RAMP DOWN RATE IN THE REVISED INTERIM OPERATION PLAN: IS MOTHER NATURE TOO HARSH ON THE ENDANGERED MUSSELS IN THE APALACHICOLA RIVER?

Wei Zeng and Yi Zhang

AUTHORS: Basin Analysis Program, Environmental Protection Division, Georgia Department of Natural Resources, 2 Martin Luther King, Jr. Drive, SE, Suite 1058 East Floyd Tower, Atlanta, Georgia 30334.
REFERENCE: *Proceedings of the 2011 Georgia Water Resources Conference*, held April 11–13, 2011, at the University of Georgia.

Abstract. A careful review of the pre-impoundment data shows that much of the natural ramp down rate at the receding limb of peaking flow events would be "outlawed" or not allowed by provisions of the Revised Interim Operation Plan – the operational guidance of the Army Corps of Engineers in its operation of the Apalachicola-Chattahoochee-Flint River Basin. This begs the question of whether it is in the interest of the endangered animals for the Corps to provide something that even Mother Natural could not provide.

INTRODUCTION

In April 2008, the Army Corps of Engineers (Corps) published its Revised Interim Operation Plan (RIOP) for the Apalachicola-Chattahoochee-Flint (ACF) River Basin. In the following June, U.S. Fish and Wildlife Service (USWFS) published its Biological Opinion (BiOp) supporting the RIOP.

The RIOP calls for specific releases depending on the amount of basin inflow, defined as total amount of water entering the Corps' major storage reservoirs in the basin, and status of system storage in the basin. Such releases are supposed to provide protected habitat and environment for the endangered sturgeon and mussels in the Apalachicola River.

Aside from the flow requirements, the RIOP also calls for limitations on the stage fall rate, referred in the RIOP and BiOp as Maximum Fall Rate. The stage fall rate is defined as "vertical drop in river stage (water surface elevation) that occurs over a given period. The RIOP fall rates are expressed in units of feet per day (ft/day). In the rest of this paper, we will use the term "ramp down rate" as well.

The BiOp states, "By capturing high flows in storage, reservoirs typically accelerate the drop in stage compared to pre-reservoir conditions by closing spillway gates during flood recession, which may reduce germination and survival of riparian tree seedlings that colonize banks and sandbars by drying these areas out too fast. Successful regeneration of riparian vegetation is essential in the balance of erosion and deposition to maintain channel stability." (See Section 3.3.5, Page 57 of USFWS 2008)

The BiOp also states, "We further focus on fall rates, and not rise rates, in this analysis due to the possible effect of stranding listed species and host fishes for the mussels in higher portions of the stream channel or floodplain when river stages decline too rapidly." The BiOp further declares that the extreme fall rates, those that are in the range of 1.0 to 2.0 feet per day or greater, more than doubled for the post-impoundment period in comparison to the pre-impoundment period, implying that reservoir operations caused this change.

The purpose of the Maximum Fall Rate, according to these statements in the Biological Opinion, is to maintain a fall rate that mimics Mother Nature, and therefore to stabilize channel and to avoid stranding mussels or host fishes at higher grounds. In other words, the Corps does not want the stage to fall so fast that there would be detrimental effects.

To achieve these objectives, the Corps set Maximum Fall Rate for flows at different ranges. For example, when flow is in the range between 8,000 cfs and 16,000 cfs, the Maximum Fall Rate is set at between the more restrictive 0.25 feet per day and the more relaxed 0.5 feet per day. Having the Maximum Fall Rate in a range is a little confusing, and it makes modeling and evaluating the impacts difficult. In practice, we believe the Corps uses the more restrictive Maximum Fall Rate. The Maximum Fall Rate schedule is shown in Table 1.

The notion that flood reduction operations at the reservoirs cause the receding limb of a flood wave to drop faster than under natural conditions, as stated in the BiOp, is against basic engineering principles and not supported by any evidence. Any hydraulic structure that restrains free flow of water in a river would cause the flow sequence to have a lower peak and a longer duration, in other words, smoother. A comparison between the fall rates of pre-impoundment period and post-impoundment period totally ignores differences in hydrological conditions between the two periods and placed the blame of fall rate changes squarely on the construction of reservoirs and the operations of them. We believe this type of comparison is less than scientifically defensible.

