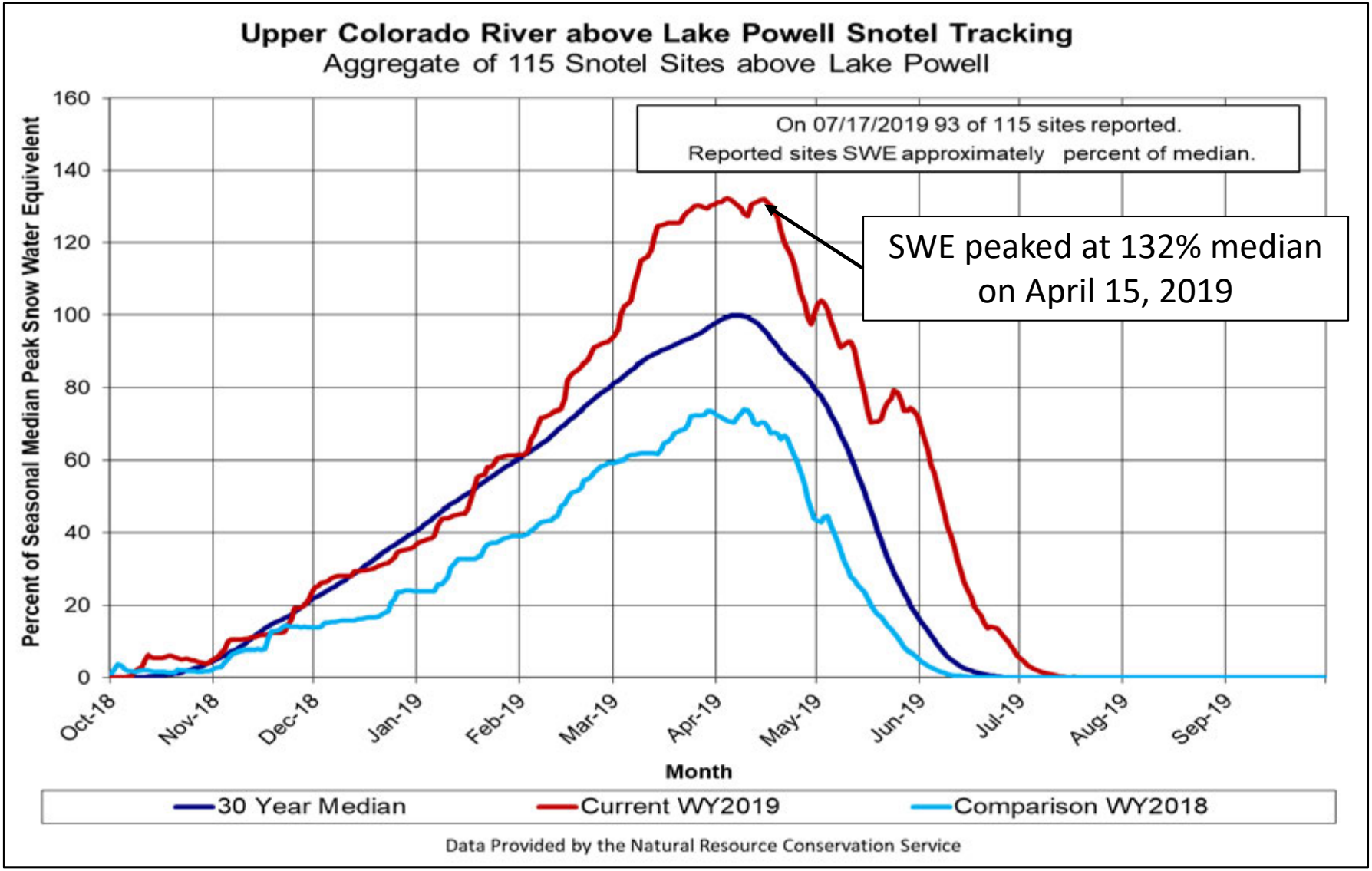
Basin Hydrology, Reservoir Operations 2019 and 2020 Hydrograph

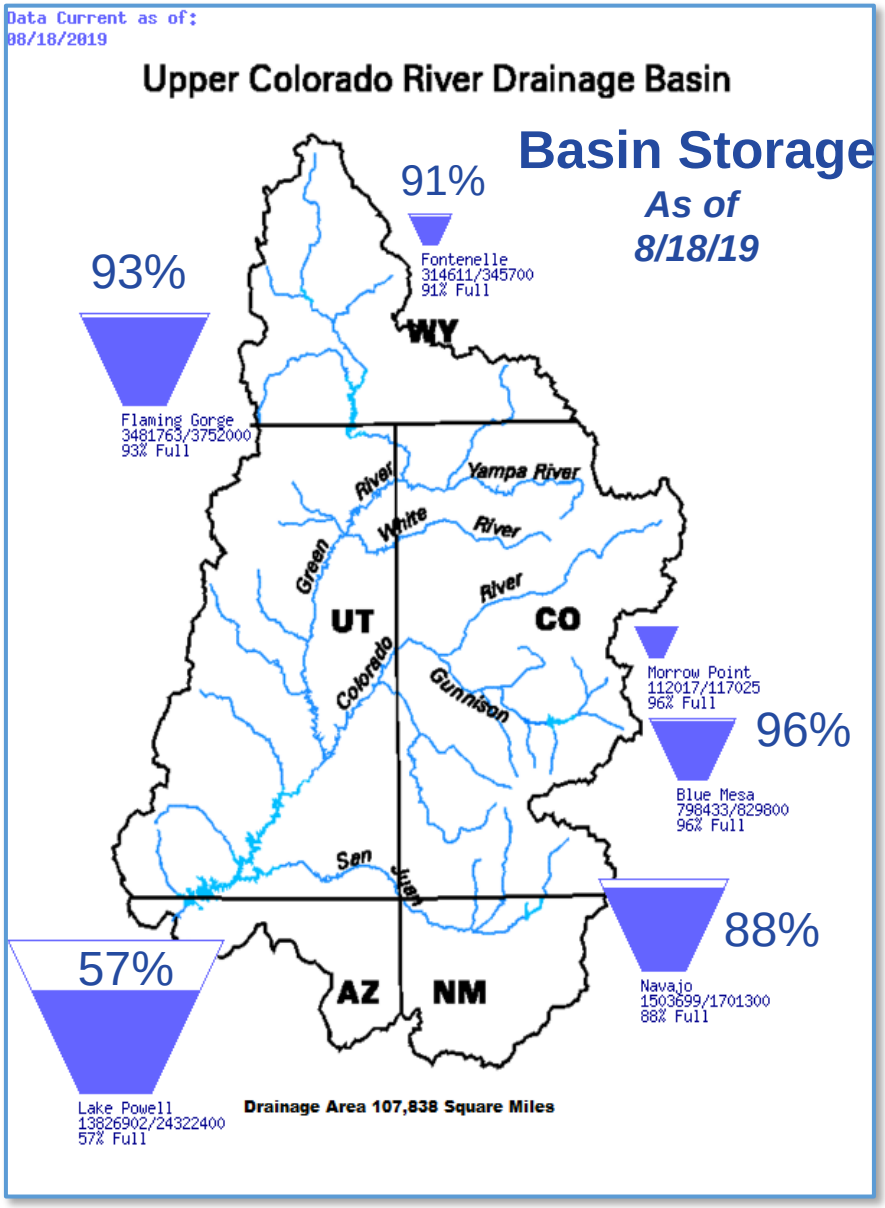
August 21, 2019

Snow Conditions



RECLAMATION
Managing Water in the West

Upper Basin Storage and Inflow



Available online at: www.usbr.gov/uc/water/basin/index.html

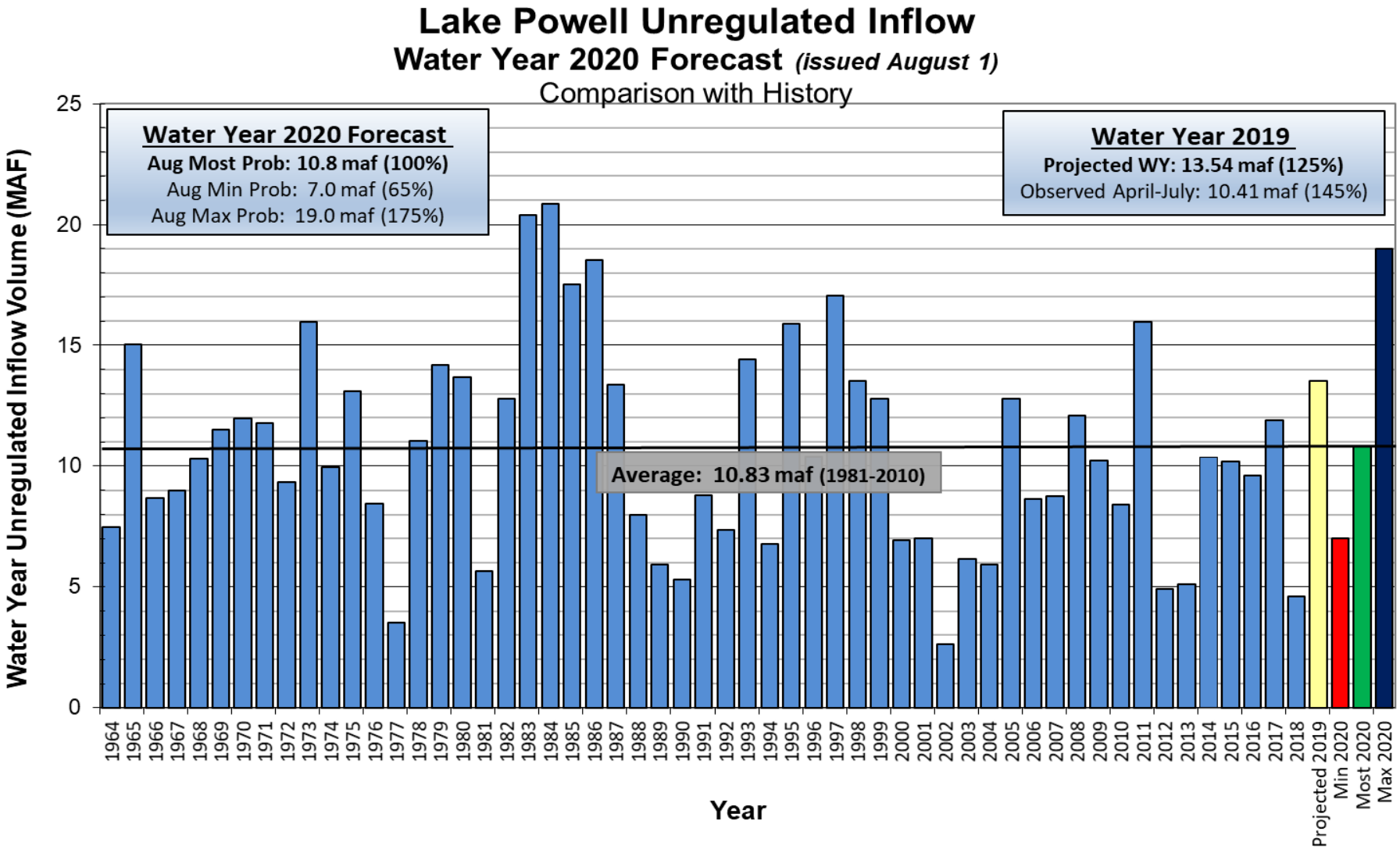
2019 April - July Observed Unregulated Inflow

