Recommended Environmental Flow Standards and Strategies for the Trinity and San Jacinto River Basins and Galveston Bay

Section 1. Introduction

- The Trinity and San Jacinto Rivers and Galveston Bay Basin and Bay Area Stakeholder Committee (Stakeholder Committee) was established in the Texas Water Code Sec. 11.02362 by the 80th Legislature. The bill recognizes that "Maintaining the biological soundness of the state's rivers, lakes, bays, and estuaries is of great importance to the public's economic health and general well-being."
- The state Environmental Flows Advisory Group appointed the members of the Stakeholder Committee to reflect a fair and equitable balance of interest groups concerned with the river basin and bay system. The Stakeholder Committee, in turn, was given the task of appointing the members of a Bay and Basin Expert Science Team (BBEST) to provide a recommended environmental flow regime for the basins and the bay considering only the "best available science."
- Texas Water Code Sec. 11.02362(o) sets out the further charge of the Stakeholder Committee: ***"Each basin and bay area stakeholders committee shall review the environmental flow analyses and environmental flow regime recommendations submitted by the committee's basin and bay expert science team and shall consider them in conjunction with other factors, including the present and future needs for water for other uses related to water supply planning in the pertinent river basin and bay system. The basin and bay area stakeholders committee shall develop recommendations regarding environmental flow standards and strategies to meet the environmental flow standards and submit those recommendations to the commission and to the advisory group in accordance with the applicable schedule specified by or established under Subsection (c), (d), or (e). In developing its recommendations, the basin and bay area stakeholders committee shall operate on a consensus basis to the maximum extent possible."***

Section 2. BBEST Recommendations

Within the constraints of the time schedule established for its work, the BBEST was unable to reach consensus on its recommended environmental flow regime. A flow regime was presented, but it was endorsed by eight of the fifteen members of the BBEST, who have been identified as the Regime Group. The other members, who have been termed the Conditional Group, presented an alternate recommendation for instream flows and commented on an alternate recommendation for freshwater inflows. The BBEST submitted its report on time as required by the schedule, and its members have spent a great deal of time working with and responding to questions from the Stakeholder Committee since then.

Section 3. Consideration of Other Factors

In its deliberations the Stakeholder Committee has considered other factors in addition to the BBEST recommendations. Human uses of water have been recognized, and were incorporated in the discussion through comments from the diverse interests included on the Stakeholder Committee. Presentations were made on behalf of the Regional Water Planning Groups (RWPGs)(C and H) that are tasked with water supply concerns in the Trinity and San Jacinto basins. The RWPGs take all identified human uses (including municipal, industrial, steam electric, etc.) into account in calculating future water needs, and then identify sources of water to meet those needs.

The problem of subsidence related to groundwater usage in the Region H area has been well documented. The Houston region (H) must rely on surface water for continued growth. The Dallas-Fort Worth area (Region C) has developed water supply lakes on a number of tributaries to the Trinity River. Lake Livingston, the only main stem reservoir between Dallas and Houston, was developed to serve water needs in Region H and the neighboring Region I. Accordingly, the San Jacinto and Trinity River basins are essentially fully permitted to water rights holders.

At the same time, there are human uses that rely on sufficient environmental flows. Recreational use (including fishing, boating, nature tourism, etc.) of the rivers, reservoirs, and the bay contribute to the economies of a number of communities in the region, as well as to the State as a whole.

Section 4. Recognition of Analytic and Data Shortcomings: Adaptive Management

Nearly all the discussions/arguments reported by the BBEST in determining environmental flows have been re-played within the Stakeholder Committee. Clearly, improvements are needed in some of the analytic techniques available to determine flow needs. Just as clearly, many years and a great deal of effort has been devoted to perfecting the science of establishing environmental flow needs.

There are data gaps – places where monitoring has not occurred; an historical record that is not as long or as continuous as would be ideal. The Stakeholder Committee will identify these gaps and suggest remedies during development of the work plan.

Decisions are almost always made in the absence of perfect information. For this reason, the State has recognized that “adaptive management” will be required for environmental flows. The standards and strategies recommended here will be revisited, reassessed, and adjusted as required by new data and understanding within the next ten years. The initial deliberations suggest that, at least for the first round, a revisit after five years may be appropriate.

Section 5. Development of Environmental Flow Standards Recommendations

The Stakeholder Committee has had a challenging time in developing a set of recommendations for environmental flow standards to maintain a sound ecological environment in the two river basins and in the highly productive Galveston Bay system.

As noted, the Stakeholder Committee was presented with two different perspectives by members of its Bay and Basin Area Expert Science Team (BBEST) regarding both instream flow needs in the river basins and the freshwater inflows needs of Galveston Bay. As a result, the Stakeholder Committee did not have a consensus environmental flow regime recommendation as a starting point to evaluate the economic and social implications of implementing such a regime, much less to craft a proposed set of environmental flow standards and develop strategies to meet those standards.

Nevertheless the Stakeholder Committee attempted to find a path forward to the development of environmental flow standards recommendations to TCEQ, using the following input and resources, among others:

- presentations made at Stakeholder Committee meetings by state agencies and others during an information gathering period conducted by stakeholders while the BBEST was doing its work;
- insights provided by the BBEST report;
- the guidance documents produced by the Texas Environmental Flows Science Advisory Committee (SAC), including its comments on the BBEST report;
- Texas Parks and Wildlife Department staff's comments on the BBEST report;
- evaluations of flow recommendations in the BBEST report that were performed by the staff of the Texas Water Development Board (TWDB) in consultation with staff of other state agencies;
- responses to questions posed to BBEST members;
- presentations and recommendations on freshwater inflows by Dr. Norman Johns of the National Wildlife Federation (NWF); and
- information generated by and lessons learned from the Galveston Bay Freshwater Inflows Group (GBFIG) deliberations in which a number of members of the Stakeholder Committee have participated since late 1996.

In addition the Stakeholder Committee was able to enlist the assistance of Suzanne Schwartz and Margaret Meniccuci of the University of Texas Center for Policy Dispute Resolution to provide professional facilitation during April and May of 2010 and to assist the committee as the stakeholders attempted to produce consensus recommendations for environmental flow standards prior to the deadline of June 1 for submission of those recommendations to TCEQ. The facilitators were retained through the auspices of the Galveston Bay Foundation (GBF) and as a result of voluntary contributions to GBF from the Lone Star Chapter of the Sierra Club, NWF, and the U. S. Fish and Wildlife Service.

This report presents a set of recommendations for environmental flow standards for instream flows in the Trinity and San Jacinto River Basins and freshwater inflows to Galveston Bay developed by members of the Stakeholder Committee for consideration by the TCEQ.

Section 6. Instream Flow Recommendations

As the Texas Environmental Flows Science Advisory Committee (SAC) observed in its "Discussion Paper: Moving from Instream Flow Regime Matrix Development to Environmental Flow Standard Recommendations:"

> *"There appears to be general agreement among aquatic biologists and ecologists that the flow requirements necessary to support a sound ecological environment in a stream system should consist of several flow components with characteristic seasonality."*

The SAC discussion paper notes that the Senate Bill 2 Texas Instream Flow Program, following guidance from the National Research Council, describes an environmental flow regime in terms of overbank flows, high flow pulses, base flows, and minimum subsistence flows. The discussion paper states that "…SAC also recommended this same structure in order to maximize consistency in the framework of environmental flow recommendations in Texas."

The Regime Group of the Bay/Basin Area Expert Science Team (BBEST) for the Trinity and San Jacinto River Basins and Galveston Bay followed this approach in reaching its conclusions and recommendations regarding instream flows necessary for a sound ecological environment.

Consistent with the guidance from the National Research Council, the practices of the Texas Instream Flow Program, the recommendation from the SAC, and the recommendations from the Regime Group of the BBEST, we support and recommend the establishment of environmental flow standards for instream flows that consist of several flow components. The following are our specific recommendations regarding those flow components.

<u>Overbank Flows</u>

Both the Conditional Group and the Regime Group of the BBEST recognized and discussed the essential role of "overbank flows" in maintaining a sound ecological environment. Overbank flows, as described by the Conditional Group, are "naturally driven, infrequent, high magnitude flow events that produce water levels that exceed channel banks and result in water entering the floodplain."

The Regime Group, drawing from the discussion in the Biological Overlays Guidance Document developed by the Texas Environmental Flows Science Advisory Committee, described in some detail the specific ecological functions performed by overbank flows. These include, for examples, dispersal of seeds for bottomland hardwood tree species, transportation of terrestrial vegetation into a stream to increase concentrations of organic carbon to the food chain, and movement of aquatic organisms to and from aquatic floodplain habitats.

The Regime Group concluded that:

> *The overbanking flow components of a flow matrix…thus have important functions for the ecological system, and for some species this component is critical for completion of the life cycle (i.e., bottomland hardwood tree species) and/or support of significant population abundance (e.g., white and black crappies, gizzard shad). It is essential to recognize that overbanking flows are a part of the natural flow regime that maintains the native biodiversity of the two basins.*

Overbank flows are a critical component of an environmental flow regime to maintain a sound ecological environment for the Trinity and San Jacinto River Basins. We do <u>not</u> recommend, however, that action be taken to produce such flows because of the possible consequences for property damage and loss of life that might result from deliberate creation of flood flows. We believe that overbank flows will continue to be produced as a result of natural occurrences.

We do urge public and private entities to be attentive, however, to the ecological benefits of overbank flows in developing policies and taking actions that might impact the floodplains in the Trinity and San Jacinto River Basins.

Further we believe that, as part of adaptive management activities in these river basins, the frequency, magnitude, and volume of overbank flows as they occur should be studied in comparison to the overbank flow recommendations of the Regime Group to determine if significant changes in such flows are occurring over time and, if so, how such changes might be affecting the ecology of the river basins.

<u>Pulse Flows</u>

As described in the SAC discussion paper referenced above, the Texas Instream Flow Program includes in the structure of an environmental flow regime:

> *…short duration, high magnitude, in-channel* high flow pulses *that occur during or immediately following rainfall events and provide spawning cues and transport of eggs and larvae of fishes and aquatic invertebrates,*

as well as helping to maintain important physical habitat features and connectivity along a stream channel…

The Regime Group of the BBEST included high pulse flows as part of its recommended environmental flow regime. We also recommend the inclusion of pulse flows in the environmental flow standards for the Trinity and San Jacinto River Basins.

Our pulse flow recommendations, found in Tables 1 and 2, were developed as follows:

- The pulse flow recommendations and frequencies of the Regime Group were used as the starting point.

- An effort was made to simplify the pulse flow recommendations of the Regime Group without losing ecological benefits of pulses.

- The following steps were taken to simplify the pulse flow recommendations:

    - Fewer pulse flows are recommended:
        - One annual high pulse flow was eliminated and the second annual high pulse flow was assigned to the spring when most pulse flows typically occur
        - The number of pulse flow recommendations during summer and fall were reduced because the ecological role of pulse flows is not considered as critical during these seasons
        - All sites now have 9 pulse flow recommendations. Previously the number of pulse flow recommendations ranged from 10 to 14.
    - Pulse recommendation values were reduced by 10% or more based on the assumption that there is not a measurable or ecological difference within 10% of a flow value.
    - Revised pulse flow values were rounded down to one or two significant figures instead of three significant figures.
    - The same values for summer and fall pulses were used because the ecological role of pulse flows is not considered as critical during these seasons.
    - The pulse flow recommendations for summer and fall were combined into one, warm, relatively dry, extended season, from July through November.
    - The Regime Group's pulse flow recommendations for peak, duration, and volume were replaced with recommendations for pulse peak alone based on the analytical difficulty at present in characterizing peak duration and volume and the potential difficulty of addressing those characteristics in permits.
    - The same seasons were used as those for base and subsistence flows.

Table 1 - Pulse Flow Recommendations for the Trinity River Basin

West Fork Trinity River at Grand Prairie Pulse Flows, w/percent of years in which pulse flows would be met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	10,000 cfs; 25% attainment frequency			
High Pulse 1	1,300 cfs; 40%	3,200 cfs; 45%		
High Pulse 2		3,200 cfs; 25%		
Low Pulse 1	300 cfs; 66%	1,200 cfs; 66%	350 cfs; 50% **	
Low Pulse 2	300 cfs; 33%	1,200 cfs; 33%	300 cfs; 40% **	

Trinity River at Dallas Pulse flows, with percent of years in which pulse flows met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	10,000 cfs; 40%			
High Pulse 1	3,400 cfs; 33%	8,000 cfs; 40%		
High Pulse 2		8,000 cfs; 25%		
Low Pulse 1	700 cfs; 66%	4,000 cfs; 66%	1,000 cfs; 50% **	
Low Pulse 2	700 cfs; 33%	4,000 cfs; 20%	1,000 cfs; 33% **	

Trinity River at Rosser Pulse Flows, with percent of years in which pulse flows met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	25,000 cfs; 32%			
High Pulse 1	5,000 cfs; 40%	12,000 cfs; 33%		
High Pulse 2		12,000 cfs; 20%		
Low Pulse 1	2,600 cfs; 50%	6,000 cfs; 60%	2,000 cfs; 50% **	
Low Pulse 2	2,600 cfs; 34%	6,000 cfs; 20%	2,000 cfs; 25% **	

Trinity River at Oakwood Pulse flows, w/percent of years in which pulse flows met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	24,000 cfs; 50%			
High Pulse 1	10,000 cfs; 40%	15,000 cfs; 45%		
High Pulse 2		15,000 cfs; 25%		
Low Pulse 1	3,000 cfs; 66%	7,000 cfs; 66%	2,500 cfs; 50% **	
Low Pulse 2	3,000 cfs; 33%	7,000 cfs; 33%	2,500 cfs; 40% **	

Trinity River at Romayor Pulse Flows, w/percent of years pulse flows would be met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	40,000 cfs; 33%			
High Pulse 1	19,000 cfs; 40%	20,000 cfs; 50%		
High Pulse 2		20,000 cfs; 25%		
Low Pulse 1	8,000 cfs; 50%	10,000 cfs; 66%	4,000 cfs; 50% **	
Low Pulse 2	8,000 cfs; 34%	10,000 cfs; 33%	4,000 cfs; 33% **	

*The overbank flow is specified here for description purposes only.

** These percentages are approximations. TWDB WAM (Water Availability Model) Run 3 analysis calculated that the Regime recommended pulses for the summer and fall high pulses would occur more frequently than the frequencies in these tables. The reduction in pulse sizes from the Regime recommendations and increased flexibility in timing (allowing summer and fall pulses to occur over a 5-month period) would be expected to increase the occurrence frequency of these pulse recommendations.

Table 2 – Pulse Flow Recommendations for the San Jacinto River Basin

West Fork San Jacinto River near Conroe Pulse Flows, with percent of years in which pulse flows would be met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	15,000 cfs; 15%			
High Pulse 1	1,800 cfs; 50%	3,400 cfs; 50%		
High Pulse 2		3,000 cfs; 25%		
Low Pulse 1	400 cfs; 66%	1,100 cfs; 66%	200 cfs; 50% **	
Low Pulse 2	400 cfs; 33%	1,100 cfs; 33%	200 cfs; 40% **	

East. Fork San Jacinto River nr Cleveland Pulse Flows, with percent of years pulse flows would be met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	4,000 cfs; 40%			
High Pulse 1	1,400 cfs; 50%	2,000 cfs; 50%		
High Pulse 2		1,500 cfs; 25%		
Low Pulse 1	400 cfs; 66%	600 cfs; 66%	200 cfs; 50% **	
Low Pulse 2	400 cfs; 33%	600 cfs; 33%	200 cfs; 40% **	

Buffalo Bayou at Piney Point Pulse Flows, with percent of years in which pulse flows would be met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	2,000 cfs; 40%			
High Pulse 1	700 cfs; 50%	1,000 cfs; 40%		
High Pulse 2		1,000 cfs; 25%		
Low Pulse 1	500 cfs; 66%	500 cfs; 66%	300 cfs; 50% **	
Low Pulse 2	500 cfs; 25%	500 cfs; 33%	300 cfs; 40% **	

Spring Creek Pulse flows,, with percent of years in which pulse flows would be met or exceeded				
	Winter	Spring	Summer	Fall
Overbank*	5,000 cfs; 50%			
High Pulse 1	1,400 cfs; 50%	2,400 cfs; 50%		
High Pulse 2		2,200 cfs; 25%		
Low Pulse 1	300 cfs; 66%	600 cfs; 66%	200 cfs; 50%**	
Low Pulse 2	300 cfs; 33%	600 cfs; 33%	200 cfs; 33% **	

*The specification of overbank flows here is for description purposes only.

** These percentages are approximations. TWDB WAM (Water Availability Model) Run 3 analysis calculated that the Regime recommended pulses for the summer and fall high pulses would occur more frequently than the frequencies in these tables. The reduction in pulse sizes from the Regime recommendations and increased flexibility in timing (allowing summer and fall pulses to occur over a 5-month period) would be expected to increase the occurrence frequency of these pulse recommendations.

Base Flows

As described in the SAC discussion paper referenced above, the Texas Instream Flow Program characterizes "base flows" as those flows:

> *…representing the range of 'average' or 'normal' flow conditions in the absence of significant precipitation or rainfall runoff events that provide instream habitat conditions needed to maintain the diversity of habitats and resources that support native aquatic and riparian species…"*

The Regime Group of the BBEST identified three levels of ecological base flow that "…represent periods when different habitats are more available than at other times." The Regime Group noted that this range of flows "…allows species of fish, invertebrates, and plants with relatively different spawning and habitat requirements to persist and contribute to the health of the aquatic community." The Group concluded that "…individual species may have different habitat needs which are 'best' supported at different ecological base flows.

