North Carolina Department of Environment and Natural Resources
Division of Water Resources

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State of North Carolina
B. Everett Jordan Lake Drought Management Plan
(DRAFT)

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The US Army Corps of Engineers has a Drought Contingency Plan for Jordan Lake.[1] The Corps' Drought Contingency Plan provides an outline of water management measures and coordination actions to consider when a severe drought occurs, but leaves the details of any particular management measures and the timing of their application to be determined as such a drought progresses. The purpose of the State of North Carolina's Jordan Lake Drought Management Plan is to provide more detailed management guidelines consistent with the Corps' Drought Contingency Plan.

I. Relationship with Corps' Drought Contingency Plan

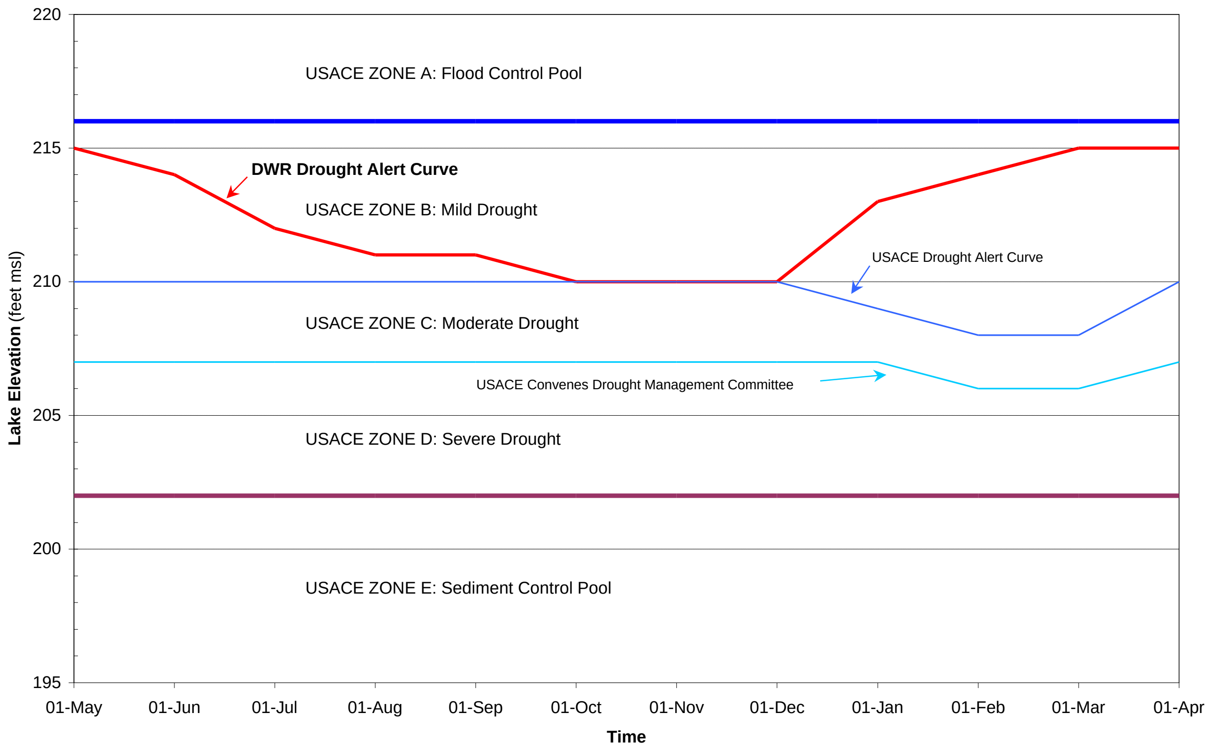
The State's Jordan Lake Drought Management Plan does not supersede the US Army Corps of Engineers' Jordan Lake Drought Contingency Plan. Rather, the State's plan nests within the Corps' plan and provides greater specificity and certainty. The Corps' plan relies on lake elevation as the primary indicator (see figure 1 on the following page). The primary elements of the Corps' plan may be described as follows.[2]

1. When the lake level drops into Zone B (below 216.0 feet msl), the Corps will initiate a water budget. The Corps will update the Division of Water Resources weekly regarding the remaining water supply and water quality storage.
2. When the lake level drops into Zone C, or the water quality storage volume falls below 45 percent as indicted by the water budget, the Corps will initiate coordination between all concerned parties.
3. When the storage volume of either the water supply pool or the water quality pool falls below 23 percent, the Corps will notify DWR that implementation of water conservation should be considered.

[1] B. Everett Jordan Lake Drought Contingency Plan (US Army Corps of Engineers' 1992 Water Control Manual for B. Everett Jordan Project, Exhibit B)
[2] B. Everett Jordan Lake Drought Contingency Plan, pp. B-5 – B-7

4. When the lake level drops into Zone D, the Corps will convene a Drought Management Committee to discuss a course of action for the continued operation of Jordan Lake and possible alternatives. The Corps' plan then provides a brief list of alternatives.

Figure 1. Drought Operation Curves[3]



The Division of Water Resources will obtain daily lake levels for Jordan Lake by automatically downloading the real-time data from the US Geological Survey's web site for station number 02098197. When the lake level drops to the DWR Drought Alert Curve (see figure 1), DWR will work with the Corps to determine if the Haw River Basin is entering a severe drought.

II. Determining a Severe Drought

We will implement drought measures when the Corps and the Division of Water Resources determine that the Haw River Basin is in a severe drought. We will determine a severe drought in the Haw River Basin based on three factors: inflows to Jordan Lake, Jordan Lake level and the time at which these occur during the climatic year. Current Jordan Lake inflows and level will be based on a moving 7-day average. We will rely upon the Corps' calculated inflows to Jordan Lake.

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[3] Based on B. Everett Jordan Lake Drought Contingency Plan, Exhibit 1

Table 1. Drought Response Triggers

Time (climatic year)	**Jordan Lake Average Daily Level (7-day)** (feet msl)	**Jordan Lake Average Daily Inflow (7-day)** (cfs)	**Drought Response** (target reduction schedule)
April	215	160	Spring-Summer
May	215	70	Spring-Summer
June	214	30	Spring-Summer
July	212	30	Spring-Summer
August	211	30	Spring-Summer
September	211	30	Spring-Summer
October	210	3	Fall-Winter
November	210	20	Fall-Winter
December	210	120	Fall-Winter
January	213	170	Fall-Winter
February	214	270	Fall-Winter
March	215	320	Fall-Winter

When Jordan Lake levels are equal to or less than the value indicated for the given month (i.e., the Drought Alert Curve), the Division of Water Resources will work with the Corps to evaluate Jordan Lake inflows. We will determine a drought is severe in the Haw River Basin and implement the previously described responses whenever Jordan Lake inflows and the Jordan Lake level are both less than the value indicated in Table 1. These drought response triggers coexist with those found in the Corps' plan.

