Review of Instream Flow Methods and Application to Baron Fork Creek, Oklahoma

PREPARED FOR: Oklahoma Water Resources Board (OWRB)

COPY TO: U.S. Army Corps of Engineers Tulsa District

PREPARED BY: CH2M HILL

DATE: September 23, 2013

1. Introduction

This memorandum briefly reviews the instream flow technical issues and potential flow-setting methodologies in Oklahoma with an example application to the Baron Fork Creek in eastern Oklahoma. It is intended to inform and encourage discussion among those interested in protecting or restoring instream values such as fish, recreation, water quality, wildlife, and aesthetics, while facilitating beneficial uses for water removed from streams. Beneficial out-of-stream uses typically include irrigation, domestic, hydropower, and industrial use. This memorandum does not address specific policy and legal issues. Discussions of these issues are available in Oklahoma Water Resources Board (OWRB) (2011) and CH2M HILL (2013). Baron Fork Creek was chosen as an example stream in dealing with the issue of instream flow needs because it is designated a "scenic" river per the Oklahoma Scenic Rivers Act of 1970, it has good long-term flow records and is relatively unregulated, and several studies have been conducted on the river associated with instream flows. Several studies (as well as OWRB hearings) were conducted in response to a water permit application by the Adair Regional Water District No. 5 in 1998. The OWRB has made its final decision on the permit, and it is not the intent of this memorandum to reopen that issue. Furthermore, the use of Baron Fork herein as an example stream to explore instream flow setting methods does not constitute the "pilot study in a scenic river" proposed by the OWRB staff in 2011. It may, however, provide some technical groundwork that would be useful in a pilot study of Baron Fork or other state scenic river.

Oklahoma is one of the few states that do not have a formal instream flow protection program. The need for such a program has been considered by the OWRB for many years and has been most recently discussed in the OWRB's *2012 Update of the Oklahoma Comprehensive Water Plan*. As part of that plan, the OWRB convened an Instream Flow Advisory Group to discuss benefits and issues regarding a potential future Oklahoma instream flow program. That effort culminated in a report titled *Instream Flow Issues and Recommendations* (OWRB 2011). Although Oklahoma does not have an instream flow protection program, the state, primarily through the OWRB, addresses instream flow issues for most streams in the state through policies and administrative procedures that recognize the environmental values associated with the state's waters. In particular, state streams designated as Outstanding Resource Waters under (785:45-3-2) or as a "scenic river area" under the Scenic Rivers Act (82 O.S. §1451–1471) are provided protection for scenic beauty, water conservation, water quality, fish, wildlife and outdoor recreation. Specific flows or methods to determine specific flows to protect these resources are generally not identified. Instream flow requirements, if any, are addressed on a case-by-case basis as the issue comes up, typically through a water use permit application.

In addition to the state administrative processes, other federal or interstate laws and regulations contribute to or require consideration of instream flows. These include:

1. Interstate Stream Compacts with New Mexico, Texas, Kansas, Arkansas, and Louisiana
2. Endangered Species Act
3. Section 10 of Rivers and Harbors Act (navigation by the Corps of Engineers)

4. Section 404 Clean Water Act: dredge and fill (by the Corps of Engineers)
5. Section 401 CWA Water Quality Certification
6. Federal Power Act (Federal Energy Regulatory Act)
7. National Environmental Policy Act

These regulatory processes are discussed briefly in a report (CH2M HILL 2013) prepared for OWRB. In addition to these primarily federal processes, the state of Oklahoma requires that a certain amount of water be maintained in streams as a set aside for future domestic use by landowners in the watershed. The rule requires that 6 acre- feet of water be set aside per household. The state's policy in implementing the rule assumes one household per quarter section; therefore, 24 acre-feet of water is set aside per square mile. This volume of water is converted to flow by assuming that the water would be used at a constant rate 365 days a year. These reserved streamflows for downstream domestic use contribute to maintaining some level of instream flow protection.

2. Methods of Quantifying Instream Flow Needs

Although the term *instream flow needs* is commonly used, the word *needs* is vague, undefined, and value-based. Asking "how much water do fish need?" is like asking "how high is up?" (Thomas R. Payne 2012). Even so, there is a recognized need to establish some quantity of flow to offer some level of protection of values associated with instream flows. Since the early 1970s, more than 200 methods or procedures have been used to quantify instream flows designed to protect instream resource values. By far, the most commonly considered instream resource value is fish. In most cases instream flows considered adequate for fisheries protection are considered protective of water quality, wildlife, and recreation values as well. The Instream Flow Council's book, *Instream Flows for Riverine Resource Stewardship* (Annear et al. 2004), contains a good summary of most of the instream flow assessment methods.