Specifically the Regime Group characterized the three levels of base flows as:

- Base flows during years or periods that are dry (but not "drought" conditions);
- Base flows during average flow years or periods, which are neither typically dry nor typically wet;
- Base flows during wetter than normal years or periods.

We also recommend environmental flow standards for the Trinity and San Jacinto River Basins that incorporate three levels of base flows [see Tables 3, Upper Trinity; Table 4, Lower Trinity; Table 5, San Jacinto; Table 6, Houston Bayous], although we have adopted the terminology of low (25^{th} percentile of flow), medium (50%), and high (75%) rather than dry, average, and wet in our presentation of the recommendations for base flows.

Base flows are specified for each season (winter, spring, summer, and fall) at each gauge in the Trinity River Basin and the San Jacinto River Basin chosen for inclusion in the proposed environmental flow standards.

Our proposals for base flows were developed using the following criteria or decision rules:

Flow Magnitudes

- Flow magnitudes were derived from the values set out in the recommendations of the Regime Group of the BBEST, but adjusted downward through rounding.

- As noted by the Science Advisory Committee, the recommendations of the Regime Group include higher flow levels necessary to encompass a flow regime.

- No base flow recommendations have been included for the Elm Fork Trinity near Carrollton based on the representation that conditions there do not merit the development of flow standards.

Attainment Frequencies

- The starting point for selection of recommended attainment frequencies for base flows was the recommendations of the Regime Group.

- When the Regime Group's recommended attainment frequencies were lower than the attainment levels from WAM (Water Availability Model) Run 3 results, which are based on full use of existing water rights and no return flows, the Regime Group's recommended frequencies were selected and rounded down.

- In instances when the WAM Run 3 attainment levels were only slightly lower than the Regime Group's recommended attainment frequencies, the WAM Run 3 attainment levels were selected. Generally, this was done when the Run 3 frequencies, after rounding, were within 10 percentile points of the Regime Group's recommended frequencies.

- Finally, in a number of instances, the WAM Run 3 attainment levels were far lower than the Regime Group's recommended frequencies. In those instances, WAM Run 8 and, where available, WAM Run 9 attainment levels were consulted.

WAM Run 8 is a representation of current conditions and includes return flow contributions. WAM Run 9 is a representation of the implementation of projects recommended in regional water planning.

In many locations, return flow contributions can reasonably be expected to continue to be available for the foreseeable future. Accordingly, in those instances, attainment frequencies above the WAM Run 3 levels but below the Regime Group's recommended values and below the Run 8 or Run 9 values were selected. Generally, the selected values are about 10 percentile points below the Regime Group's recommended attainment frequency values.

A key exception is that both flow magnitudes and attainment frequencies for Buffalo Bayou at Piney Point have been qualified in these recommendations. A relatively short period of record was used in deriving those values. WAM modeling results indicate that adjustments are needed in those values and the attainment frequency recommendations are based on the WAM modeling results. The need for future adjustments in those values is specifically acknowledged in the recommendations.

Table 3

RECOMMENDED STANDARDS FOR BASE FLOWS FOR UPPER TRINITY RIVER LOCATIONS *			
Gauge Location	Season	Recommended Standard for Base Flow	Recommended Frequency for Base Flow
W.Fork Trinity At Grand Prairie	Winter Low	50 cfs	70%
	Winter Medium	80 cfs	55%
	Winter High	110 cfs	40%
	Spring Low	50 cfs	75%
	Spring Medium	80 cfs	65%
	Spring High	130 cfs	50%
	Summer Low	40 cfs	60%
	Summer Medium	50 cfs	50%
	Summer High	80 cfs	35%
	Fall Low	35 cfs	65%
	Fall Medium	50 cfs	50%
	Fall High	75 cfs	35%
Trinity River At Dallas	Winter Low	50 cfs	70%
	Winter Medium	130 cfs	55%
	Winter High	270 cfs	40%
	Spring Low	70 cfs	75%
	Spring Medium	150 cfs	60%
	Spring High	300 cfs	50%
	Summer Low	40 cfs	65%
	Summer Medium	100 cfs	50%
	Summer High	220 cfs	30%
	Fall Low	50 cfs	65%
	Fall Medium	110 cfs	50%
	Fall High	190 cfs	35%

*Elm Fork Trinity River near Carrollton was dropped from consideration.

Table 4

RECOMMENDED STANDARDS FOR BASE FLOWS FOR LOWER TRINITY RIVER LOCATIONS			
Gauge Location	Season	Recommended Standard for Base Flow	Recommended Attainment Frequency for Standard
Trinity River Near Rosser	Winter Low	240 cfs	65%
	Winter Medium	460 cfs	50%
	Winter High	820 cfs	40%
	Spring Low	390 cfs	75%
	Spring Medium	620 cfs	65%
	Spring High	1,050 cfs	55%
	Summer Low	250 cfs	55%
	Summer Medium	400 cfs	40%
	Summer High	570 cfs	30%
	Fall Low	200 cfs	60%
	Fall Medium	320 cfs	45%
	Fall High	620 cfs	30%
Trinity River Near Oakwood	Winter Low	340 cfs	75%
	Winter Medium	620 cfs	60%
	Winter High	1,100 cfs	45%
	Spring Low	450 cfs	80%
	Spring Medium	820 cfs	65%
	Spring High	1,375 cfs	55%
	Summer Low	250 cfs	55%
	Summer Medium	400 cfs	40%
	Summer High	675 cfs	25%
	Fall Low	260 cfs	60%
	Fall Medium	425 cfs	45%
	Fall High	810 cfs	35%
Trinity River At Romayor	Winter Low	875 cfs	75%
	Winter Medium	1,500 cfs	60%
	Winter High	2,550 cfs	50%
	Spring Low	1,150 cfs	85%
	Spring Medium	1,850 cfs	75%
	Spring High	3,000 cfs	65%
	Summer Low	575 cfs	65%
	Summer Medium	900 cfs	50%
	Summer High	1,500 cfs	30%
	Fall Low	625 cfs	70%
	Fall Medium	1,000 cfs	55%
	Fall High	1,700 cfs	25%

Table 5

RECOMMENDED BASE FLOW STANDARDS FOR SAN JACINTO RIVER			
Gauge Location	Season	Recommended Standard for Base Flow	Recommended Attainment Frequency for Standard
West Fork San Jacinto River near Conroe	Winter Low	35 cfs	85%
	Winter Medium	55 cfs	70%
	Winter High	110 cfs	50%
	Spring Low	35 cfs	75%
	Spring Medium	55 cfs	60%
	Spring High	85 cfs	45%
	Summer Low	15 cfs	60%
	Summer Medium	25 cfs	45%
	Summer Dry	35 cfs	25%
	Fall Low	20 cfs	60%
	Fall Medium	25 cfs	50%
	Fall High	45 cfs	35%
Spring Creek Near Spring	Winter Low	20 cfs	80%
	Winter Medium	35 cfs	70%
	Winter High	55 cfs	55%
	Spring Low	20 cfs	80%
	Spring Medium	35 cfs	65%
	Spring High	50 cfs	50%
	Summer Low	15 cfs	60%
	Summer Medium	20 cfs	45%
	Summer High	35 cfs	30%
	Fall Low	15 cfs	65%
	Fall Medium	20 cfs	50%
	Fall High	35 cfs	35%
East Fork San Jacinto River near Cleveland	Winter Low	30 cfs	85%
	Winter Medium	40 cfs	75%
	Winter High	80 cfs	60%
	Spring Low	25 cfs	80%
	Spring Medium	40 cfs	70%
	Spring High	60 cfs	55%
	Summer Low	15 cfs	55%
	Summer Medium	20 cfs	40%
	Summer High	30 cfs	30%
	Fall Low	15 cfs	65%
	Fall Medium	25 cfs	50%
	Fall High	35 cfs	40%

Table 6

RECOMMENDED BASE FLOW STANDARDS FOR HOUSTON BAYOUS			
Gauge Location	Season	Recommended Standard for Base Flow	Recommended Attainment Frequency for Standard
Brays Bayou At Houston	Winter Low	Low, all seasons: 5 cfs Med., all seasons: 8 cfs High, all seasons: 10 cfs	80% for low, all seasons 60% for med., all seasons 50% for high, all seasons
	Winter Medium		
	Winter High		
	Spring Low		
	Spring Medium		
	Spring High		
	Summer Low		
	Summer Medium		
	Summer High		
	Fall Low		
	Fall Medium		
	Fall High		
Buffalo Bayou at Piney Point*	Winter Low	25 cfs	40%
	Winter Medium	35 cfs	30%
	Winter High	55 cfs	25%
	Spring Low	25 cfs	35%
	Spring Medium	35 cfs	30%
	Spring High	50 cfs	25%
	Summer Low	45 cfs	35%
	Summer Medium	65 cfs	25%
	Summer High	95 cfs	20%
	Fall Low	10 cfs	35%
	Fall Medium	45 cfs	25%
	Fall High	75 cfs	20%

*The attainment frequencies recommended here for this location are quite low. It appears that the BBEST recommendations from the Regime Group are based on a short period of record that may reflect an unusually wet period of time. As a result, the flow magnitudes only occur at a fairly low frequency. These values, both in magnitude and attainment frequencies, should be reassessed for the full period of record at an appropriate gauge using the same methodology used by the Regime Group of the BBEST and revised values should be used in setting standards.

Subsistence Flows

As described in the SAC discussion paper referenced above, the Texas Instream Flow Program characterizes "minimum *subsistence flows*" as flows:

> *…to maintain water quality criteria and prevent loss of aquatic organisms due to, for example, lethal high temperatures, low dissolved oxygen levels or loss of critical habitats…*

The Regime Group of the BBEST described "drought" or "subsistence" flows in a similar manner but provided more insight into the minimal yet critical nature of such flows:

> *The primary objectives of subsistence flow are to maintain water quality criteria for aquatic organisms and a minimum flow with resultant longitudinal connectivity. Secondary objectives include providing life cycle cues based on naturally occurring periods of low flow or providing habitat that ensures local populations are able to recolonize the river system once normal, base flows return….Subsistence flows represent the minimum flow requirement to maintain populations during periods of severe and prolonged drought. Subsistence flows thus should be viewed as the emergency ration of water required to prevent total extirpation of aquatic and riparian species….Subsistence flows provide minimal yet sufficient habitat of sufficient quality such that populations can recover upon return of base flow conditions. Thus, subsistence flow conditions are by definition infrequent events.*

Our proposed subsistence flow recommendations (Tables 7 and 8) were developed as follows:

Flow Magnitudes

- The flow magnitude aspects of the subsistence flow recommendations as presented here were derived from the values set out in the draft of the Subgroup Recommendations that were discussed at the meeting of the Stakeholder Committee on May 5, 2010.
- Flow magnitudes generally were rounded down from the values set out in that draft.
- One exception is that subsistence flow values for the Elm Fork Trinity near Carrollton were deleted from the recommendations, based on the representation that conditions in that area are not conducive to the development of flow standards.

Attainment Frequencies

- With one exception, the recommended attainment frequencies were set at 95%, which generally is reasonably consistent with the approach used by both the Conditional and Regime Groups of the BBEST.

- A key exception is that both flow magnitudes and attainment frequencies for Buffalo Bayou at Piney Point have been qualified in these recommendations. A relatively short period of record was used in deriving those values. WAM modeling results indicate that adjustments are needed in those values and the attainment frequency recommendations are based on the WAM modeling results. The need for future adjustments in those values is specifically acknowledged in the recommendations.

Duration Values

- Duration values have been proposed for subsistence flows. Because these are very low flow levels, it is important that they are not artificially caused to persist for extended periods of time. As Dr. Norman Johns of the National Wildlife Federation noted at the meeting of the Stakeholder Committee on May 5, 2010, a person may be able to hold his or her breath for 30 minutes a day, but not for thirty minutes at a time.

- Duration values were calculated based on the historical record using the subsistence flow magnitudes recommended by the Regime Group of the BBEST. Those results are included in the "Flows Atlas" previously distributed by the National Wildlife Federation.

- Starting from those historical durations, a proposed maximum duration was calculated that generally represents a period about 20% longer than the historical period of maximum duration. These periods of historical maximum duration typically occurred during the summer and fall.

- Because of the presence of return flow contributions in many locations that are reasonably certain to persist for the foreseeable future, long durations of flows at or below subsistence levels should be avoidable. Thus, for example, the recommended duration of subsistence flows for Trinity River at Dallas is much shorter than the historical calculation.

- In addition, because flows tend to be higher in the spring and because of the critical nature of that period ecologically, a shorter duration has been recommended for the spring period.

Table 7

RECOMMENDED FLOW STANDARDS FOR TRINITY RIVER SUBSISTENCE FLOWS				
Gauge Location	Season	Subsistence Flow Recommendations	Attainment Frequency Recommendations	Maximum Duration**
W. Fork Trinity at Grand Prairie	Winter	20 cfs	95%	2 weeks in spring; 5 weeks in others
	Spring	25 cfs	95%	
	Summer	15 cfs	95%	
	Fall	15 cfs	95%	
Trinity River at Dallas	Winter	15 cfs	95%	4 weeks in spring; 10 weeks in others
	Spring	15 cfs	95%	
	Summer	15 cfs	95%	
	Fall	15 cfs	95%	
Trinity River near Rosser	Winter	100 cfs	95%	3 weeks in spring; 8 weeks in others
	Spring	160 cfs	95%	
	Summer	70 cfs	95%	
	Fall	100 cfs	95%	
Trinity River near Oakwood	Winter	120 cfs	95%	3 weeks in spring; 8 weeks in others
	Spring	160 cfs	95%	
	Summer	70 cfs	95%	
	Fall	100 cfs	95%	
Trinity River at Romayor	Winter	525 cfs	95%	4 weeks in spring; 10 weeks in others
	Spring	700 cfs	95%	
	Summer	200 cfs	95%	
	Fall	230 cfs	95%	

**Diversions should not cause flows to continue at or below subsistence levels for a continuous period of longer than the stated duration. Any daily flow value that does not exceed the applicable subsistence value by 10% or more should be counted as being at the subsistence value for purposes of determining the length of the continuous period. Once the duration limit has been reached, in order to reset the duration calculation to allow another subsistence flow period, flows must average at least 50% more than the applicable subsistence value over a period that has a duration equaling at least 50% of the length of the applicable subsistence duration period.

Table 8

RECOMMENDED FLOW STANDARDS FOR SUBSISTENCE FLOWS FOR SAN JACINTO RIVER AND HOUSTON BAYOUS				
Gauge Location	Season	Subsistence Flow Recommendations	Attainment Frequency Recommendations	Maximum Duration*
W. Fork San Jacinto near Conroe	Winter	23 cfs	95%	4 weeks in spring; 10 weeks for others
	Spring	24 cfs	95%	
	Summer	9 cfs	95%	
	Fall	9 cfs	95%	
Spring Creek Near Spring	Winter	14 cfs	95%	4 weeks in spring; 10 weeks for others
	Spring	14 cfs	95%	
	Summer	6 cfs	95%	
	Fall	6 cfs	95%	
East Fork San Jacinto near Cleveland	Winter	22 cfs	95%	4 weeks in spring; 10 weeks for others
	Spring	18 cfs	95%	
	Summer	8 cfs	95%	
	Fall	10 cfs	95%	
Buffalo Bayou at Piney Point**	Winter	11 cfs	95%	4 weeks in spring; 10 weeks for others
	Spring	13 cfs	95%	
	Summer	26 cfs	95%	
	Fall	13 cfs	95%	
Brays Bayou at Houston	Winter	3 cfs	95%	3 weeks in spring; 10 weeks in fall; 8 weeks for others
	Spring	1 cfs	95%	
	Summer	1 cfs	95%	
	Fall	1 cfs	90%	

*Diversions should not cause flows to continue at or below subsistence levels for a continuous period of longer than the stated duration. Any daily flow value that does not exceed the applicable subsistence value by 10% or more should be counted as being at the subsistence value for purposes of determining the length of the continuous period. Once the duration limit has been reached, in order to reset the duration calculation to allow another subsistence flow period, flows must average at least 50% more than the applicable subsistence value over a period that has a duration equaling at least 50% of the length of the applicable subsistence duration period.

**The flow values recommended here for this location may be unduly high relative to the attainment frequencies. It appears that the BBEST recommendations from the Regime Group are based on a short period of record that may reflect an unusually wet period of time. As a result, the flow magnitudes may be elevated above appropriate subsistence levels. These flow magnitude values should be reassessed for the full period of record at an appropriate gauge using the same methodology used by the Regime Group of the BBEST and revised values should be used in setting standards.

7. Freshwater Inflow Recommendations

There is wide agreement among members of the Stakeholder Committee and indeed among the informed public about the productivity and ecological importance of Galveston Bay and its positive benefits for the economy of the Houston-Galveston region. This understanding of the value of Galveston Bay has led to many previous efforts to determine the level and timing of freshwater inflows, among other factors, that are essential to maintaining a sound ecological environment in the Bay. One of the most prominent efforts in that regard has been the Galveston Bay Freshwater Inflows Group (GBFIG), a process in which several members of the current Stakeholder Committee have participated for a number of years.

However, despite all of these efforts, there has been a lack of a consensus on how much freshwater the Bay truly needs and the timing and frequency of inflows to maintain Bay health. Even where there has been a tentative agreement on a "placeholder" for freshwater needs for the Bay in water planning efforts there has been no movement toward guaranteeing the future availability of that water.

