BUREAU OF RECLAMATION

Glen Canyon Monthly Operations Call

Basin Hydrology and Operations

October 19, 2022

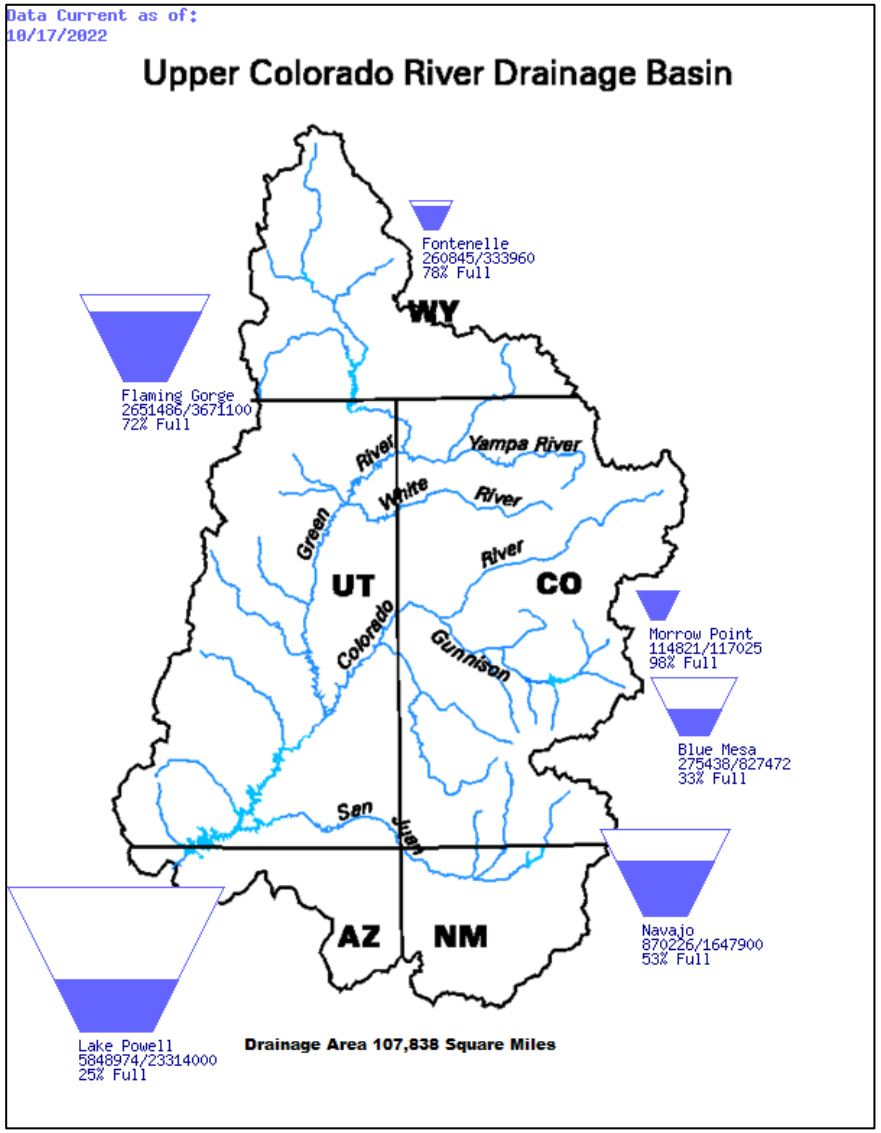
Background

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

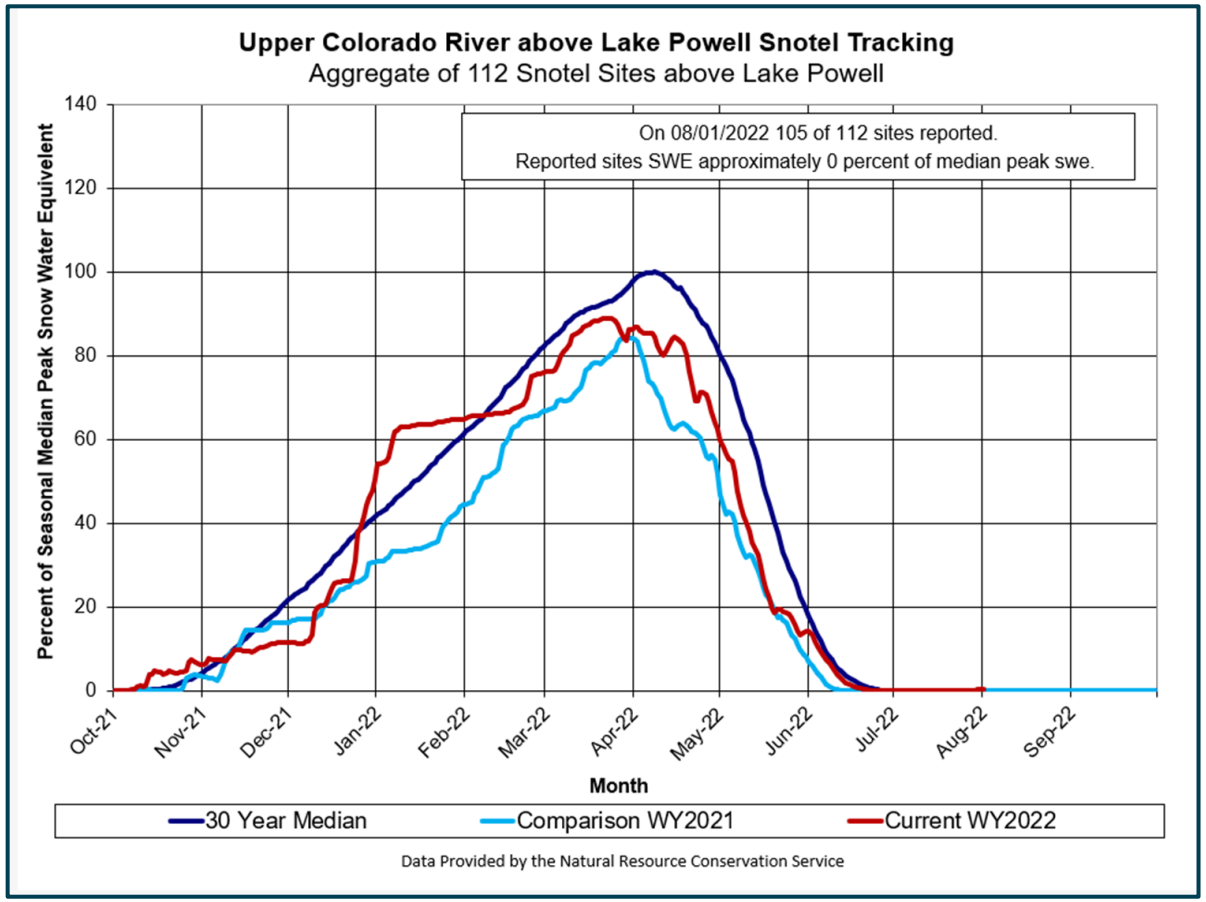
"Annually, Reclamation will develop a hydrograph based on the characteristics above. Reclamation will seek consensus on the annual hydrograph through monthly operational coordination calls with governmental entities, and regular meetings of the GCDAMP Technical Working Group (TWG) and AMWG. Reclamation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

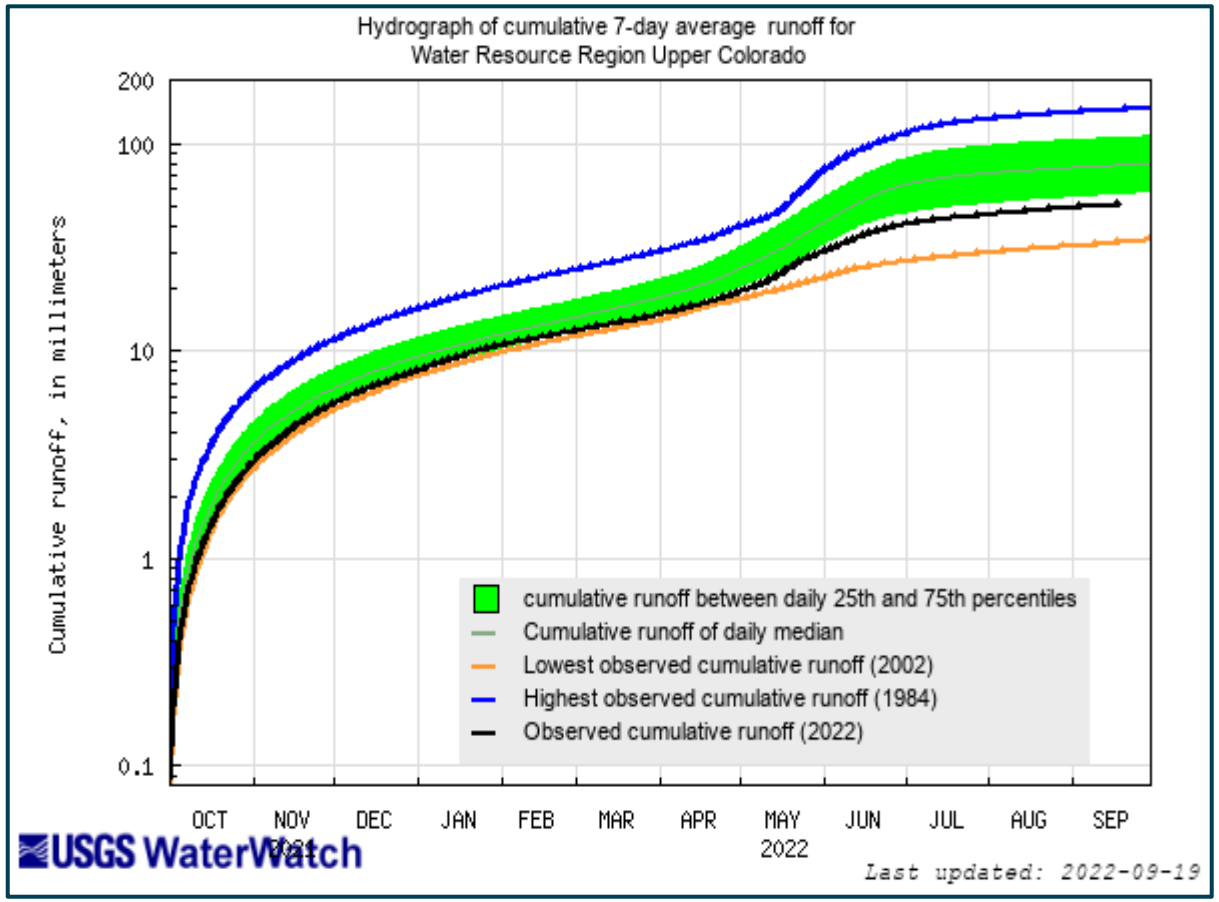
Upper Basin Storage (as of October 17, 2022)

Reservoir	Percent Current Live Storage	Current Live Storage (maf)	Live Storage Capacity (maf)	Elevation (feet)
Fontenelle	81	0.27	0.33	6,497.98
Flaming Gorge	73	2.68	3.67	6,012.97
Blue Mesa	35	0.29	0.82	7,457.69
Navajo	53	0.87	1.65	6,020.56
Lake Powell	25	5.80	23.31	3529.43
UC System Storage	34	10.04	29.79	
Total System Storage	33	19.55	58.48	



Upper Colorado SWE and Observed Inflows





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

Most Probable Forecast – October Final
Water Years 2022 (observed) and 2023 (forecasted)