III. Drought Responses

When the Corps and the Division of Water Resources determine that the Haw River Basin is in a severe drought, we will implement the following measures.

Dam Releases

The normal low-flow target at Lillington is 600 cfs, ± 50 cfs.[4] During severe droughts, we will implement a stepped reduction in the target. The stepped flow reduction allows fish time to migrate to deeper water. The stepped flow reduction also provides us time to observe any adverse impacts in water quality.

When we determine that the Haw River Basin is in a severe drought, we will immediately reduce the low-flow target at Lillington to 500 cfs. We will also notify the Division of Water Quality and the Wildlife Resources Commission. The DWQ and the WRC will begin monitoring Cape Fear River water quality and habitat, weekly. Following the first week of monitoring and prior to the next low-flow target reduction, we will meet with the DWQ and the WRC to review available data and adjust the target reduction schedule accordingly. The table on the following page describes the low-flow target reduction schedule for the spring and summer period.

[4] Unless otherwise noted, all flow values are based on a daily average.

Table 2. Low-Flow Target Reduction Schedule, Spring and Summer

Time	Lillington Gage		Lock & Dam #1 Gage
	Flow Target (cfs)	**Precision** (cfs)	**Flow** (cfs)
Day 1	500	± 50	
Day 8	450	± 50	
Day 15	400	± 50	
Day 22	350	± 50	
Day 29	300	± 25	
Day 36	250	± 25	
Day 42	250	± 25	< 200
	200	± 25	= 200

The low-flow target at Lillington of 200 cfs is based on two considerations. The design of the Jordan Lake Dam service gate is such that the minimum flow that the Corps can release is between 130 cfs and 200 cfs, depending on the current lake level. Harnett County estimates that their water supply intake could not operate at flows less than 190 cfs, measured at the Lillington gage.[5] On day 42 of the target reduction schedule, the flow at Lock & Dam #1 becomes a target. When the flow at Lock & Dam #1 is greater than, or equal to 200 cfs, the flow target at Lillington is 200 cfs. When the flow at Lock & Dam #1 is less than 200 cfs, the flow target at Lillington is 250 cfs.

On Day 29, when the low-flow target at Lillington is reduced to 300 cfs, all water supply systems withdrawing water from the Cape Fear River will implement any necessary measures to reduce the quantity of water they withdraw by 20 percent. The policies associated with this mandatory water withdrawal reduction are provided in a separate document.

During the fall and winter period, the reduction schedule is not as extreme. The following table describes the low-flow target reduction schedule for the fall and winter period.

Table 3. Low-Flow Target Reduction Schedule, Fall and Winter

Time	Lillington Gage	
	Flow Target (cfs)	**Precision** (cfs)
Day 1	500	± 50
Day 8	450	± 50
Day 15	400	± 50
Day 22	350	± 50
Day 29	300	± 25

On Day 29, when the low-flow target at Lillington is reduced to 300 cfs, all water supply systems withdrawing water from the Cape Fear River will implement any necessary measures to reduce the quantity of water they withdraw by 20 percent. The policies associated with this mandatory water withdrawal reduction are provided in a separate document.

[5] Note that the daily average flow at Lillington dropped to 155 cfs on August 6, 2002 and Harnett County's intake continued to operate.

In-Lake Water Supply Withdrawals

Only water supply systems for which the Environmental Management Commission has approved a water supply storage allocation may withdraw water from Jordan Lake. Allocation holders are required to implement Drought and Water Shortage Response Plans during severe droughts, as specified in Articles 3 and 9 of the contracts for Jordan Lake water supply storage allocations.

Jordan Lake Pool Re-Allocation

If the low-flow augmentation pool becomes depleted, other Jordan Lake pools may be temporarily re-allocated to the low-flow augmentation pool. Temporary re-allocations will increase the amount of storage available to support releases of water from Jordan Dam. However, if the lake falls to a level that would jeopardize the ability of allocation holders to withdraw water from their water supply storage, releases for downstream flow augmentation may be restricted, despite the amount of water available from the re-allocated pools. Temporary pool re-allocations will occur under the following triage approach.

Table 4. Jordan Lake Pool Re-Allocation Triage

Re-Allocation Priority	**Pool**	**Available Storage** (acre-feet)
	Low-Flow Augmentation Storage	94,600
First	Sediment Storage	74,700
Second	Un-Allocated Water Supply Storage	16,946
Third	Allocated Level II Water Supply Storage	3,664

Temporarily re-allocating the sediment storage to the low-flow augmentation pool requires approval from the Corps. Temporarily re-allocating any of the Level II water supply storage allocations requires the approval of the respective allocation holders. Such a temporary re-allocation would also require the State to reimburse the allocation holders for the limited use.

When the first pool re-allocation occurs, all water supply systems in the Cape Fear River Basin will be required to implement mandatory water use reduction measures designed to achieve at least a 20 percent reduction in water use.

IV. Refilling Jordan Lake

During an extended drought or at the conclusion of a severe drought, refilling Jordan Lake becomes a priority. In general, we will continue to restrict releases from the dam until the lake level is at normal pool. The refill strategy for the lake is described in the table on the following page.

Table 5. Jordan Lake Refill Strategy

Jordan Lake Average Level (7-day) (feet msl)	**Jordan Lake Average Daily Inflow (7-day)** (cfs)	**Jordan Lake Release**
< 216.0	NA	Low-Flow Target Reduction Schedule
216.0	= 600	Equals Inflow
216.0	> 600	Resume Normal Low-Flow Target

V. Hydrologic Modeling and Analyses

We conducted the following analyses to determine optimal drought triggers, to determine the impacts of the drought plan on lake levels and stream flows, and to verify the effectiveness of the plan.

Drought Response Triggers

We analyzed the historic records of Jordan Lake inflows and Jordan Lake levels to determine the appropriate values for the Drought Response Triggers table. We relied upon data from the Corps for the period of October 4, 1982 to October 20, 2002.

