2011 Big Creek Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
April 2014

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Escatawpa River Basin

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LIST OF ACRONYMS

A&I	Agricultural and Industrial Water Supply Use Classification
ADEM	Alabama Department of Environmental Management
AGPT	Algal Growth Potential Test
CHL *a*	Chlorophyll *a*
DO	Dissolved Oxygen
F&W	Fish and Wildlife
MAX	Maximum
MDL	Method Detection Limit
MIN	Minimum
MSC	Mean Standing Crop
NTU	Nephelometric Turbidity Units
OAW	Outstanding Alabama Waters
ONRW	Outstanding National Resource Water
PWS	Public Water Supply
QAPP	Quality Assurance Project Plan
RRMP	Rivers and Reservoirs Monitoring Program
S	Swimming and Other Whole Body Water-Contact Sports
SD	Standard Deviation
SOP	Standard Operating Procedures
TEMP	Temperature
TN	Total Nitrogen
TMDL	Total Maximum Daily Load
TP	Total Phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

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INTRODUCTION

Big Creek Reservoir is a 3,600 acre waterbody located in the western portion of Mobile County. The reservoir was created in 1952 to provide drinking water for people in the City of Mobile and surrounding areas.

In 2007, a consumption advisory was issued by the Alabama Department of Public Health for largemouth bass taken from Big Creek Reservoir due to mercury levels in fish tissue exceeding the EPA action level of 0.33 ppm. All waters within a consumption advisory are placed on Alabama's Clean Water Act (CWA) §303(d) list of impaired waters. In 2008, Big Creek Reservoir was listed on Alabama's §303(d) list of impaired waters for not meeting its Public Water Supply (PWS)/Fish & Wildlife (F&W) water use classifications due to impairments caused by atmospheric deposition of metals (mercury). A draft TMDL for mercury is scheduled for 2020 for Big Creek Reservoir.

The Alabama Department of Environmental Management (ADEM) monitored Big Creek Reservoir as part of the 2011 assessment of the Escatawpa, Mobile, and Tombigbee River basins under the Rivers and Reservoirs Monitoring Program (RRMP). ADEM began monitoring lake water quality statewide in 1985, followed by a second statewide survey in 1989. In 1990, the Reservoir Water Quality Monitoring Program (now known as RRMP) was initiated by ADEM. The current objectives of this program are to provide data that can be used to assess current water quality conditions, identify trends in water quality conditions and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria. Descriptions of all RRMP monitoring activities are available in ADEM's 2012 Monitoring Strategy (ADEM 2012).

A specific water quality criterion for nutrient management was implemented in 2010 at one location on Big Creek Reservoir (Table 1). This criterion represents the maximum growing season mean (April-October) chlorophyll *a* (chl *a*) concentration allowable while still fully supporting the reservoir's designated uses.

The purpose of this report is to summarize data collected at five stations in Big Creek Reservoir during the 2011 growing season and to evaluate trends in mean lake trophic status and nutrient concentrations using ADEM's historic dataset. Monthly and mean concentrations of

nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [chlorophyll *a* (chl *a*); algal growth potential testing (AGPT)], sediment [total suspended solids (TSS)], and trophic state [Carlson's trophic state index (TSI)] were compared to ADEM's historical data and established criteria.

METHODS

Sample sites were determined using historical data and previous assessments (Fig. 1). Specific station location information is listed in Table 1. Big Creek Reservoir was sampled in the dam forebay, mid reservoir, and upper reservoir. Two tributary embayments, Hamilton Creek and Crooked Creek, were also monitored.

Water quality assessments were conducted at monthly intervals, April-October. All samples were collected, preserved, stored, and transported according to procedures in the ADEM Field Operations Division Standard Operating Procedures (ADEM 2011), Surface Water Quality Assurance Project Plan (ADEM 2008a), and Quality Management Plan (ADEM 2008b).

Mean growing season TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions at each site. For mainstem stations, monthly concentrations of these parameters were graphed with the closest available USGS flow data and ADEM's previously collected data to help interpret the 2011 results.

Figure 1. Big Creek Reservoir with 2011 sampling locations.

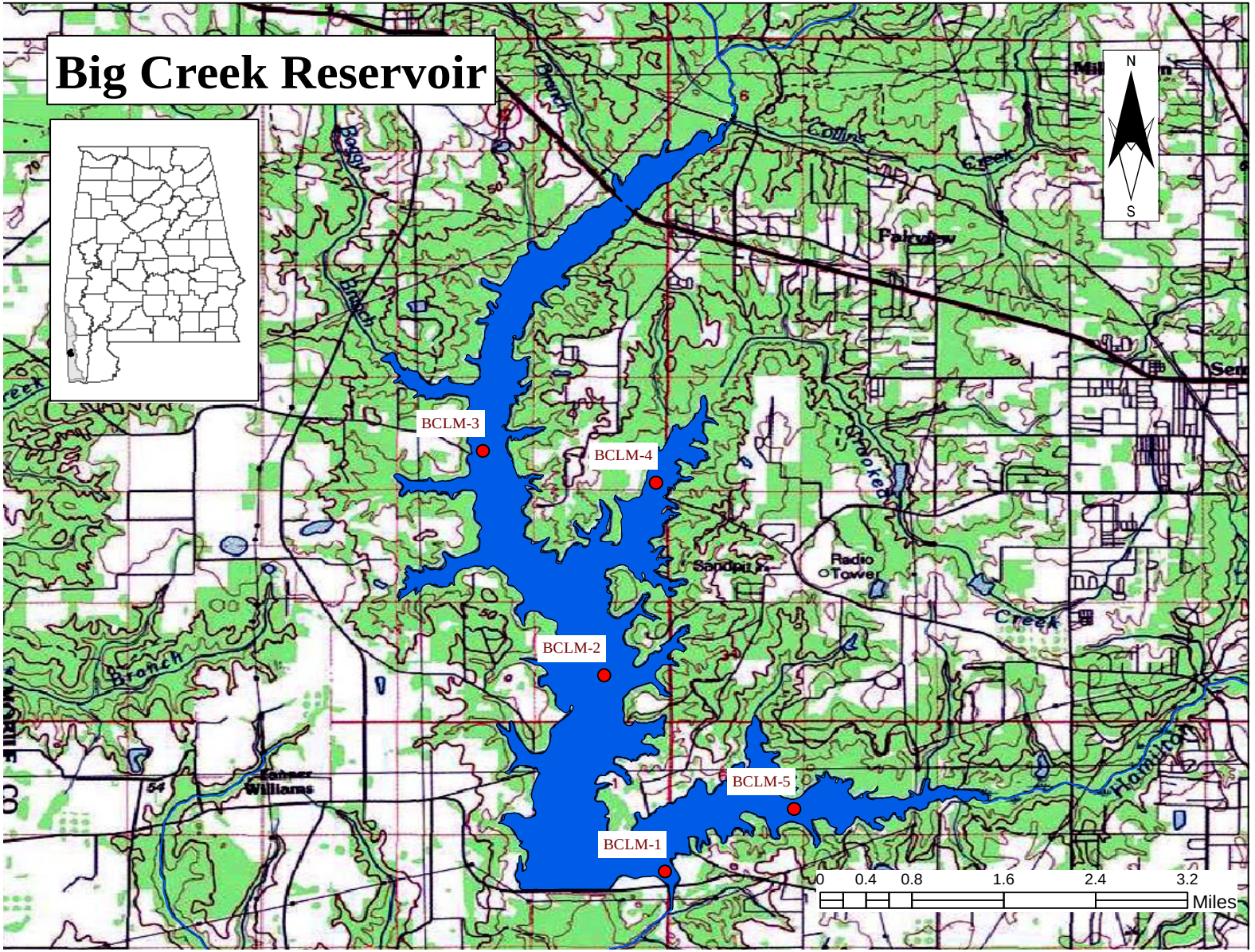


Table 1. Descriptions for the monitoring stations in 2011 for Big Creek Reservoir.

HUC	County	Station Number	Report Designation	Waterbody Name	Station Description	Chl. *a* Criterion	Latitude	Longitude
Big Creek Reservoir								
031700080402	Mobile	**BCLM-1	Lower	Big Creek	Deepest point, Big Creek channel, dam forebay.	11µg/L	30.7146	-88.3275
031700080402	Mobile	BCLM-2	Mid	Big Creek	Deepest point, Big Creek channel, approximately 0.5 mile downstream of the Crooked Creek confluence.		30.7401	-88.3351
031700080402	Mobile	BCLM-3	Upper	Big Creek	Deepest point, Big Creek channel, approximately one mile downstream of US Hwy. 98.		30.7692	-88.3505
031700080402	Mobile	BCLM-4	Crooked Cr	Big Creek	Deepest point, main creek channel, Crooked Creek embayment, approximately one mile downstream of US Hwy. 98.		30.7650	-88.3286
031700080402	Mobile	BCLM-5	Hamilton Cr	Big Creek	Deepest point, main creek channel, Hamilton Creek embayment, approximately one mile upstream of confluence with Big Creek.		30.7227	-88.3112

** Growing season mean Chl a criterion implemented at this station in 2010

RESULTS

Growing season mean graphs for TN, TP, chl *a* and TSS are provided in this section (Figs. 2 and 3). Monthly graphs for TN, TP, chl *a*, TSS, DO and TSI are also provided (Figs. 4-8 and 12). Mean monthly discharge is included in monthly graphs for TN, TP, chl *a*, TSS and TSI as an indicator of flow and retention time in the months sampled. AGPT results appear in Table 2. Depth profile graphs of temperature, DO and conductivity appear in Figures 9, 10 and 11. Summary statistics of all data collected during 2011 are presented in Appendix Table 1. The table contains the minimum, maximum, median, mean and standard deviation of each parameter analyzed.

