

Discussion Paper: Moving from Instream Flow Regime Matrix to Environmental Flow Standard Recommendations

Introduction

As the work of the Basin and Bay Expert Science Teams (BBESTs) and the Basin and Bay Area Stakeholders Committees (BBASCs) proceeds pursuant to the mandates of Senate Bill 3, the Science Advisory Committee (SAC) has identified a number of issues associated with how the instream flow matrix generated by HEFR or other methods may be translated into a recommended environmental flow regime at the BBEST level, and, subsequently, how that environmental flow analysis and recommended flow regime can be used by the stakeholder groups to develop recommendations for environmental flow standards and strategies, as required by Senate Bill 3. This document is intended to (1) outline the general procedural steps and responsibilities, (2) clarify and discuss technical issues, and (3) offer some possible options for addressing them. This document should be considered a work in progress, as the SAC is just beginning to explore these issues and because approaches that may be appropriate for the relatively more water-rich basins in the eastern part of the state may not always be appropriate as the Senate Bill 3 process moves west. Moreover, while this document offers some interpretation of the purpose and desired outcomes of various steps in the Senate Bill 3 process, the SAC does not intend, nor is it charged with, offering a legal interpretation of legislative language or its intent.

The Senate Bill 3 Process

Senate Bill 3 (SB 3) outlines a systematic process for developing and establishing requirements for environmental flows for the basin and bay systems of the state. For each basin and bay system:

- SB 3 requires each BBEST to develop environmental flow analyses and a recommended environmental flow regime(s) using best available science. The statute defines these terms as follows:
 - Environmental flow analysis: “the application of a scientifically derived process for predicting the response of an ecosystem to changes in instream flows or freshwater flows.”
 - Environmental flow regime: “a schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies.”

The statute's prescription for the BBEST is clear. Their work is to focus solely on maintenance of key aquatic habitats and specification of flows that are considered necessary to support a sound ecological environment. Hence, the product of the BBEST's efforts reflects only the environmental flow needs, and does not consider other uses for the flows, including human needs. The BBEST's "environmental-focused" recommendations maintain their integrity through the remainder of the SB 3 process. As this paper will discuss, however, the BBEST collaborative input and opinion on recommended flow standards which may not fully adopt their flow regime recommendations could be an important element to completing the SB3 objectives.

- SB 3 further requires that the BBASC review the environmental flow analyses and environmental flow regime recommendations from the BBEST and consider them, along with other factors including "the present and future needs for water for other uses related to water supply planning." Based on these deliberations, the BBASC is to develop recommendations regarding "environmental flow standards and strategies to meet the environmental flow standards...". "Environmental flow standards", under Sec. 11.1471, are to be "appropriate" for each basin and bay system and be "adequate to support a sound ecological environment, to the maximum extent reasonable considering other public interests and other relevant factors."

The flow standards developed by the BBASC will likely be based on an environmental flow regime, but it does not have to be identical. For example, an overbank flow may be an important part of a flow regime but not included as part of the standard in some segments of the basin due to concerns associated with flooding and liability. Present and future needs for water for other uses related to water supply planning or economic impacts may dictate that a recommended or adopted flow standard not conform to a particular flow regime.

- The BBEST and BBASC recommendations are transmitted to the Texas Commission on Environmental Quality (TCEQ), which is charged with adopting, by rule, appropriate environmental flow standards "that are adequate to support a sound ecological environment, to the maximum extent reasonable considering other public interests and other relevant factors". In addition to the BBEST and BBASC recommendations, the TCEQ is to consider comments from the Environmental Flows Advisory Group (EFAG) on the BBEST recommendations, other public comment, the specific extent and characteristics of the basin and bay system being evaluated, economic factors, human and other competing water needs in the basin and bay system, and information provided by the SAC. TCEQ is also directed to establish an amount of unappropriated water, if available, to be set aside to satisfy the environmental flow standards "to the maximum extent reasonable when considering human water needs."

