2008 Walter F. George Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
November 2012

Rivers and Reservoirs Monitoring Program

2008

Walter F. George Reservoir

Chattahoochee River Basin

Alabama Department of Environmental Management
Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit

November 2012

Table of Contents

LIST OF ACRONYMS

A&I	Agriculture and Industry 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
USACE	United States Army Corp of Engineers
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

In 1962, Walter F. George Reservoir was created by the United States Army Corp of Engineers (USACE) to provide hydroelectric power and navigation along the Chattahoochee River. The reservoir stretches north from Ft. Gaines, GA to Phenix City, AL and covers 45,181 acres along the Alabama/Georgia state line. Streams flowing into the reservoir from Alabama include Hatchechubbie, Cowikee, Barbour, Cheneyhatchee, and Uchee Creeks. Pataula, Turner, Hannahatchee, Hichitee, and Upatoi Creeks flow in from Georgia.

The Alabama Department of Environmental Management (ADEM) monitored Walter F. George Reservoir as part of the 2008 assessment of the Chattahoochee and Predido-Escambia River Basins under the Rivers and Reservoirs Monitoring Program (RRMP). Implemented in 1990, the 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.

In 2001, the ADEM implemented specific water quality criteria for nutrient management at the lower and mid Walter F. George Reservoir stations, which have been monitored by ADEM since 1992. These criteria represent the maximum growing season mean (April-October) chlorophyll *a* (chl *a*) concentration allowable while still fully supporting Walter F. George Reservoir's Swimming, and Fish & Wildlife (S, F&W) use classifications.

The purpose of this report is to summarize data collected at eight stations in Walter F. George Reservoir during the 2008 growing season and to evaluate growing season trends in lake trophic status and nutrient concentrations using ADEM's ten-year dataset. Monthly and/or mean concentrations of nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [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

Sampling stations were selected using historical data and previous assessments (Fig. 1). Specific location information can be found in Table 1. Walter F. George Reservoir was sampled in the dam forebay, mid, and upper reservoir. Five tributary stations; Hatchechubbee, Cowikee, Barbour, Cheneyhatchee, and Uchee Creeks, 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 2007), Surface Water Quality Assurance Project Plan (ADEM 2005), and Quality Management Plan (ADEM 2003).

Mean growing season TN, TP, chl *a*, and TSS were calculated to evaluate water quality conditions at each site. Monthly concentrations of these parameters were graphed with the closest available USACE flow data and ADEM's previously collected data to help interpret the 2008 results.

Figure 1. Walter F. George Reservoir with 2008 sampling locations.

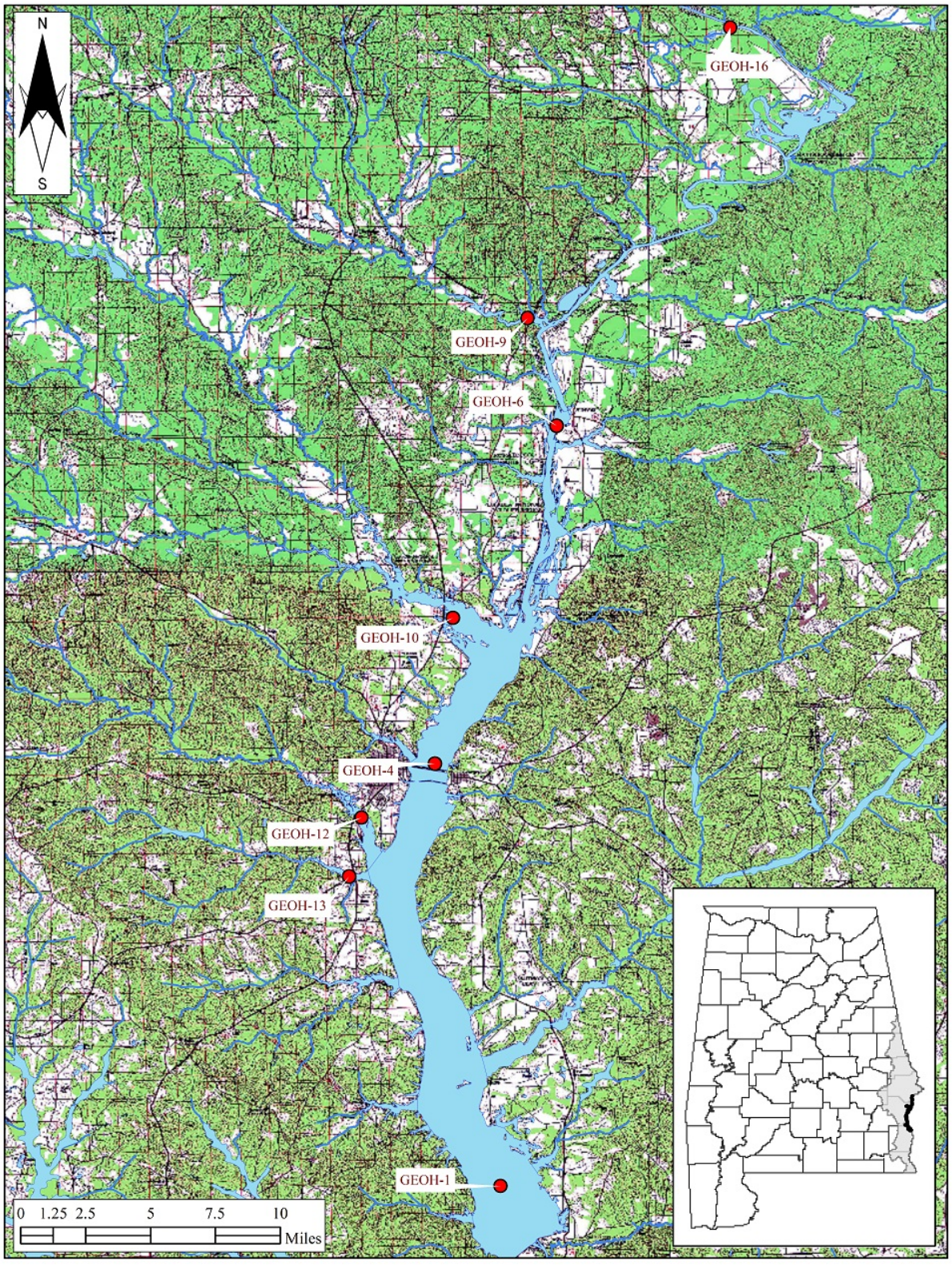


Table 1. Descriptions of the 2008 monitoring stations in Walter F. George Reservoir.

HUC	County	Station Number	Report Designation	Waterbody	Station Description	Chl *a* Criteria	Latitude	Longitude
031300031600	Henry	GEOH-1*	Lower	Chattahoochee R	Deepest point, main river channel, dam forebay. Mile 75.4.	15 ug/L	31.6570	-85.0829
031300031302	Barbour	GEOH-4*	Mid	Chattahoochee R	Deepest point, main river channel, approximately 0.25 miles upstream of U.S. Highway 82 causeway.	18 ug/L	31.8929	-85.1196
031300030903	Russell	GEOH-6	Upper	Chattahoochee R	Deepest point, main river channel, immediately downstream of Florence Marina State Park.		32.0818	-85.0516
031300030804	Russell	GEOH-9	Hatchechubbee Ck	Hatchechubbee Ck	Deepest point, main channel, Hatchechubee Ck embayment.		32.1419	-85.0678
031300031205	Barbour	GEOH-10	Cowikee Ck	Cowikee Ck	Deepest point, main channel, Cowikee Ck embayment.		31.9743	-85.1096
031300031307	Barbour	GEOH-12	Barbour Ck	Barbour Ck	Deepest point, main channel, Barbour Ck embayment.		31.8628	-85.1605
031300031310	Barbour	GEOH-13	Cheneyhatchee Ck	Cheneyhatchee Ck	Deepest point, main channel Cheneyhatchee Ck embayment.		31.8300	-85.1676
031300030505	Russell	GEOH-16	Uchee Ck	Uchee Ck	Deepest point, main creek channel, Uchee Ck embayment.		32.3044	-84.9545

*Growing season mean chl *a* criteria implemented at this station in 2001.

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 Figs. 9-11. Summary statistics of all data collected during 2008 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 that follow will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2008, the highest mean growing season TN value calculated among Walter F. George Reservoir mainstem stations was in the upper station, with Cowikee and Hatchechubbee Creeks the highest among tributary stations (Fig. 2). Mean growing season TN values in the lower and mid Walter F. George Reservoir stations declined 2004-2008. Values in the upper station increased 1999-2007 and then decreased in 2008. Monthly TN concentrations generally decreased through the growing season, April through October, in all mainstem Walter F. George stations (Fig. 4). Historic low monthly TN concentrations were measured in May, August, and October in the lower station and September and October in the mid and upper stations. A historic high monthly TN concentration was measured in June in the lower station.

The highest mean growing season TP values calculated in 2008 among Walter F. George Reservoir mainstem stations were in the upper and mid stations and among tributary stations were Uchee and Cowikee Creeks (Fig. 2). Mean growing season values in the lower and mid stations increased 2007-2008 while values were similar in the upper station. Historic high monthly TP concentrations were measured in the lower and mid stations in August (Fig. 5). A historic high concentration was also measured in the lower station in May. Monthly TP concentrations in the upper station were at or below historic means April-October.

