DEVELOPMENT OF AN INTEGRATED FLOW REGIME RECOMMENDATION FOR THE CHEOAH RIVER, N.C.

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REFERENCE: *Proceedings of the 2005 Georgia Water Resources Conference*, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute of Ecology, The University of Georgia, Athens, Georgia.

Abstract. Hydrologic pattern and variability are key determinants of aquatic community structure and stability, but instream flow recommendations commonly fail to reflect these critical components of a natural flow regime, focusing instead on provision of static, minimum flows. Restoration of a true, natural flow regime is often not possible given the existing constraints on stream systems and the competing interests of multiple water users. However, sustained biological diversity and ecosystem function are dependent on the maintenance of intra- and interannual flow regimes and natural functions. Providing an integrated flow regime that is patterned on a natural flow regime should therefore be more ecologically beneficial than other flow regime alternatives that ignore natural hydrologic pattern and variability. The principles of a natural flow regime were applied to the development of an integrated flow regime recommendation for the Cheoah River, North Carolina. The integrated flow regime recommendation consisted of a seasonally variable, aquatic base flow component and a natural-like high flow component, which was characterized by seasonally variable frequency, magnitude, and duration high flow events. The integrated flow regime recommendation was designed to balance the water demands of hydropower generation and reservoir-based recreation, while still achieving resource agency aquatic habitat restoration objectives and providing opportunities for whitewater boating.

INTRODUCTION

Variation in the magnitude, frequency, duration, timing, and rate of change of stream flows are all critical components of a natural flow regime (Poff et al., 1997). This variability in stream flow is manifested to stream biota as a change in habitat availability. Consequently, the life histories of stream fishes and other aquatic organisms are adapted to the seasonal variability of base and high flow regimes. Hydrologic pattern and variability are therefore key determinants of aquatic community structure and stability (Poff and Ward, 1989; Poff et al., 1997; Richter et al., 1996).

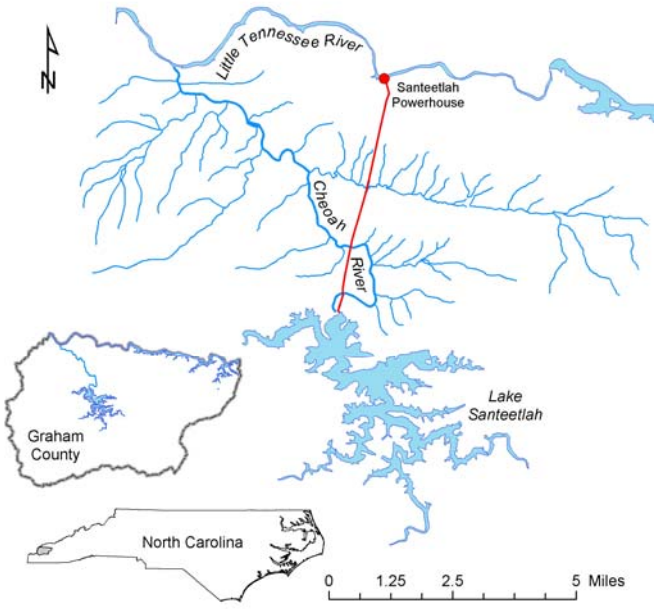

Figure 1. Cheoah River project location in Graham County, North Carolina.

Alterations to a natural flow regime may result in decreased richness, diversity, and abundance of fish species inhabiting shallow water areas, particularly fluvial specialists that prefer swift currents (Travnichek and Maceina, 1994). However, enhancements in the flow regime of a regulated river resulted in increased fish species richness and increased abundance of fluvial specialists (Travnichek et al., 1995), as well as increased macroinvertebrate densities (Gislason, 1985). Elimination of high flows can result in reduced species densities and community diversity (Robinson et al., 1998). Likewise, stable flow regimes that lack seasonal variability may favor generalist, non-native species (Tyus et al., 2000), while seasonal high flows may favor native fish species (Brown and Ford, 2002). Thus, providing a more natural flow regime should provide ecological benefits in regulated streams.

BACKGROUND

The Tapoco Hydroelectric Project (Federal Energy Regulatory Commission [FERC] No. 2169) consists of four hydroelectric developments in the Little Tennessee River basin that are owned and operated by the Tapoco Division (Tapoco) of Alcoa Power Generating, Inc. One of these, the Santeetlah Development, impounds the Cheoah River and diverts water from its 176 mi^2 drainage through a pipeline/penstock to Santeetlah Powerhouse on the Little Tennessee River (Figure 1).

