NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY
BASIN AND BAY AREA STAKEHOLDERS COMMITTEE
(NUECES BBASC)

August 22, 2012

The Honorable Troy Fraser, Co-Presiding Officer
The Honorable Allan Ritter, Co-Presiding Officer
Environmental Flows Advisory Group (EFAG)

Mr. Zak Covar, Executive Director
Texas Commission on Environmental Quality (TCEQ)

Dear Chairman Fraser, Chairman Ritter and Mr. Covar:

We submit to you the Environmental Flows Recommendations Report (Nueces BBASC Recommendations Report/Report) from the Nueces River and Corpus Christi and Baffin Bays Basin and Bay Area Stakeholders Committee (Nueces BBASC).

While the following point will be discussed, further, in this letter, recognizing the overall limited availability of surface water in the Nueces Basin, the Nueces BBASC wishes to stress, up front, that one of its most important conclusions and recommendations is that the Texas Commission on Environmental Quality (TCEQ) consult with the Nueces Estuary Advisory Council (NEAC) in TCEQ's evaluation of applications for new surface water appropriations in amounts of 500 acre-feet per year, or more, with NEAC's function being to consider and advise on how the new appropriations may affect the Nueces Bay and Delta. The Nueces BBASC feels, strongly, about the need for such coordination.

The Nueces BBASC held its organizational meeting in July 2009. It appointed members to its Basin and Bay Expert Science Team (BBEST) in April 2010 and received the BBEST's Environmental Flows Recommendations Report in October 2011. Today, after eighteen BBASC meetings and numerous subcommittee and workgroup meetings, the Nueces BBASC, with the appreciated support of consultants, the BBEST, state resource agencies, environmental organizations and other interested entities, approved this Report by consensus.

The Nueces River Basin is unlike river basins to the east. The upper Basin consists of clear running, spring fed, creeks and rivers flowing through the rugged Texas Hill Country to, mostly, recharge downstream into the Edwards Aquifer. In the central Basin, commonly known as the South Texas Brush Country, river flows slow, turn silty, and in drought conditions, often stop flowing, altogether. River flows in the lower Basin, referred to as the Coastal Bend, are reduced to, essentially, the Nueces River. Its flows and freshwater inflows into the adjoining Nueces Bay are dominated by Choke Canyon Reservoir and Lake Corpus Christi. Beyond Nueces Bay, Corpus Christi Bay, Oso Bay, Upper Laguna Madre and Baffin Bay are all characterized by having very limited fresh water supply.

The Senate Bill 3 (80^{th} Texas Legislature) environmental flows program in the Nueces River Basin and Corpus Christi and Baffin Bays has been unique in several ways.

First, the NEAC, created in 1992 and chaired by TCEQ, existed at the beginning of this process as a long established stakeholder group engaged in estuary environmental flow issues related to the Choke Canyon Reservoir Certificate of Adjudication. Its broad based membership brought to this program a recognized ethic of working together to resolve differences and a comprehensive understanding of lower Nueces Basin water issues. The Nueces BBASC was formed by taking those NEAC members who wished to serve on the BBASC and adding stakeholders to satisfy the statutory BBASC membership requirements of SB3. The resulting Nueces BBASC consists of 10 NEAC members and 15 other stakeholders from throughout the Nueces and adjoining coastal basins.

Second, the Nueces BBEST determined that the Nueces Bay and Delta is not in a sound ecological condition. This was the first instance of an unsound ecological condition finding in the SB3 environmental flows program. Further, while it was acknowledged that the Nueces BBEST's recommendations for freshwater inflows to Nueces Bay would very likely improve ecological conditions in the Nueces Bay and Delta, meeting the inflow attainment frequencies needed for most of this improvement could not happen without jeopardizing the Coastal Bend's primary water supply, the Lake Corpus Christi-Choke Canyon Reservoir System.

And, third, with the possible exception of the Rio Grande Basin, the Nueces River Basin is the driest in the SB3 program. There is limited surface water available for future appropriation, whether for human or environmental purposes, making more difficult the recovery of any unsound ecological condition.

The Nueces BBASC responded to the unsound ecological condition of the Nueces Bay and Delta determination by establishing a goal to return the bay and delta to ecological conditions existing prior to construction of Choke Canyon Reservoir to the extent possible while preserving existing water rights and yield of the reservoir system. We believe the water management strategies and adaptive management measures set forth in this Report and our pending Work Plan offer opportunities for smarter water resource management that can result in improvements to both ecological conditions and public water supply.

In conclusion, the Nueces BBASC wishes to reemphasize the importance of its recommendation that TCEQ consult with the NEAC in TCEQ's evaluation of applications for new surface water appropriations in amounts of 500 acre-feet per year, or more. NEAC's function would be to advise as to whether such new appropriations will improve, degrade, or have no significant effect on the ecological condition of the Nueces Bay and Delta.

The members of the Nueces BBASC are honored to be part of the Texas Environmental Flows Program. We believe that the recommendations in this Report achieve a balance in providing for environmental flows and water for human needs in the Nueces River Basin and Corpus Christi and Baffin Bays and would appreciate their favorable consideration.

Respectfully submitted,

Con Mims, Nueces BBASC Chair

James Dodson, Nueces BBASC Vice Chair

Environmental Flow Standards and Strategies Recommendations Report

Final Submission to the

Environmental Flows Advisory Group
and the
Texas Commission on Environmental Quality

Prepared by

Nueces River and Corpus Christi and Baffin Bay Basin and Bay Area Stakeholder Committee

August 22, 2012

Environmental Flow Standards and Strategies Recommendations Report

Prepared by

Nueces River and Corpus Christi and Baffin Bay Basin and Bay Area Stakeholder Committee (Nueces BBASC)

With Technical Support from

HDR Engineering, Inc.

and

Nueces River and Corpus Christi and Baffin Bay Basin and Bay Expert Science Team (Nueces BBEST)

August 22, 2012

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(Electronic – Provided on digital media)

Common Abbreviations

acft	acre-feet
acft/yr	acre-feet per year
ASR	Aquifer Storage and Recovery
Avg	Average
BBASC	Basin and Bay Area Stakeholders Committee
BBEST	Basin and Bay Expert Science Team
CBBEP	Coastal Bend Bays and Estuary Program
CCEFN	Consensus Criteria for Environmental Flow Needs
CCM	Comparative Cross-Section Methodology
CCR	Choke Canyon Reservoir
CCWSM	Corpus Christi Water Supply Model
cfs	cubic feet per second
DFC	Desired Future Conditions
D&L	Domestic and Livestock
EAA	Edwards Aquifer Authority
EARIP	Edwards Aquifer Recovery Implementation Program
EFAG	Environmental Flows Advisory Group
FRAT	Flow Regime Application Tool
GCD	Groundwater Conservation District
GAM	Groundwater Availability Model
GMA	Groundwater Management Area
HEFR	Hydrology-based Environmental Flow Regime
kacft	thousand acre-feet
kacft/yr	thousand acre-feet per year
LCC	Lake Corpus Christi
LNRA	Lavaca-Navidad River Authority
msl	Mean sea level
NBBASC	Nueces Basin and Bay Area Stakeholders Committee
NWF	National Wildlife Federation
PHABSIM	Physical Habitat Simulation
ppt	Parts per thousand
RWP	Regional Water Planning Group
SAC	Science Advisory Committee
SB2	Senate Bill 2
SB3	Senate Bill 3
TCEQ	Texas Commission on Environmental Quality
TIFP	Texas Instream Flow Program
TPWD	Texas Parks and Wildlife Department
TWDB	Texas Water Development Board
USGS	United States Geological Survey
WAM	Water Availability Model
WUA	Weighted Usable Area
Q95	Daily average flow rate exceeded 95 percent of the time
7Q2	Annual lowest mean discharge for seven consecutive days with a two-year recurrence interval

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Section 1. Preamble

1.1 Senate Bill 3 Environmental Flows Process

In 2007, Senate Bill 3 (SB3) of the 80th Texas Legislature established a process for developing and implementing environmental flow standards applicable to major river basins and estuarine systems across the State of Texas. The legislation identified seven basin and bay systems in Texas to be given priority for completion under SB3 (four other river major basins are as yet not scheduled). Schedules were established for the selection of stakeholder and science teams to represent these basin and bay systems and for the completion of environmental flow recommendations and flow standards. The river basin and bay system consisting of the Nueces River and Corpus Christi and Baffin Bays was identified as one of these priority basin and bay systems.

The major committees and their roles in the SB3 process are summarized in Figure 1-1. The process began with convening of the Environmental Flows Advisory Group (EFAG) in 2008. The EFAG appointed the Science Advisory Committee (SAC) in 2009 and, over time, appointed stakeholder representatives for Basin and Bay Area Stakeholder Committees (BBASCs). The BBASCs then selected a Basin and Bay Expert Science Team (BBEST), whose role it is to develop environmental flow recommendations for their basin and bay system based on the best available science. The BBASCs are then to "review the … recommendations 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 …. 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 the advisory group …" (TWC Section 11.02362(o)). Finally, the Texas Commission on Environmental Quality (TCEQ) considers the BBEST recommendations, BBASC recommendations, and other factors including economic factors and human, as well as other competing needs for water in adopting environmental flow standards (TWC Section 11.471(b)).

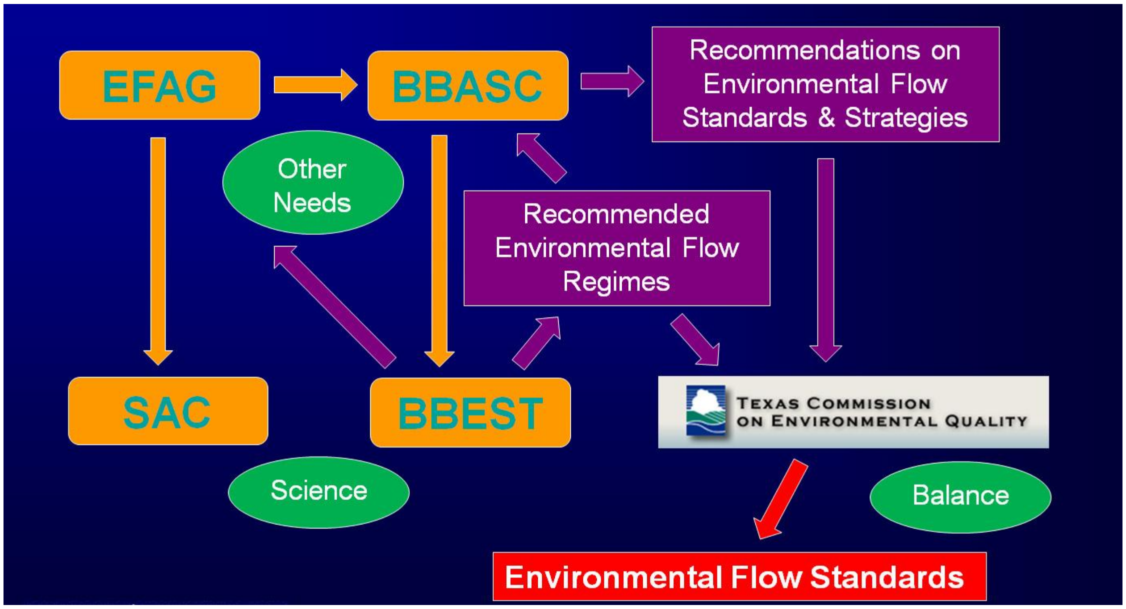

Figure 1-1.   SB3 Environmental Flow Process

1.1.1 *Environmental Flows Advisory Group*

The EFAG consists of nine members including three Texas State Senators who are appointed by the Lieutenant Governor, three State Representatives who are appointed by the Speaker of the House of Representatives, and three Commissioners or Board members, respectively, who are appointed by the Governor representing the TCEQ, Texas Parks and Wildlife Department (TPWD), and the Texas Water Development Board (TWDB). Key responsibilities of the EFAG include appointing the SAC and BBASCs.

1.1.2 *Science Advisory Committee*

The SAC includes between five and nine technical experts in diverse areas relevant to evaluation of environmental flows. Since 2009, it has provided documented guidance to both BBESTs and BBASCs. Guidance provided by the SAC has addressed geographic scope, use of hydrologic data, fluvial sediment transport (geomorphology), methodologies for establishing freshwater inflow regimes for estuaries, biological overlays, nutrient and water quality overlays, moving from flow regimes to flow standards, lessons learned from early BBESTs, work plans for adaptive management, methods for evaluating interrelationships between environmental flow regimes and water supply projects, and consideration of attainment frequencies and hydrologic conditions.

1.1.3 *Basin and Bay Area Stakeholder Committee/Nueces River and Corpus Christi and Baffin Bay Basin and Bay Area Stakeholder Committee (Nueces BBASC)*

BBASCs are meant to reflect a fair and equitable balance of interest groups concerned with particular river basins and bay systems. Interest groups represented on BBASCs include: agriculture, recreation, municipalities, soil and water conservation districts, industrial water users, commercial fishing, public interests, regional water planning, groundwater conservation districts, river authorities, and environmental groups. Within six months after the BBASC has been established, it appoints a BBEST comprised of technical experts with knowledge of its particular river basin and bay systems and/or development of environmental flow regimes. The Nueces BBASC is comprised of 36 members, many of whom also serve on the long-established Nueces Estuary Advisory Council (NEAC). Information regarding the Nueces BBASC is summarized in Section 1.2.

After a BBEST issues its recommendations report, the appointing BBASC considers the BBEST recommendations in conjunction with other factors — including the present and future needs for water for other uses related to water supply planning — and prepares recommendations on environmental flow standards and strategies on meeting those standards. Subsequently, BBASCs are charged with developing a work plan that addresses periodic review of environmental flow standards, prescribes necessary monitoring and studies, and establishes a schedule for continuing validation or refinement of environmental flow regime recommendations.

SB3 recognized the significant role that existing stakeholder groups such as the NEAC have played in identifying flows needed to support the environment of Nueces Bay while balancing the needs of other water users. It "does not prohibit … an effort to develop information on environmental flow needs and ways in which these needs can be met by a voluntary consensus building process". The NEAC has existed since 1992 and represents various interests in the Nueces River basin and in Nueces and Corpus Christi Bay. At a meeting on May 19, 2009 the NEAC chose to have its members serve as representatives on the BBASC with the additional members to be appointed to represent several missing stakeholder interests. NEAC members who represent state agencies (TPWD, TCEQ, TWDB) opted to serve as non-voting members on the Nueces BBASC. The decision by the NEAC to serve as the basis for the Nueces BBASC put them ahead of schedule in appointing their BBEST, giving their BBEST more time in which to complete their recommendations.

Members of the Nueces BBASC include:

Con Mims, Chair	Paul Carangelo	Jim Naismith
James Dodson, Vice-Chair	J. Allen Carnes	Joel Pigg
John Adams	Teresa Carrillo	Don Roach
Ray Allen	George Driskill	Carola G. Serrato
James Bader	Rocky Freund	Buddy Stanley
Tom Ballou	Gus Gonzales	Pat Suter
Scotty Bledsoe	George "Timo" Hixon	Ross Thompson
Richard Bowers	Susan Lynch	Dr. Wes Tunnell
Dr. Edward J. Buskey	Mike Mahoney	

1.1.4 *Basin and Bay Expert Science Team /Nueces River and Corpus Christi and Baffin Bay Basin and Bay Expert Science Team*

BBEST members are selected by their respective BBASCs. The team is composed of technical experts "with specific expertise regarding the river basin and bay system or regarding the development of environmental flow regimes" (TWC Section 11.02362(i)). On April 21, 2010, the Nueces BBASC appointed 12 scientists as members of the Nueces BBEST. Due to scheduling conflicts and other commitments, one original member chose to withdraw in March 2011 and was subsequently replaced by the Nueces BBASC. Active membership of the Nueces BBEST is summarized below along with administrative and subcommittee assignments.

Sam Vaugh – Chair, Hydrology Subcommittee Lead

Rocky Freund – Vice-Chair, Instream and Hydrology Subcommittees

Dave Buzan – Instream Subcommittee Lead, Estuary Subcommittee

Greg Stunz – Estuary Subcommittee Lead

Tom Arsuffi – Instream Subcommittee

Ken Dunton – Estuary Subcommittee

Ben Hodges – Estuary and Hydrology Subcommittees

David Hoeinghaus – Instream and Hydrology Subcommittees

Ryan Smith – Instream and Hydrology Subcommittees

Lonnie Stewart – Instream and Hydrology Subcommittees

Jace Tunnell – Estuary Subcommittee

Lance Williams – Instream Subcommittee

The appointment of the Nueces BBEST was ahead of the schedule set by the EFAG and allowed the BBEST extra time to develop their recommendations. While the scheduled due date for their recommendations was March 1, 2012, the BBEST completed their recommendations by October 28, 2011. The BBASC's report, commenting on the recommendations and on strategies for meeting environmental flow standards, is due on September 1, 2012.

1.1.5 *Texas Commission on Environmental Quality*

After the BBEST and BBASC reports are completed, TCEQ balances the reports and all other relevant information available. TCEQ then adopts environmental flow standards for each river basin and bay system through an established, public rule-making process.

1.2 Nueces River and Corpus Christi and Baffin Bays BBASC Meetings

1.2.1 *Nueces BBASC Meetings*

The Nueces BBASC met twice in 2009, three times in 2010, three times in 2011, and monthly in 2012 through the completion of the BBASC's charge to develop recommendations regarding environmental flow standards. The first meetings were held alternately at a lower basin site (Corpus Christi), a mid-basin site (Choke Canyon Reservoir), and an upper basin site (Uvalde). The group later agreed to hold meetings at a mid-basin site (Jourdanton) as a compromise to help eliminate long travel distances for committee members.

The earlier meetings focused on discussion of the SB3 process, the agreed order regarding operations of the Choke Canyon Reservoir / Lake Corpus Christi System, the BBASC's responsibilities, and procedural issues related to voting, number of members needed for a quorum, proxy representation and voting, and so on. BBEST members were selected at the April 21, 2010 meeting in Uvalde. Presentations at meetings have covered a range of topics including studies in Rincon Bayou, regional water supply for the Nueces River basin, a history of projects in the Nueces Delta, Edwards Aquifer Authority activities in the basin, streamflow measurements in the basin, and updates on SAC and Nueces BBEST activities. The later meetings focused on the Nueces BBEST environmental flow recommendations, implications of the opinion of the BBEST that Nueces Bay is not currently ecologically sound, development of the BBASC's own instream and bay and estuary environmental flow recommendations, and the development of a work plan to identify and prioritize future research and other activities relevant to refinement of environmental flow standards.

1.2.2 *Technical Consultants*

The BBASC is charged with balancing the BBEST's environmental flow recommendations with other uses of water in the basin and with developing strategies to meet flow standards. A Modeling Subcommittee created by the BBASC developed recommendations for modeling runs and technical analyses needed to complete these tasks. Technical assistance to help conduct these tasks was provided through support from the City of Corpus Christi, Port of Corpus Christi Authority, and from the Texas Water Development Board (TWDB) through the Nueces BBEST. Corpus Christi obtained the services of HDR Engineering, Inc. (HDR) to conduct analyses of the impacts of the recommendations on firm yield of the Lake Corpus Christi/Choke Canyon Reservoir System. The Nueces BBEST, in coordination with the BBASC Modeling Subcommittee, solicited technical support to quantify the effects of potential environmental flow standard recommendations on various water supply strategies. HDR was selected to conduct these analyses following a competitive process administered by the TWDB and the Nueces BBEST.

1.3 Introduction

The Nueces BBASC Environmental Flows Recommendations Report is comprised of six major sections, plus supporting appendices. Section 1 provides a general overview of the SB3 environmental flows process and a detailed discussion on a sound ecological environment. Section 2 describes the resources of interest throughout the region, and information and technical analyses relevant to development of the Nueces BBASC recommendations are summarized in Section 3. Nueces BBASC recommendations regarding environmental flow standards are provided in Section 4, and Nueces BBASC recommendations regarding strategies to meet environmental flow standards are summarized in Section 5. Status of the Work Plan at the time of this report is briefly discussed in Section 6.

1.4 Sound Ecological Environment

SB3 defines an environmental flow regime as:

> *"A schedule of flow quantities that reflects seasonal and yearly fluctuations that typically would vary geographically, by specific location in a watershed, and that are shown to be adequate to support a sound ecological environment and to maintain the productivity, extent, and persistence of key aquatic habitats in and along the affected water bodies."*

According to SAC guidance (SAC 2009a), a sound ecological environment:

- Sustains the full complement of native species in perpetuity;
- Sustains key habitat features required by these species;
- Retains key features of the natural flow regime required by these species to complete their life cycles; and
- Sustains key ecosystem processes and services, such as elemental cycling and the productivity of important plant and animal populations.

A "sound environment" is defined many ways. All definitions involve different interpretations of language and intent. In the Nueces BBEST's analysis, an acceptably sound ecological environment was defined by where the flow regime maintains important physical, chemical, and biological characteristics of a water body as well as the native species dependent on these characteristics.

Nueces BBEST used the following characteristics to determine whether water body was or was not a sound ecological environment:

- Loss/shift in native species composition;
- Loss/alteration of key habitat features;
- Significant alteration of the natural flow regimes required by indicator species; and
- Nutrient elemental cycling and sediment loading have been compromised.

An unhealthy environment was defined by where human modifications of the flow regime have reduced or eliminated important physical, chemical, or biological features, and significantly altered or reduced native biological community structure.

After an extensive review and analysis of comprehensive data sets that exists for the Nueces Estuary system, the BBEST reached consensus that all rivers, streams, and bays were sound ecological environments, except for the Nueces Bay and Delta region, which were determined to be unsound ecological environments. This conclusion was based on the substantial alterations in freshwater reaching the Nueces Bay and Delta, which have led to a failure to sustain a healthy complement of native species and its associated beneficial physical processes. In particular, the reduction of inflow caused:

- Loss/alteration of key habitat features and natural flow regimes required by indicator species (*Spartina alterniflora*, benthic infauna, oysters, *Rangia*, blue crabs, and Atlantic croaker); and
- Nutrient elemental cycling and sediment loading to be compromised.

In response to the BBEST's conclusion regarding the condition of the Nueces Bay and Delta, the Nueces BBASC, by consensus, adopted the following statement:

> *"The goal of the Nueces BBASC with regard to the Nueces Bay and Delta is to return the Nueces Bay and Delta to ecological conditions existing prior to construction of Choke Canyon Reservoir to the extent possible while preserving existing water rights and yield of the reservoir system. To this end, the Nueces BBASC will recommend instream flow and estuary inflow regimes that may improve the existing ecological condition of the Nueces Bay and Delta, but will not diminish its existing condition, and will set forth, in its Work Plan, strategies to enhance its ecological condition."*

The following sections of this report describe the bases for achieving the Nueces BBASC goals described above and meeting the charge of developing environmental flow standard recommendations.

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Section 2. Resources of Interest within the Basin and Bay Area

Resources of interest within the Nueces River Basin, the Nueces – Rio Grande Coastal Basin, and the associated bays and estuaries are multitude and perhaps best summarized in documents readily available on the internet including, but not limited to, the following:

a. 2011 Plateau (Region J), South Central Texas (Region L), Rio Grande (Region M), and Coastal Bend (Region N) area regional water plans: http://www.twdb.state.tx.us/wrpi/rwp/3rdround/2011RWP.asp

b. Annual reports under the Texas Clean Rivers Program: http://www.tceq.texas.gov/waterquality/clean-rivers/index.html

c. Texas Commission on Environmental Quality assessments of water availability: http://www.tceq.texas.gov/permitting/water_supply/water_rights/wam.html

d. Texas Parks and Wildlife Department data regarding stream segments they have identified as ecologically significant: http://www.tceq.texas.gov/permitting/water_supply/water_rights/wam.html

e. Freshwater Inflows to Texas Bays and Estuaries: http://midgewater.twdb.state.tx.us/bays_estuaries/b_nEpage.html; and

f. Environmental Flows Recommendations Report of the Nueces BBEST (Section 2): http://www.tceq.state.tx.us/permitting/water_supply/water_rights/eflows/nueces-river-and-corpus-christi-and-baffin-bays-stakeholder-committee-and-expert-science-team

The following sub-sections provide limited summary information regarding the geographical distributions of streamflows and freshwater inflows to bays and estuaries, surface water rights, discharges of treated effluent, the Agreed Order and reservoir operations, and the aquifers affecting this basin and bay area. A map of the area is presented in Figure 2-1. The map also includes the locations of the 20 sites for which the Nueces BBEST provided environmental flow recommendations.

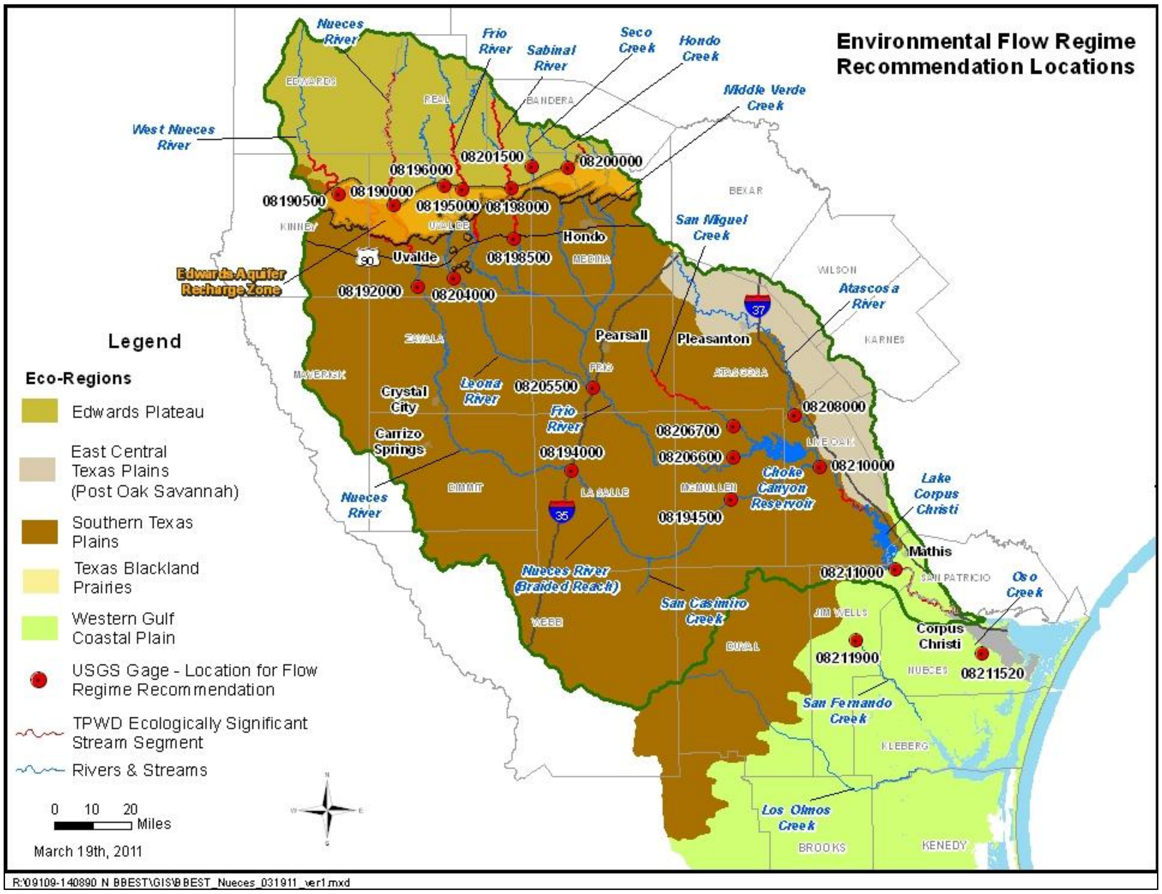

Figure 2-1. Location of the Nueces BBASC Area

2.1 Streamflow and Freshwater Inflow to Bays and Estuaries

Streamflows in the Nueces Basin can be divided into three distinct categories corresponding to the effect of the Edwards Aquifer Recharge Zone, inflows into the Choke Canyon Reservoir/Lake Corpus Christi Reservoir System (Reservoir System), and freshwater inflows into the bays and estuaries.

The headwaters of the Nueces Basin rivers: the West Nueces River, Nueces River, Dry Frio River, Frio River, Sabinal River, Seco Creek, and Hondo Creek; lie above the Edwards Aquifer Recharge Zone. These streams typically lose their base flow to the aquifer. Loss rates across the recharge zone have been measured in individual streams at rates ranging from about 50 cfs up to almost 400 cfs (USGS 1983).

Inflow into Choke Canyon Reservoir is calculated as the sum of the flow at the Frio River at Tilden (FRTT) (USGS# 0820600) plus the flow at San Miguel Creek at Tilden (SMTT) (USGS# 08206700). Inflow into Lake Corpus Christi is calculated as the flow at the Nueces River at Three Rivers (NTRT) (USGS# 08210000) (which includes flow from the Nueces River at Tilden (NRTT) (USGS# 08194500) and the Atascosa River at Whitsett (ARWT) (USGS# 08208000)) minus the discharge from Choke Canyon Reservoir. The calculated inflow into the Reservoir System is the sum of these two inflows. However, during times of very low streamflows, this calculated number can become negative. When this happens, the inflow is calculated as the sum of flows at AWRT, SMTT, FRTT, and NRTT.

The City of Corpus Christi began tracking the Reservoir System inflow in 1990 to comply with the Agreed Order, discussed below in Section 2.4. From 1990 to 2011, the minimum yearly inflow of 13,185 acft occurred in 2011, the maximum of 2,917,212 acft occurred in 2002 (Figure 2-2). To emphasize the year-to-year variability in rainfall, and therefore reservoir inflow, in this basin, the inflow in the first two weeks of May 2012 exceeded the total inflow for all of 2011.

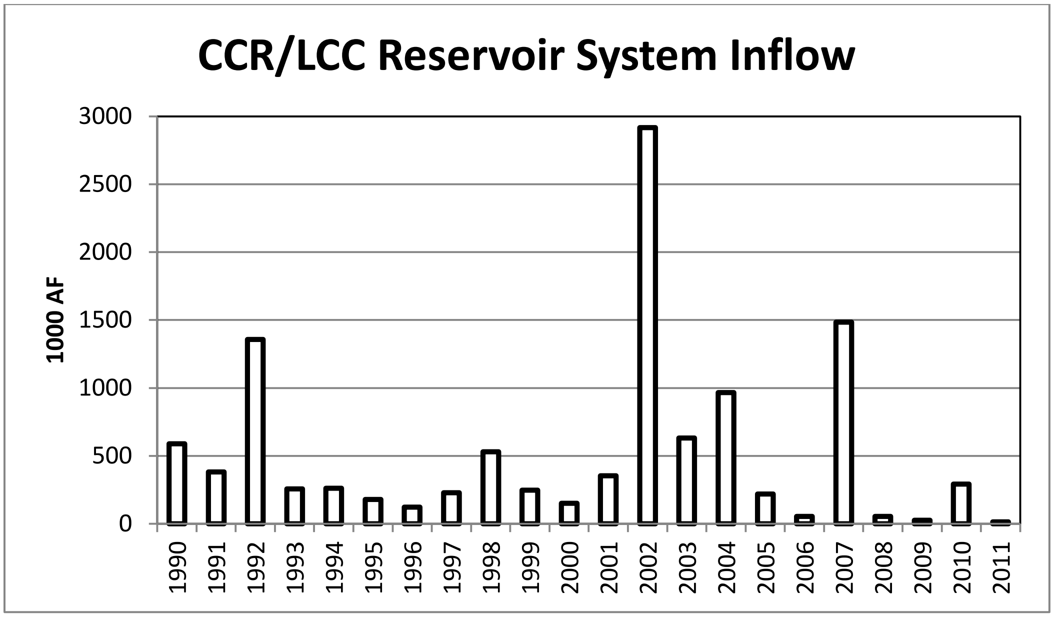

Figure 2-2. CCR/LCC Reservoir System Inflow

The Nueces Estuary is comprised of Nueces Bay and Delta system, Corpus Christi Bay, and the Oso Bay system. Baffin Bay and Upper Laguna Madre are included as part of the Laguna Madre Estuary.

Except for direct rainfall and stormwater runoff, Corpus Christi Bay has little direct freshwater inflow. Oso Bay receives inflow from Oso Creek, which is effluent dominated. Oso Bay also receives water from the Upper Laguna Madre via the American Electric Power Plant. Baffin Bay and the Upper Laguna Madre generally have relatively high salinities, due to limited freshwater inflow and extensive evaporation, and are considered negative estuaries. The BBEST has concluded that, under the current supply of available water, these three systems are considered sound ecological environments.

The Nueces Bay and Delta system is the most affected by freshwater availability, primarily dependent on pass-through of inflows and spills from Lake Corpus Christi. Freshwater inflow into the Nueces Estuary has historically been measured at Nueces River at Calallen (NCAT) (USGS# 08211500). This gauge measures the flow that goes over the saltwater barrier dam that forms the boundary between fresh and tidal waters. Since 2008 and the addition of the Rincon Pipeline, discussed in more detail in Section 2.5, pumped water to the delta is also counted towards freshwater inflows into the bays and estuaries to meet the requirements of the Agreed Order. Section 4 of the BBEST report has a thorough discussion of historical and current conditions affecting this system.

2.2 Surface Water Rights

The State of Texas owns the surface water within the state watercourses and is responsible for the appropriation of these waters. Surface water is currently allocated by the TCEQ, formerly the Texas Natural Resource Conservation Commission, for the use and benefit of all people of the state. Texas water law is based on the riparian and prior appropriation doctrines. The riparian doctrine comes from the Spanish and Mexican governments that ruled Texas prior to 1836. After 1840, the riparian doctrine provided landowners the rights to make reasonable use of water for irrigation or for other consumptive uses. In 1889, the prior appropriation doctrine was first adopted by Texas, which is based on the concept of "first in time is first in right." Over the years, the riparian and prior appropriation doctrines resulted in a system that was very difficult to manage. Various types of water rights existed simultaneously and many rights were unrecorded. In 1967, the Texas Legislature passed the Water Rights Adjudication Act that merged the riparian water rights into the prior appropriation system, creating a unified water permit system.

The adjudication process took many years, stretching into the late 1980s before it was finally completed. In the end, Certificates of Adjudication were issued for entities recognized as having legitimate water rights. Today, individuals or groups seeking a new water right must submit an application to the TCEQ. The TCEQ determines if the water right will be issued and under what conditions. The water rights grant a certain quantity of water to be diverted and/or stored, a priority date, location of diversion, and other restrictions. The priority date of a water right is essential to the operation of the water rights system. Each right is issued a priority date based on the date each right was filed at the TCEQ. All water right holders must adhere to the priority system when diverting or storing water for use. A right holder must allow water to be passed to downstream senior water rights when conditions are such that the senior water rights would not be otherwise satisfied. Other restrictions may include a maximum diversion rate and instream flow restrictions to protect existing water rights and provide environmental flows for instream needs and needs of estuary systems, although most water rights issued prior to 1985 do not include such conditions. An important exception to the rule is Certificate of Adjudication Number (CA#) 21-3214 for Choke Canyon Reservoir, which represents approximately 75% of the Nueces River Basin water rights and requires instream flows and freshwater flows for the Nueces Estuary. Operations of the Reservoir System are governed, in part, by CA #21-3214, within which Special Conditions B and E state:

> B. (Part)
>
> "Owners shall provide not less than 151,000 acft of water per annum for the estuaries by a combination of releases and spills from the reservoir system at Lake Corpus Christi Dam and return flows to the Nueces and Corpus Christi Bays and other receiving estuaries."
>
> E.
>
> "Owners shall continuously maintain a minimum flow of 33 cubic feet per second below the dam at Choke Canyon Reservoir."
>
> Special Condition B of CA #21-3214 further states:
>
> "Water provided to the estuaries from the reservoir system under this paragraph shall be released in such quantities and in accordance with such operational procedures as may be ordered by the Commission."

Hence, the certificate provided for a means to further establish specific rules governing operations of the Reservoir System with respect to maintaining freshwater inflows to the Nueces Estuary (Coastal Bend RWP 2011).

The City of Corpus Christi owns over 80% of the water rights in the Nueces River Basin which are associated with Choke Canyon Reservoir and Lake Corpus Christi. The next highest water right holder is the Zavala-Dimmit County Water Improvement District #1 with 5% of the rights.

2.3 Agreed Order and Reservoir Operations

2.3.1 *Agreed Order*

To address concerns about the health of the Nueces Estuary, a Technical Advisory Committee (TAC) chaired by the TCEQ was formed in 1990 to establish operational guidelines for the Reservoir System and desired monthly freshwater inflows to the Nueces Estuary. These operational guidelines were summarized in the 1992 Interim Order.

The monthly targets were developed by the TWDB and the TPWD in the early 1990s to maximize biological benefits for species inhabiting the estuary. Specifically, the model used to come up with the inflow numbers was the Estuarine Mathematical Programming Model (TxEMP), a non-linear optimization model. This optimization model was used in conjunction with the hydrodynamic circulation model (TxBLEND) to evaluate freshwater inflows needed to maintain salinity gradients and fisheries harvest in Texas bays and estuaries.

There are two main issues with TxEMP. First, flow results higher than the historical monthly medians are not allowed by model constraints, such that the maximum harvest (MaxH) flow can only be equal to or less than the historical monthly median inflows. Any need for inflows higher than monthly medians in any month for biological purposes cannot be directly evaluated from the model results. Second, TxEMP outputs for MaxH and MinQ (minimum inflows necessary to meet biological targets) are computed on a monthly basis according to pre-set historical bounds. Estuarine scientists now postulate that seasonal pulses could be more beneficial and critical for the biota than the strictly-defined monthly inflows currently in place for the Nueces Estuary. The Nueces BBEST recommended a seasonally-based freshwater inflow regime that incorporated this concept of pulsed inflows.

The 1992 Interim Order established a monthly schedule of desired freshwater inflows to Nueces Bay to be satisfied by spills, return flows, runoff below Lake Corpus Christi, and/or dedicated releases from the Reservoir System. Mechanisms for relief from reservoir releases under the Interim Order were based on inflow banking, monthly salinity variation in upper Nueces Bay, and implementation of drought contingency measures tied to Reservoir System storage (Coastal Bend RWP 2011).

The Nueces Estuary Advisory Council (NEAC) was formed under the 1992 Interim Order and charged with continued study of the interdependent relationship between the firm yield of the Reservoir System and the health of the Nueces Estuary. One of NEAC's primary goals was to evaluate the 1992 Interim Order and other alternative release policies and recommend a more permanent reservoir operations plan for providing freshwater inflows to the Nueces Estuary. This goal was to be achieved within 5 years of NEAC's formation (Coastal Bend RWP 2011).

The goal of recommending a more permanent reservoir operations plan was fulfilled on April 28, 1995, when the TCEQ issued an order regarding reservoir operations for freshwater inflows to the Nueces Estuary, known as the 1995 Agreed Order. This Agreed Order is very similar to the Interim Order, with one major exception—monthly releases (pass-through) to the estuary were limited to Reservoir System inflows and stored water is not required to meet estuary freshwater flow needs (Coastal Bend RWP 2011).

On April 17, 2001, the TCEQ issued an amendment to the 1995 Agreed Order to revise operational procedures in accordance with revisions requested by the City of Corpus Christi. Changes included: (1) passage of inflows to Nueces Bay and Estuary at 40 percent and 30 percent reservoir system capacity upon institution of mandatory outdoor watering restrictions; (2) calculating reservoir system storage capacity based on most recently completed bathymetric surveys; and (3) provisions for operating Rincon Bayou diversions and conveyance facility from Calallen Pool to enhance the amount of freshwater to the Nueces Bay and Delta. All Reservoir System yield analyses presented as part of 2011 Coastal Bend Regional Water Plan development were performed using the 2001 Agreed Order (Coastal Bend RWP 2011).

Table 2-1 shows the target pass-through amounts outlined in the Agreed Order. There are four zones defined by system storage that are associated with different sets of monthly pass-through targets (acft) shown in the columns of the table. For example, if the system storage is at or above 70% in May then the pass-through target equals 25,500 acft for the month. If the system storage is less than 70% but equal to or above 40% then the pass-through target is 23,500 acft for the month. Likewise, if system storage is below 40% but equal to or above 30% then the target is 1,200 acft for the month. There are no pass-through targets below system storage of 30%. Additional information for April 2001 through May 2012 includes the number of years that the reservoir system, by month, was in each of the target ranges (based on the capacity on the first day of the month), and in how many of those years inflow to the reservoir system met or exceeded the target. For example, for January, the reservoir system was above 70% of capacity in seven years and in three of those years, the target was met or exceeded. Figure 2-3 shows the monthly targets, when the Reservoir System capacity is ≥ 70%, and the mean reservoir inflow for calendar years 1995–2011.

In parentheses next to the target is the number of years that the reservoir system was in the target range, as of the first day of the month, and in how many of those years inflow into the reservoir system met or exceeded the target.

Table 2-1. Pass-Through Targets Established Under the Agreed Order (acft)

Pass-Through Targets				
Month	**Capacity ≥ 70%**	**40% ≤ Capacity < 70%**	**30% ≤ Capacity < 40%**	**Capacity < 30%**
January	2,500 (3:7)	2,500 (3:4)	1,200 (0:0)	0
February	2,500 (2:7)	2,500 (1:4)	1,200 (0:0)	0
March	3,500 (2:7)	3,500 (2:4)	1,200 (0:0)	0
April	3,500 (2:8)	3,500 (0:3)	1,200 (1:1)	0
May	25,500 (2:9)	23,500 (1:2)	1,200 (1:1)	0
June	25,500 (1:8)	23,000(0:2)	1,200 (0:1)	0
July	6,500 (2:6)	4,500 (1:3)	1,200 (0:1)	0
August	6,500 (0:7)	5,000 (0:3)	1,200 (0:0)	0
September	28,500 (0:7)	11,500 (1:3)	1,200 (1:1)	0
October	20,000 (0:7)	9,000 (0:4)	1,200 (0:0)	0
November	9,000 (1:7)	4,000 (2:4)	1,200 (0:0)	0
December	4,500 (1:7)	4,500 (1:4)	1,200 (0:0)	0
Target Total	138,800	97,000	14,400	0

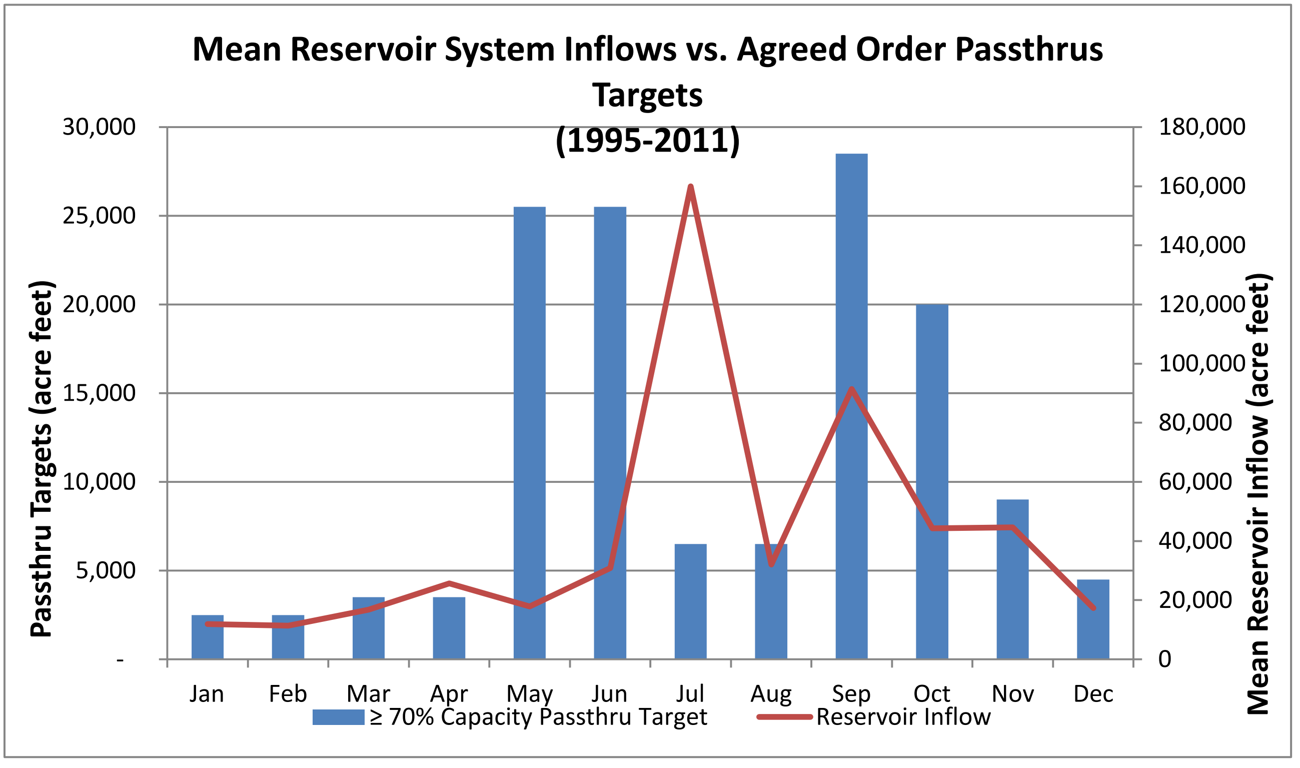

Figure 2-3. Mean monthly reservoir system inflows vs. the current 2001 Agreed Order pass-through targets when Reservoir System capacity is >= 70%

Through the re-examination of the current Agreed Order, there might be an opportunity to better manage the limited freshwater resource using Salinity Monitoring and Real-Time (SMART) Inflow Management and reviewing new data that was not available during the creation of the 1995 Agreed Order, which is the basis for the current pass-through operation of the reservoir system. See Appendix D for detailed information on SMART Inflow Management. A redistribution of pass-through targets might insure that the current operations plan mimics a more natural hydrological cycle.

Another benefit to redistribution of the pass-through targets might be to the SMART Inflow Management concept that would allow for more water to be available for banking and pulsing water into the bay during key times of the year. Table 2-2 lists reservoir monthly inflows from lowest to highest from the years of 1995 to 2011. This was constructed to show what percentile of flows are currently being passed through the reservoirs and might be useful for figuring out how the 138,000 acre feet could be redistributed in the future.

The yellow highlighted numbers represent flows that are within the 2001 Agreed Order pass-through targets. The orange highlighted numbers represent flows that are not required to be passed through the reservoir and into the bay because they are flows above the required pass amount. The top blue row shows the 2001 pass-through targets. The percentages on the left hand side of the table represent flow percentiles captured under the 2001 Agreed Order.

2.3.2 *Reservoir Operations*

The original reservoir operations plan for the Reservoir System consisted of four phases of operation depending on the water levels in the two reservoirs and water user demand:

- PHASE I applied only to the initial filling period of Choke Canyon Reservoir. It was necessary that this reservoir be filled at the earliest opportunity so that all structures and mechanical equipment could be tested. Initial filling of the reservoir also triggered the requirement that minimal flows be made available for bays and estuaries.
- PHASE II applied after Choke Canyon Reservoir filled and water user demand was less than 150,000 acft annually.
- PHASE III applied after Choke Canyon Reservoir filled and water user demand was between 150,000 and 200,000 acft annually. During this period, the water release plan prepared by the Bureau of Reclamation was to be followed to produce a dependable yield of 252,000 acft.
- PHASE IV applied after Choke Canyon Reservoir filled, water user demand exceeded 200,000 acft annually, and developed long-term supply was less than 300,000 acft annually. The reservoir system is currently operated under the Phase IV policy.

Table 2-2. Monthly reservoir system inflows are listed from lowest to highest by month from years 1995 to 2011

	Targets	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		1,149	733	433	197	154	6	50	23	273	414	175	251
		1,219	772	471	454	205	64	150	100	397	1,069	262	666
		1,533	873	984	599	258	167	317	141	1,747	1,348	376	939
25%		2,330	1,023	1,772	1,104	462	304	535	232	3,007	2,713	480	1,086
		2,969	2,143	2,083	1,450	1,839	588	814	851	5,892	3,089	2,257	1,717
		4,436	3,434	2,449	2,895	2,236	1,063	1,610	1,805	9,322	5,404	3,040	1,743
		4,490	3,781	4,942	4,062	2,922	1,102	4,991	3,058	12,969	5,813	4,935	2,442
		9,120	4,945	6,020	5,132	4,744	1,995	6,499	4,062	14,722	6,609	6,458	2,532
50%		10,650	7,523	6,877	8,969	5,118	8,720	12,352	4,407	25,016	6,622	14,148	4,657
		11,761	9,135	7,345	10,814	9,741	12,861	16,450	5,835	46,356	7,529	23,315	4,751
		12,062	11,407	8,208	17,556	11,009	13,086	31,883	7,858	49,157	12,610	24,021	10,967
		12,973	11,805	13,787	22,951	12,361	15,500	34,043	9,109	63,766	15,053	39,244	13,685
		13,874	14,252	19,067	24,940	15,558	27,023	131,662	12,967	69,331	17,447	60,179	15,297
75%		16,087	22,090	32,556	26,670	16,101	30,184	141,306	46,656	78,089	24,977	72,664	24,128
		29,170	28,200	35,188	28,802	41,458	77,285	249,346	80,345	79,484	129,887	85,091	58,002
		30,487	32,949	65,052	108,180	71,502	157,810	750,255	107,436	161,588	231,260	169,218	74,930
		37,649	37,374	78,979	171,606	108,092	177,394	1,337,481	260,321	932,297	280,307	253,185	77,334
	Total	201,959	192,439	286,213	436,381	303,760	525,152	2,719,744	545,206	1,553,413	752,151	759,048	295,127

The current operating procedures are designed to maximize the yield of the system. CCR is more efficient from an evaporation standpoint than LCC due in part to CCR being deeper and cooler than LCC. Therefore, the operating procedures leave as much water in CCR as possible to maximize water supplies. The current plan calls for:

- Lake Corpus Christi to be drawn down to 78 ft-msl;
- When Lake Corpus Christi is less than or equal to 78' and Choke Canyon Reservoir is above 155 ft-msl, releases will be made from Choke Canyon Reservoir to maintain Lake Corpus Christi at 78 ft-msl;
- When Lake Corpus Christi is less than or equal to 78' and Choke Canyon Reservoir is less than or equal to 155 ft-msl, Lake Corpus Christi will be allowed to be drawn down to its minimum level and releases from Choke Canyon Reservoir will be made only to meet water demands.

2.4 Rincon Bayou Pipeline

As mentioned above, the Rincon Bayou Pipeline was constructed as part of the 2001 amendments to the Agreed Order. This pipeline serves as the conveyance facility of freshwater from the Calallen Pool to the Upper Rincon Bayou (Figures 2-4 and 2-5). The pipeline augments the 1994 – 1999 US Department of the Interior Bureau of Reclamation Rincon Bayou Demonstration Project. This project constructed two overflow channels, one from the Nueces River to the Rincon Bayou and one within the Rincon Delta, to enhance freshwater flow to the delta. Detailed information about the project is available in the final report (Bureau of Reclamation, 2000).

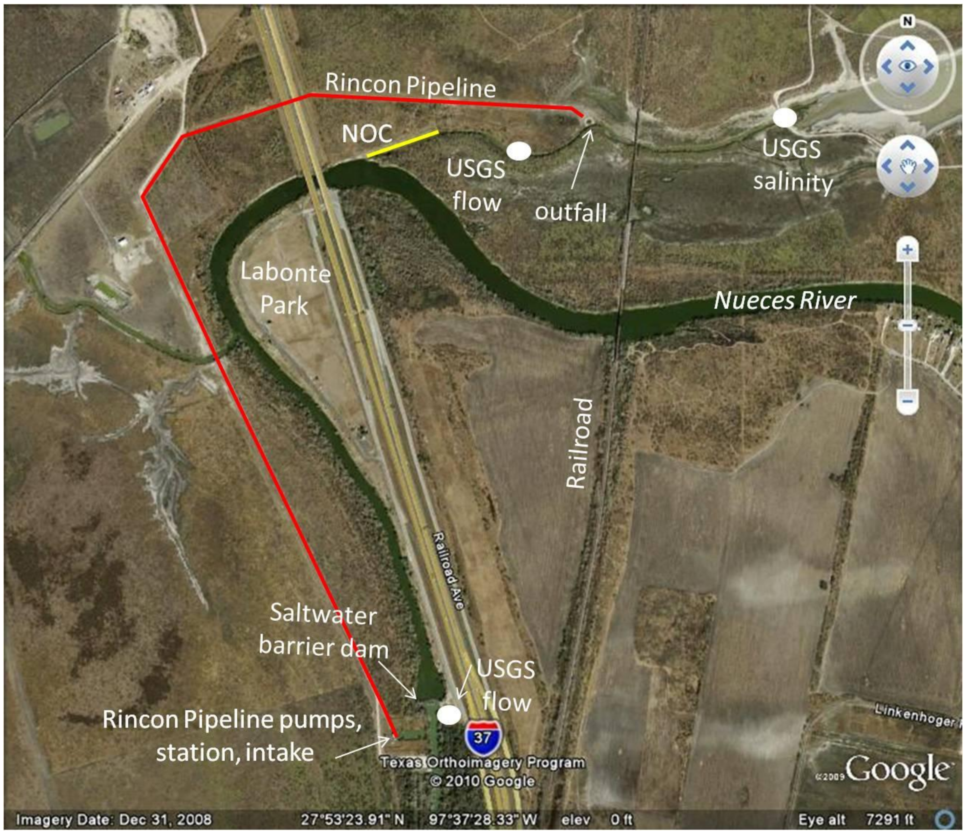

Figure 2-4. Rincon Pipeline location along the Nueces River

Figure 2-5. Rincon Pipeline outfall

It was initially to be completed in 2004, but due to difficulties in obtaining the necessary easements, then construction delays due to wet weather, the pipeline was finally completed in 2008. The 2001 Agreed Order states that up to the first 3,000 acft of required pass-through each month will be sent through the pipeline.

When the pipeline was completed, the area was experiencing minimal inflows into the reservoir system, and therefore, there were minimal pass-through requirements. The first significant reservoir inflow event occurred in September and October 2009, resulting in a 15,135 acft pass-through requirement. Of this amount, 2,987 acft were pumped to the Rincon Bayou through the pipeline, and 7,836 acft flowed pass the saltwater barrier dam. The salinity levels in the Rincon Bayou decreased to 0 ppt, and the Coastal Bend Bays and Estuaries Program (CBBEP) asked that the remaining pass-through be held in the lake, or "banked," for release at a later date.

The NEAC was apprised of this "banking" concept and the Inflow Pipeline Advisory Committee (IPAC) was formed to evaluate the process as an adaptive management approach to making the most beneficial use of the freshwater pass-through into the delta. The IPAC was tasked with providing the City with information on quantity and duration of water needed (based on water available for pass-through) in order to achieve the greatest benefit under certain seasonal conditions.

As of July 2012, there have been a total of nine pumping events, seven of which were related to banked pass-through:

September 28–October 21, 2009	2,988 acft
January 6–14, 2010:	744 acft from October 2009
May 10–31, 2010:	2,334 acft from October 2009
March 21–30, 2011:	1,001 acft from May 2010
May 3–12, 2011	1,002 acft from May 2010
June 13–22, 2011	994 acft from May 2010
November 2–22, 2011	2,031 acft from October 2011
March 7–19, 2012	1,310 acft from October 2011
June 21–July 13, 2012	2,354 acft

The pumping histories can be found at http://www.nueces-ra.org/CP/CITY/rincon/.

The results of releases of banked pass-through has been positive in terms of keeping a salinity gradient throughout the estuary, creating connectivity of biota, and reducing salinity variance which is known to increase biomass within estuarine systems. However, the process still needs further evaluation with respect to how long a pass-through amount can be banked and how it will be affected by evaporation. In general, for every one gallon of municipal and industrial water demand on the reservoir system, two gallons are lost to evaporation from the reservoir system. Any long-term operating procedures will need to be approved by the NEAC, and ultimately TCEQ.

2.5 Treated Effluent

The locations of, and permitted amount for, major dischargers of municipal treated effluent (0.5 MGD) in the Nueces River Basin and coastal waters are shown Figure 2-6.

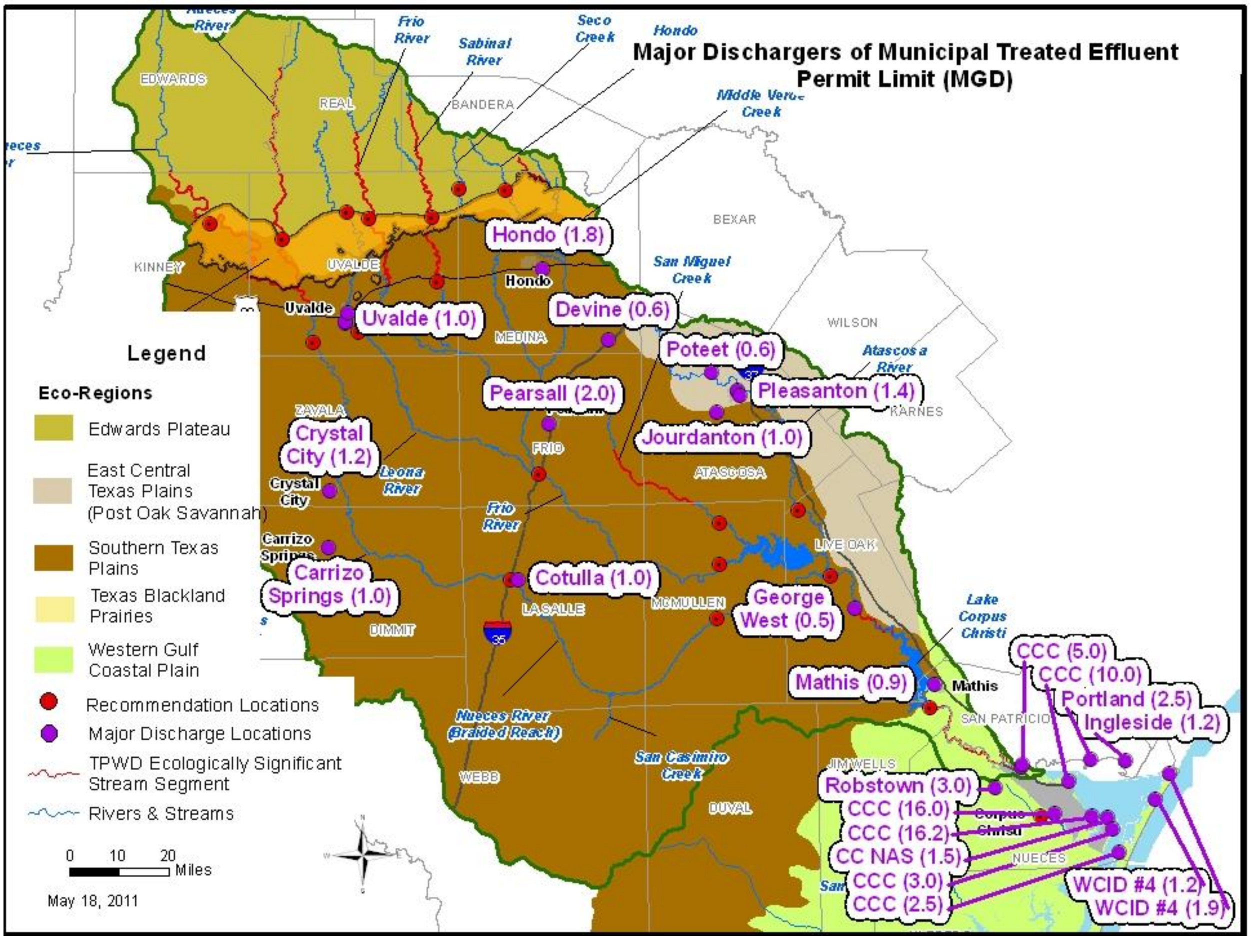

Figure 2-6. Major dischargers (> 0.5 MGD) of permitted municipally treated effluent

2.6 Aquifers

There are four major aquifers below the Nueces River Basin: the Edwards-Trinity, Edwards, Carrizo-Wilcox, and Gulf Coast (Figure 2-7). The Gulf Coast Aquifer also underlies the Nueces-Rio Grande Coastal Basin. Each of these formations contributes to streamflow through spring discharge and depletes streamflow through recharge depending on factors including geographic location, hydrologic conditions, and groundwater pumpage.

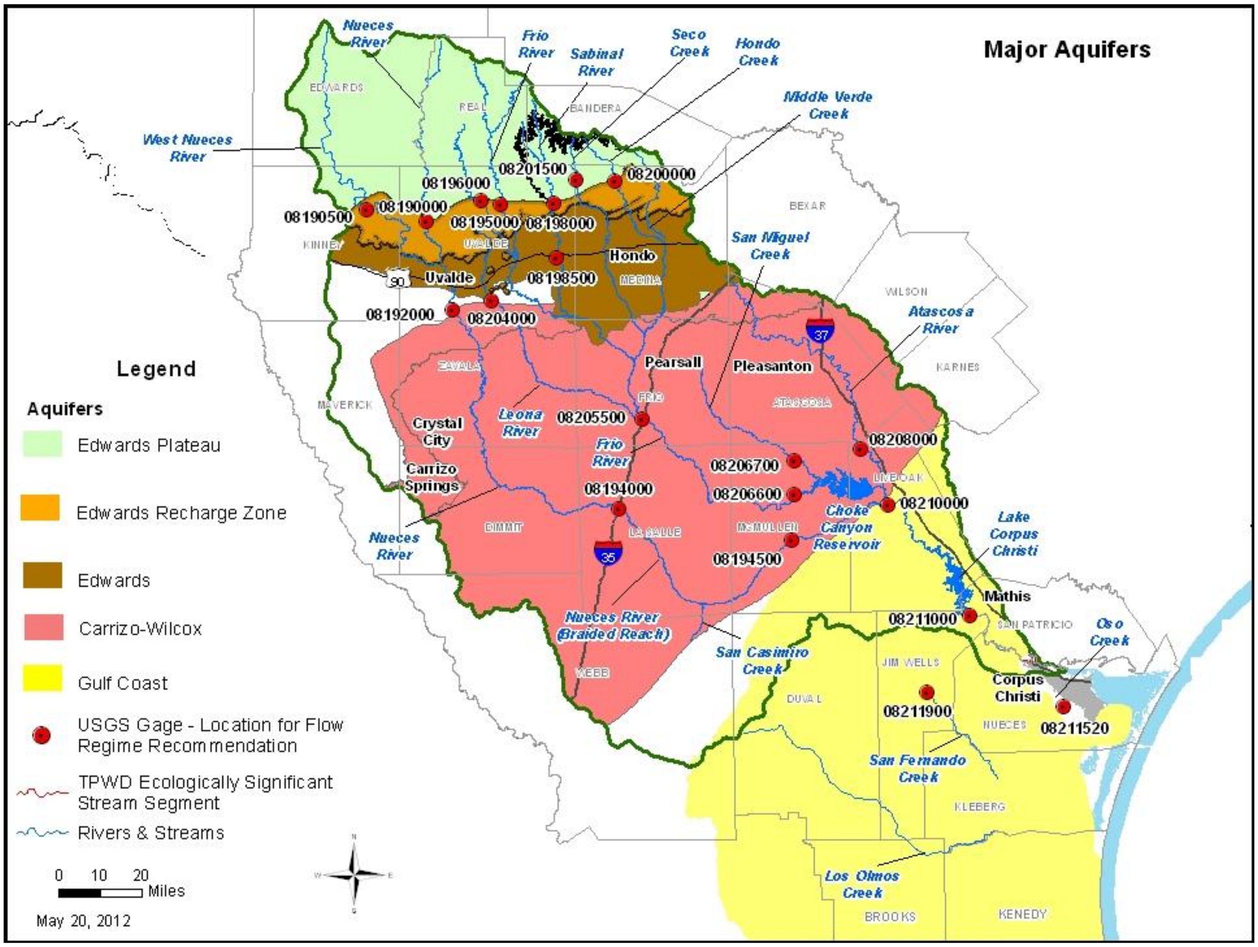

Figure 2-7. Major Aquifers within the Nueces Basin

The Edwards-Trinity Aquifer (Edwards Plateau) underlies the most northern portion of the Nueces River Basin. The aquifer consists of saturated sediments of lower Cretaceous Age Trinity Group. The Glen Rose Limestone is the primary unit in the Edwards-Trinity Aquifer in the southern areas of its extent. This unit is estimated to have a thickness of up to 300 feet in these southern areas of its extent (South Central Texas RWP 2011).

The Edwards Aquifer forms a narrow belt extending from a groundwater divide in Kinney County through the San Antonio area northeastward to the Leon River in Bell County. A groundwater divide near Kyle, in Hays County, hydrologically separates the aquifer into the San Antonio and the Austin regions except during severe drought. The aquifer, composed predominantly of limestone, formed during the early Cretaceous Period. Due to its highly permeable nature in the fresh-water zone, the Edwards Aquifer responds quickly to changes and extremes of stress placed on the system. Saturated thickness ranges from 200 to 600 feet (South Central Texas RWP 2011).

The Carrizo-Wilcox aquifer extends from the Rio Grande in South Texas northeastward into Arkansas and Louisiana. The aquifer outcrops along a narrow band that is located about 130 – 200 miles inland from the Gulf of Mexico. The aquifer dips beneath the land surface toward the coast. The Carrizo Aquifer is predominantly composed of sand locally interbedded with gravel, silt, clay, and lignite deposited during the Tertiary Period. Water-bearing thickness of the aquifer ranges from 200 feet in Dimmit County to more than 1,500 feet in the downdip portion in Atascosa County (South Central Texas RWP 2011).

The Gulf Coast Aquifer forms a wide belt along the Gulf of Mexico from Florida to Mexico, and is over 100 miles wide in most sections. The aquifer consists of complex interbedded clays, silts, sands, and gravels of the Cenozoic Age, which are hydrologically connected to form a large, leaky artesian aquifer system. This system is comprised of four major components consisting of, from deepest to shallowest, the Catahoula, Jasper, Evangeline, and Chicot aquifers. The combined thickness ranges from a few hundred feet inland to over 5000 feet seaward (South Central Texas RWP 2011).

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Section 3. Development of Nueces BBASC Recommendations

3.1 General Comments on the NUECES BBEST Recommendations Report

3.1.1 *Comments from NUECES BBASC Members*

The Environmental Flows Recommendations Report prepared by the Nueces BBEST was submitted to the EFAG, TCEQ, and Nueces BBASC on October 28, 2011. The Nueces BBEST orally presented its recommendations to Nueces BBASC on October 19, 2011. There was an interactive discussion of the recommendations at the January 25, 2012 Nueces BBASC meeting. This section includes a brief summary of Nueces BBASC comments, questions, and concerns, focusing on, but not limited to, those expressed during the January 25, 2012 meeting and subsequent discussion during a February 22, 2012 BBASC meeting regarding members' thoughts on the Nueces BBEST Environmental Flows Recommendation Report. In addition, this section includes issues raised by the Work Group formed to review the BBEST Report.

Although, the stakeholders expressed confidence in the Nueces BBEST members and the report was praised for its thorough approach to assessing the ecological recommendations of the streams, rivers, bays, and estuaries and the study area, concern was expressed by some, but not all, BBASC members regarding the characterization of Nueces Bay and Delta as ecologically unsound.

Despite this concern, the Nueces BBASC believes that the Nueces BBEST recommendations reflect a good basis from which the Nueces BBASC can make environmental flow recommendations with supplemental information from its consultants. Nueces BBASC members expressed that the information on pulses and geomorphology and their importance to the river and bay systems with regard to nutrient flows throughout the system could be a potential, positive step in protecting the rivers, bays, and estuaries.

While the Nueces BBASC generally accepted the Nueces BBEST efforts and findings, there were concerns expressed by many, but not all, stakeholders regarding the future, potential impacts of the ecologically unsound characterization of the Nueces Bay and Delta on the Texas Commission on Environmental Quality's Agreed Order for operation of the Choke Canyon Reservoir/Lake Corpus Christi System, the issuance of new water rights, as well as creating an inaccurate perception that would denigrate the long history and efforts of the Nueces Estuary Advisory Council in protecting the health of the estuary system. As such, on February 22, 2012, the BBASC enlisted the assistance of legal and environmental experts to respond to the following questions:

- Can the characterization of Nueces Bay as ecologically unsound affect the Choke Canyon Reservoir Certificate of Adjudication, the Agreed Order, or the NEAC?
- Does this characterization encourage environmental lawsuits?
- Does it preempt issuance of new water rights in the Nueces Basin?
- Should the BBASC be aware of other ramifications?

The panel included the following experts:

Colette Barron – Ms. Barron is with the Texas Parks and Wildlife Department and, also, helped draft the environmental flows section of SB3.

Tim Brown – Mr. Brown has extensive involvement with Coastal Bend water issues, including the Choke Canyon Reservoir Certificate of Adjudication, the Agreed Order, and NEAC.

Todd Chenoweth – Mr. Chenoweth is the Technical Assistant to the Deputy Director, Office of Water, Texas Commission on Environmental Quality.

Myron Hess – Mr. Hess is the Manager of Texas Water Programs for the National Wildlife Federation and helped draft the environmental flows section of SB3.

Hope Wells – Ms. Wells also helped draft the environmental flows section of SB3, and authored an article in a law publication on the topic. She is employed at San Antonio Water System.

Mike Willatt – Mr. Willatt has a long time involvement with Coastal Bend water issues and represents the San Patricio Municipal Water District and the South Texas Water Authority.

Ultimately, the stakeholder group concluded that it did not know how TCEQ's future permitting process and/or judicial process could eventually utilize the Nueces BBEST report in its permitting, regulation, and enforcement processes.

Several members expressed concerns regarding Nueces BBEST's emphasis on the lack of freshwater inflow as the overriding cause in its finding that the Nueces Delta and Bay are ecologically unsound. In particular, there was a concern how well-documented activities beginning in the late 1890's and extending into the 1960's, such as dredging, oyster shell mining, oyster harvesting, oil/gas production, and the site of an electric power plant using bay waters for cooling towers, could be minimized to such an extent in the BBEST report. In addition, concerns were expressed that the BBEST freshwater inflow recommendation for the Nueces Delta and Bay appears to be based on a different scale or measurement as compared to previous basin reports, particularly since the recommendation is geared towards restoration rather than protection. Similar statements were expressed by the Science Advisory Committee and are cited in greater detail in SubSection 3.1.2.

The following comments/questions were received during meetings of the Nueces BBASC Work Group held on October 31, 2011, November 16, 2011, December 7, 2011, and January 18, 2012:

- What are the possible impacts on future water rights?
- How does this process affect/impact the strategies/plan of the Coastal Bend Regional Water Planning Group?
- What is the reasoning for not listing Corpus Christi Bay as ecologically unsound, since it also has been largely influenced by the same manmade changes that affect Nueces Bay and Delta?
- With regards to the comparison between Nueces Bay's and Corpus Christi Bay's characterizations, there appears to be a disconnect between the findings and the explanation.
- In conjunction with the provided definition for Sound Ecological Environment, there is an inconsistency between the application of the definition and the findings which result in certain areas being found "sound" (CC Bay) as opposed to Nueces Bay.
- It appears that several outcomes hypothesized by the BBEST to potentially result as an outcome of their inflow recommendations such as growth of Spartina alterniflora in the Nueces Delta could be addressed by other strategies and activities.
- There is a concern that several outcomes believed by the BBEST to result as a consequence of their inflow recommendations such as generation of oyster reefs could not occur without massive changes to depth of water and bottom type in Nueces Bay.
- There is a concern that the BBEST finding could result in no new or amended water rights in the Nueces River Basin.
- The term "unsound" could generate new encumbrances.
- Would model runs show a significant difference in outcome between the Agreed Order criteria and the BBEST recommendations?
- Is there a value to looking at a slight alteration to proposed projects to improve availability of volumes for environmental flows?
- Does the BBEST finding regarding the Nueces Delta and Bay lend itself to an attainment issue and thereby invoke a TCEQ finding on aquatic life and subsequently a TMDL?
- BBASC should carefully consider the BBEST instream flow criteria. Without modeling, there are potential impacts on future diversions in the upper basin. The recharge dams for the Edwards Aquifer were cited as an example.
- Will there be "political" implications of the BBEST findings on Nueces Bay?

3.1.2 *Comments from Science Advisory Committee (SAC)*

The SAC issued a memorandum to the Environmental Flows Advisory Group (EFAG) on December 19, 2011 entitled "Review comments on Nueces River and Corpus Christi and Baffin Bays Basin and Bay Expert Science Team (BBEST) Environmental Flow Regime Recommendations Report dated October 28, 2011" (Appendix C). In this memorandum, the SAC reviewed and offered comment on the Nueces BBEST Environmental Flows Recommendations Report through an Introduction, a series of questions and answers, and a Summary.

In its **Introduction**, the SAC noted that the work of the Nueces BBEST is "unique for at least five reasons." First, the Nueces BBEST was formed and began working early in the SB 3 Process as a result of the existing Nueces Estuary Advisory Council (NEAC). Second, the BBEST benefited from numerous existing studies and data as compared to other BBEST groups. Third, the Nueces BBEST had to work with a drier climate than other basins including intermittent flowing streams and hypersaline estuaries. Fourth, the Nueces estuary already has an existing regulation for environmental flows. And finally, the Nueces BBEST concluded that the Nueces River Delta and Nueces Bay are not ecologically sound.

The question and answer comments of the SAC are as follows:

1. Do the environmental flow analyses conducted by the BBEST appear to be based on a consideration of all reasonably available science, without regard to the need for water for other uses?

1.1 Has the BBEST identified and considered available literature and data? Were relevant scientific data and/or analyses discounted by the BBEST?

SAC concluded that the Nueces BBEST provided an excellent description of the basins and bays as they exist today, a review of the changes that have occurred in Nueces Bay and Nueces Delta since 1900 relying upon at a minimum four long-term, detailed studies previously conducted. Further, SAC stated that the "literature reviews are excellent" and the BBEST did not discount any relevant scientific data other than gages with insufficient data.

1.2 Are the data sources and methods adequately documented?

SAC stated that "the basic sources are well documented with a considerable amount of that information presented in the detailed Appendices." However, SAC also states that "the methods for determination of instream flow recommendations are somewhat disappointing, given the importance of the recommendations and the additional time and data resources afforded to this BBEST." On page 3 of SAC's comments, there are several issues raised regarding the Nueces BBEST's use of data, "ambiguous" text and possible "oversight" to the degree that the SAC recommends that "the BBASC will be well served by receiving additional clarification from the NBBEST on their method of instream flow recommendation development; in particular, the role (if any) that the habitat analysis played in setting the recommended flow regimes."

With regards to water quality, riparian, and geomorphology, SAC concludes that the Nueces BBEST based their recommendations on more limited data and that there are not any inconsistencies or direct alterations to any HEFR (Hydrology-Based Environmental Flow Regime) recommendations.

1.3 To what extent has the BBEST considered factors extraneous to the ecosystem, especially societal constraints, such as other water needs?

SAC concluded that the "NBBEST correctly did not allow the existence of this current rule [2001 Agreed Order] to constrain the development of their environmental flow recommendations."

2. **Did the BBEST perform an environmental flow analysis that resulted in a recommended environmental flow regime adequate to support a sound ecological environment and to maintain the productivity, extent and persistence of key aquatic habitats in and along the affected water bodies?**

2.1 How is a sound environment defined and assessed for both riverine (lotic) and estuarine systems? What metrics of ecosystem health were used?

SAC notes that the Nueces BBEST followed its lead in adopting the definition of a sound environment offered by earlier science advisory groups; however, SAC also noted that the Nueces BBEST expanded the discussion to describe an unsound environment as "An unhealthy environment is where human modifications of the flow regime have reduced or eliminated important physical, chemical, or biological features, and significantly altered or reduced native biological community structure."

With regards to the metrics, SAC notes that there is not a specific discussion on metrics of instream ecosystem health beyond the acknowledgment that all rivers and streams within the Nueces Basin are sound.

2.2 How were locations selected for environmental flow analysis? Are these shown to be representative of and adequate to protect the basin? Was the process and rationale for selection adequately described? Were environmental flow regimes recommended for each selected site? Was a procedure presented by which flow regime at other locations could be estimated?

SAC comments indicate that the Nueces BBEST selected gage sites that provide good coverage across basin conditions. In addition, the Nueces BBEST provided a thorough description of the hydrology, biology, water quality, geomorphology, water availability, and water supply planning.

SAC noted that the Nueces BBEST made estuarine environmental flow recommendations only for the Nueces Delta and Nueces Bay. Several comments are made regarding the lack of recommendations for Corpus Christi Bay, Oso Bay, and Baffin Bay, as found on pages 5 and 6. The comments state that "The SAC concurs with a lack of an environmental flow recommendation for these bays because it would be inappropriate to create environmental flow regulations for these conditions and ecological soundness in these systems are not frequently driven by inflow." Since the Nueces BBEST recommended instream flow requirements for Oso Creek and similarly San Fernando Creek and Baffin Bay, the SAC described this as a "major inconsistency" that the Nueces BBEST should have discussed further in their report.

2.3 How were the historical flow periods defined and evaluated? How was a particular period selected as the basis for determining the flow regime?

SAC notes for **instream flow analyses**, the report section (3.2.2) provides a good description relative to the period of record. However, SAC also recommends that the Nueces BBEST provide additional written explanation to the BBASC regarding its decision to use HEFR results on the full period of record for all gages since "it does not appear that the ecological overlays resulted in any HEFR adjustments."

SAC notes for **estuarine flow analyses**, that the report is based on the full period of record from 1941 to present, with the span divided into three periods: Pre-Wesley Seale Dam, Pre Choke Canyon Dam, and Post Choke Canyon Dam. The SAC notes that "[T]he significance of these periods is that inflow to the delta decreased 39% from the first to second period, and 99% in the third period."

2.4 Was a sound ecological environment determined to exist at each selected site during the selected period? If not, were the underlying causes and/or modifications needed identified?

For **instream flows**, SAC comments that all twenty (20) locations are deemed to be ecologically sound. They further note, however, that the Nueces BBEST included a caveat regarding four (4) stations that have undergone substantial hydrological modifications over the years.

For the "coast", SAC notes that Corpus Christi Bay, Oso Bay and Baffin Bay and the Laguna Madre were categorized as ecologically sound; but, they also note that it was for different reasons for each bay. For Nueces Bay and Delta, SAC notes that the Nueces BBEST presented a review of the natural history and environmental changes for the last century. SAC further notes that a "broad picture of an unsound Nueces Delta and Bay relative to that of the late 19th and early 20th Century is probably correct."

SAC continues, however, by stating that "the relationship of increased salinity to periods of reservoir operation in the 20th century is open to other explanations." SAC comments on the precipitation regime and the alternating high rainfall and low rainfall periods during the period of review. Additionally, SAC comments on other hydrological changes including the deepening of the ship channel and the proximity of a power plant discharging into the Nueces Bay.

SAC concludes this section by stating that "[T]he bay has been greatly affected by other physical changes, especially dredging and dredged material disposal for navigation projects. Because large quantities of shell were removed, oyster reef restoration (as well as increased flow) might be necessary for full restoration" and "evaluation of options for managing the multiple stressors in this system should be included in the adaptive management work plan."

2.5 Was a functional relationship between flow regimes and ecological health developed? Or, were proxy or intermediate variables used? Are assumptions underlying the methodology clearly stated? To what extent were overlay considerations (sediment transport, water quality, nutrients, etc.) addressed?

SAC noted that the Nueces BBEST report did "excellent work in presenting the WUA (Weighted Usable Area) curves and the conversion of those results into a series of highly informative tables."

It was noted by the SAC that the Nueces BBEST selected a "0.5 habitat suitability value and above" for all analysis, which translates into average to preferred. In addition, SAC notes that "some discussion or analysis in the report justifying" the Nueces BBEST's selection of 75% for all three (3) base flow ranges and 20% for subsistence conditions would have been "informative and helpful." Therefore, in its examination of Nueces BBEST tables' 3.-3.3, 3.-3.5, and 3.-3.7, SAC questioned the need for further analysis as it appears that there are inconsistencies between the acceptable percentages and the actual reported results (pages 8-10). SAC concludes by recommending that the Nueces BBEST provide additional explanation to the BBASC as to "why the flow-habitat modeling work was not further explored or utilized."

With regards to the instream flow water quality, riparian, and geomorphology overlays, SAC comments that those are generally well done. SAC does, however, recommend that additional discussion between the Nueces BBEST and the BBASC is warranted regarding the role of multiple tiers of pulses.

With regards to the estuarine analysis, SAC notes that the Nueces BBEST had the benefit of five (5) studies, four previous ones and a relatively new statistical method called boosted regression trees (BRT). SAC comments that "these five studies were used to form the basis for a unique and credible approach that":

- Identified focal species;
- Developed metrics between salinity and ecological integrity; and
- Made recommendations for baseline freshwater inflow needs and a flow regime to maintain these indicators in a healthy state.

The SAC states "the sediment considerations (Section 5.3) does take a long-term view and is quite clear in the changes that have occurred." With regards to sediment transport, SAC notes that the BBEST report recognizes that the recommended instream pulses will not provide the historical sediment volumes occurring in the pre-development period.

2.6 Was a sound ecological environment demonstrated to be achieved at each selected site under conditions for the recommended flow regime?

SAC comments that for all instream sites a sound ecological environment was demonstrated. Despite SAC's opinion that the 3-level base flow and up to 15-level seasonally-dependent high flow pulses was well presented, it was not certain that the complexity of the matrix was necessary.

For the estuarine systems, SAC comments that the attainment of flow recommendations is "somewhat more complex." At this point, SAC reviews its own goals in providing comments: (1) to insure that there is a measure of consistency in scientific methods and (2) to insure that there is practicality in the recommendations put forward. SAC then comments on the other BBEST's recommendations to "protect conditions that exist now as a result of the many man-made changes" as compared to the Nueces BBEST's "recommendations to determine inflow needs to achieve SEE (sound ecological environment), and consequently would create conditions that would theoretically restore shellfish and marsh habitats." [See Section 3.3 – Characteristics of a Sound Ecological Environment – SAC and Nueces BBEST for additional details.]

2.7 Is uncertainty in the analysis described or quantified? Where models were employed, was the extent of validation and associated predictive errors described and quantified?

The SAC provided comments for Sections 3 and 4 that explain how variability is dealt with in nearly all technical analyses. However, it is not addressed in the flow recommendations of Section 6. SAC further comments that the available analytical tools could have easily provided estimates of uncertainty bounds and "it would have been beneficial if the NBBEST addressed uncertainty more fully."

In its **Summary**, the SAC commends the Nueces BBEST for the hard work and for advancing the understanding of ecological conditions throughout the basin. The SAC states that "the report is a detailed presentation with well-documented science, contains a focused approach, and takes on the difficult but necessary issue of sound ecological environment in a thoughtful way." In conclusion, SAC states that the report establishes a good foundation for the Work Plan development by the Nueces BBASC.

3.1.3 *Comments from Texas Parks and Wildlife Department (TPWD)*

In a letter and memorandum dated January 24, 2012, the TPWD provided comments on the Nueces BBEST Environmental Flows Recommendations Report. The letter with accompanying memorandum is included in Appendix I of this report.

TPWD believes that the Nueces BBEST benefited from the work of previous BBEST efforts as well as the advantage of a multitude of data from monitoring in the Nueces River Delta and Bay. However, the statement is qualified by adding that "the Nueces BBEST did not have the time, data, directive, or budget to perform a definitive analysis."

In general, the TPWD commended the Nueces BBEST for its "diligence and determination to address the requirements set forth by SB3." However, the memorandum states that "No comments are submitted at this time regarding the work plan recommendations." The TPWD states that it "supports the Nueces BBEST instream environmental flow recommendations." Further the agency's comments state that the TPWD "appreciates the efforts of the BBEST in Section 1.3 to define a sound ecological environment and generally concurs with the BBEST's assessment."

Further, the TPWD commended the Nueces BBEST on its approach to addressing the needs of **intermittent streams**. The approach is a two-fold recommendation: 1) establish a 1 cfs floor as the low-flow recommendation for all intermittent sites; and 2) the occurrence of smaller magnitude, seasonal pulses at some intermittent sites.

With regards to the Nueces BBEST's recommendation for **instream base flow**, TPWD currently supports the recommendations; however, the agency states that the flow-habitat relationships developed as a result of the SB3 process requires further evaluation at various flow levels as part of future work plan activities developed by the Nueces BBASC working with the Nueces BBEST.

With regards to the Nueces BBEST's recommendations for **instream high flow pulse** (HFP), TPWD supports the recommendations and further praised their work in this section by describing the approach as "innovative" for such a "varied geographic and hydrographic area." The Nueces BBEST recommendations consisted of between five (5) to eight (8) pulse flow events including categorization as seasonal or annual. Lower magnitude pulse tiers were used for intermittent sites. Finally, the recommendations included criteria for satisfying high pulse flow events and allowing higher-level pulse flow events to fulfill unmet annual or seasonal pulse flow events that exist at lower pulse flow or overbank levels.

With regards to **sediment transport**, TPWD drew attention to the Nueces BBEST's conclusion that seasonal pulses do not provide sufficient energy to move adequate amounts of sediment. TPWD encourages the Nueces BBEST to work with the Nueces BBASC in addressing this important issue and incorporating high flow pulses in the Nueces BBASC's work plan.

With regards to **freshwater inflow analysis**, TPWD supports the Nueces BBEST's recommendations. TPWD stated that the Nueces BBEST's recommendations are based on available information from historic flows, the impact of water supply infrastructure, estuarine biology, sediment transport, water quality, and riparian zone marsh vegetation.

The agency stated that it understands the difficulty of **integration of instream flow and estuary flow regimes** on rivers with existing water supply infrastructure. TPWD stated that the Nueces BBEST likely did not have sufficient time to thoroughly examine this topic and agreed with the BBEST's reasoning to forgo comparing instream and estuary inflow regimes. The Department suggests that the Nueces BBASC work with the Nueces BBEST in development of work plan activities as it pertains to this topic.

In conclusion, TPWD indicated that the Nueces BBEST provided flow recommendations that are adequate to support a sound ecological environment for the Nueces River Basin and associated bays and estuaries.

3.2 Consideration of Present and Future Water Needs Related to Water Supply Planning

Pursuant to its charge, the Nueces BBASC was required to *consider the present and future needs for water for other uses related to water supply planning in the pertinent river basin and bay system* during the process of developing its recommendations regarding environmental flow standards and strategies to meet them. Section 3.2 provides summaries of relevant information from the approved 2011 regional water plans for the Coastal Bend (Region N), South Central Texas (Region L), Plateau (Region J), and Rio Grande (Region M) planning areas and other sources with the intent of establishing a quantitative frame of reference for consideration of water needs for municipal, industrial, steam-electric, mining, irrigation, and livestock uses along with water needs for environmental purposes in the Nueces River Basin, the Nueces-Rio Grande Coastal Basin, and the associated bays and estuaries. Summaries for regional economic data (Section 3.2.1) are compiled from county-level data as this data is not available by river and coastal basin boundaries. Regional water demands and needs do coincide with river basin boundaries and the data presented for this section are only for those portions of the included counties that are within the Nueces River Basin or the Nueces-Rio Grande Coastal Basin. In addition, Section 3.2.3 provides a focused summary of Corpus Christi area water supplies and demands.

3.2.1 *Regional Economies Dependent on Water*

The regional economies of the Nueces River Basin and the Nueces-Rio Grande Coastal Basin may be classified into five major sectors: Trades and Services, Manufacturing, Livestock, Agricultural Production, and Oil & Gas (mining). To varying degrees, each of these sectors is dependent on a reliable water supply. Such dependence may range from direct uses in crop irrigation, watering livestock, product manufacturing, power generation, and/or hydraulic fracturing for oil & gas recovery to less direct uses for residential purposes, cooling, and domestic consumption and sanitation supporting commercial establishments.

Table 3-1 provides a county-by-county summary of estimated annual economic contribution values for each of the five major economic sectors. It is important to note that Bandera, Maverick, and Webb counties were excluded from this table as the primary economic centers for these counties are not located within the Nueces River Basin. Observations upon consideration of Table 3-1 include the following:

a. Based on data for the five major economic sectors, the regional economy is estimated at more than $21.7 billion per year.
b. Trades and Services is by far the largest sector of the regional economy as it accounts for 79.5 percent of the total tabulated annual economic contribution value.
c. Manufacturing accounts for an additional 1.2 percent[1] of the total tabulated annual economic contribution value with the remaining 19.3 percent being associated with Oil & Gas Recovery, Livestock, and Agricultural Production.
d. Approximately 59 percent of the total tabulated annual economic contribution value is associated with Nueces County and 75 percent of the total tabulated annual economic contribution value is associated with Jim Wells, Kleberg, Nueces, and Uvalde Counties.

Table 3-1. Regional Economic Data Summary[2]

County	Trades & Services Economic Activity (million dollars)[1]	Manufacturing Economic Activity (million dollars)[2]	Market Value of All Livestock (million dollars)[3]	Market Value of All Crops (million dollars)[3]	Value of Oil Production (million dollars)[4]	Value of Gas Production (million dollars)[5]	Total (million dollars)
Atascosa	$616	$0	$34	$17	$41	$47	**$755**
Brooks	$113	$0	$18	$1	$84	$407	**$623**
Dimmit	$109	$0	$19	$3	$72	$36	**$239**
Duval	$95	$0	$11	$4	$101	$493	**$704**
Edwards	$12	$0	$8	$1	$0	$120	**$141**
Frio	$185	$0	$31	$40	$34	$9	**$299**
Jim Hogg	$74	$0	(D)	(D)	$18	$157	**$249**
Jim Wells	$1,029	$0	$36	$25	$10	$46	**$1,146**
Kenedy	(D)	$0	(D)	(D)	$21	$353	**$374**
Kinney	$12	$0	$6	$1	$0	$0	**$19**
Kleberg	$807	$0	$40	$25	$39	$244	**$1,155**
La Salle	$91	$0	$23	$8	$21	$107	**$250**
Live Oak	$162	$0	$16	$5	$52	$169	**$404**
McMullen	(D)	$0	$8	$0	$89	$205	**$302**
Medina	$749	$75	$38	$43	$6	$1	**$912**
Nueces	$12,350	(D)	$3	$108	$76	$327	**$12,864**
Real	$22	$0	$2	$0	$0	$1	**$25**
Uvalde	$818	$204	$46	$32	$0	$0	**$1,100**
Zavala	$53	$0	$41	$18	$68	$13	**$193**
Total	**$17,297**	**$279**	**$380**	**$331**	**$732**	**$2,735**	**$21,754**

1. 2007 Economic Census, U.S. Department of Commerce. This value only includes trade and service sectors for which data was not withheld and includes employer sales, shipments, receipts, revenue, or business done. (D) - data withheld to avoid disclosing data for individual companies.
2. 2007 Economic Census, U.S. Department of Commerce. (D) - data withheld to avoid disclosing data for individual companies. Includes employer sales, shipments, receipts, revenue, or business done.
3. 2007 Census of Agriculture, Volume 1 Geographic Area Series, "Table 1. County Summary Highlights: 2007." (D) - data withheld to avoid disclosing data for individual producers.
4. Value of production derived from production records obtained from the Railroad Commission of Texas and an assumed price of $64.20/bbl (approx. average for 2007).
5. Value of production derived from production records obtained from the Railroad Commission of Texas and an assumed price of $7/1,000 cf (approx. average for 2007).

[1] Manufacturing actually accounts for substantially more than 1.2 percent of the total tabulated annual production value because data has been withheld for Nueces County (a large center of manufacturing) by the U.S. Department of Commerce to avoid disclosures for individual companies.

[2] As U.S. Department of Commerce Economic Census data is published every five years, 2007 data was used for all economic sectors to facilitate comparisons.

In addition to the economic data presented above, special mention is made of the potential economic impacts of oil and gas production from the Eagle Ford Shale, since production from this formation began to increase dramatically after 2007. According to readily-available estimates, oil and gas activities in the formation account for roughly six percent of the Gross Regional Product for a 24 county area (Center for Community, 2011). While some of these counties are located outside of the area encompassed by the Nueces BBASC, the majority of the oil and gas production occurring in connection with the Eagle Ford Shale occurs within the Nueces BBASC area. These activities are estimated to create close to $1.3 billion of gross state product impact while adding $2.9 billion in total economic output in 2010. Under certain assumptions, (in 2010 dollars), the Eagle Ford Shale is expected to account for close to $11.6 billion in gross state product and $21.6 billion in total economic output in 2020. It is estimated that, in 2020, this activity will support 67,971 full-time jobs in the 24 county area.

The Nueces BBASC has expressed particular interest in the health of the bays and estuaries receiving freshwater inflows from the Nueces River Basin and the Nueces–Rio Grande Coastal Basin. Although data are readily available regarding the economic impacts of bay and estuary related recreational activities and commercial fishing for the entire Gulf Coast of Texas, only limited data are available specifically for the Nueces Estuary. To some degree, such impacts are included in the economic sector identified as Trades and Services, but the source of information does not break out all such businesses specifically. Apportioning Texas Gulf Coast data from the National Marine Fisheries Service in accordance with estuary-specific data from Texas A&M University (Jones, 2001), one may estimate that the statewide economic impacts of bay and estuary related recreational fishing activities for the Nueces and Mission-Aransas Estuaries and the Laguna Madre is about $1.87 billion per year (National Marine Fisheries, 2010). Similarly, the statewide economic impacts of the Texas seafood industry attributable to the Nueces and Mission-Aransas Estuaries and the Laguna Madre are estimated to be $577 million per year (Ibid). In addition, the total annual economic impact of regional nature tourism is estimated to be almost $760 million per year (Lee, 2012). These three economic subsectors represent almost 15 percent of the regional economy and are significant.

3.2.2 *Regional Water Demand Projections*

The Texas Water Development Board (TWDB) prepares long-range projections of dry year water demand by usage type, county, and river basin to support regional water plan development, which, in turn, supports state water plan development. Dry year demand projections for six sectors of water use during the next several decades are summarized in Figure 3-1.[3] Note that this analysis only tabulated the demands for the portions of each county located in the Nueces River Basin and the Nueces-Rio Grande Coastal Basin. Observations upon consideration of Figure 3-1 include the following:

a. Water demands are expected to increase by about 27,500 acft/yr (5 percent) from year 2010 to 2060.
b. Municipal and industrial uses of water are expected to steadily increase and together represent about 40 percent of total water demands by 2060.
c. Water demands for steam-electric power generation are expected to increase while irrigation demands decrease and other uses (mining[4] and livestock) remain relatively stable in the coming decades.

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[3] Demand projections presented are from the approved 2012 State Water Plan.

[4] Draft mining demand projections for the 2016 Regional Water Plans are higher than those in previous water plans due to the Eagle Ford Shale play. The activity associated with this play is expected to peak in the 2020 to 2030 time frame, therefore, the draft mining water demand projections also peak at that time before declining through the rest of the planning horizon. In 2020, the draft water demands for mining in the Nueces BBASC area total about 38,000 acft/yr (or about 17,000 acft/yr greater than the previous projections). In 2030, the draft water demands for mining in the Nueces BBASC area are about 38,500 acft/yr (or about 17,500 acft/yr greater than the previous projections).

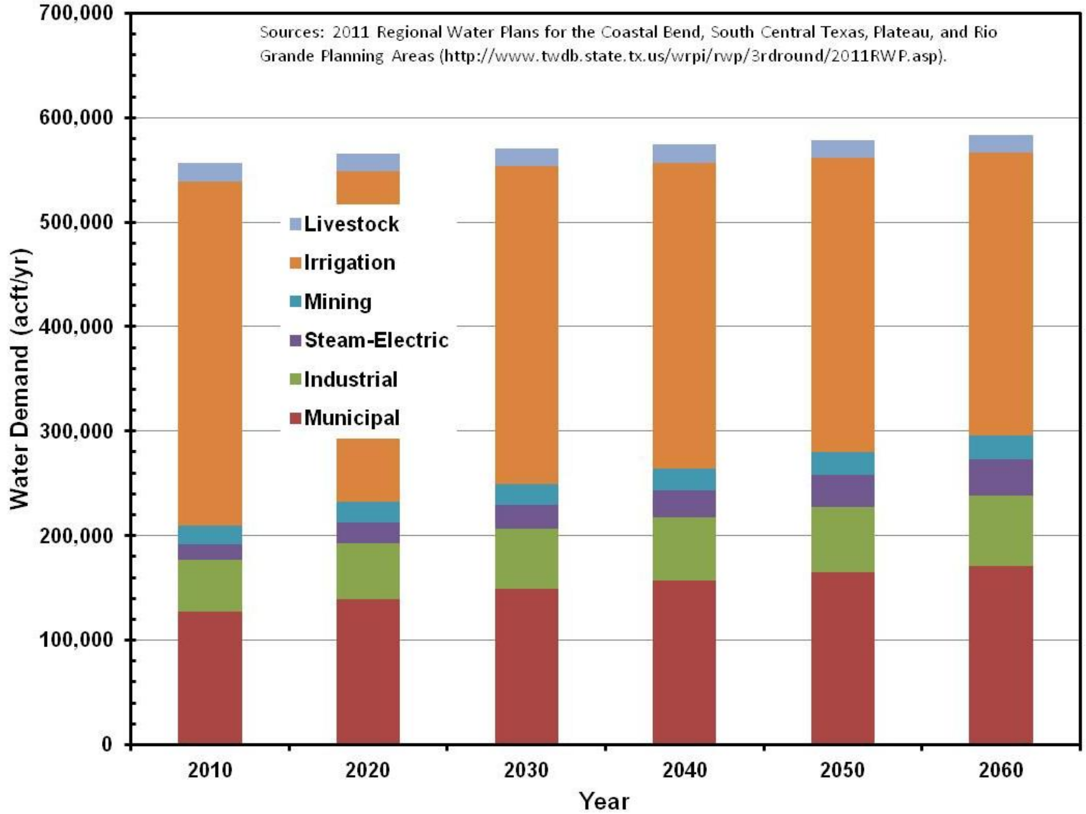

Figure 3-1. Water Demand Projections for Counties in the Nueces River Basin and/or the Nueces–Rio Grande Coastal Basin by Type of Use[5]

Needs for additional water supply are quantified in the regional water planning process by comparing projected dry year demands to reliable or firm existing supplies. Any apparent shortages resulting from these comparisons are identified as needs for additional water supply or simply needs. Figure 3-2 presents calculated needs for additional water supply through the year 2060. Observations upon consideration of Figure 3-2 include the following:

a. The need for additional reliable water supply is expected to grow from the year 2010 level of about 76,000 acft/yr to more than 113,000 acft/yr by 2060.
b. Approximately 84 percent of projected needs for additional water supply are in Nueces and Zavala Counties.
c. The needs for additional water supply associated with Zavala County are for irrigation.

[5] See Table 3.-2-.1 for a list of counties included. In addition to those counties included in Table 3.-2-.1, this figure also includes the demand projections for portions of Bandera, Maverick, and Webb Counties in the Nueces River Basin.

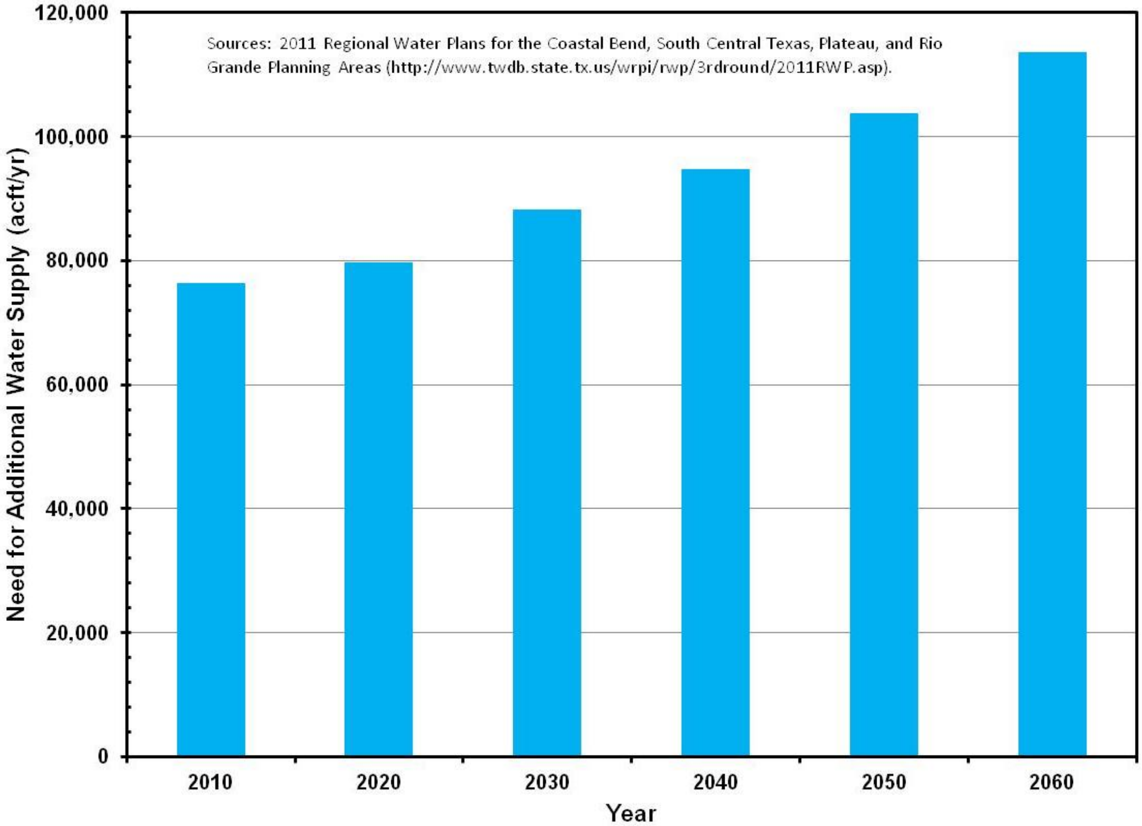

Figure 3-2. Needs for Additional Water Supply for Counties in the Nueces River Basin and/or the Nueces–Rio Grande Coastal Basin[6]

3.2.3 *Corpus Christi Area Water Supplies and Demands*

The Coastal Bend Region and Corpus Christi area depend primarily on surface water to meet the industrial and municipal demands. The surface water sources are Choke Canyon Reservoir and Lake Corpus Christi (CCR/LCC System) in the Nueces River Basin and Lake Texana in the Lavaca River Basin. Industrial and municipal water use accounts for the greatest amount of water demand totaling approximately eighty-five (85%) percent of the total Coastal Bend Region's use.[7] The primary water demand is municipal use in the greater Corpus Christi area as well as large industrial refineries along the Corpus Christi and La Quinta ship channels.

The Corpus Christi area has four wholesale providers: the City of Corpus Christi (City), San Patricio Municipal Water District (SPMWD), South Texas Water Authority (STWA), and Nueces County Water Control and Improvement District #3 (WCID #3). Along with these providers, the cities of Alice, Beeville, Mathis, and Robstown draw from this CCR/LCC System and the Nueces River below Lake Corpus Christi. Surrounding cities such as Rockport and Kingsville, Portland, Aransas Pass, and Port Aransas are supplied through these wholesale agencies.

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[6] See Table 3.-2-.1 for a list of counties included. In addition to those counties included in Table 3.-2-.1, this figure also includes the demand projections for Bandera, Maverick, and Webb Counties.

[7] The Coastal Bend Region (Region N) does not include counties within the Nueces River Basin located in Regions L, J, and M.

Lake Corpus Christi was built on the Nueces River in 1958 to increase the water supply yield to the region. The lake when full, impounds approximately 254,000 acft of water at a pool elevation of 94.00 ft. Upstream from Lake Corpus Christi, Choke Canyon Reservoir was built in 1986 on the Frio River with an impoundment capacity of approximately 750,000 acft. Water supply from Lake Texana is transported to the Coastal Bend Region via the Mary Rhodes Pipeline and provides the region with 41,840 acft/yr of firm supply and 12,000 acft/yr of water on an interruptible basis, in accordance with the contract between the City of Corpus Christi and Lavaca-Navidad River Authority (LNRA). The entire system supports over 450,000 people in the region.

Forty percent of the water used to meet the downstream customers in the Nueces basin comes from Lake Texana through the Mary Rhodes pipeline and, in 1998, the City acquired 35,000 acft/yr of water rights from the Garwood Irrigation Company from the Colorado River.

The Garwood Irrigation Company held the most senior water rights in the Lower Colorado River Basin with a priority date of November 1st, 1900. In 1993, TCEQ authorized an amendment to the Garwood water right that allows for the use of 35,000 acft/yr to be used for municipal and industrial purposes. Based on the approved TCEQ permit, the rights are limited to three diversions from the Colorado River through a pipeline. The amendment of the certificate of adjudication authorizes the City, the current owner of the water right, to divert 35,000 acft/yr from the Colorado River for irrigation, municipal, and industrial purposes at a rate not to exceed 150 cfs at the original priority date.

3.2.3.1 Safe Yield Water Supply

The City meets its water demands with its own water rights in the CCR/LCC System and through a contract with LNRA that provides water from Lake Texana. In 1999, HDR was contracted to develop a model of the system to determine the safe yield based on physical and environmental factors such as evaporation, storage, rainfall, and the most recent drought of record. A key factor in the model is the environmental flows from the 2001 Agreed Order. (See Section 2.3.1 and Appendix E for more detailed information on the Agreed Order.) Based on the Corpus Christi Water Supply Model (CCWSM), the total safe yield of the system is approximately 205,000 acft/yr which includes the LNRA call-back of 10,400 acft/yr. The call-back refers to an agreement between the City and LNRA in which LNRA reserves the right to take back 10,400 acft/yr of surface water from the City's supply if the water can be used in Jackson County. The safe yield reserves 75,000 acft, or about a six month supply, in system storage during a repeat of the drought of record. Using the CCWSM to evaluate different scenarios indicates that increasing the reserves or environmental pass-through flows may significantly decrease the safe yield of the system. Safe yield is defined as the volume of water that can be withdrawn from the system every year of the simulation period such that the minimum storage during a repeat of the drought of record results in 75,000 acft remaining in the system.

3.2.3.2 Current and Future Water Demands

As of 2010, the Corpus Christi area water demand was 150,366 acft/yr (Figure 3-3 and Table 3-2). The demand is based on actual diversions from 2010 from all entities who received either raw or treated water from the City. Forty nine percent is related to municipal uses with the remaining demand being attributed to industrial customers and other uses. There have been periods of declining demand in the residential use sector caused by wet years such as 2007.

Figure 3-3 shows the projected demands for the next sixty years in the Corpus Christi area along with available safe yield supply.

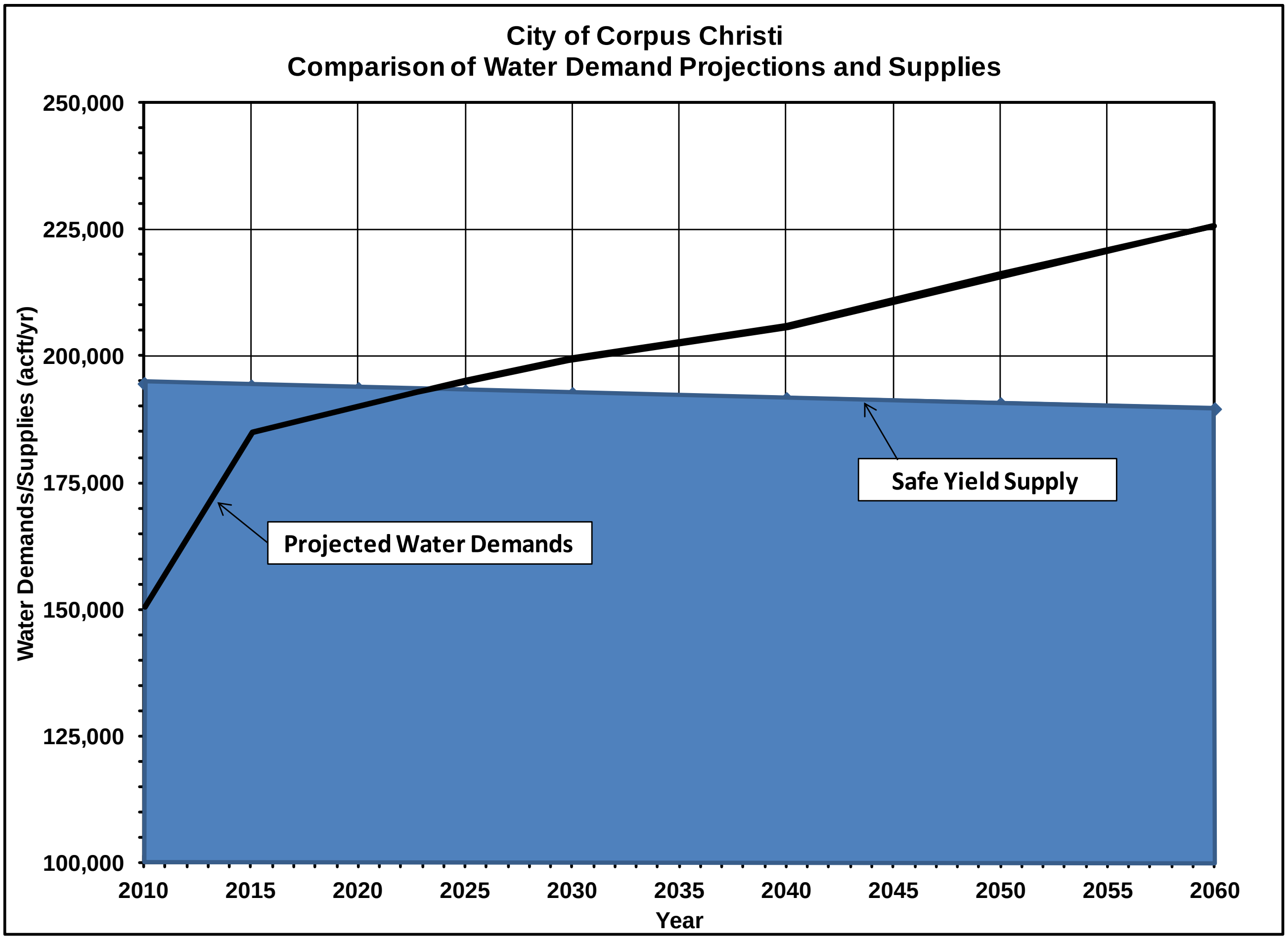

Figure 3-3. Comparison of Water Demand Projections and Supplies, 2010–2060, for entities relying on the City of Corpus Christi Water Supply. The demand increase in the early years is based on a potential large industrial customer that could contract for 21,000 acft/yr

It is expected that, by 2025, demands will exceed the safe yield of the system assuming no additional water projects are implemented. While this is a conservative calculation, the entire region could be impacted by the development and drilling in the Eagle Ford shale for oil and gas. The additional demand in the early years is due to the uncertainty of a large industrial customer contracting for 21,000 acft/yr. Industrial and commercial demand as a whole is projected to increase by 100% in the next 50 years.

Table 3-2 does not reflect the 35,000 acft/yr of new water supply from the Garwood Rights out of the Colorado River. Since the full amount may not be available during drought conditions, 32,000 acft/yr was included in Table 3-2.2 as a conservative estimate for planning purposes. With a pipeline construction cost of $120 million, it is anticipated that a portion of this water could be available by 2020. Overall, demands will increase by 50% by the year 2060, from 150,000 acft/yr to 226,000 acft/yr.

Table 3-2. City of Corpus Christi Water Demand and Supply Projections

	Year							
All values are in acft/yr	**2010**	**2015**	**2020**	**2025**	**2030**	**2040**	**2050**	**2060**
Water Demands[8]								
City of Corpus Christi[2,3]	***84,991***	***89,907***	***94,823***	***98,993***	***103,163***	***110,522***	***117,564***	***123,544***
Municipal Treated	50,995	53,944	56,894	59,396	61,898	66,313	70,538	74,126
Commercial/Industrial Treated	33,996	35,963	37,929	39,597	41,265	44,209	47,025	49,418
City of Alice[2]	7,688	7,898	8,108	8,220	8,333	8,368	8,274	8,097
City of Beeville[2]	4,514	4,576	4,638	4,665	4,692	4,652	4,624	4,512
City of Mathis[4]	690	681	673	664	654	636	624	624
San Patricio MWD[5]	40,000	40,000	40,000	40,000	40,000	40,000	42,724	45,742
Manufacturing/Industry								
Flint Hills Resources[4]	4,860	5,057	5,254	5,418	5,583	5,904	6,181	6,616
Hoechst Celanese[4]	1,260	1,311	1,362	1,405	1,448	1,531	1,603	1,716
Other Manufacturing/ Mining/Industrial[6]	0	8,000	8,000	8,000	8,000	8,000	8,000	8,000
Lon Hill[7]	3,000	3,000	3,000	3,000	3,000	3,000	3,000	3,000
City of Three Rivers and Valero Refinery[5]	3,363	3,363	3,363	3,363	3,363	3,363	3,363	3,363
Future Industrial/Mining Customers	0	21,000	21,000	21,000	21,000	21,000	21,000	21,000
Total Demands	***150,366***	***184,793***	***190,220***	***194,728***	***199,236***	***206,976***	***216,956***	***226,213***
Current CCR/LCC/Texana System and Future Mary Rhodes Phase II Supplies[8]								
Safe Yield Current System[8]	205,000	204,500	204,000	203,500	203,000	202,000	201,000	200,000
Mary Rhodes Phase II Project[9]	0	0	32,000	32,000	32,000	32,000	32,000	32,000
LNRA Call-Back	(10,400)	(10,400)	(10,400)	(10,400)	(10,400)	(10,400)	(10,400)	(10,400)
Total Supplies	**194,600**	**194,100**	**225,600**	**225,100**	**224,600**	**223,600**	**222,600**	**221,600**
Surplus/Deficit	**44,234**	**9,307**	**35,380**	**30,372**	**25,364**	**16,624**	**5,644**	**(4,613)**

[1] Water demands are based on TWDB's growth projections. Flint Hills Resources and Hoechst Celanese demands are projected based on TWDB growth trends for Nueces County -Manufacturing.

[2] Based on Year 2011 diversion data. Year 2011 was a dry year, with low rainfall during the summer when higher water demands typically occur.

[3] Water demands for treated water supply customers (Nueces County WCID # 4 , South Texas Water Authority, Violet Water Supply Corporation, and some local industries) are included in the City of Corpus Christi water demands. Diversions for treated water supplies provided by the City of Corpus Christi to San Patricio MWD were removed (3,474 acft/yr based on recent data) as San Patricio MWD contracts are considered separately in the table above. Assumes residential use is 60% and industrial use is 40%.

[4] Based on five year average diversions (Year 2007-2011). Actual water diverted in Year 2011 was 632 acft for the City of Mathis; 4,623 acft for Flint Hills Resources; and 997 acft for Hoechst Celanese.

[5] Contracted supplies of 40,000 acft/yr to SPMWD and 3,363 acft/yr for the City of Three Rivers are included in the analysis. The City of Three Rivers provides water supplies to Valero Refinery. Beginning in Year 2050, SPMWD's demand exceeds their current contract based on TWDB estimates included in the Region N 2011 Plan.

[6] Assumes an additional potential industrial water demand of 10,000 acft/yr for new or existing customers. The amount shown in this row is the approximate amount that is not included in the TWDB projections shown on the City of Corpus Christi Commercial/Industrial Treated row.

[7] Lon Hill's consumptive water use was estimated at 3,000 acft/yr and assumes that the plant will operate at or near its historical demand rate.

[8] Safe yield estimates were obtained from the Region N RWP and interpolated for years between 2010 and 2060. Intermediate time periods were interpolated.

[9] The City of Corpus Christi is authorized to divert and use up to 35,000 acft/yr associated with the Garwood Right per Certificate of Adjudication No. 14-5434. The Region N 2011 Plan shows a firm yield supply of 35,000 acft/yr to be available when operated with the City's existing CCR/LCC/Texana system. It is uncertain whether the full right would be available considering 2011 drought conditions. For this reason, an assumption of 32,000 acft/yr is considered available as a conservative estimate for planning purposes.

[8] Water demands are based on TWDB's growth projections. Flint Hills Resources and Hoechst Celanese demands are projected based on TWDB growth trends for Nueces County -Manufacturing.

3.2.4 *Regional Water Plan Strategies and Costs*

A number of water management strategies are recommended for implementation in the 2011 Coastal Bend (Region N), South Central Texas (Region L), and Plateau (Region J) Regional Water Plans to meet projected needs for additional water supply in the coming years. Among these recommended strategies are those directly, potentially, or not affected by the new environmental flow standards to be adopted by TCEQ. Strategies directly affected are identified in the following paragraph. Recommended water management strategies not affected by the environmental flow standards are generally associated with development of groundwater supplies and are not listed herein.

Recommended water management strategies in a 2011 regional water plan expected to be directly affected by TCEQ adopted environmental flow standards in the basins assigned to the Nueces BBASC include the following (listed along with the associated firm yield, unit costs for water, and planning region):

a) Nueces Off-Channel Reservoir; 30,340 acft/yr; $578 - $715/acft/yr; Region N.[9]
b) Edwards Aquifer Recharge – Type 2 Projects; 21,577 acft/yr; $1,728/acft/yr; Region L.

These recommended water management strategies are identified as being directly affected by adopted environmental flow standards because they involve new appropriations of surface waters of the state, and permits for diversion and/or impoundment must be obtained from the TCEQ. Other recommended water management strategies, such as the Mary Rhodes Phase II Project or O.N. Stevens Water Treatment Plant Improvements are not expected to be affected by environmental flow standards because they do not involve new surface water appropriations. Finally, the recommended Lavaca River Diversion and Off-Channel Reservoir Project could be affected by adopted environmental flow standards in the Colorado and Lavaca Rivers and Matagorda and Lavaca Bays Basin and Bay Area.

3.3 Analysis Performed for the Nueces BBASC

HDR Engineering (HDR) performed technical evaluations at the direction of the Nueces BBASC to assist in evaluating the effects of potential environmental flow standards on water supply projects in the Nueces River Basin. HDR was assigned to evaluate the firm yields of example large scale water supply projects in the Nueces River Basin under various environmental flow standards. The evaluations consisted of quantifying the percentages of maximum potential yield committed to the environment and the resulting streamflow remaining after diversion subject to the various environmental flow standards. To further assistance in this analysis the Nueces BBASC asked the TWDB and the Nueces BBEST to provide some additional assistance. The TWDB provided analysis on sediment and salinity impacts from the BBASC recommendations. The sediment analysis report is contained in Appendix L, and the technical presentations from the TWDB for both sediment and salinity can be found in Appendix J. Ryan Smith, with the Nature Conservancy and a Nueces BBEST member, performed habitat modeling for the BBASC to evaluate potential BBASC recommendation and compare these to the BBEST recommendation focusing on the habitat flow relationships of some of the example project sites. This presentation can also be found in Appendix J, along with the WAM and FRAT files used by HDR.

3.3.1 *Simulations for Nueces Projects*

<u>Simulation Procedure</u>

TCEQ's Nueces Water Availability Model (Nueces WAM) with a period of record from 1934 to 1989 provided the baseline regulated and unappropriated monthly streamflow volumes for the six selected Nueces BBASC example project locations. WAM simulations were performed under fully authorized conditions in which all water rights utilize their maximum authorized amounts (TCEQ WAM Run 3 Assumptions). In addition, all downstream senior water rights were assumed to be subordinated when calculating the baseline unappropriated streamflow at the evaluated project sites. In other words, the evaluated example projects

[9] Assumes 65% federal or state participation.

were not required to pass water for downstream senior water rights. The purposes of this assumption are twofold. One, it is widely accepted that any new water right in the Nueces Basin would require some type of subordination agreement with downstream senior rights in order to have viable availability determined by the Commission. Two, by not applying downstream senior pass-through, the impacts of the various environmental flow regimes can be isolated rather than masked by water that is being passed for downstream senior rights.

Monthly regulated and unappropriated streamflow volumes from the WAM were disaggregated to daily streamflow values based on daily flow patterns from nearby USGS daily streamflow gaging stations. These daily flows established the baseline or existing conditions streamflow and were inserted into version 3.6.f of the Flow Regime Assessment Tool (FRAT). Within the FRAT, various environmental flow regimes were applied using a daily simulation to estimate firm yield values for the example projects and average enhanced recharge values for the Sabinal Recharge Project. PowerPoint presentations summarizing the analyses of the example projects are included in Appendix J.

3.3.1.1 Initial Simulations

The Cotulla Reservoir project, run-of-river projects with off-channel storage near Uvalde and Cotulla, and the Sabinal recharge enhancement project were evaluated subject to four potential instream flow standards. A short description of each scenario is provided below.

No Environmental Flow Criteria

The first standard evaluated was a baseline scenario including no environmental flows criteria. This scenario represents the theoretical maximum firm yield of a project, subject only to existing senior upstream water rights. The no environmental flow criteria simulations were used as a benchmark to assess the firm yield reduction associated with the application of alternate environmental flow standards. Note that the no Environmental Flow Criteria was included in this analysis to show the percentage of the yield of a project that would be dedicated to an environmental flow recommendation. It is not included to imply that a project could be permitted without an environmental flow restriction of some kind.

Lyons Method

The second instream flow standard simulated was the Lyons Method. The Lyons Method is the default desktop environmental flow criteria used by TCEQ prior to the establishment of environmental flow standards through the SB3 process.

Consensus Criteria for Environmental Flow Needs (CCEFN)

The third instream flow standard simulated was the CCEFN method. This is the default environmental flow standard used in the regional planning process prior to the establishment of environmental flow standards through the SB3 process.

BBEST Recommendations

The fourth instream flow standard for the initial simulations was the Nueces BBEST environmental flow regime recommendations.

3.3.1.2 Intermediate Simulations

In the deliberations of the Nueces BBASC to strike a balance between environmental needs and water supply needs, several "intermediate" instream environmental flow standard scenarios were applied to the example projects. The intermediate scenarios were modifications of the BBEST recommended regimes excluding overbanking events and reducing the number base flow tiers. Pulse peak (trigger), duration, and volume values were not altered from the BBEST recommendations. All intermediate simulations include the pulse exemption rule as defined in Section 4.3.1 as applicable for run-of-river diversions (Cotulla and Laguna off-channel reservoirs). In addition, base flow values were not altered from the BBEST recommendations. Key simulations that aided the Nueces BBASC in their decision-making process include:

- **No Overbank -** Excludes overbank events from the BBEST recommendation and includes all other components subject to the pulse exemption rule.
- **No Overbank, Dry Base Only** – Excludes the overbank events from the BBEST recommendation, includes all non-exempt seasonal and annual high flow pulses, and includes only the dry hydrologic condition tier of base flows.
- **No Overbank, 50% Rule, Average (Avg) Base Only** – Excludes the overbank events from the BBEST recommendation, includes all non-exempt seasonal and annual high flow pulses, and includes only the average hydrologic condition tier of base flows with the 50% rule as defined in Section 4.1.1.2.
- **No Overbank, 50% Rule, Wet Base Only** – Excludes the overbank events from the BBEST recommendation, includes all non-exempt seasonal and annual high flow pulses, and includes only the wet hydrologic condition tier of base flows with the 50% rule as defined in Section 4.1.1.2.

3.3.1.3 Final Nueces BBASC Recommendations

The Nueces BBASC recommends environmental flow standards based on the *No Overbank, 50% Rule, Avg Base Only* scenario described above. The Nueces BBASC recommendation for each gage utilized the Nueces BBEST recommendation for each gage with the following modifications:

- The exclusion of overbank events.
- All non-exempt levels of non-overbank high flow pulses subject to the pulse exemption rule defined in Section 4.3.1.
- The average hydrologic condition tier of base flows with the 50% rule.

The final BBASC instream environmental flow standard recommendations for all selected streamflow sites are summarized in Section 4.1.

3.3.2 *Baseline and Nueces BBEST Fresh Water Inflow Recommendations*

The evaluation of the BBEST Freshwater Inflow (FWI) recommendation on the impact of future projects was performed with a different modeling tool than the instream recommendations. The Corpus Christi Water Supply Model (CCWSM), also known as the NUBAY model, was used to evaluate the impacts of applying the BBEST FWI recommendation to potential future projects. The CCWSM was originally developed in the early 1990s to evaluate the TCEQ Agreed Order (Order) issued pursuant to the Choke Canyon Reservoir Certificate of Adjudication. This Order defines how the City of Corpus Christi is to operate the reservoir system to meet certain target levels of inflow to the Nueces Estuary subject to available inflows to the reservoir system. The Nueces BBEST FWI Recommendation, while non-prescriptive in nature, was converted into an operational regime for evaluation of the potential impacts of the FWI recommendation on the yield of the CCR/LCC System as well as an example project in the Coastal Bend Regional Water Plan. Table 3-3.1 summarizes the current Order by showing the amount of pass-through required on a monthly basis, depending on levels of system storage. Table 3-3.2 summarizes the Nueces BBEST FWI recommendation which was converted into an operational structure like the Order and simulated using a version of the CCWSM capable of using seasonal, rather than monthly, freshwater inflow targets.

Table 3-3.1. 2001 Agreed Order Targets

Sys Stor. %	Jan (acft)	Feb (acft)	Mar (acft)	Apr (acft)	May (acft)	Jun (acft)	Jul (acft)	Aug (acft)	Sep (acft)	Oct (acft)	Nov (acft)	Dec (acft)	Ann. (acft)
>70	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500	138,000
70-40	2,500	2,500	3,500	3,500	23,500	23,000	4,500	5,000	11,500	9,000	4,000	4,500	97,000
40-30	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	14,400
<30	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 3-3.2. Nueces BBEST Recommendation

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations	
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)	Attainment
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000	25%
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000	80%
Subsistence (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000	95%
	Winter = Nov–Feb	Spring = Mar–Jun	Summer/Fall = Jul–Oct		

3.3.3 *Large-Scale Firm Yield Projects (Cotulla Reservoir Project and Lake Corpus Christi Off-Channel Project)*

The Cotulla Dam and Reservoir is a once proposed, but no longer active, project that would be located at river mile 250.2 on the Nueces River near the western boundary of La Salle County, approximately 8 miles west of the City of Cotulla. At normal pool elevation (454 ft-msl), the reservoir would store 527,600 acft and inundate 31,410 acres. The location of this example project is shown in Figure 3-3.1.

Due to the close proximity and minimal differences in contributing drainage area between the stream gage at Cotulla (USGS Gage 08194000) and the project site, instream flow recommendations for the Nueces River at Cotulla are assumed to be directly applicable to the project.

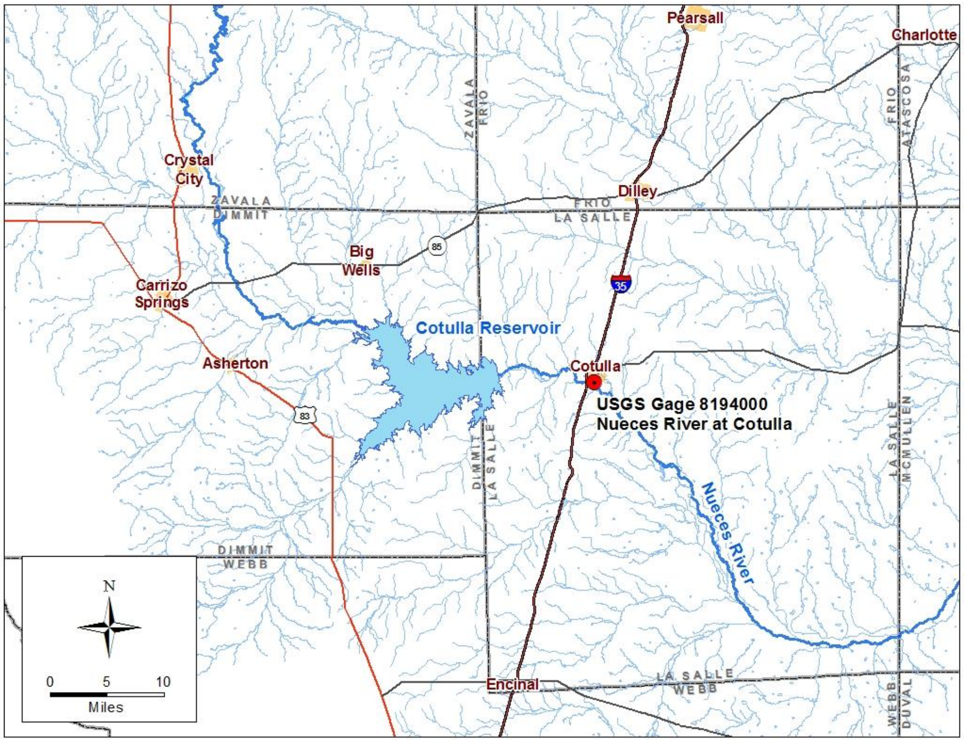

Figure 3-3.1. Location of Cotulla Reservoir Project

3.3.3.1 Initial Simulations for Cotulla Reservoir

Tables 3-3.3 through 3-3.5 provide the instream flow standards for the Lyons method, CCEFN, and BBEST recommendation for the initial simulations of the Cotulla Reservoir project. The pulse exemption rule is not applicable due to the storage capacity of the on-channel reservoir.

Table 3-3.3. Lyons Method Instream Flow Criteria for the Nueces River at Cotulla (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9.5	11.1	15.9	16.6	19.9	16.6	14.7	8.0	16.4	16.4	12.4	8.2

Table 3-3.4. Consensus Criteria for Environmental Flow Needs Instream Flow Criteria for the Nueces River at Cotulla (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Median	23.7	27.7	26.5	27.7	33.2	27.7	24.6	13.4	27.3	41.1	31.0	20.4
25th Percentile	8.3	6.9	3.9	3.9	0.5	2.4	1.4	0.3	2.8	4.0	6.7	5.3
7Q2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1

Table 3-3.5. BBEST Recommendations for the Nueces River at Cotulla (cfs)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
Overbank Events	Qp: 15,100 cfs with Average Frequency 1 per 5 years Regressed Volume is 151,000 Duration Bound is 42	Qp: 15,100 cfs with Average Frequency 1 per 5 years Regressed Volume is 151,000 Duration Bound is 42	Qp: 15,100 cfs with Average Frequency 1 per 5 years Regressed Volume is 151,000 Duration Bound is 42	Qp: 15,100 cfs with Average Frequency 1 per 5 years Regressed Volume is 151,000 Duration Bound is 42
Overbank Events	Qp: 8,410 cfs with Average Frequency 1 per 2 years Regressed Volume is 80,700 Duration Bound is 38	Qp: 8,410 cfs with Average Frequency 1 per 2 years Regressed Volume is 80,700 Duration Bound is 38	Qp: 8,410 cfs with Average Frequency 1 per 2 years Regressed Volume is 80,700 Duration Bound is 38	Qp: 8,410 cfs with Average Frequency 1 per 2 years Regressed Volume is 80,700 Duration Bound is 38
Overbank Events	Qp: 4,460 cfs with Average Frequency 1 per year Regressed Volume is 41,100 Duration Bound is 34	Qp: 4,460 cfs with Average Frequency 1 per year Regressed Volume is 41,100 Duration Bound is 34	Qp: 4,460 cfs with Average Frequency 1 per year Regressed Volume is 41,100 Duration Bound is 34	Qp: 4,460 cfs with Average Frequency 1 per year Regressed Volume is 41,100 Duration Bound is 34
Overbank Events	Qp: 1,560 cfs with Average Frequency 2 per year Volume Bound is 24,200 Duration Bound is 28	Qp: 1,560 cfs with Average Frequency 2 per year Volume Bound is 24,200 Duration Bound is 28	Qp: 1,560 cfs with Average Frequency 2 per year Volume Bound is 24,200 Duration Bound is 28	Qp: 1,560 cfs with Average Frequency 2 per year Volume Bound is 24,200 Duration Bound is 28
High Flow Pulses	Qp: 96 cfs with Average Frequency 1 per season Volume Bound is 1,570 Duration Bound is 20	Qp: 1,180 cfs with Average Frequency 1 per season Volume Bound is 17,200 Duration Bound is 24	Qp: 100 cfs with Average Frequency 1 per season Volume Bound is 1,030 Duration Bound is 16	Qp: 640 cfs with Average Frequency 1 per season Volume Bound is 8,610 Duration Bound is 26
High Flow Pulses	Qp: 8 cfs with Average Frequency 2 per season Volume Bound is 100 Duration Bound is 13	Qp: 190 cfs with Average Frequency 2 per season Volume Bound is 2,370 Duration Bound is 17		Qp: 35 cfs with Average Frequency 2 per season Volume Bound is 360 Duration Bound is 14
High Flow Pulses		Qp: 15 cfs with Average Frequency 3 per season Volume Bound is 150 Duration Bound is 11		
Base Flows (cfs)	38	31	31	42
Base Flows (cfs)	6	10	7	15
Base Flows (cfs)	1	1	1	1
Subsistence Flows (cfs)	1	1	1	1

The firm yield results for Cotulla Reservoir are presented in Figure 3-3.2. Percentages shown in Figure 3-3.2 reflect the firm yield reduction due to application of the environmental flow assumptions of each of the initial simulations (i.e. percentage of firm yield committed to environmental protection). The initial results show that the firm yield reductions from the Lyons and CCEFN standards are less than 10 percent while the BBEST recommendation would result in a yield reduction of 58 percent. This large discrepancy in yield reduction is due, in part, to the Lyons and CCEFN standards not including overbanking components. The Lyons and CCEFN standards would allow flood events during the critical drought to be impounded, whereas the BBEST recommendation would require passage of significant portions of such flood events.

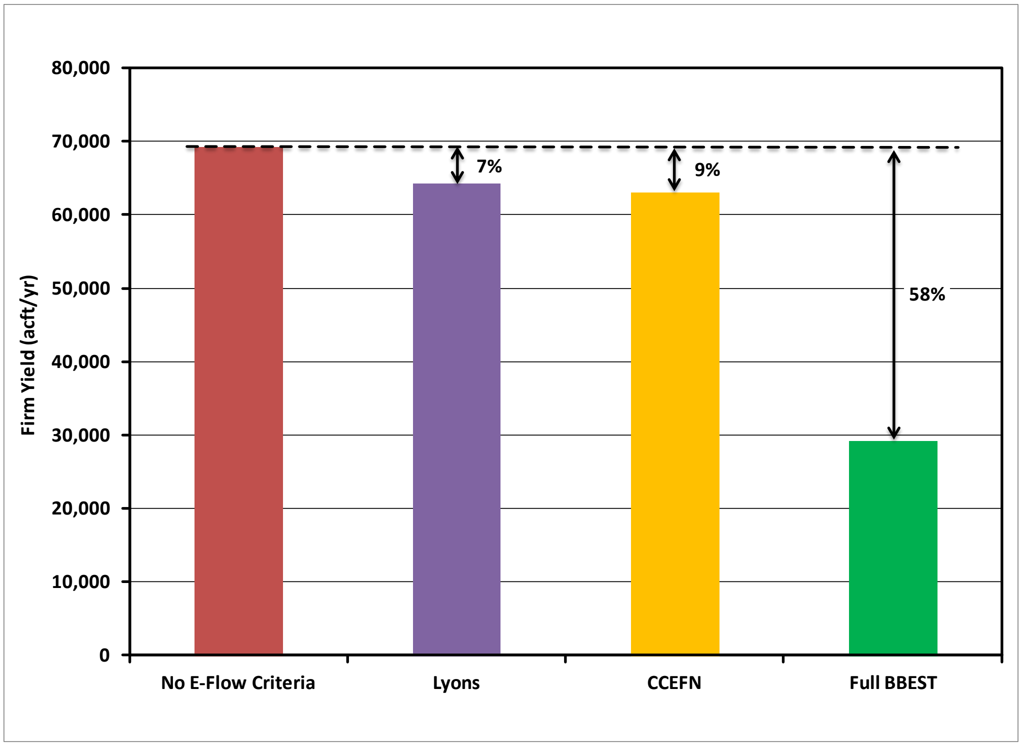

Figure 3-3.2. Initial Firm Yield Results – Cotulla Reservoir

3.3.3.2 Intermediate Simulations

A comparison of firm yields of the no environmental flows scenario, intermediate standards, and BBEST recommendation is presented in Figure 3-3.3. The results confirm that, for a large, on-channel reservoir at this location, the overbank flow range is a critical component of the firm yield. A comparison of the BBEST recommendation and No Overbank scenario shows that the yield of the reservoir almost doubles with removal of the overbank flow passage requirement.

Base flows are small and infrequent at this intermittently flowing stream location and provide negligible water for impoundment and water supply development. This is reflected in the results by the minimal differences in yield among the four intermediate standards that have varying base flow components.

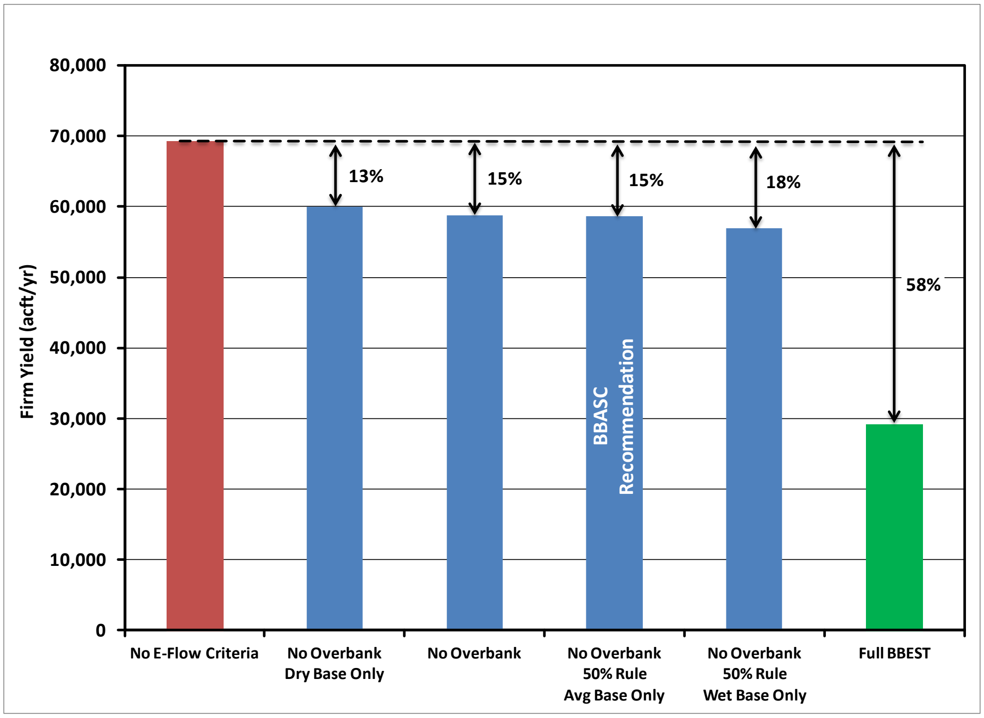

Figure 3-3.3. Intermediate Firm Yield Results – Cotulla Reservoir

3.3.3.3 Final Nueces BBASC Recommendations

The Nueces BBASC recommendation of the No Overbank, 50% Rule, Avg Base Only intermediate standard with a pulse exemption rule for the Nueces River at Cotulla is presented in Table 4-1.4 of Section 4.1.5. For the Nueces River at Cotulla, the BBASC recommendation increases the firm yield of the example project to 58,600 acft/yr from the BBEST recommendation yield of 29,200 acft/yr. This is an increase of 29,400 acft/yr or 100 percent. Figure 3-3.4 compares the BBASC recommendation firm yield with the yields of the four initial simulations. Review of Figure 3-3.4 indicates that the BBASC recommendation is less protective of water supply than the current environmental flow criteria used in water rights permitting and regional water planning, but substantially more protective of water supply than the BBEST recommendation.

The flow frequency curves of the resulting streamflow immediately downstream of this example project are presented in Figure 3-3.5. The differences in the streamflow frequencies of the BBEST and BBASC recommendations are not great. The difference between the two recommendations is primarily in the high flow range (occurring less than 5 percent of the time and beyond the scale of Figure 3-3.5) and represents the overbanking events passed under the BBEST recommendation, but impounded under the BBASC recommendation, that proved critical to the firm yield of the example project. The historical line represents the "no project" condition, which is representative of the streamflows from the WAM assuming no project.

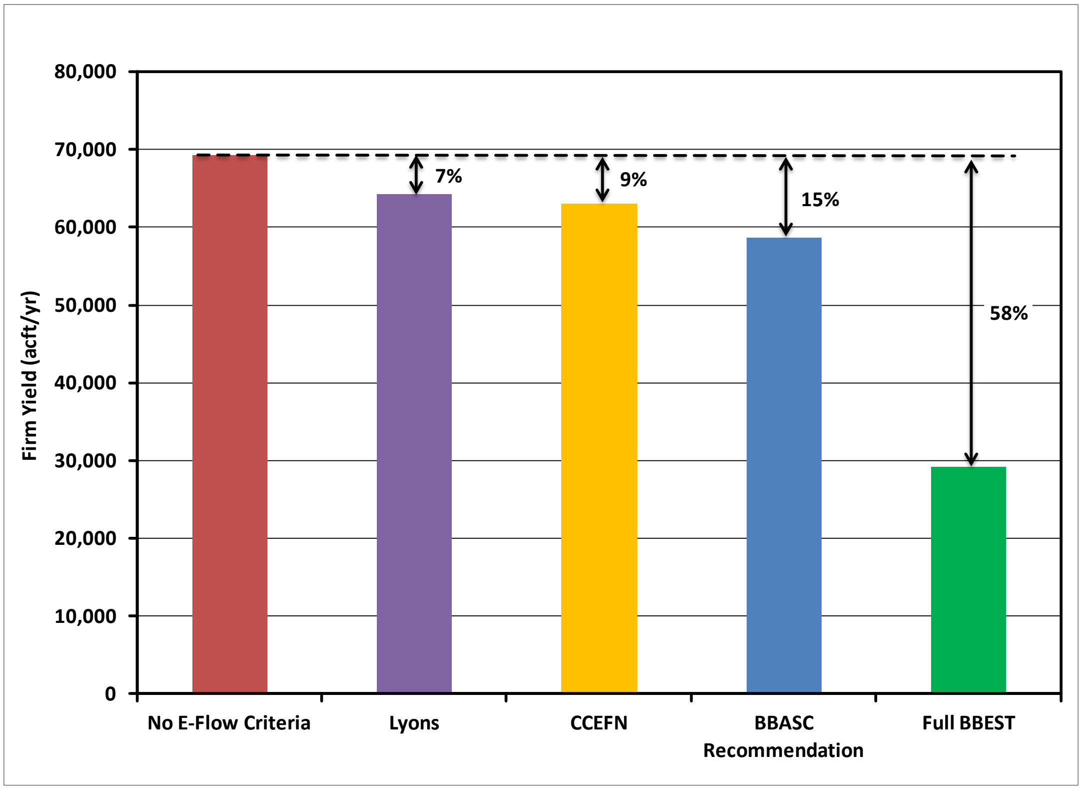

Figure 3-3.4. Final Firm Yield Results – Cotulla Reservoir Project

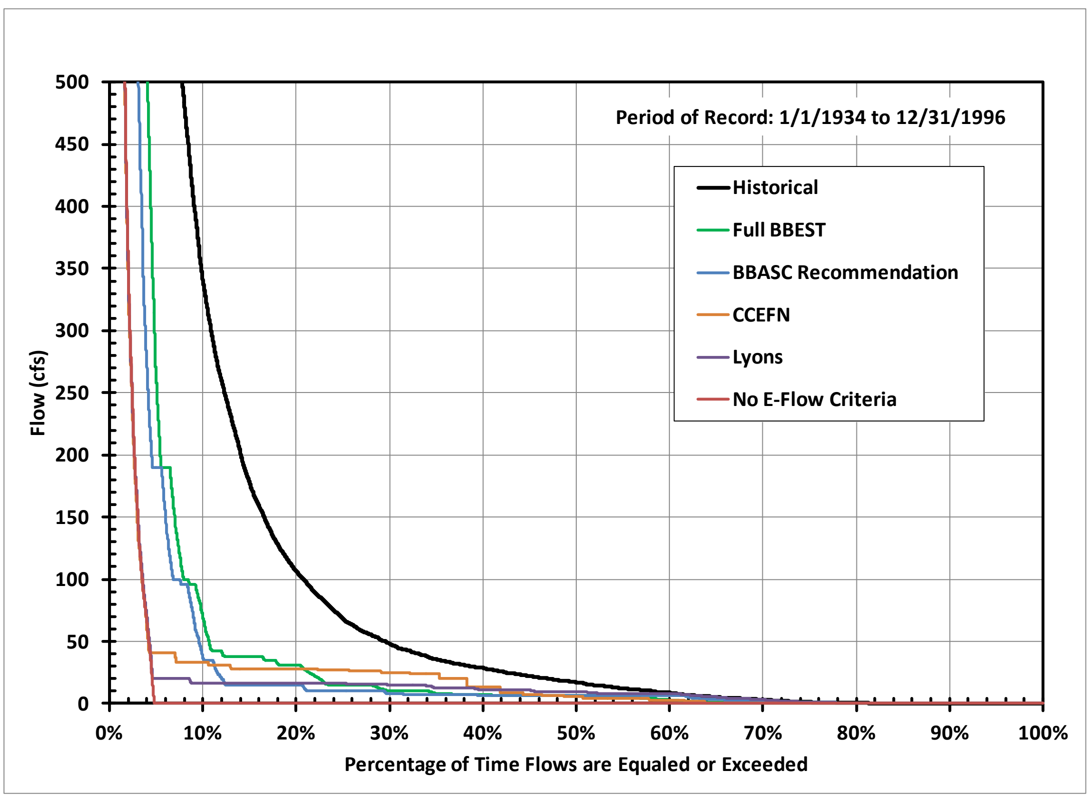

Figure 3-3.5. Downstream Flow Frequency – Cotulla Reservoir Project

3.3.4 *Lake Corpus Christi Off-Channel Reservoir*

The impacts of the Nueces BBEST FWI recommendation were evaluated using the CCWSM to simulate the Lake Corpus Christi Off-Channel Reservoir project (LCC-OCR), Figure 3.3-6. The LCC-OCR is a recommended strategy in the 2011 Region N Water Plan to meet the future water supply needs of the Corpus Christi Region. The LCC-OCR characteristics, as included in the Region N plan and simulated for the Nueces BBASC, include:

- 280,000 acft capacity at normal pool;
- Diversion from the flood pool and the top 1 foot of LCC conservation storage;
- Operation to release from off-channel storage to refill LCC when LCC reaches 80 ft-msl;
- Diversion and discharge facilities sized for 1,250 cfs; and
- Inclusion of OCR storage in the system storage calculation used to determine required pass-through targets under the Order.

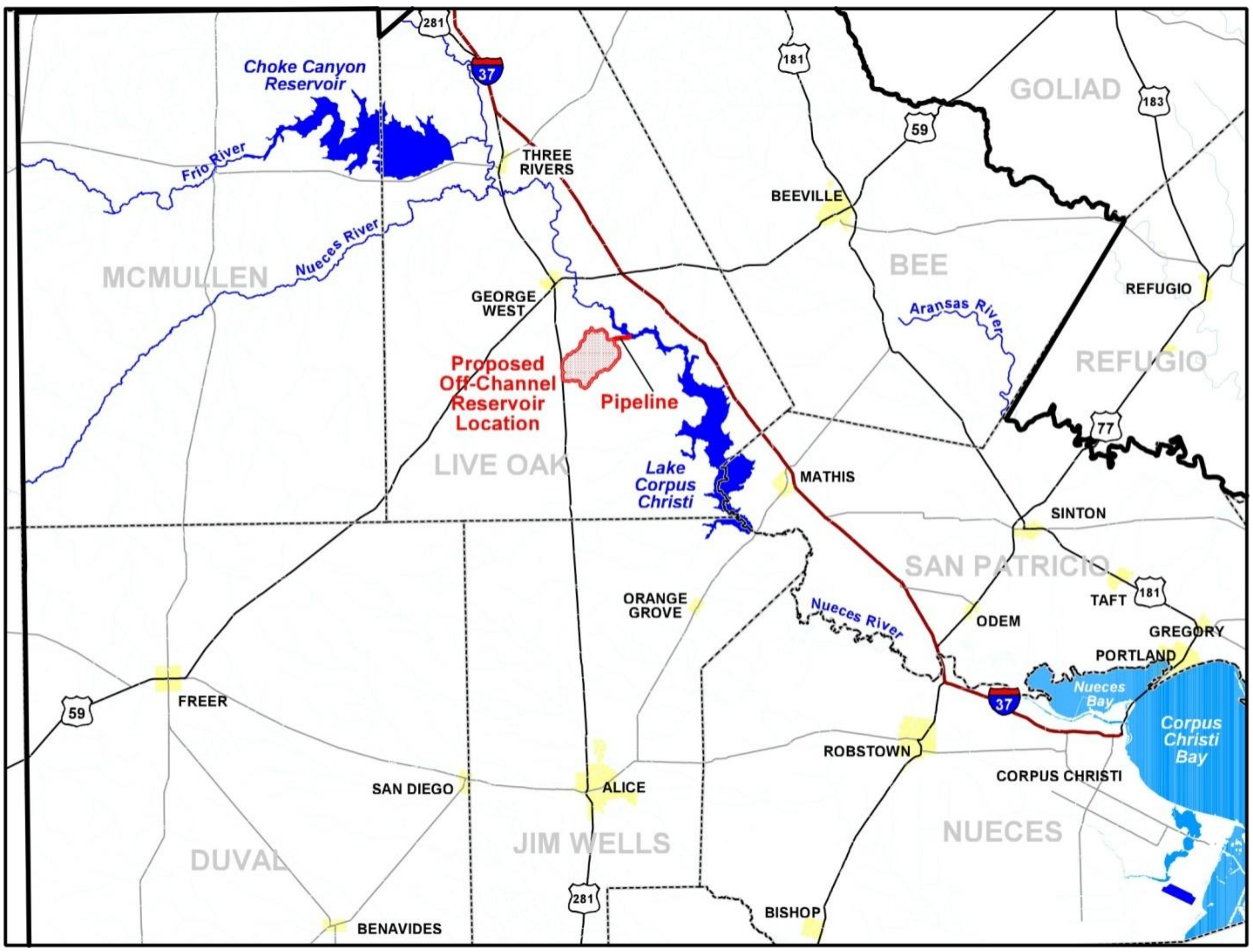

Figure 3-3.6. Off-Channel Reservoir and Pipeline to Lake Corpus Christi

3.3.4.1 Initial Simulations

The initial simulations include establishing baselines for project yield and Nueces Bay inflow. Due to the anticipated permitting and operations of this project and the connection to the existing LCC water right, this project was not evaluated for instream criteria, but only for FWI considerations. Four baseline scenarios were evaluated and are described in the following bulleted text. Each of these scenario simulations served to determine the safe yield of the system under various FWI recommendations. Safe yield, in this case, is defined as the volume of water that can be withdrawn from the system every year of the simulation period such that the minimum storage during a repeat of the drought of record would be 75,000 acft or about a six month water supply.

- No Pass-Through (No_PT) – This scenario establishes the baseline maximum theoretical yield of the system with no pass-through of inflow required to satisfy bay and estuary (B&E) targets.
- Base Safe Yield (Base_SY) – This scenario represents the current safe yield supply available from the reservoir system and is used for water supply planning purposes. Includes full application of the existing Agreed Order to determine pass-through.
- Full BBEST Recommendation (Full_BBEST) – This scenario applies the Nueces BBEST FWI recommendation in the place of the existing Agreed Order.
- Lake Corpus Christi Off-Channel Reservoir Safe Yield (OCR_SY) – This represents the safe yield of the system with the LCC-OCR added and the entire system operated under the existing Order.

Figure 3-3.7 compares the yield of these four scenarios. The figure shows the Full BBEST with the lowest yield of the four initial scenarios and the OCR-SY with the highest. Comparing the No_PT with the Base_SY shows that about 15% of the existing system yield is dedicated to the environment under existing operations compared to 35% under the Full BBEST scenario.

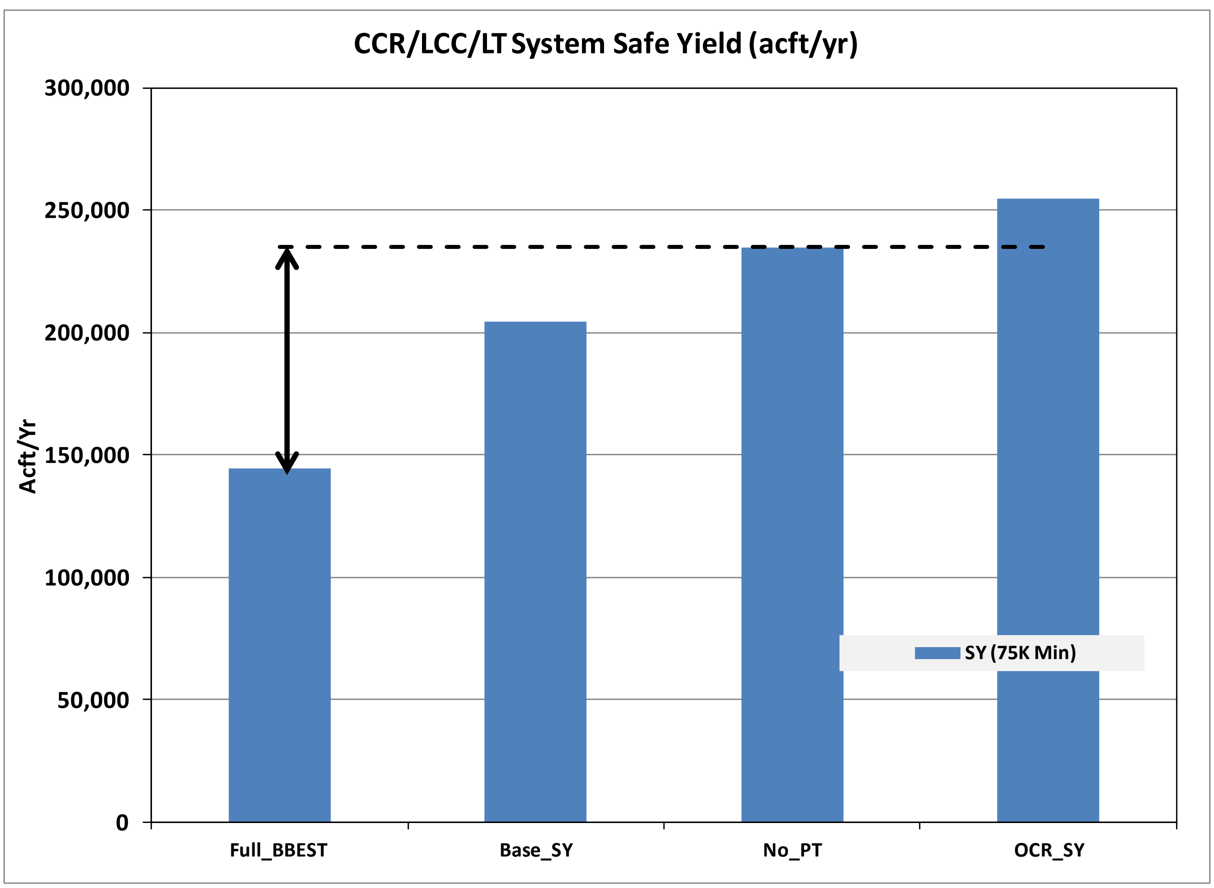

Figure 3-3.7. Comparing the Yield of the Four Scenarios

It should be noted that the understanding of the BBASC is that the environmental flow standards to be adopted by TCEQ would not replace the existing Order under which the City operates. In other words, the new standards cannot be applied retroactively. However, since the LCC-OCR would involve new appropriations and/or amendment of the City's existing rights, it could be subject to the new standards and operations of the LCC-OCR directly tied to the operations of the system. It is an assumption (for the purposes of BBASC evaluation only) that the entire system could become subject to the new Nueces B&E FWI standard.

