2007 Oliver and Holt Reservoirs Report
Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
May 2012

Rivers and Reservoirs Monitoring Program

2007

Oliver and Holt Reservoirs

Black Warrior River Basin

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LIST OF ACRONYMS

A&I	Agriculture and Industry water supply use classification
ADEM	Alabama Department of Environmental Management
AGPT	Algal Growth Potential Test
APCO	Alabama Power Company
BW	Black Warrior
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

Completed in 1940 by the US Army Corp of Engineers (COE), the William Bacon Oliver Lock and Dam was constructed on the Black Warrior River to improve barge traffic to the City of Tuscaloosa. The 1,000 surface acres impounded by Oliver Lock and Dam (Oliver Reservoir) extends 9 river miles upstream to Holt Lock and Dam. The Holt Lock and Dam opened for navigation in 1969 and, while the COE maintains dam operations, the Alabama Power Company owns and operates a generating plant at the facility. Holt Reservoir encompasses 3,200 surface acres and extends 19 river miles to Bankhead Dam.

The Alabama Department of Environmental Management (ADEM) monitored Oliver and Holt Reservoirs as part of the 2007 assessment of the Black Warrior and Cahaba River (BWC) 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 2004, the ADEM implemented a specific water quality criterion for nutrient management at the forebay of Oliver and Holt Reservoirs, which have been monitored by ADEM since 1991 and 1992 respectively. This criterion represents the maximum growing season mean (April-October) chlorophyll *a* (chl *a*) concentration allowable while still fully supporting Oliver Reservoir's Fish & Wildlife (F&W) and Holt Reservoir's Swimming/Fish & Wildlife (S/F&W) use classifications.

The purpose of this report is to summarize data collected at three stations in Oliver Reservoir and three stations in Holt Reservoir during the 2007 growing season and to evaluate growing season trends in mean lake trophic status and nutrient concentrations using ADEM's nine-year dataset. Monthly and 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. Oliver and Holt Reservoirs were sampled in the dam forebay, mid reservoir, and upper reservoir.

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 APCO (Alabama Power Company)/USGS flow data and ADEM's previously collected data to help interpret the 2007 results.

Figure 1. Oliver and Holt Reservoirs with 2007 sampling locations. A description of each sampling location is provided in Table 1.

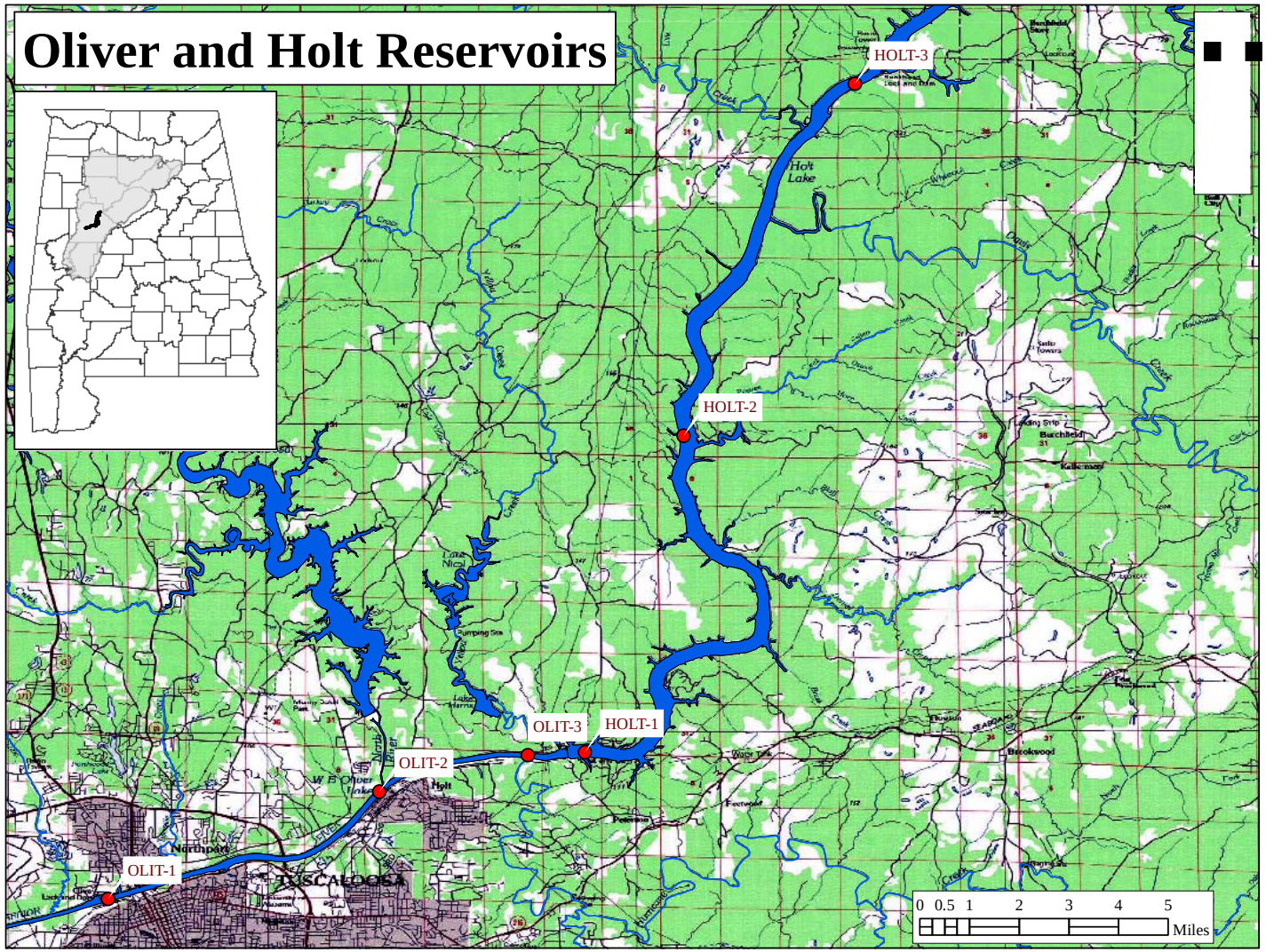


Table 1. Descriptions of the 2007 monitoring stations in Oliver and Holt Reservoirs.

HUC	County	Station Number	Report Designation	Waterbody	Station Description	Chl *a* Criteria	Latitude	Longitude
Holt Reservoir								
031601120505	Tuscaloosa	HOLT-1*	Lower Holt	Black Warrior R	Forebay area, downstream of Deerlick Ck public access area.	16 ug/L	33.2542	-87.4443
031601120306	Tuscaloosa	HOLT-2	Mid Holt	Black Warrior R	Deepest point, main river channel, immediately upstream of Pegues Creek, Black Warrior R confluence.		33.3464	-87.4155
031601120306	Tuscaloosa	HOLT-3	Upper Holt	Black Warrior R	Upper reservoir. Deepest point, main river channel, approximately 0.5 miles downstream of Big Indian Creek, Black Warrior confluence.		33.4490	-87.3657
Oliver Reservoir								
031601120505	Tuscaloosa	OLIT-1*	Lower Oliver	Black Warrior R	Deepest point, main river channel, dam forebay.	12 ug/L	33.2114	-87.5834
031601120505	Tuscaloosa	OLIT-2	Mid Oliver	Black Warrior R	Deepest point, main river channel, immediately downstream of North River, Black Warrior R confluence.		33.2426	-87.5043
031601120505	Tuscaloosa	OLIT-3	Upper Oliver	Black Warrior R	Deepest point, main river channel, approximately 0.5 miles downstream of confluence with Hurricane Creek.		33.2532	-87.4610

*Growing season mean chl *a* criteria implemented at this station in 2004.

RESULTS

Growing season mean graphs for TN, TP, chl *a*, TSS, and TSI are provided in this section (Figs. 2, 3, and 17). Monthly graphs for TN, TP, chl *a*, TSS, and DO are also provided (Figs. 4-12). Mean monthly discharge is included in monthly graphs for TN, TP, chl *a*, and TSS as an indicator of flow and retention time in the months sampled. Algal growth potential test (AGPT results appears in Table 2. Depth profile graphs of temperature, DO, and conductivity appear in Figs. 13-16. Summary statistics of all data collected during 2007 are presented in Appendix Table 1. The table contains the minimum, maximum, median, mean, and standard deviation of each parameter analyzed.

According to the National Weather Service, during 2007 Alabama recorded its driest January through August period in the past 100 years. The drought was intensified by a drier than normal preceding winter and spring. Though difficult to quantify, drought of this magnitude will affect water quality in a number of ways and is a likely factor in many of the results to follow.

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

The highest mean growing season TN value in Holt Reservoir during 2007 was in the upper station (Fig. 2). The highest mean growing season TN value calculated in Oliver Reservoir was in the lower station. Mean growing season TN values calculated in 2007 for all stations monitored in Oliver and Holt Reservoirs were the lowest since monitoring began in 1998, with the exception of the lower Oliver station (Fig. 2). The mean growing season TN concentration calculated in 2007 in the lower Oliver station was lower than 1998, 2002, and 2006, but was higher than 2003. Monthly TN concentrations were mostly below historic means for both Oliver and Holt Reservoirs, reaching historic lows June-August (Fig. 4 & 5). Monthly TN concentrations measured in all Oliver and Holt Reservoir stations declined April through July and August then increased through October (Fig. 4 & 5).

The highest mean growing season TP value in Holt Reservoir during 2007 was in the upper station (Fig. 2). The highest mean growing season TP value calculated in Oliver Reservoir was in the mid station. With the exception of the mid Holt station, mean growing season TP values for all stations monitored during 2007 in Oliver and Holt Reservoirs were the lowest on record, 1998-2007 (Fig. 2). All monthly TP concentrations measured during 2007 were equal to or below historic mean values in the mid and lower Oliver and Holt Reservoir stations (Fig. 6 & 7). Historic monthly low TP concentrations were measured in the mid Oliver station during September and the lower Holt station during June and July (Fig. 6 & 7).

The highest mean growing season chl *a* value in Holt Reservoir during 2007 was in the upper station (Fig. 3). The highest mean growing season chl *a* value calculated in Oliver Reservoir was in the lower station. Specific water quality criterion for nutrient management has been established for the lower stations on Oliver and Holt Reservoirs. The mean growing season chl *a* values calculated for both lower stations during 2007 were in compliance with the criteria limits (Fig. 3). However, mean growing season chl *a* values in the mid and lower Oliver stations have been increasing in the years sampled, reaching highest values in 2007 (Fig. 3). Mean growing season chl *a* values in mid and lower Holt Reservoir were more variable, but have increased overall since 1998. Historic, or near historic, high monthly chl *a* concentrations were measured all months monitored, except October in the mid Oliver station (Fig. 8). Historic, or near historic, high monthly chl *a* concentrations were also measured in the lower Oliver Reservoir station all months monitored, except August and September (Fig. 8). Historic low monthly chl *a* concentrations were measured in the mid Holt station during June (Fig. 9).

