RECLAMATION

Managing Water in the West

Glen Canyon Dam High Flow Protocol Hydrologic Trace Selection and Disaggregation to Hourly Flows

U.S. Department of the Interior
Bureau of Reclamation
Upper Colorado Region
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Hydrologic Trace Selection

Bureau of Reclamation's long-term planning model Colorado River Simulation System (CRSS) was run with the nonparametric paleo-conditioned (NPC) inflow hydrology for the period 2010 to 2060, resulting in 500 simulations. CRSS was initialized to January 1, 2010 observed reservoir elevations. Upper Basin depletions come from the new (2007) UCRC depletion schedule. The new ICS assumptions used in the bi-national modeling effort and in the official January 2010 CRSS run were also used.

Outside of CRSS, statistical analysis was performed on the NPC natural flow hydrology for the Colorado River at Lees Ferry. For all 500 inflow traces, the first ten years of the annual volumes were averaged then ranked. Based on the ranking, five wet, five moderate, and five dry traces were selected as candidate inflow hydrologies. Wet traces were those closest to the 90^{th} percentile (9.6% exceedance to 10.4% exceedance probability), moderate traces the 50^{th} percentile and dry traces, the 10^{th} percentile.

The 15 corresponding traces were pulled from CRSS output to gather the Lake Powell outflow for the years 2010 to 2019. Each of the wet ten-year outflow time series was plotted and the timeseries were evaluated against each other to select the best for the sediment analysis. Time series were evaluated by visual inspection to eliminate traces with step-functions and to select the time series with the least amount of trend and the greatest amount of variability. The process was repeated the select the best moderate trace and best dry trace. The final three time series are shown below. In addition, each set of 10-water year release values (10 each for wet, moderate, and dry) are plotted on top of the cumulative distribution of all Powell water year release values (see below).

As a side note, the above process was also done with the historic record natural flow (index sequential method). Results were similar between the paleo-conditioned and the historic record natural inflows. However, the pale-conditioned flows provided a slightly wider range of flows at Lees Ferry for the 10-year window.

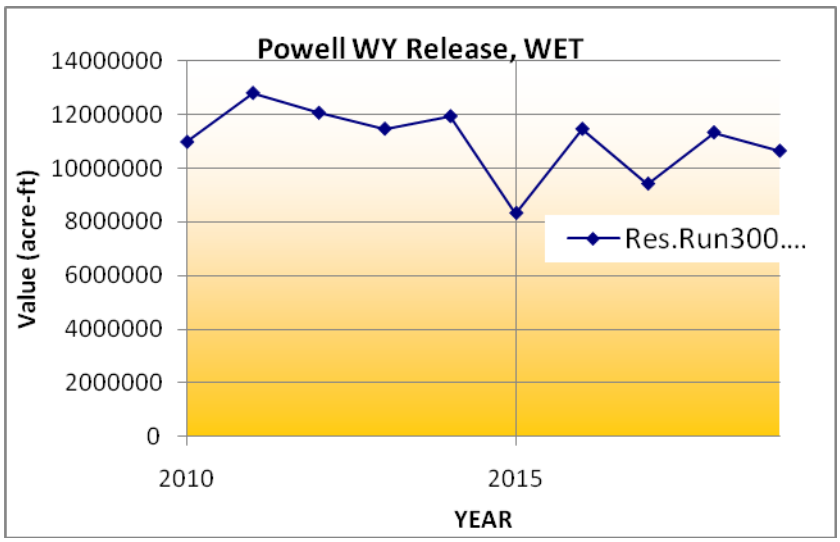

Figure 1. Lake Powell water year releases, wet trace.

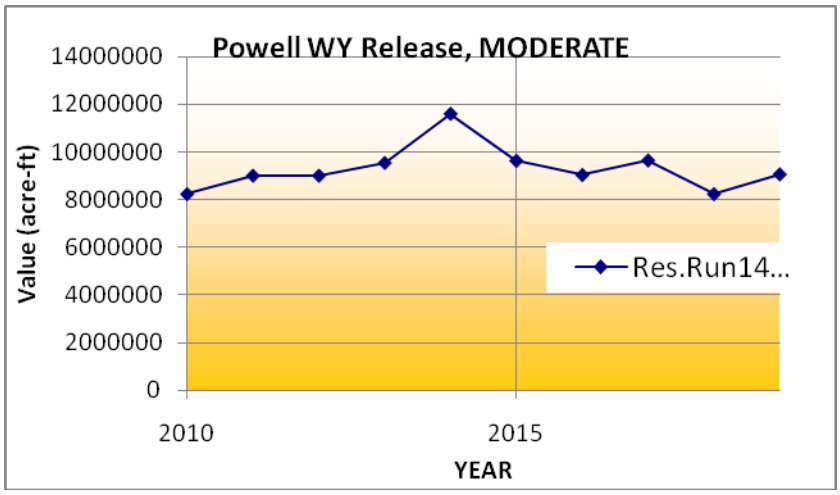

Figure 2. Lake Powell water year releases, moderate trace.

