Salinity Monitoring and Real Time (SMART) Inflow Management in the Nueces Bay and Delta

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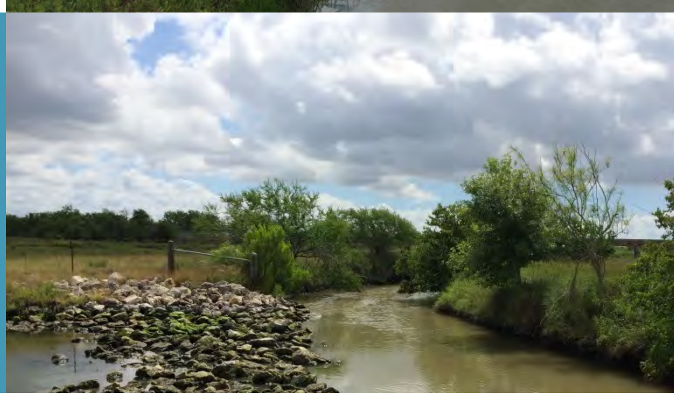

Final Report

SMART Inflow Management in the Nueces Bay and Delta

Coastal Bend Bays & Estuaries Program, Inc.

Corpus Christi, TX

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CBBEP Contract 1412

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List of Acronyms

acft	acre-feet
BBASC	Basin and Bay Area Stakeholder Committee
BBEST	Nueces River Basin and Bay Expert Science Team
CAR	Corrective Action Report
CBBEP	Coastal Bend Bays & Estuaries Program
CCR	Choke Canyon Reservoir
cfs	cubic feet per second
CCWSM	Corpus Christi Water Supply Model
DM	Data Manager
EPA	Environmental Protection Agency
ft-msl	feet above mean sea level
HDR	HDR Engineering
KCl	potassium chloride
LCC	Lake Corpus Christi
MGD	million gallons per day
NEAC	Nueces Estuary Advisory Council
PI	Principal Investigator
QAM	Quality Assurance Manager
QAO	Quality Assurance Officer
QAPP	Quality Assurance Project Plan
SMART	Salinity Monitoring and Real Time Inflow Management
SWQM	Surface Water Quality Monitoring
TAC	Technical Advisory Committee
TCEQ	Texas Commission on Environmental Quality
TWDB	Texas Water Development Board
USBR	United States Bureau of Reclamation
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WWTP	Wastewater Treatment Plant

Executive Summary

Based on available hydrologic data, droughts in the Nueces River Basin have been increasing in severity since the 1950's. Each new drought seems to redefine the critical drought used to determine water supply availability in the basin. Drought not only has a detrimental impact on water supply but also on the ecology of the Nueces Bay and Estuary. Increased municipal and industrial demands during times of more severe drought create additional challenges for environmental stewards and water supply managers in the basin to develop new adaptive management techniques to adjust to the ever changing realities of the complex system.

As part of the link between the riverine habitats of the Nueces River and the marine habitats of the Gulf of Mexico, the Nueces Delta provides a critical transitional environment utilized by both estuarine and marine plants and animals. An acceptably sound ecological environment has a flow regime that maintains important physical, chemical, and biological characteristics of a water body as well as the native species dependent on these characteristics. When the Nueces Delta is environmentally sound, the delta is inundated regularly by salt water from the bay via tides and wind, and occasionally by fresh water when the Nueces River spills over its banks. The periodic freshwater inundations by the river, which typically occur during the spring and fall, are essential in maintaining the ecological function of the delta. However, as drought severity and duration changes with each subsequent drought and as regional municipal and industrial water demands from the Nueces River have increased, freshwater inflow to the delta has been reduced below historical averages.

This project aimed to demonstrate through modeling exercises that the Salinity Monitoring and Real Time (SMART) Inflow Management concept appears to be a viable strategy for efficiently utilizing limited freshwater resources to reduce the salinity extremes that have a negative impact on estuarine productivity in the Nueces Bay and Delta system. The focus of this project was to use the Corpus Christi Water Supply Model (CCWSM) to evaluate the effects of SMART Inflow Management by varying the freshwater inflow regimes to the Nueces Bay and Delta.

The CCWSM was applied to assess dozens of alternative reservoir management scenarios that seek to ensure that water is available water supply and for environmental flow purposes. The application of the model has been focused on the concept of SMART Inflow Management and the potential impacts of this philosophy on the safe yield of the reservoir system. The results show that safe yield may be preserved or even enhanced under SMART Inflow Management scenarios that utilize seasonal targets. In addition, SMART Inflow Management results in variations in the attainment frequency of seasonal bay inflows when compared to the baseline run. The seasonal attainment frequency curves show that some alternative scenarios achieve inflows that are different with some resulting in more flow more of the time than the baseline scenario.

Key findings of the results of this analysis include:

- It is possible to operate the LCC/CCR system using SMART Inflow Management and not only preserve the safe yield but slightly increase it.
- Seasonal targets allow greater windows of opportunity for pass-throughs to occur than the monthly target system under the existing Agreed Order.

- Higher annual targets, such as those in the Agreed Order, are not required when more opportunity is made available to pass-through inflow events over a season.
- Changes in the seasonal attainment frequency volumes of Bay inflow are possible under SMART Inflow Management.
- SMART Inflow Management can provide additional opportunities for smaller fresh events that can be used in conjunction with the Rincon pipeline to supply fresh water to the Delta, where smaller inflow events provide greater benefit than the same volume released to the Bay.
- Larger events are possible under SMART Inflow Management that could allow for events large enough to drop salinities in the Bay.
- System storage is not changed significantly (1-2%) under SMART Inflow Management when compared to the baseline condition.

1.0 Introduction

The Coastal Bend Bays & Estuaries Program (CBBEP) has a goal of identifying and addressing relevant water quality and coastal habitat management questions and scientific approaches to protect estuaries. To meet these objectives, it is important to gain an understanding of the connections between estuarine water, coastal natural resources, and reservoir management. This project provides quantitative information about these relationships for the study area (See Figure 1).

This project aimed to demonstrate through modeling exercises that the Salinity Monitoring and Real Time (SMART) Inflow Management concept appears to be a viable strategy for efficiently utilizing limited freshwater resources to reduce the salinity extremes that have a negative impact on estuarine productivity in the Nueces Bay and Delta system. The purpose of this project is to use the Corpus Christi Water Supply Model (CCWSM) to evaluate the effects of SMART Inflow Management on the freshwater inflows to the Nueces Bay and Delta and the safe yield of the reservoir system. HDR utilized the CCWSM to determine the impacts of SMART Inflow Management on the Nueces Bay and Delta and the safe yield of the reservoir system.

A small advisory group has been formed from members on the Texas Commission on Environmental Quality (TCEQ) appointed Nueces Estuary Advisory Council (NEAC) to help monitor when freshwater inflows are needed into the bay and to establish criteria for storing and releasing water. This group will work under the guidance of the NEAC and be communicating with reservoir operators and TCEQ on how and when to best send water to the bay. This project provides planners, managers, decision makers, scientists and general public with additional data as they seek to develop an operational plan for SMART Inflow Management.

This final report describes the processes that were completed throughout the project period and a brief summary addressing the evaluation of the impacts of SMART Inflow Management on reservoir system yield. The report also briefly discusses the future implications of the study area with recommendations for additional investigation.

Figure 1. Location of the study area.

2.0 Corpus Christi Water Supply Model Description

The CCWSM is a multi-basin water supply model that includes operations of Choke Canyon Reservoir (CCR), Lake Corpus Christi (LCC; including reservoir "pass-throughs" for the Nueces Estuary), Lake Texana, and potential future water supplies from the Lower Colorado River (i.e. Garwood water). For the 2006 Coastal Bend Regional Water Plan (2006 Plan), the model was updated to include hydrologic conditions for the drought of the 1990's, which extended the hydrologic time period contained in the model from 1934 to 2003. The CCWSM is a planning / operational model that uses historical hydrologic data (reservoir inflows and evaporation) to simulate reservoir operations under various regulatory / demands / environmental flow scenarios.

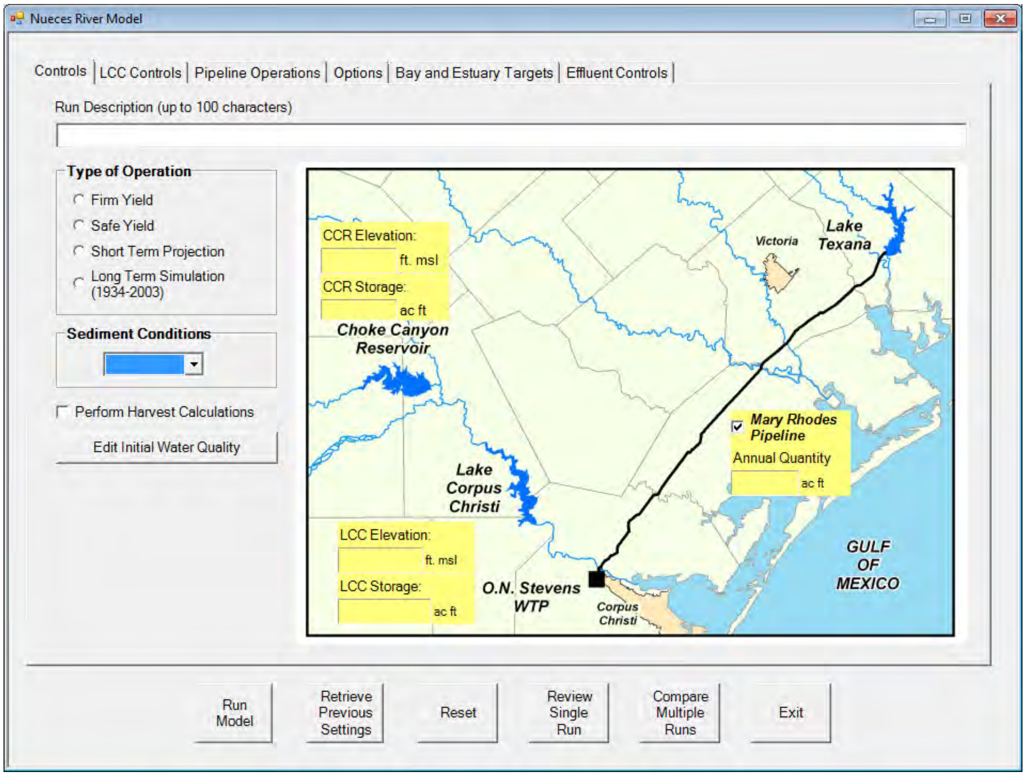

Figure 2. Corpus Christi Water Supply Model Graphical User Interface.

The model was originally developed as the tool that could be used to evaluate the effects of reservoir operation and environmental flow policies on system yield. Computations in the model simulate evaporation losses in the reservoirs, as well as channel losses in the rivers associated with water delivery from Choke Canyon Reservoir to Lake Corpus Christi, and from Lake Corpus Christi to the City of Corpus Christi's water supply intake at the Calallen diversion dam. In addition, due to sediment deposition in Choke Canyon Reservoir and Lake Corpus Christi, the model allows for a variety of sediment conditions and resulting storage capacity scenarios. The model has been developed and updated through a series of projects since 1991 (HDR, et al., "Nueces Estuary Regional Wastewater Planning Study, Phase 1," City of Corpus Christi, et al., November 1991; HDR, et al., "Nueces Estuary Regional Wastewater Planning Study, Phase 2," City of Corpus Christi, et al., March 1993; HDR, "Water Supply Update for City of Corpus Christi Service Area," City of Corpus Christi, January 1999; HDR, Supplemental Funding Work Item for 2006 Coastal Bend Regional Water Plan, 2005).

The CCWSM is a water accounting model and as such does not try to replicate existing data in the model output. The CCWSM utilizes known input data (inflows, evaporation) under a set of hypothetical operating scenarios (water rights usage, environmental pass-throughs, etc.) to evaluate the impact of the scenarios on lake levels, water supply reliability, and bay inflow. The CCWSM is a known tool that has been used by the City of Corpus Christi since its inception in the early 1990's. The CCWSM operates in a similar fashion as the state water availability models, which also do not require calibration.

3.0 Scenario Development and Interaction with Stakeholders

Study objectives and results were presented at meetings and workshops in the Corpus Christi area. The first stakeholder meeting occurred on March 26, 2014 at the CBBEP offices in Corpus Christi, TX. This meeting focused on explaining the expected outcomes of this study and receiving input from stakeholders on their perception of desired outcomes. The meeting included attendees from CBBEP, HDR Engineering, Nueces River Authority, Sherwin Alumina, Texas Water Development Board, Port of Corpus Christi Authority, Center for Coastal Studies, and the South Texas Water Authority. An agenda and presentations from this meeting may be found in the appendix.

After the initial meeting with stakeholders, HDR began the analysis with the CCWSM for multiple scenarios pertaining to baseline conditions, enhancement of delta conditions, and enhancement of bay conditions. Safe yield supply is the amount of water that can be withdrawn from a reservoir such that a given volume remains in reservoir storage during the critical month of the drought of record. Thus safe yield was utilized in this study to assess the impacts of SMART Inflow Management on water supply reliability. For regional planning purposes, the surface water availabilities for the City of Corpus Christi and their customers are currently based on safe yield analyses and assume a reserve of 125,000 acft (i.e., 14 percent of LCC/CCR system storage). The estimated relationship between water elevation, surface area, and storage capacity in the year 2020 was utilized to reflect sedimentation impacts in the reservoirs.

A stakeholder workshop occurred on April 22, 2014 at the Port of Corpus Christi. This meeting focused on explaining the preliminary results, baseline scenarios, seasonal targets, and evaluation criteria utilized for modeling exercises. The safe yield for the baseline modeling scenario was established as 219,143 acft and includes the following assumptions.

- Mary Rhodes pipeline operations of Lake Texana
  - 41,840 acft/yr firm contract
  - 12,000 acft/yr interruptible contract when Lake Texana is above 43 ft-msl
- No municipal and industrial return flow to the Bay
  - Typically this is assumed to be 5.35 MGD (about 499 acft/mo) which counts towards meeting any monthly inflow target
- Safe yield operations of the reservoir system with a reserve storage of 125,000 acft
- 2020 estimated storage conditions in all reservoirs

The meeting included attendees from CBBEP, HDR Engineering, Nueces River Authority, Sherwin Alumina, Texas Water Development Board, Port of Corpus Christi Authority, Center for Coastal Studies, Harte Research Institute, City of Corpus Christi, Texas Parks and Wildlife Department, and the South Texas Water Authority. An agenda and presentations from this meeting may be found in the appendix.

A scenario development workshop occurred on May 14, 2014 at the HDR Engineering office in Austin, TX. This meeting allowed CBBEP and HDR engineering staff to brainstorm and develop model scenarios in an interactive manner. Tradeoffs between reservoir system yield and environmental flows were discussed in depth. In addition, the CCWSM was run many times in order to assess new scenarios that were conceived at the meeting and refine existing scenarios as needed. After this meeting, several additional model runs were conducted and four modeling scenarios were identified that demonstrate potential benefits of SMART Inflow Management.

On June 6, 2014, a meeting with stakeholders was held at the meeting facility at the Nueces Delta Preserve. This meeting focused on explaining the modeling scenarios selected to demonstrate the benefits of SMART Inflow Management and getting feedback from stakeholders on how the scenarios are anticipated to enhance bay and delta conditions. The meeting included attendees from CBBEP, HDR Engineering, Nueces River Authority, Texas Water Development Board, Port of Corpus Christi Authority, Center for Coastal Studies, Harte Research Institute, City of Corpus Christi, Naismith Engineering, RPS Group, and the South Texas Water Authority. An agenda and presentations from this meeting may be found in the appendix.

Presentations on SMART Inflow Management were presented at the NEAC and Mayor's Blue Ribbon Committee meetings which occurred on June 16^{th} and June 25^{th} respectively. Agendas and presentations from these meetings may be found in the appendix.

4.0 Results of Project Analyses

One of the goals of this study was to determine if SMART Inflow Management could be a feasible alternative to the existing TCEQ Agreed Order that defines monthly pass-through targets to be met by releases of inflow to the LCC/CCR reservoir system. A series of integrated water availability modeling analyses were conducted with the CCWSM to assess the relative implications of different water management scenarios, known as SMART Inflow Management, and provide technical information to CBBEP. These analyses are useful for consideration of the balance between water supply and environmental flow needs in the development of strategies involving the reservoir system, Nueces Bay inflows, and Rincon Bayou Pipeline operations.

Dozens of alternative reservoir operating scenarios were developed and modeled as part of this study. These scenarios were all generally based on the same set of operating decisions with only the volume, timing and triggering of the release of inflows for environmental pass-through purposes being modified between simulations. Four scenarios are highlighted in this section in order to demonstrate the potential benefits of SMART Inflow Management for the Nueces Bay and Delta. While the baseline scenario utilizes monthly targets and trigger levels described in the 2001 Agreed Order, the other three scenarios presented in this section utilize seasonal release targets and varied trigger levels that result in different bay inflow regimes, which is the foundation of the SMART Inflow Management concept. Figure 3 illustrates the concept of SMART Inflow Management utilizing seasonal targets that vary by reservoir system storage zone as defined by specific trigger levels. The changing variables between scenarios included the seasonal target volumes, and the trigger levels. The seasons consist of three, four-month seasons where winter is November through February, spring is March through June, and summer is July through October. These were the same seasons defined by the Nueces BBEST in their work.

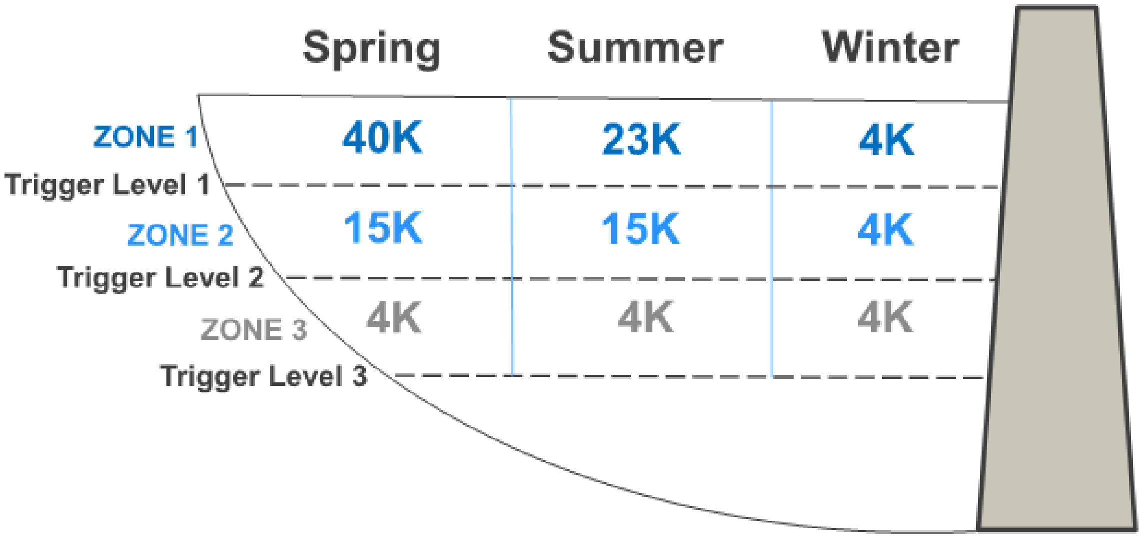

Figure 3. Schematic of hypothetical seasonal targets, trigger levels, and storage zones.

The table below describes the seasonal targets (i.e. Target 1 – Target 2 – Target 3), trigger levels (e.g. 70 percent storage), safe yields, and annual bay inflow (i.e. model output parameter "QBAY1") statistics associated with four highlighted scenarios. The release targets and trigger levels are not shown for the scenario 0ab scenario (i.e. "Baseline" scenario) as this scenario corresponds to the 2001 Agreed Order which utilizes monthly targets. Scenario 11d is hereafter referred to as the "Balance" scenario as it utilizes release targets that are fairly balanced across all seasons. Scenario 11k is hereafter referred to as the "Spring Preference" scenario as it utilizes a high spring release target for storage zone 1. Scenario 15 is hereafter referred to as the "Wet Flush" scenario as it utilizes the highest release targets for storage zone 1.

Table 1. Modeling constraints and results for selected scenarios.

Scenario	Description	Target/ Trigger Level 1	Target/ Trigger Level 2	Target/ Trigger Level 3	Safe Yield (acft)	QBAY1 Annual (acft)		
						AVG	Median	MIN
Baseline	B & E Order; *Mary Rhodes Pipeline II; No RF				219,143	387,680	167,051	1,923
Balance	3 storage trigger levels; Varied flow targets	29-29-4/70	15-4-4/40	4-4-4/30	220,568	385,663	165,922	3,932
Spring Preference	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/30	219,147	387,257	167,344	3,932
Wet Flush	2 storage trigger levels; Varied flow targets	40-19-11/70	19-15-4/50	n/a	221,476	385,372	163,418	123

The Balance scenario uses four zones defined by three triggers. Zone 1 is when the system storage is at or above trigger 1 at 70% system storage. Zone 2 is when system storage is below trigger 1 and above trigger 2 at 40% system storage. Zone 3 is when system storage is below trigger 2 and above trigger 3 at 30% system storage. Zone 4 is below trigger 3. Zone 1 targets were simulated at 29,000 acft, 29,000 acft and 4,000 acft for spring, summer and winter respectively. Zone 2 targets were simulated at 15,000 acft for spring and 4,000 acft for both summer and winter. Zone 3 targets were 4,000 acft for all seasons with no targets required in zone 4.

The Spring Preference scenario uses four zones defined by three triggers. Zone 1 is when the system storage is at or above trigger 1 at 70% system storage. Zone 2 is when system storage is below trigger 1 and above trigger 2 at 50% system storage. Zone 3 is when system storage is below trigger 2 and above trigger 3 at 30% system storage. Zone 4 is below trigger 3. Zone 1 targets were simulated at 40,000 acft, 23,000 acft and 4,000 acft for spring, summer and winter respectively. Zone 2 targets were simulated at 15,000 acft for spring and summer and 4,000 acft for winter. Zone 3 targets were 4,000 acft for all seasons with no targets required in zone 4.

The Wet Flush scenario uses three zones defined by three triggers. Zone 1 is when the system storage is at or above trigger 1 at 70% system storage. Zone 2 is when system storage is below trigger 1 and above trigger 2 at 50% system storage. Zone 3 is when system storage is below trigger 2. Zone 1 targets were simulated at 40,000 acft, 19,000 acft and 11,000 acft for spring, summer and winter respectively. Zone 2 targets were simulated at 19,000 acft for spring, 15,000 acft for summer and 4,000 acft for winter. There were no zone 3 targets.

As mentioned previously, one of the goals of the analysis of SMART Inflow Management is to change the temporal requirement of a pass-through from a monthly target to a seasonal target without negatively impacting the safe yield of the system. The results from these 3 SMART inflow scenarios show that safe yield may be maintained or enhanced with alternative reservoir release rules and seasonal targets. In addition, the mean annual bay inflow statistic varies across the different scenarios with the Balance and Spring Preference scenarios achieving the largest simulated minimum bay inflow. Seasonal attainment frequencies are shown below for the four scenarios highlighted (See Figures 4 through 6). Reservoir releases and bay inflows during the critical drought are shown below in Figures 7 through 10. Simulated system storage and storage frequency is shown below in Figures 11 through 12.

Table 2 provides a comparison of the seasonal targets, zones and triggers for each scenario presented in detail. Figure 4 presents a frequency plot of the seasonal spring inflows that occurred under the baseline (gold line) and the three SMART inflow scenarios. This graph indicates that about 40% of the time (from 0 to 40% on the x-axis of the graph) the inflows are greater than minimum targets defined by the scenarios. The middle portion of the plot (from 40% to 70% on the x-axis of the graph) provides the greatest variation between the scenarios. During this period of time the Balance scenario underperforms the baseline, but the Spring Preference and the Wet Flush scenarios outperform the baseline for about half of this portion. The lines tend to converge around the baseline for the last 30% of the x-axis, but since these are generally drier times the minor differences when the SMART scenarios are above the baseline could be more critical from a biological perspective, especially if these smaller volumes of water were to be delivered through the Rincon pipeline to the Delta.

Table 2. Spring release targets (acft) and trigger levels (%) for selected scenarios.

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	15,000 – 40%	4,000 – 30%
Spring Preference	40,000 – 70%	15,000 – 50%	4,000 – 30%
Wet Flush	40,000 – 70%	19,000 – 50%	-

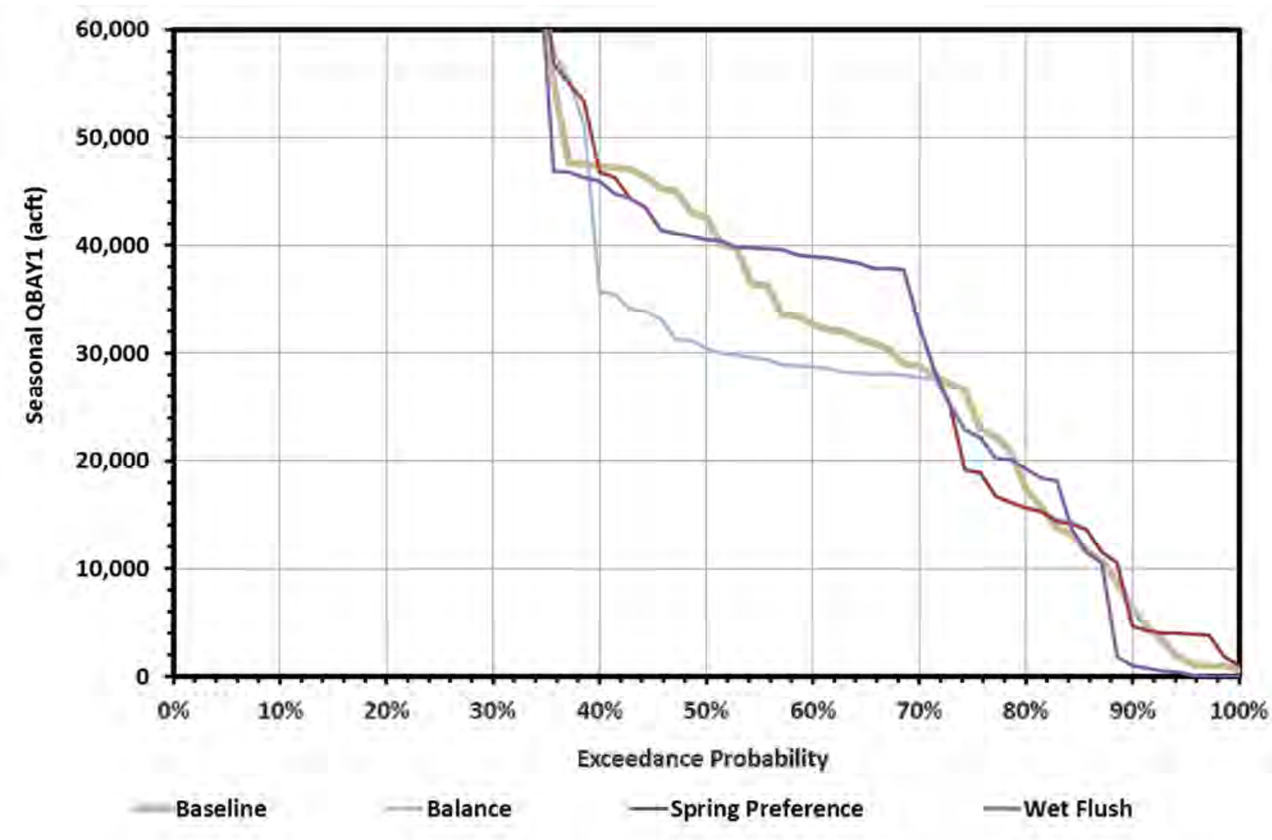

Figure 4. Seasonal attainment frequency for simulated spring (Mar. – Jun.) releases.

Table 3 provides a comparison of the seasonal targets, zones and triggers for each scenario presented in detail. Figure 5 presents a frequency plot of the seasonal summer inflows that occurred under the baseline (gold line) and the three SMART inflow scenarios. This graph indicates that about 45% of the time (from 0 to 45% on the x-axis of the graph) the inflows are greater than minimum targets defined by the scenarios. The next portion of the plot (from 45% to 85% on the x-axis of the graph) provides the greatest variation between the scenarios. During this period of time the Wet Flush scenario underperforms the baseline, but the Balance and the Spring Preference out perform the baseline for most of this portion. The lines tend to converge around the baseline for the last 10% of the x-axis, but since these are generally drier times the minor differences when the SMART scenarios are above the baseline could be more critical from a biological perspective, especially if these smaller volumes of water were to be delivered through the Rincon pipeline to the Delta.

Table 3. Summer release targets (acft) and trigger levels (%) for selected scenarios.

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	4,000 – 40%	4,000 – 30%
Spring Preference	23,000 – 70%	15,000 – 50%	4,000 – 30%
Wet Flush	19,000 – 70%	15,000 – 50%	-

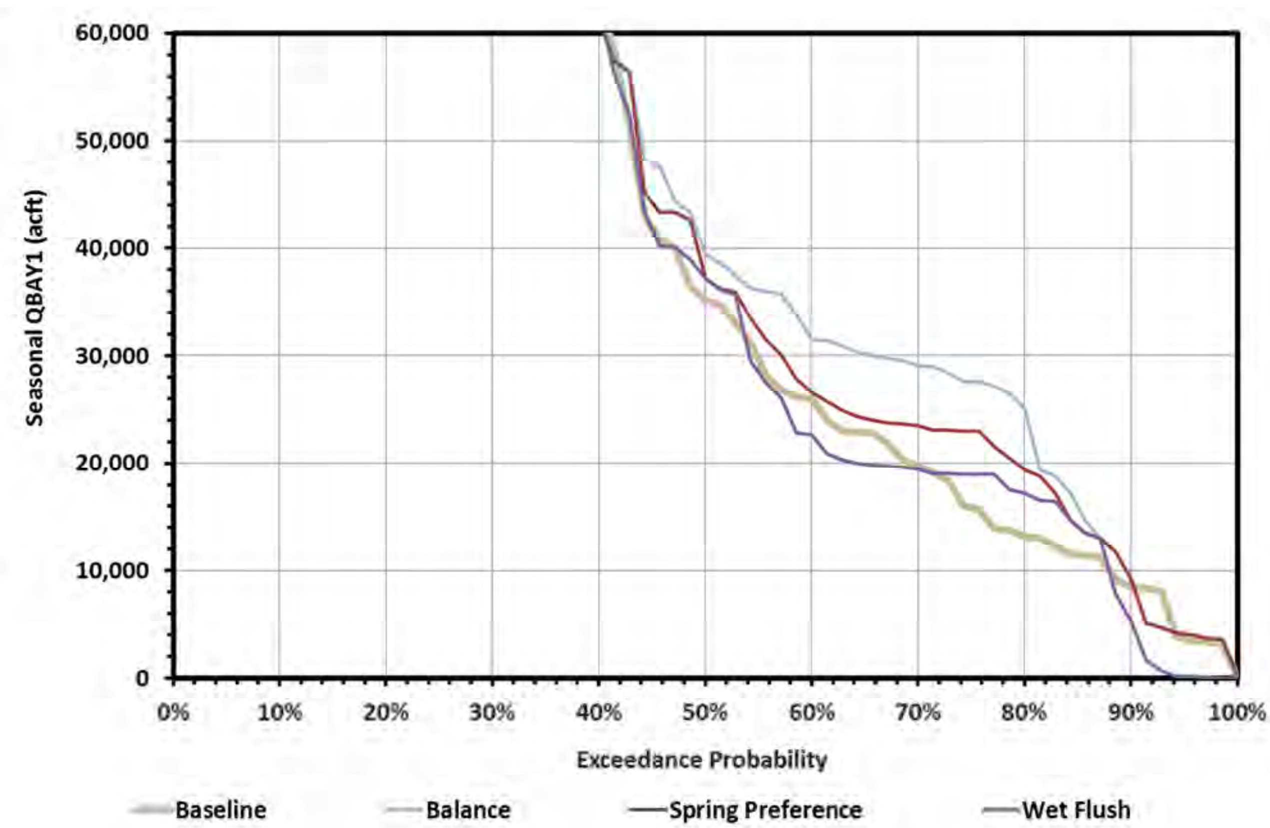

Figure 5. Seasonal attainment frequency for simulated summer (Jul. – Oct.) releases.

