2012 Oliver and Holt Reservoirs Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
July 2014

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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 nine 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 2012 assessment of the Black Warrior and Cahaba River (BWC) Basins under the Rivers and Reservoirs Monitoring Program (RRMP). ADEM began monitoring lake water quality statewide in 1985, followed by a second statewide survey in 1989. In 1990, the Reservoir Water Quality Monitoring Program (now known as RRMP) was initiated by ADEM. The current objectives of this program are to provide data that can be used to assess current water quality conditions, identify trends in water quality conditions and to develop Total Maximum Daily Loads (TMDLs) and water quality criteria. Descriptions of all RRMP monitoring activities are available in ADEM's 2012 Monitoring Strategy (ADEM 2012).

In 2004, the ADEM implemented a specific water quality criterion for nutrient management at the forebay of both 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 and Holt Reservoir's Swimming and 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 2012 growing season and to evaluate growing season trends in mean lake trophic status and nutrient concentrations using ADEM's fifteen-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 2012), Surface Water Quality Assurance Project Plan (ADEM 2012) and Quality Management Plan (ADEM 2008).

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 flow data and ADEM's previously collected data to help interpret the 2012 results.

Figure 1. Oliver and Holt Reservoirs with 2012 sampling locations.

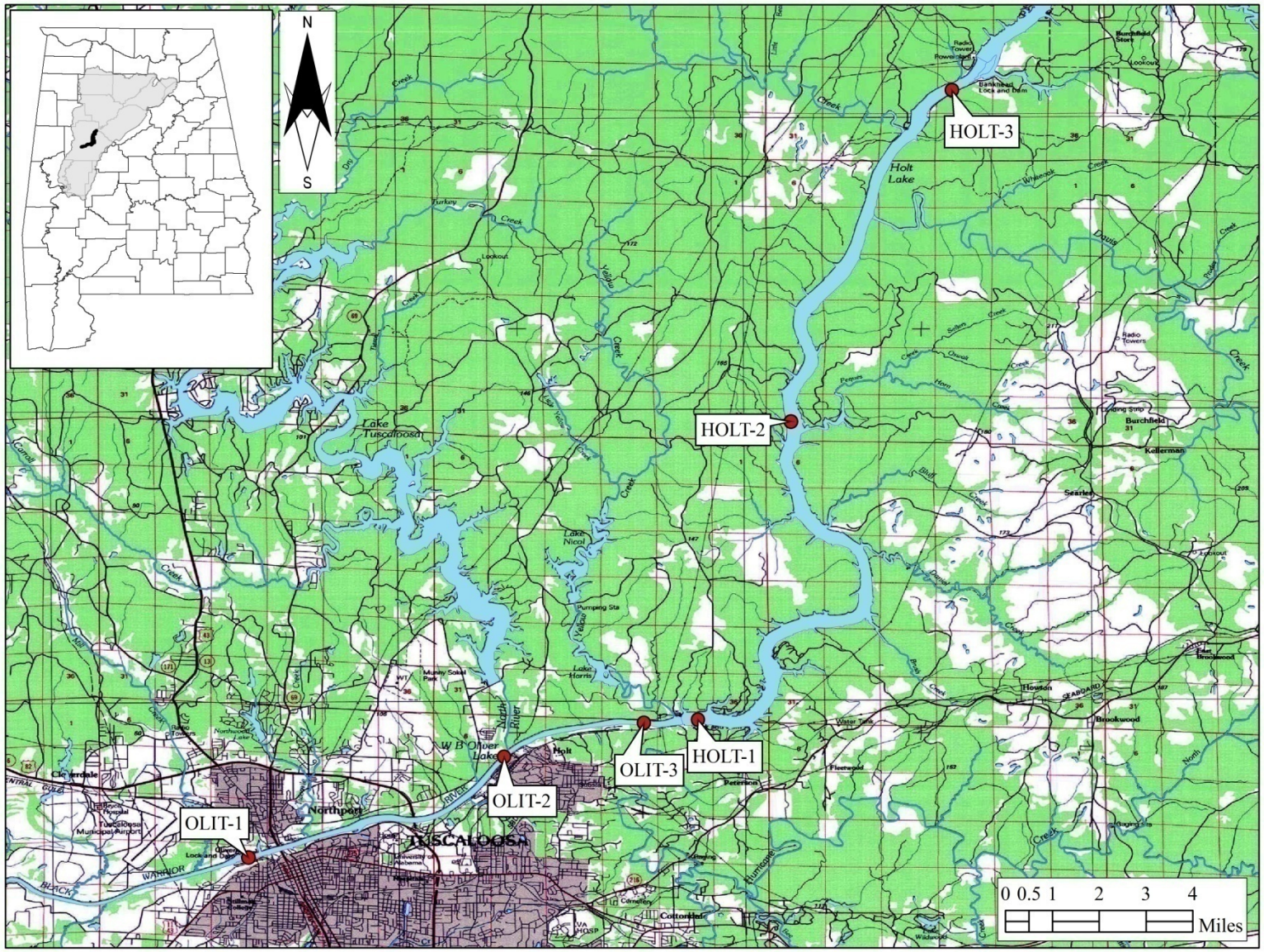


Table 1. Descriptions of the 2012 monitoring stations in Oliver and Holt Reservoirs.

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 µg/L	33.25418	-87.44429
031601120306	Tuscaloosa	HOLT-2	Mid Holt	Black Warrior R	Deepest point, main river channel, immediately upstream of Pegues Creek, Black Warrior R confluence.		33.34641	-87.41554
031601120306	Tuscaloosa	HOLT-3	Upper Holt	Black Warrior R	Deepest point, main river channel, approximately 0.5 miles downstream of Big Indian Creek, Black Warrior confluence.		33.44900	-87.36570
Oliver Reservoir								
031601120505	Tuscaloosa	OLIT-1*	Lower Oliver	Black Warrior R	Deepest point, main river channel, dam forebay.	12 µg/L	33.21139	-87.58344
031601120505	Tuscaloosa	OLIT-2	Mid Oliver	Black Warrior R	Deepest point, main river channel, immediately downstream of North River, Black Warrior R confluence.		33.24257	-87.50428
031601120505	Tuscaloosa	OLIT-3	Upper Oliver	Black Warrior R	Deepest point, main river channel, approximately 0.5 miles downstream of confluence with Hurricane Creek.		33.25320	-87.46100

*Growing season mean chl *a* criteria implemented at both stations in 2004.