Reservoir	Forecast (kaf)	Percent of Average[1]
Fontenelle	802	111
Flaming Gorge	1,179	120
Blue Mesa	1,088	161
Navajo	1,162	158
Powell	10,410	145

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

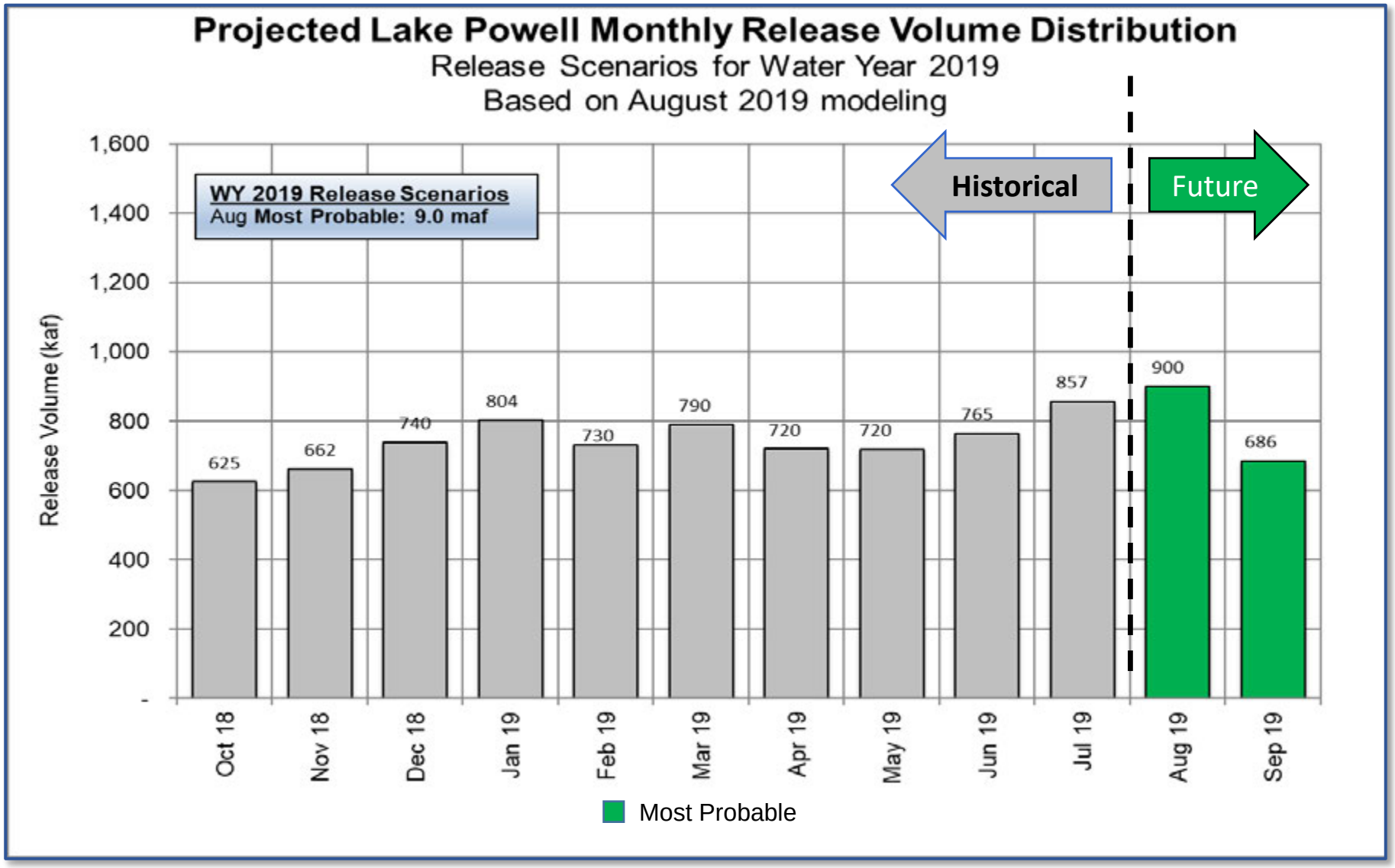
RECLAMATION
Managing Water in the West

Lake Powell Inflow



RECLAMATION
Managing Water in the West

Lake Powell Monthly Release



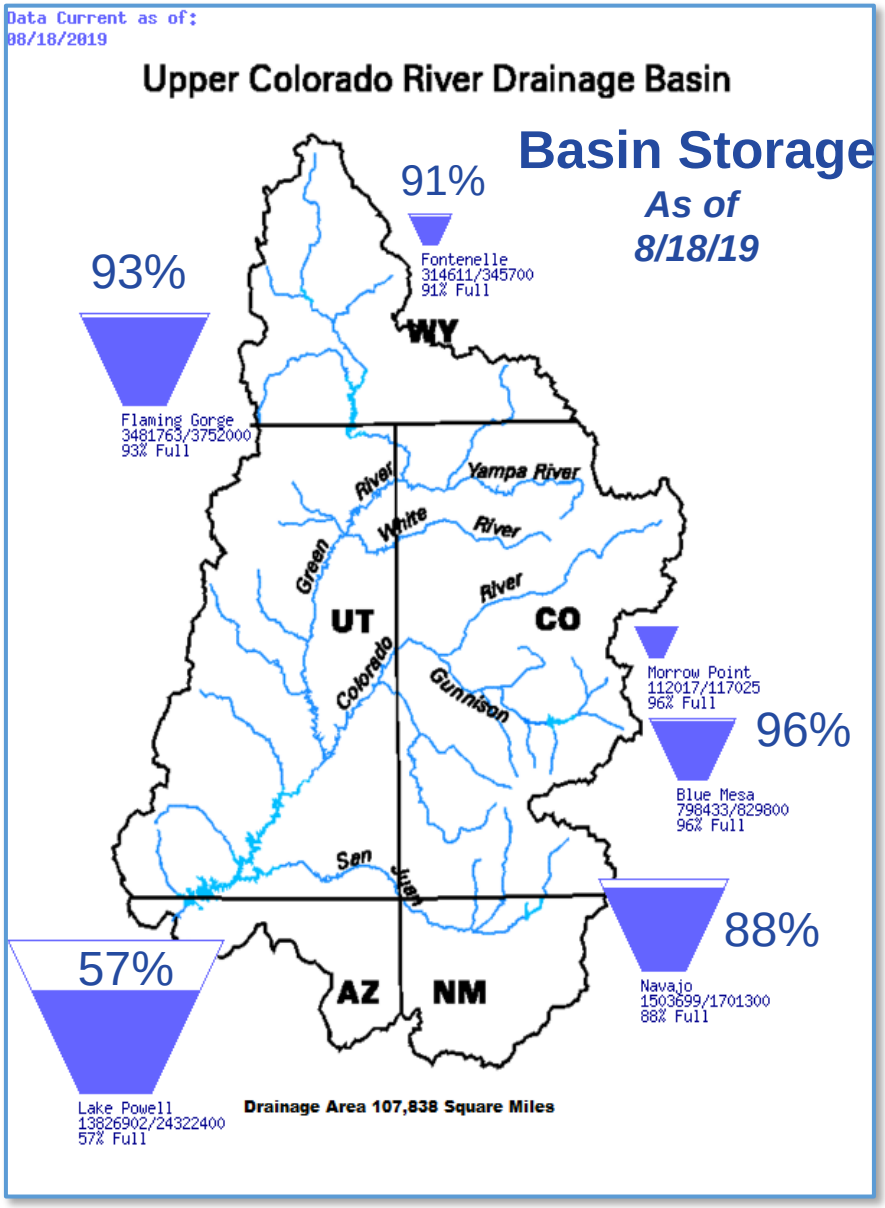
RECLAMATION
Managing Water in the West

August 24-Month Study Projections

Upper Colorado Operations

WY 2020 Official Operations Run

Upper Basin Storage and Inflow



Available online at: www.usbr.gov/uc/water/basin/index.html

Water Year 2020
Forecasted Unregulated Inflow
Issued August 1, 2019

Reservoir	Forecast (kaf)	Percent of Average[1]
Fontenelle	1,025	95
Flaming Gorge	1,385	95
Blue Mesa	970	102
Navajo	980	92
Powell	10,800	100

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

RECLAMATION
Managing Water in the West

Timing of Operational Decisions

- August 24-Month Study projections of January 1 elevations sets the operating tiers for Lake Powell and Lake Mead
- When Lake Powell is in Upper Elevation Balancing Tier, April 24-Month Study projections of September 30 elevations may result in an adjustment to Powell's operations

Upper Elevation Balancing Tier

B. Upper Elevation Balancing Tier

1. In Water Years when the projected January 1 Lake Powell elevation is below the elevation stated in the Lake Powell Equalization Elevation Table and at or above 3,575 feet, the Secretary shall release 8.23 maf from Lake Powell if the projected January 1 Lake Mead elevation is at or above 1,075 feet.

2. If the projected January 1 Lake Powell elevation is below the elevation stated in the Lake Powell Equalization Elevation Table and at or above 3,575 feet and the projected January 1 Lake Mead elevation is below 1,075 feet, the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release not more than 9.0 maf and not less than 7.0 maf from Lake Powell in the Water Year.

3. When operating in the Upper Elevation Balancing Tier, if the April 24-Month Study projects the September 30 Lake Powell elevation to be greater than the elevation in the Lake Powell Equalization Elevation Table, the Equalization Tier will govern the operation of Lake Powell for the remainder of the Water Year (through September).

