2005 Logan Martin Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
January 13, 2010

Rivers and Reservoirs Monitoring Program

2005

Logan Martin Reservoir

Coosa River Basin

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

January 2010

Table of Contents

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

The Alabama Department of Environmental Management (ADEM) monitored Logan Martin Reservoir as part of the 2005 assessment of the Alabama, Coosa, and Tallapoosa (ACT) River basins under the Rivers and Reservoirs Monitoring Program (RRMP). Implemented in 1990, the objectives of this program were 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.

Logan Martin Reservoir was placed on Alabama's 1996 Clean Water Act (CWA) §303(d) list of impaired waters for not meeting its Swimming (S)/Fish & Wildlife (F&W) water use classifications. The reservoir was listed in 1996 for impairments caused by priority organics (PCBs), nutrients, and organic enrichment/dissolved oxygen (OE/DO). A TMDL developed to address the nutrient and OE/DO impairment in Logan Martin, as well as the entire Coosa River reservoir chain, was approved by the USEPA in 2008.

The purpose of this report is to summarize data collected at nine stations in Logan Martin Reservoir during the 2005 growing season and to evaluate trends in mean lake trophic status and nutrient concentrations using ADEM's 20 year 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)) are compared to ADEM's historical data.

METHODS

Sampling stations were determined using historical data and previous assessments (Fig. 1; Table 1). Logan Martin was sampled in the dam forebay, the mid reservoir and the upper reservoir. Six tributary embayment stations were established in the larger embayments and/or those with

Figure 1. Logan Martin Reservoir with 2005 sampling locations. A description of each sampling location is provided in Table 1.

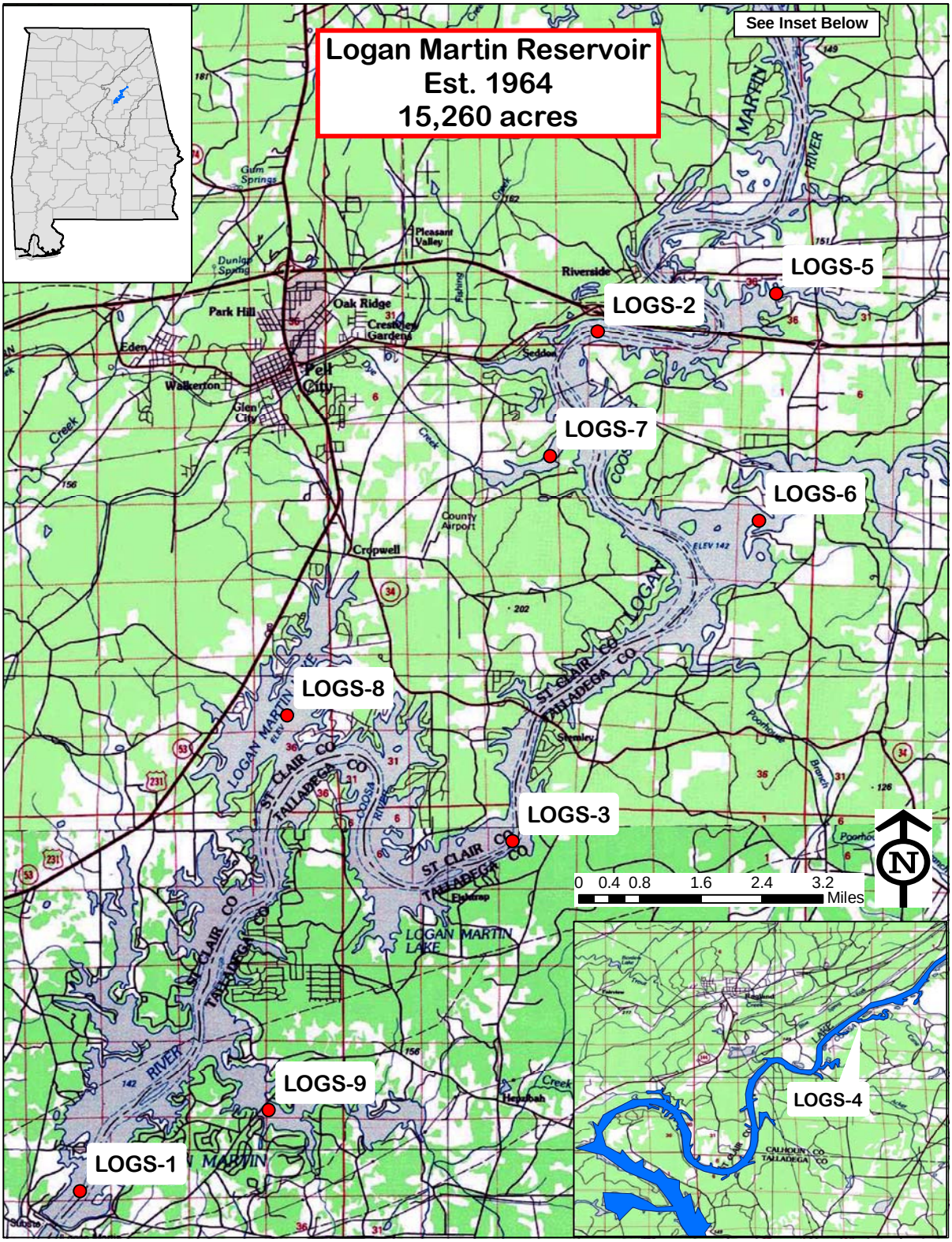


Table 1. Descriptions for the monitoring stations in 2005 for Logan Martin Reservoir.

Logan Martin Reservoir							
Sub-watershed	**County**	**Station Number**	**Report Designation**	**Waterbody Name**	**Station Description**	**Latitude**	**Longitude**
Middle Coosa (0315-0106)							
0801	St. Clair	LOGS-1**	Lower	Coosa R	Lower reservoir. Deepest point, main river channel, dam forebay .	33.4316	-86.3306
0504	Talladega	LOGS-2	Upper	Coosa R	Upper reservoir. Deepest point, main river channel. Downstream of I-20 bridge, immed. Upstream of Riverside Marina.	33.5944	-86.2117
0801	St. Clair	LOGS-3**	Mid	Coosa R	Mid reservoir. Deepest point, main river channel. Approx. 1.5 miles downstream of Alabama Hwy 34 bridge.	33.4976	-86.2319
0407	Calhoun	LOGS-4	Cane Cr	Cane Cr	Deepest point, main creek channel, Cane Creek embayment, approximately 0.25 miles upstream of Coosa River confluence.	33.7306	-86.1023
0503	Talladega	LOGS-5	Blue Eye Cr	Blue Eye Cr	Deepest point, main creek channel, Blue Eye Creek embayment, approximately 0.5 miles upstream of lake confluence.	33.6014	-86.1711
0612	Talladega	LOGS-6	Choccolocco Cr	Choccolocco Cr	Deepest point, main creek channel, Choccolocco Creek embayment, approximately 1.0 miles upstream of lake confluence.	33.5582	-86.1754
0504	St. Clair	LOGS-7	Dye Cr	Dye Cr	Deepest point, main creek channel, Dye Creek embayment, approximately 0.5 miles upstream of lake confluence.	33.5709	-86.2227
0801	St. Clair	LOGS-8	Cropwell Cr	Cropwell Cr	Deepest point, main creek channel, Cropwell Creek embayment, approximately 0.5 miles upstream of lake confluence.	33.5219	-86.2829
0502	Talladega	LOGS-9	Clear Cr	Clear Cr	Deepest point, main creek channel, Clear Creek embayment, immediately upstream of Talladega Co. Rd. 191 bridge.	33.4468	-86.2877

**Growing season mean Chl a criteria will be established at this station in 2010

larger inflows. Together, they represent a variety of landuse types and a range in upstream watershed conditions.

