Cape Fear River Basin Surface Water Assessment

Modeling of Future Water Use Scenarios

NC Division of Water Resources

October 2008

DWR
Division of Water Resources

Table of Contents

		Page
	Preface to the October 2008 Version	**3**
I.	**Introduction**	**5**
	Scope of the Model	**7**
	Scenarios Modeled	**8**
II.	**Model Assumptions**	**10**
	Inputs	**10**
	Outputs	**11**
	Withdrawals and Discharges	**12**
III.	**Effects of Future Water Use on Jordan Lake**	**15**
	Jordan Lake Operation	**15**
	Elevation Profile	**16**
	Water Supply Pool Profile	**17**
	Water Quality Pool Profile	**18**
	Duration Curves	**28**
	Jordan Lake Elevation Duration Curve	**28**
	Water Supply Pool Duration Curve	**28**
	Water Quality Pool Duration Curve	**29**
	Impacts on Frequency of Jordan Lake Drought Stage Occurrence	**33**
	Impacts on Boating at Jordan Lake	**34**
IV.	**Water Supply Demands vs. Delivery**	**35**
V.	**Water Supply Intake Impacts**	**38**
VI.	**In-stream Flow Evaluation**	**53**
	Analysis of In-stream Flows	**54**
	Stream Flow Duration Curves	**59**
	Flows at Lillington	**59**
	Flows at Locks and Dams	**59**
VII.	**Other Model Results**	**66**
VIII.	**Comments**	**67**

Preface to the October 2008 Version

Since the draft version of this document was released in March 2008, a number of changes were made to the modeling scenarios presented in this analysis. The intention of these changes is to improve the accuracy of how Jordan Lake operations are modeled and to better ensure that water supply and irrigation demands are met by the model when adequate water is available at the points of withdrawal. All changes have been incorporated into the modeling results presented in this final version. A brief description of the changes will be provided here along with an explanation of the impacts of the changes on modeling results.

Correction to Jordan Lake Water Quality Pool Accounting

For the model runs presented in the March 2008 draft, the model included inflows into Jordan Lake estimations of the water quality releases from the water quality pool. Actually, the water quality releases should only depend on the Lillington target flow and the flow from Deep River at Moncure, and not on inflows to the reservoir. This revision has been made for all runs presented in this final draft. Because the operation of the reservoir during drought depends on how much storage remains in the water quality pool, this revision had some noticeable effects on the storage remaining in the water quality pool. The corrected modeling results show in all scenarios that Jordan Lake could go into drought operations, i.e. the water quality is drawn down to drought levels, more often than under the previous scenarios. Detailed results are presented in Section III: Effects of Future Water Use on Jordan Lake.

Changes to Jordan Lake Release Assumptions

Changes were made in the logic that guides how the model calculates the Jordan Lake releases on days when the reservoir is not full. One of these changes relates to the model's use of perfect foresight. Perfect foresight means that the model knows precisely the inflows, withdrawals, and discharges for every day. For example, with perfect foresight as the model was previously set up, the model will exactly meet the Lillington target because it knows the inflows to the Deep River and all local withdrawals and discharges between the reservoir and Lillington. Reservoir operators of course do not have perfect foresight, and therefore the Lillington target is not always exactly met. To better reflect how the reservoir is actually operated, the model was revised to remove perfect foresight, and now releases the difference between the Lillington flow target and the flow in the Deep River at Moncure on the previous day (which is known to the reservoir operator). The model no longer exactly meets the Lillington target as before, but it comes very close on most days. In order to even more closely meet the Lillington target, the release was adjusted for withdrawals and discharges between the dam and Lillington.

Another change made to the model's logic relates to how the model handles demands downstream of Lillington. Before, the model could have potentially released extra water from Jordan Lake in order to meet demands downstream of Lillington. The logic was changed to prevent this from happening.

Removing perfect foresight from the Jordan release logic caused a slight reduction in water quality releases (See Section III). Regarding the change related to handling demands downstream of Lillington, it was that found that even though the possibility existed, no additional water was actually released to meet those demands under any of the previous scenarios, because the river flows were already sufficient to meet the estimated demands downstream. Therefore, the effects of this change had no impact on the results.

Revision of the Model's Weighting System

The OASIS model uses a weighting system to determine how to allocate water among competing water uses. Simply stated, the model assigns points for allocating water to each of the types of water use such as water supply demands, irrigation demands, minimum flow requirements, and reservoir storage. To determine how to allocate the water, the model tries to maximize the total number of weight points.

In the process of revising the analysis, it was discovered that at times, the model was not meeting water supply and irrigation demands, even though there was adequate water in the stream or reservoir at the point of demand. This was counter to the intent of the analysis. It happened because the weight(s) for one or more competing water uses was set higher than the demand weight.

To address this, all water supply demands and irrigation weight were examined and revised as necessary to ensure that the demands are met whenever the stream flow or reservoir level (whichever applies) is adequate to meet the demand.

This now means that if the model does not meet a water supply or irrigation demand, it is an indication that the model has predicted a stream flow at or near zero at the point of the demand or a lake level depleted to be at or very near its minimum elevation for that day.

Setting water supply and irrigation demand weights higher than weights for other water uses does not mean that meeting these demands is more important than meeting demands for the other uses. Rather, it was done to specifically evaluate how often these demands might not be met under historical stream flow conditions and current policies. The model has the ability to apply in-stream flow requirements if desired and as they become known.

Maximum Jordan Lake Water Supply Allocation

A scenario was added intended to evaluate Jordan Lake levels and downstream flow for the situation in which the water supply pool is fully allocated. The safe yield of the water supply pool is estimated to be 100 million gallons per day (mgd). Therefore, in order to develop this scenario, starting with the 2050 Demands scenario, withdrawals from Jordan Lake were increased so that the total water supply withdrawal from the reservoir is 100 mgd. This scenario is included in output related to Jordan Lake levels and stream flows downstream of the lake.

Long-Term Climate Change

A scenario has been added to this final draft which attempts to estimate what might be the expected impacts of a long term increase in ambient temperatures in the Southeastern United States. Accounting for the effects of long term global warming in hydrologic modeling is a relatively new concept and it is not yet known how best to do so. However, one relatively easy way to get an idea of the possible effects on the severity of droughts is to evaluate the impacts of a scenario in which the natural inflows to the system have been reduced. A model scenario was developed which depicts the system under projected water demands for the year 2050 in which all of the natural inflows to the system have been reduced to 80% of their estimated values based on historical flow measurements. Results from this scenario are compared to the results for the natural flows scenarios.

I. Introduction to the OASIS Model on the Surface Water Assessment

The Cape Fear River Basin Hydrologic Model (OASIS) is a computer based mathematical model that simulates surface water flows in the Cape Fear River. It has the capability to take into account a great deal of hydrologic information and water use data. It can be used to evaluate the impacts of future projected future demands and operational scenarios. The version of the model used for this analysis is based on the seventy-six year record of river flows from 1930 to 2005. The flows in this period of record include a wide range of flow conditions, like several high-flow periods and several low-flow periods, including the exceptional drought conditions of 2001-2002.

The 2003 demands scenario is used as the base case against which scenarios of projected future demands and return flows are compared. Using the model to compare future demand conditions with the base case conditions may help identify the possible impacts on reservoir levels and stream flows at points of interest around the basin due to proposed increases in water supply demands. This is the most comprehensive analysis that has been done so far using the model.

The Division of Water Resources announced the beginning of this update to the Cape Fear River Water Supply Plan in October 2007 and requested that water systems provide the Division with any revised projections of future water supply demands. Except for the twenty water users that submitted additional data, the modeled current and projected water supply demands were derived from the 2002 local water supply plans submitted by the water systems. Also at the October 2007 meeting, attendees heard presentations describing several new and expanded withdrawals that are proposed or under development that will influence future conditions of the Cape Fear River.

Recent Updates to Model Inputs

In the October 2007 meeting, Progress Energy representatives described the proposed addition of more generation capacity at the site of the Harris Nuclear Plant in southwestern Wake County. The analysis discussed in this report models the current demands and anticipated demands for the existing facilities only. In future rounds of modeling we will include the increased withdrawals needed to support the increased generation capacity.

The Lower Cape Fear Water and Sewer Authority (LCFWSA) presented information on two projects. Currently, LCFWSA has a raw water intake just behind Lock and Dam #1 in Bladen County on the main stem of the river. LCFWSA provides raw water to the City of Wilmington and Brunswick County as well as some industrial facilities. In the future, LCFWSA also anticipates supplying water to Pender County. LCFWSA expects to install an additional pipeline and intake screens to carry water from the river to pumps located on shore. This will increase capacity to withdraw water from 45 million gallons per day (mgd) to 96 mgd.

The City of Wilmington is beginning an expansion of the Sweeney Water Treatment Plant. Raw water for this plant comes from Wilmington's intake on the Cape Fear River behind Lock and Dam #1 in the vicinity of the LCFWSA intake and the authority also supplies raw water to the treatment plant. There is a node for each of these intakes in the model. In this modeling exercise, all of Wilmington's anticipated future demands that will be supplied by the Sweeney Plant is assigned to Wilmington's withdrawal node. The LCFWSA withdrawal node is assigned the anticipated future demands for their other customers. Since these two intakes withdraw water from the same location in the river, the proportioning of water between the two intakes has no effect on modeling results.

LCFWSA is also working with water users in the vicinity of Tar Heel in Bladen County on a proposed new surface water intake on the Cape Fear River. This project is proposed to reduce detrimental impacts to ground water resources in this area by shifting water users to surface water. A node has been added to the model for this new withdrawal from the Cape Fear River. As withdrawal needs get clarified, they can easily be added to the model in future model runs.

During 2004-2005, Harnett County Public Utilities expanded its raw water intake in the Cape Fear River at Lillington. The new intake structure will improve reliability of the supply and increase the capacity to withdraw water to 48 mgd.

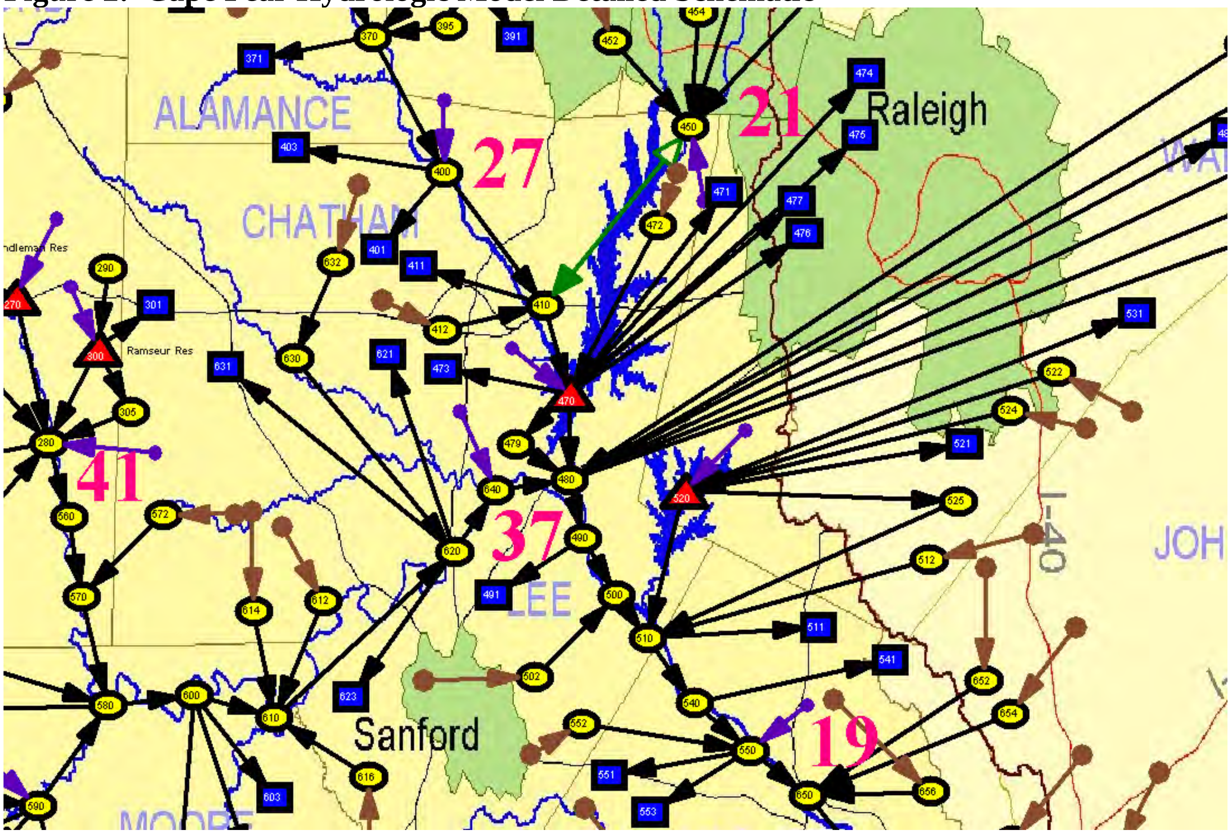
Scope of the Model

The geographic scope of the model includes the Deep River Basin, the Haw River Basin and the Cape Fear River Basin above Lock and Dam #1 in Bladen County. The following schematic map of the basin shows the geographic coverage of the model and the relative location of the various model nodes.

Figure 1: Cape Fear Hydrologic Model Schematic

Figure 2 shows an example of the complexity of the model. Each of the polygons in the schematic represents a node where the model performs a calculation to sum the effects of inflows and outflows of water. The result of each calculation is used as an input for the next downstream node. The section titled "Modeled Assumptions" describes the different types of nodes.

Figure 2: Cape Fear Hydrologic Model Detailed Schematic



Scenarios Modeled

For this round of modeling four different scenarios were modeled: a simulation of conditions without any withdrawals, discharges or storage impoundments; a characterization of current conditions and two scenarios of future withdrawals.

Scenario 1: Unregulated Flow Scenario

This scenario models stream flows which are the estimated natural flows in the basin, unaffected by impoundments, water withdrawals, or wastewater discharges. To model this scenario, all demands and discharges were set to zero. All reservoirs were assumed to have zero usable storage, meaning they are modeled to remain full and release exactly the amount of water that flows into them.

Scenario 2: 2003 Demands Base Case

This scenario is intended to reflect the current water conditions. Modeled water demands were estimated using local water supply plan data and additional information received from water systems and other registered water users. The results of the other scenarios are compared to this base case to identify possible changes in impacts due to projected changes in withdrawals and return flows.

Scenario 3: 2030 Demands

Water demands are those projected for the year 2030 using local water supply plan data with any updated projections received from water systems. Jordan Lake water supply withdrawals may, in some cases, be greater than current water supply allocations. Withdrawals are assumed to follow future water use projections provided by the allocation holders.

Scenario 4: 2050 Demands

The 2050 demand scenario is similar to Scenario 3 except that the water demands are those needed to meet water demands projected for the year 2050 in the local water supply plans.

Scenario 5: 2050 Demands with Jordan Lake Water Supply Demands set to 100 MGD

This scenario is the same as the 2050 Demands scenario except that the water supply demand from Jordan Lake are set to 100 MGD which is the estimated safe yield of the water supply pool. Under the 2050 Demands scenario, a total of 73.5 mgd is withdrawn from Jordan Lake for water supply. This scenario was developed by adding a water supply demand node to Jordan Lake and setting the annual withdrawal from the node to 26.5 mgd, bringing the total water supply withdrawal to 100 mgd. Note that the additional 26.5 mgd of water withdrawn is assumed to be a 100% consumptive use, none of the additional withdrawal being returned to the basin. This is a conservative assumption chosen to assess the maximum impacts to the Jordan Lake level of the additional withdrawal.

Scenario 6: 2050 Demands with 80% of Historic Natural Inflows

This scenario is the same as the 2050 Demands scenario except that the natural inflows to the system have all been multiplied by 0.8. The purpose of this scenario is to make an attempt to assess the potential impacts of a long period of increased ambient temperatures. The idea is that if ambient temperatures are consistently higher, this will cause an increase in evaporation and possibly cause lower net inflows to the system.

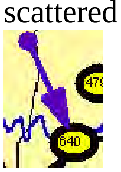
II. Model Assumptions

The Cape Fear Hydrologic Model uses a software program called OASIS (Operational Analysis and Simulation of Integrated Systems) developed by Hydrologics Inc. OASIS is a mass balance model that uses sequential calculations to simulate the routing of water through the watershed. OASIS balances water coming in with water going out at all nodes, subject to goals and constraints established for each node. The model also assigns weights to each type of water use which allows the model to make allocation decisions between competing uses. At the reservoir nodes, water is stored and released subject to user-defined operating rules. The model operates on a daily time step making one set of calculations for each day and uses daily average values for each calculation.

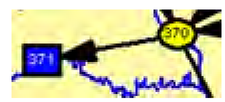
Inputs

Inputs to the model calculations include the following:

1. Estimated Daily Natural Inflows: The model uses a set of daily natural inflows which estimate the water entering the system due to runoff. These inflow data were developed using seventy-six years of flow records and are adjusted for upstream withdrawals, discharges, and reservoir operations. These inflows are modeled as entering the systems at discrete points scattered throughout the watershed. In the schematic, they are shown as purple arrows.



2. Daily Withdrawals: Water is removed from the system at discrete points, represented in the model as withdrawal nodes. These nodes show up as blue boxes on the schematic.

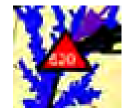


These withdrawals can be for water supply systems, industrial water users, or agricultural water users. Public water supply withdrawals are based on local water supply plan data which in some cases were updated to reflect improvements in projections of future demands. Self-supplied industrial water withdrawals were derived from data submitted under the Division's water withdrawal registration program. It is assumed to remain the same in 2030 and 2050 as it is in the base case unless additional information was available to justify changes in projections. Agricultural demands are the same as those used in previous versions of the model. Agricultural uses for livestock and irrigation were estimated with the help of county agricultural extension agents and an agricultural extension irrigation specialist. Water use estimates were developed for crops, taking into consideration variations in planting times in the upper, middle and lower regions of the basin. Livestock water needs are based on animal head counts in each county and the water use factors used by the USGS in the 1995 Estimated Water Use in North Carolina. Percentages of irrigated crops and livestock in the basin were developed for each county in consultation with county agricultural extension agents. There are individual nodes for agricultural water use in each county in the basin.

3. Daily Wastewater Discharges: Return flows from wastewater discharges are modeled similar to natural inflows, as water inputs at discrete nodes. They are represented in the schematic as brown arrows.

Inflows from wastewater discharges come from industrial and municipal wastewater treatment plants and water reclamation facilities. The inputs used in the base case were used to calculate the percentage of a facility's water withdrawal that is directly returned to the surface waters of the basin as wastewater return flow. . This percentage was then applied to estimated future withdrawals to estimate future wastewater return flows. For example, if a town withdraws 10 mgd on average and returns 6 mgd of treated wastewater, then 60% of the withdrawal is returned directly to the surface waters of the basin. In the 2030 and 2050 scenarios, the assumed wastewater discharge is again 60% of the withdrawal.

4. Reservoir Operating Guidelines and Data: The model balances inflows and outflows at each node. Inflows equal outflows on all days for all nodes except reservoir nodes, represented by red triangles in the schematic. In the case of a reservoir, the change in daily storage is considered in the balance equation. Each reservoir in the model has a set of operating guidelines. Only two reservoirs in the system have minimum release requirements, Jordan Lake and Randleman Lake. Jordan Lake has a fairly complex set of operating rules, which are explained in Section III. Randleman Lake is operated to maintain a minimum release that varies according to reservoir level. The minimum release is assumed in the model as follows:



Randleman Lake Releases

Percent Remaining in Storage	Minimum Release at Dam
0-30%	10 cfs
30-60%	20 cfs
60-100%	30 cfs

Outputs

The OASIS model can provide a variety of model run outputs in a variety of configurations. The primary outputs used for this analysis include the following:

1. Daily Flows: The model outputs daily flows into a node, out of a node, or through an arc. An arc connects two nodes, and is represented in the schematic as a black arrow between two nodes.

2. Daily Reservoir Levels
3. Daily Reservoir Releases
4. Daily Accounting of Jordan Lake Conservation Storage: The model keeps track of how much water is remaining in the water supply storage pool and the water quality storage pool. This information is used to determine the release from the reservoir during droughts.
5. Drought Stage at Jordan Lake: According to the percentage of storage remaining in water quality storage, the model outputs the daily drought stage.

Withdrawals and Discharges

Table 1 summarizes the estimated withdrawals and return flows for the base case and the 2030 and 2050 demand scenarios for the major water users modeled for this analysis. All volumes are shown in million gallons per day (MGD).

Table 1: Demands and Discharges Assumed in the Modeling (All units are in MGD)

System	Node Description	Node #	Node Type	2003	2030	2050
Angier	NC0082597 (AngiersWW)	654	WWTP Discharge	0.43	0.81	0.90
Archdale	Randleman Lake	904	Withdrawal		1.20	1.20
Asheboro	NC0026123 (AsheboroWW)	282	WWTP Discharge	5.62	7.57	9.94
Broadway	NC0059242 (BroadwayWW)	940	WWTP Discharge		0.11	0.13
Burlington	Lake Mackintosh	341	Withdrawal	10.86	11.73	15.51
	NC0083828 (BurlingtonMackintoshWW)	352	WTP Discharge	0.39	0.41	0.54
	Stoney Creek Reservoir	71	Withdrawal	7.30	5.97	7.91
	NC0023868 (BurlingtonEastWW)	106	WWTP Discharge	0.07	9.87	12.93
	NC0023876 (BurlingtonSouthWW)	362	WWTP Discharge	6.40	9.48	12.48
Carthage	Nicks Creek	701	Withdrawal	0.26	0.59	0.70
Carolina Trace WS	NC0038831 (CarolinaTraceUtilWW)	674	WWTP Discharge	0.25	0.27	0.27
Cary	Jordan Lake	471	Withdrawal	14.02	32.09	34.88
Apex	NC0081591 (CaryApxWW)	472	WTP Discharge	0.69	0.00	0.00
	Western Wake Regional WRF (CaryRegWW)	930	WWTP Discharge		18.40	20.60
Chatham Co North	Jordan Lake	473	Withdrawal	1.03	9.63	15.88
	NC0035866 (NorthChathamWW)	452	WWTP Discharge	0.01	0.05	0.08
Dunn	Cape Fear River	663	Withdrawal	3.49	11.77	17.59
	NC0078955 (DunnWW)	682	WTP Discharge		0.51	0.76
	NC0043176 (DunnWWTP)	692	WWTP Discharge	3.04	9.99	15.35
Durham	Jordan Lake	476	Withdrawal		10.00	10.00
	NC0047957 (DurhamReclamationWW)	462	WWTP Discharge	10.73	11.29	12.90
	NC0026051 (DurhamCtyTriangleWW)	454	WWTP Discharge	4.49	4.02	4.59
Elizabethtown	NC006671 (ElizabethtownWW)	960	Discharge		1.04	1.25
Erwin	Swift Textiles Reservoir	661	Withdrawal	0.65	0.89	1.06
	NC0064521 (ErwinSouthWW)	686	WWTP Discharge	0.95	0.98	1.17
	NC0001406 (BurlingtonIndustriesWW)	684	WWTP Discharge	8.74	0.00	0.00
Fayetteville	Cape Fear River	733	Withdrawal	20.00	69.18	83.11
	NC0076783 (FayettevillePOHofferWW)	744	WTP Discharge	1.23	4.71	5.73
	Little Cross Creek	761	Withdrawal	0.00	0.00	0.00
	NC0023957 (FayettevilleCrossCreekWW)	742	WWTP Discharge	12.39	31.87	43.24
	NC0050105 (FayettevilleRockfishCreekWW)	774	WWTP Discharge	13.04	24.00	24.00
Fort Bragg	Little Upper River Dam	721	Withdrawal	6.27	0.00	0.00

System	Node Description	Node #	Node Type	2003	2030	2050
Franklinville	NC0007820 (FranklinvilleWW)	910	WWTP Discharge		0.04	0.05
Fuquay-Varina	NC0028118 (FuquayVarinayWW)	552	WWTP Discharge	1.01	0.39	1.18
Goldston Gulf SD	Deep River	605	Withdrawal		0.13	1.94
Graham	Graham-Mebane Lake	321	Withdrawal	3.23	6.05	8.11
Mebane	NC0045292 (GrahamMebaneWW)	102	WTP Discharge	0.323	0.60	0.81
	NC0021211 (GrahamCtyWW)	108	WWTP Discharge	1.85	2.46	3.14
	NC0021474 (MebaneWW)	104	WWTP Discharge		1.84	2.63
Greensboro	Lake Townsend	141	Withdrawal	19.65	17.53	23.19
	NC 0081671 (GreensboroLakeTownsendWW)	142	WTP Discharge	12.76	1.56	2.07
	Lake Brandt	121	Withdrawal	11.44	8.77	11.59
	NC 0081426 (GreensboroMitchellWW)	174	WTP Discharge	0.26	0.15	0.20
	Randleman Lake	901	Withdrawal		20.83	27.54
	NC0047384 (GreensboroTZOsborneWW)	182	WWTP Discharge	23.08	26.60	40.34
	NC0024325 (GreensboroNBuffaloCrkWW)	176	WWTP Discharge	1.97	16.00	16.00
	UNC Greensboro (formerly NC0082082) (UNCGreensboroWW)	172	Discharge	0.03	0.00	0.00
Harnett Co	Cape Fear River	551	Withdrawal	7.04	27.47	40.03
	NC0021636 (LillingtonWW)	664	WWTP Discharge		0.43	0.95
	NC0030091 (BuiesCreekWW)	656	WWTP Discharge		0.50	0.50
	NC0031470 (HarnettCoWW)	950	WWTP Discharge		0.40	0.40
High Point	City and Oak Hollow Lakes	221	Withdrawal	13.12	10.58	12.30
	NC0081256 (HighPointWW)	236	WTP Discharge	0.86	0.66	0.77
	Randleman Lake	902	Withdrawal		4.80	5.44
	NC0024210 (HighPointEastWW)	232	WWTP Discharge	15.08	19.06	22.82
Holly Springs	Jordan Lake Release	924	Withdrawal		0.00	0.00
	Cape Fear River	923	Withdrawal		0.00	0.00
	NC0063096 (HollySpringsWW)	522	WWTP Discharge	0.92	4.01	4.83
Jamestown	Randleman Lake	903	Withdrawal		0.67	0.71
Lee County Cumnock Golden Poultry	Deep River	601	Withdrawal	0.65	2.50	2.50
	NC0083852 (LeeCtyWW)	616	WTP Discharge	0.16	0.40	0.40
Lower Cape Fear WSA	Cape Fear River	825	Withdrawal	17.58	21.31	25.70
Moore Co (Vass)	Thagards Lake	711	Withdrawal		0.00	0.00
Morrisville	Jordan Lake	477	Withdrawal	1.5	3.96	3.96
Orange-Alamance Orange Co	Jordan Lake	921	Withdrawal		0.00	0.00
Orange WASA	Cane Creek Reservoir	391	Withdrawal	5.43	4.68	6.90
	University Lake	431	Withdrawal	2.84	3.19	4.70
	NC0082210 (OWASA_WTP_WW)	442	WTP Discharge	0.36	0.40	0.59
	Jordan Lake	922	Withdrawal		5.00	5.00
	NC0025241 (OWASA_MasonFarmWW)	444	WWTP Discharge	8.30	9.94	12.82