Stations with the highest concentrations of nutrients, chlorophyll and TSS are noted in the paragraphs to follow. Though stations with lowest concentrations may not always be mentioned, review of the graphs included in this report will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2011, the highest mean growing season TN value was calculated for the Hamilton Creek station (Fig. 2). Mean TN concentrations at the upper, mid, and Crooked Creek stations decreased 2006-2011, while Hamilton Creek increased 2001-2011. Monthly TN concentrations were near or below historic means much of the growing season, with one historic high measured in October at the mid station (Fig. 4).

In 2011, the highest mean growing season TP value was calculated for the upper station, though concentrations were similar throughout the reservoir (Fig. 2). Mean TP concentrations have decreased 2001-2006. Monthly TP concentrations were equal to or less than historic means at each station the entire 2011 growing season (Fig. 5). Historic lows were measured May-June at the upper station, April-July at the mid station, and in April at the lower station.

In 2011, the highest growing season mean chl *a* was calculated for the Hamilton Creek station (Fig. 3). Specific water quality criterion has been established for the lower station on Big Creek Reservoir. The 2011 growing season mean chl *a* value was in compliance with the criterion limit (Fig. 3). Mean chl *a* concentrations have decreased at each station since 2006. Monthly chl *a*

concentrations for all stations were below historic means the entire growing season (Fig. 6). Monthly concentrations were at historical lows the entire growing season at the upper station and nearly the entire season at the mid station.

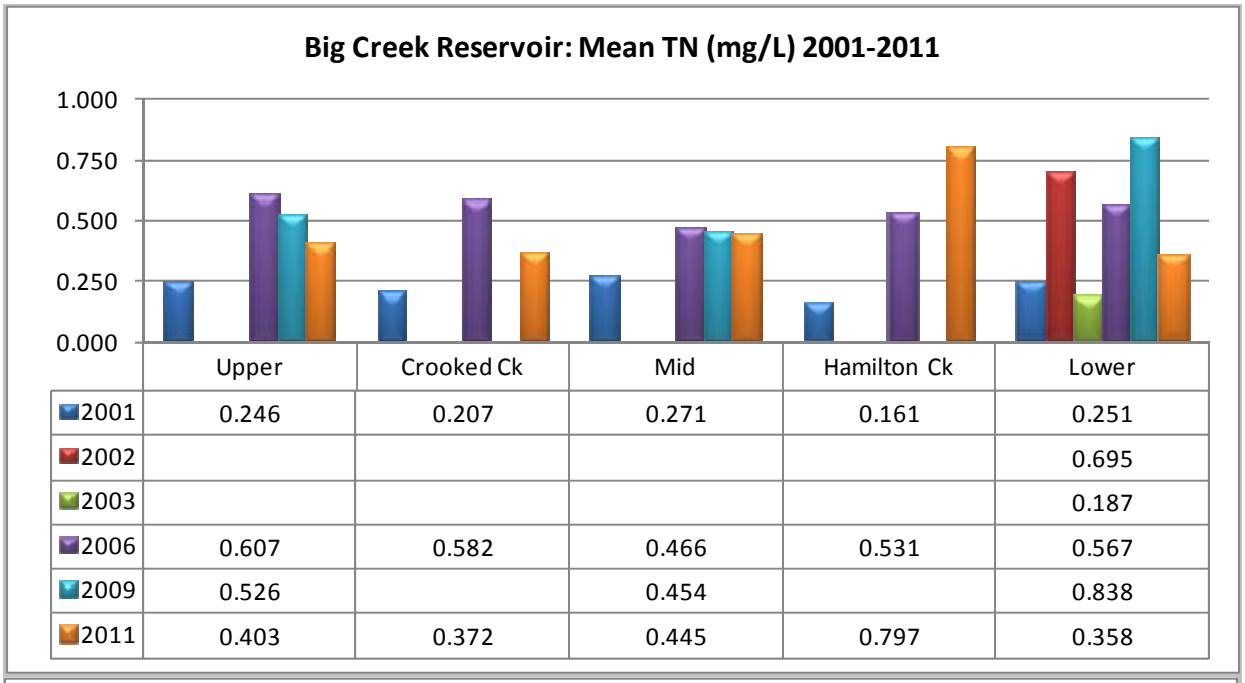
In 2011, the highest mean growing season TSS value was calculated for the Crooked Creek station (Fig. 3). Mean TSS concentrations have generally decreased at all stations since 2001. In July, the monthly TSS concentration was above historic mean at the lower station; all other measurements were below historic mean values (Fig. 7). Historic low TSS concentrations were measured April-July at the upper and mid stations and at each mainstem station in September.

In 2011, AGPT results indicated nitrogen-limited conditions at the upper and co-limiting conditions in the lower and mid stations (Table 2). Mean standing crop (MSC) values at all mainstem stations in 2011 were below the 5.0 mg/L level suggested as protective of reservoir and lake systems (Raschke and Schultz 1987).

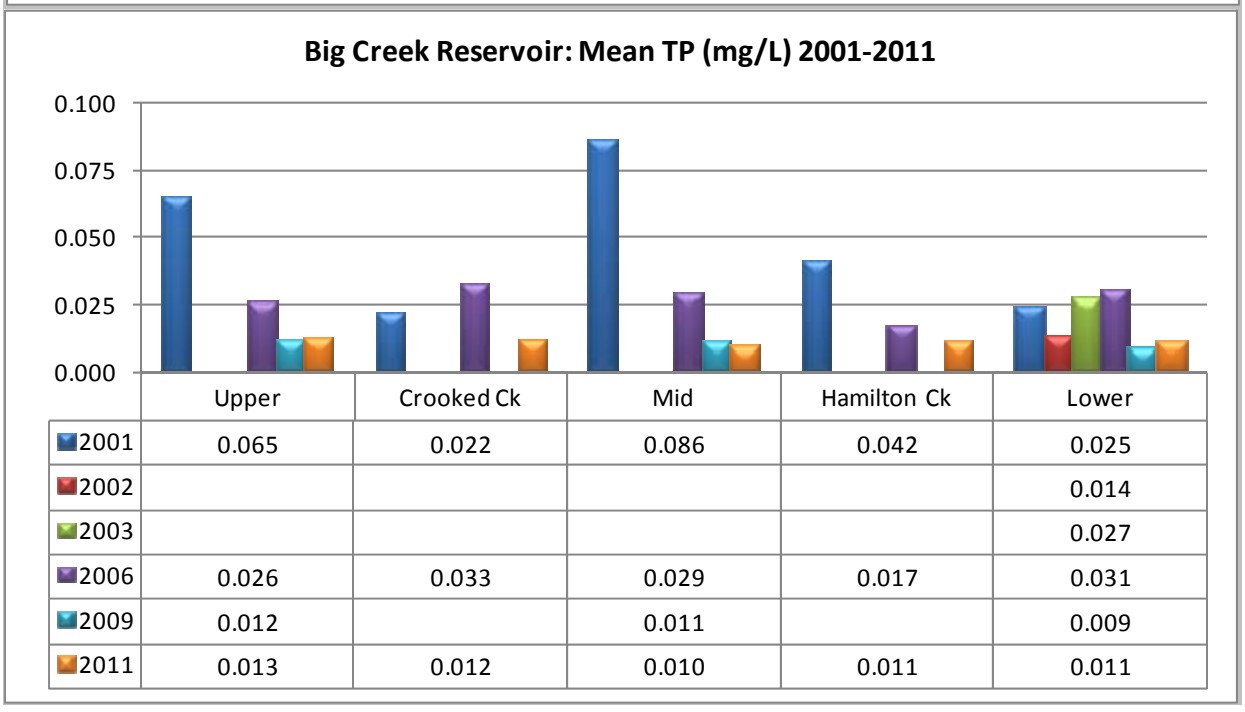
All measurements of DO concentrations were in compliance with the ADEM Criteria limit of 5.0 mg/L at 5 ft at all stations (ADEM Admin. Code R. 335-6-10-.09), April-October 2011 (Fig. 8). DO stratification occurred April-September in the mid station resulting in de-oxygenated conditions below the chemocline (Fig. 10). The upper station showed some stratification in June and August, while the lower station was thoroughly mixed (Fig. 9&11). Highest temperatures were measured in August.

TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index. TSI values for each station were oligotrophic for much of the growing season (Fig. 12). All mainstem stations were mesotrophic in September. Results for Hamilton Creek ranged from oligotrophic conditions to near eutrophic conditions in September. Crooked Creek TSI values were oligotrophic for much of the growing season, reaching mesotrophic conditions in July and September.

