

August 20, 2010

Transmittal to Basin and Bay Area Stakeholder Committees (BBASCs) and Basin and Bay Expert Science Teams (BBESTs)

Report # SAC-2010-02

Title: Considerations in the Development of an SB3 Work Plan for Adaptive Management

SB3 embraces adaptive management as a long-term mechanism for continued improvement and refinement of environmental flow standards throughout the states' basin and bay systems. Following submission of its recommendations, each BBASC with the support of its BBEST is to prepare and submit to the EFAG a work plan which is to (1) establish a periodic (no longer than ten years) review of the recommendations and standards, (2) prescribe specific monitoring and studies, and (3) establish a schedule for continuing the validation or refinement of the standards and associated analyses.

This work plan constitutes the backbone of the adaptive management process envisioned in SB3. Hence, the SAC with input from the agencies has prepared the attached guidance document on considerations in the development of work plans. The document is not intended to be prescriptive, but does present an array of topics that the SAC believes to be pertinent for consideration in construction of a viable and comprehensive work plan.

The BBASC and BBEST groups from the Trinity/San Jacinto/Galveston Bay and Sabine/Neches/Sabine Lake basins have completed and submitted their final reports, and the TCEQ has initiated the rulemaking process. The SAC encourages these groups to proceed with work plan development so as to have, at a minimum, a proposed draft available as the TCEQ completes the rulemaking and adopts standards.

Finally, the SAC acknowledges the linkage suggested by both BBASCs between the SB3 environmental flows development and the SB1 regional planning process. The results of the SB3 work should provide an avenue for improving the level of technical knowledge and regulatory certainty to inform future deliberation by the Regional Water Planning Groups. In addition, the detailed water needs analysis provided by the planning groups should also inform the work of the BBASCs. The Trinity/San Jacinto/Galveston Bay BBASC recognized the importance of synchronizing these planning processes, as well as ground water planning, so as to make the work products of each available to the other. And, as suggested by the Sabine/Neches/Sabine Lake BBASC, further integration of the planning cycle of these processes could have merit and might appropriately influence the content and phasing of the basin's work plan.



Robert J. Huston, Chairman, SB3 Science Advisory Committee

**Considerations in the Development of an SB3 Work Plan for Adaptive
Management.**

**Senate Bill 3 Science Advisory Committee
for Environmental Flows**

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Document Version Date: August 20, 2010

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1.0 INTRODUCTION

Senate Bill 3 (SB3) requires creation of a “work plan” to facilitate the adaptive management of the environmental flow standards adopted for each basin and bay system. Developing the work plan will require resolving at least three main questions: 1) what monitoring, special studies, or other information is required to fill data gaps and validate and refine the environmental flow analyses and environmental flow regime, as well as the environmental flow standards and achievement strategies; 2) what will be the appropriate schedule for studies and review of the standards; and 3) how will the work be paid for? The purpose of the current document is to provide guidance on work plan development.

2.0 BACKGROUND

A key step for the Basin and Bay Area Stakeholders Committees (BBASCs), pursuant to the mandates of SB3, is the preparation of a work plan. SB3 offers the following language for timing of and what components should be incorporated in the work plan.

Section 11.02362 (p) In recognition of the importance of adaptive management, after submitting its recommendations regarding environmental flow standards and strategies to meet the environmental flow standards to the commission, each basin and bay area stakeholders committee, with the assistance of the pertinent basin and bay expert science team, shall prepare and submit for approval by the advisory group a work plan. The work plan must:

- (1) establish a periodic review of the basin and bay environmental flow analyses and environmental flow regime recommendations, environmental flow standards, and strategies, to occur at least once every 10 years;*
- (2) prescribe specific monitoring, studies, and activities; and*
- (3) establish a schedule for continuing the validation or refinement of the basin and bay environmental flow analyses and environmental flow regime recommendations, the environmental flow standards adopted by the commission, and the strategies to achieve those standards.*

Section 11.1471 (f) An environmental flow standard or environmental flow set-aside adopted under Subsection (a) may be altered by the commission in a rulemaking process undertaken in accordance with a schedule established by the commission. In establishing a schedule, the commission shall consider the applicable work plan approved by the advisory group under Section 11.02362 (p).

Section 11.02362 (p) specifically addresses the requirements of the plan, while Section 11.1471 (f) refers to the plan in the context of altering adopted environmental flow standards or set asides. The focus of this document will be on the former. After evaluating the language for what a work plan must accomplish, there are three main components: 1) develop a schedule for review, 2) prescribe monitoring, studies, etc. during that interim period and potentially beyond, and 3) establish an approach for

validation or refinement of the environmental flow recommendation(s). These address three aspects of the environmental flow determination: 1) the regime recommendations (and underlying analyses), 2) the standards used to implement the regime recommendations to the maximum extent reasonable, and 3) the strategies employed to achieve these standards.

Although the SB3 schedule for work plan development seems clear (“to be submitted after the development and submittal of flow recommendations to the TCEQ”), this still raises the question as to when exactly, i.e., prior to or following TCEQ rulemaking? This is addressed in 3.0 below.

The components that must be included in the work plan also lead to several questions. Some basic questions relative to the development and implementation of the work plan are:

- What can be done to provide more confidence in the effectiveness and appropriateness of environmental flow recommendations and fill gaps where recommendations were absent or had high uncertainty?
- How do the BBASC and BBEST go about evaluating the:
 - flow recommendations over time,
 - adopted flow standards over time,
 - employed strategies over time?
- How will the BBASC and BBEST determine whether the standards and implementation strategies are maintaining a sound ecological environment?
- Would different quantities of flow for certain components of an environmental flow regime be equally effective for maintaining a sound ecological environment?
- Who will fund, coordinate and implement the overall work plan?

The work plan is essentially the backbone of the adaptive management process. Adaptive management is interpreted to encompass the entire process that is envisioned in SB3 for the work plan. Adaptive management needs three main components to be effective. It must first have a procedure for identifying what further study or clarification is required. Secondly, it must have funding and resources to address those issues. Finally, it must have a mechanism to support some level of change in the standards and/or implementation strategies. What is clear is that adaptive management will play an important role in the process and that the work plan is the appropriate instrument for outlining the framework for adaptive management in each respective basin.

SB3 requires that the environmental flow recommendations be revisited within a 10-year time frame, that is on a periodic schedule no longer than ten (10) years. The information gathered pursuant to carrying out the work plan will be used to address three key activities:

- Verify the assumptions and fill data gaps that were identified in the development of the original environmental flow recommendations, and collect data to test the prediction that the recommended flow is capable of protecting ecological soundness.
- Document activities and perform analyses to evaluate the effectiveness of the recommended flow regimes in context of variability of parameters needed to create and test the flow regime. This includes testing the cause-and-effect relationships between flow and ecological responses.
- Reaffirm or revise the original flow regime recommendation based on the first two activities. This will need to include an analysis of variability such that the BBASC will know what trade-offs are being made when choosing among flow regime alternatives.

3.0 SB3 PROCESS AND WORKPLAN ROLE

The SB3 process leading up to work plan development is summarized below:

- BBEST develops flow recommendations based solely on best available science.
- BBASC reviews 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, so as to develop environmental flow standards and strategies to meet the standards.
- BBASC finalizes recommendations regarding environmental flow standards and strategies to meet these standards, and submits these to the TCEQ and the EFAG.
- Upon submittal of recommendations to the TCEQ and EFAG, the BBASC with assistance from the BBEST prepares and submits the work plan.

The process does not end with the submittal of BBASC recommendations. The TCEQ then promulgates environmental flow standards through a rule-making process and may determine applicable set-asides. TCEQ is to consider the environmental flow regimes recommended by the BBEST and the standards and strategies to meet the standards developed by the BBASC. TCEQ will also consider 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. It is not clearly defined in SB3 whether the work plan is to be considered in the TCEQ rule-making process. It would appear to be beneficial to TCEQ to have at least a proposed draft work plan to consider during the rule making process.

A review of the recommendations from the first two SB3 basins (Trinity/San Jacinto/Galveston Bay and Sabine/Neches/Sabine Lake) reveals differences in their respective dependence on adaptive management. Clearly, the level of dependence on

adaptive management to establish an initial set of environmental flow recommendations and standards will greatly influence the content, and perhaps the schedule, of the basin work plans.

4.0 WORKPLAN DEVELOPMENT

Throughout the initial BBEST and BBASC process, a recurring theme echoed from both basins engaged in SB3 to date has been that there is limited information to describe or define the ecological role that flow plays in supporting aquatic and/or riparian communities. Thus, the principal immediate technical goal of the work plan for these two basins is to fill in data gaps and assist in establishing a cause-and-effect relationship of some measure(s) of ecosystem health to the magnitude, timing, and duration of environmental flows (by which is meant instream flows for the riverine environment and freshwater inflows for the estuarine environment). While mechanisms have been identified whereby these flows may affect the system ecology, there are other factors acting upon and within water bodies that can also exert influence. An important technical issue is *isolating* the effect of flow from other drivers and *quantifying* the contribution of flow relative to the other factors influencing ecological response. New field data are essential to this task. It is necessary to have measurements of the suite of parameters that characterize an aquatic ecosystem, of the flows that potentially exert environmental controls on the ecosystem, and of the other factors, internal and external, operating to influence that ecosystem.

In a laboratory setting, the procedure to quantify the cause-and-effect relationships of flow to ecosystem health would be straightforward: i.e., to conduct a controlled experiment in which all other factors are held constant, and flow alone is varied, and measure the accompanying response in the ecosystem directly. In nature, such an approach is impossible, because we cannot in fact control any of the external factors. However, we can use statistical control of conditions that are operating at the time of the field measurements as long as all these conditions are measured and included in the design and analysis of the monitoring program. The response data will include the combined influences of all of the physico-chemical processes at work in the water body and its environment. In order to sort out the influence of any variable, it is necessary to sample over a wide range of values of all of the controlling parameters. This requires not just a single comprehensive field-measurement exercise, but multiple such exercises over a period of time and appropriate spatial scale.

The development of a work plan will require marshalling various sources of data on streamflow, hydrometeorology, concentrations of key constituents in the water, and the metric used to indicate ecosystem health (e.g., the presence and abundance of important organisms). One of the more important attributes of a potential data set for the purposes of the work plan is that the data be in a digital format complete with metadata, e.g., positioning information (i.e., georeferencing and depth), and be fully documented as to methods and protocols. It is also important that the data collection be sustained over a period sufficient to capture the range of natural variability.

In data collection activities, a distinction is made between a monitoring program, a survey, and a research study. A monitoring program is a data collection enterprise put in place for a protracted or indefinite period in order to observe a suite of variables. Monitoring programs have the objective of assembling a long-term data base, frequently serve multiple purposes, and are characterized by consistency in the parameters measured and uniformity in sampling intensity over time. The daily streamflow data of the U.S. Geological Survey (USGS) is an example. A survey is similar to a monitoring program in serving multiple purposes and having the objective of accumulating a data base, but is limited in time and generally more intensive than a monitoring program. The Texas Instream Flow Program (TIFP) is an example. A research study is a targeted effort keyed to testing of specific hypotheses. It is frequently motivated by a scientific question, is limited in space, time and resources (especially funding), and often selects variables to be monitored that are immediately pertinent to the scientific question. Academic projects are examples of research studies.

Given sufficient time and resources, the best approach to data collection for environmental flows would be to combine approaches and merge results from all three types of data-collection programs. For the initial phases of work specified in a work plan, the minimum requirements will be (1) to identify existing long-term monitoring programs from which data is available, perhaps modifying or augmenting these programs to better address the requirements of the work plan, and (2) to collect data to verify and/or establish indicator response to the recommended flow regimes.