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, dissolved oxygen (DO) and TSI are also provided (Figs. 4-12 and 17). 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. 13-16. Summary statistics of all data collected during 2012 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, chl *a* and TSS are noted in the paragraphs to follow. Though stations with the lowest concentrations may not always be mentioned, review of the graphs included in this report will indicate these stations that may be potential candidates for reference waterbodies and watersheds.

In 2012, the highest mean growing season TN value calculated among Oliver Reservoir stations was in the lower Oliver station (Fig. 2). The highest value among Holt Reservoir stations was in the upper Holt station. Mean growing season TN values in all Oliver and Holt Reservoir stations have varied in the years monitored. Monthly TN concentrations were below historic means most months monitored in all Oliver Reservoir stations, with the highest concentrations measured in April (Fig. 4). A historic high monthly TN concentration was measured in the upper Oliver station in September. The highest monthly TN concentration measured in the lower Holt station was in April, while the highest concentrations measured in the mid and upper Holt stations were in September and October, respectively (Fig. 5). Monthly concentrations in mid and lower Holt stations were below historic means, April-July.

In 2012, mean growing season TP values among Oliver Reservoir stations were similar (Fig. 2). Among Holt Reservoir stations, the highest mean TP value was in the upper Holt station while the lowest was in the lower Holt station. Mean growing season TP values among all Oliver Reservoir stations have generally decreased 1998-2012. Among all Holt Reservoir stations, mean growing season TP values have remained stable 2007-2012. Monthly TP concentrations were below historic means most months monitored in all Oliver and Holt

Reservoir stations (Fig. 6 and 7). With the exception of the upper Holt station, the highest monthly TP concentrations in all Oliver and Holt Reservoir stations were measured in September and were associated with a high flow event. Historic low monthly TP concentrations were measured in the upper Oliver station in May, June, July and August. Historic low TP concentrations were also measured in the lower Holt station in May and in the upper Holt station in April, May and October.

Specific water quality criteria for nutrient management have been established for the lower stations in Oliver and Holt Reservoirs. The growing season mean chl *a* value calculated for both lower stations during 2012 were in compliance with the criteria limits (Fig. 3). In 2012, the highest mean growing season chl *a* value calculated among Oliver Reservoir stations was in the upper Oliver station, while the lowest value was in the lower Oliver station. Among Holt Reservoir stations, the highest mean chl *a* value was in the lower Holt station, while the lowest was in the upper Holt station. With the exception of the lower Oliver station and the upper Holt station, the highest monthly chl *a* concentrations were measured in August (Fig. 8 and 9). Monthly chl *a* concentrations were near or below historic means most months monitored in all Oliver and Holt Reservoir stations, with historic lows measured most months. However, historic high monthly chl *a* concentrations were measured in the upper Oliver station in August and October, the lower Holt station in August and the upper Holt station in July.

In 2012, mean growing season TSS values among Oliver and Holt Reservoir stations were similar and have declined overall in the years monitored (Fig. 3). The 2012 monthly TSS concentrations were below historic means, often the lowest measurement on record, during most months monitored in all Oliver and Holt Reservoir stations (Fig. 10 and 11).

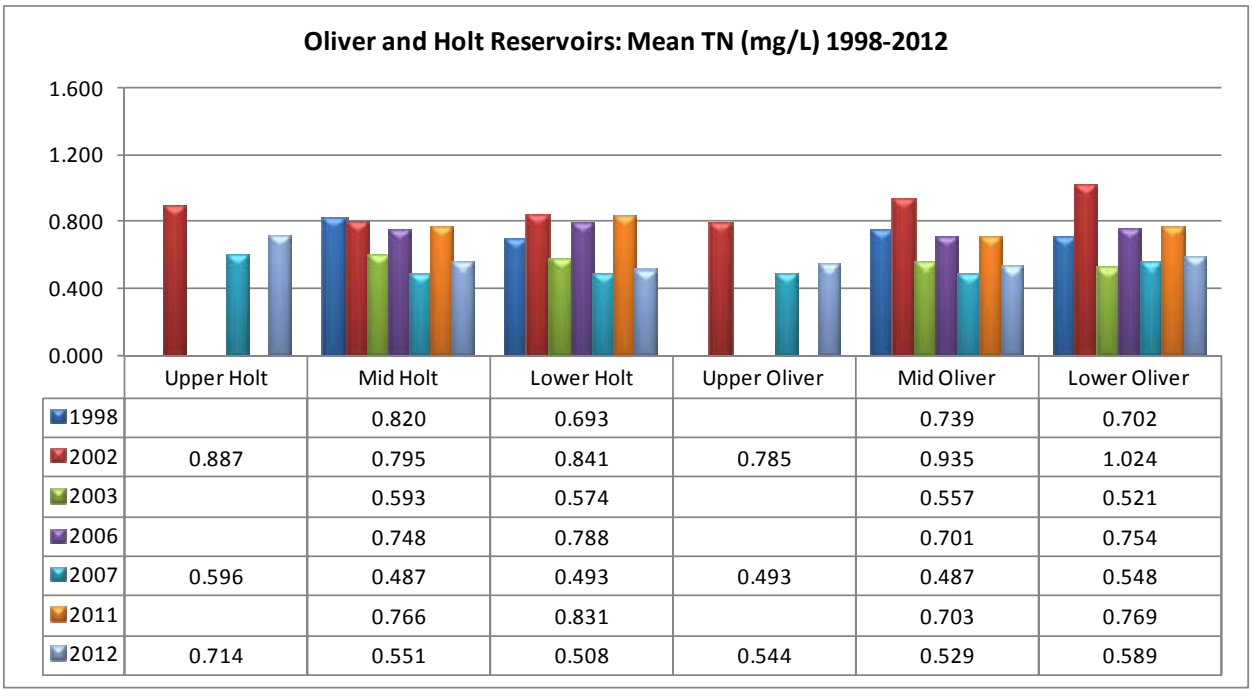
In 2012, AGPT results indicate all stations sampled in Oliver and Holt Reservoirs were above 5 mg/L MSC (Table 2), the value that Raschke and Schultz (1987) defined as protective of reservoir and lake systems. MSC values in the mid and upper Holt stations were above 20 mg/L, the value defined as protective of flowing streams and rivers (Raschke et al. 1996). Limiting nutrient status determined by AGPT results indicate nitrogen and phosphorus as co-limiting in the lower and upper Oliver stations while the mid station was phosphorus limited. Nitrogen was

the limiting nutrient in the lower Holt station. No limiting nutrient could be determined in the mid and upper stations.