2.1 Principals of Stream Function

To understand and evaluate the usefulness of various methods of recommending instream flows, it is important to understand some basic principles of stream ecology and how the stream's hydrologic behavior dictates its function. The function of a river results from the interaction of three "master parameters" (Leopold 1994): landscape, flow regime, and sediment regime. Typically, when one parameter changes the other two adjust to meet a new dynamic equilibrium. This principle is most pronounced with large storage reservoirs that change all three parameters. For example, a flood control reservoir will reduce peak flows, which in turn will cause the stream channel downstream of the dam to shrink by vegetation encroachment. The reservoir will trap sediment, thereby adding to downstream channel changes. It is important to consider such interactions when assessing alternative instream flow regimes. This is especially important when considering flow prescriptions that approximate or mimic the natural flow regime. Factors that cannot effectively be reversed, such as physical changes that have occurred to the channel or floodplain, and interruption to the sediment supply, must be considered (Annear et al. 2004). In some cases, simply restoring or mimicking the natural hydrograph can be non- or counter-productive to the purpose for which the prescription is intended if the landscape and sediment regime changes are not factored into the interpretation.

When determining how to address an instream flow issue it is important to distinguish between two types of projects or proposals: those that would significantly alter the hydrograph, and those that would merely divert a small amount of water at a constant rate over a prescribed period. For simplicity, these are referred to below as large projects and small projects.

2.2 Large Projects

When assessing the impacts of a large water storage/flow-regulation project that would significantly alter the hydrograph (as well as the landscape and sediment regime), consideration of "environmental flow needs" is more important than it would be for small projects. Environmental (or ecological) flows are those that provide inter- and intra-annual variable flow patterns that mimic the natural hydrograph in terms of magnitude, frequency, duration, timing, and rate of change (Annear et al. 2004). These hydrologic patterns and variability are key determinants of fish and aquatic organism community structure and stability (Poff and Ward 1989). Applying the environmental flow concept often focuses on four flow components of the flow regime (TIFP 2008):

- **Subsistence flows** are those corresponding to infrequent low flow events that occur naturally during droughts. The objectives of subsistence flows are to maintain water quality criteria and prevent loss of aquatic organisms.
- **Base flows** represent the "normal" flow conditions in the absence of significant precipitation events. Emphasis is typically placed on the summer base flow period because fish populations tend to track existing environmental conditions, which are often worst in streams during the warm low flow period. Most "standard setting" methods used to determine minimum instream flows pertain to base flows.
- **High-flow pulses** are short-duration, high-magnitude flows (but within channels) that follow rainfall events. High-flow pulses serve to maintain important habitat features and connectivity along a stream. Some critical fish behaviors, such as migration or spawning, are often associated with flow pulses.
- **Overbank flows** are infrequent, high-magnitude flow events that produce water levels that exceed those of the channel banks. The high flows maintain riparian areas, transport sediments and nutrients, recharge floodplain aquifers, provide lateral connectivity to channel water bodies, move organic debris to the main channel, and provide life-cycle clues for aquatic and terrestrial species.

Water projects large enough to warrant consideration of environmental flow needs are often projects with a federal nexus. As such, the instream flow issue is usually addressed in some federal permitting or licensing process. Regulatory processes invariably require detailed project-specific studies wherein alternative instream flow regimes are assessed. The use of simple "standard setting" methods for recommending instream flows usually is inappropriate for these types of projects. Various methods and procedures are available to describe environmental flows for the purpose of informing the flow recommendation process, such as Indicators of Hydrologic Alteration, Hydroecological Integrity Assessment Process, Ecological Limits of Hydrologic Alteration, Hydrology-Based Environmental Flow Regime. Researchers at OSU's Water Resources Research Institute recently applied the Hydroecological Integrity Assessment Process approach to characterize and classify 88 streams in Oklahoma based on hydrologic regime (Turton et al. 2009). The four groupings of streams fell roughly within ecoregions defined by climate, geology, soils, and vegetation.

Oklahoma water plans have not recognized environmental flow needs or made provisions for protecting them. However, the most recent revision of the Oklahoma Comprehensive Water Plan identifies instream flows as a subject worthy of additional discussion. As such, the plan formalizes an instream flow workgroup, recommends a pilot study on a state-designated scenic river, and outlines economic, legal, and policy studies associated with a potential instream flow protection program.

2.3 Small Projects

What constitutes a small water project is arbitrary, but for the purpose of discussing methods of determining instream flow recommendations, small projects are those that would not regulate flow by the storage and release of water. For small projects, then, the issue of higher environmental flow, such as pulse or overbank flows, is irrelevant. The potential impacts of smaller projects on instream resource values such as fish are usually focused on the subsistence flows and base flows, particularly during the summer low flow months when water needs for domestic and agricultural use are typically highest.

2.4 Categories and Types of Instream Flow Methods

In general, application of instream flow methods and studies falls into three categories based on the purpose or level of need for the information (Olson 1996):

- **Reconnaissance or Planning Level—**The goal is to identify potential instream flow concerns.

- **Feasibility Level—**The goal is to determine if the proposed project/diversion is likely to be compatible with existing instream resource uses.
- **Operational Level—**The goal is to quantify impacts, develop mitigation measures, and negotiate operational strategies with the permitting agencies.

Methods used for recommending instream flows for planning and reconnaissance application typically are simple desktop types, commonly referred to as standard setting. In many states, the preferred desktop method is one that provides a conservative instream flow recommendation that is then qualified by such terms as “preliminary,” “target,” “initial,” “planning level,” “desired,” or similar vague language. This provides flexibility for the instream flow recommendation to be modified, typically downward, based on results of additional site- or project-specific studies. The extent of studies needed varies depending on the size of the proposed water diversion and the potential for significant impacts.