April – July 2022
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 October 1, 2022

Reservoir	Inflow (kaf)	Percent of Avg[1]
Fontenelle	744	69
Flaming Gorge	897	64
Blue Mesa	661	73
Navajo	574	63
Powell	6,083	67

Water Year 2023
Unregulated Inflow Forecast
as of October 1, 2022

Reservoir	Inflow (kaf)	Percent of Avg[1]
Fontenelle	930	87
Flaming Gorge	1,215	86
Blue Mesa	820	91
Navajo	790	87
Powell	8,100	89

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

Upper Colorado Basin

Hydrology and Operations Projections Based on October 2022 24-Month Study

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

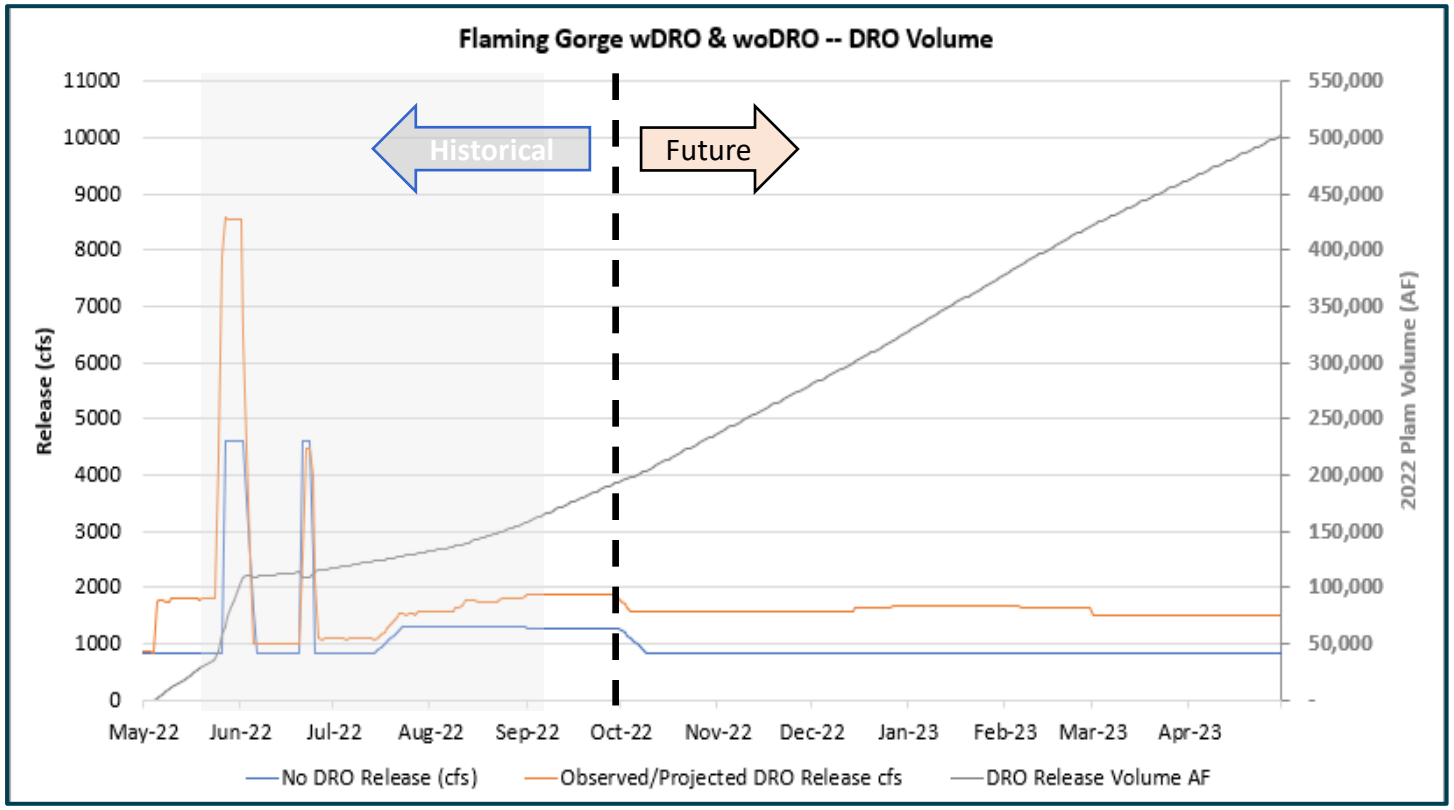
Drought Response Operations Agreement (DROA)

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 2022/2023 Plan



August 24-Month Study Projections

Upper Colorado Basin Region Operations

Lake Powell & Lake Mead Operational Table

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

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	
3,505.66 ft *Jan 1, 2023* *Projection*			1,025		5.8
	Lower Elevation Balancing Tier Balance contents with a min/max release of 7.0 and 9.5 maf			**Shortage Condition** Deliver 7.0[6] maf Further measures may be undertaken[7]	
3,490		4.0	1,000		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.

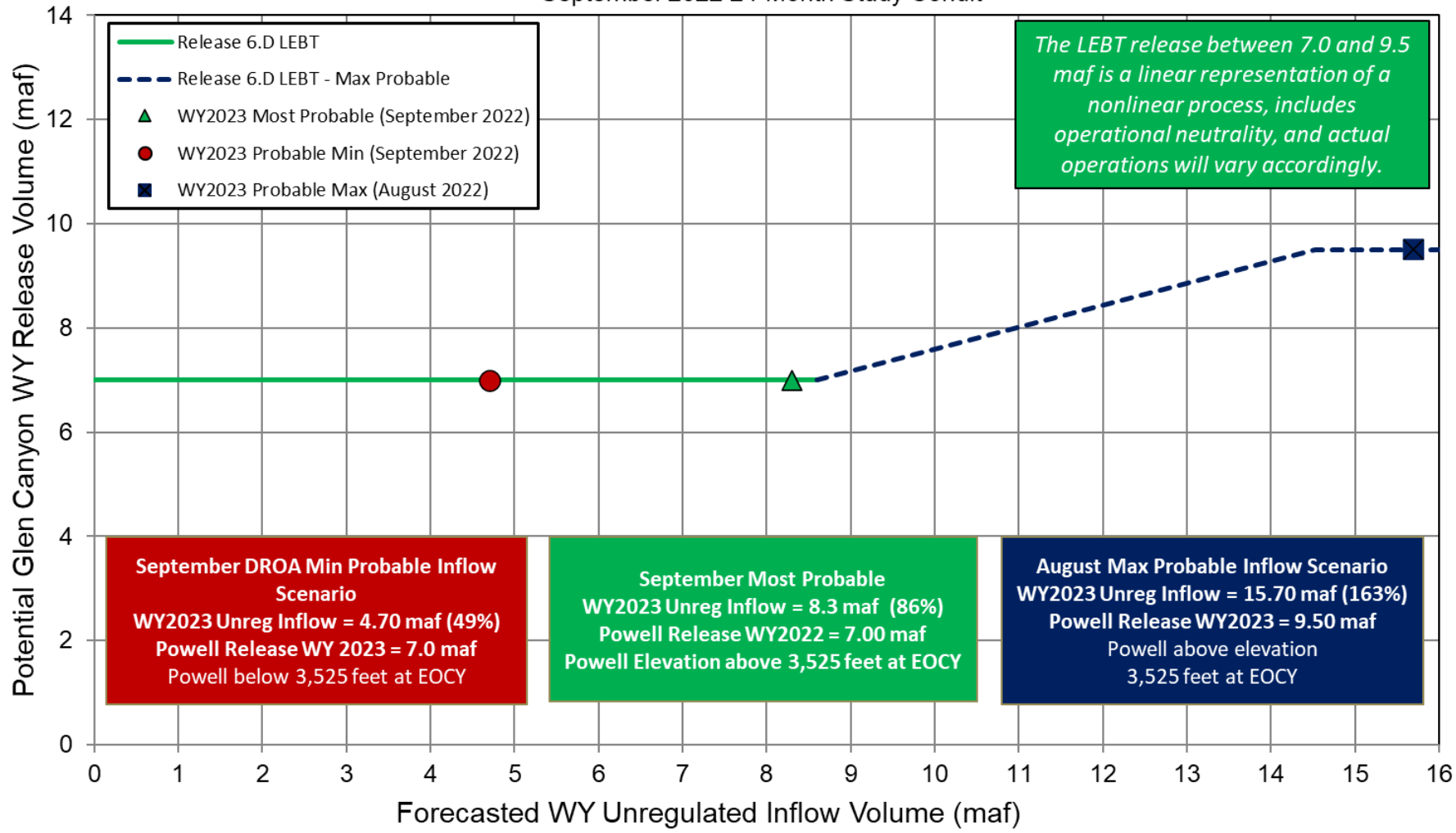
[2] The operating determination for WY 2023 is based on a projected elevation "as if" the 0.48 maf were delivered to Lake Mead with a Glen Canyon Dam release pattern of 8.23 maf.

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.

Lake Powell Release Scenarios under Section 6.D, Operational Neutrality and WY2023 Protect Powell Elevation 3,525 ft

Water Year 2023 Release Volume as a Function of the Lower Elevation Balancing Tier based on August and September 2022 24-Month Study Condit



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

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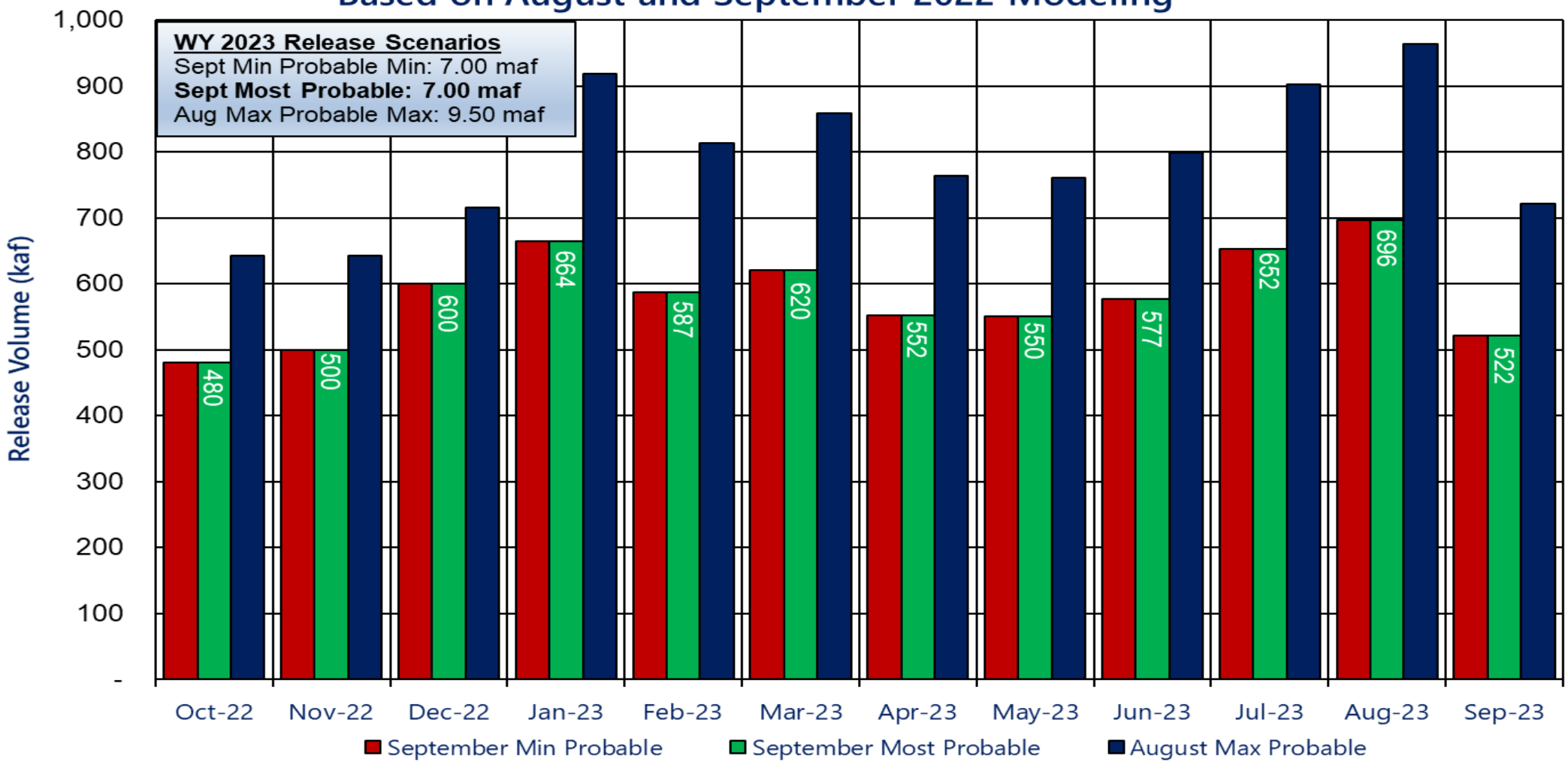
Potential Lake Powell Monthly Release Volume Distribution