The highest mean growing season TSS value in Holt reservoir during 2007 was in the upper station (Fig. 3). The highest mean growing season TSS value calculated in Oliver reservoir was in the lower station. Mean growing season TSS values have decreased at the mid and lower Oliver and Holt Reservoir stations since 2003 (Fig. 3). The 2007 mean growing season TSS values calculated for all Oliver and Holt Reservoir stations were the lowest on record, 1998-2007. Monthly TSS concentrations were below historic means, often the lowest measurement on record (1998-2007), in both the mid and lower Oliver stations in the months sampled (Fig. 10). Historic, or near historic, low monthly TSS concentrations were also

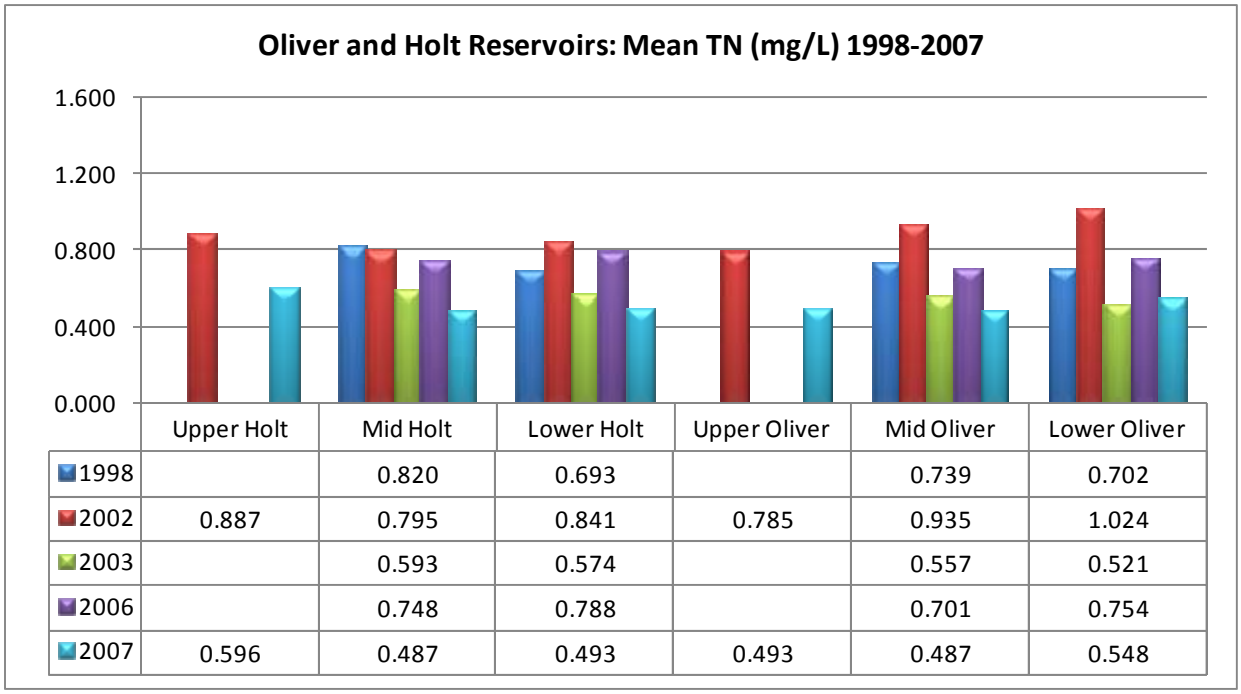
measured in the mid and lower Holt stations all months monitored with the exception of September and May respectively (Fig. 11).

AGPT results for the mid and lower Holt Reservoir stations indicate phosphorus limited conditions 1998-June 2007 (Table 2). The mid Holt Reservoir station was also phosphorus limited in July 2007 with nitrogen and phosphorus co-limiting in August. The lower Holt station was co-limiting in July 2007 and phosphorus limited in August (Table 2). AGPT results for the mid and lower Oliver Reservoir stations indicate phosphorus limited conditions 1998-July 2007 (Table 2). The mid Oliver station was non-limiting while the lower station was co-limiting in August 2007. AGPT results indicate all stations sampled in Oliver and Holt Reservoirs remained below 5 mg/L MSC (Table 2), the value that Raschke et al. (1996) defined as protective of reservoir and lake systems.

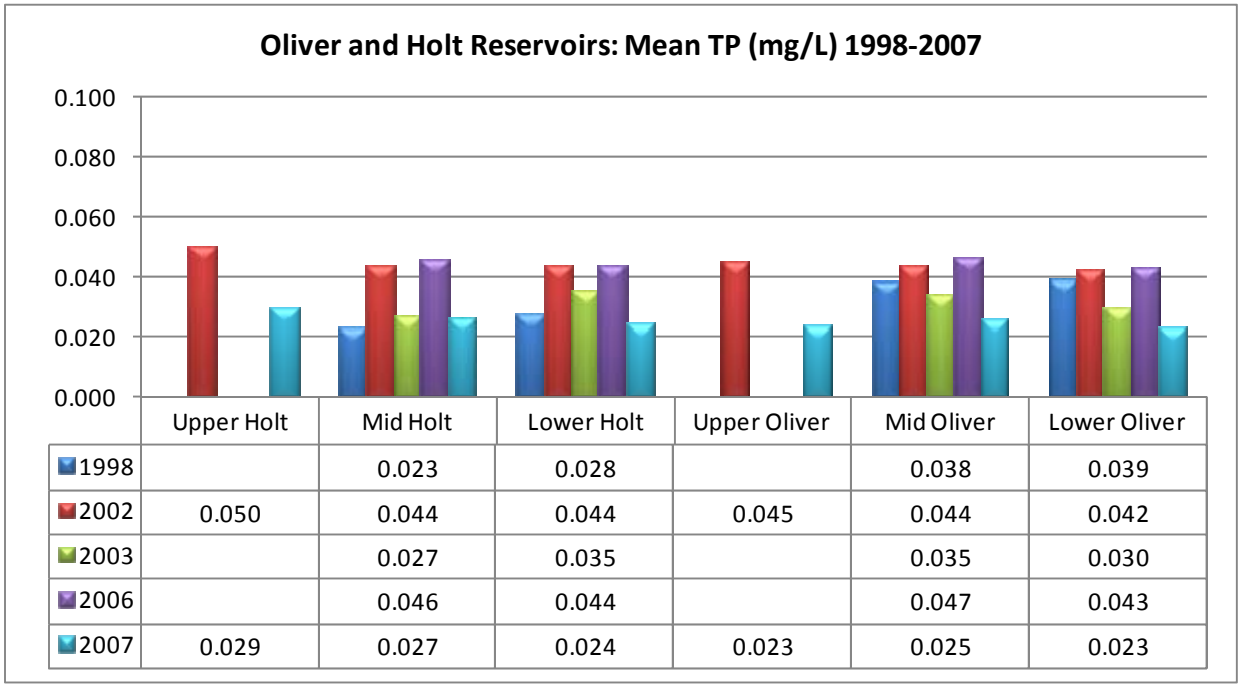
The dissolved oxygen concentrations at the lower Holt station in September and October, and the upper Oliver station in August were near or below the ADEM criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/L at 5.0 ft (1.5 m) (Fig. 12). All other measurements of dissolved oxygen concentrations in the upper and mid Holt Reservoir stations and lower and mid Oliver Reservoir stations met the ADEM Criteria (5.0 mg/L at 5.0 ft) (Fig. 12). Profiles of dissolved oxygen, temperature, and conductivity show both the lower and upper Oliver stations to be well-mixed April-October (Fig. 13 & 14). Profiles at lower Holt showed some stratification May-October, while upper Holt remained mixed all months sampled (Fig. 15 & 16). The highest temperatures were measured in August at all stations in Oliver and Holt Reservoirs (Fig. 13, 14, 15, & 16).

Mean growing season TSI values were calculated using season mean chl *a* values and Carlson's Trophic State Index. The mid and lower Holt and Oliver stations have increased from mesotrophic to eutrophic 1998-2007 (Fig. 17).

Figure 2. Mean growing season TN and TP measured in Oliver and Holt Reservoirs, April-October, 1998-2007. Stations are illustrated from upstream to downstream as the graph is read from left to right.

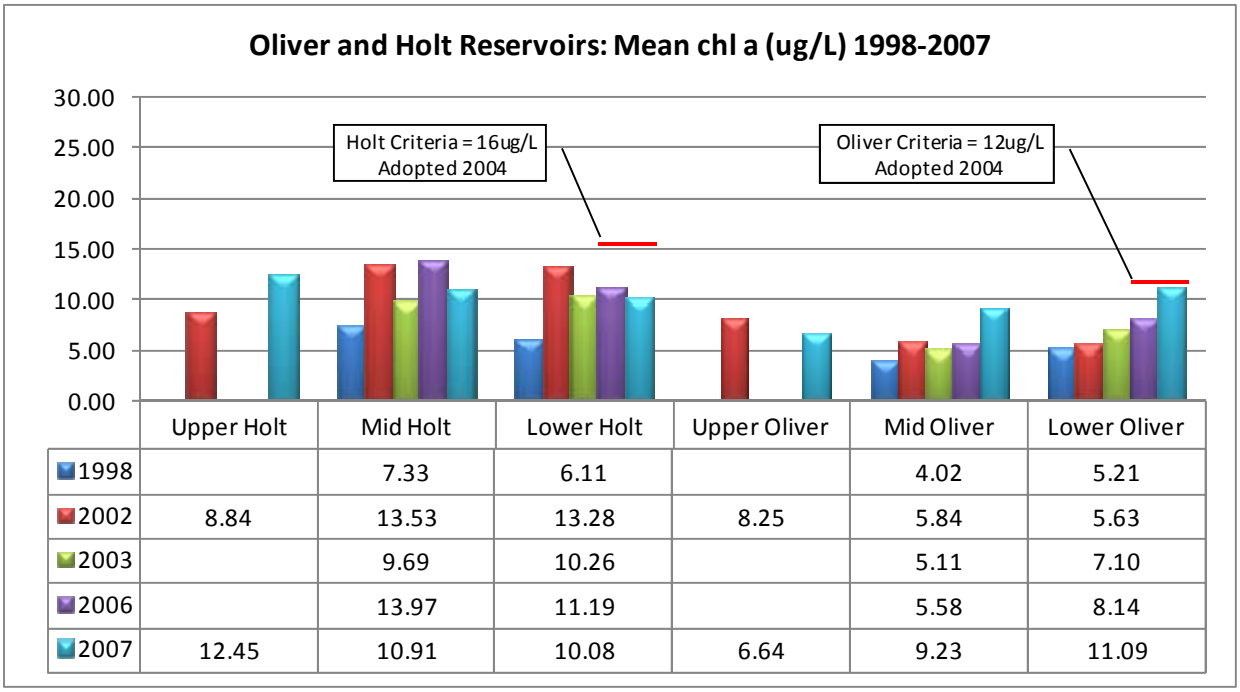


	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		0.820	0.693		0.739	0.702
2002	0.887	0.795	0.841	0.785	0.935	1.024
2003		0.593	0.574		0.557	0.521
2006		0.748	0.788		0.701	0.754
2007	0.596	0.487	0.493	0.493	0.487	0.548

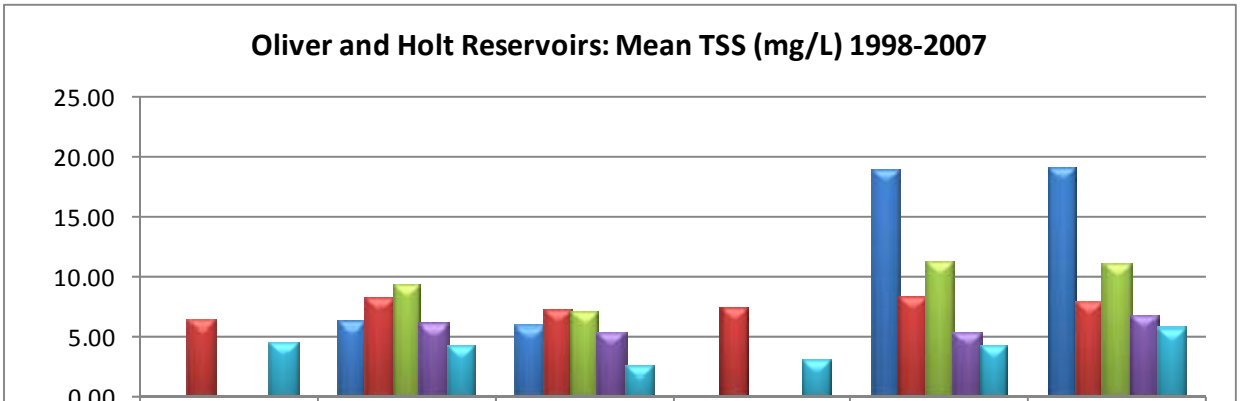


	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		0.023	0.028		0.038	0.039
2002	0.050	0.044	0.044	0.045	0.044	0.042
2003		0.027	0.035		0.035	0.030
2006		0.046	0.044		0.047	0.043
2007	0.029	0.027	0.024	0.023	0.025	0.023

Figure 3. Mean growing season chl *a* and TSS measured in Oliver and Holt Reservoirs, April-October, 1998-2007. Stations are illustrated from upstream to downstream as the graph is read from left to right. Chl *a* criteria applies to the growing season mean of the lower stations only.