There are three main types of methods for determining the baseflow component of an instream flow regime recommendation.

Hydrologic methods use historical (or simulated) streamflow statistics to guide recommendations. The Tennant method (Table 1) and numerous modifications of it is the most commonly used hydrologic method. It defines categories of protection (good, fair, poor) based on percentages of mean annual flow (MAF). It is quite simple but its development relied heavily on professional judgment and thus it is not very scientifically supportable. In addition, its categories of protection level are based on value terms. Application of the method for defining acceptable baseflows in different states has ranged widely from 10 to 40 percent of MAF, but 30 percent of MAF seems to be the most commonly used value for low flow months. Because of its simplicity, the method has received wide acceptance, primarily for planning and reconnaissance level applications.

TABLE 1
Recommended Instream Flows by the Tennant Method

	Recommended Flow (% of mean annual flow)	
Flow Descriptions	**Low Flow Period**	**High Flow Period**
Flushing or maximum	200	200
Optimum range	60–100	60–100
Outstanding	40	60
Excellent	30	50
Good	20	40
Fair or degrading	10	30
Poor or minimum	10	10
Severe degradation	< 10	< 10

One factor typically not considered when using hydrologic methods is stream size. The Tennant method, for example, is based on the assumption that aquatic habitat conditions are similar among streams when they are carrying the same proportion of their mean annual flow. However, a compilation of studies that developed habitat-flow curves for salmon and trout shows that maximum habitat flows (curve peak), when expressed as proportion of MAF, decline as the stream size (based on MAF) increases (Hatfield and Bruce 2000). A similar relationship was observed for smallmouth bass in the Upper James River basin in Virginia, where lower proportions of average streamflow were required to maintain optimum habitat as stream size increased (Leonard et al. 1986).

Other hydrologic methods include the use of monthly median (50 percent exceedance) flows or an exceedance value (e.g., 80 percent) based on the annual hydrograph. The use of monthly median flows is based on the principle that fish and aquatic species in a particular stream have adapted to the historic streamflow regime, which, at least for the baseflows, is best defined by median rather that mean flows.

A common issue when using hydrologic methods is the question of whether to use flow data representing existing flow conditions or historic natural flows, assuming such data are available or can be reasonably simulated. Does the term *protection* of instream flow values infer existing conditions as the baseline, or historic conditions? This is yet another example of a policy-oriented value-based question rather than a technical issue that must be considered when dealing with instream flow management. Similarly, there may be a need to consider future hydrologic regimes as affected by climate cycles or climate change. A recent study by the U.S. Geological Survey done in cooperation with OWRB found that base flows and total annual flows for many Oklahoma streams have been trending upward since 1980 (Esralew and Lewis 2010).

Hydraulic methods are a step up from hydrologic methods in that they make use of stream/site specific data and thus are not considered desktop methods. By far, the most commonly used hydraulic method is the wetted-perimeter method. The method is based on the assumption that there is a direct relationship between fish habitat (or aquatic organism productivity) and the wetted perimeter of a riffle. It also assumes that protecting riffle habitats will provide protection for pools and other types of stream habitats. In practice, the bottom elevation of a representative riffle is surveyed, and several measurements of water surface elevation and water edge at the riffle are made at multiple flows. A plot is then developed showing the relationship between wetted perimeter and discharge. The point of maximum curvature (inflection point) is used to determine the habitat protection flow. It essentially identifies the most efficient flow for optimizing aquatic productivity. In practice, the identified flow from the wetted perimeter method can vary considerably depending on the cross section selected in the field. A cross section that is abnormally wide, for example, would produce an unrealistically high flow recommendation. Also, the wetted perimeter method may not be appropriate for predominately spring-fed or highly flashy streams. Gippel and Stewardson (1998) present a good review of the limitations associated with the wetted perimeter method.

Colorado uses the R2-Cross method to define instream flow requirements. The method also uses data from representative riffles, but applies depth and velocity criteria as well as percent of bankfull wetted perimeter to identify the flow that provides the desired riffle condition.

Incremental methods produce relationships between increments of streamflow and habitat for selected fish species and their life stages. The Instream Flow Incremental Methodology (IFIM) developed by the U.S. Fish and Wildlife Service is the primary example of this method used globally. The habitat modeling part of the methodology involves the integration of a stream hydraulic model, which predicts depth and velocity changes by flow, with habitat criteria defined as suitable depth, velocity, substrate, and cover for the selected fish species. The models are collectively called Physical Habitat Simulation, or PHABSIM.