Instream Flow Regime Matrix

There appears to be general agreement among aquatic biologists and ecologists that the flow requirements necessary to support a sound ecological environment in a stream system should consist of several flow components with characteristic seasonality. Following guidance from the National Research Council, the Senate Bill 2 Texas Instream Flow Program (TIFP) uses the following structure to describe an environmental flow regime:

- minimum *subsistence flows* to maintain water quality criteria and prevent loss of aquatic organisms due to, for example, lethal high temperatures, low dissolved oxygen levels or loss of critical habitats;
- *base flows* representing the range of “average” or “normal” flow conditions in the absence of significant precipitation or runoff events that provide instream habitat conditions needed to maintain the diversity of habitats and resources that support native aquatic and riparian species;
- short duration, high magnitude, in-channel *high flow pulses* that occur during or immediately following rainfall events and provide spawning cues and transport of eggs and larvae of fishes and aquatic invertebrates, as well as helping to maintain important physical habitat features and connectivity along a stream channel
- *overbank flows* consisting of infrequent, high magnitude flow events that produce water levels that exceed channel banks and result in water entering the floodplain to maintain riparian habitat

The SAC also recommended this same structure in order to maximize consistency in the framework of environmental flow recommendations in Texas.

The Hydrology-based Environmental Flow Regime model (HEFR) provides a calculation tool that determines magnitudes for the various environmental flow components, based on a specified historical daily flow record and user input regarding desired flow characteristics. Output from HEFR is in the format of a “flow matrix,” or array such as the generic example shown in Figure 1. The daily flow record for a specific historical period is sorted into the four TIFP component flows, and the data sets for each of these are further sorted into time-period categories before being subjected to statistical analyses. By “time-period categories” is meant some subdivision of the calendar year, e.g., season, month, or user-defined periods of possibly different lengths. The fact that the number and length of these calendar periods are at the disposal of the user is emphasized in Figure 1 by the nonspecific terms *season*, *period*, *bin*, and *span*. A different time-period term is assigned to each flow component to emphasize that the user may define distinct calendar periods for each flow component. For example, the rare overbank flows may be evaluated on an annual basis, the high-flow pulses on a semiannual basis (loosely, the “spring” pulses and the “fall” pulses), base flows on a monthly or seasonal basis to display the seasonal variation in streamflow, and subsistence flows on an annual basis. HEFR includes the capability to separate and identify a sequence of daily flows as an “event” for purposes of analyzing the overbank and flood pulse component flows. The statistics of these events are then quantified by return frequency, peak flow, duration, etc., following the usual conventions of hydrology. HEFR also has the ability to apply a climatological sorting of the data record into “wet,” “dry,” and “average,” according to user-input criteria, so that flow component analyses are developed for each climatological category.

As indicated in Figure 1, the user has a wide range of options for the computed products of HEFR. For baseflows and subsistence flows, in particular, these can be flow values at a specified frequency, frequencies at specified flow, or other statistical parameters. The purpose of providing such a range of options is to allow evaluation of the flow time series in light of relationships between flow and the stream ecosystem that might be indicated by scientific studies of the riverine environment. Lacking such scientific results, the user may specify standard frequency or flow magnitude levels, such as decile points on the frequency distribution, or integral-year return periods for high-flow pulses, together with standard time periods, such as months, to obtain a statistical analysis of the flow time series. In fact, the default option for HEFR is a flow matrix in which wet, dry and average years are defined by quartile points on

the frequency distribution (excluding the lowest 2.5% of data, which are defined to be “subsistence”), and the table entries are seasonal medians for base flows and some combination of seasonal quartile and median flood parameters for high-flow pulse events. The quartile-frequency magnitudes are chosen for numerical convenience only (because 25 divides evenly into 100), and have no physical or ecological significance. While this default flow matrix, or a similar statistical depiction of only the hydrological record, may represent a starting point for environmental flow analyses, it must be remembered that the matrix is based on little or no consideration of the actual flow requirements for specific aquatic organisms.