4.1 Existing Programs and Potential Resources

Regardless whether the data collection activity proposed in the work plan is a monitoring program, survey, or research study, the BBASC will need to consider how this work will be funded, coordinated, and carried out into the future. Therefore, a prerequisite for work plan development is obtaining a thorough understanding of existing programs that are in place within the respective basins on the federal, state, regional, and local levels. To provide some background on the federal and state level activities, a questionnaire (Appendix A) was developed and responses solicited from several federal and state entities. In this context, “program” is not limited to data collection projects, but can encompass any sort of agency activity that involves technical or scientific issues of Texas watercourses. The goal of the exercise was to identify what programs are currently being funded and carried out in the state, and to ask whether there might be the possibility for adaptations to any of these existing programs that might provide either a funding mechanism or foundation for some of the activities likely to be considered in work plan development. Responses were received from the Texas Water Development Board (TWDB), Texas Parks and Wildlife Department (TPWD), TCEQ, TIFP and the Galveston Bay National Estuary Program. The responses are included in Appendix B. From this feedback, it appears that opportunities might be available through some of these federal or state programs. Key programs identified are:

- TCEQ Clean Rivers Program
- TIFP Senate Bill 2 (SB2) studies

- TWDB and TPWD joint freshwater inflow studies program and Datasonde Program
- TWDB Research and Planning Fund studies
- National Estuary Programs for Galveston Bay and the Coastal Bend Bays

While it is not clear what specific role the BBASC and BBEST will play in executing the work prescribed in their basin work plan, the five year term of their respective appointments suggests that they are to play a continuing role in the SB3 adaptive management process. At a minimum, the BBASC and BBEST appear uniquely positioned to provide coordination and oversight of the work to be undertaken.

It is important to note that existing programs will not provide a panacea for funding a work plan. These data collection programs were designed with their own goals, objectives, methods, and have their own funding sources. These programs are funded by federal, state, regional and/or local levels of government and the direction, objective, and priorities of the agency collecting the data may change or cease altogether. Therefore, any SB3 monitoring program that chooses to make use of another agencies data should be in frequent contact with the agencies collecting the data to be aware of any changes that might have occurred or may be contemplated with the data collection. In some instances the agencies may request additional funding or reimbursement to maintain collection of data critical to an SB3 work plan. It is unrealistic to expect that these programs will divert resources away from other “mission critical” programs to satisfy the needs of the stakeholders and science teams to complete their own work plan.

While using existing resources will be an important approach to funding some of the work plan activities it will likely be insufficient. Therefore, each BBASC, supported by their respective BBEST, will have to be innovative in recommending ways to fund the studies and activities necessary to carry out the adaptive management process. It may be necessary to form partnerships with other state and federal agencies, academic institutions, and local and regional entities (e.g. cities, water systems, or river authorities) to identify cost-sharing opportunities, other available resources, or fund raising opportunities.

There are periodic requests for proposals from Texas-based funding agencies (for example, Texas Sea Grant, Texas Water Research Institute, Coastal Management Program, Coastal Impact Assistance Program, etc.) that provide opportunities for the science teams to collaborate in a request for funds to support SB3 studies. Because the SB3 process has identified large information gaps, exposed the complexity of relating environmental flow to ecological health, and will have an enormous impact on the future development of water resources, many important questions have been uncovered that will form the basis for competitive proposals. Awards from these programs are based on a competition and ranking of proposals, so science teams must acknowledge that a proposal submission does not guaranty an award. However, writing a formal proposal that is subject to peer-review is a useful activity to hone elements of a work plan, regardless of the funding outcome.

Outreach activities are also useful to help garner support for funding studies. It is important for the researchers performing work plan studies to report on their activities on a regular basis, such as participating in annual water conferences. Convening sessions that focus on SB3 activities at annual water conferences would elevate the prominence of environmental flow issues, and provide an opportunity for individuals from different parts of the State to learn from one another. As people outside the SB3 process learn about the complexity and importance of environmental flow studies, they will be attracted to the topic and the field will grow because new opportunities will be created.

Finally, a commitment of continued funding of SB3 work plan execution by the State will be necessary if the fundamental objectives of establishing basin specific environmental flow standards, and an adaptive management framework for their continued improvement and refinement, are to be realized.

4.2 Work Plan Approach (Research Studies, Surveys, and Monitoring Program)

An SB3-based work plan will likely include short-term research studies, focused surveys (short- or long-term), and long-term monitoring programs. Short-term research studies and focused surveys will likely be needed to address data gaps or shortcomings in the BBEST and/or BBASC recommendations. The main goal for these activities will be establishing linkages between flow and ecology to better document what flows are necessary and/or to better define the role of prescribed flow components. Long-term monitoring will also likely be needed over an extended evaluation period with designated review points. The long-term monitoring should focus on whether the recommendations, standards, and implementation strategies are meeting the goals and objectives set forth in SB3.

There are two main categories of the environmental flow recommendations: 1) those that pertain to rivers, streams and tributaries (instream flow); and 2) those that pertain to the bays and estuaries (freshwater inflow). Regardless of category or nature of the study or monitoring, it will be important to focus on the key indicators of ecological health identified in the flow recommendations. Community assemblage data (i.e., diversity and abundance of species) is valuable to establish the overall ecological health of a system over time because it is an indicator of ecosystem integrity. However, information collected at the community level often does not provide the level of detail to answer specific questions relative to ecological linkages to instream flows or freshwater inflows. For example, community assemblage data is not likely to provide information about which flows trigger spawning or migration events. As such, focusing on key indicators of ecosystem sustainability may be required.

An indicator of ecosystem health does not necessarily have to be an organism. It could be a water quality parameter (such as temperature, ion concentration, ion ratios, pH, chlorophyll, dissolved oxygen (DO) [instream] or salinity [estuary]), or a physical habitat attribute (such as riffle area [instream] or seagrasses, marsh vegetation, or oyster reefs [estuary]), or a measure of function (such as growth, productivity, or reproductive success). The indicator could also be a specific aquatic organism, but in these instances

careful consideration of how to tie the measure for a given organism back to a change in habitat condition caused by a change in instream flow or freshwater inflow will need to be considered. Additionally, there are many factors in addition to flow that can lead to a change in organism response (e.g., stocking, harvesting, climate change, pollution, etc.) and any study, survey, or monitoring activity must be designed to tease out this information to obtain a defensible answer.

In addition to designing detailed research studies and focused surveys to fill data gaps and answer specific flow-ecology linkage questions, long-term monitoring will be a key component of the work plan. This involves monitoring over an extended period of time with the goal of developing a data set that will facilitate periodic review of the basin and bay environmental flow analyses and environmental flow regime recommendations, and allow validation of standards and achievement strategies. Designing a monitoring plan to evaluate whether the system is maintaining a sound ecological environment can be accomplished assuming that the work plan has a specific definition for what constitutes a “sound ecological environment”. However, SB3 appears to be asking for more than this. It specifies, “...periodic review of the ...recommendations, environmental flow standards, and strategies... for continuing their validation or refinement...” To accomplish this, an on-going baseline data set will likely be necessary, but should be at a level that one can isolate and separate the effects of external factors including instream flows or freshwater inflows, and focus directly on the standards and strategies, and then at a later stage of analysis deal with the issue of “validation”. A monitoring plan should strive to separate effects due to natural variation from variation caused by anthropogenic activities.

The validation of flow recommendations/standards/strategies raises additional questions for consideration by the respective BBASC and BBEST (e.g., what does validation consist of? and when is validation considered successful?). The central aspect of validation is to confirm or refute that the recommended standards are protective of a sound ecological environment. Validation is successful when it can be confirmed that the environmental response to flow is as predicted by the flow recommendations. In any event it will be important to identify the range or bounds of acceptable responses to the standard of a sound environment.

Another challenge is that there may be limitations on the ability to perform a research study because the flows consistent with a specific flow recommendation or standard might not occur during the available study period, due simply to the normal variation in stream flows.

5.0 WORK PLAN - DISCUSSION ITEMS

Each basin and bay will likely require specific research studies, surveys, and monitoring programs. As such, key issues surrounding the components of instream flow (Section 5.1) and freshwater inflow (Section 5.2) are presented below as a starting point for BBASC and BBEST discussions. Although presented in separate sections, specific studies and/or monitoring components for instream flow and freshwater inflow should be

developed, when practicable, to explore potential linkages between both sets of environmental flow requirements. The following discussion items are in no way intended to be a prescription for work plan content, but rather points to consider.

5.1 Instream Flow – rivers, streams, tributaries

Following on the guidance of SB2, the four flow components of a riverine environment have been characterized as subsistence flows, base flows, high-flow pulses, and overbanking flows.

Subsistence flows - The main unknowns surrounding subsistence flows typically center on water quality and aquatic habitat. Ideas for discussion could include:

- Water quality information at extremely low flows. Because subsistence flows are typically extremely low, they are not often experienced and thus, this information is currently unavailable at most sites that have long-term data collection and is otherwise non-existent from many streams within the basin. Parameters that should be considered include: major ions and ion ratios, pH, temperature, trace metals and diurnal variations in DO.
- Additional water quality sites in tributaries and locations with no current water quality monitoring but with flows that frequently reach zero.
- Development of models at sites with existing information to predict conditions at extremely low flows.
- Collection of biological and habitat data at extremely low flows to document ecological condition within the stream.

The TCEQ Clean Rivers Program is a good starting point to investigate relative to potential resources associated with subsistence flow studies/monitoring.

Base flows - The main issue surrounding base flows appears to be the ecological linkage of biological organisms to stream flow. Ideas for discussion could include:

- Quantification of available aquatic habitat at a variety of instream flows. Similar to SB2 studies, but on a site by site basis and focused on specific indicators.
- Establishment of an ecological linkage to flow for selected indicators. Even when a quantification of aquatic habitat can be made as proposed for SB2 studies or suggested in the previous bullet, the question remains as to what that amount of habitat really means ecologically, and how much of that habitat is really needed to protect the aquatic assemblage present. One potential strategy would be to study several levels of base flow in an attempt to document specific ecological linkages. As highlighted in both BBEST reports completed to date, some ecological linkages are known. A simple example of a known linkage is: if no riffle habitat is available in the system, little or no spawning or reproduction will occur for species that require riffle habitat to spawn. What is unknown is how much of that riffle habitat is necessary to maintain the population of that aquatic

species in a healthy state (5%, 10%, or 90%?). It may require longer term surveys and more detailed analyses to answer these questions.

- Evaluation of the role of intra- and inter-annual variability. The basic question is: Are different base flow levels really necessary? Could one average base level or something else be sufficient? Potential surveys could include detailed biological sampling for both fish and macroinvertebrates coupled with detailed habitat data collection (including physical habitat and water quality) over a range of flows and seasons. An assessment of geomorphology and riparian health would also be valuable components to this type of survey. Again, answers to this question may require longer term surveys.

The TIFP SB2 studies and academic research projects are examples of on-going programs that might assist with answering these types of questions.

Pulse and Overbank flows – A key question is: what is the ecological role of high flow pulses and overbank flows for the instream aquatic community and adjacent riparian community? Ideas for discussion could include:

- Evaluation of before and after ecological conditions for a series of flow pulse magnitudes and durations. Potential studies would likely need to include instream habitat and aquatic sampling, geomorphologic sampling, and riparian assessments. A seasonal component would also be important to document in this study effort.
- Specifically to overbank flows would be documentation of the ecological linkage to backwater/oxbow areas that are connected by these flow magnitudes and durations.

