APPENDIX B – ENGINEERING REPORT

Improving the Lake Okeechobee Regulation Schedule Performance by Adjusting the Classification Limits for the Hydrologic Conditions and Outlooks

Calvin J. Neidrauer, P.E.
South Florida Water Management District

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1. Purpose and Scope

This report summarizes a fine-tuning adjustment to the Lake Okeechobee regulation schedule that was recommended by South Florida Water Management District (SFWMD) staff. The scope of this report is limited to describing the basis and details of the adjustment, and a summary of the simulated and expected performance compared to the unadjusted regulation schedule.

This report does not describe the details of the recent SFWMD analysis which evaluated seven alternative modifications to the regulation schedule. The simulation results of that effort and the analyses of ecological and water supply performance were presented by SFWMD staff at the Water Resources Advisory Committee workshops on Lake Okeechobee on 07June2004 and 28June2004.

2. Summary

As part of recent efforts to improve the performance of the current regulation schedule for Lake Okeechobee, Water Supply and Environment (WSE), several alternative schedule modifications have been developed and analyzed by SFWMD staff. Of the alternatives that were evaluated, the Class Limit Adjustment (CLA) alternative appears to provide the most improvement to the in-lake performance with minimal or no adverse impacts to the performance of the other lake management objectives.

The Class Limit Adjustment to the Lake Okeechobee regulation schedule, WSE, is basically a fine-tuning of some of the schedule parameters to improve the performance of the regulation schedule. The WSE schedule was the first Lake Okeechobee regulation schedule to explicitly utilize hydrologic indicators of the actual and forecast lake inflows as part of the release decision. These hydrologic indicators are quantitative estimates that are subdivided into 4-6 qualitative classifications. Through an iterative modeling process, the numeric limits of these classes were adjusted to increase the duration of time that the WSE schedule called for releases while in Zone D.

The CLA is a relatively minor improvement to the WSE regulation schedule and does not significantly change the balance of the performance of the multiple lake management objectives that was achieved by WSE (Final Environmental Impact Statement, USACE 31March2000). Rather, the CLA slightly improves the overall performance of WSE by providing increased flexibility to make Zone D releases.

The increased flexibility associated with the CLA will allow more frequent pulse releases when the Lake is in Zone D. When low to moderate releases are done over a longer time-frame and in an estuarine-sensitive manner, then there may be some avoidance of the higher, damaging discharges. The trade-off here is more low & moderate, perhaps stressful releases, but potentially less high, damaging discharges.

Simulation results have shown that CLA nearly doubles (from 17% to 34%) the amount of time that the estuary decision tree leads to Zone D releases. In addition, CLA increases the opportunity to make Zone D releases south by approximately 10-15% of the time (from 62% to 75%).

The CLA to WSE is expected to further improve the ecological performance and flood protection of the lake with minimal effects on the performance relative to estuarine high discharges, and water supply objectives. Incidental benefits to the Everglades Water Conservation Areas (WCAs), and to the estuary low-flow performance were also observed from the analyses. Details on these performance evaluations are outside the scope of this report, but were presented at the Water Resources Advisory Committee workshops on Lake Okeechobee on 07June2004 and 28June2004. The bottom line is the CLA to WSE moves the multi-objective balance closer to optimal by further improving the in-lake performance with very slight changes, if any, to the performance of the other lake management objectives.

3. Background

The current regulation schedule used for managing water levels in Lake Okeechobee is known as the Water Supply & Environment (WSE) regulation schedule (Figure 1). WSE was adopted as the official regulation schedule in July 2000 after an extensive multi-agency and multi-objective evaluation process which is described in the Final Environmental Impact Study (FEIS, USACE 31March2000). The first releases made under WSE occurred in July 2002. In the relatively short two-year period since releases began under WSE, this new schedule has demonstrated superior performance as compared with the previous regulation schedule, Run 25.

However, even with the limited track record, some weaknesses of WSE have become evident. WSE performance during the relatively wet El Nino – enhanced winter & spring of 2003 was better than Run 25, but in hindsight it could have been even better.

The schedule called for no releases to the estuaries during a long period from February to June of 2003. During this time the schedule did call for maximum practicable releases south to the WCAs, however releases were limited due to high WCA stages and limited treatment capacity in STA-1W. The Lake stage at the beginning of the 2003 wet season was about 14.6 feet, NGVD, or about in the middle of Zone D. August and September inflows pushed the Lake stage into

Zone C and for a short time into Zone B. To regulate the high Lake stage, large damaging discharges to both estuaries were required. Public concern for the health of the lake and the downstream estuaries led to commitments by executive management of the SFWMD and U.S. Army Corps of Engineers (USACE) to re-examine the WSE regulation schedule.

A specific weakness of WSE has been the rather large amount of time that the estuary decision tree (Figure 3) calls for no releases while the Lake stage is in Zone D of the regulation schedule. There have been times when the prudent action has been to make a release to the estuaries, but the decision tree did not lead to that action.

Another weakness of WSE has been the limited release volumes that have been made to the Water Conservation Areas (WCAs). The WCA decision tree (Figure 2) often points to a southward release, but high WCA stages and limited water quality treatment capacity constrained southward releases. The schedule needs to explicitly recognize the need to make pulse releases (Table 1) to the estuaries when southward releases have been constrained for extended periods.

Recent simulation modeling has shown that of the time the Lake stage is in Zone D, WSE triggers pulse releases to the estuaries only about 17% of the time. The same analysis shows releases to the WCAs are triggered about 62% of the time when the Lake stage is in Zone D. Increasing the duration of time that the decision trees call for Zone D releases was a specific objective of the SFWMD's recent efforts to improve WSE.

The USACE has initiated a multi-phase effort to improve the Lake Okeechobee regulation schedule. The current phase of their effort aims to implement a small modification to the schedule that increases the flexibility and opportunities to make releases when the Lake stage is in Zone D. The USACE's intent is to implement such a schedule modification as a temporary deviation. The USACE will prepare an Environmental Assessment (EA) document to determine if the analysis will lead to a Finding of No Significant Impact (FONSI). The next phase of the USACE's effort will likely be a more-detailed study of the Lake Okeechobee regulation schedule similar to the study that led to the current schedule (FEIS, USACE 31March2000). That phase will also examine the concurrent effects of new storage areas and other changes to the infrastructure of the C&SF water control system. The study will likely take a few years to complete as it will require a more-detailed analyses and Environmental Impact Statement (EIS).

The CLA was designed to be a small and easily-implemented change to improve the WSE regulation schedule that could potentially meet the USACE's objectives for short-term implementation via an EA and FONSI. The proposed CLA can also be considered as a starting point for further, more-significant modifications to the schedule which will require a more-detailed analysis and EIS.

4. Hydrologic Conditions and Outlooks used by WSE

The WSE schedule (Figure 1 of this report and Figure 7-1 of the Water Control Plan (WCP) for Lake Okeechobee and Everglades Agricultural Area (EAA), dated July 2000) introduced a hydrologic status parameter and a hydrologic forecast parameter as official components of the regulation schedule. The use of these parameters with decision trees (Figures 2 & 3 of this report and Figures 7-2 & 7-3 of the WCP for Lake Okeechobee and EAA) guide the Lake Okeechobee release decisions that are made by water managers.

The Tributary Hydrologic Condition (THC) is a measure of the hydrologic state of the Upper and Lower Kissimmee River Basins. The Lake Okeechobee Net Inflow Outlook (LONINO) is a forecast parameter that has been the subject of much research and investigation during the past decade in particular.

a. Tributary Hydrologic Condition (THC)
   There are two measures of the tributary hydrologic condition: (1) 30-day net rainfall and (2) 14-day average S-65E flow. Table 7-4 from the Water Control Plan for Lake Okeechobee and EAA shows the official classifications and limits for the THC. Note that the wetter of the two measures represents the THC that is used with the decision trees.

b. Lake Okeechobee Net Inflow Outlook (LONINO)
   The LONINO is an outlook, or forecast, of the expected net inflow to the Lake. The LONINO is defined as NI = RF – ET + inflows. Where NI = Net Inflow; RF & ET = rainfall and evapotranspiration, respectively, over the lake surface area; and inflows = all other inflows to the lake. T here a re two n et inflow outlooks that are used with the WSE decision trees: (1) Seasonal LONINO and (2) Multi-Seasonal LONINO. The Seasonal LONINO estimates the net inflow to the Lake for the upcoming 6-months. The Multi-Seasonal LONINO estimates the inflows for the remainder of the current season (wet or dry season) plus the following season (dry or wet season).

   After implementation of the WSE regulation schedule in July 2000, additional published research confirmed the use of several global climate indexes as predictors to Lake Okeechobee net inflows. The recent work by the National Oceanic and Atmospheric Administration (Mestas-Nunez & Enfield, March 2003) recommended the use of the El Nino Southern Oscillation (ENSO) the Atlantic Multi-Decadal Oscillation (AMO), and the Pacific Decadal Oscillation for estimating the seasonal and multi-seasonal LONINO. In 2003, the USACE accepted SFWMD staff's recommendation to use AMO/ENSO method for estimating the LONINO.

5. Classifications of the Hydrologic Conditions and Outlooks used by WSE

Classification limits are used to define the hydrologic conditions and outlooks that are used by the decision trees for the WSE regulation schedule. The WCP for Lake Okeechobee and EAA (USACE, July 2000) contains three tables which define the class limits. These tables are shown below with both the original and adjusted class limits.

Table 7-4
Class limits for Tributary Hydrologic Conditions

Net rainfall (inches - past 4 weeks)	S-65E flows (cfs - 2 week average)	Tributary Condition Class (wetter of the two indicators)
< -3.0	< ~~500~~ 200	Very Dry
-3 to -1.01	~~500~~ 200- ~~1499~~ 499	Dry
-1 to 1.99	~~1500~~ 500-3499	Normal
2 to 3.99	3500-5999	Wet
4 to 7.99	6000-8999	Very Wet
≥ 8	≥ 9000	Extremely Wet

Table 7-7
Classification of Lake Okeechobee Net Inflow Seasonal Outlook

Lake Net Inflow Prediction (million acre-feet)	Equivalent Depth[1] (feet)	Lake Net Inflow Outlook Class
> ~~1.5~~ 0.93	> ~~3.2~~ 2.0	Very Wet
~~1.01~~ 0.71 to ~~1.5~~ 0.93	~~2.11~~ 1.51 to ~~3.2~~ 2.0	Wet
~~0.5~~ 0.35 to ~~1.0~~ 0.70	~~1.1~~ 0.75 to ~~2.1~~ 1.5	Normal
< ~~0.5~~ 0.35	< ~~1.1~~ 0.75	Dry

[1] Volume-depth conversion based on average lake surface area of 467000 acres.

Table 7-10
Classification of Lake Okeechobee Net Inflow Multi-Seasonal Outlook

Lake Inflow Prediction (million acre-feet)	Equivalent Depth (feet)	Lake Net Inflow Outlook Class
> 2.0	> 4.3	Very Wet
~~1.51~~ 1.18 to 2.0	~~3.21~~ 2.51 to 4.3	Wet
0.5 to ~~1.5~~ 1.17	1.1 to ~~3.2~~ 2.5	Normal
< 0.5	< 1.1	Dry

6. Methodology Used to Determine the Class Limit Adjustments

The multi-objective performance of the regulation schedule was expected to be sensitive to changes in the class limits for hydrologic conditions and the seasonal and multi-seasonal outlooks. Sensitivity testing demonstrated this was true. The challenge was to select meaningful class limits that improved in-lake management objectives while not adversely affecting the performance relative to estuarine, Everglades, and water supply objectives.

By way of an extensive trial-and-error process using the South Florida Water Management Model (SFWMM), an adjusted set of class limits was selected which improved several measures of performance. The new class limits also significantly increase the frequency that the decision trees call for releases when the Lake stage is in Zone D. Section 7 describes in more detail the simulated and expected performance changes resulting from CLA.

Figures 4-8 compare the frequency distributions of the hydrologic conditions and outlooks with the original and adjusted class limits. The class limit adjustments generally shifted the distributions toward the wetter classes. Data for the period 1965-2000 were used to generate the frequency distributions.

a. Tributary Hydrologic Condition (THC)

1) *30-day Net Rainfall*

Figure 4 compares the frequency distribution of the 30-day net rainfall over the upper and lower Kissimmee Basins. No changes were made to the class limits for the 30-day net rainfall since the original distribution was somewhat normal and reasonable. Thus the distribution of the data did not change.

2) *14-day average S-65E flow*

Figure 5 compares the frequency distribution of the 14-day average S-65E flow. Only 2 of the 5 class limits were changed as shown on the figure and in Table 7-4 above. The adjusted limits shifted 40% of the distribution from the dry and very dry classes to the normal class.

3) *THC*

The THC is defined as the wetter of the two indicators. Figure 6 compares the THC resulting from the adjusted class limits with the THC distribution from the original limits. The adjusted limits shifted 11% of the distribution from the dry and very dry classes to the normal class. The result of this adjustment is a reduction in the duration of time that the outcome of the decision trees is no-discharge.

b. Lake Okeechobee Net Inflow Outlook (LONINO)

1) *Seasonal LONINO*

Figure 7 compares the frequency distribution of the Seasonal LONINO. All three class limits were changed as shown on the figure and in Table 7-7 above. The change most relevant to the estuary decision tree is the 12% increase in the Very Wet class frequency.

2) *Multi-Seasonal LONINO*
Figure 8 compares the frequency distribution of the Multi-Seasonal LONINO. Only one of the three class limits was changed as shown on the figure and in Table 7-10. The change shifted 21% of the distribution from the normal class to the wet class. As with the change to the Seasonal LONINO class limits, this change reduces the duration of time that the estuary decision tree outcome is no-discharge.

7. Expected Performance of the Class Limit Adjustments

Long-term performance of the CLA to WSE was evaluated based on computer model simulations. The hindsight performance of the CLA was also estimated assuming it were in operation during the past two years of WSE implementation. The results of these performance evaluations are summarized in this section after an initial discussion of multi-objective performance, trade-offs and balance.

a. Multi-objective Performance, Trade-offs and Balance
It is important to recognize that a fundamental trade-off exists among the competing Lake Okeechobee management objectives. Performance trade-offs are not at all unusual for large-scale, multi-purpose, water resource facilities. Table 2 summarizes the basic trade-offs among the multiple lake management objectives for Lake Okeechobee.

Table 2. Basic Trade-offs among competing lake management objectives

Lake Okeechobee	Tends to Benefit (improve)	Tends to Impact (worsen)
Lower stage Regulation	• In-lake Ecology • Reduces the occurrences of high damaging Estuary flows • Estuary low flows • Flood Protection	• Water Supply (ag, urban & environmental water supply) • Increases the occurrences of low & moderate, possibly stressful Estuary flows.
Higher stage Regulation	• Water Supply (ag, urban & environmental water supply) • Decreases the occurrences of low & moderate, possibly stressful Estuary flows.	• In-lake Ecology • Increases the occurrences of high damaging Estuary flows • Flood Protection

Long-term simulations demonstrated that WSE provides a balance of the multi-objective performance of the competing lake management objectives which is nearly optimal. That is, improvement in performance one objective is difficult, if not impossible, to achieve without a worsening of the performance of a competing objective. This optimal balance does not, however, provide optimal performance for any of the individual lake management objectives.

The CLA to WSE moves the balance closer to optimal by further improving the in-lake performance with inconsiderable impacts to the performance of the other lake management objectives.

b. Simulated Performance of the CLA

The performance of the CLA was simulated using the South Florida Water Management Model (SFWMM v5.4.2) by the SFWMD's Office of Modeling. SFWMD staff designed and analyzed several alternative modifications to WSE and presented the performance evaluations at two WRAC workshops, 7June04 and 28June04. This report summarizes the performance of the CLA alternative relative to the baseline WSE schedule with the original class limits.

Note that some of the performance measure graphics include two additional simulations which represent the extremes of Zone D operation. ZD-NVR, or NVR, denotes a simulation that never makes a Zone D release when the lake stage is in Zone D. ZD-ALWYS, or ALW, denotes a simulation that always makes a Zone D release when the lake stage is in Zone D. For the estuaries, the level of the pulse release depends on how far the lake stage is into Zone D. These extreme simulations were performed to define the range of possible performance that can be attained from modifying Zone D release rules.

1) Lake Stages and Release Volumes

Simulation results were summarized to compare the duration of time the Lake stage was in the various zones of the regulation schedule. Table 3 shows the original class limits trigger the estuary decision tree to discharge to the estuaries only about 17% of the time. With the adjusted class limits, the decision tree triggers releases to the estuaries 34% of the time. Table 3 also shows that the adjusted class limits increase the duration of time the decision tree triggers releases to the WCAs from 62% to 75% of the time when the Lake stage is in Zone D. These additional opportunities and added flexibility to make regulatory discharges south and low-level pulse releases to the estuaries help to lower the lake stage in anticipation of wet periods.

Figure 9 shows a comparison of the stage duration curves for the CLA and baseline simulation. Also shown on the figure are the ZD_ALWYS and ZD_NVR duration curves which bracket the BASE and CLA. Note that the CLA curve falls about ½ way between the extremes and shifts the higher stages downward as much as 0.4ft. The Lake stages at the lower end of the curve are relatively unchanged relative to the base. This indicates that water supply performance may not be affected. Performance relative to water supply is described in further detail below.

Figure 10 shows the mean annual regulatory releases from the Lake. The CLA simulation increases total regulatory discharges by about 4% relative to the Base. The increased flow to the estuaries does not necessarily mean that the performance of the estuaries is worse. Some of the increased flow occurs during dry periods when the estuaries benefit from the low-level pulse releases. Estuary performance is described further below.

Table 3. Zone Statistics from 36-yr SFWMM Simulations

% of time (36-yr simulation) that LOK stage was ...	WSE BASE	ZD ALWAYS	ZD NEVER	CLA
... in Zone A	0	0	0	0
... in Zone B	1	1	2	1
... in Zone C	6	3	7	4
... in Zone D	36	22	38	33
... in Zone D3	12	3	15	9
... in Zone D2	12	5	12	11
... in Zone D1	12	14	10	13
... below ZoneD	57	74	49	62
... in Zone D & Part 1 called for maximum practicable south	62	71	62	75
... in Zone D & Part 2 called for pulses to the Estuaries	17	100	1	34

Source: SFWMMv5.4.2 Simulations (June 2004)
SFWMM simulations driven by 1965-2000 rainfall, etc. (36yrs or 13149 days)

The following sections summarize the performance of the Class Limit Adjustment to the WSE schedule for the primary resource areas that are affected by Lake Okeechobee stage regulation.

2) *Lake Okeechobee*

To evaluate Lake ecology, three hydrologic performance measures were used as ecological surrogates:

a. *Number of weeks Lake stage is below 10 ft (target is zero weeks).*
   As compared to the BASE, CLA improves performance by reducing the number of weeks from about 78 to 58.
b. *Number of weeks Lake stage is above 17 ft (target is zero weeks).*
   As compared to the BASE, CLA only slightly improves performance by reducing the number of weeks from about 9 to 7.
c. *A 'stage envelope' performance measure that quantifies departure of the long-term stage from an optimal envelope that the Lake stage is desired to stay within (except drought years). The target is an average departure of less than 0.25 ft.*
   As compared to the BASE, CLA reduces the average departure from about 0.95 ft to about 0.84 ft.

To evaluate flood protection, Figure 11 shows a performance measure that compares the maximum Lake stage and the number of days the stage exceeds 16.5ft, NGVD, during the beginning of the peak of the hurricane

season. As compared to the base, the CLA simulation lowers the peak stage by over 0.5ft, and reduces the number of days above 16.5ft from 17 to 3.

3) *Water Supply*

For the Lake Okeechobee Service Area (LOSA), which is includes the EAA, C43 & C44 basins, and other areas supplied by Lake Okeechobee, performance is measured by the frequency and severity of water use cutbacks per the Lake Okeechobee Supply-Side Management Plan. For the Lower East Coast Service Areas (LECSAs), water supply performance measures count the simulated number of times water restrictions are triggered by low groundwater stages on the coast, or by the Lake Okeechobee Supply-Side Management Plan restrictions.

Table 4 summarizes the simulated water supply performance for the LOSA. For the 36-year simulation period the CLA slightly increases the cutback volumes and increases the percent of demands not met by 1%. Figure 12 illustrates the cutback volumes and % of demands not met for the seven years in the 36-yr simulation with the largest cutbacks.

Table 4. Lake Okeechobee Service Area Water Supply Assessment

Simulation	Total(36yr) SSM Cutbacks (1000af)	Additional SSM cutbacks over Base (1000af)	Water Yrs with SSM cutbacks >100,000af	Water Yrs with SSM cutbacks >350,000af	EAA % of Demands not Met	Other LOSA % of Demands not Met
Base	1,442		4	0	8%	6%
CLA	1,640	198	4	0	9%	7%

Table 5 summarizes the simulated water supply performance for the LECSAs. For the 36-year simulation period the CLA added one month of water restrictions compared to the Base. The additional month was due to the model assumption that phase 1 water restrictions in the LECSAs are triggered if the LOSA experiences water restrictions per the Supply-Side Management Plan. CLA did not affect local groundwater conditions or regional system water supply deliveries to the LECSAs.

Table 5. Lower East Coast Service Area Water Supply Assessment

	Months of Water Shortages in the LECSAs				
Simulation	SA-1	SA-2	SA-3	SA-4	Restrictions triggered by LOK SSM & dry season criteria
Base	35	127	32	30	29
CLA	36	128	33	31	30

SFWMD staff evaluations considered the water supply performance of the CLA to be not different from the base for both the LOSA and LECSAs.

4) *St. Lucie Estuary*

The St. Lucie Estuary (SLE) performance was evaluated by SFWMD staff by counting the number of times during the 36-yr simulation that the average monthly flows to the estuary exceeded specified flow limits. The flow limits create a flow envelope that corresponds to key estuary salinity ranges. The flow envelope is defined as:

<350cfs: below oyster envelope
350-2000cfs: creates salinity appropriate for oysters in the middle estuary
2000-3000cfs: creates stressful low salinity conditions in the estuary
>3000cfs: creates damaging low salinity in the estuary

Table 6. St. Lucie Estuary Mean Monthly Flow Envelope Summary

Total inflows to SLE (basin runoff from C23,C24, C44, etc, plus LOK releases) (mean monthly cfs)	BASE (months)	CLA (months)	CLA-BASE (months)
< 350 cfs (less is better)	136	129	-7 (better)
350-2000 cfs (more is better)	231	235	+4 (better)
2000-3000 cfs (less is better)	33	40	+7 (worse)
> 3000 cfs (less is better)	32	28	-4 (better)

SFWMD estuary scientists evaluated the simulation results for the St. Lucie Estuary and concluded that the effect of CLA on the ecology of the SLE is slightly improved but probably not significantly different than the Base.

5) *Caloosahatchee Estuary*

The Caloosahatchee Estuary (CE) performance was evaluated by SFWMD staff by counting the number of times during the 36-yr simulation that the average monthly flows to the estuary exceeded specified flow limits. The flow limits create a flow envelope that corresponds to key estuary salinity ranges. The flow envelope is defined as:

<300cfs: creates damaging high salinity in upper estuary
300-2800cfs: preferred flow range
2800-4500cfs: creates damaging low salinity in the lower estuary
>4500cfs: creates damaging low salinity in the San Carlos Bay

Table 7. Caloosahtatchee Estuary Mean Monthly Flow Envelope Summary

Inflows to CE at S-79 (C43 basin runoff plus LOK releases) (mean monthly cfs)	BASE (months)	CLA (months)	CLA-BASE (months)
< 300 cfs (less is better)	156	149	-7 (better)
300-2800 cfs (more is better)	207	207	0
2800-4500 cfs (less is better)	37	42	+5 (worse)
> 4500 cfs (less is better)	32	34	+2 (worse)

The small increase in the number of exceedences of both the 2800cfs and 4500 cfs discharge limits is counterintuitive. Typically an increase in the low to moderate discharges leads to a decrease in high discharge events. This expectation was observed with the St. Lucie Estuary performance but not with the CE performance.

A closer look at the simulation results revealed that the small increase in high discharge events is due, in part, to the simple logic built-into the model for determining the pulse release level. When a Zone D pulse release is triggered in the simulation, the model makes Level 1 pulses when the Lake stage in the bottom 1/3 of Zone D, Level 2 pulses when the stage is in the middle 1/3 of Zone D, and Level 3 pulses when the stage is in the upper 1/3 of Zone D. This assumption is valid for the simulation, however for the real system operation it is a guideline. The condition of the CE is a consideration when the actual release decisions are made.

The C-43 basin runoff alone contributes to 60-65% of the high discharge events at S-79. The other high discharge events occur when the sum of the basin runoff plus the Lake release exceeds the limit at S-79. Both the level of the pulse release and the timing of the pulse release from Lake Okeechobee at S-77 contribute to exceedences of the high discharge limits at S-79. Because estuary salinity conditions are a factor in deciding the level of the pulse release for the real system, the small increases from the CLA simulation are not likely to be realized in the real system.

SFWMD estuary scientists evaluated the simulation results for the Caloosahatchee Estuary and surmise that the effect of CLA on the ecology of the CE is probably not significantly different than the Base. The conclusion is that the enhanced flexibility associated with the CLA can allow for more environmentally sensitive management of discharges to the estuaries.

6) *Everglades WCAs*
Several measures of performance for the Everglades WCAs were evaluated by SFWMD staff. Hydroperiod differences relative to the Natural System Model were for the most part, not affected by CLA. However, there was a slight improvement, an extended hydroperiod, in Northern WCA-3A with CLA. CLA produced an improved habitat suitability for wading birds relative to the base case. CLA's performance for small fish was not different from the Base.

SFWMD staff evaluations of the CLA relative to the Baseline were classified into 5 broad categories (++ substantially better than the Base, + slightly better than the Base, 0 not different from the Base, - slightly worse than the Base, and – substantially worse than the Base). These performance evaluations were presented at two WRAC workshops, 7June04 and 28June04.

Performance of the CLA relative to the Base was briefly described in this section and is summarized below.

Summary of performance of the 36-yr CLA simulation relative to the Baseline:

- LOK Flood Protection: substantially better
- LOK Ecology: slightly better
- Water Supply: no change
- St.Lucie Estuary: no change
- Caloosahatchee Estuary: no change
- Everglades Hydroperiod and Ecology: slightly better

c. How much would the CLA have changed the WSE decision tree outcomes during the past 2 years?

WSE was implemented in July 2000, but the Lake stage did not rise into Zone D until two years later. A review of the weekly release decisions beginning in July 2002 allowed a hindsight analysis to be done. This analysis assumed the current method for estimating LONINO (AMO/ENSO) and the CLA were in place during the past two years. Results of this analysis are summarized below.

During the 100 weeks from 8July2002 to 31May2004, the Lake stage was in Zone D for 85 weeks (85% of the time). Table 8 shows that of the 85 weeks that the Lake stage was in Zone D, the CLA with the AMO/ENSO method would have significantly increased the number of weeks that the decision trees led to release decisions. It is important to recognize beginning in July 2003, the AMO/ENSO method for estimating LONINO replaced the use of the Croley and ENSO sub-sampling methods. Thus the improvement shown in Table 8 is due to both the AMO/ENSO method and the CLA.

Table 8. Comparison of the decision tree outcomes

Decision Tree Outcome	Actual	Estimated with CLA
Part 1 (Max practicable to WCAs)	69 weeks (81%)	83 weeks (98%)
Part 2 (up to L3 pulse to Estuaries)	25 weeks (29%)	49 weeks (58%)

During April-July of 2003, a period that included the El Nino – enhanced spring of 2003, had CLA been in operation, it would have triggered an additional 14 weeks of pulse releases to the Estuaries. During that same time CLA would have triggered an additional 4 weeks of releases to the WCAs.

