

Sub-Seasonal and Seasonal Precipitation Forecasting for Drought Preparedness

Upper Colorado River Basin Reservoir
Applications

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The Upper Colorado River Commission

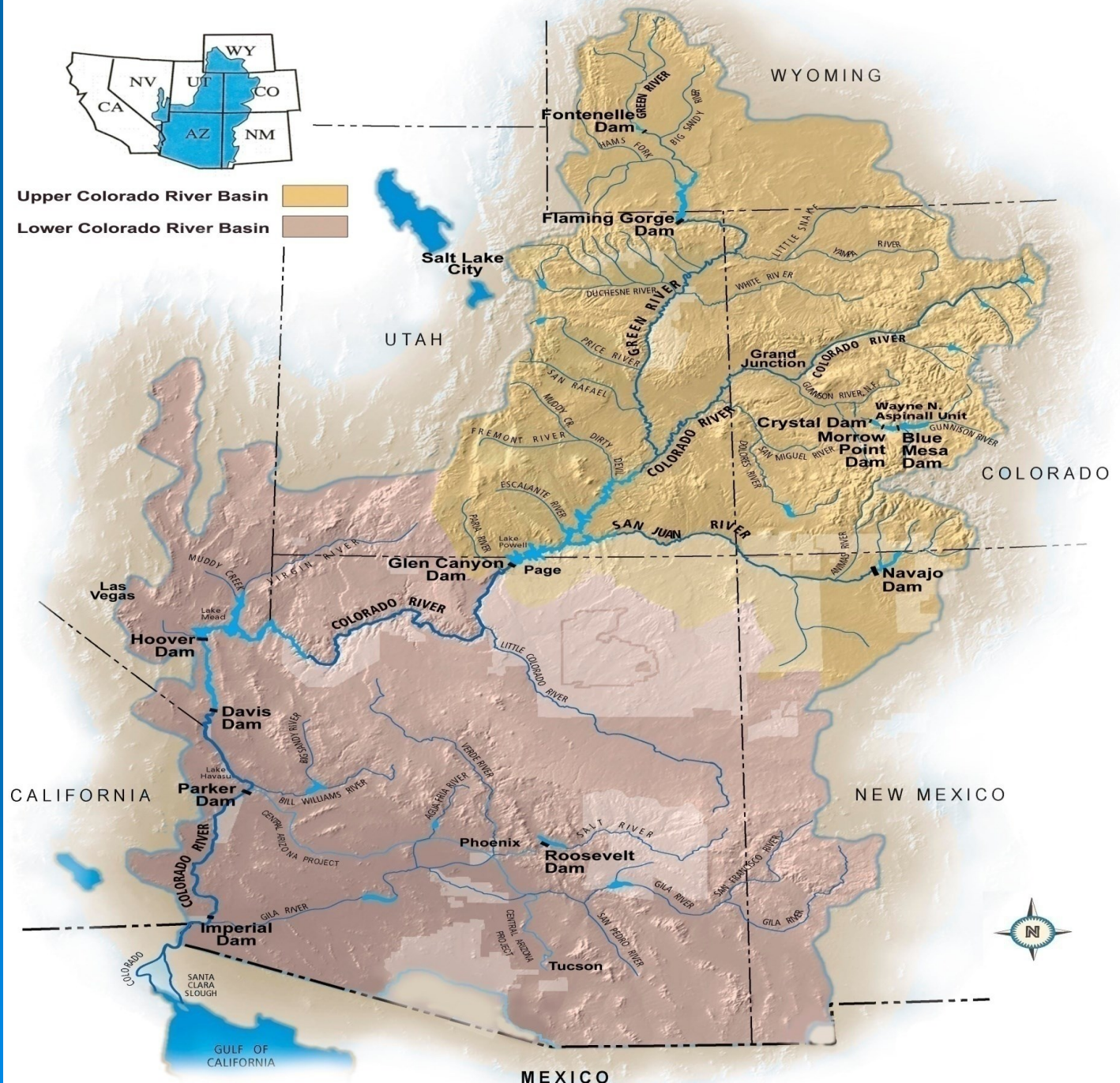
- Interstate water administrative agency created in the 1948 Upper Basin Compact
- States of Co, Ut, NM, Wy & Federal Chair
- Responsibilities include
 - Studies, findings of water deliveries to LB, determine uses in UB, findings of extraordinary drought, determinations of curtailment of uses in UB etc

