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Minimum Flow is a Myth

by

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During the warmwater stream symposium in 1980, when discussing low flow as a limiting factor in warmwater streams, I warned fisheries management personnel that the concept of a single minimum or base flow for fishery habitat maintenance that has evolved in the western region of the United States could very well become a real threat to low gradient, eastern, warmwater stream fisheries (Stalnaker 1981). The minimum flow concept rose from western water law as a mechanism to either reserve an amount of water from future appropriations or as a means of granting an instream water right for fishery purposes. This led to the myth that a consistent methodology could be used to establish a single minimum discharge value for any given stream. Experience has shown that as water becomes fully appropriated to upstream use or storage, the minimum flow, if not frequently violated in time, tends to become the average flow condition. Too often the minimum becomes the objective rather than the means to achieve some riverine fishery or recreation management goal. Such persistent low flows are not necessarily desirable from the water management perspective, being inflexible in the face of competitive uses or during unusual water supply conditions (e.g., drought), and certainly do not meet all the desired environmental needs. This difficulty with minimum flows arises in part because all the instream uses for which flows may be needed are not identified. Most often overlooked are necessary periodic high flows that move bedload, flush sediments, rejuvenate the floodplain, and generally maintain the structural characteristics of a stream channel, which should be maintained in dynamic equilibrium with its watershed (Stalnaker 1979).

A common misconception among water management personnel and consumers is that inclusion of all the identifiable instream uses of water in an instream flow requirement will dictate an additive treatment of their respective needs. This, it is further assumed, will result in total allocation of the stream flow to instream uses. Contrary to this view, a considerable degree of compatibility exists among many instream uses and downstream delivery requirements for offstream or consumptive uses. However, in order to deal with these compatible uses, the instream flow advocate and the water resource manager must be aware of both the timing and the magnitude of all the demands being placed on the stream system. Such a common understanding, which should lead to the identification of instream flow requirements, will protect all complimentary uses as well as meet downstream delivery requirements.

It is evident from reviewing the literature and from the discussions during this workshop that many methods for evaluating instream flow needs have evolved since the 1960's. I prefer to categorize such methods as "standard setting" or "incremental." Standard setting methodologies, on one hand, refer to those measurements and interpretive techniques designed to generate a flow value (or values) intended to maintain the fishery or recreational use at some acceptable level (usually dictated by policy). Incremental methodologies, on the other hand, are organized and repeatable processes by which (1) a fishery habitat–stream flow relation and the hydrology of the stream are transformed into a baseline habitat time series, (2) proposed water management alternatives are simulated and compared with the baseline, and (3) project operating rules are negotiated.

Trihey and Stalnaker (1985) suggested that a hierarchical approach to hydro licensing and relicensing be followed that in essence takes advantage of both the standard setting and incremental approaches. A three-tiered hierarchy was suggested including reconnaissance, feasibility, and operational or design studies for evaluating hydro projects. It is important to recognize that such licensing is

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generally a multiyear process. Adopting the suggested hierarchical approach can lead to greater understanding among the resource agencies, the applicant, and the general public, leading to negotiated conditions for the license. Specifically, the reconnaissance study identifies the stream segments of potential impact, the project location configuration, and possible operating scheme. With- and without-project hydrologic conditions are compared to determine whether the project seems to be "benign" and compatible with resource agency policies. In other words, there is little change in the flow pattern below the project. In the feasibility study, the use of a previously set standard can be quite advantageous. At this level of analysis, comparison is made between the projected stream flow conditions and the stream flow maintenance standard to identify major issues and periods of incompatibility. Standard setting methods (such as the New England Flow Method and the Arkansas and North Carolina methods) were discussed during this workshop; they and the optimum flow proposed for western Virginia are excellent examples by which one can screen for hydro projects that seem to be incompatible with agency policy and environmental protection goals. When it becomes obvious that project operations and the maintenance of stream flow standards are incompatible, impacts need to be quantified and mitigation measures agreed on. Then much more detailed operational level studies are appropriate. Only during this third study phase do the incremental methods become useful and, in fact, necessary.

The majority of States now recognize instream flows and have identified procedures for incorporating such uses in water planning (Reiser et al. 1989). Adoption of a standard setting approach by the State Water Resources and Fisheries Management agencies greatly facilitates identification of incompatible water development projects during feasibility studies. Stream flow assessment methods, such as the Instream Flow Incremental Methodology used by the U.S. Fish and Wildlife Service, have consequently evolved to become environmental assessment techniques and are used for evaluating the effects of proposed reservoir construction, water diversions, or hydroelectric operations on downstream fish habitats. Quite often such impact assessments become a matter of comparison among several possible, but not always measurable, water management schemes, leading to the necessity of simulation modeling for making these comparisons. Only the physical–chemical aspects of the habitat are evaluated, and comparisons are judged on the potential habitat limitations that may result from a proposed change in the way stream flows are controlled and routed through stream segments. It is important to realize that minimum flows, optimal flows, and even stream flow standards are not impact assessment tools. When it comes to relicensing of hydroelectric projects, the questions really are focused on the effects that may result from a change in project operations. Minimum flow has no logical argument in such an institutional process and, in fact, as hydro projects go to increased peaking operations (involving daily and hourly rapid fluctuations in the tailwater releases), it is often the high flows that are of more concern from a biological standpoint than the low or minimum flows.