These additional releases would likely have lowered the Lake stage by over one-foot which would have reduced the need for the Zone C discharges that occurred during Aug-Sep of 2003.

Conversely, during the winter and spring of 2004, a period when a formal deviation to the WSE schedule was in place, had the CLA been in operation instead, the decision trees would not have called for releases. Lake stages would likely have been about 0.8ft higher at the end of the 2004 dry season. This is important considering the late start of the 2004 wet season, the below-normal wet season rainfall as of the date of this report, and growing concerns about water supplies.

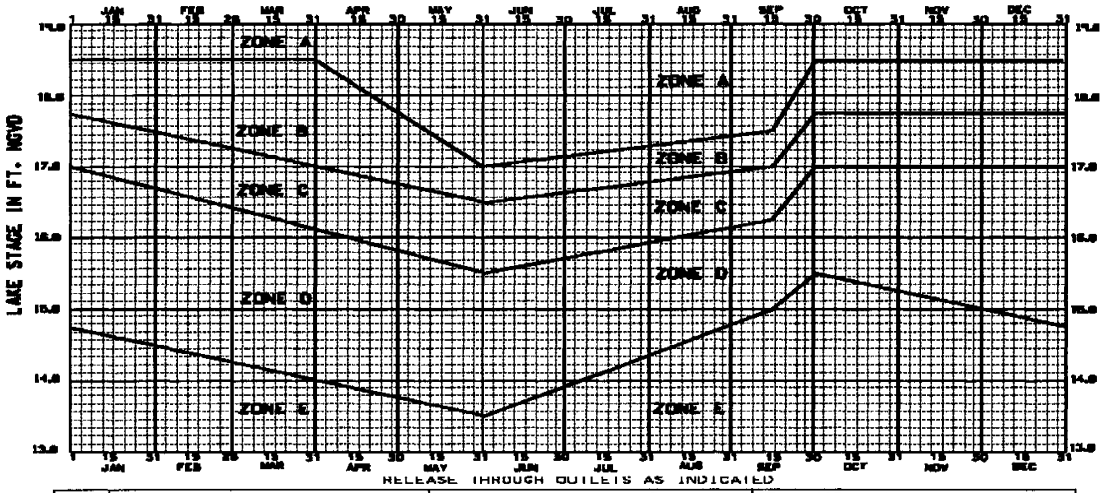
8. Recommendations

It is recommended that the Class Limit Adjustment (CLA) to WSE be further evaluated in the Environmental Assessment in an effort to improve the in-lake performance with minor, if any, impacts to the performance of the other lake management objectives. The changes proposed by the CLA are minor, easily-implemented, and tie into the information presented in the WSE FEIS (USACE 31March2000). Basically, the adjustment only requires changing six class limits on three tables in the Water Control Plan for Lake Okeechobee and the EAA (WCP). The simplicity of the modification and the demonstrated benefits with nominal adverse impacts may result in a Finding of No Significant Impact (FONSI) through an Environmental Assessment (EA) document.

As part of this short-term effort to improve WSE, the following recommendations are suggested for consideration by the USACE as potential additions to the Water Control Plan to further increase the flexibility of the WSE regulation schedule.

a. Modify the class limits of Tables 7-4, 7-7, and 7-10 of the WCP as shown in this report.
b. Consider adding language in the WCP to allow water managers to make different levels of Zone D pulse releases to the estuaries depending on local basin runoff characteristics (magnitude and timing).
c. Consider adding language in the WCP recognizing that the long-term performance of WSE was based, in part, on a simulation model assumption that Level 1 pulses were made in the bottom 1/3 of Zone D, Level 2 pulses were made in the middle 1/3 of Zone D, and Level 3 pulses were made in the upper 1/3 of Zone D. This model assumption should be a guideline for real-time operation, but the real-time assessment of estuarine conditions should be an important consideration for the release decision.
d. Consider adding language in the WCP that encourages more aggressive pulse releases to the estuaries when releases south have been limited for prolonged periods.

Figure 1. Lake Okeechobee Regulation Schedule
Water Supply and Environment (WSE)



ZONE	AGRICULTURAL CANALS To WCAs (1,2)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)
C (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 6500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 3500 CFS)
D (3,5)	AS NEEDED TO MINIMIZE ADVERSE IMPACTS TO THE LITTORAL ZONE WHILE NOT ADVERSELY IMPACTING THE EVERGLADES. (SEE NOTE 5.)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 4500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 2800 CFS)
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS.
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS. RELEASES ARE SUBJECT TO THE GUIDELINES IN THE WSE OPERATIONAL DECISION TREE, PARTS 1 AND 2.
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS.
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES
(5) ONLY WHEN THE WCAs ARE BELOW THEIR RESPECTIVE SCHEDULES

CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE
DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 8 NOVEMBER 1999

WSE (WITH CLIMATE OUTLOOK)

Table 1. Pulse Release Schedule

Pulse Releases - Three Levels

Table 7-11 Master Water Control Plan for Lake Okeechobee

Day of Pulse	Level I		Level II		Level III	
	St. Lucie S-80 (cfs)	Caloos. S-77 (cfs)	St. Lucie S-80 (cfs)	Caloos. S-77 (cfs)	St. Lucie S-80 (cfs)	Caloos. S-77 (cfs)
1	1200	1000	1500	1500	1800	2000
2	1600	2800	2000	4200	2400	5500
3	1400	3300	1800	5000	2100	6500
4	1000	2400	1200	3800	1500	5000
5	700	2000	900	3000	1000	4000
6	600	1500	700	2200	900	3000
7	400	1200	500	1500	600	2000
8	400	800	500	800	600	1000
9	0	500	400	500	400	500
10	0	500	0	500	400	500
Average Flow	**730**	**1600**	**950**	**2300**	**1170**	**3000**
Volume (Ac-Ft)	14,480	31,736	18,843	45,621	23,207	59,505
*Equivalent Depth (ft)	0.03	0.07	0.04	0.10	0.05	0.13

*Volume-Depth conversion based on average lake surface area of 467000 acres

Figure 2.
WSE Operational Guidelines Decision Tree
Part 1: Define Lake Okeechobee Discharges to the Water Conservation Areas

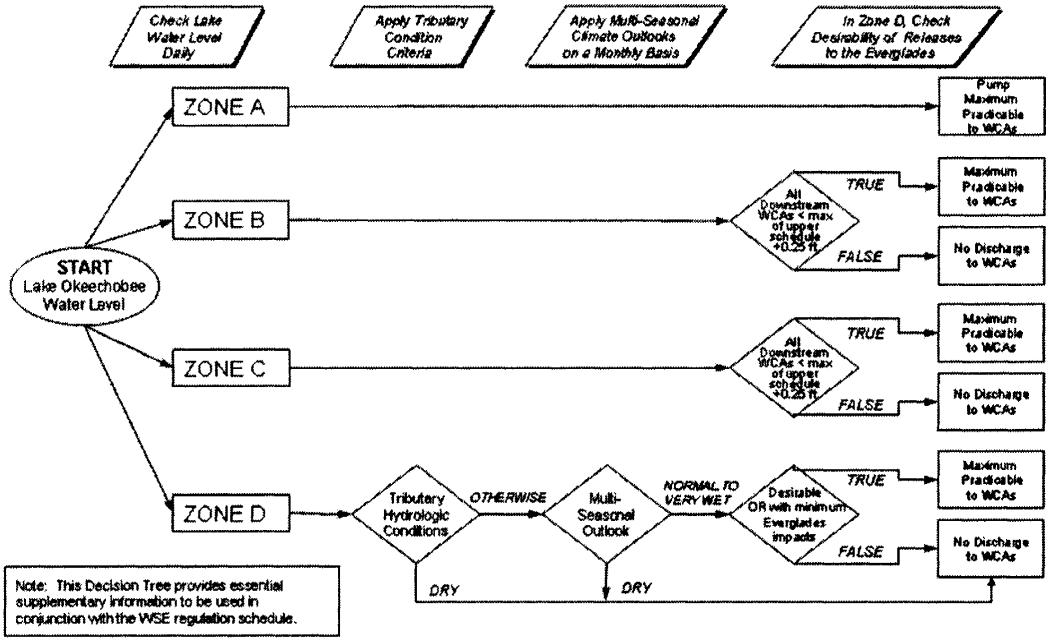


Figure 3.
WSE Operational Guidelines Decision Tree
Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)

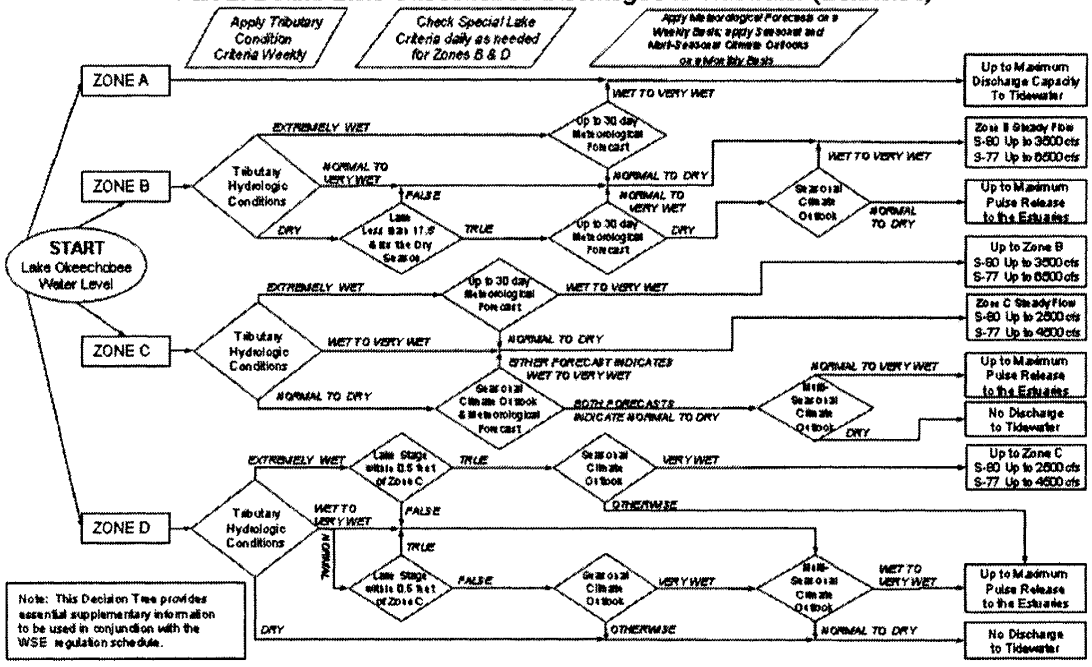


Figure 4.

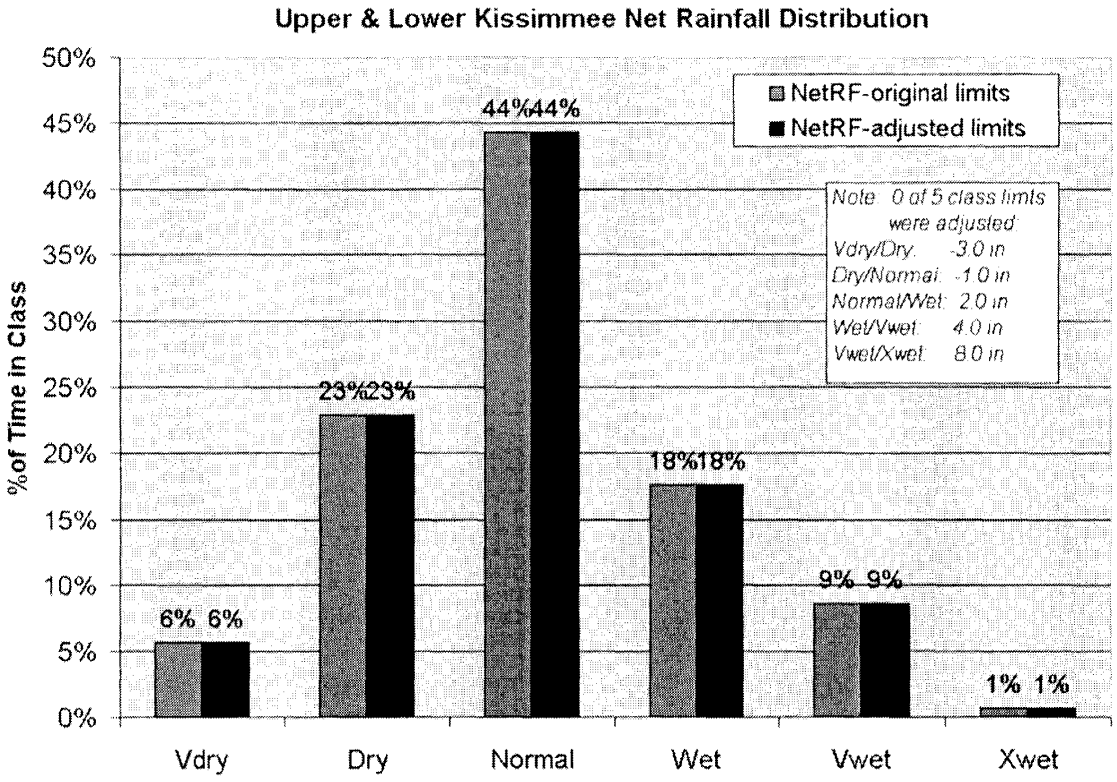

Upper & Lower Kissimmee Net Rainfall Distribution
%of Time in Class
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
NetRF-original limits
NetRF-adjusted limits
Note: 0 of 5 class limits were adjusted
Vdry/Dry: -3.0 in
Dry/Normal: -1.0 in
Normal/Wet: 2.0 in
Wet/Vwet: 4.0 in
Vwet/Xwet: 8.0 in
6% 6%
23%23%
44%44%
18%18%
9% 9%
1% 1%
Vdry
Dry
Normal
Wet
Vwet
Xwet

Figure 5.

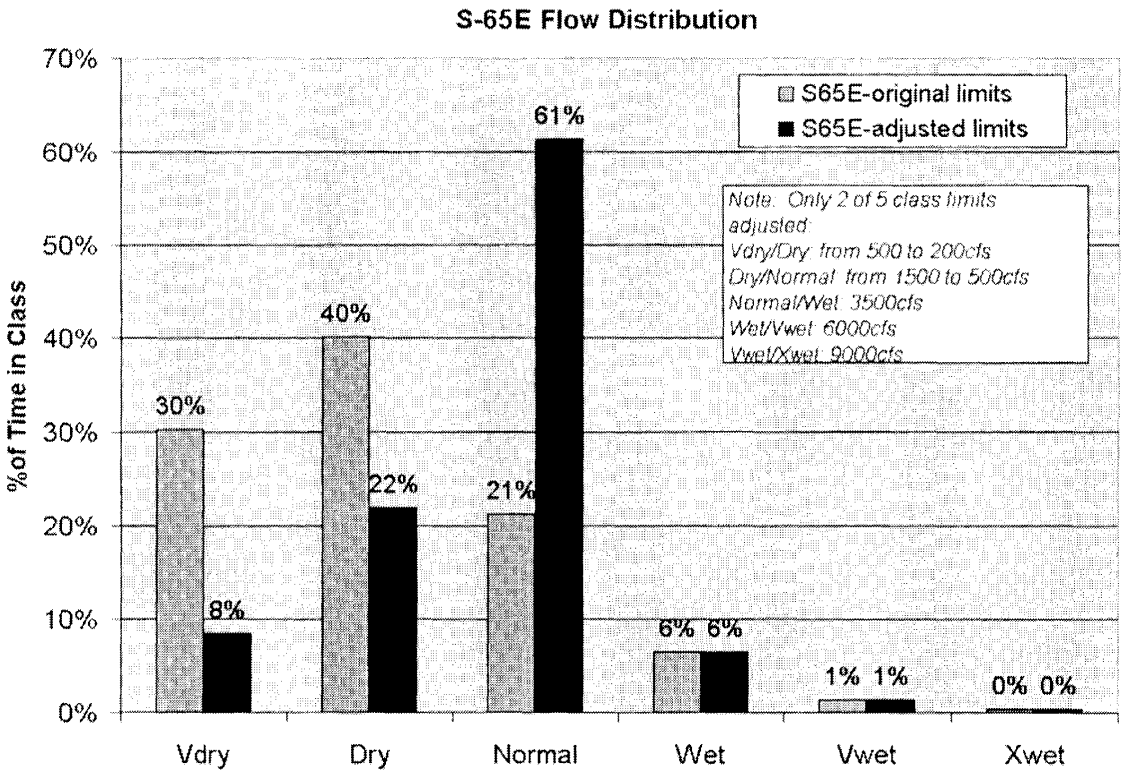

S-65E Flow Distribution
70%
60%
50%
40%
30%
20%
10%
0%
%of Time in Class
S65E-original limits
S65E-adjusted limits
Note. Only 2 of 5 class limits adjusted
Vdry/Dry from 500 to 200cfs
Dry/Normal from 1500 to 500cfs
Normal/Wet 3500cfs
Wet/Vwet 6000cfs
Vwet/Xwet 9000cfs
30%
8%
40%
22%
21%
61%
6%
6%
1%
1%
0%
0%
Vdry
Dry
Normal
Wet
Vwet
Xwet

Figure 6.

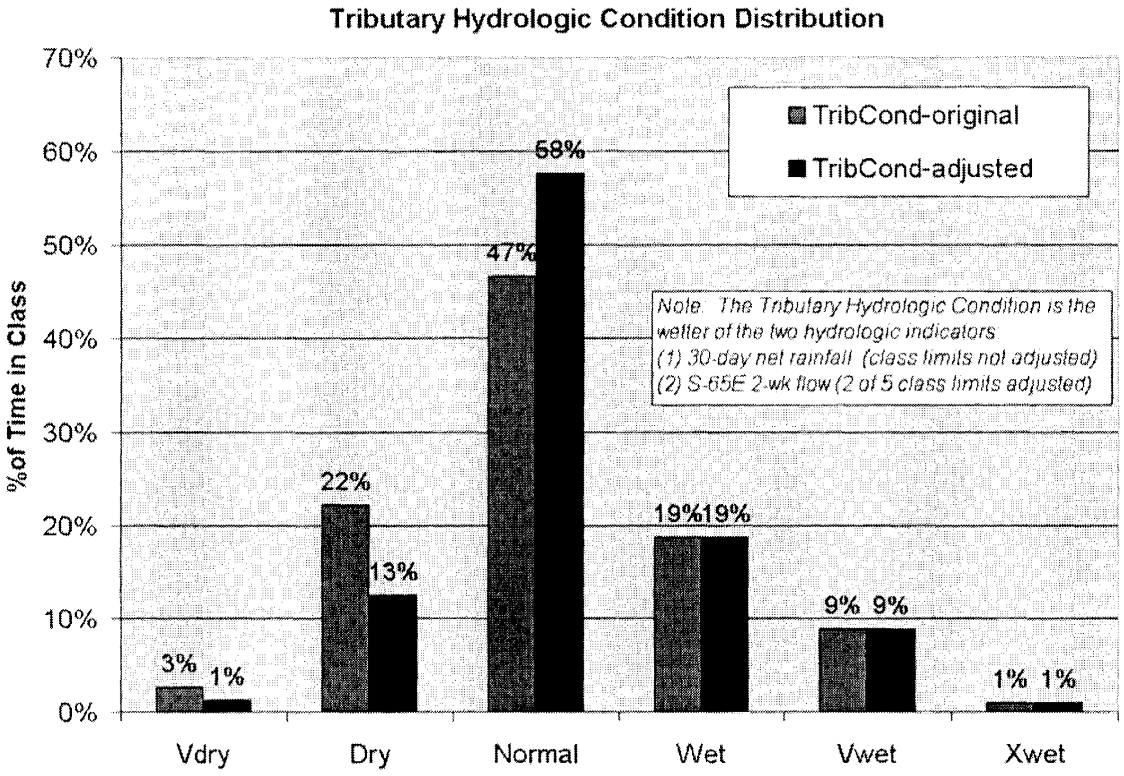

Tributary Hydrologic Condition Distribution
70%
60%
50%
40%
30%
20%
10%
0%
%of Time in Class
TribCond-original
TribCond-adjusted
Note: The Tributary Hydrologic Condition is the wetter of the two hydrologic indicators
(1) 30-day net rainfall (class limits not adjusted)
(2) S-65E 2-wk flow (2 of 5 class limits adjusted)
3%
1%
22%
13%
47%
58%
19%
19%
9%
9%
1%
1%
Vdry
Dry
Normal
Wet
Vwet
Xwet

Figure 7.

Seasonal LONINO Distribution

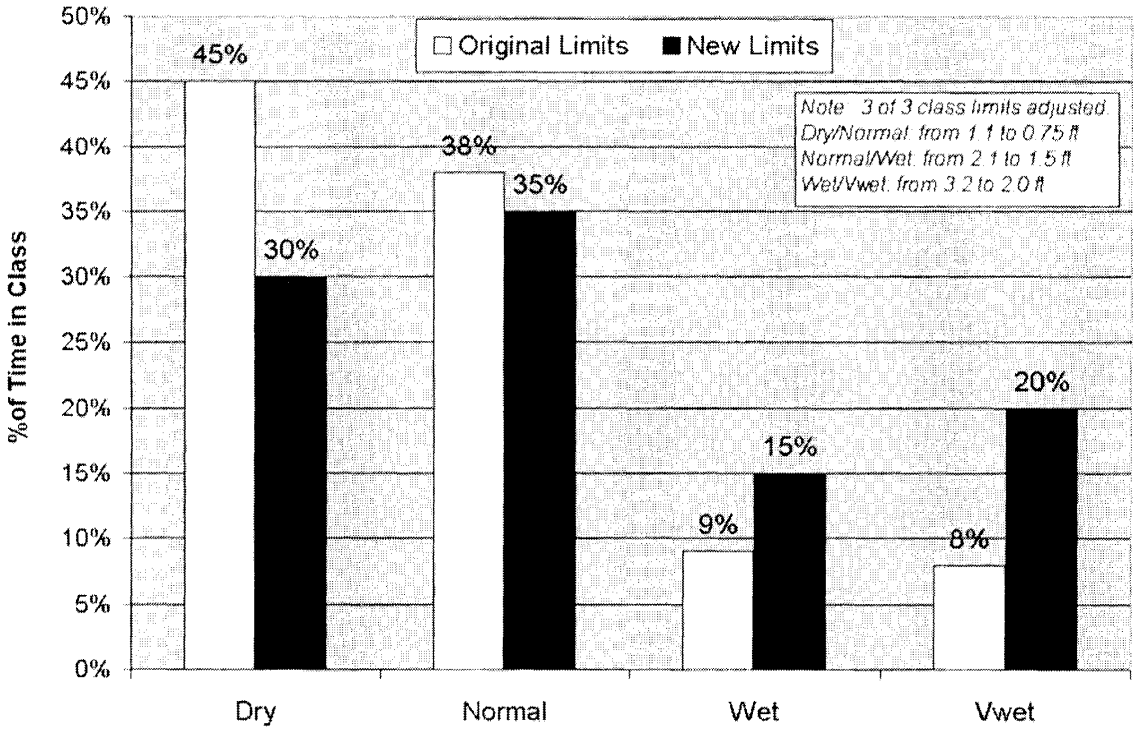


Figure 8.

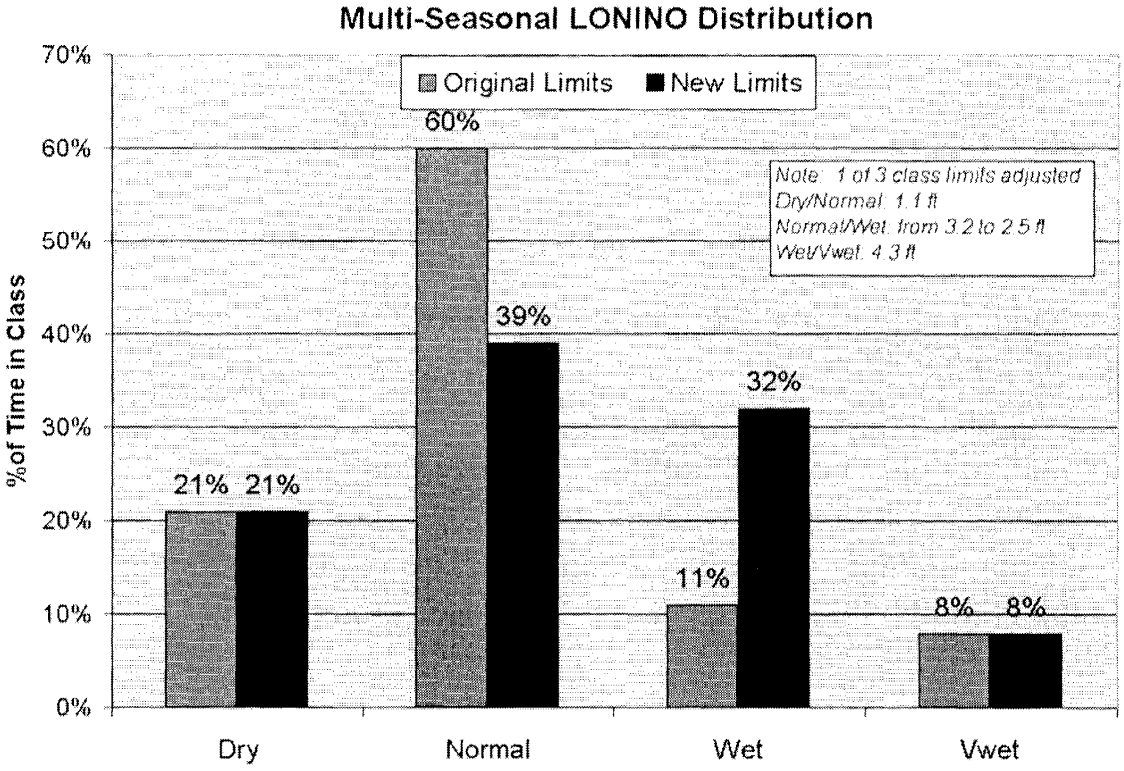

Multi-Seasonal LONINO Distribution
Original Limits
New Limits
Note: 1 of 3 class limits adjusted
Dry/Normal: 1.1 ft
Normal/Wet: from 3.2 to 2.5 ft
Wet/Vwet: 4.3 ft
% of Time in Class
70%
60%
50%
40%
30%
20%
10%
0%
21%
21%
60%
39%
11%
32%
8%
8%
Dry
Normal
Wet
Vwet

Figure 9.