Similar to base flows, it appears that TIFP SB2 studies and academic research projects would be good starting points to investigate potential cost-sharing opportunities.

While each component flow identified in the TIFP might comprise a hydroclimatological condition to be sought in a focused research study as suggested above, the caution laid out in Section 4.0 about the inability of data collection in nature to design the conditions for measurement must be borne in mind. Data collection protocols and analysis methods can be specified for each of the above, but in reality the data collection generally must be carried out under the conditions actually encountered, especially if automated measurement equipment is used, and analyzed after the fact. Such data should be evaluated for ecosystem responses to the full spectrum of streamflow, even if some of these conditions are of less immediate concern in the flow recommendation. To this end, the data-collection design should include sufficient hydrologic (and, if warranted, hydraulic) measurement to support determination of ecosystem responses. This may necessitate supplemental equipment, such as automated water-level recording in ungaged drainageways.

5.2 Bays and Estuaries

A basic question for the bays and estuaries inflow regimes may be: have key ecological components of the estuaries been adequately identified and sufficiently inventoried over time? If not, the work plan may consider field efforts to document important marsh areas, oyster reefs, or benthic communities. Another key question for the bays and estuaries is: whether variability of flows (i.e., low, moderate, and high) or seasonality of flows are needed in a particular bay system to maintain ecological health or is an annual or monthly volume of water met at some frequency level sufficient to provide a sound ecological environment? Ideas for discussion could include:

- Evaluating the ecological conditions of the bay over a range of freshwater inflow conditions.
- Conducting targeted before and after studies to evaluate the response time of marshes, benthos, and/or oyster reefs to freshwater inflow. These organisms are fixed in place and cannot move when salinity conditions change.
- Examining year-to-year differences for ecological indicator response to the wet and dry cycles along the Texas coast.
- Improved or more rigorous determination of inflows from nongaged segments of the estuary watershed.

With respect to the first suggested topic, the TPWD coastal fisheries database is an example of a data set accumulated over a long period of time under a range of inflow conditions. However, caution is urged because this data set was designed for a different purpose and uses random sampling to estimate bay-wide, long-term trends, not relationships along salinity gradients within bays. The inability to confidently extract flow to ecological relationships from that data set, leads one to question whether the environmental flows focus should be on other more specific animal or plant communities (e.g., benthic invertebrates or phytoplankton), habitat types (e.g. marshes, oyster reefs) or on sampling the bay along known salinity gradients, rather than an overall bay sampling approach that is provided by the probabilistic sampling design employed by TPWD. Also, the TPWD fisheries database focuses on mobile fauna, and adult fauna, which might not be as responsive to flows as sessile fauna and flora, primary producers or filter feeders, or juvenile stages that have an estuarine-dependent life cycle.

Another open question is: whether the current supply of sediment is sufficient to maintain the existing marsh and shallow water habitat features in bays and estuaries? Ideas to consider for addressing this question might be:

- Tracking the changes in physical habitats in bay systems over a suitable period, taking into account changes in relative sea level.
- Estimating the pre-development contribution of sediment and quantifying the existing sediment contribution of major and minor streams flowing to the bays and estuaries.

- Evaluating guidelines and approximate costs for constructing habitat features that might be needed to mitigate for impacts of new projects.

Similar to sediment input, a key bay and estuary issue is whether the recommended freshwater inflow regime for a particular system provides the needed supply of nutrients, primarily nitrogen, to sustain a level of productivity that may be needed to maintain a sound ecological environment that is appropriate for that system. Items for discussion could include:

- Estimating the nutrient supplies to the bays and estuaries that existed in a natural condition.
- Quantifying the current nutrient loads supplied by river inflows and assessing the current levels of indicators of primary production.

Several on-going programs exist on both the federal and state level relative to bays and estuaries studies/monitoring. The BBASC may consider coordination or collaboration with the TWDB/TPWD Bays and Estuaries Program, TPWD Coastal Fisheries program, Dermo Watch Program, National Estuary Programs and their State counterparts, other state agencies (e.g., TCEQ, Texas Department of State Health Services), river authorities, or academic research initiatives. Additionally, should habitat restoration be considered, the BBASC may consider discussions with the USACE because of their extensive project experience involving mitigation plans. Depending on the basin, there will likely be a range of issues for consideration that the BBASC in conjunction with the BBEST may need to evaluate in the development of a basin-specific work plan.

6.0 SCHEDULE

Activities described in Section 5.0 could have different schedules based on the goal of the activity recommended and a phased timeline should be developed. Specific research studies or survey activities will likely be very focused on flow-response relationships, some with a short time-frame with others requiring much longer data collection periods. Long-term monitoring will be on-going with a schedule of data collection to be outlined in the work plan. Validation activities will occur periodically as specified in the work plan. SB3 states that review activities are, “*to occur at least once every 10 years*”. The BBEST or the BBASC may specify a shorter period, especially to deal with critical uncertainties in the flow recommendations because if these issues are not resolved, then the review of flow recommendations in the future will still be limited by the same data gaps that exist today. An evaluation of the standards and implementation strategies is anticipated to be a continuing process, as it may take decades to gather the appropriate data sets to fully assess success of the recommended flow regimes to protect ecological soundness (e.g., validation of implementation strategies).

APPENDIX A - SAC WORKPLAN QUESTIONNAIRE

3-31-2010

Questionnaire for State, Federal, Local, and Academic programs to assist the Senate Bill 3 Work Plan development process.

The Texas Environmental Flows Science Advisory Committee (SAC) respectfully requests your participation in a brief questionnaire regarding Work Plan development under Senate Bill 3 (SB3). Each Basin and Bay Area Stakeholders Committee, with assistance from their Basin and Bay Expert Science Teams, are required to develop a "work plan" for their basin/bay system that includes prescribing various monitoring, studies and other activities to help review, validate, or refine the basin/bay environmental flow analyses and flow regime recommendations, and the environmental flow standards and strategies adopted by the TCEQ. It is anticipated that basin/bay groups may have interest in obtaining more system-specific information on such topics as river hydrology, flow/ecology relationships for instream and estuarine bioindicators species/salinity relationships, water quality, geomorphology, etc. The SAC is interested in exploring options for maximizing synergy from various on-going or upcoming programs as they might relate to data, analysis, or other aspects of environmental flows. The specific language in SB3 regarding the "**work plan**" is presented below, followed by a short list of questions that will better inform work plan guidance being considered by the SAC.

*Section 11.02362 (p) In recognition of the importance of adaptive management, after submitting its recommendations regarding environmental flow standards and strategies to meet the environmental flow standards to the commission, each basin and bay area stakeholders committee, with the assistance of the pertinent basin and bay expert science team, shall prepare and submit for approval by the advisory group a **work plan**. The **work plan** must:*

- (4) establish a periodic review of the basin and bay environmental flow analyses and environmental flow regime recommendations, environmental flow standards, and strategies, to occur at least once every 10 years;*
- (5) prescribe specific monitoring, studies, and activities; and*
- (6) establish a schedule for continuing the validation or refinement of the basin and bay environmental flow analyses and environmental flow regime recommendations, the environmental flow standards adopted by the commission, and the strategies to achieve those standards.*

Questions:

- A) What on-going or future sampling, monitoring, intensive study programs, or projects do you have that might be useful for the basin/bay groups to know about as they formulate their work plans? What is the purpose of those programs?
- B) Are you considering changing or evolving any of your current programs in a direction that might link them more closely to environmental flow analysis? If so, what changes are you considering that might be of interest to the basin/bay groups as they formulate their work plans? If not, does the opportunity of contributing to

implementation of basin/bay work plans raise your interest in such change or evolution?

- C) What barriers are you encountering to expand program elements, particularly as they might relate to information useful for the basin/bay work plans on environmental flows?

Please respond via email to SAC Chairman Robert Huston (bandshuston@sbcglobal.net) and SAC member Ed Oborny (eoborny@bio-west.com) prior to Monday, April 12th. The SAC thanks you in advance for your participation with this important statewide environmental initiative.

APPENDIX B – RESPONSES TO SAC WORKPLAN QUESTIONNAIRE

Information to Assist Work Plan Development Guidance Prepared by the Texas Water Development Board for the Texas Environmental Flows Science Advisory Committee

The information below is being provided to the Texas Environmental Flows Science Advisory Committee (SAC) in response to questions seeking to inform work plan guidance being considered by the SAC.

A) What on-going or future sampling, monitoring, intensive study programs or projects do you have that might be useful for the basin/bay groups to know about as they formulate their work plans? What is the purpose of those programs.

Streamflow and Reservoir Data

TWDB partners with the United States' Geological Survey annually through a cooperative contract to collect statewide streamflow and reservoir monitoring data. In FY 2010, the total cost of the State-Federal Cooperative Program for Water Resources Investigations for stream gaging was \$1,613,775. Of this amount, Texas Water Development Board (TWDB) is credited with paying \$963,555 (60 percent) and the U.S. Geological Survey (USGS) paid the rest. The program pays for 92 streamflow gages and 57 reservoir level gages. The program is authorized by TWC Section 16.019 which calls for TWDB to study the occurrence and quantity of surface waters in the state.

Bay and Estuary Data

Several ongoing data collection and field study efforts have been conducted in Texas' bays and estuaries for the last two decades. These are described below.

Datasonde program

TWDB has collected continuous water quality data at multiple sites in Texas' estuaries since 1986. The parameters monitored include temperature, pH, dissolved oxygen, salinity, conductivity, and others. Not all parameters are available at all sites. See: [datahttp://midgewater.twdb.state.tx.us/bays_estuaries/sondpage.html#data](http://midgewater.twdb.state.tx.us/bays_estuaries/sondpage.html#data) for more details. The purpose of this program is to provide long-term monitoring and to support model development and analyses of Texas' bays and estuaries. Funding for this program has been provided by TWDB's Research and Planning Fund (described below). In 2010, TWDB committed \$60,500 for this effort. This effort is authorized by several section of the Texas Water Code, including Sections 11.1491, 16.012, and 16.058.

Field studies

Synoptic, short-term field studies as well as longer term data collection efforts have been conducted by TWDB since the 1980's in all of Texas' major and minor bays. The

focus of current studies is now on Texas' minor estuaries. Data is now being collected in the San Bernard Estuary, the Brazos Estuary, and the Rio Grande Estuary. The purpose of these studies is to support model development and analyses of Texas' bays and estuaries.

Data for studies conducted as far back as 1987 is available at:

http://midgewater.twdb.state.tx.us/bays_estuaries/surveypage.html

Data for other studies is available on request to TWDB. Parameters monitored include temperature, pH, dissolved oxygen, salinity, conductivity, velocity, water level, flowrate, and some meteorological parameters. Not all parameters are available at all sites.

Tide-gage

TWDB has contributed financial support to the Texas Coastal Ocean Observation Network (TCOON) since 1991 for the collection of water levels (tides) at multiple sites on the Texas coast. In 2010, TWDB provided \$55,000 from the Board's Research and Planning Fund for this effort.