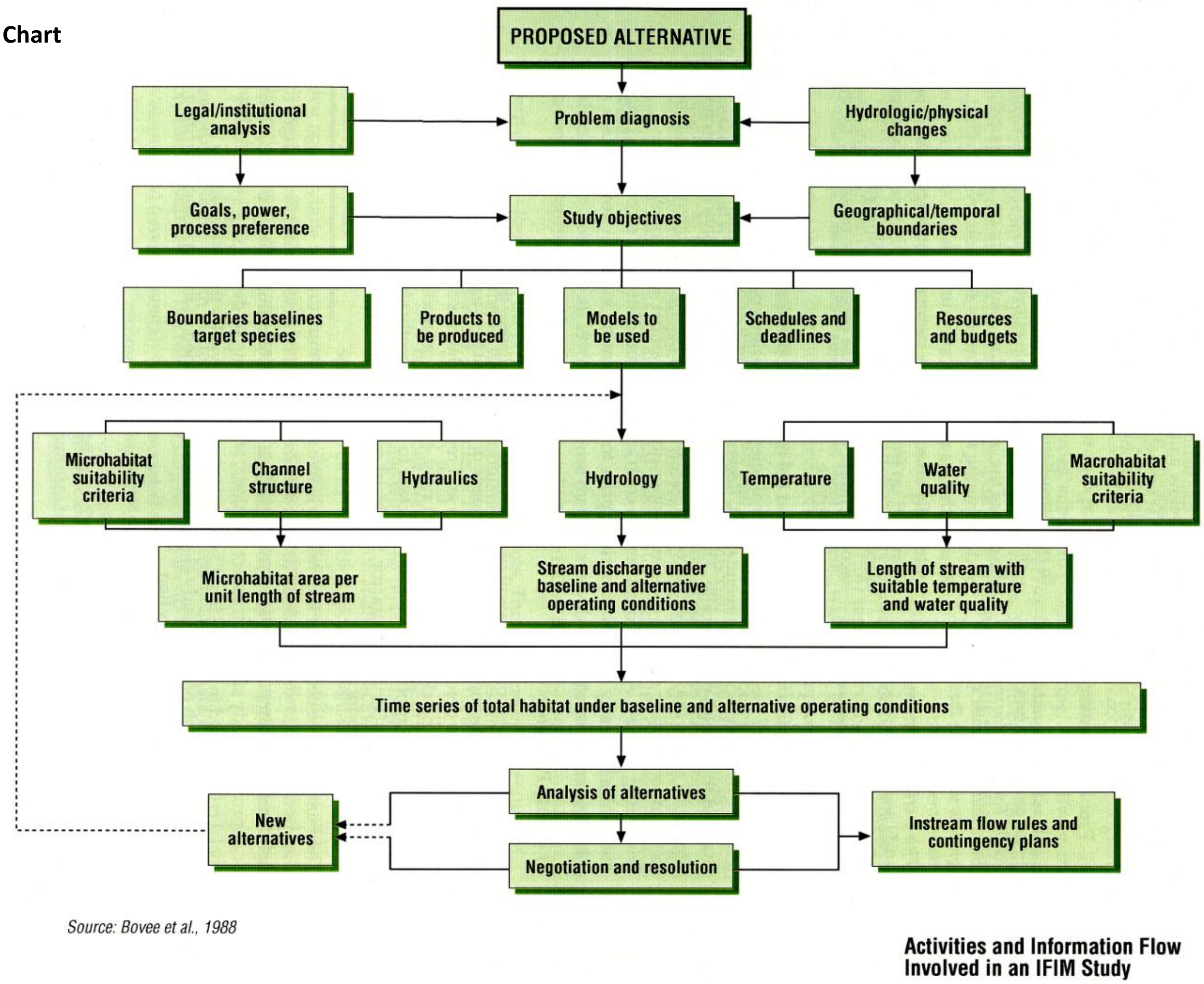
The IFIM is referred to as a *methodology* in contrast to a *method* because it outlines a process for arriving at an acceptable instream flow regime that considers multiple technical and social issues (Trihey and Stalnaker 1985). The typical steps of an IFIM study include the following:

1. Legal and institutional analysis
2. Strategy design
3. Technical studies scoping
4. Development of habitat models (PHABSIM)
5. Formulation of alternatives
6. Negotiations to reach resolution

The IFIM process has been described in a flow chart consisting of 26 activity or information steps (Bovee 1988) (Figure 1). It is important to note that the IFIM and its associated habitat models do not prescribe a single solution regarding an acceptable instream flow value or regime. Rather it provides technical information that is then subject to different interpretations, and to identification of social needs, thus facilitating a negotiated solution that balances among conflicting values.

Because of its high cost, the IFIM methodology is used primarily to assess major water withdrawal projects or proposed dams. However, it is frequently used in conjunction with other studies associated with stream ecosystems (geomorphology, hydrologic alteration, fish biology, riparian vegetation, water quality, sediment regime) to develop guidelines, including instream flow prescriptions, for future water management within a watershed. Good examples of basinwide studies focused on future water allocation and instream flows needs include those being conducted in Alberta, Canada (Clipperton et al. 2003), and Texas (TWDB 2008).

FIGURE 1
IFIM Flow Chart



Although the PHABSIM models in IFIM produce multiple habitat-flow curves for different fish species or groupings, these data are often relied upon to recommend a single minimum flow value or a simple minimum flow regime. Invariably, the study results are subject to different interpretations influenced by one's personal values or organizational positions. Fisheries resource agencies often recommend the flow that provides the maximum habitat—the peak of the curve—for a selected species and life stage. In many cases, this may not be an appropriate use of the results. Federal fisheries agencies reviewing PHABSIM studies for ESA-listed salmon on the west coast recently concluded in several cases that flow providing at least 80 percent of the maximum habitat allows conservation and recovery of the fish populations (NMFS 2013). That same 80 percent of maximum habitat value has been used in Canada for prescribing instream flows for trout (Clipperton et al. 2003).