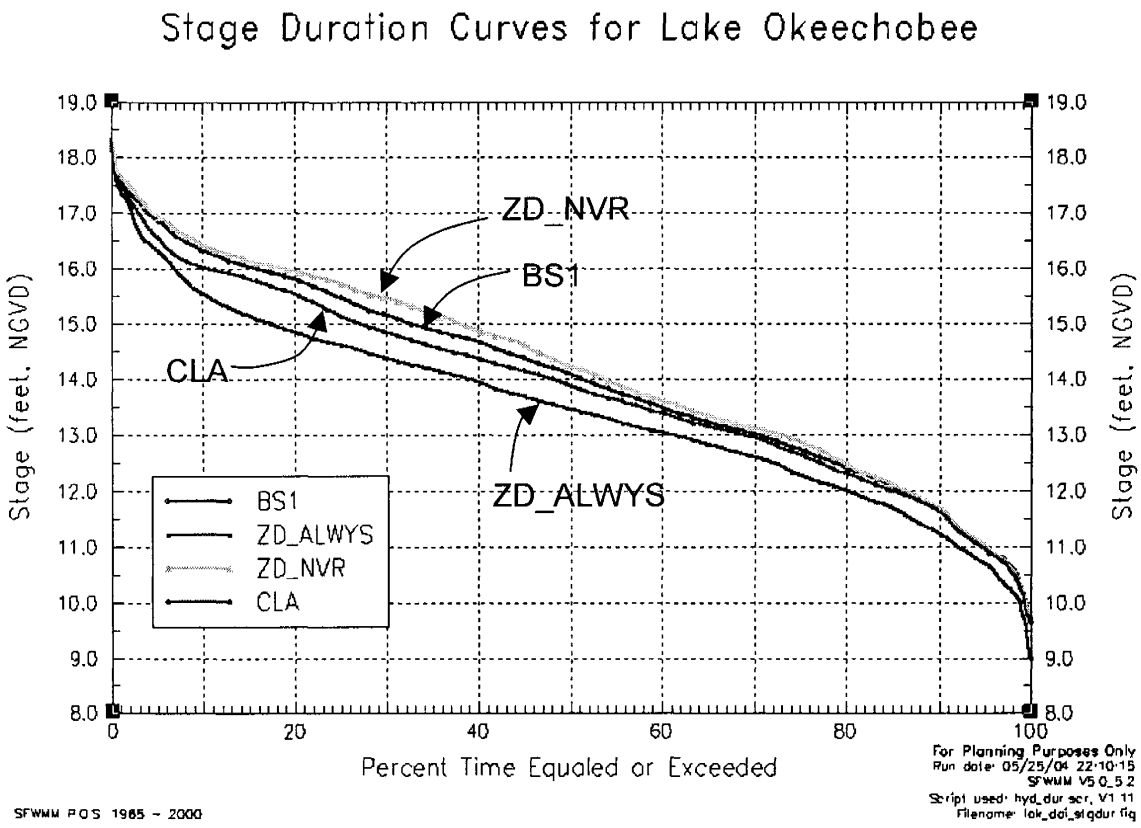
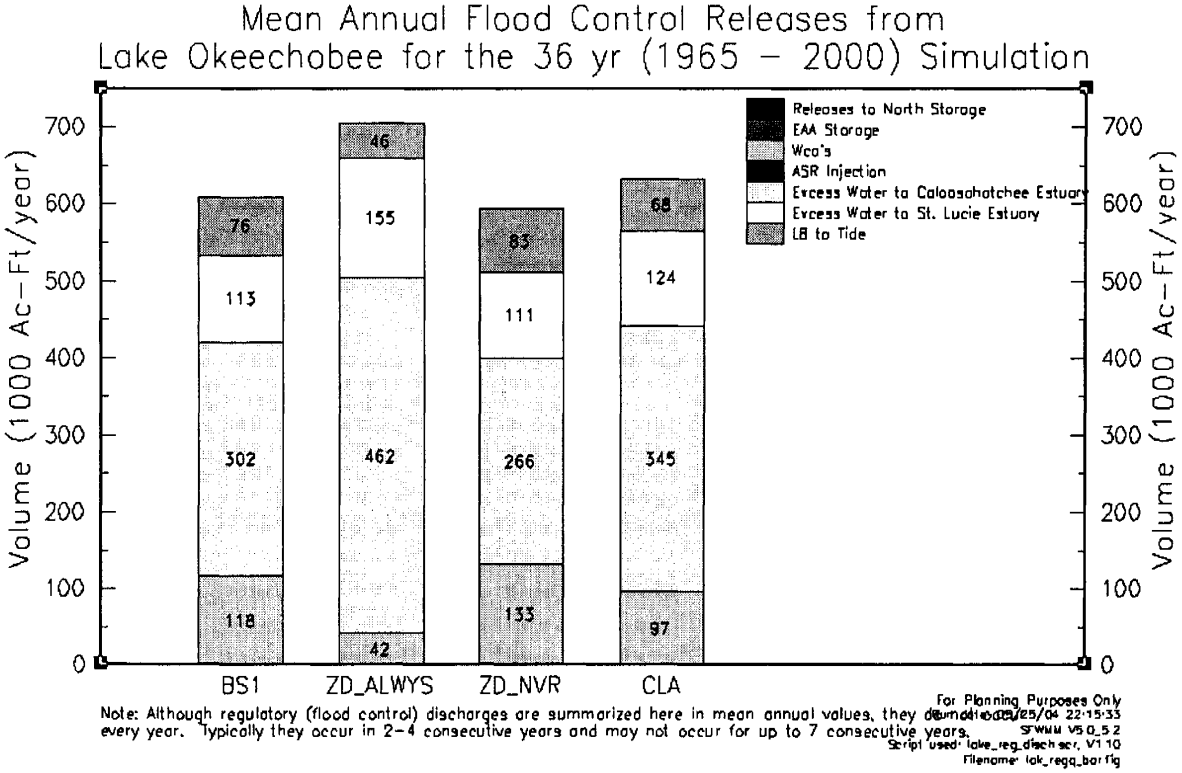
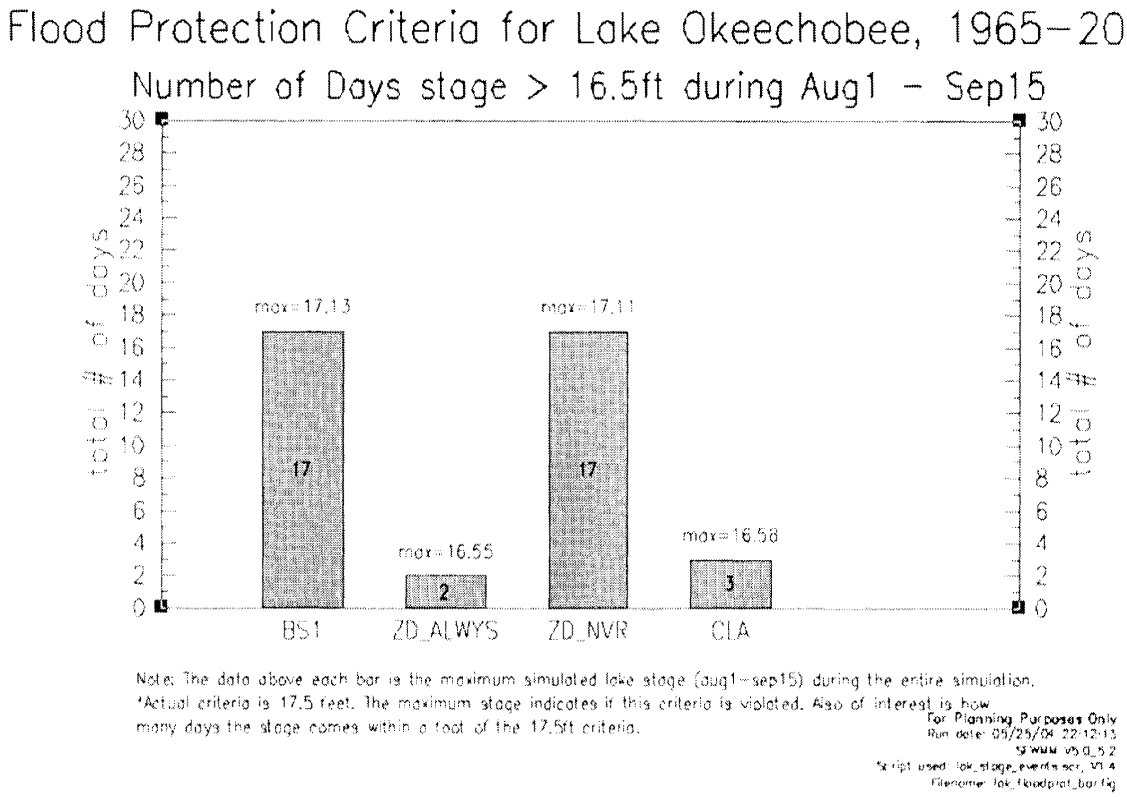

Stage Duration Curves for Lake Okeechobee
Stage (feet, NGVD)
Percent Time Equaled or Exceeded
ZD_NVR
BS1
CLA
ZD_ALWYS
BS1
ZD_ALWYS
ZD_NVR
CLA
For Planning Purposes Only
SFWMM POS 1965 - 2000

Figure 10.



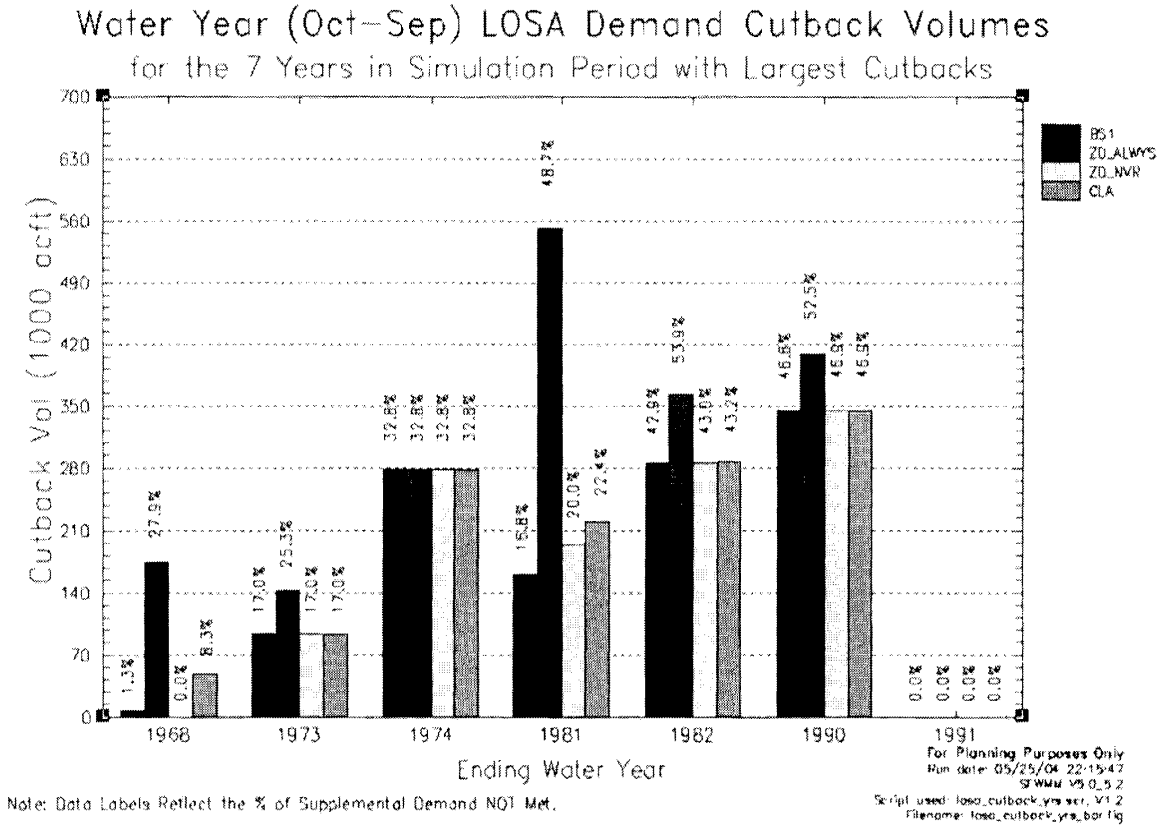
Note: Although regulatory (flood control) discharges are summarized here in mean annual values, they do not occur every year. Typically they occur in 2–4 consecutive years and may not occur for up to 7 consecutive years.

Figure 11.



Note: The data above each bar is the maximum simulated lake stage (aug1-sep15) during the entire simulation.
*Actual criteria is 17.5 feet. The maximum stage indicates if this criteria is violated. Also of interest is how many days the stage comes within a foot of the 17.5ft criteria.

Figure 12.


Water Year (Oct-Sep) LOSA Demand Cutback Volumes
for the 7 Years in Simulation Period with Largest Cutbacks
Cutback Vol (1000 acft)
700
630
560
490
420
350
280
210
140
70
0
1.3%
27.9%
0.0%
8.3%
17.0%
25.3%
17.0%
17.0%
32.8%
32.8%
32.8%
32.8%
15.8%
48.3%
20.0%
22.4%
42.8%
53.9%
43.0%
43.2%
46.8%
52.5%
46.8%
46.8%
0.0%
0.0%
0.0%
0.0%
1968
1973
1974
1981
1982
1990
1991
Ending Water Year
BS1
ZD_ALWYS
ZD_NVR
CLA
Note: Data Labels Reflect the % of Supplemental Demand NOT Met.
For Planning Purposes Only
Run date: 05/25/04 22:15:47
SFWMM V5.0_5.2
Script used: losa_cutback_yrs.scr, V1.2
Filename: losa_cutback_yrs_bar.fig

Water Resources Advisory Committee

Lake Okeechobee Workshop

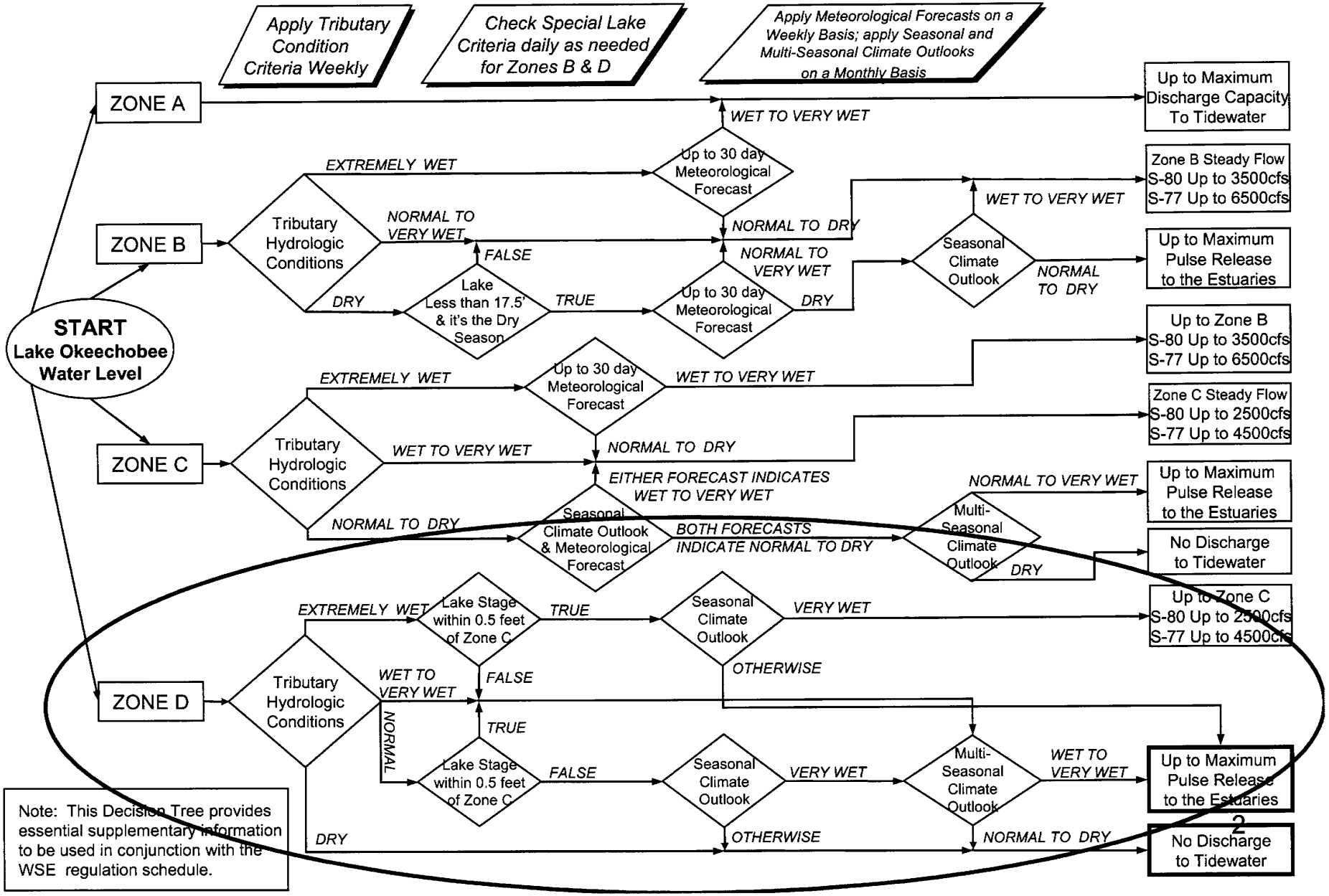
07 June 2004

Lake Okeechobee WSE Schedule Improvement Study WSE-SIS Regional Modeling Results

WRAC
Lake Okeechobee Water Levels Issues Workshop
June 7, 2004

WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)



Modification of 'no discharge to tide' box in Zone D portion of the WSE decision tree

Simulation	LEGEND	Description
Base	BS1	Base run - no modifications to WSE – AMO/ENSO sub sampling for LONINO
Alternative 1	LE1	Low level releases from the **L**ake to the **E**stuaries **1**
Alternative 2	LE2	Low level releases from the **L**ake to the **E**stuaries **2**
Alternative 3	PDI	Low level releases from the Lake to the Estuaries are adjusted depending on the **P**almer **D**rought Severity **I**ndex (PDSI) for the Lake tributaries.
Alternative 5	A5	Same as BS1 with deviation operations for WSE: Level I pulse releases during dry season from Nov-Mar, and ½ level I pulse release from Apr-May
Alternative 6	A6	Same as A5 (deviation) but no discharges allowed when La Nina conditions are forecast for the oncoming dry season
Alternative 7	A7	Same as BS1 with deviation operations for WSE: Level I pulse releases during dry season from Nov-Mar and wet season June-Oct, and ½ level I pulse release from Apr-May. Deviation operations are discontinued when La Nina conditions are forecast for the oncoming dry season
WSE Adjustment	CLA	**C**lassification **L**imit **A**djustments for the tributary hydrologic condition and the Lake Okeechobee net inflow outlook (LONINO)
Sensitivity 1	ZD_ALWYS	Always release up to maximum pulse release to the estuaries in Zone D
Sensitivity 2	ZD_NVR	No discharge to tidewater in Zone D even if WSE calls for pulse releases

St. Lucie Estuary: SLE; Caloosahatchee Estuary: CE; Palmer Drought Severity Index: PDSI; Lake Okeechobee Net Inflow Outlook: LONINO

Base (BS1)

- Same as the ICU 2000B2 Simulation, with:
  - WSE is similar (L1, L2 and L3 in Zone D)
  - Sub sampling from AMO-ENSO conditions to determine seasonal and multi seasonal LONINO
  - LOK regulatory releases through L8 and C51 to tide
  - LOSA SSM line 13.0 to 10.5
  - Phased cutbacks for LOSA
  - Adjusted for STA treatment area & South Miami-Dade operations

LE1 Simulation

- WSE is modified by having low level releases to the CE and SLE when LOK is in Zone D and WSE calls for "no discharge to tide." The following flows (cfs) are maintained at the S-79 and S-80 structures

	J	F	M	A	M	J	J	A	S	O	N	D
S-79	800	800	500	500	500	0	0	0	0	0	500	800
S-80	200	200	200	200	200	0	0	0	0	0	200	200

LE2 Simulation

- This Alternative is the same as WSE-LE1, except that flows at S-79 continue from November to May at a reduced rate of 300 cfs when the lake falls into the upper 0.5 ft of Zone E (flows in cfs).

		J	F	M	A	M	J	J	A	S	O	N	D
S-79	D	800	800	500	500	500	0	0	0	0	0	500	800
	E	300	300	300	300	300	0	0	0	0	0	300	300
S-80	D	200	200	200	200	200	0	0	0	0	0	200	200
	E	0	0	0	0	0	0	0	0	0	0	0	0

PDI Simulation

- This alternative identifies water releases to the estuaries when the Lake stage is in Zone D and WSE falls in the "no discharge to tide" box. Releases are function of the PDSI values

		Releases (cfs)			
PDSI		November to February		March to May	
Category	Values (inches)	CE	SLE	CE	SLE
Extreme Drought	< -3.0	800 @ S-79	200 @ S-80	500 @ S-79	200 @ S-80
Moderate Drought	-3.0 to -2.0	800 @ S-79	200 @ S-80	500 @ S-79	200 @ S-80
Mild Drought	-2.0 to -1.0	800 @ S-79	200 @ S-80	500 @ S-79	200 @ S-80
Normal	-1.0 to 1.0	800 @ S-79	200 @ S-80	800 @ S-79	200 @ S-80
Wetter than Normal	1.0 to 2.0	800 @ S-77	200 @ S-308	800 @ S-79	200 @ S-80
Unusually Wet	2.0 to 3.0	Pulse I @ S-77	200 @ S-308	Pulse I @ S-79	200 @ S-308
Extremely Wet	> 3.0	Pulse 2 @ S-77	200 @ S-308	Pulse 2 @ S-79	200 @ S-308

Alternative 5 Simulation (A5)

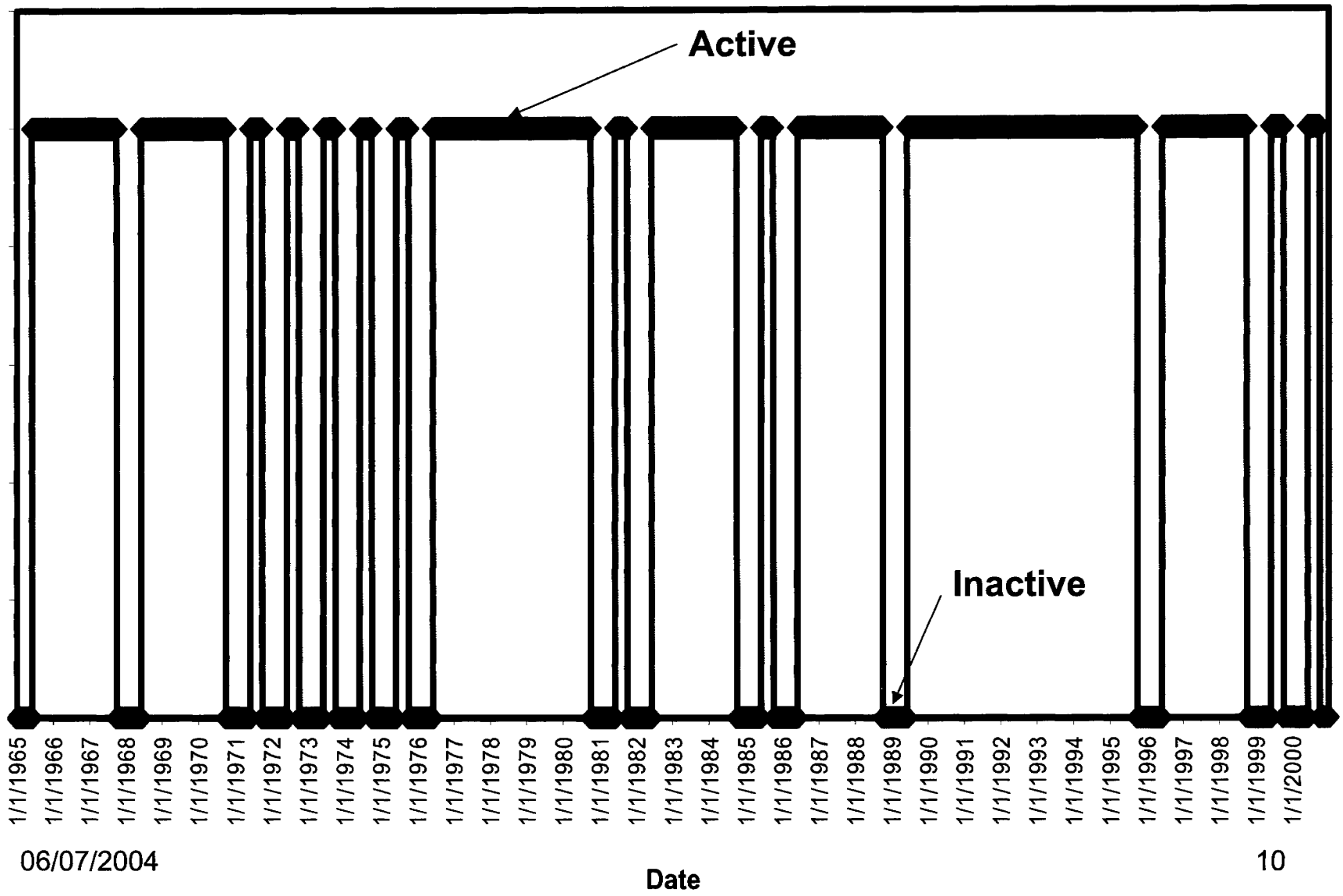
- LOK WSE Planned Deviation as implemented in 2003 – 2004
- When Lake stage is in Zone D and WSE falls in the "no discharge to tide" box, perform the following releases:

Jan-Mar	Level I to both estuaries
Apr-May	½ Level I to both estuaries
Jun-Oct	No releases
Nov-Dec	Level I to both estuaries

Alternative 6 Simulation (A6)

- Same as A5 simulation, but deviation operations are terminated when dry conditions are forecast at the beginning of the dry season (Oct. 1)
- Criteria:
  - PDSI is less than -2.5 inches on September 30th
  - ENSO (Nino 3) indicator is less than -0.6 degrees Centigrade on September 30th

Periods with WSE Deviation Active



Alternative 7 Simulation (A7)

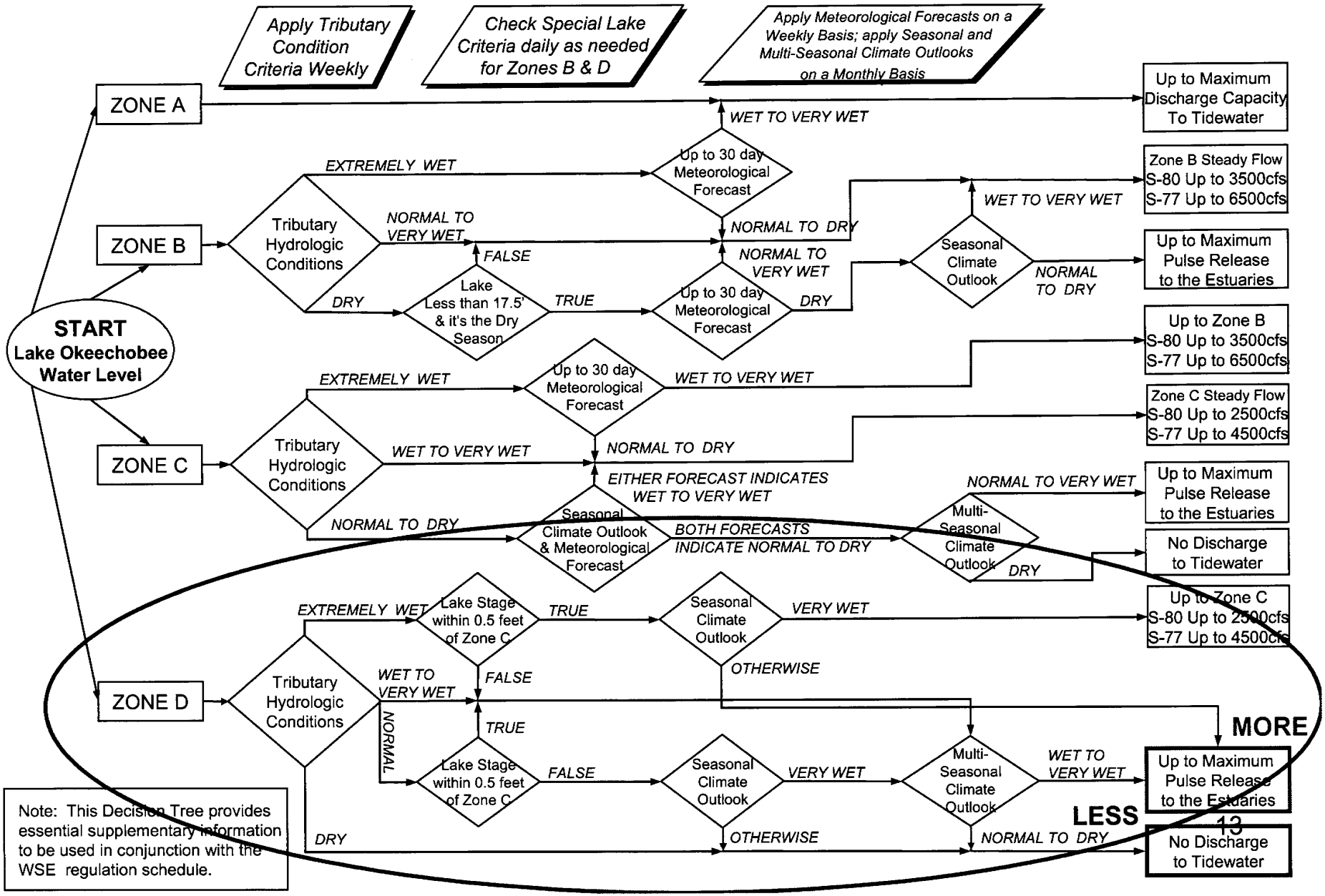
- Same as A6, but deviation operations are performed all year, with Level 1 pulse releases to both estuaries for the period June-October (wet season)

Class Limits Adjustment (CLA)

- Goal: Improve performance of WSE with minimal changes to the schedule
- Strategy: Adjust class limits for…
  - Tributary Hydrologic Conditions
  - Seasonal LONINO
  - Multi-Seasonal LONINO
- General Objective: Increase frequency of Zone D pulse releases to improve in-lake performance without significantly impacting estuary & water supply performance.

WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)



CLA-Changes in LONINO

LOK Equivalent Depth (feet)

- Seasonal

Very Wet

3.2' to 2.0'

Wet

2.1' to 1.5'

Normal

1.1' to 0.75'

Dry

- Multi-seasonal

Very Wet

4.3'

Wet

3.2' to 2.5'

Normal

1.1'

Dry

CLA-Changes in Tributary Conditions

S-65E 14-day moving average flow (cfs)

Extremely Wet	9000 cfs
Very Wet	6000 cfs
Wet	3500 cfs
Normal	1500 to 500 cfs
Dry	500 to 200 cfs
Very Dry	

Establish Solution Bounds

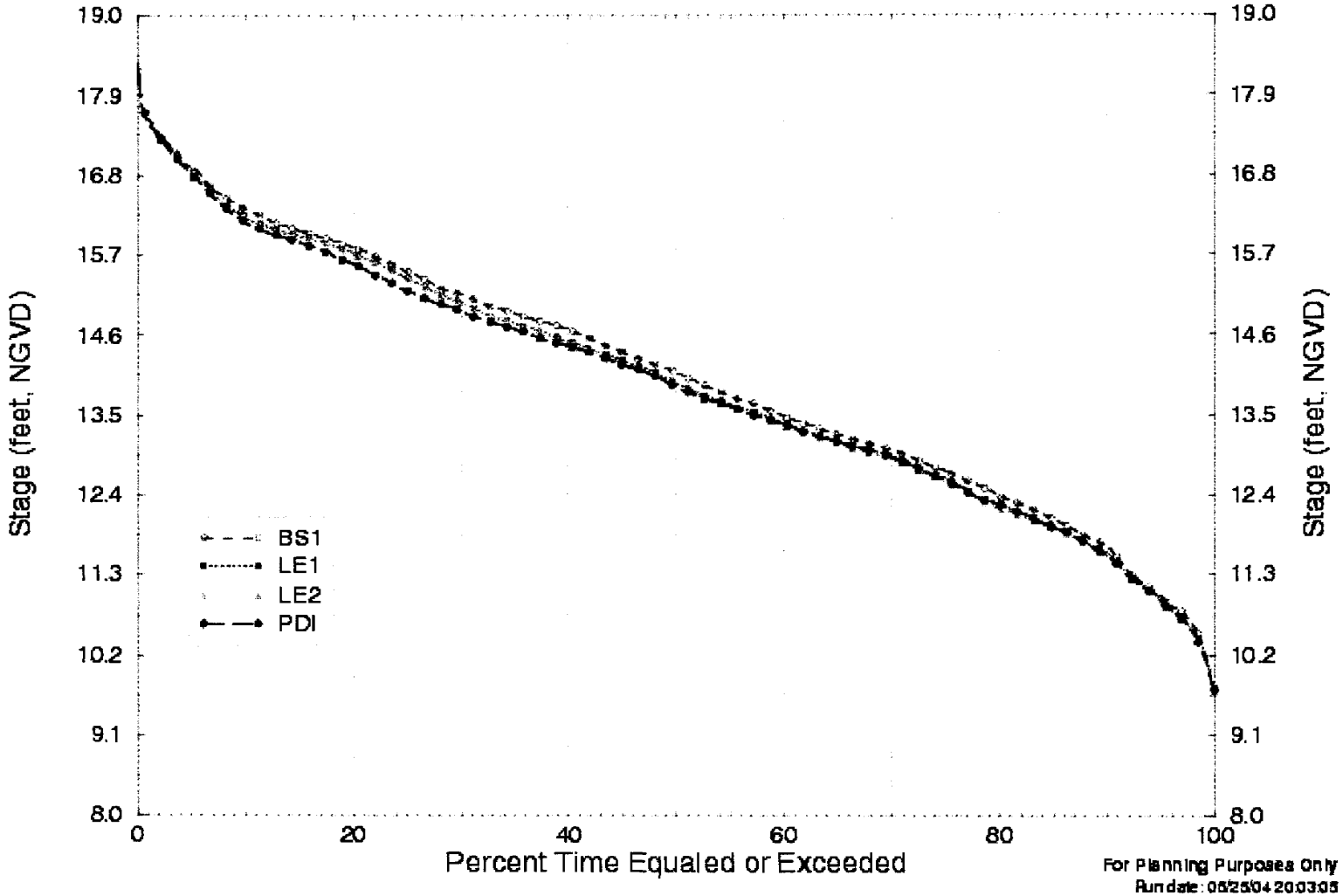
- Never do releases when Lake stage is in Zone D of WSE (ZD_NVR)
- Always release when Lake stage is in Zone D of WSE (ZD_ALWYS)

Summary of Results

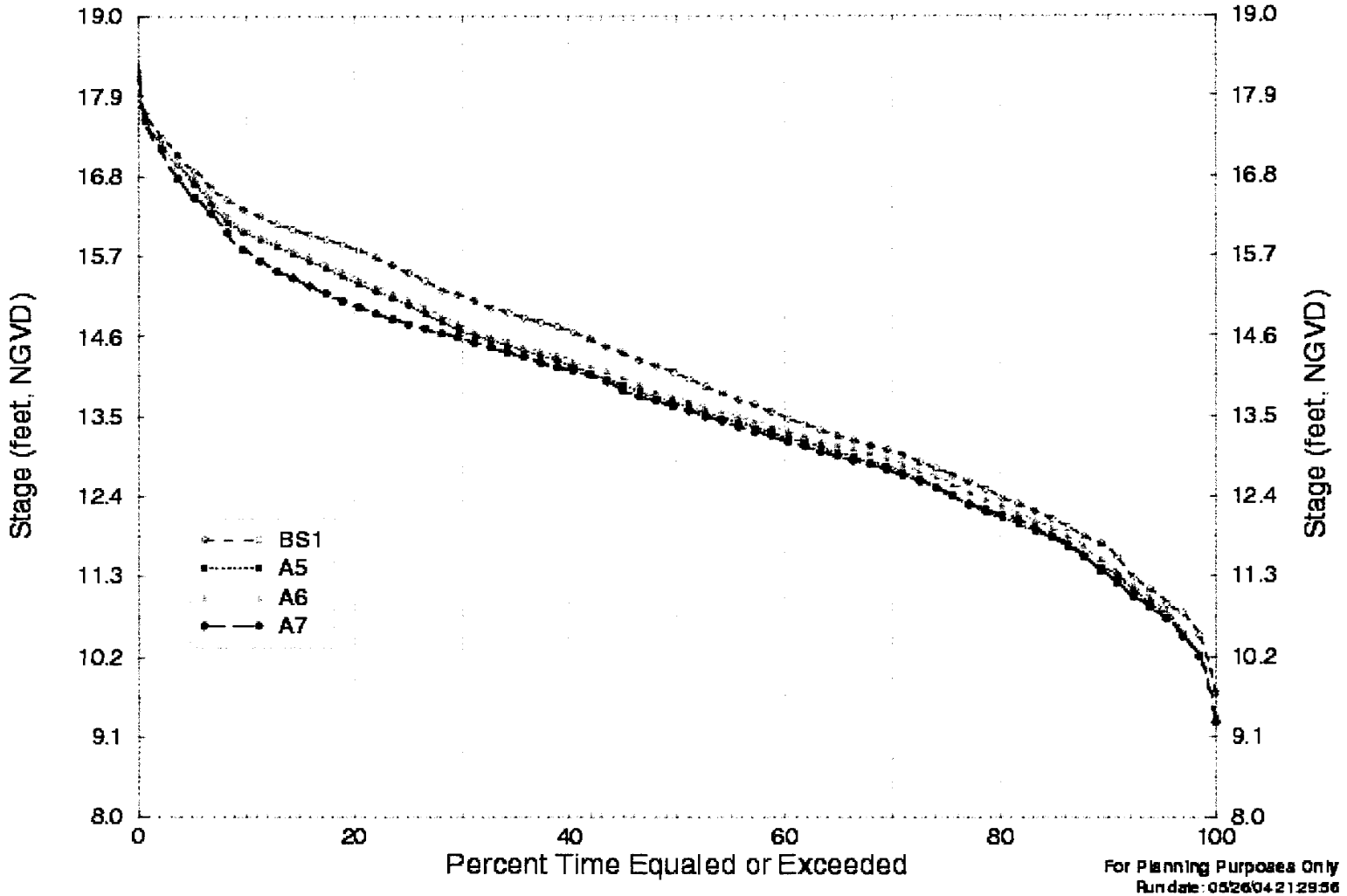
Performance summary table for the WSE-SIS model runs. Performance is compared to the Base run, and symbols indicate the following: ++ = substantially better than Base, + = slightly better than Base, 0 = not different from Base, - = slightly worse than Base, and - - = substantially worse than Base. Everglades is still under evaluation

Simulation	LOK Flood	LOK Ecology	CE High Flow	CE Low Flow	SLE High Flow	SLE Low Flow	LOSA	LEC
LE1	0	0	0	++	0	0	-	0
LE2	0	0	0	++	0	0	-	0
PDI	0	0	0	++	-	+	-	0
A5	0	+	+	++	-	++	- -	0
A6	0	+	0	++	-	++	- -	0
A7	+	++	-	++	0	+	- -	- -
CLA	++	+	-	0	-	+	0	0
ZD_ALWYS	++	++	-	++	0	++	- -	- -
ZD_NVR	0	- -	+	0	-	-	0	0

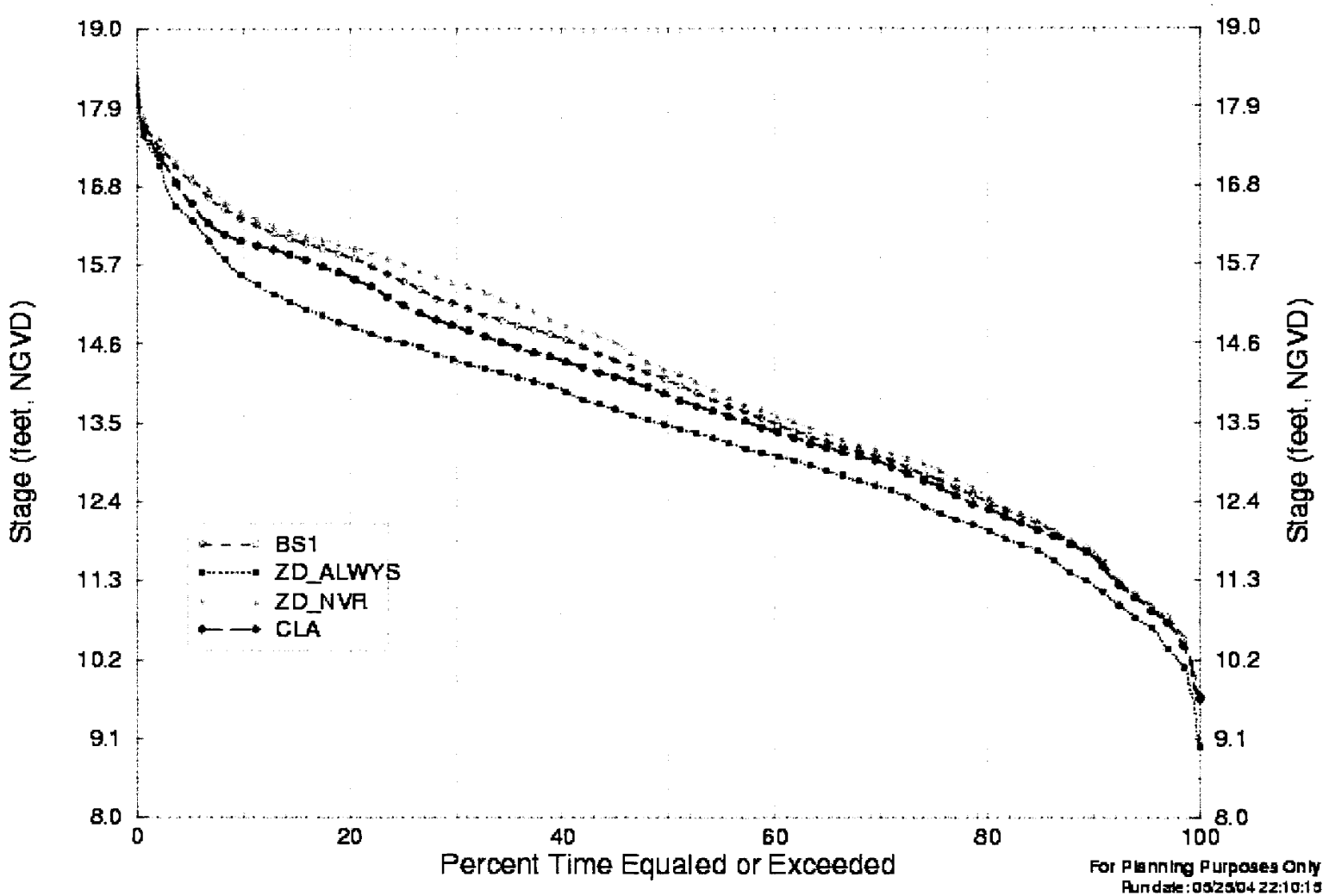
Stage Duration Curves for Lake Okeechobee



Stage Duration Curves for Lake Okeechobee



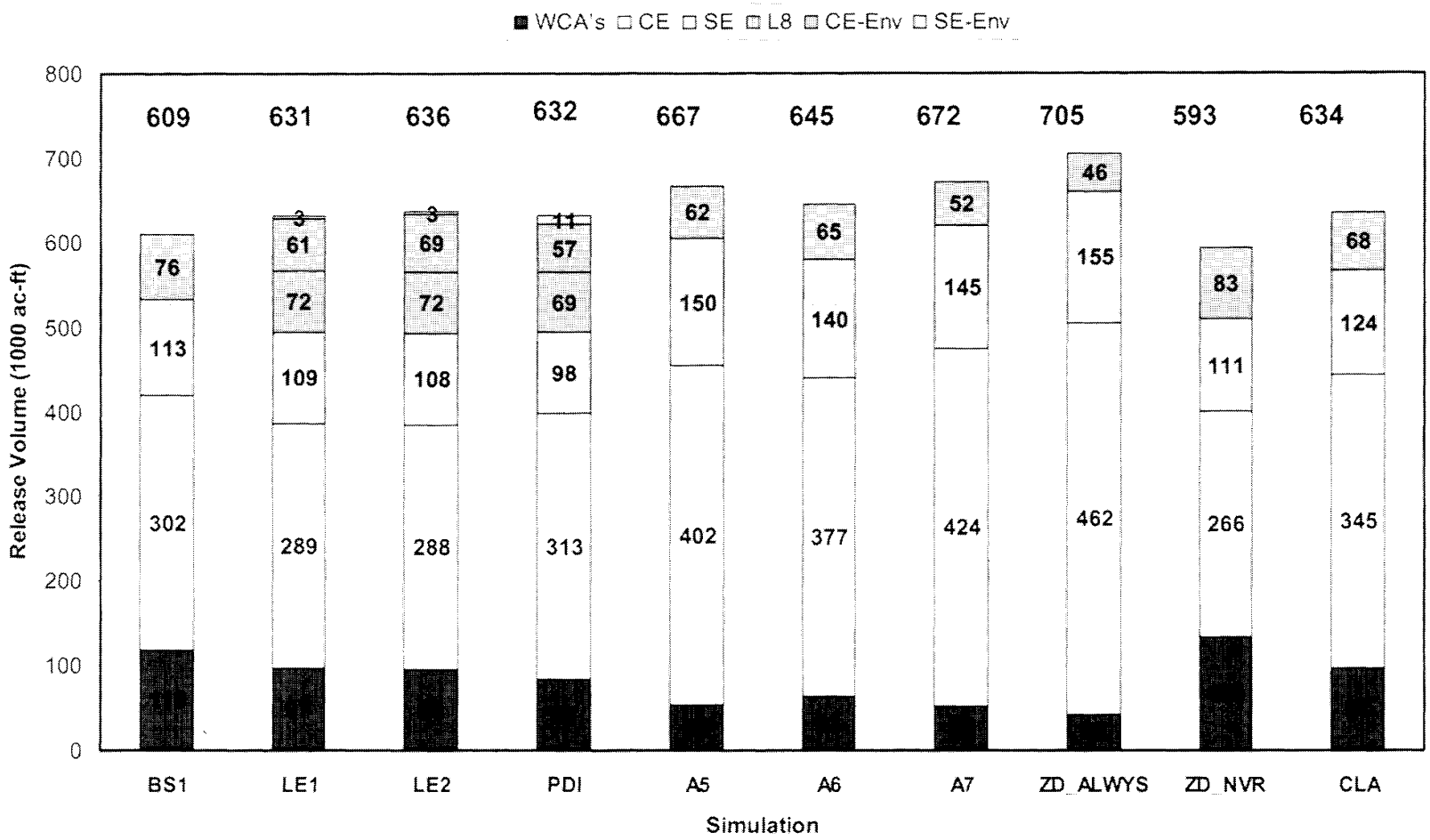
Stage Duration Curves for Lake Okeechobee



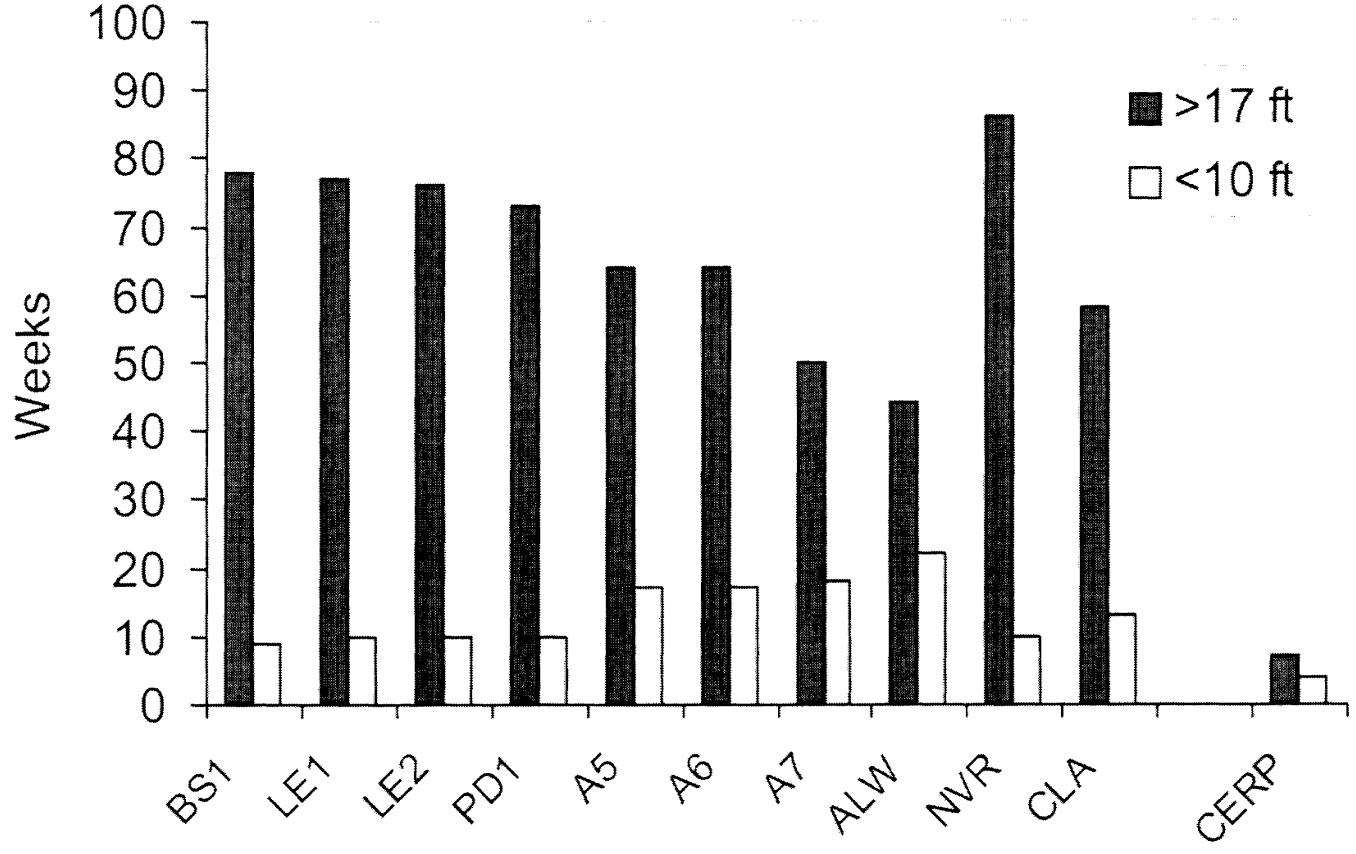
SFWMM P.O.S. 1965 – 2000

For Planning Purposes Only
Run date: 05/25/04 22:10:16
SFWMM V5.0_5.2
Script used: hyd_dur.scr, V1.11
Filename: lok_dai_stgdur.fig

Lake Okeechobee Mean Annual Releases
Flood Control and Environmental

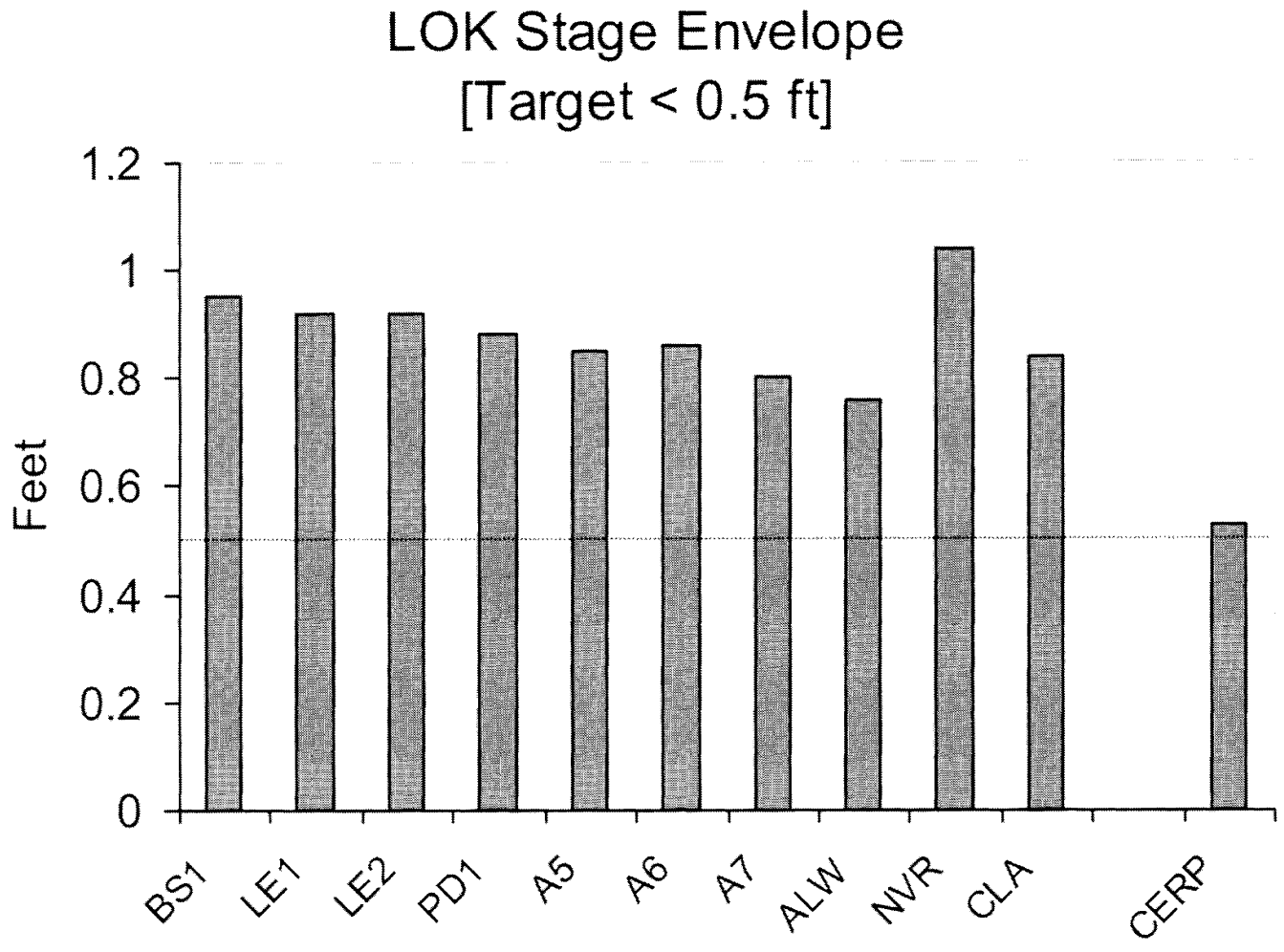


LOK Extreme High and Low Stage
[Targets = 0 Weeks]



LOK Stage Envelope Performance Measure

Stage	J	F	M	A	M	J	J	A	S	O	N	D
19	3.5	4	4.5	5	6	6.5	6.5	6	5	4	3.5	3.5
18.5	3	3.5	4	4.5	5.5	6	6	5.5	4.5	3.5	3	3
18	2.5	3	3.5	4	5	5.5	5.5	5	4	3	2.5	2.5
17.5	2	2.5	3	3.5	4.5	5	5	4.5	3.5	2.5	2	2
17		2	2.5	3	4	4.5	4.5	4	3	2		
16.5	1		2	2.5	3.5	4	4	3.5	2.5		1	1
16	0.5	1		2	3	3.5	3.5	3	2	1	0.5	0.5
15.5	0	0.5	1		2.5	3	3	2.5		0.5	0	0
15	0	0	0.5	1	2	2.5	2.5	2	1	0	0	0
14.5	0	0	0	0.5		2	2		0.5	0	0	0
14	0.5	0	0	0	1			1	0	0	0.5	0.5
13.5	1	0.5	0	0	0.5	1	1	0.5	0	0	1	1
13		1	0.5	0	0	0.5	0.5	0	0	0.5		
12.5	2		1	0.5	0	0	0	0	0	1	2	2
12	2.5	2		1	0	0	0	0	0.5		2.5	2.5
11.5	3	2.5	2		0.5	0.5	0.5	0.5	1	2	3	3
11	3.5	3	2.5	2	1	1	1	1		2.5	3.5	3.5
10.5	4	3.5	3	2.5					2	3	4	4
10	4.5	4	3.5	3	2	2	2	2	2.5	3.5	4.5	4.5
9.5	5	4.5	4	3.5	2.5	2.5	2.5	2.5	3	4	5	5
9	5.5	5	4.5	4	3	3	3	3	3.5	4.5	5.5	5.5
8.5	6	5.5	5	4.5	3.5	3.5	3.5	3.5	4	5	6	6
8	5.6	6	5.5	5	4	4	4	4	4.5	5.5	5.6	5.6
7.5	7	6.5	6	5.5	4.5	4.5	4.5	4.5	5	6	7	7