Overbank Flows	Return period (yrs) and associated peak flow and duration evaluated by calendar "season"												
	Statistics on frequency, duration and volume by calendar "period"												
High Flow Pulses	Statistics on frequency, duration and volume by calendar "period"												
	Statistics on frequency, duration and volume by calendar "period"												
Base Flows (cfs)	Frequency of specified magnitude, magnitude of specified frequency, or key point(s) on freq(Q) ogive, evaluated by calendar "bin"												
	Frequency of specified magnitude, magnitude of specified frequency, or key point(s) on freq(Q) ogive, evaluated by calendar "bin"												
	Frequency of specified magnitude, magnitude of specified frequency, or key point(s) on freq(Q) ogive, evaluated by calendar "bin"												
Subsistence Flows (cfs)	Flow magnitude or statistic of flow category, by calendar "span"												
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	
	Winter			Spring			Summer			Fall			
Hydrologic Conditions	Wet						High Flow Pulse Characteristics	F = Frequency (per season)					
	Average							D = Duration (days)					
	Dry							Q = Peak Flows (cfs)					
	Subsistence							V = Volume (ac-ft)					

Figure 1 –Instream Flow Regime Matrix

While aspects of historical hydrologic conditions may form the initial basis for establishing instream environmental flow requirements by the BBESTs, consideration also is being given to applying information from other disciplines with regard to environmental flow needs, where this information is available. This includes information pertaining to aquatic biology, water quality and nutrients, and fluvial sediment transport. For example, special flow needs may be required to assure that the essential elements for maintaining suitable habitat conditions, including primary productivity, are provided to support particular aquatic species, or certain subsistence flows may be needed during certain times of the year to maintain minimum dissolved oxygen levels that are known to be critical for specific organisms. The existing erosional and depositional processes that influence channel stability and geomorphology also could be affected by a proposed environmental flow regime, which may or may not result in a change to an existing sound ecological environment. For example, a particular water development project with stipulated instream environmental flow requirements could alter flow conditions enough to cause the existing channel to be reconfigured for some distance downstream, but such altered channel conditions may (or may not) still support a sound ecological environment. During the initial phase of establishing environmental flow regime recommendations, it is likely that a certain degree of subjectivity and professional judgment will be necessary to address how each of these disciplines influences the

environmental flow regime recommendations, with the goal still being the development of the environmental flow conditions necessary to support a sound ecological environment.

During the course of its deliberations to develop environmental flow recommendations, the BBEST may find it useful, or maybe even necessary, to translate a particular instream flow regime, or a set of instream flow regimes, into continuous time-series hydrographs at downstream locations. Such time series hydrographs are important for evaluating achievement of attainment guidelines and potentially to facilitate one or more of the overlay processes, e.g., biology [citation], water quality [citation], or sediment [citation]. Information from these overlays would be expected to help (re)define the required flow regime (in an iterative sense: define a preliminary flow regime → develop time series hydrographs → evaluate using overlays → redefine flow regime → continue loop). Such time-series hydrographs also could provide insight into potential effects on existing erosional and depositional processes that influence sediment transport and eventually channel stability and geomorphology, and they may be essential for evaluating the impacts of a set of instream environmental flow regimes on the magnitude and timing of freshwater inflows to a downstream estuarine system.

If such time-series hydrographs are to be developed, then an assumption must be made as to what condition of future water development, i.e., water development infrastructure, is to be utilized. By *infrastructure* is meant an assumed condition of future annual diversion and/or reservoir storage capacity that is defined for a particular water course or an entire river basin for the purpose of evaluating the effect of certain environmental flow restrictions designed specifically to satisfy a proposed environmental flow regime(s) or standard(s). It must be recognized that definition of future water development infrastructure is fundamentally the province of the BBASC, and not the BBEST. Therefore, should the BBEST find it necessary to take this step in order to understand and refine its flow regime recommendations, it must be stressed that any future infrastructure assumptions are just that – *assumptions* – and are not to be viewed as undermining the province of the BBASC to introduce future conditions into their standards deliberations.

