Flow Recommendations for Youghiogheny River Lake

Submitted to USACE-Pittsburgh District by The Nature Conservancy[1] – July 2014

I. Introduction

These recommendations build on two previous studies and are the first of a series of project-specific flow recommendations that we plan to develop for reservoirs in the Pittsburgh District. These recommendations incorporate information from:

- The Ecosystem Flow Recommendations for the Upper Ohio River in Western Pennsylvania[2], which includes a series of ecological needs that would be met by managing flows within the recommended limits to alteration and potentially-affected ecological functions if flows are altered beyond these limits. In order to identify which ecological functions are likely to be affected by operations of the Youghiogheny Dam, we refined the potentially affected ecological functions with more specific biological data from the Youghiogheny River.

- The reach-specific hydrologic analysis for the two reaches in the Youghiogheny River that was included in the Ecological Flow Study for the Monongahela River[3] (See Section 4.5 for results for the two Youghiogheny River reaches). This study compared baseline (i.e., without the influence of reservoir operations) and current flows to identify the flow components that are altered by current operations.

Building on these results, we analyzed flows on daily and monthly time-steps to refine these estimates of hydrologic alteration and develop more specific flow recommendations in a form that could be operationalized. Depending on the flow component, the prescription is presented as either (a) a range of flows (in cfs) or (b) the frequency of events (either in events or days) above a specified magnitude. These flow recommendations are intended to restore the flow components that would have the most ecological benefits (Figure 1):

  - Spring baseflows
  - Spring high flow pulses
  - Bankfull events and small floods
  - Summer baseflows
  - Summer high flow pulses
  - Transition between fall and winter flows

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[2]DePhilip, M. and T. Moberg. 2013. Ecosystem flow recommendations for the Upper Ohio River basin in Western Pennsylvania. The Nature Conservancy. Harrisburg, PA. Available online http://www.nature.org/media/pa/ecosystem-flow-recommendations-upper-ohio-river-pa-2013.pdf

[3]The Nature Conservancy. 2014. Ecological Flow Study for the Monongahela River. Harrisburg, PA. Report submitted to U.S. Army Corps of Engineers.

