RESERVOIR FISH HABITAT ASSESSMENT
AQUATICS 02

Executive Summary

Aerial estimates at 1-foot contours for 7 shallow water fish habitats (8 in Lake Wateree) were determined for the drawdown zones in 10 of the 11 Catawba-Wateree River reservoirs and evaluated for losses at a range of expected pool elevations that were unique to each reservoir. Each reservoir exhibited bathymetry and distributions of habitat that resulted in somewhat different estimates for each. Overall, significant amounts of fish habitat were dewatered as water levels within each reservoir receded based on existing guide curves and normal minimum pool elevations. Due to its shallow distribution in most reservoirs, vegetation/confluences was the habitat type most frequently dewatered at normal minimum pool elevations, followed by riprap/piers. At existing guide curve elevations and at elevations approaching normal minimum pool, portions of most habitat types were generally available for use by fish.

Introduction

Relicensing of the Catawba-Wateree Project requires an assessment of potential impacts to fish and wildlife resources by the project and its operations. Inasmuch as hydropower operations result in water level fluctuations in 11 reservoirs that comprise the Catawba-Wateree Project, it is important to evaluate the availability of shallow water fish habitat in the drawdown zone of these reservoirs, and to determine the relation between the amount of habitat and various water levels associated with project operations. In 2004, Duke Power implemented a study entitled Reservoir Fish Habitat Assessment (Aquatics 02 Study Plan, Appendix A) to accomplish this. The objectives of this study were to: (1) identify the magnitude, season, frequency, and duration of water level fluctuations in each reservoir, (2) evaluate vertical distributions of major shallow water habitat types in each reservoir, and (3) assess changes in the reservoir-wide surface area for the various types of shallow water fish habitat at a range of expected pool elevations.

Study Methodology

Historical operational records identifying the magnitude, season, frequency, and duration of water level fluctuations in each reservoir are summarized in Duke Power's Reservoir Level Study—Operations 02 (Duke Power 2004). Therefore, selected data (Appendix B) from this report were used to meet our first objective.

To evaluate the vertical distribution of the major types of shallow water fish habitat in each reservoir, we used fish habitat maps developed by Duke Power in 1998 that delineated full pool distributions of various habitat types (e.g., cobble, riprap/piers, vegetation/confluences, mud flats, sand, clay or clay/sand mixture in Lake Wateree, and woody debris) that were identified in consultation with resource agencies in both North

Carolina and South Carolina. Definitions and pictures of these habitats are in Appendix C. From these maps, representative transects perpendicular to the shoreline were selected and habitat elevations extending to normal minimum pool elevation or near normal minimum pool elevation were determined for each reservoir using an Abney level and stadia rod (Appendix D). The number of transects selected and their distribution throughout the reservoirs was determined from total shoreline length comprising each habitat type and its distribution in the reservoir. Ten transects were selected for all habitat types comprising more than five miles of shoreline and five transects were generally selected for habitat types comprising less than five miles of shoreline (provided five separate habitat locations were present). The vertical distributions of habitat from selected transects were summarized by one-foot contours from full pool elevations (feet above mean sea level). Full pool elevations were: 1,200.0 feet for Lake James, 995.1 feet for Lake Rhodhiss, 935.0 feet for Lake Hickory, 838.1 feet for Lookout Shoals Lake, 760.0 feet for Lake Norman, 647.5 feet for Mountain Island Lake, 569.4 feet for Lake Wylie, 417.2 feet for Fishing Creek Reservoir, 355.8 feet for Great Falls-Dearborn Reservoir, 284.4 feet for Cedar Creek Reservoir, and 225.5 feet for Lake Wateree. In this report, full pool will be referred to as the 100-foot contour and drawdowns will be at 1-foot contours below this so that data presented here are consistent with that in the Reservoir Level Study—Operations 02. Mean habitat elevations for all habitat types were then incorporated into a GIS data base that also contained full pool habitat types and bathymetric data for 10 of the 11 reservoirs. Bathymetric data originated from two sources. Data for Lake James, Lake Rhodhiss, Lake Lookout Shoals, Lake Norman, Lake Wylie, Fishing Creek Reservoir, and Lake Wateree, were collected hydroacoustically by Duke Power. Data for Lake Hickory, Mountain Island Lake, and Cedar Creek Reservoir were collected from aerial flights using Light Detection and Ranging (LiDAR) technology in winter when these reservoirs were drawn down to near normal minimum pool elevation. Unfortunately, Lake Hickory was at elevation 96.1 (95 is normal minimum pool) and Cedar Creek Reservoir was at elevation 96.8 (96 is normal minimum pool) when the LiDAR data were collected. The LiDar data collected from Great Falls-Dearborn Reservoir were not useable and no other bathymetric data were available for this reservoir. Thus, an assessment of water level fluctuations on this reservoir was not attempted. For the other 10 reservoirs, vertical distributions of habitat and bathymetric data were used to define cells of habitat at one-foot contours and area of each cell was calculated and summed by habitat type for each reservoir. This provided areal estimates of habitat at one-foot contours in all reservoirs. In addition, water willow (*Justicia americana*) was identified in 2005 as an additional habitat type of concern for Lake Wateree. Since this habitat type was not sampled in 2004, its spatial and vertical distributions within the lake were determined and these data used to approximate areal estimates of water willow at one-foot drawdowns of Lake Wateree using the same techniques employed for the other habitat types.

Results and Discussion

Lake James

The existing guide curve for this reservoir begins with an elevation of 96 feet in January which declines to 92 feet by March. Elevations increase in April and May reaching 98 feet in June. Elevations then remain here until September. After September, elevations decline to 96 feet in October and remain there through December (Appendix B). Normal minimum pool elevations are 94 feet in January, 92 feet in February-April, 94 feet in May, 96 feet in June-September, and 94 feet in October-December. Normal maximum pool elevation is 99.5 feet during all months. From 1964 through 2003, reservoir elevations were within +/- 1 foot of the target elevation 37.1% of the time, +/- 2 feet 56.7% of the time, and +/- 3 feet 69.6% of the time. Average daily elevations were generally highest in April through September, intermediate in March, October, November, and December, and lowest in January and February.

Riprap/piers, vegetation/confluences, mud flats, sand, clay, and woody debris composed most of the shallow water fish habitat in Lake James with cobble composing only a moderate amount (Figure 1). Areal estimates for all habitats at various contours were variable as reservoir elevations receded. The greatest declines in habitat were noted for riprap/piers (48%), vegetation/confluences (71%), mud flats (62%), sand (35%), and clay (23%) during a drawdown of only 1 foot (Table 1). No riprap/pier habitat was observed below an elevation of 94 feet and no vegetation/confluence habitat was observed below an elevation of 96 feet.

Because we were unable to draw Lake James down to the normal minimum pool elevation of 92 feet during the vertical mapping of shallow water fish habitat, we can only project areal estimates of habitat to a minimum pool elevation of 93 feet. However, we were able to determine that drawdowns to 93 feet eliminated only riprap/pier and vegetation/confluence habitats for use by fish. All other habitat types were available to fish at existing guide curve elevations and at elevations approaching normal minimum pool elevation.

Figure 1. Areal estimates of shallow water fish habitat at one-foot drawdowns in Lake James.

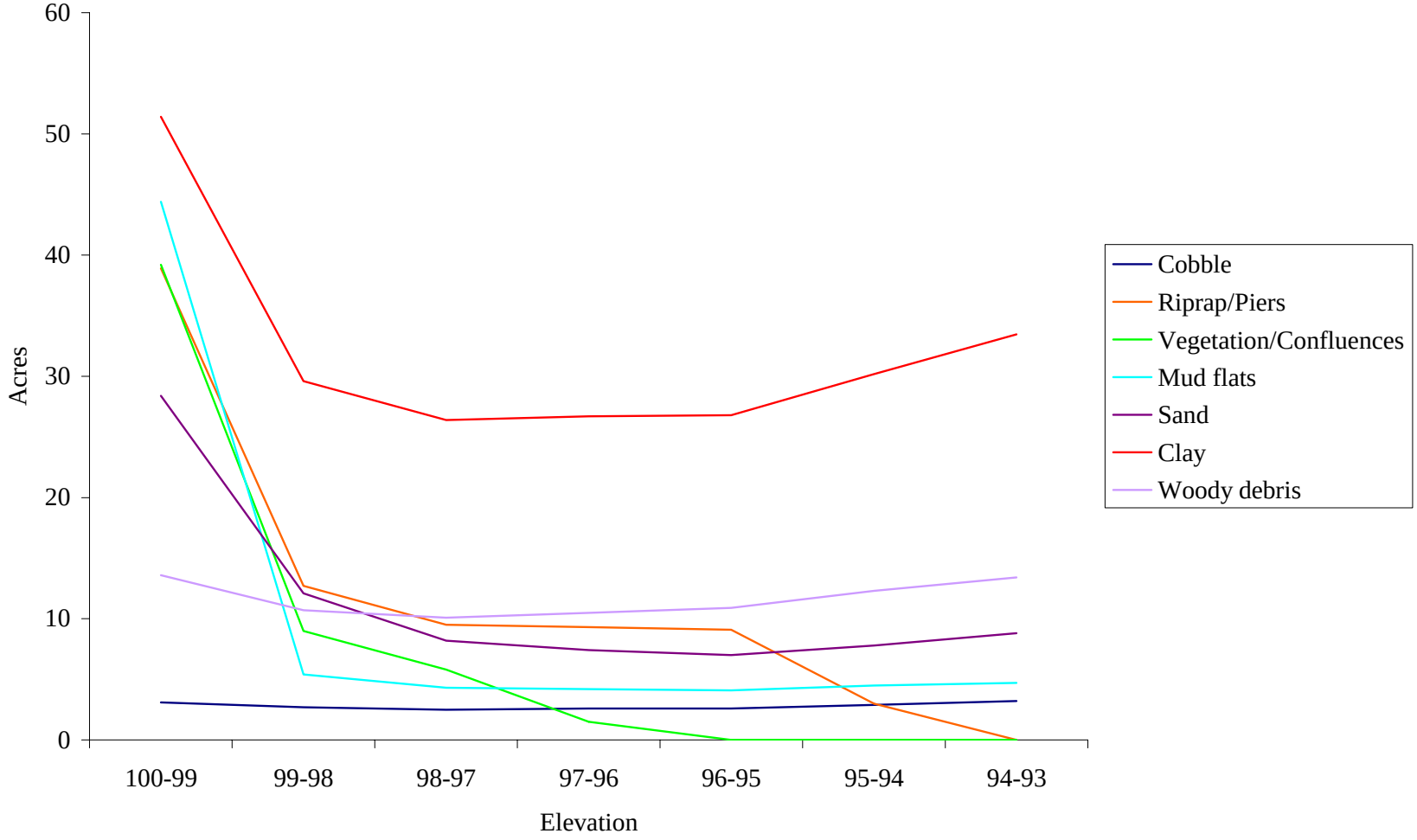

Table 1. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Lake James.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	3	20		39	82		39	55		44	71		28	79		51	224		14	82	
99-98	3	17	-15	13	43	-48	9	16	-71	5	27	-62	12	51	-35	30	173	-23	11	68	-17
98-97	2	14	-30	9	30	-63	6	7	-87	4	22	-69	8	39	-51	26	143	-36	10	57	-30
97-96	3	12	-40	9	21	-74	1	1	-98	4	18	-75	7	31	-61	27	117	-48	11	47	-43
96-95	3	9	-55	9	12	-85	0	0	-100	4	14	-80	7	24	-70	27	90	-60	11	36	-56
95-94	3	6	-70	3	3	-96	0	0	-100	5	10	-86	8	17	-78	30	63	-72	12	25	-70
94-93	3	3	-85	0	0	-100	0	0	-100	5	5	-93	9	9	-89	33	33	-85	13	13	-84

Lake Rhodhiss

The existing guide curve for this reservoir is a monthly elevation of 97 feet with a normal minimum pool elevation of 95 feet and a normal maximum pool elevation of 99.5 feet (Appendix B). From 1964 through 2003, elevations were within +/- 1 foot of the target elevation 77.5% of the time, +/- 2 feet 93.2% of the time, and +/- 3 feet 98.3% of the time. Average daily elevations were generally highest in February through June, with only moderate reductions in elevations at other times of the year.

Vegetation/confluences, clay, and woody debris composed most of the shallow water fish habitat in Lake Rhodhiss with cobble, riprap/piers, mud flats, and sand composing only moderate amounts of habitat (Figure 2). Areal estimates for all habitats at various contours were variable as reservoir elevations receded (Table 2). No vegetation/confluence habitat was observed at elevations below 97 feet.

In Lake Rhodhiss, environmental habitat was generally not available to fish at the existing guide curve elevation or at normal minimum pool elevation. All other habitat types were available to fish at the existing guide curve elevation and at elevations above normal minimum pool. Historically, water levels in Lake Rhodhiss were somewhat more stable near the target elevation than other reservoirs on the upper Catawba-Wateree River and thus the development of emergent plants at elevations ranging from full pool down to 97 feet may have been a function this.

Figure 2. Areal estimates of shallow water fish habitat at one-foot drawdowns in Lake Rhodhiss.

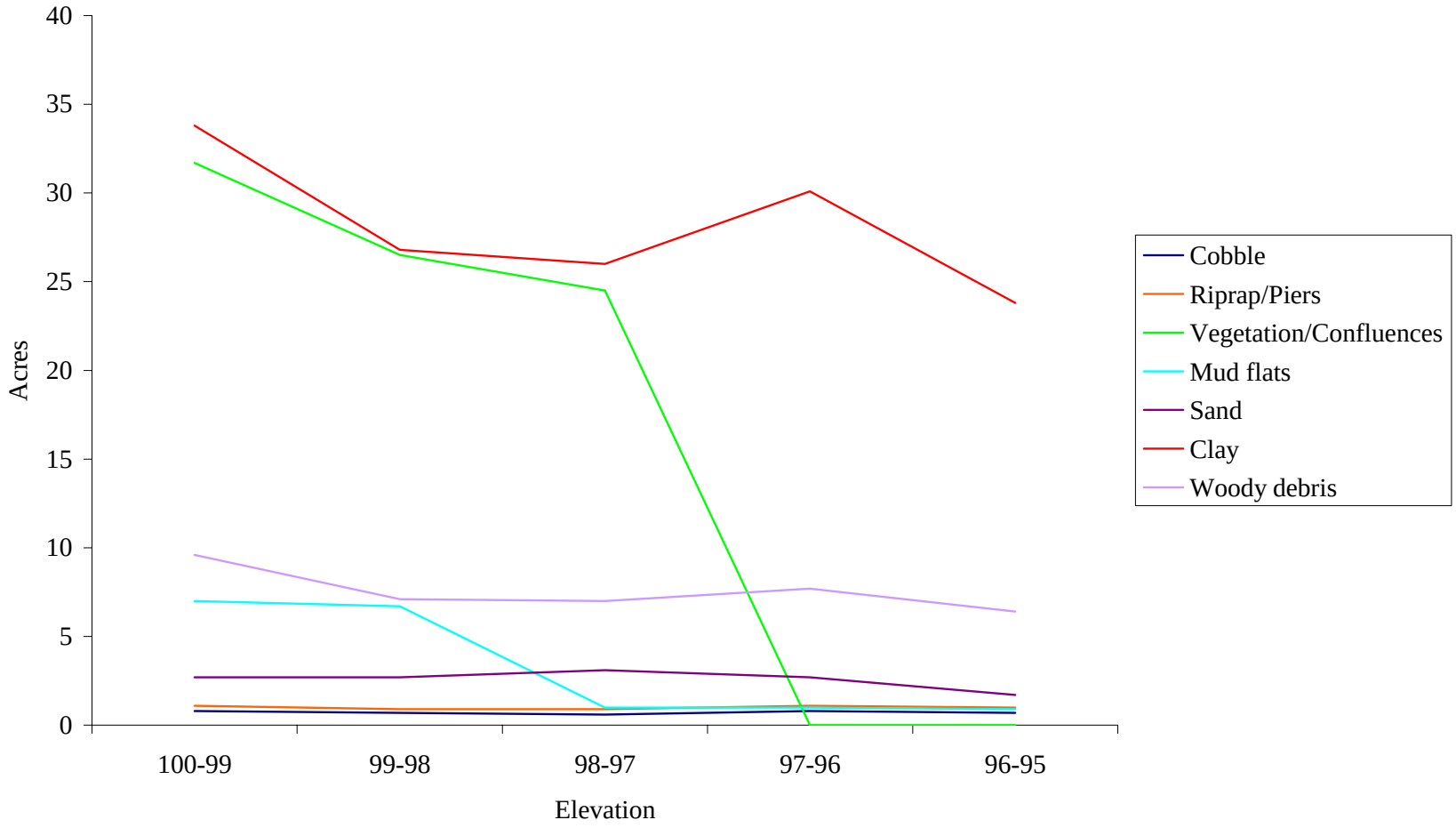

Table 2. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Lake Rhodhiss.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	1	5		1	5		32	82		7	17		3	14		34	141		10	38.1	
99-98	1	4	-20	1	4	-20	26	50	-39	7	10	-41	3	11	-21	27	107	-24	7	28.1	-26
98-97	1	3	-40	1	3	-40	24	24	-71	1	3	-82	3	8	-43	26	80	-43	7	21.1	-45
97-96	1	2	-60	1	2	-60	0	0	-100	1	2	-88	3	5	-64	30	54	-62	7.7	14.1	-63
96-95	1	1	-80	1	1	-80	0	0	-100	1	1	-94	2	2	-86	24	24	-83	6.4	6.4	-83

Lake Hickory

The existing guide curve for this reservoir is a monthly elevation of 97 feet with normal minimum and normal maximum pool elevations of 95 feet and 99.5 feet, respectively (Appendix B). From 1964 through 2003, elevations were within +/- 1 foot of the target elevations 75.5% of the time, +/- 2 feet 91.4% of the time, and +/- 3 feet 98.9% of the time. Average daily elevations were generally highest in March-June with only moderate reductions in elevations at other times of the year.

Riprap/pier, vegetation/confluence, and clay habitat composed most of the shallow water habitat in Lake Hickory with cobble, sand, and woody debris composing only moderate amounts (Figure 3). No natural habitat was identified in Lake Hickory. Areal estimates for all habitats at various contours were variable as reservoir elevations receded (Table 3).

Even though we do not have bathymetric data available from Lake Hickory below an elevation of 96 feet, we can use the vertical habitat distribution data (Table 3, Appendix D) to conclude that fish would not have access to vegetated/confluence and riprap/pier habitats at normal minimum pool. All other habitats present in Lake Hickory appear to be available to fish at existing guide curve elevations and at elevations approaching normal minimum pool. Lake Hickory, like Lake Rhodhiss, has relatively stable water levels that appear to encourage emergent plants to colonize shoreline areas at elevations ranging from full pool down to 96-97 feet.

Figure 3. Areal estimates of shallow water fish habitat at one-foot drawdowns in Lake Hickory.

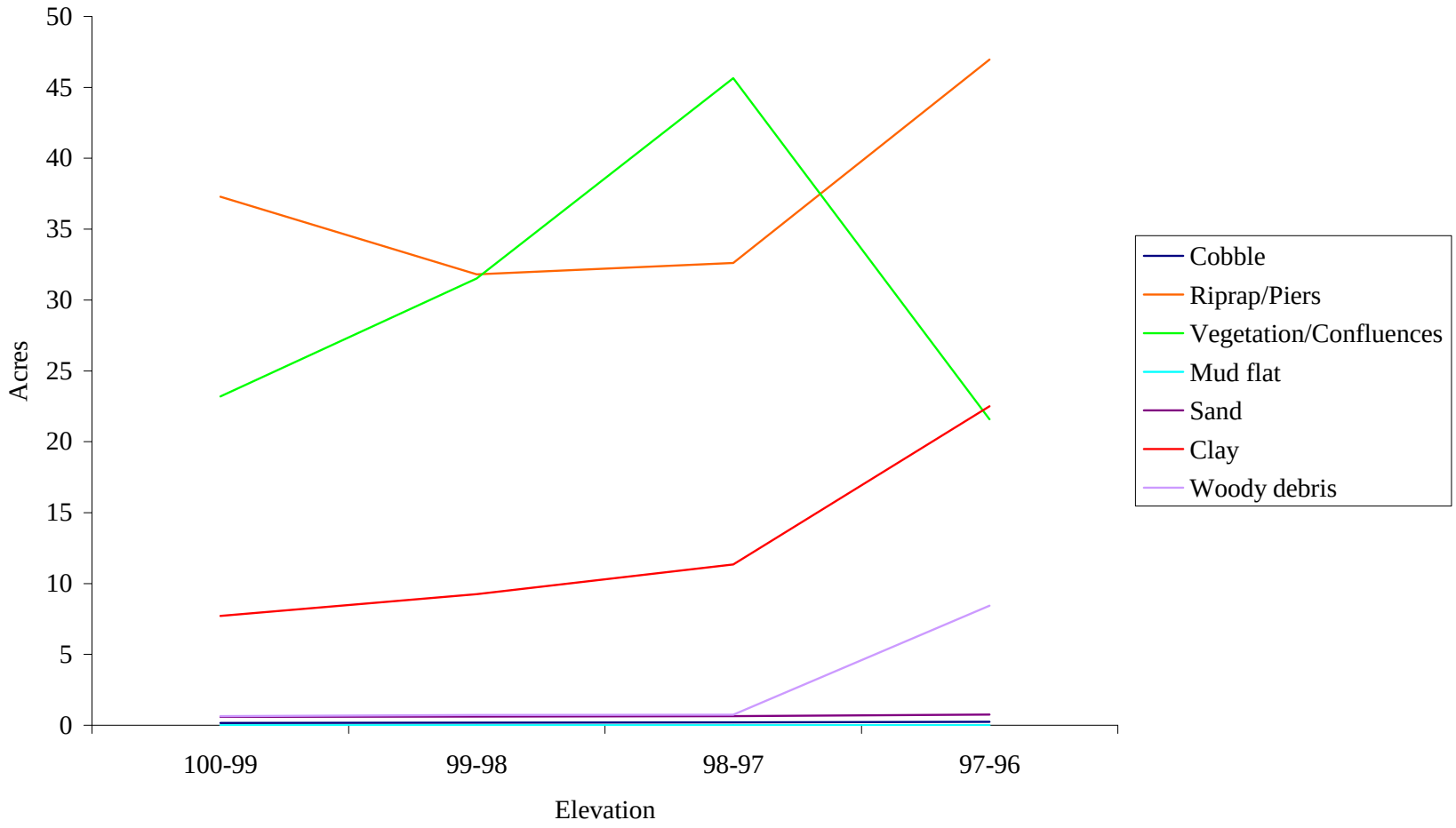

Table 3. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Lake Hickory.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0.2	0.8		37	149		23	123		0	0		0.6	2.7		8	51		0.6	10.1	
99-98	0.2	0.6	-25	32	112	-25	32	100	-19	0	0	0	0.6	2.1	-22	9	43	-16	0.7	9.5	-6
98-97	0.2	0.4	-50	33	80	-46	46	68	-45	0	0	0	0.7	1.5	-44	11	34	-33	0.8	8.8	-13
97-96	0.2	0.2	-75	47	47	-68	22	22	-82	0	0	0	0.8	0.8	-70	23	23	-55	8	8	-21

Lookout Shoals Lake

The existing guide curve for this reservoir is a monthly elevation of 97 feet with a normal minimum pool elevation of 95 feet and a normal maximum pool elevation of 99.5 feet (Appendix B). From 1964 through 2003, elevations were within +/- 1 foot of the target elevation 58.4% of the time, +/- 2 feet 89.7% of the time, and +/- 3 feet 93.5% of the time. Average monthly elevations were generally highest in March through August with only moderate reductions in elevations at other times of the year.

Riprap/piers, vegetation/confluences, and clay composed most of the shallow water fish habitat in Lookout Shoals Lake with cobble, mud flats, sand, and woody debris composing only moderate amounts (Figure 4). Areal estimates for all habitat types generally declined as reservoir elevations receded (Table 4). The greatest declines in habitat were noted for vegetation/confluences and clay during drawdowns of only 1 foot. Even though progressive declines were noted in riprap/pier, vegetation/confluence, and clay habitat at drawdowns of 2-5 feet, vegetation/confluences was the only habitat that was almost totally eliminated by such drawdowns.

In Lookout Shoals Lake, drawdowns most severely impacted the availability of vegetation/confluence habitat to fish. At the existing guide curve elevation and at normal minimum pool, this habitat was mostly unavailable for use by fish. All other habitat types were available to fish at the existing guide curve elevation and at elevations above normal minimum pool.

Figure 4. Areal estimates of shallow water fish habitat at one-foot drawdowns in Lookout Shoals Lake.