Figure 2. Mean growing season TN and TP measured in Big Creek Reservoir, April-October, 2001-2011. Bar graphs consist of mainstem and embayment stations, illustrated from upstream to downstream as the graph is read from left to right.

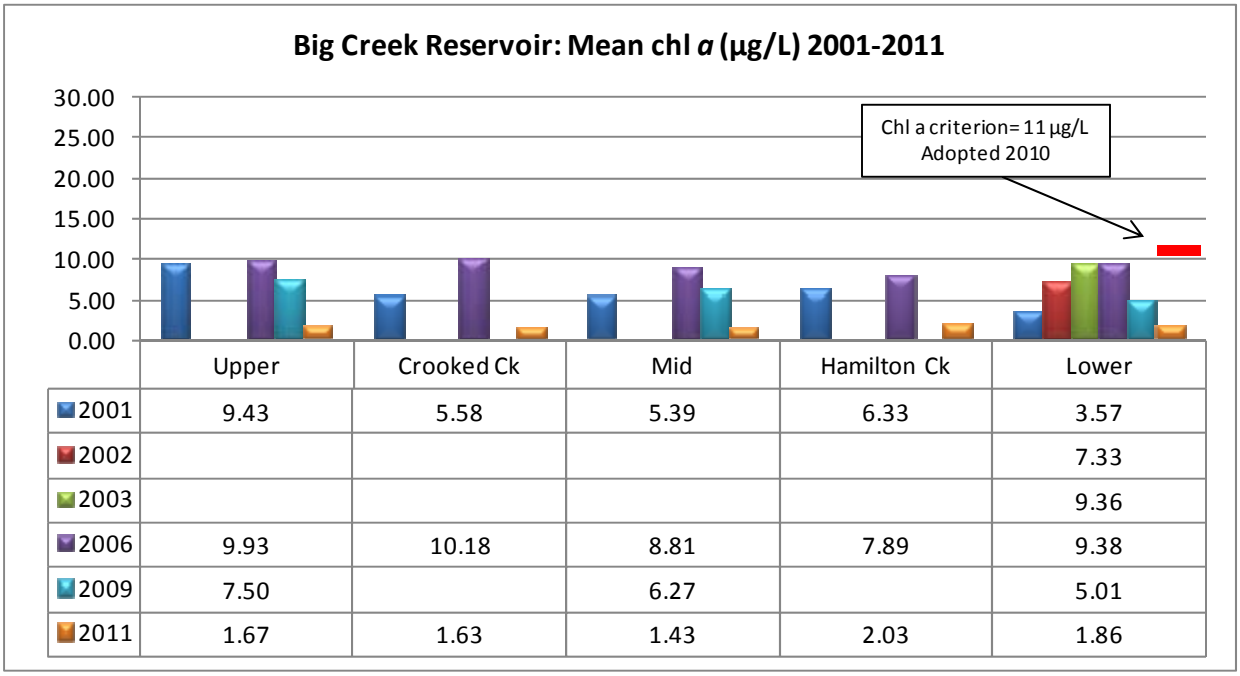


	Upper	Crooked Ck	Mid	Hamilton Ck	Lower
2001	0.246	0.207	0.271	0.161	0.251
2002					0.695
2003					0.187
2006	0.607	0.582	0.466	0.531	0.567
2009	0.526		0.454		0.838
2011	0.403	0.372	0.445	0.797	0.358

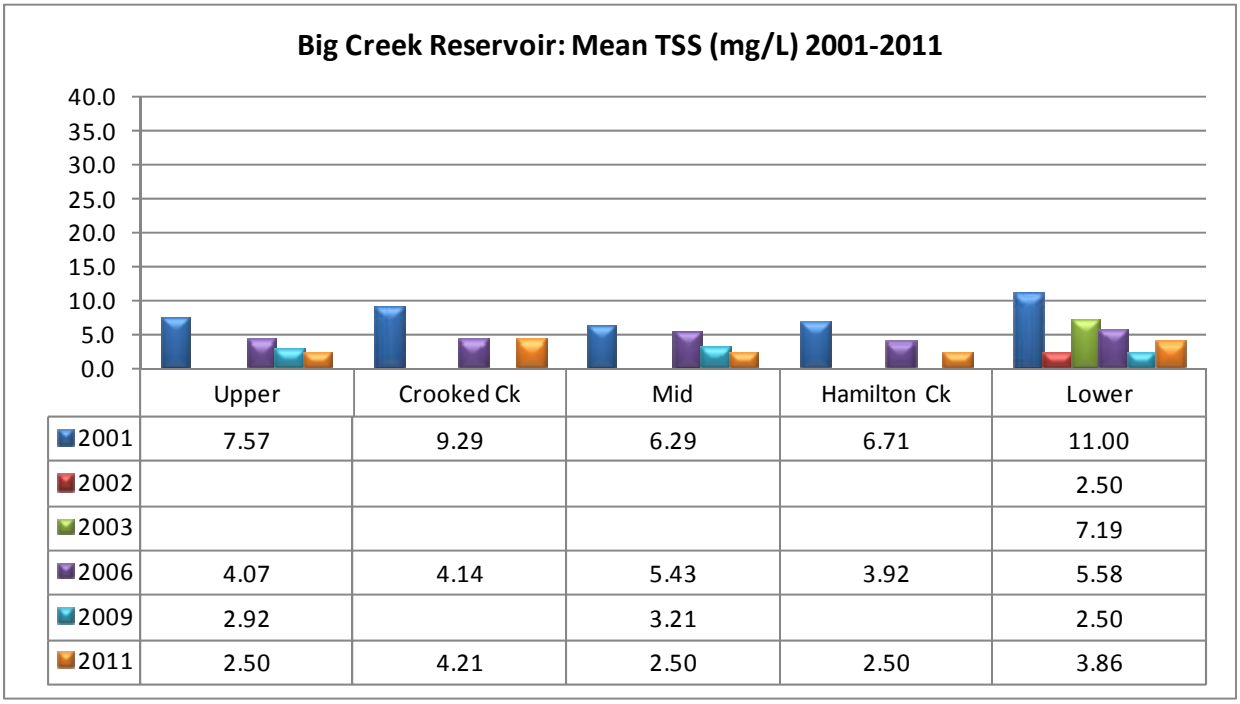


	Upper	Crooked Ck	Mid	Hamilton Ck	Lower
2001	0.065	0.022	0.086	0.042	0.025
2002					0.014
2003					0.027
2006	0.026	0.033	0.029	0.017	0.031
2009	0.012		0.011		0.009
2011	0.013	0.012	0.010	0.011	0.011

Figure 3. Mean growing season chl *a* and TSS measured in Big Creek Reservoir, April-October, 2001-2011**.** Bar graphs consist of mainstem and embayment stations, illustrated from upstream to downstream as the graph is read from left to right.



	Upper	Crooked Ck	Mid	Hamilton Ck	Lower
2001	9.43	5.58	5.39	6.33	3.57
2002					7.33
2003					9.36
2006	9.93	10.18	8.81	7.89	9.38
2009	7.50		6.27		5.01
2011	1.67	1.63	1.43	2.03	1.86



	Upper	Crooked Ck	Mid	Hamilton Ck	Lower
2001	7.57	9.29	6.29	6.71	11.00
2002					2.50
2003					7.19
2006	4.07	4.14	5.43	3.92	5.58
2009	2.92		3.21		2.50
2011	2.50	4.21	2.50	2.50	3.86

Figure 4. Monthly TN of the mainstem stations in Big Creek Reservoir, April-October 2011**.** Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. TN was plotted vs. the closest discharge (USGS 02479945 Big Creek near Wilmer, AL).