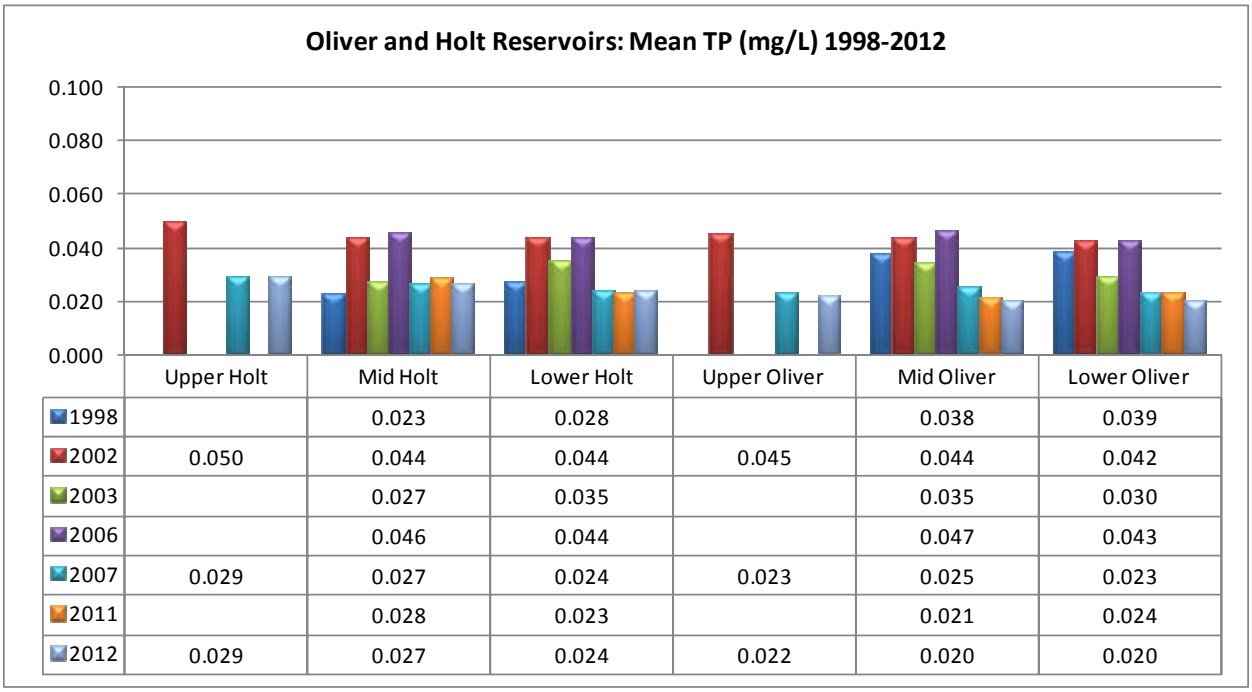
Dissolved oxygen concentrations were near or below the ADEM criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/L at 5.0 ft (1.5 m) in all Oliver Reservoir stations in September (Fig. 12). DO concentrations were also near the ADEM Criteria in the upper Oliver station in July. Among Holt Reservoir stations, dissolved oxygen concentrations in the lower and mid stations were also near or below the ADEM criteria in September. Based on monthly profiles, both the upper and lower Oliver stations were thoroughly mixed April-October, with highest temperatures measured in July (Fig. 13 and 14). DO profiles from the lower Holt station show stratification in most months, with complete deoxygenation in the lower 5m of the water column in June and July (Fig. 15). Highest temperatures in Holt were measured in July (Fig. 16). Based on conductivity profiles, chemoclines were measured in the lower Holt station in May.

TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index. Among the Oliver Reservoir stations, the upper station had the highest TSI value, reaching eutrophic conditions in August (Fig. 17). All other TSI values among Oliver Reservoir stations were variable. The highest TSI values among Holt Reservoir stations also indicated eutrophic conditions in the upper station in July, and lower station in August. All other TSI values among Holt Reservoir stations were variable.

Figure 2. Mean growing season TN and TP measured in Oliver and Holt Reservoirs, April-October, 1998-2012. Stations are illustrated from upstream to downstream as the graph is read from left to right.