Figure 2. Jordan Lake Daily Inflows, Period of Record

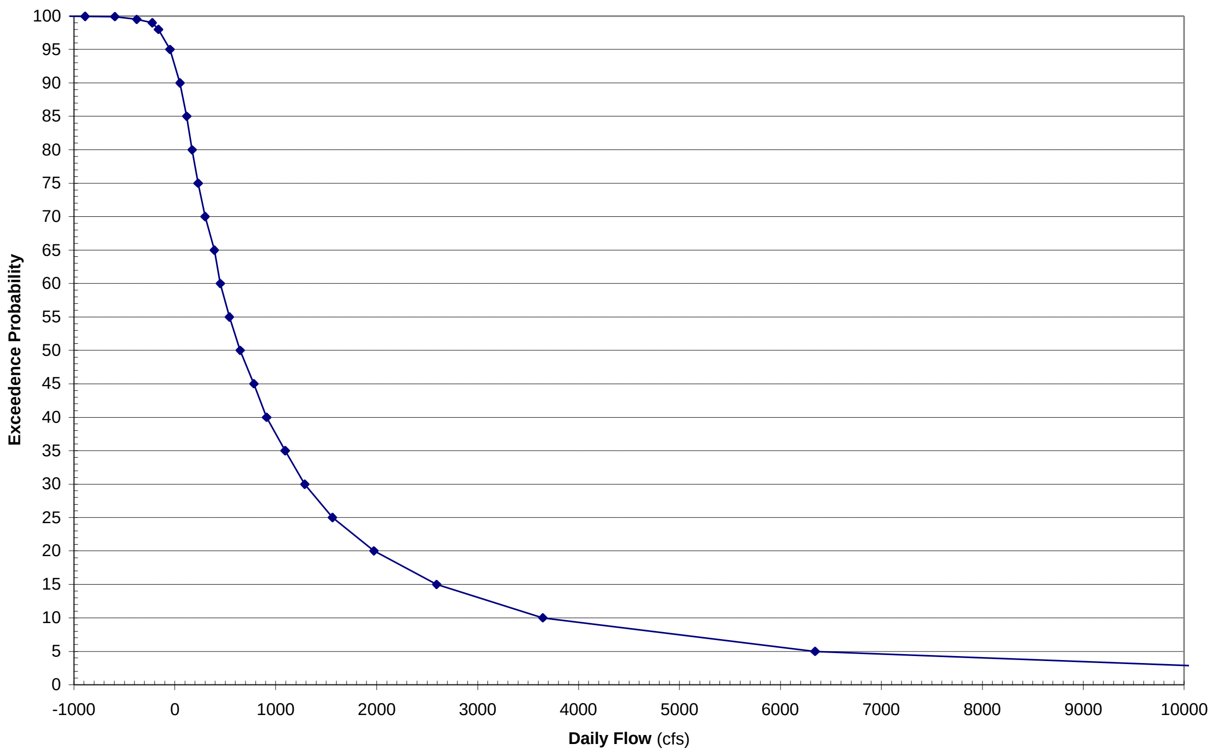


Figure 3. Jordan Lake Daily Inflows, by Month

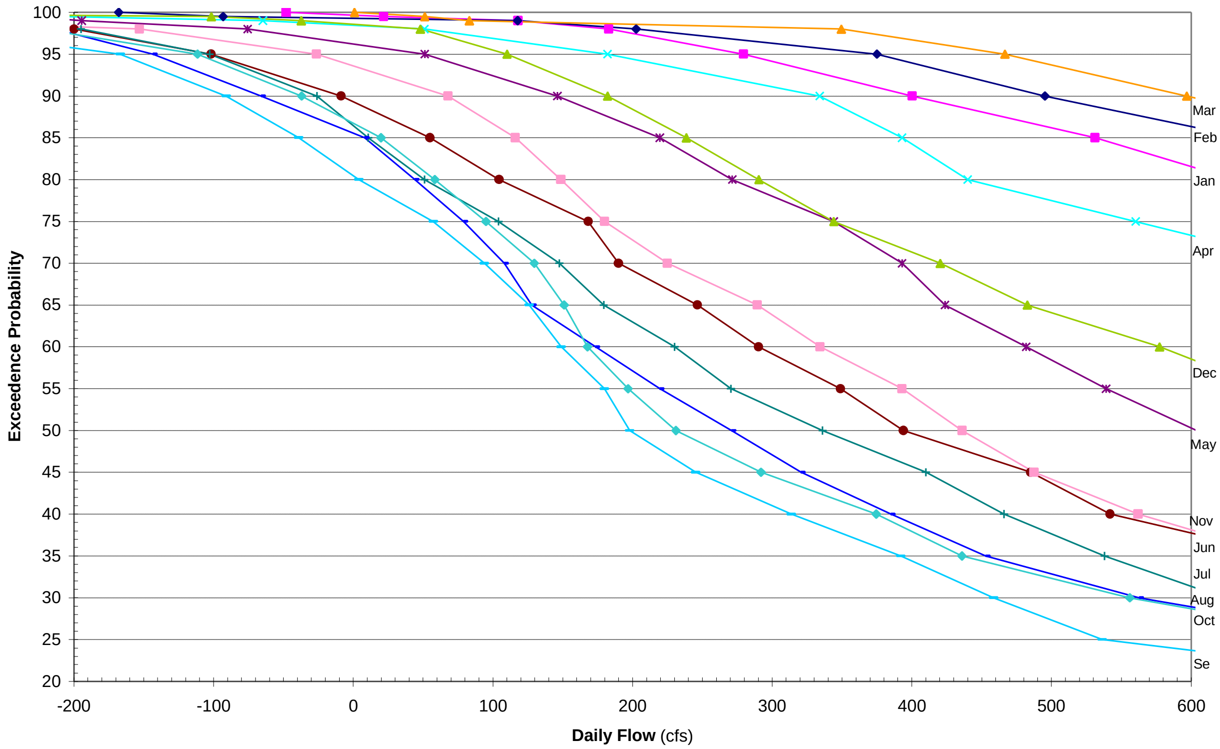


Figure 4. Jordan Lake Daily Inflows, Statistics by Month and Drought Response Trigger