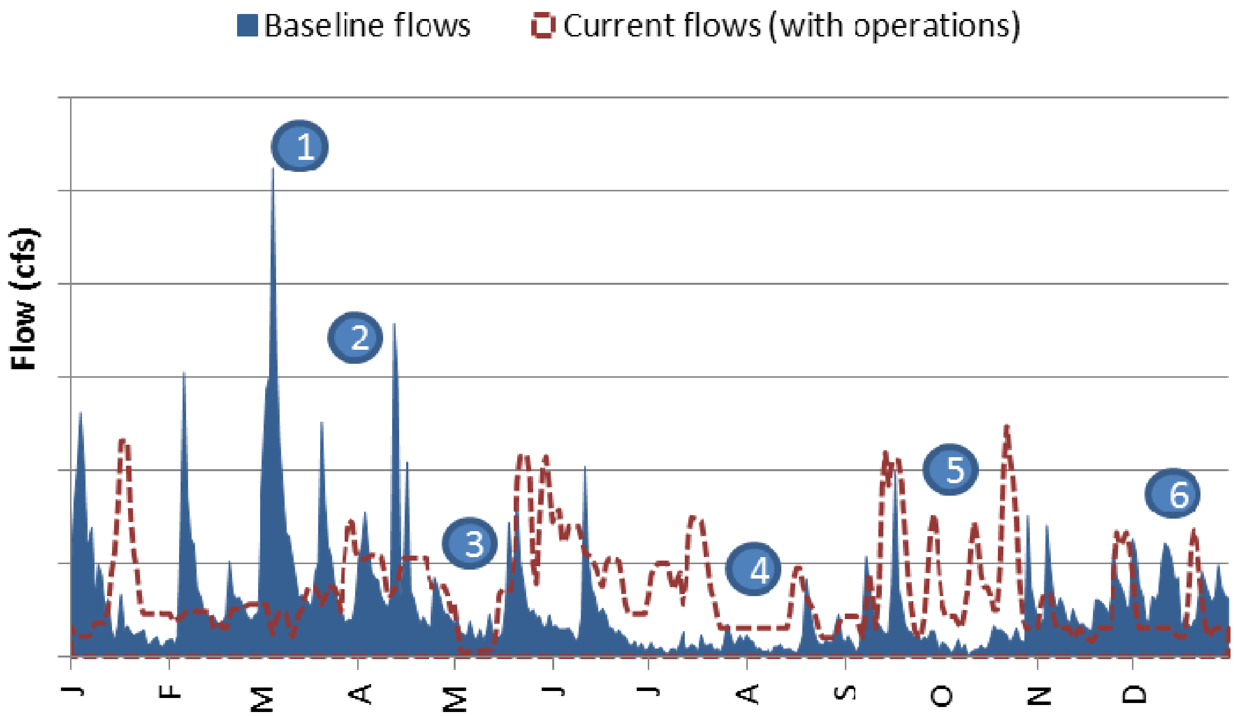

Figure 1. Comparison between baseline and current flows downstream of Youghiogheny River Lake and a summary of ecological functions provided by the baseline (minimally-altered) flow regime.

1 – Bankfull and small floods support vegetation establishment and growth and maintain channel morphology and sediment distribution

2 – Spring high flow pulses support fish spawning and connectivity among habitats and maintain streamside vernal habitats

3 – Spring baseflows provide fish spawning habitat and allow access to shallow-slow margin spawning and nursery habitat

4 – Summer baseflows provide suitable habitat for small-bodied fishes and mussels and support seasonal temperatures

5 – Summer high flow pulses must not be too high or too frequent so as to create unsuitable velocities and depths

6 – Fall and winter baseflows provide suitable overwinter habitat for many lifestages and maintain stable habitat during hibernation

Current operations have reduced the magnitude of spring baseflows (3), elevated magnitude of summer baseflows (4), reduced the magnitude and frequency of bankfull events, small floods, and spring high flow pulses (1, 2), increased frequency of summer high flow pulses (5) and (in some years) created winter flows that are lower than early fall flows (6).

II. Flow Recommendations

The flow recommendations for the Youghiogheny River are illustrated in Figure 2 and presented in Table 1. Recommended flows are specified for the reaches (1) immediately below Youghiogheny River Lake and (2) at Connellsville for the reach downstream to the confluence with the Monongahela.

These recommendations are intended to improve streamflow conditions and availability and quality of habitat for riverine and floodplain species by restoring key components of the flow regime. They are a starting point for discussion with the District, other natural resource agencies, and other stakeholders about feasibility, including operational flexibility, structural limitations, compatibility with other project purposes, and ecological benefits.