System	Node Description	Node #	Node Type	2003	2030	2050
Pittsboro	Haw River	401	Withdrawal	0.65	8.14	8.14
	NC0020354 (PittsboroWW)	412	WWTP Discharge	0.45	4.23	4.23
Progress Energy	Shearon Harris	521	Withdrawal	31.41	31.41	31.41
		524	Discharge	19.5	19.5	19.5
Progress Energy	Cape Fear Plant	487	Withdrawal	194.15	194.15	194.15
		512	Discharge	194	194	194
Raeford	NC0026514 (RaefordWW)	772	WWTP Discharge	1.88	3.61	4.10
Ramseur	Sandy Creek	301	Withdrawal	0.58	0.92	1.09
	NC0026565 (RamseurWW)	572	WWTP Discharge	0.27	0.34	0.40
Randleman	Randleman City Reservoir	261	Withdrawal	0.90	0.16	0.55
	Randleman Lake	905	Withdrawal		1.01	1.01
	NC0025445 (RandlemanWW)	252	WWTP Discharge	1.09	1.08	1.45
Randolph Co	Randleman Lake	906	Withdrawal		6.00	6.00
Reidsville	Lake Reidsville	31	Withdrawal	5.75	5.41	5.76
	NC0046345 (Reidsville_WTP_WW)	24	WTP Discharge	0.48	0.46	0.49
	NC0024881 (ReidsvilleWW)	42	WWTP Discharge	3.05	3.46	3.63
Robbins	Brooks	591	Withdrawal	0.26	0.24	0.27
	NC0062855 (RobbinsWW)	582	WWTP Discharge	0.25	0.16	0.19
Sanford	Cape Fear River	491	Withdrawal	6.53	21.06	39.73
	NC0002861 (SanfordWW)	502	WTP Discharge	0.65	2.09	3.93
	NC0024147 (Sanford_WWTP)	612	WWTP Discharge	4.38	12.36	23.67
Siler City	Rocky River	631	Withdrawal	2.97	5.83	6.00
	NC0058548 (SilerCityWW)	632	WWTP Discharge	2.96	4.56	5.40
Spring Lake	NC0030970 (SpringLakeWW)	722	WWTP Discharge	0.90	1.42	1.85
Star	NC0058548 (StarWW)	592	WWTP Discharge	0.16	0.11	0.12
Wake Co - RTP South	Jordan Lake	474	Withdrawal	0.39	2.65	3.82
Wilmington	Cape Fear River	823	Withdrawal	14.80	30.70	39.80

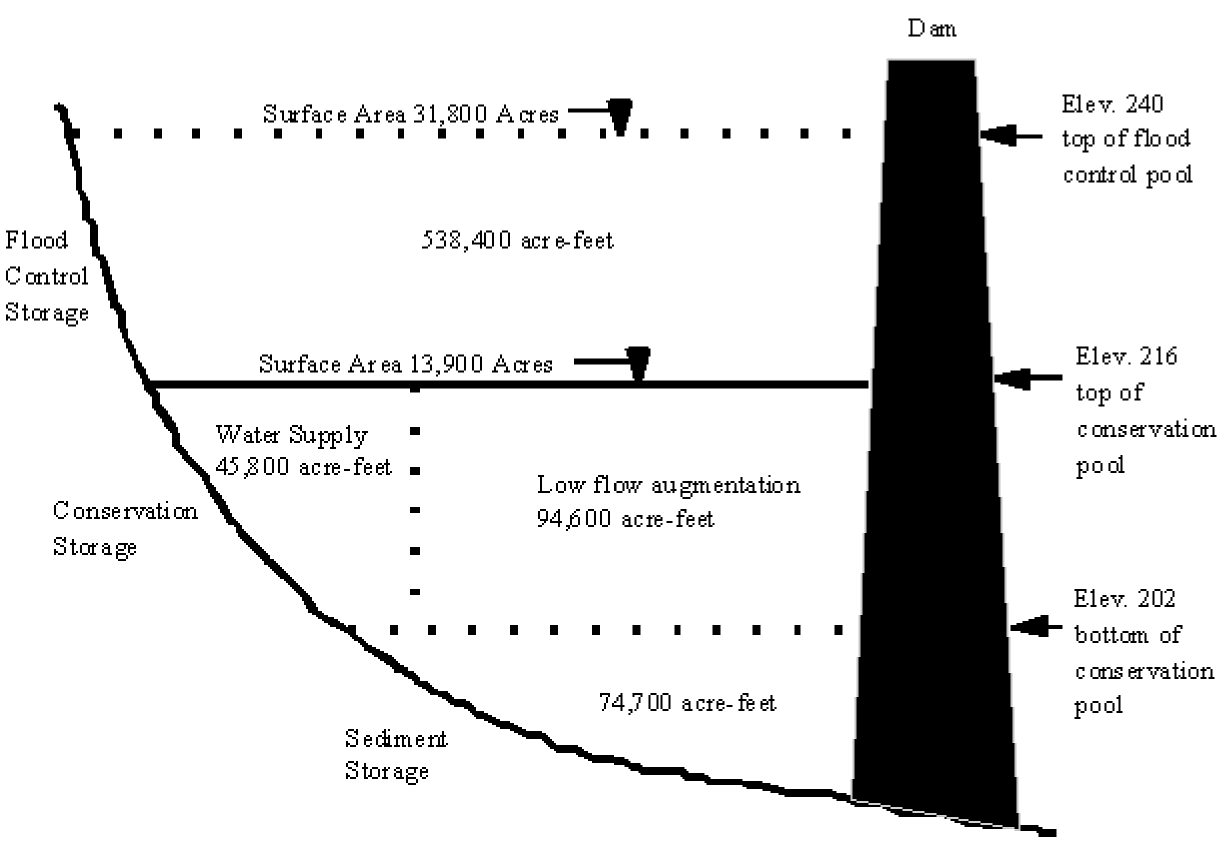
III. Effects of Future Water Use on Jordan Lake

Jordan Lake Operation

Jordan Lake is operated by the US Army Corps of Engineers. It was designed to provide for water supply, recreation, flood control, fish and wildlife management, and low-flow augmentation. As is typical for multi-purpose reservoirs, the Lake's storage volume of the impoundment is divided vertically into pools that are delineated by elevation, above sea level. These levels are shown in Figure 3. The normally empty flood control storage provides about 538,000 acre feet of controlled flood storage above the conservation pool. The conservation pool provides storage for water supply and low flow augmentation. Below the conservation pool the sediment pool, provides space for the accumulation of sediment.

The top of the conservation pool corresponds with the normal lake level of 216 feet above mean sea level (MSL). At this elevation, Jordan Lake covers 13,900 acres. As the following Figure shows, usable water in the lake at its normal elevation amounts to a total volume of approximately 140,400 acre-feet and is referred to as the conservation storage. Approximately 45,800 acre-feet in conservation storage, or about 15 billion gallons, is designated to provide water supply, and is called the **water supply pool**. This amount of storage is estimated to be able to furnish approximately 100 million gallons per day (MGD) during the severest drought.

Figure 3: Jordan Lake Storage Volume



In addition to water supply, the Lake's conservation storage provides 94,600 acre-feet of water for downstream flow augmentation to benefit water quality and economic development. This storage is generally referred to as the flow augmentation or **water quality pool**. The water quality pool is used to maintain a target minimum flow of about 388 MGD (600 cfs) at Lillington during non-drought periods, and less during droughts. Inflows to and withdrawals from each of these storage pools are accounted-for independently. Therefore, withdrawals from the water supply storage pool do not reduce the amount of water remaining in the flow augmentation pool.

Jordan Lake has more complex operating rules than the other reservoirs in the basin. During droughts, the Army Corps of Engineers operates the lake according to a schedule that indicates how releases should be varied as the water quality pool draws down. The Corps is in the process of recommending that these operating rules be approved for permanent operations.

In general, releases from the lake depend on the amount of water remaining in the water quality pool. There is a downstream target flow at Lillington that affects how much water must be released from the dam. The operating schedule shown in Table 2 summarizes the proposed drought management protocol and is included in the model used for this analysis.

Table 2: Jordan Lake Operating Rules During Drought

Drought Stage	% Remaining in WQ Pool	Minimum Release (cfs)	Lillington Target (cfs)
0	80-100	40	600
1	60-80	40	450-600
2	40-60	40	300-450
3	20-40	200	None
4	0-20	100	None

Presentation of Modeling Results

The following sections present the results of modeling the various scenarios used in this analysis. The results are shown in several different presentation formats to aid understanding.

Elevation Profile

Elevation profiles show how reservoir levels vary over a specified period of time. They are useful for examining the shorter term fluctuations in reservoir elevation. The Jordan Lake elevation profile in Figure 4 shows the expected daily lake elevation for each of the three demand scenarios over the entire 76-year period of record.

It is of particular interest to notice the behavior of the lake elevation during drought periods, when it is drawn down to the lowest levels. As expected, the elevation profile for the three demand scenario in Figure 4 shows that during the major droughts on record, Jordan Lake is expected to be drawn down increasingly further as water supply demands increase from the base case to the 2050 demand levels. The profile shows a minimum lake elevation of about 207.5 feet being reached under the estimated 2050 demands scenario during the 2002 drought. Another deep drawdown occurs in the 1952-53 drought, drawing the water level down to just below 208 feet.

Figure 5 shows a comparison between the elevation profiles for Jordan Lake for the 2050 demands scenarios assuming the actual projected Jordan Lake water supply demands in one scenario and water supply demands of 100 mgd, the full estimated safe yield of the water supply pool, in the other scenario. The added water supply demands tend to further draw down the lake from about 0.5 to 2 feet for most droughts. The lowest expected elevation is just above 206 feet for the droughts of the 1950s and 2002.

Figure 6 shows a comparison between the 2050 demands scenario with natural inflows and the 2050 scenario with 80% of natural inflows. Reducing the natural inflows tends to further draw down the elevation by about 0.5 to 1 foot for most droughts. However, for a 20% reduction of the 2002 drought conditions, the water level would be expected to decline an additional 2.5 feet to an elevation of about 205 feet.

Water Supply Pool Profile

Table 3 shows that Jordan Lake currently has combined estimated water supply withdrawals of 16.94 mgd. This increases to 63.33 mgd in 2030 and 73.54 mgd in 2050.

Table 3

Jordan Lake Water Supply Withdrawals

All Units in MGD

System	Node #	Allocation	2003	2030	2050
Cary/Apex	471	32	14.02	32.09	34.88
Chatham Co North	473	6	1.03	9.63	15.88
Durham	476	10	0	10	10
Morrisville	477	3.5	1.5	3.96	3.96
Orange WASA	922	5	0	5	5
Wake Co - RTP	474	3.5	0.39	2.65	3.82
Total Jordan Lake Demand			**16.94**	**63.33**	**73.54**

The water supply pool profiles for the three demands scenarios in Figure 7 shows, as expected, that the pool is drawn down increasingly as water supply demand increases from the base case up to 2050 demand levels. It shows that the minimum predicted storage remaining in the water supply pool is about 50% reached during the 1952-53 drought under the 2050 demands scenario. It also shows that the water supply pool would again drop below 55% remaining during a repeat of the 2002 drought conditions with the projected 2050 demands.

Figure 8 shows that the water supply pool profile is lowered significantly under the 100 mgd water supply scenario, lowering the pool as low as 20% full in three different droughts over the period of record. Because the pool was not fully depleted under this scenario would indicate that the safe yield of the water supply pool may be slightly higher than 100 mgd.

Figure 9 shows that reducing system inflows to 80% of the historical natural inflows under 2050 demands is expected to impact the water supply pool by drawing it down an additional 2 to 10 percent for most droughts, down to a low of about 45 % full.

Water Quality Pool Profile

The water quality (WQ) or flow augmentation pool profile in Figure 10 shows some interesting and apparently non-intuitive results. However, on closer look, the results are easily explained. An interesting observation is that the periods when the water quality pool is drawn down the most do not always occur under the 2050 demands scenario, but rather sometimes under the base case demand scenarios. The lowest expected level predicted by the model is just above 20% remaining under the base case demands and the inflows during the 1952-53 drought conditions. There were no expected occurrences of Stage 4 drought (WQ pool below 20%) under any of the demands scenarios. This is an indication that the Corps of Engineers' drought response measures are effective at maintaining the water quality pool storage even during the most severe drought conditions.

It is important to understand why the model sometimes predicts the water quality pool to drawn down further under current base case demands than under the higher 2050 demands. The Town of Cary is currently in the process of developing the Western Wake wastewater treatment plant that is expected to discharge treated wastewater to the Cape Fear River below the Jordan Lake and upstream of the Lillington gage. Discharges from this plant will flow by the Lillington gage and therefore reduce the amount of water that must be released from the Jordan dam to meet the target flow at Lillington specified under the drought operating rules. Since water released from the dam to meet the Lillington target comes out of the water quality pool, the increased future discharges from the Western Wake plant in effect relieve stress on the water quality pool to meet the Lillington in-stream flow target. Therefore, as withdrawals from the water supply pool increase with increasing future water supply demands, releases from the water quality pool that are required to meet the in-stream flow target at Lillington during drought tend to decrease.

Figure 11 is a comparison of the water quality pool profiles for the normal 2050 demands and scenario and the scenario in which the water supply demands from Jordan Lake are increased to 100 mgd. It shows that as expected, increasing water supply demands to 100 mgd have little or no noticeable impact on the water quality pool.

Figure 12 is a comparison of the water quality pool profiles for the normal projected 2050 demands and scenario and the scenario in which the inflow to the system are reduced to 80% of historical inflows. It shows an impact of an additional 3 to 10 percent of draw down on the water quality pool for most droughts. This would cause an increase in occurrences of drought response measures which will be described later in this document.