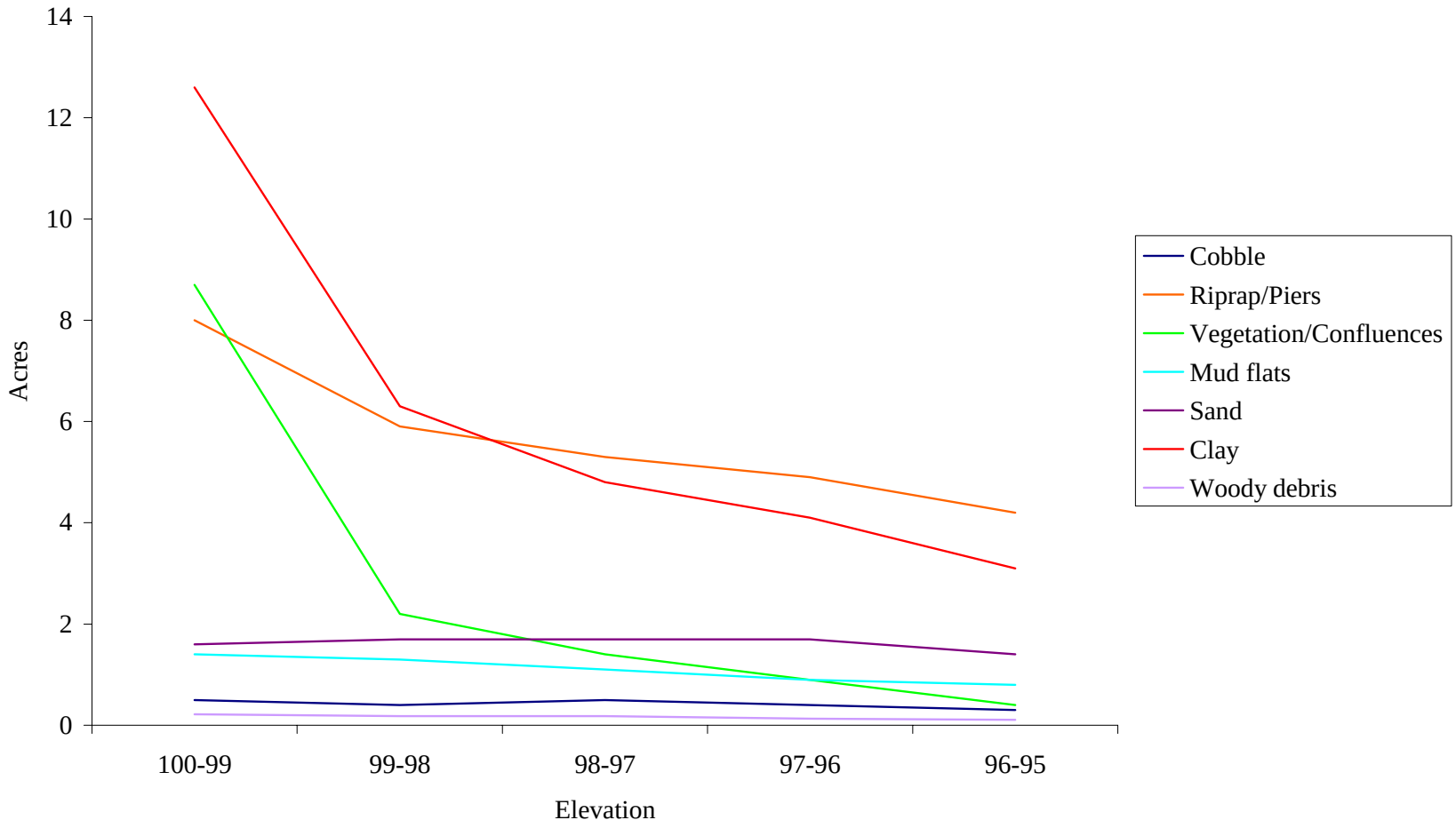

Table 4. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Lookout Shoals Lake.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0.5	2.1		8	28		9	13.4		1	5		1.6	8.1		13	31		0.2	0.8	
99-98	0.4	1.6	-24	6	20	-29	2	4.4	-67	1	4	-20	1.7	6.5	-20	6	18	-42	0.2	0.6	-25
98-97	0.5	1.2	-43	5	14	-50	1	2.4	-82	1	3	-40	1.7	4.8	-41	5	12	-61	0.2	0.4	-50
97-96	0.4	0.7	-67	5	9	-68	1	1.4	-90	1	2	-60	1.7	3.1	-62	4	7	-77	0.1	0.2	-75
96-95	0.3	0.3	-86	4	4	-86	0.4	0.4	-97	1	1	-80	1.4	1.4	-83	3	3	-90	0.1	0.1	-88

Lake Norman

The existing guide curve for this reservoir begins with an elevation of 96 feet in January and declines to 92 feet by March (Appendix B). Elevations then gradually increase monthly reaching 98 feet in June and remain at this elevation through September. After September, elevations decline to 97.5 feet in October and further decline to 97 feet in early December. By late December elevations are near 96 feet. Normal minimum pool elevation is 94 feet in January, 92 feet in February- April, 94 feet in May, 96 feet in June-September, 95 feet in October, and 94 feet in November-December. Normal maximum pool elevation is 99.5 feet during all months. From 1964 through 2003, reservoir elevations were within +/- 1 foot of the target elevation 36.6% of the time, +/- 2 feet 59.9% of the time, and +/- 3 feet 76.9% of the time. Average daily elevations were highest in April through August with only moderate reductions in elevations at other times.

Riprap/piers, vegetation/confluences, and clay composed most of the shallow water fish habitat in Lake Norman with cobble, mud flats, sand, and woody debris composing only moderate or lesser amounts (Figure 5). Areal estimates of habitat at various contours were variable as reservoir elevations receded (Table 5). The greatest declines in habitat were for riprap/piers and clay at drawdowns of 5-7 feet, and for vegetation/confluences at drawdowns of 1-3 feet. No riprap/pier habitat was observed at elevations below 94 feet and no vegetation/confluence habitat was observed at elevations below 96 feet.

Because we were unable to draw Lake Norman down to the normal minimum pool elevation of 92 feet during the vertical mapping of shallow water fish habitat, we can only project areal estimates of habitat to a minimum pool elevation of 93 feet. However, we were able to determine that drawdowns to 93 feet prevented fish from using riprap/pier and vegetated/confluence habitats. At the existing guide curve elevations, vegetated/confluence habitat was not useable by fish at elevations below 96 feet and riprap/pier habitat was not useable at elevations below 94 feet. All other habitat types were useable at existing guide curve elevations and at elevations approaching normal minimum.

Figure 5. Areal estimates of shallow water fish habitat at one-foot drawdowns in Lake Norman.

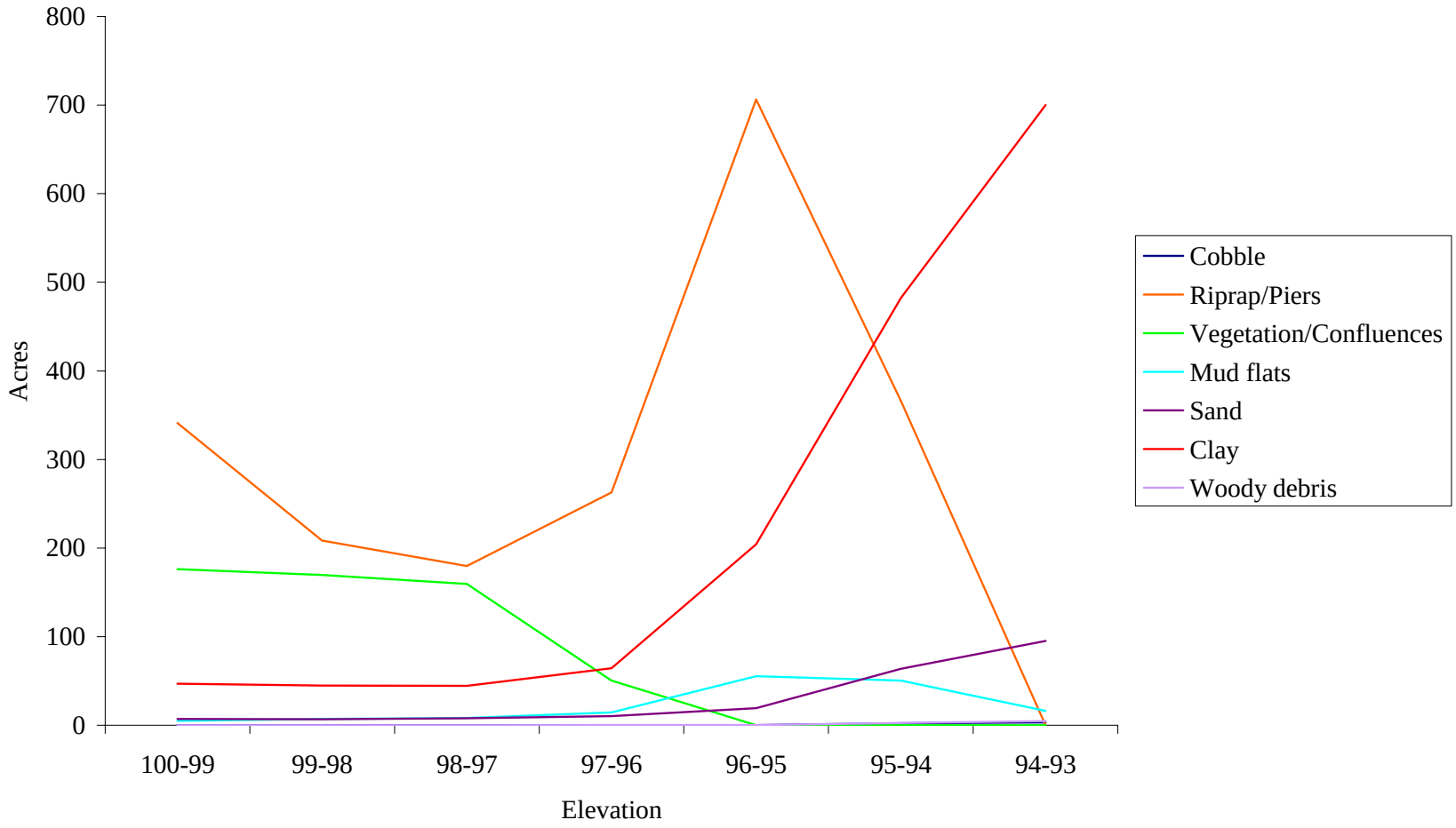

Table 5. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Lake Norman.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0.2	6.3		341	2064		176	555		5	157		7	210		47	1586		0.1	8.7	
99-98	0.2	6.1	-3	208	1723	-17	170	379	-32	7	152	-3	7	203	-3	45	1539	-3	0.1	8.6	-1
98-97	0.2	5.9	-6	180	1515	-27	159	209	-62	8	145	-8	8	196	-7	44	1494	-6	0.1	8.5	-2
97-96	0.3	5.7	-10	263	1335	-35	50	50	-91	14	137	-13	10	188	-10	64	1450	-9	0.2	8.4	-3
96-95	0.4	5.4	-14	706	1072	-48	0	0	-100	56	123	-22	19	178	-15	204	1386	-13	0.2	8.2	-6
95-94	2	5	-21	366	366	-82	0	0	-100	51	67	-57	64	159	-24	482	1182	-25	3	8	-8
94-93	3	3	-52	0	0	-100	0	0	-100	16	16	-90	95	95	-55	700	700	-56	5	5	-43

Mountain Island Lake

The existing guide curve for this reservoir is a monthly elevation of 96 feet with a normal minimum pool elevation of 94.5 feet and a normal maximum pool elevation of 99.5 feet (Appendix B). From 1964 through 2003, reservoir elevations were within +/- 1 foot of the target elevation 74.6% of the time, +/- 2 feet 95.0% of the time, and +/- 3 feet 98.2% of the time. Average daily elevations were highest in January-June, with moderate reductions in elevations at other times.

Riprap/piers, vegetation/confluences, and clay composed most of the shallow water fish habitat in Mountain Island Lake with cobble, mud flats, sand, and woody debris composing only moderate amounts (Figure 6). Areal estimates of habitat at various contours were somewhat variable as reservoir elevations receded (Table 6). The greatest declines were noted for vegetation/confluences at drawdowns of 1-4 feet, and mud flats and clay at 4-5 feet.

In Mountain Island Lake, all habitats were available to fish at the existing guide curve elevation and available at elevations approaching normal minimum pool elevation. Relatively stable water levels near target elevation appeared to encourage emergent plants to colonize shoreline areas at elevations ranging from full pool down to 95 feet.

Figure 6. Areal estimates of shallow water fish habitat at one-foot drawndowns in Mountain Island Lake.

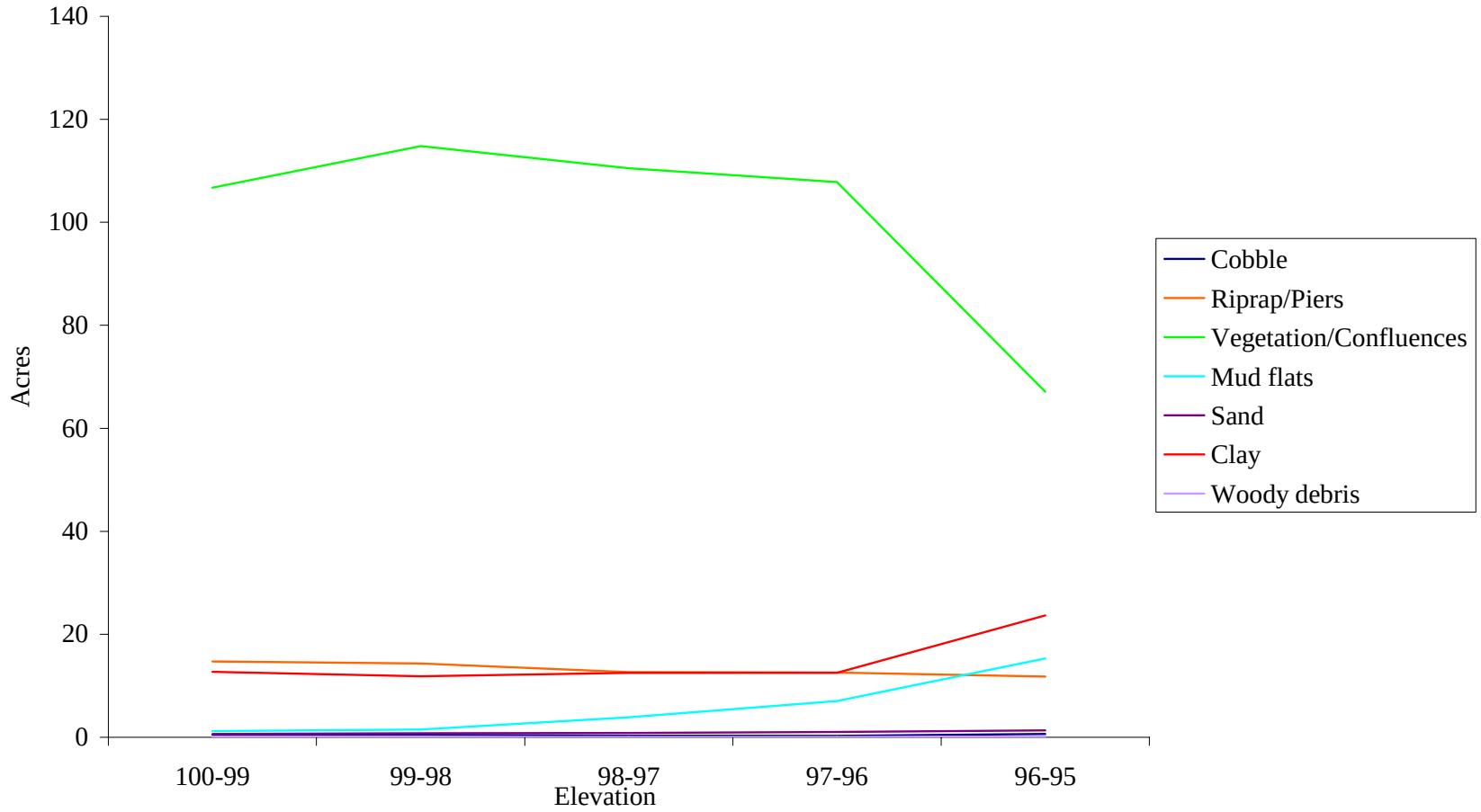

Table 6. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Mountain Island Lake.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0.4	2.1		15	67		107	507		1	29		0.6	4.2		13	73		0.1	0.5	
99-98	0.5	1.7	-19	14	52	-22	115	400	-21	2	28	-3	0.8	3.6	-14	12	60	-18	0.1	0.4	-20
98-97	0.3	1.2	-43	13	38	-43	110	285	-44	4	26	-10	0.8	2.8	-33	12	48	-34	0.1	0.3	-40
97-96	0.3	0.9	-57	13	25	-63	108	175	-65	7	22	-24	1	2	-52	12	36	-51	0.1	0.2	-60
96-95	0.6	0.6	-71	12	12	-82	67	67	-87	15	15	-48	1	1	-76	24	24	-67	0.1	0.1	-80

Lake Wylie

The existing guide curve for this reservoir is a monthly elevation of 97 feet with a normal minimum pool elevation of 95 feet and a normal maximum pool elevation of 99.5 feet (Appendix B). From 1964 through 2003, elevations were within +/- 1 foot of the target elevation 72.7% of the time, +/- 2 feet 90.9% of the time, and +/- 3 feet 98.5% of the time. Average daily elevations were highest in January-June and then generally declined through the fall.

Riprap/pier, vegetation/confluence, and clay habitats composed most of the shallow water fish habitat in Lake Wylie with cobble, mud flats, sand, and woody debris composing only moderate or lesser amounts (Figure 7). Areal estimates for all habitats at various contours were variable as reservoir elevations receded (Table 7). The greatest declines in habitat were for riprap/piers, vegetation/confluences, mud flats, and clay at drawdowns of 3-4 feet. No vegetated/confluence habitat was observed at elevations below 96 feet.

In Lake Wylie, drawdowns most severely impacted the availability of vegetation/confluence habitat to fish. However, this habitat was available to fish at the existing guide curve elevation, but not at normal minimum pool. All other habitats were available to fish at the existing guide curve elevation and at elevations above normal minimum pool. As noted for other reservoirs, stable water levels near the existing guide curve appeared to encourage emergent plants to colonize the shoreline at elevations ranging from full pool to 96-97 feet.

Figure 7. Areal estimates of shallow water fish habitat at one-foot drawdowns in Lake Wylie.

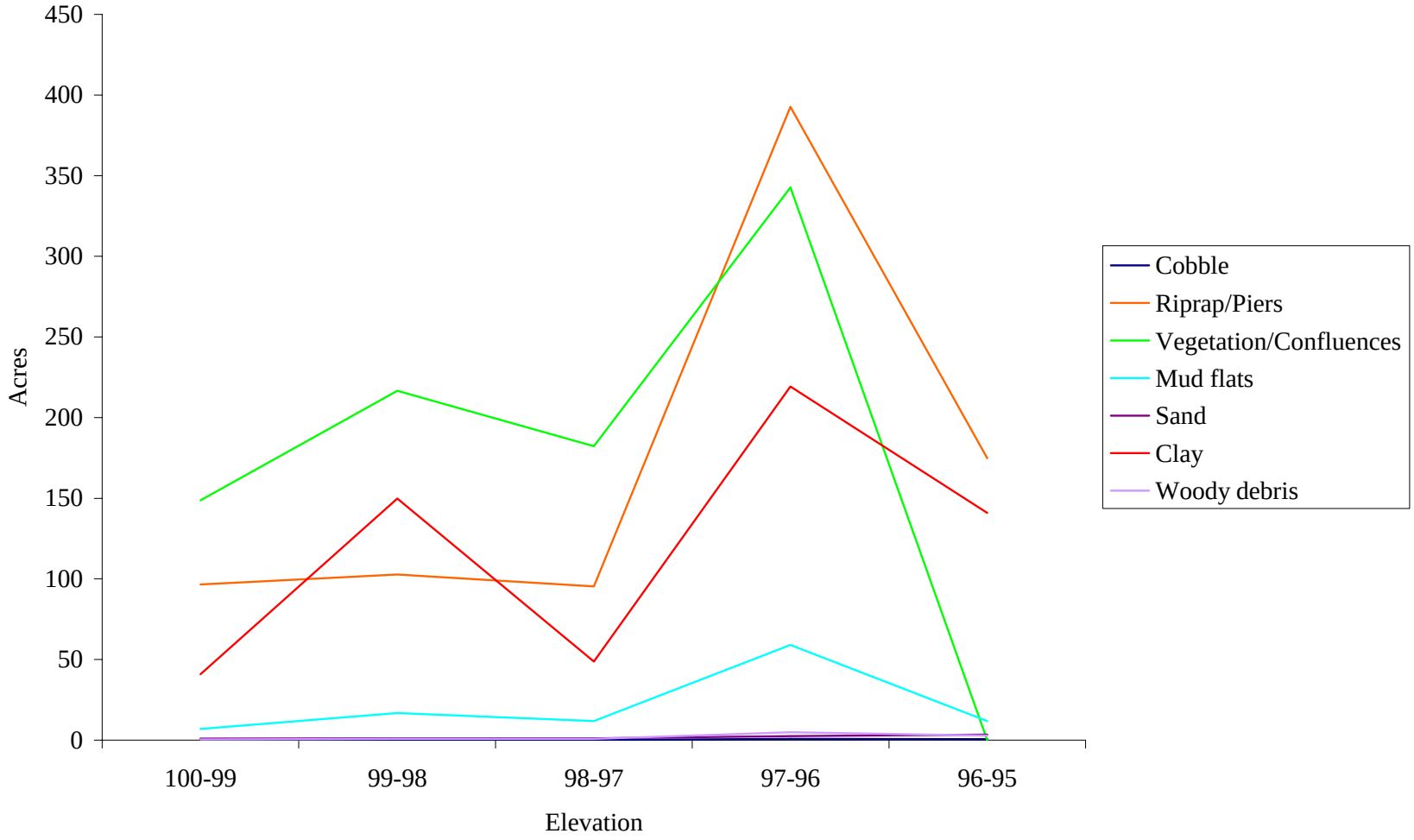

Table 7. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Lake Wylie.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0.6	2.7		97	863		149	891		7	107		1	10		41	600		0.5	10.2	
99-98	0.4	2.1	-22	103	766	-11	217	742	-17	17	100	-7	1	9	-10	150	559	-7	0.8	9.7	-5
98-97	0.2	1.7	-37	95	663	-23	182	525	-41	12	83	-22	1	8	-20	49	409	-32	0.9	8.9	-13
97-96	0.8	1.5	-44	393	568	-34	343	343	-62	59	71	-34	3	7	-30	219	360	-40	5	8	-22
96-95	0.7	0.7	-74	175	175	-80	0	0	-100	12	12	-89	4	4	-60	141	141	-77	3	3	-71

Fishing Creek Reservoir

The existing guide curve for this reservoir is a monthly elevation of 97 feet with a normal minimum pool elevation of 95 feet and a normal maximum pool elevation of 99.5 feet (Appendix B). From 1964 through 2003, elevations were within +/- 1 foot of the target elevation 67.6% of the time, +/- 2 feet 90.3% of the time, and +/- 3 feet 98.9% of the time. Average daily elevations were highest in January-May and then declined somewhat through the fall.

Vegetation/confluences and clay composed most of the shallow water fish habitat in Fishing Creek Reservoir with cobble, riprap/piers, mud flats, sand, and woody debris composing only moderate amounts (Figure 8). Areal estimates of all habitats at various contours were variable as reservoir elevations receded (Table 8). The greatest declines in habitat were for vegetation/confluences at drawdowns of 1 foot and 4 feet, and for clay at a drawdown of 5 feet. No vegetation/confluence habitat was observed at elevations below 96 feet.

At the existing guide curve elevation, all habitat types were available to fish and most were available at normal minimum pool elevation. However, vegetation/confluence habitat was not available to fish at normal minimum pool elevation.

Figure 8. Areal estimates of shallow water fish habitat at one-foot drawdowns in Fishing Creek Reservoir.

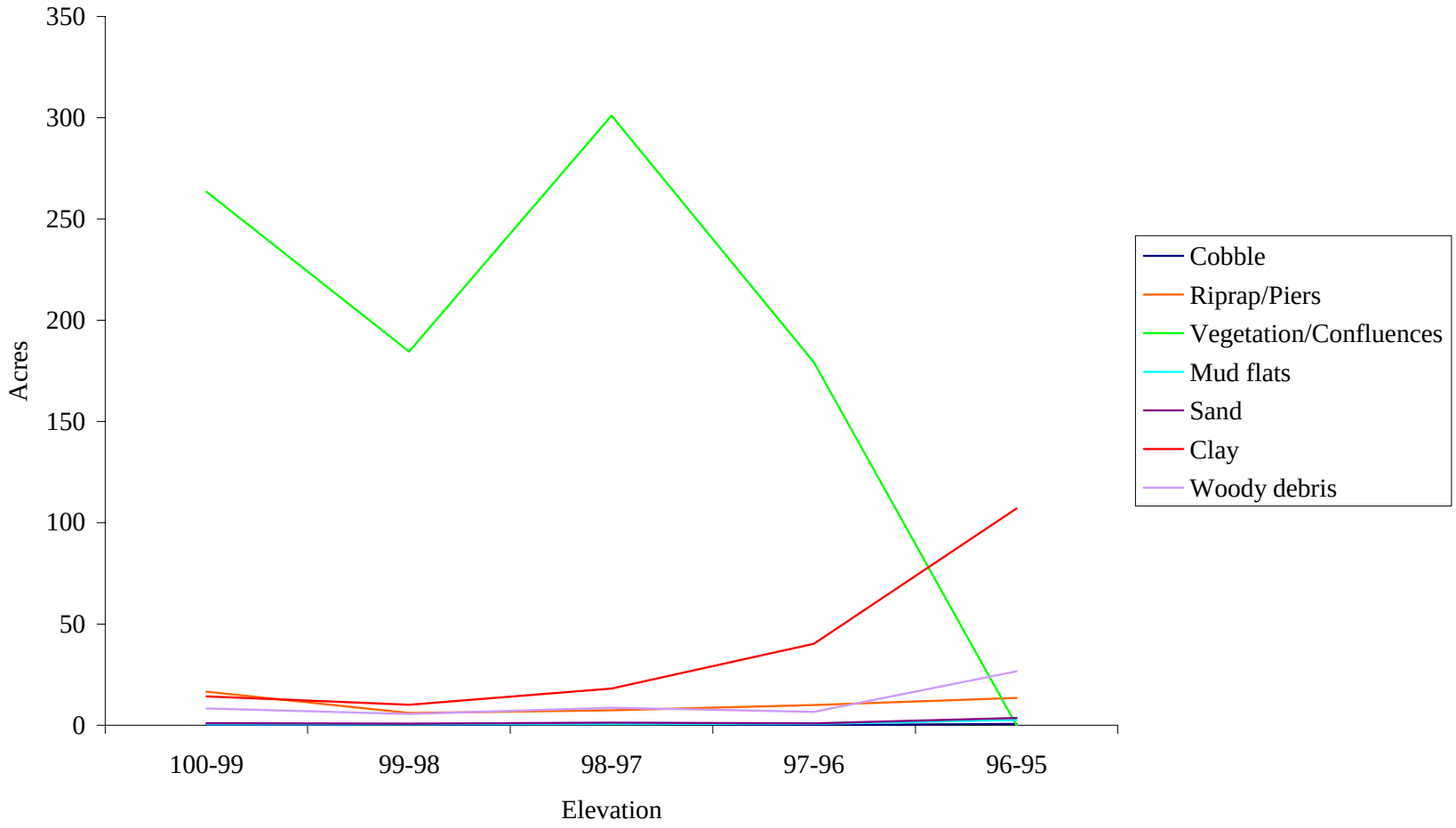

Table 8. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Fishing Creek Reservoir.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0.1	1.5		17	53		263	928		0.6	5.3		1	7.6		14	189		8	57	
99-98	0.1	1.4	-7	6	36	-32	185	665	-28	0.5	4.7	-11	0.7	6.6	-13	10	175	-7	6	49	-14
98-97	0.6	1.3	-13	7	30	-43	301	480	-48	0.6	4.2	-21	1	5.9	-22	18	165	-13	9	43	-25
97-96	0.1	0.7	-53	10	23	-57	179	179	-81	0.6	3.6	-32	0.9	4.9	-36	40	147	-22	7	34	-40
96-95	0.6	0.6	-60	13	13	-75	0	0	-100	3	3	-43	4	4	-47	107	107	-43	27	27	-53

Great Falls-Dearborn Reservoir

The existing guide curve for this reservoir is a monthly elevation of 98 feet with a normal minimum pool elevation of 95 feet and a normal maximum pool elevation of 99.5 feet (Appendix B). From 1964 through 2003, elevations were within +/- 1 foot of the target elevation 72.1% of the time, +/- 2 feet 96.5% of the time, and +/- 3 feet 99.0% of the time. Average daily elevations varied monthly in this reservoir with little evidence of any seasonal trends.