Release Scenarios for Water Year 2023

Based on August and September 2022 Modeling



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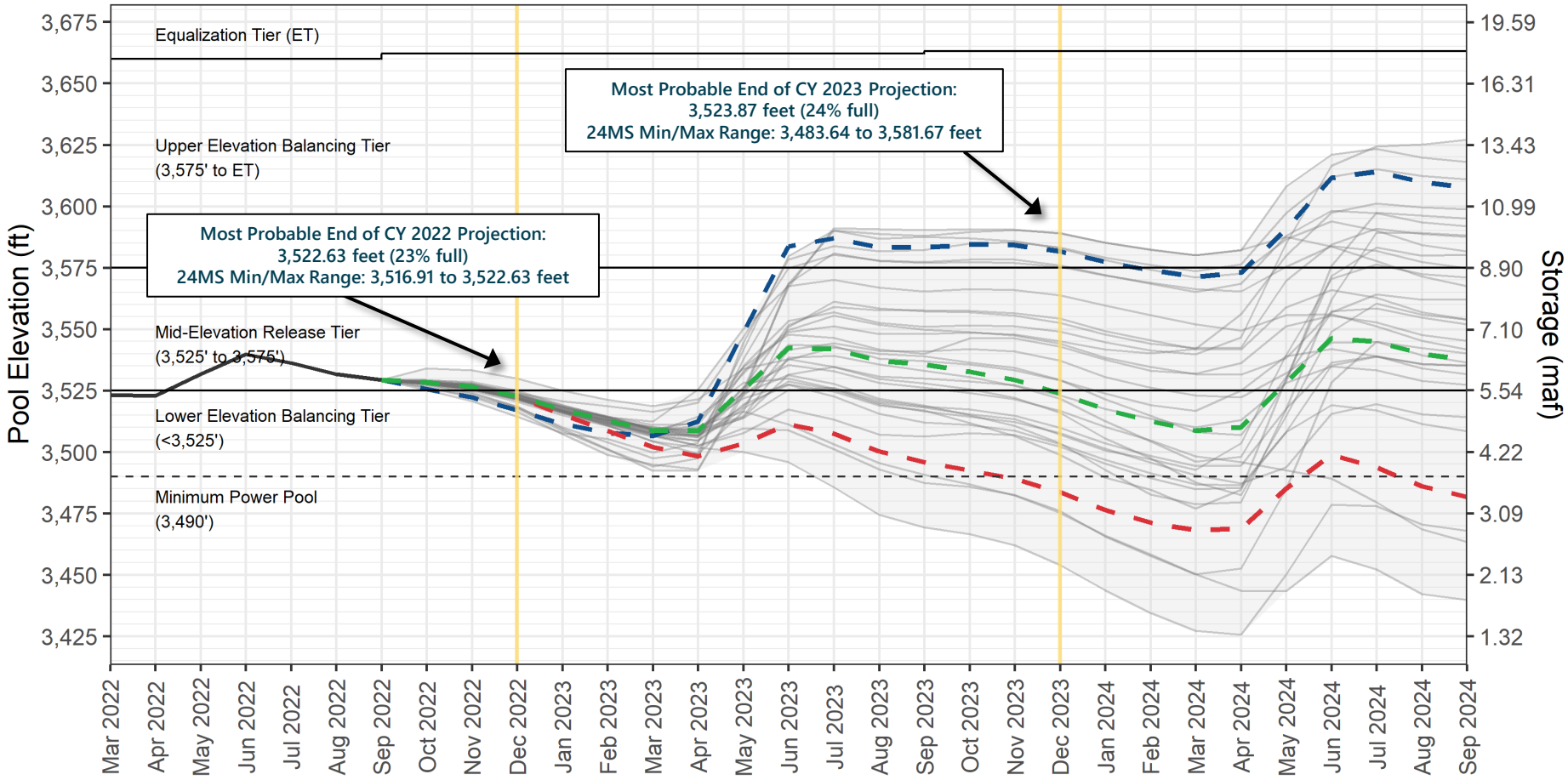
Reclamation Operational Modeling
Model Comparison

	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 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

Lake Powell End-of-Month Elevations[1]

CRMMS Projections from October 2022



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

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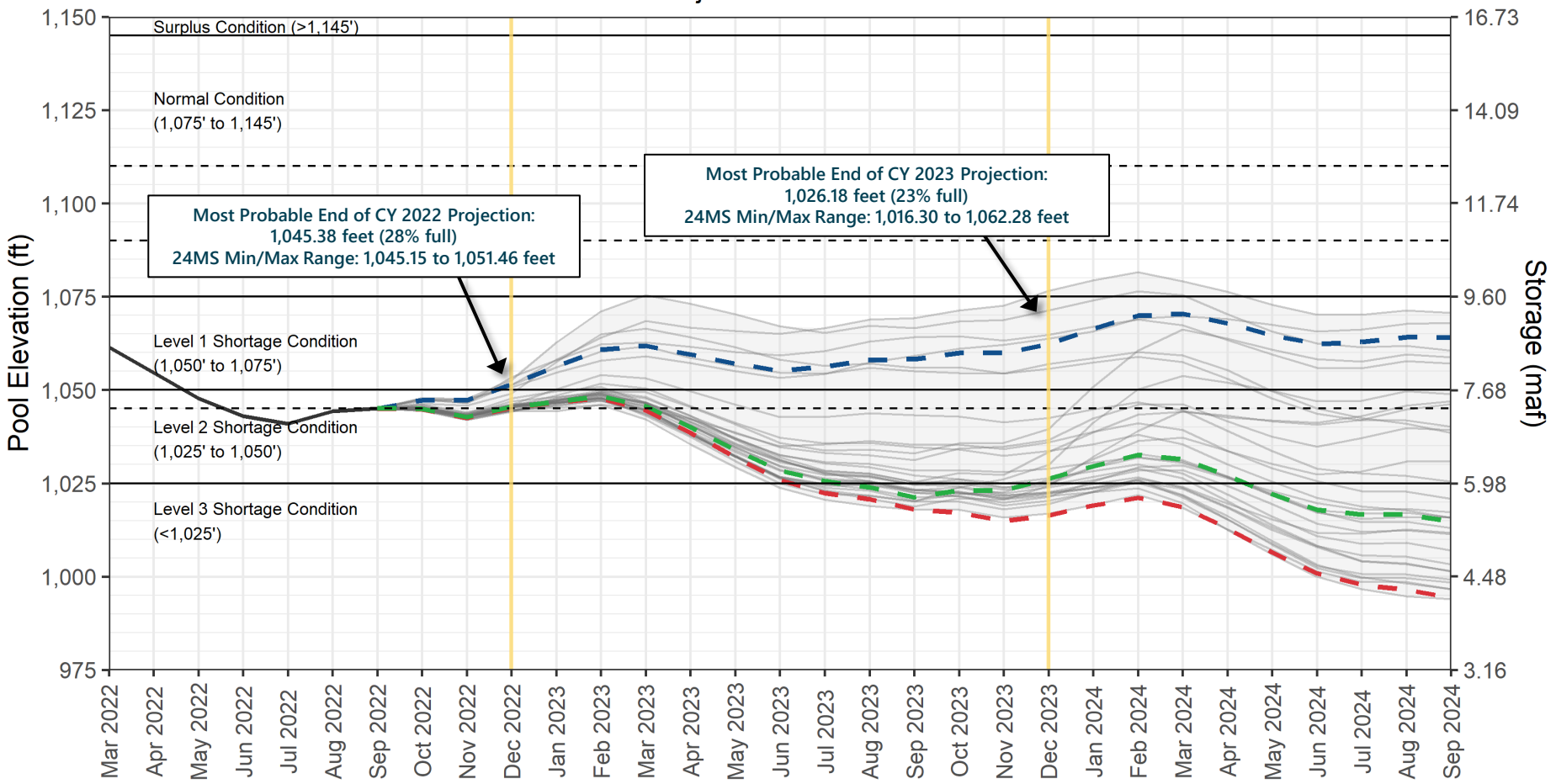
Upper Basin – Lake Powell
Percent of Traces with Event or System Condition
Results from August 2022 CRMMS-ESP (values in percent) [1,2,3,4,5,6,7]

Event or System Condition	2023	2024	2025	2026	2027[5]
Equalization Tier (Powell ≥ Equalization [EQ] Elevation)	**0**	**0**	**3**	**13**	**13**
Equalization – annual release > 8.23 maf	*0*	*0*	*3*	*13*	*13*
Equalization – annual release = 8.23 maf	*0*	*0*	*0*	*0*	*0*
Upper Elevation Balancing Tier (Powell < EQ Elevation and ≥ 3,575 ft)	**0**	**13**	**27**	**23**	**33**
Upper Elevation Balancing – annual release > 8.23 maf	*0*	*10*	*27*	*23*	*33*
Upper Elevation Balancing – annual release = 8.23 maf	*0*	*0*	*0*	*0*	*0*
Upper Elevation Balancing – annual release < 8.23 maf	*0*	*3*	*0*	*0*	*0*
Mid-Elevation Release Tier (Powell < 3,575 and ≥ 3,525 ft)	**0**	**37**	**37**	**33**	**27**
Mid-Elevation Release – annual release = 8.23 maf	*0*	*0*	*7*	*7*	*3*
Mid-Elevation Release – annual release = 7.48 maf	*0*	*37*	*30*	*27*	*23*
Lower Elevation Balancing Tier (Powell < 3,525 ft)	**100**	**50**	**33**	**30**	**27**
Lower Elevation Balancing – annual release > 8.23 maf	*23*	*20*	*13*	*13*	*17*
Lower Elevation Balancing – annual release < 8.23 maf	*77*	*30*	*20*	*17*	*10*

Notes:
[1] Modeled operations include the 2007 Interim Guidelines, Upper Basin Drought Response Operations, Lower Basin Drought Contingency Plan, Minute 323, including the Binational Water Scarcity Contingency Plan, 2022 Drought Response Operations Plan, and 2022 Glen Canyon Dam operational adjustment.
[2] The projected operating tiers are computed "as if" the 480 kaf reduced release from Glen Canyon Dam in water year 2022 was delivered to Lake Mead.
[3] When Lake Powell is operating in the Lower Elevation Balancing Tier in water year 2023 or 2024, balancing releases were limited (with a minimum of 7.0 maf) to protect Lake Powell from declining below 3,525 feet at the end of December 2023 or 2024.
[4] Reservoir conditions for 2022-2027 were simulated using the August 2022 CRMMS in ensemble mode using the CBRFC unregulated inflow forecast ensemble (CRMMS-ESP) dated August 2, 2022.
[5] For modeling purposes, simulated years beyond 2026 assume a continuation of the 2007 Interim Guidelines, the 2019 Colorado River Basin Drought Contingency Plans, and Minute 323, including the Binational Water Scarcity Contingency Plan. Except for certain provisions related to ICS recovery and Upper Basin demand management, operations under these agreements are in effect through 2026. Reclamation anticipates beginning a process in early 2023 to develop operations for post-2026, and the modeling assumptions described here are subject to change for the analysis to be used in that process.
[6] Percentages shown in this table may not be representative of the full range of future possibilities that could occur with different modeling assumptions.
[7] Percentages shown may not sum to 100% due to round to the nearest percent.