Specific water quality criteria for nutrient management have been established for the lower and mid stations in Walter F. George Reservoir and the growing season mean chl *a* values for both stations in 2008 were in compliance with the criteria limits (Fig. 3). In 2008, the highest mean growing season chl *a* value calculated among Walter F. George Reservoir mainstem stations was in the mid station. Mean chl *a* values in the lower and mid stations in 2008 were lower than those from 1999-2007. Among tributary stations the highest mean growing season chl *a* value calculated was in Hatchechubbee Ck while the lowest was in Uchee Ck. Near historic high monthly chl *a* concentrations were measured in the lower station June and October while the concentration at the upper station was highest in July (Fig. 6). Concentrations were noticeably lower in April and May In both the upper and lower stations. In the mid station, a historic high chl *a* concentration was measured in April and historic low concentrations were measured in May, June, September, and October.

The mean growing season TSS values calculated in 2008 in all Walter F. George Reservoir stations, mainstem and tributaries, were the lowest since monitoring began in 1999 (Fig. 3). Monthly TSS concentrations measured in all mainstem stations were at or below historic means most months monitored (Fig. 7).

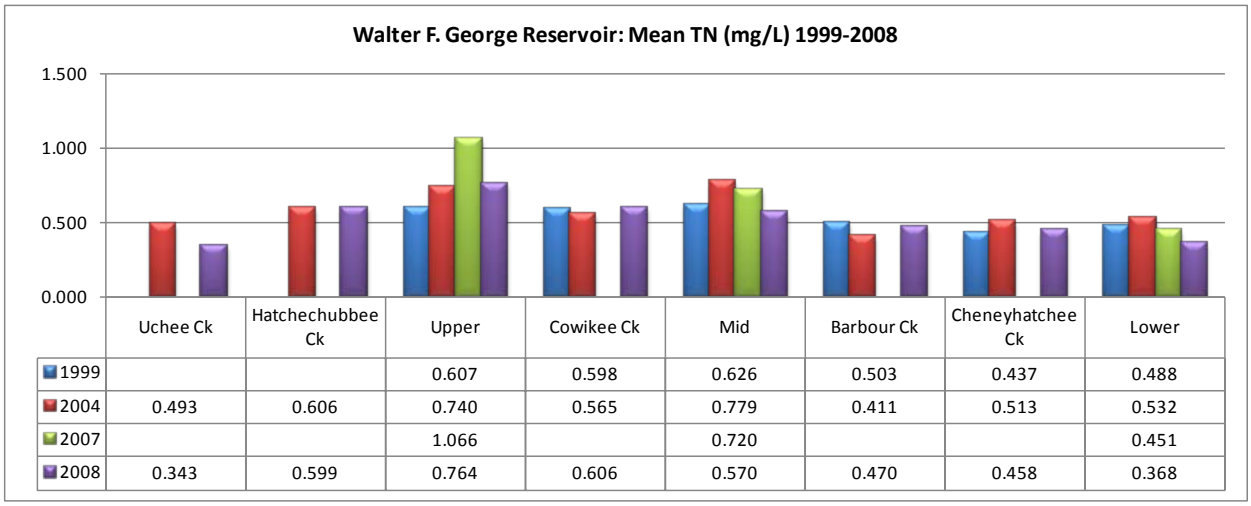
AGPT results in the lower station have alternated between co-limiting and phosphorus limiting since testing began in 1999 (Table 2). With the exception of nitrogen limiting conditions in the upper station in August 1999, the mid and upper stations have remained phosphorus limited all years monitored, 1999-2008. AGPT results in both the lower and mid stations remained below 5 mg/L MSC in 2008, the value that Raschke et al. (1996) defined as protective of reservoir and lake systems. The more riverine upper station is above 5 mg/l MSC but is below 20mg/L MSC, the value that Raschke et al. (1996) defined as protective of flowing stream and river systems.

Dissolved oxygen (DO) measurements in the upper mainstem station in September and the Uchee Ck embayment station in July did not meet the ADEM Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/L at 5.0 ft (1.5 m) (Fig. 8). All other measurements of DO concentrations in Walter F. George Reservoir mainstem and tributary stations met the ADEM criteria. Based on monthly DO profiles, anoxic conditions existed during June and July in the

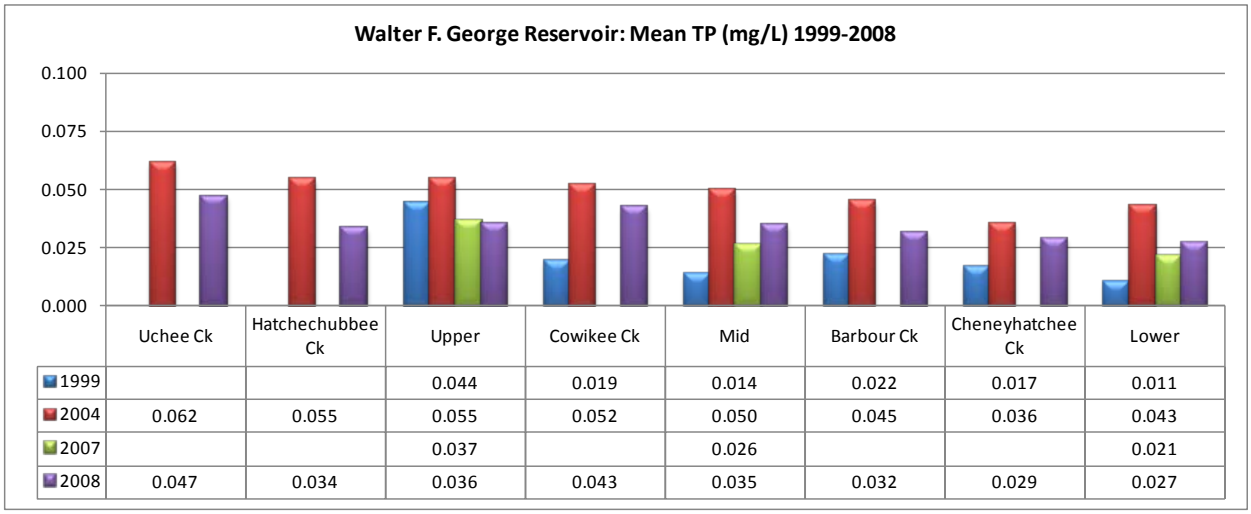
lower station at depths greater than 9.0m, mid station at depths greater than 11.0-13.0m, and in the upper station at depths greater than 11.0m (Fig. 9, 10, and 11). Highest temperatures were measured in July in all Walter F. George Reservoir mainstem stations.

TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index. The lower and upper Walter F. George Reservoir stations were mesotrophic in April, oligotrophic in May, and eutrophic June – October (Fig. 12). TSI values in the mid station were eutrophic all months monitored except May when values were in the mesotophic range. Cheneyhatchee, Barbour, and Cowikee Creeks were eutrophic all months monitored, except May when values were in the mesotrophic range. Hatchechubbee Creek reached hypereutrophic conditions in July and was eutrophic all other months monitored except May when it was oligotrophic. TSI values calculated for Uchee Creek varied between mesotrophic and eutrophic conditions, April through October.

Figure 2. Mean growing season TN and TP measured in Walter F. George Reservoir, April-October, 1999-2008. Stations are illustrated from upstream to downstream as the graph is read from left to right.

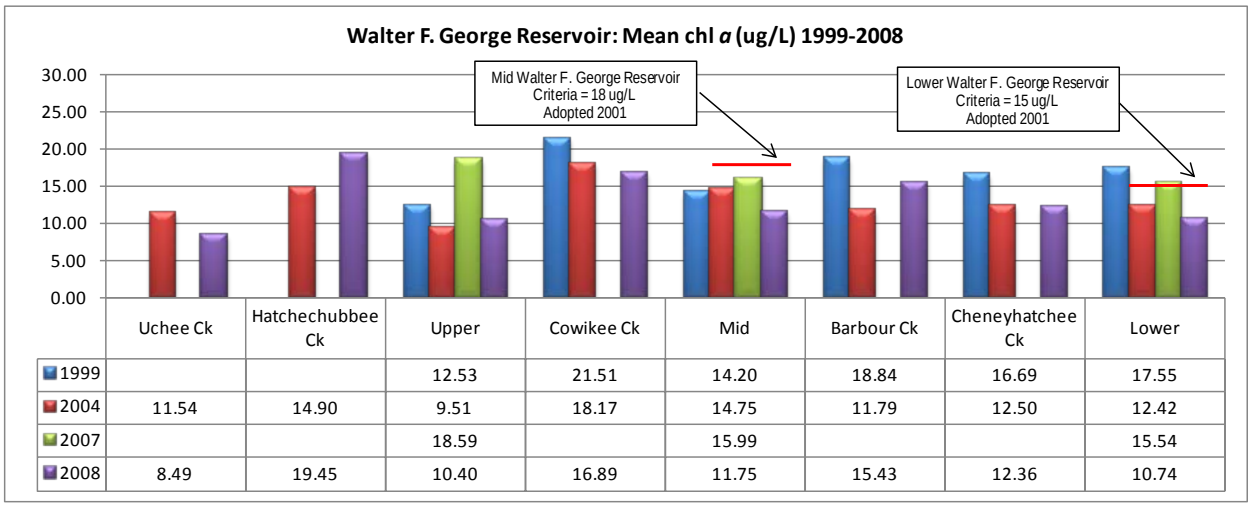


	Uchee Ck	Hatchechubbee Ck	Upper	Cowikee Ck	Mid	Barbour Ck	Cheneyhatchee Ck	Lower
1999			0.607	0.598	0.626	0.503	0.437	0.488
2004	0.493	0.606	0.740	0.565	0.779	0.411	0.513	0.532
2007			1.066		0.720			0.451
2008	0.343	0.599	0.764	0.606	0.570	0.470	0.458	0.368