Other Targeted Studies

TWDB Research and Planning Fund

TWDB provided \$671,139 in both FY09 and FY10 from its Research and Planning Fund to support a wide range of environmental monitoring and studies. In addition to supporting the Datasonde Program, field studies, and tide-gage monitoring program described above, this fund also supports targeted environmental studies for both instream flows, including SB2 studies, and bays and estuaries. The purpose of these studies is to fill in identified data and knowledge gaps and to enhance our modeling and analysis capabilities in support of environmental flows development. Topics funded in FY09 and FY10 include:

FY09

- (a) Coast-wide bay water quality monitoring (Ddatasonde Program) (\$46,000)
- (b) Tide monitoring for bays and estuaries (TCOON) (\$50,000)
- (c) Automated monitoring of salinity in the Lower Laguna Madre and nearshore Gulf of Mexico (\$33,170)
- (d) Gulf inlet monitoring at Aransas Pass (\$10,000)
- (e) Rio Grande Estuary water quality monitoring (\$20,000)
- (f) Applicability of Surface Water Assessment Tool as a rainfall-runoff model (\$35,000)
- (g) Developing, testing, and comparing UTBEST hydrodynamic model code (\$30,000)
- (h) Developing, testing, and comparing FVCOM hydrodynamic model code (\$25,000)
- (i) Developing, testing, and comparing SELFE hydrodynamic model code (\$25,000)
- (j) Data collection and analysis of benthic communities in response to wet versus dry climatological conditions and freshwater inflow in Guadalupe Estuary (\$20,000)

- (k) Phytoplankton responses to freshwater inflow in Galveston Bay (\$34,000)
- (l) Trinity River nutrient load study (\$37,400)
- (m) Implementing and further developing a statewide Hydrologic Information System to analyze and disseminate data related to the state's water resources (\$95,480)
- (n) Investigating flow induced channel changes on the Middle and Lower Brazos River (\$40,000)
- (o) Developing a tool to assess the impact of flow regimes on sediment movement through reaches of the Lower San Antonio River (\$35,000)
- (p) Identifying the influence of flows on formation and maintenance of geomorphic units of the Lower San Antonio River (\$35,000)
- (q) Facilitating public/stakeholder meetings and process development within the San Antonio, Sabine, and Brazos River basins (\$75,090)
- (r) Development of communication tools and outreach to public/stakeholders within the San Antonio, Sabine and Brazos River basins (\$24,999)

FY10

- (a) Coast-wide bay water quality monitoring (Datasonde Program) (\$60,500)
- (b) Tide monitoring for bays and estuaries (TCOON) (\$55,000)
- (c) Gulf inlet monitoring at Aransas Pass (\$10,000)
- (d) Rio Grande Estuary water quality monitoring (\$20,000)
- (e) Surface Water Assessment Tool (SWAT) Model Study, Phase II (\$35,000)
- (f) Field study of decoupled surface-channel flows in Corpus Christi Bay (\$30,000)
- (g) Coast-wide numerical grid and hydrodynamic model development (\$30,000)
- (h) Guadalupe Estuary benthic monitoring (\$31,070)
- (i) Phytoplankton response to freshwater inflows in Galveston Bay (\$18,000)
- (j) Trinity River nutrient and sediment load study (\$15,000)
- (k) Validating a quantitative real-time Polymerase Chain Reaction (PCR) method to detect Dermo (\$31,000)
- (l) Radio tracking of blue sucker in lower Sabine River sub-basin (\$75,000)
- (m) Riparian connectivity along the Brazos and San Antonio rivers (\$35,000)
- (n) Riparian connectivity along the Sabine River (\$30,000)
- (o) Geomorphic unit mapping on the Sabine River (\$40,000)
- (p) Geomorphic unit mapping on the San Antonio River (\$45,000)
- (q) Channel avulsion processes in San Antonio River/Elm Bayou area (\$48,000)
- (r) Woody debris assessment in San Antonio River/Elm Bayou area (\$25,000)
- (s) Assistance in development of the Texas Instream Flow Program (\$37,569)

USACE Texas Water Allocation Assistance Fund (TWAA)

The U.S. Corps of Engineers' TWAA fund has been used to support some environmental studies. The primary purpose of this fund is to support implementation of water planning strategies. Environmental studies supported with TWAA funds include:

FY09

- (a) Impacts of severe droughts on estuaries (\$60,000)
- (b) Blue sucker studies (\$150,000)

- (c) Geomorphic studies on the Brazos River (\$75,000)
- (d) Riparian studies on Brazos and San Antonio Rivers (\$70,000)
- (e) Geomorphic studies on the Lower Sabine River (\$52,000)

FY10

- (a) Insream flow study for Allens Creek project. (\$250,000)

B) Are you considering changing or evolving current programs to more closely link them to environmental flow analyses? What changes are you considering?

TWDB is interested in identifying monitoring or special studies that would benefit SB2, SB3 and other ongoing priorities.

C) What barriers are you encountering to expand program elements?

Funding remains the critical issue. Funding provided by the Board's Research and Planning Fund is subject to change. In addition, these funds are used to support long term monitoring as well as special studies, making it difficult to expand one effort without impacting the other. TWAA funds are also variable from year to year and there is no guarantee that this source of funding will continue in the future.

TPWD Responses to SAC Questions April 12, 2010

As the state agency responsible for protection of state fish and wildlife resources, Texas Parks and Wildlife Department is committed to supporting the environmental flow process as set forth by Senate Bill 3. The recently published "*Land and Water Resources Conservation and Recreation Plan*" includes overarching goals consistent with the SB3 goals. Following are descriptions of selected resource monitoring programs currently ongoing at TPWD and responses to SAC questions regarding those programs.

Questions:

A) What on-going or future sampling, monitoring, intensive study programs, or projects do you have that might be useful for the basin/bay groups to know about as they formulate their work plans? What is the purpose of those programs?

1.) TPWD/TWDB Bays and Estuaries Study Program

In response to Senate Bill 137 (1975), House Bill 2 (1985), Senate Bill 683 (1987), Senate Bill 1 (1997), and other legislative directives, the Texas Water Development Board (TWDB), the Texas Parks & Wildlife Department (TPWD), and the Texas Commission on Environmental Quality (TCEQ) have jointly established and maintained a data collection and analytical study program focused on determining the effects of and needs for freshwater inflows to the state's bays and estuaries. TWDB is the lead agency on freshwater inflow intensive surveys designed to collect physical measurements (water level, velocity, etc.) of the bays and the mixing of fresh and seawater within them for modeling purposes. They include both short-term intensive inflow studies and longer-term water quality and tide gaging data collection efforts conducted by the TWDB and contracted to other agencies or universities.

2.) Coastal Fisheries Resource Monitoring Data Program

Beginning in 1975, TPWD has conducted resource monitoring in Texas bays and Gulf of Mexico (TTS) to study the supply, economic value, environment and breeding habits of finfish, shrimp and oysters. TPWD Coastal Fisheries Division employees a scientifically sound method that incorporates stratified random sampling to independently monitor trends in species composition, distribution, size and relative abundance. Following are the gear types and number of samples collected:

- Gill nets (Spring/Fall, 45 per season/bay=780/year). Shoreline, adult and sub-adult finfish, blue crabs.
- Bay trawls (1,680/year). Open bay, juvenile and sub-adult finfish and invertebrates.
- Gulf trawls (16/month/Gulf area =960/year). Open Gulf, TTS, juvenile and sub-adult finfish and invertebrates.
- Bag seines (10-20/month/bay=160/year). Shoreline, juvenile finfish and invertebrates.
- Oyster dredges (20-30/month/bay =1,200/year). Oyster reefs, oysters.
- Total—6,780/year.

For each sample the following parameters are recorded:

- All organisms identified to species and counted.
- Lengths of up to 19 individuals per species.
- Date, latitude-longitude of sample location.
- Water temperature (°C).
- Salinity (‰).
- Dissolved oxygen (ppm).
- Turbidity (NTU).
- Depth (m).

3.) Coastal Fisheries Tidal Stream Studies

(Last portion of sampling Texas tidal streams-Arroyo Colorado and Rio Grande, funds from pass through funds from TCEQ, to be finished Nov. 2013.)

The initial tidal stream Use Attainability Analysis (UAA) study began in 2003 to collect data supporting the development of a standardized methodology for assessing ecosystem health and assigning site-specific uses and criteria within tidally influenced portions of streams. The UAA study sampled streams on the upper Texas coast (Cow Bayou and Lost River), as well as the mid coast (Tres Palacios, West Carancahua and Garcitas Creek). Dissolved oxygen has been shown to be a significant factor in structuring the biological components of ecosystems within freshwater. While dissolved oxygen is also recognized to be an important factor within tidally influenced waterbodies, some of the differences in the indicators of ecosystem health primarily involved upstream – downstream gradients that were more closely related to salinity structure. The initial UAA study introduced a new assessment methodology to integrate the physical, chemical, and biological components of ecosystem health and this methodology will be applied to the Arroyo Colorado Tidal and the Rio Grande River Tidal.

4.) Coastal Fisheries Dermo Program-

In previous years, TPWD has collected oyster samples with corresponding water salinity and temperature from various upper Coast bays: San Antonio, Matagorda, Galveston and Sabine Lake). These samples have been analyzed by Dr. Sammy Ray to determine the levels of Dermo (*Perkinsus marinus*) infection. Dr Ray has maintained the historical dataset as far back as 1998, which includes all Dermo data from the Gulf of Mexico on a website (www.oystersentinel.org).

Because the current histological technique for determining Dermo incidence is highly dependent upon the expertise of the person reading the histological slides, this was identified as critical need to address for the future of the Dermo program. Recognizing this certainty and the impact to the efficacy of using historical data, the TWDB Research and Planning Fund Project contracted with Texas Parks and Wildlife Department (TPWD) in Nov 2009 to parallel test a newer quantitative method to the traditional method. Having comparable values between the two methodologies will allow for a shift in techniques and still maintain the ability to utilize historical data for future assessments.

This project will provide:

- Correlation of results for both methodologies (and historical Mackin Scale Intensity)
- Recommendations for future sampling methodologies (e.g., sample size, frequency) and discussion of long-term monitoring needs with respect to Dermo infection as a variable for consideration.
- Correlation between the historical data with the rapid assessment method in a monitoring program, as an index of condition of the ecological condition of the estuary under varying rates of freshwater inflow.
- Discussion of long-term monitoring needs with respect to Dermo infection as a variable for consideration.
- Recommendations for a monitoring program to track Dermo incidence and level of infection in Texas oysters as it relates freshwater inflows which could serve as the beginnings of a suite of sampling programs aimed at monitoring freshwater inflow effects.

5.) Coastal Fisheries Rapid Habitat Assessment Program

(Base line data: Wetland plant composition along a salinity gradient within Matagorda Bay--just beginning and to be finished by Aug 2011)

Wetlands within the Matagorda Bay ecosystem are under constant threat from human-induced (development, freshwater diversion, species introduction, etc.) and natural disturbances (climate change, sea level rise, etc.). Obtaining baseline knowledge of current wetland conditions will allow resource managers to better understand how these changes are affecting their plant communities.

Using three transects along a salinity gradient, from fresh to saline marshes, TPWD will document how native plant communities are affected by invasive plants and salinity changes. The ultimate purpose of this project is to begin to determine baseline conditions in Matagorda Bay marshes. The data collected will be used to determine what factors govern zonation in Texas marshes and to determine if these variables can be translated into parameters that can be used to recommend freshwater inflows that are needed to maintain present vegetative community types. Since this project will provide baseline data, these field sites can be revisited and used to monitor the effects of existing and future freshwater inflow management regimes and/or the effectiveness of invasive species management. As an assessment is made about rate of spread of invasives, eradication steps will be determined and additional funds solicited to initiate eradication.