Lake Mead End-of-Month Elevations[1]

CRMMS Projections from October 2022



[1] Projected Lake Mead end-of-month physical elevations from the latest CRMMS-ESP and 24-Month Study inflow scenarios.

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Lower Basin – Lake Mead
Percent of Traces with Event or System Condition
Results from August 2022 CRMMS-ESP (values in percent) [1,2,3,4,5,6,7]

Event or System Condition	2023	2024	2025	2026	2027[5]
Surplus Condition – any amount (Mead ≥ 1,145 ft)	**0**	**0**	**0**	**0**	**0**
Surplus – Flood Control	0	0	0	0	0
Normal or ICS Surplus Condition (Mead < 1,145 and > 1,075 ft)	**0**	**7**	**0**	**7**	**13**
Recovery of DCP ICS / Mexico's Water Savings (Mead >/≥ 1,110 ft)	0	0	0	0	0
DCP Contribution / Mexico's Water Savings (Mead ≤ 1,090 and > 1,075 ft)	0	7	0	3	3
Shortage Condition – any amount (Mead ≤ 1,075 ft)	**100**	**93**	**100**	**93**	**87**
Shortage / Reduction – 1st level (Mead ≤ 1,075 and ≥ 1,050)	*0*	*17*	*30*	*13*	*10*
DCP Contribution / Mexico's Water Savings (Mead ≤ 1,075 and > 1,050 ft)	0	17	30	13	10
Shortage / Reduction – 2nd level (Mead < 1,050 and ≥ 1,025)	*100*	*57*	*30*	*33*	*33*
DCP Contribution / Mexico's Water Savings (Mead ≤ 1,050 and > 1,045 ft)	100	0	0	13	3
DCP Contribution / Mexico's Water Savings (Mead ≤ 1,045 and > 1,040 ft)	0	10	0	7	3
DCP Contribution / Mexico's Water Savings (Mead ≤ 1,040 and > 1,035 ft)	0	7	7	3	10
DCP Contribution / Mexico's Water Savings (Mead ≤ 1,035 and > 1,030 ft)	0	13	7	7	7
DCP Contribution / Mexico's Water Savings (Mead ≤ 1,030 and ≥/> 1,025 ft)	0	27	17	3	10
Shortage / Reduction – 3rd level (Mead < 1,025)	*0*	*20*	*40*	*47*	*43*
DCP Contribution / Mexico's Water Savings (Mead </≤ 1,025 ft)	0	20	40	47	43

Notes:
[1] Modeled operations include the 2007 Interim Guidelines, Upper Basin Drought Response Operations, Lower Basin Drought Contingency Plan, Minute 323, including the Binational Water Scarcity Contingency Plan, 2022 Drought Response Operations Plan, and 2022 Glen Canyon Dam operational adjustment.
[2] The projected operating tiers are computed "as if" the 480 kaf reduced release from Glen Canyon Dam in water year 2022 was delivered to Lake Mead.
[3] When Lake Powell is operating in the Lower Elevation Balancing Tier in water year 2023 or 2024, balancing releases were limited (with a minimum of 7.0 maf) to protect Lake Powell from declining below 3,525 feet at the end of December 2023 or 2024.
[4] Reservoir conditions for 2022-2027 were simulated using the August 2022 CRMMS in ensemble mode using the CBRFC unregulated inflow forecast ensemble (CRMMS-ESP) dated August 2, 2022.
[5] For modeling purposes, simulated years beyond 2026 assume a continuation of the 2007 Interim Guidelines, the 2019 Colorado River Basin Drought Contingency Plans, and Minute 323, including the Binational Water Scarcity Contingency Plan. Except for certain provisions related to ICS recovery and Upper Basin demand management, operations under these agreements are in effect through 2026. Reclamation anticipates beginning a process in early 2023 to develop operations for post-2026, and the modeling assumptions described here are subject to change for the analysis to be used in that process.
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[7] Percentages shown may not sum to 100% due to round to the nearest percent.

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	18,250	18,200	SEP 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	SEP 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 08-17-2022)			

1 Projected release, based on September 2022 minimum and most and August 2022 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.

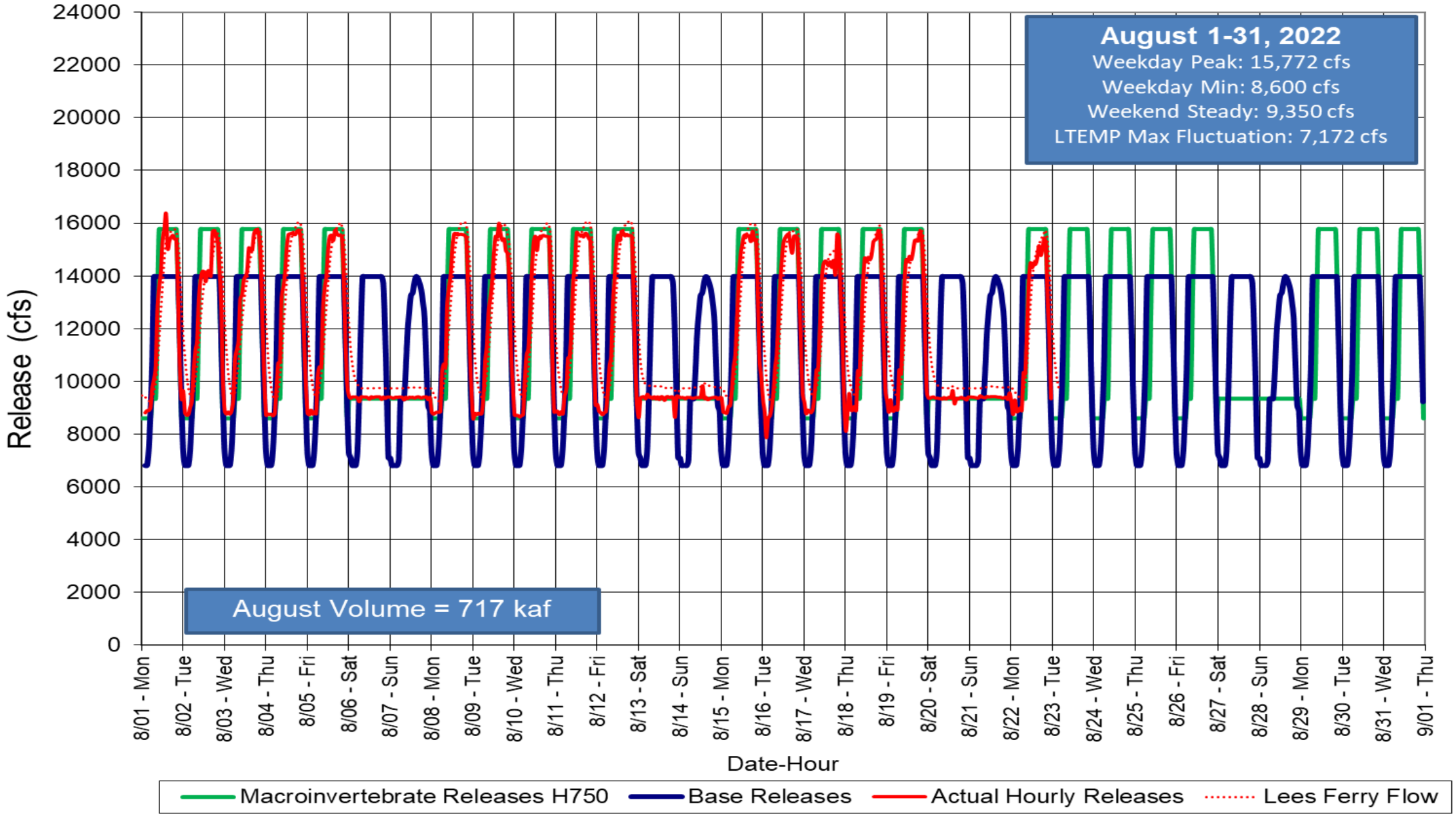
Glen Canyon Dam Power Plant Unit Outage Schedule for WY2023

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	8	6	6	4	6	6	6	6	6	4	
Capacity (cfs)	18,200	18,100	24,600	17,800	17,600	11,000	17,500	18,100	18,650	18,650	18,500	11,600	SEP MOST[2]
Capacity (kaf/month)	1,120	1,200	1,510	1,200	1,200	740	1,040	1,110	1,110	1,130	1,120	730	SEP 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 08-17-2022)			

1 Projected release, based on September 2022 minimum and most and August 2022 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 August 2022