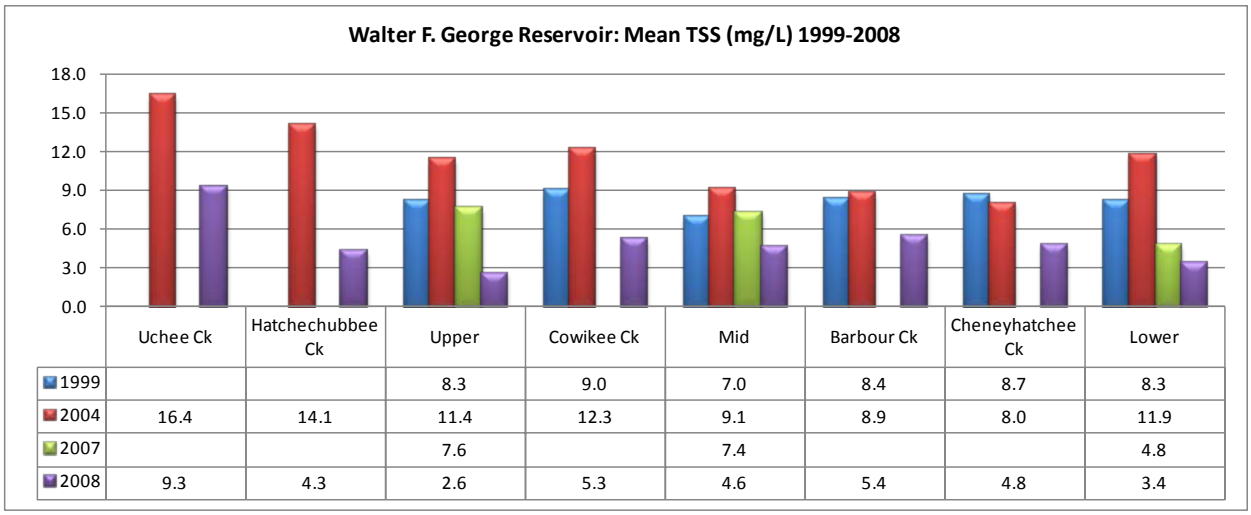


	Uchee Ck	Hatchechubbee Ck	Upper	Cowikee Ck	Mid	Barbour Ck	Cheneyhatchee Ck	Lower
1999			0.044	0.019	0.014	0.022	0.017	0.011
2004	0.062	0.055	0.055	0.052	0.050	0.045	0.036	0.043
2007			0.037		0.026			0.021
2008	0.047	0.034	0.036	0.043	0.035	0.032	0.029	0.027

Figure 3. Mean growing season chl *a* and TSS measured in Walter F. George Reservoir, April-October, 1999-2008. Stations are illustrated from upstream to downstream as the graph is read from left to right. Chl *a* criteria applies to the growing season means of the lower and mid stations.

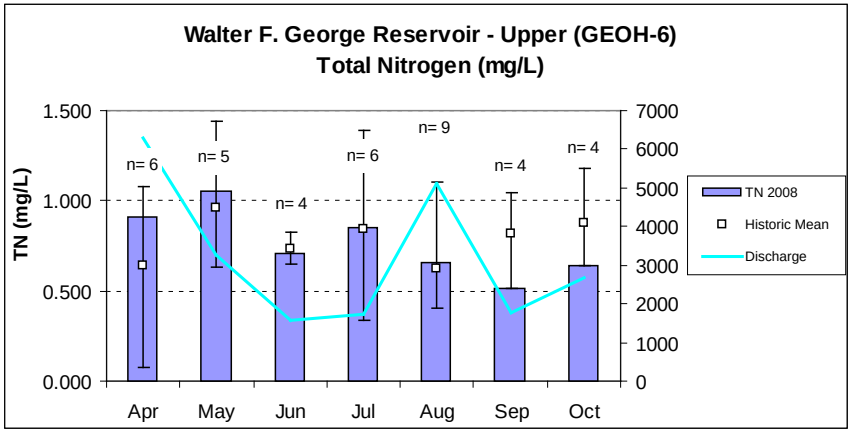


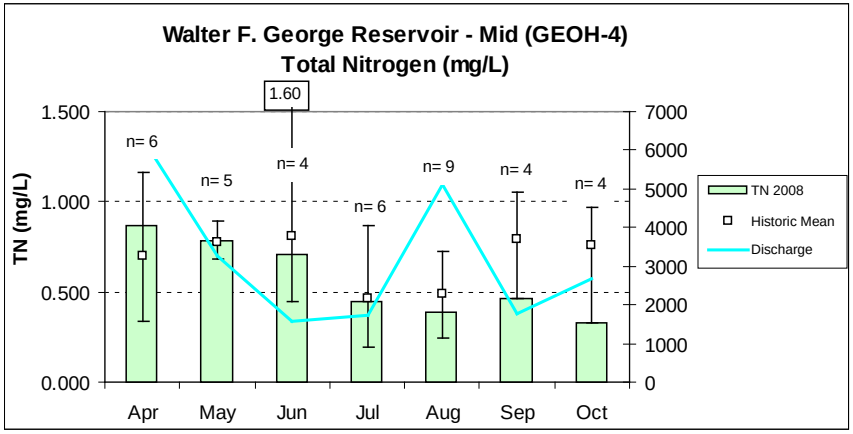
	Uchee Ck	Hatchechubbee Ck	Upper	Cowikee Ck	Mid	Barbour Ck	Cheneyhatchee Ck	Lower
1999			12.53	21.51	14.20	18.84	16.69	17.55
2004	11.54	14.90	9.51	18.17	14.75	11.79	12.50	12.42
2007			18.59		15.99			15.54
2008	8.49	19.45	10.40	16.89	11.75	15.43	12.36	10.74



	Uchee Ck	Hatchechubbee Ck	Upper	Cowikee Ck	Mid	Barbour Ck	Cheneyhatchee Ck	Lower
1999			8.3	9.0	7.0	8.4	8.7	8.3
2004	16.4	14.1	11.4	12.3	9.1	8.9	8.0	11.9
2007			7.6		7.4			4.8
2008	9.3	4.3	2.6	5.3	4.6	5.4	4.8	3.4

Figure 4. Monthly TN concentrations measured in Walter F. George Reservoir, April-October 2008 vs. average monthly discharge. Monthly discharge acquired from USACE. Each bar graph depicts monthly changes in each station. The historic mean (1992-2008) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





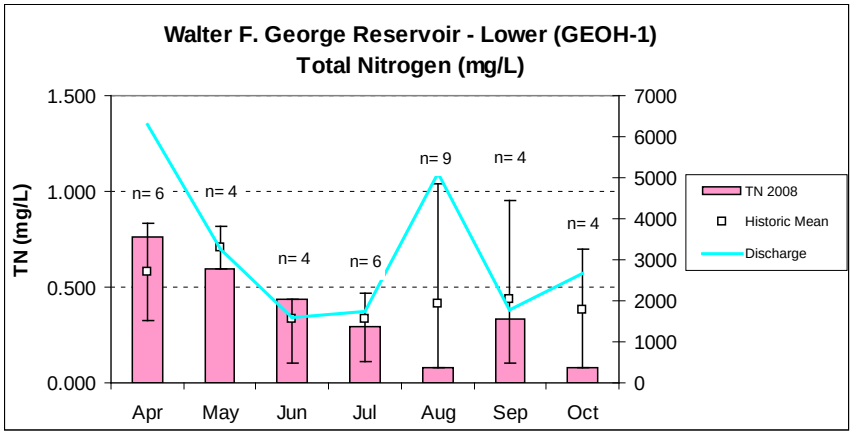
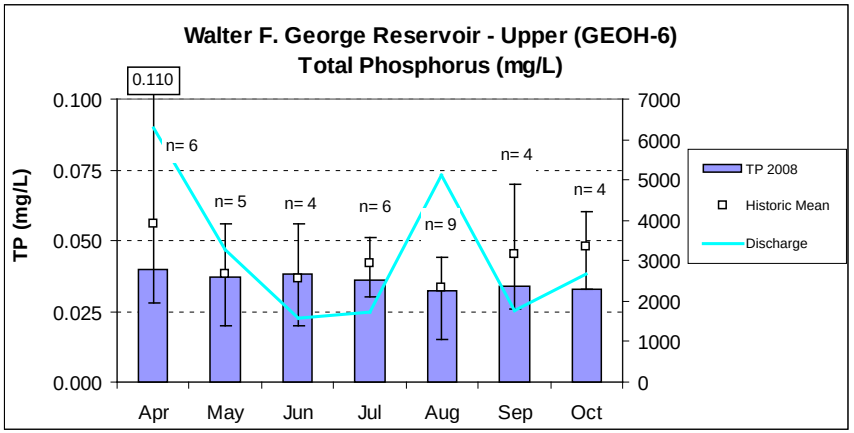
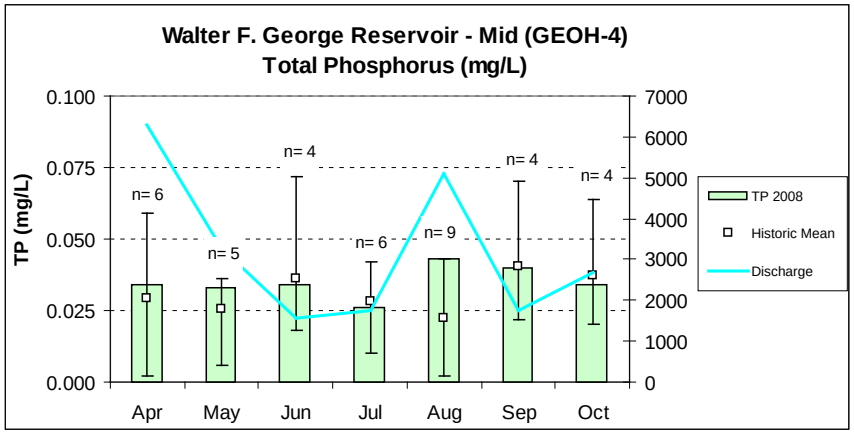