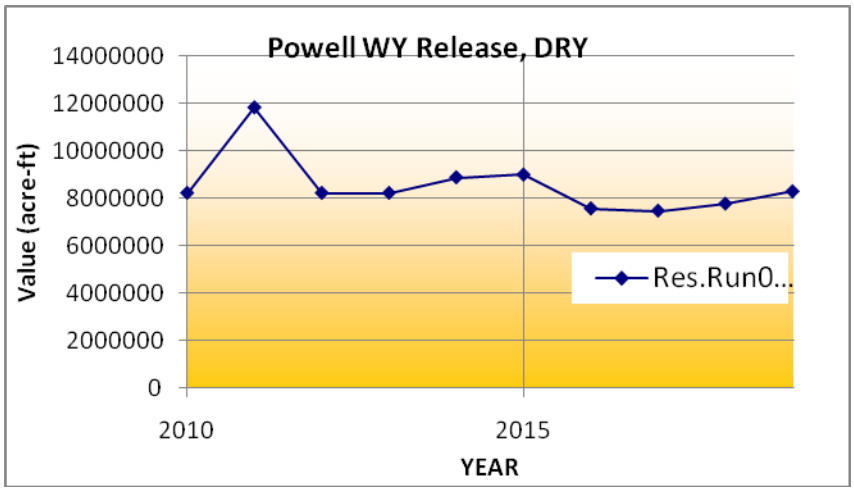

Figure 3. Lake Powell water year releases, dry trace.

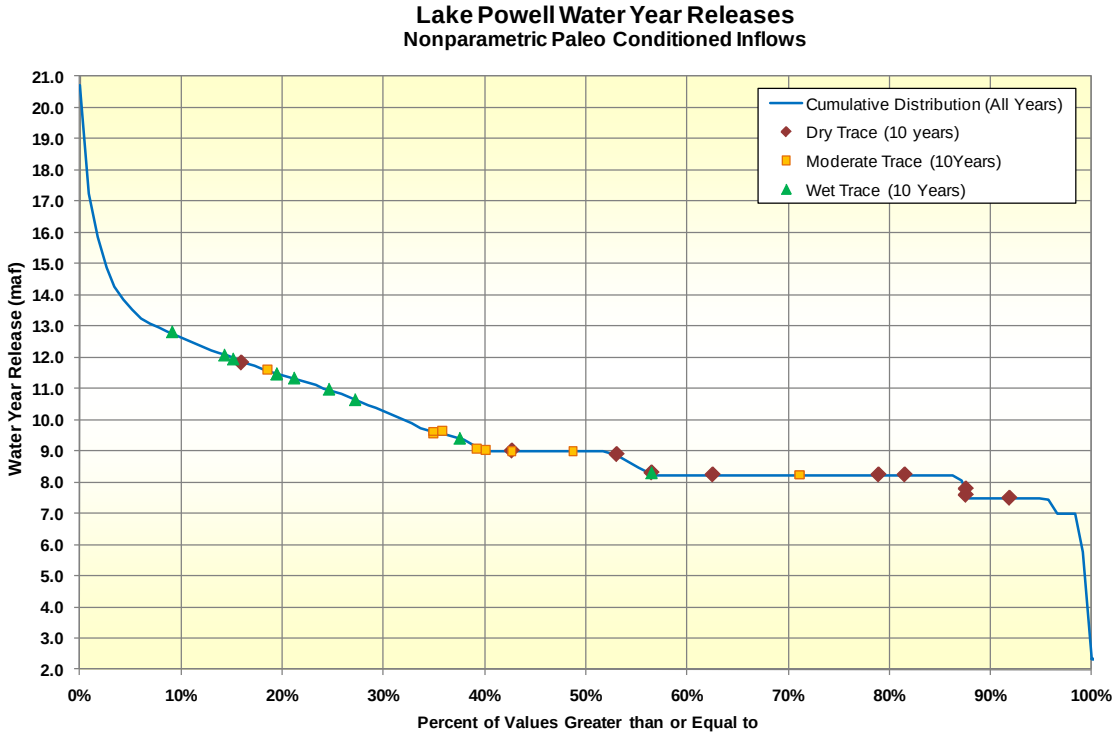

Figure 4. Lake Powell water year releases, all CRSS runs with values from selected dry, moderate, and wet traces highlighted.

Disaggregation to Hourly Flows

Methodology for disaggregation from monthly to hourly releases in order to assess sediment input and erosion in the Grand Canyon downstream of Glen Canyon Dam was agreed upon during the LTEP process in 2006. This same methodology was utilized in the current analysis.

Disaggregation of monthly to hourly flows for Glen Canyon Dam releases have specific operational constraints that must be addressed. These operational constraints are as follows:

- Maximum daily change in cubic feet per second (cfs) per day for various monthly release volumes in thousands of acre-feet (KAF)

Table 1. Monthly release volumes and associated maximum daily change.