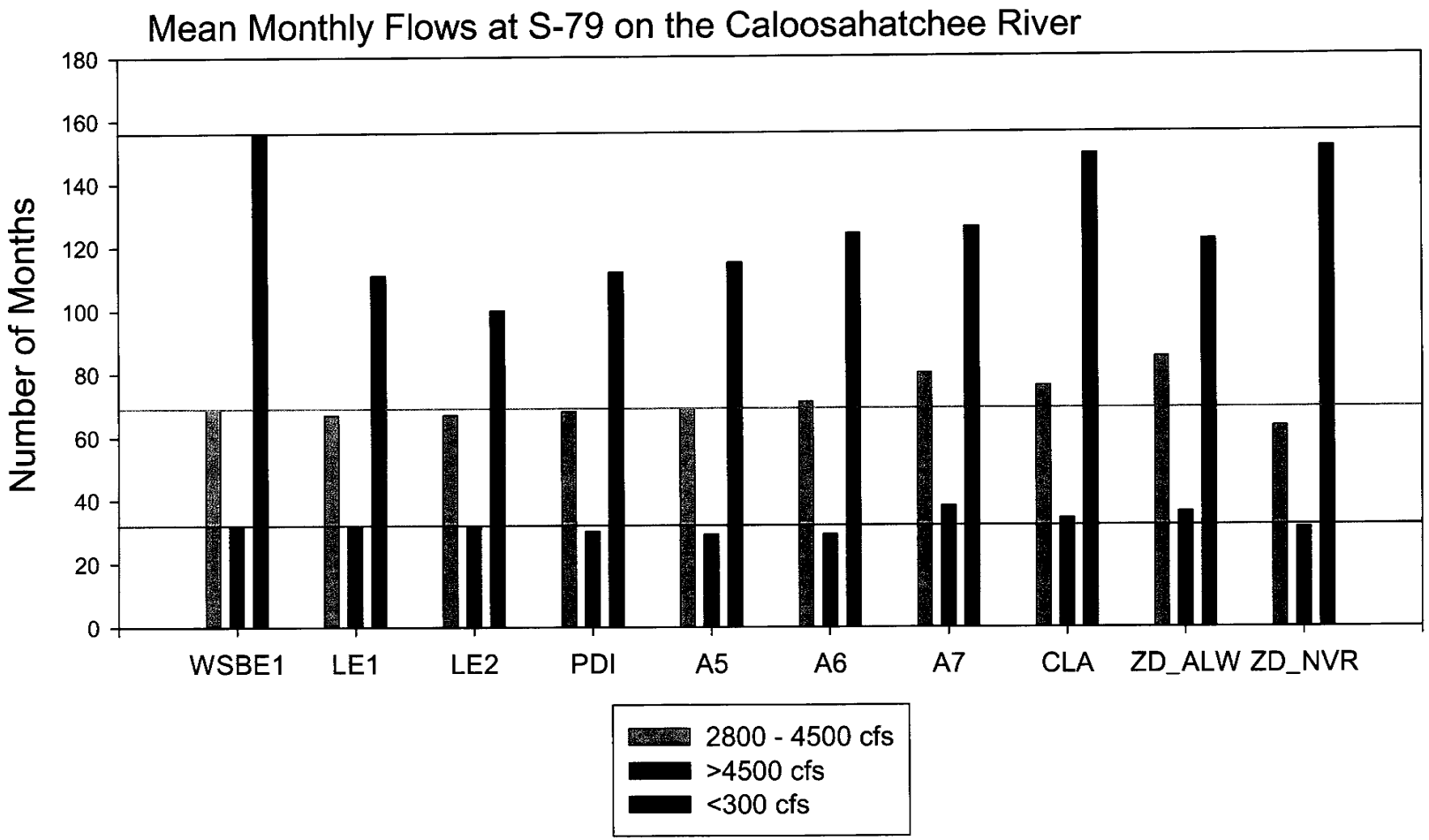

LOK Stage Envelope
[Target < 0.5 ft]
Feet
1.2
1
0.8
0.6
0.4
0.2
0
BS1
LE1
LE2
PD1
A5
A6
A7
ALW
NVR
CLA
CERP

Flow Envelope for the Caloosahatchee at S-79

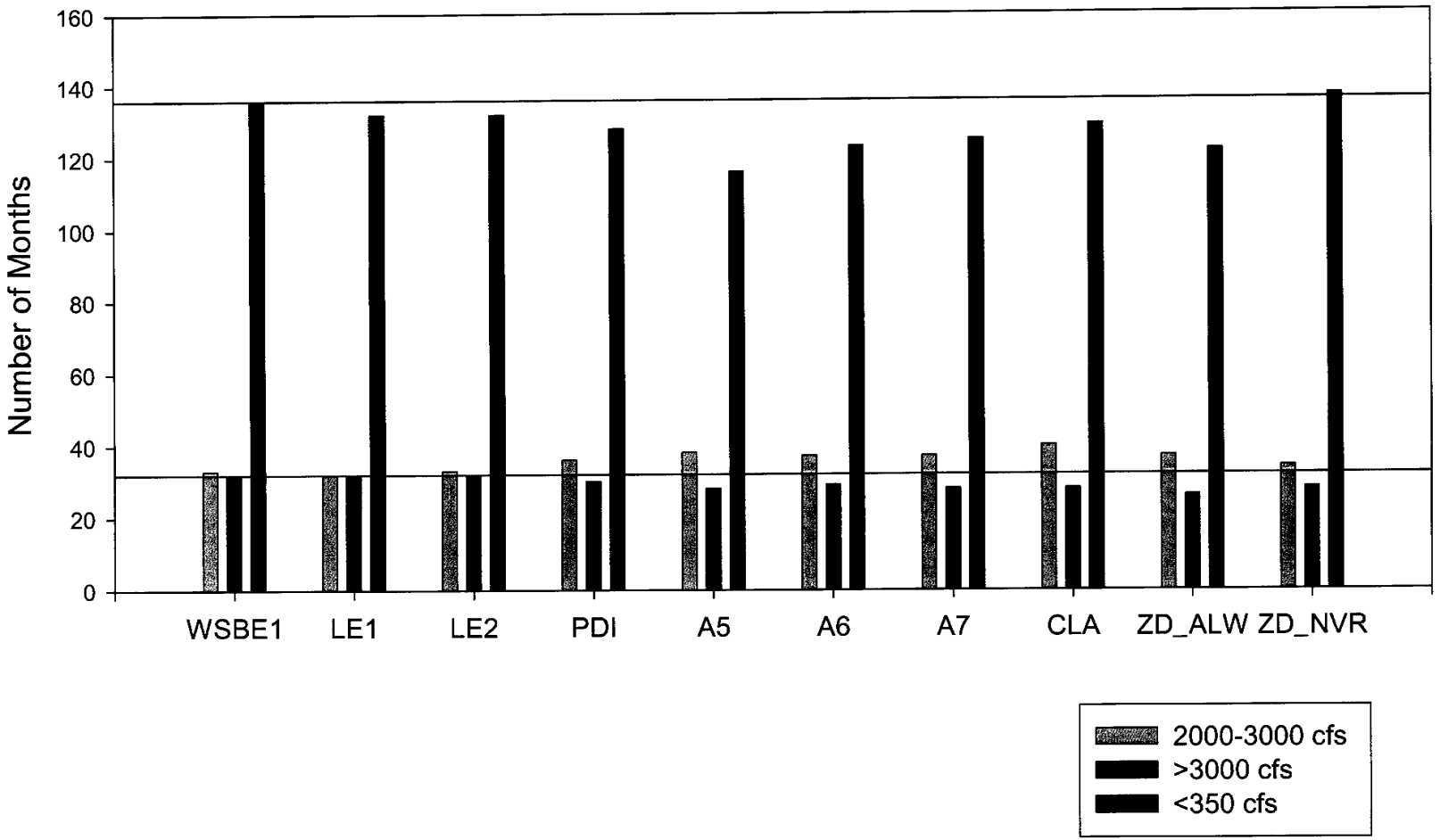
- < 300 cfs: high damaging salinity in upper estuary
- 2800 – 4500 cfs: low damaging salinity in the seaward portion of the estuary
- >4500 cfs: low damaging salinity in San Carlos Bay

Flow Envelope for the St. Lucie Estuary

- <350 cfs: salinity too high in estuary
- 2000 – 3000 cfs: creates stressful low salinity conditions in estuary
- >3000 cfs: low damaging salinity in estuary


Mean Monthly Flows at S-79 on the Caloosahatchee River
Number of Months
180
160
140
120
100
80
60
40
20
0
WSBE1
LE1
LE2
PDI
A5
A6
A7
CLA
ZD_ALW
ZD_NVR
2800 - 4500 cfs
>4500 cfs
<300 cfs

Mean Monthly inflow to the St. Lucie Estuary
(C44, C23, C24, Northfork, Southfork, LOK regulatory releases)



Lower East Coast Water Supply Assessment – WSE Runs					
	Months of Water Shortages in Lower East Coast Service Areas				
Simulation	SA-1	SA-2	SA-3	SA-4	Lake O and Dry Season Criteria
BS1	35	127	32	30	29
LE1	36	128	34	31	30
LE2	36	128	34	31	30
PDI	36	128	34	31	30
A5	36	128	34	31	30
A6	35	127	32	30	29
A7	43	131	41	38	37
CLA	36	128	33	31	30
ZD_ALWYS	47	131	45	42	41
ZD_NVR	34	126	31	29	28

Lower East Coast Water Supply Assessment – Alternatives Compared to WSE-B1						
		Additional Months of Water Shortages Compared to BS1				
Simulation	Assessment	SA-1	SA-2	SA-3	SA-4	Lake O and Dry Season Criteria
LE1	0	1	1	2	1	1
LE2	0	1	1	2	1	1
PDI	0	1	1	2	1	1
A5	0	1	1	2	1	1
A6	0	0	0	0	0	0
A7	--	8	4	9	8	8
CLA	0	1	1	1	1	1
ZD_ALWYS	--	12	4	13	12	12
ZD_NVR	0	-1	-1	-1	-1	-1

Lake Okeechobee Service Area Water Supply Assessment – Alternatives Compared to BS1							
		Water Shortage Measures and Comparisons to BS1					
Simulation	Assessment	SSM Cutbacks (acre ft.)	Additional SSM Cutbacks compared to BS1 (acre ft.)	Water Years with SSM Cutbacks >100,000 acre feet	Water Years with SSM Cutbacks >350,000 acre feet	EAA Percent of Demands not Met (%)	Other Lake Okeechobee Service Area Percent of Demands not Met (%)
BS1		1,441,780		4	0	8	6
LE1	-	1,774,570	332,790	5	1	10	8
LE2	-	1,810,750	368,970	7	1	10	8
PDI	-	1,673,340	231,560	5	1	9	7
A5	--	2,214,780	773,000	7	2	12	8
A6	--	2,034,440	592,660	6	2	11	8
A7	--	2,286,280	844,500	7	2	12	9
CLA	0	1,640,170	198,390	4	0	9	7
ZD_ALWYS	--	2,689,980	1,248,200	8	3	14	10
ZD_NVR	0	1,401,960	-39,820	4	0	8	5

Questions ?

Water Resources Advisory Committee

Lake Okeechobee Workshop

28 June 2004

Lake Okeechobee Regulation Schedule (WSE) Improvements

Classification Limit Adjustments for the Tributary Hydrologic Condition and the Lake Okeechobee Net Inflow Outlook (LONINO)

(WRAC) Issues Workshop on Lake Okeechobee

June 28, 2004

Calvin Neidrauer, P.E.
Water Control Operations
South Florida Water Management District

Topics

- WSE Basics
- Class Limit Adjustment (CLA)

Lake Okeechobee Regulation Schedule WSE - What it is & What it's not

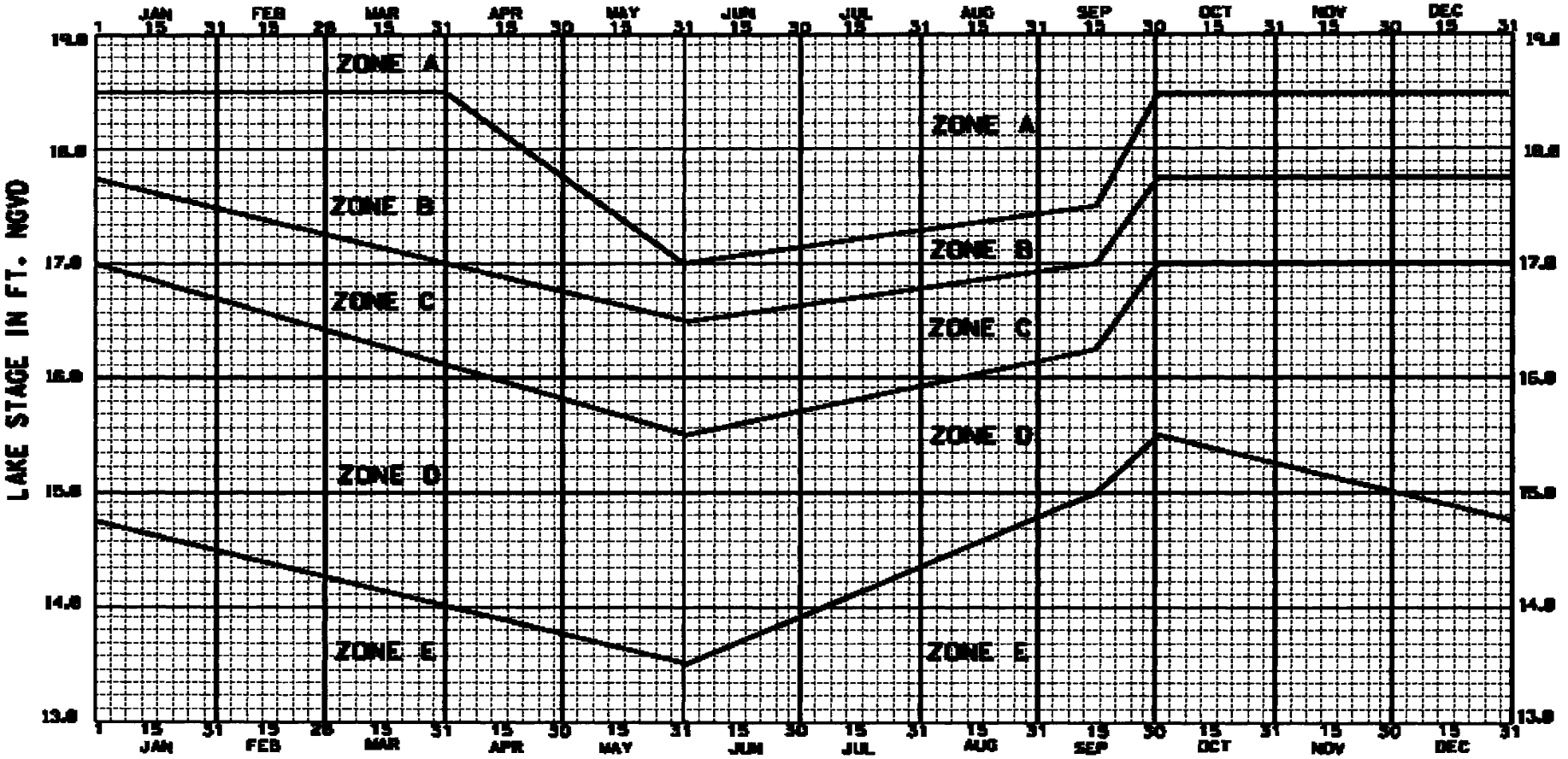
- What WSE is...
  - New & improved regulation schedule (implemented July 2000)
  - WSE = Water Supply and Environment
  - Improves multi-objective performance and better balances competing lake management objectives
- What WSE is not...
  - Not a schedule for water supply deliveries
  - Still a flood release schedule (push vs pull)
  - Not a panacea for the lake health

WSE Regulation Schedule Major Features

- Initiates discharges at lower stages under special conditions to WCAs & estuaries
- Pulse releases made to estuaries for extended periods when very large inflows are expected
- Discharges not required when drier conditions are expected - benefits water supply
- Provides more flexibility in release decisions
  - Uses climate & hydrologic forecasting
  - Decision trees are part of the schedule
  - Outflow rules provide ranges vs fixed rates

WSE Regulation Schedule Operational Elements

- Lake Okeechobee Water Level Criteria
- Tributary Hydrologic Conditions
  - 30 Day Net Rainfall
  - 2-week average Kissimmee River inflow
- Lake Okeechobee Net Inflow Outlook (LONINO)
  - Seasonal LONINO (6 months)
  - Multi-Seasonal LONINO (up to 12 months)
  - LONINO developed by SFWMD's Office of Modeling



RELEASE THROUGH OUTLETS AS INDICATED

ZONE	AGRICULTURAL CANALS To WCAs (1,2)	CALOOSAHATCHEE RIVER AT S-77 (1,2,4)	ST. LUCIE CANAL AT S-80 (1,2,4)
A	PUMP MAXIMUM PRACTICABLE	UP TO MAXIMUM CAPACITY	UP TO MAXIMUM CAPACITY
B (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM MAXIMUM PULSE RELEASE UP TO MAXIMUM CAPACITY)
C (3)	MAXIMUM PRACTICABLE RELEASES	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 6500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 3500 CFS)
D (3,5)	AS NEEDED TO MINIMIZE ADVERSE IMPACTS TO THE LITTORAL ZONE WHILE NOT ADVERSELY IMPACTING THE EVERGLADES. (SEE NOTE 5.)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 4500 CFS)	RELEASES PER DECISION TREE (THESE CAN RANGE FROM NO DISCHARGE UP TO 2500 CFS)
E	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE	NO REGULATORY DISCHARGE

NOTES: (1) SUBJECT TO FIRST REMOVAL OF RUNOFF FROM DOWNSTREAM BASINS
(2) GUIDELINES FOR WET, DRY AND NORMAL CONDITIONS ARE BASED ON: 1) SELECTED CLIMATIC INDICES AND TROPICAL FORECASTS AND 2) PROJECTED INFLOW CONDITIONS. RELEASES ARE SUBJECT TO THE GUIDELINES IN THE WSE OPERATIONAL DECISION TREE, PARTS 1 AND 2.
(3) RELEASES THROUGH VARIOUS OUTLETS MAY BE MODIFIED TO MINIMIZE DAMAGES OR OBTAIN ADDITIONAL BENEFITS. CONSULTATION WITH EVERGLADES AND ESTUARINE BIOLOGISTS IS ENCOURAGED TO MINIMIZE ADVERSE EFFECTS TO DOWNSTREAM ECOSYSTEMS.
(4) PULSE RELEASES ARE MADE TO MINIMIZE ADVERSE IMPACTS TO THE ESTUARIES
(5) ONLY WHEN THE WCAs ARE BELOW THEIR RESPECTIVE SCHEDULES

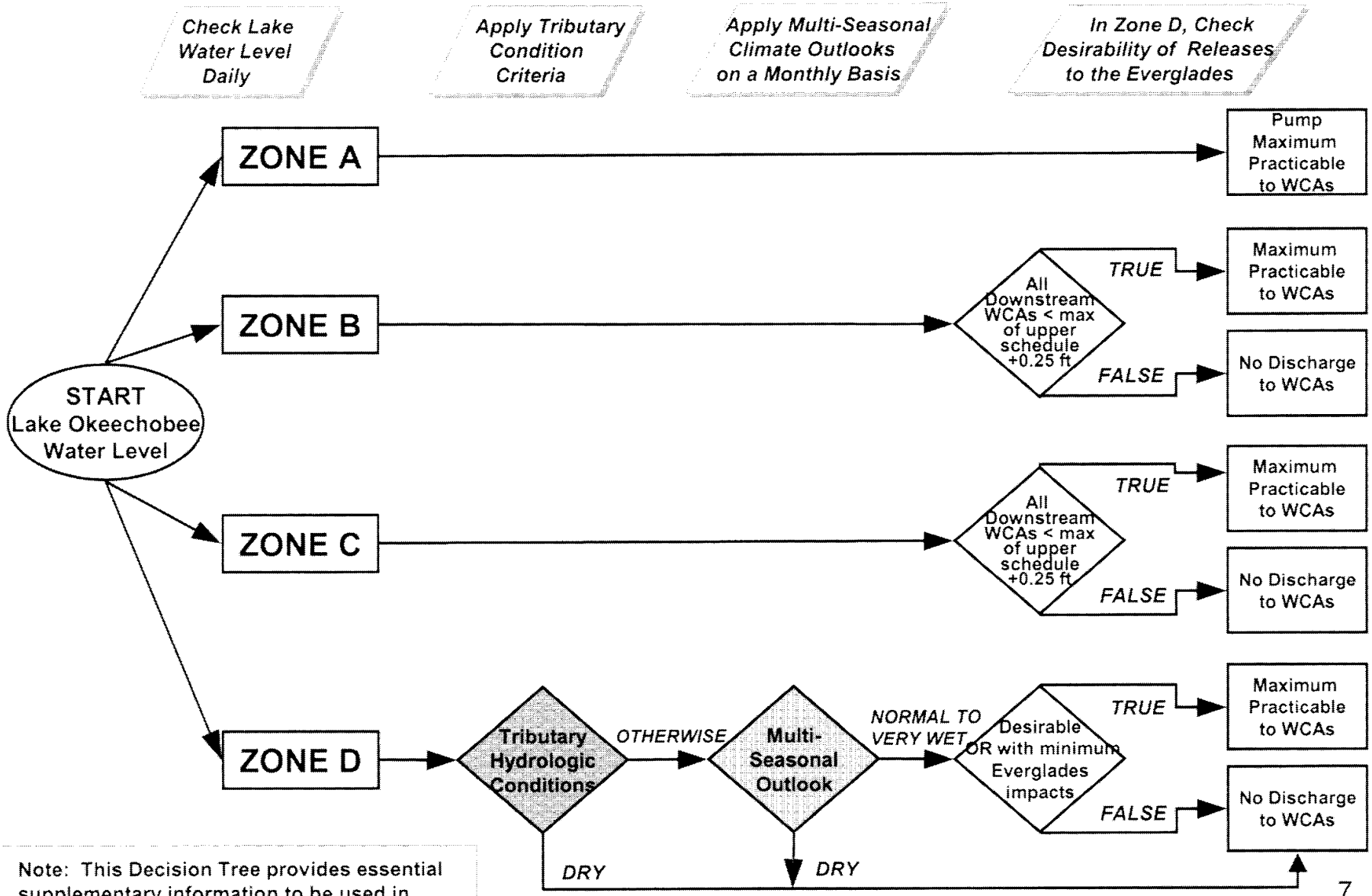
CENTRAL AND SOUTHERN FLORIDA
INTERIM REGULATION SCHEDULE
LAKE OKEECHOBEE

DEPARTMENT OF THE ARMY, JACKSONVILLE DISTRICT
CORPS OF ENGINEERS, JACKSONVILLE, FLORIDA
DATED: 5 NOVEMBER 1999

WSE (WITH CLIMATE OUTLOOK)

WSE Operational Guidelines Decision Tree

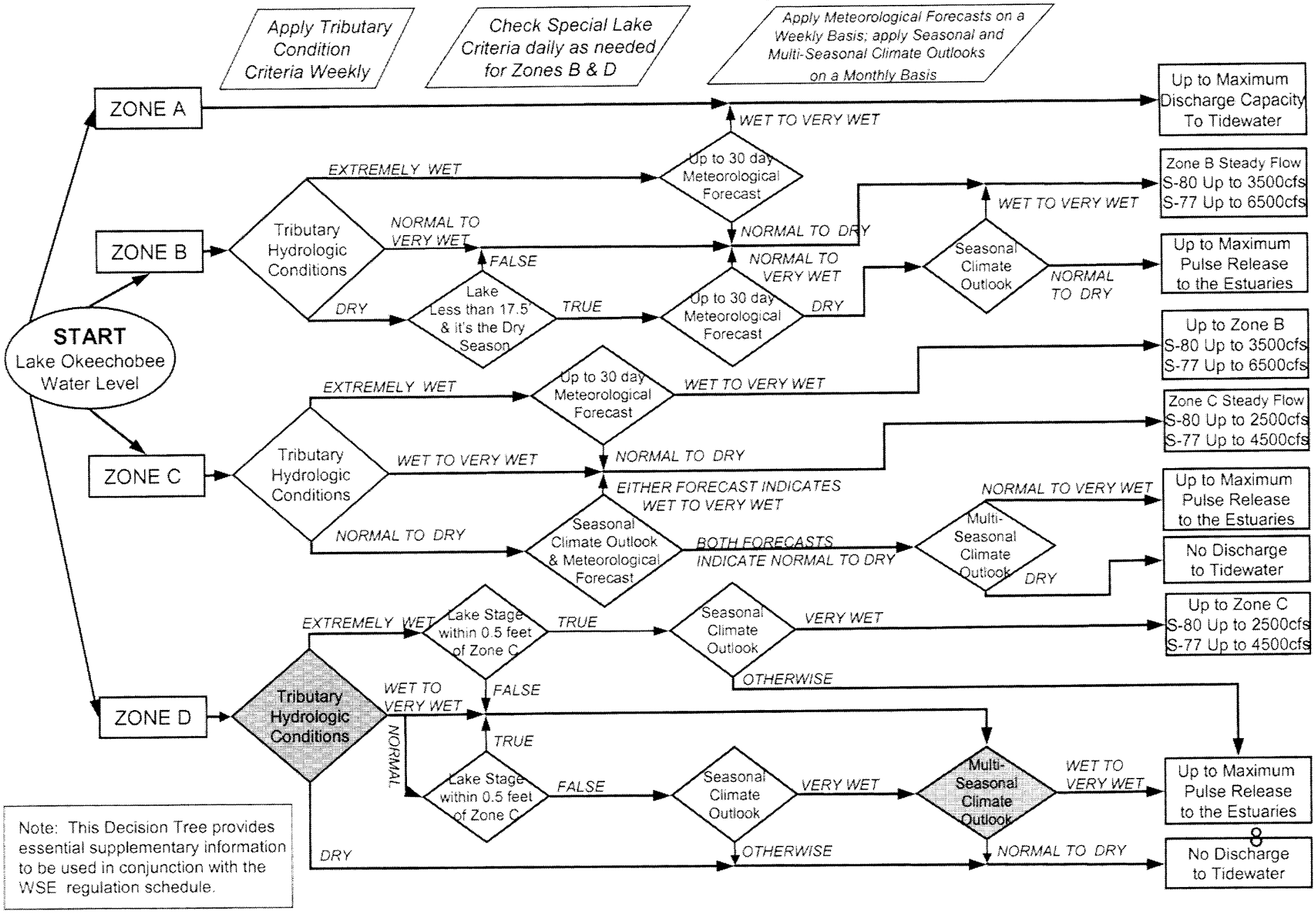
Part 1: Define Lake Okeechobee Discharges to the Water Conservation Areas



Note: This Decision Tree provides essential supplementary information to be used in conjunction with the WSE regulation schedule.