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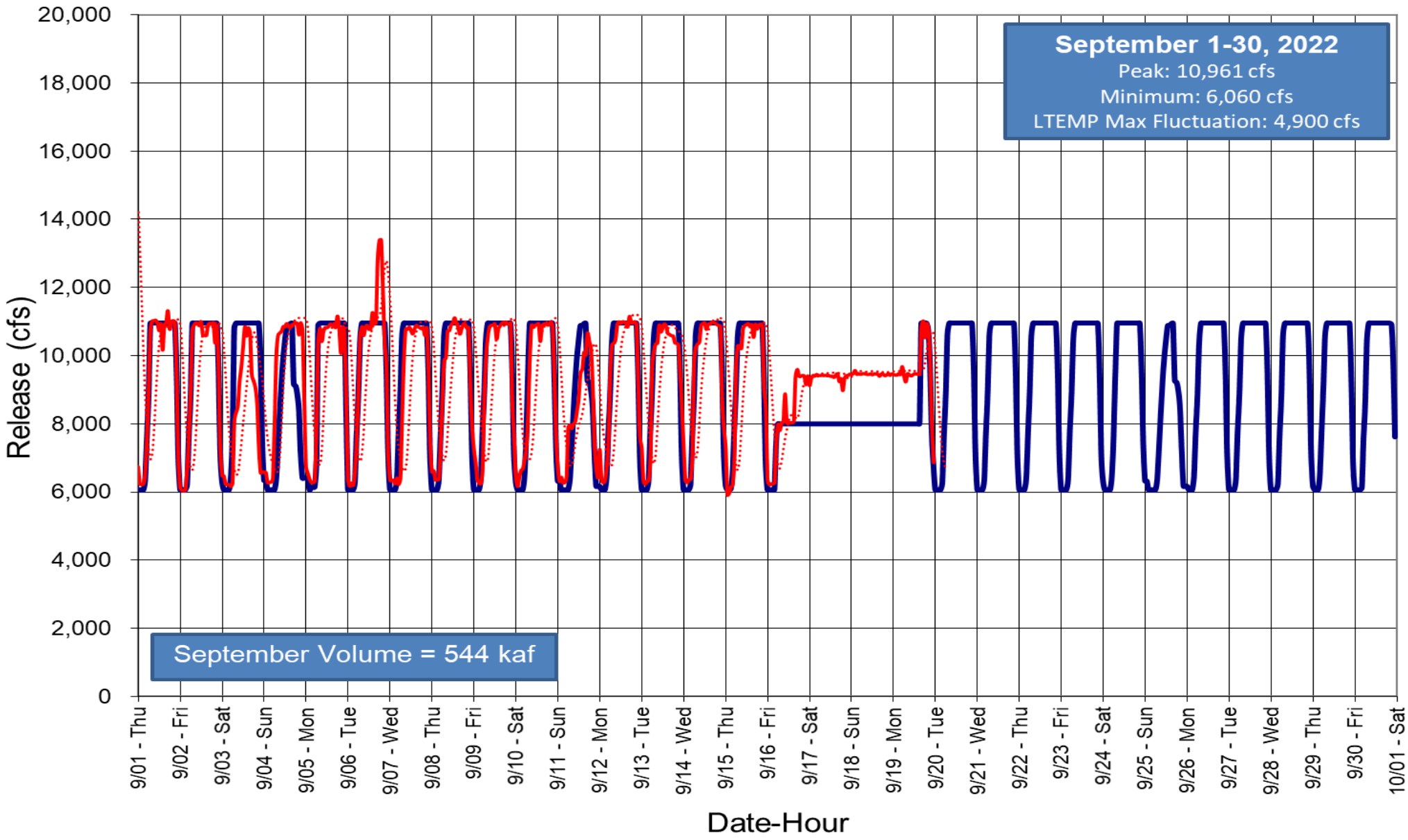
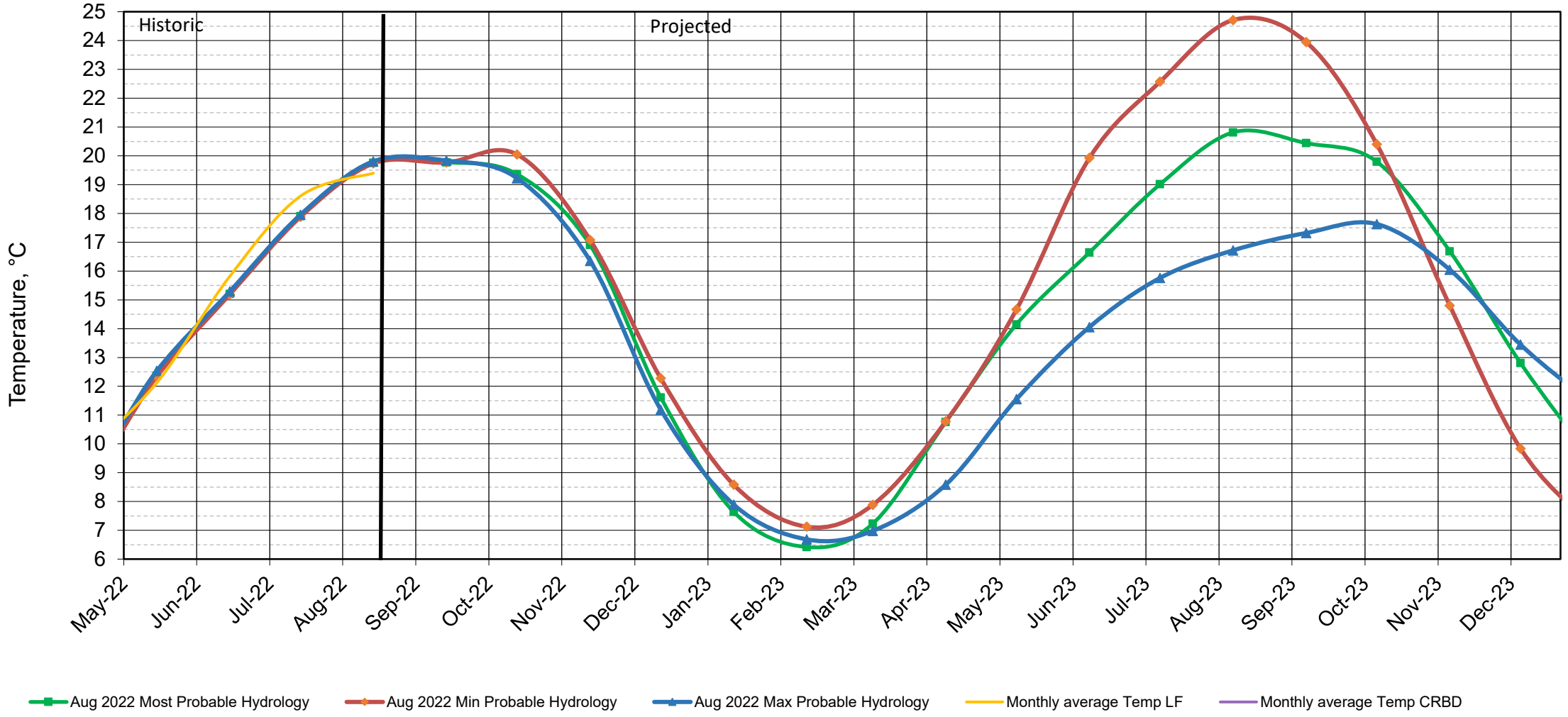
Glen Canyon Dam Hourly Release Pattern September 2022



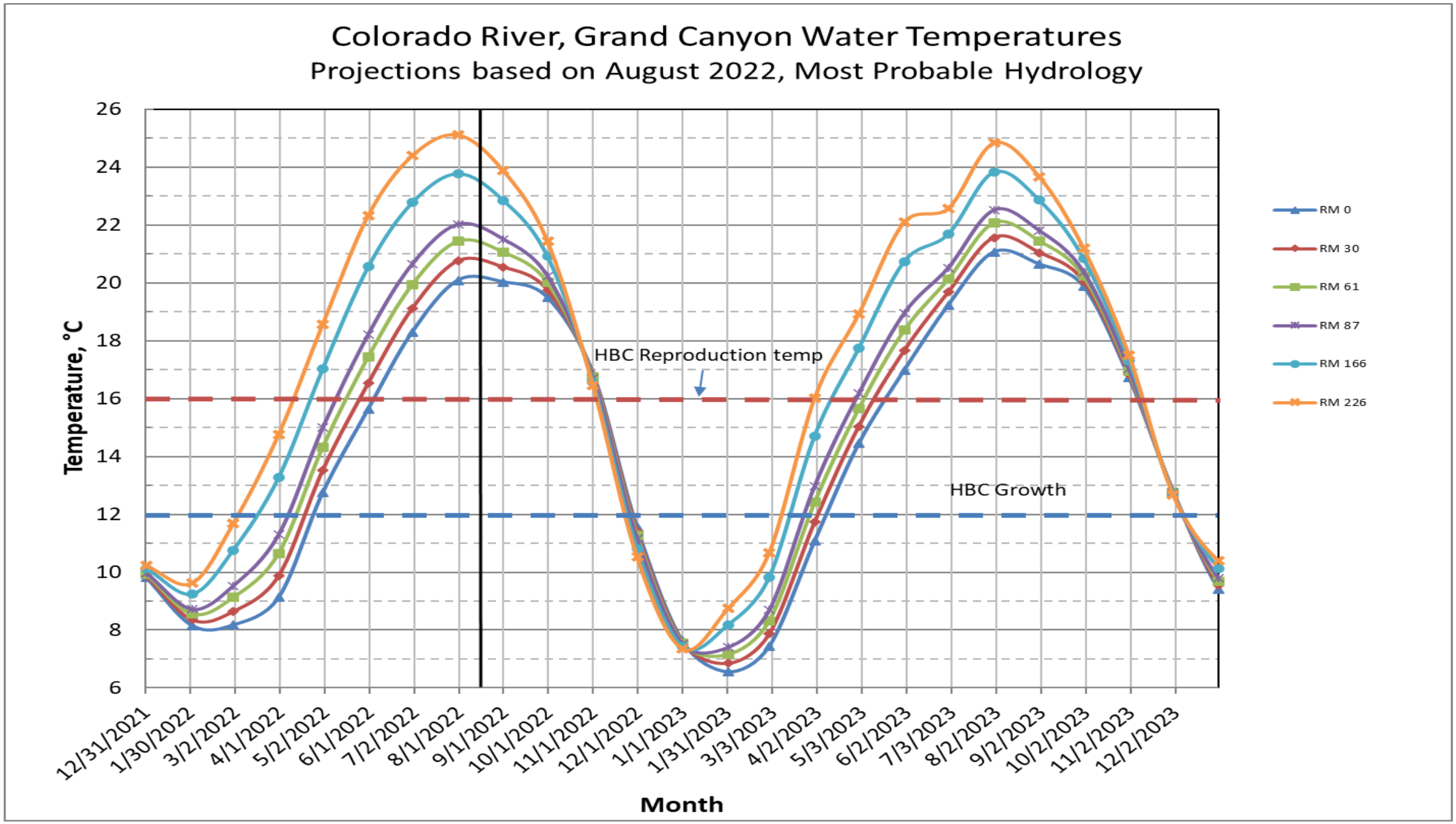
Water Quality

Lake Powell Release Temperature

Projected Temperature based on August 2022 Forecast



#Projection start date is based on initial conditions (March 2021)