IFIM studies, particularly the PHABSIM models, are not immune from potential biases. Selection of representative study sites and stream cross sections are especially important steps in producing results that truly represent the stream reach in question. Selection of fish species or species guilds to model can also affect the results. One person's "key" species may be another person's "scrap" fish. Finally, the selection of fish habitat criteria or the means of developing site-specific criteria can greatly affect the model results. Various considerations and study techniques have been developed to avoid or minimize these potential biases.

2.5 Previous Instream Flow Method Reviews for Oklahoma

Instream flow needs and methods to quantify flows for protection of instream-related resources in Oklahoma have been the subject of several reports as far back as 1981. All these reports were written by researchers at Oklahoma State University or by the OWRB staff:

- Orth and Maughan 1981—application of Tennant method to Oklahoma
- OWRB (Saja Varghese) 1999—assessment of methods
- OWRB 2009—memorandum supporting comprehensive water plan update)
- OWRB 2011—instream flow issues and recommendations
- Turton et al. 2009 (OSU)—assessment of environmental flows in Oklahoma
- Fisher, Seilheimer, and Taylor 2012 (OSU)—biological assessment of environmental flows

Nearly all the simple standard-setting methods for recommending minimum flows identified in these reports are considered baseflow methods, in that they typically do not address needs for high channel maintenance flows or pulse peak flows. There are, however, simple desktop approaches to address high flow components as well (Reiser et al. 1989).

2.6 The One-size-fits-all Problem with Standard Setting Methods

Standard setting methods, although simple, suffer from the one-size-fits-all approach. Hydrologic methods like Tennant are not appropriate for predominately spring-fed streams because they tend to prescribe a flow that is often much lower than the natural base flow. For flashy and intermittent streams, the Tennant method may prescribe a flow for months in which there may be no natural flow. The Tennant method may prescribe too little flow for small streams and too much for large streams if the purpose is to protect fish habitat. The use of monthly median flows (or seasonal medians) helps avoid some of these problems, but the stream must have sufficient flow records to compute monthly medians.

Standard setting methods also suffer problems associated with using average conditions (e.g., flow) as their basis, yet average conditions are not necessarily common. For example, the year-to-year variability in mean annual flow in Baron Fork Creek measured at Eldon, Oklahoma, has been greater than 11-fold during the period of record from 1949 through 2012. Drought year contingency plans, which can include instream flow prescriptions, are a common approach for dealing with this issue in dry years. This approach is especially useful in the western states where snowpack measurements can forecast summer droughts. Forecasting droughts in Oklahoma may be more difficult.

Applying simple desktop methods to streams that have highly regulated flow or where baseflows have been reduced over time is especially problematic. The desktop methods are principled on the natural flow concept whereby fish and other aquatic resources have adapted to the natural hydrologic regime. But this principle becomes less supportable scientifically as the stream’s functional components (landscape/ geomorphology, hydrology, and sediment regime) have been altered over time from natural conditions.

Finally, application of any desktop method should take into account the current goals or future desired condition of the particular stream and its watershed. This is primarily a policy issue, not a technical one. For example, in a highly regulated stream, where much of the water already has been dedicated to out-of-stream use, such as irrigation or municipal supply, the protection or restoration of instream values such as fish may be of low priority. On the other hand, a designated scenic river that is largely unregulated would be expected to receive a higher degree of protection for instream resources, thereby justifying a more conservative approach to setting minimum flow requirements.

To help address the one-size-fits-all syndrome with standard setting methods, some states have categorized streams by various metrics so that different instream flow methods or different protection standards can be applied to different stream categories. Examples of stream categories include these:

- Physical/hydrological types, often associated with ecoregions defined by geology, climate, and vegetation types. An example would be stable vs. flashy streams. Such a categorization has already been done for Oklahoma streams (Turton et al. 2009).
- Degree of hydrologic and physical alterations (past and future). There are several software programs available to quantify hydrologic alterations. Physical alteration requires geomorphic and sediment studies.

- Current water use or watershed goals (irrigation, hydropower, municipal, industrial, recreation, scenic, ecological).
- Size of stream, typically based on average annual flow.

Oregon is a state that uses a stream-type and project-type categorization framework to determine what instream flow methods are appropriate and what intensity of technical study is needed to address instream flow issues (Oregon Water Resources Department 2010).

3. Baron Fork Instream Flow Recommendations Derived from Different Baseflow Methods

To exemplify the application of various instream flows setting methods, we chose Baron Fork Creek in eastern Oklahoma. We selected the stream because it has good flow records, is unregulated, supports a robust fish population of more than 60 species, and is designated a scenic river by the state. The stream has been the subject of instream flow considerations and proceedings associated with water permit applications filed by the Adair County Rural Water District No. 5 in 1988 and 1998. The instream flow history includes the following:

- 50 cfs by OWRB for state Scenic River Act compliance—Board decision June 1981
- 13.5 cfs initial decision by OWRB in 1988 Adair case—Board decision April 1989
- 75 cfs Adair case 1998 permit application–Board decision June 1998
- 50 cfs Board decision in 2003 following review of IFIM study

We caution that Baron Fork is representative of only one type of stream hydrology, and it has a special status designation (scenic). Thus, the use of Baron Fork as an example stream should not be viewed as representative of most other streams in the state.