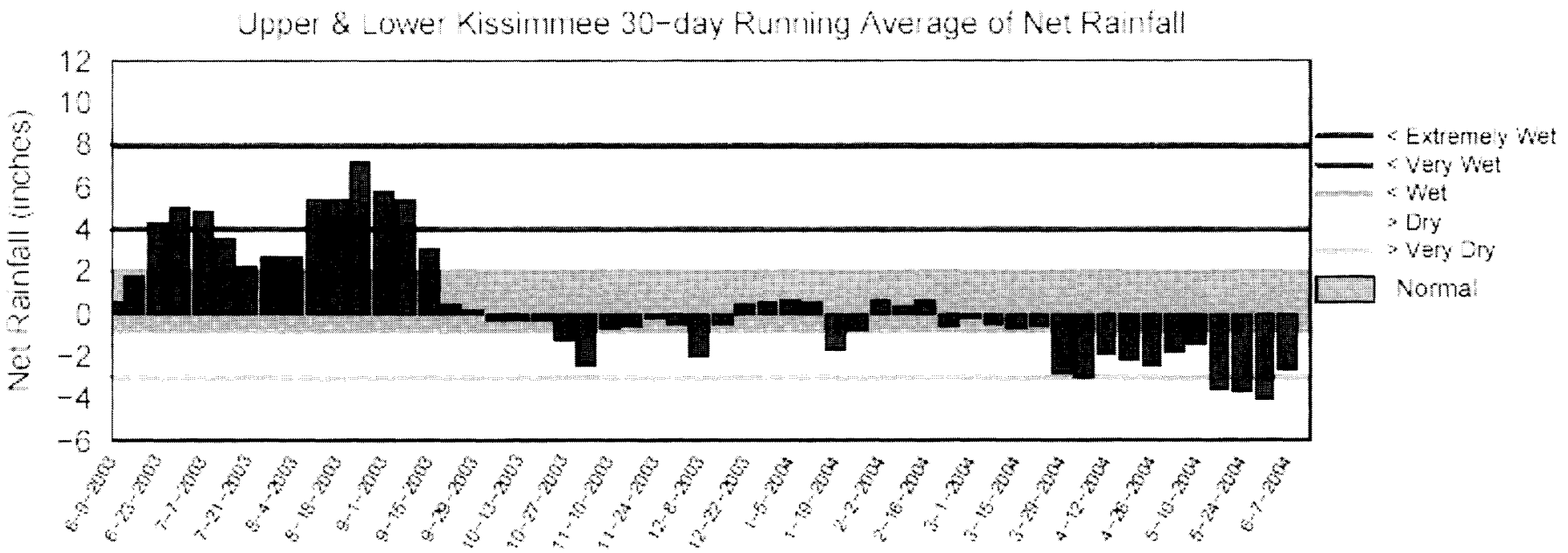
WSE Operational Guidelines Decision Tree

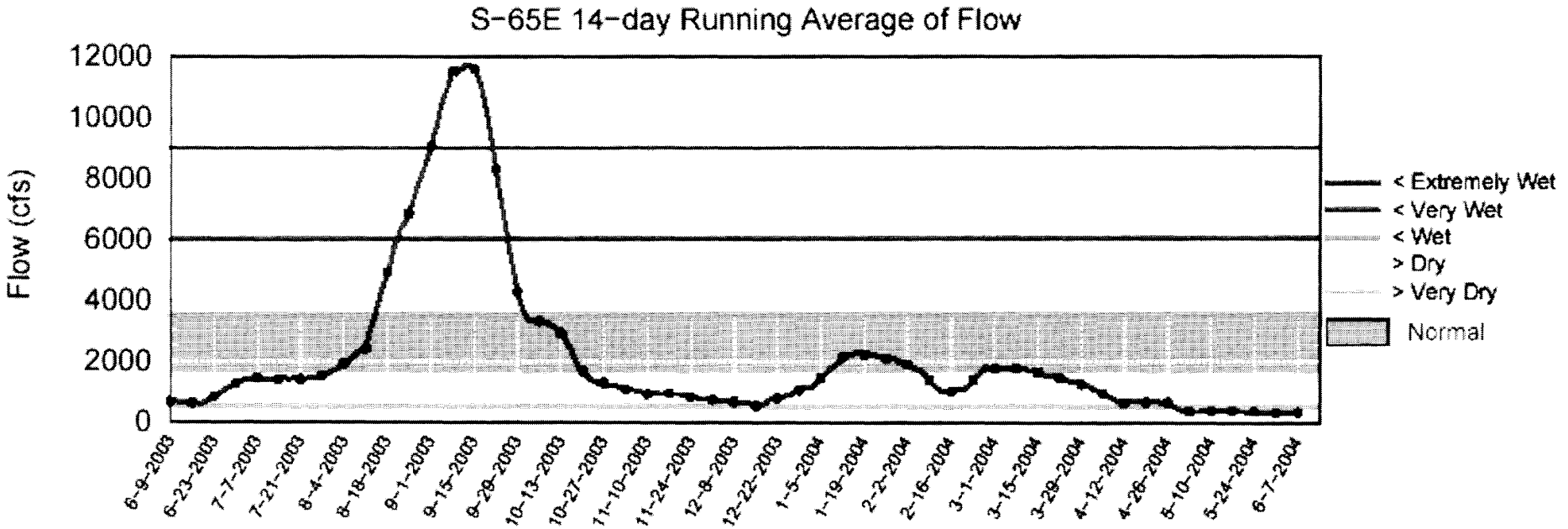
Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)



Note: This Decision Tree provides essential supplementary information to be used in conjunction with the WSE regulation schedule.

Tributary Basin Condition Indicators as of June 08, 2004





Classification of Tributary Hydrologic Conditions

Class Limits for Tributary Hydrologic Conditions*

Net rainfall [inches] (previous 4 week sum)	S-65E flows [cfs] (previous 2 week mean)	Tributary Condition**
< -3.00	< 500	Very Dry
-3.00 to –1.01	500-1499	Dry
-1.00 to 1.99	1500-3499	Normal
2.00 to 3.99	3500-5999	Wet
4.00 to 7.99	6000-8999	Very Wet
>= 8	>=9000	Extremely Wet

***Corresponds to Table 7-4 in the Lake Okeechobee Water Control Plan**

****Use the wettest classification of the two tributary condition indicators**

Classification of Lake Okeechobee Net Inflow Outlook (LONINO)

Seasonal LONINO

Classification of Lake Okeechobee Net Inflow Seasonal Outlook*

Lake Net Inflow Prediction [million acre-feet]	Equivalent Depth** [feet]	Lake Okeechobee Net Inflow Seasonal Outlook
> 1.5	> 3.2	Very Wet
1.01 to 1.5	2.11 to 3.2	Wet
0.5 to 1.0	1.1 to 2.1	Normal
< 0.5	< 1.1	Dry

*Corresponds to Table 7-7 in the Lake Okeechobee Water Control Plan

**Volume-depth conversion based on average lake surface area of 467,000 acres

Multi-Seasonal LONINO

Classification of Lake Okeechobee Net Inflow Multi-Seasonal Outlook*

Lake Net Inflow Prediction [million acre-feet]	Equivalent Depth** [feet]	Lake Okeechobee Net Inflow Multi-Seasonal Outlook
> 2.0	> 4.3	Very Wet
1.51 to 2.0	3.21 to 4.3	Wet
0.5 to 1.5	1.1 to 3.2	Normal
< 0.5	< 1.1	Dry

*Corresponds to Table 7-10 in the Lake Okeechobee Water Control Plan

**Volume-depth conversion based on average lake surface area of 467,000 acres

File Edit View Go Communicator Help

www.sfwmd.gov/org/pld/hsm/reg_app/lok_reg

LAKE OKEECHOBEE OPERATIONS

Current Week
- Executive Summary
- Technical Summary

Decision Tree
- Part 1: WCAs
- Part 2: Estuaries

Archived Summaries

W S E
Water Supply & Environment
- Schedule with Rules
- Classification Tables

Lake Okeechobee
- Water Report
- Stage Hydrograph

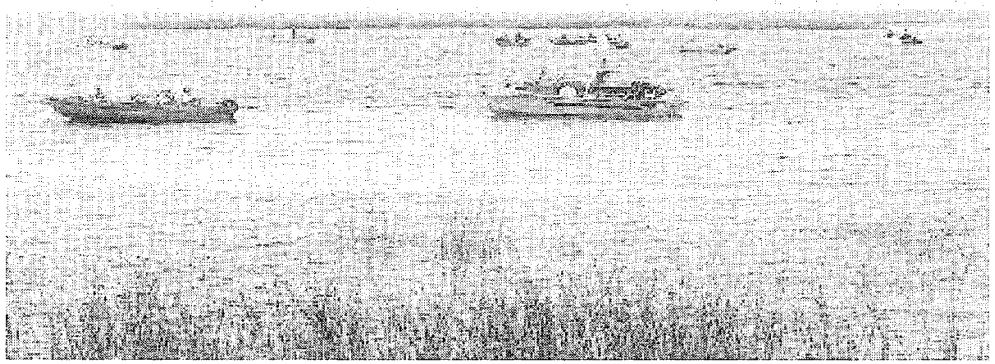
Tributary Conditions
- Current Conditions
- Archived Conditions

SFWMD Weather

CPC Climate Outlooks
- Seasonal Window

WSE

WSE, which is short for Water Supply/Environmental, is the new regulation schedule that was approved in July 2000 for the regulation of Lake Okeechobee water levels. Detailed analysis demonstrated that WSE's performance is equal to, or better than the previous regulation schedule, Run 25, for flood protection, water supply, and environmental objectives, including benefits to the lake ecosystem. The WSE regulation schedule incorporates tributary hydrologic conditions and climate forecasts into the operational guidelines and is used in conjunction with the Operational Guidelines Decision Tree. The Decision Tree is divided into 2 parts. Part 1 defines Lake Okeechobee discharges to the Water Conservation Areas and Part 2 defines Lake Okeechobee discharges to tidewater (the estuaries). The operational flexibility of the WSE schedule allows for adjustments to be made in the timing and magnitude of Lake Okeechobee regulatory discharges based on conditions in the Lake tributary basins and in the extended meteorological and climate outlooks.



Document: Done

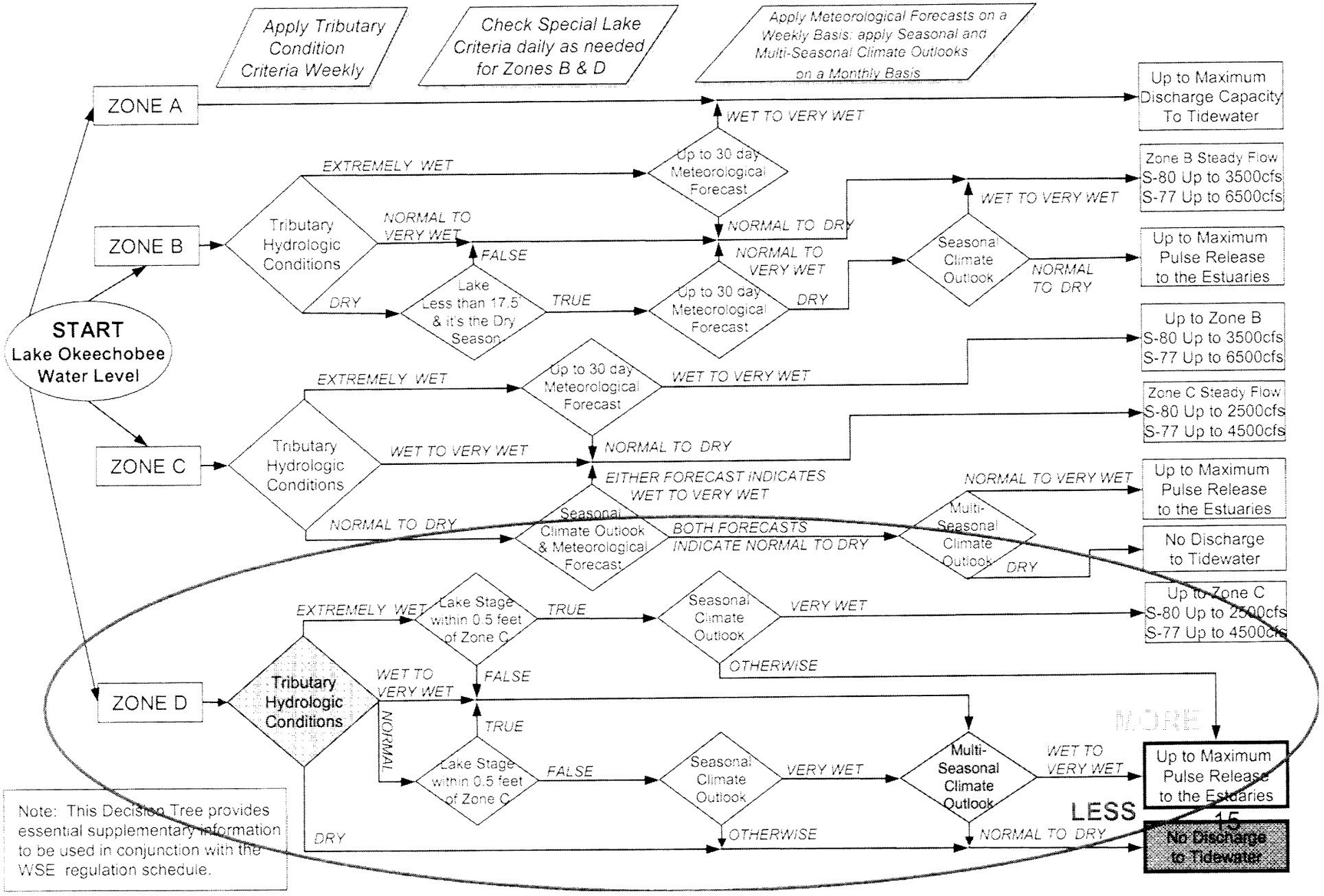
Classification Limit Adjustments

LOK Regulation Schedule (WSE) Improvements - Class Limit Adjustments

- Goal: Improve performance of WSE with minimal changes to the schedule
- Strategy: Adjust class limits for…
  - Tributary Hydrologic Conditions
  - Seasonal LONINO
  - Multi-Seasonal LONINO
- General Objective: Increase frequency of Zone D pulse releases to improve in-lake performance without significantly impacting estuary & water supply performance.

WSE Operational Guidelines Decision Tree

Part 2: Define Lake Okeechobee Discharges to Tidewater (Estuaries)



CLA-Changes in Tributary Conditions

S-65E 14-day moving average flow (cfs)

Extremely Wet	
	9000 cfs
Very Wet	
	6000 cfs
Wet	
	3500 cfs
Normal	
	1500 to 500 cfs
Dry	
	500 to 200 cfs
Very Dry	

CLA-Changes in LONINO

LOK Equivalent Depth (feet)

- Seasonal

Very Wet

3.2' to 2.0'

Wet

2.1' to 1.5'

Normal

1.1' to 0.75'

Dry

- Multi-seasonal

Very Wet

4.3'

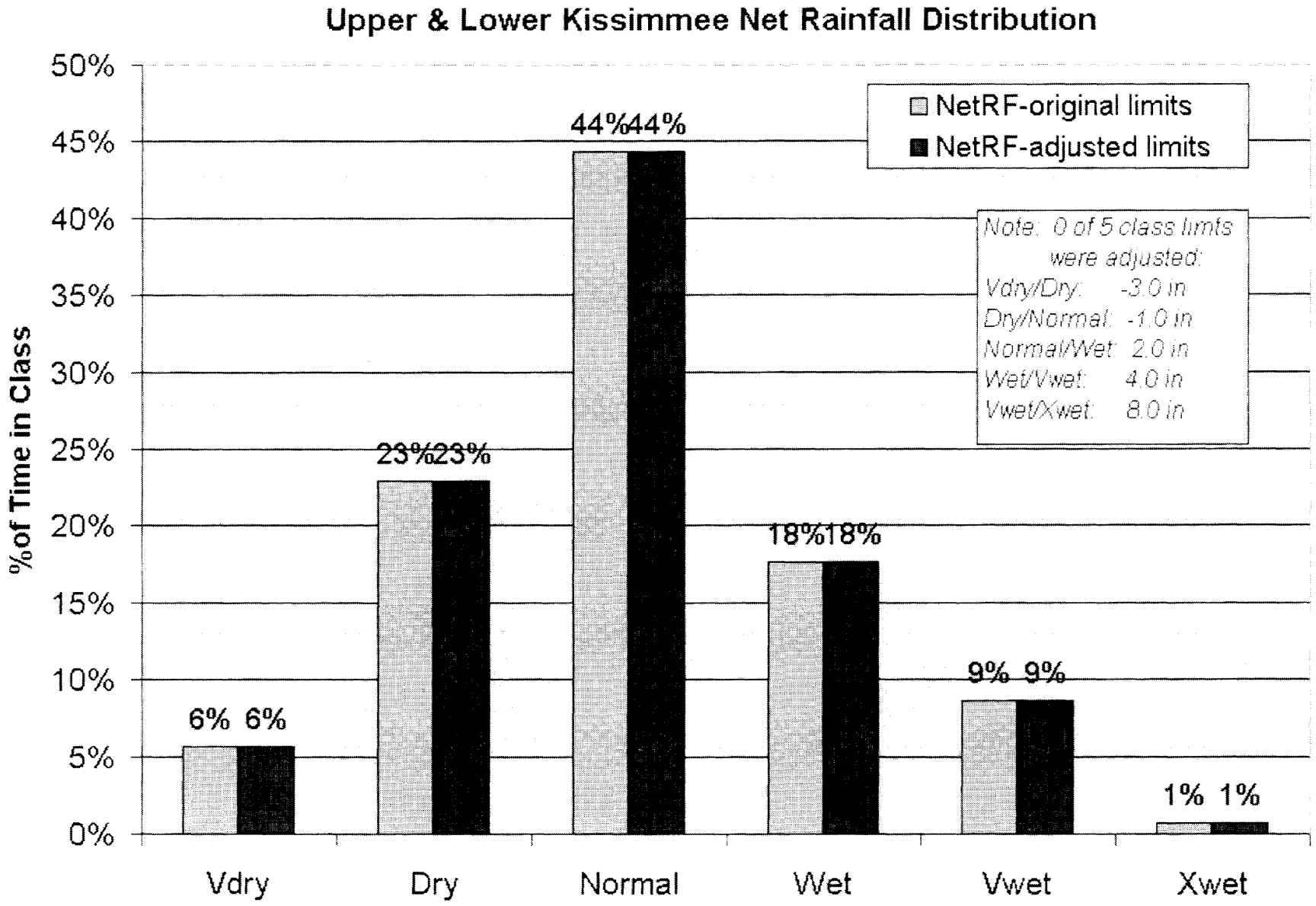
Wet

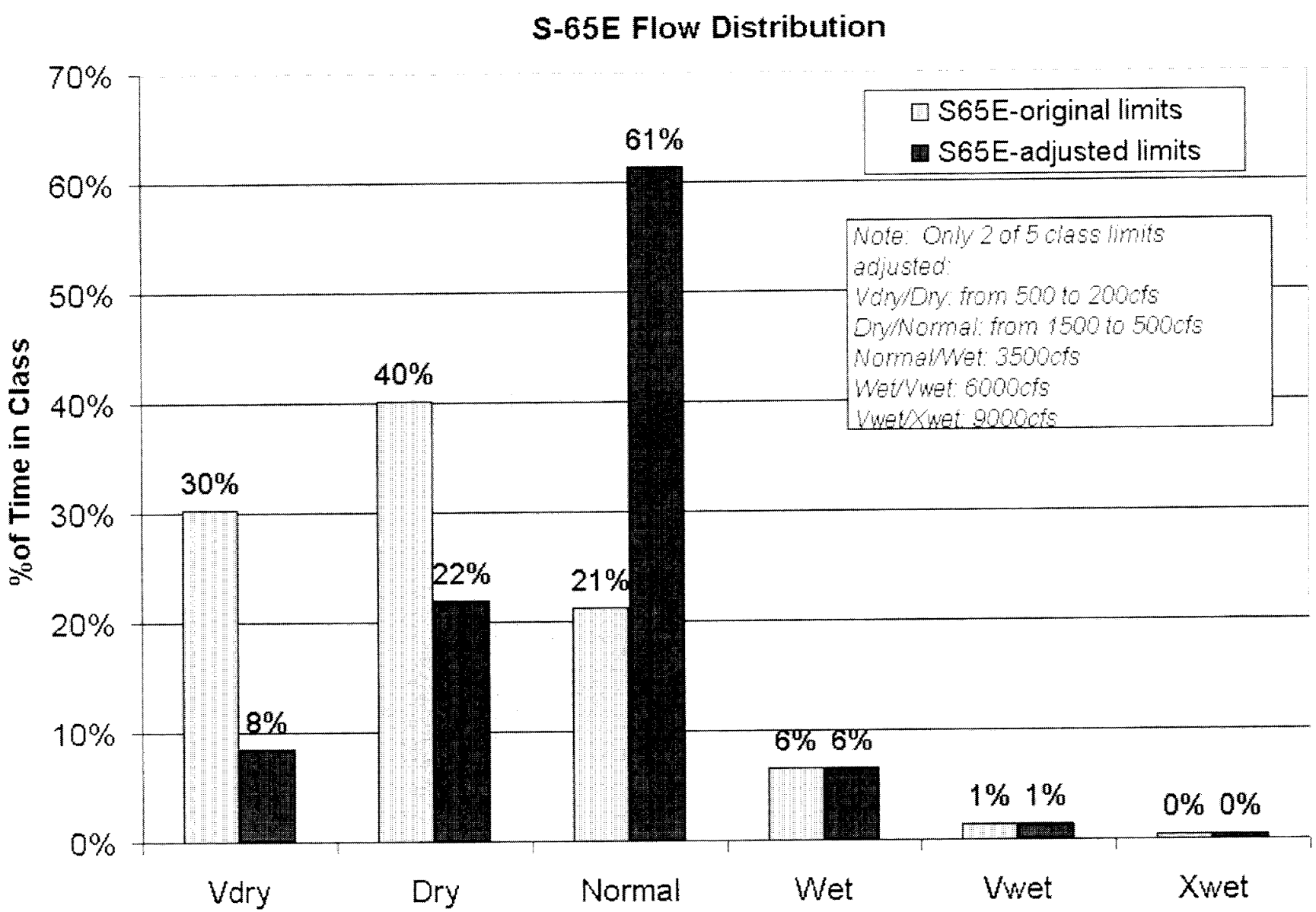
3.2' to 2.5'

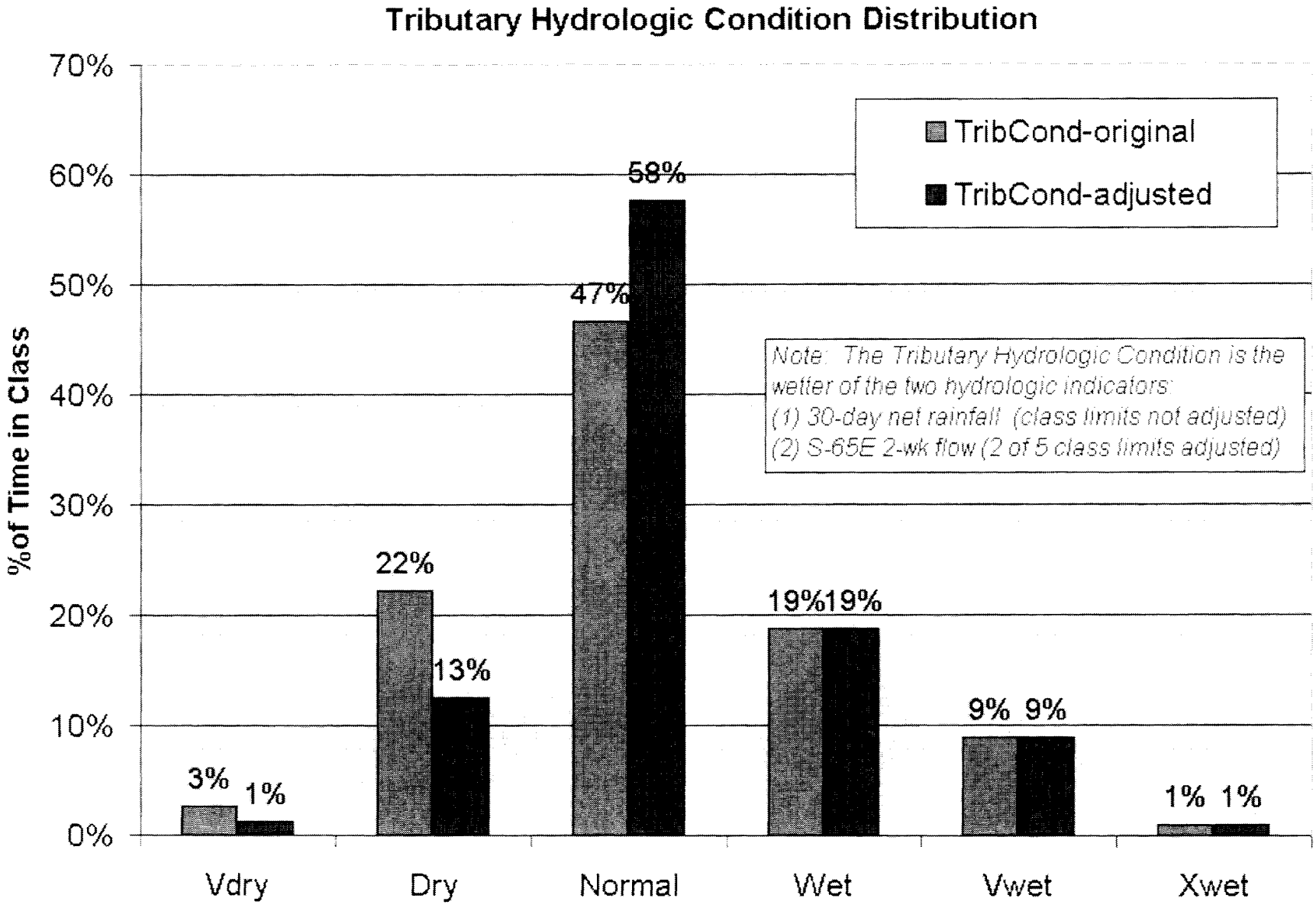
Normal

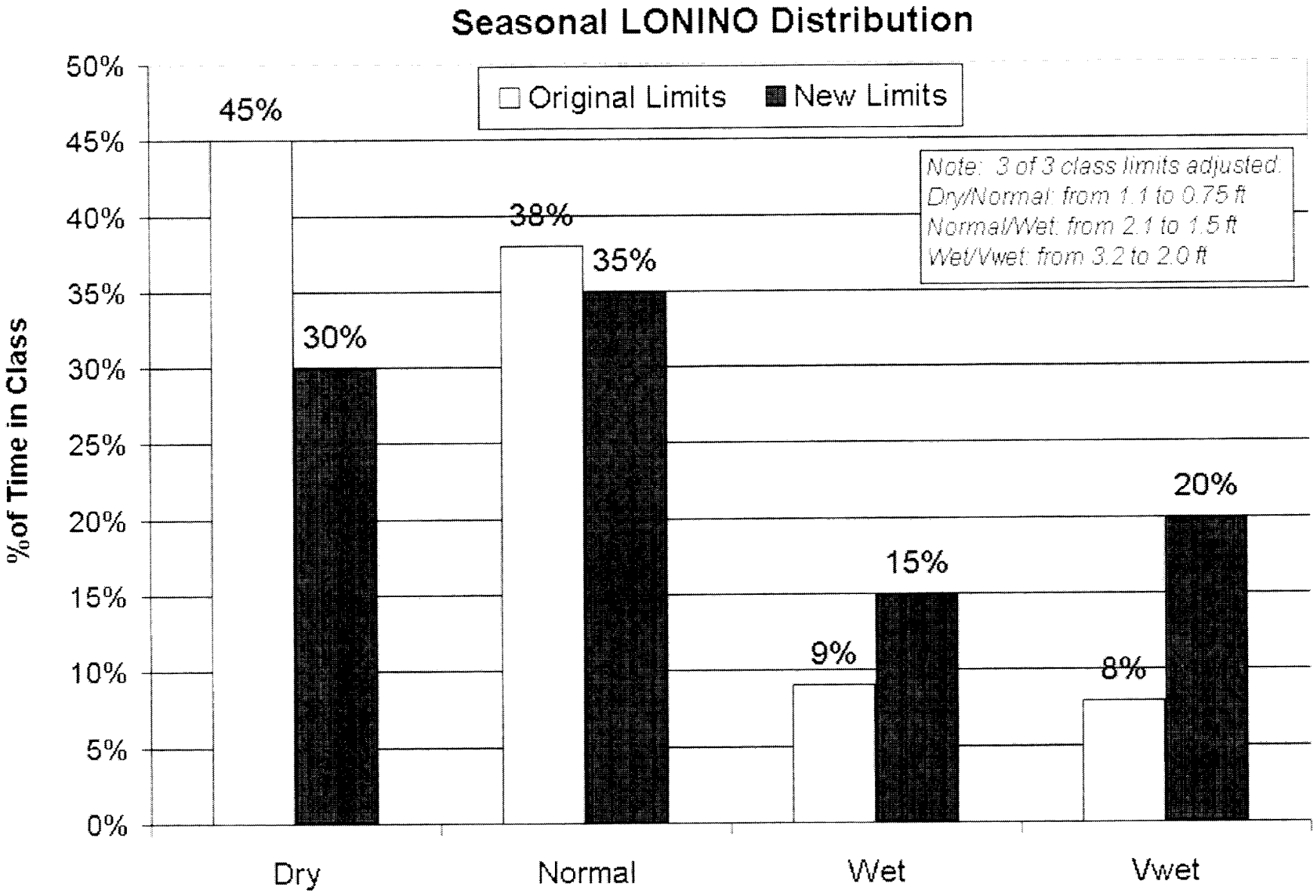
1.1'