Table 4 provides a comparison of the seasonal targets, zones and triggers for each scenario presented in detail. Figure 6 presents a frequency plot of the seasonal winter inflows that occurred under the baseline (gold line) and the three SMART inflow scenarios. This graph indicates that about 25% of the time (from 0 to 25% on the x-axis of the graph) the inflows are greater than minimum targets defined by the scenarios. The next portion of the plot (from 25% to 80% on the x-axis of the graph) provides the greatest variation between the scenarios. During this period of time the Balance and the Spring Preference scenarios underperforms the baseline with their consistent 4,000 acft targets, but only slightly. The Wet Flush out perform the baseline for most this portion with its higher 11,000 acft target. The lines tend to converge around the baseline for the last 20% of the x-axis with the Balance and Spring Preference scenarios providing more water than the baseline through this portion. As mentioned previously since these are generally drier times the minor differences when the SMART scenarios are above the baseline could be more critical from a biological perspective, especially if these smaller volumes of water were to be delivered through the Rincon pipeline to the Delta.

Table 4. Winter release targets (acft) and trigger levels (%) for selected scenarios.

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	4,000 – 70%	4,000 – 40%	4,000 – 30%
Spring Preference	4,000 – 70%	4,000 – 50%	4,000 – 30%
Wet Flush	11,000 – 70%	4,000 – 50%	-

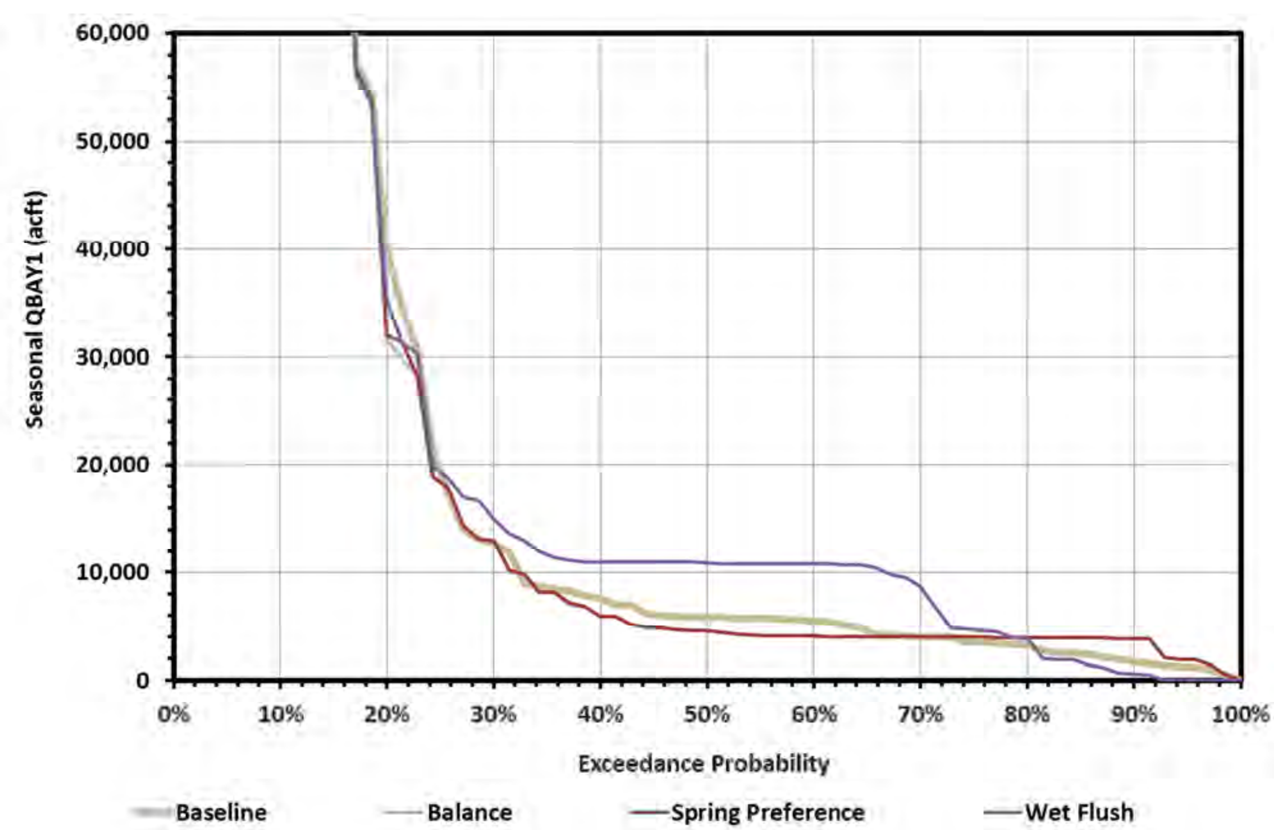

Figure 6. Seasonal attainment frequency for simulated winter (Nov. – Feb.) releases.

Figures 7 through 10 illustrate the differences between the 4 scenarios when focusing on the critical drought period of the model, a five year period from 1992 - 1996. These plots show the total system storage as the blue line on the charts, with monthly pass-throughs of inflow represented by the green bars. For the SMART inflow scenarios the baseline storage trace is also shown on the graph to illustrate one of the differences between the different simulations. These plots show that there are differences in the water balance of the reservoir system under these different scenarios, but that the safe yield of these scenarios is essentially the same as all the storage traces converge at the low point of summer 1996. One conclusion from these plots is that during a critical drought drawdown, the SMART Inflow Management scenarios tend to allow for more releases through the early to mid part of the drought while providing a few additional releases nearer the critical point of the drought (in all but the Wet Flush scenario).

Figure 11 shows that generally the SMART scenarios allow for more water to be released to the Bay as evidenced by the 1-2% lower system storage levels as shown for the 15% to 85% portion of the x-axis. The last 15% of the x-axis shows that some of the SMART scenarios result in system storage that is greater than the baseline storage, but all four lines still converge at the low point of the graph (minimum storage during the drought of record).

Figure 12 shows how these differences play out in the time period history of the model. Most of the differences are evident at the peaks and valleys of the plot. For example, the drought of the 1960s that the Spring Preference scenario resulted in lower system storage levels because it allowed for more inflows to be passed to the Bay than the baseline or the other SMART scenarios.

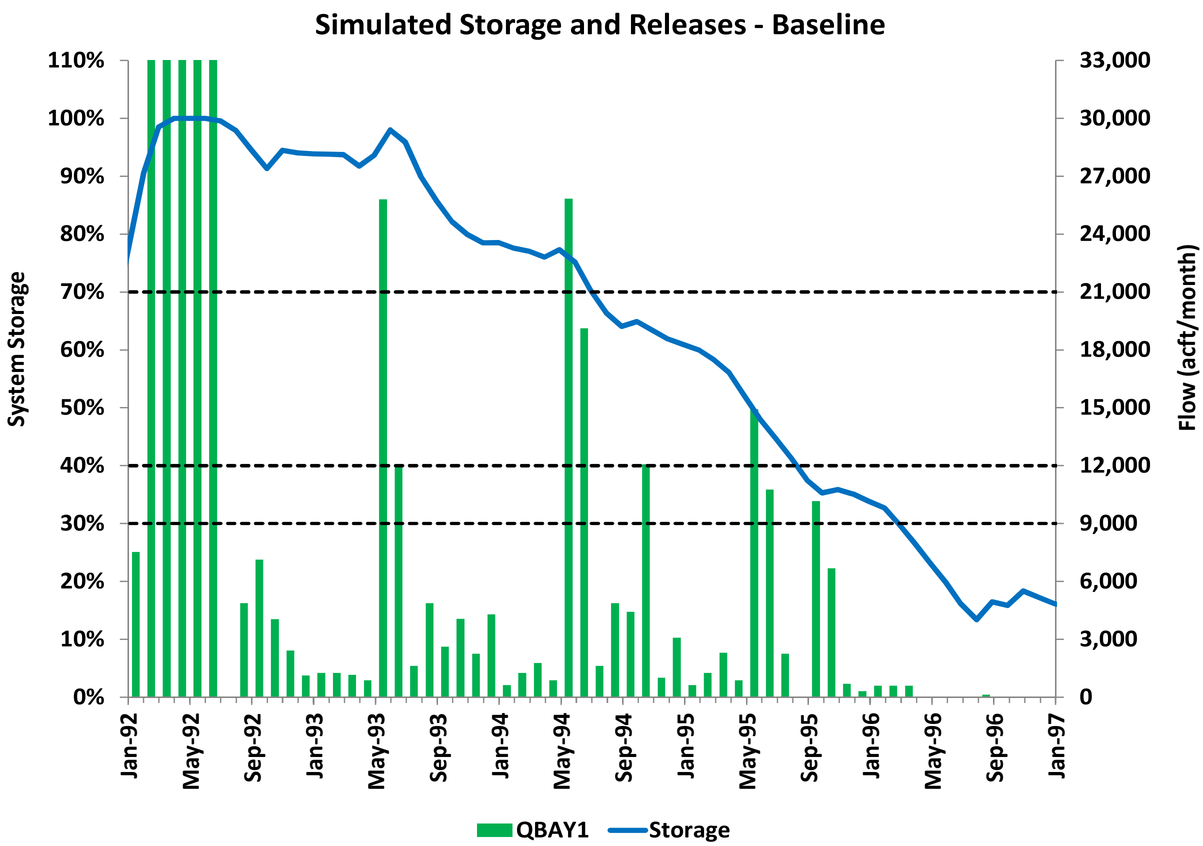

Figure 7. Simulated storage/inflow pass-throughs for Baseline scenario during critical drought.

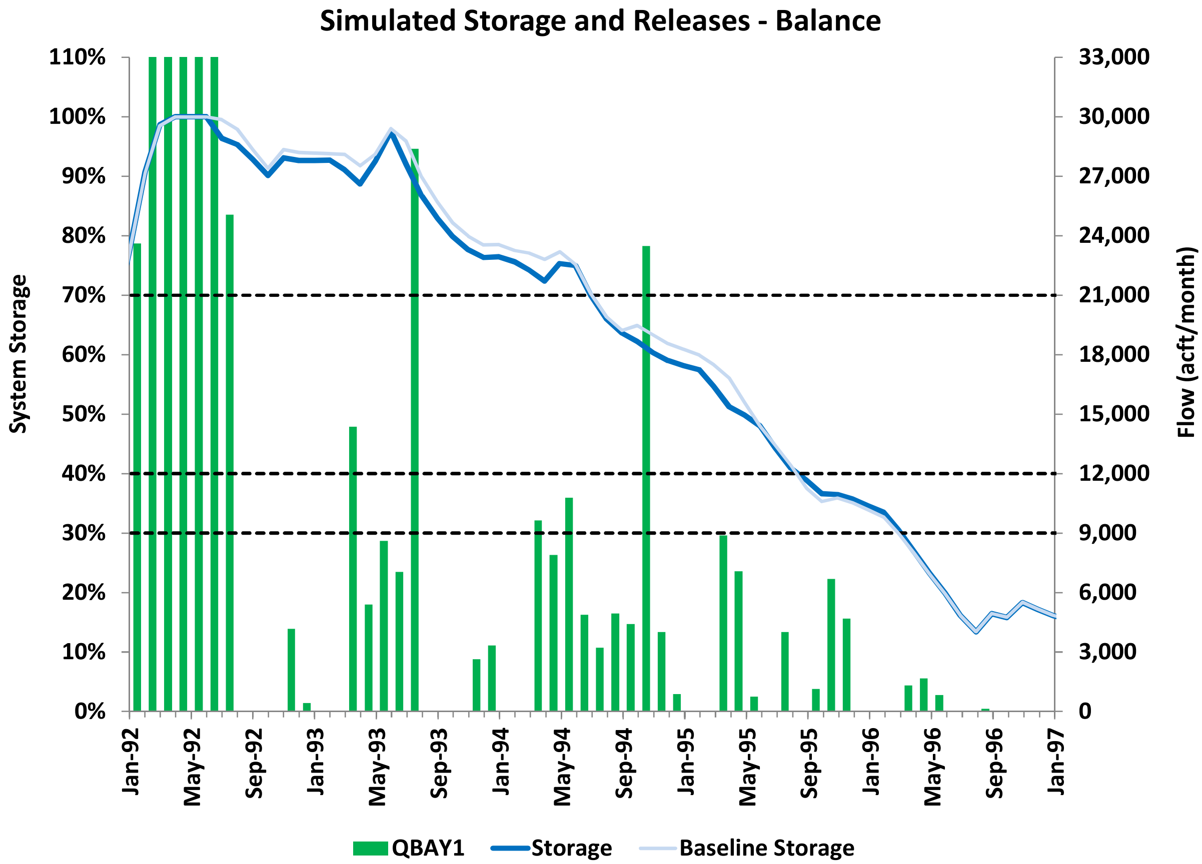

Figure 8. Simulated storage/inflow pass-throughs for Balance scenario during critical drought.

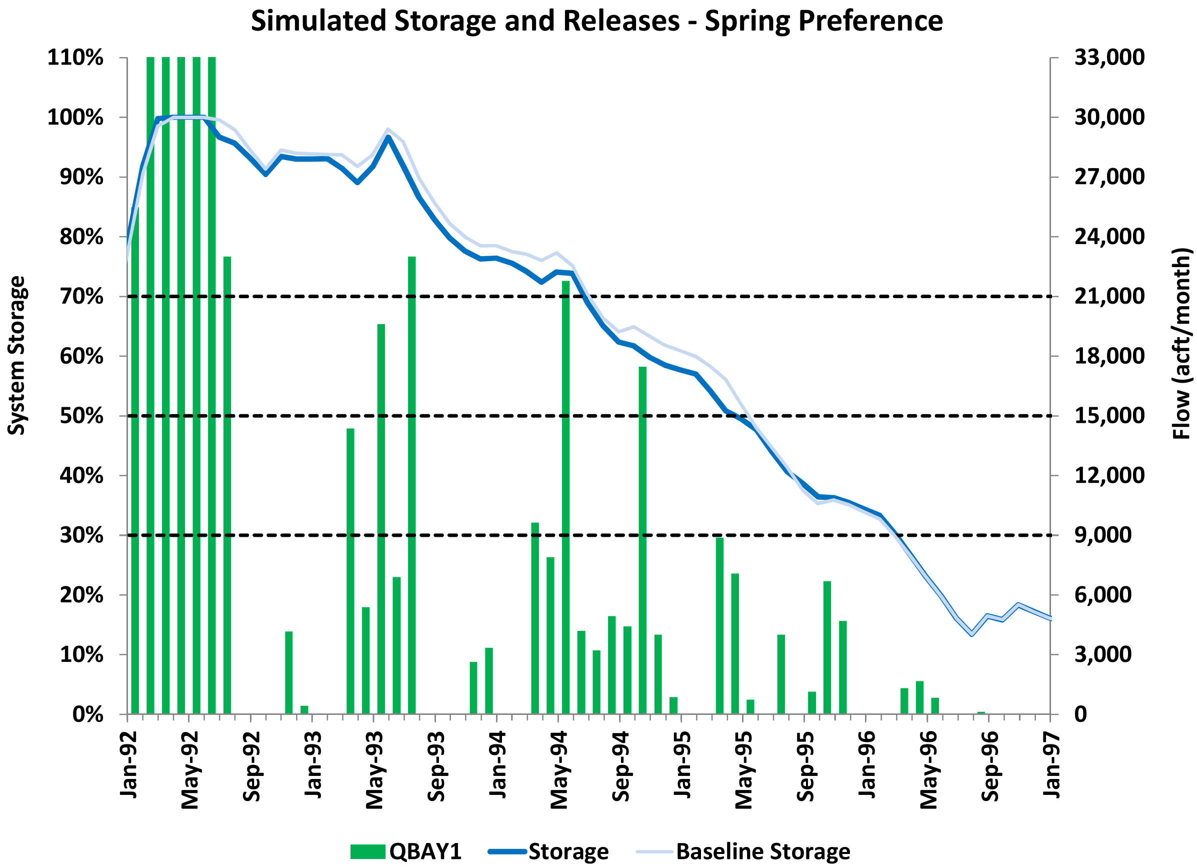

Figure 9. Simulated storage/inflow pass-throughs for Spring Preference scenario during critical drought.

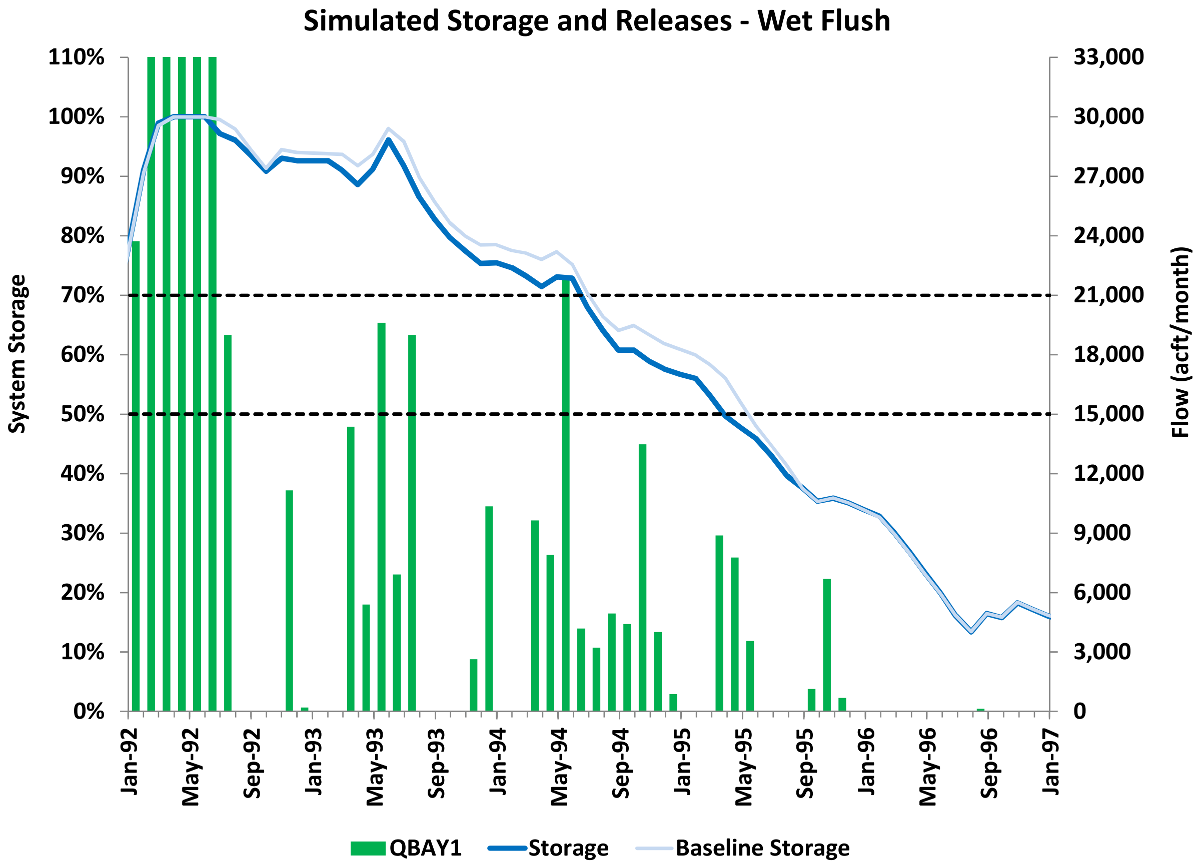

Figure 10. Simulated storage/inflow pass-throughs for Wet Flush scenario during critical drought.

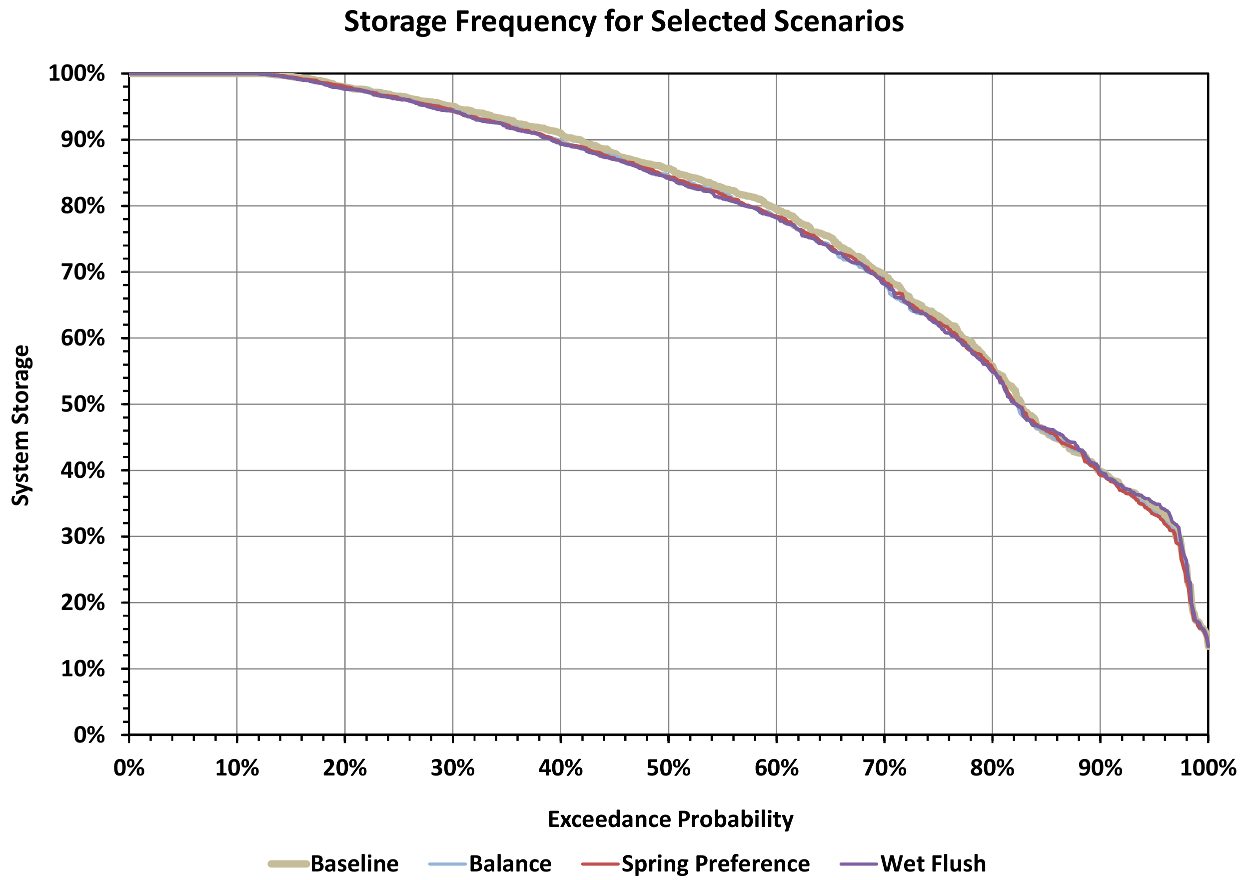

Figure 11. Simulated system storage frequency for selected scenarios.

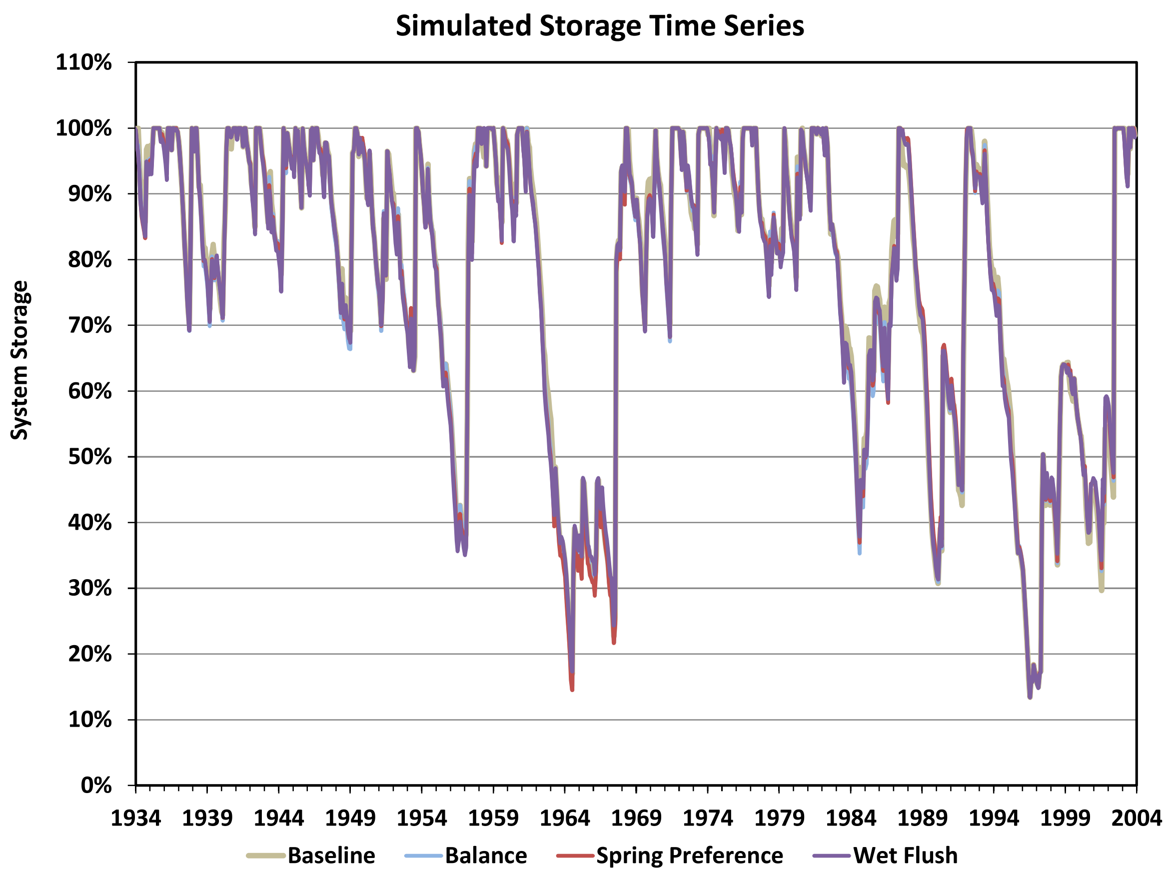

Figure 12. Simulated system storage time series for selected scenarios.

5.0 Zone Changes within a Season and Operational Considerations

The CCWSM is designed to set the seasonal target at the beginning of the season based on beginning system storage and does not allow for a resetting of this target if the system storage were to drop into another zone at some time within the same season. There was discussion among the stakeholders with regards to how often this occurred and what if any impact this might have to the safe yield of the system if this option were modified in the model.

A post processing of the data was performed which showed that this instance of system storage changing from one zone to another during a season occurred 24 times. Thirteen of these events occurred during times when system storage dropped resulting in a higher seasonal target than typically associated with that lower zone. Eleven of these events occurred during times when system storage increased resulting in a lower seasonal target than typically associated with that higher zone. During the critical drought this occurs twice and results in approximately 15,000 acft of water being passed through that could have been held back had the seasonal target shifted when the zone shifted from the change in system storage. For example, the analysis suggests that if reservoir operators reduce the release target during a given season as the storage volume decreases, significant volumes of water (e.g. 11,000 acft during the summer of 1994) would not be released under actual operating conditions.

This analysis showed that there is a potential impact to safe yield that could be reduced by modifying this assumption. This modification should be considered in future analysis if time and budget allow for model improvements. However, the overall impact of this issue is a small one and does not negate the findings of this report.

For future considerations and under actual reservoir operations, the seasonal targets could be reduced appropriately when the reservoir storage changes enough to cause a shift to a lower storage zone during a given season. This modification would reduce the potential pass-through liability or negate it completely if in the early months of the season more water was released than the new target would require. This would provide some additional benefit to the water supply of the reservoir system as it leaves more water in storage to be managed during the drought.

Another consideration of seasonal targets is the operational aspect of physically passing through these inflows in a different manner than is typically practiced today under the Agreed Order. Today, the operators of the Lake system account for inflows through the month, apply credits from salinity or the previous month's over-passage, account for return flows and intervening flow below the dam, and then schedule releases to occur after the month is over and into the first few weeks of the next month. This allows for the maximum advantage for the inflows to occur naturally in the downstream watershed instead of having to release the water from the reservoir system. In the model using SMART Inflow Management, the assumption is that the releases occur in the same month that the inflows happen. Actual operations under SMART Inflow Management should be discussed with several stakeholder groups, but especially the City of Corpus Christi as the operator of the reservoirs for water supply. One potential solution may be to release inflows up to the target amounts as close to when they occur as operationally possible. When releases are made that could have been held back because of intervening flow downstream of the reservoirs, a credit could be applied going forward that reduces the current season's total remaining target or the next season's target if the amount released is a significant event.

6.0 Conclusions / Recommendations

The CCWSM was applied to assess dozens of alternative reservoir management scenarios that seek to ensure that water is available for human needs while making fresh water available to support fauna and biota in the Nueces Bay and Delta. The application of the model has been focused on the concept of SMART Inflow Management and the potential impacts of this philosophy on the safe yield of the reservoir system. The results show that safe yield may be preserved or even enhanced under SMART Inflow Management scenarios that utilize seasonal targets. In addition, SMART Inflow Management results in variations in the attainment frequency of seasonal bay inflows when compared to the baseline run. The seasonal attainment frequency curves show that the three highlighted alternative scenarios achieve inflow regimes that are different than the baseline scenario (corresponding to current operating conditions) while meeting and/or exceeding the baseline scenario's safe yield volume. Simultaneously, system storage frequency does not change significantly from the baseline scenario under the three alternative scenarios (See Figure 11).

While these results suggest that SMART Inflow Management may allow for additional benefits to the Nueces Bay and Delta, future work should consider how the reservoir operators are likely to implement release rules that are different than the current operating procedures. A small committee of stakeholders may be organized to meet with reservoir operators to gain insight on likely reservoir operation procedures when storage zones change over the course of a season.

The CCWSM currently is not able to change seasonal release targets during a given season as the system storage fluctuates. It would be beneficial to modify the model to allow for this functionality as part of future work. Simultaneously, the model could be updated to run on newer operating systems as opposed to Windows XP.

Key findings of the results of this analysis include:

- It is possible to operate the LCC/CCR system using SMART Inflow Management and not only preserve the safe yield but mildly increase it.
- Seasonal targets allow greater windows of opportunity for pass-throughs to occur than the monthly target system under the existing Agreed Order.
- Higher annual targets, such as those in the Agreed Order, are not required when more opportunity is made available to pass-through inflow events over a season.
- Changes in the seasonal attainment frequency volumes of Bay inflow are possible under SMART Inflow Management.
- SMART Inflow Management can provide additional opportunities for smaller fresh events that can be used in conjunction with the Rincon pipeline to supply fresh water to the Delta, where smaller inflow events provide greater benefit than the same volume released to the Bay.
- Larger events are possible under SMART Inflow Management that could allow for events large enough to drop salinities in the Bay.

- System storage is not changed significantly (1-2%) under SMART Inflow Management when compared to the baseline condition.

Opportunities for additional study, questions still remaining, and other insights:

- The CCWSM should be updated to address various ways to deal with the issue of storage zone changes within a season that could lower season targets.
- A discussion should take place to evaluate operational limits, constraints and opportunities for enhancement under SMART Inflow Management as compared to the operations of the Agreed Order.
- The results of this study should be incorporated with the results of other ongoing research of freshwater inflow impacts to the Nueces Bay and Delta.

7.0 REFERENCES

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APPENDIX A – Additional Results for Modeled Scenarios

Table A1. Modeling constraints and results for various inflow scenarios (0 to 10b).