Figure 4: Jordan Lake Elevation Profile

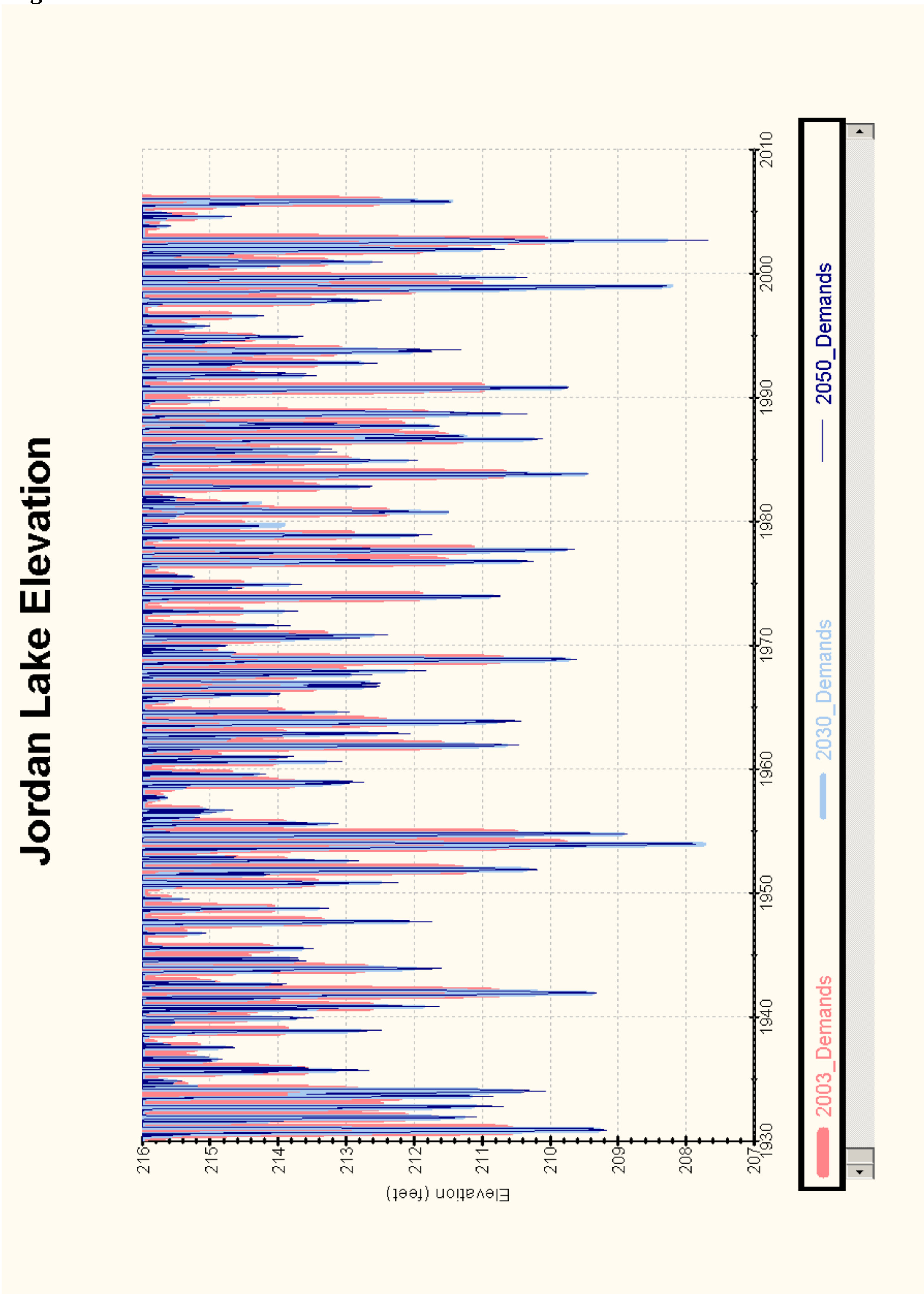


Figure 5: Jordan Lake Elevation Profile – 100 MGD Water Supply Demand Scenario

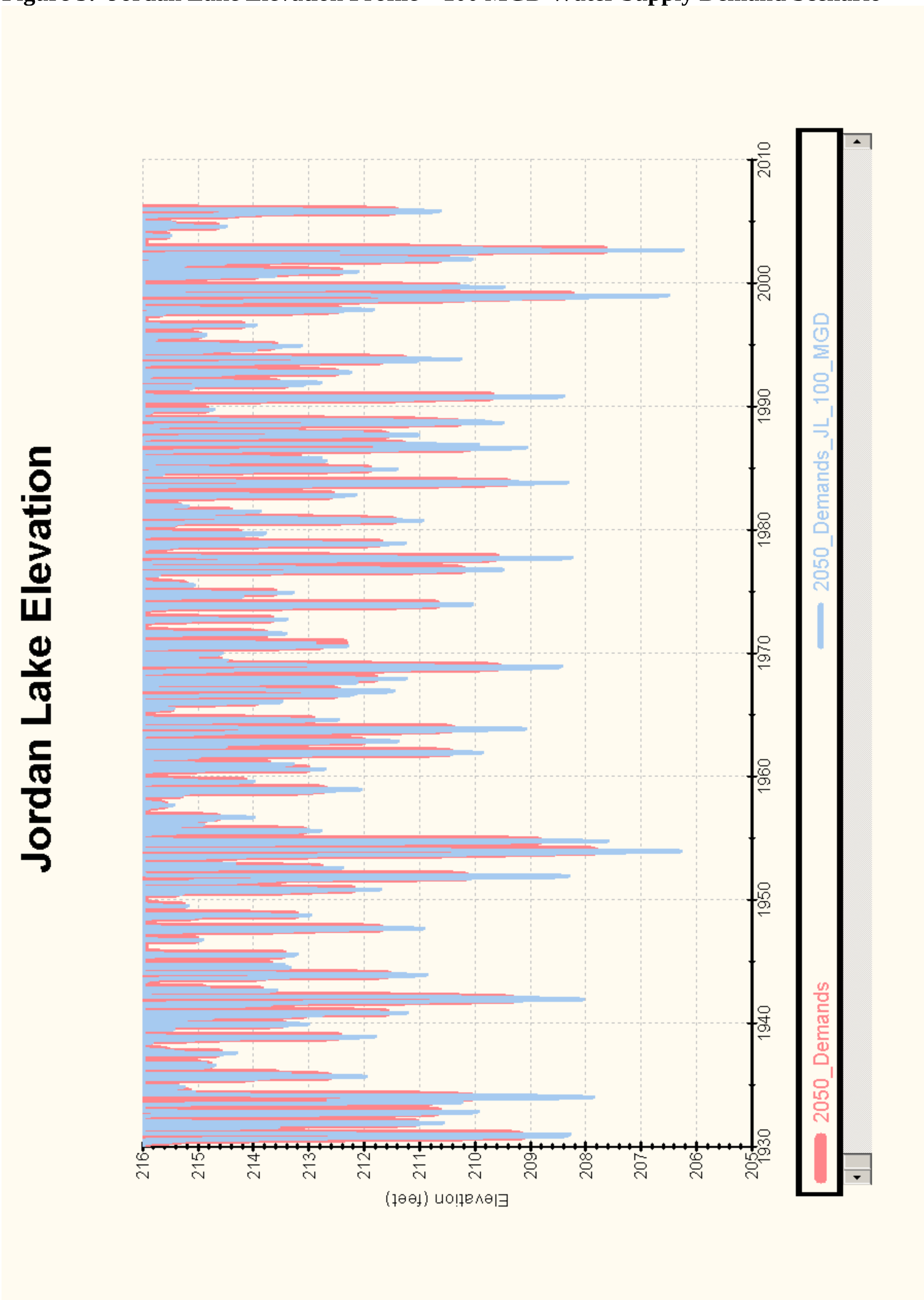


Figure 6: Jordan Lake Elevation Profile – 80 % Inflows Scenario

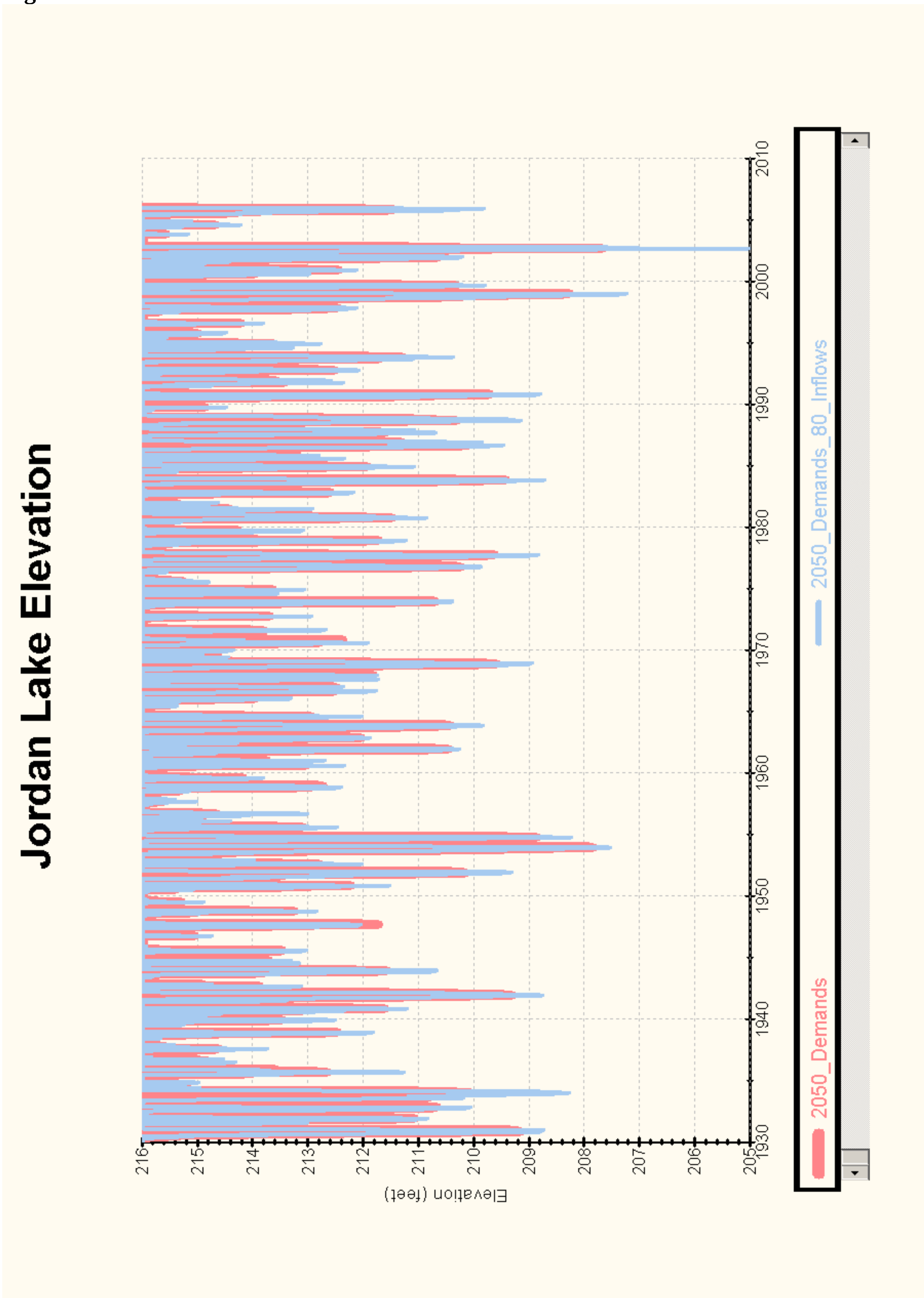


Figure 7: Jordan Lake Water Supply Pool Profile – Demands Scenarios

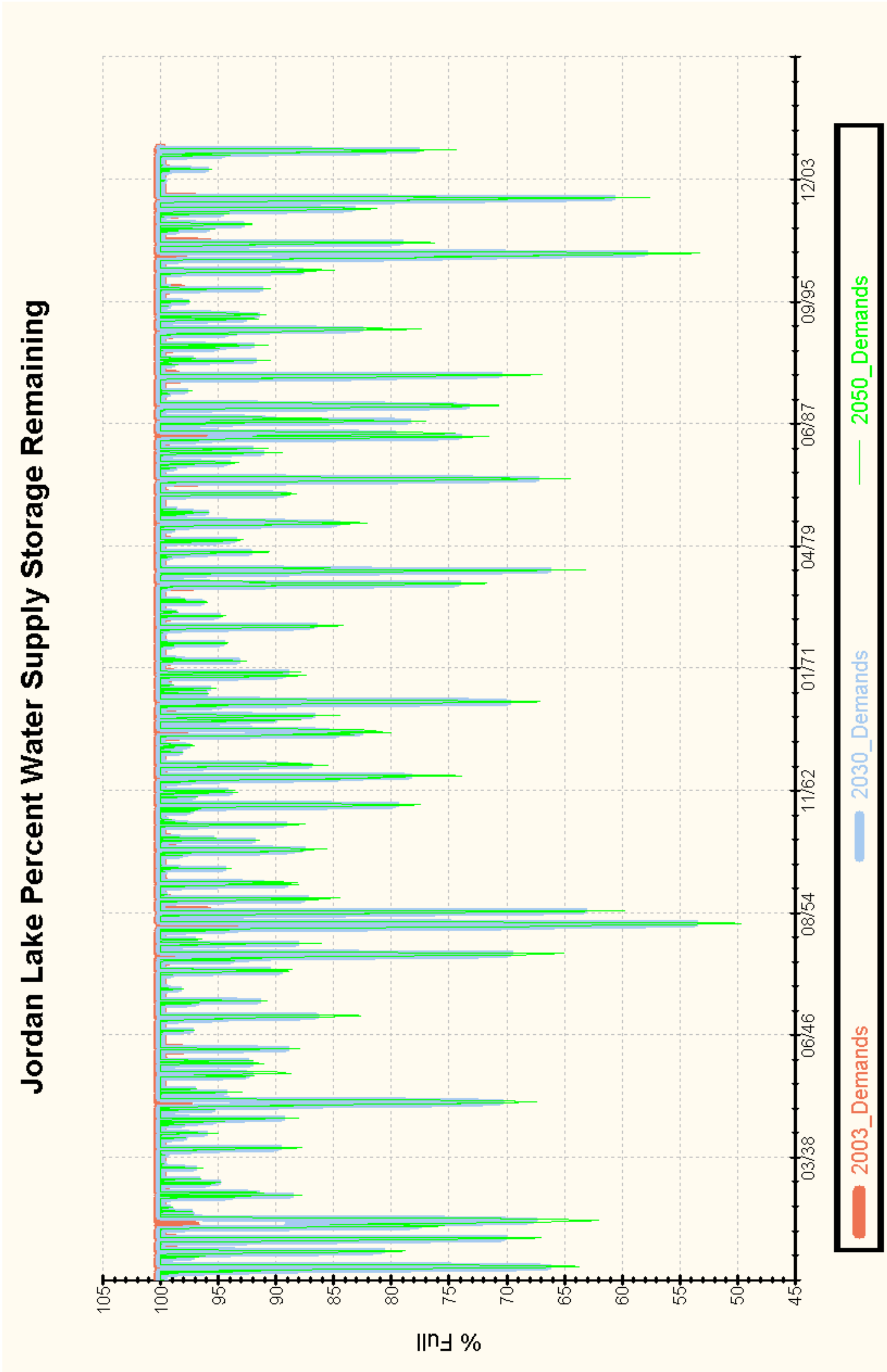


Figure 8: Jordan Lake Water Supply Pool Profile – 100 MGD Scenario

Figure 9: Jordan Lake Water Supply Pool Profile – 80% Inflows

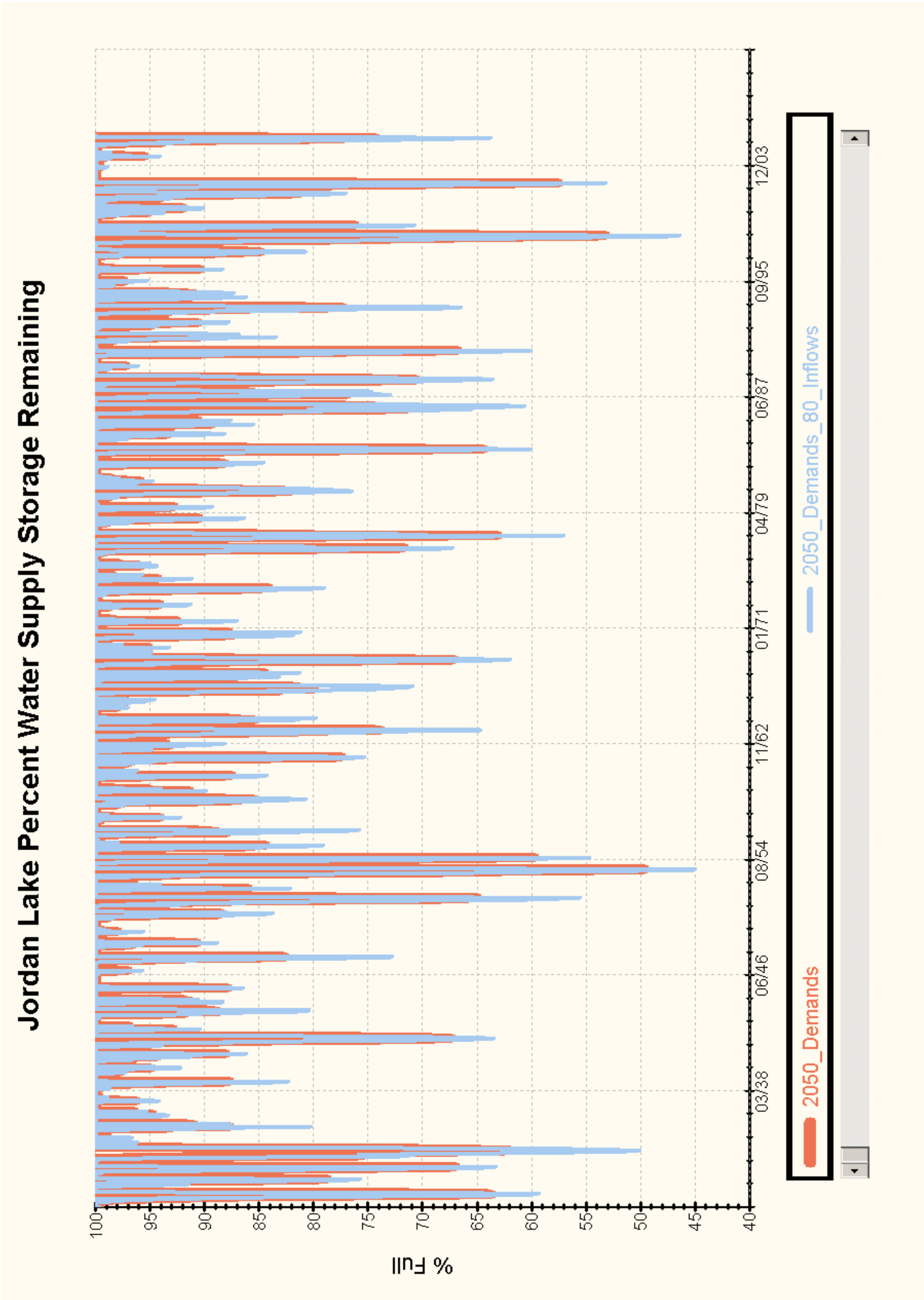


Figure 10: Jordan Lake Water Quality Pool Profile – Demands Scenarios

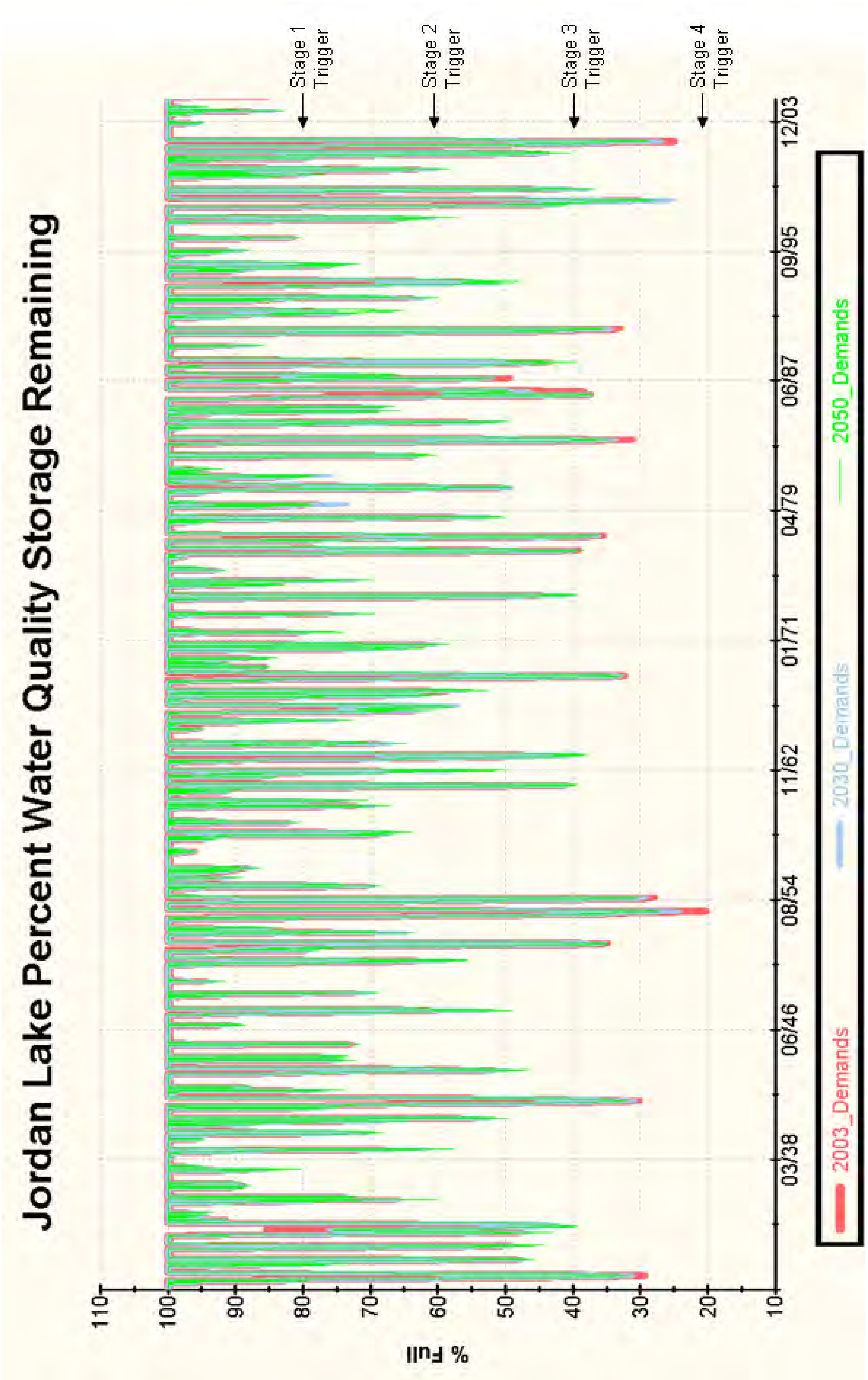


Figure 11: Jordan Lake Water Quality Pool Profile – 100 MGD Water Supply Demand

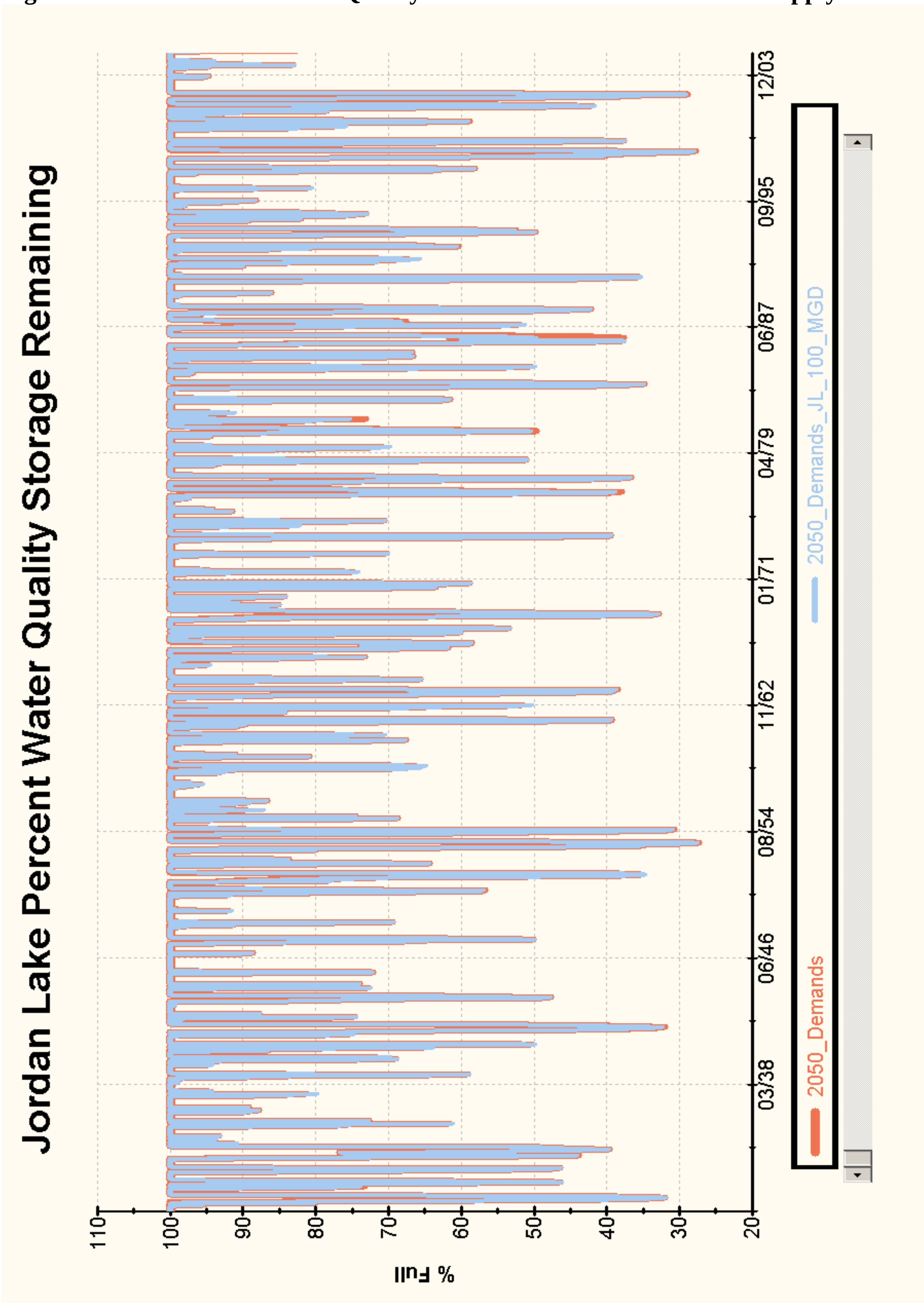
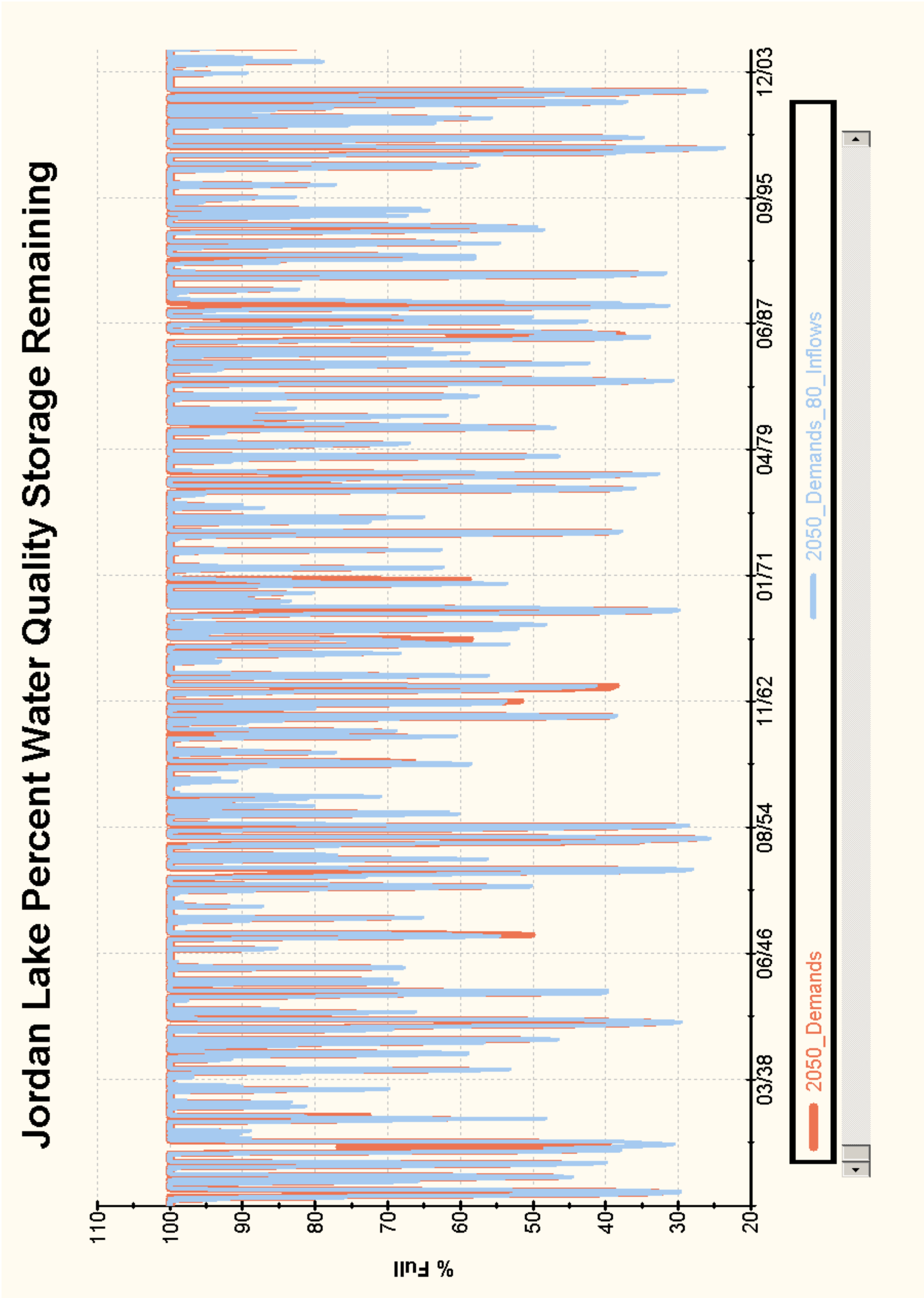


Figure 12: Jordan Lake Water Quality Pool Profile – 80% Inflow



F

Duration Curves

Another way to present predicted reservoir storage impacts shown by the model is by the use of duration curves. Duration curves are cumulative frequency curves showing the percentage of time over the period of record that a particular reservoir level is less than or equal to a specified amount. The curves show in a probabilistic way how reservoir levels vary over the entire period of record based on the conditions specified in the model. They are useful for comparing scenarios over a long time scale. The area under the curve is a long term representation of the amount of water in storage. Therefore, the lower the curve, the less water being stored over the entire 76 year record.

Jordan Lake Elevation Duration Curve

Figure 13 shows elevation duration curves for all five scenarios. The curves show that, as expected, less water is stored in the lake as water supply demands increase. The differences between the scenarios are only seen to the left of 50% on the x-axis. Therefore, the duration curve only shows the driest 50% of the days on record. The duration curves again show the minimum elevation reached as about 207.5 feet for the 2050 demands scenario. The vertical difference between the curves for the 2030 and 2050 scenarios indicate the predicted impact to reservoir water levels due to the conditions modeled in these scenarios.

The incremental impact of increasing water supply demands to 100 mgd under 2050 conditions is shown to pull the 2050 demands curve down from 0.5 to 1 foot. The impacts of reducing inflows to 80% of historical inflows even further lowers the 2050 demands curve another 0.25 to 0.5 foot.

Water Supply Pool Duration Curve

Since the conditions of the water supply pool are not directly related to the level of water in the reservoir, water supply pool conditions are shown as the percent of storage remaining.

The water supply duration curves in Figure 14 show a clear impact of the increased water supply demands predicted for Jordan Lake in the 2030 and 2050 demands scenarios. The 2030 and 2050 cases are both significantly below the base case 2003 demands curve. The difference between the 2030 and 2050 curves is not as drastic. The curves show that the lowest predicted draw down of the water supply pool for the three primary scenarios modeled is to about 50% of storage remaining under the projected 2050 demands scenario.

Reducing inflows to 80% of historical has a noticeable impact on the 2050 curve, but an even greater impact is that of increasing water supply demands to 100 mgd.

Water Quality Pool Duration Curve

The water quality pool duration curves in Figure 15 show how future water supply withdrawals impact the water quality pool. The 2003 base case curve is the highest of the curves, meaning that over the entire period of record, more water is held in water quality storage for this scenario than the other two. During wetter periods, between 5% and 35% on the x-axis, the base case scenario is noticeably higher than the 2030 and 2050 scenarios. However, all scenarios are very similar during the driest 2-3% of the time. This is another indication that the Jordan Lake drought response measures for the deeper stages of drought, Stage 3 and 4, tend to prevent further lowering of the water quality pool once the pool reaches 40% full.

As expected, increasing water supply demands from Jordan Lake to 100 mgd shows little noticeable impact on the duration curve. However, reducing inflows to 80% of historical shows a very noticeable lowering of the 2050 curve.

Figure 13: Jordan Lake Elevation Duration Curve

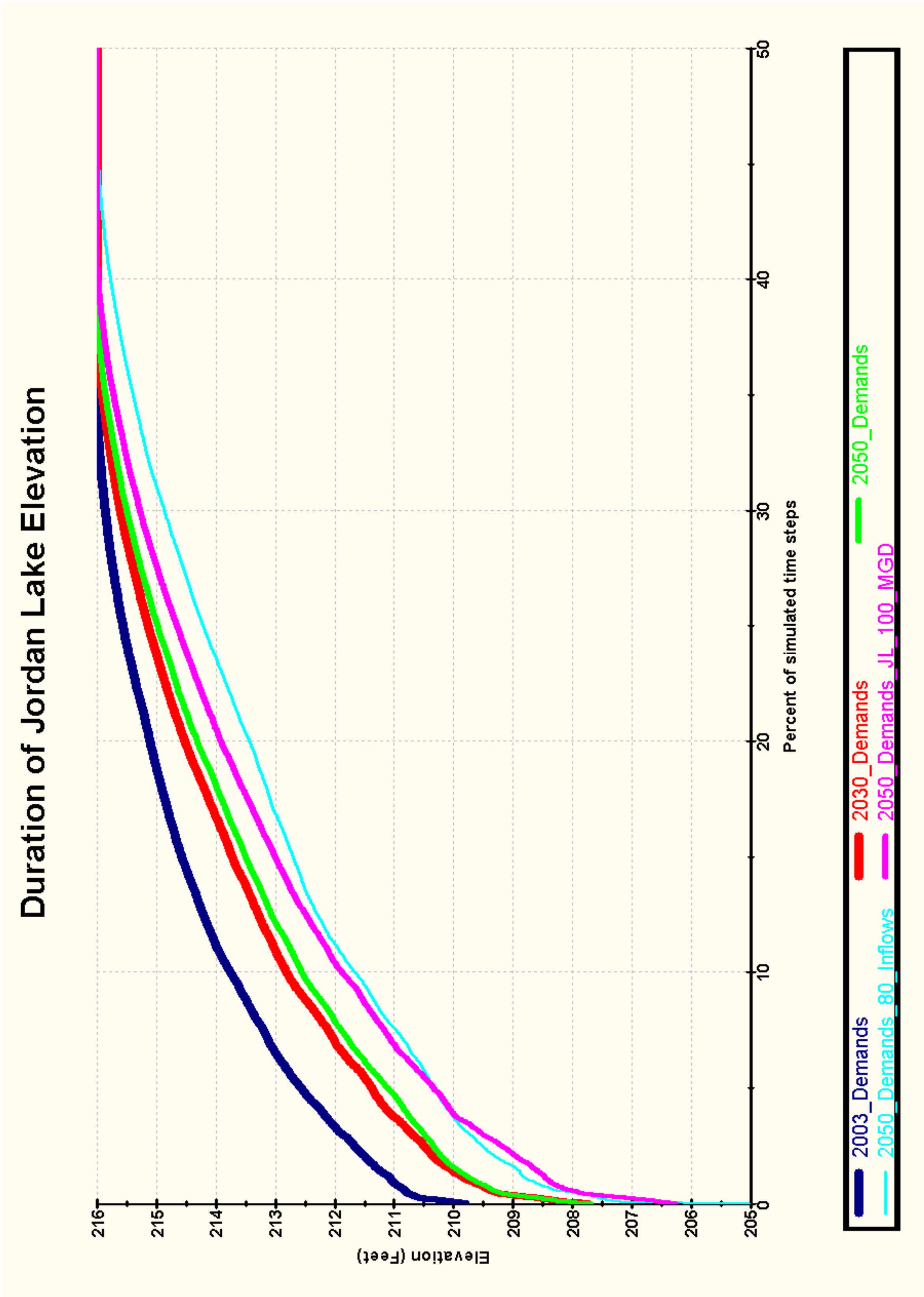


Figure 14: Jordan Lake Water Supply Pool Duration Curve

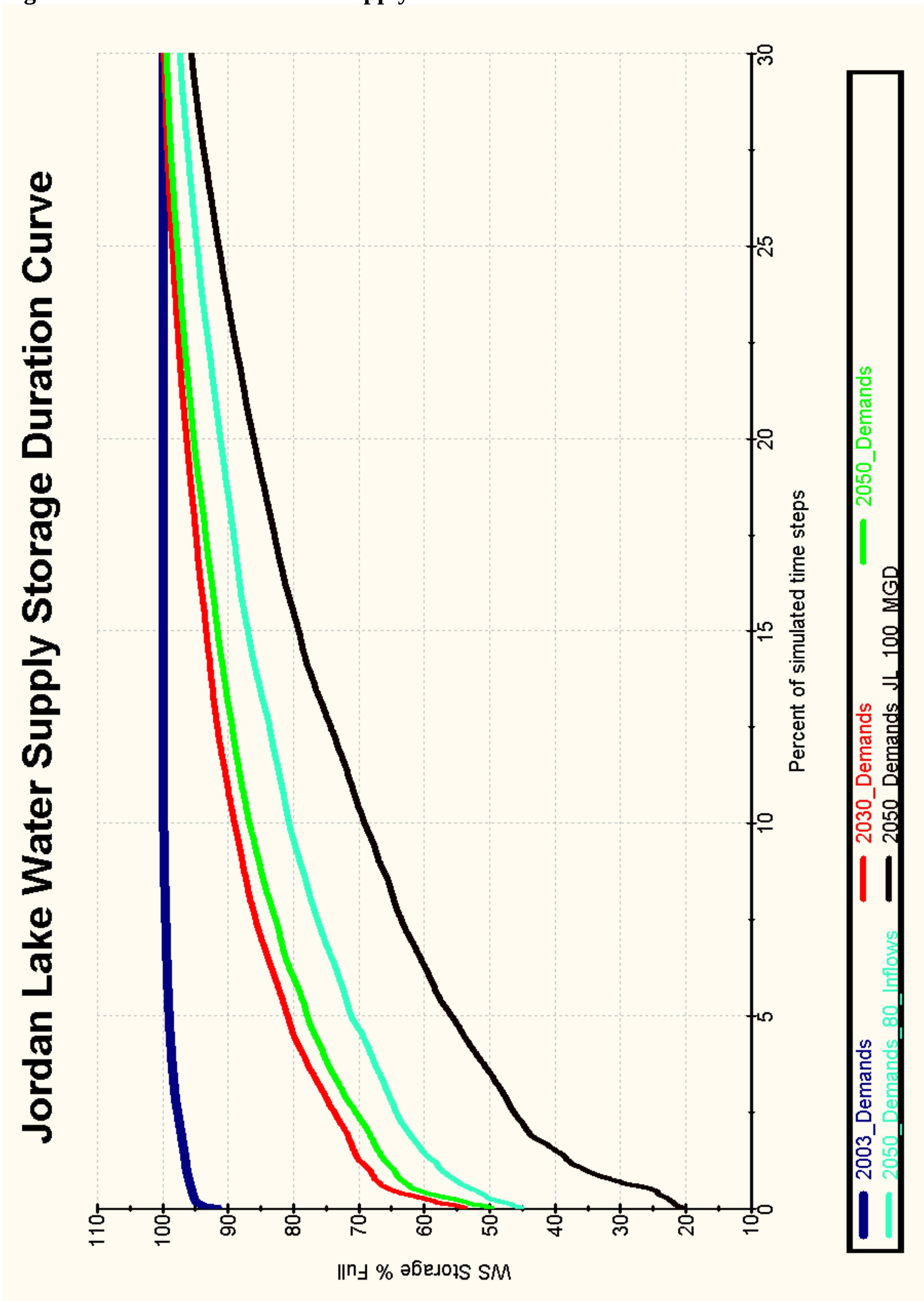
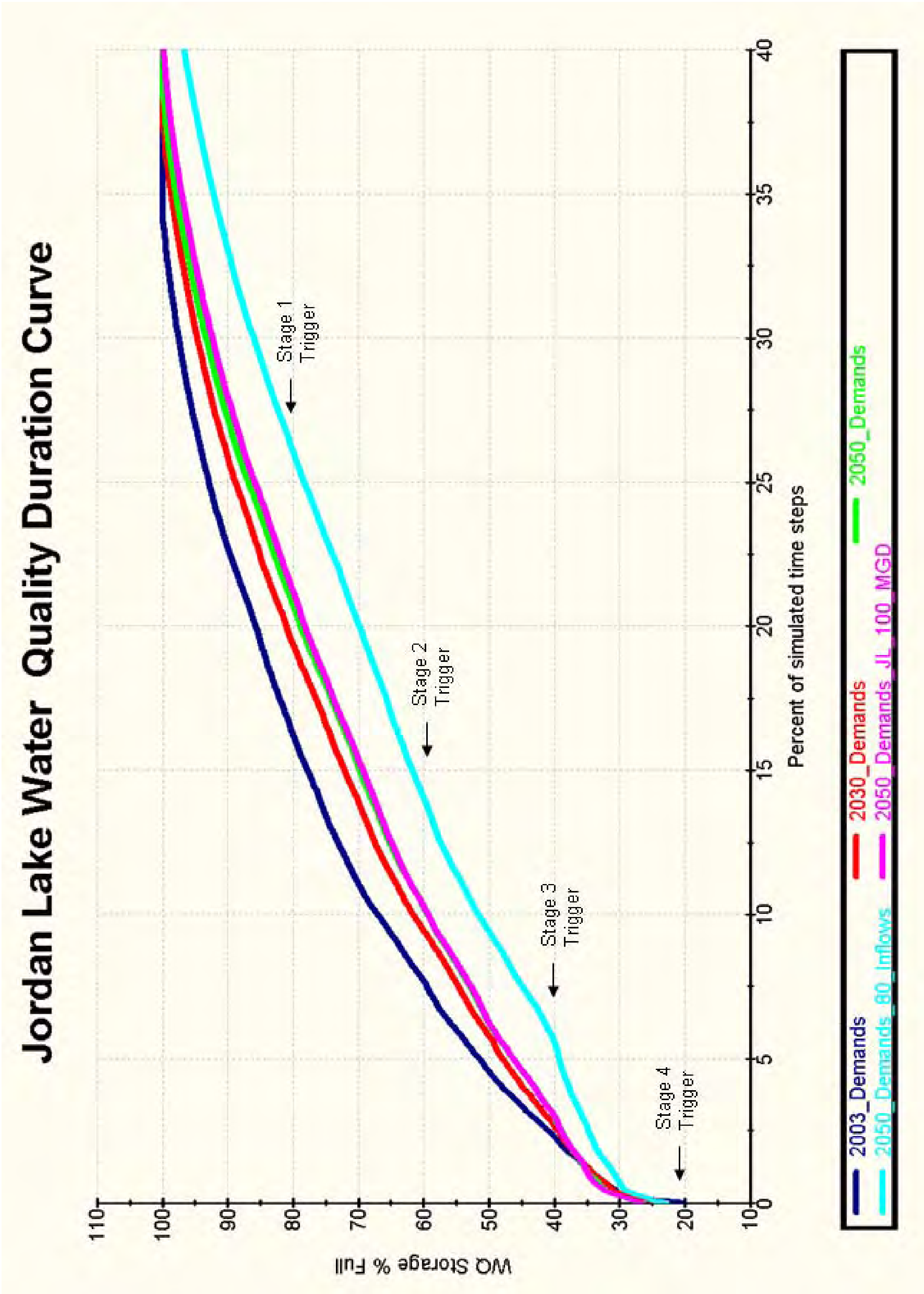