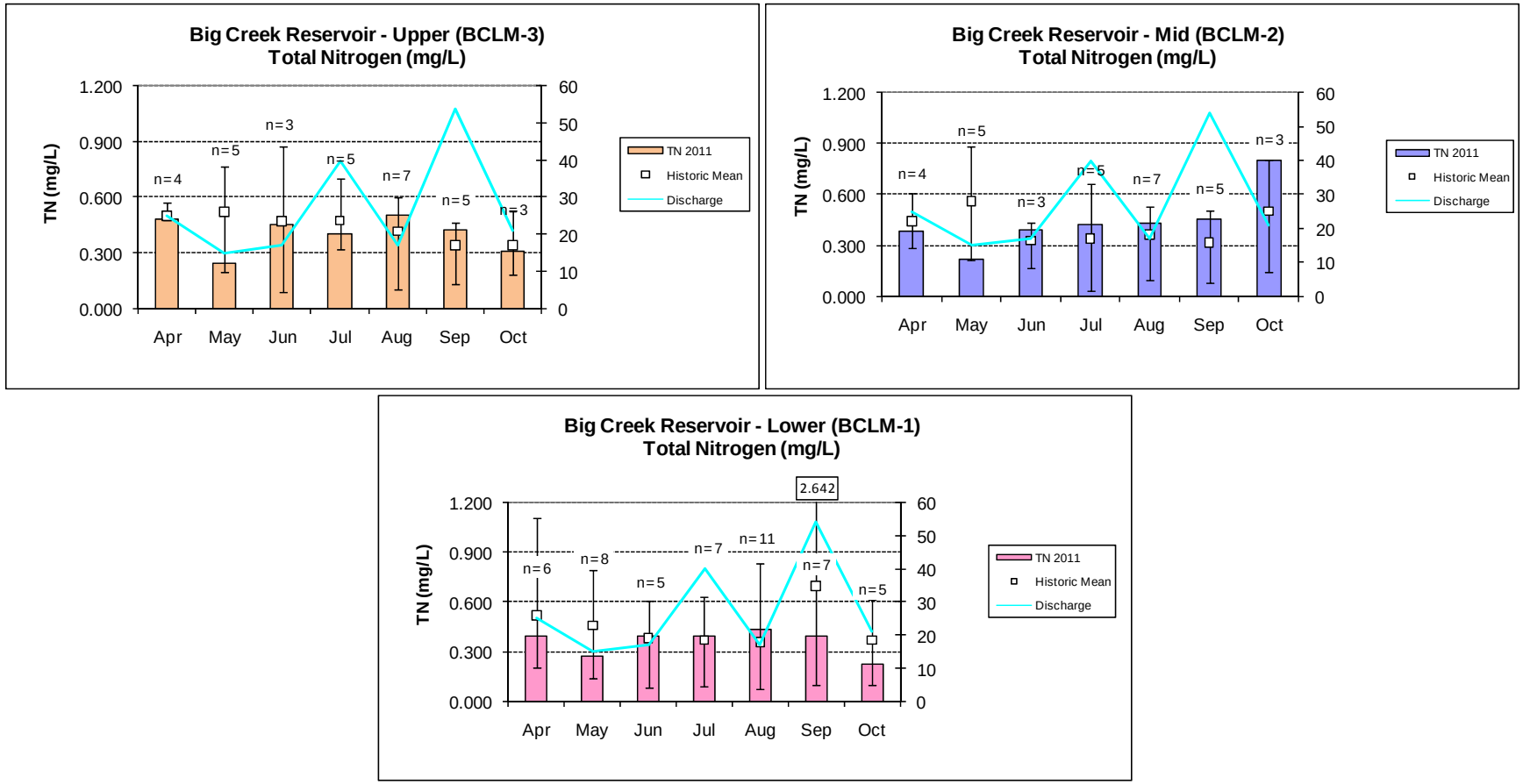


Figure 5. Monthly TP of the mainstem stations in Big Creek Reservoir, April-October 2011. Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. TP was plotted vs. the closest discharge (USGS 02479945 Big Creek near Wilmer, AL).

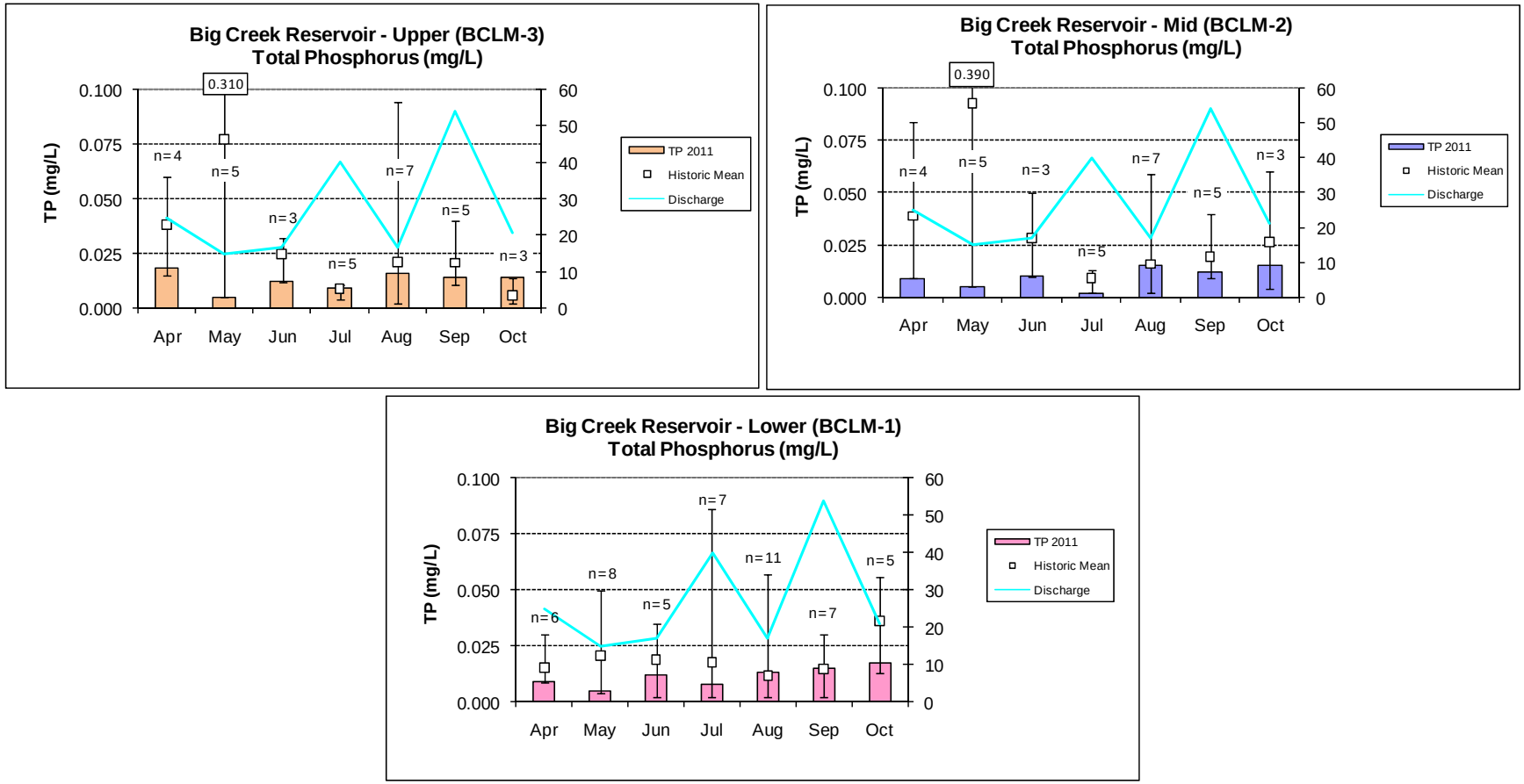


Figure 6. Monthly chl *a* of the mainstem stations in Big Creek Reservoir, April-October 2011**.** Each bar graph depicts monthly changes in each station**.** The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. Chl *a* was plotted vs. the closest discharge (USGS 02479945 Big Creek near Wilmer, AL).