6.) Coastal Fisheries Ambient Bay Water Quality Monitoring Project-

This is a datasonde project (funded as state pass through funds from TWDB to TPWD)-has been ongoing for a number of years and has expanded to the lower Laguna Madre and other sites within Ecosystems (Aransas and San Antonio Bay). Currently there are a minimum of 14 long-term datasonde sites (2 Sabine Lake, 5 Galveston Bay, 2 Matagorda bay, 1 San Antonio Bay, 1 Corpus Christi bay, 1 upper Laguna Madre), 2 short term datasonde site (San Bernard River area, Cedar Lakes) and 2 new sites (lower Laguna Madre). These sites have datasondes that are capable of continuous water quality measurement in situ. The data is used for freshwater inflow needs for these systems.

7.) Coastal Fisheries Rollover Pass project-

(Monitoring for Porewater Salinity and Marsh Changes with the Closure of Rollover Pass-planned to begin summer 2010 and cover a pre- and post- closure sampling period.)

Currently, The Texas GLO has an application to close Rollover Pass. In preparation of this possible closure, in a partnership with USFWS, TPWD proposes to monitor the following in the East Bay system including Oyster Bayou, East Bay Bayou, and Rollover Bay:

- changes in water salinity in tidal bayous,
- pore-water salinity of adjacent intertidal wetland sediments,
- plant cover and diversity.

Monitoring salinity changes within the two tidal bayous and Rollover Bay will provide an opportunity to compare potential changes with historical trends for these three sites. Monitoring the salinity of sediment pore-water in the intertidal emergent marshes of East Bay Bayou will provide an important assessment of the environmental factors that influence plant growth and species composition in what is currently considered an estuarine salt marsh system. This in conjunction with datasonde near Rollover Pass will allow for better correlation with local pass salinity changes with those in system.

8.) Inland Fisheries Standardized Reservoir Monitoring

Inland Fisheries staff conducts standardized monitoring of reservoir habitat, vegetation, and sport fish populations throughout the state. During a recent year, that comprised fisheries surveys on 167 reservoirs totaling 1.227 million surface acres. Creel surveys were completed on 30 reservoirs; habitat surveys on 25; and vegetation surveys on 69.

9.) Inland Fisheries Heart of the Hills Science Center Research Programs

Staff at Heart of the Hills Fisheries Science Center is working on the following projects:

1. Year Class Strength + Modeling -- These studies attempt to describe how water management plans, through their effects on reservoir water level, create predictable variation in sport fisheries among Colorado River basin reservoirs.
2. Reservoir fish habitat and angler access -- Modeled availability of reservoir fish habitat and angler access under current and future hydrologic scenarios in the Colorado River basin; used modified LCRA WAM models.

3. River-reservoir transition zones -- This new study attempts to define critical connections between Colorado River basin reservoirs and tributary river segments regulating population dynamics of species' that use both habitats during their life history.
4. Telemetry of Alligator gar and Striped bass in the Lower Trinity River -- This study uses telemetry to monitor seasonal movements and habitat use by adult alligator gar and striped bass in the Trinity River downstream of Livingston Dam. Hydrologic and bathymetric data are being collected for their potential to explain movement, habitat use, and effect of proposed changes in dam operations.

10.) Inland Fisheries River Studies Program

The River Studies Program is the Department's lead on instream flow assessments and implementation of the Texas Instream Flow Program. River Studies also implements long-term studies to provide data from large geographic areas to address broad scale policy and regulatory issues. Special studies are also performed in response to proposed projects that may alter flow regimes, habitat, and/or water quality. Projects include:

1. Assessments of instream flow needs on the lower San Antonio, middle and lower Brazos, and lower Sabine rivers. Participation in spring flow assessments at Comal and San Marcos springs.
2. Ongoing development of biotic and habitat indices for assessment of fish assemblage and aquatic ecosystem health.
3. Large scale synoptic studies sampling streams on an ecoregional basis. This has included a study of least disturbed wadeable streams in the state, another project focusing on wadeable streams in the three eastern Texas ecoregions, and most recently, sampling larger order systems as part of the National River and Stream Assessment, a nationwide USEPA study.
4. Cooperatively participate with TCEQ in UAAs and other water quality assessments. This has been conducted on an as-needed basis since 1987.

11.) State Wildlife Grants

The Department funds, through State Wildlife Grants, research projects that complement environmental flow programs. Ongoing projects include the Digital Fish Atlas, a web-based survey of fish experts to develop habitat suitability criteria for Texas fishes, and a flow and salinity-based population dynamics model of prairie stream fishes in the upper Brazos River.

12.) GIS Lab Texas Ecological Systems Database Project

The goals of this statewide project are to increase resolution of remotely-sensed land cover mapping for Texas and to use field data to validate the project. The project schedule is shown below. Terrestrial vegetation that will be mapped includes wetlands and riparian areas along rivers and streams. An inundation analysis conducted for the Sabine/Neches BBEST relied upon the classification maps to develop relationships between overbanking events and riparian habitat area inundated. An interpretive booklet contains full metadata for each phase. Data files and additional information are located at:

<http://www.tpwd.state.tx.us/landwater/land/maps/gis/tescp/index.phtml>

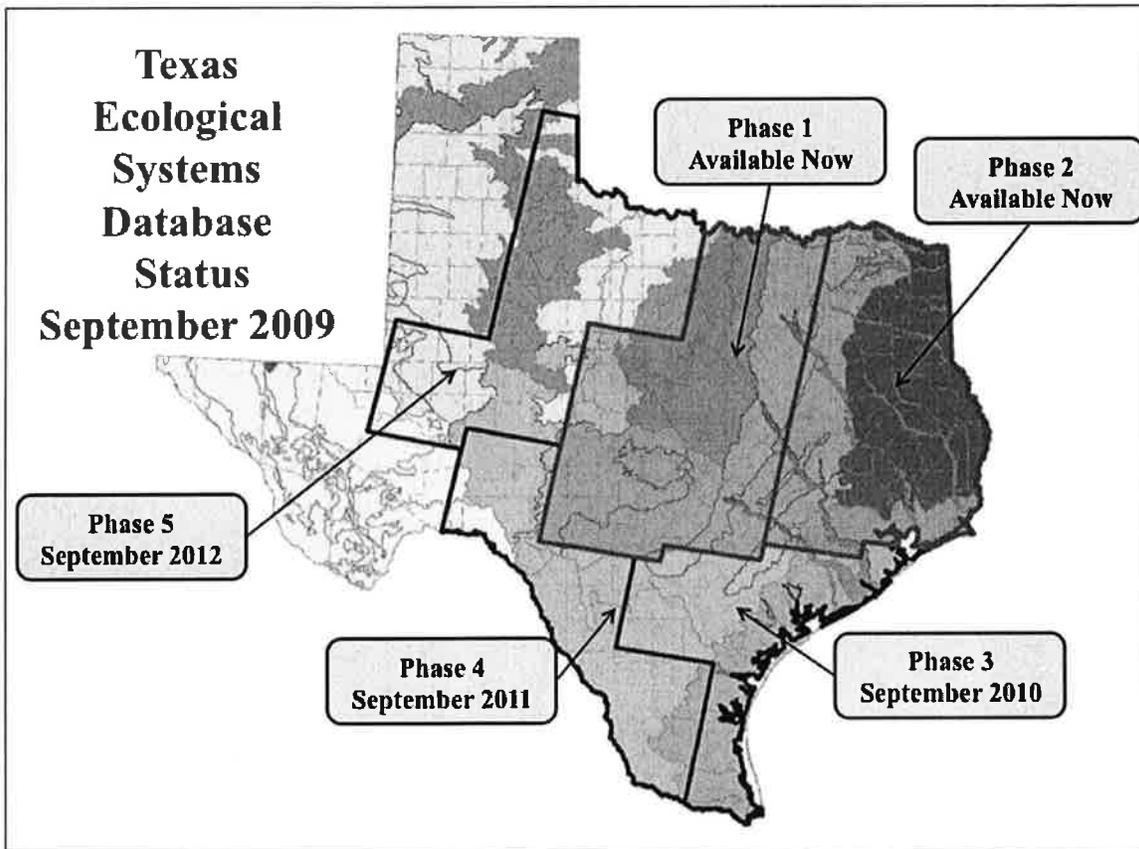


Figure 1. Schedule for completion of the Ecological Systems Database.

B) Are you considering changing or evolving any of your current programs in a direction that might link them more closely to environmental flow analysis? If so, what changes are you considering that might be of interest to the basin/bay groups as they formulate their work plans? If not, does the opportunity of contributing to implementation of basin/bay work plans raise your interest in such change or evolution?

Many of our current programs do link closely with environmental flow analysis and our staff is encouraged to focus on projects (as those mentioned above) that will assist in identifying instream flow and freshwater inflow needs, water quality needs as well as ecosystem responses to proposed projects/flow alteration. The TPWD/TWDB Bay and Estuary Study Program, in particular, is interested in SAC input regarding future program direction.

TPWD has no current plans to alter ongoing long term monitoring programs like the Coastal Fisheries Resource Monitoring program sampling from the current format given our long time series and our need for the information on our targeted species. We will continue to look for funding sources to provide additional data as needed and remain receptive to recommended changes.

C) What barriers are you encountering to expand program elements, particularly as they might relate to information useful for the basin/bay work plans on environmental flows?

The most obvious barriers TPWD faces are funding and FTE restrictions, as well as agreement in the community regarding what would be the target of any additional monitoring. Other potential issues include:

- Changing priorities;
- With the Dermo project, because of the proactive contract between TWDB and TPWD to correlate results of two methodologies to utilize historical data, the one concern of not maintaining consistent methodologies to compare long-term Dermo data has been addressed. However, the future of this sampling program has not been decided nor what the sampling program consist of (e.g., who will shepherd this program with a scientifically valid sampling regime, maintain the website, expand more routine sampling, development of several committed partners).
- Rapid Habitat Assessment- project is temporary with funds lasting until Aug 2011, depending upon the success of this project, it could be expanded.
- Rollover Pass-this is a temporarily funded project and problems with continuing this would include loss of equipment, extended period before closure of the pass (therefore no post closure data) and the need for additional or other sites for documenting any impact.
- Ambient Bay Water Quality Monitoring Project- the monitoring is long-term, but the contract with TPWD is yearly. Continuation of this work will depend upon the ability for TPWD to do the work with these funds (and existing staff) or whether TWDB will be able to subcontract the work elsewhere, at the same or reduced effort.
- Tidal Streams work-temporary and should be finished Nov. 2013.

TCEQ Responses to SAC Questions:

A) What on-going or future sampling, monitoring, intensive study programs, or projects do you have that might be useful for the basin/bay groups to know about as they formulate their work plans? What is the purpose of those programs?

- **Texas Instream Flow Program (TIFP):** The primary objective of the program is to determine the amount of water required to maintain a healthy river (sound ecological environment). All TIFP sampling would be potentially useful for reference in work plan formulation.
- **Clean Rivers Program (CRP):** Each CRP regional water authority, in collaboration with TCEQ region office staff, conducts and coordinates regular (monthly or quarterly) sampling of physical and chemical constituents (typically flow, nutrients, DO, pH, specific conductance, temperature, chlorophyll *a*, TSS, and indicator bacteria) in all the major rivers and reservoirs of the state. In addition, many small streams are also sampled on a regular basis. On a less frequent basis, sampling is conducted for biological assemblages and metals/organics in water and sediment. Additional intensive study sampling may be conducted if funding is available. Many intensive studies were conducted in the past, but due to limited funding and increased expenses, intensive studies were dropped. This program is designed to conduct monitoring, assess water quality, and inform stakeholders so that recommendations can be made for future action. The main purpose of this program is to provide quality-assured surface water quality data to the TCEQ for use in decision-making. In addition, the data collected is analyzed by the regional water authorities to inform the stakeholders of water quality conditions within their basin(s). The main TCEQ use that the program has been supporting is the Clean Water Act Section 305(b) Assessment and Section 303(d) List of Impaired Waters, in addition to providing data in support of Water Quality Standards development.
- **Surface Water Quality Monitoring Program (SWQM):** The SWQM Program works with the TCEQ Clean Rivers Program staff to coordinate and oversee the routine monitoring schedule for the state. This monitoring includes quarterly sampling at approximately 1700 stations throughout the State. The resulting data are intended to provide information on ambient water quality. The SWQM Program also implements a biological monitoring program to collect data to characterize the ecological condition of freshwater streams and rivers. This program also supports the development of site-specific water quality standards. The SWQM Program also participates in a national effort that implements probabilistic surveys to determine the condition of rivers, streams, lakes, estuaries and wetlands. The SWQM Program coordinates the continuous water quality

network which serves to provide a continuous record of field parameters at approximately 70 sites around the State.