3.3.4.2 Intermediate Simulations

Several intermediate simulations were performed looking at various impacts to yield and average bay inflow associated with modifications to the BBEST FWI recommendation. A summary of these scenarios and the associated results are included in presentation format in Appendix J. Generally, these scenarios include modifying the BBEST volume targets, seasonal requirements, system storage zone triggers, or specified attainment frequencies. Some of the intermediate simulations summarized in Appendix J are listed below.

- Seasonal Order – Uses the targets from the existing Order, but applies the targets seasonally like the BBEST FWI recommendation.
- Spring Only BBEST – Uses only the spring targets from the BEBST recommendation.
- Spring_88K_40_BBEST –Operations to meet the base spring target of 88,000 acft anytime the reservoir system storage is above 40 percent of capacity.
- Spring_88K_50_BBEST –Operations to meet the base spring target of 88,000 acft anytime the reservoir system storage is above 50 percent of capacity.
- NoPass_40_Order –Uses the existing order targets, but does not require a pass-through below 40 percent of system storage.
- 3K_All_Months –Simulates the pass-through of at least 3,000 acft/mo (limited by system inflow) in all months, regardless of system storage.

Nueces Bay and Delta salinities are understood to be key indicators for assessing the health of the ecosystem. The relationship between freshwater inflows and salinities was investigated to determine possible salinity-based targets that could be used to manage the system more effectively both for water supply and for environmental purposes. The TWDB supported this effort using the TxBLEND model, a salinity model of Nueces estuarine systems including Nueces Bay. Four scenarios were evaluated with this model and the results are summarized in a presentation and report in Appendix F. While the results of this analysis did not provide a clear salinity-focused approach to managing the freshwater inflows into the Nueces Bay and Delta, it did provide the impetus for Salinity Monitoring and Real-Time (SMART) Inflow Management which is discussed in Sections 5 and 6 of this report.

3.3.4.3 Final Recommendation

After much evaluation of various FWI regimes, the Nueces BBASC approved a modified BBEST FWI regime recommendation that includes the same targets and seasons as the Nueces BBEST FWI recommendation, but with modified attainment frequencies and no supplemental overbank recommendation. The Nueces BBASC FWI recommendation for Nueces Bay is shown in Table 3-3.6 and explained in greater detail in Section 4.2. This recommendation focuses on protecting the water supply of the basin while providing for the environmental flow needs of the Nueces Bay and Delta.

The FWI attainment frequencies in the Nueces BBASC recommendation correspond to the volumes of bay inflow associated with operating the existing Corpus Christi water supply system (including Choke Canyon Reservoir, Lake Corpus Christi, and firm and interruptible supplies from Lake Texana) under the safe yield demand of 205,000 acft/yr using the existing Order. Note that these FWI attainment frequencies are more than what can be obtained under firm yield or full utilization of the existing water rights (see Appendix G for more detail). The likelihood of a new appropriation not violating these attainment frequencies is small, leaving little, if any, water for new appropriations in the lower basin. This is the reason for the Nueces BBASC recommendation that NEAC review all applications for new appropriations seeking in excess of

500 acft/yr. This review allows for the possibility that NEAC could choose to recommend approval of an application violating specified attainment frequencies, but providing significant benefits to the bay and estuary through operations, permit conditions, or adaptive management.

Table 3-3.6. Modified BBEST Regime Recommended by the Nueces BBASC

Condition (Target Salinity)	**Nueces Bay Freshwater Inflow Regime (% Attainment)**			**Recommendations** Annual Total (acft)
High (10)	125,000 acft (11%)	250,000 acft (11%)	375,000 (12%)	750,000 (16%)
Base (18)	22,000 acft (23%)	88,000 acft (30%)	56,000 (40%)	166,000 (47%)
Sub. (34)	5,000 acft (69%)	10,000 acft (88%)	15,000 acft (74%)	30,000 (95%)
	Winter = Nov–Feb	Spring = Mar–Jun	Summer/Fall = Jul–Oct	

3.3.5 *Recharge Dams and Upper Nueces Basin Streamflow (Intermittent Streams)*

3.3.5.1 Sabinal Recharge Project

The Nueces BBASC selected the Sabinal Recharge Reservoir as an example project to consider the effects of various instream flow standards on recharge enhancement and streamflows. The Sabinal recharge project is part of a recommended water management strategy in the 2011 South Central Texas Regional Water Plan and is located on the Sabinal River over the Edwards Aquifer recharge zone directly downstream of USGS Gage 08198000. Figure 3-3.7 illustrates the location of the recharge reservoir and the recharge zone of the Edwards Aquifer. The Sabinal Recharge Reservoir was simulated at a conservation pool elevation of 1141.6 ft-msl. At this elevation, the reservoir has a capacity of 8,750 acft and a footprint of 449 acres. As this project is located on an intermittent stream atop the Edwards Aquifer recharge zone, the reservoir impounds water only for infrequent periods of short duration.

Due to the close proximity and minimal differences in contributing drainage area between the stream gage near Sabinal (USGS Gage 08198000) and the project site, instream flow recommendations made at the gage by the BBEST and BBASC were assumed to be directly applicable to the project.

For each of the various instream flow criteria selected for simulations, a long-term annual average (1934-1996) and drought annual average (1947-1956) of enhanced recharge were calculated. For the simulations, enhanced recharge was defined as the additional recharge that would occur across the entire Edwards Aquifer recharge zone as a result of project operations.

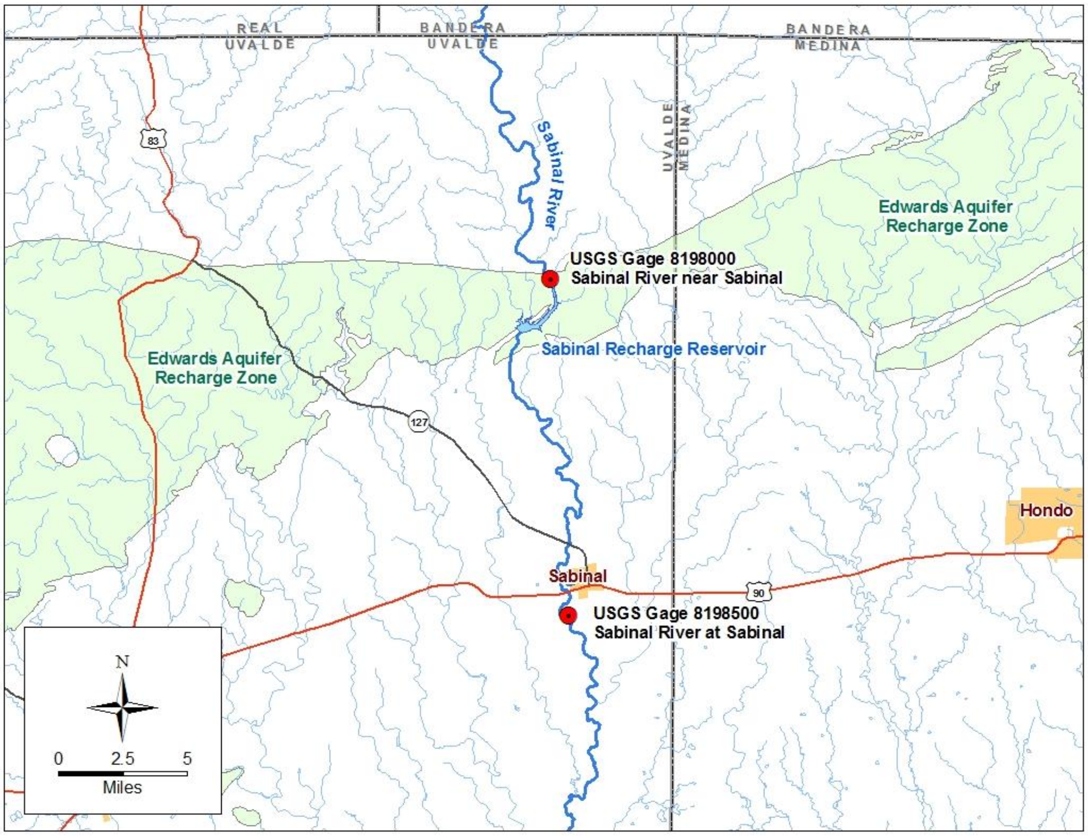

Figure 3-3.7. Location of Sabinal Reservoir Recharge Project

3.3.5.2 Initial Simulations for Sabinal Recharge Project

Tables 3-3.7 through 3-3.9 provide the instream flow regimes for the Lyons method, CCEFN, and BBEST recommendation for the initial simulations of the Sabinal Recharge Reservoir. The pulse exemption rule recommended by the Nueces BBASC is not applicable due to the storage capacity of the on-channel reservoir.

Table 3-3.7. Lyons Method Instream Flow Criteria for the Sabinal River near Sabinal (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
9.6	11.2	17.4	16.8	19.8	19.2	12.0	9.6	10.2	9.2	10.4	10.8

Table 3-3.8. Consensus Criteria for Environmental Flow Needs Instream Flow Criteria for the Sabinal River near Sabinal (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Medain	24.0	28.0	29.0	28.0	33.0	32.0	20.0	16.0	17.0	23.0	26.0	27.0
25th Percentile	12.0	12.0	12.0	12.0	11.0	7.5	3.3	0.8	0.8	4.4	9.7	9.2
7Q2	4.9	4.9	4.9	4.9	4.9	4.9	3.3	0.8	0.8	4.4	4.9	4.9

Table 3-3.9. BBEST Recommendations for the Sabinal River near Sabinal (cfs)

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 5,200 cfs with Average Frequency 1 per 5 years Regressed Volume is 46,200 Duration Bound is 75			
	Qp: 2,350 cfs with Average Frequency 1 per 2 years Regressed Volume is 20,000 Duration Bound is 54			
	Qp: 1,020 cfs with Average Frequency 1 per year Regressed Volume is 8,290 Duration Bound is 38			
	Qp: 330 cfs with Average Frequency 2 per year Volume Bound is 5,420 Duration Bound is 24			
	Qp: 62 cfs with Average Frequency 1 per season Volume Bound is 1,530 Duration Bound is 17	Qp: 180 cfs with Average Frequency 1 per season Volume Bound is 2,210 Duration Bound is 15	Qp: 100 cfs with Average Frequency 1 per season Volume Bound is 1,180 Duration Bound is 12	Qp: 53 cfs with Average Frequency 1 per season Volume Bound is 840 Duration Bound is 12
		Qp: 64 cfs with Average Frequency 2 per season Volume Bound is 750 Duration Bound is 10	Qp: 11 cfs with Average Frequency 2 per season Volume Bound is 130 Duration Bound is 5	
		Qp: 22 cfs with Average Frequency 3 per season Volume Bound is 240 Duration Bound is 6		
Base Flows (cfs)	35		29	35
	21		13	21
	11	8	3	10
Subsistence Flows (cfs)	1			

The long term averages and drought averages of simulated recharge enhancement for the Sabinal Recharge Project are presented in Figure 3-3.8 for the initial simulations. Percentages shown in Figure 3-3.8 reflect the reductions in enhanced recharge due to application of environmental flow standards. The initial results show that there are no changes in average annual enhanced recharge among the no environmental flow, Lyons, and CCEFN standards scenarios. This is a result of the absence of high flow pulse components in these standards. During low flow conditions, all streamflow infiltrates over the recharge zone whether or not the project is in place. Therefore, high flow pulses are the controlling factor in enhanced recharge from the project and base flow criteria have negligible affects. The BBEST recommendation includes seven levels of high flow pulse passage requirements which are reflected in the results by the 36 percent and 81 percent decreases in respective long-term and drought average enhanced recharge estimates.

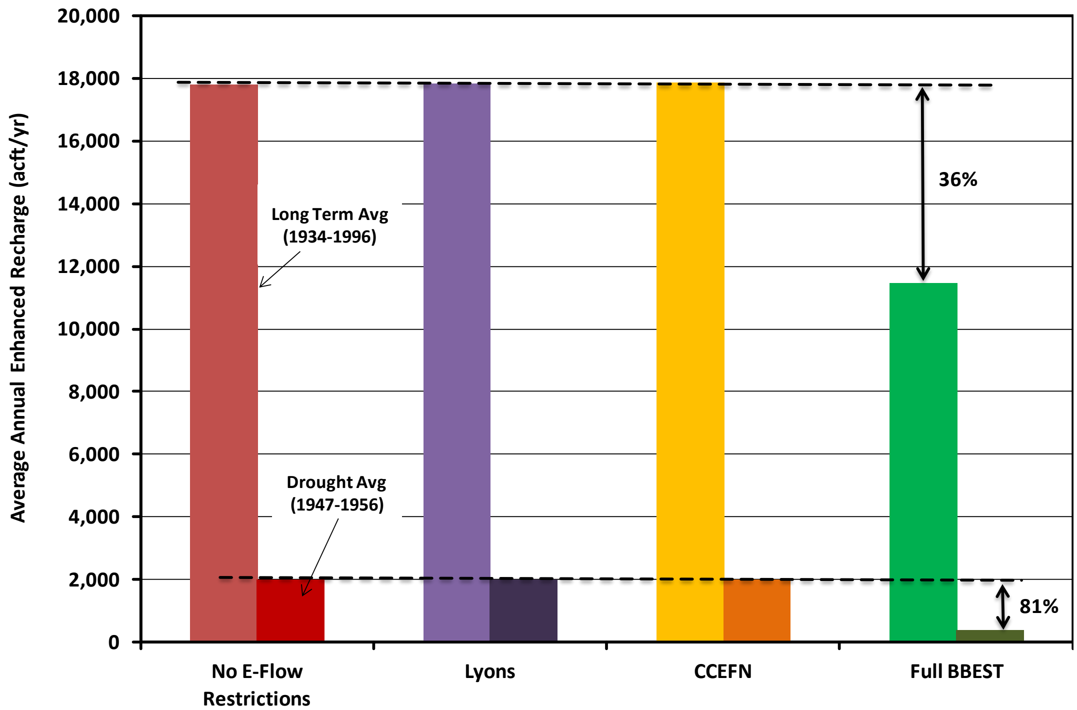

Figure 3-3.8. Initial Average Enhanced Recharge Results – Sabinal Recharge Reservoir

3.3.5.3 Intermediate Simulations

The BBEST recommendation for the Sabinal River near Sabinal does not include overbank events, therefore, the intermediate runs omit the annual pulses in an attempt to reveal any significant effects of the larger pulses on enhanced recharge.

A comparison of average enhanced recharge for the intermediate simulations and the no environmental flows and BBEST recommendation simulations is presented in Figure 3-3.9. The results show that by eliminating the large annual pulse requirements from the BBEST recommendation, the enhanced recharge reduction (or commitment to the environment) is reduced from 36 percent to 4 percent for the long term average and from 81 percent to 18 percent for the drought average. This confirms that the ability to impound large annual pulses is critical to enhanced recharge for this example project. This is expected since the fundamental purpose of the project is to impound high flow events for recharge. The results also show that variations in base flow criteria do not significantly affect enhanced recharge.

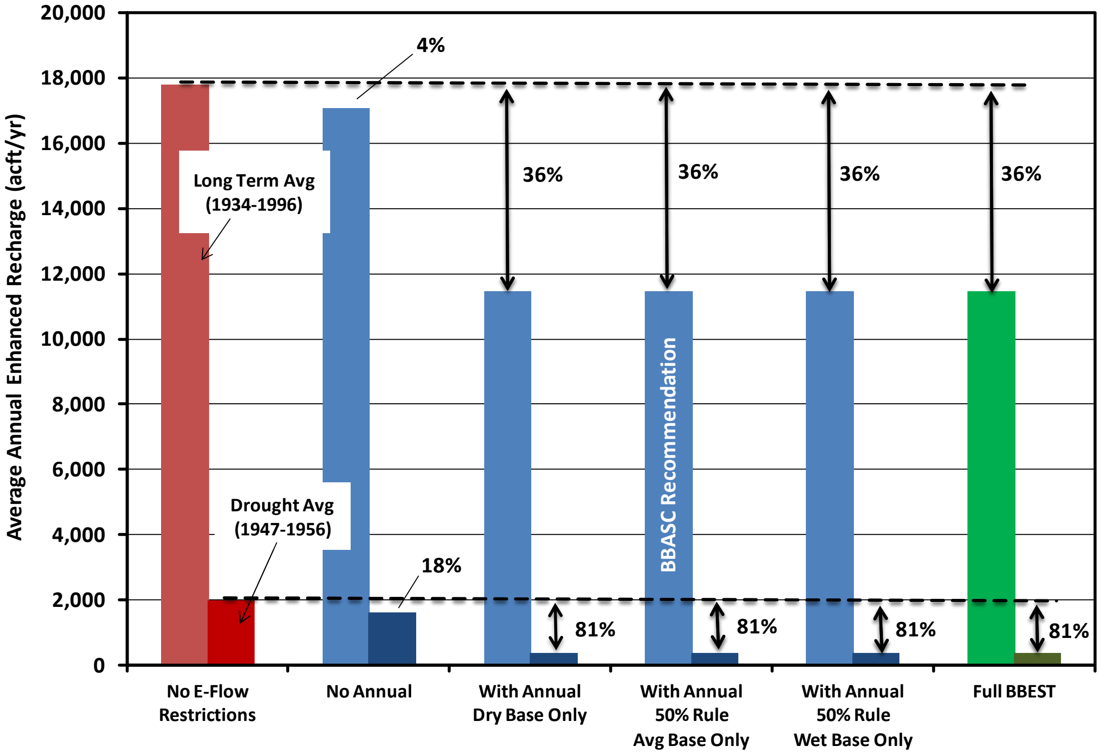

Figure 3-3.9. Intermediate Average Enhanced Recharge Results – Sabinal Recharge Reservoir

3.3.5.4 Final Nueces BBASC Recommendations

The Nueces BBASC selected the simulation including the annual pulses and the average hydrologic conditions tier of base flows with the 50% rule as the final BBASC recommendation. The final instream Nueces BBASC recommendation for the Sabinal River at Sabinal is presented in Table 4.1.8 in Section 4.1.9.

The Nueces BBASC recommendation does not increase the enhanced recharge over the BBEST recommendation. This is due to the only difference between the two scenarios being in the base flow criteria, which have no effect on enhanced recharge.

The frequency curves of resulting streamflow immediately downstream of the example project subject to various potential environmental flow standards are presented in Figure 3-3.11. The figure shows that there are some variations in the streamflows below 50 cfs (about 14 percent of the time) between the BBEST and BBASC recommendations. However, these flows would have infiltrated the streambed and contributed to aquifer recharge with or without the project in place and, therefore, contribute to neither enhanced recharge nor flows downstream of the Edwards Aquifer recharge zone. The streamflow frequency curves also show that high flows are impounded under the no environmental flow, Lyons, and CCEFN criteria, thereby significantly increasing enhanced recharge from the project.

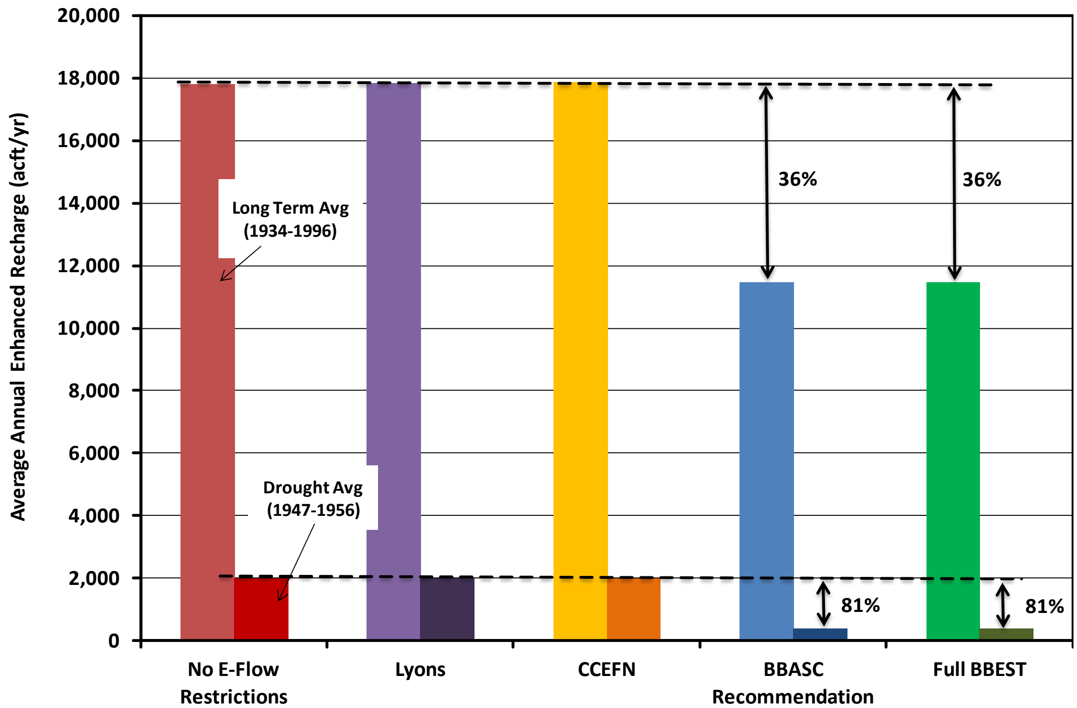

Figure 3-3.10. Final Average Enhanced Recharge Results – Sabinal Recharge Reservoir

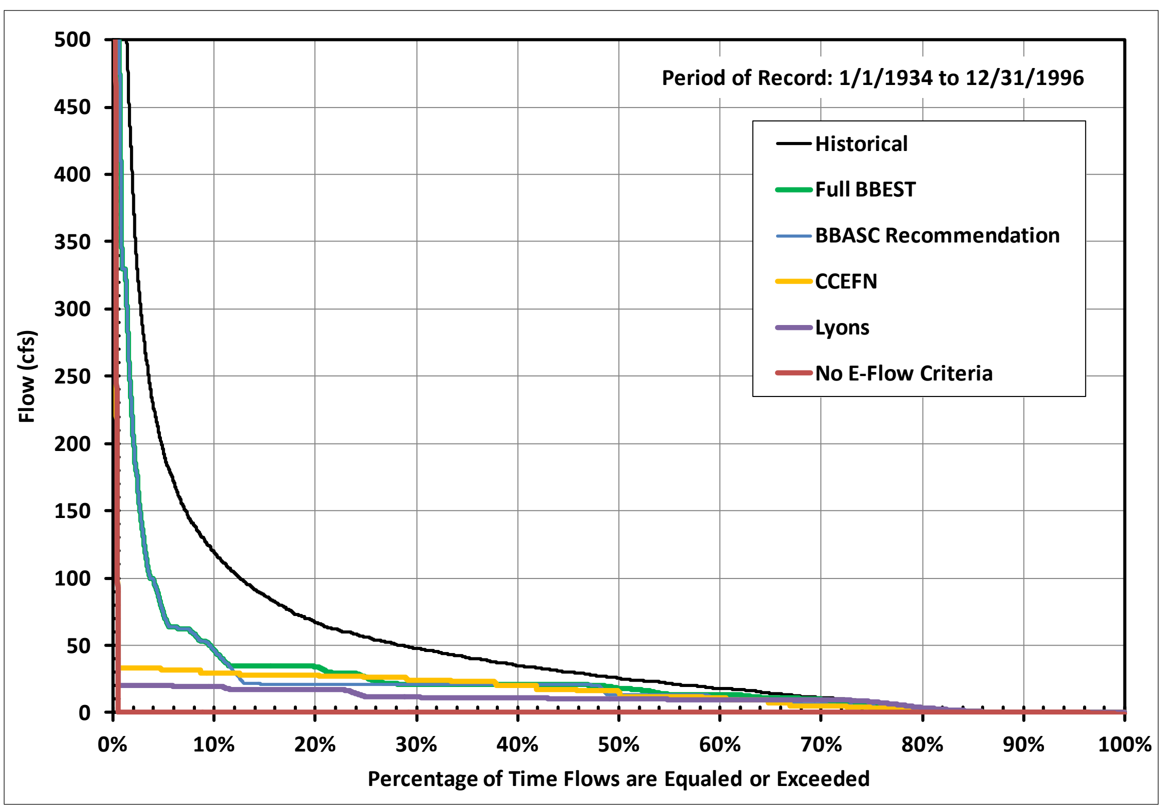

Figure 3-3.11. Downstream Flow Frequency – Sabinal Recharge Reservoir

3.3.6 *Run-of-River Projects*

3.3.6.1 Cotulla Run-of-River with Off-Channel Reservoir

The Cotulla Run-of-River Project includes a 44,000 acft off-channel reservoir (OCR) with an average depth of 25 ft. The reservoir would impound streamflows diverted from the Nueces River at the same location as the Cotulla on-channel reservoir example project. Figure 3-3.12 illustrates the approximate location of the run-of-river diversion site for the Cotulla OCR. The diversions were assumed to have a maximum rate of 400 cfs. To compare the different instream flow criteria scenarios, firm yields of the OCR under the various instream flow standards were calculated and the results are presented herein.

Due to the close proximity and minimal differences in contributing drainage area between the streamgage at Cotulla (USGS Gage 08194000) and the run-of-river diversion location, instream flow recommendations made for the Nueces River at Cotulla are assumed to be directly applicable to the project.

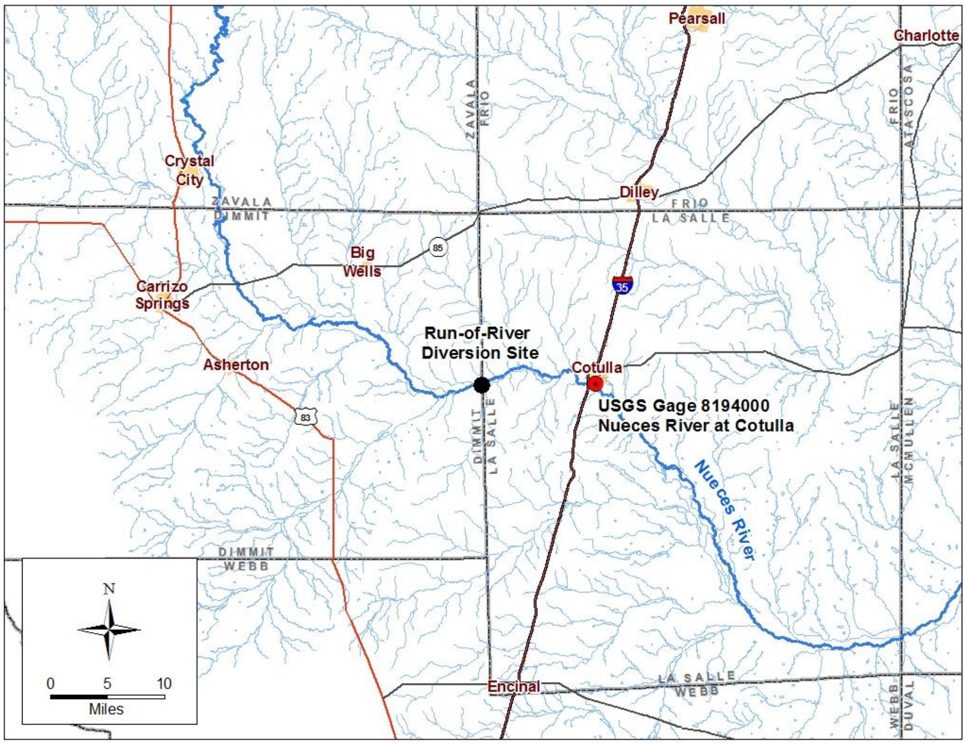

Figure 3-3.12. Location of Cotulla Run-of-River Project

3.3.6.2 Initial Simulations for Cotulla Run-of-River Project

Instream flow criteria for the Lyons method, CCEFN, and the BBEST recommendation for the initial simulations are identical to those for Cotulla Reservoir and are presented in Tables 3-3.3 through 3-3.5.

The firm yield results for the Cotulla Run-of-River Project are presented in Figure 3-3.13. The BBEST recommendation would dedicate approximately 25 percent of the potential yield of the project to meeting instream flow requirements. The yield reductions of 16 and 19 percent associated with the CCEFN and Lyons criteria, respectively, suggest that the yield of the project is driven by the base flow and high flow pulse criteria.

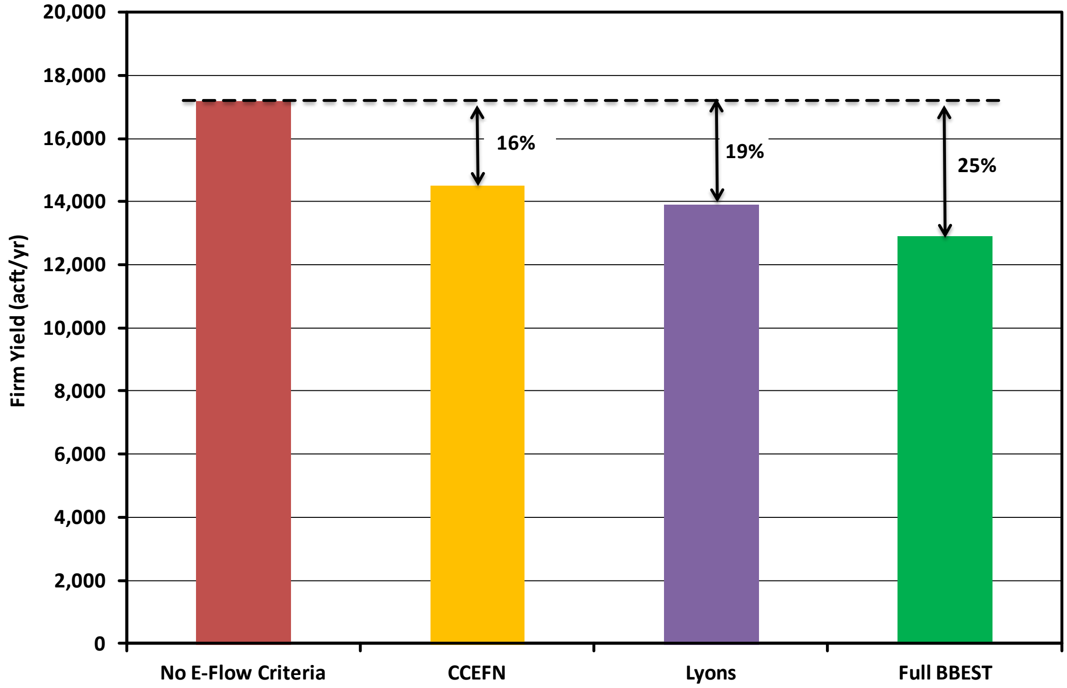

Figure 3-3.13. Initial Firm Yield Results – Cotulla Run-of-River Project

3.3.6.3 Intermediate Simulations for Cotulla Run-of-River Project

The pulse exemption applies only to the overbank pulses because the maximum diversion rate of 400 cfs triggers exemption of any high flow pulses greater than or equal to 2,000 cfs. All of the BBEST recommended seasonal high flow pulses below 2,000 cfs are not subject to the pulse exemption rule recommended by the Nueces BBASC.

A comparison of firm yields for the intermediate simulations and the no environmental flows and BBEST recommendations is presented in Figure 3-3.14. The results show that the scenario with the least stringent base flow criteria (No Overbank-Dry Base Only) has the least reduction in yield, whereas the scenario with the most stringent base flow criteria (No Overbank-50% Rule-Wet Base Only) has the largest reduction in yield. In addition, there is no difference in yield between the No Overbank and BBEST recommendation standards which suggests that the overbank pulses have no effect on the yield of the example project. This confirms the concept that the base flow and smaller high flow pulses are the critical components with respect to the firm yield of the run-of-river diversion project.

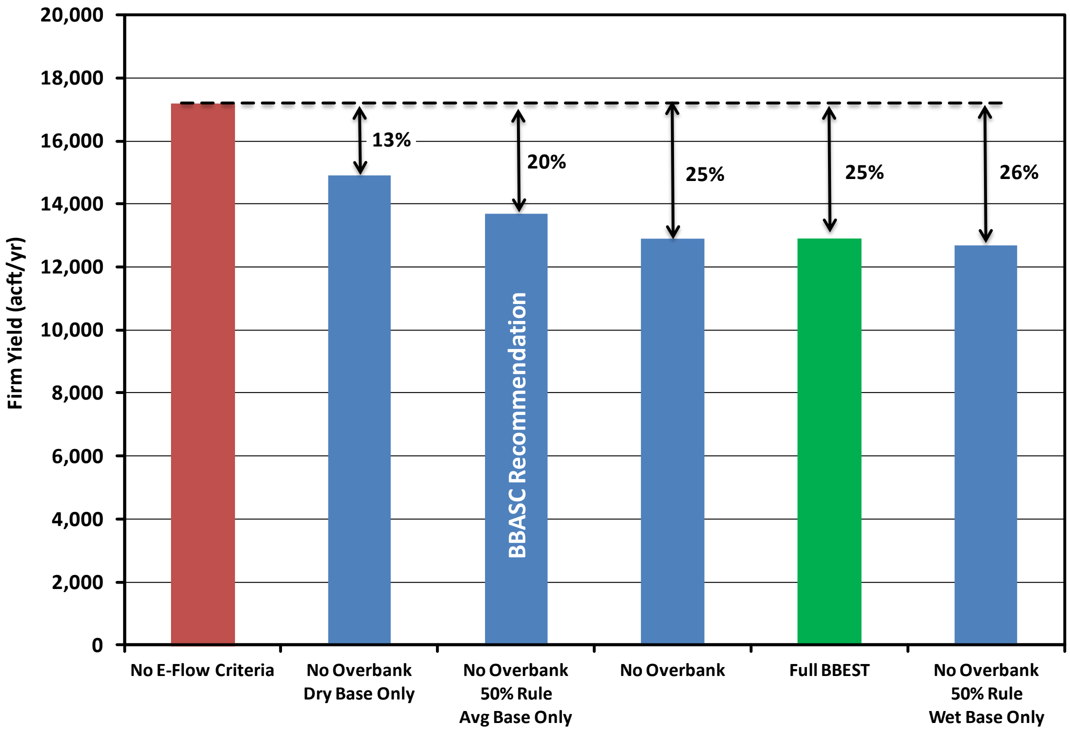

Figure 3-3.14. Intermediate Firm Yield Results – Cotulla Run-of-River Project

3.3.6.4 Final Nueces BBASC Recommendations

The Nueces BBASC selected the simulation excluding the overbank events and including the average hydrologic condition tier of base flows with the 50% rule and the pulse exemption rule as representative of the final BBASC environmental flow standard recommendation. The final instream Nueces BBASC recommendation for the Nueces River at Cotulla is presented in Table 4-1.4 in Section 4.1.5.

For the Nueces River at Cotulla, the Nueces BBASC recommendation increased the firm yield of the project to 13,700 acft/yr from the BBEST recommendation yield of 12,900 acft/yr. This is an increase of 800 acft/yr or 6.2 percent. Figure 3-3.15 compares the BBASC recommendation firm yield with the yields of the four initial simulations. Review of Figure 3-3.15 indicates that the BBASC recommendation is somewhat1-4% less protective of water supply than the current environmental flow criteria used in water rights permitting and regional water planning, but 6-9% more protective of water supply than the BBEST recommendation.

Frequency curves of the resulting streamflow immediately downstream of the example project are presented in Figure 3-3.16. Review of Figure 3-3.16 indicates that there is no significant difference in resulting streamflow between the BBEST and BBASC recommendations. This is apparent for both the high flow pulse range and base flow range of streamflows.

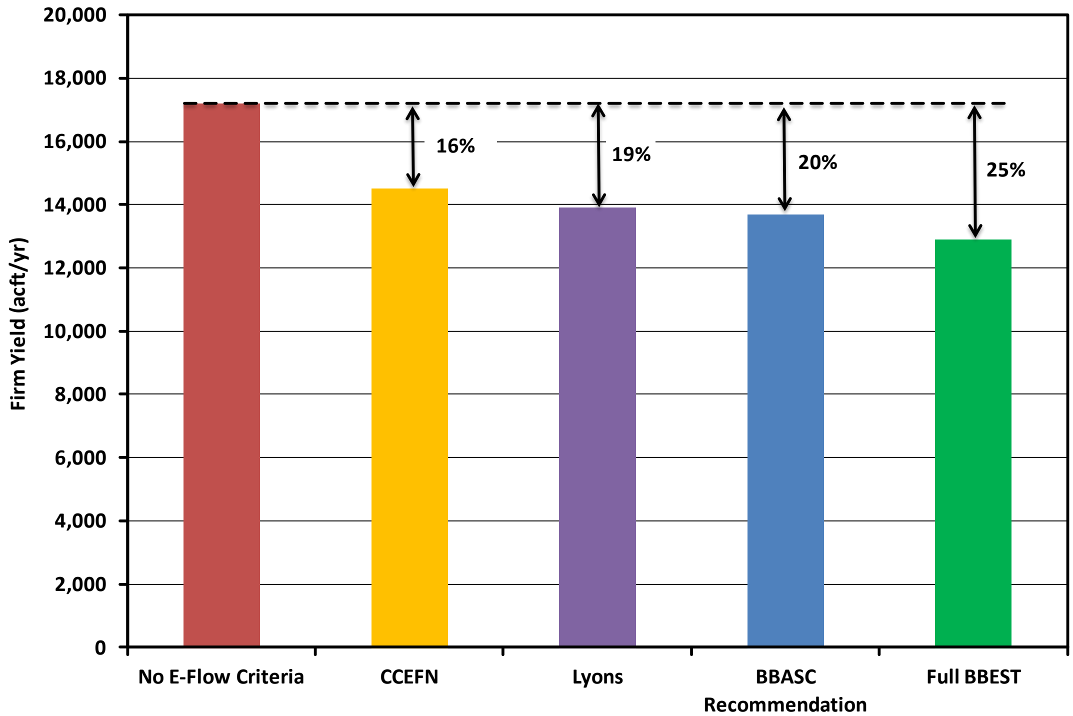

Figure 3-3.15. Final Firm Yield Results – Cotulla Run-of-River Project

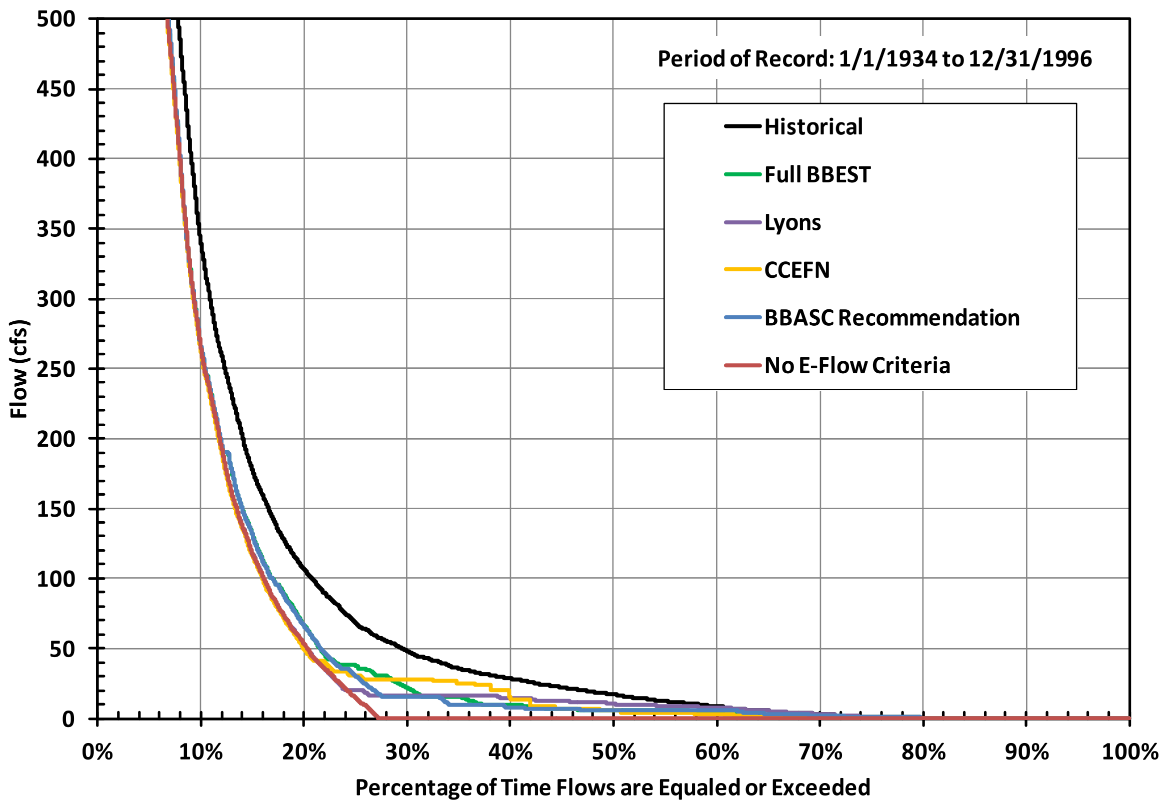

Figure 3-3.16. Downstream Flow Frequency – Cotulla Run-of-River Project

3.3.6.5 Laguna Run-of-River with Off-Channel Reservoir

The Laguna Run-of-River example project includes facilities for a maximum diversion of 400 cfs from the Nueces River to a 44,000 acft, 387 acre off-channel reservoir (OCR). The reservoir would impound streamflows diverted from the Nueces River at the USGS stream gage located at Laguna. Figure 3-3.17 illustrates the approximate location of the run-of-river diversion site for the Laguna OCR. To compare the different instream flow standards, firm yields of the off-channel reservoir under the various potential standards were calculated and the results are presented herein.

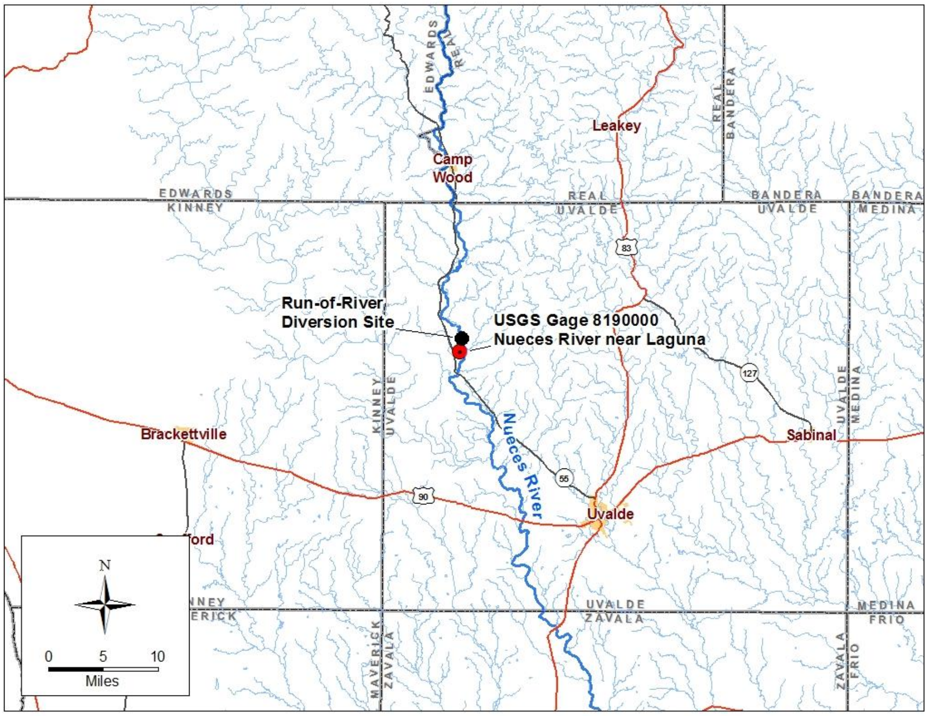

Figure 3-3.17. Location of Laguna Run-of-River Project

3.3.6.6 Initial Simulations

Tables 3-3.10 through 3-3.12 provide the instream flow regimes for the Lyons method, CCEFN, and BBEST recommendation for the initial simulations of the Laguna run-of-river diversions.

Table 3-3.10. Lyons Method Instream Flow Criteria for the Nueces River at Laguna (cfs)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
32.6	31.3	48.4	48.6	50.1	47.7	39.6	31.0	33.1	37.6	39.8	34.0

Table 3-3.11. Consensus Criteria for Environmental Flow Needs Instream Flow Criteria for the Nueces River at Laguna (cfs)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Medain	81.6	78.2	80.6	81.0	83.5	79.6	66.0	51.6	55.1	94.1	99.5	85.1
25th Percentile	55.0	55.3	56.1	53.0	54.9	46.8	34.8	25.7	27.8	39.8	45.6	54.2
7Q2	29.5	29.5	29.5	29.5	29.5	29.5	29.5	25.7	27.8	29.5	29.5	29.5

Table 3-3.12. BBEST Recommendations for the Nueces River at Laguna (cfs)

Overbank Events	Qp: 15,600 cfs with Average Frequency 1 per 5 years Regressed Volume is 124,000 Duration Bound is 107			
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600 Duration Bound is 64			
	Qp: 2,220 cfs with Average Frequency 1 per year Regressed Volume is 18,400 Duration Bound is 46			
	Qp: 590 cfs with Average Frequency 2 per year Volume Bound is 11,300 Duration Bound is 26			
	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
		Qp: 99 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 9		
Base Flows (cfs)	92		76	92
	65		48	65
	51	44	32	41
Subsistence Flows (cfs)	14	18	16	14
	Dec, Jan, Feb, Mar	Apr, May, Jun	Jul, Aug, Sep	Oct, Nov
	Winter	Spring	Summer	Fall

The firm yield results for the Laguna project are presented in Figure 3-3.18. Similar to the Cotulla run-of-river example project, the base flow criteria is the component that causes the greatest reduction in yield. This is reflected in the initial simulation results for all three standards having large yield reductions compared to the no environmental flow yield, even though the Lyons and CCEFN standards do not have overbank or high flow pulse components.

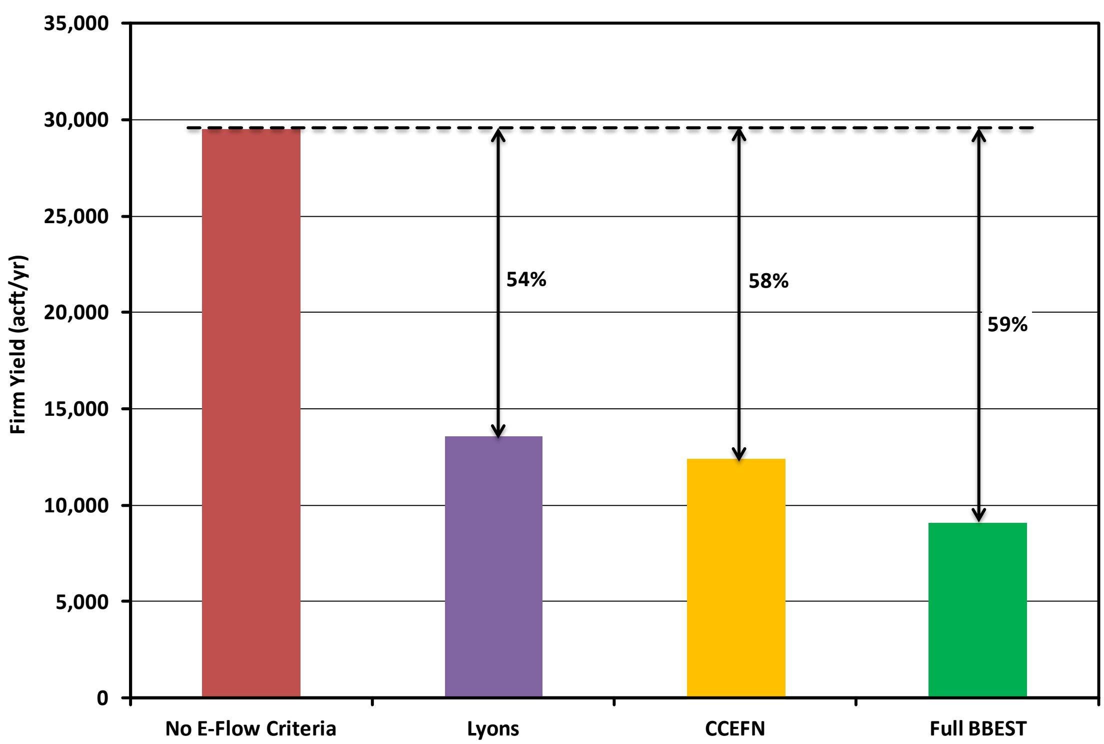

Figure 3-3.18. Initial Firm Yield Results – Laguna Run-of-River Project

3.3.6.7 Intermediate Simulations

Application of the pulse exemption rule recommended by the Nueces BBASC to the 400 cfs diversion rate allows for the exclusion of overbank or high flow pulses with a peak greater than or equal to 2,000 cfs. Therefore, the overbank and two largest annual pulses are omitted from the intermediate instream flow simulations.

The firm yield results of the intermediate simulations are presented in Figure 3-3.19. These results show that the pulse exemption rule applied to the BBEST recommendation does not have an effect on yield. Similar to the Cotulla Run-of-River example project, the intermediate scenarios with the less stringent base flows components provide for less reduction in yield.

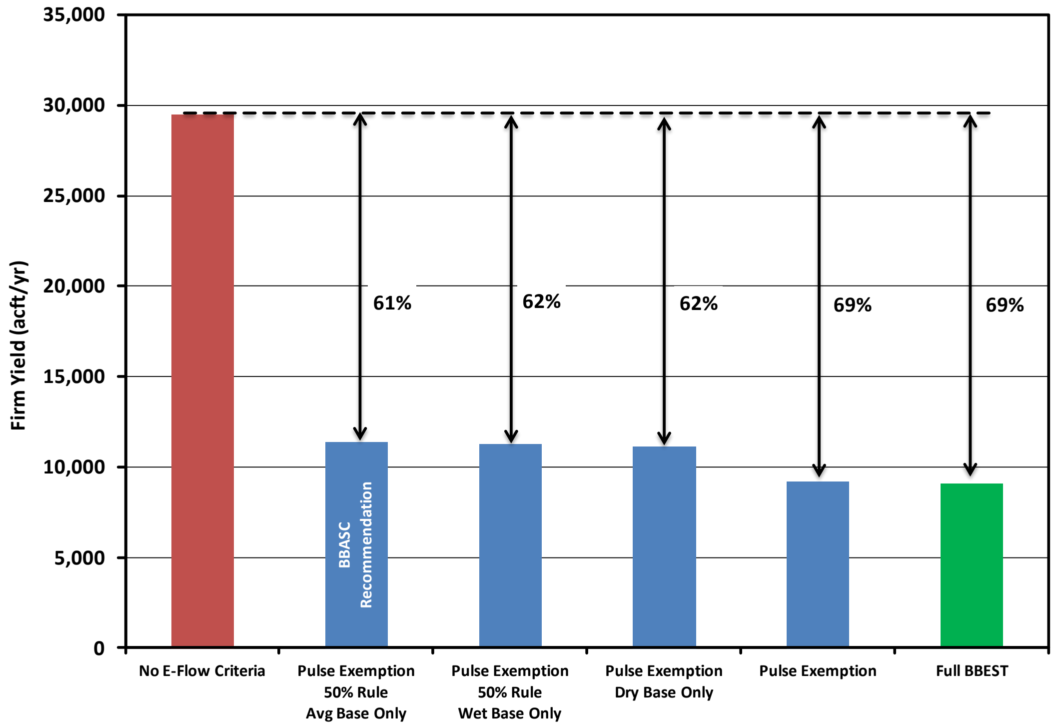

Figure 3-3.19. Intermediate Firm Yield Results – Laguna Run-of-River Project

3.3.6.8 Final Nueces BBASC Recommendations

The Nueces BBASC selected the simulation excluding the overbank events and the average hydrologic condition tier of base flows with the 50% rule and the pulse exemption rule as representative of the final BBASC recommendation. The final instream Nueces BBASC recommendation for the Nueces River at Laguna is presented in Table 4.1.1 in Section 4.1.2.

For the Nueces River Run-of-River example project at Laguna, the Nueces BBASC recommendation increased the firm yield of the project to 11,400 acft/yr from the BBEST recommendation of 9,100 acft/yr. This is an increase of 2,300 acft/yr or 25.3 percent. Figure 3-3.20 compares the BBASC recommendation firm yield with the yields of the four initial simulations. Review of Figure 3-3.20 indicates that the BBASC recommendation is somewhat less protective of water supply than the current environmental flow criteria used in water rights permitting and regional water planning, but more protective of water supply than the BBEST recommendation.

Frequency curves of the resulting streamflow immediately downstream of the example project are presented in Figure 3-3.21. The figure shows that there are minimal differences in flow frequency between the BBASC and BBEST recommendations.

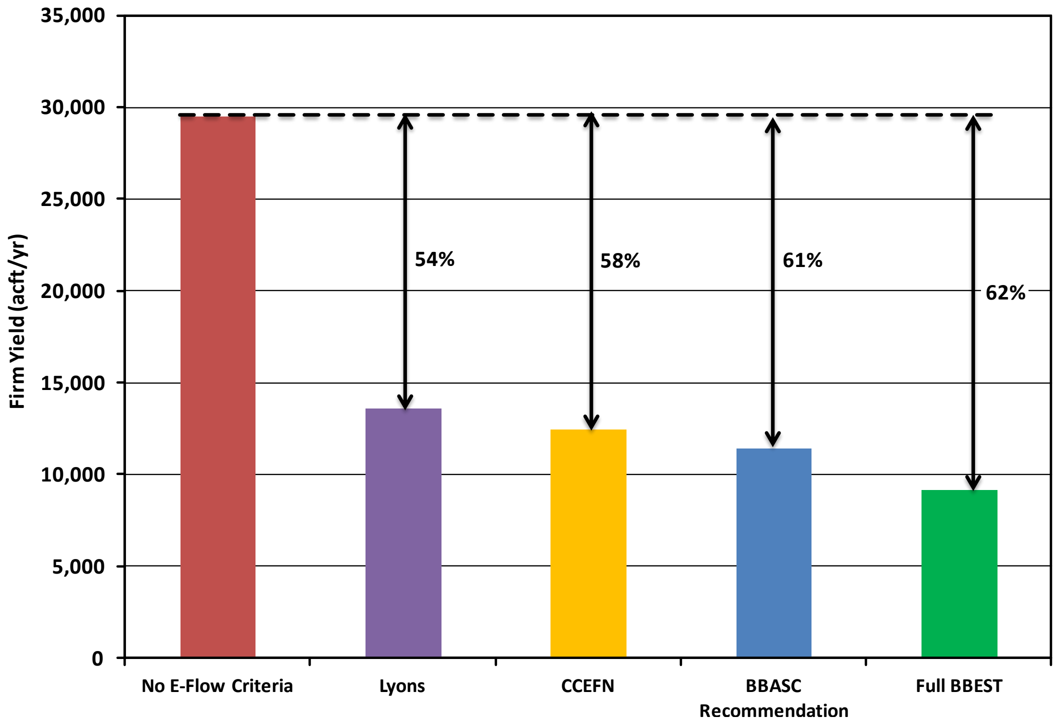

Figure 3-3.20. Final Firm Yield Results – Laguna Run-of-River Project

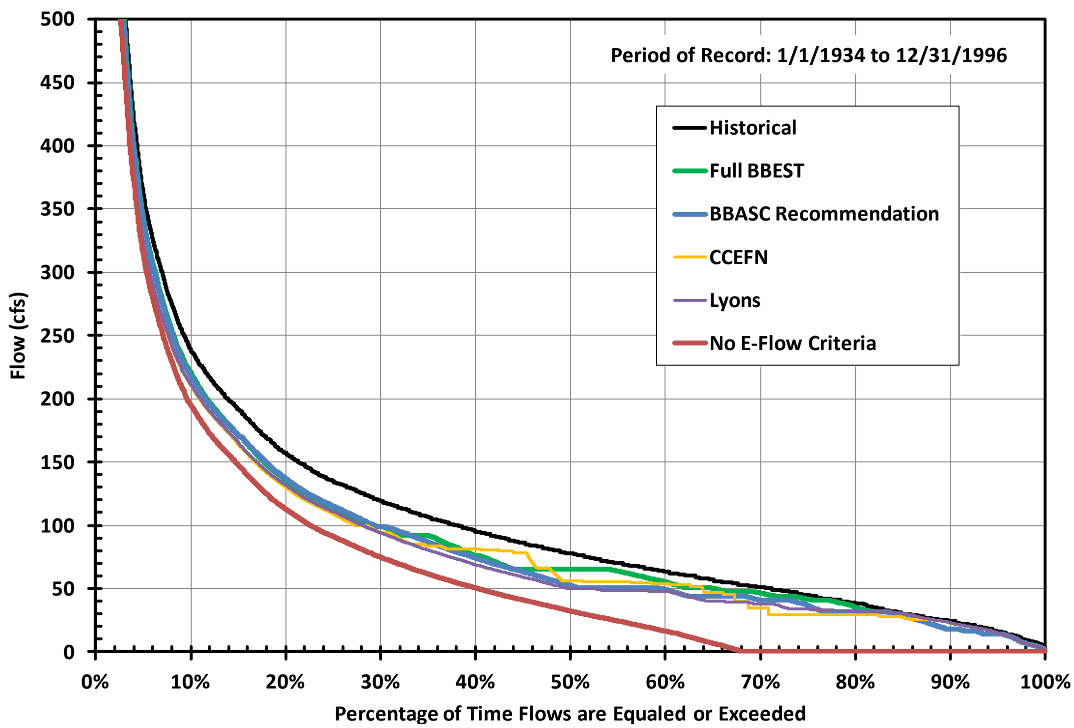

Figure 3-3.21. Downstream Flow Frequency – Laguna Run-of-River Project

3.3.7 *Effects of Climate Change on Streamflow and Freshwater Inflow*

This section briefly highlights some issues associated with global warming and associated climatological changes and sea level rise that could potentially impact the availability of water in the Nueces River Basin.

3.3.7.1 Temperature

Local temperature changes due to global warming are likely to soon become strong enough to overwhelm natural variability, leading to temperatures in the neighborhood of 4°F warmer than recent decades by the middle of this century (Nielsen-Gammon, 2011). Generally, an increase in temperature is indicated for the entire south-central U.S. The estimated 2050 climate for the Texas area model-averaged predicted results for air temperature for scenarios A2 and A1B at the 2050 time point were obtained from IPCC 2007. These prove to be about a +2°C (+3.6°F) increment in temperature (Nielsen-Gammon, 2011). Note: For more information on the A2 and A1B scenarios go to http://www.ipcc.ch/publications_and_data/ar4/wg1/en/spmsspm-projections-of.html.

Temperature has a significant effect on evapotranspiration, i.e. direct evaporation back into the atmosphere from the land, from water in reservoir storage, or uptake by plants and subsequent transpiration. Increase in the rate of evapotranspiration is just one significant consequence of the increase in temperature. Other examples include, but are not limited to, increased forced evaporation (power generation), and increased municipal and industrial water demands, and increased agricultural water demand (Ward, 2011).

3.3.7.2 Precipitation

In the case of precipitation, observed variations in Texas over the past century are larger than most future climate projections of precipitation change by mid-century, and are unexplained. Thus, it cannot be said whether future precipitation will be more or less than present-day precipitation in Texas (Nielsen-Gammon, 2011). Others, however, suggest a reduction in precipitation and drier soils are indicated for the Texas region, but the range about this prediction for precipitation is considerable (Ward, 2011).

The estimated 2050 climate for the Texas area model-averaged predicted results for precipitation for scenarios A2 and A1B at the 2050 time point were obtained from IPCC 2007. These prove to be about a 5 percent decrease in precipitation (Ward, 2011).

3.3.7.3 Potential Resultant Change to Stream Characteristics and Flow due to Climate Change of Temperature and Precipitation

It is well understood that stream and river channels in the Nueces basin exhibit “flashy” flows with pronounced peaks in flow and rapid rise and recession. It is also well understood that a Nueces basin stream may be characterized as being dry, or when water is present exhibiting no flow or a low base flow upon which are superposed occasional storm hydrographs whose frequency and intensity vary seasonally if not inter-annually and which, are often separated by long periods of dry conditions. This variability means river flows are not dependable as a source and most of the time in most of the state there will be too little river flow to meet the water supply needs (Ward, 2011); thus reservoirs and inter basin transfers have been necessary.

Although the postulated alterations in temperature and precipitation for the climate change scenarios are modest, their effect on the water resources is dramatic: a reduction of 17 percent in runoff and 26 percent in flows to the coast under normal conditions at year 2050 demands. Under drought conditions, the year 2000 runoff and flows to the coast are reduced to 41% and 32% of normal, respectively, i.e. reductions of 59% and 68% from normal. Under greenhouse-warmed 2050 conditions the 2000 runoff and flows to the coast are reduced further to 35% and 27%, respectively, i.e. additional reductions of 15% and 10% (Ward, 2011).

At 2050 projected water uses under drought conditions, the effect of greenhouse climate change is to reduce flows to the coast by an additional 42% statewide, to a level 15% of the 2000 normal (Ward, 2011). Moreover, climate change may well increase the severity of extreme drought (Ward, 2011). Unless by a fluke of Texas climate there is an increase in precipitation sufficient to offset the increase in evaporation from Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System and plant transpiration and decreased soil moisture and runoff due to increase in temperatures, the expected overall effect should be for increased frequency of less runoff, lower river and stream flows and lower combined reservoir levels. Thus, the projection for the Nueces basin is for an increase in the frequency of the reservoir system to approach the safe yield operating threshold. Concomitantly, relative to known safe yield for the CCR/LCC System, it should be anticipated that there will be less water available for environmental flows to Nueces Bay. Reduced inflows would exacerbate existing sediment deficits in the Nueces Delta.

3.3.7.4 Sea Level Rise (SLR)

Understanding the effects of sea-level rise is critical to determining the efficacy of fresh water inflow management hypothesized prior to the onset of significant consequences of SLR. Estuarine salinity is an indicator of changes in the fresh water input to an estuary because fresh water dilutes sea water when fresh water flows to the coast (Montagna et al., 2011). Sea level rise in Nueces Bay due to climate change will increase the volume of water of marine salinity to be diluted by fresh water inflow. One probable consequence of SLR would be that more fresh water inflow would be necessary to offset the commensurate increase in volume of marine salinity water in order to maintain ecologically correct target salinities in Nueces Bay and/or Delta.

It is assumed the ecological condition of the Nueces Bay also benefits from the existence of suitable habitat for marine organisms (e.g., reef structure, seagrass, wetland) at a time appropriate in their life history. SLR will result in inundation of these coastal habitats. While an earlier habitat change analysis conducted by Longley in 1995 assumed only inflow rates will change, rising sea levels may obliterate habitat (Montagna et al., 2011) in addition to the increased salinity.

Using equations utilized by the US Army Corps of Engineers to evaluate the effects of relative sea level rise on civil works project design (Engineering Circular 1165-2-212 dated 1 October 2011) preliminary estimates for future location-specific change can be developed. EC 1165-2-212 uses "low", "intermediate" and "high" rates of SLR where low is the historic trend, intermediate is the local adaptation of the National Research Council 1987 curves and equations, and high also adopted from NRC 1987 use curves that exceed the upper bounds of the IPCC 2001 and 2007 estimates, but are within the range of peer-reviewed outcomes (CCSP, 2009).

Based on Table 3-3.13, SLR for the YR 25 would be 129 mm (0.425 foot) to 302.5 mm (0.99 foot) above 2012 water levels for the low and high estimates, respectively, and for the YR 50 SLR would be 258 mm (0.846 foot) to 605 mm (1.98 foot) above today’s water levels for the low and high estimates, respectively.

Table 3-3.13. Estimates for local sea level change for Corpus Christi Bay in millimeters (sum of eustatic and relative). Modified/adapted from USACE 2012.

	LOW	INTERMEDIATE	HIGH
YR 1	5.16	7.65	12.1
YR 5	28.8	38.25	60.5
YR 10	57.6	76.5	121
YR 15	77.4	114.75	181.5
YR 20	103.2	153	242
YR 25	129	191.25	302.5
YR 35	108.6	267.75	423.5
YR 45	232.2	344.25	544.5
YR 50	258	382.5	605.5

Note: These estimates are for a location on the north shore of Corpus Christi Bay and change rates low = 5.16 mm/year, intermediate 7.65 mm/yr, and high 12.096 mm/yr, extrapolating linearly in 5 year time steps.

While localized relative SLR estimates would be needed for Nueces Bay/Delta, the implications of SLR on the Nueces Bay are primarily an increase in the volume of marine/high salinity waters that will contravene the hypothetical effectiveness of freshwater inflows (measured at Salt 3) released from storage to the Bay via the Nueces River. The timing and the scope of diminishment of inflow effectiveness is dependent upon the actual rate of SLR; however, the faster the onset and the higher the level of SLR the sooner and more unlikely target salinities will be able to be maintained.

The implications of SLR on the Nueces Delta are more complex. Conceptually, rising water levels that will eventually inundate the Delta completely may initially have potential short term benefits. For example, providing lower salinity water e.g., 28–35 ppt (lower relative to typical hypersalinity in the Delta) sufficient to promote survival and growth of intertidal marsh vegetation such as *Spartina alterniflora* and provide better access for motile estuarine marsh dependant species. Similarly, higher (bay) water levels may cause any freshwater inflows via pumping or other delivery to the Delta to reside longer in the upper reaches thus prolonging effectiveness for salinity reduction. However, the rising water level will also initially enhance erosion of the frontal portion of the Delta causing short term recession (loss of land). In the short term, there could be loss of Delta acreage but an increase in Delta vegetative cover. Mid to long term higher range SLR estimates would eventually inundate many portions of the Delta causing the Delta to become an open water habitat and the resultant probable outcome is an extensive loss of emergent vegetative cover. However, under higher SLR estimates, the land north of the IH-37 bridge could become the area where the Delta ecosystem services retreat. The higher SLR scenario suggests that short to long term land acquisition, habitat preservation and freshwater inflow management efforts would be applicable to the lands above the IH-37 bridge. However, as discussed in Section 6, the call to refine the SLR estimates and effects of management are a key consideration and should not preclude current management activities below IH-37 in the Nueces Delta.

3.3.7.5 Discussion and Conclusions

The description of some of the potential consequences of climatological change are presented as a means of addressing the question of whether Nueces basin water supply is potentially vulnerable to climate change projected for a global warmed scenario. If the changes manifest as projected, the answer is clearly affirmative (Ward, 2011).

Taking flows to the coast as a measure of river-basin impact, the net effect statewide under the assumed greenhouse climate change, i.e. a 3.6°F increase in air temperature and a 5% decrease in precipitation, is to reduce these flows by about 25% under normal conditions and by 42% under drought conditions. And, relative to the already reduced flows under 2050 projected water-use demands with the effect of a greenhouse climate imposed change, the 2050 projected flows to the coast would be 70% of the 2000 normal values under normal conditions, and 15% of 2000 normal under drought conditions (Ward, 2011).

The preceding flow-to-coast estimates are for the entire Texas region (Ward, 2011); a Nueces basin specific description of the effects of climate change would be useful to regional water supply planners and managers. In general however, the effect of climate on water demands and watershed processing of rainfall is to amplify the changed-climate signal, because the causal connections are nonlinear and reinforcing (Ward, 2011). Most of the IPCC 2007 model simulations indicate greater temperature rises and less rainfall in the interior and western areas of the south central U.S, which becomes more exaggerated with distance south into Mexico (Ward, 2011). Much more runoff (per unit rainfall) occurs when the watershed is saturated during the wet season, and much less runoff (per unit rainfall) occurs when the watershed is desiccated during the dry season than reflected in the equations. The historic intra-annual variation of precipitation in the region is expected to be particularly exacerbated by climate change; the extremes of runoff as a function of rainfall are diminished and the climate-change response muted (Ward, 2011). This would imply less runoff into streams and rivers in the upland reaches of Texas basins (Ward, 2011) (potentially including the Nueces), and a reduced capture efficiency of reservoirs (Ward, 2011) (such as Choke Canyon Reservoir/Lake Corpus Christi System). Additionally, the intra-annual variation in temperature would have a nonlinear effect on evaporative losses, hence reduced reservoir storage, increase in drawdown, and reduction of spills. Thus the ability of the reservoirs to meet the present demands in a climate-change future is optimistic and yet it is evident that population/demand growth alone would make it extremely difficult to cope with a drought similar to the 1950's under the 2050 demand scenario, during which many water uses would have to be curtailed. When the consequences of global warming for Texas climate and SLR effects are included in the analysis, the situation is even more serious (Ward, 2011).

3.3.8 *Effects of Invasive Plant Species on Streamflow*

Section 3.6 of the Nueces BBEST report provides an overview of the riparian communities, processes, and interactions in the Nueces Basin. As described in the Nueces BBEST report, riparian communities of the Nueces Basin provide many ecosystem functions including quality habitat for native fish, wildlife, and bird species, while, also, being integral to bank and floodplain stability. The Nueces BBEST report discusses the importance of timing, magnitude and frequency of flood disturbance events on determining community structure within riparian corridors, including invasive non-native species. The report discusses water needs for the riparian community, but only contains minimal discussion on water use of the riparian community. Invasive non-native species are a serious threat to riparian plant communities in that they often invade streamside areas and out-compete native plants. Not only do they tend to provide less quality habitat for wildlife, species such as tamarisk and giant reed use large amounts of water.

There is limited information on the annual rates of evapotranspiration (ET) in native and non-native communities in the Nueces Basin. As such, it is difficult to fully assess the effect that non-native plants are having on the regional water budget. The Nueces BBASC recognizes this as a key component to be further explored in the Work Plan as a better understanding of this topic may assist in improving water management options and/or restoration efforts.

Section 4. Nueces BBASC Recommendations for Environmental Flow Standards

The recommendations of the Nueces BBASC regarding environmental flow standards for the Nueces River Basin, the Nueces – Rio Grande Coastal Basin, and Nueces Bay are summarized in the following pages. Although Corpus Christi, Oso, and Baffin Bays and the upper Laguna Madre are included in the designated basin and bay area, no quantitative recommendations regarding environmental flow standards are made for these bay and estuarine systems. The environmental flow standard recommendations of the Nueces BBASC include not only schedules of flow quantities, but also descriptions of how these flow quantities are to be applied in the context of environmental flow standards. It is the general expectation of the Nueces BBASC that the TCEQ will consider direct translation of recommended instream environmental flow standards into rules and, ultimately, consider seasonal subsistence, base, and pulse flow values within such recommended standards as potential permit conditions applicable to new surface water appropriations. Such permit conditions may specify when impoundment or diversion of streamflow is authorized under a new water rights permit. Similarly, it is the expectation of the Nueces BBASC that the TCEQ will consider direct translation recommended environmental flow standards for Nueces Bay, expressed in terms of seasonal subsistence, base, and high freshwater inflow volumes and associated attainment goals, into rules and, ultimately, apply such rules in the evaluation of applications for new surface water appropriations. The Nueces BBASC believes that it is important to explicitly address application or implementation of the recommended environmental flow standards.

The following subsections of this report focus on presentation and brief discussion of the recommended environmental flow standards for instream locations (Section 4.1) and for bays and estuaries (Section 4.2). Additional recommendations regarding environmental flow standards ultimately becoming water right permit conditions are presented and briefly discussed in Section 4.3.

The Nueces BBASC recommendations regarding environmental flow standards included in this section were adopted by consensus.

4.1 Nueces BBASC Recommendations for Instream Flow Standards

Recommendations regarding instream environmental flow standard components are included in Section 4.1.1. The recommended environmental flow standards for 18 stream locations throughout the Nueces River Basin are summarized in Sections 4.1.2 through 4.1.19 in upstream to downstream order. The recommended environmental flow standards for two instream location in the Nueces – Rio Grande Coastal Basin are summarized in Sections 4.1.20 and 4.1.21. All locations for Nueces BBASC instream environmental flow standard recommendations are shown in Figure 4-1.1.

4.1.1 *Schedule of Flow Quantities*

The tables in the following sub-sections provide the numerical elements of the Nueces BBASC instream environmental flow standard recommendations. Another essential component of the Nueces BBASC environmental flow standard recommendations is specification of how such numerical elements might be applied to new surface water appropriations. Hence, our recommendations regarding application or implementation of environmental flow standards are summarized in the following paragraphs, progressing from low- to high-flow situations. It is noted that the Nueces BBASC recommendations regarding application of environmental flow standards are generally consistent with, though somewhat less complicated than, the Nueces BBEST recommendations as summarized in Section 6.3 of the Nueces BBEST Environmental Flows Recommendations Report. The tables for each of the recommended sites are also presented in Appendix A.

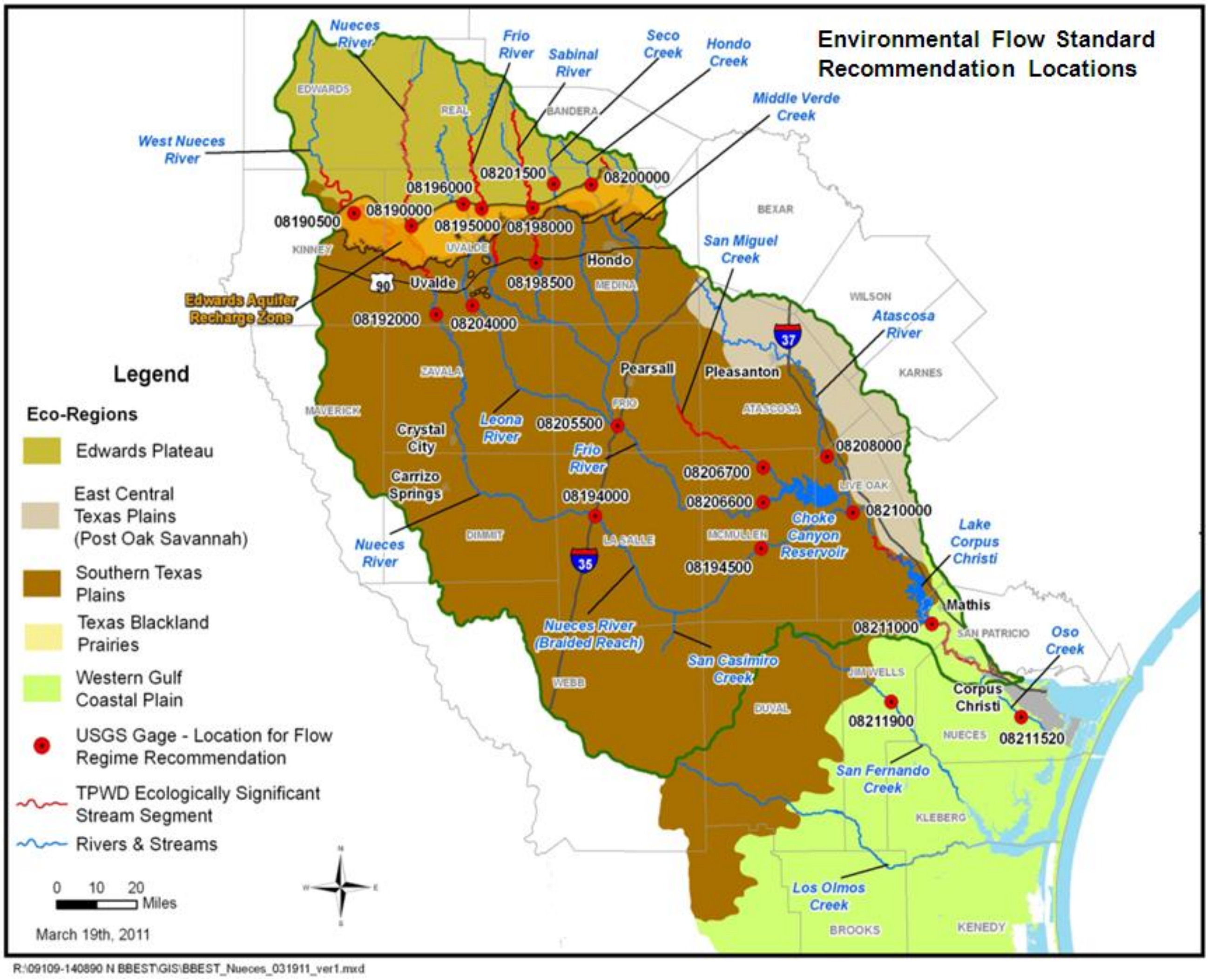

Figure 4-1.1. Nueces BBASC Instream Environmental Flow Standard Recommendation Locations

4.1.1.1 Subsistence Flows

Ecological functions of subsistence flows include provision for aquatic habitat, longitudinal connectivity, dissolved oxygen, and temperature sufficient to ensure survival of aquatic species through low flow periods to the extent possible recognizing that many stream segments in the Nueces River Basin and Nueces – Rio Grande Coastal Basin are naturally intermittent. Recommendations of the Nueces BBASC indicate that translation of seasonal subsistence flows into environmental flow standards and permit conditions should not result in more frequent occurrence of flows less than the recommended seasonal subsistence values as a result of the issuance of new surface water appropriations or amendments. Specific recommendations of the Nueces BBASC regarding application of the subsistence flow component of its recommended environmental flow standards are summarized as follows:

a. If inflow is less than the seasonal subsistence value, then all inflow must be passed and none impounded or diverted. Hydrologic conditions are not a factor.

4.1.1.2 Base Flow and 50% Rule

Base flows provide variable flow conditions, suitable and diverse aquatic habitat, longitudinal connectivity, soil moisture, and water quality sufficient to sustain aquatic species and proximate riparian vegetation for extended periods. As simply stated in SAC guidance, "base flows provide instream habitat conditions needed to maintain the diversity of biological communities in streams and rivers (SAC, August 31, 2009)." Specific recommendations of the Nueces BBASC regarding application of the base flow component of its recommended environmental flow standards are summarized as follows:

a. Seasonal base flow values are those associated with average hydrologic conditions in the environmental flow regime recommendations of the Nueces BBEST. With only one base flow recommendation for each season at each location, consideration of hydrologic conditions in not necessary.
b. If inflow is less than the seasonal base value and greater than the seasonal subsistence value, then the seasonal subsistence flow plus 50 percent of the difference between inflow and the seasonal subsistence value must be passed, and the balance may be impounded or diverted to the extent available, subject to senior water rights. This "50% Rule" is recommended by the Nueces BBASC for all instream measurement sites.
c. If inflow is less than the lowest applicable pulse peak value and greater than the seasonal base value, then that seasonal base value must be passed, and the balance may be impounded or diverted to the extent available, subject to senior water rights.

4.1.1.3 High Flow Pulses

High flow pulses provide elevated in-channel flows of short duration, recruitment events for organisms, lateral connectivity, channel and substrate maintenance, limitation of riparian vegetation encroachment, and in-channel water quality restoration after prolonged low flow periods as necessary for long-term support of a sound ecological environment. Overbank flows, a sub-set of high flow pulses, provide significantly elevated flows exceeding channel capacity, life phase cues for organisms, riparian vegetation diversity maintenance, conditions conducive to seedling development, floodplain connectivity, lateral channel movement, floodplain maintenance, recharge of floodplain water table, flushing of organic material into the channel, nutrient deposition in the floodplain, and restoration of water quality in isolated floodplain water bodies as necessary for long-term support of sound ecological environments. Specific recommendations of the Nueces BBASC regarding application of the high flow pulse components of its recommended environmental flow standards are summarized as follows:

a. The Nueces BBASC recommends that applicable high flow pulses for a new surface water appropriation be determined in accordance with the Pulse Exemption Rule as described in Section 4.3.1.
b. If inflow is greater than a specified peak trigger (Q_p) and less than the next greatest specified peak trigger, and all applicable pulse recommendations have not been satisfied, then all inflow up to the lower of the two peak triggers must be passed until either the recommended volume or duration has passed, and the balance of inflow may be impounded or diverted to the extent available, subject to senior water rights.
c. If all applicable pulse recommendations have been satisfied and inflow is greater than the seasonal base value, then that seasonal base value must be passed, and the balance may be impounded or diverted to the extent available, subject to senior water rights.
d. Pulse events are identified upon occurrence of specified trigger flow, counted in the season or year in which they begin, and assumed to continue into the following season or year as necessary to meet specified volumes or durations. Once a pulse event has been identified, volumes passed during the event, but prior to exceeding the specified trigger flow (equivalent to Q_p in the environmental flow recommendations), may be credited towards the specified volume requirement.
e. One large pulse counts as one pulse in each of the smaller categories subject to reset at season or return period end.

f. Each return period (i.e., season, series of months, one-year, two-years, or five-years) is independent of the preceding and subsequent return period with respect to high flow pulse attainment frequency.

4.1.1.4 Geographic Interpolation

The Nueces BBASC has provided environmental flow standard recommendations at streamflow gaging stations located throughout the Nueces River Basin and the Nueces – Rio Grande Coastal Basin. These reference locations are, among other things, representative of major streams above and below existing reservoirs and the outcrop of the Edwards Aquifer as well as tributary streams. The Nueces BBASC recommends that the TCEQ develop appropriate methods for geographic interpolation of flow conditions applicable to future inter-adjacent permits and amendments from reference locations for which environmental flow standards are established. Such methods should include, at a minimum, drainage area adjustments, but may also include consideration of springflow contributions, channel losses, aquifer recharge zones, soil cover complex, area specific ecological considerations and other factors as necessary and appropriate. The Nueces BBASC recommends that instream environmental flow standards be applicable below the streamflow gaging stations on the Nueces River near Mathis, Oso Creek at Corpus Christi, and San Fernando Creek near Alice all the way to Nueces, Oso, and Baffin Bays, respectively.

4.1.1.5 General Consideration

The Nueces BBASC recommends that flows passed for senior water rights count toward satisfaction of any specified subsistence, base, and pulse flow rates and volumes.

4.1.2 *Nueces River at Laguna*

The streamflow gaging station and recommended instream flow measurement point on the Nueces River at Laguna (USGS #08190000) is located in western Uvalde County, has a drainage area of 737 square miles, has records extending back in time through 1924, and is considered perennial with measured flows essentially 100 percent of the time. It is located immediately upstream of the Edwards Aquifer recharge zone in the Edwards Plateau eco-region, within a stream segment identified by the TPWD as ecologically significant, and at the downstream boundary of a stream segment conditionally recommended by the South Central Texas Regional Water Planning Group to the Texas Legislature for designation as having unique ecological value.

The Nueces River at Laguna is the location most studied by the Nueces BBEST and BBASC. The Nueces BBASC selected this as a key location assumed to be representative of other Edwards Plateau eco-region locations. Field data collection, including cross-section surveys, substrate classification, flow measurements, and hydraulic profile development for riffle, run, and pool habitats, was performed by contractors to Nueces BBEST supported by TPWD and TWDB staff. Using this information and available habitat suitability data for representative species, relationships between flow and weighted usable habitat were developed for this site. Both the Nueces BBEST and BBASC simulated streamflows resulting from operations of an example water supply project at this location with run-of-river diversions and off-channel storage managed subject to a range of potential environmental flow recommendations. The resulting time series of simulated streamflows facilitated evaluation of the frequency of availability of weighed usable habitat for representative species (Appendix J) which inform base and subsistence flow recommendations. Time series of simulated streamflows and knowledge of local soil characteristics facilitated evaluations of sediment transport (Appendix J) which inform high flow pulse recommendations. Only the Nueces BBASC considered simulated firm yields of the example project in fulfilling its charge to recommend balanced environmental flow standards. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.1.

Table 4-1.1. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River at Laguna (Appendix A–A.1)

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600 Duration Bound is 64			
	Qp: 2,220 cfs with Average Frequency 1 per year Regressed Volume is 18,400 Duration Bound is 46			
	Qp: 590 cfs with Average Frequency 2 per year Volume Bound is 11,300 Duration Bound is 26			
	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
		Qp: 99 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 9		
Base Flows (cfs)	65		48	65
Subsistence Flows (cfs)	14	18	16	14

Pulse volumes are in units of acre-feet and durations are in days.

4.1.3 *West Nueces River near Brackettville*

The streamflow gaging station and recommended instream flow measurement point on the West Nueces River at Brackettville (USGS #08190500) is located in eastern Kinney County, has a drainage area of 694 square miles, has records extending back in time through 1940, and is considered intermittent with measured flows less than 95 percent of the time. It is located in the Edwards Aquifer recharge zone, within the Edwards Plateau eco-region, and within a stream segment identified by the TPWD as ecologically significant. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.2.

Table 4-1.2. Nueces BBASC Environmental Flow Standard Recommendation, West Nueces River near Brackettville (Appendix A–A.2)

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 11,200 cfs with Average Frequency 1 per 5 years Regressed Volume is 39,200 Duration Bound is 48			
High Flow Pulses	Qp: 4,090 cfs with Average Frequency 1 per 2 years Regressed Volume is 16,200 Duration Bound is 40			
High Flow Pulses	Qp: 1,020 cfs with Average Frequency 1 per year Regressed Volume is 4,810 Duration Bound is 31			
High Flow Pulses	Qp: 25 cfs with Average Frequency 2 per year Volume Bound is 360 Duration Bound is 16			
High Flow Pulses		Qp: 5 cfs with Average Frequency 1 per season Volume Bound is 76 Duration Bound is 10	Qp: 5 cfs with Average Frequency 1 per season Volume Bound is 84 Duration Bound is 13	
Base Flows (cfs)	1			
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.4 *Nueces River Below Uvalde*

The streamflow gaging station and recommended instream flow measurement point on the Nueces River below Uvalde (USGS #08192000) is located in southwestern Uvalde County, has a drainage area of 1861 square miles, has records extending back in time through 1940, and is considered intermittent with measured flows less than 95 percent of the time. It is located immediately downstream of the Edwards Aquifer recharge zone and within the Southern Texas Plains eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.3.

Table 4-1.3. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River Below Uvalde (Appendix A–A.3)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 6,920 cfs with Average Frequency 1 per 2 years Regressed Volume is 57,100 Duration Bound is 73			
High Flow Pulses	Qp: 2,550 cfs with Average Frequency 1 per year Regressed Volume is 19,500 Duration Bound is 49			
High Flow Pulses	Qp: 510 cfs with Average Frequency 2 per year Volume Bound is 8,240 Duration Bound is 26			
High Flow Pulses	Qp: 13 cfs with Average Frequency 1 per season Volume Bound is 100 Duration Bound is 5	Qp: 110 cfs with Average Frequency 1 per season Volume Bound is 1,280 Duration Bound is 11	Qp: 15 cfs with Average Frequency 1 per season Volume Bound is 100 Duration Bound is 4	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 690 Duration Bound is 11
High Flow Pulses		Qp: 20 cfs with Average Frequency 2 per season Volume Bound is 200 Duration Bound is 6		
Base Flows (cfs)	21		17	19
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.5 *Nueces River at Cotulla*

The streamflow gaging station and recommended instream flow measurement point on the Nueces River at Cotulla (USGS #08194000) is located in western La Salle County, has a drainage area of 5171 square miles, has records extending back in time through 1927, and is considered intermittent with measured flows less than 95 percent of the time. In fact, no flow is recorded at this station more than 40 percent of the time. It is located in the heart of the Southern Texas Plains eco-region at the upstream extent of the braided reach of the Nueces River.

The Nueces River at Cotulla is the second most studied location selected by the Nueces BBEST and BBASC. The Nueces BBASC selected this as a key location assumed to be representative of other Southern Texas Plains eco-region locations. The Nueces BBEST performed an extended field reconnaissance of the Nueces River on the Hixon Ranch under very dry hydrologic conditions during the summer of 2011. The Nueces BBEST and BBASC simulated streamflows resulting from operations of an example on-channel reservoir water supply project at this location subject to a range of potential environmental flow recommendations. In addition, the Nueces BBASC simulated streamflow resulting from example run-of-river diversions and off-channel storage managed subject to a range of potential environmental flow recommendations. These time series of simulated streamflows and knowledge of local soil characteristics facilitated evaluations of sediment transport (Appendix J) which inform high flow pulse recommendations. Only the Nueces BBASC considered simulated firm yields of the example projects in fulfilling its charge to recommend balanced environmental flow standards. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.4.

Table 4-1.4. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River at Cotulla (Appendix A–A.4)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 96 cfs with Average Frequency 1 per season Volume Bound is 1,570 Duration Bound is 20		Qp: 100 cfs with Average Frequency 1 per season Volume Bound is 1,030 Duration Bound is 16	
	Qp: 8 cfs with Average Frequency 2 per season Volume Bound is 100 Duration Bound is 13	Qp: 190 cfs with Average Frequency 2 per season Volume Bound is 2,370 Duration Bound is 17		Qp: 35 cfs with Average Frequency 2 per season Volume Bound is 360 Duration Bound is 14
		Qp: 15 cfs with Average Frequency 3 per season Volume Bound is 150 Duration Bound is 11		
Base Flows (cfs)	6	10	7	15
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.6 *Nueces River at Tilden*

The streamflow gaging station and recommended instream flow measurement point on the Nueces River at Tilden (USGS #08194500) is located in central McMullen County, has a drainage area of 8,093 square miles, has records extending back in time through 1943, and is considered intermittent with measured flows less than 95 percent of the time. It is located in the Southern Texas Plains eco-region downstream of the braided reach of the Nueces River. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.5.

Table 4-1.5. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River at Tilden (Appendix A–A.5)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 300 cfs with Average Frequency 1 per season Volume Bound is 4,610 Duration Bound is 22	Qp: 880 cfs with Average Frequency 1 per season Volume Bound is 12,200 Duration Bound is 22	Qp: 320 cfs with Average Frequency 1 per season Volume Bound is 4,390 Duration Bound is 21	Qp: 840 cfs with Average Frequency 1 per season Volume Bound is 10,900 Duration Bound is 23
	Qp: 87 cfs with Average Frequency 2 per season Volume Bound is 1,260 Duration Bound is 18	Qp: 280 cfs with Average Frequency 2 per season Volume Bound is 3,360 Duration Bound is 18	Qp: 11 cfs with Average Frequency 2 per season Volume Bound is 96 Duration Bound is 10	Qp: 220 cfs with Average Frequency 2 per season Volume Bound is 2,390 Duration Bound is 16
	Qp: 9 cfs with Average Frequency 3 per season Volume Bound is 110 Duration Bound is 12	Qp: 89 cfs with Average Frequency 3 per season Volume Bound is 930 Duration Bound is 14		Qp: 29 cfs with Average Frequency 3 per season Volume Bound is 250 Duration Bound is 10
		Qp: 8 cfs with Average Frequency 4 per season Volume Bound is 60 Duration Bound is 8		
Base Flows (cfs)	1	3	1	12
Subsistence Flows (cfs)	1	1	1	1

Pulse volumes are in units of acre-feet and durations are in days.

4.1.7 *Frio River at Concan*

The streamflow gaging station and recommended instream flow measurement point on the Frio River at Concan (USGS #08195000) is located in northern Uvalde County, has a drainage area of 389 square miles, has records extending back in time through 1924, and is considered perennial with measured flows more than 95 percent of the time. It is located immediately upstream of the Edwards Aquifer recharge zone, within the Edwards Plateau eco-region, within a stream segment identified by the TPWD as ecologically significant, and at the downstream boundary of a stream segment conditionally recommended by the South Central Texas Regional Water Planning Group to the Texas Legislature for designation as having unique ecological value.

Special studies were conducted for the Nueces BBEST on the Frio River upstream of Concan in Garner State Park. Field data collection, including cross-section surveys, substrate classification, flow measurements, and hydraulic profile development for riffle, run, and pool habitats, was performed by contractors to Nueces BBEST supported by TPWD and TWDB staff. Using this information and available habitat suitability data for representative species, relationships between flow and weighted usable habitat were developed for this site. These relationships informed the base and subsistence flow recommendations of the Nueces BBEST and BBASC. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.6.

Table 4-1.6. Nueces BBASC Environmental Flow Standard Recommendation, Frio River at Concan (Appendix A–A.6)

	Dec Jan Feb Mar	Apr May Jun	Jul Aug Sep	Oct Nov
High Flow Pulses	Qp: 8,860 cfs with Average Frequency 1 per 5 years Regressed Volume is 79,000 Duration Bound is 104			
	Qp: 4,870 cfs with Average Frequency 1 per 2 years Regressed Volume is 41,700 Duration Bound is 76			
	Qp: 1,780 cfs with Average Frequency 1 per year Regressed Volume is 14,300 Duration Bound is 45			
	Qp: 540 cfs with Average Frequency 2 per year Volume Bound is 9,430 Duration Bound is 24			
	Qp: 89 cfs with Average Frequency 1 per season Volume Bound is 2,100 Duration Bound is 12	Qp: 300 cfs with Average Frequency 1 per season Volume Bound is 3,550 Duration Bound is 12	Qp: 240 cfs with Average Frequency 1 per season Volume Bound is 2,990 Duration Bound is 13	Qp: 79 cfs with Average Frequency 1 per season Volume Bound is 900 Duration Bound is 5
		Qp: 120 cfs with Average Frequency 2 per season Volume Bound is 1,320 Duration Bound is 8	Qp: 43 cfs with Average Frequency 2 per season Volume Bound is 400 Duration Bound is 4	
Base Flows (cfs)	61		47	55
Subsistence Flows (cfs)	11	10		
	Winter	Spring	Summer	Fall

Pulse volumes are in units of acre-feet and durations are in days.

4.1.8 *Dry Frio River near Reagan Wells*

The streamflow gaging station and recommended instream flow measurement point on the Dry Frio River near Reagan Wells (USGS #08196000) is located in northern Uvalde County, has a drainage area of 126 square miles, has records extending back in time through 1953, and is considered perennial with measured flows more than 95 percent of the time. It is located immediately upstream of the Edwards Aquifer recharge zone within the Edwards Plateau eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.7.

Table 4-1.7. Nueces BBASC Environmental Flow Standard Recommendation, Dry Frio River near Reagan Wells (Appendix A–A.7)

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 2,970 cfs with Average Frequency 1 per 5 years Regressed Volume is 27,200 Duration Bound is 82			
	Qp: 1,700 cfs with Average Frequency 1 per 2 years Regressed Volume is 15,300 Duration Bound is 64			
	Qp: 540 cfs with Average Frequency 1 per year Regressed Volume is 4,660 Duration Bound is 38			
	Qp: 210 cfs with Average Frequency 2 per year Volume Bound is 3,500 Duration Bound is 26			
	Qp: 32 cfs with Average Frequency 1 per season Volume Bound is 650 Duration Bound is 13	Qp: 120 cfs with Average Frequency 1 per season Volume Bound is 1,470 Duration Bound is 16	Qp: 81 cfs with Average Frequency 1 per season Volume Bound is 1,100 Duration Bound is 15	Qp: 35 cfs with Average Frequency 1 per season Volume Bound is 620 Duration Bound is 13
	Qp: 7 cfs with Average Frequency 2 per season Volume Bound is 98 Duration Bound is 5	Qp: 30 cfs with Average Frequency 2 per season Volume Bound is 370 Duration Bound is 9	Qp: 12 cfs with Average Frequency 2 per season Volume Bound is 160 Duration Bound is 7	
Base Flows (cfs)	12	9	8	12
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.9 *Sabinal River near Sabinal*

The streamflow gaging station and recommended instream flow measurement point on the Sabinal River near Sabinal (USGS #08198000) is located in northeastern Uvalde County, has a drainage area of 206 square miles, has records extending back in time through 1943, and is considered intermittent with measured flows less than 95 percent of the time. No flow is recorded at this station almost 10 percent of the time. It is located immediately upstream of the Edwards Aquifer recharge zone, within the Edwards Plateau eco-region, within a stream segment identified by the TPWD as ecologically significant, and about 2.7 miles below the downstream boundary of a stream segment conditionally recommended by the South Central Texas Regional Water Planning Group to the Texas Legislature for designation as having unique ecological value.

The Nueces BBASC considered simulated recharge enhancement and streamflows resulting from operations of an example on-channel recharge dam project near this location subject to a range of potential environmental flow recommendations. As this example project is part of a recommended water management strategy in the 2011 South Central Texas Regional Water Plan, the Nueces BBASC evaluated it in fulfilling its charge to recommend balanced environmental flow standards. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.8.

Table 4-1.8. Nueces BBASC Environmental Flow Standard Recommendation, Sabinal River near Sabinal (Appendix A–A.8)

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 5,200 cfs with Average Frequency 1 per 5 years Regressed Volume is 46,200 Duration Bound is 75			
	Qp: 2,350 cfs with Average Frequency 1 per 2 years Regressed Volume is 20,000 Duration Bound is 54			
	Qp: 1,020 cfs with Average Frequency 1 per year Regressed Volume is 8,290 Duration Bound is 38			
	Qp: 330 cfs with Average Frequency 2 per year Volume Bound is 5,420 Duration Bound is 24			
	Qp: 62 cfs with Average Frequency 1 per season Volume Bound is 1,530 Duration Bound is 17	Qp: 180 cfs with Average Frequency 1 per season Volume Bound is 2,210 Duration Bound is 15	Qp: 100 cfs with Average Frequency 1 per season Volume Bound is 1,180 Duration Bound is 12	Qp: 53 cfs with Average Frequency 1 per season Volume Bound is 840 Duration Bound is 12
		Qp: 64 cfs with Average Frequency 2 per season Volume Bound is 750 Duration Bound is 10	Qp: 11 cfs with Average Frequency 2 per season Volume Bound is 130 Duration Bound is 5	
		Qp: 22 cfs with Average Frequency 3 per season Volume Bound is 240 Duration Bound is 6		
Base Flows (cfs)	21	21	13	21
Subsistence Flows (cfs)	1	1	1	1

Pulse volumes are in units of acre-feet and durations are in days.

4.1.10 *Sabinal River at Sabinal (below Edwards Outcrop)*

The streamflow gaging station and recommended instream flow measurement point on the Sabinal River at Sabinal (USGS #08198500) is located in eastern Uvalde County, has a drainage area of 241 square miles, has records extending back in time through 1953, and is considered intermittent with measured flows less than 95 percent of the time. It is located immediately downstream of the Edwards Aquifer recharge zone, within the Southern Texas Plains eco-region, and is at the downstream boundary of a stream segment identified by the TPWD as ecologically significant. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.9.

Table 4-1.9. Nueces BBASC Environmental Flow Standard Recommendation, Sabinal River at Sabinal (below Edwards Outcrop) (Appendix A–A.9)

<table>
<tr><td rowspan="4">High Flow Pulses</td><td colspan="12">Qp: 1,070 cfs with Average Frequency 1 per year
Regressed Volume is 6,690
Duration Bound is 29</td></tr>
<tr><td colspan="12">Qp: 230 cfs with Average Frequency 2 per year
Volume Bound is 2,680
Duration Bound is 17</td></tr>
<tr><td colspan="5">Qp: 21 cfs with Average Frequency 1 per season
Volume Bound is 310
Duration Bound is 11</td><td colspan="3">Qp: 56 cfs with Average Frequency 1 per season
Volume Bound is 430
Duration Bound is 9</td><td colspan="2">Qp: 3 cfs with Average Frequency 1 per season
Volume Bound is 27
Duration Bound is 5</td><td colspan="2">Qp: 20 cfs with Average Frequency 1 per season
Volume Bound is 150
Duration Bound is 6</td></tr>
<tr><td colspan="5"></td><td colspan="3">Qp: 3 cfs with Average Frequency 2 per season
Volume Bound is 18
Duration Bound is 3</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Base Flows (cfs)</td><td colspan="5">2</td><td colspan="5">1</td><td colspan="2">2</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="12">1</td></tr>
<tr><td></td><td>Nov</td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td></tr>
<tr><td></td><td colspan="5">Winter</td><td colspan="3">Spring</td><td colspan="2">Summer</td><td colspan="2">Fall</td></tr>
</table>

Pulse volumes are in units of acre-feet and durations are in days.

4.1.11 *Hondo Creek near Tarpley*

The streamflow gaging station and recommended instream flow measurement point on Hondo Creek near Tarpley (USGS #08200000) is located in northwestern Medina County, has a drainage area of 95.6 square miles, has records extending back in time through 1953, and is considered intermittent with measured flows less than 95 percent of the time. It is located immediately upstream of the Edwards Aquifer recharge zone, within the Edwards Plateau eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.10.

Table 4-1.10. Nueces BBASC Environmental Flow Standard Recommendation, Hondo Creek near Tarpley (Appendix A–A.10)

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 3,340 cfs with Average Frequency 1 per 5 years Regressed Volume is 30,400 Duration Bound is 51			
High Flow Pulses	Qp: 1,470 cfs with Average Frequency 1 per 2 years Regressed Volume is 12,200 Duration Bound is 38			
High Flow Pulses	Qp: 790 cfs with Average Frequency 1 per year Regressed Volume is 6,200 Duration Bound is 30			
High Flow Pulses	Qp: 330 cfs with Average Frequency 2 per year Volume Bound is 4,530 Duration Bound is 22			
High Flow Pulses	Qp: 61 cfs with Average Frequency 1 per season Volume Bound is 1,020 Duration Bound is 15	Qp: 290 cfs with Average Frequency 1 per season Volume Bound is 3,360 Duration Bound is 18	Qp: 90 cfs with Average Frequency 1 per season Volume Bound is 890 Duration Bound is 12	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 580 Duration Bound is 11
High Flow Pulses	Qp: 16 cfs with Average Frequency 2 per season Volume Bound is 200 Duration Bound is 8	Qp: 91 cfs with Average Frequency 2 per season Volume Bound is 950 Duration Bound is 12	Qp: 24 cfs with Average Frequency 2 per season Volume Bound is 220 Duration Bound is 7	Qp: 13 cfs with Average Frequency 2 per season Volume Bound is 120 Duration Bound is 6
High Flow Pulses	Qp: 6 cfs with Average Frequency 3 per season Volume Bound is 54 Duration Bound is 5	Qp: 36 cfs with Average Frequency 3 per season Volume Bound is 340 Duration Bound is 9	Qp: 4 cfs with Average Frequency 3 per season Volume Bound is 34 Duration Bound is 4	
High Flow Pulses		Qp: 6 cfs with Average Frequency 4 per season Volume Bound is 52 Duration Bound is 5		
Base Flows (cfs)	6	5	9	8
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.12 *Seco Creek at Miller Ranch near Utopia*

The streamflow gaging station and recommended instream flow measurement point on Seco Creek near Utopia (USGS #08201500) is located in northwestern Medina County, has a drainage area of 45 square miles, has records extending back in time through 1962, and is considered perennial with measured flows more than 95 percent of the time. It is located upstream of the Edwards Aquifer recharge zone in the Edwards Plateau eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.11.

Table 4-1.11. Nueces BBASC Environmental Flow Standard Recommendation, Seco Creek at Miller Ranch near Utopia (Appendix A–A.11)

<table>
<tr><td rowspan="6">High Flow Pulses</td><td colspan="4">Qp: 1,600 cfs with Average Frequency 1 per 5 years
Regressed Volume is 17,500
Duration Bound is 62</td></tr>
<tr><td colspan="4">Qp: 700 cfs with Average Frequency 1 per 2 years
Regressed Volume is 6,790
Duration Bound is 44</td></tr>
<tr><td colspan="4">Qp: 310 cfs with Average Frequency 1 per year
Regressed Volume is 2,720
Duration Bound is 31</td></tr>
<tr><td colspan="4">Qp: 120 cfs with Average Frequency 2 per year
Volume Bound is 1,710
Duration Bound is 21</td></tr>
<tr><td>Qp: 21 cfs with Average Frequency 1 per season
Volume Bound is 290
Duration Bound is 12</td><td>Qp: 91 cfs with Average Frequency 1 per season
Volume Bound is 1,140
Duration Bound is 17</td><td>Qp: 38 cfs with Average Frequency 1 per season
Volume Bound is 360
Duration Bound is 11</td><td>Qp: 23 cfs with Average Frequency 1 per season
Volume Bound is 270
Duration Bound is 11</td></tr>
<tr><td>Qp: 9 cfs with Average Frequency 2 per season
Volume Bound is 100
Duration Bound is 8</td><td>Qp: 33 cfs with Average Frequency 2 per season
Volume Bound is 360
Duration Bound is 12</td><td>Qp: 11 cfs with Average Frequency 2 per season
Volume Bound is 93
Duration Bound is 7</td><td>Qp: 7 cfs with Average Frequency 2 per season
Volume Bound is 65
Duration Bound is 6</td></tr>
<tr><td>Base Flows (cfs)</td><td>4</td><td colspan="2">3</td><td>4</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="4">1</td></tr>
<tr><td></td><td>Dec Jan Feb Mar</td><td>Apr May Jun</td><td>Jul Aug Sep</td><td>Oct Nov</td></tr>
<tr><td></td><td>Winter</td><td>Spring</td><td>Summer</td><td>Fall</td></tr>
</table>

Pulse volumes are in units of acre-feet and durations are in days.

4.1.13 *Leona Springs near Uvalde*

The discontinued streamflow gaging station and recommended instream flow measurement point on the Leona River below Leona Springs southeast of Uvalde (USGS #08204000) is located in southern Uvalde County, has records extending from 1939 through 1964, and is considered intermittent with measured flows less than 95 percent of the time. It is located downstream of the Edwards Aquifer recharge zone, within the Southern Texas Plains eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.12. The Nueces BBEST and BBASC are both of the opinion that insufficient data are available to specify high flow pulses as part of the recommendation.

Table 4-1.12. Nueces BBASC Environmental Flow Standard Recommendation, Leona Springs near Uvalde (Appendix A–A.12)

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Base Flows (cfs)	25				20			18			22	
Subsistence Flows (cfs)	1											
	Winter				Spring			Summer			Fall	

Insufficient data are avaiable for development of high flow pulse recommendations at this location.

4.1.14 *Frio River near Derby*

The streamflow gaging station and recommended instream flow measurement point on the Frio River near Derby (USGS #08205500) is located in southern Frio County, has a drainage area of 3,429 square miles, has records extending back in time through 1927, and is considered intermittent with measured flows less than 95 percent of the time. In fact, no flow is recorded at this station more than 33 percent of the time. It is located in the heart of the Southern Texas Plains eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.13.

Table 4-1.13. Nueces BBASC Environmental Flow Standard Recommendation, Frio River near Derby (Appendix A–A.13)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 1,670 cfs with Average Frequency 2 per year Volume Bound is 18,800 Duration Bound is 25			
	Qp: 87 cfs with Average Frequency 1 per season Volume Bound is 1,450 Duration Bound is 20	Qp: 900 cfs with Average Frequency 1 per season Volume Bound is 7,940 Duration Bound is 17	Qp: 58 cfs with Average Frequency 1 per season Volume Bound is 510 Duration Bound is 13	Qp: 350 cfs with Average Frequency 1 per season Volume Bound is 4,340 Duration Bound is 24
	Qp: 12 cfs with Average Frequency 2 per season Volume Bound is 190 Duration Bound is 15	Qp: 210 cfs with Average Frequency 2 per season Volume Bound is 1,810 Duration Bound is 14		Qp: 7 cfs with Average Frequency 2 per season Volume Bound is 97 Duration Bound is 12
		Qp: 49 cfs with Average Frequency 3 per season Volume Bound is 420 Duration Bound is 11		
		Qp: 5 cfs with Average Frequency 4 per season Volume Bound is 41 Duration Bound is 8		
Base Flows (cfs)	17	11	7	12
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.15 *Frio River at Tilden*

The streamflow gaging station and recommended instream flow measurement point on the Frio River at Tilden (USGS #08206600) is located in north central McMullen County, has a drainage area of 4,493 square miles, has records extending back in time through 1933, and is considered intermittent with measured flows less than 95 percent of the time. It is located in the heart of the Southern Texas Plains eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.14.

Table 4-1.14. Nueces BBASC Environmental Flow Standard Recommendation, Frio River at Tilden (Appendix A–A.14)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 5,320 Duration Bound is 20		Qp: 270 cfs with Average Frequency 1 per season Volume Bound is 2,440 Duration Bound is 14	Qp: 960 cfs with Average Frequency 1 per season Volume Bound is 10,400 Duration Bound is 20
High Flow Pulses	Qp: 86 cfs with Average Frequency 2 per season Volume Bound is 1,070 Duration Bound is 13	Qp: 460 cfs with Average Frequency 2 per season Volume Bound is 4,470 Duration Bound is 14	Qp: 36 cfs with Average Frequency 2 per season Volume Bound is 280 Duration Bound is 9	Qp: 120 cfs with Average Frequency 2 per season Volume Bound is 1,080 Duration Bound is 12
High Flow Pulses	Qp: 25 cfs with Average Frequency 3 per season Volume Bound is 290 Duration Bound is 9	Qp: 190 cfs with Average Frequency 3 per season Volume Bound is 1,790 Duration Bound is 12		Qp: 13 cfs with Average Frequency 3 per season Volume Bound is 100 Duration Bound is 7
High Flow Pulses	Qp: 6 cfs with Average Frequency 4 per season Volume Bound is 63 Duration Bound is 6	Qp: 83 cfs with Average Frequency 4 per season Volume Bound is 730 Duration Bound is 10		
Base Flows (cfs)	12	7	2	3
Subsistence Flows (cfs)	1	1	1	1

Pulse volumes are in units of acre-feet and durations are in days.

4.1.16 *San Miguel Creek near Tilden*

The streamflow gaging station and recommended instream flow measurement point on San Miguel Creek near Tilden (USGS #08206700) is located in north central McMullen County, has a drainage area of 783 square miles, has records extending back in time through 1965, and is considered intermittent with measured flows less than 95 percent of the time. In fact, no flow is recorded at this station more than 29 percent of the time. The San Miguel Creek watershed is located in the Southern Texas Plains eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.15.

Table 4-1.15. Nueces BBASC Environmental Flow Standard Recommendation, San Miguel Creek near Tilden (Appendix A–A.15)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 990 cfs with Average Frequency 2 per year Volume Bound is 7,310 Duration Bound is 18			
	Qp: 160 cfs with Average Frequency 1 per season Volume Bound is 1,580 Duration Bound is 19	Qp: 690 cfs with Average Frequency 1 per season Volume Bound is 4,940 Duration Bound is 16	Qp: 160 cfs with Average Frequency 1 per season Volume Bound is 1,040 Duration Bound is 13	Qp: 300 cfs with Average Frequency 1 per season Volume Bound is 2,010 Duration Bound is 15
	Qp: 45 cfs with Average Frequency 2 per season Volume Bound is 470 Duration Bound is 16	Qp: 220 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 14	Qp: 16 cfs with Average Frequency 2 per season Volume Bound is 110 Duration Bound is 10	Qp: 44 cfs with Average Frequency 2 per season Volume Bound is 310 Duration Bound is 12
	Qp: 14 cfs with Average Frequency 3 per season Volume Bound is 160 Duration Bound is 14	Qp: 100 cfs with Average Frequency 3 per season Volume Bound is 740 Duration Bound is 13		Qp: 5 cfs with Average Frequency 3 per season Volume Bound is 35 Duration Bound is 8
	Qp: 7 cfs with Average Frequency 4 per season Volume Bound is 86 Duration Bound is 13	Qp: 47 cfs with Average Frequency 4 per season Volume Bound is 340 Duration Bound is 12		
Base Flows (cfs)	2		1	2
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.17 *Atascosa River at Whitsett*

The streamflow gaging station and recommended instream flow measurement point on the Atascosa River near Tilden (USGS #08208000) is located in northwestern Atascosa County, has a drainage area of 1171 square miles, has records extending back in time through 1933, and is considered perennial with measured flows more than 95 percent of the time. It is located in the Southern Texas Plains and Post Oak Savannah eco-regions. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.16.

Table 4-1.16. Nueces BBASC Environmental Flow Standard Recommendation, Atascosa River at Whitsett (Appendix A–A.16)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 1,990 cfs with Average Frequency 2 per year Volume Bound is 14,800 Duration Bound is 19			
High Flow Pulses	Qp: 730 cfs with Average Frequency 1 per season Volume Bound is 5,720 Duration Bound is 18	Qp: 1,770 cfs with Average Frequency 1 per season Volume Bound is 12,500 Duration Bound is 16	Qp: 250 cfs with Average Frequency 1 per season Volume Bound is 1,960 Duration Bound is 12	Qp: 620 cfs with Average Frequency 1 per season Volume Bound is 4,320 Duration Bound is 14
High Flow Pulses	Qp: 230 cfs with Average Frequency 2 per season Volume Bound is 1,960 Duration Bound is 14	Qp: 600 cfs with Average Frequency 2 per season Volume Bound is 4,280 Duration Bound is 13	Qp: 37 cfs with Average Frequency 2 per season Volume Bound is 280 Duration Bound is 7	Qp: 100 cfs with Average Frequency 2 per season Volume Bound is 720 Duration Bound is 9
High Flow Pulses	Qp: 74 cfs with Average Frequency 3 per season Volume Bound is 690 Duration Bound is 11	Qp: 220 cfs with Average Frequency 3 per season Volume Bound is 1,550 Duration Bound is 11	Qp: 5 cfs with Average Frequency 3 per season Volume Bound is 34 Duration Bound is 4	Qp: 21 cfs with Average Frequency 3 per season Volume Bound is 150 Duration Bound is 6
High Flow Pulses	Qp: 28 cfs with Average Frequency 4 per season Volume Bound is 280 Duration Bound is 9	Qp: 80 cfs with Average Frequency 4 per season Volume Bound is 580 Duration Bound is 9		
Base Flows (cfs)	9	5	4	
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.18 *Nueces River near Three Rivers*

The streamflow gaging station and recommended instream flow measurement point on the Nueces River near Three Rivers (USGS #08210000) is located in central Live Oak County, has a drainage area of 15,427 square miles, has records extending back in time through 1916, and is considered perennial with measured flows more than 95 percent of the time. It is located downstream of Choke Canyon Reservoir within the Southern Texas Plains eco-region. Streamflows at this location have been affected by deliberate impoundment in and releases from Choke Canyon Reservoir since 1982.

The Nueces River near Three Rivers is the third most studied location selected by the Nueces BBEST and BBASC. The Nueces BBASC selected this as a key location assumed to be representative of other locations downstream of major reservoirs. Field data collection, including cross-section surveys, substrate classification, flow measurements, and hydraulic profile development for riffle, run, and pool habitats, was performed by contractors to Nueces BBEST supported by TPWD and TWDB staff. Using this information and available habitat suitability data for representative species, relationships between flow and weighted usable habitat were developed for this site. The Nueces BBASC simulated streamflows at this site resulting from operations of example water supply projects on the Nueces River at Cotulla (an on-channel reservoir and, alternatively, run-of-river diversions with off-channel storage managed subject to a range of potential environmental flow recommendations). The resulting time series of simulated streamflows facilitated evaluation of the frequency of availability of weighed usable habitat for representative species (Appendix J) which inform base and subsistence flow recommendations. Time series of simulated streamflows and knowledge of local soil characteristics also facilitated evaluations of sediment transport (Appendix J) which inform high flow pulse recommendations. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.17.

Table 4-1.17. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River near Three Rivers (Appendix A–A.17)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 2,050 cfs with Average Frequency 1 per season Volume Bound is 26,800 Duration Bound is 18	Qp: 4,090 cfs with Average Frequency 1 per season Volume Bound is 64,600 Duration Bound is 22	Qp: 1,100 cfs with Average Frequency 1 per season Volume Bound is 13,600 Duration Bound is 15	Qp: 2,420 cfs with Average Frequency 1 per season Volume Bound is 34,200 Duration Bound is 19
	Qp: 720 cfs with Average Frequency 2 per season Volume Bound is 8,460 Duration Bound is 13	Qp: 1,660 cfs with Average Frequency 2 per season Volume Bound is 22,200 Duration Bound is 16	Qp: 280 cfs with Average Frequency 2 per season Volume Bound is 2,520 Duration Bound is 9	Qp: 710 cfs with Average Frequency 2 per season Volume Bound is 7,920 Duration Bound is 13
	Qp: 320 cfs with Average Frequency 3 per season Volume Bound is 3,430 Duration Bound is 11	Qp: 690 cfs with Average Frequency 3 per season Volume Bound is 7,830 Duration Bound is 12	Qp: 34 cfs with Average Frequency 3 per season Volume Bound is 200 Duration Bound is 4	Qp: 160 cfs with Average Frequency 3 per season Volume Bound is 1,340 Duration Bound is 8
	Qp: 140 cfs with Average Frequency 4 per season Volume Bound is 1,410 Duration Bound is 8	Qp: 320 cfs with Average Frequency 4 per season Volume Bound is 3,190 Duration Bound is 10		Qp: 15 cfs with Average Frequency 4 per season Volume Bound is 82 Duration Bound is 4
Base Flows (cfs)	37		30	37
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.19 *Nueces River near Mathis*

The streamflow gaging station and recommended instream flow measurement point on the Nueces River near Mathis (USGS #08211000) is located on the western boundary of San Patricio County (and the northeastern boundary of Jim Wells County), has a drainage area of 16,503 square miles, has records extending back in time through 1940, and is considered perennial with measured flows essentially 100 percent of the time. It is located downstream of Lake Corpus Christi within the Western Gulf Coastal Plain eco-region. Streamflows at this location have been affected by deliberate impoundment in and releases from Lake Corpus Christi since 1958. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.18.

Table 4-1.18. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River near Mathis (Appendix A–A.18)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 1,120 cfs with Average Frequency 1 per season Volume Bound is 14,200 Duration Bound is 12	Qp: 2,540 cfs with Average Frequency 1 per season Volume Bound is 49,400 Duration Bound is 19	Qp: 370 cfs with Average Frequency 1 per season Volume Bound is 4,970 Duration Bound is 10	Qp: 1,550 cfs with Average Frequency 1 per season Volume Bound is 24,700 Duration Bound is 15
High Flow Pulses	Qp: 590 cfs with Average Frequency 2 per season Volume Bound is 6,270 Duration Bound is 9	Qp: 420 cfs with Average Frequency 2 per season Volume Bound is 5,090 Duration Bound is 9	Qp: 150 cfs with Average Frequency 2 per season Volume Bound is 1,650 Duration Bound is 6	Qp: 240 cfs with Average Frequency 2 per season Volume Bound is 2,670 Duration Bound is 7
Base Flows (cfs)	96	120	140	110
Subsistence Flows (cfs)	37	37	37	37

Pulse volumes are in units of acre-feet and durations are in days.

4.1.20 *Oso Creek at Corpus Christi*

The streamflow gaging station and recommended instream flow measurement point on Oso Creek at Corpus Christi (USGS #08211520) is located in Nueces County, has a drainage area of 90.3 square miles, has records extending back in time through 1973, and is considered perennial with measured flows more than 95 percent of the time. It is located in the Nueces – Rio Grande Coastal Basin within the Western Gulf Coastal Plain eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.19.

Table 4-1.19. Nueces BBASC Environmental Flow Standard Recommendation, Oso Creek at Corpus Christi (Appendix A–A.19)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses			Qp: 21 cfs with Average Frequency 1 per season Volume Bound is 160 Duration Bound is 8	
	Qp: 59 cfs with Average Frequency 2 per season Volume Bound is 450 Duration Bound is 13	Qp: 48 cfs with Average Frequency 2 per season Volume Bound is 330 Duration Bound is 9	Qp: 6 cfs with Average Frequency 2 per season Volume Bound is 39 Duration Bound is 6	Qp: 64 cfs with Average Frequency 2 per season Volume Bound is 450 Duration Bound is 11
Base Flows (cfs)	2			
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.1.21 *San Fernando Creek near Alice*

The streamflow gaging station and recommended instream flow measurement point on San Fernando Creek near Alice (USGS #08211900) is located in Jim Wells County, has a drainage area of 507 square miles, has discontinuous records extending back in time through 1965, and is considered perennial with measured flows more than 95 percent of the time. It is located in the Nueces – Rio Grande Coastal Basin within the Western Gulf Coastal Plain eco-region. The environmental flow standard recommendation of the Nueces BBASC for this location is summarized in Table 4-1.20.

Table 4-1.20. Nueces BBASC Environmental Flow Standard Recommendation, San Fernando Creek near Alice (Appendix A–A.20)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 170 cfs with Average Frequency 2 per year Volume Bound is 1,490 Duration Bound is 17			
	Qp: 14 cfs with Average Frequency 1 per season Volume Bound is 170 Duration Bound is 12	Qp: 65 cfs with Average Frequency 1 per season Volume Bound is 470 Duration Bound is 11	Qp: 17 cfs with Average Frequency 1 per season Volume Bound is 140 Duration Bound is 9	Qp: 28 cfs with Average Frequency 1 per season Volume Bound is 240 Duration Bound is 10
	Qp: 7 cfs with Average Frequency 2 per season Volume Bound is 78 Duration Bound is 9	Qp: 14 cfs with Average Frequency 2 per season Volume Bound is 100 Duration Bound is 7	Qp: 4 cfs with Average Frequency 2 per season Volume Bound is 37 Duration Bound is 6	Qp: 8 cfs with Average Frequency 2 per season Volume Bound is 69 Duration Bound is 8
Base Flows (cfs)	2		1	
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

4.2 Nueces BBASC Recommendations for Estuary Freshwater Inflow Standards

The Nueces BBASC recognizes the need for specific bay and estuary inflow standards. The Nueces BBASC recommends that the Nueces BBEST estuary freshwater inflow volume recommendations with specific seasonal volumes be adopted as inflow standards, but that the attainment frequency goals, or how often those volumes are to be met, be modified to accommodate stakeholder efforts to balance environmental and water supply needs so that water supply projects might be permitted.

The environmental flow standard recommendations of the Nueces BBASC for freshwater inflows to Nueces Bay are presented in Table 4-2.1. In this table, recommended annual and seasonal freshwater inflow volumes for Nueces Bay are presented along with recommended attainment frequencies for subsistence, base, and high flow conditions. The Nueces BBASC recommends that compliance with these recommended freshwater inflow volumes be assessed by accounting for all freshwater inflows to Nueces Bay including gaged streamflow at Calallen (USGS# 08211500), measured runoff that is not measured by the streamflow gaging station at Calallen, diversions into Rincon Bayou and the Nueces Delta, and/or discharges of treated wastewater. Attainment frequency goals, i.e. how often the stated volumes are met, are shown in parentheses under the seasonal and annual volume targets.

Table 4-2.1. Nueces BBASC Flow Standard Recommendation, Nueces Bay

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime – Seasonal Targets (Attainment Frequency)			Recommendations Annual Volume (acft) (Attainment Frequency)
High (10)	125,000 acft (11%)	250,000 acft (11%)	375,000 (12%)	750,000 (16%)
Base (18)	22,000 acft (23%)	88,000 acft (30%)	56,000 (40%)	166,000 (47%)
Sub. (34)	5,000 acft (69%)	10,000 acft (88%)	15,000 acft (74%)	30,000 (95%)
	Winter = Nov–Feb	Spring = Mar–Jun	Summer/Fall = Jul–Oct	

The values in the first column labeled Condition (Target Salinity) are the same as recommended by the Nueces BBEST. The next three columns under Nueces Bay Freshwater Inflow Regime – Seasonal Targets are the volume targets for these seasons followed by the attainment frequency in parentheses. The last column sums up the annual volume targets for each condition and also provides the attainment frequencies in parentheses. The bottom row of the table defines the months in each season. Note that the Summer and Fall seasons are combined into one and include the months of July through October. Permitting of future new appropriations would consider be constrained by the attainment frequency goals in this table.

The Nueces BBASC also recommends that a special provision be included with the Environmental Flow Standard for the Nueces Bay and Estuary that provides the Nueces Estuary Advisory Council (NEAC) the opportunity to review and provide recommendations to TCEQ for application for new appropriations of water in excess of 500 acft/yr. This review allows for the possibility that NEAC could chose to recommend approval of an application violating specified attainment frequencies, but providing significant benefits to the bay and estuary through operations, permit conditions, or adaptive management.

The attainment frequencies in the Nueces BBASC Environmental Flow Standard Recommendation for Nueces Bay above were derived as the attainment frequencies achievable when the Corpus Christi water supply system (i.e. Choke Canyon Reservoir, Lake Corpus Christi, and firm and interruptible supplies water from Lake Texana) is operated to produce the 205,000 acft/yr safe yield supply. This analysis was performed using the CCWSM and is explained in Section 3.3.3. Note that these FWI attainment frequencies are more than what can be obtained under firm yield or full utilization of the existing water rights (see Appendix G for more detail).

While recognizing that there is ecological importance of periodic inundation of the Nueces Delta from overbanking events, the Nueces BBASC does not include a specific overbanking component in the recommendation. The Nueces BBEST defined an overbanking event as occurring when gaged streamflow at Calallen (USGS# 08211500) equals or exceeds 3,600 cfs and the volume passing this gage during the high flow pulse event equals or exceeds 39,000 acft. Overbanking of the Nueces River in this magnitude below Lake Corpus Christi results in the loss of property and access for individuals inhabiting this stretch of river and should not be recommended as part of a standard or a permit requirement.

For the same reasons discussed in Sections 1, 2, and 4 of the Nueces BBEST report, the Nueces BBASC has chosen not to provide freshwater inflow regime recommendations for Corpus Christi, Oso, and Baffin Bays or the upper Laguna Madre.

4.3 Water Right Permit Conditions

4.3.1 *Pulses and Overbanking*

From an ecological perspective, the Nueces BBASC recognizes that available hydrologic, biological, geomorphologic, and riparian vegetation data and professional judgment suggest that high flow pulses are necessary to provide in-channel flows of varying magnitude and duration, recruitment events for organisms, lateral connectivity, channel and substrate maintenance, limitation of riparian vegetation encroachment, in-channel water quality restoration after prolonged low flow periods, and freshwater and sediment inflows to bays and estuaries as necessary for long-term support of sound ecological environments. Similarly, the Nueces BBASC recognizes available hydrologic, biological, geomorphologic, and riparian vegetation data and professional judgment suggest that overbank flows are necessary to provide life phase cues for organisms, riparian vegetation diversity maintenance, conditions conducive to seedling development, floodplain connectivity, lateral channel movement, floodplain maintenance, recharge of floodplain water tables, flushing of organic material into the channel, nutrient deposition in the floodplain, restoration of water quality in isolated floodplain water bodies, and freshwater and sediment inflows to bays and estuaries as necessary for long-term support of sound ecological environments.

From water supply planning and operations perspectives, the Nueces BBASC recognizes that pulses, and particularly large pulses, will continue to occur, even subject to the effects of new infrastructure. It is for this reason, along with recognition of legal precedent associated with flooding and potential assignment of legal liability to owners of water rights, that the Nueces BBASC has not included pulses with peaks in excess of bank-full capacity (overbank flows) in its environmental flow standard recommendations. The ability of a new appropriation to significantly reduce the flow from a pulse is logically related to the diversion rate and/or impoundment capacity relative to the peak flow rate and/or volume associated with the pulse. A permit requirement to pass the pulse may place an administrative requirement on a project that could reduce the firm yield and/or increase the cost of a project without necessarily producing quantifiable benefits to the environment. Quantitative demonstration of environmental benefits of high flow pulses for instream aquatic and riparian habitats in the Nueces River Basin is limited. In addition, the multiple tiers of pulses are complex to the point of making administration, accounting, and operations difficult for both the TCEQ South Texas Watermaster and water suppliers up and down the river.

The Nueces BBASC has chosen to balance water supply and environmental considerations by recommending exemption of smaller diverters from high flow pulse requirements based on a ratio of their maximum diversion rate to the pulse peak. Specifically, the Nueces BBASC recommends a Pulse Exemption Rule under which an applicant would be exempt from all high flow pulse passage requirements for which the applicant's maximum diversion rate is less than 20 percent of the seasonal, bi-annual, annual, or multi-annual pulse peak shown in the Nueces BBASC environmental flow standard recommendations. This recommended Pulse Exemption Rule is illustrated in Table 4-3.1 for a hypothetical applicant seeking to divert from the Nueces River at Laguna. As shown by green marks in Table 4-3.1, an applicant seeking a maximum diversion rate of only 15 cfs would be exempt from all but the fall and winter one per season pulses. An applicant seeking a maximum diversion rate of 400 cfs, however, would only be exempt from the one per year and one per two years pulses as shown by the red marks in Table 4-3.1. Finally, an applicant seeking to construct an on-channel reservoir on the Nueces River at Laguna capable of impounding more than about 1900 acft in one day (20 percent of 4,750 cfs converted to acft/day) would be subject to all recommended high flow pulses.

Geomorphic or sediment transport analyses were performed by TWDB staff to assist the Nueces BBASC in formulating the high flow pulse component of its instream environmental flow standard recommendations. These analyses are summarized in Appendix L of this report. Evaluations of example run-of-river diversion projects on the Nueces River at Laguna and Cotulla (with off-channel storage) operated subject to Nueces BBASC environmental flow standard recommendations showed limited (7–13 percent) reductions in instream sediment transport relative to an historical baseline. Evaluation of an example on-channel reservoir project on the Nueces River at Cotulla operated subject to Nueces BBASC environmental flow standard recommendations, however, showed a more significant (62 percent) reduction in instream sediment transport relative to an historical baseline. The Nueces BBASC recognizes that the impacts of its high flow pulse environmental flow standard recommendations on firm yield are more significant for on-channel reservoir projects than for run-of-river diversions with off-channel storage. The Nueces BBASC also recognizes that the potential ecological effects of on-channel reservoir projects are more significant than those for run-of-river diversions with off-channel storage.

Table 4-3.1. Example Application of the Pulse Exemption Rule – Nueces River at Laguna

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600 Duration Bound is 64			
	Qp: 2,220 cfs with Average Frequency 1 per year Regressed Volume is 18,400 Duration Bound is 46			
	Qp: 590 cfs with Average Frequency 2 per year Volume Bound is 11,300 Duration Bound is 26			
	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
		Qp: 99 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 9		
Base Flows (cfs)	65		48	65
Subsistence Flows (cfs)	14	18	16	14

Pulse volumes are in units of acre-feet and durations are in days.

4.3.2 *Sediment and Nutrient Considerations*

4.3.2.1 Instream Geomorphic (Sediment Transport) Analysis

The TWDB, on behalf of the Nueces BBASC, analyzed changes in sediment transport that might occur in the Nueces basin with changes in flow patterns under different hypothetical water development project scenarios. The TWDB report of its analysis is included in Appendix L with a technical presentation included in Appendix J that was given to the BBASC. Analyzes were conducted for the Nueces River at Laguna, at Cotulla, and at Three Rivers. These analyses generally indicate how changes in flow due to hypothetical projects may affect sediment movement with a comparison of historical conditions and Nueces BBEST flow recommendations. These results were also used by the Nueces BBASC to make decisions on modifying the Nueces BBEST instream flow recommendations to meet human water needs.

A more detailed review of these results and decisions can be found in the Analysis Performed for the Nueces BBASC Section 3.3 of this report.

4.3.2.2 Nueces Bay and Delta Analysis

The Nueces BBASC acknowledges the importance of both sediment and nutrient loads transported by rivers and streams to the water quality in estuaries and bays and the health of these coastal ecosystems. The Nueces BBASC recognizes the issues raised by the Nueces BBEST that the Nueces River is the most significant source of sediment and nutrients to Nueces Bay and Delta. Below is a discussion on the importance of each constituent from the perspective of the Nueces BBASC.

<u>Sediment</u>

The Nueces BBEST described previous studies showing that Lake Corpus Christi is trapping 97% of the sediment transported by the Nueces River, the major source of flows and sediments into Nueces Bay. This is sediment that before the construction of Wesley E. Seale Dam and impoundment of water in Lake Corpus Christi would have reached the Nueces Estuary. The Nueces BBEST summarized the latest studies by Ockerman and Heitmuller 2010 which also suggest that current sediment supply to the Nueces Bay has been significantly reduced. The Nueces BBASC generally agrees with the Nueces BBEST that, due to Lake Corpus Christi's location of less than 50 miles from the mouth of Nueces Bay, and the fact that it effectively traps most of the sediment being transported by the Nueces River, instream flow recommendations made by the Nueces BBEST in the geomorphic overlay for upland river reaches are not likely to provide the necessary sediment inflows to maintain existing river deltas and tidal channels in the tidal marshes and subtidal environments.

The Nueces BBASC also agrees that overbanking events are beneficial for the ecological function of the river, bay, and delta, but the Nueces BBASC is not recommending the obligation of permit conditions to protect overbanking flows, rather that these types of events will occur naturally during storm events. Several factors influencing this decision include: 1) the reservoirs are not currently designed to release enough water needed to flow out of the banks of the river; 2) human development currently exists along the banks of the river; and 3) the quantity of water needed to create an overbanking event typically only occurs during natural storm events.

While sediment load downstream of Lake Corpus Christi has appeared to decrease, detailed impacts, benefits, deficiencies or needs associated with these reduced sediment loads have not been clearly defined by existing studies. Future considerations might include investigations that address spatial extent or location of impact (e.g., in the vicinity of the dam, along the Nueces River between the dam and the estuary, near the City of Corpus Christi water supply intake, and/or within the Nueces Delta) and should also address magnitude and character of sediment needs (i.e. daily or annual volumes of particular sediment grain size classes). Other studies may relate sediment loads to ecological needs, which may be species-specific and may include marsh maintenance, in-stream turbidity/clarity, and in-stream habitat including channel bed characteristics.

However, the Nueces BBEST did not attempt to quantify the sediment loadings necessary to maintain current bay and delta conditions. The Nueces BBASC agrees that this should be a major item of study included in the adaptive management section of this report.

Nutrients

The Nueces BBEST briefly described the relationship between freshwater inflow and nutrients in the Nueces River below the Calallen Dam. The data used in a study to explain the relationships came from fourteen monitoring stations that have been consistently sampled (mostly monthly) since 2001. Data showed that low flow (approx. 10 m^3s^{-1}, 700 acft d^{-1}) in the Nueces River below Calallen Dam causes stagnation and phytoplankton blooms (high chlorophyll-a concentrations).

As noted by the Nueces BBEST, nutrients are needed to sustain life and that excess nutrient loads from human activities may cause unbalanced and unhealthy changes in water quality that are harmful to aquatic organisms. Based on the limited nutrient data available, the Stakeholder Committee would like there to be ongoing studies designed to help characterize both sediment and nutrient load transported into Nueces Bay as related to localized periods of high flow and releases of water from reservoirs upstream in the watershed. Consistent with our approach for sediment loadings, the Stakeholder Committee has acknowledged the importance of nutrients but has not recommended any specific restrictions on diversion or impoundment based on nutrient loading.

Section 5. Recommendations Regarding Potential Strategies to Meet Environmental Flow Standards

Senate Bill 3 (SB3) mandates that each bay/basin area stakeholders committee: 1) develop recommendations on environmental flow standards; and 2) develop strategies to meet these standards. In the process of developing environmental flow standards recommendations for the Nueces River and Corpus Christi and Baffin Bays, the Nueces BBASC reviewed the Bay and Basin Expert Science Team (Nueces BBEST) report along with additional analysis presented to the stakeholders committee.

Strategy Options for Achieving Environmental Flow Standards

Below, the Nueces BBASC has provided a list of potential strategies that can be voluntarily implemented by current and future water rights permit holders and others to assist in meeting the instream and bay and estuary environmental flow standards recommended by the Nueces BBASC. This list of strategies is not intended to be exhaustive and many other options may exist. The Nueces BBASC will explore the feasibility of implementing specific strategies in its Work Plan.

Facility Operational Modification to Enhance Environmental Flows

- Modifying a facility's (e.g., a water treatment plant, a reservoir) operation and/or schedule of releases may help provide environmental flows to a river or bay. The amount and timing of releases from a facility or multiple facilities in a watershed could attempt to mimic natural flow patterns of the river system or inflow to a bay.

Water Right Management

- The existing location and timing of diversions of water rights in the basin may inhibit opportunities for better resource management Combinations of opportunities may exist whereby water right diversion points could be relocated, older rights used in conjunction with new water rights, or new water rights used in conjunction with currently unused rights to improve delivery efficiencies to both water users and the environment. Contractual agreements and permit amendments may be necessary.

Reduction of Groundwater Pumping for Spring Flow Protection

- Reducing groundwater pumping where practical may enhance spring flows to provide river flows.

Land Stewardship Watershed or Catchment Stewardship

- Use land management practices demonstrated to put more water into the water table. Seek local, regional, state, and federal funding and tax incentives for landowners to voluntarily implement such practices.
- A well-managed, healthy watershed can provide a desirable environment for livestock and wildlife and increase groundwater penetration and recharge. Flood attenuation and improved water quality are additional benefits resulting from proper watershed and riparian zone stewardship.
- Selective brush management and subsequent improved rangeland management can increase groundwater recharge and spring flows. Normally, Ashe juniper (cedar, mountain cedar) has been the target brush species, but in other cases mesquite control has produced desirable hydrological benefits. Similarly, removal of invasive plant species such as *Arundo donax* (Giant cane) from riparian areas may increase water availability by reducing evapotranspiration.
- Restored and healthy wetlands on the rivers or on the Gulf coast provide very productive wildlife habitat, filtering and cleansing actions desirable for inflows, and can protect inland communities from hurricanes and flooding.
- Investigate removal of water hyacinth from Lake Corpus Christi.

Explore Dedication of Water from Existing, New or Underutilized Permits to Environmental Flows

- Some permit holders may be willing to have conditions voluntarily placed on their permits, such as a certain percent or set amount of the water being dedicated to provide environmental flows.
- Agricultural or municipal water permit holders could voluntarily commit water saved through conservation measures to environmental flows.
- Investigate the availability of funding for agricultural water conservation practices (i.e. USDA Environmental Quality Incentives Program (EQIP) and other federal funding sources).
- Willing water permit holders donate, sell or lease all or part of their permit so that that water can stay in the stream for environmental flow protection. Permit may be changed to add instream and/or bay and estuary use. To be most effective, these permits would need to be firm water that is fairly senior. Use of a water trust can be helpful for keeping track of water dedicated for environmental flow purposes.

Municipal, Industrial, Mining and Agricultural Conservation to reduce water use and demand

- Water users within the Nueces River Basin, both large and small, should set goals to decrease future surface and/or groundwater use using the Water Smart Program (TWDB) or other conservation programs which best fit the entity's situation.
- Conservation programs/strategies may include stringent leak detection, low water use appliances, increasing block rate structures, customer education program, rainwater harvesting, use of recycled water and gray water, year round residential lawn watering schedules, xeriscaping, and others. Water harvesting projects can be eligible for state wide recognition from the TWDB water catchment awards program.
- Innovative technologies should be investigated and implemented to reduce evaporation from public water treatment plant reservoirs, i.e. physical covering of water holding basins with plastic balls or structural covering. Chemical covering maybe applicable in less windy environments.
- Implement advanced agricultural irrigation conservation strategies, including installation of more efficient water delivery systems (impervious canal liners, covered canals, pipelines, etc.), improved center pivot systems (i.e. LEPA systems), and in-ground moisture monitors, plus the planting of improved crop varieties and other farming methods.

Effluent Reuse

- The benefits of reuse wastewater to the ecological and reservoir system yield in the Nueces Delta have been well documented. Beginning in the early 1990s and continuing through today, research findings, scientific monitoring studies, and engineering reports have all supported the diversion and use of Allison WWTP effluent for fresh water inflow purposes and the enhancement of productivity in the Nueces Delta (Coastal Bend RWP 2011, Section 4C.5.1 thru Section 4C.5.3). However, recent regulatory TPDES permit limits require that the ammonia be reduced from the effluent, also reducing the ecological benefit to the estuaries. Discharges not meeting permitted levels currently required for discharge into the Delta are discharged to the river. Renewed efforts need to be made by the City of Corpus Christi, NEAC, and BBASC to work with TCEQ and EPA to increase the permitted level for ammonia (NH_3 as N) to the current Allison WWTP design capabilities. Higher limits would allow for an increase of environmental flows to the Delta by 2 MGD or a little under 2,245 acft per year.
- Industry also needs the flexibility to reuse effluent to reduce water demands. Reuse would allow for more fresh water to remain in the reservoirs, at times leading to increased flows to the bay and estuary. (Coastal Bend RWP 2011, Section 4C.6.3). BBASC encourages industry to re-examine their current water conservation and reuse practices for possible improvements.

Develop conjunctive use water projects

- To reduce reliance on surface water, particularly during drought conditions, water providers should be encouraged to develop conjunctive use water projects using both groundwater and surface water. Better data on groundwater availability is now available for local ground water districts and Groundwater Management Areas (GMAs) within the Nueces River Basin, including modeled available groundwater reports from the TWDB, increasing the certainty of groundwater use planning.

Develop alternative water supplies to increase availability of water for environmental flows

- Alternative water supplies, such as desalination of brackish groundwater or seawater desalination, can provide additional water for human uses as well as for environmental flows.
- Additional water supply projects could be developed to capture water during higher flows events to allow for releases to support the river/bay system during no or low flow periods or when needed. The projects could be off-channel surface water storage, aquifer storage and recovery (ASR), or a combination of off-channel storage and ASR.
- Explore potential for direct reuse of municipal and industrial waste water (e.g., by reverse osmosis treatment) for potable or other surface water supplies in some areas of the basins, where there is a net benefit to environmental flows.

Drought Contingency Plan Triggers

- Evaluate potential changes in the current City of Corpus Christi Water Conservation and Drought Contingency Plan to determine the impact on water supply, supply infrastructure and environmental flows. Consideration should be given to moving some measures now contained in the Drought Contingency portion of the plan into the Water Conservation section (i.e., implement year-round lawn watering schedules designed to minimize evaporation losses). Care should be exercised, however, to retain drought management measures which have the ability to significantly reduce water demand, on a temporary basis, during more critical stages of a drought so as to protect water supplies for both human and environmental needs.

Re-examination of the 2001 Agreed Order Monthly Targets

- The monthly targets that are in the 2001 Agreed Order were established about 20 years ago. A preliminary assessment of 20 years of inflow data (Appendix E) show that there is no longer a peak in inflow during the months of May and June for either the reservoirs or the bay. The data suggests that a redistribution of monthly targets to months when natural hydrological peaks occur might benefit both the public water supply in the form of salinity credits, as well as the bay.

Salinity Monitoring and Real Time (SMART) Inflow *Management*

- Obtaining environmental enhancements based on a desired salinity range may be achieved through seasonal timing of releases made available from reservoir pass-through, combined with real- time knowledge of the current bay salinity condition and near and long term weather and climate forecasting. SMART Inflow Management may include some or all of these considerations and may be specified for year-round or by season. The Nueces BBASC has initiated some preliminary modeling work on banking water (storing in the reservoir) for later pass-through when conditions in the bay and/or delta might benefit more from a pulsed event, and the results look promising (Appendix H). Further analysis should be conducted to determine full impact on reservoir operation, system storage, water supply, and bay enhancements by incorporating ungaged flow data and analysis from the TXRR model.

Explore Landform Modifications to Nueces Bay and Nueces Delta

- Throughout the world, construction of water control structures has been used for effective management of fish and wildlife habitat and protection preferred natural resources. Maximizing the benefits of available freshwater inflows from managed events such as pumped discharge, low volume natural or inducted "overbank", and/or reuse of effluent, will likely require earthwork and related facilities of landscape scale within the Delta. Similarly, construction of appropriate design facilities in the Bay proper to ensure longer retention of desired salinity levels at Salt 3 from spills or pass-through events should be explored. Preliminary modeling performed by the TWDB (Matsumoto et al, 2000) for a hypothetical structure in Nueces Bay indicated a potential for salinity reduction benefits. These landforms can also provide erosion protection, platforms for wetland and reef habitat development and they should be reinvestigated.
- A large scale earthwork project in the mid 1980s and early 1990s in the Nueces Delta intentionally created conditions suitable for the survival and continued persistence of *Spartina alterniflora* (smooth cordgrass). The results were achieved without requirement for freshwater to ameliorate hypersaline soil conditions. The mechanics of this large scale project are known and can be adapted for application within the Delta.

Use of Oil Spill Restoration and Other Mitigation Funds for Water Use Efficiency and Conservation

- Use oil spill restoration (e.g., Early Restoration Funds, NRDA Funds, and/or Clean Water Act Funds from Restore Act), Supplemental Environmental Program (SEP), and other fund sources such as from in-lieu mitigation, to develop proposals for current senior water right owners to convert to other less water intensive business uses and/or dedicate water for environmental flows. This concept of funding use could be applied, as examples, to convert to xeriscape the small to large private or public urban landscapes that depend on heavy water use, and/or implement projects that improve quantity or utilization of flows to Nueces Delta and Bay.

Section 6. Status of Work Plan and Adaptive Management

6.1 Background

Pursuant to SB3 of the 80th Texas Legislature, as quoted below, the Nueces BBASC is charged with development of a Work Plan to be submitted to the Environmental Flows Advisory Group (EFAG) for approval.

> *In recognition of the importance of adaptive management, after submitting its recommendations regarding environmental flow standards and strategies to meet the environmental flow standards to the commission, each basin and bay area stakeholders committee, with the assistance of the pertinent basin and bay expert science team, shall prepare and submit for approval by the advisory group a work plan. The work plan must:*
>
> *(1) establish a periodic review of the basin and bay environmental flow analyses and environmental flow regime recommendations, environmental flow standards, and strategies, to occur at least once every 10 years;*
>
> *(2) prescribe specific monitoring, studies, and activities; and*
>
> *(3) establish a schedule for continuing the validation or refinement of the basin and bay environmental flow analyses and environmental flow regime recommendations, the environmental flow standards adopted by the commission, and the strategies to achieve those standards.*

Future work, referred to as "adaptive management", will be conducted within the context of the Work Plan. The Work Plan will be completed and submitted after submission of the Nueces BBASC's Recommendations Report. However, the Nueces BBASC has begun to identify items for inclusion in the Work Plan and, while not complete or prioritized, believes the items being considered, to date, may be of interest to the EFAG and others as indications of adaptive management actions being considered.

The Nueces BBASC recommends that a *periodic review of the basin and bay environmental flow analyses and environmental flow regime recommendations, environmental flow standards, and strategies occur at least once every 5 years.*

6.2 Future Research, Data Collection, Monitoring and other Adaptive Management Work Plan Activities

At this point, the Nueces BBASC Work Plan, largely, includes monitoring, studies, and activities recommended by the Nueces BBEST in its Environmental Flows Recommendations Report (October 2011), with a few others added by the Nueces BBASC.

The following list of adaptive management activities will be modified by the Nueces BBASC when actual Work Plan development begins.

Work Plan subjects are categorized based on relevance to rivers and streams, bays, and basin-wide.

RIVERS AND STREAMS

1. Describe relationships between flow and physical, chemical, and biological structure and function of the streams and how these relationships support ecological health. (BBEST)

There has been practically no study of the interrelationships between environmental flow regime components and stream health in the Nueces basin. It would be valuable to analyze the results of future studies and monitoring described in the work plan in a holistic manner to improve understanding of flow and environmental health in Nueces basin streams.

2. Describe the role of flow in the ecological health of the stream. (BBEST)

This is an overarching goal that could be accomplished by combining information collected from 2011 through 2020 in the upcoming period between review of the standards with earlier data. The next work plan report could summarize results of monitoring and studies conducted in the basins for this adaptive management process and obtained from other sources during the interim. The focus of the report would be on relationships between flows and ecological health in a minimum of two representative streams in each of the Edwards Plateau, South Texas Brush Country, and Coastal Bend reaches. One stream in each reach would be perennial and the other intermittent with perennial pools.

3. Identify stream locations and estuaries not included in the BBEST environmental flow regime report that should be analyzed for relationships between flow and environmental health. (BBEST)

This would be a desk-top study based in part on review of expected water demands and availability identified by regional water planning. This review would help identify water bodies that may have future water rights applications for diversions.

4. Conduct additional modeling of relationships between in-stream habitat and flow. (BBEST)

The BBEST and its contractors made considerable progress in understanding relationships between instream habitat suitability, however the work was based on fish habitat relationships from streams outside the basin, was only conducted at three sites, and was only conducted under one flow condition at two of the sites. Factors possibly complicating this analysis include human alterations to physical habitat not associated with flow like channel clearing and shaping for flood control, invasion of noxious plants (giant cane) or animals (armored catfish) that alter physical habitat. Specific tasks may include:

- Suitable habitat may be in small, disconnected patches and higher or lower flows might be needed to connect or increase size of suitable habitat patches. In order to address this, a habitat mapping approach such as a 2-dimensional model (e.g., River2D) or MesoHabSim that produces a spatially explicit, continuous map of habitat at the site at multiple flow levels would be necessary to evaluate how patches of habitat are connected at different flows.
- Develop habitat suitability models for non-native species. Such models would help evaluate potential interactions between modified flow regimes and likelihood of establishment of non-native species (most of which are adapted to relatively stable deep water habitats).
- Collect basin-specific information about the instream habitats utilized by different species of fish and their different life stages.
- Collect more habitat utilization data from different streams and at different flows.
- Model hydraulic conditions under several different flows.

Sample the cross-sections measured at these three sites to obtain at least one additional set of hydraulics measurements near the middle or upper end of the base flow recommendations. This would allow evaluation of another source of uncertainty, the stage-discharge rating curves used at each site.

5. Describe ecological services provided by perennial pools. (BBEST)

There are a number of streams in the Nueces basin which stop flowing at times. Little is known about the ecological structure and function of these pools and particularly the relation of their environmental health to flow. It is important to study how the different flow regime components support environmental health in these perennial pools.

This could be a special study conducted on at least one stream in each of the Edwards Plateau, South Texas Brush Country, and Coastal Bend reaches with a report summarizing results produced by the next report. Some monitoring programs do not collect information from perennial pools when there is no flow. In some cases there may be questions about how to access streams for sampling when there is no flow and the perennial pool is not near the established monitoring site. Existing monitoring programs could be asked to monitor physical, chemical, and biological conditions when streams stop flowing and form perennial pools. This sampling would focus on fish, benthic macroinvertebrates, mussels, riparian plants, and as resources permit, wildlife using the riparian zone. It would also focus on seasons when perennial pools are most likely to occur. Water chemistry would be monitored in conjunction with biological monitoring and, preferably, continuous recording water quality meters would be installed.

6. Identify flow regime components and quantities necessary to sustain mussels and compare to flow regimes identified necessary to sustain fish communities. (BBEST)

Some streams in the Nueces basin have diverse mussel communities with at least 11 species, including the state-listed threatened golden orb, found at sites on the Nueces River between Cotulla and Lake Corpus Christi. Some species may live over 100 years. Very little is known about the distribution of mussels, their life stages, life cycles, and relationships to flow. Some species depend on certain species of fish to complete the parasitic life stage of the mussel.

This could be a special study including a special survey to identify where mussels are living in the basin, with greater emphasis initially on threatened species. Special studies would then be conducted on at least two streams to describe the life histories of the mussels and their relationships to different environmental flow regime components. An interim report would be produced sometime in the future, including specific recommendations for future study. Since TPWD has listed 15 species of mussels as threatened and the U.S. Fish and Wildlife Service is considering listing some of those same species as federally threatened species, it is possible there may be funding readily available for this work, particularly through the U.S. Fish and Wildlife Service's State Wildlife Grant program than for other monitoring described here.

7. Describe how surface flow patterns and quantities are changing compared to the period of record patterns. Include consideration of possible future flows and diversions. (BBEST)

Flow patterns vary naturally over time. Some flow patterns may be relatively long and influenced by several different global climate drivers, e.g., Southern Pacific Oscillation, North Atlantic Oscillation, etc. Some streams in the basin have very limited records of flow, in some cases only back to the early 1970s. It will be important in considering whether there should be changes to environmental flow standards to understand if, and how flow patterns have changed from the patterns used to develop the flow recommendations in this report.

Preliminary flow data review would be conducted every three years and recommendations would be issued regarding the continuation of monitoring at gages and the addition of flow monitoring at new sites.

8. Describe groundwater flow into streams and how is it changing. (BBEST)

Aerial photography and anecdotal reports of landowners indicate there are perennial pools that have not dried up in recent history. These pools are being sustained by groundwater input. Groundwater and surface water interchange may be much more important in this relatively arid part of Texas.

This may require creation of long-term groundwater monitoring locations combined with special studies analyzing relationships between groundwater levels, stream flows, groundwater withdrawals, land cover/use patterns, and meteorological conditions for specific streams. Monitoring could be designed to last 50 years out into the future to capture long-term patterns in groundwater-surface water interchange. Special studies analyzing relationships between groundwater levels, stream flows, and groundwater withdrawals, combined with a review of monitoring data could be conducted every 5-10 years.

9. Describe relationships between benthic macroinvertebrates and flow. (BBEST)

Very little is known about benthic macroinvertebrates in Nueces basin streams. Stream macro-invertebrates are periodically decimated by natural disturbances, such as floods and droughts (Resh, et al., 1988). Flow regime plays a major role in structuring habitat conditions for stream macroinvertebrates through direct effects, as well as interaction with substrate, food supply and physico-chemical parameters

(Ward, 1992). Benthic macroinvertebrates are reliable indicators of localized alterations in streams (Rosenberg and Resh, 1992) and are being increasingly used in evaluating effects of hydrology and habitat changes. Rapid bioassessment protocols have been developed for benthic macroinvertebrates and additional quarterly monitoring of benthic macroinvertebrates in conjunction with water quality monitoring would help clarify relationships between benthic macroinvertebrates and flow.

10. Identify water development activities planned for the future, and how they might influence groundwater, river flows, and physical and hydrologic connections between the two. (BBEST)

Human population is predicted to double and there will be changing demands for surface water and groundwater as there are changes in industrial, agricultural, and oil and gas exploration water uses.

Water development possibilities identified in the regional water plans and from other sources should be evaluated. These studies would start as desk-top studies involving the prioritization of possible water development activities to evaluate. Desk-top studies would then compile and review available information about groundwater, stream flow, and possible links between the two in the area of the planned water development. As necessary, field studies would be conducted to provide needed information. Possible water development activities are likely to occur distant from the sites for which environmental flow regimes have been identified. Groundwater/surface water linkages between the location of the possible water development and the site where environmental flow standards have been set should be understood.

11. Describe changes in geomorphology, i.e. trends in channel elevation, longitudinal profile, width, floodplain width, stream form, bed sediment size, and the role the flow regime contributes to those changes. (BBEST)

The relatively short amount of time which the BBEST had to develop environmental flow recommendations did not permit in-depth analysis of the relationships between channel shape and flow. Channels move and change, but maintain a dynamic equilibrium within the range of historic flows. A substantial change in the historic flow patterns used to develop the flow recommendations may cause the channel shape to change beyond its dynamic equilibrium. If the channel shape changes substantially, it alters the relationships between flow and aquatic habitat and the riparian community.