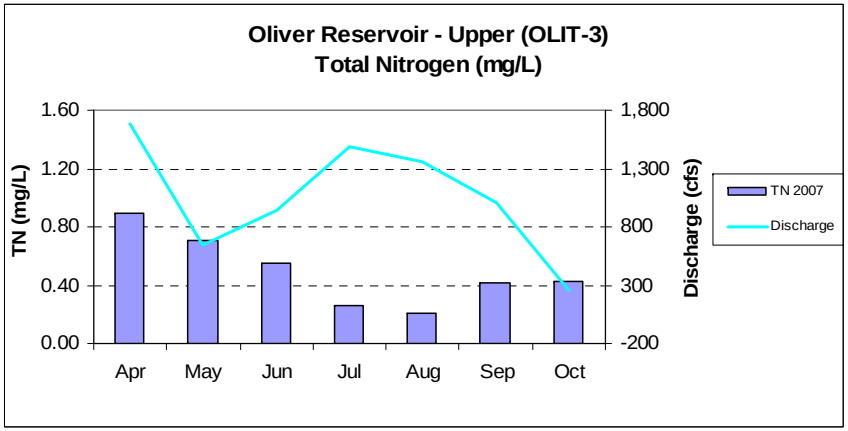


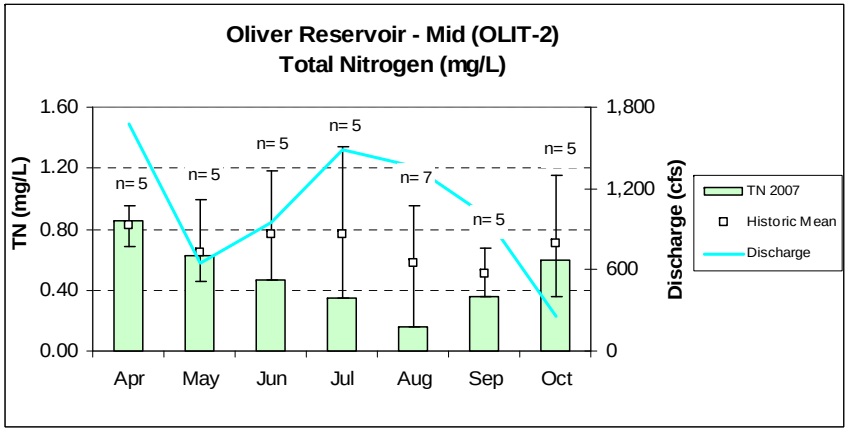
	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		7.33	6.11		4.02	5.21
2002	8.84	13.53	13.28	8.25	5.84	5.63
2003		9.69	10.26		5.11	7.10
2006		13.97	11.19		5.58	8.14
2007	12.45	10.91	10.08	6.64	9.23	11.09



	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		6.29	5.86		18.86	19.14
2002	6.43	8.29	7.29	7.43	8.43	7.86
2003		9.43	7.14		11.29	11.00
2006		6.14	5.43		5.43	6.71
2007	4.63	4.20	2.61	3.06	4.31	5.69

Figure 4. Monthly TN concentrations measured in Oliver Reservoir, April-October 2007 vs. average monthly discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





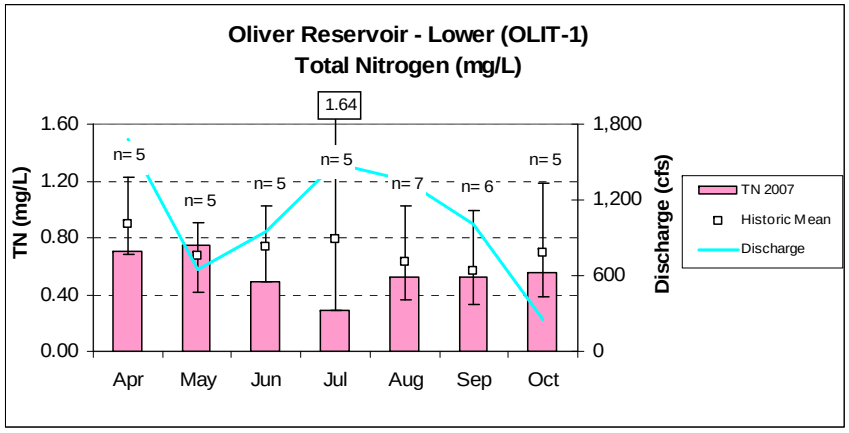
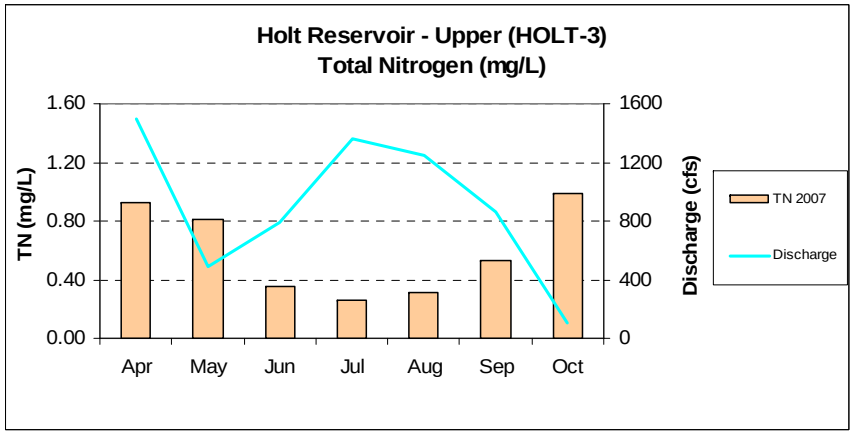
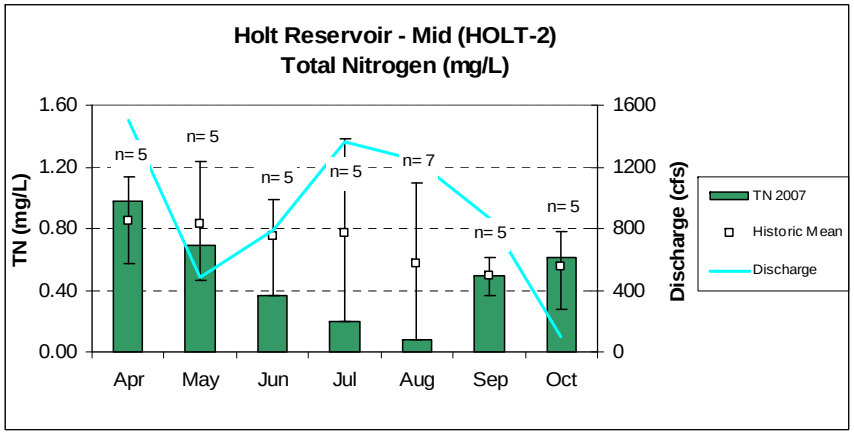


Figure 5. Monthly TN concentrations measured in Holt Reservoir, April-October 2007 vs. average monthly discharge measured at Holt L&D APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





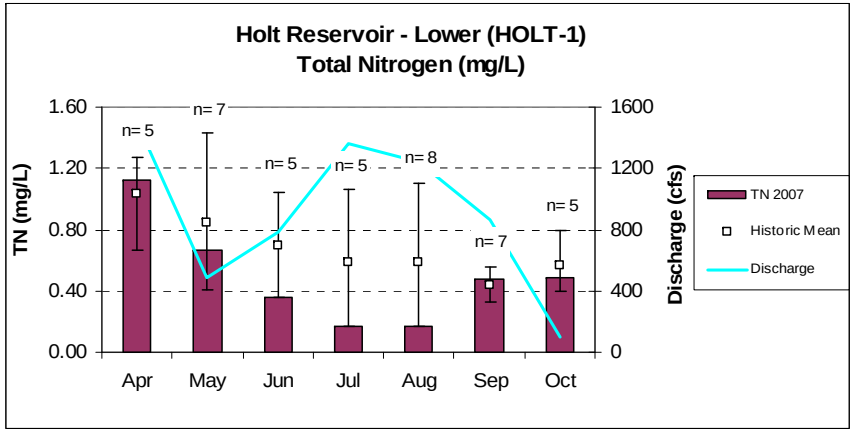
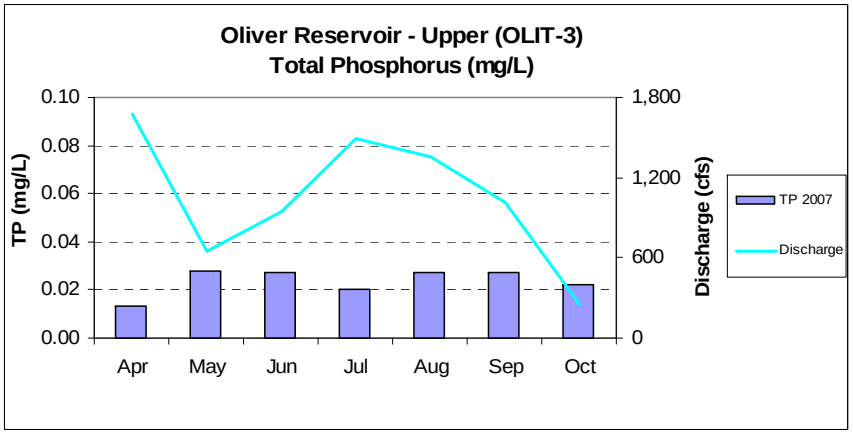
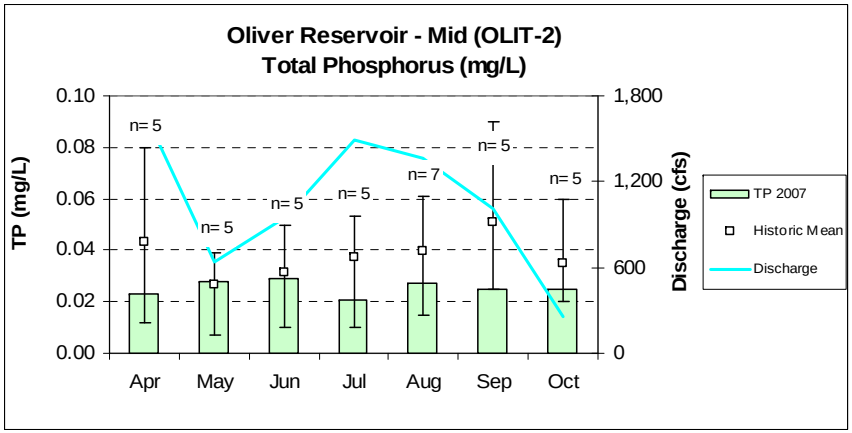


