

Instream Flow Council Peer Review of:

Recommendations for Estimating Flows to Maintain Ecological Integrity in Streams and Rivers in North Carolina. Submitted to the North Carolina Department of Environment and Natural Resources by the North Carolina Ecological Flows Science Advisory Board. November 2013.

Background

Per a formal request and sponsorship by North Carolina Wildlife Resources Commission's (WRC) Instream Flow Council (IFC) Governing Council Member, Mr. Chris Goudreau, the IFC agreed to enter into a contractual agreement with the North Carolina Department of Environment and Natural Resources (DENR), Division of Water Resources (DWR) to perform a peer review of the North Carolina Ecological Flows Science Advisory Board (EFSAB) report entitled: "*Recommendations for Estimating Flows to Maintain Ecological Integrity in Streams and Rivers in North Carolina*".

The IFC has conducted three peer reviews of this nature to date, adhering to the Peer Review Policy. The IFC criteria for peer review require that the peer review request is sponsored by an IFC Governing Council member in good standing and that the IFC agrees to conduct the peer review. Through a written request dated March 25, 2014, DENR sought IFC peer review through North Carolina's WRC IFC representative, Mr. Chris Goudreau – the agency being an IFC member in good standing. At the June 2014 IFC biennial meeting, the IFC agreed orally to perform the review. Following the IFC meeting Mr. Goudreau facilitated communications between IFC and DENR. IFC and DENR reached mutual agreement to contract terms on September 15, 2014 (Contract No. 6175). A no-cost time extension was granted January 13, 2015 extending the completion date until April 01, 2015. The contract asked five questions relating to 1) the EFSAB report, 2) the effectiveness of recommendations, 3) foreseeable implementation challenges, 4) how well the EFSAB report met certain requirements in Session Law 2010-143, and 5) how well the EFSAB met certain requirements in Session Law 2010-143. The contract also permitted IFC to expand upon the five basic questions. The peer review is structured into sections that follow these groups of questions provided by DENR; the five verbatim questions are in bold.

1. Document Review

The November 2013 EFSAB report reviewed by the IFC is posted online:

http://www.ncwater.org/files/eflows/sab/EFSAB_Final_Report_to_NCDENR.pdf

The Executive Summary provides a succinct and clear synopsis of the EFSAB charge, process, and recommendations.

1.1 Is the EFSAB report well-grounded in current riverine science?

Yes, the report is well-grounded in current riverine science. The EFSAB did a very thorough job researching the latest in riverine science, and references cited in this report are current, relevant to the scale of the recommendations, and heavily cited in other works. The report provides a reasonable history of instream flow science and focuses on the works that are most relevant to the flow alteration of, and available information for, North Carolina. Those references that are incorporated into specific

aspects of the report are current and in many cases regionally significant. In addition to providing a thorough list of references, the public process provided an opportunity for some of the study authors to present information directly to the stakeholders as guest speakers. In the case that DENR desires to update the EFSAB in the future, the IFC has other recommendations, not included herein, to improve the EFSAB report for public comprehension and participation. The IFC also suggests the EFSAB review Annear et al. (2004) relative to assessments and characterizations of instream flow methods including standard-setting approaches/methods such as 7Q10 and Tennant as there are some nuances in EFSAB Section 2.3 that could be better addressed.

1.2 From a science perspective are there fundamental flaws with the report?

While no fundamental flaws with the EFSAB recommendations were identified by the IFC review team, we offer the following comments.

As recognized by the EFSAB, there is a lack of information regarding coastal plain streams, headwater streams, and large rivers. Interim guidelines for these streams should be established and research prioritized, planned, and scheduled to address science needs in these riverine ecosystems.

One key consideration that should be addressed either by definition or clarification early in the report (or both places) is to assert that references to “flow” do in fact mean “flow regime”. Failure to make this clear distinction risks allowing readers to infer that the authors support a single flow level for riverine protection when, in fact, they are relating recommendations to a flow regime. Though the authors do use the full term (flow regime) in several places, this use should be consistent throughout the report.

While the use of a stream classification system (e.g., Environmental Flow Specialists Inc. or McManamay et al.) was deemed not appropriate for developing flow recommendations at this time due to uncertainty, it may provide improved models with additional and better flow-ecology data. Sample sizes of streams used in this analysis may have been too small to find utility in a stream classification system; however, such a system might help further refine the percentage-of-flow approach in the future. Thus, utilizing a stream classification based on larger samples sizes and additional stream habitat/flow data from a broader suite of stream types should be considered. Perhaps streamflow gages from nearby states can be integrated with North Carolina data to improve the utility of using a stream classification system. Additional gaging in state is also encouraged to improve precision and accuracy of flow estimate models and to support periodic updates to current predictive models.