Figure 15: Jordan Lake Water Quality Pool Duration Curve



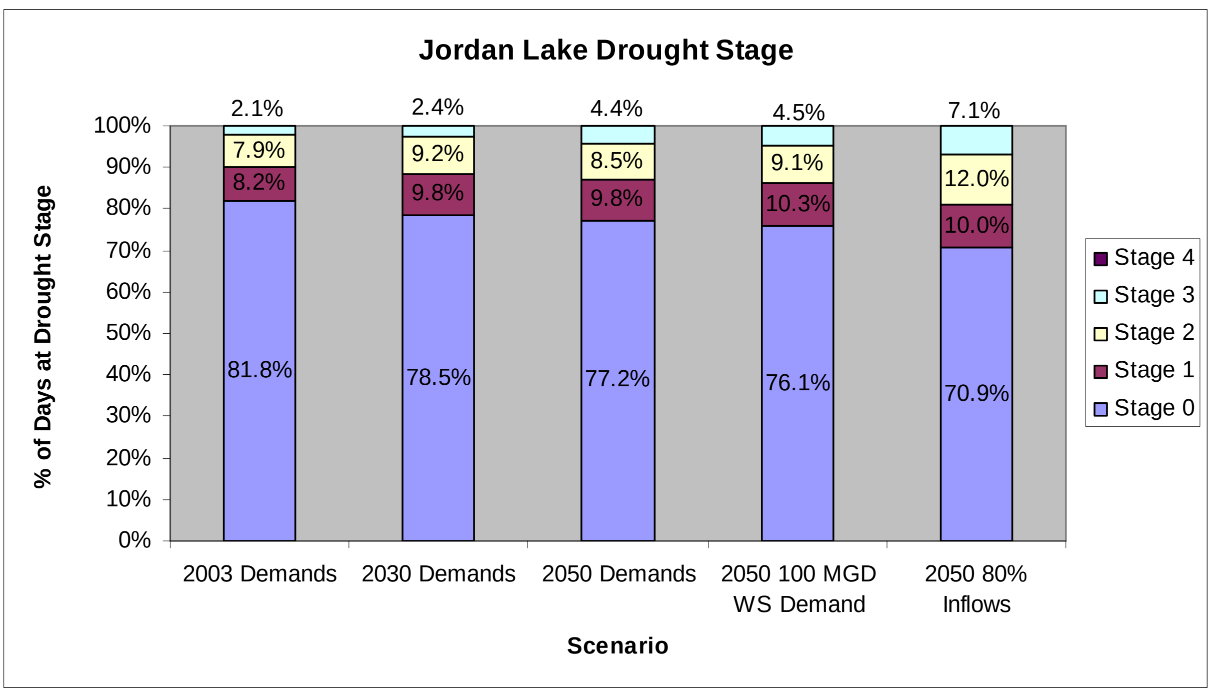
Impacts on Frequency of Jordan Lake Drought Stage Occurrence

Figure 16 depicts how frequently each stage of drought is expected to be reached for the five scenarios. The model counts the number of days during the 76-year period that the reservoir operates at each of the drought stages and this chart summarizes the totals.

Because the drought stage designation is related to the percent of storage remaining in the water quality pool, these results are an alternative way to depict the previously presented duration curves and profiles of the water quality pool storage. For all scenarios, the reservoir operates at stage 0 more than 70% of the time. The 2030 and 2050 demands scenarios show an increase in the number of days at drought stage 1 from 8.2% for the base case to 9.8%. There is also an increase in the percent of days at Stage 2 from 7.9% for the base to 9.2% and 8.5% respectively for the 2030 and 2050 scenarios. The percent of days at Stage 3 is 2.1% and 2.4% for the 2003 and 2030 scenarios, but increases to 4.4% for the 2050 scenario. Finally, none of the five scenarios have Jordan Lake reaching Stage 4 drought level on any days.

Increasing water supply demands to 100 mgd has a small impact on drought stage occurrences as compared to the 2050 scenario. However, reducing inflows to 80% of historical has a great impact on the occurrence of Stage 2 and 3 drought occurrence. Stage 2 occurrences are increased from 8.5% to 12.0% of the days, and Stage 3 occurrences are increased from 4.4% to 7.1% of the days.

Figure 16: Jordan Lake Drought Stage Occurrence

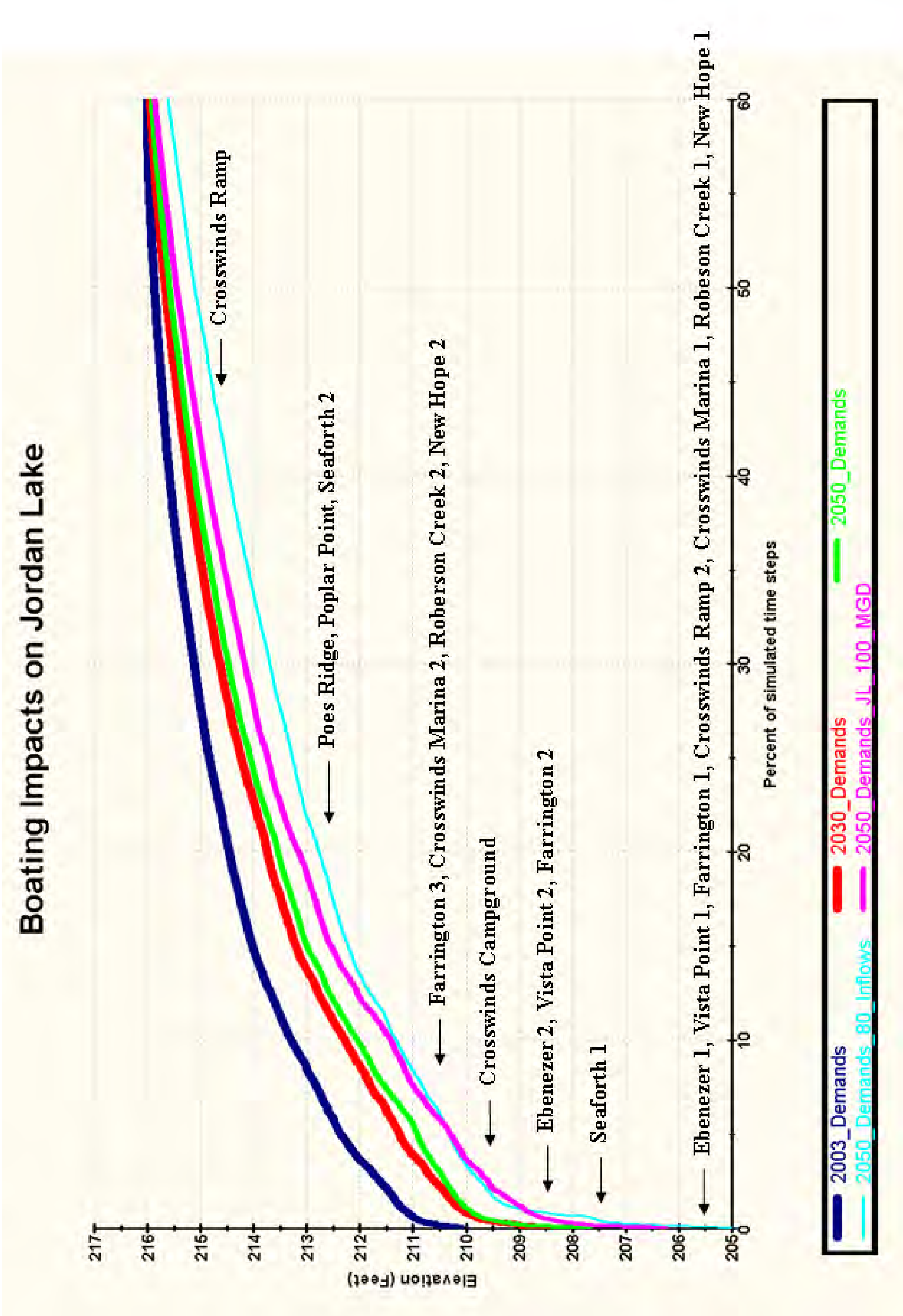


Stage	% Remaining in Water Quality Pool
4	0-20
3	20-40
2	40-60
1	60-80
0	80-100

Impacts on Boating at Jordan Lake

Figure 17 shows the duration curves for Jordan Lake for the five scenarios and the elevation levels of each of the boat ramps. From this curve, it can be estimated how often to expect that the various boat ramps might be impacted.

Figure 17: Jordan Lake Boating Impacts



IV. Water Supply Demands vs. Delivery

Note: The results presented in this section are only for the three water demands scenarios; the base case, 2030, and 2050 demands scenarios.

There are 42 modeled water supply demand nodes. In the scenarios, the nodes were individually examined to determine if the projected available quantity for surface water would be sufficient to meet projected demand at each of those nodes. The withdrawal amounts assumed by the model at each water supply node are summarized in the previous section titled “Withdrawals and Discharges”.

For demand nodes on run-of-river sections of streams, the model has a set of weights and goals that determine whether water supply demands can be met. The model uses these weights to prioritize water uses. Simply stated, the weights assign points to each type of use such as a water supply demand, irrigation demand, minimum release from a reservoir, or reservoir storage. The model allocates water by choosing the allocation which maximizes the total weight points. At this time, minimum in-stream flow needs have not been identified and therefore have not been assigned a weight. Using the model to analyze in-stream flows at additional nodes may help identify in-stream flow concerns downstream of water supply withdrawals. In future model runs, in-stream flow targets may be set as needed which may further constrain water supply withdrawals.

For demand nodes from reservoirs, the water supply demand is met if the reservoir has sufficient water remaining in storage. If the model predicts that a demand from a reservoir is not met, this is an indication that the reservoir has been depleted.

Water demand deliveries were compared to water supply demand for each of the three demands scenarios. **The model predicts that for 31 of the 42 water supply nodes, the full demand is met for all days for all three water demand scenarios.** However, there are 10 nodes for which the full demand is not met under all three water demand scenarios.

Table 4 summarizes the instances in which the model predicts that the full water supply demand would not be met in one or more scenarios. They are listed in alphabetical order and divided into systems which have only a single water supply and systems which have multiple water supplies.

As explained in the preface, the water supply demand weights have been closely examined since the draft version of this report was released in March 2008. Many water supply demands weights were adjusted to ensure that the demands would be met if adequate water is available at the withdrawal point. For this reason, a number of systems which previously had a small predicted water supply deficit, no longer have one. Also, in the draft version, there was a significant predicted deficit for the Fayetteville Glenville Lake withdrawal. For modeling purposes, this demand was moved to Fayetteville’s run-of-river intake on the Cape Fear River. Subsequently, no deficit is now predicted for Fayetteville’s water supply, as the flow at the run-of-river intake is expected to be adequate to meet its demands.

The largest water supply deficit predicted by the model is for Orange Water and Sewer Authority (OWASA) University Lake, which shows a deficit in 24 of the 76 years in the 2050 scenario. However, this deficit is likely due not to an actual water supply shortage, but rather how the model deals with the OWASA two-reservoir water system. The model assigns separate water demands to each water supply. In actuality, if University Lake is depleted, the Cane Creek Reservoir is used to meet the demands. However, the model is currently not set up to take this into account. This is also the case with Greensboro, High Point, and Fort Bragg, which have smaller deficits at one of their sources. It should be noted that the Cane Creek Reservoir water supply withdrawals showed no deficits in the 2003 and 2030 scenarios, but did have one 2-day deficit under the 2050 scenario.

The model predicts a deficit for Fort Bragg under the base case scenario in 7 of the 76 years. However, in future scenarios, the Fort Bragg demand is to be met mostly by Fayetteville, so no deficit was predicted in either 2030 or 2050. Fort Bragg's future demands were considered by the model in Fayetteville's demands for future scenarios.

Among the water systems with only one water supply, deficits were predicted for Cone Mills Richland, Dupont, Ramseur, Randleman, and Robbins. However, only for Ramseur was a deficit predicted in more than two of the 76 years.

The model predicts significant water supply deficits for Ramseur both under the base case scenario and future scenarios. The Ramseur reservoir is small as is Ramseur's projected water supply demand, not expected to exceed 1.1 mgd before the year 2050. However, further attention may be necessary as the model shows a clear potential water supply shortage.

Table 4: Water Supply Demand Deficits Predicted by the OASIS Model

Model Scenario Water Systems	2003 Demand (mgd)	# of Days Per Year Demand Not Met	Longest Deficit (Days)	Years Demand Not Met Out of 76	2030 Demand (mgd)	# of Days Per Year Demand Not Met	Longest Deficit (Days)	Years Demand Not Met Out of 76	2050 Demand (mgd)	# of Days Per Year Demand Not Met	Longest Deficit (Days)	Years Demand Not Met Out of 76
Systems With a Single Water Sources												
Cone Mills Richland Lake									0.7	0.1	4	2
Dupont					12.3	0.0	1	1	12.3	0.0	1	1
Ramseur	0.58	1.8	34	12	0.9	2.8	35	16	1.1	3.8	43	20
Randleman					0.2	0.8	16	2	0.6	0.3	15	1
Robbins CB Brooks	0.26	0.8	33	2	0.24	0.8	33	2	0.27	0.8	33	2
Systems With Multiple Water Sources												
Ft. Bragg	6.3	0.6	12	7								
Greensboro Townsend Lake									23.2	5.5	36	3
High Point - F Ward	13.12	2.1	34	5					12.3	1.2	16	4
OWASA Cane Creek									7.0	0.0	2	1
OWASA University Lake	2.8	1.9	48	7	3.2	1.9	7	7	4.7	11.5	92	24

# of Days Per Year Demand Not Met = Number of days out of the full 27,394 days of record that the model shows the full demand maybe is not met, divided by 76 (years of record).
Longest Deficit (Days) = The greatest number of consecutive days over the entire 76 year record that the full water supply demand maybe is not met.
Years Demand Not Met = The number of years out of a total of 76 that the full water supply demand maybe is not met.
Systems in Red are those for which a deficit is predicted in any scenario seven or more years out of the 76 year record.

V. Water Supply Intake Impacts

There are fourteen reservoirs that are considered in the model. Following are duration curves for the water surface elevation for each of the reservoirs. Each plot includes a curve for all five scenarios. If the information is available, the levels of the water withdrawal intakes are indicated on the plots. These plots are useful to estimate the percentage of time that reservoir levels are predicted to drop low enough to impact the water supply intakes. For most reservoirs, very few impacts to water supply intakes are predicted. However, the Ramsuer Reservoir is expected to fall below the level of the intake more often than for any of the other reservoirs. Also, in actual practice, water system operators would take actions by imposing water conservation measures to reduce the likelihood of the reservoir levels dropping below the level of the intake. In cases where a water system has more than one water source, one reservoir could be allowed to be exhausted while holding the other sources in reserve.