In this paper, we try to study the ramp down rates to see if Mother Nature, as reflected by the pre-impoundment hydrological data, has a passing score under the RIOP

Maximum Fall Rate requirements. We also try to understand the storage implications of the Maximum Fall Rate provisions. Finally, we try to understand whether the more frequent greater ramp down rates, as alluded to in the BiOp, were caused by Mother Nature, instead of the Corps flood reduction operations.

APPROACH

Using observed flow and stage time series data for the pre-impoundment period, we look at whether the Maximum Fall Rates prescribed by the Corps in the RIOP and blessed by the USFWS conform to what Mother Nature provided. Since the first of the ACF projects, Jim Woodruff Lock and Dam was completed in 1957, we used observed flow and stage height at the Chattahoochee, Florida gage for the period between January 1, 1930 and December 31, 1956 (USACE 1989). The data reflect the natural state of the Apalachicola River before any major reservoir regulations.

Comparing the magnitude and frequency of the natural fall rates to the RIOP Maximum Fall Rates, we look at whether we (the operators of the reservoir system) are “outlawing” some of Mother Nature’s behavior today. Using the Corps methodology of categorizing flows into less-than-8,000-cfs, between-8,000-and-16,000-cfs, and between-16,000-and-20,000-cfs classes. In each class, the natural ramp down rate (or fall rate) has a range that can be expressed with an exceedance curve to show the magnitude as well as frequency of the rates. Such exceedance curves can then be compared to the RIOP Maximum Fall Rates. (See Figures 1 through 3.)

The extent of the Maximum Fall Rate forbidding significant fraction of naturally occurring ramp down rates can be clearly seen. For example, when flow at Chattahoochee, Florida was in the range between 8,000 cfs and 16,000 cfs in the period 1930 to 1956, natural ramp down rates range from 0.02 feet per day to 0.67 feet per day, corresponding to 5 percent and 95 percent exceedance levels respectively. The RIOP’s Maximum Fall Rate for flows in this class, however, calls for ramp down rate not greater than 0.25 feet per day, making 40% of the higher but *natural* ramp down rates “illegitimate.” (See Figure 2.) Similarly, for the class of flow between 16,000 cfs and 20,000 cfs, the RIOP’s Maximum Fall Rate would “outlaw” about one quarter of the natural ramp down rates. (See Figure 3.)

What happens when the Corps implements a Maximum Fall Rate that is much more stringent than what Mother Nature provides? Storage augmentation is needed. Comparing the natural flow time series of the falling limb of flood events, we look at whether, under the RIOP, we are doing something to augment Mother Nature using storage, especially under drought conditions.

Figure 4 shows the flow sequence of an event in October 1934, when flow was receding from over 30,000 cfs to just above 10,000 cfs. Per the RIOP Maximum Fall Rate provisions, the natural ramp down rates associated with this event are not allowed. We plotted the flow sequence in compliance with the RIOP Maximum Fall Rate requirement. It is clearly shown how the Corps would need to augment Mother Nature to be in compliance with the RIOP. The storage needed for maintaining this set of fall rates, which are unnatural, is 18,750 acre-feet, or about 1.2% of the ACF system conservation storage. Note that this is the amount of storage needed in one event.

Figure 5 shows the flow sequence of another event in October 1956, when flow was receding from about 25,000 cfs to about 7,500 cfs. Substantial amount of storage is needed to maintain the RIOP Maximum Fall Rates. By our calculation, the necessary amount of storage is 62,600 acre-feet, or about 3.9% of system conservation storage.

Aggregating the amount of storage needed for such augmentation of Mother Nature, we look at how much additional storage is needed to comply with the Maximum Fall Rate provisions of the RIOP in a drought year. Table 2 shows the amount of storage needed for augmentation in the drought years of 1941, 1951, 1954, 1955, and 1956. It is astonishing to us that the Maximum Fall Rate provisions of the RIOP will require as much as 10% of total ACF system conservation storage to make Mother Nature’s flow “smoother.” In the three consecutive years of drought in the mid-1950s, the aggregated amount of storage needed to perform this “smoothing” is equivalent to 24% of system conservation storage. Note that this is before any consideration of summer and fall flow augmentation to meet minimum flow requirements. (See Table 2.)