This would be a desk-top study utilizing available data and aerial photography for at least two representative streams in each of the three reaches. Review of available literature review would guide identification of additional field data and/or aerial photography that should be collected. Indicators of change in channel morphology and their levels useful in identifying ecologically harmful changes in channel morphology would be identified. The cumulative impacts of multiple, relatively small, diversions on channel morphology would be evaluated in this analysis. Limited availability and resolution of Light Detection and Ranging (LIDAR) data that measures ground surface elevation along with the dynamic nature of stable channels could complicate this analysis.

12. Identify the best period of record to use in deciding which hydrologic condition and hydrologic triggers should be used. (BBEST)

If the TCEQ establishes environmental flow standards with multiple base flows, the TCEQ will identify a hydrological condition and triggers which direct how water diversions to different levels of base flow are made.

This will be a desk-top study of flows and climate for a minimum of two sites in each of the Edwards Plateau, South Texas Brush Country, and Coastal Bend. Consideration will be given to how well the hydrologic condition represents the actual flow regime, the ability of the hydrologic condition and triggers to represent the natural variability of flows, and the ease with which the hydrologic triggers can be used by the regulated community.

13. Identify key flow-dependent ecosystem functional (create ecological structure) processes associated with a sound ecological environment. (BBEST)

Riverine ecosystems are complex systems of interacting abiotic and biotic components. To manage these systems effectively, a basic understanding of these interactions (such as food web dynamics, reproductive cues, species recruitment, and colonization) is required. Attempting to manage a riverine ecosystem without adequate understanding of such processes can be problematic.

This should be a desk top study at this time given the substantial lack of information on the ecological structure of the streams and riparian zones of the Nueces River Basin. The work plan should identify and evaluate key ecosystem processes and services, such as elemental cycling and the productivity of important plant and animal populations in a minimum of two representative streams in each of the Edwards Plateau, South Texas Brush Country, and Coastal Bend reaches. Examples include primary production (periphyton, macrophytes), secondary production, organic matter dynamics (coarse particulate organic matter, fine particulate organic matter), trophic level dynamics and food webs, resistance and resilience of stream communities to drought and floods, invasive species impacts to water quantity and quality (giant cane, salt cedar), invasive species effects on interspecific competition (e.g., giant cane and historical riparian community, zebra mussels and native mussels).

14. Develop sustainability boundary analysis. (BBEST)

The primary tasks that need to be addressed in further development of the sustainability boundaries analysis are evaluation of other measures of flow to build boundaries around and to evaluate the best alteration thresholds to define sustainability. The Nueces BBEST experimented with mean monthly flow in this analysis to define normal conditions, but the work plan should evaluate other potential measures of normal flow conditions. These might include simple measures of flow variability such as median daily or monthly flows across the period of record. They could also be flow components such as base dry flows by month or high flow pulses. The Nueces BBEST's initial analysis used the 10% and 20% thresholds suggested by Richter et al. 2011, but more extensive use of this method should not be made without evaluating and potentially modifying these thresholds or considering other bases (e.g., standard deviation) for defining thresholds. One way thresholds might be evaluated is through flow-ecology relationships built from ecology data from a suite of streams with a range of levels of flow alteration across the Nueces River Basin, central Texas, or all of Texas.

The work plan might also involve application of the sustainability boundaries approach to other locations in the Nueces River Basin. This would involve using FRAT or other tools to develop time series of flow for other locations to evaluate flow recommendation implementation scenarios.

BAYS

15. Describe relationships between freshwater inflow to bays and physical, chemical, and biological structure and function of the estuaries and how these relationships support ecological health. (BBEST)

It would be valuable to analyze the results of future studies and monitoring in a holistic manner to improve understanding of flow and environmental health in Nueces basin estuaries. This is an overarching goal that would be accomplished by combining information collected in the upcoming period between review of the standards with earlier data. The next work plan report would summarize results of monitoring and studies conducted for this adaptive management process and obtained from other sources.

The BBEST report focused on relationships between inflow and ecological health in Nueces Bay where most freshwater impact occurs. However, the BBEST did not conduct in-depth analysis of freshwater inflows and environmental health in other related bays systems. For future studies, assessment would be conducted on the importance of freshwater inflow to Corpus Christi and Oso bays. Planning would begin for freshwater inflow studies for the hypersaline areas Baffin Bay and the upper Laguna Madre as well.

16 Describe and design studies to address relationships between abundance of fish and shellfish in the bay and bay salinities. (BBEST)

The BBEST's initial study relied heavily on TPWD's substantial database that includes species and abundance of fish and shellfish as well as salinity when samples were collected. This is certainly one of the best coastal fisheries monitoring programs in the world. However, it is not designed to address some site specific fine-scale questions like those dealing with salinity and fisheries abundance. Monitoring should continue, but this program should be expanded to address specific regional questions that are not readily possible with the current design of the TPWD monitoring program. Synoptic surveys should be designed specifically to describe relationships between abundance of important estuarine fish and shellfish and salinity. These directed studies would greatly enhance our understanding of freshwater inflows on fish and shellfish in this region.

17. Identify improvements made in methods for determining environmental flow regimes for estuaries. (BBEST)

Intensive literature review combined with expert meetings and consultation would be conducted to stay abreast of latest developments in this field of science, particularly as it relates to freshwater inflows from arid watersheds into estuaries. New techniques would be evaluated and applied to Nueces Bay, as appropriate.

18. Describe the relationship between freshwater inflow and location and area of oyster reefs, and health and abundance of oysters in Nueces Bay. (BBEST)

Historical information indicates oysters were much more abundant in Nueces Bay 70–100 years ago. Recent information is lacking for this important estuarine indicator due to lack of monitoring and studies on this species in the region.

Oysters should be mapped every 5 years with side-scan sonar (this may be done by TPWD since it has acquired side-scan sonar capability), and related to inflow. Dermo monitoring by the Oyster Sentinel program would be continued. Water quality monitoring (temperature, salinity, oxygen, and pH) would be conducted with continuously recording meters placed on the reefs in the locations where Oyster Sentinel samples would be collected. Oyster reef mapping would help understand oyster response to freshwater inflow to the bay. It would also create a baseline which would help evaluate any strategies to improve conditions for oysters in the bay.

19. Evaluate potential for Allison wastewater effluent with its nutrients and other return flows (e.g., Oso Bay returns) to improve environmental health of the Rincon Bayou delta. (BBEST/BBASC)

Assessing alternative sources of water such as treated effluent from the Allison wastewater treatment plant that is discharged into the Rincon Bayou delta could be important in the future. The wastewater discharge permit requires a significant amount of ammonia-nitrogen removal from the effluent before it can be discharged into the delta. Moving the entire discharge to the delta would require a change in the discharge permit requirements.

Analysis should be conducted to determine the volume of wastewater and nitrogen that could be added to the Rincon Bayou delta from the Allison wastewater treatment plant and other areas such as those being released to Oso Bay. This analysis should also involve an assessment of the regulatory changes necessary to maximize the contribution of the wastewater treatment plants to the delta's environmental health.

20. Identify vegetation/marsh changes occurring in the Rincon Bayou delta and relationship of those changes to freshwater inflow. (BBEST)

Health of the marsh plant community in the Rincon Bayou delta has been used to demonstrate effects of changes in freshwater inflow. Continue field studies in the Rincon Bayou delta to track changes in vegetation and marsh condition and relate those changes to freshwater inflow patterns.

21. Define ecological effects of zero flow event duration, intervals between periods of zero flow, and long-term frequency of zero flow occurrences. (BBEST)

From 1989 to October 2011, 18 percent of the days have had no flow from the Nueces River into Nueces Bay. Only one of 23 years during this period has had flow every day. Some no flow periods have lasted for two consecutive months.

Monitoring, research, and studies are on-going and planned for Nueces Bay and the Nueces delta. Attention should be placed in these studies and future studies to ensure information collected can also be used to evaluate how periods of no flow are affecting ecological health of the bay and delta.

22. Continued monitoring of Vegetative Indicators. (BBEST)

Two marsh plant species proved to be useful indicators of the timing and quantity of freshwater inflows. Smooth cordgrass (*Spartina alterniflora*) abundance was strongly correlated with freshwater inflows because it is found adjacent to tidal creeks where it is directly impacted by the salinity of tidal creek water. *Borrichia frutescens*, the primary competitor of *S. alterniflora*, is found at higher elevations where salts concentrate in dry well drained sediments. Freshwater inflows are important because they flush accumulated salts from sediment porewaters and maintain adequate soil moisture. Future monitoring should assess whether decreased freshwater inflows are altering the competitive balance among plant species or impacting their distributions. Detailed investigations on the spatial and temporal variability of environmental variables such as porewater salinity are necessary in order to predict the response of vegetation communities to changes in freshwater inflow. Future monitoring of environmental conditions in the Nueces Delta should include porewater measurements taken over a variety of spatial and temporal scales. Previous studies have collected data from selected sites on a quarterly or monthly basis. In contrast to quarterly or monthly monitoring schemes, continuous monitoring can resolve the impact of individual freshwater inflow events. Low cost continuous monitoring of porewater conditions via remotely deployed sensors would enable researchers to investigate the importance of freshwater inflow to vegetation health.

23. Salinity Monitoring and Real Time (SMART) Inflow Management. (BBASC)

Managed flow regimes to enhance environmental benefits can result from timely pass-through releases based on the salinity range desired, constraints on timing of year, on current conditions in the bay, and on future weather forecasts (near and long term). SMART Inflow Management may include some or all of these considerations, and may be specified for year-round or by season.

The Nueces BBASC has initiated some preliminary modeling work on banking water (storing in the reservoir) for later pass-through when conditions in the bay and/or delta might benefit more from a pulsed event, and the results look promising (Appendix H)**.** The early analysis show that there could be some advantage to the bay ecology in creating a more consistent salinity gradient throughout the estuary as well as some economic benefits to the reservoirs without significant impact to water supply.

Further analysis should be conducted to determine full impact on reservoir operation, system storage, water supply, and bay enhancements.

24. Re-examination of the 2001 Agreed Order Monthly Targets. (BBASC)

The monthly targets that are in the 2001 Agreed Order were established about 20 years ago. A preliminary assessment of 20 years of inflow data (Appendix E) show that there is no longer a peak in inflow during the months of May and June for either the reservoirs or the Nueces Bay. The data suggests that a redistribution of monthly targets to months when natural hydrological peaks occur might benefit both the public water supply in the form of salinity credits, as well as the Nueces Bay.

25. Safe Yield Demand vs. current demand. (BBASC)

The Corpus Christi Water Supply Model (CCWSM) developed and used by HDR Engineering calculates the full use of the current safe yield of the system at 205,000 acft/yr. Actual annual water use under current demands is around 133,000 acft/yr. Safe yield is defined as the volume of water that can be withdrawn from the system every year of the simulation period such that the minimum storage during a repeat of the drought of record results in a minimum storage of 75,000 acft remaining in the system. Concern was raised by several Nueces BBASC members about how demand on the reservoir system (Choke Canyon Reservoir and Lake Corpus Christi combined) will continue to grow from current levels which will result in less inflows to the bay compared to today's condition. Note that the average usage over the last 20 years is closer to 120,000 acft, but 2 out of the last 3 years have been over 133,000 acft. In the future, as full utilization becomes reality, the reservoir system will be at lower capacities more often, requiring less water to be passed through to the bay due to lower monthly targets established in the 2001 Agreed Order.

Since the Nueces BBASC is recommending attainment frequencies modeled by the CCWSM based on utilization of the safe yield, then current conditions in the bay can only become less ecologically sound as freshwater going to the bay becomes reduced over time (see Appendix G). It is recommended that this issue be investigated further through the adaptive management process already in place with the Nueces Estuary Advisory Council to make sure that the Nueces BBASC's goals of protecting safe yield of the system while also improving conditions in Nueces Bay and Delta are achieved. Under the current Nueces BBASC recommendations, the attainment frequencies for bay inflows do not appear to be sufficient to maintain a sound ecological environment today or in the future.

26. **Explore Landform Modifications to Nueces Bay and Nueces Delta. (BBASC)**

Evaluate land form modifications within the delta and bay necessary to maximize benefits of fresh inflow from all sources in all seasons and climates. Management of fresh water for environmental outcomes regularly rely upon use of water control structures such as diversion and distribution channels, barriers, sills, levees, weirs, pumps and similar appurtenances. The volume and availability of fresh water inflows to the Nueces Delta and/or Bay are frequently limited. The current use of pumping and suggestions for possible future changes in operational practices or redirection and reuse of waste water discharges may increase the water available but extensive earthwork and related infrastructure/land form modifications may be necessary to optimize the utilization of inflows.

BASIN-WIDE

27. Implement a program to evaluate effectiveness of strategies to meet environmental flow standards used in areas where there may be inadequate amounts of water for an environmentally sound stream or estuary. (BBEST)

Part of this program would involve the design of desk-top or field studies to determine strategy effectiveness in: 1) restoring or providing ecological structure and function provided by a sound flow regime; or 2) restoring environmentally sound flow regimes.

28. Implement a program to evaluate possible effects of climate change and sea level rising on water resources and the ecological health of the Nueces Basin and associated bays. (BBEST/BBASC)

Clearly, with increasing demand for water from a variety of current and future users, water supply for bay ecological health has the potential to be compromised. Moreover, the BBEST report did not address any changes in supply due to climate change-water availability relationships. Studies should be performed to assess future water supply and its impact on the environment in terms of conservation, alternative water supplies such as pipelines, relationships between groundwater and surface waters, desalination potential, and other methods to maintain supply of freshwater inflow to the estuary. The studies should be Nueces Basin specific and identify and describe the range of consequences of global warmed climate change on water resources, water supplies, and the ecological health of the Nueces Basin and Nueces, Corpus Christi and Baffin bays. The results of these studies will be useful to the Nueces BBASC in its adaptive management work and to regional water supply planners and managers.

6.3 Form of Work Plan

The Work Plan will include "scopes of work" for each activity that will provide:

- Cost, budget and funding
- Activity Identification
- Activity Priority
- Dependency on other Work Plan activities
- Description of what is needed to be done
- Description of monitoring, special studies, research, or modeling needed
- Description of why the activity is needed
- Description of where the activity will take place
- Activity Schedule
- People and organizations involved and their respective responsibilities

6.4 Work Plan Product

On or before the 5th anniversary of TCEQ's adoption of environmental flow standards for the Nueces basin, the Nueces BBASC will submit a report to the TCEQ and Environmental Flows Advisory Group that will:

- Summarize relevant monitoring, special studies, and research done;
- Validate or suggest refinement of the BBEST's 2011 environmental flows analyses and recommendations;
- Describe environmental flow regimes for sites not included in the original BBEST and BBASC recommendations, as appropriate;
- Validate TCEQ's environmental flow standards or suggest refinements to those standards; and
- Validate strategies implemented to provide environmental flows or, where appropriate, propose new strategies or refinements to existing strategies.

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Appendix A – Nueces BBASC Environmental Flow Standard Recommendation Tables

Table A.1. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River at Laguna

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600 Duration Bound is 64			
	Qp: 2,220 cfs with Average Frequency 1 per year Regressed Volume is 18,400 Duration Bound is 46			
	Qp: 590 cfs with Average Frequency 2 per year Volume Bound is 11,300 Duration Bound is 26			
	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
		Qp: 99 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 9		
Base Flows (cfs)	65	65	48	65
Subsistence Flows (cfs)	14	18	16	14

Pulse volumes are in units of acre-feet and durations are in days.

Table A.2. Nueces BBASC Environmental Flow Standard Recommendation, West Nueces River near Brackettville

<table>
<tr><td rowspan="5">High Flow Pulses</td><td colspan="12">Qp: 11,200 cfs with Average Frequency 1 per 5 years
Regressed Volume is 39,200
Duration Bound is 48</td></tr>
<tr><td colspan="12">Qp: 4,090 cfs with Average Frequency 1 per 2 years
Regressed Volume is 16,200
Duration Bound is 40</td></tr>
<tr><td colspan="12">Qp: 1,020 cfs with Average Frequency 1 per year
Regressed Volume is 4,810
Duration Bound is 31</td></tr>
<tr><td colspan="12">Qp: 25 cfs with Average Frequency 2 per year
Volume Bound is 360
Duration Bound is 16</td></tr>
<tr><td colspan="4"></td><td colspan="3">Qp: 5 cfs with Average Frequency 1 per season
Volume Bound is 76
Duration Bound is 10</td><td colspan="3">Qp: 5 cfs with Average Frequency 1 per season
Volume Bound is 84
Duration Bound is 13</td><td colspan="2"></td></tr>
<tr><td>Base Flows (cfs)</td><td colspan="12">1</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="12">1</td></tr>
<tr><td></td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td></tr>
<tr><td></td><td colspan="4">Winter</td><td colspan="3">Spring</td><td colspan="3">Summer</td><td colspan="2">Fall</td></tr>
</table>

Pulse volumes are in units of acre-feet and durations are in days.

Table A.3. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River Below Uvalde

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 6,920 cfs with Average Frequency 1 per 2 years Regressed Volume is 57,100 Duration Bound is 73			
	Qp: 2,550 cfs with Average Frequency 1 per year Regressed Volume is 19,500 Duration Bound is 49			
	Qp: 510 cfs with Average Frequency 2 per year Volume Bound is 8,240 Duration Bound is 26			
	Qp: 13 cfs with Average Frequency 1 per season Volume Bound is 100 Duration Bound is 5	Qp: 110 cfs with Average Frequency 1 per season Volume Bound is 1,280 Duration Bound is 11	Qp: 15 cfs with Average Frequency 1 per season Volume Bound is 100 Duration Bound is 4	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 690 Duration Bound is 11
		Qp: 20 cfs with Average Frequency 2 per season Volume Bound is 200 Duration Bound is 6		
Base Flows (cfs)	21		17	19
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.4. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River at Cotulla

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
High Flow Pulses	Qp: 96 cfs with Average Frequency 1 per season Volume Bound is 1,570 Duration Bound is 20								Qp: 100 cfs with Average Frequency 1 per season Volume Bound is 1,030 Duration Bound is 16			
	Qp: 8 cfs with Average Frequency 2 per season Volume Bound is 100 Duration Bound is 13					Qp: 190 cfs with Average Frequency 2 per season Volume Bound is 2,370 Duration Bound is 17					Qp: 35 cfs with Average Frequency 2 per season Volume Bound is 360 Duration Bound is 14	
						Qp: 15 cfs with Average Frequency 3 per season Volume Bound is 150 Duration Bound is 11						
Base Flows (cfs)	6					10			7		15	
Subsistence Flows (cfs)	1											
	Winter					Spring			Summer		Fall	

Pulse volumes are in units of acre-feet and durations are in days.

Table A.5. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River at Tilden

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 300 cfs with Average Frequency 1 per season Volume Bound is 4,610 Duration Bound is 22	Qp: 880 cfs with Average Frequency 1 per season Volume Bound is 12,200 Duration Bound is 22	Qp: 320 cfs with Average Frequency 1 per season Volume Bound is 4,390 Duration Bound is 21	Qp: 840 cfs with Average Frequency 1 per season Volume Bound is 10,900 Duration Bound is 23
	Qp: 87 cfs with Average Frequency 2 per season Volume Bound is 1,260 Duration Bound is 18	Qp: 280 cfs with Average Frequency 2 per season Volume Bound is 3,360 Duration Bound is 18	Qp: 11 cfs with Average Frequency 2 per season Volume Bound is 96 Duration Bound is 10	Qp: 220 cfs with Average Frequency 2 per season Volume Bound is 2,390 Duration Bound is 16
	Qp: 9 cfs with Average Frequency 3 per season Volume Bound is 110 Duration Bound is 12	Qp: 89 cfs with Average Frequency 3 per season Volume Bound is 930 Duration Bound is 14		Qp: 29 cfs with Average Frequency 3 per season Volume Bound is 250 Duration Bound is 10
		Qp: 8 cfs with Average Frequency 4 per season Volume Bound is 60 Duration Bound is 8		
Base Flows (cfs)	1	3	1	12
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.6. Nueces BBASC Environmental Flow Standard Recommendation, Frio River at Concan

<table>
<tr><td rowspan="6">High Flow Pulses</td><td colspan="12">Qp: 8,860 cfs with Average Frequency 1 per 5 years
Regressed Volume is 79,000
Duration Bound is 104</td></tr>
<tr><td colspan="12">Qp: 4,870 cfs with Average Frequency 1 per 2 years
Regressed Volume is 41,700
Duration Bound is 76</td></tr>
<tr><td colspan="12">Qp: 1,780 cfs with Average Frequency 1 per year
Regressed Volume is 14,300
Duration Bound is 45</td></tr>
<tr><td colspan="12">Qp: 540 cfs with Average Frequency 2 per year
Volume Bound is 9,430
Duration Bound is 24</td></tr>
<tr><td colspan="4">Qp: 89 cfs with Average Frequency 1 per season
Volume Bound is 2,100
Duration Bound is 12</td><td colspan="3">Qp: 300 cfs with Average Frequency 1 per season
Volume Bound is 3,550
Duration Bound is 12</td><td colspan="3">Qp: 240 cfs with Average Frequency 1 per season
Volume Bound is 2,990
Duration Bound is 13</td><td colspan="2">Qp: 79 cfs with Average Frequency 1 per season
Volume Bound is 900
Duration Bound is 5</td></tr>
<tr><td colspan="4"></td><td colspan="3">Qp: 120 cfs with Average Frequency 2 per season
Volume Bound is 1,320
Duration Bound is 8</td><td colspan="3">Qp: 43 cfs with Average Frequency 2 per season
Volume Bound is 400
Duration Bound is 4</td><td colspan="2"></td></tr>
<tr><td>Base Flows (cfs)</td><td colspan="7">61</td><td colspan="3">47</td><td colspan="2">55</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="4">11</td><td colspan="8">10</td></tr>
<tr><td></td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td></tr>
<tr><td></td><td colspan="4">Winter</td><td colspan="3">Spring</td><td colspan="3">Summer</td><td colspan="2">Fall</td></tr>
</table>

Pulse volumes are in units of acre-feet and durations are in days.

Table A.7. Nueces BBASC Environmental Flow Standard Recommendation, Dry Frio River near Reagan Wells

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
High Flow Pulses	Qp: 2,970 cfs with Average Frequency 1 per 5 years Regressed Volume is 27,200 Duration Bound is 82											
	Qp: 1,700 cfs with Average Frequency 1 per 2 years Regressed Volume is 15,300 Duration Bound is 64											
	Qp: 540 cfs with Average Frequency 1 per year Regressed Volume is 4,660 Duration Bound is 38											
	Qp: 210 cfs with Average Frequency 2 per year Volume Bound is 3,500 Duration Bound is 26											
	Qp: 32 cfs with Average Frequency 1 per season Volume Bound is 650 Duration Bound is 13				Qp: 120 cfs with Average Frequency 1 per season Volume Bound is 1,470 Duration Bound is 16			Qp: 81 cfs with Average Frequency 1 per season Volume Bound is 1,100 Duration Bound is 15			Qp: 35 cfs with Average Frequency 1 per season Volume Bound is 620 Duration Bound is 13	
	Qp: 7 cfs with Average Frequency 2 per season Volume Bound is 98 Duration Bound is 5				Qp: 30 cfs with Average Frequency 2 per season Volume Bound is 370 Duration Bound is 9			Qp: 12 cfs with Average Frequency 2 per season Volume Bound is 160 Duration Bound is 7				
Base Flows (cfs)	12				9			8			12	
Subsistence Flows (cfs)	1											
	Winter				Spring			Summer			Fall	

Pulse volumes are in units of acre-feet and durations are in days.

Table A.8. Nueces BBASC Environmental Flow Standard Recommendation, Sabinal River near Sabinal

<table>
<tr><td rowspan="7">High Flow Pulses</td><td colspan="12">Qp: 5,200 cfs with Average Frequency 1 per 5 years
Regressed Volume is 46,200
Duration Bound is 75</td></tr>
<tr><td colspan="12">Qp: 2,350 cfs with Average Frequency 1 per 2 years
Regressed Volume is 20,000
Duration Bound is 54</td></tr>
<tr><td colspan="12">Qp: 1,020 cfs with Average Frequency 1 per year
Regressed Volume is 8,290
Duration Bound is 38</td></tr>
<tr><td colspan="12">Qp: 330 cfs with Average Frequency 2 per year
Volume Bound is 5,420
Duration Bound is 24</td></tr>
<tr><td colspan="4">Qp: 62 cfs with Average Frequency 1 per season
Volume Bound is 1,530
Duration Bound is 17</td><td colspan="3">Qp: 180 cfs with Average Frequency 1 per season
Volume Bound is 2,210
Duration Bound is 15</td><td colspan="3">Qp: 100 cfs with Average Frequency 1 per season
Volume Bound is 1,180
Duration Bound is 12</td><td colspan="2">Qp: 53 cfs with Average Frequency 1 per season
Volume Bound is 840
Duration Bound is 12</td></tr>
<tr><td colspan="4"></td><td colspan="3">Qp: 64 cfs with Average Frequency 2 per season
Volume Bound is 750
Duration Bound is 10</td><td colspan="3">Qp: 11 cfs with Average Frequency 2 per season
Volume Bound is 130
Duration Bound is 5</td><td colspan="2"></td></tr>
<tr><td colspan="4"></td><td colspan="3">Qp: 22 cfs with Average Frequency 3 per season
Volume Bound is 240
Duration Bound is 6</td><td colspan="3"></td><td colspan="2"></td></tr>
<tr><td>Base Flows (cfs)</td><td colspan="7">21</td><td colspan="3">13</td><td colspan="2">21</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="12">1</td></tr>
<tr><td></td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td><td>Nov</td></tr>
<tr><td></td><td colspan="4">Winter</td><td colspan="3">Spring</td><td colspan="3">Summer</td><td colspan="2">Fall</td></tr>
</table>

Pulse volumes are in units of acre-feet and durations are in days.

Table A.9. Nueces BBASC Environmental Flow Standard Recommendation, Sabinal River at Sabinal (below Edwards Outcrop)

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 1,070 cfs with Average Frequency 1 per year Regressed Volume is 6,690 Duration Bound is 29			
	Qp: 230 cfs with Average Frequency 2 per year Volume Bound is 2,680 Duration Bound is 17			
	Qp: 21 cfs with Average Frequency 1 per season Volume Bound is 310 Duration Bound is 11	Qp: 56 cfs with Average Frequency 1 per season Volume Bound is 430 Duration Bound is 9	Qp: 3 cfs with Average Frequency 1 per season Volume Bound is 27 Duration Bound is 5	Qp: 20 cfs with Average Frequency 1 per season Volume Bound is 150 Duration Bound is 6
		Qp: 3 cfs with Average Frequency 2 per season Volume Bound is 18 Duration Bound is 3		
Base Flows (cfs)	2	1		2
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.10. Nueces BBASC Environmental Flow Standard Recommendation, Hondo Creek near Tarpley

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 3,340 cfs with Average Frequency 1 per 5 years Regressed Volume is 30,400 Duration Bound is 51			
	Qp: 1,470 cfs with Average Frequency 1 per 2 years Regressed Volume is 12,200 Duration Bound is 38			
	Qp: 790 cfs with Average Frequency 1 per year Regressed Volume is 6,200 Duration Bound is 30			
	Qp: 330 cfs with Average Frequency 2 per year Volume Bound is 4,530 Duration Bound is 22			
	Qp: 61 cfs with Average Frequency 1 per season Volume Bound is 1,020 Duration Bound is 15	Qp: 290 cfs with Average Frequency 1 per season Volume Bound is 3,360 Duration Bound is 18	Qp: 90 cfs with Average Frequency 1 per season Volume Bound is 890 Duration Bound is 12	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 580 Duration Bound is 11
	Qp: 16 cfs with Average Frequency 2 per season Volume Bound is 200 Duration Bound is 8	Qp: 91 cfs with Average Frequency 2 per season Volume Bound is 950 Duration Bound is 12	Qp: 24 cfs with Average Frequency 2 per season Volume Bound is 220 Duration Bound is 7	Qp: 13 cfs with Average Frequency 2 per season Volume Bound is 120 Duration Bound is 6
	Qp: 6 cfs with Average Frequency 3 per season Volume Bound is 54 Duration Bound is 5	Qp: 36 cfs with Average Frequency 3 per season Volume Bound is 340 Duration Bound is 9	Qp: 4 cfs with Average Frequency 3 per season Volume Bound is 34 Duration Bound is 4	
		Qp: 6 cfs with Average Frequency 4 per season Volume Bound is 52 Duration Bound is 5		
Base Flows (cfs)	6	5	9	8
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.11. Nueces BBASC Environmental Flow Standard Recommendation, Seco Creek at Miller Ranch near Utopia

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
High Flow Pulses	Qp: 1,600 cfs with Average Frequency 1 per 5 years Regressed Volume is 17,500 Duration Bound is 62											
	Qp: 700 cfs with Average Frequency 1 per 2 years Regressed Volume is 6,790 Duration Bound is 44											
	Qp: 310 cfs with Average Frequency 1 per year Regressed Volume is 2,720 Duration Bound is 31											
	Qp: 120 cfs with Average Frequency 2 per year Volume Bound is 1,710 Duration Bound is 21											
	Qp: 21 cfs with Average Frequency 1 per season Volume Bound is 290 Duration Bound is 12				Qp: 91 cfs with Average Frequency 1 per season Volume Bound is 1,140 Duration Bound is 17			Qp: 38 cfs with Average Frequency 1 per season Volume Bound is 360 Duration Bound is 11			Qp: 23 cfs with Average Frequency 1 per season Volume Bound is 270 Duration Bound is 11	
	Qp: 9 cfs with Average Frequency 2 per season Volume Bound is 100 Duration Bound is 8				Qp: 33 cfs with Average Frequency 2 per season Volume Bound is 360 Duration Bound is 12			Qp: 11 cfs with Average Frequency 2 per season Volume Bound is 93 Duration Bound is 7			Qp: 7 cfs with Average Frequency 2 per season Volume Bound is 65 Duration Bound is 6	
Base Flows (cfs)	4				3						4	
Subsistence Flows (cfs)	1											
	Winter				**Spring**			**Summer**			**Fall**	

Pulse volumes are in units of acre-feet and durations are in days.

Table A.12. Nueces BBASC Environmental Flow Standard Recommendation, Leona Springs near Uvalde

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Base Flows (cfs)	25				20			18			22	
Subsistence Flows (cfs)	1											
	Winter				**Spring**			**Summer**			**Fall**	

Insufficient data are avaiable for development of high flow pulse recommendations at this location.

Table A.13. Nueces BBASC Environmental Flow Standard Recommendation, Frio River near Derby

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 1,670 cfs with Average Frequency 2 per year Volume Bound is 18,800 Duration Bound is 25			
	Qp: 87 cfs with Average Frequency 1 per season Volume Bound is 1,450 Duration Bound is 20	Qp: 900 cfs with Average Frequency 1 per season Volume Bound is 7,940 Duration Bound is 17	Qp: 58 cfs with Average Frequency 1 per season Volume Bound is 510 Duration Bound is 13	Qp: 350 cfs with Average Frequency 1 per season Volume Bound is 4,340 Duration Bound is 24
	Qp: 12 cfs with Average Frequency 2 per season Volume Bound is 190 Duration Bound is 15	Qp: 210 cfs with Average Frequency 2 per season Volume Bound is 1,810 Duration Bound is 14		Qp: 7 cfs with Average Frequency 2 per season Volume Bound is 97 Duration Bound is 12
		Qp: 49 cfs with Average Frequency 3 per season Volume Bound is 420 Duration Bound is 11		
		Qp: 5 cfs with Average Frequency 4 per season Volume Bound is 41 Duration Bound is 8		
Base Flows (cfs)	17	11	7	12
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.14. Nueces BBASC Environmental Flow Standard Recommendation, Frio River at Tilden

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 5,320 Duration Bound is 20		Qp: 270 cfs with Average Frequency 1 per season Volume Bound is 2,440 Duration Bound is 14	Qp: 960 cfs with Average Frequency 1 per season Volume Bound is 10,400 Duration Bound is 20
	Qp: 86 cfs with Average Frequency 2 per season Volume Bound is 1,070 Duration Bound is 13	Qp: 460 cfs with Average Frequency 2 per season Volume Bound is 4,470 Duration Bound is 14	Qp: 36 cfs with Average Frequency 2 per season Volume Bound is 280 Duration Bound is 9	Qp: 120 cfs with Average Frequency 2 per season Volume Bound is 1,080 Duration Bound is 12
	Qp: 25 cfs with Average Frequency 3 per season Volume Bound is 290 Duration Bound is 9	Qp: 190 cfs with Average Frequency 3 per season Volume Bound is 1,790 Duration Bound is 12		Qp: 13 cfs with Average Frequency 3 per season Volume Bound is 100 Duration Bound is 7
	Qp: 6 cfs with Average Frequency 4 per season Volume Bound is 63 Duration Bound is 6	Qp: 83 cfs with Average Frequency 4 per season Volume Bound is 730 Duration Bound is 10		
Base Flows (cfs)	12	7	2	3
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.15. Nueces BBASC Environmental Flow Standard Recommendation, San Miguel Creek near Tilden

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 990 cfs with Average Frequency 2 per year Volume Bound is 7,310 Duration Bound is 18			
High Flow Pulses	Qp: 160 cfs with Average Frequency 1 per season Volume Bound is 1,580 Duration Bound is 19	Qp: 690 cfs with Average Frequency 1 per season Volume Bound is 4,940 Duration Bound is 16	Qp: 160 cfs with Average Frequency 1 per season Volume Bound is 1,040 Duration Bound is 13	Qp: 300 cfs with Average Frequency 1 per season Volume Bound is 2,010 Duration Bound is 15
High Flow Pulses	Qp: 45 cfs with Average Frequency 2 per season Volume Bound is 470 Duration Bound is 16	Qp: 220 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 14	Qp: 16 cfs with Average Frequency 2 per season Volume Bound is 110 Duration Bound is 10	Qp: 44 cfs with Average Frequency 2 per season Volume Bound is 310 Duration Bound is 12
High Flow Pulses	Qp: 14 cfs with Average Frequency 3 per season Volume Bound is 160 Duration Bound is 14	Qp: 100 cfs with Average Frequency 3 per season Volume Bound is 740 Duration Bound is 13		Qp: 5 cfs with Average Frequency 3 per season Volume Bound is 35 Duration Bound is 8
High Flow Pulses	Qp: 7 cfs with Average Frequency 4 per season Volume Bound is 86 Duration Bound is 13	Qp: 47 cfs with Average Frequency 4 per season Volume Bound is 340 Duration Bound is 12		
Base Flows (cfs)	2		1	2
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.16. Nueces BBASC Environmental Flow Standard Recommendation, Atascosa River at Whitsett

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
High Flow Pulses	Qp: 1,990 cfs with Average Frequency 2 per year Volume Bound is 14,800 Duration Bound is 19											
	Qp: 730 cfs with Average Frequency 1 per season Volume Bound is 5,720 Duration Bound is 18					Qp: 1,770 cfs with Average Frequency 1 per season Volume Bound is 12,500 Duration Bound is 16			Qp: 250 cfs with Average Frequency 1 per season Volume Bound is 1,960 Duration Bound is 12		Qp: 620 cfs with Average Frequency 1 per season Volume Bound is 4,320 Duration Bound is 14	
	Qp: 230 cfs with Average Frequency 2 per season Volume Bound is 1,960 Duration Bound is 14					Qp: 600 cfs with Average Frequency 2 per season Volume Bound is 4,280 Duration Bound is 13			Qp: 37 cfs with Average Frequency 2 per season Volume Bound is 280 Duration Bound is 7		Qp: 100 cfs with Average Frequency 2 per season Volume Bound is 720 Duration Bound is 9	
	Qp: 74 cfs with Average Frequency 3 per season Volume Bound is 690 Duration Bound is 11					Qp: 220 cfs with Average Frequency 3 per season Volume Bound is 1,550 Duration Bound is 11			Qp: 5 cfs with Average Frequency 3 per season Volume Bound is 34 Duration Bound is 4		Qp: 21 cfs with Average Frequency 3 per season Volume Bound is 150 Duration Bound is 6	
	Qp: 28 cfs with Average Frequency 4 per season Volume Bound is 280 Duration Bound is 9					Qp: 80 cfs with Average Frequency 4 per season Volume Bound is 580 Duration Bound is 9						
Base Flows (cfs)	9					5			4			
Subsistence Flows (cfs)	1											
	Winter					**Spring**			**Summer**		**Fall**	

Pulse volumes are in units of acre-feet and durations are in days.

Table A.17. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River near Three Rivers

	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
High Flow Pulses	Qp: 2,050 cfs with Average Frequency 1 per season Volume Bound is 26,800 Duration Bound is 18	Qp: 4,090 cfs with Average Frequency 1 per season Volume Bound is 64,600 Duration Bound is 22	Qp: 1,100 cfs with Average Frequency 1 per season Volume Bound is 13,600 Duration Bound is 15	Qp: 2,420 cfs with Average Frequency 1 per season Volume Bound is 34,200 Duration Bound is 19
	Qp: 720 cfs with Average Frequency 2 per season Volume Bound is 8,460 Duration Bound is 13	Qp: 1,660 cfs with Average Frequency 2 per season Volume Bound is 22,200 Duration Bound is 16	Qp: 280 cfs with Average Frequency 2 per season Volume Bound is 2,520 Duration Bound is 9	Qp: 710 cfs with Average Frequency 2 per season Volume Bound is 7,920 Duration Bound is 13
	Qp: 320 cfs with Average Frequency 3 per season Volume Bound is 3,430 Duration Bound is 11	Qp: 690 cfs with Average Frequency 3 per season Volume Bound is 7,830 Duration Bound is 12	Qp: 34 cfs with Average Frequency 3 per season Volume Bound is 200 Duration Bound is 4	Qp: 160 cfs with Average Frequency 3 per season Volume Bound is 1,340 Duration Bound is 8
	Qp: 140 cfs with Average Frequency 4 per season Volume Bound is 1,410 Duration Bound is 8	Qp: 320 cfs with Average Frequency 4 per season Volume Bound is 3,190 Duration Bound is 10		Qp: 15 cfs with Average Frequency 4 per season Volume Bound is 82 Duration Bound is 4
Base Flows (cfs)	37		30	37
Subsistence Flows (cfs)	1			

Pulse volumes are in units of acre-feet and durations are in days.

Table A.18. Nueces BBASC Environmental Flow Standard Recommendation, Nueces River near Mathis

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
High Flow Pulses	Qp: 1,120 cfs with Average Frequency 1 per season Volume Bound is 14,200 Duration Bound is 12					Qp: 2,540 cfs with Average Frequency 1 per season Volume Bound is 49,400 Duration Bound is 19			Qp: 370 cfs with Average Frequency 1 per season Volume Bound is 4,970 Duration Bound is 10		Qp: 1,550 cfs with Average Frequency 1 per season Volume Bound is 24,700 Duration Bound is 15	
	Qp: 590 cfs with Average Frequency 2 per season Volume Bound is 6,270 Duration Bound is 9					Qp: 420 cfs with Average Frequency 2 per season Volume Bound is 5,090 Duration Bound is 9			Qp: 150 cfs with Average Frequency 2 per season Volume Bound is 1,650 Duration Bound is 6		Qp: 240 cfs with Average Frequency 2 per season Volume Bound is 2,670 Duration Bound is 7	
Base Flows (cfs)	96					120			140		110	
Subsistence Flows (cfs)	37											
	Winter					**Spring**			**Summer**		**Fall**	

Pulse volumes are in units of acre-feet and durations are in days.

Table A.19. Nueces BBASC Environmental Flow Standard Recommendation, Oso Creek at Corpus Christi

<table>
<tr><td rowspan="2">High Flow Pulses</td><td colspan="8"></td><td colspan="2">Qp: 21 cfs with Average Frequency 1 per season
Volume Bound is 160
Duration Bound is 8</td><td colspan="2"></td></tr>
<tr><td colspan="5">Qp: 59 cfs with Average Frequency 2 per season
Volume Bound is 450
Duration Bound is 13</td><td colspan="3">Qp: 48 cfs with Average Frequency 2 per season
Volume Bound is 330
Duration Bound is 9</td><td colspan="2">Qp: 6 cfs with Average Frequency 2 per season
Volume Bound is 39
Duration Bound is 6</td><td colspan="2">Qp: 64 cfs with Average Frequency 2 per season
Volume Bound is 450
Duration Bound is 11</td></tr>
<tr><td>Base Flows (cfs)</td><td colspan="12">2</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="12">1</td></tr>
<tr><td></td><td>Nov</td><td>Dec</td><td>Jan</td><td>Feb</td><td>Mar</td><td>Apr</td><td>May</td><td>Jun</td><td>Jul</td><td>Aug</td><td>Sep</td><td>Oct</td></tr>
<tr><td></td><td colspan="5">Winter</td><td colspan="3">Spring</td><td colspan="2">Summer</td><td colspan="2">Fall</td></tr>
</table>

Pulse volumes are in units of acre-feet and durations are in days.

Table A.20. Nueces BBASC Environmental Flow Standard Recommendation, San Fernando Creek near Alice

High Flow Pulses	Qp: 170 cfs with Average Frequency 2 per year Volume Bound is 1,490 Duration Bound is 17			
	Qp: 14 cfs with Average Frequency 1 per season Volume Bound is 170 Duration Bound is 12	Qp: 65 cfs with Average Frequency 1 per season Volume Bound is 470 Duration Bound is 11	Qp: 17 cfs with Average Frequency 1 per season Volume Bound is 140 Duration Bound is 9	Qp: 28 cfs with Average Frequency 1 per season Volume Bound is 240 Duration Bound is 10
	Qp: 7 cfs with Average Frequency 2 per season Volume Bound is 78 Duration Bound is 9	Qp: 14 cfs with Average Frequency 2 per season Volume Bound is 100 Duration Bound is 7	Qp: 4 cfs with Average Frequency 2 per season Volume Bound is 37 Duration Bound is 6	Qp: 8 cfs with Average Frequency 2 per season Volume Bound is 69 Duration Bound is 8
Base Flows (cfs)	2		1	
Subsistence Flows (cfs)	1			
	Nov, Dec, Jan, Feb, Mar	Apr, May, Jun	Jul, Aug	Sep, Oct
	Winter	Spring	Summer	Fall

Pulse volumes are in units of acre-feet and durations are in days.

Table A.21. Nueces BBASC Flow Standard Recommendation, Nueces Bay

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime – Seasonal Targets (Attainment Frequency)			Recommendations Annual Volume (acft) (Attainment Frequency)
High (10)	125,000 acft (11%)	250,000 acft (11%)	375,000 (12%)	750,000 (16%)
Base (18)	22,000 acft (23%)	88,000 acft (30%)	56,000 (40%)	166,000 (47%)
Sub. (34)	5,000 acft (69%)	10,000 acft (88%)	15,000 acft (74%)	30,000 (95%)
	Winter = Nov–Feb	Spring = Mar–Jun	Summer/Fall = Jul–Oct	

Nueces River, Corpus Christi Bay, Baffin Bay
Stakeholders Committee
10:00 AM July 22, 2009
Texas A&M Research Center
1619 Garner Field Road, Uvalde, Texas

MINUTES

Call to order – TCEQ as temporary Chair

Herman Settemeyer, TCEQ and NEAC Chair, called the meeting to order.

Roll Call – TCEQ as temporary Chair

Roll call was taken.

Elect Officers – TCEQ as temporary Chair

The group took nominations of committee officer from members. Con Mims was elected committee chair and James Dodson was elected as committee vice-chair by consensus.

Review background leading to formation of the Nueces River, Corpus Christi Bay and Baffin Bay Area Stakeholders Committee (Stakeholders Committee)

Member Ray Allen gave an overview of the events related to the managing of freshwater inflows to the Nueces estuary, noting dates, water rights, reservoir construction, and the agreed order issued by the Texas Water Commission (now TCEQ).

Passage of SB 3 (80R) and expansion of NEAC membership to meet SB 3 (80R)

Committee chair Con Mims discussed the expansion of the current NEAC membership in order to satisfy the requirements of Senate Bill 3/Environmental flows. He noted that the statute included a specific provision as stated below:

"Notwithstanding the other provisions of this section, in the event the commission, by permit or order, has established an estuary advisory council with specific duties related to implementation of permit conditions for environmental flows, that council may continue in full force and effect and shall act as and perform the duties of the basin and bay area stakeholders committee under this section. The estuary advisory council shall add members from stakeholder groups and from appropriate science and technical groups, if necessary, to fully meet the criteria for membership and shall operate under the provisions of the statute." This provision applies directly to the NEAC.

He continued, noting that the statute mandated that 17 interest groups be included as members of the this stakeholder committee for this group which will be named the Nueces River and Corpus Christi and Baffin Bays Basin and Bay Area Stakeholder Committee (BBASC). Members discussed the interest groups represented by existing NEAC members, and the expansion of the membership in order to ensure the mandated interest groups were represented.

Chairman Mims then discussed the expanded role of the committee, noting that the NEAC was focused on freshwater inflow requirements, but that SB3 also required the development of instream flow recommendations. In both aspects the goal is to ensure a sound ecological environment

Discussion of Senate Bill 3

Cory Horan, TCEQ, gave an overview of the SB3 statute, Texas Water Code Section 11.02362, and the charge to develop environmental flow regime recommendations. He explained that the Environmental Flows Advisory Group (EFAG) is composed of nine members including three members appointed by the governor, three members of the senate appointed by the lieutenant governor, and three members of the House of Representatives appointed by the speaker of the House of Representatives. The group must consist of one member from each of the three resource agencies: the Texas Commission on Environmental Quality (TCEQ), the Texas Parks and Wildlife Commission (TPWD), and the Texas Water Development Board (TWDB). The EFAG appoints the members of the Texas Environmental Flows Science Advisory Committee (SAC).

SAC Chairman Bob Huston discussed the SAC role in the environmental flows development process. The SAC shall serve as an objective scientific body to advise and make recommendations to the advisory group on issues relating to the science of environmental flow protection. The SAC will also develop recommendations to help provide overall direction, coordination, and consistency relating to environmental flow methodologies for bay and estuary studies and instream flow studies, environmental flow programs at the TCEQ, TPWD and TWDB, and the work of the Basin and Bay Expert Science Teams (BBEST). He also noted that the SAC will primarily interact with the BBESTs, and that a member of the SAC will be appointed as a liaison to each BBEST. The SAC liaison to this basin and bay BBEST will be Dr. Paul Montagna.

Cory Horan explained the roles of the BBASC and the BBESTs.

Each BBASC shall establish a basin and bay expert science team for their particular basin and bay system. The BBEST shall develop environmental flow analyses and a recommended environmental flow regime for the river basin and bay system for which the team is established through a collaborative process designed to achieve a consensus. In developing the analyses and recommendations, the BBEST must consider all reasonably available science, without regard to the need for the water for other uses, and their recommendations must be based solely on the best science available. The BBEST shall finalize environmental flow regime recommendations and submit them to the BBASC, the EFAG, and the TCEQ. The BBASC and the EFAG may not change the environmental flow analyses or environmental flow regime recommendations of the BBEST.

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.

In recognition of the importance of adaptive management, after submitting its recommendations regarding environmental flow standards and strategies to meet the environmental flow standards to the commission, each BBASC, with the assistance of the pertinent BBEST, shall prepare and submit for approval by the advisory group a work plan. The work plan must:
(1) establish a periodic review of the basin and bay environmental flow analyses and environmental flow regime recommendations, environmental flow standards, and strategies, to occur at least once every 10 years;
(2) prescribe specific monitoring, studies, and activities; and
(3) establish a schedule for continuing the validation or refinement of the basin and bay environmental flow analyses and environmental flow regime recommendations, the environmental flow standards adopted by the commission, and the strategies to achieve those standards.

Mr. Horan then discussed the schedule for completion of the development of environmental flow regime recommendations as dictated by SB3. He noted that for this particular basin and bay system, the appointment of stakeholders was not scheduled until September 1, 2010, but that with the provision allowing the expanded NEAC to serve as the BBASC, the group could begin work at the time of its choosing. As such the date relevant to the group in the development of an environmental flow analyses and environmental flow regime recommendations is due on September 1, 2010. Chairman Mims noted that while this BBASC and BBEST were ahead of the SB3 mandated schedule, the group should not wait in beginning the process regardless of the formal schedule. The BBASC members approved this recommendation by consensus.

Discuss Administration of Stakeholders Committee – TCEQ
Mr. Horan then discussed the administration of the BBASC with regard to the three resource agencies. He noted that the agencies were to provide administrative and technical support to both the BBASC and BBEST, with TCEQ taking the lead on administrative and logistical support. The TCEQ will post notice of each meeting of the BBASC and BBEST. He noted that per the statute these meetings are to be open to the public, but are not required to meet the provisions of the open meetings act. He discussed actions previously taken by established BBASCs which had developed ground rules under which the group will operate. He also noted that while the TWDB provided funds to the BBESTs and to the SAC, the BBASC members were not eligible for reimbursement of expenses related to SB3 activities. He noted that other groups have allowed, as

set in their ground rules, opportunities for public comment at each of the meetings.

Cindy Loeffler, TWDB, noted that staff from the three resource agencies would continue as voting members of the NEAC, but would NOT be considered as voting members of the BBASC or BBEST. Staff will remain available for both technical and administrative support.

Membership
Chairman Mims and Vice-Chair Dodson then discussed the membership of the BBASC. It was noted that the EFAG did not appoint this group, but that a list of the expanded NEAC membership would be provided to the EFAG. The membership requirements set forth in SB3 were discussed. The members discussed potential candidates to meet the membership requirements and various interest groups named in SB3. The group also indicated, to the greatest extent possible, that interest groups should be represented in both the upper and lower parts of the basin. By consensus, the group agreed to allow the chair to contact potential members and if those potential members are not inclined to serve, the chair would seek additional candidates for approval by the committee.

Discuss establishing a "basin and bay expert science team" – TCEQ
As charged by SB3, the BBASC is to establish a BBEST. Members discussed potential candidates and areas of expertise that would need to be represented in the BBEST. SAC Chairman Huston noted the separation of duties between the BBEST and BBASC, but recommended that each group communicate with each other so that all parties will be informed of the activities of each group. The members agreed that a joint meeting of both the BBASC and BBEST was appropriate.

Discuss Stakeholder Committee meeting schedule – TCEQ
Members discussed the scheduling of future meetings. The members agreed by consensus to hold meetings on a quarterly basis. Meeting locations will vary to ensure equal representation throughout the basin.

Items suggested for future agendas include:
- Establishment to bylaws
- BBEST appointment
- Reaffirm expanded membership and fill vacancies as necessary
- Technical presentations to inform members of various considerations necessary for the development of environmental flow regime recommendations.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
9:00 A.M. ON OCTOBER 21, 2009
GYMNASIUM BUILDING, CALLIHAM UNIT, CHOKE CANYON STATE PARK
THREE RIVERS, TEXAS

MINUTES

Call to order and Roll Call

Committee chair Con Mims called the meeting to order. Roll call was taken.

Comments from Texas Commission on Environmental Quality

Cory Horan, TCEQ, discussed the SB3 process, noting that representativeness among the SB3 mandated interest groups was an important part of the process. He noted that one of the key steps in the process was the establishment of the Basin and Bay Expert Science Team (BBEST) by the BBASC members. He discussed SAC activities and the guidance documents the SAC has developed. He noted that the primary use of the guidance documents would be by the BBESTs, but also noted that it would be beneficial for the BBASC members to familiarize themselves with the guidance documents. This will assist the BBEST members in fully understanding the science based environmental flow recommendations that are to be developed by the BBEST. Chairman Mims discussed the intent of the committee to hold meetings throughout the basin in order to familiarize members with the various areas of the basin, ensuring representativeness among those attending and allowing for increased public participation.

Review membership and authorize changes as necessary

Chairman Mims discussed the expanded membership and the interest groups that were represented on the committee. He discussed the committee desire to have members that truly reflected the various interest groups throughout the basin. After a review of those present, the commercial fisheries and electric generation interest groups were not present. The group agreed that there was a need for those interests to be represented. The committee chairs will seek out potential members to fill these gaps.

At this point member Ray Allen, Coastal Bend Bays and Estuaries Program (CBBEP) gave an update on the Rincon Bayou Salinity study.

Approve Meeting Rules

The members then discussed the draft meeting rules prepared by the chairs and distributed to members prior to the meeting. After discussion the members approved by consensus the meeting rules as drafted with the caveat that they can be amended by majority vote.

Discuss the responsibilities, composition, funding, and establishment of the Basin and Bay Expert Science Team (BBEST)

Cory Horan discussed the statutory requirements and the roles and responsibilities of the Basin and Bay Expert Science Teams. It was noted that staff from the three resource agencies, the TCEQ, TWDB, and TWPD, would be non-voting members of the BBEST and would provide both technical and administrative support. The members then discussed the areas of expertise to be represented on the BBEST. By consensus the committee agreed to form a subcommittee comprised of members Wes Tunnel, Ray Allen, Dr. Jim Gallagher and Harry Shulz, with James Dodson serving as chair of this subcommittee. This subcommittee will develop a list of the needed expertise and potential candidates to meet those needs, as well as come up with a recommended number for the size of the BBEST. The subcommittee will report back to the group for discussion and approval of the recommended BBEST candidates.

Establish a preliminary BBASC work schedule
The committee discussed topics for upcoming meetings and meeting locations. Topics to be discussed are:

- Report of the BBEST subcommittee and consideration and discussion of potential candidates.
- Report on the agreed order establishing the NEAC
- Other topics relating to lower basin characteristics

It was noted that time and travel for BBASC members is not eligible for reimbursement.

Discuss time and location for next meeting
The group agreed to hold the next meeting in the lower part of the basin, specifically Corpus Christi, TX. The meeting will begin at 10:00 at the Harte Research Institute, pending confirmation of room availability.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
JANUARY 20, 2010
HARTE RESEARCH INSTITUTE
TEXAS A&M UNIVERSITY-CORPUS CHRISTI
CORPUS CHRISTI, TEXAS

MINUTES

Call to order, roll call, and review membership and authorize changes as necessary

Chairman Mims called the meeting to order. Roll call and a quorum was reached. A review of the current membership was discussed. Vacancies of the various interest groups were discussed:

- recreational water users (upper basin)
- municipal (upper basin)
- commercial fisheries (lower basin)
- electrical generation (upper basin)

By consensus the members agreed to attempt to fill these vacancies, however, if a reasonable effort was made to find candidates or if a candidate is not found or not available, the position will remain vacant.

Elect officers for Calendar Year 2010

After discussion, Con Mims was nominated for committee chair and James Dodson was nominated as committee vice-chair. By consensus the committee members approved these nominations.

Presentation on City of Corpus Christi's regional water supply program

Member Gus Gonzalez, city of Corpus Christi, provided an overview of Corpus Christi's water supply and water planning. He discussed background for region N water planning, the city's regional water supply, and opportunities and their impacts. He also noted sources of water, discussed raw and treated water customer, as well as raw water status and trends.

Presentation on accomplishments of the Nueces Estuary Advisory Council and the Agreed Order and discussion on how this will be used

Member Ray Allen, Coastal Bend Bays and Estuaries Program, discussed the agreed orders that created the Nueces Estuary Advisory Council, providing background and perspective. He also discussed the history of Nueces delta water projects.

Comments from Texas Commission on Environmental Quality
Cory Horan, TCEQ gave a brief update on environmental flow activities across the state, noting the environmental flow recommendation reports from the Trinity/San Jacinto and Sabine/Neches BBESTs had been submitted to the EFAG, the TCEQ, and their related BBASC.

Comments from Texas Environmental Flows Science Advisory Committee Liaison, Paul Montagna, on completed BBEST reports
Dr. Paul Montagna provided an overview of the SAC process and charges of each group. He noted the the deadline for the SAC to provide comments on the submitted BBEST reports was in February 2010.
BBEST Budget Discussion
Ruben Solis, TWDB, discussed funding for the SB3 BBESTs. He noted that funding wasn't allocated for the Nueces BBEST as they will not be created until the next fiscal biennium. He noted that the BBEST would be allocated $188,000 for fiscal year 2011.

Discussion and appropriate action on selection of Basin and Bay Expert Science Team (BBEST) members
Vice-chair James Dodson discussed the activities of the BBEST selection work group. He identified the various areas of expertise the that the subcommittee was focusing on. He explained that the next setps were to distribute nomination forms to gather additional nominees, and that these would be compiled and distributed to BBASC members, with the formal selection to occur at the April committee meeting. The subcommittee has recommended that the BBEST be made of 12 members. March 31, 2010 will be the deadline for submission of nominations.

Discuss time and location for next meeting
The next committee meeting is scheduled for April 21, 2010 at 10:00 am. The meeting will be held in the upper basin, specific location TBD.
Potential agenda items include:

- Report from BBEST selection subcommittee
- BBEST selection
- Regional presentations
    - Edwards Aquifer recharge structures
    - Region L plan as it affects the Nueces basin
    - Instream ecology of upper basin
- Discussion of SAC implementation guidance

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE
10:00 A.M. – 3:00 P.M.
APRIL 21, 2010

TEXAS A&M UNIVERSITY RESEARCH AND EXTENSION CENTER
1619 GARNER FIELD ROAD
UVALDE, TEXAS

MINUTES

Call to order, roll call, and review membership and authorize changes, as necessary

Chairman Mims called the meeting to order. Roll call was taken and a quorum was reached. A review of the current membership was discussed. Several members have not attended meetings. The members recommended that the chairs attempt to contact those who have not participated and request that they participate in the future. If they do not respond or wish not to serve they will be removed from the group membership. This recommendation was approved by consensus. The committee will consider replacing members if needed at future meetings.

Public Comments

Jace Tunnel, Coastal Bend Bays and Estuaries Program (CBBEP) discussed freshwater inflows into Corpus Christi bay.

Sky Lewey, Nueces River Authority (NRA), discussed a basin riparian publication developed by the NRA. She also discussed upcoming riparian workshops.

Comments from Texas Commission on Environmental Quality

Cory Horan, TCEQ, discussed activities of other SB3 BBASCs. He noted that each had held a joint meeting with their respective BBEST after they were formed. He discussed the statutory delineations among each group. The members agreed that a joint meeting of the BBEST and BBASC would be appropriate.

Discussion and appropriate action on selection of Basin and Bay Expert Science Team (BBEST) members

Vice chair James Dodson provided an overview of the BBEST selection subcommittee and explained the process which was used to evaluate BBEST candidates. The subcommittee has provided a list of potential candidates to serve on the BBEST. Members discussed the candidates and their field of expertise. The recommended candidates were:

- Tom Arsuffi, PhD Freshwater fisheries and ecology Tx Tech Univ – Junction
- Dave Buzan Freshwater and coastal ecosystems PBS&J Consulting

- Ken Dunton, PhD Estuarine ecology, botany & geochemistry UTMSI
- Rocky Freund Water quality, information systems & GIS Nueces River Authority
- Wayne Gardner, PhD Coastal/freshwater biogeochemistry UTMSI
- Ben Hodges, PhD Environmental fluid mechanic, modeling UT – Austin (CRWR)
- David Hoeinghaus, PhD Freshwater ecology & conservation biology University of North Texas
- Ryan Smith Freshwater fisheries and hydrology The Nature Conservancy
- Greg Stunz, PhD Marine fisheries and estuarine ecology TAMUCC (HRI)
- Sam Vaugh, P.E. Hydrology and hydrologic modeling HDR Engineering
- Lance Williams, PhD Stream ecology and fisheries UT – Tyler

By consensus, the group approved this list of candidates with the addition of Lonnie Stewart.

Presentation on Edwards Aquifer Authority activities (Tentative)
John Hoyt, Edwards Aquifer Authority (EAA), provided an overview on the activities of the EAA. He discussed EAA operations, including regulatory programs, water quality and quantity programs, as well as data collection. He discussed current research projects, EAA participation in Region L water planning, and gave an overview of the types of recharge structures. He also discussed research enhancement studies.

Presentation on Environmental flows of the upper Nueces River Basin and relationship to Hill Country aquifers
Ryan Smith, Nature Conservancy, discussed the background and context of work being done in the upper reaches of the Nueces river watershed. He also presented an overview of the data available by individual disciplines.

Darwin Ockerman, USGS, gave a presentation on upper Nueces watershed streamflow measurements and preliminary results. He noted that the USGS had conducted gain/loss surveys and that a draft report of the project would be available in the fall of 2010.

Discuss time, location, and agenda items for next meeting
The next meeting will be held in Corpus Christi on July 21, 2010 at 10:00.

Potential meeting topics include:

- Discussion of SAC developed discussion paper
- Lower basin characteristics
- BBEST / BBASC interaction

Adjourn

DRAFT

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDER COMMITTEE
10:00 A.M. – 3:00 P.M.
OCTOBER 20, 2010
HARTE RESEARCH INSTITUTE
TEXAS A&M UNIVERSITY-CORPUS CHRISTI
CORPUS CHRISTI, TEXAS

MINUTES

Call to order, roll call, and review membership and authorize changes as necessary
Chairman Mims called the meeting to order. Roll call was taken. Attendance did not reach a quorum. Rocky Freund announced that due to membership in the BBEST she was resigning from the BBASC.

Minutes
Corey Horan, TCEQ, had previously distributed to members copies of the draft minutes of all previous meetings for review. He suggested that since a quorum had not been reached the comment period for the draft minutes should be extended until Friday October 29, 2010. If substantial comments are received, the draft minutes will be revised and redistributed for review. Members agreed to an on line vote for minute approval.

Administrative Business
Attendance
Chairman Mims noted the lack of attendance of several members. He asked membership approval to send an email or letter to those members who have not attended a meeting, or have only attended one meeting, requesting their attendance at future meetings due to the importance of a quorum to conduct business. He also would ask those members who are not interested in serving as a stakeholder, to voluntarily resign. Since a quorum had not been reached, the motion to remove those individuals from the membership could not be accepted. It was noted that if those members were removed, membership would still be representative of each of the SB3 interest groups.

"Environmental Interests" Representative to Nueces BBASC
Since no quorum was reached, consideration of NWF subcommittee nominee John Adams as an addition to the Nueces BBASC to represent the environments interest was postponed until the next meeting.

Nueces BBEST update
Rocky Freund presented an overview of the charges and an update on the activities of the Basin and Bay Expert Science Team (Nueces BBEST). Ms. Freund presented a list of the members, and dates of past and future meetings. She stated that the BBEST has been meeting monthly since June and the next meeting will be held on Friday, October 22, 2010. She described the roles of and relationship between the SAC, BBEST, BBASC, TWDB and TCEQ. She stated that she and Dr. Stunz were elected as Co-Chair and Chair, respectively. Three subcommittees were formed: instream, estuary, and hydrology; and the subcommittees have met via conference calls. The subcommittees will bring

recommendations to the whole membership for final decisions. She discussed the draft budget. Funding is available for time and travel reimbursement, and professional services. After recommendations are made to the whole BBEST, the team will also provide assistance to BBEST with the work plan development. Ms. Freund also summarized two presentations made to the team on Geographic scope, and the HEFR methodology. She stated that their official charge is to have the recommendations to the entire committee by March 1, 2012. However, the team set an internal target date of October 1, 2011. She presented the draft timeline for necessary tasks and analysis highlighting decision making deadlines, and potential sites for assessment. She reviewed their charge of defining a Sound Ecological Environment and the needed studies: flow regime components, seasons for hydrgraphic separation, geomorphology, sediment transport and others. She also presented an update on the hydrology subcommittee; in particular, a hydro pilot project. Dr. Gregg Stunz presented an overview of the estuary subcommittee conference call meeting held September 2, 2010. He said members established goals and discussed deliverables. He added that most work will take place from now through the early part of next year.

Texas Environmental Flows Science Advisory Committee update
SAC member Dr. Ed Oborny was to make a presentation on the "Lessons Learned from Initial SB3 BBEST Activities". However, Chairman Mims at the suggestion of Corey Horan, TCEQ, asked that the presentation be postponed until the BBEST committee had actually made their recommendations. Dr. Oborny presented an overview of the October SAC meeting. He discussed that revisions made to the hydrologic methods document which would be of more interest to the BBEST, and a document spearheaded by Dr. Bob Brandes based on the results of the first two BBASCs showing how the BBASC and BBEST recommendations would impact a real water supply project by applying the environmental flows and reviewing the impacts. Plans are to finalize the draft documents at the next SAC meeting October 27, 2010.

Presentation: Senate bill 3 Environmental Flows – What Have We Learned
Dr. Ed Oborny gave a brief overview of four SAC documents that could be used as tools for a better understanding of the overall process:

- "Lessons Learned" Document: The document presents a summary of what was learned from the first two BBESTs. It includes the charges of the members, relevant timelines, understanding of the terminology, and importance of good interaction between the BBEST and BBASC;
- Discussion Paper: The paper is an overview of the process used to go from instream flow recommendations to developing environmental flow standards;
- Work Plan Development Document: The work plan is the specific responsibility of the BASC. However, it is will require the interaction of both the BBEST and BBASC.
- Environmental Flow Regimes and Water Supply Projects Document.

Dr. Oborny discussed "Sound Ecological Environment" which is the charge of the BBEST to define. He added that the BBEST must determine what is good for the environment based on science while the BBASC is charged with balancing all the water needs. He presented a slide showing the basic components of environmental flows and explained the four main components of a flow regime: subsistence flows, base flows, high flow pulses and overbanking flows. He encouraged BBASC members to be prepared for the BBEST recommendations and know how the committee intends to proceed. He suggested that members document concerns throughout the process so those concerns can be addressed in the work plan. The work plan should include short term and long term studies as well as long term monitoring component to assess the success of the recommendations and assess the standards put forth by TCEQ. Dr. Oborney recommended that future meetings continue to include updates by the BBEST and suggested that at the meeting prior to the October 1, 2011 deadline, the BBEST update include tentative recommendations at specific gages. He also suggested a presentation by Dr. Brandes on the WAM/Projected Water Supply document so members will have a better understanding of what the environmental flow recommendations mean.

Presentation: "Recent Freshwater Inflows and Pumping Events to Nueces Bay"
BBASC member Ray Allen presented a general overview of the watershed and the Nueces River delta. He noted that the location of the lower Nueces River adjacent to the shoreline allows discharge into Nueces Bay without going through the delta complex. He discussed the City of Corpus Christi's agreement to put in a pumping system and pipeline that has the ability to deliver up to 3,000 acre-feet of water per month into the upper Recon Bayou (??). This water will ultimately flow through the delta and contribute to the critical habitat located there. Mr. Allen discussed salinity levels in the delta complex, the targeted salinity boundaries, indicator species chosen in 1994, and effects of extended droughts. Since the end of 2009, inflows have increased resulting in a drop in salinity, and studies have found that tides, river flows and wind driven events are critical to salinity levels. Members discussed how to improve the dispersion of water through the estuary and future study of the sediment accretions and losses in the area due to subsidence and multiple reservoirs upstream.

Schedule - Update
Corey Horan (TCEQ) discussed the future schedule and target dates. He stated that the Environmental Flows Advisory Group which provides direction throughout this process has extended the deadlines for the development of the BBEST recommendations until March 1, 2012, and felt that the BBEST committee would probably extend their self-imposed deadline of October 1, 2011, accordingly. Once the BBEST recommendations have been presented to the BBASC, members will have an opportunity to review and comment on the BBEST recommendations as well as provide their own recommendations on the environmental flow regime and environmental flow analysis for submittal to the SAC and TCEQ. He added that the BBEST and BBASC are fortunate to be able to make use of the lessons learned and experience gained from the previous groups. The stakeholder group will have until 6 months from that date, September 1, 2012 to submit their comments and recommendations. TCEQ will have one year until September 1, 2013 to develop the environmental flow standards and establish rules. He reminded members that work will continue after these dates on the Work Plan. Chairman Mims mentioned that meetings will be held quarterly until after the BBEST report has been received then meetings will be held more frequently.

Discuss time, location, presentation and actions for next (January 18, 2011) meeting
Chairman Mims announced that the next meeting will be held at 10 am on Tuesday, January 18, 2011 at the Research Center in Uvalde. Potential agenda items will include:

- Formalize membership
- BBEST update
- Presentation on HEFR and other tools
- Presentation on WAM under current rules and regulations
- Presentation on Technical Terminology (Jargon)

- Presentation on Environmental Flow Regimes and the Effects on Water Supply Projects by Dr. Brandes
- Update on Trinity and Sabine BBEST/BBASC Activities
- Update on San Antonio and Guadalupe BBEST/BBASC Activities
- Determine what BBEST will do once recommendations received (2nd or 3rd meeting)

Chairman Mims asked that a draft agenda considering the above items be distributed to members in late December.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
Texas A&M University Research and Extension Center
1619 Garner Field Road in Uvalde, Texas
January 19, 2011

Minutes

The meeting was called to order by Chairman Con Mims. The agenda was approved with the combining of Items 2 and 3.

Discussion occurred regarding the status of agency representatives as voting members of the Committee. Agency representatives are on the Committee as a result of their status on the Nueces Estuary Advisory Council (NEAC). Agencies included are the Texas Commission on Environmental Quality (TCEQ), Texas Water Development Board, Texas Parks and Wildlife, and General Land Office. Herman Settemeyer indicated that TCEQ would not be a voting member, but would ask management for an answer. The other agencies are going to check and report back at the next meeting.

The status of Committee members was addressed. Bobby Dullnig, Charlie Alegria, Foster Edwards, and Ben Vaughan have resigned. No response was received from Bill Klepac, Mike Petter, Ray Burdette, or Harry Schulz. The committee voted to accept the resignations and to consider those that did not respond as having resigned. The Committee also approved the nomination of Don Roach to replace Jim Naismith. Jim Naismith will be the alternate for Don Roach. Additionally, the Mayor of Mathis has changed and thus is not currently a voting member until approved. The Committee approved the nomination of Joel Pigg to replace Lee Sweeten (Manager, Real-Edwards Conservation and Reclamation District) and the nomination of John Adams to replace Brian Nicolau (Environmental Interests) on the Committee.

The membership roll call established a quorum for the meeting.

No action was taken on the minutes from the last meeting.

Sky Lewey (Nueces River Authority) gave a presentation of Riparian Zone areas. Ms. Lewey discussed riparian areas along rivers and creeks, properly functioning riparian areas, issues associated with changing channel conditions, roles of vegetation, and the down cutting and widening of stream channels. Ms. Lewey discussed the workshops that have and will be conducted on these issues and their attempts to work with landowners to help achieve healthy riparian areas along streams.

Sam Vaugh, chair of the Nueces BBEST, gave a presentation on the activities of the science team. The BBEST has three subcommittees – Hydrology, Instream, and Estuary. The Hydrology subcommittee is looking to establish flow recommendations at 21 stream gage locations within the basin. The large variations in basin geographic scope, the HEFR model outputs, the division of flows (base flows/pulse flows), seasonal flow groupings, calculations of flows (from subsistence to overbanking), frequency of flows, and then the correlation of flows to biology was discussed. The Instream subcommittee is focusing on overlays of water quality, sediment, and riparian data. The Estuary subcommittee is focusing on overlays of focal species, estuarine inflows, salinity variations, and nutrients. The subcommittee is working through whether the current estuary conditions represent a "sound ecological environment". Mr. Vaugh discussed the conversion of flow regimes into permit conditions.

Mr. Vaugh indicated the BBEST is required to use the best available science in coming up with their recommendations. Their report is due March 12, 2012 but they hope to have it by late 2011. The Stakeholder Committee will then have six months to review and provide comments.

Mark Wenzel (TWDB) gave a presentation on the geomorphology overlay as used in the BBEST analysis. The sediment transport and how rivers adjust to flow and sediment was addressed. The Sediment Analysis Model (SAM) which is used to estimate sediment transport and effective transport was discussed. The model is used to make future projections and predictions regarding sediment changes related to water changes.

The next meeting is scheduled for April 20, 2011 in Corpus Christi, Texas.

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
APRIL 20, 2011, 10:00 A.M. – 2:00 P.M.
HARTE RESEARCH INSTITUTE
TEXAS A&M UNIVERSITY-CORPUS CHRISTI
CORPUS CHRISTI, TEXAS

The meeting was called to order by Chairman Con Mims. A quorum was present for the meeting. The minutes of the January 19, 2011 meeting were approved.

The voting status of state agency members who were members of the Nueces BBASC was addressed. The bylaws will be amended to say that state agency staff will be non-voting members.

Jace Tunnell was nominated and elected to replace Wayne Gardner, who resigned, on the Nueces BBEST.

A presentation on Railroad Commission (RRC) Activities was given by Bill Miertschin. Mr. Miertschin spoke about RRC functions, regulations, and activities in the Nueces basin. A drilling completion video shown at: http://www.northernoil.com/drilling.php was presented. Primary directives are related to geothermal operations and include protecting the environment, preventing waste, and promoting conservation. TAC rules for RRC include water protection and protection of birds. RRC monitors drilling operations to ensure compliance with drilling regulations. RRC has 264 staff working on field operations, responsible for 395,000 wells, in 232 of 254 counties. 31,517 wells have been plugged since 1984 for $182 million. Statewide, drilling permits ranged from 9716 in 2002, 24,073 in 2008, to 3,180 so far in 2011. Drilling and completion requires about 10 ac-ft of water per well. Eagle Ford might require 11,540 a-f total, or 7.5% of total groundwater use relative to 2007. There was a suggestion for TCEQ to discuss their role in drilling activities at the next meeting.

The presentation on the History of the Agreed Order for operation of the Choke Canyon-Lake Corpus Christi Reservoir System was skipped until the next meeting.

Paul Montagna, the SAC liaison, discussed that TCEQ had published final rules for the Sabine and Trinity basins. He indicated that the Lavaca-Colorado and Guadalupe-San Antonio have submitted their BBEST reports to their BBASCs. He indicated the SAC has put out guidance documents on attainment frequencies and implementation, and on work-plan development.

The BBEST update was provided by Sam Vaugh, Nueces BBEST chairman. He indicated that the BBEST is accelerating its activities in light of the possibility of no funding after August 31 and will try to complete their report by early September 2011. The BBEST had field reconnaissance meetings in the upper basin and at Choke Canyon and the Nueces Delta. He indicated that Wayne Gardner resigned and was replaced with Jace

Tunnell. The BBEST has identified 20 gages throughout the basin at which recommendations will be developed. The HEFR model is being used to develop initial flow regimes based on historical flow statistics. Perennial streams were defined as those that flow 95% of the time. The BBEST is contracting for the development of flow/habitat relationships for the streams, with TWDB and TPWD providing technical support. Analyses will be conducted at 6 sites (3 on the Nueces, one each on Frio River, Atascosa River, and Seco Creek). Water quality (DO, temperature, nutrients), geomorphology, and riparian overlays will also be considered. Estuary analyses focused on Nueces Bay. Preliminary opinion is that Nueces Bay is "not presently representative of a sound ecological environment" based on historically declining abundances of eastern oysters and rangia clams and on hypersaline conditions in the Nueces delta. The BBEST is planning a review of the Nueces Estuary history, correlation of nutrient data with freshwater inflow, and application of statistical analysis of flows to TPWD fishery abundance data.

Herman Settemeyer discussed the draft rules for Sabine and Trinity before the Commission today (4/20) as well as the TCEQ sunset legislation which was passed out of the House on 4/19, and will come before the Senate next week.

The next meeting is scheduled for July 20, 2011 in Uvalde.

Meeting Adjourn.

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE
10:00 A.M. – 3:00 P.M.
OCTOBER 19, 2011

TEXAS A&M UNIVERSITY RESEARCH AND EXTENSION CENTER
1619 GARNER FIELD ROAD
UVALDE, TEXAS

MEETING MINUTES

Members Present: Con Mims, Chair; James Dodson, Vice Chair; Jace Tunnel (for Ray Allen), Rocky Freund, Gus Gonzales, Don Roach (for Jim Naismith); Wes Tunnel; Mike Mahoney; Tom Ballou; Joel Pigg; John Adams; Ross Thompson; Scotty Bledsoe; Teresa Carrillo; Jim Bader

Call to order and Roll Call

Chairman Con Mims called the meeting to order and roll call was taken.

Review membership and authorize changes, as necessary

Chairman Mims noted that member Dr. Jim Gallagher, representing agricultural water users, had resigned from the BBASC. As there is another member representing agricultural water users on the BBASC, the members agreed that representation for this category was adequate. By consensus the members agreed and that no replacement for Dr. Gallagher was necessary.

Chairman Mims noted that member Andy Garza, representing soil and water conservation districts, had also resigned from the BBASC. By consensus the members agreed to appoint Jim Bader, Texas State Soil and Water Conservation Board (TSSWCB), to the BBASC representing soil and water conservation districts.

With Mr. Bader in attendance the BBASC reached a quorum.

Approve Minutes

The minutes for the April 20, 2011 BBASC meeting were approved by consensus.

Comments from Texas Commission on Environmental Quality

Cory Horan, TCEQ, recommended that members familiarize themselves with the recommendation reports produced by other BBASC groups as well as environmental flows rules adopted by the TCEQ.

Chairman Mims noted that the BBEST report is based on best available science and is not subject to change by the BBASC.

Presentation on the Nueces River and Corpus Christi Bay and Baffin Bay Basin and Bay Area Expert Science Team's (Nueces BBEST) environmental flows recommendations report

BBEST Chair Sam Vaugh began a discussion of the environmental flow recommendations developed by the Nueces BBEST.

He identified the geographic scope and the 20 USGS gage locations the BBEST had selected. He noted the group elected to use the Hydrology-Based Environmental Flow Regime (HEFR) methodology to identify the statistical hydrology, and then applied biological, water quality, and geomorphic overlays to determine whether adjustments to the HEFR regime were appropriate. Members Ryan Smith and Dave Buzan explained the BBEST instream flow analysis and recommendations. They noted that while no SB2 type data existed within the basin, the BBEST initiated cross section data collection and analysis performed at 3 selected sites. In their habitat analysis the BBEST superimposed the HEFR generated flow ranges over their habitat availability curves to determine if the HEFR flows were maintaining enough habitat on a species by species, and not by guild, basis. The group concluded that the HEFR numbers would maintain suitable habitat and water quality sufficient to support a sound ecological environment.

BBEST member Greg Stunz led a discussion regarding the BBEST's Bay and Estuary recommendations. He noted that the group focused mainly on the Nueces River delta and Nueces Bay. The group evaluated the changes from historic conditions, primarily the oyster fishery, and historic inflows to the bay and determined that the system did not constitute a sound ecological environment. In developing their freshwater inflow recommendations the group considered historic water availability, freshwater inflow/salinity relationships, and ecological needs of selected focal species. He noted that the seasonal inflow recommendations were based on meeting the biological needs of all indicator species, while accounting for historical patterns of water availability.

Chairman Vaugh then explained how the BBEST evaluated the practical application of their environmental flow regime recommendations using a theoretical water supply project.

Discussion and appropriate action on future activities and responsibilities of the Nueces BBASC, meeting schedules, funding, and Nueces BBEST support

Vice Chairman James Dodson reviewed the BBASC time frame noting that recommendations from the BBASC were due to TCEQ and the Environmental Flows Advisory Group (EFAG) on September 1, 2012. The BBASC agreed to form a subcommittee that will meet several times over the next two months in order to review the BBEST report and recommendations and prepare a work plan for the development, by the full BBASC, of comments, recommendations and strategies to be submitted to TCEQ by September 1. The subcommittee members are: Ray Allen (&/or alternate Jace Tunnell); Jim Tolan; Gus Gonzalez; Con Mims; Rocky Freund;

Teresa Carrillo; Joel Pigg; Don Roach and James Dodson (subcommittee lead). Any BBASC member can participate in these subcommittee meetings.

Ruben Solis, TWDB, informed the BBASC that $22,000 has been made available to the BBEST to directly assist the BBASC in evaluating the BBEST recommendations. SB3 does not allocate funding for the BBASC itself.

Members discussed funding for BBASC activities and public outreach and education on environmental flows and the group's activities. The subcommittee will explore these issues and report back to the full BBASC. It was noted that comments from the public are accepted and will be incorporated into the group's meeting minutes.

Public comment
There was no public comment at this time.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
JANUARY 25, 2012

NATURAL RESOURCES BUILDING, FIRST FLOOR CONFERENCE ROOM
TEXAS A&M UNIVERSITY – CORPUS CHRISTI
CORPUS CHRISTI, TEXAS

MINUTES

Call to order Roll Call
Chairman Con Mims called the meeting to order. Roll call was taken and a quorum was reached.

Public comment
There was no public comment at this time.

Approve Minutes
The minutes from the October 19, 2011 meeting were approved by consensus.

Elect Officers for 2012
Member Ray Allen moved to re-elect Con Mims as BBASC Chair and James Dodson as BBASC Vice-Chair. Member Carola Serrato seconded and the members unanimously approved the motion.

Comments from SAC liaison
SAC liaison Paul Montagna provided a brief update on SAC activities. The SAC is currently evaluating work plans for adaptive management developed for other basins. He urged members to consider these SAC evaluations when it comes time for development of the work plan by this BBASC.

Report on reservoir conditions
Member Ray Allen distributed a handout explaining reservoir storage and capacity. Members discussed reservoir status with respect to the 2011 drought.

Discussion and appropriate action on report from Nueces BBASC Work Group
Vice-chair James Dodson provided a report of the BBASC work group evaluating the Nueces BBEST report. The work group is performing a detailed review of the BBEST recommendations and provided a summary document outlining their findings for members to review. The group had also considered and have provided information regarding a public information program, as suggested during the October 19, 2011 BBASC meeting, to disseminate information and inform the public regarding the BBASC environmental flow recommendations and those adopted by the TCEQ. This work group will continue to meet and will present their recommendations for approval by the full BBASC membership.

Discussion and appropriate action on potential technical and facilitation assistance
Per previous discussion, the BBASC agreed by consensus to not procure facilitation services to support the BBASC. After further discussion the BBASC agreed to delegate to the BBASC work group the authority to develop contracts and scopes of work for additional technical support to follow up on BBEST recommendations. The full BBASC will review any scope or contract for approval prior to execution.

Discussion and appropriate action on the Nueces BBEST environmental flows recommendations report

- **Texas Parks and Wildlife Department response to Nueces BBEST report**
  Dr. Jim Tolan, TPWD, distributed a memo containing TPWD staff perspectives on the Nueces BBEST report. Dr. Tolan provided a brief overview of TPWD's comments and concerns, noting TPWD's concurrence with the BBEST's determination of sound ecological environment, and the unsound environment determination of Nueces Bay.

- **Nueces BBEST clarification of its recommendations pursuant to Nueces BBASC questions and SAC comments**
  BBEST Chair Sam Vaugh, HDR, provided an overview of the BBEST environmental flow recommendations. He identified and addressed comments made by the SAC, TPWD, and initial comments by the BBASC members. He noted that the BBEST will respond to BBASC direction and inquiries as best they can, but will not respond directly to TPWD or SAC comments unless requested to do so by the BBASC members. All inquiries to the BBEST can be sent through Cory Horan, TCEQ. In discussing a water right for the City of Corpus Christi off channel reservoir, Mr. Vaugh clarified that environmental flow standards would only be applied to new appropriations, and thus the City's water right would not be subject to TCEQ adopted environmental flow standards. The members discussed how flow standards would be implemented, whether or not a water right holder could divert or pass water, and how those determinations are made. The members also discussed a proposal to evaluate the BBEST recommendations as applied to the BBEST selected sites the Nueces River at Laguna, TX, the Nueces River at Cotulla, TX, and the Nueces River at Three Rivers, TX. Each of these sites represents a distinct ecoregion within the basin.

Discussion and appropriate action on future activities and responsibilities of the Nueces BBASC, including meeting schedules, funding, and Nueces BBEST support
Cory Shockley, HDR, provided an overview of the 2001 TCEQ Agreed Order vs. the BBEST recommendations, noting similarities and differences. He discussed efforts to update the City of Corpus Christi water supply model with the ability to operate the system in accordance with the BBEST recommendations applied, and how often those recommendations are met. Once this project is complete the results will be provided to the BBASC for consideration of how the BBEST recommendations could, if applicable, affect existing water supplies. Member Gus Gonzalez also noted that the City of Corpus Christi is also funding an effort to evaluate the BBEST determination that Nueces Bay represents an unsound ecological environment. These results will also be presented to the BBASC for consideration.

Discussion and appropriate action on meeting schedule and agenda items for next meeting
Future BBASC meetings will occur on a monthly basis, to be held on the 4th Wednesday of the month.

Public comment
There were no public comments at this time.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
LIBRARY/COMMUNITY CENTER, 1101 CAMPBELL AVENUE, JOURDANTON, TX
FEBRUARY 22, 2012 10:00 A.M. – 3:00 P.M.

MINUTES

Members Present: Con Mims, Chair; Ray Allen; Tom Ballou; Richard Bowers; Paul Carangelo; Teresa Carrillo; J. Allen Carnes; George Driskill; Rocky Freund; Gus Gonzalez; Timo Hixon; Susan Lynch; Mike Mahoney; Joel Pigg; Don Roach (for Jim Naismith); Carola Serrato; Buddy Stanley; Wes Tunnell.

1. **Call to order**
   Chairman Con Mims called the meeting to order.

2. **Roll Call**
   Roll call was taken and a quorum was reached.

3. **Public comment**
   Tyson Broad, Sierra Club, spoke to the group recommending against the use of proxies, noting it would have been difficult in the Guadalupe-San Antonio BBASC process if that group had allowed proxies. He reasoned that an issue proposed at the beginning of their meeting often looked considerably different by the time a vote was taken.

4. **Approve Minutes**
   The minutes from the January 25, 2012 meeting were approved with slight revisions.

5. **Comments from SAC liaison**
   None

6. **Comments from Texas Commission on Environmental Quality**
   Cory Horan, TCEQ, reported that draft rules for the Guadalupe/San Antonio and Colorado/Lavaca environmental flow standards would be published soon. He encouraged members to familiarize themselves with these and other draft rules.

7. **Discussion and appropriate action on amendment of Meeting Rules to allow proxies**
   The BBASC members considered a proposed amendment regarding the use of proxies. After discussion the members concluded the following: A proxy is a Member who is designated by an absent Member to represent the absent Member in a meeting for all matters including reaching consensus and voting. For quorum purposes, the absent Member is considered to be present by proxy and part of the quorum. If a Member wishes to be represented at a meeting by proxy, his/her proxy delegate must be made known to

the Chair by email or fax prior to the meeting. Oral requests for proxy designations will not be accepted. The written proxy designation should note the absent member's interest group so that stakeholder representation is documented; e.g. "I *XXX*, representing Agricultural Irrigation, hereby designate *XXX* as my proxy for the *Xmonth Xdate, 2012* meeting of the Nueces BBASC." A Member may not serve as the proxy delegate for more than two absent Members at a single meeting. By consensus the members approved the use of proxies according to the terms above.

8. **Discussion and appropriate action on report from and recommendations of the Public Information/Education Program Subcommittee, including selection of a public education consultant**
The members evaluated a proposal regarding a targeted public education and information program submitted by Don Rodman of the Rodman Company. By consensus the members approved the contract at a cost of $12,500 to be funded by Port Industries and administered by the Coastal Bend Bays and Estuaries Program.

9. **Approve creation and membership of an Education Committee**
The BBASC formed a subcommittee to evaluate and advise the full BBASC on outreach and education issues. Subcommittee members include James Dodson (Chair), Jennifer Ellis, Don Roach, Ray Allen, Gus Gonzalez, Tom Ballou, Carola Serrato, and Terresa Carillo.

10. **Report on modeling being commissioned by City of Corpus Christi**
Member Ray Allen gave an update on the modeling subcommittee meeting held in Corpus Christi on February 17th at the Coastal Bend Bays & Estuaries Program office. The modeling subcommittee ran through various scenarios with the newly updated CCWSM. The various modeling scenarios runs were to determine impacts on safe yield under certain conditions (i.e. inserting the BBEST recommendations into the current reservoir operating plan, changing trigger levels at which BBEST recommendations would be activated, inclusion of an off channel reservoir, and adding in Garwood). Mr. Allen explained that this was a first time run at seeing how the BBEST recommendations would impact safe yield and that more detailed modeling work could now be focused on new strategies to benefit both the bay and M&I.

11. **Review Scope of Work for Technical Support for Development of Nueces BBASC Recommendations Report (SOW), modify for clarification as needed, and authorize the Nueces BBASC Work Group to work with the technical consultant to accomplish the SOW with continuing guidance from the Nueces BBASC**
It was noted that HDR Engineering, Inc. was willing to compile and draft the BBASC recommendations report. This task will cost between $25,000 and $30,000. The members will evaluate funding opportunities to support this work. The members agreed that the Nueces BBASC Work Group would support and direct the work of the technical consultants.

12. **Discussion and appropriate action on drafting the BBASC's Recommendations Report, including responsibilities, schedule, procuring assistance, and funding**
Following up on previous meetings there was further discussion on drafting the BBASC's recommendations report, including status updates, writing responsibilities, and scheduling.

13. **Panel discussion on ramifications of the Nueces BBEST's declaration that the Nueces Bay and Delta region is an unsound ecological environment**
There was a panel discussion on ramifications of the Nueces BBEST's declaration that the Nueces Bay and Delta region is an unsound ecological environment. The panelists were Tim Brown, whose clients include City of Corpus Christi; Mike Willatt, whose clients include San Patricio Municipal Water District and South Texas Water Authority; Colette Barron, Texas Parks and Wildlife Department; Myron Hess, National Wildlife Federation; Hope Wells, San Antonio Water System; and, Todd Chenoweth, Texas Commission on Environmental Quality.

There were four questions posed:
1. Can the BBEST declaration that the Nueces Bay and Delta are not in sound ecological condition affect the Choke Canyon Reservoir Certificate of Adjudication, the TCEQ approved Agreed Order for operating the Lake Corpus Christi/Choke Canyon Reservoir system, or the Nueces Estuary Advisory Council?
2. Does it encourage environmental lawsuits?
3. Does it preclude issuance of new water rights in the Nueces Basin?
4. What other consequences can it have?

Concerning panel response to Question 1: All agreed that the TCEQ could use the Agreed Order to "step in", but it could do that at any time, regardless of this declaration. No one felt it had any effect on the Certificate of Adjudication or NEAC.

Concerning panel response to Question 2: One said that law suits need no encouragement. All agreed that one needs a cause of action to have a lawsuit. This declaration is nothing more than new information. It is expert opinion. It can be used as evidence in a suit. But, it does not encourage a lawsuit.

Concerning panel response to Question 3: The declaration will not preclude issuance of new water rights. The ultimate environmental flow standards resulting from this process and adopted by TCEQ will determine issuance of new water rights.

Concerning panel response to Question 4: A consequence is that the declaration can become a persistent distraction to BBASC. No other consequences were noted.

14. **Discussion and appropriate action on meeting schedule and agenda items for next meeting**
    The next meeting of the Nueces River and Corpus Christi and Baffin Bays will be held on March 28, 2012. The meeting will again be held at the Jourdanton Library and Community Center.

15. **Public comment**
    There was no public comment at this time.

16. **Adjourn**

MINUTES

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
LIBRARY/COMMUNITY CENTER, 1101 CAMPBELL AVENUE, JOURDANTON, TX
MARCH 28, 2012

Members present: Con Mims, Chair; James Dodson, Vice Chair; Ray Allen (proxy for Ed Buskey, proxy for Wes Tunnell); Dick Bowers; Paul Carangelo; Rocky Freund; Gus Gonzalez; Timo Hixon; Don Roach; Carola Serrato; Pat Suter; Buddy Stanley; Mike Mahoney; Tom Ballou; John Adams; George Driskill; Teresa Carrillo

1. **Call to order**
   Chairman Con Mims called the meeting to order.

2. **Roll Call**
   A quorum was reached.

3. **Public comment**
   There was no public comment at this time.

4. **Approve Minutes**
   Approval of the February 22, 2012 minutes was postponed.

5. **Comments from SAC liaison**
   No comments from the SAC liaison.

6. **Comments from Texas Commission on Environmental Quality**
   No comments from the TCEQ.

7. **Discussion and appropriate action on funding BBASC meetings**
   Chairman Mims discussed the costs of securing the Jourdanton Library and Community Center for the BBASC meetings. The members agreed to continue to meet at this location and the group will explore potential sources of funding for future meetings.

8. **Discussion and appropriate action on report from the Public Information/Education Program Subcommittee**

The next BBASC workgroup meeting will be held on April 3, 2012. This subcommittee agreed to consider this issue and report back to the full BBASC at the April 25, 2012 meeting.

9. Discussion and appropriate action on the schedule and responsibilities for drafting the BBASC's Recommendations Report

BBASC Alternate Jace Tunnell provided an update on the BBASC report schedule, noting that scheduled sections had been drafted. He discussed the rule process and explained options. It was suggested that the work group can provide their comments on drafted report sections for consideration by the full BBASC and that the lead authors can present their drafts for discussion at BBASC meetings.

10. Discussion and appropriate action on selection and work of technical assistance consultant

Ruben Solis, TWDB, noted that the technical support contract had been awarded to HDR, Inc., with input from the BBASC Work Group. Sam Vaugh, HDR, provided an overview of the technical support work to support the Nueces BBASC. The technical support scope of work includes:

- Evaluations of planned water supply project
- Evaluation of potential environmental flow standards and strategies
- BBASC recommendations regarding environmental flow standards
- Technical support during BBASC meetings and report compilation

11. Discussion and appropriate action on modeling commissioned by City of Corpus Christi

Member Ray Allen updated the members on modeling activities being performed by HDR, Inc. He noted that consultants are looking at different scenarios based on the flow recommendations developed by the Nueces BBEST. Technical consultant Cory Shockley, HDR, discussed the progress and analysis performed to date. Preliminary modeling results show that every time the model was run under the various scenarios the attainment frequencies were not met, and implementation of the BBEST recommendations reduced the safe yield.

Ruben Solis, TWDB, discussed their work regarding model simulation for salinity reduction and maintenance in Nueces Bay. They found that the TxBLEND modeling results do match up with actual data.

12. Discussion and appropriate action on formulating BBASC goals relating to the ecological condition of Nueces Bay and Delta

The group considered what goal regarding the ecological condition of the Nueces Bay and Delta and adopted the following:

The goal of the Nueces BBASC with regard to the Nueces Bay and Delta is to return the Nueces Bay and Delta to ecological conditions existing prior to construction of Choke Canyon Reservoir to the extent possible while preserving existing water rights and yield of the reservoir system. To this end, the Nueces BBASC will recommend instream flow and estuary inflow regimes that may improve the existing ecological condition of the Nueces Bay and Delta, but will not diminish its existing condition, and will set forth, in its Workplan, strategies to enhance its ecological condition.

13. Introductory discussion on developing potential strategies to meet environmental flow recommendations

Norman Johns, National Wildlife Federation, presented a paper outlining potential strategies to meet environmental flow standards. Strategies outlined included:

- Donation, sale, or lease of existing water permits
- Voluntary dedication of conserved water from current permits to environmental flows
- Voluntary dedication of wastewater return flows

14. Public comment

There was no public comment at this time.

15. Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
LIBRARY/COMMUNITY CENTER, 1101 CAMPBELL AVENUE, JOURDANTON, TX
APRIL 25, 2012

Minutes

Members Present: Con Mims, Chair; James Dodson, Vice Chair; Ray Allen; Paul Carangelo; Gus Gonzalez; Don Roach; Carola Serrato; Wes Tunnell; Buddy Stanley; Mike Mahoney; Tom Ballou; Joel Pigg; John Adams; Susan Lynch; Scotty Bledsoe, Teresa Carillo

1. Call to order
Chairman Con Mims called the meeting to order.

2. Roll Call
Roll call was taken and a quorum was reached.

3. Public comment
There were no public comments at this time.

4. Approve Minutes
The members reviewed and approved the February 22 and March 28, 2012 minutes with slight revisions.

5. Comments from SAC liaison
None

6. Comments from Texas Commission on Environmental Quality
None

7. Discussion with Kathy Alexander, Technical Specialist to the Water Supply Division, Texas Commission on Environmental Quality on dedication of wastewater return flows to support inflows to the Nueces Bay and Delta
At the request of the BBASC, Kathy Alexander, TCEQ, discussed the concept of using treated wastewater as a way to help control salinities and improve estuarine habitat in the Nueces Delta. She noted that to deliver return flows via bed & banks, an entity would need to apply for a water right permit and all factors determining conditions would be site specific, with the intended purpose of use of return flows being considered. The members discussed existing studies to evaluate this use of wastewater dedication. The members agreed to include recommendations for wastewater dedication not in the recommendations report but in the work plan for adaptive management.

8. Activities of the Public Information/Education Program Subcommittee and the BBASC's public information consultant, The Rodman Company

The members discussed deliverables recommended by the public information subcommittee, including a fact sheet and website on the SB3 process. They agreed that the primary audience would be public officials and informed leaders knowledgeable of long term water supply planning. All deliverables will be reviewed with input from the public information subcommittee before being finalized.

9. Schedule and responsibilities for drafting the BBASC's Recommendations Report

The members agreed that all sections of the recommendation report drafted by an individual will be approved by the full BBASC and will remain open for revision through the end of the approval process. BBASC alternate Jace Tunnell reviewed the outline and schedule for development of the recommendations report, noting completed sections and discussing the sections that will need to be drafted by the next (May 23, 2012) meeting. He requested that members begin to review those portions of the report that have been completed so the group can begin to address any comments or suggested revisions.

10. Activities of the Modeling Subcommittee and technical presentations on modeling funded by Texas Water Development Board and/or City of Corpus Christi

Chairman Mims explained that the technical consultants (HDR, Inc.) are performing model runs to demonstrate how the BBEST recommended flow regimes would affect water supplies in future permitting actions. This is being done in order to have a better understanding of the impact of the BBEST recommendations to inform the BBASC response. Sam Vaugh, HDR, explained that the analysis being performed was to inform the BBASC in two ways: 1) by identifying firm yield for both regional water planning group planned projects and theoretical example projects, as well as 2) the resulting flows, the indication that what the BBASC can choose to do has ecological ramifications and flows are the starting point for their evaluation. For planned water supply projects, preliminary evaluations were presented based on four different criteria: 1) no environmental flow standards, 2) the TCEQ default methodology, 3) using regional water planning models, and 4) application of full BBEST recommendations. For 3 theoretical example projects, preliminary evaluations were presented based on: 1) no environmental flow standards, 2) application of full BBEST recommendations, and 3) a range of potential modifications to the BBEST recommendations. Cory Shockley, HDR, reviewed the results of model outputs for each of these scenarios and discussed the initial conclusions from this evaluation. Pursuant to the 4/3/2012 request of the BBASC, Mr. Shockley defined and presented preliminary evaluations of a "Modified BBEST" scenario (including an overbank exemption, a pulse exemption rule, a single tier of seasonal average condition base flows, and a 50% rule for diversions between seasonal base and subsistence flows) for BBASC consideration. The BBASC agreed to ask the technical consultants, with support from the BBEST and TWDB, to evaluate the environmental effects of applying the modified BBEST scenario to each of the 3 theoretical example projects in terms of relationships between flow and species habitat and sediment transport. The BBASC also requested evaluation of an alternative modified BBEST scenario using the 50% rule applied to wet (high) base flows for discussion at the next meeting. Quantitative evaluations of environmental effects will be performed for 3 sites (Nueces River at Laguna, Cotulla, and Three Rivers) at which quantitative data is available, one for each ecoregion in the study area.

Regarding freshwater inflows to Nueces Bay and Delta, Mr. Shockley began by comparing the BBEST recommendations against the 2001 agreed order using the Corpus Christi Water Supply Model. He also explained the differences in how each should be considered. In evaluating different scenarios he is looking to explain three different aspects: 1) what is the inflow to bay and delta and how does it change, 2) affects to system yield, and 3) what is the reservoir storage and how does it change. He presented the model outputs regarding these different scenarios. After discussion the members directed the technical consultants to continue this analysis, refining the bay and estuary analysis and providing flows for the TxBLEND analysis to be performed by the TWDB.

Member Ray Allen provided a handout showing simulated freshwater inflows to Nueces Bay. He explained what water would be available for the Nueces Delta under different scenarios (e.g. no pumping). This takeaway message is that, if you have some water management of the system and can focus it on Rincon Bayou and Nueces Bay and Delta, you will see ecological benefits even in drought years (2011). After discussion, the members agreed to direct the BBASC work group to evaluate and bring back next month a recommendation as to how to proceed. All BBASC members are invited to attend the meetings of the BBASC work group.

11. Strategies to meet environmental flow recommendations
This topic was addressed in earlier discussions and will be continued in future meetings.

12. Future activities and responsibilities of the BBASC
The next BBASC meeting will be held at 10:00 a.m. on May 23, 2012. The meeting will again be held at the Jourdanton, TX Library and Community Center.

13. Public comment
Norman Johns, National Wildlife Federation, suggested that the BBASC not lessen the strategies discussion in the main body of their recommendations report. He noted there is value in including this discussion in the BBASC report as well as in the work plan for adaptive management.

14. Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
LIBRARY/COMMUNITY CENTER, 1101 CAMPBELL AVENUE, JOURDANTON, TX
MAY 23, 2012

MINUTES

Members Present: Con Mims, Chair; James Dodson, Vice Chair (Proxy for Don Roach, Tom Ballou); Ray Allen; Richard Bowers; Paul Carangelo; Gus Gonzalez; Carola Serrato; Wes Tunnell; Buddy Stanley; Mike Mahoney; Timo Hixon; Joel Pigg; John Adams; George Driskill; Ross Thompson; Scotty Bledsoe.

Call to order and Roll Call
Roll call was taken and a quorum was reached.

Public comment
There were no public comments at this time.

Approve Minutes
Technical consultant Sam Vaugh reviewed his comments to the draft minutes. Mr. Vaugh's comments were accepted and the minutes were approved by consensus.

Comments from SAC liaison
None

Comments from Texas Commission on Environmental Quality
None

Activities of the Public Information/Education Program Subcommittee and the public information consultant
Nothing to report at this time.

Schedule and responsibilities for drafting the BBASC's Recommendations Report
Jace Tunnell reviewed the report outline and schedule. He reported on completed portions of the recommendations report and noted that these have been posted to the ftp site.

Activities of the Modeling Subcommittee and technical presentations on modeling funded by Texas Water Development Board and/or City of Corpus Christi

Cory Shockley, HDR, provided a summary of the analysis presented to the BBASC from the April meeting which included a review of model comparisons from the various scenarios being evaluated. The scenarios are: modified BBEST (overbank exemption, pulse exemption rule, single tier of seasonal average condition base flows, and a 50% rule for diversions between seasonal base and subsistence flows), full BBEST, no environmental flow criteria, Lyons, and CCEFN (regional water planning). At that April meeting the BBASC directed the technical consultants to perform additional evaluations of an alternative modified BBEST scenario using the 50% rule applied to wet (high) base flows. One proposed project (Sabinal recharge reservoir) and three hypothetical projects were evaluated: Laguna with off-channel reservoir and Cotulla with both on and off-channel reservoir. Mr. Shockley reviewed the results of this additional analysis, identifying the differences in both yield/supply and flows as compared to the other modeled scenarios presented at the April meeting. He noted that the modified BBEST wet scenario generally results in higher base flows than the modified BBEST average scenario.

BBEST member Ryan Smith presented recent habitat analysis for the different scenarios being evaluated by the BBASC to determine if those flows create enough habitat to maintain a sound ecological environment. He presented simple hydraulic modeling that shows a relationship between flow and habitat, as shown in percent maximum habitat available. He used a 75% minimum threshold for base flows and 20% for subsistence flows. This allows the BBASC to look at raw flow assessments from a biological perspective. For the Nueces River at Laguna analysis he found that "enough" habitat (i.e., per 75% minimum threshold of Maximum WUA used by BBEST) is maintained for fewer species under the full 50% diversion of the Modified BBEST A scenario. He noted that in most cases it is not far below the 75% minimum threshold and that Guadalupe Bass and Texas Shiner (both of which are species of greatest conservation needs, as determined by TPWD) do not meet the 75%. A TPWD representative clarified that neither of these species is listed as threatened or endangered by the TPWD or the USFWS. He found that "enough" habitat was maintained for more species by the Modified BBEST W scenario. For the Nueces at Three Rivers he found "enough" habitat (i.e., per 75% minimum threshold of Maximum WUA used by BBEST) is not maintained for all species under the full 50% diversion of Modified BBEST A scenario. However, neither is it under the Full BBEST recommendation. He found that "enough" habitat was maintained for more species by Modified BBEST W scenario. For the Frio River at Concan he found that "Enough" habitat (i.e., per 75% minimum threshold of Maximum WUA used by BBEST) is maintained for all species at Concan under the full 50% diversion of both the Modified BBEST A and Modified BBEST W scenarios. He concluded by suggesting that habitat analysis is not the only aspect to apply when evaluating whether or not a sound ecological environment is protected. Chairman Mims suggested that the work plan could include additional recommendations beyond this habitat analysis.

Mark Wentzel, TWDB, presented his recent sediment transport analysis for three sites, Nueces River at Laguna, Nueces River at Cotulla, and Nueces River at Three Rivers. He explained that sediment analysis is important in that evaluating how sediment transport changes will provide an evaluation of how these different scenarios might affect shape of channel, which in turn affects habitat. He presented the results of their analysis for each of the three sites with both on and off-channel reservoirs under the following eflow scenarios: historical (baseline), full BBEST, Modified BBEST A, Modified BBEST W, and no eflows. He concluded that with off-channel reservoirs sediment remained relatively stable; for on-channel reservoirs the closer you get to the reservoir you can expect larger magnitude type changes which should be evaluated with more specific studies. Farther downstream this is less of a concern.

BBASC instream flow and estuary freshwater inflow recommendations

Instream Flow:

Cory Shockley resumed this discussion by suggesting the group needs to decide whether to apply the 50% rule to either wet base flows or average base flows and responded to questions regarding his analysis utilizing the modified BBEST wet and modified BBEST average scenarios. BBEST member Smith also clarified that there are higher frequencies of meeting a 75% of Maximum habitat criterion at Laguna for more species under the modified BBEST average scenario than under the modified BBEST wet scenario. After discussion by the members the BBASC, by consensus, adopted the following instream flow recommendations:

The BBEST's instream flow standards be modified at all locations in the basin, except the Lake Corpus Christi Off-Channel Reservoir site, which will be subject to estuary freshwater inflow standards, by:

a) eliminating the overbank requirement,

(b) eliminating high flow pulses where the maximum diversion rate of a future application is less than 20% of the rate which triggers a high flow pulse requirement, and

(c) having only one (the "average"), instead of three, tiers of base flows and applying a 50% rule which allows for diversions below the base flow equal to 50% of the difference between the seasonal base average and subsistence flows.

These recommendations are with the BBASC's understanding that they will not have an unmitigated effect on the reservoir system safe yield or existing water rights, because any new project will have to honor senior water rights, and they will not adversely affect Nueces Bay and Delta, because of pass through and other requirements of the agreed order.

Freshwater inflows:
Mr. Shockley presented his evaluation of four scenarios regarding a freshwater inflow regime to the Nueces Bay and Delta:

- BBEST recommendation
- Agreed order safe yield
- No Pass through
- And OCR agreed order safe yield

After discussion the BBASC agreed to table this discussion to the June 2012 BBASC meeting to allow evaluation and recommendation by the Nueces BBASC Work Group.

Work Plan and strategies to meet environmental flow recommendations
This discussion was postponed until the June 2012 BBASC meeting.

Public comment
There was no public comment at this time.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
LIBRARY/COMMUNITY CENTER, 1101 CAMPBELL AVENUE, JOURDANTON, TX
JUNE 20, 2012

MINUTES

Members Present: Con Mims, Chair (Proxy for Scotty Bledsoe); James Dodson, Vice Chair; Ray Allen; Paul Carangelo; Carola Serrato; Wes Tunnell; Buddy Stanley; Mike Mahoney; Joel Pigg; George Driskill; Don Roach (Proxy for Tom Ballou); Rocky Freund; Gus Gonzalez; Paul Carangelo (Proxy for Carola Serrato, Dick Bowers); Pat Suter; Timo Hixon; Teresa Carillo (Proxy for John Adams); Susan Lynch.

Call to order and Roll Call
Roll call was taken and a quorum was reached.

Public Comment
There were no public comments at this time.

Approve Minutes
Approval of meeting minutes was postponed until the next meeting.

Comments from SAC liaison
None

Comments from Texas Commission on Environmental Quality
None

Activities of the Public Information/Education Program Subcommittee and the public information consultant
There was no report at this time.

Schedule and responsibilities for drafting the BBASC's Recommendations Report
Jace Tunnell discussed the status of the BBASC recommendations report. All sections of the report should be posted to the ftp site by Saturday, July 25, 2012. HDR will then compile the sections into a single document and email the document to all BBASC members by Wednesday, August 1st. Members will have until Wednesday, August 8th to review and submit comments. Revisions will be re-posted to the ftp site for review on Wednesday, August 15th. HDR will then prepare the final document to be presented Wednesday, August 22, 2012 and submitted to TCEQ on Friday, August 31, 2012.

Activities of the Modeling Subcommittee and technical presentations on modeling funded by Texas Water Development Board and/or City of Corpus Christi

Instream Workgroup: Sam Vaugh presented an update on the instream flow recommendations. He discussed the revisions made to the tables summarizing the instream flow recommendations to reflect the changes to the structure of the recommendations discussed at the last meeting. He reviewed section 4.1 of the report on how to use and implement the tables and sections 4.1.2 – 4.1.21 which include the flow recommendation tables organized from upstream to downstream in the basin. Members agreed to include pictures with each table as done in the BBEST report. He noted that the pulse exemption rule agreed to at the last meeting will be located in section 4.3.1,

Pulses and Overbank Flow.

Mr. Vaugh presented recommendations of the BBEST not yet discussed by the BBASC. He presented a background on pulse volume regression and bound *vs*. regression values and explained how they are calculated. When applied at the Sabinal Recharge Reservoir and Cotulla off-channel reservoir, the analyses indicated that the use of high flow pulse volume and duration bound values results in greater pulse duration and volume passage than typically occurred historically thus reducing firm yield of potential projects and increasing environmental protection. Use of the regressed high flow pulse volume and duration values are consistent with historical streamflow events increasing firm yield of potential projects and reducing environmental protection. As a result of these findings, the workgroup recommended no modifications to the BBASC instream recommendations, including upper bounds on some pulse volumes and durations, as recommended by the BBEST and agreed to by consensus during the last meeting. The workgroup also recommended the proposed work plan include further investigations of the ecological and water supply ramifications of this recommendation.

Chairman Mims opened the floor to discussion. Mr. Vaugh noted that the regression graphs were generated using HEFR. Members asked whether the bound values were associated with back-transform values because there may be an issue with using a linear x-y scale for the graphs since the regression equation is based on logarithmic transformation of the data. It was decided that this issue could be addressed in the further investigation recommended by the workgroup.

Members moved to adopt the Instream Environmental Flow Standard Recommendation of the work group, and the motion was approved by consensus.

Estuary and Delta Workgroup: In response to previous inquiries, Section 4.4 has been changed to *Nueces BBASC comments on the SB3 Process* to include any comments BBASC members wish to include in the report.

Cory Shockley, HDR, updated members on the status of the Bay and Estuary discussions. He explained that an attainment frequency is the percent of time in which the inflow into the Bay and Estuary equals or exceeds a specific volume as determined by the BBEST. He discussed how it is influenced by natural hydrology, system demand, and system operations. In general, greater attainment frequency results in lower system yield.

The workgroup focus was to find an acceptable balance between attainment frequency and yield by adjusting the attainment frequency to meet the volume targets recommended by the BBEST. The workgroup (Option 2) that was presented at the last meeting includes the full utilization of the system safe yield under the existing order.

The workgroup proposed that for the Nueces Bay and Delta inflow recommendations the BBASC adopt the BBEST volume targets and the BBASC attainment frequencies associated with full utilization of the system safe yield under the existing agreed order. In addition, the work group recommended a NEAC review and recommendation to TCEQ for new appropriations in excess of 1,000 acre-feet/year. Members discussed this proposal.

BBASC member Ray Allen cautioned members to avoid extremes that could result in making conditions worse during periods of drought and emphasized the need for managing flows throughout the year to meet subsistence flow requirements. Members expressed the importance of getting new ideas such as those from NEAC for the BBASC to pursue. It was added that the there is a finite amount of water and the only recourse may be in adaptive management. Members discussed whether to refine and improve the attainment frequencies by pursuing water management strategies and adaptive management strategies.

Member Ray Allen suggested changing 1,000 acre-feet to 500 acre-feet as the limit above which NEAC will review a request for a new appropriation of water. Members agreed.

Members moved to adopt the Estuary and Delta Environmental Flow Standard Recommendation as amended, and the motion was approved unanimously

Instream Flow and Estuary Freshwater Inflow Recommendations
Chair Mims and BBASC member Teresa Carillo will work on section 4.2 of the report concerning the instream flow and estuary freshwater inflow recommendations. Once completed, it will be emailed to BBASC members for review.

Strategies to Meet Environmental Flow Recommendations (Section 5 of the Recommendation Report)
Chair Mims distributed copies of the current working draft of Section 5 - *Recommendations Regarding Potential Strategies to Meet Environmental Flow Standards*. He explained the difference between strategies and work plan

recommendations. Members then discussed each strategy listed in the recommendation and whether each should be included in the report.

Members reviewed the draft strategies identified in section 5, revising per discussion. Members approved by consensus the strategies as amended.

Chair Mims will revise the document as agreed and submit the corrected document as soon as possible.

Future activities and responsibilities of the BBASC

The next meeting of the BBASC is scheduled for Wednesday, July 25, 2012 where members will discuss development of the work plan. The Workgroup is scheduled to meet on Monday, August 6, 2012.

Public comment

There were no comments at this time.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
LIBRARY/COMMUNITY CENTER, 1101 CAMPBELL AVENUE, JOURDANTON, TX
JULY 25, 2012

MINUTES

Members Present: Con Mims, Chair (Proxy for Mike Mahoney); James Dodson, Vice-Chair; Ray Allen; Richard Bowers; Wes Tunnell (Proxy for Ed Buskey); Paul Carangelo; Gus Gonzalez; Don Roach (Proxy for Tom Ballou); Carola Serrato; Teresa Carillo (Proxy for Pat Suter); Buddy Stanley; Timo Hixon; Joel Pigg; Susan Lynch; Scotty Bledsoe.

Call to order
Chairman Con Mims called the meeting to order.

Roll Call
Roll call was taken and a quorum was reached.

Public comment
There were no public comments at this time.

Approve Minutes
Approval of meeting minutes for the May 23, 2012 and June 20, 2012 was postponed.

Comments from SAC liaison
There were no SAC comments at this time.

Comments from Texas Commission on Environmental Quality
Cory Horan, TCEQ, informed the members that the proposed rules regarding environmental flow standards for the Guadalupe/San Antonio and Colorado/Lavaca basin and bay systems are scheduled for approval by the TCEQ Commissioners on August 8, 2012.

Activities of the Public Information/Education Program Subcommittee and the BBASC's public information consultant
The members discussed the public outreach flier developed by Don Rodman entitled: "Water for Flowing Rivers and Productive Bays." The corresponding website was also discussed. Members provided minor comments and the flier was approved. The flier will be sent out electronically to members and individuals associated with the BBASC and will include a request to distribute beyond the BBASC e-mail list. The document will also be available on the Nueces BBASC outreach website: www.NuecesSB3.org.

Schedule and responsibilities for drafting the BBASC's Recommendations Report
Jace Tunnell provided an update on the status of the BBASC recommendations report. He noted that only section 4.4 is incomplete. All report sections to date have been posted to the Nueces River Authority ftp site. A draft report will be distributed to the

BBASC members on August 1, 2012. All comments on the draft report are to be sent to Cory Shockley, HDR by August 8, 2012. Comments will be distributed to the primary authors and their responses will be returned to HDR by August 15, 2012. HDR will incorporate all comments and deliver a final version of the report to the BBASC members on August 22, 2012. HDR will then submit the final recommendations report to the Environmental Flows Advisory Group (EFAG) and the TCEQ on or before August 31, 2012. Cory Shockley also reviewed the process for addressing any remaining comments and how these should be submitted by the members and target dates for completion.

Activities of the Modeling Subcommittee and technical presentations on modeling funded by Texas Water Development Board and/or City of Corpus Christi
There was nothing to report at this time.

Work Plan and adaptive management (Section 6–Status of Work Plan and Adaptive Management)
Chairman Mims discussed the latest version of the work plan for adaptive management which was distributed to the members. He clarified that this draft is not the final work plan which will be completed after September 1, 2012. This draft was provided to give the members an indication of the types of things likely to be considered for the work plan. The members reviewed section 6.0, status of work plan and adaptive management, providing comments and making revisions to the document per discussion. After discussion the members agreed by consensus to a 5-year review cycle for revisiting and evaluating the work plan. The 5-year review cycle will begin on the date TCEQ adopts environmental flow standards. By consensus section 6, status of work plan and adaptive management, was approved including revisions made and agreed upon per discussion.

Comments on Recommendations Report
Jennifer Ellis, National Wildlife Federation, explained that some issues have come up in other basin activities regarding the way TCEQ models and assesses water availability in their permitting process. She explained that TCEQ's WAM run 3 is done in a monthly time step while some of the BBASC work is done on a daily time-step basis. As other SB3 groups have evaluated modeling processes they have found that this difference between daily and monthly may be significant. Recommendations have been made to TCEQ to consider using daily time step. She suggested that reports and recommendations like those that come out of the BBASC process can influence and encourage TCEQ toward this direction.

Chairman Mims proposed that section 4.4 could reflect comments from the BBASC members and from those entities or individuals who have been involved in the process but are not part of the BBASC members. After discussion the members agreed to allow outside comments which will be included in the appendix to section 4.4. These comments must be provided to Cory Shockley at HDR by August 8^{th}, 2012.

Future activities and responsibilities of the BBASC
At the August 22, 2012 BBASC meeting the members will approve their environmental flows recommendations report for submittal to the TCEQ and EFAG. A BBASC Work Plan subcommittee will be appointed to develop a draft work plan for consideration by the full BBASC.

Public comment
Jennifer Ellis stated that the Science Advisory Committee (SAC) had met to discuss their review of the Guadalupe/San Antonio and Colorado/Lavaca work plans. Their review is not complete but the SAC agreed that the Guadalupe/San Antonio work plan was a very good document. She suggested the BBASC use their work plan as a template. Chairman Mims agreed.

Adjourn

MEETING OF THE NUECES RIVER AND CORPUS CHRISTI BAY AND BAFFIN BAY BASIN AND BAY AREA STAKEHOLDERS COMMITTEE (NUECES BBASC)
10:00 A.M. – 3:00 P.M.
LIBRARY/COMMUNITY CENTER, 1101 CAMPBELL AVENUE, JOURDANTON, TX
AUGUST 22, 2012

MINUTES

The minutes from the August 22, 2012 meeting of the Nueces River and Corpus Christi Bay and Baffin Bay Basin and Bay Area Stakeholders Committee (Nueces BBASC) were not available at the time of the printing of this report.

These final approved minutes should be available at the following website:

http://www.tceq.state.tx.us/permitting/water_supply/water_rights/eflows/nueces-river-and-corpus-christi-and-baffin-bays-stakeholder-committee-and-expert-science-team

December 19, 2011

The Honorable Troy Fraser, Co-Chair
Environmental Flows Advisory Group
P. O. Box 12068 – Capitol Station
Austin, TX 78711

The Honorable Allan Ritter, Co-Chair
Environmental Flows Advisory Group
P. O. Box 2910
Austin, TX 78768-2910

Dear Senator Fraser and Representative Ritter:

The Basin and Bay Expert Science Team (BBEST) for the Nueces River and Corpus Christi and Baffin Bays completed their environmental flow recommendation report on October 28, 2011. The report was submitted to the Environmental Flows Advisory Group (EFAG), the Texas Commission on Environmental Quality (TCEQ), and their Basin and Bay Area Stakeholder Committee.

The report is very comprehensive and clearly represents a substantial effort by the members of the science team to address their charge as stipulated in Senate Bill 3. The state can be proud we have so many dedicated scientists willing to participate in this program.

Attached are review comments prepared and adopted by the Texas Environmental Flows Science Advisory Committee (SAC) pursuant to Texas Water Code **Sec. 11.02362(q)**, as added by Senate Bill 3 in the 80th Texas Legislature, 2007. The statute calls for the SAC to provide input to the EFAG for its use in reviewing the BBEST environmental flow analyses and environmental flow regime recommendations. The attached review follows a modified framework adopted by the SAC in December 2010, and reflects the consensus opinion of the SAC members. Should the advisory group deem it appropriate to submit comments to the TCEQ as they undertake rulemaking for this basin, the SAC trusts that you will find the enclosed review helpful, and we stand ready to support your preparation of comments in any way you deem appropriate.

Sincerely,

Robert J. Huston
SAC Chairman

CC: Con Mims, Nueces River and Corpus Christi and Baffin Bays Area Stakeholder Committee Chair
Sam Vaugh, Nueces River and Corpus Christi and Baffin Bays BBEST Chair
Mark Vickery, Executive Director, Texas Commission on Environmental Quality

Memorandum

To: **Environmental Flows Advisory Group (EFAG)**
From: **Texas Environmental Flows Science Advisory Committee (SAC)**
Date: **December 19, 2011**
Re: **Review comments on Nueces River and Corpus Christi and Baffin Bays Basin and Bay Expert Science Team (NBBEST) Environmental Flow Regime Recommendations Report dated October 28, 2011**

Introduction

The Nueces River and Corpus Christi and Baffin Bays Basin and Bay Expert Science Team (NBBEST) submitted its environmental flow analyses and environmental flow regime recommendations to its Stakeholder Committee, the EFAG and the Texas Commission on Environmental Quality (TCEQ) on October 28, 2011, and this was followed by a presentation to the SAC at its regular meeting on November 2, 2011. Texas Water Code **Sec. 11.02362 (q),** as added by Senate Bill 3 in the 80th Texas Legislature, 2007 (SB 3), provides that "In accordance with the applicable schedule…the advisory group, with input from the science advisory committee, shall review the environmental flow analyses and environmental flow regime recommendations submitted by each basin and bay expert science team. If appropriate the advisory group shall submit comments on the analyses and recommendations to the commission for use by the commission in adopting rules under Section 11.1471. Comments must be submitted not later than six months after the date of receipt of the analyses and recommendations." This memorandum represents the SAC's input to the EFAG based on our review of the NBBEST report.

The SAC notes that the work of the Nueces BBEST is unique for at least five reasons: 1) the NBBEST was formed and started the SB3 process earlier because a preexisting group called the Nueces Estuary Advisory Committee was allowed under the statute to expand and form the basin stakeholder committee (Nueces BBASC) and begin work, 2) the estuarine group had more coastal data and flow studies available than other BBESTs, 3) the NBBEST had to deal with a drier climate than previous BBESTs, with many intermittently flowing streams and marine and hypersaline estuaries, 4) the Nueces estuary already has an existing regulation for environmental flows that is similar in many respects to an SB3 flow regime, and finally 5) the NBBEST concluded that some estuaries in their geographic region were not ecologically sound.

SAC Review and Comments

1. Do the environmental flow analyses conducted by the BBEST appear to be based on a consideration of all reasonably available science, without regard to the need for water for other uses?

1.1 Has the BBEST identified and considered available literature and data? Were relevant scientific data and/or analyses discounted by the BBEST?

The literature reviews are excellent. The NBBEST relied upon guidance provided by the SAC and took advantage of literature reviews provided by other basins' BBEST reports. Relative to instream flow, an exceptional description of the Nueces Basin ecological systems was presented considering the somewhat limited amount of available information. It does not appear that the NBBEST discounted any instream data or analyses, other than streamflow data determined to be from gauges with insufficient records.

The NBBEST benefited by at least four long-term, detailed, studies previously conducted for the Nueces Estuary specifically addressing environmental flow needs: The Texas Water Development Board funded studies performed by the University of Texas Marine Science Institute from 1988 – 1996, the Bureau of Reclamation Demonstration Project (1994-2000), the City of Corpus Christi Nueces River Overflow Channel Project (2002-2010), and the Army Corps of Engineers Nueces Basin Feasibility Study (2007-present).

The NBBEST report provides an excellent description of the basins and bays as they exist today, plus a review of the changes that have occurred in Nueces Bay and Nueces Delta since 1900. The presentation (in Section 2.0) of the ecoregions within the watersheds and bays is excellent. The coupling of photographs for each individual site with the flow regimes was exceptionally helpful (Section 6.1). The NBBEST directly used the extensive information available for the Nueces estuary, and Nueces, Corpus Christi, and Baffin Bays, as well as the significantly more limited information available for the Nueces River and its tributaries.

1.2 Are the data sources and methods adequately documented?

While the report does not specifically cite all the individual SAC guidance documents that were likely used in the NBBEST's deliberations, the basic data sources are well documented with a considerable amount of that information presented in the detailed Appendices. There are several instances of citations appearing in the body of the report that are absent in the Reference list, without any obvious reason for doing so. The methods for most data analyses relative to the estuarine recommendations were adequately documented.

However, the methods for determination of instream flow recommendations are somewhat disappointing, given the importance of these recommendations and the additional time and data resources afforded to this BBEST. The NBBEST states on Page 3-2, **"Based on the recommendation of the National Research Council (NRC, 2005), and consistent with Maidment, et al. (2005), the SAC (2009) implemented the HEFR Methodology."** The HEFR methodology was never "implemented" by the SAC nor was the SAC's consideration of HEFR for environmental flow analyses based on NRC recommendations or information from Maidment. Rather, HEFR was simply deemed a useful tool for the determination of an environmental flow regime, in conjunction with consideration of water quality, geomorphologic, and biologic components. (See SAC-2009-1 - HEFR methodology guidance document). We further note that the apparent reference to the HEFR Guidance on page 3-2 is incorrect in that the SAC HEFR document is not listed in the references. In fact, the NBBEST report is somewhat inconsistent in its references to documents listed in Section 8 – References, particularly when referencing numerous SAC guidance documents.

While an impressive body of work is presented in the determination of physical-habitat requirements as a function of flow, the following NBBEST statement (Page 3-39) indicates that it predetermined that this work would only be used to verify historical hydrology-based instream flow recommendations, **"We utilized flow-habitat modeling in the biological overlay to answer the following question: *Do the hydrology-based flow regime recommendations maintain sufficient instream habitat quality, quantity, and diversity that provide a sound ecological environment?* "** It is the SAC's opinion that setting up a question to only use site-specific flow-habitat data to verify historical hydrology-based flow regimes from the onset sidesteps the biological overlay process. The additional work that was conducted by the state agencies and subsequently analyzed by consultants and the NBBEST should have been evaluated first on its merit of setting or adjusting recommendations via the overlay process, only falling back to a verification mode if that is all that it was deemed useful for. However, the text throughout this section is somewhat ambiguous on this subject and this may in fact have been the process as suggested by the following statement on Page 3-65, **"In part as a result of the uncertainties described in the paragraphs above, the BBEST decided it was not appropriate to set flow regime values based on the habitat suitability analysis, but it was appropriate to conclude that HEFR-based flows support instream habitat."**

How exactly the detailed depictions of WUA curves and associated tables for the individual fish species resulted in (or "indicated") the recommendation of maintenance of the historical HEFR flows is the crux, when it had just been deemed too uncertain to use to set or adjust any recommendation. It is recognized that this is a complex topic and may simply have been an oversight with difficult schedule demands. Thus, the BBASC will be well served by receiving additional clarification from the NBBEST on their method of instream flow recommendation development; in particular, the role (if any) that the habitat analysis played in setting the recommended flow regimes.

Also, a clear presentation is not provided as to exactly how zero flows were handled in the development of the recommended instream flow regimes, but the NBBEST does note that **"Subsistence flow recommendations of no less than 1 cfs by the Nueces BBEST for intermittent gage locations ensures that ecological functions associated with subsistence flow will be supported no less frequently than they have been historically."** While this somewhat arbitrary floor on subsistence flows certainly is protective of ecological functions under low-flow conditions, it would be helpful if the NBBEST had offered a more concise explanation of how the zero-flow issue was or was not addressed in the development of the recommended instream flow regimes and the extent to which zero-flows were accounted for in the HEFR analyses that formed the bases for the recommended instream flow regimes.

The water quality, riparian, and geomorphology methodologies were based on more limited data sets and don't provide any inconsistencies, nor do they directly alter any HEFR recommendations.

1.3 To what extent has the BBEST considered factors extraneous to the ecosystem, especially societal constraints, such as other water needs?

External societal factors did not play a role in the methodologies or recommendations of flow regimes to protect ecological soundness. However, other factors were reviewed and discussed in the context of issues that drive flow regimes. A preliminary evaluation of environmental flow regime recommendations with WAMs was conducted and presented in Sections 6.3. We presume that this was presented only as an example of how the proposed flow recommendations might be interpreted so as to assist the BBASC with their charge.

A unique aspect of the Nueces estuary with regard to the major reservoirs in the basin is that these reservoirs have been governed by a special permit condition regarding inflows since construction of Choke Canyon Reservoir in 1983 and adoption of a TCEQ Agreed Order requiring environmental flows since 1990. These special conditions are discussed in Section 6.2. While the flow requirements have changed several times, the current Agreed Order of 2001 establishes monthly pass-through targets that depend on the elevation of the Choke Canyon Reservoir and the salinity of Nueces Bay. The NBBEST correctly did not allow the existence of this current rule to constrain the development of their environmental flow recommendations.

2. Did the BBEST perform an environmental flow analysis that resulted in a recommended environmental flow regime adequate to support a sound ecological environment and to maintain the productivity, extent and persistence of key aquatic habitats in and along the affected water bodies?

2.1 How is a sound environment defined and assessed for both riverine (lotic) and estuarine systems? What metrics of ecosystem health were used?

Section 1.3 presents a good overview, definition, and discussion of nuances regarding a sound ecological environment. A consensus was reached on the definition of a sound ecological environment. The NBBEST followed the SAC lead in adopting the definition of a sound environment offered by earlier science advisory groups. They expand the discussion to describe unsound as, **"An unhealthy environment is where human modifications of the flow regime have reduced or eliminated important physical, chemical, or biological features, and significantly altered or reduced native biological community structure."** There is not a specific discussion in this section on metrics of instream ecosystem health beyond the acknowledgement that **"...a review of available biological, physical, and chemical data indicates that Nueces basin streams maintain acceptable sound environments."** For the estuary, the NBBEST used changes in hydrology, marsh plants, and shellfish populations as indicators of soundness.

2.2 How were locations selected for environmental flow analysis? Are these shown to be representative of and adequate to protect the basin? Was the process and rationale for selection adequately described? Were environmental flow regimes recommended for each selected site? Was a procedure presented by which the flow regime at other locations could be estimated?

The NBBEST selected gage locations for instream flow recommendations that provide good coverage across basin conditions. Locations for instream flow recommendations were based primarily on stream gage distribution and period of record, with consideration of hydrology, biology, water quality, geomorphology, water availability and water supply planning, all of which were thoroughly described. A procedure for flow regime determination at other locations is not stated, but the NBBEST does recommend that TCEQ develop such a method considering drainage area adjustments, effects of Edwards and other aquifer recharge zones, springflow contributions, channel losses, soil cover complex, etc.

The NBBEST makes estuarine environmental flow recommendations for only the Nueces Delta and Nueces Bay. The NBBEST opines that Corpus Christi Bay, Baffin Bay, and Laguna Madre do not require inflow recommendations because these are marine and hypersaline environments, the biological resources are adapted to conditions with very little freshwater inflow, and these bays are in sound ecological health as is. This essentially is recommending the status quo. The SAC concurs with a lack of an environmental flow recommendation for these bays because it would be inappropriate to create environmental flow regulations for these conditions and ecological soundness in these systems are not frequently driven by inflow. It is likely that the environmental flow recommendation for Nueces Bay would also benefit Corpus Christi Bay, but this is not described in the report. Finally, while Oso Bay is declared to be a sound ecological environment (p. 1-9), no flow recommendations are made for this bay.

Relative to the linkage between instream and estuarine flow requirements, one major inconsistency is that instream flow regimes are developed for Oso Creek and San Fernando Creek, even though no inflow regime is recommended for Oso Bay (fed by Oso Creek) nor Baffin Bay (fed by San Fernando Creek which flows to Cayo del Grullo, a tertiary bay flowing into Baffin Bay). These creeks would be largely dry except where supported by return flows or specific rainfall events. If flow was not dominated by return flow, then an instream flow recommendation still might make sense for instream habitat purposes, even if not specifically needed for estuarine health, but these distinctions are not discussed in the report. For these two bays, the NBBEST opines that the natural flow conditions do not drive soundness and thus there is no inflow regime requirement. As such, it is interesting that Oso Creek (wastewater dominated) and San Fernando Creek were given instream flow regime recommendations.

2.3 How were the historical flow periods defined and evaluated? How was a particular period selected as the basis for determining the flow regime?

For the instream flow analyses, Section 3.2.2 provides a good description accompanied by several figures relative to the period of record discussion. The NBBEST selected 7 representative sites throughout the basin and compared pre- and post-development, and the full period of record. Following the exercise, it was concluded, **"Upon consideration of these significant changes in streamflow, the Nueces BBEST decided to apply HEFR for early (pre-development) and late (post-development) sub-periods as well as the full period of record at each selected streamflow gaging station…"** A graphical depiction of several of hydrological changes at the representative sites are presented, and then the section abruptly ends with the statement, **"On July 29, 2011, the Nueces BBEST chose by consensus to use HEFR results based on the full period of record to form the basis of its instream flow regime recommendations subject to the ongoing ecological overlay process."** It will be important for the NBBEST to articulate in future correspondence with the BBASC why this decision was made for all gages, as it does not appear that the ecological overlays resulted in any HEFR adjustments.

For the estuarine analyses, the full period of record from 1941 to present was used. The record was divided into three periods: 1941–1957 before Wesley Seale Dam was constructed forming Lake Corpus Christi, 1958-1982 before impoundment of Choke Canyon Reservoir, and 1983-2009 the period after the impoundment of Choke Canyon Reservoir. The significance of these periods is that inflow to the estuary decreased 39% from the first to second period, and 99% in the third period.

2.4 Was a sound ecological environment determined to exist at each selected site during the selected period? If not, were the underlying causes and/or modifications needed identified?

For the instream flows, a sound ecological environment was determined at all 20 locations with the caveat that this includes four stations that have undergone substantial hydrological modifications over the years. Two of these locations are below major reservoirs, while another (Oso Creek) is nearly 100% dominated by wastewater discharges.

For the coast, Corpus Christi Bay, Oso Bay, Baffin Bay, and Laguna Madre were deemed to be sound, but this conclusion was reached for different reasons in each bay (Section 1.3). The NBBEST concludes that freshwater has little direct impact on Corpus Christi Bay, including relatively limited reduction in salinity, even from large-scale floods. Baffin Bay and Laguna Madre are little affected by development and are naturally hypersaline. Oso Bay, with salinities largely driven by waste water treatment plant discharges, was found to provide habitat for many plant and animal species.

However, the NBBEST found that Nueces Bay and Nueces Delta are no longer ecologically sound environments (Section 1.3.2). The report presents a review of the natural history and environmental changes that occurred in the Nueces Delta and Nueces Bay over the past century (Section 2.8), and how these changes have been influenced by humans. The NBBEST concludes that the existing estuarine environments of the Nueces Estuary are <u>not ecologically sound</u> because: 1) hydrological alterations have caused the salinities in the Nueces Delta to be higher than in Nueces Bay, which results in a loss of a salinity gradient that influences zonation found in an ecologically sound estuary, 2) reduced overbanking below the Calallen tidal dam, and 3) reduced sediment supply, which is leading to erosion of the delta. The biological consequence is that the system has lost shellfish populations (which are indicators of freshwater inflow effects). The basis of this opinion is outlined in Sections 2.8, 4.3, and 4.4, which paints a picture of an estuary that at one time (i.e., in the 19th century) was much fresher and more productive. However, diminished freshwater inflows have contributed to it becoming more saline, less productive, and "more barren," as primarily indicated by the reductions of oysters and *Rangia* clams. The SAC believes this broad picture of an unsound Nueces Delta and Bay relative to that of the late 19th and early 20th Century is probably correct.

However, the relationship of increased salinity to periods of reservoir operation in the 20th century is open to other explanations. For example, the precipitation regime is apparently different during the three periods analyzed by the NBBEST (Figure 4.1.2 of the WAM-naturalized flow). Also, there has been some work in assembling historic precipitation data and dendroclimatology to construct variations in climate over the years, dating back to the early 19th century, and this information could have provided a more complete picture (see, e.g. Stahle and Cleaveland, 1995, Cleaveland, 2006, Banner et al., 2010 for dendrochronological studies in Texas; Loaiciga et al., 1993, for a general overview of the use of dendrochronology in hydrology; Lowry, 1959 and Mové et al., 1988 for analysis and historical data on drought cycles in Texas). During this entire period, the Nueces basin has alternated between high rainfall and low rainfall periods.

In addition to the many hydrological changes that have occurred in the Nueces Basin, it is possible that factors other than altered inflow play a role in the higher salinities. . Deepening of the ship channels could have introduced more oceanic salinity water from the Gulf of Mexico during tidal events, and the Nueces Bay power plant uses somewhat higher salinity ship channel water for cooling and discharges it into Nueces Bay. Given more time and resources for detailed studies, it would be useful to develop a salt budget for future planning purposes, and perhaps this should be included in the adaptive management phase.

Finally, the NBBEST report concludes that "restoration" of the Nueces Bay and Delta ecosystem is dependent upon restoring inflow. The bay has been greatly affected by other physical changes, especially dredging and dredged material disposal for navigation projects. Because large quantities of shell were removed, oyster reef restoration (as well as increased flow) might be necessary for full restoration. Again, evaluation of options for managing the multiple stressors in this system should be included in the adaptive management work plan.

2.5 Was a functional relationship between flow regimes and ecological health developed? Or, were proxy or intermediate variables used? Are assumptions underlying the methodology clearly stated? To what extent were overlay considerations (sediment transport, water quality, nutrients, etc.) addressed?

For instream flows, a version of PHABSIM was used at three locations where site-specific field data were collected. The measure of ecological health was, in effect, abundance of individual fish species and associated habitat requirements, namely depth, velocity, and substrate. The individual photograph of each fish focal species provides a useful connection to existing conditions. The report does excellent work in presenting the WUA curves and the conversion of those results into a series of highly informative tables (Tables 3.3.3 through 3.3.8).

Along the way several key instream flow analysis decisions were reached by the NBBEST. The most puzzling is at the very start of the habitat modeling (Section 3.3.1.1.4), with the question posed to be addressed by the analysis (see 1.2 above). Nevertheless, the second major decision was the selection of the 0.5 habitat suitability value and above for all analysis. When a typical instream habitat model is run, it generates a range of habitat suitability values from 0 to 1 across and down the stream channel for evaluation. A zero does not register as habitat while a 1 is most preferred by whatever species you are working with. Choosing 0.5 and above means that you are only considering habitat in the river that is average to preferred. This is not uncommon in instream science and only highlighted here to carry forward the discussion.

The third important decision point was the selection of an "enoughness" threshold, which was developed and explained in one paragraph on page 3-42. An enoughness threshold is defined as a minimum percentage of maximum habitat that constitutes sufficient habitat for a particular species. Several percentages were evaluated and the NBBEST ultimately selected 75 percent for all three base flow ranges, and 20 percent for subsistence conditions. Some discussion or analysis in the report justifying these thresholds would have been informative and helpful in understanding the final recommendations, even though professional judgment is very much part of science and inherent in the BBEST process.

So, to answer the question of verifying the historical hydrology, the NBBEST then conducted an exercise to evaluate the HEFR results. For example, to receive an affirmative, a Base-Low HEFR result would need to provide 75% of the maximum habitat (remember not any habitat, but 0.5 or greater habitat) with the flow number generated by HEFR for each fish focal species. This is shown for each fish focal species for each of the three base flows and subsistence flow by the shaded boxes on Table 3.3.5 (Frio River at Concan) [see below, Page 3-46 NBBEST report]. Any unshaded boxes were then reviewed by the BBEST and in all three model sites agreed acceptable by the NBBEST as no alterations were made via this analysis to any HEFR base or subsistence flow numbers in this report.

Table 3.3.5. Percent of maximum weighted usable habitat area with a 0.5 minimum quality threshold for 8 focal species resulting from Nueces BBEST flow recommendations at the Frio River at Concan. Shown are percentages for Subsistence and all three ranges of Base Flows. Shaded cells are those flows meeting "enoughness" thresholds of 20 percent for Subsistence flows and 75 percent for all three ranges of Base Flows.

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
Greenthroat darter	Subsistence	41%	38%	38%	38%
	Base-Low	82%	80%	73%	75%
	Base-Medium	90%	89%	83%	86%
	Base-High	96%	96%	93%	96%
Central stoneroller	Subsistence	60%	56%	56%	56%
	Base-Low	95%	92%	87%	89%
	Base-Medium	97%	98%	95%	97%
	Base-High	97%	97%	97%	97%
Texas shiner	Subsistence	57%	55%	55%	55%
	Base-Low	83%	80%	79%	79%
	Base-Medium	90%	89%	83%	87%
	Base-High	95%	94%	92%	94%
Guadalupe bass	Subsistence	63%	61%	61%	61%
	Base-Low	85%	84%	78%	80%
	Base-Medium	89%	88%	85%	87%
	Base-High	94%	94%	92%	94%
Gray redhorse	Subsistence	78%	76%	77%	77%
	Base-Low	91%	90%	88%	89%
	Base-Medium	94%	93%	91%	92%
	Base-High	95%	95%	94%	95%
Channel catfish, Adult	Subsistence	74%	73%	73%	73%
	Base-Low	84%	82%	82%	82%
	Base-Medium	87%	87%	84%	86%
	Base-High	89%	89%	89%	89%
Longear sunfish	Subsistence	78%	77%	77%	77%
	Base-Low	91%	90%	88%	88%
	Base-Medium	94%	93%	91%	92%
	Base-High	96%	96%	95%	96%
Largemouth bass	Subsistence	81%	80%	80%	80%
	Base-Low	92%	92%	90%	91%
	Base-Medium	93%	93%	92%	93%
	Base-High	97%	97%	95%	97%

The NBBEST did not take this analysis further to try and tease out some flow-ecological relationships that have been so very elusive throughout the SB3 process. For instance, it is interesting that for the Nueces River at Laguna (Table 3.3.3, NBBEST report) the lowest percent of maximum for Subsistence for any species is 49% whereas the enoughness threshold was selected at 20%. Conversely, a highly altered site (Nueces at Three Rivers, Table 3.3.7, NBBEST report) had percents of maximum habitat values below the enoughness threshold, yet this site was still deemed sound. The wide-range of habitat conditions deemed as "acceptable" subsistence conditions presented with these two examples beckons further analysis. Furthermore, an evaluation of the very same tables shows that for all three examples the Base-High enoughness threshold of 75% was nearly always exceeded. In fact, the Frio at Concan site (Table 3.3.5, above) has Base-High percent of maximums for all species in the 90% or higher range, yet no alterations to HEFR were discussed. It will be important for the NBBEST to provide further clarification to the BBASC as to why the flow-habitat modeling work was not further explored or utilized.

The water quality, riparian, and geomorphology overlays for instream flows are generally well done. The water quality analysis is thorough and demonstrates the uniqueness of this basin with intermittent streams and extended periods of zero flows. The discussion of the primary purpose of pulse flows in replenishing perennial pools was very well written and informative. In general, even with the many challenges in this basin, high quality of river water is typical at most stations even under low-flow conditions. The riparian overlay is a well-written description of the dependence the riparian community upon river flow. However, site-specific data appears quite limited system-wide and this overlay could not be used to support any adjustments. The geomorphology overlay presents several water planning examples similar to what has been presented in previous BBEST reports. The report is unclear whether or not there is a direct interaction or effect of the geomorphic overlay on HEFR recommendations. Were pulses added to the HEFR regime in order to gain more total annual volume, which in turn would create more sediment yield or were those pulses already programmed in the default HEFR configuration? This is another area where the SAC recommends that the NBBEST should have extended conversations with the BBASC on the role of the multiple tiers of pulses.

In the estuarine analysis, the NBBEST benefited by at least four long-term and detailed studies performed specifically to identify flow-ecological relationships in Nueces Bay and Nueces Delta (see SAC comment 1.1 above). During those studies, extensive examinations of flow conditions and biological responses to flow regimes were made over all trophic levels. These studies were used to evaluate how flow regimes are related to ecological health, and to make recommendations for a flow regime to maintain ecological soundness. In addition, new work was commissioned by the NBBEST (using funds made available by reducing the SAC budget) to use a relatively new statistical technique called boosted regression trees (BRT) that uses the TPWD coastal fisheries monitoring program data and additional variables such as distance from the river or pass to calculate the preferred salinity zone of species and likelihood of finding these organisms under different salinity conditions. Together, these five studies were used to form the basis for a unique and credible approach that identified focal species (marsh plants, benthic infauna, and nekton), develop quantitative metrics between salinity and ecological integrity as evidenced by abundance, distribution, and diversity patterns as indicators of estuarine health, and make recommendations for baseline freshwater inflow needs and a regime to maintain these estuarine indicators in a healthy state (Section 4).

The nutrient consideration (Section 5.2) is limited to relatively recent data so temporal changes could not be addressed. The sediment consideration (Section 5.3) does take a long term view and is quite clear in the changes that have occurred. It recognizes that the recommended instream flow pulses in the recommendations will not provide the historical sediment inflows that existed before the development of the watershed and urbanization of the estuary.

2.6 Was a sound ecological environment demonstrated to be achieved at each selected site under conditions of the recommended flow regime?

Yes, for instream at all selected sites. However, to a certain extent, this was moot, since the stream and river segments were determined to be presently healthy, and the flow regime recommendation was to revert to historical-data-based flows (HEFR statistics for the instream flows), even though strict adherence to the HEFR-based flows and associated attainment frequencies does not specifically preserve the historical statistics of all flows.

Although well presented, it was not demonstrated that all of the flow components of the recommended instream flow regimes, including three levels of base flow and up to fifteen levels of seasonally-dependent high-flow pulses, are necessary to protect a sound ecological environment. It was unclear whether the NBBEST evaluated the potential for simplifying this matrix.

For the various estuarine systems, the attainment of the flow recommendations is somewhat more complex. Thus far, other bays along the Texas coast were characterized by their BBESTs as currently supporting a Sound Ecological Environment (SEE), despite a wide range of modifications from the natural condition, so consequently the inflow recommendations were designed to support what are essentially current conditions. The NBBEST made the judgment that a portion of their estuarine area, Nueces Delta and Nueces Bay, did not pass the SEE muster. This judgment is based on a combination of historical information documenting how Nueces Bay once had thriving oyster and *Rangia* clam populations that are no longer present, and an understanding of the changes in inflows that have occurred as the human population has increased. This judgment required establishment of freshwater inflow needs and has led to very different estuary inflow recommendations for Nueces Bay than currently exist (compare Figures 6.2.1 and 6.2.2).

Our goal in providing SAC comments is not to question the judgment of BBESTs on what constitutes a SEE, but rather to insure that there is a measure of consistency in scientific methods and practicality in the recommendations put forward. On the consistency point, there is little difference in scientific approach employed by the NBBEST and other BBESTs. The other BBESTs developed recommendations to protect conditions that exist now as a result of the many man-made changes, while the NBBEST has developed recommendations to determine inflow needs to achieve a SEE, and consequently would create conditions that would theoretically restore shellfish and marsh habitats.

There is nothing wrong with setting an inflow regime goal at a level that appears to have existed before major population moved into the watershed and water needs developed. That would seem to be a perfectly valid goal that offers opportunities to approach the habitat improvements identified with a number of methods. But while the goal is established by the NBBEST, the BBASC must also consider the human water needs under existing or projected water demand scenarios. Section 6.2 presents a comparison of the existing Agreed Order to the NBBEST recommended flow regimes.

One point lacks clarity, the last paragraph on page 5-3 simply says it is not appropriate to compare the river inflow regime to the bay regime because they are different, when in fact the river is the conveyance of water supply for the City of Corpus Christi, so the flow at Mathis is not related to flows at Calallen that would enter the bay. The section 5.4 language is more explicit in the recommended regime not being achieved and the opportunities to explore alternative ways.

2.7 Is uncertainty in the analyses described or quantified? Where models were employed, was the extent of validation and associated predictive errors described and quantified?

While variability is dealt with in nearly all the technical analyses in Sections 3 and 4, it is not addressed in the flow recommendations in Section 6. In fact, the term "uncertainty" appears only in the instream modeling section, pertaining to flow-habitat modeling, specifically with regard to habitat criteria and hydraulic modeling (where it is addressed qualitatively), and nowhere else in the document - especially not in the estuary section. The analytical tools that were used would very easily enable the estimation of uncertainty bounds, and it would have been beneficial if the NBBEST addressed uncertainty more fully. We observe that some of the numbers in Table 4.5.1 are thresholds (e.g., 166,000 ac-ft/yr) while some are midrange, about which there is considerable leeway, as suggested by the range of optimal salinities for the focal species.

Summary

The Nueces BBEST was in the fortunate position that allowed it to start its work early, and indeed present a report almost five months prior to its due date, which provides the BBASC additional time to complete their deliberations. Overall, the NBBEST is to be commended for all the hard work conducted and for advancing the understanding of ecological conditions throughout the basin. The report is a detailed presentation with well-documented science, contains a focused approach, and takes on the difficult but necessary issue of sound ecological environment in a thoughtful way. Section 7 which addresses Adaptive Management is an excellent addition to this report. It is thorough, its presentation succinct, and it establishes a good foundation for the Work Plan to be developed by the BBASC.

The finding that Nueces Bay and Nueces Delta are unsound ecological environments presents a unique challenge to the Nueces BBASC, not heretofore faced by any other BBASC nor the TCEQ; namely, to consider development of management goals to move toward a sound ecological environment for Nueces Bay and Nueces Delta. Furthermore, because the Mathis gage instream flow regime does not represent flow to the bay, this presents an additional challenge to formulating recommended standards, and strategies to meet the standards to the maximum extent possible.

The Nueces Bay recommendation is presented in Table 4.5.1 (page 4-43, and then again in Table 6.1.2.1. There is one point of confusion, and that is whether the NBBEST is recommending the application of both seasonal and annual flow volumes. The footnote to Table 4.5.1 adds to the confusion and appears to be an operational recommendation. The SAC suggests that the NBBEST clarify the application of this recommendation to the Stakeholders.

In Section 6, two projects and alternatives are examined which culminate in conclusions on page 6.38 as follows, **"These two examples also highlight the very significant differences between perennial and intermittent streams and between the relative ecological risks associated with on-channel reservoirs as compared to run-of-river diversions with (or without) off-channel storage. Regarding the latter point, *the Nueces BBEST recommends regulatory consideration of site-specific geomorphology and aquatic and riparian habitat studies in the permitting of any large, on-channel reservoirs in the Nueces River Basin.*"** This site specific study recommendation raises a valid point, and the NBBEST should hold extensive conversations with the BBASC to explain the basis of this recommendation.

Although an excellent report overall, there are a few places where the report could have provided more explanation and these are highlighted below:

- While the data analyses presented in the estuary section of the report and much of it is excellent ancillary information that fills out the picture of the Nueces estuary and ecosystem, some of it is obscure and its immediate bearing on the inflow issue is not at all clear. This makes it difficult to follow the reasoning that results in recommendation presented in Table 4.5.1. This could have been easily clarified by inserting statements of why the NBBEST is addressing this topic, what the conclusion is, how we are going to use the result. For example, while the drought analysis is very interesting, how was it used?
- The relation between Rincon flow and (pore) salinity shown in Fig 4.3.4 is clear, as is the relation of *Spartina* coverage to salinity in Figs 4.3.2 and 4.3.3. A better explanation of how the NBBEST arrives at 166,000 ac-ft/yr (which appears only in the caption of Table 4.3.1) in the Nueces would have been helpful.
- While it looks like the Salt03 vs. cumulative monthly inflow at Calallen gage in Fig. 4.2.1 is the main device for relating flow to salinity, it is not clear how this is related to the TPWD monitoring results displayed in maps in Fig. 4.1.5.

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APPENDIX D1
Salinity Monitoring and Real-Time (SMART) Inflow Management
June 1, 2012

Introduction

The Nueces BBEST reports that there is a loss of salinity gradient in the Nueces Bay and Delta that influences a zonation of communities found within the bay system. Connectivity of freshwater is another issue within the delta, and high salinity variance is found both in the delta and the bay. The salinity gradient between the bay and delta are compromised due to both the connectivity and high salinity variance. These challenges have spurred discussions of strategies to remedy the problems while still protecting the safe yield of the reservoir system. One of the strategies includes implementing the SMART Inflow Management concept.

The Salinity Monitoring and Real-Time (SMART) Inflow Management strategy seeks multiple goals: 1) to assure adequate environmental flows to Nueces Bay and Delta that creates measureable ecological benefits, 2) provides connectivity between Bay and Delta while also providing for a reduced variance in salinities, and 3) helps to maintain recreational and economic values within the reservoirs for longer periods of time. SMART Inflow Management looks to manage salinity conditions in the bay and delta rather than through monthly target volumes of water being sent to the bay.

Under the current 2001 Agreed Order, the City of Corpus Christi (City) is required to provide freshwater inflows into the Nueces Estuary. Each month the City is required to “pass through” to the Nueces Estuary an amount of water equal to the measured inflow into the Choke Canyon Reservoir/Lake Corpus Christi Reservoir System (Reservoir System), up to a target amount. The target amount varies by month and is calculated based on the combined storage volume of the Reservoir System. In order for SMART Inflow Management to be implemented under the current Agreed Order, a water “banking” concept would need to be created where any required monthly pass through water could be stored in the reservoir until a later date pending either: 1) Bay and/or Delta conditions need freshwater (i.e. salinities are increasing above a certain threshold), or 2) a large enough volume of water has been banked over time in order to create significant changes in salinities for the Bay.

Through modeling exercises, the SMART Inflow Management concept appears to be a viable strategy for efficiently utilizing the limited freshwater resource available to create bay and delta conditions that have a salinity gradient, connectivity, and a reduction in the salinity extremes that have a negative impact on estuarine productivity.

The following pages describe analyses performed during the BBASC process to help understand the outcomes and benefits associated with SMART Inflow Management.

Nueces Bay Modeling

Managed flow regimes to enhance environmental values can be comprised of maintenance of minimum (subsistence) flows, capping of maximum flow pass through releases based on salinity range desired, constraints on timing of year, on current conditions in the bay, and on future weather forecasts (near and long term). SMART Inflow Management may include some or all of these considerations, and may be specified for year-round or by season.