Figure 5. Monthly TP concentrations measured in Walter F. George Reservoir, April-October 2008 vs. average monthly discharge. Monthly discharge acquired from USACE. Each bar graph depicts monthly changes in each station. The historic mean (1992-2008) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





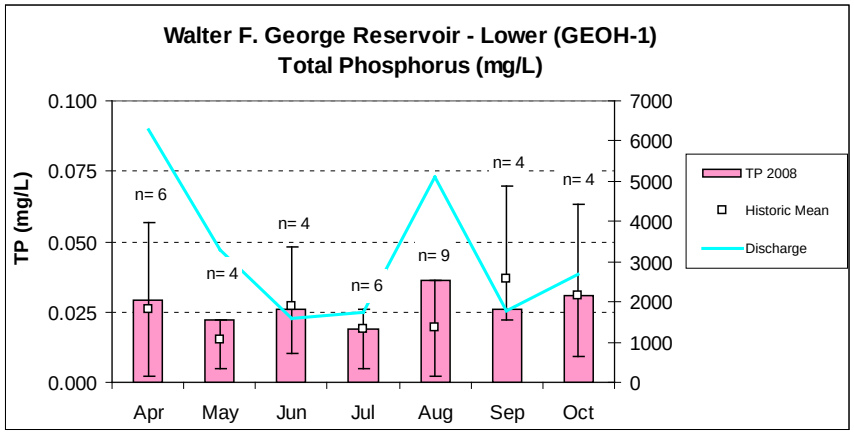
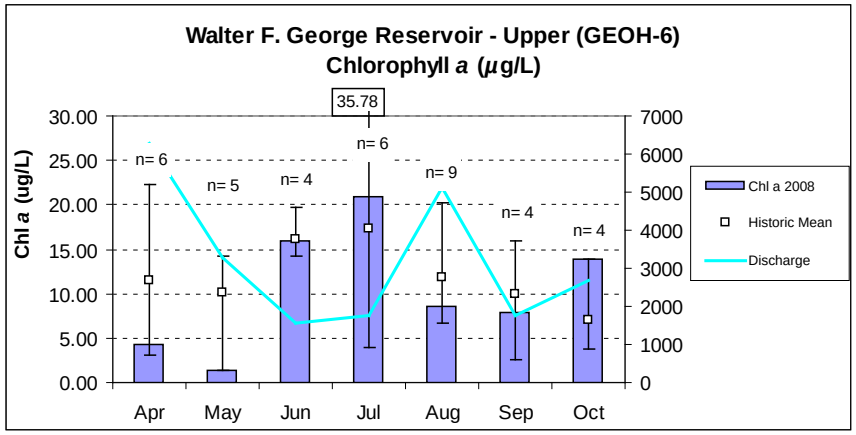
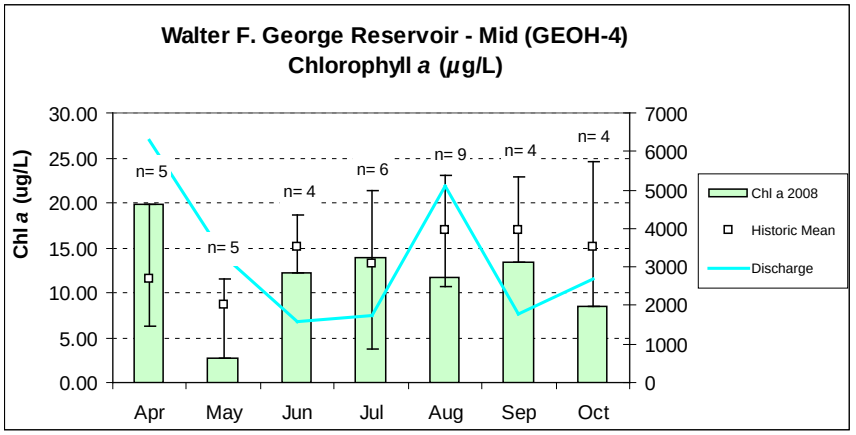


Figure 6. Monthly chl *a* concentrations measured in Walter F. George Reservoir, April-October 2008 vs. average monthly discharge. Monthly discharge acquired from USACE. Each bar graph depicts monthly changes in each station. The historic mean (1992-2008) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





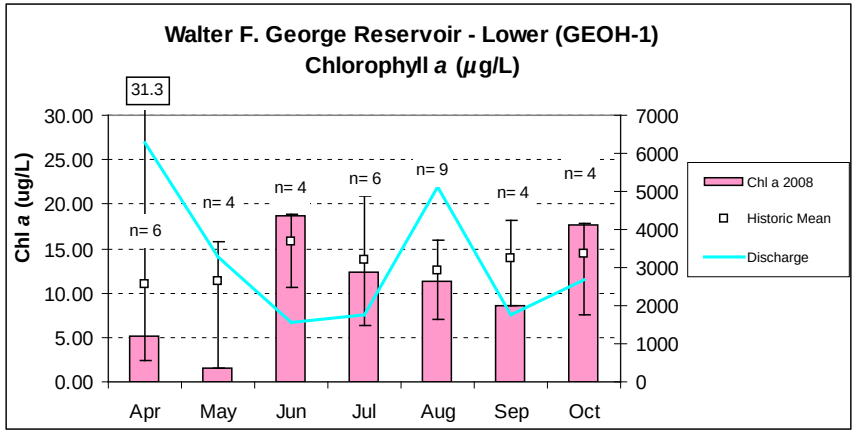
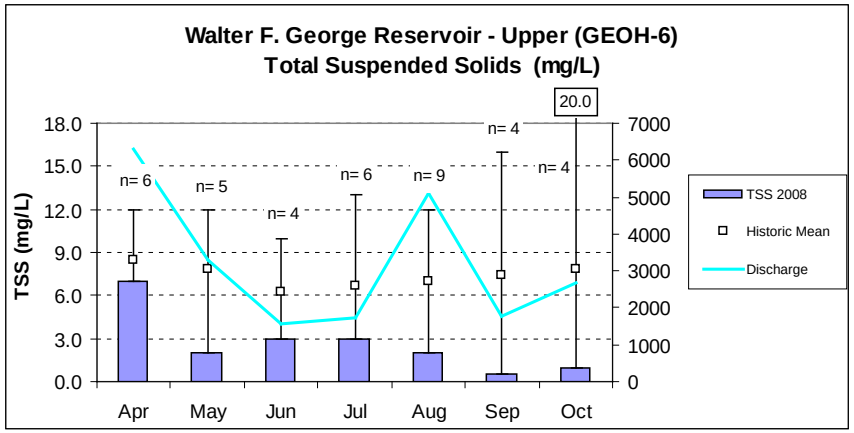
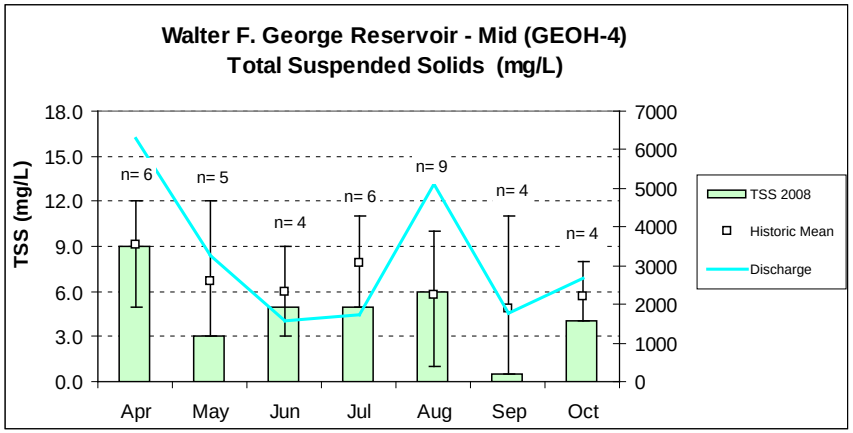