Figure 6. Monthly TP concentrations measured in Oliver Reservoir, April-October 2007 vs. average monthly discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





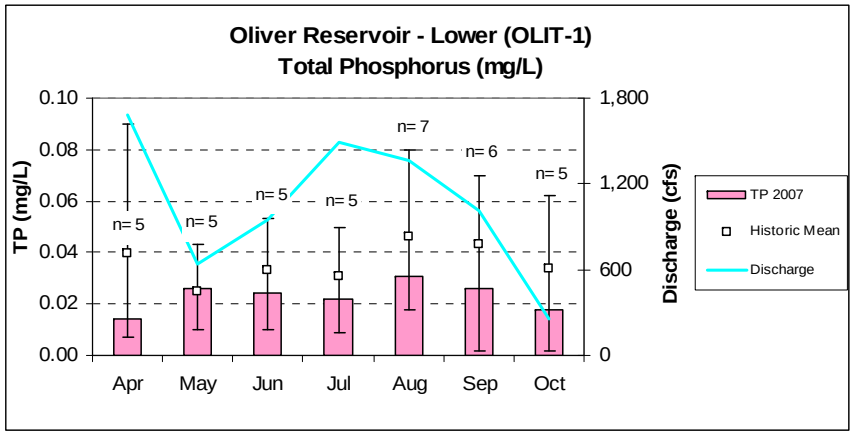
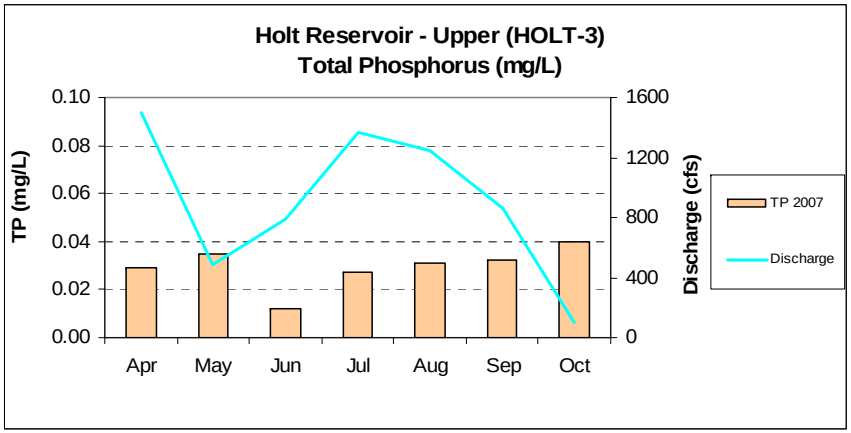
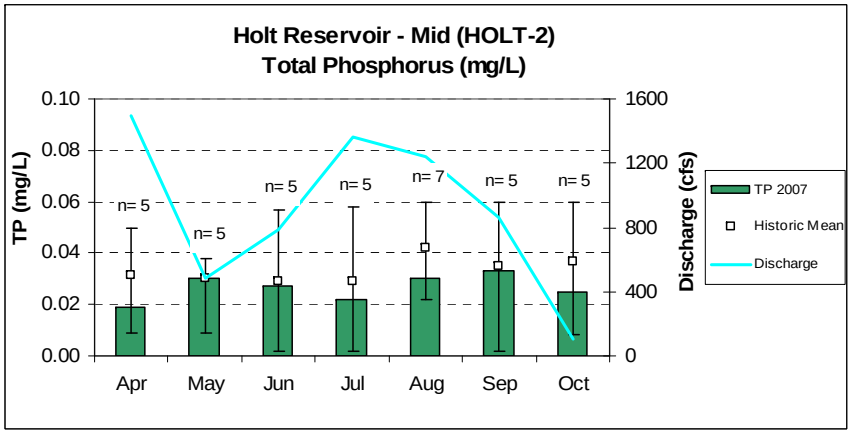


Figure 7. Monthly TP concentrations measured in Holt Reservoir, April-October 2007 vs. average monthly discharge measured at Holt L&D APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





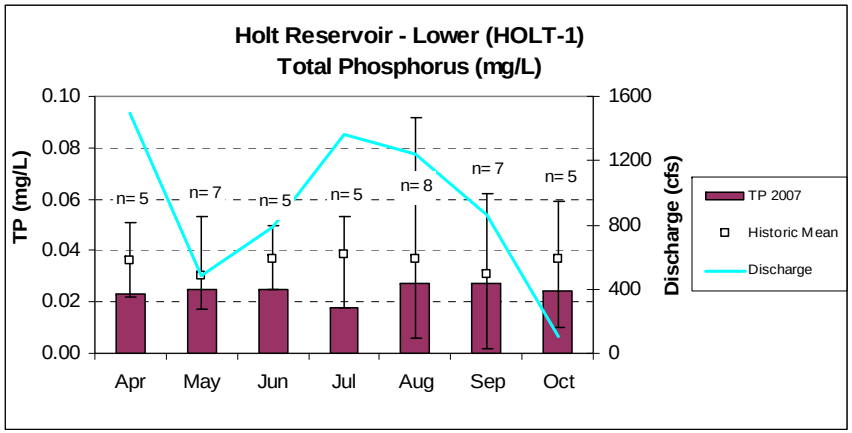


Figure 8. Monthly chl *a* concentrations measured in Oliver Reservoir, April-October 2007 vs. average monthly discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

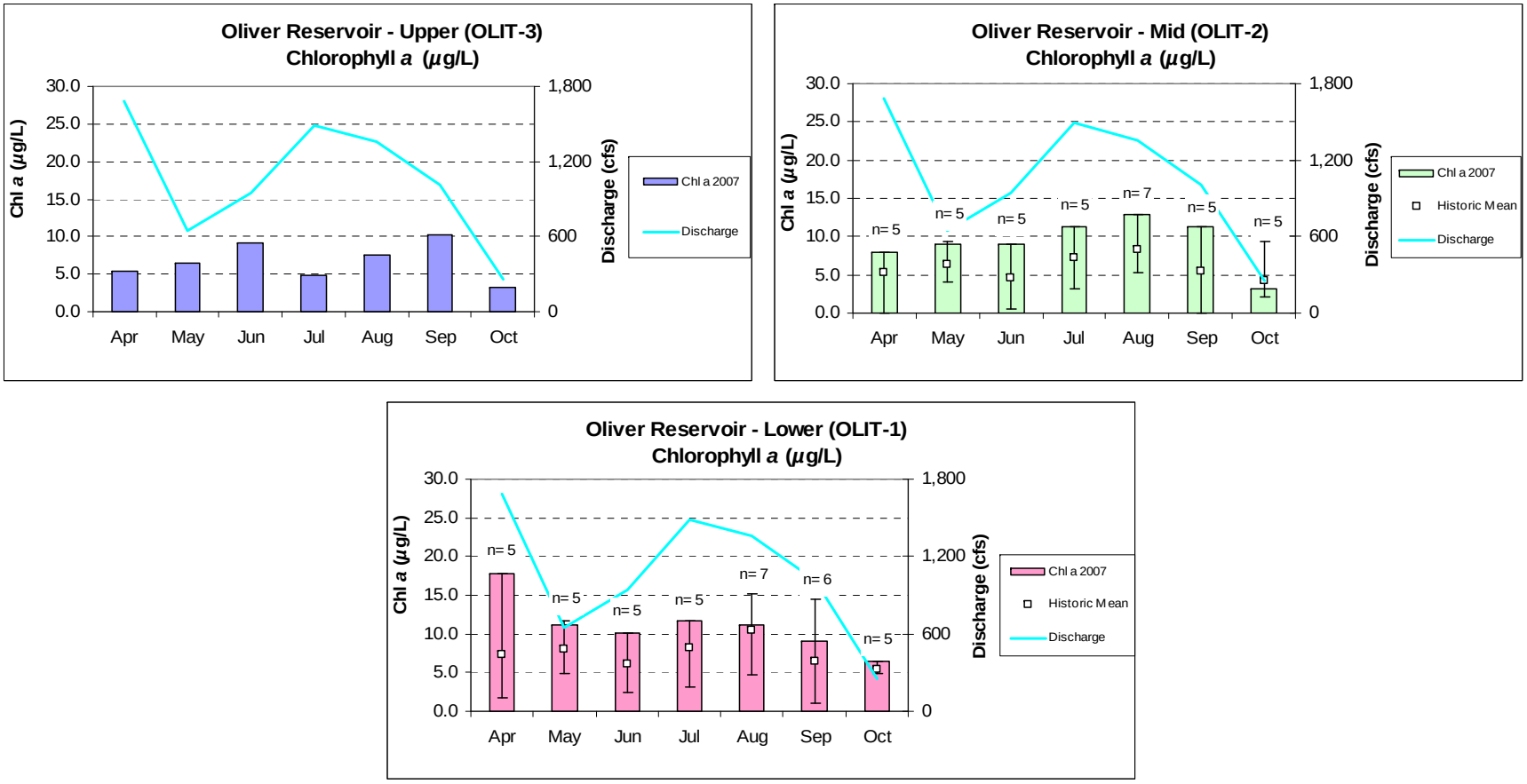
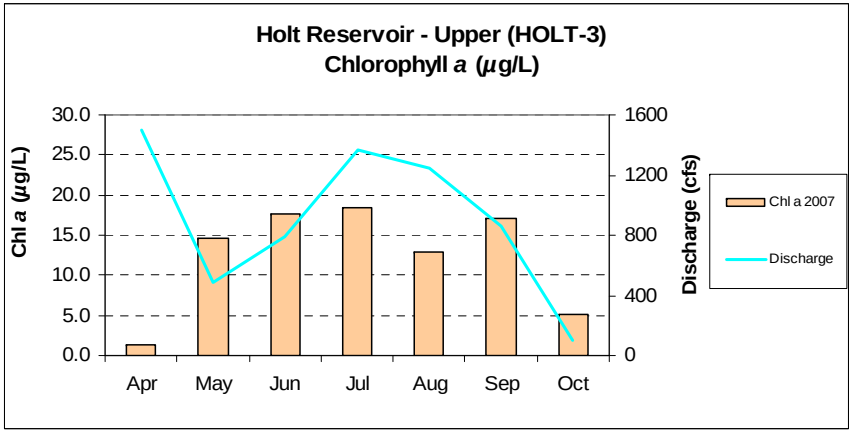
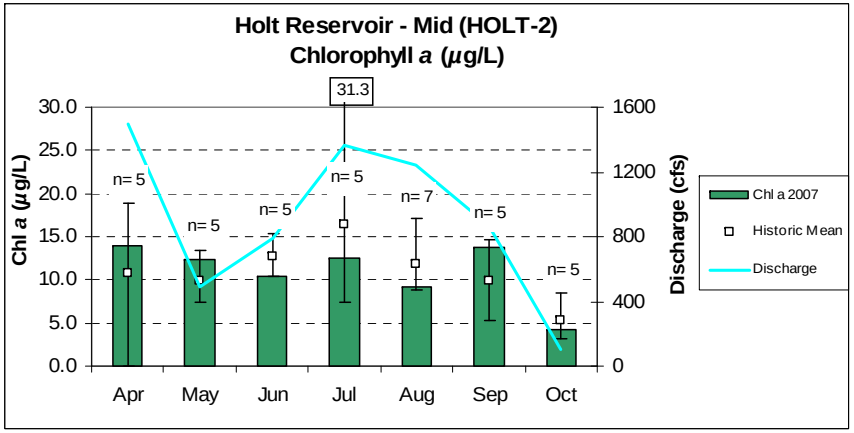