TxBLEND Model Runs
To examine the feasibility of SMART Inflow Management, the Texas Water Development Board (TWDB) initiated several simulated freshwater inflow events into Nueces Bay to gauge the response on salinity. TWDB applied the TxBLEND model, which is a hydrodynamic model that simulates the effect

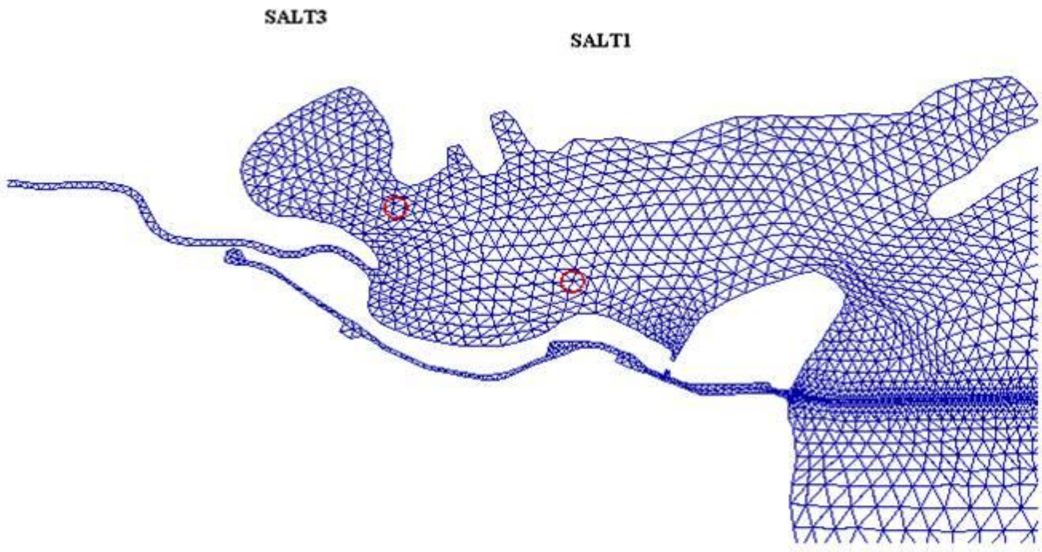


Figure 1. TWDB's TxBLEND model grid of Nueces Bay, Nueces River, Inner Harbor, and the western portion of Corpus Christi Bay. The red circles identify Salt3 and Salt1 real-time monitoring salinity stations.

of inflows on salinities in the bay using a finite element grid made up of nodes and linear triangular elements across the bay and neighboring bay systems (Figure 1). The TWDB modeled various scenarios of bay conditions during different seasons in the year.

Several rules were developed in order to run TxBLEND, including:

- Freshwater inflows are provided in sufficient quantities and at appropriate times of the year in order to maintain a target salinity range. BBEST Spring Season (March to June) – 1 or 2 inflow events, that lower salinity at Salt3 to ≤18 and keeps levels <25 for 4 weeks. BBEST Summer/Fall Season (July to October) – same as spring. BBEST Winter Season (November to February) – 1 or 2 inflow events, that lowers salinity at Salt3 to ≤30 so that salinities aren't too high going into spring.
- Utilize data from nodes near Salt3.

Table 1 shows results of initial TxBLEND model runs using the above criteria. One of the interesting results of running TxBLEND was that there is an approximate 1 ppt decrease in salinity around Salt3 with the release of every 1,000 acre feet of water. For example, if salinities were 30 at Salt3 and 10,000 acre feet went over the Calallen Dam, then it could be expected that salinity would drop to around 20. Figure 2 demonstrates this concept nicely where salinity around Salt3 was 30.2 ppt before a 12,000 acre foot release over Calallen Dam occurred and decreased salinity to 18.9.

In order to keep salinity below 25 for a 4 week period during the summer, a second release of water was necessary of 10,000 acre feet which dropped salinity from 25 to 16.6 (Figure 3). The impact of these two releases is about a 7 week period below 25 ppt for 22,000 acre feet of water.

These model runs show several important points: 1) it takes approximately 1,000 acre feet to decrease salinity at Salt3 by 1 ppt, 2) managed seasonal pulses can reduce salinity variance in lower Nueces Bay, and 3) a salinity gradient can be achieved with a modest amount of timed freshwater inflow.

Table 1. TxBLEND initial SMART Inflow Management model results for various scenarios conducted in Nueces Bay.

Test	inflow (acft)	salinity at start	salinity lowest	reduction (ppt)	reduction rate (ppt/1,000 acft
30-Winter	12,000	29.8	17.94	11.86	0.99
30-Summer	12,000	30.22	18.91	11.31	0.94
25-Winter	10,000	24.85	17.68	7.17	0.72
40-Summer	18,000	40.1	21.66	18.44	1.02
30Winter+Maintenance	10,000	25.11	16.28	8.83	0.88
30Summer+Maintenance	10,000	25	16.69	8.31	0.83
25Winter+Maintenance	10,000	25.15	18.51	6.64	0.66
40Summer+Maintenance	10,000	25	18.49	6.51	0.65

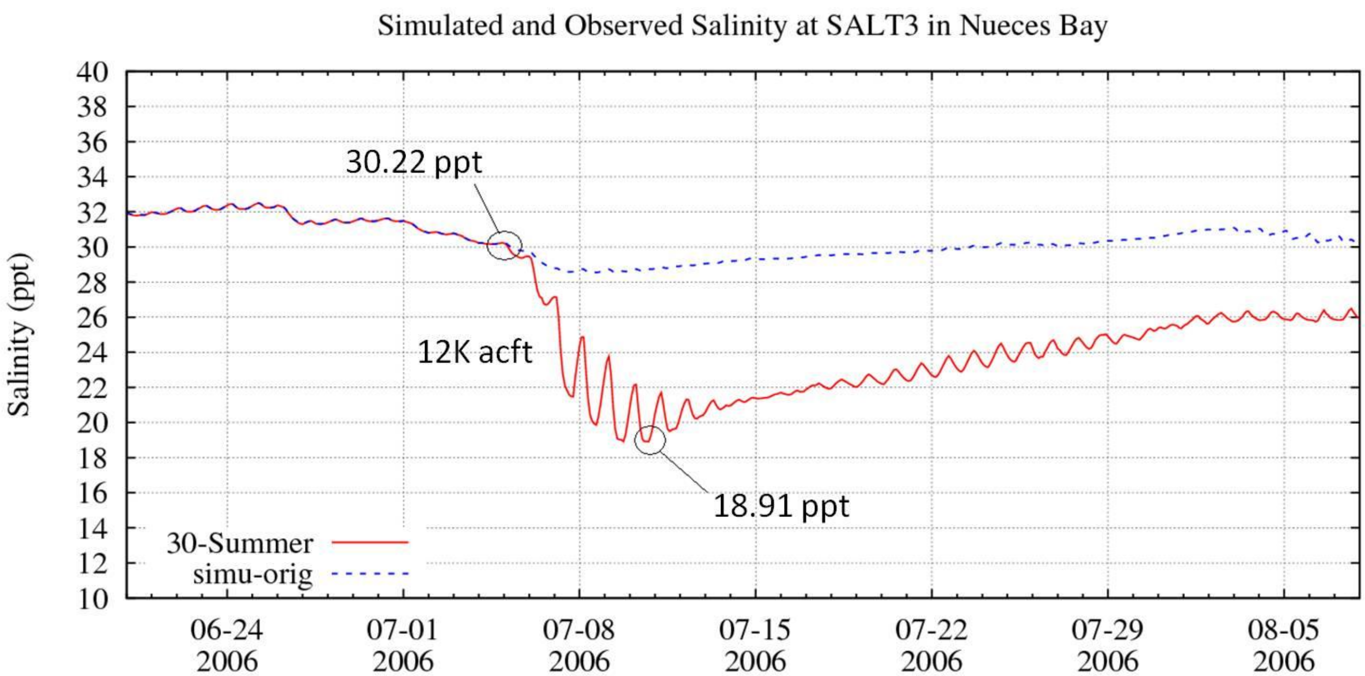


Figure 2. TxBLEND simulation of a single 12,000 acre feet freshwater inflow pulsed event into Nueces Bay and the impact to salinity at Salt3. Source: TWDB.

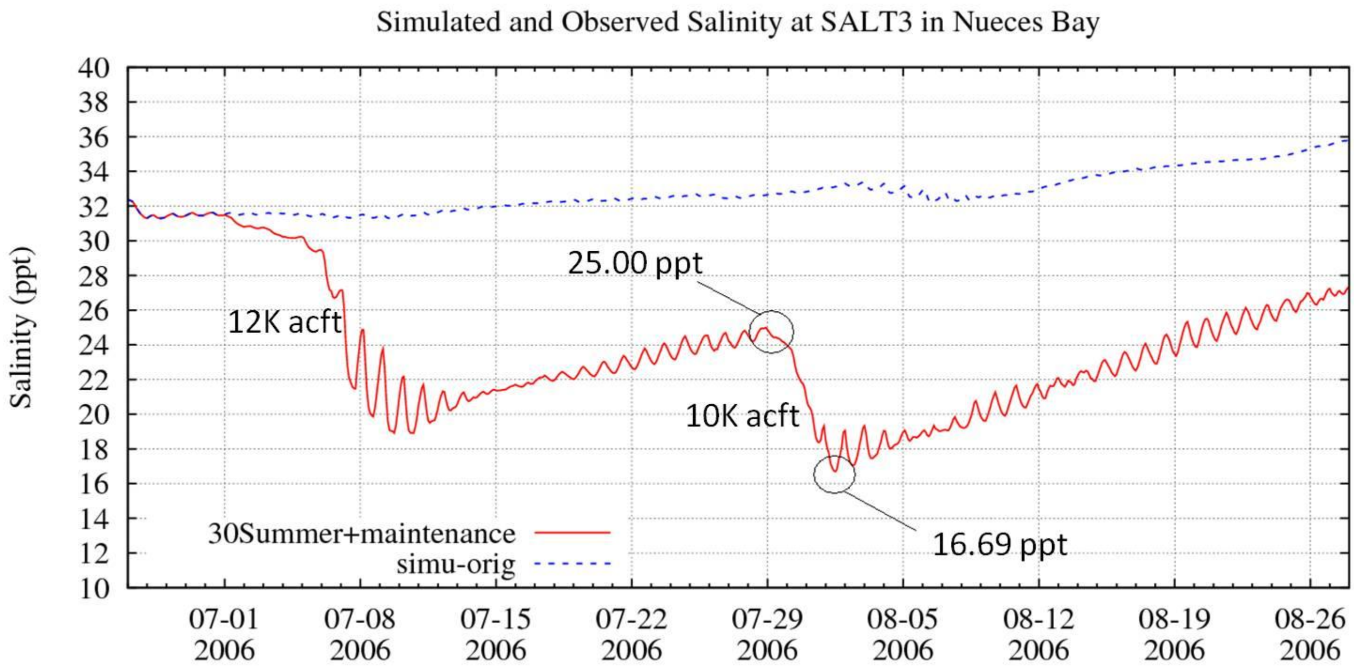


Figure 3. TxBLEND simulation of multiple freshwater inflow pulsed events into Nueces Bay and the impact on salinity at Salt3. Source: TWDB.

SMART Evaluation

To better understand the challenges and outcomes in implementing SMART Inflow Management, another method for evaluating salinities in the bay under the current monthly operational plan was undertaken, called the SMART Evaluation. The process involved an accounting exercise of calculating available monthly pass throughs, natural freshwater inflow events over the Calallen Dam and through the Rincon Bayou Pipeline, and a review of salinity at Salt3.

Figure 4 represents actual data recorded between 2010 and 2011 by continuous monitoring stations at Salt3 in Nueces Bay and flow data from a USGS station at Calallen Dam along the Nueces River. 2010 was a moderate year in terms of freshwater inflow to Nueces Bay with a total of 96,803 acre feet of gauged water entering the bay and delta. 2011 was the driest one year record of freshwater inflow entering the bay with only 7,307 acre feet entering the bay. The contrast between the moderately wet year vs. the extremely dry year presents a good opportunity to simulate the SMART Inflow Management concept to see how much water could be banked (stored in the reservoir for later use) in 2010 and released as needed during 2011 to meet specific conditions within Nueces Bay.

Similar to preparing to run the TxBLEND model, there were rules developed to simulate when water could and would be banked, when and how much of the banked water would be released, and what conditions were desired within the bay.

The following rules were developed for the SMART Evaluation:

- Salt3 data would be used for measuring salinity in Nueces Bay
- Flows over the Calallen Dam and through the Rincon Bayou Pipeline would be used as total inflow into Nueces Bay
- The desired salinity range for the entire year would be 18 to 30, except in the winter season (November to February)

- All available pass throughs would be banked until salinities during the spring and/or summer/fall reached above 30 for more than a 10 day period at which time banked water would be released from the reservoir
- The target salinity to hit with banked water is 18
- Banked water would be released from the reservoir at 1,000 acre feet per day
- Salinity decrease calculation was based on TxBLEND results of 1,000 acre feet per 1 ppt decrease
- The first release for the spring season would be March 15th and the following releases would be after salinity was above 30 for more than 10 days
- The rate of salinity recovery would be based on data collected at Salt3 during similar type conditions
- The only amount of water available for use is the amount of water that had been banked based on the 2001 Agreed Order

Results of the SMART Evaluation show that in 2010 there were a total of 96,803 acre feet of freshwater inflows into Nueces Bay and Delta. Of the total inflows into Nueces Bay, 55,309 acre feet of pass throughs were available to bank, and the other 41,494 acre feet were natural flows from rain events below Lake Corpus Christi. In 2011 there was 9,468 acre feet of total inflows into the bay and delta, of which 5,994 acre feet were pass throughs available for banking. The other 3,474 acre feet were natural flows over Calallen Dam and through the Rincon Bayou Pipeline. Figure 4 illustrates the inflows from 2010 to 2011 and the changes to salinity at Salt3 as they occurred.

Using the SMART Evaluation rules listed above, an assessment was initiated looking at the same data over the past two years, but instead of allowing all the required pass throughs to enter the bay, they were banked and simulated on an as needed basis depending on conditions in the bay. Figure 5 shows the results of the simulation.

Several interesting things were learned from the evaluation: 1) timing seasonal pulses with banked water for a specified salinity range at Salt3 is an achievable goal in some years, 2) it only takes around 42,000 acre feet to manage a salinity range of 18 to 30 at Salt3 during a drought year, 3) a reduced salinity variance occurred by banking water from both extreme low salinity to extreme high salinity, and 4) during a moderately wet year it only took 12,000 acre feet to keep salinity in the 18 to 30 range.

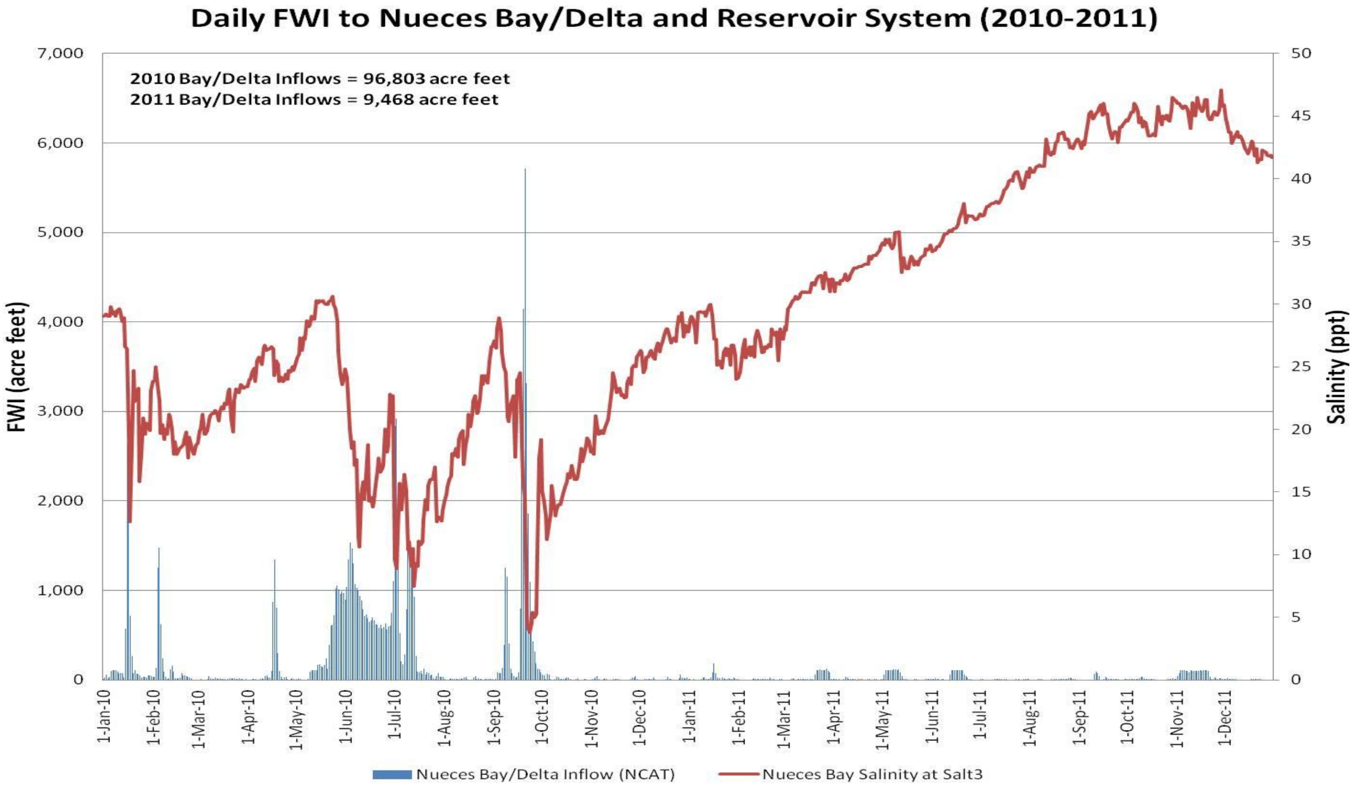


Figure 4. Salinity data from Salt3 and freshwater inflow daily flows in acre feet over the Calallen Dam and through the Rincon Bayou Pipeline.

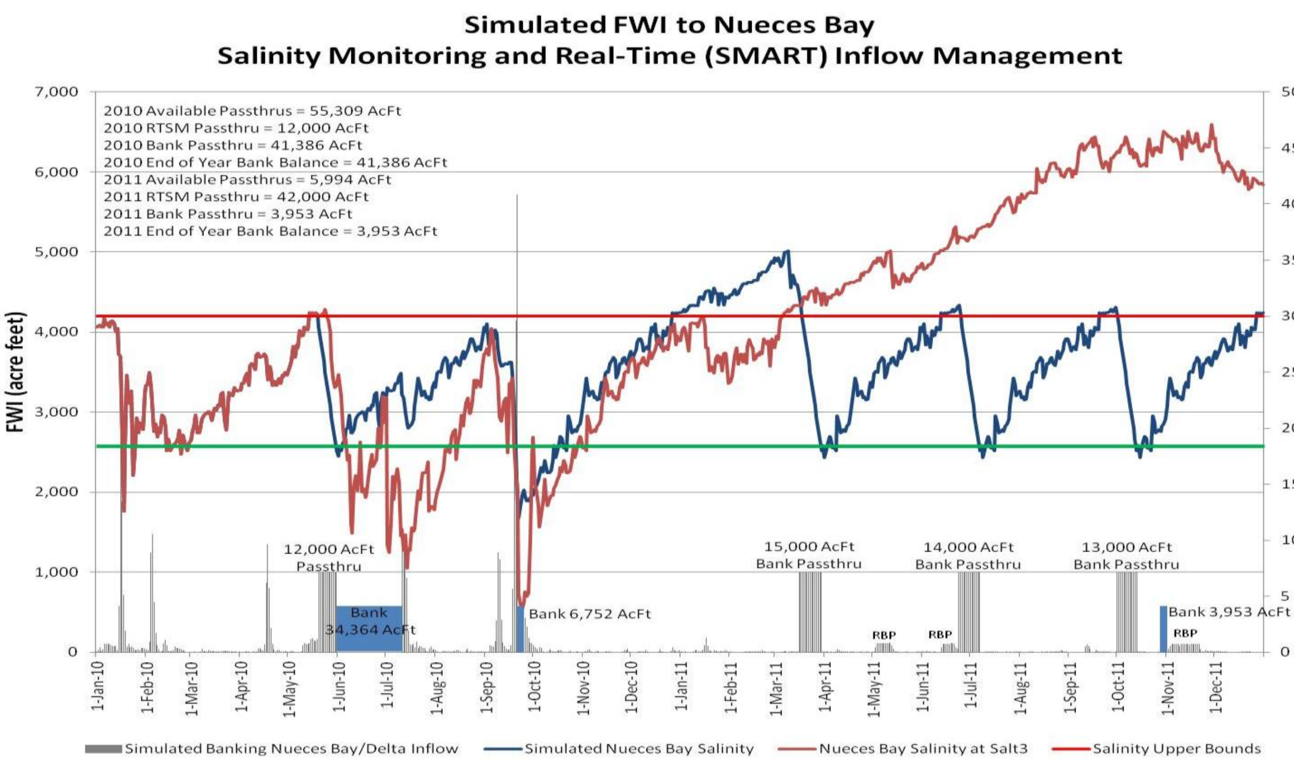


Figure 5. SMART Evaluation simulation results for implementing SMART Inflow Management in Nueces Bay. The red line is Salt3 salinity data as measured by the station. The blue line is simulated data using the SMART Evaluation rules. The straight green and red lines define the preferred salinity range.

Nueces Delta Modeling

Since late 2009, the City of Corpus Christi (City) has been implementing the water banking concept for delivery of freshwater inflows to the Nueces Delta via the Rincon Bayou Pipeline (Figure 6). Currently, the 2001 Agreed Order states that the first 3,000 acre feet of pass throughs each month shall go through the pipeline but there is no mention of the way to deliver the water in terms of timing, quantity, and duration. Through the Nueces Estuary Advisory Council (NEAC) an Inflow Pipeline Advisory Committee (IPAC) was formed at the request of the City of Corpus Christi on how and when to deliver water to the Nueces Delta. The IPAC advises the City on when and how banked water should be delivered to the Nueces Delta in order to have the greatest ecological benefit to the system. The IPAC determines water delivery based on several factors, including: how much banked water is available for use, timing of year, current salinity levels, tide levels, and future weather forecasts.

Similar to Nueces Bay, a SMART Evaluation was performed on the Nueces Delta in where observed salinity data from the Nueces Delta 2 (NUDE2) station was graphed with Rincon Pipeline Inflows from mid 2009 to April 2012. The difference between the bay and delta evaluation runs is that SMART Inflow Management is already occurring in the delta, meaning the simulation actually take out the pumped water to see what salinities would have been if SMART Inflow Management was not being implemented. Figure 7 depicts the results in a visual format showing observed salinities vs. simulated salinities. The goal of managing salinities below 30 was achievable most of the time if banked water is available and quantities used to manage this area are relatively small compared to what is necessary to keep Nueces Bay below 30 during drought years. A total of 12,397 acre feet were pumped through the pipeline from late 2009 to early 2012 on an as needed basis based on conditions in the delta. The reduction in high salinity extremes that limits biodiversity was virtually eliminated, except for a four month period in mid to late 2011when there was no banked water to pass through the pipeline. Based on model results, this four month period could have been avoided with approximately 3,000 acre feet and a salinity gradient could have been maintained.

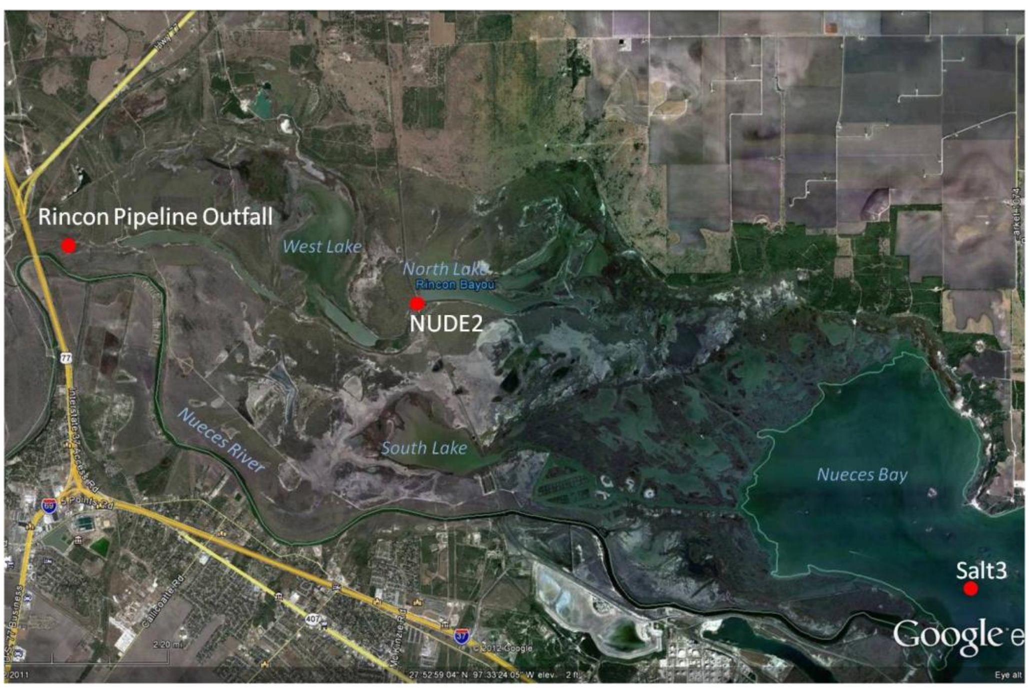


Figure 6. Location of Rincon Bayou Pipeline outfall and NUDE2 salinity station in the Nueces Delta.

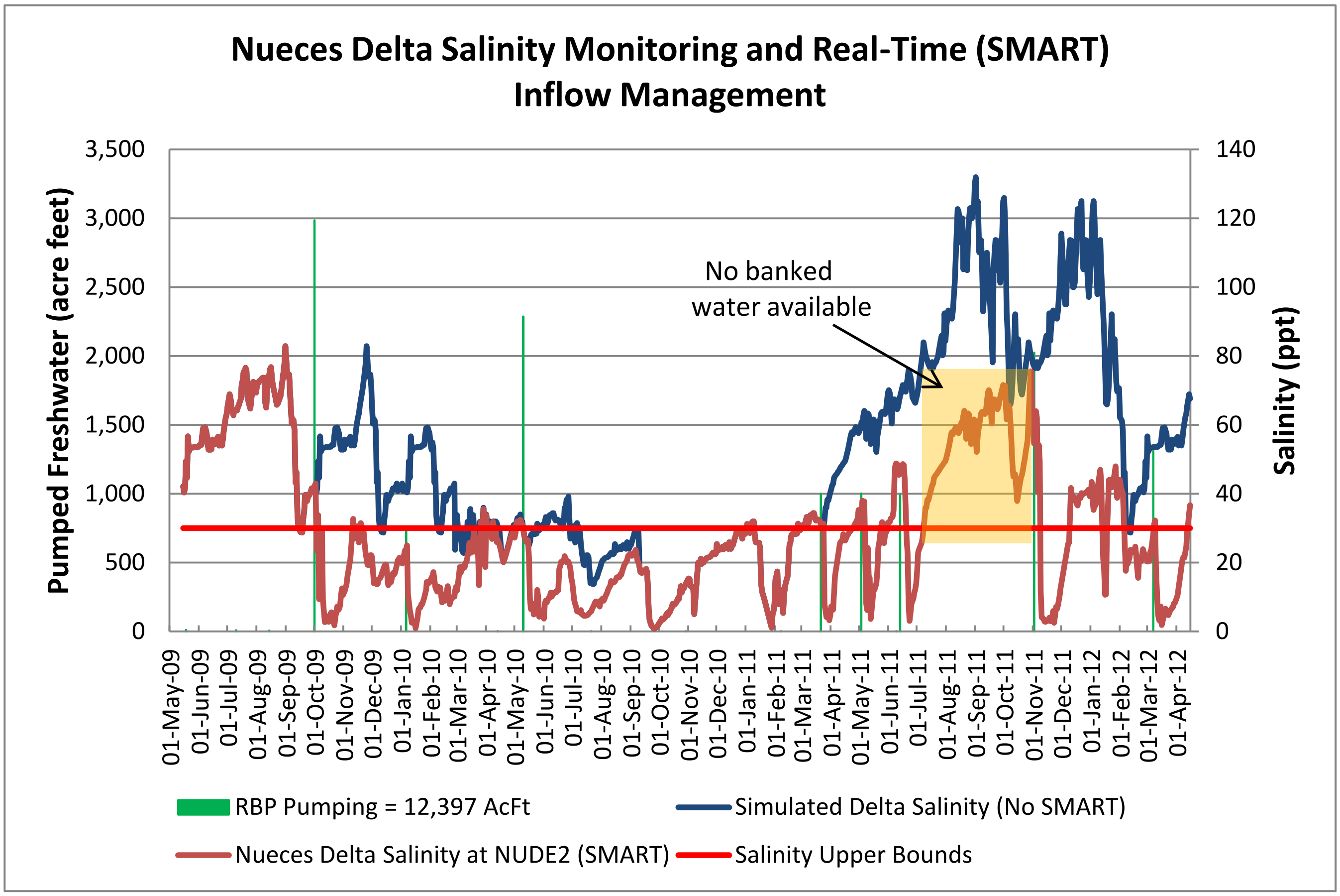


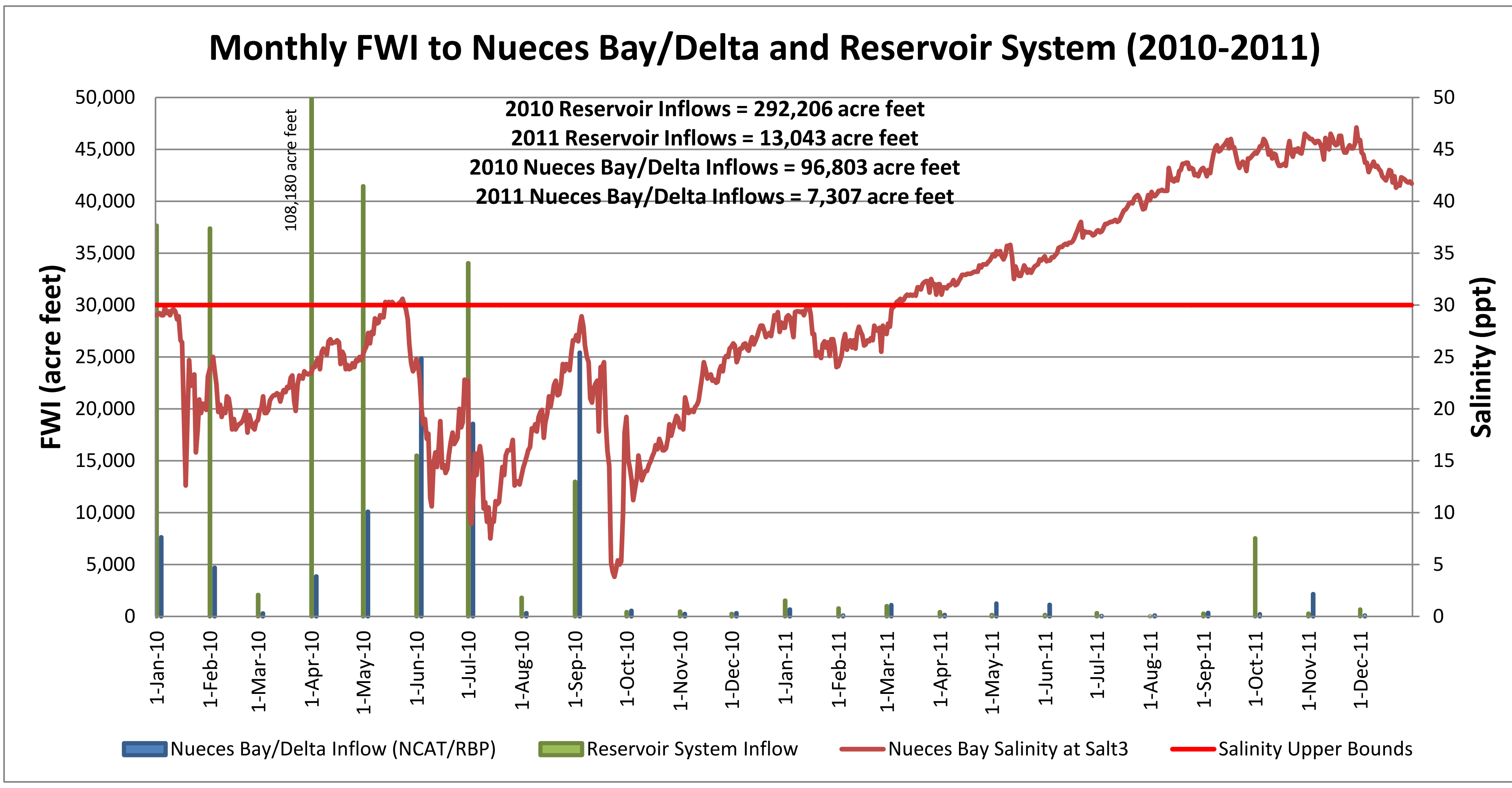
Figure 7. SMART Evaluation simulation results for the Nueces Delta. The red line is NUDE2 salinity data as measured by the station. The blue line is simulated data using the SMART Evaluation rules of staying below 30 ppt. The straight red line defines the upper bound salinity range that would trigger a pass through event into the Rincon Bayou via the pipeline.

Summary

The SB3 process is concentrated on establishing environmental flow regimes for new water rights permits, which is different than developing new ways of managing water under existing permits in a system that only has new water rights available during rare flood events. SMART Inflow Management is about better water management under the current Agreed Order by allowing water to be banked and released during more beneficial time periods. This strategy not only has ecological benefits, but also economic and water supply advantages.

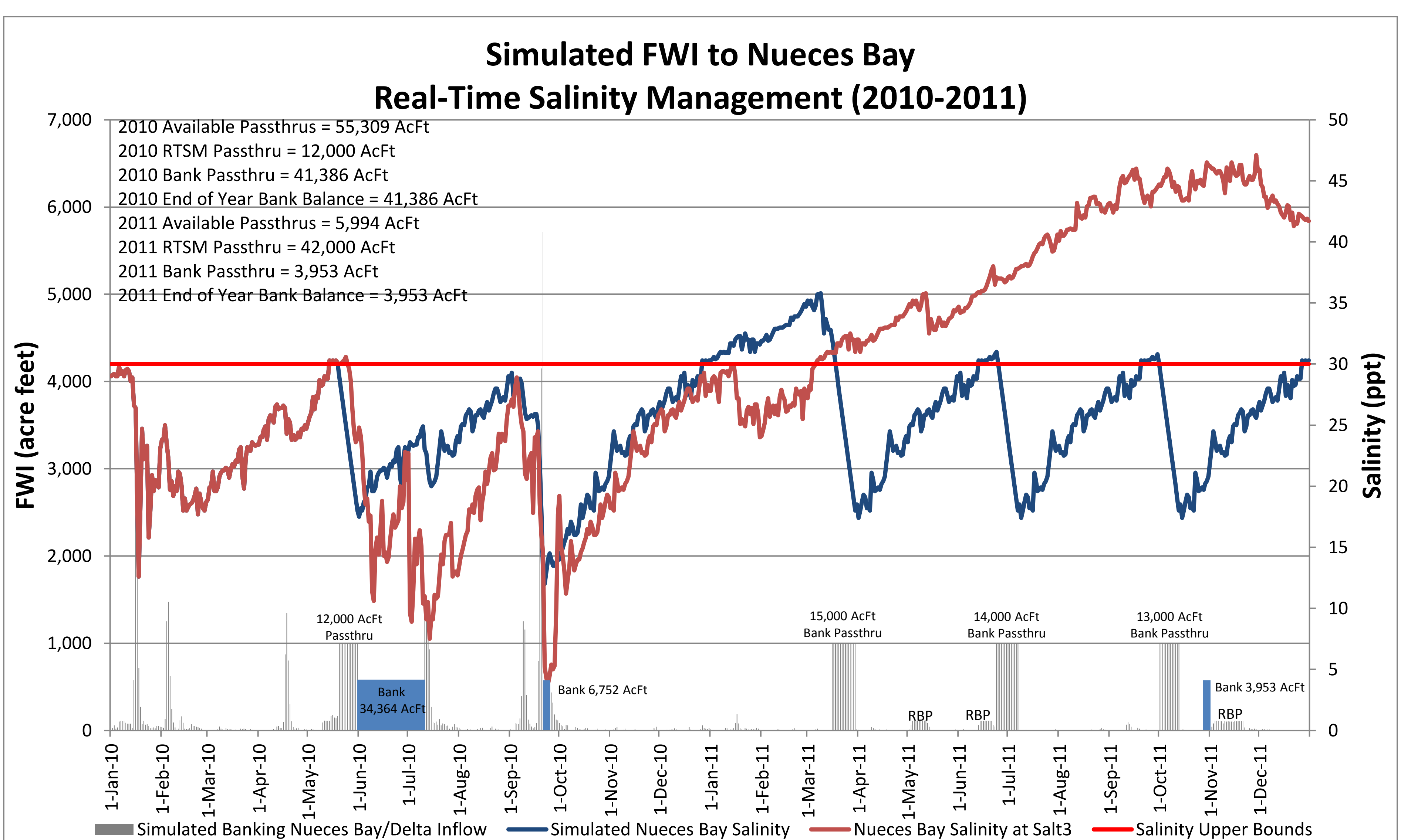
The next step should include a thorough evaluation of the SMART Inflow Management concept by the Nueces Estuary Advisory Council (NEAC). Items that the NEAC might need to address include: Reservoir system capacity level impacts on banked water, evaporation rates on banked water, maximum quantity of water that can be banked, spills, and their impact on banked water, creation of a scientific/stakeholder committee to advise decision making, and establishing a trial period (5 or 10 years) for confirming viability and to improve the strategy prior to implementation.

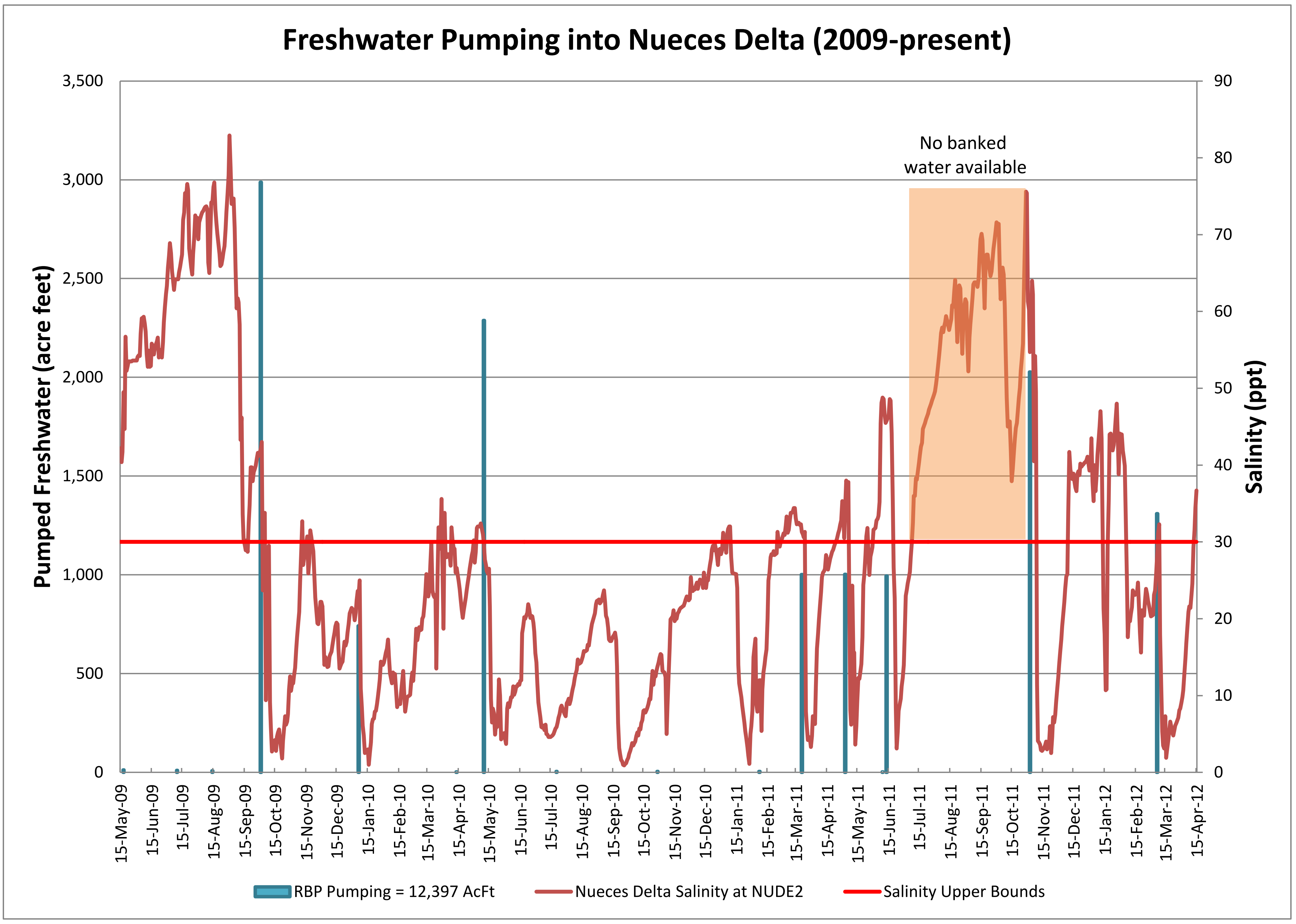
Managing environmental flows into Nueces Bay has been done since the early 1990s; it is now time to refine the management scheme to achieve the maximum ecological benefits within the realm possible using the new data gathered over the past 20 years.

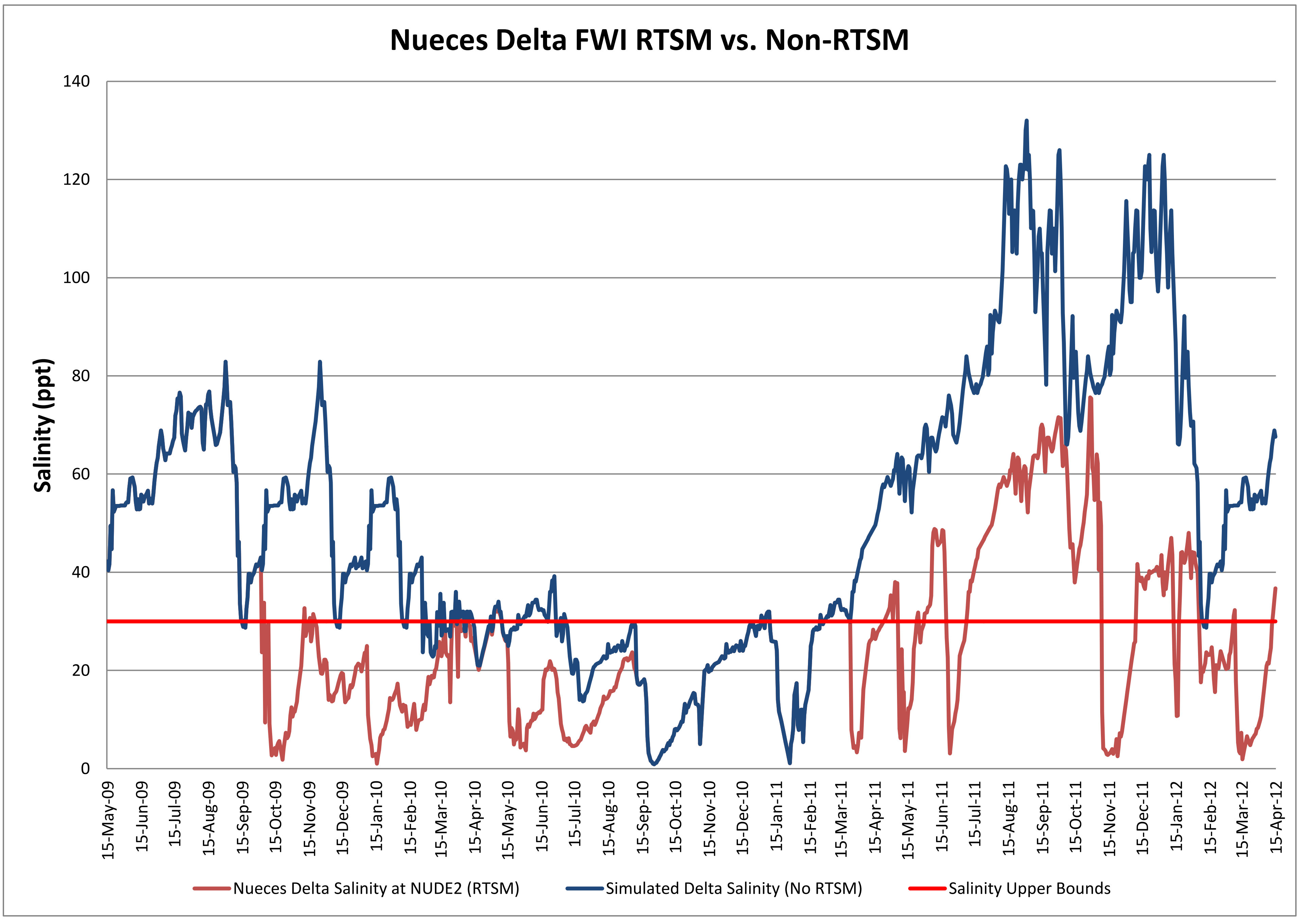


The table below shows monthly 2010 flow data at the Mathis flow gauge (NRMT) and diversions for municipal and industrial use (M&I). Diversions were subtracted from the Mathis flow to produce the Lake Corpus Christi generated flows to Nueces Bay (LCC to Estuary). Finally, additional water measured flowing over the Calallen Dam (NCAT) was place into the rainfall generated below Lake Corpus Christi column (WSBLCC to Estu [Watershed Below Lake Corpus Christi to Estuary]). The final Nueces Bay/Delta inflow (includes Rincon Bayou Pipeline [RBP]) is summed in the NCAT/RBP Flow column. The LCC to Estuary column is what is thought to be bankable water. All numbers are in acre feet.

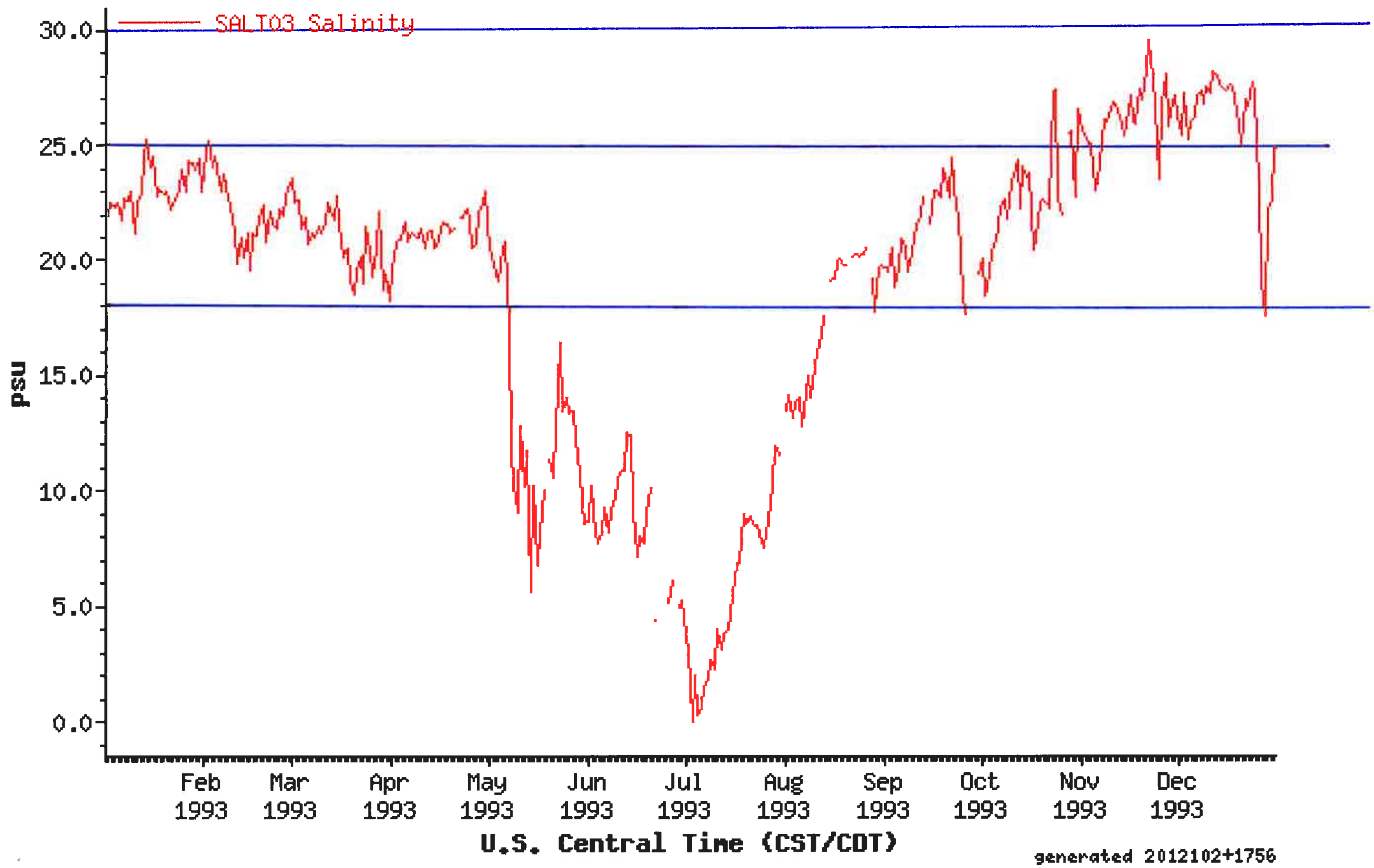
2010	Reservoir System Inflows	NMRT Flow	M&I Diversion	LCC to Estuary	WSBLCC to Estu	NCAT/RBP Flow
Jan	37,649 AcFt	6,219 AcFt	4,296 AcFt	1,923 AcFt	5,703 AcFt	7,626 AcFt
Feb	37,374	3,613	3,641	-	4,698	4,698
Mar	2,083	4,141	4,730	-	300	300
Apr	108,180	4,532	4,856	-	3,856	3,856
May	41,458	18,546	5,894	12,652	0	10,139
Jun	15,500	31,405	7,558	23,847	1,019	24,866
Jul	34,043	14,607	4,472	10,135	8,413	18,548
Aug	1,805	6,189	6,216	-	312	312
Sep	12,969	10,983	4,231	6,752	18,660	25,412
Oct	414	4,536	4,690	-	551	551
Nov	480	4,242	4,811	-	230	230
Dec	251	3,736	4,638	-	309	309
Totals	**292,206**	**112,749**	**60,033**	**55,309**	**44,051**	**96,847**



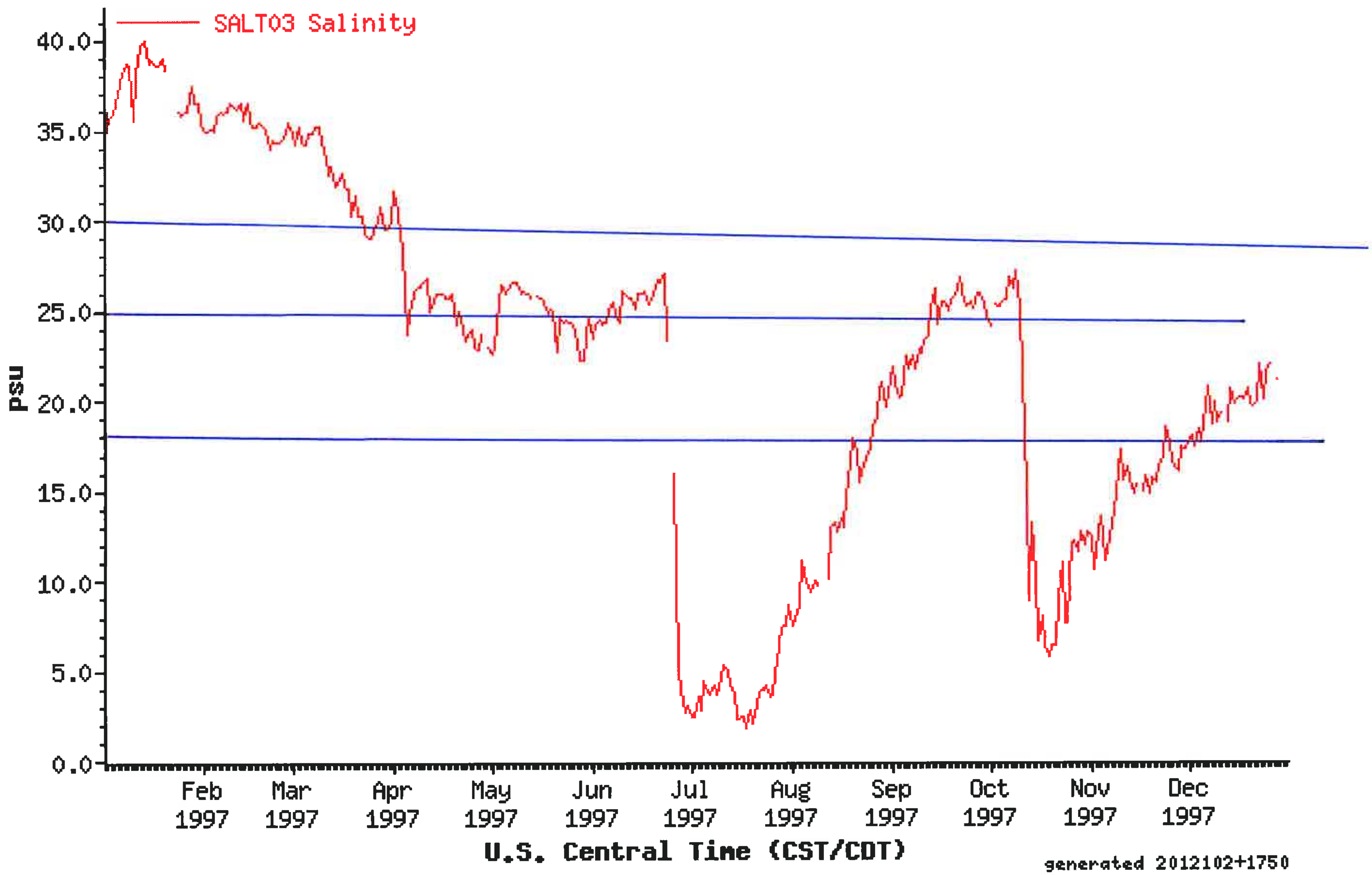

Freshwater Pumping into Nueces Delta (2009-present)
Pumped Freshwater (acre feet)
Salinity (ppt)
No banked water available
3,500
3,000
2,500
2,000
1,500
1,000
500
0
90
80
70
60
50
40
30
20
10
0
15-May-09
15-Jun-09
15-Jul-09
15-Aug-09
15-Sep-09
15-Oct-09
15-Nov-09
15-Dec-09
15-Jan-10
15-Feb-10
15-Mar-10
15-Apr-10
15-May-10
15-Jun-10
15-Jul-10
15-Aug-10
15-Sep-10
15-Oct-10
15-Nov-10
15-Dec-10
15-Jan-11
15-Feb-11
15-Mar-11
15-Apr-11
15-May-11
15-Jun-11
15-Jul-11
15-Aug-11
15-Sep-11
15-Oct-11
15-Nov-11
15-Dec-11
15-Jan-12
15-Feb-12
15-Mar-12
15-Apr-12
RBP Pumping = 12,397 AcFt
Nueces Delta Salinity at NUDE2
Salinity Upper Bounds


Nueces Delta FWI RTSM vs. Non-RTSM
Salinity (ppt)
140
120
100
80
60
40
20
0
15-May-09
15-Jun-09
15-Jul-09
15-Aug-09
15-Sep-09
15-Oct-09
15-Nov-09
15-Dec-09
15-Jan-10
15-Feb-10
15-Mar-10
15-Apr-10
15-May-10
15-Jun-10
15-Jul-10
15-Aug-10
15-Sep-10
15-Oct-10
15-Nov-10
15-Dec-10
15-Jan-11
15-Feb-11
15-Mar-11
15-Apr-11
15-May-11
15-Jun-11
15-Jul-11
15-Aug-11
15-Sep-11
15-Oct-11
15-Nov-11
15-Dec-11
15-Jan-12
15-Feb-12
15-Mar-12
15-Apr-12
Nueces Delta Salinity at NUDE2 (RTSM)
Simulated Delta Salinity (No RTSM)
Salinity Upper Bounds

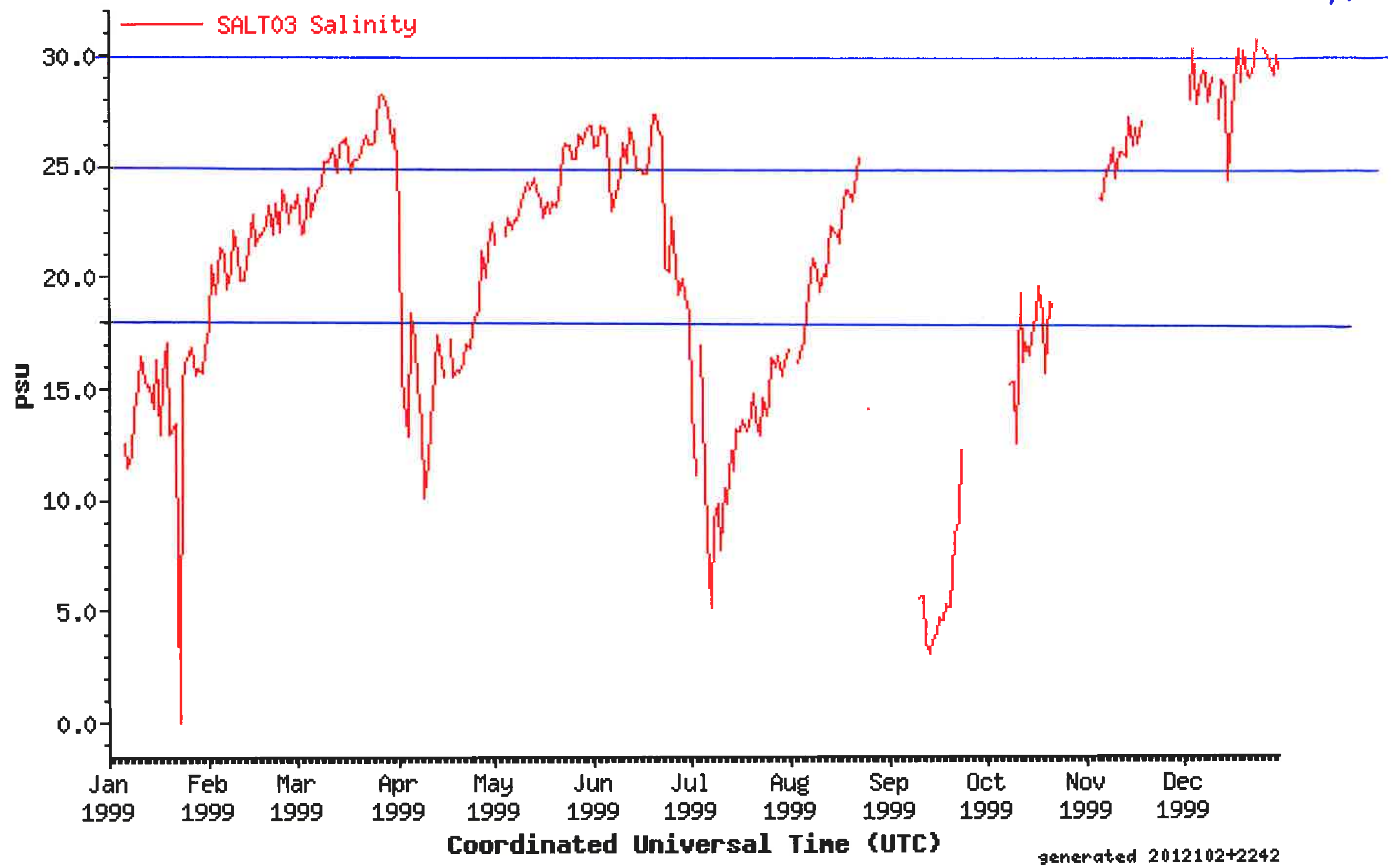
TOTAL INFLOWS
79,939 AF



TOTAL INFLOWS
129,353 AF

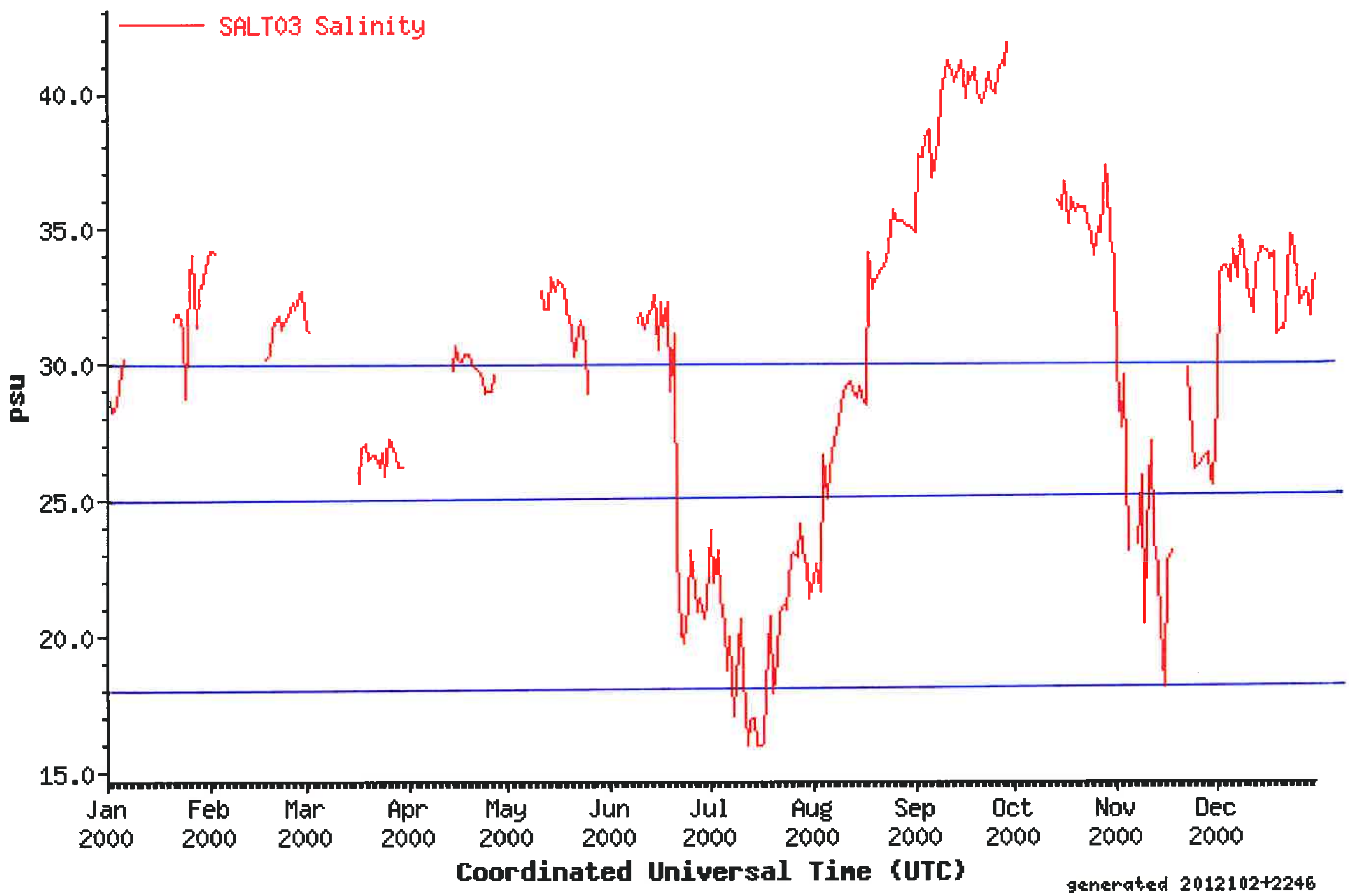


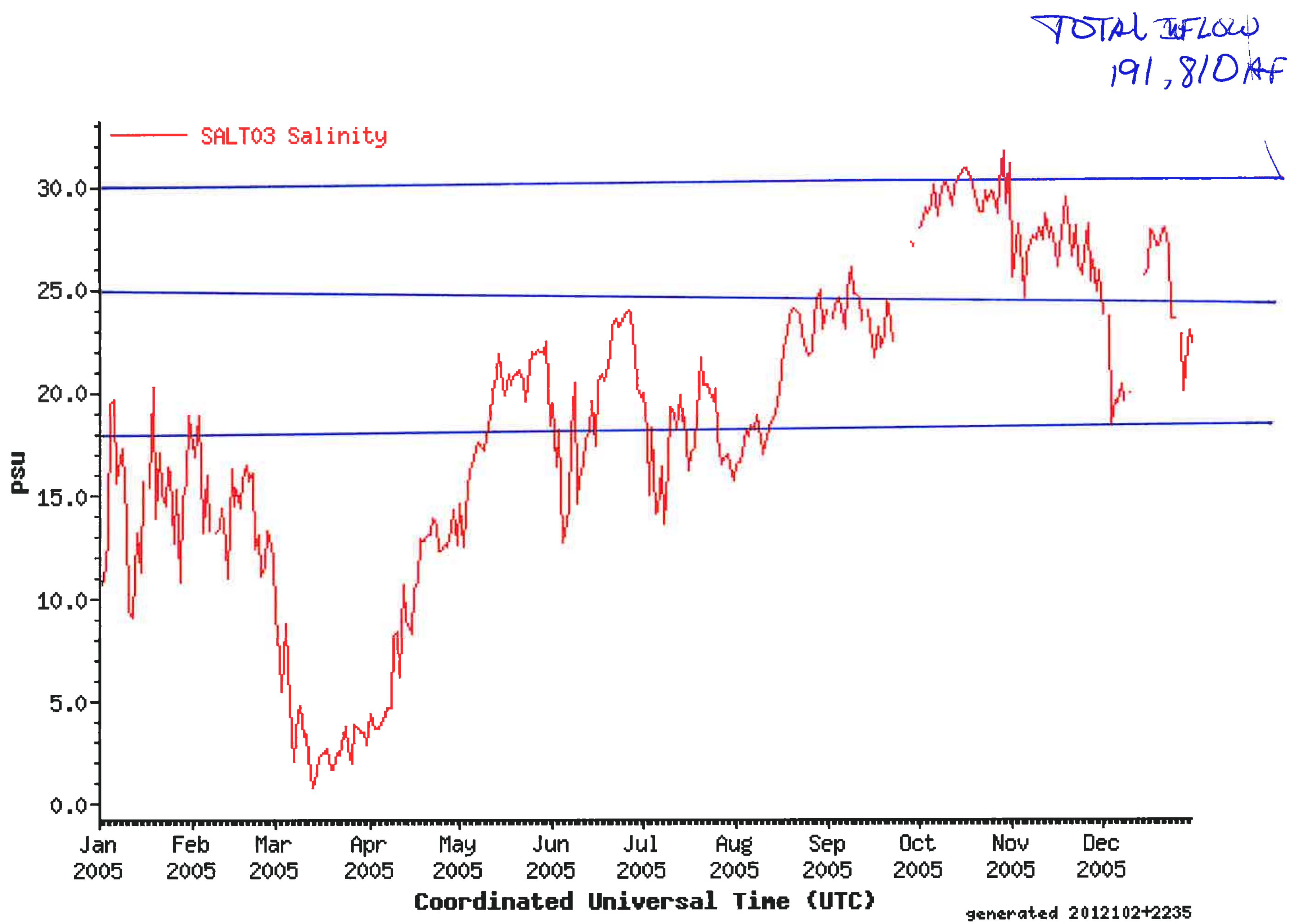
TOTAL INFLOW
108,768
AF



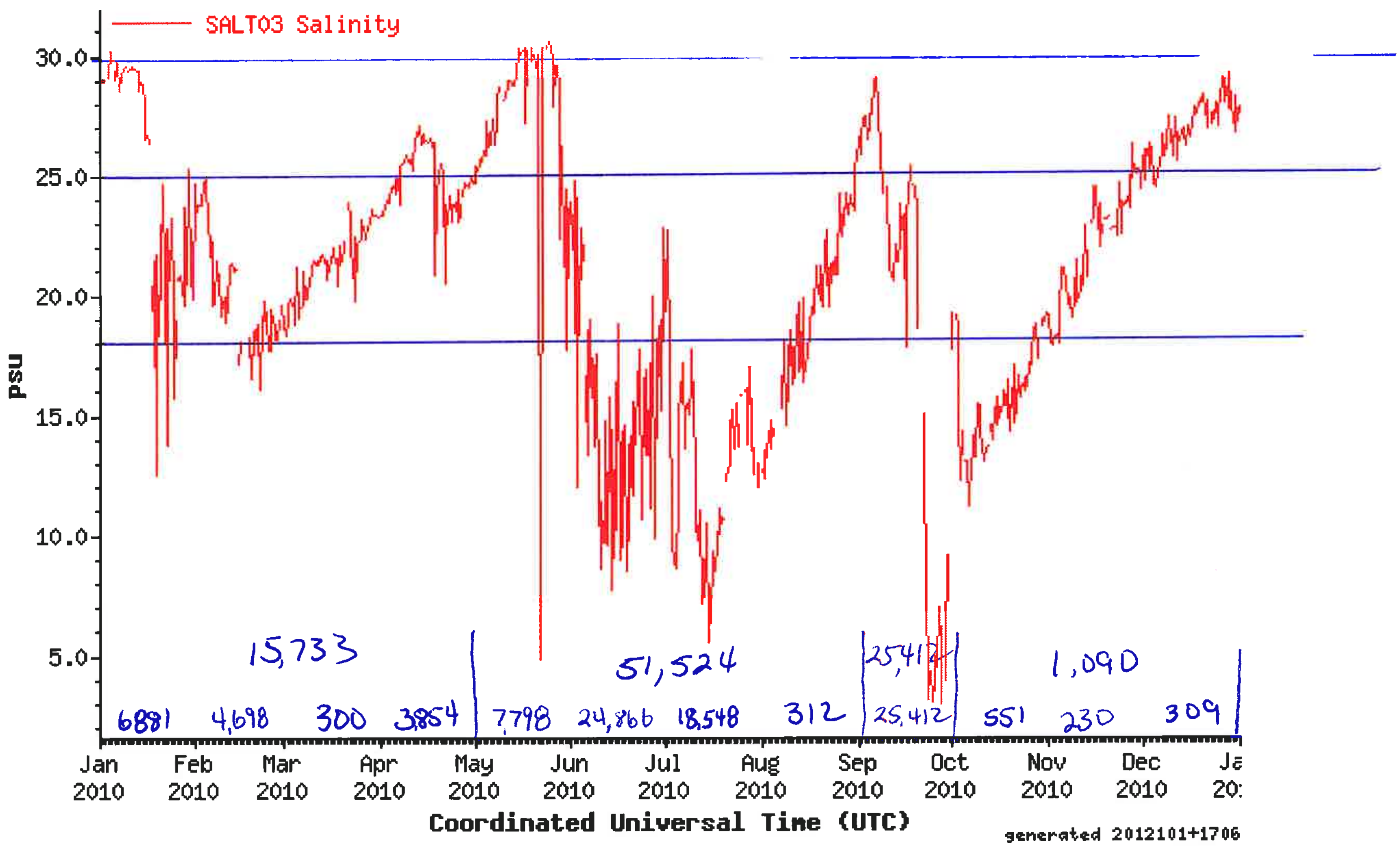
- Total Flow to Reservoirs
- NCAT
- Monthly Flows

TOTAL INFLOW=55,440 AF




TOTAL INFLOW
191,810 AF
SALT03 Salinity
psu
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Jan 2005
Feb 2005
Mar 2005
Apr 2005
May 2005
Jun 2005
Jul 2005
Aug 2005
Sep 2005
Oct 2005
Nov 2005
Dec 2005
Coordinated Universal Time (UTC)
generated 2012102+2235

TOTAL FWINFlow = 93,759 AF



Appendix E
Agreed Order Re-examination

Agreed Order - Re-examined

The Nueces BBASC is strategizing on ways to incorporate the Nueces BBEST recommendation of seasonal pulses into an operational plan that is feasible for both human water supply needs and the environment. In order to adequately account for how changes in current operations would be impacted by going to a seasonal approach, several items under the current 2001 Agreed Order were reviewed: Monthly targets, freshwater inflow credits (salinity, return-flow, and surplus), and a review of the benefits of the 2001 Agreed Order in creating a quasi-natural flow regime as intended by the Special Condition 5.B., Certificate of Adjudication No. 21-3214. Through the re-examination of the current Agreed Order, there might be an opportunity to better manage the limited freshwater resource using SMART Inflow Management and reviewing new data that was not available during the creation of the 1995 Agreed Order, which is the basis for the current pass through operation of the reservoir system.

Choke Canyon Reservoir and Lake Corpus Christi are major reservoirs within the Nueces River Basin. Choke Canyon Reservoir is a Bureau of Reclamation Project operated by the City of Corpus Christi. The city owns Lake Corpus Christi and operates the two together as the Choke Canyon Reservoir/Lake Corpus Christi (CCR/LCC) System to meet municipal and industrial water demands. The city operates the CCR/LCC System in compliance with a TCEQ Agreed Order, a legal imperative. The Agreed Order, last amended and issued April 4, 2001, established an operating procedure pertaining to Special Condition 5.B., Certificate of Adjudication No. 21-3214 (the water right for Choke Canyon Reservoir), held by the City of Corpus Christi, the Nueces River Authority (NRA), and the City of Three Rivers.

This order specifies monthly inflow targets for Nueces Bay that must be met by allowing inflows to pass through the reservoirs to the Nueces Bay and Estuary. These monthly inflow targets are based on total system storage of the reservoirs.

The monthly targets were developed by the TWDB and the TPWD in the early 1990s to maximize biological benefits for species inhabiting the estuary. Specifically, the model used to come up with the inflow numbers was the Estuarine Mathematical Programming Model (TxEMP), a non-linear optimization model. This optimization model was used in conjunction with the hydrodynamic circulation model (TxBLEND) to evaluate freshwater inflows needed to maintain salinity gradients and fisheries harvest in Texas bays and estuaries.

From the TxEMP Model, the 2001 Agreed Order established a monthly schedule of desired freshwater inflows to Nueces Bay to be satisfied by reservoir spills, return flows, runoff below Lake Corpus Christi, and/or pass-throughs of system inflows. In simplest terms, the amount of water that flows into the reservoir system, up to a target amount, must be "passed through" to the bays and estuaries. Inflows above the target amount, which varies by month, can be captured for future use. The maximum required pass-through amount for any given year is 138,000 acft. When the reservoir system is greater than or equal to 70 percent of full (Table 2), the annual Nueces Bay inflow target is 138,000 acft. Under the current 2001 Agreed Order, pass-throughs can be reduced based on excess inflow from the previous month for up to one half of the following month's inflow requirement or low monthly salinity variation in the upper Nueces Bay (Table 3). When reservoir system storage is below 70 percent of capacity, but above 40 percent, the annual Nueces Bay inflow target is 97,000 acft. If system storage drops below 40 percent, but is above 30 percent, the City automatically enacts drought contingency measures and the pass-through requirements drop to 1,200 acft per month (the monthly median inflow to Lake Corpus Christi during the drought of record). If the system storage drops below 30 percent, the City automatically enacts more stringent drought contingency measures and pass-throughs from the reservoir system are suspended.

There are two main issues with TxEMP. First, flow results higher than the historical monthly medians are not allowed by model constraints, such that the maximum harvest (MaxH) flow can only be equal to or less than the historical monthly median inflows. Any need for inflows higher than monthly medians in any month for biological purposes cannot be directly evaluated from the model results. Second, TxEMP outputs for MaxH and MinQ (minimum inflows necessary to meet biological targets) are computed on a monthly basis according to pre-set historical bounds. Estuarine scientists now postulate that seasonal pulses could be more beneficial and critical for the biota than the strictly-defined monthly inflows currently in place for the Nueces Estuary. The Nueces BBEST recommended a seasonally-based freshwater inflow regime that incorporated this concept of pulsed inflows.

Monthly Targets

The first analysis simply looked at the 2001 Agreed Order monthly inflow targets vs. the mean monthly reservoir system inflow and Nueces Bay inflow (Figures 8 and 9, respectfully). As described in the Nueces BBEST report, there has been a shift in monthly freshwater inflow patterns to the Nueces Bay, and based on this analysis there is a similar pattern of inflow into the reservoirs. Pass through targets were originated by looking at historical inflow patterns data into Nueces Bay and then divvying up the 138,000 acre feet among the months that had the highest historical inflow as a way to mimic nature. In reality what we have seen is a shift in the inflow patterns, which coincidently misses the large pass through target months and could mean less water to the bay, impairing the original intent of the Agreed Order by mimicking nature. A redistribution of pass through targets might insure that the current operations plan mimics a more natural hydrological cycle.

Table 2. 2001 Agreed Order established monthly "pass-through" targets for freshwater inflows to the Nueces Estuary. Capacity refers to the percent of the combined storage capacity of Choke Canyon Reservoir and Lake Corpus Christi.

2001 Agreed Order Pass-Through Targets (acft)				
Month	**Capacity ≥ 70%**	**40% ≤ Capacity < 70%**	**30% ≤ Capacity < 40%**	**Capacity < 30%**
Jan	2,500	2,500	1,200	0
Feb	2,500	2,500	1,200	0
Mar	3,500	3,500	1,200	0
Apr	3,500	3,500	1,200	0
May	25,500	23,500	1,200	0
June	25,500	23,000	1,200	0
July	6,500	4,500	1,200	0
Aug	6,500	5,000	1,200	0
Sept	28,500	11,500	1,200	0
Oct	20,000	9,000	1,200	0
Nov	9,000	4,000	1,200	0
Dec	4,500	4,500	1,200	0
Total	138,000	97,000	14,400	0

Table 3. 2001 Agreed Order established salinity relief credit structure to reduce pass-through amount to Nueces Bay. Credits can be obtained in two ways: 1) In any given month, if the average salinity during the week of the 15th through the 21st, is at or below the Salinity Lower Bound (SLB) for the following month at Salt03 salinity station in Nueces Bay, then the target amount for the following month will be completely suspended. 2) In any given month, if the average daily salinity is X practical salinity units (psu) below the Salinity Upper Bound (SUB) for 10 consecutive days, then the target is reduced by Y%.

Month	**Salinity Lower Bounds**	**Salinity Upper Bounds**	**Reduction for Average Salinity**		
			5 psu below SUB	**10 psu below SUB**	**15 psu below SUB**
Jan	5	30	25%	50%	75%
Feb	5	30	25%	50%	75%
Mar	5	30	25%	50%	75%
Apr	5	30	25%	50%	75%
May	1	20	0%	25%	75%
June	1	20	0%	25%	75%
July	2	25	25%	50%	75%
Aug	2	25	25%	50%	75%
Sept	5	20	0%	25%	75%
Oct	5	30	0%	25%	75%
Nov	5	30	25%	50%	75%
Dec	5	30	25%	50%	75%

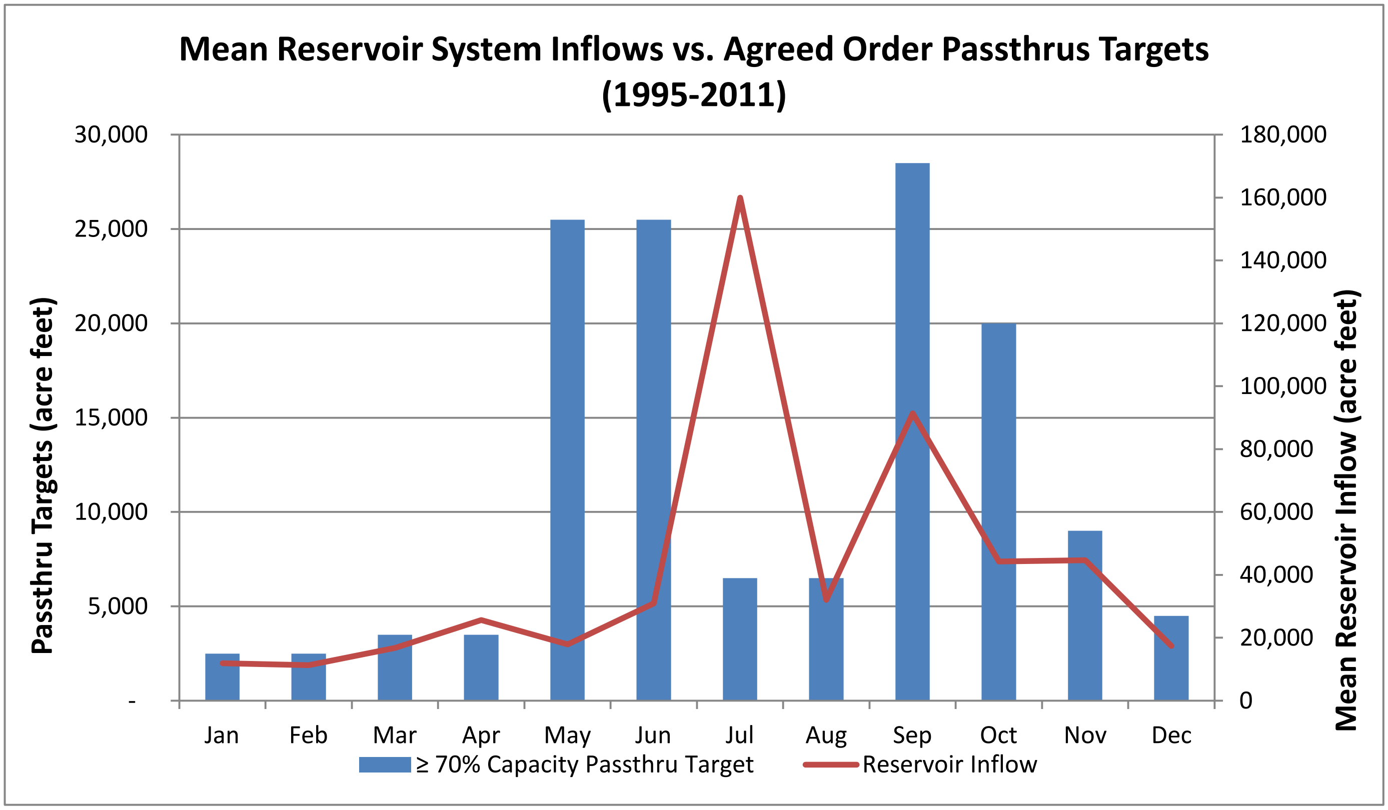


Figure 8. Mean monthly reservoir system inflows vs. the current 2001 Agreed Order pass through targets when reservoir system capacity is above 70%.

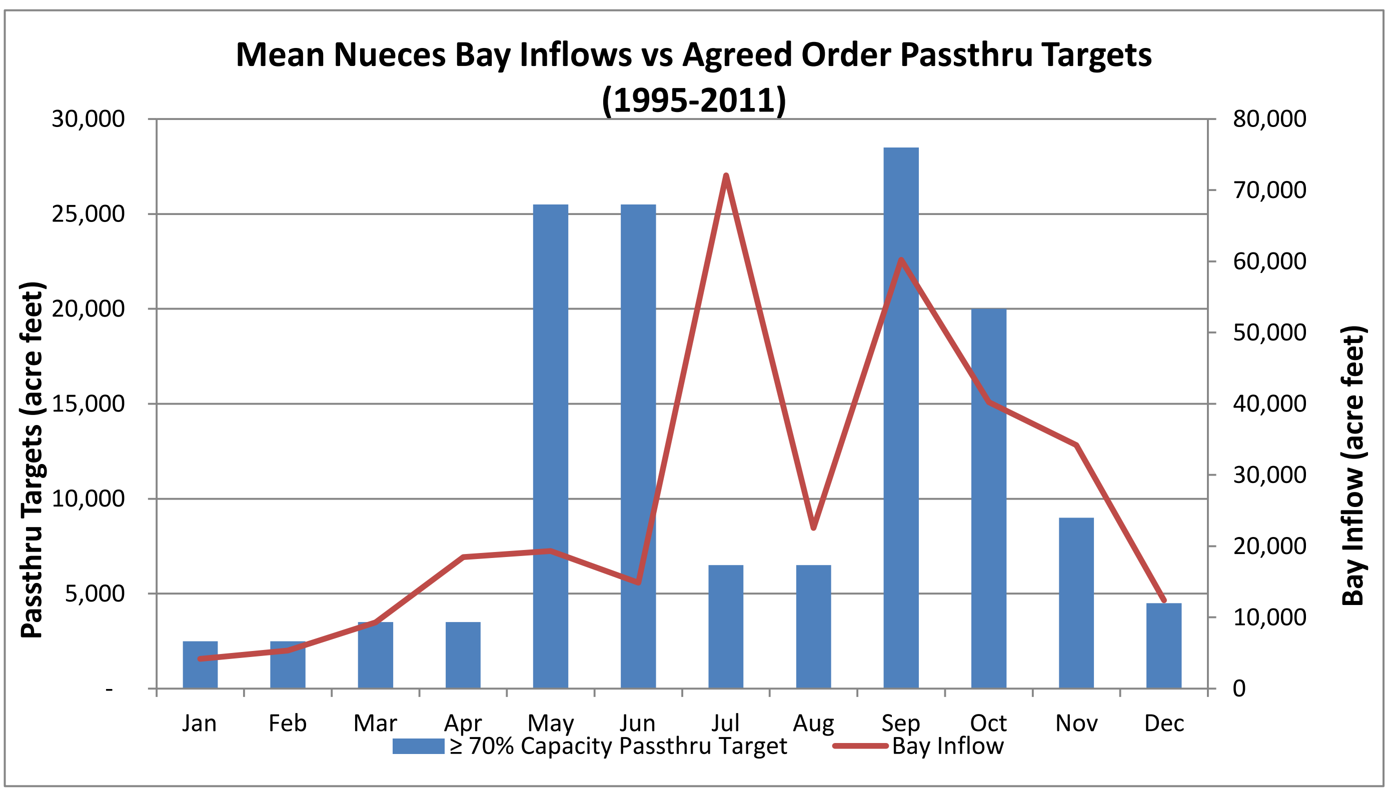


Figure 9. Mean monthly Nueces Bay inflows vs. the current 2001 Agreed Order pass through targets when reservoir system capacity is above 70%.

Another benefit to redistribution of the pass through targets might be to the SMART Inflow Management concept that would allow for more water to be available for banking and pulsing water into the bay during key times of the year. Table 4 lists reservoir monthly inflows from lowest to highest from the years of 1995 to 2011. This was constructed to show what percentile of flows are currently being passed through the reservoirs and might be useful for figuring out how the 138,000 acre feet could be redistributed in the future.

Table 4. Monthly reservoir system inflows are listed from lowest to highest by month from years 1995 to 2011. The yellow highlighted numbers represent flows that are within the 2001 Agreed Order pass through targets. The orange highlighted numbers represent flows that are not required to be passed through the reservoir and into the bay because they are flows above the required pass amount. The top blue row shows the 2001 pass through targets. The percentages on the left hand side of the table represent flow percentiles captured under the 2001 Agreed Order.

	Targets	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
		1,149	733	433	197	154	6	50	23	273	414	175	251
		1,219	772	471	454	205	64	150	100	397	1,069	262	666
		1,533	873	984	599	258	167	317	141	1,747	1,348	376	939
25%		2,330	1,023	1,772	1,104	462	304	535	232	3,007	2,713	480	1,086
		2,969	2,143	2,083	1,450	1,839	588	814	851	5,892	3,089	2,257	1,717
		4,436	3,434	2,449	2,895	2,236	1,063	1,610	1,805	9,322	5,404	3,040	1,743
		4,490	3,781	4,942	4,062	2,922	1,102	4,991	3,058	12,969	5,813	4,935	2,442
		9,120	4,945	6,020	5,132	4,744	1,995	6,499	4,062	14,722	6,609	6,458	2,532
50%		10,650	7,523	6,877	8,969	5,118	8,720	12,352	4,407	25,016	6,622	14,148	4,657
		11,761	9,135	7,345	10,814	9,741	12,861	16,450	5,835	46,356	7,529	23,315	4,751
		12,062	11,407	8,208	17,556	11,009	13,086	31,883	7,858	49,157	12,610	24,021	10,967
		12,973	11,805	13,787	22,951	12,361	15,500	34,043	9,109	63,766	15,053	39,244	13,685
		13,874	14,252	19,067	24,940	15,558	27,023	131,662	12,967	69,331	17,447	60,179	15,297
75%		16,087	22,090	32,556	26,670	16,101	30,184	141,306	46,656	78,089	24,977	72,664	24,128
		29,170	28,200	35,188	28,802	41,458	77,285	249,346	80,345	79,484	129,887	85,091	58,002
		30,487	32,949	65,052	108,180	71,502	157,810	750,255	107,436	161,588	231,260	169,218	74,930
		37,649	37,374	78,979	171,606	108,092	177,394	1,337,481	260,321	932,297	280,307	253,185	77,334
	Total	201,959	192,439	286,213	436,381	303,760	525,152	2,719,744	545,206	1,553,413	752,151	759,048	295,127

Pass Through Credits

It was recognized early on that low salinities are good for the bay, but there can be too much of a good thing which was part of the reason for creating salinity relief credits. The credit system was established for a couple of reasons: 1) to prevent Nueces Bay from getting more freshwater inflow during periods when salinities were already low in the bay, and 2) for gains in water supply. While managing for both water supply and environmental conditions in the bay is good, it can only be as good as the structure of the frame work it was established under.

Today we have more information on how the reservoir system works and how the 2001 Agreed Order effects quantities of water reaching the bay. When looking at the credit history from 1998 to 2011, it is clear that out of three credit types (return flow, surplus, and salinity credit) the salinity credit receives the most recognition in most years in terms of impacting the quantity of water reaching Nueces Bay (Figure 10). As would be expected, during wet years there are more credits for salinity. In dry to moderate years there appears to be more surplus credits than in wet years. The return flow credit of 500 acre feet per month for effluent discharges from the Allison Waste Water Treatment Plant is the same every month no matter what the conditions may be because these are actual discharges occurring into Nueces River below the Calallen Dam.

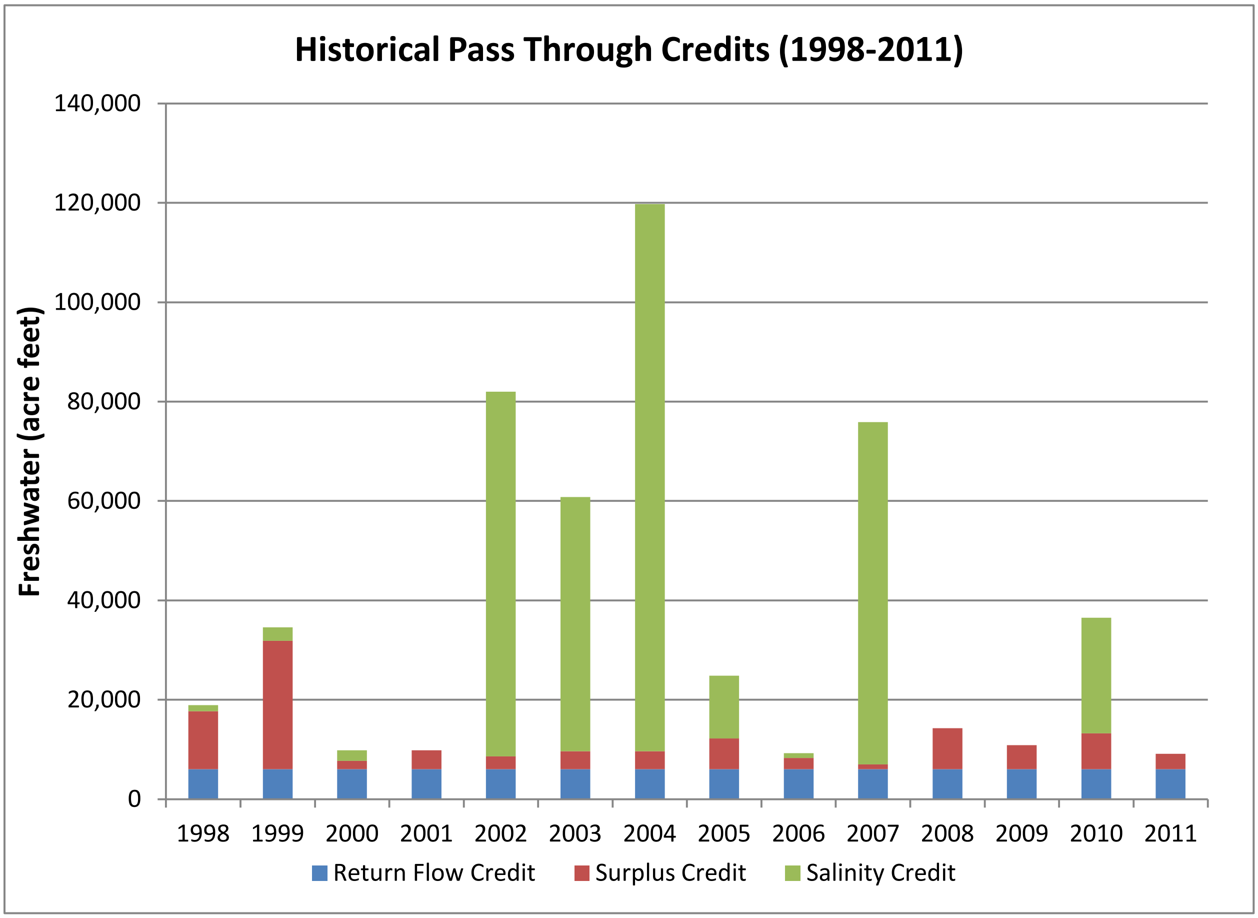


Figure 10. Annual credits received by the City of Corpus Christi.

A more informative approach at looking at credits is to look at monthly mean credits over time and compare the credit amounts to mean bay inflows (Figure 11). By comparing total mean monthly credits received vs. mean monthly Nueces Bay inflow there is a pattern that is closely tied to that of the established monthly inflow targets, except for May and June that show a lower than expected credit over time. This is due to the monthly target structure under the Agreed Order, where May and June do not receive as much inflow as other months with high monthly targets so they are less likely to receive credits.

In summary, a shift in the 2001 Agreed Order monthly targets could be beneficial for water supply in that the salinity and surplus credits would increase depending on which months the targets were distributed in. A shift in monthly targets might also be beneficial to the implementation of the SMART Inflow Management in that there could potentially be more bankable water available in some years.

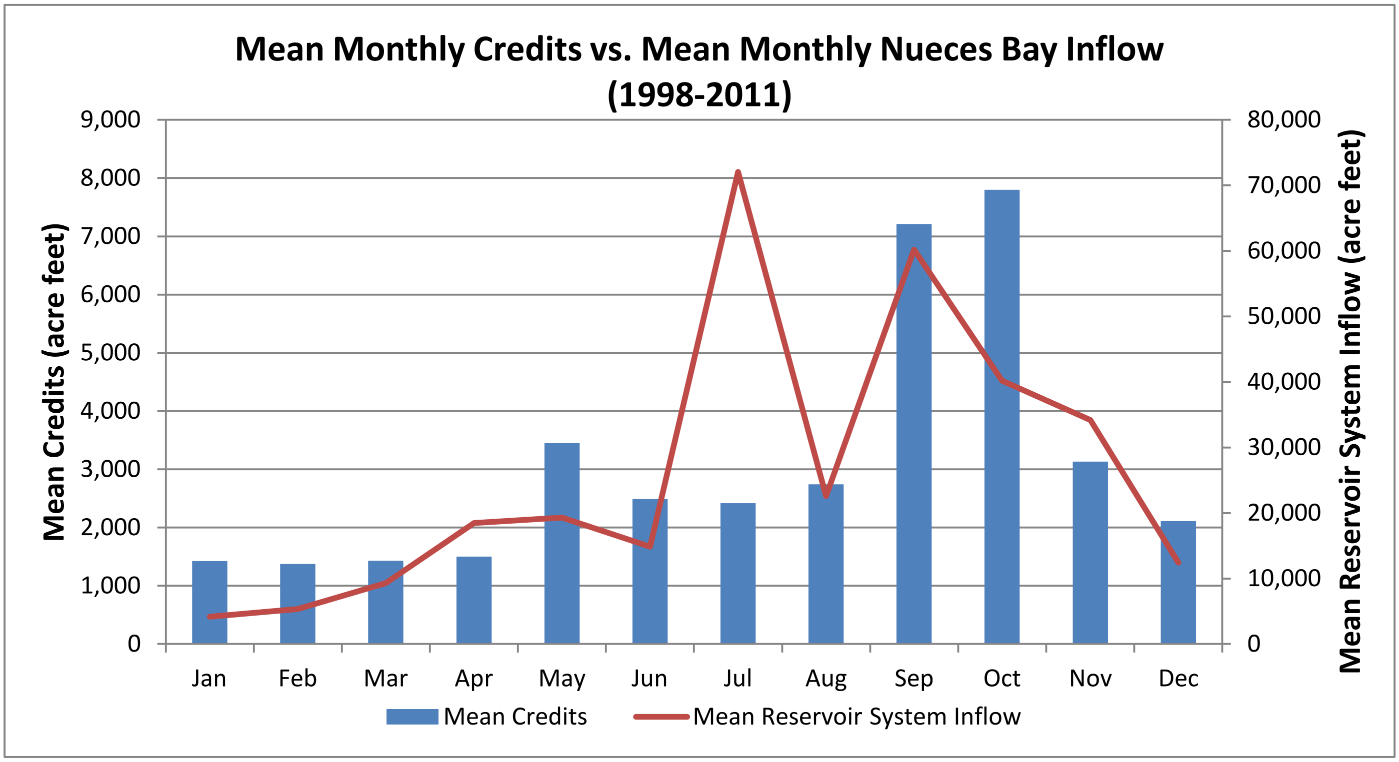


Figure 11. Mean monthly credits received by the City of Corpus Christi vs. mean monthly inflows into Nueces Bay during 1998 to 2011.

Comparison of Two Hydrology Datasets, as Applied to the TxBLEND Model, on Salinity Condition in Nueces Bay

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Introduction

A recent Texas Water Development Board (TWDB) technical memo documented the calibration and validation of the Nueces Estuary TxBLEND hydrodynamic and salinity transport model in which inflows to Nueces Bay, via the Nueces River Inflow Point, were based on the USGS stream gage on the Nueces River at Calallen plus return flows from the Allison Wastewater Treatment Plant (WWTP, Schoenbaechler *et al.* 2011a). As such, the inflows captured only a portion of the total inflows entering Nueces Bay, though it closely represented inflows entering the bay via the Nueces River. At the request of the Senate Bill 3 Nueces Basin and Bay Expert Science Team (BBEST), TWDB prepared an alternate hydrology dataset to better represent *total* inflows entering Nueces Bay. Specifically, the alternate hydrology was based on the USGS stream gage on the Nueces River at Calallen plus inflows from a portion of watersheds #20005 and #21010 and all of watershed #22012, as well as the Allison WWTP return flows and any other appropriate diversion and returns for these watersheds. Under this alternate hydrology, total inflows to Nueces Bay are better represented, though due to constraints on the model design, the inflows are applied solely to the Nueces River Inflow Point, which may slightly over-represent inflows entering the system at this location. This technical memo documents salinity output from the TxBLEND model using this alternate hydrology dataset as applied to the Nueces River Inflow Point. Additionally, this memo documents the comparison between TxBLEND model output using two different hydrology datasets (1) that which was used in the calibration and validation of the TxBLEND model and also (2) the proposed alternate hydrology described herein.

Methodology

Model Domain and Inputs

The model domain, parameters, and model inputs (except for inflows) are consistent with that used for calibration and validation of the Nueces Estuary TxBLEND model (Schoenbaechler *et al.* 2011a). However in the *Alternate Hydrology* simulation presented here, results are focused on salinity in Nueces Bay for the period 2000 – 2009.

Inflows

As described in the calibration and validation report for the Nueces Estuary TxBLEND model (Schoenbaechler *et al.* 2011a):

> "Daily inflow values for Nueces Bay were modified from those prepared for TWDB coastal hydrology dataset version #TWDB201004 for the Nueces Estuary, which is based on gaged inflows from the U.S. Geological Survey (USGS) stream gage on the Nueces River at Mathis (Station no. 08211000, Schoenbaechler *et al*., 2011b), to better reflect inflows entering Nueces Bay via the Nueces River inflow point. However, the modified hydrology was used only after 1989, when the Nueces River at Calallen gage (Station no. 08211500) became operational. Before then, daily inflows prepared for hydrology version #TWDB201004 (for only the portion of flows that drain to Nueces Bay) were applied to the Nueces River inflow point. Specifically, those flows were based on gaged inflows from the USGS gage at Mathis,

> and ungaged inflows from watersheds #20005, #21010, #22012, and #22013. Diversions and return flows also were accounted for in those ungaged watersheds."

After 1989, daily inflow values were modified by using the USGS stream gage at Calallen due to its close proximity to the bay and by applying return flows from the Allison WWTP (as a constant 10.5 acre-feet per day based on the daily average discharge from 2003 – 2009; Table 1). This modification slightly under-represents total inflows entering Nueces Bay but more accurately reflect total inflows entering the bay via the Nueces River Inflow Point. However, other hydrology data sets can be developed and applied to the TxBLEND model.

Table 1 describes three hydrology data sets that are relevant to consider when conducting freshwater inflow analyses of Nueces Bay. The dataset referred to as *TxBLEND Nueces River Inflow Point (Calibration Hydrology)* is that which was applied to the calibration and validation of the model, as described above. The dataset referred to as *TxBLEND Nueces River Inflow Point (Alternate Hydrology)* is that which was requested by the Nueces BBEST and better represents total inflows entering Nueces Bay, but with a slight over-representation of inflows passing through the Nueces River Inflow Point. Both of these hydrology datasets were modified from an earlier version of hydrology, #TWDB201004, which lacked some diversion and return flow data (refer to Schoenbaechler *et al*. 2011b for specific information about each version of hydrology and refer to Figures 6 and 11 in Schoenbaechler *et al*. 2011a for plots comparing the *Calibration Hydrology* to total inflows to the estuary). After 1989, both of these datasets are based on using the USGS stream gage for the Nueces River at Calallen. Also presented, for comparison purposes only, is a description of the most recent version of hydrology developed for the entire Nueces Estuary, #TWDB201101-*Full Hydrology*, which includes updated diversion and return flow data, as well as a description of the subset of inflows which drain into Nueces Bay (referred to as *TWDB201101-Nueces Bay Hydrology*). These last two descriptions are based on using the USGS stream gage for the Nueces River near Mathis and ungaged flows from the watershed below that gage. Figure 1, below, is provided to serve as an aid for understanding the various hydrology datasets described in Table 1.

Table 1. Comparison of components used to estimate inflows for four hydrology datasets. *TWDB201101-Full Hydrology* represents the most recent TWDB estimate of freshwater inflow to the Nueces Estuary. *TWDB201101-Nueces Bay Hydrology* represents only the inflows entering Nueces Bay, a subset of the full hydrology. The two *TxBLEND Nueces River Inflow Point* hydrology datasets represent those inflows applied to the Nueces Bay Inflow Point in the TxBLEND model for the Nueces Estuary. The *Calibration Hydrology* was used to calibrate and validate the model from 1987- 2009 and represents inflows passing from the Nueces River watershed into Nueces Bay; whereas, the *Alternate Hydrology* was applied to better represent total inflows entering Nueces Bay for all surrounding watersheds. Refer to Figure 1 for gage, watershed, diversion, and return flow locations.

Inflow Component	**TWDB201101 (Full Hydrology) 1941 - 2009**	**TWDB201101 (Nueces Bay Hydrology) 1977 - 2009**	**TxBLEND Nueces River Inflow Point (Calibration Hydrology)**		**TxBLEND Nueces River Inflow Point (Alternate Hydrology) 1990 - 2009**
			1987 - 1989	**1990 - 2009**	
Gaged Watersheds	#08211000 - Nueces R. nr Mathis (1941 – 2009) #08211520 - Oso Creek @ Corpus Christi (1977 – 2009)	#08211000 - Nueces R. nr Mathis	#08211000 - Nueces R. nr Mathis	#08211500 – Nueces R. @ Calallen	#08211500 – Nueces R. @ Calallen
Ungaged Watersheds	100% of all watersheds: #21010, #20005, #22012, #22013, #22011, #22014, #22015, and before 1977, #22010 (which has since been gaged by Oso Crk gage)	100% of area of #21010, 50% of area of #20005, 100% of area of #22012, 0% of area of #22013 (not included as drains to Corpus Christi Ship Channel)	100% of all watersheds: #21010, #20005, #22012, #22013	None included	20% of area of #21010, 50% of area of #20005, 100% of #22012, 0% of #22013 (not included as drains to Corpus Christi Ship Channel)
Returns	All return flow data available	100% of #21010, 13% of #20005, 100% of #22012	100% of #21010, #20005, #22012, #22013	Return flows from Alison Wastewater Treatment Plant only	100% of #21010, 13% of #20005, 100% of #22012
Diversions	All diversion data available	100% of #21010	100% of #21010, #20005	n/a	n/a

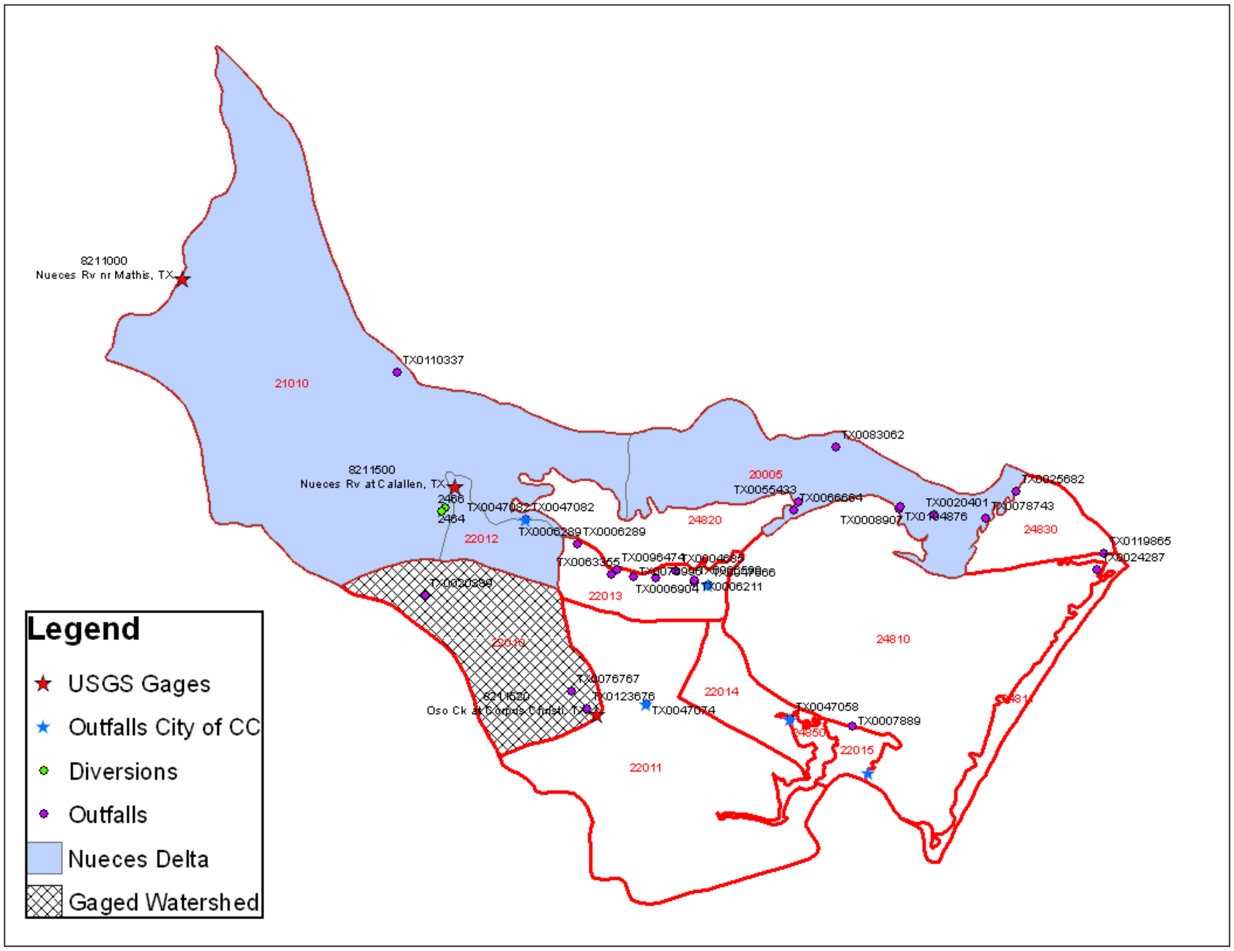


Figure 1. Location of USGS stream gages (red stars), permitted diversion points (green circles), wastewater outfalls (purple circles) and City of Corpus Christi outfalls (blue stars) in the Nueces Estuary watershed. Watersheds #21010, #22012, and a portion of #20005 drain to the Nueces Delta and are highlighted in blue.

While all three Nueces Bay inflow hydrology datasets are comparable in terms of average annual inflow (Table 2), there are annual and intra-annual differences such that none of the hydrology datasets yield consistently more or less inflows (Figures 2 and 3). However, a comparison of the two TxBLEND hydrology datasets shows that the *Alternate Hydrology* captures more inflows than the *Calibration Hydrology*. This is consistent with having included those inflows contributed from the watersheds surrounding Nueces Bay in the *Alternate Hydrology*. The effect of including these additional watersheds and applying all Nueces Bay inflows to the Nueces River Inflow Point in the TxBLEND model is described in the following sections. Though not applied to the TxBLEND model at this time, inflow estimates for *TWDB201101-Nueces Hydrology* (based on the USGS stream gage on the Nueces River near Mathis) includes higher inflow events, which are not captured by either of the TxBLEND hydrology datasets (Figure 4). Figure 5 focuses specifically on the 2000 – 2009 period, which was simulated for this technical memo, and shows flows ranging from 0 – 200,000 acre-feet per month to allow for a better visual comparison of differences among the hydrology datasets.

Table 2. Annual total freshwater inflow (in acre-feet) to Nueces Bay, as estimated by three hydrology datasets: *TWDB201101-Nueces Bay Hydrology*, *TxBLEND Calibration Hydrology*, and *TxBLEND Alternate Hydrology*, for the period 1990 – 2009.

Year	TWDB201101 Nueces Hydrology	TxBLEND Nueces Calibration Hydrology	TxBLEND Nueces Alternate Hydrology
1990	247,789	195,324	202,311
1991	114,446	97,035	114,330
1992	959,322	479,915	530,274
1993	146,305	79,845	102,473
1994	144,310	55,430	69,233
1995	103,377	52,098	71,419
1996	32,173	10,036	11,478
1997	236,346	126,910	150,699
1998	272,042	198,978	209,347
1999	158,846	111,901	126,500
2000	68,066	51,671	61,490
2001	244,006	277,886	296,372
2002	2,263,878	2,483,278	2,528,243
2003	493,223	554,650	573,029
2004	899,765	923,845	956,209
2005	189,078	184,193	198,628
2006	66,066	38,150	65,681
2007	1,118,550	1,160,271	1,209,915
2008	43,822	32,265	47,665
2009	27,407	19,228	30,903
Average Inflow	372,369	346,241	364,661

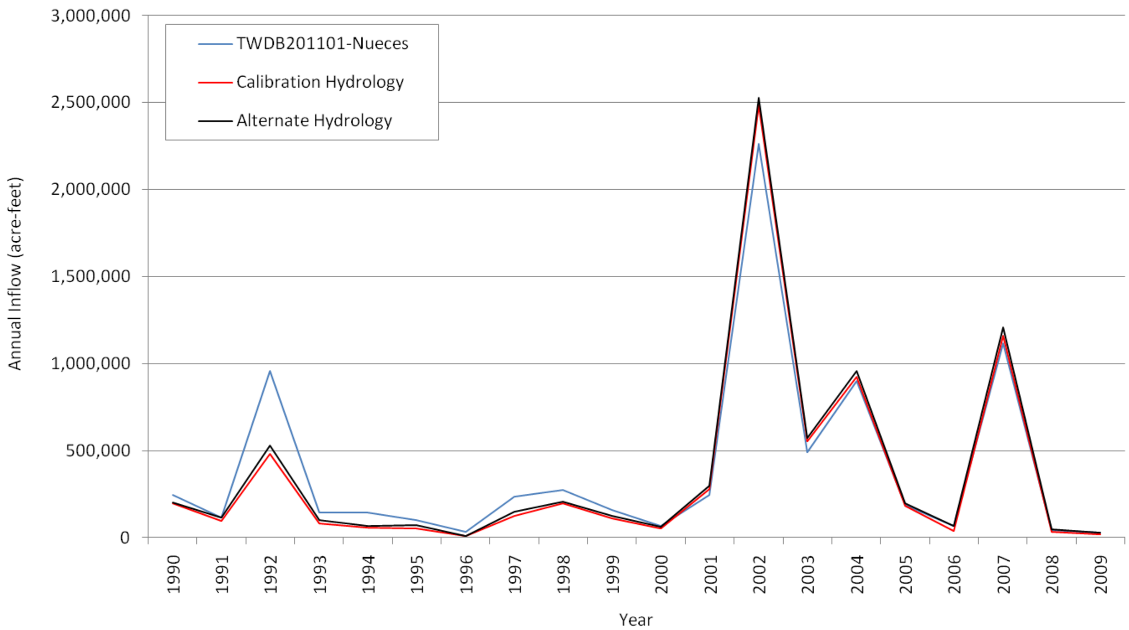


Figure 2. Annual freshwater inflow estimates (in acre-feet) to Nueces Bay between three hydrology datasets for 1987 – 2009; *TWDB201101-Nueces Bay Hydrology* (*blue*), *TxBLEND Calibration Hydrology* (*red*), and *TxBLEND Alternate Hydrology* (*black*).

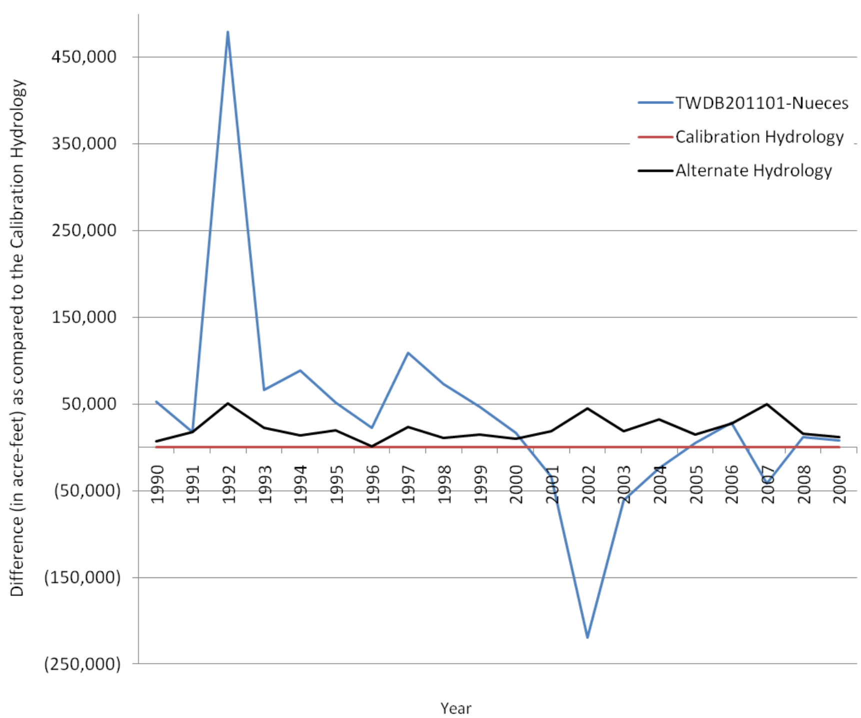


Figure 3. Difference in annual inflow estimates (in acre-feet) to Nueces Bay for three hydrology datasets from 1987 – 2009; *TWDB201101-Nueces Bay Hydrology* (*blue*), *TxBLEND Calibration Hydrology* (*red*), and *TxBLEND Alternate Hydrology* (*black*). Differences are compared to the *TxBLEND Calibration Hydrology*.

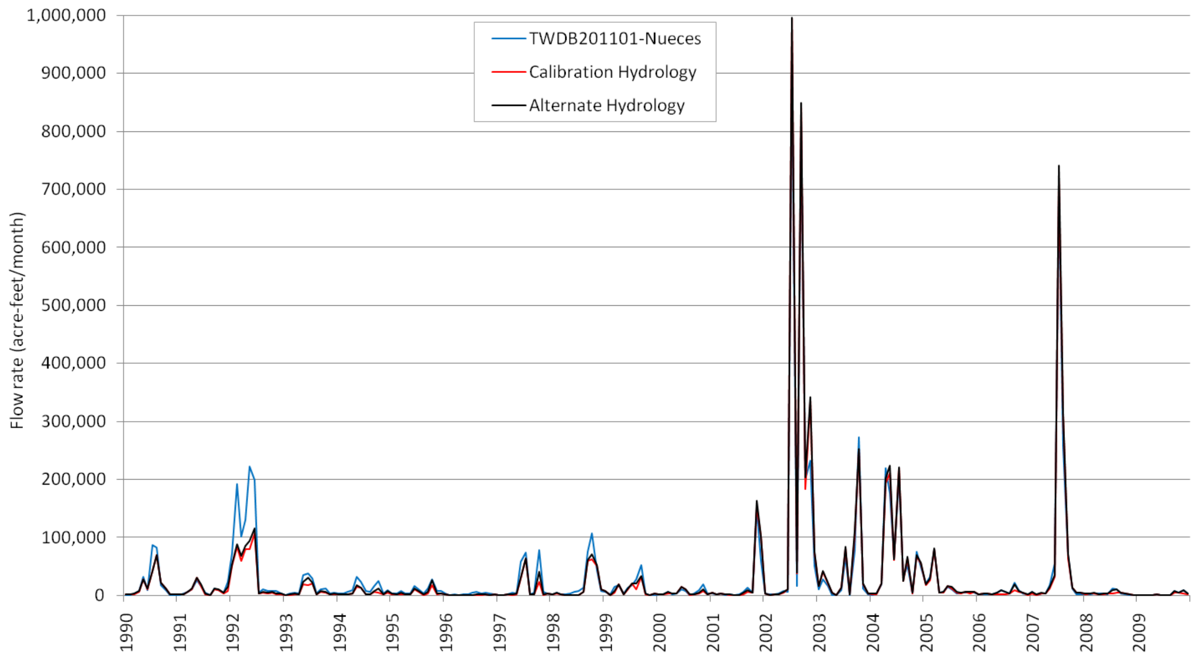


Figure 4. Freshwater inflow (in acre-feet per month) to Nueces Bay as estimated by three hydrology datasets: *TWDB201101-Nueces Bay Hydrology* (*blue*), *TxBLEND Calibration Hydrology* (*red*), and *TxBLEND Alternate Hydrology* (*black*), for the period 1987 – 2009.

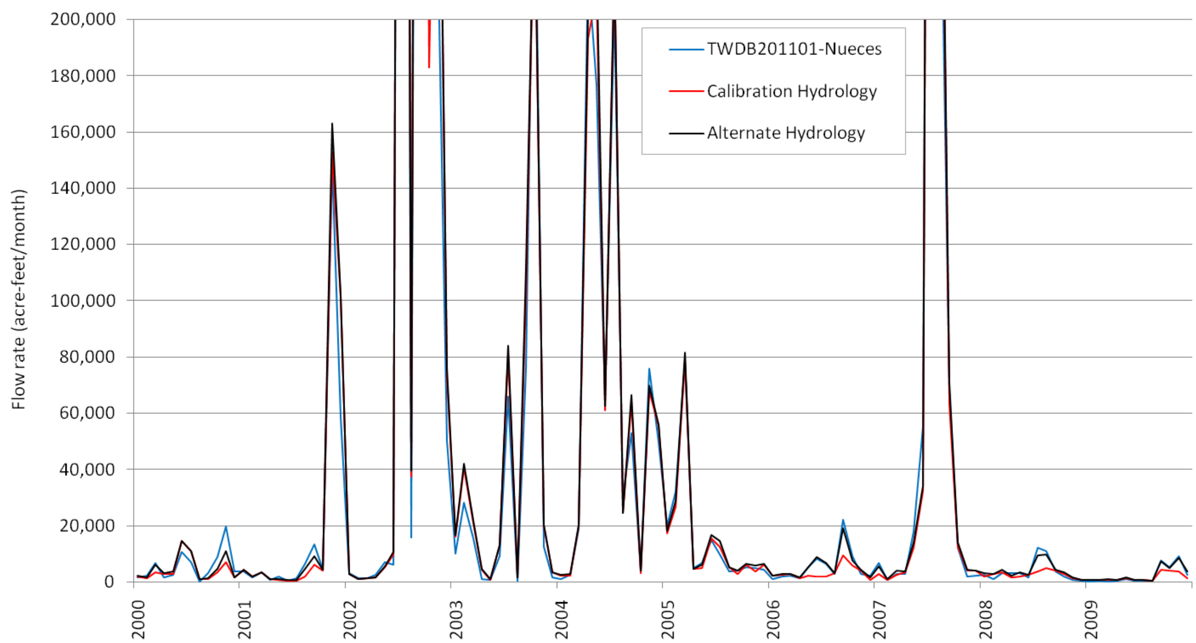


Figure 5. Freshwater inflow to Nueces Bay (in acre-feet per month, up to 200,000 acre-feet) as estimated by three hydrology datasets: *TWDB201101-Nueces Bay Hydrology* (*blue*), *TxBLEND Calibration Hydrology* (*red*), and *TxBLEND Alternate Hydrology* (*black*), for the period 2000 – 2009.

Results

TxBLEND Salinity Results Based on the Alternate Hydrology

TxBLEND daily salinity output at the mid-Nueces Bay site for the period 2000 – 2009 was compared to observed measurements of salinity obtained from the SALT01 station maintained by the Division of Nearshore Research (DNR; http://lighthouse.tamucc.edu/Salinity/HomePage; Figures 6 – 9). For this site under the *Alternate Hydrology*, the difference between mean simulated and observed salinity for the two time periods was less than 2 ppt (Table 3), and the results were similar to those observed under the *Calibration Hydrology*. For both hydrology data sets, r^2 values and Nash-Sutcliffe Efficiency Criterion (E) were high, indicating good model performance in representing salinity conditions during both periods. Additionally, Root Mean Square Error (RMS) for observed versus simulated salinity was similar between the two hydrology datasets, indicating that the model's response to inflows is consistent for both scenarios. *Note*: Because the *Calibration Hydrology* was used to both calibrate (2000 – 2004) and validate (2005 – 2009) the TxBLEND model, salinity results for the *Alternate Hydrology* are presented for the same two time periods to allow for direct comparison of model performance between the two hydrology datasets.

Time-series plots of observed versus simulated salinity at mid-Nueces Bay under the *Alternate Hydrology* (Figures 6 – 9) show that the model captures long-term trends in salinity, generally rising and falling with the patterns observed in measured data. For the 2000 – 2004 simulation period, the model tends to under-predict salinity values more often than over-predicting salinity. For the 2005 – 2009 simulation period, the model tends to over-predict salinity more often but still captures long-term trends in changing salinity. These plots also may be compared to those developed to show observed salinities at the mid-Nueces Bay site versus simulated salinities using the *Calibration Hydrology* (Figures 47 – 48, 59 – 60 in Schoenbaechler *et al*. 2011a). Again, both hydrology datasets yield similar model predictions.

Table 3. Summary statistics for comparisons of simulated to observed daily salinity for the Nueces Bay site for various periods from 2000 - 2009 under two hydrology datasets. The *Calibration Hydrology* dataset was used to calibrate the model for the period 2000 – 2004 and validate the model from 2005 – 2009. (Data and plots are available in Schoenbaechler *et al.* 2011a.) The *Alternate Hydrology* was applied to the calibrated model for the full period, but statistics were calculated separately for each time period to aid in comparing the effect of each hydrology dataset.

Nueces Bay Hydrology Dataset	Period	Days	r^2	RMS (ppt)	NSEC (E)	Average Salinity (ppt)		
						Simulated Salinity	Observed Salinity	Difference (Sim-Obs)
Calibration Hydrology	2000 - 2004	1,413	0.91	3.8	0.90	19.4	20.2	-0.8
	2005 - 2009	1,328	0.84	4.3	0.79	26.8	25.0	1.8
Alternate Hydrology	2000 - 2004	1,413	0.91	3.8	0.89	19.1	20.2	-1.1
	2005 - 2009	1,328	0.84	4.1	0.81	26.3	25.0	1.3

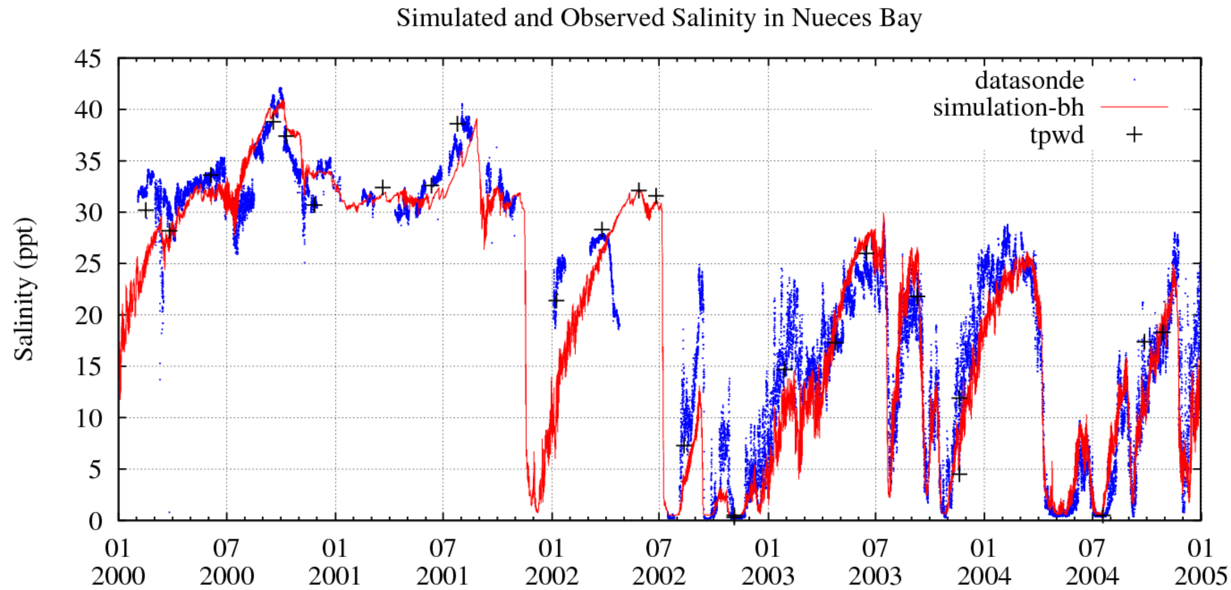


Figure 6. Observed (*blue*) versus simulated (*red*) salinities at the Nueces Bay site in the Nueces Estuary for 2000 – 2004, using the *Alternate Hydrology* dataset. Point measurement data collected by TPWD (+) near this site also was included for comparison.

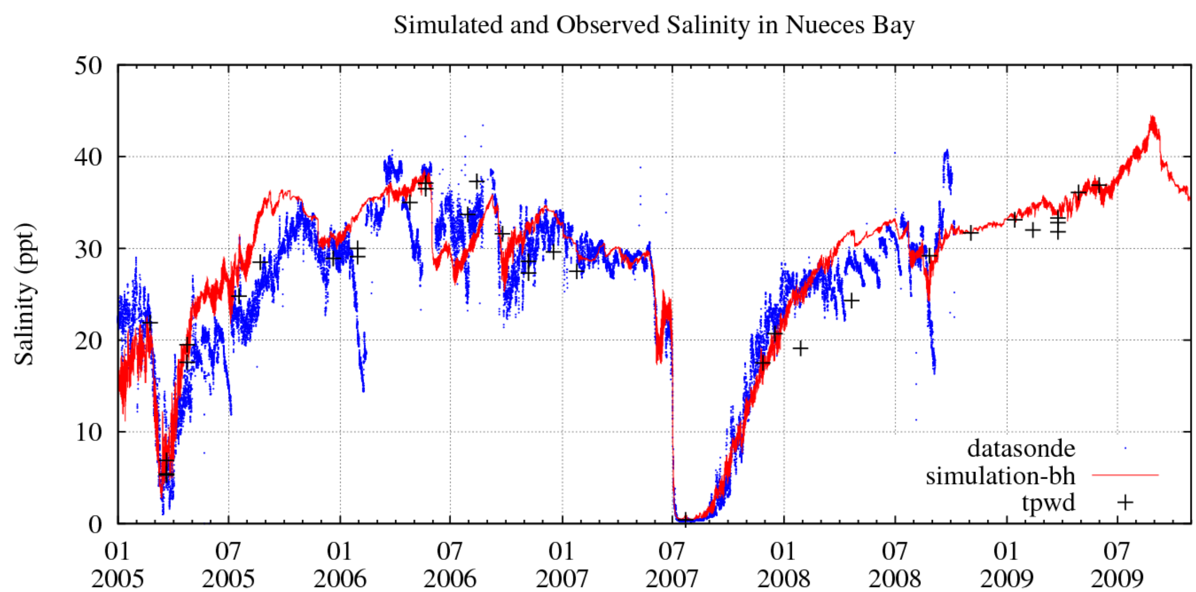


Figure 7. Observed (*blue*) versus simulated (*red*) salinities at the Nueces Bay site in the Nueces Estuary for a period from 2005 – 2009, using the *Alternate Hydrology* dataset. Point measurement data collected by TPWD (+) near this site also was included for comparison.

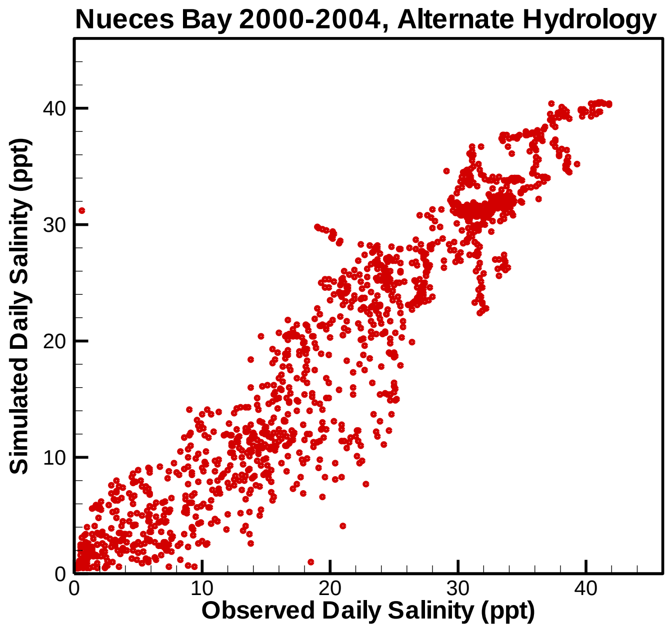


Figure 8. Scatter plot comparing simulated to observed salinities at the Nueces Bay site for the period from 2000 – 2004 ($r^2 = 0.91$).

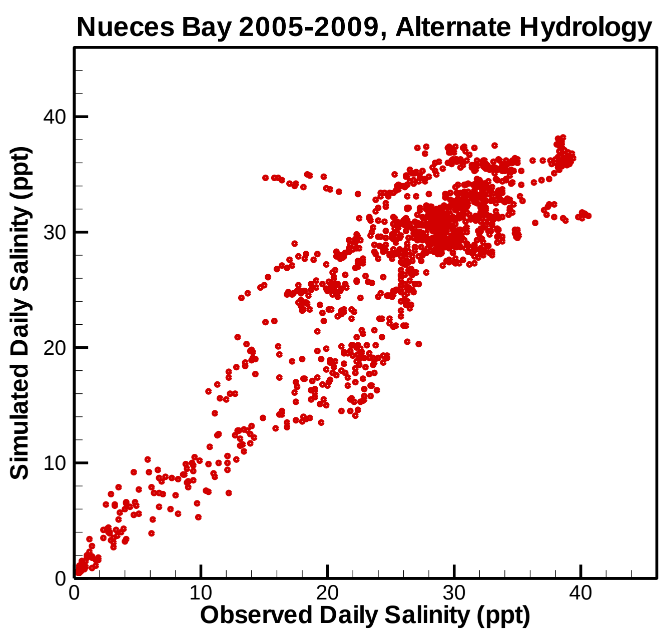


Figure 9. Scatter plot comparing simulated to observed salinities at the Nueces Bay site for the period from 2005 – 2009 ($r^2 = 0.84$).

Comparison of Salinity Simulations for the Calibration Hydrology and Alternate Hydrology

To directly compare each model scenario to one another, Figures 10 and 11 plot the time-series of simulated daily salinity for both hydrology scenarios. From these plots, it is evident that there is little difference in simulated salinities between these two hydrology scenarios. This is due primarily to there being little difference between the two hydrology datasets. In late 2001 (Figure 10), the *Alternate Hydrology* yields higher inflows than the *Calibration Hydrology*, which results in lower simulated salinities than predicted by the *Calibration Hydrology*. This situation occurs again from 2006 to early 2007, in mid-2008, and in late 2009 (Figure 11).

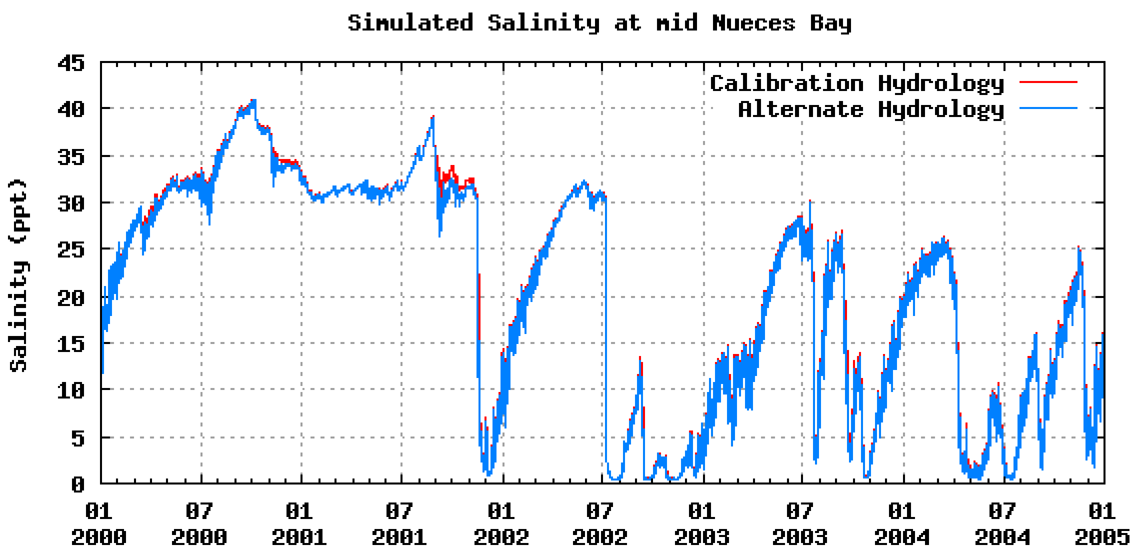


Figure 10. Comparison of simulated salinities between the Calibration Hydrology (red) and Alternate Hydrology (blue) at the mid-Nueces Bay site for 2000 – 2004.

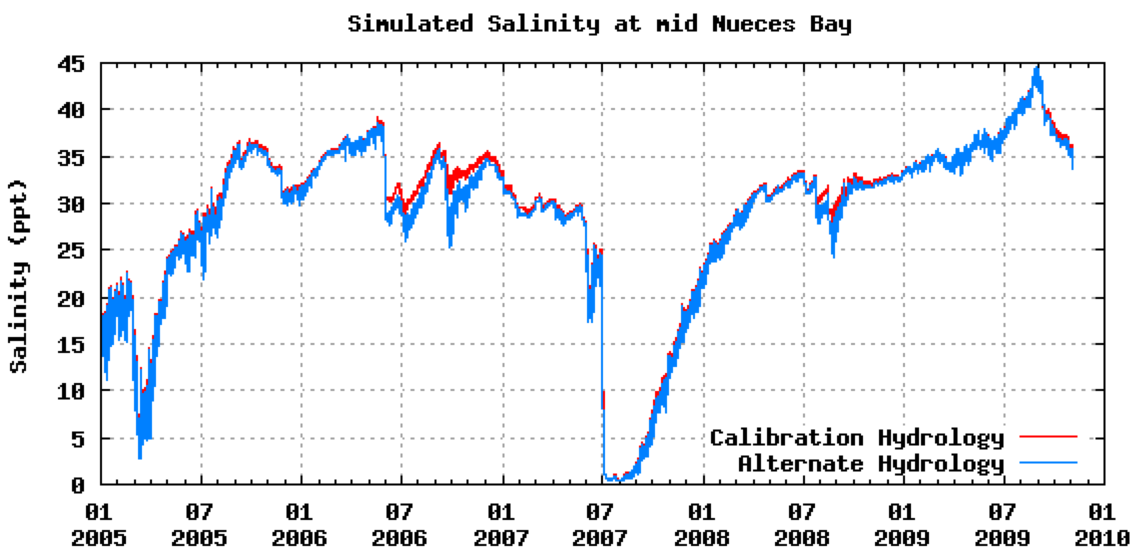


Figure 11. Comparison of simulated salinities between the Calibration Hydrology (red) and Alternate Hydrology (blue) at the mid-Nueces Bay site for 2005 – 2009.

Discussion

This technical memo describes three estimates of total freshwater inflow for Nueces Bay which were developed using a distinct combination of stream gages, watersheds, diversion, and return flow data. Each of these three hydrology versions provide reasonable estimates of flows entering Nueces Bay. For studies which are aimed at evaluating estuarine responses to total inflows to Nueces Bay or for studies where the geographic distribution of inflows is not important, the more appropriate hydrology may be *TWDB201101-Nueces Bay Hydrology* as it represents all inflows entering from the Nueces Basin as well as the surrounding coastal watersheds. For studies where the geographic distribution of inflows is important, such as the TxBLEND hydrodynamic and salinity transport model where only a single inflow point exists by which to input all representative inflows, it then becomes necessary to carefully consider which hydrology best captures the question of interest or it becomes necessary to model more than one scenario. The latter option was demonstrated in this technical memo by comparing an *Alternate Hydrology* to a previously modeled *Calibration Hydrology* (see Schoenbaechler *et al*. 2011a).

For the scenarios presented herein, the *Alternate Hydrology* differed from the *Calibration Hydrology* by an average of 21,165 acre-feet or 17%, with a minimum difference of 1,442 acre-feet in 1996 and a maximum difference of 50,359 acre-feet in 1992. Overall, these differences were not sufficient to dramatically alter the salinity predictions modeled by TxBLEND in Nueces Bay. Although at times, the higher inflows captured by the *Alternate Hydrology*, such as in 2001, 2006, early 2007, mid-2009 and late 2009, were large enough to result in lower salinity predictions by a few parts per thousand, in mid-Nueces Bay as compared to those simulated by the *Calibration Hydrology*.

Literature Cited

Schoenbaechler, C., C.G. Guthrie, J. Matsumoto, Q. Lu, and S. Negusse. 2011a. *TxBLEND Model Calibration and Validation for the Nueces Estuary.* Texas Water Development Board, Austin, Texas. 61pp.

Schoenbaechler, C., C.G. Guthrie, and Q. Lu. 2011b. *Coastal Hydrology for the Nueces Estuary: Hydrology for Version TWDB201101 with Updates to Diversion and Return Data for 2000 - 2009.* Texas Water Development Board, Austin, Texas. 20pp.

Appendix G

Safe Yield Demand vs. Current Demand

Concern was raised by several Nueces BBASC members about how demand on the reservoir system (Choke Canyon Reservoir and Lake Corpus Christi combined) will continue to grow from current levels which will result in less inflows to the bay compared to today's condition. The Corpus Christi Water Supply Model (CCWSM) developed and used by HDR Engineering calculates the full use of the current safe yield of the system at 205,000 acft/yr. Actual annual water use under current demands is around 133,000 acft/yr. Safe yield is defined as the volume of water that can be withdrawn from the system every year of the simulation period such that the water remaining in storage during a repeat of the drought of record results in a minimum storage of 75,000 acft remaining in the system. Actual annual water use under current demands is around 133,000 acft. Note that the average usage over the last 20 years is closer to 120,000 acft, but 2 out of the last 3 have been over 133,000 acft. In the future, as higher demands become reality, the reservoir system will be at lower capacities more often, requiring less water to be passed through to the bay due to lower monthly targets established in the 2001 Agreed Order.

Since the Nueces BBASC is recommending attainment frequencies modeled by the CCWSM that assume full implementation and use of the safe yield demand of the system, the current conditions in the bay could become less ecologically sound due to reduced freshwater inflow going to the bay over time. Table 1 shows the CCWSM safe yield attainment frequencies vs. the current demand attainment frequencies and the percent reduction in freshwater inflows to the bay as the higher demands are realized. All graphs and tables were developed by HDR Engineering and were provided to the BBASC for review.

Table 1. Nueces BBASC recommendations showing current demand percent attainment vs. safe yield demand and the percent reduction of freshwater to the bay as current demand reaches 205,000 acft/yr.

	Target Volume (acft)	BBEST Recommended % Attain	Current Demand D=133K % Attain	Safe Yield Demand D=205K % Attain	Current Demand vs. Safe Yield % Reduction
Winter High Flow	125,000	20	13	11.5	-1.5
Spring High Flow	250,000	25	14	11.5	-2.5
Summer / Fall High Flow	375,000	20	13	12.5	-0.5
Annual High Flow	750,000	25	20	16	-4
Winter Base Flow	22,000	60	30	23	-7
Spring Base Flow	88,000	60	37	29	-8
Summer / Fall Base Flow	56,000	75	45	40	-5
Annual Base Flow	166,000	80	58	47	-11
Winter Subsistence Flow	5,000	95	88	68	-20
Spring Subsistence Flow	10,000	95	95	88	-7
Summer / Fall Subsistence Flow	15,000	95	90	74	-16
Annual Subsistence Flow	30,000	95	99	94	-5

To illustrate the derivation of the attainment frequencies look at Figure 1, which is a graph of annual attainment frequencies for high, base, and subsistence flows. The graph contains two series of ranked bars, which correspond to the bay inflow for that year under either the safe yield (205,000 acft demand) or the current demand (133,000 acft). The graphs also have colored lines that represent the BBEST target volumes for high, base and subsistence.

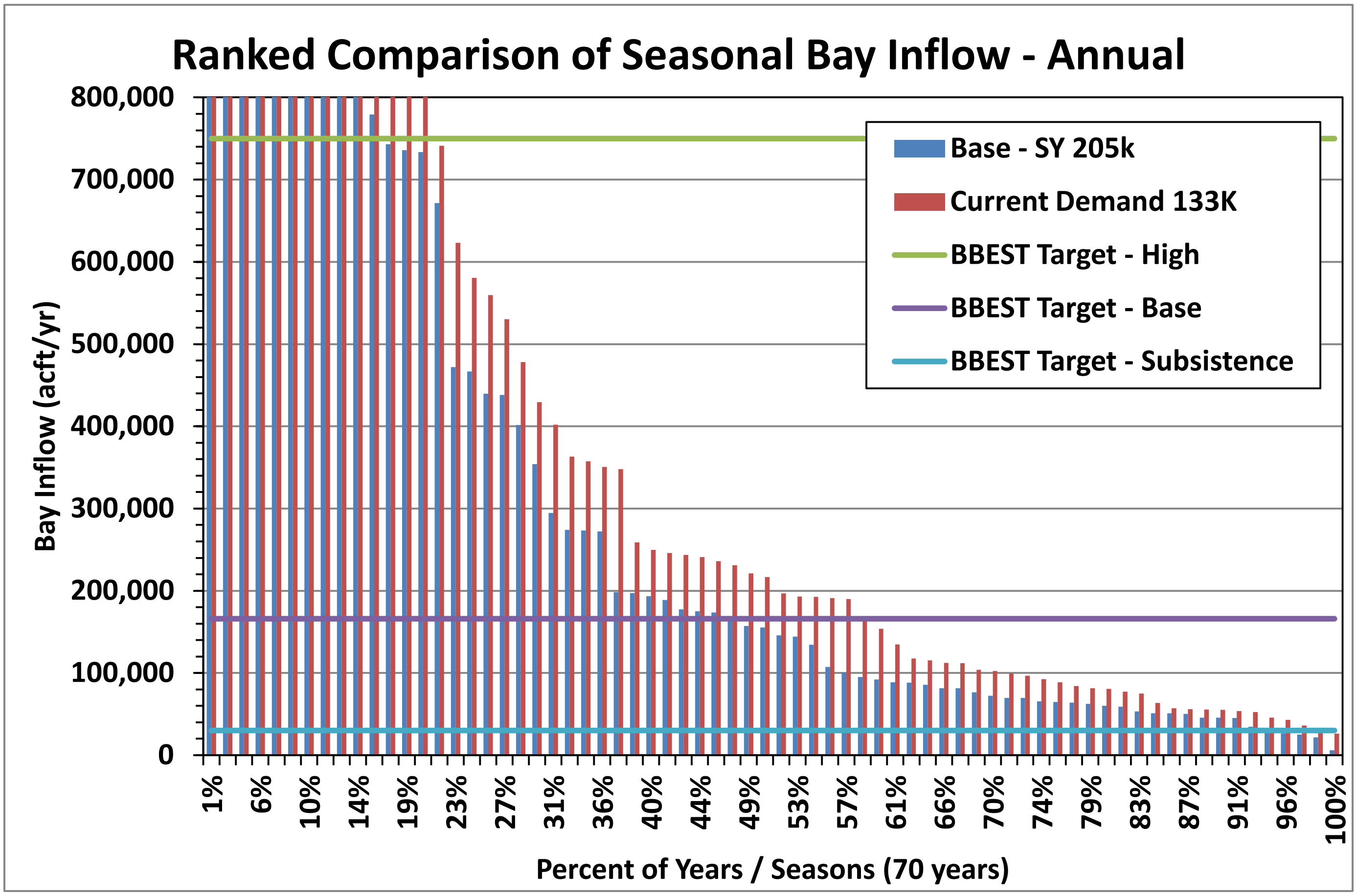


Figure 1. Graph of annual attainment frequencies for high, base, and subsistence flows under current demand vs. full utilization (Base – SY 205K). SY = Safe Yield.

As an example, in the purple line (BBEST Base volume target) on Figure 1, there are 7 more red bars than blue bars that go above the purple line. This illustrates the ~11% difference between the current use and the Safe yield scenario. From this comparison one can see that 7 of those years show higher bay inflow for the current use scenario than the safe yield scenario. This doesn't illustrate how these years occurred (i.e. was it during a wet period or a dry period) but it does show how the attainment frequencies are derived. Each year that is not met is about a 1.5% change in the attainment frequency, so a 7 year difference is about an 11% change in frequency of attainment.

It is recommended that this issue be investigated further through the adaptive management process already in place with the Nueces Estuary Advisory Council to provide for opportunities for the Nueces BBASC's goals of protecting safe yield of the system while also improving conditions in Nueces Bay and Delta are achieved. The concern is that the Nueces Bay and Delta is in an unsound condition with the current level of demand, so additional reductions to bay inflows could result in a less sound ecological environment in the future.

<u>Seasonal Attainment Frequencies</u>

To help illustrate even further, Figures 2, 3, and 4 were created to show seasonal attainment frequencies for high, base, and subsistence flows for winter, spring, and summer/fall.

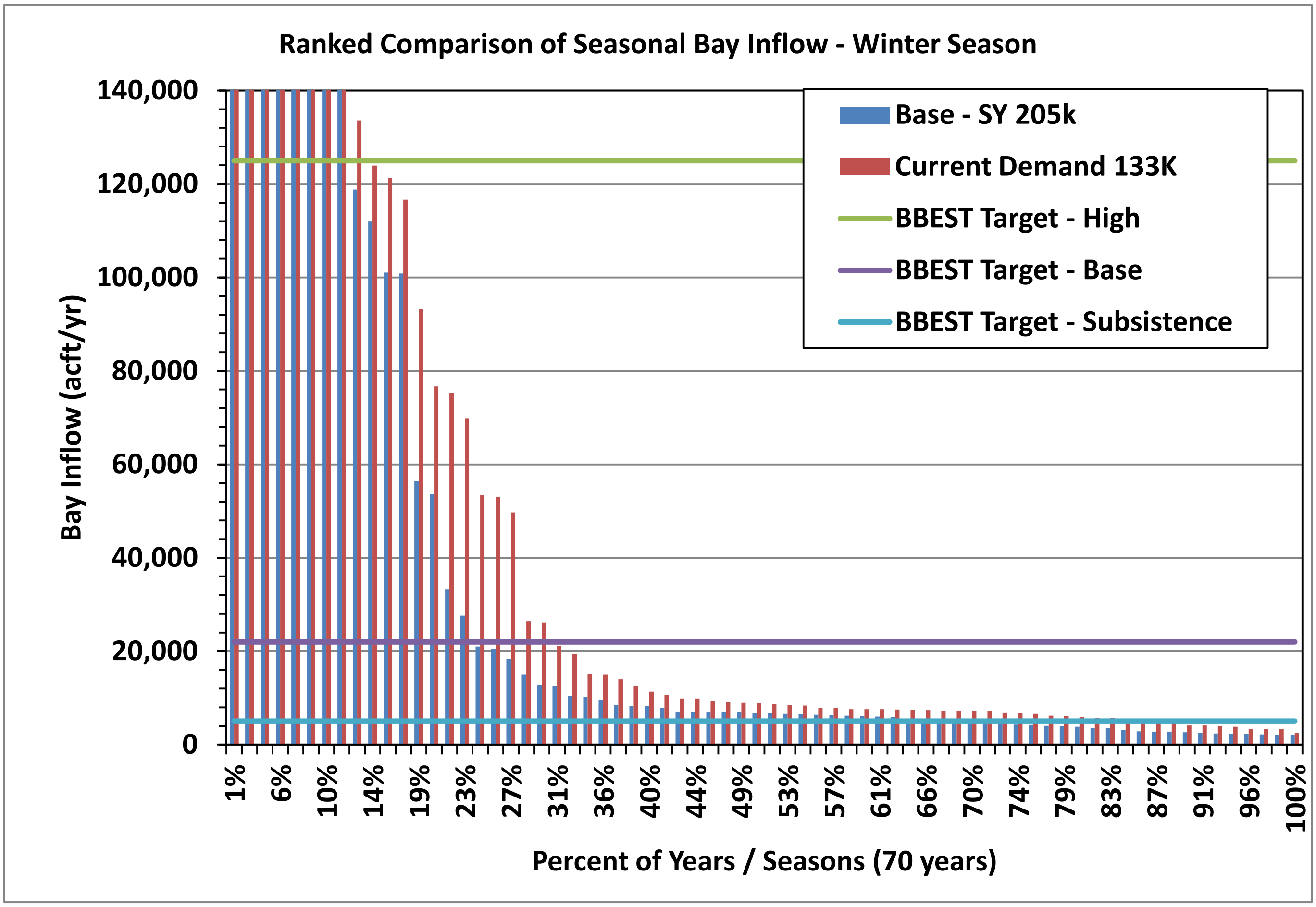


Figure 2. Graph of winter season attainment frequencies for high, base, and subsistence flows under current demand vs. full utilization (Base – SY 205K). SY = Safe Yield.

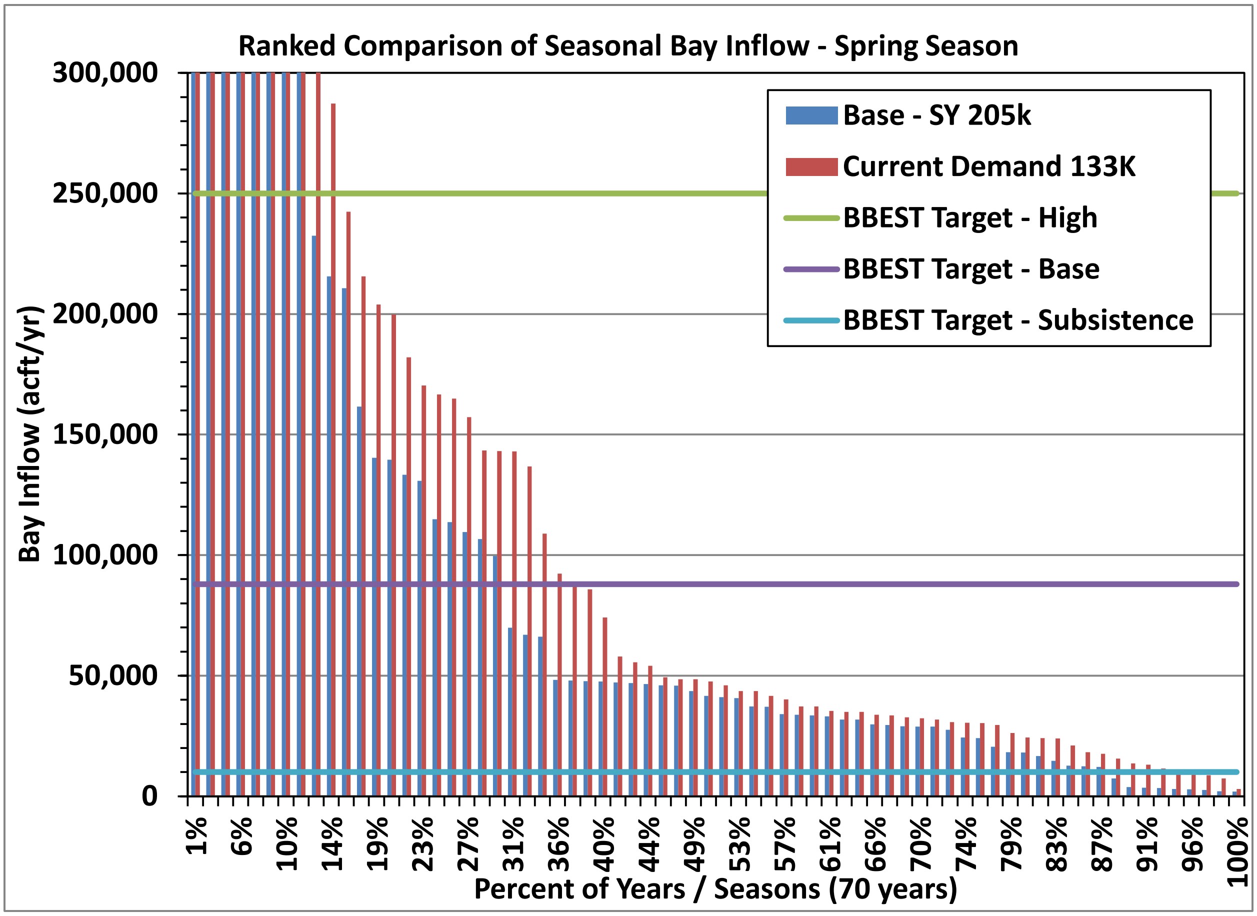


Figure 3. Graph of spring season attainment frequencies for high, base, and subsistence flows under current demand vs. full utilization (Base – SY 205K). SY = Safe Yield.