The report presents considerable evidence, mostly through quantile regression, that there is a clear link between ecodeficit (see Figure 11, 3.1.2) and fish and macroinvertebrate diversity indices. The analysis is clear, simple, and well supported in the literature. It is unclear, however, exactly how the biological information is to be applied. EFSAB recommends that the biology be used to suggest further analysis if the alteration of the biological indices exceeds 5-10%, but does not outline how this will happen. Will the analysis happen on a watershed-wide basis; will index sites be developed? At one point the report states that biological information has poor predictive capability and should not be applied to any given site, but then also states that an alteration of greater than 5-10% is the initial criteria for further review.

There seems to be a considerable amount of information in Appendix D (Flow Alteration–Biological Response Relationships to Support the Determination of Ecological Flow in North Carolina) that, while referenced, was not used to develop the EFSAB recommendations, despite the utility of biological response models to provide “statistically significant trends under various scenarios” of flow alteration. Considering that biological condition is a dynamic process with upper and lower natural limits in terms of numbers of organisms and relative abundance of species within a community of organisms, biological indices should be referenced to some reasonable period of time (e.g., average condition measured two to three years following project implementation at a minimum). Documented alteration at any level demands knowledge of the existing condition (e.g., variability and rate of change) and such level of information is often lacking. Regardless, this concept simply reinforces the need for long-term monitoring and suggests that use of appropriate reference streams may be appropriate or needed in some situations.

The EFSAB highlights a key issue with implementation of the biological response strategy, namely that percentage-based reductions in diversity (or richness) could result in disparate impacts to sites with “exceptional quality conditions”. IFC agrees with the EFSAB suggestion (page 25, 3.1.2) that additional measures may be necessary for these exceptional sites. The DENR may wish to request that the EFSAB develop a trial balloon for such “additional protection” in cooperation with willing stakeholders.

1.3 Does the document miss key concepts from the literature?

IFC did not identify key concepts that were missing from the literature or report and its appendices; however, EFSAB provides an additional recommendation related to Threatened and Endangered Species (Section 3.3.1) that for planning purposes, reaches that include listed species automatically receive additional analysis (i.e., red flag) and calls for research on the flow requirements of listed species. IFC finds that recommendation to be sound but would like to amplify regarding freshwater mussels (unionids). Mussels are one of the most imperiled fauna in North America (see Williams et al. 1993) and some species may be very sensitive to flow alterations given not only their habitat preferences but the complex life history strategies involving parasitic larval stages and their fish hosts. Sufficient data for characterizing the status of mussel communities in North Carolina streams may not have been available to the EFSAB and thus analysis was precluded. IFC recommends a focus on the collection of mussel data in general, rather than limited to specific listed species, to ensure that biological response models for freshwater mussels can be developed in the future.

By policy, the IFC (Annear et al. 2004) encourages that all studies of flow needs recognize and address flow regime needs in terms of hydrology, biology, geomorphology, connectivity, and water quality. While many of these elements are considered at some level in the report (directly or indirectly), it would be helpful to note this policy and establish that the complex interaction of these riverine components is what determines the form and function of flowing waters. In places throughout the report where mention is made to the need to conduct future studies, it would be productive to note that such detailed studies should include consideration of these five elements and their interaction.

IFC also recommends assessment of changes to natural water level variation that may be associated with releases of water for environmental flow regime management also be considered for water management planning purposes in future updates.

1.4 Are the recommendations credible and defensible?

Yes, IFC believes the recommendations are credible and defensible. The EFSAB highlighted areas of uncertainty (e.g., stream classification) that resulted in the best available data and statistical techniques and information being brought to bear on recommendations.

The recommendations are based on significant trends that illustrate the reduction in aquatic habitat quality and integrity with increases in anthropogenic alteration. Consequently, the recommendations are appropriate for their use in a statewide framework and are suitable for assessing the general severity of certain stressors on ecosystems (Armstrong et al. 2011). Site-specific predictions of aquatic community integrity would not be appropriate in this case as regionally-derived flow-ecology relationships can be imprecise or inaccurate in determining the conditions, impacts, and community attributes at any given site. The lack of precision and accuracy is also compounded by the complications associated with space for time substitution analyses. Some applications using benthic macroinvertebrates outperform those for fishes (see EFSAB Appendix D). Site-specific impact assessment using regionally-derived flow-ecology relationships based on fish communities should be viewed with caution until they can be further refined. Further research into flow-ecology relationships of fish and benthic macroinvertebrates should be emphasized as a high priority.