Example infrastructure options that could be used by the BBEST include (1) surface water development projects as identified and considered in the State's ongoing regional water supply planning program which currently is embodied in the TWDB's 2007 State Water Plan, or (2) some other assumed infrastructure condition considered reasonable and appropriate for the evaluation of the impacts of specified instream environmental flow requirements. Most, if not all, of the proposed major surface water development projects in the 2007 State Water Plan already have been represented in the water availability models (WAMs) for river basins across the state through the regional planning process¹, although none with any of the environmental flow requirements that are likely to emerge from the BBEST analyses (these would have to be added). Still, the means readily exists in the WAMs for performing at least the initial evaluation of the effect of proposed environmental flow requirements on future flow characteristics with implementation of what is considered to be the official plan for future water development projects.

An important aspect of the multi-tiered structure for a recommended environmental flow regime as described above is the attainment frequency, or range of attainment frequencies, at which each of the

¹ It should be recognized that the WAMs modified through the regional planning process to reflect implementation of future water supply development projects may not contain the same assumptions regarding existing water rights and prior appropriation as the WAMs currently used by the TCEQ for permitting purposes.

different flow components should occur in order to support a sound ecological environment. Such frequencies, or range of frequencies, for the various flow components can be expressed as the percent of time certain flow magnitudes are expected to be equaled or exceeded during certain time periods (e.g., monthly, seasonally or annually) with existing and proposed (new water right permits or amendments) water use activities in place and operating. In the context of an environmental flow regime or standard, it is anticipated that attainment frequency guidelines would most likely be applicable to base flows, high pulse flows and/or overbank flows. The need to achieve minimum subsistence flows generally would apply all of the time to the extent such flows are available under existing conditions; thus, an attainment frequency for a particular subsistence flow probably is not relevant.

Information in the SAC's 2009 Instream Flow report [citation] addresses attainment frequencies for high flow pulses and overbank events. For base flows, in the absence of specific information describing biological-flow relationships and the flows necessary to support existing ecosystems, a preliminary estimate of the attainment frequency guidelines may be informed by consideration of the historical occurrence of the recommended flow magnitudes. This approach pre-supposes that historical flow frequencies for these components of the flow regime represent what have likely been more than adequate to support a sound ecological environment even though specific biological data may not have yet been identified or developed to support this hypothesis. This appears to be a reasonably valid approach for proceeding with the development of appropriate environmental flow requirements pursuant to SB 3; although, there certainly could be other means for addressing attainment frequencies for base flows.

Conceptual Model for Flow Regime Application

In this section is outlined a conceptual model describing the process by which the BBASC can apply an environmental flow regime as developed by the BBEST in the formulation of an environmental flow standard(s) in accordance with the provisions of SB 3. It is important to note that the array of flow components comprising the environmental flow regime does not necessarily represent a flow standard(s). It may be desirable to simplify the articulation of flow standards to provide wider coverage over larger geographical areas than the single points in a stream upon which individual flow regimes were derived, to be more applicable cumulatively to multiple organisms important to the river ecosystem, or to incorporate information regarding existing or future water diversions and needs. In essence, the environmental flow regime that is produced by a HEFR-type analysis using a record of daily flows and perhaps scientific results relating elements of the ecosystem to streamflow must be further digested to formulate flow standards. It is envisioned that this digestion will be iterative, in which (1) various strategies and magnitudes of draft standards are formulated, incorporating aggregate ecological and hydrological results and recommended environmental flow regime(s) from the BBEST; (2) these draft standards are tested by hydrological and water availability modeling under existing and/or projected future hydrological modifications and water use activities and needs; and (3) the success of achieving a balance with regard to achieving a "sound ecological environment" and satisfying existing and/or future water uses and needs is evaluated.