Scenario	Description	Safe Yield (acft)	QBAY1 Annual (acft)		
			AVG	Median	MIN
0	B & E Order	191,839	390,467	164,530	6,515
0a	B & E Order; No RF	188,434	387,593	167,632	1,923
Baseline	B & E Order; *Mary Rhodes Pipeline II; No RF	219,143	387,680	167,051	1,923
0b	B & E Order; *Mary Rhodes Pipeline II	222,606	390,537	169,042	6,515
0abc/10	B & E Order; *Mary Rhodes Pipeline II; RF = 10 MGD	225,419	393,185	170,599	11,331
0abc/15	B & E Order; *Mary Rhodes Pipeline II; RF = 15 MGD	227,328	397,003	173,646	16,923
0abc/21.4	B & E Order; *Mary Rhodes Pipeline II; RF = 21.4 MGD	229,157	402,478	178,706	24,099
1b	No Pass Throughs	256,128	360,176	128,196	6,001
1ab	No Pass Throughs; No RF	256,128	354,187	122,207	13
2b/30	2000 acft during ODD months; 30% storage constraint	251,617	358,344	126,747	3,013
2b/40	2000 acft during ODD months; 40% storage constraint	252,301	357,508	125,881	1,123
3b/30	2000 acft during EVEN months; 30% storage constraint	252,423	357,606	125,911	2,123
3b/40	2000 acft during EVEN months; 40% storage constraint	252,913	357,182	125,566	123
4b/30	4000 acft each season; 30% storage constraint	245,550	363,600	131,743	3,932
4b/40	4000 acft each season; 40% storage constraint	247,662	361,573	132,259	123
5b/30	1000 acft each month; 30% storage constraint	252,540	357,525	126,153	2,123
5b/40	1000 acft each month; 40% storage constraint	252,927	357,185	125,493	623
6b/30	19K/19K/4K acft each season; 30% storage constraint	224,193	380,849	147,789	7,563
6b/40	19K/19K/4K acft each season; 40% storage constraint	227,368	378,160	147,134	123
7b/30	15000 acft each season; 30% storage constraint	220,213	385,430	162,264	7,563
7b/40	15000 acft each season; 40% storage constraint	226,148	379,893	152,611	123
8b/30	29K/29K/4K acft each season; 30% storage constraint	210,749	392,556	164,345	7,563
8b/40	29K/29K/4K acft each season; 40% storage constraint	213,810	390,158	167,405	123
9b/30	15K/15K/4K acft each season; 30% storage constraint	229,588	376,471	141,287	7,563
9b/40	15K/15K/4K acft each season; 40% storage constraint	232,839	373,476	141,905	123
10b/30	23K/23K/4K acft each season; 30% storage constraint	218,391	387,098	161,925	7,563
10b/40	23K/23K/4K acft each season; 40% storage constraint	221,703	384,505	160,388	123

Table A2. Modeling constraints and results for various inflow scenarios (11 to 14).

Scenario	Description	Target/ Trigger Level 1	Target/ Trigger Level 2	Target/ Trigger Level 3	Safe Yield (acft)	QBAY1 Annual (acft)		
						AVG	Median	MIN
11	3 storage trigger levels; Varied flow targets	29-29-4/50	15-15-4/40	4-4-4/30	214,651	390,764	173,012	3,932
12	3 storage trigger levels; Varied flow targets	29-23-4/50	23-15-4/40	4-4-4/30	215,712	389,798	169,490	3,932
13	3 storage trigger levels; Varied flow targets	29-23-4/50	23-23-4/40	4-4-4/30	215,712	389,812	166,181	3,932
14	4 storage trigger levels; Varied flow targets	29-29-4/75	23-23-4/50	15-15-4/40	213,001	392,293	172,269	11,456
11b	3 storage trigger levels; Varied flow targets	29-29-4/70	15-15-4/40	4-4-4/30	217,935	387,960	169,261	3,932
11c	3 storage trigger levels; Varied flow targets	23-23-4/50	15-15-4/40	4-4-4/30	219,550	386,320	164,722	3,932
Balance	3 storage trigger levels; Varied flow targets	29-29-4/70	15-4-4/40	4-4-4/30	220,568	385,663	165,922	3,932
11e	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/40	4-4-4/30	216,184	389,667	170,313	3,932
11f	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/50	4-4-4/35	217,272	388,689	169,222	123
11g	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/50	2-2-2/30	217,851	388,171	168,234	2,039
11h	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/50	2-2-2/35	218,394	387,708	167,690	123
11i	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	2-2-2/35	221,355	385,301	164,728	123
11j	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/35	220,232	386,279	166,259	123
Spring Preference	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/30	219,147	387,257	167,344	3,932
11l	3 storage trigger levels; Varied flow targets	40-23-4/70	19-19-4/50	4-4-4/30	218,239	388,062	168,253	3,932
11m	3 storage trigger levels; Varied flow targets	40-23-4/70	19-19-4/50	4-4-4/35	219,325	386,910	167,166	123
11n	3 storage trigger levels; Varied flow targets	40-23-15/70	19-19-15/50	4-4-4/35	213,766	392,385	170,920	123
11o	3 storage trigger levels; Varied flow targets	40-23-15/70	19-19-4/50	4-4-4/35	216,365	390,114	168,438	123
11p	3 storage trigger levels; Varied flow targets	40-19-12/70	19-19-4/50	4-4-4/35	218,855	387,719	167,636	123
11q	3 storage trigger levels; Varied flow targets	40-19-11/70	19-19-4/50	4-4-4/35	219,235	387,331	167,256	123
11r	3 storage trigger levels; Varied flow targets	45-19-11/70	19-19-4/50	4-4-4/35	218,397	388,214	166,314	123
11s	3 storage trigger levels; Varied flow targets	40-19-11/70	24-19-4/50	4-4-4/35	217,942	388,518	168,038	123
11t	3 storage trigger levels; Varied flow targets	40-19-11/70	19-19-11/50	4-4-4/35	218,584	388,518	168,038	123
Wet Flush	2 storage trigger levels; Varied flow targets	40-19-11/70	19-15-4/50	n/a	221,476	385,372	163,418	123

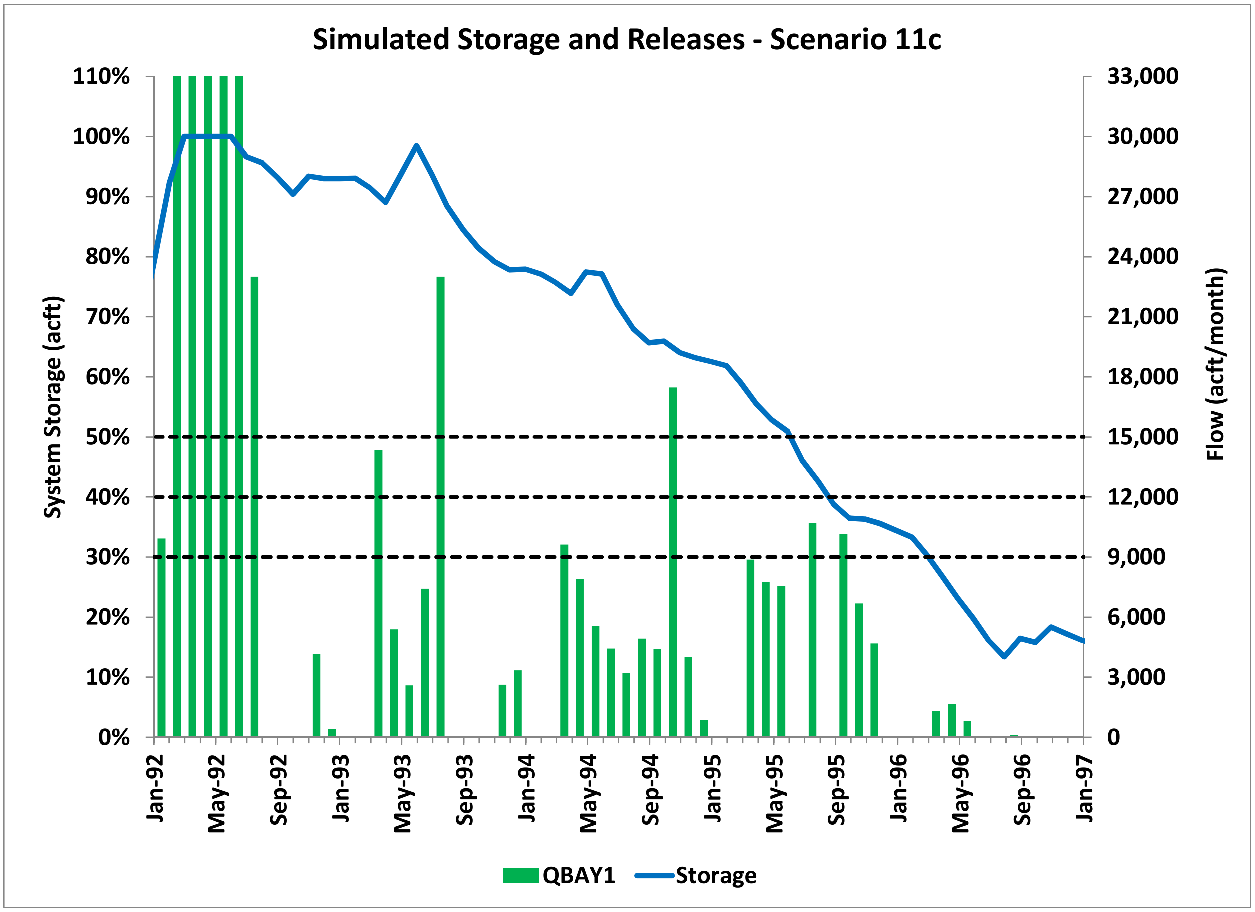

Figure A1. Simulated storage/inflow pass-throughs for Scenario 11c during critical drought.

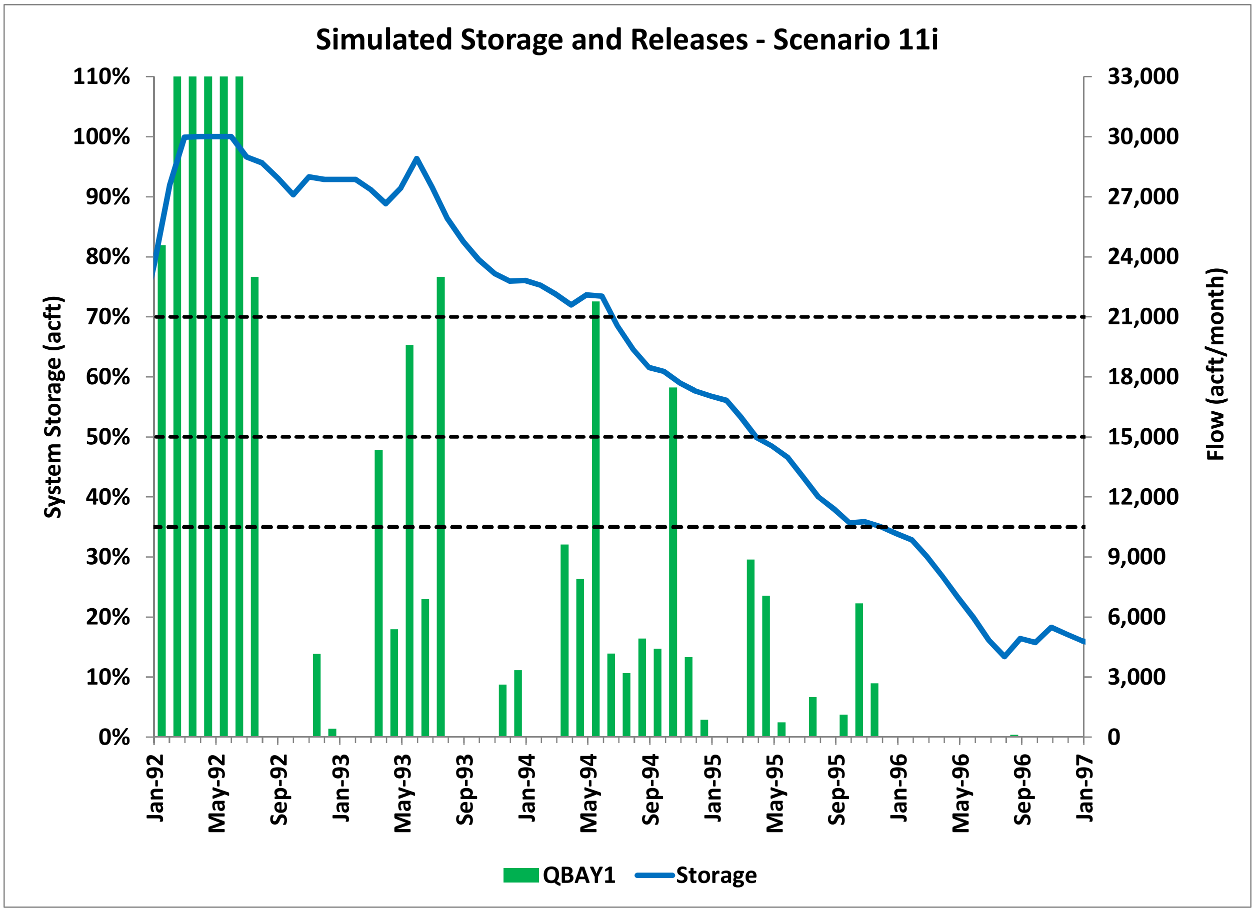

Figure A2. Simulated storage/inflow pass-throughs for Scenario 11i during critical drought.

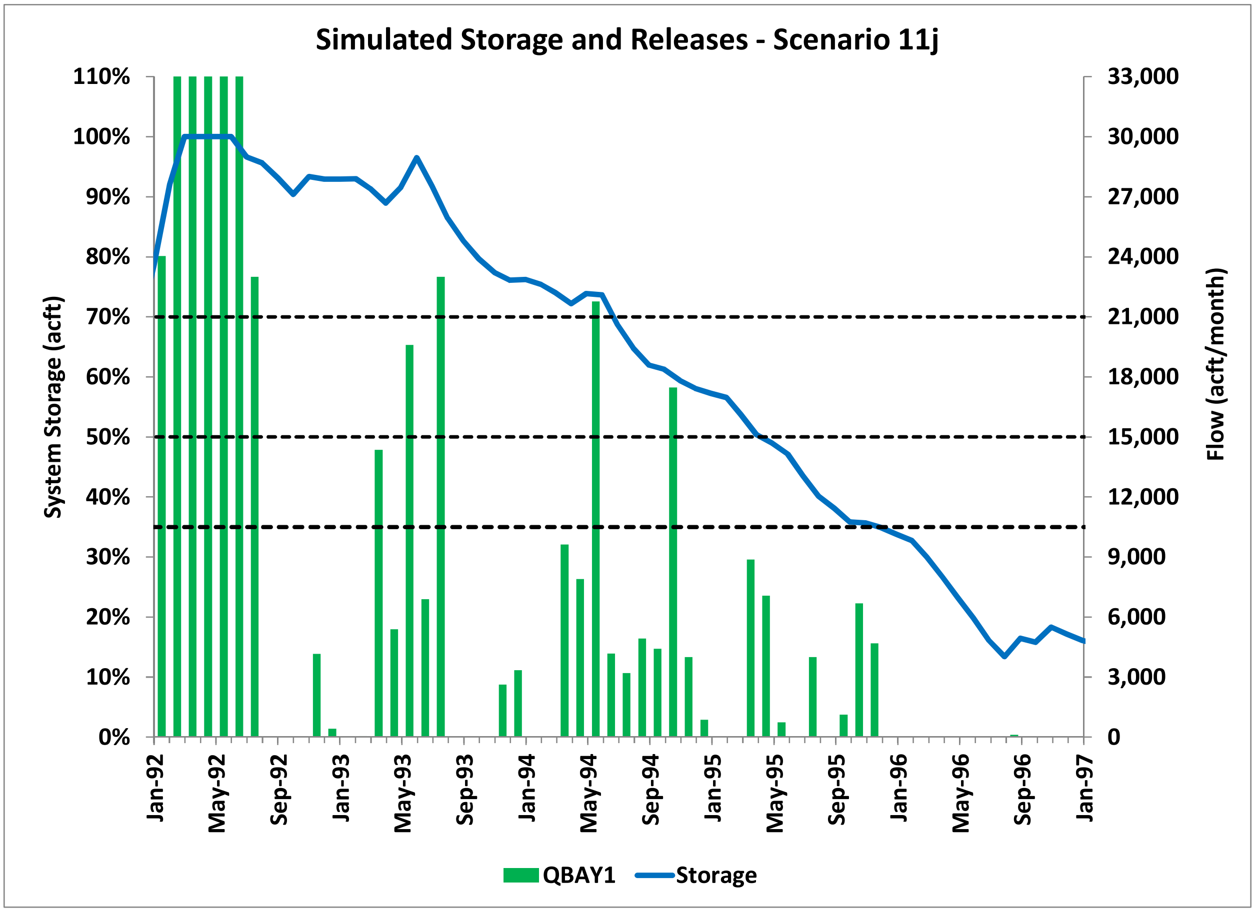

Figure A3. Simulated storage/inflow pass-throughs for Scenario 11j during critical drought.

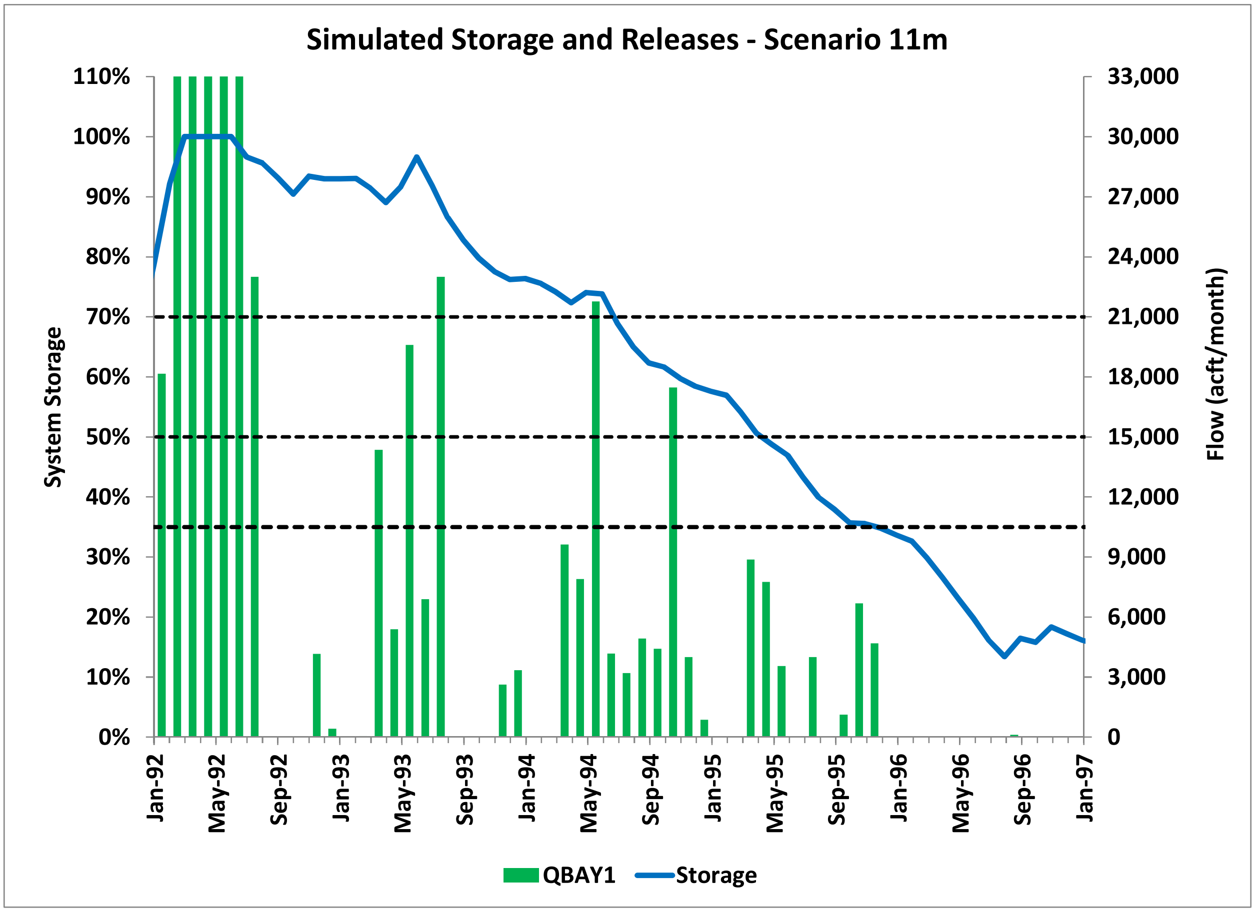

Figure A4. Simulated storage/inflow pass-throughs for Scenario 11m during critical drought.

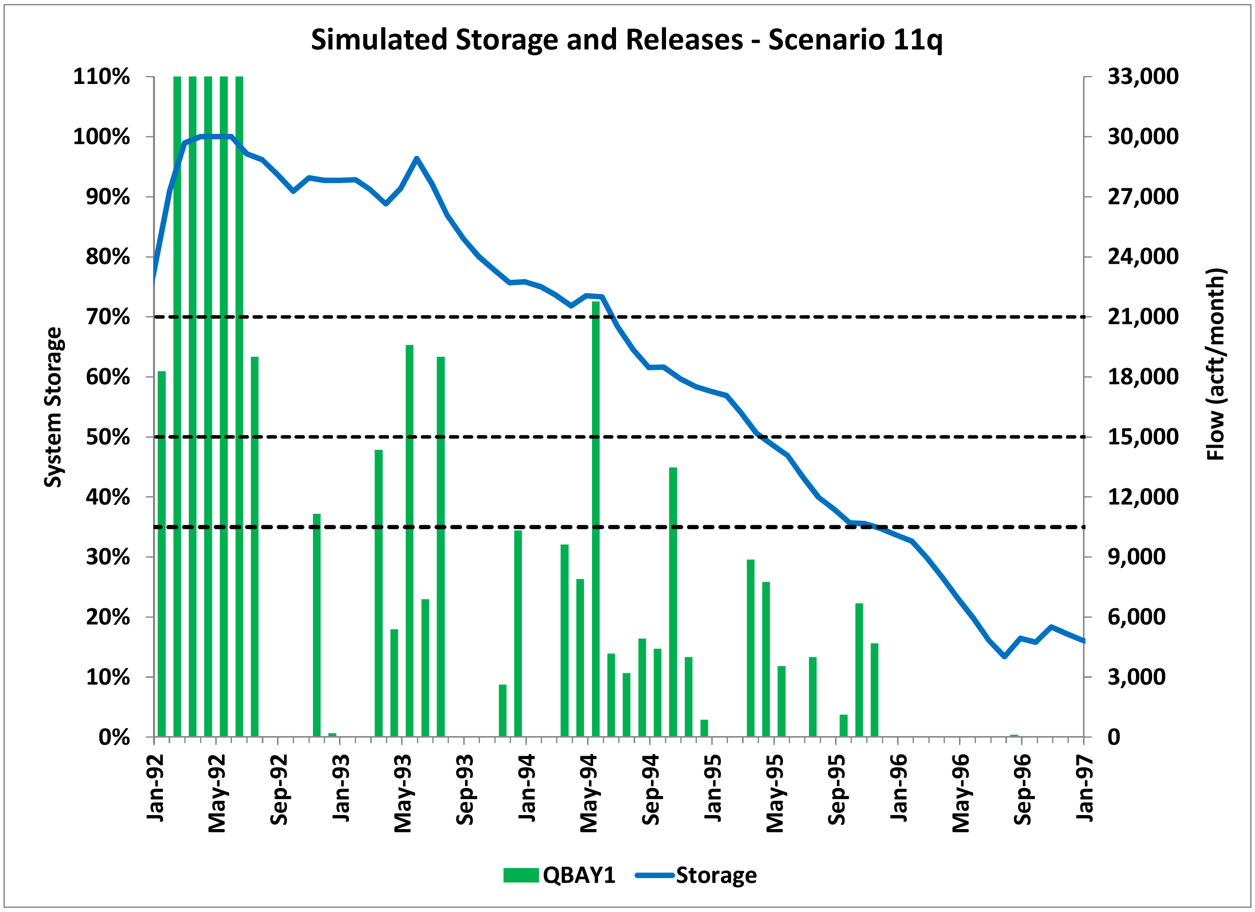

Figure A5. Simulated storage/inflow pass-throughs for Scenario 11q during critical drought.

Appendix B – SMART Inflow Meeting on 3-26-14

Coastal Bend Bays & Estuaries Program, Inc.

1305 N. Shoreline, Suite 205, Corpus Christi, Texas 78401-1500 • 361-885-6202 • 361-881-5168 (fax)

SMART Inflow Management Modeling Meeting

Meeting Notes

Date: March 26, 2014
Time: 9:00 am to 11:30 am
Location: CBBEP Offices, 1305 N. Shoreline Blvd, Corpus Christi, TX.

List of Attendees:

Person	Affiliation	Email
Jace Tunnell	Coastal Bend Bays & Estuaries Program	jtunnell@cbbep.org
Ray Allen	Coastal Bend Bays & Estuaries Program	rallen@cbbep.org
Leo Trevino	Coastal Bend Bays & Estuaries Program	Ltrevino@cbbep.org
Cory Shockley	HDR Engineering	Cory.shockley@hdrinc.com
Tony Smith	RPS Group	Tony.smith@rpsgroup.com
Con Mims	Nueces River Authority	cmims@nueces-ra.org
Rocky Freund	Nueces River Authority	rfreund@nueces-ra.org
Brent Clayton	City of Corpus Christi	brentc@cctexas.com
Steve Hoey	Sherwin Alumina	sahoey@sherwinalumina.com
Tom Ballou	Sherwin Alumina	tbballou@sherwinalumina.com
Junji Matsumoto	Texas Water Development Board	jmatsumo@twdb.texas.gov
Paul Carangelo	Port of Corpus Christi Authority	paul@pocca.com
Erin Hill	Center for Coastal Studies	Erin.hill@tamucc.edu
Carola Serrato	South Texas Water Authority	cserrato@stwa.org

Agenda followed at meeting:

- Introductions
- Project Background and Goals (Jace – see attached presentation)
- CCWSM Capabilities (Cory – see attached presentation)
- Scenario Building (Cory – see attached presentation)
- Next Steps (Jace)

The following pages consist of the handouts and presentations given at the meeting.

SMART Inflow Management Project
-Kickoff Meeting-
March 26, 2014

Project Purpose

This project aims to demonstrate through modeling exercises that the Salinity Monitoring and Real Time (SMART) Inflow Management concept appears to be a viable strategy for efficiently utilizing limited freshwater resources to reduce the salinity extremes that have a negative impact on estuarine productivity. In order for SMART Inflow Management to be implemented under the current 2001 Agreed Order, a water "banking" concept will 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. In order to validate the preliminary modeling efforts conducted to date that show an improvement to managing freshwater inflows into the bay, HDR will utilize the Corpus Christi Water Supply Model (CCWSM) to determine the impacts of SMART Inflow Management on the Nueces Delta and Bay and the safe yield of the reservoir system.

The overall end product of this project will be a final report that describes the process that was completed throughout the project period and a brief summary addressing the evaluation of the impacts of SMART Inflow Management on reservoir system yield. The final report will also briefly discuss the future implications of the study area with recommendations for additional investigation.

Model Application and Tasks

Pass-through banking allows the CCWSM model to store water, which would normally be passed through to the bay, for subsequent larger releases. The theory is that there could be more biological productivity and benefits from a larger pulse release than a sustained lower flow event. This is due in part to how higher flow events in the lower Nueces River near Calallen enter the Nueces delta whereas smaller low flow events tend to stay in the river channel and discharge into Nueces Bay, bypassing the upper estuary and delta.

HDR Engineering will use the existing reservoir inflow data, bay inflow data, and stream gauge data to conduct the following tasks:

1. Conduct a series of integrated water availability and water quality modeling analyses to assess the relative implications of different water management scenarios and provide technical information to NEAC for consideration of the balance between water supply and environmental flow needs in the development of strategies involving the reservoir system, Nueces Bay inflows, and Rincon Bayou Pipeline operations.
2. Present results of these analyses at meetings and stakeholder workshops in the area and gather stakeholder input on actions to reduce vulnerability and opportunities to enhance bay and estuary conditions while maintaining safe system yield.

Nueces Inflow Release Program (NIRP): Pilot Project

August 16, 2013

Introduction

In 2012 the Nueces Basin and Bay Area Stakeholder Committee (BBASC) 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 goal for this pilot project is to increase ecosystem productivity and diversity throughout the Nueces Bay and Delta by managing the timing of freshwater inflow events, while working within the parameters of the 2001 Agreed Order, the drought relief provisions, and not impacting the safe yield of the reservoir system. Based on key indicator species and natural hydrology of the system, better management of freshwater inflows can be achieved.

Background Studies

The Nueces Bay and Delta complex has been the subject of scientific study during the last two decades (Figure 1). During this time several studies and reports have helped our understanding of these two systems and will ultimately be the basis for establishing a desired condition in the bay and delta, as well as the methodology chosen for measuring a successful inflow program; these studies and reports include:

- There has been a ~55 percent reduction in flow to Nueces Bay and ~99 percent reduction to the delta as a result of reservoir construction and modifications and channelization of the lower Nueces River. Due to reduced quantity of freshwater inflow there is only around 1 over banking per every 3 years in the Nueces Delta as opposed to pre-dam years of overbanking almost 3 times per year allowing for flushing of the system and new deposition of sediments and nutrients (Bureau of Reclamation, 2000).
- Increased inflow to Rincon Bayou is having beneficial biological effects (Montagna et al., 2002; Palmer et al., 2002; Ward et al., 2002).
- Montagna et al. (2009) showed that, during 1976-1982 (pre-Choke Canyon Reservoir), the average salinity in Nueces Bay was below 26 ppt one hundred percent of the time; while during 1983-2002 (post-Choke Canyon Reservoir), salinities were below 26 ppt only five percent of the time.

- The City of Corpus Christi funded scientific studies in the Nueces Delta from 1995 to 2010 in order to enhance and monitor changes in ecological conditions in the Nueces Estuary. Many scientific reports and publications have been written that document changes in the ecology of the delta due to freshwater inflows, including: the Nueces Delta Studies Integrated Monitoring Plan compiled by Alan Plummer Associates in 2009; the Rincon Bayou Diversion Project Report by Montagna et al. in 2011; and the Nueces Delta Synthesis Report by Montagna et al. in 2009.
- In 2011 the Nueces Basin and Bay Expert Science Team (BBEST) reported that an ecologically sound Nueces Bay and Delta would contain sediment shoaling during flood events, creating new habitat. Additionally, the salinities in Nueces Bay/Delta would not exceed 18 ppt for most of the year (especially during the fall), allowing plant (*Spartina alterniflora*) and animal communities (benthic infauna, oysters, blue crabs, Atlantic croaker) to persist at sustainable population levels and to colonize new areas. The BBEST report states that a modification of flow regime will be required to rebuild these species and processes to sound levels. Further recommending that to restore Nueces Bay and Delta to a sound state that the frequency of seasonal inflow attainments will need to be increased from current levels.
- The BBEST also performed a statistical analysis that predicted probability of occurrence for blue crab based on salinity values. Figure 2 shows blue crab probability of occurrence within specific salinity ranges and Figure 3 shows a visual map of crab occurrence under average salinity conditions. Figure 4 shows what happens to blue crab populations in Nueces Bay when salinities are either reduced or increased from the average salinity conditions. There is a significant increase in blue crab populations with decreasing salinities, and a decrease in populations when salinities increase from the average.

Figure 1. Location of the Nueces Bay and Delta in relation to Texas. Also shown is the Nueces River in blue, the Rincon Bayou in yellow, and the Rincon Bayou Pipeline (RBP) in red.

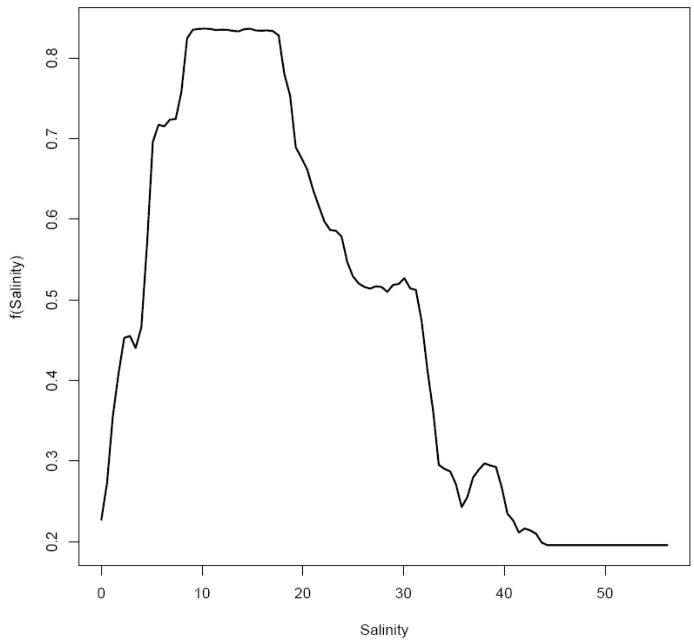

Figure 2. Blue crab salinity preference range within Nueces Bay is approximately 10 -20 ppt. This boosted regression tree model uses TPWD bag seine data to create these values. Image from Nueces BBEST, 2011.