Colorado River Basin



Upper Colorado River Basin

Lower Colorado River Basin



Current Use Estimates

MAF/ year

Upper Basin uses incl. reservoir evap. 4.0 - 4.5

Lower Basin mainstream uses 7.5 - 7.5

Lower Basin reservoir evap. 1.0 - 1.5

Lower Basin tributaries 2.0 - 2.5

Total Lower Basin 10.5 - 11.5

Subtotal 14.5 - 16.0

Add Mexico 1.5 1.5

TOTAL 16.0 – 17.5

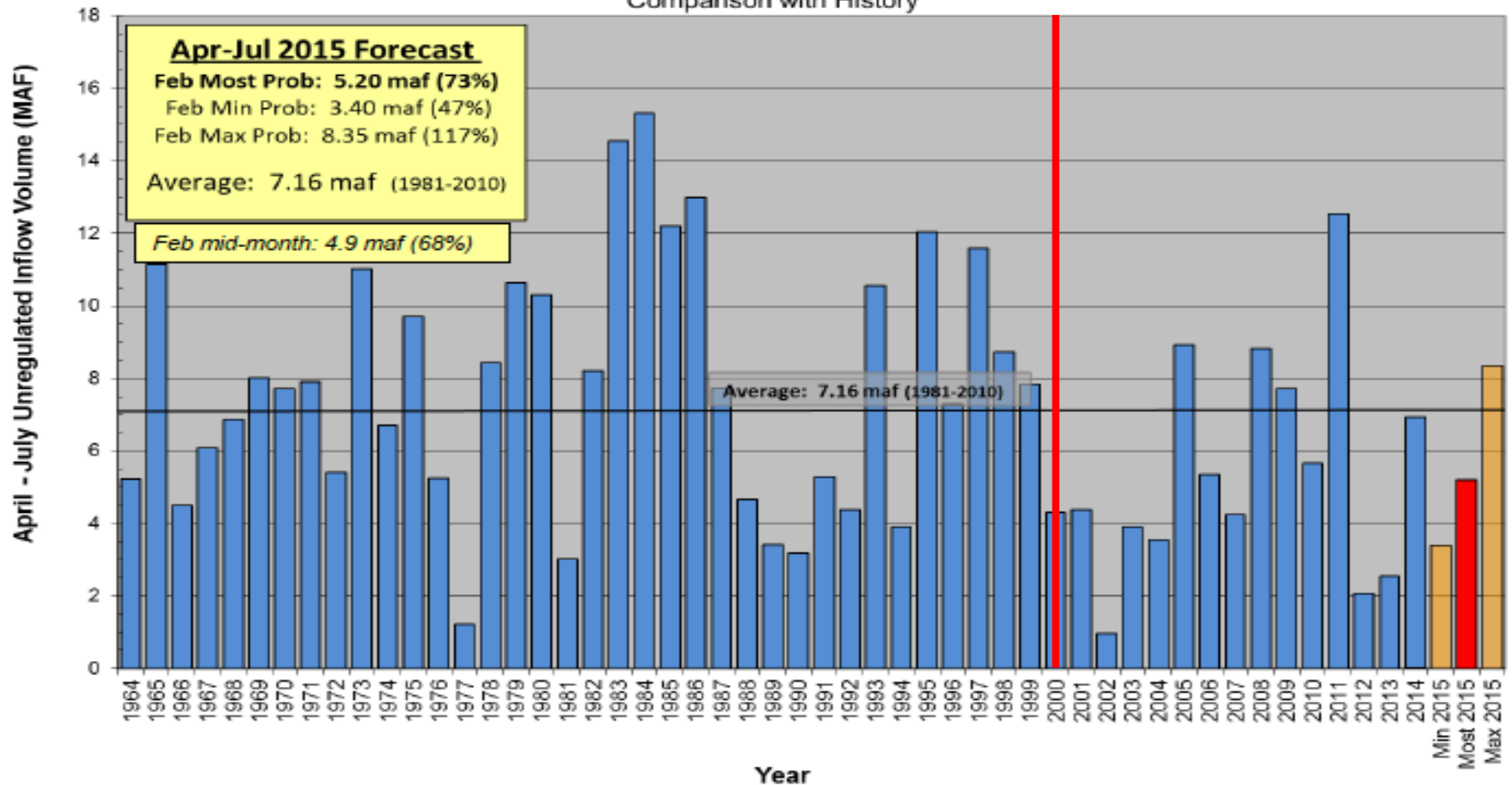
Hydrology comparison

- 2000-2014 12.3 MAF @ LF
- 1988-2014 13.2 MAF @ LF
- Basin Study CC 13.7 MAF @ LF
- 1906-2014 GR 14.8 MAF @ LF
- 1120-1172 PH 12.7 MAF @ LF