Specific steps for undertaking this process by the BBASC are described below. As with the analyses undertaken by the BBEST, some of these steps are iterative and may be cycled several times as refinements and adjustments are made by the BBASC to proposed environmental flow standards.

- Step 1 Using existing water availability models from the TCEQ with all existing water rights fully engaged as authorized, determine attainment frequencies for the specific base flows, high-flow pulses, and overbank flows incorporated in proposed environmental flow regimes recommended by the BBEST.

Consideration of information describing the attainment frequencies of the different components of a flow regime under conditions reflecting existing water rights authorizations will be important to establish a baseline from which further evaluations of required attainment frequencies can be undertaken. It is recognized that the initial a priori definition of appropriate attainment frequencies will likely be very difficult because of the lack of scientific studies of site-specific environmental flow requirements, and if undertaken, will likely be founded to a large extent on professional judgment and experience. Another complicating factor will be working with the one month time step employed in existing water availability models to address attainment frequencies of higher flow events that, particularly on smaller streams, often have durations of less than a month. While there are techniques available to address this topic, the assumptions involved must be clearly explained. Quantifying the attainment frequencies of the different flow components under conditions reflecting existing water rights authorizations will, at a minimum, provide a starting point for evaluating the adequacy of these projected attainment frequencies and provide direction as to how these attainment frequencies may need to be adjusted, if at all.

Comment [11]: I not suggesting an alternative to WAMs for this purpose, only that the limitations are recognized and understood.

- Step 2 Operate the appropriate water availability models (WAMs) used for regional water supply planning in the basin of interest to assess the potential impacts of a proposed environmental flow regime or flow standard or set of such regimes or standards on available surface water supplies and future flow conditions for an assumed future water supply development scenario.

As with similar analyses that may have been employed by the BBEST, this step will require some assumptions regarding exercise of existing rights and future water supply infrastructure. These assumptions should be clearly stated and documented. As previously discussed, the most reasonable future water supply development scenario is likely to be one that encompasses the recommended water supply strategies adopted through the regional water supply planning process as described in the 2007 State Water Plan. Information from this step will be useful to the BBASC for evaluating the impacts of proposed environmental flow requirements on the ability to satisfy future human water needs and for assessing the effectiveness of the proposed environmental flow requirements for supporting a sound ecological environment.

- Step 3 The BBASC reviews the BBEST's environmental flow analyses and environmental flow regime recommendations and considers them in conjunction with other factors, including the present and future needs for water for other uses related to water supply planning.

This step is the basic foundation for the work of the BBASC. Information from Steps 1 and 2 provide input to this effort, with iterations between Steps 2 and 3 providing refinements and adjustments to proposed environmental flow standards.

- Step 4 The BBASC develops its own recommendations regarding environmental flow standards and strategies to meet the environmental flow standards and submits those to the TCEQ and the EFAG. Again, all assumptions used should be fully documented.

This step culminates the work of the BBASC. The end product is a set of recommended environmental flow standards and strategies to meet the flow standards.

The SB 3 process of course does not end here. The TCEQ promulgates environmental flow standards and determines applicable set-asides after considering the environmental flow regimes recommended by the BBEST and the environmental flow standards and strategies to meet the standards developed by the BBASCs, EFAG comments, information provided by the SAC and other interested parties, public comment, and other factors relevant to environmental flow issues including economic impacts, human and other competing water needs, and river basin and bay system characteristics.

TCEQ then evaluates future water right permit applications taking into consideration the adopted environmental flow standards and set-asides. Individual permit restrictions are formulated as required to ensure that the adopted environmental flow standards and set-asides are reasonably satisfied. *Permit restrictions* (synonymous, in this context, with *flow restrictions* or *permit conditions*) are the set of rules defining when diversions and/or impoundment of streamflows are allowed and authorized under a specific water right permit. Historically, this has been a set of minimum flows specified in a water right permit for different months or seasons (such as those derived with the Lyons Method [citation]) or for different hydrologic conditions (such as those based on the Consensus Planning Criteria [citation]) below which flows cannot be diverted and/or impounded. Recommended attainment frequency guidelines for specific flow values are not necessarily stipulated, nor determined, though they could be.