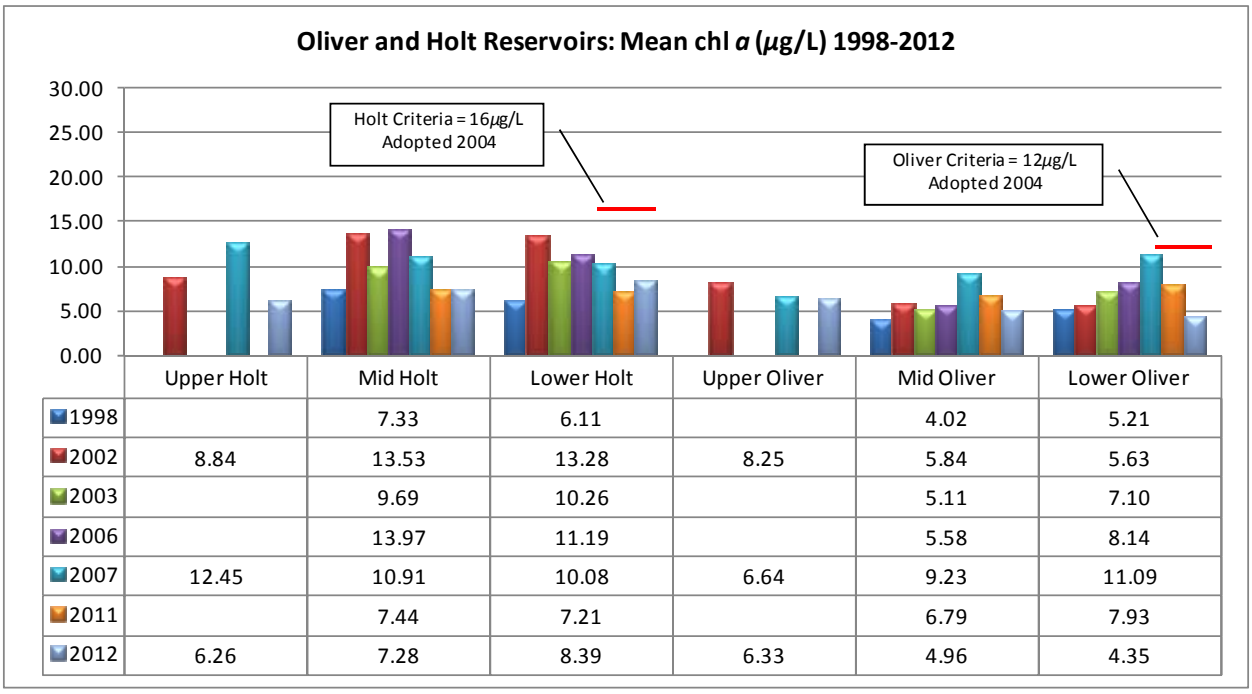


	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		0.820	0.693		0.739	0.702
2002	0.887	0.795	0.841	0.785	0.935	1.024
2003		0.593	0.574		0.557	0.521
2006		0.748	0.788		0.701	0.754
2007	0.596	0.487	0.493	0.493	0.487	0.548
2011		0.766	0.831		0.703	0.769
2012	0.714	0.551	0.508	0.544	0.529	0.589

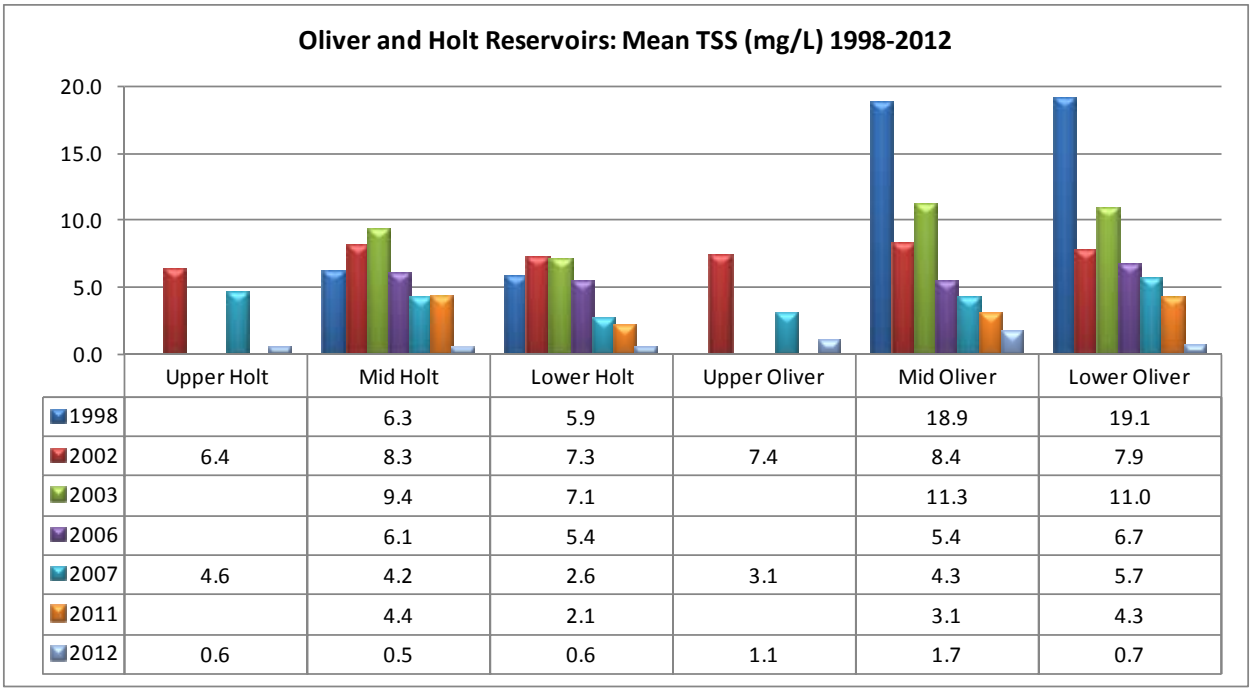


	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		0.023	0.028		0.038	0.039
2002	0.050	0.044	0.044	0.045	0.044	0.042
2003		0.027	0.035		0.035	0.030
2006		0.046	0.044		0.047	0.043
2007	0.029	0.027	0.024	0.023	0.025	0.023
2011		0.028	0.023		0.021	0.024
2012	0.029	0.027	0.024	0.022	0.020	0.020

Figure 3. Mean growing season chl a and TSS measured in Oliver and Holt Reservoirs, April-October, 1998-2012. 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.

