Stakeholder Questions for the Colorado Lavaca BBEST

Environmental Flow Regime Questions (focusing on Instream flow)

1. Seasons are different for upper/lower Colorado. Does that create a problem?

No, the fact that the seasons used for the sites in the upper Colorado were slightly different from the seasons used in the lower Colorado and Lavaca basins does not cause a problem. Spring (March – June) and summer (July – August) are the same for all sites. The only different month between seasons between the upper Colorado sites and the other sites was November. November was considered in the winter in the upper Colorado and considered in the fall at the other sites. The BBEST placed considerable emphasis on the determination of the months making up each season and believes the different seasons, although only slightly different, are ecologically meaningful, and as a consequence the recommended flow regimes for those seasons are more meaningful than if the BBEST had chosen the standard seasons for all sites.

2. What is significance of 25/50/75 percentiles as base flow levels?

The 25/50/75 percentile levels are intended to provide variability within and between years in base flow conditions. This variability is important to environmental health and is consistent with the Texas Instream Flow Programs' Technical guidance which states on page 103:

> "The primary objective of base flow recommendations will be to ensure adequate habitat conditions, including **variability**, to support the natural biological community of the specific river sub-basin. These habitat conditions are expected to vary from day to day, season to season, and year to year. This **variability** is essential in order to balance the distinct habitat requirements of various species, guilds, and assemblages." (bold emphasis added by the BBEST)

Flow recommendations at these three percentile levels which vary by season or month (providing variability within a year) are intended to meet the primary objective of base flow recommendations. Section 3.7 of the BBEST report describes the ecological basis for these recommendations and analysis of habitat availability as a function of discharge confirms that the recommended range of flow conditions achieves adequate habitat availability for all habitat guilds.

It is worth noting that there is nothing sacrosanct about the three, 25/50/75, percentile levels. These values are a convenient rule of thumb that has been employed in many other river systems both nationally and internationally. It is possible some other percentiles could provide acceptable levels of instream habitat variability and in fact the study on the Lower Colorado River conducted for the LCRA-SAWS water project found that two levels base flows provided acceptable habitat conditions given the objectives, constraints and other factor specific to that project. This determination was made after conducting comprehensive site specific studies including spatially explicit habitat modeling and habitat time series analysis and integrating assessments of water quality and sediment transport. Notably this decision was influenced by the occurrence of a state threatened species (*Cycleptus elongatus* - blue sucker) in the Lower Colorado and the habitat conditions needed by this species for spawning.

Additional data obtained via adaptive management or more comprehensive instream flow analysis might support a refinement to the BBEST recommendations, however given the available data and the uncertainty associated with the flow - habitat models developed by the BBEST, the team elected to apply the precautionary principle and recommend three levels over a wide range of base flows to provide greater confidence that the recommended flows will continue to support natural diversity of habitat conditions found in these river systems.

3. What is the BBEST opinion of how less flow might impact particular segments? What amount of change is significant in terms of the environment?

Basically, the greater the deviation from the natural flow regime components, the greater the ecological risk of maintaining a sound ecological environment.

Impacts of 'less flow' to particular segments will be a function of geomorphology, characteristics of the flow (spring versus rain dominated), resident aquatic community, and how much less flow is being anticipated in terms of subsistence, base flows, pulse flows, or overbank flows. Changes in the magnitude, frequency, timing, duration, or rate of change are related to the actual amount of change and sensitivity of the aquatic community to magnitude and characteristics of the change. There is very little guidance in the peer-reviewed literature on how incremental changes to each flow regime component (i.e., magnitude, timing, duration, frequency, rate of change) affect environmental health. The literature only provides some insights on rather substantial changes to the flow regime component. As noted in the BBEST report in the geomorphological overlay, Biedenharn et al. (2000) report that channels should remain dynamically stable if the sediment transport capacity of a reach is within 10% of the sediment supplied to the reach. As flow alterations (diversions) to these high flow components increase then the degree of channel change increases.

The complexity of flow alterations to other components of the flow regime such as the magnitude, timing and duration of daily flows are a function of the river's geomorphology and resident ecology. Based on the nature of the site specific characteristics in terms of physical and biological attributes, the United Kingdom adopted environmental flow standards ranging between 7.5 to 30 percent of the natural daily flows (Acreman et al., 2010). Other research has suggested that alterations of a 50% change or greater in flow magnitudes (including peak, total or mean, base or hourly discharge) had a negative impact on fish communities (Poff and Zimmerman 2010). Decreases in the mean annual maximum flow on the order of 60 percent increased likelihood of degraded fish communities (Carlisle 2010).

4. How are currently required environmental flow releases and permit conditions reflected/ addressed?

The BBEST used daily average stream flows from USGS gaging stations in its instream flow analysis which reflect past and current permitted water withdrawals and return flows. Currently required environmental flow releases and permit conditions are reflected in the USGS stream flow data to the extent that reservoir operations and water right diversions have historically adhered to permit conditions (if any were assigned). In many cases, permittees have never withdrawn all the water they are permitted to use. Consequently, the daily average flows used by the BBEST do not reflect how much water would have been in rivers if all the permittees used all the water they were permitted to use.

Existing permit conditions were not incorporated by the BBEST into its flow regime recommendations. The BBEST task was to develop recommendations absent consideration of existing or future surface water permits, water management practices or infrastructure. Only data from existing studies were incorporated by the BBEST into its recommendations. Study results that are directly reflected in the BBEST flow regime recommendations include:

- BIO-WEST, Inc. 2008. Lower Colorado River, Texas Instream Flow Guidelines: Colorado River Flow Relationships to Aquatic Habitat and State Threatened Species: Blue Sucker. Prepared for Lower Colorado River Authority and San Antonio Water System. Dated March 31, 2008.
- Matagorda Bay Health Evaluation (MBHE) 2008. Final Report, Matagorda Bay Inflow Criteria (Colorado River), Matagorda Bay Health Evaluation. Prepared for Lower Colorado River Authority and San Antonio Water System. December 2008.
- BIO-WEST, Inc. 2010. Assessment of Instream Flow Needs Associated with the Lometa Water System Diversion. Prepared for Lower Colorado River Authority and San Antonio Water System.

5. In the Lavaca – for East & West Mustang Creeks and Sandy Creek: Flows from April to September include Garwood return flow. Things have and will change. How does this impact the recommendation?

Environmental flow recommendations that appear influenced by irrigation return flow include those for the Navidad River, Sandy Creek, East and West Mustang Creek, and Tres Palacios Creek, all having higher flows in July than in June and August. The Lavaca River had slightly higher flows in August than during July and September.

The stakeholders may ask the BBEST to conduct more analysis at these sites. These new analyses might be used by the stakeholders to propose recommendations for these sites that attempt to eliminate the influence of summer irrigation return flows. Stakeholders could then ask the BBEST to evaluate their proposed recommendations to determine if they would protect a sound environment.

This is a situation where it may be appropriate for the stakeholders to ask the BBEST to conduct analysis of the summer flows at these sites and provide the stakeholders with alternative recommendations for the summer which will protect a sound environment and which will not include irrigation return flows.