Monthly Release Volume (KAF)	Daily Change Limit (cfs/day)
< 600	5,000
>= 600 and < 800	6,000
>= 800	8,000

- Maximum release of 25,000 cfs
- Minimum release of 8,000/5,000 cfs
- Turbine release capacity at different hydraulic head
- Seasonal differences in electrical demand

Western Area Power Administration (Western) utilizes GTMax, optimization software developed by Argonne National Laboratories (Argonne) to generate hourly release schedules for the Colorado River Storage Program system based on water availability, historic electrical demand, environmental and operational constraints. The GTMax model output received from Western/Argonne contained 33 runs created around a matrix. There were 11 runs at three different elevations (3,700, 3,600 and 3,489 feet) to account for release based on hydraulic head. At each elevation level there were hourly patterns for an entire calendar year at specific monthly volumes that transitioned the MLFF restrictions (i.e., in January there was a monthly release of both 799 and 800 KAF release to transition between 6,000 cfs and 8,000 cfs daily release restrictions).

The monthly release volumes discussed in the hydrologic trace selection above were compared against the GTMax matrix. The hourly GTMax output was scaled and interpolated based on percent difference between the monthly volumes in the hydrologic trace selection. There are some instances where the daily change is approximately 100 cfs greater than the allowable daily change, but the scaled pattern was decreased such that it was unrealistic release pattern. During wet releases, the scaled hourly pattern would exceed the 25,000 cfs maximum release, and in those instances releases are assumed to be steady at the scaled monthly volume. While this is an unrealistic release pattern, it is assumed to be adequate for this analysis.

Table 2. GTMax Matrix Output

			Monthly Release (TAF)											
Output Folder	Run	Reservoir Elevation (ft)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Run11	11	3,700.00	2,152	1,944	2,152	2,083	2,635	4,710	3,100	2,152	2,083	2,152	2,083	2,152
Run10	10	3,700.00	1,537	1,388	1,537	1,488	1,537	1,488	1,537	1,537	1,488	1,537	1,488	1,537
Run9	9	3,700.00	1,055	1,000	1,000	1,000	1,000	1,000	1200	1,000	1,000	1,000	1,000	1,260
Run8	8	3,700.00	850	900	900	900	900	900	1,000	900	850	900	900	900
Run7	7	3,700.00	800	800	800	800	800	800	850	880	800	800	800	800
Run6	6	3,700.00	799	799	799	799	799	799	799	799	799	799	799	799
Run5	5	3,700.00	650	650	650	640	650	650	650	745	620	660	660	660
Run4	4	3,700.00	600	600	600	600	600	600	600	600	600	600	600	600
Run3	3	3,700.00	599	599	599	599	599	599	599	599	599	599	599	599
Run2	2	3,700.00	550	550	550	500	550	560	560	550	560	480	480	480
Run1	1	3,700.00	434	392	434	420	434	420	434	434	420	434	420	434
Run22	22	3,600.00	2,152	1,944	2,152	2,083	2,635	4,710	3,100	2,152	2,083	2,152	2,083	2,152
Run21	21	3,600.00	1,537	1,388	1,537	1,488	1,537	1,488	1,537	1,537	1,488	1,537	1,488	1,537
Run20	20	3,600.00	1,055	1,000	1,000	1,000	1,000	1,000	1,200	1,000	1,000	1,000	1,000	1,260
Run19	19	3,600.00	850	900	900	900	900	900	1,000	900	850	900	900	900
Run18	18	3,600.00	800	800	800	800	800	800	850	880	800	800	800	800
Run17	17	3,600.00	799	799	799	799	799	799	799	799	799	799	799	799
Run16	16	3,600.00	650	650	650	640	650	650	650	745	620	660	660	660
Run15	15	3,600.00	600	600	600	600	600	600	600	600	600	600	600	600
Run14	14	3,600.00	599	599	599	599	599	599	599	599	599	599	599	599
Run13	13	3,600.00	550	550	550	500	550	560	560	550	560	480	480	480
Run12	12	3,600.00	434	392	434	420	434	420	434	434	420	434	420	434
Run33	33	3,489.90	2152	1944	2152	2083	2635	4710	3100	2152	2082.63	2152	2083	2152
Run32	32	3,489.90	1537	1388	1537	1488	1537	1488	1537	1537	1487.59	1537	1488	1537
Run31	31	3,489.90	1055	1000	1000	1000	1000	1000	1200	1000	1000	1000	1000	1260
Run30	30	3,489.90	850	900	900	900	900	900	1000	900	850	900	900	900
Run29	29	3,489.90	800	800	800	800	800	800	850	880	800	800	800	800
Run28	28	3,489.90	799	799	799	799	799	799	799	799	799	799	799	799
Run27	27	3,489.90	650	650	650	640	650	650	650	745	620	660	660	660
Run26	26	3,489.90	600	600	600	600	600	600	600	600	600	600	600	600
Run25	25	3,489.90	599	599	599	599	599	599	599	599	599	599	599	599
Run24	24	3,489.90	550	550	550	500	550	560	560	550	560	480	480	480
Run23	23	3,489.90	434	392	434	420	434	420	434	434	420	434	420	434