- **Total Maximum Daily Load Program (TMDL):** The purpose of the TMDL program is to resolve water quality problems that cause a water body to be listed on the list of impaired waters (303(d) list). The program will conduct water quality sampling to determine the maximum amount of a contaminant that is permissible and sets limits on categories of sources of that pollutant. Following that, the program will assist stakeholders in the affected watershed in developing a plan to improve water quality. The attached spreadsheet lists the current TMDL projects that are or will be conducting water quality sampling.
- **Nonpoint Source Pollution Program (NPS):** The TCEQ Nonpoint Source Program current list of projects under contract in Senate Bill 3 basins is attached.
- **Water Quality Standards Program (WQS):** The TCEQ Water Quality Standards Group develops the Texas Surface Water Quality Standards (30 TAC §307.1-307.10), which define the water quality uses and appropriate “instream” criteria for the streams, rivers, lakes, reservoirs, and estuaries in the state. The TCEQ Water Quality Standards Group conducts aquatic life and recreational use-attainability analysis (UAA) and other standards development projects. On-going and future projects include numerous aquatic life and recreational UAAs, and the development of numerical nutrient criteria for reservoirs, streams, rivers, and estuaries. These projects are used to develop water quality uses and criteria that are incorporated into the Texas Surface Water Quality Standards. For assigning and assessing aquatic life uses in streams both the Water Quality Standards Group and the Surface Water Quality Monitoring Team apply indices of biological integrity to fish and invertebrates data to define aquatic life use categories. These indices are regionalized for fish and the indices have been developed over a number of years in coordination with Texas Parks and Wildlife. Habitat surveys are also included in UAA sampling studies. Attached is a list of the WQS Group's 2010 projects. WQS projects are also located with other TCEQ water program projects on the Coordinated Monitoring website under “Special Projects” at: <http://cms.lcra.org>.
- **Water Rights Permitting and Availability Section Projects:**
 - Environmental Flows Information System: This is a continuation of work performed in FY08-09, a comprehensive data repository system will be tested, finalized, and deployed which makes environmental data available in a consistent and accessible format.

- Texas Digital Fish Atlas: This is the continuation of an effort to build a comprehensive, fully geo-referenced and quality-checked database of specimen-vouchered fish occurrence data in Texas.
- Determination and Validation of Hydrology Based Flow Regimes Using a Workflow Process: This is a continuation of previous work to refine methods to geo-spatially select gages, import web based USGS gage flow information for those gages into existing environmental flow regime tools, validate and perform calculations on the outputs, and incorporate the tools, data, and calculations into a workflow process.
- Modeling Complex Water Management Strategies and Instream Flow Requirements: This is a continuation of previous work to investigate and facilitate the modeling of complex instream flow regimes.

B) Are you considering changing or evolving any of your current programs in a direction that might link them more closely to environmental flow analysis? If so, what changes are you considering that might be of interest to the basin/bay groups as they formulate their work plans? If not, does the opportunity of contributing to implementation of basin/bay work plans raise your interest in such change or evolution?

- **TIFP:** The TIFP is designed to develop site-specific flow recommendations for the priority river segments outlined in the Technical Overview Document. The development of these recommendations and instream flow criteria will directly support the adaptive management component of SB3.
- **CRP:** The possibility of changing or evolving the program to support other water quality needs is one of the objectives outlined for our program. We have not made substantial changes to our water quality monitoring program in the past, but all ideas and needs are considered when we plan our sampling for each fiscal year. Presently, we haven't considered changing our plans and it would take at least a year to re-direct our resources. We are interested in hearing about opportunities to support all agency and stakeholder needs. It would mean that other needs would be dropped, so a full discussion and understanding of what we could drop and what we could take on would need to occur. There are very limited resources in many of the basins, and often some stakeholder priorities would still need to be fulfilled.
- **SWQM:** The current water quality monitoring programs have a well defined purpose for collecting and evaluating physical, chemical, and biological data from water bodies throughout Texas. Many of these programs are defined through federal funding mechanisms that are focused on the collection of water quality data. In addition, the SWQM

program currently has limited resources to make changes to these programs and change direction.

- **TMDL:** The responsibility of the TMDL program is solely on water quality and it is not clear that the analyses and activities of the program could be applied in any manner to environmental flow analyses. There are no plans to institute changes in the program that would contribute to environmental flow analyses.
- **NPS:** Watershed Protection Plans (WPPs) are a relatively new tool being created and used by stakeholders in the State of Texas with funding from the Texas Nonpoint Source Program primarily under the CWA § 319(h) Grant. The goal of all WPPs is to ensure that the watershed of focus meets water quality standards. WPPs are holistic and therefore may address water quantity, as well. A current example of a WPP that addresses flows is the Caddo Lake Watershed Protection Plan. These plans include an initial Watershed Characterization of the quantity, along with the quality of water in the stream, river or lake of concern. Water quality and quantity data collected during the planning process is up loaded into the Surface Water Quality Information System (SWQMIS) database used by the Texas Clean Rivers and Surface Water Quality Monitoring Programs. This data may be used in the biannual state water quality assessment, the Texas Water Quality Inventory (which includes the CWQ § 305(b) Report and the 303(d)). Based on available historical and current data, a WPP is created to reduce pollutant loads by utilizing improved land and storm water management practices. WPPs may make recommendations regarding permits, water use and water treatment. However, WPPs are non-regulatory tools and therefore, do not affect decisions made regarding permits issued by the TCEQ. For non-permitted issues related to instream flows, recommendations can also be made in the WPP. After the completion of the WPP, recommended management practices not required by a permit may be funded under the CWA § 319(h) Grant Program. Relevant examples include promoting/demonstrating low impact development (LID) and brush control practices to maintain base flows, increase recharge to aquifers. LID is also a water conservation measure. The TCEQ Nonpoint Source Program is currently developing a template for WPPs. To address findings and recommendations made in Environmental Flows studies, the WPP template may be altered to include relevant flows information for applicable watersheds under future contracts.
- **WQS:** No, however, the Water Quality Standards Group is evaluating ways to make our final UAA reports more readily available to others.
- **Water Rights Permitting and Availability Section Projects:** In developing these contracts, the Water Rights Section staff works with

contractors to tailor the scopes of work to support the environmental flows process.

C) What barriers are you encountering to expand program elements, particularly as they might relate to information useful for the basin/bay work plans on environmental flows?

- **TIFP:** The study designs are developed through a stakeholder process which involves the creation of study goals, objectives and indicators. Consequently, these may not be consistent across the various priority river basins.
- **CRP:** Funding is the biggest barrier to expanding program elements. This type of work falls within the scope of the program as a whole. The secondary barrier is understanding the type, extent, amount, and overall description of the work needed/involved in providing information for developing environmental flows.
- **SWQM:** Many of the SWQM program activities are tied to federal funding sources that dictate our water quality monitoring priorities.
- **TMDL:** Regulatory requirements of the TMDL program and budget limitations preclude implementing changes in the program that would contribute to environmental flow analyses.
- **NPS:** The program focuses on water bodies that are currently not meeting the designated water quality standards due primarily to pollutant loadings associated with storm flow events. This focus is distinctly different than the low flow issues addressed by the Instream Flow Program. The connection between storm flow events and instream flows is not well established and takes a large amount of time and money to study in each individual watershed in order to make the connection. The focus of the Nonpoint Source Program at the watershed level (generally 100 sq. mi. or less) provides only a small portion of information needed for the SB3 initiative. Also, much of the data collected for WPPs is storm-flow based. Many of the best management practices utilized for improving water quality may not have data available or be utilized for water conservation, maintaining base flows, and groundwater recharge.
- **WQS:** The Water Quality Standards Group has different priorities, such as aquatic life and recreational UAAs, standards development projects, and triennial rulemaking, which make it difficult to expand program elements. One additional difficulty is that our procedures to sample and assign aquatic life uses have focused on small, unclassified "wadeable" streams. The associated techniques are often not directly transferrable to larger rivers that are frequently the concern of inflow studies. However,

the Water Quality Standards Group is evaluating ways to make our final UAA reports more readily available to others.

- **Water Rights Permitting and Availability Section Projects:** Contract terms and funding would be the only limitations.

TMDL Team Projects with On-going or Planned Monitoring

Name	Parameter of Concern	Project Manager	Project Type	Segment(s)
Atascosa River	DO	Russell Kotara	TMDL	2107
Guadalupe River Above Canyon	Bacteria	Amanda Ross	Implementation Plan	1806 0702, 0801, 0901, 1001, 1005, 1006, 1007, 1101, 1103, 1113, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2436, 2437, 2438, 2439, 2501
Houston Ship Channel/Galveston Bay System	Dioxin and PCBs	Larry Koenig	TMDL/Data Collection	0501B, 0502A, 1209J, 1209K, 1217
Lampasas & Navasota Tributaries	Bacteria	Eric Reese	Data Collection	1906
Lower Leon Creek	Bacteria and DO	Eric Reese	TMDL	2482
Nueces Bay	Zinc	Amanda Ross	Implementation Plan	2001, 2003
Tidal Streams DO II	DO	Jason Leifester	Data Collection	
Upper San Antonio River	Bacteria	Amanda Ross	Implementation Plan	1910, 1910A, 1911

TCEQ Nonpoint Source Program – Current Projects in SB3 Basins

Sabine

1. On-Site Sewage Facilities (OSSFs) upgrades in Adams and Cow Bayous- This Project will improve water quality in two tributaries of the Neches River by identifying and replacing faulty OSSFs or installing new ones where needed.

Trinity

1. Stormwater Management Program for Cedar Creek- This project will implement strategies defined in the Cedar Creek Watershed Protection Plan, specifically, by reducing the impact of stormwater runoff by best management plan (BMP) such as rainwater harvesting and erosion control measures.
2. City of Denton - Lake Lewisville- This project will select, design, and construct BMPs to implement the Hickory Creek Watershed Protection Plan (WPP).

San Jacinto

1. Bastrop Bayou Watershed Protection Plan- This project will develop a watershed protection plan that includes on the ground implementation of BMPs to reduce non-point source pollution.
2. Development of Total Maximum Daily Loads (TMDLs) - This assessment project involves the development of nine TMDLs for Upper Oyster Creek, Guadalupe River above Canyon Lake, Upper Trinity River, West Fork Trinity River below Lake Worth, Lower West Fork Trinity River, Oso Bay, and Oso Creek.
3. BMP Evaluation for the Control of Bacteria Loads in the Houston Area- This project will support the development of TMDL implementation plans in the entire Houston metro area which includes 2 major watersheds with 38 additional segments with bacteria impairments.
4. TMDL Development for Oyster Water Use Impairments on the Middle Texas Coast- This project will fund the initial phases of TMDL development for these segments including the preparation of a Quality Assurance Project Plan, initial data collection and preliminary watershed modeling.
5. TMDL Development for Fish Consumption Use Impairments in the Houston Ship Channel and Galveston Bay System- This project will fund TMDL development for Houston Ship Channel and Galveston Bay.
6. Dickinson Bayou Watershed Strategies of Growth- This project will implement portions of the Dickinson Bayou Watershed Protection Plan.
7. Lake Houston Water Quality Restoration- This project will be applied to design and construct a pilot project to enhance wetlands.