6. Should there be a different flow regime for the upper and lower Colorado?

The study on the Lower Colorado River conducted for the LCRA-SAWS water project found that two levels base flows provided acceptable habitat conditions given the objectives, constraints and other factors specific to that project. This determination was made after conducting comprehensive site specific studies including spatially explicit habitat modeling and habitat time series analysis and integrating assessments of water quality and sediment transport. Notably this decision was influenced by the occurrence of a state threatened species (*Cycleptus elongatus* - blue sucker) in the lower Colorado and the habitat conditions needed by this species for spawning.

Additional data obtained via adaptive management or more comprehensive instream flow analysis might support a refinement to the BBEST recommendations, however given the available data and the uncertainty associated with the flow - habitat models developed by the BBEST, the team elected to apply the precautionary principle and recommend three levels over a wide range of base flows to provide greater confidence that the recommended flows will continue to support natural diversity of habitat conditions found in these river systems.

7. How can we be reassured that BBASC doesn't recommend a flow regime that would result in further decline in the systems?

We want to stress that the BBEST environmental flow recommendations specifically protect these systems in a state of a sound ecological environment and will not result in 'further decline in the systems'. It is certain that the further a BBASC flow regime departs (reduction in base flow regime tiers, reduced flow magnitudes in a season, reduction in durations or number of pulse flows, etc) from the BBEST recommendations, the higher the risk to sound ecological environments.

We cannot assure that any BBASC recommended flow regime would not result in 'a further decline in the systems' without having the opportunity to review the specific flow regime being recommended. One approach to quantify the effect of the BBASC recommendations would to simulate expected future flows based on an implementation of the flow standards recommended by the BBASC.

The Science Advisory Committee, with the support of TPWD and building on work begun by the Sabine-Neches BBEST, has developed a tool (FRAT - Flow Regime Analysis Tool) that has been customized to evaluate the daily environmental flow regime targets developed by the Colorado-Lavaca BBEST. Using inputs from the WAM, this computer program can be used to determine the yield of water supply projects and report the frequency of meeting the flow regime targets. These frequencies can be compared to the historical frequencies that the BBEST determined to be sufficient to meet the goals of a sound environment. If the attainment frequencies are not satisfied at their historical frequencies, the BBASC should consult with the scientist on the BBEST to evaluate the significance of the shortfalls. Three possible outcomes of this process are:

1. Accept the lower frequencies as an acceptable trade-off in evaluating and balancing competing needs for water,
2. Recommend environmental standards that differ from the BBEST regime targets, or
3. Develop strategies to more closely mimic the BBEST recommended flow regime.

8. Talk with BBEST about no-flow periods:

- **would it play into permitting?**
- **keep it in mind in developing strategies**
  How should it be reflected in the BBASC report?

It is not known at this time how TCEQ will consider no-flow periods in permitting.

For streams that commonly have no-flow periods, the BBEST recommends the BBASC communicate to the TCEQ that diversions should not cause no-flow periods to occur sooner, more frequently, or last longer than they have in the past to maintain a sound environment. Since all streams with periods of no flow that were reviewed by the BBEST have perennial pools during no-flow periods, the BBEST also considers it important to communicate to TCEQ that diversions should not be made from natural perennial pools during no-flow conditions. These perennial pools provide critical refuge for fish and other aquatic organisms when the river stops flowing.

The permitting approach will affect the likelihood of this happening. For example, the approach suggested at the bottom of p. 6-3 would not allow diversions when the flow is less than the subsistence value. This is a level when the river is already drying up relatively quickly and diverting flow at these levels would be expected to cause the river to stop flowing quicker than normal. This approach would also not allow diversions when the flow is below the low base flow value except during extreme drought. The BBEST recommends that the BBASC report recommend that diversions not be allowed when flows are below subsistence levels and that diversions only be allowed below low base flows during extreme drought.

The BBEST also recommends that the BBASC recommend a hydrological condition like reservoir storage levels or the preceding 3 months of total stream flow that TCEQ would use to manage diversions as flow drops through different levels of base flows as the river dries up. Regulating diversions over three levels of base flows will help the river flow decline at a rate which is hoped will not cause the river to stop flowing much more quickly than normal.

9. What will it look like when a major senior water right moves?

This will require more specific information such as whether the move will be upstream, downstream, or from a tributary to a main stem, main stem to tributary, etc, in order to properly answer. In general, moving a water right (any water right, regardless of size or priority) requires an amendment by TCEQ and this triggers an analysis to ensure no water rights, senior or junior, are impacted by the move. These types of analyses are done using a WAM RUN3 model approach (all existing water rights represented with their full authorized amounts) with the reliability of all existing water rights noted before and after the proposed move. In most cases, the amendment process results in the TCEQ imposing flow conditions on the associated amendment to protect intervening water rights and also to protect environmental flows that would be impacted by the amended water right diverting water at the new location. For a major senior water right, this often times results in the amended water right having flow restrictions imposed even it had no such restrictions at its original location. Historically, the TCEQ has used existing desk top methods (such as Modified Lyons) for determining the environmental flow requirements that would be placed on amendments the location of use is changed. The environmental flow standards developed by TCEQ as a result of the SB3 process might result in a modification of TCEQ's existing process for setting environmental flow requirements, and thus the authorization to divert water at the new locations would be subject to the SB3 type flow requirements.

10. Upper Colorado- is more concerned with how often we must have these flows.

The Texas Instream Flow Program, Science Advisory Committee and (thus far) majorities of all of the BBEST committees, including the Colorado Lavaca BBEST have relied heavily on the scientifically-accepted concept called the "Natural Flow Paradigm." The Natural Flow Paradigm generally states that the safest and simplest approach to insure that both natural variability and threshold conditions are restored or conserved is to mimic the natural flow pattern as closely as possible including variability patterns (wet, dry and average years, seasonal), and associated duration and magnitude of flows. This is done by using software such as HEFR that provides quantifiable endpoints that describe this distribution and recommends flow regimes that attempt to duplicate these endpoints as close as possible.
However the SAC discussion paper on "Moving from Instream Flow Regime Matrix Development to Environmental Flow Standard Recommendations" posits that historical frequencies are likely more than adequate.

> "An important aspect of the multi-tiered structure for a recommended environmental flow regime as described above and depicted in Figure 1 *{HEFR Output table}* is the attainment frequency, or range of attainment frequencies, at which each of the 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 (SAC, 2009a) 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 for those systems considered to be characterized by a sound ecological environment. This approach pre-supposes that historical flow frequencies for these components of the flow regime represent <u>what have likely been more than adequate to support a sound ecological environment</u> 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 considering attainment frequencies for base flows."

The goal of the BBEST recommendations "is to produce an instream flow regime that mimics natural patterns by providing the target base flows at frequencies which closely approximate historical occurrences."