Figure 18: Jordan Lake Elevation Duration Curve

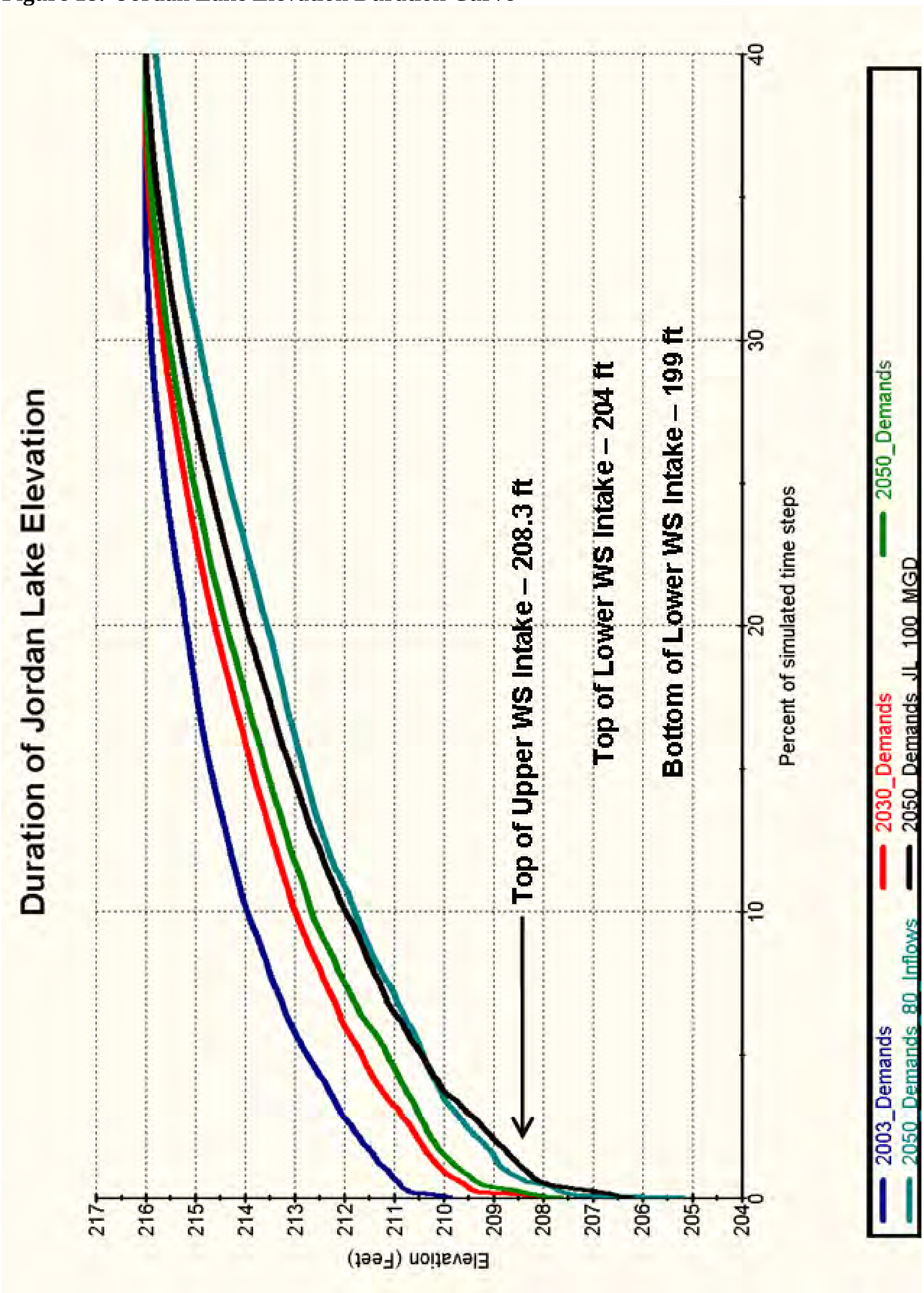


Figure 19: Lake Mackintosh Elevation Duration Curve

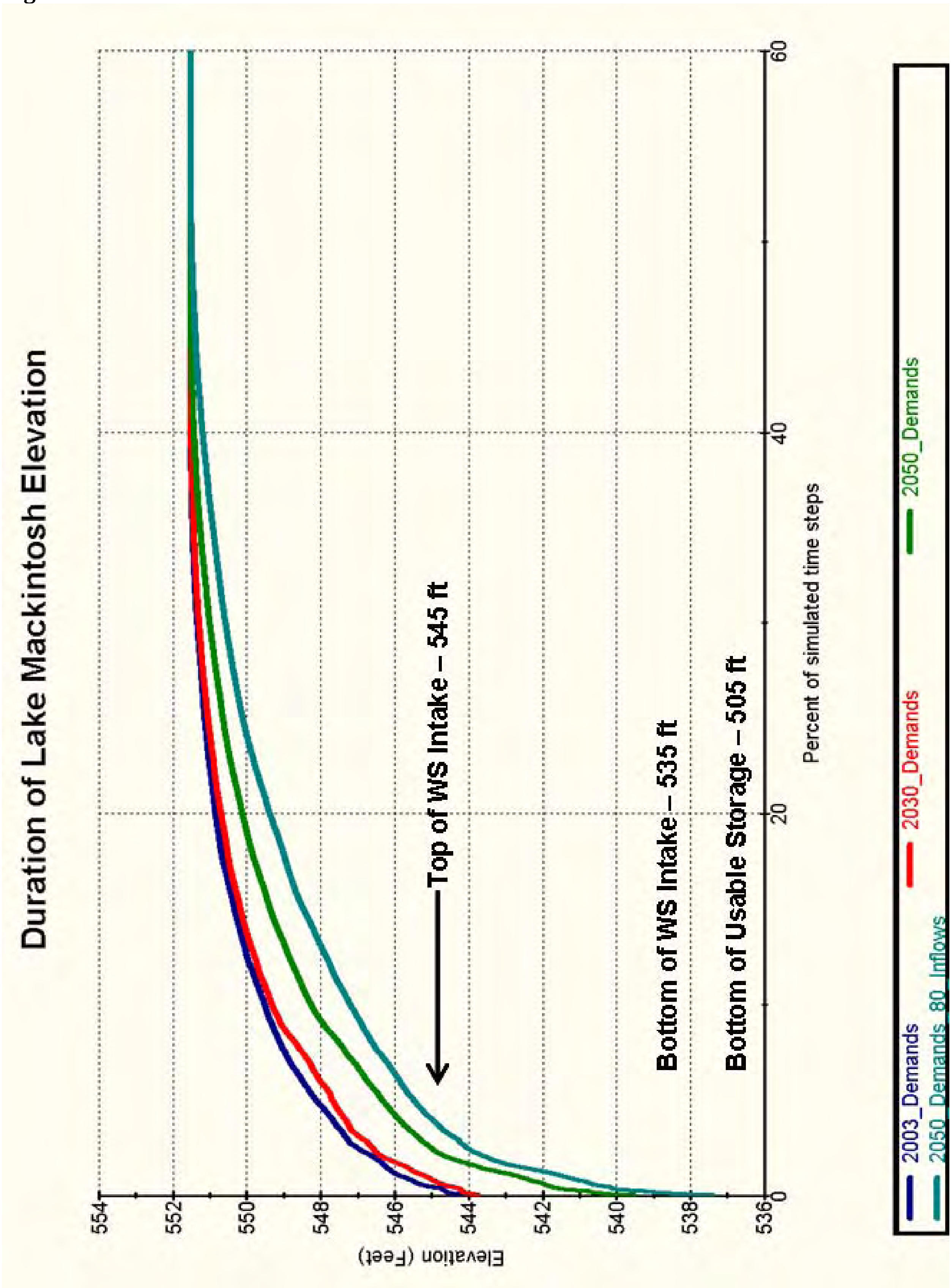


Figure 20: Graham Mebane Reservoir Elevation Duration Curve

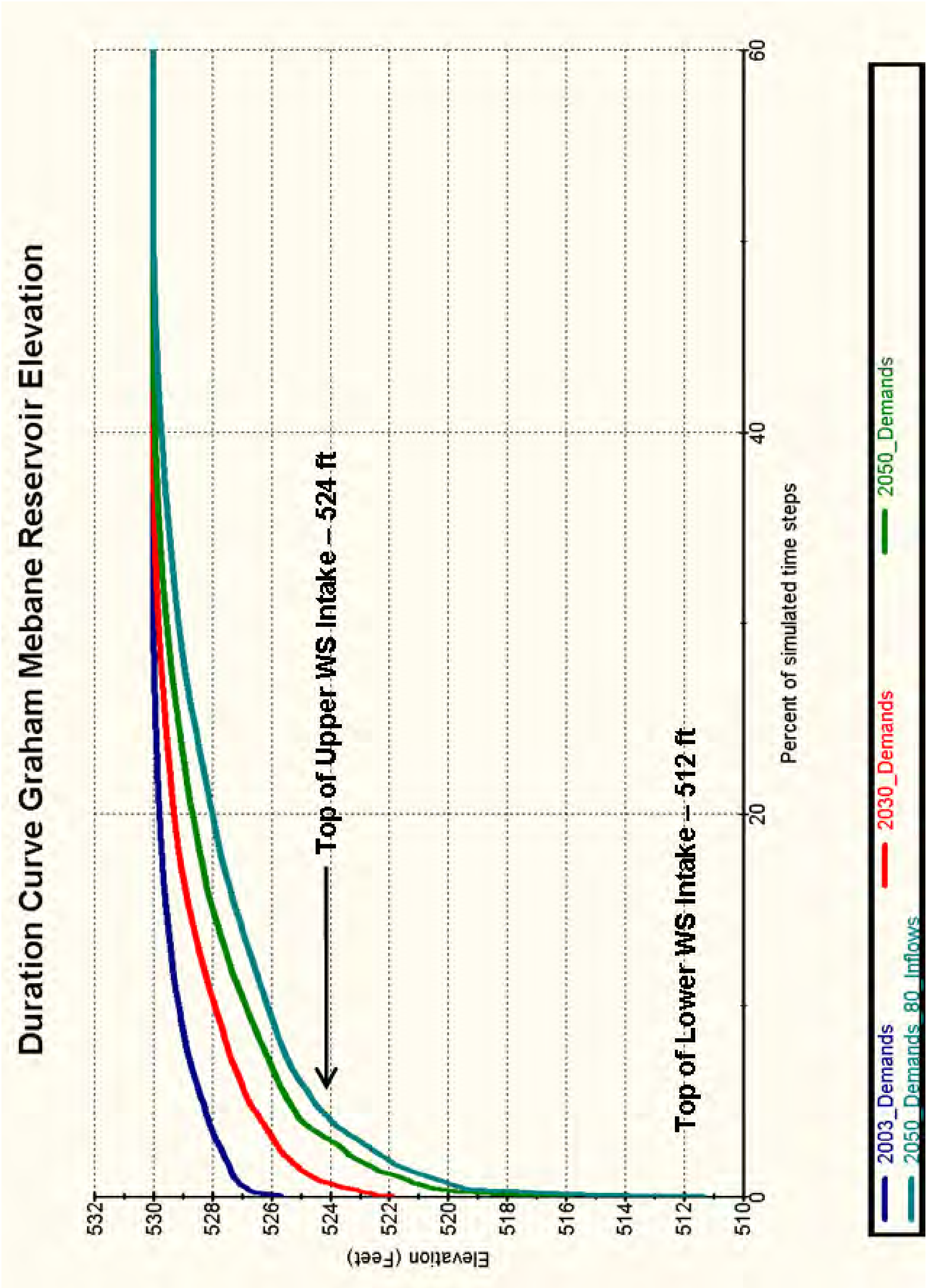


Figure 21: Cane Creek Reservoir Elevation Duration Curve

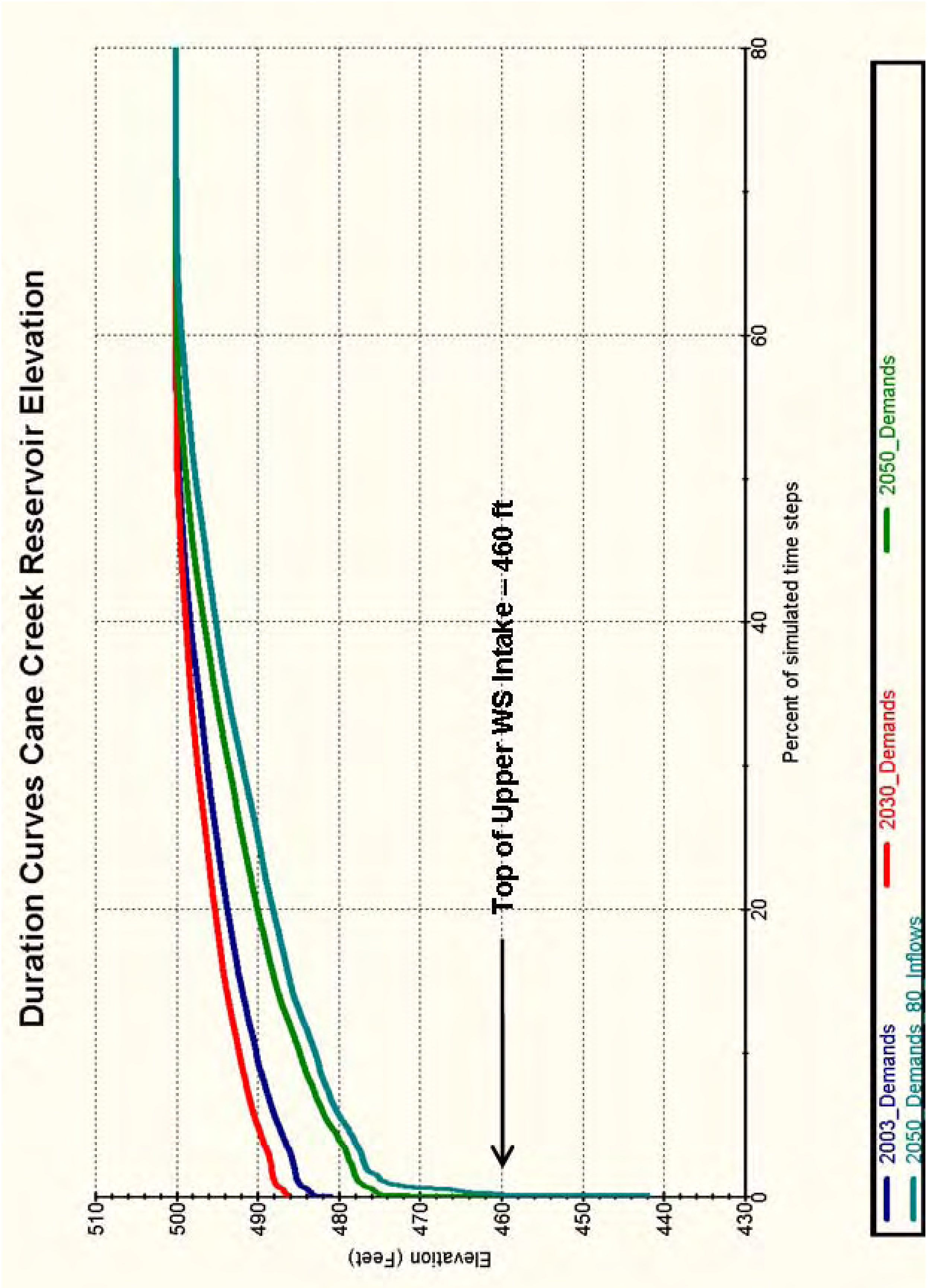


Figure22: Glenville Reservoir Elevation Duration Curve

Note: The model assumes no water supply withdrawals from Glenville Reservoir.

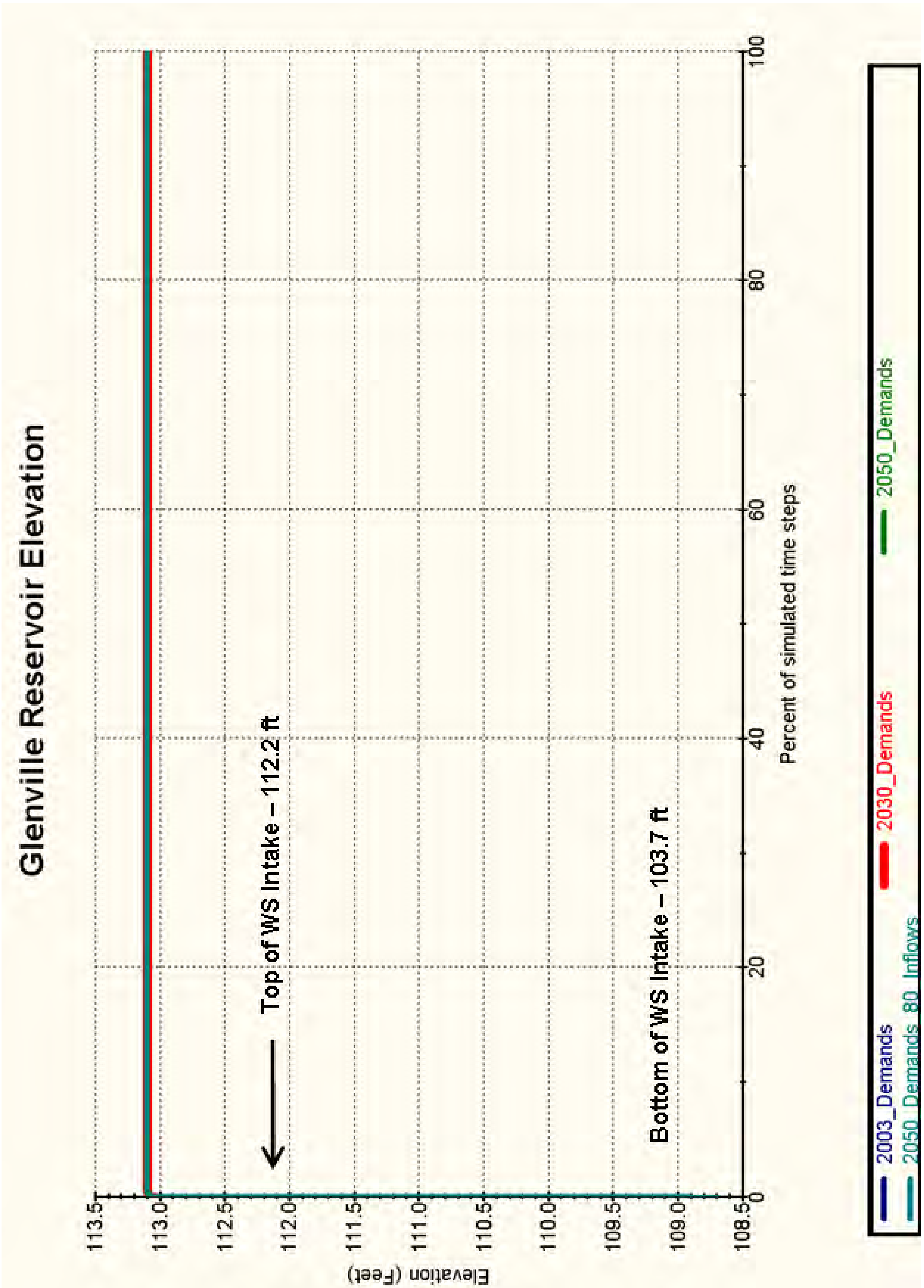


Figure 23: Townsend Reservoir Elevation Duration Curve

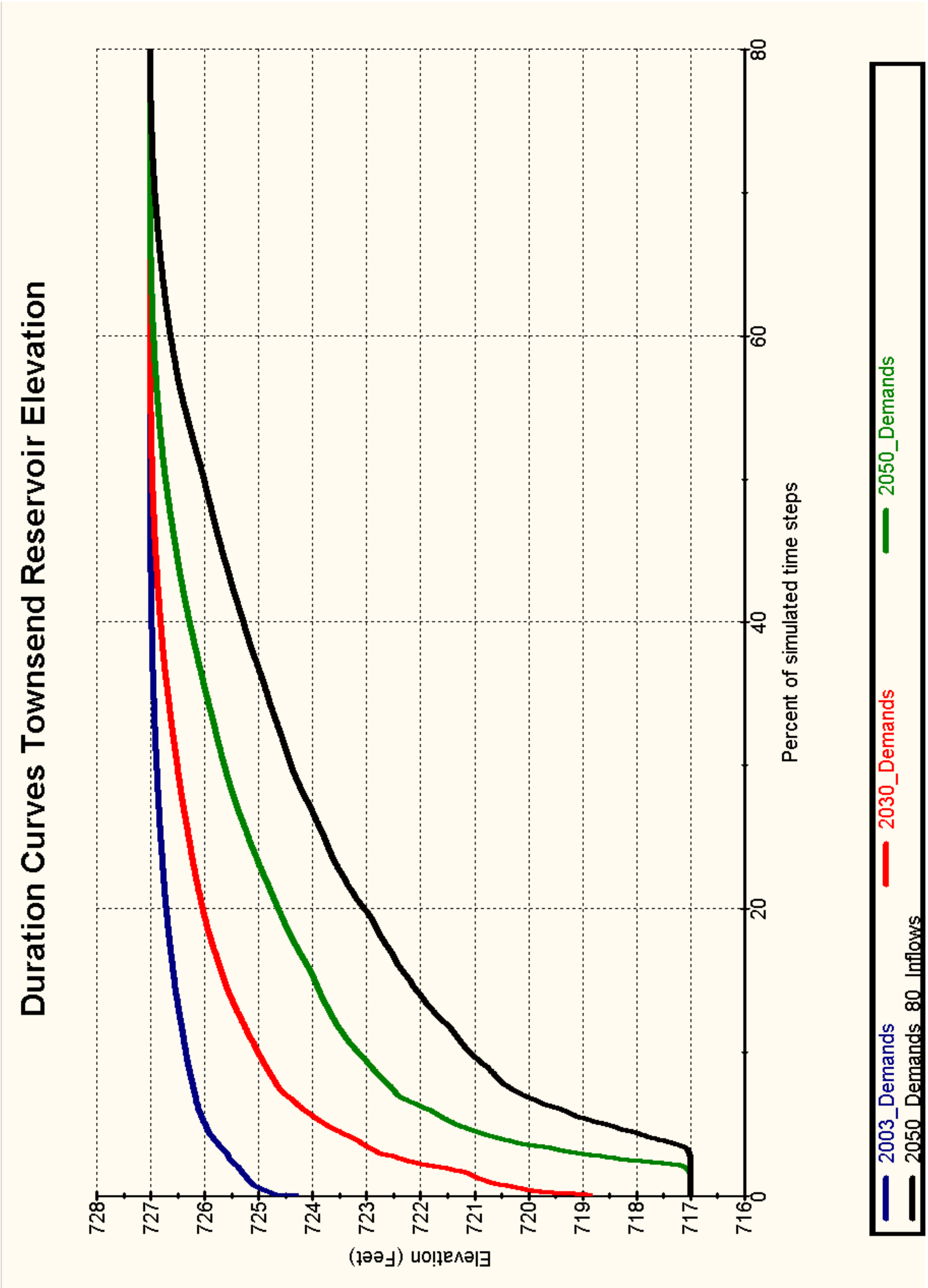


Figure24: Harris Lake Elevation Duration Curve

Note: Water supply demands are assumed the same from Harris Lake for all scenarios.