Streamflows in Baron Fork are lowest in the summer and early autumn months based on gage records from 1948 – 1999 at Eldon. Average monthly flows are about twice the median flows for July through September, but the ratio increases considerably in October and November as more high flow events affect the hydrologic pattern (Table 2). The mean annual flow for the Baron Fork at Eldon is 333 cfs.

TABLE 2
Discharge for the Summer and Autumn Low-Flow Months in Baron Fork Creek at Eldon (1948–1999)

Statistic (condition)	Discharge (cfs)				
	July	**August**	**September**	**October**	**November**
25th percentile (dry)	40	24	19	23	40
Median (normal)	71	44	36	50	79
75th percentile (wet)	130	75	71	99	259
Monthly mean	155	76	129	178	311

The base flows in Baron Fork are affected by some diversions for domestic and irrigation use. Layher (1998) estimated that streamflow at Eldon could be diminished by up to 19.6 cfs during the summer if all upstream water rights were being used simultaneously. In another analysis, based on reported water use, the OWRB estimated that 1,580 acre-feet per year was being diverted from the stream and its tributaries (OWRB 1998). If that amount of water were used primarily for irrigation over a 5-month period, it would equate to 5 cfs in those months. For the purposes of computing instream flow values for the Baron Fork, we used the flow statistics available at the Eldon gage without accounting for upstream withdrawals.

We applied the instream flow standard setting methods used in Arkansas, Kansas, Texas, South Carolina, and Georgia to Baron Fork. All these examples use hydrologic data as the basis. We also applied the Orth and Maughan modification of the Tennant method for Oklahoma streams. Methods that are modifications of the

Tennant method yielded instream flow values of 33 cfs (Orth and Maughen), 66 cfs (South Carolina), and 100 cfs (Georgia) (Table 3). This rather wide range reflects the flexibility of use with the same method and highlights the differences in the degree of protection for instream flows among the states. Similar differences are evident among those states that use monthly median flows. Monthly median flows used to determine baseflow instream flows are 60 percent (Texas), 80 percent (Kansas), and 100 percent (Arkansas). For the Baron Fork these equate to 30 cfs, 40 cfs, and 50 cfs for the three methods, respectively.

TABLE 3
Results of Various Instream Flow Methods Applied to Baron Fork Creek

Methods	Resulting Minimum Flow in Baron Fork (cfs)
State Standard Setting	
Arkansas—50% of mean monthly flow (July–October), or 100% of median flow (July–October)	67 cfs / 50 cfs
Kansas—Generally 80% of monthly median (some streams are set at 90%)	40 cfs
Texas (Lyons Method: small diversions)— 60% of monthly median flow (March–September), 40% of monthly median flow (October–February), *or* 7Q2 flow if higher	30 cfs (July–September)
South Carolina (modified Tennant Method)—20% mean annual flow (July–November)	66 cfs
Georgia (modified Tennant Method)—30% mean annual flow	100 cfs
Orth and Maughan (1981) modified Tennant for OK—10% mean annual flow (July–December)	33 cfs
Others	
Wetted perimeter	~50 cfs
PHABSIM shallow-fast habitat guild	50 cfs (peak of habitat curve), 30 cfs (80% peak of curve)
PHABSIM smallmouth bass	50–75 cfs (peak of habitat curve), ~ 30 cfs (80% peak of curve)
Oklahoma domestic use set aside	10 cfs (at Eldon)

Figure 2 presents PHABSIM model outputs for Baron Fork (Fisher and Remshardt 2000). Depending on how the results are interpreted, instream flow recommendations could range from 30 to 75 cfs.

We were unable to apply the wetted perimeter method directly to Baron Fork without the needed field data, but the results would likely be similar to the PHABSIM results for the shallow-fast habitat guild. This curve (see Figure 2) peaked at 50 cfs, which would likely correspond to the recommended instream flow using the wetted perimeter method.

The domestic use set aside for the Baron Fork at Eldon computes to approximately 10 cfs. The computation is based on a watershed area of 312 square miles upstream of the gage site. The unused portion of this set aside water contributes to the maintenance of minimal flows at Eldon, but the computed flow is considerably less than what would be considered adequate for protection of instream resources based on the other methods discussed above. The domestic set-aside flow of 10 cfs for the Baron Fork contributes only 20 percent to the currently established minimum flow of 50 cfs.