In the absence of bathymetric data for this reservoir, we can only speculate regarding the impact the existing guide curve and normal minimum pool elevations may have on shallow water fish habitat. Using the vertical distribution habitat data (Table 9, Appendix D), it appears that all habitats noted in the reservoir were available to fish at elevations associated with the existing guide curve and at elevations approaching normal minimum pool elevation.

Cedar Creek Reservoir

The existing guide curve for this reservoir is a monthly elevation of 98 feet with a normal minimum pool elevation of 96 feet and a normal maximum pool elevation of 99.5 feet (Appendix B). From 1964 through 2003, elevations were within +/- 1 foot of the target elevation 73.7% of the time, +/- 2 feet 93.5% of the time, and +/- 3 feet 96.6% of the time. Average daily elevations were highest in winter and spring, and declined somewhat in the summer and fall.

Vegetation/confluences and clay composed most of the shallow water fish habitat in Cedar Creek Reservoir with riprap/piers, mud flats, sand, and woody debris composing only moderate amounts (Figure 9, Table 9). No cobble habitat was observed in this reservoir.

In Cedar Creek Reservoir, all habitats present were available to fish at the existing guide curve elevation. Inasmuch as bathymetric data for this reservoir extended only to elevation 96.8 feet, we were not able to accurately determine aerial estimates of habitat at a drawdown of 3-4 feet. It does appear and the vertical distribution habitat data (Table 10, Appendix D) does indicate that all habitats present in this reservoir were available to fish at the existing guide curve and at normal minimum pool elevations.

Figure 9. Areal estimates of shallow water fish habitat at one-foot drawdowns in Cedar Creek Reservoir.

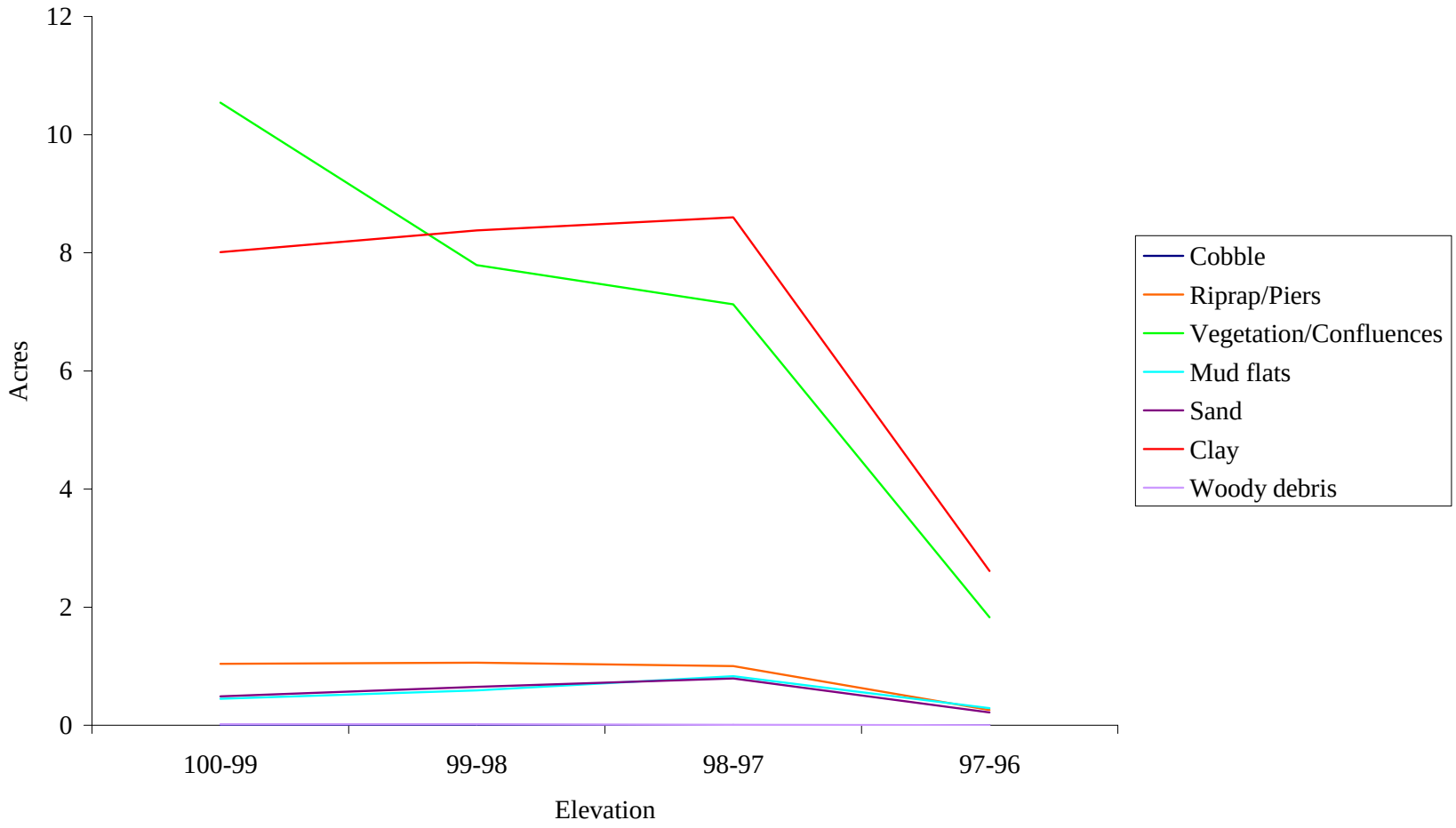

Table 9. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Cedar Creek Reservoir.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0	0		1	3.3		11	28		0.4	2.1		0.5	2.1		8	28		0.02	0.06	
99-98	0	0	0	1	2.3	-30	8	17	-39	0.6	1.7	-19	0.6	1.6	-24	8	20	-29	0.02	0.04	-33
98-97	0	0	0	1	1.3	-61	7	9	-68	0.8	1.1	-48	0.8	1	-52	9	12	-57	0.02	0.02	-67
97-96	0	0	0	0.3	0.3	-91	2	2	-93	0.3	0.3	-86	0.2	0.2	-90	3	3	-89	0	0	-100

Lake Wateree

The existing guide curve for this reservoir begins with an elevation of 94.5 feet in January that increases to 95.5 feet in February and 97 feet in March. Elevations remain at 97 feet from March through November and then decline to 95.5 by December and to 94.5 feet by late December (Appendix B). Normal minimum pool and normal maximum pool elevations are 94 feet and 99.5 feet, respectively. From 1964 through 2003, elevations were within +/- 1 foot of the target elevation 65.1% of the time, +/- 2 feet 81.6% of the time, and +/- 3 feet 92.0% of the time (Appendix C). Average daily elevations generally increased from January through April, and then decline gradually thereafter.

Water willow, riprap/piers, vegetation/confluences, and clay/sand composed most of the habitat in Lake Wateree with cobble, mud flats, sand, and woody debris composing only moderate or lesser amounts (Figure 10). Areal estimates of habitat at various contours were variable as reservoir elevations receded (Tables 10-11). The greatest declines in habitat were noted for water willow at drawdowns of 5-6 feet and riprap/piers and clay/sand at drawdowns of 4-5 feet, and for vegetation/confluences at drawdowns of 1-2 feet. No vegetation/confluence habitat was observed at elevations below 97 feet.

Because we were unable to draw Lake Wateree down to the normal minimum pool elevation of 94 feet during the vertical mapping of the shallow water fish habitat, we can only project aerial estimates of habitat to a minimum pool elevation of 95 feet. However, drawdowns of more than 95 feet in this reservoir are for only short periods of time in winter. Under the existing guide curve, vegetation/confluence habitat was not available to fish at elevations below 97 feet. All other habitat types were useable by fish at most existing guide curve elevations and at elevations approaching normal minimum pool.

Figure 10. Areal estimates of shallow water fish habitat at one-foot drawdowns in Lake Wateree.

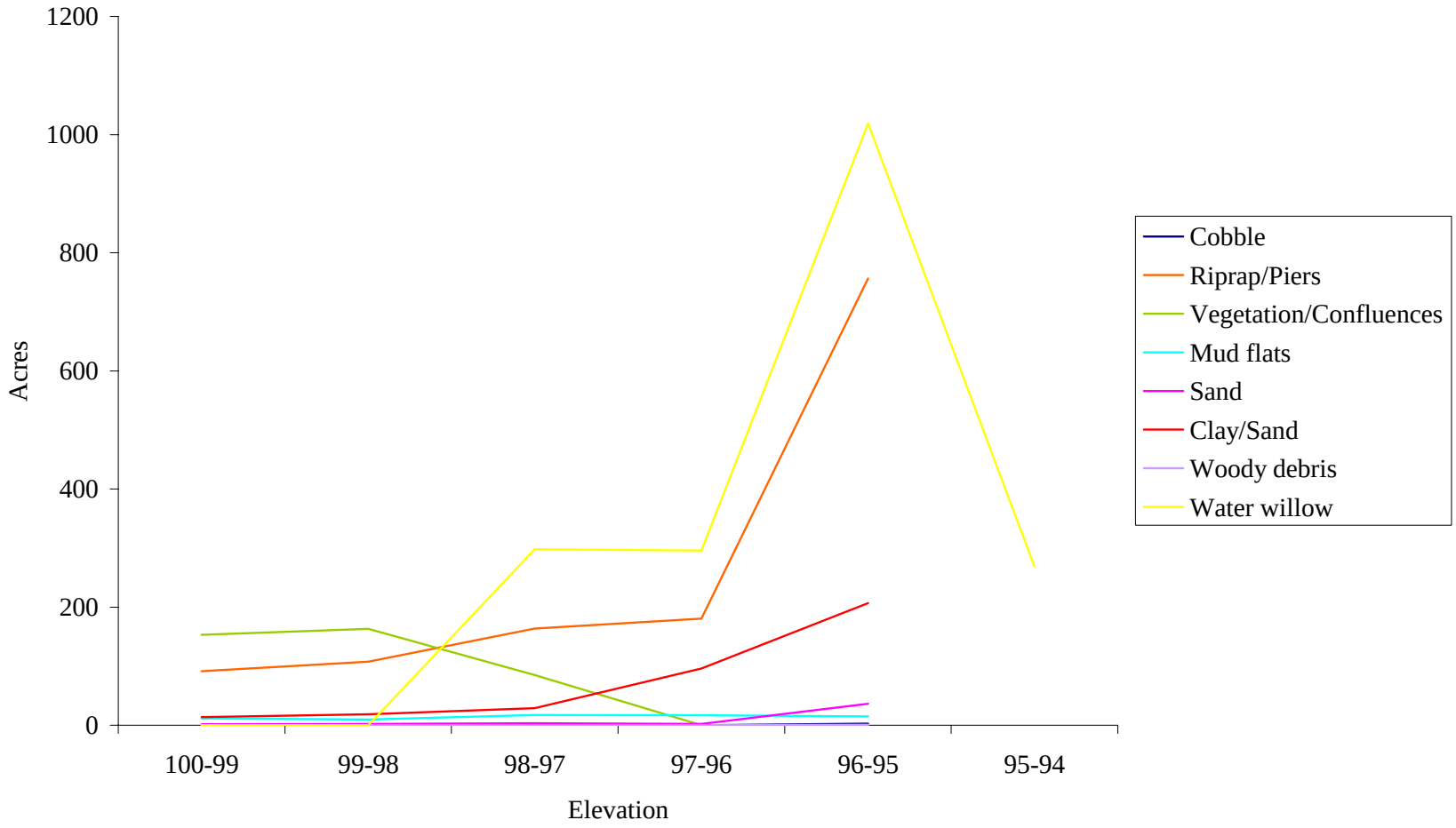

Table 10. Acres of shallow water fish habitat (A), and total acres (TA) and percent loss (%) in acres of habitat at one-foot elevations associated with normal drawdowns in Lake Wateree.

	Habitat																			
	Cobble			Riprap/Piers			Vegetation/ Confluences			Mud flats			Sand			Clay/Sand			Woody debris		
Elevation	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%	A	TA	%
100-99	0.1	3.8		92	1302		153	401		12	71		2	45		14	365		0.01	0.76	
99-98	0.2	3.7	-3	108	1210	-7	163	248	-38	10	59	-17	2	43	-4	19	351	-4	0.01	0.75	-1
98-97	0.3	3.5	-8	164	1102	-15	85	85	-79	17	49	-31	3	41	-9	29	332	-9	0.03	0.74	-3
97-96	0.2	3.2	-16	181	938	-28	0	0	-100	17	32	-55	2	38	-16	96	303	-17	0.01	0.71	-7
96-95	3	3	-21	757	757	-42	0	0	-100	15	15	-79	36	36	-20	207	207	-43	0.7	0.7	-8

Table 11. Acres of water willow (A), and total acres (TA) and percent loss (%) in acres at one-foot elevations associated with normal drawdowns of Lake Wateree.

Elevation	A	TA	%
100-99	0	1882	
99-98	0	1882	
98-97	298	1882	
97-96	296	1584	-16
96-95	1019	1288	-19
95-94	269	269	-79

Key Findings and Recommendations

Study results indicate that water levels within the Catawba-Wateree River reservoirs are variable based on existing guide curves developed for each. In general, areal estimates for all habitat types declined as water levels receded, with the greatest declines in habitat availability occurring at drawdowns of 1-3 feet. The vegetation/confluence habitat type was most impacted by drawdowns and was not available to fish at normal minimum pool elevations. However, most of the other habitat types were available to fish at normal minimum pool elevations.

Of the types of shallow water habitat identified in this report, those that provide significant habitat complexity (i.e., cobble, riprap/piers, vegetation/confluences, woody debris, and water willow) are most important to fish (Barwick 2004). Habitat complexity is a major determinant in fish diversity (Benson and Magnuson 1992), fish distribution (Gelwick and Matthews 1990; Bryan and Scarnecchia 1992; Beaucamp et al. 1994; Irwin et al. 1997; Jennings et al. 1999; Hatzenbeler et al. 2000; Trial et al. 2001), predator-prey interactions (Hall and Werner 1977; Crowder and Cooper 1982; Savino and Stein 1982; Johnson et al. 1988), and survival of young (Aggus and Elliott 1975; Miranda et al. 1984; Bryan and Scarnecchia 1992), Thus, any water level and habitat management strategy developed for the Catawba-Wateree River reservoirs should concentrate on maximizing the availability of complex habitat to fish.

Implementation of such a strategy would appear best during spring and summer primarily for the nonstorage reservoirs (Lake Rhodhiss, Lake Hickory, Lookout Shoals Lake, Mountain Island Lake, Lake Wylie, Fishing Creek Reservoir, Cedar Creek Reservoir, and Great Falls-Dearborn Reservoir) on the Catawba-Water River. Numerous studies have indicated that increased water levels can possibly result in improved recruitment of young fish and the formation of large year classes that may dominate a fishery for years (Aggus and Elliott 1975; Martin et al. 1981; Miranda et al. 1984; Ploskey 1986). However, the success of such a strategy is dependent upon the duration, timing, and the type of substrate inundated during the high-water event. The feasibility of doing this annually would also have to be evaluated within the operational constraints and safeguards for the entire reservoir system.

References Cited

Aggus, L. R., and G. V. Elliott. 1975. Effects of cover and food on year-class strength of largemouth bass. Pages 317-322 in H. Clepper, editor. Black bass biology and management. Sport Fishing Institute, Washington, DC.

Barwick, D. H. 2004. Species richness and centrarchid abundance in littoral habitats of three southern U. S. reservoirs. North American Journal of Fisheries Management 24: 76-81.

Beauchamp, D. A., E. R. Byron, and W. A. Wurtsbaugh. 1994. Summer habitat use by littoral-zone fishes in Lake Tahoe and the effects of shoreline structures. North American Journal of Fisheries Management 14:385-394.

Benson, B. J., and J. J. Magnuson. 1992. Spatial heterogeneity of littoral fish assemblages in lakes: relation to species diversity and habitat structure. Canadian Journal of Fisheries and Aquatic Sciences 49:1493-1500.

Bryan, M. D., and D. L. Scarnecchia. 1992. Species richness, composition, and abundance of fish larvae and juveniles inhabiting natural and developed shorelines of a glacial Iowa lake. Environmental Biology of Fishes 35:329-341.

Crowder, L. B., and W. E. Cooper. 1982. Habitat structural complexity and the interaction between bluegills and their prey. Ecology 63:1802-1813.

Duke Power. 2004. Reservoir level study (Operations 02). Study Report (10NOV04). Duke Power, Charlotte, North Carolina.

Gelwick, F. P., and W. J. Matthews. 1990. Temporal and spatial patterns in littoral-zone fish assemblages of a reservoir (Lake Texoma, Oklahoma-Texas, U.S.A.). Environmental Biology of Fishes 27:107-120.

Hall, D. J., and E. E. Werner. 1977. Seasonal distribution and abundance of fishes in the littoral zone of a Michigan lake. Transactions of the American Fisheries Society 106:545-555.

Hatzenbeler, G. R., M. A. Bozek, M. J. Jennings, and E. E. Emmons. 2000. Seasonal variation in fish assemblage structure and habitat structure in the nearshore littoral zone of Wisconsin lakes. North American Journal of Fisheries Management 20: 360-368.

Irwin, E. R., R. L. Noble, and J. R. Jackson. 1997. Distribution of age-0 largemouth bass in relation to shoreline landscape features. North American Journal of Fisheries Management 17:882-893.

Jennings, M. J., M. A. Bozek, G. R. Hatzenbeler, E. E. Emmons, and M. D. Staggs. 1999. Cumulative effects of incremental shoreline habitat modification on fish assemblages in north temperate lakes. North American Journal of Fisheries Management 19:18-27.

Johnson, D. L., R. A. Beaumier, and W. E. Lynch, Jr. 1988. Selection of habitat structure interstice size by bluegills and largemouth bass in ponds. Transactions of the American Fisheries Society 117:171-179.

Miranda, L. E., W. L. Shelton, and T. D. Bryce. 1984. Effects of water level manipulation on abundance, mortality, and growth of young-of-year largemouth bass in West Point Reservoir, Alabama-Georgia. North American Journal of Fisheries Management 4:314-320.

Savino, J. F., and R. A. Stein. 1982. Predator-prey interaction between largemouth bass and bluegills as influenced by simulated, submersed vegetation. Transactions of the American Fisheries Society 111:255-266.

Trial, P. F., F. P. Gelwick, and M. A. Webb. 2001. Effects of shoreline urbanization on littoral fish assemblages. Journal of Lake and Reservoir Management 17:127-138.

Appendix A

Study Plan Name: Reservoir Fish Habitat Assessment **Study Plan Designation:** Aquatics 02

Study Short Description: Determine the shallow water fish habitat available in reservoir water level fluctuation zones and determine the relationship of habitat to project operations

Applicable Hydro Projects/Developments: All

Prerequisite Study Designation: Terrestrial 01, Operations 02

The purpose of this document is to describe the study scope, methodology and uses for the results. Previous versions of the study scope document have been reviewed and discussed by the resource agencies and other members of the Aquatics Resource Committee or Study Team and based on these discussions appropriate methodologies have been added. This document is intended to be the final Study Plan for Aquatics 02.

I. Study Objectives

a) Identify magnitude, season, frequency, and duration of water level fluctuations in each reservoir.
b) Evaluate vertical distributions of the major types of shallow water fish habitat (i.e., emergent vegetation, large woody debris, riprap and piers, along with clay, sand, and cobble substrates that are included and defined in Duke's current Catawba-Wateree Shoreline Management Plan.
c) Assess changes in the lake wide surface area of these habitat types under various water level changes associated with project operations.

II. Basis

The FERC licensing process requires an assessment of any potential impacts to fish and wildlife resources by the project and its operation (18CFR4.51).

III. Geographic and Temporal Scope

Shallow water fish habitat in all 11 Catawba-Wateree reservoirs will be surveyed during periods when water levels are near maximum drawdown. This will benefit habitat identification and measurement. Generally, larger reservoirs (e.g., James, Norman, Wylie, and Wateree) will be surveyed in winter and smaller reservoirs in summer. However, meteorological conditions and other operational constraints may dictate timing of these surveys. Target completion date for the field surveys is December 2004 and for the final report is May 2005.

IV. Methodology

Historical hydro operational records will be used to identify magnitude, season, frequency, and duration of water level fluctuations in each reservoir on the Catawba-Wateree River. Depending on the availability and the format of the data, records from 1982-2002 will be evaluated. Current shallow water fish habitat maps delineating full pool distributions of the various types of habitat will be the basis for all habitat surveys. From these maps, representative transects perpendicular to the shoreline will be selected and habitat elevation extending through the drawdown zone will be determined using an Abney level and stadia rod. The number of transects selected and their

distribution throughout the reservoirs will be determined from the total length of shoreline comprising each habitat type and its distribution throughout the reservoir. Generally, 10 transects will be selected for all habitat types composing > 5 miles of shoreline and 5 transects will be selected for habitat types composing < 5 miles (provided 5 different locations are present). This will result in the selection of 50-60 transects for most reservoirs. The vertical distributions of the habitats from the resulting transects will be summarized by one-foot depth contours from full pool. This information will be incorporated into a GIS data base that also contains bathymetric data either previously collected or acquired from aerial photography. These data will then be used to calculate changes in areal estimates of habitat at one-foot changes in reservoir water levels throughout the current maximum drawdown zone.

V. Study Participants

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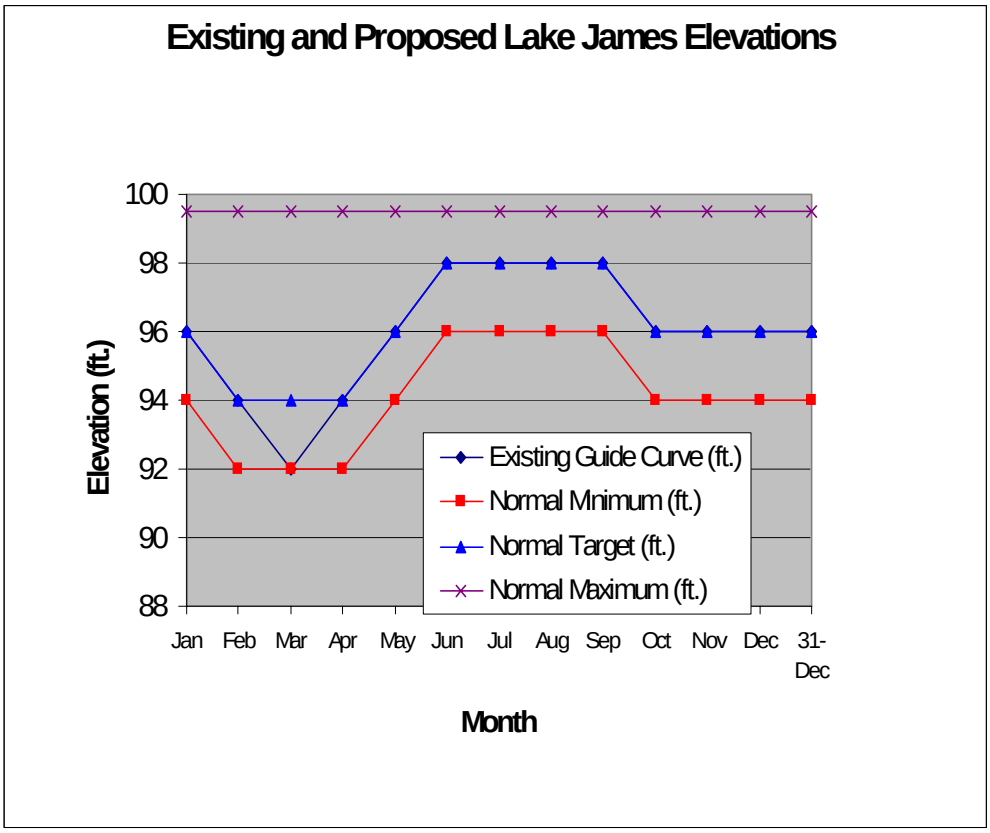
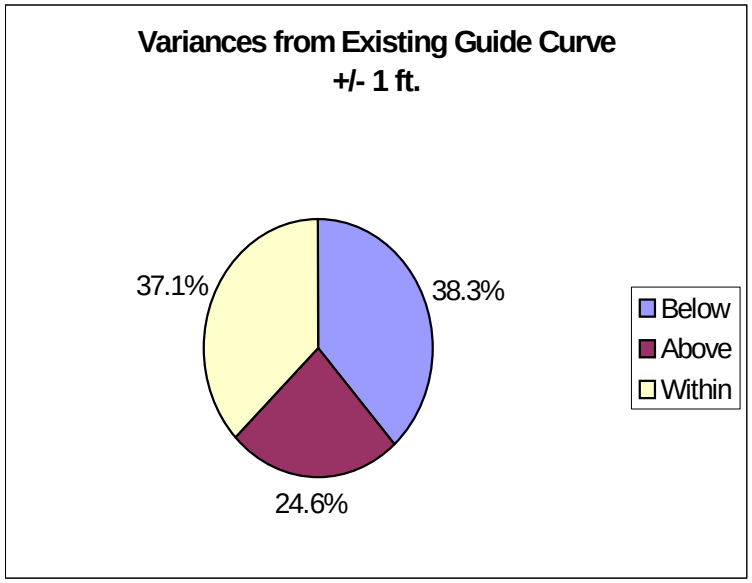
Supporting Consultants	Steve Arnold	Devine Tarbell Associates	207-775-4495	stephen.arnold@ framatome-anp.com
Other Participants	Steve Johnson	Duke Power	704-373-4391	**srjohnso@duke -energy.com**