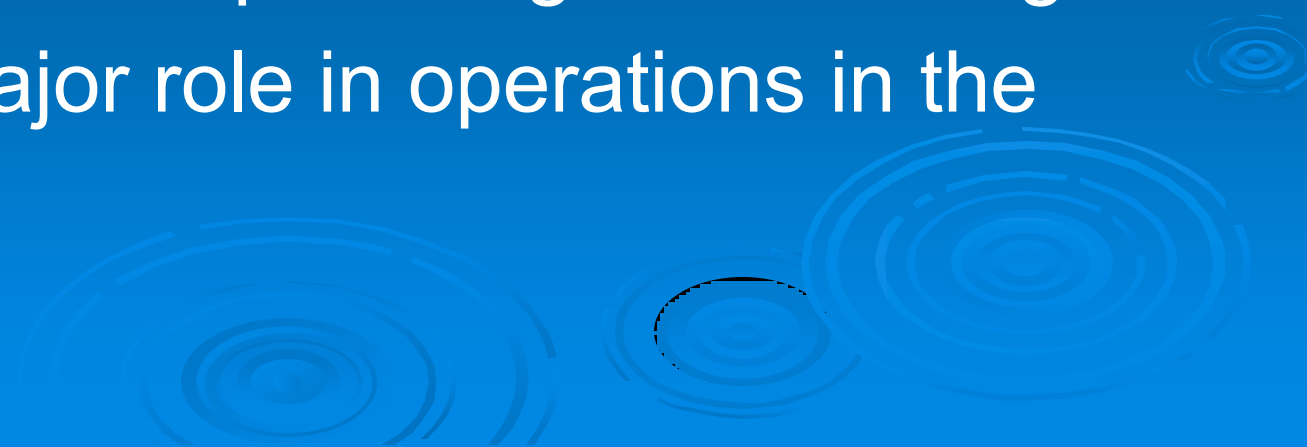
CC –climate change GR – gage period NF PH – paleo-hydrology

Drought

Lake Powell Unregulated Inflow
Apr - Jul 2015 Forecast
Issued Feb 3
Comparison with History



BOR 24-Month Study Forecast of Reservoir Elevations

- Deterministic Model forecast of reservoir elevation by month for 2 years
 - Uses Colorado River Basin Forecast Center estimates of precipitation and runoff
 - Uses reservoir operator goals and targets
 - Plays a major role in operations in the Basin
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24 Month Prediction Study

Upper Colorado River Commission

August 24 Month Study

Lake Powell

Calendar Year	Projected elevation (feet)	Observed Elevation (feet)	Error (projected - observed) (feet)	Error (absolute value) (feet)	Projected Operating Tier	Correct Operating Tier
2014	3596.62	3597.75	-1.13	1.13	Upper Elevation Balancing	Upper Elevation Balancing
2013	3578.32	3584.43	-6.11	6.11	Upper Elevation Balancing	Upper Elevation Balancing
2012	3614.89	3609.82	5.07	5.07	Upper Elevation Balancing	Upper Elevation Balancing
2011	3646.26	3639.75	6.51	6.51	Equalization	Upper Elevation Balancing
2010	3628.73	3626.54	2.19	2.19	Upper Elevation Balancing	Upper Elevation Balancing
2009	3634.76	3626.22	8.54	8.54	Upper Elevation Balancing	Upper Elevation Balancing
2008	3625.75	3617.89	7.86	7.86	Upper Elevation Balancing	Upper Elevation Balancing
2007	3596.40	3594.64	1.76	1.76	Upper Elevation Balancing	Upper Elevation Balancing
2006	3597.03	3603.39	-6.36	6.36	Upper Elevation Balancing	Upper Elevation Balancing
2005	3603.30	3598.17	5.13	5.13	Upper Elevation Balancing	Upper Elevation Balancing
2004	3568.26	3564.42	3.84	3.84	Mid Elevation Release	Mid Elevation Release
2003	3601.08	3597.22	3.86	3.86	Upper Elevation Balancing	Upper Elevation Balancing
2002	3617.76	3620.10	-2.34	2.34	Upper Elevation Balancing	Upper Elevation Balancing
2001	3659.00	3656.17	2.83	2.83	Equalization	Equalization
2000	3673.02	3669.89	3.13	3.13	Equalization	Equalization
		Average Error	2.32	4.44		