Figure 9. Monthly chl *a* concentrations measured in Holt Reservoir, April-October 2007 vs. average monthly discharge measured at Holt L&D APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





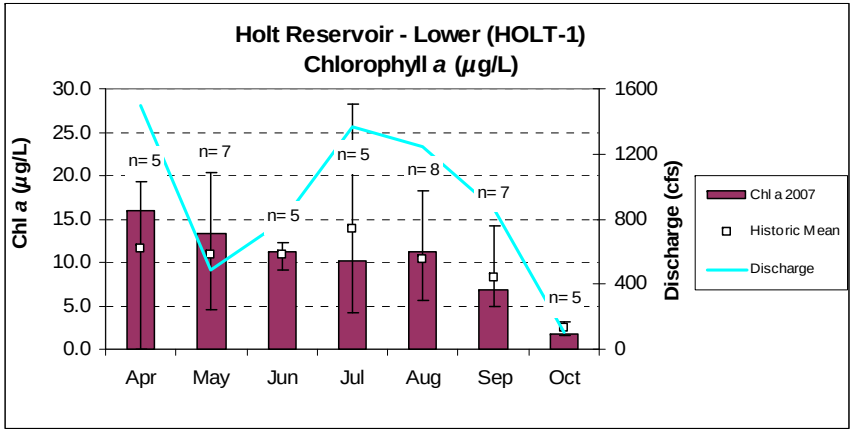
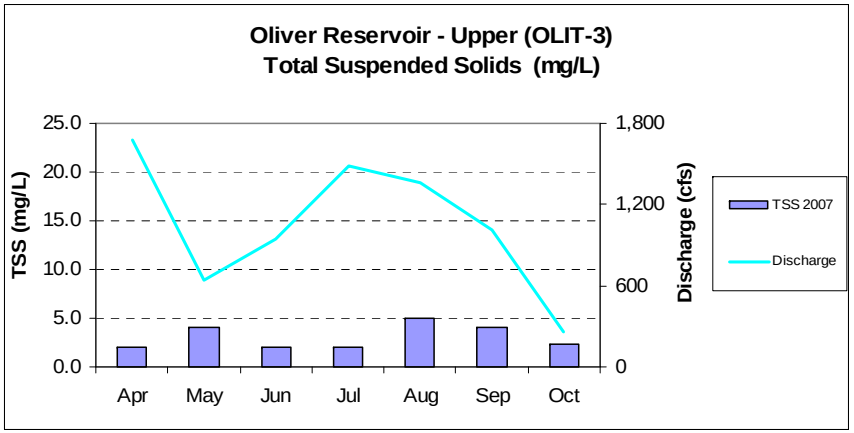
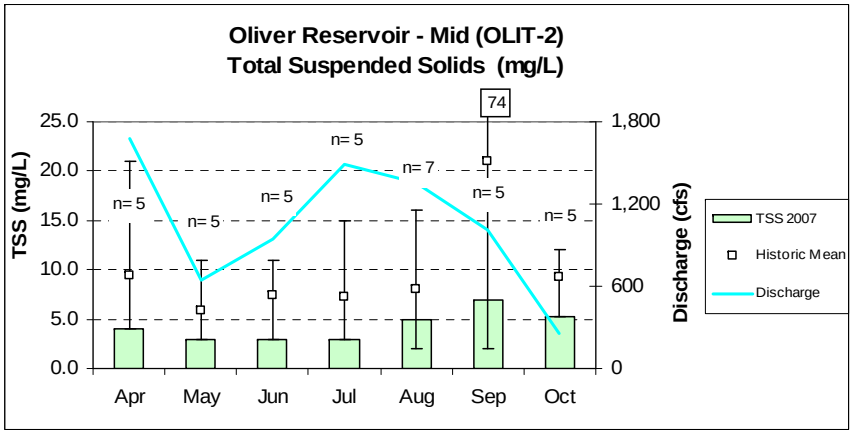


Figure 10. Monthly TSS concentrations measured in Oliver Reservoir, April-October 2007 vs. average monthly discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





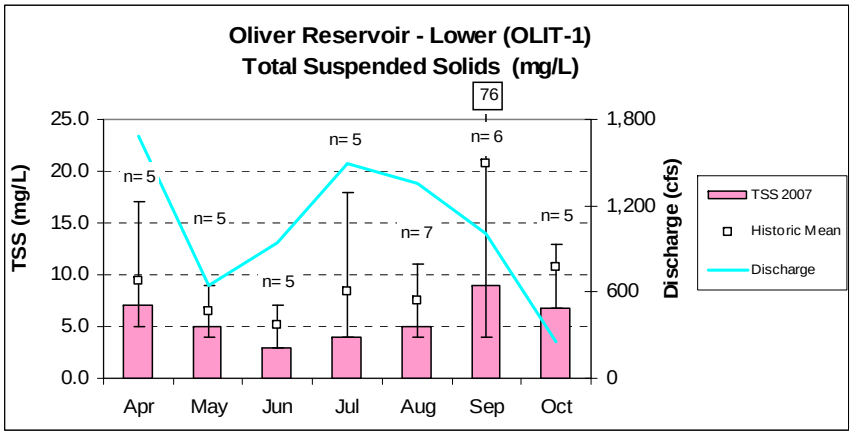
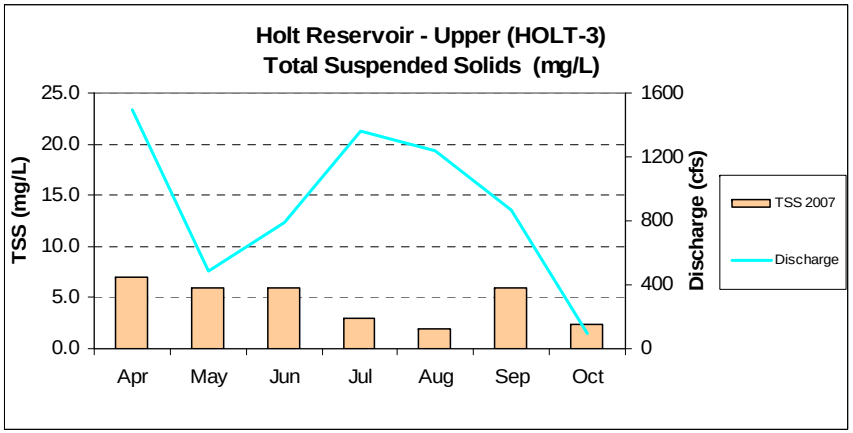
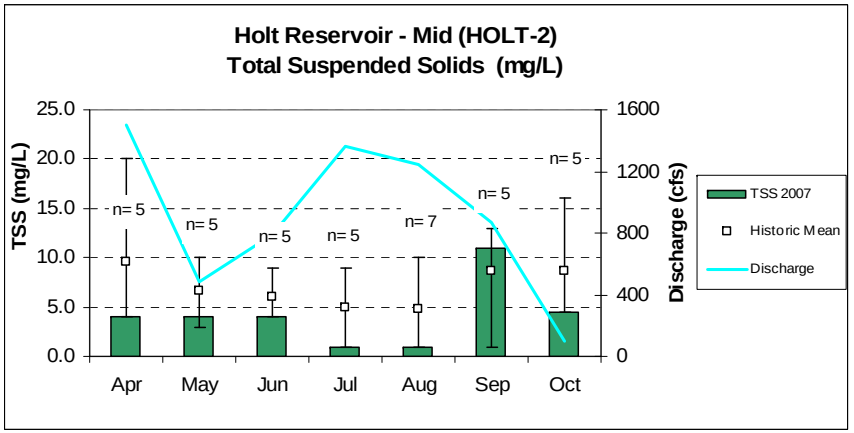


Figure 11. Monthly TSS concentrations measured in Holt Reservoir, April-October 2007 vs. average monthly discharge measured at Holt L&D APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2007) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





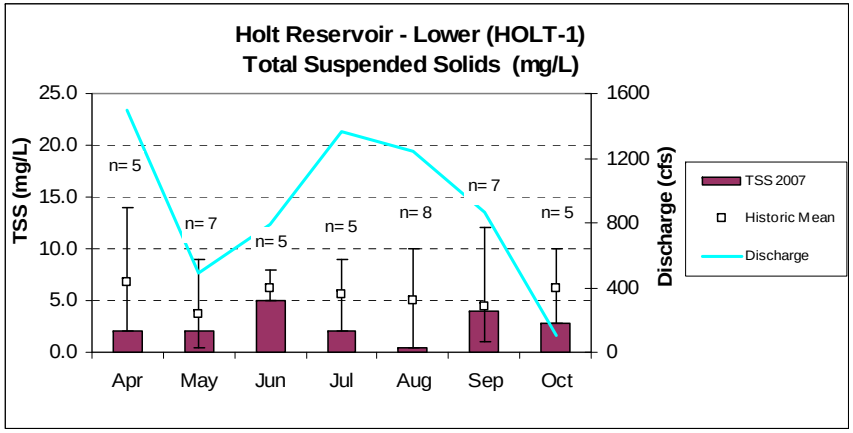
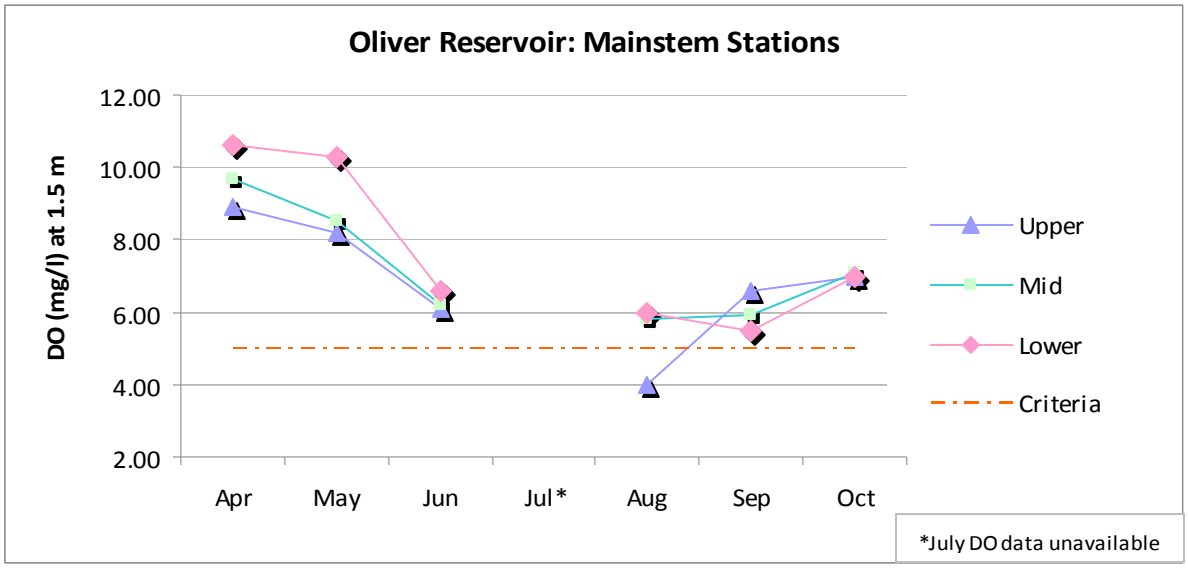


Table 2. Algal growth potential test results (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status in Oliver and Holt Reservoir stations, 1998-2007. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Station	Holt						Oliver					
	Upper		Mid		Lower		Upper		Mid		Lower	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient	MSC	Limiting Nutrient
August 1998			2.66	Phosphorus	2.60	Phosphorus			2.79	Phosphorus	2.27	Phosphorus
August 2002	3.76	Phosphorus	4.52	Phosphorus	4.06	Phosphorus	2.89	Phosphorus	3.15	Phosphorus	3.19	Phosphorus
June 2007			3.71	Phosphorus	3.74	Phosphorus			2.33	Phosphorus	3.55	Phosphorus
July 2007			4.01	Phosphorus	4.02	Co-limiting			2.09	Phosphorus	2.54	Phosphorus
August 2007			2.37	Co-limiting	2.34	Phosphorus			3.34	Non-Limiting	2.60	Co-limiting

Figure 12. Monthly DO concentrations at 1.5 m (5 ft) for Oliver and Holt Reservoir stations collected April-October 2007. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/L at this depth (ADEM 2005).