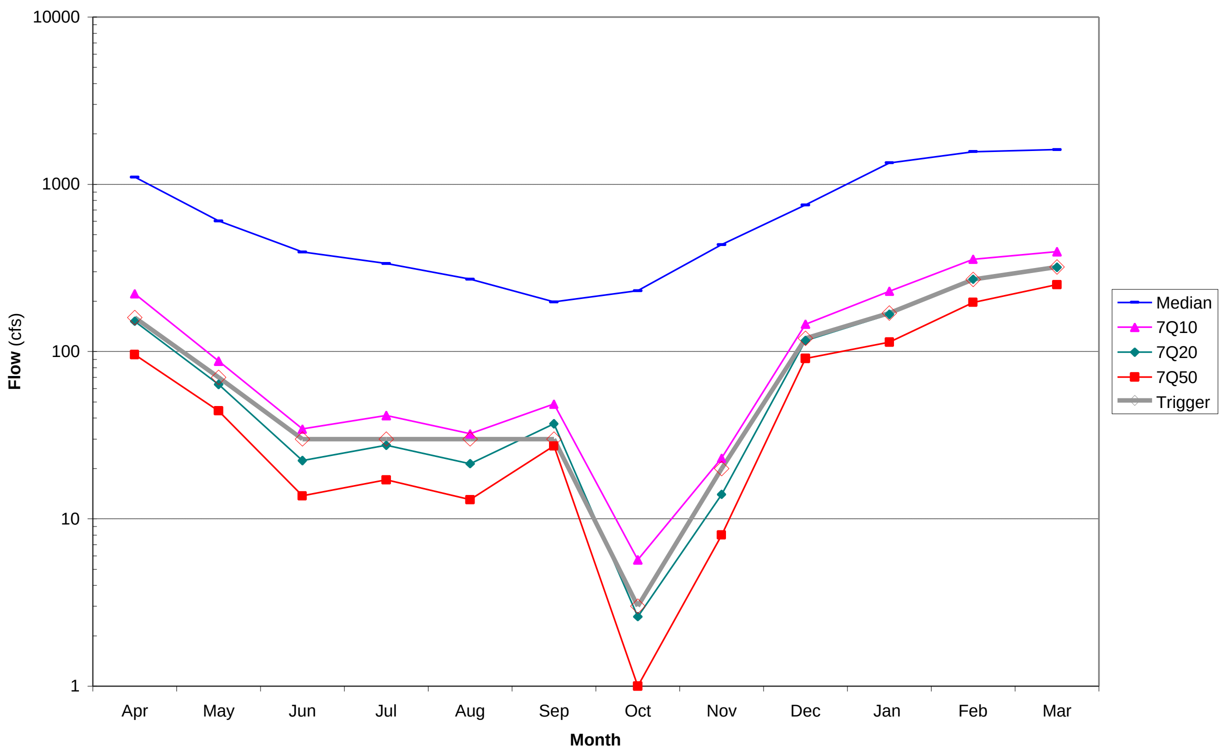


Figure 5. Jordan Lake Daily Levels, Period of Record

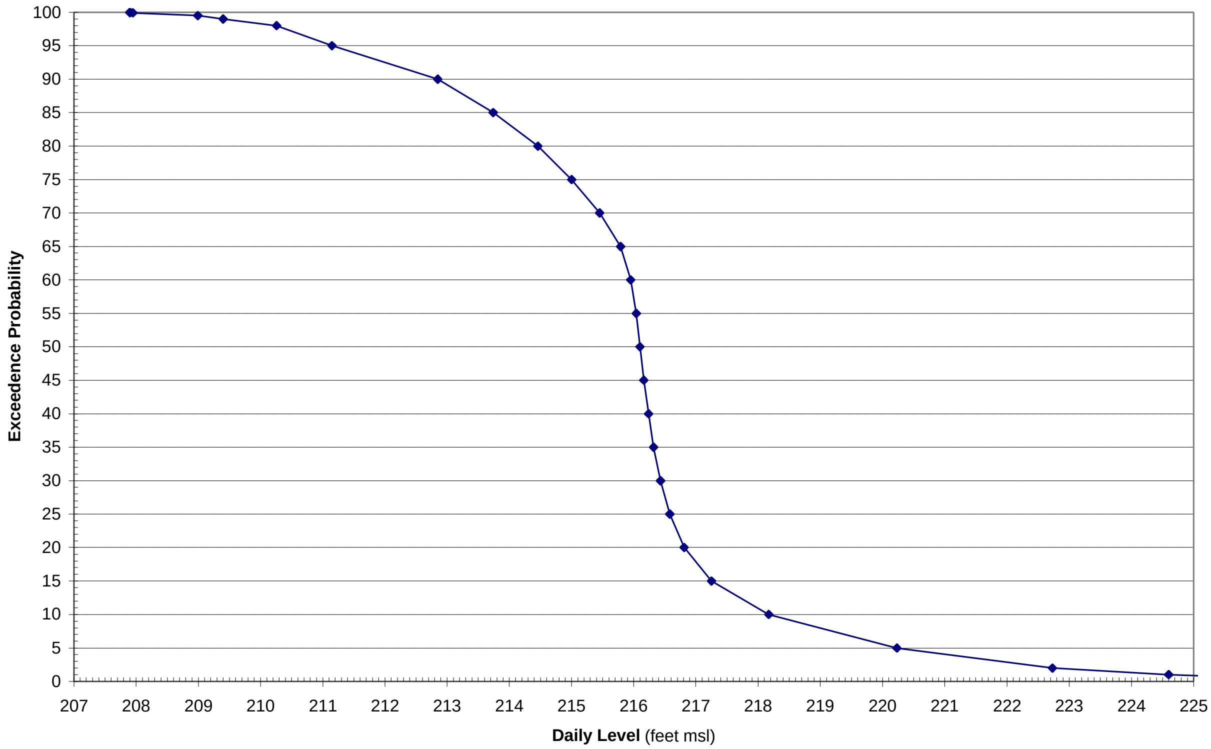


Figure 6. Jordan Lake Daily Levels, by Month

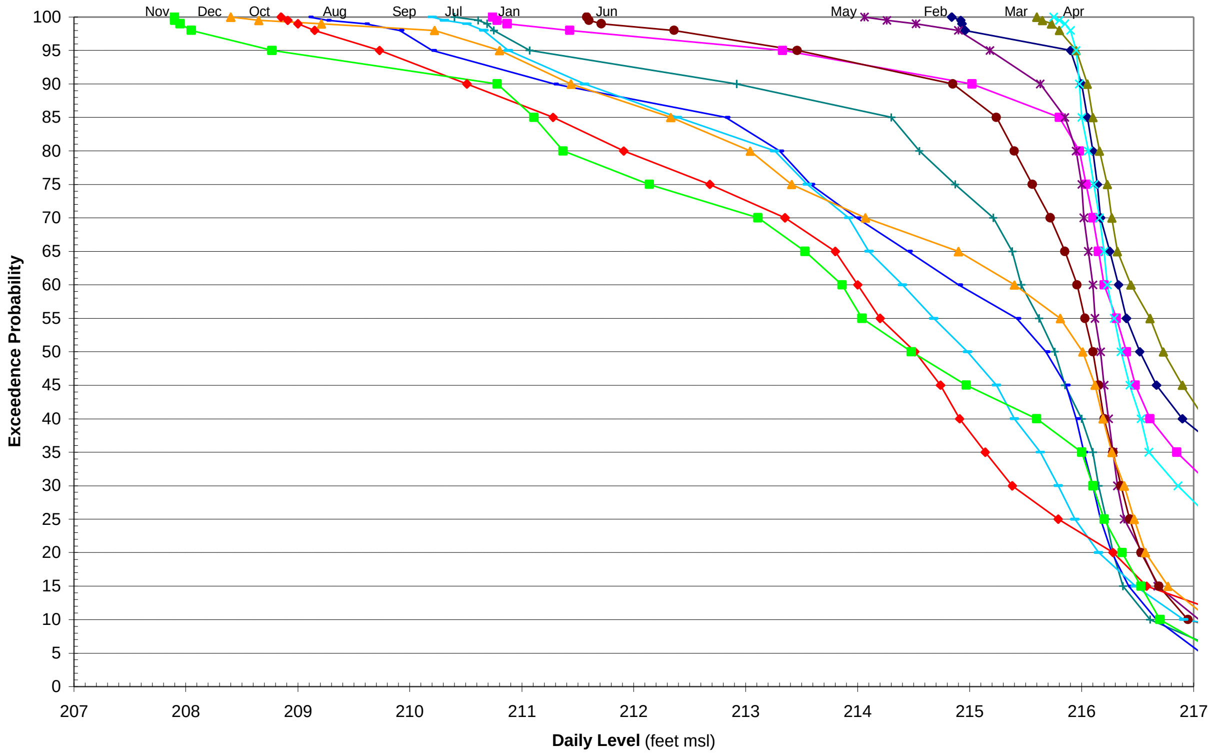
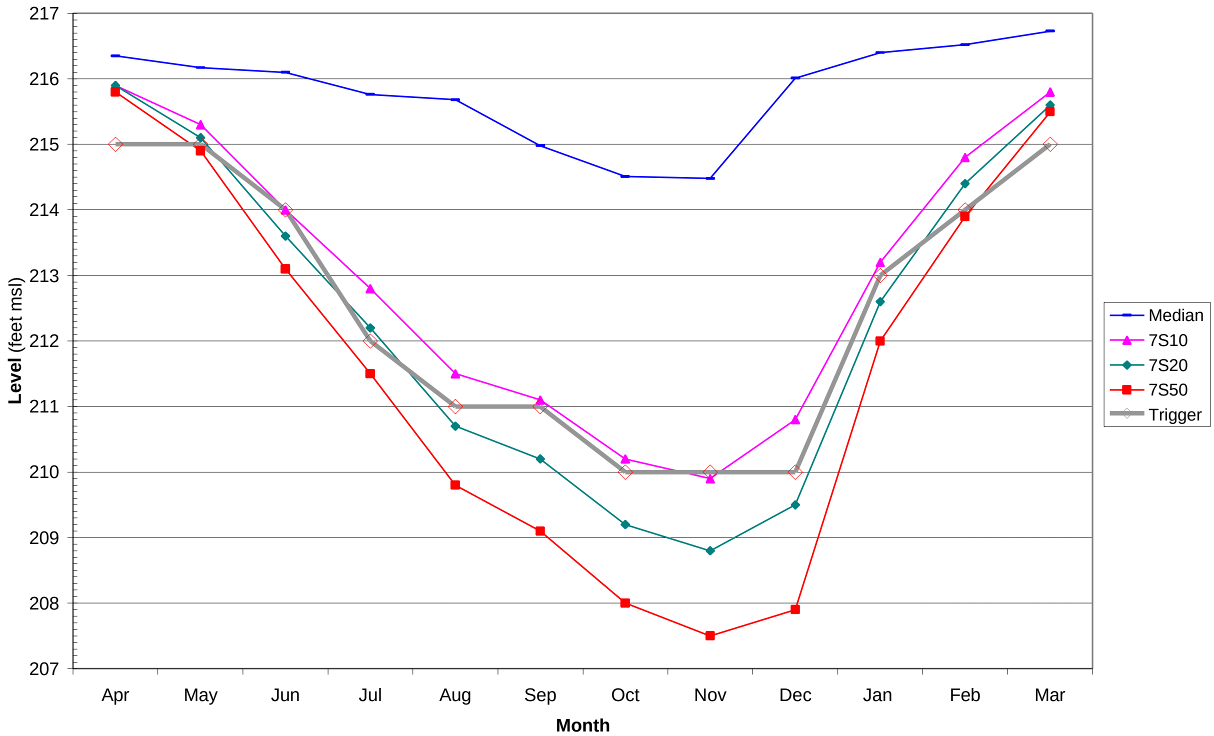


Figure 7. Jordan Lake Daily Levels, Statistics by Month and Drought Response Trigger



Analyzing data for the period from February 4, 1982 to October 31, 2002 provides an indication of the impact the drought management plan will have on lake operations. Had this drought management plan been in effect since the lake was first filled, a drought response would have been triggered six times. The following table describes those events.

Table 6. Hypothetical Drought Response Events

Event	**Triggered** (date)	**Jordan Lake Average Daily Level (7-day)** (feet msl)	**Jordan Lake Average Daily Inflow (7-day)** (cfs)	**Duration** (days)	**Normal Operation Resumed** (date)	**Jordan Lake Average Daily Level (7-day)** (feet msl)	**Jordan Lake Average Daily Inflow (7-day)** (cfs)
1	9/23/1983	210.9	10	73	12/5/1983	216.0	2415
2	6/20/1986	214.0	10	201	1/7/1987	216.0	2037
3	8/23/1988	211.0	-11	104	12/5/1988	216.0	1211
4	9/28/1990	211.0	4	26	10/24/1990	216.0	7220
5	1/1/2002	211.0	122	26	1/27/2002	216.0	4960
6	5/25/2002	214.8	25	141	10/13/2002	216.0	9380

The following six figures provide comparisons of the historic Jordan Lake outflows and the hypothetical, drought response outflows during those six events. Note that the hypothetical drought responses under the drought management plan are similar to the historic drought responses, but the drought management plan generally triggers an earlier and more extreme drought response.