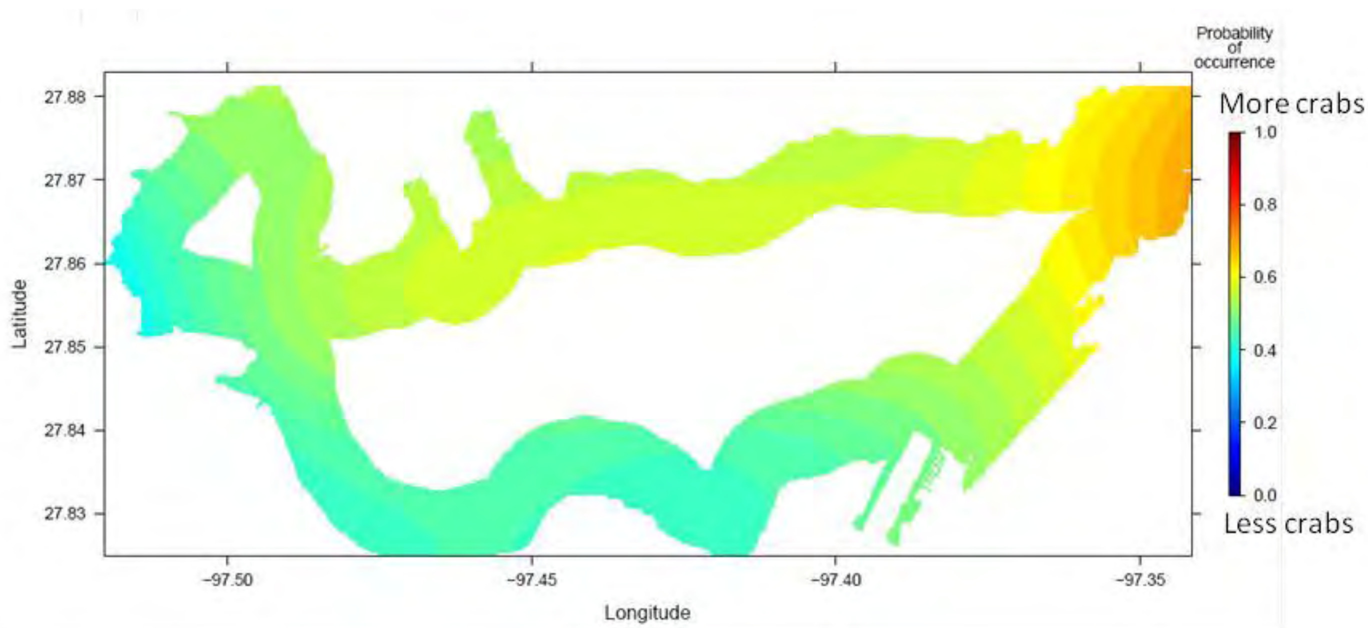

Figure 3. Probability of occurrence map of blue crab as predicted by a boosted regression tree (BRT) model under average salinity conditions in Nueces Bay. The blue color means a less probability of finding blue crabs and the yellow to orange color means more likely to find blue crabs. Modified from Nueces BBEST, 2011.

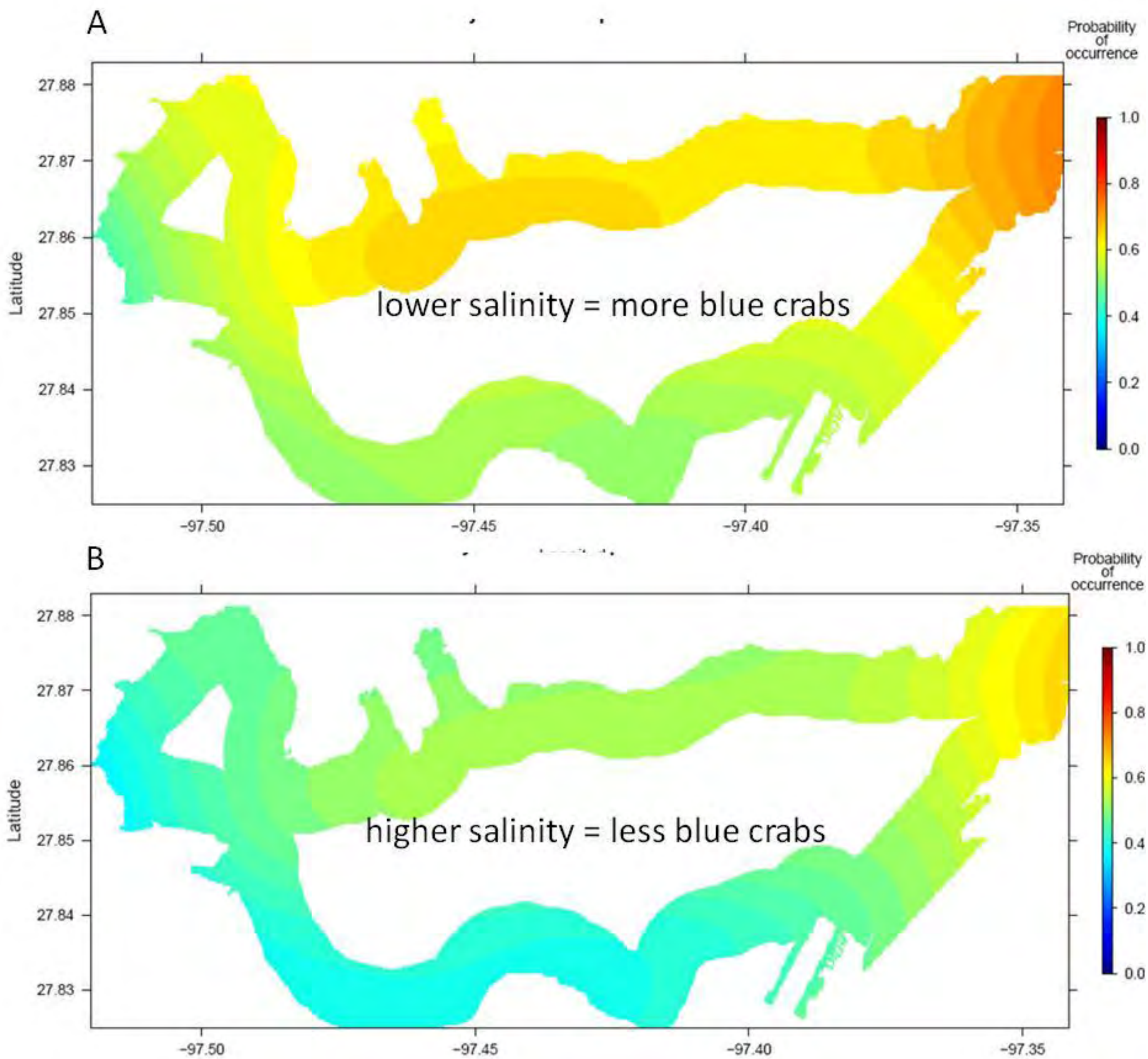

Figure 4. Blue crab predicted probability of occurrence as predicted by a boosted regression tree (BRT) model when mean salinity is reduced 10 ppt (A) and increased 10 ppt (B). The more yellow and orange found on the map, the more crabs are being found in the bay due to reduced salinities (e.g. A is more desirable conditions for blue crab populations than B). Modified from Nueces BBEST, 2011.

Pilot Project

Through these studies and reports, the City of Corpus Christi (City) and the Coastal Bend & Bays Estuary Program (CBBEP) have designed the Nueces Inflow Release Program (NIRP) to implement a pilot project that will monitor salinity (as an indicator for water quality and biological productivity) in Nueces Bay and Delta (Rincon Bayou) with manageable goals while balanced with conservation efforts per Corpus Christi Water Department objectives. Attainment calculations can be another means of monitoring success of establishing a salinity gradient and connectivity throughout the delta and bay.

As reported by the Nueces BBEST, the salinity gradient within the bay system, made up of Nueces Delta and Bay, influences the zonation of communities. The salinity gradient between the bay and delta are compromised due to reduced freshwater inflow (frequency and volume). Based on these reports, the Nueces BBASC developed the Salinity Monitoring and Real-Time (SMART) Inflow Management plan which seeks multiple goals:

1) Provide adequate environmental flows to Nueces Bay and Delta that creates measureable ecological benefits
2) Maintain connectivity within the delta and bay system while also providing for a reduced high salinities
3) Preserve existing safe yield of the reservoirs system.

Previous research has shown an annual salinity average of 18 ppt would provide most favorable conditions within Nueces Bay at salinity station SALT03 (Nueces BBEST, 2011). The NIRP will utilize the SMART Inflow Management plan to maintain salinity within the bay system between predetermined thresholds of 18 to 30 ppt, in an effort to reduce high salinity within the bay system. Through modeling exercises, the SMART Inflow Management concept appears to be a viable strategy for efficiently utilizing the limited freshwater resource.

Additional information describing analyses performed during the BBASC process, outcomes and benefits associated with SMART Inflow Management, and possible ways to improve water availability for implementing the concept are available in Appendix A.

The following pages describe how the SMART Inflow Management concept would be implemented on a trial basis for the Nueces Delta. Also discussed are the recommendations to help move this effort forward while measuring success.

Measuring Success

The past two decades of scientific study in the Nueces Bay and Delta have established that freshwater inflows significantly improve biological productivity and diversity. The simplest, lowest cost, and easiest ecosystem indicator identified for Nueces Bay and Delta is salinity. Through consistent monitoring of salinities at NUDE2 and Salt03, a percentage of months within a calendar year that have a monthly average below 30 ppt can be calculated as a measure of success. This data will be used to determine the effectiveness of the current release operations.

Recommendations for Nueces Delta (Rincon Bayou Pipeline)

Hodges et al. in December 2012 completed a report that states: "The long-term prognosis for the Nueces Delta under present conditions is poor and the vulnerability of the system is high. Freshwater inundation over the past 30 years has simply been insufficient in volume and distribution to maintain a healthy marsh, so the delta front is eroding into Nueces Bay, the marsh plants are under stress, and the connectivity of aquatic habitat is threatened."

The following goals and actions are a strategy for addressing these issues:

i. **Management Goal -** Maintain salinity levels at 0-30 ppt throughout the year as measured at monitoring station NUDE 2 with a monthly average attainment level of 11 out of 12 months (92%), when the combined reservoir capacity is ≥ 40% (Table 1). Below 40% the 2001 Agreed Order drought contingency plan would be initiated. Attainment level is calculated by the number of months salinity is measured with a monthly average between 0 and 30 ppt throughout a calendar year.

ii. **Management Action -** To achieve the management goal, maximum inflows of 2,000* AF delivered via the Rincon Bayou Pipeline (RBP) may be needed every other month (6 times per year) for a total of 12,000** AF/year. During wet weather conditions less inflow will be required. The NEAC – Inflow Pipeline Advisory Committee (IPAC) using salinity data provided by monitoring station NUDE 2 and other stations will advise the City of Corpus Christi of the need for a delivery of inflows to Rincon Bayou. The 2001 Agreed Order currently calls for up to 3,000 AF/month to be pumped to the Rincon Bayou via the RBP. This strategy could be a reduction in pumping cost to the City of Corpus Christi.

iii. **Banked Water -** In order to meet the Management Goal for the Nueces Delta, a strategy of maintaining up to 12,000 AF to ensure a full year supply of water available for delivery to the Nueces Delta down to a combined reservoir capacity of 40%. Below 40% the 2001 Agreed Order drought contingency plan would be initiated. Since 2009, the most amount of water pumped through the Rincon Bayou Pipeline during one calendar year has been around 5,000 AF in 2011. This strategy would ensure freshwater to the most important area of the Nueces Estuary. Evaporation rates on banked water will need to be evaluated and determined during the pilot project period.

**2,000 AF and **12,000 AF is an estimate of water need for the delta based on previous pumping events and should be considered on a trial basis during the pilot project in order to refine our knowledge of actual water quantity needed to meet the management goal.*

Table 1. Monthly table showing how banked water to the Nueces Delta would be implemented.

	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
	Winter				Spring				Summer Fall			
Salinity Condition (ppt)	0 -30 all year											
Events	≤ 6											
Trigger Date	rolling 5 day average over 30 ppt measured at NUDE2											
FWI Quantity	2,000 acft every other month in order to meet condition											
Attainment	Monthly average salinity below 30 ppt for 11 out of 12 months in a calendar year											

Recommendations for Nueces Bay

In order to make sound decisions on water management strategies for Nueces Bay a concerted effort needs to be made to ensure that various scenarios of bay inflows do not impact the reservoir system's safe yield. In thinking through these strategies, CBBEP will be contracting with a consultant in the fall of 2013 to run the Corpus Christi Water Supply Model. For this reason, it is recommended that no management goal or action be described until further information can be obtained.

Other Planned Nueces Bay and Delta Studies

- CBBEP will be contracting with the Texas Water Development Board (TWDB) in the fall of 2013 to enhance the TXBlend model. The model grid will be improved to more accurately predict salinity changes in Nueces Bay from inflows entering from the Nueces River. The model will also be enhanced by the inclusion of the Nueces Delta, which previously has not existed in the model. This will allow for freshwater inflow scenarios to be run to see how various quantities of water effect salinities throughout the delta under certain hydrological conditions.
- CBBEP will be contracting with the Harte Research Institute for Gulf of Mexico Studies (HRI) in the fall of 2013 to monitor the effects of pumping water through the Rincon Bayou Pipeline to the benthic macrofauna. This study will allow for a clearer view of what the biology is doing before, during, and after freshwater pumping occurs.

Summary

The proposed strategy to implement SMART Inflow Management over a trial period can reduce salinity variance and re-establish a natural salinity gradient across the Nueces Estuary for ecological benefits. SMART Inflow Management is about better water management under the current 2001 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. Allowing banked water to the Nueces Delta by using SMART Inflow Management ensures consistent freshwater to the most important part of the Nueces Estuary while having an added benefit to the City of Corpus Christi of not having to run the Rincon Bayou pumps as often as the current 2001 Agreed Order mandates, which is up to the first 3,000 acre feet per month of pass throughs.

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, 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.

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SMART Inflow Management Project – Project Intro.

JACE TUNNELL

MARCH 26, 2014

Background

- Project concept from 2012 Nueces BBASC Work Plan
- Funded in September 2013 by CBBEP through TCEQ 604b funds
- Quality Assurance Project Plan developed and approved in February 2014
- Final Report due August 31, 2014

Goals

- Figure out adequate flows to implement SMART Inflow Management for bay and delta
- Make sure the flows do not impact reservoir system safe yield.

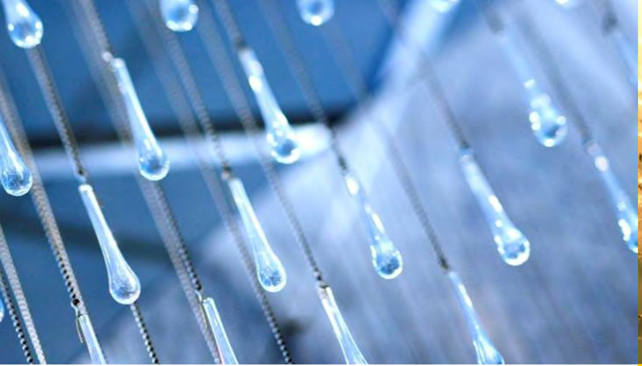
Starting Point

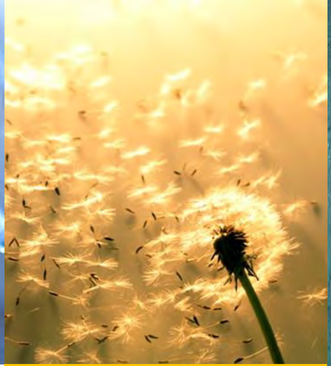
- Nueces Delta
  - Nueces Inflow Release Program (NIRP)
    - Operational Plan to implement SMART Inflow Management
    - Developed by City and CBBEP and to be approved by NEAC
  - Does the NIRP criteria impact safe yield?

- Nueces Bay
  - Develop inflow strategy that has a spring and fall pulse and uses some form of banking, considering evaporative losses.

Next Steps

- Run CCWSM on NIRP criteria.
- Develop additional modeling scenarios for Bay and/or Delta.





SALINITY MONITORING AND REAL TIME (SMART) INFLOW MANAGEMENT IN NUECES DELTA AND BAY

Cory Shockley, PE – HDR

March 26, 2014

TOPICS

» CCWSM History
» CCWSM Application / Options
» Project Goals
» Scenario Development Discussion

CCWSM HISTORY

- Corpus Christi Water Supply Model
  - AKA NuBay Model (early 90's)
  - Developed to evaluate Agreed Order Options
  - Monthly Model
  - 70 years of Hydrology (1934 – 2003)
- Updated over the Years
  - City of Corpus Christi
  - Region N
  - Nueces Feasibility Study (USACE)
  - Nueces BBASC
- Reservoir Operations Model
- Water Supply Planning Tool
- Environmental Flow Regime Tool

CCWSM OPTIONS / FUNCTIONS

» Corpus Christi Water Supply Model
- Four Simulation Modes
  - » Long-Term
  - » Firm Yield
  - » Safe Yield
  - » Projection
- Water Supply Options
  - » CCR/LCC/LT System
  - » Mary Rhodes Pipeline
  - » Other New Sources
- Bay and Estuary Targets
  - » Agreed Order Operations
    - Salinity Relief
  - » Pass-Through Banking

2001 TCEQ Agreed Order

- Operational in Application
- Monthly Targets and Requirements
- 4 Defined Storage Trigger Zones
- Based on System Storage
- Below 30% - No Passes
- Salinity & "Spill Banking" Relief

PROJECT GOALS

- Evaluate SMART Inflow Management
- Quantify changes to FWI to Nueces Delta and Bay
- Quantify Impacts to Safe Yield of Water Supply System

SCENARIO BUILDING

- Previous Scenario Evaluation
  - Nueces BBASC
    - Base – Safe Yield
    - No Pass-Throughs
    - Seasonal Order
    - Seasonal Targets (x’s 3)
    - 3,000 acft/mo - All Months
    - Reduced May/June
  - Not All Applicable to this Analysis
  - Separate Effort to look at Agreed Order Targets
    - Nueces BBASC Work Plan Study #1

SCENARIO BUILDING - DELTA

» SMART Inflow Management for Delta
- NIRP Recommendation
- Up to 2,000 acft/mo (every other month) up to 12,000 acft/yr
- Agreed Order Targets below 40% System Storage
- Banking under the Agreed Order
- Releasing using SMART Inflow Management
- Variations of these Volumes / Triggers
- Impact on Safe Yield

SCENARIO BUILDING - BAY

» SMART Inflow Management for Bay
  - Two Seasonal Pulses
  - Spring and Fall
  - 15,000 acft each
  - Banking under the Agreed Order
  - Releasing using SMART Inflow Management
  - Variations of these Volumes / Triggers
  - Impact on Safe Yield

SCENARIO DISCUSSION

Appendix C – SMART Inflow Meeting on 4-22-14

SMART Inflow Management Modeling Meeting

Meeting Notes

Date: April 22, 2014
Time: 10:00 am to 12:00 pm
Location: Port of Corpus Christi, 222 Power Street, Corpus Christi, Texas 78401.

List of Attendees:

Person	Affiliation	Email
Jace Tunnell	Coastal Bend Bays & Estuaries Program	jtunnell@cbbep.org
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Leo Trevino	Coastal Bend Bays & Estuaries Program	Ltrevino@cbbep.org
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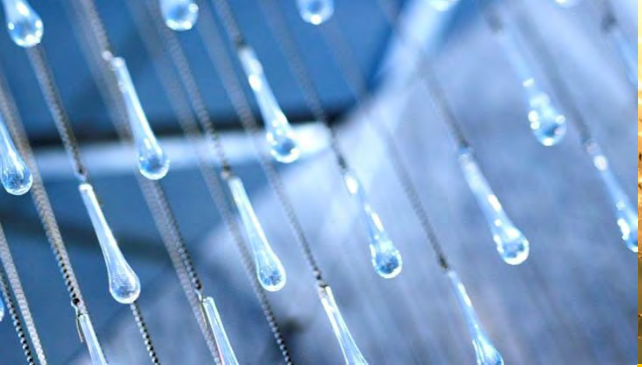
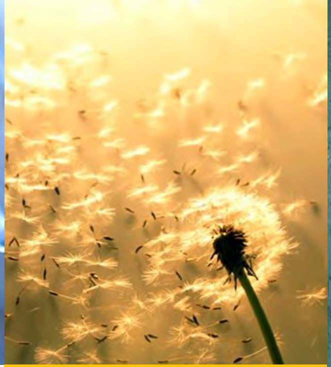
Jim Tolan	Texas Parks & Wildlife Department	James.tolan@tpwd.texas.gov

The following pages consist of the presentation given by Cory Shockley at the meeting.


SALINITY MONITORING AND REAL TIME (SMART) INFLOW MANAGEMENT IN NUECES DELTA AND BAY

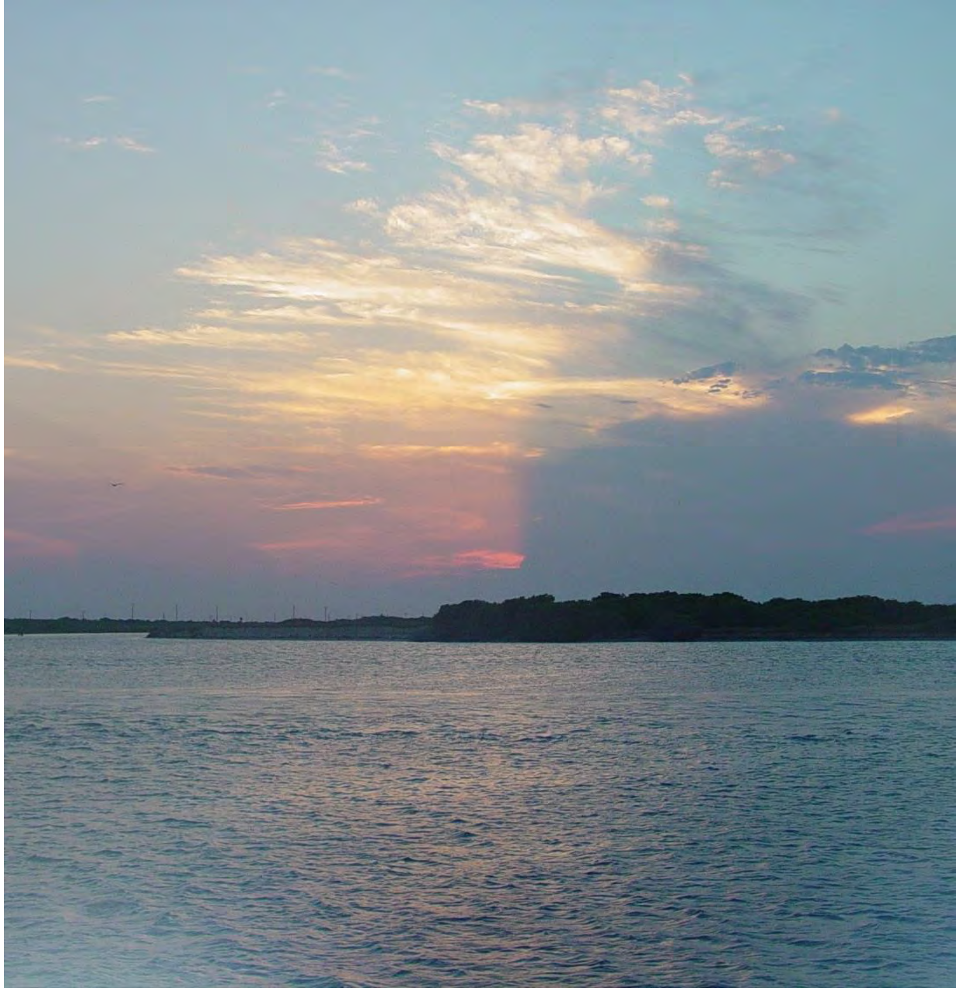
Cory Shockley, PE – HDR

Christian Braneon, EIT, PhD - HDR

April 22, 2014

TOPICS

» Project Background / Goals
» Scenario Results
» Scenario Refinement / Discussion



PROJECT BACKGROUND / GOALS

» Project Background
  - Project concept from 2012 Nueces BBASC Work Plan
  - Funded in September 2013 by CBBEP through TCEQ 604b funds
  - Quality Assurance Project Plan developed and approved in February 2014
  - Final Report due August 31, 2014

» Project Goals
  - Evaluate SMART Inflow Management
  - Quantify changes to FWI to Nueces Delta and Bay
  - Quantify Impacts to Safe Yield of Water Supply System

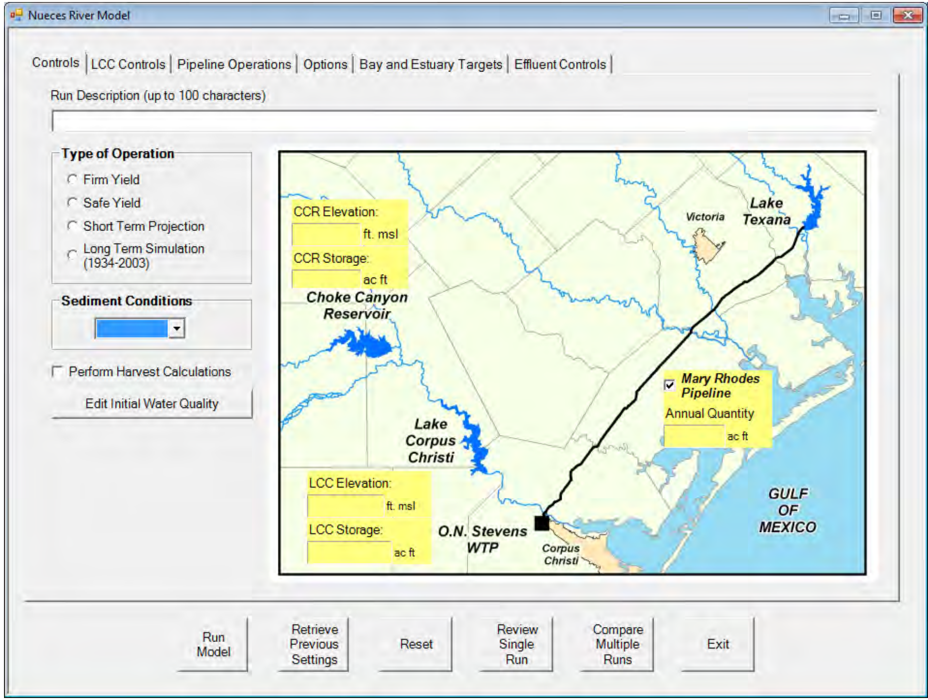
» Starting Point
  - Delta – Nueces Inflow Release Program (NIRP)
  - Bay – Seasonal Pulse Components

SCENARIO BUILDING

» Modeling Assumptions
- 2020 Estimated Sediment Conditions
- Safe Yield with 125,000 acft Storage Reserve
- Others consistent with Regional Planning

» 30 Scenarios / 3 Groups
- Group 1 – Baseline Runs
- Group 2 – Delta Runs
- Group 3 – Bay Runs

» Results
- Yields
- Bay Inflows
- Attainment Frequencies



SCENARIO RESULTS FOR GROUP 1 - BASELINE

» 6 Scenarios
  - 0 – Existing Agreed Order Safe Yield
  - 0a – Existing Agreed Order Safe Yield, No Return Flow (~500 acft/mo M&I to the Bay)
  - 0b – 0 with MRP2 (up to 35,000 acft/yr)
  - 0ab – 0b with no return flow
  - 1b – No Pass Through Requirements
  - 1ab – 1b with No Return Flow

» Key Findings
  - 0 – Matches Safe Yield used for Regional Planning = 191,839 acft/yr
  - 0ab – Selected Baseline Scenario for Comparison = 219,143 acft/yr
  - Comparing 1ab and 0ab = 36,985 acft/yr of “yield” available for SMART Inflow Management

SCENARIO RESULTS FOR GROUP 1 - BASELINE

Scenario	Description	Return Flows (500 acft)	Safe Yield (acft)	QBAY1 Annual (acft)		
				AVG	Median	MIN
0	B & E Order	Y	191839	390467	164530	6515
0a	B & E Order; No RF	N	188434	387593	167632	1923
0b	B & E Order; *Mary Rhodes Pipeline II	Y	222606	390537	169042	6515
0ab	B & E Order; *Mary Rhodes Pipeline II; No RF	N	219143	387680	167051	1923
1b	No Pass Throughs	Y	256128	360176	128196	6001
1ab	No Pass Throughs; No RF	N	256128	354187	122207	13

SCENARIO RESULTS FOR GROUP 2 – DELTA RUNS

- » 8 Scenarios
  - Variations of smaller monthly / seasonal targets
  - 2,000 acft every other month / 4,000 acft per season
  - 40% - 30% minimum system storage trigger
- » Key Findings
  - Uses 4,000 – 10,000 acft/yr of "available yield"
  - Seasonal targets provide more opportunity for pass-throughs
    - » More yield impact

Year/Run	Scenario	Description	Return Flows (500 acft)	Safe Yield (acft)	QBAY1 Annual (acft) AVG	Median	MIN
2020 Safe Yield	0ab	B & E Order; *Mary Rhodes Pipeline II; No RF	N	219143	387680	167051	1923
2020 Safe Yield	2b/30	2000 acft during ODD months; 30% storage constraint	N	251617	358344	126747	3013
2020 Safe Yield	2b/40	2000 acft during ODD months; 40% storage constraint	N	252301	357508	125881	1123
2020 Safe Yield	3b/30	2000 acft during EVEN months; 30% storage constraint	N	252423	357606	125911	2123
2020 Safe Yield	3b/40	2000 acft during EVEN months; 40% storage constraint	N	252913	357182	125566	123
2020 Safe Yield	4b/30	4000 acft each season; 30% storage constraint	N	245550	363600	131743	3932
2020 Safe Yield	4b/40	4000 acft each season; 40% storage constraint	N	247662	361573	132259	123
2020 Safe Yield	5b/30	1000 acft each month; 30% storage constraint	N	252540	357525	126153	2123
2020 Safe Yield	5b/40	1000 acft each month; 40% storage constraint	N	252927	357185	125493	623

SCENARIO RESULTS FOR GROUP 3 - BAY

» 10 Scenarios
  - Built on the 4,000 acft/season Delta run
    » 30% & 40% reservoir level triggers
  - 2 big season pulses – Spring and Summer
    » 4,000 + 11,000 = 15,000 acft/season
    » 19,000; 23,000; 29,000 acft/season
  - 15,000 acft every season

» Key Findings
  - All but 2 scenarios above the baseline target yield
    » The 29,000 seasonal pulses are about 5,000 to 8,000 acft/yr less

SCENARIO RESULTS FOR GROUP 3 - BAY

Scenario	Description	Return Flows (500 acft)	Safe Yield (acft)	QBAY1 Annual (acft)		
				AVG	Median	MIN
0ab	B & E Order; *Mary Rhodes Pipeline II; No RF	N	219143	387680	167051	1923
6b/30	19K/19K/4K acft each season; 30% storage constraint	N	224193	380849	147789	7563
6b/40	19K/19K/4K acft each season; 40% storage constraint	N	227368	378160	147134	123
7b/30	15000 acft each season; 30% storage constraint	N	220213	385430	162264	7563
7b/40	15000 acft each season; 40% storage constraint	N	226148	379893	152611	123
8b/30	29K/29K/4K acft each season; 30% storage constraint	N	210749	392556	164345	7563
8b/40	29K/29K/4K acft each season; 40% storage constraint	N	213810	390158	167405	123
9b/30	15K/15K/4K acft each season; 30% storage constraint	N	229588	376471	141287	7563
9b/40	15K/15K/4K acft each season; 40% storage constraint	N	232839	373476	141905	123
10b/30	23K/23K/4K acft each season; 30% storage constraint	N	218391	387098	161925	7563
10b/40	23K/23K/4K acft each season; 40% storage constraint	N	221703	384505	160388	123

SEASONAL ATTAINMENT FREQUENCIES

» How often is the seasonal target met for different scenarios?