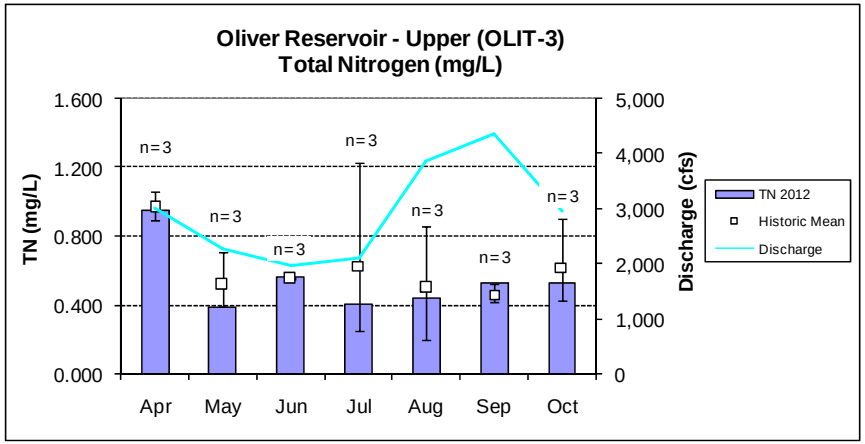


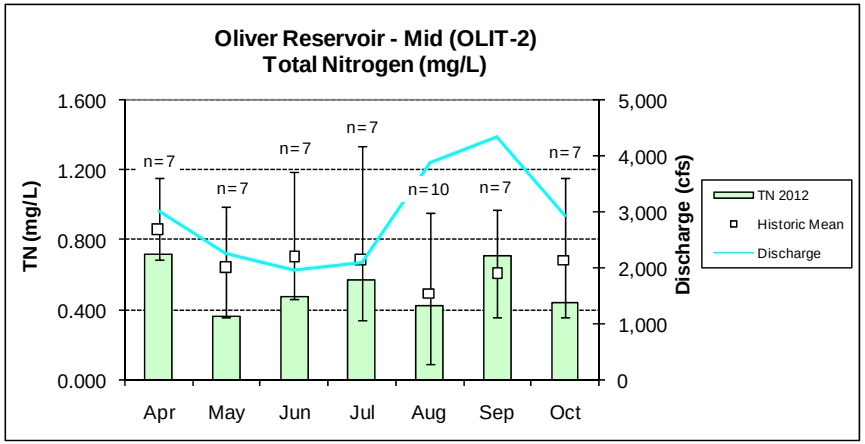
	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		7.33	6.11		4.02	5.21
2002	8.84	13.53	13.28	8.25	5.84	5.63
2003		9.69	10.26		5.11	7.10
2006		13.97	11.19		5.58	8.14
2007	12.45	10.91	10.08	6.64	9.23	11.09
2011		7.44	7.21		6.79	7.93
2012	6.26	7.28	8.39	6.33	4.96	4.35



	Upper Holt	Mid Holt	Lower Holt	Upper Oliver	Mid Oliver	Lower Oliver
1998		6.3	5.9		18.9	19.1
2002	6.4	8.3	7.3	7.4	8.4	7.9
2003		9.4	7.1		11.3	11.0
2006		6.1	5.4		5.4	6.7
2007	4.6	4.2	2.6	3.1	4.3	5.7
2011		4.4	2.1		3.1	4.3
2012	0.6	0.5	0.6	1.1	1.7	0.7

Figure 4. Monthly TN concentrations measured in Oliver Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.





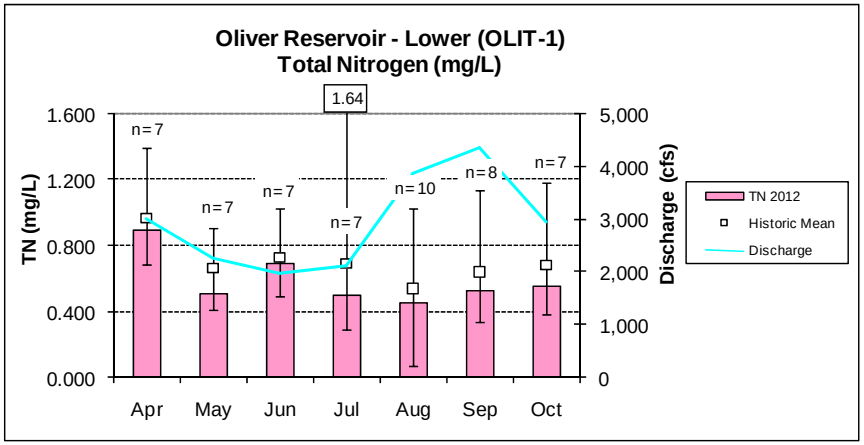


Figure 5. Monthly TN concentrations measured in Holt Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at Holt L&D, provided by APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