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 (SOP), Surface Water Quality Assurance Project Plan (QAPP), and Quality Management Plan (QMP).

RESULTS

Summary statistics of all data collected during 2005 are presented in Appendix Table 1. The table contains the min, max, median, average, and standard deviation of each parameter analyzed.

Mean TN concentrations ranged from 0.588 mg/l to 0.639 mg/l in the mainstem stations, and increased downstream to upstream (Fig. 2). In the tributary embayments, mean TN concentrations ranged from 0.543 mg/l at Clear Creek in the lower reservoir to 0.714 mg/l at Dye Creek in the mid-reservoir (Fig. 2). Monthly concentrations were generally higher than the corresponding historical means April through September (Fig. 3, 4, & 5).

At the three mainstem stations, mean TP concentrations ranged from 0.050 mg/l in the mid-reservoir to 0.064 mg/l in the upper reservoir (Fig. 2). Of the tributary embayments, the mean TP concentrations ranged from 0.043 mg/l in Cropwell Creek to 0.082 mg/l in Choccolocco Creek (Fig. 2). Monthly TP concentrations decreased as flow decreased during August through October (Fig. 3, 4, & 5).

Mean chl *a* concentrations ranged from 16.68 ug/L at the lower reservoir station to 22.25 ug/L at Choccolocco Ck embayment (Fig. 2). Within mainstem stations, monthly chl *a* concentrations were lowest in June, the lowest of all historical data for each station that month (Fig. 3, 4, & 5). The ADEM monitored growing season mean chl *a* concentrations at mainstem reservoir stations in 1997, 2000, 2004, and 2005 (Fig. 6). Mean chl *a* has steadily decreased at the upper and mid-reservoir stations. The growing season mean at the lower station was highest in 1997, but remained stable 2000-2005 (Fig.6).

Mean TSS concentrations were higher in the upper portion of the reservoir and decreased downstream (Fig. 2). Highest monthly TSS concentrations in the mainstem stations occurred in April (Fig. 3, 4, & 5).

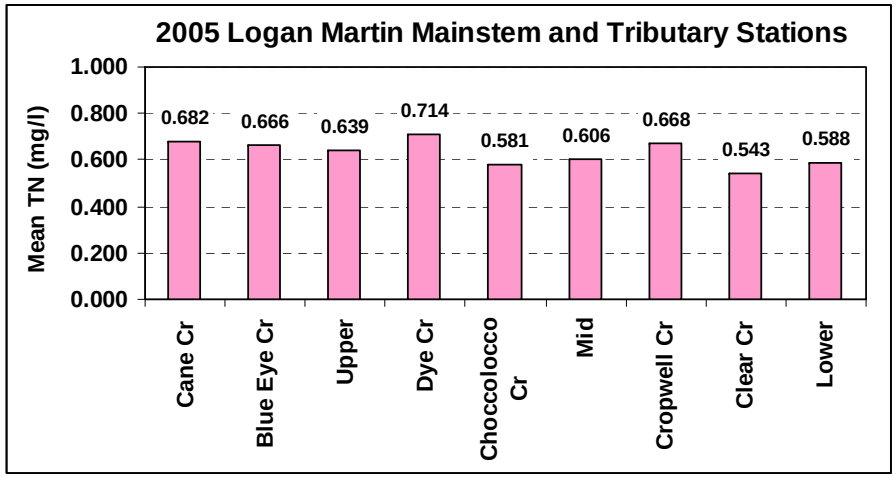
AGPT results indicated nitrogen limiting conditions in the mid- and lower reservoir stations and non-limiting conditions at the upper station (Table 2). Similar results were obtained at the upper and mid-reservoir stations in 2000. However, the 2000 AGPT results indicated phosphorus limiting conditions in the lower station. Mean standing crop (MSC) values ranged from 2.25 mg/l at the mid-reservoir station to 2.93 mg/l at the lower reservoir station. Raschke and Schultz (1987) defined 5 mg/l MSC as protective of reservoir and lake systems.

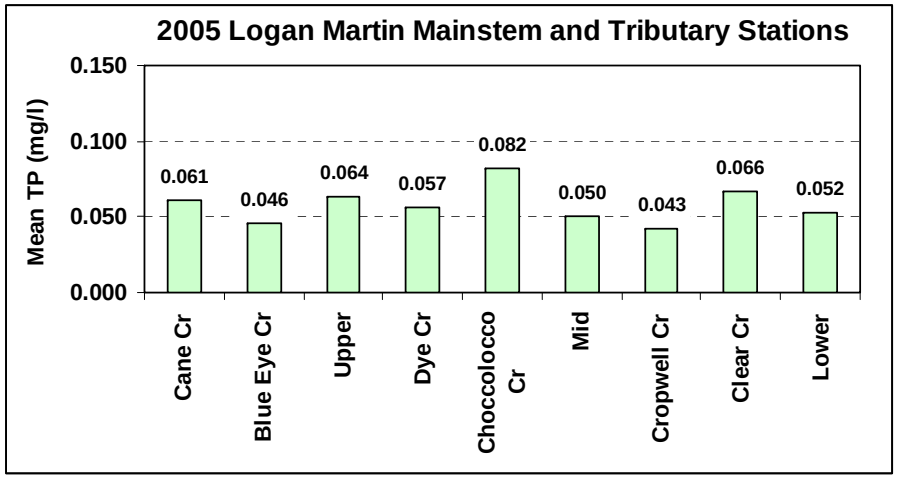
Dissolved oxygen concentrations at Blue Eye Creek and Dye Creek were less than 5.0 mg/l at a depth of 5 ft in August. All other measurements of dissolved oxygen concentrations were above the ADEM Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/l (Fig. 7 & 8). While the water column at the upper station was mixed during Jun-Sep, the mid and lower stations showed oxygen stratification. At the stratified mid and lower stations, water column oxygen concentrations began to drop near 4m and were completely deoxygenated from 10m to the bottom (Fig. 7). Warmest water temperatures occur in July for the mid and lower stations and in Sept for the upper station.

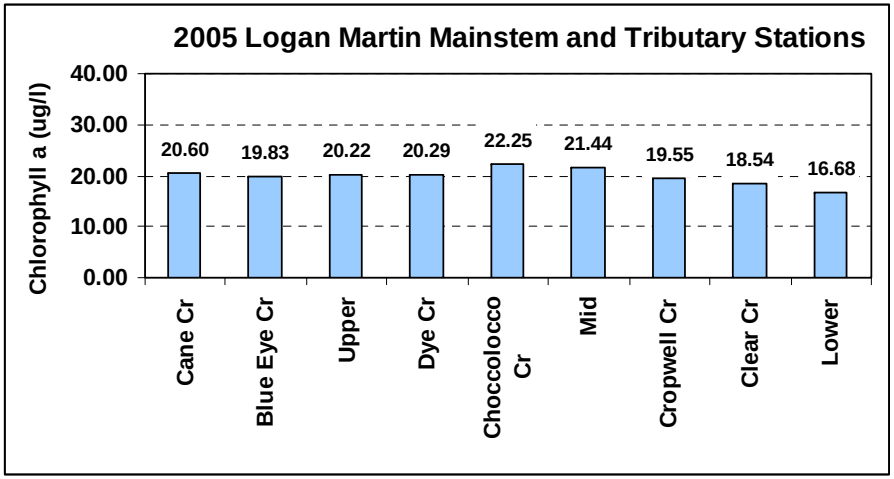
Carlson's TSI values, calculated from corrected chl *a* concentrations, showed similar trends for all stations (Fig.9). Stations exhibited eutrophic conditions Jul-Oct.