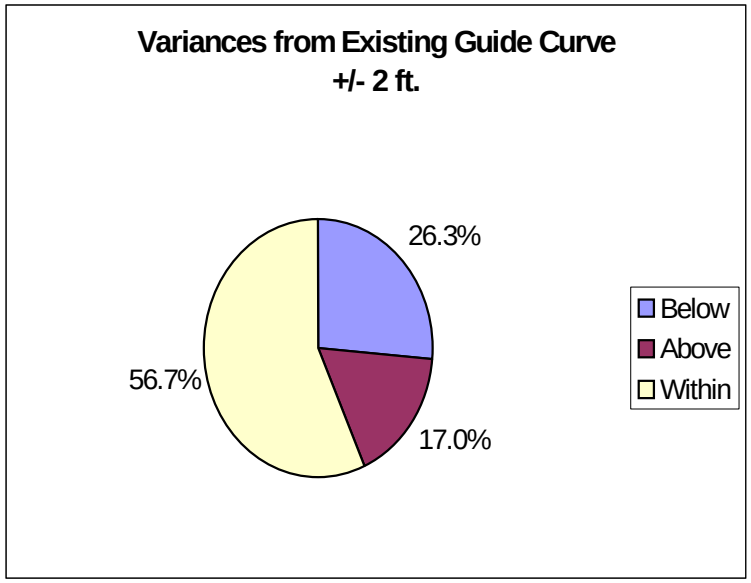
VI. List of Attachments

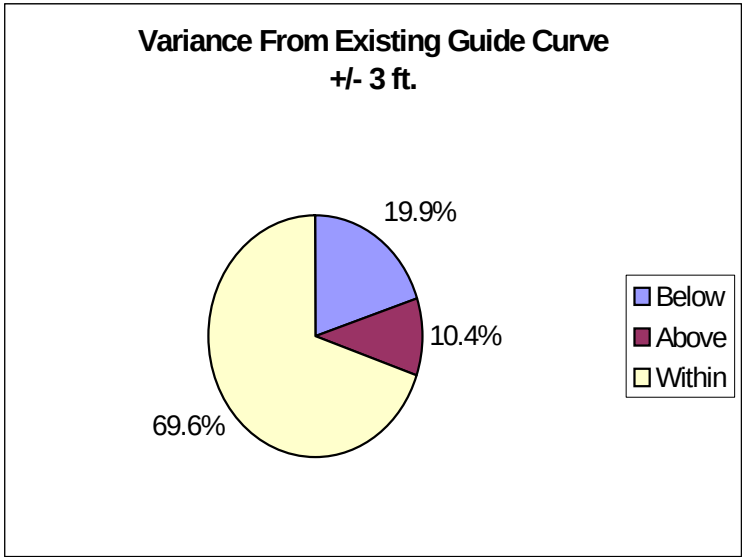
VII. List of References

Appendix B


Existing and Proposed Lake James Elevations
100
98
96
94
92
90
88
Elevation (ft.)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
31-Dec
Month
Existing Guide Curve (ft.)
Normal Mnimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)





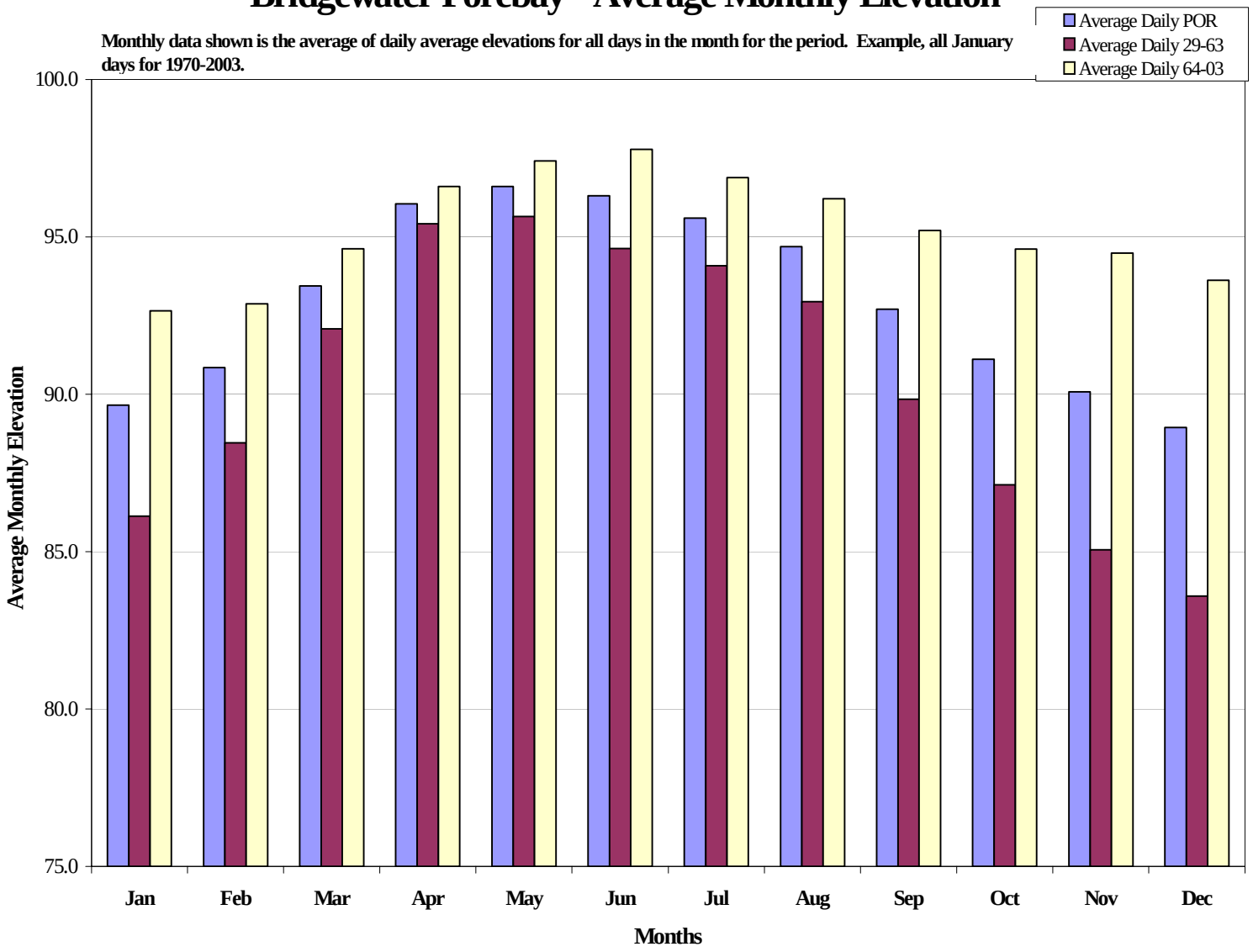


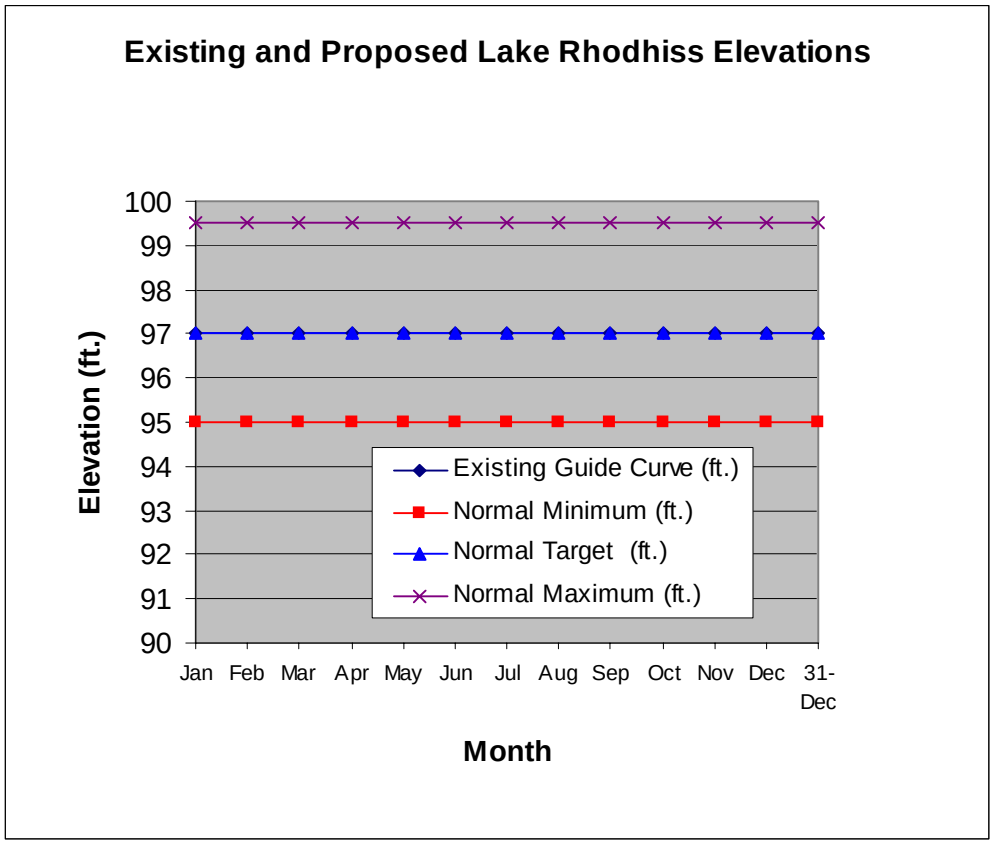
Bridgewater Development (Lake James)

Reservoir Level Study

for Period of Record 1964 - 2003

Bridgewater Forebay - Average Monthly Elevation

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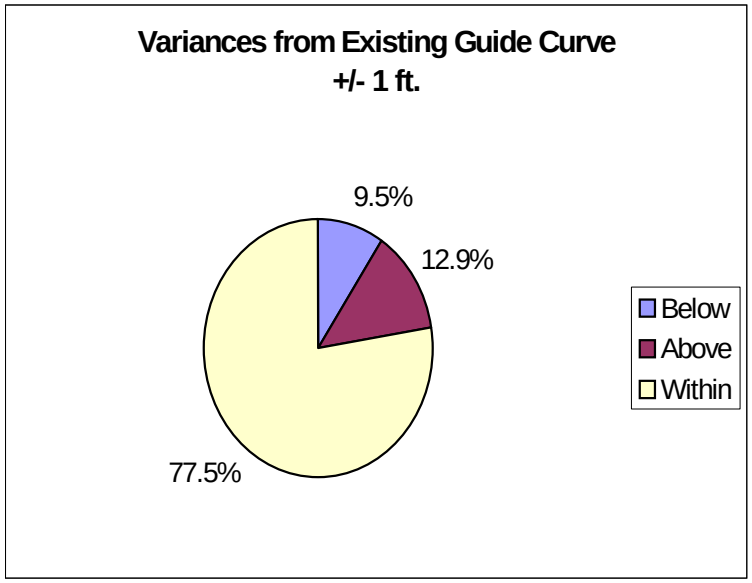
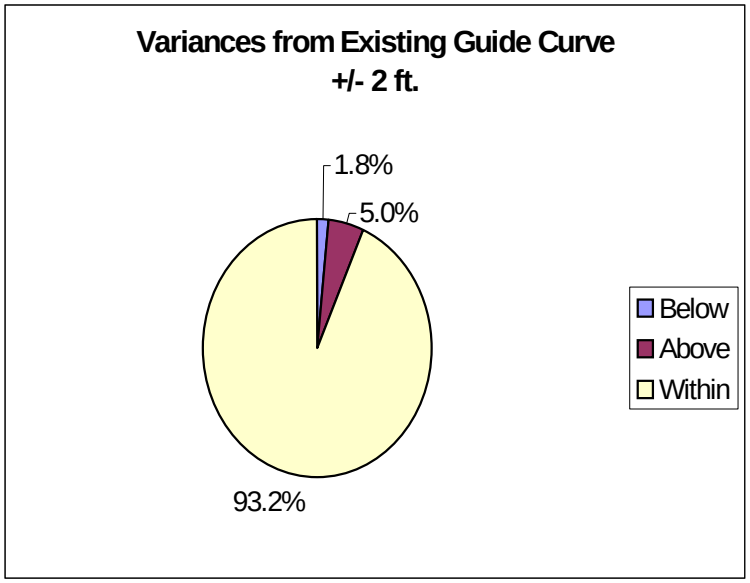
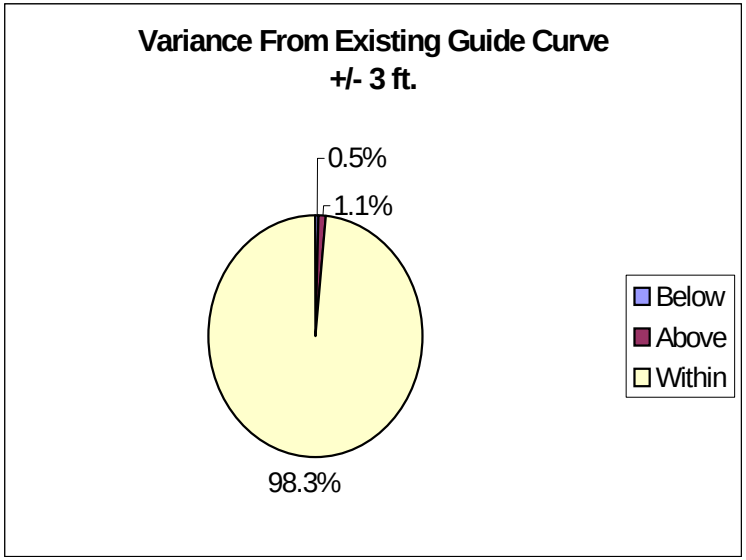
100
99
98
97
96
95
94
93
92
91
90
Elevation (ft.)
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
31-Dec
Month







Rhodhiss Development (Lake Rhodhiss)

Reservoir Level Study

for Period of Record 1964 - 2003

Rhodhiss Forebay - Average Monthly Elevation

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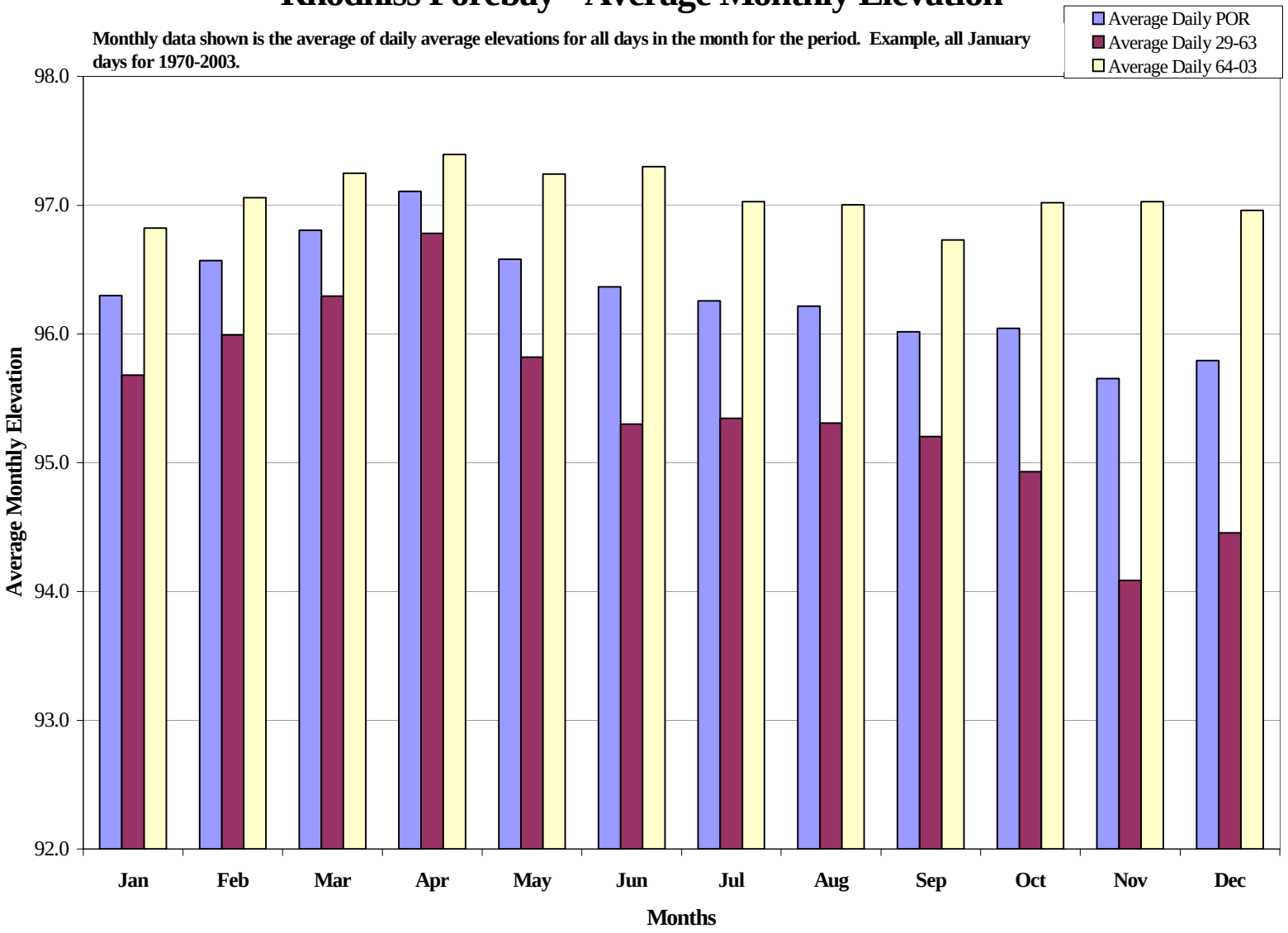

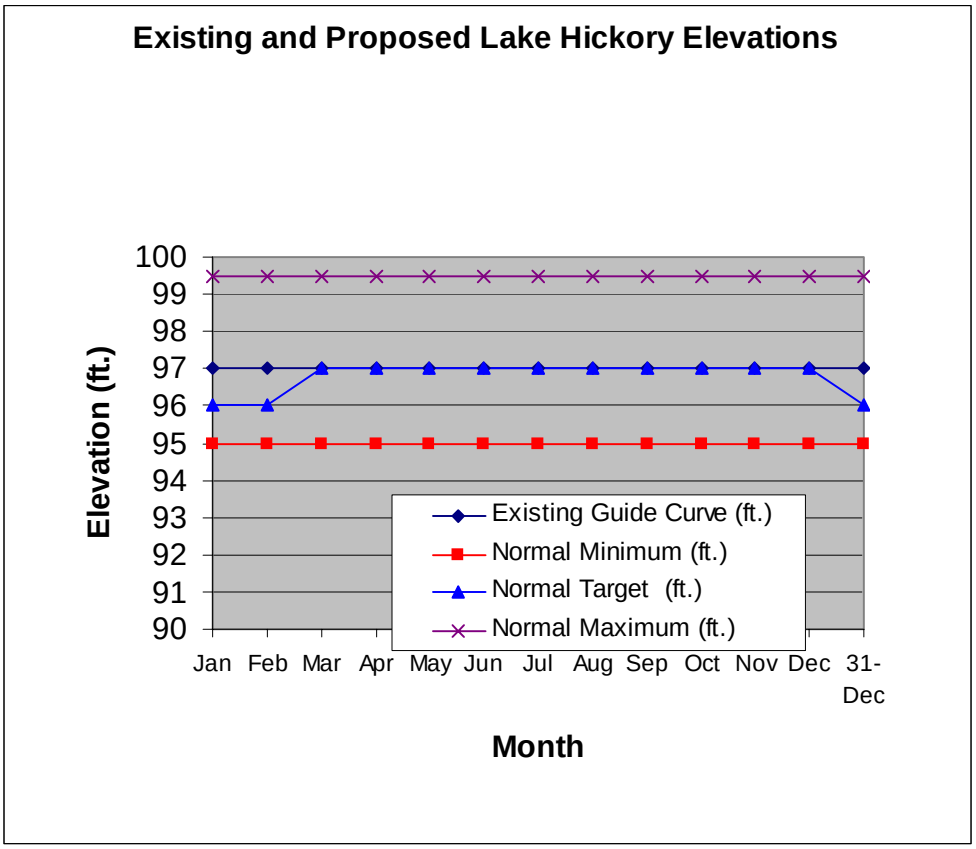
Existing and Proposed Lake Hickory Elevations
Elevation (ft.)
100
99
98
97
96
95
94
93
92
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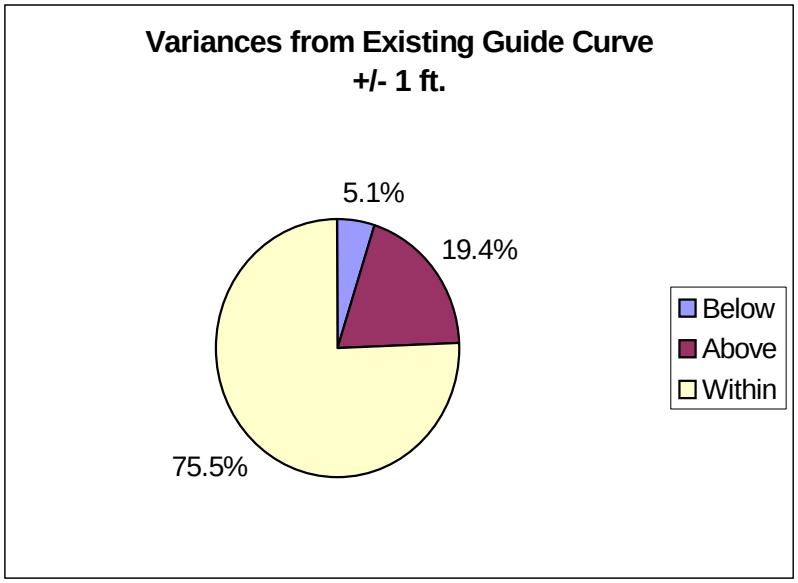
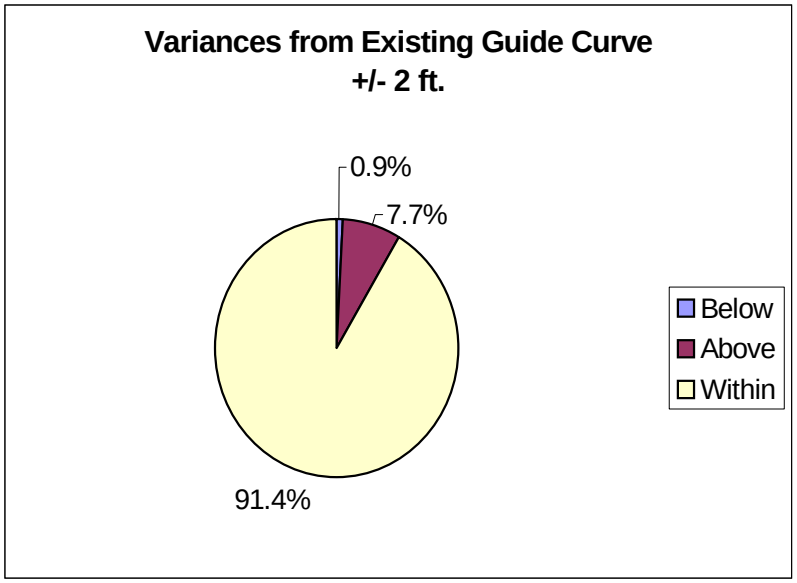
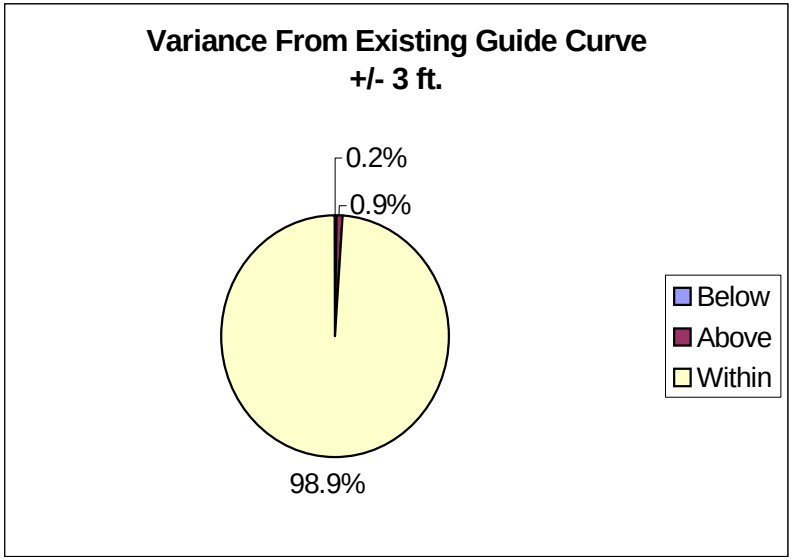
90
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
31-Dec
Month
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)