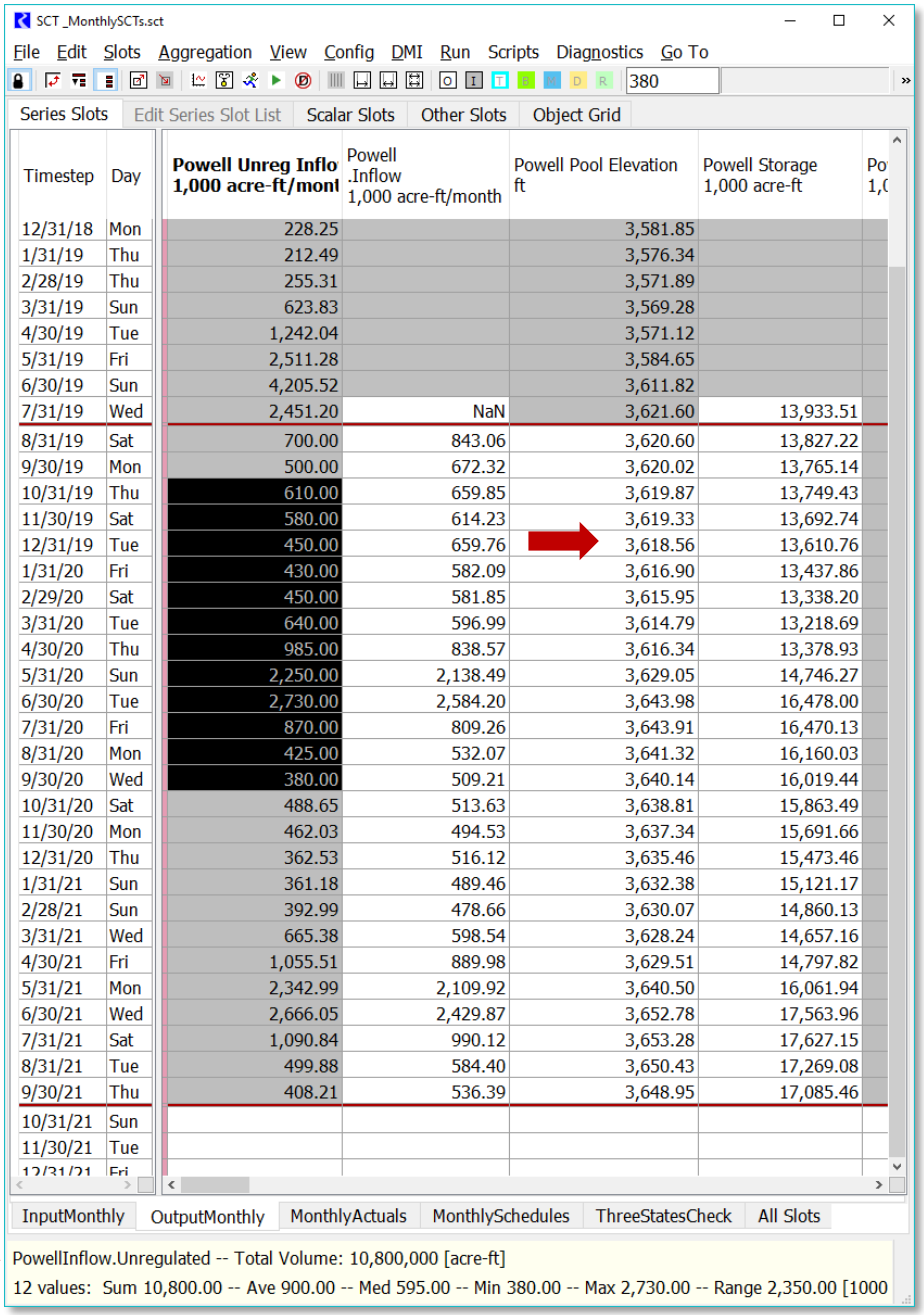
4. When operating under Section 6.B.1, if the April 24-Month Study projects the September 30 Lake Mead elevation to be below 1,075 feet and the September 30 Lake Powell elevation to be at or above 3,575 feet, the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release not more than 9.0 maf and not less than 8.23 maf from Lake Powell in the Water Year.

5. When Lake Powell is projected to be operating under Section 6.B.2. and more than 8.23 maf is projected to be released from Lake Powell during the upcoming Water Year, the Secretary shall recalculate the August 24-Month Study projection of the January 1 Lake Mead elevation to include releases above 8.23 maf that are scheduled to be released from Lake Powell during the months of October, November, and December of the upcoming Water Year, for the purposes of determining Normal or Shortage conditions pursuant to Sections 2.A. or 2.D. of these Guidelines.

August Determination

April Determination

RECLAMATION
Managing Water in the West



Timestep	Day	Powell Unreg Inflo 1,000 acre-ft/mont	Powell .Inflow 1,000 acre-ft/month	Powell Pool Elevation ft	Powell Storage 1,000 acre-ft	Po 1,(
12/31/18	Mon	228.25		3,581.85		
1/31/19	Thu	212.49		3,576.34		
2/28/19	Thu	255.31		3,571.89		
3/31/19	Sun	623.83		3,569.28		
4/30/19	Tue	1,242.04		3,571.12		
5/31/19	Fri	2,511.28		3,584.65		
6/30/19	Sun	4,205.52		3,611.82		
7/31/19	Wed	2,451.20	NaN	3,621.60	13,933.51	
8/31/19	Sat	700.00	843.06	3,620.60	13,827.22	
9/30/19	Mon	500.00	672.32	3,620.02	13,765.14	
10/31/19	Thu	610.00	659.85	3,619.87	13,749.43	
11/30/19	Sat	580.00	614.23	3,619.33	13,692.74	
12/31/19	Tue	450.00	659.76	3,618.56	13,610.76	
1/31/20	Fri	430.00	582.09	3,616.90	13,437.86	
2/29/20	Sat	450.00	581.85	3,615.95	13,338.20	
3/31/20	Tue	640.00	596.99	3,614.79	13,218.69	
4/30/20	Thu	985.00	838.57	3,616.34	13,378.93	
5/31/20	Sun	2,250.00	2,138.49	3,629.05	14,746.27	
6/30/20	Tue	2,730.00	2,584.20	3,643.98	16,478.00	
7/31/20	Fri	870.00	809.26	3,643.91	16,470.13	
8/31/20	Mon	425.00	532.07	3,641.32	16,160.03	
9/30/20	Wed	380.00	509.21	3,640.14	16,019.44	
10/31/20	Sat	488.65	513.63	3,638.81	15,863.49	
11/30/20	Mon	462.03	494.53	3,637.34	15,691.66	
12/31/20	Thu	362.53	516.12	3,635.46	15,473.46	
1/31/21	Sun	361.18	489.46	3,632.38	15,121.17	
2/28/21	Sun	392.99	478.66	3,630.07	14,860.13	
3/31/21	Wed	665.38	598.54	3,628.24	14,657.16	
4/30/21	Fri	1,055.51	889.98	3,629.51	14,797.82	
5/31/21	Mon	2,342.99	2,109.92	3,640.50	16,061.94	
6/30/21	Wed	2,666.05	2,429.87	3,652.78	17,563.96	
7/31/21	Sat	1,090.84	990.12	3,653.28	17,627.15	
8/31/21	Tue	499.88	584.40	3,650.43	17,269.08	
9/30/21	Thu	408.21	536.39	3,648.95	17,085.46	
10/31/21	Sun					
11/30/21	Tue					
12/31/21	Fri					

Powell Operating Tier Determination Run

8.23 maf release in WY 2020

Water Year 2020

Most Probable Inflow
10.80 maf (100% of average)

RECLAMATION
Managing Water in the West

Lake Powell & Lake Mead Operational Table

Operational Tiers for Water/Calendar Year 2020[1]

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)		15.5 - 19.3 (2008-2026)
	Upper Elevation Balancing Tier[2] Release 8.23 maf; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	
3,618.56 ft Jan 1, 2020 Projection		
3,575		9.5
	Mid-Elevation Release Tier Release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	
3,525		5.9
	Lower Elevation Balancing Tier Balance contents with a min/max release of 7.0 and 9.5 maf	
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]		22.9 (approx.)[2]
	Domestic Surplus or ICS Surplus Condition Deliver > 7.5 maf	
1,145		15.9
	Normal or ICS Surplus Condition Deliver ≥ 7.5 maf	
1,105		11.9
1,089.40 ft Jan 1, 2020 Projection		
1,075		9.4
	Shortage Condition Deliver 7.167[4] maf	
1,050		7.5
	Shortage Condition Deliver 7.083[5] maf	
1,025		5.8
	Shortage Condition Deliver 7.0[6] maf Further measures may be undertaken[7]	
1,000		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 operational tier determinations were based on August 2019 24-Month Study projections and will be documented in the draft 2020 AOP.

RECLAMATION
Managing Water in the West

Upper Elevation Balancing Tier

B. Upper Elevation Balancing Tier

1. In Water Years when the projected January 1 Lake Powell elevation is below the elevation stated in the Lake Powell Equalization Elevation Table and at or above 3,575 feet, the Secretary shall release 8.23 maf from Lake Powell if the projected January 1 Lake Mead elevation is at or above 1,075 feet.

2. If the projected January 1 Lake Powell elevation is below the elevation stated in the Lake Powell Equalization Elevation Table and at or above 3,575 feet and the projected January 1 Lake Mead elevation is below 1,075 feet, the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release not more than 9.0 maf and not less than 7.0 maf from Lake Powell in the Water Year.

3. When operating in the Upper Elevation Balancing Tier, if the April 24-Month Study projects the September 30 Lake Powell elevation to be greater than the elevation in the Lake Powell Equalization Elevation Table, the Equalization Tier will govern the operation of Lake Powell for the remainder of the Water Year (through September).

4. When operating under Section 6.B.1, if the April 24-Month Study projects the September 30 Lake Mead elevation to be below 1,075 feet and the September 30 Lake Powell elevation to be at or above 3,575 feet, the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release not more than 9.0 maf and not less than 8.23 maf from Lake Powell in the Water Year.