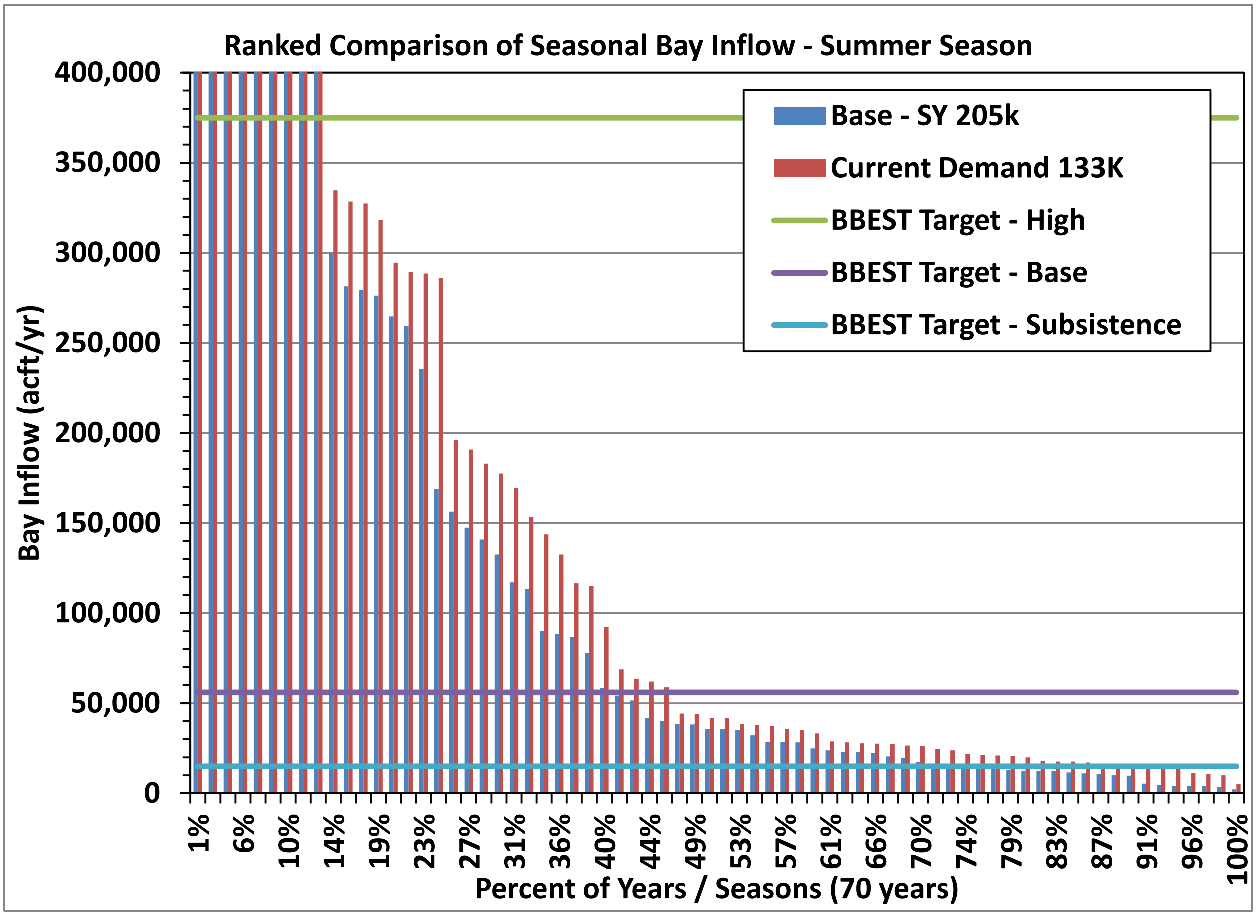
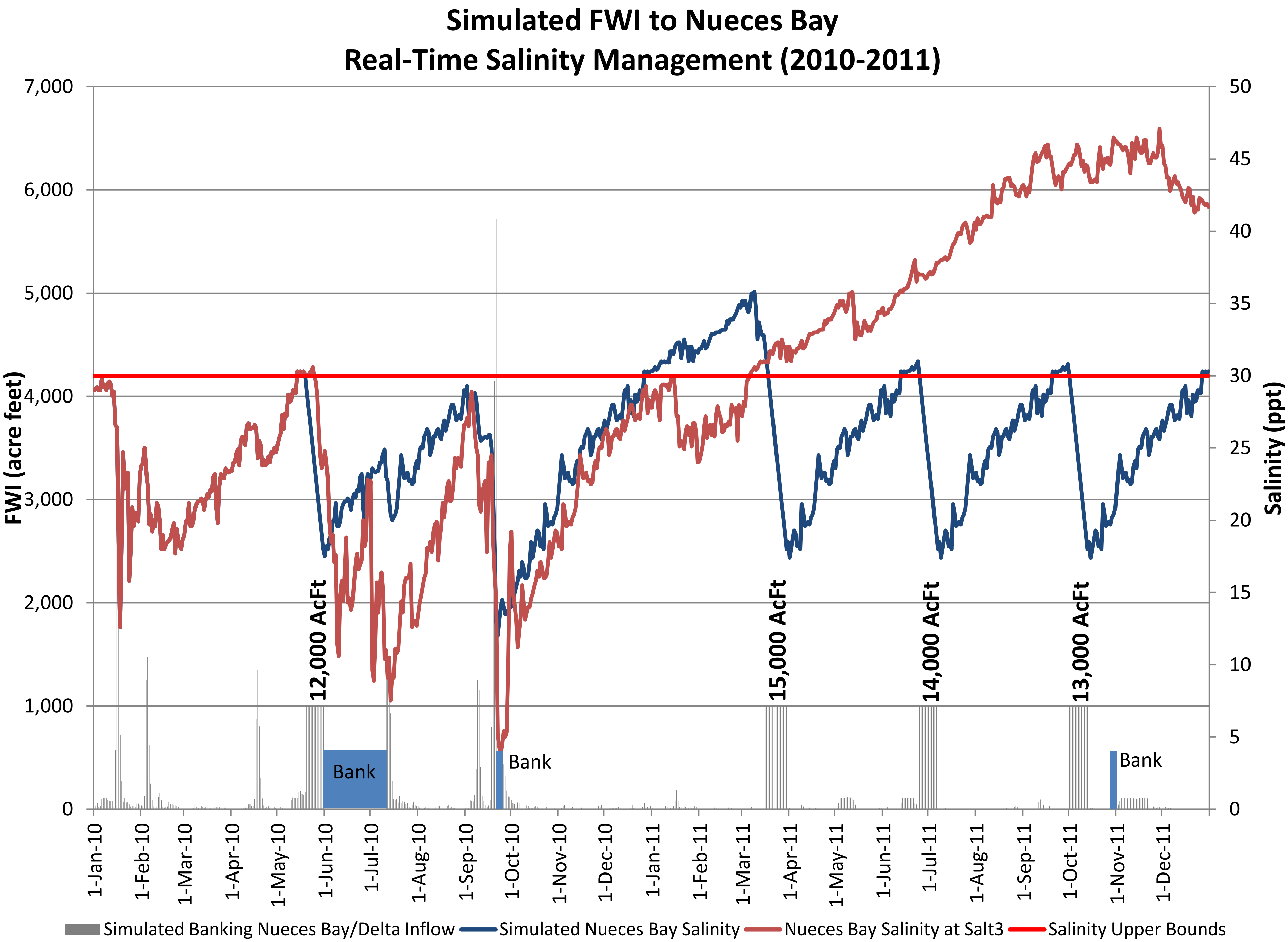
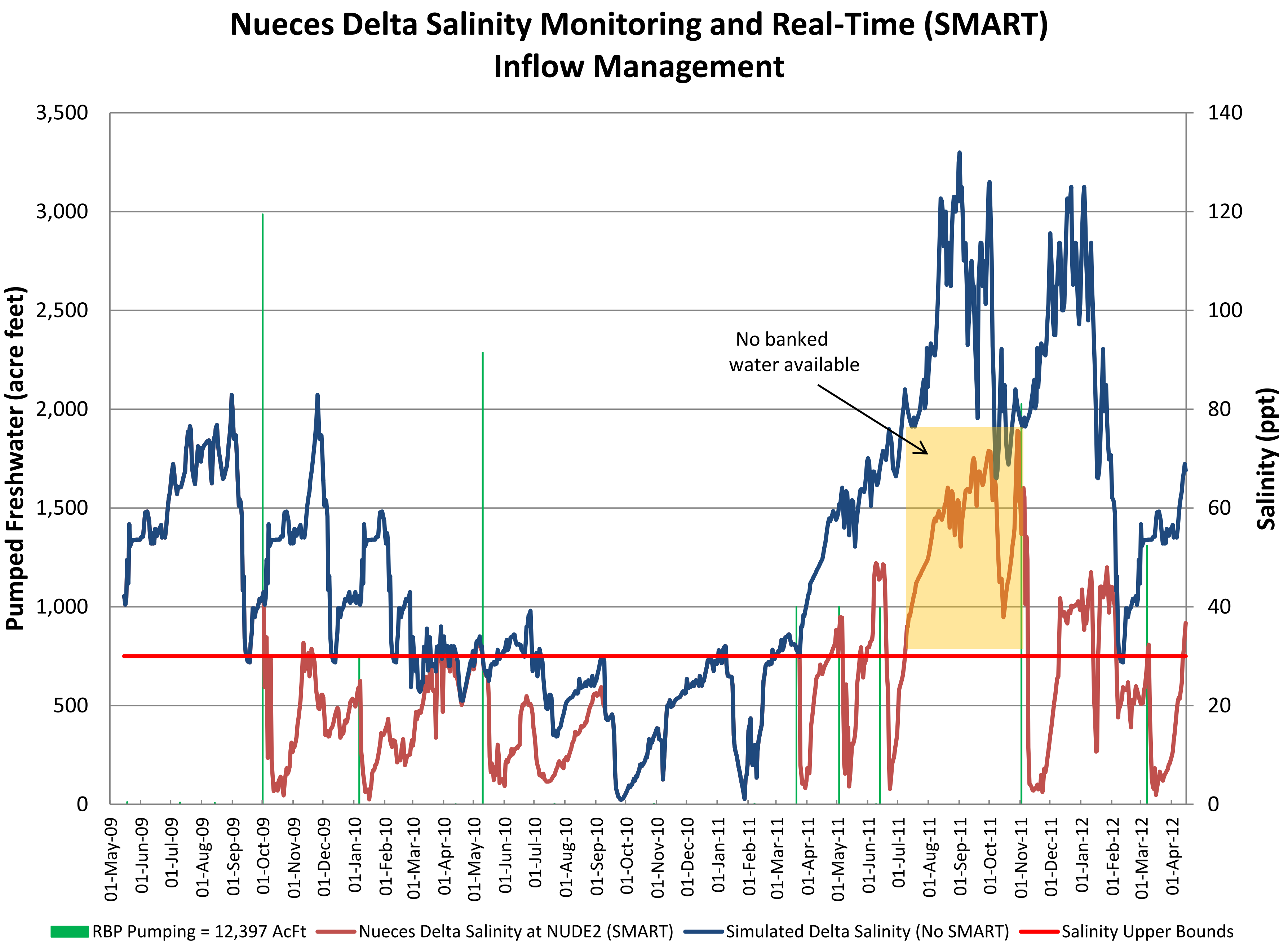


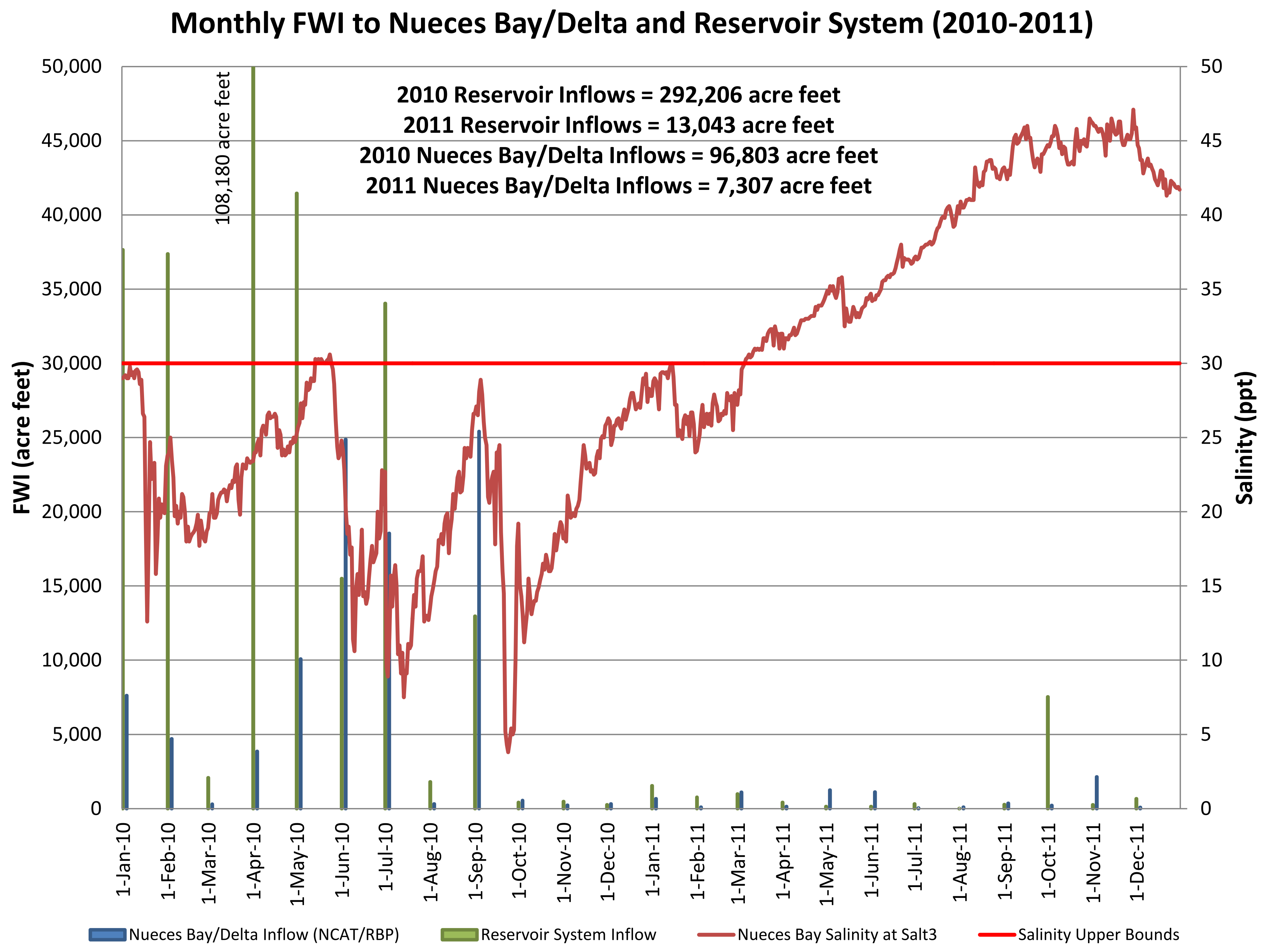
Figure 4. Graph of summer/fall season attainment frequencies for high, base, and subsistence flows under current demand vs. full utilization (Base – SY 205K). SY = Safe Yield.



Simulated FWI to Nueces Bay
Real-Time Salinity Management (2010-2011)
FWI (acre feet)
Salinity (ppt)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
50
45
40
35
30
25
20
15
10
5
0
12,000 AcFt
15,000 AcFt
14,000 AcFt
13,000 AcFt
Bank
Bank
Bank
1-Jan-10
1-Feb-10
1-Mar-10
1-Apr-10
1-May-10
1-Jun-10
1-Jul-10
1-Aug-10
1-Sep-10
1-Oct-10
1-Nov-10
1-Dec-10
1-Jan-11
1-Feb-11
1-Mar-11
1-Apr-11
1-May-11
1-Jun-11
1-Jul-11
1-Aug-11
1-Sep-11
1-Oct-11
1-Nov-11
1-Dec-11
Simulated Banking Nueces Bay/Delta Inflow
Simulated Nueces Bay Salinity
Nueces Bay Salinity at Salt3
Salinity Upper Bounds



Nueces Delta Salinity Monitoring and Real-Time (SMART) Inflow Management
Pumped Freshwater (acre feet)
Salinity (ppt)
3,500
3,000
2,500
2,000
1,500
1,000
500
0
140
120
100
80
60
40
20
0
No banked water available
01-May-09
01-Jun-09
01-Jul-09
01-Aug-09
01-Sep-09
01-Oct-09
01-Nov-09
01-Dec-09
01-Jan-10
01-Feb-10
01-Mar-10
01-Apr-10
01-May-10
01-Jun-10
01-Jul-10
01-Aug-10
01-Sep-10
01-Oct-10
01-Nov-10
01-Dec-10
01-Jan-11
01-Feb-11
01-Mar-11
01-Apr-11
01-May-11
01-Jun-11
01-Jul-11
01-Aug-11
01-Sep-11
01-Oct-11
01-Nov-11
01-Dec-11
01-Jan-12
01-Feb-12
01-Mar-12
01-Apr-12
RBP Pumping = 12,397 AcFt
Nueces Delta Salinity at NUDE2 (SMART)
Simulated Delta Salinity (No SMART)
Salinity Upper Bounds



Monthly FWI to Nueces Bay/Delta and Reservoir System (2010-2011)
2010 Reservoir Inflows = 292,206 acre feet
2011 Reservoir Inflows = 13,043 acre feet
2010 Nueces Bay/Delta Inflows = 96,803 acre feet
2011 Nueces Bay/Delta Inflows = 7,307 acre feet
108,180 acre feet
FWI (acre feet)
Salinity (ppt)
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
50
45
40
35
30
25
20
15
10
5
0
1-Jan-10
1-Feb-10
1-Mar-10
1-Apr-10
1-May-10
1-Jun-10
1-Jul-10
1-Aug-10
1-Sep-10
1-Oct-10
1-Nov-10
1-Dec-10
1-Jan-11
1-Feb-11
1-Mar-11
1-Apr-11
1-May-11
1-Jun-11
1-Jul-11
1-Aug-11
1-Sep-11
1-Oct-11
1-Nov-11
1-Dec-11
Nueces Bay/Delta Inflow (NCAT/RBP)
Reservoir System Inflow
Nueces Bay Salinity at Salt3
Salinity Upper Bounds

2010	Reservoir System Inflows	NRMT Flow	M&I Diversion	LCC to Estuary	WSBLCC to Estu	NCAT/RBP Flow
Jan	37,649 AcFt	6,219 AcFt	4,296 AcFt	1,923 AcFt	5,703 AcFt	7,626 AcFt
Feb	37,374	3,613	3,641	-	4,698	4,698
Mar	2,083	4,141	4,730	-	300	300
Apr	108,180	4,532	4,856	-	3,856	3,856
May	41,458	18,546	5,894	12,652	0	10,139
Jun	15,500	31,405	7,558	23,847	1,019	24,866
Jul	34,043	14,607	4,472	10,135	8,413	18,548
Aug	1,805	6,189	6,216	-	312	312
Sep	12,969	10,983	4,231	6,752	18,660	25,412
Oct	414	4,536	4,690	-	551	551
Nov	480	4,242	4,811	-	230	230
Dec	251	3,736	4,638	-	309	309
Totals	**292,206**	**112,749**	**60,033**	**55,309**	**44,051**	**96,847**

TEXAS PARKS & WILDLIFE

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January 24, 2012

The Honorable Troy Fraser, Co-Chair
Environmental Flows Advisory Group
Texas Senate
P.O. Box 12068 - Capitol Station
Austin, TX 78711

The Honorable Allan Ritter, Co-Chair
Environmental Flows Advisory Group
Texas House of Representatives
P.O. Box 2910
Austin, TX 78768-2910

Re: Texas Parks and Wildlife Department Staff Perspectives on Nueces River and Corpus Christi Bay and Baffin Bay Expert Science Team Report and Recommendations Report

Dear Chairman Fraser and Chairman Ritter:

As you know, the Basin and Bay Area Expert Science Teams (BBEST) for the Nueces River and Corpus Christi Bay and Baffin Bay Expert Science Team recently submitted their environmental flow regime recommendation report. The Texas Environmental Flows Science Advisory Committee (SAC) has reviewed the BBEST report with the intent to provide comments to assist the Environmental Flows Advisory Group as it considers the regime recommendations.

As the agency charged with the responsibility to protect the state's fish and wildlife resources, Texas Parks and Wildlife Department (TPWD) is in a unique position to have data and scientific expertise to support the challenges of determining the environmental needs of Texas rivers, streams, estuaries, and bays. TPWD has been involved in the development of technical guidance documents and tools for the SAC and has provided assistance to the BBESTs in crafting environmental flow regime recommendations. Based on staff expertise, involvement, and commitment to the success of SB 3 efforts, TPWD reviewed and compiled comments on the BBEST report.

I have attached the comments and respectfully request that you consider them. These comments are intended to assist the Environmental Flows Advisory Group, the Texas Commission on Environmental Quality, and the Basin and Bay Area Stakeholders Committees for the Nueces River and Corpus Christi Bay and Baffin Bay Expert Science Team Recommendation Report.

I look forward to continuing to work with you and others as we strive to ensure that the needs of the state's fish and wildlife resources are considered and addressed across the state. Thank you for your consideration of this matter. Should you have any questions, please contact Cindy Loeffler at 512-389-8715.

Sincerely,

Karen J. Hixon
Member

KJH:CL:ch

Attachments

cc: EFAG Members
SAC Members
Nueces River and Corpus Christi Bay and Baffin Bay Expert Science Team and Stakeholder Committee members
Mr. Todd Chenoweth, TCEQ
Mr. Cory Horan, TCEQ
Dr. Ruben Solis, TWDB

4200 SMITH SCHOOL ROAD
AUSTIN, TEXAS 78744-3291
512.389.4800
www.tpwd.state.tx.us

To: Commissioner Karen J. Hixon
Executive Director Carter Smith
Deputy Executive Director Ross Melinchuk

24JAN12

From: John Botros, Inland Fisheries Division
David Bradsby, Water Resources Branch
Lynne Hamlin, Water Resources Branch
Cindy Loeffler, Water Resources Branch
Kevin Mayes, Inland Fisheries Division
Clint Robertson, Inland Fisheries Division
James Tolan, Coastal Fisheries Division

Re: Texas Parks and Wildlife Department Staff Perspectives on the Nueces River and Corpus Christi Bay and Baffin Bay Expert Science Team Report and Recommendations

As you know, a statewide process for identifying and protecting environmental flows for Texas Rivers and bay systems was passed in 2007 and is currently underway throughout most of the state. Senate Bill 3 (SB 3), Article 1 of the 70th Texas Legislature, outlines a collaborative process involving regional stakeholders and expert scientists with an interest in the water resources of the basin. One of the first steps in the SB 3 process was the appointment of a Nueces River and Corpus Christi Bay and Baffin Bay Expert Science Team (Nueces BBEST) who were tasked with developing science-based environmental flows recommendations for the basin and bay system by October 2011. The Nueces BBEST fulfilled their task and this memorandum summarizes TPWD staff comments on the report. SB 3 directed each BBEST to develop an environmental flow regime recommendation:

> *...through a collaborative process designed to achieve a consensus. In developing the analyses and recommendations, the science team must consider all reasonably available science, without regard to the need for the water for other uses, and the science team's recommendations must be based solely on the best science available.*

The Nueces BBEST engaged resource agency staff and others throughout the process. Texas Parks and Wildlife Department (TPWD) assisted and supported the BBEST by providing data, maps, and information related to riparian habitats; assisting the BBEST contractor with the cross-sectional data collection for fish habitat-flow modeling; developing distributional lists of fish species and habitat suitability criteria; enhancing and improving the Hydrology-based Environmental Flow Regime (HEFR) methodology; refining and improving the Flow Regime Application Tool (FRAT); and assisting with meeting logistics. The BBEST fostered participation by TPWD and others that resulted in the use of best available science to generate environmental flow regime recommendations that TPWD generally supports.

Having worked on numerous instream flow and freshwater inflow recommendations over many years, TPWD is familiar with the uncertainty embedded in such efforts, cognizant of the challenges faced by the BBEST, appreciative of the efforts expended by the members and grateful for the many opportunities to provide input throughout the process. The BBEST had approximately twelve months and a limited budget for outside services to meet the SB 3 charge.

The difficulty of the challenge cannot be overstated and the progress of the BBEST is commendable. The Nueces BBEST clearly learned and benefitted from the experiences of previous BBESTs and extended the state of the science in several respects. Furthermore, the Nueces BBEST had the additional advantage of extensive monitoring data collected in the Nueces River delta and bay. That said, it is widely recognized that the science of environmental flows is not an exact one, and the Nueces BBEST did not have the time, data, directive, or budget to perform a definitive analysis.

This memorandum contains general comments regarding the Nueces BBEST report and the SB 3 charge to develop an environmental flow regime for the Nueces River, Corpus Christi Bays, and Baffin Bay. These comments are intended to assist the Environmental Flows Advisory Group, the Texas Commission on Environmental Quality, and the Nueces Basin and Bay Area Stakeholder Committee (Nueces BBASC) in reviewing the BBEST recommendations.

General Comments

TPWD commends the Nueces BBEST for its diligence and determination to address the requirements set forth by SB 3. In general, the BBEST followed guidance provided by the Texas Environmental Flows Science Advisory Committee (SAC) and addressed the requirements set forth by SB 3. The BBEST utilized a report format similar to previous BBEST reports and consists of seven sections including recommendations for future work to be conducted within the context of an adaptive management work plan. No comments are submitted at this time regarding the work plan recommendations.

Preamble and Overview

This section contains a thorough explanation of the SB 3 process and the BBEST charge. TPWD appreciates the efforts of the BBEST in Section 1.3 to define a sound ecological environment and generally concurs with the BBEST's assessment.

Instream Flow Analyses

TPWD supports the Nueces BBEST instream environmental flow recommendations. The Nueces BBEST followed guidance provided by the SAC as well as the general flow regime framework utilized by previous BBESTs (i.e., Guadalupe-San Antonio and Colorado-Lavaca) in developing the instream flow recommendations. The Nueces BBEST relied on information and data on historic flows, instream biology, water quality, sediment transport, and riparian zone biology in an attempt to identify relationships between flow and aquatic ecology. After thorough analysis and deliberation, consensus instream flow recommendations were adopted by the Nueces BBEST.

TPWD commends the Nueces BBEST for addressing the flow needs of intermittent streams and agrees with the BBEST that these types of streams are important ecological features that warrant consideration and streamflow protection. The Nueces BBEST approached this in two ways: 1) a 1 cfs floor was established as the low-flow recommendation at all intermittent sites, and 2) by recommending smaller magnitude, seasonal pulses at some intermittent sites. TPWD supports this approach for protecting flow at intermittent sites for the following reasons. Although the 1 cfs subsistence flow recommendation at locations of prolonged very low or no flow periods may seem high and somewhat arbitrary, TPWD believes the recommendation is important for protecting the lowest flows at these sites, allowing these areas to dry at more natural rates thereby maintaining frequencies of occurrence and duration of extreme low flow events from being exacerbated by new water development. Further, the BBEST recognized the importance and need of smaller seasonal pulses which may occur during prolonged dry periods to refill pools that provide critical refugia, reconnect isolated aquatic habitats, and allow animals to redistribute among stream habitats.

For the base flow recommendations, the Nueces BBEST worked heavily with habitat-flow modeling based on limited physical and hydraulic data collected by the state agencies. Although extensive effort was devoted by the BBEST on developing fish habitat-flow relationships, the BBEST ultimately used this work as a verification of the base flow values generated using HEFR. Due to the uncertainties involved in the analysis, the short timeframe the process provided to develop the flow-habitat relationships, and the low-flow conditions at the time the data was collected, it is TPWD opinion that the BBEST made an appropriate decision to use the modeled results to verify the default values in this case. TPWD supports the BBEST's recommended base flows with the caveat that the flow-habitat relationships developed through the SB3 process should be further evaluated at different flow levels as part of future workplan activities developed by the BBASC in conjunction with the BBEST.

TPWD supports the high flow pulse (HFP) recommendations of the BBEST. Five to eight levels of pulse flow events were recommended by the Nueces BBEST depending on the site. The five levels of pulse flow events were categorized as seasonal or annual frequency events as derived using HEFR. The BBEST also manually added lower magnitude pulse tiers at the intermittent sites in order to address the flashy intermittent hydrology observed at these sites. The adopted criteria describe the qualifications for meeting a high pulse flow event and the criteria for allowing higher-level pulse flow events to satisfy the yet unmet annual or seasonal pulse flow events that exist at lower pulse flow or overbank levels. The approach employed by the team to address the HFP calculations for such a varied geographic and hydrographic area is innovative and should be sufficient to provide the ecological functions of HFPs in areas with such wide-ranging (fluctuating) hydrology.

The Texas Water Development Board, on the behalf of Nueces BBEST, evaluated the relationship between flow and sediment transport at three locations: the Nueces River at Laguna, the Nueces River at Cotulla, and the Nueces River at Three Rivers. The analyses focused on sediment transport under various scenarios (water development projects) with the environmental flow regimes implemented. The BBEST concluded that seasonal pulses alone do not provide enough energy to move adequate amounts of sediment and that larger high flow pulses are required to maintain sediment movement in the basin. TPWD encourages the BBEST to work with the Nueces BBASC to understand the importance of this issue and assist the BBASC in determining appropriate high flow pulse recommendations for the stakeholder report. Further evaluation of high flow pulses is a topic that could also be addressed in the Nueces BBASC work plan.

Freshwater Inflow Analyses

Similarly, TPWD supports the Nueces BBEST bay and estuary environmental flow recommendations. The Nueces BBEST evaluated and, when appropriate, employed guidance provided by the SAC as well as the general flow regime framework utilized by previous BBESTs. The BBEST should be commended for their effort since the vast majority of contributions to this section were from the original research and analyses of the BBEST scientists specifically for the BBEST. The Nueces BBEST utilized available information on historic flows, the impact of water supply infrastructure, estuarine biology, sediment transport, water quality, and riparian zone marsh vegetation in their evaluation of relationships between flow and aquatic ecology. After thorough analysis and deliberation, consensus bay and estuary environmental flow recommendations were adopted by the Nueces BBEST.

Integration of Instream Flow and Estuary Inflow Regimes

TPWD understands the difficulty of integrating instream flow and estuary flow regimes on rivers with existing water supply infrastructure and in all likelihood the BBEST did not have enough time to examine this topic thoroughly and within the framework of a presently regulated system. TPWD staff agrees with the BBEST's justification for not comparing the instream and estuary inflow regimes, and further suggest that work on this topic should continue as part of future workplan activities developed by the BBASC in conjunction with the BBEST.

Concluding Comments

Overall, the Nueces BBEST members met their charge and provided a suite of environmental flow recommendations adequate to support a sound ecological environment. TPWD plans to remain involved with the important work of SB 3 and is looking forward to providing technical assistance and guidance to the expert science team and stakeholders when requested. Since the work of the BBEST does not end with the publication of a BBEST report, TPWD staff is also looking forward to assisting the BBEST and the BBASC with the development of a focused and prioritized Adaptive Management Work Plan that is intended to address knowledge gaps and issues raised in the BBEST report.

Thank you for the opportunity to share these comments with you.

Corpus Christi Water Supply Model Updates for Evaluation of BBEST Recommendation

Presentation to Nueces BBASC

Cory Shockley, PE – HDR Engineering

January 25, 2012

Discussion

- Agreed Order vs. BBEST Recommendation
- Attainment Frequencies – Agreed Order
- CCWSM (a.k.a NUBAY) Model Updates
- Theoretical Safe Yield – BBEST Recommendation
- Attainment Frequencies – BBEST Recommendation

Agreed Order Compared to BBEST Recommendation

2001 TCEQ Agreed Order

- Operational
- Monthly
- 4 Defined Storage Zones
- Based on System Storage
- Below 30% - No Passes
- Salinity & “Spill Banking” Relief

BBEST Recommendation

- Long-Term Simulation
- Seasonal
- 3 Hydrologic Conditions
- No Relation to System Storage
- Passes in all Zones
- No Relief Provisions

Order Compared to BBEST

2001 TCEQ Agreed Order

Sys Stor. %	Jan (acft)	Feb (acft)	Mar (acft)	Apr (acft)	May (acft)	Jun (acft)	Jul (acft)	Aug (acft)	Sep (acft)	Oct (acft)	Nov (acft)	Dec (acft)	Ann. (acft)
>70	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500	138,000
70-40	2,500	2,500	3,500	3,500	23,500	23,000	4,500	5,000	11,500	9,000	4,000	4,500	97,000
40-30	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	14,400
<30	0	0	0	0	0	0	0	0	0	0	0	0	0

2011 BBEST Recommendation

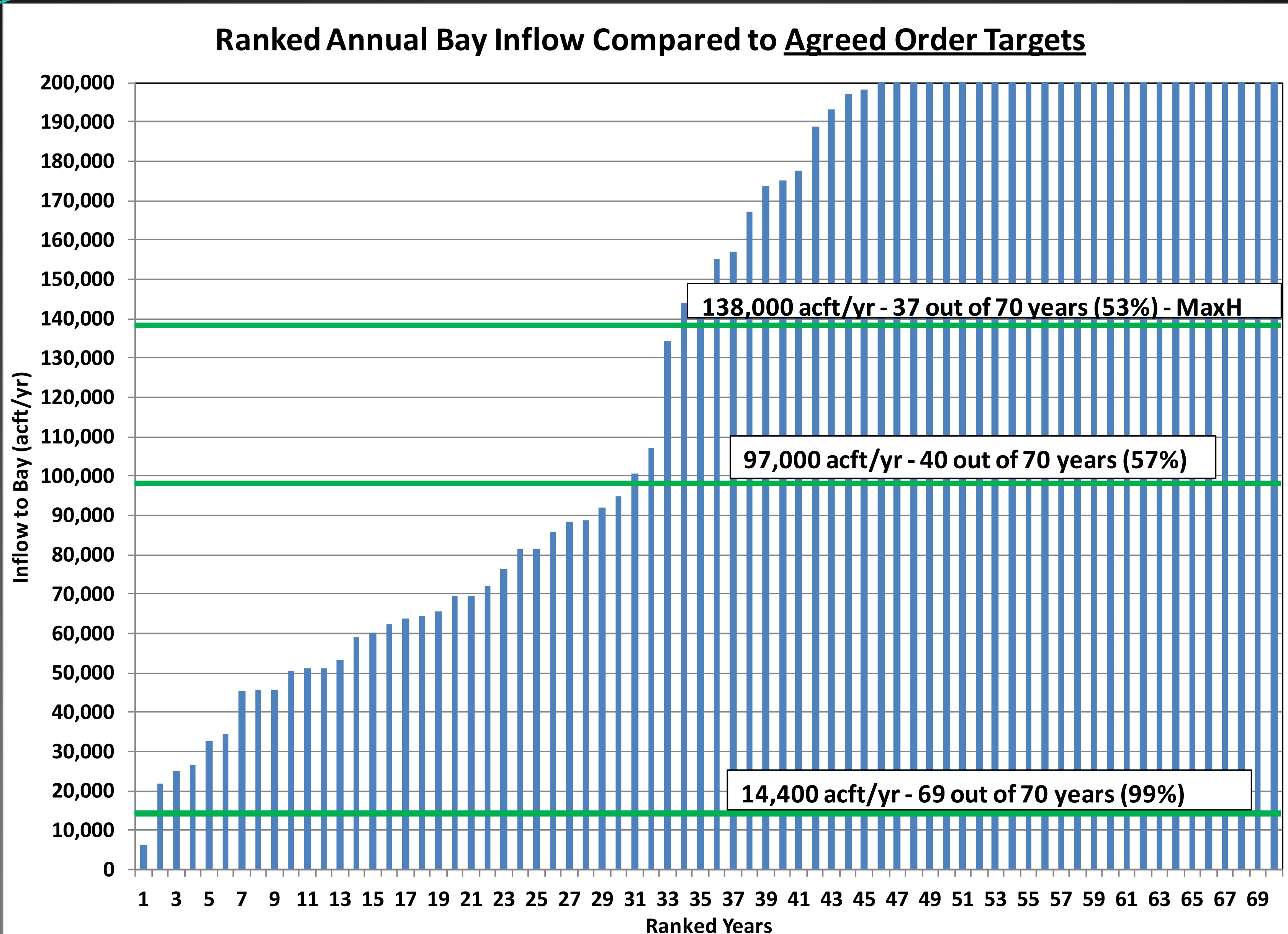
Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations	
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)	Attainment
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000	25%
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000	80%
Subsistence (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000	95%
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct		

Existing Order - Attainment

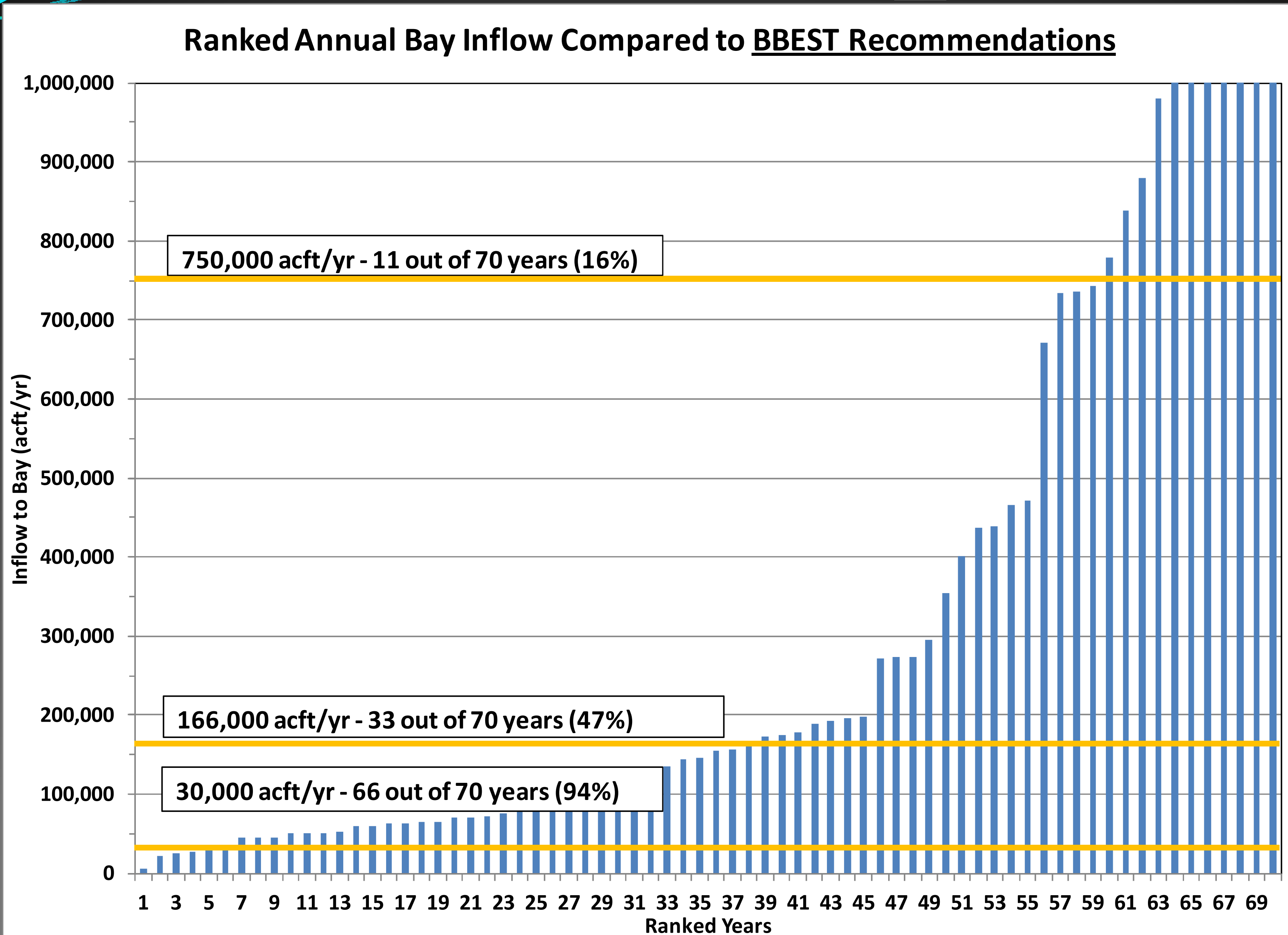
- Four Scenarios
  - 1 - Base - CCR/LCC/LT Safe Yield (75,000 acft min. stor.)
  - 2 - Base + Garwood (35,000 acft/yr)
  - 3 - Base + OCR (280,000 acft / 1,250 cfs)
  - 4 - Base + Garwood + OCR

	Safe Yields =	205,000	236,000	255,000	286,000
		Base	+ Garwood	+ O/C	+Garwood + O/C
Annual Volume	Target Attainment	Model Attainment			
750000	25%	16%	16%	11%	11%
166000	80%	47%	46%	39%	37%
30000	95%	94%	96%	90%	89%

Agreed Order – Nueces Bay Inflow



Agreed Order – Nueces Bay Inflow

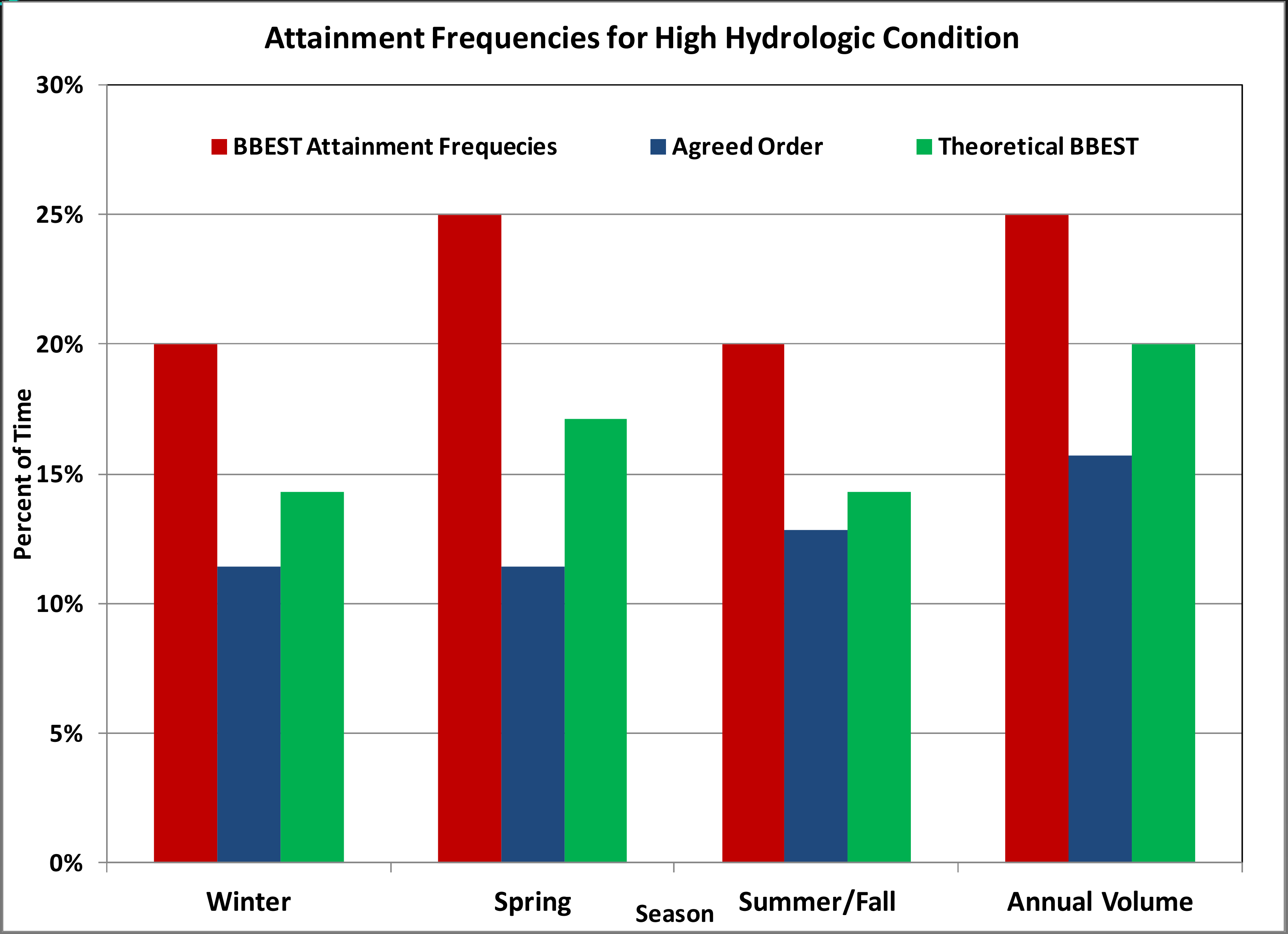


CCWSM – BBEST Recommendation

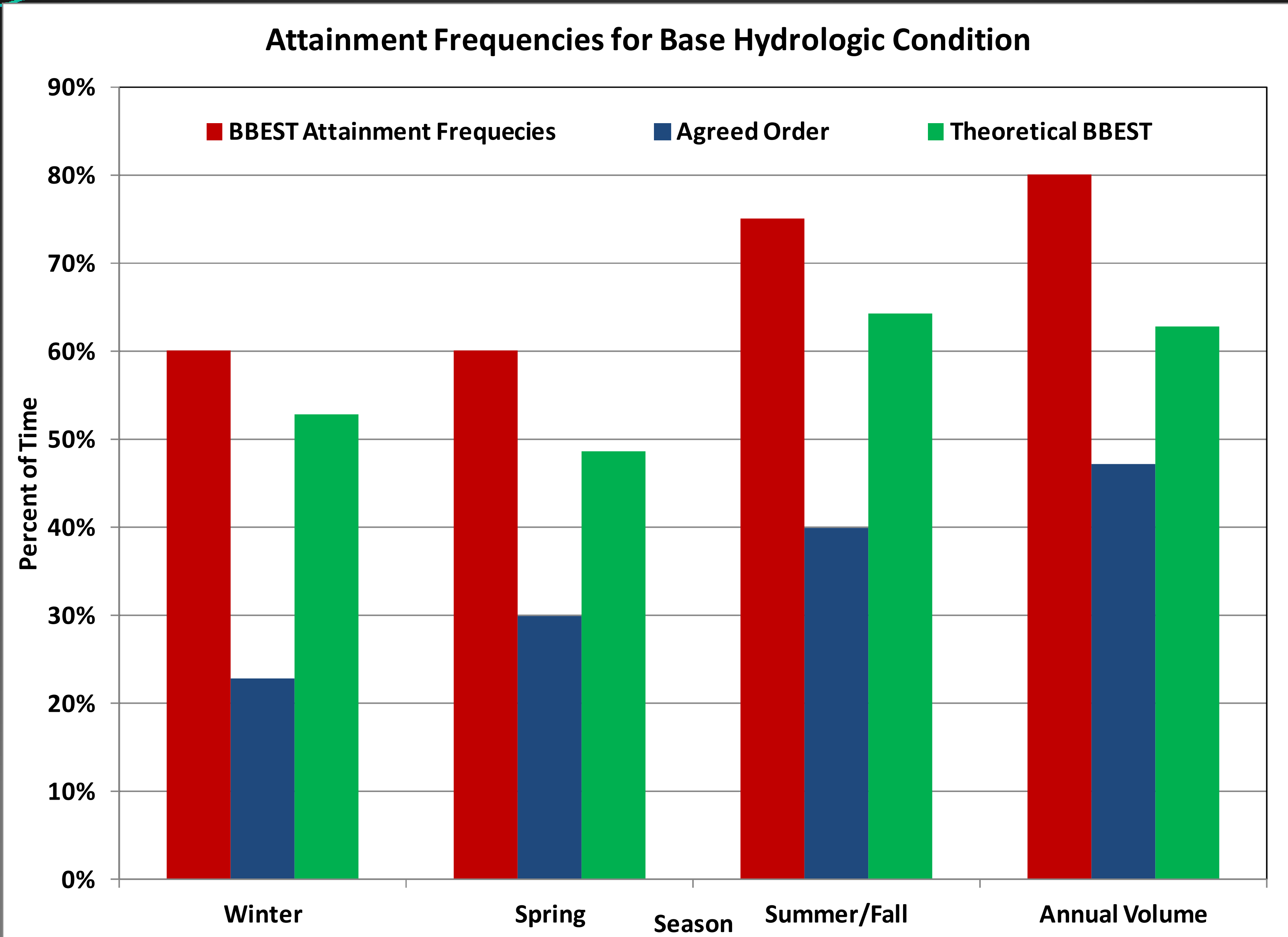
- Potential / Theoretical 82,000 acft/yr reduction in Safe Yield
- Subsistence Condition Annual attainment frequency above target
- Annual Base and High are below target
- Seasonally –Subsistence attainment frequency is above target for Spring and Summer / Fall

	Safe Yields =	205,000	236,000	255,000	286,000	123,000
		Base	+ Garwood	+ O/C	+Garwood + O/C	BBEST
Annual Volume	Target Attainment	Model Attainment				
750000	25%	16%	16%	11%	11%	20%
166000	80%	47%	46%	39%	37%	63%
30000	95%	94%	96%	90%	89%	99%

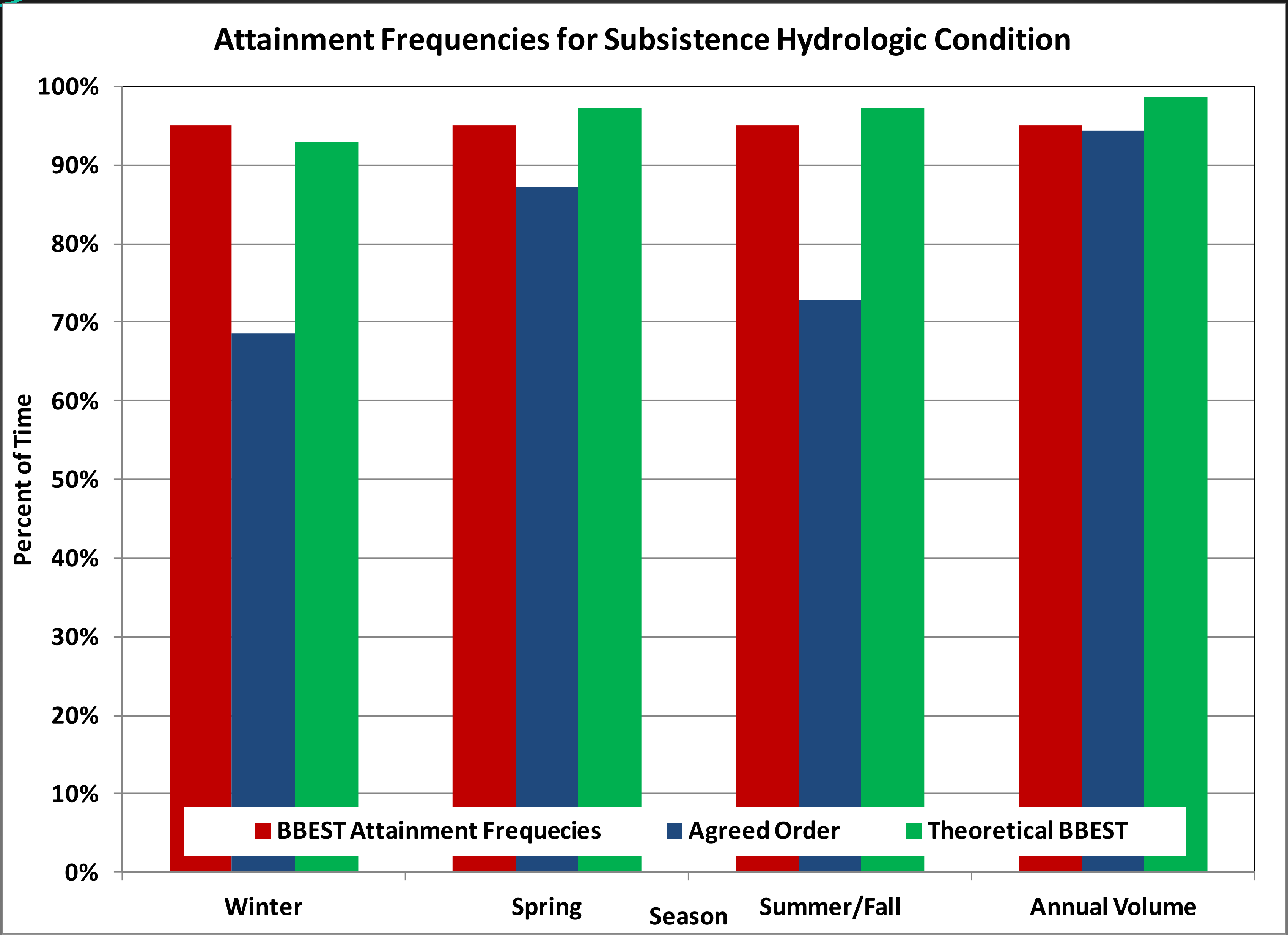
Attainment Frequencies



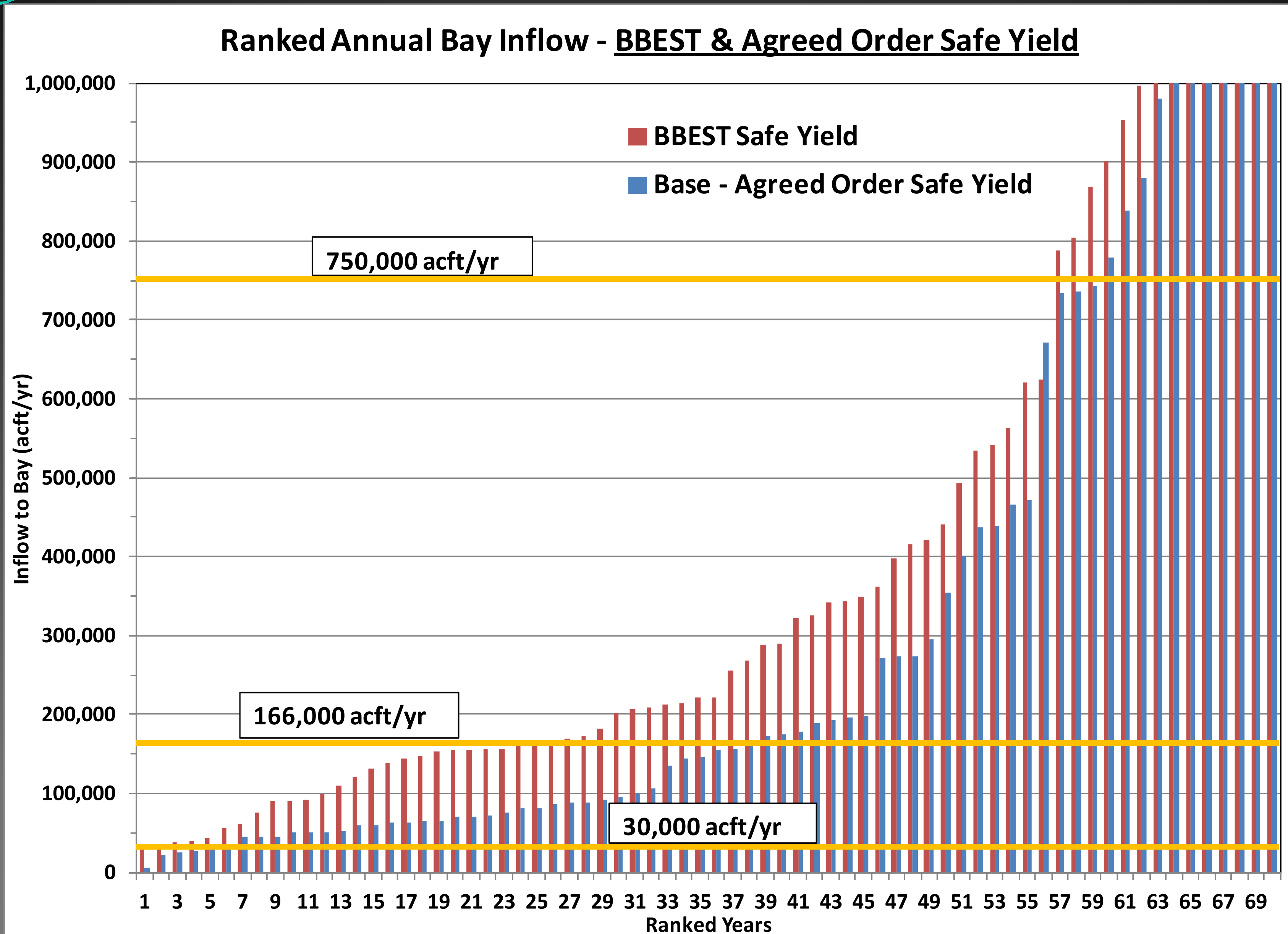
Attainment Frequencies



Attainment Frequencies



Nueces Bay Inflow



Path Forward / Questions?

- Finish up model development
  - Spill Banking
  - Operational Delivery
  - Projection Mode
- Evaluate additional scenarios with BBEST
  - Garwood
  - OCR
- Evaluate different Triggers Targets, and/or Attainment Frequencies for BBASC Recommendation

Nueces BBASC Technical Consultant Update

Presentation to Nueces BBASC
Cory Shockley, PE – HDR Engineering
March 28, 2012

Discussion

- Contract Pending with TWDB
- Contract Pending with CBBEP
- BBEST evaluation using CCWSM
- Real-Time Salinity Management

HDR Work Efforts

- Current Contract with City of Corpus Christi
  - Ongoing CCWSM code updates and scenario evaluation
- Pending Contract with TWDB
  - Nueces BBASC Technical Consultant
  - Selected
  - Awaiting NTP
  - 1st Deliverable April BBASC Meeting
- Pending Contract with CBBEP
  - For BBASC Report Compilation

BBEST Recommendation Evaluation with CCWSM

Modified

- Triggers
- Seasonal Volumes

Observed

- Seasonal and Annual Attainment Frequencies
- Annual Bay Inflows

Measured

- Impacts to Lake Level
- Reduction in Safe Yield

Preliminary Results Indicate

- Attainment frequencies were not met
  - Exception – Annual 30,000 acft 95%
- Safe yield decreases
- Bay inflow increases
- Modifying triggers provides most flexibility
- Alternative supply options = slight variation
  - Garwood
  - LCC Off-Channel
  - Combinations

Remaining Questions

- Is the channel below LCC sufficient to deliver seasonal volumes?
  - Should this constraint be added to the model.
- Are the return flow credits working correctly in the seasonal model?
  - Yes.
- The seasonal model does not currently consider salinity relief, should this be modified?
  - Possibly. Real-Time Salinity Management (RTSM)

Real-Time Salinity Management

- Salinity – Key Factor in Bay and Delta Health
- Rincon Pump Station Operations
  - Actual, measurable results
  - Inflow versus Salinity Drop relationship
- Could a similar method be a “better” solution for Bay
- Possible Analysis:
  - Lag-1 Salinity Equation from BBEST Report
  - TxBlend Modeling at TWDB
  - Result in adaptive management regime

Path Forward / Questions?

- Support Modeling Subcommittee
  - Salinity Management / Spill Banking
  - Evaluate BBASC Recommendations
    - Triggers / Targets,
    - Attainment Frequencies
    - Other Scenarios
- BBASC Technical Consultant
  - Planned Water Supply Evaluations
- BBASC Report Support

Order Compared to BBEST

2001 TCEQ Agreed Order

Sys Stor. %	Jan (acft)	Feb (acft)	Mar (acft)	Apr (acft)	May (acft)	Jun (acft)	Jul (acft)	Aug (acft)	Sep (acft)	Oct (acft)	Nov (acft)	Dec (acft)	Ann. (acft)
>70	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500	138,000
70-40	2,500	2,500	3,500	3,500	23,500	23,000	4,500	5,000	11,500	9,000	4,000	4,500	97,000
40-30	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	14,400
<30	0	0	0	0	0	0	0	0	0	0	0	0	0

2011 BBEST Recommendation

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations	
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)	Attainment
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000	25%
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000	80%
Subsistence (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000	95%
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct		

Agreed Order Compared to BBEST Recommendation

2001 TCEQ Agreed Order

- Operational
- Monthly
- 4 Defined Storage Zones
- Based on System Storage
- Below 30% - No Passes
- Salinity & “Spill Banking” Relief

BBEST Recommendation

- Long-Term Simulation
- Seasonal
- 3 Hydrologic Conditions
- No Relation to System Storage
- Passes in all Zones
- No Relief Provisions

Order Compared to BBEST

2001 TCEQ Agreed Order

Sys Stor. %	Jan (acft)	Feb (acft)	Mar (acft)	Apr (acft)	May (acft)	Jun (acft)	Jul (acft)	Aug (acft)	Sep (acft)	Oct (acft)	Nov (acft)	Dec (acft)	Ann. (acft)
>70	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500	138,000
70-40	2,500	2,500	3,500	3,500	23,500	23,000	4,500	5,000	11,500	9,000	4,000	4,500	97,000
40-30	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	14,400
<30	0	0	0	0	0	0	0	0	0	0	0	0	0

2011 BBEST Recommendation

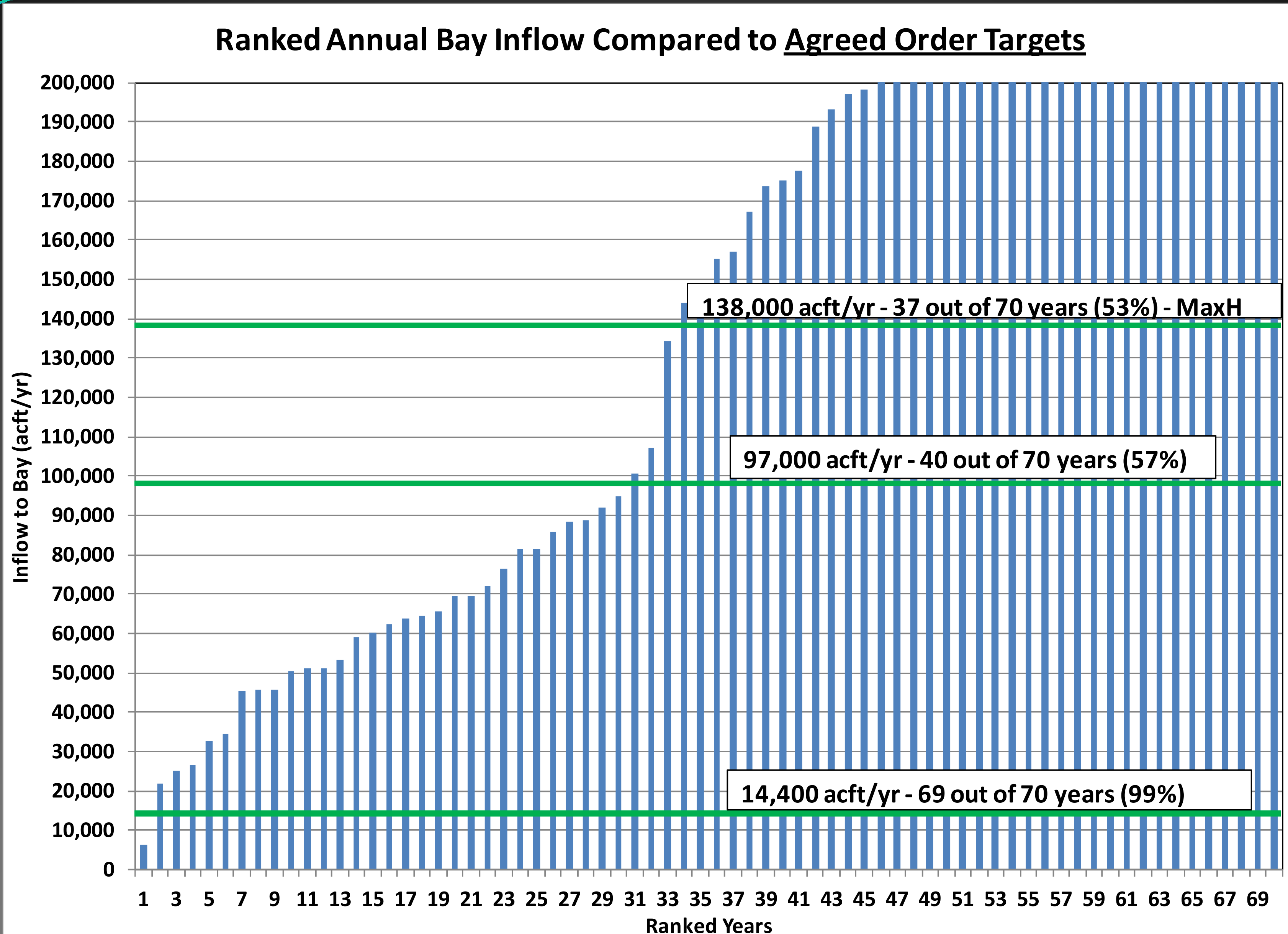
Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations	
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)	Attainment
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000	25%
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000	80%
Subsistence (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000	95%
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct		

Existing Order - Attainment

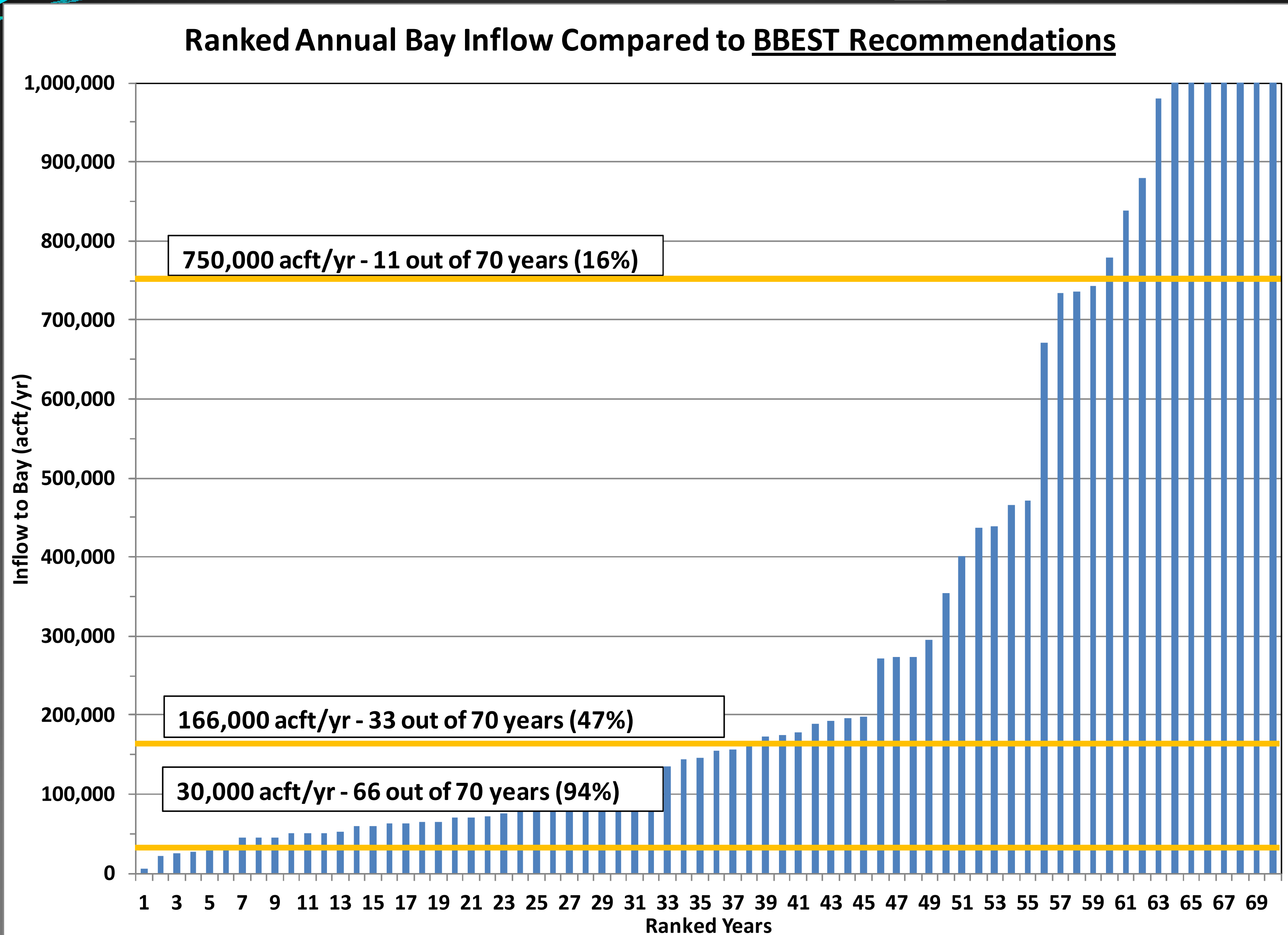
- Four Scenarios
  - 1 - Base - CCR/LCC/LT Safe Yield (75,000 acft min. stor.)
  - 2 - Base + Garwood (35,000 acft/yr)
  - 3 - Base + OCR (280,000 acft / 1,250 cfs)
  - 4 - Base + Garwood + OCR

	Safe Yields =	205,000	236,000	255,000	286,000
		Base	+ Garwood	+ O/C	+Garwood + O/C
Annual Volume	**Target Attainment**	**Model Attainment**			
750000	25%	16%	16%	11%	11%
166000	80%	47%	46%	39%	37%
30000	95%	94%	96%	90%	89%

Agreed Order – Nueces Bay Inflow



Agreed Order – Nueces Bay Inflow

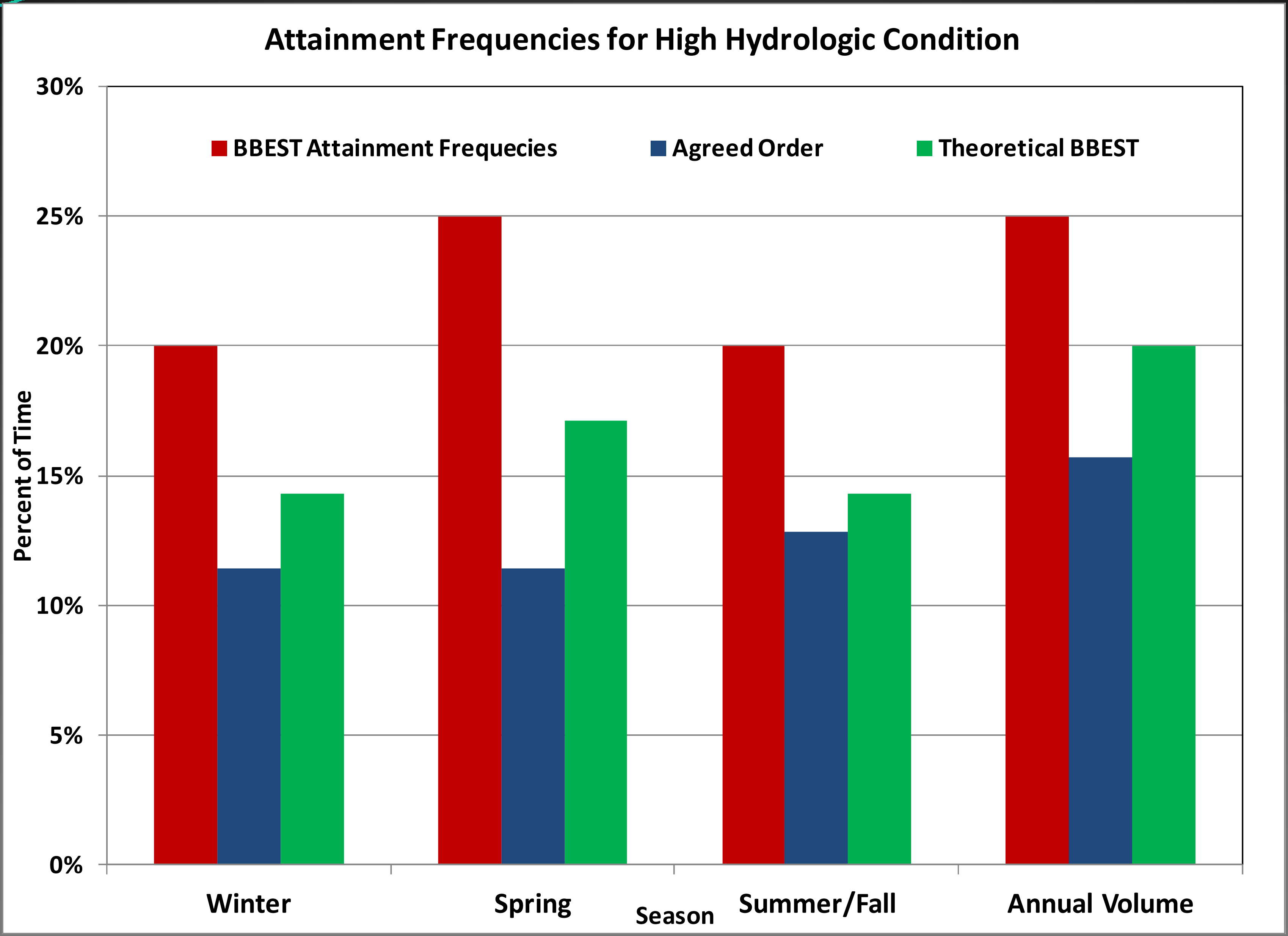


CCWSM – BBEST Recommendation

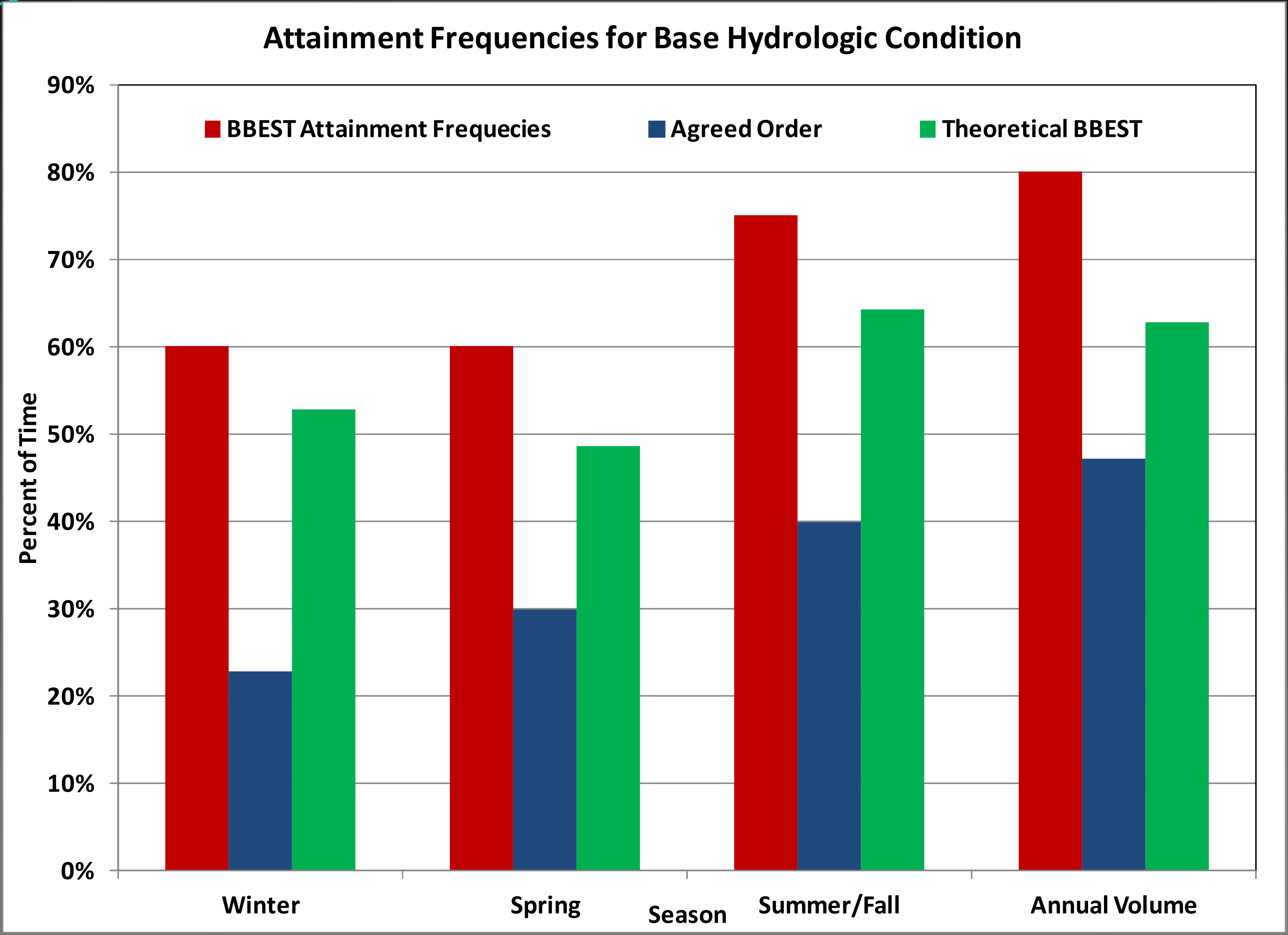
- Potential / Theoretical 82,000 acft/yr reduction in Safe Yield
- Subsistence Condition Annual attainment frequency above target
- Annual Base and High are below target
- Seasonally –Subsistence attainment frequency is above target for Spring and Summer / Fall

	Safe Yields =	205,000	236,000	255,000	286,000	123,000
		Base	+ Garwood	+ O/C	+Garwood + O/C	BBEST
Annual Volume	Target Attainment	Model Attainment				
750000	25%	16%	16%	11%	11%	20%
166000	80%	47%	46%	39%	37%	63%
30000	95%	94%	96%	90%	89%	99%

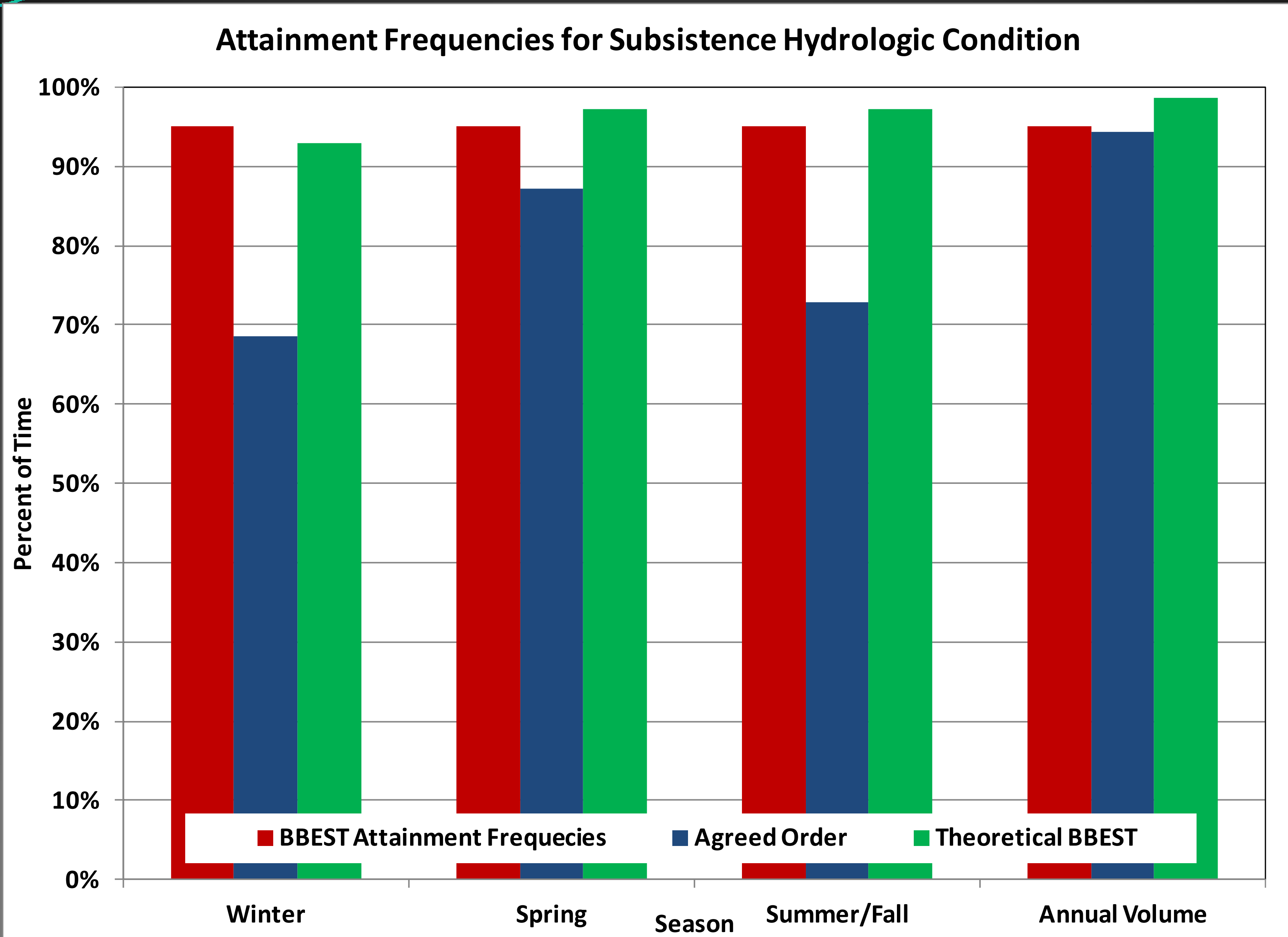
Attainment Frequencies



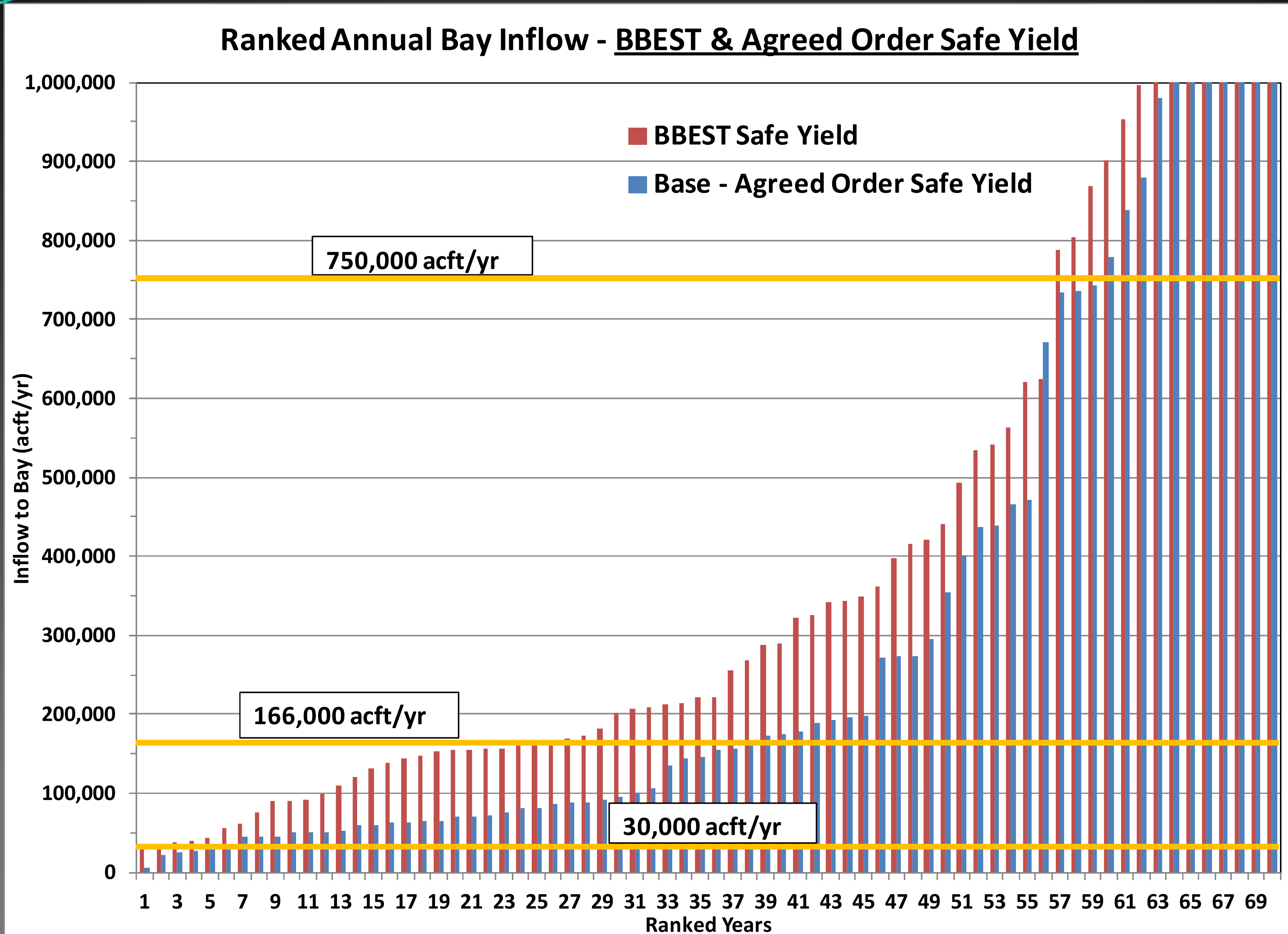
Attainment Frequencies



Attainment Frequencies



Nueces Bay Inflow



Nueces River and Corpus Christi and Baffin Bays
Basin and Bay Area Stakeholders Committee
(Nueces BBASC)

Discussion of Nueces BBASC Technical Support Work

Sam Vaugh
March 28, 2012

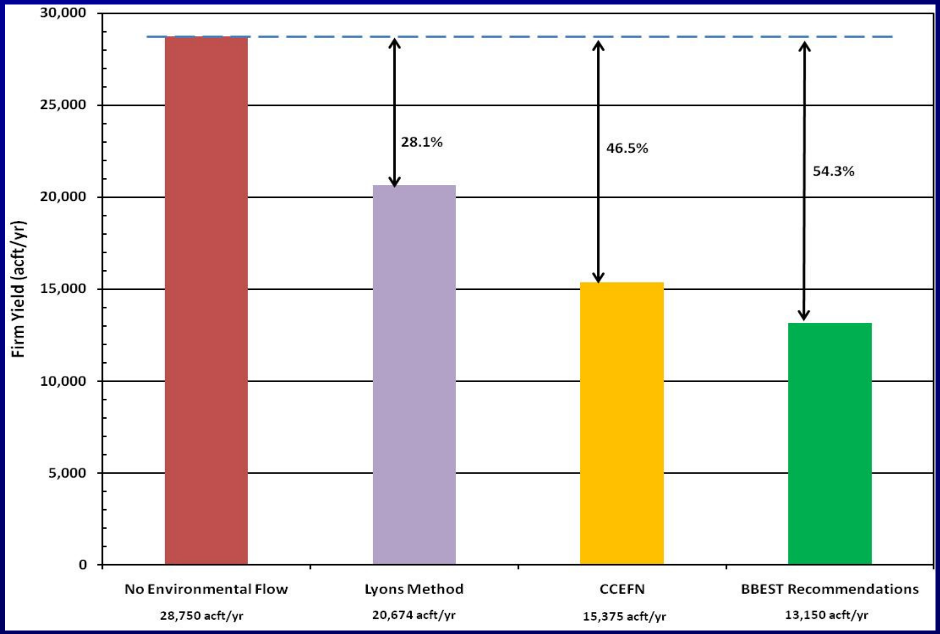
Topics of Discussion in Technical Support Scope of Work

1) Planned Water Supply Project Evaluation
2) Potential Standard & Strategy Evaluations
3) BBASC Recommendations Regarding Environmental Flow Standards
4) Meetings & Technical Reporting

Planned Water Supply Project Evaluation

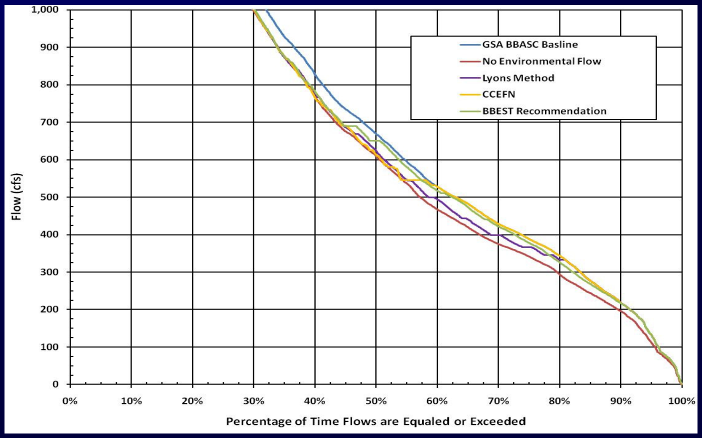
1) **Nueces Off-Channel Reservoir (Region N)**
   a) **280,000 acft storage capacity**
   b) **1250 cfs Maximum Diversion from Lake Corpus Christi (LCC) when LCC is in top 1 foot of conservation pool or spilling**
2) **Lower Sabinal Edwards Aquifer Recharge Enhancement Project**
   a) **8,750 acft storage capacity**
   b) **454 acres temporarily inundated when full**

Planned Water Supply Project Evaluation



1) Firm Yield
2) Cost of Water

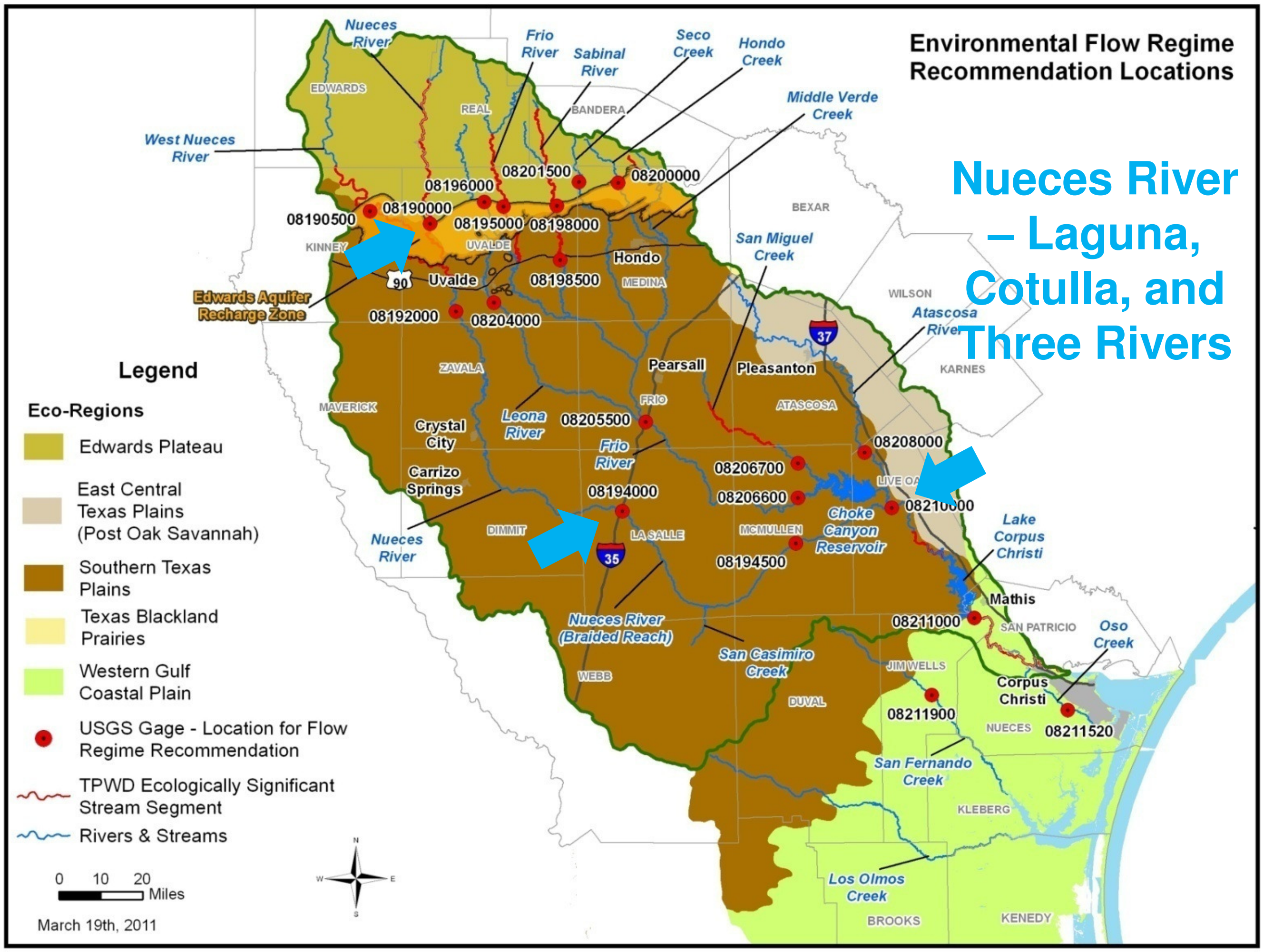
3) Resulting Streamflows
4) Ecological Significance



Potential Standard & Strategy Evaluations

1) **CCWSM (NuBay) simulations to be determined in consultation with BBASC and Modeling Workgroup**
2) **Rincon Bayou Pipeline strategy simulations for meeting salinity targets to be determined in consultation with BBASC and Modeling Workgroup**
3) **Evaluate effects of potential instream environmental flow standards:**
   a) **Nueces River @ Laguna**
   b) **Nueces River @ Cotulla**
   c) **Nueces River @ Three Rivers**

Focal Sites for BBASC Instream Flow Standard Recommendations



R:\09109-140890 N BBEST\GIS\BBEST_Nueces_031911_ver1.mxd

Example Applications of Environmental Flow Standard Recommendations

1) Laguna = Run-of-River Diversion (up to 400 cfs) w/ Off-Channel Storage Reservoir (44,000 acft).
2) Cotulla = On-Channel Reservoir (527,600 acft).
3) Cotulla = Run-of-River Diversion (up to 400 cfs) w/ Off-Channel Storage Reservoir
4) Three Rivers = Run-of-River Diversion (up to 400 cfs)
5) These are theoretical projects for illustrative purposes only. No such projects are recommended in any current regional or state water plan.

BBEST Flow Regime Recommendation

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
Overbank Events	Qp: 15,600 cfs with Average Frequency 1 per 5 years Regressed Volume is 124,000 Duration Bound is 107			
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600 Duration Bound is 64			
	Qp: 2,220 cfs with Average Frequency 1 per year Regressed Volume is 18,400 Duration Bound is 46			
	Qp: 590 cfs with Average Frequency 2 per year Volume Bound is 11,300 Duration Bound is 26			
	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
		Qp: 99 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 9		
Base Flows (cfs)	92		76	92
	65		48	65
	51	44	32	41
Subsistence Flows (cfs)	14	18	16	14

Wet

Avg

Dry

Flow Levels	
	High (75th %ile)
	Medium (50th %ile)
	Low (25th %ile)
	Subsistence

Pulse volumes are in units of acre-feet and durations are in days.
Period of Record used : 1/1/1924 to 12/31/2009.

Nueces River @ Laguna (NRL)

BBASC May Consider Simpler Environmental Flow Standard Recommendations

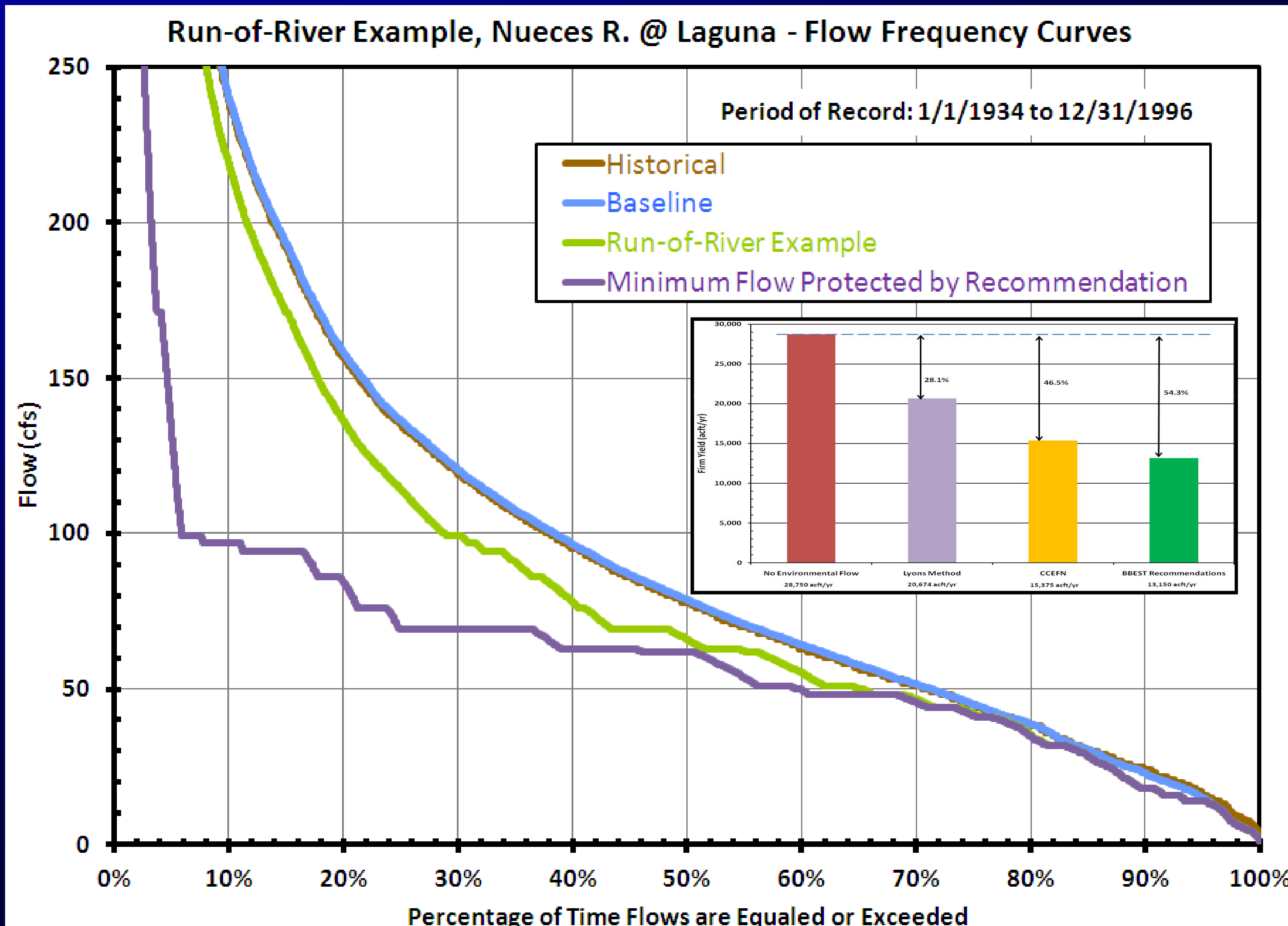
1) Eliminate tier(s) of seasonal Base flows?
2) Eliminate Hydrologic Conditions w/ only one tier of seasonal Base flows?
3) "50% Rule" between Base and Subsistence flows?
4) Eliminate tier(s) of seasonal Pulse flows ("Pulse Exemption Rule")?
5) Eliminate Overbank flows?

The Flow Regime Application Tool (FRAT) May be Used to Perform Example Applications of Potential Instream Flow Regime Recommendations

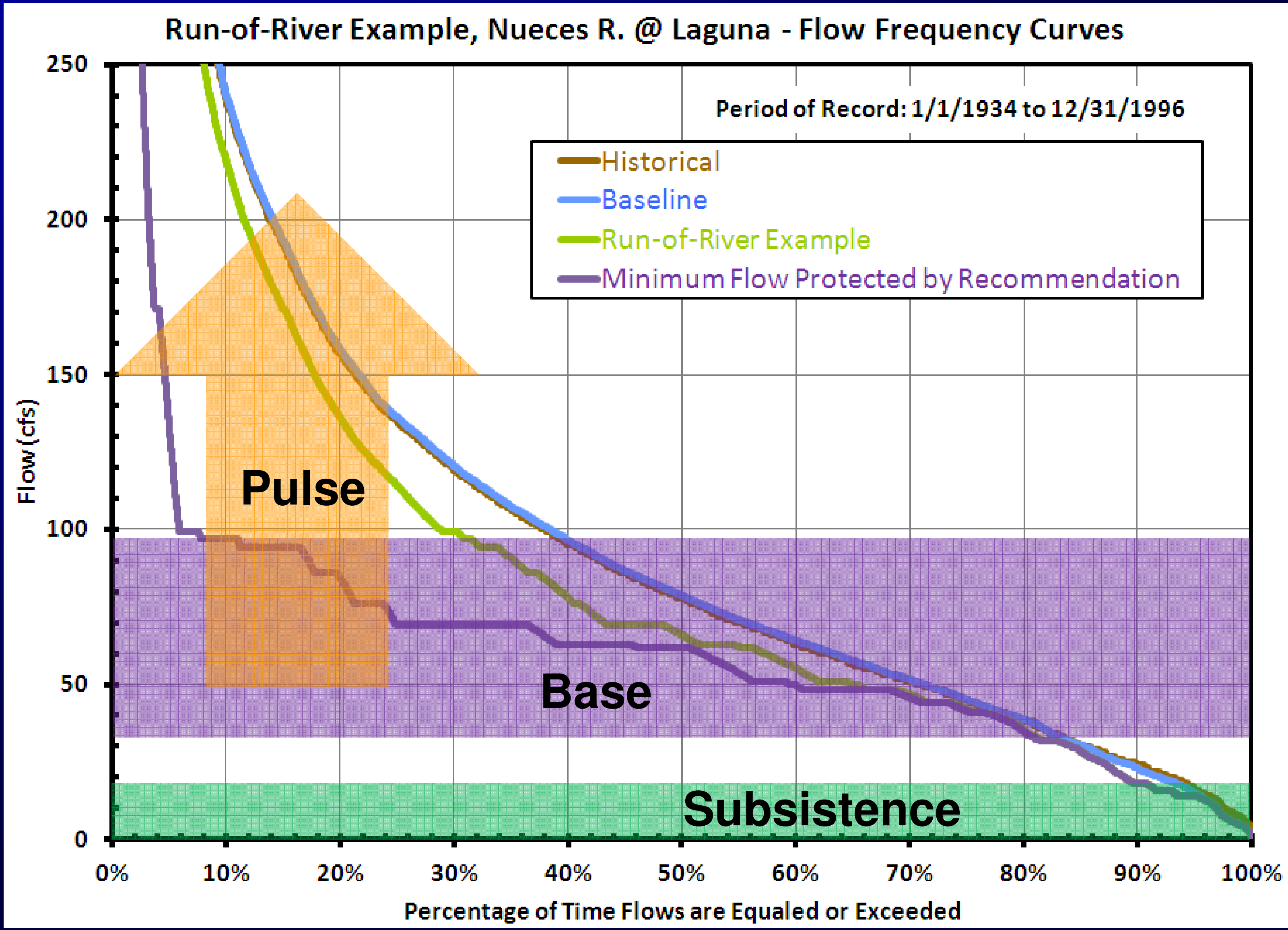
↓

The BBASC Considers Water Supply (e.g., Availability, Firm Yield) and Resulting Flows to Balance BBEST Environmental Recommendations

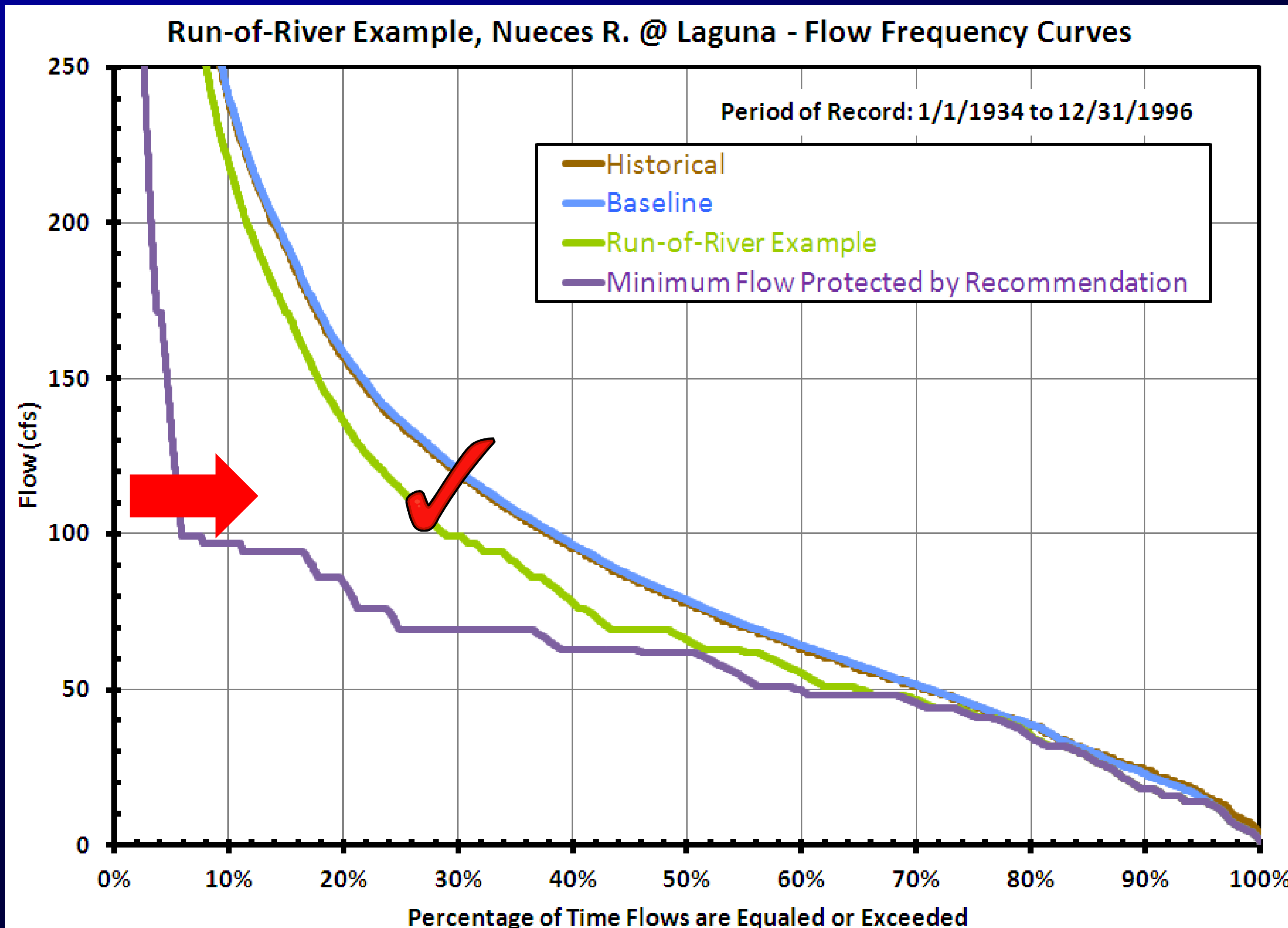
Example Application of Instream Flow Regime Recommendations



Flow Regime Components



Example Application of Instream Flow Regime Recommendations



Questions, Comments, & Discussion

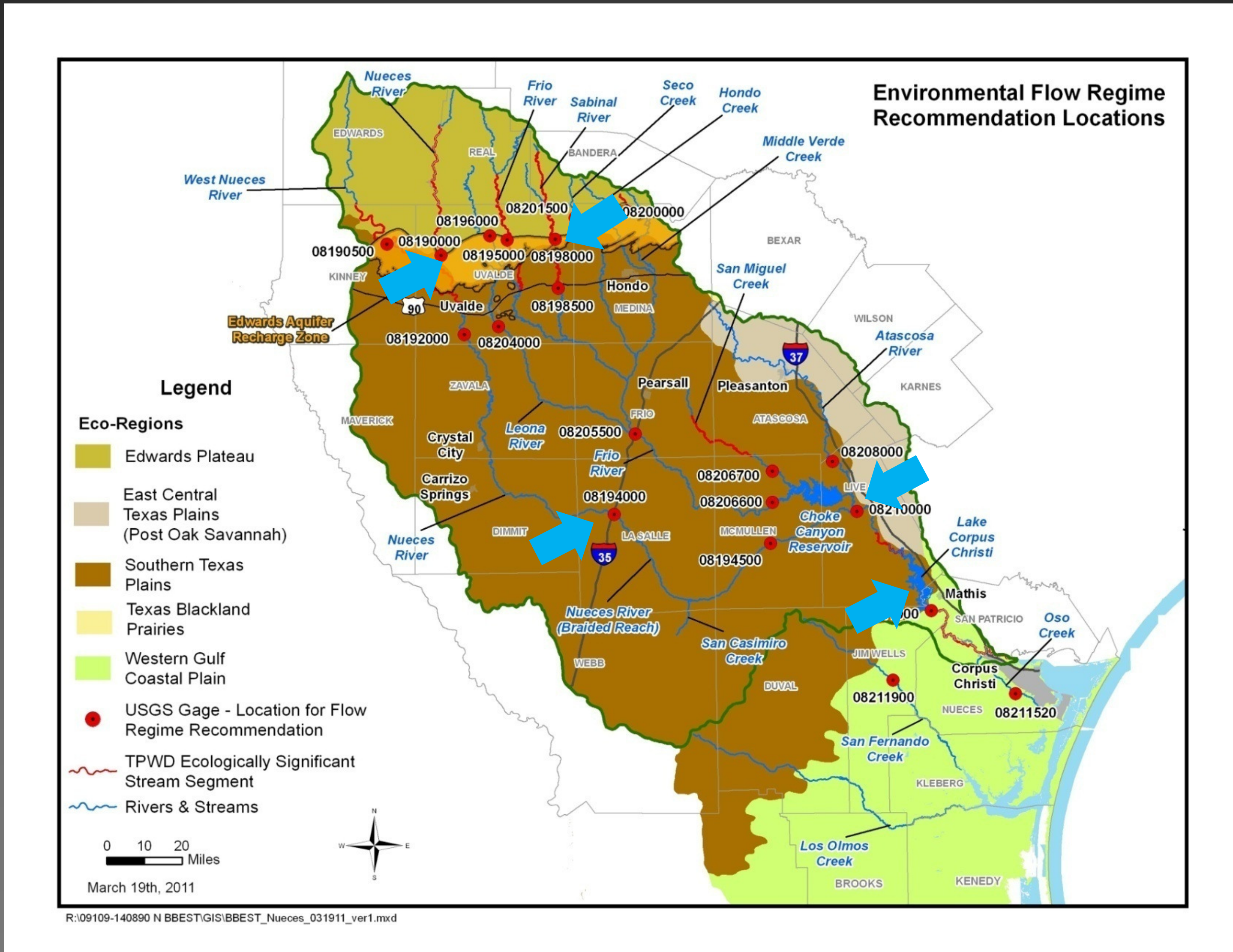
Updates on Modeling Efforts of Nueces BBASC Technical Consultant

Presentation to Nueces BBASC
Sam Vaugh, PE
Cory Shockley, PE – HDR Engineering
April 25, 2012

Discussion

- Instream Flow
  - Planned Water Supply Project Evaluations
    - Sabinal Recharge Dam
  - Standard and Strategy Evaluation
    - Nueces River @ Laguna
    - Nueces River @ Cotulla
- Nueces Bay & Delta
  - Planned Water Supply Project Evaluations
    - Lake Corpus Christi Off Channel Reservoir
  - B&E Scenario Evaluation

Focal Sites for BBASC Instream Flow Standard Recommendations

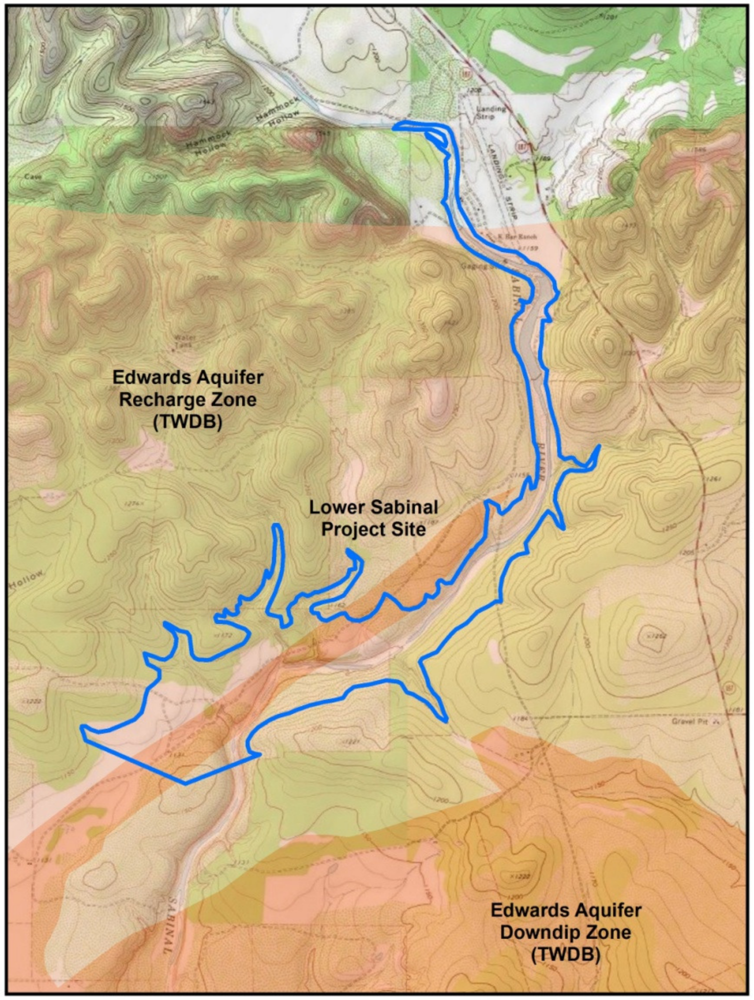


Planned Water Supply Projects

- Lower Sabinal Recharge Project
- Potential Environmental Flow Standards
  - No E-Flow Restrictions
  - Lyons (TCEQ)
  - CCEFN (Regional Water Planning)
  - Full BBEST

Lower Sabinal Recharge Project

- Recommended - Region L Plan
- Capacity 8,750 acft
- Enhanced Recharge
  - The additional recharge that would occur across the <u>entire</u> Edwards aquifer recharge zone on the Sabinal River from the implementation of the Sabinal Recharge Dam.

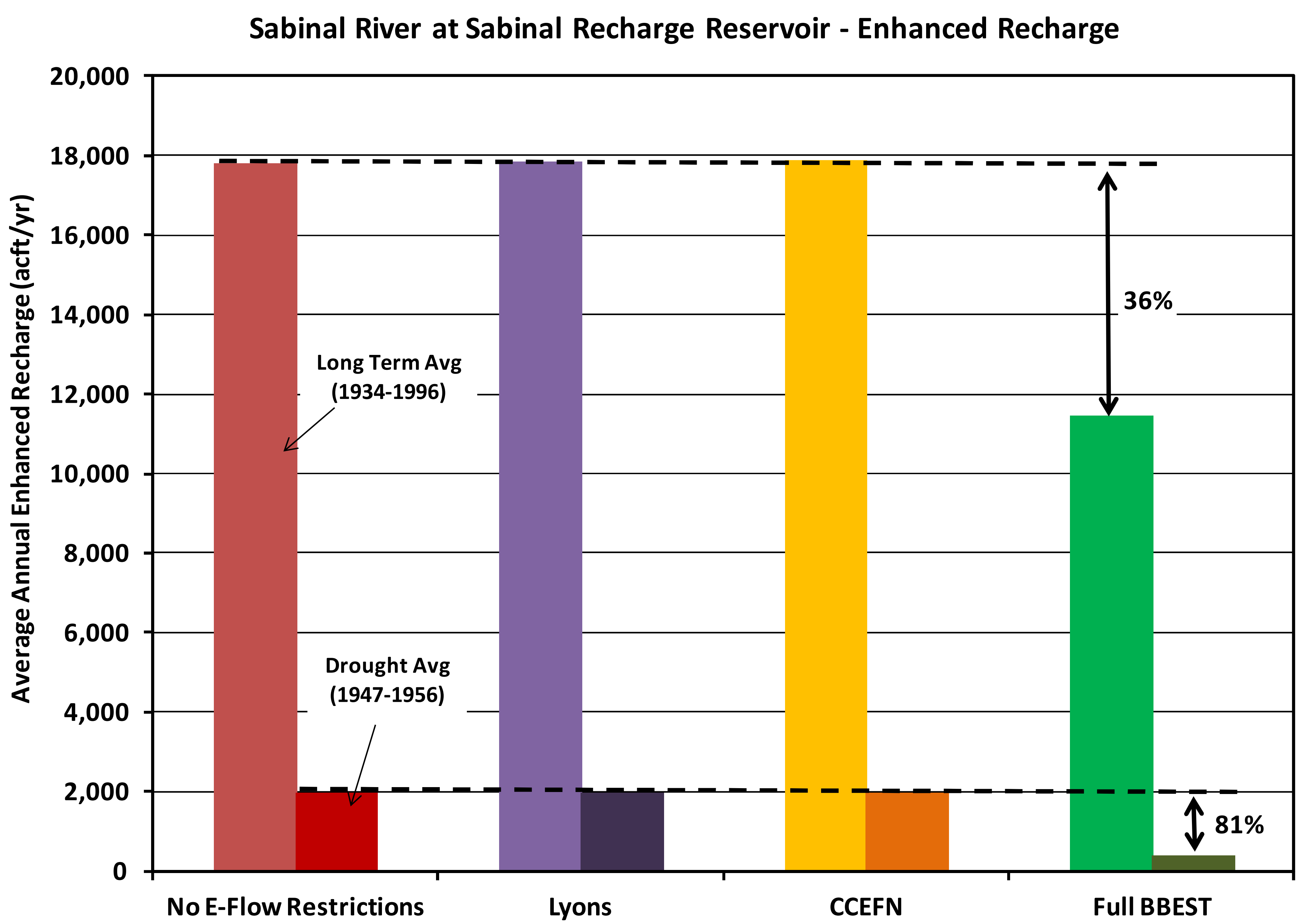


Sabinal River near Sabinal

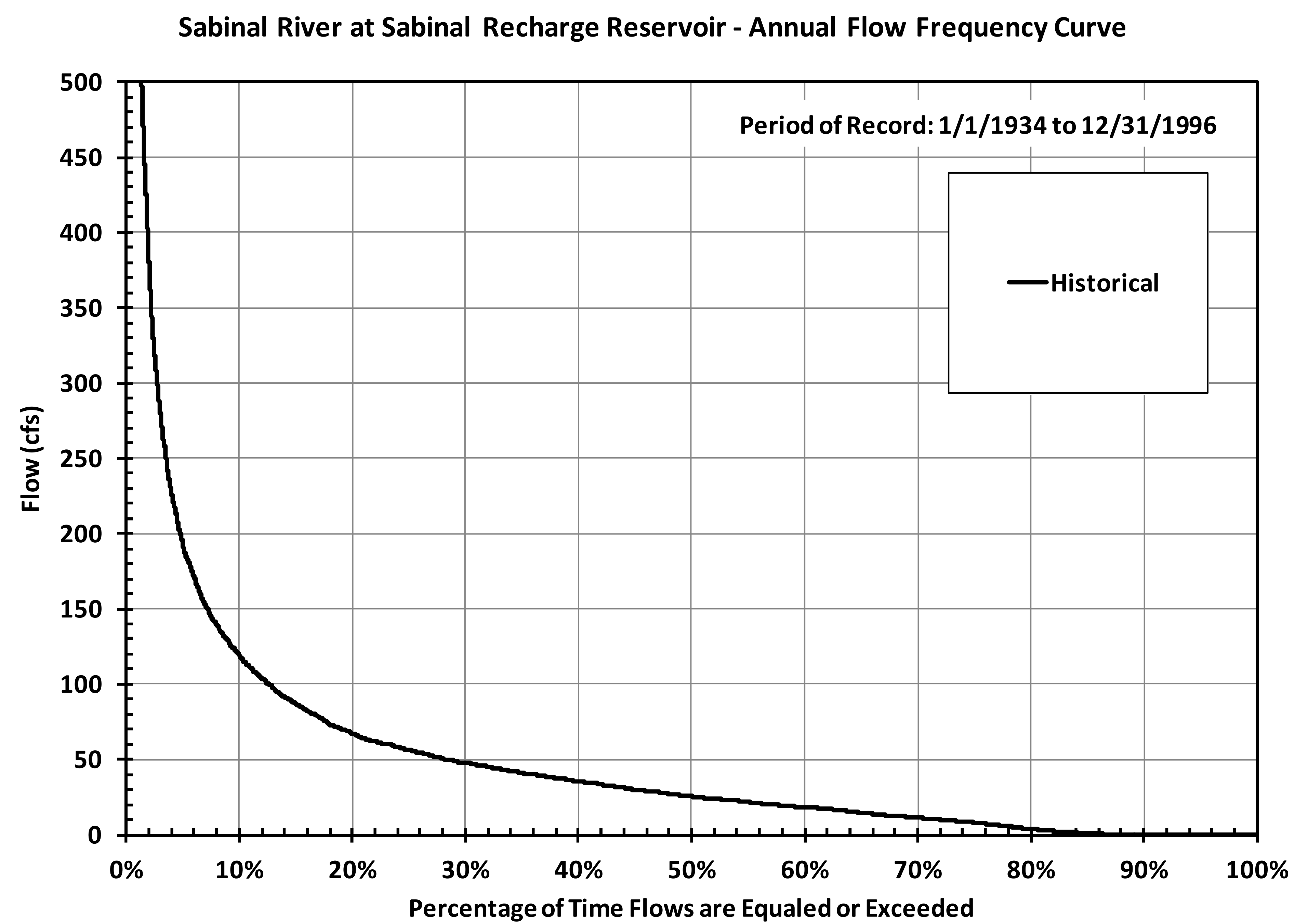
<table>
<tr><td rowspan="7">High Flow Pulses</td><td colspan="4">Qp: 5,200 cfs with Average Frequency 1 per 5 years
Regressed Volume is 46,200
Duration Bound is 75</td></tr>
<tr><td colspan="4">Qp: 2,350 cfs with Average Frequency 1 per 2 years
Regressed Volume is 20,000
Duration Bound is 54</td></tr>
<tr><td colspan="4">Qp: 1,020 cfs with Average Frequency 1 per year
Regressed Volume is 8,290
Duration Bound is 38</td></tr>
<tr><td colspan="4">Qp: 330 cfs with Average Frequency 2 per year
Volume Bound is 5,420
Duration Bound is 24</td></tr>
<tr><td>Qp: 62 cfs with Average Frequency 1 per season
Volume Bound is 1,530
Duration Bound is 17</td><td>Qp: 180 cfs with Average Frequency 1 per season
Volume Bound is 2,210
Duration Bound is 15</td><td>Qp: 100 cfs with Average Frequency 1 per season
Volume Bound is 1,180
Duration Bound is 12</td><td>Qp: 53 cfs with Average Frequency 1 per season
Volume Bound is 840
Duration Bound is 12</td></tr>
<tr><td></td><td>Qp: 64 cfs with Average Frequency 2 per season
Volume Bound is 750
Duration Bound is 10</td><td>Qp: 11 cfs with Average Frequency 2 per season
Volume Bound is 130
Duration Bound is 5</td><td></td></tr>
<tr><td></td><td>Qp: 22 cfs with Average Frequency 3 per season
Volume Bound is 240
Duration Bound is 6</td><td></td><td></td></tr>
<tr><td rowspan="3">Base Flows (cfs)</td><td colspan="2">35</td><td>29</td><td>35</td></tr>
<tr><td colspan="2">21</td><td>13</td><td>21</td></tr>
<tr><td>11</td><td>8</td><td>3</td><td>10</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="4">1</td></tr>
<tr><td></td><td>Dec Jan Feb Mar</td><td>Apr May Jun</td><td>Jul Aug Sep</td><td>Oct Nov</td></tr>
<tr><td></td><td>Winter</td><td>Spring</td><td>Summer</td><td>Fall</td></tr>
</table>

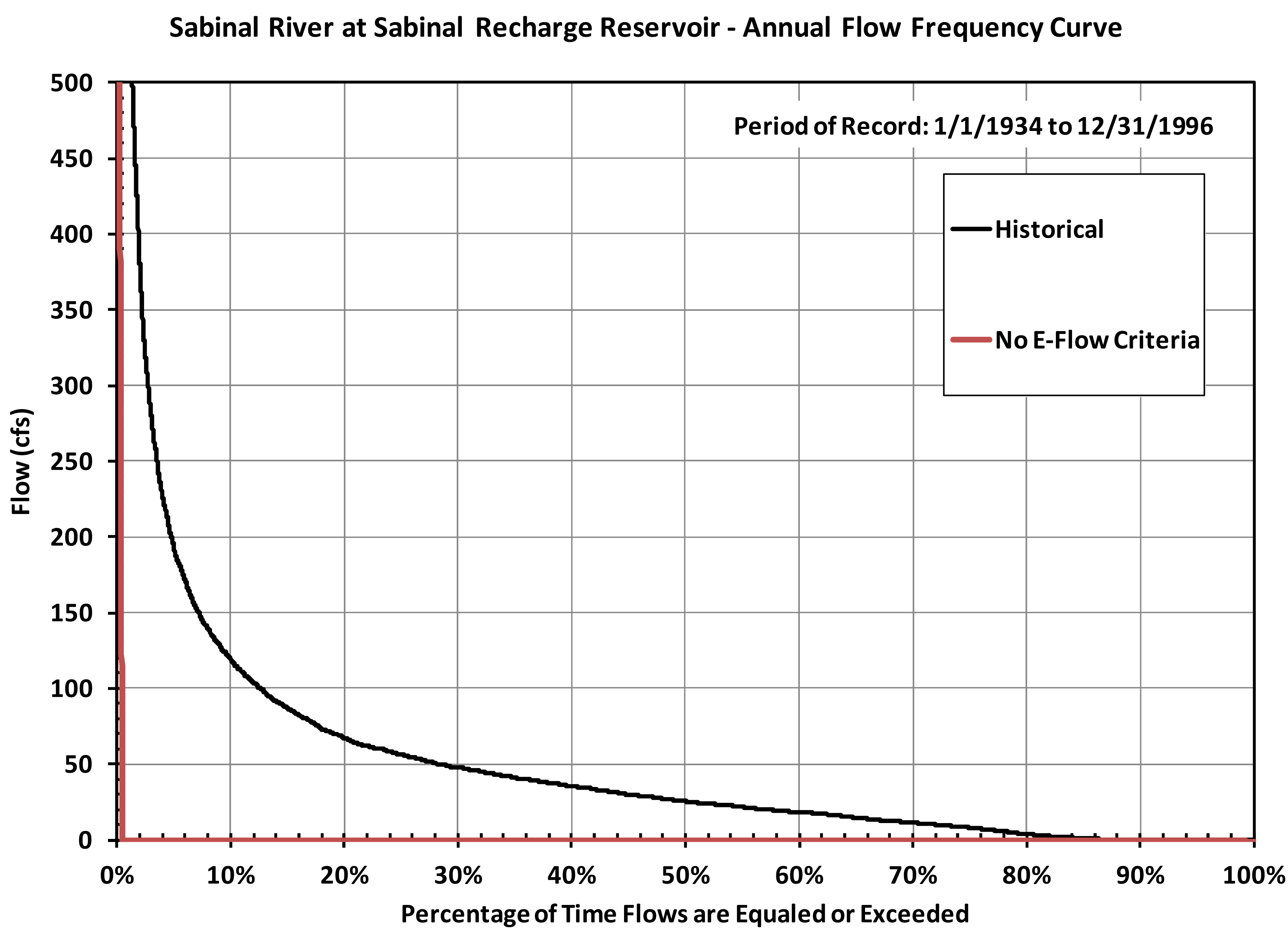
Flow Levels	
	High (75th %ile)
	Medium (50th %ile)
	Low (25th %ile)
	Subsistence

Pulse volumes are in units of acre-feet and durations are in days.
Period of Record used: 1/1/1943 to 12/31/2009.

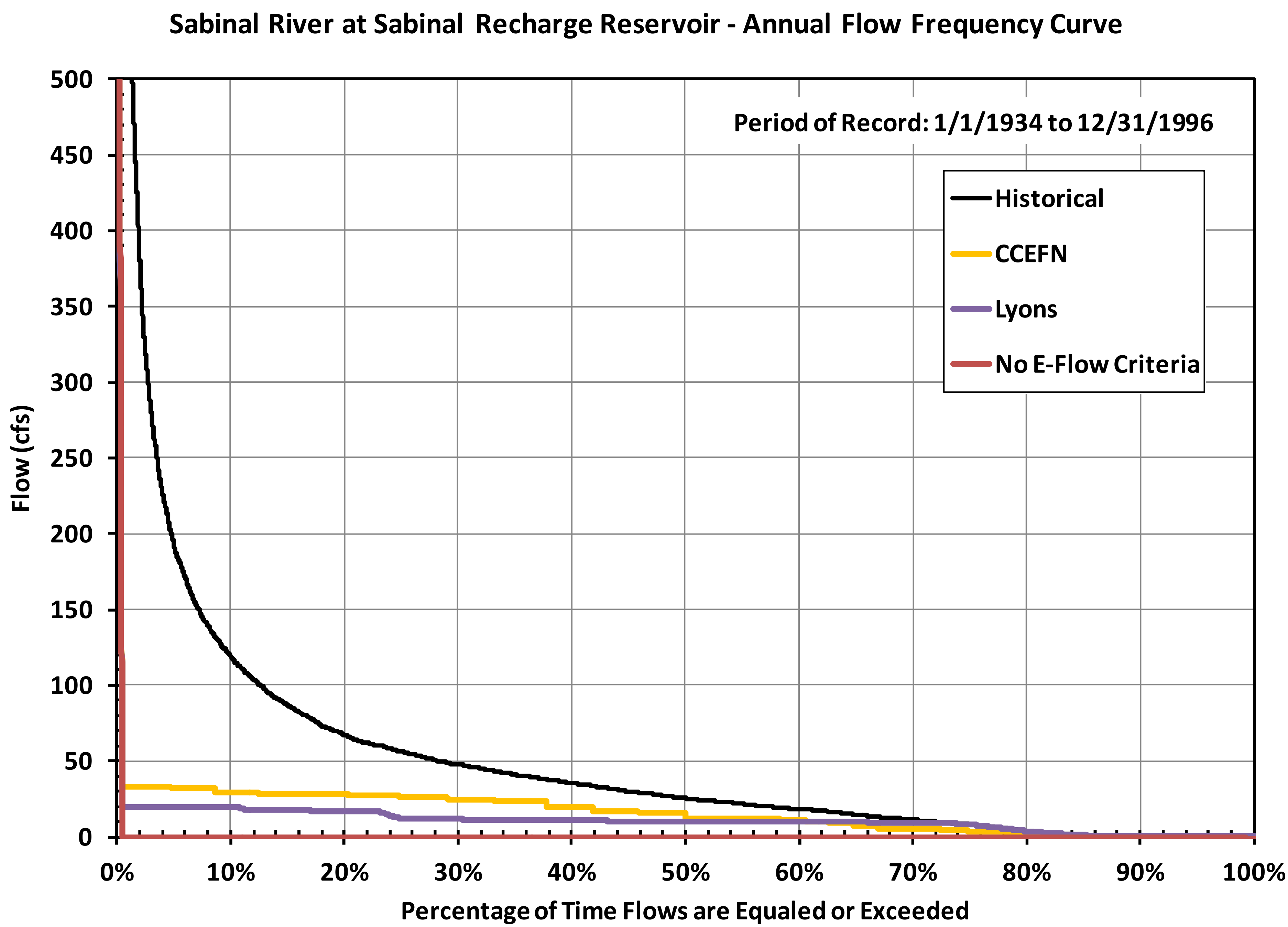


Sabinal River at Sabinal Recharge Reservoir - Enhanced Recharge
Average Annual Enhanced Recharge (acft/yr)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Long Term Avg (1934-1996)
Drought Avg (1947-1956)
36%
81%
No E-Flow Restrictions
Lyons
CCEFN
Full BBEST

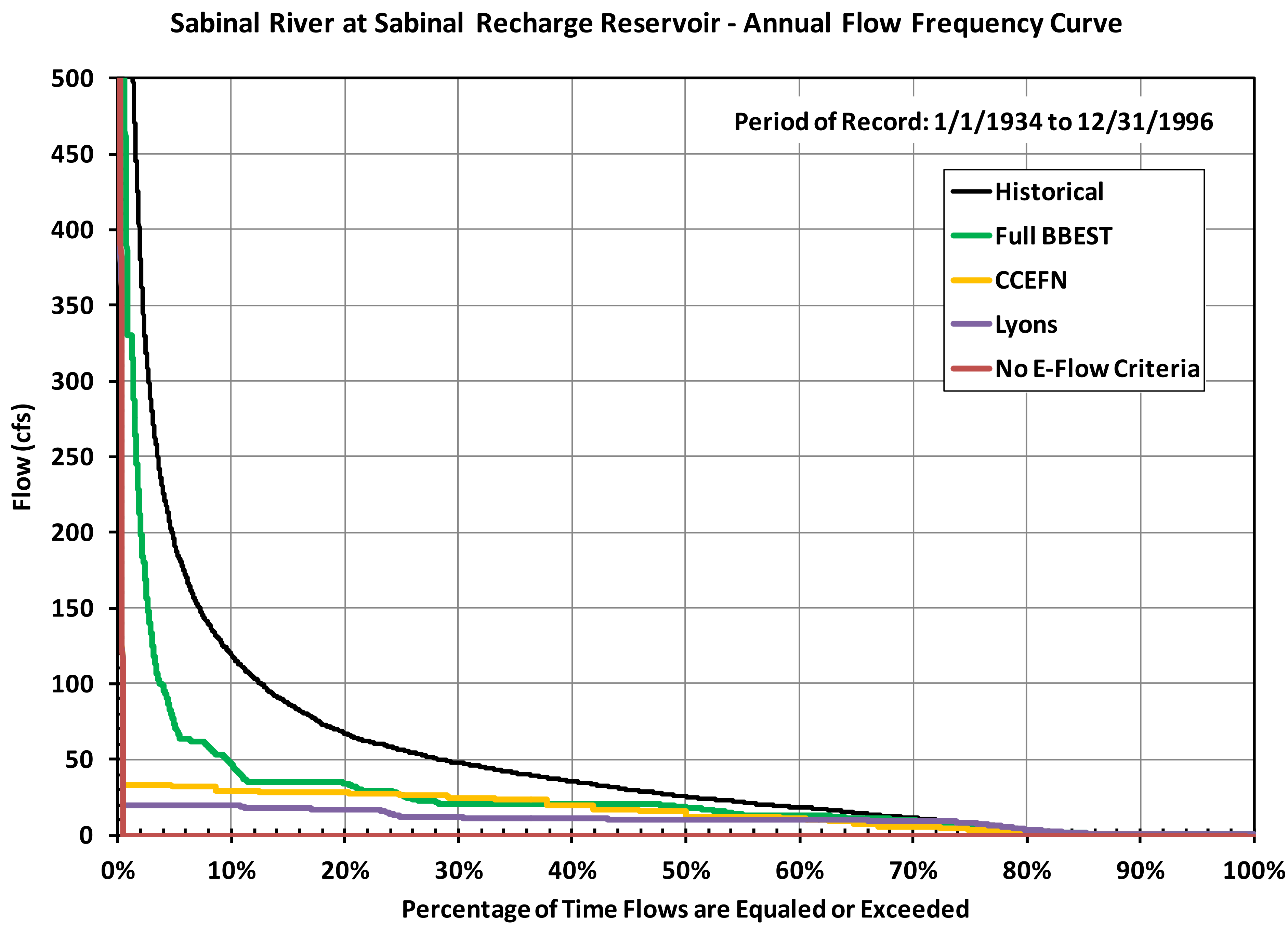

Sabinal River at Sabinal Recharge Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded



Sabinal River at Sabinal Recharge Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded



Sabinal River at Sabinal Recharge Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
CCEFN
Lyons
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded


Sabinal River at Sabinal Recharge Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
CCEFN
Lyons
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

Sabinal Recharge Dam

- Preliminary Conclusions
  - The impoundment of high flow pulses by the Sabinal Dam provides the greatest opportunity for recharge enhancement.
  - Variations in base flow criteria have negligible effects on enhanced recharge.
- Downstream Impacts
  - System yield = -1,900 to -2,300 acft/yr
  - Average Annual Bay Inflow = -850 acft/yr

Standard & Strategy Evaluation

- Laguna ROTR with OCR
- Cotulla Reservoir
- Cotulla ROTR with OCR
- Evaluate:
  - No Recommendation
  - BBEST Recommendation
  - Modifications to BBEST Recommendation
- Results:
  - Yield
  - Streamflows

Laguna ROTR - OCR

- Environmental Flow Standards
  - None
  - Full BBEST
  - Modified BBEST
    - No Overbank Flow Criteria
    - No Overbank with Pulse Exemption
    - No Overbank with Pulse Exemption and Dry Base Flows
    - No Overbank with Pulse Exemption and 50% Rule with Avg. Base Flows

E-Flow Criteria Definitions

- Overbank Exemption
- Pulse Exemption Rule
  - If the diversion rate of a run-of-river or off-channel reservoir diversion is less than 20% of the flow pulse trigger, then the pulse can be omitted from the E-flow criteria.
  - The 20% rule is not applicable to on-channel reservoirs
- Single Tier of Base Flows
- Single Tier of Base Flows with 50% Rule
  - Diversions may not exceed 50% of the difference between the base flow and the subsistence flow.

Nueces River @ Laguna - BBEST

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
Overbank Events	[illegible] 15,600 cfs with Average Frequency 1 per 5 [illegible] [illegible] Duration Bound is 107			
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600 [illegible]			
High Flow Pulses	[illegible] Regressed Volume is 18,400 Duration Bound is 46			
High Flow Pulses	Qp: 590 cfs with Average Frequency 2 per year Volume Bound is 11,300 Duration Bound is 26			
High Flow Pulses	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
High Flow Pulses		Qp: 99 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 9		
Base Flows (cfs) – High	92		76	92
Base Flows (cfs) – Medium	65		48	65
Base Flows (cfs) – Low	51	44	32	41
Subsistence Flows (cfs)	14	18	16	14

Flow Levels	
	High (75th %ile)
	Medium (50th %ile)
	Low (25th %ile)
	Subsistence

Pulse volumes are in units of acre-feet and durations are in days.
Period of Record used : 1/1/1924 to 12/31/2009.

Nueces River @ Laguna - BBEST

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
Overbank Events	15,600 cfs with Average Frequency 1 per 5 ye[illegible] Duration Bound is 107			
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600			
	[illegible] Regressed Volume is 18,400 Duration Bound is 46			
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	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
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Base Flows (cfs)	92		76	92
	65		48	65
	51	44	32	41
Subsistence Flows (cfs)	14	18	16	14

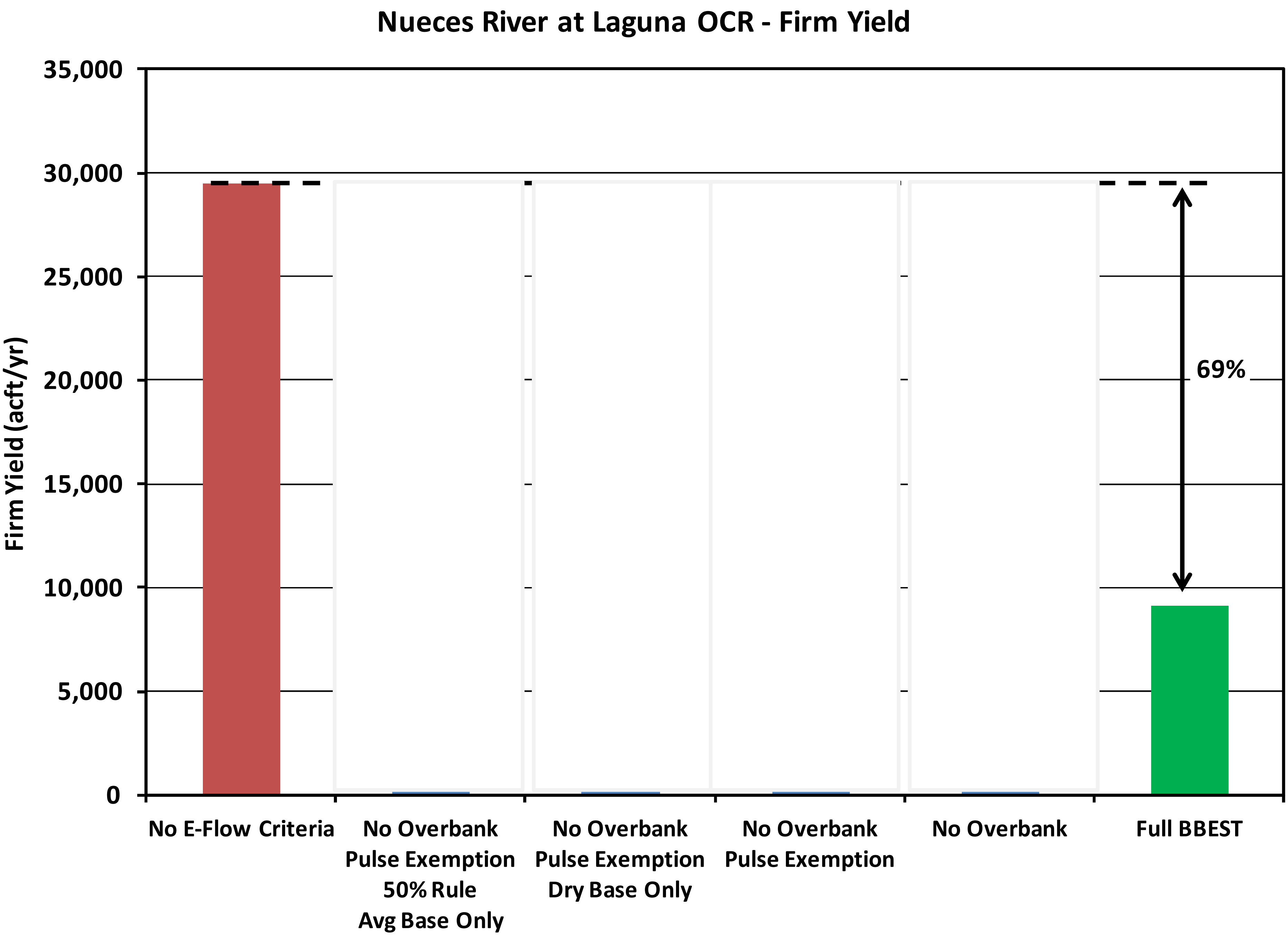
Flow Levels	
	High (75th %ile)
	Medium (50th %ile)
	Low (25th %ile)
	Subsistence

Pulse volumes are in units of acre-feet
Period of Record used : 1/1/1924 to 1

50%

Nueces River @ Laguna Hypothetical Project

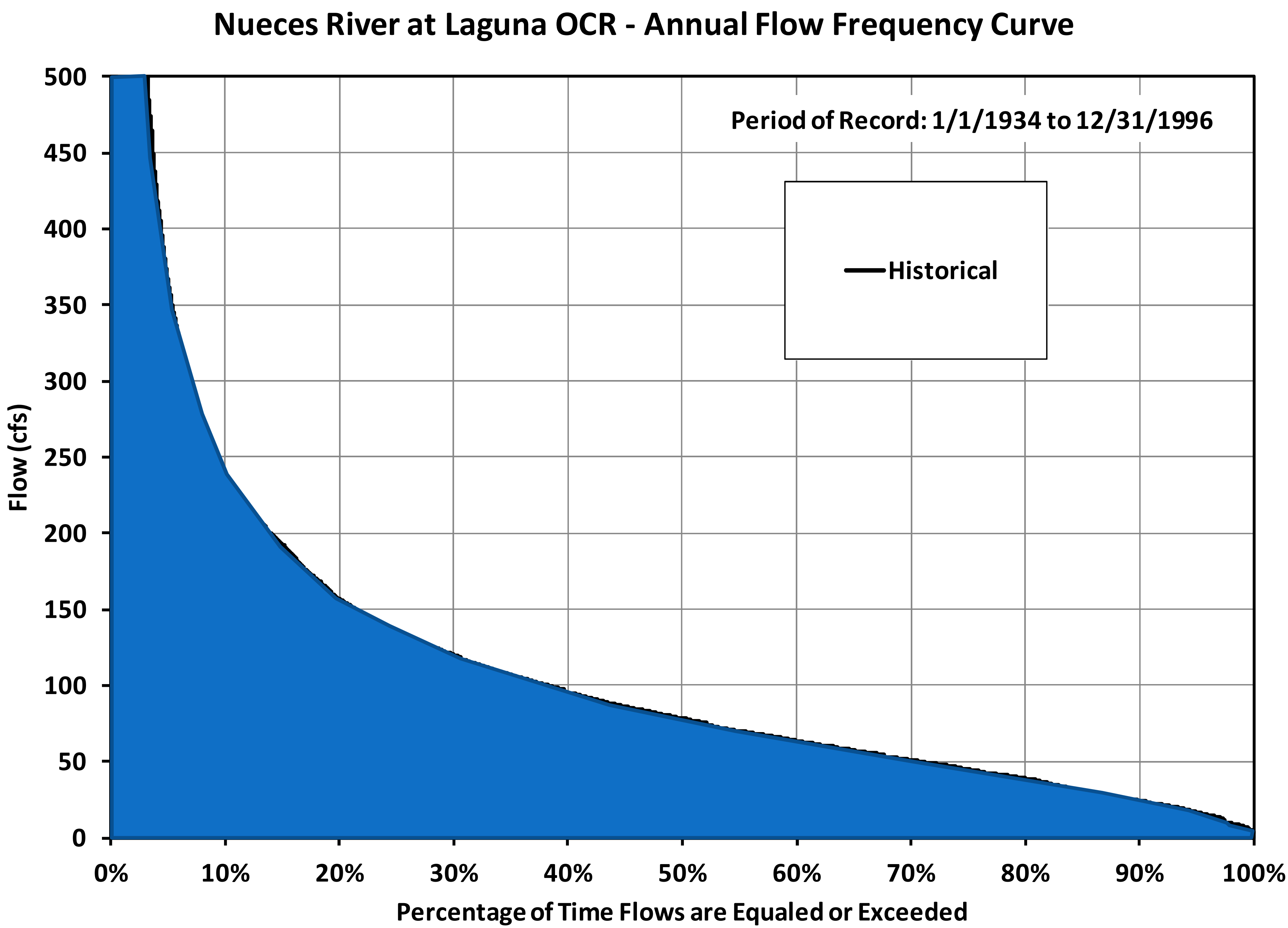
- Run of the River Diversion (400 cfs)
- Off Channel Reservoir (44,000 acft)



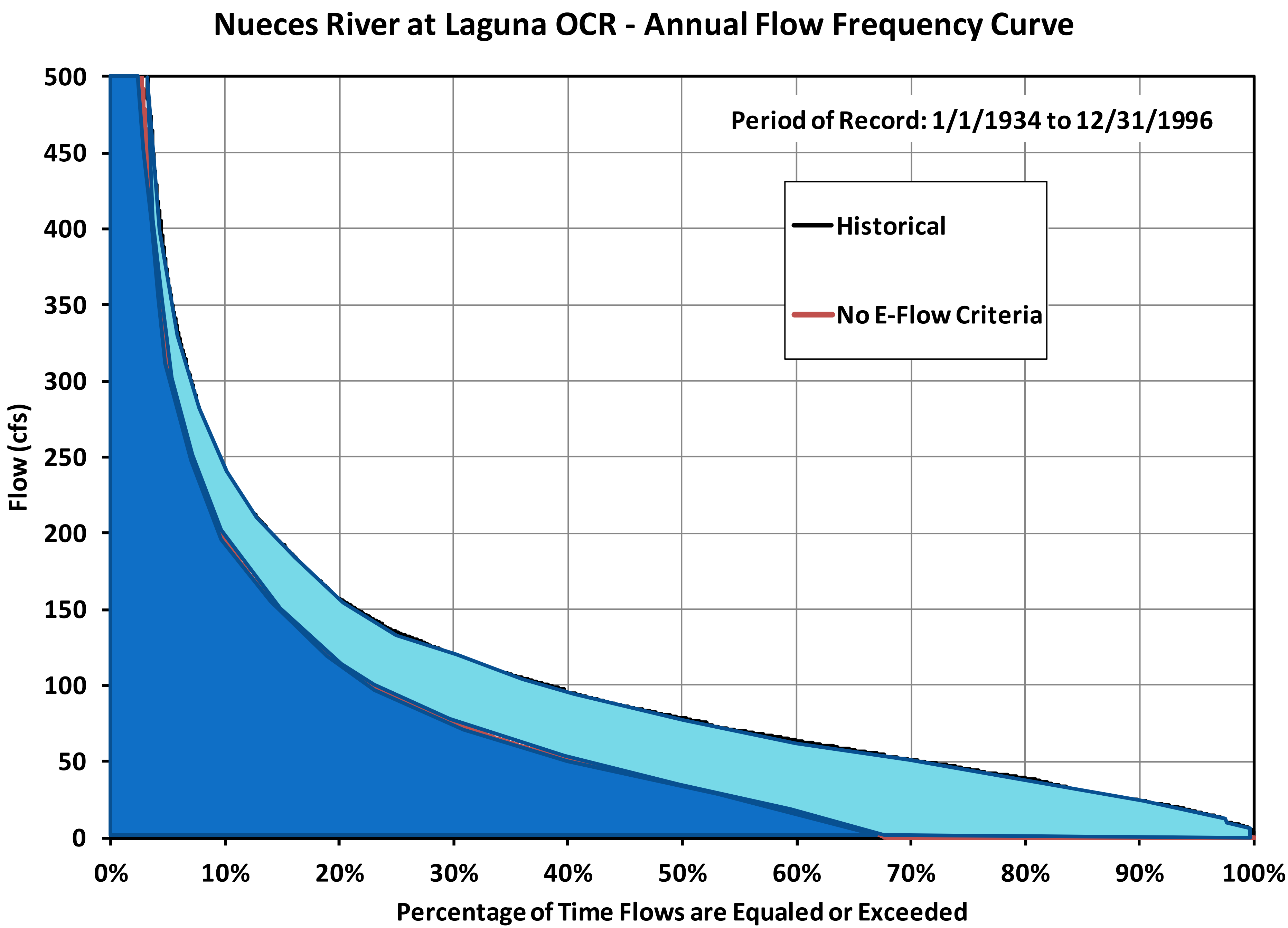
Nueces River at Laguna OCR - Firm Yield
Firm Yield (acft/yr)
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
69%
No E-Flow Criteria
No Overbank Pulse Exemption 50% Rule Avg Base Only
No Overbank Pulse Exemption Dry Base Only
No Overbank Pulse Exemption
No Overbank
Full BBEST

Defined – Modified BBEST

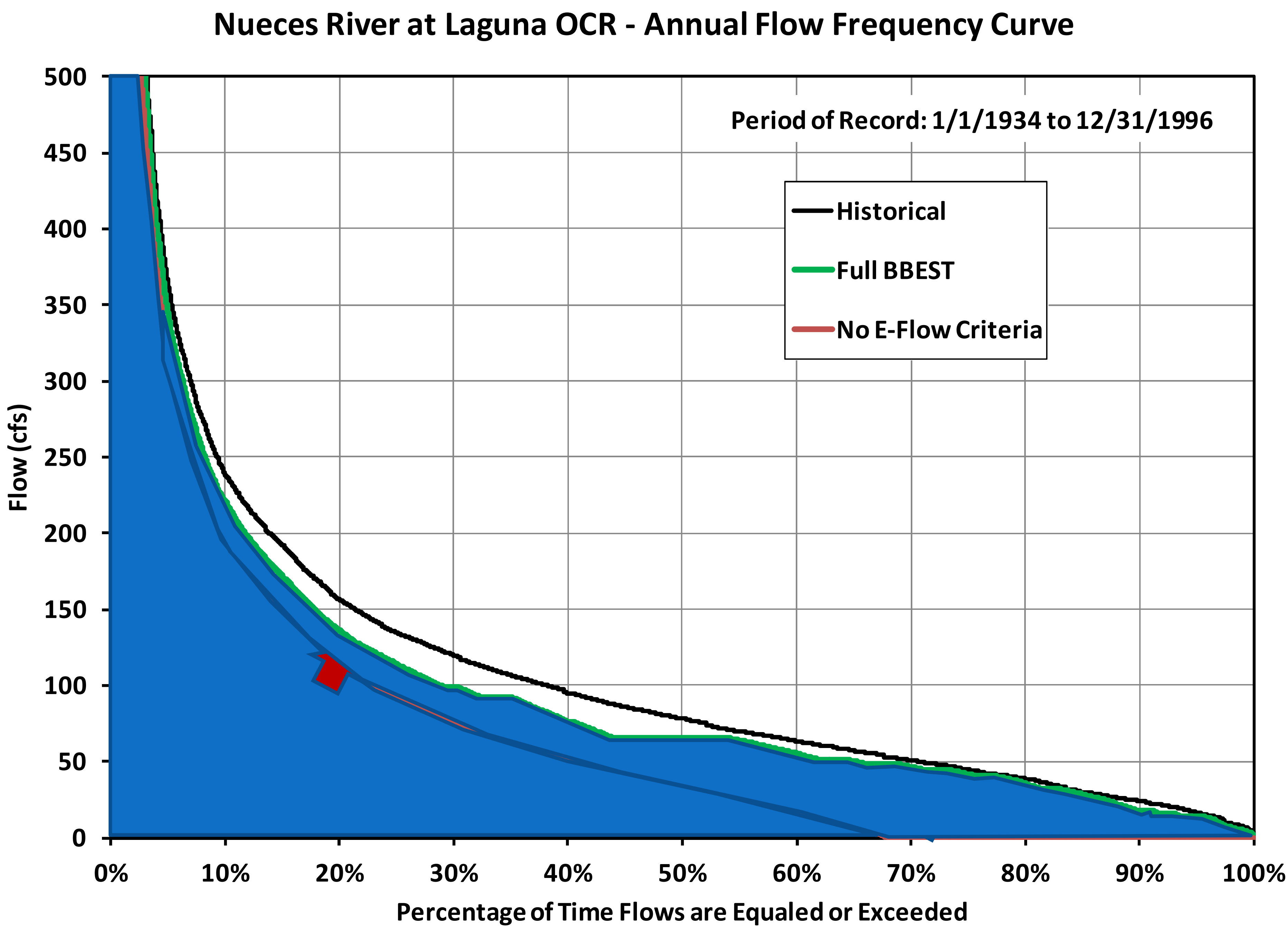
- Overbank Exemption
- Pulse Exemption Rule
  - diversion rate < 20% of the flow pulse trigger
  - 20% rule not applicable to on-channel reservoirs
- Single Tier of Base Flows with 50% Rule
  - Diversions may not exceed 50% of the difference between the base flow and the subsistence flow.