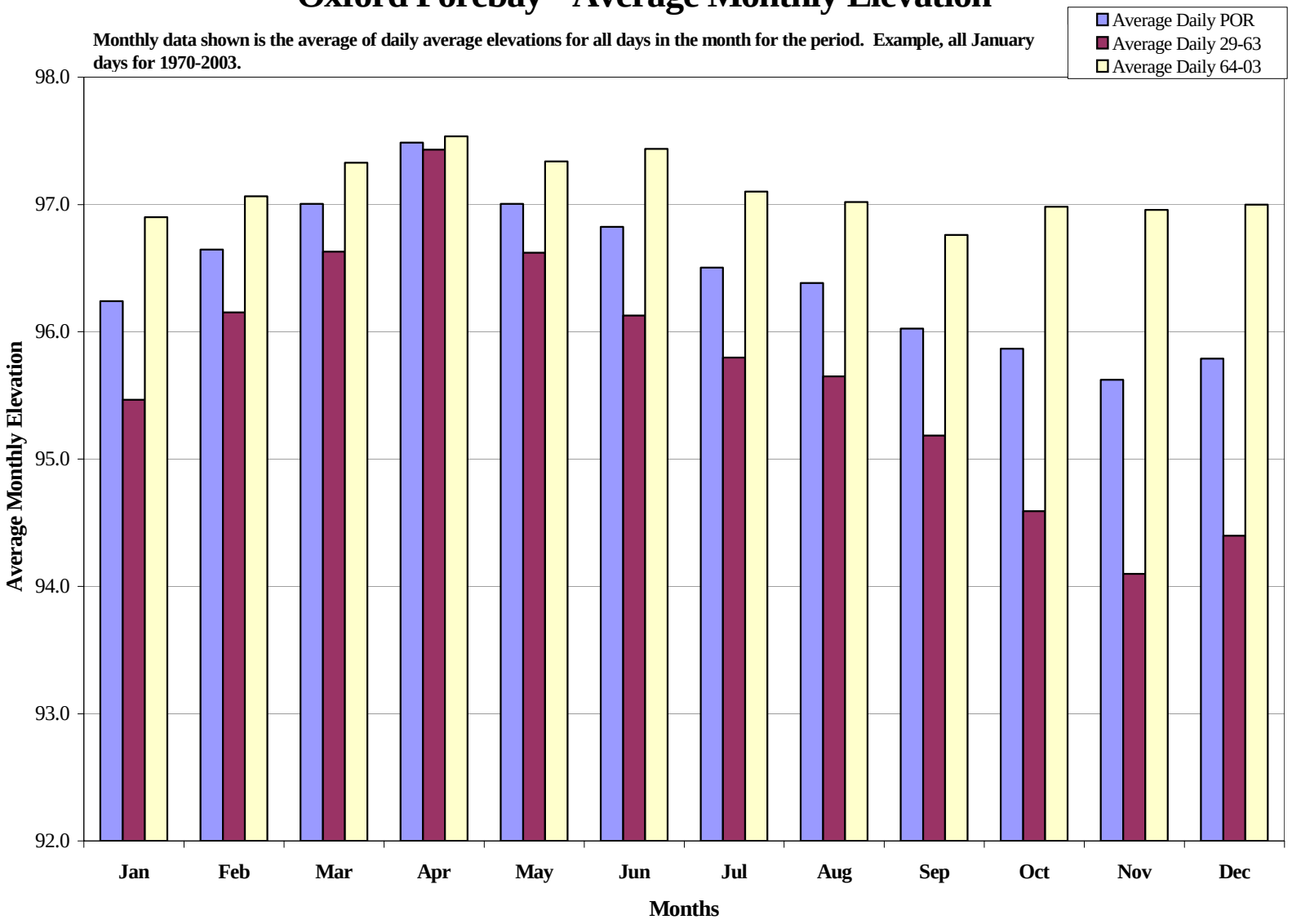
Oxford Development (Lake Hickory)

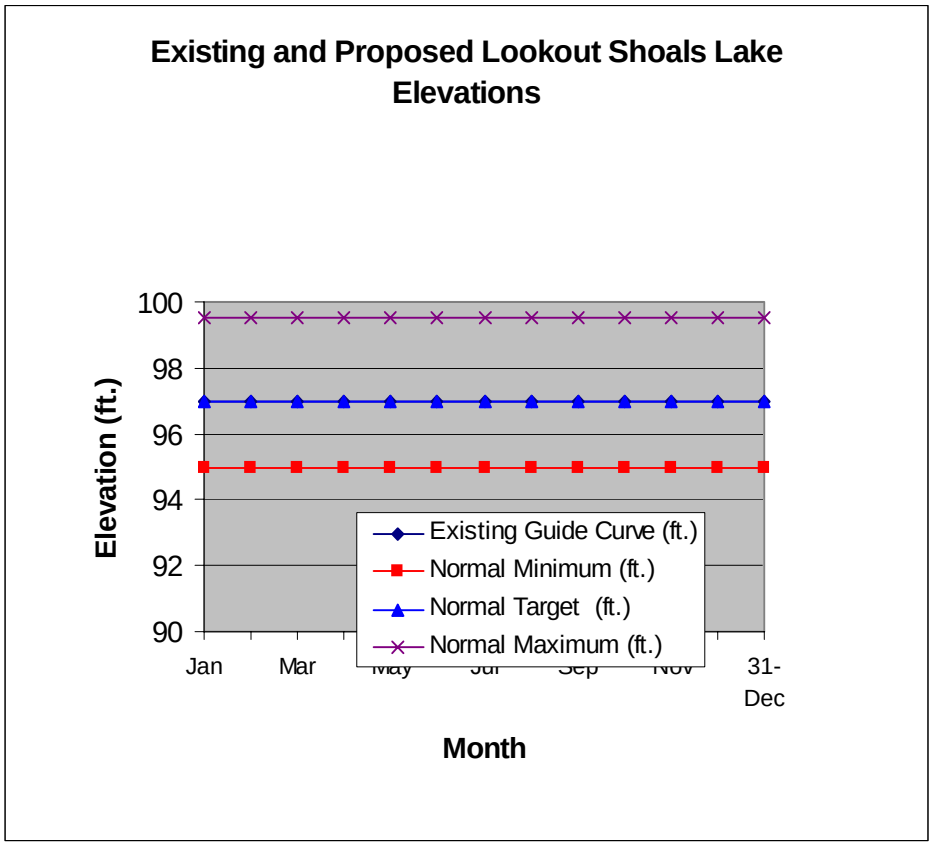
Reservoir Level Study

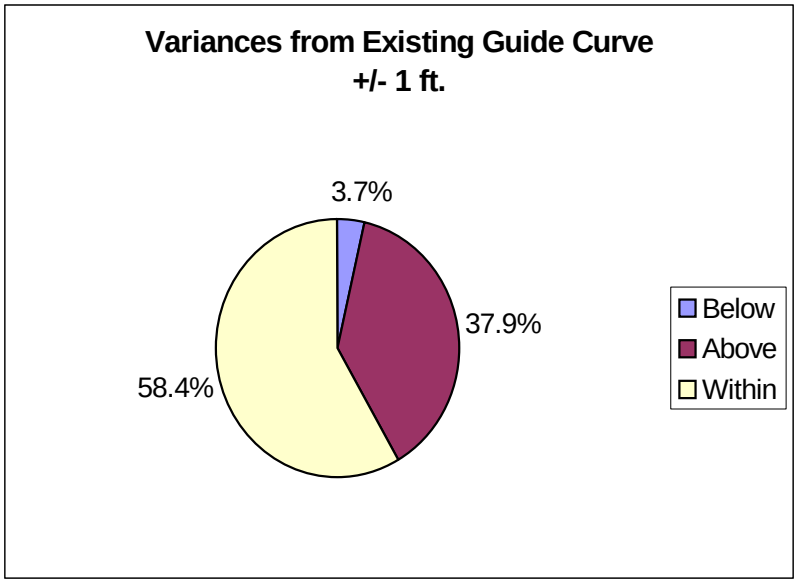
for Period of Record 1964 - 2003

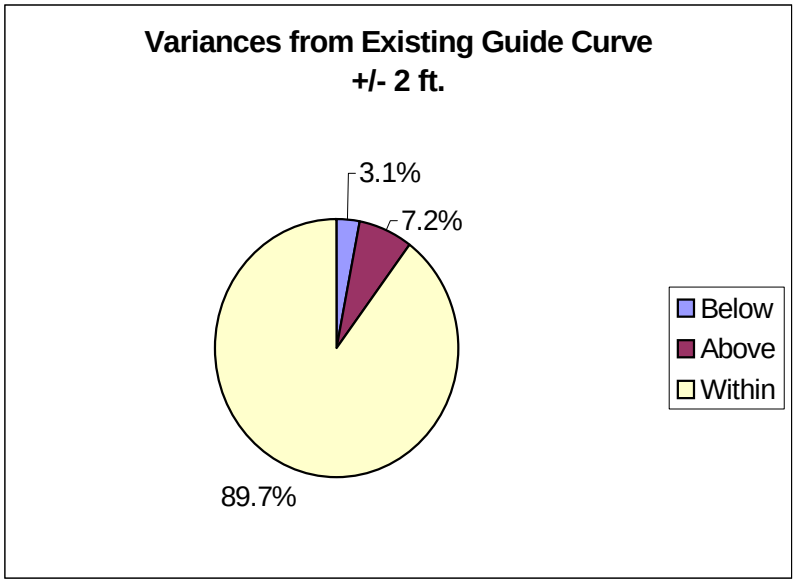
Oxford Forebay - Average Monthly Elevation

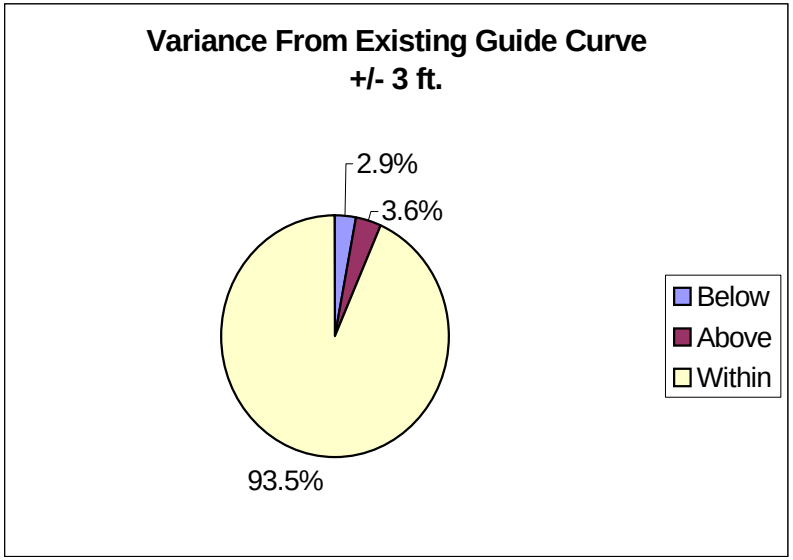
Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.




Existing and Proposed Lookout Shoals Lake Elevations
Elevation (ft.)
100
98
96
94
92
90
Jan
Mar
31-Dec
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)
Month





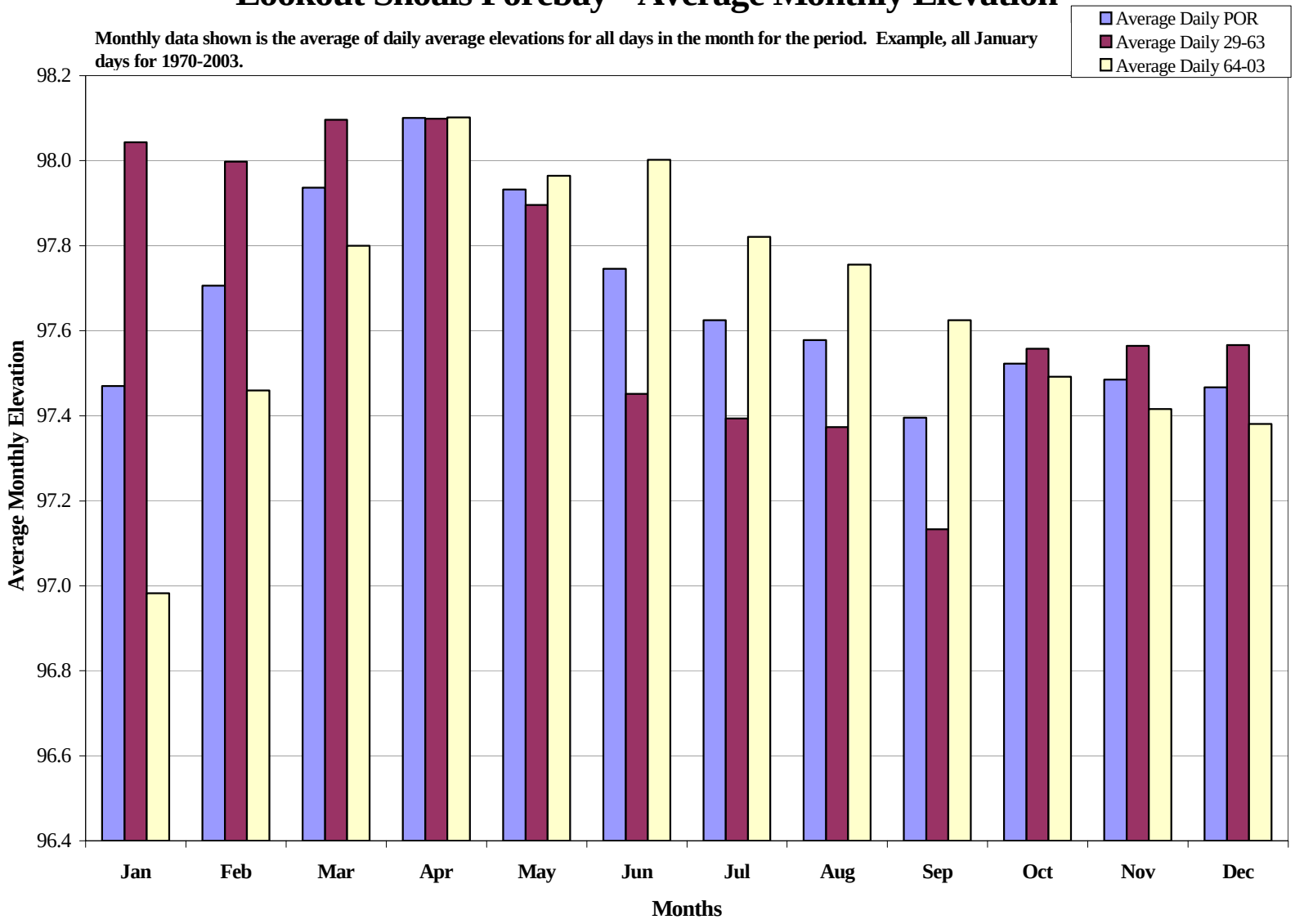


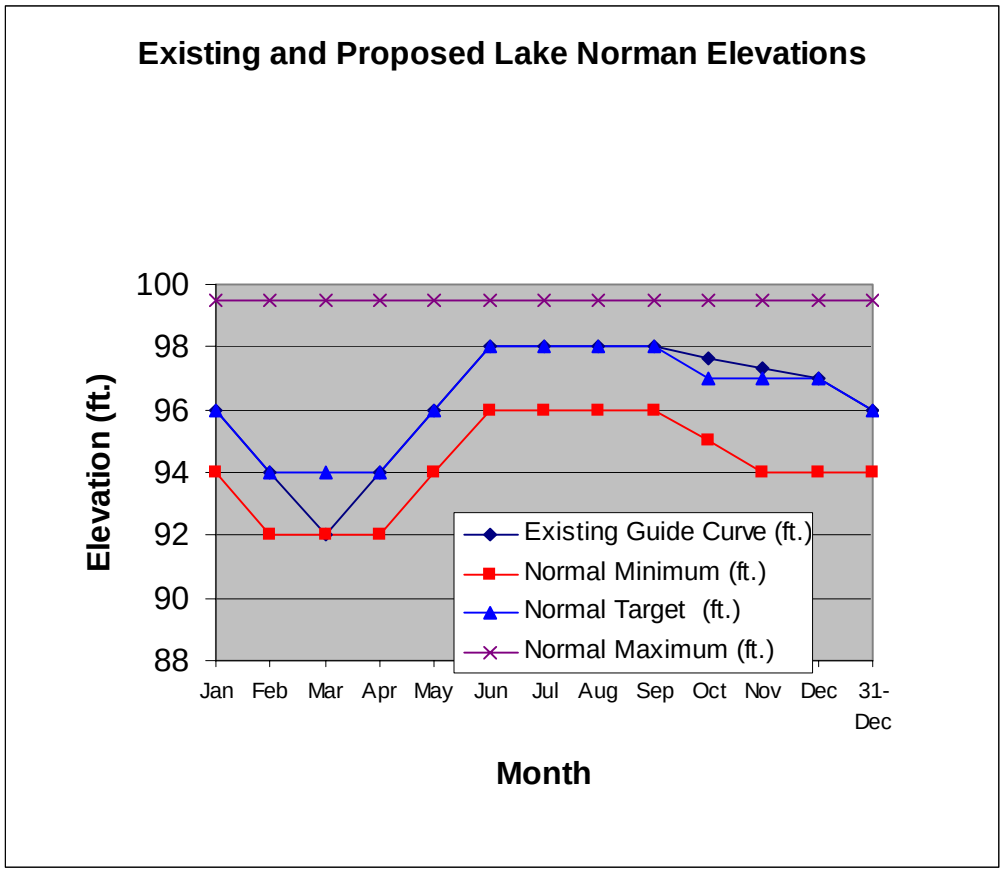
Lookout Shoals Development (Lookout Shoals Lake)

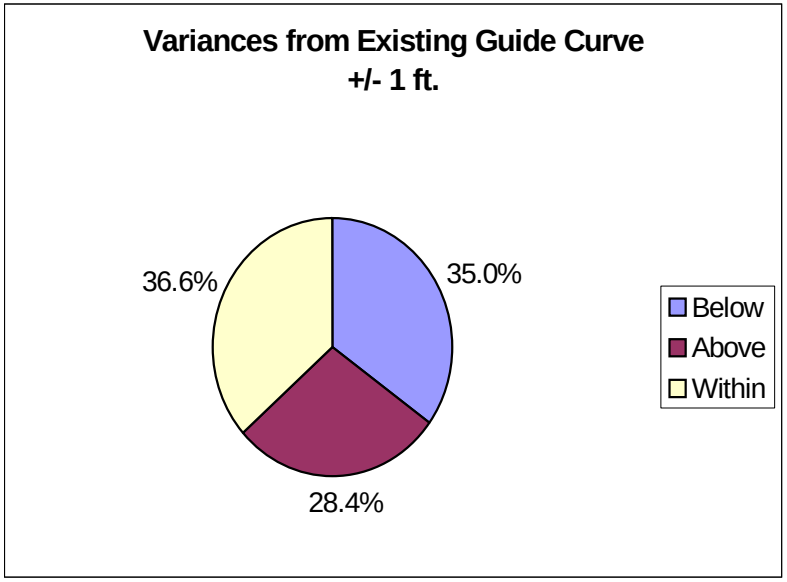
Reservoir Level Study

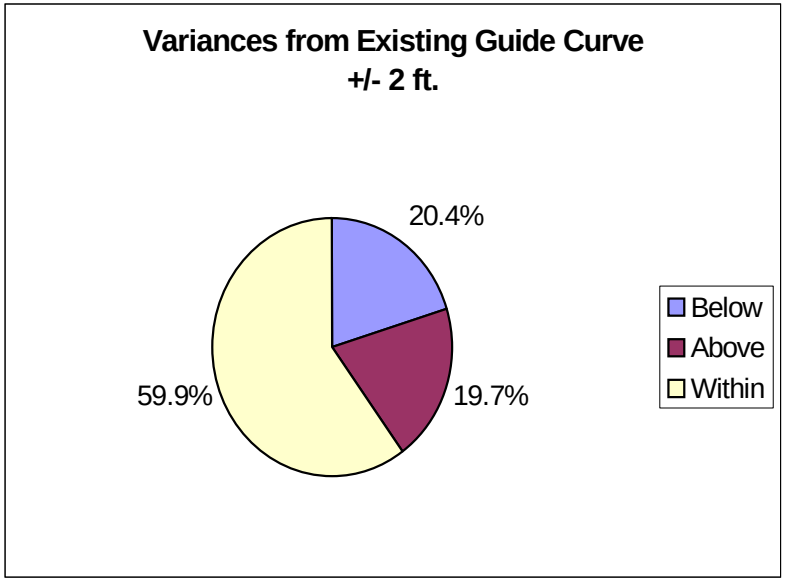
for Period of Record 1964 - 2003

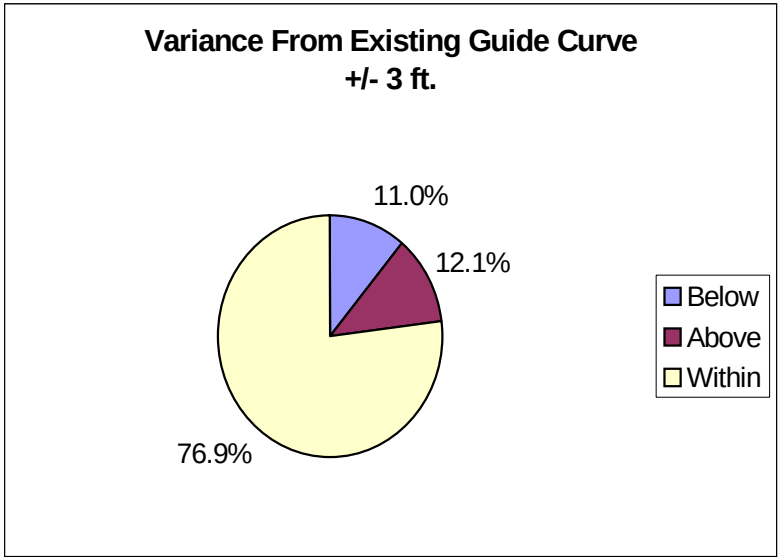
Lookout Shoals Forebay - Average Monthly Elevation




Existing and Proposed Lake Norman Elevations
100
98
96
94
92
90
88
Elevation (ft.)
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
31-Dec
Month







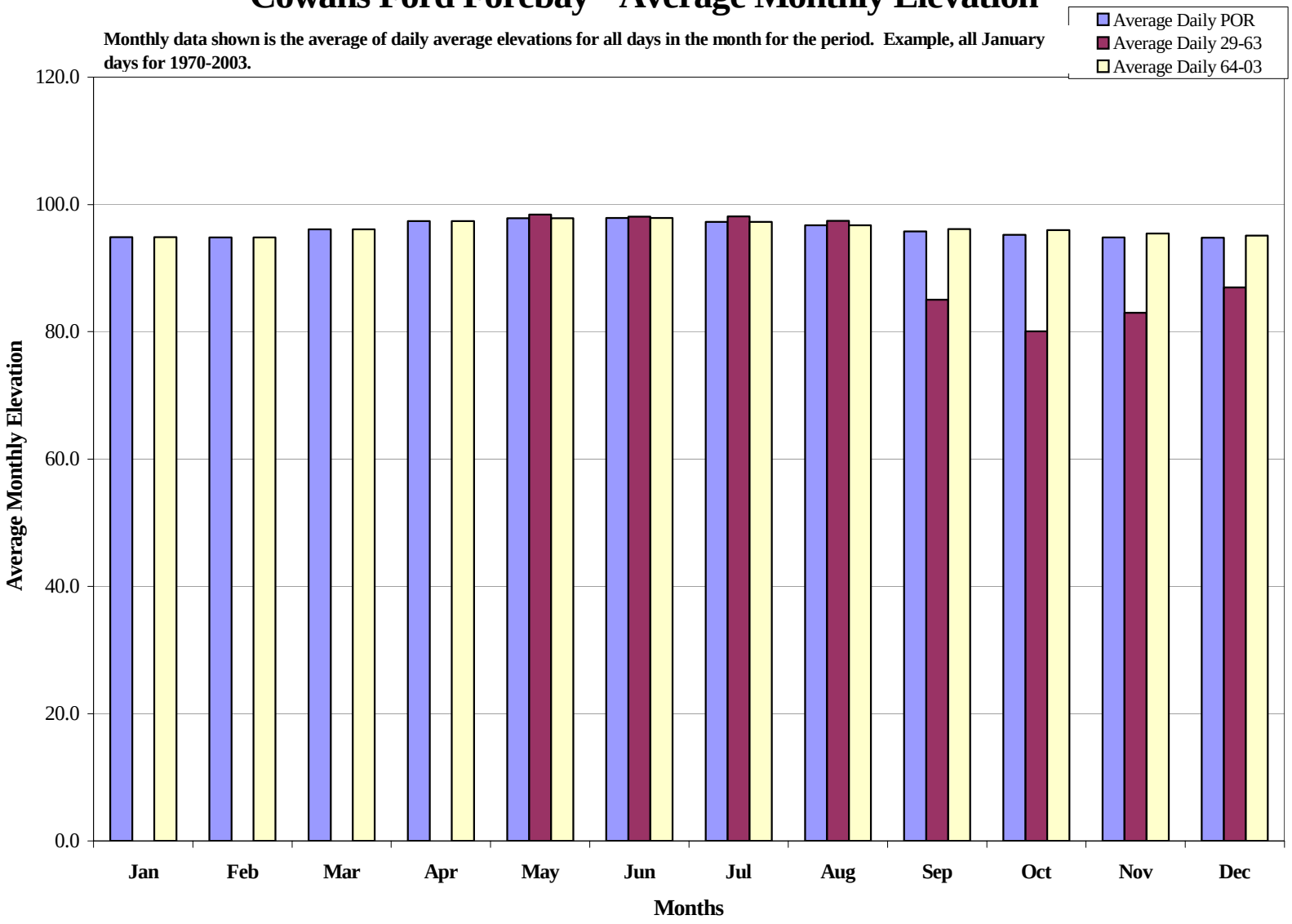
Cowans Ford Development (Lake Norman)