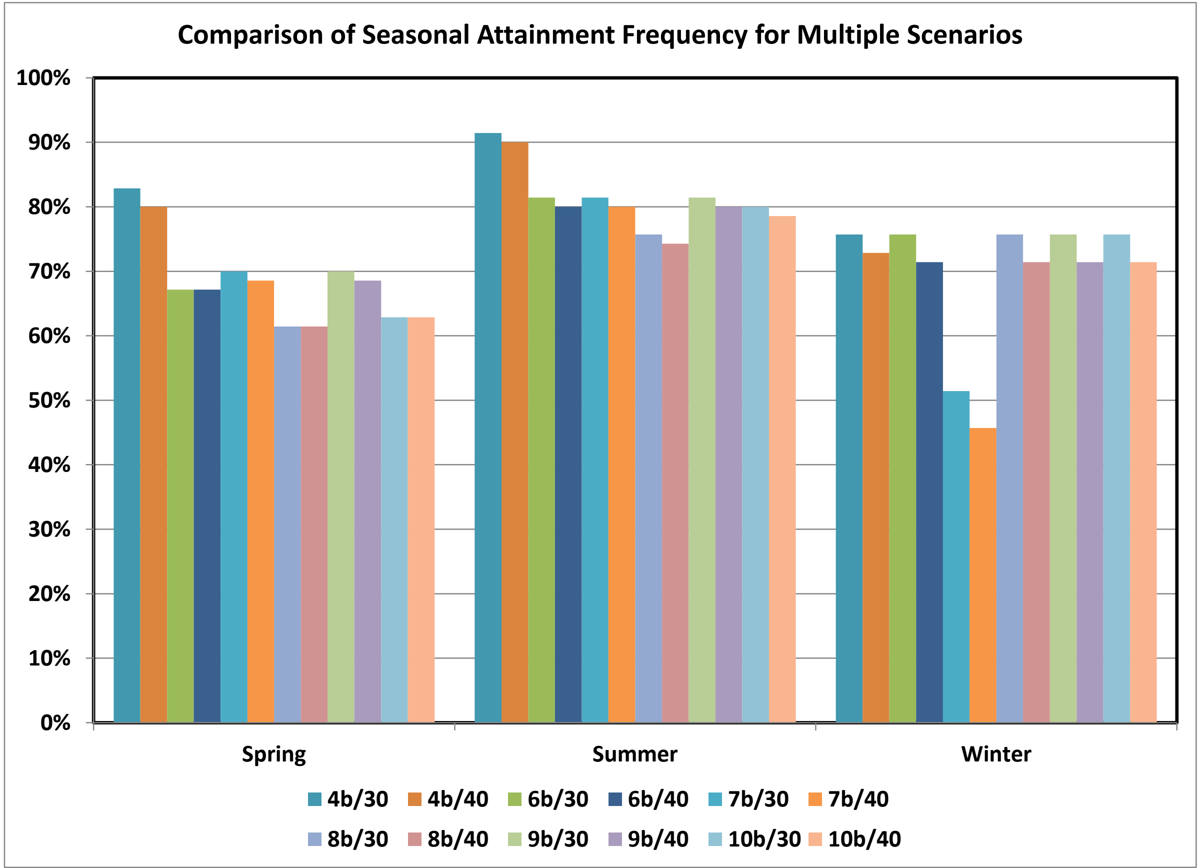
» 70 seasons contained in the simulations

- 1934 – 2003
- Winter – Nov-Feb
- Spring – Mar-Jun
- Summer – Jul-Oct

Scenario	Description	Attainment Frequency		
		Spring	Summer	Winter
4b/30	4000 acft each season; 30% storage constraint	82.86%	91.43%	75.71%
4b/40	4000 acft each season; 40% storage constraint	80.00%	90.00%	72.86%
6b/30	19K/19K/4K acft each season; 30% storage constraint	67.14%	81.43%	75.71%
6b/40	19K/19K/4K acft each season; 40% storage constraint	67.14%	80.00%	71.43%
7b/30	15000 acft each season; 30% storage constraint	70.00%	81.43%	51.43%
7b/40	15000 acft each season; 40% storage constraint	68.57%	80.00%	45.71%
8b/30	29K/29K/4K acft each season; 30% storage constraint	61.43%	75.71%	75.71%
8b/40	29K/29K/4K acft each season; 40% storage constraint	61.43%	74.29%	71.43%
9b/30	15K/15K/4K acft each season; 30% storage constraint	70.00%	81.43%	75.71%
9b/40	15K/15K/4K acft each season; 40% storage constraint	68.57%	80.00%	71.43%
10b/30	23K/23K/4K acft each season; 30% storage constraint	62.86%	80.00%	75.71%
10b/40	23K/23K/4K acft each season; 40% storage constraint	62.86%	78.57%	71.43%

SEASONAL ATTAINMENT FREQUENCIES

- Summer has higher AF
- Winter topped out?
- Lower Targets = Higher Attainment
- Small differences in the 30 – 40% triggers



SCENARIO BUILDING – NEXT STEPS / REFINEMENT

» SMART Inflow Management for Bay
  - Refine the seasonal targets
  - Look at a stepped approach
    » Big target above 70%
    » Medium target below 70% above 40%
    » Small target below 40% above 30%
    » No target below 30%
  - Discussion

SCENARIO DISCUSSION

Appendix D – SMART Inflow Meeting on 6-4-14

SMART Inflow Management Modeling Meeting

Meeting Notes

Date: June 4, 2014
Time: 9:00 am to 12:00 pm
Location: Nueces Delta Preserve

List of Attendees:

Person	Affiliation	Email
Jace Tunnell	Coastal Bend Bays & Estuaries Program	jtunnell@cbbep.org
Ray Allen	Coastal Bend Bays & Estuaries Program	rallen@cbbep.org
Jake Herring	Coastal Bend Bays & Estuaries Program	jherring@cbbep.org
Cory Shockley	HDR Engineering	Cory.shockley@hdrinc.com
Christian Braneon	HDR Engineering	Christian.braneon@hdrinc.com
Con Mims	Nueces River Authority	cmims@nueces-ra.org
Rocky Freund	Nueces River Authority	rfreund@nueces-ra.org
Brent Clayton	City of Corpus Christi	brentc@cctexas.com
Bill Green	City of Corpus Christi	billg@cctexas.com
Wesley Nebgen	City of Corpus Christi	wesleyN@cctexas.com
Junji Matsumoto	Texas Water Development Board	jmatsumo@twdb.texas.gov
Paul Carangelo	Port of Corpus Christi Authority	paul@pocca.com
Erin Hill	Center for Coastal Studies	Erin.hill@tamucc.edu
Brien Nicolau	Center for Coastal Studies	Brien.Nicolau@tamucc.edu
Bruce Moulton		bmoulton@austin.rr.com
Terry Palmer	Harte Research Institute	Terry.palmer@tamucc.edu
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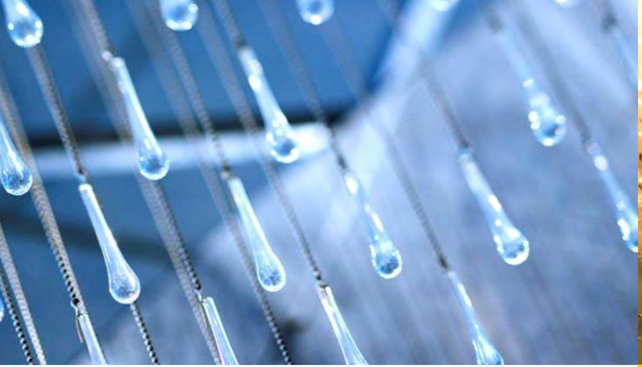
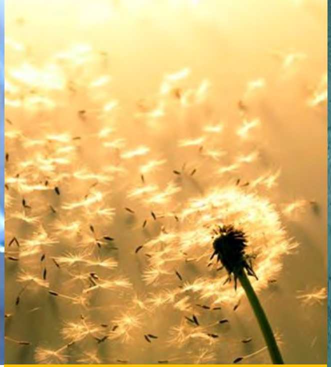




SALINITY MONITORING AND REAL TIME (SMART) INFLOW MANAGEMENT IN NUECES DELTA AND BAY

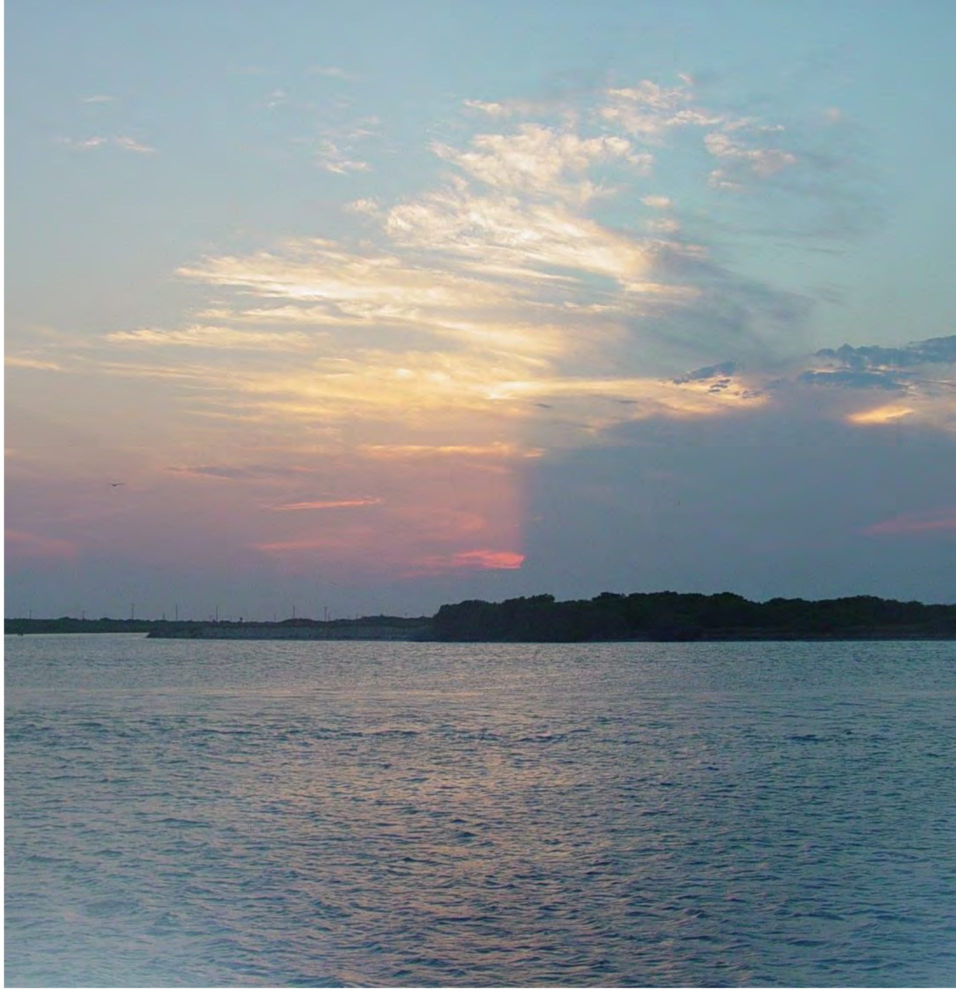
Cory Shockley, PE – HDR

Christian Braneon, EIT, PhD – HDR

June 4, 2014

TOPICS

» Project Background / Goals
» Scenario Results
» Scenario Refinement / Discussion



PROJECT BACKGROUND / GOALS

» Project Background
  - Project concept from 2012 Nueces BBASC Work Plan
  - Funded in September 2013 by CBBEP through TCEQ 604b funds
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  - Final Report due August 31, 2014

» Project Goals
  - Evaluate SMART Inflow Management
    - » Quantify changes to FWI to Nueces Delta and Bay
    - » Quantify Impacts to Safe Yield of Water Supply System

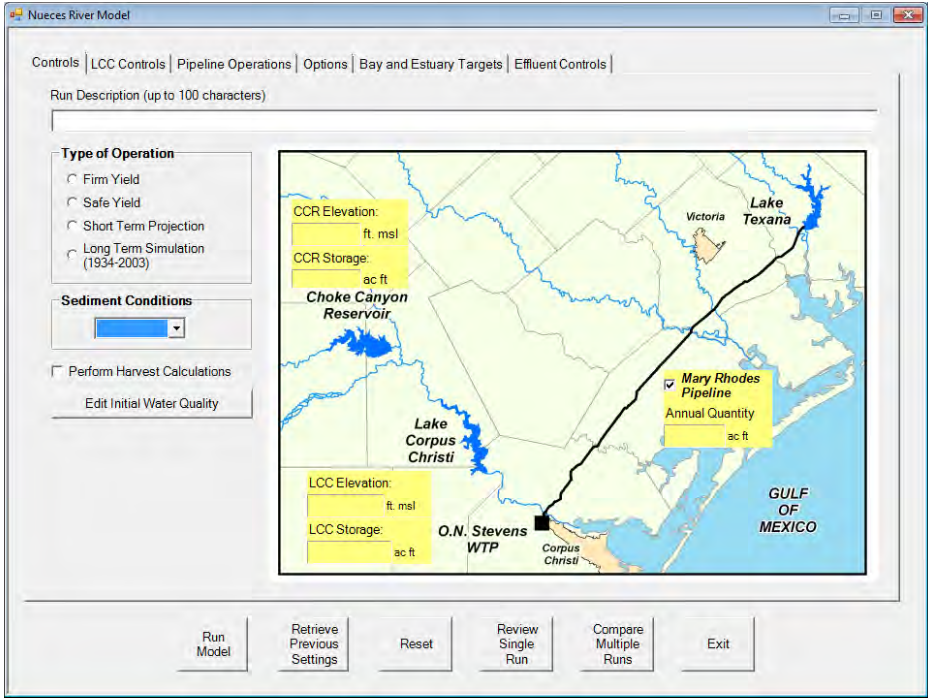
» Starting Point
  - Delta – Nueces Inflow Release Program (NIRP)
  - Bay – Seasonal Pulse Components

SCENARIO BUILDING

» Modeling Assumptions
  • 2020 Estimated Sediment Conditions
  • Safe Yield with 125,000 acft Storage Reserve
  • Others consistent with Regional Planning

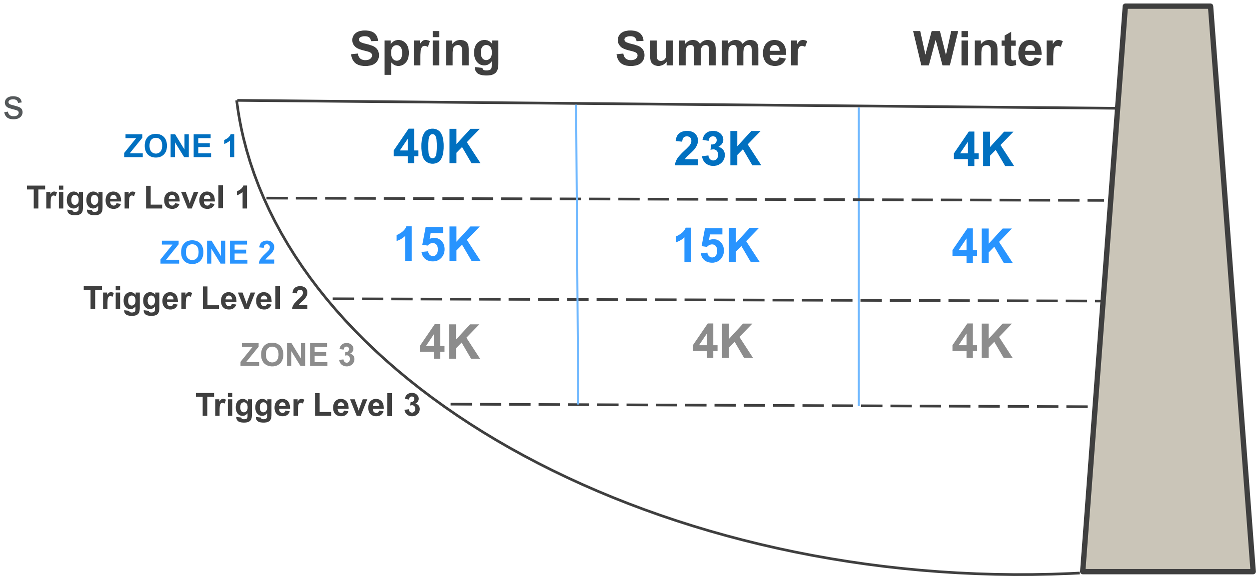
» 30 Scenarios
  • Stepped Approach runs
  • Varied triggers/targets

» Results
  • Yields
  • Bay Inflows
  • Attainment Frequencies



SCENARIO RESULTS – STEPPED APPROACH

» 24 Scenarios
  • Varied storage trigger levels
    » 50% - 40% - 30%
    » 75% - 50% - 40%
    » 70% - 50% - 35%
    » 70% - 50% - 30%
    » 70% - 40% - 30%
    » 70% - 50%
  • Varied seasonal targets



» Key Findings
  • Multiple trigger/target combinations achieve similar yields
  • Higher spring targets (i.e. > 30K) are achievable without reducing yield
  • Minimum flow to the bay can be enhanced without compromising yield

SCENARIO RESULTS FOR GROUP A – STEPPED APPROACH

Scenario	Description	Target/ Trigger Level 1	Target/ Trigger Level 2	Target/ Trigger Level 3	Return Flows (acft)	Safe Yield (acft)	QBAY1 Annual (acft)		
							AVG	Median	MIN
0ab	B & E Order; *Mary Rhodes Pipeline II; No RF				0	219,143	387,680	167,051	1,923
11	3 storage trigger levels; Varied flow targets	29-29-4/50	15-15-4/40	4-4-4/30	0	214,651	390,764	173,012	3,932
12	3 storage trigger levels; Varied flow targets	29-23-4/50	23-15-4/40	4-4-4/30	0	215,712	389,798	169,490	3,932
13	3 storage trigger levels; Varied flow targets	29-23-4/50	23-23-4/40	4-4-4/30	0	215,712	389,812	166,181	3,932
14	4 storage trigger levels; Varied flow targets	29-29-4/75	23-23-4/50	15-15-4/40	0	213,001	392,293	172,269	11,456
11b	3 storage trigger levels; Varied flow targets	29-29-4/70	15-15-4/40	4-4-4/30	0	217,935	387,960	169,261	3,932
11c	3 storage trigger levels; Varied flow targets	23-23-4/50	15-15-4/40	4-4-4/30	0	219,550	386,320	164,722	3,932
11d	3 storage trigger levels; Varied flow targets	29-29-4/70	15-4-4/40	4-4-4/30	0	220,568	385,663	165,922	3,932

SCENARIO RESULTS FOR GROUP B – STEPPED APPROACH

Scenario	Description	Target/ Trigger Level 1	Target/ Trigger Level 2	Target/ Trigger Level 3	Return Flows (acft)	Safe Yield (acft)	QBAY1 Annual (acft)		
							AVG	Median	MIN
0ab	B & E Order; *Mary Rhodes Pipeline II; No RF				0	219,143	387,680	167,051	1,923
11e	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/40	4-4-4/30	0	216,184	389,667	170,313	3,932
11f	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/50	4-4-4/35	0	217,272	388,689	169,222	123
11g	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/50	2-2-2/30	0	217,851	388,171	168,234	2,039
11h	3 storage trigger levels; Varied flow targets	40-29-4/70	15-15-4/50	2-2-2/35	0	218,394	387,708	167,690	123
11i	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	2-2-2/35	0	221,355	385,301	164,728	123
11j	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/35	0	220,232	386,279	166,259	123
11k	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/30	0	219,147	387,257	167,344	3,932
11l	3 storage trigger levels; Varied flow targets	40-23-4/70	19-19-4/50	4-4-4/30	0	218,239	388,062	168,253	3,932
11m	3 storage trigger levels; Varied flow targets	40-23-4/70	19-19-4/50	4-4-4/35	0	219,325	386,910	167,166	123
11n	3 storage trigger levels; Varied flow targets	40-23-15/70	19-19-15/50	4-4-4/35	0	213,766	392,385	170,920	123
11o	3 storage trigger levels; Varied flow targets	40-23-15/70	19-19-4/50	4-4-4/35	0	216,365	390,114	168,438	123
11p	3 storage trigger levels; Varied flow targets	40-19-12/70	19-19-4/50	4-4-4/35	0	218,855	387,719	167,636	123
11q	3 storage trigger levels; Varied flow targets	40-19-11/70	19-19-4/50	4-4-4/35	0	219,235	387,331	167,256	123
11r	3 storage trigger levels; Varied flow targets	45-19-11/70	19-19-4/50	4-4-4/35	0	218,397	388,214	166,314	123
11s	3 storage trigger levels; Varied flow targets	40-19-11/70	24-19-4/50	4-4-4/35	0	217,942	388,518	168,038	123
11t	3 storage trigger levels; Varied flow targets	40-19-11/70	19-19-11/50	4-4-4/35	0	218,584	388,518	168,038	123
15	2 storage trigger levels; Varied flow targets	40-19-11/70	19-15-4/50	n/a	0	221,476	385,372	163,418	123

SELECTED SCENARIO RESULTS – STEPPED APPROACH

Scenario	Description	Target/ Trigger Level 1	Target/ Trigger Level 2	Target/ Trigger Level 3	Return Flows (acft)	Safe Yield (acft)	QBAY1 Annual (acft)		
							AVG	Median	MIN
0ab	B & E Order; *Mary Rhodes Pipeline II; No RF				0	219,143	387,680	167,051	1,923
11c	3 storage trigger levels; Varied flow targets	23-23-4/50	15-15-4/40	4-4-4/30	0	219,550	386,320	164,722	3,932
11d	3 storage trigger levels; Varied flow targets	29-29-4/70	15-4-4/40	4-4-4/30	0	220,568	385,663	165,922	3,932
11i	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	2-2-2/35	0	221,355	385,301	164,728	123
11j	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/35	0	220,232	386,279	166,259	123
11k	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/30	0	219,147	387,257	167,344	3,932
11m	3 storage trigger levels; Varied flow targets	40-23-4/70	19-19-4/50	4-4-4/35	0	219,325	386,910	167,166	123
11q	3 storage trigger levels; Varied flow targets	40-19-11/70	19-19-4/50	4-4-4/35	0	219,235	387,331	167,256	123
15	2 storage trigger levels; Varied flow targets	40-19-11/70	19-15-4/50	n/a	0	221,476	385,372	163,418	123

SCENARIO RESULTS – DETAILED RESULTS

Scenario	Description	Target/ Trigger Level 1	Target/ Trigger Level 2	Target/ Trigger Level 3	Return Flows (acft)	Safe Yield (acft)	QBAY1 Annual (acft)		
							AVG	Median	MIN
0ab	B & E Order; *Mary Rhodes Pipeline II; No RF				0	219,143	387,680	167,051	1,923
11d	3 storage trigger levels; Varied flow targets	29-29-4/70	15-4-4/40	4-4-4/30	0	220,568	385,663	165,922	3,932
11k	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/30	0	219,147	387,257	167,344	3,932
15	2 storage trigger levels; Varied flow targets	40-19-11/70	19-15-4/50	n/a	0	221,476	385,372	163,418	123

» Key Variables - Seasonal Targets

- Spring Targets
  - » 40K vs 29K – Zone 1
  - » 19K vs 15K – Zone 2
- Summer Targets
  - » 29K vs 23K vs 19K – Zone 1
  - » 15K vs 4K – Zone 2
- Winter Targets
  - » 11K vs 4K – Zone 1
  - » 4K vs No target – Zone 3

» Key Variables - Levels

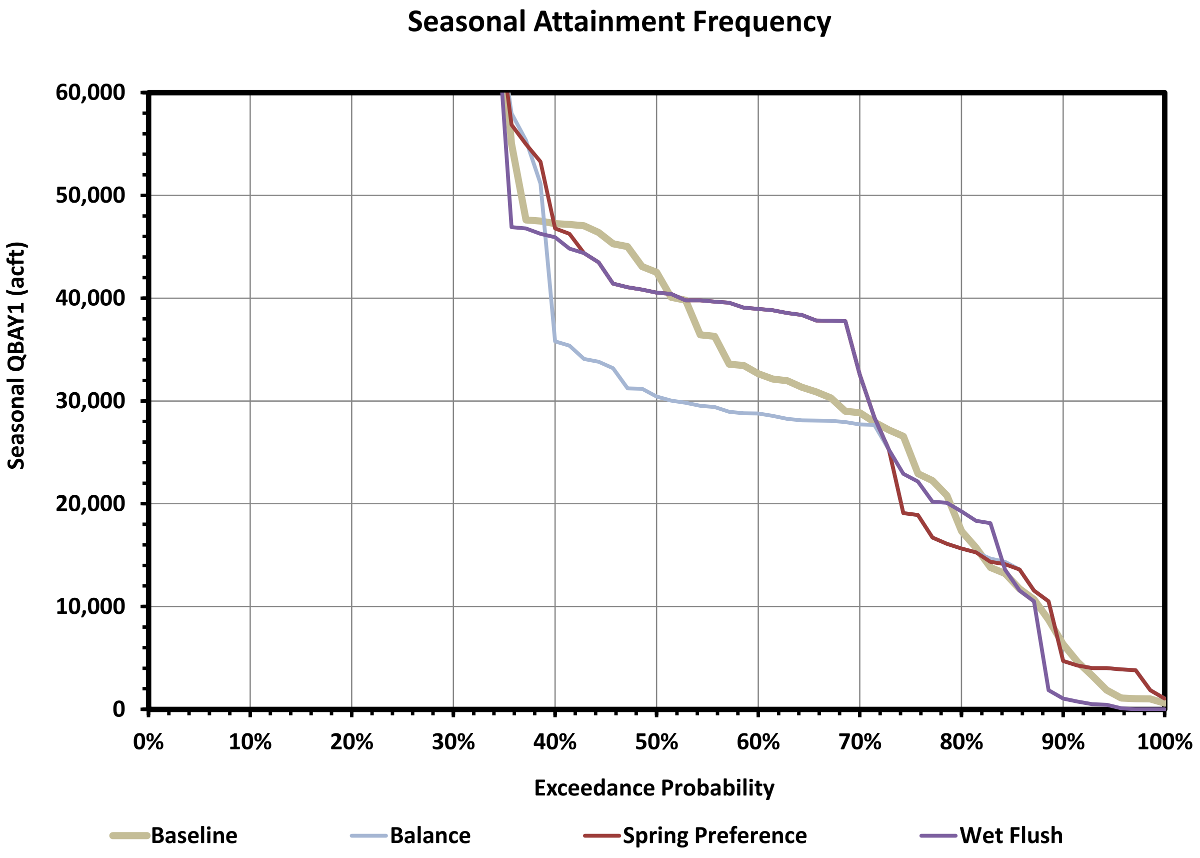
- Trigger Level 2
  - » 50% vs 40%
- Trigger Level 3
  - » 30% vs No Trigger Level

» Scenario Descriptions

- 0ab – Baseline
  - » Current SY
- 11d – Balance
  - » 3 Zones
  - » Fairly balanced seasons
- 11k – Spring Preference
  - » 3 Zones
  - » Higher spring targets (Zone 1)
- 15 – Wet Flush
  - » 2 Zones
  - » Highest Zone 1 targets

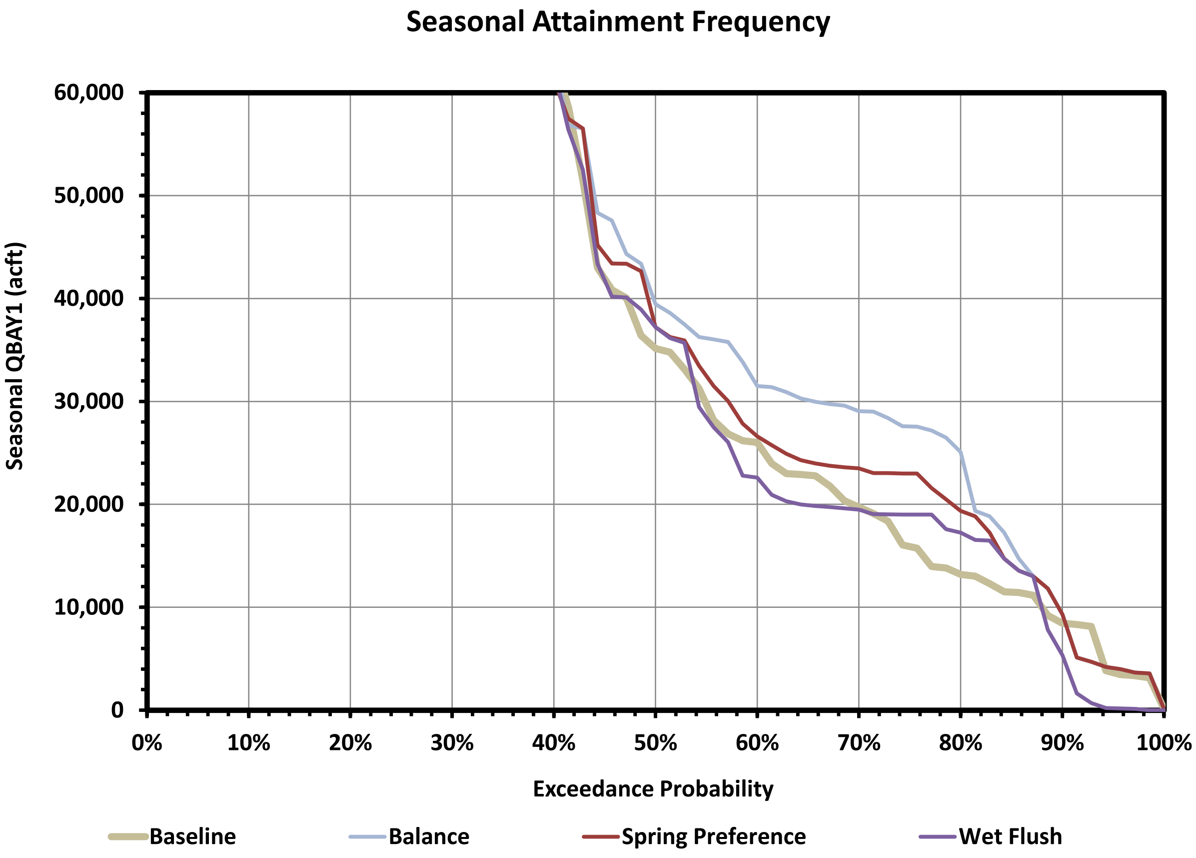
SEASONAL ATTAINMENT – SPRING

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	15,000 – 40%	4,000 – 30%
Spring Preference	40,000 – 70%	15,000 – 50%	4,000 – 30%
Wet Flush	40,000 – 70%	19,000 – 50%	-



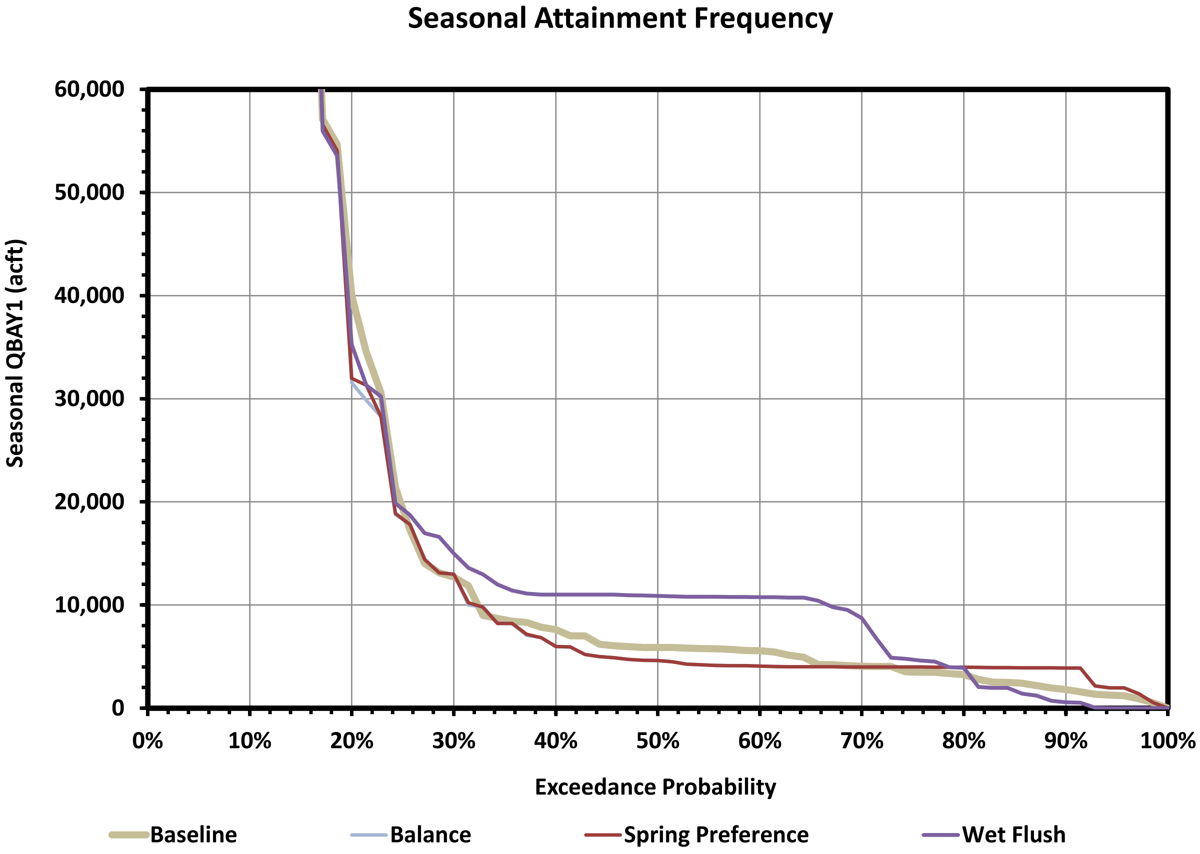
SEASONAL ATTAINMENT – SUMMER

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	4,000 – 40%	4,000 – 30%
Spring Preference	23,000 – 70%	15,000 – 50%	4,000 – 30%
Wet Flush	19,000 – 70%	15,000 – 50%	-