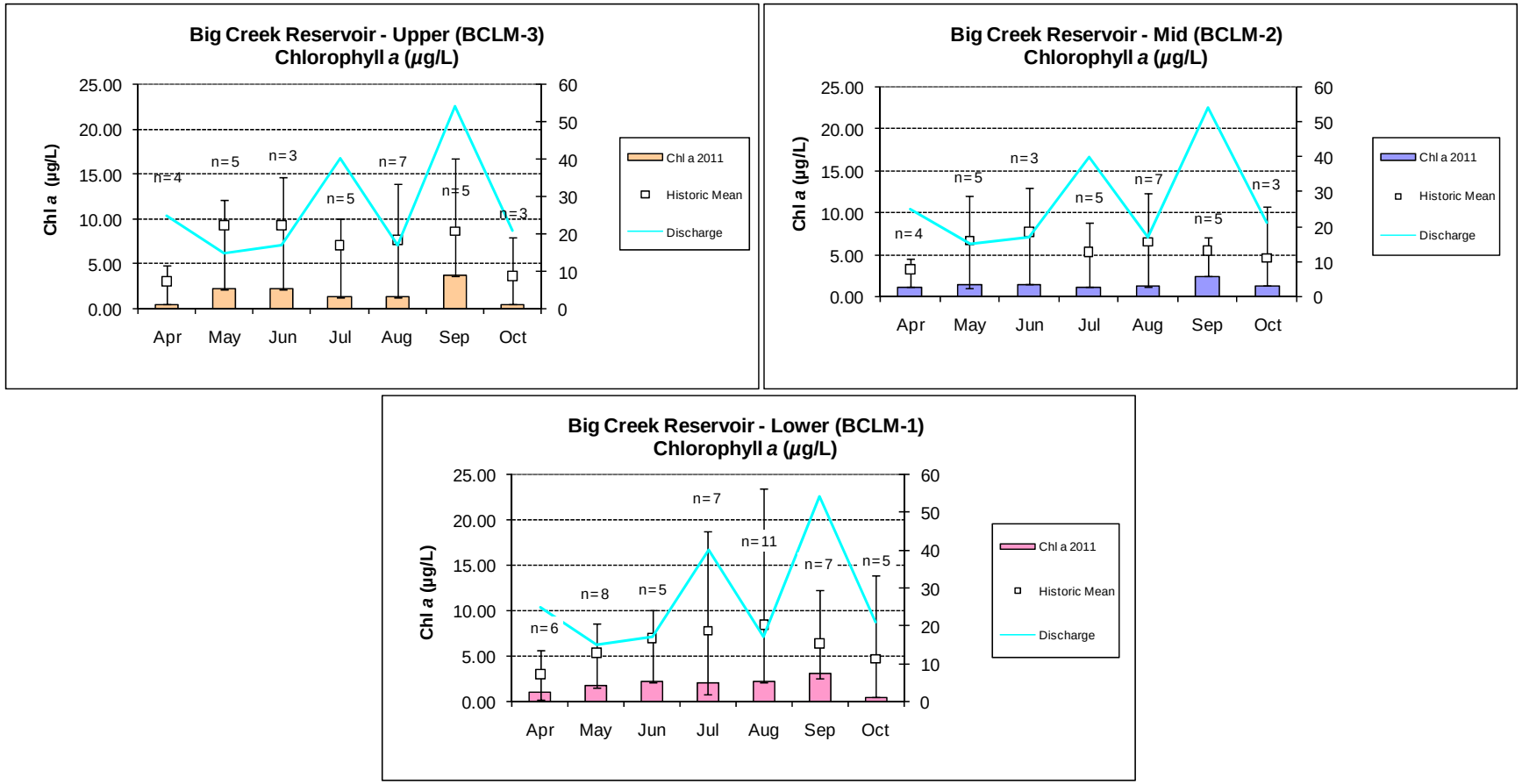


Figure 7. Monthly TSS of the mainstem stations in Big Creek Reservoir, April-October 2011**.** Each bar graph depicts monthly changes in each station. The historic mean and min/max range are also displayed for comparison. The "n" value equals the number of data points included in the monthly historic calculations. TSS was plotted vs. the closest discharge (USGS 02479945 Big Creek near Wilmer, AL).

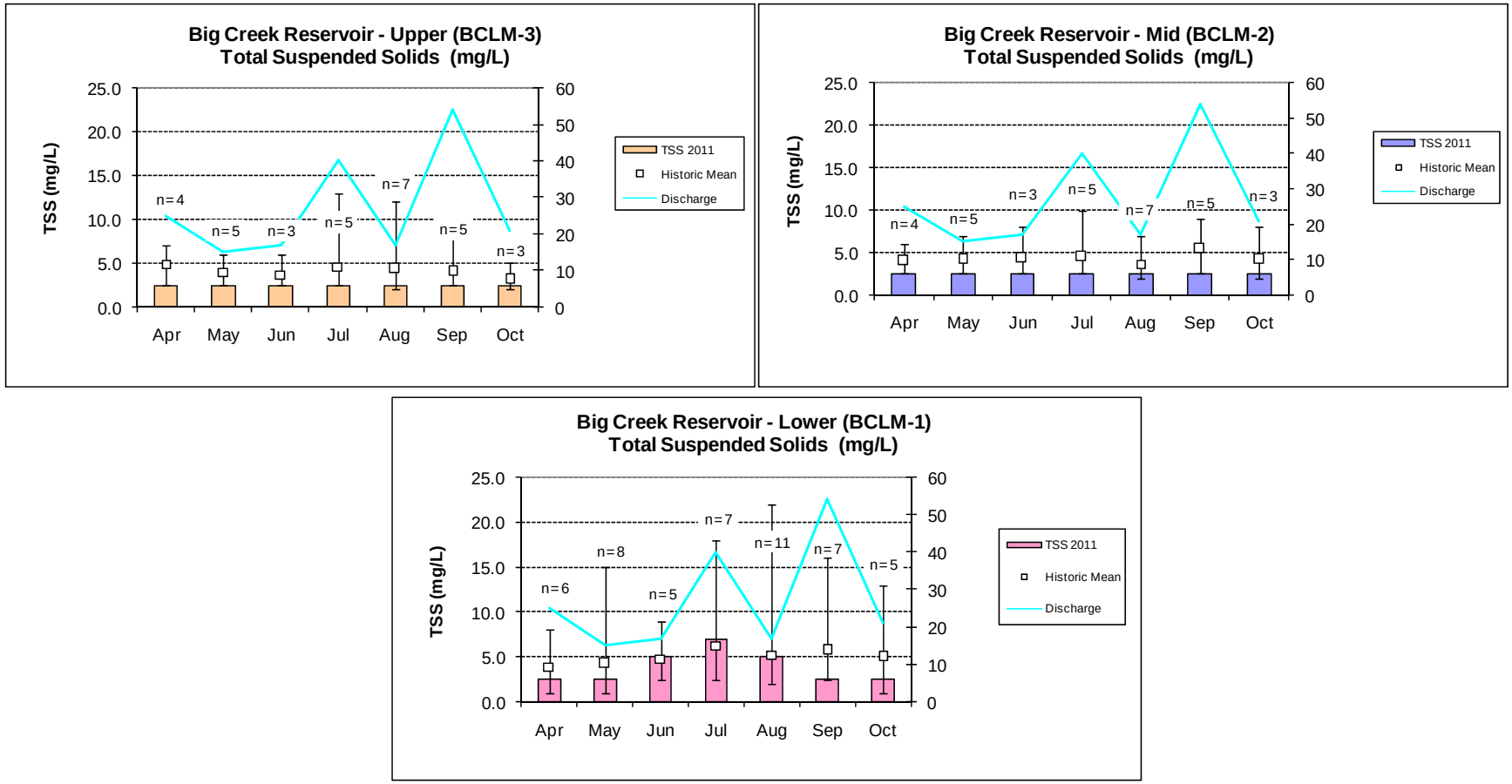
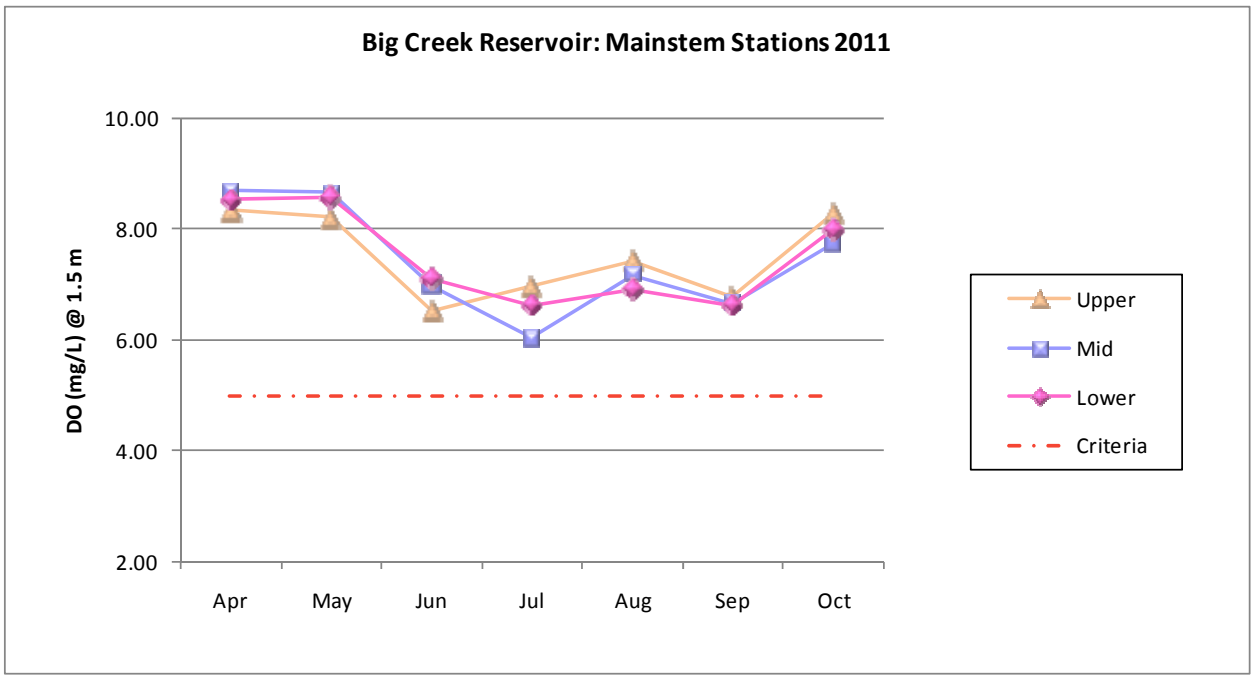


Table 2. Algal growth potential test results (expressed as mean Maximum Standing Crop (MSC) dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Station	2001 Control mean MSC	2001 Limiting Nutrient	2006 Control mean MSC	2006 Limiting Nutrient	2011 Control mean MSC	2011 Limiting Nutrient
Upper	1.80	Phosphorus	4.33	Phosphorus	2.87	Nitrogen
Mid	1.77	Phosphorus	3.46	Phosphorus	2.28	Co limiting
Lower	1.46	Phosphorus	4.20	Phosphorus	2.40	Co limiting

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Big Creek Reservoir stations collected April-October 2011. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/L at this depth (ADEM 2011). In tributaries, when total depth was less than 3 m, criteria apply to the mid-depth reading.