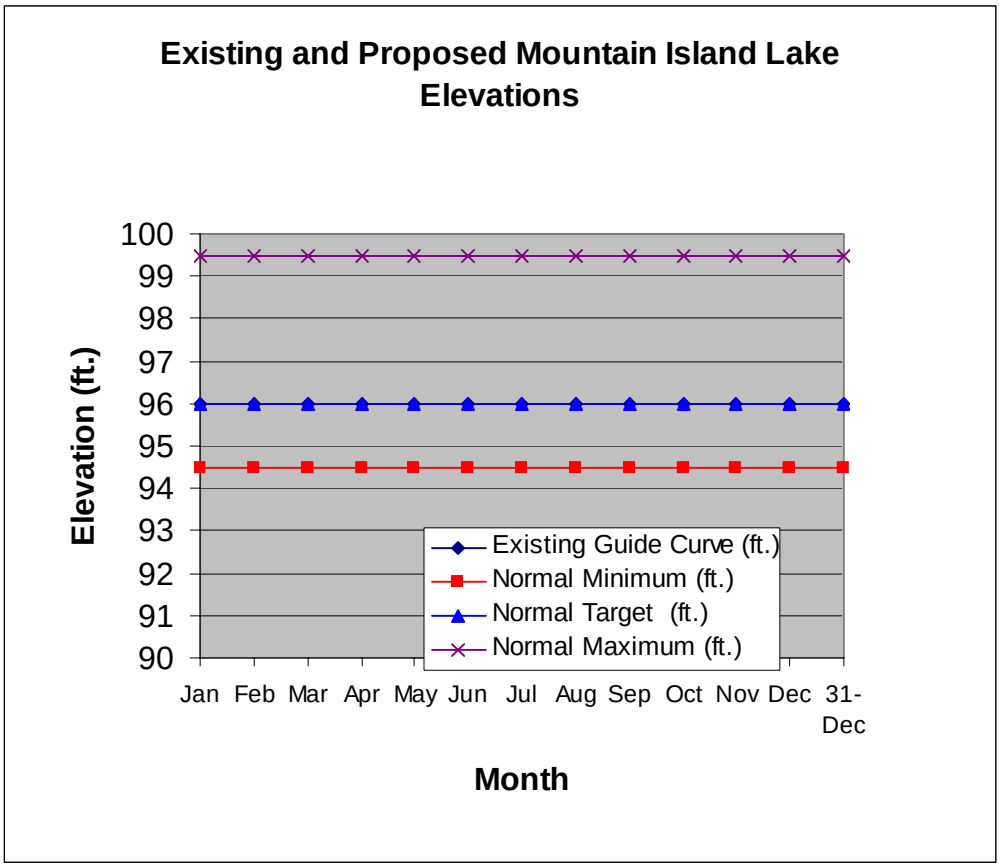
Reservoir Level Study

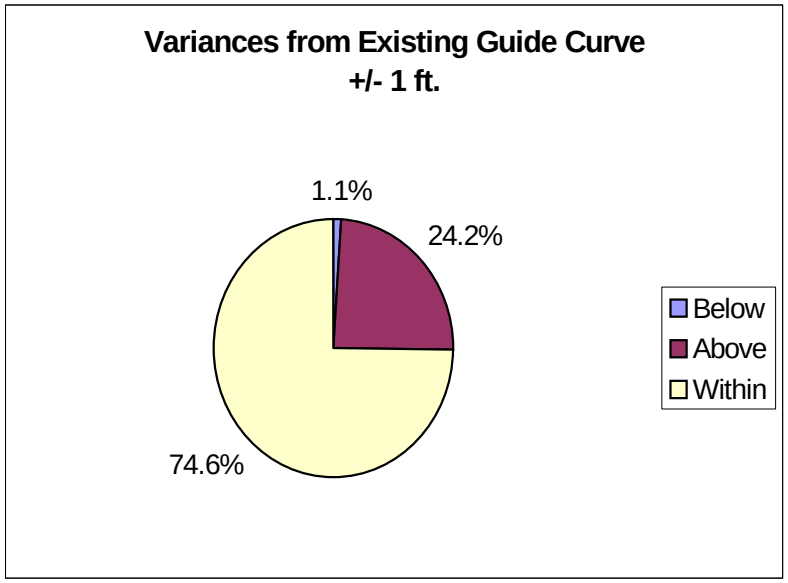
for Period of Record 1964 - 2003

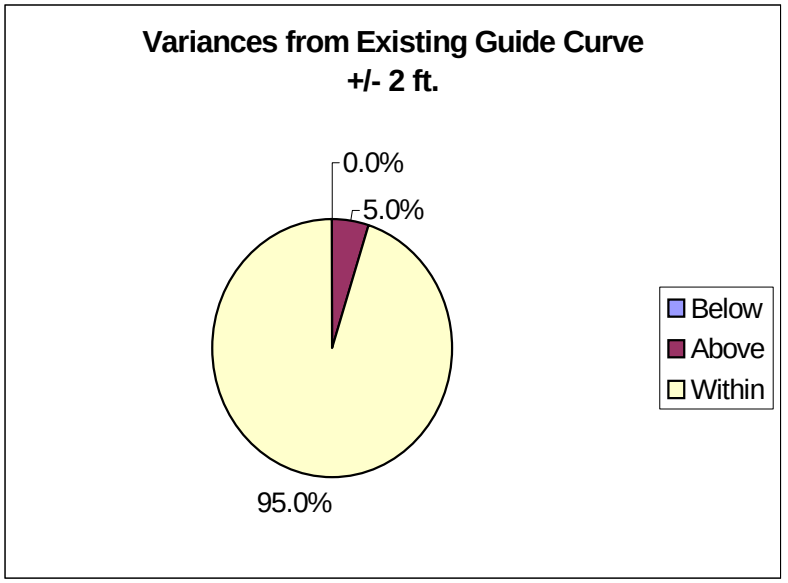
Cowans Ford Forebay - Average Monthly Elevation

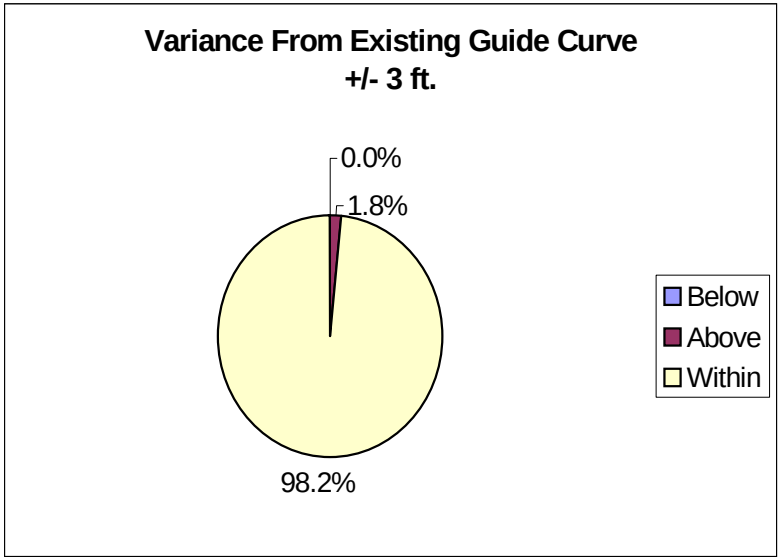
Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.




Existing and Proposed Mountain Island Lake Elevations
Elevation (ft.)
100
99
98
97
96
95
94
93
92
91
90
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec 31-Dec
Month
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)







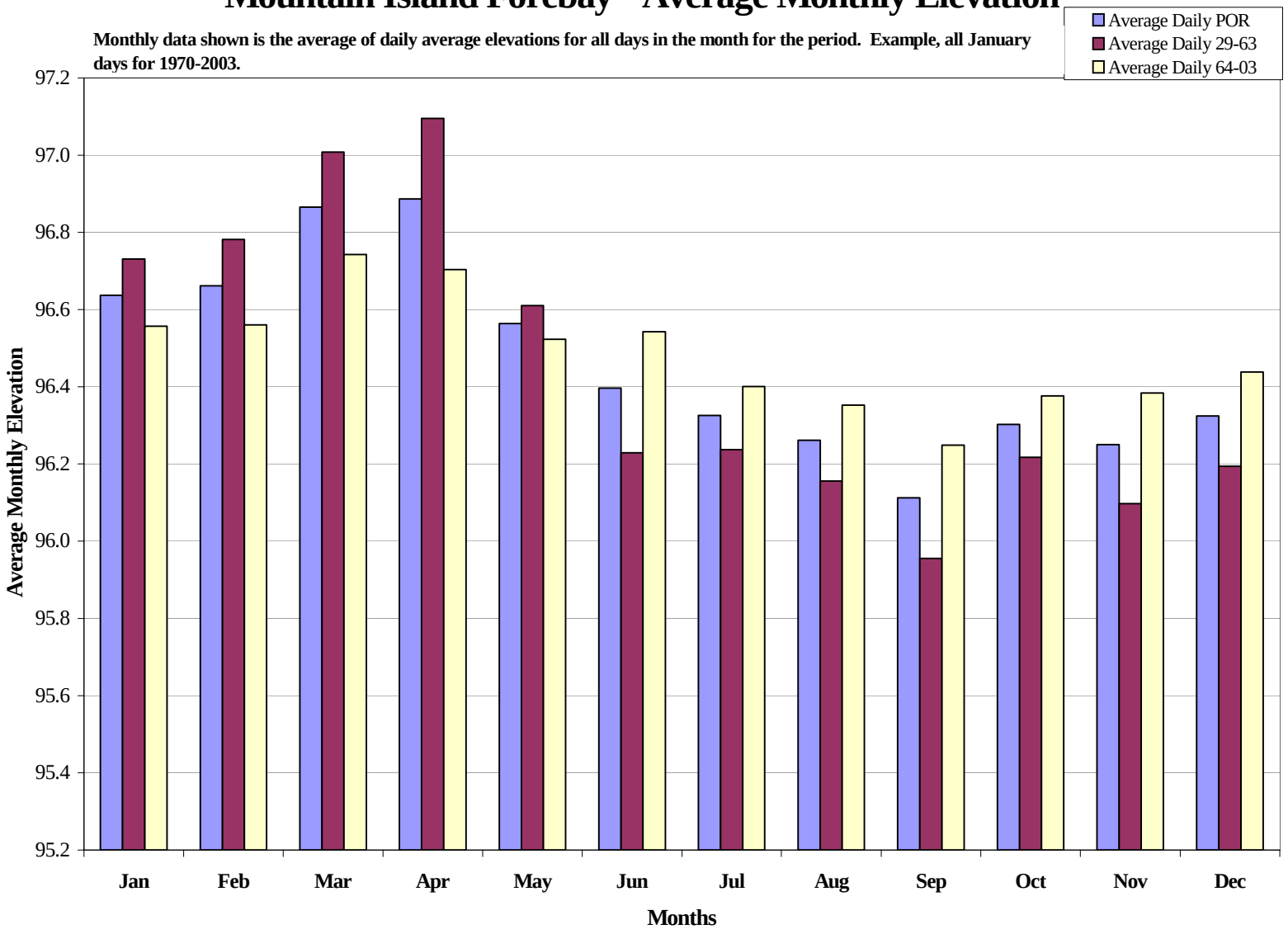
Mountain Island Development (Mountain Island Lake)

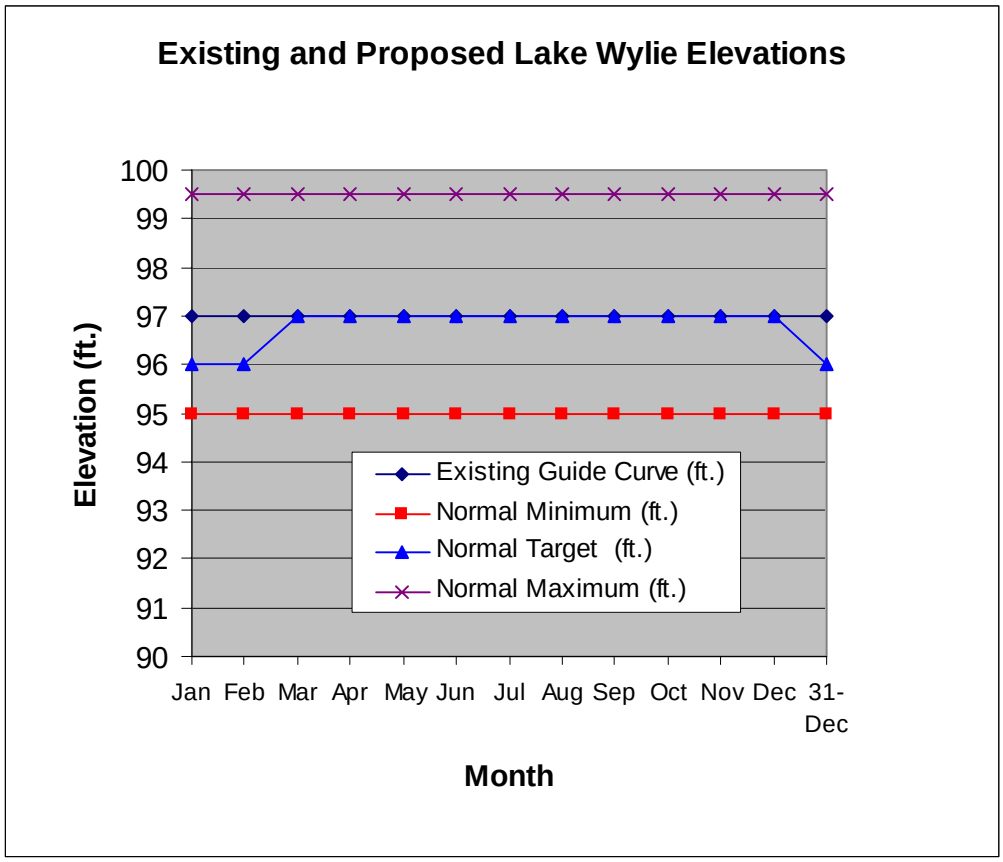
Reservoir Level Study

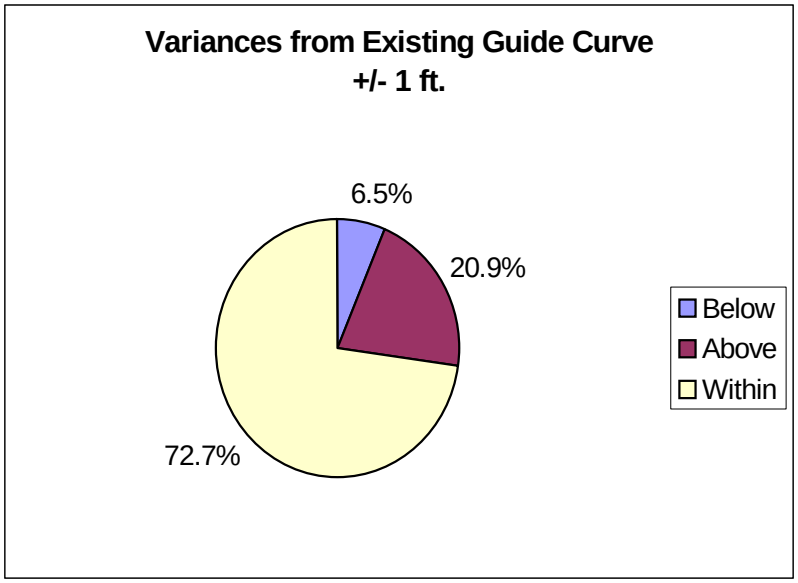
for Period of Record 1964 - 2003

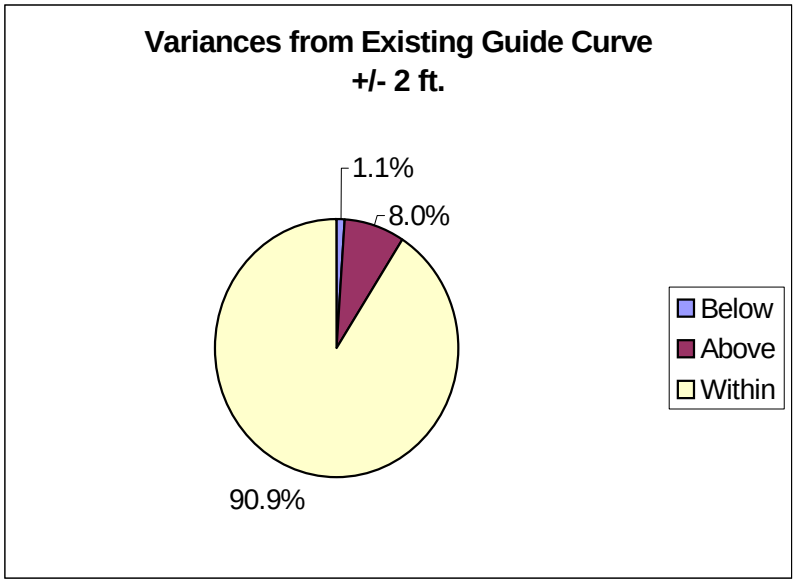
Mountain Island Forebay - Average Monthly Elevation

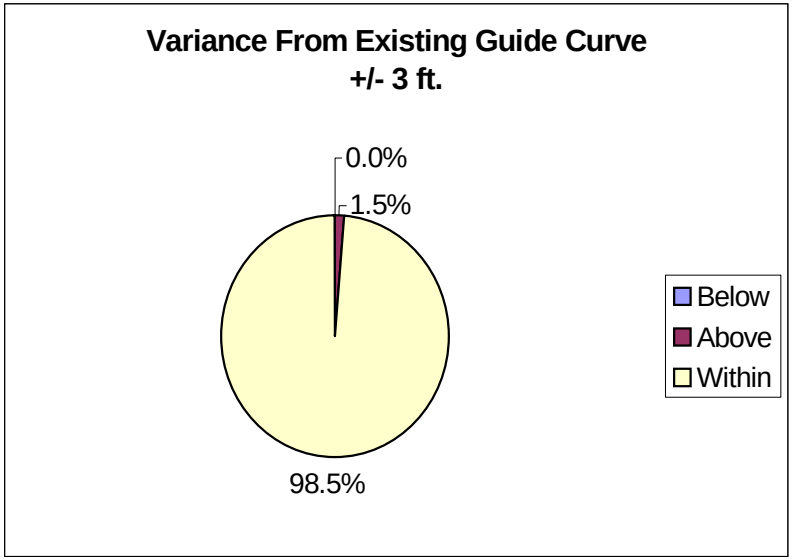
Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.




Existing and Proposed Lake Wylie Elevations
100
99
98
97
96
95
94
93
92
91
90
Elevation (ft.)
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec 31-Dec
Month







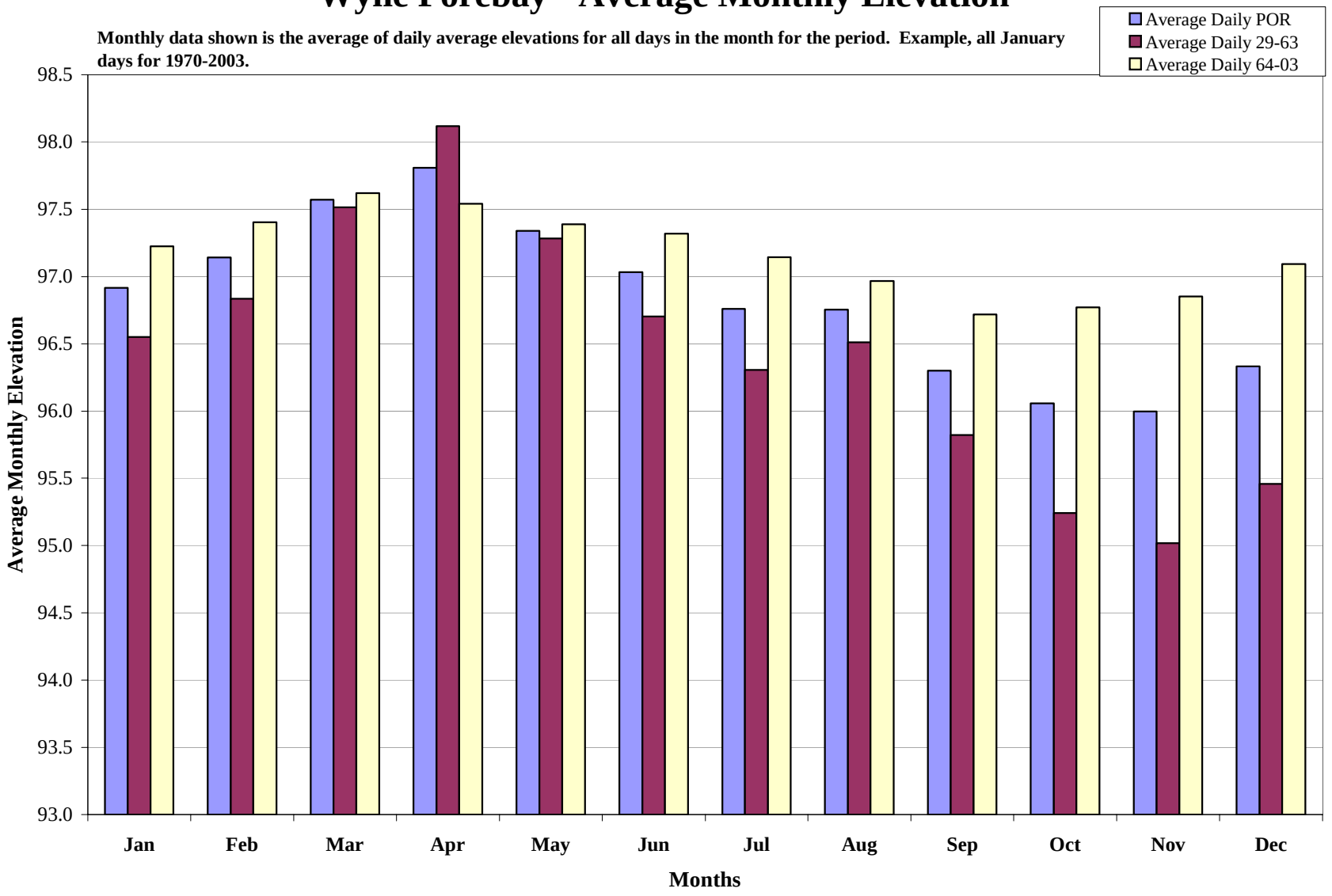
Wylie Development
(Lake Wylie)

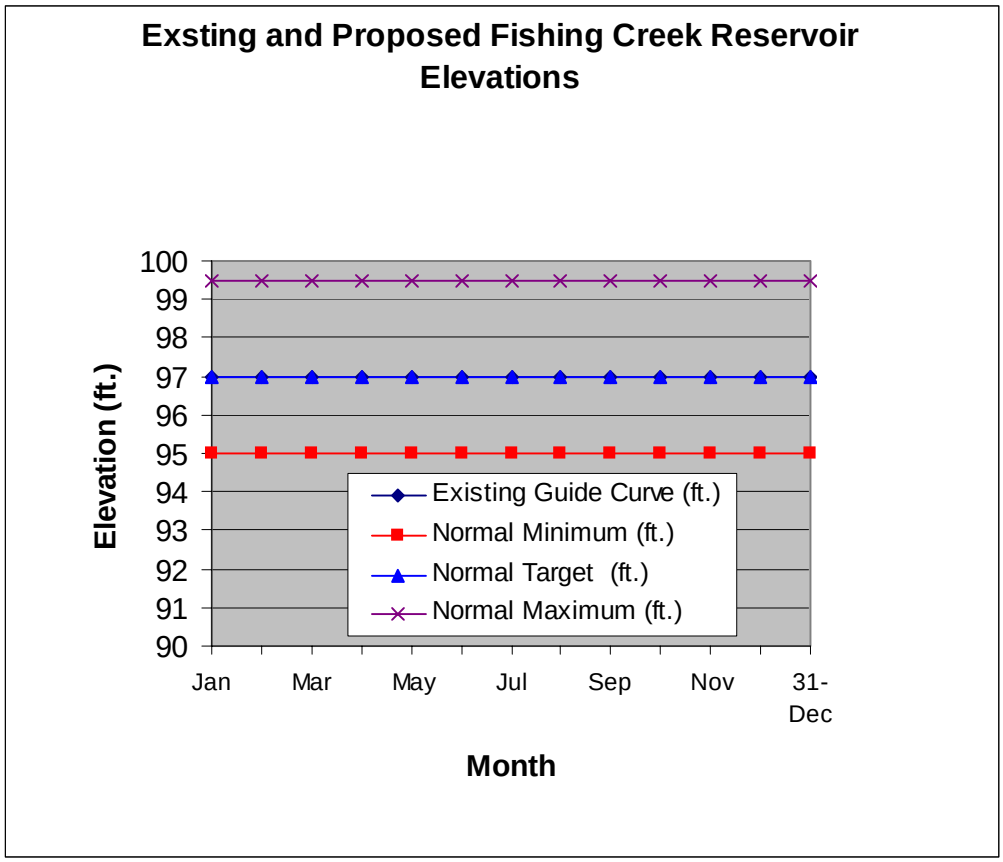
Reservoir Level Study

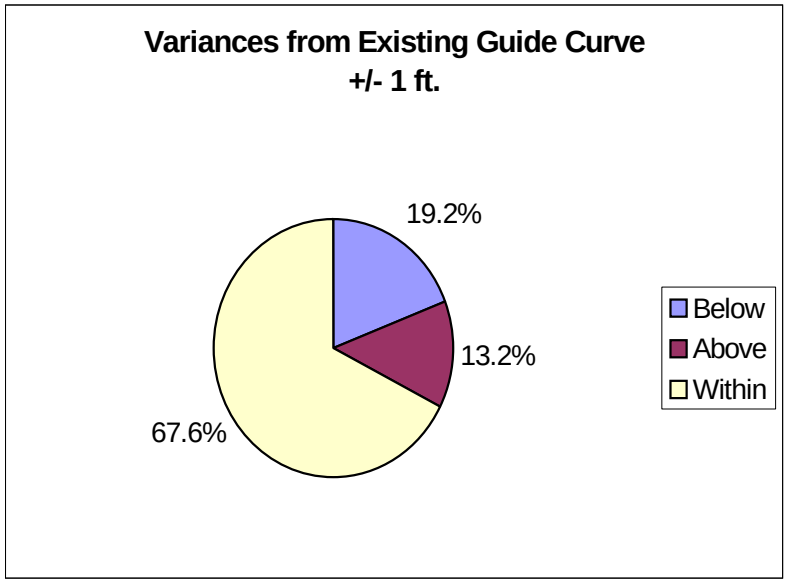
for Period of Record
1964 - 2003

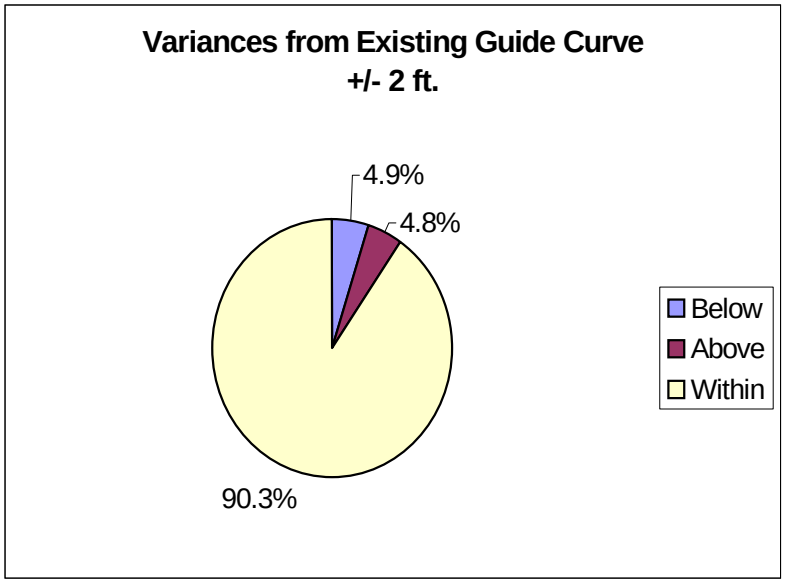
Wylie Forebay - Average Monthly Elevation

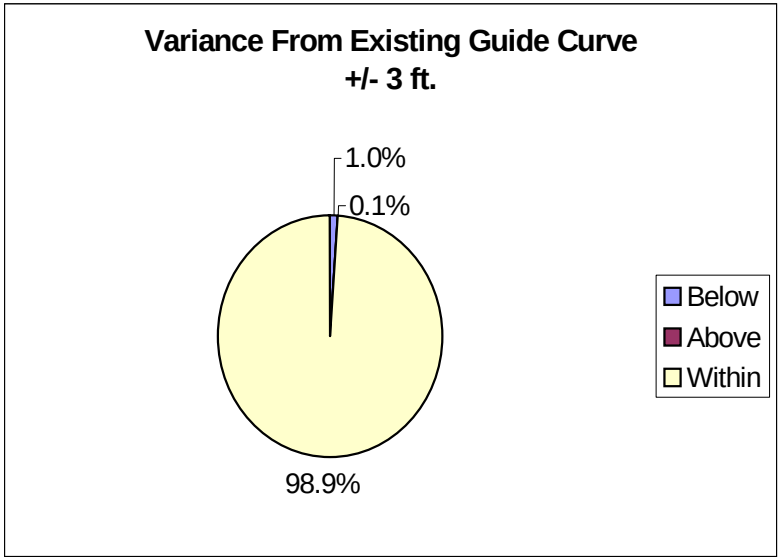
Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.