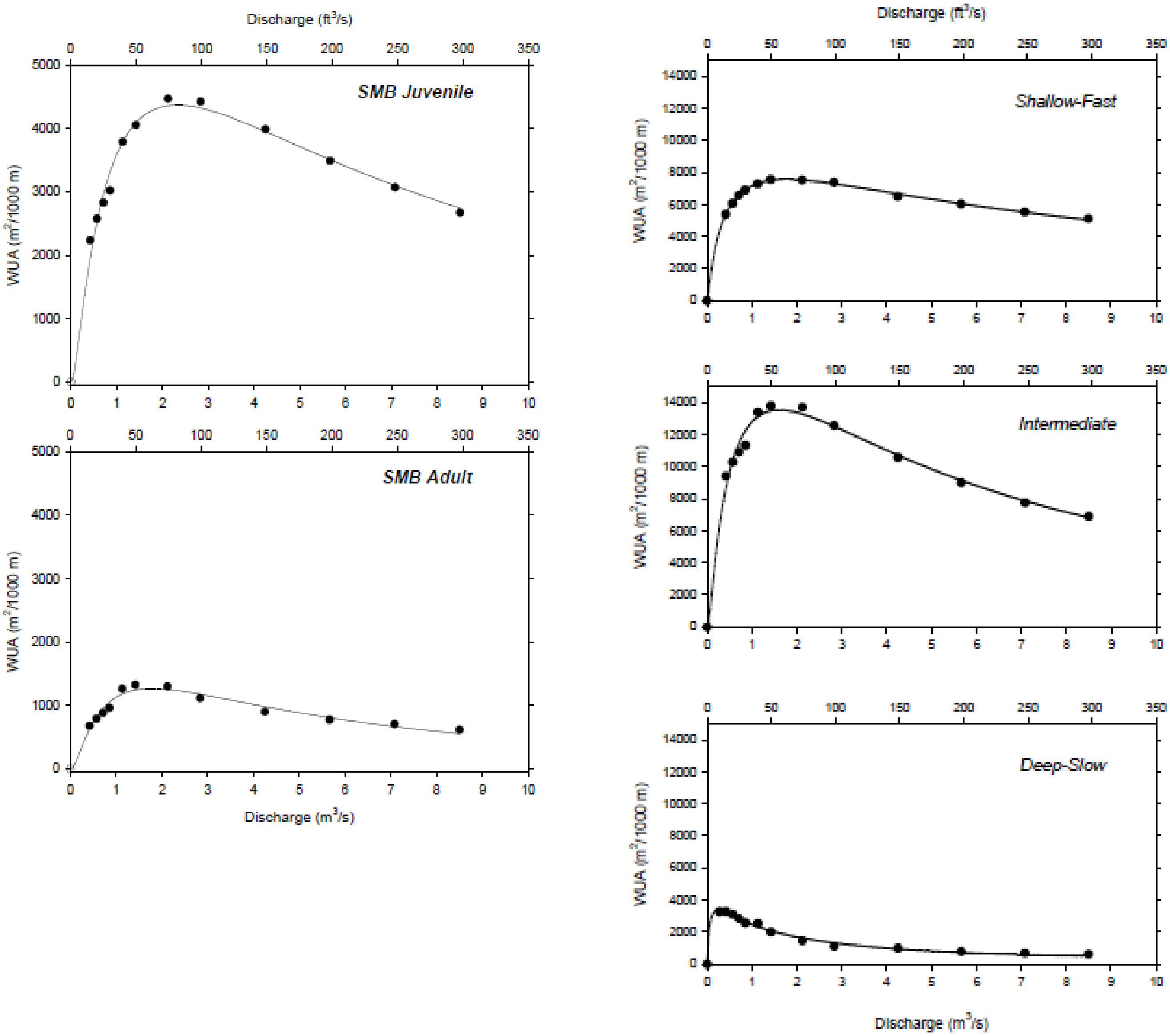
4. Summary

This memorandum discusses technical issues associated with the potential application of available instream flow methods to streams in Oklahoma. The primary concern with using simple desktop methods is that they tend to be one-size-fits-all. While appearing easy to use, they can make instream flow setting complicated and contentious. Acknowledging that flows developed from these methods are to be regarded “preliminary” until further studies and negotiations can be completed, if necessary, can make their use more acceptable.

Most desktop instream flow methods have considerable flexibility that can allow their use to be applied with different value-based standards (e.g., good, fair, poor) on a case-by-case basis. Categorizing streams based on several criteria (hydrologic regime, management goals, degree of alteration, size) can assist in tailoring the application of instream flow methods and standards to meet the particular circumstances.

FIGURE 2

PHABSIM Model Outputs for Baron Fork



Multiple instream flow baseflow methods were applied to the Baron Fork Creek in eastern Oklahoma to exemplify the range of results that can be derived. Instream flows for the summer baseflow period derived from these various methods ranged from 30 to 100 cfs. A comprehensive IFIM study of Baron Fork yielded results that would support a minimum instream flow of between 30 and 75 cfs, depending on how the results are interpreted (technical) and the level of protection appropriate to the stream (policy). The Oklahoma domestic use set aside water calculated for Baron Fork at Eldon provides only a nominal contribution to instream flows at that site.

5. References

Annear, T., I. Chisholm, H. Beacher,and A. Locke. 2004. Instream Flows for Riverine Resource Stewardship, rev. ed. Instream Flow Council, Cheyenne, WY.