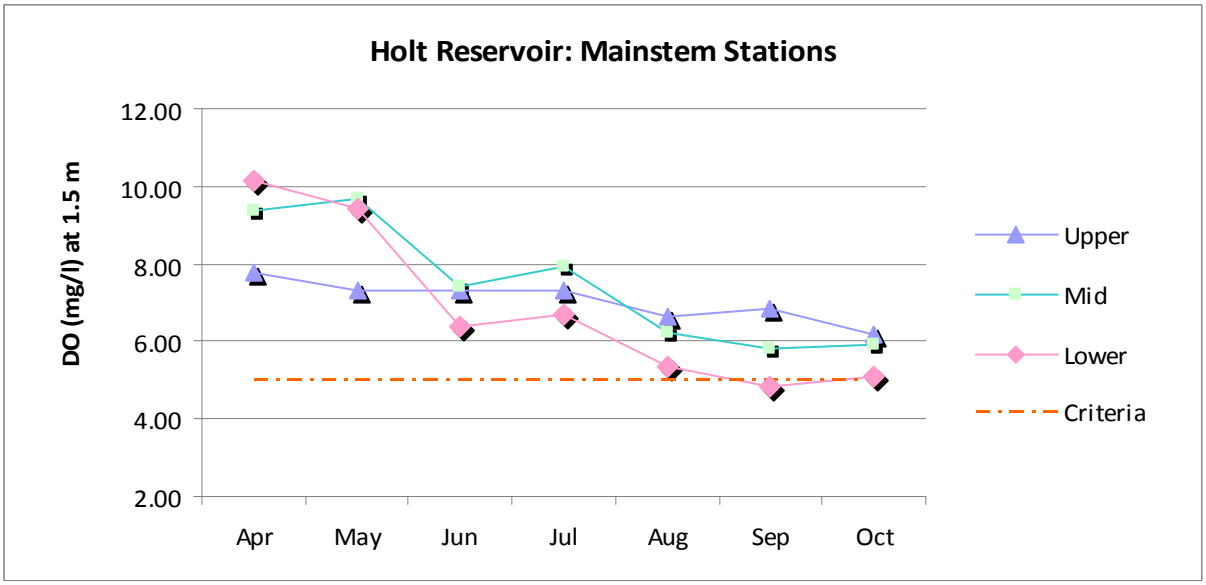


Figure 13. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in lower Oliver Reservoir, April-October 2007.

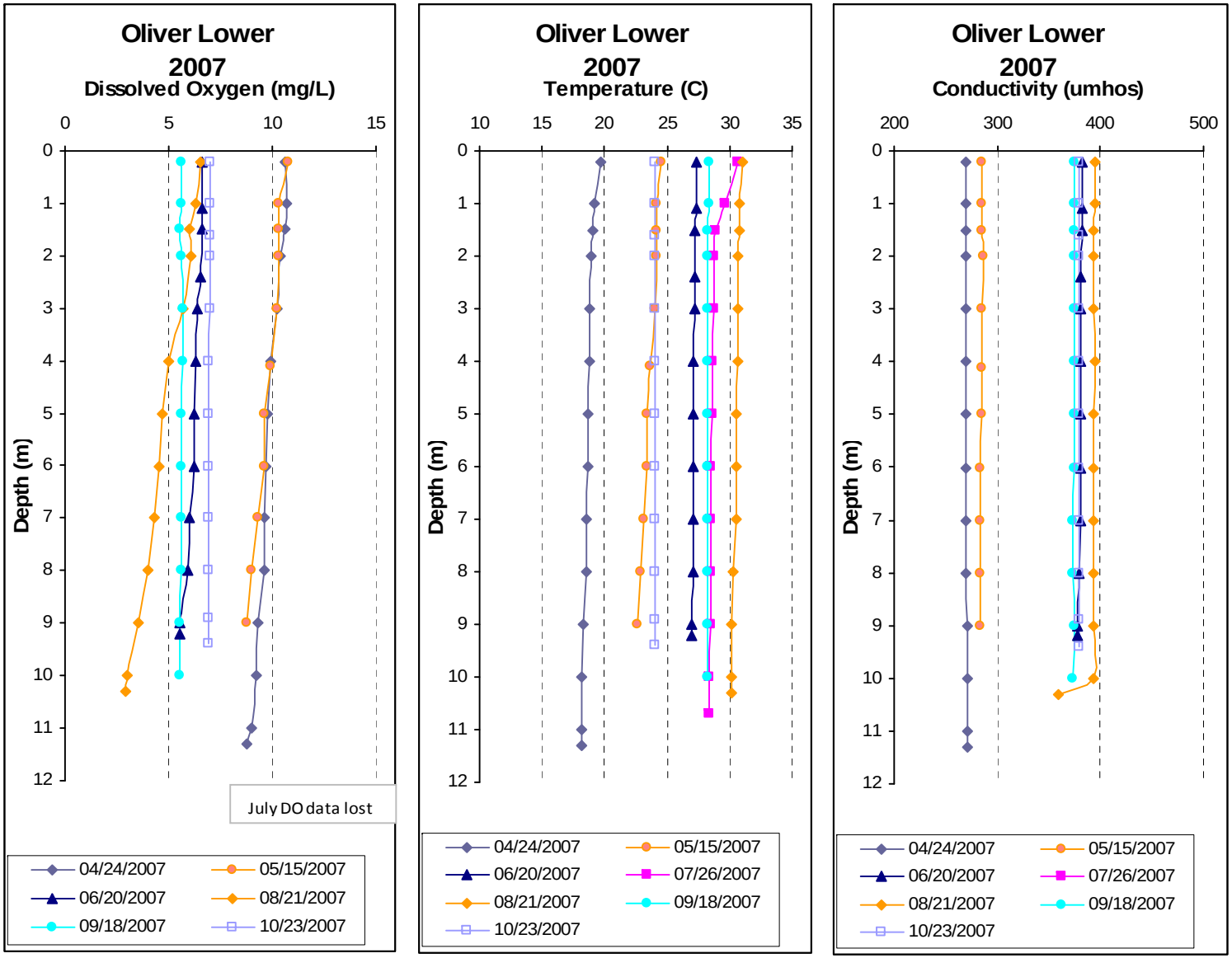


Figure 14. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in upper Oliver Reservoir, April-October 2007.

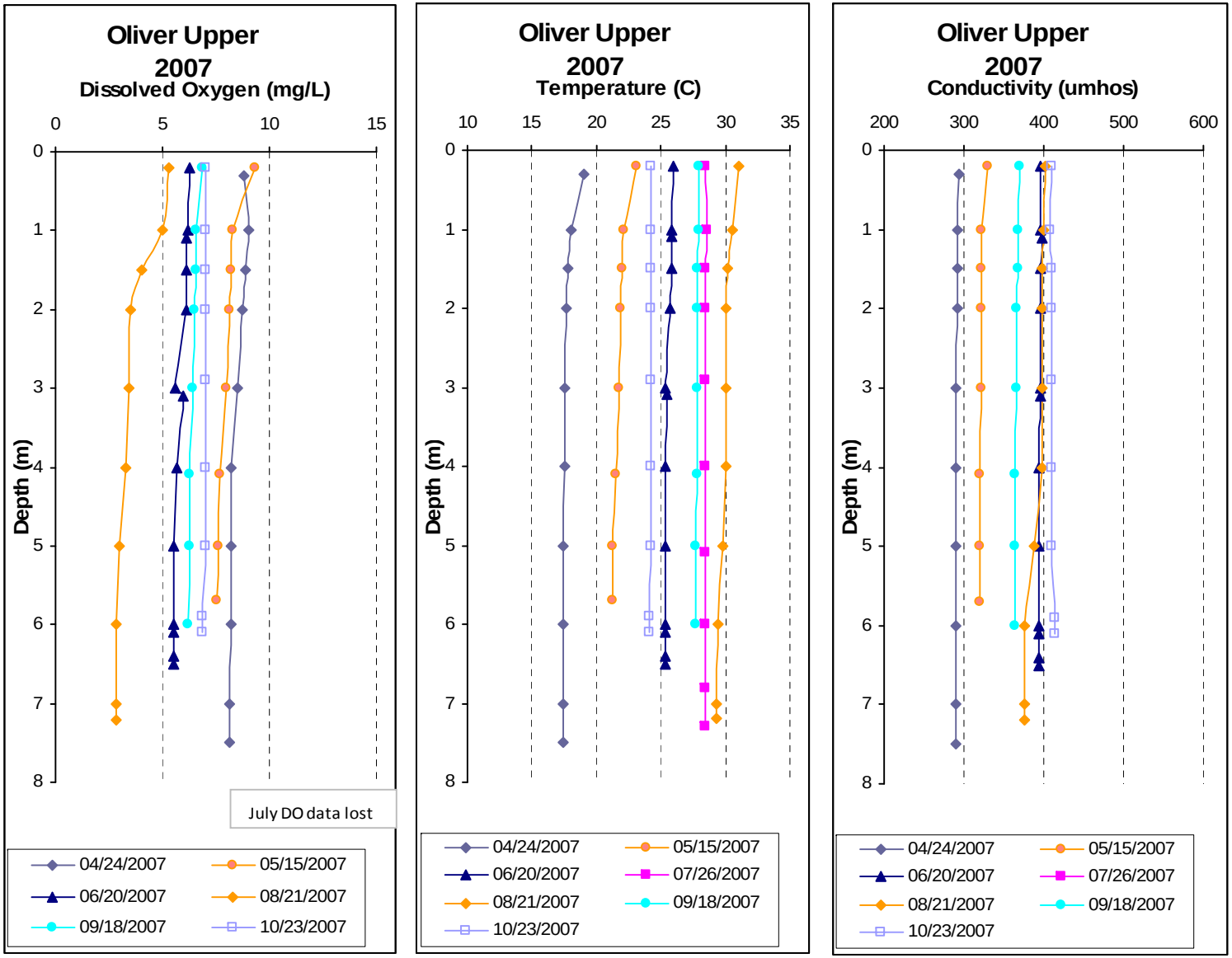


Figure 15. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in lower Holt Reservoir, April-October 2007.