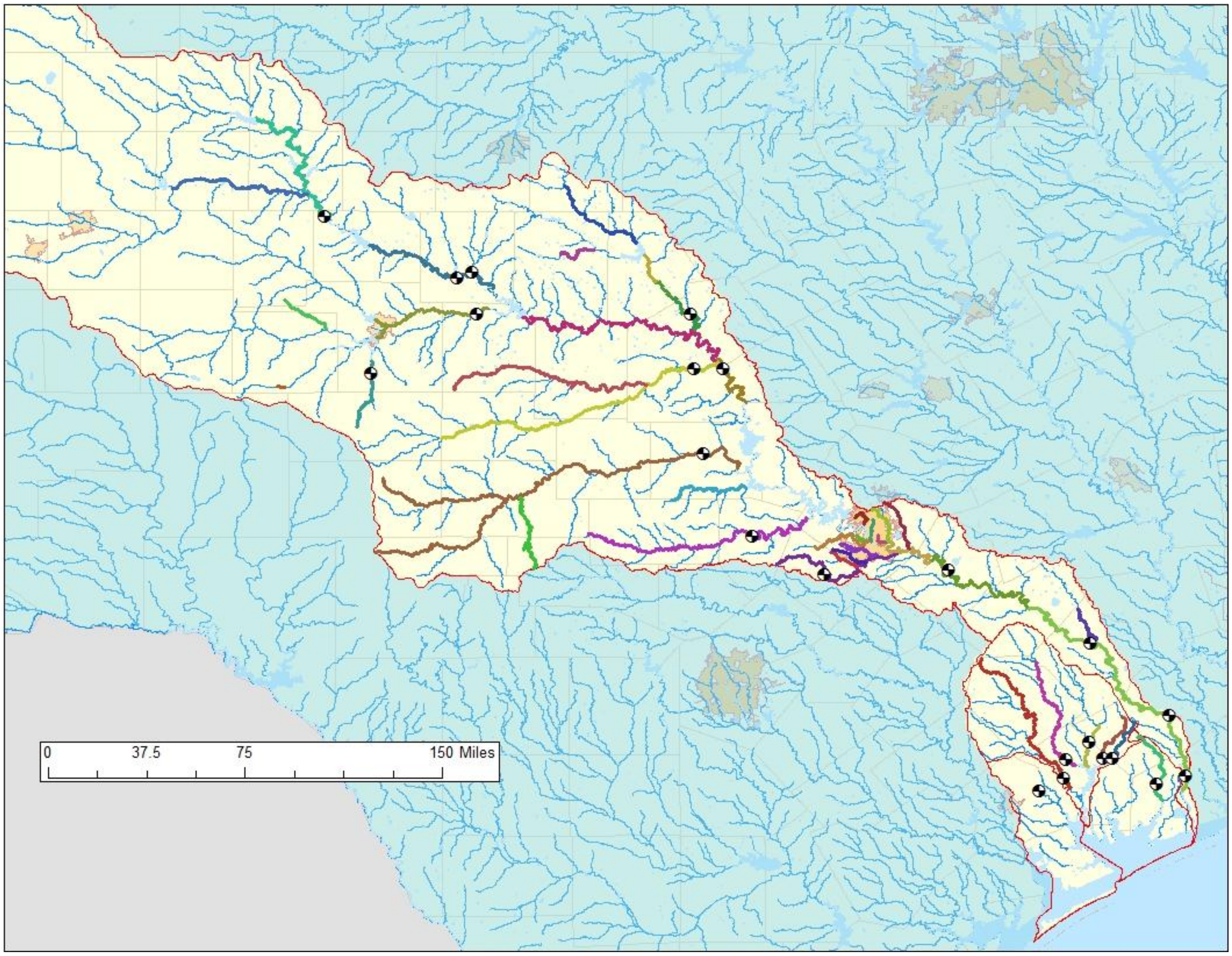
11. What is the geographical scope of the standards? Upper; middle; lower; by basin?

I'm not sure I completely understand this question however, if it means where on the river do the flow standards apply, the answer is that the BBEST did not specify the geographic scope the flow regimes. I think this was probably an oversight. Fortunately, the CL BBEST selected many sites and these cover a very wide geographic scope including at least one site on most of the TCEQ classified stream segments which should facilitate the translation of recommendations to sites not specifically identified by the BBEST.

See the map below. Colored segments are TCEQ classified segments for which water quality standards have been set. The black and white circles represent the sites with BBEST environmental flow recommendations.

The first two BBEST's addressed this issue directly, and might provide reasonable guidance to the BBASC. From the Trinity - San Jacinto report:

"Recommendations derived from specific gage sites will apply to the river segments for which they had been formulated. Translation of individual recommendations to nearby segments may be a subject of the SB3-required work plan to be developed by the BBASC. Consistent with the Sabine Neches BBEST recommendation, it is the recommendation of the Trinity San Jacinto BBEST 'that the TCEQ develop appropriate methods for interpolation of flow conditions applicable to future inter-adjacent permits and amendments from reference locations for which flow regimes supporting a sound ecological environment are established. Such methods should include, at a minimum, drainage area adjustments, but may also include consideration of spring flow contributions, channel losses, aquifer recharge zones, soil cover complex, and other factors as necessary and appropriate.'"



12. Are daily average flows appropriate to use? What happens in drought?

Yes. Daily average flows are appropriate data for the following reasons:

- A daily sampling rate provides information about daily fluctuations in stream flows. Texas streams can have a high degree of daily fluctuation in stream flow rate, especially in response to storm events.
- Daily average flows, as provided to the public by the USGS, are the most readily available and practical source of stream flow data in the United States. Stream flows of shorter measurement duration, such as hourly or 15-minute measurements, are not commonly available.
- Though some USGS stream gaging stations offer instantaneous maximum and minimum stream flow measurements on a daily basis in addition to the daily average flow, not all stations in the Colorado or Lavaca basins provide these data. Those that do may not have continuous data availability for maximum and minimum daily flows.

Stream flows during drought conditions are usually very small relative to a stream's normal base flow conditions. Additionally, stream flow variability during droughts tends to be relatively lower on a day-to-day basis than the flow variability after storms.

Daily average flows are appropriate for use during drought and low flow conditions with the caveat that water management practices could possibly result in very short term detrimental fluctuations that are not represented in daily averages. For example, a stream flowing at 10 cfs could be drawn down to near zero flow for a several hours. The daily average flow may be reported as 8 cfs even though the stream experienced a potentially catastrophic short-term loss of water.

The BBEST environmental flow regime recommendations do not contain flow recommendations of less than 1 cfs for any stream, though the report does recognize that some streams will naturally experience days of zero flow.

13. What would be the impact of just having base flow components? What information helps BBASC evaluate what type of flow regime components to use?

Confining the environmental flow regime to only base flow components would result in severe impacts to fish, mussels, macroinvertebrates, and aquatic vegetation at a minimum. Failure to provide pulse and overbank flows would have serious negative impacts to the riparian systems and result in substantial changes to the sediment dynamics of the river leading to alterations in available habitats. The imbalance in the sediment dynamics would result in long term adjustments in the river channel morphology that would result in changes in the aquatic community such as its structure, composition, distribution, and density. It is very unlikely if not impossible to maintain a sound ecological environment if only base flows are incorporated into the environmental flow regime recommendations. The Texas Instream Flow Program (TIFP) clearly identifies subsistence flows, three base flow components, pulse flows and overbank flows as critical elements of an environmental flow regime. This was clearly confirmed by the National Academy of Science review of the TIFP. Failure to incorporate other flow regime components would also be in conflict with the Science Advisory Committee guidance documents. The published scientific literature is also very clear regarding the importance of all the flow regime components recommended by the BBEST as serving critical ecological functions and processes necessary to sustain healthy aquatic ecosystems.