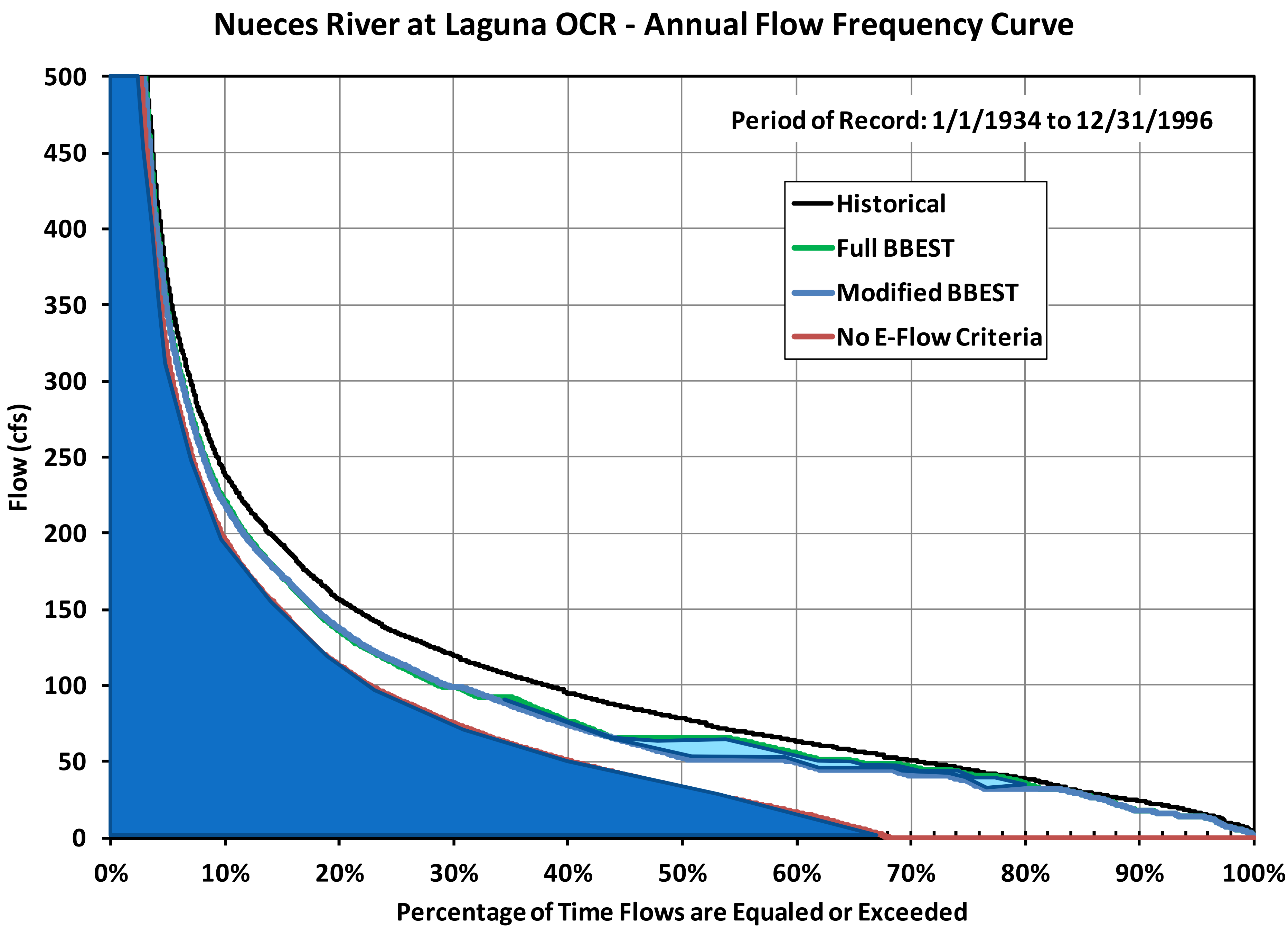
Nueces River at Laguna OCR - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

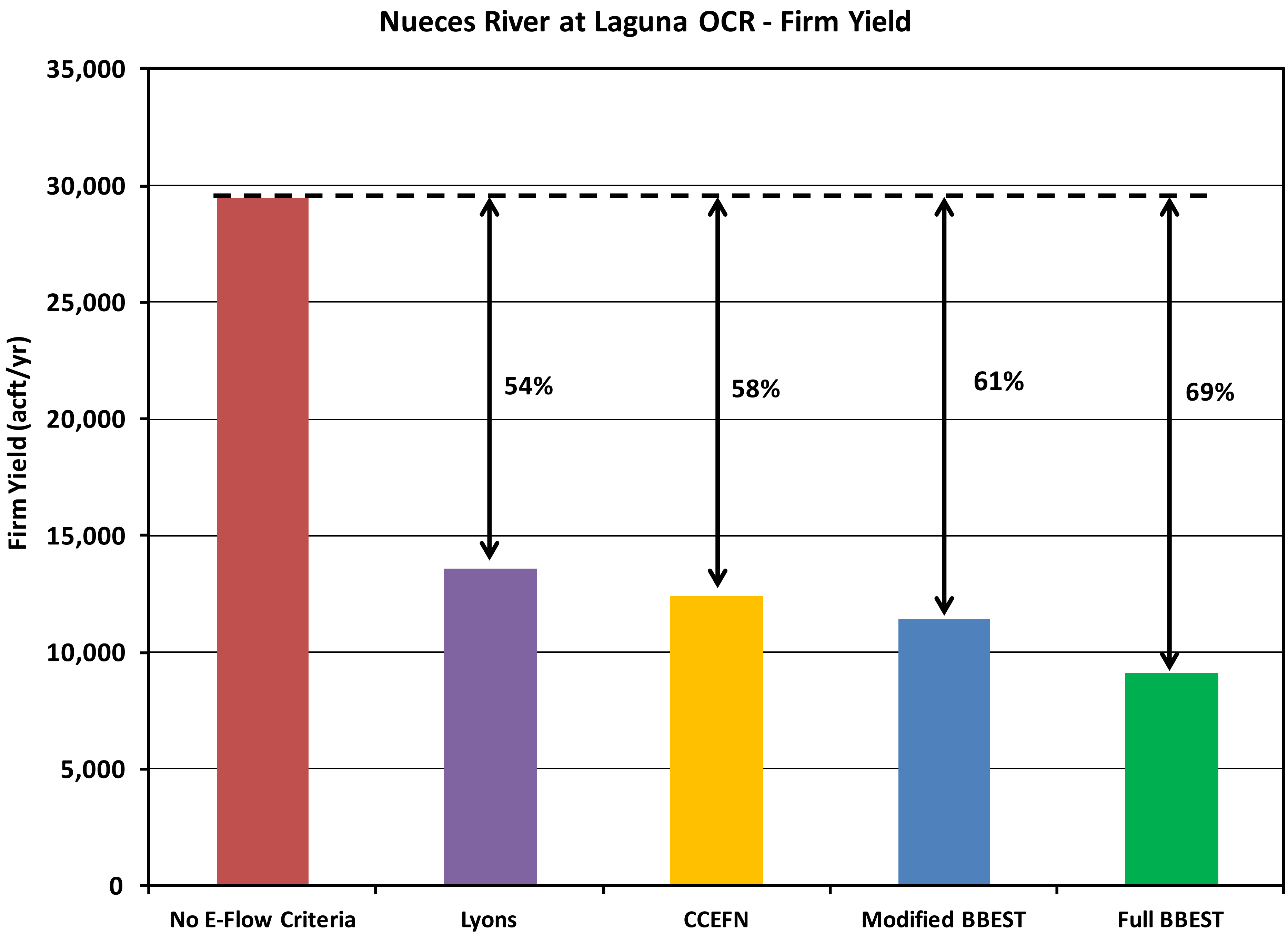


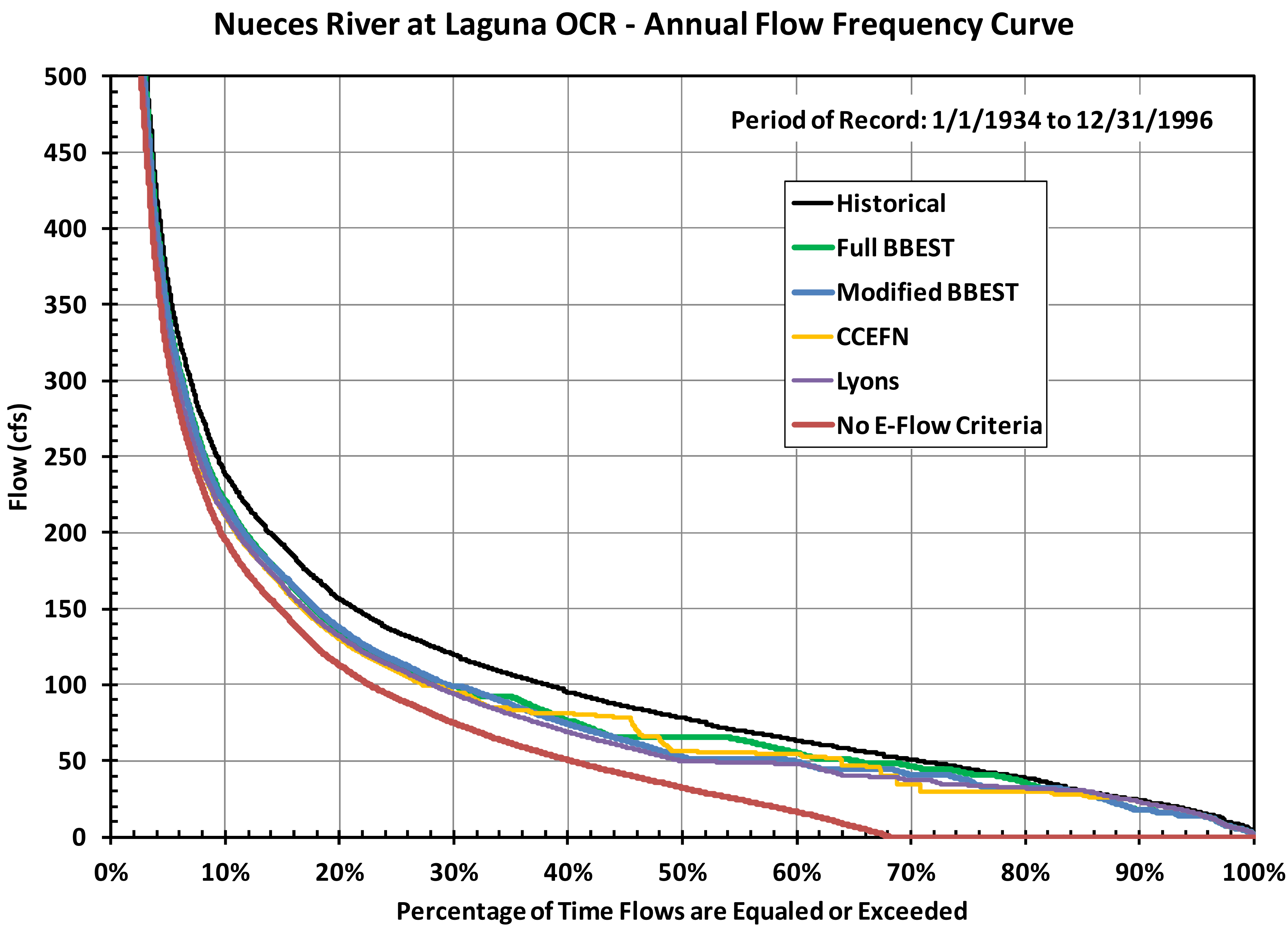
Nueces River at Laguna OCR - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded



Nueces River at Laguna OCR - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded


Nueces River at Laguna OCR - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded


Nueces River at Laguna OCR - Firm Yield
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Firm Yield (acft/yr)
54%
58%
61%
69%
No E-Flow Criteria
Lyons
CCEFN
Modified BBEST
Full BBEST



Nueces River at Laguna OCR - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST
CCEFN
Lyons
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

Nueces River @ Cotulla Hypothetical Projects

- Cotulla Reservoir – On Channel
  - Capacity = 527,000 acft
- Cotulla ROTR – Off Channel
  - Diversion = 400 cfs
  - Capacity = 40,000 acft

Nueces River @ Cotulla - BBEST

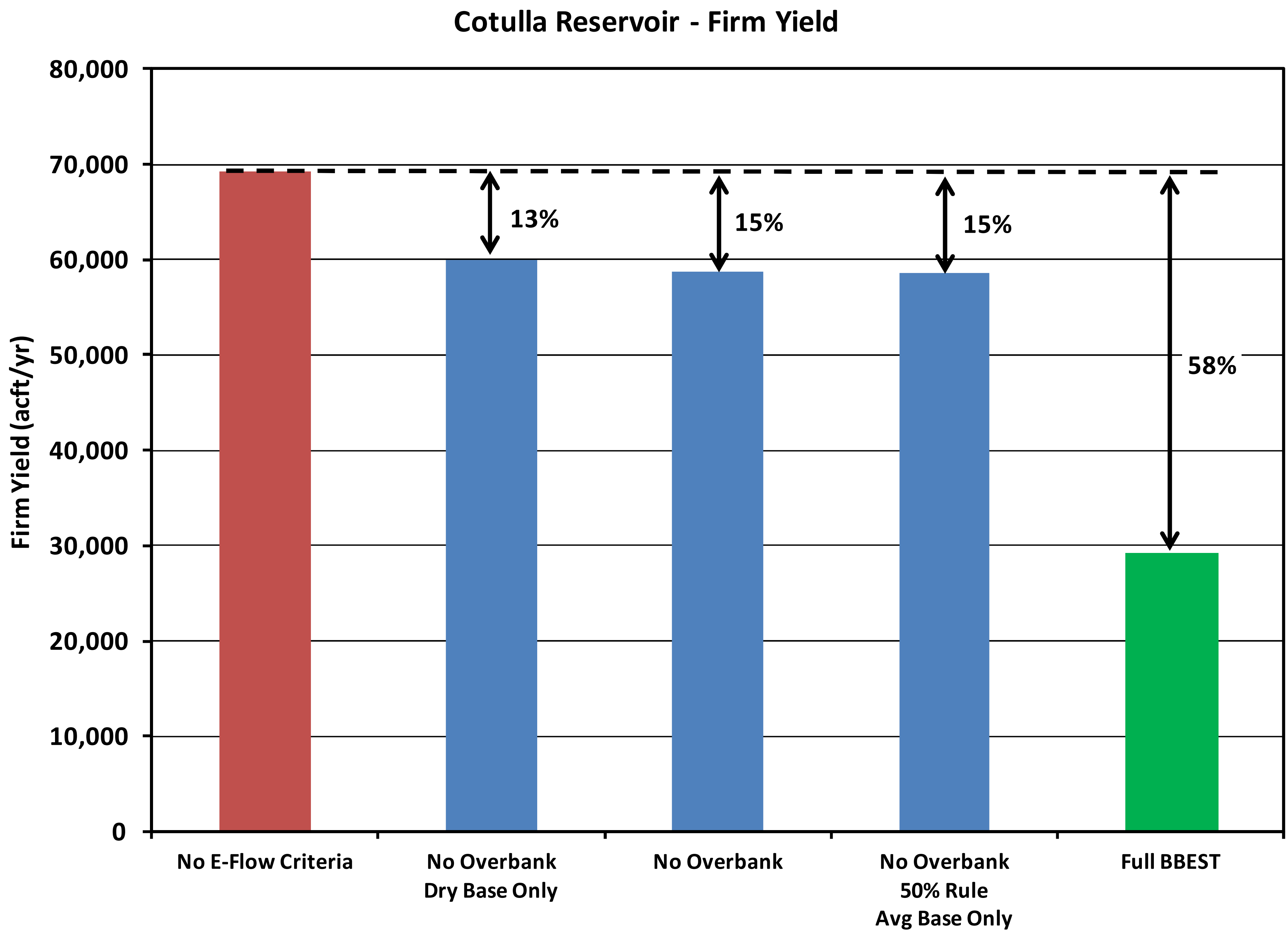
<table>
<tr><td rowspan="4">Overbank Events</td><td colspan="4">Qp: 15,100 cfs with Average Frequency 1 per 5 years
Regressed Volume is 151,000
Duration Bound is 42</td></tr>
<tr><td colspan="4">Qp: 8,410 cfs with Average Frequency 1 per 2 years
Regressed Volume is 80,700
Duration Bound is 38</td></tr>
<tr><td colspan="4">Qp: 4,460 cfs with Average Frequency 1 per year
Regressed Volume is 41,100
Duration Bound is 34</td></tr>
<tr><td colspan="4">Qp: 1,560 cfs with Average Frequency 2 per year
Volume Bound is 24,200
Duration Bound is 28</td></tr>
<tr><td rowspan="3">High Flow Pulses</td><td>Qp: 96 cfs with Average Frequency 1 per season
Volume Bound is 1,570
Duration Bound is 20</td><td>Qp: 1,180 cfs with Average Frequency 1 per season
Volume Bound is 17,200
Duration Bound is 24</td><td>Qp: 100 cfs with Average Frequency 1 per season
Volume Bound is 1,030
Duration Bound is 16</td><td>Qp: 640 cfs with Average Frequency 1 per season
Volume Bound is 8,610
Duration Bound is 26</td></tr>
<tr><td>Qp: 8 cfs with Average Frequency 2 per season
Volume Bound is 100
Duration Bound is 13</td><td>Qp: 190 cfs with Average Frequency 2 per season
Volume Bound is 2,370
Duration Bound is 17</td><td></td><td>Qp: 35 cfs with Average Frequency 2 per season
Volume Bound is 360
Duration Bound is 14</td></tr>
<tr><td></td><td>Qp: 15 cfs with Average Frequency 3 per season
Volume Bound is 150
Duration Bound is 11</td><td></td><td></td></tr>
<tr><td rowspan="3">Base Flows (cfs)</td><td>38</td><td colspan="2">31</td><td>42</td></tr>
<tr><td>6</td><td>10</td><td>7</td><td>15</td></tr>
<tr><td colspan="4">1</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="4">1</td></tr>
<tr><td></td><td>Nov Dec Jan Feb Mar</td><td>Apr May Jun</td><td>Jul Aug</td><td>Sep Oct</td></tr>
<tr><td></td><td>Winter</td><td>Spring</td><td>Summer</td><td>Fall</td></tr>
</table>

Flow Levels	
	High (75th %ile)
	Medium (50th %ile)
	Low (25th %ile)
	Subsistence

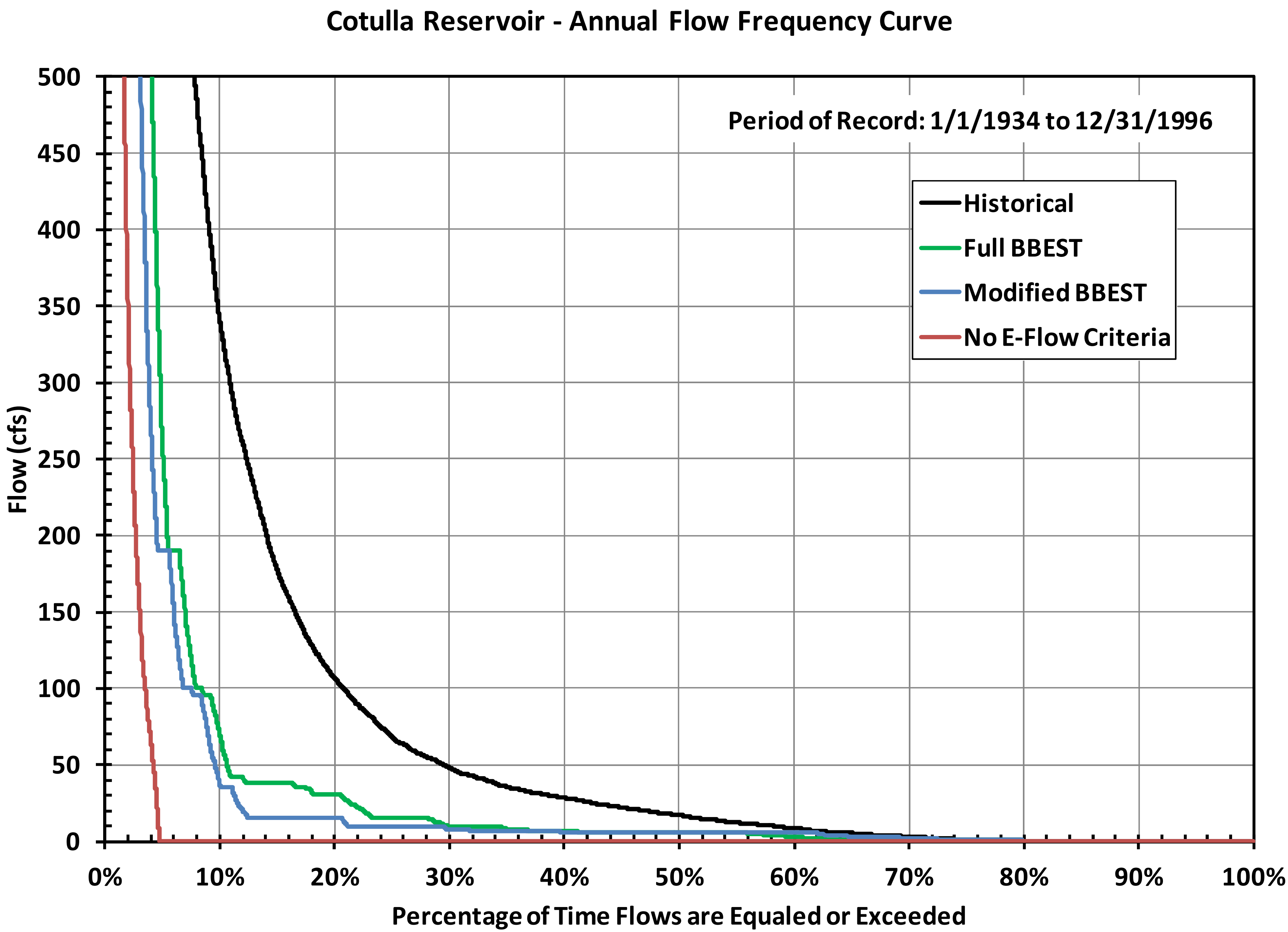
Pulse volumes are in units of acre-feet and durations are in days.
Period of Record used : 1/1/1927 to 12/31/2009.

Cotulla Reservoir

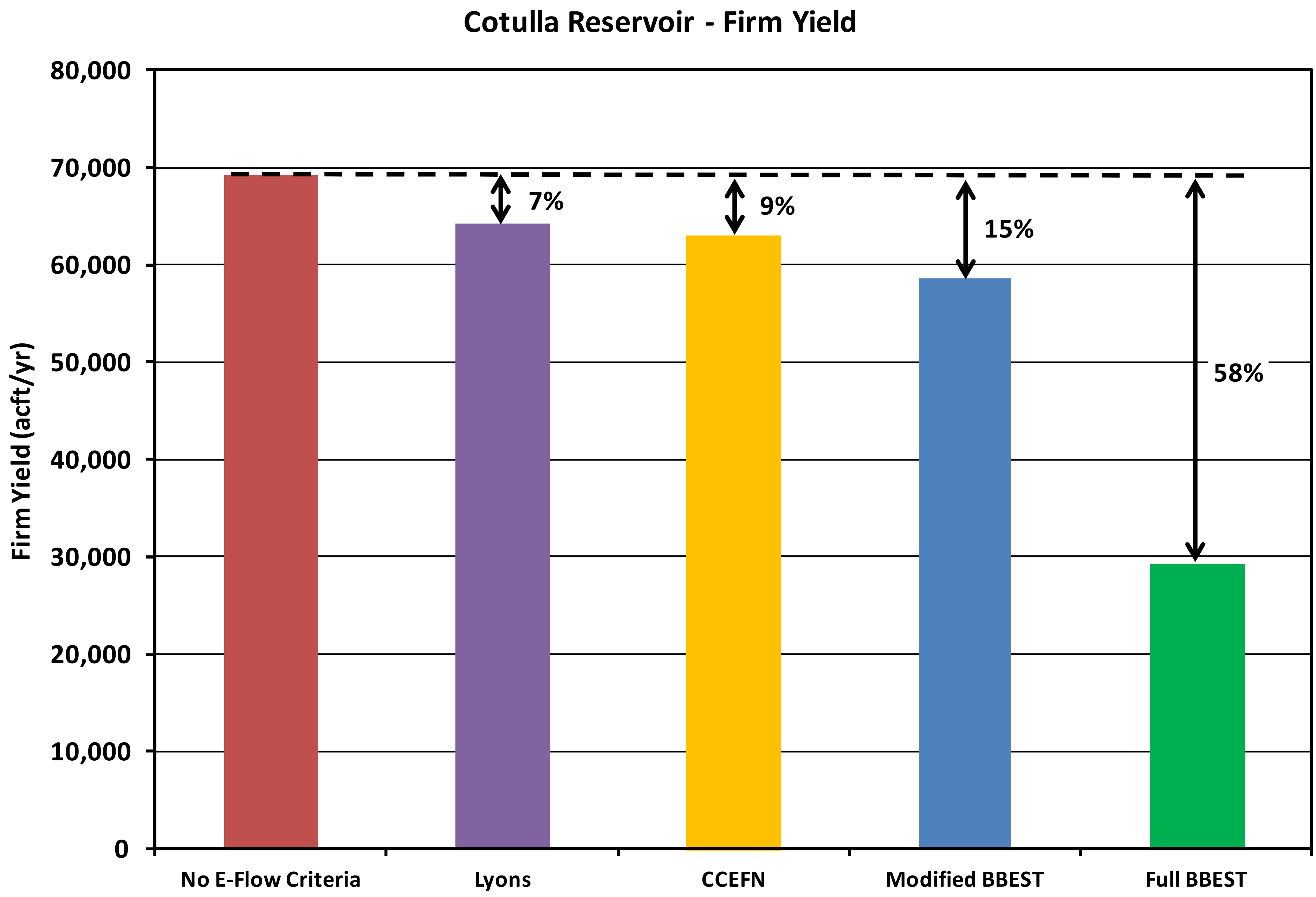
- Flow Criteria Scenarios
  - None
  - Full BBEST
  - Modified BBEST
    - No Overbank Flow Criteria
    - No Overbank with 50% Rule and Avg. Base Flows
    - No Overbank with Dry Base Flows

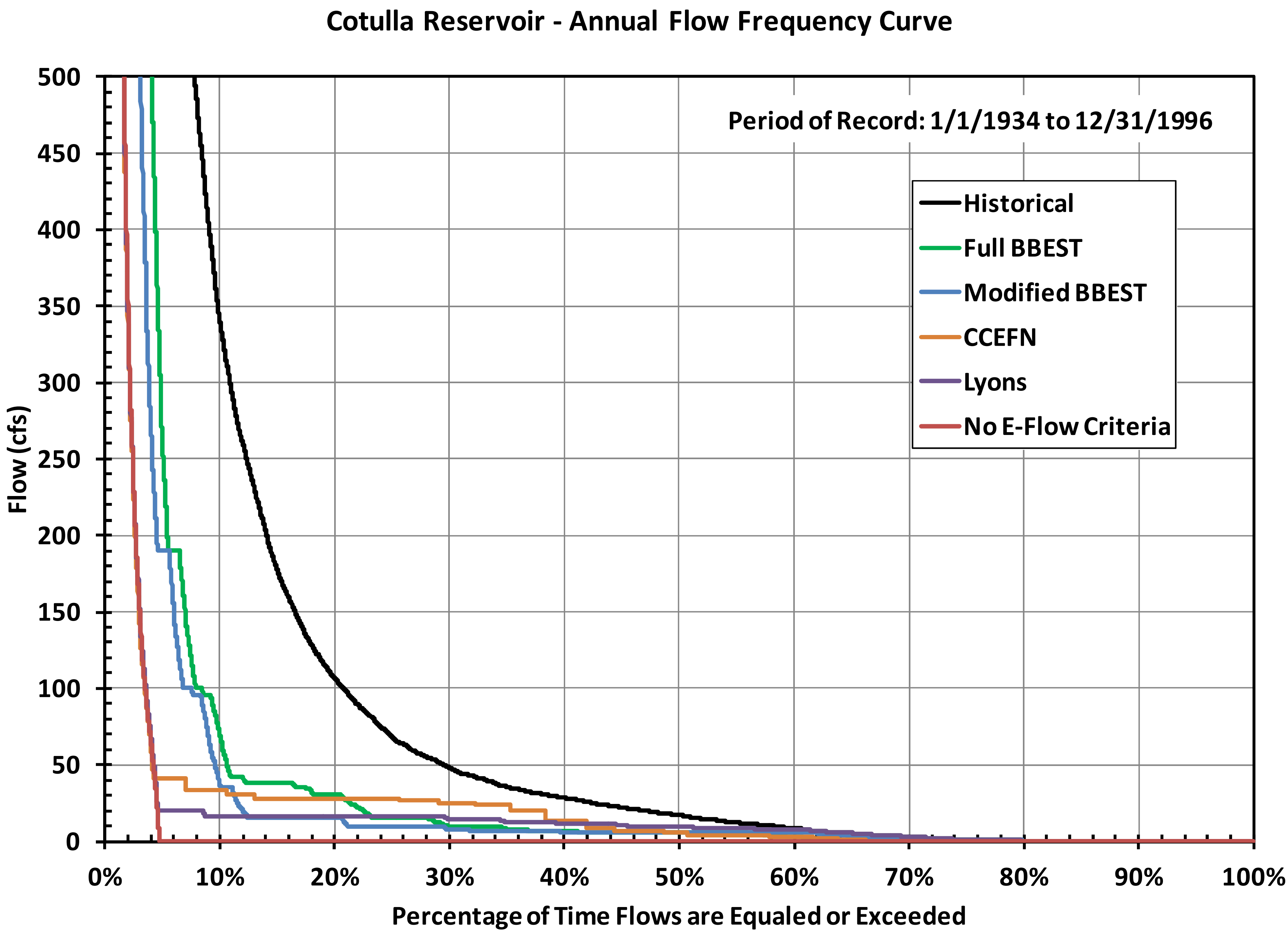


Cotulla Reservoir - Firm Yield
Firm Yield (acft/yr)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
13%
15%
15%
58%
No E-Flow Criteria
No Overbank Dry Base Only
No Overbank
No Overbank 50% Rule Avg Base Only
Full BBEST



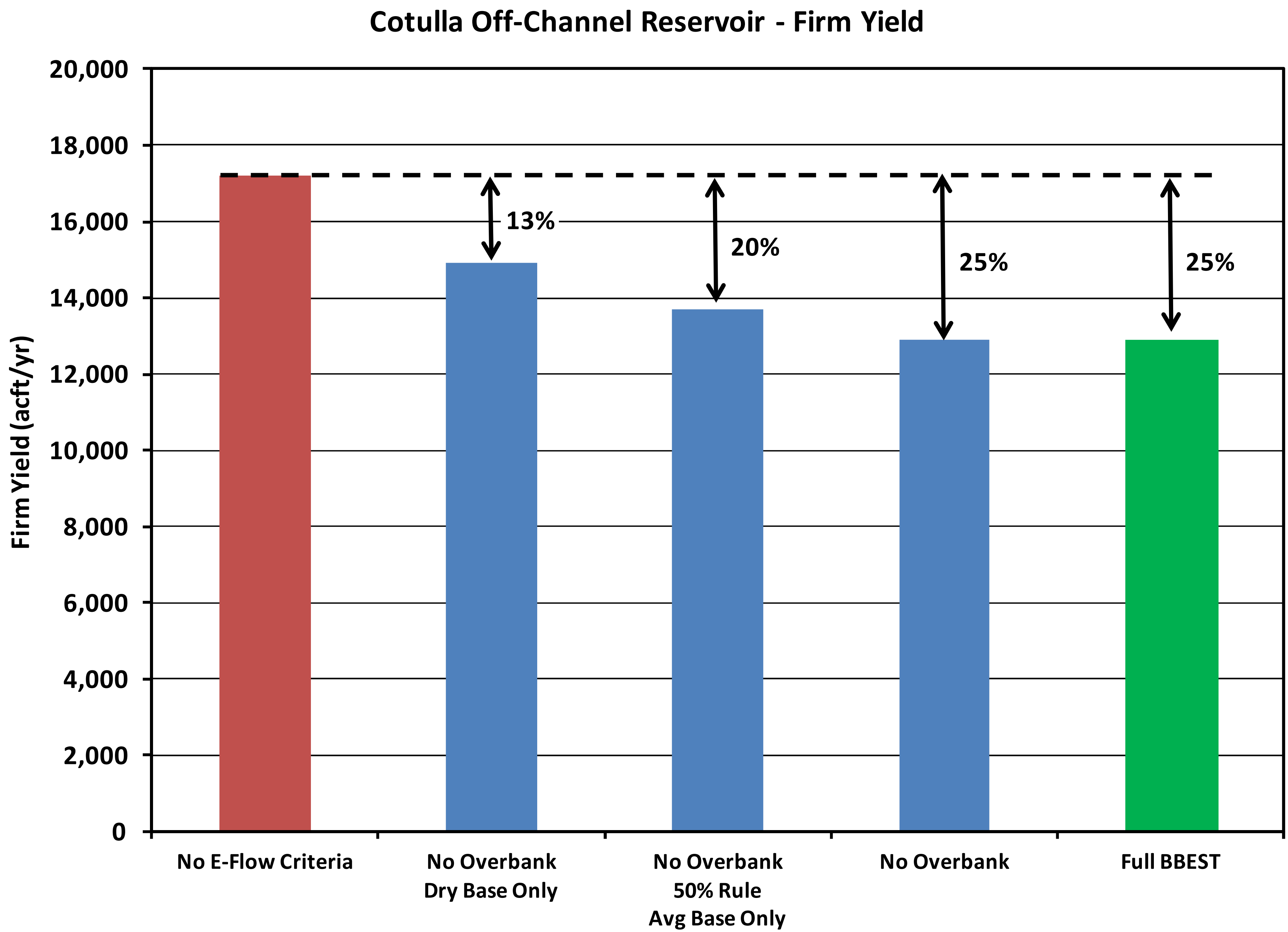
Cotulla Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

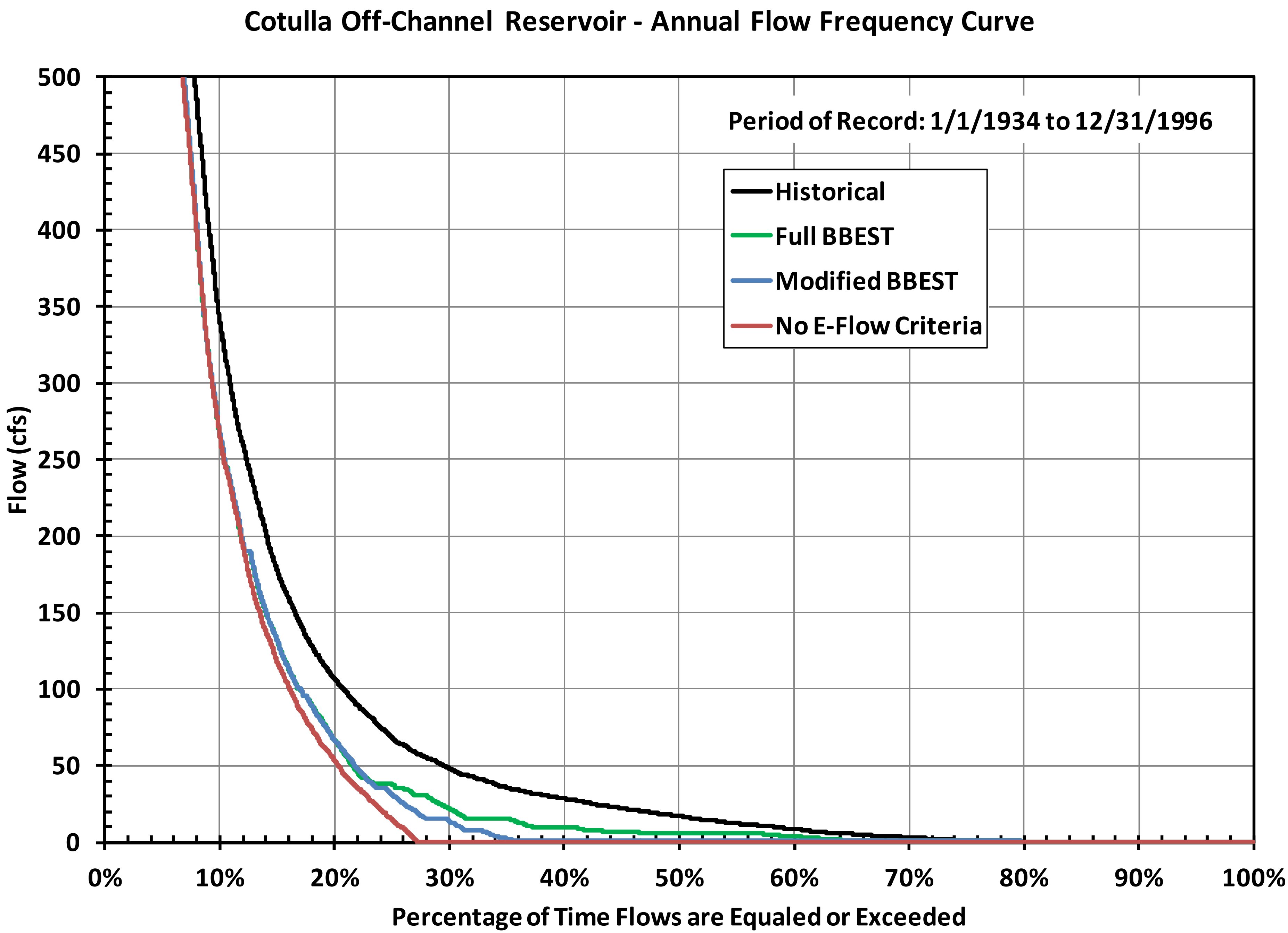

Cotulla Reservoir - Firm Yield
Firm Yield (acft/yr)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
7%
9%
15%
58%
No E-Flow Criteria
Lyons
CCEFN
Modified BBEST
Full BBEST


Cotulla Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST
CCEFN
Lyons
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

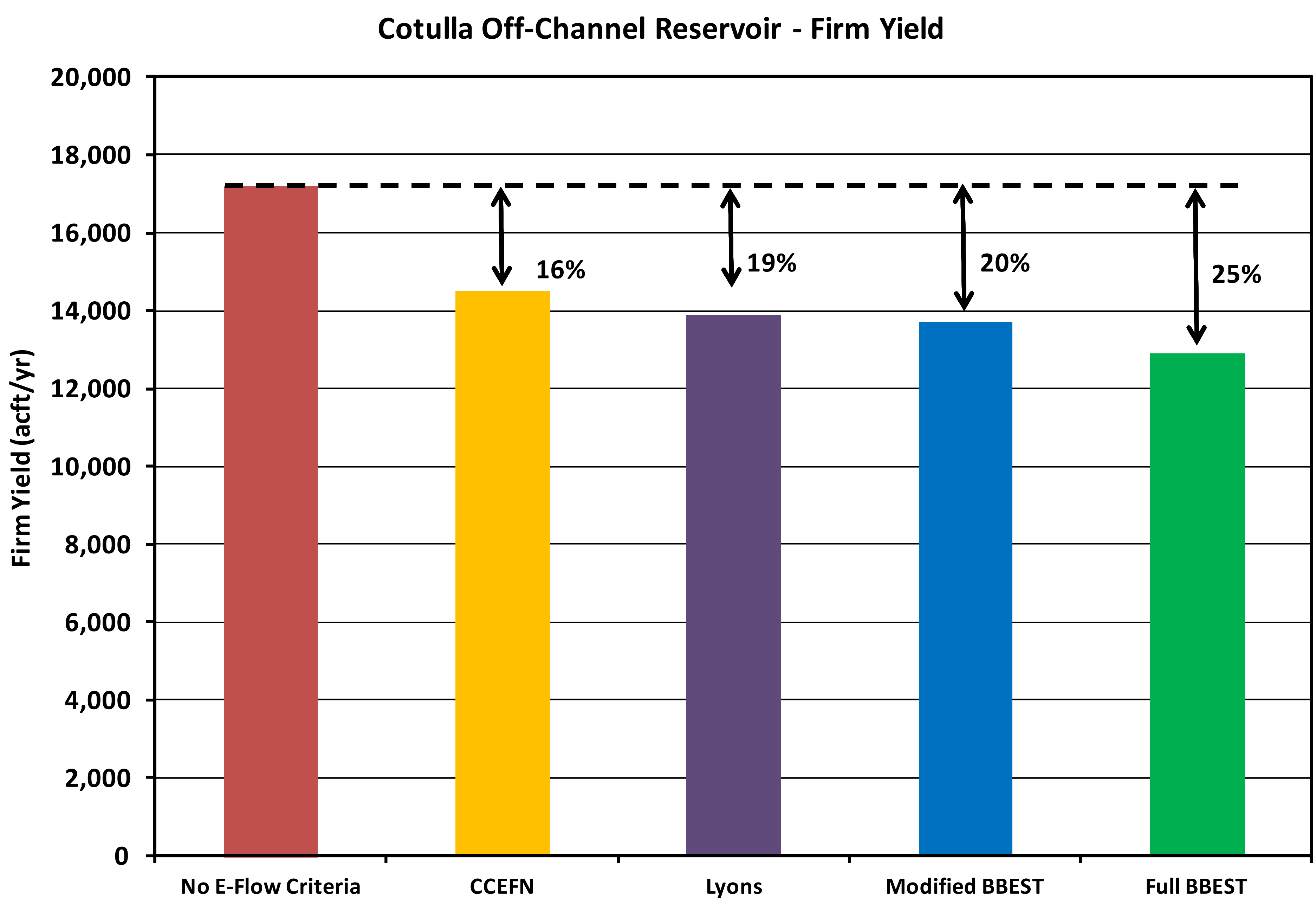
Cotulla ROTR OCR

- Flow Criteria Scenarios
  - None
  - Full BBEST
  - Modified BBEST
    - No Overbank Flow Criteria
    - Pulse Exemption Did Not Qualify
    - No Overbank with 50% Rule and Avg. Base Flows
    - No Overbank with Dry Base Flows

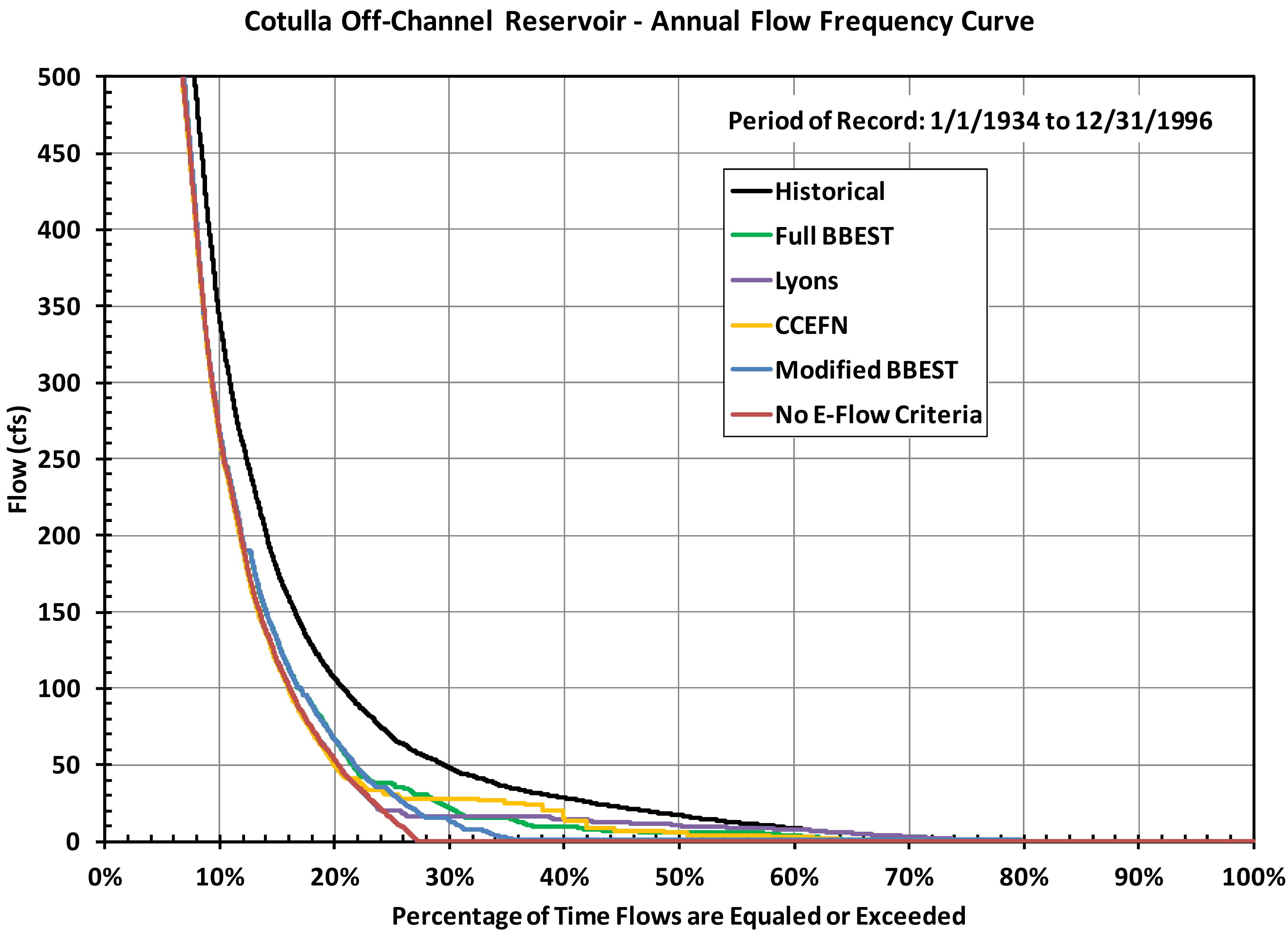

Cotulla Off-Channel Reservoir - Firm Yield
Firm Yield (acft/yr)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
13%
20%
25%
25%
No E-Flow Criteria
No Overbank
Dry Base Only
No Overbank
50% Rule
Avg Base Only
No Overbank
Full BBEST



Cotulla Off-Channel Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded



Cotulla Off-Channel Reservoir - Firm Yield
Firm Yield (acft/yr)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
16%
19%
20%
25%
No E-Flow Criteria
CCEFN
Lyons
Modified BBEST
Full BBEST



Cotulla Off-Channel Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Lyons
CCEFN
Modified BBEST
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

Path Forward

- Proposal for BBASC Instream Environmental Flow Standard Recommendation
  - Modified BBEST
    - Overbank Exemption
    - Pulse Exemption Rule
    - Average Base Flow with 50% Rule
  - BBEST
  - Alternative BBEST modification
- Continue Technical Analysis
  - Coordinate with BBEST to evaluate ecological effects of the Instream Recommendations

Corpus Christi Water Supply Model

- Period of Record 70 years (1934 – 2003)
- Monthly Model
- Change Demand on System
- Change B&E Operations
- Results
  - Bay Inflow
  - Reservoir Storage
  - System Yield

Order Compared to BBEST

2001 TCEQ Agreed Order

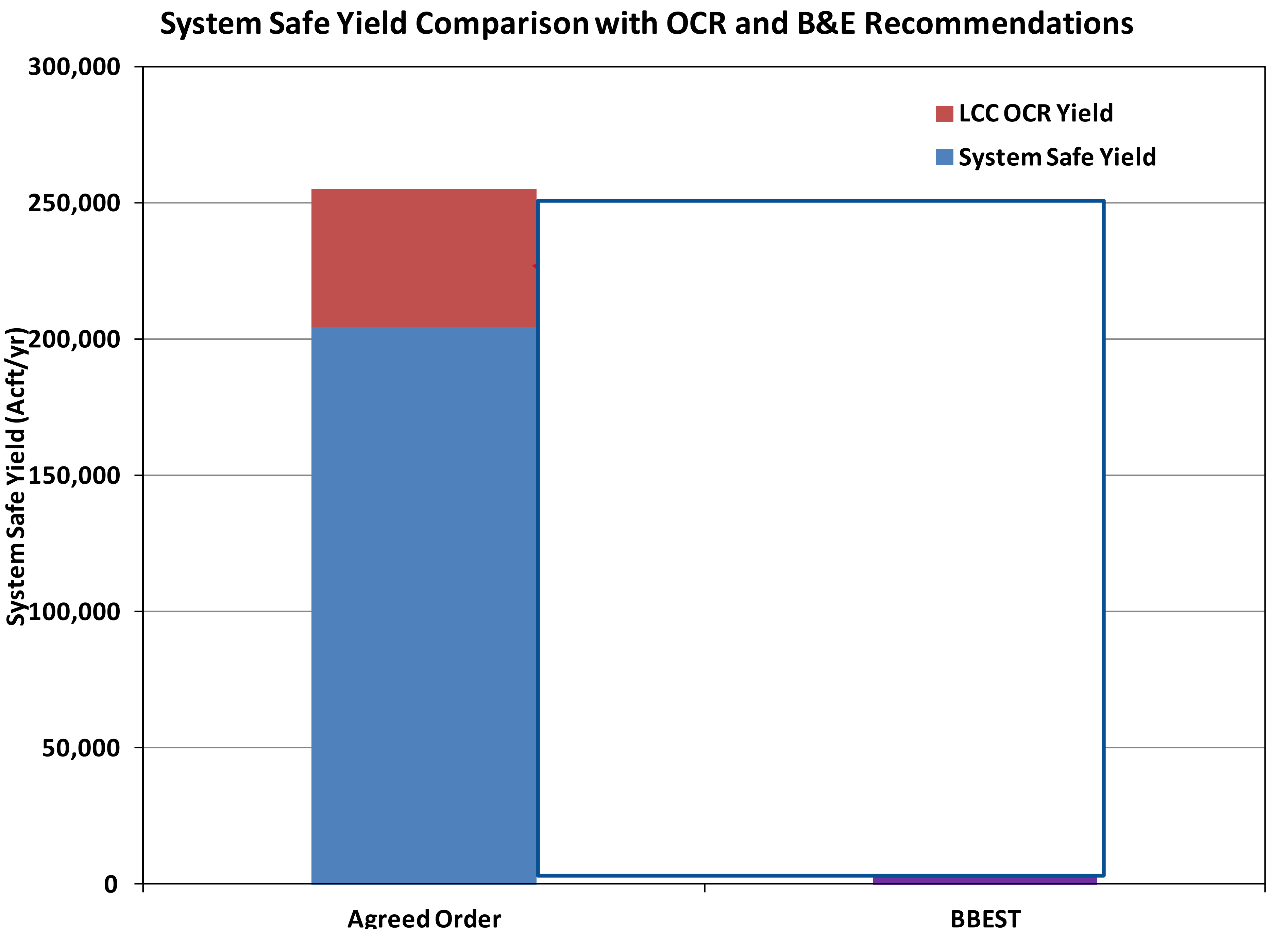
Sys Stor. %	Jan (acft)	Feb (acft)	Mar (acft)	Apr (acft)	May (acft)	Jun (acft)	Jul (acft)	Aug (acft)	Sep (acft)	Oct (acft)	Nov (acft)	Dec (acft)	Ann. (acft)
>70	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500	138,000
70-40	2,500	2,500	3,500	3,500	23,500	23,000	4,500	5,000	11,500	9,000	4,000	4,500	97,000
40-30	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	14,400
>30	0	0	0	0	0	0	0	0	0	0	0	0	0

2011 BBEST Recommendation

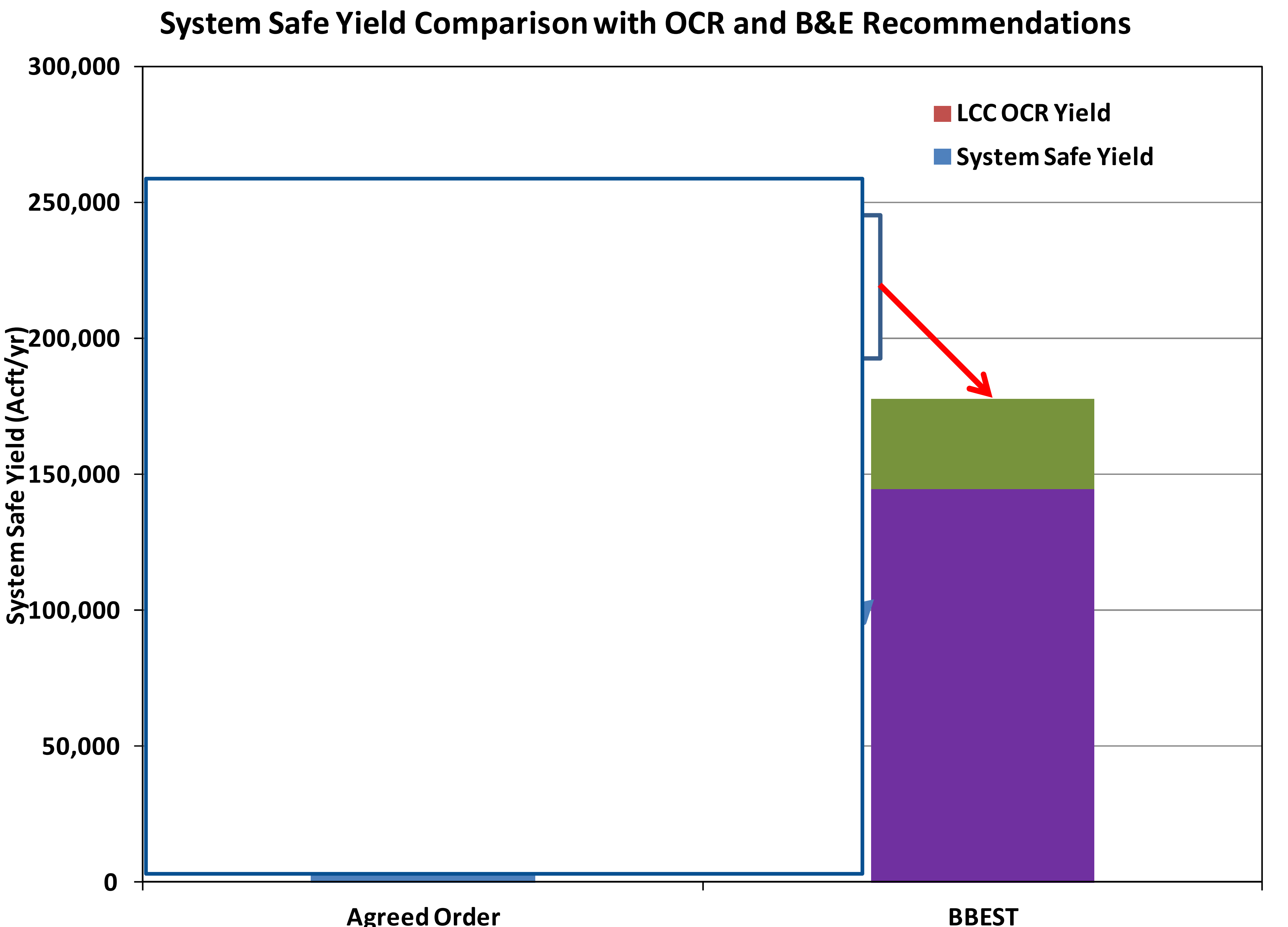
Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations	
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)	Attainment
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000	25%
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000	80%
Subsistence (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000	95%
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct		

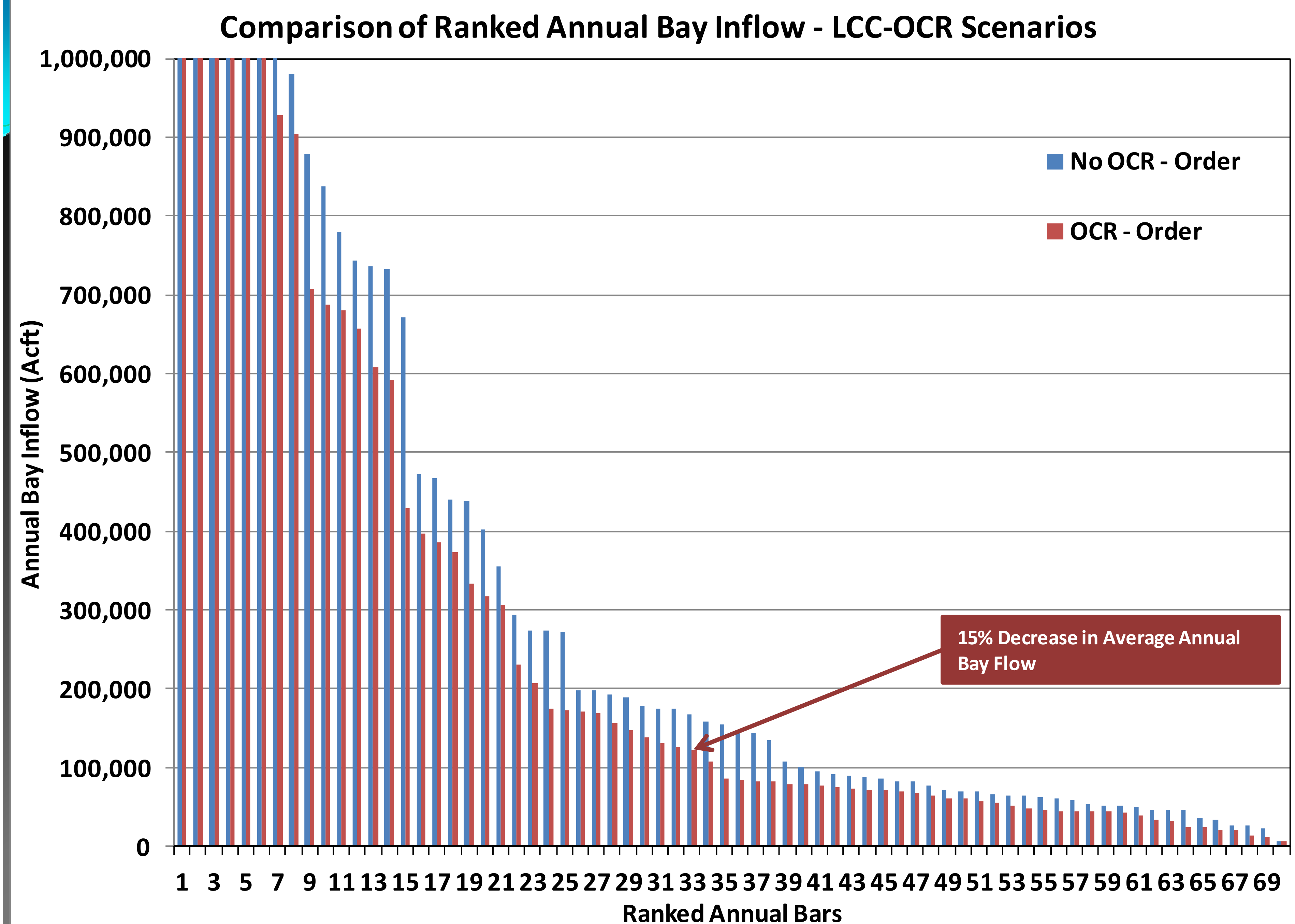
Planned Water Supply Projects

- Lake Corpus Christi – Off Channel Reservoir (LCC – OCR)
- 280,000 acft capacity
- Divert flood flows and top foot of LCC
- Refill LCC trigger at 80 ft-msl.
- Maximum 1,250 cfs diversion rate
- Modeled with
  - Existing TCEQ Agreed Order
  - BBEST Recommendation (Operational)

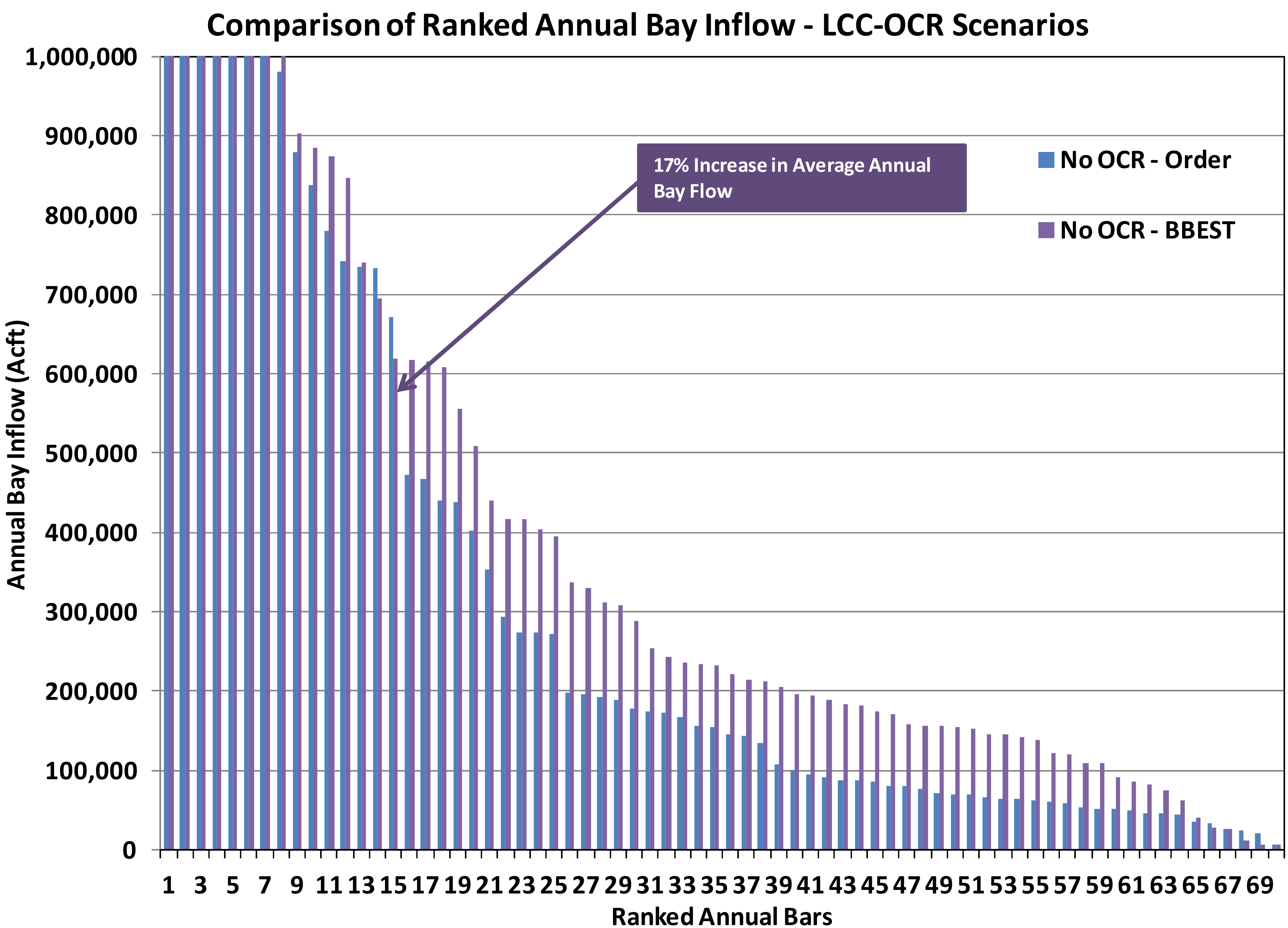


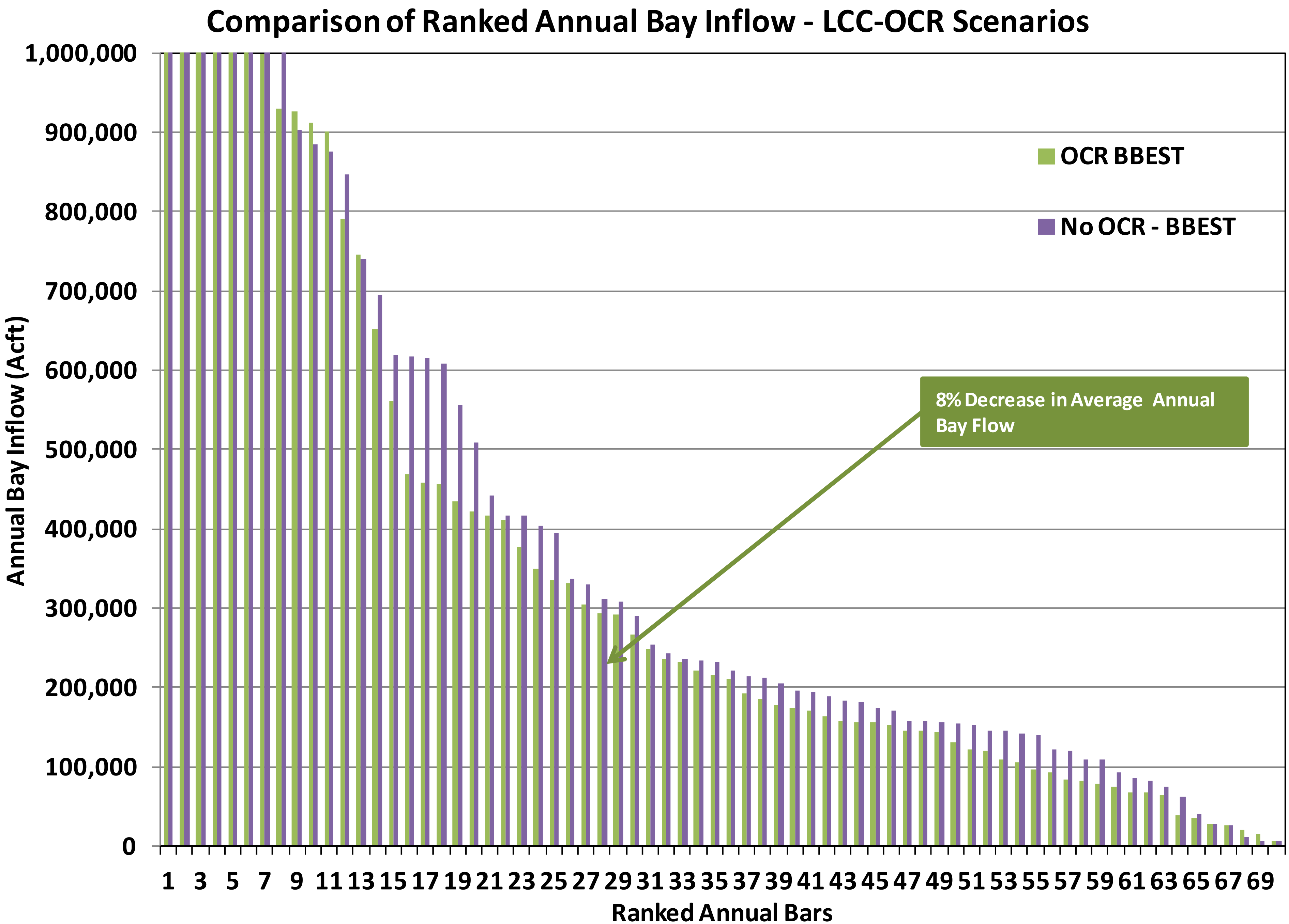
System Safe Yield Comparison with OCR and B&E Recommendations
300,000
250,000
200,000
150,000
100,000
50,000
0
System Safe Yield (Acft/yr)
LCC OCR Yield
System Safe Yield
Agreed Order
BBEST


System Safe Yield Comparison with OCR and B&E Recommendations
300,000
250,000
200,000
150,000
100,000
50,000
0
System Safe Yield (Acft/yr)
LCC OCR Yield
System Safe Yield
Agreed Order
BBEST



Comparison of Ranked Annual Bay Inflow - LCC-OCR Scenarios
Annual Bay Inflow (Acft)
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
No OCR - Order
OCR - Order
15% Decrease in Average Annual Bay Flow
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69
Ranked Annual Bars

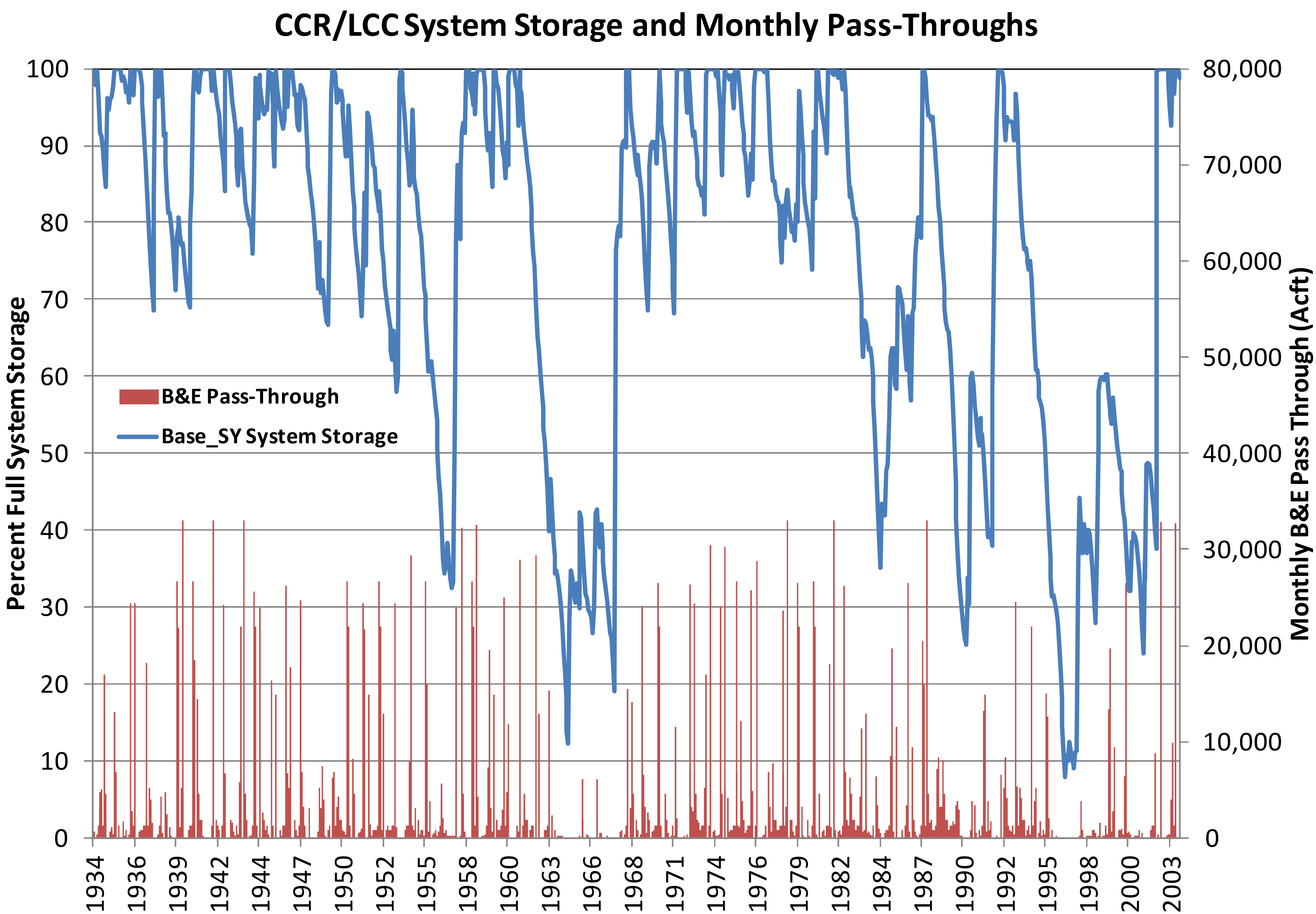

Comparison of Ranked Annual Bay Inflow - LCC-OCR Scenarios
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Annual Bay Inflow (Acft)
17% Increase in Average Annual Bay Flow
No OCR - Order
No OCR - BBEST
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69
Ranked Annual Bars

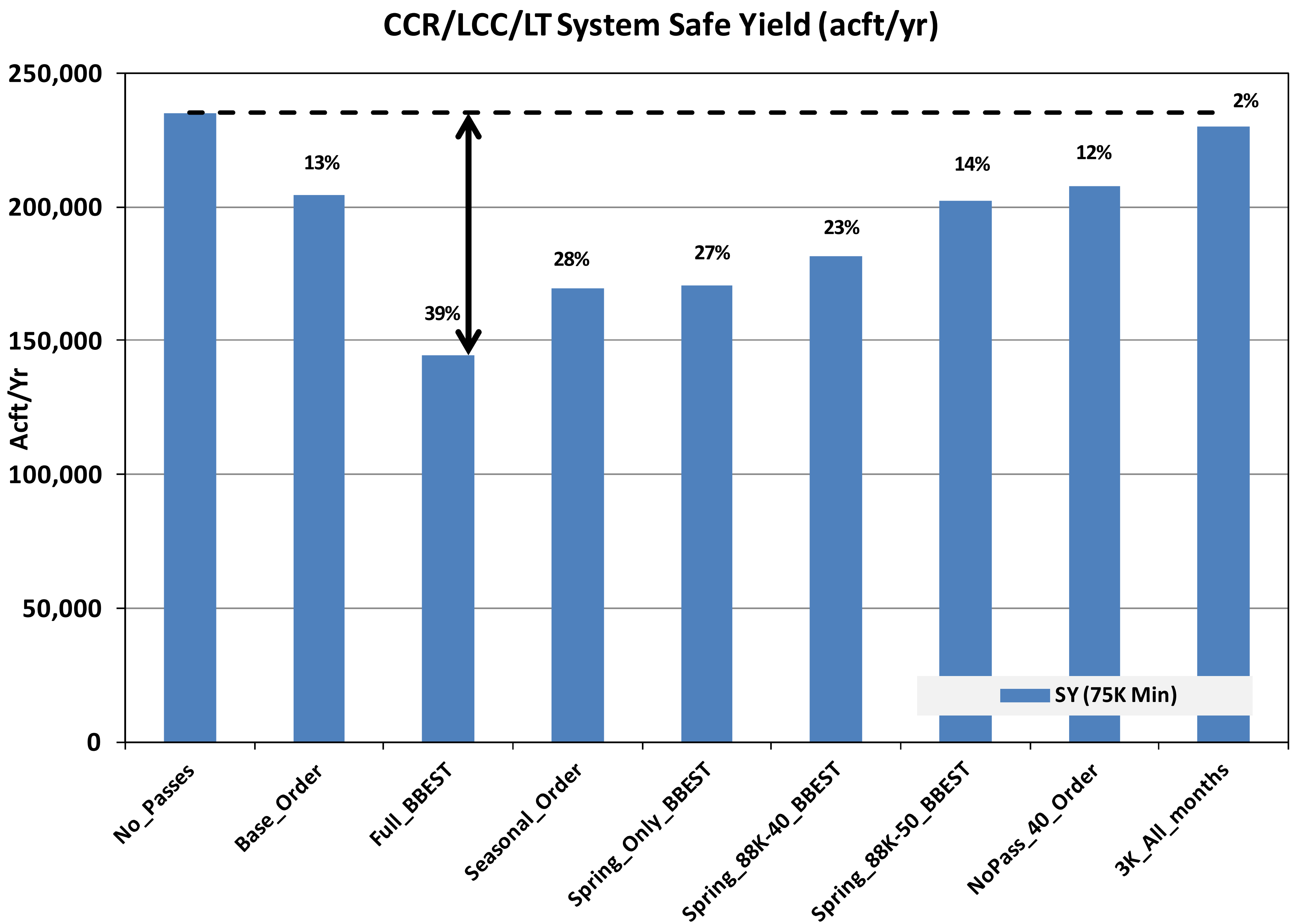


Comparison of Ranked Annual Bay Inflow - LCC-OCR Scenarios
1,000,000
900,000
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Annual Bay Inflow (Acft)
OCR BBEST
No OCR - BBEST
8% Decrease in Average Annual Bay Flow
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69
Ranked Annual Bars

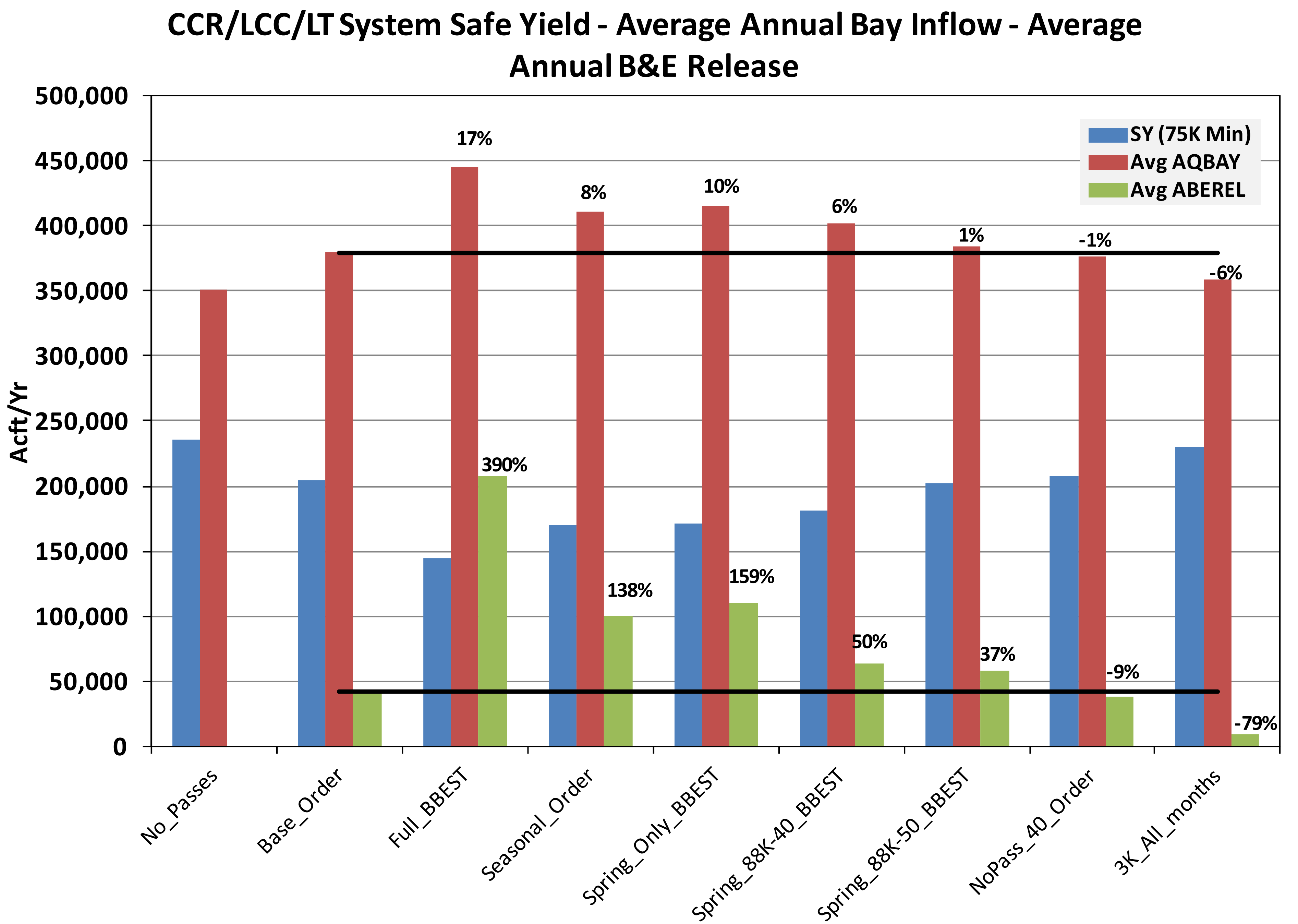
CCWSM Scenarios and B&E Analysis

- Modeled Safe Yield Scenarios (75K Min Stor)
  - No Pass-Throughs
  - Base – Safe Yield – Order
  - Full – BBEST
  - Seasonal – Order
  - Spring Only Targets - BBEST
    - Full BBEST
    - 88,000 – 40%
    - 88,000 – 50%
  - No Pass-Throughs – 40%
  - 3,000 All Months


CCR/LCC System Storage and Monthly Pass-Throughs
Percent Full System Storage
Monthly B&E Pass Through (Acft)
B&E Pass-Through
Base_SY System Storage
100
90
80
70
60
50
40
30
20
10
0
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1934
1936
1939
1942
1944
1947
1950
1952
1955
1958
1960
1963
1966
1968
1971
1974
1976
1979
1982
1984
1987
1990
1992
1995
1998
2000
2003



CCR/LCC/LT System Safe Yield (acft/yr)
250,000
200,000
150,000
100,000
50,000
0
Acft/Yr
13%
39%
28%
27%
23%
14%
12%
2%
SY (75K Min)
No_Passes
Base_Order
Full_BBEST
Seasonal_Order
Spring_Only_BBEST
Spring_88K-40_BBEST
Spring_88K-50_BBEST
NoPass_40_Order
3K_All_months


CCR/LCC/LT System Safe Yield - Average Annual Bay Inflow - Average Annual B&E Release
Acft/Yr
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
SY (75K Min)
Avg AQBAY
Avg ABEREL
17%
8%
10%
6%
1%
-1%
-6%
390%
138%
159%
50%
37%
-9%
-79%
No_Passes
Base_Order
Full_BBEST
Seasonal_Order
Spring_Only_BBEST
Spring_88K-40_BBEST
Spring_88K-50_BBEST
NoPass_40_Order
3K_All_months

Path Forward / Questions?

- Continue Technical Analysis
  - Refine B&E Analysis
  - Provide Flows for TxBLEND Analysis
- Report Compilation

Sabinal Yield Plot with modified BBEST

Sabinal Yield Plot with Streamflows

Agreed Order Compared to BBEST Recommendation

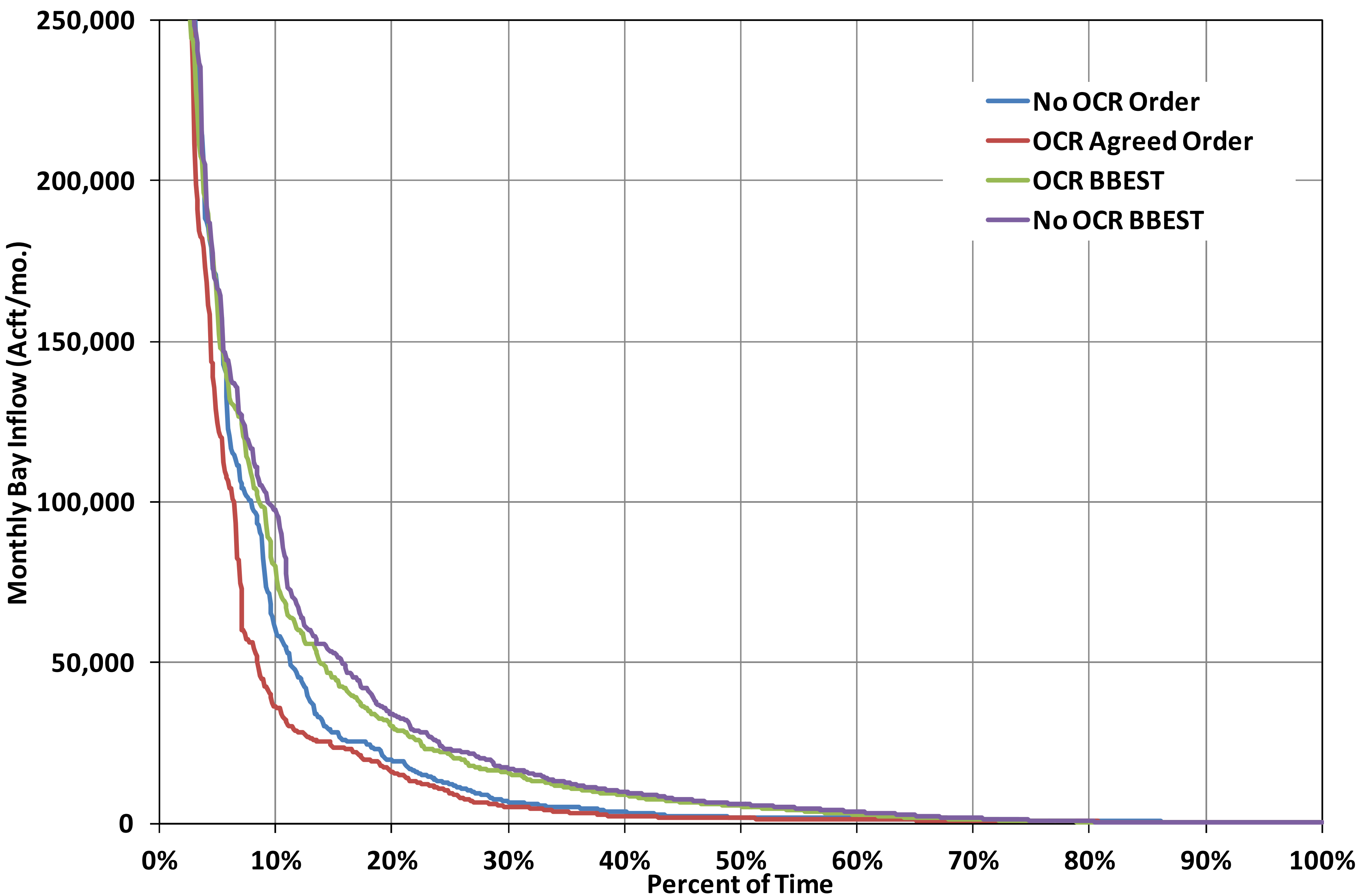
2001 TCEQ Agreed Order

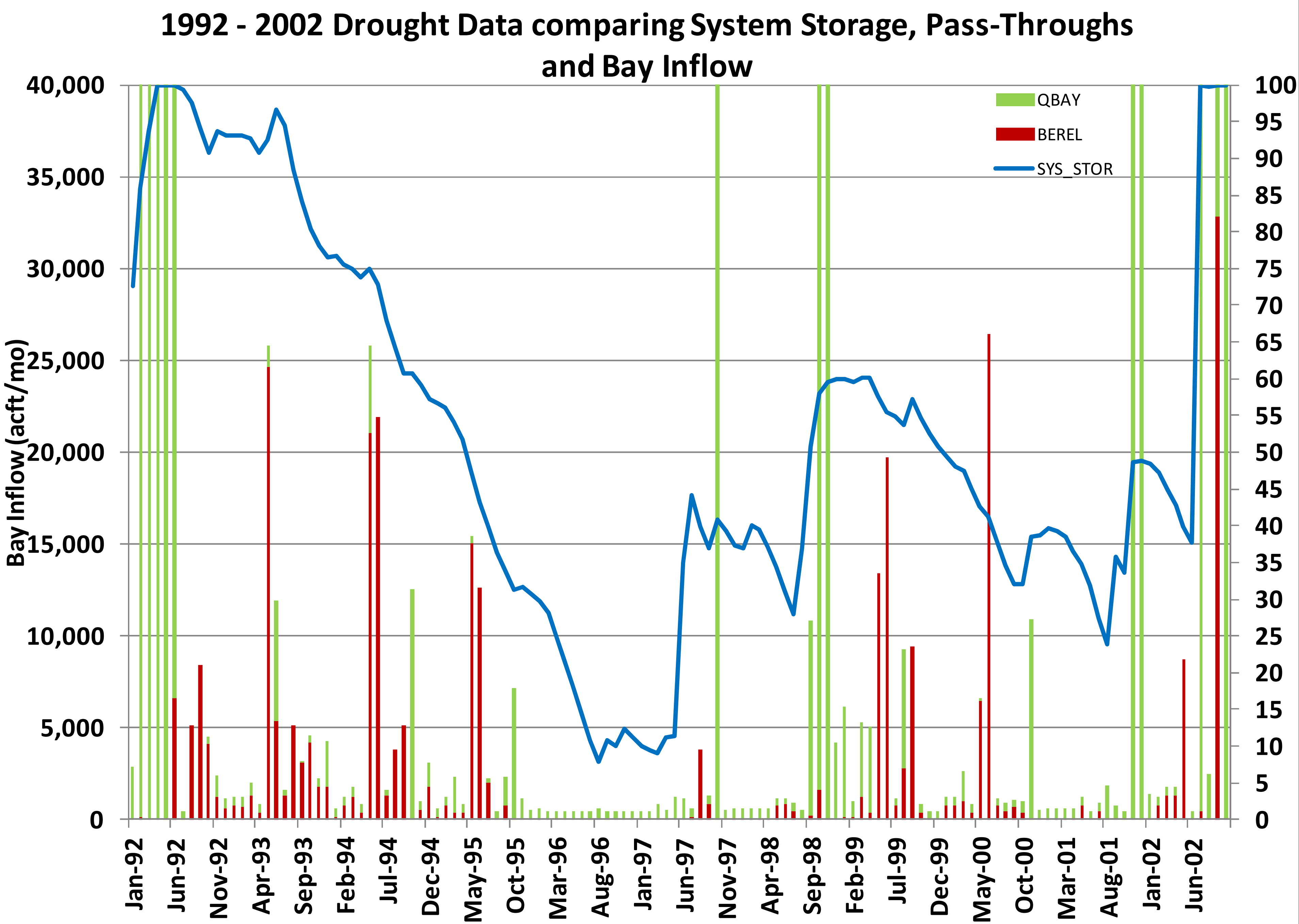
- Operational
- Monthly
- 4 Defined Storage Zones
- Based on System Storage
- Below 30% - No Passes
- Salinity & “Spill Banking” Relief

BBEST Recommendation

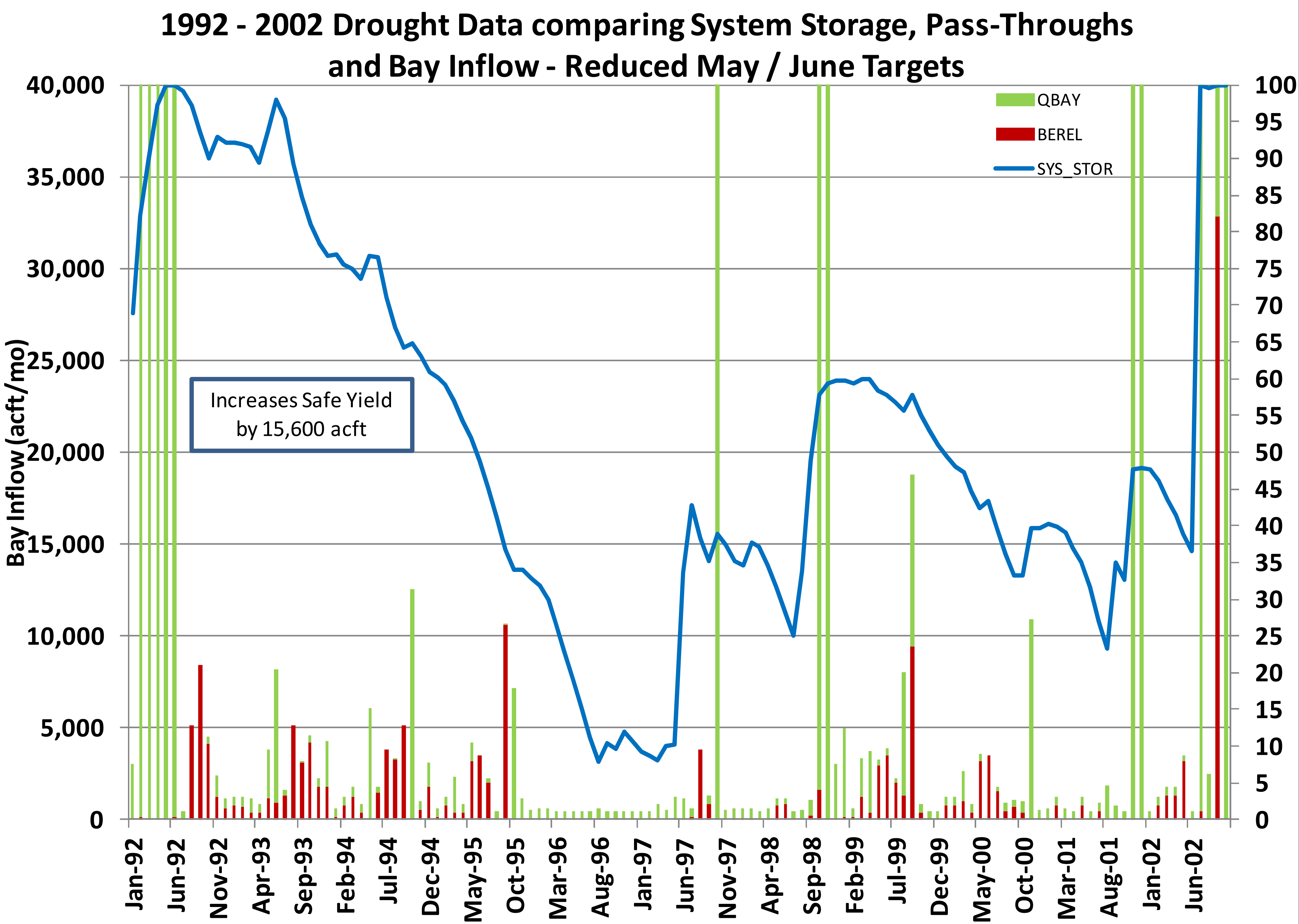
- Long-Term Simulation
- Seasonal
- 3 Hydrologic Conditions
- No Relation to System Storage
- Passes in all Zones
- No Relief Provisions

Frequency Plot of Monthly Bay Inflow - LCC-OCR Scenarios

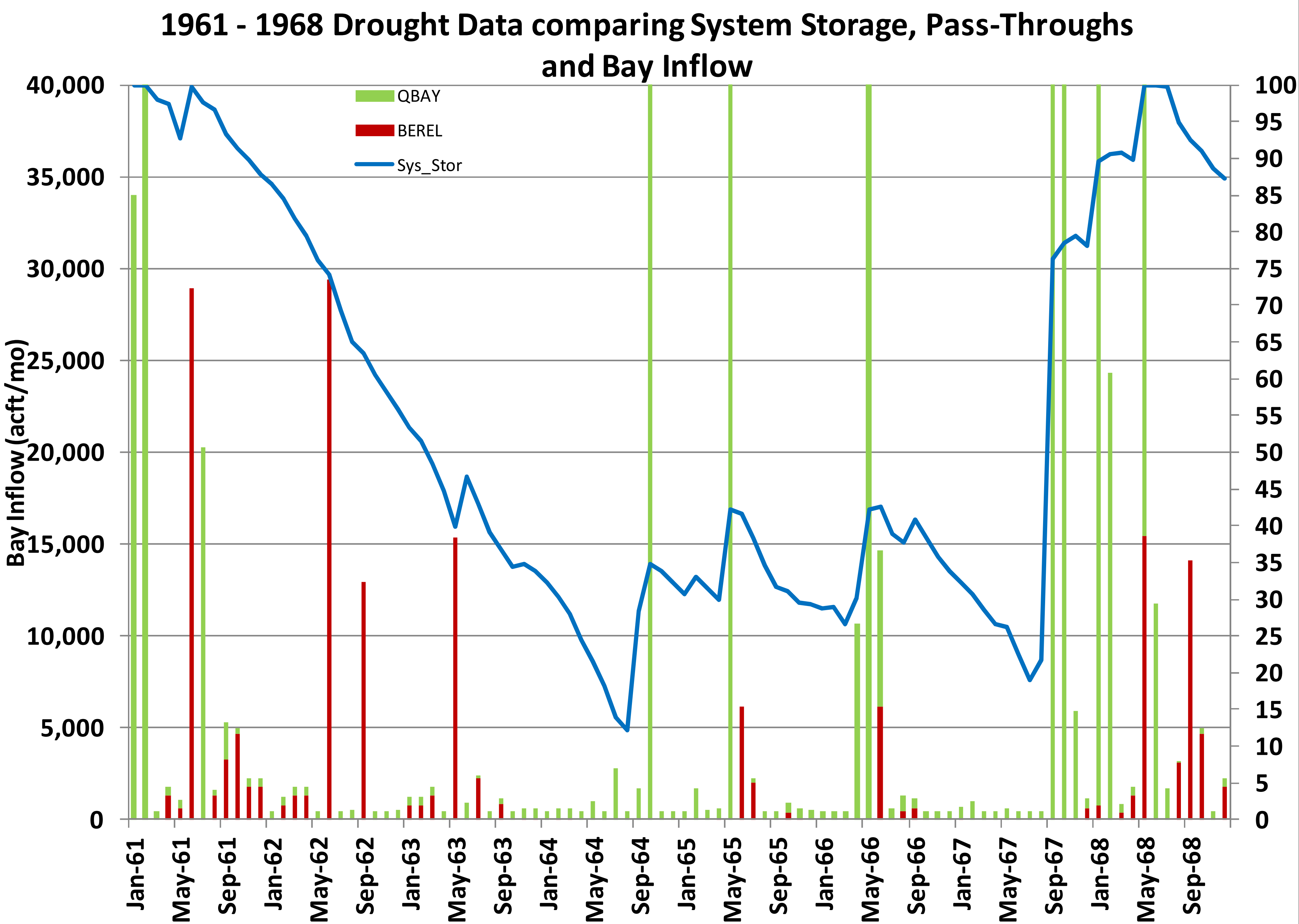




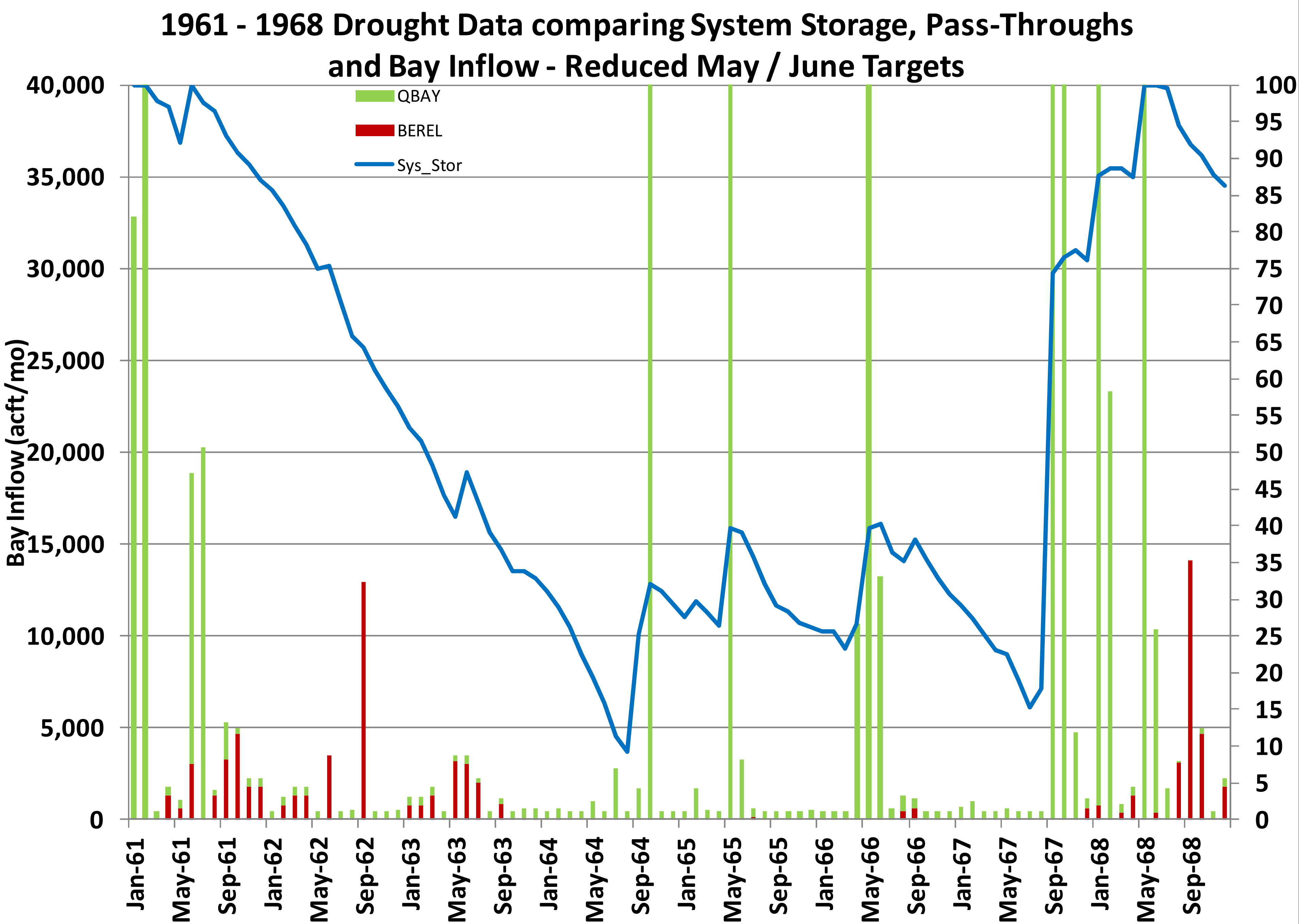
1992 - 2002 Drought Data comparing System Storage, Pass-Throughs and Bay Inflow
Bay Inflow (acft/mo)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
QBAY
BEREL
SYS_STOR
Jan-92
Jun-92
Nov-92
Apr-93
Sep-93
Feb-94
Jul-94
Dec-94
May-95
Oct-95
Mar-96
Aug-96
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02



1992 - 2002 Drought Data comparing System Storage, Pass-Throughs and Bay Inflow - Reduced May / June Targets
Bay Inflow (acft/mo)
QBAY
BEREL
SYS_STOR
Increases Safe Yield by 15,600 acft
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Jan-92
Jun-92
Nov-92
Apr-93
Sep-93
Feb-94
Jul-94
Dec-94
May-95
Oct-95
Mar-96
Aug-96
Jan-97
Jun-97
Nov-97
Apr-98
Sep-98
Feb-99
Jul-99
Dec-99
May-00
Oct-00
Mar-01
Aug-01
Jan-02
Jun-02



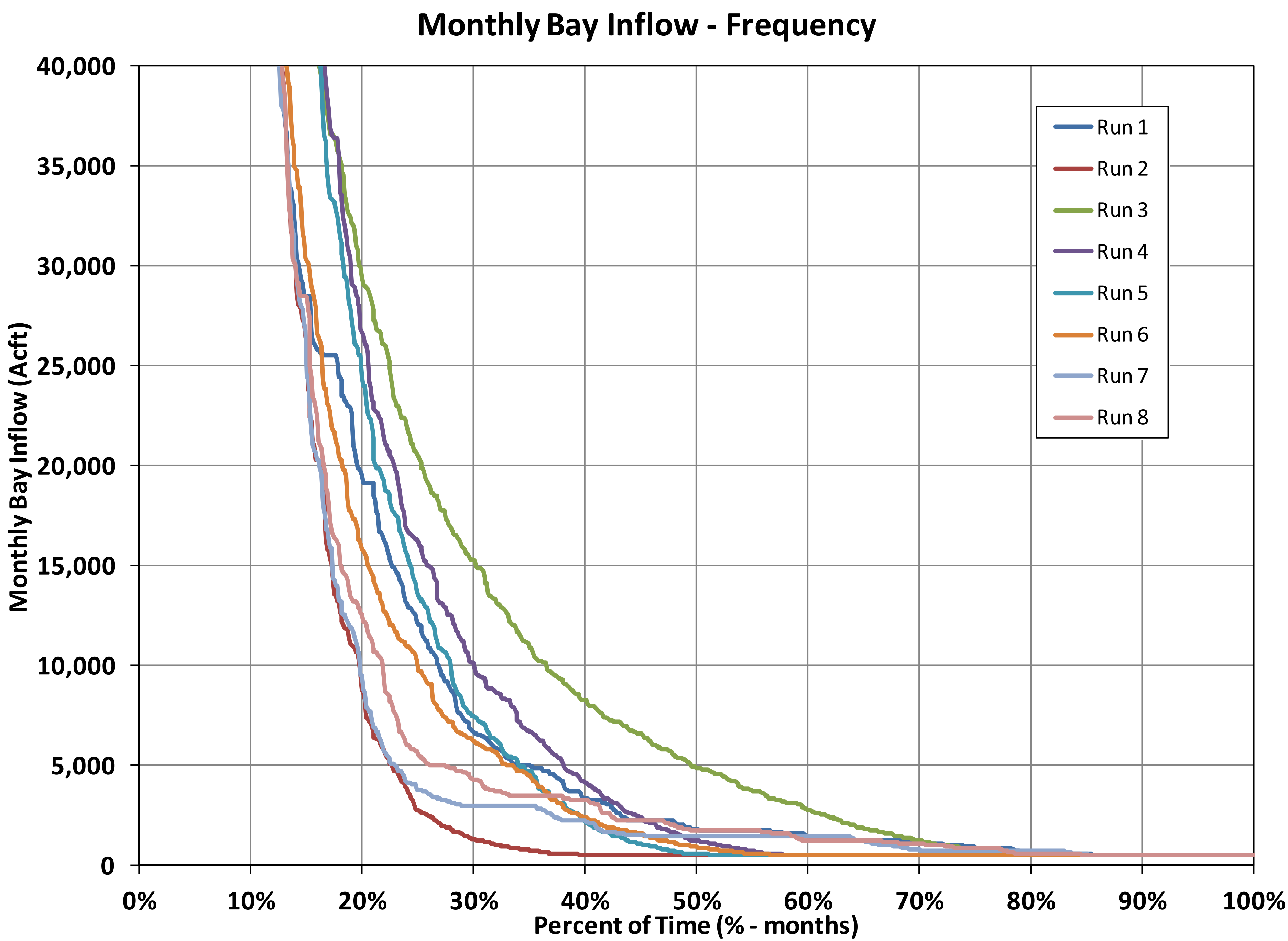
1961 - 1968 Drought Data comparing System Storage, Pass-Throughs and Bay Inflow
QBAY
BEREL
Sys_Stor
Bay Inflow (acft/mo)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Jan-61
May-61
Sep-61
Jan-62
May-62
Sep-62
Jan-63
May-63
Sep-63
Jan-64
May-64
Sep-64
Jan-65
May-65
Sep-65
Jan-66
May-66
Sep-66
Jan-67
May-67
Sep-67
Jan-68
May-68
Sep-68


1961 - 1968 Drought Data comparing System Storage, Pass-Throughs and Bay Inflow - Reduced May / June Targets
QBAY
BEREL
Sys_Stor
Bay Inflow (acft/mo)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
Jan-61
May-61
Sep-61
Jan-62
May-62
Sep-62
Jan-63
May-63
Sep-63
Jan-64
May-64
Sep-64
Jan-65
May-65
Sep-65
Jan-66
May-66
Sep-66
Jan-67
May-67
Sep-67
Jan-68
May-68
Sep-68

Scenario Results

- Yield vs. Avg. Annual Bay Inflow

Run #	Run Description	SY (75K Min)	Avg AQBAY
1	Base_SY	204,449	379,284
2	No_PT	235,001	350,800
3	Seasonal_order	169,691	410,454
4	Spring_target	170,889	415,491
5	Summer_Tar	180,960	405,900
6	Winter_Tar	213,264	372,547
7	3K_All_months	230,089	358,019
8	Reduced may June	220,110	364,423



Monthly Bay Inflow - Frequency
Monthly Bay Inflow (Acft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time (% - months)
Run 1
Run 2
Run 3
Run 4
Run 5
Run 6
Run 7
Run 8

Updates on Modeling Efforts of Nueces BBASC Technical Consultant

Presentation to Nueces BBASC
Sam Vaugh, PE
Cory Shockley, PE – HDR Engineering
May 23, 2012

April 23rd Discussion

- Instream Flow
  - Planned Water Supply Project Evaluations
    - Sabinal Recharge Dam
  - Standard and Strategy Evaluation
    - Nueces River @ Laguna
    - Nueces River @ Cotulla
  - Yield vs. e-flow regime
    - Recommendation
      - Develop Modified BBEST W
      - Ecological and sediment analysis
        - Modified BBEST A
        - Modified BBEST W

April 23rd Discussion

- Nueces Bay & Delta
  - Planned Water Supply Project Evaluations
    - Lake Corpus Christi Off Channel Reservoir
  - B&E Scenario Evaluation
    - Yield
    - Average Bay Inflow
  - Path Forward
    - Evaluate scenarios to recommend attainment frequencies of meeting the BBEST targets that allow for the balance for human needs.

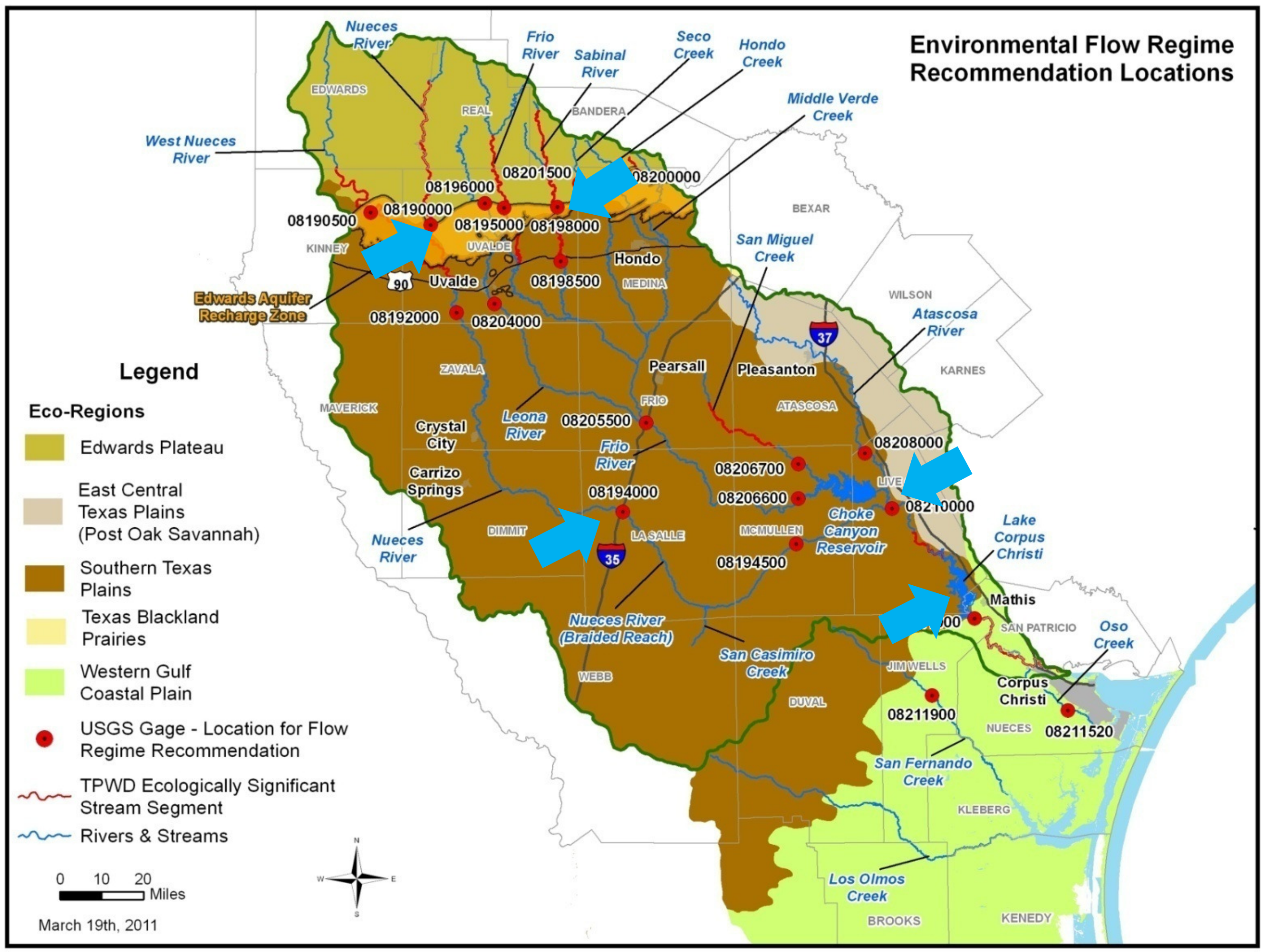
Discussion

- Instream Flow
  - HDR
    - Summary of April 23rd Analysis
    - Presentation of Modified BBEST W
  - BBEST
    - Presentation of Aquatic Habitat Analysis
  - TWDB
    - Presentation of Sediment Analysis
- BBASC vote to adopt an e-flow regime

Discussion

- Nueces Bay & Delta
  - B&E Scenario Evaluation
    - BBEST Recommendation
    - Agreed Order Safe Yield
    - No Pass-Thru's
    - OCR Order Safe Yield
  - Yield
  - Attainment Frequencies
  - Salinity
- BBASC vote to adopt an e-flow regime

Focal Sites for BBASC Instream Flow Standard Recommendations



R:\09109-140890 N BBEST\GIS\BBEST_Nueces_031911_ver1.mxd

Defined – Modified BBEST

- Overbank Exemption
- Pulse Exemption Rule
  - diversion rate < 20% of the flow pulse trigger
  - 20% rule not applicable to on-channel reservoirs
- Single Tier of Base Flows with 50% Rule
  - Diversions may not exceed 50% of the difference between the base flow and the subsistence flow.
  - Evaluated Wet and Average Base Flow Tiers

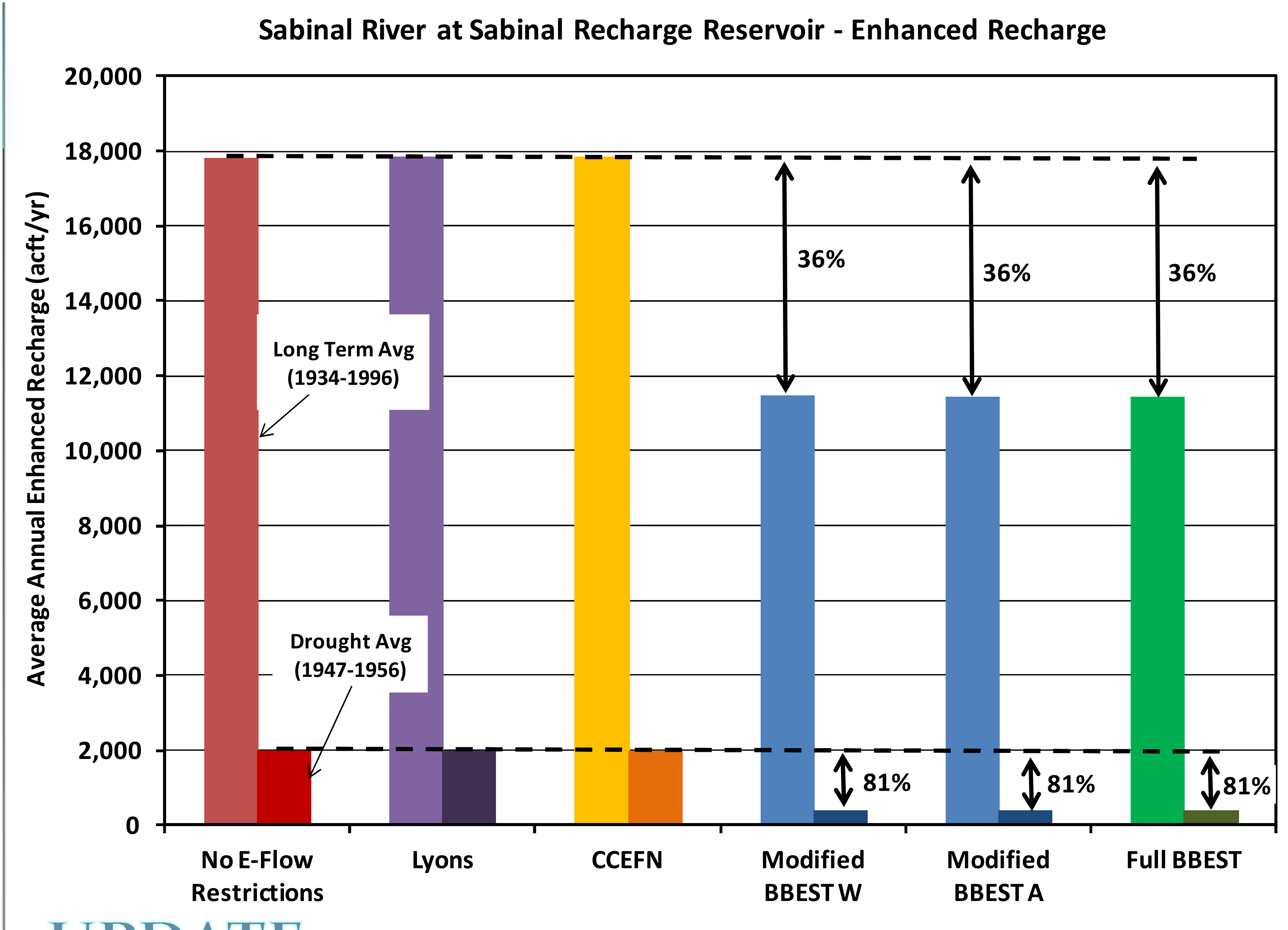
Sabinal River near Sabinal

	Winter (Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug, Sep)	Fall (Oct, Nov)
High Flow Pulses	Qp: 5,200 cfs with Average Frequency 1 per 5 years Regressed Volume is 46,200 Duration Bound is 75			
High Flow Pulses	Qp: 2,350 cfs with Average Frequency 1 per 2 years Regressed Volume is 20,000 Duration Bound is 54			
High Flow Pulses	Qp: 1,020 cfs with Average Frequency 1 per year Regressed Volume is 8,290 Duration Bound is 38			
High Flow Pulses	Qp: 330 cfs with Average Frequency 2 per year Volume Bound is 5,420 Duration Bound is 24			
High Flow Pulses	Qp: 62 cfs with Average Frequency 1 per season Volume Bound is 1,530 Duration Bound is 17	Qp: 180 cfs with Average Frequency 1 per season Volume Bound is 2,210 Duration Bound is 15	Qp: 100 cfs with Average Frequency 1 per season Volume Bound is 1,180 Duration Bound is 12	Qp: 53 cfs with Average Frequency 1 per season Volume Bound is 840 Duration Bound is 12
High Flow Pulses		Qp: 64 cfs with Average Frequency 2 per season Volume Bound is 750 Duration Bound is 10	Qp: 11 cfs with Average Frequency 2 per season Volume Bound is 130 Duration Bound is 5	
High Flow Pulses		Qp: 22 cfs with Average Frequency 3 per season Volume Bound is 240 Duration Bound is 6		
Base Flows (cfs) – High	35	35	29	35
Base Flows (cfs) – Medium	21	21	13	21
Base Flows (cfs) – Low	11	8	3	10
Subsistence Flows (cfs)	1	1	1	1

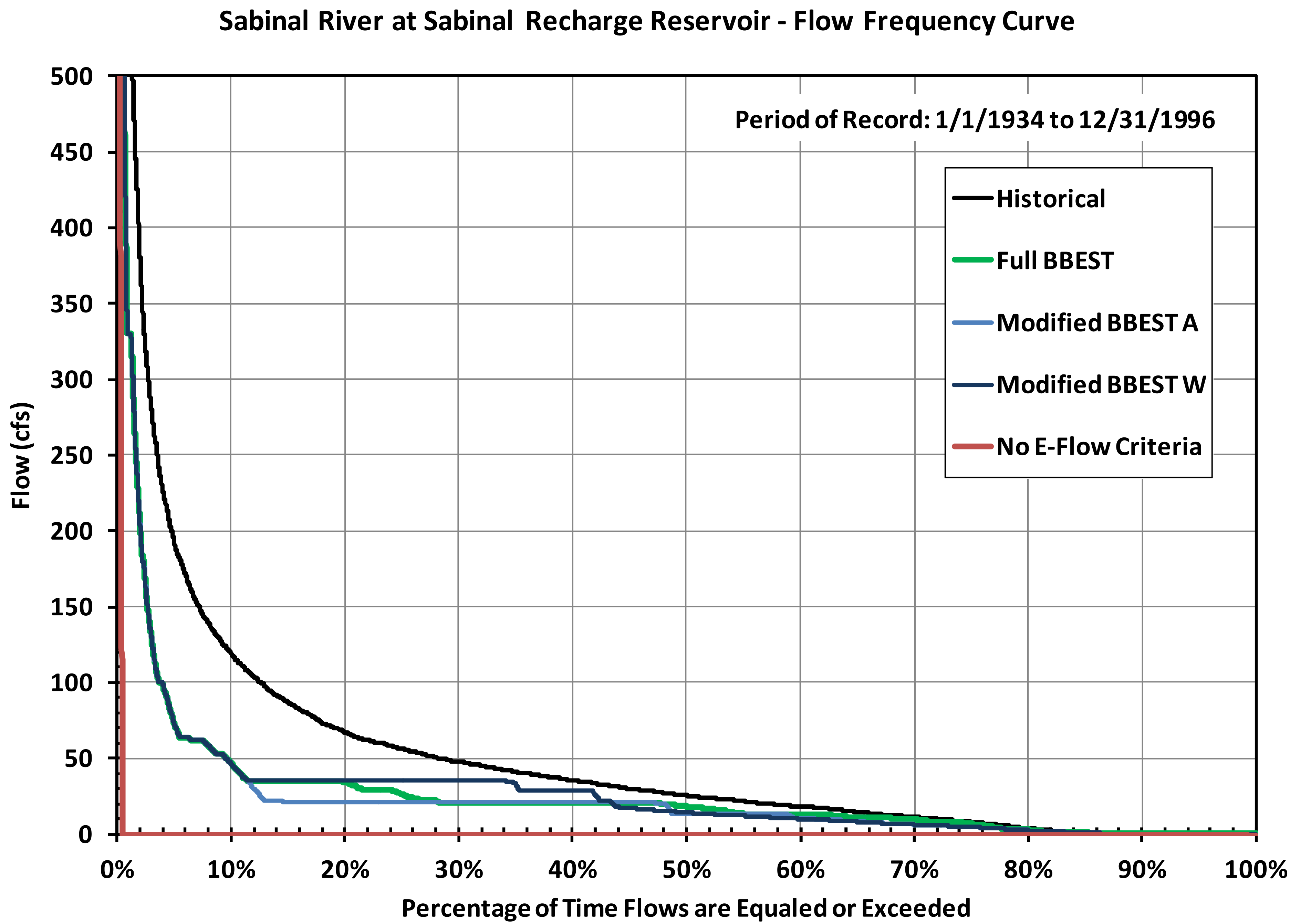
Note: the first four pulse entries, and the subsistence flow of 1 cfs, each span all four seasons in the original chart. The High 35 and Medium 21 base flows each span Winter and Spring.

Flow Levels	
High (75th %ile)	
Medium (50th %ile)	
Low (25th %ile)	
Subsistence	

Pulse volumes are in units of acre-feet and durations are in days.
Period of Record used: 1/1/1943 to 12/31/2009.



Sabinal River at Sabinal Recharge Reservoir - Enhanced Recharge
Average Annual Enhanced Recharge (acft/yr)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
Long Term Avg
(1934-1996)
Drought Avg
(1947-1956)
36%
36%
36%
81%
81%
81%
No E-Flow Restrictions
Lyons
CCEFN
Modified BBEST W
Modified BBEST A
Full BBEST
UPDATE


Sabinal River at Sabinal Recharge Reservoir - Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST A
Modified BBEST W
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

UPDATE

Sabinal Recharge Dam

- Preliminary Conclusions
  - The impoundment of high flow pulses by the Sabinal Dam provides the greatest opportunity for recharge enhancement.
  - Variations in base flow criteria have negligible effects on enhanced recharge.
- Downstream Impacts
  - System yield = -1,900 to -2,300 acft/yr
  - Average Annual Bay Inflow = -850 acft/yr

Standard & Strategy Evaluation

- Laguna ROTR with OCR
- Cotulla Reservoir
- Cotulla ROTR with OCR
- Evaluate:
  - No Recommendation
  - BBEST Recommendation
  - Modifications to BBEST Recommendation
- Results:
  - Yield
  - Streamflows

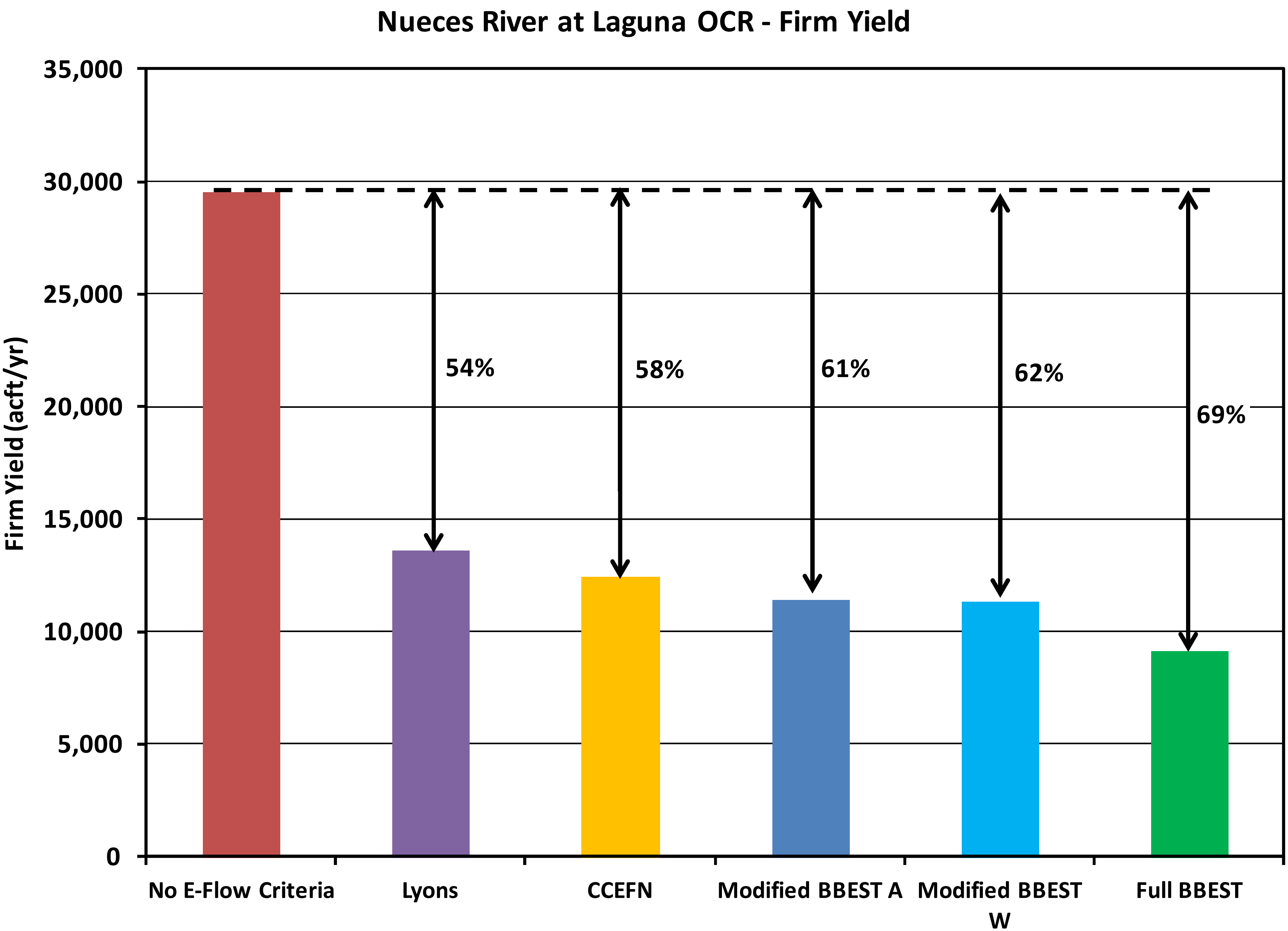
Nueces River @ Laguna - BBEST

	Winter	Spring	Summer	Fall
Overbank Events	15,600 cfs with Average Frequency 1 per 5 ye Duration Bound is 107			
High Flow Pulses	Qp: 4,750 cfs with Average Frequency 1 per 2 years Regressed Volume is 38,600			
	Regressed Volume is 18,400 Duration Bound is 46			
	Qp: 590 cfs with Average Frequency 2 per year Volume Bound is 11,300 Duration Bound is 26			
	Qp: 48 cfs with Average Frequency 1 per season Volume Bound is 1,000 Duration Bound is 7	Qp: 390 cfs with Average Frequency 1 per season Volume Bound is 6,070 Duration Bound is 17	Qp: 170 cfs with Average Frequency 1 per season Volume Bound is 3,100 Duration Bound is 14	Qp: 50 cfs with Average Frequency 1 per season Volume Bound is 800 Duration Bound is 5
		Qp: 99 cfs with Average Frequency 2 per season Volume Bound is 1,560 Duration Bound is 9		
Base Flows (cfs)	92		76	92
	65		48	65
	51	44	32	41
Subsistence Flows (cfs)	14	18	16	14
	Dec, Jan, Feb, Mar	Apr, May, Jun	Jul, Aug, Sep	Oct, Nov

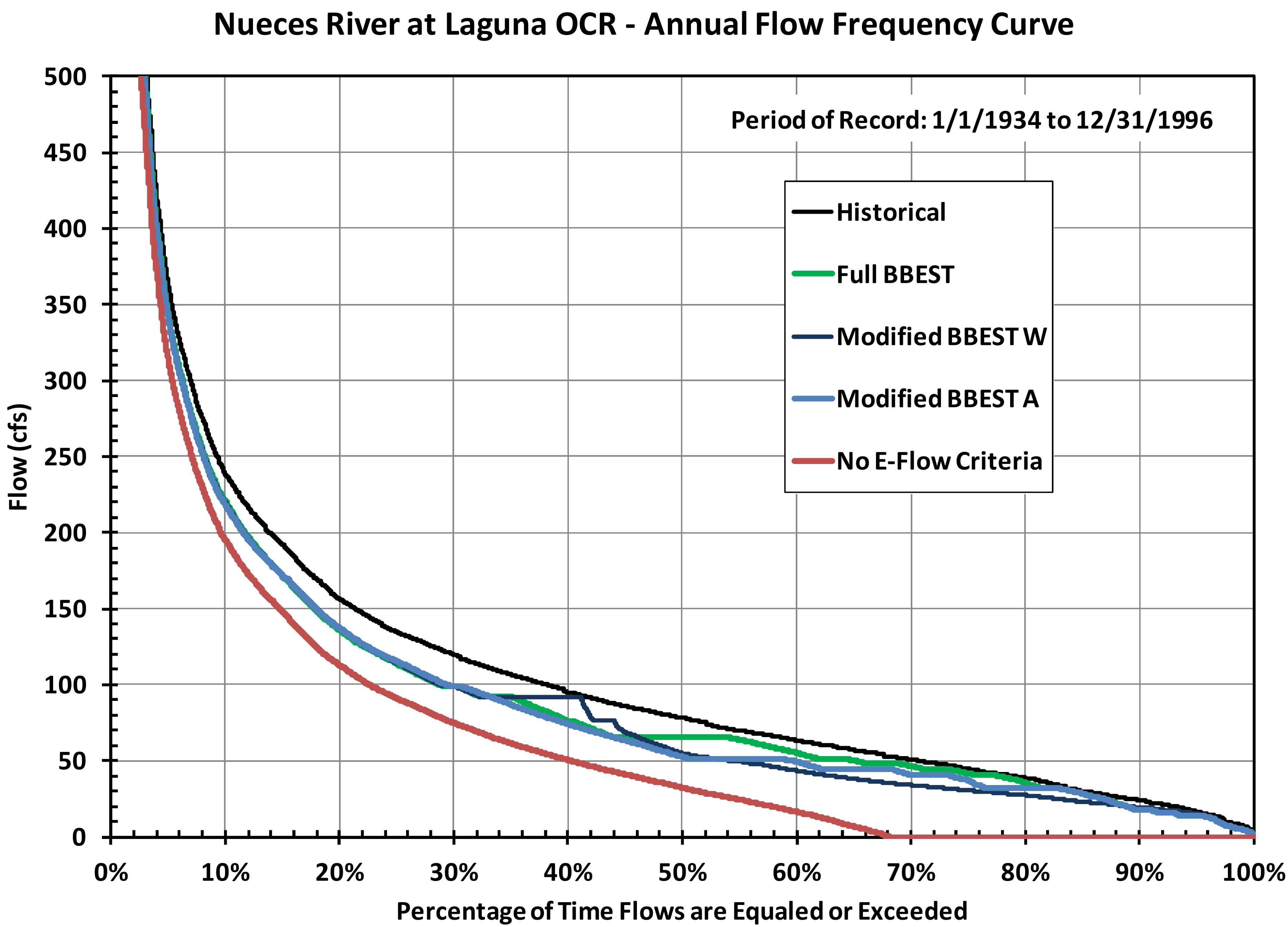
Flow Levels	
	High (75th %ile)
	Medium (50th %ile)
	Low (25th %ile)
	Subsistence

Pulse volumes are in units of acre-feet
Period of Record used : 1/1/1924 to 1

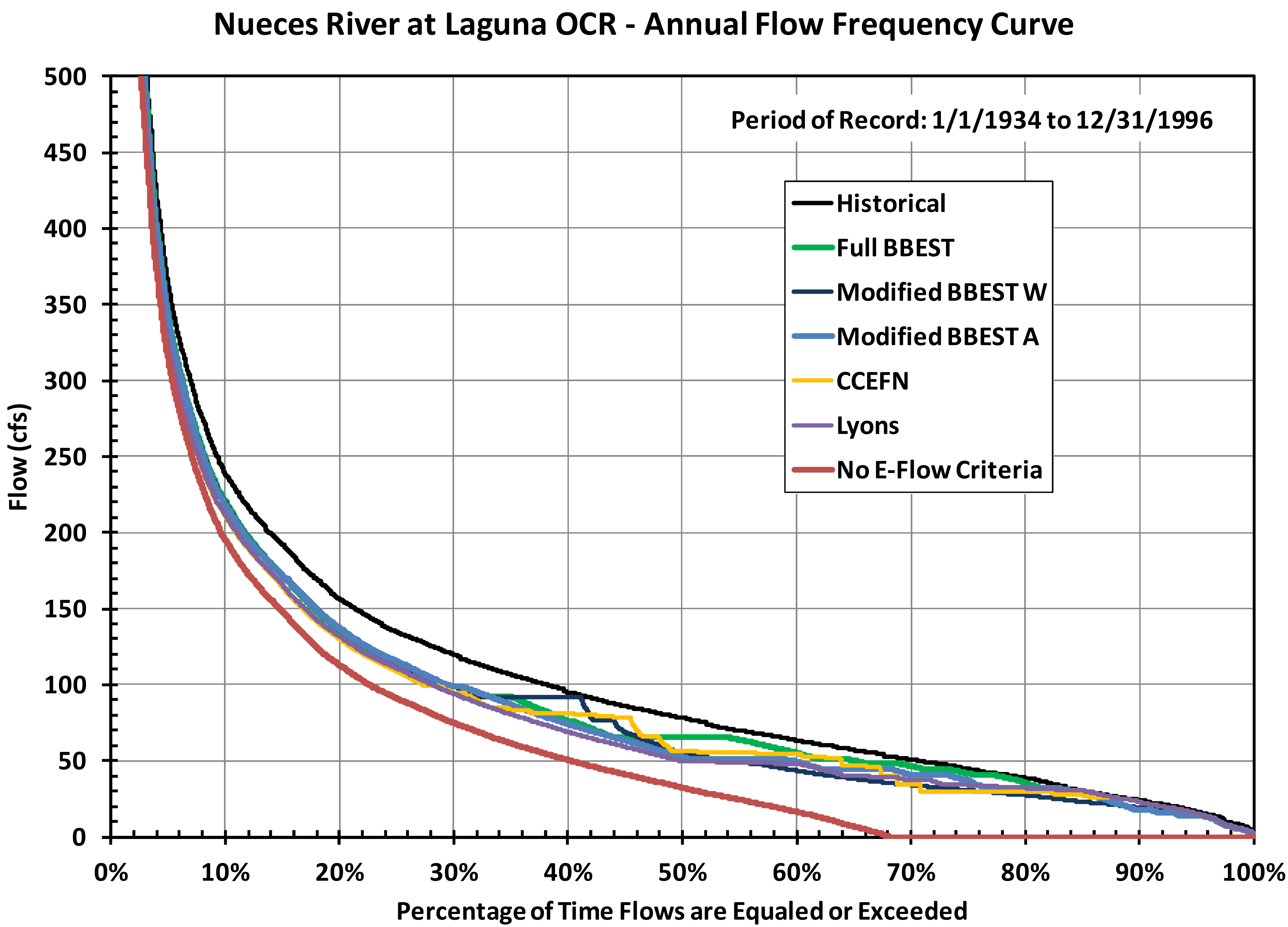
50%


Nueces River at Laguna OCR - Firm Yield
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Firm Yield (acft/yr)
54%
58%
61%
62%
69%
No E-Flow Criteria
Lyons
CCEFN
Modified BBEST A
Modified BBEST W
Full BBEST

UPDATE


Nueces River at Laguna OCR - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST W
Modified BBEST A
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

UPDATE



Nueces River at Laguna OCR - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST W
Modified BBEST A
CCEFN
Lyons
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

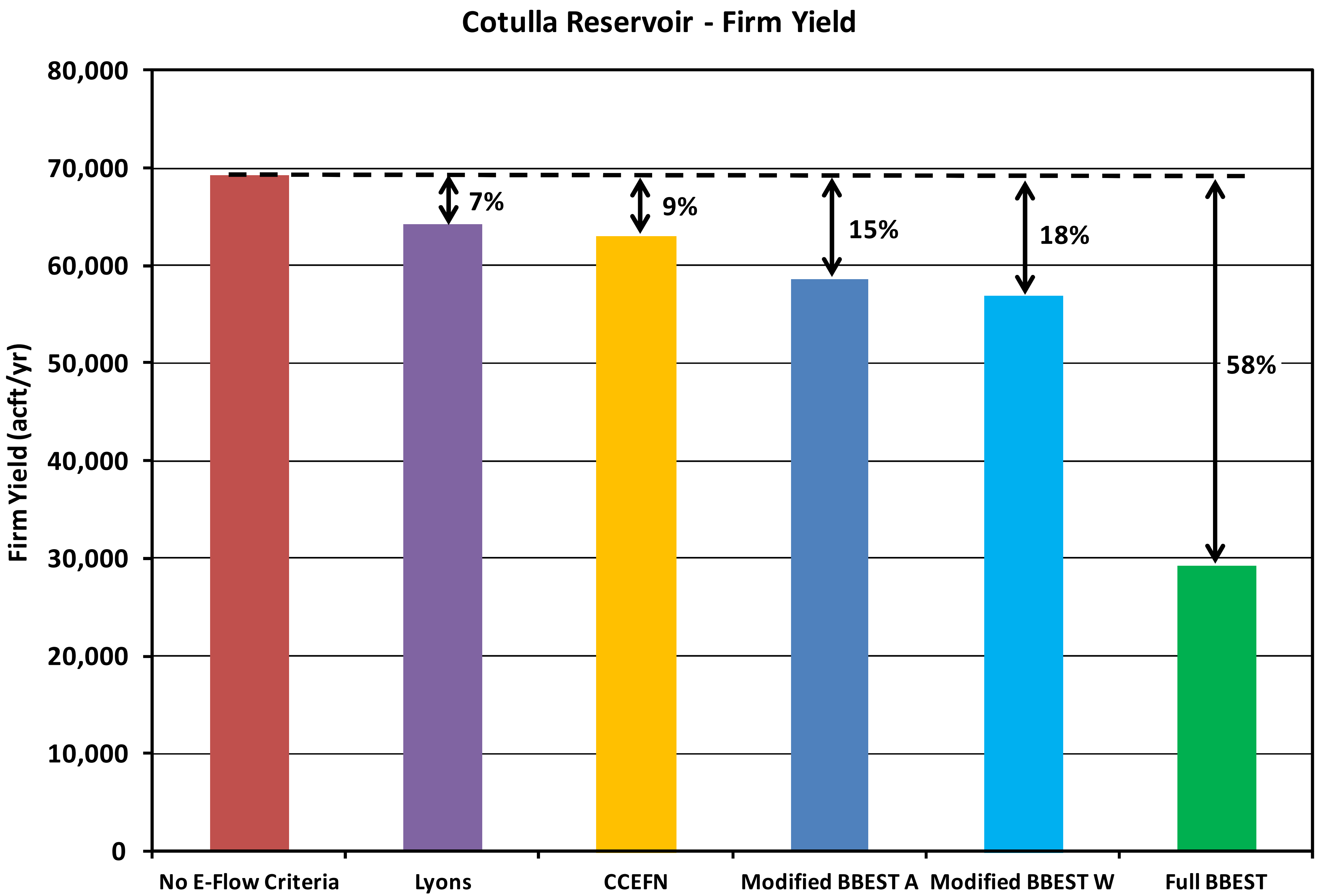
UPDATE

Nueces River @ Cotulla - BBEST

<table>
<tr><th></th><th>Winter (Nov, Dec, Jan, Feb, Mar)</th><th>Spring (Apr, May, Jun)</th><th>Summer (Jul, Aug)</th><th>Fall (Sep, Oct)</th></tr>
<tr><td rowspan="4">Overbank Events</td><td colspan="4">Qp: 15,100 cfs with Average Frequency 1 per 5 years
Regressed Volume is 151,000
Duration Bound is 42</td></tr>
<tr><td colspan="4">Qp: 8,410 cfs with Average Frequency 1 per 2 years
Regressed Volume is 80,700
Duration Bound is 38</td></tr>
<tr><td colspan="4">Qp: 4,460 cfs with Average Frequency 1 per year
Regressed Volume is 41,100
Duration Bound is 34</td></tr>
<tr><td colspan="4">Qp: 1,560 cfs with Average Frequency 2 per year
Volume Bound is 24,200
Duration Bound is 28</td></tr>
<tr><td rowspan="3">High Flow Pulses</td><td>Qp: 96 cfs with Average Frequency 1 per season
Volume Bound is 1,570
Duration Bound is 20</td><td>Qp: 1,180 cfs with Average Frequency 1 per season
Volume Bound is 17,200
Duration Bound is 24</td><td>Qp: 100 cfs with Average Frequency 1 per season
Volume Bound is 1,030
Duration Bound is 16</td><td>Qp: 640 cfs with Average Frequency 1 per season
Volume Bound is 8,610
Duration Bound is 26</td></tr>
<tr><td>Qp: 8 cfs with Average Frequency 2 per season
Volume Bound is 100
Duration Bound is 13</td><td>Qp: 190 cfs with Average Frequency 2 per season
Volume Bound is 2,370
Duration Bound is 17</td><td></td><td>Qp: 35 cfs with Average Frequency 2 per season
Volume Bound is 360
Duration Bound is 14</td></tr>
<tr><td></td><td>Qp: 15 cfs with Average Frequency 3 per season
Volume Bound is 150
Duration Bound is 11</td><td></td><td></td></tr>
<tr><td rowspan="3">Base Flows (cfs)</td><td>38</td><td colspan="2">31</td><td>42</td></tr>
<tr><td>6</td><td>10</td><td>7</td><td>15</td></tr>
<tr><td colspan="4">1</td></tr>
<tr><td>Subsistence Flows (cfs)</td><td colspan="4">1</td></tr>
</table>

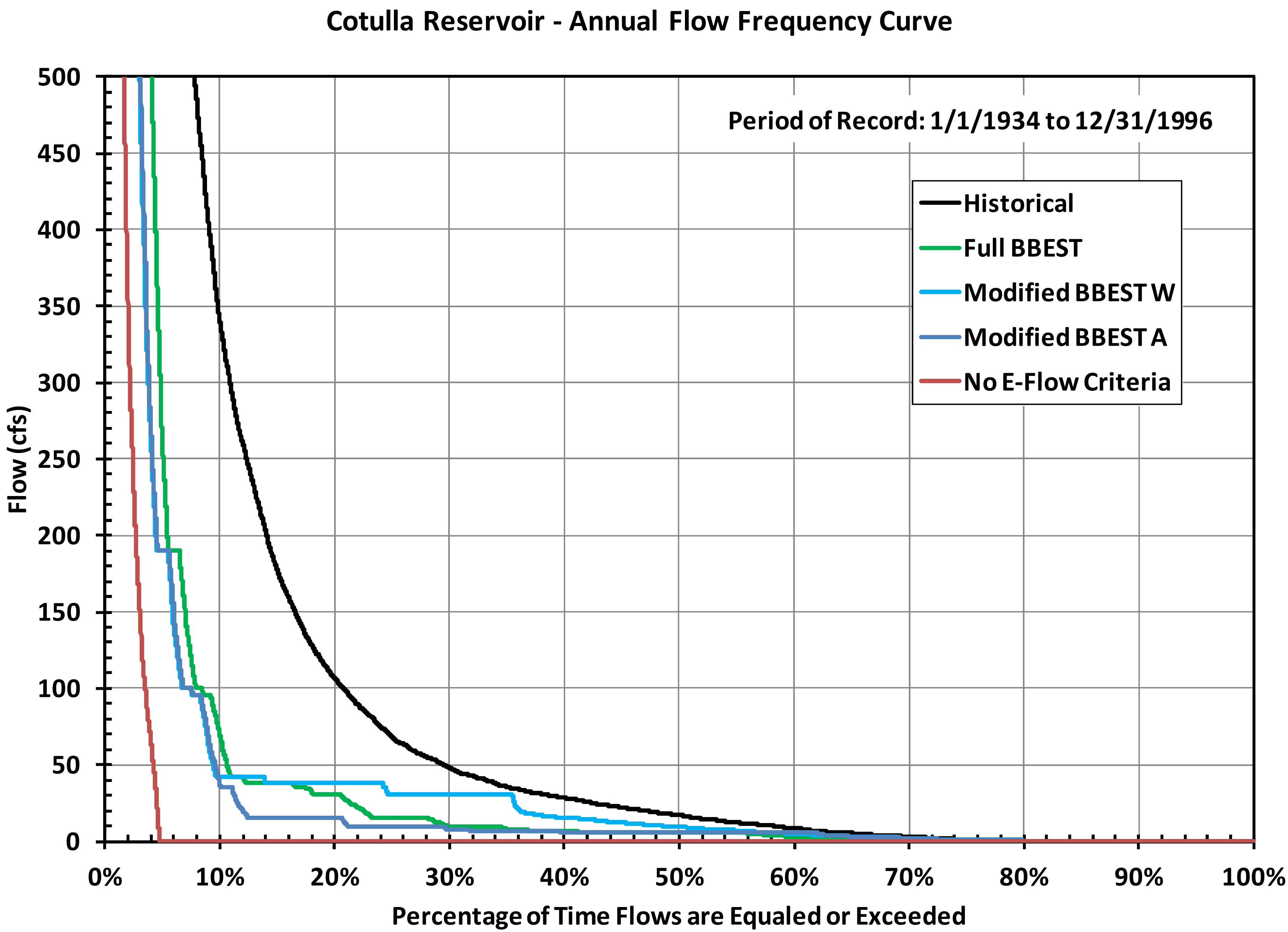
Flow Levels	
High (75th %ile)	
Medium (50th %ile)	
Low (25th %ile)	
Subsistence	

Pulse volumes are in units of acre-feet and durations are in days.
Period of Record used : 1/1/1927 to 12/31/2009.

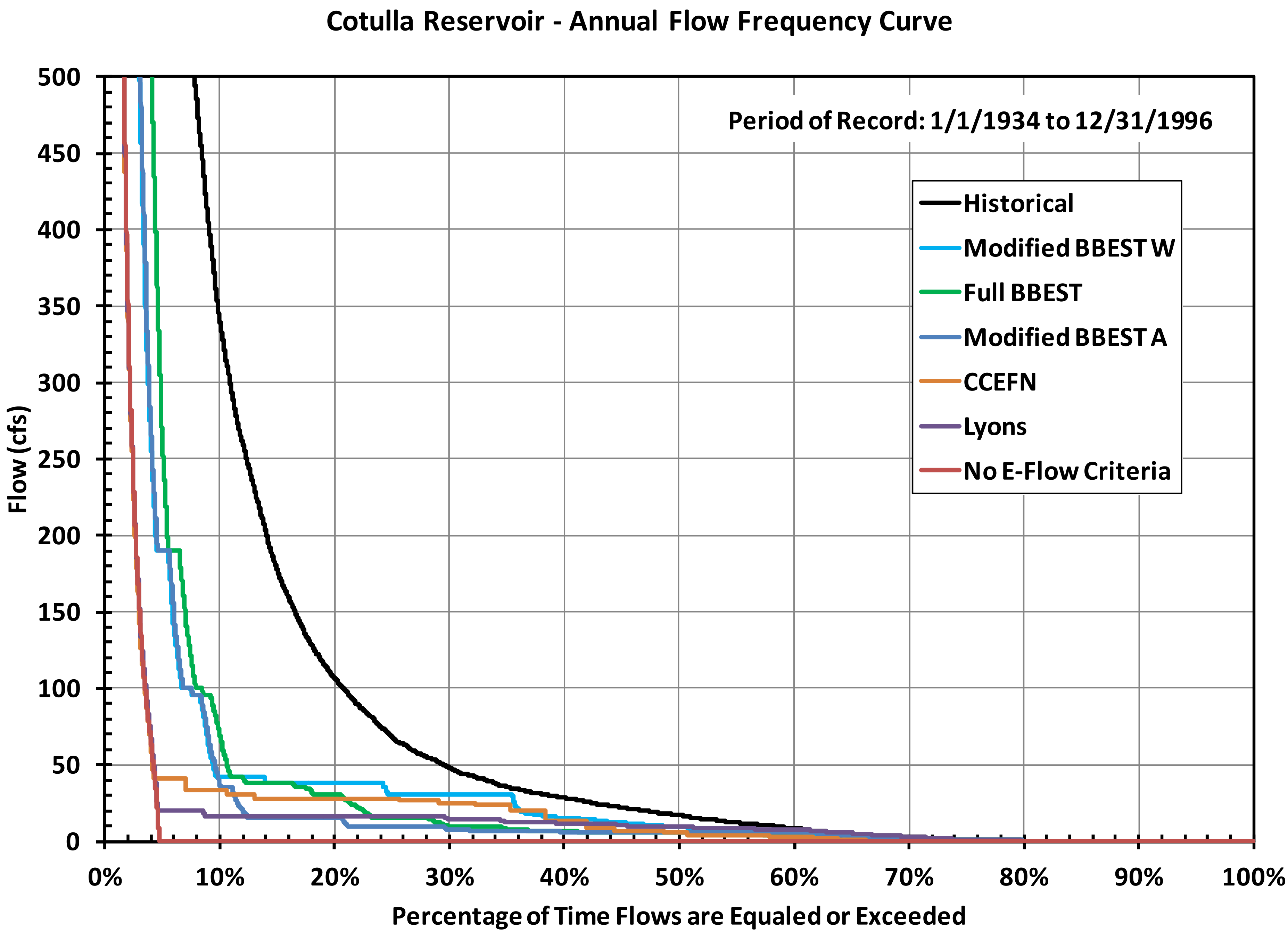


Cotulla Reservoir - Firm Yield
Firm Yield (acft/yr)
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
7%
9%
15%
18%
58%
No E-Flow Criteria
Lyons
CCEFN
Modified BBEST A
Modified BBEST W
Full BBEST

UPDATE



Cotulla Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Full BBEST
Modified BBEST W
Modified BBEST A
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded


Cotulla Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Modified BBEST W
Full BBEST
Modified BBEST A
CCEFN
Lyons
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

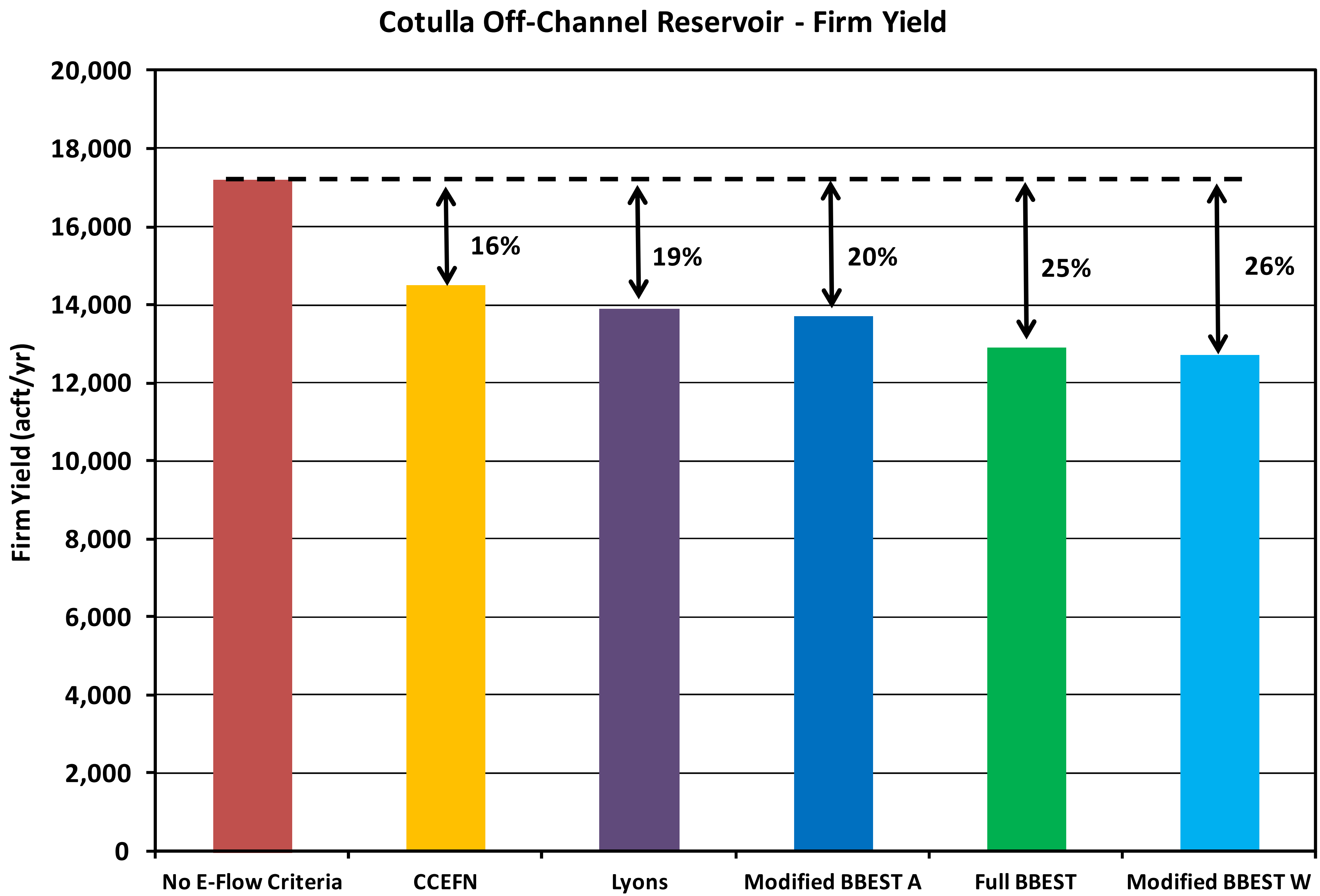
UPDATE

Nueces River @ Cotulla - BBEST

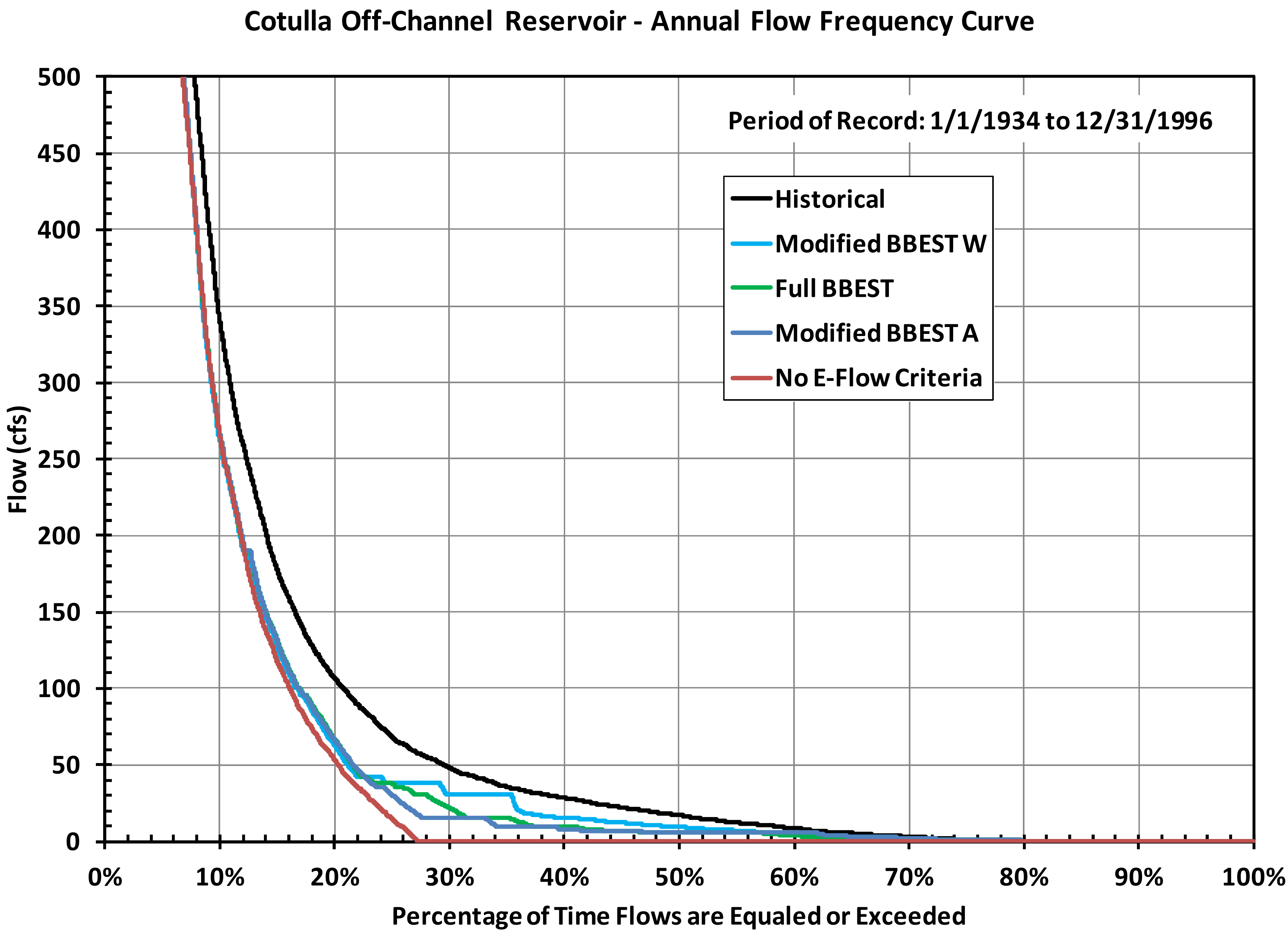
	Winter (Nov, Dec, Jan, Feb, Mar)	Spring (Apr, May, Jun)	Summer (Jul, Aug)	Fall (Sep, Oct)
Overbank Events	Qp: 15,100 cfs with Average Frequency 1 per 5 years Regressed Volume is 151,000 Duration Bound is 42			
Overbank Events	Qp: 8,410 cfs with Average Frequency 1 per 2 years Regressed Volume is 80,700 Duration Bound is 38			
Overbank Events	Qp: 4,460 cfs with Average Frequency 1 per year Regressed Volume is 41,100 Duration Bound is 34			
Overbank Events	Qp: 1,560 cfs with Average Frequency 2 per year Volume Bound is 24,200 Duration Bound is 28			
High Flow Pulses	Qp: 96 cfs with Average Frequency 1 per season Volume Bound is 1,570 Duration Bound is 20	Qp: 1,180 cfs with Average Frequency 1 per season Volume Bound is 17,200 Duration Bound is 24	Qp: 100 cfs with Average Frequency 1 per season Volume Bound is 1,030 Duration Bound is 16	Qp: 640 cfs with Average Frequency 1 per season Volume Bound is 8,610 Duration Bound is 26
High Flow Pulses	Qp: 8 cfs with Average Frequency 2 per season Volume Bound is 100 Duration Bound is 13	Qp: 190 cfs with Average Frequency 2 per season Volume Bound is 2,370 Duration Bound is 17		Qp: 35 cfs with Average Frequency 2 per season Volume Bound is 360 Duration Bound is 14
High Flow Pulses		Qp: 15 cfs with Average Frequency 3 per season Volume Bound is 150 Duration Bound is 11		
Base Flows (cfs) – High	38	31	31	42
Base Flows (cfs) – Medium	6	10	7	15
Base Flows (cfs) – Low	1	1	1	1
Subsistence Flows (cfs)	1	1	1	1

Flow Levels	
	High (75th %ile)
	Medium (50th %ile)
	Low (25th %ile)
	Subsistence

Pulse volumes are in units of acre-feet and durations are in days.
Period of Record used : 1/1/1927 to 12/31/2009.