The Regime Group of the BBEST for the Trinity and San Jacinto River Basins and Galveston Bay advanced our understanding of the important biological indicators of bay health and added to our knowledge of the needs of the Bay. Ultimately, of course, the BBEST did not produce a consensus recommendation on freshwater inflow needs for the Stakeholder Committee to consider.

Dr. Norman Johns of the National Wildlife Federation (NWF) developed freshwater inflow recommendations for consideration by the Stakeholder Committee during the spring after the completion of the BBEST approach. One set of recommendations was termed a "consolidated" approach in which Dr. Johns attempted to reconcile to the extent possible the freshwater inflow recommendations of the Regime Group and the more general perspective provided by the Conditional Group about the inflow needs of Galveston Bay.

Dr. Johns also presented recommendations regarding possible inflow criteria for drought periods. The Stakeholder Committee did not have sufficient time to consider fully the recommendations from NWF regarding freshwater inflow needs, but it is important that the State of Texas move forward in putting into place some level of protection for inflows to Galveston Bay through environmental flow standards.

The issue of specifying freshwater inflow needs for Galveston Bay and developing management approaches to provide necessary flows has been a major concern by many interests in the Houston-Galveston area and throughout the Trinity and San Jacinto Basins for decades. The Galveston Bay Freshwater Inflows Group (GBFIG), which includes representatives from most of the same interests represented on the current Stakeholder Committee, has met periodically since December 1996 in an effort to come

to a voluntary resolution of many of the issues involved with providing those freshwater inflows.

The lack of an action-forcing mechanism, however, was an impediment to GBFIG reaching resolution, although the Region H Water Planning Group did include GBFIG numbers for annual inflow needs of Galveston Bay as a placeholder for Bay needs in the Region H Plan. The SB 3 environmental flows process provides the action-forcing mechanism to move forward on meeting the Bay's needs through the adoption of environmental flow standards by TCEQ. It is in that context that we recommend environmental flow standards for freshwater inflows for Galveston Bay. Our recommendations are based on the current scientific thinking about inflow needs.

There is a broad recognition that estuaries require a range of inflows, performing a variety of functions. This was highlighted by the Science Advisory Committee (SAC) in their guidance document for establishing estuarine inflow regimes:

> *The recommended regime should be designed to cover the full flow spectrum, from very low flows (near drought-of-record conditions), in which species refuge becomes of primary importance, to higher flow events sufficient to provide adequate nutrient and sediment supply to the bay system for longer-term ecological health.*

Thus, we present two tiers of criteria covering low to medium inflow conditions and a separate Drought Inflow Criteria. There will, of course, be a continuing dialogue among Galveston Bay advocates, technical experts, and other interested parties regarding the comprehensive needs of the Bay.

We must emphasize that the needs of the Bay are likely more extensive than just the establishment of the criteria herein. For example, the Regime Group of the BBEST pointed out the importance of periodic high flow events to the health of the oyster population in the Galveston Bay:

> *Scientific studies have shown that the health of the oyster population can be enhanced by periodic flood events. Specifically a two week period of salinity below 5 psu will significantly reduce the level of infection by* Perkinsus*….An additional recommendation is that a high flow event should occur at least once per decade. This event should lower the salinity in the area assigned to the oyster health indicator to less than 5 psu for a period of two weeks.*

High flow events are also needed to maintain sediment and nutrient loads for Galveston Bay. There is probably not an imminent threat to the provision of high flow events. They are likely to continue to be provided through natural events for the foreseeable future, but for the long term this is a topic that needs to be addressed.

The prospects of providing a periodic high flow event at some point in the future will require continued research and analyses.

Medium Inflow Criteria

The "Medium Inflow Criteria" table (Table 9) was developed using the following decision points and assumptions:

- Criteria inflow magnitudes were based on the Salinity Zone Analysis recommendations of the Regime Group of the BBEST, with some changes discussed below. In each season, the Regime Group values are complemented with HEFR-derived "Base Wet" inflows as outlined in NWF Technical Memorandum to the Stakeholder Committee regarding "Consolidated Inflows" (April 2, 2010). HEFR-derived values are rounded to nearest 1000 acre-foot increments. [HEFR is a hydrology-based environmental flow regime approach.]

- Criteria developed through the Salinity Zone Analyses were based on assumed "antecedent" conditions ("salty", "suitable", or "fresh") thus yielding a range of inflows that would lead to desired salinity conditions for indicator species. Here we utilize the antecedent condition of "salty" for each season.

- Inflows for the winter season by the Regime Group are based on suitable habitat for menhaden (an indicator species) and range from a low requirement of 469,000 acre-feet/month to a high value of 2.2 million acre-feet/month. In devising this medium inflow criteria, the high value was utilized in one month with an assumption that this would freshen a significant portion of the bay, thus allowing for the lower value in the following month. The Regime Group recommended that inflows be pro-rated by long-term inflow ratios of 54% and 28% for the Trinity River and San Jacinto/Buffalo Bayou, respectively.

- Spring inflow requirements (1.315 million and 302,000 acre-feet/month respectively for the Trinity River and San Jacinto/Buffalo Bayou) are set based on the reproductive requirements of Rangia as the indicator species. These apply for one month complemented with two months of HEFR-derived "Base Wet" inflows.

- Summer inflow requirements (285,000 and 257,000 acre-feet/mon., respectively for the Trinity River and San Jacinto/Buffalo Bayou) are set based on the requirements of oysters in the mid bay. These apply for two months.

- Fall inflow requirements for the Trinity River, are based on survival needs of Vallisneria as the indicator species: 400,000 acre-feet/month for two months.

- Fall inflow requirements for the San Jacinto/Buffalo Bayou are based on reproductive requirements of Rangia of 358,000 acre-feet/month for one month.

The following notes regarding interpretation of these inflow recommendations set out in the following tables relate to assessing the attainment of these inflow levels and how that information was utilized in developing the recommended criteria:

- In those criteria table rows in which monthly volumes are specified within a season (e.g. spring in the Trinity or San Jacinto/Buffalo Bayou), the individual values are those of the Salinity Zone Analysis recommendation for one or two months with the remaining month(s) of the season utilizing HEFR-derived inflows. This method honors the Salinity Zone approach.

- In those criteria table rows in which a total inflow per season is specified (e.g. winter for either the Trinity or San Jacinto/Buffalo Bayou), the total criteria volume is the sum of the Salinity Zone Analysis recommendation for one or two months with the remaining month(s) of the season complimented with HEFR-derived inflows. The seasonal sum approach was utilized in several season and criteria level (Medium or Low Base) combinations, where the magnitudes of the two values were close and a strict monthly inflow approach was not essential.

- The columns "Attainment tabulation" are a summary of how often (how many seasons) the criteria were met or exceeded under Historic and WAM simulated scenarios. The period of record utilized is 1941-96.

- Attainment is measured in two manners depending on whether a seasonal sum criteria (e.g. winter for either the Trinity or San Jacinto/Buffalo Bayou) or a specific monthly approach is taken (e.g. spring in the Trinity or San Jacinto/Buffalo Bayou). For the seasonal sum approach, the cumulative total inflow for the season must meet or exceed the criteria. Furthermore to meet the specifications of this seasonal sum criteria type, each individual month must have an inflow of 50% of the minimum of either the HEFR-derived base average or the Salinity Zone approach value. Those values are indicated by the text “minimum in a month”. The statistics for historic and WAM attainment were developed in this manner.

- For the criteria rows in which specific monthly volumes are called for within a season, the evaluation of attainment is done for each individual component of that season’s criteria. For example, in Table 9 for Trinity River basin inflows in spring, one month in the Mar-May window must have inflows at or above 1.315 million acre-feet/month, and the remaining two at or above 230,000 acre-feet/month.

- The definition of “Recommended criteria attainment” means that inflows are recommended to meet or exceed these magnitudes at the stated frequency over a long-term period of record similar to that utilized in WAM modeling.

- For both the criteria illustrated in Tables 9 and 10, the final recommended attainment for the criteria are all set to 80% of the historic attainment level.

Table 9 - Galveston Bay: Medium Inflow Criteria

Trinity River basin								
		Attainment tabulation						Recommended criteria attainment / (percent of seasons)
		no. seas-ons	number seasons criteria met					
Season	Recommended Criteria		Hist.	Natrl.	Run 8	Run 3	Run 9	
Winter [Dec-Feb]	total inflow/season = 1,686,000 ac-ft	55	23	27	20	14	21	18 / (33%)
Spring [Mar-May]	1 month @1,315,000 ac-ft 2 months @230,000 ac-ft	56	20	26	17	8	17	16 / (29%)
Summer [Jun-Aug]	total inflow/season = 713,000 ac-ft	56	33	32	21	14	22	26 / (46%)
Fall [Sep-Nov]	total inflow/season = 919,000 ac-ft	56	20	23	12	7	12	16 / (29%)

San Jacinto / Buffalo Bayou combined								
		Attainment tabulation						Recommended criteria attainment / (percent of seasons)
		no. seas-ons	number seasons criteria met					
Season	Recommended Criteria		Hist.	Natrl.	Run 8	Run 3	Run 9	
Winter [Dec-Feb]	total inflow/season = 896,000 ac-ft	55	23	18	18	12	11	18 / (33%)
Spring [Mar-May]	1 month @302,000 ac-ft 2 months @116,000 ac-ft	56	14	9	9	7	6	11 / (20%)
Summer [Jun-Aug]	total inflow/season = 611,000 ac-ft	56	22	19	19	15	16	18 / (32%)
Fall [Sep-Nov]	total inflow/season = 548,000 ac-ft	56	20	14	15	13	13	16 / (29%)

Low Base Inflow Criteria

The "Low Base Inflow Criteria" table (Table 10) was developed using the following decision points and assumptions, as well as those noted above as being applicable for all levels of inflow criteria:

- Criteria inflow magnitudes were based on the Salinity Zone Analysis recommendations, with some changes discussed below, complemented with HEFR-derived "Base Average" inflows as outlined in NWF Technical Memorandum to the Stakeholder Committee regarding "Consolidated Inflows" (April 2, 2010).

- Inflows recommended by the Regime Group of the BBEST for the winter season, based on suitable habitat for menhaden (an indicator species), are 253,000 and 131,000 acre-feet/month, respectively, for the Trinity and San Jacinto/Buffalo Bayou basins with an antecedent condition of “suitable”. The number of months that this inflow should prevail within the season is not specified in the BBEST report. For these inflow criteria we have assumed applicability for two of three months.

- The criteria for spring inflows from the San Jacinto / Buffalo Bayou combined drainage were originally set by the Regime Group of the BBEST in their Salinity Zone approach to 302,000 acre-feet/month for one month. This was based on the area-inflow regressions for satisfying oyster requirements, but assuming an antecedent condition of "salty", thus requiring a high amount of inflow. For this low inflow criteria we have assumed the lower level of 125,000 acre-feet/month, based in a assumed antecedent condition of “suitable.”

- The Criteria for summer inflows from San Jacinto / Buffalo Bayou combined were originally set by the Regime Group in their Salinity Zone approach to 257,000 acre-feet/month for 2 months. This was based on the area-inflow regressions for satisfying oyster requirements, but assuming an antecedent condition of "salty". This assumption thus requires a high inflow volume, to get salinities into the desired range for oysters. The attainment of these relatively high inflow values was only 9/56 historic summer seasons in the 1941-96 period. We elected to use a more moderate assumption of “all” antecedent conditions resulting in a value of 82,000 acre-feet/month for the combined San Jacinto/Buffalo Bayou contribution.

- The Criteria for fall inflows from San Jacinto / Buffalo Bayou combined were originally set by the Regime Group of the BBEST in their Salinity Zone approach as 250,000 acre-feet/month for one month based on a goal of getting good conditions for Rangia (an indicator species) spawning: 2-10 ppt. However, most of the area used in the analysis lies to the east in an area more heavily influenced by the Trinity River (Figure 31 in the BBEST report). Because of these considerations and since this is a low inflow criteria with Rangia spawning already protected in the spring, here the inflow level is lowered to the HEFR-derived value of 67,000 acre-feet for all three months in the fall.

Table 10 - Galveston Bay: Low Base Inflow Criteria

Trinity River basin								
		Attainment tabulation						Recommended criteria attainment / (percent of seasons)
		no. seas-ons	number seasons criteria met					
Season	Recommended Criteria		Hist.	Natrl.	Run 8	Run 3	Run 9	
Winter [Dec-Feb]	total inflow/season = 629,000 ac-ft minimum in a month = 61,500 ac-ft	55	42	42	34	18	40	34 / (62%)
Spring [Mar-May]	1 month @742,000 ac-ft 2 months @126,000 ac-ft	56	37	39	29	21	32	30 / (54%)
Summer [Jun-Aug]	total inflow/season = 509,000 ac-ft minimum in a month = 49,500 ac-ft	56	35	25	6	0	7	28 / (50%)
Fall [Sep-Nov]	total inflow/season = 362,000 ac-ft minimum in a month = 40,000 ac-ft	56	32	29	9	3	14	26 / (46%)

San Jacinto / Buffalo Bayou combined								
		Attainment tabulation						Recommended criteria attainment / (percent of seasons)
		no. seas-ons	number seasons criteria met					
Season	Recommended Criteria		Hist.	Natrl.	Run 8	Run 3	Run 9	
Winter [Dec-Feb]	total inflow/season = 349,000 ac-ft minimum in a month = 43,500 ac-ft	55	39	32	39	26	23	31 / 56%)
Spring [Mar-May]	1 month @125,000 ac-ft 2 months @82,000 ac-ft	56	26	21	21	10	9	21 / (38%)
Summer [Jun-Aug]	total inflow/season = 234,000 ac-ft minimum in a month = 35,000 ac-ft	56	42	19	36	12	16	34 / (61%)
Fall [Sep-Nov]	total inflow/season = 201,000 ac-ft minimum in a month = 33,500 ac-ft	56	34	22	43	16	12	27 / (48%)

Drought Inflow Criteria

Following is an explanation of the factors incorporated into the recommendation for drought inflow criteria for Galveston Bay found in Table 11 on the following page:

- Each one of the criteria is couched as a total inflow per three-month season. Criteria inflow magnitudes were initially based on HEFR-derived "Base Dry" and "Subsistence" inflows as outlined in NWF Technical Memorandum (May 4, 2010) regarding potential drought criteria inflows methods. Criteria inflow magnitudes were adjusted till the historic attainment level for each season and drainage was 95%. The final recommended attainment for the criteria is set to equal that of the historic record, namely, that they should be met or exceeded in 95% of seasons. The rationale for this is that these are near worst-case inflow levels.

- If these recommended drought criteria inflows for the Trinity River basin were to persist for a whole year the total inflow would be approximately 0.996 million ac-ft/yr (MAFY). The minimum historic inflow from the Trinity River basin in the 1941-96 period was 1.21 MAFY. Thus we recommend that the inflows from the Trinity River basin not persist at the levels of the proposed criteria for more than two consecutive seasons and not more than three seasons within a year.

- If these recommended drought criteria inflows for the San Jacinto/Buffalo Bayou basin were to persist for a whole year the total inflow would be approximately 0.505 million ac-ft/yr (MAFY). The minimum historic inflow from the San Jacinto/Buffalo Bayou basin in the 1941-96 period was 0.553 MAFY. Thus we recommend that the inflows from the San Jacinto/Buffalo Bayou basin not persist at the levels of the proposed criteria for more than two consecutive seasons and not more than three seasons within a year.

Table 11 - Galveston Bay: Drought Inflow Criteria

Trinity River basin

Season	Recommended Drought Criteria	Attainment tabulation: no. seasons	Attainment tabulation: number seasons criteria met: Hist.	Natrl.	Run 8	Run 3	Run 9	Recommended criteria attainment / (percent of seasons)
Winter [Dec-Feb]	total inflow/season = 275,310 ac-ft	55	52	50	43	29	48	52 / (95%)
Spring [Mar-May]	total inflow/season = 397,860 ac-ft	56	53	54	48	38	50	53 / (95%)
Summer [Jun-Aug]	total inflow/season = 211,820 ac-ft	56	53	51	35	27	36	53 / (95%)
Fall [Sep-Nov]	total inflow/season = 110,700 ac-ft	56	53	50	34	16	39	53 / (95%)

San Jacinto / Buffalo Bayou combined

Season	Recommended Drought Criteria	Attainment tabulation: no. seasons	Attainment tabulation: number seasons criteria met: Hist.	Natrl.	Run 8	Run 3	Run 9	Recommended criteria attainment / (percent of seasons)
Winter [Dec-Feb]	total inflow/season = 122,830 ac-ft	55	52	51	56	48	48	52 / (95%)
Spring [Mar-May]	total inflow/season = 155,390 ac-ft	56	53	47	56	40	40	53 / (95%)
Summer [Jun-Aug]	total inflow/season = 134,460 ac-ft	56	53	38	56	30	30	53 / (95%)
Fall [Sep-Nov]	total inflow/season = 92,470 ac-ft	56	53	46	56	41	38	53 / (95%)

Coastal Basin Inflows

While we make no quantified recommendations of inflow criteria for coastal basin contributions to Galveston Bay, protection of these inflows is critically important. We do not anticipate large-scale water supply development in these basins. Historically, these basins have collectively contributed about 18% of the inflows to Galveston Bay (BBEST report, page 154) and those contributions should be protected with little change. It may be possible with further study in the future to establish specific, quantified inflow criteria, perhaps using the same salinity zone techniques utilized by the BBEST for larger sections of the Bay.