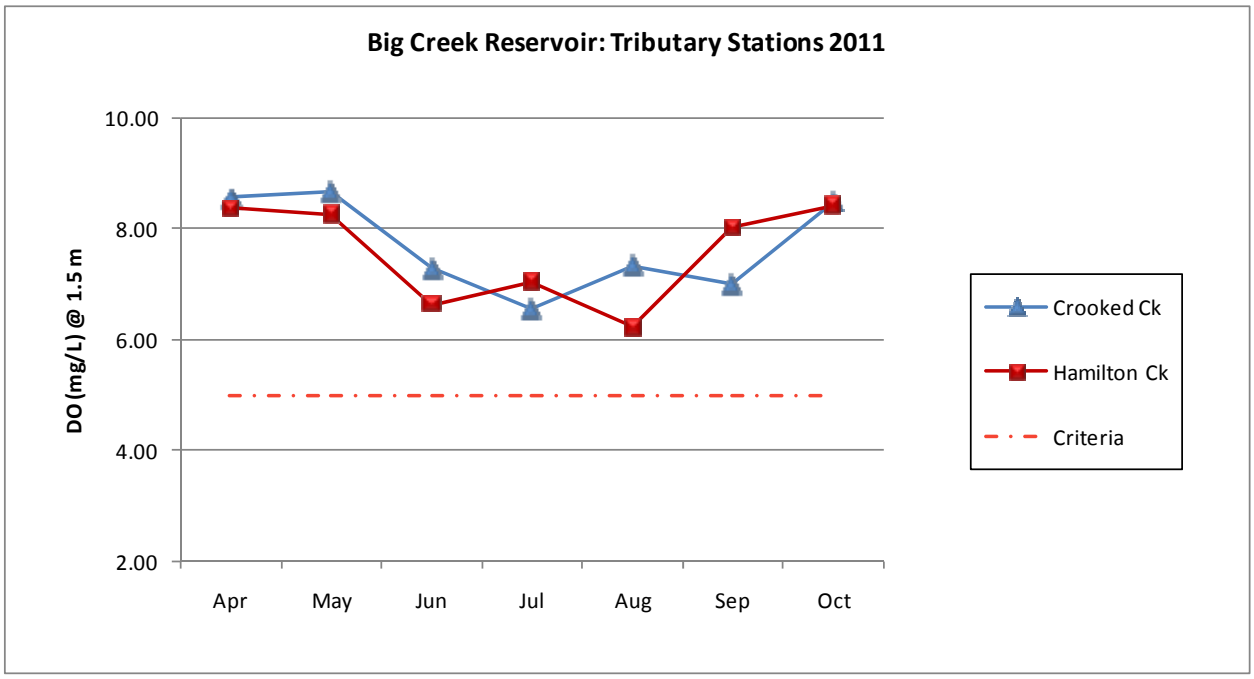


Figure 9. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in lower Big Creek Reservoir, April-October 2011.

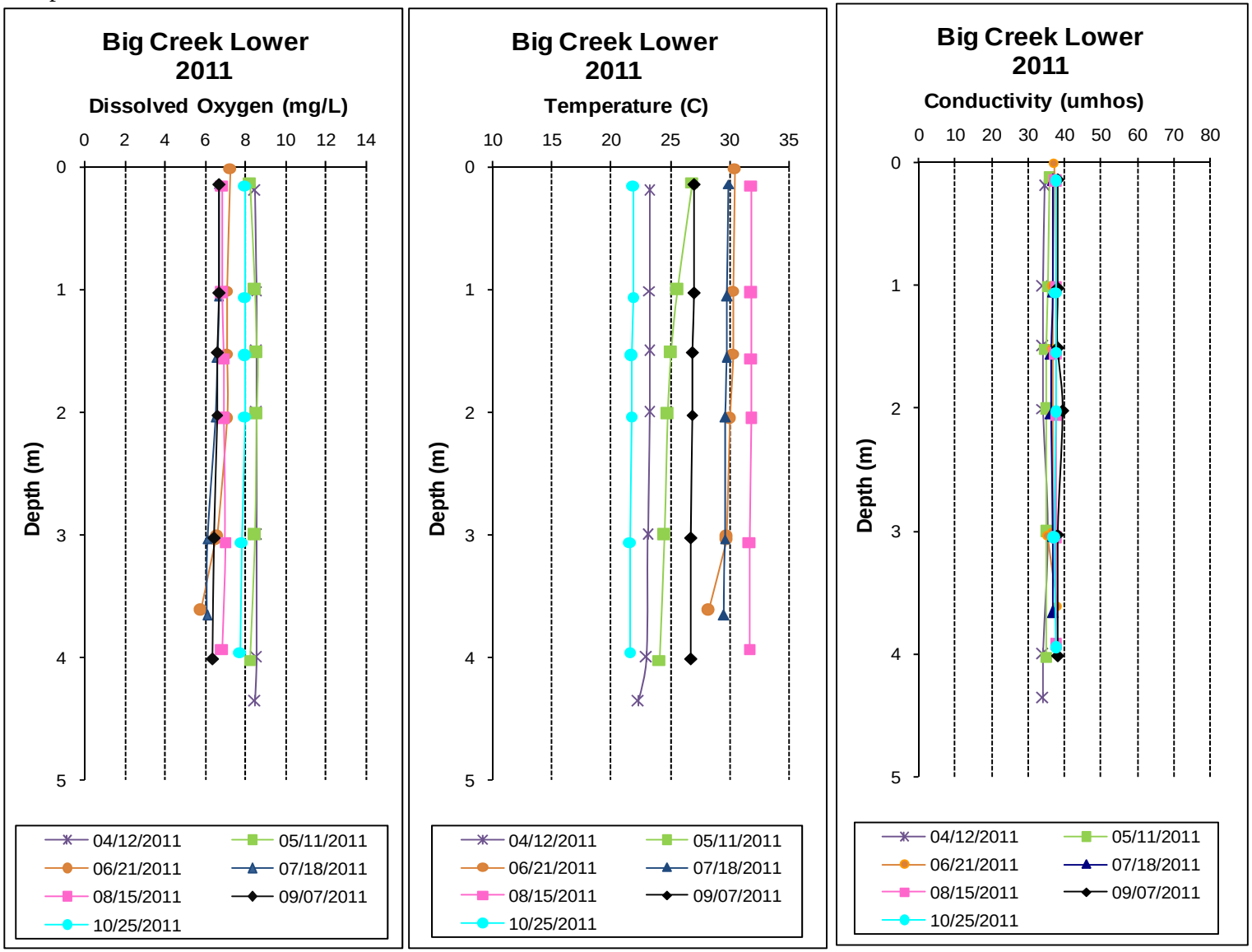


Figure 10. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in mid Big Creek Reservoir, April-October 2011.