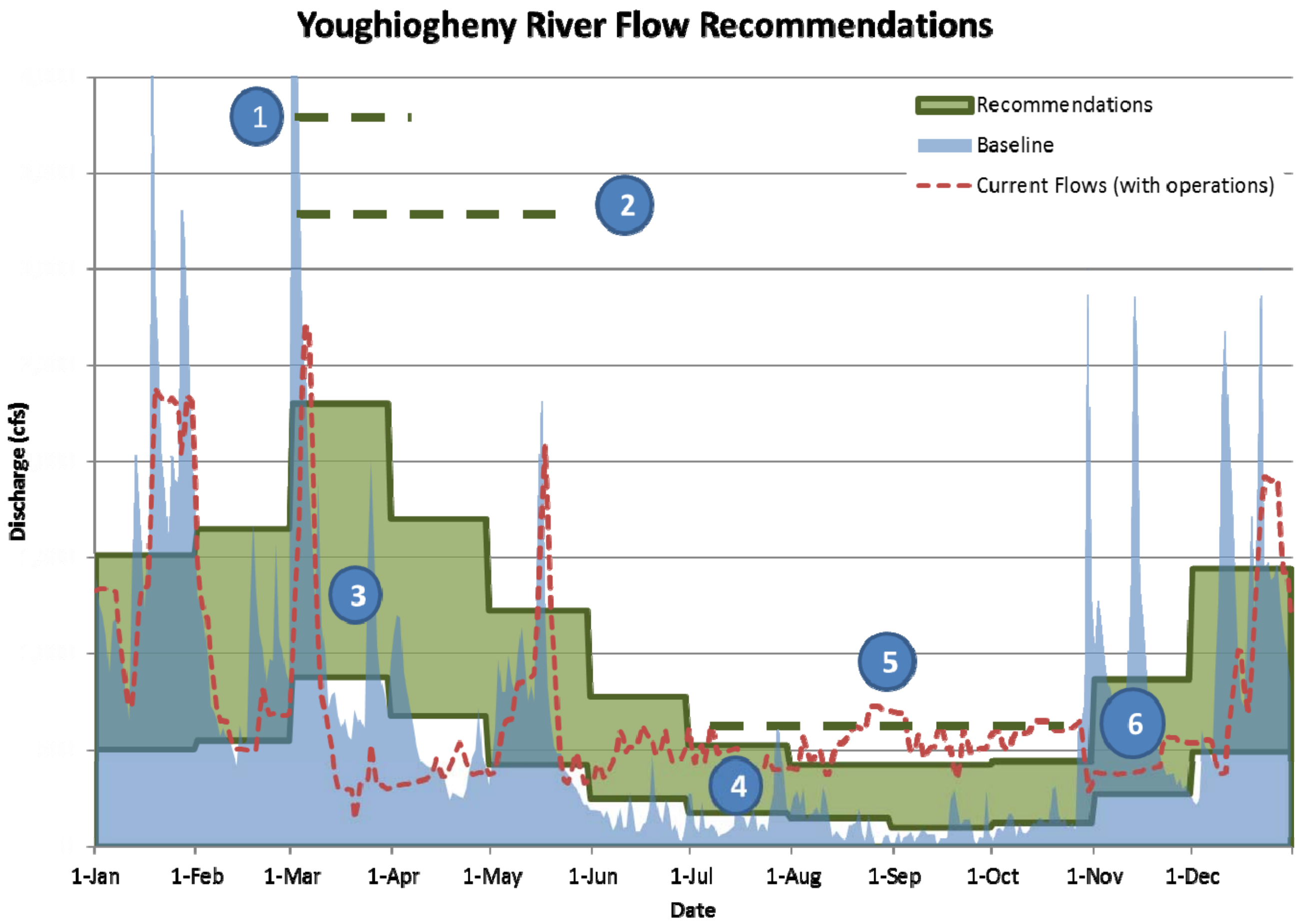

Figure 2. Illustration of recommendations high flow events in spring and summer (1, 2, 5) and for baseflow in spring, summer, fall and winter (3, 4, 6). The green dashed lines indicate the months during which the high flow events should occur. The baseline and current flows illustrate how current operations typically affect flows.

Table 1. Youghiogheny River flow recommendations.

	SPRING		
1	**Restore bankfull and small flood frequency and magnitude (Annual, and Mar, Apr)**	**Below Youghiogheny River Lake:** Release a bankfull event approximately every 2-5 years (estimated bankfull below Youghiogheny River Lake: 10,000 cfs).	**At Connellsville:** Release a bankfull event approximately every 2-5 years (estimated bankfull at Connellsville: 36,000 cfs [based on AHPS]).
		Below Youghiogheny River Lake: Release flow to meet a target of >37,500 cfs at Confluence, PA. This event would inundate approximately half of mapped floodplain scour vegetation communities on the upper and lower reaches.	
2	**Restore high flow pulses during spring (pulse defined as March-April Q_{10})**	**Below Youghiogheny River Lake:** Release 1-3 events each year > 3,200 cfs during spring for channel maintenance, habitat availability and seed dispersal	**At Connellsville:** 2-5 events each year > 6100 cfs
			At Connellsville: 1 event each year > 24,500 cfs to overtop the dam and connect upstream and downstream reaches during late March or early April
3	**Restore magnitude and timing (seasonality) of spring baseflows (March, Apr, May)**	Approximately 50% of daily flows in March, April and May should be within the range defined by the monthly Q_{25} and Q_{75}: **Below Youghiogheny River Lake:** March: 875-2,300 cfs Apr: 675-1,700 cfs May: 425-1,225 cfs	**At Connellsville:** March: 2,600-7,000 cfs Apr: 2,000-5,250 cfs May: 1,400–3,825 cfs
	SUMMER		
4	**Restore magnitude and timing (seasonality) of summer baseflows (June, July, Aug, Sept)**	Approximately 50% of daily flows in June, July, Aug and Sept should be within the range defined by the monthly Q_{25} and Q_{75}: **Below Youghiogheny River Lake:** June: 250-775 cfs; July: 175-525 cfs; Aug: 150-425 cfs; Sept: 100-425 cfs	**At Connellsville:** June: 675-2150 cfs; July: 575-1625 cfs; Aug: 400-1275 cfs; Sept: 275-1150 cfs
5	**Reduce magnitude and frequency of summer high flow events (July, Aug, Sept)**	**Below Youghiogheny River Lake:** There should be fewer than 16 days in July, August, and September (combined) when flows exceed 825 cfs.	
	FALL/WINTER		
6	**Maintain late fall and winter flows that are as high or higher than early fall flows**	**Below Youghiogheny River Lake and at Connellsville:** Late fall and winter flows should be equal to or exceed the daily flows during October.	