2. Recommendation Effectiveness

2.1 Are the recommendations well suited for the intended end use, specifically protecting ecological integrity in basin-wide water planning?

The EFSAB recommendations include two simultaneous strategies to assess the maintenance of ecological flows (section 3.1): 1) the percentage-of-flow approach (80-90% flow-by) combined with critical low flow threshold and 2) a biological response strategy to be used as a decision criterion that initiates further review. If both of these strategies, including the critical flow threshold, are implemented as recommended then the recommendations should be quite effective as a set of guiding principles for basin-wide water planning, except in headwater streams, coastal plain streams, and large rivers. For those systems the effectiveness is less clear as the science needs for those systems have not been fully developed as noted in the report and its appendices. However, the effectiveness of the recommendations in protecting ecological integrity will only be determined on the ground through individual water allocation decisions, monitoring and, when warranted, adaptive management. If the decisions and water resource management follow the spirit and intent of the report findings, then they will become effective over time. The recommendations are measureable and directly tied to well understood surrogates of ecological integrity; the percentage-of-flow approach incorporates inter-annual variability of hydrology and applies to all flow components (e.g., subsistence, base flows, high flow pulses, and overbanking flows) and further protection is possible through the establishment of critical low flow thresholds to avoid increases in the severity and duration of drought periods, for

example. However, the EFSAB did not recommend a specific low flow threshold strategy but recommends “that DENR establish these values based on an analysis of typical and extreme low-flow conditions in North Carolina.”

3. Implementation Challenges

3.1 Are there foreseeable implementation challenges the DWR should be aware of based on the design and principles behind the recommendation?

For the % flow-by method, IFC recommends that a single percentage, rather than a range, be identified. There is a potentially substantial difference between 80% and 90% of ambient flow and consequent biological responses depending on the degree of existing hydrologic alteration and the biological condition. Since this is a planning (as opposed to permitting/regulatory) tool, IFC recommends going with a flow-by standard of 90% to be conservative and institute action (e.g., closer examination) with smaller changes in predicted streamflow. IFC thinks 90% is particularly appropriate since the 2010 baseline is also recommended by the EFSAB (page 19).

The previous comment applies equally to the biological response strategy. The IFC recommends 5% ecological change. Using a range for either method is confusing and potentially exposes the process to regulatory or legal challenges if one region or entity is treated differently than another.

When available IFC strongly recommends using unaltered flow as baseline for (at a minimum) purposes of comparison. Noting whether animal and plant communities are native or altered should also be integrated with assessments of altered and unregulated hydrologic conditions. Using 2010 as baseline will not address cumulative impacts that have already occurred. Flow-by conditions of 80-90% are only protective, as indicated in the supporting literature, if they are 80-90% of natural conditions. The EFSAB recommendations, it seems, are not based on natural conditions, but instead on baseline conditions, which include existing withdrawals and returns. Depending on the amount of alteration already existing in the basin, the 80-90% pass-by flows from the natural condition can already have been largely surpassed. The literature does not suggest that ecological integrity will be maintained if a river with 10-20% alteration is further impacted by an additional 10-20% reduction in daily average stream flow.

Again, since this is for planning purposes, not permitting, getting the best information available makes the most sense. By using unaltered (“natural”) flows as a baseline, the basins already heavily altered from their natural state will be identified, which might not be evident from a 2010 baseline. IFC acknowledges there may be constraints imposed by definitions in Section 2. G.S. 143-355 related to 1) ecological integrity and 2) prevailing ecological conditions. Ecological flows means those flows designed to protect ecological integrity. Ecological integrity is defined in G.S. 143-355(1)(b) and specifically refers to “prevailing ecological conditions.” Prevailing ecological conditions, in G.S. 143-355(1)(d) in turn references conditions that exist “after the construction and operation of existing flow modification devices, such as dams”.

Once the baseline is determined, the terminology throughout the document should be reviewed to standardize the use of the terms “baseline,” “natural,” and “unaltered.”

The EFSAB recommends 80-90% of the instantaneous modeled baseline flow be protected in the stream. Baseline flows are defined as unregulated flows (pages 12 and 13) and are described in figure 8 as “natural” and figure 10 as “unaltered.” However, on page 19 “baseline conditions” are defined parenthetically as flow regimes incorporating current withdrawals and returns. The EFSAB report recommends that the baseline should be the management regime that existed when the law went into effect in 2010. Then, on page 18, EFSAB recommends that the ecological flow should be 80-90% of the instantaneous modeled baseline flow. When these items are taken together, it could be interpreted that the existing altered flow regime could be considered the baseline and any proposed alteration that is taking an additional 10-20% of instantaneous stream flow could be considered minimal (acceptable).