August TSI values calculated from data collected at mainstem stations, 1985-2005, are presented in Fig. 10. August TSI at the upper and mid station continued to be in the upper eutrophic levels, 1990-2005, with the lower mainstem station remaining stable in the mid-eutrophic range.

Figure 2. Mean total nitrogen (TN), mean total phosphorus (TP), mean chlorophyll a (Chl *a*) and mean total suspended solids (TSS) of all stations in Logan Martin Reservoir, April-October 2005. Bar graphs consist of multiple stations, illustrated from upstream to downstream as the graph is read from left to right.







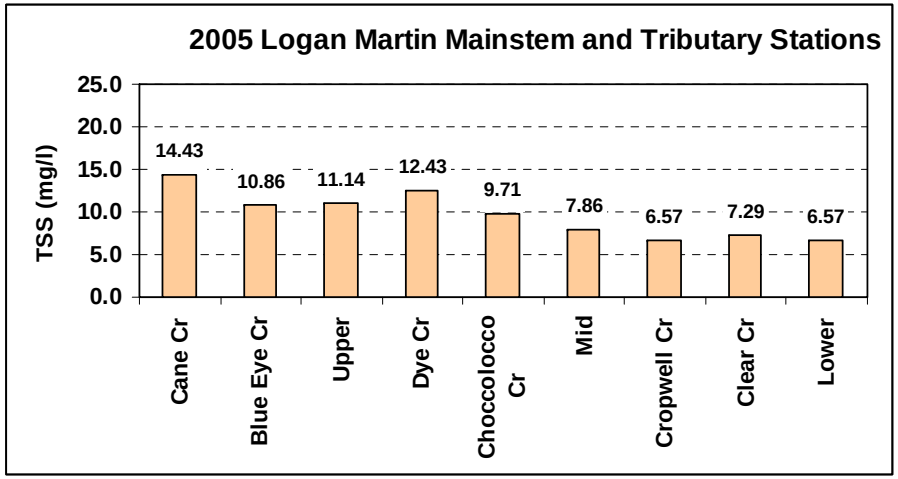
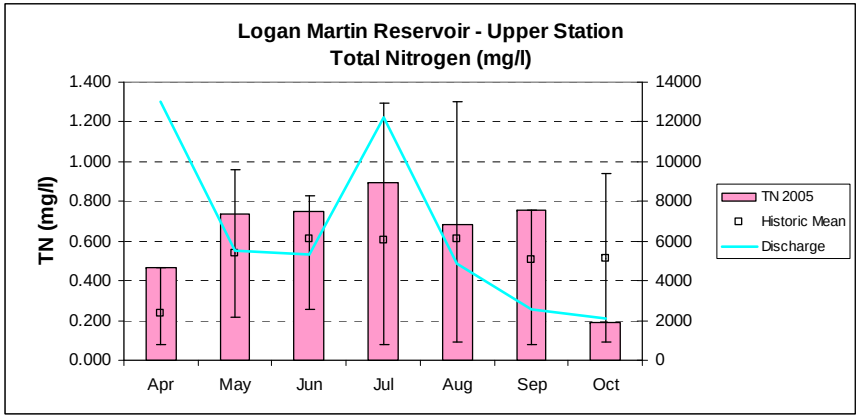
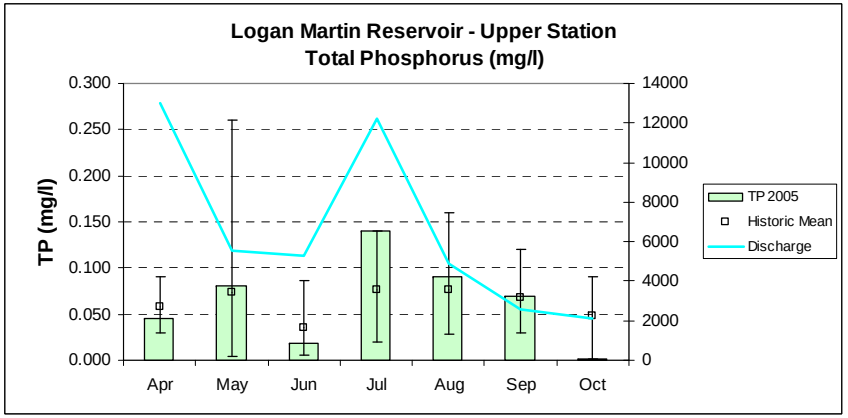
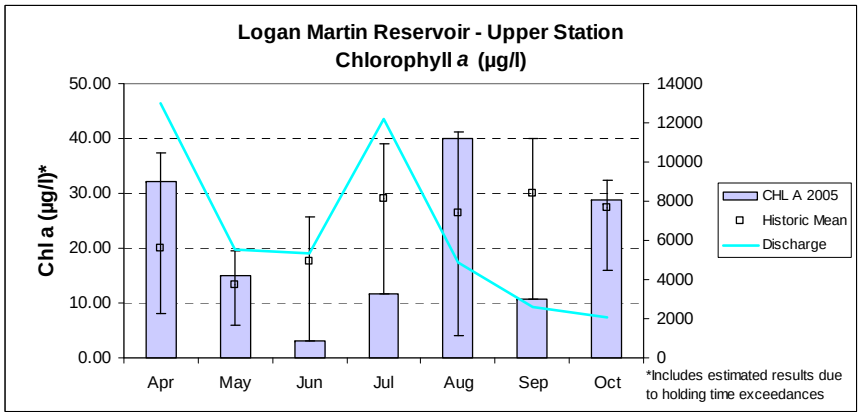


Figure 3. Total nitrogen (TN), total phosphorus (TP), chlorophyll a (Chl *a*) and total suspended solids (TSS) of the upper station in Logan Martin Reservoir, April-October 2005. Each bar graph depicts monthly changes in the variables at the upper station. Historic mean and min/max range are displayed for comparison. Nutrients and TSS are plotted vs. discharge (Coosa River near Rome, GA).







