Instream Flows for Riverine Resource Stewardship

Revised Edition

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applied in a process similar to that used in Washington. Practitioners would then need to compare recommendations to the flow that maximizes spawning weighted usable area for salmon (or other) species of interest.

Critical Opinion: Use of Toe-Width method is limited to small- to mid-sized alluvial streams in Washington State, primarily on the western side of the Cascade Mountains. The method should not be used in other regions; however, the basic approach could be used to develop similar equations for other systems. It has a high error associated with the regression, even on the streams where it is appropriate. It is viewed in Washington as a reconnaissance level method, but not the preferred method when flow recommendations will be controversial. This method is designed for spawning salmon and steelhead (*anadromous salmonids*) and employs several regression equations with channel cross-section parameters for spawning and rearing of different species of salmon and steelhead. Rearing equations are correlated to the breakpoint of wetted perimeter. Other methods must be used in conjunction with this method to address other ecosystem components.

WETTED PERIMETER

Summary: The Wetted Perimeter method uses a graphical representation of the wetted perimeter versus discharge as a surrogate for physical habitat. It selects the breakpoint on this graph as the prescribed instream flow.

Objective: The purpose of the method is to provide an objective means of determining a minimum instream flow prescription for the low flow period.

Type of Technique: Standard setting

Description: A graphical plot of the wetted perimeter versus discharge on which a visual breakpoint (often referred to as the inflection) is selected as the instream flow recommendation. Wetted perimeter is that distance along the stream bottom from the wetted edge on one side to the wetted edge on the other side measured at a given discharge. Discharge is measured following standard practices. Multiple measurements of the ground profile are taken across the channel from bankfull on one side to bankfull on the opposite. The most common application places a single transect across the stream where the channel is rectangular in shape (usually at the high point of a riffle). For ungaged streams, multiple discharge measurements must be made to develop a stage-discharge relation. More recent practice is to use computer programs based on Manning's equation to compute the stage-discharge relation for a cross section.

Appropriate Scale: River reach. Should only be applied to riffle mesohabitat types.

Riverine Component(s) Addressed: Biology is addressed through consideration of hydraulic habitat.

Assumptions: The method application assumes that the flow represented by the breakpoint will protect the food producing riffle habitats at a level sufficient to maintain the existing fish population at some acceptable level of sustained production. The method further assumes that the stream channel is stable and unchanging over time.

Level of Effort: Several visits to the site at numerous discharges (10 or more) are necessary if empirical relations are to be used. With hydraulic models that simulate stage-discharge relations, less than one day at the site is needed. However, as with all simulation models, two or more additional site visits at different discharges are needed to compare empirical observations with model output.

Historical Development: Initially the model was based on multiple measurements to develop empirical relations. It is now common to use computer programs to analyze cross sections and develop stage-discharge relations and wetted perimeter plots (Grant et al. 1992). Gippel and Stewardson (1996) critically evaluated the "inflection point" and noted that the determination of the breakpoint is highly error prone. They also presented a technique for mathematically defining the point of maximum curvature. Annear and Conder (1983) likewise found considerable variation in using inflection points for determining instream flow levels when compared to other methods. Early reports (Collings 1974) estimated that the discharge represented by the breakpoint protected 50-80% of the maximum available wetted perimeter. The Oregon Department of Fish and Wildlife recommended that at least 50% of available wetted perimeter be maintained (Ken Thompson, personal communication; Stalnaker and Arnette 1976). Tennant (1976b) found that discharges covering 50% of the wetted perimeter in Montana streams represented approximately 10% of the mean annual flow. Nelson (1980) attempted to demonstrate healthy standing crops of trout in Montana streams subject to low flows defined by the wetted perimeter. Gippel and Stewardson (1996) found that the discharge represented by the wetted perimeter breakpoint in two high mountain streams in Australia was similar to the 95% exceedence flow. Dunbar et al. (1998) concluded that the discharge determined by the breakpoint still significantly reduced invertebrate production.

Application: Wetted Perimeter may be used to establish a low flow standard. However, it should be used in conjunction with evaluations of the other ecosystem components so that it only establishes the low flow season recommendation.

Strengths: Easily measured on site for ungaged streams. Useful only if instream flow prescriptions are for the low flow season (such as constraining permits for water withdrawal during summer and fall only) and flow is known to be nearly natural (not effected by water withdrawals) for the other seasons.

Limitations and Constraints: This method addresses only low flows (usually summer/fall) and does not address intra- or interannual variability. The method also does not address channel geomorphology, water quality, or connectivity and should be restricted to streams with well-defined riffle and pool sequences. For channels with cross-sectional shapes that are parabolic or V-shaped, the wetted perimeter versus discharge relation continually rises and does not show a well-defined break point. For braided channels, multiple break points may be observed. The determination of inflection or break points for all habitat types can be somewhat subjective to identify precisely. The method should not be applied to pool cross sections or to alluvial streams that are usually low gradient, meandering, and have pool-crossing bar features.

Calibration and Validation: When based on multiple empirical measurements, no calibration is necessary. On the other hand, when using computer programs that are based on Water Surface Profile (WSP) programs based on Manning's equation to calculate stage-discharge relations, some site measurements are needed to validate by comparing predicted versus observed wetted perimeter for at least three widely spaced discharges.

Critical Opinion: The Wetted Perimeter method uses measurements of hydraulic habitat to derive recommendations and assumes a relation between habitat and biology. Use of this method should be restricted to streams or stream segments where the stage at the chosen transect area is flow-sensitive and represents the geomorphic structure and shape of the river channel throughout the targeted river segment. Such areas are often, though not always, associated with bedrock-controlled high gradient streams with well-defined, rectangular-shaped riffles and no significant floodplains. If used in other streams, it should be considered as only one component of a recommendation that uses additional analyses. In selecting a low flow season discharge with this method, it is recommended that the flow prescribed be that discharge that covers at least 50% of the wetted perimeter in streams that are less than 50 feet wide and between 60 and 70% in larger streams (Nehring 1979) or the breakpoint on the wetted perimeter discharge relation, whichever is higher. The method typically does not provide the necessary regime of flows that are critical to riverine ecology, but it may be a component.