8. Strategies

One of the key charges in S.B. 3 for the Stakeholder Committee, in addition to development of environmental flow standard recommendations, is the recommendation of strategies to meet those standards. The Stakeholder Committee has not had sufficient time to develop a number of specific water management strategies for meeting all of the proposed environmental flow standards, but it is possible to make certain general observations in that regard and offer some direction for future consideration about how to implement the standards.

When recommended attainment frequencies are lower than the WAM Run 3 results, a set aside of unappropriated flows in combination with previously appropriated flows that must remain in the stream to meet existing water rights can reasonably be expected to be an adequate strategy for meeting the standards.

However, when the recommended attainment frequency is higher than the WAM Run 3 results, other strategies will need to be considered. In many instances, return flows currently are present in the stream and, as a result of permit conditions in existing indirect reuse permits, can reasonably be expected to continue to be present for the foreseeable future. Accordingly, reliance on a reasonable level of return flows also is a viable strategy for meeting environmental flow standards.

Some other possibilities include purchase and voluntary conversion of selected water rights to environmental flow maintenance, payment for on-farm conservation techniques and an agreement to dedicate for environmental flow purposes the irrigation water conserved, and lease of irrigation water through a “dry year” option, to name a few.

The Galveston Bay Freshwater Inflows Group (GBFIG) a number of years ago began outlining possible strategies for providing water for freshwater inflows to Galveston Bay, but that process was never completed. As the TCEQ moves forward to a rule-making process to consider adoption of environmental flow standards for the Trinity and the

San Jacinto River Basins, interested parties need to begin a more in-depth evaluation of the possible strategies that might be used to implement the standards adopted.

Implementation of Multi-Level Flow Recommendations in Water Rights Permitting

Rules for the implementation of environmental flow standards should be developed to limit impacts from new authorizations such that they do not cause flow levels to fall below indicated attainment frequencies. Implementation of additional voluntary strategies will also be needed to achieve compliance with the flow standards in some locations.

The level of flow regime specification and the ability to adjust to changing conditions will differ among different applicants for new authorizations. Small permits which lack the infrastructure to significantly impact high flow events will only be subject to the base flow requirements, including subsistence flows. For these smaller permits, determinations of applicable conditions (i.e., high, medium, or low) should be made on a seasonal basis and remain constant for the entire season. New authorizations that are larger in size have the ability to impact flows throughout the full flow regime and will also need to be evaluated and made subject to permit conditions in order to avoid impairing specified high pulse events. These larger water rights, which may include storage or significant pumping capacity, should normally make adjustments to changing hydrologic conditions on shorter time scales. For instance if in the beginning of the spring season, flows and/or reservoir levels are low, diverters may be subject to the low base-flow targets, but if conditions change dramatically over a monthly time-scale, adjustments could be appropriate. The same should be true if the season started out with higher flows or reservoir levels but then moved into a drier condition.

For both small and large permits, a periodic determination will need to be made as to the current hydrologic condition. While a number of trigger options are available (estimates of natural flows, rainfall, Palmer drought index) total water in storage, as a percentage of total conservation pool capacity in the basin upstream of the relevant diversion, appears to be an acceptable mechanism for determining applicable conditions and corresponding diversion limitations. For small water rights, the percentage of storage as predicted for the first day within the respective season would control for that entire season. The specific storage triggers to be used should be calculated, and revised on a periodic basis, to provide that high condition base-flow diversion limitations would be applicable, over the long-term, about 25% of the time, medium condition base-flow diversion limitations would be applicable about 40% of the time, and low condition base-flow diversion limitations would be applicable about 25% of the time. Subsistence diversion limits would apply as an absolute minimum limitation. Larger water rights might rely on the same trigger (e.g., reservoir level) but the storage percentages should be determined through a more detailed hydrologic analysis to reflect recommended attainment frequencies and the timeframe for reassessing the existing hydrologic conditions should be shorter.

Special Note on Pulse Flow Implementation Recommendation

Where possible, we recommend that pulse flows that occur within each season, up to the recommended number of pulse flows for that season, be passed downstream. Passage of pulse flows should occur, if possible, regardless of whether or not all the pulse flows occurred in the same season in the previous year. For example, if three pulses occur during the winter, those three pulses should be passed. Pulses that occur in the winter after the first three pulses would not need to be passed. The number of pulses recommended is conservative compared to the number of pulses that historically occurred at the recommended sites. If adaptive management suggests this approach is too restrictive or not restrictive enough then this recommendation should be modified appropriately. It is recommended that permits include special conditions so that when implemented in the WAM they do not predict failure to meet their attainment targets over the long term. Consistent with the Stakeholder Committee's understanding of the provisions of S.B. 3, no ***mandated*** releases from storage under existing water rights are recommended to meet pulse flow recommendations.

9. Looking Forward – Developing a Work Plan

The next major task for the Stakeholder Committee will be the development of a work plan identifying additional research needs, monitoring sites, strategy development, and other actions necessary to continue to refine our knowledge and understanding of the Trinity and San Jacinto River Basins and Galveston Bay in order to take steps to assure the maintenance of a sound ecological environment in the region and the provision of adequate water supplies to meet the needs of the region. We look forward to developing a work plan over the next several months that will achieve that aim and aid us in the process of adaptive management over the years.

Flows Atlas

Compilation of instream flow & estuary freshwater inflow statistics for the Trinity and San Jacinto River Basins and Galveston Bay

April 2010

NATIONAL WILDLIFE FEDERATION

Flows Atlas
Compilation of instream flow & estuary freshwater inflow statistics for the Trinity and San Jacinto River Basins and Galveston Bay

Submitted to: Trinity and San Jacinto Rivers and Galveston Bay Basin and Bay Area Stakeholder Committee

April 2010

Submitted by:

National Wildlife Federation, Austin, Texas

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Flows Atlas

1.0 Background

The purpose of this report is to document various calculations to help inform the development of instream flow and estuary inflow regimes and flow standards for the Senate Bill 3 (SB3) process in Texas. This Atlas presents flow statistics that we believe have great utility for SB3 stakeholders and scientists, as well as the public. There are two versions of this Atlas, with one covering the Sabine and Neches River basins and Sabine Lake estuary and the other covering the Trinity and San Jacinto River basins and Galveston Bay estuary. This document presents some basic magnitude and duration measures. The magnitude measures document a full range of flow percentiles for river sites and for bay inflows in the basins while duration measures only pertain to characterization of vey low flows at river sites. Table 1 lists the river sites identified for analysis by the respective Bay Basin Expert Science Teams (BBEST).

Table 1 - River Sites identified by the Trinity/San Jacinto BBEST

USGS Gauge No.	Location
08049500	W Fk Trinity Rv at Grand Prairie
08055500	Elm Fk Trinity Rv nr Carrollton
08057000	Trinity Rv at Dallas
08062500	Trinity Rv nr Rosser
08062700	Trinity Rv at Trinidad
08065000	Trinity Rv nr Oakwood
08065350	Trinity Rv nr Crockett
08066500	Trinity Rv at Romayor
08068000	W Fk San Jacinto Rv nr Conroe
08068500	Spring Ck nr Spring
08080700	E Fk San Jacinto Rv nr Cleveland
08073700	Buffalo Bayou at Piney Point
08075000	Brays Bayou at Houston

Figure 1 Map of Sites in the Trinity and San Jacinto River basins

2.0 Magnitude measures at River Sites

Flow magnitude is the most common measurement used to define environmental flows. Other parameters include duration, frequency, timing, rate of change, range of variability and volume. While these other parameters apply to specific components of the flow regime (which typically includes subsistence flows, base flows, high flow pulses and overbank flows), the magnitude measure is important for all of the flow components.

Flow magnitude is the primary parameter used to define base or low flow requirements. Base flows are the dominant flow condition in most rivers. These low-flow levels in a river impose a fundamental constraint on a river's aquatic communities because they determine the amount of aquatic habitat (e.g. runs, riffles, pools) and this has a strong influence on the diversity and number of organisms that can live in the river. An environmental flow regime includes base flows with both intra- and inter-annual variability. Aquatic organisms have adapted life history traits that respond to seasonal changes in flows and year to year variability is essential in order to balance the distinct habitat requirements of various species, guilds, and assemblages.

Each of the sites listed in Table 1 was analyzed to determine the percentile flows, measured as a flow rate in units of cubic feet per second (cfs), in two ways. First is the most basic approach of using regular monthly categories. For instance, for any given site, all the flows that occurred during the month of January through a certain period of record were lumped together and flow percentiles (e.g. the 5^{th}, 10^{th}, … percentiles) calculated for that month. The magnitude measure results of the monthly approach are in the Table series 2 (i.e. 2-1, 2-2, …).

Because the BBESTs recommended flows on a seasonal basis, flow magnitude percentiles by season also are presented. Consistent with the approach used to define the recommendations, all of the daily flows in a season, as defined by the two BBESTs, were lumped together and statistics calculated based on this population. The results of the seasonal approach are presented in Table series 3.

3.0 Magnitude measures, Estuary

The magnitude of flow is also an important consideration in the development of inflow recommendations for estuaries. The inflow magnitude is a significant factor regulating salinity conditions in the estuary especially during times of average to low inflow conditions. Higher flows are important in that they are most responsible for the transportation of nutrients and sediments into the estuary. While river flows are typically measured in terms of instantaneous flow rates, estuarine inflows are less sensitive to instantaneous fluctuations in flow and thus are generally evaluated in terms of monthly, seasonal, or even annual estimates. Table series 4

includes volume percentiles for estuary inflows in units of 1000s of acre feet per month, season, and year.

4.0 Duration measures at River Sites, Context for BBEST recommendations

In additional to flow magnitude, extended durations of low flow conditions can be an important factor affecting a sound ecological environment. Low flows may result in disconnected pools, along with confined and crowded habitat conditions, which may have a significant effect on predator prey interactions and increase competition for scarce resources. Low flows also have direct relationships to degraded water quality conditions including increased temperature and decreased water quality conditions. While most native species are adapted to natural drought conditions characteristic of some Texas summers, an increase of drought durations may lead to stress beyond the tolerance of some species. Series 5 tables present results of an analysis of the duration, in number of days, for which flows remain below the subsistence level recommended by the "Regime" group of the BBEST. These tables include results for different time periods: the entire period of record for which gage data are available, an earlier subset intended to reflect less altered flow conditions, and a more recent period reflective of current water management practices.

5.0 Examples

The percentile statistics presented in the series 2, 3, and 4 tables are intended to provide some context from which to consider the flow recommendations developed by the BBEST. Percentile statistics are most easily explained with an example. In Figure 2, which was excerpted from one of the series 3 tables of seasonal percentiles for riverine sites, the 4th percentile flow in the spring season is reported as 366 cfs. This means that for all the days that occurred in the spring months during that period of record, during 4 percent of those days flow was less than 366 cfs and in 96 percent of the days flow was greater than 366 cfs. The series 2 tables can be understood the same way.

Start / End	Whole period of record January, 1924 December, 2008			
Flow percentile level	season			
	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	98	66	8	28
1%	149	182	54	85
2%	175	260	66	96
3%	211	305	80	106
4%	248	366	95	116
5%	292	423	105	130
10%	441	680	173	208
15%	586	871	259	295

Figure 2 Example seasonal percentiles for a riverine site.

Figure 3 shows an excerpted part of one of the freshwater inflow tables presented in the series 4 tables. The percentiles reported in the freshwater inflow tables are somewhat different from the statistics presented in the riverine tables (Series 2 and 3). The riverine statistics present results based on different subsets of historical data for individual days (grouped by month or by season). However, the freshwater inflow tables include seasonal and annual totals, grouped and sorted by those totals. Thus, for example, from Figure 3, the total volume for the entire Spring season (sum of March, April and May volumes) was greater than 2,443 in 1000s of acre-feet (or 2,443,000) in 60 percent of the spring seasons for the period and less in 40 percent of the spring seasons.

Start / End	Whole period of record January, 1941 December, 2005				
Flow percentile level	annual	seaon	month		
		Spring Mar-May	Mar	Apr	May
0%	1,871	399	74	136	118
*	*	*	*	*	*
*	*	*	*	*	*
*	*	*	*	*	*
40%	8,441	2,443	598	547	847
45%	10,731	2,748	684	619	997
50%	11,163	3,487	771	662	1,312
55%	11,571	3,614	857	710	1,385
60%	12,705	3,939	991	798	1,515
65%	13,433	4,103	1,329	987	1,678
*	*	*	*	*	*
*	*	*	*	*	*
*	*	*	*	*	*
100%	21,960	9,196	4,456	5,290	4,571

Figure 3 Example of percentiles for a freshwater inflow site.

Table 2 - 1 Monthly Percentiles at Trinity River near Rosser.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Trinity Rv nr Rosser (USGS guage no. 08062500)

Start / End	Whole period of record January, 1939 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	64	81	87	104	139	116	100	107	94	96	100	79
1%	91	126	122	152	168	132	124	117	113	114	120	100
2%	137	162	152	167	226	153	130	132	120	120	128	128
3%	147	174	158	203	282	187	144	138	124	124	131	137
4%	152	188	167	258	313	217	158	144	132	131	137	147
5%	162	203	177	310	335	254	174	148	142	138	148	150
10%	243	310	366	417	553	406	309	220	206	228	200	218
15%	345	443	472	538	720	542	382	313	284	290	264	339
20%	433	563	564	658	834	700	433	376	346	358	366	418
25%	492	704	704	827	978	790	498	430	401	406	440	490
30%	603	819	828	941	1,160	907	552	476	462	451	526	538
35%	744	919	967	1,100	1,470	1,030	626	523	518	541	585	664
40%	838	1,040	1,110	1,260	1,790	1,260	688	556	565	615	679	775
45%	910	1,150	1,301	1,480	2,270	1,641	747	605	622	687	774	860
50%	1,040	1,280	1,625	1,775	2,875	2,105	836	652	686	751	845	928
55%	1,160	1,550	2,040	2,180	3,710	2,885	932	701	766	797	903	1,030
60%	1,340	1,952	2,544	2,770	4,624	3,900	1,050	784	828	844	1,000	1,220
65%	1,580	2,370	3,100	3,587	5,726	5,200	1,210	845	874	961	1,140	1,500
70%	1,903	2,950	3,863	4,600	6,810	5,983	1,643	932	955	1,160	1,380	1,923
75%	2,398	3,680	5,530	5,780	8,048	7,370	2,338	1,060	1,090	1,548	1,773	2,648
80%	3,220	4,552	7,290	7,132	9,914	9,084	3,028	1,290	1,370	2,112	2,552	3,972
85%	4,426	6,410	9,932	8,717	11,865	10,600	4,470	1,833	1,820	3,013	3,960	6,140
90%	6,682	9,000	12,200	11,000	15,300	12,600	6,512	2,994	2,612	5,110	6,637	8,062
95%	9,806	13,915	15,155	16,005	22,510	17,605	9,852	5,956	5,341	8,303	12,005	10,800
96%	10,924	15,300	16,324	18,104	25,072	19,008	11,200	6,180	6,054	9,214	13,004	11,700
97%	12,800	17,738	17,693	21,209	29,193	21,900	12,400	7,359	7,361	10,500	13,800	13,893
98%	15,562	22,030	21,724	26,134	34,500	26,802	15,400	8,255	9,501	13,000	15,700	17,182
99%	16,800	29,338	27,093	38,002	45,837	40,014	17,162	9,196	11,202	18,462	20,202	23,900
max	29,100	49,000	54,900	133,000	107,000	64,600	34,400	23,500	24,000	60,300	49,700	89,800

Table 2 - 2 Monthly Percentiles at Trinity River at Trinidad.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Trinity Rv at Trinidad (USGS guage no. 08062700)

Start / End	Whole period of record January, 1965 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	325	335	335	335	386	351	314	312	338	344	345	355
1%	375	395	415	457	428	388	347	342	366	370	377	395
2%	395	409	478	520	517	405	389	385	383	391	405	415
3%	410	435	529	542	574	444	403	408	406	405	415	434
4%	425	468	570	569	660	483	415	419	420	414	424	446
5%	435	510	596	589	691	545	428	429	441	416	442	459
10%	507	715	709	698	821	697	499	501	484	448	509	521
15%	591	798	857	868	935	802	564	530	525	541	570	581
20%	697	899	1,010	952	1,110	942	644	585	582	620	645	677
25%	829	1,025	1,148	1,100	1,320	1,070	715	621	631	674	700	738
30%	919	1,160	1,260	1,237	1,539	1,237	798	671	694	716	763	827
35%	1,010	1,300	1,460	1,430	2,010	1,550	864	736	745	754	833	901
40%	1,100	1,478	1,880	1,770	2,650	2,020	914	774	790	793	888	969
45%	1,210	1,750	2,434	2,166	3,534	2,653	971	810	832	836	935	1,070
50%	1,330	2,140	2,865	2,860	4,330	3,620	1,050	848	871	895	1,000	1,180
55%	1,497	2,701	3,460	3,550	5,393	4,473	1,150	890	902	946	1,120	1,350
60%	1,790	3,382	4,492	4,460	6,374	5,484	1,300	930	953	1,028	1,274	1,680
65%	2,229	3,990	6,359	5,627	7,660	6,754	1,650	985	1,030	1,190	1,540	2,149
70%	3,081	4,758	8,135	7,100	8,923	7,889	2,140	1,080	1,150	1,440	2,013	3,142
75%	4,125	6,050	10,500	8,653	10,600	9,350	2,753	1,243	1,320	1,833	2,883	4,820
80%	5,520	7,930	12,600	10,520	12,540	10,420	4,070	1,630	1,620	2,560	4,226	7,078
85%	7,196	10,170	14,700	13,130	14,955	12,200	5,542	2,330	2,090	4,036	6,343	8,700
90%	10,600	14,400	18,270	15,800	18,340	14,200	7,840	4,257	2,761	5,991	12,600	11,370
95%	16,370	19,500	24,700	20,705	29,170	18,610	12,700	7,063	5,001	10,885	17,605	18,355
96%	17,448	21,864	27,196	22,096	34,240	20,500	13,448	7,400	5,515	12,196	18,800	21,544
97%	18,922	24,674	28,522	25,186	40,388	23,515	15,322	7,844	5,903	14,844	20,943	24,422
98%	20,600	28,932	30,174	27,924	51,300	27,210	17,748	8,401	7,520	19,318	24,448	30,596
99%	26,322	35,158	33,896	34,929	61,855	36,977	25,559	11,022	9,348	25,433	30,667	42,922
max	38,600	44,400	42,800	51,500	94,100	60,200	58,100	26,000	15,200	39,300	46,700	75,400