The hydraulic capacity of the Santeetlah pipeline/penstock (950 cfs) exceeds the average annual inflow of Lake Santeetlah (480 cfs), and there has been no requirement for a minimum flow release below the Santeetlah Development dam since its completion in 1928. Consequently, for the past 75 years flows in the approximately 9.3-mile-long bypass reach of the Cheoah River have been limited to leakage from the dam, tributary inflow and accrual, and periodic, large-magnitude spill events from the dam. These spill events occur when the storage and hydraulic capacity of the development is overwhelmed by inflows. This hydrologic pattern, combined with associated disruption of sediment transport processes, has significantly altered the existing aquatic and riparian habitat conditions of the Cheoah River bypass from the natural, pre-dam condition (Normandeau, 2002).

Tapoco is pursuing a license from the FERC for the continued operation of the Tapoco Hydroelectric Project. The relicensing process affords an opportunity for the evaluation of the environmental effects of project operations. The Resource Agency Group was formed to represent the interests of the North Carolina Department of Environment and Natural Resources, the North Carolina Wildlife Resources Commission, the U.S. Fish & Wildlife Service, and the U.S. Forest Service (USFS) in the collaborative relicensing negotiations for the Santeetlah Development. Under a national contract with the USFS, ENTRIX provided the Resource Agency Group with technical assistance and strategic consultation during that process.

INTEGRATED FLOW REGIME RECOMMENDATION

The Resource Agency Group believes that the Cheoah River is capable of significant ecological recovery under properly planned restoration efforts that include stream flow enhancement as a primary focus. Additionally, the Resource Agency Group considered that its resource management objectives are more likely to be met if stream flows in the Cheoah River are patterned on a natural flow regime.

The flow regime recommendation developed by the Resource Agency Group consisted of two parts – a seasonally variable, aquatic base flow component and a natural-like high flow component, which was characterized by seasonally variable frequency, magnitude, and duration high flow events (Table 1). This "integrated flow regime" recommendation and its supporting rationale were set forth in two technical memoranda developed by ENTRIX with support from the Resource Agency Group (ENTRIX, 2002a and 2002b). The recommendation relied on a broad use and interpretation of underlying instream flow study results (Normandeau, 2002), other technical studies performed in support of the Tapoco relicensing, and additional analyses of historic stream flows for the Cheoah River and other regional reference streams.

Aquatic Base Flow Component

The aquatic base flow regime represents the minimum monthly releases from Santeetlah Dam that would provide base stream flows and levels of protective aquatic habitat in the Cheoah River. These flows would vary seasonally, and the amount of flow at any given point in the Cheoah River bypass would vary depending on accrual and tributary flow additions. The aquatic base flow recommendation does not represent a base flow discharge that would provide optimum, naturally occurring, or pre-impoundment levels of aquatic habitat availability in the Cheoah River. Rather, it represented the Resource Agency Group's estimate of a release flow that would provide a base level of aquatic habitat protection while still balancing the competing interests of multiple water users on the Cheoah River.

Table 1. The Resource Agency Group integrated flow regime recommendation for the Cheoah River, NC.

Flow Regime Component	Month											
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Aquatic base flow												
Release (cfs)	160	175	175	175	160	125	80	50	50	50	70	130
High flow												
No. of events	2-3[1]	2	2	2	1	1	0-1[1]	0-1[1]	0-1[1]	0-1[1]	1	2-3[1]
Duration (days)	3	3	3	2	2	1	1	1	1	1	1	2
Target flow (cfs)	1,100	1,250	1,100	1,050	1,050	950	1,050	850	1,050	1,300	1,100	1,150

[1]The higher of the two numbers to be implemented every other year.

The base flow regime recommendation was supported by multiple analyses and data, including Index C, wetted perimeter, and mesohabitat/habitat diversity (ENTRIX, 2002b). The general congruence of these data and analyses strengthened the base flow recommendation and provided evidence that reduced minimum flow requirements of other base flow alternatives would fail to provide adequate aquatic habitat protection in the Cheoah River. In particular, the recommendation for base flow releases of 50 cubic feet per second (cfs) during the summer months in the Cheoah River was based on maintenance of threshold levels of habitat diversity and shallow (<1.5 ft) and medium (1.5-3 ft) depth, fast water (>1 ft/sec) mesohabitats.

Habitat diversity and shallow-fast and medium-fast mesohabitats are of seasonal importance to spawning success, but are also important to the juvenile and adult life stages of fluvial specialists, which dominate the fish assemblage of the Cheoah River. These mesohabitats are also essential to benthic macroinvertebrate production in high gradient, coarse bottom stream systems (Gore et al., 2001). Additionally, general habitat diversity and fish species diversity are significantly correlated (Karr, 1981). Persistence of habitat diversity and shallow- and medium-fast mesohabitats throughout the entire year was therefore considered critical to creation of aquatic habitat conditions that would support a more diverse community of aquatic biota of a type and composition native to the Cheoah River.