14. What will be the effects if future flows are lower than the flows used to calculate the environmental flow recommendations?

This question is related to a number of other question including 5, 9, 15 and 16 and the response to these questions may address some of this issue. The short answer is that a change in the flow regime can result in a change in the ecological functions that are provided by these flows. This is true regardless of the cause of the alteration. Lower subsistence flows may result in a lower ability to assimilate pollutants or higher water temperatures. Lower base flows and less variability may result in a bottleneck in suitable habitat which can lead to shifts in community structure or loss of some species that may be out-competed for limited resources. Lower high flow pulses may lead to changes in sediment transport characteristics and destabilized channels. Finally the loss of overbank flows can result in loss of bottomland vegetation as less water tolerant upland species move into riparian areas. There are hundreds of scientific studies documenting the effects of altered flow regimes on natural systems. In their paper "Ecological responses to altered flow regimes: a literature review to inform the science and management of environmental flows" published in Freshwater Biology in 2010, Poff and Zimmerman cite 189 studies documenting effect of alterations to flow regimes.

Bay and Estuary/Freshwater Inflow and Combining FWI and ISF

18. How can the Matagorda Bay Health Flows (MBHE) analysis be converted into an environmental flows regime? This looks backwards at a how these flows were met, not forward at what flows are actually needed for environmental health.

This is an issue that deserves some additional review, in order to incorporate the freshwater inflow needs of the bay with the current state of methods to write water permits.

The MBHE inflow regime identifies five levels of freshwater inflows designed to ensure ecological health and productivity of Matagorda Bay. For operating a water right permit (e.g. knowing when to divert or store water), engagement of each inflow level would be tied to a hydrologic condition or trigger (e.g. reservoir storage content). The trigger would specify which inflow level is engaged (MBHE 3, for example), and diversion or impoundment would occur once the inflow condition was satisfied. In this case, the trigger is forward looking as it sets an environmental flow need for that year. The Water Availability Model sub-committee is developing specific runs that will provide examples.

19. How to we deal with the interrelationship of Matagorda Bay and Lavaca Bay?

There is significant hydrological and biological interaction between Lavaca and Matagorda Bay. The interrelationship is already reflected in the historical salinity data used from the system. Water exchange between the systems directly influences salinity and therefore habitat conditions. Matagorda Bay is typically much saltier than Lavaca Bay and there is a gradient of salinity through the bay system (lower salinity near the inflow sources, highest near the confluence with the Gulf of Mexico). In wetter years, inflows into Lavaca Bay dilute and moderate salinity levels in Matagorda Bay. Lavaca Bay salinity is higher in low flow years due to less dilution and a stronger influence from Matagorda Bay.

The freshwater inflow recommendations for Lavaca Bay utilize inflow-salinity relationships that account for water exchange between the bay systems. These relationships estimate the amount of freshwater inflows necessary to create a desired salinity conditions at several oyster reefs throughout Lavaca Bay. Productive oyster reefs in Lavaca Bay are situated between the freshwater inflow sources and the open waters of Matagorda Bay.

20. Explain the linkage between the instream flow and freshwater inflow recommendations.

The instream flow recommendations are comprised of daily flow rates. The bay and estuary freshwater inflow recommendations are comprised of seasonal flow volumes. Unlike the instream environment, the bay and estuary environment does not depend on certain daily flows or daily variability. The recommendations for instream and bay and estuary environment, however, should be comparable in terms of long-term flow volume.

The BBEST made an effort to check the instream flow and bay and estuary freshwater inflow recommendations for general compatibility of their respective long-term annual volumes. Chapter 4 of the BBEST report shows the results of the comparative analysis. Analysis in Chapter 4 indicates the instream flow and freshwater inflow recommendations are reasonably comparable.

Sources, Use and Verification of Data

14. What effort was made to verify the data?

Calculation of Recommended Environmental Flow Regimes:

The data used for the HEFR analysis is U. S. Geological Survey data approved for use by the USGS. These data undergo a rigorous data quality review. HEFR (Hydrology-based Environmental Flow Regime) tool, which uses USGS data for its input data, has recently gone through its third revision. Its development, use by numerous users, regular maintenance, and revision, ensure it is relatively computationally sound.

Because of the accepted quality of the USGS data and the HEFR tool, we are highly confident of the values in the "HEFR/Hydrologic Regime" tables that are in the detailed summaries for each of the stream sites. HEFR analysis was conducted under a variety of different periods of record and HEFR parameterizations. Additionally, Dave Buzan prepared the "Summary of Historical USGS Flow Records" that are in the detailed summaries for each of the stream sites. During that process, he compared the different flow values and pulse occurrences summarized from the USGS data to the HEFR output in order to determine if one or the other was not comparable. The BBEST also reviewed the daily average flow data for the period of record at eight of the eighteen designated stream sites (not including the sites on the Colorado River downstream of Austin) and compared stable and pulse flow conditions to HEFR output. This analysis indicated that certain flows identified as base or flow pulses by the HEFR tool may not be considered base or pulse flows when reviewed by a BBEST member. However the effect of this variation in flow classification was evaluated and did not significantly affect HEFR output.

HEFR outputs were rounded and modified to simplify the application of the HEFR outputs. These modified values are included in the "Recommended Environmental Flow Regime" for each site. These modifications of HEFR values were made once, spot-checked by Joe Trungale (who ran HEFR) and developed an automated tool for rounding values, and then the modifications were repeated.

Therefore we believe the values in the "Recommended Environmental Flow Regime" for each site are reasonably accurate.

Water Availability Model (WAM) Analysis:

WAM analysis was applied to the recommended environmental flow regime in order to help the stakeholders start to see where the recommended environmental flow regimes appear to be satisfied under currently permitted water use. Streams where the recommended environmental flow regimes may not always be satisfied under currently permitted water use might be places where the stakeholders focus their efforts. The WAM results in the BBEST report will not be used by the TCEQ in any way for development of environmental flow standards. TCEQ will conduct its own WAM analysis, using a revised version of the WAM model which was not available when the BBEST prepared its report.

As for how the WAM comparisons that are presented in the report were computed and verified, the following is offered to better explain the process:

For each site the following was obtained:

(1) The historical daily flows used to produce the HEFR results in the BBEST report.

(2) Monthly simulated WAM flows were extracted from the appropriate versions of WAM.

(3) The HEFR results presented in the BBEST report.

(4) The flow recommendations presented in the BBEST report.