Figure 7. Monthly TSS concentrations measured in Walter F. George Reservoir, April-October 2008 vs. average monthly discharge. Monthly discharge acquired from USACE. Each bar graph depicts monthly changes in each station. The historic mean (1992-2008) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





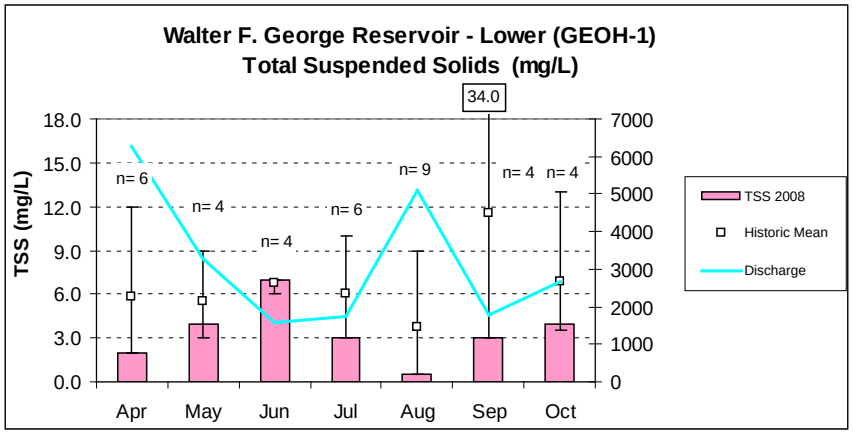
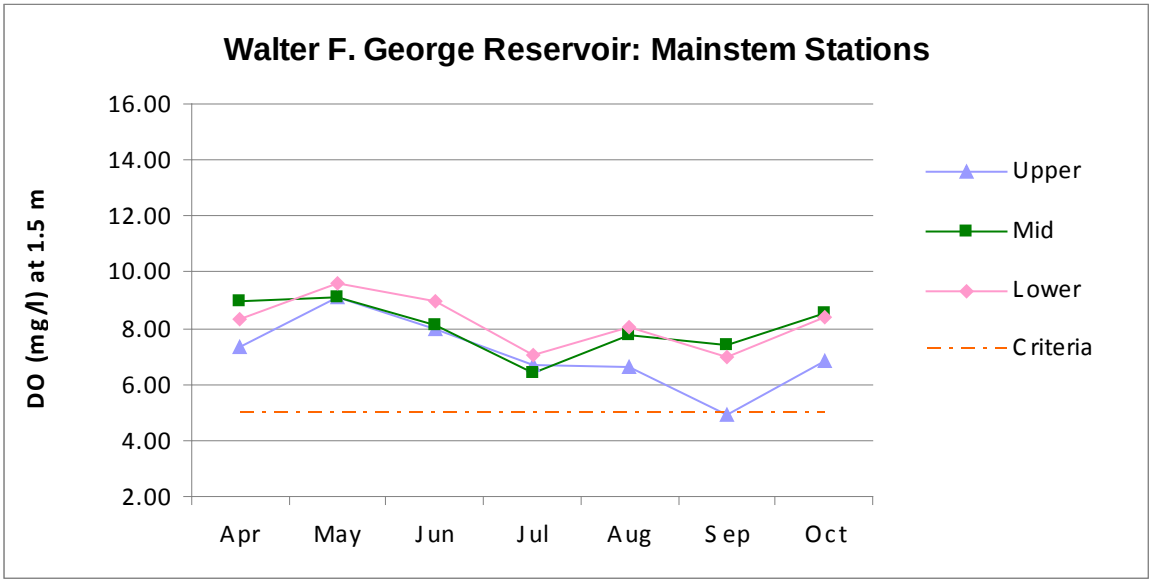


Table 2. Algal growth potential test results, Walter F. George Reservoir, 1999-2008 (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Station	Upper		Mid		Lower	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
June 1999	7.24	Phosphorus	5.69	Phosphorus	2.08	Co-limiting
July 1999	12.06	Phosphorus	2.5	Phosphorus	1.38	Co-limiting
August 1999	31.67	Nitrogen	8.04	Phosphorus	2.19	Phosphorus
August 2004	6.46	**	3.29	Phosphorus	2.16	Co-limiting
August 2008	6.32	Phosphorus	3.56	Phosphorus	3.39	Phosphorus

**The limiting nutrient status could not accurately be determined.

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Walter F. George Reservoir stations collected April-October 2008. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/L at this depth (ADEM 2005).



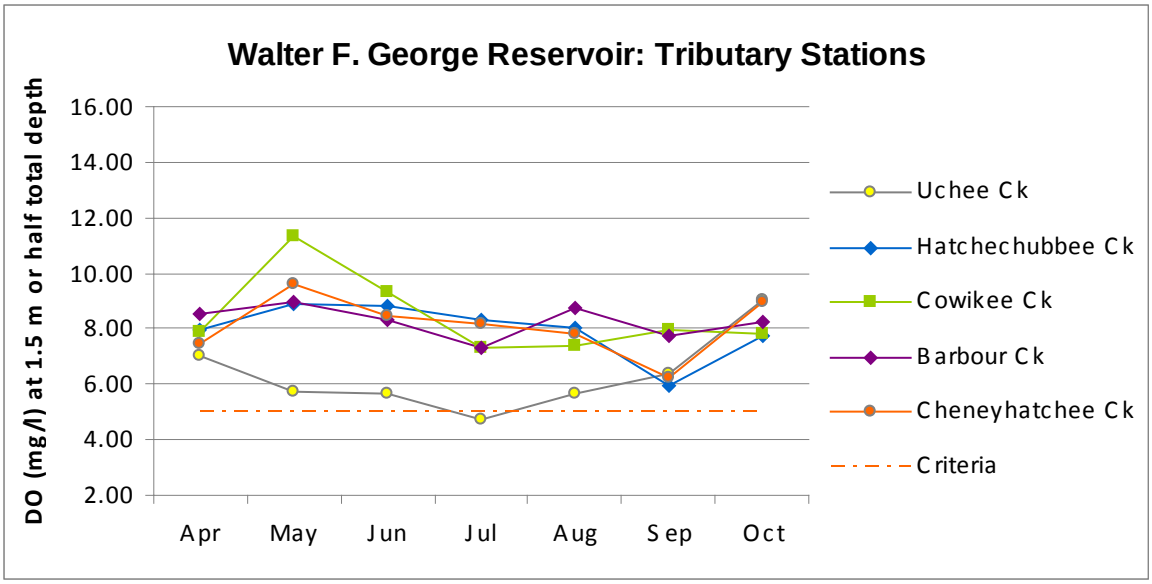


Figure 9. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the lower Walter F. George Reservoir station, April-October 2008.

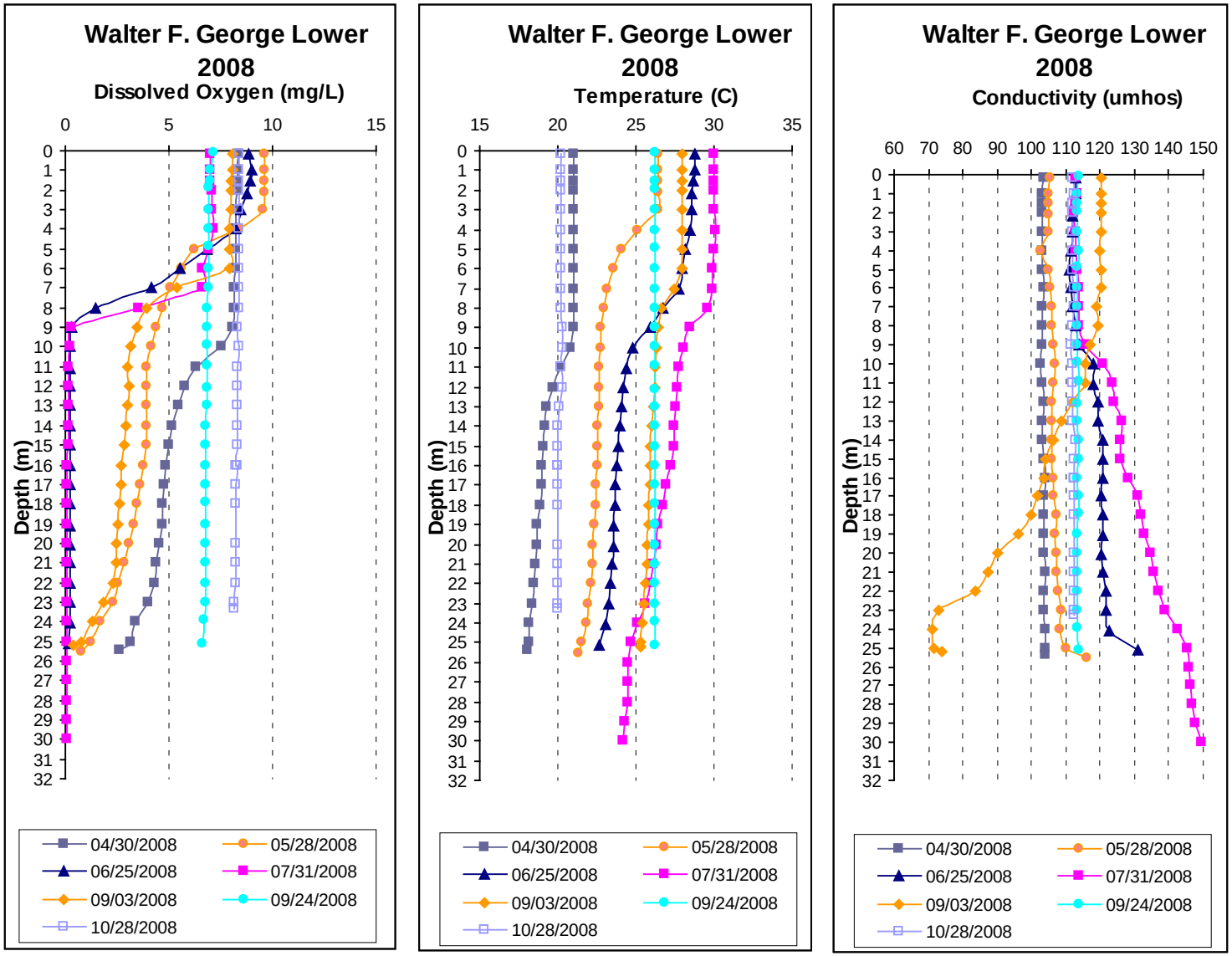


Figure 10. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the mid Walter F. George Reservoir station, April-October 2008.