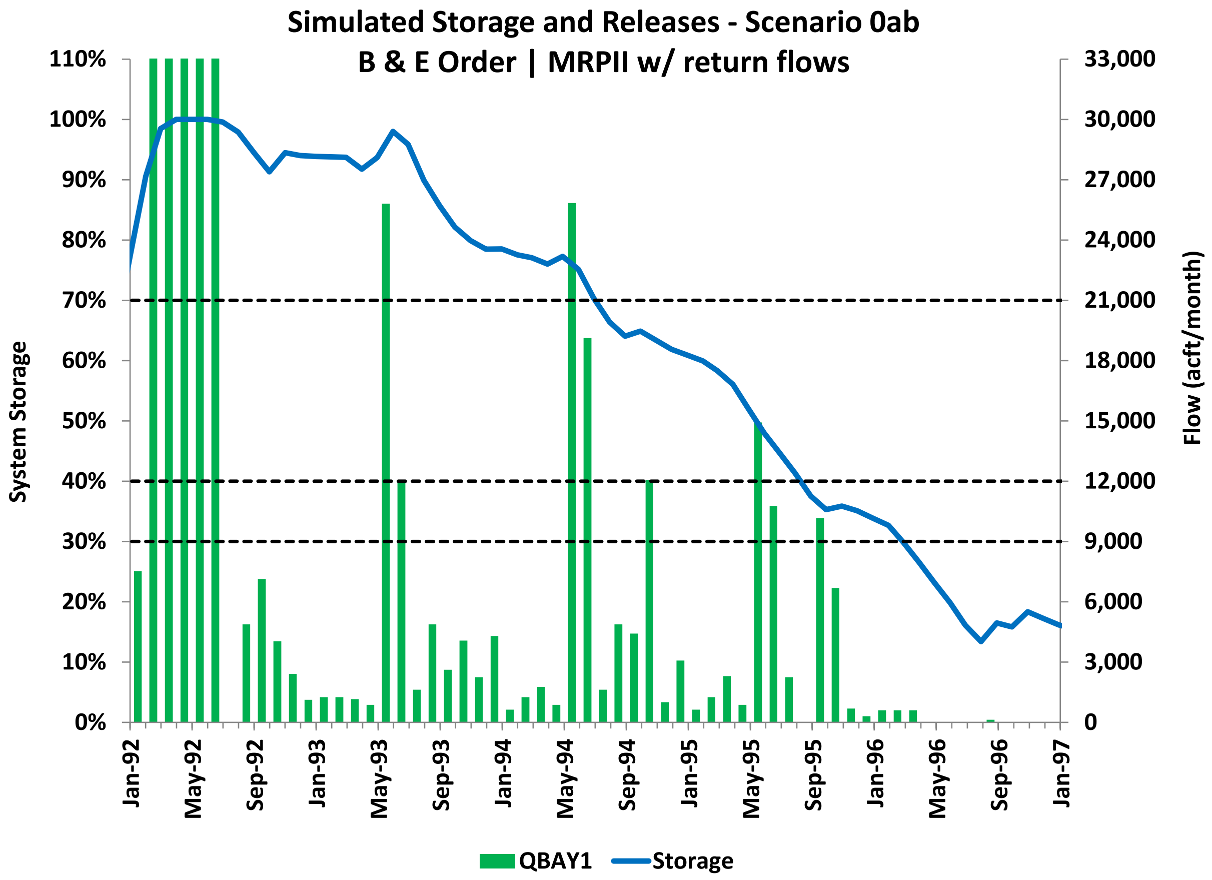


SEASONAL ATTAINMENT – WINTER

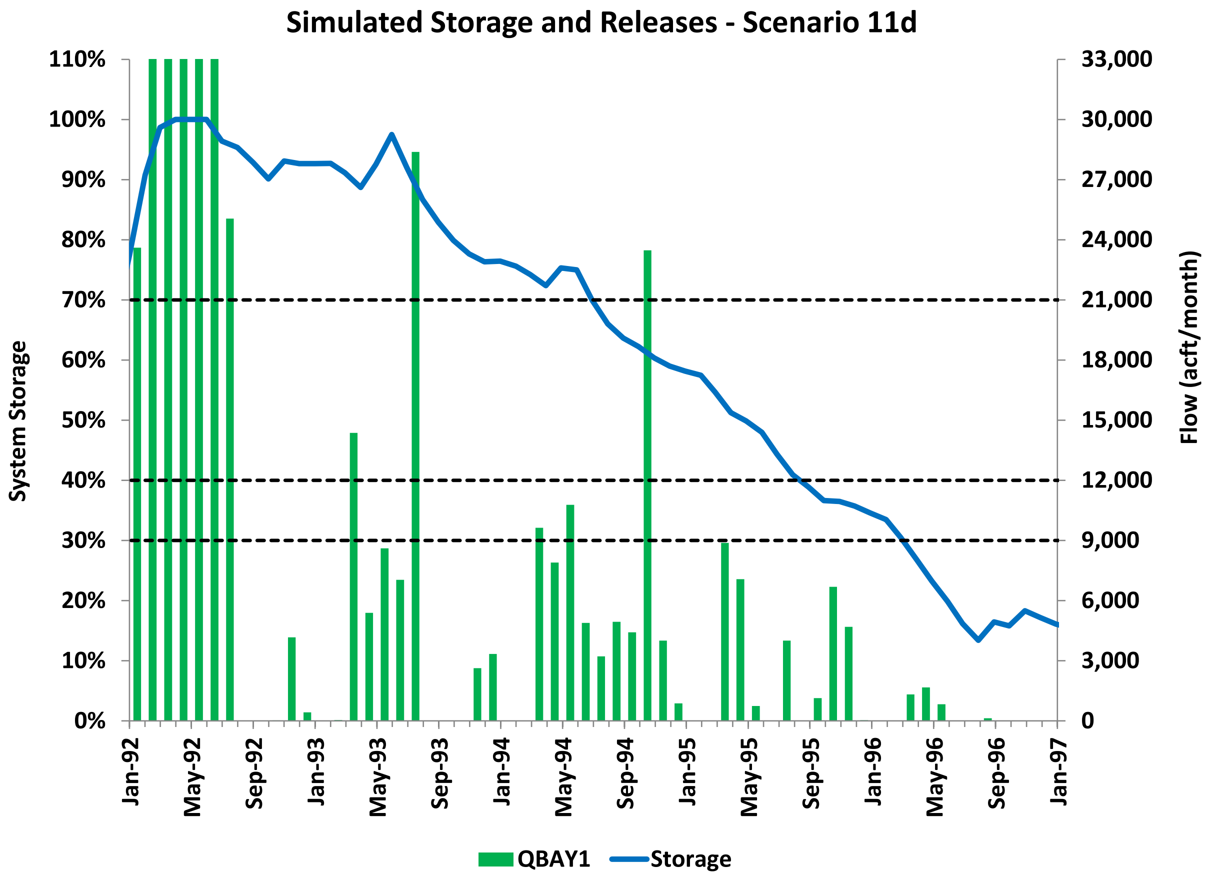
Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	4,000 – 70%	4,000 – 40%	4,000 – 30%
Spring Preference	4,000 – 70%	4,000 – 50%	4,000 – 30%
Wet Flush	11,000 – 70%	4,000 – 50%	-



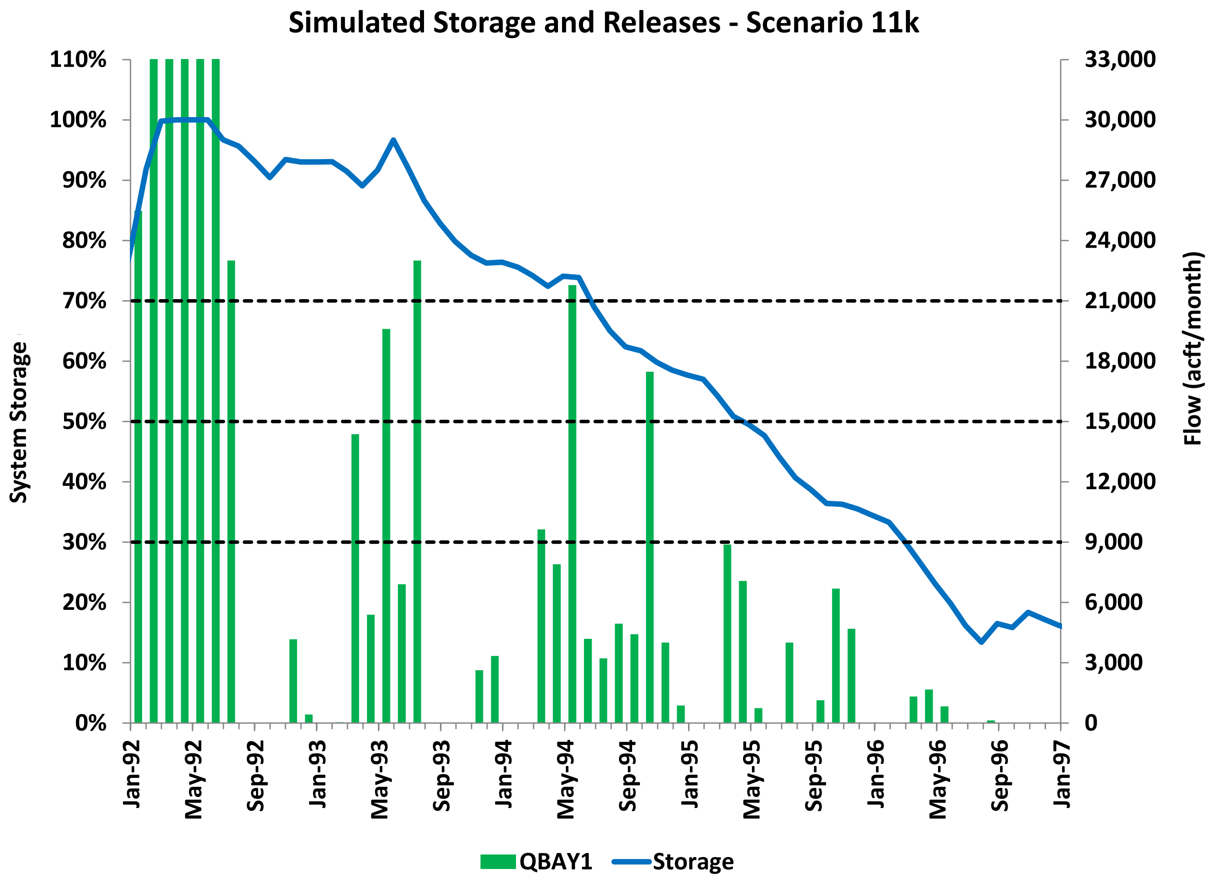
SCENARIO RESULTS FOR SCENARIO 0AB-BASELINE



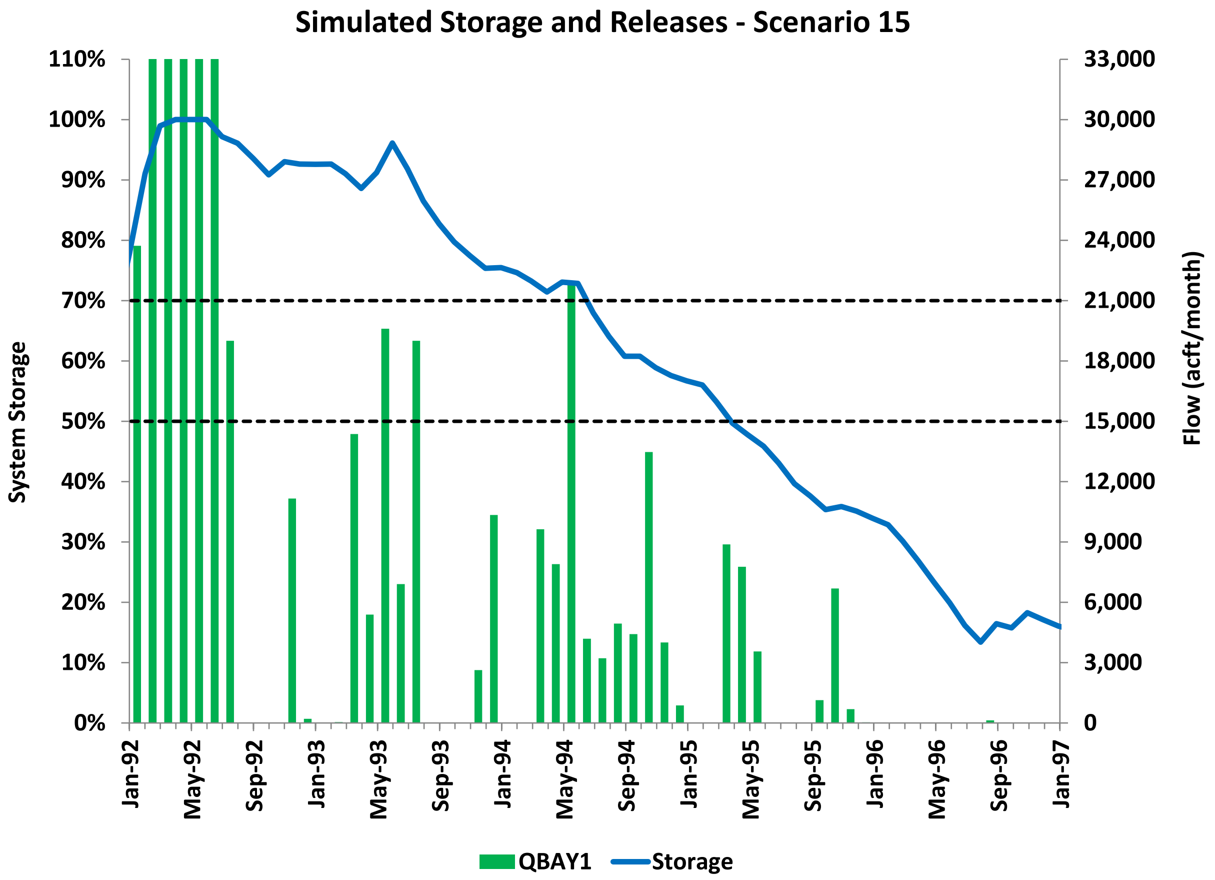
SCENARIO RESULTS FOR SCENARIO 11D-BALANCE



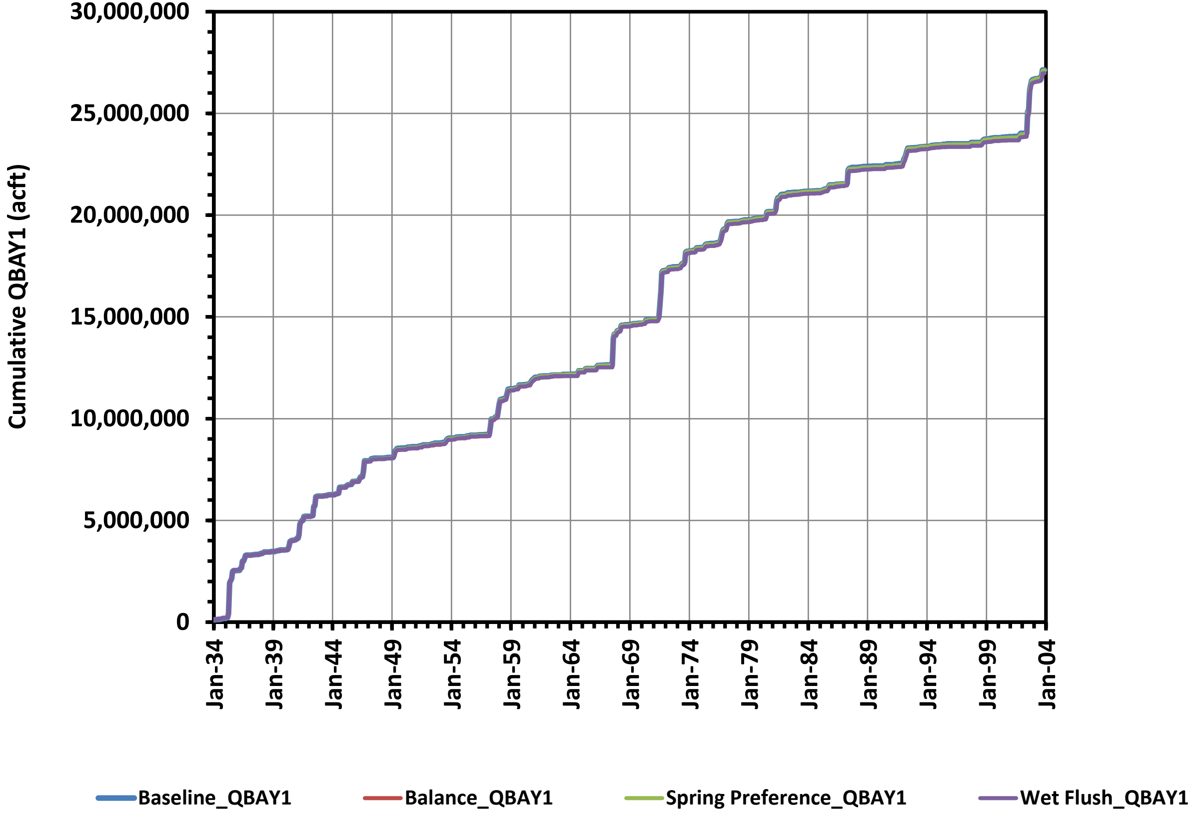
SCENARIO RESULTS FOR SCENARIO 11K-SPRING PREFERENCE



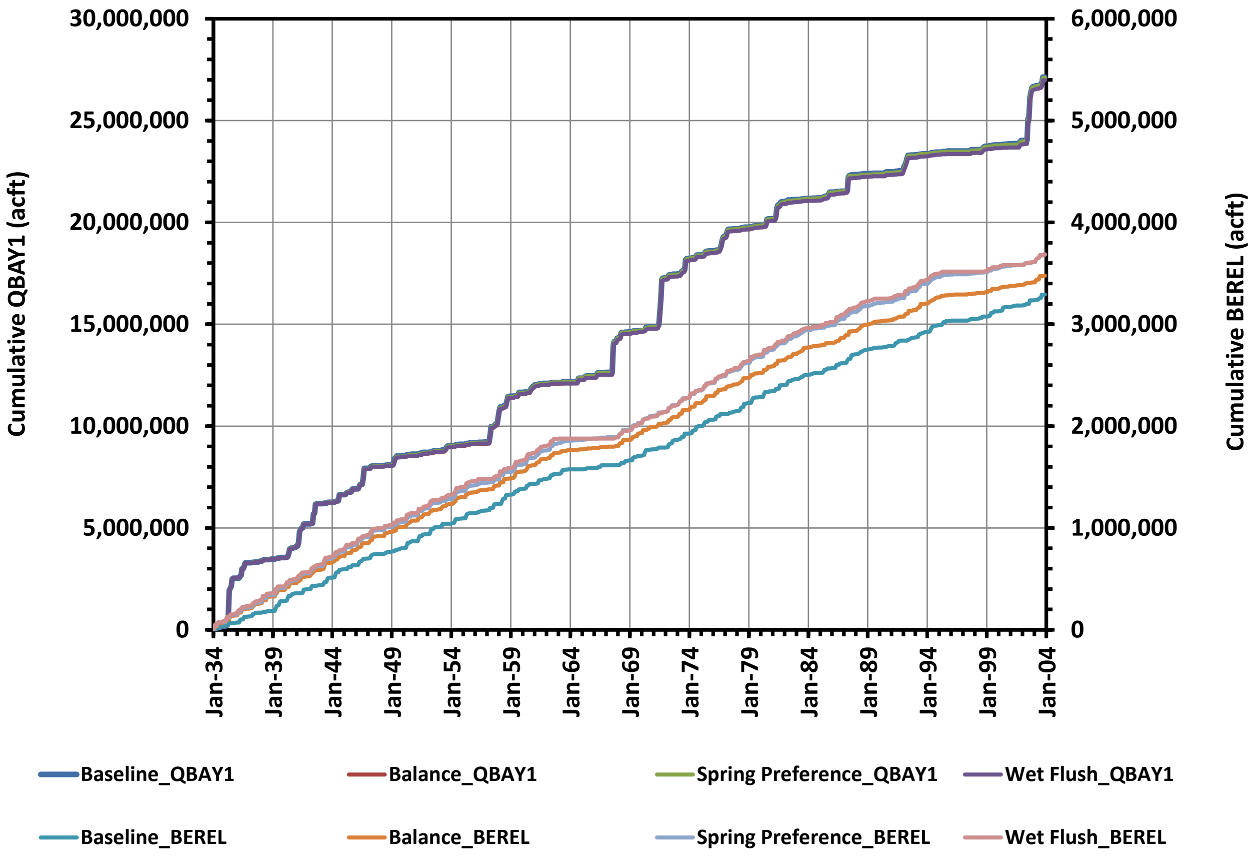
SCENARIO RESULTS FOR SCENARIO 15-WET FLUSH



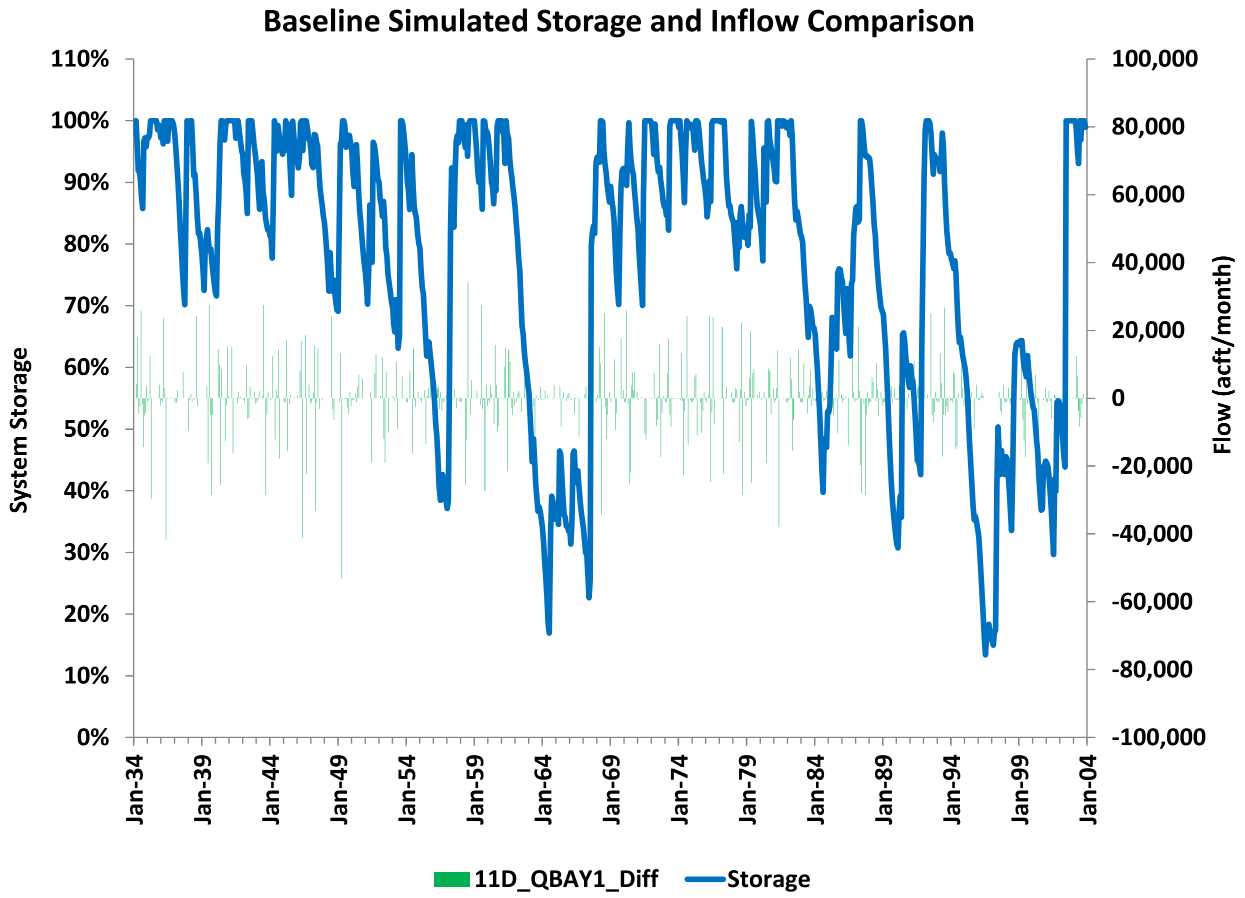
CUMULATIVE BAY INFLOW COMPARISON



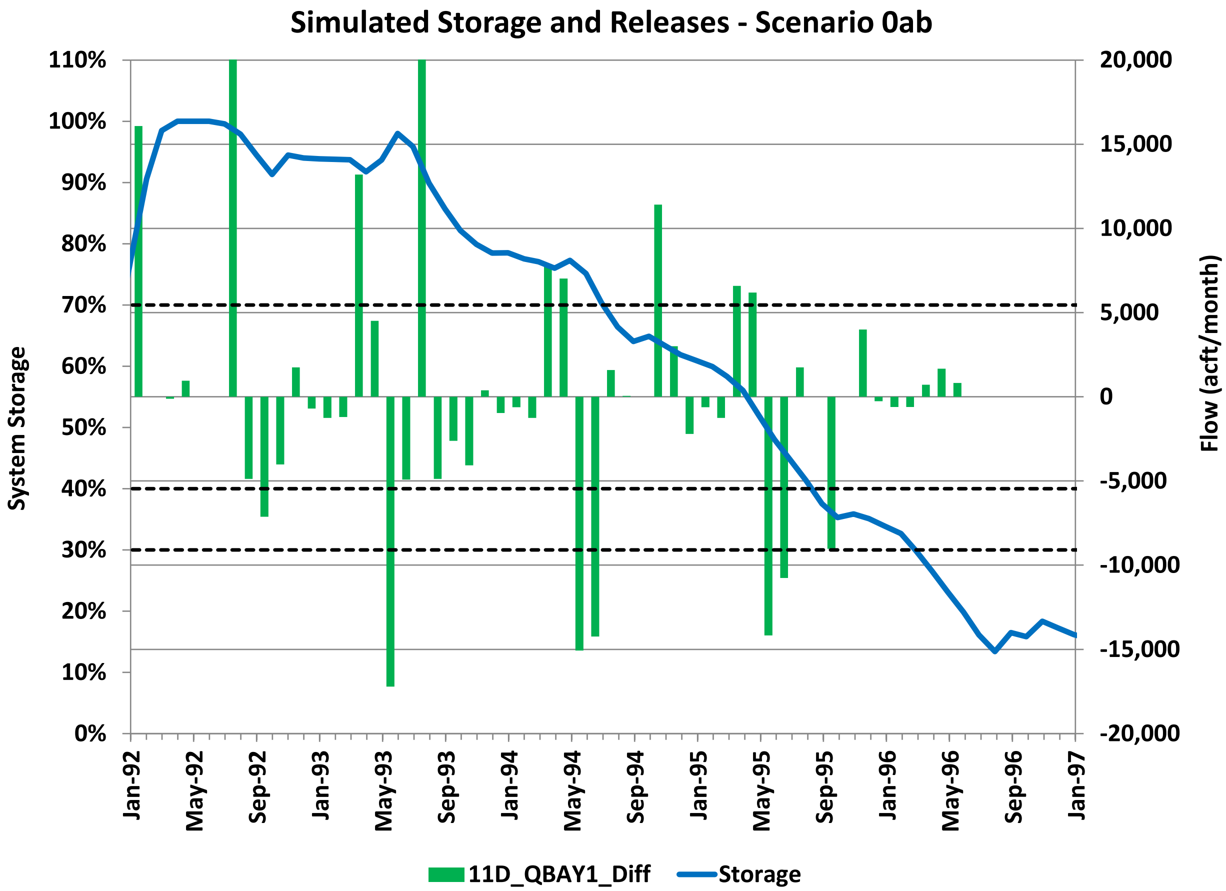
CUMULATIVE BEREL & BAY INFLOW COMPARISON



QBAY DELTA - TIME SERIES



QBAY DELTA – DROUGHT TIME SERIES

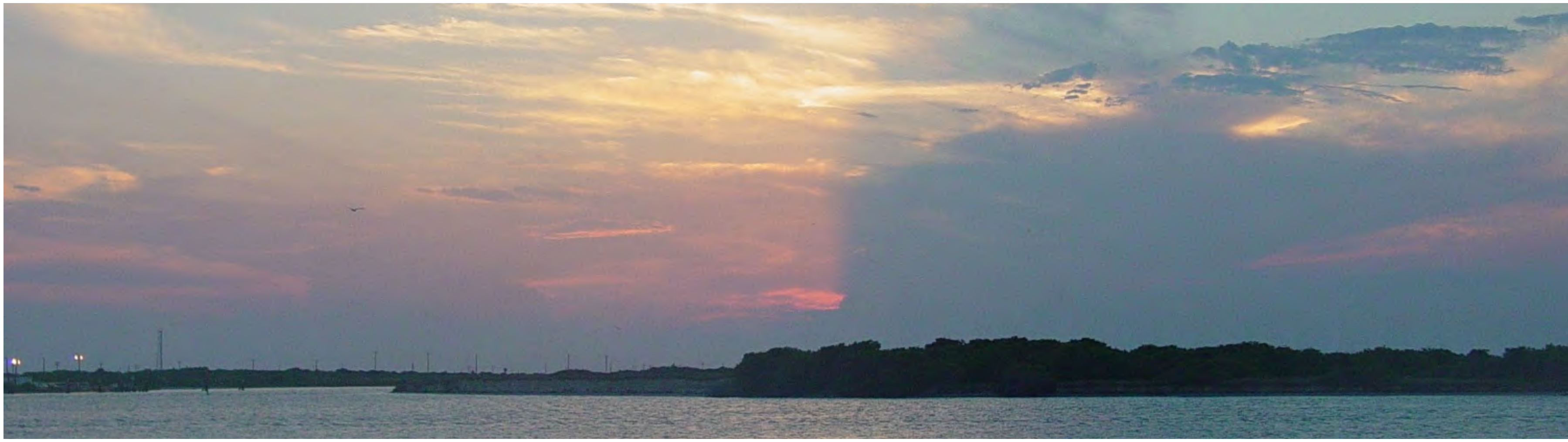


SCENARIO BUILDING – NEXT STEPS / REFINEMENT

» SMART Inflow Management for Bay
- Opportunities to use SMART Inflow Management exist
  » No decrease to safe yield
  » Modified attainment frequencies
  » Changes inflow regime compared to Order
- Does change in flow regime equal increased biologic productivity?
  » Is change better?
  » Long-term, similar results to the Order
  » Short-term, critical times may be the difference