For each site, the process is as follows:

PROCESS 1

The historical daily flows and the HEFR-based flow recommendations were placed into a spreadsheet which computes the number of days in which each of the flow recommendations were met or exceeded. The results of this spreadsheet were compared to the actual HEFR program results and were found to be the same results that HEFR reported for the non-pulse flows, and were seldom the same results HEFR reports for pulse flows. The reason for the pulse flow compliance differing between the spreadsheet process and HEFR was simply because the spreadsheet process counts pulses differently that the HEFR program does, a subject discussed extensively among the BBEST team, but not related to the overall process you have questioned. Since the spreadsheet process and the HEFR results matched for non-pulse flows, this part of the process was deemed to be valid. The period-of-record outside of the WAM period of record (after 1998 for sites in the Colorado, 1996 for all other sites) was then deleted from the spreadsheet, so that a common period between historical flows and WAM flows could be compared. In addition, HEFR-based flow recommendations were replaced with the final flow recommendations presented in the report. This slightly changed the attainment frequencies, as would be expected, by eliminating part of the period-of-record and changing the flow recommendations slightly. The resulting historical attainment information was then summarized and reported in the "HIST" column in the BBEST report's Section 5 tables.

PROCESS 2

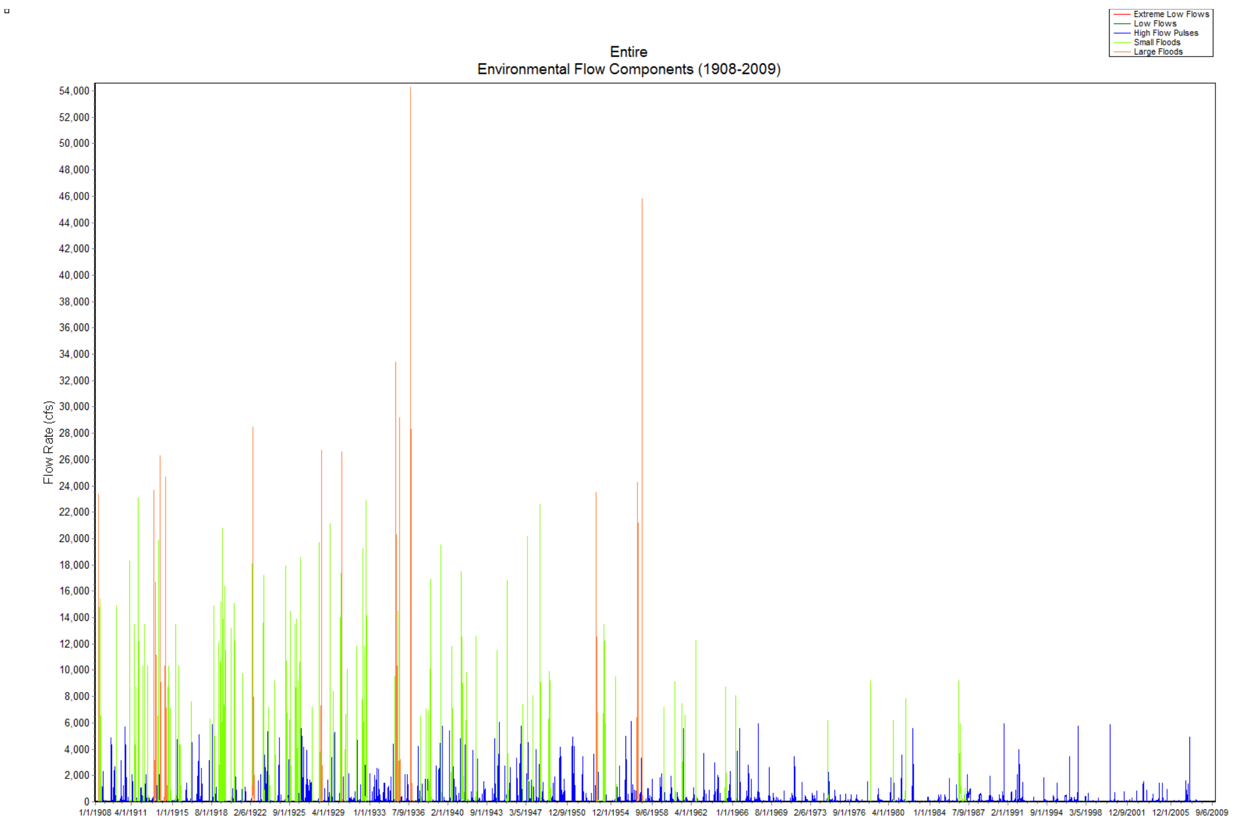
In another spreadsheet process, the historical daily flows were then used to breakdown the WAM monthly simulated flows into estimates of WAM daily flows. This process was done by calculating a factor for each day of the period-of-record by dividing the historical flow each day by the total monthly historical flow for the month. The resulting factors represent the daily distribution of the historical flows. This process was checked by adding up all of the factors for each month of the period-of-record and verifying that a 1.0 was computed for each month. The column of daily factors was then pasted into the spreadsheet process described above (PROCESS1), and the WAM monthly simulated flows were then multiplied by the daily factors described above to produce a representation of daily WAM flows. For several of the sites, the resulting column of estimated daily flows was totaled to monthly values and verified that the result was the same as the beginning information extracted from WAM. Now, having the daily representation of WAM's simulated flows in the same spreadsheet that calculated the historical attainment frequencies, the sheet was recalculated, producing attainment frequencies using exactly the same counting process and period of record as was used to determine the historical attainment frequency information. This information is what is reported in the BBEST report in the "AVG" column in the Section 5 tables.

Admittedly, there were a lot of steps to develop the final information reported in the BBEST report's Section 5 tables and it is possible that some errors were made. However, as the description above details, every reasonable step that we could think of was used to cross check interim results with information from either outside of the processes; or by adding up results of complex calculations within the calculations to see that they totaled what the process began with. If you have any specific questions about the WAM comparisons for any of the sites, please feel free to point these out and we will be glad to review our results to ensure there are no errors.

15. How did BBEST use pre-development and post-development data? Were the post-development data adequately considered in developing recommendations?

Flows in the upper Colorado indicate a downward trend through the historical record. so the question arose is In deciding to use the period from 1940-2009 as an input to HEFR, “Has the BBEST relied on a period that is heavily biased by the earlier, wetter period and results in flow recommendations that are not observed in the current period of record?” The next question is, “If we had chosen the later period would the recommendations be different? Finally which set really better describe the natural flow regime indicative of sound environment?

Figure 1 Colorado River at Ballenger



The hydrology subcommittee met several times early in the process to discuss the appropriate period of record. Preliminary analyses were preformed to evaluate the impact of selecting different time periods and a range of parameters for the base flow separation. With respect to period-of-record the BBEST focused on the gages at Ballinger and Columbus and reviewed early HEFR outputs (at the June 2, 2010 meeting) based on the following periods of record. (The HEFR outputs are provided below)

	Entire		Pre		Post	
	Begin	End	Begin	End	Begin	End
Ballinger	1908	2009	1908	1967	1970	2009
Columbus	1917	2009	1917	1936	1970	2009

While the BBEST final decision to use a consistent period of record was not made at this time, a review of the outputs from this meeting suggest that, for Ballinger, the choice of period of record is much less significant for the base flow components than the pulses, which do show a significant difference between the pre and post periods, while all of the flows at Columbus were very different based on the different periods.