Table 2 - 3 Monthly Percentiles at Trinity River near Oakwood.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Trinity Rv nr Oakwood (USGS guage no. 08065000)

Start / End	Whole period of record January, 1924 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	128	141	128	75	208	66	8	28	32	58	28	98
1%	173	211	218	211	338	156	58	54	54	75	110	128
2%	202	333	272	253	407	177	86	65	66	85	120	145
3%	224	376	298	296	473	214	105	70	73	86	137	153
4%	265	414	323	390	540	268	137	86	86	99	156	176
5%	305	455	365	454	662	315	150	96	100	106	169	208
10%	473	618	642	666	890	545	241	148	146	157	248	310
15%	623	750	816	895	1,080	730	354	213	211	272	323	423
20%	752	924	1,000	1,050	1,310	889	437	318	312	345	455	560
25%	908	1,100	1,240	1,240	1,620	1,080	527	384	375	455	535	653
30%	1,060	1,330	1,500	1,520	2,090	1,287	598	440	439	527	636	800
35%	1,200	1,550	1,760	1,772	2,650	1,610	696	512	527	623	733	930
40%	1,390	1,830	2,120	2,140	3,426	1,990	794	580	601	692	838	1,050
45%	1,600	2,179	2,613	2,601	4,436	2,520	889	633	676	773	926	1,210
50%	1,860	2,640	3,410	3,210	5,720	3,410	1,020	700	762	838	1,040	1,460
55%	2,270	3,280	4,200	4,000	7,055	4,460	1,160	772	833	910	1,150	1,740
60%	2,838	4,160	5,380	5,104	8,826	5,800	1,370	830	909	1,030	1,360	2,250
65%	3,900	4,960	7,490	6,144	10,500	7,567	1,730	917	1,010	1,250	1,700	2,860
70%	4,960	6,014	9,316	7,660	12,300	9,823	2,200	1,030	1,160	1,616	2,200	4,066
75%	6,325	7,615	11,600	10,100	14,100	12,200	3,030	1,200	1,390	2,105	2,868	6,375
80%	8,632	10,080	14,500	13,020	16,220	13,600	4,174	1,520	1,810	2,842	4,136	8,564
85%	11,500	13,100	16,800	16,500	19,590	15,800	5,718	2,189	2,350	4,258	5,987	10,900
90%	14,360	16,100	20,800	20,000	25,860	18,810	8,016	3,556	3,621	7,006	10,310	14,460
95%	20,530	22,800	29,200	25,655	40,330	26,055	13,200	6,055	6,911	12,100	17,800	19,130
96%	22,464	27,188	32,464	27,512	45,328	28,304	15,264	6,952	7,920	13,000	19,304	21,828
97%	25,198	31,994	34,792	31,506	52,776	31,500	17,100	7,600	9,677	14,500	21,512	24,200
98%	30,200	38,392	37,896	38,714	62,060	38,700	19,900	8,952	10,500	16,532	25,004	28,928
99%	38,132	47,997	43,466	54,071	76,828	50,804	25,864	12,000	12,200	18,966	33,508	41,862
max	73,700	61,700	82,400	153,000	129,000	69,300	70,600	21,500	25,800	39,600	69,300	103,000

Table 2 - 4 Monthly Percentiles at Trinity River near Crockett.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Trinity Rv nr Crockett (USGS guage no. 08065350)

Start / End	Whole period of record January, 1964 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	340	420	539	467	405	403	298	278	291	387	467	551
1%	400	633	618	643	581	532	341	330	322	433	515	624
2%	649	663	781	722	688	579	383	380	417	470	575	649
3%	670	705	903	777	829	644	427	405	430	493	605	675
4%	707	748	966	834	915	781	450	448	455	515	620	697
5%	745	836	1,020	898	982	844	462	467	476	545	630	721
10%	900	1,140	1,274	1,170	1,194	1,049	596	575	620	647	745	872
15%	1,081	1,367	1,480	1,420	1,371	1,180	720	655	719	731	844	972
20%	1,280	1,550	1,690	1,598	1,560	1,400	814	747	774	802	955	1,130
25%	1,445	1,808	1,970	1,840	1,885	1,680	914	792	833	845	1,103	1,230
30%	1,600	2,056	2,244	2,187	2,520	2,087	1,000	832	891	895	1,200	1,360
35%	1,750	2,420	2,700	2,772	3,290	2,510	1,110	875	950	956	1,310	1,550
40%	1,940	2,830	3,166	3,346	4,090	3,330	1,210	919	1,010	1,050	1,440	1,750
45%	2,200	3,320	3,940	4,040	5,393	4,341	1,400	977	1,070	1,140	1,581	2,013
50%	2,500	4,110	4,980	4,890	6,890	5,335	1,550	1,050	1,170	1,280	1,780	2,520
55%	3,114	4,901	6,497	5,970	8,602	6,569	1,760	1,120	1,260	1,420	2,040	3,110
60%	3,608	5,616	8,580	7,394	10,400	8,360	2,124	1,244	1,400	1,614	2,460	3,958
65%	4,701	6,660	10,600	8,840	12,600	10,400	2,482	1,381	1,559	1,851	3,030	5,404
70%	6,364	8,369	13,680	11,530	14,100	13,000	3,140	1,570	1,743	2,206	3,903	7,360
75%	7,930	10,525	17,000	15,275	16,300	14,800	4,235	1,900	2,000	2,685	5,445	9,350
80%	10,720	13,880	19,100	17,820	18,600	16,920	5,294	2,446	2,450	3,422	7,536	11,400
85%	13,800	16,900	21,400	19,700	22,000	18,765	7,159	3,630	2,923	4,804	11,265	14,490
90%	18,500	20,500	25,000	22,800	26,880	21,500	9,964	5,264	3,961	8,424	17,800	19,420
95%	24,860	27,690	32,230	26,000	41,830	26,755	14,900	7,858	6,036	14,200	22,055	25,490
96%	26,000	28,780	34,800	27,404	45,572	28,500	17,024	8,085	6,921	15,624	23,604	27,800
97%	27,654	31,974	36,918	28,400	50,462	29,706	20,318	8,903	7,926	17,118	25,553	32,000
98%	30,024	35,216	40,412	29,800	63,408	32,206	25,012	10,836	9,842	18,812	27,908	36,648
99%	42,572	37,903	45,336	33,000	71,738	35,865	39,836	17,318	11,802	21,200	33,406	43,578
max	69,400	44,900	58,400	57,800	109,000	53,300	66,300	23,300	14,600	26,700	39,100	106,000

Table 2 - 5 Monthly Percentiles at West Fork Trinity River at Grand Prairie.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: W Fk Trinity Rv at Grand Prairie (USGS guage no. 08049500)

Start / End	Whole period of record: January, 1926 – December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	16	18	14	11	20	16	11	9	8	9	10	15
1%	19	23	20	23	24	23	16	14	12	12	18	20
2%	24	28	26	27	34	31	18	15	14	14	20	25
3%	29	37	35	33	45	38	21	16	16	15	23	27
4%	37	44	43	47	52	44	23	18	18	18	25	29
5%	46	50	50	53	58	50	26	20	18	20	28	33
10%	61	69	70	80	92	74	42	32	33	40	41	53
15%	85	85	97	106	118	93	57	47	51	58	53	73
20%	97	102	118	125	139	107	75	61	66	74	70	94
25%	114	115	140	141	170	126	92	75	78	90	85	108
30%	125	141	168	165	197	149	105	86	93	106	104	124
35%	140	165	197	195	230	168	116	97	111	120	118	135
40%	162	189	223	224	267	197	128	113	124	132	132	150
45%	185	215	252	251	310	228	142	124	139	145	146	164
50%	202	234	287	292	379	276	160	137	153	155	161	184
55%	220	265	335	333	496	334	176	152	165	169	175	204
60%	245	296	391	410	656	432	195	170	178	183	188	228
65%	284	347	481	528	834	579	223	185	196	208	209	256
70%	338	428	595	726	1,110	802	264	209	223	257	243	291
75%	403	522	771	889	1,450	1,118	328	252	276	354	307	345
80%	541	682	1,040	1,142	1,962	1,610	428	329	344	457	446	468
85%	755	959	1,692	1,587	2,664	2,197	635	405	445	660	676	630
90%	1,070	1,550	2,550	2,142	3,916	3,191	1,136	518	657	1,146	1,010	1,080
95%	1,584	3,058	3,964	3,616	6,190	4,600	2,360	1,100	1,240	2,040	1,760	1,710
96%	1,898	3,960	4,361	4,094	7,571	5,340	2,551	1,221	1,474	2,371	2,299	1,982
97%	2,398	4,524	4,727	4,500	8,928	6,906	2,877	1,500	1,693	2,838	3,130	2,227
98%	3,751	5,657	5,106	4,992	12,012	8,693	3,614	1,830	2,452	3,680	4,095	2,751
99%	4,811	7,572	6,856	7,811	16,728	11,000	4,764	2,296	3,964	5,800	5,849	5,970
max	13,400	16,700	24,100	24,900	48,900	37,100	12,400	7,000	10,200	19,500	17,200	31,900

Table 2 - 6 Monthly Percentiles at Elm Fork Trinity River near Carrollton.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Elm Fk Trinity Rv nr Carrollton (USGS guage no. 08055500)

Start / End	Whole period of record January, 1907 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	0	0	0	0	0	0	0	0	0	0	0	0
1%	0	0	0	0	0	0	0	0	0	0	0	0
2%	0	0	0	0	0	0	0	0	0	0	0	0
3%	0	0	0	0	2	0	0	0	0	0	0	0
4%	0	0	0	2	10	0	0	0	0	0	0	0
5%	0	0	0	5	18	5	0	0	0	0	0	0
10%	2	4	8	33	48	51	19	1	2	3	1	2
15%	16	15	30	59	77	79	51	25	18	22	13	16
20%	34	32	52	79	98	98	85	62	45	41	28	39
25%	51	48	67	97	116	114	104	86	65	58	46	54
30%	68	69	83	112	135	133	120	108	79	70	61	68
35%	79	84	100	131	154	157	137	128	91	81	73	79
40%	88	98	113	150	178	182	149	141	102	92	83	90
45%	100	110	130	178	213	217	163	152	115	102	93	102
50%	110	127	159	210	265	247	180	164	127	113	102	113
55%	122	152	199	250	353	307	195	177	139	130	113	128
60%	140	182	254	336	491	389	215	192	153	149	130	151
65%	170	240	324	505	726	540	243	210	170	165	149	182
70%	240	315	468	692	1,160	997	273	234	188	191	172	249
75%	302	420	756	1,083	1,840	1,580	318	267	218	223	227	342
80%	449	597	1,360	1,824	2,858	2,724	389	313	256	265	267	535
85%	725	1,100	2,419	3,070	3,559	3,605	682	362	318	388	418	984
90%	1,410	2,370	3,669	4,310	4,648	4,570	1,969	571	389	753	1,081	2,220
95%	3,760	3,990	4,880	5,311	5,956	5,400	4,980	1,997	1,072	2,338	3,921	4,796
96%	4,276	4,915	5,121	6,000	6,900	6,356	5,300	3,616	1,806	3,361	4,310	5,000
97%	5,272	5,347	5,352	7,188	8,450	6,902	5,912	4,810	3,125	3,962	4,902	5,452
98%	5,710	6,770	5,953	9,608	11,000	7,473	6,476	5,368	3,796	4,828	6,990	6,841
99%	7,104	9,253	8,690	14,400	14,956	9,923	6,730	6,392	5,100	6,888	7,864	7,529
max	27,200	49,400	42,800	77,800	71,400	65,700	10,600	8,340	20,200	10,500	20,500	66,000

Table 2 - 7 Monthly Percentiles at Trinity River at Dallas.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Trinity Rv at Dallas (USGS guage no. 08057000)

Start / End	Whole period of record January, 1904 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	0	0	0	0	0	0	0	0	0	0	0	0
1%	11	7	0	0	0	0	9	0	0	0	0	0
2%	19	13	10	0	0	0	19	0	0	0	0	0
3%	24	18	27	20	13	9	24	0	0	0	13	13
4%	28	26	30	28	32	19	28	0	0	0	19	16
5%	32	30	32	40	60	41	34	2	15	13	23	22
10%	55	67	66	73	115	93	60	28	24	38	46	53
15%	92	100	95	130	184	163	88	47	46	65	71	79
20%	123	141	138	192	247	227	132	66	75	94	106	118
25%	177	195	191	240	324	289	177	105	102	141	140	160
30%	214	234	243	312	402	337	207	150	151	175	172	193
35%	250	282	301	387	500	408	236	190	200	207	202	234
40%	301	340	376	457	630	463	280	223	231	237	237	281
45%	340	410	454	558	810	548	315	255	265	269	272	333
50%	401	463	533	682	1,070	680	360	291	301	319	325	389
55%	464	553	650	840	1,380	894	405	329	346	364	368	441
60%	519	670	811	1,054	1,900	1,210	456	364	381	397	421	502
65%	588	760	1,030	1,410	2,681	1,720	502	411	420	440	474	602
70%	721	925	1,360	1,930	3,430	2,520	604	454	460	521	549	751
75%	930	1,225	1,990	2,620	4,480	3,588	814	504	512	689	683	993
80%	1,310	1,668	3,104	3,940	5,500	4,734	1,320	608	622	988	960	1,502
85%	1,850	2,731	4,489	5,087	7,240	5,857	2,380	830	837	1,560	1,510	2,520
90%	3,090	4,264	6,152	6,500	9,684	7,891	4,250	1,620	1,340	2,640	3,120	4,632
95%	5,466	7,781	9,162	10,300	14,500	11,100	6,329	3,560	3,420	5,153	6,620	6,710
96%	6,444	9,497	10,384	11,504	16,900	12,000	6,908	4,755	4,140	5,967	7,710	7,015
97%	8,068	11,300	11,600	13,200	20,800	13,500	7,985	5,114	5,105	7,091	8,955	7,508
98%	10,784	14,004	12,692	18,606	24,092	17,002	9,596	5,988	6,680	9,078	10,800	9,135
99%	13,300	18,268	15,946	26,504	33,776	22,702	11,500	6,705	9,081	13,692	14,051	15,152
max	41,400	60,900	49,200	103,000	152,000	60,300	31,500	12,600	25,500	33,600	43,100	54,300

Table 2 - 8 Monthly Percentiles at Trinity River at Romayor.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Trinity Rv at Romayor (USGS guage no. 08066500)

Start / End	Whole period of record January, 1925 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	324	325	339	390	414	270	140	104	124	139	192	250
1%	342	446	466	415	728	440	190	140	148	170	255	345
2%	369	637	630	637	933	520	232	162	191	210	279	354
3%	530	756	665	714	1,071	590	262	203	205	230	295	382
4%	571	830	721	828	1,190	698	315	245	245	250	372	448
5%	631	893	811	950	1,240	850	360	270	268	257	400	491
10%	880	1,270	1,160	1,390	1,570	1,090	555	366	345	341	525	717
15%	1,120	1,670	1,490	1,660	1,870	1,420	808	465	435	434	655	830
20%	1,436	2,004	1,920	1,900	2,150	1,790	1,000	540	519	536	765	930
25%	1,815	2,320	2,198	2,190	2,628	2,195	1,140	655	630	650	875	1,040
30%	2,169	2,820	2,750	2,650	3,080	2,530	1,350	790	746	723	969	1,260
35%	2,531	3,400	3,431	3,223	4,010	2,770	1,500	950	845	795	1,060	1,601
40%	2,920	4,110	4,332	3,906	5,042	3,292	1,730	1,080	971	895	1,220	1,982
45%	3,564	4,888	5,284	4,676	6,487	4,210	1,930	1,164	1,050	966	1,470	2,467
50%	4,445	5,600	6,520	5,760	7,880	5,275	2,160	1,260	1,150	1,045	1,725	3,400
55%	5,526	6,440	8,350	7,045	10,300	6,610	2,500	1,330	1,220	1,150	2,060	4,480
60%	7,100	7,734	10,400	8,230	12,200	8,550	2,740	1,440	1,330	1,320	2,420	5,928
65%	8,938	9,488	12,400	10,200	14,500	11,135	3,170	1,560	1,540	1,510	3,084	7,379
70%	11,200	11,500	15,110	13,000	17,600	13,430	3,851	1,790	1,743	1,901	3,820	8,942
75%	13,825	14,100	17,700	15,700	20,725	16,300	4,760	2,050	1,980	2,480	5,300	10,600
80%	15,900	17,000	20,400	19,120	24,940	19,800	6,076	2,514	2,340	3,480	7,232	13,600
85%	19,800	20,400	24,055	23,800	31,255	24,400	8,600	3,080	3,080	5,176	10,300	16,800
90%	23,800	25,200	29,700	27,800	38,170	30,000	12,400	4,737	4,841	9,258	17,710	22,070
95%	34,900	33,740	38,285	35,200	49,885	40,610	19,000	7,890	9,081	15,685	26,200	30,400
96%	37,388	37,300	40,700	37,424	53,964	43,472	20,988	8,406	10,048	18,700	29,724	33,676
97%	41,264	39,584	44,773	40,000	59,000	48,886	24,400	8,889	11,543	21,700	33,500	36,864
98%	48,094	44,712	50,876	43,562	64,094	52,562	34,482	10,594	13,062	25,876	39,400	41,964
99%	52,982	54,300	60,188	52,181	77,379	57,010	46,400	16,000	19,562	35,785	46,562	49,300
max	84,000	67,200	67,600	104,000	110,000	94,200	81,700	33,500	47,300	117,000	95,000	79,100