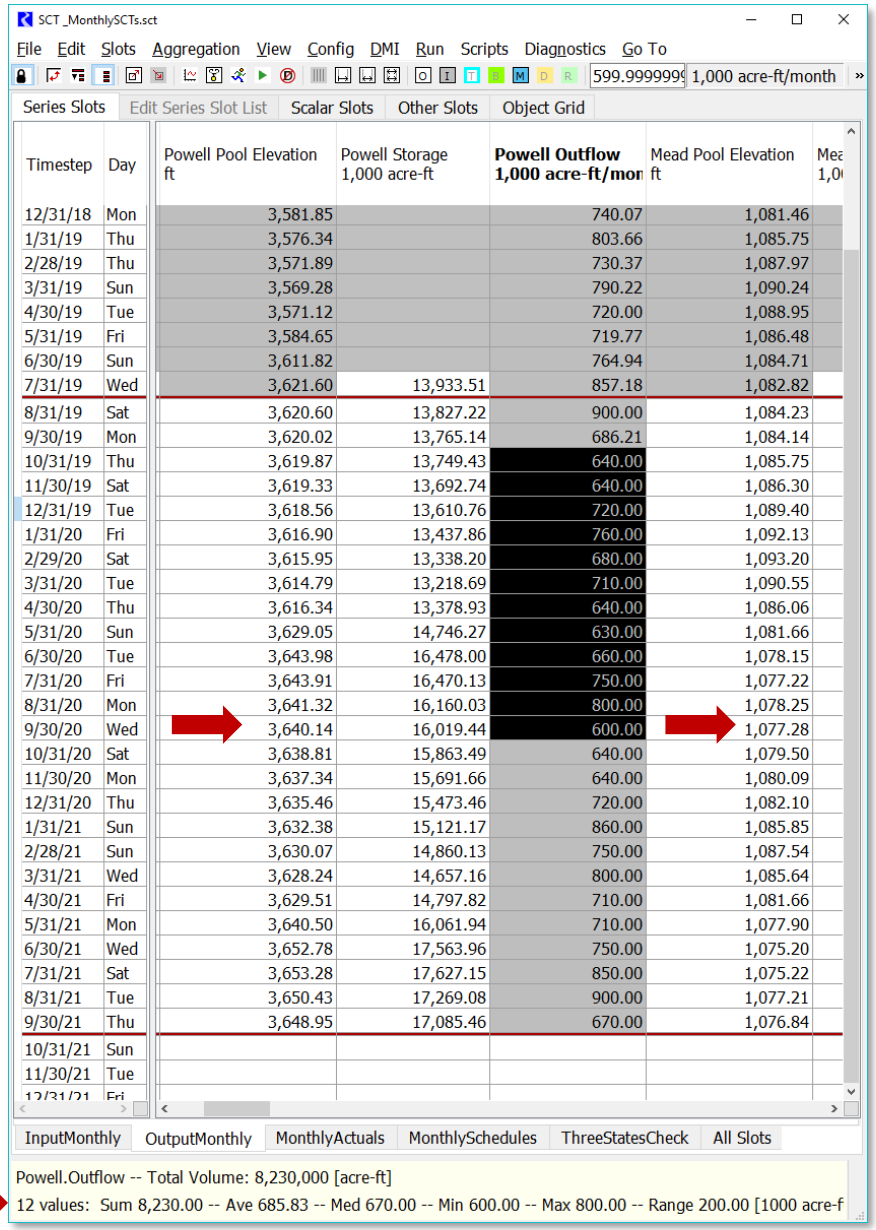
5. When Lake Powell is projected to be operating under Section 6.B.2. and more than 8.23 maf is projected to be released from Lake Powell during the upcoming Water Year, the Secretary shall recalculate the August 24-Month Study projection of the January 1 Lake Mead elevation to include releases above 8.23 maf that are scheduled to be released from Lake Powell during the months of October, November, and December of the upcoming Water Year, for the purposes of determining Normal or Shortage conditions pursuant to Sections 2.A. or 2.D. of these Guidelines.

August Determination

April Determination

RECLAMATION
Managing Water in the West

Official WY 2020 Operations Run


SCT _MonthlySCTs.sct

File Edit Slots Aggregation View Config DMI Run Scripts Diagnostics Go To

599.9999999 1,000 acre-ft/month

Series Slots | Edit Series Slot List | Scalar Slots | Other Slots | Object Grid

Timestep	Day	Powell Pool Elevation ft	Powell Storage 1,000 acre-ft	**Powell Outflow 1,000 acre-ft/mon**	Mead Pool Elevation ft	Mea 1,0
12/31/18	Mon	3,581.85		740.07	1,081.46	
1/31/19	Thu	3,576.34		803.66	1,085.75	
2/28/19	Thu	3,571.89		730.37	1,087.97	
3/31/19	Sun	3,569.28		790.22	1,090.24	
4/30/19	Tue	3,571.12		720.00	1,088.95	
5/31/19	Fri	3,584.65		719.77	1,086.48	
6/30/19	Sun	3,611.82		764.94	1,084.71	
7/31/19	Wed	3,621.60	13,933.51	857.18	1,082.82	
8/31/19	Sat	3,620.60	13,827.22	900.00	1,084.23	
9/30/19	Mon	3,620.02	13,765.14	686.21	1,084.14	
10/31/19	Thu	3,619.87	13,749.43	640.00	1,085.75	
11/30/19	Sat	3,619.33	13,692.74	640.00	1,086.30	
12/31/19	Tue	3,618.56	13,610.76	720.00	1,089.40	
1/31/20	Fri	3,616.90	13,437.86	760.00	1,092.13	
2/29/20	Sat	3,615.95	13,338.20	680.00	1,093.20	
3/31/20	Tue	3,614.79	13,218.69	710.00	1,090.55	
4/30/20	Thu	3,616.34	13,378.93	640.00	1,086.06	
5/31/20	Sun	3,629.05	14,746.27	630.00	1,081.66	
6/30/20	Tue	3,643.98	16,478.00	660.00	1,078.15	
7/31/20	Fri	3,643.91	16,470.13	750.00	1,077.22	
8/31/20	Mon	3,641.32	16,160.03	800.00	1,078.25	
9/30/20	Wed	3,640.14	16,019.44	600.00	1,077.28	
10/31/20	Sat	3,638.81	15,863.49	640.00	1,079.50	
11/30/20	Mon	3,637.34	15,691.66	640.00	1,080.09	
12/31/20	Thu	3,635.46	15,473.46	720.00	1,082.10	
1/31/21	Sun	3,632.38	15,121.17	860.00	1,085.85	
2/28/21	Sun	3,630.07	14,860.13	750.00	1,087.54	
3/31/21	Wed	3,628.24	14,657.16	800.00	1,085.64	
4/30/21	Fri	3,629.51	14,797.82	710.00	1,081.66	
5/31/21	Mon	3,640.50	16,061.94	710.00	1,077.90	
6/30/21	Wed	3,652.78	17,563.96	750.00	1,075.20	
7/31/21	Sat	3,653.28	17,627.15	850.00	1,075.22	
8/31/21	Tue	3,650.43	17,269.08	900.00	1,077.21	
9/30/21	Thu	3,648.95	17,085.46	670.00	1,076.84	
10/31/21	Sun					
11/30/21	Tue					
12/31/21	Fri					

InputMonthly | OutputMonthly | MonthlyActuals | MonthlySchedules | ThreeStatesCheck | All Slots

Powell.Outflow -- Total Volume: 8,230,000 [acre-ft]

12 values: Sum 8,230.00 -- Ave 685.83 -- Med 670.00 -- Min 600.00 -- Max 800.00 -- Range 200.00 [1000 acre-f

Water Year 2020

Based on Tier Determination Run:
Start with Powell Release = 8.23 maf.

Operating under Upper Elevation Balancing Tier (6.B.1).

RECLAMATION
Managing Water in the West

Upper Elevation Balancing Tier

B. Upper Elevation Balancing Tier

1. In Water Years when the projected January 1 Lake Powell elevation is below the elevation stated in the Lake Powell Equalization Elevation Table and at or above 3,575 feet, the Secretary shall release 8.23 maf from Lake Powell if the projected January 1 Lake Mead elevation is at or above 1,075 feet.

2. If the projected January 1 Lake Powell elevation is below the elevation stated in the Lake Powell Equalization Elevation Table and at or above 3,575 feet and the projected January 1 Lake Mead elevation is below 1,075 feet, the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release not more than 9.0 maf and not less than 7.0 maf from Lake Powell in the Water Year.

3. When operating in the Upper Elevation Balancing Tier, if the April 24-Month Study projects the September 30 Lake Powell elevation to be greater than the elevation in the Lake Powell Equalization Elevation Table, the Equalization Tier will govern the operation of Lake Powell for the remainder of the Water Year (through September).

4. When operating under Section 6.B.1, if the April 24-Month Study projects the September 30 Lake Mead elevation to be below 1,075 feet and the September 30 Lake Powell elevation to be at or above 3,575 feet, the Secretary shall balance the contents of Lake Mead and Lake Powell, but shall release not more than 9.0 maf and not less than 8.23 maf from Lake Powell in the Water Year.

5. When Lake Powell is projected to be operating under Section 6.B.2. and more than 8.23 maf is projected to be released from Lake Powell during the upcoming Water Year, the Secretary shall recalculate the August 24-Month Study projection of the January 1 Lake Mead elevation to include releases above 8.23 maf that are scheduled to be released from Lake Powell during the months of October, November, and December of the upcoming Water Year, for the purposes of determining Normal or Shortage conditions pursuant to Sections 2.A. or 2.D. of these Guidelines.