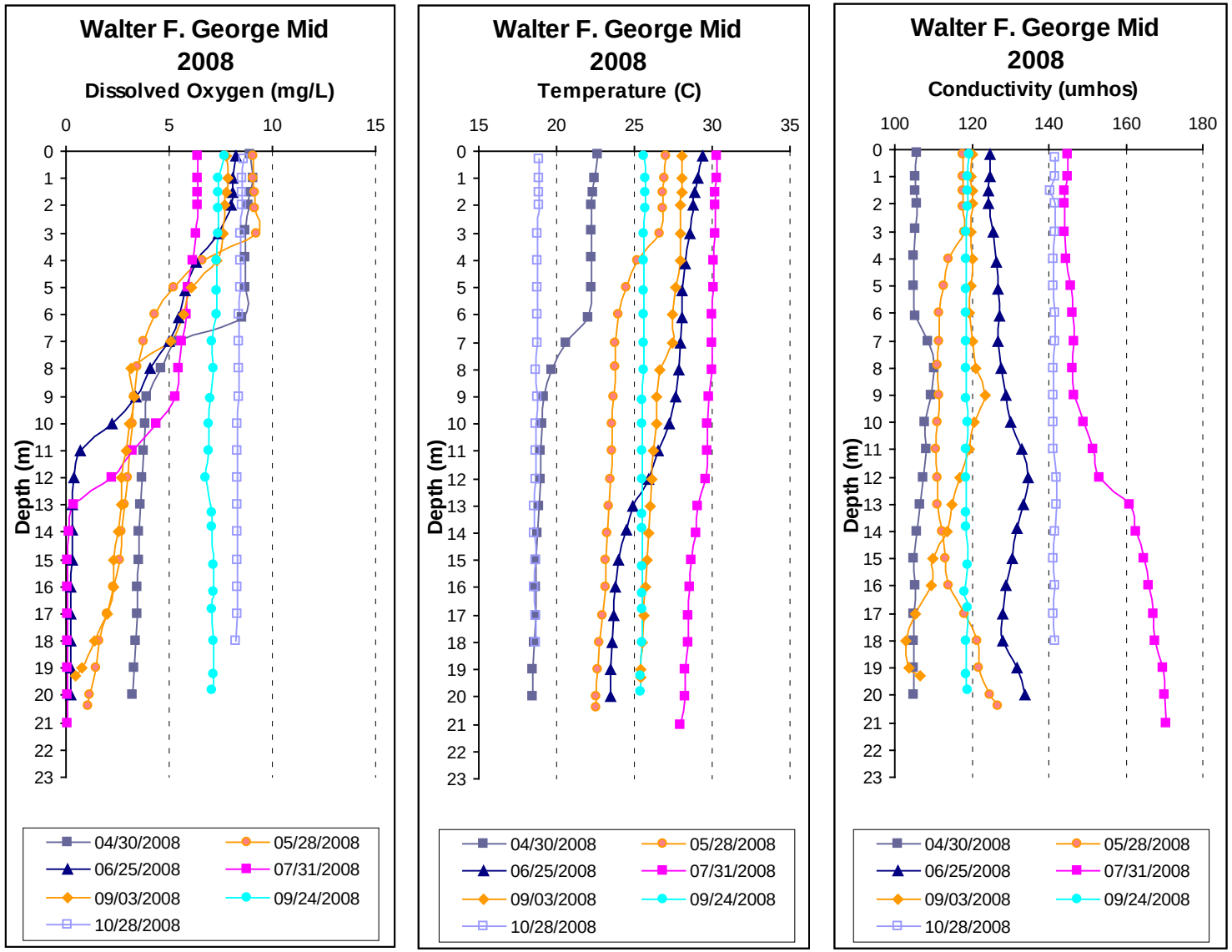


Figure 11. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the upper Walter F. George Reservoir station, April-October 2008.

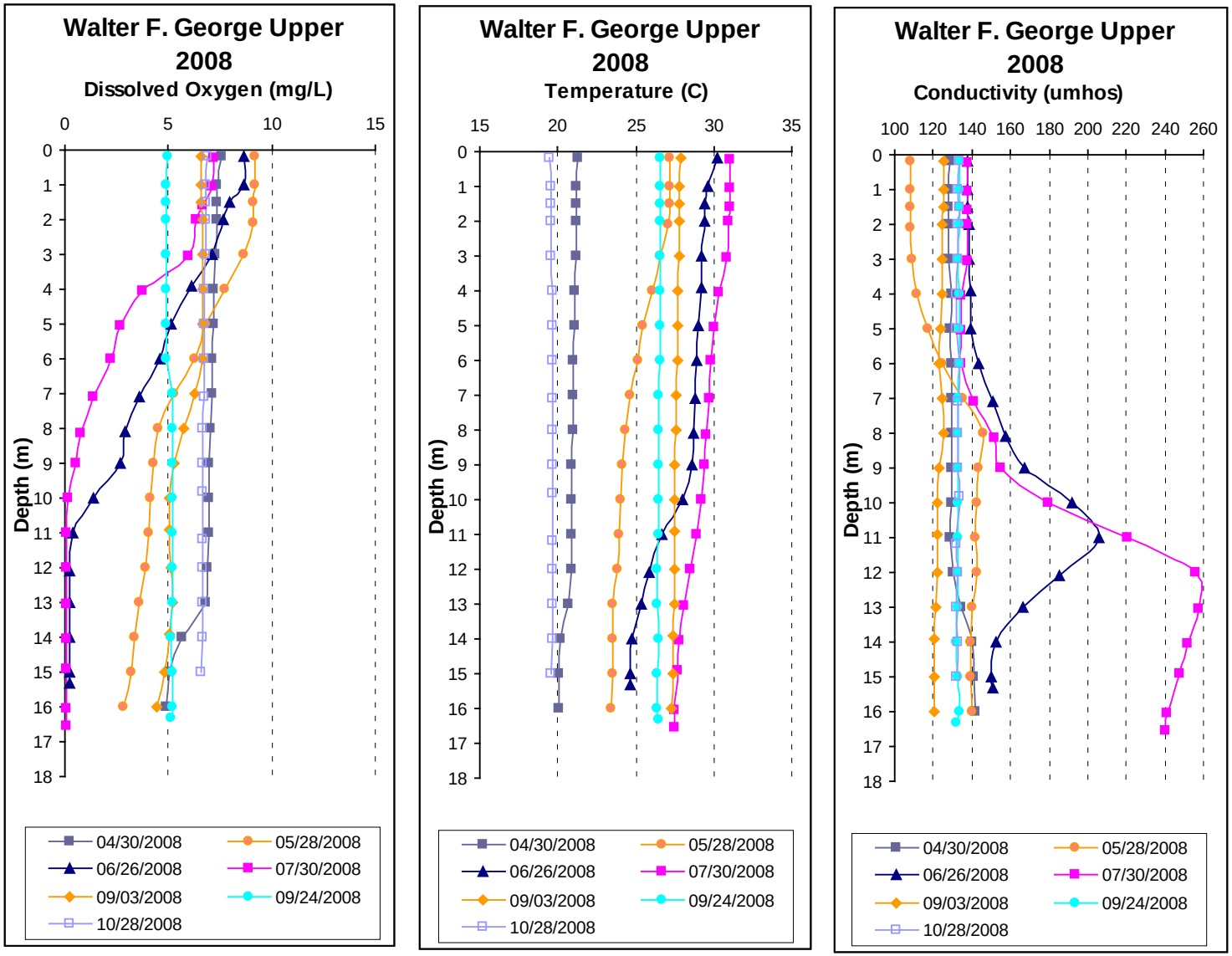
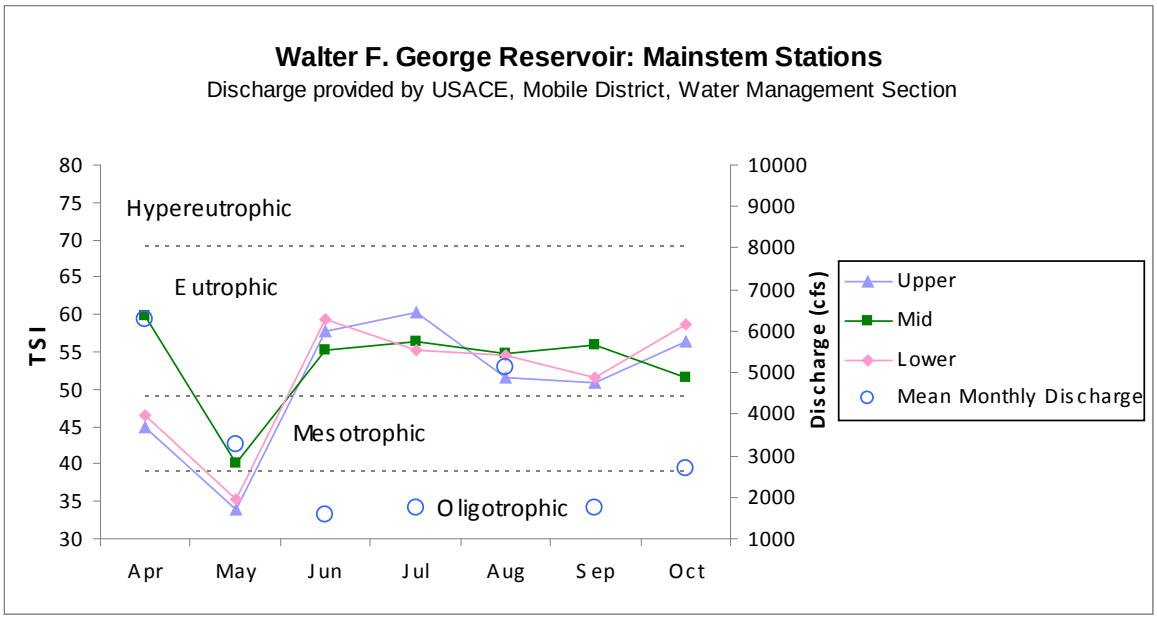
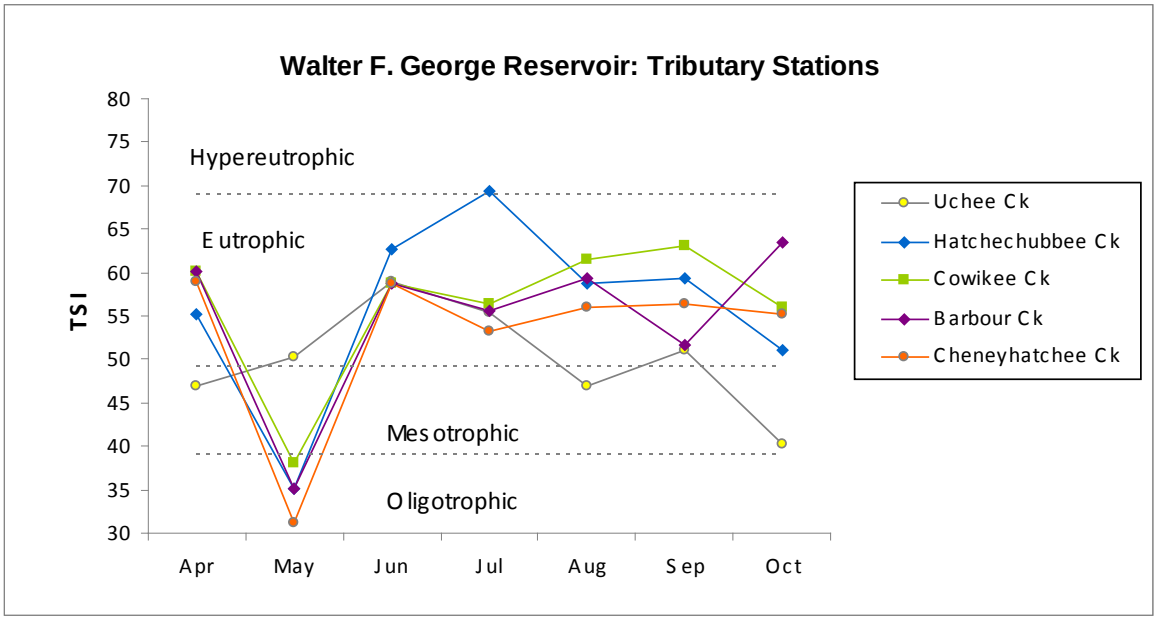