III. Summary of Methods

We used two approaches to develop recommendations for the timing, magnitude and frequency of flows that have been altered by current operations of Youghiogheny Lake Dam. For **high flow events**, we used stage and elevation data (e.g., location and elevation of scour vegetation communities, dam elevation) to define the flow magnitude that we anticipate would restore a particular ecological function. For **monthly baseflow and high flow pulses**, we used baseline flow data and the Indicators of Hydrologic Alteration (IHA) to analyze long-term variability of selected flow statistics. The recommendations would restore naturally-occurring flow variability that has been affected by current operations.

(1) Bankfull events and small floods – The height of Connellsville Dam combined with the elimination of high flow events has reduced the upstream-downstream connectivity between the lower and upper Youghiogheny River. We anticipate that making releases high enough to inundate the dam during the migration and spawning season (late March-early April) will increase connectivity for fish. We worked with the dam operator to document dates the dam was inundated. We then correlated those dates to discharge at the USGS gage at Connellsville and found that the dam was inundated at a discharge of 24,400 cfs. Therefore we recommend a target flow of 24,500 cfs at Connellsville to temporarily inundate the dam. We have not confirmed whether the hydraulic conditions under this discharge (i.e., velocity and depth) are suitable for passage.

To define the magnitude of small flood events, we used elevation data for the Ordinary High Water (OHW) mark surveyed by the Corps on the Youghiogheny in 1994. The elevation of the OHW is defined in the field using multiple indicators including soils and vegetation to determine the transition between wetland and upland conditions. The elevation of the OHW approximates the 3-year flood. We recommend restoring this event to occur once every 2 to 5 years.

In order to estimate the magnitude of a small flood event that would support scour-dependent floodplain plant communities, we used LiDAR imagery to determine the elevation of scour vegetation communities[4]. We then used Arc GIS to estimate cross-sectional area of the inundated floodplain at the respective elevation and Manning's equation to calculate discharge.

(2, 5) High flow pulses (less than bankfull) – The magnitude and frequency of spring and summer high flow pulses were calculated in IHA. The baseline magnitude and frequency of pulses were calculated by restricting the period of analysis to the months of interest (March-April or July-September) and obtaining the Q_{10} for the period by setting the High Pulse Threshold to the Q_{50} (median) +40%. The High Pulse Threshold (in cfs) is in the IHA output on the "sco" (scorecard) sheet, Parameter Group #4. This step established the magnitude of the high flow pulses in each season under baseline conditions.

High pulse frequency recommendations can be presented in two ways: number of pulse events or number of days above the threshold. Since high pulses in spring are often multi-day events caused by spring storms, snowmelt, and rain-on-snow events, the spring high flow pulse recommendation is for a *number of events* in spring of each year. The spring high pulse frequency recommendation is a range based on the number of high flow events that typically occur in a year under baseline conditions – the upper and lower bounds for this range were taken from the RVA Boundaries on the "rva" (range of variability analysis) sheet in the IHA output.

[4]Occurrences of scour vegetation data were obtained from the Pennsylvania Natural Heritage program. Six species compose the basin's floodplain scour community: Blue monkshood (*Aconitum uncinatum*), Monongahela Barbara's buttons (*Marshalia grandiflora*), Blue False-indigo (*Baptisa australis*), Tufted Hair-grass (*Deschampsia cespitosa*), Flat-Stemmed spikerush (*Eleocharis compressa*), and Sand grape (*Vitis rupestris*).