August Determination

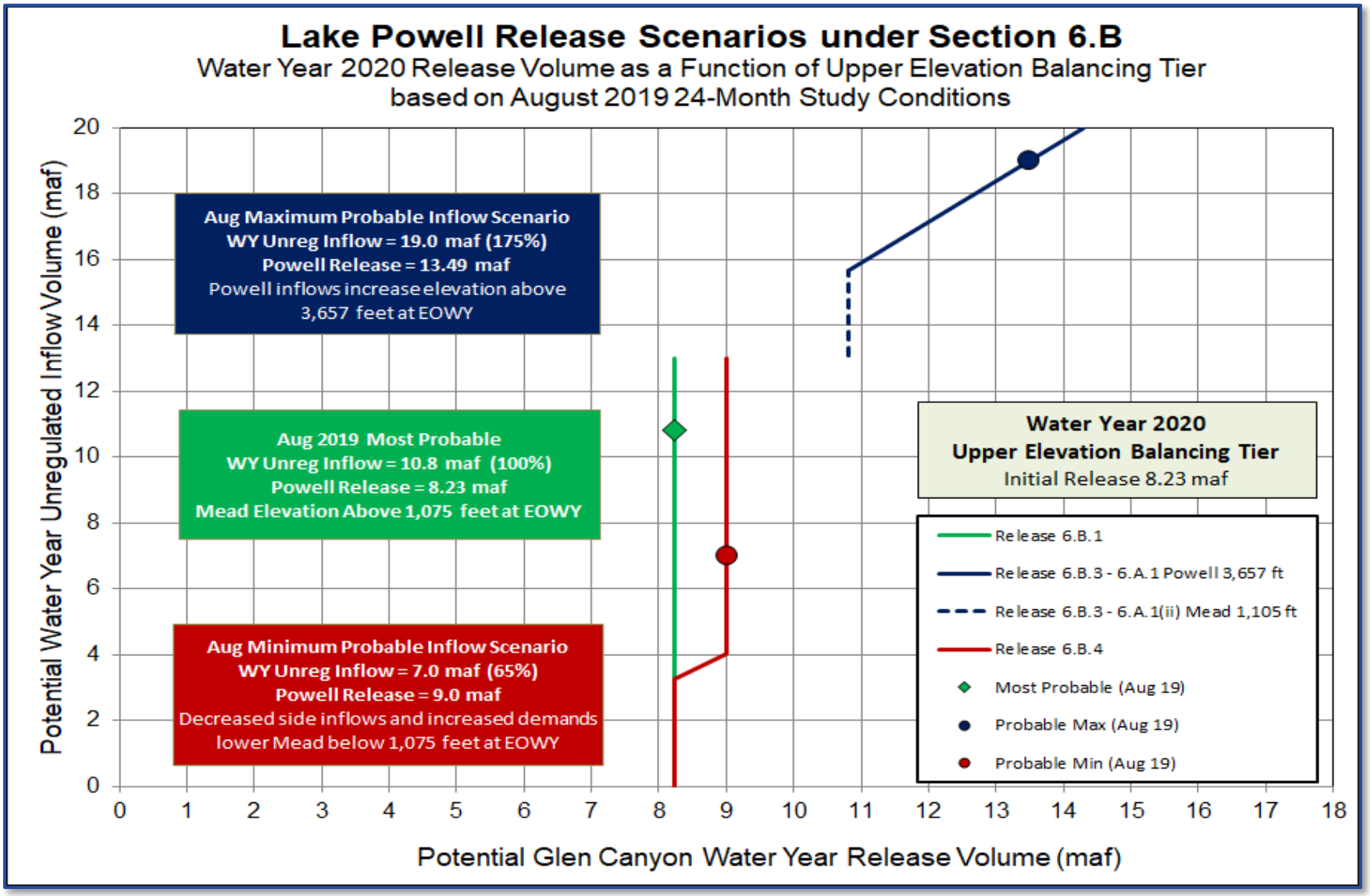
April Determination

RECLAMATION
Managing Water in the West

Equalization Tier

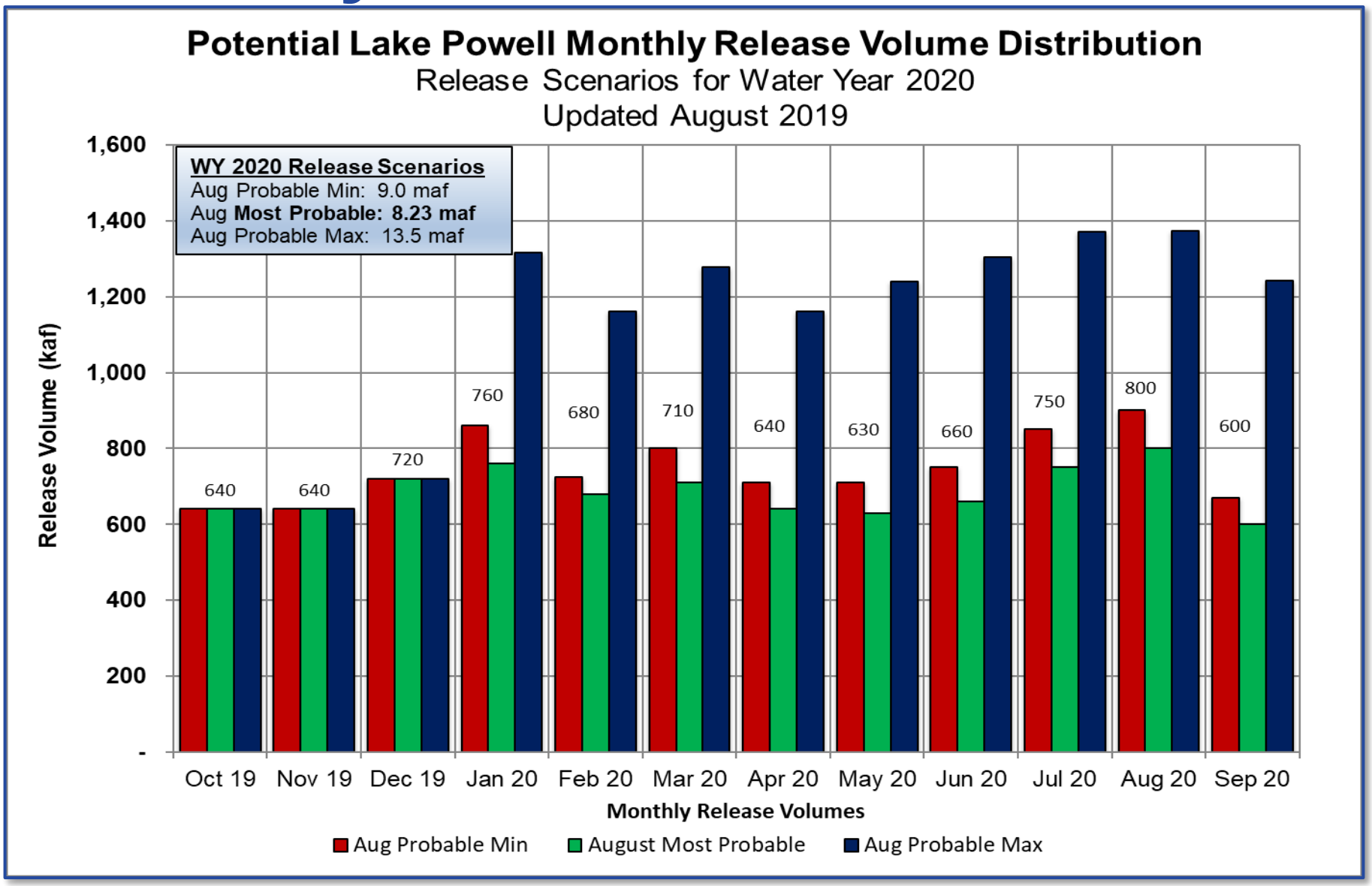
1. In Water Years when Lake Powell elevation is projected on January 1 to be at or above the elevation stated in the Lake Powell Equalization Elevation Table, an amount of water will be released from Lake Powell to Lake Mead at a rate greater than 8.23 maf per Water Year to the extent necessary to avoid spills, or equalize storage in the two reservoirs, or otherwise to release 8.23 maf from Lake Powell. The Secretary shall release at least 8.23 maf per Water Year and shall release additional water to the extent that the additional releases will not cause Lake Powell content to be below the elevation stated in the Lake Powell Equalization Elevation Table or cause Lake Mead content to exceed that of Lake Powell; provided, however, if Lake Powell reaches the elevation stated in the Lake Powell Equalization Elevation Table for that Water Year and the September 30 projected Lake Mead elevation is below elevation 1,105 feet, the Secretary shall release additional water from Lake Powell to Lake Mead until the first of the following conditions is projected to occur on September 30: (i) the reservoirs fully equalize; (ii) Lake Mead reaches elevation 1,105 feet; or (iii) Lake Powell reaches 20 feet below the elevation in the Lake Powell Equalization Elevation Table for that year.