Table 2 - 9 Monthly Percentiles at West Fork San Jacinto River near Conroe.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: W Fk San Jacinto Rv nr Conroe (USGS guage no. 08068000)

Start / End	Whole period of record: January, 1940 – December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	16	16	16	13	14	0	7	7	0	8	8	9
1%	18	22	22	18	21	15	9	7	7	8	10	17
2%	19	27	25	22	25	16	10	8	8	8	11	20
3%	23	30	28	26	27	18	11	9	8	9	12	22
4%	27	33	30	29	28	20	12	9	9	9	13	23
5%	28	36	33	31	29	21	12	9	9	10	14	24
10%	38	54	49	39	34	25	15	12	12	12	22	29
15%	49	74	58	45	38	27	18	14	15	15	24	34
20%	62	87	68	52	42	30	20	16	17	19	27	41
25%	74	106	79	58	47	33	21	18	20	21	30	50
30%	91	129	93	65	54	38	23	20	22	23	33	62
35%	111	155	107	73	63	43	26	22	24	26	40	75
40%	134	187	122	84	71	48	28	24	26	28	48	89
45%	161	219	143	95	85	53	31	25	29	31	57	114
50%	195	262	169	108	107	62	35	27	32	35	65	139
55%	255	322	205	133	135	72	39	28	36	41	77	167
60%	332	402	244	158	174	87	45	31	43	49	99	207
65%	424	532	304	200	233	105	53	34	52	62	129	248
70%	562	714	381	256	324	134	62	40	66	83	172	338
75%	750	911	502	367	493	191	79	46	86	107	224	467
80%	1,070	1,182	710	569	730	317	99	57	111	164	371	642
85%	1,520	1,630	1,073	959	1,103	575	131	79	148	220	652	1,000
90%	2,272	2,351	1,570	1,652	1,750	1,090	239	96	216	420	1,201	1,560
95%	3,614	3,581	2,620	3,318	3,056	2,871	673	164	566	1,351	2,350	2,762
96%	4,014	3,931	2,890	3,822	3,510	3,685	870	195	709	1,720	2,762	3,050
97%	4,606	4,375	3,276	4,766	4,100	4,588	1,110	234	1,117	2,237	3,658	3,492
98%	5,427	5,403	3,670	6,532	5,170	5,477	1,495	350	1,702	3,216	5,026	4,345
99%	7,653	6,835	5,605	9,993	6,307	9,665	2,132	697	3,052	5,545	11,524	5,518
max	17,700	15,900	18,600	28,900	29,400	28,400	7,920	29,400	12,500	97,200	92,900	20,200

Table 2 - 10 Monthly Percentiles at Spring Ck near Spring.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Spring Ck nr Spring (USGS guage no. 08068500)

Start / End	Whole period of record January, 1940 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	3	5	4	8	6	4	2	2	2	1	2	3
1%	6	8	11	10	8	5	3	3	3	3	3	7
2%	9	14	13	11	10	6	4	4	4	5	5	8
3%	12	15	14	12	13	7	6	4	4	5	6	10
4%	12	17	15	15	15	9	6	5	5	5	6	10
5%	14	20	16	18	16	10	7	5	5	6	7	12
10%	17	26	21	23	20	15	9	7	8	8	11	16
15%	23	32	26	27	26	19	11	9	10	10	14	19
20%	29	39	33	32	30	22	13	11	12	12	17	21
25%	36	46	39	37	35	25	17	13	14	14	20	26
30%	43	53	46	41	40	28	19	16	17	16	23	30
35%	52	63	52	46	44	31	22	18	19	18	27	36
40%	63	75	62	50	50	35	25	20	21	20	30	44
45%	74	87	70	56	56	39	27	22	24	23	34	54
50%	90	100	80	62	62	46	31	24	26	25	38	62
55%	105	116	90	69	72	53	35	26	29	28	44	72
60%	126	136	105	78	84	62	40	29	33	34	51	87
65%	156	166	122	90	105	74	46	32	39	41	66	102
70%	196	215	140	108	137	90	53	36	45	49	82	122
75%	267	281	168	136	198	118	64	42	56	58	107	154
80%	375	387	222	176	321	167	76	49	71	73	141	211
85%	568	601	340	263	479	306	102	64	97	115	209	324
90%	971	1,070	568	508	853	591	168	92	154	207	432	632
95%	1,742	1,946	1,340	1,631	1,773	1,381	342	181	396	566	1,400	1,200
96%	2,049	2,191	1,555	2,010	2,215	1,882	458	228	515	828	1,690	1,415
97%	2,367	2,480	1,939	2,576	2,783	2,369	762	300	893	1,279	2,419	1,670
98%	2,797	2,900	2,594	3,201	3,367	3,302	1,155	412	1,472	3,274	3,232	1,985
99%	3,703	4,006	3,393	5,169	4,820	5,272	1,737	1,006	3,620	4,755	5,963	2,737
max	9,270	9,400	6,990	26,900	10,700	18,900	7,530	20,800	13,700	55,900	31,500	15,600

Table 2 - 11 Monthly Percentiles at East Fork San Jacinto River near Cleveland.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: E Fk San Jacinto Rv nr Cleveland (USGS guage no. 08070000)

Start / End	Whole period of record January, 1940 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	10	12	12	9	9	7	4	3	3	4	6	8
1%	14	17	18	14	13	9	5	5	4	6	8	12
2%	16	20	24	20	16	10	7	6	7	7	10	15
3%	19	26	26	22	18	11	7	6	7	8	10	16
4%	22	29	28	24	20	12	8	7	7	8	11	18
5%	24	31	29	25	21	13	8	8	8	9	12	20
10%	29	39	36	31	25	16	11	9	10	10	16	23
15%	34	50	42	38	29	19	13	11	12	11	18	26
20%	40	65	51	43	32	21	15	12	13	14	20	29
25%	49	75	61	48	37	24	17	14	15	15	22	33
30%	67	86	69	55	41	27	19	15	17	17	24	38
35%	80	95	78	60	45	30	21	16	18	19	27	46
40%	94	107	89	66	50	33	24	18	20	20	30	55
45%	107	120	100	71	56	38	26	20	21	23	34	66
50%	123	133	112	77	64	43	29	22	23	25	38	75
55%	141	152	124	85	75	50	33	23	25	28	45	92
60%	163	183	139	96	87	59	38	25	28	30	53	110
65%	199	215	162	110	102	69	44	27	30	35	63	127
70%	246	274	189	130	126	82	50	30	35	40	80	152
75%	338	347	226	162	165	103	59	32	42	48	103	192
80%	459	462	299	207	231	139	72	38	52	57	137	263
85%	653	726	447	345	379	210	90	46	70	77	205	413
90%	941	1,110	724	650	673	487	134	63	108	131	402	652
95%	1,690	1,746	1,151	1,520	1,210	1,261	266	117	219	436	1,080	1,331
96%	1,960	2,060	1,275	1,862	1,485	1,602	349	144	297	656	1,365	1,520
97%	2,269	2,311	1,506	2,239	1,937	2,023	492	191	411	1,059	1,949	1,740
98%	2,900	2,770	1,782	2,706	2,530	2,636	816	255	681	2,007	2,956	2,117
99%	3,637	3,596	2,425	3,975	4,058	4,271	1,562	640	1,173	3,826	5,122	2,980
max	19,000	8,280	6,620	30,400	15,700	31,900	4,940	7,170	8,340	44,200	43,200	14,100

Table 2 - 12 Monthly Percentiles at Brays Bayou at Houston.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Brays Bayou at Houston (USGS guage no. 08075000)

Start / End	Whole period of record January, 1937 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	1	1	0	0	1	0	0	0	0	0	0	0
1%	1	3	1	1	1	1	1	1	0	0	0	1
2%	5	4	2	1	1	1	1	1	1	1	1	2
3%	5	5	3	2	1	2	2	1	1	1	1	4
4%	6	6	3	3	3	3	2	1	1	1	2	4
5%	6	7	4	3	3	3	2	2	2	2	3	5
10%	10	10	7	6	7	6	6	5	6	5	5	8
15%	15	14	9	8	10	9	8	7	9	7	8	12
20%	23	23	12	11	15	15	12	11	13	10	14	20
25%	31	29	20	17	21	20	19	18	20	14	24	26
30%	41	39	26	23	27	27	24	25	27	21	30	35
35%	54	51	33	32	40	37	35	33	38	32	40	48
40%	76	70	43	43	52	53	50	45	52	49	54	65
45%	94	92	57	56	72	70	70	63	80	68	77	89
50%	103	100	76	80	97	89	94	89	98	89	95	98
55%	111	110	95	96	103	102	103	104	104	99	101	104
60%	117	118	104	104	108	108	108	109	111	104	108	111
65%	125	126	113	110	113	116	115	115	119	110	112	118
70%	138	138	120	115	121	128	124	124	128	117	117	125
75%	160	155	129	126	134	151	137	139	142	124	127	136
80%	199	185	143	139	167	205	156	159	164	139	151	158
85%	270	250	170	170	253	292	195	192	218	180	209	213
90%	410	404	243	241	434	469	301	283	331	316	332	333
95%	740	746	558	633	845	895	535	474	674	722	855	620
96%	881	885	703	763	1,020	1,082	674	581	805	917	1,026	777
97%	1,104	1,070	876	985	1,284	1,342	810	773	1,002	1,321	1,335	907
98%	1,628	1,314	1,324	1,370	1,708	1,596	1,084	1,115	1,416	1,544	1,841	1,280
99%	2,428	2,000	1,820	2,255	2,347	3,076	1,854	1,791	2,383	2,332	3,190	1,758
max	4,880	5,930	8,890	8,030	7,710	14,000	6,020	13,100	13,600	16,300	8,660	5,380

Table 2 - 13 Monthly Percentiles at Buffalo Bayou at Piney Point.

Flow Statistic: Percentile flow magnitudes (cfs), by month.

Site: Buffalo Bayou at Piney Point (USGS guage no. 08073700)

Start / End	Whole period of record January, 1964 December, 2008											
Flow percentile level	month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
min	8	8	7	7	10	7	15	17	11	12	7	6
1%	10	10	9	10	15	16	20	24	20	24	9	9
2%	13	13	11	12	17	25	26	28	32	32	12	10
3%	15	16	12	13	19	27	32	33	35	36	13	13
4%	19	18	14	14	20	29	37	40	40	40	14	15
5%	22	20	16	15	26	30	40	46	42	44	16	18
10%	31	34	24	26	43	38	50	57	51	52	30	34
15%	57	52	35	31	52	47	60	64	58	55	42	46
20%	67	61	46	39	64	55	67	70	63	61	57	56
25%	76	69	53	47	72	64	74	74	69	66	62	64
30%	85	76	59	53	79	76	81	82	79	74	70	74
35%	97	86	67	59	86	87	88	88	89	81	82	88
40%	109	101	82	69	101	97	96	96	98	92	92	99
45%	126	115	97	83	124	118	105	105	107	103	100	113
50%	142	132	115	92	158	151	118	116	121	120	117	136
55%	166	170	145	107	217	197	131	134	142	142	144	161
60%	226	222	195	121	270	289	158	153	165	180	201	213
65%	304	330	262	155	349	372	187	180	209	245	307	285
70%	399	445	343	229	464	484	227	227	270	345	433	389
75%	460	632	469	360	581	634	280	275	348	445	684	555
80%	569	805	662	584	807	822	357	350	451	597	958	737
85%	745	939	855	835	1,014	999	510	437	612	829	1,200	945
90%	983	1,204	1,180	1,370	1,306	1,241	874	555	835	1,270	1,540	1,236
95%	1,400	1,596	1,680	1,700	1,676	1,750	1,636	957	1,260	1,758	1,830	1,598
96%	1,506	1,750	1,760	1,750	1,806	1,800	1,706	1,106	1,320	1,853	1,870	1,703
97%	1,595	1,847	1,880	1,800	1,930	1,890	1,805	1,215	1,506	1,925	1,940	1,805
98%	1,703	1,927	1,993	1,870	2,000	1,990	1,970	1,753	1,630	1,990	1,970	1,876
99%	1,872	2,021	2,072	1,975	2,410	2,371	2,120	1,964	1,730	2,042	2,045	2,102
max	2,050	2,340	4,740	2,590	3,900	3,970	2,660	2,390	4,270	4,480	4,180	2,770

Table 3 - 1 Seasonal Percentiles at Trinity River near Rosser.

Percentile flow magnitudes (cfs), by season.

Site: Trinity Rv nr Rosser (USGS guage no. 08062500)

Start End	Whole period of record January, 1939 December, 2008			
Flow	season			
percentile level	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	64	87	94	96
1%	106	144	116	115
2%	134	162	124	124
3%	147	181	134	128
4%	152	211	144	132
5%	167	255	152	141
10%	255	418	240	206
15%	369	551	328	282
20%	455	700	385	360
25%	526	820	442	412
30%	645	949	500	486
35%	778	1,100	543	564
40%	861	1,310	598	635
45%	950	1,630	654	727
50%	1,070	2,020	715	787
55%	1,210	2,580	793	843
60%	1,430	3,310	855	922
65%	1,760	4,280	943	1,059
70%	2,240	5,550	1,060	1,260
75%	2,908	6,773	1,273	1,660
80%	3,950	8,340	1,780	2,262
85%	5,455	10,400	2,580	3,357
90%	7,993	12,700	4,261	5,722
95%	11,300	17,400	7,171	9,950
96%	12,900	19,300	7,920	11,524
97%	15,100	23,083	8,948	13,000
98%	17,066	27,900	10,622	14,362
99%	23,283	37,800	14,200	19,631
max	89,800	133,000	34,400	60,300

Table 3 - 2 Seasonal Percentiles at Trinity River at Trinidad.

Percentile flow magnitudes (cfs), by season.

Site: Trinity Rv at Trinidad (USGS guage no. 08062700)

Start End	Whole period of record January, 1965 December, 2008			
Flow	season			
percentile	Winter	Spring	Summer	Fall
level	Dec-Feb	Mar-Jun	Jul-Sep	Oct-Nov
min	325	335	312	344
1%	385	405	350	374
2%	405	462	385	395
3%	420	523	405	410
4%	436	567	417	415
5%	453	597	429	424
10%	542	733	493	483
15%	634	869	540	555
20%	757	998	596	629
25%	842	1,150	650	688
30%	937	1,310	710	731
35%	1,030	1,580	769	784
40%	1,140	2,020	816	835
45%	1,260	2,610	861	889
50%	1,440	3,340	900	939
55%	1,720	4,209	955	1,010
60%	2,140	5,400	1,020	1,150
65%	2,885	6,636	1,120	1,330
70%	3,820	8,060	1,290	1,660
75%	4,995	9,733	1,630	2,188
80%	6,680	11,500	2,210	3,204
85%	8,830	13,600	3,110	4,941
90%	11,900	16,400	4,946	8,822
95%	17,750	22,965	7,829	15,185
96%	19,720	25,732	8,411	16,800
97%	22,300	28,700	9,786	18,800
98%	26,360	33,266	13,000	22,502
99%	35,100	41,399	16,853	27,951
max	75,400	94,100	58,100	46,700

Table 3 - 3 Seasonal Percentiles at Trinity River near Oakwood.

Percentile flow magnitudes (cfs), by season.

Site: Trinity Rv nr Oakwood (USGS guage no. 08065000)

Start End	Whole period of record January, 1924 December, 2008			
Flow	season			
percentile level	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	98	66	8	28
1%	149	182	54	85
2%	175	260	66	96
3%	211	305	80	106
4%	248	366	95	116
5%	292	423	105	130
10%	441	680	173	208
15%	586	871	259	295
20%	708	1,060	354	399
25%	866	1,270	420	496
30%	1,020	1,560	491	574
35%	1,160	1,880	565	665
40%	1,370	2,320	644	752
45%	1,620	2,941	722	838
50%	1,930	3,790	800	914
55%	2,380	4,850	879	1,030
60%	2,990	6,180	976	1,180
65%	4,000	7,880	1,114	1,450
70%	5,200	10,000	1,320	1,888
75%	6,803	12,300	1,700	2,480
80%	8,960	14,500	2,252	3,344
85%	11,900	16,900	3,340	5,142
90%	15,000	21,100	5,220	8,406
95%	20,900	29,200	8,570	14,680
96%	23,016	33,300	10,024	16,600
97%	26,900	37,993	11,400	18,048
98%	32,300	44,324	13,562	20,832
99%	43,045	59,648	18,400	26,816
max	103,000	153,000	70,600	69,300

Table 3 - 4 Seasonal Percentiles at Trinity River near Crockett.