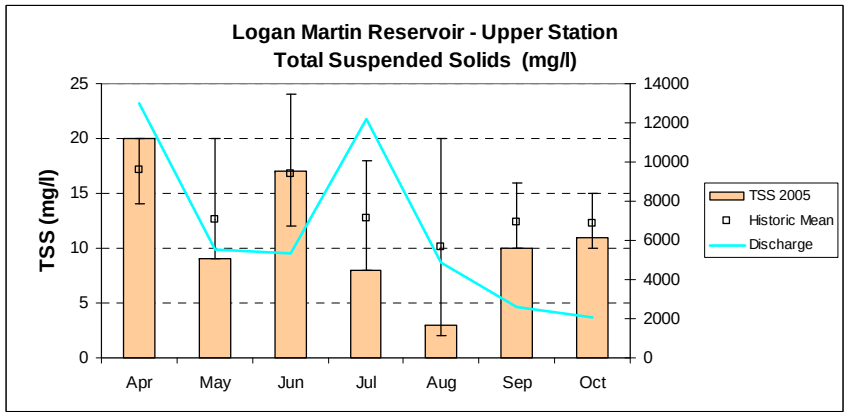
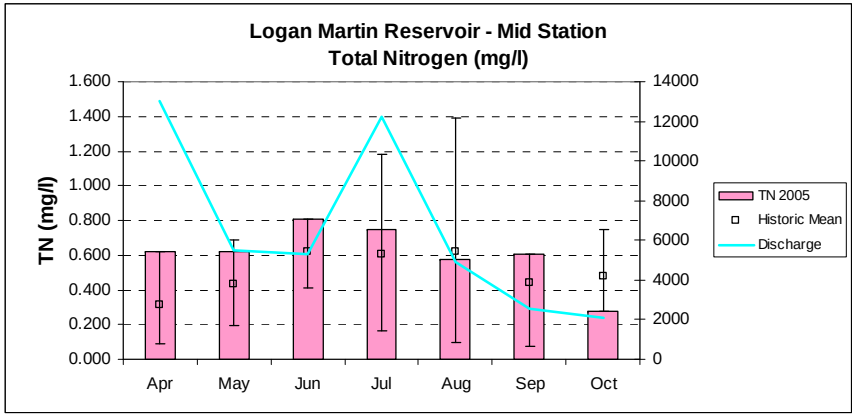
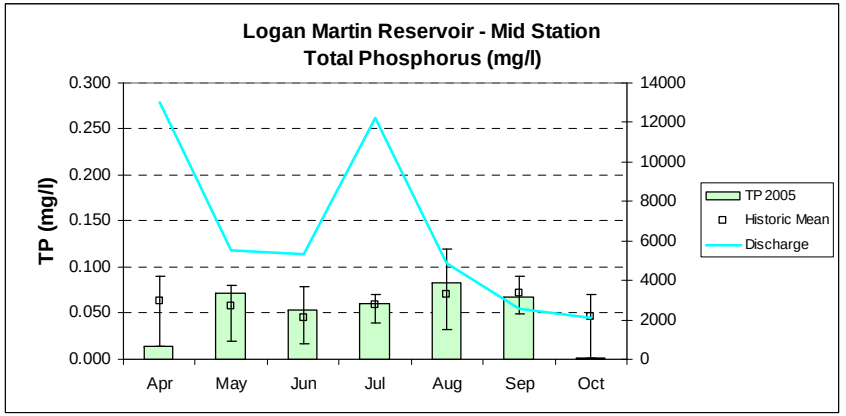
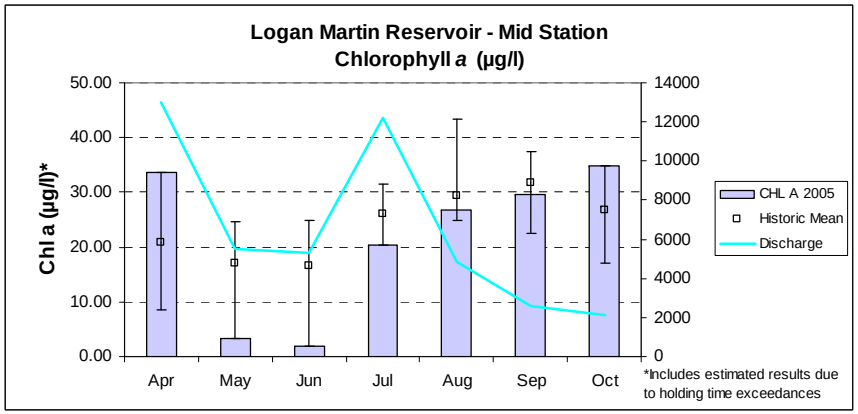


Figure 4. Total nitrogen (TN), total phosphorus (TP), chlorophyll a (Chl *a*) and total suspended solids (TSS) of the mid station in Logan Martin Reservoir, April-October 2005. Each bar graph depicts monthly changes in the variables at the mid-station. Historic mean and min/max range are displayed for comparison. Nutrients and TSS are plotted vs. discharge (Coosa River near Rome, GA).







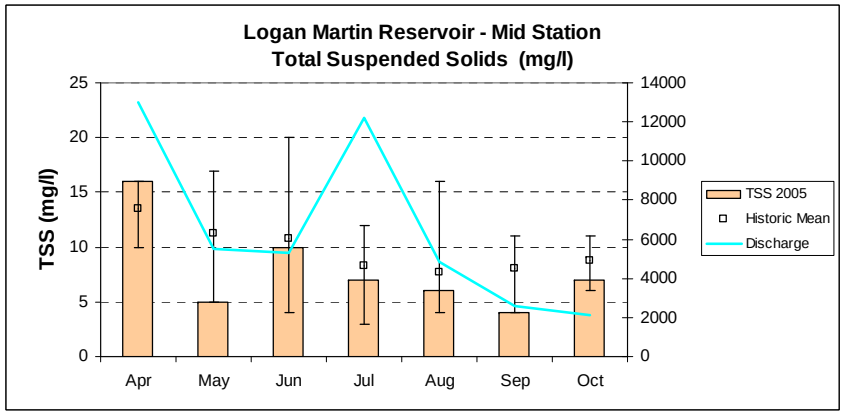
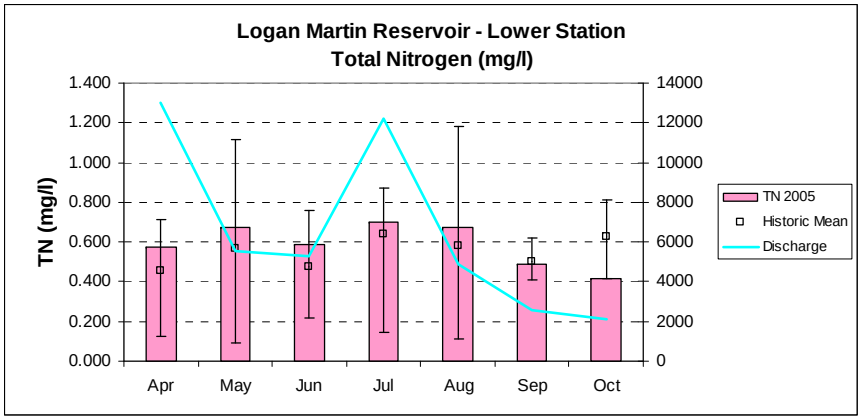
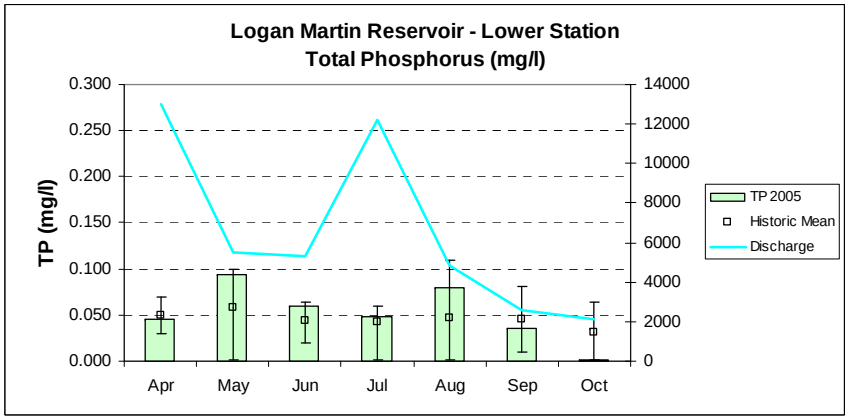
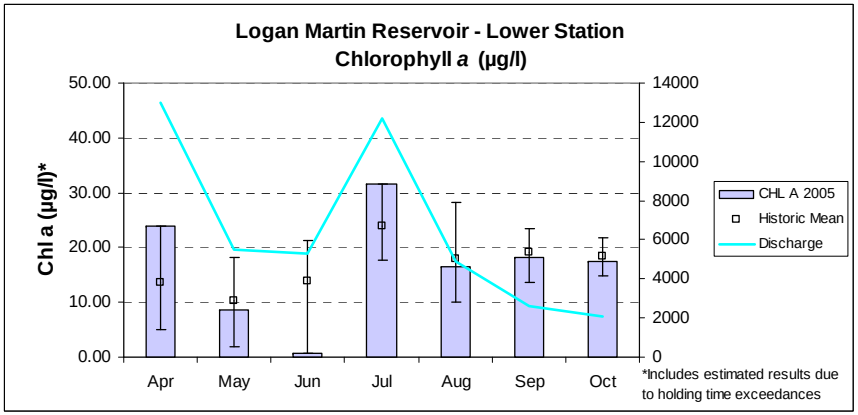


Figure 5. Total nitrogen (TN), total phosphorus (TP), chlorophyll a (Chl *a*) and total suspended solids (TSS) of the dam forebay station in Logan Martin Reservoir, April-October 2005. Each bar graph depicts monthly changes in the variables at the lower station. Historic mean and min/max range are also displayed for comparison. Nutrients and TSS are plotted vs. discharge (Coosa River near Rome, GA).