Release Scenarios



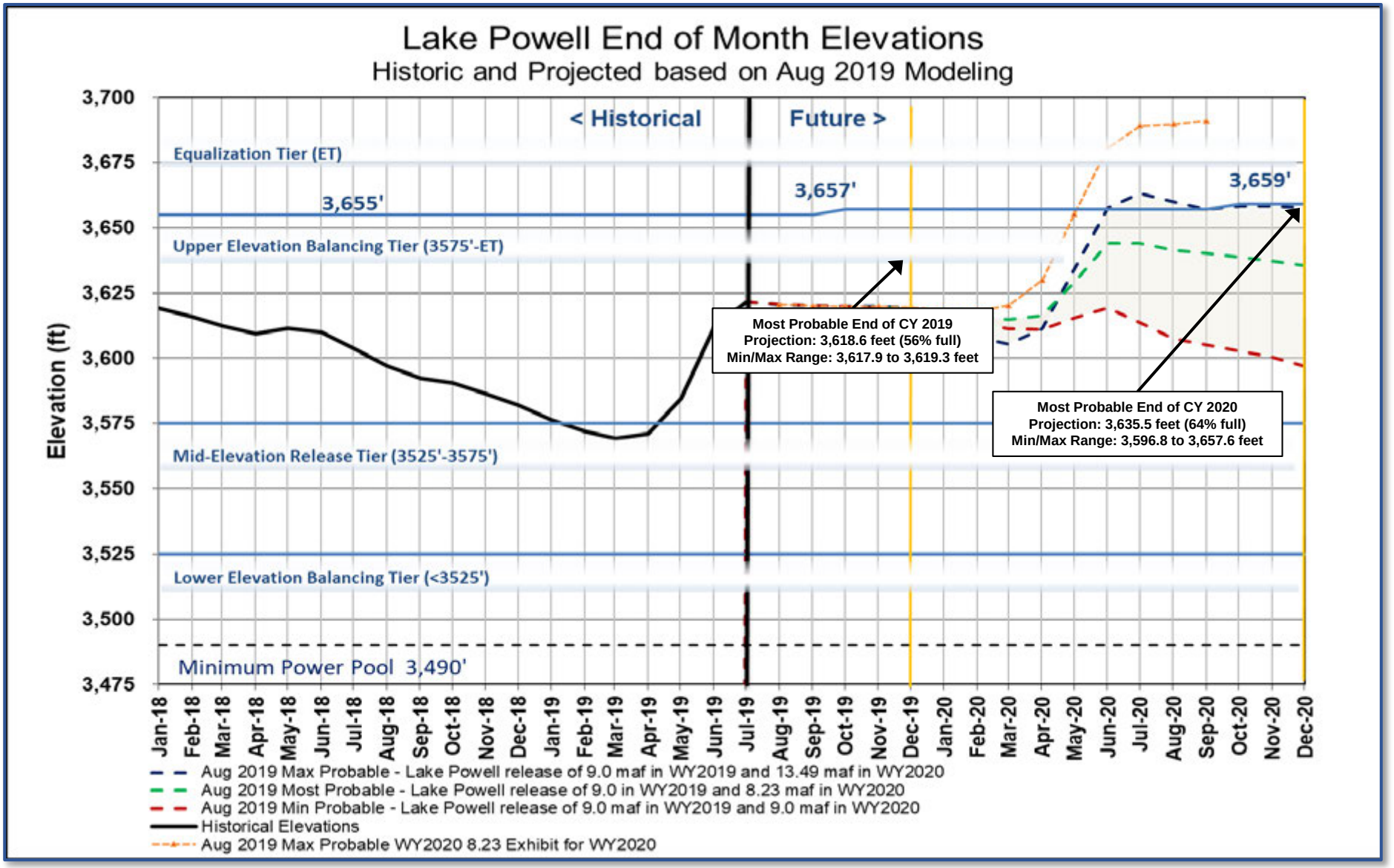
RECLAMATION
Managing Water in the West

Monthly Release Volumes



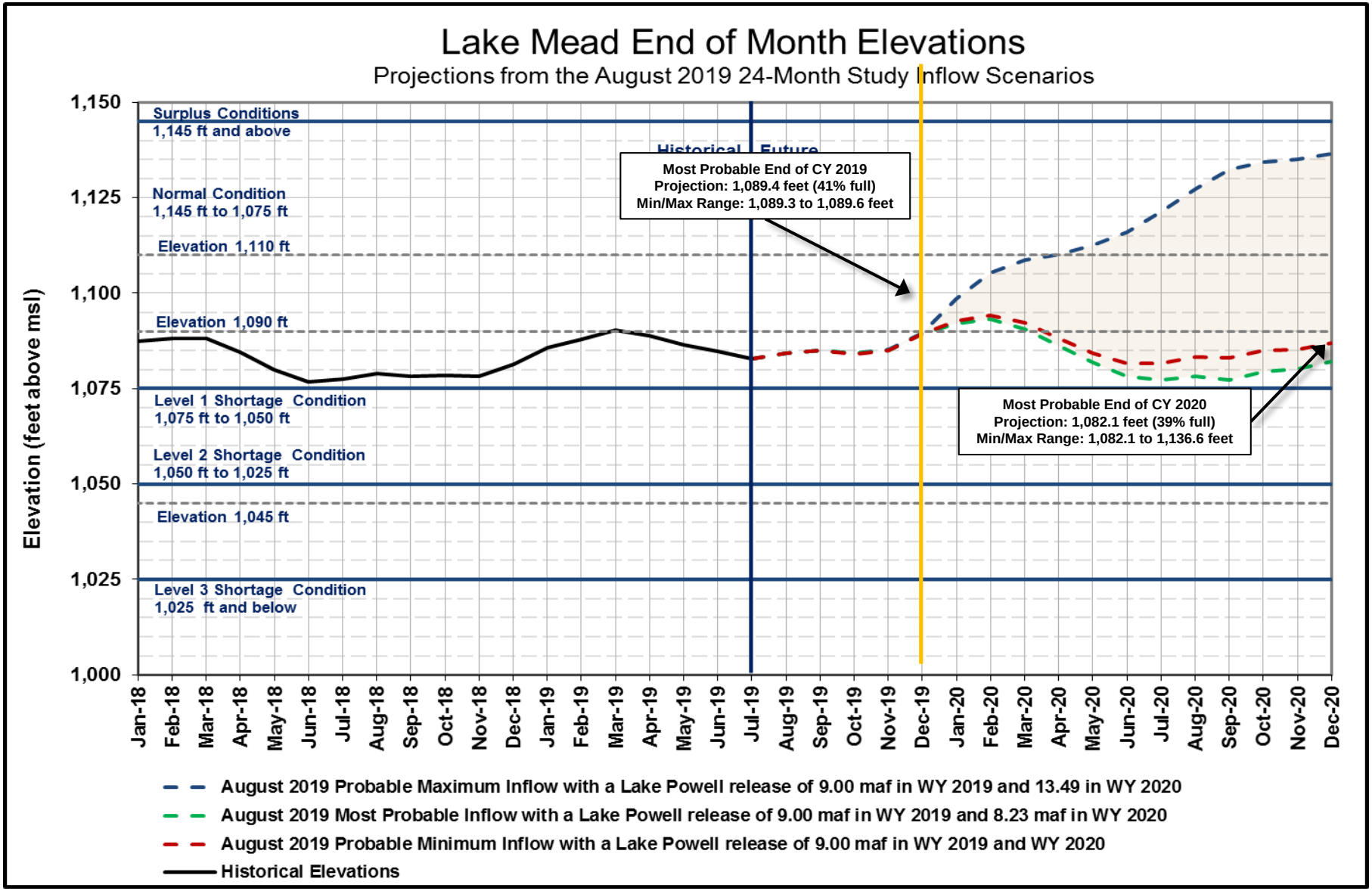
RECLAMATION
Managing Water in the West

Powell Elevations



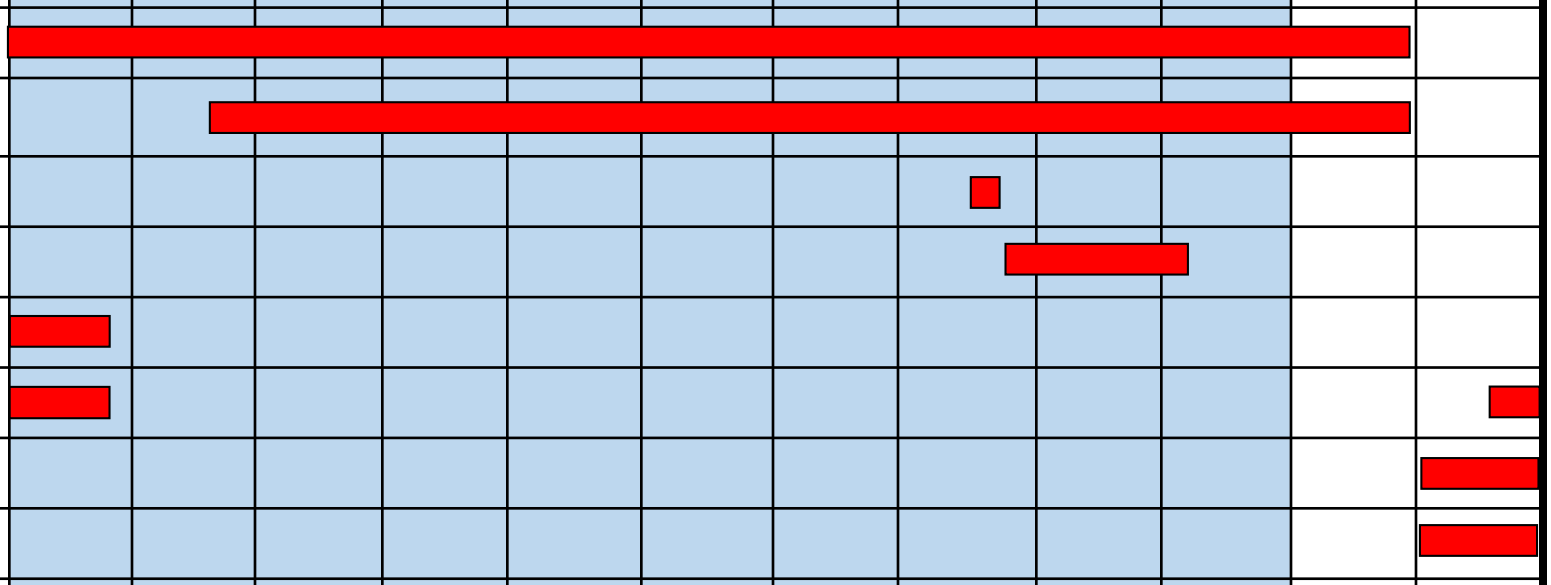
RECLAMATION
Managing Water in the West

Mead Elevations



RECLAMATION
Managing Water in the West

Glen Canyon Power Plant Planned Unit Outage Schedule for Water Year 2019



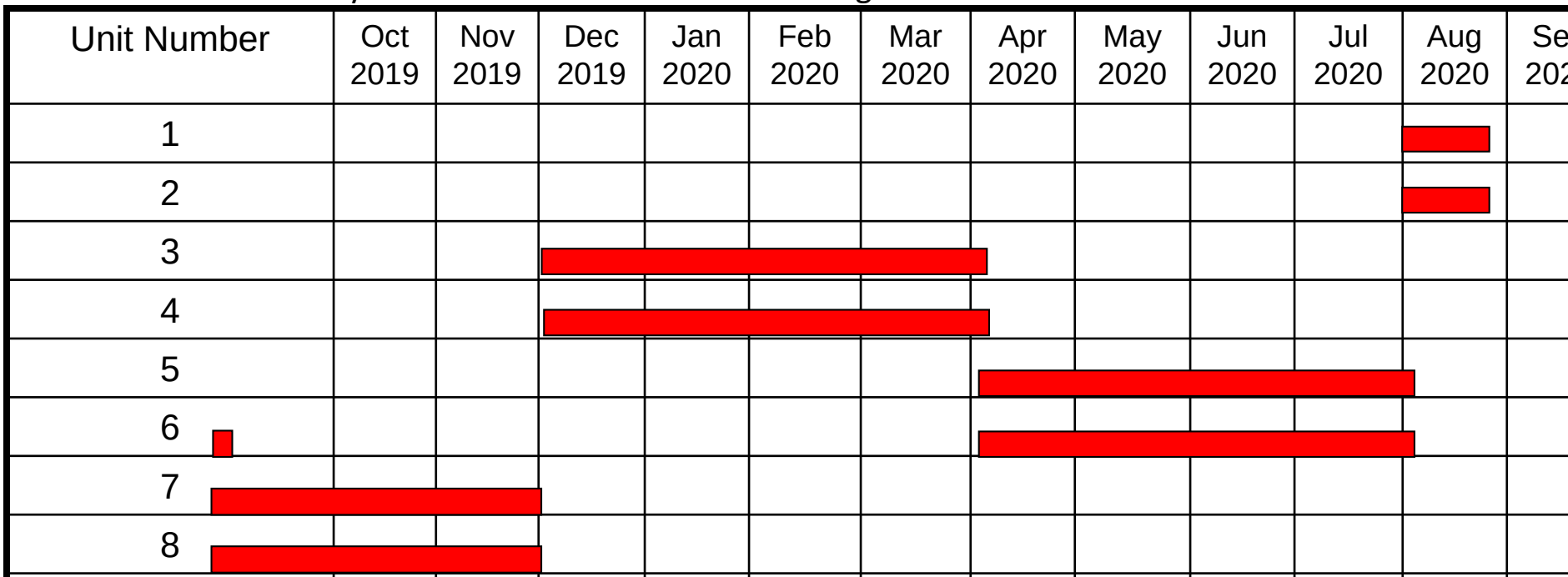
Unit Number	Oct 2018	Nov 2018	Dec 2018	Jan 2019	Feb 2019	Mar 2019	Apr 2019	May 2019	Jun 2019	Jul 2019	Aug 2019	Sep 2019	
Units Available	5	7	6	6	6	5	5	5	5	5/6	6	5	
Capacity (cfs)	**16,000**	**19,700**	**19,400**	**19,300**	**15,700**	**18,600**	**18,600**	**15,300**	**15,300**	**15,600**	**20,800**	**17,000**	
Capacity (kaf/month)	1,050	1,300	1,190	1,190	1,070	1,140	1,110	1,100	940	1,090	1,290	1,100	
Max (kaf) [1]	625	662	740	804	730	790	720	720	765	860	900	686	9.0
Most (kaf) [2]	625	662	740	804	730	790	720	720	765	860	900	686	9.0
Min (kaf) [1]	625	662	740	804	730	790	720	720	765	860	900	686	9.0