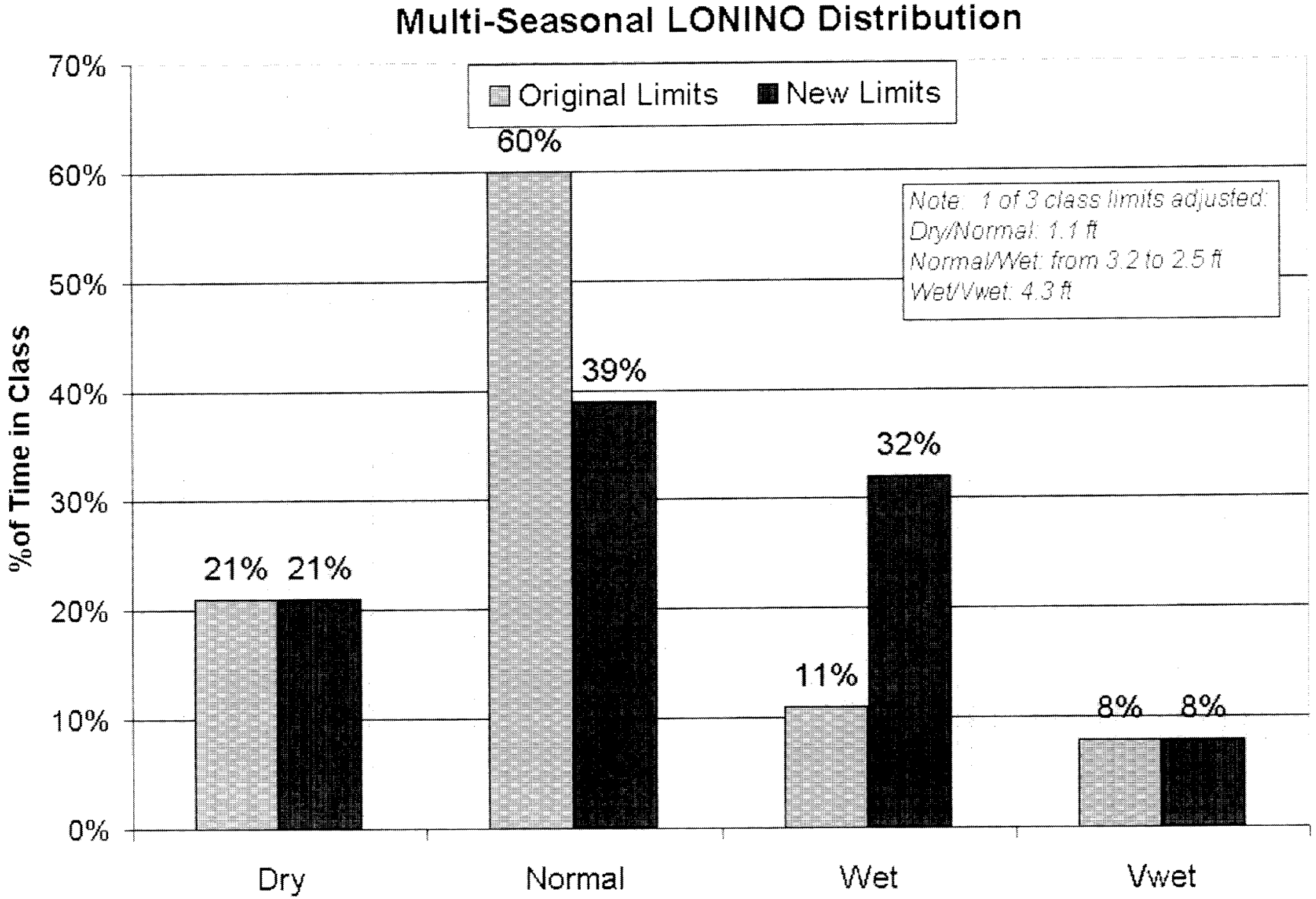
Dry


Upper & Lower Kissimmee Net Rainfall Distribution
%of Time in Class
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
NetRF-original limits
NetRF-adjusted limits
Note: 0 of 5 class limts were adjusted:
Vdry/Dry: -3.0 in
Dry/Normal: -1.0 in
Normal/Wet: 2.0 in
Wet/Vwet: 4.0 in
Vwet/Xwet: 8.0 in
6% 6%
23%23%
44%44%
18%18%
9% 9%
1% 1%
Vdry
Dry
Normal
Wet
Vwet
Xwet


S-65E Flow Distribution
70%
60%
50%
40%
30%
20%
10%
0%
%of Time in Class
S65E-original limits
S65E-adjusted limits
Note: Only 2 of 5 class limits adjusted:
Vdry/Dry: from 500 to 200cfs
Dry/Normal: from 1500 to 500cfs
Normal/Wet: 3500cfs
Wet/Vwet: 6000cfs
Vwet/Xwet: 9000cfs
30%
8%
40%
22%
21%
61%
6%
6%
1%
1%
0%
0%
Vdry
Dry
Normal
Wet
Vwet
Xwet


Tributary Hydrologic Condition Distribution
70%
60%
50%
40%
30%
20%
10%
0%
%of Time in Class
TribCond-original
TribCond-adjusted
Note: The Tributary Hydrologic Condition is the wetter of the two hydrologic indicators:
(1) 30-day net rainfall (class limits not adjusted)
(2) S-65E 2-wk flow (2 of 5 class limits adjusted)
3%
1%
22%
13%
47%
58%
19%
19%
9%
9%
1%
1%
Vdry
Dry
Normal
Wet
Vwet
Xwet


Seasonal LONINO Distribution
Original Limits
New Limits
Note: 3 of 3 class limits adjusted:
Dry/Normal: from 1.1 to 0.75 ft
Normal/Wet: from 2.1 to 1.5 ft
Wet/Vwet: from 3.2 to 2.0 ft
%of Time in Class
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
45%
30%
38%
35%
9%
15%
8%
20%
Dry
Normal
Wet
Vwet


Multi-Seasonal LONINO Distribution
Original Limits
New Limits
Note: 1 of 3 class limits adjusted:
Dry/Normal: 1.1 ft
Normal/Wet: from 3.2 to 2.5 ft
Wet/Vwet: 4.3 ft
%of Time in Class
70%
60%
50%
40%
30%
20%
10%
0%
21%
21%
60%
39%
11%
32%
8%
8%
Dry
Normal
Wet
Vwet

What changes in WSE performance can be expected from the Class Limit Adjustments?

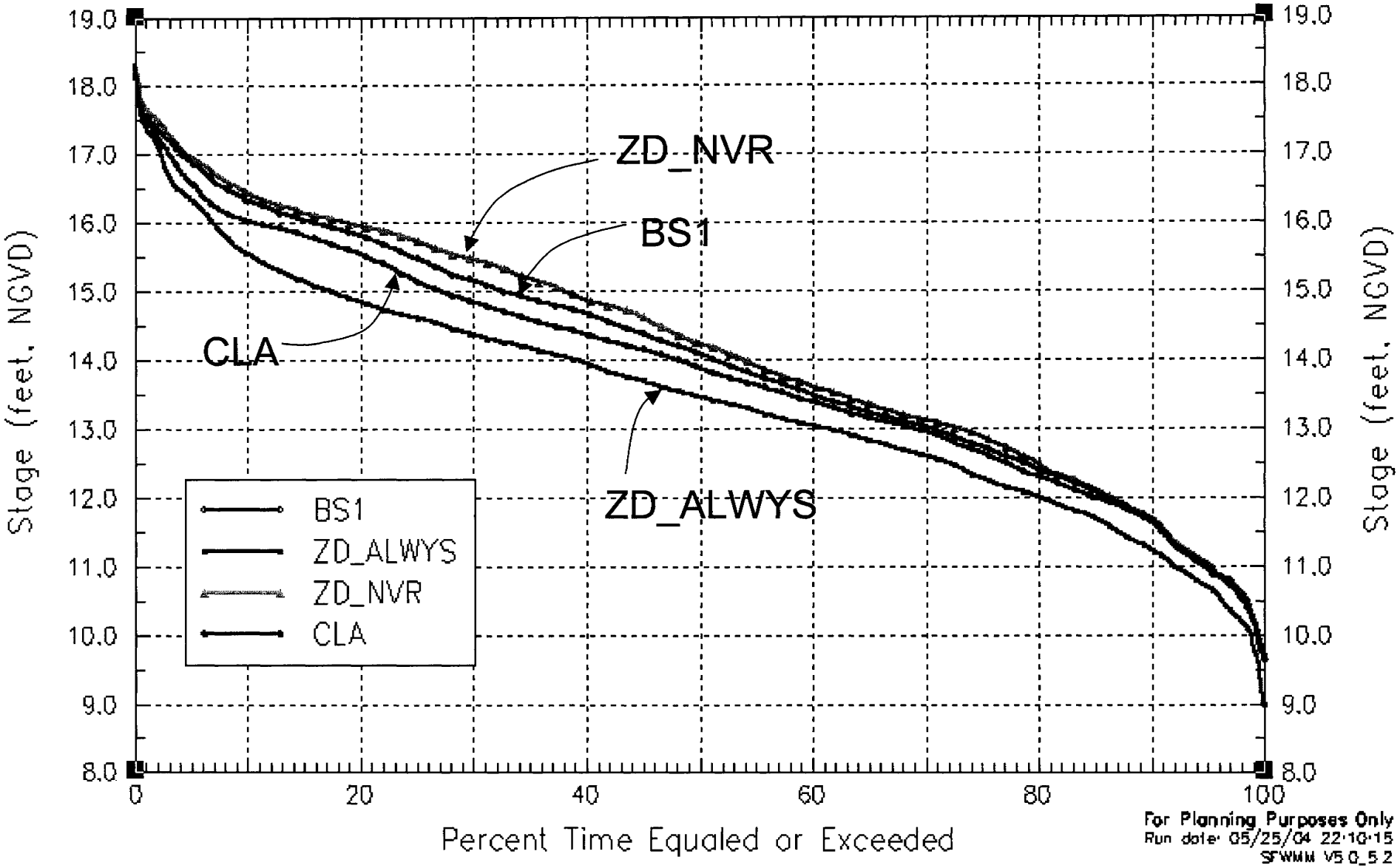
- Office of Modeling SFWMM simulation results presented 07-June-2004
- Multi-objective balance of WSE with CLA was better than the other 6 alternative schedule modifications
- Performance of the 36-yr simulation relative to baseline:
  - LOK Flood Protection: substantially better
  - LOK Ecology: slightly better
  - Water Supply: no change
  - Caloosahatchee Estuary Low flows: no change
  - Caloosahatchee Estuary High flows: slightly worse
  - St.Lucie Estuary Low flows: slightly better
  - St.Lucie Estuary High stressful flows: slightly worse
  - St.Lucie Estuary High damaging flows: slightly better
  - Everglades: TBD

Summary of SFWMM Results

Performance summary table for the WSE-SIS model runs. Performance is compared to the Base run, and symbols indicate the following: ++ = substantially better than Base, + = slightly better than Base, 0 = not different from Base, - = slightly worse than Base, and - - = substantially worse than Base. Everglades is still under evaluation

Simulation	LOK Flood	LOK Ecology	CE High Flow	CE Low Flow	SLE High Flow	SLE Low Flow	LOSA	LEC
LE1	0	0	0	++	0	0	-	0
LE2	0	0	0	++	0	0	-	0
PDI	0	0	0	++	-	+	-	0
A5	0	+	+	++	-	++	- -	0
A6	0	+	0	++	-	++	- -	0
A7	+	++	-	++	0	+	- -	- -
CLA	++	+	-	0	-	+	0	0
ZD_ALWYS	++	++	-	++	0	++	- -	- -
ZD_NVR	0	- -	+	0	-	-	0	0

Stage Duration Curves for Lake Okeechobee



SFWMM POS 1965 - 2000

For Planning Purposes Only
Run date: 05/25/04 22:10:15
SFWMM V5.0_5.2
Script used: hyd_dur scr, V1.11
Filename: lok_doi_stgdur fig

WSE Schedule Zone Statistics

% of time (36-yr simulation) that LOK stage was …	WSE BASE	ZD ALWAYS	ZD NEVER	CLA
… in Zone A	0	0	0	0
… in Zone B	1	1	2	1
… in Zone C	6	3	7	4
… in Zone D	**36**	22	38	**33**
… in Zone D3	12	3	15	9
… in Zone D2	12	5	12	11
… in Zone D1	12	14	10	13
… below ZoneD	57	74	49	62
… in Zone D & Part 1 called for max practicable south	**62**	71	62	**75**
… in Zone D & Part 2 called for pulses to Estuaries	**17**	100	1	**34**

Source: SFWMMv5.4.2 Simulations (June 2004)
SFWMM simulations driven by 1965-2000 rainfall, etc. (36yrs or 13149 days)

How much would the CLA have changed the WSE decision tree outcomes during the past 2 years?

- During the 100 weeks from 8July2002 to 31May2004, LOK stage was in Zone D for 85 weeks.
- Of the 85 Zone D weeks…

Decision Tree Outcome	Actual	Estimated with CLA
Part 1 (Max practicable to WCAs)	69 weeks (81%)	83 weeks (98%)
Part 2 (up to L3 pulse to Estuaries)	25 weeks (29%)	49 weeks * (58%)

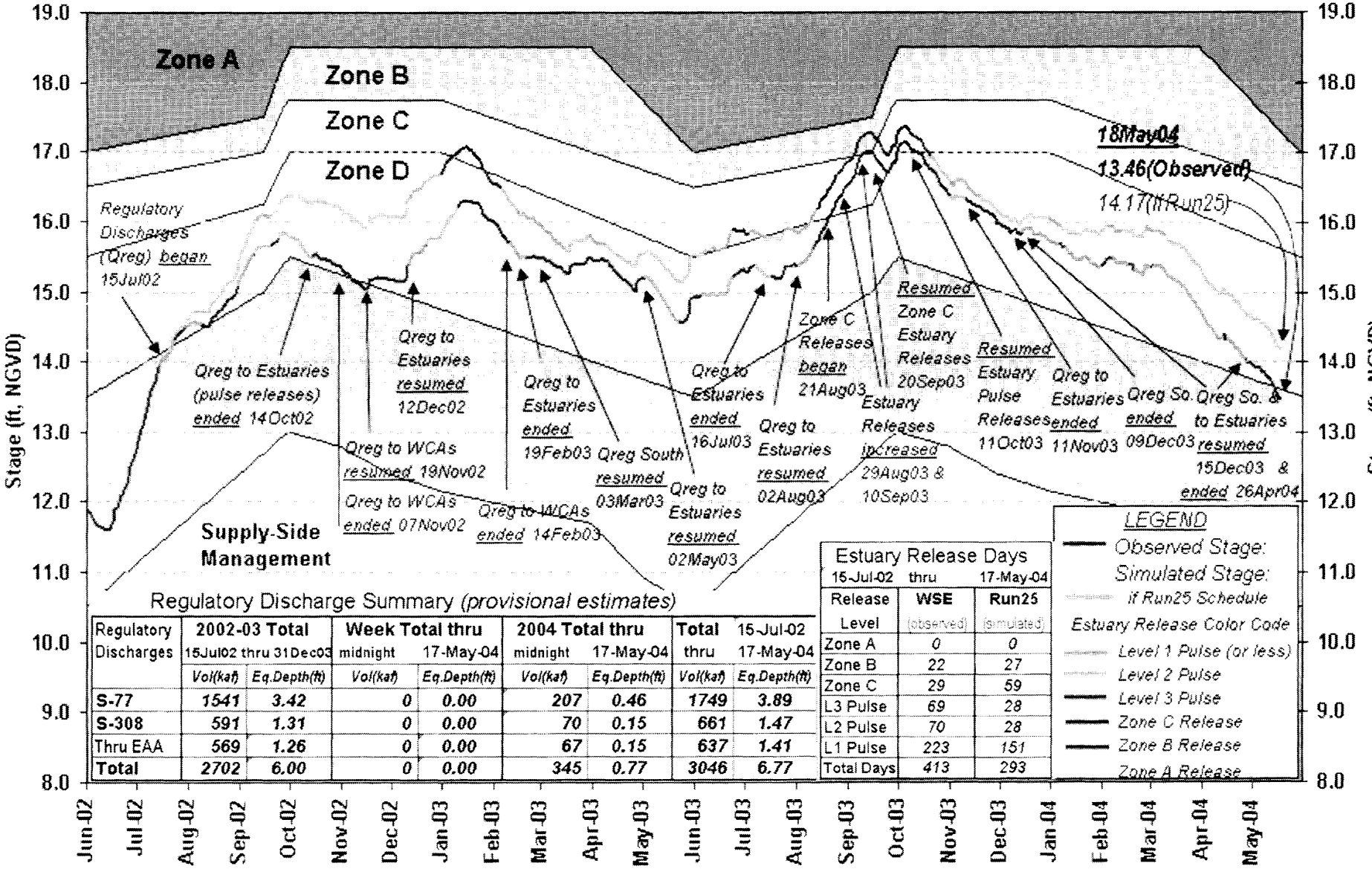
* 14 of the 24 additional weeks were during April-July of 2003. The additional pulse releases would likely have reduced the need for Zone C releases in Aug-Sep of 2003.

Conclusions & Recommendations

- WSE performance can be improved by making class limit adjustments (CLA) to the classifications of the tributary hydrologic condition and the LONINO.
- Simulated performance of the CLA was superior to the other alternatives evaluated.
- The CLA doubles the % of time the WSE schedule calls for pulse releases while in Zone D.
- The CLA might be easily implemented by the USACE since it only requires changing 6 numbers in the federal Water Control Plan.
- Suggest WRAC Working Group recommend CLA to WRAC and USACE for further NEPA (EA) analysis.


SOUTH FLORIDA WATER MANAGEMENT DISTRICT
PROTECTOR OF THE EVERGLADES SINCE 1949

Lake Okeechobee Stage Comparison



Regulatory Discharge Summary *(provisional estimates)*

Regulatory Discharges	2002-03 Total 15Jul02 thru 31Dec03		Week Total thru midnight 17-May-04		2004 Total thru midnight 17-May-04		Total thru 17-May-04	
	Vol(kaf)	Eq.Depth(ft)	Vol(kaf)	Eq.Depth(ft)	Vol(kaf)	Eq.Depth(ft)	Vol(kaf)	Eq.Depth(ft)
S-77	*1541*	*3.42*	*0*	*0.00*	*207*	*0.46*	*1749*	*3.89*
S-308	*591*	*1.31*	*0*	*0.00*	*70*	*0.15*	*661*	*1.47*
Thru EAA	*569*	*1.26*	*0*	*0.00*	*67*	*0.15*	*637*	*1.41*
Total	*2702*	*6.00*	*0*	*0.00*	*345*	*0.77*	*3046*	*6.77*

Estuary Release Days 15-Jul-02 thru 17-May-04

Release Level	WSE (observed)	Run25 (simulated)
Zone A	*0*	*0*
Zone B	*22*	*27*
Zone C	*29*	*59*
L3 Pulse	*69*	*28*
L2 Pulse	*70*	*28*
L1 Pulse	*223*	*151*
Total Days	*413*	*293*

LEGEND

Observed Stage:

Simulated Stage:

if Run25 Schedule

Estuary Release Color Code

Level 1 Pulse (or less)

Level 2 Pulse

Level 3 Pulse

Zone C Release

Zone B Release

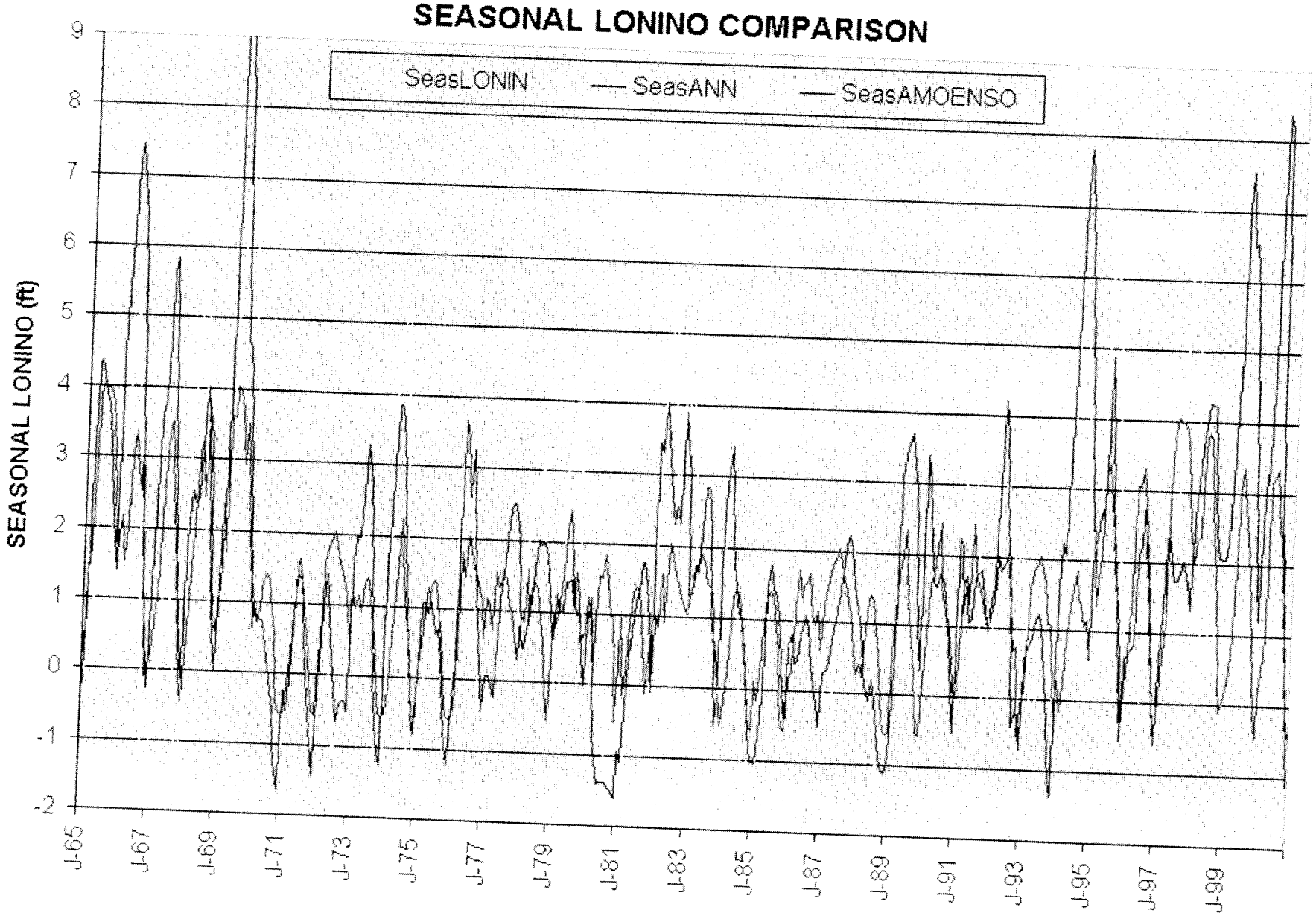
Zone A Release

Pulse Releases - Three Levels

Table 7-11 Master Water Control Plan for Lake Okeechobee

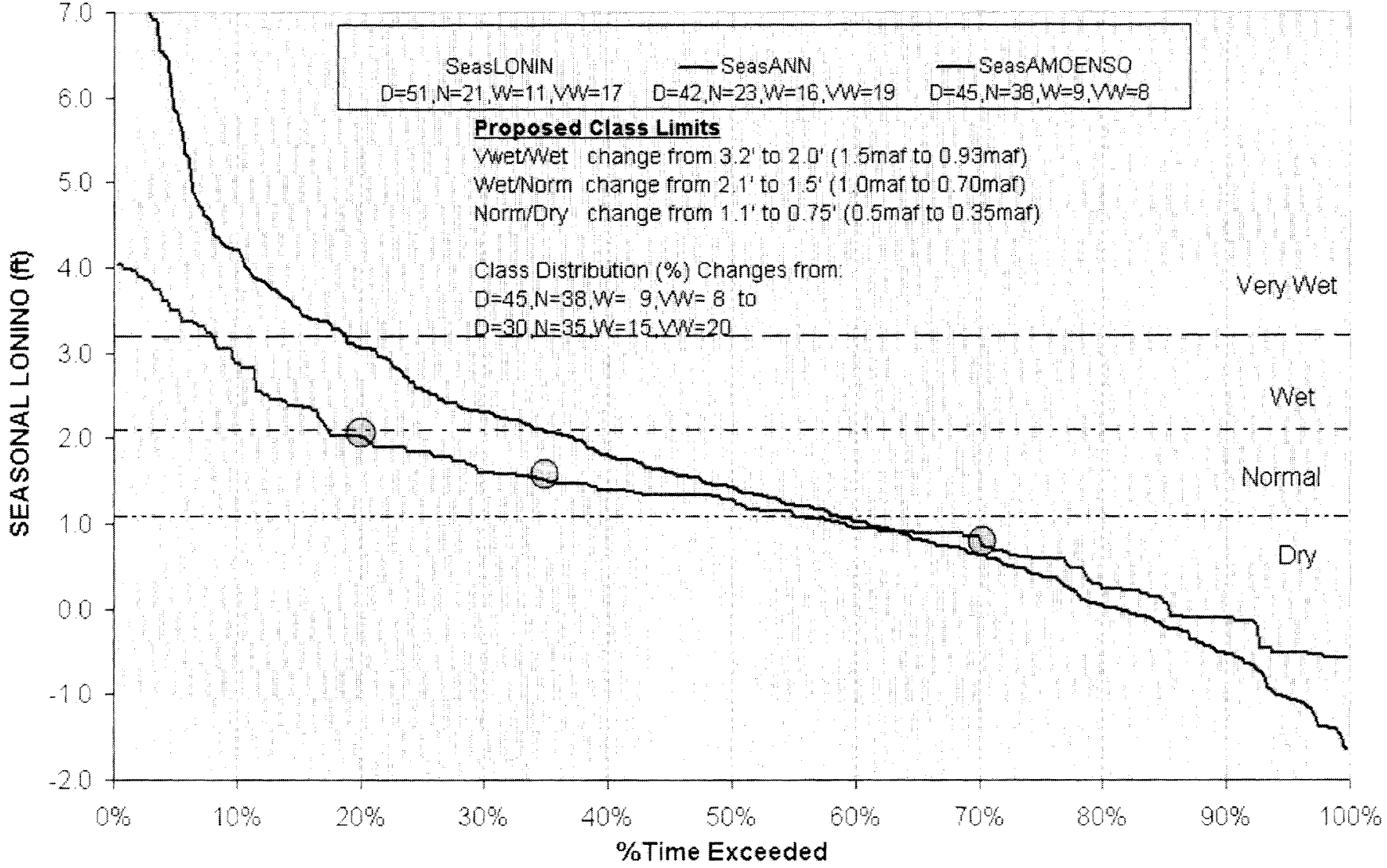
Day of Pulse	Level I		Level II		Level III	
	St. Lucie S-80 (cfs)	Caloos. S-77 (cfs)	St. Lucie S-80 (cfs)	Caloos. S-77 (cfs)	St. Lucie S-80 (cfs)	Caloos. S-77 (cfs)
1	1200	1000	1500	1500	1800	2000
2	1600	2800	2000	4200	2400	5500
3	1400	3300	1800	5000	2100	6500
4	1000	2400	1200	3800	1500	5000
5	700	2000	900	3000	1000	4000
6	600	1500	700	2200	900	3000
7	400	1200	500	1500	600	2000
8	400	800	500	800	600	1000
9	0	500	400	500	400	500
10	0	500	0	500	400	500
Average Flow	**730**	**1600**	**950**	**2300**	**1170**	**3000**
Volume (Ac-Ft)	14,480	31,736	18,843	45,621	23,207	59,505
*Equivalent Depth (ft)	0.03	0.07	0.04	0.10	0.05	0.13