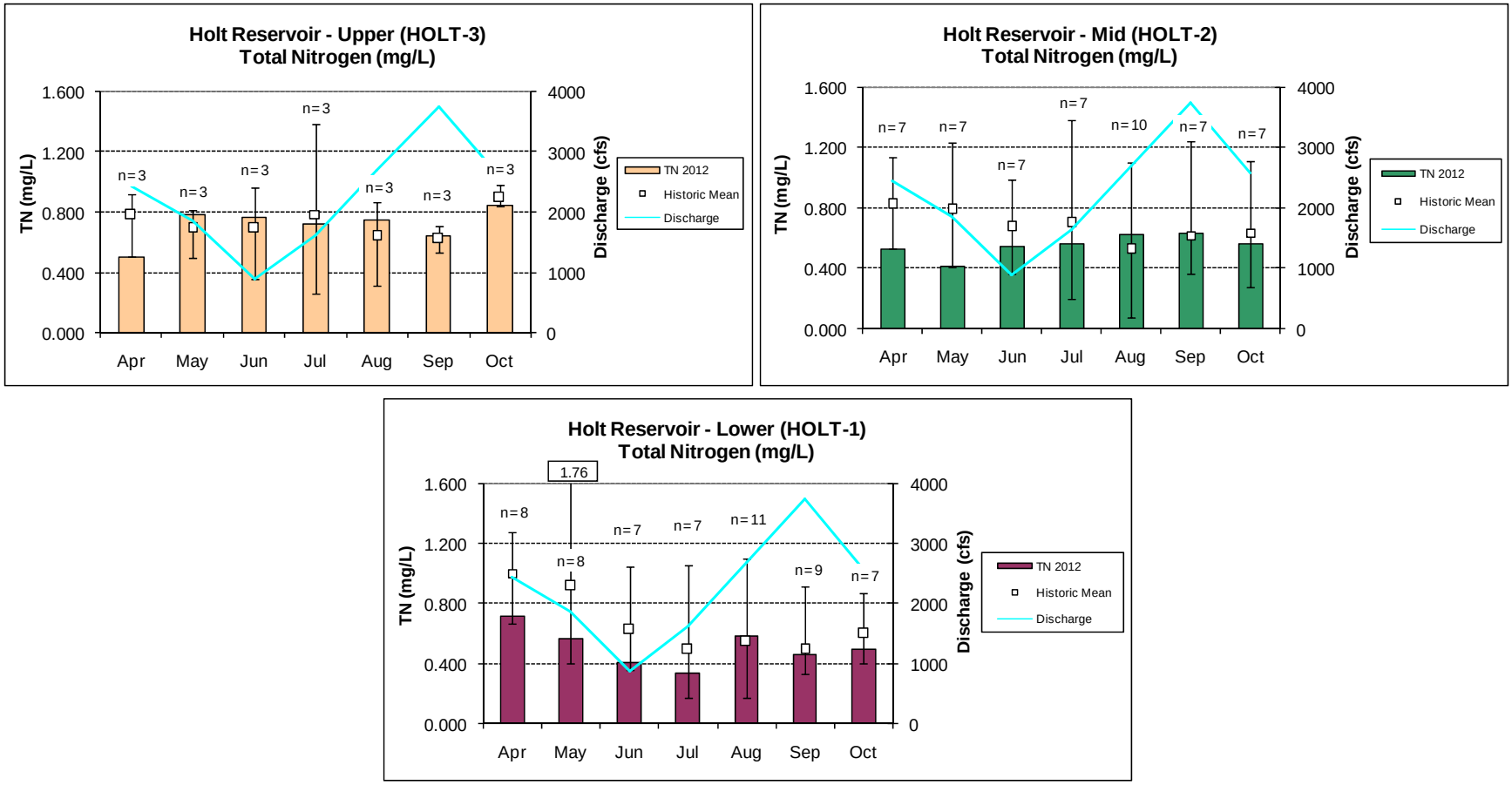


Figure 6. Monthly TP concentrations measured in Oliver Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

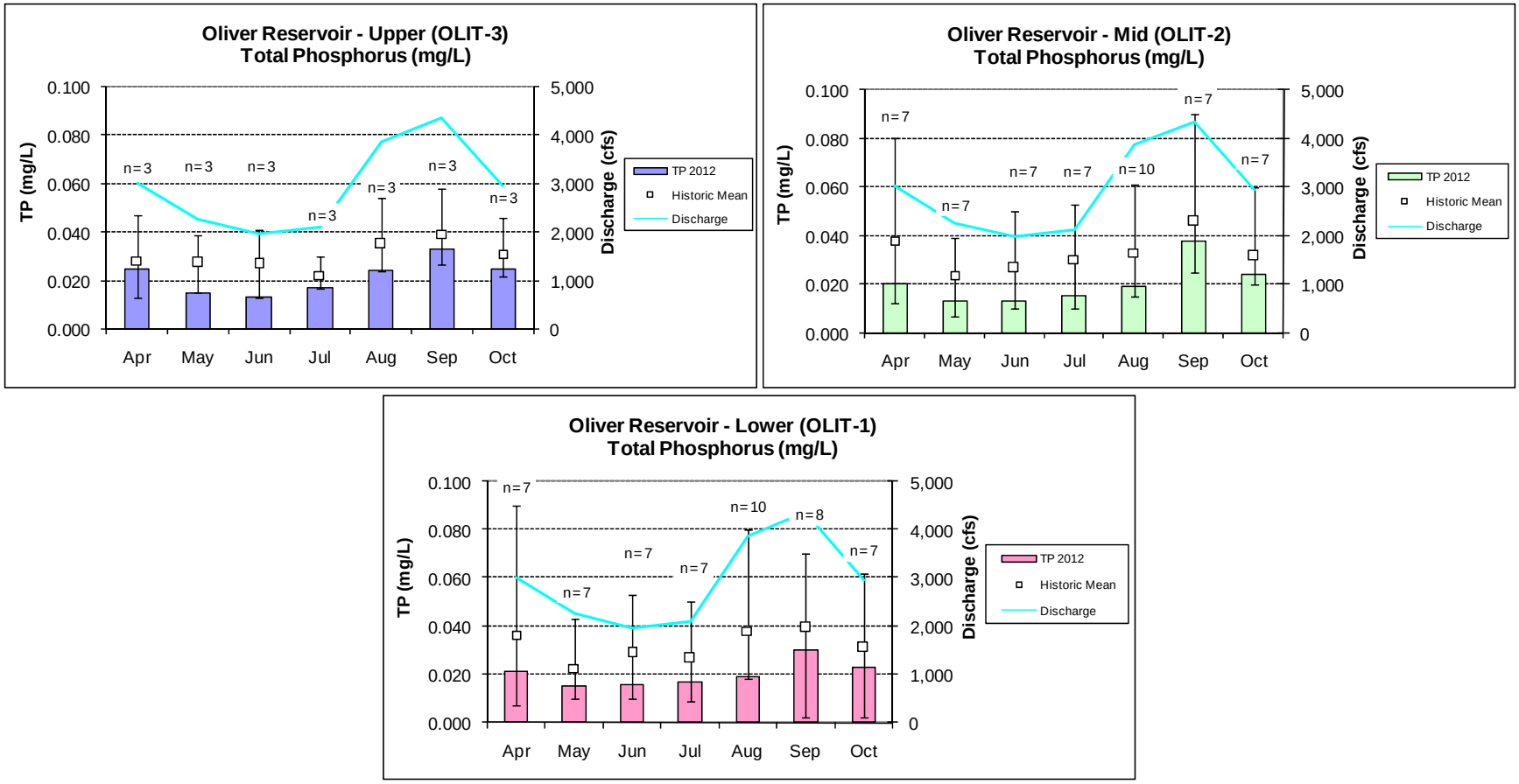


Figure 7. Monthly TP concentrations measured in Holt Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at Holt L&D, provided by APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