DISCUSSIONS

The notion that reservoir operations in general cause fall rates to be larger than under natural conditions is against the laws of physics and the principle of mass continuity. Any hydraulic project with even trivial storage causes incoming flow events to be smoother. Even channel storage will have the same effects. This is called attenuation. The net effect of the attenuation process is that the peaks of flood events are lower and delayed, and the duration of the event is longer. In other words, what used to be an acute and sharp increase and fall in flow is generally replaced by a delayed, slower, and longer process.

The BiOp’s comparison between fall rates in the Pre-Lanier period and the Post-West Point period seems to imply that the differences in fall rates, especially the higher fall rates beyond 1 to 2 feet per day, were caused by the existence of the ACF reservoirs. However, a critically flawed assumption in this comparison is that the natural fall rates without the reservoirs would have been the same. In other words, the comparison is done with the erroneous assumption that natural hydrological conditions remained the same in the Post-West Point period as in the Pre-Lanier period and that any changes in the fall rates were caused by the existence and operation of the reservoirs.

A careful review of daily change in flow magnitude strongly suggests that the increased flow differential and consequent larger fall rates for the Post-West Point period has a natural footprint. Figure 6 shows frequency and magnitude of daily Unimpaired flow differential (amount of flow reduction between two consecutive days) for the Pre-Lanier and Post-West Point periods. Using the Unimpaired Flow data, we removed the Corps' operation from consideration. This figure shows that flow fell naturally at a faster daily pace in the Post-West Point period than in the Pre-Lanier period. This seems to be the case throughout the entire range of comparison. The larger fall rates for the Post-West Point period, therefore, is at least partially natural.

It is conceivable that sudden closing of flood control gates may cause abrupt reduction in flow. However, avoiding sudden gate closing and consequent abrupt flow reduction is totally different from having to use storage to artificially and arbitrarily sustain a fall rate that is milder than what Mother Nature provides.

If mimicking Mother Nature is underlying the practice of Maximum Fall Rates, then minor changes in operation should be able to prevent sudden drop of flow rates, and it should not involve using storage to augment flow Mother Nature provides. If the Corps and USFWS consider natural flows provided by Mother Nature as insufficient to protect the endangered mussels, then this should be stated in the BiOp and supported by scientific evidence and analyses.

CONCLUSIONS

Our analysis shows that the Maximum Fall Rate provisions in the RIOP are arbitrary, unnecessary, and unnatural. Such provisions would not allow a significant portion of natural fall rates to take place. They would require operations of the reservoir system to provide artificial fall rates that are much milder than what would occur naturally. These operations would results in the use of substantial amount of storage to augment flow, even in drought years. We recommend that the fall rate provisions be suspended before more thorough studies are conducted to determine true needs of the endangered species.

Table 1. Maximum Fall Rate schedule by the RIOP

Release Range (cfs)	Maximum Fall Rate (ft/day)
≥ 30,000 **	Fall rate is not limited ***
≥ 20, 000 and < 30,000 *	1.0 to 2.0
Exceeds powerhouse capacity (~16,000) and < 20,000 *	0.5 to 1.0
Within powerhouse capacity and > 8,000 *	0.25 to 0.5
Within powerhouse capacity and ≤ 8,000 *	0.25 or less

* Maximum fall rate schedule is suspended in Composite Zone 4.

** Consistent with safety requirements, flood control purposes, and equipment capabilities.

*** For flows greater than 30,000 cfs, it is not reasonable and prudent to attempt to control down ramping rate, and no ramping rate is required.

Table 2. Needs for flow augmentation to comply with the Maximum Fall Rate

Year	Annual Augmentation Needed for the Maximum Fall Rates (acre-feet)	Equivalent Percentage of System Conservation Pool
1941	82,700	5%
1951	66,100	4%
1954	74,800	5%
1955	157,900	10%
1956	141,200	9%

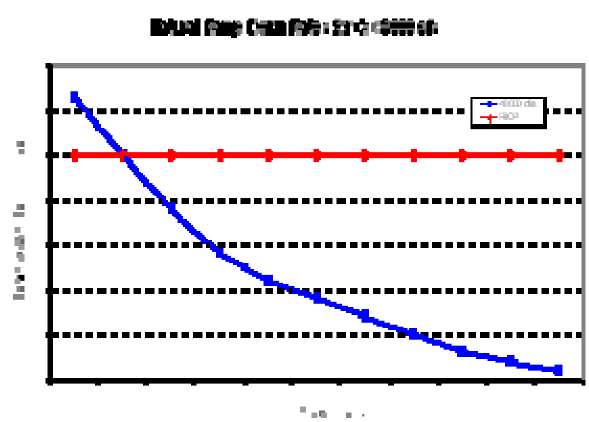

Figure 1. Comparison of natural ramp down rate and the RIOP maximum ramp down rate, when flow < 8000 cfs

