Grand Canyon Monitoring and Research Program

U.S. Department of the Interior
U.S. Geological Survey

Calculated Hydrographs for the Colorado River Downstream from Glen Canyon Dam during the Experimental Release, March 22–April 8, 1996

As part of Glen Canyon Environmental Studies, an experimental flood release from Glen Canyon Dam of discharges up to 45,000 cubic feet per second (cfs) is planned for spring 1996. To aid in preparation for this release and to help researchers and boaters who will be working and traveling on the Colorado River during that time, this Fact Sheet presents estimates of the progression and evolution of the step waves that will result from the transitions between high and low flow.

The experimental release will consist of a low steady flow, a rapid increase to the steady high flow, and a decrease back down to a steady low flow (Wegner and others, 1996). After a steady flow of 8,000 cfs lasting 96 hours, the discharge at the dam will be increased to 45,000 cfs over 10 hours. After 167 hours at 45,000 cfs, the discharge at the dam will be decreased over 46 hours until 8,000 cfs is reached, and held at 8,000 cfs for 88 hours (fig. 1). For the calculations described below, a steady 15,000 cfs flow was added to the beginning and end of the experimental flow to approximate the the transitions between regular dam operation and the experimental flow. The rising and falling limbs of the dam release travel downstream as waves that move faster than the speed of the water. The higher discharge part of the wave moves faster than the lower discharge part, and this, along with smoothing of the sharp transitions between steady discharge and decreasing discharge, causes the wave to change shape as it travels downstream. The rising limb of the wave will steepen and the trailing limb will be stretched out.

The calculations of wave propagation were made with a one-dimensional model developed for the Colorado River between Glen Canyon Dam and Lake Mead (Wiele and Smith, in press). It has been shown to be accurate for discharges up to about 30,000 cfs, the highest discharge for which measurements of flow velocities, used to obtain channel roughness, and channel shape are available. For the calculations presented here, channel shape and roughness above 30,000 cfs were extrapolated using functions developed from data obtained below 30,000 cfs. The extrapolated channel shape and roughness affect the shape of the entire wave, including that part of the wave below 30,000 cfs, so the accuracy of the predicted hydrographs is degraded because of the uncertainty of the channel properties above 30,000 cfs. Tests of model accuracy during development showed that the average error in predicted travel time at Diamond Creek (240 miles downstream from the dam) ranged from 1.8 to 4.6 percent for daily waves with peaks less than 30,000 cfs.

Model-calculated hydrographs at the locations of USGS streamflow-gaging stations show the changes in wave shape, approximate wave travel times, and the approximate times at which the flow will be at the high and low discharges (fig. 1). On the rising limb, the wave steepens (fig. 2*A*) and the increase from 10,000 cfs to 40,000 cfs that takes 7.5 hours at the dam will take only about 2 hours at National Canyon, 181 miles downstream. The rising limb of the wave will reach a stable shape around National Canyon that will propagate with little change as it moves downstream. The falling limb will stretch out over the entire study reach (fig. 2*B*), taking about 39 hours to fall from 40,000 cfs to 10,000 cfs at the dam and about 63 hours to fall the same amount at Diamond Creek, 240 miles below the dam.