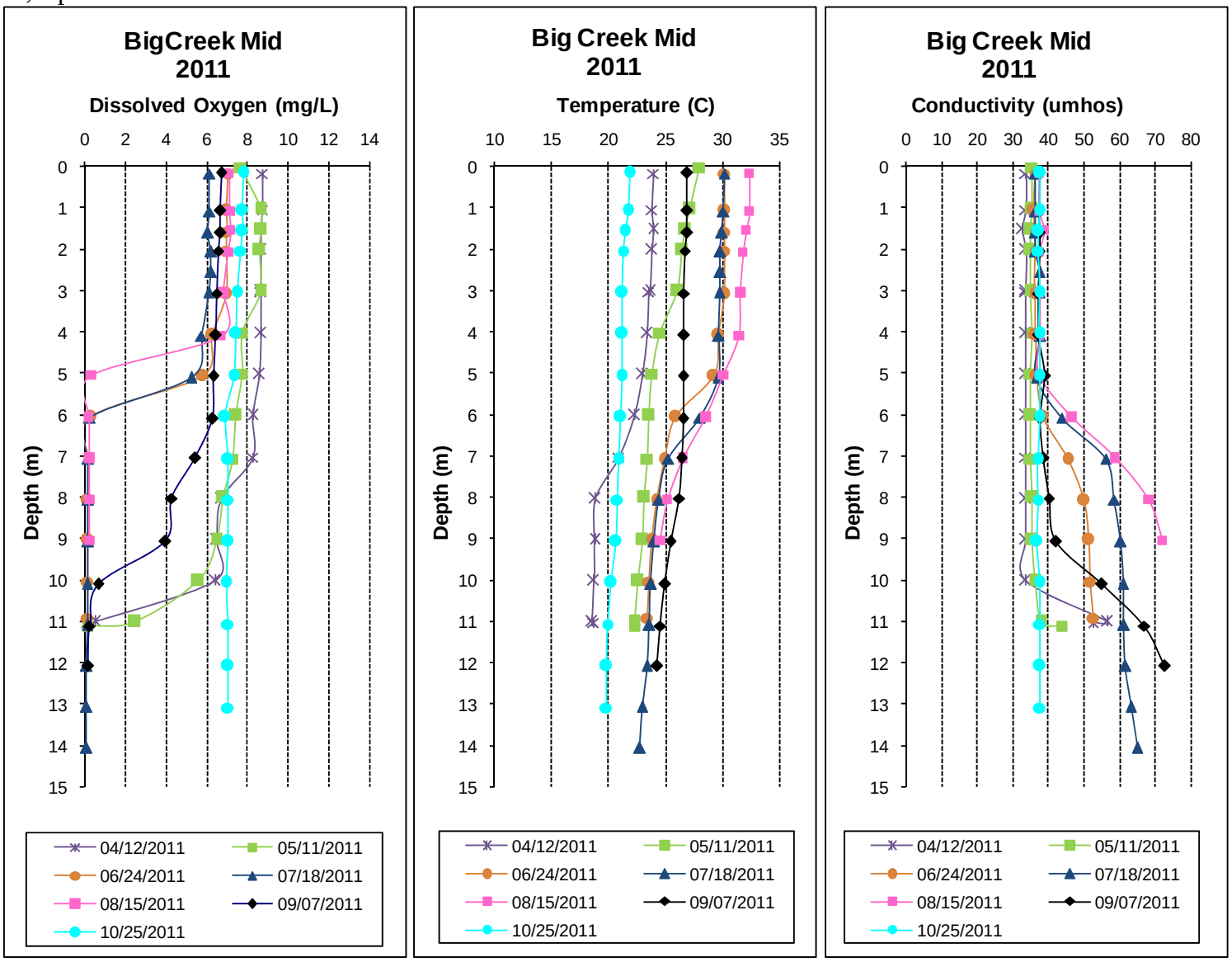


Figure 11. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in upper Big Creek Reservoir, April-October 2011.

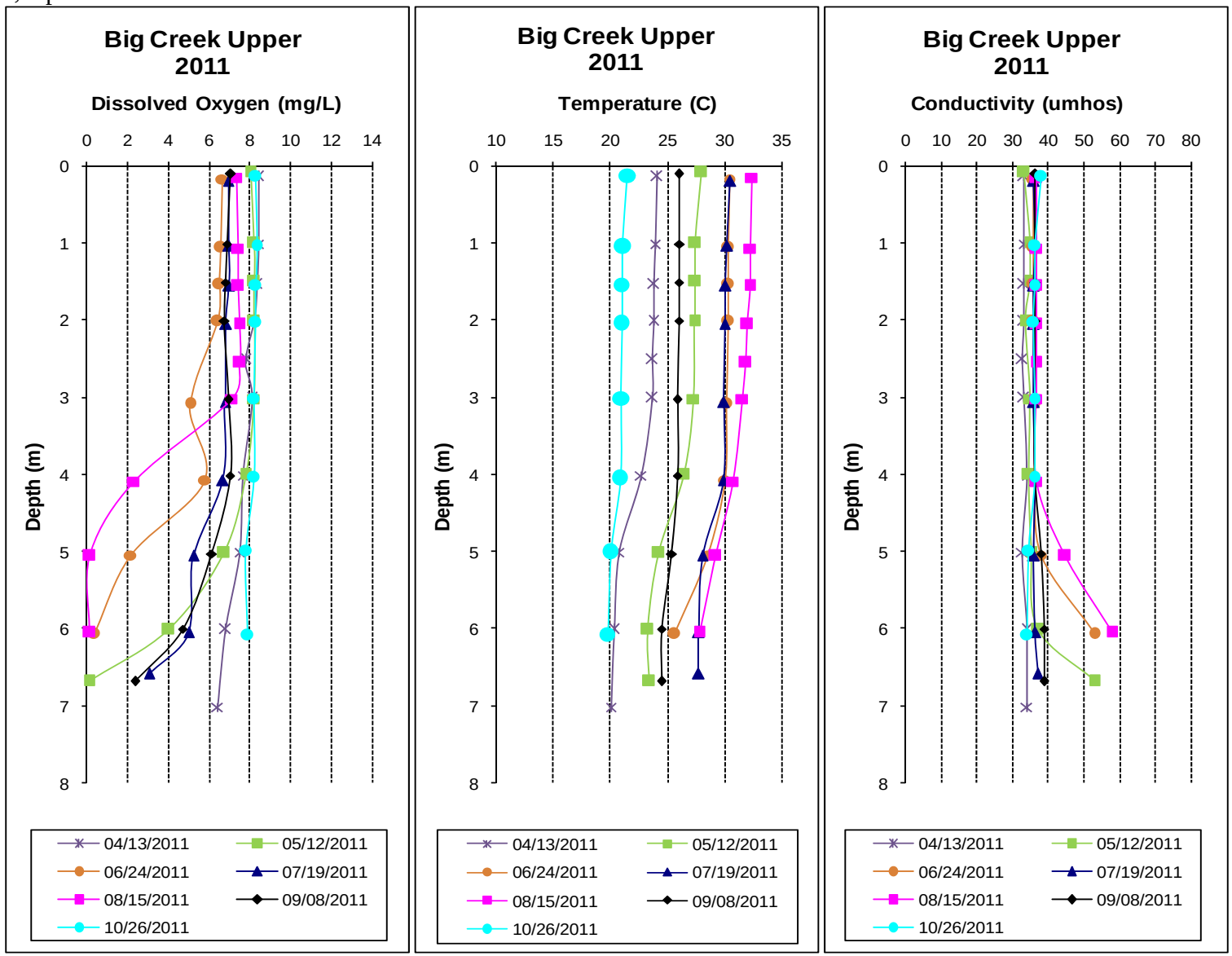
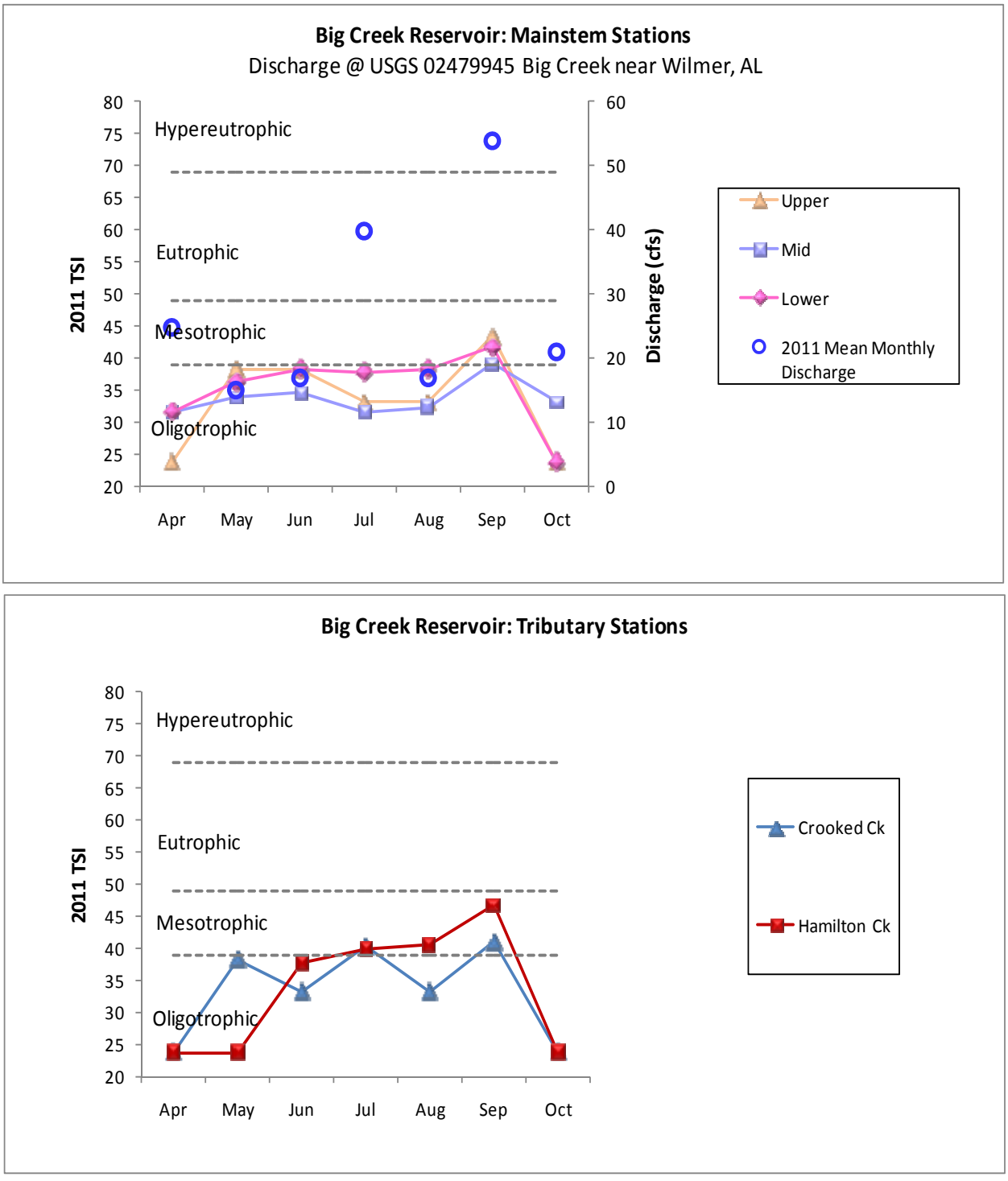


Figure 12. Monthly TSI values calculated for mainstem and tributary Big Creek Reservoir stations using chl *a* concentrations and Carlson's Trophic State Index calculation.