Permit restrictions designed to protect the environment pursuant to SB 3 are generally expected to be tied to actual instream flow values though applicable permit restrictions during wet, average, and dry conditions and may vary based on triggers associated with reservoir storage, cumulative flows, drought indices, and/or other factors. With the adoption of environmental flow standards by the TCEQ, the objective of permit restrictions as formulated and implemented by the TCEQ will be to ensure that the essential elements of the environmental flow standards are satisfied. In this regard, it is anticipated that the level of complexity incorporated into permit restrictions will vary in relation to the size of a permit authorization (diversion rate, annual diversion amount, and/or on-stream impoundment capacity) and the degree to which said authorization could potentially impact streamflows relative to environmental flow requirements. The permit restrictions would therefore conform with some translation of the flow requirements of the adopted environmental flow standards, but may not necessarily incorporate all aspects for each type of permit. The exact nature of how the adopted flow standards will be translated into specific permit conditions is unknown at this time, but will have to be addressed by the TCEQ.

One last element of the overall SB 3 environmental flow process relates to the environmental flow “set-aside”. As defined by SB 3, the set-aside is “an amount of unappropriated water, if available, to be set aside to satisfy the environmental flow standards² to the maximum extent reasonable when considering human water needs”. It is further noted that the TCEQ may not issue a new appropriation or an amendment that increases the amount of water authorized to be stored, taken or diverted if such issuance would impair an environmental flow set-aside. As indicated, the environmental flow set-aside relates to a specific amount of unappropriated water at a specific location that apparently is intended to protect and reserve water specifically for satisfying the adopted environmental flow standards. In any event, special

² Since the “standards” already consider human water needs, this language from the statute seems redundant.

conditions would likely be included in any new permit or amendment that effectively would ensure that the adopted environmental flow standards would be satisfied.

Issues Discussion

Application of “Best Available Science” – maybe insert some words from Guillen

Lack of Sufficient Site-Specific Data and Analyses - As the SB 3 environmental flow process has initially has been undertaken for the Sabine/Neches and Trinity/San Jacinto basins and their associated bay and estuarine systems and as the SAC has deliberated how to facilitate this process, issues have arisen with regard to the lack of sufficient site-specific scientific data and analyses describing the essential relationships between environmental flows and the actual needs of aquatic organisms in those systems. As a surrogate for such information, statistical flow parameters based on historical hydrologic conditions are being examined as a default for establishing environmental flow requirements in those stream systems considered to currently reflect a sound ecological environment. The premise is that if a sufficiently close representation of key elements of the historical hydrology is maintained, then a reasonable approximation of the historical sound ecological environment is likely to also be maintained, while at the same time making available water for development. In this regard, any recommendations for environmental flow requirements replicating these historical flow parameters (and their historical frequencies of occurrence) logically might be considered an approximation (arguably the *maximum*) of the flow conditions needed to continue to support a sound ecological environment as available water resources are being developed. The presumption is that different quantities of flow, different frequencies of occurrence, or different seasonal distribution patterns of recommended flows may also be adequate. Depending on how the parameters are chosen and calculated, various components of the overall environmental flow matrix could be altered, perhaps significantly, from the historical period of record and still yield a sound ecological environment.

Comment [mek2]: I have some language I'm working on for this bullet (and possibly above bullet), but no time to finish so will bring to the meeting.