The challenge now before us is to progress beyond the minimum flow and even habitat impact assessment and to focus on scientific principles in understanding riverine systems. Management biologists must get involved with water management in riverine environments. By definition, management is a designed and directed change in a system. The improvement of basic understanding of ecology of our stream systems, coupled with the use of engineering tools and simulation modeling, provides an opportunity for fisheries to be enhanced downstream of the many hydroelectric projects coming up for relicensing in the 1990's. This will occur only if fishery managers and natural resource agencies do the designing and directing of the change in the operating systems, working hand-in-hand with the hydro project applicants and the Federal Energy Regulatory Commission.

Information Sources

Bovee, K. D. 1982. A guide to stream analysis using the Instream Flow Incremental Methodology. Instream Flow Information Paper 12. U.S. Fish Wildl. Serv., FWS/OBS 82/26. 248 pp.

Bovee, K. D. 1985. Evaluation of the effects of hydropeaking on aquatic macroinvertebrates using PHABSIM. Pages 236–241 *in* F. W. Olson, R. G. White, and R. H. Hamre, eds. Proceedings of the symposium on small hydropower and fisheries. American Fisheries Society, Bethesda, Md. 497 pp.

Bovee, K. D. 1986. Development and evaluation of habitat suitability criteria for use in the Instream Flow Incremental Methodology. Instream Flow Information Paper 21. U.S. Fish Wildl. Serv., Biol. Rep. 86(7). 235 pp.

Bovee, K. D., and J. R. Zuboy. 1988. Proceedings of a workshop on development and evaluation of habitat suitability criteria. U.S. Fish Wildl. Serv., Biol. Rep. 88(11). 407 pp.

Connell, J. H., and W. P. Sousa. 1983. On the evidence needed to judge ecological stability or persistence. Am. Nat. 121(6):789–824.

Estes, C. C. 1984. Evaluation of methods for recommending instream flows to support spawning by salmon. M.S. thesis, Washington State University, Pullman. 156 pp.

Leonard, P. M., D. J. Orth, and C. J. Goudreau. 1985. Development of a method for recommending instream flows for fishes in the upper James River, Virginia. Va. Water Resour. Res. Bull. 152, 122 pp.

Loar, J. M., and M. J. Sale. 1981. Analysis of environmental issues related to small-scale hydroelectric development. V. Instream flow needs for fishery resources. Oak Ridge National Laboratory ORNL/TM-7861, Oak Ridge, Tenn. 123 pp.

McKinney, M. J., and J. G. Taylor. 1988. Western state instream flow programs: a comparative assessment. Instream Flow Information Paper 18. U.S. Fish. Wildl. Serv., Biol. Rep. 89(2). 78 pp.

Orsborn, J. F., and C. H. Allman. 1976. Instream flow needs, Vols. I and II. American Fisheries Society, Bethesda, Md. 551 pp. and 657 pp.

Orth, D. J. 1987. Ecological considerations in the development and application of instream flow-habitat models. Regulated Rivers 1:171–181.

Prewitt, C. G. 1982. The effect of depth–velocity correlations on aquatic physical habitat usability estimates. Ph.D. dissertation, Colorado State University, Fort Collins. 83 pp.

Raley, C., W. Hubert, and S. Anderson. 1988. Maintenance of flows downstream from water development projects in Colorado, Montana, and Wyoming. U.S. Fish. Wildl. Serv., Biol. Rep. 88(27). 73 pp.

Reiser, D. W., M. P. Ramey, and T. R. Lambert. 1985. Review of flushing flow requirements in regulated streams. Pacific Gas and Electric Company, Department Engineering Research, San Ramon, Calif. 97 pp.

Reiser, D. W., T. A. Wesche, and C. Estes. 1989. Status of instream flow legislation and practices in North America. Fisheries 14(2):22–29.

Stalnaker, C. B. 1979. Myths concerning instream flows: a background to understanding instream uses. Pages 1–7 *in* P. S. Wassenberg, S. Olive, J. L. Demott, and C. B. Stalnaker, eds. Elements in negotiating stream flows associated with federal projects. Instream Flow Information Paper 9. U.S. Fish Wildl. Serv., FWS/OBS 79/03. 71 pp.

Stalnaker, C. B. 1981. Low flow as a limiting factor in warmwater streams. Pages 192–199 *in* L. Krumholz, ed. Warmwater streams symposium. American Fisheries Society, Bethesda, Md. 422 pp.

Stalnaker, C. B. 1982. Instream flow assessments come of age in the decade of the 1970's. Pages 119–141 in W. T. Mason, Jr., and S. Iker, eds. Research on fish and wildlife habitat. U.S. Environ. Prot. Agency EPA-600/8-82.022. 248 pp.

Stalnaker, C. B., R. T. Milhous, and K. D. Bovee. 1989. Hydrology and hydraulics applied to fishery management in large rivers. Pages 13–30 *in* D. D. Dodge, ed. Proceedings of the international large river symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106. 629 pp.

Trihey, E. W., and C. B. Stalnaker. 1985. Evolution and application of instream flow methodologies to small hydropower development: an overview of the issues. Pages 176–183 *in* F. W. Olson, R. G. White, and R. H. Hamre, eds. Proceedings of the symposium on small hydropower and fisheries. American Fisheries Society, Bethesda, Md. 497 pp.

Wesche, T. A., and P. A. Rechard. 1980. A summary of instream flow methods for fisheries and related research needs. Eisenhower Consortium Bull. 9. Water Resources Research Institute, University of Wyoming, Laramie. 122 pp.