High Flow Component

The high flow regime recommendation was designed to approximate the high flow regime that would be expected in the bypass reach of the Cheoah River if inflows to Santeetlah Reservoir were not diverted. Because it is not possible to fully reproduce the flow variability associated with reservoir inflows, the high flow regime recommendation was patterned after the high flow regime evident in the record of project impoundment inflows, but did not attempt to fully mimic those inflows. Additionally, correct scaling of high flow magnitudes to the aquatic base flow recommendation was not rigorously pursued. This is because such scaling was not considered fully attainable with the constraints placed on stream flows by the presence of Santeetlah Dam and multiple water uses of the Cheoah River.

A high flow event was defined as an average daily inflow event that exceeds some threshold discharge value. During relicensing process, 1,000 cfs was reported to provide near optimal conditions for rafting in the Cheoah River. The Resource Agency Group recognized that flows lower than 1,000 cfs may at times constitute high flows from a hydrologic or biological perspective. Duration statistics for the Cheoah River indicate that base inflows approach 700 cfs in some winter months, but flow events greater than 700 cfs constitute high flow events during the relatively dry, summer months when base inflows are much lower. Therefore a threshold value of 700 cfs was considered in the development of the high flow regime recommendation to exclude the contribution of base inflows while still accounting for smaller magnitude high flow events. However, it is clear based on the high flow event analysis that flows of a magnitude around 1,000 cfs constitute a considerable portion of the high flow events that would be expected in the Cheoah River bypass reach.

The high flow recommendation was based on analysis of the high flow event frequency, duration, and magnitude evident in the 30-year project inflow record (ENTRIX, 2002b). The analysis generally relied on the characterization of a median high flow event as the target for a simplified high-flow event release regime (Table 1). The statistical distribution of high flow event data does not follow a normal distribution. In such situations, the mean value can be skewed by outliers. Median values were therefore chosen to represent conditions that would typically be expected, independent of the extreme magnitude and long duration events that occur infrequently in the inflow record.

These recommendations generally do not account for the fact that during some months, natural high flow events can be more frequent and of considerably longer duration. However, months with such high flow occurrences are much less frequent (i.e., occur in a small number of years). Additionally, sporadic large magnitude flows will continue to be spilled from Santeetlah Dam in some years, producing additional events and/or longer duration high flow events. Likewise, tributary accrual may also result in the occurrence of high flow events in the lower portion of the Cheoah River bypass in some years. The constraints associated with lake level fluctuations, dam outlet structures, and the current and continuing need for hydropower generation also impose limitations on the production of more frequent and longer duration high flow events.

DISCUSSION

The integrated flow regime recommendation developed for the Cheoah River was based on the principles of the natural flow regime. However, in developing the recommendation it was recognized from the outset that the Cheoah River is a highly altered system. Restoration of a natural flow regime is not fully attainable with the constraints placed on flows and habitat by the presence of Santeetlah Dam. Additionally, there are other existing and potential uses of the Cheoah River, including a broad range of recreational uses. The integrated flow regime recommendation considered those uses and would provide flows suitable for recreational uses such as rafting, canoeing or kayaking, and fishing.

The integrated flow regime recommendation therefore represented a compromise of factors that were considered acceptable to the resource agencies and which should provide a substantial enhancement to the aquatic system. However, the enhancement represented by this proposal is less than an "optimum" attainable condition for the aquatic community, because it already considers, accepts and attempts to balance other needs and constraints including hydropower generation.

Many elements of the integrated flow regime recommendation were included in the Settlement Agreement reached for the Tapoco Hydroelectric Project, and were thus codified into the FERC license granted for that project. Additionally and as part of that agreement, the Resource Agency Group and Tapoco are currently developing a monitoring plan that will be used to assess biotic and abiotic responses following implementation of the new flow regime in the Cheoah River.

CONCLUSION

Given the competing interests of multiple water users and other constraints placed on regulated river systems, providing a natural flow regime is typically not practicable. However, sustained biological diversity and ecosystem function are dependent on the maintenance of intra- and interannual flow regimes and natural functions (Annear et al., 2002). Providing an "integrated flow regime" that is patterned on a natural flow regime should therefore be more ecologically beneficial than other flow regime alternatives that ignore natural hydrologic pattern and variability.

ACKNOWLEDGEMENTS

The technical memorandum entitled, Integrated Flow Recommendation for the Cheoah River, from which much of the material presented within this manuscript was drawn, was developed by the members of the Resource Agency Group.

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