Effect of Changing Conditions - In addition, it is important to recognize that, because conditions in some watersheds have changed over the historical period, there is no guarantee that the biological response to a repeat of historical hydrologic conditions (say the drought of record, for example) would be essentially the same as it was many decades ago. Even acknowledging these qualifications, the presumption is that some lesser quantities of flow or some lesser frequency of occurrence than were experienced historically may still be adequate to sustain a sound ecological environment. As discussed further below, as a result of more extensive future utilization of existing water rights that are not subject to newly adopted environmental flow standards, for the vast majority of watersheds, flows are likely to be significantly reduced below historical levels. Implementation of environmental flow standards and application of these standards to new permits for storage or diversion will minimize additional changes to various aspects of existing flow conditions. With the continuing effort to derive meaningful information describing important relationships between environmental flows and the actual needs of aquatic organisms in these systems, it is anticipated that the current hydrology-based estimates of environmental flow requirements likely will be refined in the future. SB 3 recognizes this possibility through its adaptive management provisions.

Expected future flow conditions - A key issue in developing environmental flow standards that will meet the SB 3 statutory tests is what flow characteristics will result from implementation of the standards under future conditions, i.e., with the exercise of existing water rights and with potential future water

development in place. First of all, it is important to recognize that these environmental flow requirements will only apply to permits and permit amendments for new appropriations and authorizations to store, take or divert surface water that are issued by the TCEQ on or after September 1, 2007. All water right authorizations issued prior to this date will be unchanged by these requirements. This means that, at a minimum, there is the possibility that the future characteristics of flow conditions in a particular system ultimately would reflect full utilization of surface water to the extent authorized as of September 1, 2007. Existing water availability models (WAMs) maintained by the TCEQ for all river basins in the state can provide (possibly with some modifications to reflect actual return flow conditions) an indication of the characteristics of these future flow conditions. The WAM also can be used to assess different assumed variations in the utilization of existing rights.

Comment [mek3]: This is problematic to me the way it is laid out. True, SB 3 does not mandate any changes in existing water rights. However, to say it this way writes off the ability of the stakeholders to recommend strategies to meet environmental flow standards that might involve, say lease or other dedication of existing, but unlikely to be used, water rights to e-flows.

One option for assessing the effectiveness of a set of proposed environmental flow requirements would be to extend the existing WAMs to include some or all of the anticipated future water development projects with appropriate provisions incorporated for satisfying the proposed environmental flow requirements. The official plan that identifies and describes all major future surface water development projects currently being considered for implementation across the state through the year 2060 is the Texas Water Development Board's 2007 State Water Plan. Most, if not all, of these proposed major surface water development projects already have been represented in the WAMs through the regional planning process³, although none with any of the environmental flow requirements that are likely to emerge from the SB 3 process (these would have to be added). Still, the means readily exists in the WAMs for performing at least the initial evaluation of the effect of proposed environmental flow requirements on future flow characteristics with implementation of what is considered to be the official plan for future water development projects.

Another option that has been discussed for assessing the effectiveness of a set of proposed environmental flow requirements is to consider the "infinite infrastructure" scenario whereby the only flow remaining in a stream or passing into a coastal bay after application of a particular set of environmental flow requirements is the environmental flow prescription itself. In other words, all other streamflow would be fully consumed by water development projects, either existing or proposed. The occurrence of such flow conditions appears to be highly unlikely and impracticable and essentially impossible in the basins currently under evaluation, either under existing water right conditions (Jon Albright's analysis) or with substantial new reservoir development (Sam Vaughn's simulation). That may or may not be the case in basins in drier parts of the state, especially with respect to subsistence and dry period base flows. Furthermore, it is unclear as to what would be learned by analyzing this type of infinite implementation scenario with regard to future streamflow characteristics. It has to be assumed that any set of recommended instream environmental flow requirements would already incorporate those flow components (magnitudes and frequencies) that have been generally agreed upon as being important for supporting a sound ecological environment. So, by definition, future flow conditions with these environmental flow requirements implemented would have to be characterized by the occurrence of these specific flow magnitudes at their designated frequencies in order for diversions under new permits to be allowed. It seems that the real issue is whether the recommended environmental flow components themselves reflect the proper magnitudes and frequencies to achieve their designated objectives, and this,

Comment [14]: Support George's earlier comment that either a citation needed or the points need to be summarized here.