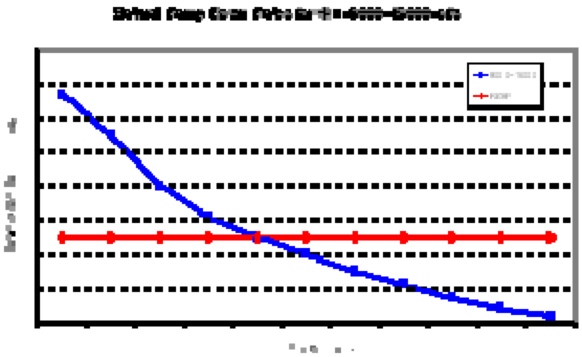

Figure 2. Comparison of natural ramp down rate and the RIOP maximum ramp down rate, when flow is between 8000 and 16000 cfs

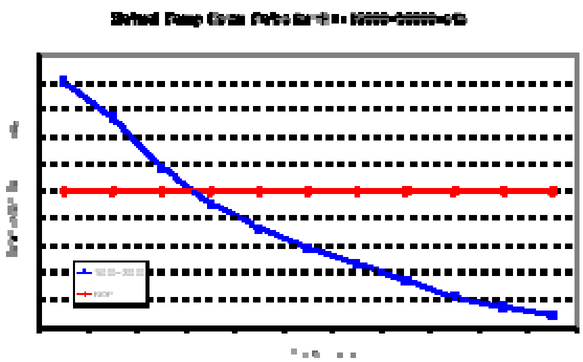

Figure 3. Comparison of natural ramp down rate and the RIOP maximum ramp down rate, when flow is between 16000 and 20000 cfs

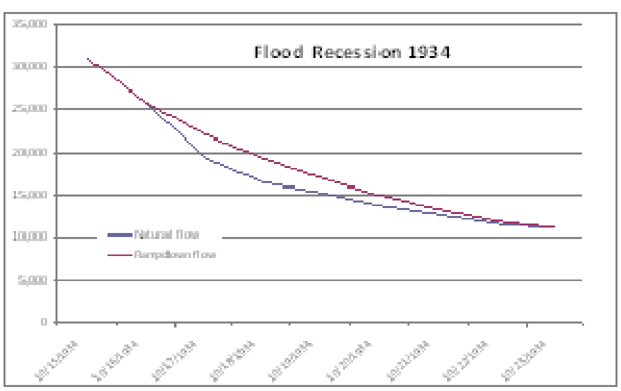

Figure 4. The receding phase of an October 1934 flood and what would happen under the RIOP ramp down control

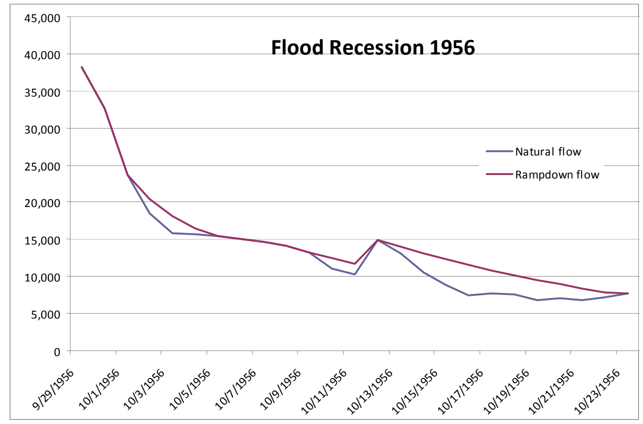

Figure 5. The receding phase of an October 1956 flood and what would happen under the RIOP ramp down control

REFERENCES

[1] U.S. Fish and Wildlife Service (2008). Biological Opinion on the U.S. Army Corps of Engineers, Mobile District, Revised Interim Operating Plan for Jim Woodruff Dam and the Associated Releases to the Apalachicola River. U.S. Fish and Wildlife Service, Panama City Field Office, Florida. [2] Haan, Charles T., 2002, Statistical Methods in Hydrology, Iowa State Press.