Ultimately the BBEST decided to use a consistent period (1940-2009) for all sites except for the Lower Colorado (including Columbus) for which the results from the comprehensive instream flow study were used (and were based on the period following impoundment of the Highland Lake). The final recommended flows for Ballinger (BBEST report page 2-23), while somewhat higher than the values presented in the Ballenger post figure below ended up being reasonably close. We went through several iterations of the HEFR with different parameters and chose seasonal rather than monthly targets, so a direct comparison is not really possible based solely on the information present here, but it does not appear that the final flows recommended are outside the range of the flow that regularly occurred more recently.

The next step for the BBASC might be to evaluate the frequency at which these flows are met given application of the flow standards to a water project. (see comments/response to question #9)

Ballinger Pre

Overbank Flows	Qp: 4,900 cfs with Average Frequency 1 per year Regressed Volume is 8,740 to 30,274 (19,507) Regressed Duration is 2 to 11 (4)											
High Flow Pulses	Qp: 107 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 13,380 (2,068) Regressed Duration is 1 to			Qp: 6,080 cfs with Average Frequency 1 per season Regressed Volume is 9,257 to 28,833 (19,045) Regressed Duration is 2 to			Qp: 4,410 cfs with Average Frequency 1 per season Regressed Volume is 5,984 to 27,117 (16,551) Regressed Duration is 2 to			Qp: 4,420 cfs with Average Frequency 1 per season Regressed Volume is 7,608 to 27,245 (17,427) Regressed Duration is 2 to		
				Qp: 3,240 cfs with Average Frequency 2 per season Regressed Volume is 1,076 to 20,648 (10,862) Regressed Duration is 1 to			Qp: 2,200 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 19,672 (9,107) Regressed Duration is 2 to			Qp: 2,000 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 18,274 (8,454) Regressed Duration is 1 to		
Base Flows (cfs)	28 (32.5%)	26 (27.2%)	19 (30.0%)	22 (28.4%)	30 (39.9%)	41 (63.1%)	48 (59.4%)	38 (47.0%)	40 (41.8%)	39 (52.8%)	38 (47.4%)	33 (36.3%)
	12 (54.0%)	11 (53.2%)	9.9 (51.8%)	9.2 (47.9%)	9.9 (55.4%)	17 (74.0%)	26 (72.2%)	16 (61.2%)	16 (54.9%)	15 (66.6%)	16 (64.4%)	16 (57.4%)
	4.8 (75.4%)	3.6 (73.8%)	4.5 (74.6%)	3.4 (68.3%)	2.4 (71.9%)	4.1 (84.5%)	9.8 (83.8%)	3.3 (72.8%)	2.9 (68.0%)	3.8 (79.9%)	4.4 (76.8%)	6.1 (75.8%)
Subsistence Flows (cfs)	0.4 (96.2%)	0.3 (95.3%)	0.2 (95.8%)	0 (100.0%)	0 (100.0%)	0.2 (95.3%)	0.41 (95.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0.3 (95.2%)
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Winter			Spring			Summer			Fall		

Ballinger Post

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Overbank Flows	Qp: 3,250 cfs with Average Frequency 1 per 2 years Regressed Volume is 11,166 to 35,681 (23,424) Regressed Duration is 2 to 16 (6)											
High Flow Pulses				Qp: 196 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 16,424 (137) Regressed Duration is 1 to			Qp: 249 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 12,828 (2,639) Regressed Duration is 1 to			Qp: 296 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 9,526 (1,321) Regressed Duration is 1 to		
							Qp: 98 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 11,596 (1,403) Regressed Duration is 1 to					
Base Flows (cfs)	24 (29.8%)	23 (30.2%)	21 (31.9%)	21 (33.9%)	18 (34.7%)	24 (35.6%)	19 (38.8%)	13 (30.4%)	17 (31.3%)	16 (34.8%)	19 (34.4%)	23 (31.2%)
	12 (53.4%)	12 (55.1%)	11 (55.5%)	10 (55.8%)	7.9 (55.6%)	11 (55.7%)	8.2 (57.5%)	4.5 (49.3%)	5.9 (50.8%)	9 (53.6%)	11 (56.6%)	12 (53.8%)
	5.8 (76.8%)	6.4 (77.0%)	5.6 (77.6%)	4.4 (77.1%)	2.5 (77.7%)	3.1 (75.9%)	2.1 (76.4%)	1.5 (69.2%)	1.8 (70.4%)	3.8 (73.5%)	5.9 (74.9%)	6.1 (75.9%)
Subsistence Flows (cfs)	0.79 (95.0%)	2.8 (95.2%)	1.4 (95.8%)	0.76 (95.0%)	0.58 (95.1%)	0.33 (95.2%)	0.1 (95.2%)	0 (100.0%)	0 (100.0%)	0.07 (95.0%)	0.4 (95.0%)	0.58 (95.0%)
	Winter			Spring			Summer			Fall		

Ballinger (Entire HEFR v 7.1)

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Overbank Flows	Qp: 4,900 cfs with Frequency 1 per year Volume is 8,592 to 30,814 (19,703) Duration is 2 to 11 (4)											
High Flow Pulses				Qp: 3,820 cfs with Frequency 1 per season Volume is 1,350 to 23,917 (12,634) Duration is 2 to 10 (4)			Qp: 3,180 cfs with Frequency 1 per season Volume is 1,845 to 22,927 (12,386) Duration is 2 to 11 (4)			Qp: 2,760 cfs with Frequency 1 per season Volume is 1,653 to 20,818 (11,235) Duration is 1 to 10 (4)		
				Qp: 1,180 cfs with Frequency 2 per season Volume is #N/A to 17,289 (6,003) Duration is 1 to 8 (3)			Qp: 1,060 cfs with Frequency 2 per season Volume is #N/A to 16,144 (5,603) Duration is 1 to 9 (3)			Qp: 806 cfs with Frequency 2 per season Volume is #N/A to 13,578 (3,993) Duration is 1 to 8 (3)		
Base Flows (cfs)	26 (31.3%)	24 (28.7%)	20 (31.2%)	22 (30.7%)	24 (37.8%)	33 (52.1%)	35 (51.3%)	28 (40.0%)	27 (37.6%)	27 (44.7%)	29 (41.7%)	28 (34.7%)
	12 (53.9%)	12 (51.8%)	10 (54.0%)	10 (50.9%)	10 (55.9%)	13 (67.3%)	15 (66.5%)	9 (55.7%)	9 (53.2%)	11 (61.6%)	13 (59.9%)	14 (56.2%)
	6 (76.0%)	5 (75.0%)	6 (75.1%)	4 (72.1%)	3 (74.2%)	4 (81.5%)	5 (80.8%)	2 (71.3%)	2 (69.4%)	4 (77.6%)	6 (76.0%)	6 (76.3%)
Subsistence Flows (cfs)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)	0 (100.0%)
	Winter			Spring			Summer			Fall		

Columbus (Pre)