The reconciliation of these statewide recommendations with site-specific application and interpretation will be challenging. These recommendations are cumulative and individual permitted projects will need to be reviewed with that cumulative backdrop in mind. Additionally, once a new withdrawal is authorized, the existing basin flow-by value will need to be updated to reflect the new withdrawal. The EFSAB report clearly identifies a need to avoid a moving baseline, but tracking this kind of data will be challenging. The authors should consider adding recommendations for how to track this data.

The flow-by range of 10-20% is based on instantaneous flows and many permitted withdrawals are seasonal or pulse-type flows that might leave the seasonal or annual average alteration within the flow-by range, but potentially have far more dramatic impacts seasonally or daily. The evaluation of flow-by flows will also need to be done on the daily time-step with a clear understanding of the periodicity and volumes proposed for withdrawal. As long as the scale of withdrawal matches the scale of the analysis, a correct assessment of impacts will result. Again, this is recognized in the report and the principle of instantaneous flow-by needs to be maintained during implementation.

3.2 Are there foreseeable implementation challenges the Department should be aware of based on the knowledge or data requirements for calculating flow recommendations?

The challenge related to using altered/modified hydrology as a baseline (i.e., 2010), especially in flow regulated river reaches, has been articulated under other headings and clearly applies to the calculation of flow recommendations using the percentage-of-flow approach.

The critical low flow threshold was not identified by the EFSAB but EFSAB suggests that one be established and IFC concurs. Care should be taken to identify a low flow threshold that is not set too high resulting in a threshold that would exceed “unaltered” hydrology for longer durations or more frequently than historically occurred (Figure 10 depicts a short event). In some systems, extreme low flows may also play an important role in structuring biotic assemblages. As noted previously, connectivity influences biotic communities at many levels, one of which is temporal. Though managers often strive to maintain continuous year-round connectivity, many native fish communities maintain their structure courtesy of brief periods of hydrologic disconnectivity (when rivers cease flowing but still maintain disconnected pools). Thus the recommendation to determine low flow cut-offs or thresholds on a stream-by-stream basis has merit.

3.3 Are there foreseeable implementation challenges the Department should be aware of based on the proposed/intended uses for the recommendations?

If the flow alteration is not on the same time step as the modeled alterations to flow, then the altered measured stream flow will not match the alteration to modeled stream flow and consequently, the impact to biota. IFC concurs with the EFSAB that a daily time step is appropriate given that the basinwide hydrologic models use daily average flow. Alberta relies on a standard of instantaneous daily flow-by so this level of management does have precedent and is feasible.

3.4 Are there foreseeable implementation challenges the Department should be aware of based on the policy questions and challenges we may face in the future?

The IFC did not identify any particular challenges that could be classified as such. IFC does however note the challenge of integrating these planning tool proposals with the need to account for essential water uses. Trial application of these recommendations in subbasins with willing stakeholder partners might prove useful as a vehicle to test, refine, and adapt these recommendations.

Because the recommendations in the report are tied closely to hydrology, there may be issues in some drainages or segments with having adequate hydrology data to draw on (gages). Gaging may also be a requirement for all sites once they are permitted.

Creating or maintaining institutional capacity may be an issue. Ensuring there is adequate (permanent) staff with appropriate funding and training with effective interagency coordination is always an important element of implementing a policy such as this. A study conducted by the IFC (Annear et al. 2009) found that the most effective agencies were those with water management authority that had specifically assigned staff to deal with all instream flow issues in the state. States that rotated such assignments among various sections or individuals were deemed less effective.

4 and 5. Session Law 2010-143

Session Law 2010-143 is included as Appendix A to the EFSAB report.

4. Does the EFSAB's document adequately and reasonably meet the requirements of Session Law 2010-143 as defined in Sections 1 and 2 (G.S. 143-350(3) and G.S. 143-355(o)(1))?

G.S. 143-350(3) defines "essential water use" as "the use of water necessary for firefighting, health, and safety; water needed to sustain human and *animal life*; and water necessary to satisfy federal, State, and local laws for the protection of public health, safety, welfare, the *environment*, and *natural resources*; and a minimum amount of water necessary to ~~maintain~~ support and sustain the economy of the state, region, or area." Italics added.

G.S. 143-355(o)(1) defines multiple terms including ecological flow, ecological integrity, groundwater resource, prevailing ecological condition, and surface water resource.