SCENARIO DISCUSSION

Appendix E – SMART Inflow Meeting on 6-16-14



SMART INFLOW MANAGEMENT – MODELING ANALYSES

NEAC – JUNE 16, 2014
CORY SHOCKLEY

DISCUSSION

Background

Goals

Analysis & Results

Conclusions / Next Steps

BACKGROUND

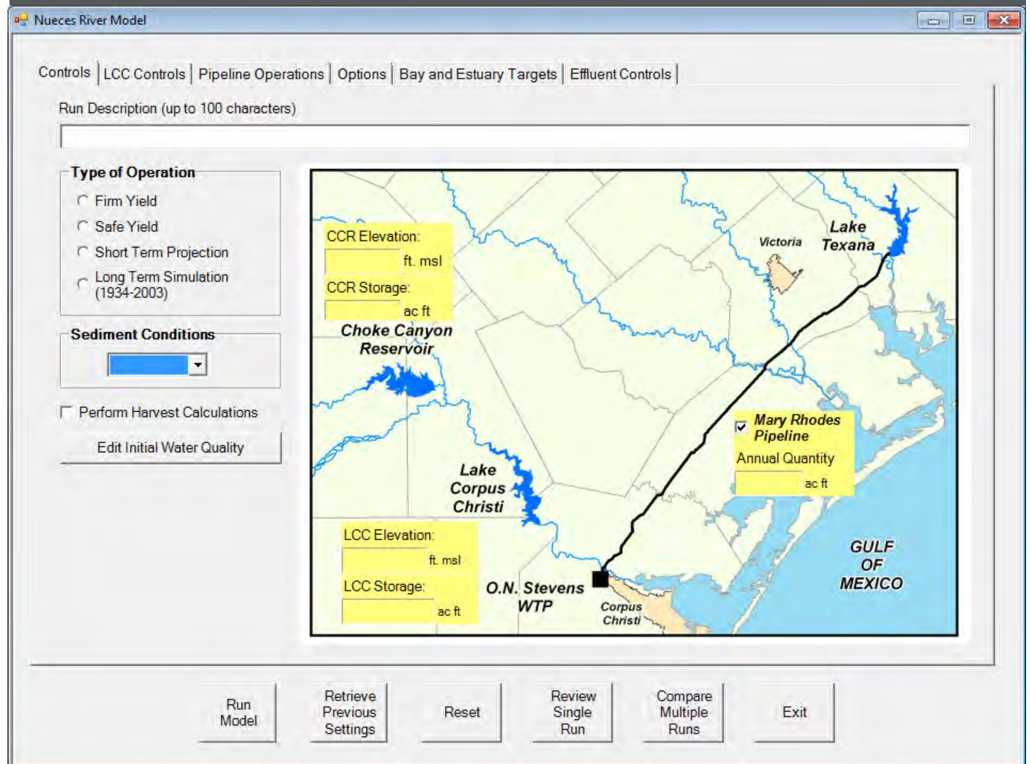
- Project concept from 2012 Nueces BBASC Work Plan
- Funded in September 2013 by CBBEP through TCEQ 604b funds
- Quality Assurance Project Plan (QAPP) developed and approved in February 2014
- Final report due August 31, 2014

GOALS

- Evaluate SMART Inflow Management
- Quantify changes to Freshwater Inflows (FWI) to Nueces Delta and Bay
- Quantify impacts to Safe Yield of water supply system

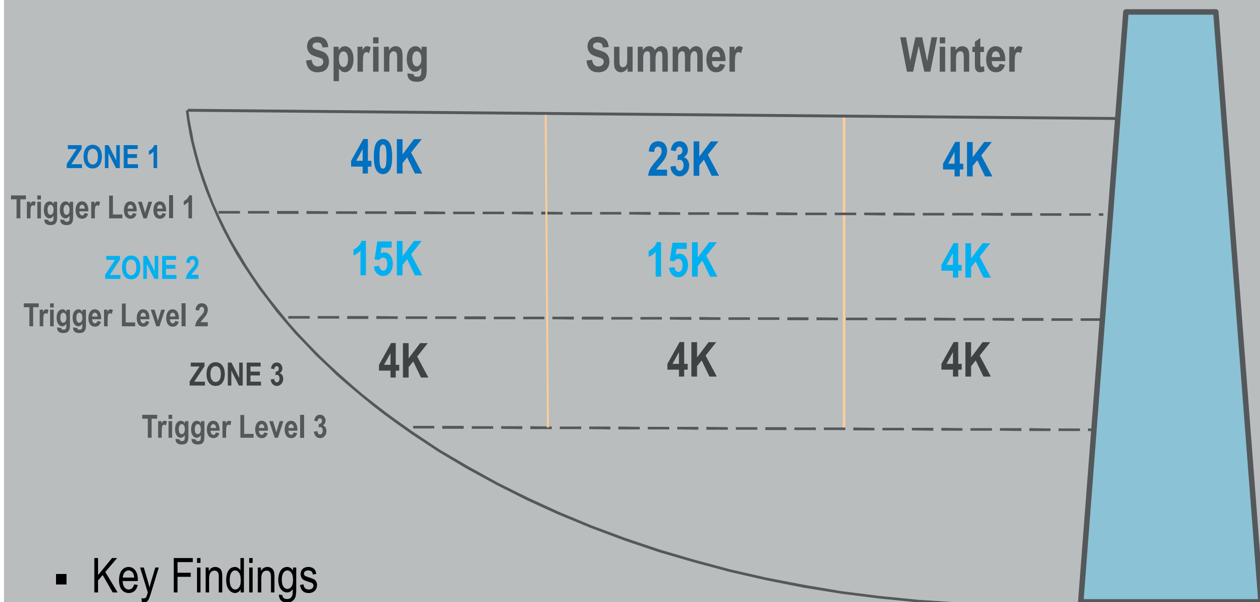
ANALYSIS

- Evaluate SMART Inflow Management
  - Using Corpus Christi Water Supply Model (CCWSM)
  - Delta – Nueces Inflow Release Program (NIRP)
  - Bay – seasonal pulse components
- Results
  - Yields & FWI
- Modeling Assumptions
  - 2020 estimated sediment conditions
  - Safe Yield with 125,000 acft storage reserve
  - Others consistent with Regional Planning
  - MRP II; No Return Flows (5.35 MGD to Bay)



ANALYSIS

- Targets
  - Seasonal volumes
  - Three 4-month seasons
- Triggers
  - Specific system storage levels
  - 70% - 40% - 30%
- Zones
  - System storage between triggers
  - Targets determined by system storage on 1st day of season



- Key Findings
  - Seasonal targets provide more opportunity for pass-throughs
  - Multiple trigger/target combinations achieve similar yields
  - Higher spring targets (i.e. > 30K) are achievable without reducing yield
  - Minimum flow to the bay can be enhanced without compromising yield

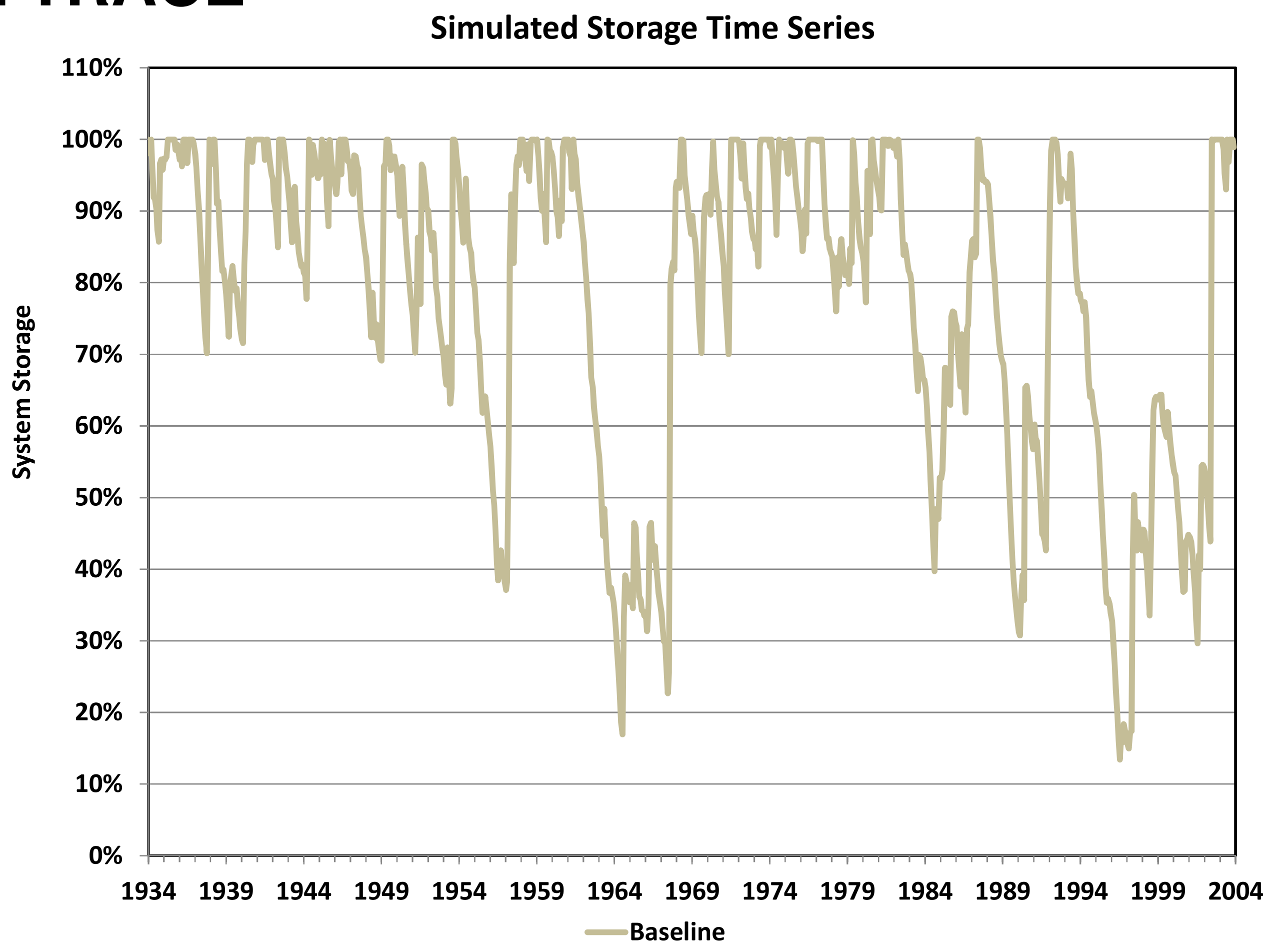
RESULTS

- Over 30 scenarios evaluated
  - 8 resulted in yields greater than Safe Yield
  - 3 summarized in detail

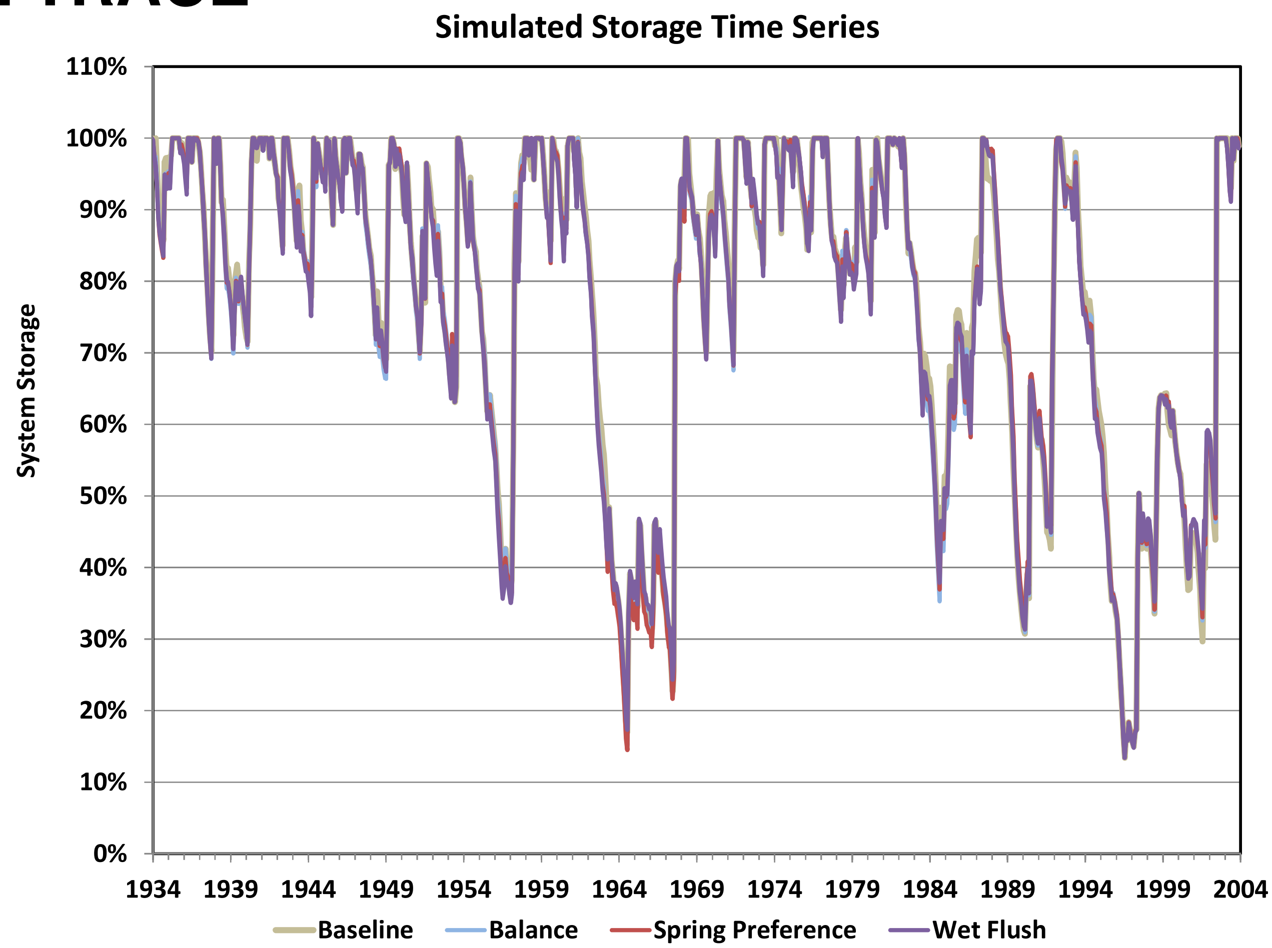
Scenario	Description	Target/ Trigger Level 1	Target/ Trigger Level 2	Target/ Trigger Level 3	Return Flows (acft)	Safe Yield (acft)	QBAY1 Annual (acft)		
							AVG	Median	MIN
0ab	B & E Order; *Mary Rhodes Pipeline II; No RF				0	219,143	387,680	167,051	1,923
11d	3 storage trigger levels; Varied flow targets	29-29-4/70	15-4-4/40	4-4-4/30	0	220,568	385,663	165,922	3,932
11k	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/30	0	219,147	387,257	167,344	3,932
15	2 storage trigger levels; Varied flow targets	40-19-11/70	19-15-4/50	n/a	0	221,476	385,372	163,418	123

Scenario	Description	Safe Yield (acft/yr)
Oab	Baseline	219,143
11d	Balance	220,568
11k	Spring Preference	219,147
15	Wet Flush	221,476

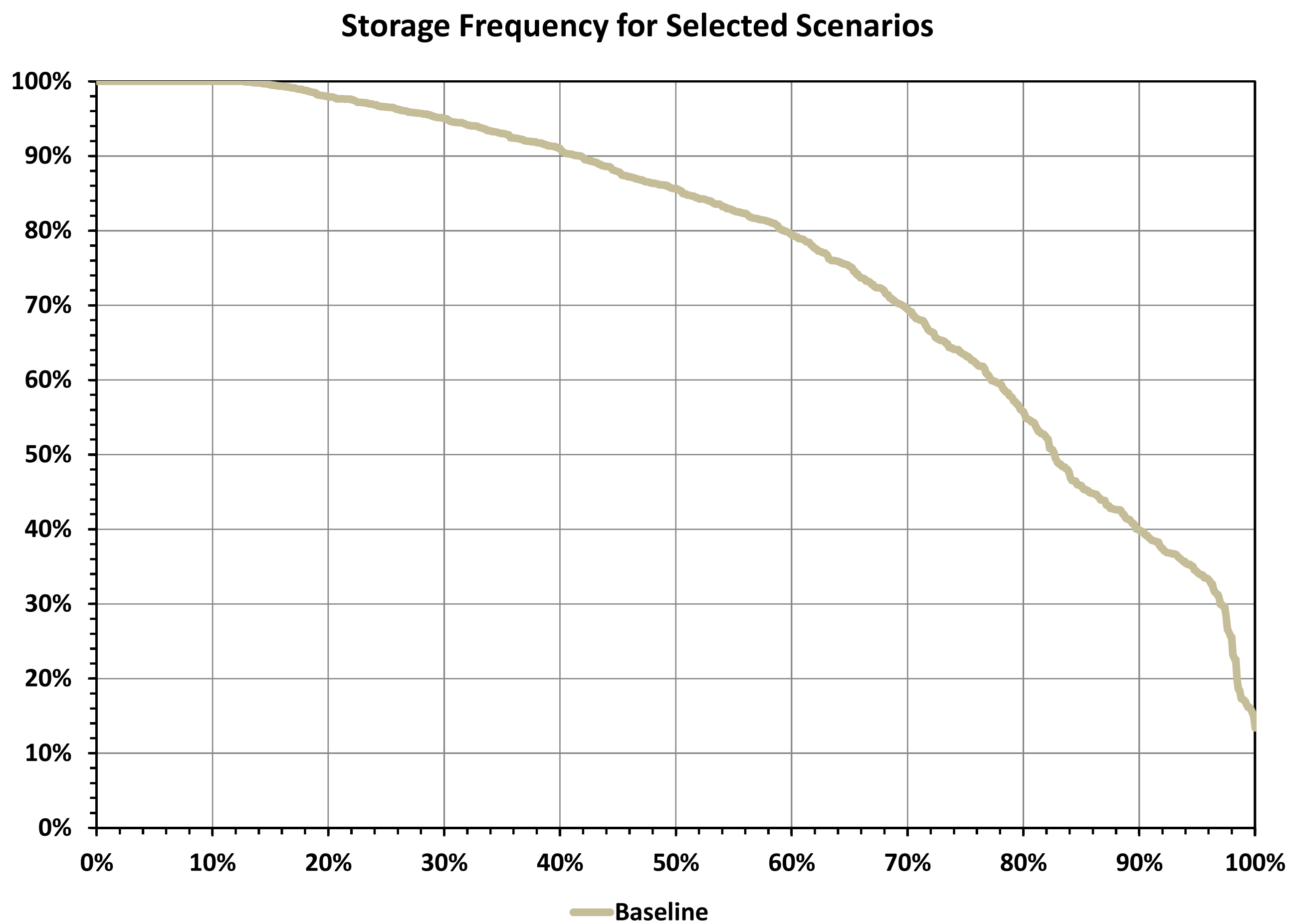
RESULTS – TIME SERIES STORAGE TRACE



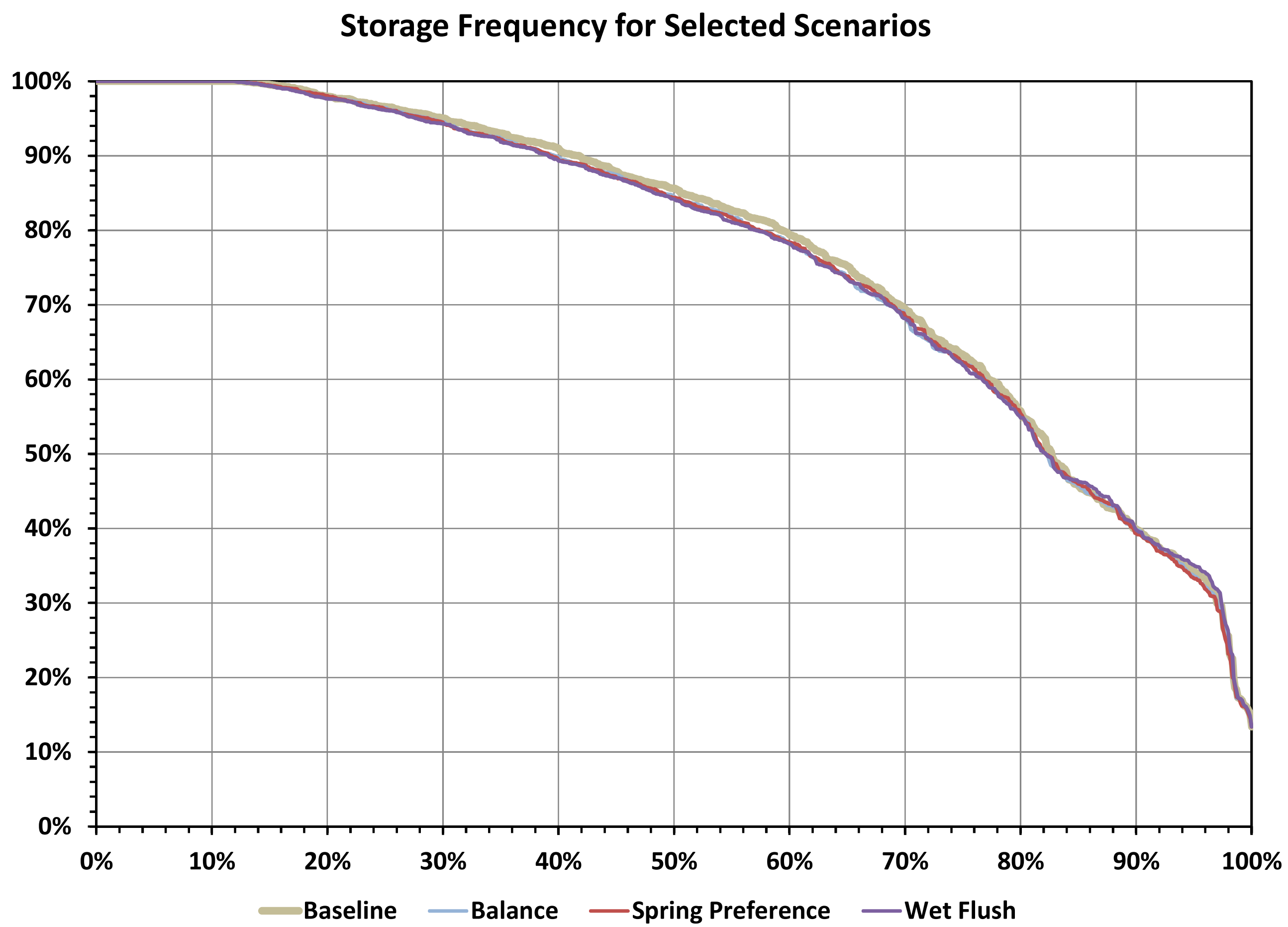
RESULTS – TIME SERIES STORAGE TRACE



RESULTS – FREQUENCY STORAGE TRACE



RESULTS – FREQUENCY STORAGE TRACE



SEASONAL ATTAINMENT – SPRING

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	15,000 – 40%	4,000 – 30%
Spring Preference	40,000 – 70%	15,000 – 50%	4,000 – 30%
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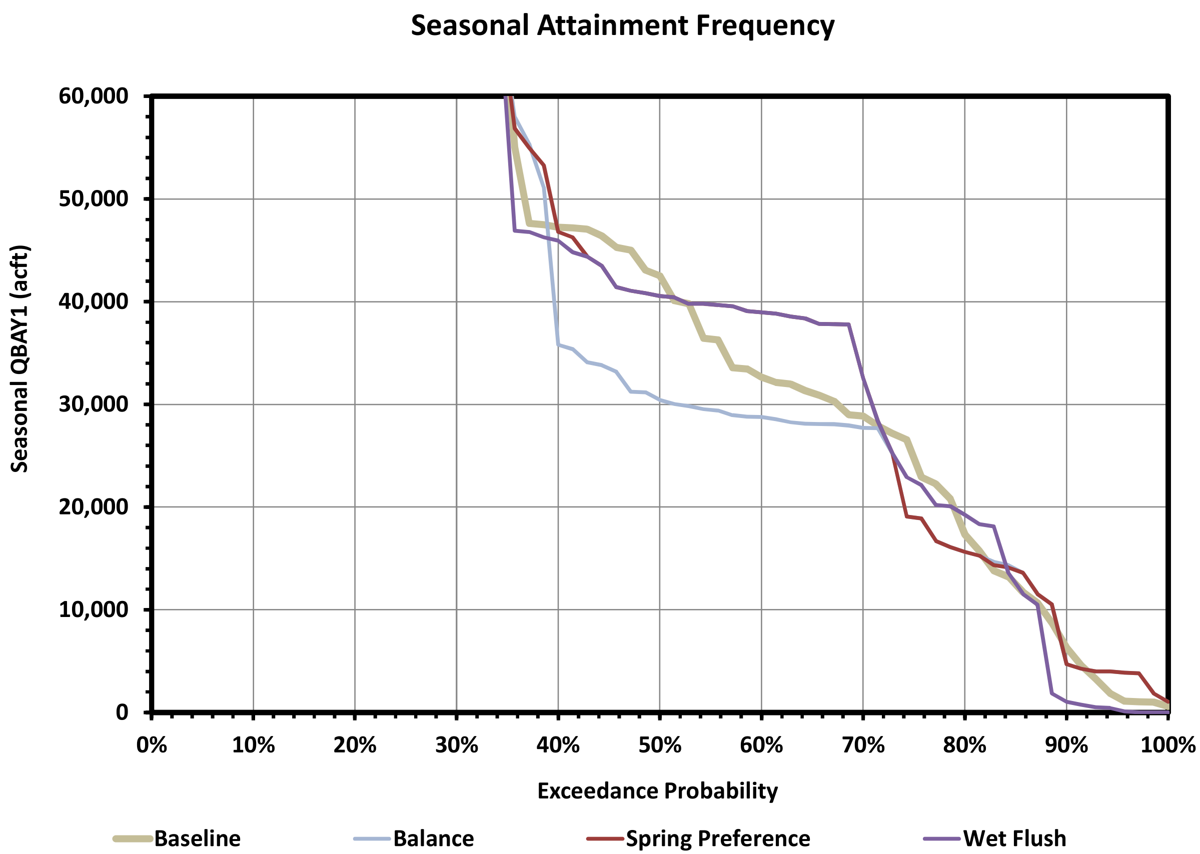

SEASONAL ATTAINMENT – SUMMER

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	4,000 – 40%	4,000 – 30%
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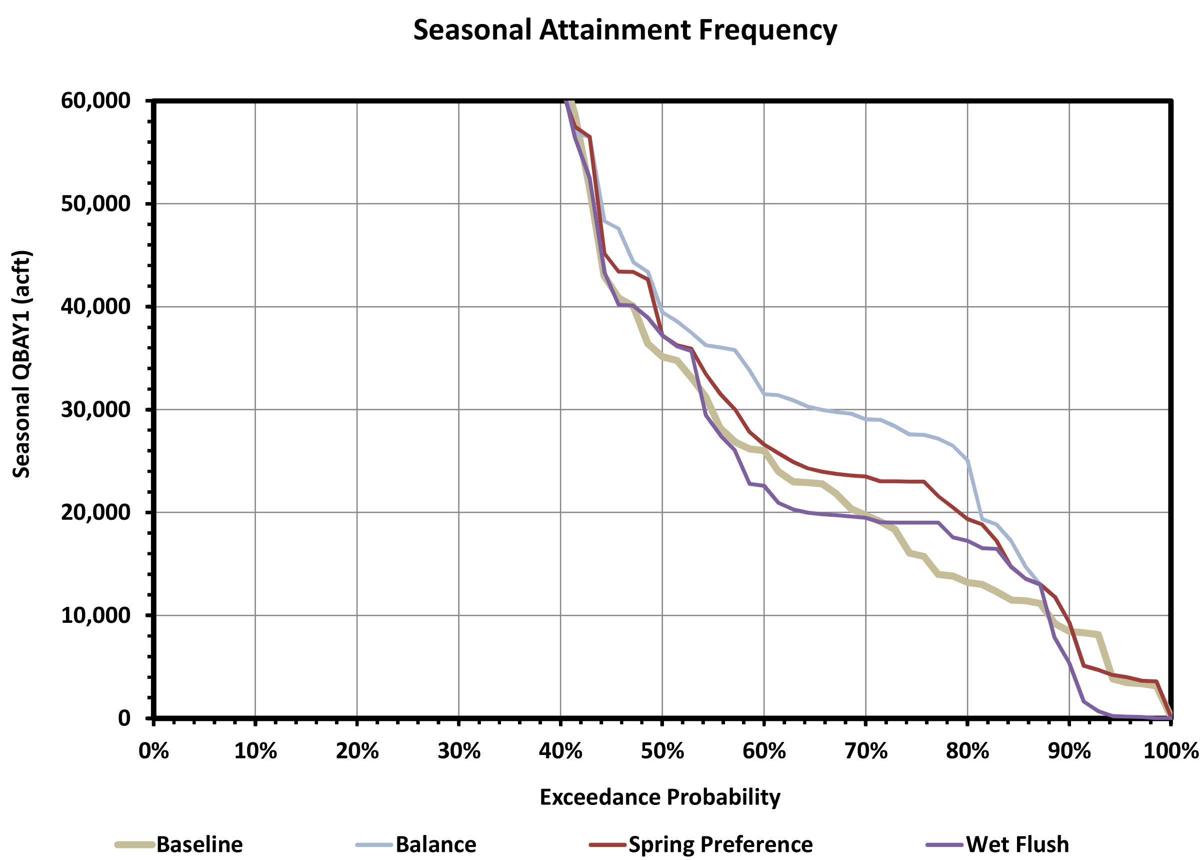

SEASONAL ATTAINMENT – WINTER

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
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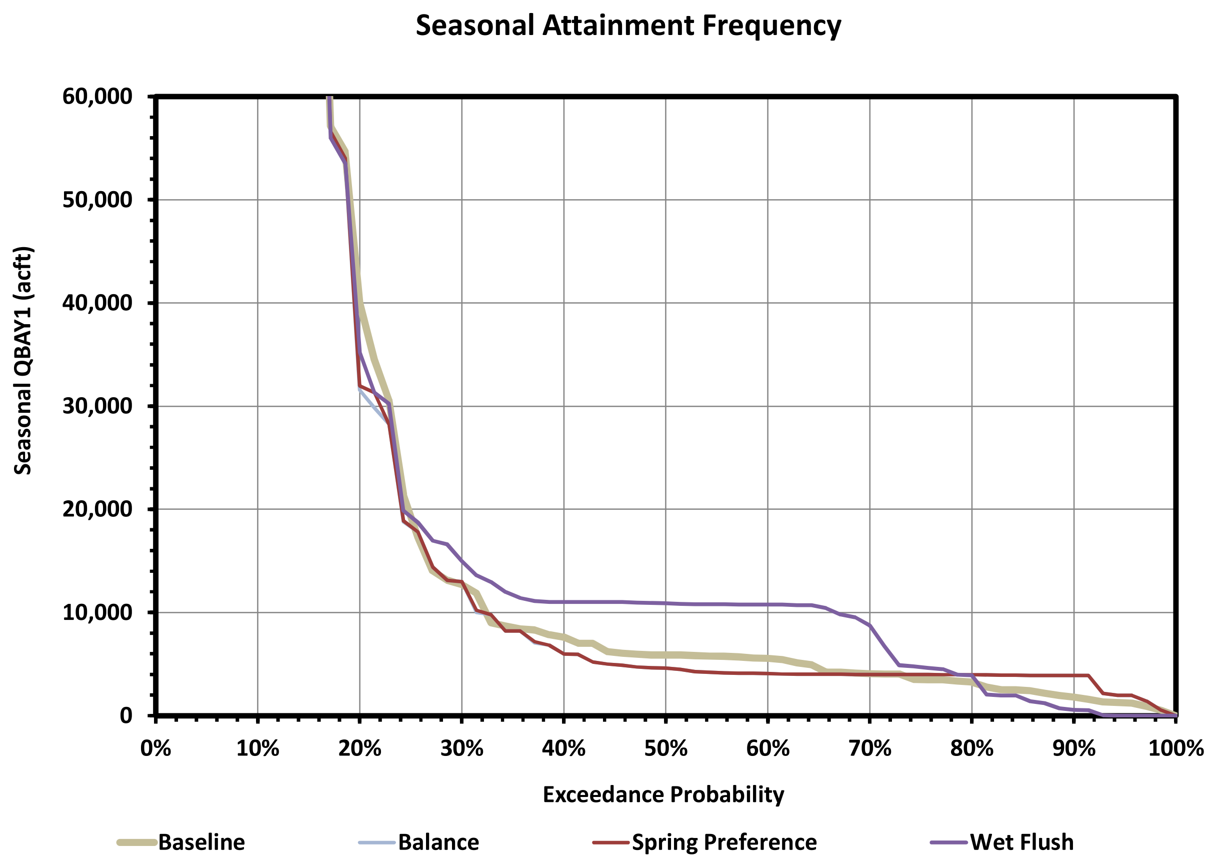

CONCLUSIONS / NEXT STEPS

- Evaluate SMART Inflow Management ✓
  - Opportunities to use SMART Inflow Management – Exist
    - Small quantities (4,000 acft per season) are easily achievable – Water to Delta
    - Larger targets are possible – Water to Bay
      - No decrease to Safe Yield
      - Modified attainment frequencies
      - Different than Agreed Order
  - Is change better?
    - Long-term, similar results to the Order
    - Short-term, critical times may be the difference especially in the Delta
- Developing draft report
- Final report due August 2014