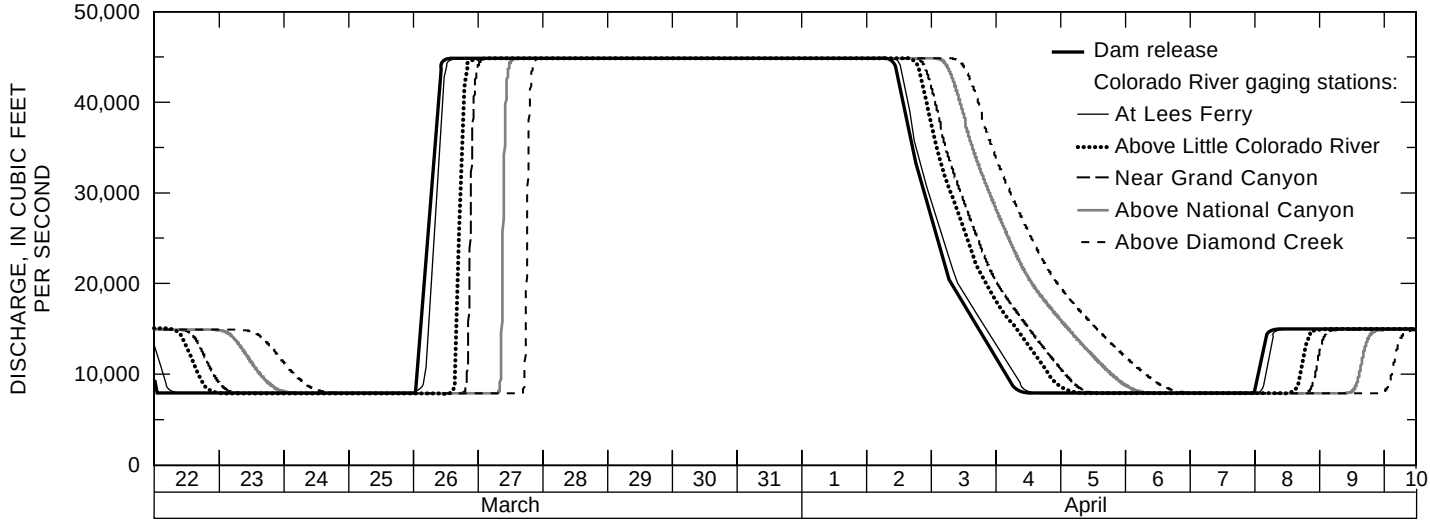

Figure 1. Hydrograph of proposed experimental flow release and calcula ted hydrographs for gaging stations.

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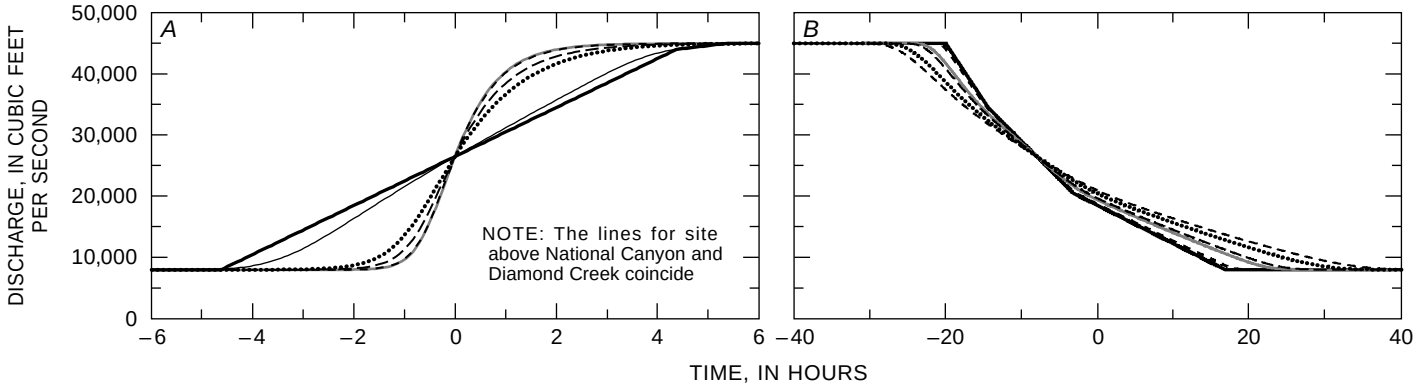

Figure 2. Hydrographs of rising (*A*) and falling (*B*) limbs of the dam releases and calculated hydrographsshowingthewave steepening on the rising limb and stretching out on the falling limb as it moves downstream. Sites are as defined in figure 1. Hydrographs have been shifted in time so that they are centered about the discharge midpoint to show the differences in rates at which the discharge changes.