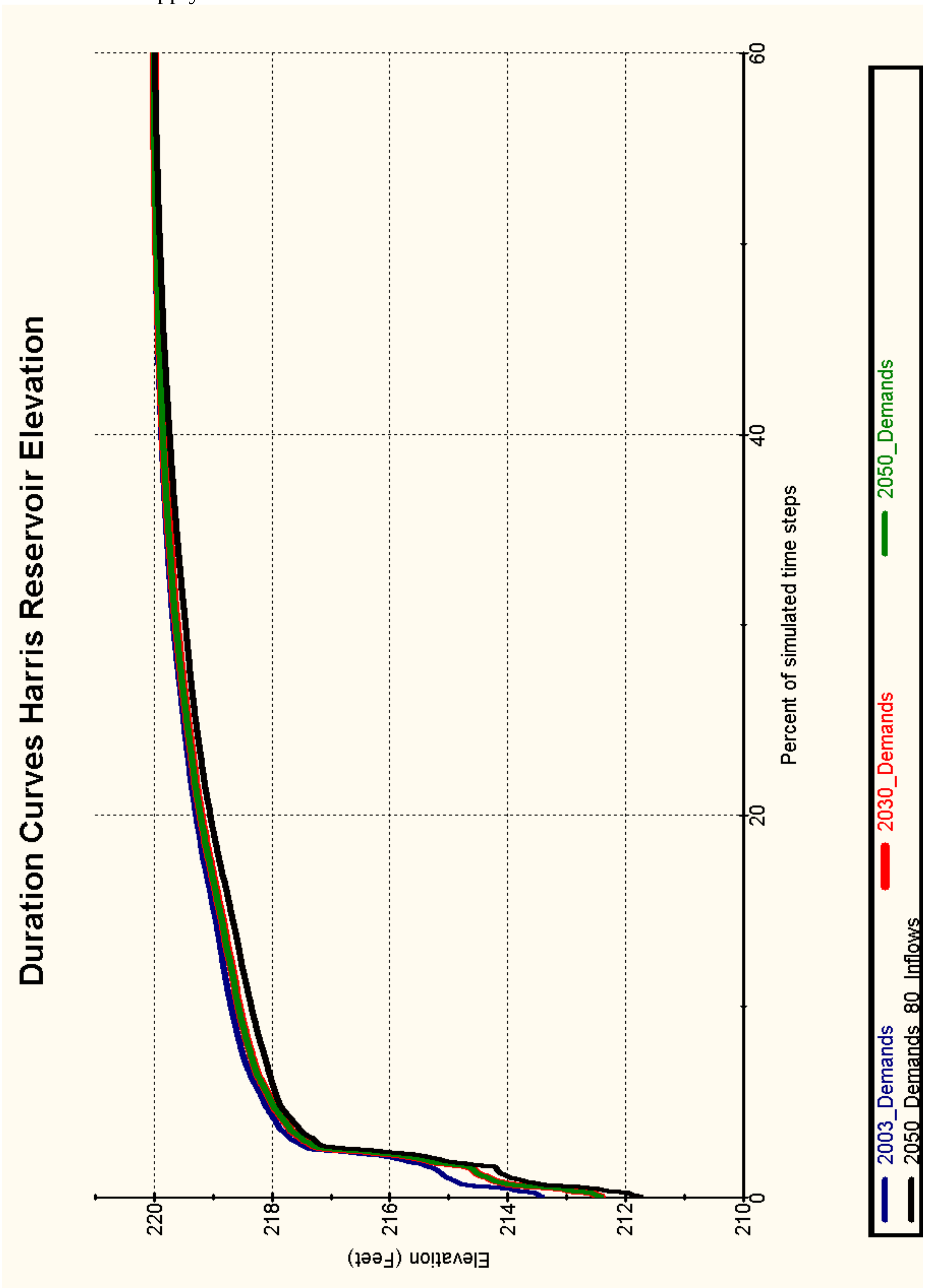


Figure25: High Point Reservoir Elevation Duration Curve

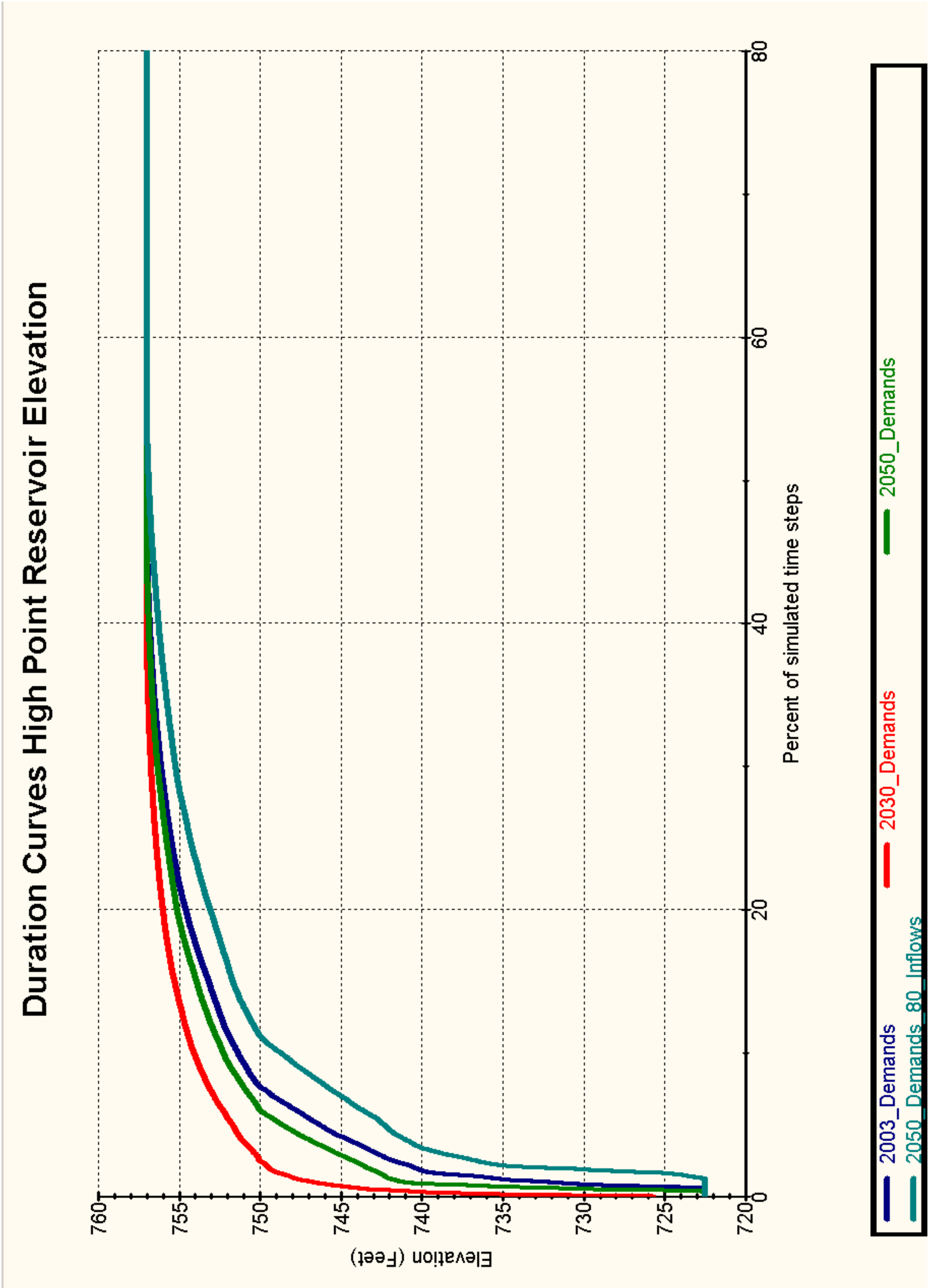


Figure 26: Old Stoney Creek Reservoir Elevation Duration Curve

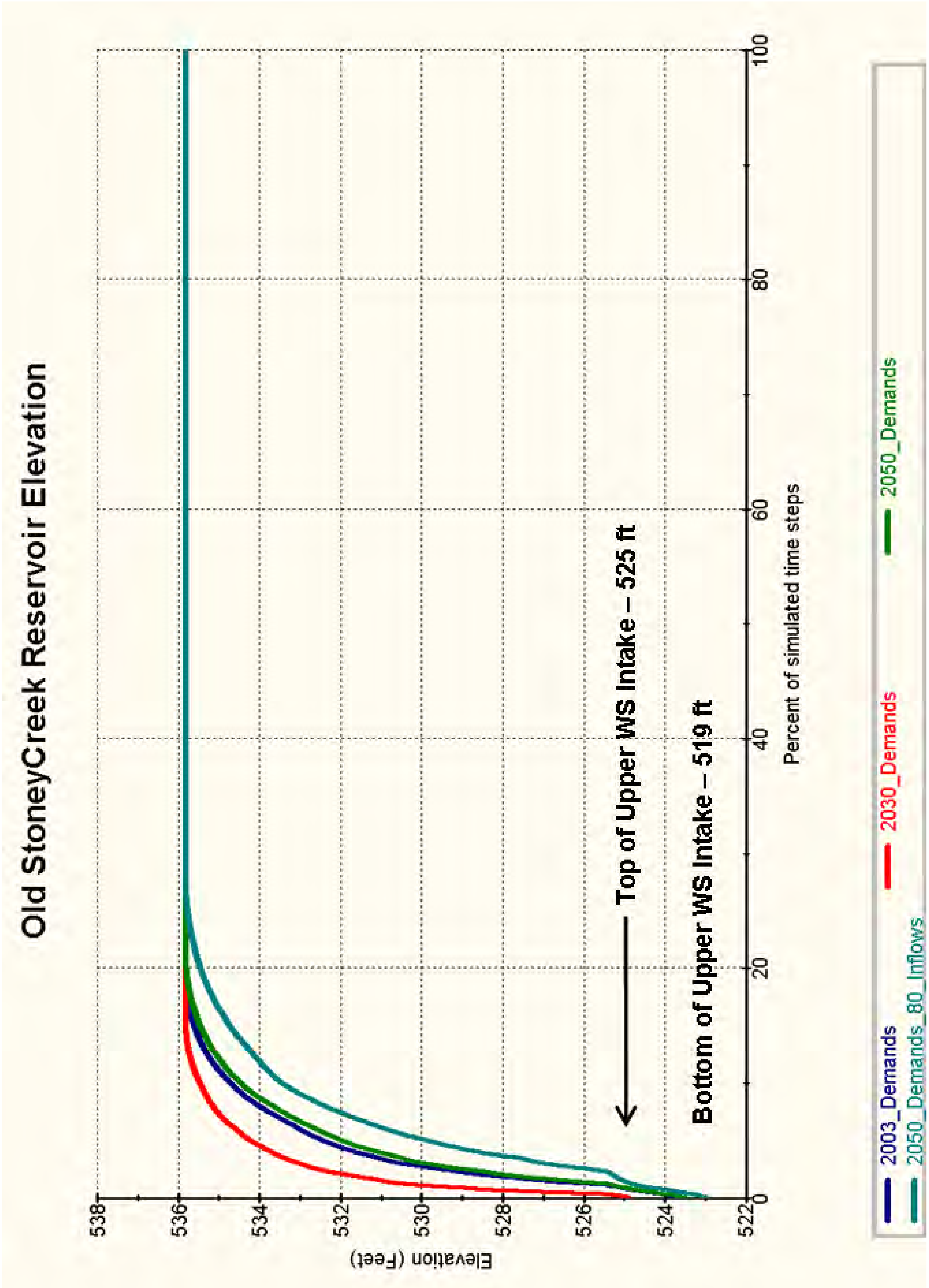


Figure 27: Ramseur Reservoir Elevation Duration Curve

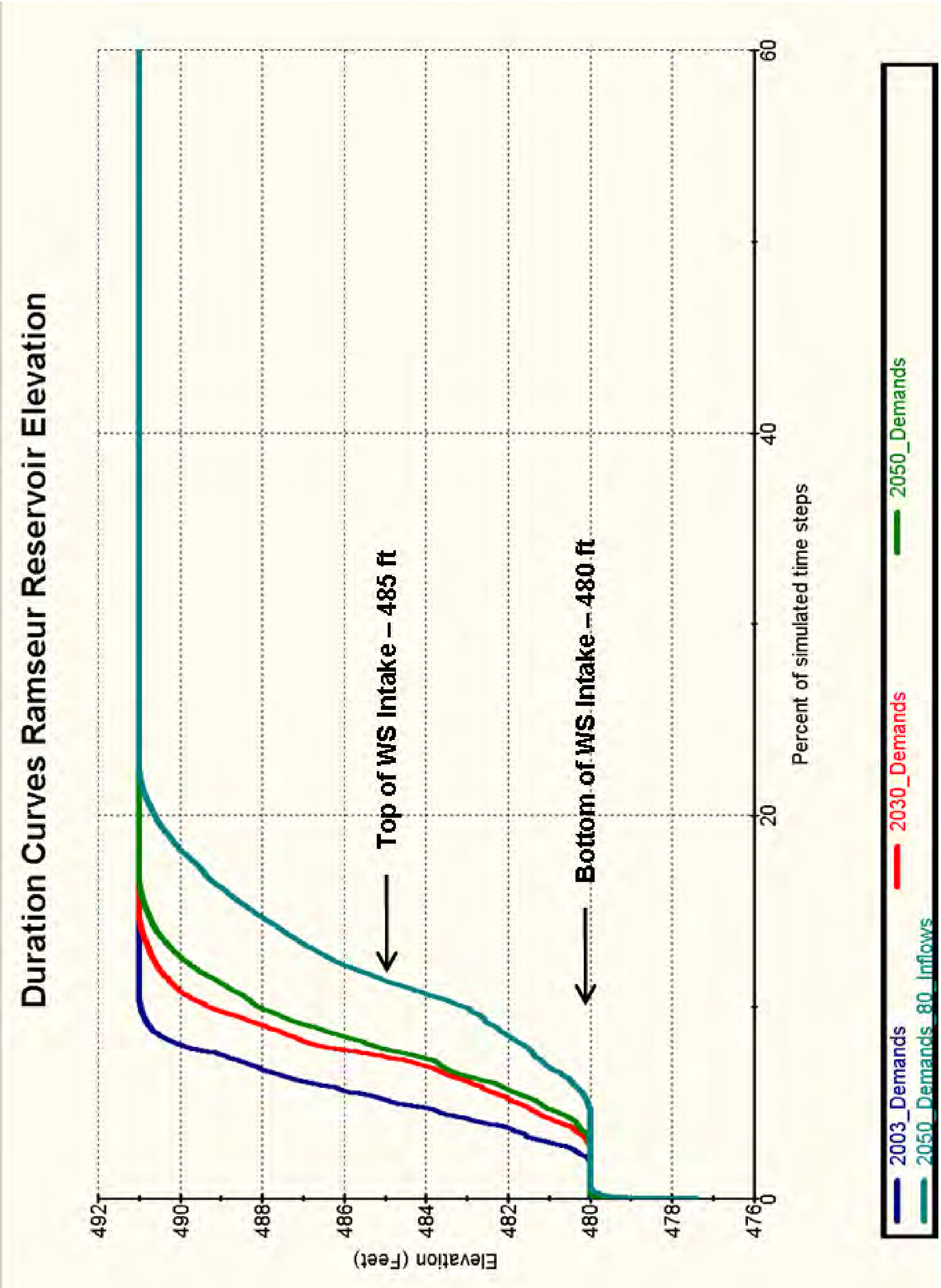


Figure 28: Randleman Reservoir Elevation Duration Curve

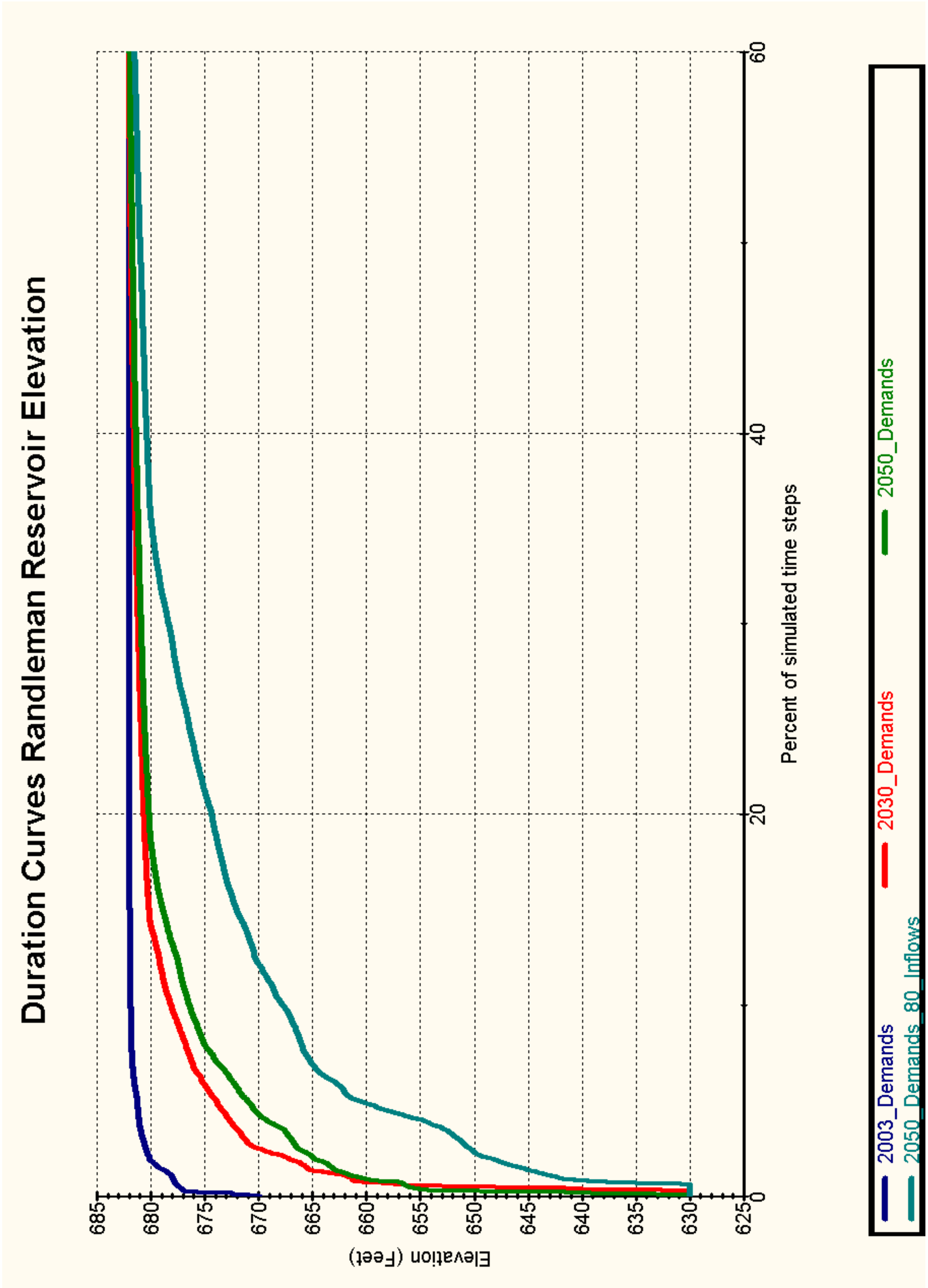


Figure 29: Lake Reidsville Elevation Duration Curve

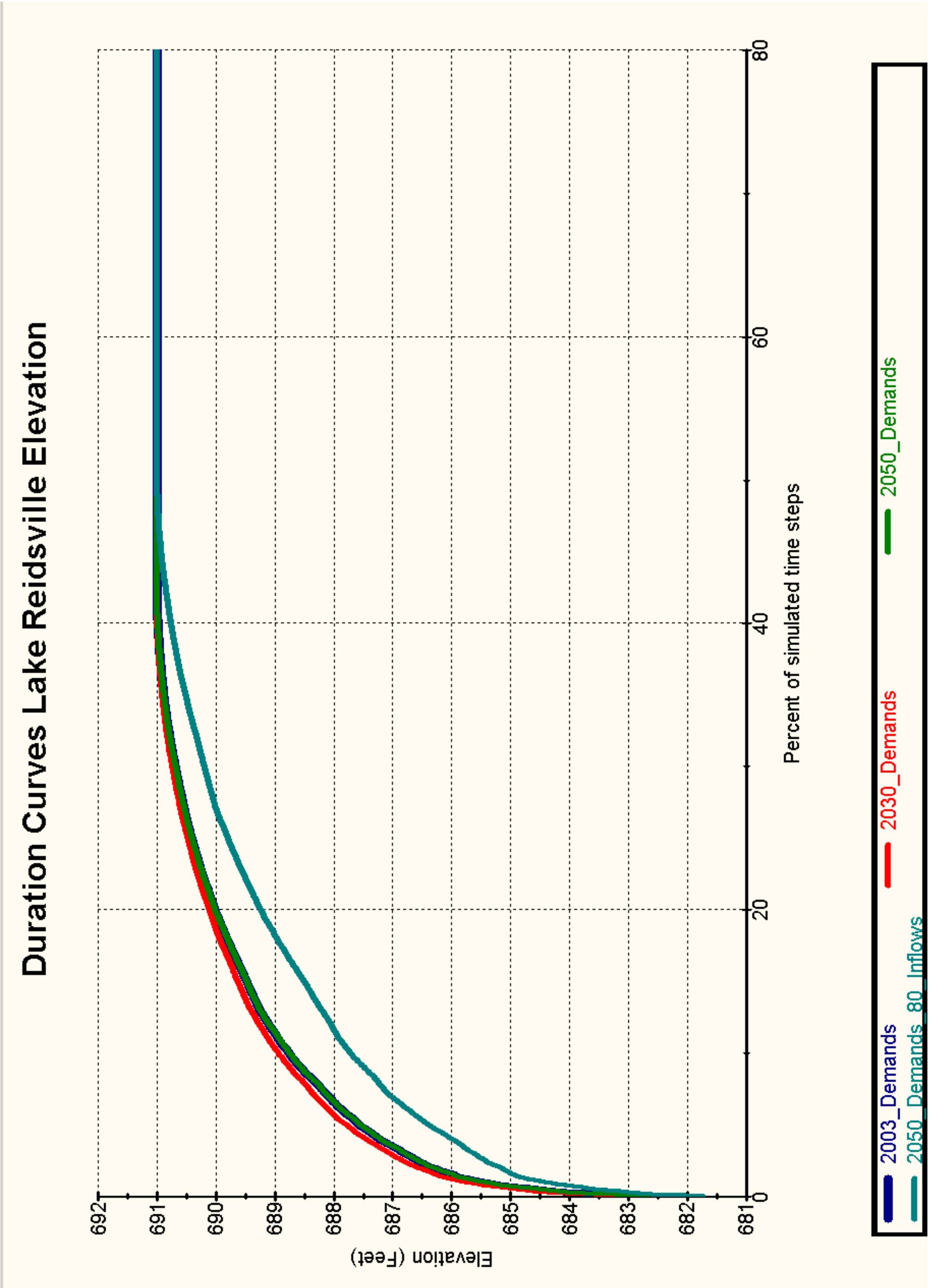


Figure 30: University Lake Elevation Duration Curve

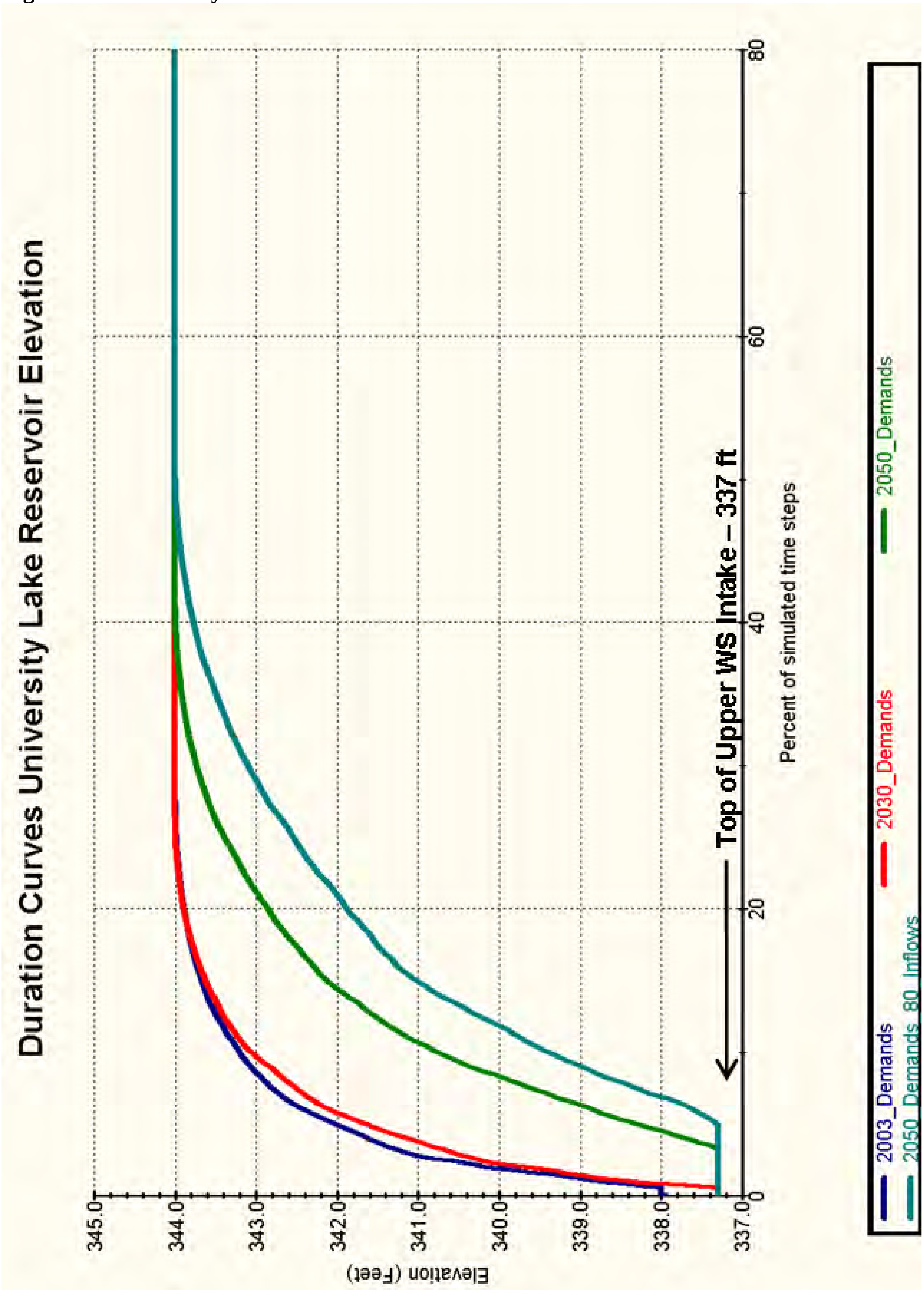
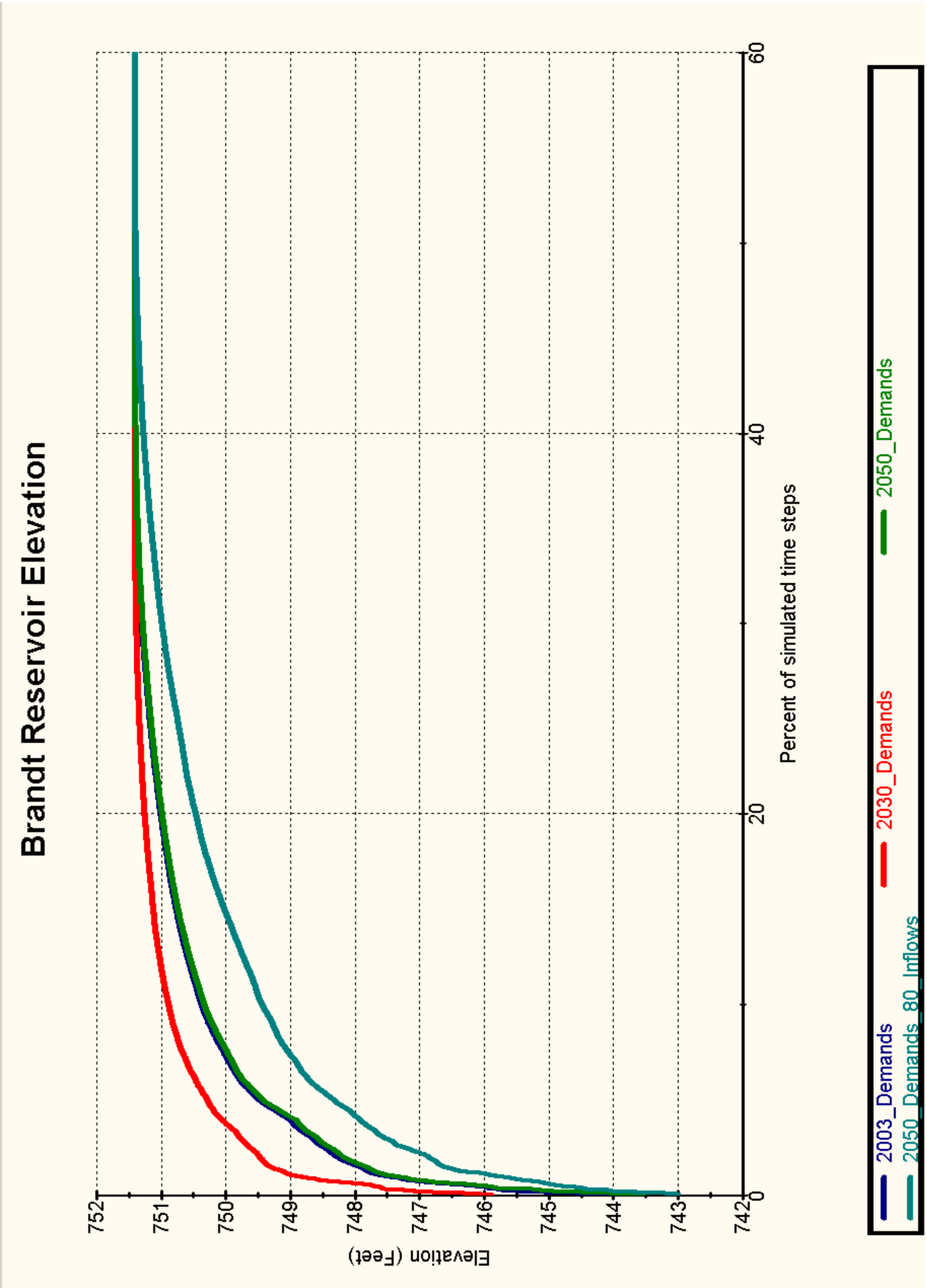


Figure 31: Brandt Reservoir Elevation Duration Curve



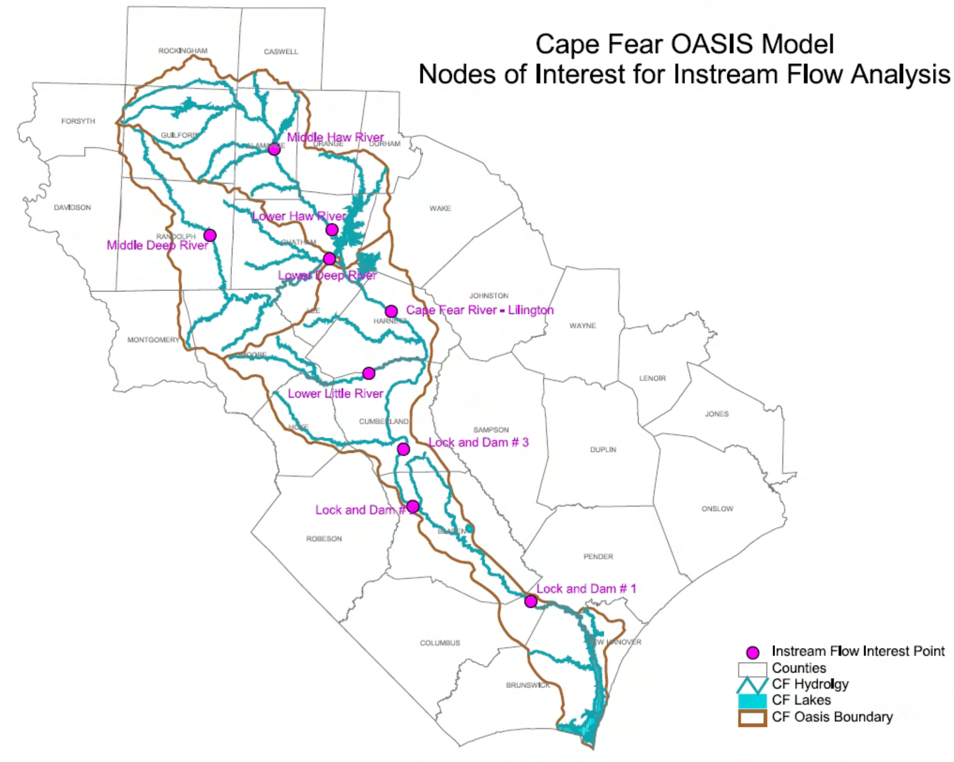
VI. In-stream Flow Evaluation

Predicted stream flows at certain points of interest were evaluated. The purpose of examining in-stream flows is to evaluate potential impacts on aquatic ecosystems, including fish and other aquatic organisms, that could be caused by changes in flows resulting from reservoir operations or water supply withdrawals. The following table shows the nodes of interest that were identified through discussions with the NC Wildlife Resources Commission. NCWRC also expressed interest in assessing in-stream flows on Rockfish Creek, Upper Little River and Rocky River, but because of the way the system is modeled, this was not possible.

Table 5: **Nodes of Interest for In-stream Flow**

River	Location / Section	Node
Deep River	Middle portion	280
Haw River	Middle portion	360
Haw River	Lower portion	410
Cape Fear River	Lillington	550
Deep River	Lower portion	640
Little River	Lower portion	720
Cape Fear River	Lock and Dam #3	780
Cape Fear River	Lock and Dam #2	790
Cape Fear River	Lock and Dam #1	820

Figure 32 shows the geographic locations of the points of interest.
Figure 32: In-stream Flow Analysis Nodes of Interest



Analysis of In-stream Flows

An adaptation of the Tennant Method[1] for evaluating in-stream flows was used for evaluating the modeled in-stream flows. Under this method, daily stream flows are compared to the historical average annual flow at the point of interest. The historical average annual flow was determined using the model under the Unregulated scenario.

Depending on the percentage of annual flow, the Tennant Method provides guidelines for evaluating the adequacy of the flow for the given time of the year. Table 6 summarizes these guidelines.

[1] *In-stream Flows for Riverine Resource Stewardship: 2004 Revised Edition, Multiple Authors* .

Table 6: **Modified Tennant Method Guidelines for Evaluating In-stream Flows**

	Description of Flow Levels	March to May	June to November	December to February
Level 1	< 10% of QAA*	Severe Degradation	Severe Degradation	Severe Degradation
Level 2	10 - 20% of QAA	Poor or Minimum	Fair or Degrading	Fair or Degrading
Level 3	20 - 30% of QAA	Fair or Degrading	Good	Good
Level 4	30 - 40% of QAA	Good	Excellent	Excellent
Level 5	40 - 50% of QAA	Excellent	Outstanding	Outstanding
Level 6	50 - 60% of QAA	Outstanding	Outstanding	Outstanding
Level 7	60 - 100% of QAA	Optimum	Optimum	Optimum
Level 8	100 - 200% of QAA	Optimum to Flushing	Optimum to Flushing	Optimum to Flushing
Level 9	>200 of QAA	Flushing or Maximum Flow	Flushing or Maximum Flow	Flushing or Maximum Flow

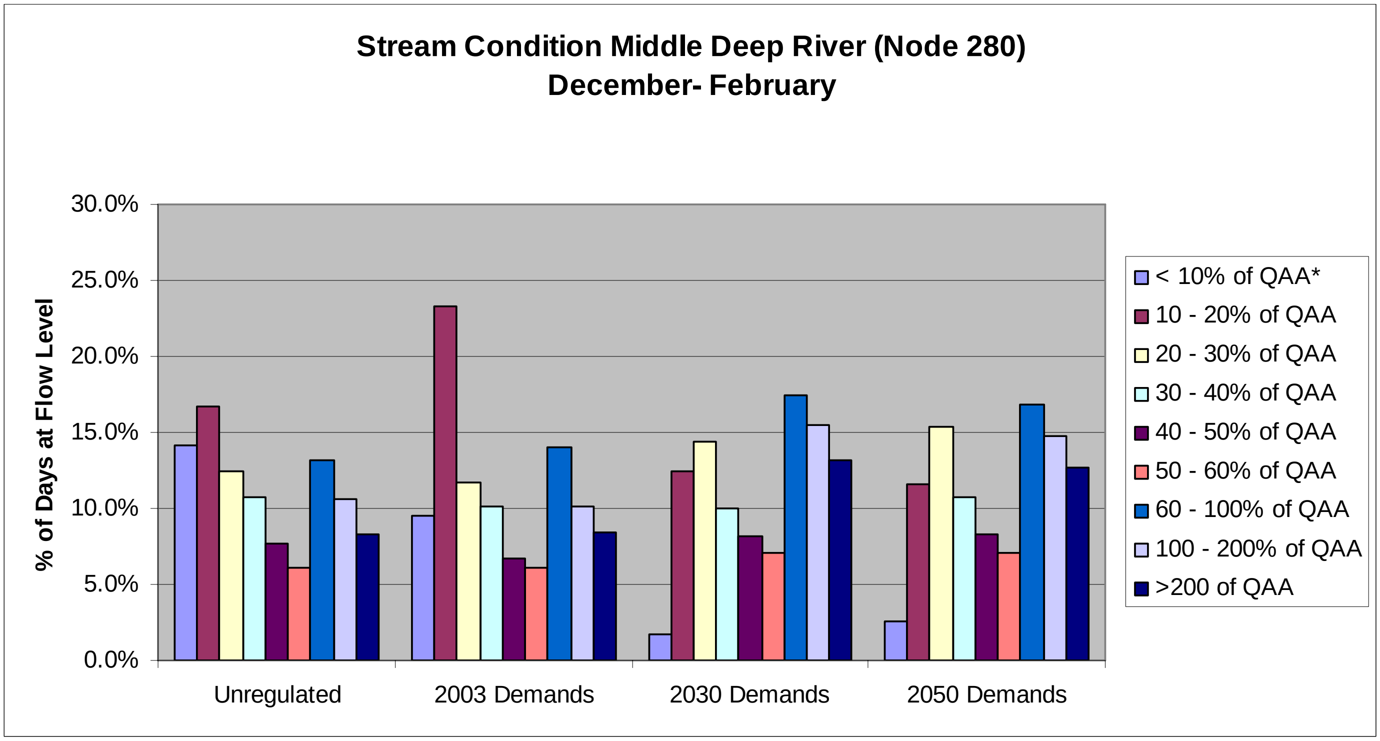
*QAA is the Average Annual Flow

The Tennant method is used as a **preliminary screening device** to see how projected increases in water use will affect stream flows at selected locations. When new or increased water withdrawals are planned, the permitting process will require site-specific in-stream flow studies to determine required in-stream flow levels.

The following plots show an example of a summary of stream flow levels using the Tennant Method for one of the points of interests identified in Table 5. Daily stream flows at all points of interest were estimated using the model for the entire 76-year record. Then, the percentage of days over the 76-year period within each of the various stream flow ranges was calculated.

The complete summary of results at all points of interest will be made available on the Division of Water Resources website under Cape Fear River Basin Planning.