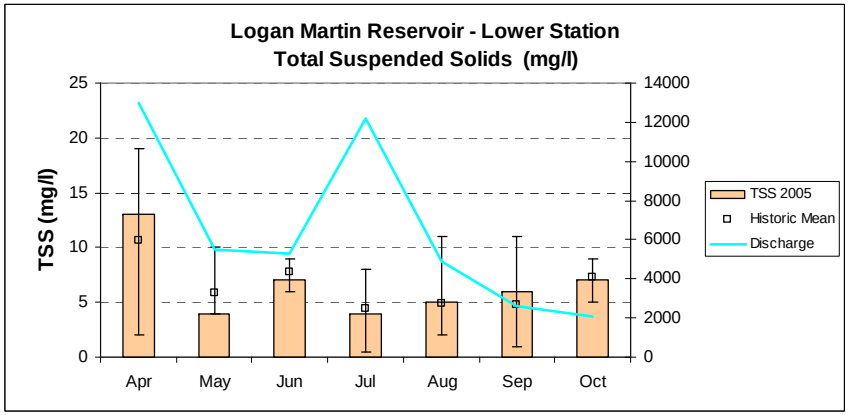


Figure 6. Growing season mean chlorophyll a concentrations of mainstem Logan Martin Reservoir, 1997 through 2005.

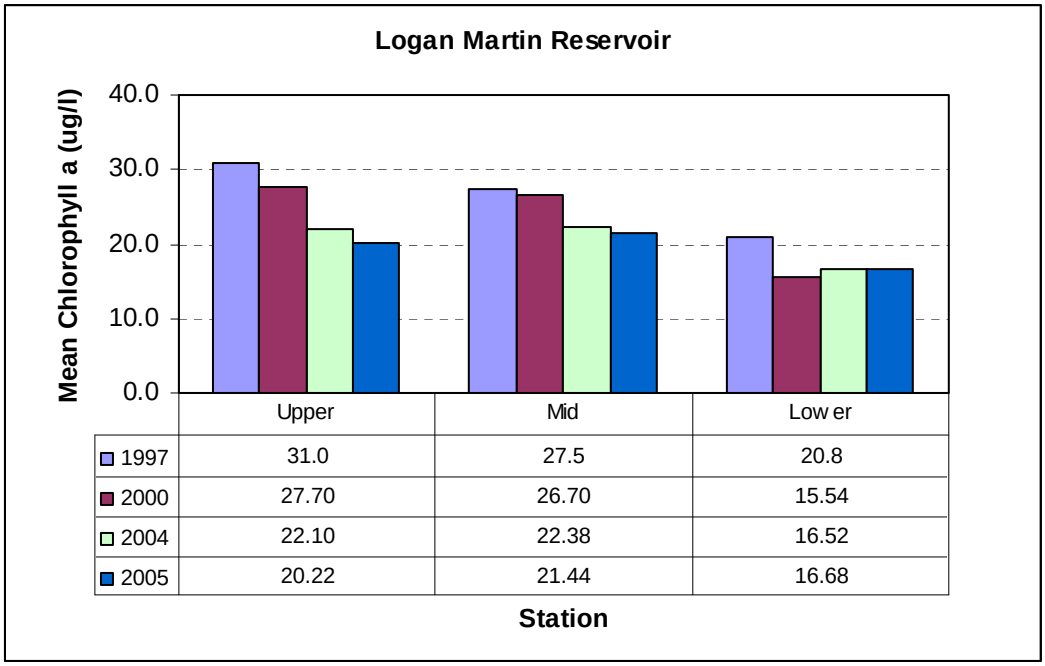


Table 2. Algal growth potential test results (expressed as mean Maximum Standing Crop (MSC) or dry weights of *Selenastrum capricornutum* in mg/L) and limiting nutrient status from 2000 and 2005. Mean standing crop (MSC) values below 5 mg/l are considered to be protective in reservoirs and lakes (Raschke and Schultz 1987).

Station	2000 Control mean MSC	2000 Limiting Nutrient	2005 Control mean MSC	2005 Limiting Nutrient
Upper	4.23	Non Limiting	2.75	Non Limiting
Mid	3.70	Nitrogen	2.25	Nitrogen
Lower	1.17	Phosphorus	2.93	Nitrogen

Figure 7. Depth profiles of dissolved oxygen (DO) and temperature (Temp) in Logan Martin Reservoir, June-September 2005. Although profiles were measured April-October, these select months were chosen as they represent the warmest water temperatures and most stratified dissolved oxygen concentrations. ADEM Water Quality Criteria pertaining to non-wadeable river and reservoir waters require a DO concentration of 5.0 mg/l at 5.0 ft (1.5m)(ADEM Admin. Code R. 335-6-10-.09). Under extreme natural conditions such as drought, the DO concentration may be as low as 4.0 mg/l.