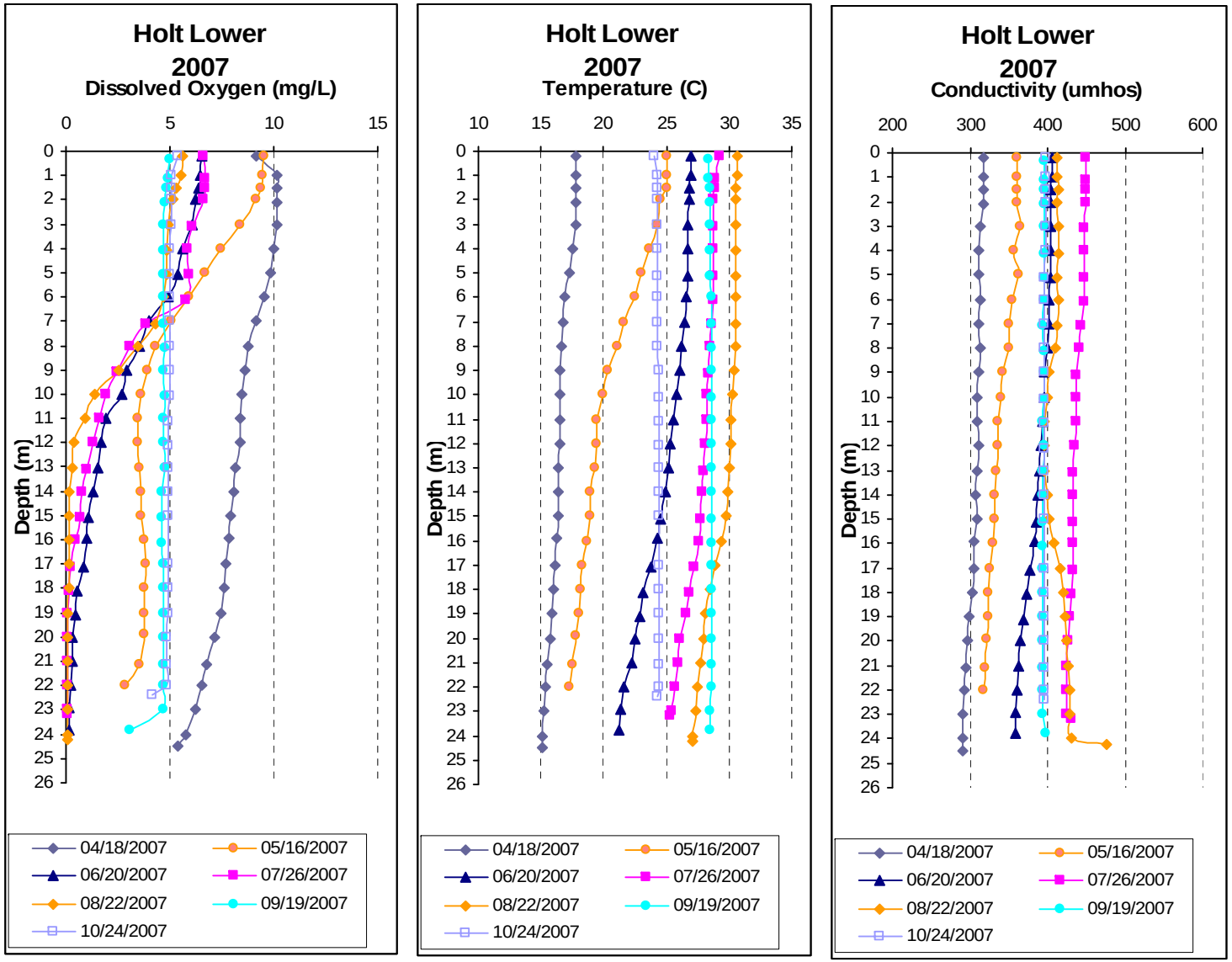


Figure 16. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in upper Holt Reservoir, April-October 2007.

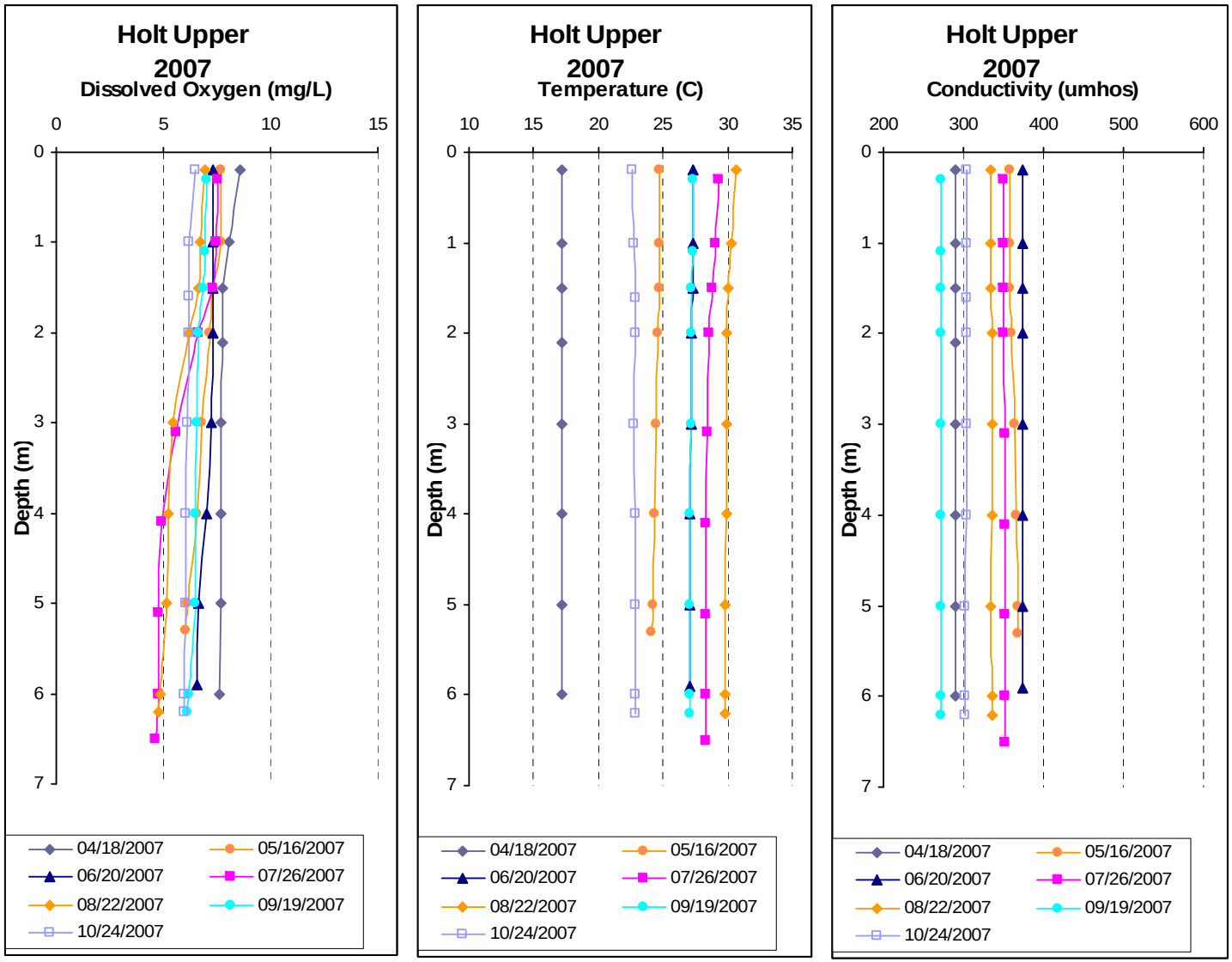
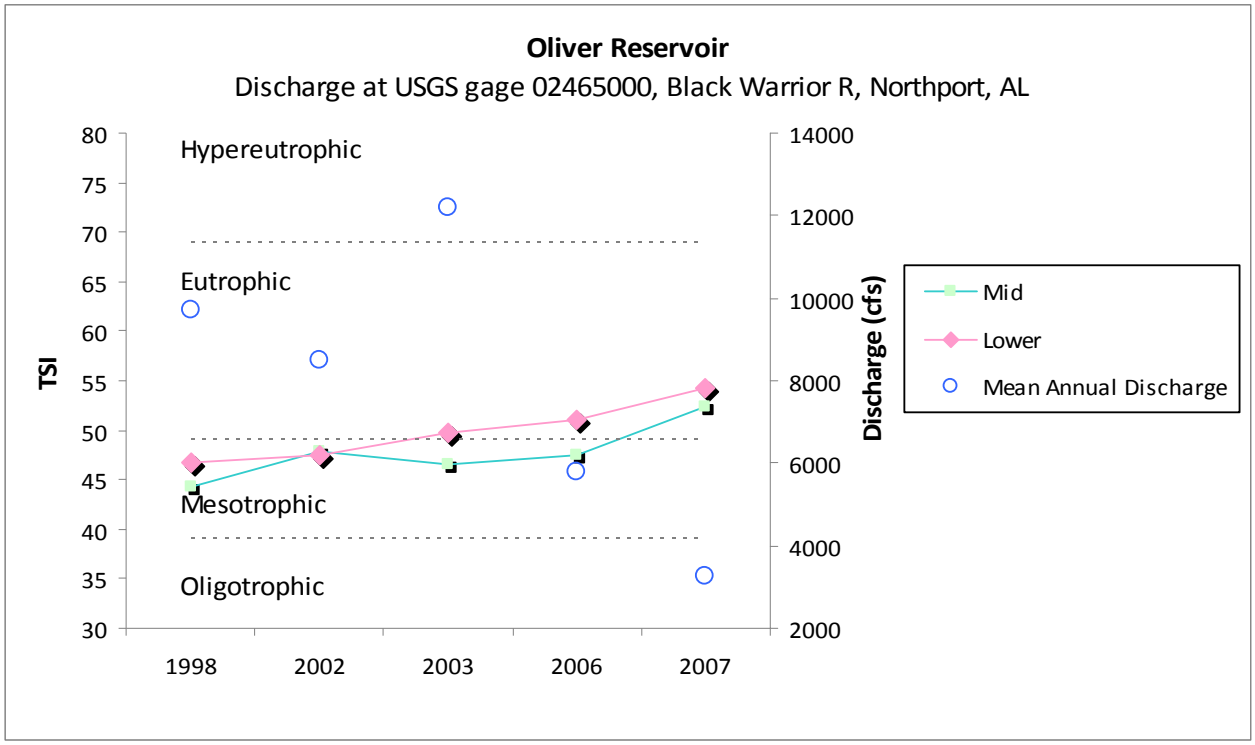
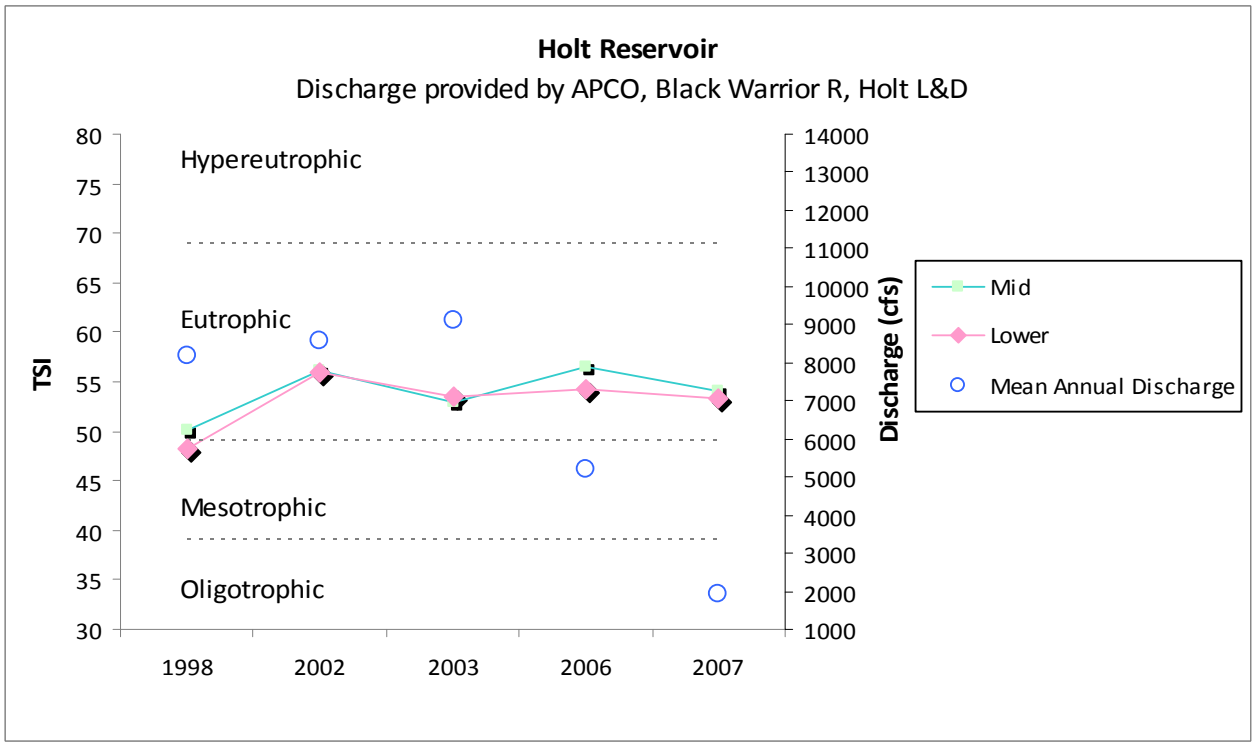