Overbank Flows	Qp: 46,900 cfs with Average Frequency 1 per 2 years Regressed Volume is 238,591 to 629,918 (434,255) Regressed Duration is 3 to 22 (9)											
High Flow Pulses	Qp: 10,900 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 216,328 (91,097)			Qp: 32,000 cfs with Average Frequency 1 per season Regressed Volume is 62,221 to 442,184 (252,203)			Qp: 11,500 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 349,935 (119,954)			Qp: 41,300 cfs with Average Frequency 1 per season Regressed Volume is 101,652 to 477,952		
	Qp: 3,850 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 131,665 (5,592) Regressed Duration is 1 to			Qp: 13,600 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 295,670 (105,778)			Qp: 4,060 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 241,734 (11,199) Regressed Duration is 1 to			Qp: 13,100 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 270,622 (82,770)		
Base Flows (cfs)	1325 (38.1%)	1360 (37.1%)	1395 (39.8%)	1860 (38.7%)	1830 (46.5%)	2230 (61.5%)	2310 (54.3%)	1630 (36.5%)	1340 (25.8%)	1640 (41.0%)	1703 (43.9%)	1630 (40.7%)
	882 (56.3%)	869 (57.3%)	884 (59.1%)	1130 (56.8%)	1080 (62.2%)	1410 (73.9%)	1630 (69.7%)	989 (56.3%)	812 (41.8%)	827 (57.8%)	1025 (58.1%)	1030 (57.7%)
	590 (76.1%)	501 (77.6%)	590 (79.5%)	615 (74.8%)	618 (77.3%)	956 (85.8%)	984 (84.8%)	633 (76.3%)	489 (57.7%)	520 (75.2%)	607 (72.7%)	610 (75.0%)
Subsistence Flows (cfs)	285 (95.2%)	340 (95.5%)	369 (95.0%)	296 (95.3%)	299 (95.0%)	498 (95.0%)	536 (95.0%)	331 (95.0%)	125 (95.2%)	278 (95.2%)	187 (95.5%)	196 (95.0%)
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Winter			Spring			Summer			Fall		

Columbus (Post)

Overbank Flows	Qp: 46,900 cfs with Average Frequency 1 per 2 years Regressed Volume is 293,218 to 753,220 (523,219) Regressed Duration is 4 to 27 (11)											
High Flow Pulses	Qp: 8,740 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 291,510 (85,411) Regressed Duration is 2 to			Qp: 11,000 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 311,798 (151,081)			Qp: 4,310 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 353,213 (#N/A) Regressed Duration is 1 to			Qp: 8,630 cfs with Average Frequency 1 per season Regressed Volume is #N/A to 189,916 (55,802) Regressed Duration is 1 to		
	Qp: 3,820 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 191,323 (#N/A) Regressed Duration is 1 to			Qp: 4,690 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 169,880 (8,938) Regressed Duration is 1 to						Qp: 3,700 cfs with Average Frequency 2 per season Regressed Volume is #N/A to 145,735 (11,384) Regressed Duration is 1 to		
Base Flows (cfs)	1215 (32.6%)	1660 (34.9%)	1180 (36.0%)	1505 (42.0%)	1860 (41.1%)	2260 (45.2%)	2490 (49.1%)	2200 (40.2%)	2010 (29.0%)	1910 (30.7%)	1250 (34.4%)	973 (32.5%)
	635 (50.3%)	864 (53.2%)	726 (54.8%)	880 (59.3%)	1440 (60.7%)	1920 (63.6%)	2210 (66.0%)	1880 (59.9%)	1650 (52.5%)	1550 (54.3%)	928 (55.2%)	588 (50.3%)
	457 (68.0%)	524 (71.6%)	498 (73.6%)	597 (76.5%)	1080 (80.6%)	1640 (82.2%)	1930 (83.3%)	1530 (80.0%)	1330 (76.5%)	1280 (77.5%)	625 (76.0%)	461 (68.2%)
Subsistence Flows (cfs)	246 (95.0%)	266 (95.0%)	285 (95.0%)	292 (95.1%)	754 (95.0%)	1310 (95.2%)	1561 (95.0%)	1220 (95.2%)	991 (95.0%)	985 (95.0%)	366 (95.1%)	253 (95.0%)
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Winter			Spring			Summer			Fall		

Columbus (Entire HEFR v 7.1)

Overbank Flows	Qp: 46,900 cfs with Frequency 1 per 2 years Volume is 236,231 to 738,447 (487,339) Duration is 4 to 22 (9)											
High Flow Pulses	Qp: 9,030 cfs with Frequency 1 per season Volume is #N/A to 268,277 (86,800) Duration is 2 to 8 (4)			Qp: 14,600 cfs with Frequency 1 per season Volume is #N/A to 411,376 (146,427) Duration is 2 to 12 (5)			Qp: 6,060 cfs with Frequency 1 per season Volume is #N/A to 400,745 (58,258) Duration is 1 to 8 (3)			Qp: 13,400 cfs with Frequency 1 per season Volume is #N/A to 262,787 (82,761) Duration is 1 to 8 (3)		
	Qp: 4,050 cfs with Frequency 2 per season Volume is #N/A to 173,868 (#N/A) Duration is 1 to 4 (2)			Qp: 5,210 cfs with Frequency 2 per season Volume is #N/A to 300,478 (35,358) Duration is 1 to 6 (2)								
Base Flows (cfs)	1500 (34.0%)	1700 (35.6%)	1670 (37.9%)	1710 (39.8%)	1810 (43.2%)	2290 (49.1%)	2450 (49.0%)	2160 (40.1%)	2010 (30.2%)	1920 (32.9%)	1480 (35.7%)	1480 (35.6%)
	852 (51.8%)	960 (53.8%)	907 (56.0%)	972 (57.2%)	1310 (61.6%)	1820 (66.2%)	2100 (66.1%)	1810 (60.5%)	1620 (51.9%)	1480 (54.7%)	975 (54.9%)	800 (52.9%)
	523 (69.6%)	552 (71.8%)	570 (74.2%)	615 (74.6%)	910 (79.6%)	1440 (83.0%)	1750 (83.2%)	1370 (79.5%)	1240 (73.0%)	1100 (76.6%)	618 (74.4%)	505 (70.3%)
Subsistence Flows (cfs)	249 (93.9%)	246 (95.0%)	258 (96.2%)	270 (96.0%)	285 (98.9%)	304 (99.8%)	N/A	258 (99.6%)	225 (97.2%)	271 (99.1%)	254 (96.9%)	258 (93.9%)
	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Winter			Spring			Summer			Fall		

Biology

16. **There were 5 species for Matagorda Bay; why were other species excluded?**

The initial MBHE stakeholder group used habitat and biostatistical analyses with 10 "key" aquatic species to focus the freshwater inflow biological analysis. These species were selected because they represent a wide spectrum of trophic levels in the estuarine food web, in addition to being recreationally or commercially important in Matagorda Bay. During the life history review and existing data collection for these species, which included additional field collection of habitat-preference data at several sites in the eastern Arm of Matagorda Bay, the team identified relationships of juvenile life stages of five of the "key" species. A sixth species, eastern oyster, was also addressed with a different habitat assessment method. The remaining species did not have as specific habitat preferences identified in the literature, and were not collected in adequate numbers during the 3-year field work to use with habitat modeling. However, all 10 species were assessed in the biostatistical analysis component. The flow regimes developed from these key species are protective of all species that utilize Matagorda Bay (not limited to the needs of just these 5 species). The BBEST expressed confidence that the MBHE study is the best available science, and agreed that the suite of components analyzed in the study incorporated a range of ecologically-important processes. However, several data gaps do exist in the biological record for the bay, and the BBEST recommends that the work plan include efforts to fill these gaps. The BBEST also recognized there are hundreds of species in Matagorda Bay and there is never enough time or money to evaluate the relationships with freshwater inflow for all those species.