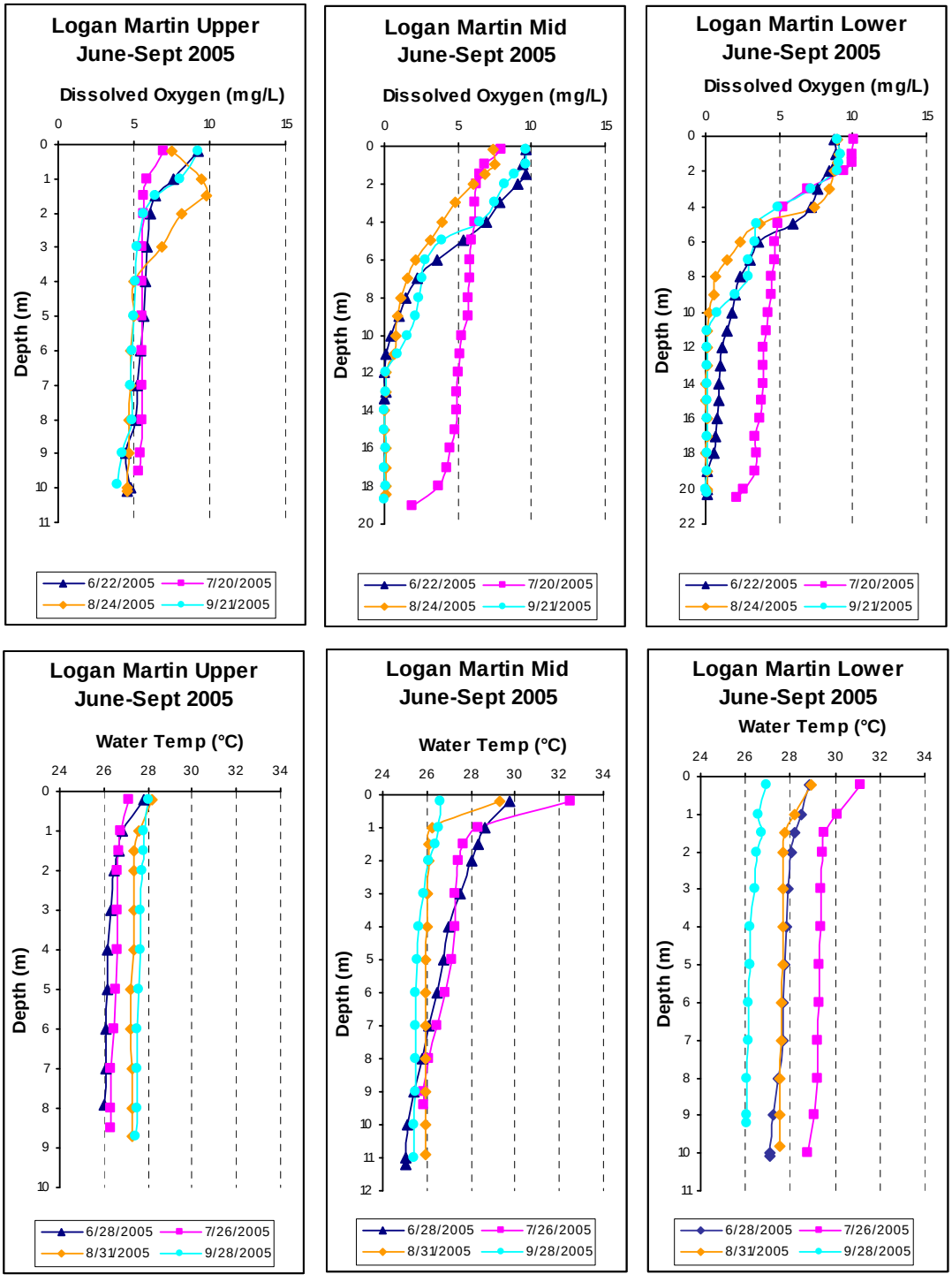
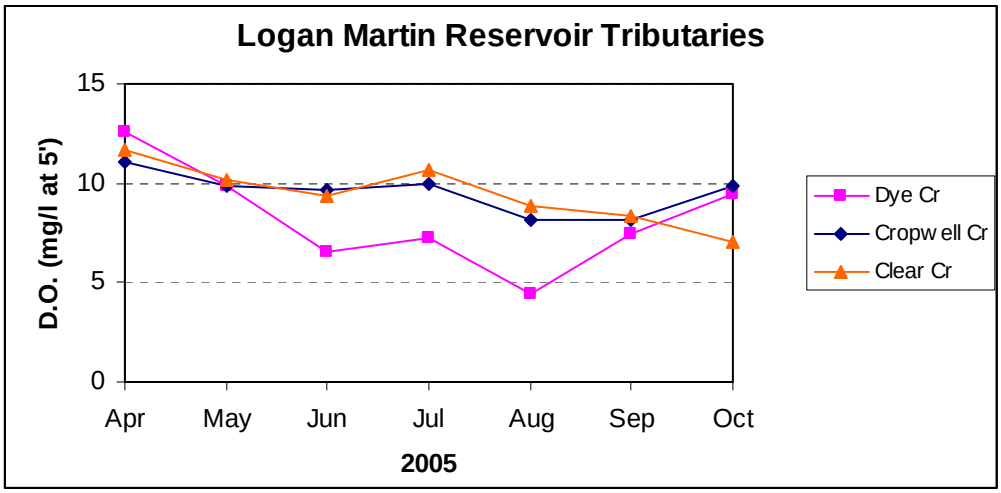


Figure 8. DO concentrations at 5 ft. for Logan Martin Reservoir tributaries collected April-October 2005. For tributary embayments, which are typically not as deep as mainstem stations and usually maintain a mixed water column throughout the season, profiles were collected but only the monthly DO concentrations at a depth of 5ft (1.5m) are graphed. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/l at this depth (ADEM 2005).



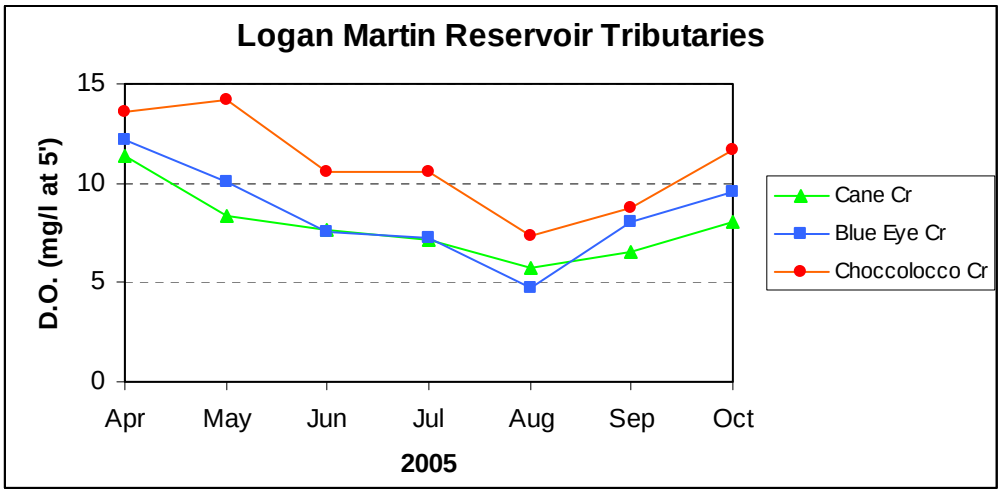


Figure 9. Monthly TSI values for mainstem and tributary stations using chlorophyll a concentrations and the Carlson's Trophic State Index calculation, April-October 2005.