1 Projected release, based on Aug 2019 Min and Max Probable Inflow Projections and 24-Month Study model runs (updated 8-19-2019)

2 Projected release, based on Aug 2019 Most Probable Inflow Projections and 24-Month model runs

RECLAMATION
Managing Water in the West

Glen Canyon Power Plant Planned Unit Outage Schedule for Water Year 2020



Unit Number	Oct 2019	Nov 2019	Dec 2019	Jan 2020	Feb 2020	Mar 2020	Apr 2020	May 2020	Jun 2020	Jul 2020	Aug 2020	Se 202
1												
2												
3												
4												
5												
6												
7												
8												
Units Available	5/6	6	6	6	6	6	6	6	6	6	6	6
Capacity (cfs)	**20,700**	**20,700**	**20,700**	**20,700**	**20,700**	**20,700**	**20,700**	**20,900**	**21,300**	**21,300**	**21,200**	**21,2**
Capacity (kaf/month)	1,100	1,230	1,270	1,315	1,190	1,280	1,230	1,320	1,310	1,375	1,375	1,3
Max (kaf) [1]	640	640	720	1315	1161	1278	1160	1240	1304	1371	1372	124
Most (kaf) [2]	640	640	720	760	680	710	640	630	660	750	800	60
Min (kaf) [1]	640	640	720	860	750	800	710	710	750	850	900	67

13.5
8.23
9.0

1 Projected release, based on Aug 2019 Min and Max Probable Inflow Projections and 24-Month Study model runs (updated 8-19-2019)

2 Projected release, based on Aug 2019 Most Probable Inflow Projections and 24-Month Study model runs

RECLAMATION
Managing Water in the West

Upper Basin – Lake Powell
Percent of Traces with Event or System Condition
Results from June 2019 MTOM/CRSS[1,2,3,4] (values in percent)

Event or System Condition	2020	2021	2022	2023	2024
Equalization Tier (Powell ≥ Equalization [EQ] Elevation)	**13**	**28**	**25**	**30**	**28**
Equalization – annual release > 8.23 maf	*13*	*28*	*25*	*29*	*27*
Equalization – annual release = 8.23 maf	*0*	*0*	*0*	*<1*	*<1*
Upper Elevation Balancing Tier (Powell < EQ Elevation and ≥ 3,575 ft)	**87**	**71**	**58**	**54**	**54**
Upper Elevation Balancing – annual release > 8.23 maf	*6*	*43*	*35*	*34*	*33*
Upper Elevation Balancing – annual release = 8.23 maf	*80*	*27*	*23*	*20*	*20*
Upper Elevation Balancing – annual release < 8.23 maf	*0*	*<1*	*0*	*<1*	*<1*
Mid-Elevation Release Tier (Powell < 3,575 and ≥ 3,525 ft)	**0**	**2**	**17**	**16**	**16**
Mid-Elevation Release – annual release = 8.23 maf	*0*	*0*	*0*	*0*	*2*
Mid-Elevation Release – annual release = 7.48 maf	*0*	*2*	*17*	*16*	*14*
Lower Elevation Balancing Tier (Powell < 3,525 ft)	**0**	**0**	**<1**	**<1**	**2**
Below Minimum Power Pool (Powell < 3,490 ft)	0	0	0	0	<1

[1] Reservoir initial conditions on December 31, 2019 were simulated using MTOM based on the CBRFC unregulated inflow forecast ensemble dated June 4, 2019.
[2] Each of the 35 initial conditions from MTOM were coupled with 112 hydrologic inflow sequences based on resampling of the observed natural flow record from 1906-2017 for a total of 3,920 traces analyzed.
[3] Percentages shown in this table may not be representative of the full range of future possibilities that could occur with different modeling assumptions.
[4] Percentages shown may not sum to 100% due to rounding to the nearestpercent.

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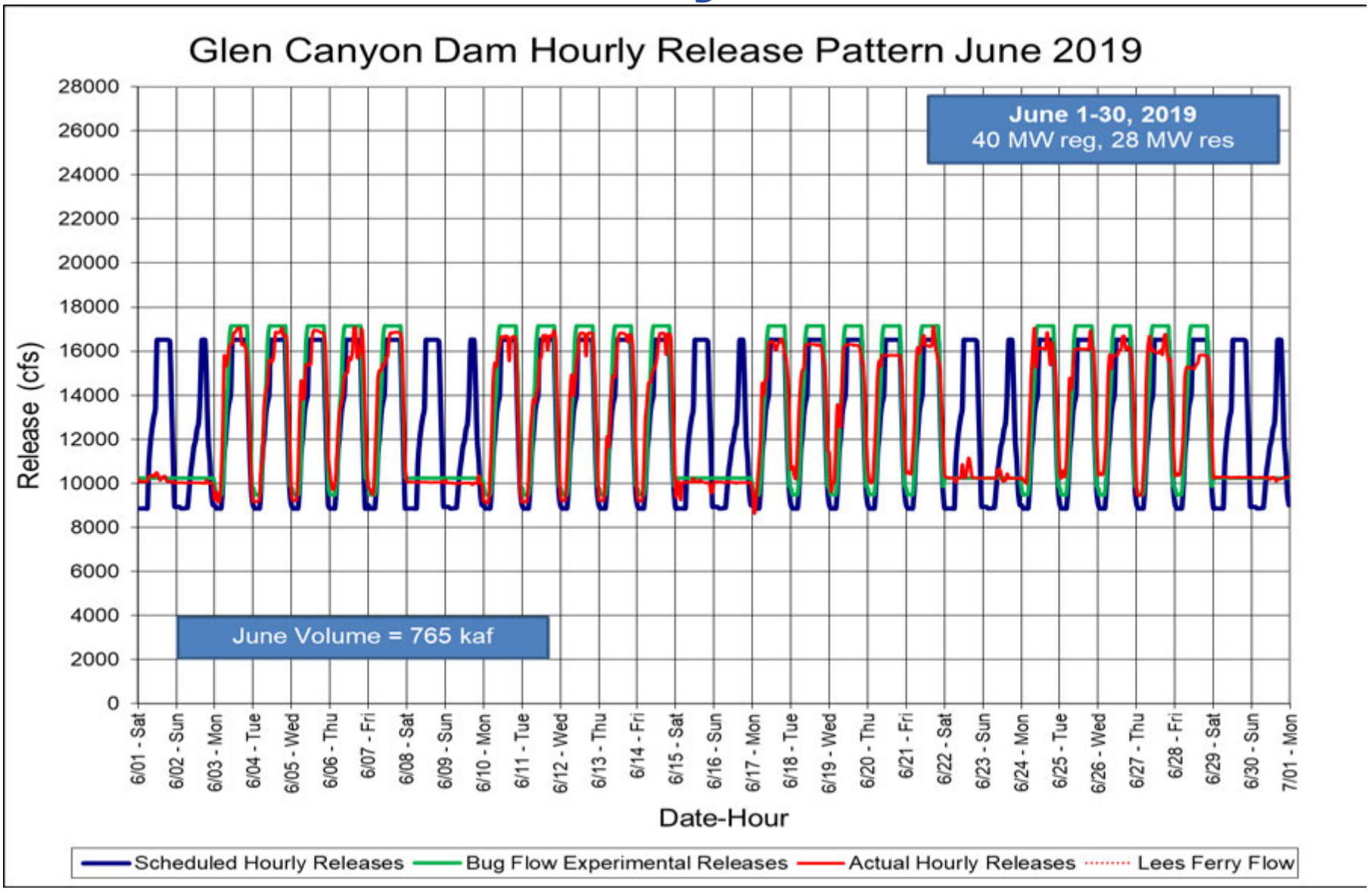
Managing Water in the West

June 2019 Hourly Releases



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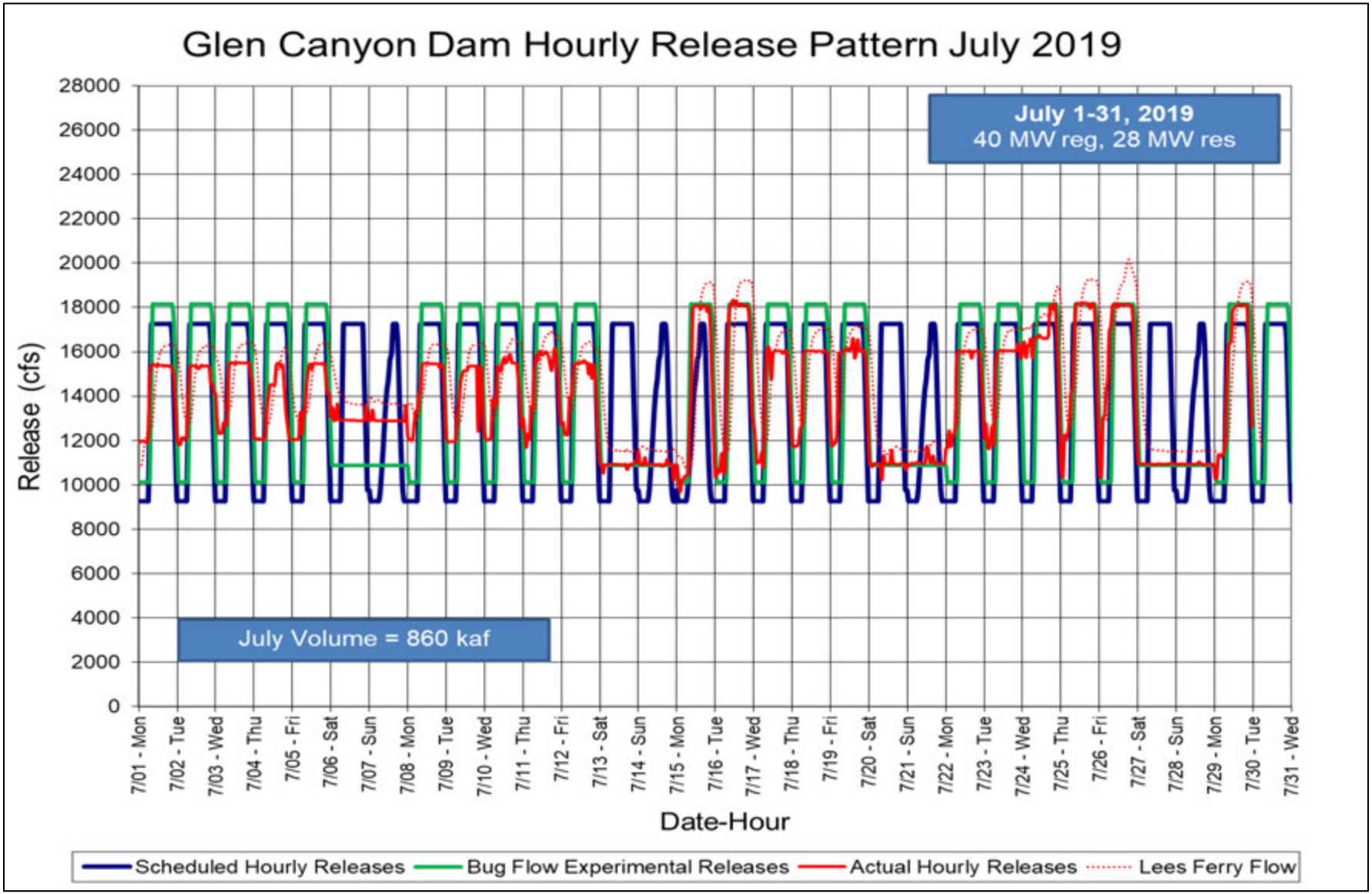
July 2019 Hourly Releases