Since summer high pulses are typically much lower magnitude than spring events and are typically short events – often one day – during and after summer thunderstorms, our recommendation is for to limit the *number of days* that exceed the baseline summer high pulse threshold.

(3, 4) Monthly baseflows – Monthly baseflow recommendations were based on IHA results. The IHA output includes a sheet labeled "fdc" (flow duration curve) that includes the monthly flow exceedence values calculated for the period of record (here, WY 1960-2013). We extracted the Q_{25} and Q_{75} values from the baseline condition and used these values to establish the recommended range of daily flows for each month. We recommend that 50% of the daily flows be within the recommended range for each month.

(6) Seasonal transitions – Fall to winter – Under baseline conditions, flows are typically low in early fall and increase during late fall and into winter as the growing season ends. We calculated the daily flows in October of each year in the baseline condition and compared them with daily flows in the November, December, January, and February. Winter flows occasionally fell below October flows naturally, but this occurred infrequently in the baseline condition. Therefore we recommend that ate fall and winter flows should be equal to or exceed the daily flows during October. The actual flow value (in cfs) will change in each year; the goal is to restore the typical seasonal pattern of late fall and winter flows that are higher than early fall flows.

IV. Potential Response Metrics

We recommend that several factors be tracked when implementing these recommendations (Table 2):

1. Are operational changes meeting the discharge targets for each **flow component**?
2. If so, do the target discharges create the **desired habitat / restore desired function**?
3. And if so, has there been a **biological response** to these changing conditions?

Table 2. Potential habitat and biological responses associated with restoring each flow component.

Flow component	Habitat/ecological function response	Biological response
Bankfull and small floods	• Floodplain scour • Channel maintenance	• Floodplain vegetation diversity • Distribution of scour vegetation
Spring high flow pulses	• Longitudinal connectivity among upstream and downstream reaches • Lateral connectivity between river and side channel habitats	• Presence of migratory fishes upstream of Connellsville • Diversity and abundance of spring-spawning fishes
Spring baseflows	• Fish spawning habitat availability	• Diversity and abundance of spring-spawning fishes
Summer baseflows	• Extent of riffle habitat • Suitable velocity for riffle fishes • Stream temperature	• Diversity and abundance of riffle/small-bodied fishes • Mussel recruitment
Summer high flow pulses	• Suitable velocity for riffle fishes	• Diversity and abundance of riffle/small-bodied fishes • Mussel recruitment
Fall and winter baseflows	• Stability of bed and bank hibernation habitat • Wetted overwinter habitat	• Reptile and amphibian population size, diversity, overwinter survival • Overwinter fish survival

V. Conclusion

Operation of Youghiogheny Lake Dam has significantly altered the seasonality and high and low flow components on the Youghiogheny River, particularly on the reach upstream of Connellsville. These flow recommendations were developed to reduce potential effects of hydrologic alteration on river-specific ecosystem needs. We prioritized recommendations for those parts of the flow regime that are most affected by, and most likely to benefit from, adjustments to reservoir releases, while still meeting the primary purposes of the dam. Some recommendations may be implementable in the short-term, while others will require additional field reconnaissance to determine the implications of changes to river stage and to refine these recommendations.

These recommendations combines several of the methods for coming up with environmental flow alternatives described in a recent technical note by USACE-ERDC[5] and illustrate some of the best practices contained therein. Collaboration on these recommendations are one step in the adaptive management framework that USACE and the Conservancy have jointly applied at eight demonstration sites through the Sustainable Rivers Project[6].

[5]McKay, S.K., Alternative Environmental Flow Management Schemes. 2013. U.S. Army Engineer Research and Development Center (ERDC), Environmental Laboratory, Athens, GA.

[6]Andrew T. Warner, Leslie B. Bach & John T. Hickey (2014): Restoring environmental flows through adaptive reservoir management: planning, science, and implementation through the Sustainable Rivers Project, Hydrological Sciences Journal, DOI: 10.1080/02626667.2013.843777