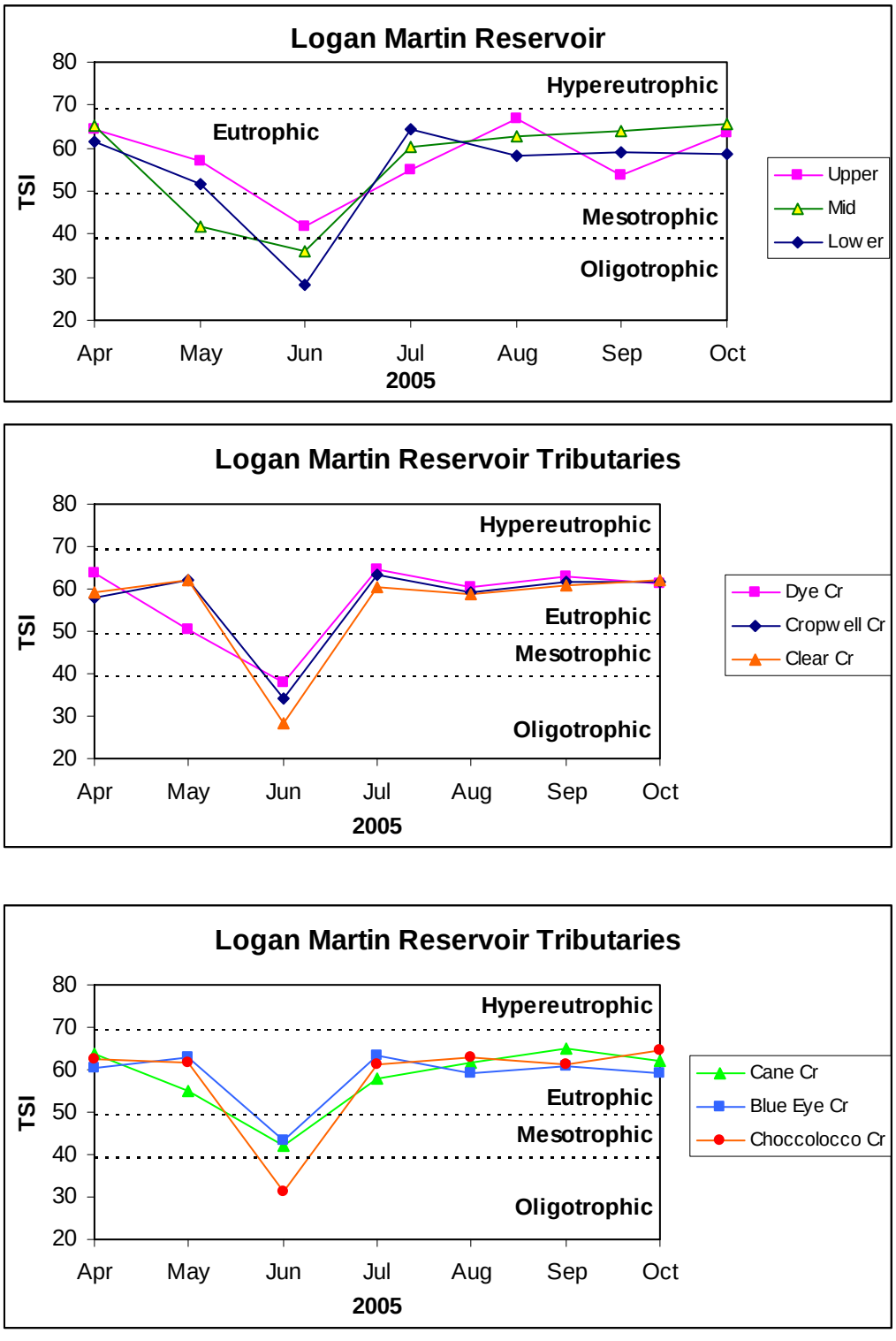
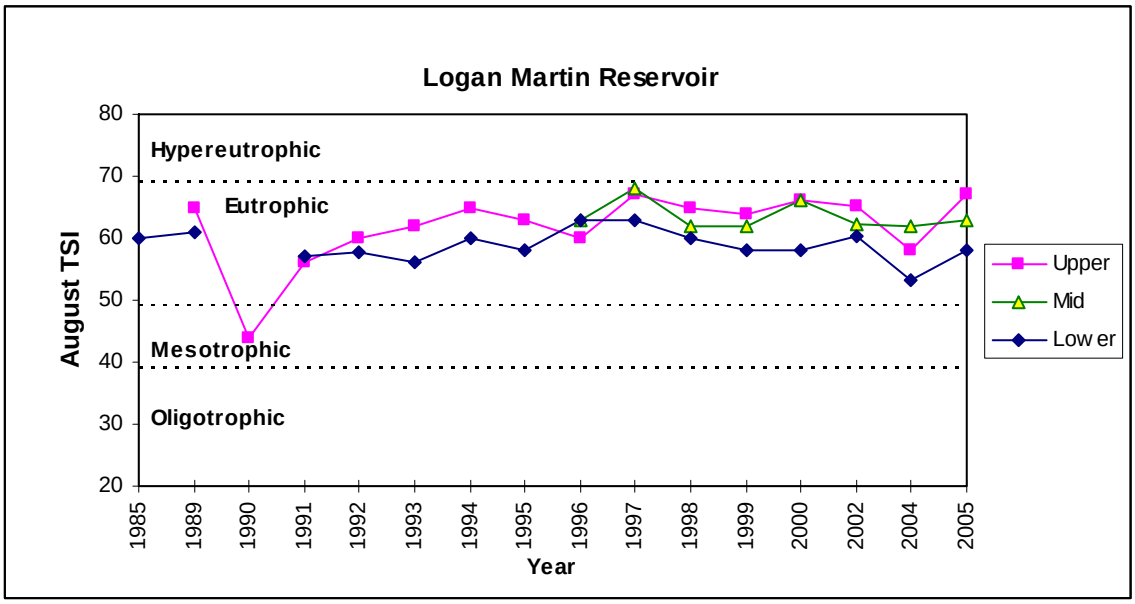


Figure 10. Trophic State Index values from critical period sampling (August sampling only) from 1985 to 2005.



REFERENCES

ADEM. 2008 (as amended). Standard Operating Procedures #2041 *In Situ* Surface Water Quality Field Measurements-Temperature, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2008 (as amended). Standard Operating Procedures #2042 *In Situ* Surface Water Quality Field Measurements-pH, Alabama Department of Environmental Management (ADEM), Montgomery, AL.

ADEM. 2008 (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. 2008 (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.

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 water quality data collected April-October, 2005. Minimum (Min) and maximum (Max) values calculated using minimum detection limits (MDL) when results were less than this value. Median (Med), average (Ave), and standard deviations (SD) values were calculated by multiplying the MDL by 0.5 when results were less than this value.

Station	Parameter	N	Min	Max	Median	Avg	SD
LOGS-1	Alkalinity (mg/L)	7	7.2	73.2	51.4	50.5	20.8
	Hardness (mg/L)	4	50.0	67.3	58.9	58.8	9.5
	Total Dissolved Solids (mg/L)	7	29.0	108.0	77.0	74.7	25.1
	Total Suspended Solids (mg/L)	7	4.0	13.0	6.0	6.6	3.1
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.017	0.008	0.009	0.004
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.110	0.018	0.036	0.044
	Total Kjeldahl Nitrogen (mg/L)	7	0.307	0.683	0.588	0.551	0.139
	Total Nitrogen (mg/L)	7	0.420	0.700	0.590	0.587	0.103
	Total Phosphorus (mg/L)	7	< 0.004	0.094	0.049	0.052	0.030
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.017	0.006	0.008	0.005
	Chlorophyll a (mg/L)[J]	7	0.80	31.51	17.36	16.68	9.94
	Turbidity (NTU)	7	3	5	3	4	1
	Secchi (m)	7	1.08	2.80	1.32	1.53	0.58
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	< 1	---
LOGS-2	Alkalinity (mg/L)	7	39.5	68.2	53.2	53.9	9.7
	Hardness (mg/L)	4	51.5	69.0	59.4	59.8	8.7
	Total Dissolved Solids (mg/L)	7	17.0	91.0	70.0	67.7	24.9
	Total Suspended Solids (mg/L)	7	3.0	20.0	10.0	11.1	5.7
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.025	0.008	0.012	0.007
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.214	0.003	0.060	0.082
	Total Kjeldahl Nitrogen (mg/L)	7	0.187	0.745	0.680	0.578	0.215
	Total Nitrogen (mg/L)	7	0.190	0.900	0.730	0.639	0.236
	Total Phosphorus (mg/L)	7	< 0.004	0.140	0.069	0.064	0.047
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.019	0.004	0.007	0.006
	Chlorophyll a (mg/L)[J]	7	3.20	40.05	14.95	20.22	13.46
	Turbidity (NTU)	7	9	23	14	14	5
	Secchi (m)	7	0.53	0.85	0.66	0.66	0.10
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	< 1	---
LOGS-3	Alkalinity (mg/L)	7	42.9	68.1	54.9	55.6	9.3
	Hardness (mg/L)	4	49.7	71.7	60.8	60.8	10.7
	Total Dissolved Solids (mg/L)	7	66.0	100.0	87.0	83.4	13.0
	Total Suspended Solids (mg/L)	7	4.0	16.0	7.0	7.9	4.1
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.064	0.008	0.016	0.021
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.151	0.003	0.040	0.056
	Total Kjeldahl Nitrogen (mg/L)	7	0.270	0.801	0.572	0.566	0.157
	Total Nitrogen (mg/L)	7	0.270	0.800	0.620	0.604	0.170
	Total Phosphorus (mg/L)	7	< 0.004	0.083	0.060	0.050	0.031
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.013	0.002	0.006	0.005
	Chlorophyll a (mg/L)[J]	7	1.78	34.89	26.70	21.44	13.81
	Turbidity (NTU)	7	5	15	6	7	4
	Secchi (m)	7	0.64	1.10	1.00	0.94	0.17
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	1	---