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APPENDIX

Appendix Table 1. Summary of water quality data collected April-October, 2011. Minimum (min) and maximum (max) values calculated using minimum detection limits when results were less than this value. Median (med), mean, and standard deviation (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Med	Mean	SD
BCLM-1	**Physical**						
	Turbidity (NTU)	7	1.0	3.0	2.0	1.9	0.9
	Total Dissolved Solids (mg/L)	7	23.0	31.0	26.0	25.6	2.8
	Total Suspended Solids (mg/L)	7	< 5.0	7.0	2.5	3.9	1.8
	Hardness (mg/L)	4	9.0	9.8	9.4	9.4	0.3
	Alkalinity (mg/L) [J]	7	5.0	7.0	6.0	5.9	0.7
	Photic Zone (m)	7	3.78	4.50	4.00	4.08	0.26
	Secchi (m)	7	1.65	4.50	2.30	2.71	0.92
	Chemical						
	Ammonia Nitrogen (mg/L) [J]	7	< 0.014	0.050	0.007	0.013	0.016
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	< 0.006	0.095	0.003	0.019	0.034
	Total Kjeldahl Nitrogen (mg/L) [J]	7	0.220	0.430	0.390	0.339	0.081
	Total Nitrogen (mg/L) [J]	7	< 0.223	0.433	0.393	0.358	0.077
	Dissolved Reactive Phosphorus (mg/L) [J]	7	< 0.004	0.014	0.007	0.007	0.004
	Total Phosphorus (mg/L) [J]	7	0.005	0.017	0.012	0.011	0.004
	CBOD-5 (mg/L) [J]	7	< 1.0	1.0	0.5	0.5	0.0
	Chlorides (mg/L)	7	< 0.2	17.0	0.1	2.5	6.4
	Biological						
	Chlorophyll a (ug/L)	7	< 1.00	3.10	2.10	1.86	0.84
	E. coli (mpn/100mL) [J]	3	1	21	1	8	12
BCLM-2	**Physical**						
	Turbidity (NTU)	7	0.0	3.0	1.0	1.3	1.0
	Total Dissolved Solids (mg/L)	7	18.0	31.0	26.0	25.4	4.1
	Total Suspended Solids (mg/L)	7	< 5.0	5.0	2.5	2.5	0.0
	Hardness (mg/L)	4	9.0	9.4	9.0	9.1	0.2
	Alkalinity (mg/L) [J]	7	4.0	6.0	5.0	5.1	0.7
	Photic Zone (m)	7	4.01	6.45	5.52	5.30	0.88
	Secchi (m)	7	1.73	3.36	2.70	2.63	0.59
	Chemical						
	Ammonia Nitrogen (mg/L) [J]	7	< 0.014	0.040	0.007	0.012	0.012
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	< 0.006	0.087	0.003	0.020	0.031
	Total Kjeldahl Nitrogen (mg/L) [J]	7	0.190	0.800	0.420	0.424	0.188
	Total Nitrogen (mg/L) [J]	7	< 0.218	0.803	0.423	0.445	0.176
	Dissolved Reactive Phosphorus (mg/L) [J]	7	< 0.006	0.015	0.006	0.007	0.004
	Total Phosphorus (mg/L) [J]	7	< 0.004	0.015	0.010	0.010	0.005
	CBOD-5 (mg/L) [J]	7	< 1.0	1.0	0.5	0.5	0.0
	Chlorides (mg/L) [J]	7	< 0.2	5.1	0.1	0.8	1.9
	Biological						
	Chlorophyll a (ug/L)	7	1.10	2.40	1.30	1.43	0.45
	E. coli (mpn/100mL) [J]	3	< 1	19	2	7	10

Station	Parameter	N	Min	Max	Med	Mean	SD
BCLM-3	**Physical**						
	Turbidity (NTU)	6	1.0	2.0	1.0	1.3	0.5
	Total Dissolved Solids (mg/L)	7	18.0	43.0	27.0	28.0	7.6
	Total Suspended Solids (mg/L)	7	< 5.0	5.0	2.5	2.5	0.0
	Hardness (mg/L)	4	8.0	9.0	8.7	8.6	0.4
	Alkalinity (mg/L) [J]	7	5.0	5.0	5.0	5.0	0.0
	Photic Zone (m)	7	4.07	6.08	4.90	4.87	0.69
	Secchi (m)	7	1.64	3.65	2.50	2.64	0.81
	Chemical						
	Ammonia Nitrogen (mg/L) [J]	7	< 0.014	0.017	0.007	0.007	0.001
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	< 0.006	0.082	0.016	0.028	0.031
	Total Kjeldahl Nitrogen (mg/L) [J]	7	0.230	0.500	0.400	0.376	0.094
	Total Nitrogen (mg/L) [J]	7	< 0.246	0.503	0.427	0.403	0.094
	Dissolved Reactive Phosphorus (mg/L) [J]	7	< 0.004	0.010	0.006	0.006	0.002
	Total Phosphorus (mg/L) [J]	7	0.005	0.018	0.014	0.013	0.004
	CBOD-5 (mg/L) [J]	7	< 1.0	1.0	0.5	0.5	0.0
	Chlorides (mg/L) [J]	7	< 0.2	4.8	0.1	0.8	1.8
	Biological						
	Chlorophyll a (ug/L)	7	< 1.00	3.70	1.30	1.67	1.13
	E. coli (mpn/100mL) [J]	3	< 1	13	2	5	7
BCLM-4	**Physical**						
	Turbidity (NTU)	6	0.0	3.0	1.5	1.7	1.2
	Total Dissolved Solids (mg/L)	7	18.0	39.0	27.0	27.3	6.3
	Total Suspended Solids (mg/L)	7	< 5.0	6.0	5.0	4.2	1.6
	Hardness (mg/L)	4	7.5	9.7	9.0	8.8	1.0
	Alkalinity (mg/L) [J]	7	4.0	7.0	6.0	5.9	1.1
	Photic Zone (m)	7	3.10	4.50	3.50	3.57	0.49
	Secchi (m)	7	1.57	3.20	1.88	2.29	0.72
	Chemical						
	Ammonia Nitrogen (mg/L) [J]	7	< 0.014	0.017	0.007	0.007	0.001
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	< 0.006	0.079	0.003	0.016	0.028
	Total Kjeldahl Nitrogen (mg/L) [J]	7	0.180	0.450	0.400	0.356	0.106
	Total Nitrogen (mg/L) [J]	7	< 0.194	0.453	0.429	0.372	0.107
	Dissolved Reactive Phosphorus (mg/L) [J]	7	< 0.005	0.011	0.007	0.007	0.003
	Total Phosphorus (mg/L) [J]	7	0.005	0.018	0.012	0.012	0.005
	CBOD-5 (mg/L) [J]	7	< 1.0	1.0	0.5	0.5	0.0
	Chlorides (mg/L) [J]	7	< 0.2	4.8	0.1	0.8	1.8
	Biological						
	Chlorophyll a (ug/L)	7	< 1.00	2.90	1.30	1.63	0.99
	E. coli (mpn/100mL) [J]	3	< 1	8	2	4	3

Station	Parameter	N	Min	Max	Med	Mean	SD
BCLM-5	**Physical**						
	Turbidity (NTU)	7	1.0	2.0	1.0	1.2	0.4
	Total Dissolved Solids (mg/L)	7	19.0	33.0	26.0	25.3	4.7
	Total Suspended Solids (mg/L)	7	< 5.0	5.0	2.5	2.5	0.0
	Hardness (mg/L)	4	8.9	10.0	9.7	9.6	0.5
	Alkalinity (mg/L)[J]	7	5.0	6.0	6.0	5.7	0.5
	Photic Zone (m)	7	3.70	6.53	5.30	5.11	0.90
	Secchi (m)	7	1.55	4.59	2.10	2.60	1.03
	Chemical						
	Ammonia Nitrogen (mg/L) [J]	7	< 0.014	0.017	0.007	0.007	0.001
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7	< 0.006	0.100	0.003	0.023	0.038
	Total Kjeldahl Nitrogen (mg/L)[J]	7	0.220	3.200	0.430	0.774	1.074
	Total Nitrogen (mg/L)[J]	7	< 0.266	3.203	0.433	0.797	1.063
	Dissolved Reactive Phosphorus (mg/L)[J]	7	< 0.006	0.020	0.006	0.007	0.006
	Total Phosphorus (mg/L) [J]	7	0.005	0.016	0.011	0.011	0.004
	CBOD-5 (mg/L)[J]	7	< 1.0	1.0	0.5	0.5	0.0
	Chlorides (mg/L)	7	< 0.2	7.0	0.1	1.1	2.6
	Biological						
	Chlorophyll a (ug/L)	7	< 1.00	5.20	2.10	2.03	1.73
	E. coli (mpn/100mL)[J]	3	< 1	34	2	12	19

J=one or more of the values provided are estimated; < = Actual value is less than the detection limit