Colorado River, Grand Canyon Water Temperatures
Projections based on August 2022, Most Probable Hydrology
Temperature, °C
26
24
22
20
18
16
14
12
10
8
6
HBC Reproduction temp
HBC Growth
12/31/2021
1/30/2022
3/2/2022
4/1/2022
5/2/2022
6/1/2022
7/2/2022
8/1/2022
9/1/2022
10/1/2022
11/1/2022
12/1/2022
1/1/2023
1/31/2023
3/3/2023
4/2/2023
5/3/2023
6/2/2023
7/3/2023
8/2/2023
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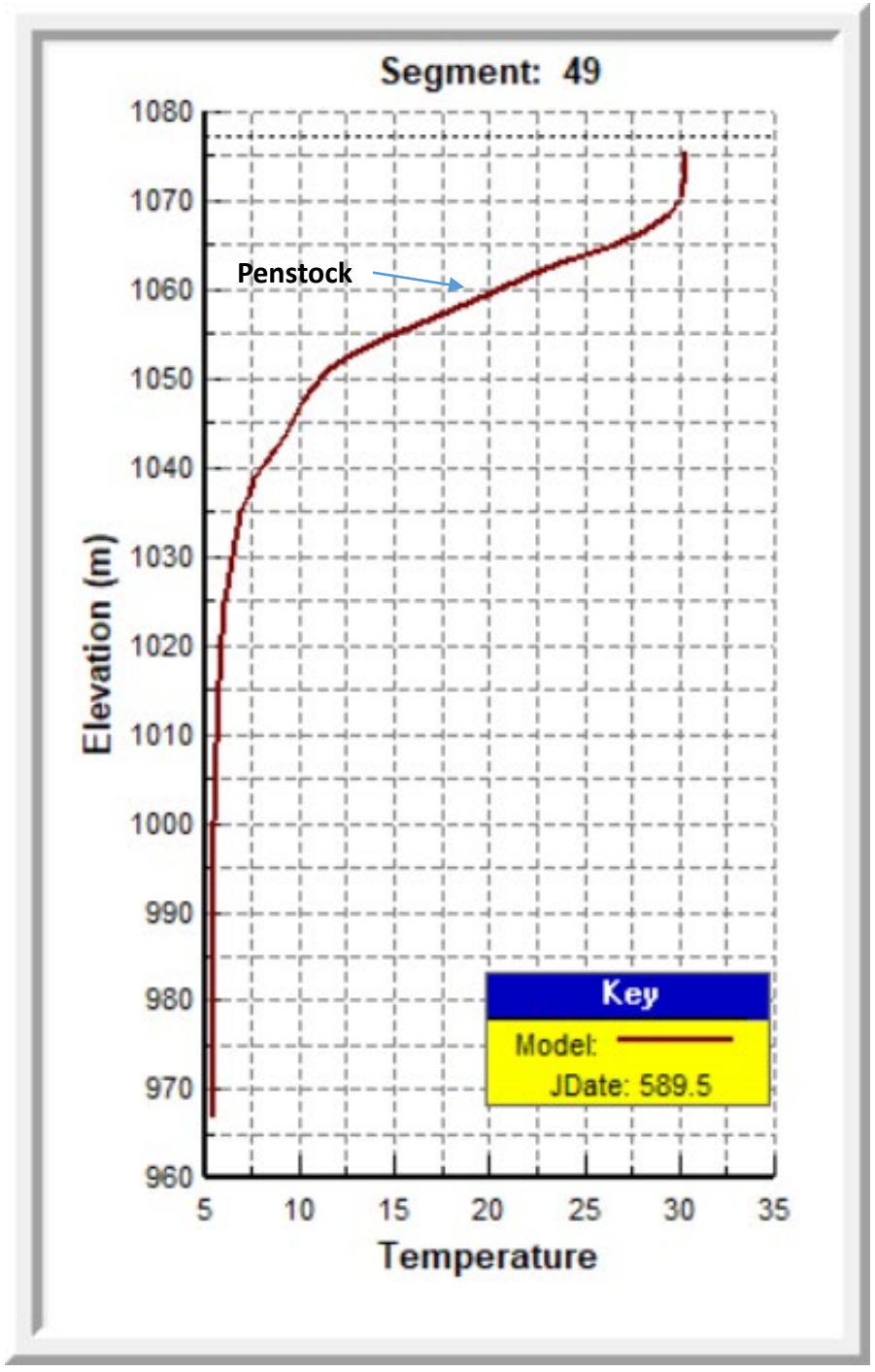
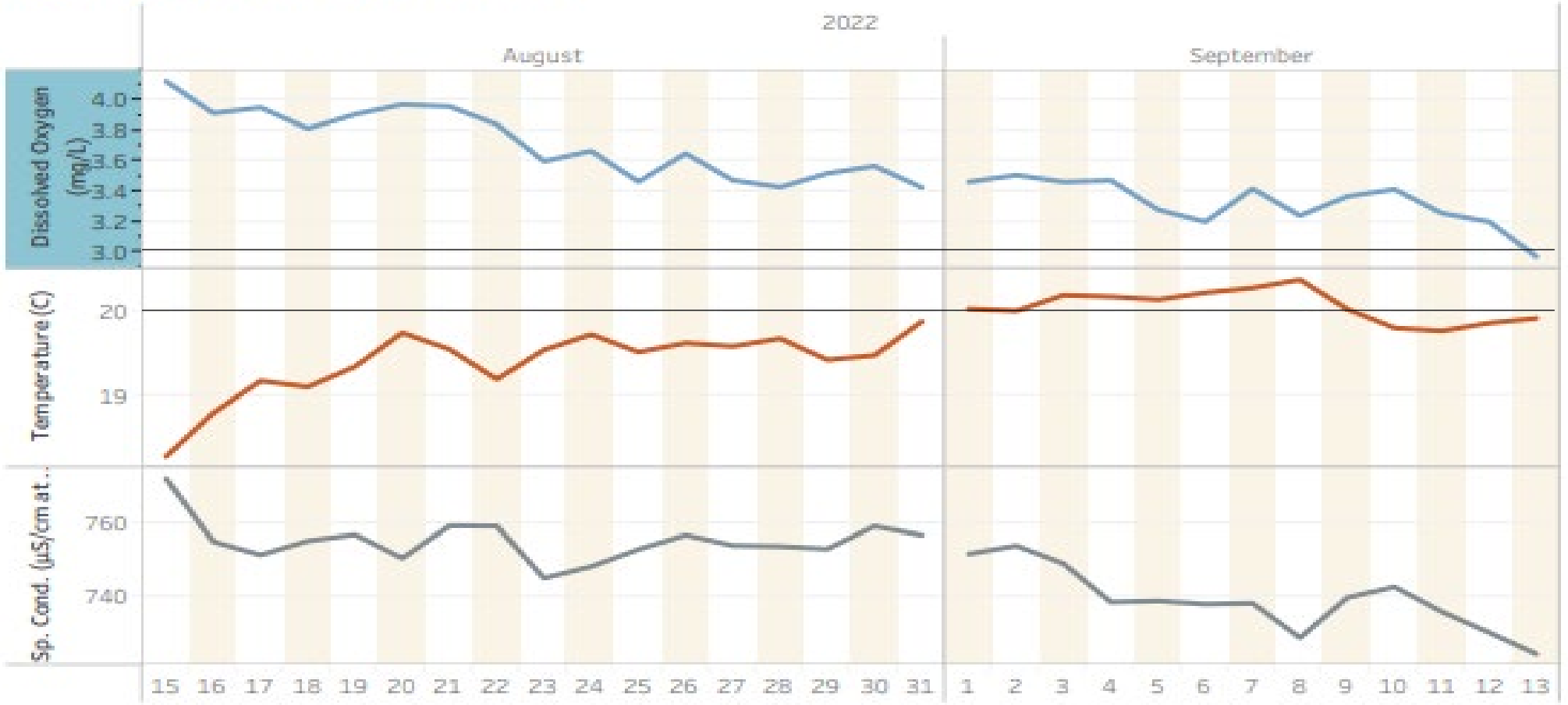
RM 30
RM 61
RM 87
RM 166
RM 226


Segment: 49
Penstock
Elevation (m)
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
960
5
10
15
20
25
30
35
Temperature
Key
Model:
JDate: 589.5

Daily Water Quality Data at Glen Canyon Dam

Downl..

Daily Dissolved Oxygen & Temperature Values



The trends of daily average Dissolved Oxygen, Temperature and Specific Conductance shown for the past 30 days.

Select Date Extent
8/15/2022 to 9/13/2022

These data are preliminary or provisional and are subject to revision. They are being provided to meet the need for timely best science. The data have not received final approval by the U.S. Geol..

Daily Water Quality Data at Glen Canyon Dam

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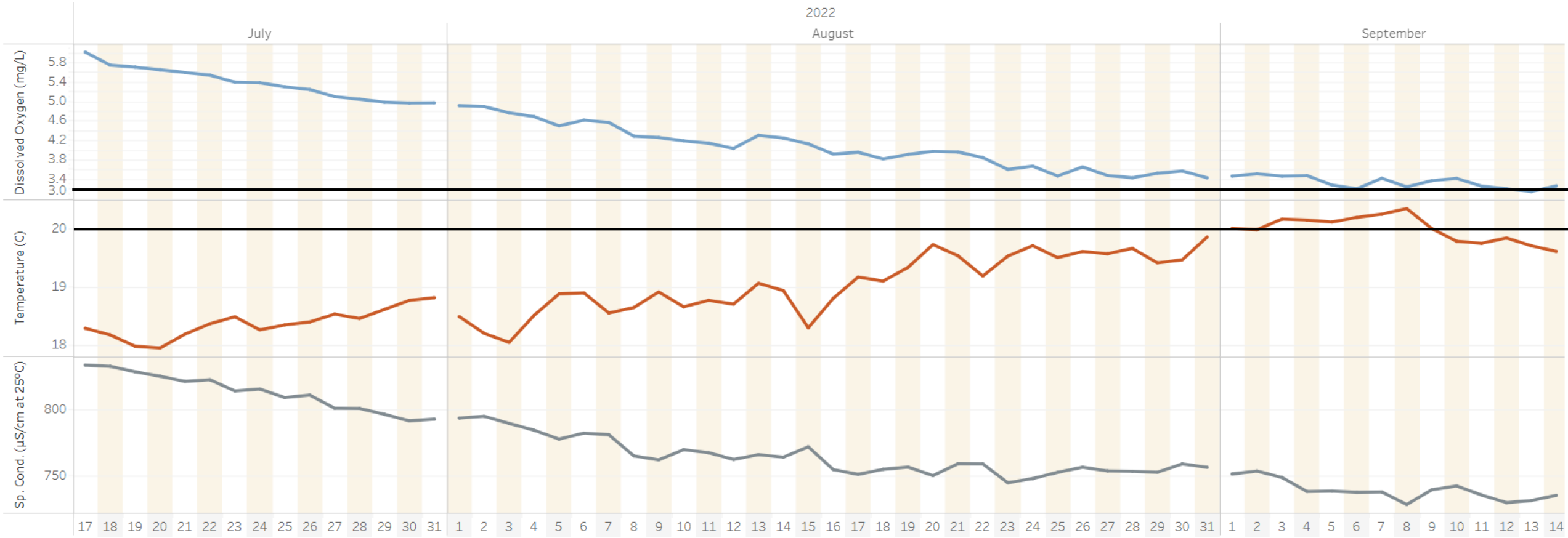
USGS