Figure 17. Mean growing season TSI values for Oliver and Holt Reservoirs using chl *a* concentrations and Carlson's Trophic State Index calculation.





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APPENDIX

Appendix Table 1. Summary of Oliver and Holt Reservoir water quality data collected April-October, 2007. 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	Avg	SD
HOLT-1	**Physical**							
	Turbidity (NTU)	7		2.6	4.0	3.0	3.1	0.5
	Total Dissolved Solids (mg/L)	7		18.0	229.0	203.0	179.3	72.8
	Total Suspended Solids (mg/L)	7	<	1.0	5.0	2.0	2.6	1.5
	Hardness (mg/L)	4		58.9	108.0	80.1	81.8	24.0
	Alkalinity (mg/L)	7		55.7	88.9	76.9	75.6	11.4
	Photic Zone (m)	7		3.85	5.83	5.10	5.03	0.73
	Secchi (m)	7		1.39	2.26	1.91	1.86	0.26
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.064	0.008	0.016	0.021
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.003	0.468	0.145	0.174	0.170
	Total Kjeldahl Nitrogen (mg/L)	7		0.161	0.654	0.280	0.319	0.173
	Total Nitrogen (mg/L)	7	<	0.169	1.122	0.476	0.493	0.330
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.019	0.007	0.008	0.006
	Total Phosphorus (mg/L)	7		0.018	0.027	0.025	0.024	0.003
	CBOD-5 (mg/L)	7	<	1.0	3.9	1.1	1.8	1.5
	Chlorides (mg/L)[J]	7		16.0	29.2	25.7	24.4	4.3
	Biological							
	Chlorophyll *a* (ug/L)[J]	7		1.78	16.02	11.21	10.08	4.63
	Fecal Coliform (col/100 mL)[J]	1					2	
HOLT-2	**Physical**							
	Turbidity (NTU)	7		2.8	4.2	3.6	3.4	0.5
	Total Dissolved Solids (mg/L)	7		142.0	233.0	184.0	186.9	34.1
	Total Suspended Solids (mg/L)	7		1.0	11.0	4.0	4.2	3.3
	Hardness (mg/L)	4		55.9	97.0	74.8	75.6	18.6
	Alkalinity (mg/L)	7		58.4	86.5	71.0	73.7	9.4
	Photic Zone (m)	7		3.50	5.98	4.60	4.61	0.80
	Secchi (m)	7		1.04	1.90	1.65	1.66	0.30
	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	0.508	0.112	0.155	0.184
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.150	0.490	0.401	0.332	0.158
	Total Nitrogen (mg/L)[J]	7	<	0.076	0.978	0.491	0.487	0.306
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.004	0.016	0.008	0.008	0.004
	Total Phosphorus (mg/L)	7		0.019	0.033	0.027	0.027	0.005
	CBOD-5 (mg/L)	7	<	1.0	3.2	0.5	1.5	1.3
	Chlorides (mg/L)[J]	7		13.9	23.8	19.9	19.4	3.1
	Biological							
	Chlorophyll *a* (ug/L)[J]	7		4.27	13.88	12.28	10.91	3.38
	Fecal Coliform (col/100 mL)[J]	1					1	

Station	Parameter	N		Min	Max	Med	Avg	SD
HOLT-3	**Physical**							
	Turbidity (NTU)	7		2.6	3.7	3.0	3.0	0.5
	Total Dissolved Solids (mg/L)	7		1.0	229.0	166.0	151.4	76.6
	Total Suspended Solids (mg/L)	7		2.0	7.0	6.0	4.6	2.1
	Hardness (mg/L)	4		51.3	94.0	75.0	73.8	19.2
	Alkalinity (mg/L)	7		62.9	88.3	75.0	74.3	9.3
	Photic Zone (m)	7		4.10	6.20	4.68	4.88	0.76
	Secchi (m)	7		1.24	2.66	1.73	1.80	0.50
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.039	0.008	0.012	0.012
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7		0.007	0.555	0.117	0.194	0.210
	Total Kjeldahl Nitrogen (mg/L)	7		0.238	0.683	0.365	0.402	0.162
	Total Nitrogen (mg/L) [J]	7		0.257	0.984	0.532	0.596	0.306
	Dissolved Reactive Phosphorus (mg/L) [J]	7	<	0.004	0.028	0.008	0.010	0.008
	Total Phosphorus (mg/L)	7		0.012	0.040	0.031	0.029	0.009
	CBOD-5 (mg/L)	7	<	1.0	3.4	1.7	1.5	1.1
	Chlorides (mg/L) [J]	7		10	19	15	14	3
	Biological							
	Chlorophyll *a* (ug/L) [J]	7		1.34	18.51	14.60	12.45	6.68
	Fecal Coliform (col/100 mL) [J]	1					1	
OLIT-1	**Physical**							
	Turbidity (NTU)	7		3.8	7.2	6.2	5.7	1.3
	Total Dissolved Solids (mg/L)	7		150.0	1,640.0	218.0	452.3	541.1
	Total Suspended Solids (mg/L)	7		3.0	9.0	5.0	5.7	2.0
	Hardness (mg/L)	4		58.2	110.0	75.6	79.8	24.3
	Alkalinity (mg/L)	7		52.4	86.8	73.3	71.4	13.8
	Photic Zone (m)	7		2.88	5.24	4.05	4.19	0.84
	Secchi (m)	7		0.91	1.53	1.28	1.27	0.24
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.025	0.008	0.012	0.008
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.003	0.389	0.084	0.158	0.156
	Total Kjeldahl Nitrogen (mg/L)	7		0.264	0.517	0.405	0.390	0.101
	Total Nitrogen (mg/L)	7	<	0.293	0.745	0.523	0.548	0.149
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.005	0.010	0.008	0.008	0.002
	Total Phosphorus (mg/L) [J]	7		0.014	0.031	0.024	0.023	0.006
	CBOD-5 (mg/L)	7	<	1.0	4.6	1.7	2.0	1.6
	Chlorides (mg/L) [J]	7		12.9	25.4	24.0	21.4	4.9
	Biological							
	Chlorophyll *a* (ug/L) [J]	7		6.41	17.80	11.21	11.09	3.47
	Fecal Coliform (col/100 mL) [J]	1					4	

Station	Parameter	N		Min	Max	Med	Avg	SD
OLIT-2	**Physical**							
	Turbidity (NTU)	7		2.7	5.9	4.6	4.5	1.2
	Total Dissolved Solids (mg/L)	7		150.0	2,182.0	216.0	483.7	749.7
	Total Suspended Solids (mg/L)	7		3.0	7.0	4.0	4.3	1.5
	Hardness (mg/L)	4		59.5	104.0	79.2	80.5	22.3
	Alkalinity (mg/L)	7		54.7	86.8	74.9	73.1	13.4
	Photic Zone (m)	7		3.80	5.92	4.13	4.48	0.79
	Secchi (m)	7		1.17	1.70	1.36	1.43	0.22
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.015	0.008	0.008	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.003	0.471	0.155	0.199	0.185
	Total Kjeldahl Nitrogen (mg/L)	7		0.153	0.445	0.302	0.288	0.103
	Total Nitrogen (mg/L)	7	<	0.154	0.857	0.467	0.487	0.230
	Dissolved Reactive Phosphorus (mg/L) [J]	7		0.005	0.014	0.009	0.009	0.003
	Total Phosphorus (mg/L)	7		0.021	0.029	0.025	0.025	0.003
	CBOD-5 (mg/L)	7	<	1.0	2.2	1.1	1.1	0.6
	Chlorides (mg/L) [J]	7		12.9	27.7	23.8	21.7	5.1
	Biological							
	Chlorophyll *a* (ug/L) [J]	7		3.20	12.82	9.08	9.23	3.13
	Fecal Coliform (col/100 mL) [J]	1					19	
OLIT-3	**Physical**							
	Turbidity (NTU)	7		3.2	4.9	4.1	4.1	0.6
	Total Dissolved Solids (mg/L)	7		174.0	238.0	196.0	204.9	26.6
	Total Suspended Solids (mg/L)	7		2.0	5.0	2.4	3.1	1.2
	Hardness (mg/L)	3		59.7	97.0	64.9	73.9	20.2
	Alkalinity (mg/L)	7		56.6	86.9	75.8	73.9	11.2
	Photic Zone (m)	7		3.75	5.55	4.53	4.59	0.62
	Secchi (m)	7		1.22	1.82	1.55	1.55	0.24
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.015	0.034	0.008	0.011	0.010
	Nitrate+Nitrite Nitrogen (mg/L) [J]	7		0.013	0.492	0.198	0.224	0.190
	Total Kjeldahl Nitrogen (mg/L)	7		0.190	0.400	0.265	0.269	0.073
	Total Nitrogen (mg/L) [J]	7		0.203	0.892	0.426	0.493	0.245
	Dissolved Reactive Phosphorus (mg/L) [J]	7	<	0.004	0.018	0.009	0.009	0.005
	Total Phosphorus (mg/L)	7		0.013	0.028	0.027	0.023	0.006
	CBOD-5 (mg/L)	7	<	1.0	2.6	1.6	1.5	0.8
	Chlorides (mg/L) [J]	7		14.0	28.0	23.0	22.2	4.5
	Biological							
	Chlorophyll *a* (ug/L) [J]	7		3.20	10.15	6.41	6.64	2.45
	Fecal Coliform (col/100 mL) [J]	1					8	

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