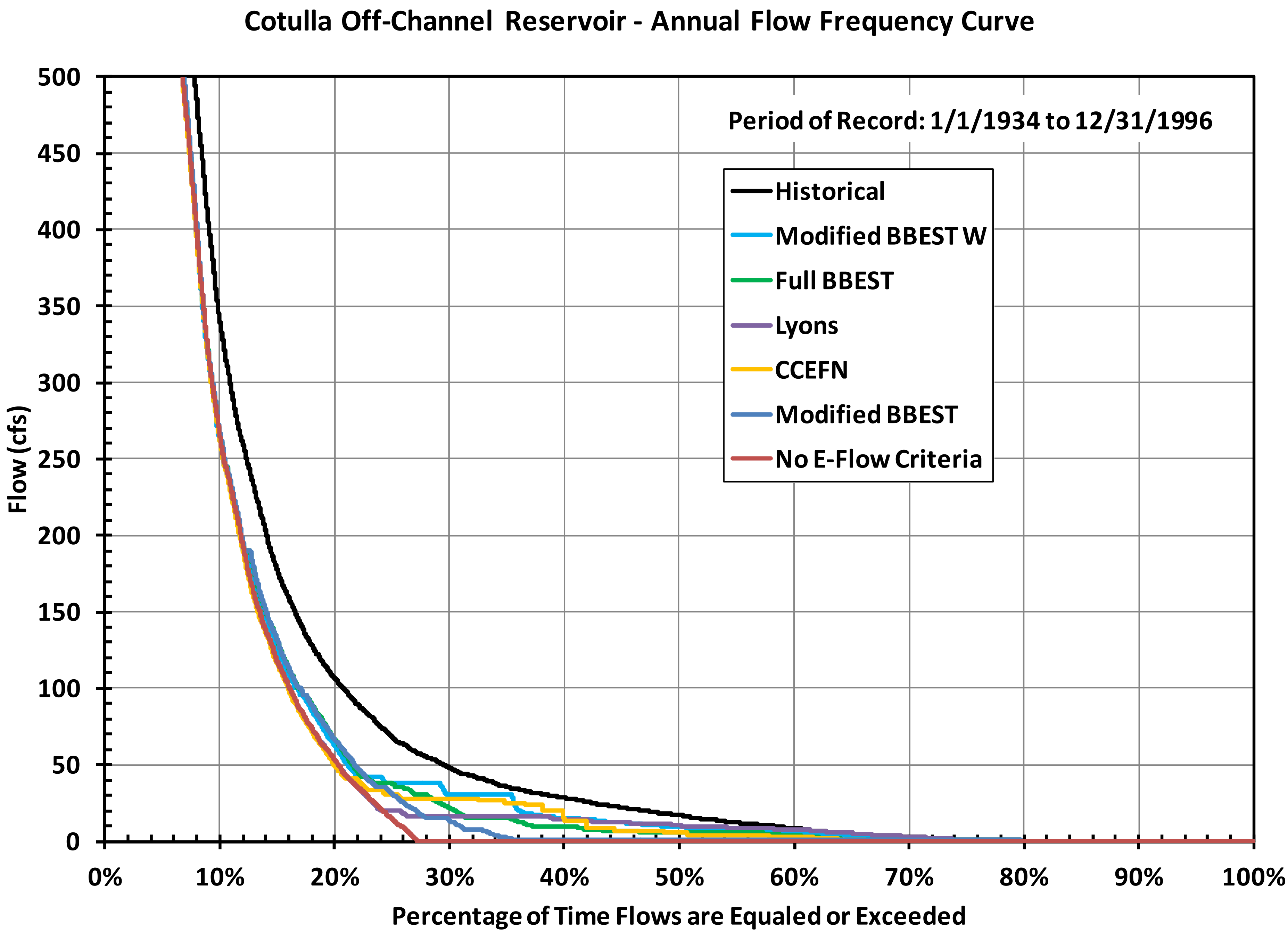

Cotulla Off-Channel Reservoir - Firm Yield
Firm Yield (acft/yr)
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
16%
19%
20%
25%
26%
No E-Flow Criteria
CCEFN
Lyons
Modified BBEST A
Full BBEST
Modified BBEST W

UPDATE



Cotulla Off-Channel Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Modified BBEST W
Full BBEST
Modified BBEST A
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

UPDATE



Cotulla Off-Channel Reservoir - Annual Flow Frequency Curve
Period of Record: 1/1/1934 to 12/31/1996
Historical
Modified BBEST W
Full BBEST
Lyons
CCEFN
Modified BBEST
No E-Flow Criteria
Flow (cfs)
500
450
400
350
300
250
200
150
100
50
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of Time Flows are Equaled or Exceeded

UPDATE

Path Forward

- Additional Presentations
  - BBEST - Aquatic Habitat
  - TWDB - Sediment Transport
- BBASC Adopt an Instream Environmental Flow Standard Recommendation
  - Modified BBEST
    - Overbank Exemption
    - Pulse Exemption Rule
    - Base Flow with 50% Rule
      - Wet
      - Average

Nueces Bay and Delta Inflow Regime

- BBASC Direction
  - Utilize BBEST Volume Targets
  - Modify Attainment Frequencies for Balance
- Four Focused Scenarios
  - BBEST Recommendation
  - Agreed Order – Safe Yield
  - No Pass Thru's
  - OCR Agreed Order Safe Yield
- Results
  - Yield vs. Bay Inflow vs. Salinity

Order Compared to BBEST

2001 TCEQ Agreed Order

Sys Stor. %	Jan (acft)	Feb (acft)	Mar (acft)	Apr (acft)	May (acft)	Jun (acft)	Jul (acft)	Aug (acft)	Sep (acft)	Oct (acft)	Nov (acft)	Dec (acft)	Ann. (acft)
>70	2,500	2,500	3,500	3,500	25,500	25,500	6,500	6,500	28,500	20,000	9,000	4,500	138,000
70-40	2,500	2,500	3,500	3,500	23,500	23,000	4,500	5,000	11,500	9,000	4,000	4,500	97,000
40-30	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	1,200	14,400
<30	0	0	0	0	0	0	0	0	0	0	0	0	0

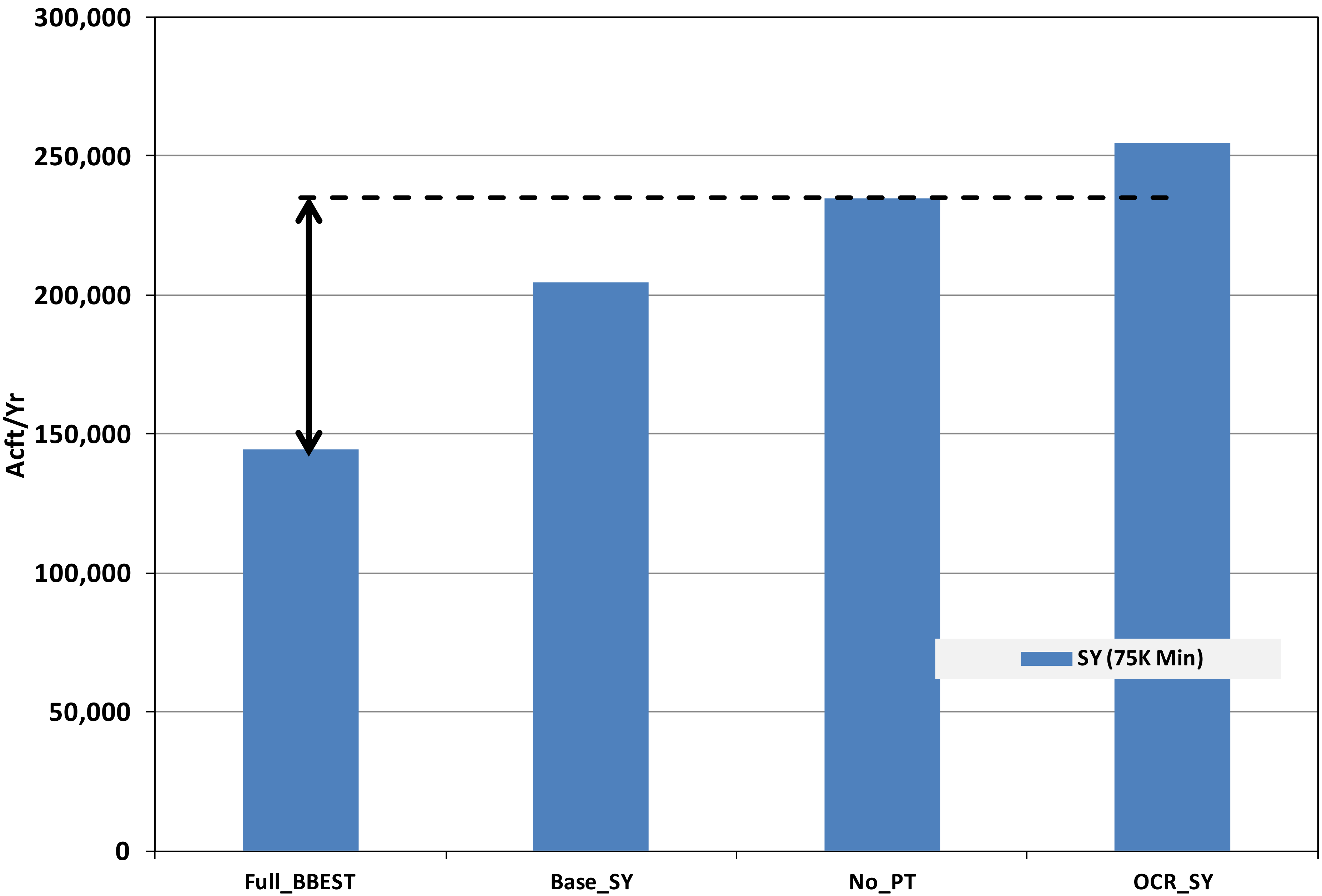
2011 BBEST Recommendation

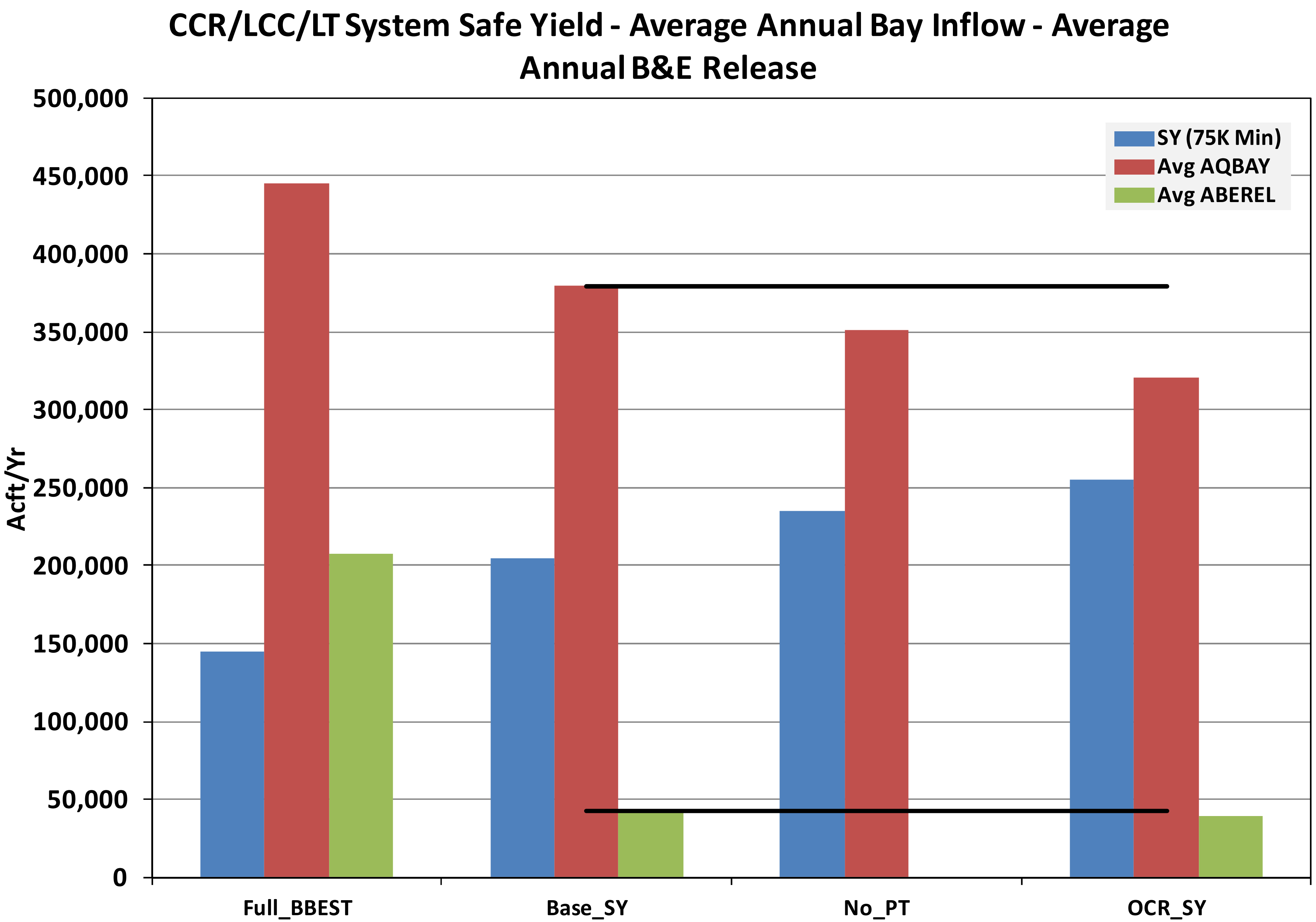
Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations	
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)	Attainment
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000	25%
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000	80%
Subsistence (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000	95%
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct		

BBEST Recommendation for B&E

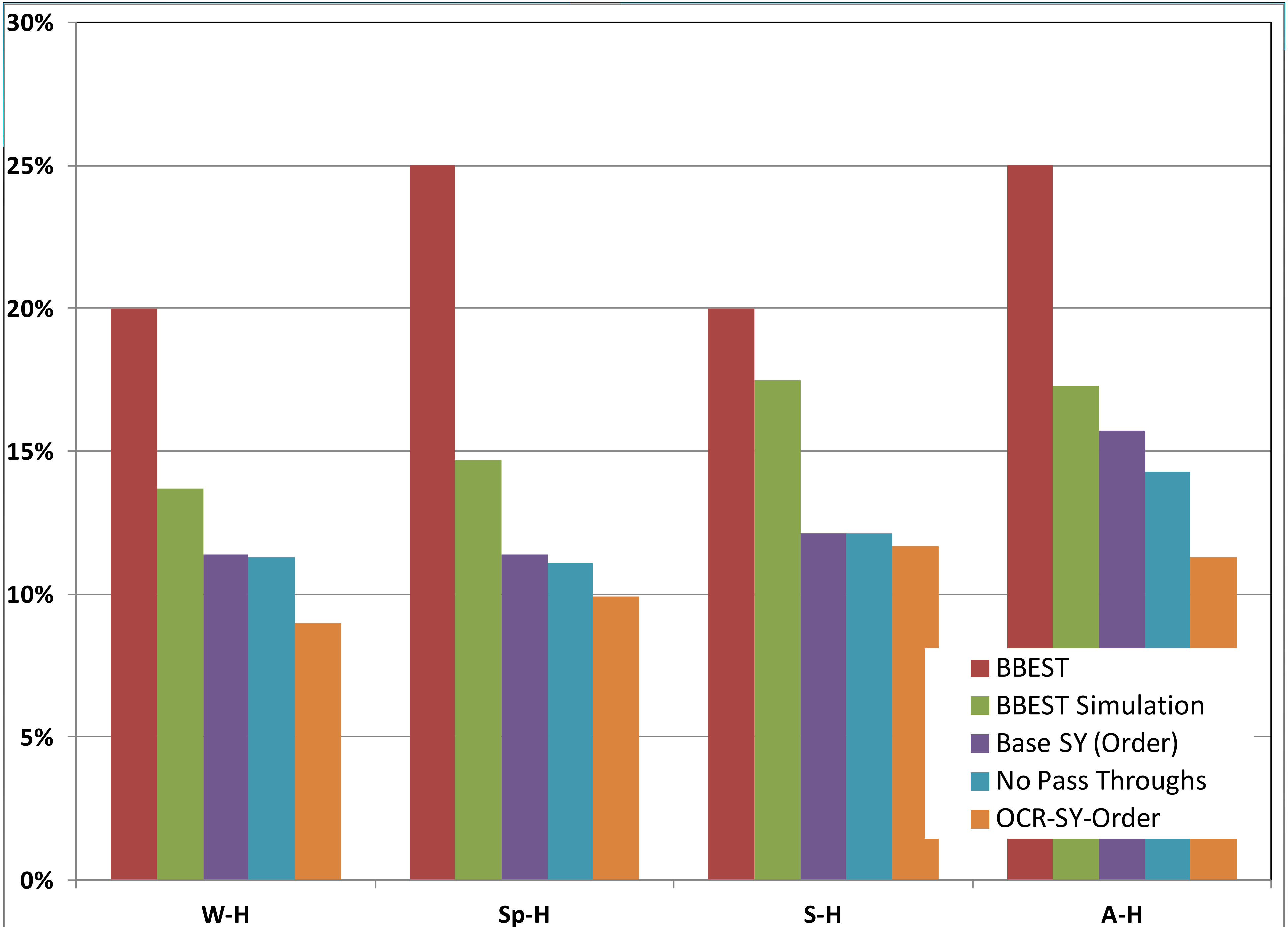
Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000 (25%)
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000 (80%)
Sub. (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000 (95%)
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct	

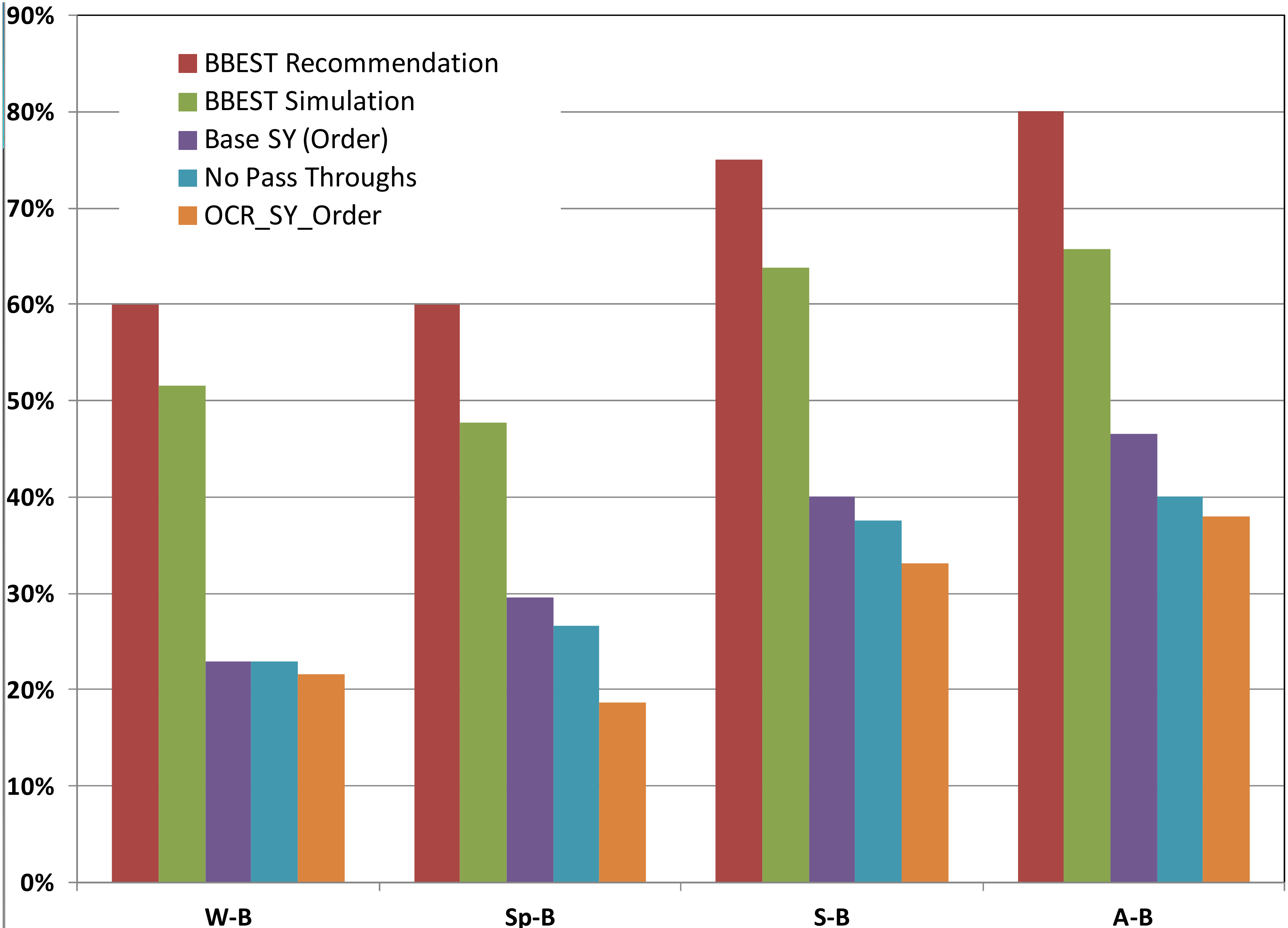
CCR/LCC/LT System Safe Yield (acft/yr)

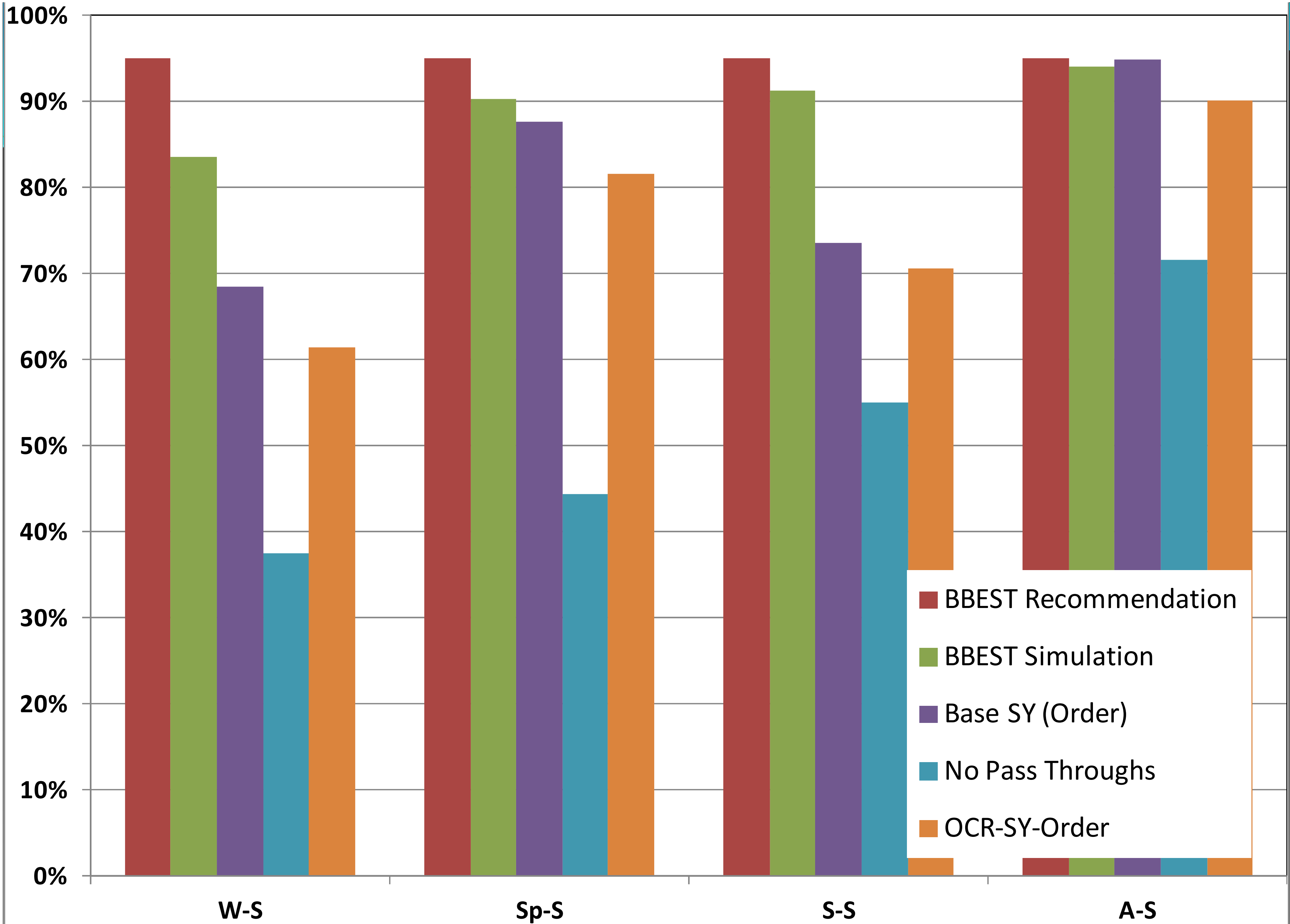




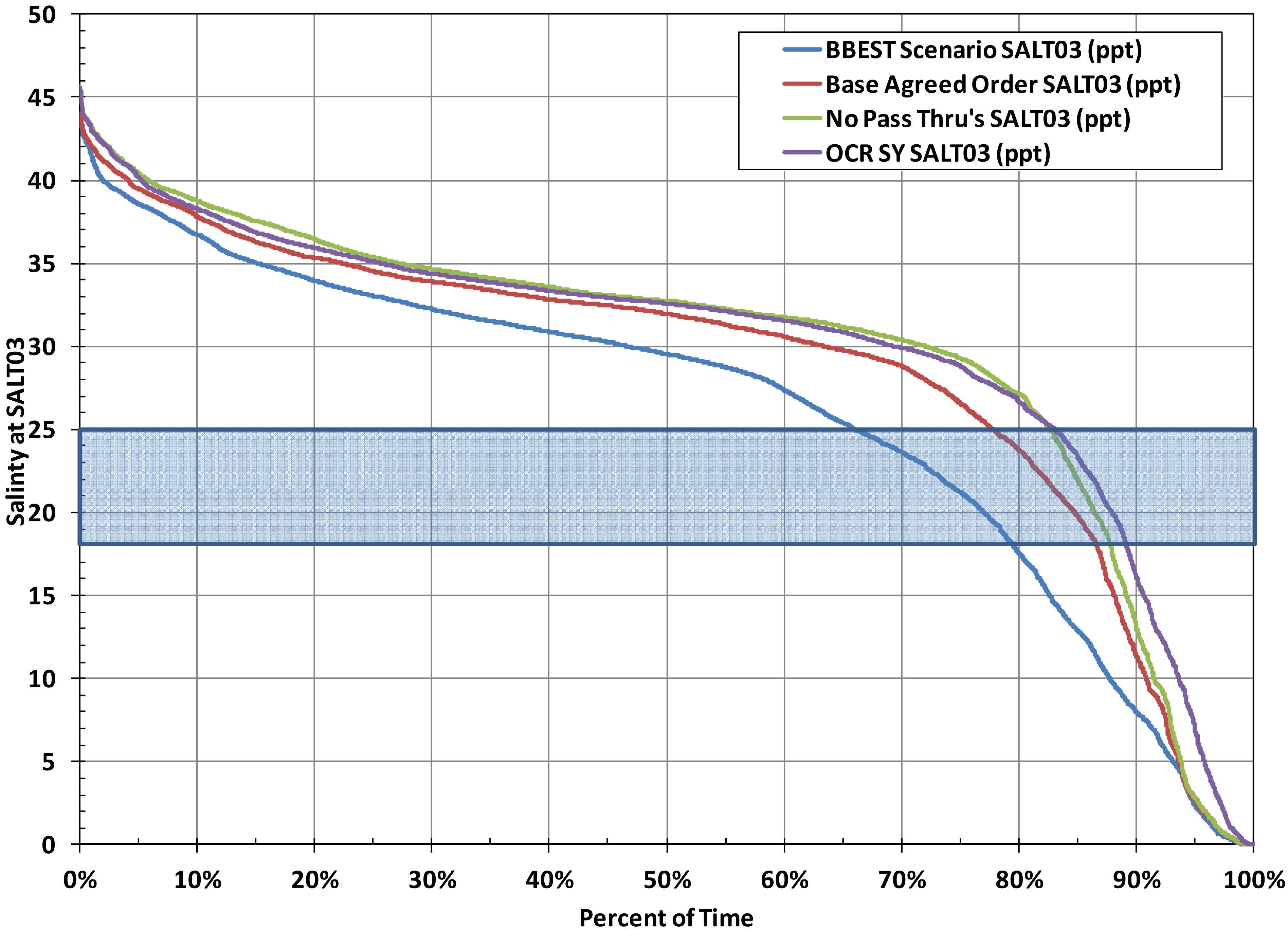
CCR/LCC/LT System Safe Yield - Average Annual Bay Inflow - Average Annual B&E Release
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
Acft/Yr
SY (75K Min)
Avg AQBAY
Avg ABEREL
Full_BBEST
Base_SY
No_PT
OCR_SY


30%
25%
20%
15%
10%
5%
0%
W-H
Sp-H
S-H
A-H
BBEST
BBEST Simulation
Base SY (Order)
No Pass Throughs
OCR-SY-Order

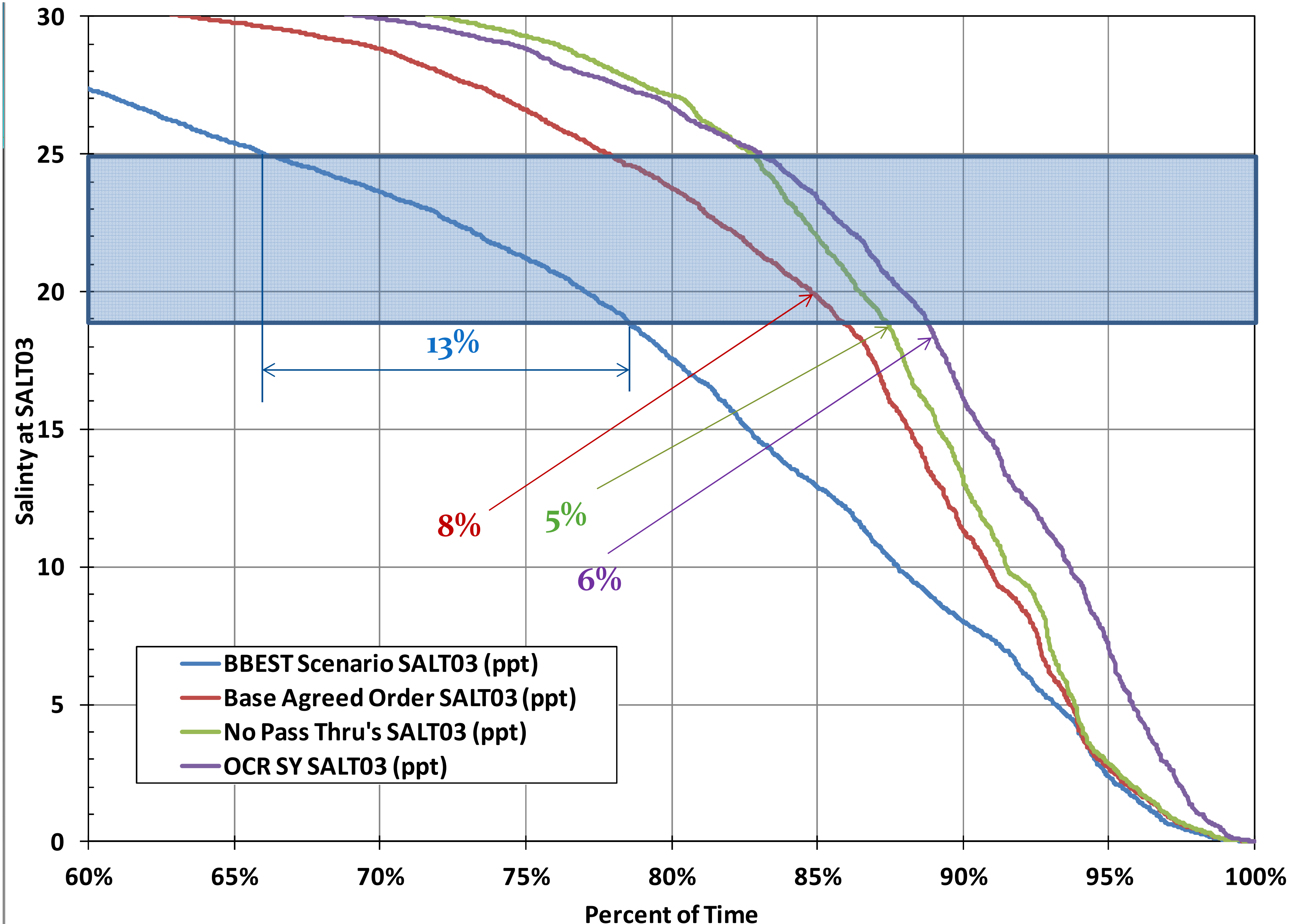

90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
BBEST Recommendation
BBEST Simulation
Base SY (Order)
No Pass Throughs
OCR_SY_Order
W-B
Sp-B
S-B
A-B



100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
W-S
Sp-S
S-S
A-S
BBEST Recommendation
BBEST Simulation
Base SY (Order)
No Pass Throughs
OCR-SY-Order



BBEST Scenario SALT03 (ppt)
Base Agreed Order SALT03 (ppt)
No Pass Thru's SALT03 (ppt)
OCR SY SALT03 (ppt)
Salinty at SALT03
50
45
40
35
30
25
20
15
10
5
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time



30
25
20
15
10
5
0
Salinty at SALT03
60%
65%
70%
75%
80%
85%
90%
95%
100%
Percent of Time
13%
8%
5%
6%
BBEST Scenario SALT03 (ppt)
Base Agreed Order SALT03 (ppt)
No Pass Thru's SALT03 (ppt)
OCR SY SALT03 (ppt)

B&E – Attainment Freq – Opt 1

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations
				Annual Total (acft)
High (10)	125,000 acft (9%)	250,000 acft (10%)	375,000 (12%)	750,000 (11%)
Base (18)	22,000 acft (22%)	88,000 acft (19%)	56,000 (33%)	166,000 (38%)
Sub. (34)	5,000 acft (61%)	10,000 acft (82%)	15,000 acft (71%)	30,000 (90%)
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct	

B&E – Attainment Freq – Opt 2

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations
				Annual Total (acft)
High (10)	125,000 acft (11%)	250,000 acft (11%)	375,000 (12%)	750,000 (16%)
Base (18)	22,000 acft (23%)	88,000 acft (30%)	56,000 (40%)	166,000 (47%)
Sub. (34)	5,000 acft (69%)	10,000 acft (88%)	15,000 acft (74%)	30,000 (95%)
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct	

For BBASC Consideration

- BBASC Adopt an Estuary & Delta Environmental Flow Standard Recommendation
  - BBEST Seasonal Volume Targets
  - Attainment Frequencies
    - Option 1 - Agreed Order plus OCR
    - Option 2 - Agreed Order

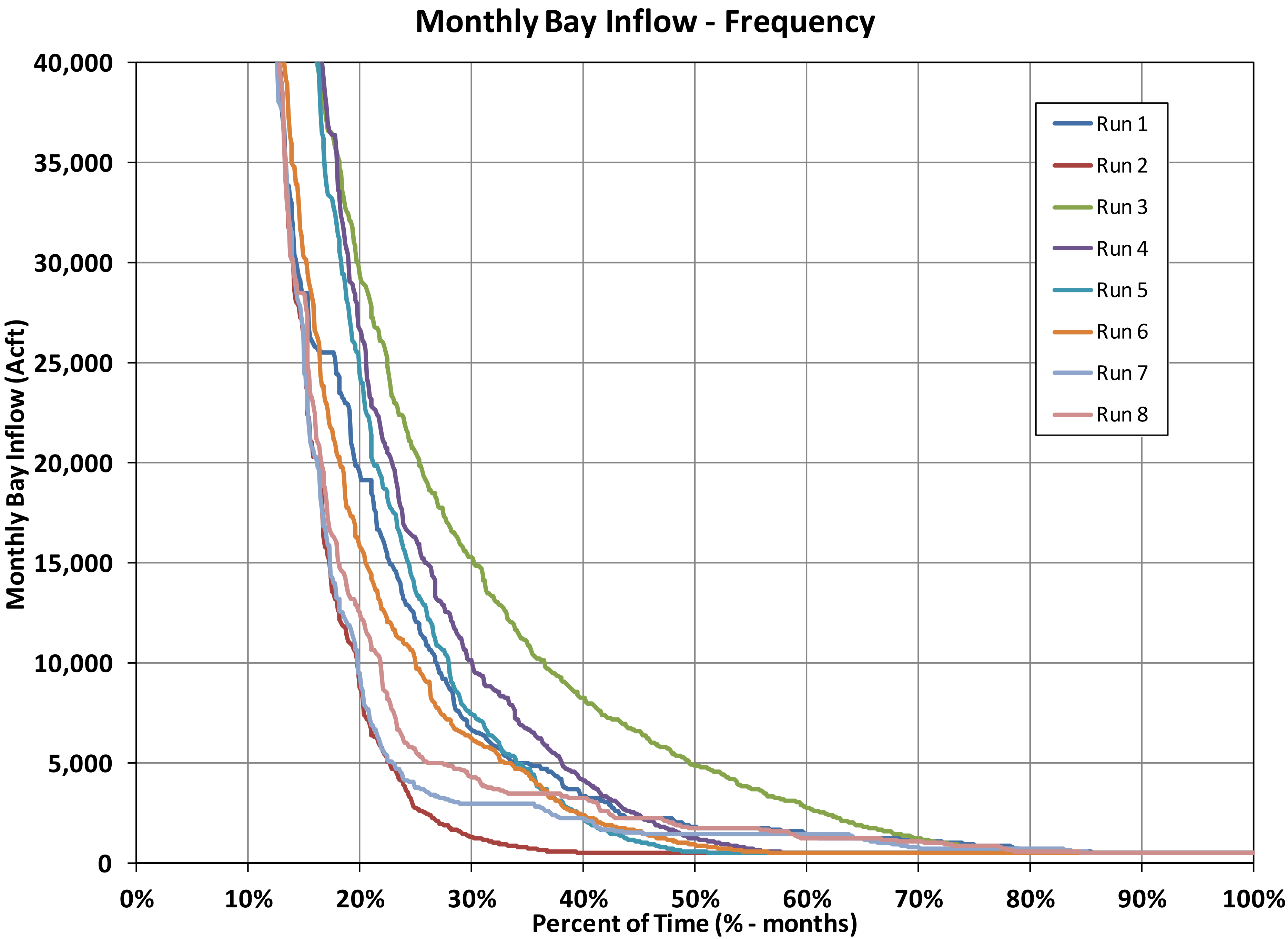
Path Forward / Questions?

- Report Compilation

Scenario Results

- Yield vs. Avg. Annual Bay Inflow

Run #	Run Description	SY (75K Min)	Avg AQBAY
1	Base_SY	204,449	379,284
2	No_PT	235,001	350,800
3	Seasonal_order	169,691	410,454
4	Spring_target	170,889	415,491
5	Summer_Tar	180,960	405,900
6	Winter_Tar	213,264	372,547
7	3K_All_months	230,089	358,019
8	Reduced may June	220,110	364,423


Monthly Bay Inflow - Frequency
Monthly Bay Inflow (Acft)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time (% - months)
Run 1
Run 2
Run 3
Run 4
Run 5
Run 6
Run 7
Run 8

Updates on Modeling Efforts of Nueces BBASC Technical Consultant

Presentation to Nueces BBASC

Cory Shockley, PE

HDR Engineering

June 20, 2012

Discussion

- Nueces Bay & Estuary
  - Attainment Frequencies
  - Recommendation from Workgroup
    - Option 2 – Full Utilization of Existing Order
    - Comparison
      - BBEST vs. Recommendation vs. Current Use
- BBASC vote to adopt an e-flow standard recommendation for Nueces B&E

What is an Attainment Frequency?

- Percent of time (number of seasons or years) in which the inflow into the Nueces Bay and Estuary equals or exceeds a specific volume.
  - There are 70 years / seasons simulated in the model (1934 – 2003).
  - The volumes were determined by the BBEST.
- Three key factors contribute to attainment frequency:
  - Natural Hydrology
  - System Demand
  - System Operations

Nueces Bay and Estuary EFR

- BBASC Direction
  - BBASC Adopted Goal
  - Utilize BBEST Volume Targets
  - Modify Attainment Frequencies for Balance
- Scenarios for Additional Evaluation
  - Existing Agreed Order
  - Current Use Conditions
- Workgroup Recommendation
  - Existing Agreed Order – Attainment Frequencies
  - NEAC Oversight for New Large Water Rights

Nueces BBASC Goal Regarding the Ecological Condition of Nueces Bay and Estuary

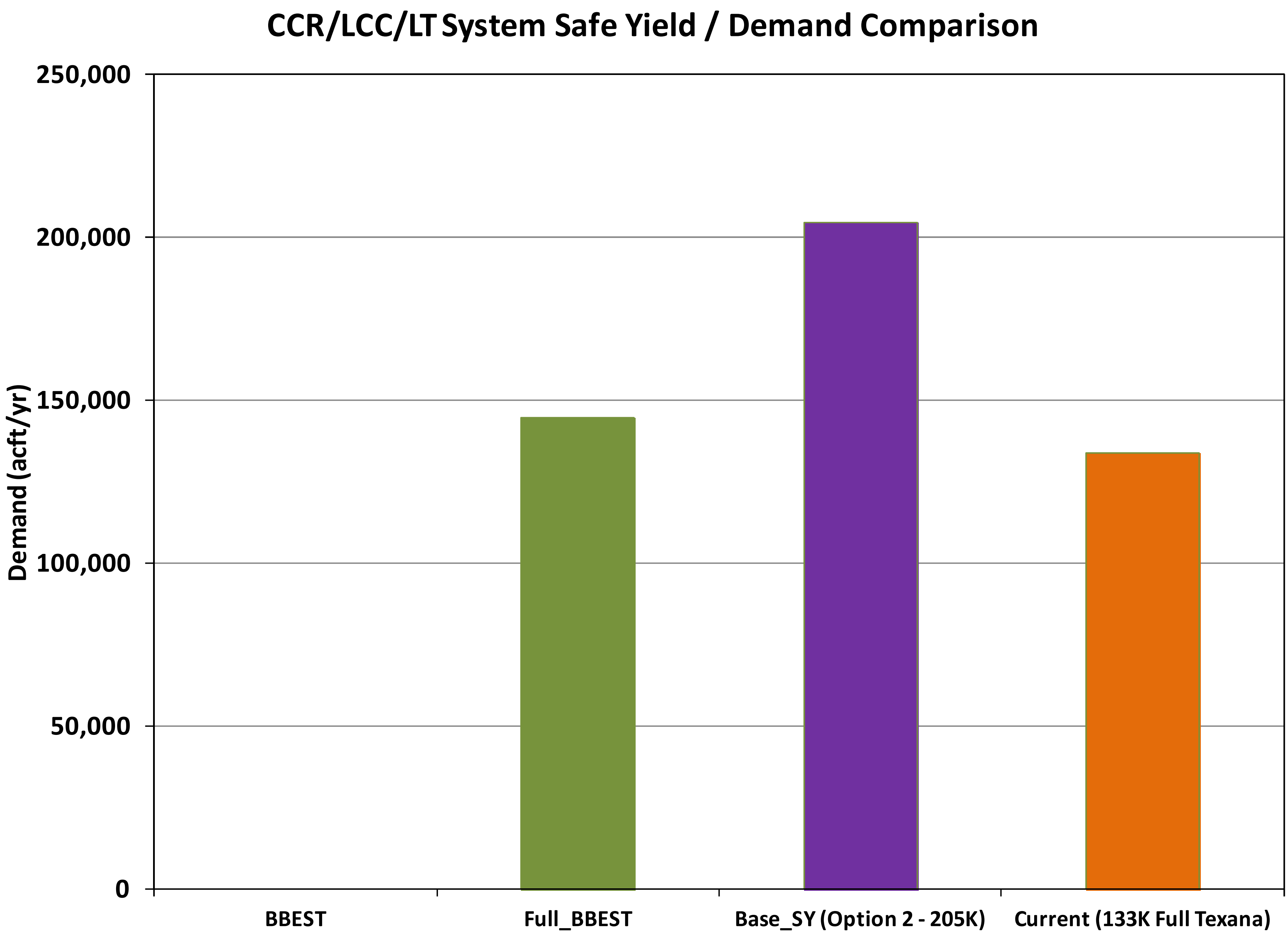
The goal of the Nueces BBASC with regard to the Nueces Bay and Delta is to return the Nueces Bay and Delta to ecological conditions existing prior to construction of Choke Canyon Reservoir to the extent possible while preserving existing water rights and yield of the reservoir system. To this end, the Nueces BBASC will recommend instream flow and estuary inflow regimes that may improve the existing ecological condition of the Nueces Bay and Delta, but will not diminish its existing condition, and will set forth, in its work plan, strategies to enhance its ecological condition.

BBEST Recommendation for B&E

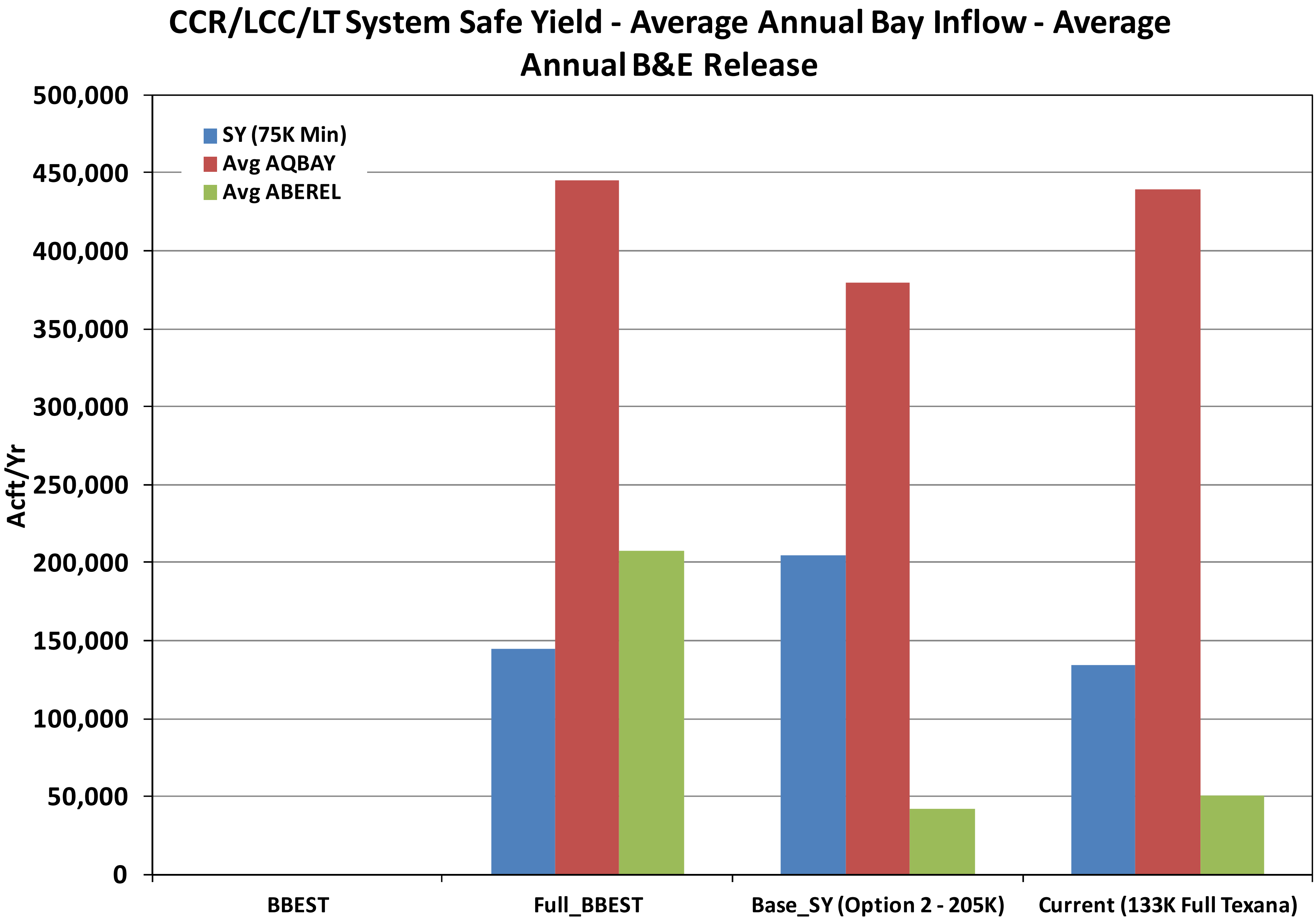
Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations
	One overbanking event per year of 39,000 acft; maximum discharge of 3,600 cfs			Annual Total (acft)
High (10)	125,000 acft (20%)	250,000 acft (25%)	375,000 (20%)	750,000 (25%)
Base (18)	22,000 acft (60%)	88,000 acft (60%)	56,000 (75%)	166,000 (80%)
Sub. (34)	5,000 acft (95%)	10,000 acft (95%)	15,000 acft (95%)	30,000 (95%)
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct	

BBASC Workgroup Recommendation for B&E

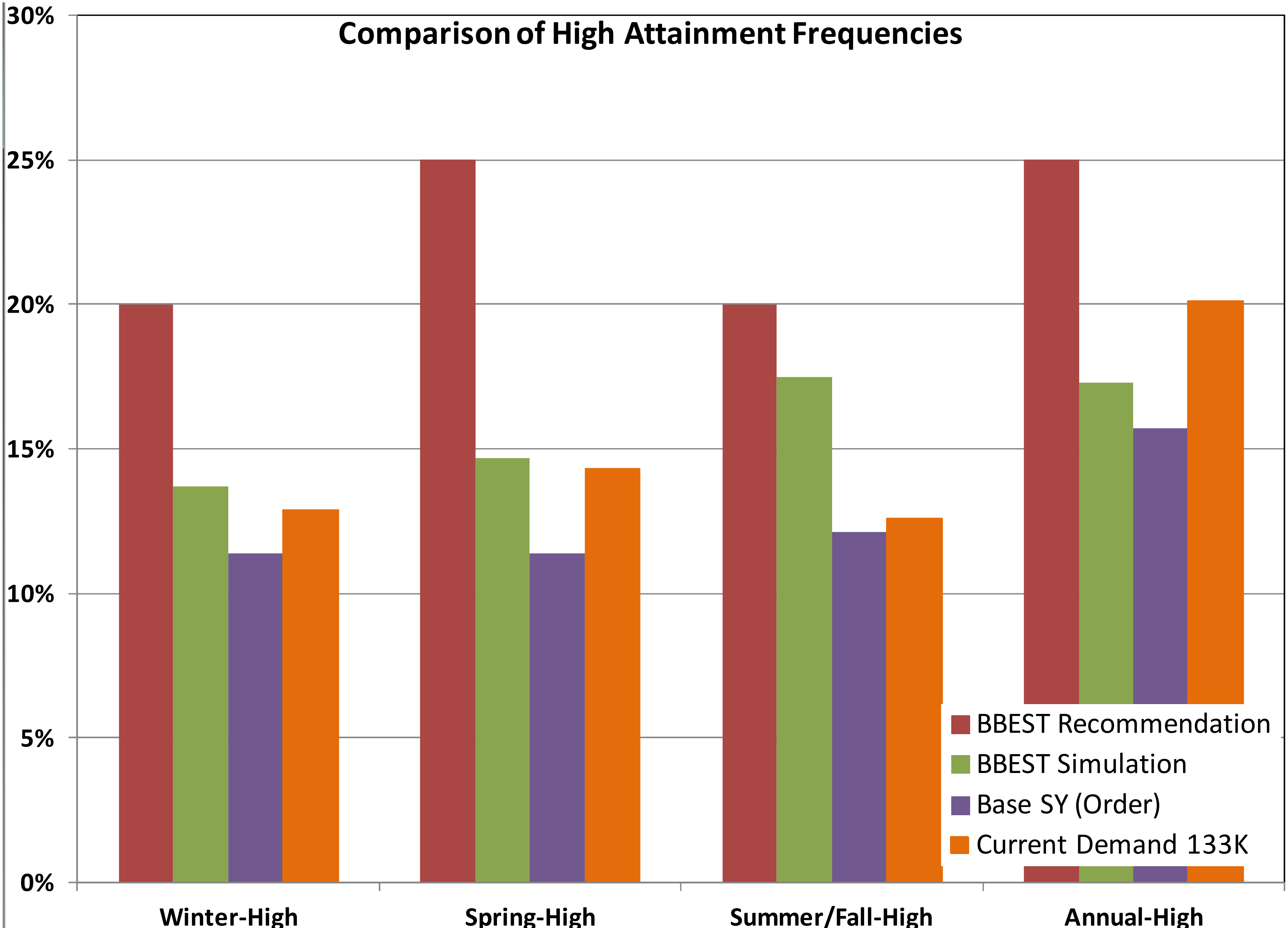
Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations
				Annual Total (acft)
High (10)	125,000 acft (11%)	250,000 acft (11%)	375,000 (12%)	750,000 (16%)
Base (18)	22,000 acft (23%)	88,000 acft (30%)	56,000 (40%)	166,000 (47%)
Sub. (34)	5,000 acft (69%)	10,000 acft (88%)	15,000 acft (74%)	30,000 (95%)
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct	

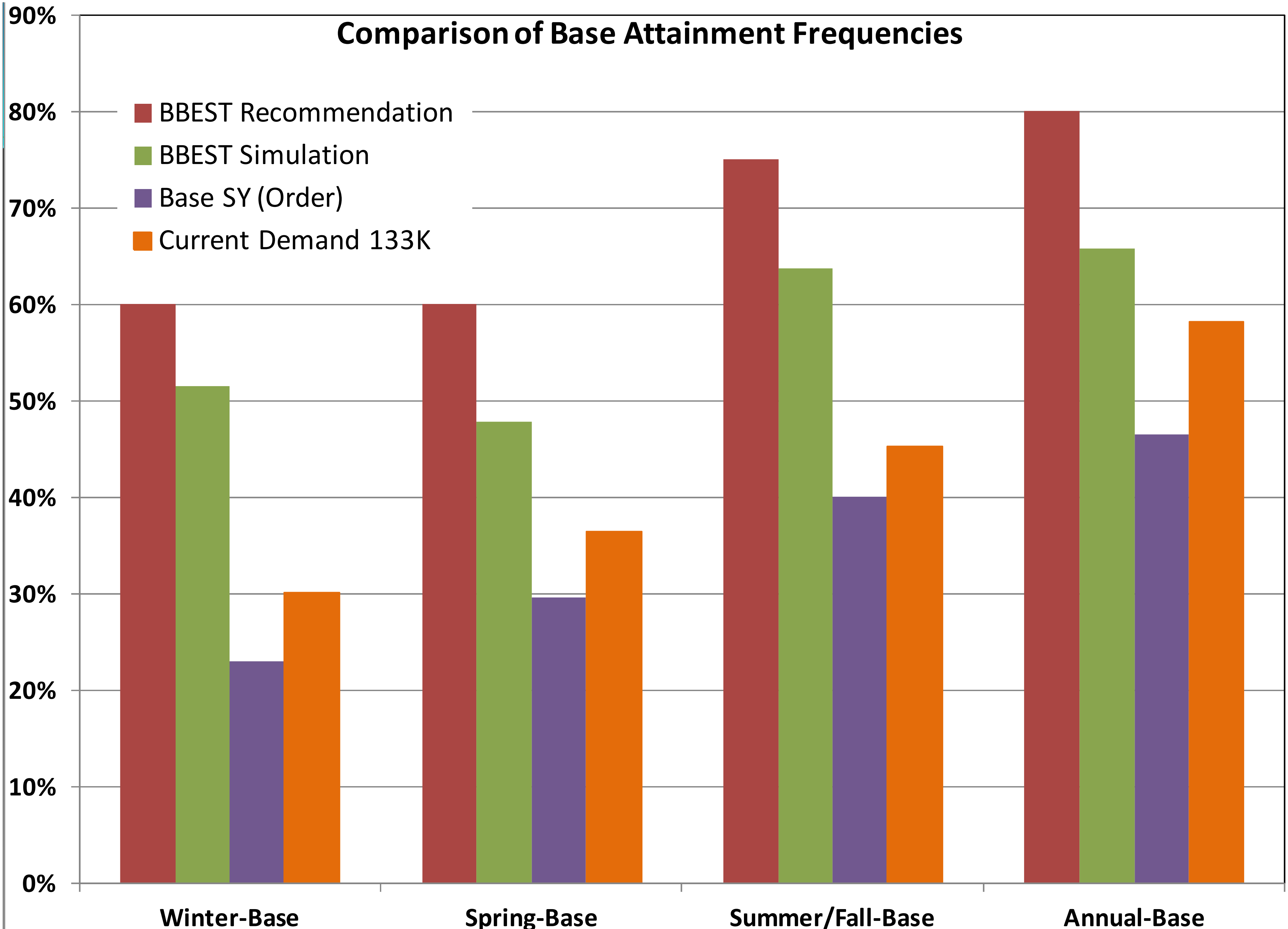


CCR/LCC/LT System Safe Yield / Demand Comparison
250,000
200,000
150,000
100,000
50,000
0
Demand (acft/yr)
BBEST
Full_BBEST
Base_SY (Option 2 - 205K)
Current (133K Full Texana)

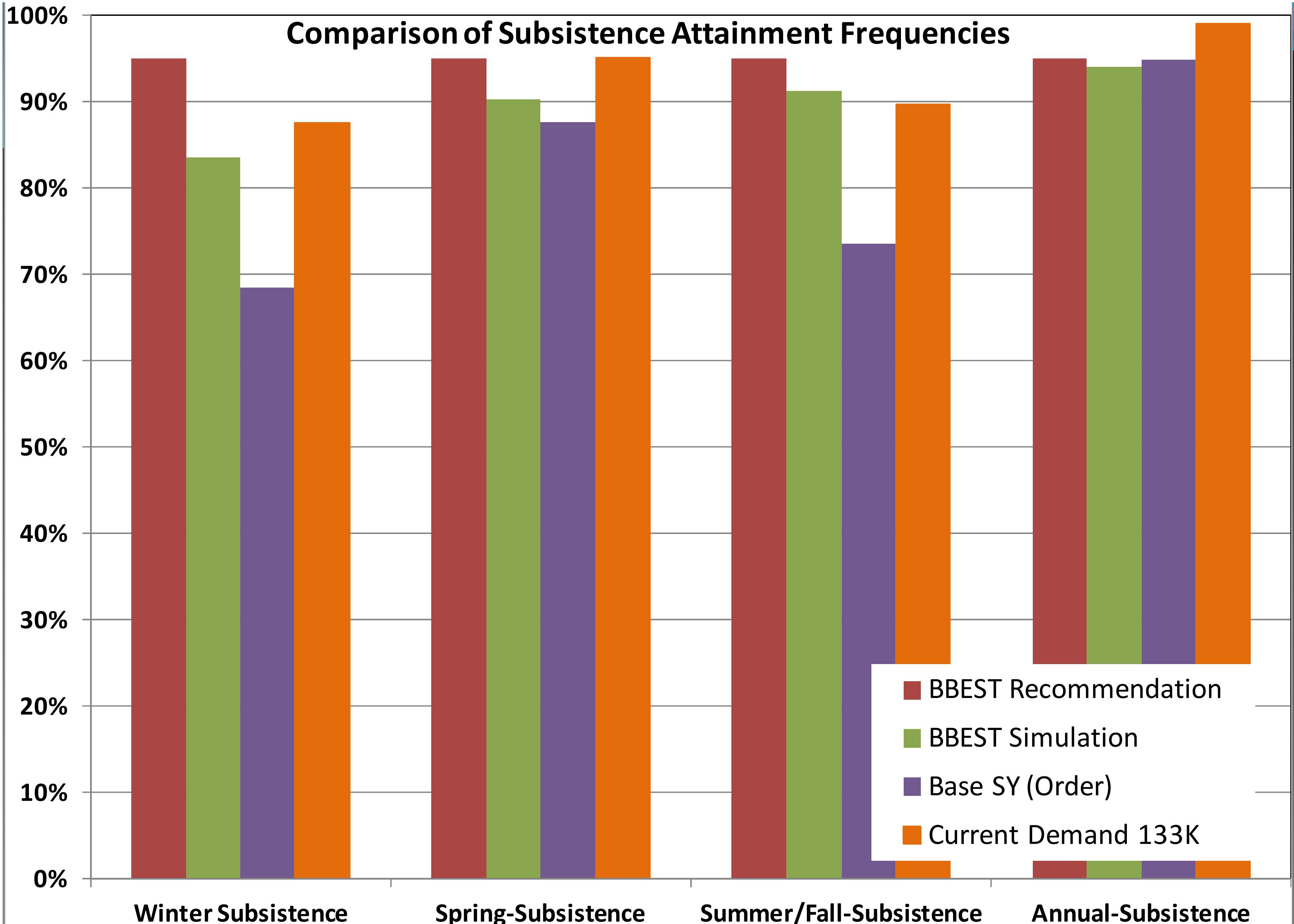


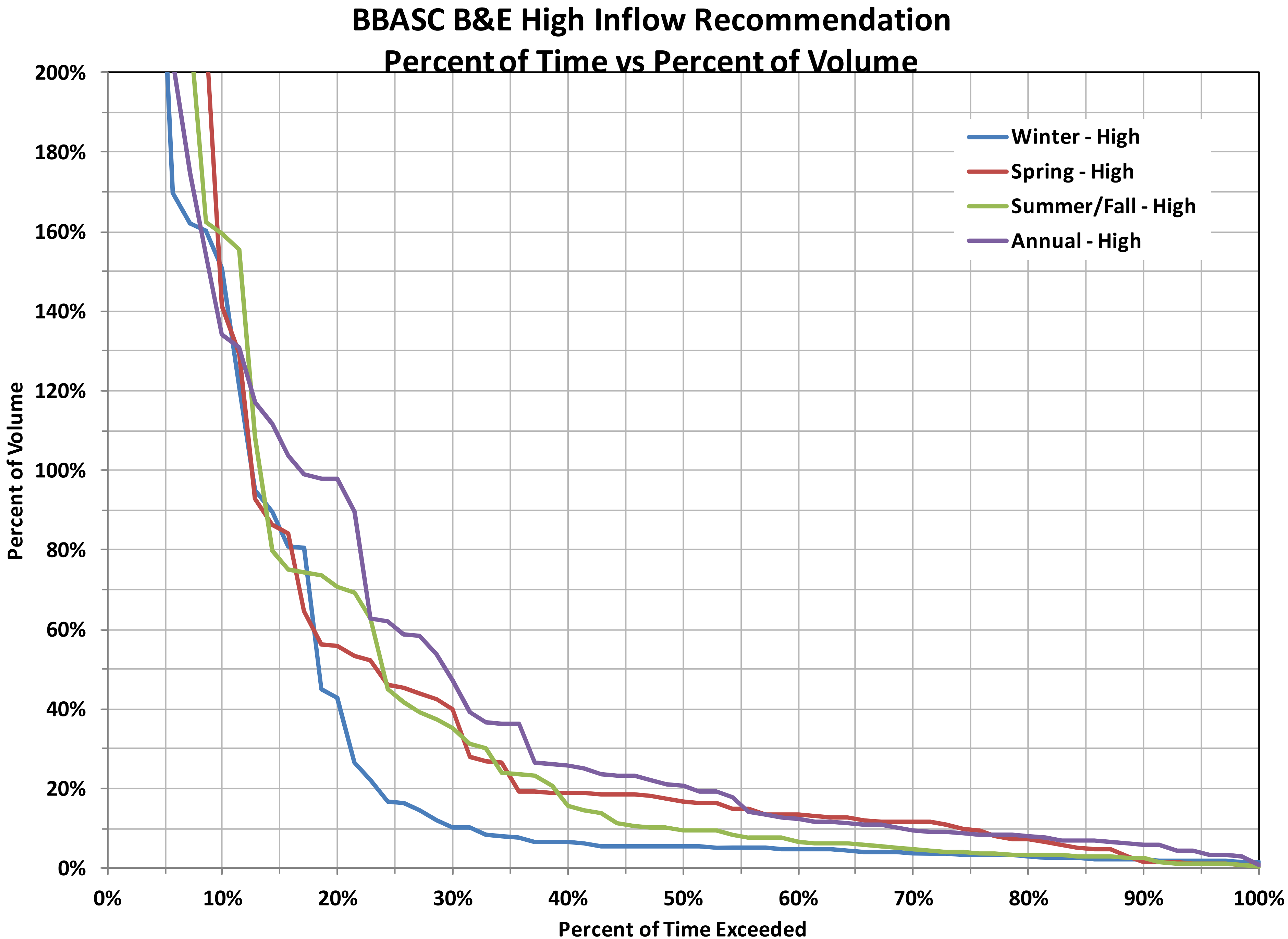
CCR/LCC/LT System Safe Yield - Average Annual Bay Inflow - Average Annual B&E Release
SY (75K Min)
Avg AQBAY
Avg ABEREL
Acft/Yr
500,000
450,000
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
BBEST
Full_BBEST
Base_SY (Option 2 - 205K)
Current (133K Full Texana)

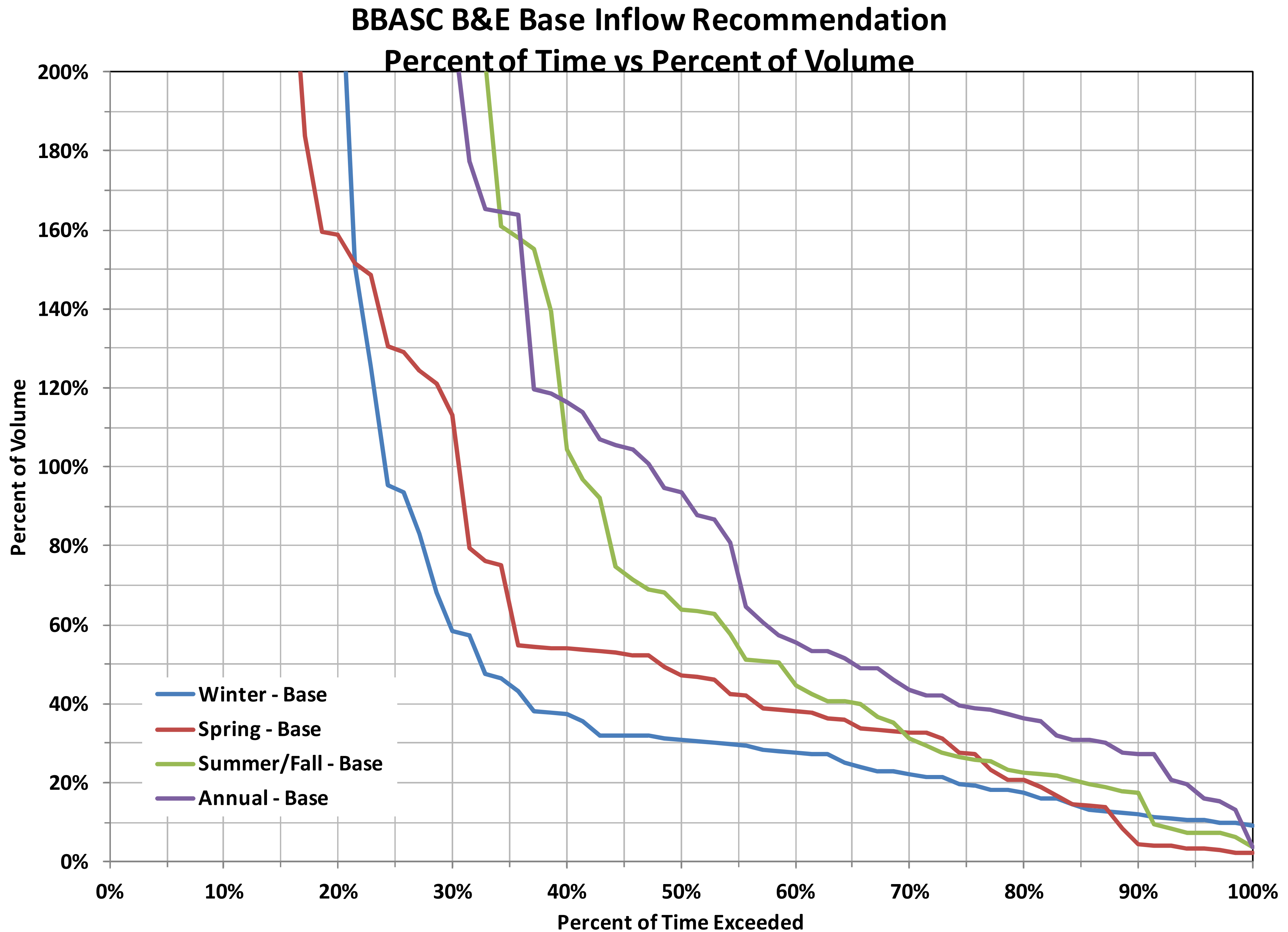

Comparison of High Attainment Frequencies
30%
25%
20%
15%
10%
5%
0%
Winter-High
Spring-High
Summer/Fall-High
Annual-High
BBEST Recommendation
BBEST Simulation
Base SY (Order)
Current Demand 133K

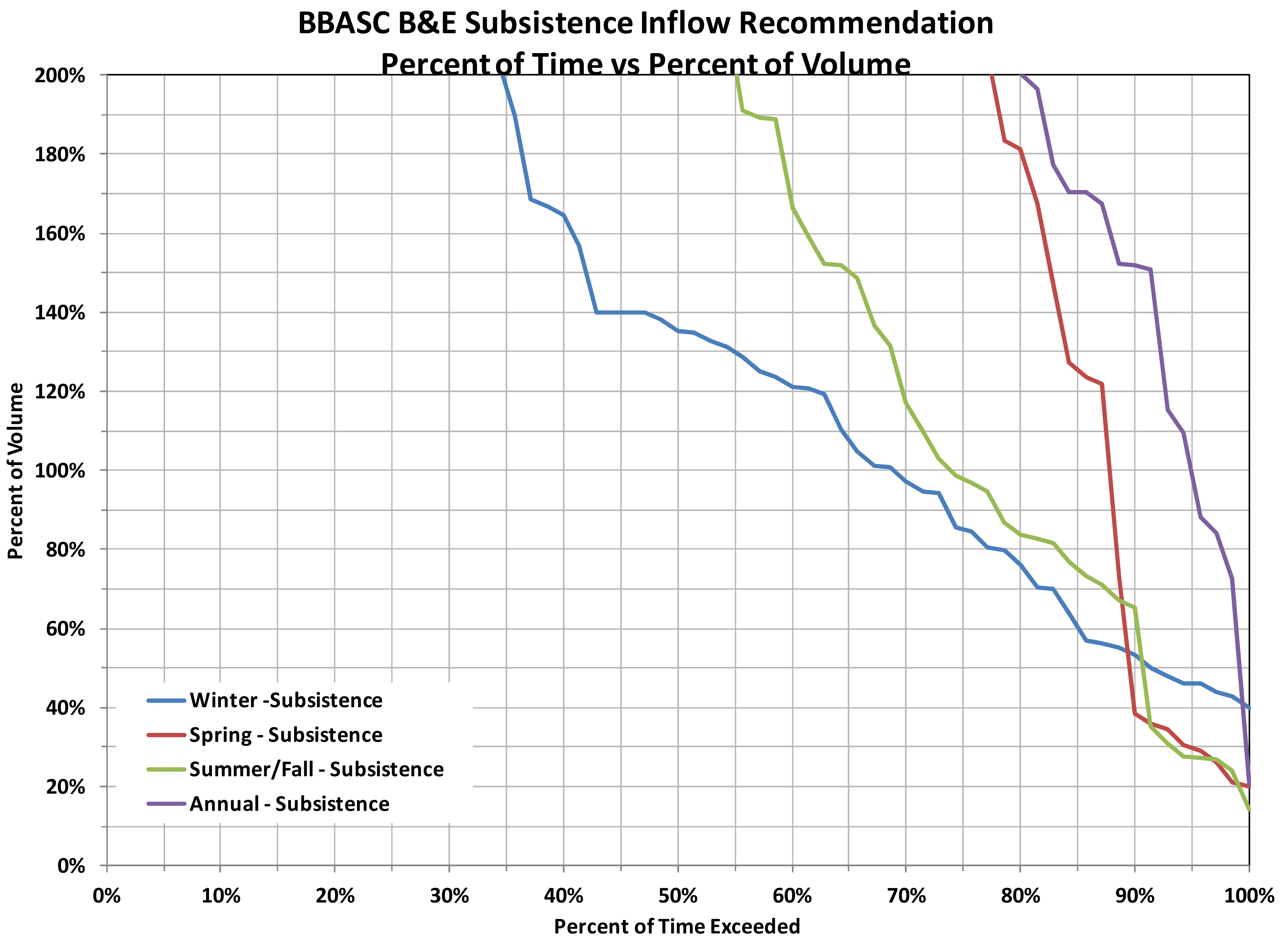


Comparison of Base Attainment Frequencies
BBEST Recommendation
BBEST Simulation
Base SY (Order)
Current Demand 133K
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Winter-Base
Spring-Base
Summer/Fall-Base
Annual-Base

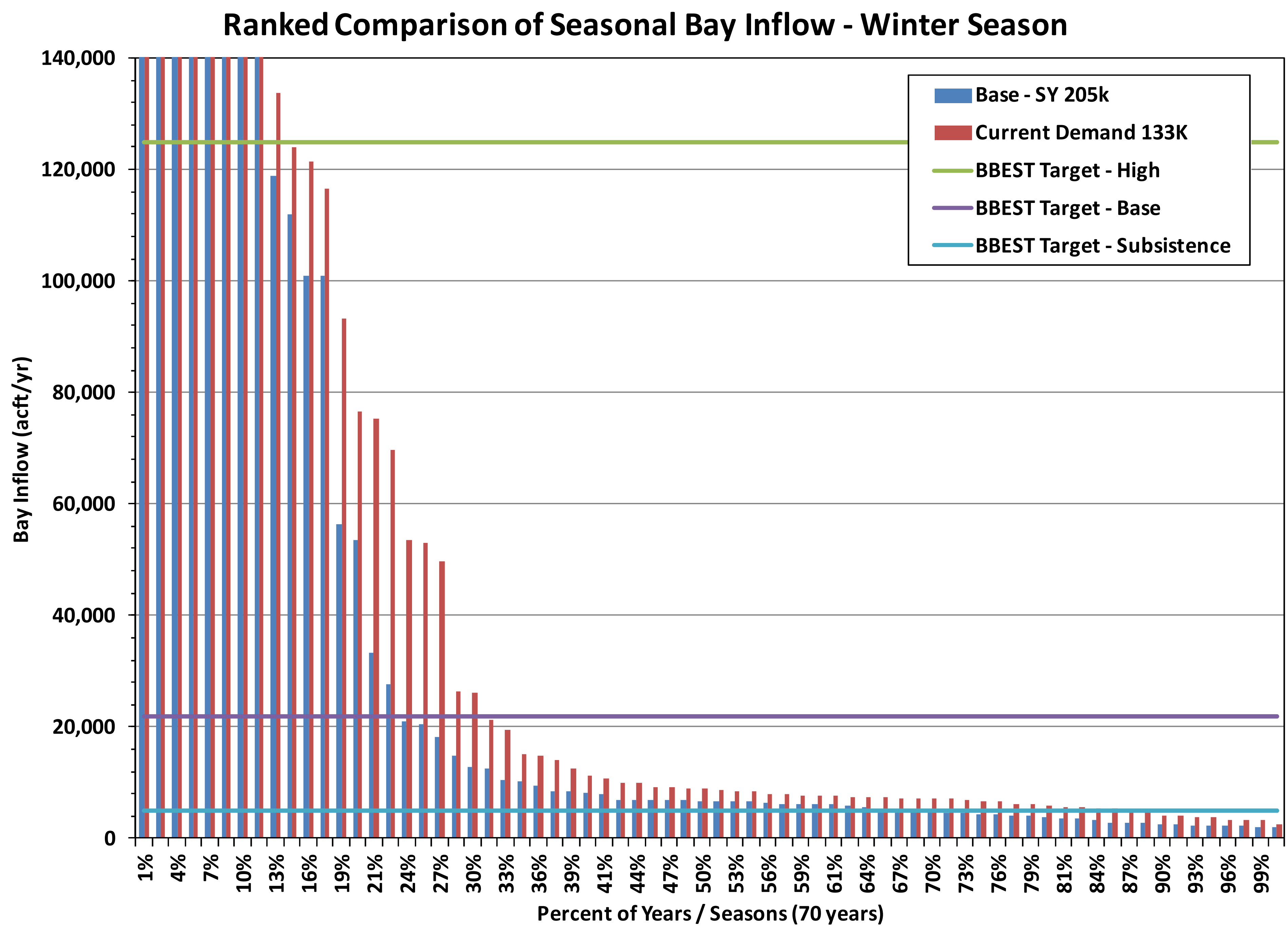

Comparison of Subsistence Attainment Frequencies
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Winter Subsistence
Spring-Subsistence
Summer/Fall-Subsistence
Annual-Subsistence
BBEST Recommendation
BBEST Simulation
Base SY (Order)
Current Demand 133K


BBASC B&E High Inflow Recommendation
Percent of Time vs Percent of Volume
Winter - High
Spring - High
Summer/Fall - High
Annual - High
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
Percent of Volume
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Exceeded

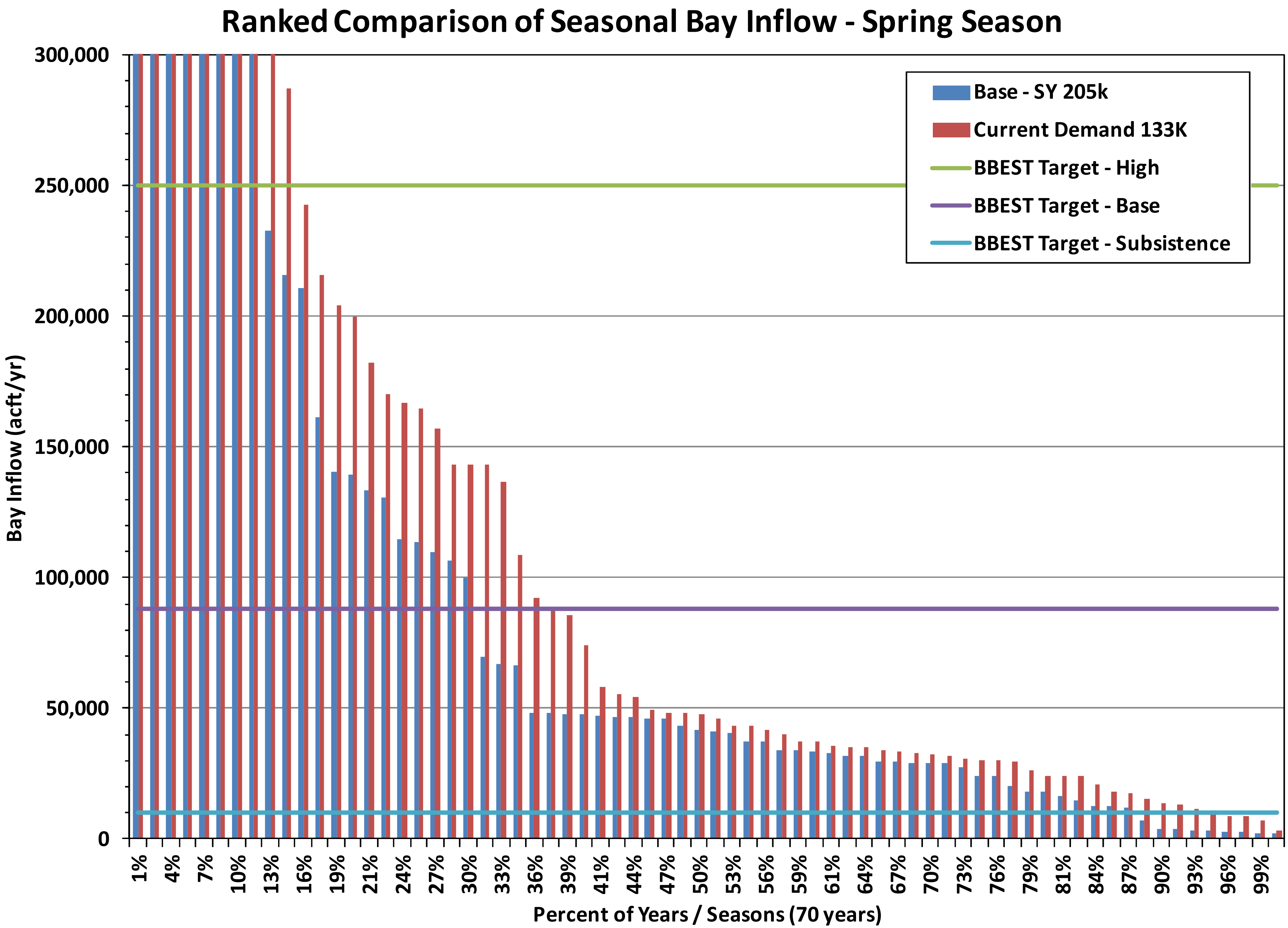

BBASC B&E Base Inflow Recommendation
Percent of Time vs Percent of Volume
Percent of Volume
Percent of Time Exceeded
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Winter - Base
Spring - Base
Summer/Fall - Base
Annual - Base



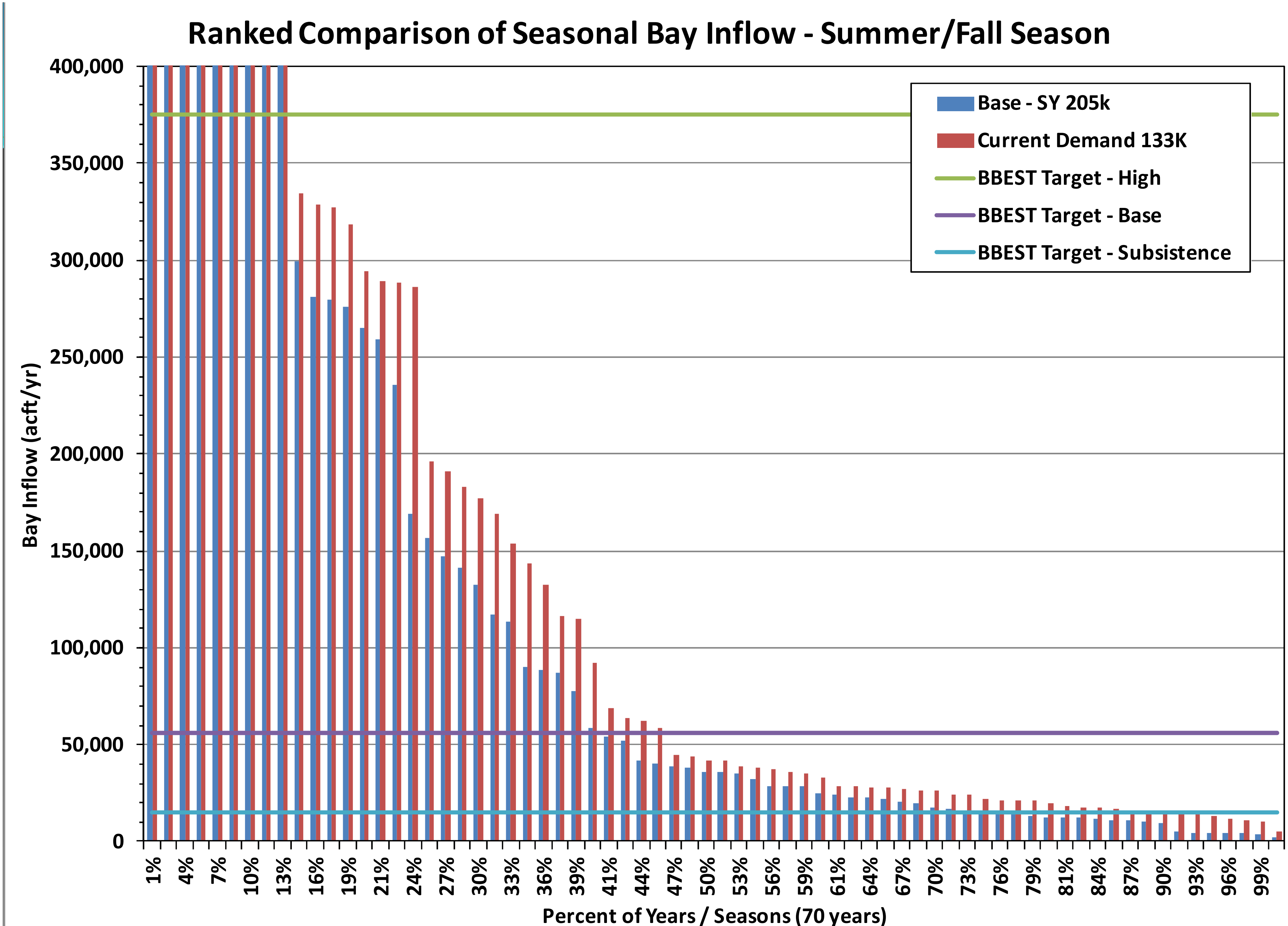
BBASC B&E Subsistence Inflow Recommendation
Percent of Time vs Percent of Volume
Percent of Volume
200%
180%
160%
140%
120%
100%
80%
60%
40%
20%
0%
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percent of Time Exceeded
Winter -Subsistence
Spring - Subsistence
Summer/Fall - Subsistence
Annual - Subsistence

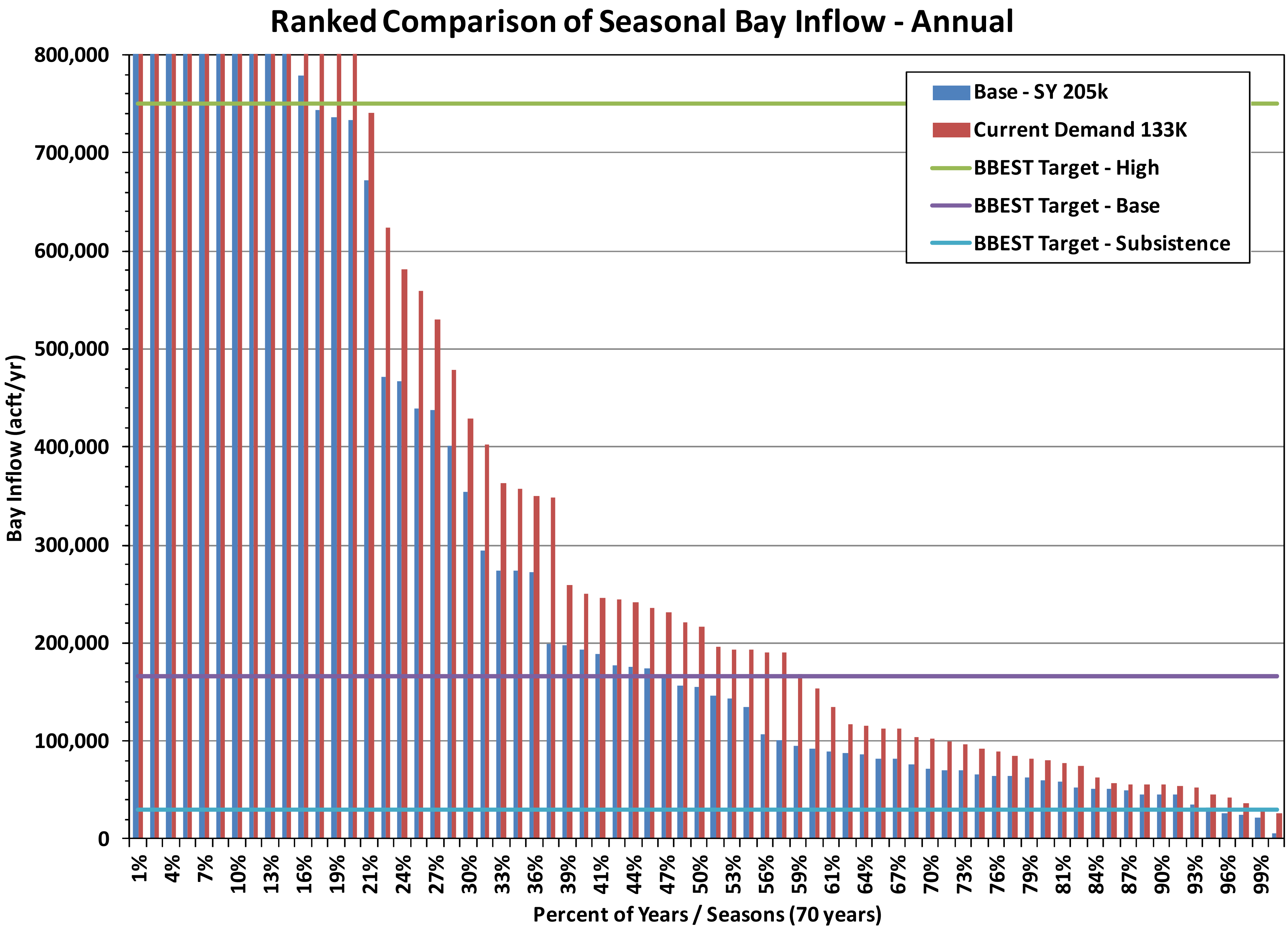


Ranked Comparison of Seasonal Bay Inflow - Winter Season
Base - SY 205k
Current Demand 133K
BBEST Target - High
BBEST Target - Base
BBEST Target - Subsistence
Bay Inflow (acft/yr)
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
1% 4% 7% 10% 13% 16% 19% 21% 24% 27% 30% 33% 36% 39% 41% 44% 47% 50% 53% 56% 59% 61% 64% 67% 70% 73% 76% 79% 81% 84% 87% 90% 93% 96% 99%
Percent of Years / Seasons (70 years)



Ranked Comparison of Seasonal Bay Inflow - Spring Season
Base - SY 205k
Current Demand 133K
BBEST Target - High
BBEST Target - Base
BBEST Target - Subsistence
Bay Inflow (acft/yr)
300,000
250,000
200,000
150,000
100,000
50,000
0
1%
4%
7%
10%
13%
16%
19%
21%
24%
27%
30%
33%
36%
39%
41%
44%
47%
50%
53%
56%
59%
61%
64%
67%
70%
73%
76%
79%
81%
84%
87%
90%
93%
96%
99%
Percent of Years / Seasons (70 years)


Ranked Comparison of Seasonal Bay Inflow - Summer/Fall Season
Bay Inflow (acft/yr)
Percent of Years / Seasons (70 years)
Base - SY 205k
Current Demand 133K
BBEST Target - High
BBEST Target - Base
BBEST Target - Subsistence



Ranked Comparison of Seasonal Bay Inflow - Annual
Bay Inflow (acft/yr)
800,000
700,000
600,000
500,000
400,000
300,000
200,000
100,000
0
Base - SY 205k
Current Demand 133K
BBEST Target - High
BBEST Target - Base
BBEST Target - Subsistence
1%
4%
7%
10%
13%
16%
19%
21%
24%
27%
30%
33%
36%
39%
41%
44%
47%
50%
53%
56%
59%
61%
64%
67%
70%
73%
76%
79%
81%
84%
87%
90%
93%
96%
99%
Percent of Years / Seasons (70 years)

For BBASC Consideration

- BBASC Adopt an Estuary & Delta Environmental Flow Standard Recommendation
  - BBEST Volume Targets
  - BBASC Attainment Frequencies
    - Agreed Order Safe Yield (205K)
- NEAC review and recommendations to TCEQ for applications for new appropriations in excess of 1,000 acft/yr.

BBASC Recommendation for B&E

Condition (Target Salinity)	Nueces Bay Freshwater Inflow Regime (Attainment)			Recommendations
				Annual Total (acft)
High (10)	125,000 acft (11%)	250,000 acft (11%)	375,000 (12%)	750,000 (16%)
Base (18)	22,000 acft (23%)	88,000 acft (30%)	56,000 (40%)	166,000 (47%)
Sub. (34)	5,000 acft (69%)	10,000 acft (88%)	15,000 acft (74%)	30,000 (95%)
	Winter = Nov - Feb	Spring = Mar - Jun	Summer/Fall = Jul - Oct	

*NEAC review and recommendations to TCEQ for applications for new appropriations in excess of 1,000 acft/yr.

Updates on Nueces BBASC Report Compilation

Presentation to Nueces BBASC

Cory Shockley, PE

HDR Engineering

July 25, 2012

Report Schedule

- July 25 – BBASC Meeting. All Sections Posted. HDR Begin Compile.
  - 1 Week
- August 1 – HDR deliver compiled electronic draft.
  - 1 Week
- August 8 – All Comments due to Authors.
  - 1 Week
- August 15 – Final Sections Posted / Submitted to HDR.
  - 1 Week
- August 22 – BBASC Meeting. Final Hard Copy Delivered.
  - Include Bubble Comments to Address.
- August 31 – HDR Submit Final Report to TCEQ.

Key Points

- Live Edit of Section 6
- HDR Sections
  - 3.3.1 – 3.3.5 – Summary of Analysis
  - 4 – Env. Flow Standards
- Appendices
  - Partial List – Still Developing
- Final Copy – Three Ring Binder

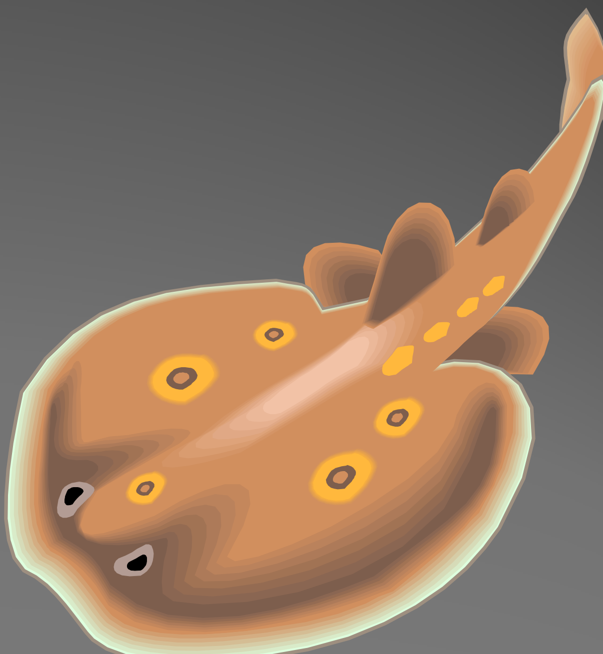
Key Points

- Section 4.4 – Nueces BBASC Comments on SB3 Process
- All Submitted Sections can have Track Changes Approved?
- Preference for file format for electronic draft on 8/1
  - Word to allow for Track Changes
- Author / HDR Notification
  - Email

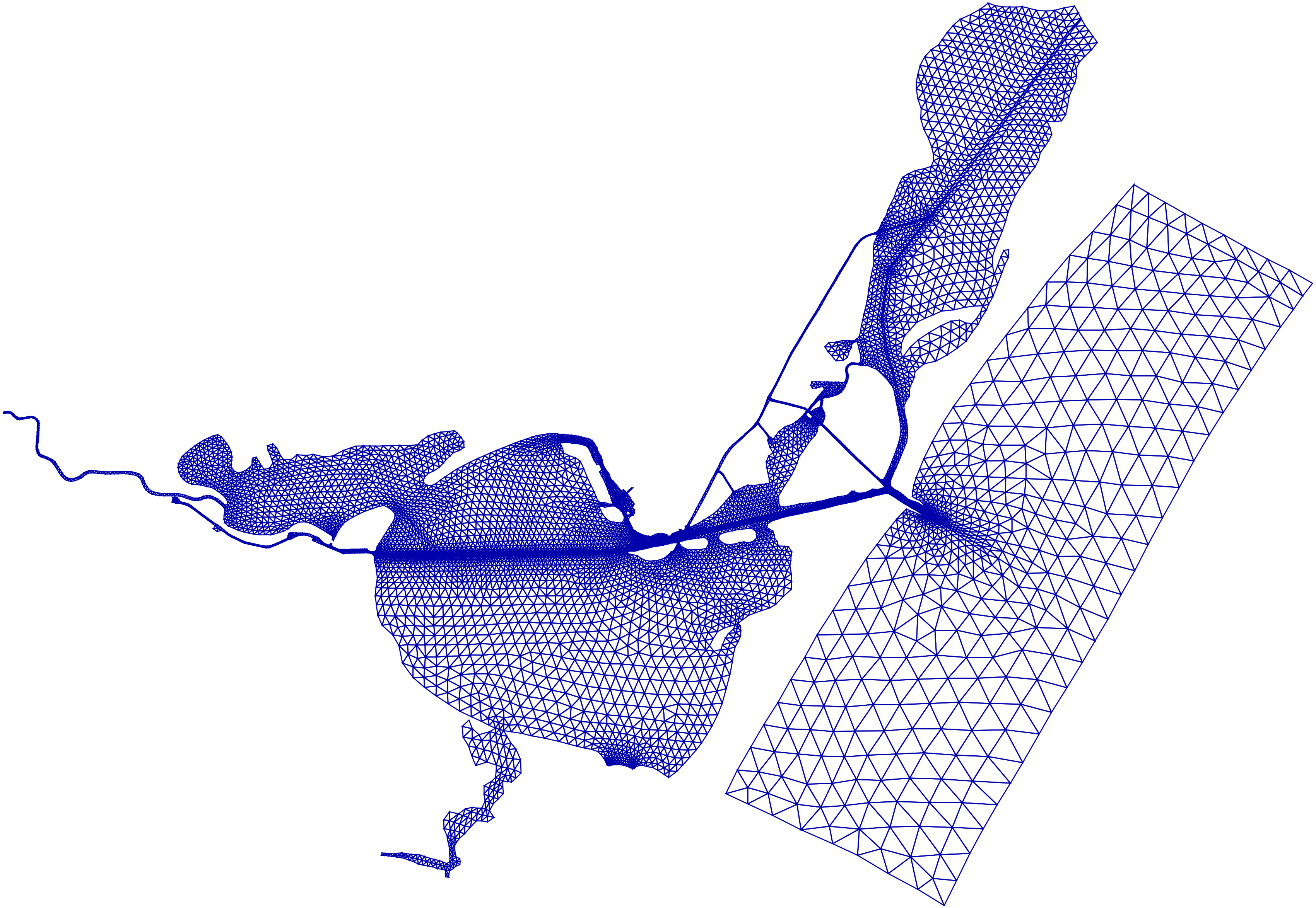
List of Appendices

- Recommended Env. Flow Tables
- Approved Minutes from BBASC Meetings
- SAC Comments on BBEST Report
- TPWD Comments on BBEST Report
- Summary Information presented to BBASC
  - WAM / FRAT / CCWSM Runs
  - TWDB Sediment Analysis
  - Habitat – Flow Analysis
- Report on Strategies to Meet E-Flow Standards by NWF
- Technical Presentations presented to Nueces BBASC from January 2012 – June 2012.
- Others as indicated in Report

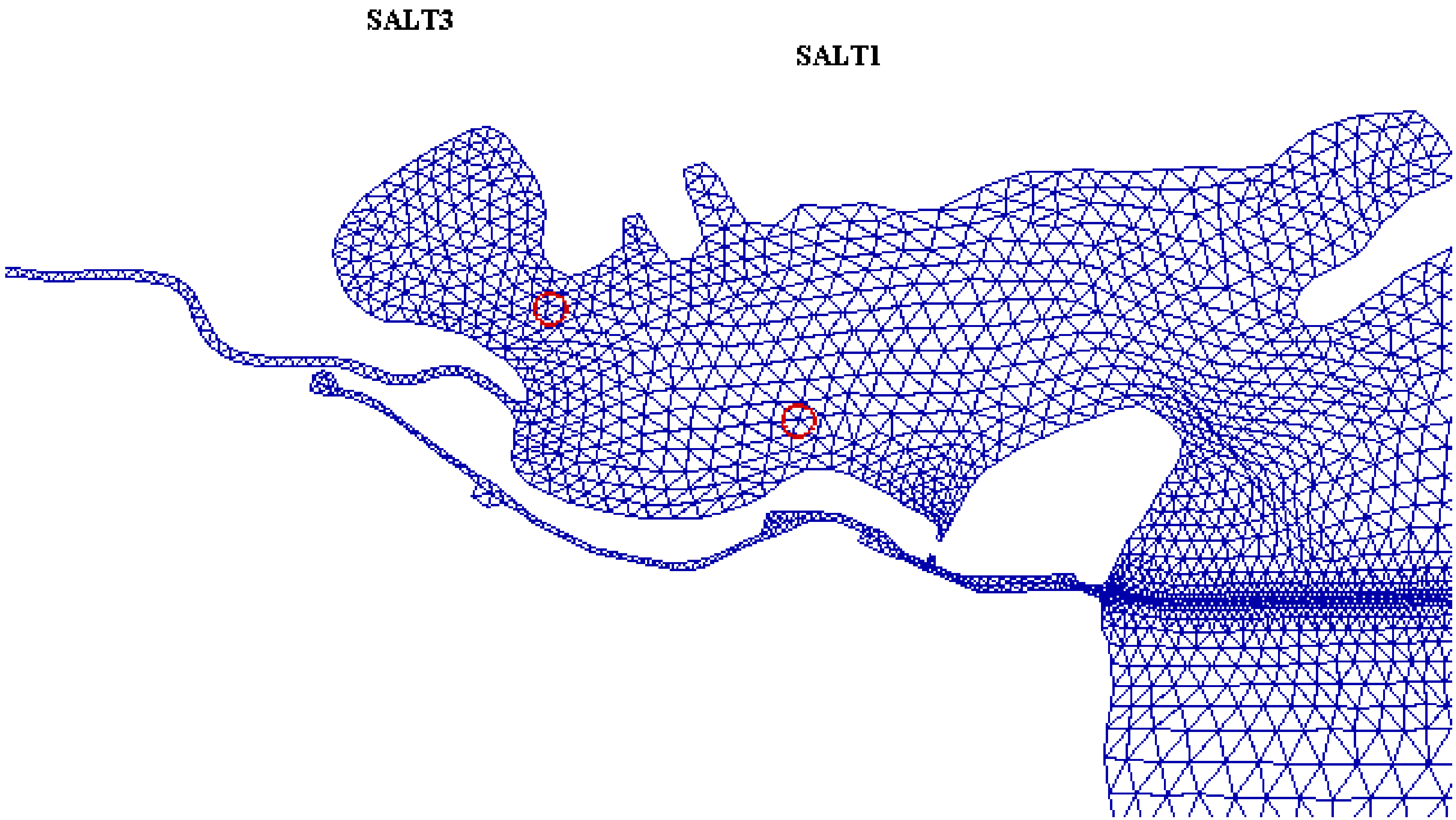
Questions

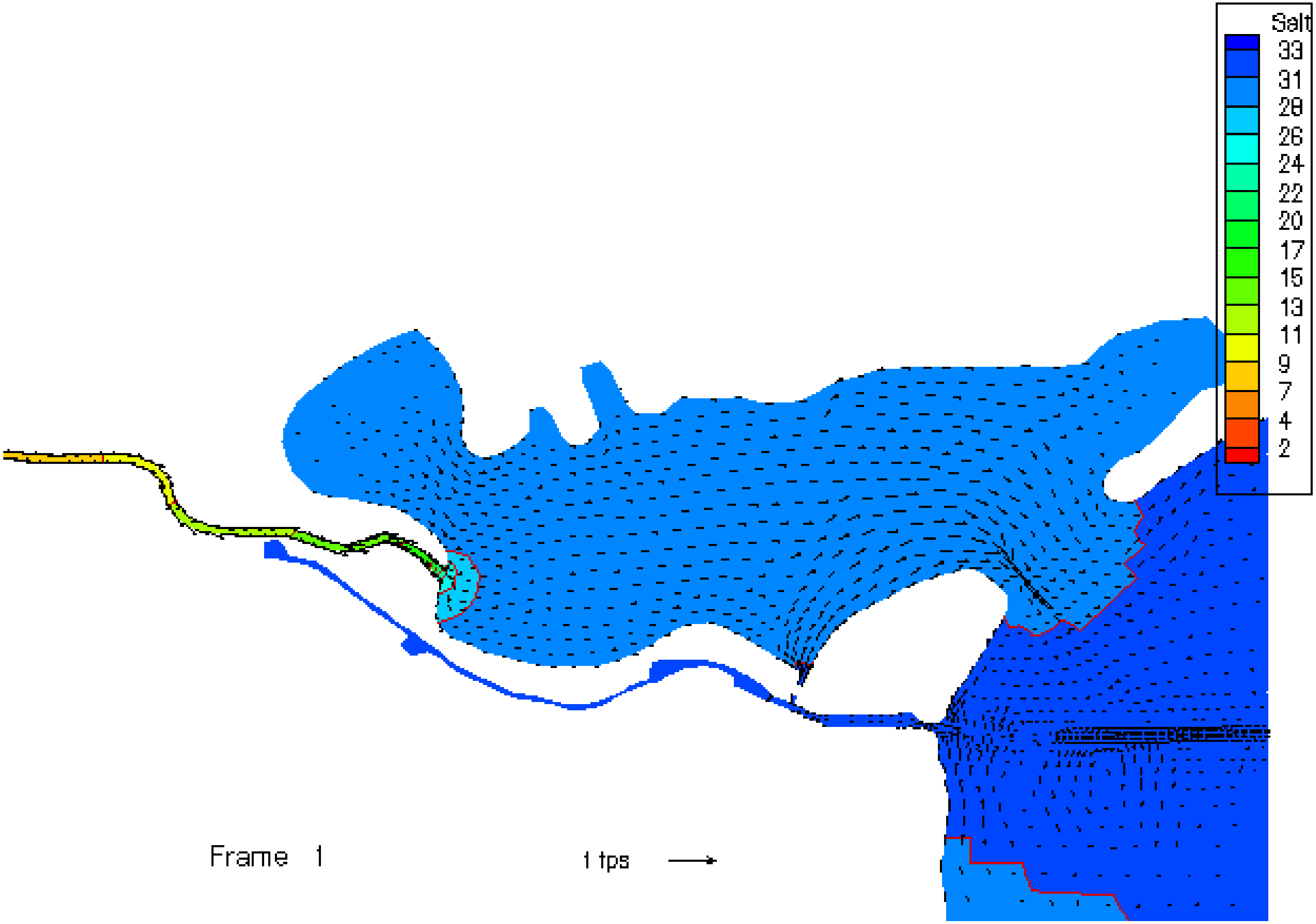


Model Simulation for Salinity Reduction and Maintenance in Nueces Bay



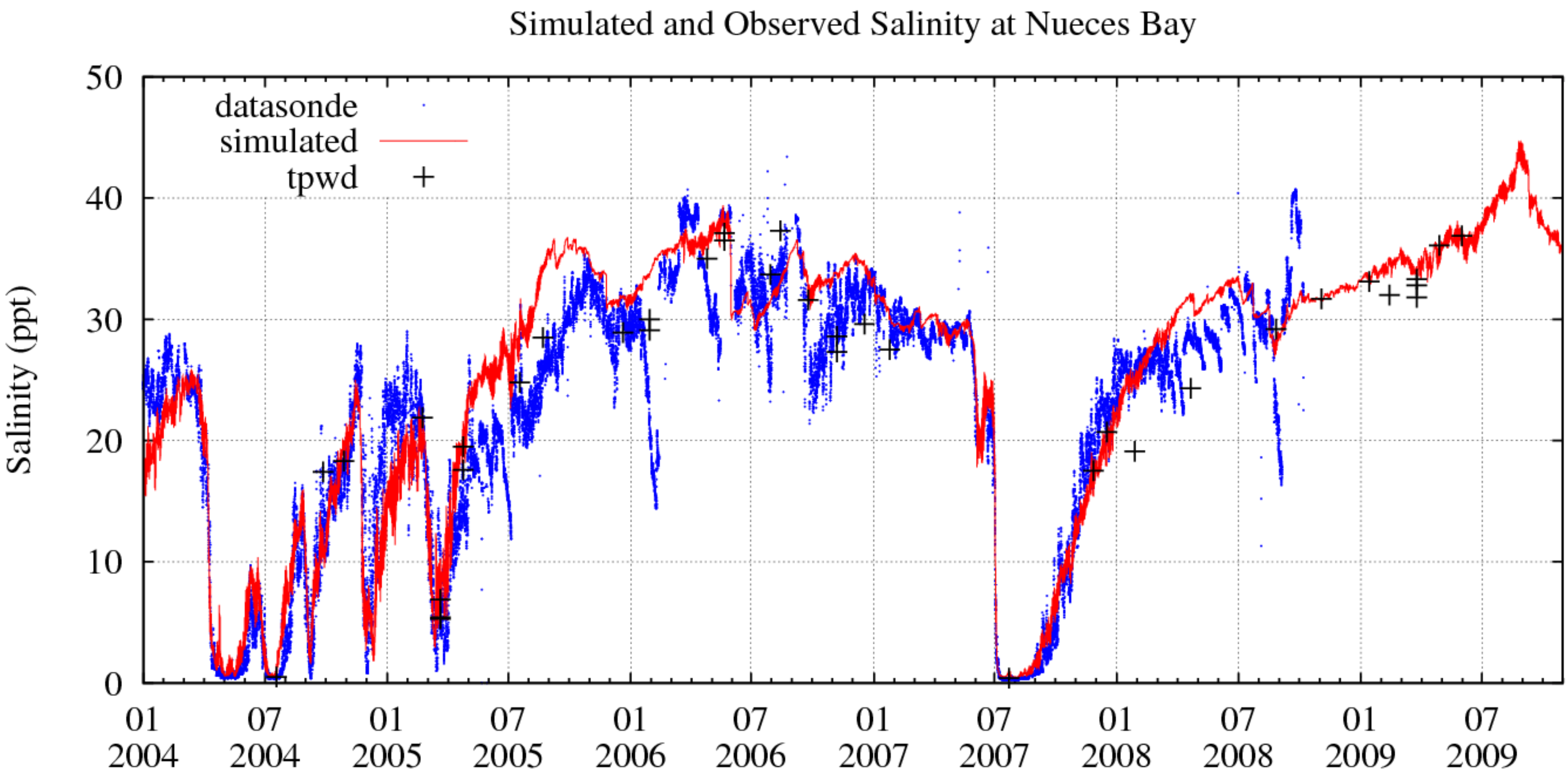
Nueces BBASC model, nn=7,895, ne=13,905


SALT3
SALT1

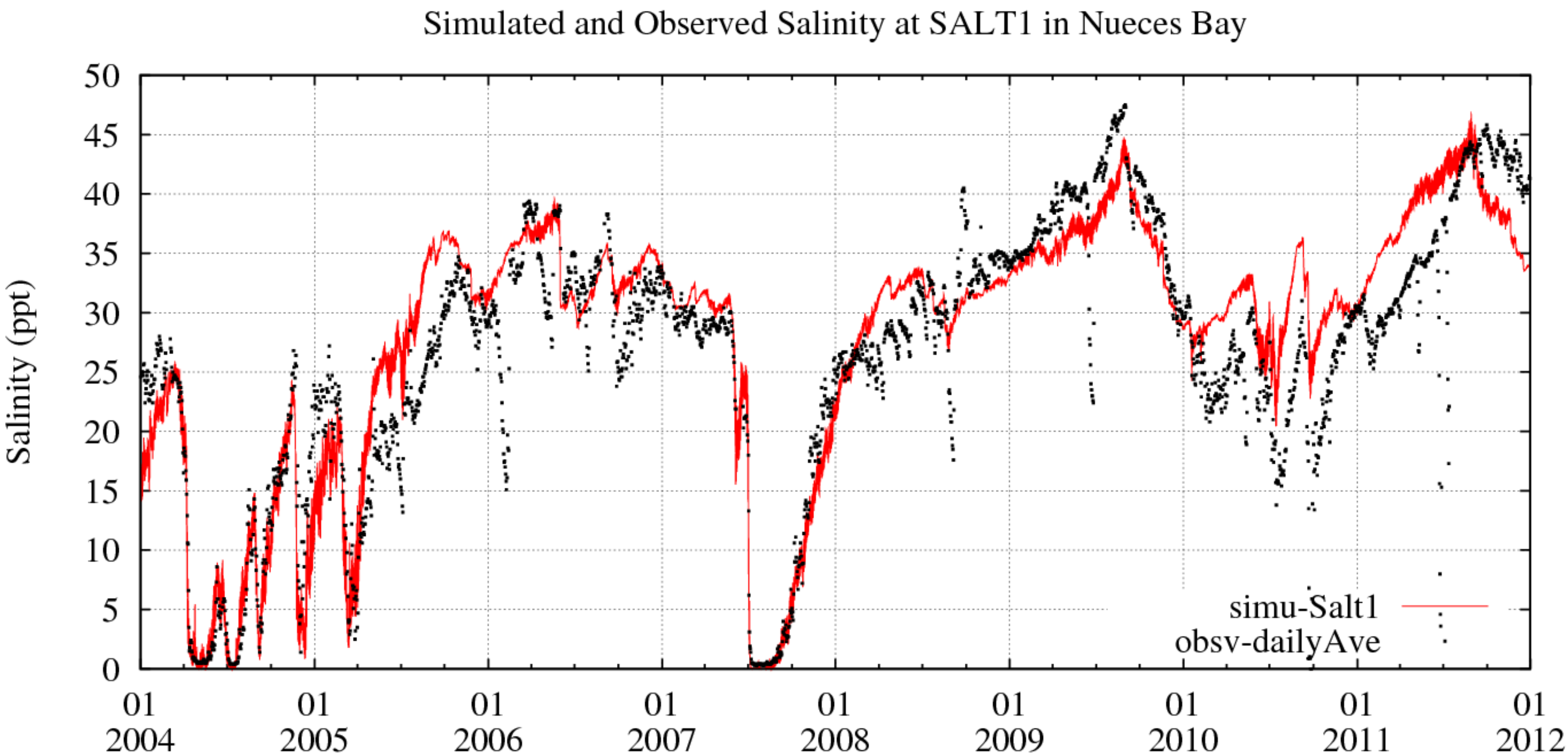


Test: 30-Winter, 8 days: 1/1-1/8/2006, every 2 hour

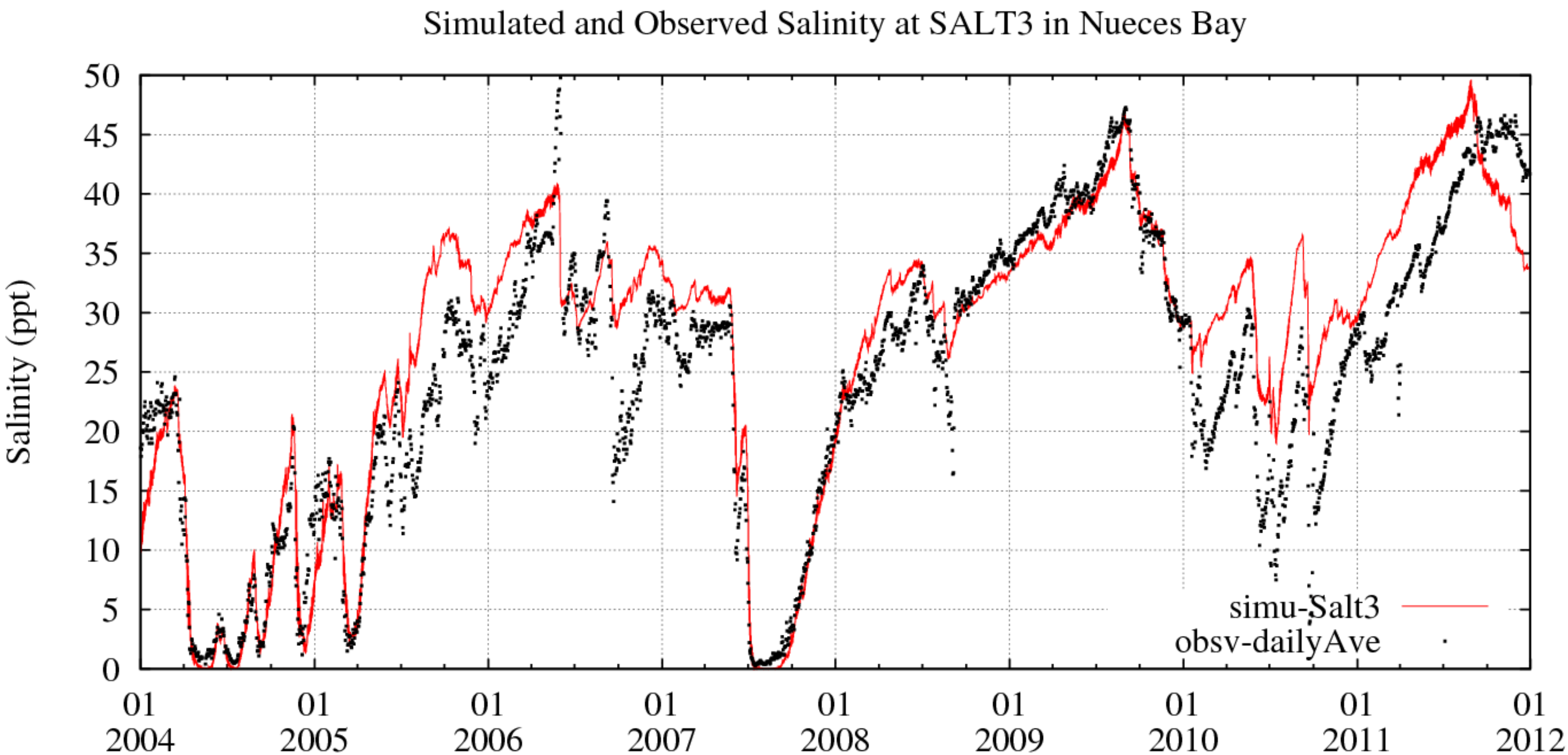
Corpus Christi Bay Model used for BBEST simulation



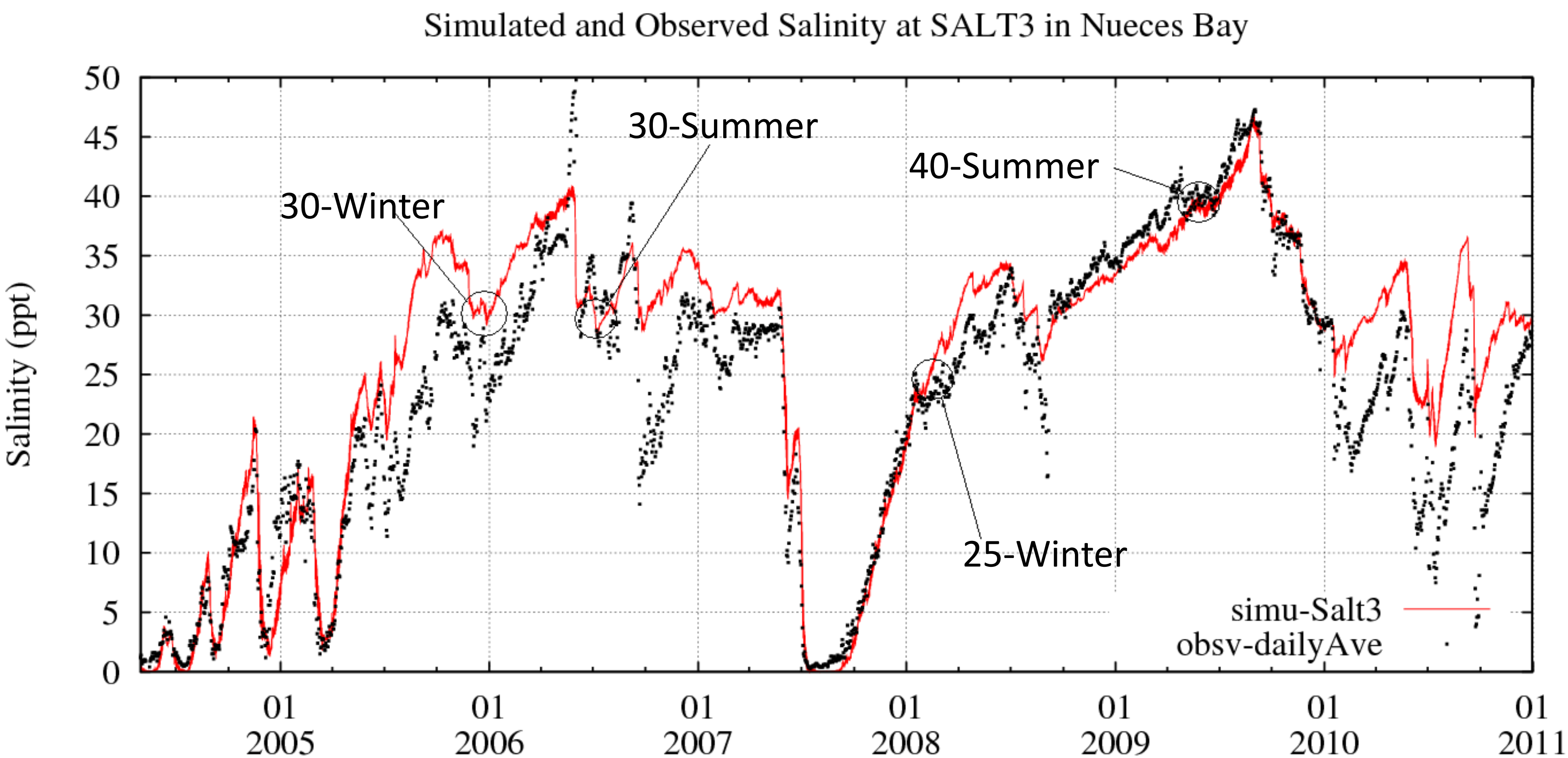
New Nueces Bay BBASC model simulation

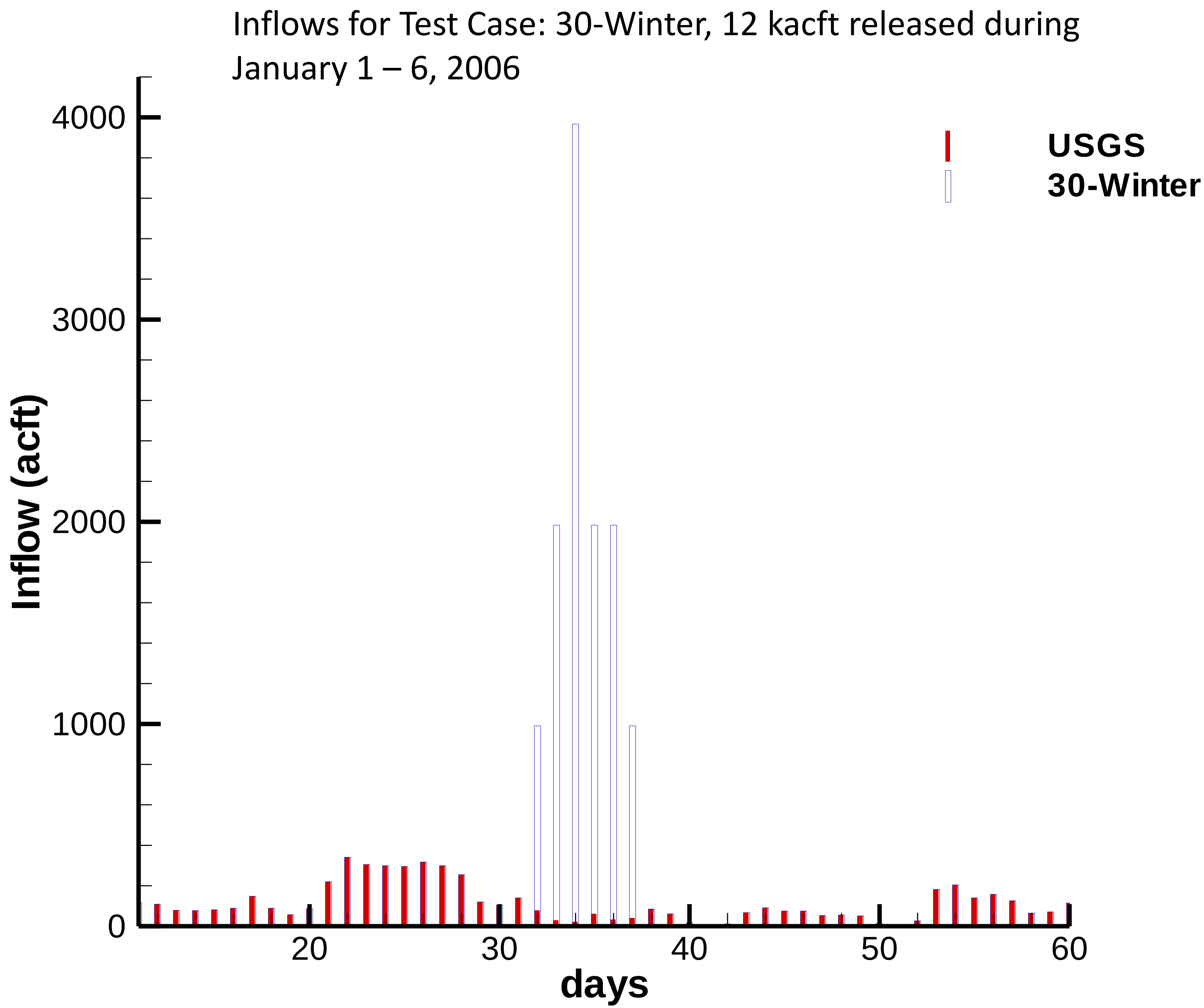


New Nueces Bay BBASC model simulation

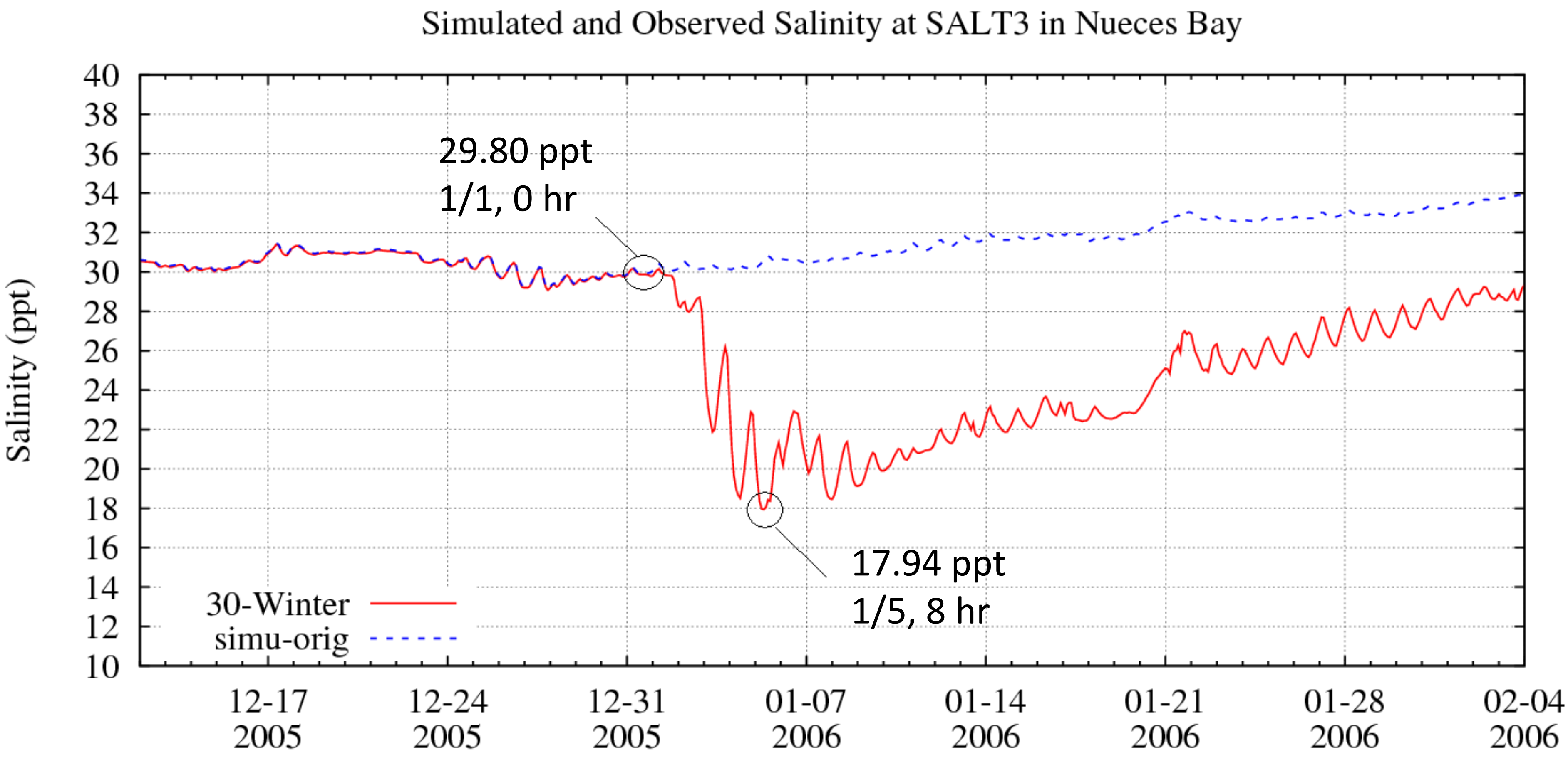


Test design for TxBLEND experiments

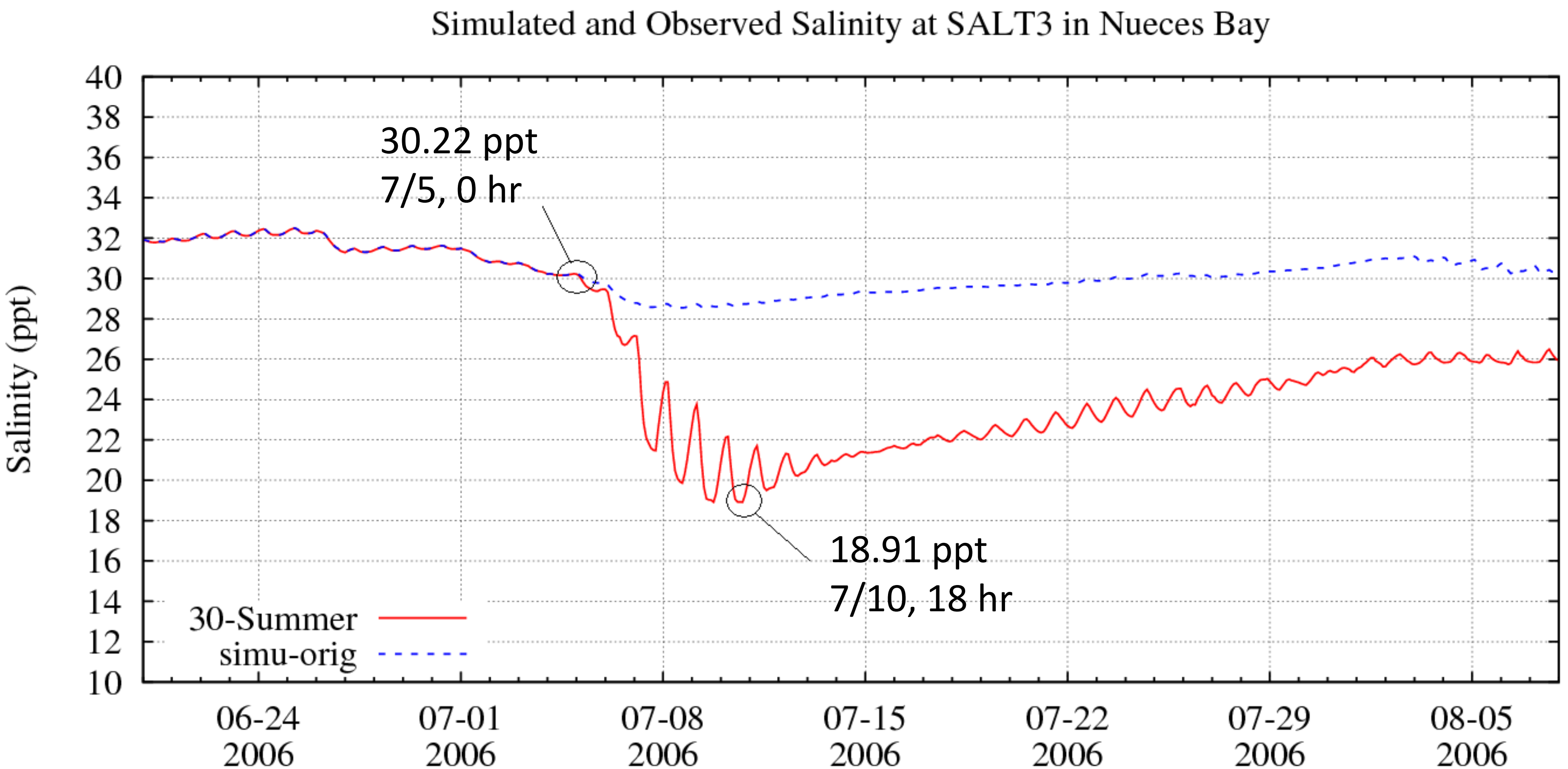



Inflows for Test Case: 30-Winter, 12 kacft released during
January 1 – 6, 2006
Inflow (acft)
0
1000
2000
3000
4000
20
30
40
50
60
days
USGS
30-Winter

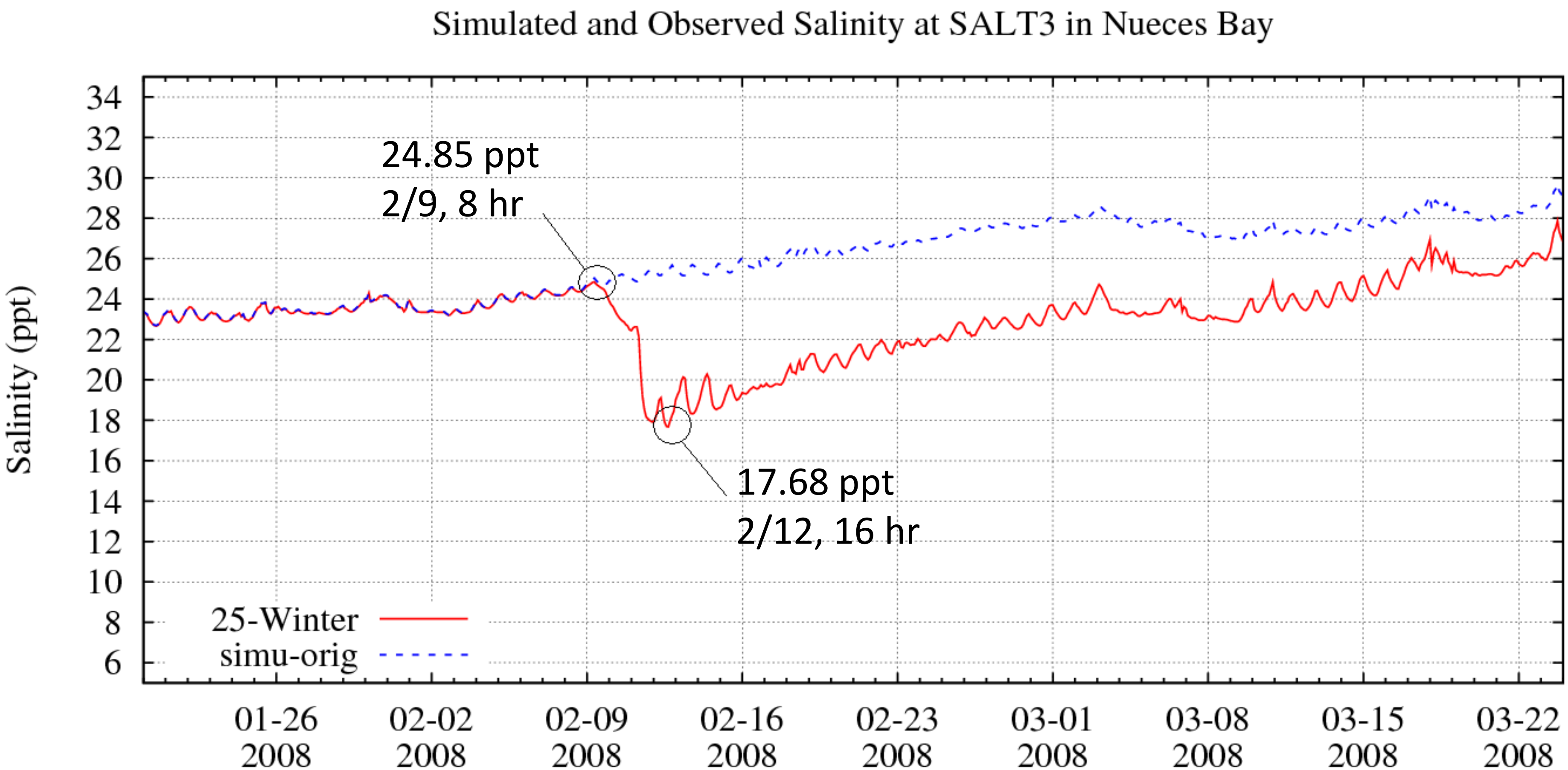
Test: 30-Winter, 12 kacft released 1/1 – 1/6/2006



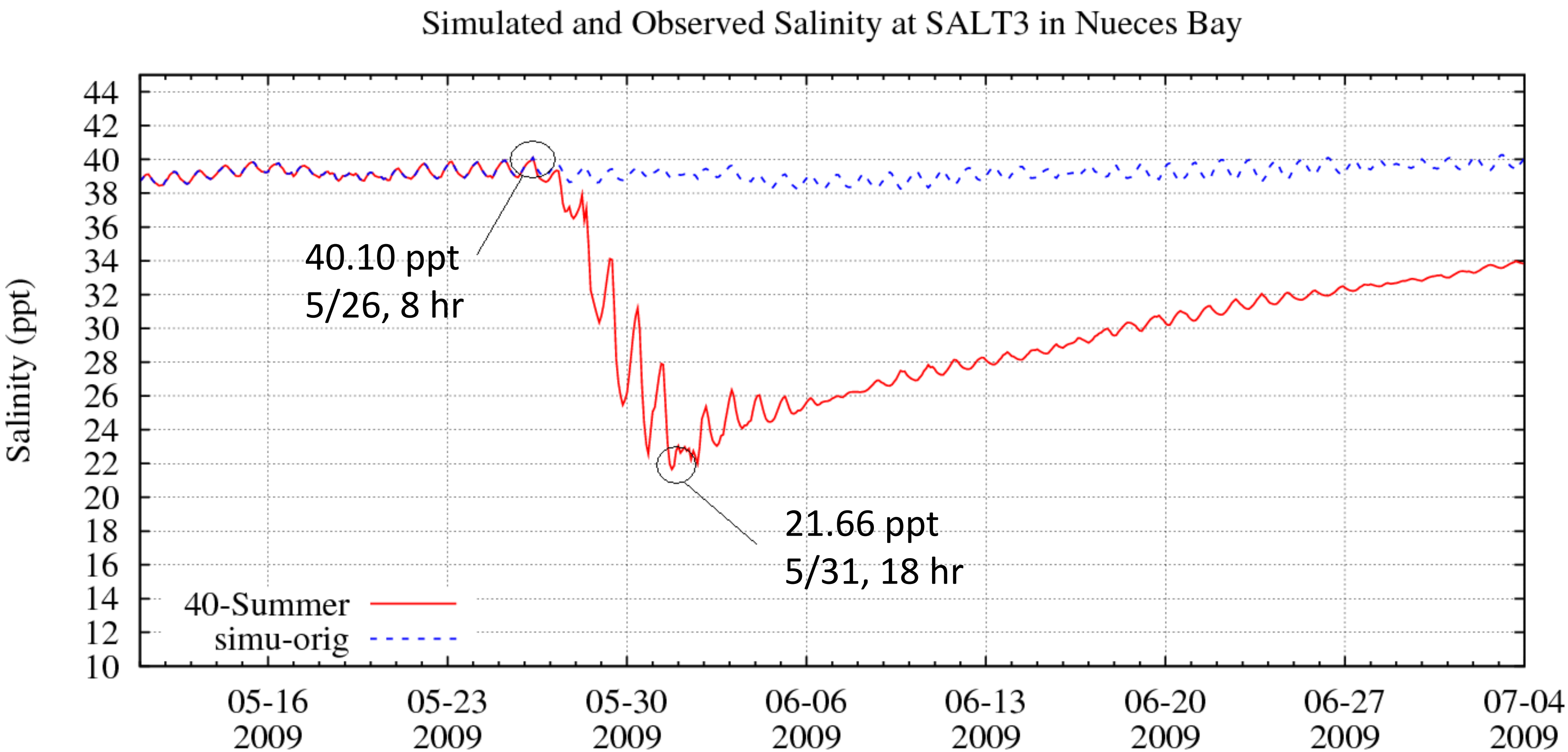
Test: 30-Summer, 12 kacft released 7/5 – 7/10/2006

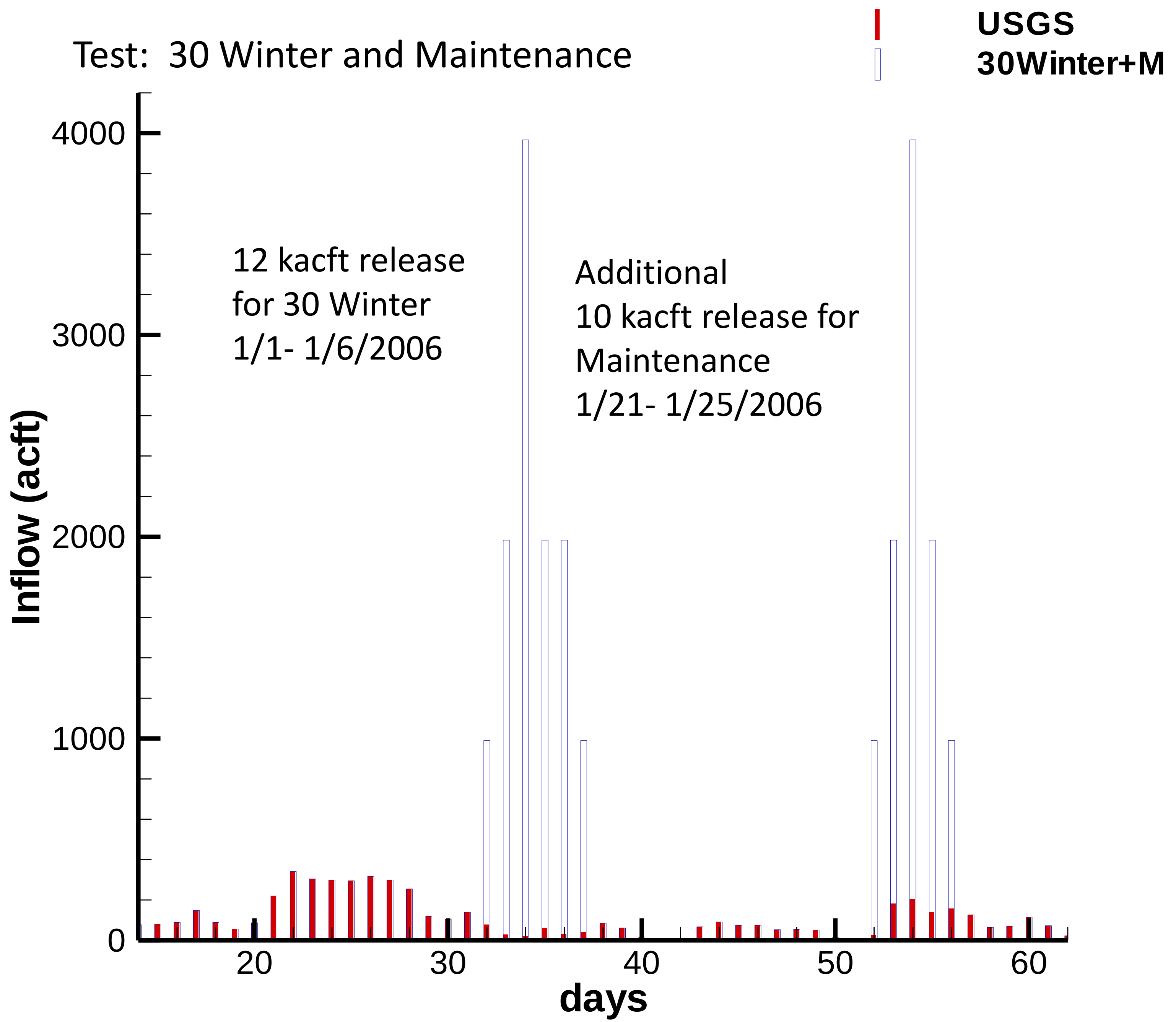


Test: 25-Winter, 10 kacft released 2/9 – 2/13/2008



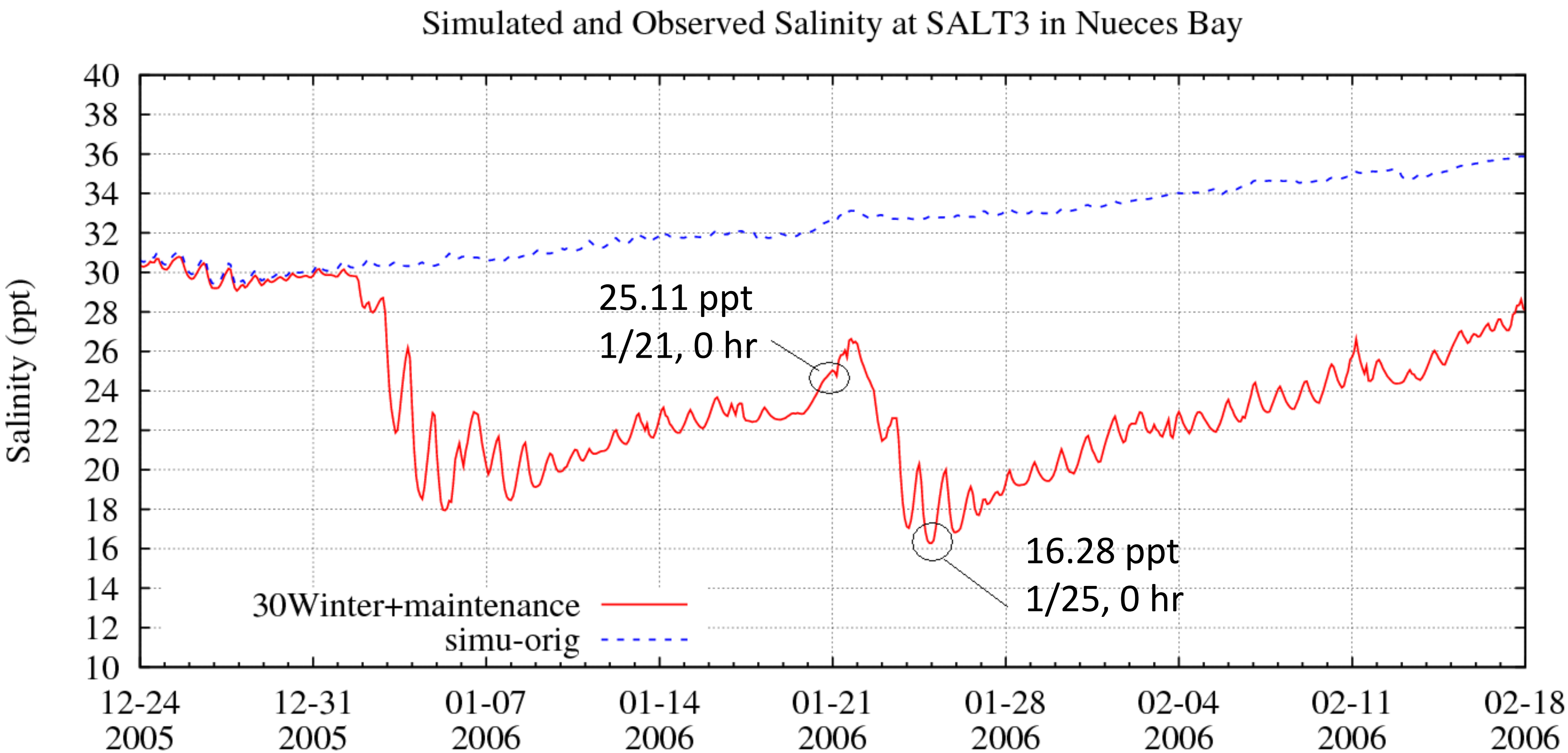
Test: 40-Summer, 18 kacft released 5/26 – 6/1/2009