Bovee, K.D. 1988. Use of the instream flow incremental methodology to evaluate trout populations in four Colorado streams. Proceedings of the Annual Conference Western Association of Fish and Wildlife Agencies 68:227-257.

CH2M HILL. 2013. Instream flow Advisory Group Support, Background Report. Prepared for Oklahoma Water Resources Board and US Army Corps of Engineers, Tulsa District.

Clipperton, G. C., W. Koning, A. G. Locke, J.M. Mahony, and B. Quazi. 2003. Instream flow needs determination for the south Saskatchewan River Basin, Alberta, Canada.

Esralew, R.A. and J.M. Lewis. 2010. Trends in base flow, total flow, and baseflow index of selected streams in and near Oklahoma through 2008. US geological Survey Scientific Investigations Report 2010–5104, 143 p.

Fisher, W. L., and W. J. Remshardt. 2000. Instream Flow Assessment of Baron Fork Creek, Oklahoma. Oklahoma Cooperative Fish and Wildlife Research Unit, Oklahoma State University, Stillwater, OK.

Fisher, W. L., T. S. Seillheimer, and J. M. Taylor. 2012. Biological assessment of environmental flows for Oklahoma. Open file report 2012-1114. U.S. Department of Interior. U.S. Geological Survey, Reston, Virginia.

Gippel C.J. and M.J. Stewardson. 1998. Use of wetted perimeter in defining minimum environmental flows. Regulated Rivers: Research and Management. 14: 53-67.

Hatfield, T. and J. Bruce. 2000. Predicting salmonid habitat-flow relationships for streams from western North America. N. Am. J. of Fish. Mgt 20 (4): 1005-1015.

Layher, W. G. 1998. Preliminary Instream Flow Assessment for the Barren Fork Creek, Oklahoma. Layher Biologics RTEC, Inc. Pine Bluff, Arkansas

Leonard, P.M., D.J. Orth, and C.J. Goudreau. 1986. Development of a method for recommending instream flows for fishes in the upper James River, Virginia. Virginia Water Resources Research Center. Virginia Polytechnic Institute and State University, Blacksburg, VA.

Leopold, L.B. 1994. A View of the River. Harvard Univ. Press. Cambridge, MA.

National Marine Fisheries Service. 2013. Biological Opinions on the effects of proposed Klamath Project operations from May 31, 2013, through March 31, 2023, on five federally listed threatened and endangered species. NMFS file no. SWR-2012-9372.

Oklahoma Water Resources Board. 2012. Oklahoma Comprehensive Water Plan. Executive Report.

Oklahoma Water Resources Board. 2011. Instream Flow Issues and Recommendations. Oklahoma Comprehensive Water Plan Supplemental Report.

Oklahoma Water Resources Board. 2009. Oklahoma Comprehensive Water Plan. 2011 Update. Technical memorandum. Instream flows in Oklahoma and the west.

Oklahoma Water Resources Board. 2003. Agency Rule Report prepared March 19, 2003 for Amendments to Title 785, Chapter 20. Appropriation and Use of Stream Water.

Oklahoma Water Resources Board. 1999. Assessment of minimum instream flows and potential for application to Oklahoma's "ORW" waters. Prepared by Saji Varghese.

Oklahoma Water Resources Board. 1998. Findings of Fact, Conclusions of Law and Board Order in the matter of the Application of Adair County Rural Water District No. 5 for a permit to use stream water from Baron Fork Creek. Application No. 94-34.

Olson, F. W. 1996. The study and protection of instream flows. Paper presented at the 1996 American Water Resources Association annual meeting, Anaheim, CA.

Oregon Water Resources Department. 2010. White paper: peak and ecological flow; a scientific framework for implementing Oregon HB 3369.

Orth, D. J., and O. E. Maughan. 1981. Evaluation of the "Montana Method" for recommending instream flows in Oklahoma streams. Pro. Okla. Acad. Sci. 61:62-66.

Payne, T. R. 2012. Instream flow assessment. The science of the art, approaches to evaluating riverine aquatic habitat. The Water Report, issue #95. January 15, 2012.

Poff, N.L., and J.V. Ward 1989. Implications of streamflow variability and predictability for lotic community structure: a regional analysis of streamflow patterns. Canadian J. of Fisheries and Aquatic Science, 46: 1805-1818.Reiser, D.W., M.P. Ramey, and T.A. Wesche. 1989. Flushing Flows. Chapter 4 in: J.A. Gore and G.E. Petts, editors, Alternatives in Regulated River Management. CRC Press, Boca Raton, FL.

Texas Water Development Board. 2008. Texas Instream Flow Studies: Technical Overview. Texas Water Development Board Report No. 369.

Trihey E.W. and C. Stalnaker. 1985. Evolution and application if instream flow methodologies to small hydropower development: An overview of issues. In F.W. Olson, R.G. White, and R.H. Hamre, editors, Symposium on Small Hydropower and Fisheries. American Fisheries Society, Bethesda, MD.

Turton D., B.Fisher, T.S. Seilheimer, and R.A. Esralwe. 2009. An assessment of environmental flows for Oklahoma. Oklahoma Water Resources Research Institute. Oklahoma State Univ. Stillwater, OK.