Exsting and Proposed Fishing Creek Reservoir Elevations
Elevation (ft.)
100
99
98
97
96
95
94
93
92
91
90
Jan
Mar
May
Jul
Sep
Nov
31-Dec
Month
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)







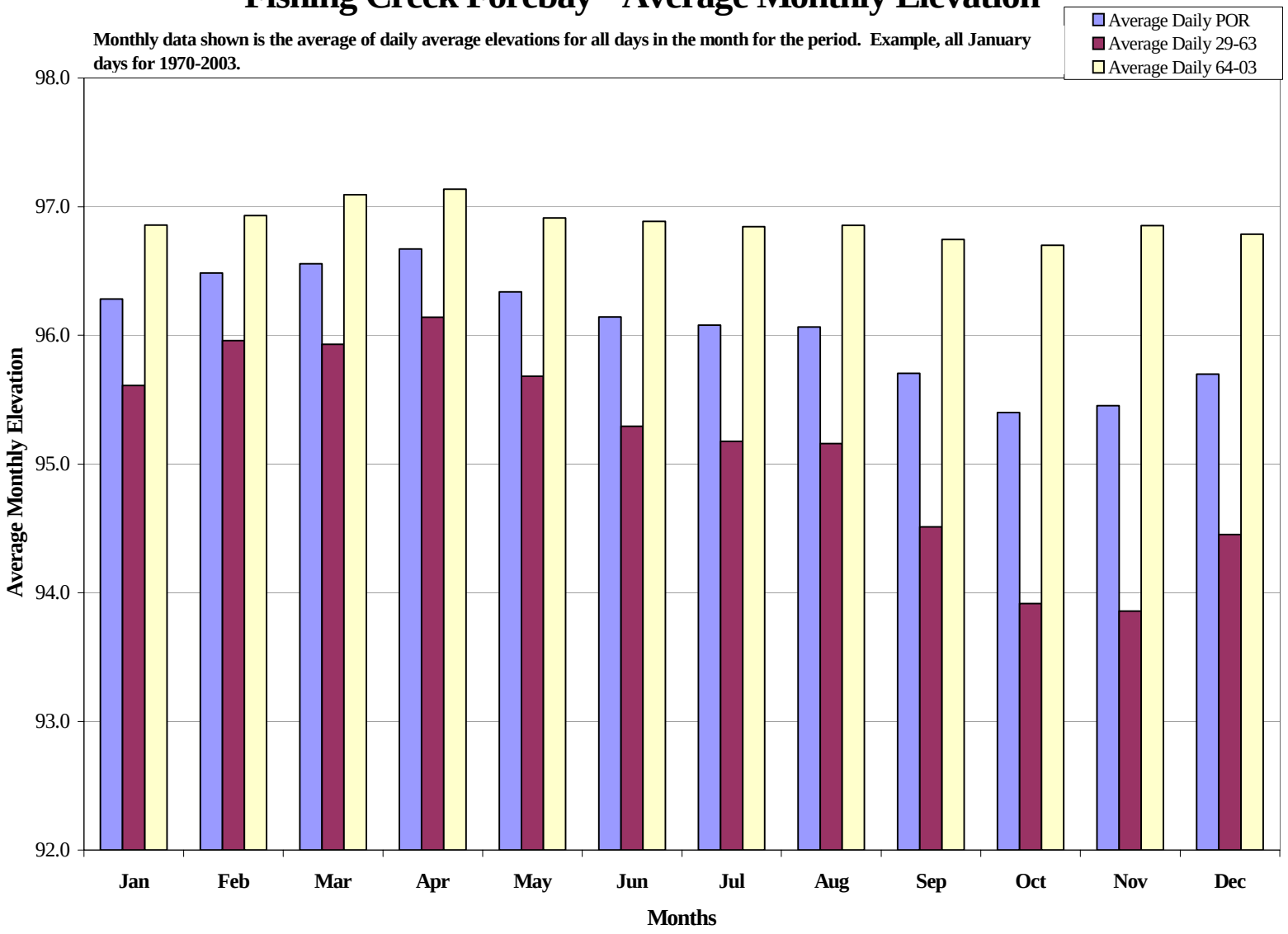
Fishing Creek Development (Fishing Creek Lake)

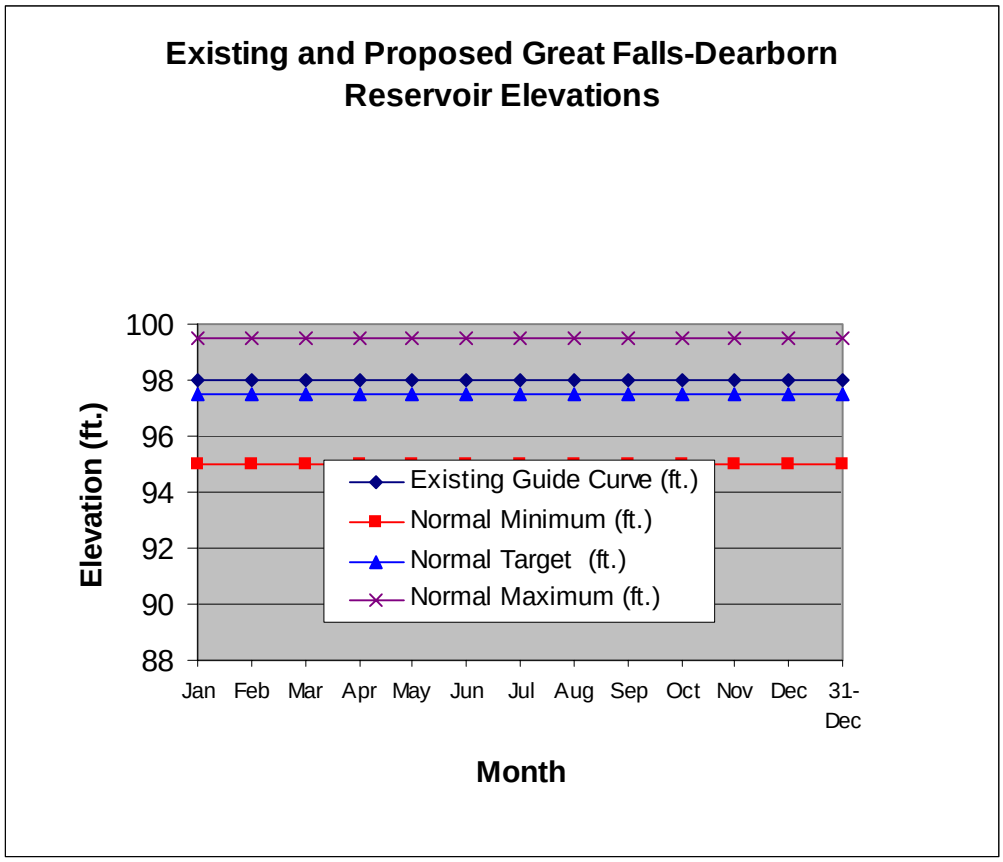
Reservoir Level Study

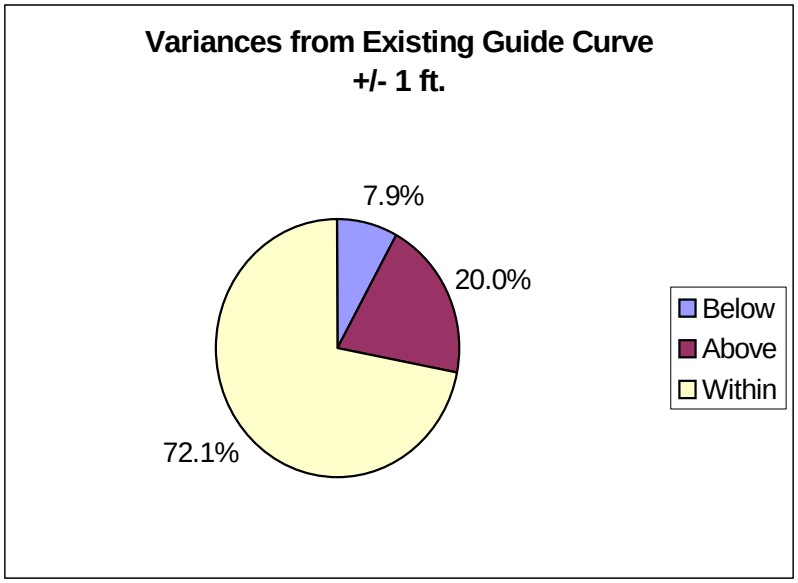
for Period of Record 1964 - 2003

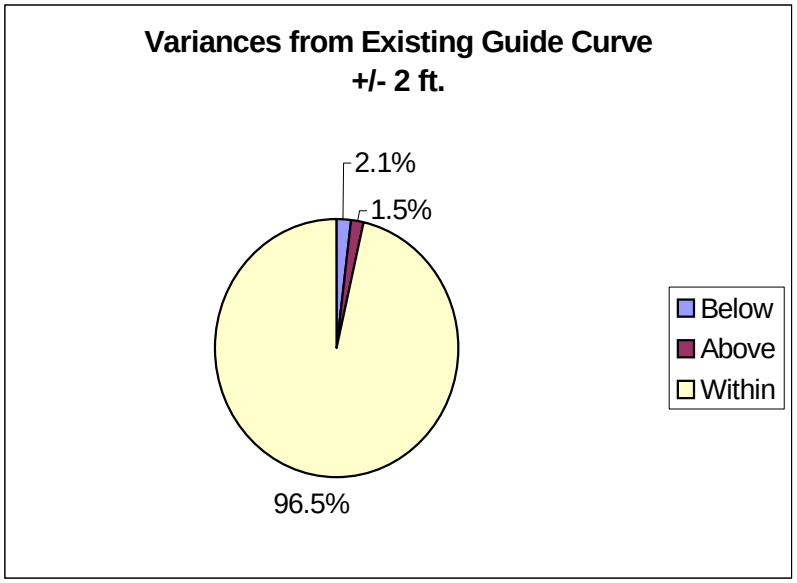
Fishing Creek Forebay - Average Monthly Elevation

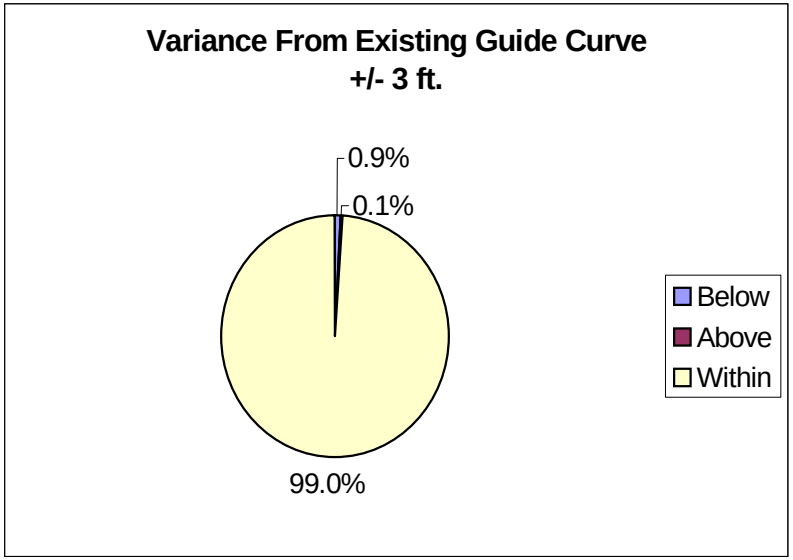
Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.




Existing and Proposed Great Falls-Dearborn Reservoir Elevations
100
98
96
94
92
90
88
Elevation (ft.)
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
31-Dec
Month







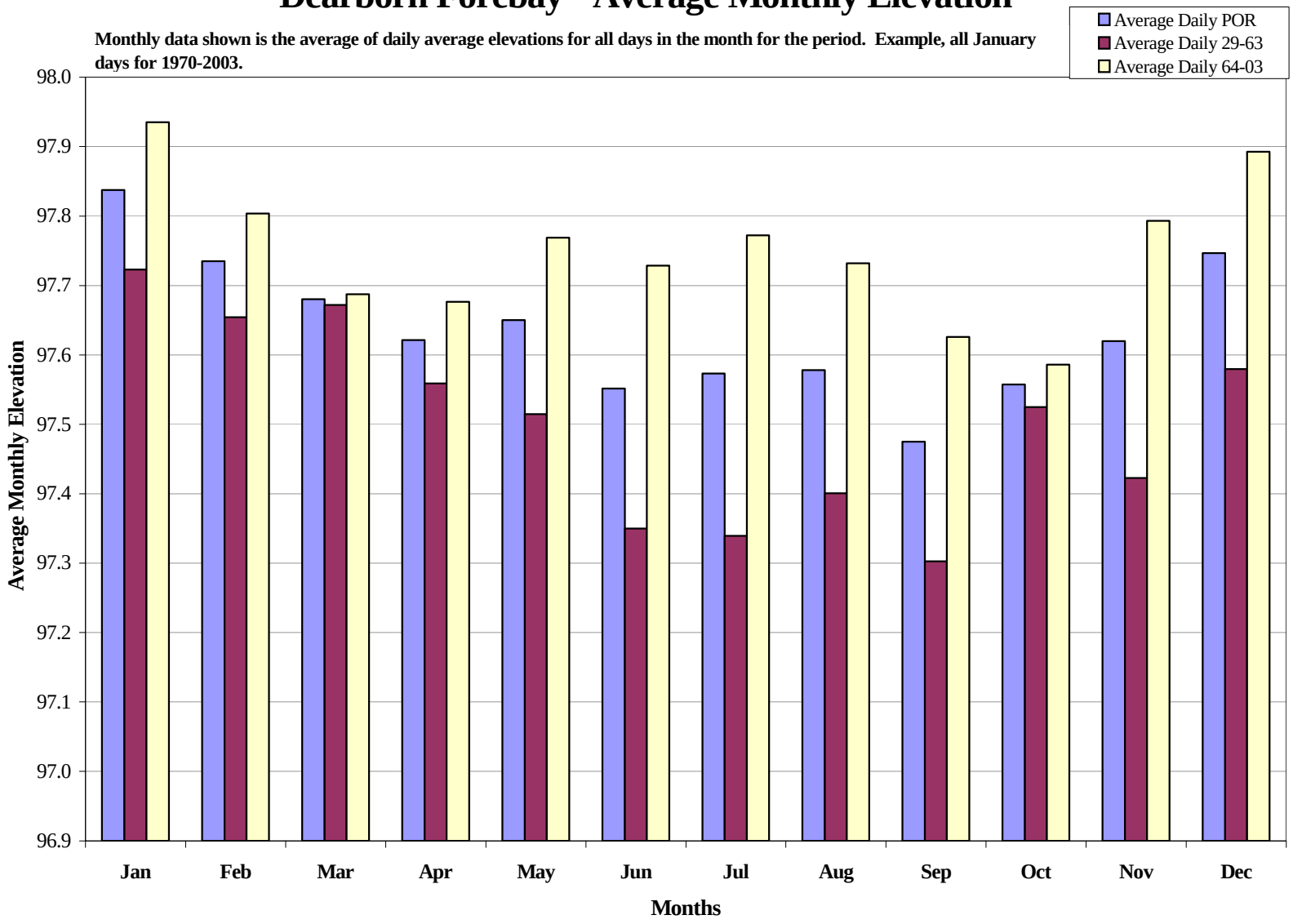
Dearborn Development (Great Falls-Dearborn Reservoir)

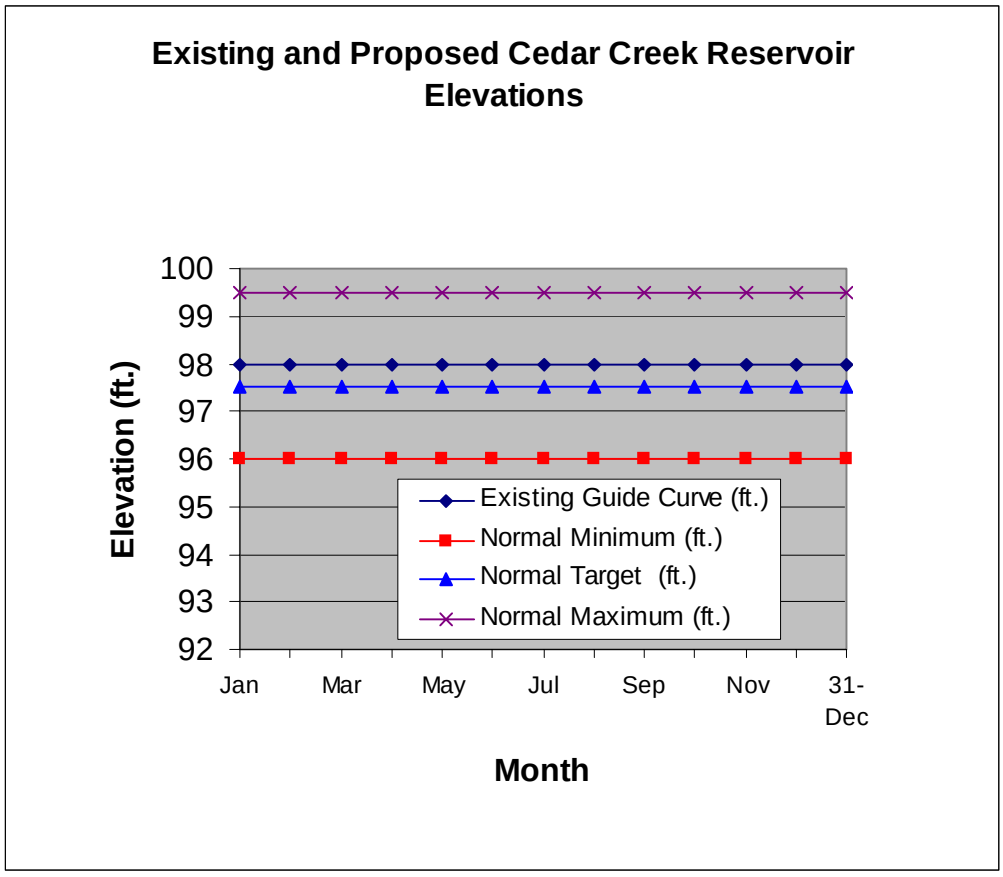
Reservoir Level Study

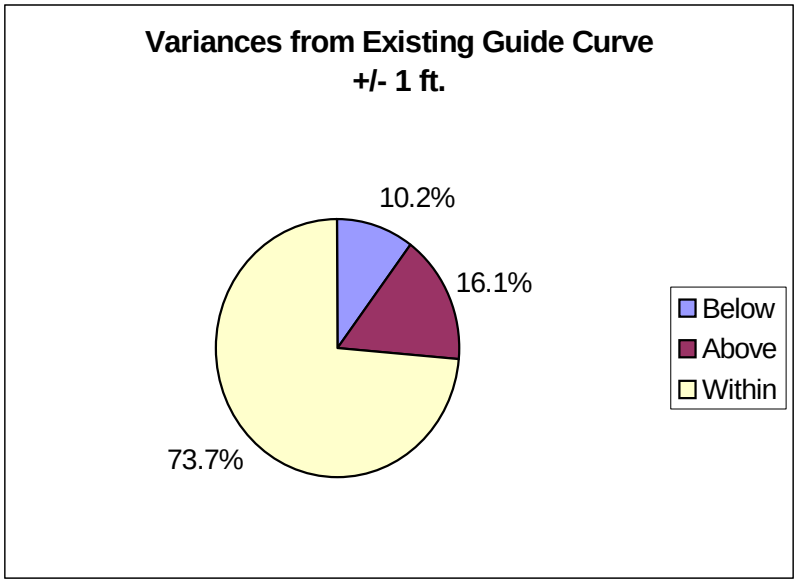
for Period of Record 1964 - 2003

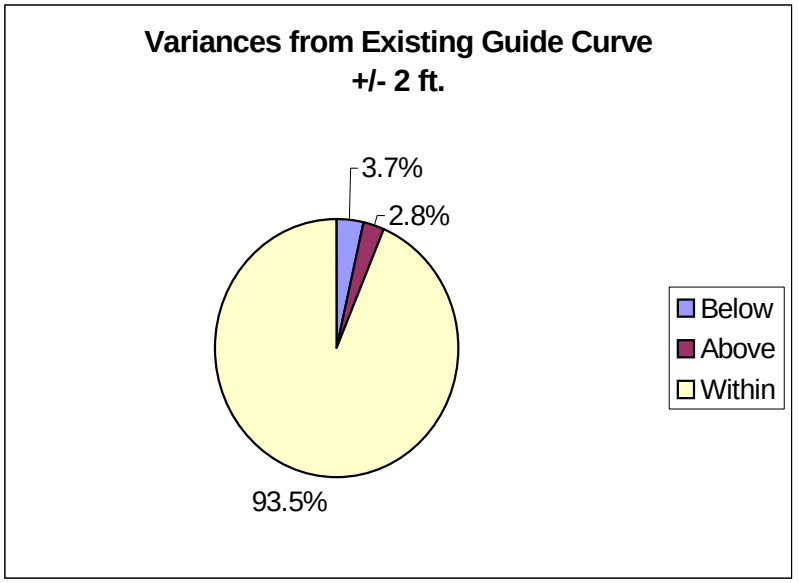
Dearborn Forebay - Average Monthly Elevation

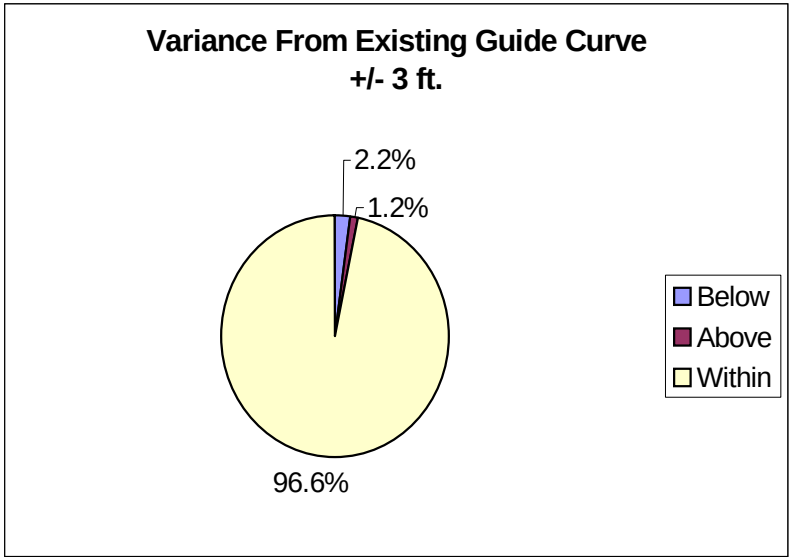
Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.




Existing and Proposed Cedar Creek Reservoir Elevations
100
99
98
97
96
95
94
93
92
Elevation (ft.)
Jan
Mar
May
Jul
Sep
Nov
31-Dec
Month
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum (ft.)