Percentile flow magnitudes (cfs), by season.

Site: Trinity Rv nr Crockett (USGS guage no. 08065350)

Start	Whole period of record January, 1964			
End	December, 2008			
Flow	season			
percentile level	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	340	403	278	387
1%	604	579	330	467
2%	652	667	388	500
3%	676	793	427	533
4%	709	878	449	575
5%	744	925	467	599
10%	915	1,160	600	688
15%	1,110	1,360	700	786
20%	1,270	1,570	770	845
25%	1,450	1,860	828	912
30%	1,613	2,230	889	1,022
35%	1,820	2,820	950	1,120
40%	2,070	3,480	1,020	1,230
45%	2,460	4,350	1,100	1,360
50%	2,980	5,385	1,200	1,500
55%	3,580	6,800	1,340	1,700
60%	4,566	8,620	1,500	1,950
65%	5,687	10,600	1,694	2,340
70%	7,327	13,400	2,003	2,800
75%	9,158	15,900	2,480	3,630
80%	11,800	18,100	3,192	5,144
85%	15,300	20,300	4,450	7,844
90%	19,500	24,000	6,231	12,620
95%	25,895	29,955	9,761	18,900
96%	27,800	32,600	11,300	20,500
97%	30,217	36,333	13,066	21,900
98%	34,756	41,322	15,222	24,200
99%	40,739	50,200	22,200	27,680
max	106,000	109,000	66,300	39,100

Table 3 - 5 Seasonal Percentiles at West Fork Trinity River at Grand Prairie.

Percentile flow magnitudes (cfs), by season.

Site: W Fk Trinity Rv at Grand Prairie (USGS guage no. 08049500)

Start / End	Whole period of record January, 1926 December, 2008			
Flow percentile level	season			
	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	15	11	8	9
1%	21	22	14	14
2%	25	29	16	16
3%	29	38	17	18
4%	35	48	19	21
5%	42	53	21	25
10%	60	80	36	41
15%	82	101	52	55
20%	97	122	68	73
25%	113	143	80	88
30%	127	168	95	105
35%	145	197	110	119
40%	163	227	121	132
45%	185	261	134	146
50%	205	302	150	158
55%	227	362	165	172
60%	253	453	180	186
65%	290	592	200	209
70%	342	778	233	250
75%	427	1,010	286	328
80%	558	1,440	368	455
85%	793	2,000	463	672
90%	1,190	2,945	739	1,080
95%	2,060	4,528	1,450	1,990
96%	2,440	5,040	1,710	2,365
97%	3,050	5,963	2,199	2,924
98%	4,190	7,940	2,633	3,995
99%	6,385	11,500	3,823	5,870
max	31,900	48,900	12,400	19,500

Table 3 - 6 Seasonal Percentiles at Elm Fork Trinity River near Carrollton.

Percentile flow magnitudes (cfs), by season.

Site: Elm Fk Trinity Rv nr Carrollton (USGS guage no. 08055500)

Start End	Whole period of record January, 1907 December, 2008			
Flow	season			
percentile	Winter	Spring	Summer	Fall
level	Dec-Feb	Mar-Jun	Jul-Sep	Oct-Nov
min	0	0	0	0
1%	0	0	0	0
2%	0	0	0	0
3%	0	0	0	0
4%	0	0	0	0
5%	0	2	0	0
10%	2	32	5	1
15%	16	59	34	18
20%	34	80	61	35
25%	51	98	82	52
30%	68	113	100	65
35%	81	132	115	76
40%	91	154	130	87
45%	103	180	143	98
50%	116	223	156	107
55%	132	267	171	121
60%	157	350	187	140
65%	196	498	205	157
70%	268	775	234	185
75%	350	1,310	268	224
80%	522	2,170	315	267
85%	873	3,285	383	418
90%	1,980	4,360	709	892
95%	4,150	5,290	3,440	3,180
96%	4,908	5,760	4,271	3,940
97%	5,330	6,810	4,990	4,500
98%	6,699	8,664	5,577	5,807
99%	7,798	11,600	6,530	7,730
max	66,000	77,800	20,200	20,500

Table 3 - 7 Seasonal Percentiles at Trinity River at Dallas.

Percentile flow magnitudes (cfs), by season.

Site: Trinity Rv at Dallas (USGS guage no. 08057000)

Start End	Whole period of record January, 1904 December, 2008			
Flow	season			
percentile	Winter	Spring	Summer	Fall
level	Dec-Feb	Mar-Jun	Jul-Sep	Oct-Nov
min	0	0	0	0
1%	0	0	0	0
2%	13	0	0	0
3%	18	13	0	0
4%	23	28	12	13
5%	27	37	17	18
10%	56	85	34	43
15%	91	137	58	68
20%	124	197	85	100
25%	172	253	129	141
30%	214	320	174	174
35%	253	394	211	204
40%	304	468	240	237
45%	353	565	279	271
50%	413	700	315	322
55%	475	890	355	366
60%	549	1,160	400	406
65%	660	1,580	441	456
70%	800	2,270	485	536
75%	1,050	3,250	570	684
80%	1,470	4,410	732	970
85%	2,290	5,620	1,200	1,540
90%	4,034	7,530	2,231	2,796
95%	6,702	11,255	4,920	5,760
96%	7,359	12,300	5,406	6,832
97%	8,820	14,400	6,240	8,300
98%	11,748	18,500	7,368	9,800
99%	15,048	25,691	9,563	14,000
max	60,900	152,000	31,500	43,100

Table 3 - 8 Seasonal Percentiles at Trinity River at Romayor.

Percentile flow magnitudes (cfs), by season.

Site: Trinity Rv at Romayor (USGS guage no. 08066500)

Start / End	Whole period of record January, 1925 December, 2008			
Flow percentile level	season			
	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	250	270	104	139
1%	345	469	154	210
2%	376	630	192	236
3%	490	720	224	255
4%	550	830	258	270
5%	646	925	275	290
10%	855	1,290	395	416
15%	1,030	1,650	495	525
20%	1,290	1,960	630	652
25%	1,670	2,278	770	745
30%	2,010	2,720	915	826
35%	2,430	3,240	1,050	926
40%	2,930	4,070	1,150	1,020
45%	3,710	5,090	1,260	1,110
50%	4,610	6,340	1,390	1,260
55%	5,610	7,829	1,550	1,480
60%	6,940	9,922	1,750	1,780
65%	8,460	12,200	1,980	2,190
70%	10,400	14,700	2,320	2,750
75%	12,900	17,700	2,720	3,673
80%	15,700	21,200	3,490	5,224
85%	19,100	25,400	4,770	7,800
90%	23,600	31,300	7,176	12,500
95%	33,200	40,965	11,900	21,900
96%	36,080	44,400	13,592	24,308
97%	39,100	48,600	16,900	28,300
98%	45,500	54,200	19,946	33,654
99%	52,400	61,753	30,546	43,700
max	84,000	110,000	81,700	117,000

Table 3 - 9 Seasonal Percentiles at West Fork San Jacinto River near Conroe.

Percentile flow magnitudes (cfs), by season.

Site: W Fk San Jacinto Rv nr Conroe (USGS guage no. 08068000)

Start End	Whole period of record January, 1940 December, 2008			
Flow	season			
percentile	Winter	Spring	Summer	Fall
level	Dec-Feb	Mar-Jun	Jul-Sep	Oct-Nov
min	9	0	0	8
1%	18	17	7	8
2%	21	20	8	9
3%	23	23	9	10
4%	26	24	9	11
5%	27	26	10	11
10%	36	32	13	15
15%	46	38	15	20
20%	59	44	18	22
25%	74	51	20	25
30%	88	58	22	28
35%	109	67	24	30
40%	132	77	26	34
45%	160	91	28	40
50%	194	107	30	49
55%	234	130	34	58
60%	301	161	38	71
65%	388	207	44	89
70%	516	279	53	118
75%	707	388	67	167
80%	970	600	88	220
85%	1,390	930	113	379
90%	2,080	1,570	173	786
95%	3,349	2,920	406	1,926
96%	3,758	3,420	568	2,297
97%	4,222	4,095	795	2,913
98%	4,999	5,186	1,200	4,301
99%	6,662	7,530	2,145	7,794
max	20,200	29,400	29,400	97,200

Table 3 - 10 Seasonal Percentiles at Spring Ck near Spring.

Percentile flow magnitudes (cfs), by season.

Site: Spring Ck nr Spring (USGS guage no. 08068500)

Start	Whole period of record January, 1940			
End	December, 2008			
Flow	season			
percentile level	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	3	4	2	1
1%	7	7	3	3
2%	9	10	4	5
3%	11	11	5	5
4%	13	13	5	6
5%	14	14	6	6
10%	18	20	8	9
15%	23	24	10	12
20%	28	28	12	14
25%	34	33	15	16
30%	41	38	17	19
35%	50	43	20	21
40%	59	48	22	24
45%	69	55	24	27
50%	82	62	27	31
55%	97	71	30	37
60%	113	82	33	43
65%	136	98	38	50
70%	171	122	44	60
75%	227	152	53	79
80%	316	212	66	109
85%	500	353	87	162
90%	867	633	137	303
95%	1,627	1,532	299	1,006
96%	1,889	1,910	388	1,394
97%	2,220	2,375	562	2,045
98%	2,655	3,107	1,001	3,257
99%	3,486	4,507	1,906	5,183
max	15,600	26,900	20,800	55,900

Table 3 - 11 Seasonal Percentiles at East Fork San Jacinto River near Cleveland.

Percentile flow magnitudes (cfs), by season.

Site: E Fk San Jacinto Rv nr Cleveland (USGS guage no. 08070000)

Start End	Whole period of record January, 1940 December, 2008			
Flow	season			
percentile	Winter	Spring	Summer	Fall
level	Dec-Feb	Mar-Jun	Jul-Sep	Oct-Nov
min	8	7	3	4
1%	14	11	5	7
2%	16	13	6	8
3%	19	15	7	9
4%	20	17	7	9
5%	22	18	8	10
10%	28	24	10	11
15%	33	28	12	14
20%	38	33	13	17
25%	47	38	15	19
30%	60	44	16	20
35%	72	50	18	22
40%	85	57	20	24
45%	98	65	22	27
50%	112	73	24	30
55%	127	83	26	34
60%	147	97	29	39
65%	178	112	32	46
70%	218	135	37	54
75%	285	167	44	67
80%	397	222	53	94
85%	586	353	69	134
90%	909	647	99	253
95%	1,600	1,250	196	812
96%	1,800	1,520	244	1,067
97%	2,140	1,880	345	1,488
98%	2,620	2,447	601	2,530
99%	3,440	3,688	1,010	4,648
max	19,000	31,900	8,340	44,200

Table 3 - 12 Seasonal Percentiles at Brays Bayou at Houston.

Percentile flow magnitudes (cfs), by season.

Site: Brays Bayou at Houston (USGS guage no. 08075000)

Start End	Whole period of record January, 1937 December, 2008			
Flow	season			
percentile	Winter	Spring	Summer	Fall
level	Dec-Feb	Mar-Jun	Jul-Sep	Oct-Nov
min	0	0	0	0
1%	1	1	1	0
2%	3	1	1	1
3%	4	2	1	1
4%	5	3	2	2
5%	6	3	2	2
10%	9	7	5	5
15%	14	9	8	7
20%	22	13	12	12
25%	29	19	19	18
30%	39	26	25	26
35%	50	35	35	36
40%	71	47	49	50
45%	92	65	70	73
50%	100	84	96	92
55%	108	100	104	100
60%	115	106	109	106
65%	122	113	116	112
70%	132	120	126	117
75%	150	133	140	126
80%	181	154	161	143
85%	243	211	201	192
90%	381	346	300	326
95%	712	744	556	777
96%	834	895	698	977
97%	1,050	1,150	870	1,330
98%	1,380	1,480	1,241	1,625
99%	2,092	2,342	2,048	2,942
max	5,930	14,000	13,600	16,300

Table 3 - 13 Seasonal Percentiles at Buffalo Bayou at Piney Point.

Percentile flow magnitudes (cfs), by season.

Site: Buffalo Bayou at Piney Point (USGS guage no. 08073700)

Start	Whole period of record January, 1964			
End	December, 2008			
Flow	season			
percentile level	Winter Dec-Feb	Spring Mar-Jun	Summer Jul-Sep	Fall Oct-Nov
min	6	7	11	7
1%	9	11	20	12
2%	12	14	28	14
3%	15	15	34	18
4%	17	18	39	23
5%	20	20	42	28
10%	34	31	52	43
15%	51	41	61	53
20%	61	49	66	59
25%	70	57	73	65
30%	79	66	81	72
35%	90	77	88	82
40%	103	87	96	92
45%	117	101	105	102
50%	138	120	118	119
55%	165	152	134	143
60%	220	204	159	187
65%	301	290	190	265
70%	410	384	236	385
75%	526	531	292	526
80%	692	715	381	749
85%	899	946	501	1,040
90%	1,162	1,270	751	1,406
95%	1,540	1,700	1,260	1,810
96%	1,640	1,782	1,490	1,860
97%	1,770	1,869	1,644	1,940
98%	1,870	1,970	1,780	1,980
99%	2,004	2,196	2,040	2,047
max	2,770	4,740	4,270	4,480

Table 4 - 1 Estuary Inflow Percentiles for Galveston Bay.

Inflow Statistic: Percentile flow magnitudes (1000 ACFT per month), by years, seasons and months.

Total Inflow to Galveston Bay.

Start / End	Whole period of record January, 1941 December, 2005																		
Flow percentile level	annual		season					month											
			Winter Dec-Feb	Spring Mar-May	Summer Jun-Aug	Fall Sep-Nov		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0%	1,871		363	399	237	143		42	71	74	136	118	57	44	21	16	21	31	55
1%	1,984		446	437	321	185		56	78	87	142	125	97	63	39	23	26	40	66
2%	2,151		537	517	375	214		66	94	98	152	132	125	77	51	36	32	55	73
3%	2,389		640	648	390	226		72	124	107	166	139	137	83	54	58	39	79	75
4%	2,666		724	673	427	259		92	127	115	179	146	143	89	58	66	42	85	83
5%	2,970		793	686	467	290		111	131	123	187	151	153	95	61	73	44	88	90
10%	4,133		970	889	684	466		176	165	184	212	236	209	143	93	117	77	93	103
15%	4,847		1,247	1,114	740	563		241	306	240	308	280	274	176	119	162	91	142	153
20%	5,432		1,378	1,328	791	692		288	351	301	378	381	319	215	137	180	110	187	191
25%	6,881		1,804	1,741	925	815		357	431	389	403	462	373	232	171	203	124	242	323
30%	7,411		1,924	2,151	983	896		385	600	521	432	544	470	253	176	212	181	269	425
35%	7,814		2,168	2,250	1,089	959		425	636	567	485	743	519	288	196	237	203	307	476
40%	8,441		2,319	2,443	1,258	1,037		609	719	598	547	847	576	314	214	270	226	344	583
45%	10,731		2,445	2,748	1,462	1,121		720	981	684	619	997	815	379	230	326	246	372	658
50%	11,163		2,709	3,487	1,988	1,133		818	1,055	771	662	1,312	874	426	268	348	261	414	726
55%	11,571		3,118	3,614	2,085	1,361		909	1,118	857	710	1,385	946	517	295	415	292	445	861
60%	12,705		3,350	3,939	2,491	1,827		1,098	1,156	991	798	1,515	1,091	557	306	463	327	481	939
65%	13,433		3,466	4,103	2,755	2,062		1,162	1,339	1,329	987	1,678	1,413	608	344	583	383	594	984
70%	13,775		3,744	4,215	2,959	2,421		1,426	1,369	1,536	1,566	1,898	1,602	684	517	626	553	784	1,111
75%	14,453		4,045	5,649	3,265	2,997		1,513	1,403	1,646	1,675	2,049	1,827	759	571	671	885	1,004	1,350
80%	16,087		4,236	6,575	3,948	3,433		1,640	1,583	1,893	2,028	2,217	2,000	940	670	836	944	1,185	1,593
85%	17,490		4,855	6,908	4,060	3,904		2,150	1,866	1,984	2,214	2,730	2,695	1,123	701	1,195	1,128	1,734	1,828
90%	19,097		5,282	7,117	4,814	4,656		2,470	1,918	2,336	2,446	3,211	3,139	1,425	757	1,524	1,780	1,982	2,073
95%	20,557		6,042	7,492	5,179	5,472		2,826	2,137	2,888	2,888	4,077	3,640	1,684	915	1,787	2,426	2,678	2,392
96%	20,816		6,810	7,984	5,292	5,686		2,934	2,230	3,189	3,034	4,215	3,726	1,947	982	1,879	2,722	2,941	2,489
97%	20,999		7,800	8,514	5,433	5,945		3,134	2,342	3,546	3,169	4,335	3,785	2,267	1,150	1,981	3,037	3,247	2,585
98%	21,316		8,091	8,524	5,555	6,057		3,968	2,506	3,741	3,456	4,386	3,906	2,351	1,818	2,041	3,422	3,480	2,607
99%	21,637		8,952	8,769	6,126	6,500		4,421	3,161	4,053	4,196	4,467	3,978	2,406	2,113	2,274	3,861	3,936	2,745
100%	21,960		10,257	9,196	7,045	7,203		4,579	4,198	4,456	5,290	4,571	4,012	2,438	2,116	2,643	4,341	4,565	2,974

Table 4 - 2 Estuary Inflow Percentiles for Galveston Bay (Trinity Basin only).