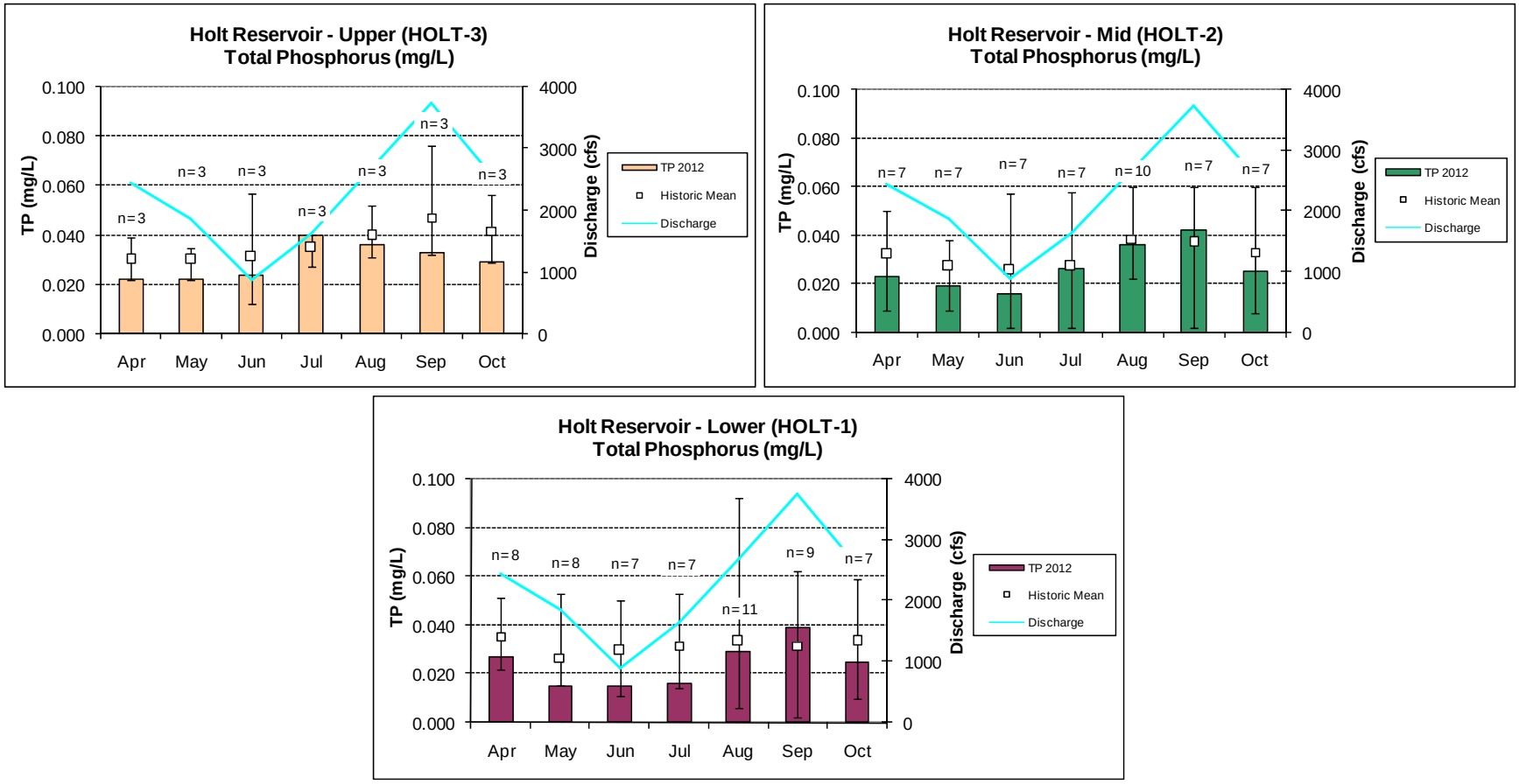


Figure 8. Monthly chl *a* concentrations measured in Oliver Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