8. Westfield Estates WPP Implementation- This project will implement portions of Westfield Estates WPP.
9. Coastal Zone Reauthorization Amendments (CZARA) OSSF Reconnaissance; Training; and Replacement- This project will conduct reconnaissance, inspection, and pump out and replace OSSFs where needed in Galveston County and other coastal counties identified by Section 6217 jurisdictional areas to identify areas of chronic OSSF failure
10. City of Houston - White Oak Bayou- This project will construct Low Impact Development (LID) BMP's in a redeveloping sub-area of the City's urban watershed.

Brazos

1. North Bosque River Watershed Assessment- This project is designed to evaluate the large scale effectiveness of BMP strategies identified in the North Bosque Implementation Plan.
2. Lampasas Watershed Assessment- This project will involve a water quality monitoring program to identify pollutant loading and target problem areas within the city's failing septic systems for future BMP implementation.
3. Lake Granbury Coves Water Quality Improvement- This project will develop a locally driven WPP for Lake Granbury's bacteria water quality concern.
4. Bosque Continuous Monitoring- This project will continue operation and maintenance of two existing Bosque River watershed continuous water quality monitoring stations at Clifton and State Highway 6.

Colorado

1. Onion Creek Continuous Monitoring & Stormwater BMP- The project will include continuous monitoring of water quality and flow to monitor water entering the aquifer.
2. Brady Creek WPP- This project will complete a nine element WPP for Brady Creek.
3. San Bernard River WPP- The three projects funded under this contract will give local governments tools to help their decision making in regard to maintaining or improving water quality within the region.

Guadalupe

1. TMDL Project in Upper Guadalupe River Watershed- This project will aid in the creation of an implementation plan for the TMDL on an impaired segment of the Guadalupe River at Kerrville.
2. Plum Creek WPP Implementation- This project will perform implementation, education and outreach activities in the city portion of the Plum Creek watershed.

3. Plum Creek WPP Implementation (Guadalupe Blanco River Authority) - This project will conduct a water quality monitoring to help characterize watersheds.
4. Plum Creek WPP Implementation (City of Lockhart) – This project will reduce nonpoint source pollution from entering Plum Creek, the City of Lockhart.
5. Plum Creek WPP Implementation (City of Luling) - This project will reduce nonpoint source pollution from entering Plum Creek, the City of Luling.
6. Composting Project for Water Hyacinth- This project involves the development of a large-scale demonstration compost operation that utilizes invasive water hyacinth harvested from Spring Lake.
7. Spring Lake & Sink Creek Continuous Monitoring- This project involves the development of a large-scale demonstration compost operation that utilizes invasive water hyacinth harvested from Spring Lake.

San Antonio

1. TMDL Implementation in the Upper San Antonio River Watershed- This project will assist in the creation of a TMDL implementation plan for three segments of the San Antonio River.
2. Cibolo Creek WPP- This project will develop a Watershed Protection Plan for Cibolo Creek, in Kendall County.
3. Salado Creek Continuous Water Monitoring- The project will include continuous monitoring of water quality and flow which will actuate the structural BMP(s) when flow, turbidity, conductivity or the combination of the two or more of the measures exceed an established trigger.

Nueces

1. Tule Creek Stormwater Wetlands- This project will improve the water quality in Tule Creek by restoring wetlands with non-point source runoff treatment capability and habitat value, and improving water quality from Tule Creek discharge to Little Bay and Aransas Bay.
2. On-site Sewage Facility Up-grades in the Oso Creek Watershed- This watershed protection project proposes to identify high priority areas in the Oso Creek watershed causing the highest bacteria loads to Oso Creek and either replace existing failing septic systems or install new septic systems where none currently exist.

Rio Grande

1. Arroyo Colorado Watershed Protection Plan Implementation This project will continue to fund the watershed coordinator, who will coordinate and track implementation actions outlined in the WPP, continue to investigate what can be done to make practices and management changes last over

time, sponsor local workshops with the TSSWCB and Extension Service, and publicize / build awareness of our watershed work.

2. Arroyo Colorado WPP Implementation- This project will design and construct innovative storm water Best Management Practices in connection with regional detention facilities (RDF) in McAllen, Texas.
3. Construction of Wetland Treatment Systems in the Arroyo Colorado Watershed- This project will implement enhanced wastewater and storm water treatment projects proposed in the Arroyo Colorado PRP.

TCEQ Water Quality Standards 2010 Projects

WQS Contract Projects

- **Recreational use-attainability analyses (UAAs):** This project will evaluate the recreational use for the Navasota River above Lake Mexia (1210A), Brazos River Above Possum Kingdom (1208), East Yegua Creek (1212B), and Lower Cibolo Creek (1902). These water bodies are 303(d) listed as impaired for bacteria. This project is tentatively scheduled to begin in February 2010 and end in November 2010.

WQS Group Project Manager:

Laurie Eng
512-239-1713
leng@tceq.state.tx.us

- **Nutrient criteria development projects:** Two projects will be conducted to collect information and data that can be used by the TCEQ Water Quality Standards Group for the development of numerical nutrient criteria for streams, rivers, and estuaries.

One project includes (1) a historical review of all nutrient data collected and major nutrient/eutrophication studies performed in Texas on all waterbody types excluding reservoirs and (2) a review of the detailed numerical nutrient criteria plans developed by other states for all waterbody types. This project is tentatively scheduled to begin in February 2010 and end in August 2010.

The second project involves sampling attached vegetation and nutrients on additional small streams in Texas that are located east of Interstate Highway 35 in the Brazos and Colorado River Basins. Existing and non-TCEQ stations will be selected for this project. This project is tentatively scheduled to begin in February 2010 and end in August 2011.

WQS Group Project Manager:

Jason Godeaux
512-239-2495
jgodeaux@tceq.state.tx.us

WQS Group Projects

- **Aquatic Life UAAs:** The WQS Group will complete UAAs in the Beaumont area on Boggy Creek (0607A), Willow Creek (0607C), and Cypress Creek (0608C). These water bodies are on the 303(d) list as impaired for depressed dissolved oxygen. These UAA projects began in 2007 and early 2008 and will be completed by the end of this year.

WQS Group Project Manager:

Laurie Eng
512-239-1713
leng@tceq.state.tx.us

- **Mid-Pecan Bayou (Segment 1431) Aquatic Life UAA:** The WQS Group will begin an aquatic life UAA on Mid-Pecan Bayou in 2010. The purpose of this UAA is to determine the appropriate aquatic life use and dissolved oxygen criteria for this classified segment. Currently there is an average dissolved oxygen criteria of 2.0 mg/L and no designated aquatic life use for this segment in Appendix A of the Texas Surface Water Quality Standards. This project will be completed in 2011.

WQS Group Project Manager:
Debbie Miller
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- **Recreational UAAs:** The WQS Group will conduct Recreational UAAs on the Spicewood tributary to Shoal Creek (1403J), Taylor Slough South (1403K), Westlake-Davenport Tributary to Lake Austin (1403R), Walnut Creek (1428B), Eanes Creek (1429B), Waller Creek (1429C). These water bodies are on the 303(d) list as impaired for bacteria. This RUAA will be conducted this summer.

WQS Group Project Manager:
Laurie Eng
512-239-1713
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TIFP Responses to SAC Questions:

A) What on-going or future sampling, monitoring, intensive study programs, or projects do you have that might be useful for the basin/bay groups to know about as they formulate their work plans? What is the purpose of those programs?

- The objective of the Texas Instream Flow Program (TIFP) is to define a healthy environment (a sound ecological environment) and determine the amount of water required to maintain that environment for Texas' rivers and streams. The objective is carried out by completing multi-year, multi-disciplinary instream flow studies for river sub-basins in collaboration with study cooperators and stakeholders, as described in the Technical Overview.
- Revenue sources the agencies have tapped to fund instream flow research:
 - TWDB Research and Planning Funds are used to fund projects, which may address broad issues such as how geomorphic assessments should be for completed for instream flow assessments to river- or species-specific studies. Final project reports are available on the TIFP website. Research and Planning Funds available to TIFP have totaled about \$335,000 per year for the last several years.
 - TWDB has occasionally tapped into federal money to support TIFP studies. Sources have included the Army Corps of Engineer's Texas Water Allocation Assistance Fund and cost sharing dollars from the U.S. Geological Survey. Final project reports are available on the TIFP website. In the past several years, federal dollars routed through TWDB have varied between \$0 and \$340,000 per year.
 - TCEQ has funded the development of a water quality model sensitive to flow changes that can be applied on a statewide basis.
 - TPWD is funding research through its State Wildlife Grants to address broad information needs related to instream flow initiatives. For example, the Digital Fish Atlas was partially funded through the SWG program.
- Priority studies and expected completion dates:
 - Lower San Antonio River and lower Cibolo Creek – A Draft Study Design that has passed review from local stakeholders has been provided to the local Basin and Bay Expert Science Team (BBEST). The Draft Study Design includes a synopsis of current scientific understanding of the lower San Antonio River and lower Cibolo Creek. Preliminary results from this study will be available to share with the local BBEST by approximately January 2011. A Final Report with flow regime recommendations will be completed by approximately December 2011.
 - Middle and lower Brazos River – A Study Design for this sub-basin will be completed in Summer 2010 and will be available for the local

BBEST when they begin their work in Fall 2010. Some preliminary results from this study may be available to share with the local BBEST before their recommendations are due in October 2011. A Final Report with flow regime recommendations will be completed by December 2013.

- Lower Sabine River - A Draft Study Design for this sub-basin is currently available but will not be finalized until Summer 2010. A Final Report with flow regime recommendations will be completed by December 2013.
- Middle Trinity River - A Final Report with flow regime recommendations will be completed by December 2016.
- Lower Guadalupe River - A Final Report with flow regime recommendations will be completed by December 2016.

B) Are you considering changing or evolving any of your current programs in a direction that might link them more closely to environmental flow analysis? If so, what changes are you considering that might be of interest to the basin/bay groups as they formulate their work plans? If not, does the opportunity of contributing to implementation of basin/bay work plans raise your interest in such change or evolution?

- TIFP is designed to develop site specific flow recommendations for Texas' river and streams. The basic methodology that has been reviewed by both stakeholders within the state and recognized national experts. For application to specific sub-basins, the basic methodology is adapted in order to more accurately assess instream flow needs in those areas. The methodology is also intended to adapt to incorporate improved data collection and analysis techniques as they are developed. The final result of TIFP studies will be flow recommendations for specific sub-basins based on state-of-the-art instream flow study methods. These results will directly support the adaptive management component of SB3.

C) What barriers are you encountering to expand program elements, particularly as they might relate to information useful for the basin/bay work plans on environmental flows?

- TIFP Study Designs are developed through a stakeholder process which involves the creation of study goals, objectives and indicators. Consequently, these may not be consistent across the various priority river basins.
- Resources available for completing TIFP studies and carrying out subsequent monitoring and adaptive management are limited. At the present time, expenditures for monitoring and adaptive management reduce resources available for studies in additional sub-basins and vice versa.