As G.S. 143-350(3) relates to ecological or environmental flow (italicized above), IFC did not find any reasons to suggest the EFSAB report did not meet the requirements. As noted earlier, these definitions may constrain what can be used in a planning tool. To our knowledge, strategies for water management options that might be triggered by these planning strategies when water sources are deemed inadequate to meet all needs haven't been devised. Developing such options might be a future action for the EFSAB to tackle.

The notion of "minimum amount of water necessary" is a potentially contentious concept. Some tend to think of "minimum" as the least amount of water needed to keep fish (or other aquatic organisms) alive. Drawing from the apparent intent of the legislation, a more proper definition of "minimum" would be "no more flow than is necessary to support the long-term habitat processes of a river ecosystem". In this case, "minimum" would be a relatively large number that falls in the range of 80%-90% of the instantaneous daily flow. In other jurisdictions where this term has been included in statute without definition, water managers have noted the legislative intent was actually a low flow approximating base flow levels. We encourage the authors to make a clear distinction of the meaning of "minimum" early in their report to head off any future disagreements with this concept.

5. Did the EFSAB adequately and reasonably meet the requirements of Session Law 2010-143 as described in Section 2 (G.S. 143-355(o)(4))?

Section 2 (G.S. 143-355(o)(4)) relates to ecological flow, the charge to the Department, and the composition and role of the Science Advisory Board.

The EFSAB assisted in characterizing the ecology of streams in North Carolina. The EFSAB was represented by 16 entities/interests (Appendix B) including all those required (at least up through August 2013). All but one of the invited groups were represented although it is not clear if one of the experts represented manufacturing or if an expert for such was invited. Each representative appeared to have the required expertise in aquatic ecology and habitat. The EFSAB appeared to have discovered and/or reviewed all relevant information (see response to 1.1). IFC finds no reasons to suggest that the EFSAB did not meet the requirements of Section 2 (G.S. 143-355(o)(4)).

6. IFC Review Summary

The report outlines methods for reviewing the cumulative impacts of essential water uses and ecological flows within a basin, sets a baseline against which further alteration will be measured, and incorporates biological information in the planning process. The report also recommends taking a conservative approach in circumstances where little is known or where statewide recommendations might not be appropriate (headwater streams, large rivers, and coastal systems).

The fact that flow alteration impacts fish communities and other flow dependent uses is not new science, it is common knowledge in the fishery community and beyond supported by extensive research results. What is new, and will be slightly different for each jurisdiction and each stakeholder-driven process, is the amount of alteration considered acceptable or the amount of alteration that triggers some corresponding action (water conservation, reduction in use, or finding alternative sources). The

report recommends 80-90% flow-by of instantaneous flows. This range certainly has some support in the report's cited literature. A range of 10-20% hydrologic alteration can also have very significant impacts to more sensitive natural resources. There does not seem to be a mechanism whereby the Department can recommend that even lower alterations receive a "yellow" or "red" light. Additionally, the EFSAB needs to clearly state that the baseline refers to estimated natural conditions. The literature cited in the EFSAB report does support the contention that a 10% reduction in natural intra- and inter-annual flow regimes can support a diverse aquatic community. It does not, however, support the contention that a 10% reduction in altered flow regimes can achieve the same outcome, especially if there are existing changes to animal and plant communities.

The EFSAB also addresses the report's limitations. The report is not an implementation plan or a method for protecting stream flow in any given stream reach, nor is it a comprehensive instream flow policy. It is not a site-specific evaluation of stream and river resources and impacts, but certainly illustrates the circumstances in which site-specific work will be required. This is a starting point from which to begin discussions about allocation, over-allocation, statewide river management strategies, and a standardized method to examine basin-level water planning and biological response potentially in regionally-specific (or other appropriate classification scheme) terms coupled with a heightened consideration of ecologically significant (or other outstanding quality) areas or sensitive or imperiled taxa. It also serves as a basis to support collection of additional hydrologic data to further refine predictive models used for water resources planning and monitoring.

The EFSAB recommendations go well beyond science, which we find most appropriate. They use basic scientific concepts, well supported by literature, that have been fully vetted by a diverse group of aquatic experts. Science provided the tool with which to examine flow alteration (hydrologic modeling) and biological response (quantile regression) and the public process determined not only a base level of acceptable alteration, but a process to follow when that basic decision might not be enough, or conversely too much, for any given water allocation decision. The body of evidence provided in the EFSAB report supports the conclusion that stream flow alteration impacts habitat, flora, and fauna. The difficult part of any water management program is finding the right tool that can be applied in the jurisdiction. This process appears to provide that tool. The IFC recommends this report be updated at least once every five years to track the status of these recommendations and account for new information that will better inform the planning process.

7. References

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