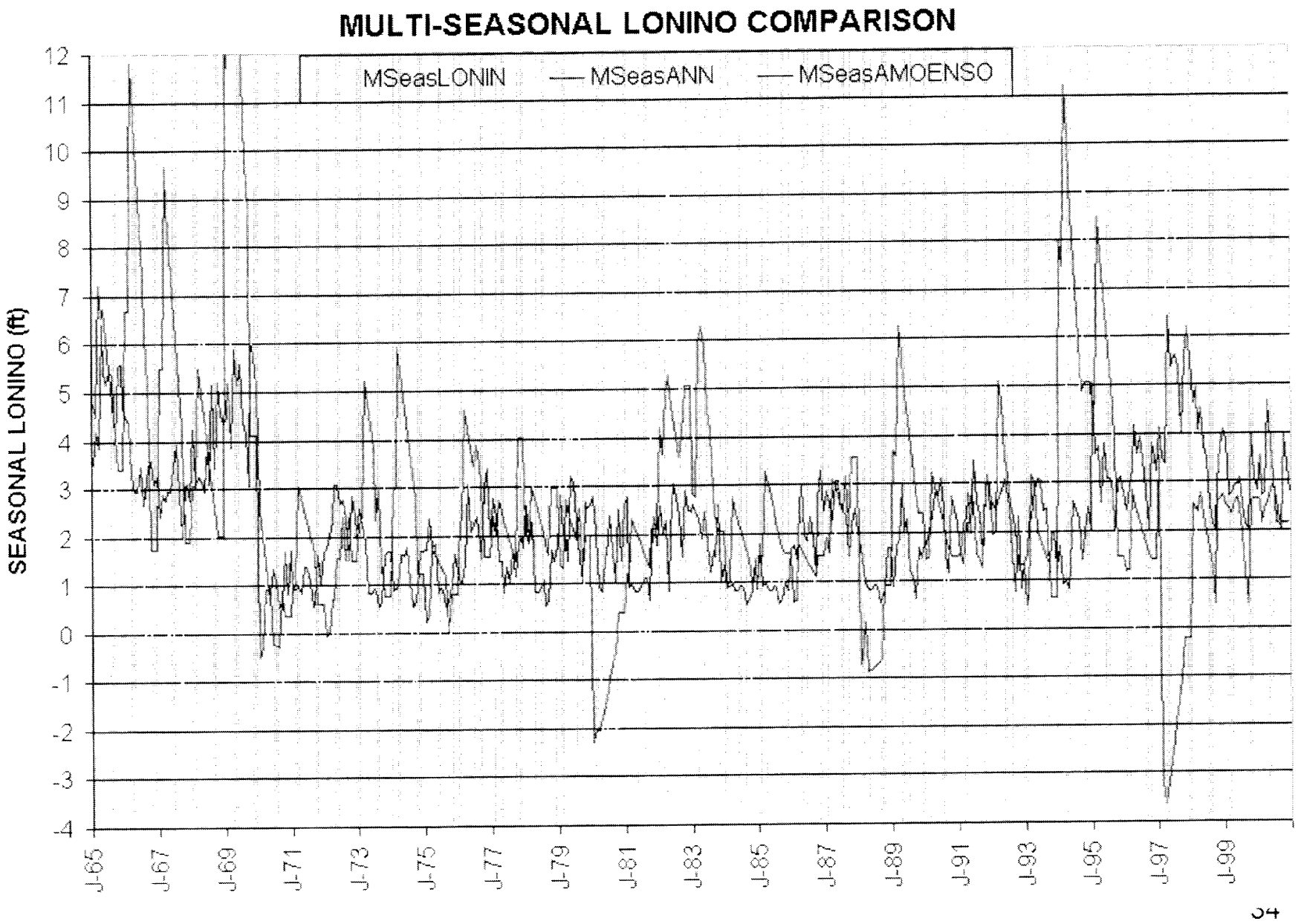
*Volume-Depth conversion based on average lake surface area of 467000 acres

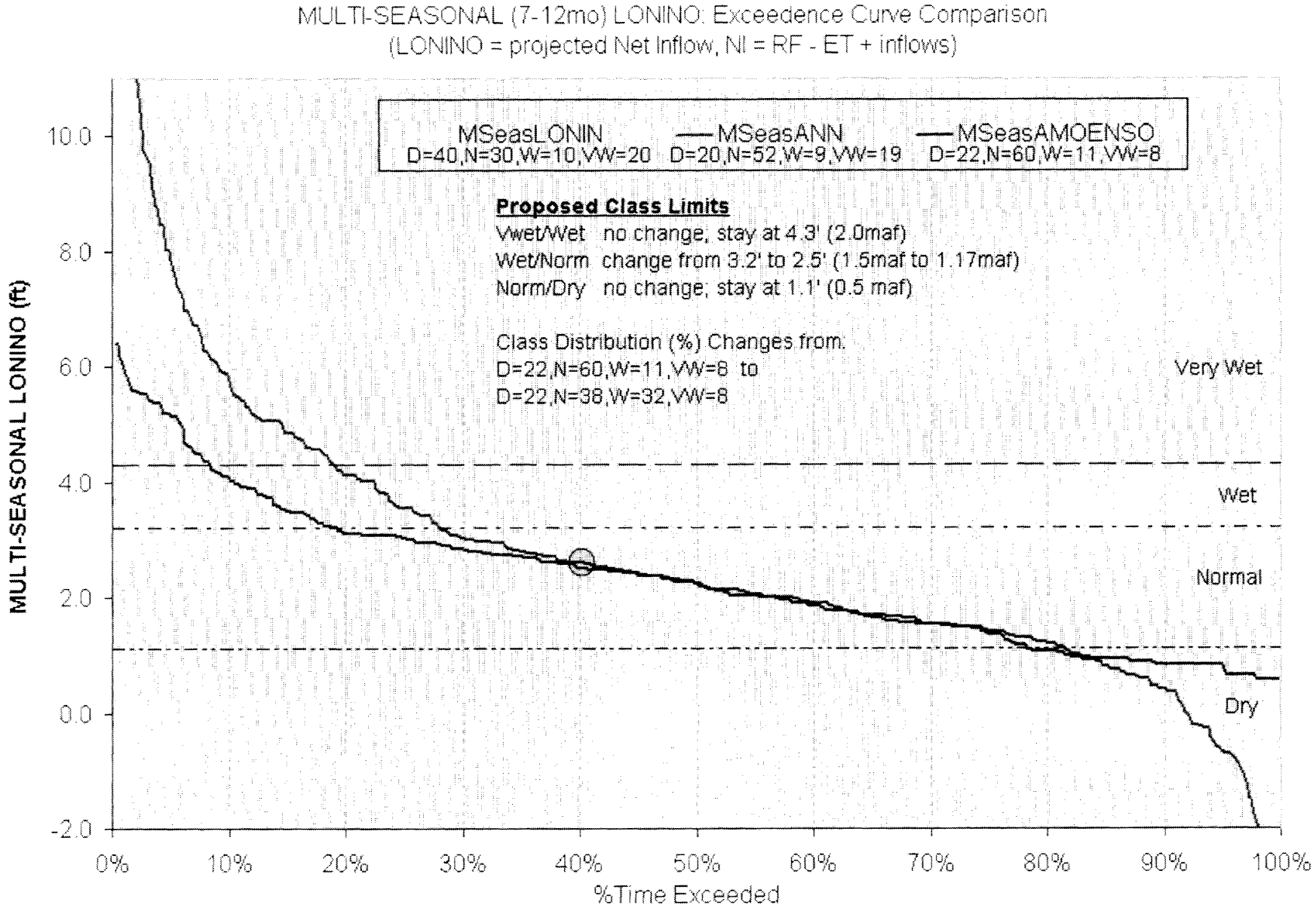

SEASONAL LONINO COMPARISON
SeasLONIN
SeasANN
SeasAMOENSO
SEASONAL LONINO (ft)
9
8
7
6
5
4
3
2
1
0
-1
-2
J-65
J-67
J-69
J-71
J-73
J-75
J-77
J-79
J-81
J-83
J-85
J-87
J-89
J-91
J-93
J-95
J-97
J-99

SEASONAL (6mo) LONINO: Exceedence Curve Comparison

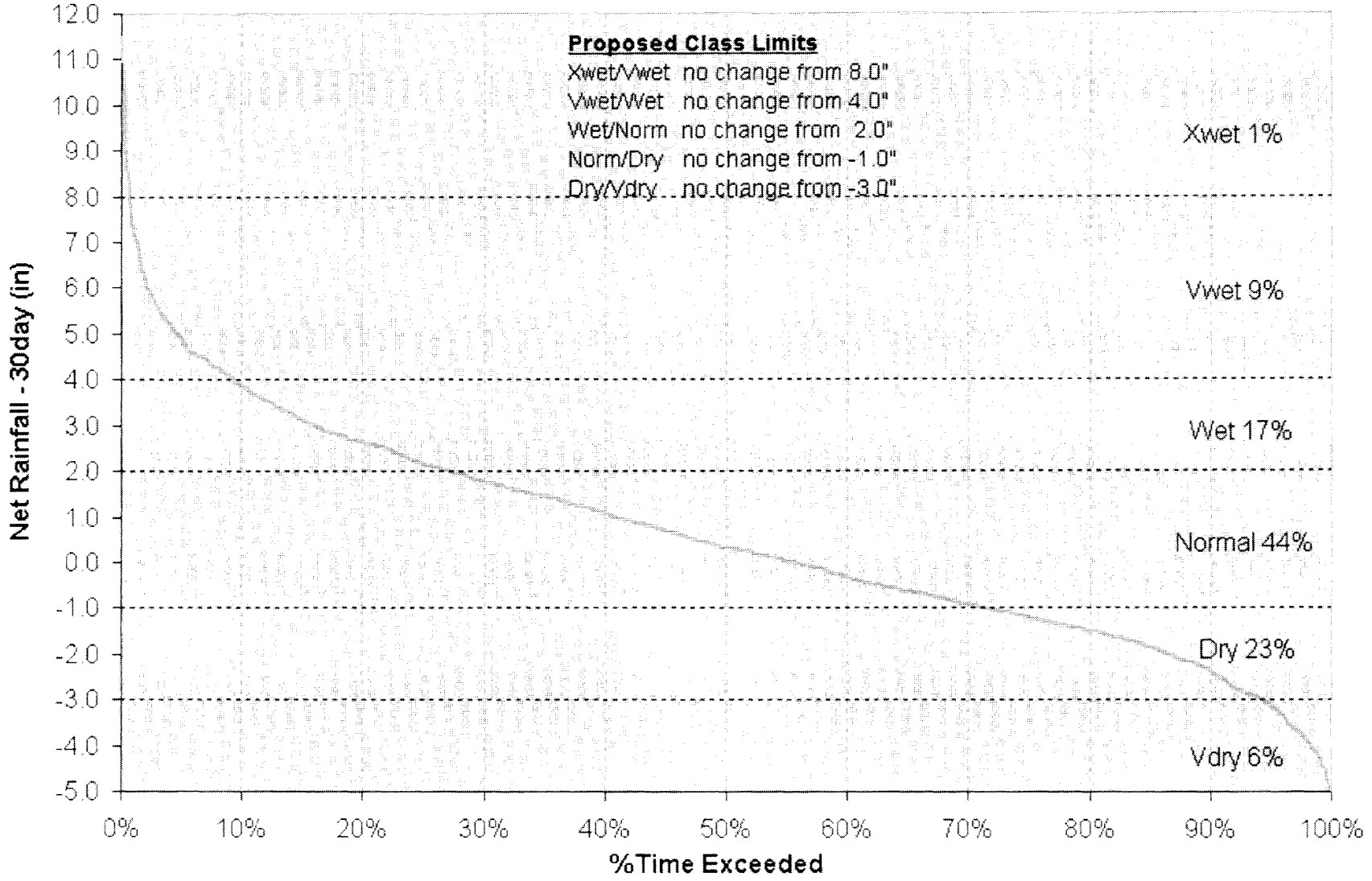
(LONINO = projected Net Inflow, NI = RF - ET + inflows)



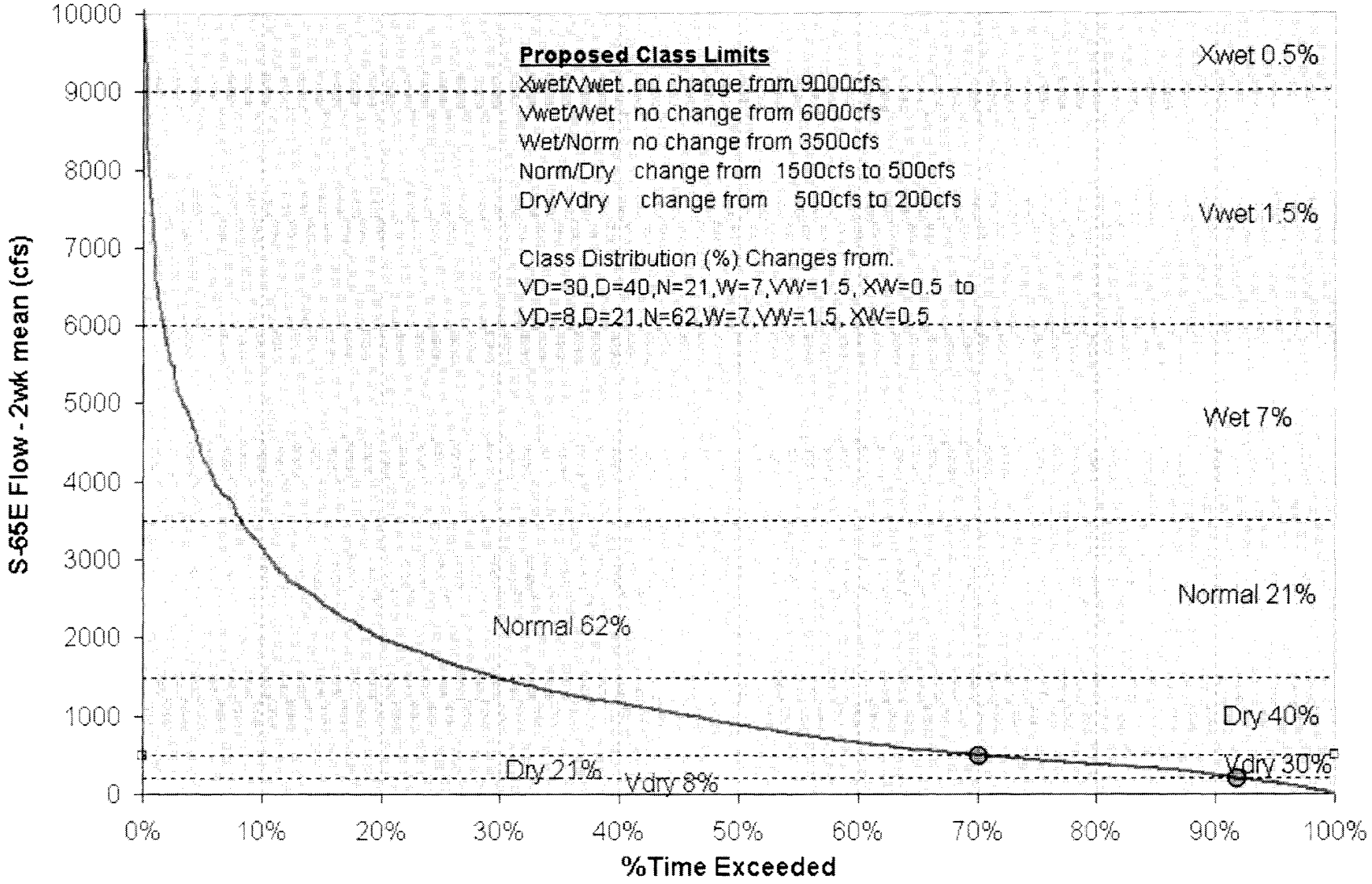

MULTI-SEASONAL LONINO COMPARISON
MSeasLONIN
MSeasANN
MSeasAMOENSO
SEASONAL LONINO (ft)
12
11
10
9
8
7
6
5
4
3
2
1
0
-1
-2
-3
-4
J-65
J-67
J-69
J-71
J-73
J-75
J-77
J-79
J-81
J-83
J-85
J-87
J-89
J-91
J-93
J-95
J-97
J-99

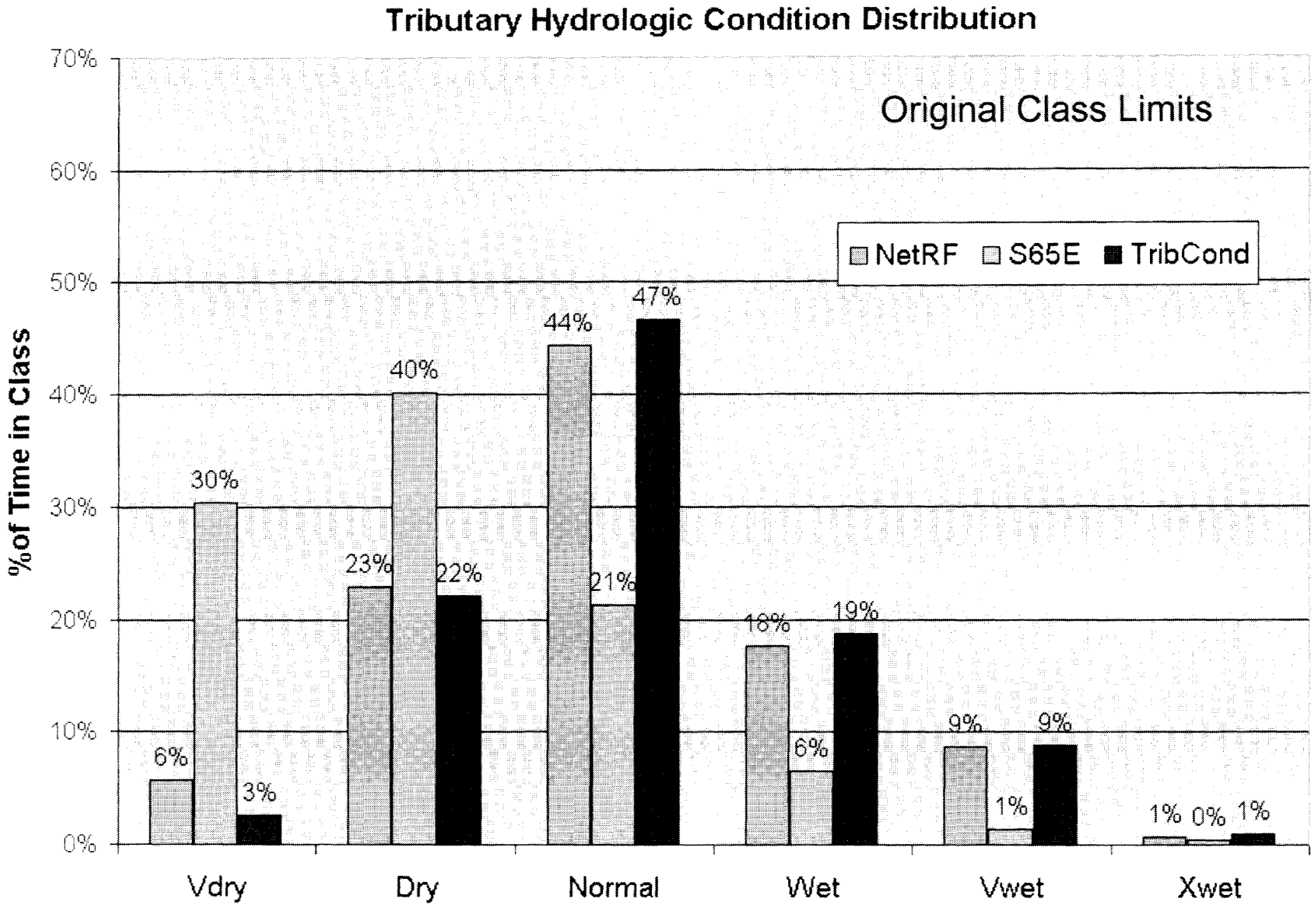

MULTI-SEASONAL (7-12mo) LONINO: Exceedence Curve Comparison
(LONINO = projected Net Inflow, NI = RF - ET + inflows)
MSeasLONIN
D=40,N=30,W=10,VW=20
MSeasANN
D=20,N=52,W=9,VW=19
MSeasAMOENSO
D=22,N=60,W=11,VW=8
Proposed Class Limits
Vwet/Wet no change; stay at 4.3' (2.0maf)
Wet/Norm change from 3.2' to 2.5' (1.5maf to 1.17maf)
Norm/Dry no change; stay at 1.1' (0.5 maf)
Class Distribution (%) Changes from:
D=22,N=60,W=11,VW=8 to
D=22,N=38,W=32,VW=8
Very Wet
Wet
Normal
Dry
MULTI-SEASONAL LONINO (ft)
10.0
8.0
6.0
4.0
2.0
0.0
-2.0
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
%Time Exceeded

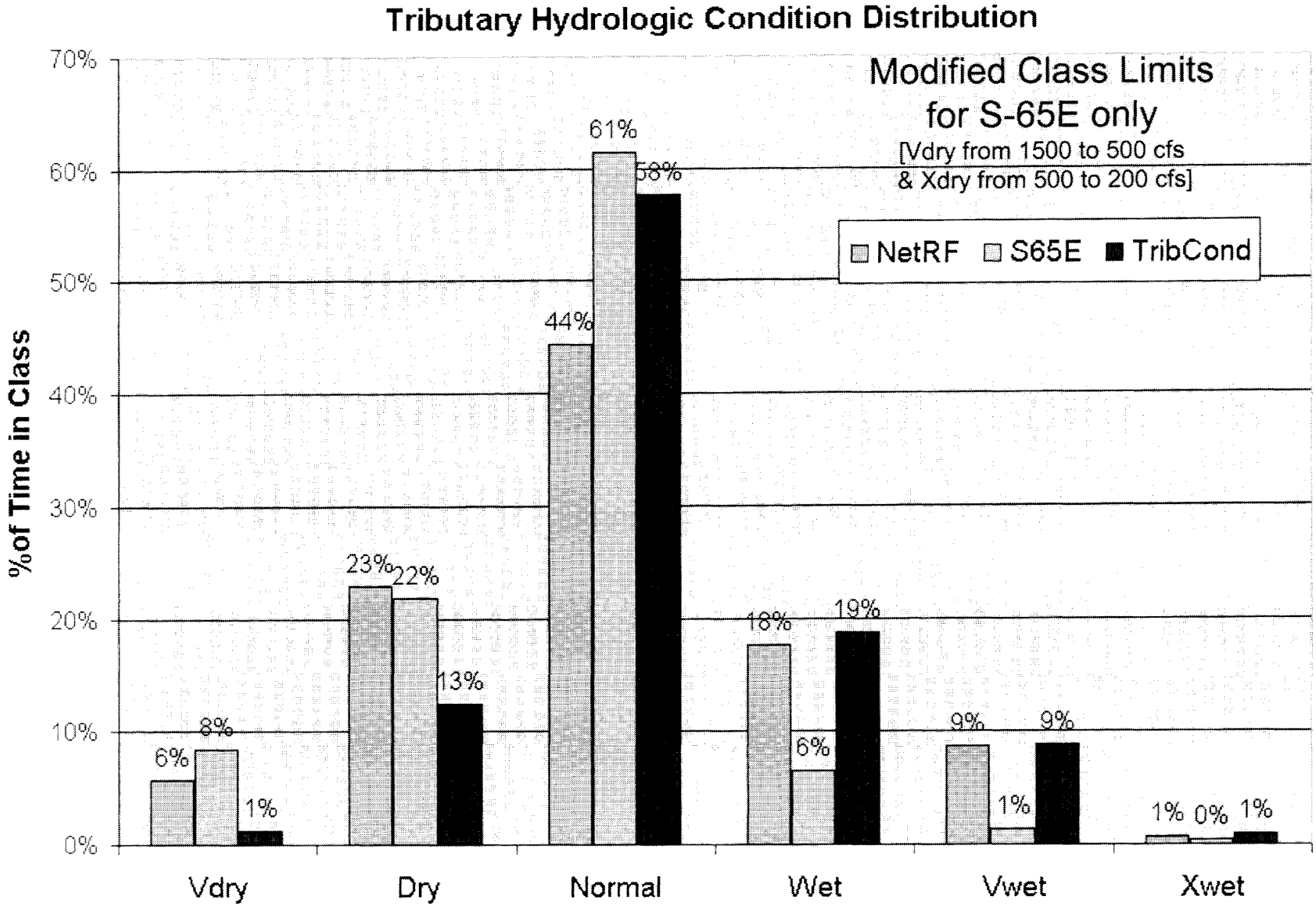
Tributary Condition: Net Rainfall (30day)
Exceedence Curve & Thresholds



Tributary Condition: S-65E Flow (2week mean)
Exceedence Curve & Thresholds




Tributary Hydrologic Condition Distribution
Original Class Limits
NetRF
S65E
TribCond
%of Time in Class
70%
60%
50%
40%
30%
20%
10%
0%
6%
30%
3%
23%
40%
22%
44%
21%
47%
18%
6%
19%
9%
1%
9%
1%
0%
1%
Vdry
Dry
Normal
Wet
Vwet
Xwet


Tributary Hydrologic Condition Distribution
Modified Class Limits
for S-65E only
[Vdry from 1500 to 500 cfs
& Xdry from 500 to 200 cfs]
NetRF
S65E
TribCond
%of Time in Class
70%
60%
50%
40%
30%
20%
10%
0%
6%
8%
1%
23%
22%
13%
44%
61%
58%
18%
6%
19%
9%
1%
9%
1%
0%
1%
Vdry
Dry
Normal
Wet
Vwet
Xwet