Figure 33: Stream Condition for the Middle Deep River – Dec-Feb

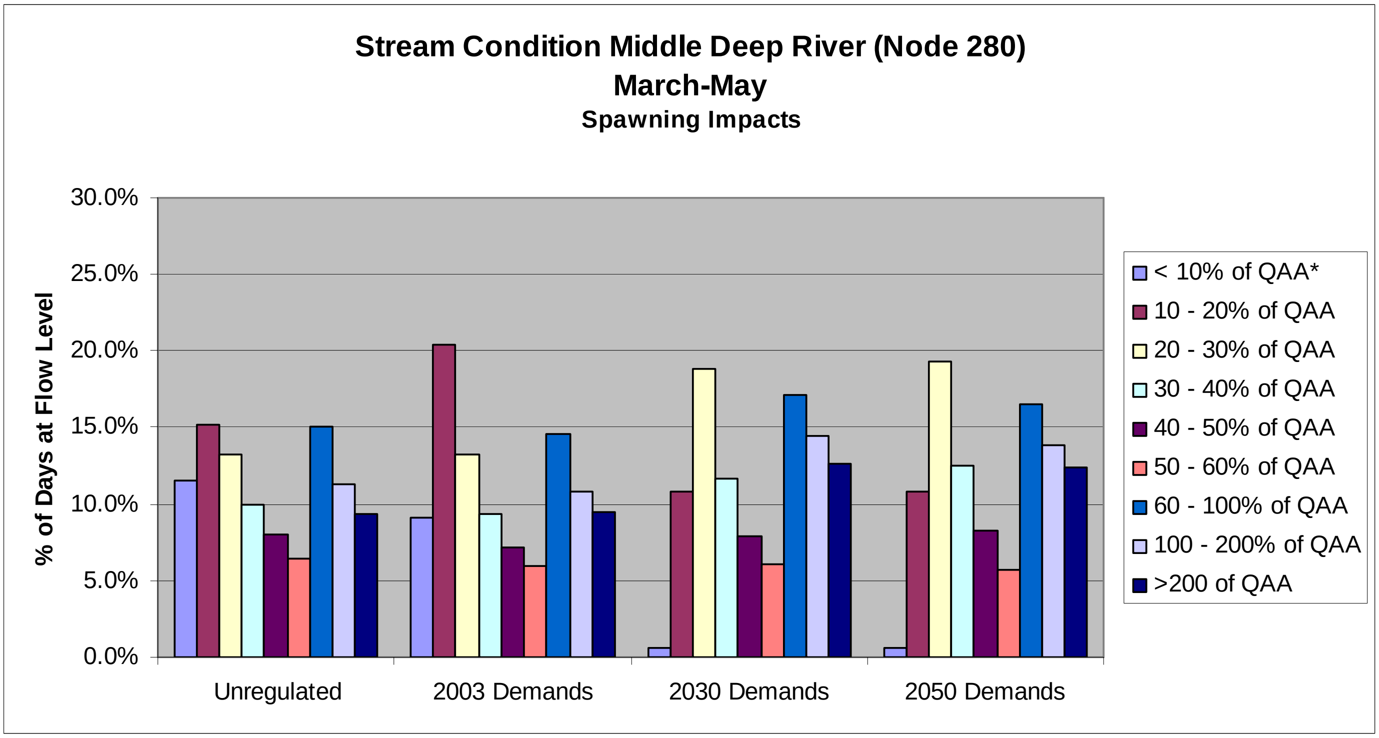


***QAA (average annual flow) at Node 280 = 227 mgd**

Table 7

Level	Dec-Feb	Unregulated	2003 Demands	2030 Demands	2050 Demands
1	< 10% of QAA*	14.1%	9.6%	1.7%	2.6%
2	10 - 20% of QAA	16.7%	23.3%	12.5%	11.5%
3	20 - 30% of QAA	12.5%	11.7%	14.4%	15.4%
4	30 - 40% of QAA	10.8%	10.1%	10.0%	10.7%
5	40 - 50% of QAA	7.7%	6.7%	8.1%	8.3%
6	50 - 60% of QAA	6.0%	6.1%	7.1%	7.1%
7	60 - 100% of QAA	13.2%	14.0%	17.4%	16.9%
8	100 - 200% of QAA	10.6%	10.1%	15.5%	14.8%
9	>200 of QAA	8.3%	8.4%	13.2%	12.7%

Figure 34: Stream Condition for the Middle Deep River – Mar-May

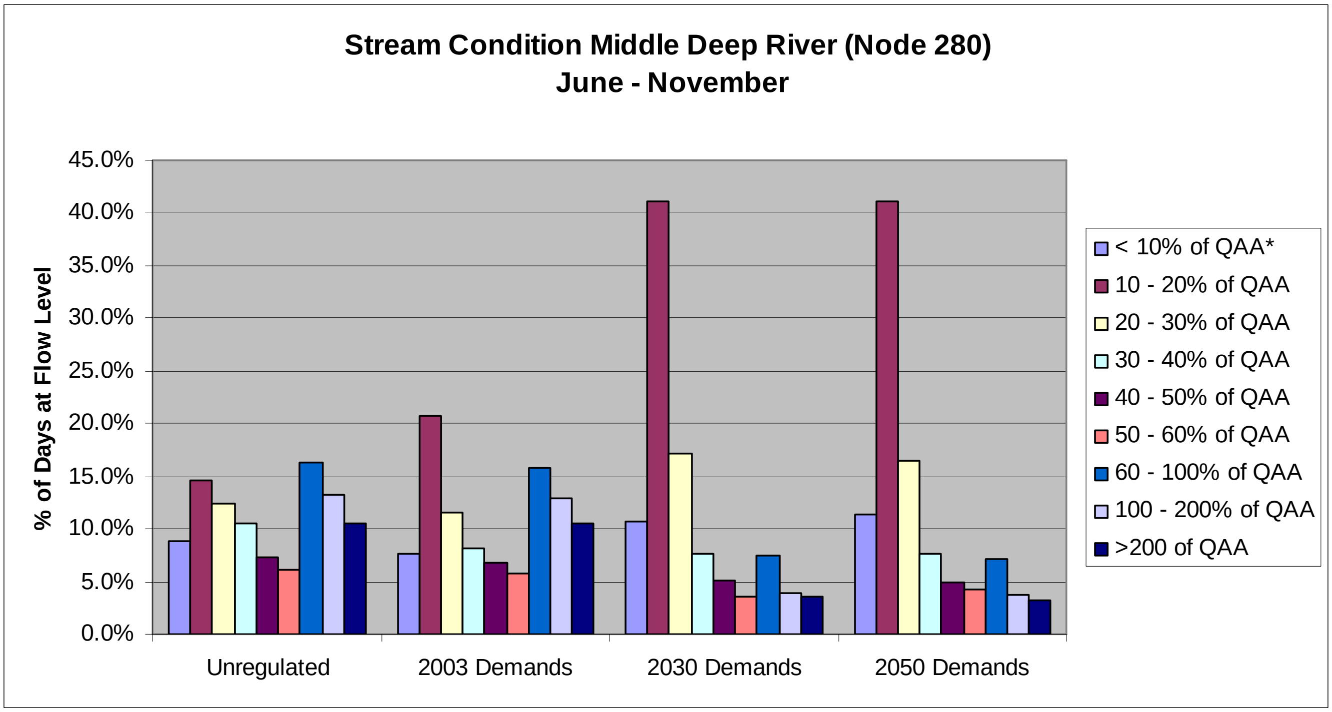


***QAA (average annual flow) at Node 280 = 227 mgd**

Table 8

Mar-May	Unregulated	2003 Demands	2030 Demands	2050 Demands
< 10% of QAA*	11.5%	9.1%	0.6%	0.6%
10 - 20% of QAA	15.1%	20.3%	10.8%	10.8%
20 - 30% of QAA	13.3%	13.2%	18.8%	19.3%
30 - 40% of QAA	10.0%	9.3%	11.7%	12.5%
40 - 50% of QAA	8.0%	7.2%	7.9%	8.3%
50 - 60% of QAA	6.4%	5.9%	6.1%	5.7%
60 - 100% of QAA	15.0%	14.6%	17.1%	16.5%
100 - 200% of QAA	11.2%	10.9%	14.5%	13.9%
>200 of QAA	9.4%	9.5%	12.6%	12.4%

Figure 35: Stream Condition for the Middle Deep River – June-Nov



***QAA (average annual flow) at Node 280 = 227 mgd**

Table 9

June-Nov	Unregulated	2003 Demands	2030 Demands	2050 Demands
< 10% of QAA*	8.9%	7.6%	10.7%	11.3%
10 - 20% of QAA	14.6%	20.7%	41.0%	41.1%
20 - 30% of QAA	12.3%	11.6%	17.1%	16.5%
30 - 40% of QAA	10.6%	8.1%	7.6%	7.7%
40 - 50% of QAA	7.3%	6.8%	5.1%	5.0%
50 - 60% of QAA	6.0%	5.8%	3.6%	4.2%
60 - 100% of QAA	16.3%	15.7%	7.5%	7.2%
100 - 200% of QAA	13.3%	13.0%	3.9%	3.7%
>200 of QAA	10.6%	10.6%	3.5%	3.3%

Stream Flow Duration Curves

The following flow duration curves for the flows at Lillington and Lock and Dam #1 are included because of their particular interest. These results and flow results for other nodes and other model outputs are available at:

http://www.ncwater.org/Data_and_Modeling/CF/

Flows at Lillington

The duration curves for flows at Lillington have an unusual shape during low flow times. This is explained by how the model handles Jordan Lake operations. During low flow periods, the model operates Jordan Lake by strictly following the drought operations plan. The model releases water from the lake to meet a downstream target flow at Lillington. For example, during Drought Stage 1, the model meets a downstream flow of 600 cfs at Lillington. For this reason, the curves tend to flatten at the 600 cfs flow level. The length of the flat segment represents the amount of time the lake is operating under Drought Stage 1. The same is true for the other drought stages but at different flow levels.

As expected, all of the demand scenarios are above the unregulated curve during low flow periods. This is true because during low flow periods, the lake is releasing water to maintain-stream flows above what would occur if the lake were absent. During higher flow periods, the unregulated curve is higher than the demand scenarios. This is because during high flows, the lake often stores much of the inflow, releasing less downstream than would occur were the lake absent.

Flows at the Locks and Dams

The duration curves at the lock and dams are smooth. This is because the locks and dams are far enough downstream of the lake that the lake releases are no longer the dominant factor in determining the stream flows. However, the effects of Jordan Lake are still apparent. Flows under the three demand scenarios are higher than the unregulated flows during low flow periods and lower during high flow periods.

Figure 36: Lillington Flow Duration Curve

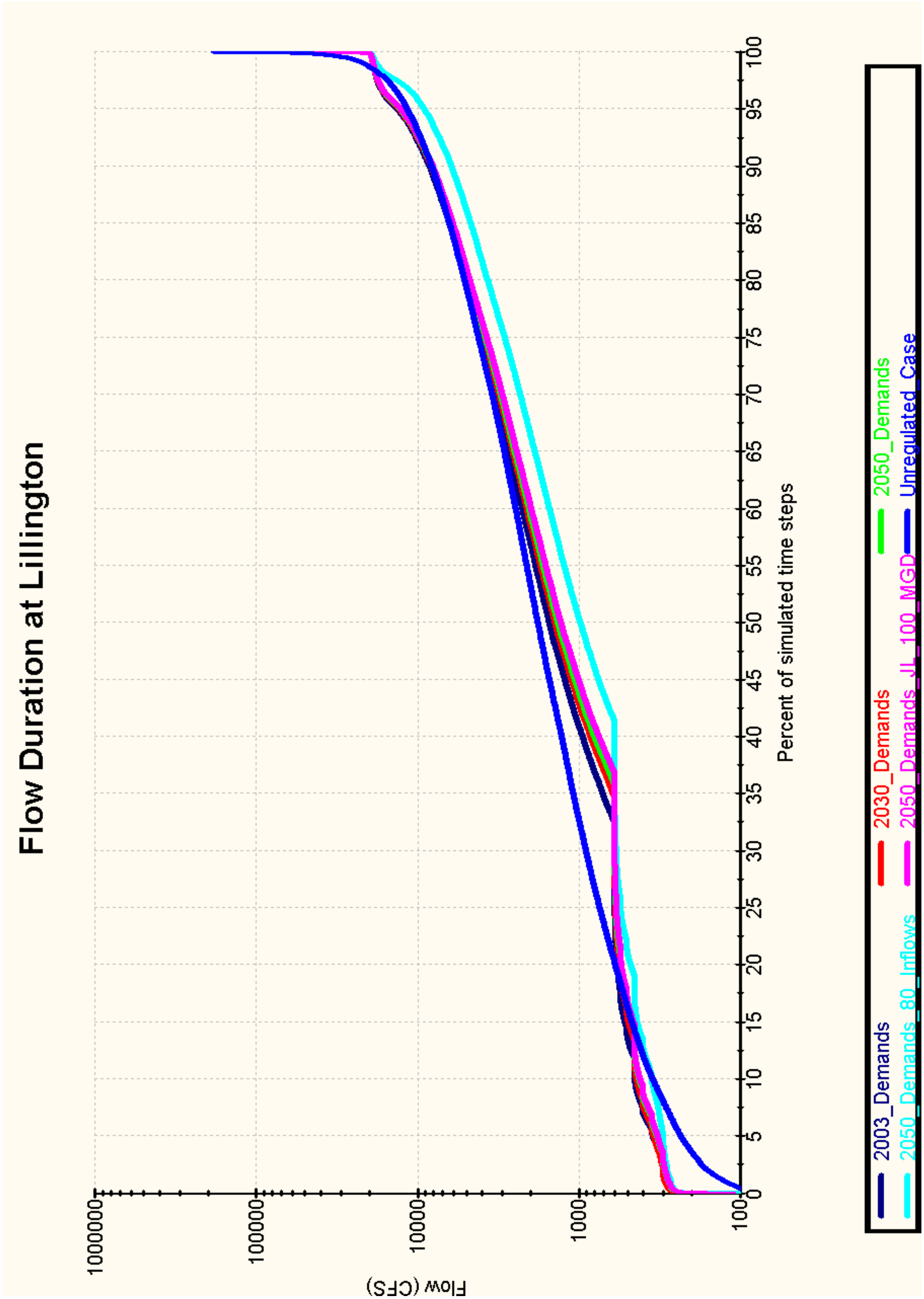


Figure 37: Lillington Flow Duration Curve - Close-up

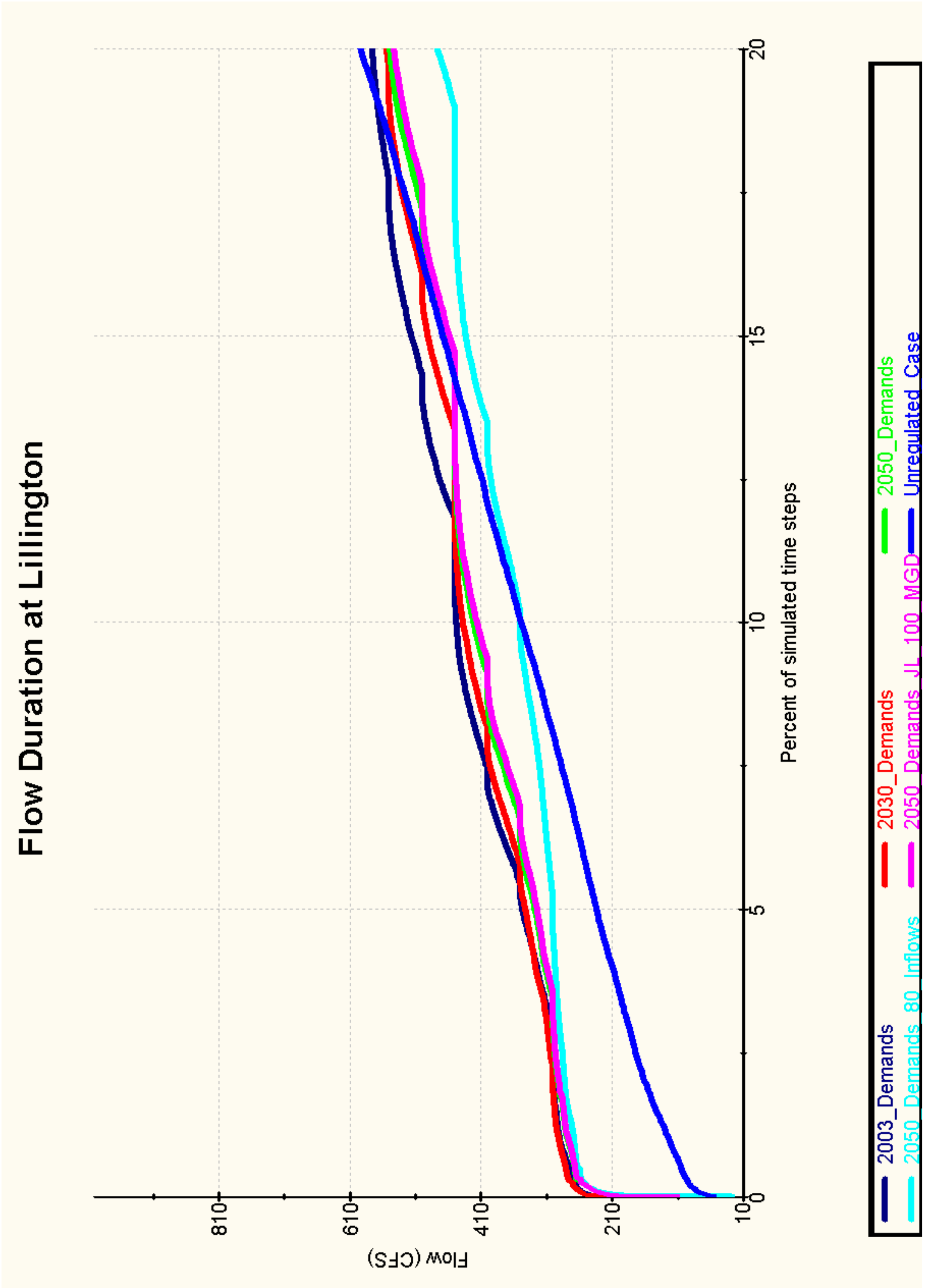


Figure 38: Lock and Dam #3 Flow Duration Curve

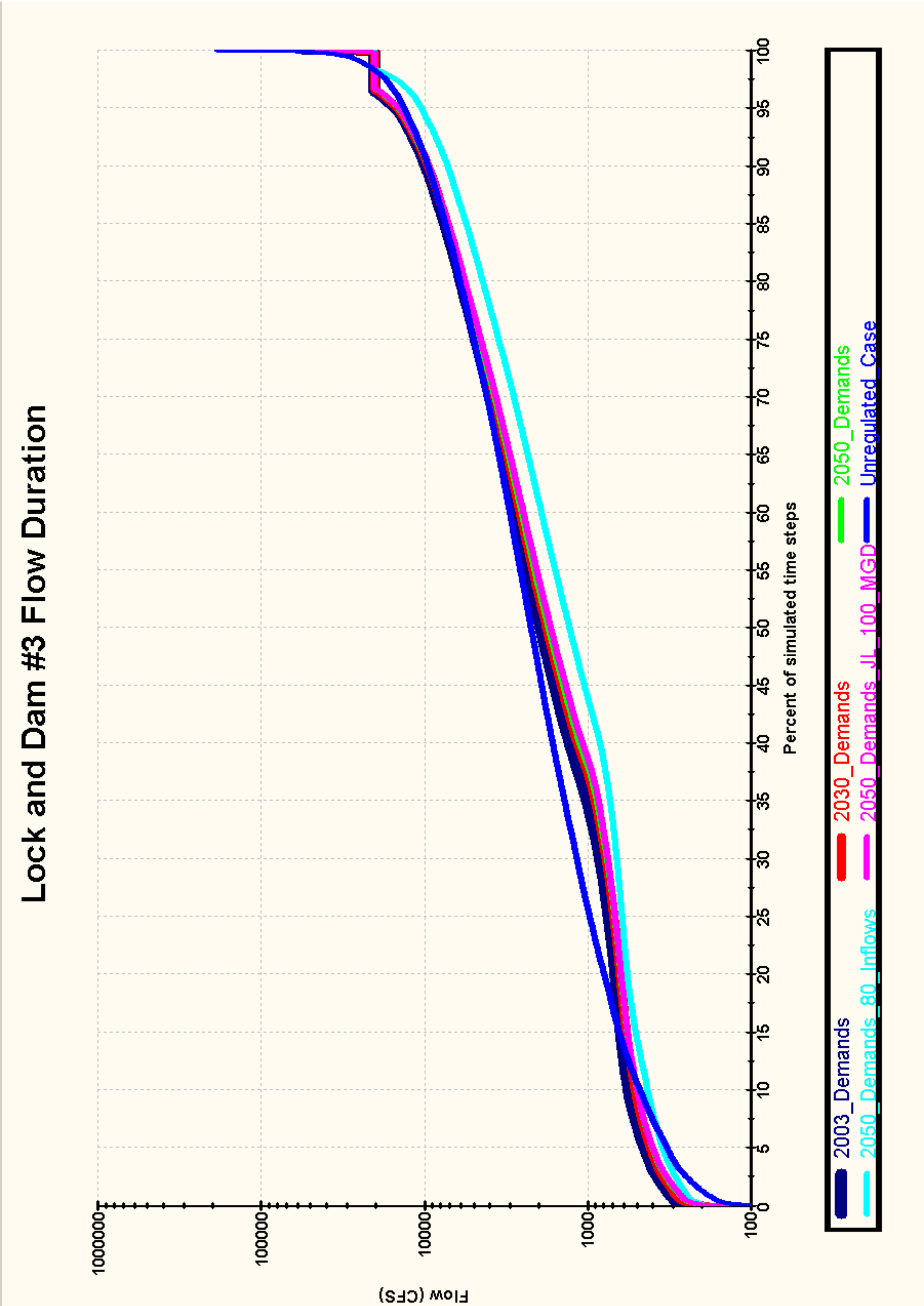


Figure 39: Lock and Dam #3 Flow Duration Curve _ Close-up

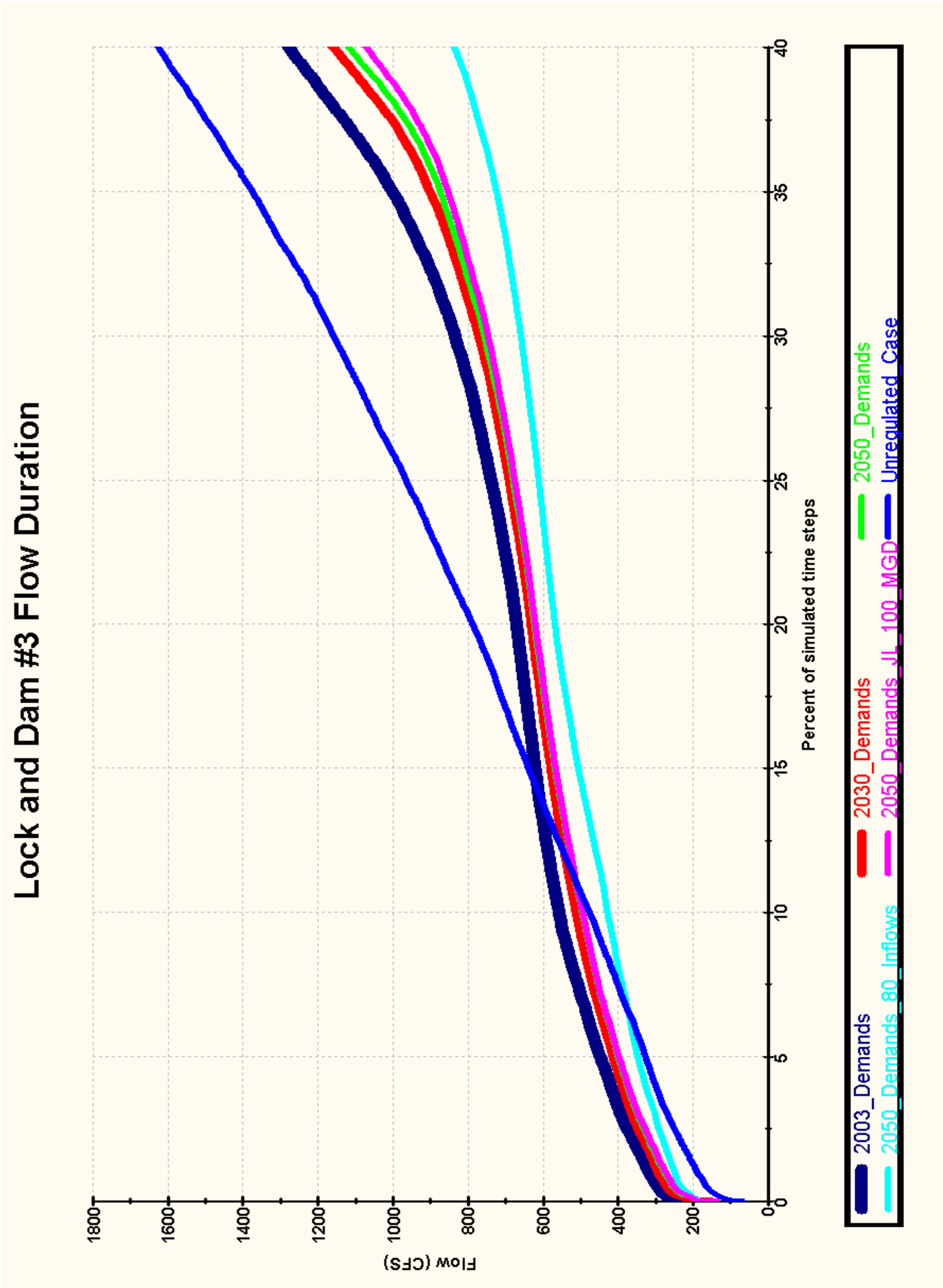


Figure 40: Lock and Dam #1 Flow Duration Curve

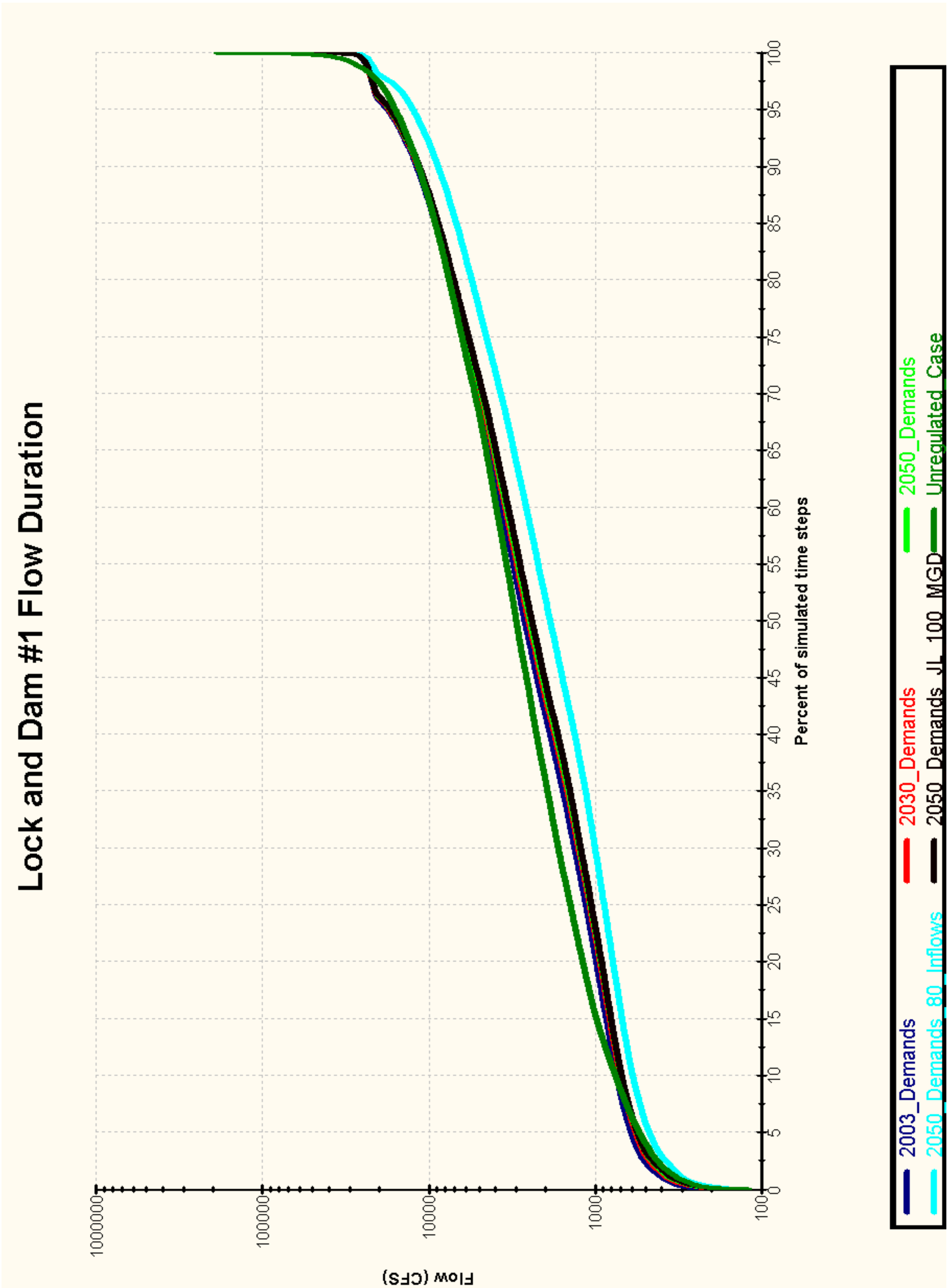
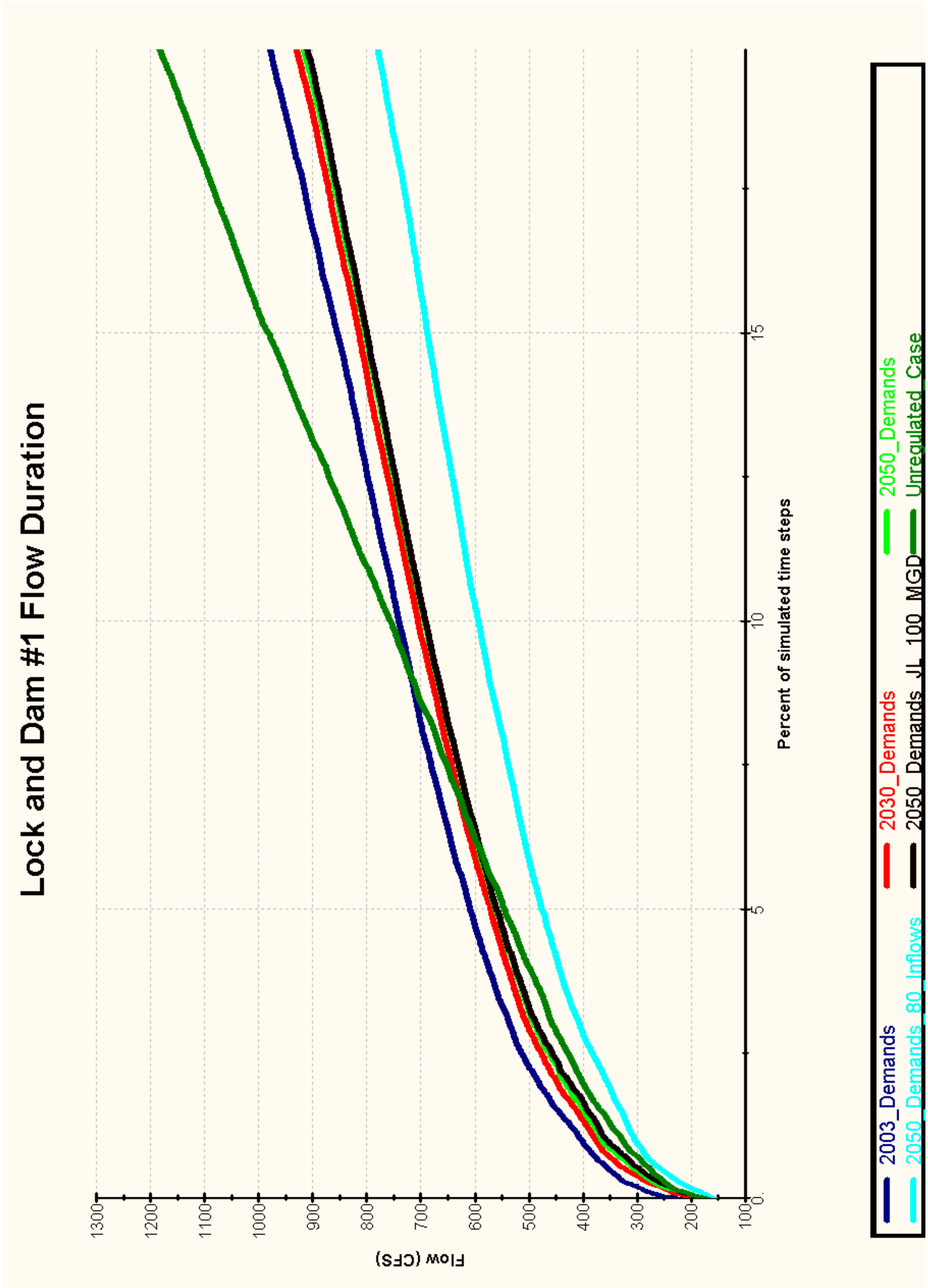


Figure 41: Lock and Dam #1 Flow Duration Curve - Close-up



VII. Other Model Results

All of the model results in this reports along with output for any other model nodes of interest are available at the following Division of Water Resources website:

http://www.ncwater.org/Data_and_Modeling/CF/

VII. Comments

After the meeting in May, we received some written comments from Professor Richard Whisnant, Sydney Miller, Paul E. Peterson, Mick Noland, Mick Greeson that have helped to improve with the final version of this document.