Figure 8. Hypothetical Drought Response, Event 1

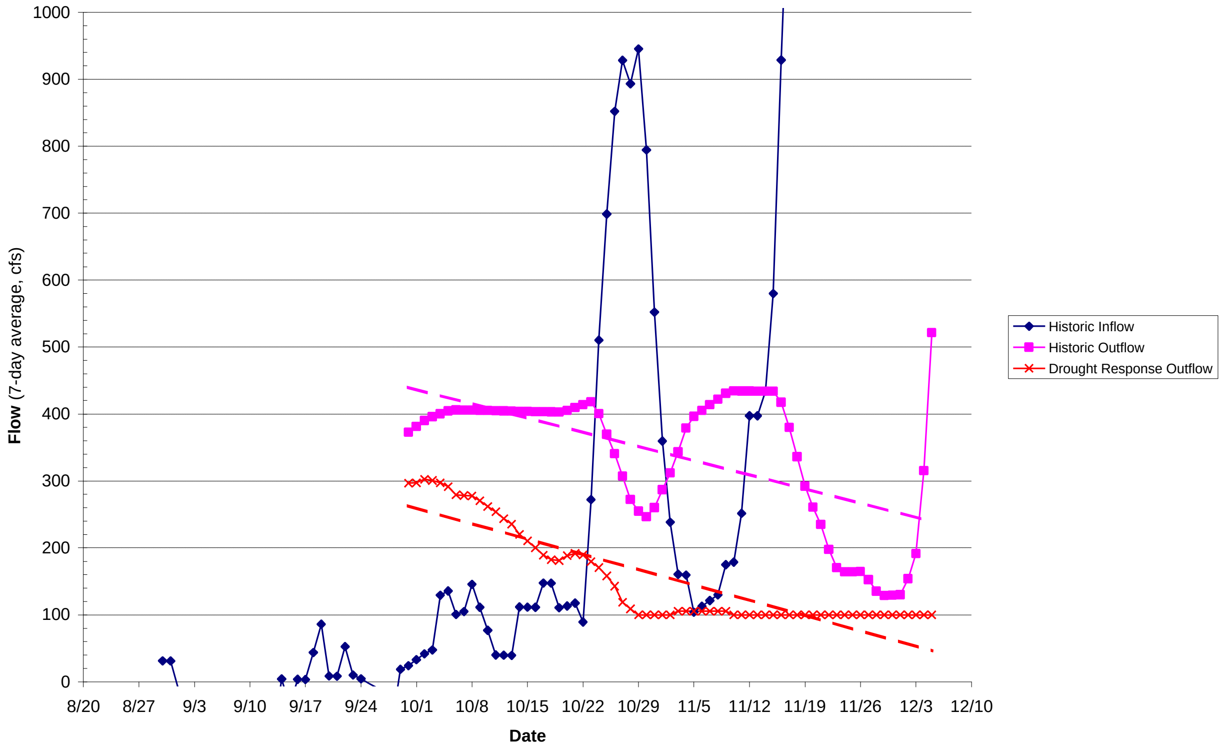


Figure 9. Hypothetical Drought Response, Event 2

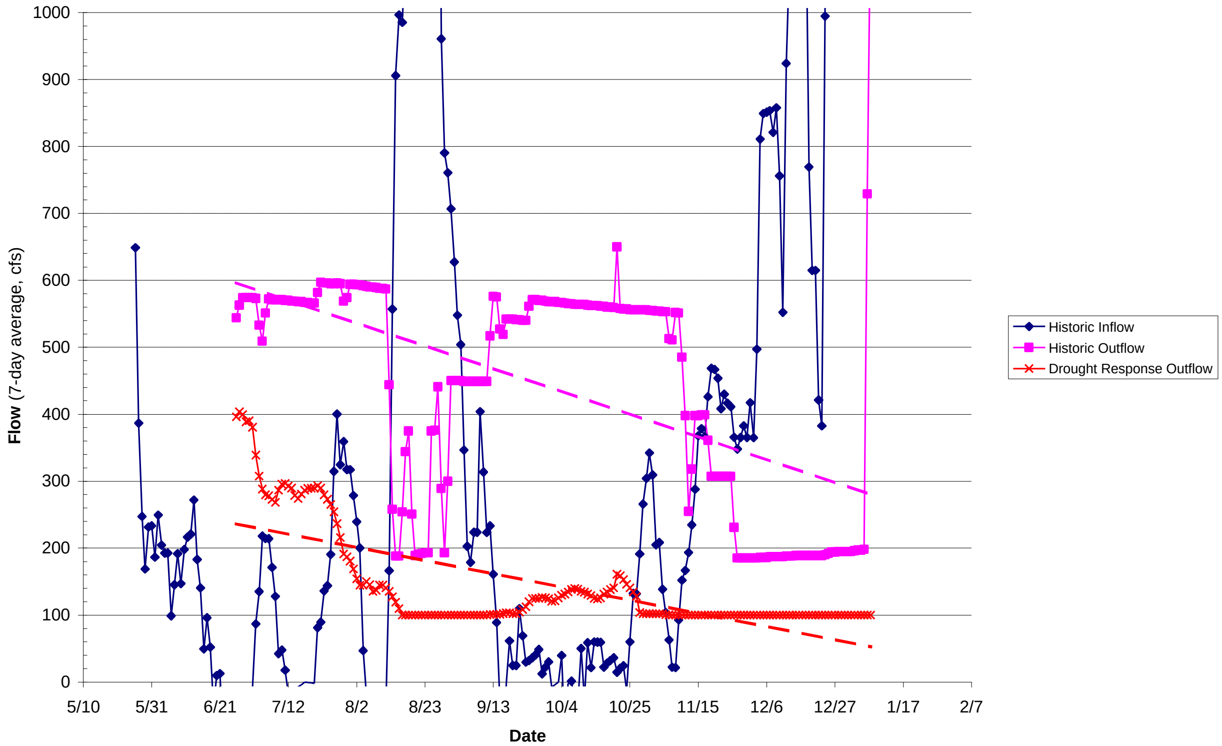


Figure 10. Hypothetical Drought Response, Event 3

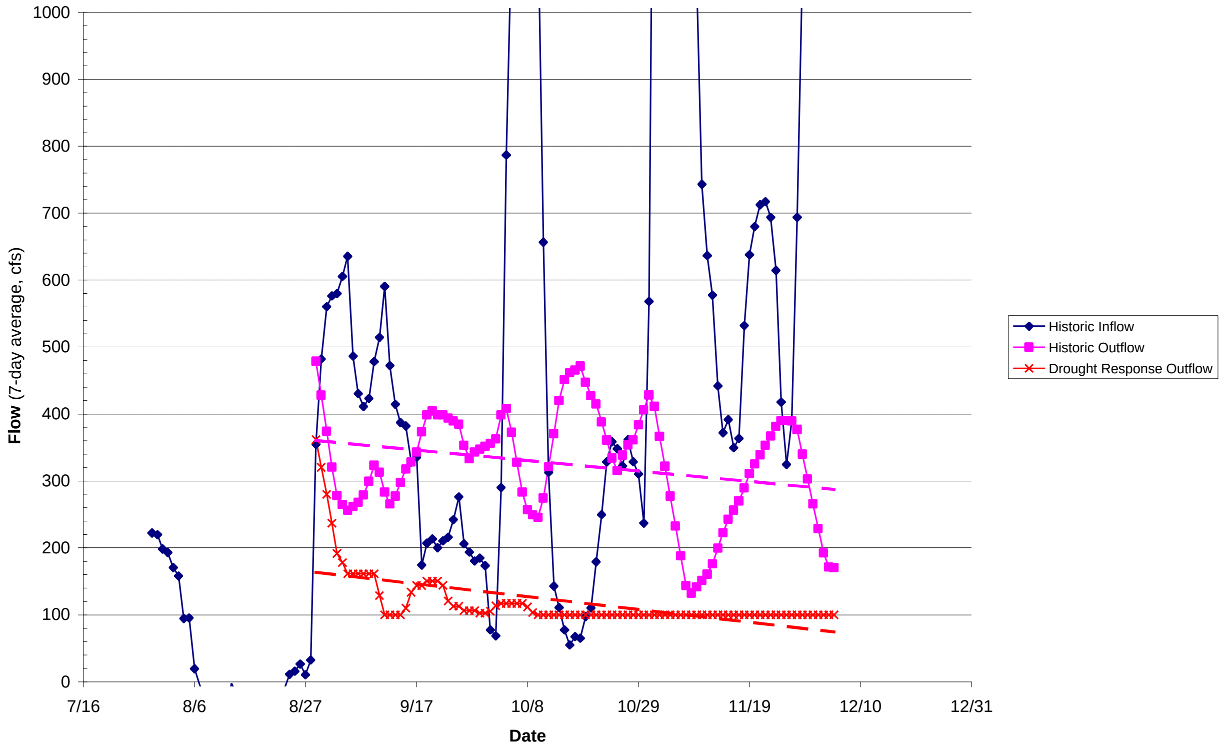


Figure 11. Hypothetical Drought Response, Event 4

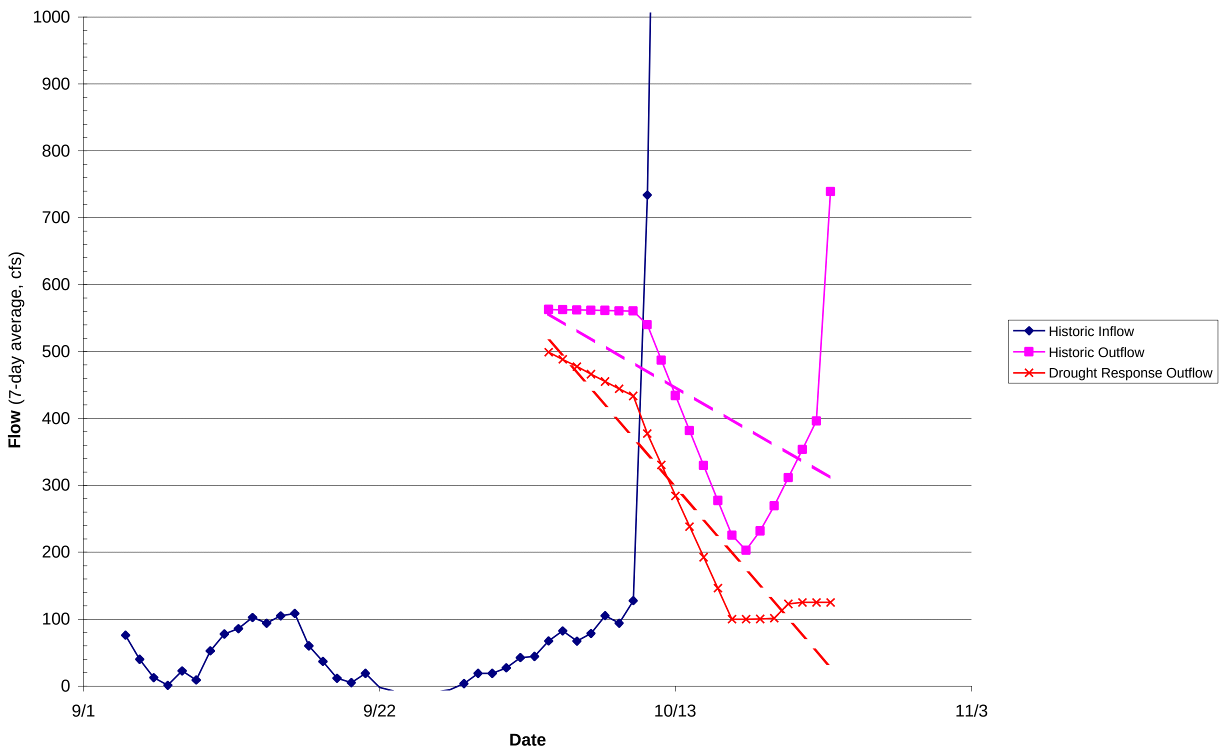


Figure 12. Hypothetical Drought Response, Event 5

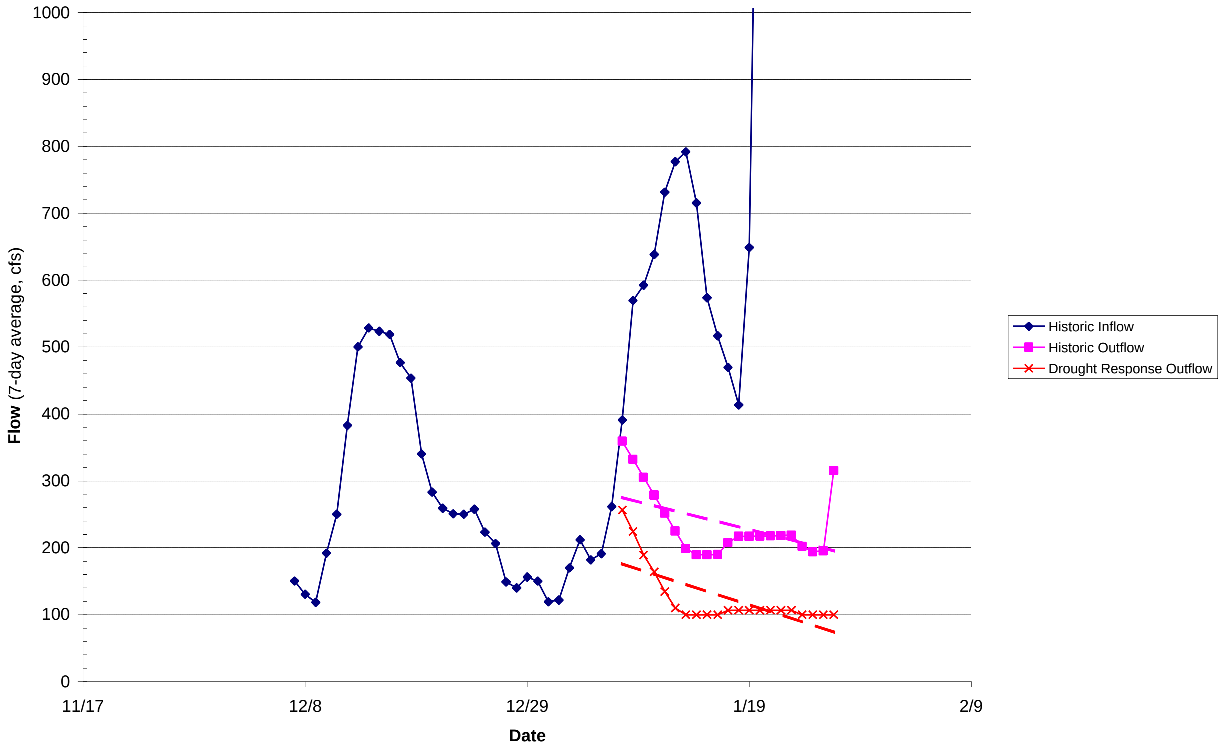
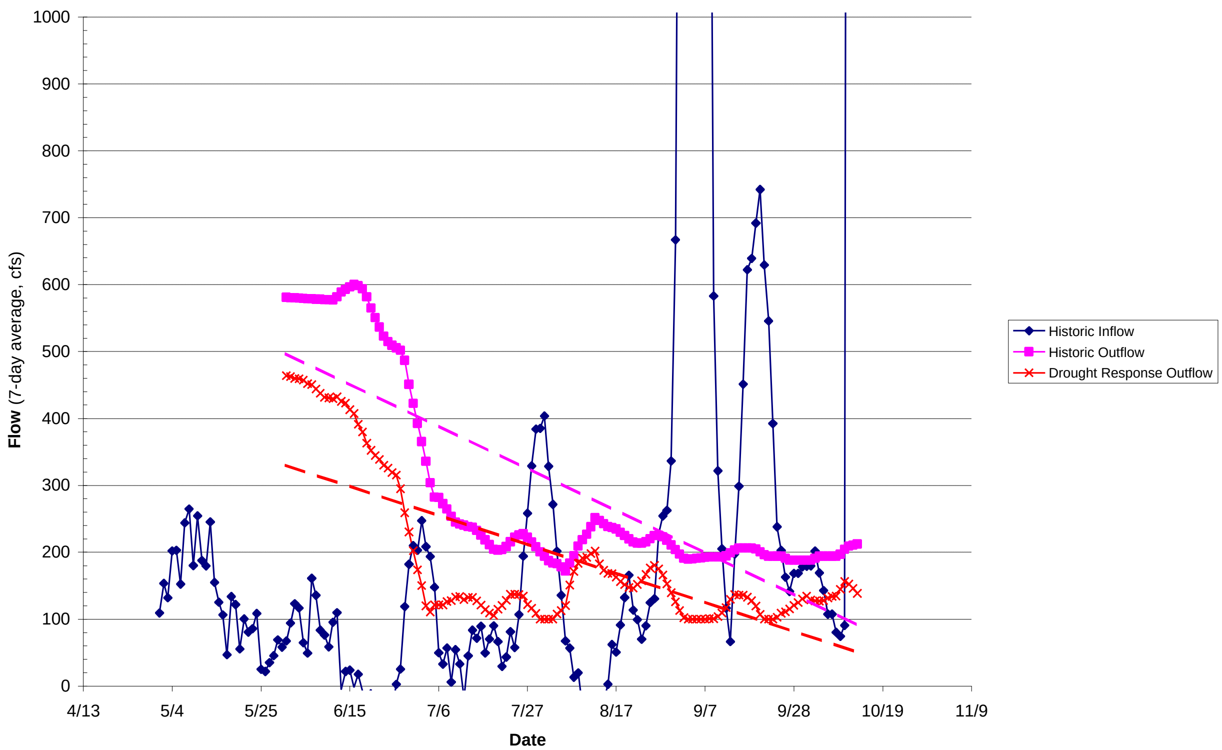


Figure 13. Hypothetical Drought Response, Event 6



In-Lake Drought Management Impacts

We must analyze the impacts of the drought management plan on lake levels and outflows, and compare the result with the results obtained from the Cape Fear River Basin Hydrologic Model scenarios (i.e., 1998 Scenario, 2030 Scenario and 2050 Scenario). Lake level analyses are important to understand the potential impacts to water supply withdrawals, recreation and habitat.

We will probably have to use a different model from the Cape Fear River Basin Hydrologic Model to analyze the impacts of the Jordan Lake Drought Management Plan, as the stepped target reduction scheme is not compatible with that model. Jordan Lake inflow results from the CFRBHM scenarios, as well as Deep River outflow results and the relative contributions of the local flows between Jordan Dam and Lillington, will serve as inputs to the Jordan Lake drought management model.

Cape Fear River Drought Management Impacts

We must analyze the impacts of the drought management plan on Cape Fear River flows and compare the result with the results obtained from the Cape Fear River Basin Hydrologic Model scenarios (i.e., 1998 Scenario, 2030 Scenario and 2050 Scenario). We can probably use the Cape Fear River Basin Hydrologic Model for this analysis, as we can use the Jordan Lake release results from the Jordan Lake drought management model as inputs to the Cape Fear model.