Daily Dissolved Oxygen & Temperature Values

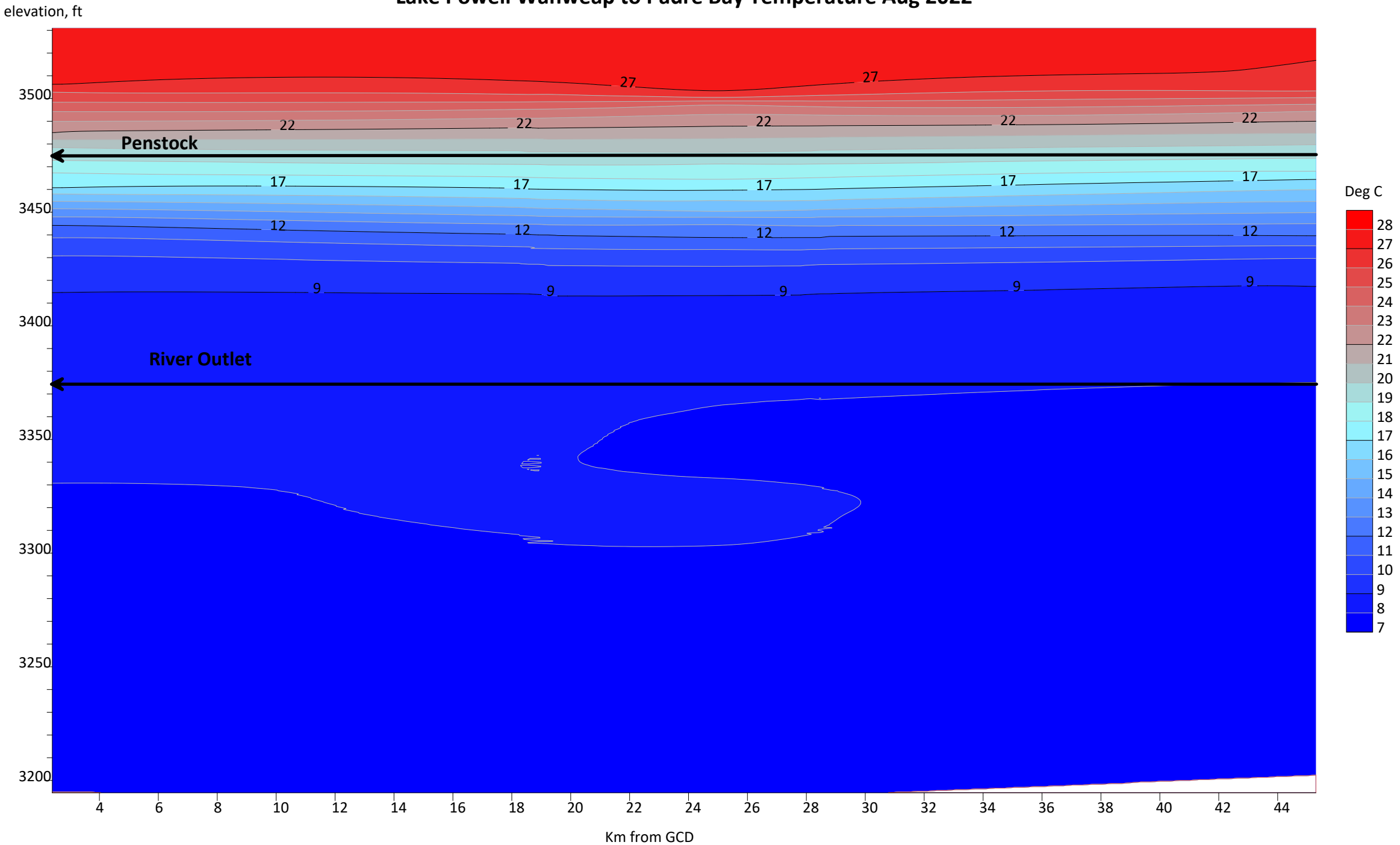


The trends of daily average Dissolved Oxygen, Temperature and Specific Conductance shown for the past 30 days.

