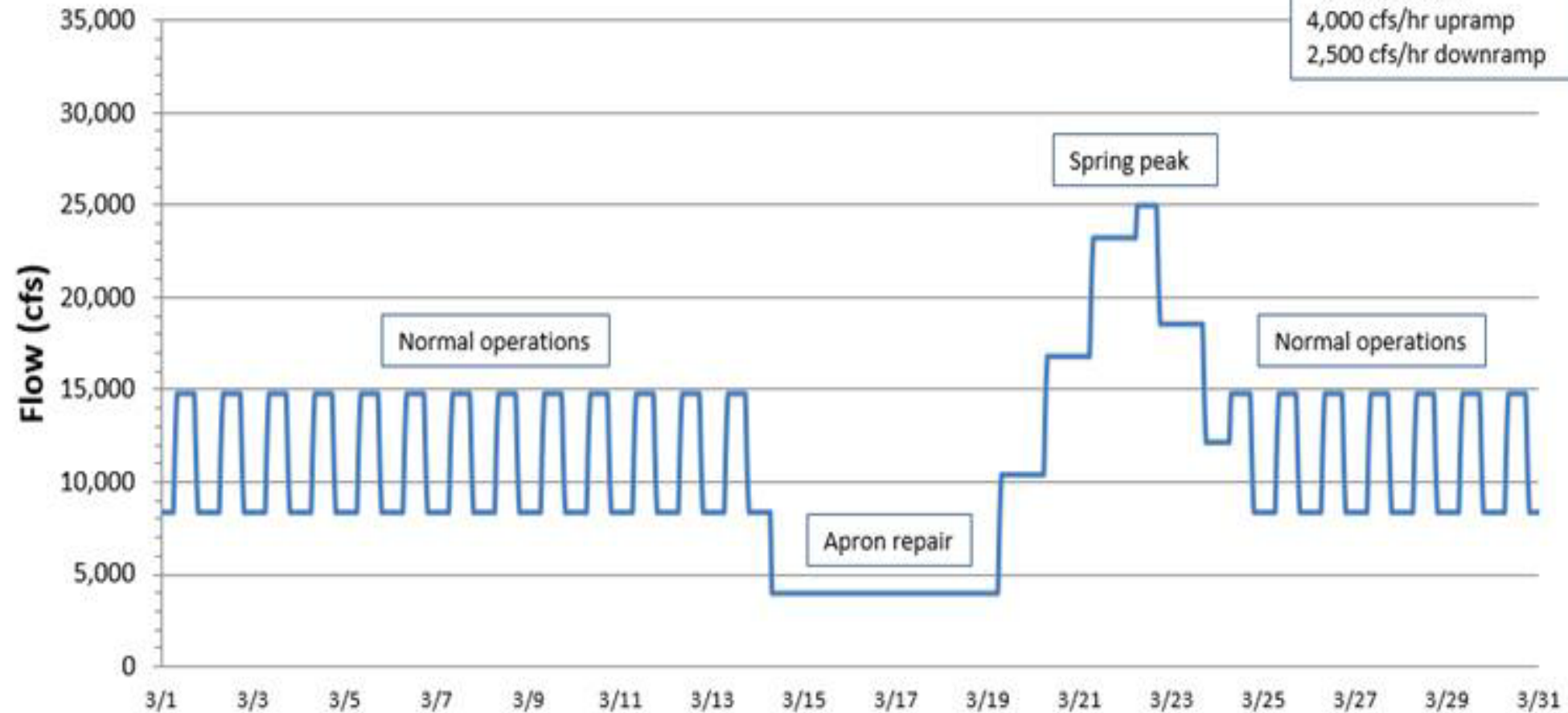


Potential WY2021 Experimentation



Apron Repair w-Spring Peak w-in ROD

March vol: 713,000 af
dfr: 6,417 cfs
4,000 cfs/hr upramp
2,500 cfs/hr downramp



*Example for conceptual use only. Among other things, adjustments need to be made to utilize remaining monthly volume.

**Maximum powerplant release is about 26,400 cfs with all 8 units and a reservoir elevation of 3,627 ft (based on the 2018 HFE).



Potential LTEMP Flow Experiments

Water Year 2021

GCD Experimental Flow	Duration	Implementation Window
Fall HFE	up to 96 hours	October - November
Extended Duration Fall HFE	97- 192* or 97-250 hours***	October - November
Spring HFE ^Δ	up to 96 hours	March – April
Proactive Spring HFE ^{Δ◇}	24 hours**	April – June
Trout Management Flows	up to 3 cycles/month for 4 months	May – August
Macroinvertebrate Flows	target 2-3 replicates	May – August

* First test not to exceed 192 hours

** First test 24 hours

*** After first test, up to 250 hours

Δ no Spring HFE in same WY as extended duration Fall HFE

◇ no proactive Spring HFE in same WY as sediment-driven Spring HFE

Questions/Discussion



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