August 24 Month Study Lake Mead

Calendar Year	Projected elevation (feet)	Lake Mead December 31 actual elevation (feet)	Error (projected - observed) (feet)	Error (absolute value) (feet)
2014	1083.37	1087.79	-4.42	4.42
2013	1103.08	1106.73	-3.65	3.65
2012	1119.14	1120.36	-1.22	1.22
2011	1134.12	1132.83	1.29	1.29
2010	1086.38	1086.30	0.08	0.08
2009	1098.47	1096.30	2.17	2.17
2008	1110.41	1110.97	-0.56	0.56
2007	1114.73	1114.81	-0.08	0.08
2006	1127.48	1128.12	-0.64	0.64
2005	1136.74	1137.52	-0.78	0.78
2004	1124.28	1130.01	-5.73	5.73
2003	1138.99	1139.12	-0.13	0.13
2002	1151.47	1152.13	-0.66	0.66
2001	1178.51	1177.37	1.14	1.14
2000	1195.81	1196.12	-0.31	0.31
		Average Error	(0.90)	1.52

Statistical Summary – 24-month study predictions

Lake Powell							
24 - Month Study	Average Error in Prediction (ft.)	Absolute Average Error in Prediction (ft.)	Maximum Error (ft.)	Number of Times Error Over 5.00 ft.	Number of Over-predictions	Number of Under-predictions	Number of Incorrect Tier Predictions
August	2.32	4.44	8.54	7	11	4	1
October	1.13	2.31	7.71	1	12	3	0

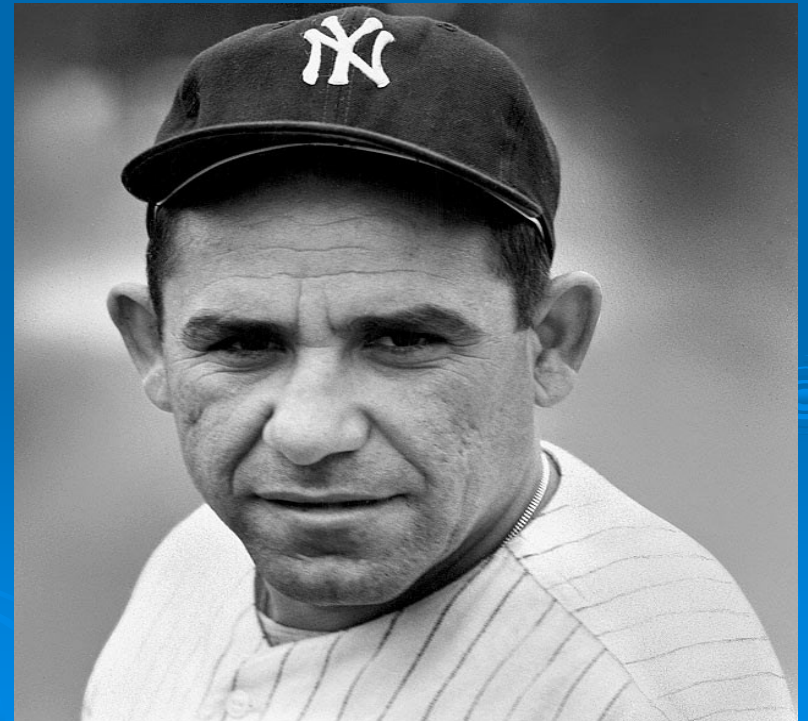
Lake Mead							
24 - Month Study	Average Error in Prediction (ft.)	Absolute Average Error in Prediction (ft.)	Maximum Error (ft.)	Number of Times Error Over 3.00 ft.	Number of Over-predictions	Number of Under-predictions	Number of Incorrect Tier Predictions
August	-0.90	1.52	5.73	3	4	11	0
October	-0.59	1.30	5.78	1	5	10	0

24- Month Study Source of Error

- Precipitation forecast error
 - Runoff predictions forecast error
 - Operations model error
 - Can't do without it. It helps us see where we are going.
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- Decorative water ripples in the bottom right corner of the slide.

Yogi Berra

- “You’ve got to be very careful if you don’t know where you are going, because you might not get there...”