Inflow Statistic: Percentile flow magnitudes (units 1000 ACFT), by years, seasons and months.

Inflow to Galveston Bay from the Trinity River Drainage.

Start	Modern period January, 1977																		
End	December, 2005																		
Flow	annual		season					month											
percentile			Winter	Spring	Summer	Fall													
level			Dec-Feb	Mar-May	Jun-Aug	Sep-Nov		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0%	1,625		424	163	222	96		49	40	17	92	48	75	63	12	30	18	21	32
1%	1,691		490	255	234	114		59	41	30	93	54	82	67	25	33	19	24	34
2%	1,757		556	346	246	132		69	43	44	94	61	90	71	38	35	19	27	36
3%	1,823		622	438	258	150		78	45	57	94	67	98	76	50	38	20	31	38
4%	1,871		664	492	268	166		84	53	79	95	73	103	79	59	40	20	33	40
5%	1,896		676	494	276	180		84	72	112	96	79	105	81	63	40	21	34	41
10%	3,470		730	653	315	217		88	200	198	150	92	120	90	71	49	23	46	47
15%	3,961		854	1,010	351	270		145	267	319	216	126	137	97	72	60	33	57	74
20%	4,106		1,024	1,205	365	283		216	356	382	231	176	166	103	73	72	36	81	145
25%	4,358		1,258	1,313	471	343		311	424	387	294	256	189	106	74	75	47	93	190
30%	5,310		1,394	1,541	596	374		331	492	406	329	314	322	119	78	79	64	126	244
35%	5,591		1,463	1,900	651	404		387	609	443	338	462	390	140	85	87	67	152	288
40%	5,846		1,619	2,042	851	455		410	650	472	349	526	420	159	89	93	79	180	353
45%	6,596		1,714	2,158	920	498		463	670	568	402	612	556	189	94	110	113	225	492
50%	7,085		1,906	2,192	1,077	519		466	697	684	478	624	635	206	107	121	116	239	577
55%	7,646		2,012	2,356	1,163	990		521	744	878	522	759	767	258	127	129	135	276	644
60%	7,858		2,206	2,541	1,420	1,115		575	859	1,014	650	991	856	292	132	154	197	411	661
65%	8,661		2,291	2,665	1,560	1,157		610	913	1,055	770	1,070	1,097	323	143	193	223	495	719
70%	8,974		2,422	2,877	1,765	1,254		636	954	1,220	1,058	1,151	1,328	380	189	246	277	721	973
75%	9,449		2,561	3,096	1,955	1,356		723	981	1,304	1,254	1,195	1,364	401	207	254	289	917	1,158
80%	10,056		2,696	4,064	2,127	1,540		1,031	1,040	1,414	1,409	1,217	1,403	436	235	314	413	1,028	1,231
85%	10,216		2,904	4,344	2,465	1,834		1,600	1,119	1,461	1,624	1,335	1,426	474	335	363	629	1,153	1,286
90%	11,014		4,166	4,808	2,691	2,207		1,758	1,144	2,040	1,712	1,563	1,769	685	412	396	723	1,298	1,467
95%	11,725		5,350	5,338	3,011	2,679		2,463	1,256	2,739	1,758	1,719	2,077	1,014	487	555	858	1,410	1,900
96%	12,049		5,601	5,386	3,078	2,885		2,777	1,287	2,869	1,767	1,738	2,126	1,103	521	598	892	1,439	2,010
97%	12,355		5,934	5,643	3,295	3,020		2,981	1,531	3,013	1,796	2,060	2,158	1,233	538	627	1,095	1,533	2,057
98%	12,648		6,327	6,057	3,626	3,102		3,102	1,935	3,168	1,839	2,609	2,177	1,394	542	645	1,424	1,676	2,057
99%	12,940		6,720	6,472	3,956	3,184		3,223	2,339	3,322	1,882	3,159	2,196	1,556	546	662	1,753	1,818	2,058
100%	13,232		7,113	6,886	4,287	3,265		3,344	2,743	3,477	1,926	3,709	2,215	1,717	551	680	2,082	1,961	2,058

Table 4 - 3 Estuary Inflow Percentiles for Galveston Bay (San Jacinto Basin only).

Inflow Statistic: Percentile flow magnitudes (units 1000 ACFT), by years, seasons and months.

Inflow to Galveston Bay from the San Jacinto River & Buffalo Bayou Drainages.

Start	Modern period January, 1977																	
End	December, 2005																	
Flow	annual	season				month												
percentile level		Winter Dec-Feb	Spring Mar-May	Summer Jun-Aug	Fall Sep-Nov	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0%	1,099	256	159	184	145	50	46	45	43	48	52	48	49	48	43	44	45
1%	1,197	262	168	186	147	57	51	48	44	49	55	50	50	48	44	45	46
2%	1,295	268	178	187	150	63	55	50	46	49	57	52	51	49	44	47	47
3%	1,393	273	188	189	152	70	59	53	47	50	60	53	52	50	44	48	47
4%	1,462	278	202	192	161	76	62	55	48	52	63	55	52	50	45	50	49
5%	1,492	282	221	197	176	80	62	58	48	54	66	57	52	51	46	54	51
10%	1,739	292	304	219	226	95	80	81	53	66	75	62	55	56	50	65	62
15%	1,825	324	430	236	255	102	100	110	62	72	78	70	58	58	53	76	69
20%	1,946	438	485	289	271	122	121	114	88	78	93	73	64	63	58	83	119
25%	2,233	582	511	324	300	136	156	120	103	103	112	75	67	67	72	95	156
30%	2,399	636	562	368	307	147	194	139	107	122	132	76	76	75	75	120	158
35%	2,458	758	592	431	320	190	205	162	115	170	163	79	78	82	83	131	186
40%	2,657	808	640	463	414	208	237	188	150	188	194	115	80	85	88	151	227
45%	3,045	849	672	516	434	239	302	220	160	232	218	120	84	91	92	162	231
50%	3,179	921	840	578	576	246	305	230	166	261	262	141	91	99	103	183	235
55%	3,450	992	875	609	763	266	310	277	180	335	271	150	94	112	120	191	251
60%	3,623	1,047	887	653	882	322	325	287	219	375	297	182	117	131	147	214	266
65%	3,775	1,056	980	762	902	351	369	295	251	423	356	214	146	170	188	238	278
70%	4,044	1,130	1,061	919	944	421	392	328	330	436	476	253	157	276	246	274	288
75%	4,175	1,188	1,193	1,010	1,006	490	505	358	342	453	534	281	166	322	331	304	311
80%	4,258	1,270	1,299	1,074	1,106	492	533	428	429	491	657	298	172	374	385	477	387
85%	4,435	1,310	1,419	1,158	1,245	548	542	546	454	540	728	309	189	397	475	556	469
90%	4,678	1,399	1,628	1,232	1,386	611	559	612	577	620	769	331	205	462	568	712	541
95%	5,129	1,586	1,779	1,337	1,923	661	666	642	711	828	800	367	273	591	828	888	620
96%	5,309	1,638	1,789	1,360	2,053	668	699	646	748	878	802	382	300	640	835	950	633
97%	5,495	1,685	1,842	1,458	2,171	676	743	665	852	916	915	399	395	708	925	1,030	643
98%	5,683	1,727	1,926	1,612	2,279	685	794	694	1,006	947	1,110	417	542	788	1,078	1,124	651
99%	5,872	1,770	2,011	1,767	2,387	693	846	723	1,161	978	1,306	434	689	869	1,231	1,217	658
100%	6,060	1,813	2,095	1,921	2,495	702	897	753	1,315	1,008	1,502	451	835	950	1,384	1,311	666

Table 4 - 4 Estuary Inflow Percentiles for Galveston Bay (Coastal basins only)

Inflow Statistic: Percentile flow magnitudes (units 1000 ACFT), by years, seasons and months.

Inflow to Galveston Bay from Coastal Drainages.

Start	Modern period January, 1977																	
End	December, 2005																	
Flow	annual		season					month										
percentile level			Winter Dec-Feb	Spring Mar-May	Summer Jun-Aug	Fall Sep-Nov		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0%	760		98	39	60	143		18	15	9	7	8	20	11	11	7	9	7	11
1%	838		100	41	74	155		21	16	10	7	8	22	12	12	11	9	9	11
2%	916		102	44	88	167		24	16	11	7	9	24	13	12	15	10	12	12
3%	994		104	46	102	178		28	16	13	7	9	26	15	13	19	10	14	12
4%	1,041		109	55	113	187		31	16	14	8	9	27	17	13	21	10	16	15
5%	1,045		120	72	120	191		36	17	14	9	10	28	19	14	22	11	17	21
10%	1,116		150	128	135	214		49	18	18	13	12	34	28	16	29	17	19	34
15%	1,203		186	153	138	243		55	20	19	14	54	41	32	19	34	23	39	38
20%	1,266		249	193	153	299		62	24	21	16	59	52	38	22	58	29	64	45
25%	1,357		286	215	218	322		94	34	28	20	79	61	46	36	76	34	81	48
30%	1,412		336	225	242	346		105	44	35	22	82	66	56	42	94	43	91	54
35%	1,533		381	236	352	369		115	63	43	29	102	105	61	44	115	46	105	60
40%	1,911		398	266	446	395		123	73	51	49	108	121	76	48	133	50	115	75
45%	1,970		470	303	457	466		129	83	60	61	128	154	82	53	150	63	136	83
50%	2,101		492	320	475	556		158	91	98	64	159	181	100	60	157	73	143	96
55%	2,279		529	346	528	602		172	122	104	83	169	235	150	81	190	77	160	118
60%	2,330		549	455	568	662		195	161	111	115	206	264	158	90	265	99	186	143
65%	2,567		628	502	611	722		212	189	127	141	223	268	172	118	286	212	200	162
70%	2,748		630	583	708	803		223	225	148	171	235	300	178	148	305	266	205	187
75%	2,948		637	717	782	870		230	242	199	219	249	327	184	163	398	316	208	250
80%	3,018		660	751	837	993		317	252	248	245	304	419	242	272	505	335	256	290
85%	3,179		727	843	1,130	1,123		390	294	346	261	308	589	249	307	638	394	270	314
90%	3,296		841	897	1,305	1,200		458	361	376	369	341	666	332	352	725	448	344	350
95%	3,914		1,227	981	1,504	1,519		533	412	395	481	348	815	402	480	808	726	474	430
96%	4,093		1,235	988	1,524	1,577		538	435	401	481	350	848	404	526	830	798	489	463
97%	4,218		1,241	1,030	1,581	1,613		578	456	406	492	373	890	566	569	858	835	517	481
98%	4,302		1,244	1,098	1,665	1,631		645	476	410	511	410	939	847	608	890	846	556	486
99%	4,386		1,247	1,165	1,749	1,649		713	496	414	530	447	988	1,129	648	923	856	595	491
100%	4,470		1,250	1,232	1,833	1,667		780	516	418	549	485	1,038	1,410	688	955	867	633	495

Table 5 - 1 Duration of instream subsistence flow at Trinity River near Rosser.

Low-flow durations (days), instream.

Site: Trinity Rv nr Rosser (USGS guage no. 08062500)

Subsistence targets (cfs)

Winter	106
Spring	212
Summer	142
Fall	125

Start End	Whole period of record January, 1939 December, 2008	Pre-development period January, 1939 December, 1952	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	49	33	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	5	1	0

Table 5 - 2 Duration of instream subsistence flow at Trinity River at Trinidad.

Low-flow durations (days), instream.

Site: Trinity Rv at Trinidad (USGS guage no. 08062700)

Subsistence targets (cfs)

Winter	415
Spring	515
Summer	403
Fall	408

Start End	Whole period of record January, 1965 December, 2008	Pre-development period January, 1965 December, 1989	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	24	24	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	0	0	0

Table 5 - 3 Duration of instream subsistence flow at Trinity River near Oakwood.

Low-flow durations (days), instream.

Site: Trinity Rv nr Oakwood (USGS guage no. 08065000)

Subsistence targets (cfs)

Winter	196
Spring	280
Summer	70
Fall	101

Start End	Whole period of record January, 1924 December, 2008	Pre-development period January, 1924 December, 1964	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	44	44	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	2	2	0

Table 5 - 4 Duration of instream subsistence flow at Trinity River near Crockett.

Low-flow durations (days), instream.

Site: Trinity Rv nr Crockett (USGS guage no. 08065350)

Subsistence targets (cfs)

Winter	674
Spring	783
Summer	425
Fall	530

Start End	Whole period of record January, 1964 December, 2008	Pre-development period January, 1964 December, 1989	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	30	30	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	0	0	0

Table 5 - 5 Duration of instream subsistence flow at West Fork Trinity River at Grand Prairie.

Low-flow durations (days), instream.

Site: W Fk Trinity Rv at Grand Prairie (USGS guage no. 08049500)

Subsistence targets (cfs)

Winter	24
Spring	28
Summer	15
Fall	16

Start End	Whole period of record January, 1926 December, 2008	Pre-development period January, 1926 December, 1956	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	27	27	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	0	0	0

Table 5 - 6 Duration of instream subsistence flow at Elm Fork Trinity River near Carrollton.

Low-flow durations (days), instream.

Site: Elm Fk Trinity Rv nr Carrollton (USGS guage no. 08055500)

Subsistence targets (cfs)

Winter	24
Spring	28
Summer	15
Fall	16

Start End	Whole period of record January, 1907 December, 2008	Pre-development period January, 1907 December, 1952	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	353	353	18
Events with duration greater than 90 days	9	8	0
Events with duration greater than 60 days	17	15	0
Events with duration greater than 30 days	34	29	0

Table 5 - 7 Duration of instream subsistence flow at Trinity River at Dallas.

Low-flow durations (days), instream.

Site: Trinity Rv at Dallas (USGS guage no. 08057000)

Subsistence targets (cfs)

Winter	24
Spring	28
Summer	15
Fall	16

Start End	Whole period of record January, 1904 December, 2008	Pre-development period January, 1904 December, 1953	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	245	245	0
Events with duration greater than 90 days	6	6	0
Events with duration greater than 60 days	8	8	0
Events with duration greater than 30 days	15	15	0

Table 5 - 8 Duration of instream subsistence flow at Trinity River at Romayor.

Low-flow durations (days), instream.

Site: Trinity Rv at Romayor (USGS guage no. 08066500)

Subsistence targets (cfs)

Winter	542
Spring	720
Summer	210
Fall	250

Start End	Whole period of record January, 1925 December, 2008	Pre-development period January, 1925 December, 1968	Modern (post) period January, 1989 December, 2008
Maximum Duration (days)	75	57	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	1	0	0
Events with duration greater than 30 days	8	7	0

Table 5 - 9 Duration of instream subsistence flow at West Fork San Jacinto River near Conroe.

Low-flow durations (days), instream.

Site: W Fk San Jacinto Rv nr Conroe (USGS guage no. 08068000)

Subsistence targets (cfs)

Winter	23
Spring	24
Summer	9
Fall	9

Start End	Whole period of record January, 1940 December, 2008	Pre-development period January, 1940 December, 1973	Modern (post) period January, 1974 December, 2008
Maximum Duration (days)	55	55	15
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	3	3	0

Table 5 - 10 Duration of instream subsistence flow at Spring Ck near Spring.

Low-flow durations (days), instream.

Site: Spring Ck nr Spring (USGS guage no. 08068500)

Subsistence targets (cfs)

Winter	14
Spring	14
Summer	6
Fall	6

Start End	Whole period of record January, 1940 December, 2008	Pre-development period January, 1940 December, 2008	Modern (post) period January, 2009 December, 2008
Maximum Duration (days)	61	61	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	1	1	0
Events with duration greater than 30 days	7	7	0

Table 5 - 11 Duration of instream subsistence flow at East Fork San Jacinto River near Cleveland.

Low-flow durations (days), instream.

Site: E Fk San Jacinto Rv nr Cleveland (USGS guage no. 08070000)

Subsistence targets (cfs)

Winter	22
Spring	18
Summer	8
Fall	10

Start End	Whole period of record January, 1940 December, 2008	Pre-development period January, 1940 December, 2008	Modern (post) period January, 2008 December, 2008
Maximum Duration (days)	58	58	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	6	6	0

Table 5 - 12 Duration of instream subsistence flow at Brays Bayou at Houston.

Low-flow durations (days), instream.

Site: Brays Bayou at Houston (USGS guage no. 08075000)

Subsistence targets (cfs)

Winter	3
Spring	1
Summer	1
Fall	0

Start End	Whole period of record January, 1937 December, 2008	Pre-development period January, 1937 December, 1960	Modern (post) period January, 1984 December, 2008
Maximum Duration (days)	37	37	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	1	1	0

Table 5 - 13 Duration of instream subsistence flow at Buffalo Bayou at Piney Point.

Low-flow durations (days), instream.

Site: Buffalo Bayou at Piney Point (USGS guage no. 08073700)

Subsistence targets (cfs)

Winter	11
Spring	13
Summer	26
Fall	13

Start End	Whole period of record January, 1964 December, 2008	Pre-development period January, 1964 December, 1975	Modern (post) period January, 1988 December, 2008
Maximum Duration (days)	25	25	0
Events with duration greater than 90 days	0	0	0
Events with duration greater than 60 days	0	0	0
Events with duration greater than 30 days	0	0	0