RINCON BAYOU
CBBEP Nueces Delta Preserve

Appendix F – SMART Inflow Meeting on 6-25-14

HDR

SMART INFLOW MANAGEMENT – MODELING ANALYSES

MAYOR'S BLUE RIBBON COMMITTEE
JUNE 25, 2014
CORY SHOCKLEY, PE

DISCUSSION

Background

Goals

Analysis & Results

Conclusions / Next Steps

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- Project concept from 2012 Nueces BBASC Work Plan
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- Quantify changes to Freshwater Inflows (FWI) to Nueces Delta and Bay
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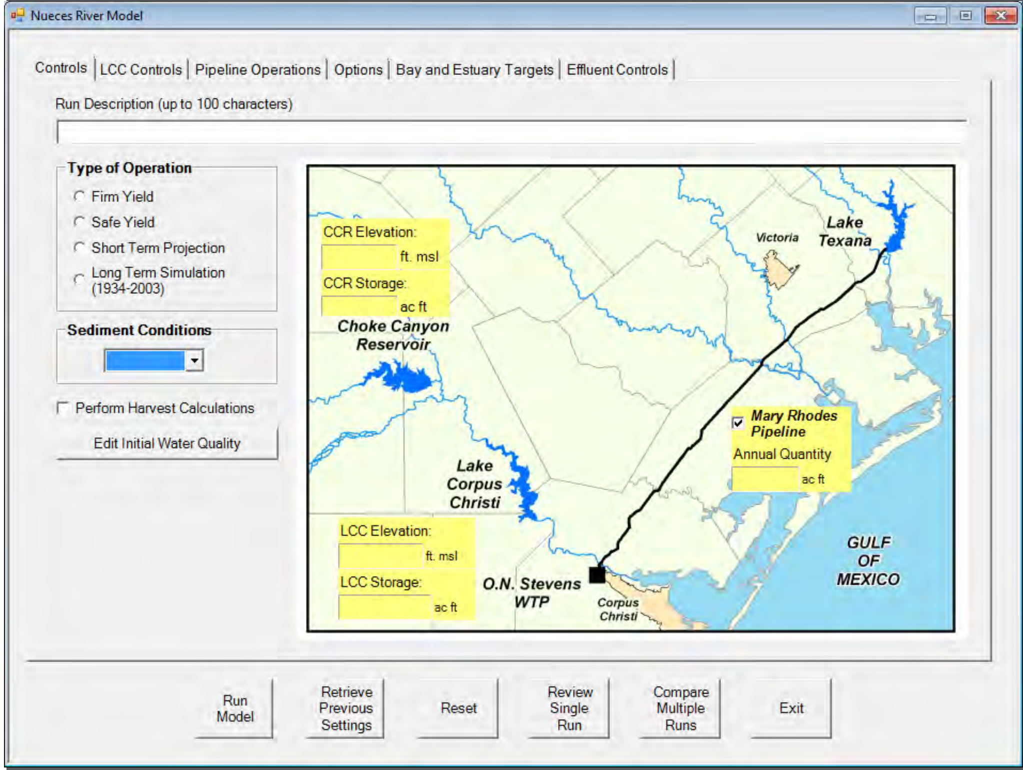

ANALYSIS

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  - Specific system storage levels
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- Zones
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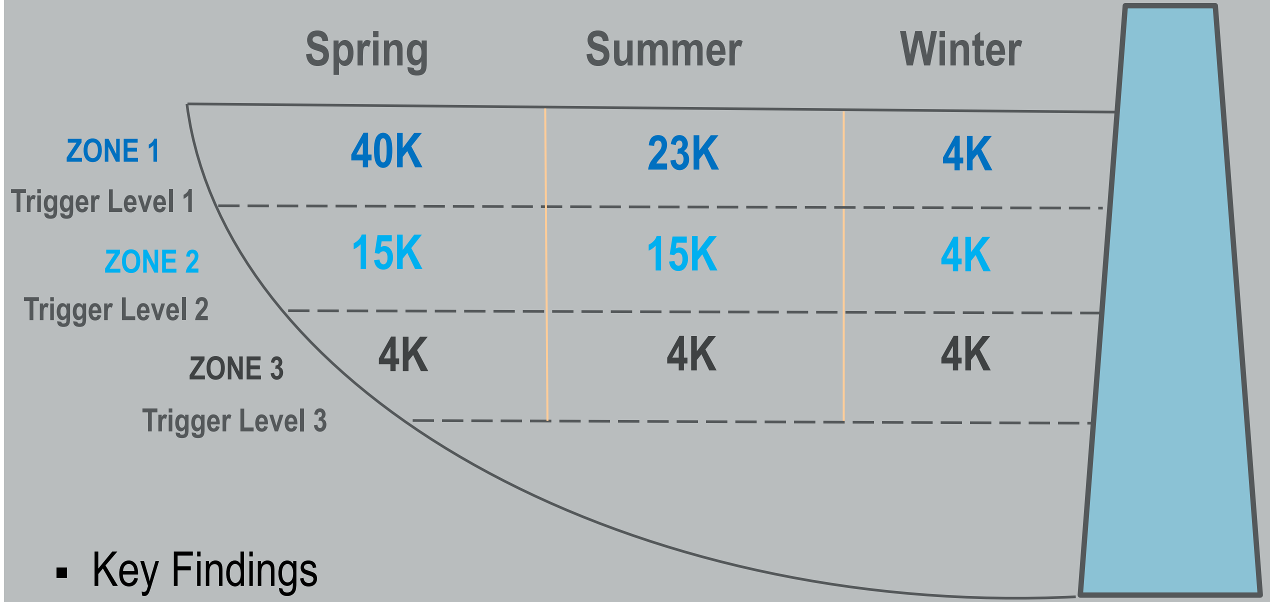
  - Targets determined by system storage on 1st day of season



- Key Findings
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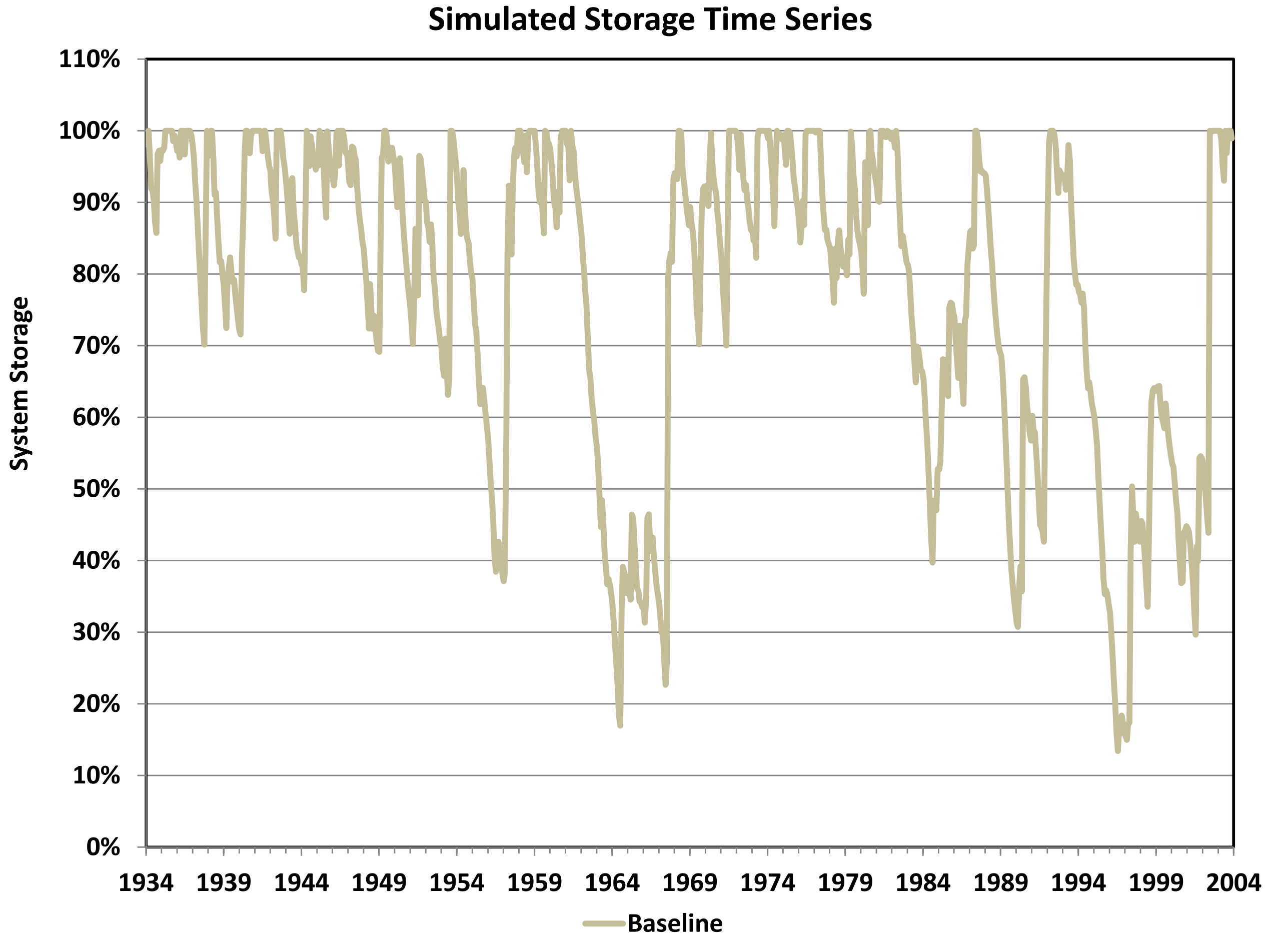
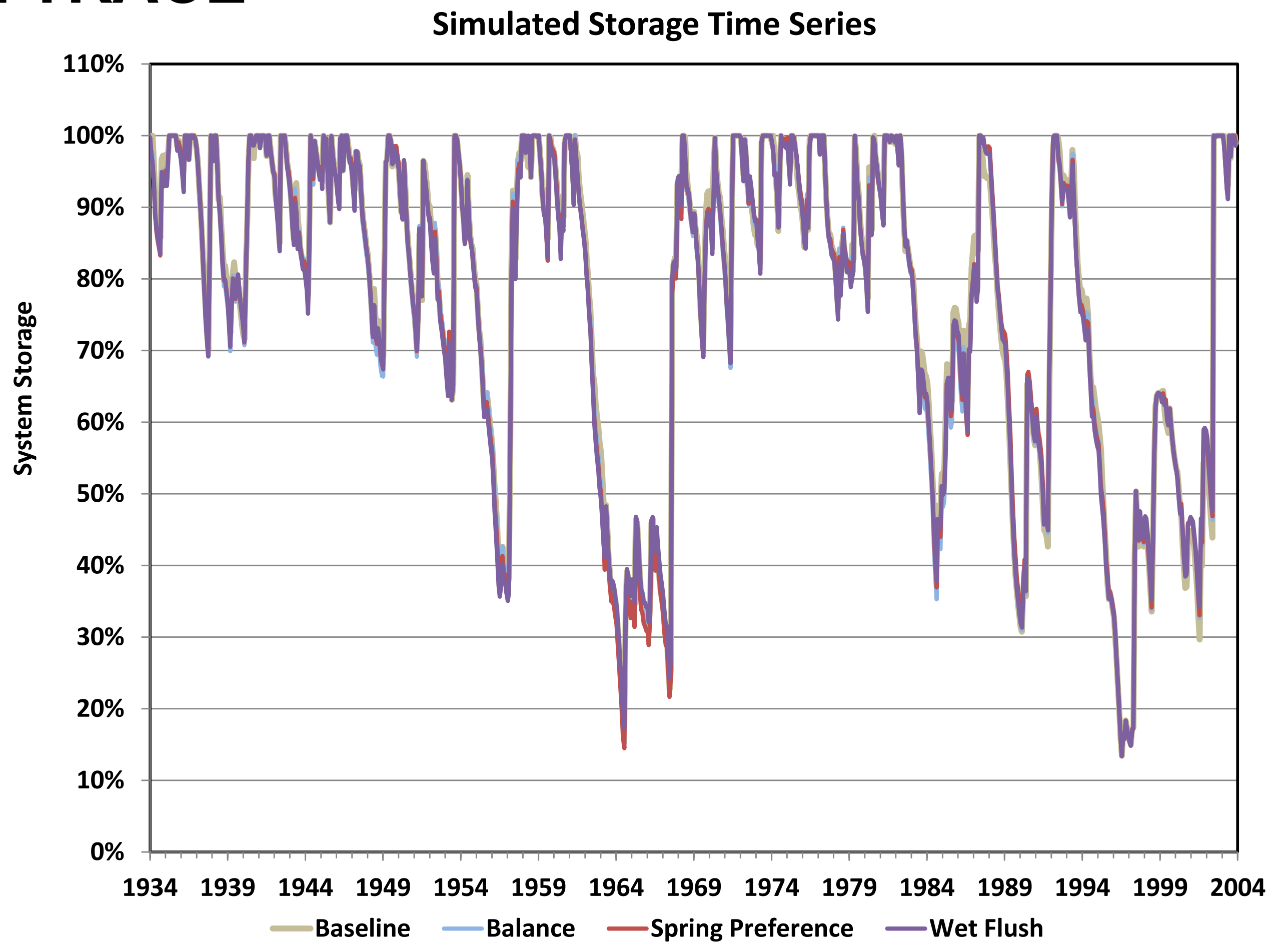
11d	3 storage trigger levels; Varied flow targets	29-29-4/70	15-4-4/40	4-4-4/30	0	220,568	385,663	165,922	3,932
11k	3 storage trigger levels; Varied flow targets	40-23-4/70	15-15-4/50	4-4-4/30	0	219,147	387,257	167,344	3,932
15	2 storage trigger levels; Varied flow targets	40-19-11/70	19-15-4/50	n/a	0	221,476	385,372	163,418	123

Scenario	Description	Safe Yield (acft/yr)
Oab	Baseline	219,143
11d	Balance	220,568
11k	Spring Preference	219,147
15	Wet Flush	221,476

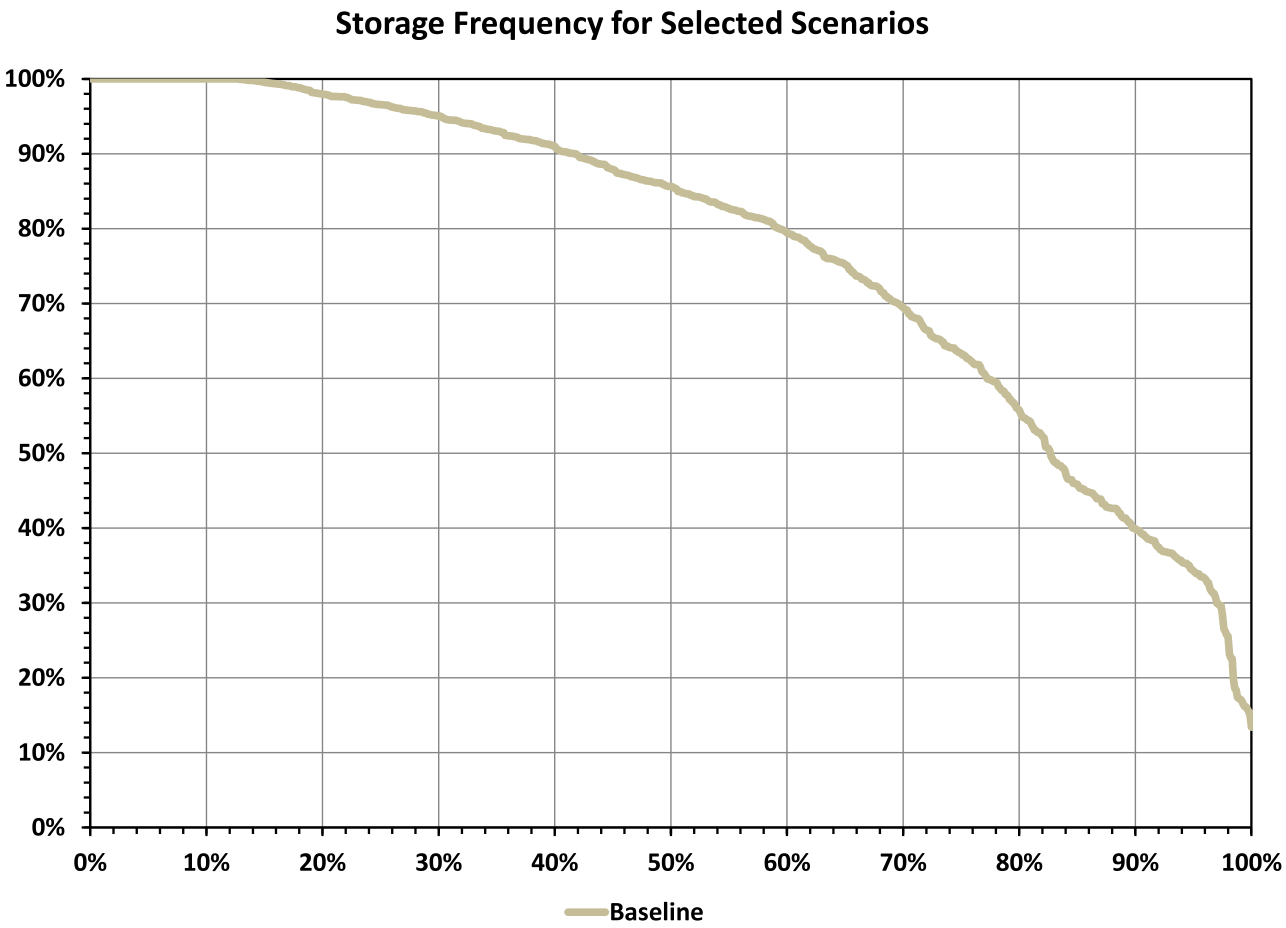
RESULTS – TIME SERIES STORAGE TRACE



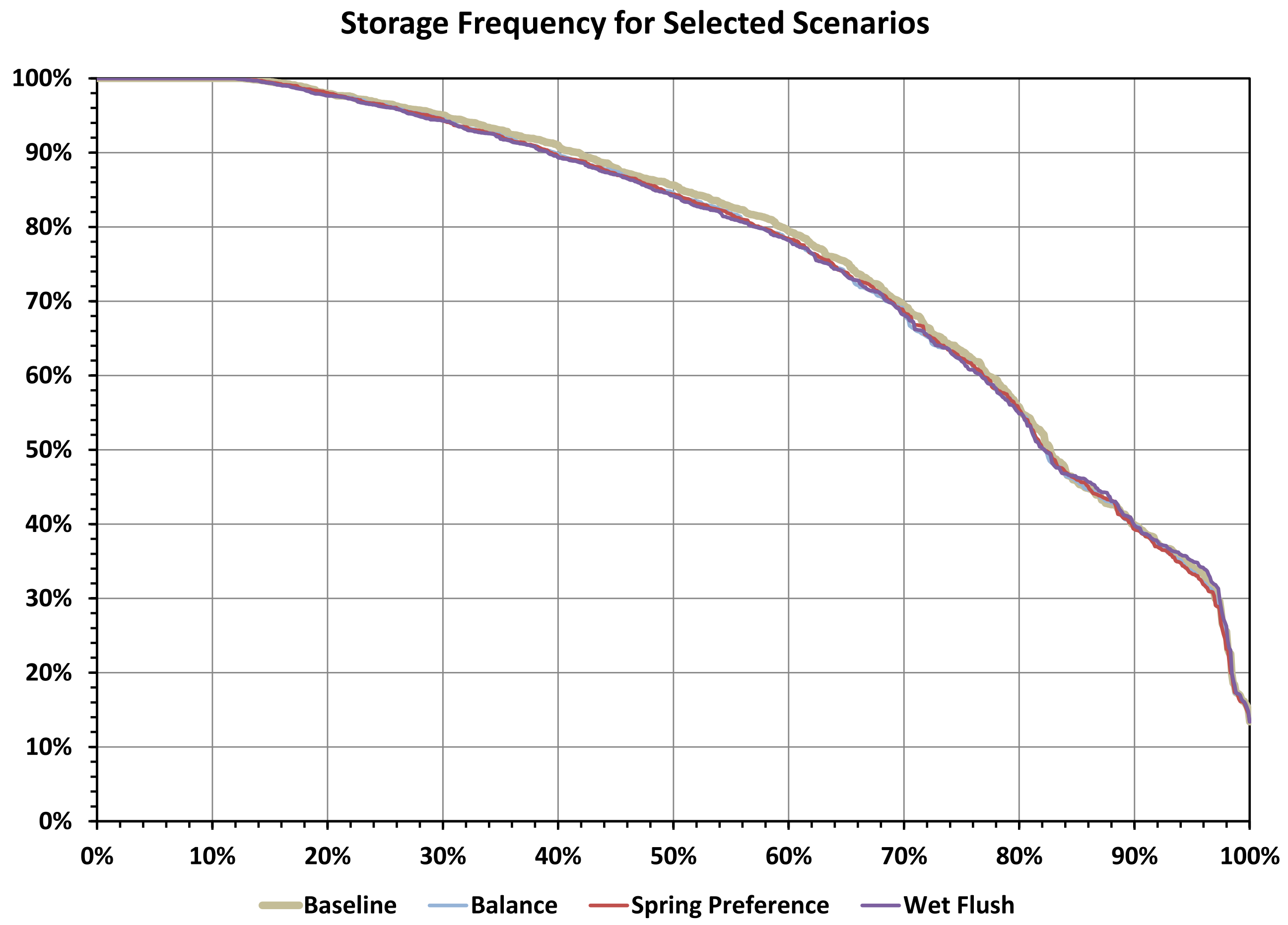
RESULTS – TIME SERIES STORAGE TRACE



RESULTS – FREQUENCY STORAGE TRACE

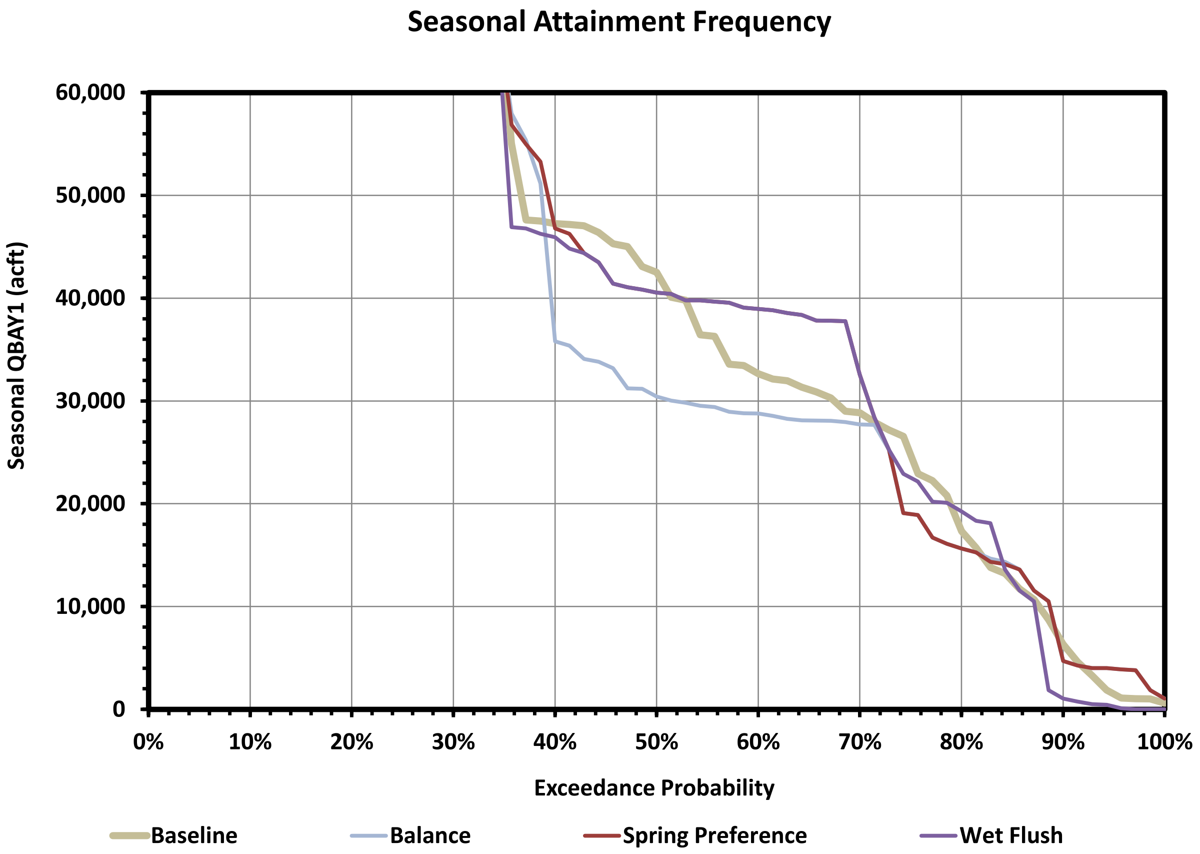


RESULTS – FREQUENCY STORAGE TRACE



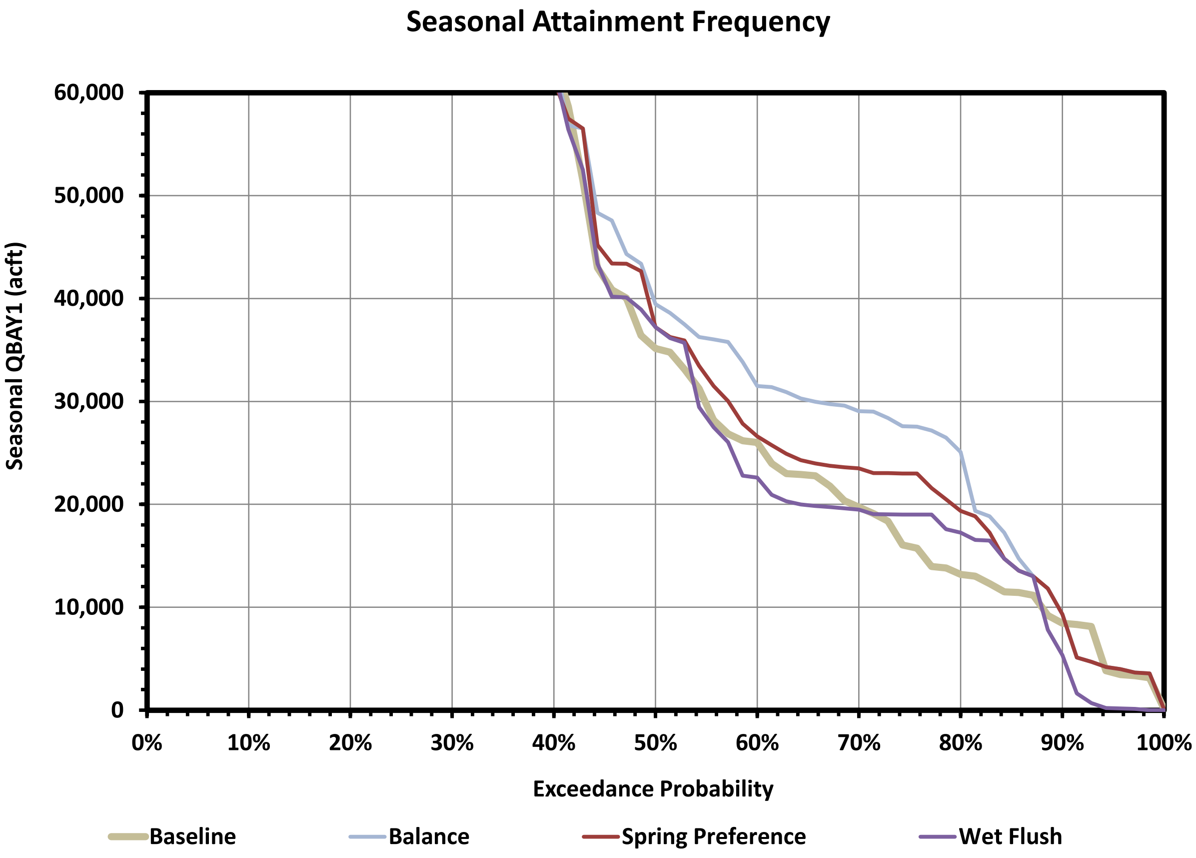
SEASONAL ATTAINMENT – SPRING

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	15,000 – 40%	4,000 – 30%
Spring Preference	40,000 – 70%	15,000 – 50%	4,000 – 30%
Wet Flush	40,000 – 70%	19,000 – 50%	-



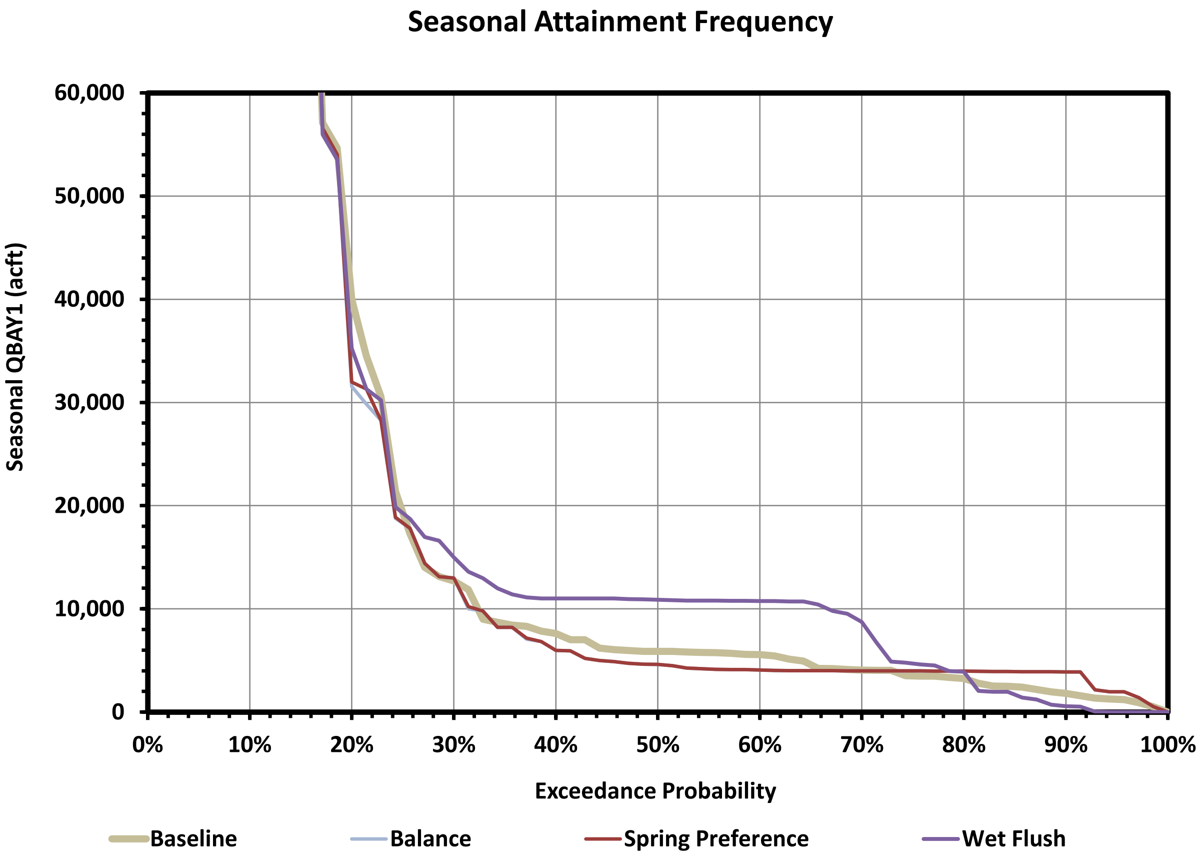
SEASONAL ATTAINMENT – SUMMER

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	29,000 – 70%	4,000 – 40%	4,000 – 30%
Spring Preference	23,000 – 70%	15,000 – 50%	4,000 – 30%
Wet Flush	19,000 – 70%	15,000 – 50%	-



SEASONAL ATTAINMENT – WINTER

Scenario	Zone 1	Zone 2	Zone 3
Baseline	Agreed Order Monthly Targets		
Balance	4,000 – 70%	4,000 – 40%	4,000 – 30%
Spring Preference	4,000 – 70%	4,000 – 50%	4,000 – 30%
Wet Flush	11,000 – 70%	4,000 – 50%	-



CONCLUSIONS / NEXT STEPS

- Evaluate SMART Inflow Management
  - Opportunities to use SMART Inflow Management – Exist
    - Small quantities (4,000 acft per season) are easily achievable – Water to Delta
    - Larger targets are possible – Water to Bay
      - No decrease to Safe Yield
      - Modified attainment frequencies
      - Different than Agreed Order
  - Is change better?
    - Long-term, similar results to the Order
    - Short-term, critical times may be the difference especially in the Delta
- Developing draft report
- Final report due August 2014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