EXAMPLES OF FORECASTING IMPACTING OPERATIONS



Compact Curtailment

- Upper Basin compact obligation not to deplete beyond ability to supply 75maf to the lower basin in a 10 year running total
- Must anticipate and avoid under-delivery
- Must take action perhaps in April to avoid under delivery by September 30.
- Big consequences

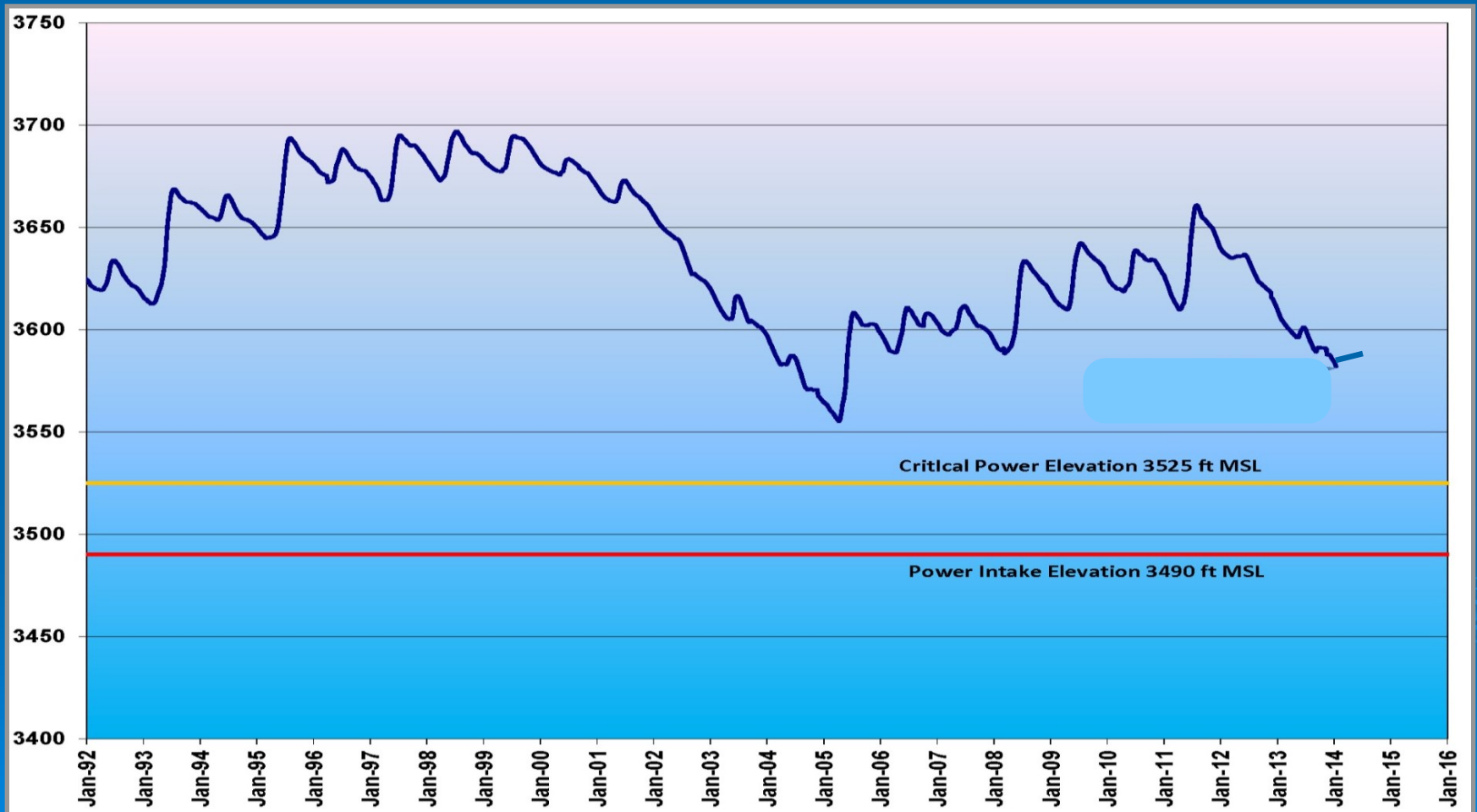
Drought Contingency Planning

The Basin States and the Bureau of Reclamation are planning for drought response to reduce risks associated with reaching critical reservoir elevations at Lake Powell and Lake Mead. These are low probability events, but with high consequences.