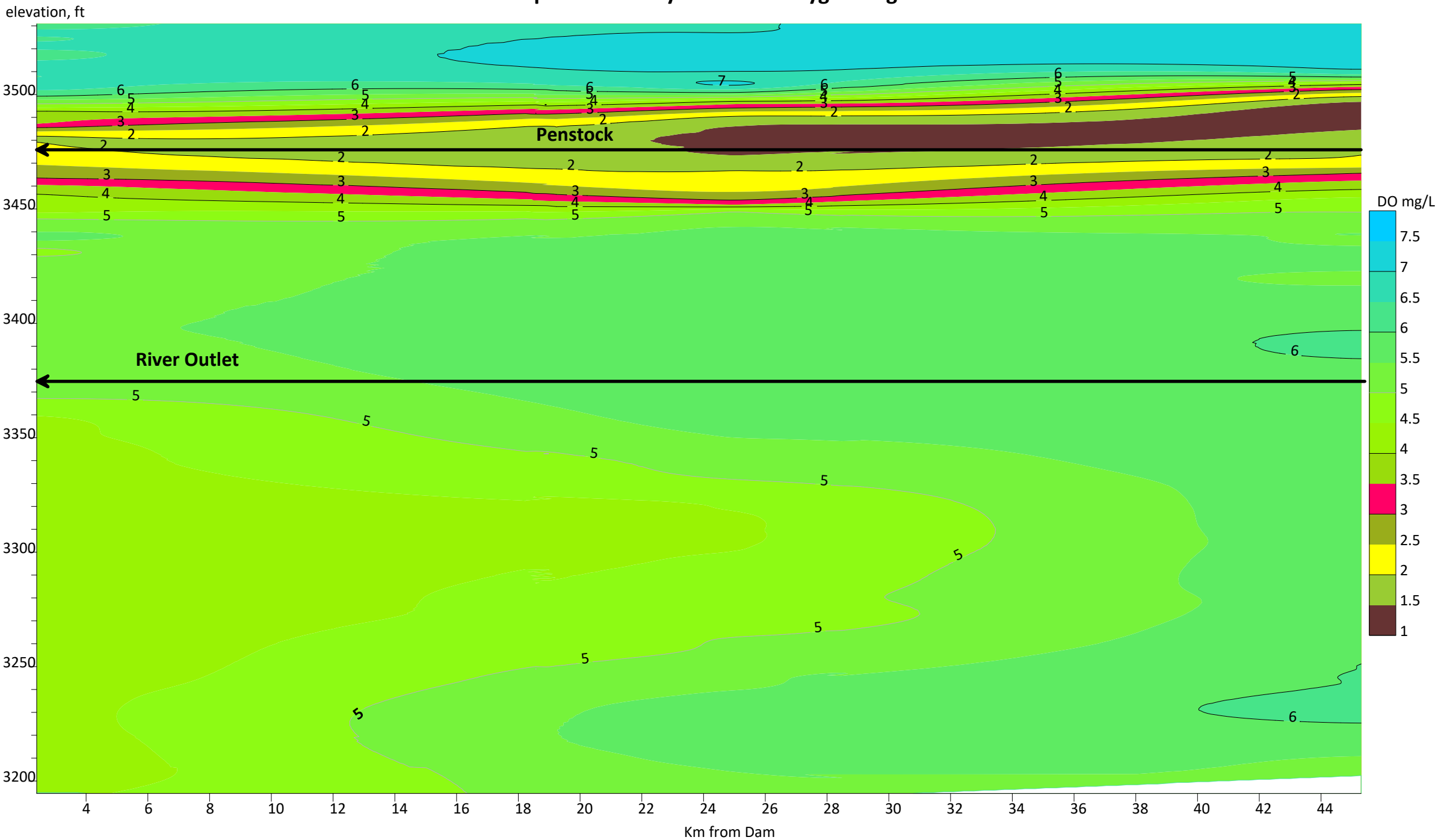
Select Date Extent

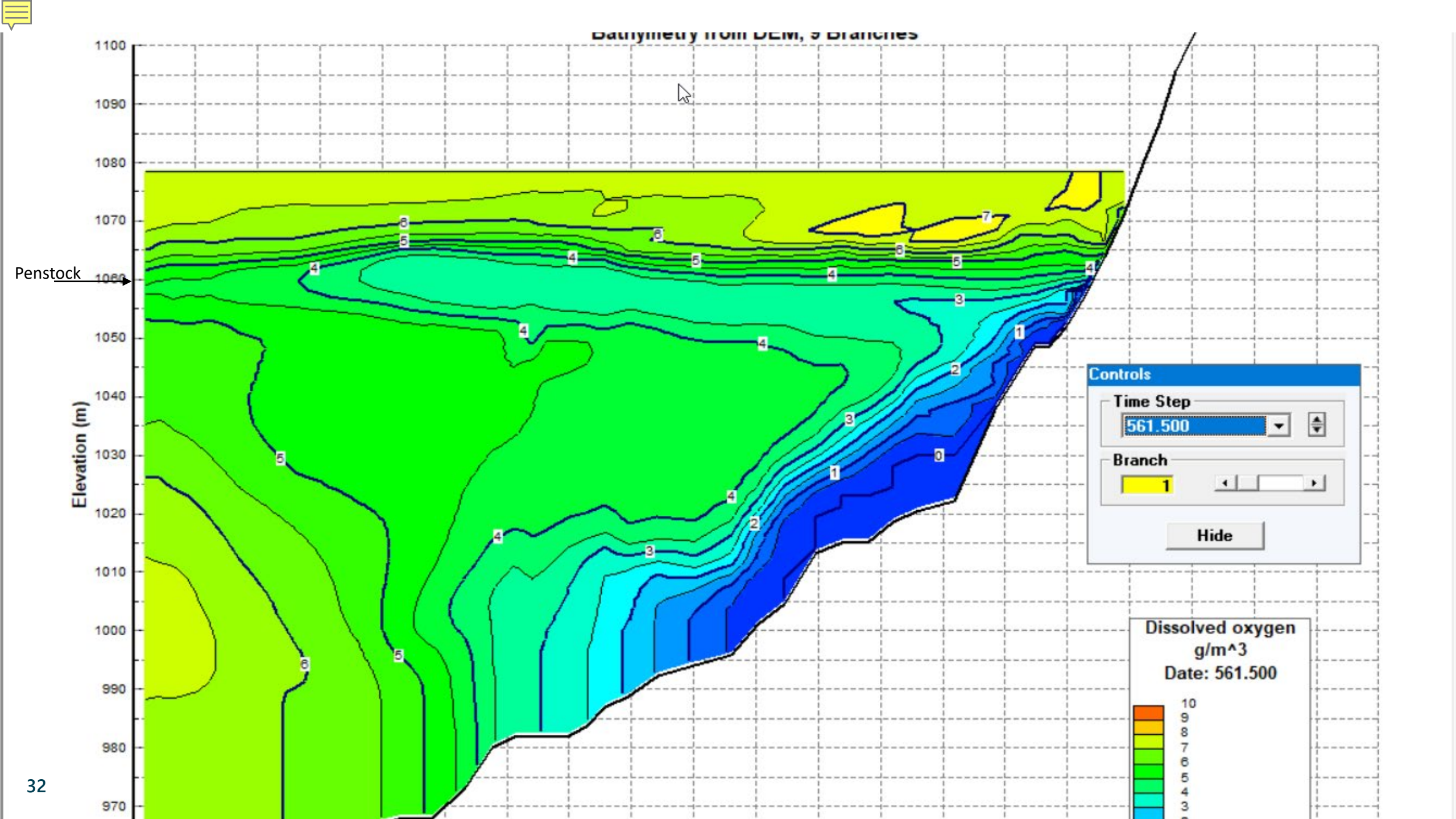
Last 60 days

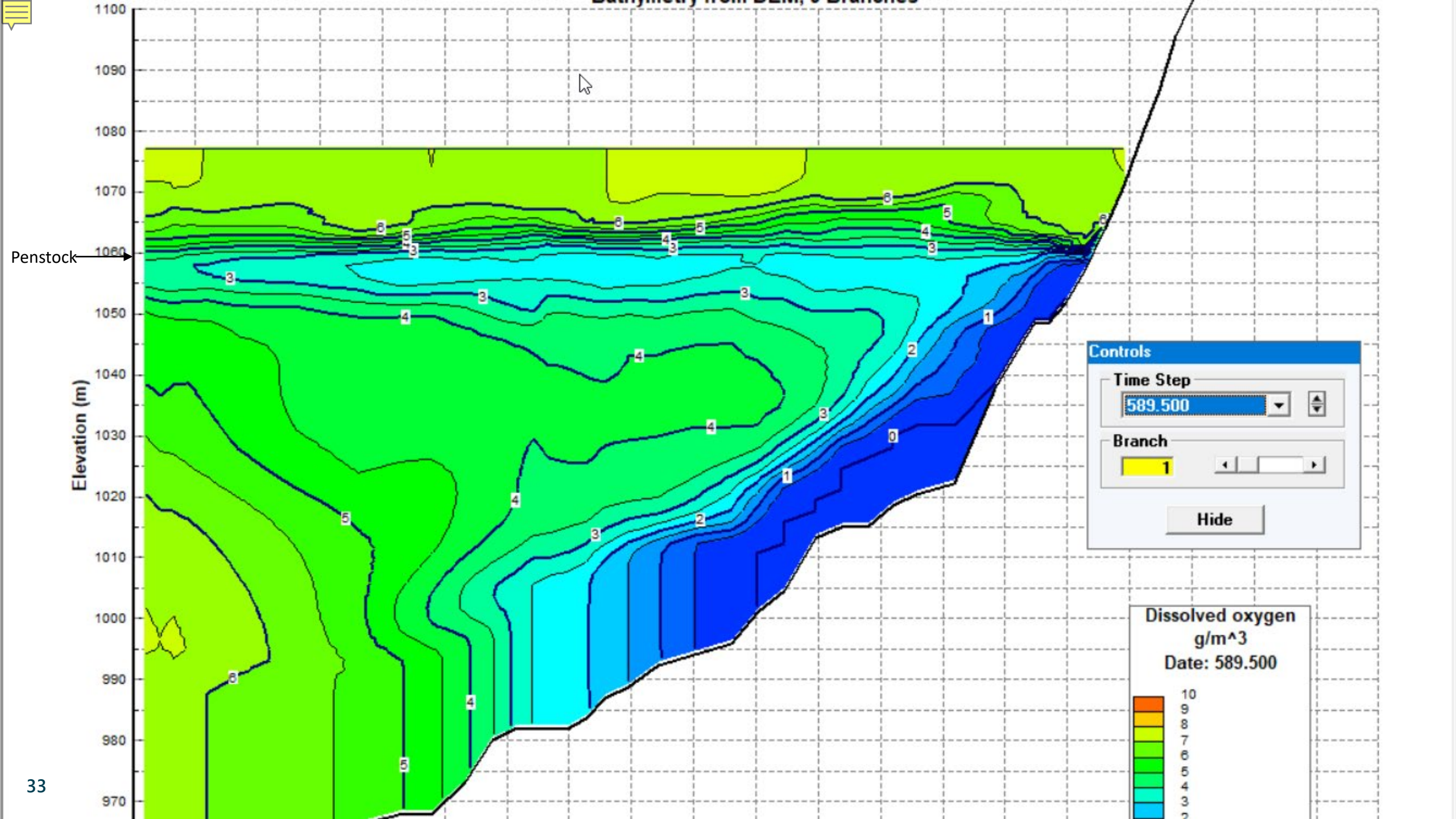
Lake Powell Wahweap to Padre Bay Temperature Aug 2022



Wahweap to Padre Bay Dissolved Oxygen Aug 2022




Bathymetry from DEM, 9 Branches
Penstock
Elevation (m)
1100
1090
1080
1070
1060
1050
1040
1030
1020
1010
1000
990
980
970
Controls
Time Step
561.500
Branch
1
Hide
Dissolved oxygen
g/m^3
Date: 561.500
10
9
8
7
6
5
4
3


Penstock
Elevation (m)
1100
1090
1080
1070
1060
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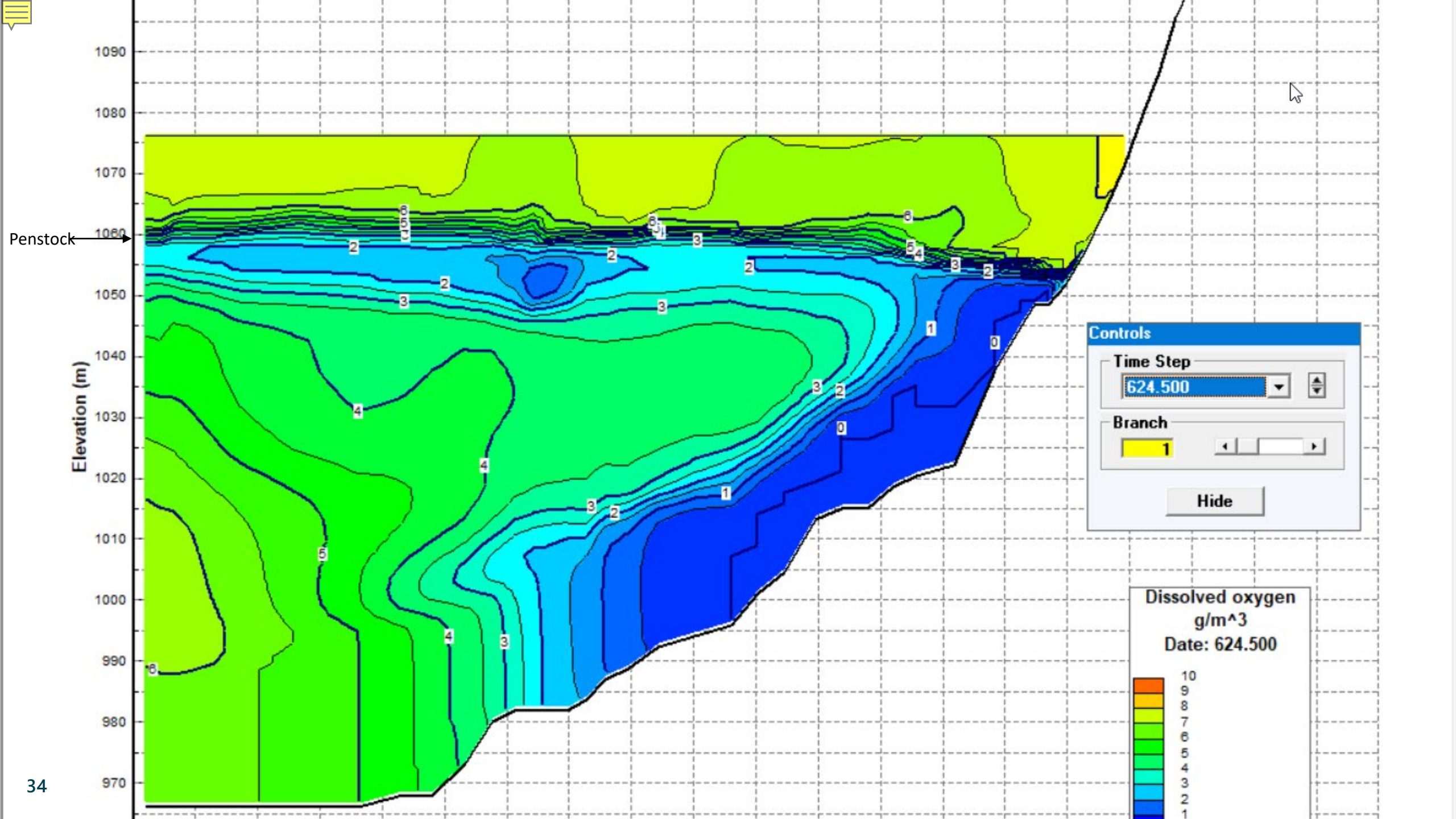
1040
1030
1020
1010
1000
990
980
970
Controls
Time Step
589.500
Branch
1
Hide
Dissolved oxygen
g/m^3
Date: 589.500
10
9
8
7
6
5
4
3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Elevation (m)
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1080
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1060
1050
1040
1030
1020
1010
1000
990
980
970
Controls
Time Step
624.500
Branch
1
Hide
Dissolved oxygen
g/m^3
Date: 624.500
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9
8
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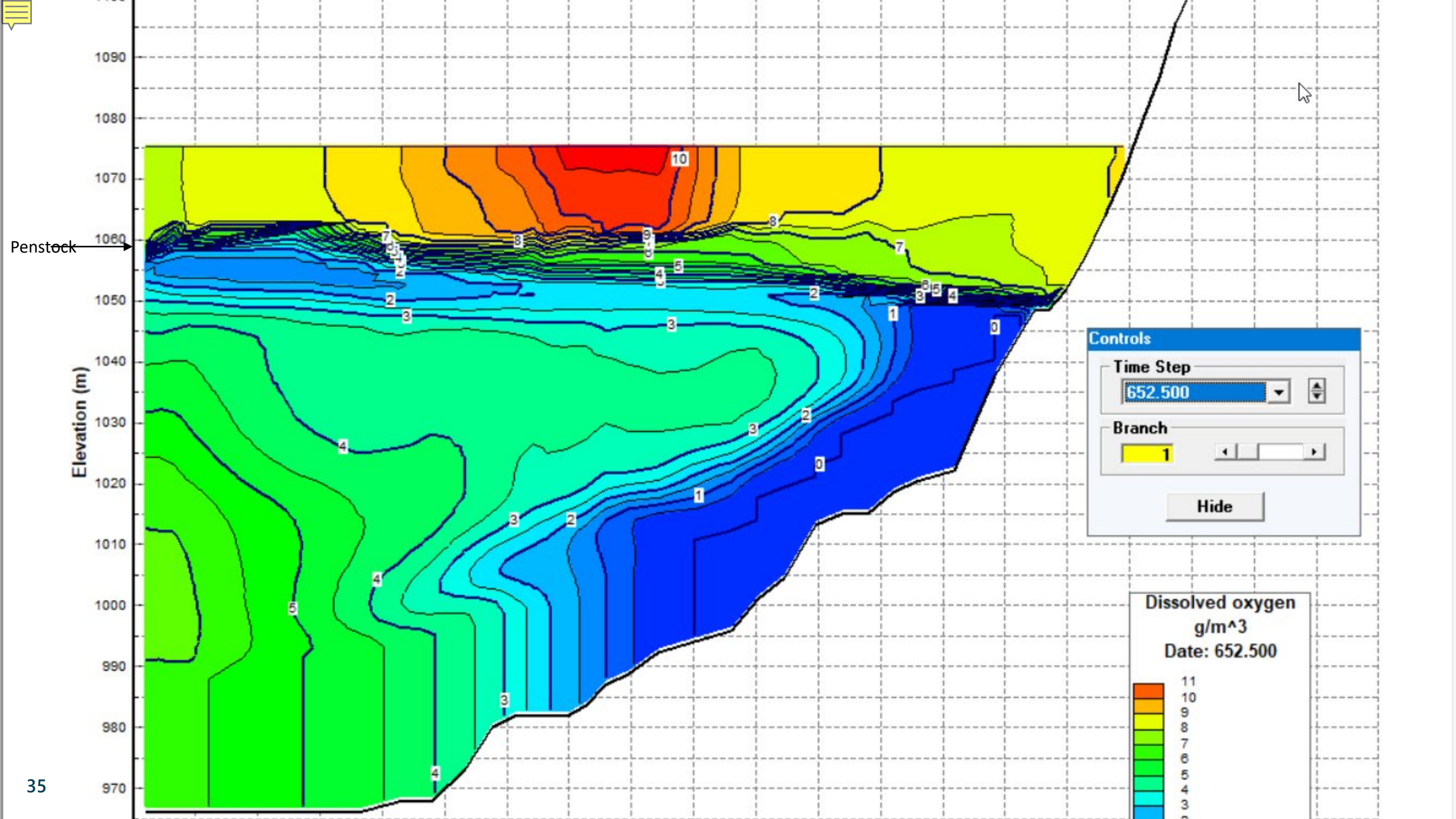
5
4
3
2
1


Penstock
Elevation (m)
1090
1080
1070
1060
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1040
1030
1020
1010
1000
990
980
970
Controls
Time Step
652.500
Branch
1
Hide
Dissolved oxygen
g/m^3
Date: 652.500
11
10
9
8
7
6
5
4
3


Questions?
BUREAU OF
RECLAMATION