Jucilene,
Here is some feedback for you on the report. I thought the report was very well written, particularly in its summary description of the model and the Jordan Reservoir storage system. I appreciate that.

I have the following suggestions for future reports. First, I do not recall a discussion of uncertainty in the report. I think the authors of future such reports should explicitly discuss the uncertainty and confidence levels associated with the inputs, assumptions and outputs in the model. Even better would be some explicit sensitivity analysis--what are the most sensitive variables?

Second, I believe any future such reports by the Division should include a model run with explicitly conservative low-flow assumptions. The question many people will want an answer to is: if flows are again as low as they were in 2007-08, and demand is up to 2050 projections including those left out of the March 2008 report, and it is on average 4 degrees F. hotter as the IPCC says it likely will be, and there is a lot more flashiness in the basin both from urbanization and changes in precipitation patterns, what are the concerns about water supply in the basin, for drinking water, cooling water, irrigation and in-stream flows?

We have started a page on the water wiki (our website for collecting and discussing information relevant to the water allocation study) that discusses these assumptions, the ones we are aware of. I would very much appreciate any input that division modelers have on this page of the wiki. http://sogweb.sog.unc.edu/Water/index.php/River_basin_models Having missed all the meetings thus far on the Cape Fear model, I am sure there is a lot more I have to learn about it.

Finally, I am having trouble finding a summary of the agricultural water use data plugged into the model. Your data page has a .pdf document describing the methodology for collecting the data, but I assume there is a table somewhere comparable to the table for public water supplies that was included in the March report document, showing what water use values were actually plugged into the model. I think those values should be made explicit and public--probably they are and I just can't seem to find them.

Thanks again to all in the division who are working on these models,
Richard Whisnant
UNC Chapel Hill
919.962.9320

MEMORANDUM

Date: March 26, 2008

To: Phil Fragapane, NC Division of Water Resources

From: Sydney Miller, Water Resources Program Manager

Subject: Draft Cape Fear River Basin Water Supply Plan (March 20, 2008)

I have reviewed the *Draft Cape Fear River Basin Water Supply Plan: Modeling of Future Water Use Scenarios* dated March 20, 2008. I offer the following comments and questions.

1. Pages 6 and 14 – Do the 2030 Demands and 2050 Demands scenarios use current Jordan Lake water supply storage allocations? The 2030 and 2050 scenarios I had developed assume increased allocations in some cases, consistent with the methodology for the previous iteration of the Draft Cape Fear River Basin Water Supply Plan.

2. Page 7 – Natural inflows are represented by purple arrows and wastewater discharges are represented by brown arrows in the OASIS model.

3. Pages 12-14 – Are the 2030 Demands and 2050 Demands scenarios based on the draft 2030 and 2050 scenarios that I provided on March 13, 2008? I incorporated some changes in the "Jordan_WQ_WS_Accounts" OCL file that prevent water supply storage accounts from going into negative quantities and also limit water supply deliveries to no more than the amount available in storage plus inflow.

4. Page 14 – With the Jordan Lake water supply storage pool fully allocated and under a total demand of 100 mgd in the 2050 Demands scenario, the water quality pool performs more similarly to the 2030 Demands scenario.

5. Pages 18-51 – I think the plots of duration curves for each of the scenarios by parameter are the best way to show the relative differences between scenarios.

6. Page 25 – In the 2050 Demands scenario with current Jordan Lake allocations and with the corrected "Jordan_WQ_WS_Accounts" OCL file, there is a shortage in meeting Morrisville's demand for 9 days in the period of record.

7. Pages 41-45 – In displaying the results of the modified Tennant Method for evaluating in-stream flows, consider showing the cumulative percentages for the flow levels as a single bar for each scenario. For example, in the chart on page 43, rather than having 9 bars for each scenario, there would be one bar for each of the four scenarios. The first bar (the Unregulated scenario) would show level 1 at 0.3%, level 2 at 2.2%, level 3 at 7.5%, level 4 at 14%, etc.

The only other comment I have at this time (other than those listed below by Paul Peterson, consultant to PWC) is as follows: How will the State verify that the Rocky River Reservoir and Randleman Reservoir are being operated in accordance with the guidelines that are assumed in the modeling runs? There needs to be some type of reporting requirement that is timely enough for the Corps to use in determining release rates during drought conditions.

Mick Noland
Chief Operating Officer
Water Resources Division
Public Works Commission of the
City of Fayetteville

Mick,

I took a look at DWR's March 20, 2008 draft Cape Fear River Basin Water Supply Plan (Modeling of Future Water Use Scenarios). I have a few initial comments:

Page 9: For 2050, the assumed Western Wake Regional WRF discharge is 20.6 mgd. Is that consistent with current plans for this WRF? This is an important assumption since page 14 highlights that the increased future discharges from the Western Wake WRF will relieve stress on the Jordan Lake water quality pool to meet the Lillington in-stream flow target.

Page 24: Fayetteville's demand at the Cape Fear demand node was reportedly met for the full record, while it is stated that the deficit at Glenville Lake would be met by increasing withdrawals from the Cape Fear River. Is there some way to easily confirm that the deficit at Glenville Lake could have been offset in all cases? If deficits are simulated for PWC and other utilities, and could have been offset through other sources for those systems, then aren't we underestimating total basin demand during critical low flow periods by not simulating those offsets?

Page 25: The simulated Glenville Lake deficit of 97.1 days per year on average (or 27% of the time) highlights the need to confirm that the deficit at Glenville Lake could have been offset in all cases through increased withdrawals from the Cape Fear River.

Other: Is there an outline for the complete Cape Fear River Basin Water Supply Plan? In DWR's March 2002 draft plan, available supply was quantified for each system and compared against the demand projections.
Is that sort of comparative analysis planned for this updated plan?

Paul E. Peterson
Malcolm Pirnie, Inc.
701 Town Center Drive
Suite 600
Newport News, VA 23606
757-873-4347 (phone)
757-593-0193 (mobile)
757-873-8723 (fax)

April 30, 2008

<u>Via Email</u>

Mr. Phil Fragapane
DENR – Division of Water Resources
1611 Mail Service Center
Raleigh, NC 27699-1611

Subject: Cape Fear Water Model

Dear Mr. Fragapane:

The North Carolina Wildlife Resources Commission (NCWRC) provides the following comments upon reviewing The North Carolina Division of Water Resource's draft "Cape Fear River Basin Water Supply Plan: Modeling of Future Water Use Scenarios" dated March 20, 2008.

Introduction

This section would benefit from the addition of several paragraphs explaining the purpose and need for the modeling effort and how the results will be used. Explaining how this modeling process is related to the statewide and basin water supply plans would help the reader understand the context of the report. We believe the title of the report and the content of the report should compatible. This document is not the water supply plan for the Cape Fear River basin, but rather a summary of modeling results which are an important input to developing/revising the water supply plan. Furthermore, the modeling report is useful not only for (human) water supply decisions, but could be used for water management in a larger sense.

The first paragraph seems more appropriately located in Section II, Model Assumptions, which should be retitled as Model Description and Assumptions. Paragraphs three through seven in this section are further details of the model and should be moved to Section II.

Although this model is based on a fairly significant period of record, it is important to continue to add data for the model to be as accurate as possible. Specifically, data from the 2007 drought should be added to the Cape Fear River model as it has shed light on many areas with insufficient water to meet demand.

Scope of the Model

The model does not appear to include the Black River or Northeast Cape Fear River sub-basins. Are there other portions of the Cape Fear basin that are not included in the model? Please explicitly state which portions are not included, explain why they are not part of the model, and if they will be included in a future update.

Scenarios Modeled

Please describe how evaporation from the reservoirs was handled by the model for Scenario 1. It should have been set to zero.

It is unclear in the descriptions for Scenarios 2 - 4 exactly how the proposed plans described in paragraphs 3-7 of the Introduction were handled in the model. Please clarify.

We suggest that a new scenario be modeled; one that fully allocates the water supply pool (approximately 100 mgd) of Jordan Lake.

Model Assumptions – Inputs

Estimated Daily Natural Inflows – Please describe how the Estimated Daily Natural Inflow dataset was developed. Was it based on a variety of stream flow gages in the watershed? If so, which ones? If the gages were not on the modeled stream node, how were the gage records adjusted for differences in watershed size. It appears from the figures (please number the figures) on pages 4 and 5 that only two Daily Natural Inflow input nodes were used – one on the Rocky River and one on the Deep River. Please describe why natural inflows were not used on the many other streams in the basin.

Daily Withdrawals – During the March 20, 2008 meeting it was explained that the annual average withdrawals for each node was adjusted on a monthly basis to reflect differences in demand throughout the year. Please include a description of this in the report and provide an example in a table.

The unnumbered table (please number the tables) on pages 9 – 11 lists the water withdrawals and discharges for the base case scenario and for 2030 and 2050 projections. In some cases the table indicates a drop in use from 2003 to 2030 and then an increase again between 2030 and 2050 (e.g., Fuquay-Varina). Please explain. It would also help if you could provide a summary table that indicates how the number and percentage of nodes, by type of withdrawal (e.g., water supply, industry, agriculture, etc.) showing a decrease, no change or an increase over time. For those nodes that show no change or a decrease from the base case condition, please explain the reason. Also, please describe how the individual water users take into account any changes in use due to a drop in per capita use due to more efficient use or mandatory restrictions?

Please explain the assumptions and rationale for dealing with groundwater and wells. For example, increases in the number of private and public wells could affect the baseflow of a stream, and therefore, the Natural Inflow dataset. Also, wastewater discharges from well systems could increase the stream flows in certain areas.

Daily Wastewater Discharges – Water reclamation and reuse is becoming more viable and common. Often the water is applied on the land surface instead of being returned to the stream. How does, or will, the model account for this change in water use, particularly during the growing season, when much of it will be lost to evaporation?

The assumption of projecting the same percentage return of wastewater in the future as under the base case scenario may not be valid in that it is basically assuming the same mixture of use by a system's customers. For example, if the current return percentage of 60% is based on a mix of 65% residential and 35% industrial, a future return percentage of 60% may not be correct if the overall demand increases and the mix becomes 90% residential and 10% industrial.

Reservoir Operating Guidelines and Data – Please describe how evaporation from the reservoirs was handled throughout the year.

Effects of Future Water Use on Jordan Lake

We understand that the Western Wake Partners are investigating a discharge to Harris Lake which would eliminate the direct discharge to Cape Fear River. Depending on available data and the timing, this may or may not be feasible. If the discharge is moved to Harris Lake, this affects several things: 1) the discharge to Cape Fear River would be reduced by about 38 mgd; 2) this would affect the model predictions for Jordan Lake and downstream, particularly for 2030 and 2050; 3) this could potentially reduce the amount of water Progress Energy withdraws directly from Cape Fear River; 4) currently Harris Lake does not have a minimum release, if the new reactors are approved and new construction on the dam occurs, it's likely this would include a minimum release from the dam, but the anticipated minimum release of 20 cfs might be affected. Please discuss these possibilities.

The report includes several figures and tables showing the percent of time that Jordan Lake is at various elevations. However, it is equally necessary to understand the absolute number and duration of occurrences that elevations drop below a given point. For example, the figure on page 17 should indicate the number of times that the stage 1, 2 and 3 triggers are made, along with the median and maximum duration of the events.

Water Supply Demands vs. Delivery

The second paragraph on page 24 include the sentence: "In general, for the Cape Fear model, water supply demands have a higher weight than the in-stream flow needs, and therefore are met first." We are unsure how to interpret the meaning of this sentence. As used here, what does the term "weight" mean? Did the model logic require that water supply demand be met before providing an in-stream flow or was a percentage of in-stream flow met?

We recognize the need to meet public water supply demand, but since the model does not yet include the worst drought on record, we believe the model should be extremely conservative in allocating water to meet future water supply demands (e.g., a local government requesting an increase from 40 mgd to 90 mgd). The model should err on the side of leaving more water in the river rather than allocating the maximum amount available based on the current model. We strongly request that we be included in the process of developing appropriate in-stream flow targets and requirements so that the model can provide a better indication of the areas of concern.

Water Supply Intake Impacts

The report states: "In case where a water system has more than one water source, one reservoir could be allowed to be exhausted while holding the other source in reserve." Is this how some water supply reservoirs are actually managed, or is this just how the model was designed? We believe that there should be some provision, in the model and in real practice, to protect the aquatic resources of the reservoirs from being eliminated due to a complete drawdown.

In-stream Flow Evaluation

Our interest in the in-stream flow evaluation is at two levels – a general concern for protecting the fish and wildlife resources of the Cape Fear basin, and a specific concern for protecting rare species. There are two federally endangered species in the Cape Fear Basin and a number of state-listed species. The Shortnose Sturgeon is located downstream of lock and dam #1. The Cape Fear Shiner is found in the Deep, Rocky, Haw, and Cape Fear rivers, although the populations in the Haw and Cape Fear are very small. The complete list of priority species in the Cape Fear basin is quite large (Table 1).

Table 1. Priority aquatic species in the Cape Fear River Basin as listed in the "North Carolina Wildlife Action Plan (2005).

Group	Common Name	State Status (Federal Status)
Fish	Shortnose Sturgeon	Endangered (Endangered)
	Cape Fear Shiner	Endangered (Endangered)
	Atlantic Sturgeon	Special Concern
	Highfin Carpsucker	Special Concern
	Thinlip Chub	Special Concern
	Carolina Darter	Special Concern
	Bluefin Killifish	Special Concern
	Least Killifish	Special Concern
	Broadtail Madtom	Special Concern
	Sandhills Chub	Special Concern
	Roanoke Bass	Significantly Rare
	Pinewoods Shiner	Significantly Rare
	Carolina Redhorse	Significantly Rare
	Snail Bullhead	
	Everglades Pygmy Sunfish	
	Banded Pygmy Sunfish	
	Blackbanded Sunfish	
	Banded Sunfish	
	Lake Chubsucker	
	Banded Killifish	
	Lined Topminnow	
	Dollar Sunfish	
	Spotted Sunfish	
	Notchlip Redhorse	
	Shorthead Redhorse	
	V-lip Redhorse	
	Comely Shiner	
	Ironcolor Shiner	
	Taillight Shiner	
	Sea Lamprey	
	Sailfin Molly	
Mussels	Brook Floater	Endangered
	Barrel Floater (possibly extirpated)	Endangered
	Atlantic Pigtoe	Endangered
	Yellow Lampmussel	Endangered
	Savannah Lilliput	Endangered
	Carolina Creekshell	Endangered
	Triangle Floater	Threatened
	Roanoke Slabshell	Threatened
	Eastern Lampmussel	Threatened
	Eastern Pondmussel	Threatened
	Creeper (Squawfoot)	Threatened
	Notched Rainbow	Special Concern
	Pod Lance	Special Concern
	Cape Fear Spike	Special Concern
	Eastern Creekshell	Significantly Rare
	Box Spike	
	Carolina Slabshell	
	Variable Spike	
Crayfish	Greensboro Burrowing Crayfish	Special Concern
	Carolina Ladle Crayfish	Significantly Rare
	Sandhills Spiny Crayfish	Significantly Rare
	Croatan Crayfish	Significantly Rare
	Edisto Crayfish	
Snails	Greenfield Rams-horn	Endangered
	Magnificent Rams-horn	Endangered
	Rotund Mysterysnail	Significantly Rare

Based on the list of rare species and other factors, the North Carolina Wildlife Action Plan (2005) lists the following watersheds in the Cape Fear River basin as priority watersheds for conservation (see Figure 1 below):

- Upper Haw River
- Middle Haw River tributaries
- Deep/Rocky/Haw/Cape Fear Rivers
- New Hope Watershed above B. Everett Jordan Reservoir
- Cape Fear sandhills tributaries
- Lower Cape Fear/Black/South Rivers
- Northeast Cape Fear River
- Town Creek
- Merrick's Creek/Holly Shelter Game Lands
- Orton Pond/Military Ocean Terminal Sunny Point

Currently, the Cape Fear hydrologic model analyzes nodes only the mainstem Cape Fear and three major tributaries. In order for this model to be more useful for understanding potential impacts to in-stream flows, we would need to see the daily flows for the period of record for each scenario at each junction node and gage node. Additional nodes may need to be added to represent some of the priority watersheds. A good quality map clearly showing each node and arc is also required. The maps in the document and on the web site are of poor quality.

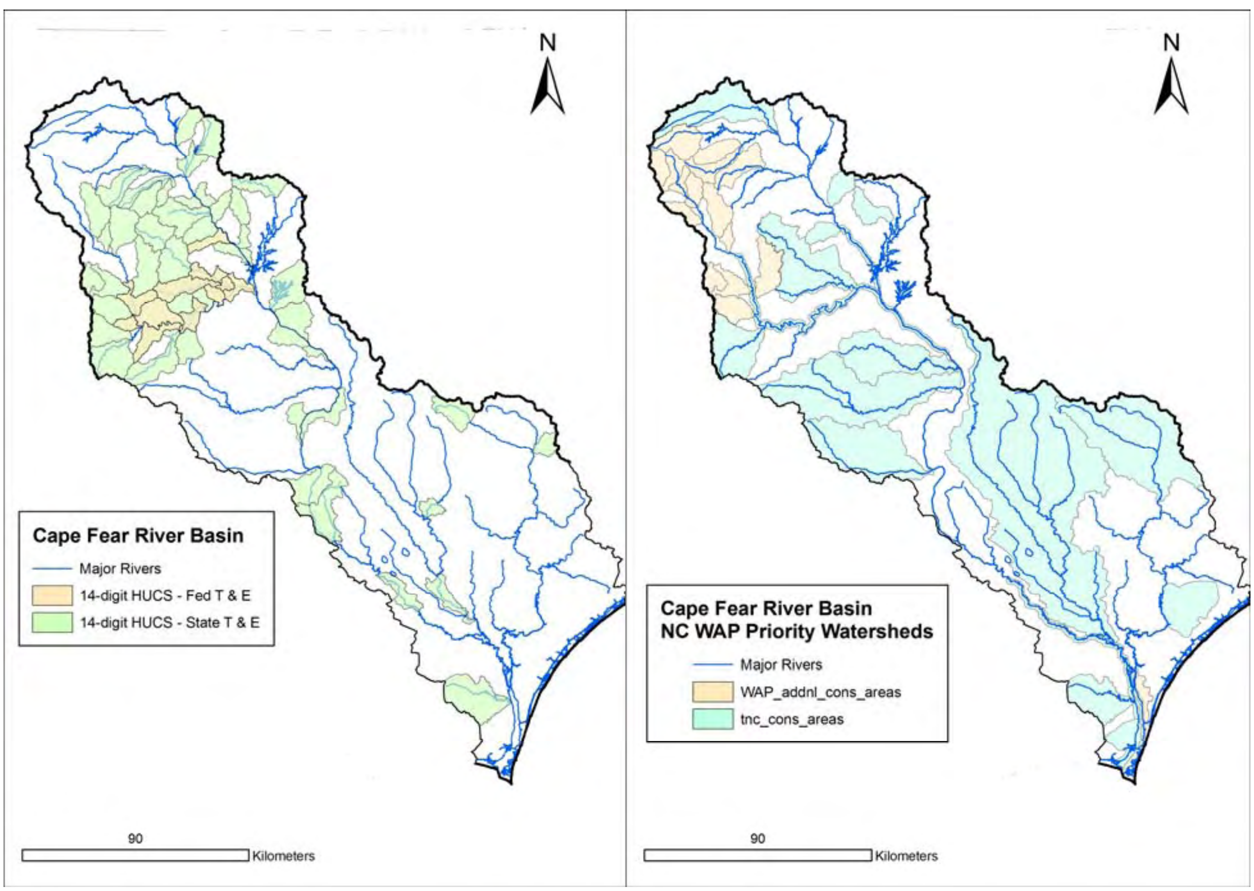


Figure 1. Maps from the Wildlife Action Plan (2005) showing watersheds containing state and federal listed species (left) and priority watershed for conservation (right.

We also reviewed the separate document “Cape Fear River Basin Model In-stream Flow Analysis”. For each node we suggest that the median flow be reported in addition to the mean annual flow. The graph for node 280 (December – February) is missing. The graph and table for node 640 (March – May) is repeated.

In general, the in-stream flow analysis indicates that most of the nodes modeled showed a moderate to substantial increase in the amount of time at Level 2 (10-20% of QAA) under the current and future scenarios compared to the Unregulated scenario for the June to November time period. These impacts were seen on the Deep, Haw and Cape Fear Rivers, all of which are included on our list of priority watersheds for protecting rare species. The Cape Fear River at Lillington showed impacts during all months, with more than 50% of the time in Level 2, compared to 21% in the Unregulated scenario.

The analysis seems to show that the impacts are less at the lowermost nodes, suggesting that greater impacts may be occurring on the smaller rivers and streams in the upper portions of the basin. If this is the case, our need to have additional data for the smaller streams using this model or some other approach becomes critical.

Finally, as we stated in our February 12, 2008 letter, we believe that the analysis conducted as part of this study should only be used as a basic screening tool, not to analyze scenarios at a site-specific level, and we have concerns about using the Tennant method in North Carolina. We repeat our recommendations that other methods of screening (e.g., IHA and ELOHA) should be investigated as tools for understanding the impacts to in-stream flows.

General Comments

As population increases in the Cape Fear River, so will the demand for water. Minor droughts may be exacerbated by larger populations and the perceived need to maintain water-dependent landscaping. Local water conservation plans vary widely in terms of conservation measures and triggers for implementing conservation measures (e.g., voluntary, mandatory, etc.). The disparities in the initiation and magnitude of conservation measures among local water suppliers led to confusion among the populace and a lack of confidence in the State’s ability to manage water. We recommend the development of basinwide water conservation plans based on primarily on hydrological triggers (e.g., reservoir level, water quality and/or water supply pool remaining, etc.), and less on financial triggers. When the hydrologic trigger is reached, then all local governments should be required to adopt similar water conservation measures. The model should be updated to include a basinwide conservation plan (triggers and reductions) to understand how the impacts to water supplies and in-stream flows would be reduced.

The 7Q10 table in the first draft of the report was useful and should be included in the final report as a way to understand how water quality, and therefore habitat, are expected to be affected by current and future scenarios.

Requests to construct “off-line” reservoirs and skim high flows have been increasing and it is likely these will increase even more following this drought. While one or two of these projects may not have a significant impact on in-stream flow, we expect that multiple off-line reservoirs could affect the river system. Updates to the model should take into account projected use of this technique.

Thank you for the opportunity to provide input. If DWR is contemplating similar efforts for other river basins, please let us know at an early stage so we may have sufficient time to provide you with meaningful input. If you have any questions concerning these comments, please contact me at 828-652-4360 ext. 223.

Sincerely,

Christopher Goudreau
Special Projects Coordinator

April 30, 2008

NC Division of Water Resources
1611 Mail Service Center
Raleigh, NC 27699-1611

Dear Ms. Jucilene Hoffmann:

Progress Energy Carolinas, Inc. (PEC) owns and operates four thermoelectric plants in the Cape Fear River Basin that depend on the water resources in the Basin for cooling and other operational needs. Moving upstream from the mouth of the Cape Fear River, the PEC plants located in the Basin are as follows: the Brunswick Nuclear Plant located near Southport, NC; the Sutton Plant located near Wilmington, NC; the Harris Nuclear Plant located near New Hill, NC; and the Cape Fear Plant located near Moncure, NC. Accordingly, PEC is especially interested in the Cape Fear River Basin Hydrologic Model and the management of the water resources in the Cape Fear River Basin. The company has received and reviewed the March 20, 2008 draft of the report titled "Cape Fear River Basin Water Supply Plan: Modeling of Future Water Use Scenarios," and offers the following comments:

The discharge data for PEC's Harris Nuclear Plant listed in the table titled "Demands and Discharge Assumed in the Modeling" is not accurate. For node #524, the flow for 2003 is listed as 5.82 MGD. PEC's records indicate that the average daily discharge from the Harris Nuclear Plant for 2003 was 19.5 MGD.

The discharge data for PEC's Cape Fear Plant listed in the table titled "Demands and Discharge Assumed in the Modeling" is not accurate. For node #512, the flow for 2003 is listed as 202.29 MGD. PEC's records indicate that the average daily discharge from the Cape Fear Plant for 2003 was approximately 194 MGD.

PEC appreciates the opportunity to review and comment on the draft plan. Should you have questions or require additional information, please contact Mick Greeson at (919) 546-5438 or me at (919) 546-3775.

Sincerely,

Caroline Choi
Director, Energy Policy and Strategy

CC:mrg