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Critical Powell Elevations



Extended Operations

Navajo Reservoir



Flaming Gorge Reservoir



Blue Mesa Reservoir



- Agree on triggers and operations to implement under emergency conditions to maintain minimum power pool elevation at Lake Powell

- By conserving water (temporarily) in Lake Powell or moving water available from upper CRSP facilities.



Lake Powell

Extended Reservoir Operations

- Requires taking actions in advance of hitting critical elevations in Lake Powell
 - Depends upon forecasts to anticipate when critical elevations are at risk
 - Requires time for benefits to accrue in Powell
 - Consequences for taking actions when it turns out they were not needed
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2007 Interim Guidelines

low and high reservoir rules

Lake Powell Operational Tiers
(subject to April adjustments or mid-year review modifications)

Lake Powell Elevation (feet)	Lake Powell Operational Tier	Lake Powell Active Storage (maf)
3,700	Equalization Tier equalize, avoid spills or release 8.23 maf	24.32
3,636 – 3,666 (see table below)	----- Upper Elevation Balancing Tier release 8.23 maf; if Lake Mead < 1,075 feet, balance contents with a min/max release of 7.0 and 9.0 maf	15.54 – 19.29 (2008 – 2026)
3,575	----- Mid-Elevation Release Tier release 7.48 maf; if Lake Mead < 1,025 feet, release 8.23 maf	9.52
3,525	----- Lower Elevation Balancing Tier balance contents with a min/max release of 7.0 and 9.5 maf	5.93
3,370		0

Interim Guidelines Actions Affected by Forecast Error

- Equalization or 8.23 maf
- Operating Tier determination – 7.0 to 9.5maf
- Surplus water use - 100kaf to 250kaf
- Lower basin shortage – 333 kaf to 500 kaf
- Delivery of banked water – 300 to 400 kaf

Conclusions

- Drought planning and general operations are greatly affected by the accuracy of the forecast
- Inaccuracy in forecasts have large consequences for water availability
- We cannot get by without forecasts



Flaming Gorge



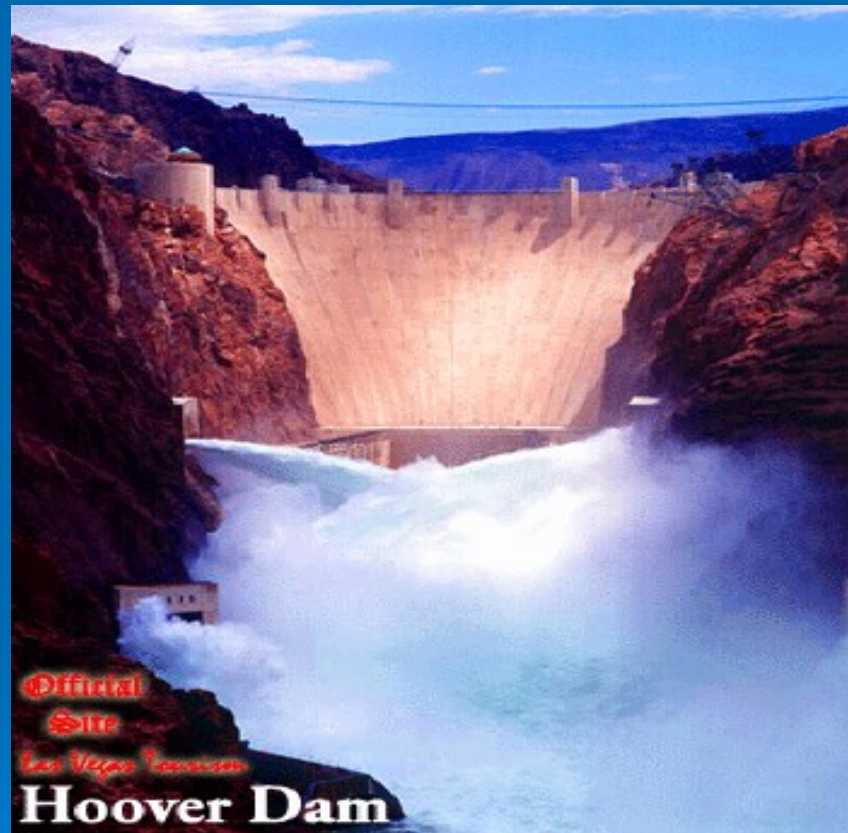
Blue Mesa



Navajo



Hoover Dam



Glen Canyon