17. Concern expressed that Lavaca riparian area species selected and sites used may not be representative of all riparian areas.

The BBEST recognizes that the riparian systems vary considerably between smaller tributaries with narrow riparian zones and fewer wetland species dominating the community, as compared to broader riparian bottomland forests on the mainstem of the Lavaca and Navidad Rivers. We illustrated the riparian area around the gage for about a 3-mile stretch of the river, using current and historical aerial photography (via Google Earth) and Texas Ecological System Classification Program mapped community data (from TPWD), as well as some site-specific information on where tree species were located in the riparian landscape. At several locations, the riparian zone appeared to be in transition around the gage from a narrower, less-wooded riparian zone upstream of the gage to a wider riparian zone with larger, wooded bends downstream of the gage (e.g., Lavaca River near Edna).

The reach-scale riparian analysis was intended to help us understand whether pulse flows were an important environmental flow regime component at each site, and the illustration on p. 2-153 indicates a nice overlap between the flood stage elevation and the floodplain vegetative communities. Additionally, although the riparian vegetative community may be in transition at this point, the categories used by TPWD for the different vegetative communities are relatively inclusive and it is likely that there is not substantial change in plant community composition for some distance upstream and downstream. For example, the riparian zone on small tributaries (West Mustang Creek and Tres Palacios Creek) were dominated by the mapped community "Coastal Bend Riparian Hardwood Forest", which includes cedar elm, pecan, black willow, sugar hackberry, honey mesquite, and plateau live oak. Somewhat larger tributaries began to exhibit a dominant community of "Coastal Bend Floodplain Hardwood Forest" with species that included American sycamore, American elm, pecan and sugar hackberry; but also had patches of "Floodplain Live Oak Forest", dominated by live oak. The Lavaca River near Edna and Navidad River at Strane Park sites were dominated by much broader riparian communities of the "Floodplain Hardwood Forest" and surrounding floodplain grassland.

The extent of these Texas Ecological System Classification Program-mapped riparian communities, together with the National Weather Service flood-stage elevation information and life history information for the dominant plant species in the communities, gave the BBEST confidence that pulse flows are important to some riparian communities. These pulse flows are most important to communities that are dominated by wetland and facultative plant species. Without site-specific pulse-flow modeling, the BBEST relied on the aforementioned data to identify that 1) pulses that occur annually are important to create moist soil conditions and allow seed dispersal and germination, and 2) larger pulses that occur over longer time periods, including 2-year and 5-year events, are important for seed dispersal and germination within higher areas of the riparian zone, for species that do not have a good seed crop every year, and for preventing the invasion of upland species in the riparian zone.

It is also understood that land use has a large impact on the riparian condition (e.g., extent of forested areas, plant species recruitment, stability of the river banks), and can override benefits to recruitment that environmental flows provide.

Other Questions

18. Why did the BBEST choose to call the 70-year history a sound ecological environment, given the fact that it blends pre-development and post-development flows?

Available published literature, monitoring data on fish distribution, community structure, and abundance strongly supported that the existing aquatic communities represented a sound ecological environment. In those few instances where the available data suggested changes over time, these changes were not attributable to changes in the flow regime over the pre, post, or full period of records at the gage locations. Furthermore, the assessment of the differences in flow between the pre, post, and full periods did not suggest changes in flow attributes (frequency, magnitude, duration, timing, or rate of change) were substantially different enough to expect it would contribute to changes in the fish communities our assessment of available data.

19. Is BBEST saying things need to stay as they currently are to assure a sound ecological environment?

No. The BBEST report does not require or prescribe a static state of conditions to assure a sound ecological environment. The BBEST recognizes that natural and man-made conditions have and will change over time. Today's sound ecological environment can exist within a broad range of short term conditions. Long term or permanent changes to hydrologic conditions that are being contemplated may require revisiting the environmental flow regime recommendations through the adaptive management process. A sound ecological environment can potentially be maintained after changes in hydrologic conditions relative to those in existence today. In other words, the BBEST environmental flow regime recommendations are protective of today's sound ecological environment. Future hydrologic conditions may support sound ecology too, and the environmental flow regime recommendations can be adapted as provided for by the SB 3 legislation.

20. What is the relevance of the fact that the BBEST analysis was "a compromise and incremental process?"

The BBEST did not make any compromises in development of the flow recommendations. We engaged in an open discussion of the pertinent available data, analyses and scientific issues at each step of the process and were able to reach full consensus on each technical point and the elements of the recommended flow regime. We in fact used an incremental approach starting with a critical comparative evaluation of changes in the flow attributes generated by HEFR for the pre, post, and full periods. This was followed by a detailed evaluation of the HEFR parameterization and comparison between MBFIT versus HEFR defined base flow separation approaches. An independent day-to-day examination of base flow versus pulse flow results derived by the selected HEFR base flow separation was made by two members of the BBEST at several gage locations. This step involved changes to the daily base versus pulse flow defined by HEFR and the revised HEFR statistics were compared. This clearly demonstrated that these manual changes resulted in less than a 10 percent change in the magnitudes of the seasonal HEFR low, medium, and high base flow values and very little change in the pulse flow magnitudes or durations. Water quality, geomorphology, riparian, and biological overlays were then incrementally applied and evaluated as well as the integrated implications of each component. Only after all these incremental steps were completed did we reach consensus on our flow regime recommendations.

21. How much water do different estuarine species need in order to maintain their populations?

Estuarine organisms are adapted to a wide range of dynamic conditions. Species productivity and populations are influenced by a number of factors such as freshwater inflows, harvest pressure, physical modifications, and meteorology. Freshwater inflow is important in moderating salinity and providing key habitat, particularly to juvenile life stages of many species. Lower salinity marsh habitats provide juveniles (e.g. shrimp) the appropriate conditions to thrive and grow. Different species have different salinity needs: select habitat for juvenile white shrimp occurs between 8 – 15 ppt while brown shrimp thrive in 10-25 ppt. Upon maturation, most species can tolerate wider ranges of salinity.

Adult oysters are immobile, making them dependent upon the surrounding chemical environment. Oysters grow optimally over a salinity range from approximately 10 to 25 ppt and salinity conditions outside of this range for extended period are detrimental to oyster populations.

The freshwater inflow recommendations for Lavaca and Matagorda Bays were designed to provide a range of habitat conditions to promote healthy ecosystems.