Figure 12. Monthly TSI values calculated for mainstem and tributary Walter F. George Reservoir stations using chl *a* concentrations and Carlson's Trophic State Index calculation. Monthly discharge acquired from USACE.





REFERENCES

ADEM. 2003. Quality Assurance Management Plan For The Alabama Department Of Environmental, Alabama Department of Environmental Management (ADEM), Montgomery, AL. 25 pp.

ADEM. 2005. Study Plan and Quality Assurance Project Plan (QAPP) for Surface Water Quality Monitoring of Non-Wadeable Rivers, Reservoirs, Tributary Embayments, and Estuarine/Marine Waters in Alabama. Alabama Department of Environmental Management (ADEM), Montgomery, AL. 110 pp.

ADEM. 2007 (as amended). Standard Operating Procedures #2041 *In Situ* Surface Water Quality Field Measurements-Temperature, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2042 *In Situ* Surface Water Quality Field Measurements-pH, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2043 *In Situ* Surface Water Quality Field Measurements–Conductivity, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2044 *In Situ* Surface Water Quality Field Measurements–Turbidity, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2045 *In Situ* Surface Water Quality Field Measurements–Dissolved Oxygen, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2046 Photic Zone Measurement and Visibility Determination, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2061 General Surface Water Sample Collection, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2062 Dissolved Reactive Phosphorus (DRP) Surface Water Sample Collection and Field Processing, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2007 (as amended). Standard Operating Procedures #2063 Water Column Chlorophyll *a* Sample Collection and Field Processing, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

Alabama Department of Environmental Management Water Division (ADEM Admin. Code R. 335-6-10-.09). 2005. Specific Water Quality Criteria. Water Quality Program. Chapter 10. Volume 1. Division 335-6.

Alabama Department of Environmental Management Water Division (ADEM Admin. Code R. 335-6-10-.11). 2005. Water Quality Criteria Applicable to Specific Lakes. Water Quality Program. Chapter 10. Volume 1. Division 335-6.

American Public Health Association, American Water Works Association and Water Pollution Control Federation. 1998. Standard methods for the examination of water and wastewater. 20th edition. APHA, Washington, D.C.

Carlson, R.E. 1977. A trophic state index. Limnology and Oceanography. 22(2):361-369.

Lind, O.T. 1979. Handbook of common methods in limnology. The C.V. Mosby Co., St. Louis, Missouri. 199 pp.

Raschke, R.L. and D.A. Schultz. 1987. The use of the algal growth potential test for data assessment. Journal of Water Pollution Control Federation 59(4):222-227.

Raschke, R. L., H. S. Howard, J. R. Maudsley, and R. J. Lewis. 1996. The Ecological Condition of Small Streams in the Savannah River Basin: A REMAP Progress Report. EPA Region 4, Science and Ecosystem Support Division, Ecological Assessment Branch, Athens, GA.

U.S. Environmental Protection Agency. 1990. The lake and reservoir restoration guidance manual. 2nd edition. EPA-440/4-90-006. U.S.E.P.A. Office of Water. Washington, D.C. 326 pp.

Welch, E.B. 1992. Ecological Effects of Wastewater. 2nd edition. Chapman and Hall Publishers. London, England. 425 pp.

Wetzel, R.G. 1983. Limnology. 2nd edition. Saunders College Publishing. Philadelphia, Pennsylvania. 858 pp.

APPENDIX

Appendix Table 1. Summary of Walter F. George Reservoir water quality data collected April-October, 2008. 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
GEOH-1	Physical							
	Turbidity (NTU)	7		2.3	3.1	2.6	2.6	0.3
	Total Dissolved Solids (mg/L)	7		6.0	70.0	62.0	51.1	22.6
	Total Suspended Solids (mg/L)	7	<	1.0	7.0	3.0	3.4	2.0
	Hardness (mg/L)	4		19.7	25.0	22.7	22.5	2.4
	Alkalinity (mg/L)	7		18.6	27.1	24.8	24.2	3.0
	Photic Zone (m)	7		3.51	6.16	4.72	4.79	0.93
	Secchi (m)	7		1.33	2.12	1.67	1.69	0.28
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.003	0.382	0.004	0.077	0.142
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.470	0.313	0.291	0.160
	Total Nitrogen (mg/L)	7	<	0.076	0.762	0.331	0.368	0.254
	Dissolved Reactive Phosphorus (mg/L)	7		0.006	0.010	0.008	0.008	0.001
	Total Phosphorus (mg/L)	7		0.019	0.036	0.026	0.027	0.006
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		5.5	8.4	7.4	7.1	1.1
	Biological							
	Chlorophyll a (ug/L)	7		1.60	18.69	11.39	10.74	6.24
	Fecal Coliform (col/100 mL)[J]	1					1	
GEOH-4	Physical							
	Turbidity (NTU)	7		3.3	5.8	4.1	4.3	0.8
	Total Dissolved Solids (mg/L)	7		30.0	84.0	56.0	54.3	20.0
	Total Suspended Solids (mg/L)	7	<	1.0	9.0	5.0	4.6	2.6
	Hardness (mg/L)	4		19.8	25.2	23.8	23.2	2.4
	Alkalinity (mg/L)	7		22.7	31.8	27.5	27.4	3.2
	Photic Zone (m)	7		2.79	4.16	3.45	3.42	0.44
	Secchi (m)	7		0.91	1.94	1.33	1.32	0.32
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.010	0.358	0.134	0.139	0.122
	Total Kjeldahl Nitrogen (mg/L)	7		0.173	0.683	0.435	0.431	0.176
	Total Nitrogen (mg/L)	7		0.329	0.869	0.467	0.570	0.212
	Dissolved Reactive Phosphorus (mg/L)	7		0.007	0.012	0.008	0.009	0.002
	Total Phosphorus (mg/L)	7		0.026	0.043	0.034	0.035	0.005
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		4.5	10.1	8.1	7.8	1.8
	Biological							
	Chlorophyll a (ug/L)	7		2.67	19.76	12.28	11.75	5.23
	Fecal Coliform (col/100 mL)[J]	1					1	