Station	Parameter	N	Min	Max	Median	Avg	SD
LOGS-4	Alkalinity (mg/L)	7	50.3	64.9	56.8	56.6	5.0
	Hardness (mg/L)	4	54.7	69.9	61.9	62.1	7.0
	Total Dissolved Solids (mg/L)	7	46.0	107.0	95.0	86.3	21.1
	Total Suspended Solids (mg/L)	7	3.0	25.0	15.0	14.4	8.4
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.049	0.008	0.015	0.015
	Nitrate+Nitrite Nitrogen (mg/L)	7	0.007	0.205	0.108	0.096	0.066
	Total Kjeldahl Nitrogen (mg/L)	7	0.312	0.971	0.495	0.585	0.219
	Total Nitrogen (mg/L)	7	0.340	1.050	0.580	0.681	0.254
	Total Phosphorus (mg/L)	7	< 0.004	0.087	0.072	0.061	0.030
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.016	0.002	0.005	0.006
	Chlorophyll a (mg/L)[J]	7	3.20	33.64	24.03	20.60	10.60
	Turbidity (NTU)	7	11	20	12	14	3
	Secchi (m)	7	0.55	0.71	0.63	0.63	0.05
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	5	---
LOGS-5	Alkalinity (mg/L)	7	49.8	86.0	69.7	70.2	11.9
	Hardness (mg/L)	4	75.8	94.2	77.8	81.4	8.7
	Total Dissolved Solids (mg/L)	7	11.0	109.0	95.0	82.7	33.3
	Total Suspended Solids (mg/L)	7	4.0	16.0	11.0	10.9	3.8
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.052	0.008	0.014	0.017
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.113	0.040	0.051	0.049
	Total Kjeldahl Nitrogen (mg/L)	7	0.363	0.878	0.573	0.616	0.193
	Total Nitrogen (mg/L)	7	0.480	0.960	0.610	0.667	0.179
	Total Phosphorus (mg/L)	7	< 0.004	0.081	0.050	0.046	0.026
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.008	0.005	0.005	0.003
	Chlorophyll a (mg/L)[J]	7	3.74	28.30	20.83	19.83	8.11
	Turbidity (NTU)	7	8	13	10	10	2
	Secchi (m)	7	0.59	0.88	0.86	0.80	0.11
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	6	---
LOGS-6	Alkalinity (mg/L)	7	58.8	80.7	74.2	69.9	8.0
	Hardness (mg/L)	4	57.3	83.0	78.6	74.4	11.6
	Total Dissolved Solids (mg/L)	7	7.0	100.0	79.0	69.7	32.4
	Total Suspended Solids (mg/L)	7	6.0	14.0	9.0	9.7	3.2
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.072	0.015	0.026	0.024
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.172	0.008	0.044	0.067
	Total Kjeldahl Nitrogen (mg/L)	7	0.248	0.726	0.582	0.536	0.153
	Total Nitrogen (mg/L)	7	0.420	0.730	0.590	0.581	0.101
	Total Phosphorus (mg/L)	7	0.061	0.123	0.074	0.082	0.023
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.035	0.006	0.009	0.012
	Chlorophyll a (mg/L)[J]	7	1.07	32.04	24.03	22.25	9.87
	Turbidity (NTU)	7	7	10	8	8	1
	Secchi (m)	7	0.66	0.97	0.78	0.79	0.11
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	< 1	---

Station	Parameter	N	Min	Max	Median	Avg	SD
LOGS-7	Alkalinity (mg/L)	7	49.1	65.6	53.4	56.3	6.7
	Hardness (mg/L)	4	52.1	71.4	61.6	61.7	8.9
	Total Dissolved Solids (mg/L)	7	24.0	80.0	66.0	55.4	24.5
	Total Suspended Solids (mg/L)	7	8.0	18.0	12.0	12.4	3.6
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.058	0.008	0.019	0.019
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.101	0.002	0.025	0.037
	Total Kjeldahl Nitrogen (mg/L)	7	0.406	1.010	0.588	0.688	0.255
	Total Nitrogen (mg/L)	7	0.450	1.030	0.690	0.713	0.247
	Total Phosphorus (mg/L)	7	< 0.004	0.085	0.071	0.057	0.029
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.010	0.005	0.005	0.003
	Chlorophyll a (mg/L)[J]	7	2.14	31.51	22.43	20.29	11.30
	Turbidity (NTU)	7	8	12	11	11	1
	Secchi (m)	7	0.62	1.06	0.79	0.82	0.14
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	1	---
LOGS-8	Alkalinity (mg/L)	7	46.9	66.7	57.9	56.8	7.5
	Hardness (mg/L)	4	46.2	67.9	58.2	57.6	9.7
	Total Dissolved Solids (mg/L)	7	12.0	97.0	68.0	68.7	28.1
	Total Suspended Solids (mg/L)	7	4.0	11.0	6.0	6.6	2.2
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.053	0.008	0.016	0.017
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.115	0.002	0.032	0.044
	Total Kjeldahl Nitrogen (mg/L)	7	0.355	0.906	0.585	0.635	0.225
	Total Nitrogen (mg/L)	7	0.360	0.910	0.590	0.669	0.225
	Total Phosphorus (mg/L)	7	< 0.004	0.076	0.044	0.043	0.031
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.006	0.002	0.003	0.002
	Chlorophyll a (mg/L)[J]	7	1.42	27.77	23.85	19.55	8.94
	Turbidity (NTU)	7	4	5	4	4	1
	Secchi (m)	7	0.95	1.46	1.19	1.16	0.19
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	< 1	---
LOGS-9	Alkalinity (mg/L)	7	38.1	59.9	52.5	51.2	8.5
	Hardness (mg/L)	4	44.2	64.3	51.6	52.9	9.1
	Total Dissolved Solids (mg/L)	7	30.0	81.0	68.0	62.3	16.2
	Total Suspended Solids (mg/L)	7	6.0	11.0	7.0	7.3	1.8
	Ammonia Nitrogen (mg/L)	7	< 0.015	0.028	0.018	0.018	0.008
	Nitrate+Nitrite Nitrogen (mg/L)	7	< 0.003	0.110	0.002	0.026	0.041
	Total Kjeldahl Nitrogen (mg/L)	7	0.277	0.654	0.579	0.515	0.155
	Total Nitrogen (mg/L)	7	0.280	0.700	0.600	0.543	0.164
	Total Phosphorus (mg/L)	7	< 0.004	0.146	0.065	0.066	0.044
	Dissolved Reactive Phosphorus (mg/L)	7	< 0.004	0.008	0.002	0.003	0.002
	Chlorophyll a (mg/L)[J]	7	0.80	25.37	21.09	18.54	8.33
	Turbidity (NTU)	7	3	4	4	4	0
	Secchi (m)	7	1.14	1.66	1.37	1.35	0.18
	Fecal Coliform (col/100 mL)[J]	1	---	---	---	1	---

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