TIFP RESPONSES TO SAC QUESTIONS: Prepared by Dakus Geesling (TCEQ), Kevin Mayes (TPWD), and Mark Wentzel (TWDB)

To: Science Advisory Committee (SAC) Chairman Robert Huston
April 12, 2010
(bandshuston@sbcglobal.net)

Date:

Science Advisory Committee (SAC) member Ed Oborny
(eoborny@bio-west.com)

From: Helen E. Drummond, Director, Galveston Bay Estuary Program

Re: Galveston Bay Estuary Program Response to Questionnaire for State, Federal, Local, and Academic programs to assist the Senate Bill 3 Work Plan development process.

Dear Chairman Huston and SAC member Oborny:

The Galveston Bay Estuary Program appreciates the opportunity to collaborate with the Science Advisory Committee in its efforts to ensure the best available science is used in the development, validation and refinement of the basin/bay environmental flow analyses and flow regime recommendations, and the environmental flow standards and strategies adopted for the Galveston Bay area.

The Estuary Program submits the following information in response to your questionnaire.

Question A: What on-going or future sampling, monitoring, intensive study programs, or projects do you have that might be useful for the basin/bay groups to know about as they formulate their work plans? What is the purpose of those programs?

Response A: The estuary program's monitoring and research program supports an ecosystem-based approach to resource management that is realized through implementation of *The Galveston Bay Plan (The Plan)*.

The purpose of the monitoring and research program is to maximize the effectiveness of plan implementation by increasing understanding of the bay ecosystem, assessing environmental health (or conditions), improving resource management, evaluating the efficacy of actions where possible, communicating results, and recommending revisions/refinements when applicable. To carry out this purpose, a data system is maintained, environmental and programmatic assessments are conducted as needed, data gaps are identified, applied research needs are ranked based on data and information needs identified by resource managers implementing the Galveston Bay Plan and priorities identified by the Galveston Bay Council.

The Estuary Program's current priorities as identified in *the Plan* and the Estuary Program's 10-Year Strategic Action Plan are:

- protecting, creating, and restoring coastal habitat; building public stewardship;
- conducting watershed-based initiatives and outreach to improve and protect water-quality; monitoring and assessing the safety of consuming Galveston Bay seafood; and
- supporting state and regional efforts to develop management strategies for balancing freshwater needs for human consumption and bay productivity.

Under our data system, data are assembled from state and local monitoring partners, analyzed, and distributed to all potential users electronically. Data assembled include, but is not limited to water quality and living resource data from TCEQ and TPWD. When monitoring information fails to generate better understanding, the program directs limited resources for targeted applied research. The applied research is directly tied to the Galveston Bay ecosystem and the *Plan*. Projects usually focus upon the data gaps found when trying to make management decisions with existing monitoring data. This research improves our knowledge of the bay and its relation to human uses, and strengthens the connection between scientists and resource managers. Management action plans are adapted according to the findings of monitoring and research performed.

Monitoring and research projects are developed and overseen by the Monitoring and Research Committee of the Galveston Bay Council.

Monitoring and Research Projects

The Estuary Program has funded one monitoring and two research projects that might be useful for the basin/bay groups, one completed in 2007 and one in 2010. The research projects collectively have looked at the effects of season, frequency, and magnitude of freshwater inflows on the distribution and composition of phytoplankton communities in response to nutrients. Continued support for this work is proposed for 2010-2012, but is pending Galveston Bay Council, and subsequently EPA approval. The 2010-2012 work would expand the scope to look at the effects of fresh water inflows and salinity on indicator species identified as part of the Bay and Basin Expert Science Team's regime recommendations: *Vallisneria* (wild celery) and *Atlantic rangia*.

Monitoring Project

"Galveston Bay Status and Trends Program: Special Analysis," Dr. Jim Lester, Houston Advanced Research Center.

Abstract: Certain aspects of Galveston Bay and the surrounding watershed are examined to assess the overall health of the bay ecosystem through Indicators of Bay Health. Important indicators of bay health include: water and sediment quality, populations of native and nonnative fish and wildlife, quantity and quality of diverse habitats, and the amount of freshwater flowing into the bay. The status and trends of human uses of the bay and watershed ecosystems are also evaluated, including: recreational and commercial fisheries harvest, seafood safety, transportation and shipping, recreation, and commercial and residential development.

Although each indicator provides insight into one aspect of bay health and can be examined independently, all are interconnected, and there an integrated, ecosystem-level understanding of the state of Galveston Bay is assessed using data from various sources. The Galveston Bay Status and Trends project gathers, manages, and analyzes data collected by agencies and organizations at the federal, state, and local level and analyzes it to describe the indicators of bay health. This project is conducted by the Houston Advanced Research Center for the Estuary Program.

Special analysis can also be done, depending on resources available. For example, under the Status and Trends project, HARC provided support to the BBEST in analyzing the monitoring data on salinity and organism abundance. This data can be used for assessments of biology - salinity interactions in the future if needed.

Research Projects

1. "Use of High-Resolution Spatial Mapping to Estimate Plankton Response to Freshwater Inflows Entering Galveston Bay: *Importance to Watershed Development and Ecosystem Health*", Stephen Davis, et al., Texas A&M University, Final Report to GBEP, 2007.

Abstract: River inflow and nutrient loading to an estuary contribute greatly to estuarine water quality and ecosystem health, and in some estuaries, poor health, reduced productivity, and even losses of coastal wetlands have been linked to modifications in freshwater input. Given the rapid development in Texas and the state's plans for water diversion along the coast, an understanding of the importance of freshwater inflow events on water quality, phytoplankton structure, and water column productivity is needed.

This was a two-year study centered on the Galveston Bay Estuary designed to characterize and map water quality and quantify water column productivity across the entire estuary during different inflow conditions at approximately monthly intervals. To do this, we conducted continuous (spatial) samplings of surface water quality across a range of inflow events to the Galveston Bay estuary. Simultaneously, we collected grab samples at fixed stations for nutrient analyses, water column productivity estimate, and HPLC pigment analyses to infer plankton community dynamics in response to water quality/nutrient availability.

The project spanned a range of inflow conditions into the Galveston Bay estuary between 2005 and 2006. Spatial maps generated from these samplings provide a clear depiction of inflow effects on water quality in the system. In some cases, prolonged inflows freshened much of the bay (e.g., October 2006)—yielding correspondingly high, bay-wide concentrations of CDOM. Fixed station data supported this, particularly with regard to inorganic nutrient (N and P) concentrations. Our data suggest that the upper bay is likely limited by the availability of N (based on molar ratios of N:P) and this may be enhanced by inflow events. The strength of N limitation seemed to relax in the lower region of the bay.

HPLC pigment data, indicating the relative composition of the phytoplankton community, are still being processed at this time and are not expected until late 2007. So, we are still missing data from a few key months in early 2006. Despite this, we employed non-metric multi-dimensional scaling—a descriptive multi-variate statistical approach—to look for patterns in our data indicating a connection between inflows and phytoplankton community dynamics in this study. We found noticeable differences in upper bay vs. lower bay water quality—much of which related to aforementioned river inflow effects on salinity, inorganic nitrogen, and CDOM concentrations. There were also distinct effects of large or prolonged inflow events that seemed to be related fixed station water quality and HPLC pigment/CHEMTAX data.

Further data collection in this system, enumeration of existing phytoplankton samples from 2005-2006, and additional analysis will enable us to further clarify the importance of pulsed inflow events in this estuarine system.

2. "Galveston Bay Plankton Analysis", Antonietta S. Quigg, et al., Texas A&M University at Galveston, Final Report to GBEP, 2010.

Abstract: The Galveston Bay Estuary Program identified an "examination of the impacts of freshwater inflow and bay circulation" as priority areas in its comprehensive conservation and management action plan for 2001-2005. Specifically, the goal is to ensure *beneficial* freshwater inflows necessary for a salinity, nutrient and sediment loading regimes adequate to maintain productivity of economically important and ecologically characteristic species in Galveston Bay. The major gap in the present knowledge is a clear understanding of the downstream ecological impacts of changes to freshwater inflows on estuaries, specifically phytoplankton communities. Hence, phytoplankton community structure was monitored in response to freshwater inflows in Galveston Bay. The project spanned a range of inflow conditions into the Galveston Bay estuary between January 2005 and December 2006. Using a multi-variate and multi-dimensional statistical approach, we did find that specific genera of diatoms and dinoflagellates, the two major groups, occur in specific parts of Galveston Bay at specific times of the year (Figures 7 to 9). For example, the diatoms *Navicula*, *Thalassionema*, *Thalassiosira* and to a lesser extent *Pleurosigma*, were most abundant at Stations 1 and 4 (Bolivar Pass near mouth and Morgan's Point in the middle of Galveston Bay respectively) during the spring and summer months (March to August 2005). *Cylindrotheca* and many of the other diatoms were present mostly at Station 6 (Trinity River basin), but to a lesser extent in other parts of Galveston Bay. These euryhaline phytoplankton are common to many bays and estuaries throughout the world and form the base of many important trophic food webs, supporting zooplankton and fish populations. Unfortunately, we also identified species which have been associated with harmful algal blooms. These include the diatoms *Pseudo-nitzschia* and *Nitzschia* and the dinoflagellates *Akashiwo*, *Dinophysis*, *Prorocentrum* and *Protoperidinium*. These phytoplankton species have been implicated in fish kills and shellfish hatchery closures around the world. We did not detect any *Karenia brevi* or *Pfiesteria* sp. in our microscopic examination – blooms of these two species in Galveston Bay would severely disrupt the Galveston Bay ecosystem. Understanding the linkages between the magnitude of freshwater inflows and phytoplankton community structure in Galveston Bay remains a challenge; requiring further data collection in the Galveston Bay system, enumeration of existing newly collected phytoplankton samples from 2008-2009, and analysis of additional parameters in order to further clarify the importance of inflow events in this estuarine system.

Question B: Are you considering changing or evolving any of your current programs in a direction that might link them more closely to environmental flow analysis? If so, what changes are you considering that might be of interest to the basin/bay groups as they formulate their work plans? If not, does the opportunity of contributing to implementation of basin/bay work plans raise your interest in such change or evolution?

Response B: As noted in the response to Question A above, supporting state and regional efforts to develop management strategies for balancing freshwater needs for human consumption and bay productivity is one of the Estuary Program's priorities. As such, the Estuary Program is interested in and amenable to directing some monitoring and research toward efforts that would contribute to implementation of the Galveston Bay Area Bay/Basin work plan, namely toward addressing environmental flows to the bay and in coastal streams.

Funding is limited, but recognizing there are data needs associated with indicator species and seafood surveys and needs for the use of better technology for monitoring flows and water constituents, we would gladly coordinate with Texas Water Development Board, Texas Parks and Wildlife and others to maximize the benefits of our efforts.

Question C: What barriers are you encountering to expand program elements, particularly as they might relate to information useful for the basin/bay work plans on environmental flows?

Response C: Available funding is a limiting factor.

Lastly, for several years, the Galveston Bay Estuary Program has funded facilitation of the Galveston Bay Freshwater Inflows Group with the goal of providing a forum for open discussion and as a means for building consensus on approaches and strategies for ensuring freshwater inflows to Galveston Bay. We have been pleased with collaboration of this group and are heartened by the hard work and determination of the bay/basin groups' effort advance these efforts and meet the requirements of Senate Bill 3.

If you have any questions, please feel free to contact me hdrummon@tceq.state.tx.us or 281-486-1240.