The length of time the flows will be at their steady high and low discharges will decrease downstream from the dam as a result of the stretching of the falling limb and the smoothing of the initial wave shape (fig. 3). The first low flow, scheduled to last 96 hours at the dam, will last only about 74 hours at Diamond Creek. The high flow, which will be held steady for 167 hours at the dam, will last 160 hours at Diamond Creek. The second low flow, lasting 88 hours at the dam, will last about 76 hours at Diamond Creek. Approximate times for the beginning and ending of the steady flows at the streamflow-gaging stations are listed in the table 1 below. Because the smoothing of the initial wave causes the transitions to the steady flows to be gradual, discharges 2 percent above the low steady discharge (8,160 cfs) and 2 percent below the high steady discharge (44,100 cfs) were used to define the points of transition.

The length of time the entire length of the study reach will simultaneously be at the steady low flow depends on the dam release and the wave travel time. The flow will be at a steady 8,000 cfs, plus tributary inflow, through the entire length of the study reach simultaneously for about 1 day before (March 24 at about 1500 hours to March 26 at about 0100 hours) and after (April 6 at about 2000 hours to April 8 at about 0000 hours) the high flow (figs. 1 and 3; table 1).

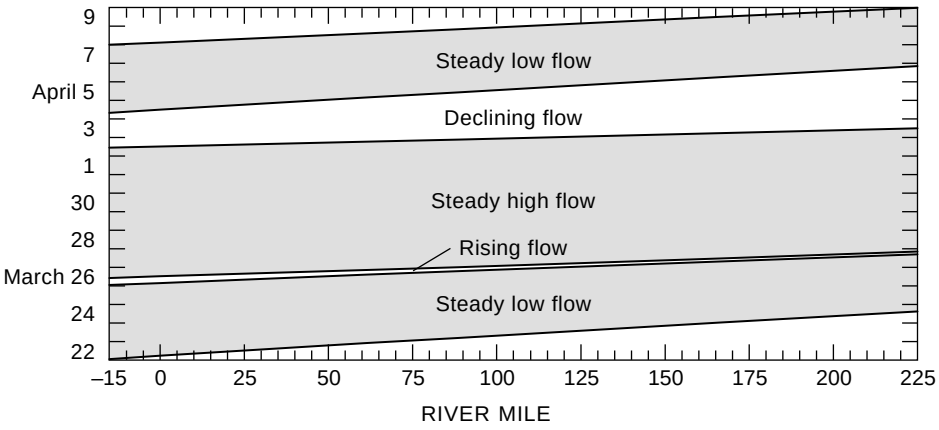

Figure 3. Periods of low and high steady flows separated by periods of rising and declining flows as functions of river mile.

Table 1. Beginning and ending times [month–day/hour, in military time] of the steady flows at the dam and at the streamflow-gaging stations

[River mile measured upstream (–) or downstream (+) from Lees Ferry]

Sites	Steady low flow		Steady high flow		Steady low flow	
	Start	End	Start	End	Start	End
Glen Canyon Dam, river mile –15	**03–22 0100**	**03–26 0100**	**03–26 1100**	**04–02 1000**	**04–04 0800**	**04–08 0000**
Streamflow-gaging stations:						
At Lees Ferry, river mile 0	**03–22 0600**	**03–26 0300**	**03–26 1200**	**04–02 1200**	**04–04 1200**	**04–08 0300**
Above Little Colorado River, river mile 62	**03–22 2200**	**03–26 1400**	**03–26 2000**	**04–02 1900**	**04–05 0400**	**04–08 1500**
Near Grand Canyon river mile 88	**03–23 0500**	**03–26 1900**	**03–27 0000**	**04–02 2100**	**04–05 1000**	**04–08 2000**
National Canyon, river mile 166	**03–24 0000**	**03–27 0800**	**03–27 1100**	**04–03 0600**	**04–06 0600**	**04–09 1200**
Diamond Creek, river mile 225	**03–24 1500**	**03–27 1700**	**03–27 2000**	**04–03 1200**	**04–06 2000**	**04–10 0000**

References

Wegner, D.L. Stevens, L., and Melis, T., 1996, Controlled flood studies, Glen Canyon Dam, Spring, 1996: Glen Canyon Environmental Studies Office, Bureau of Reclamation, Flagstaff, Arizona.

Wiele, S.M. and Smith, J.D., in press, A reach-averaged model of diurnal discharge wave propagation down the Colorado River through the Grand Canyon: Water Resources Research.

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