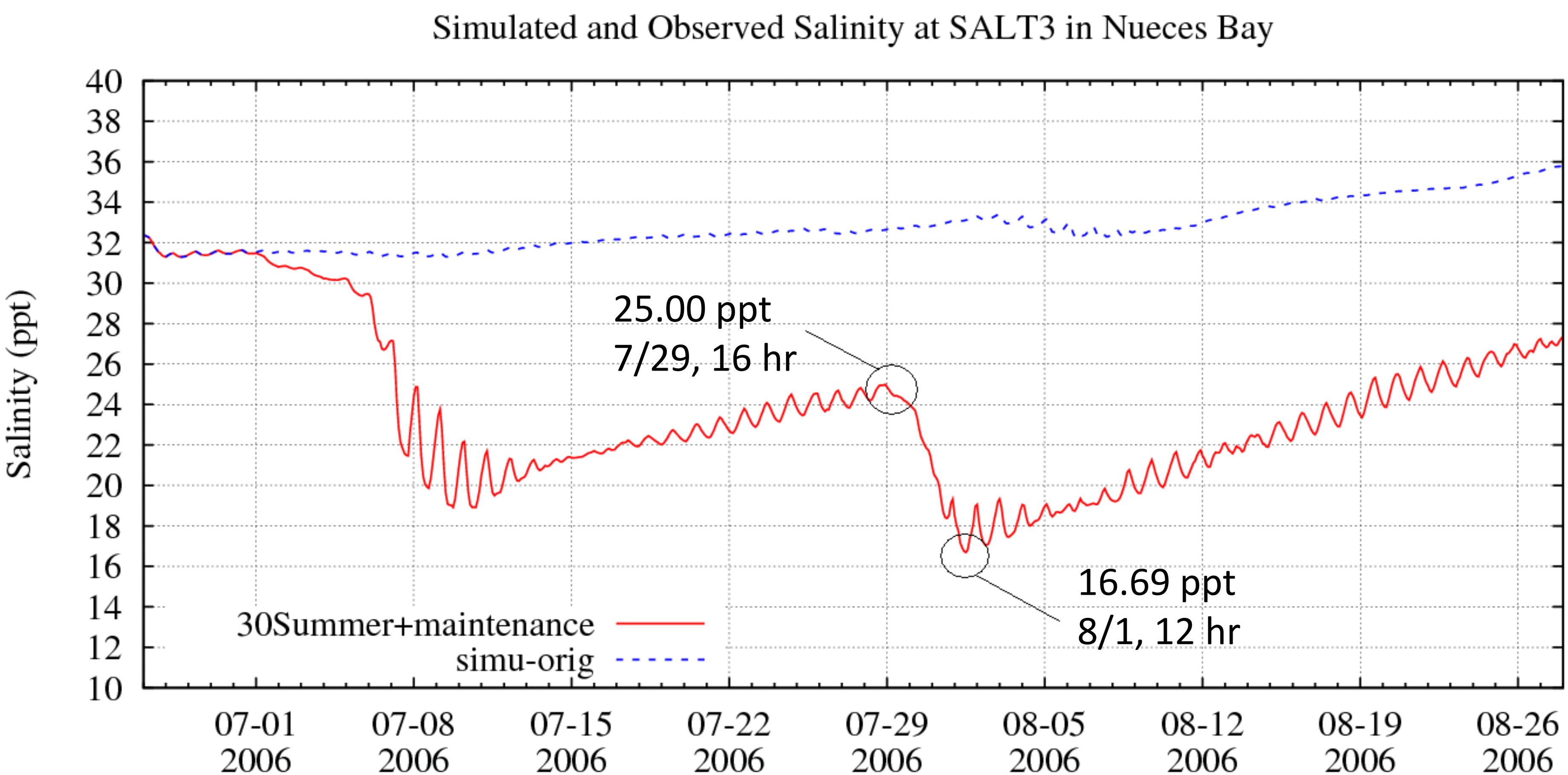


Test: 30 Winter and Maintenance
USGS
30Winter+M
12 kacft release
for 30 Winter
1/1- 1/6/2006
Additional
10 kacft release for
Maintenance
1/21- 1/25/2006
Inflow (acft)
0
1000
2000
3000
4000
20
30
40
50
60
days

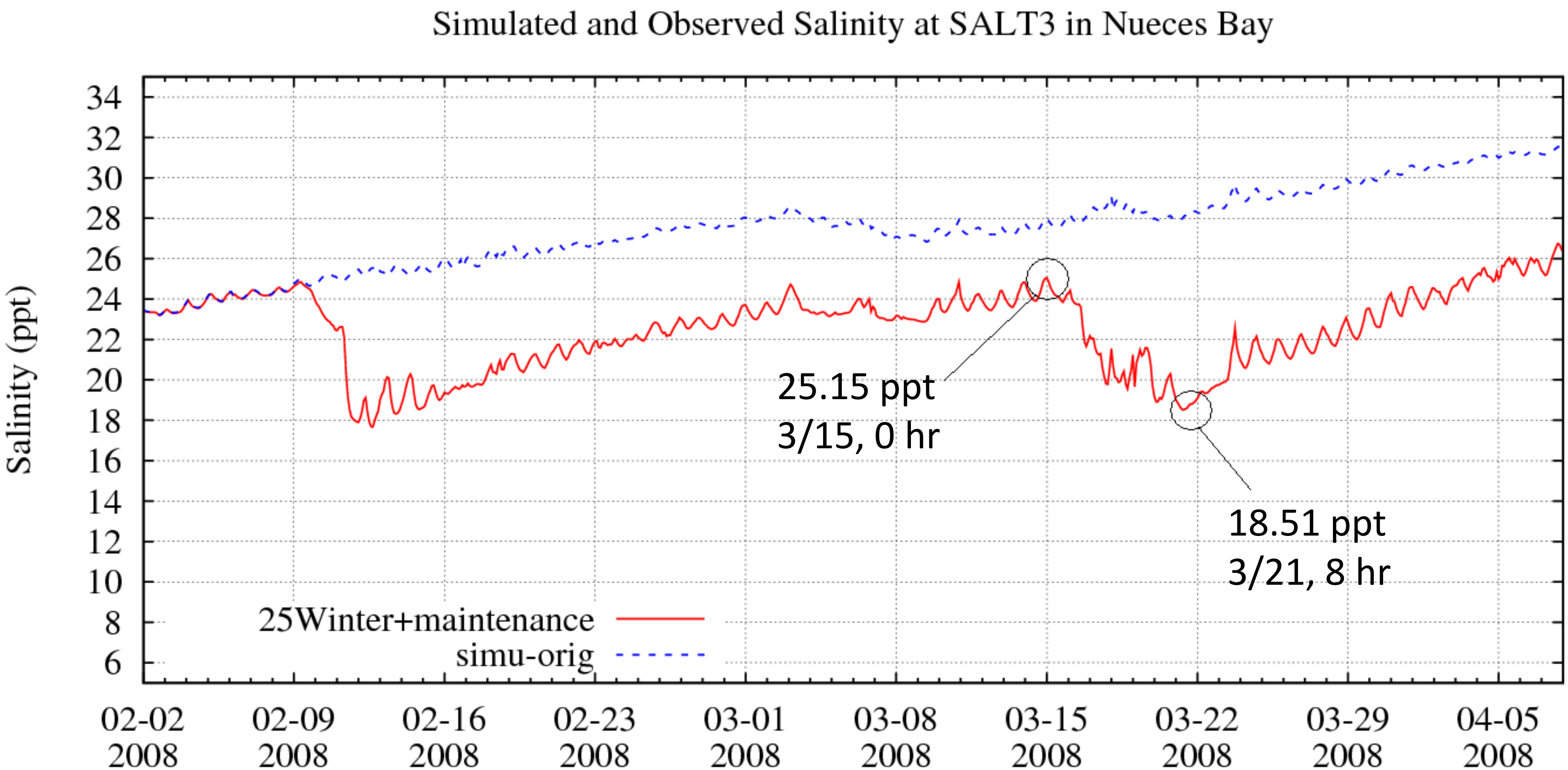
Test: 30-Winter and Maintenance, 10 kacft released 1/21 – 1/25/2006



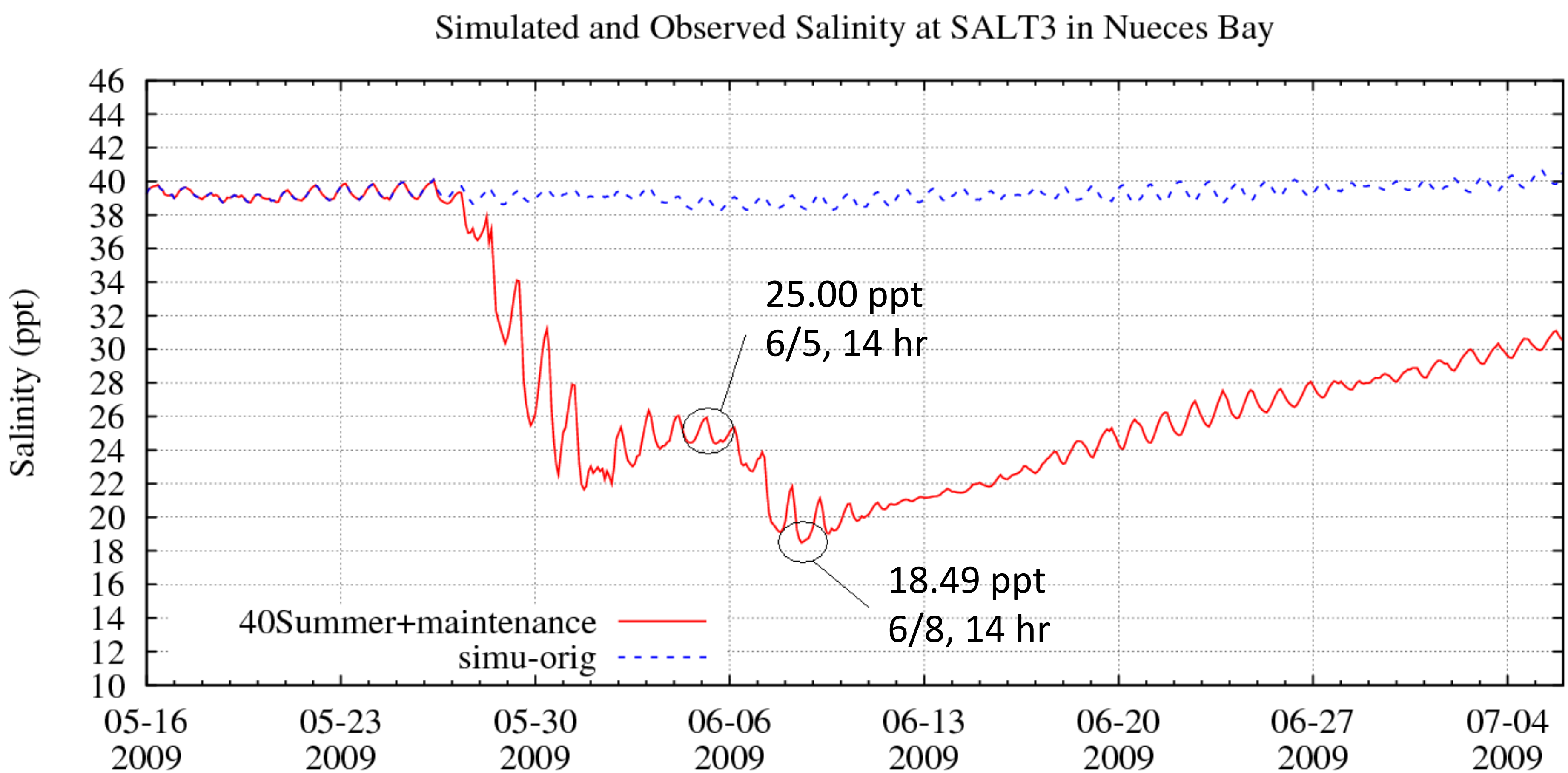
Test: 30-Summer and Maintenance, 10 kacft released 7/29 – 8/2/2006



Test: 25-Winter and Maintenance, 10 kacft released 3/15 – 3/19/2008



Test: 40-Summer and Maintenance, 10 kacft released 6/5 – 6/9/2009



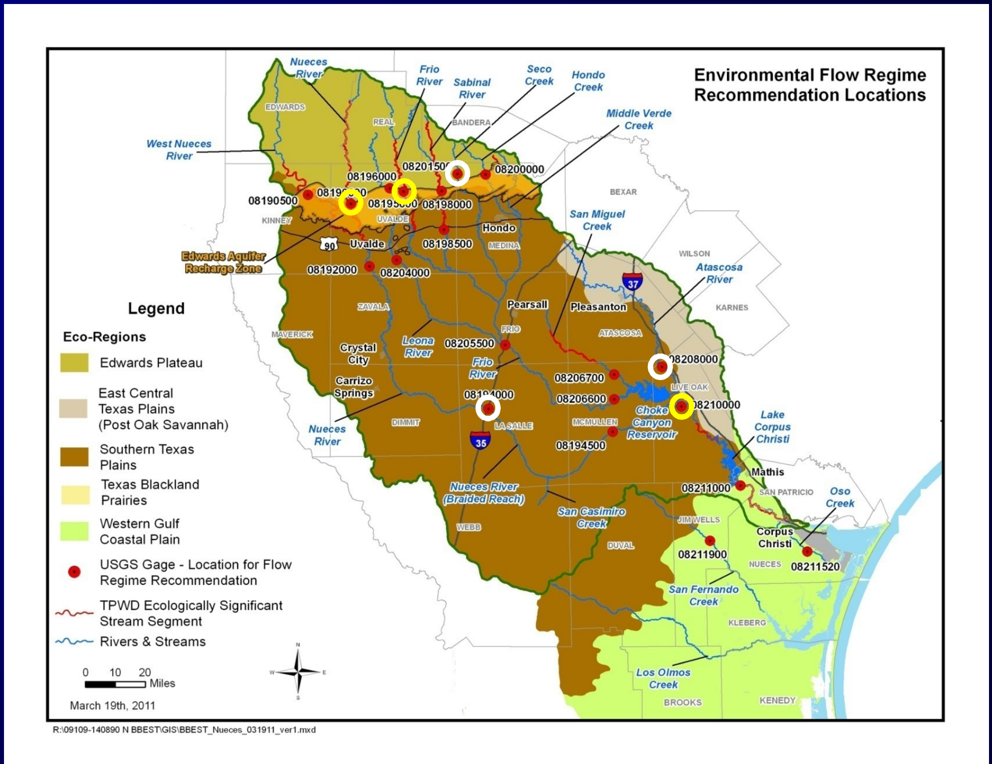
Test case	inflow (acft)	salinity at start	salinity lowest	reduction (ppt)	reduction rate (ppt/1000acft)
30-Winter	12,000	29.80	17.94	11.86	0.99
30-Summer	12,000	30.22	18.91	11.31	0.94
25-Winter	10,000	24.85	17.68	7.17	0.72
40-Summer	18,000	40.10	21.66	18.44	1.02
30Winter+Maintenance	10,000	25.11	16.28	8.83	0.88
30Summer+Maintenance	10,000	25.00	16.69	8.31	0.83
25Winter+Maintenance	10,000	25.15	18.51	6.64	0.66
40Summer+Maintenance	10,000	25.00	18.49	6.51	0.65

BBASC Scenarios – Instream Habitat

- For BBASC – Evaluate amount of instream habitat maintained by 2 possible BBASC recommendations scenarios
  - Modified BBEST A
  - Modified BBEST W
  - Also, included no E-flow criteria
- Do these flow recommendations scenarios maintain adequate instream habitats to maintain SEE?
  - Emphasis on base flows, but also subsistence, HFPs
- Time series at 2 locations
  - Nueces River at Laguna – effects of hypothetical off-channel reservoir
  - Nueces River at Three Rivers – effects of upstream Cotulla Reservoir and off-channel reservoir (separate)
- Evaluate habitat maintained at all 3 sites under the full 50% diversion in both the Modified BBEST A and W scenarios

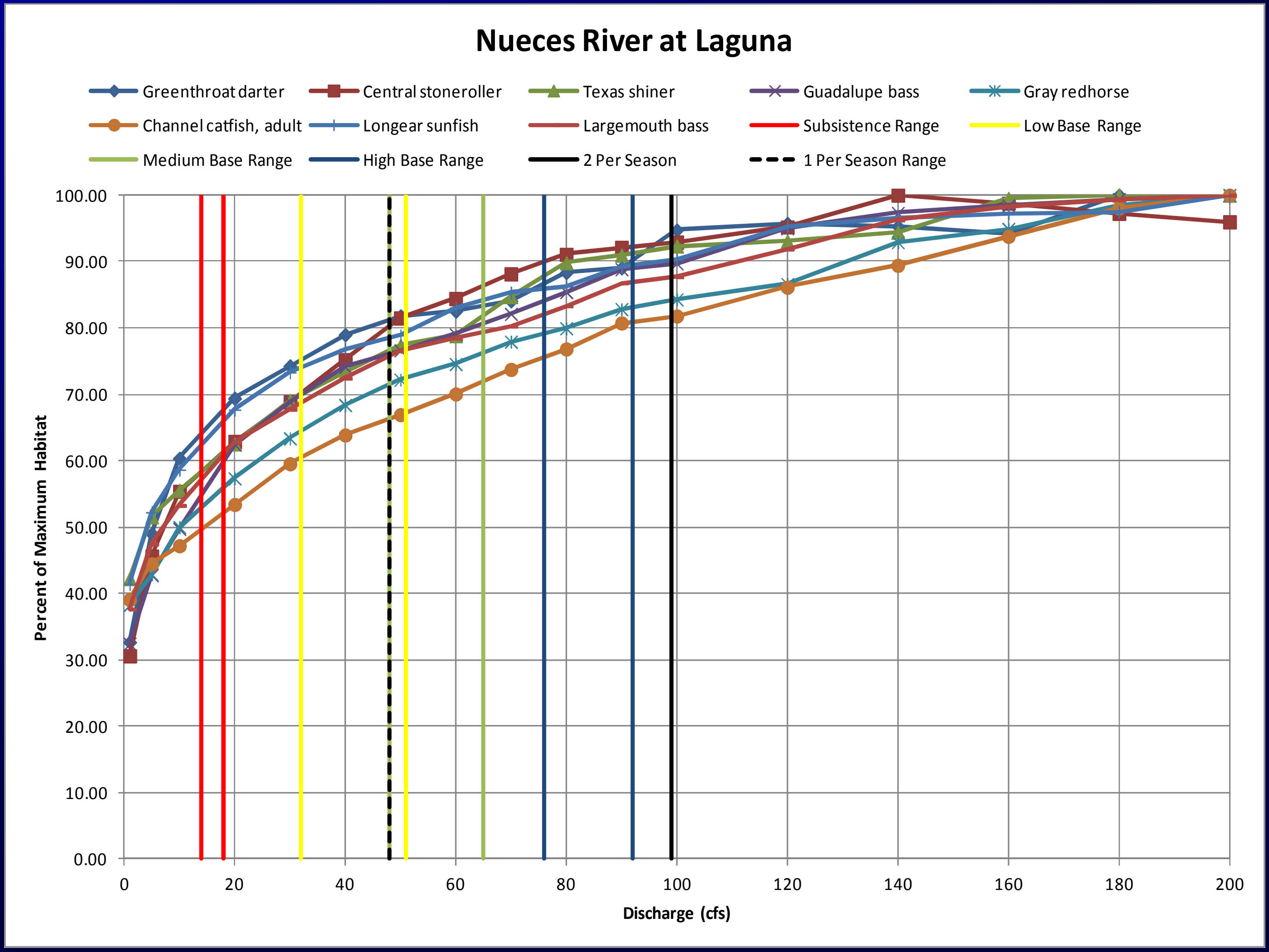
Background, Methods

- No existing flow-habitat studies in the Nueces Basin
- Prioritize site-specific field data
- Sites – 6 winnowed to 3 (low or no flow at 3)
  - Nueces River @ Laguna
  - Frio River @ Concan
  - Nueces River @ Three Rivers



Laguna – % Max WUA, 0.5 Threshold

How much is "enough"? – we used 75% for base flows, 20% for subsistence



Laguna – "enoughness" assessment

- **Full BBEST recommendation (Table 3.3.3 from BBEST report)**
- **Percent of maximum WUA thresholds**
  - **75% for base flows**
  - **20% for subsistence flows**

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
Greenthroat darter	Subsistence	64%	68%	66%	63%
	Base-Low	82%	80%	75%	79%
	Base-Medium	84%	83%	81%	83%
	Base-High	91%	89%	87%	93%
Central stoneroller	Subsistence	58%	61%	60%	58%
	Base-Low	82%	78%	70%	76%
	Base-Medium	88%	86%	80%	85%
	Base-High	92%	92%	90%	93%
Texas shiner	Subsistence	58%	61%	60%	58%
	Base-Low	78%	75%	70%	74%
	Base-Medium	84%	81%	77%	80%
	Base-High	92%	91%	88%	92%
Guadalupe bass	Subsistence	55%	60%	57%	54%
	Base-Low	77%	75%	70%	74%
	Base-Medium	82%	80%	76%	80%
	Base-High	89%	87%	84%	89%
Gray redhorse	Subsistence	53%	56%	54%	52%
	Base-Low	72%	70%	64%	69%
	Base-Medium	78%	76%	71%	75%
	Base-High	83%	82%	79%	84%
Channel catfish, adult	Subsistence	50%	52%	51%	49%
	Base-Low	67%	65%	60%	64%
	Base-Medium	73%	71%	66%	71%
	Base-High	81%	79%	76%	81%
Longear sunfish	Subsistence	62%	66%	64%	61%
	Base-Low	79%	78%	74%	77%
	Base-Medium	85%	84%	78%	83%
	Base-High	90%	88%	86%	90%
Largemouth bass	Subsistence	57%	61%	59%	56%
	Base-Low	77%	74%	69%	73%
	Base-Medium	80%	79%	76%	79%
	Base-High	87%	85%	82%	87%

Laguna – "enoughness" assessment

- **Modified BBEST A**
  - **"Base-Medium 50%" = % of maximum WUA maintained by flow resulting from full 50% diversion between Base-Medium and Subsistence**

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
greenthroat darter	Subsistence	64%	68%	66%	63%
	Base-Medium 50%	79%	80%	75%	79%
	Base-Medium	84%	83%	81%	83%
central stoneroller	Subsistence	58%	61%	60%	58%
	Base-Medium 50%	75%	76%	70%	75%
	Base-Medium	88%	86%	80%	85%
Texas shiner	Subsistence	58%	61%	60%	58%
	Base-Medium 50%	73%	74%	70%	73%
	Base-Medium	84%	81%	77%	80%
Guadalupe bass	Subsistence	55%	60%	57%	54%
	Base-Medium 50%	74%	75%	70%	73%
	Base-Medium	82%	80%	76%	80%
gray redhorse	Subsistence	53%	56%	54%	52%
	Base-Medium 50%	68%	69%	64%	68%
	Base-Medium	78%	76%	71%	75%
channel catfish, adult	Subsistence	50%	52%	51%	49%
	Base-Medium 50%	64%	64%	60%	64%
	Base-Medium	73%	71%	66%	71%
longear sunfish	Subsistence	62%	66%	64%	61%
	Base-Medium 50%	77%	77%	74%	77%
	Base-Medium	85%	84%	78%	83%
largemouth bass	Subsistence	57%	61%	59%	56%
	Base-Medium 50%	72%	73%	69%	72%
	Base-Medium	80%	79%	76%	79%

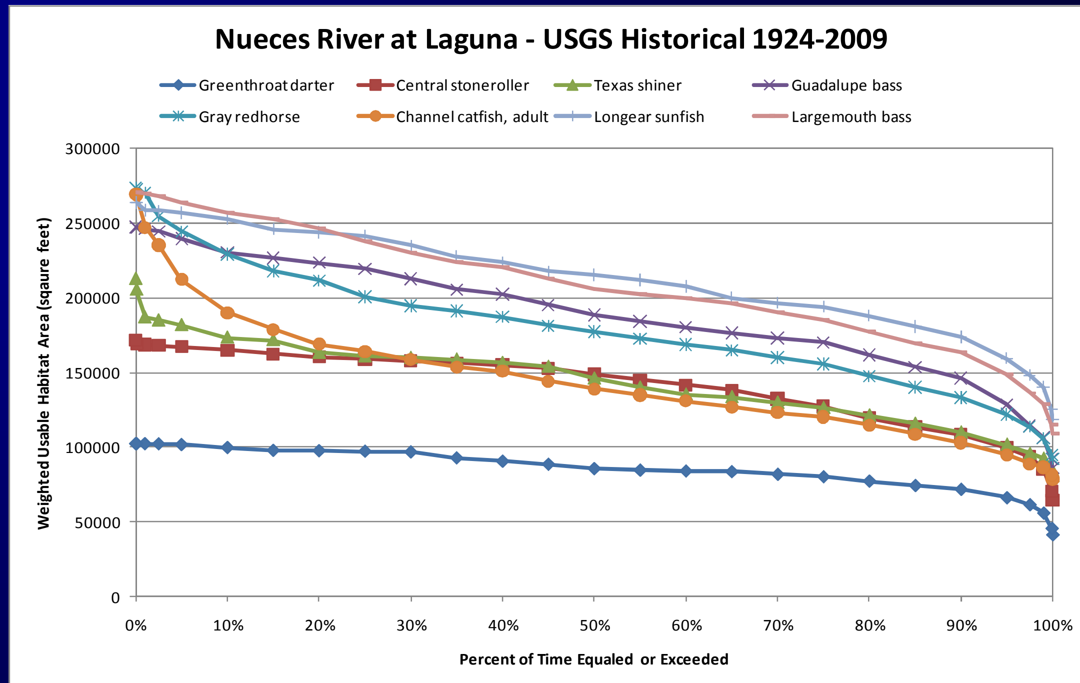
Laguna – "enoughness" assessment

- **Modified BBEST W**
  - **"Base-High 50%" = % of maximum WUA maintained by flow resulting from full 50% diversion between Base-High and Subsistence**

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
greenthroat darter	Subsistence	64%	68%	66%	63%
	Base-High 50%	82%	82%	81%	82%
	Base-High	91%	89%	87%	93%
central stoneroller	Subsistence	58%	61%	60%	58%
	Base-High 50%	82%	83%	79%	82%
	Base-High	92%	92%	90%	93%
Texas shiner	Subsistence	58%	61%	60%	58%
	Base-High 50%	78%	78%	76%	78%
	Base-High	92%	91%	88%	92%
Guadalupe bass	Subsistence	55%	60%	57%	54%
	Base-High 50%	77%	78%	76%	77%
	Base-High	89%	87%	84%	89%
gray redhorse	Subsistence	53%	56%	54%	52%
	Base-High 50%	73%	73%	71%	73%
	Base-High	83%	82%	79%	84%
channel catfish, adult	Subsistence	50%	52%	51%	49%
	Base-High 50%	68%	68%	66%	68%
	Base-High	81%	79%	76%	81%
longear sunfish	Subsistence	62%	66%	64%	61%
	Base-High 50%	80%	81%	78%	80%
	Base-High	90%	88%	86%	90%
largemouth bass	Subsistence	57%	61%	59%	56%
	Base-High 50%	77%	77%	75%	77%
	Base-High	87%	85%	82%	87%

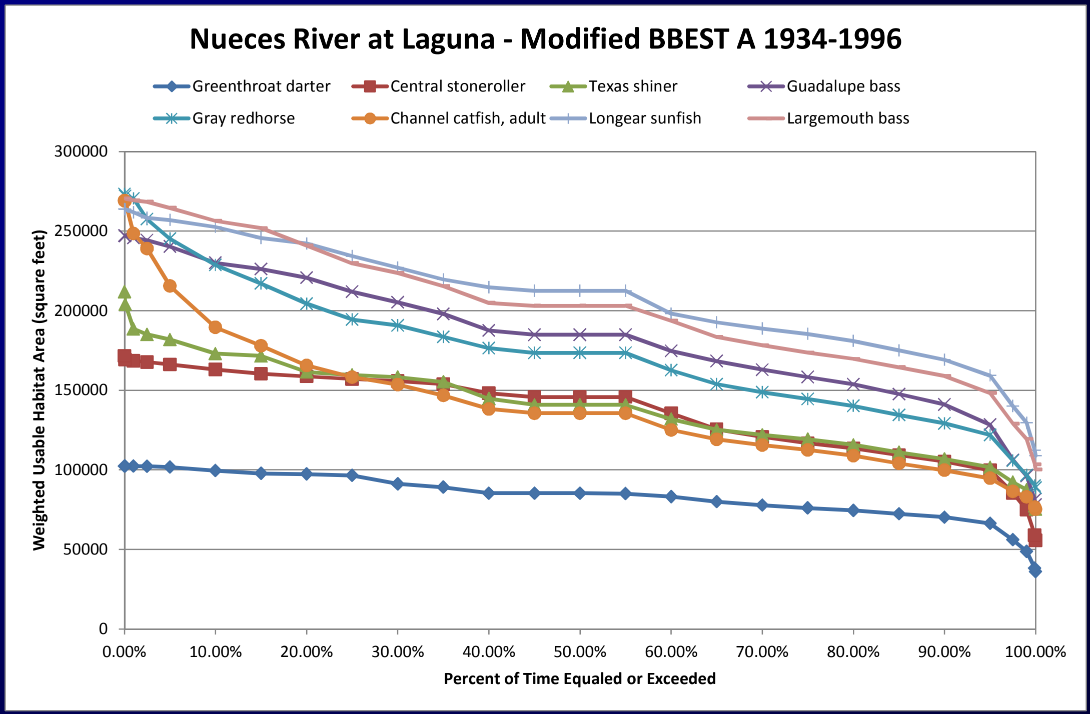
Laguna – Habitat Time Series

- Habitat time series and attainment frequency of 75% threshold
  - BBEST: historical flows, FRAT output for 3 scenarios at Laguna, pre-/post-Choke Canyon for Three Rivers
- Just modeled flows (flows up to 850 cfs, not all flows)



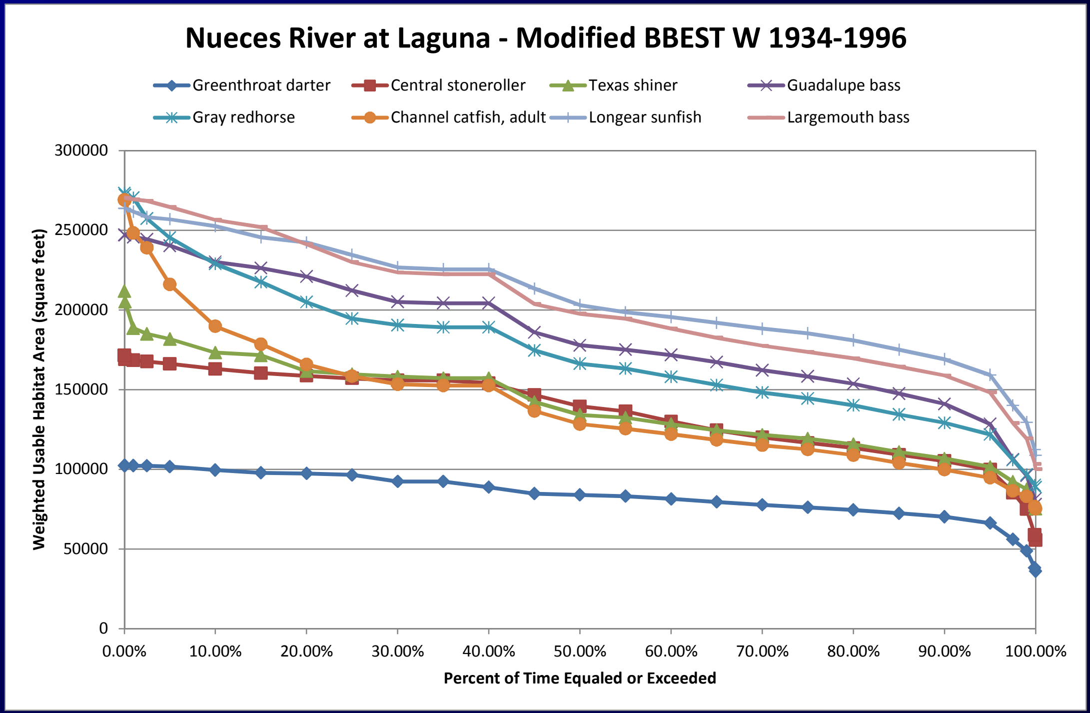
Laguna – Habitat Time Series

- Modified BBEST A



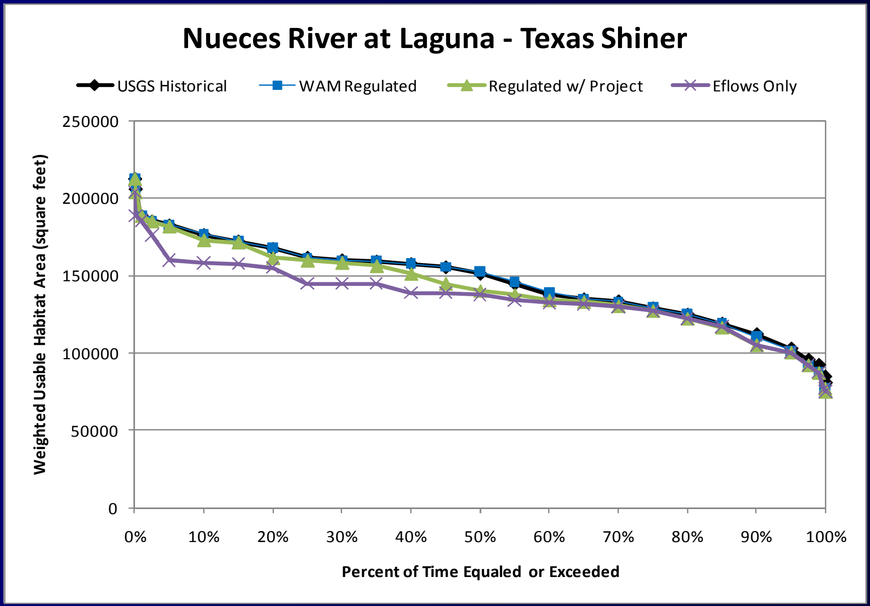
Laguna – Habitat Time Series

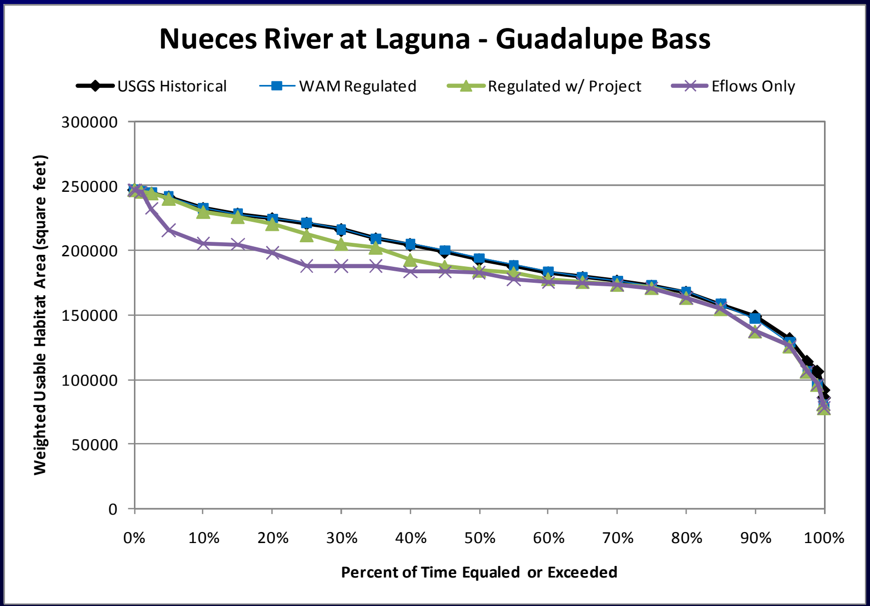
- Modified BBEST W



Laguna – Habitat Time Series

- Evaluation of instream habitat under example application scenarios
- FRAT used to generate flow time series
- BBEST: 4 scenarios
  - USGS historical
  - WAM regulated baseline
  - Project with flow recommendations
  - Flow recommendations only





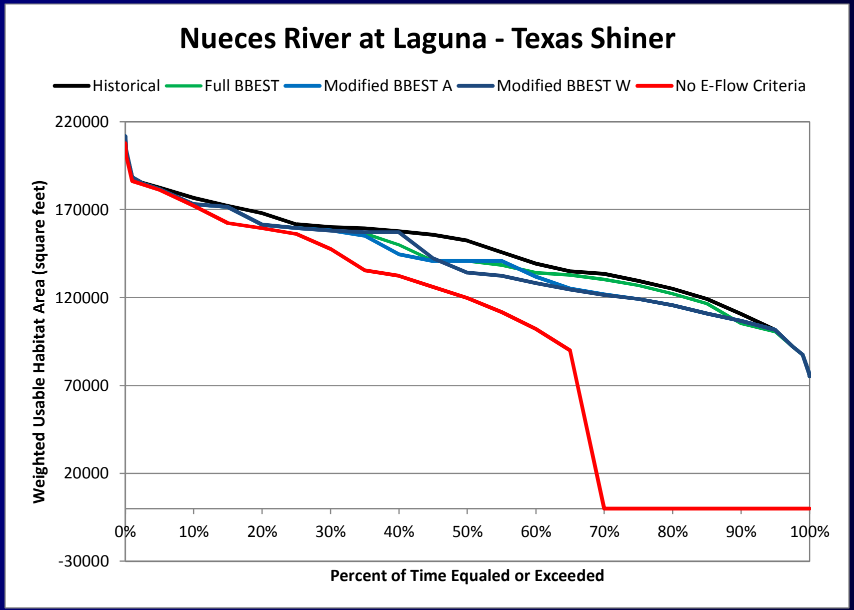
Laguna – Habitat Time Series

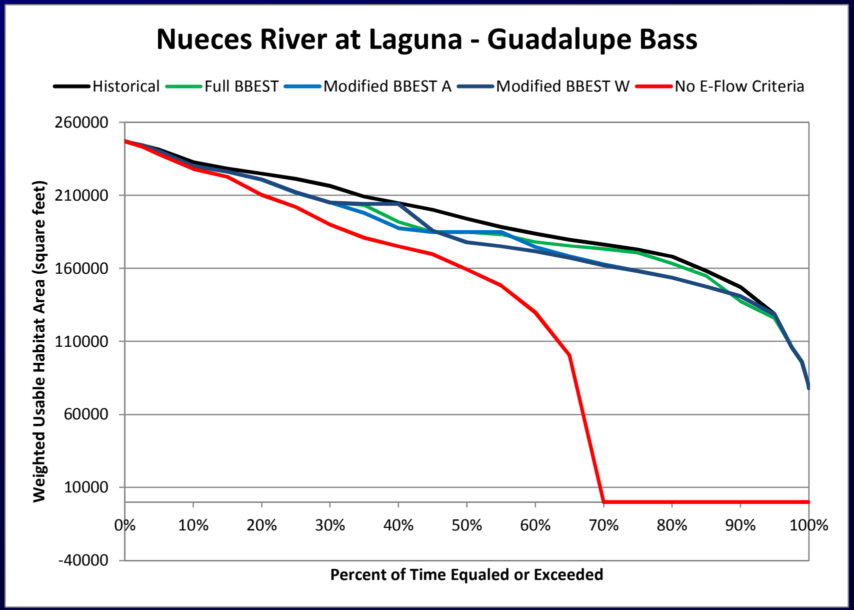
Frequency of meeting 75% of Maximum WUA threshold under the different scenarios

Percent Exceedence Level	Greenthroat darter			Central stoneroller			Texas shiner			Guadalupe bass			Gray redhorse			Channel catfish, adult			Longear sunfish			Largemouth bass		
	USGS	Project	Eflows	USGS	Project	Eflows	USGS	Project	Eflows	USGS	Project	Eflows	USGS	Project	Eflows	USGS	Project	Eflows	USGS	Project	Eflows	USGS	Project	Eflows
99.99%	41%	35%	35%	38%	33%	33%	47%	44%	44%	38%	34%	34%	41%	39%	39%	42%	40%	40%	47%	43%	43%	43%	39%	39%
99.9%	45%	37%	37%	42%	35%	35%	49%	45%	45%	40%	35%	35%	42%	40%	40%	43%	41%	41%	50%	44%	44%	45%	40%	40%
99%	55%	48%	48%	51%	44%	44%	54%	51%	51%	46%	42%	42%	47%	43%	43%	46%	44%	44%	56%	51%	51%	50%	47%	47%
98%	60%	55%	55%	55%	51%	51%	56%	54%	54%	50%	46%	46%	50%	46%	47%	47%	46%	46%	59%	55%	56%	53%	50%	50%
95%	66%	64%	64%	60%	58%	58%	60%	58%	58%	57%	55%	55%	54%	53%	53%	51%	50%	50%	64%	62%	62%	59%	57%	57%
90%	71%	68%	68%	65%	61%	61%	65%	61%	61%	65%	60%	60%	60%	56%	56%	56%	52%	52%	70%	66%	66%	65%	61%	61%
85%	74%	73%	73%	69%	68%	68%	69%	68%	68%	69%	67%	68%	63%	62%	62%	60%	58%	58%	73%	72%	72%	68%	67%	67%
80%	78%	76%	76%	74%	72%	72%	72%	71%	71%	73%	71%	71%	67%	66%	66%	63%	62%	61%	76%	75%	75%	72%	70%	70%
75%	80%	79%	79%	78%	76%	76%	75%	74%	74%	75%	75%	74%	70%	69%	69%	65%	64%	64%	78%	77%	77%	74%	73%	73%
70%	82%	80%	80%	82%	79%	79%	78%	76%	76%	77%	76%	76%	72%	71%	71%	67%	66%	66%	79%	78%	78%	77%	75%	75%
65%	82%	81%	81%	83%	81%	80%	78%	77%	77%	78%	77%	76%	74%	72%	71%	69%	67%	66%	81%	79%	78%	78%	76%	76%
60%	83%	82%	81%	85%	83%	81%	80%	78%	77%	80%	78%	76%	75%	73%	72%	71%	68%	67%	83%	81%	79%	79%	77%	76%
55%	84%	83%	82%	88%	85%	82%	84%	80%	78%	82%	80%	77%	78%	75%	73%	73%	71%	68%	85%	83%	80%	80%	79%	77%
50%	85%	83%	83%	90%	86%	85%	88%	81%	80%	84%	80%	80%	79%	76%	75%	76%	72%	71%	86%	84%	83%	82%	79%	79%
45%	88%	84%	83%	91%	88%	86%	90%	84%	81%	87%	82%	80%	81%	78%	76%	78%	73%	71%	87%	85%	84%	85%	80%	79%
40%	89%	85%	83%	92%	90%	86%	92%	88%	81%	89%	84%	80%	83%	79%	76%	81%	76%	71%	90%	86%	84%	87%	82%	79%
35%	93%	89%	84%	93%	92%	88%	93%	91%	84%	91%	88%	82%	85%	82%	78%	83%	80%	73%	92%	89%	85%	89%	86%	80%
30%	95%	91%	84%	94%	92%	88%	93%	92%	84%	94%	89%	82%	86%	84%	78%	85%	81%	73%	95%	90%	85%	91%	87%	80%
25%	95%	94%	84%	94%	93%	88%	94%	93%	84%	96%	92%	82%	90%	85%	78%	88%	84%	73%	96%	93%	85%	95%	90%	80%
20%	95%	95%	87%	95%	94%	91%	97%	94%	90%	98%	96%	86%	94%	90%	81%	92%	88%	78%	97%	96%	87%	97%	94%	84%
15%	96%	96%	91%	96%	95%	92%	100%	100%	92%	99%	99%	89%	99%	95%	83%	98%	94%	81%	98%	97%	90%	99%	98%	87%
10%	98%	97%	91%	98%	97%	92%	100%	100%	92%	100%	100%	89%	100%	100%	84%	100%	100%	81%	100%	100%	90%	100%	100%	87%
5%	100%	99%	94%	99%	98%	93%	100%	100%	93%	100%	100%	94%	100%	100%	86%	100%	100%	85%	100%	100%	94%	100%	100%	91%
3%	100%	100%	96%	100%	99%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1%	100%	100%	99%	100%	100%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
0.1%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
0.01%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Laguna – Habitat Time Series

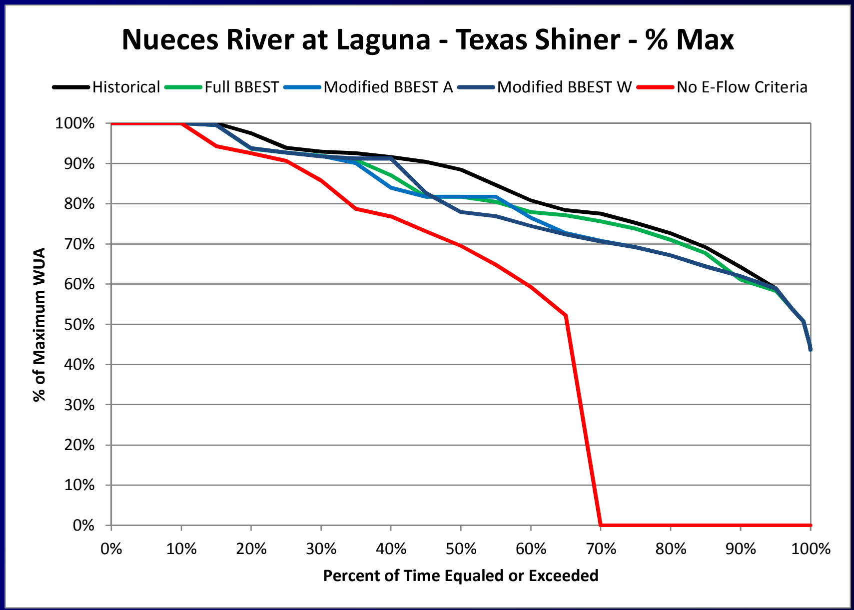
- BBASC: 5 scenarios
  - Historical
  - Full BBEST
  - Modified BBEST A
  - Modified BBEST W
  - No E-Flow criteria

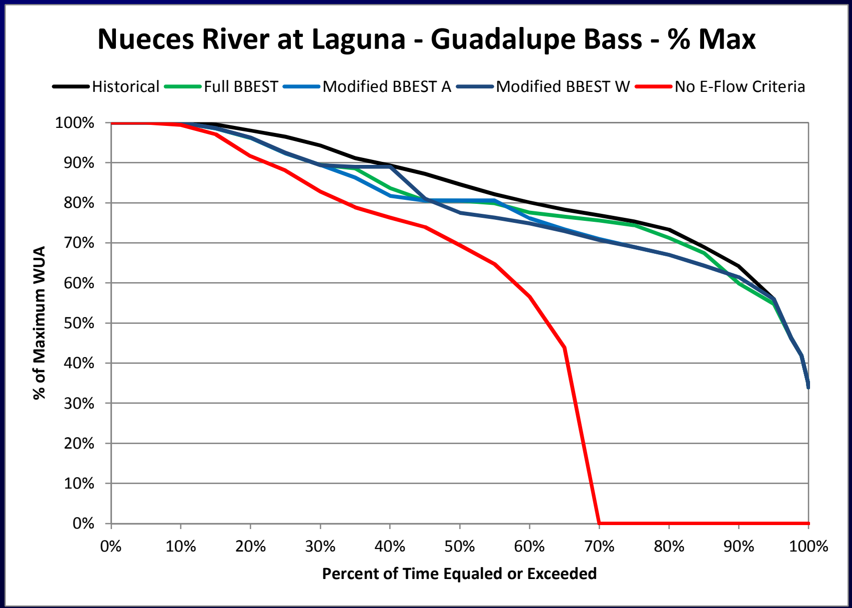




Laguna – Habitat Time Series

- BBASC: 5 scenarios
  - Historical
  - Full BBEST
  - Modified BBEST A
  - Modified BBEST W
  - No E-Flow criteria





Laguna – Habitat Time Series (BBASC)

Frequency of meeting 75% of Maximum WUA threshold under the different scenarios

Percent Exceedence Level	Greenthroat darter					Central stoneroller					Texas shiner					Guadalupe bass				
	Hist	Full	Mod A	Mod W	No E	Hist	Full	Mod A	Mod W	No E	Hist	Full	Mod A	Mod W	No E	Hist	Full	Mod A	Mod W	No E
99.99%	35%	35%	35%	35%	0%	33%	33%	33%	33%	0%	44%	44%	44%	44%	0%	34%	34%	34%	34%	0%
99.90%	37%	37%	37%	37%	0%	35%	35%	35%	35%	0%	45%	45%	45%	45%	0%	35%	35%	35%	35%	0%
99%	48%	48%	48%	48%	0%	44%	44%	44%	44%	0%	51%	51%	51%	51%	0%	42%	42%	42%	42%	0%
98%	55%	55%	55%	55%	0%	51%	51%	51%	51%	0%	54%	54%	54%	54%	0%	46%	46%	46%	46%	0%
95%	65%	64%	65%	65%	0%	59%	58%	59%	59%	0%	59%	58%	59%	59%	0%	56%	55%	56%	56%	0%
90%	70%	68%	69%	69%	0%	64%	61%	62%	62%	0%	64%	61%	62%	62%	0%	64%	60%	61%	61%	0%
85%	74%	73%	71%	71%	0%	69%	68%	65%	65%	0%	69%	68%	64%	64%	0%	69%	67%	64%	64%	0%
80%	78%	76%	73%	73%	0%	74%	72%	67%	67%	0%	73%	71%	67%	67%	0%	73%	71%	67%	67%	0%
75%	80%	79%	74%	74%	0%	78%	76%	69%	69%	0%	75%	74%	69%	69%	0%	75%	74%	69%	69%	0%
70%	82%	80%	76%	76%	0%	82%	79%	71%	71%	0%	78%	76%	71%	71%	0%	77%	76%	71%	71%	0%
65%	82%	81%	78%	78%	51%	84%	81%	74%	74%	47%	78%	77%	73%	72%	52%	78%	76%	73%	73%	44%
60%	83%	82%	81%	80%	65%	86%	83%	80%	77%	59%	81%	78%	77%	74%	59%	80%	78%	76%	75%	57%
55%	84%	83%	83%	81%	71%	88%	85%	86%	81%	65%	85%	80%	82%	77%	65%	82%	80%	81%	76%	65%
50%	86%	83%	83%	82%	75%	90%	86%	86%	83%	70%	89%	82%	82%	78%	70%	85%	81%	81%	78%	69%
45%	88%	83%	83%	83%	78%	91%	86%	86%	87%	75%	90%	82%	82%	83%	73%	87%	81%	81%	81%	74%
40%	89%	84%	83%	87%	81%	92%	90%	88%	91%	81%	92%	87%	84%	91%	77%	89%	84%	82%	89%	76%
35%	94%	88%	87%	90%	82%	93%	92%	91%	92%	84%	93%	91%	90%	91%	79%	91%	89%	86%	89%	79%
30%	95%	90%	89%	90%	84%	94%	92%	92%	92%	89%	93%	92%	92%	92%	86%	94%	89%	89%	89%	83%
25%	95%	94%	94%	94%	88%	94%	93%	93%	93%	91%	94%	93%	93%	93%	91%	96%	92%	92%	92%	88%
20%	95%	95%	95%	95%	93%	95%	94%	94%	94%	93%	98%	94%	94%	94%	93%	98%	96%	96%	96%	92%
15%	96%	96%	96%	96%	95%	96%	95%	95%	95%	94%	100%	100%	100%	100%	94%	99%	99%	99%	99%	97%
10%	98%	97%	97%	97%	96%	98%	96%	96%	97%	95%	100%	100%	100%	100%	100%	100%	100%	100%	100%	99%
5%	100%	99%	99%	99%	99%	99%	98%	98%	98%	98%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3%	100%	100%	100%	100%	100%	100%	99%	99%	99%	99%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
0.10%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
0.01%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Laguna – Habitat Time Series (BBASC)

Frequency of meeting 75% of Maximum WUA threshold under the different scenarios

Percent Exceedence Level	Gray redhorse					Channel catfish, adult					Longear sunfish					Largemouth bass				
	Hist	Full	Mod A	Mod W	No E	Hist	Full	Mod A	Mod W	No E	Hist	Full	Mod A	Mod W	No E	Hist	Full	Mod A	Mod W	No E
99.99%	39%	39%	39%	39%	0%	40%	40%	40%	40%	0%	43%	43%	43%	43%	0%	39%	39%	39%	39%	0%
99.90%	40%	40%	40%	40%	0%	41%	41%	41%	41%	0%	44%	44%	44%	44%	0%	40%	40%	40%	40%	0%
99%	43%	43%	43%	43%	0%	44%	44%	44%	44%	0%	51%	51%	51%	51%	0%	47%	47%	47%	47%	0%
98%	46%	46%	46%	46%	0%	46%	46%	46%	46%	0%	55%	55%	55%	55%	0%	50%	50%	50%	50%	0%
95%	54%	53%	54%	54%	0%	50%	50%	50%	50%	0%	63%	62%	63%	63%	0%	58%	57%	58%	58%	0%
90%	59%	56%	57%	57%	0%	55%	52%	53%	53%	0%	69%	66%	67%	67%	0%	64%	61%	62%	62%	0%
85%	63%	62%	59%	59%	0%	60%	58%	55%	55%	0%	73%	72%	69%	69%	0%	68%	67%	64%	64%	0%
80%	68%	66%	62%	62%	0%	63%	61%	58%	58%	0%	76%	75%	72%	72%	0%	72%	70%	66%	66%	0%
75%	70%	69%	63%	63%	0%	65%	64%	60%	60%	0%	78%	77%	73%	73%	0%	74%	73%	68%	68%	0%
70%	72%	71%	65%	65%	0%	67%	66%	61%	61%	0%	79%	78%	75%	75%	0%	77%	75%	70%	69%	0%
65%	74%	72%	68%	67%	44%	69%	67%	63%	63%	45%	82%	79%	76%	76%	53%	78%	76%	72%	71%	48%
60%	76%	73%	71%	69%	54%	71%	68%	66%	65%	51%	84%	81%	78%	77%	64%	79%	77%	76%	74%	58%
55%	78%	75%	76%	72%	59%	74%	71%	72%	67%	56%	85%	84%	84%	79%	70%	80%	79%	79%	76%	65%
50%	79%	76%	76%	73%	64%	76%	72%	72%	68%	60%	86%	84%	84%	80%	74%	83%	79%	79%	77%	68%
45%	81%	76%	76%	77%	68%	79%	72%	72%	72%	64%	88%	84%	84%	85%	77%	85%	79%	79%	80%	72%
40%	84%	79%	78%	83%	72%	81%	75%	73%	81%	67%	90%	86%	85%	89%	79%	87%	82%	80%	87%	76%
35%	85%	83%	81%	83%	74%	83%	80%	78%	81%	70%	92%	89%	87%	89%	83%	89%	87%	84%	87%	78%
30%	86%	84%	84%	84%	78%	86%	81%	81%	81%	74%	95%	90%	90%	90%	86%	91%	87%	87%	87%	81%
25%	91%	85%	85%	86%	82%	88%	84%	84%	84%	80%	96%	93%	93%	93%	88%	95%	90%	90%	90%	86%
20%	94%	90%	90%	90%	85%	92%	88%	88%	88%	83%	97%	96%	96%	96%	92%	98%	94%	94%	94%	89%
15%	99%	95%	95%	96%	92%	98%	94%	94%	95%	89%	98%	97%	97%	97%	96%	99%	98%	98%	98%	96%
10%	100%	100%	100%	100%	98%	100%	100%	100%	100%	98%	100%	100%	100%	100%	98%	100%	100%	100%	100%	99%
5%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
3%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
0.10%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
0.01%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Laguna – Habitat Time Series (BBASC)

Frequency of meeting 75% of Maximum WUA threshold under the different scenarios

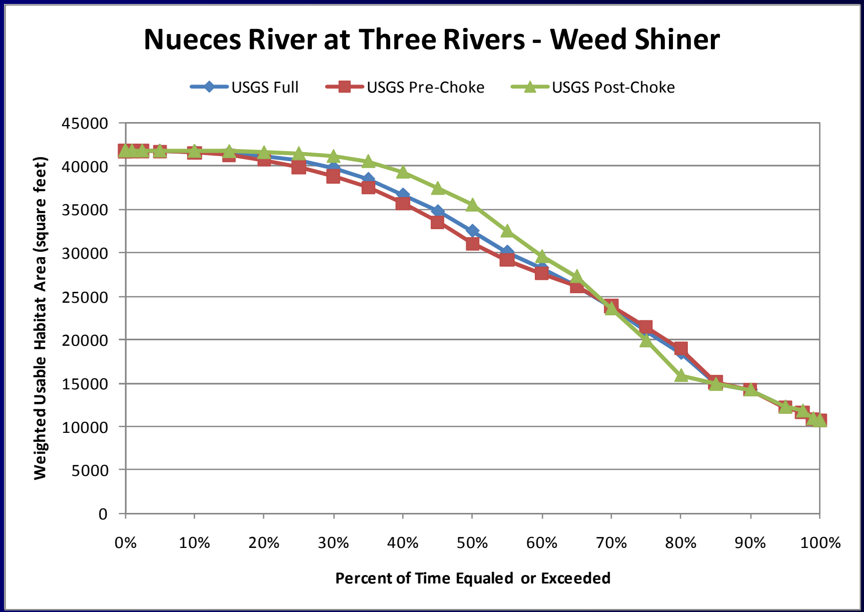
Focal Species	Historical	Full BBEST		Modified A		Modified W		No E-Flows	
	Attainment Frequency	Attainment Frequency	Change from Hist.	Attainment Frequency	Change from Hist.	Attainment Frequency	Change from Hist.	Attainment Frequency	Change from Hist.
Greenthroat darter	80%	80%	0%	70%	-10%	70%	-10%	50%	-30%
Central stoneroller	75%	75%	0%	60%	-15%	60%	-15%	45%	-30%
Texas shiner	75%	70%	-5%	60%	-15%	55%	-20%	40%	-35%
Guadalupe bass	75%	70%	-5%	60%	-15%	60%	-15%	40%	-35%
Gray redhorse	60%	55%	-5%	55%	-5%	45%	-15%	30%	-30%
Channel catfish, adult	50%	40%	-10%	35%	-15%	40%	-10%	25%	-25%
Longear sunfish	80%	80%	0%	70%	-10%	70%	-10%	45%	-35%
Largemouth bass	70%	70%	0%	60%	-10%	55%	-15%	40%	-30%

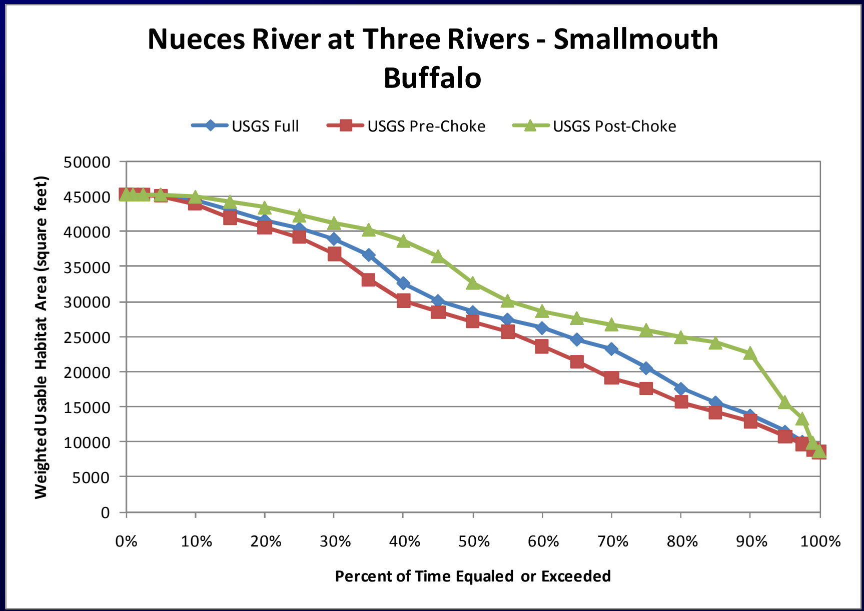
Laguna Summary

- Laguna
  - "Enough" habitat (i.e., per 75% minimum threshold of Maximum WUA used by BBEST) is maintained for fewer species under the full 50% diversion of Modified BBEST A scenario
    - But, in most cases it is not far below 75%
    - Guadalupe bass, Texas shiner (TPWD SGCNs) do not meet 75%
  - "Enough" maintained for more species by Modified BBEST W scenario
  - Time Series: Both Modified BBEST A and W result in a 10-15% reduction for most focal species in the historical attainment frequency of the BBEST's 75% of Maximum WUA threshold

Three Rivers – Habitat Time Series

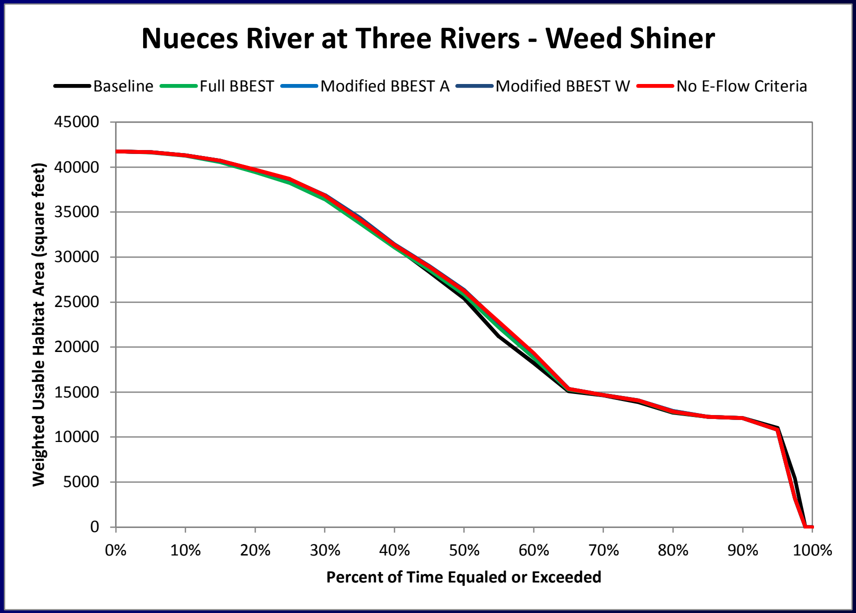
- Evaluation of instream habitat under 3 periods of record (USGS gage)
  - Pre-Choke Canyon Reservoir
  - Post-Choke Canyon Reservoir
  - Full period (which was used for flow recommendations)

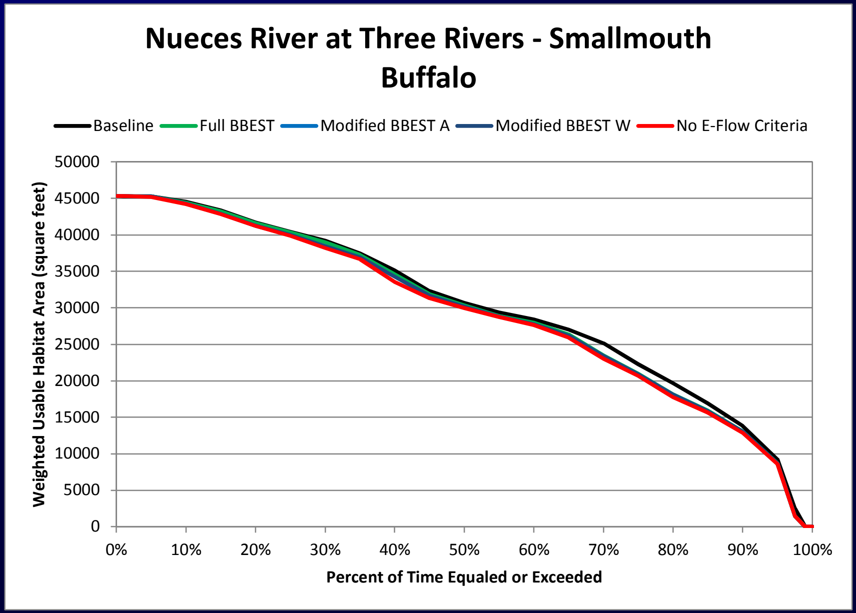




Three Rivers – Habitat Time Series

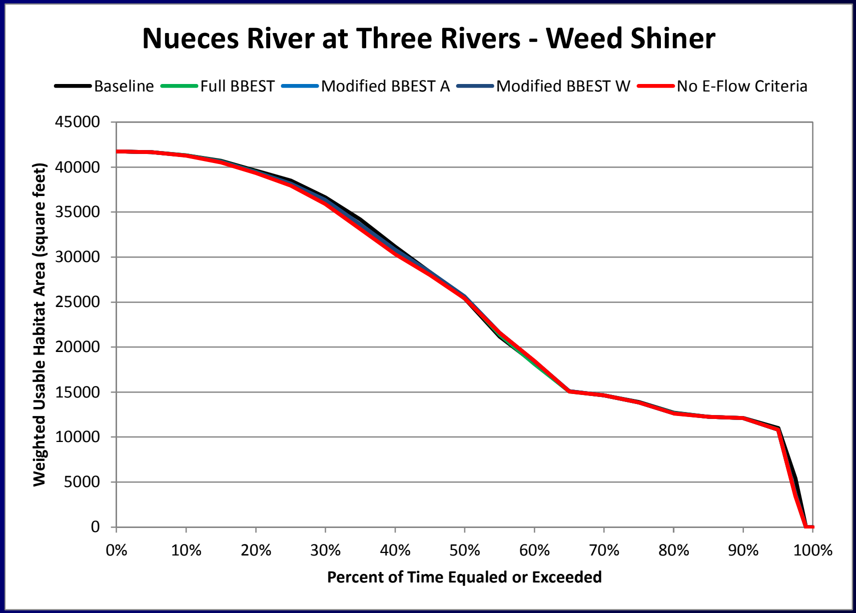
- BBASC: with Cotulla Reservoir, 5 scenarios
  - Baseline
  - Full BBEST
  - Modified BBEST A
  - Modified BBEST W
  - No E-Flow criteria

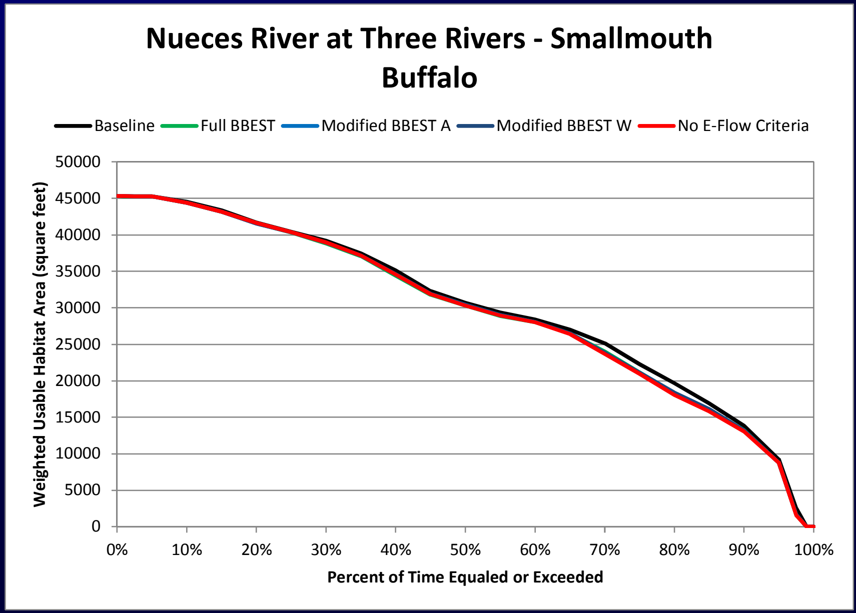




Three Rivers – Habitat Time Series

- BBASC: with off-channel reservoir (OCR), 5 scenarios
  - Baseline
  - Full BBEST
  - Modified BBEST A
  - Modified BBEST W
  - No E-Flow criteria





Three Rivers – "enoughness" assessment

- **Modified BBEST A**
  - **"Base-Medium 50%" = % of maximum WUA maintained by flow resulting from full 50% diversion between Base-Medium and Subsistence**

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
Channel catfish, Juvenile	Subsistence	20%	20%	20%	20%
	Base-Medium 50%	88%	88%	75%	88%
	Base-Medium	98%	99%	99%	98%
Red shiner	Subsistence	40%	40%	40%	40%
	Base-Medium 50%	88%	88%	80%	88%
	Base-Medium	97%	97%	95%	97%
Weed shiner	Subsistence	44%	44%	44%	44%
	Base-Medium 50%	90%	90%	82%	90%
	Base-Medium	100%	100%	100%	100%
Bullhead minnow	Subsistence	38%	38%	38%	38%
	Base-Medium 50%	76%	76%	71%	76%
	Base-Medium	97%	96%	92%	96%
Smallmouth buffalo	Subsistence	19%	19%	19%	19%
	Base-Medium 50%	44%	44%	41%	44%
	Base-Medium	57%	56%	52%	56%
Blue catfish	Subsistence	16%	16%	16%	16%
	Base-Medium 50%	41%	41%	38%	41%
	Base-Medium	55%	53%	49%	54%
Channel catfish, Adult	Subsistence	22%	22%	22%	22%
	Base-Medium 50%	46%	46%	43%	46%
	Base-Medium	58%	57%	54%	58%
Flathead catfish, juvenile	Subsistence	54%	54%	54%	54%
	Base-Medium 50%	88%	88%	82%	88%
	Base-Medium	99%	98%	96%	98%
Freshwater drum	Subsistence	27%	27%	27%	27%
	Base-Medium 50%	56%	56%	52%	56%
	Base-Medium	70%	69%	65%	69%
River carpsucker	Subsistence	41%	41%	41%	41%
	Base-Medium 50%	91%	91%	83%	91%
	Base-Medium	98%	98%	100%	98%
Longear sunfish	Subsistence	40%	40%	40%	40%
	Base-Medium 50%	83%	83%	76%	83%
	Base-Medium	96%	96%	94%	96%
Spotted gar	Subsistence	24%	24%	24%	24%
	Base-Medium 50%	85%	75%	61%	66%
	Base-Medium	70%	68%	62%	69%
Largemouth bass	Subsistence	34%	34%	34%	34%
	Base-Medium 50%	95%	92%	86%	89%
	Base-Medium	91%	90%	87%	90%

Three Rivers – "enoughness" assessment

- **Modified BBEST W**
  - **"Base-High 50%" = % of maximum WUA maintained by flow resulting from full 50% diversion between Base-High and Subsistence**

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
Channel catfish, Juvenile	Subsistence	20%	20%	20%	20%
	Base-Medium 50%	97%	98%	98%	99%
	Base-Medium	98%	100%	97%	98%
Red shiner	Subsistence	40%	40%	40%	40%
	Base-Medium 50%	100%	98%	95%	96%
	Base-Medium	94%	97%	100%	99%
Weed shiner	Subsistence	44%	44%	44%	44%
	Base-Medium 50%	99%	100%	99%	100%
	Base-Medium	89%	94%	99%	97%
Bullhead minnow	Subsistence	38%	38%	38%	38%
	Base-Medium 50%	100%	98%	90%	95%
	Base-Medium	86%	94%	100%	99%
Smallmouth buffalo	Subsistence	19%	19%	19%	19%
	Base-Medium 50%	62%	59%	51%	55%
	Base-Medium	89%	83%	65%	74%
Blue catfish	Subsistence	16%	16%	16%	16%
	Base-Medium 50%	62%	58%	48%	52%
	Base-Medium	88%	77%	65%	70%
Channel catfish, Adult	Subsistence	22%	22%	22%	22%
	Base-Medium 50%	65%	60%	53%	56%
	Base-Medium	88%	83%	71%	78%
Flathead catfish, juvenile	Subsistence	54%	54%	54%	54%
	Base-Medium 50%	100%	99%	95%	97%
	Base-Medium	95%	95%	99%	97%
Freshwater drum	Subsistence	27%	27%	27%	27%
	Base-Medium 50%	77%	72%	64%	68%
	Base-Medium	98%	100%	84%	95%
River carpsucker	Subsistence	41%	41%	41%	41%
	Base-Medium 50%	95%	97%	99%	99%
	Base-Medium	84%	89%	93%	92%
Longear sunfish	Subsistence	40%	40%	40%	40%
	Base-Medium 50%	100%	98%	93%	95%
	Base-Medium	94%	98%	100%	100%
Spotted gar	Subsistence	24%	24%	24%	24%
	Base-Medium 50%	85%	75%	61%	66%
	Base-Medium	95%	92%	88%	90%
Largemouth bass	Subsistence	34%	34%	34%	34%
	Base-Medium 50%	95%	92%	86%	89%
	Base-Medium	97%	100%	97%	99%

Ryan Smith Conclusions

- Three Rivers
  - Time Series: Little effect of either the upstream Cotulla Reservoir or the hypothetical off-channel reservoir on habitat frequencies at Nueces River at Three Rivers relative to the WAM regulated flows baseline (not to historical flows)
  - "Enough" habitat (i.e., per 75% minimum threshold of Maximum WUA used by BBEST) is not maintained for all species at Three Rivers under the full 50% diversion of Modified BBEST A scenario
    - But, neither is it under the Full BBEST recommendation
    - "Enough" maintained for more species by Modified BBEST W scenario

Frio Concan – "enoughness" assessment

- Modified BBEST A
  - "Base-Medium 50%" = % of maximum WUA maintained by flow resulting from full 50% diversion between Base-Medium and Subsistence

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
greenthroat darter	Subsistence	41%	38%	38%	38%
	Base-Medium 50%	77%	77%	70%	74%
	Base-Medium	90%	89%	83%	86%
central stoneroller	Subsistence	60%	56%	56%	56%
	Base-Medium 50%	90%	90%	85%	88%
	Base-Medium	97%	98%	95%	97%
Texas shiner	Subsistence	57%	55%	55%	55%
	Base-Medium 50%	79%	79%	77%	79%
	Base-Medium	90%	89%	83%	87%
Guadalupe bass	Subsistence	63%	61%	61%	61%
	Base-Medium 50%	81%	81%	77%	79%
	Base-Medium	89%	88%	85%	87%
gray redhorse	Subsistence	78%	76%	77%	77%
	Base-Medium 50%	89%	89%	87%	88%
	Base-Medium	94%	93%	91%	92%
channel catfish, adult	Subsistence	74%	73%	73%	73%
	Base-Medium 50%	82%	82%	81%	82%
	Base-Medium	87%	87%	84%	86%
longear sunfish	Subsistence	78%	77%	77%	77%
	Base-Medium 50%	89%	89%	87%	88%
	Base-Medium	94%	93%	91%	92%
largemouth bass	Subsistence	81%	80%	80%	80%
	Base-Medium 50%	91%	91%	89%	90%
	Base-Medium	93%	93%	92%	93%

Frio Concan – "enoughness" assessment

- Modified BBEST W
  - "Base-High 50%" = % of maximum WUA maintained by flow resulting from full 50% diversion between Base-High and Subsistence

Focal Species	Flow Component	Percent of Maximum Weighted Usable Area			
		Winter	Spring	Summer	Fall
greenthroat darter	Subsistence	41%	38%	38%	38%
	Base-High 50%	82%	82%	82%	82%
	Base-High	96%	96%	93%	96%
central stoneroller	Subsistence	60%	56%	56%	56%
	Base-High 50%	94%	94%	94%	94%
	Base-High	97%	97%	97%	97%
Texas shiner	Subsistence	57%	55%	55%	55%
	Base-High 50%	82%	82%	82%	82%
	Base-High	95%	94%	92%	94%
Guadalupe bass	Subsistence	63%	61%	61%	61%
	Base-High 50%	85%	85%	85%	85%
	Base-High	94%	94%	92%	94%
gray redhorse	Subsistence	78%	76%	77%	77%
	Base-High 50%	91%	91%	91%	91%
	Base-High	95%	95%	94%	95%
channel catfish, adult	Subsistence	74%	73%	73%	73%
	Base-High 50%	84%	84%	84%	84%
	Base-High	89%	89%	89%	89%
longear sunfish	Subsistence	78%	77%	77%	77%
	Base-High 50%	91%	91%	91%	91%
	Base-High	96%	96%	95%	96%
largemouth bass	Subsistence	81%	80%	80%	80%
	Base-High 50%	92%	92%	92%	92%
	Base-High	97%	97%	95%	97%

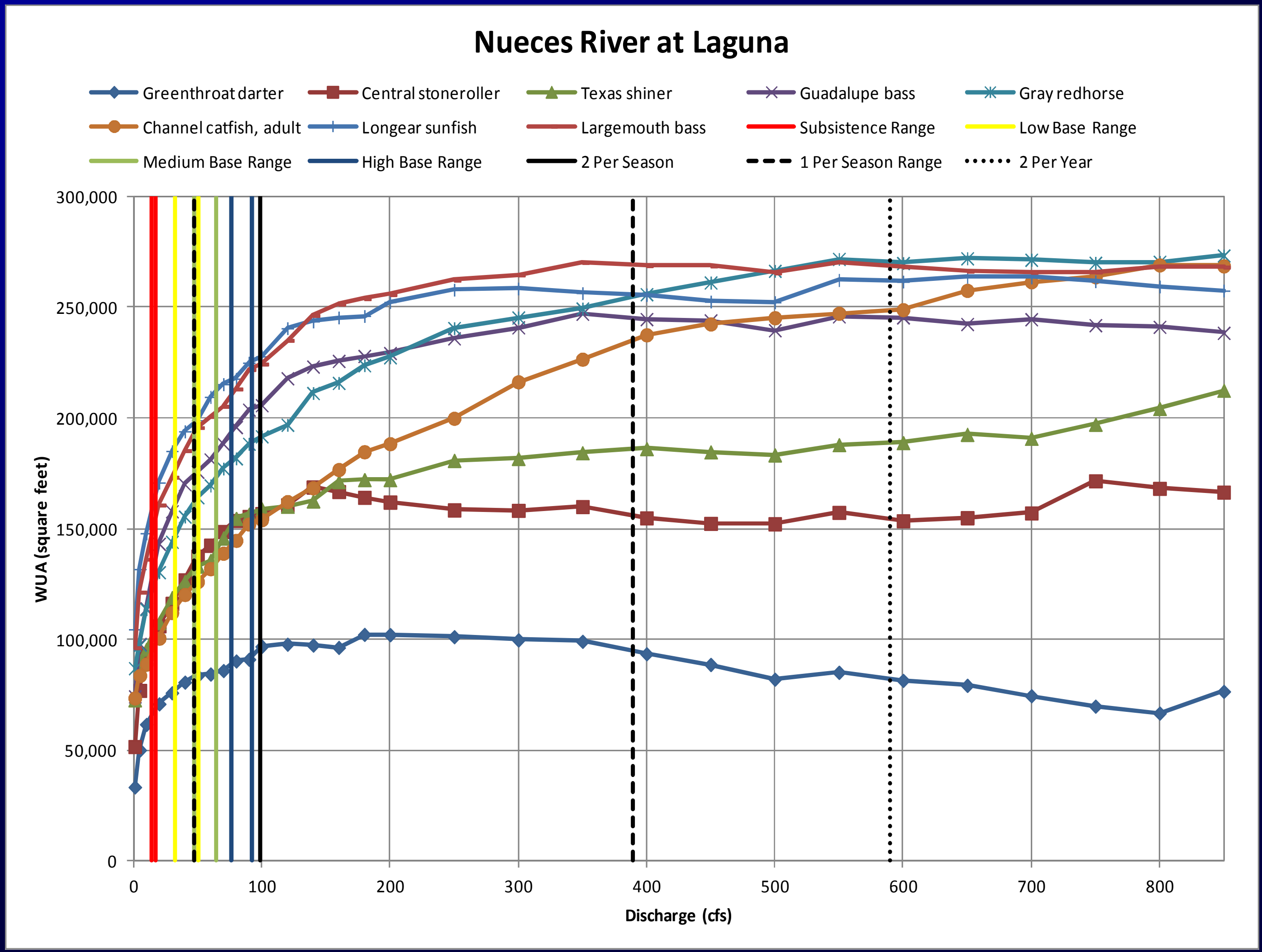
Ryan Smith Conclusions

- Frio River at Concan
  - "Enough" habitat (i.e., per 75% minimum threshold of Maximum WUA used by BBEST) is maintained for all species at Concan under the full 50% diversion of both the Modified BBEST A and W scenario

Methods, Decision Points

- 8 focal species
- Measure
  - WUA and % of maximum WUA
- Quality threshold
  - 0.5 Minimum habitat suitability score to evaluate highest quality habitats
- "Enoughness"
  - 75% of max WUA for base flow (at least one season-base flow level), 20% for subsistence
- Cross-section subsets?
  - All cross-sections, but results for riffle, run, pool subsets in Appendix
- Time series

Laguna – WUA, 0.5 Quality Threshold



Geomorphic (Sediment Transport) Analysis for Nueces BBASC

May 23, 2012

Mark Wentzel
Surface Water Resources Division
Water Science and Conservation

Study Locations

- Nueces River at Laguna
- Nueces River at Cotulla
- Nueces River at Three Rivers

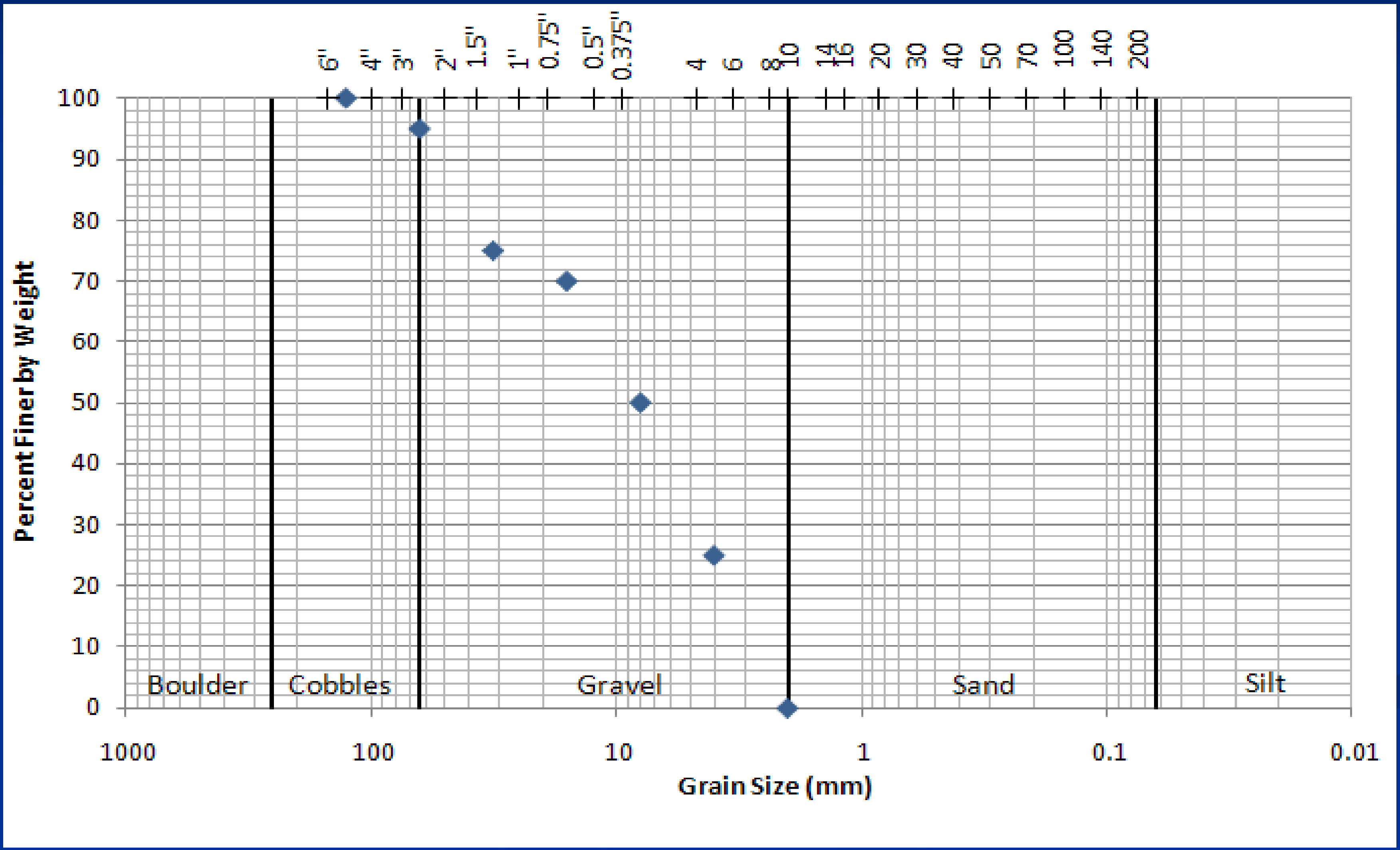
Time Period

- 1934-1996

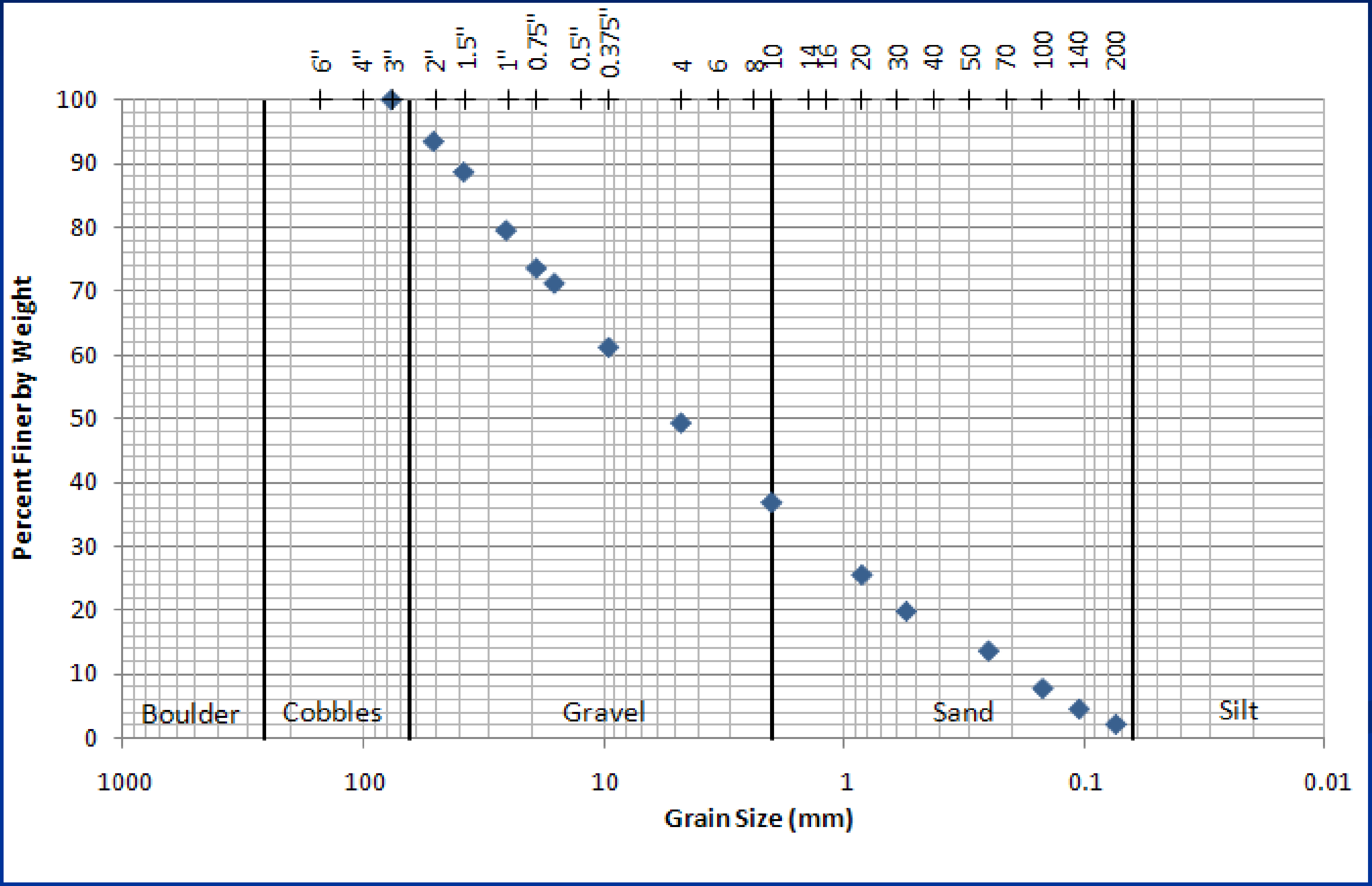
Flow Scenarios

- On/off-channel reservoirs w/ differing EFC

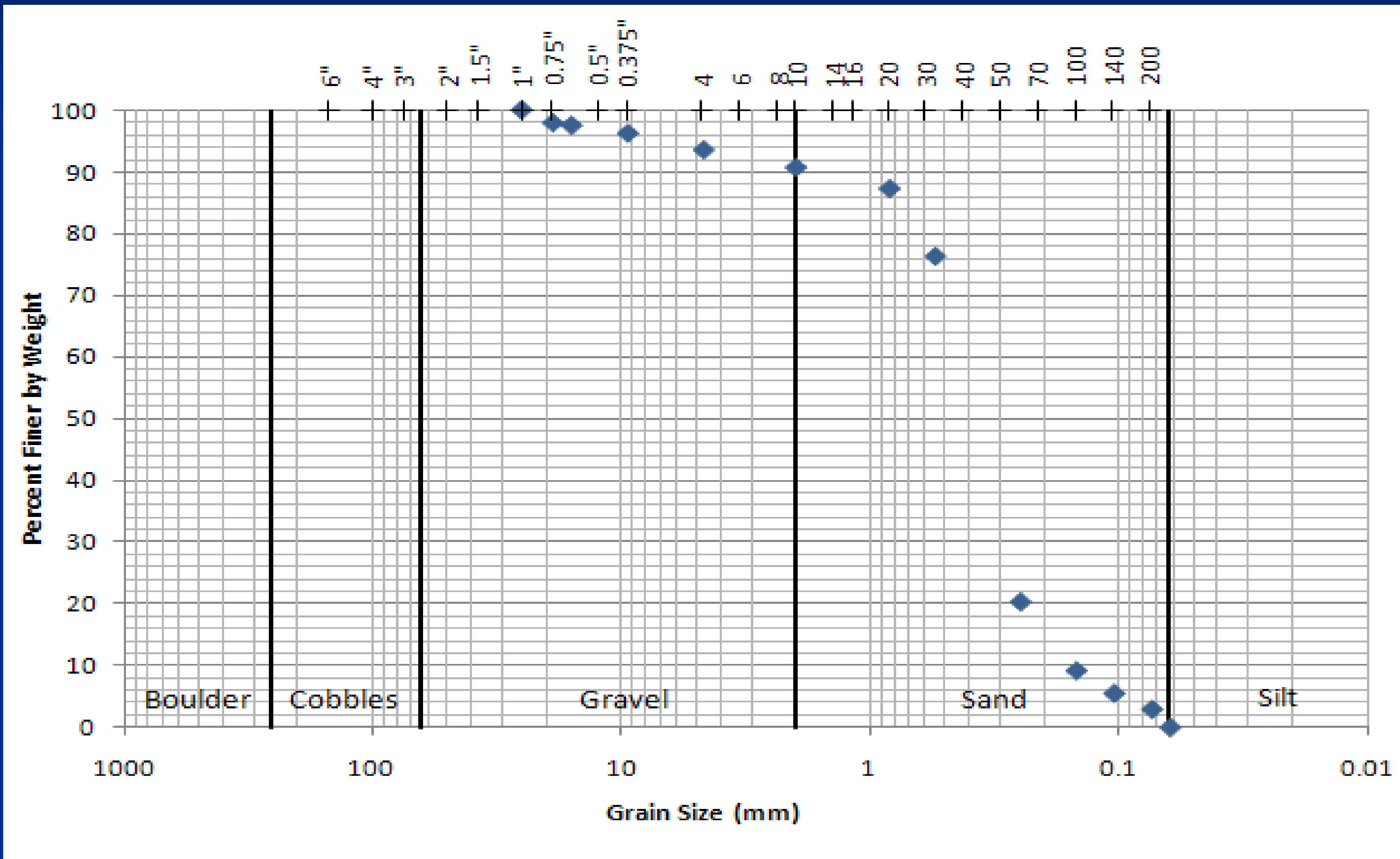
Size distribution of sediment particles from the Nueces River at Laguna



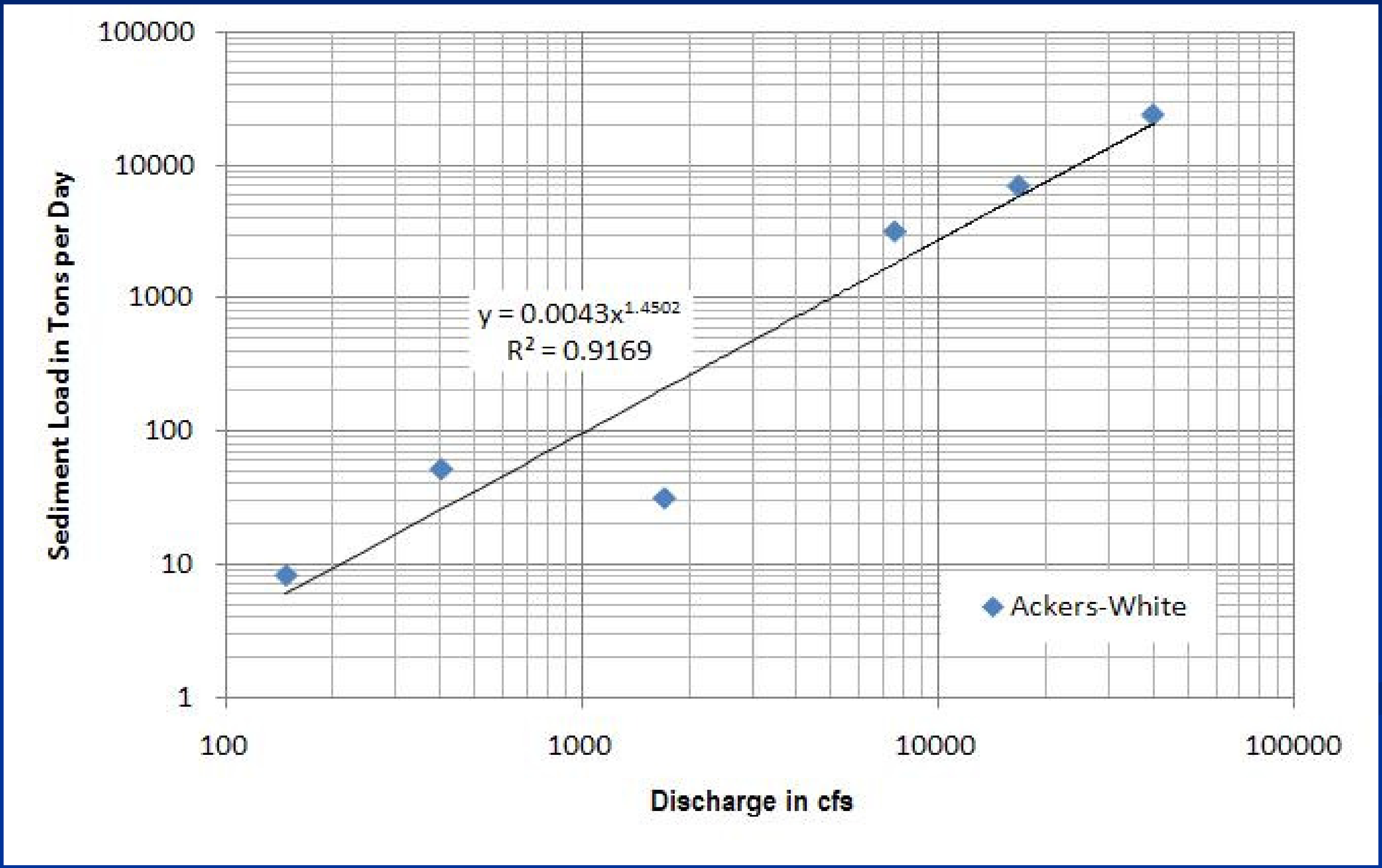
Size distribution of sediment particles from the Nueces River at Cotulla



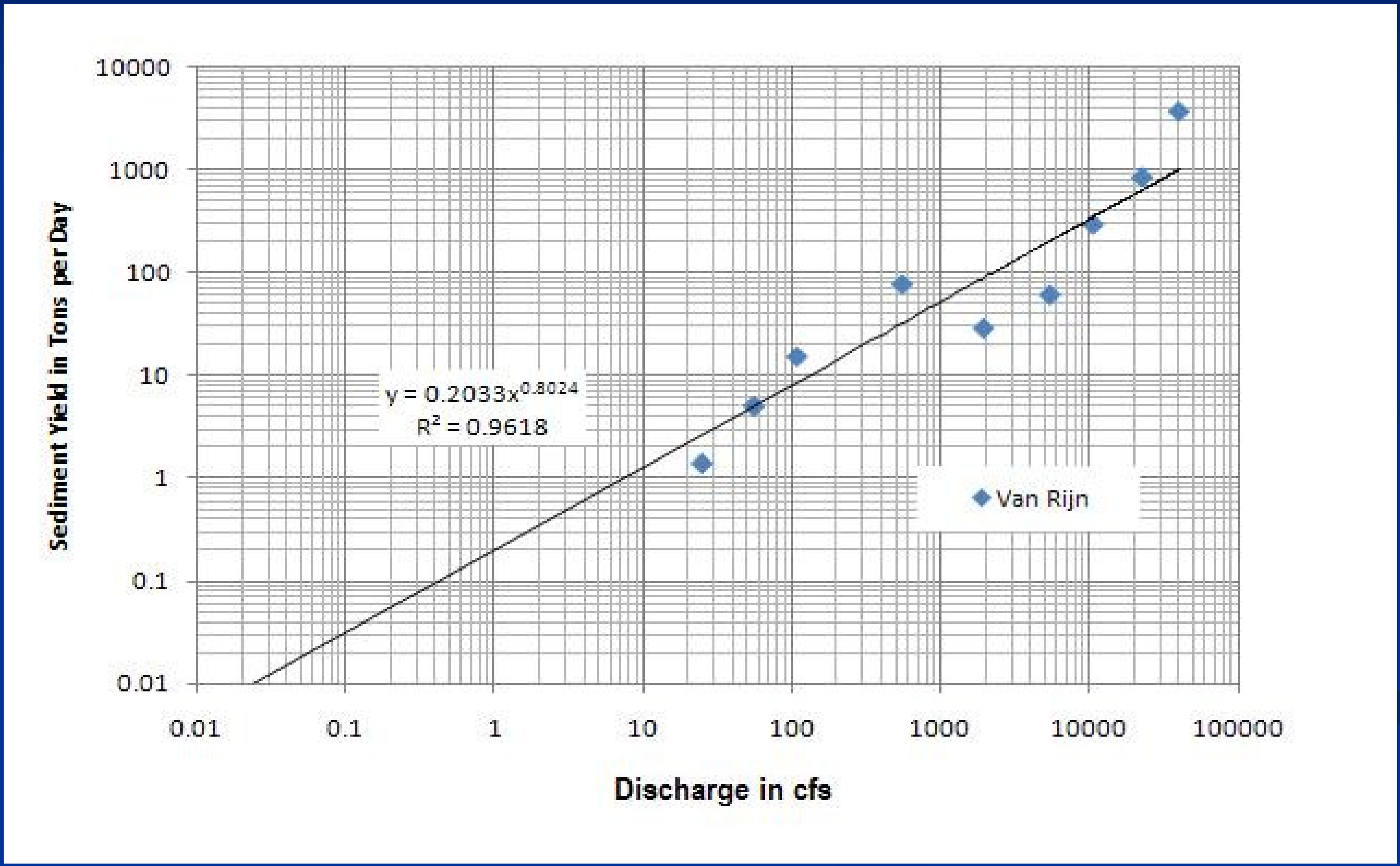
Size distribution of sediment particles from the Nueces River at Three Rivers



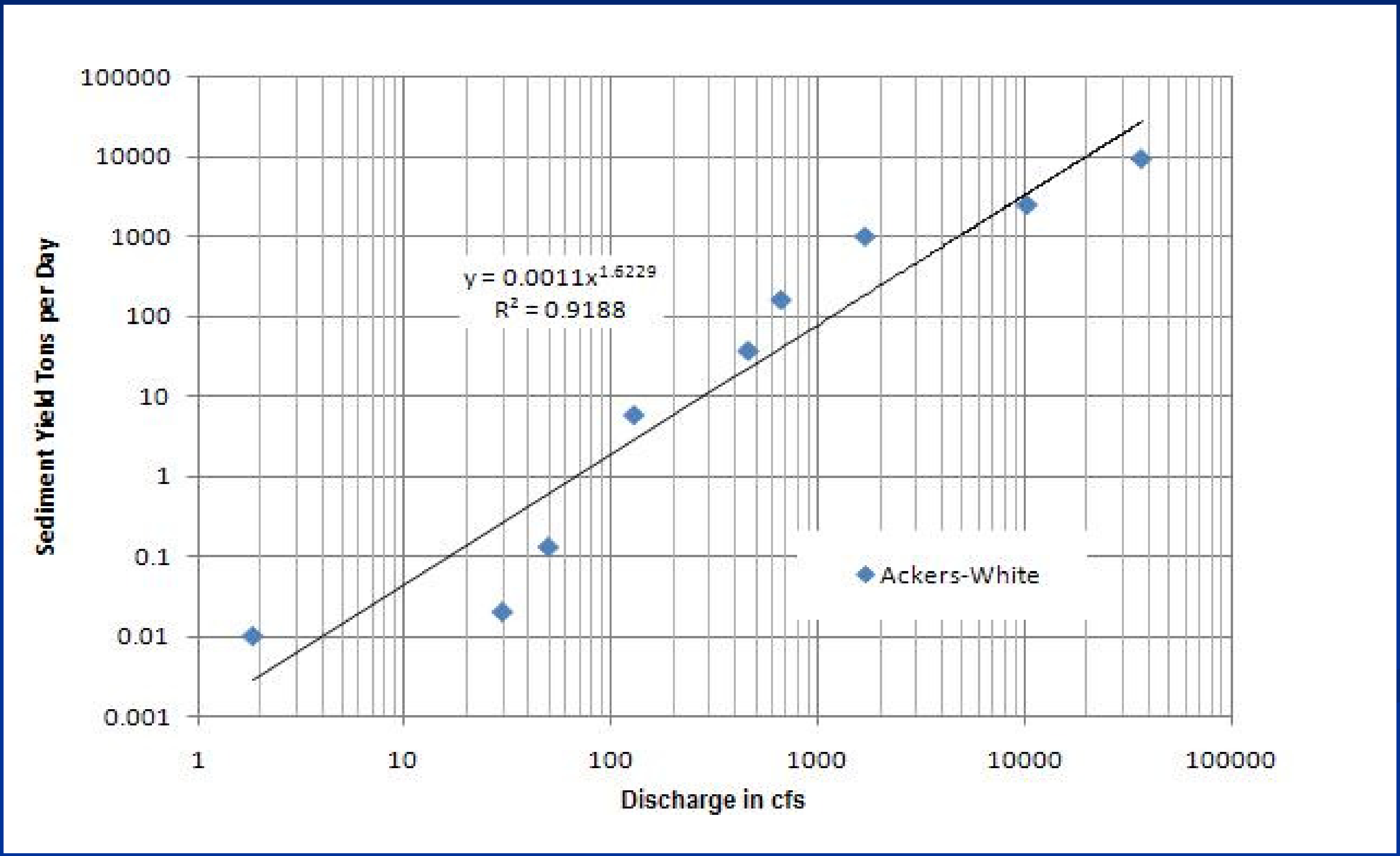
Sediment rating curve for the Nueces River at Laguna



Sediment rating curve for the Nueces River at Catulla



Sediment rating curve for the Nueces River at Three Rivers



Results: Nueces River at Laguna (with an off-channel reservoir)

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Historical (baseline)	115,000 (100%)	7,413 (100%)
Full BBEST	104,000 (90%)	6,964 (93%)
Modified BBEST A	102,000 (89%)	6,930 (93%)
Modified BBEST W	102,000 (89%)	6,998 (94%)
No E-Flows	84,000 (73%)	6,708 (90%)

Results: Nueces River at Cotulla (with an on-channel reservoir)

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Historical (baseline)	178,600 (100%)	4,160 (100%)
Full BBEST	94,900 (53%)	2,203 (53%)
Modified BBEST A	63,900 (36%)	1,569 (38%)
Modified BBEST W	66,500 (37%)	1,754 (42%)
No E-Flows	52,000 (29%)	1,002 (24%)

Results: Nueces River at Cotulla (with an off-channel reservoir)

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Historical (baseline)	178,600 (100%)	4,160 (100%)
Full BBEST	161,200 (90%)	3629 (87%)
Modified BBEST A	160,200 (90%)	3604 (87%)
Modified BBEST W	161,200 (90%)	3677 (88%)
No E-Flows	156,700 (88%)	3397 (81%)

Results: Nueces River at Three Rivers (with an on-channel reservoir at Cotulla)

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Baseline No Project	666,100 (100%)	92,500 (100%)
Full BBEST	626,200 (94%)	86.000 (93%)
Modified BBEST A	613,000 (92%)	84,000 (91%)
Modified BBEST W	614,400 (92%)	84,400 (91%)
No E-Flows	609,500 (92%)	83,700 (90%)

Results: Nueces River at Three Rivers (with an off-channel reservoir at Cotulla)

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Baseline No Project	666,100 (100%)	92,500 (100%)
Full BBEST	657,600 (99%)	91,500 (99%)
Modified BBEST A	656,300 (90%)	91,300 (99%)
Modified BBEST W	656,700 (99%)	91,300 (99%)
No E-Flows	655,600 (98%)	91,600 (99%)

8.0 Implementation Strategies

8.1 Statutory Requirements for Implementation Strategies in Stakeholder Committee Report

Section 11.02362 (o) Texas Water Code: 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 …(*Emphasis Stakeholder Committee*)

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

> (3) establish a schedule for continuing the validation or refinement of the basin and bay environmental flow analyses and environmental flow regime recommendations, the environmental flow standards adopted by the commission, and the strategies to achieve those standards. *(Emphasis Stakeholder Committee)*

8.2 Further Development Through Work Plan Process.

The Stakeholder Committee has identified various categories and approaches for strategies to meet the environmental flow standards recommended. The Committee recognizes that much more work is needed to develop specific strategies that are ready for implementation. The Committee acknowledges the importance of strategies in meeting the environmental flow standards being recommended and intends to continue work in refining these strategy recommendations, including by identifying potential approaches for implementing the recommendations, through the work plan process.

8.3 Regulatory Strategies:

A. A set standard of net benefit to environmental flows in basin of origin should be applied to inter-basin transfers to include potential return of return flows. Flexibility should be authorized to allow project participants to achieve the net benefit through a variety of mechanisms, including, for example, the purchase and conversion of other water rights to environmental protection purposes.

B. Explore methods for increasing reliability, using firm yield concepts, for voluntary implementation strategies to meet environmental needs.

C. Consider ways to dedicate cancelled water rights to environmental flows.

D. Consider ways to use tax incentives to encourage donation of water rights

E. Consider ways to encourage local governments to require developers to coordinate with local entities and perform pre-development studies to determine that sufficient water is available for proposed development projects.

F. Consider creating incentives that apply to future new appropriation authorizations, to the extent that they do not involve an interbasin transfer to dedicate a reasonable portion of resulting return flows to environmental flow protection. Incentives should be available if an appreciable amount of return flows could be generated.

8.4 Voluntary Strategies

SB 3 Legislative Findings Supporting the Use of Voluntary Strategies

> **11.0235(b) TWC.** 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 legislature encourages voluntary water and land stewardship to benefit the water in the state, as defined by Section 26.001.
>
> **11.0235(d-3)(2)TWC.** In those basins in which the unappropriated water that will be set aside for instreamflow and freshwater inflow protection is not sufficient to fully satisfy the environmental flow standards established by the commission, a variety of market approaches, both public and private, for filling the gap must be explored and pursued. *(Emphasis ours)*

Since there is very little unappropriated water in the Colorado River that could be reliably developed, there may rarely be new permits issued in that basin to which the environmental flow regime standards adopted by the Colorado and Lavaca Rivers and Matagorda and Lavaca Bay and Basin Stakeholder Committee will apply. Consequently, strategies to implement the recommended flow regimes in the Colorado Basin will necessarily have to focus primarily on voluntary activities funded privately or through grants.

8.5 Strategies Applicable Throughout the Colorado and Lavaca River Basins

A. Donation, Purchase or Lease of Existing Water Permits - Current Texas law does not permit the issuance of new permits for instream flows dedicated to environmental needs or bay and estuary inflows, but does authorize amendments to existing permits or certificates of adjudication to change the use to, or add a use for, instream flows dedicated to environmental needs or bay and estuary inflows.

- Willing water rights holders should be encouraged to donate, sell or lease all or part of their permitted or adjudicated water rights to the Texas Water Trust or to private 501 (C)(3)water trusts which would:

  1. Receive and hold tax-deductible donations of water rights and obtain monetary donations for the purchase or lease of water rights .

  2. Purchase water rights to be to be amended to add instream uses.

  3. Pay irrigators for forbearance from irrigating during drought years to compensate for crop loss.

4. Lease rights on a long-term basis for instream flows

5. File the water right amendment with the TCEQ for the permit holders, do the accounting and maintain records.

This strategy may be most suited to specific locations where recreational use, habitat preservation or esthetics are of special concern to the local or regional community.

- Obtain grants, donations or state or federal funding for purchase or lease of water rights for environmental flows and for riparian restoration projects.

B. Promote Water Stewardship Practices to Qualify for Appraisal as Open-Space Land

- Look for opportunities to promote and encourage those landowner water stewardship practices, including the holding of a water right that authorizes the use of a specified minimum amount of water for instream flows for environmental needs or bay and estuary, which shall make the landowner eligible for appraisal open-space land for purposes of ad valorem property tax exemption.
- Develop an educational program to inform landowners of this new opportunity for open-space exemption.

C. Conservation

Incentives for water users to use good management practices:

- Surface water saved through installation of more efficient equipment or management practices should not be subject to cancellation for non-use
- BBASC should work with NRCS to give priority to EQIP contract awards for water conservation practices including brush control and laser leveling.
- Obtain grants, donations or state or federal funding for riparian restoration projects.
- Development of various incentive programs, for example, funding for an entity to promote conservation, with a portion of conserved water dedicated to environmental flow protection.
- Public relations program to encourage municipalities to adopt water –use rate structures that will encourage conservation.

D. Explore ways to improve water availability information for prospective land purchasers.

E. Alternative Water Supplies

- Explore potential for substituting treated effluent (e.g., direct reuse) for surface water supplies in some areas of the basins, where there is a net benefit to environmental flows.
- Explore potential, incentives, and grants or state funding for household graywater use.
- Explore potential for conjunctive use to help protect environmental flows during dry periods.

F. Groundwater Management for Springflow Protection

- Participate in Groundwater Management Area meetings and support the adoption of Desired Future Conditions and groundwater management approaches which will protect key springflows and groundwater-derived base flows.
- Encourage the TWDB to perform or fund studies - especially co-operative studies among multiple groundwater districts -which determine levels of pumping and aquifer drawdown that impair flows from key springs.

G. Diversion Point Management

Opportunities may exist for conservation groups to work with a number of water right holders along a river segment to relocate water right diversion points or use older rights in conjunction with newer rights to improve delivery efficiencies. This has been done in the Entiat River in Washington State.
(See http://www.warivers.org/entiat.html)

H. Voluntary Dedication of Wastewater Return Flows

8.6 Site Specific Implementation Strategies

Generally, all implementation strategies are considered to be applicable for all locations unless the general discussion indicates otherwise. Where certain strategies are considered to be particularly appropriate for a given area, those specific strategies are listed below.

Upper Colorado

- State funding or tax incentives for brush control of cedar and mesquite
- State funding or tax incentives for salt clean-up on land
- State funding for studies determining reasons for downward trends in streamflow in the Upper Colorado

Lower Colorado

- State funding or tax incentives for nuisance vegetation control including noxious, invasive plants and establishment of native vegetation

Lavaca-Navidad River

- State funding for sediment control

Coastal Streams

- Add stream gages

Matagorda Bay

- Install gages on Turtle and Keller Creeks.

East Matagorda Bay

- Conduct study of the needs of East Matagorda Bay, including the feasibility of directing additional flows to the bay.
- Redirect flood flows from in Brazoria County to East Matagorda Bay
- Build small channels without boat access to improve circulation in East Matagorda Bay
- Evaluate reasonableness of pumping groundwater into East Matagorda Bay
- Build siphons or pipelines under the intracoastal waterway to ensure that local inflows actually reach the bay.
- Assure that strategies chosen are not impaired by the intracoastal waterway
- Explore the feasibility and efficacy of using various cuts to increase freshwater inflows to the bay- e.g., St. Mary's Bayou and Caney Creek

Lavaca Bay

- Add salinity monitoring sites

5.0 Recommendations Regarding Potential Strategies to Meet Environmental Flow Standards

Senate Bill 3 (SB3) mandates that each bay/basin area stakeholders committee: 1) develop recommendations on environmental flow standards, and 2) develop strategies to meet these standards. In the process of developing environmental flow standards recommendations for the Guadalupe, San Antonio Bay and Basin Area, the Bay and Basin Area Stakeholders Committee (GSA BBASC) reviewed the Bay and Basin Expert Science Team (GSA BBEST) report along with additional analysis and science that was commissioned by and presented to the stakeholders committee.

The GSA BBEST report recognizes that, based on the available science, with a few noted exceptions, a sound ecological environment exists in these rivers, bays and estuaries today. However, during the GSA BBASC deliberations, GSA BBEST members presented additional analysis regarding the potential impact full utilization of existing water rights could have on flows. The additional information raised concerns among GSA BBASC members that the "sound ecological environment" found today could change, particularly during lower flow times of the year, if all existing water rights are fully utilized as permitted.

The GSA BBASC recognized specific basin-wide flow recommendations were not in place prior to the SB3 process and would not have been included as water permit requirements. Both the GSA BBEST report and the GSA BBASC report will form the basis of new Texas Commission on Environmental Quality (TCEQ) environmental flow standards. The GSA BBASC developed and will submit its recommended instream and bay and estuary flow standards to the TCEQ for application to future permits, but also endorses the use of these same instream flow regime standards and bay and estuary seasonal attainment criteria as voluntary targets for current permit holders. The GSA BBASC recognizes that voluntary implementation of water use and management strategies will improve the effective use of limited surface water within the basin particularly during the driest times when water is in its highest demand and flow is at its lowest. Implementation of strategies is also a vital component toward reaching recommended flow attainment targets while achieving a balance between water supply and environmental needs.

The GSA BBASC requested the National Wildlife Federation (NWF), in association with Intera Geosciences & Engineering, to conduct a preliminary evaluation of three potential strategies: Wastewater Dedication, Dry Year Option and Purchase/Conversion of under-utilized water rights and a combination of these strategies. The report on this evaluation is included as Appendix H in the GSA BBASC report. In summary, the evaluation found that the strategies applied individually, or in combination, can produce additional beneficial flow to the bays and estuaries during the driest times.

During the development of the Adaptive Management Plan/Work Plan, the GSA BBASC will determine what additional science is needed to better link specific quantity of inflow to measurable improvements to the quality of the environment benefit in the rivers and bays. The GSA BBASC will also identify obstacles in State rules or laws that could impede the implementation of the strategy options listed and recommend steps to remove or modify these obstacles. In the interim, the GSA BBASC encourages the TCEQ, Texas Water Development Board (TWDB), Texas Parks and Wildlife Department (TPWD) and Region L, J and N Regional Water Planning Groups to aggressively promote the implementation of these or other water use and management strategies to help achieve the GSA BBASC recommended flow standards for the Guadalupe and San Antonio river basins, bays and estuaries.

It is noted that the GSA BBASC narrative regarding the Strategies Addressing Environmental Flow Standards was adopted by a vote of 23 to 1, while the *Data and Tools Needed for Achieving Environmental Flow Standards* and *Strategy Options for Achieving Environmental Flow Standards* (listed below) were adopted by consensus.

<u>Data and Tools Needed for Achieving Environmental Flow Standards</u>

The GSA BBASC were informed throughout its deliberations of gaps in data and information which exists today and serve as obstacles to accurately assessing current and future water use within the basin. These information gaps could also affect the ability to assess the effectiveness of environmental flow strategies toward meeting the instream flow regime and bay and estuary attainment criteria recommended by the GSA BBASC. Below is a list some of the data tools the GSA BBASC identified that should be explored by TCEQ. The GSA BBASC will also develop work on additional data needs during the upcoming work on the Adaptive Management Plan/Work Plan.

- **Secure agreement from TCEQ to perform a full accounting of all existing surface water use within the basin to allow for more accurate model projections of current and future water needs**
  - A more accurate accounting of actual surface water use, including an estimation of riparian and domestic and livestock (D&L) use will improve data used for water availability models while providing information to determine if existing water rights could be voluntarily repurposed to assist in meeting flow standards.

- **Improve access to and management of historical TCEQ data on wastewater return flows in order to improve understanding the role wastewater return flows have in providing flows for environmental purposes**

- **Explore the addition of streamgages in the lower basin to increase data to more accurately measure the contribution of river flows to the bay and estuary system**

- **Update the Guadalupe–San Antonio Water Availability Model (GSA WAM) used by TCEQ for permitting**
  - The current period of record for the GSA WAM is 1934 through 1989 (56 years). The exclusion of the most recent 22 years of data in the model causes credibility issues with the data because many of the recent high flow and drought events are not included in the model. Furthermore, a longer period of record would provide more complete data for the next round of GSA BBASC Recommendations regarding the attainment frequencies associated with the Environmental Flow Standards Recommendations for the Guadalupe and Mission-Aransas Estuaries (Section 4.2).

Strategy Options for Achieving Environmental Flow Standards

Below, the GSA BBASC has provided a list of potential strategies that can be voluntarily implemented by current and future water rights permit holders and applicants, state agencies or others to assist in meeting the instream and bay and estuary environmental flow standards recommended by the GSA BBASC. These strategies can also serve as a menu of options to meet the requirements of the proposed 10 percent dedication recommended by the GSA BBASC for the bay and estuary (refer to Section 4.3.2). This list of strategies is not intended to be exhaustive and many other options may exist. Members of the GSA BBASC will explore the feasibility of implementing specific strategies during upcoming work on the Adaptive Management Plan/Work Plan by the GSA BBASC.

- **Explore the donation, sale or lease of new or under-utilized water permits**
  - Willing water permit holders donate, sell or lease all or part of their permit so that that water could stay in the stream for environmental flow protection. Permit would be changed to add instream and/or bay and estuary use. To be most effective, these permits would need to be firm water that is fairly senior.
  - Use of a water trust can be helpful for keeping track of water dedicated for environmental flow purposes.

- **Dedication of wastewater return flows**
  - Dedication of permitted wastewater return flow toward environmental flow needs. The wastewater could be generated by a new permitted project, an existing project or through agreement or voluntary commitment of wastewater generated by a municipality. Water quality should be considered.

- **Dry Year Option (for Irrigation Permit)**
  - Agricultural water rights holders could be compensated for not diverting water during dry years. Priority should be given to agricultural water rights that have recent historical use. This approach reduces instream water use during critically dry periods in order to increase flows.

- **Increase storage of water for releases for environmental flows**
  - Additional storage could be added to projects to store water during higher flows to allow for releases to support the river/bay system during low flow periods when flow is needed.
  - Develop project to store surface water during higher flows (surface storage or aquifer storage and recovery) to have a solely dedicated source for environmental flows during drier times.

- **Dedication of Conserved Water from Current Permits to Environmental Flows**
  - Permit holders could voluntarily commit water that is saved through conservation methods to environmental flows. Most applicable to agricultural or municipal water permit holders.
  - Possible Environmental Quality Incentives Program (EQIP) funding for agricultural conservation practice/s and other available federal funding.

- **Facility Optimization to Enhance Environmental Flows**
  - Modify a facility's operation and/or schedule of releases can help provide environmental flows. The amount and timing of releases can attempt to better mimic the natural flow patterns of the river system, thereby protecting environmental flows. This can be done to an individual facility or to multiple facilities in a watershed for an additive effect.

- **Water Right Management**
  - The existing location and timing of diversions of water rights in the basin may inhibit opportunities for better resource management that could help support environmental flows.
  - Combinations of opportunities may exist whereby water right diversion points could be relocated, older rights used in conjunction with new water rights, or new water rights used in conjunction with currently unused rights to improve delivery efficiencies to both water users and the environment. Contractual agreements will be necessary.

- **Set-Asides of Unappropriated Water**
  - Some or all of unappropriated flow within the basins could be left in the river or removed from the amount of water available for future permitting. SB3 contemplates set-asides of unappropriated water by TCEQ.

- **Reduction of Groundwater Pumping**
  - Reducing groundwater pumping can allow springs to provide river baseflows.

- **Land Stewardship Programs**
  - Local, regional, state, and federal incentives for landowners to use good land management practices which will put more water into the water table.

  - ***Riparian Zone and Wetland Restoration and Stewardship***
    - Proper stewardship of riparian zones on the basin's creeks and rivers can build up the in-bank water holding capacities which serve to maintain base flows during dry periods and provide a healthy riparian habitat for both aquatic species and other wildlife. Flood attenuation and improved water quality are additional benefits resulting from proper stewardship of riparian zones.
    - Restored and healthy wetlands on the rivers or on the Gulf provide very productive wildlife habitat, filtering and cleansing actions desirable for inflows, and protection for inland communities from hurricanes.

  - ***Watershed or Catchment Stewardship***
    - A well-managed, healthy watershed not only provides a desirable livestock and wildlife environment, but increases groundwater penetration and recharge, reduces floods and provides other benefits.

    - Karst limestone watersheds are common across the Hill Country and Edwards Plateau, selective brush management and subsequent improved rangeland management has proven to sometimes increase ground recharge and springflows. Normally, ashe juniper (cedar, mountain cedar) has been the target brush species, but in other cases mesquite control has produced desirable hydrological benefits.

- **Water Dedication from Existing Permits**
  - Some permit holders may be willing to have conditions placed on their permits, such as a certain percent or set amount of the water being dedicated to provide environmental flows.

- **Municipal, Industrial, Mining and Agricultural Conservation to reduce water use and demand**
  - Each city, town and water utility, both large and small, should set goals to lower future surface and/or groundwater use using a conservation program which best fits their situation for both the utility and customers. The goal would be to reduce per capita water use and reduce demand for river diversions.
  - Effective conservation programs/strategies include: stringent leak detection, low water use appliances, inverted pyramid rate structures, customer education program, rainwater harvesting, use of recycled water and gray water, and others.
  - Agricultural irrigation conservation including installation of efficient of water delivery systems (canal, pipelines, etc.), improve center pivot systems, add in-ground moisture monitors, improve crop varieties and other farming methods.

- **Develop conjunctive use water projects**
  - To reduce reliance on surface water, water project developers should be encouraged to develop conjunctive use water projects using both groundwater and surface water. Better data on groundwater availability is now available for defined Groundwater Management Areas and modeled available groundwater reports to the TWDB increasing the certainty of groundwater use planning.

- **Develop alternate water supplies**
  - Alternative water supplies such as desalination of brackish groundwater or seawater desalination offer options to surface water usage and can provide additional water that could be stored and released for environmental flows.

- **Programs addressing logjam removal**
  - A logjam removal program could yield flow benefits to the bay and estuaries and improve stream bed conditions as well as riparian health in associated areas of the basin.

Potential Strategies
to Meet Environmental Flow Standards

updated 2/2012

Senate Bill 3 (SB3) mandates that each bay/basin area stakeholder committee: 1) develop recommendations for environmental flow standards, and 2) develop recommendations for strategies to meet these standards.

The first portion of this charge—the **recommendations on environmental flow standards**—is primarily the stakeholder committee's own version of their expert science team's environmental flow recommendations: **a schedule of flow amounts and the associated timing and frequency of those flows that they recommend be protected**. Stakeholders are recommending that the Texas Commission on Environmental Quality (TCEQ) adopt these as the environmental flow protection standards that will then be used to set conditions on new water use permits granted in their bay/basin. **Although, in the permitting process, these "standards" will only be applied to new water use permits, they also represent a larger statement of what environmental flow protection goals should exist in a basin regardless of permitting activity.**

The second part of the stakeholder committee's initial task is to recommend **"strategies to meet these standards."** In this context, "strategies" refers to the **various ways the water needed to fulfill these recommended environmental flow protection standards could be made available** for that purpose. Thus, **"strategies" are distinct in that they can address environmental flow problems that may already exist due to existing water use permits.**

Stakeholders' recommended environmental flow protection standards: amounts & timing
+ Strategies that could provide water to fulfill recommended flow amounts & timing

= September 1, 2012 Nueces Stakeholders' Report to TCEQ
(then used to adopt environmental flow standards that will be applied to new permits)

In an effort to bring to light examples of strategies that might be available to help meet the stakeholder committee's recommended environmental flow standards, here is a brief description of some potential strategies, followed by a short Q & A section.

Strategies to Meet Environmental Flow Standards

1. **Donation, Sale or Lease of Existing Water Permits**
    - Willing water permit holders donate, sell or lease all or part of their permit so that that water could stay in the stream for environmental flow protection. Permit would be changed to add instream protection as an authorized use. To be most effective, these permits would need to be firm water that is fairly senior.
    - Use of a water trust can be helpful for keeping track of things: the money for leasing/purchasing permits, the resulting tax deductible contributions, etc.
    - Examples of existing Texas water trusts are the Texas Water Trust, the Guadalupe-Blanco River Trust, and the Trans-Pecos Water Trust.

2. **Voluntary Dedication of Wastewater Return Flows from Current Permits**
   - This could be a dedication of some or all of the wastewater return flows associated with a permit. This strategy would be most effective with firm water permits.
   - Example: City of Houston 50% direct reuse agreement; Houston Chronicle article: http://www.texaswatermatters.org/pdfs/news_655.pdf

3. **Dry Year Option (for Irrigation Permit)**
   - Farmer is compensated for not planting (and not watering) crops during a dry year. This approach reduces water use during critically dry periods in order to increase flows by allowing the water to stay in the stream.
   - Example: Edwards Aquifer Recovery Implementation Program is considering the Voluntary Irrigation Suspension Program http://earip.org/Article.aspx?ID=19.

4. **Increase New Project's Storage Capacity, then Dedicate a Portion to Environmental Flows**
   - This could potentially allow for releases to support the river/bay system during low flow periods when flow is so needed.
   - Resulting reductions in yield/increase in project cost could potentially be compensated.
   - The incremental cost associated with constructing larger storage to augment environmental flows may be relatively small.

5. **Voluntary Dedication of Conserved Water from Current Permits to Environmental Flows**
   - Most applicable to Agricultural or Municipal water permit holders
   - Possible EQIP funding for conservation practice/s and other federal funding available
   - Example: In Washington, the Dungeness River Agricultural Water Users Association agreed to withdraw no more than 50 percent of the river's flow at any given time. Additionally they have committed to a long-term conservation and efficiency program.http://www.sustainablenorthwest.org/stories/dungeness-river-watershed-restoration/

6. **Dam Reoperation**
   - Redesigning a dam's schedule of releases can help provide environmental flows. The amount and timing of releases can attempt to better mimic the natural flow patterns of the river system, thereby protecting environmental flows. This can be done for an individual dam or for multiple dams in a watershed for an additive effect.
   - Example: Green River Dam in Kentucky: http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/kentucky/placesweprotect/green_river_plan_approved_oct_20061.pdf
   - Example: The Nature Conservancy's Sustainable Rivers Project: http://www.nature.org/ourinitiatives/habitats/riverslakes/sustainable-rivers-project.xml

7. **Water Right Management**
   - The existing geographic and temporal arrangement of water rights in the basin may inhibit opportunities for better resource management that could help support environmental flows.
   - Combinations of opportunities may exist whereby water right diversion points could be relocated, older rights used in conjunction with new water rights, or new water rights used in conjunction with currently unused rights to improve delivery efficiencies to both water users and the environment. Contractual agreements will be necessary.

- Example: In the Entiat River in Washington, conservation groups worked with willing landowners to move diversion points to better maintain flows during summer low flows. http://www.warivers.org/entiat.html

8. Set-Asides of Unappropriated Water

- In basins where there is still water available for permitting beyond what has been given out in existing permits, some or all of that water can be taken off the table from future permitting and left in the river to provide environmental flows. SB3 contemplates set-asides of unappropriated water by TCEQ.
- Example: Instream flow protections exist in one form or another in most western states. http://www.blm.gov/nstc/WaterLaws/stateflowsummary.html

9. Restrictions on Groundwater Pumping

- Restricting Groundwater pumping in a drought can allow springs to provide river baseflows.

10. Private Land Stewardship Programs

- Incentives for landowners to use good land management practices which will put more water into the water table.
- There are numerous programs both at the state and federal level

11. Voluntarily Placing Conditions on Existing Permits

- Some permit holders may be willing to have conditions placed on their permits, such as a certain percent or set amount of the water being dedicated to provide environmental flows.
- If this was anything but voluntary, it would likely be very controversial.
- Example: Such a strategy was used in Washington's Methow basin: http://www.warivers.org/methow2.html

12. Cancellation of Unused Water Permit/s by TCEQ

- TCEQ does have the power to cancel water permits that have not been used for 10 years (full cancelation), or the portion of the permit that has not been used for 10 years (partial cancelation). This does not include water rights for projects within regional water plans. However, this has rarely been done in Texas, and would, undoubtedly, be highly controversial.
- Cancelation of unused rights could make more water available for projects and for environmental flow protection.

Questions and Answers

1) **What role will strategies play in stakeholder deliberations about how to balance human and environmental water needs?**
Some may view a lack of water availability as a barrier to recommending strong flow protection

standards. This lack of availability may be due to the amount of permits already granted within a basin. Or, it might be because the yield and/or cost impacts to potential future projects when applying the flow standards is perceived as being too great. Either way, it would be easy to conclude that the only option is to whittle away at the set of protections that stakeholders are contemplating. But this is not the only path. **A suite of strategies could potentially add up to meet the stakeholder committee's preferred level of flow protection while still allowing for future water development. Strategies allow us to take a second look at how to provide the preferred level of protections, regardless of how much water is available.**

2) **What does a stakeholder committee's strategy recommendation look like?**
The strategies recommendation piece of the report may be nothing more than a laundry list of ideas that the stakeholder committee comes to agreement on as having some potential to help meet their recommended protection goals. Or, it may be a more extensive effort to determine, on a site specific basis, which strategies can effectively be used to fulfill which parts of the flow regime recommendations. Neither the Trinity/San Jacinto stakeholder committee nor the Sabine/Neches stakeholder committee got to the point of including strategy recommendations in their reports. The Guadalupe/San Antonio and the Colorado/Lavaca stakeholder committees both included a list of potential strategies in their recommendations reports. Additionally, the Guadalupe/San Antonio committee also made an effort to quantify the effects of a few select strategies and included that analysis in their report.

3) **How can the standards that stakeholders recommend help address existing environmental flow shortfalls that are a result of water permits already issued? How can the strategies address existing problems?**
Because the standards will be used when granting new water permits, these will not directly address any flow shortfalls that exist due to existing water permits. However, the standards are more than just restrictions on new permits, they are flow protection goals that can then also be worked towards through other means. Strategies are those other means. So the combination of the standards, plus strategies to meet them, can help address shortfalls due to existing permits.

4) **How does the level of appropriation within a basin affect the usefulness of strategies?**
In river basins that have substantial unappropriated flow - thus water for new permits - the environmental flow protections placed on those permits may prove to be an effective vehicle to meet some or all of the adopted SB3 standards. In other basins, especially those with little or no unappropriated flow, there may be significant gaps in meeting some or all of the adopted environmental flow standards. And in between, even in river basins where there is still limited water available for future permits, we will likely still come up short in providing flows to meet all the various components of the environmental flow standards. These cases are where the environmental flow strategies can provide a means to bridge some of these gaps through other approaches not related to new permit conditions.

5) How will strategies recommendations be used?
Strategies recommendations will likely be the first step in creating a road map for how to get to the recommended standards, or protection goals, the stakeholders envision for their bay/basin area. Recommended strategies might be used by water planners, by state and/or federal agency staff, by legislators, by water permit holders, by non-profit organizations, by water supply entities, and anyone else who might pursue the protection goals set out by the stakeholder committees.

Geomorphic (Sediment Transport) Analysis for Nueces BBASC

STUDY LOCATIONS

Nueces River at Laguna:

Soils of the Nueces watershed upstream of the Laguna USGS gage site in Uvalde County are predominantly thin layers of clay and loam, two to eighteen inches thick, overlying limestone bedrock, fractured limestone, or caliche (USDA, 1976). Stream bed materials consist primarily of gravel, coarse gravel, and bedrock with some silt and organic matter near the shores (Trungale and Hardy, 2011).

Nueces River at Cotulla:

Relatively deep clayey loams and sandy loams are the primary soils of LaSalle County around the Nueces River near Cotulla gage location (USDA, 1994). Stream bottom sediments are typically clay, silt, sand, and gravel.

Nueces River at Three Rivers:

Soils of Live Oak County drained by the Nueces River near the Three Rivers gage location are a mixture of thin to very deep clayey, sandy, and gravelly loams (USDA, 2006). Stream sediments are primarily sand with silt and slight amounts of organic matter (Trungale and Hardy, 2011).

ANALYSIS

Stream sediments were collected from each study location in 2011 and analyzed by the TWDB. Particles were largest at the Nueces River at Laguna where all particles were larger than sand and about 95% of all particles were gravel-sized (Figure 1). At the Nueces River at Cotulla, about 37% of all particles were sand with most of the remaining particles gravel-sized (Figure 2). The finest sediments were measured from the Nueces River at Three Rivers where 91% of the sediment particles were sand (Figure 3).

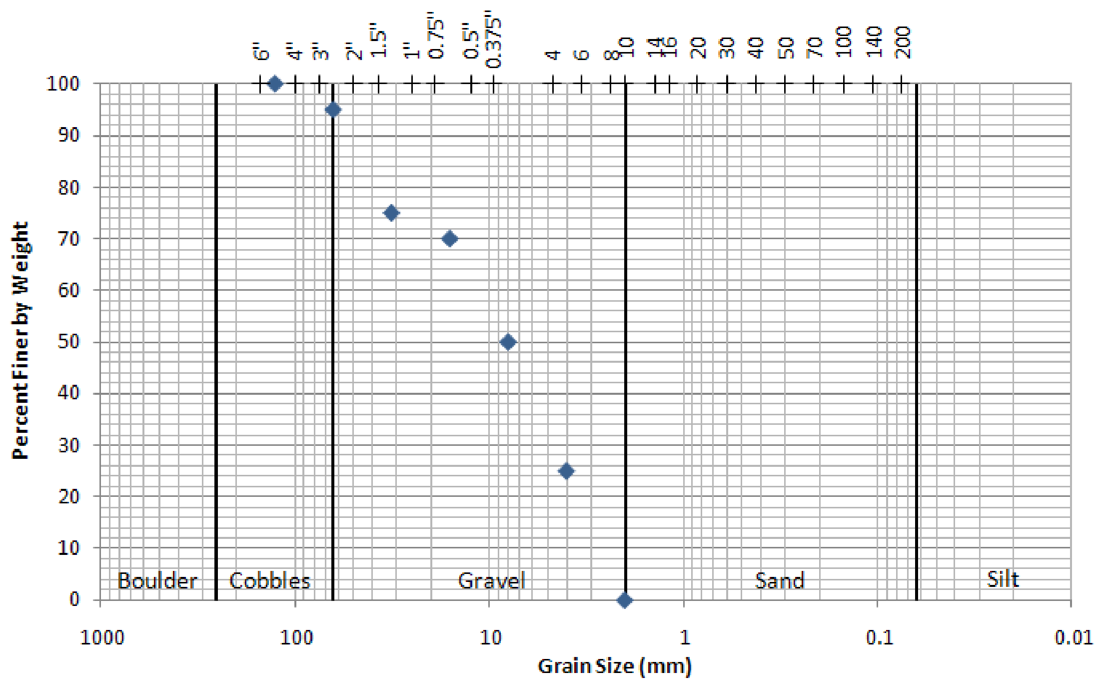


Figure 1. Size distribution of sediment particles from the Nueces River at Laguna (TWDB data).

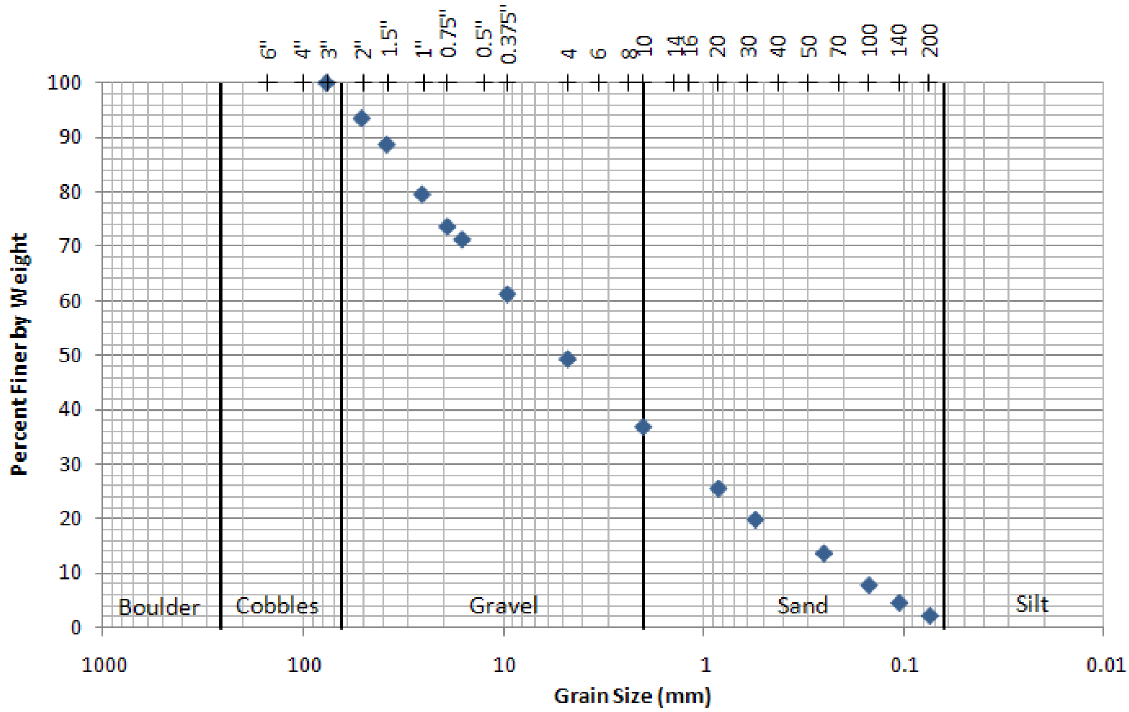


Figure 2. Size distribution of sediment particles from the Nueces River at Cotulla (TWDB data).

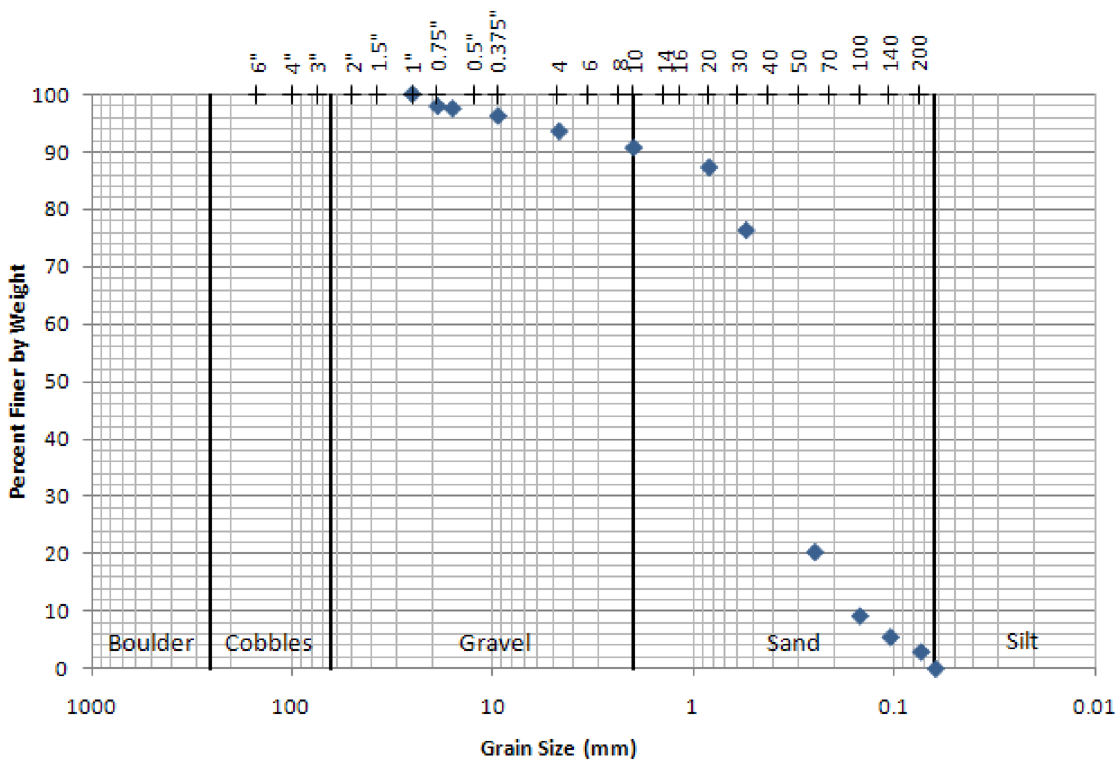


Figure 3. Size distribution of sediment particles from the Nueces River at Three Rivers (TWDB data).

Flow data (daily average flow and measurements of average velocity, channel width, depth from the U.S. Geological Survey), computed energy slopes, and stream bed gradation were obtained for each study location. These data were input into a computer model (SAMWin) and equations were generated to estimate tons of sediment carried by different river flow rates. SAMWin is a computer model that calculates erosion, deposition, and movement of sediments in streams and assists in the evaluation of channel stability. Results are shown in Figures 4-6. In these figures, blue diamonds represent bed material load as calculated using SAMWin. An appropriate sediment transport equation, either Ackers-White or Van Rijn, was used to calculate each data point.

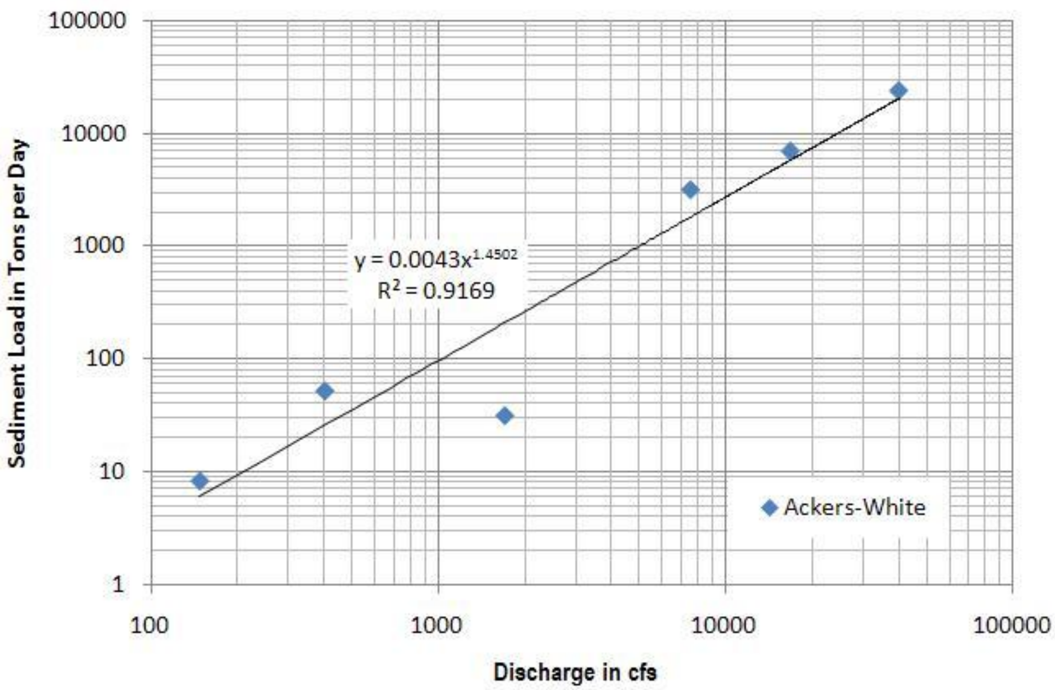


Figure 4. Sediment rating curve for the Nueces River at Laguna.

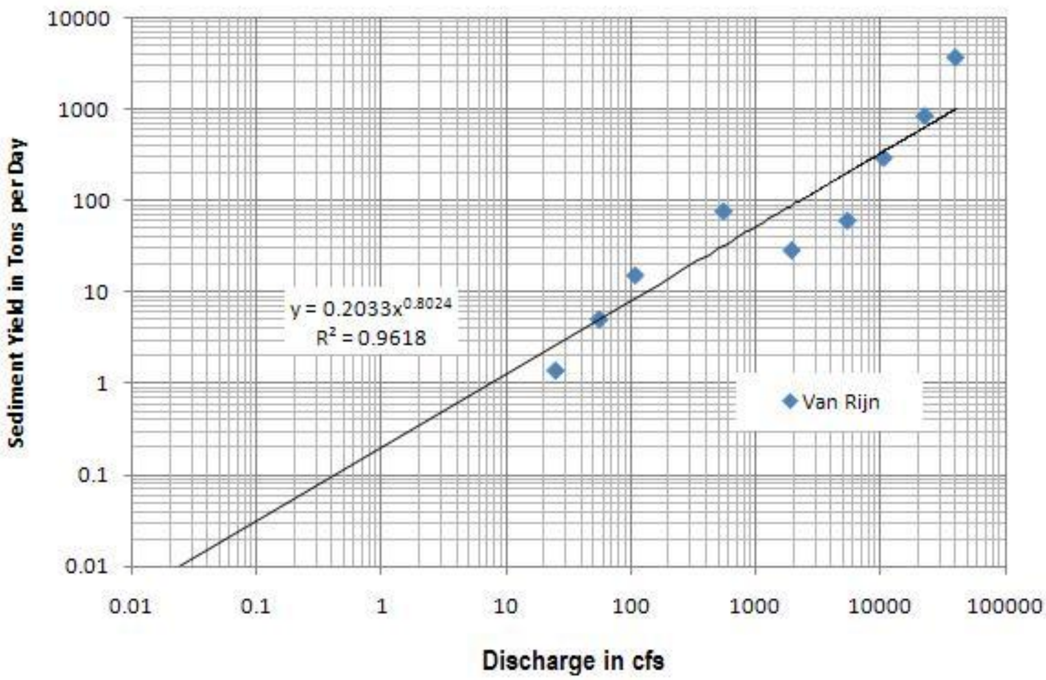


Figure 5. Sediment rating curve for the Nueces River at Cotulla.

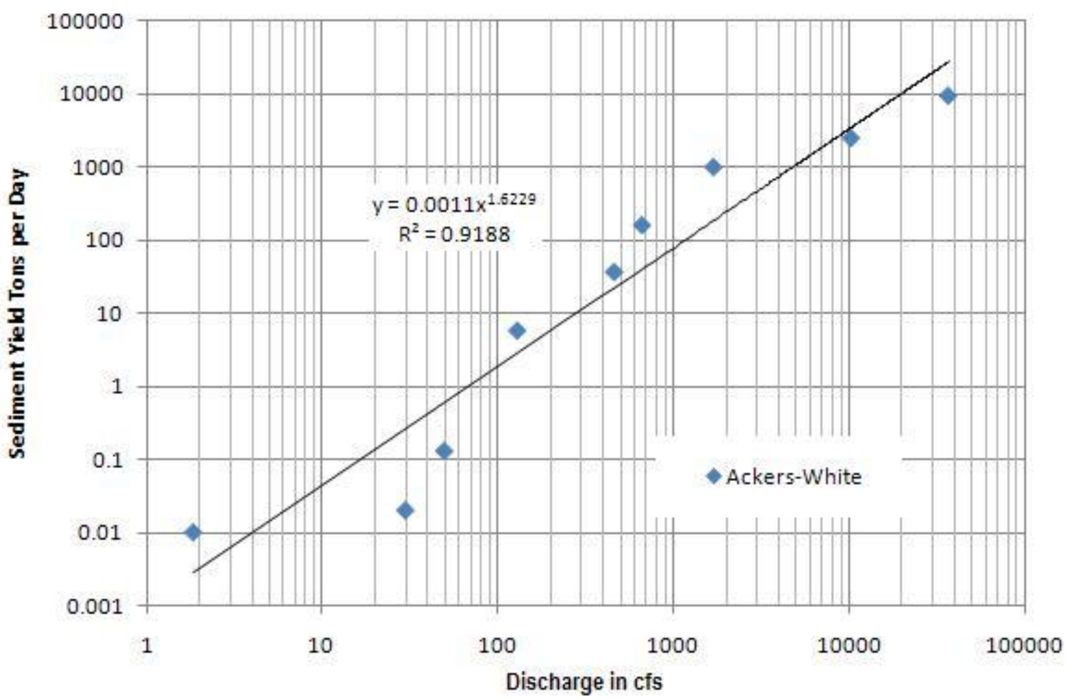


Figure 6. Sediment rating curve for the Nueces River at Three Rivers.

FLOW SCENARIOS

Sediment transported by different flow scenarios were calculated for each site. Flow scenarios were evaluated to understand how sediment movement might vary with different environmental flow criteria. Daily average flow for the time period from 1934-1996 was available for each flow scenario, allowing calculation of daily sediment transport. Daily values of flow and sediment transport were summed to obtain average annual values over the entire 1934-1996 time period for each flow scenario. Results from each flow scenario were compared to results from a baseline condition (scenario) which varied by site.

RESULTS

Nueces River at Laguna (off-channel reservoir project):

The following flow scenarios representing regulated flows in the Nueces River near Laguna were evaluated. Historical gage data from this site was selected as the baseline condition. Other flow scenarios represent the application of different environmental flow criteria to a hypothetical off-channel reservoir project upstream of the site.

- Historical (baseline)
- Full BBEST
- Modified BBEST A
- Modified BBEST W
- No E-Flows

Table 1. Average annual water remaining in the river and sediment moved by the river for different flow scenarios for the Nueces River at Laguna (with an off-channel reservoir project).

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Historical (baseline)	115,000 (100%)*	7,413 (100%)*
Full BBEST	104,000 (90%)	6,964 (93%)
Modified BBEST A	102,000 (89%)	6,930 (93%)
Modified BBEST W	102,000 (89%)	6,998 (94%)
No E-Flows	84,000 (73%)	6,708 (90%)

*Numbers in parenthesis represent percentages relative to baseline conditions.

The river bed at Laguna consists of gravel and cobble size material. Low flows at this location move very little sediment and flows less than 78 cfs result in no movement of bed material. In the Historical flow scenario, 50% of the days have a flow less than 78 cfs. Because no bed material is moved on those days anyway, decreasing flow on days with flow less than 78 cfs does not decrease the Average Annual Sediment moved by the river at Laguna. Much of the annual reduction in Average Annual Water remaining in the river for the No E-Flows scenario is from flow diversion on days when flow was less than 78 cfs. This explains why the water remaining in the river decreased by 27% while the Average Annual Sediment moved by the river was reduced by only 10%.

Nueces River at Cotulla (on-channel reservoir project):

The following flow scenarios representing regulated flows in the Nueces River near Cotulla were evaluated. Historical gage data from this site was selected as the baseline condition. Other flow scenarios represent the application of different environmental flow criteria to a hypothetical on-channel reservoir project upstream of the site.

- Historical (baseline)
- Full BBEST
- Modified BBEST A
- Modified BBEST W
- No E-Flows

Table 2. Average annual water remaining in the river and sediment moved by the river for different flow scenarios for the Nueces River at Cotulla (with an on-channel reservoir project).

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Historical (baseline)	178,600 (100%)	4,160 (100%)
Full BBEST	94,900 (53%)	2,203 (53%)
Modified BBEST A	63,900 (36%)	1,569 (38%)
Modified BBEST W	66,500 (37%)	1,754 (42%)
No E-Flows	52,000 (29%)	1,002 (24%)

*Numbers in parenthesis represent percentages relative to baseline conditions.

Nueces River at Cotulla (off-channel reservoir project):

The following flow scenarios representing regulated flows in the Nueces River near Cotulla were evaluated. Historical gage data from this site was selected as the baseline condition. Other flow scenarios represent the application of different environmental flow criteria to a hypothetical off-channel reservoir project upstream of the site.

- Historical (baseline)
- Full BBEST
- Modified BBEST A
- Modified BBEST W
- No E-Flows

Table 3. Average annual water remaining in the river and sediment moved by the river for different flow scenarios for the Nueces River at Cotulla (with an off-channel reservoir project).

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Historical (baseline)	178,600 (100%)	4,160 (100%)
Full BBEST	161,200 (90%)	3629 (87%)
Modified BBEST A	160,200 (90%)	3604 (87%)
Modified BBEST W	161,200 (90%)	3677 (88%)
No E-Flows	156,700 (88%)	3397 (81%)

*Numbers in parenthesis represent percentages relative to baseline conditions.

<u>Nueces River at Three Rivers (Cotulla on-channel reservoir project)</u>:
The following flow scenarios representing regulated flows in the Nueces River near Three Rivers were evaluated. Regulated flows (created from WAM Run 3 flows) with no upstream project at Cotulla were selected as the baseline condition. Other flow scenarios represent the application of different environmental flow criteria to a hypothetical on-channel reservoir project located at Cotulla.

- No Project (baseline)
- Full BBEST
- Modified BBEST A
- Modified BBEST W
- No E-Flows

Table 4. Average annual water remaining in the river and sediment moved by the river for different flow scenarios for the Nueces River at Three Rivers (with an on-channel reservoir project at Cotulla).

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Baseline No Project	666,100 (100%)	92,500 (100%)
Full BBEST	626,200 (94%)	86.000 (93%)
Modified BBEST A	613,000 (92%)	84,000 (91%)
Modified BBEST W	614,400 (92%)	84,400 (91%)
No E-Flows	609,500 (92%)	83,700 (90%)

*Numbers in parenthesis represent percentages relative to baseline conditions.

Nueces River at Three Rivers (Cotulla off-channel reservoir project):

The following flow scenarios representing regulated flows in the Nueces River near Three Rivers were evaluated. Regulated flows (created from WAM Run 3 flows) with no upstream project at Cotulla were selected as the baseline condition. Other flow scenarios represent the application of different environmental flow criteria to a hypothetical off-channel reservoir project located at Cotulla.

- No Project (baseline)
- Full BBEST
- Modified BBEST A
- Modified BBEST W
- No E-Flows

Table 5. Average annual water remaining in the river and sediment moved by the river for different flow scenarios for the Nueces River at Three Rivers (with an off-channel reservoir project at Cotulla).

Flow Scenario	Average Annual Water Remaining in the River (acre-feet)	Average Annual Sediment Moved by the River (tons)
Baseline No Project	666,100 (100%)	92,500 (100%)
Full BBEST	657,600 (99%)	91,500 (99%)
Modified BBEST A	656,300 (99%)	91,300 (99%)
Modified BBEST W	656,700 (99%)	91,300 (99%)
No E-Flows	655,600 (98%)	91,600 (99%)

*Numbers in parenthesis represent percentages relative to baseline conditions.

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ADDITIONAL RESOURCES

Earth's Waters: Rivers and Sediments: http://ga.water.usgs.gov/edu/earthriverssed.html

Role of Sediment Transport, a Power Point presentation: http://www.forwatershed.org/TheRoleofSedimentTransportinStreamCondition.pdf

Description of Streams and Drainage Systems: http://www.tulane.edu/~sanelson/geol111/streams.htm