Station	Parameter	N		Min	Max	Med	Mean	SD
GEOH-6	**Physical**							
	Turbidity (NTU)	7		4.5	9.2	5.8	6.8	2.1
	Total Dissolved Solids (mg/L)	7		16.0	88.0	62.0	63.7	25.6
	Total Suspended Solids (mg/L)	7	<	1.0	7.0	2.0	2.6	2.1
	Hardness (mg/L)	4		17.0	25.8	22.2	21.8	4.4
	Alkalinity (mg/L)	7		22.9	163.0	27.2	45.9	51.7
	Photic Zone (m)	7		2.11	3.59	2.57	2.70	0.52
	Secchi (m)	7		0.84	1.43	1.02	1.09	0.20
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.037	0.008	0.012	0.011
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.126	0.550	0.306	0.331	0.131
	Total Kjeldahl Nitrogen (mg/L)	7		0.221	0.728	0.379	0.433	0.182
	Total Nitrogen (mg/L)	7		0.518	1.057	0.711	0.764	0.186
	Dissolved Reactive Phosphorus (mg/L)	7		0.006	0.013	0.010	0.010	0.002
	Total Phosphorus (mg/L)	7		0.032	0.040	0.036	0.036	0.003
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		2.6	11.7	8.4	8.1	2.8
	Biological							
	Chlorophyll a (ug/L)	7		1.42	20.83	8.54	10.40	6.84
	Fecal Coliform (col/100 mL)[J]	1					6	
GEOH-9	**Physical**							
	Turbidity (NTU)	7		4.2	6.3	5.9	5.5	0.7
	Total Dissolved Solids (mg/L)	7		10.0	94.0	68.0	60.0	30.6
	Total Suspended Solids (mg/L)	7		2.0	9.0	4.0	4.3	2.4
	Hardness (mg/L)	4		16.8	27.7	23.4	22.8	4.9
	Alkalinity (mg/L)	7		21.3	30.1	27.7	26.5	3.2
	Photic Zone (m)	7		2.71	3.76	3.04	3.16	0.41
	Secchi (m)	7		0.97	1.28	1.11	1.14	0.12
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.036	0.410	0.166	0.214	0.138
	Total Kjeldahl Nitrogen (mg/L)	7		0.208	0.575	0.355	0.385	0.130
	Total Nitrogen (mg/L)	7		0.440	0.827	0.513	0.599	0.157
	Dissolved Reactive Phosphorus (mg/L)	7		0.005	0.012	0.009	0.008	0.003
	Total Phosphorus (mg/L)	7		0.017	0.052	0.034	0.034	0.010
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		2.6	10.4	8.3	7.8	2.5
	Biological							
	Chlorophyll a (ug/L)	7		1.60	51.80	17.62	19.45	16.31
	Fecal Coliform (col/100 mL)[J]	1					3	

Station	Parameter	N		Min	Max	Med	Mean	SD
GEOH-10	**Physical**							
	Turbidity (NTU)	7		4.3	9.0	5.7	6.0	1.7
	Total Dissolved Solids (mg/L)	7		34.0	106.0	58.0	61.4	24.7
	Total Suspended Solids (mg/L)	7		3.0	11.0	4.0	5.3	2.9
	Hardness (mg/L)	4		16.6	30.4	24.9	24.2	6.4
	Alkalinity (mg/L)	7		17.4	32.0	29.0	27.1	5.0
	Photic Zone (m)	7		2.41	3.72	2.92	3.01	0.54
	Secchi (m)	7		0.81	1.31	1.02	1.03	0.19
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.003	0.236	0.042	0.062	0.085
	Total Kjeldahl Nitrogen (mg/L)	7		0.361	0.779	0.524	0.544	0.169
	Total Nitrogen (mg/L)	7	<	0.388	1.015	0.586	0.606	0.233
	Dissolved Reactive Phosphorus (mg/L)	7		0.007	0.012	0.008	0.009	0.002
	Total Phosphorus (mg/L)	7		0.031	0.058	0.040	0.043	0.009
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		5.2	9.8	7.3	7.4	1.4
	Biological							
	Chlorophyll a (ug/L)	7		2.14	27.23	17.62	16.89	8.20
	Fecal Coliform (col/100 mL)[J]	1					10	
GEOH-12	**Physical**							
	Turbidity (NTU)	7		3.6	11.5	4.3	5.5	2.7
	Total Dissolved Solids (mg/L)	7		36.0	84.0	54.0	57.7	19.5
	Total Suspended Solids (mg/L)	7		2.0	12.0	4.0	5.4	3.8
	Hardness (mg/L)	4		17.9	28.1	23.8	23.4	4.4
	Alkalinity (mg/L)	7		21.6	30.2	28.1	27.1	2.9
	Photic Zone (m)	7		2.51	4.34	3.84	3.57	0.62
	Secchi (m)	7		0.80	1.82	1.35	1.28	0.34
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.003	0.276	0.018	0.060	0.099
	Total Kjeldahl Nitrogen (mg/L)	7		0.239	0.531	0.421	0.410	0.106
	Total Nitrogen (mg/L)	7	<	0.285	0.788	0.422	0.470	0.170
	Dissolved Reactive Phosphorus (mg/L)	7		0.008	0.010	0.010	0.009	0.001
	Total Phosphorus (mg/L)	7		0.021	0.049	0.030	0.032	0.009
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		5.3	8.1	7.6	7.2	1.1
	Biological							
	Chlorophyll a (ug/L)	7		1.60	28.48	17.62	15.43	8.71
	Fecal Coliform (col/100 mL)[J]	1					1	

Station	Parameter	N		Min	Max	Med	Mean	SD
GEOH-13	**Physical**							
	Turbidity (NTU)	7		3.4	6.0	4.8	4.8	1.0
	Total Dissolved Solids (mg/L)	7		16.0	82.0	56.0	49.4	23.3
	Total Suspended Solids (mg/L)	7	<	1.0	13.0	4.0	4.8	4.2
	Hardness (mg/L)	4		19.9	24.1	23.0	22.5	1.9
	Alkalinity (mg/L)	7		20.5	30.0	26.2	25.9	3.0
	Photic Zone (m)	7		3.16	5.21	3.75	3.76	0.71
	Secchi (m)	7		1.16	1.55	1.27	1.31	0.14
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.003	0.282	0.018	0.060	0.102
	Total Kjeldahl Nitrogen (mg/L)	7		0.199	0.565	0.365	0.398	0.124
	Total Nitrogen (mg/L)	7	<	0.217	0.818	0.376	0.458	0.206
	Dissolved Reactive Phosphorus (mg/L)	7		0.007	0.011	0.009	0.009	0.001
	Total Phosphorus (mg/L)	7		0.019	0.044	0.027	0.029	0.008
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		1.3	8.2	7.6	6.7	2.5
	Biological							
	Chlorophyll a (ug/L)	7		1.07	18.16	13.35	12.36	5.73
	Fecal Coliform (col/100 mL)[J]	1					2	
GEOH-16	**Physical**							
	Turbidity (NTU)	7		9.3	18.5	14.8	13.8	3.3
	Total Dissolved Solids (mg/L)	7		16.0	72.0	52.0	47.1	20.0
	Total Suspended Solids (mg/L)	7		3.0	20.0	9.0	9.3	6.1
	Hardness (mg/L)	4		13.6	23.5	14.6	16.6	4.6
	Alkalinity (mg/L)	7		8.4	16.6	15.2	14.1	2.8
	Photic Zone (m)	7		1.53	2.25	1.96	1.91	0.24
	Secchi (m)	7		0.45	1.03	0.68	0.67	0.20
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.003	0.063	0.014	0.026	0.023
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.463	0.352	0.317	0.141
	Total Nitrogen (mg/L)[J]	7	<	0.089	0.464	0.363	0.343	0.138
	Dissolved Reactive Phosphorus (mg/L)	7		0.010	0.015	0.012	0.013	0.002
	Total Phosphorus (mg/L)	7		0.037	0.059	0.045	0.047	0.009
	CBOD-5 (mg/L)	7	<	1.0	2.0	0.5	0.6	0.2
	Chlorides (mg/L)[J]	7		2.9	7.1	4.4	4.5	1.3
	Biological							
	Chlorophyll a (ug/L)	7		2.67	18.16	7.48	8.49	5.23
	Fecal Coliform (col/100 mL)	1					110	

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