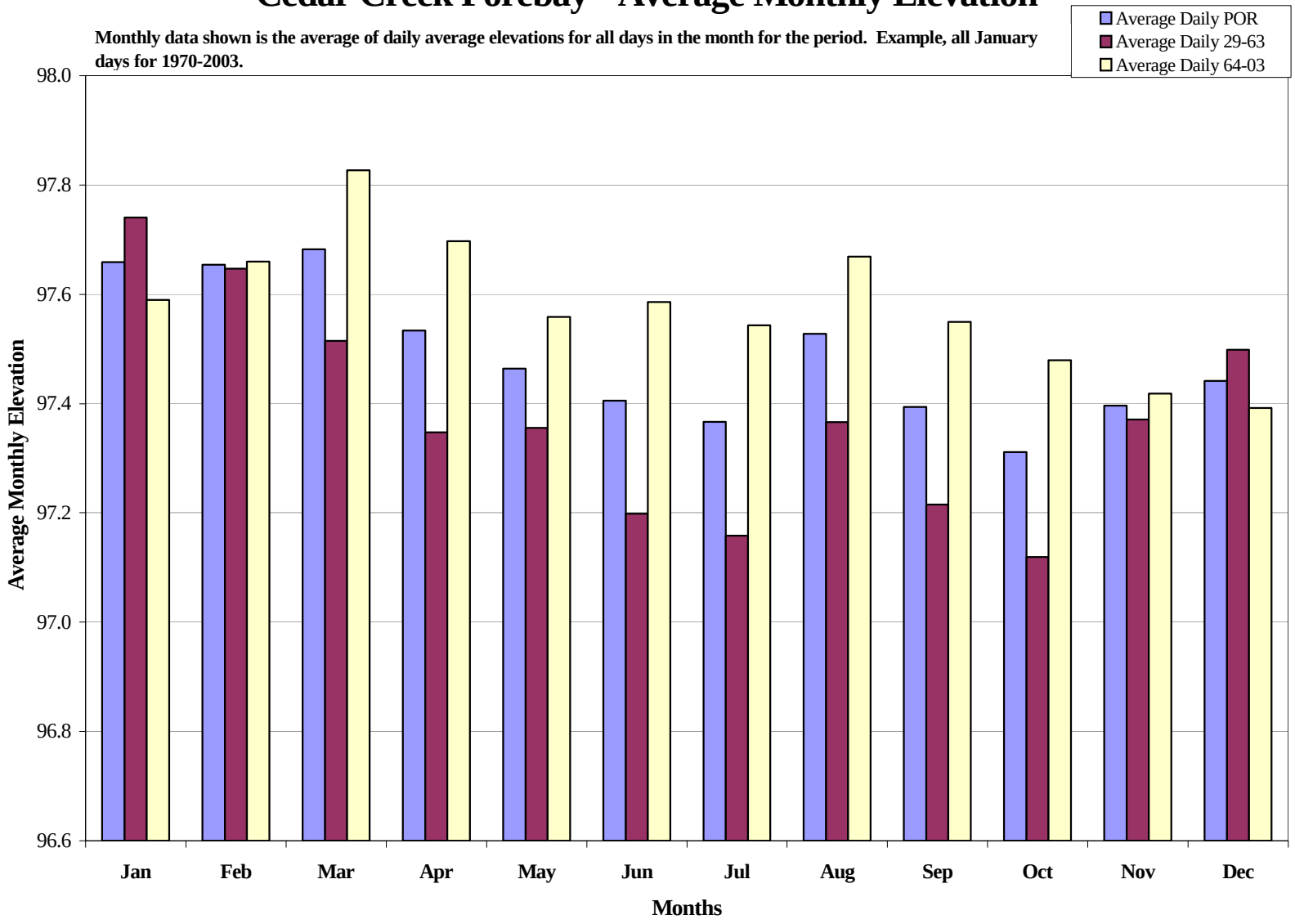
Cedar Creek Development (Rocky Creek Lake)

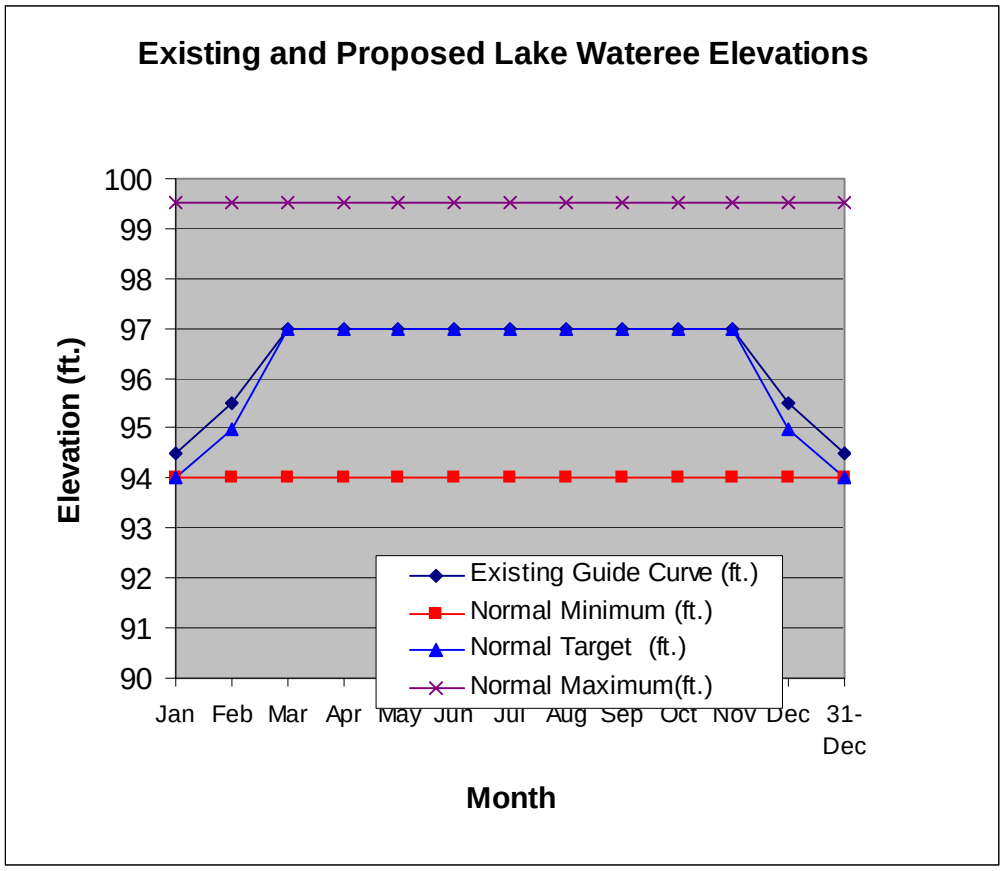
Reservoir Level Study

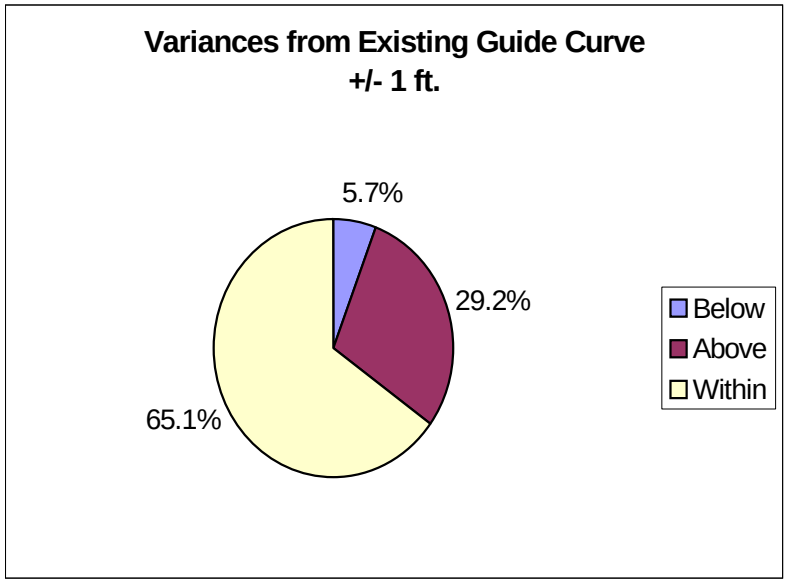
for Period of Record 1964 - 2003

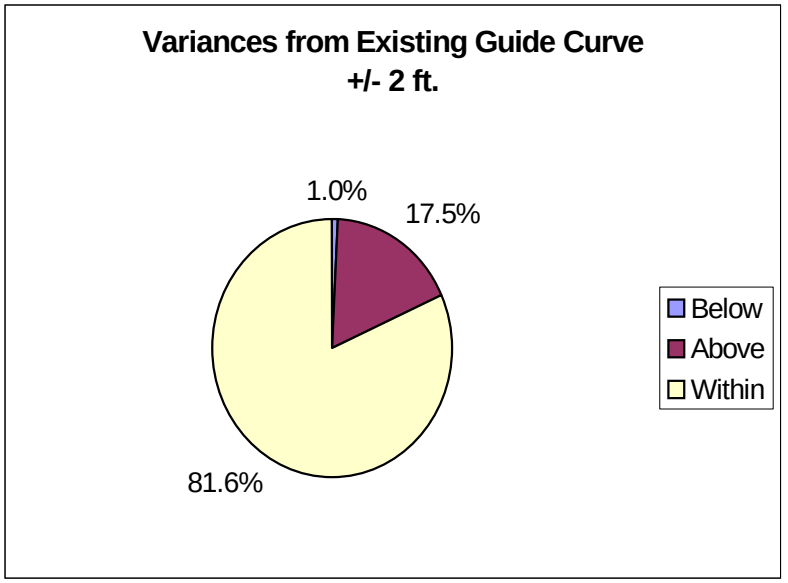
Cedar Creek Forebay - Average Monthly Elevation

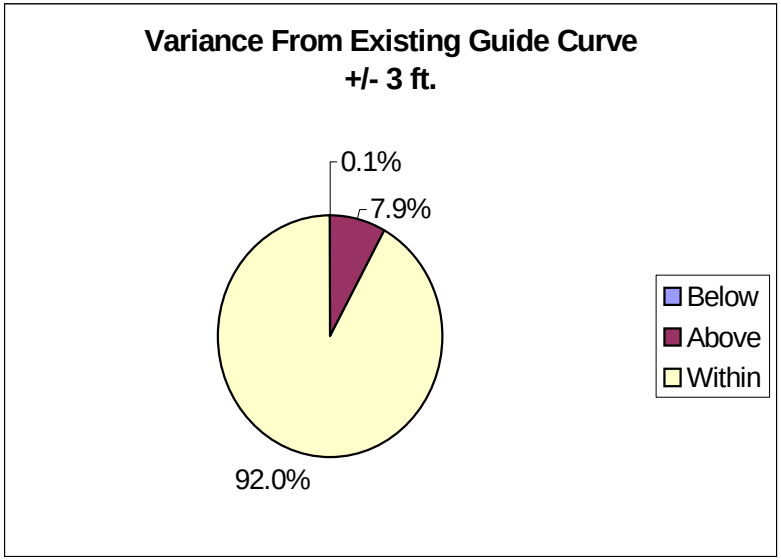
Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.




Existing and Proposed Lake Wateree Elevations
Elevation (ft.)
100
99
98
97
96
95
94
93
92
91
90
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
31-Dec
Month
Existing Guide Curve (ft.)
Normal Minimum (ft.)
Normal Target (ft.)
Normal Maximum(ft.)







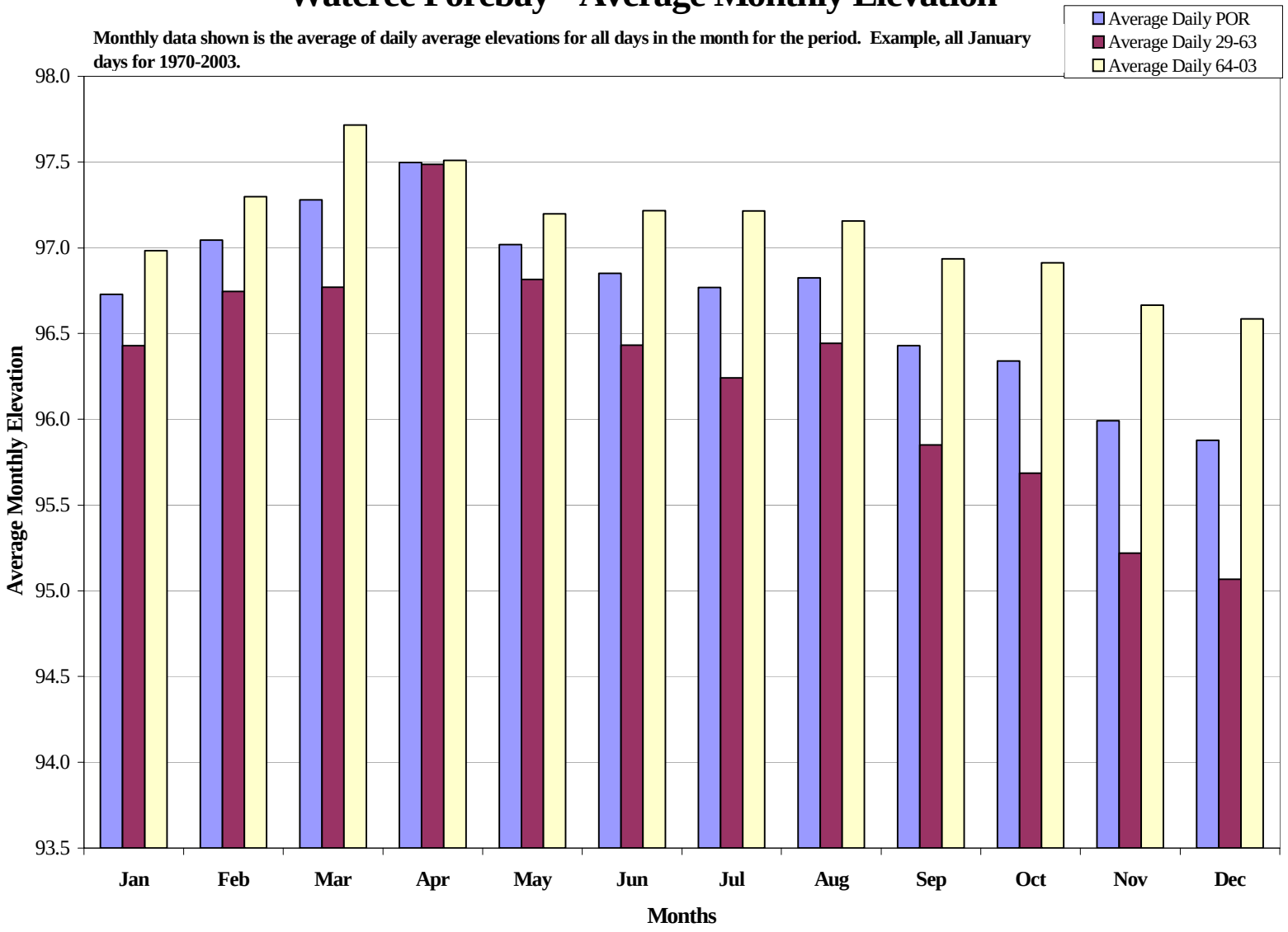
Wateree Development
(Lake Wateree)

Reservoir Level Study

for Period of Record
1964 - 2003

Wateree Forebay - Average Monthly Elevation

Monthly data shown is the average of daily average elevations for all days in the month for the period. Example, all January days for 1970-2003.



Appendix C

Cobble --Shorelines where cobble composes > 50% of the substrate for a linear distance of 100 feet.

Riprap/Piers--Shorelines with riprap or piers that intrude into the reservoir.

Vegetation/Confluence--Shorelines where stable, emergent vegetation (any portion of which is at least 5 horizontal feet wide) composes > 50% of the area between the minimum lakeward distance of the vegetation for a linear distance of 100 feet or where a stream confluence enters the reservoir.

Mud flat--Shorelines with a mud substrate for a linear distance of 100 feet that are also < 3 feet deep (at normal pool elevations) 150 feet from shore.

Sand--Shorelines where sand composes > 50% of the substrate for a linear distance of 100 feet.

Clay--Shorelines where clay composes > 50% of the substrate for a linear distance of 100 feet.

Woody debris--Shorelines where 4 or more felled trees (> 10 inches in diameter) extend into the reservoir within a linear distance of 100 feet.

Water willow--Shorelines that support significant stands of water willow *Justicia americana.*

Appendix D

Table 1. Range in elevations (feet) associated with major littoral habitat types found in Lake James, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay[3] Elevation	Woody debris[4] Elevation
1	100.0-93.0	100.0-95.6	100.0-96.2	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
2	100.0-93.0	100.0-96.2	100.0-96.6	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
3	100.0-93.0	100.0-93.0	100.0-97.9	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
4	100.0-93.0	100.0-94.1	100.0-96.5	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
5	100.0-93.0	100.0-93.0	100.0-97.2	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
6		100.0-93.0	100.0-97.1		100.0-93.0	100.0-93.0	
7		100.0-95.6	100.0-96.2		100.0-93.0	100.0-93.0	
8		100.0-95.6	100.0-96.5		100.0-93.0	100.0-93.0	
9		100.0-95.6	100.0-97.0		100.0-93.0	100.0-93.0	
10		100.0-95.6	100.0-96.2		100.0-93.0	100.0-93.0	
Mean	100.0-93.0	100.0-94.7	100.0-96.7	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0

[1] Piers extend through drawdown zone, considerable riprap extending through most of the drawdown zone (to 95.4 feet, on average), and predominately a clay substrate deeper than the riprap

[2] Predominately a mud substrate

[3] Predominately a clay substrate through the drawdown zone

[4] Predominately a clay substrate under the woody debris

Table 2. Range in elevations (feet) associated with major littoral habitat types found in Lake Rhodhiss, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay Elevation	Woody debris[3] Elevation
1	100.0-95.0	100.0-95.0	100.0-97.6	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
2	100.0-95.0	100.0-95.0	100.0-97.1	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
3	100.0-95.0	100.0-95.0	100.0-97.0	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
4	100.0-95.0	100.0-95.0	100.0-97.0	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
5	100.0-95.0	100.0-95.0	100.0-96.9	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
6			100.0-96.2			100.0-95.0	100.0-95.0
7			100.0-97.8			100.0-95.0	100.0-95.0
8			100.0-96.8			100.0-95.0	100.0-95.0
9			100.0-96.6			100.0-95.0	100.0-95.0
10			100.0-96.8			100.0-95.0	100.0-95.0
Mean	100.0-95.0	100.0-95.0	100.0-97.0	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0

[1] Piers and riprap extend through the drawdown zone

[2] Mud substrate

[3] Predominately a clay substrate under the woody debris

Table 3. Range in elevations (feet) associated with major littoral habitat types found in Lake Hickory, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand[3] Elevation	Clay Elevation	Woody debris[4] Elevation
1	100.0-95.0	100.0-95.6	100.0-96.7		100.0-96.7	100.0-95.0	100.0-95.0
2	100.0-95.0	100.0-95.7	100.0-96.7		100.0-95.0	100.0-95.0	100.0-95.0
3	100.0-95.0	100.0-95.0	100.0-97.0		100.0-95.0	100.0-95.0	100.0-95.0
4	100.0-95.0	100.0-96.5	100.0-96.8		100.0-95.0	100.0-95.0	100.0-95.0
5	100.0-95.0	100.0-96.2	100.0-96.2		100.0-95.0	100.0-95.0	100.0-95.0
6		100.0-96.3	100.0-97.1			100.0-95.0	
7		100.0-96.6	100.0-96.2			100.0-95.0	
8		100.0-96.4	100.0-96.3			100.0-95.0	
9		100.0-96.7	100.0-96.5			100.0-95.0	
10		100.0-95.0	100.0-96.5			100.0-95.0	
Mean	100.0-95.0	100.0-96.0	100.0-96.6		100.0-95.3	100.0-95.0	100.0-95.0

[1] Piers extend through drawdown zone, considerable riprap extending through most of the drawdown zone (to 96.1, on average), and predominately a clay substrate deeper than the riprap

[2] Mud substrate

[3] Sand extending through most of the drawdown zone with cobble deeper than the sand

[4] Predominately a clay substrate under the woody debris

Table 4. Range in elevations (feet) associated with major littoral habitat types found in Lookout Shoals Lake, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay Elevation	Woody debris[3] Elevation
1	100.0-95.0	100.0-95.0	100.0-95.8	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
2	100.0-95.0	100.0-95.0	100.0-95.8	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
3	100.0-95.0	100.0-95.3	100.0-95.0	100.0-95.0	100.0-95.8	100.0-95.0	100.0-95.0
4	100.0-95.0	100.0-95.0	100.0-95.2	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
5	100.0-95.0	100.0-95.0	100.0-96.0	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
6		100.0-95.0	100.0-95.9			100.0-95.0	
7		100.0-96.0	100.0-95.0			100.0-95.0	
8		100.0-95.0	100.0-95.8			100.0-95.0	
9		100.0-95.0	100.0-95.0			100.0-95.0	
10		100.0-95.0	100.0-95.0			100.0-95.0	
Mean	100.0-95.0	100.0-95.1	100.0-95.5	100.0-95.0	100.0-95.2	100.0-95.0	100.0-95.0

[1] Piers and predominately clay substrate through drawdown zone, riprap limited (to 95.4, on average)

[2] Mud substrate

[3] Predominately a cobble substrate under the woody debris

Table 5. Range in elevations (feet) associated with major littoral habitat types found in Lake Norman, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay Elevation	Woody debris[3] Elevation
1	100.0-93.0	100.0-94.6	100.0-96.5	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
2	100.0-93.0	100.0-96.3	100.0-96.8	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
3	100.0-93.0	100.0-95.6	100.0-97.8	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
4	100.0-93.0	100.0-93.0	100.0-96.2	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
5	100.0-93.0	100.0-96.0	100.0-96.5	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0
6		100.0-93.0	100.0-96.5		100.0-93.0	100.0-93.0	
7		100.0-96.2	100.0-96.3		100.0-93.0	100.0-93.0	
8		100.0-93.6	100.0-96.8		100.0-93.0	100.0-93.0	
9		100.0-96.2	100.0-96.8		100.0-93.0	100.0-93.0	
10		100.0-94.6	100.0-96.5		100.0-93.0	100.0-93.0	
Mean	100.0-93.0	100.0-94.9	100.0-96.7	100.0-93.0	100.0-93.0	100.0-93.0	100.0-93.0

[1] Piers extend through drawdown zone, considerable riprap extending through most of the drawdown zone (to 95.1,on average), and predominately a clay substrate deeper than the riprap

[2] Predominately a mud substrate

[3] Predominately a sand substrate under the woody debris

Table 6. Range in elevations (feet) associated with major littoral habitat types found in Mountain Island Lake, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay Elevation	Woody debris[3] Elevation
1	100.0-95.0	100.0-95.9	100.0-95.8	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
2	100.0-95.0	100.0-95.0	100.0-95.9	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
3	100.0-95.0	100.0-95.8	100.0-95.4	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
4	100.0-95.0	100.0-95.1	100.0-96.3	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
5	100.0-95.0	100.0-95.4	100.0-95.7	100.0-95.0	100.0-95.9	100.0-95.0	100.0-95.0
6		100.0-96.2	100.0-96.0			100.0-95.0	
7		100.0-95.2	100.0-95.1			100.0-95.0	
8		100.0-96.3	100.0-95.3			100.0-95.0	
9		100.0-96.4	100.0-95.9			100.0-95.0	
10		100.0-95.0	100.0-95.3			100.0-95.0	
Mean	100.0-95.0	100.0-95.6	100.0-95.7	100.0-95.0	100.0-95.2	100.0-95.0	100.0-95.0

[1] Piers extend through drawdown zone, riprap generally extending through most of the drawdown zone (to 95.6,on average), and predominately a clay substrate deeper than the riprap

[2] Mud substrate

[3] Predominately a clay substrate under the the woody debris

Table 7. Range in elevations (feet) associated with major littoral habitat types found in Lake Wylie, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Caly Elevation	Woody debris[3] Elevation
1	100.0-95.0	100.0-95.4	100.0-96.4	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
2	100.0-95.0	100.0-95.0	100.0-95.8	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
3	100.0-95.0	100.0-95.2	100.0-96.2	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
4	100.0-95.0	100.0-97.0	100.0-96.4	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
5		100.0-95.0	100.0-96.5	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
6		100.0-95.3	100.0-96.1		100.0-95.0	100.0-95.0	
7		100.0-95.7	100.0-96.1		100.0-95.0	100.0-95.0	
8		100.0-95.0	100.0-96.6		100.0-95.0	100.0-95.0	
9		100.0-96.4	100.0-96.2		100.0-95.0	100.0-95.0	
10		100.0-95.0	100.0-96.3		100.0-95.0	100.0-95.0	
Mean	100.0-95.0	100.0-95.5	100.0-96.3	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0

[1] Piers extend through drawdown zone, riprap extending through most of the drawdown zone (to 95.5, on average), and predominately a clay substrate deeper than the riprap

[2] Mud substrate

[3] Predominately a clay substrate under the woody debris

Table 8. Range in elevations (feet) associated with major littoral habitat types found in Fishing Creek Reservoir, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay Elevation	Woody debris[3] Elevation
1	100.0-95.0	100.0-95.0	100.0-95.9	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
2		100.0-95.0	100.0-95.6		100.0-95.0	100.0-95.0	100.0-95.0
3		100.0-96.8	100.0-95.8		100.0-95.0	100.0-95.0	100.0-95.0
4		100.0-96.3	100.0-96.3			100.0-95.0	100.0-95.0
5		100.0-95.5	100.0-96.2			100.0-95.0	100.0-95.0
6			100.0-96.3			100.0-95.0	100.0-95.0
7			100.0-96.3			100.0-95.0	100.0-95.0
8			100.0-96.3			100.0-95.0	100.0-95.0
9			100.0-96.8			100.0-95.0	100.0-95.0
10			100.0-95.8			100.0-95.0	100.0-95.0
Mean	100.0-95.0	100.0-95.7	100.0-96.1	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0

[1] Piers extend through drawdown zone, riprap extending through most of the drawdown zone (to 95.8, on average), and predominately a clay substrate deeper than the riprap

[2] Mud substrate

[3] Predominately a clay substrate under the woody debris

Table 9. Range in elevations (feet) associated with major littoral habitat types found in Great Falls-Dearborn Reservoir, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay Elevation	Woody debris[3] Elevation
1		100.0-95.0	100.0-95.6	100.0-95.0		100.0-95.0	100.0-95.0
2		100.0-95.0	100.0-97.0	100.0-95.0		100.0-95.0	100.0-95.0
3		100.0-95.0	100.0-96.0			100.0-95.0	100.0-95.0
4		100.0-95.9	100.0-95.7			100.0-95.0	100.0-95.0
5		100.0-97.0	100.0-96.5			100.0-95.0	100.0-95.0
Mean		100.0-95.6	100.0-96.2	100.0-95.0		100.0-95.0	100.0-95.0

[1] No piers and mud deeper than the riprap

[2] Mud substrate

[3] Predominately a clay substrate under the woody debris

Table 10. Range in elevations (feet) associated with major littoral habitat types found in Cedar Creek Reservoir, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay Elevation	Woody debris[3] Elevation
1		100.0-95.0	100.0-95.7	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
2		100.0-95.0	100.0-96.4	100.0-95.0		100.0-95.0	100.0-95.0
3		100.0-95.0	100.0-96.7	100.0-95.0		100.0-95.0	100.0-95.0
4		100.0-95.0	100.0-96.0	100.0-95.0		100.0-95.0	100.0-95.0
5		100.0-95.0	100.0-95.8	100.0-95.0		100.0-95.0	100.0-95.0
6						100.0-95.0	
7						100.0-95.0	
8						100.0-95.0	
9						100.0-95.0	
10						100.0-95.0	
Mean		100.0-95.0	100.0-96.1	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0

[1] No piers, riprap limited and extending through the drawdown zone

[2] Mud substrate

[3] Predominately a clay substrate under the woody debris

Table 11. Range in elevations (feet) associated with major littoral habitat types found in Lake Wateree, 2004.

Transect	Cobble Elevation	Riprap/Piers[1] Elevation	Vegetation/ Confluences[2] Elevation	Mud flats Elevation	Sand Elevation	Clay/Sand Elevation	Woody debris[3] Elevation
1	100.0-95.0	100.0-95.0	100.0-98.1	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
2	100.0-95.0	100.0-95.0	100.0-98.3	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
3	100.0-95.0	100.0-95.0	100.0-97.5	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
4	100.0-95.0	100.0-95.0	100.0-97.6	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
5	100.0-95.0	100.0-95.0	100.0-97.7	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0
6		100.0-95.0	100.0-96.7		100.0-95.0	100.0-95.0	
7		100.0-95.0	100.0-98.4		100.0-95.0	100.0-95.0	
8		100.0-95.0	100.0-98.4		100.0-95.0	100.0-95.0	
9		100.0-95.0	100.0-96.8		100.0-95.0	100.0-95.0	
10		100.0-95.0	100.0-97.5		100.0-95.0	100.0-95.0	
Mean	100.0-95.0	100.0-95.0	100.0-97.7	100.0-95.0	100.0-95.0	100.0-95.0	100.0-95.0

[1] Mostly piers with a mixture of clay and sand extending through drawdown zone, riprap limited (to 96.4, on average, when present)

[2] Mud substrate

[3] Predominately a sand substrate under the woody debris