³ It should be recognized that the WAMs modified through the regional planning process to reflect implementation of future water supply development projects may not contain the same assumptions regarding existing water rights and prior appropriation as the WAMs currently used by the TCEQ for permitting purposes.

of course, is the crux of the difficulties in identifying an adequate environmental flow regime as defined by SB 3.

The WAMs could also be used to evaluate various “future infrastructure” scenarios to help evaluate strategies for meeting environmental flow standards, as the stakeholder committees may chose to look at more than one future scenario as part of their work. Nothing in SB 3 limits the range of environmental flow analyses that could be undertaken by the BBESTs to provide information and perspective to the BBSACs (or, for that matter, analyses that could be done by the BBSACs, with the help of BBESTs.) These model results with the instream environmental flow requirements implemented would be especially useful for describing future freshwater inflows to the state’s bay and estuary systems as these inflows may be modified by future water development projects and/or environmental flow standards and strategies.

Comment [mek5]: These strategies may be about more than infrastructure...

Comment [RJB6]: This paragraph has been moved here from above to form the basis for a discussion of interactions between the BBESTs and BBASCs and the need for technical analyses by the BBASCs.

Observations and conclusions

- 1) Permit restrictions need not be as complex as the underlying environmental flow regime or flow standard themselves. For example, for a relatively small new appropriation that is likely to not appreciably alter normal or above-normal streamflows, the requirement for high-flow pulses or overbanking flows would not be necessary.
- 2) The approach for defining attainment frequency guidelines for base flows based on historical flow frequencies offers a straightforward and practicable method. However, it is important to recognize that this approach only provides a starting point. The BBEST should employ the various overlay methodologies to inform appropriate attainment frequencies until such time as more appropriate and specific information describing biological-flow relationships and the flows necessary to support existing ecosystems becomes available.
- 3) It is important to further recognize that attainment frequency guidelines less than those based on historical flows may, in fact, support a sound ecological environment and should be considered when sufficiently supported by professional judgment and experience. Similarly, in some watersheds, it may be possible that attainment frequencies based solely on historical flows could be determined not to be adequate to support a sound ecological environment.
- 4) The question of future infrastructure is still manifest if a time series of future hydrology is desired, particularly because of the need to consider impacts on high flow pulses and overbank flows. Some level of expected infrastructure, consistent with meeting the desired future water needs for other (human) uses, must be assumed to provide a meaningful analysis and evaluation of instream flows with the environmental flow regimes or standards imposed. Infrastructure associated with year-2060 proposed surface water development projects included in the 2007 State Water Plan is one option for estimating future conditions. However, to the extent that an assumed level of infrastructure is relied upon in evaluating the adequacy of a recommended flow regime or standard, the environmental flow standard should reflect that assumption in order to ensure that the assumption is not violated in applying the standard. Adaptive management with regard to environmental flow requirements must be planned for and incorporated as an integral part of future environmental flow analyses. Senate Bill 3 contains provisions for such continuing

adaptive management activities after the environmental flow standards and set-asides are initially adopted by the TCEQ and includes a mechanism for adjusting the conditions requiring protection of instream flows or freshwater inflows included in new individual water right permits (maximum increase of 12.5% of the annualized amount required for protection of instream flows or freshwater inflows). Each BBASC, with assistance from its associated BBEST, is required to prepare and submit to the EFAG for approval a work plan that includes the following:

- Program for the review of environmental flow analyses, flow regimes, flow standards and strategies, and set-asides at least once every 10 years,
- Program for basin and bay specific monitoring, studies, and activities, and
- Schedule for continuing the validation or refinement of environmental flow analyses, flow regimes, flow standards and strategies, and set-asides.

References