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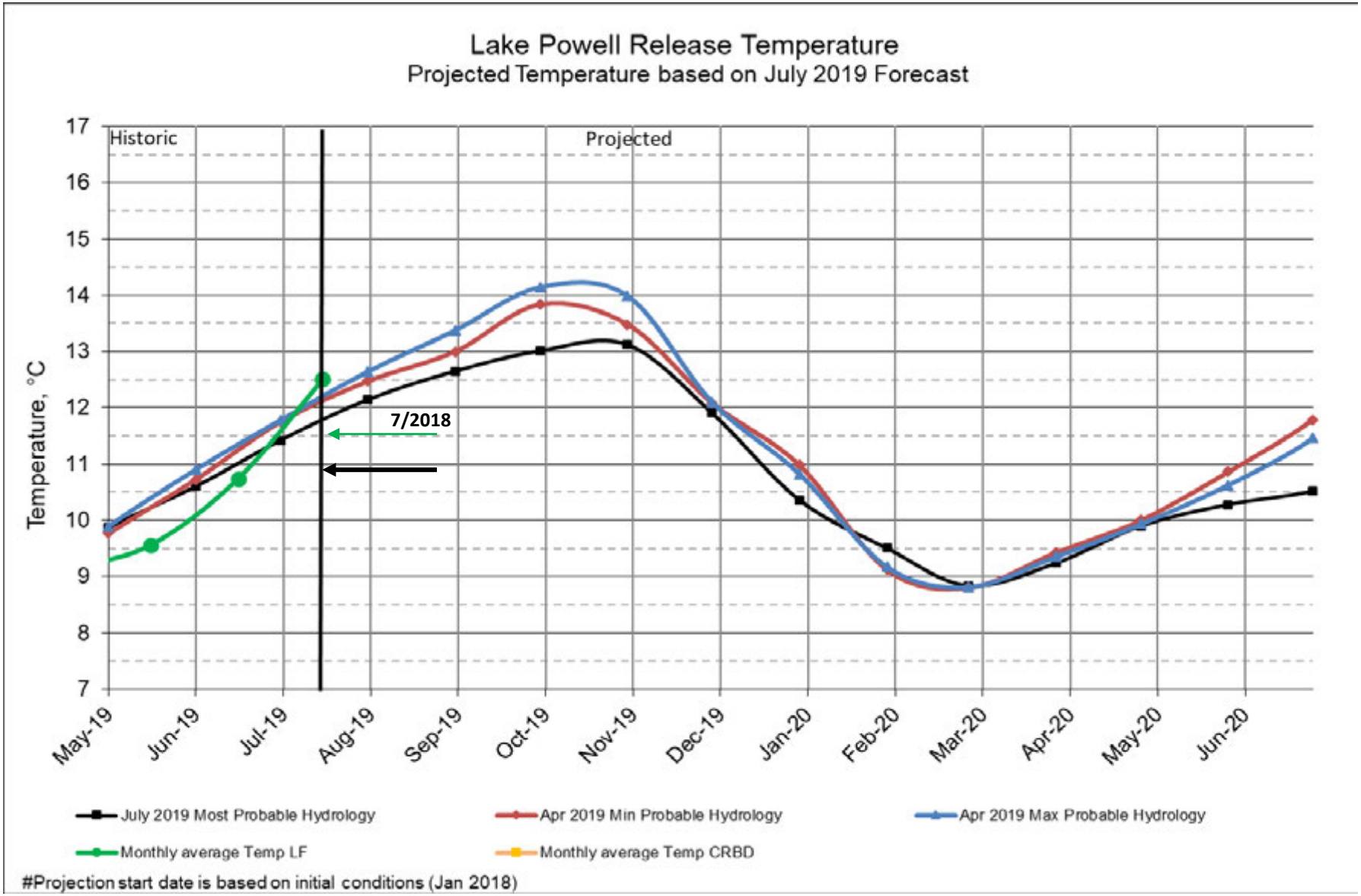
Lake Powell Release Temperatures



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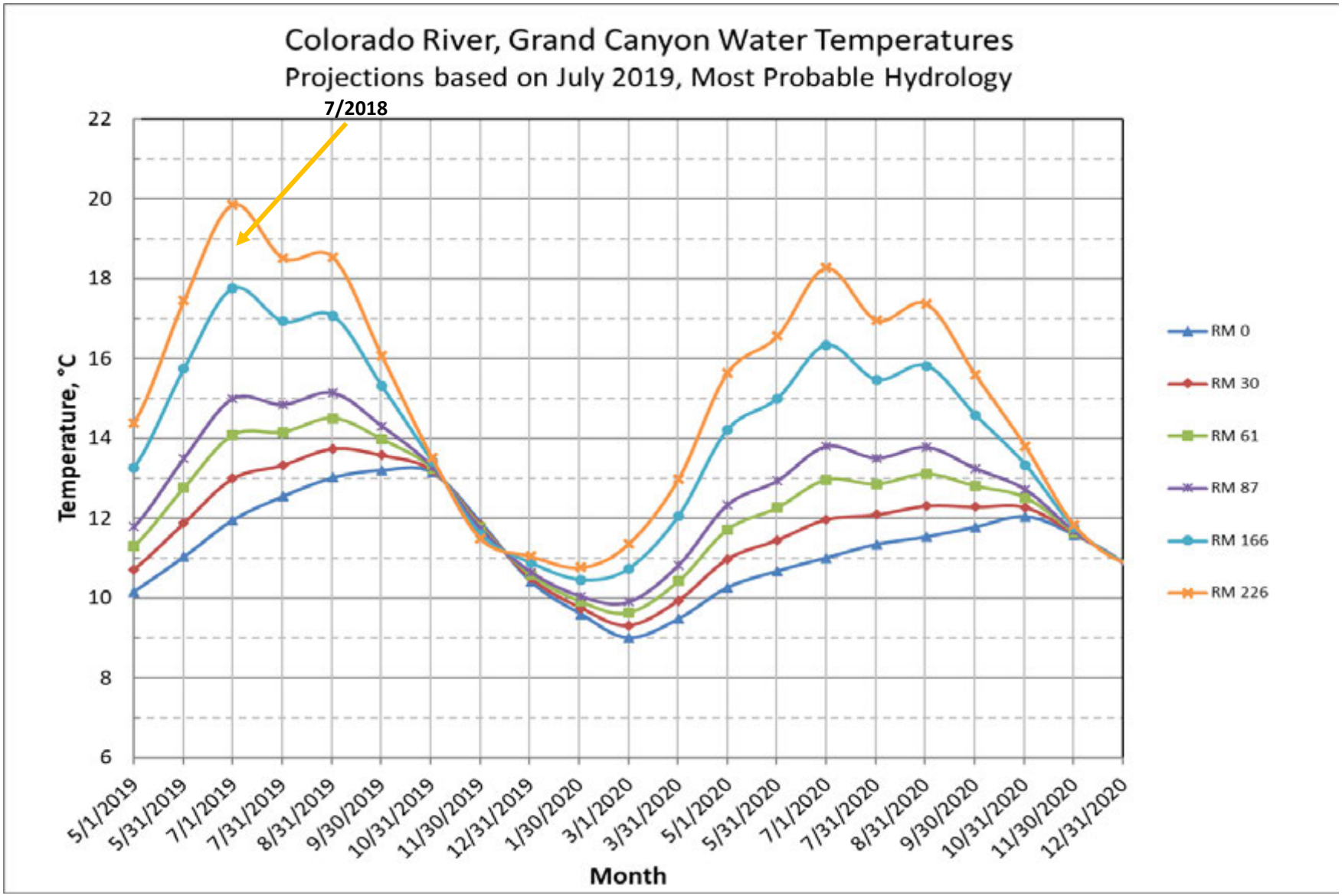
Grand Canyon Water Temperatures



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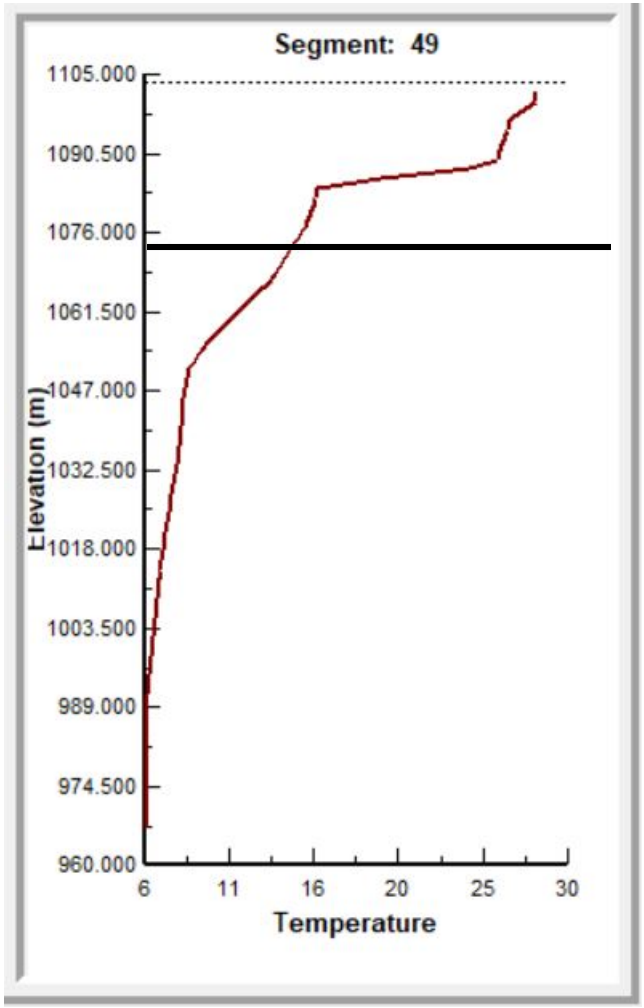
Lake Powell Reservoir Temperature Profile



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Questions and Discussion