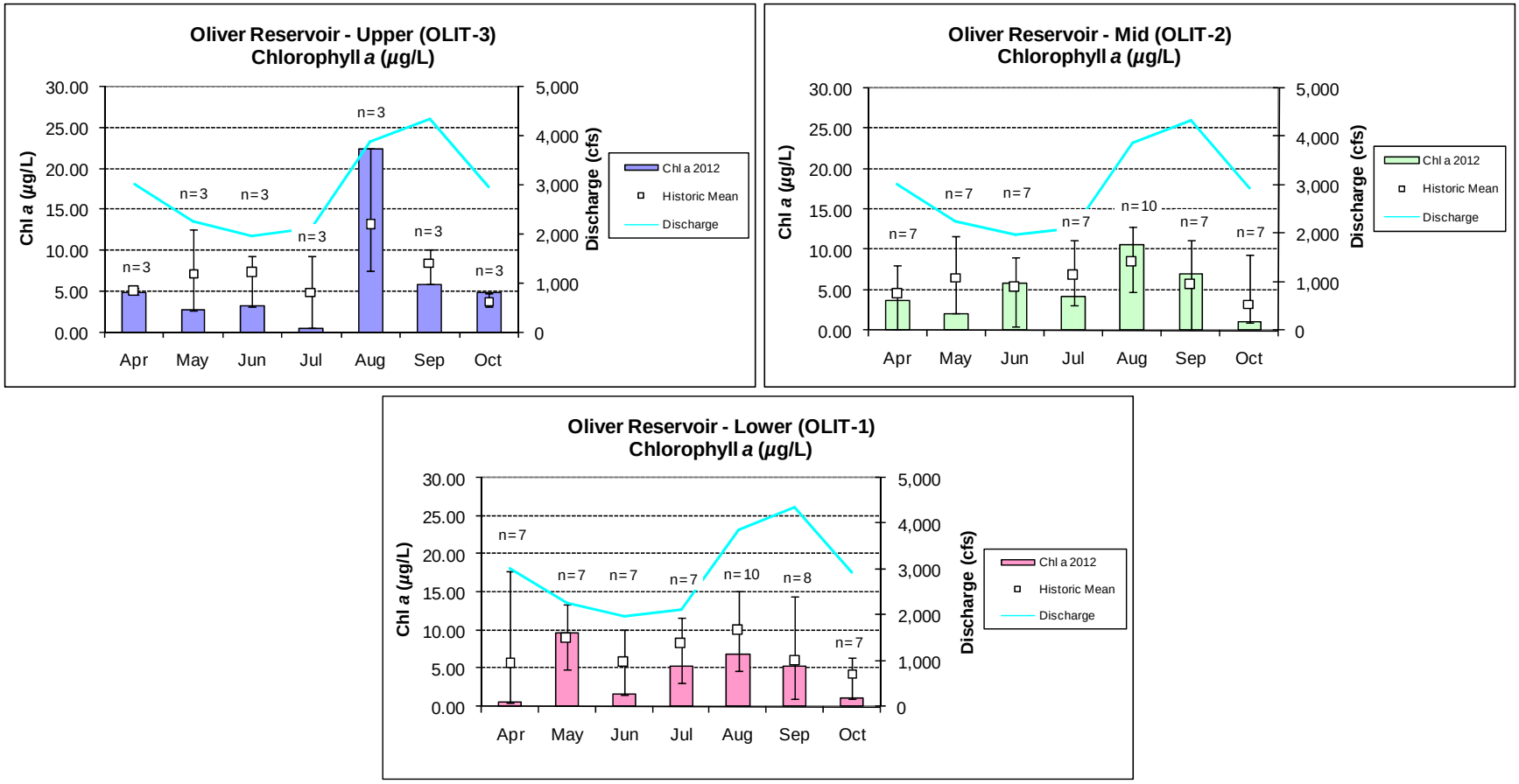


Figure 9. Monthly chl *a* concentrations measured in Holt Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at Holt L&D, provided by APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

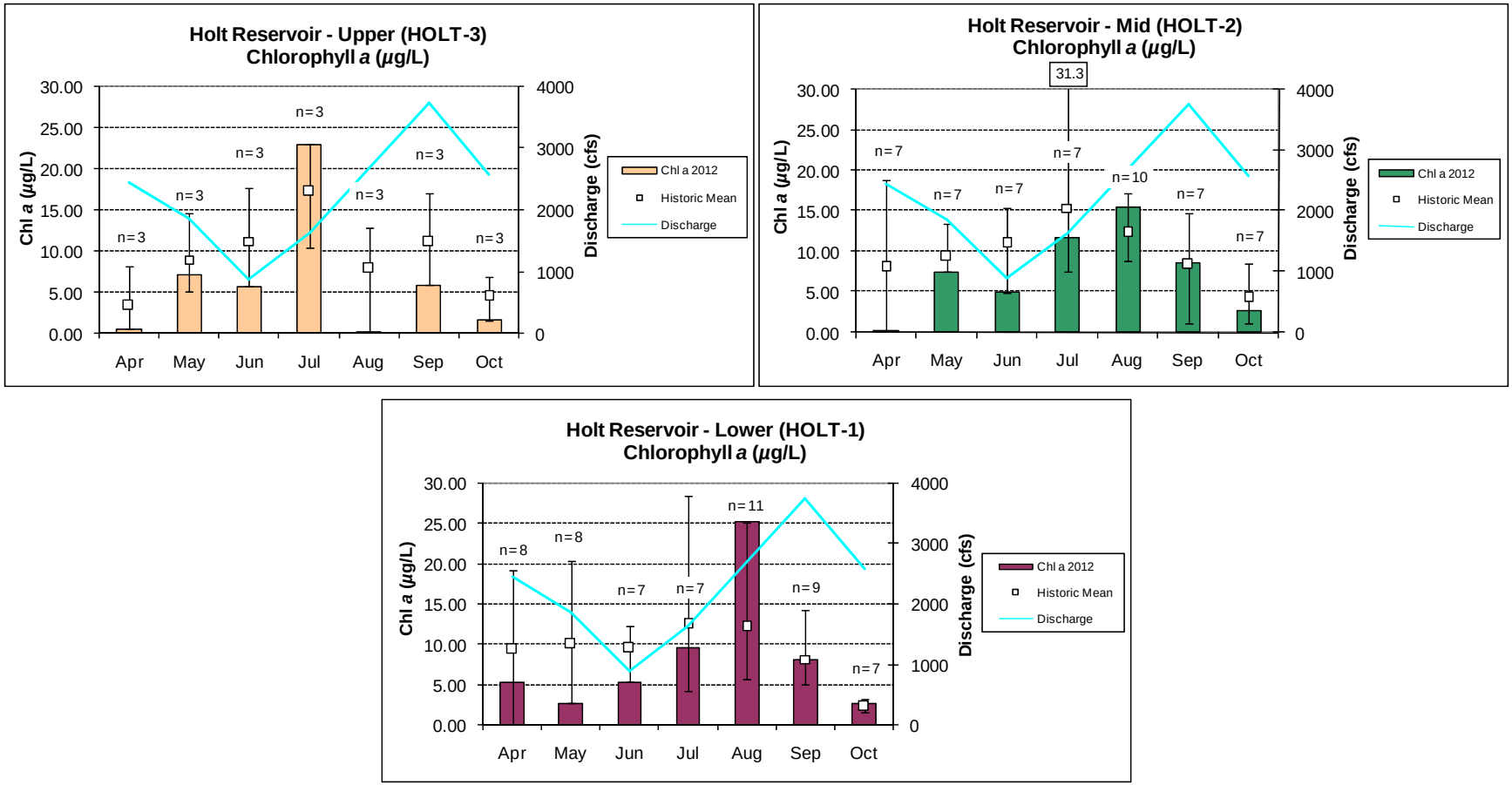


Figure 10. Monthly TSS concentrations measured in Oliver Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at USGS gage 02465000, Black Warrior R at Northport AL. Each bar graph depicts monthly changes in each station. The historic mean (1991-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

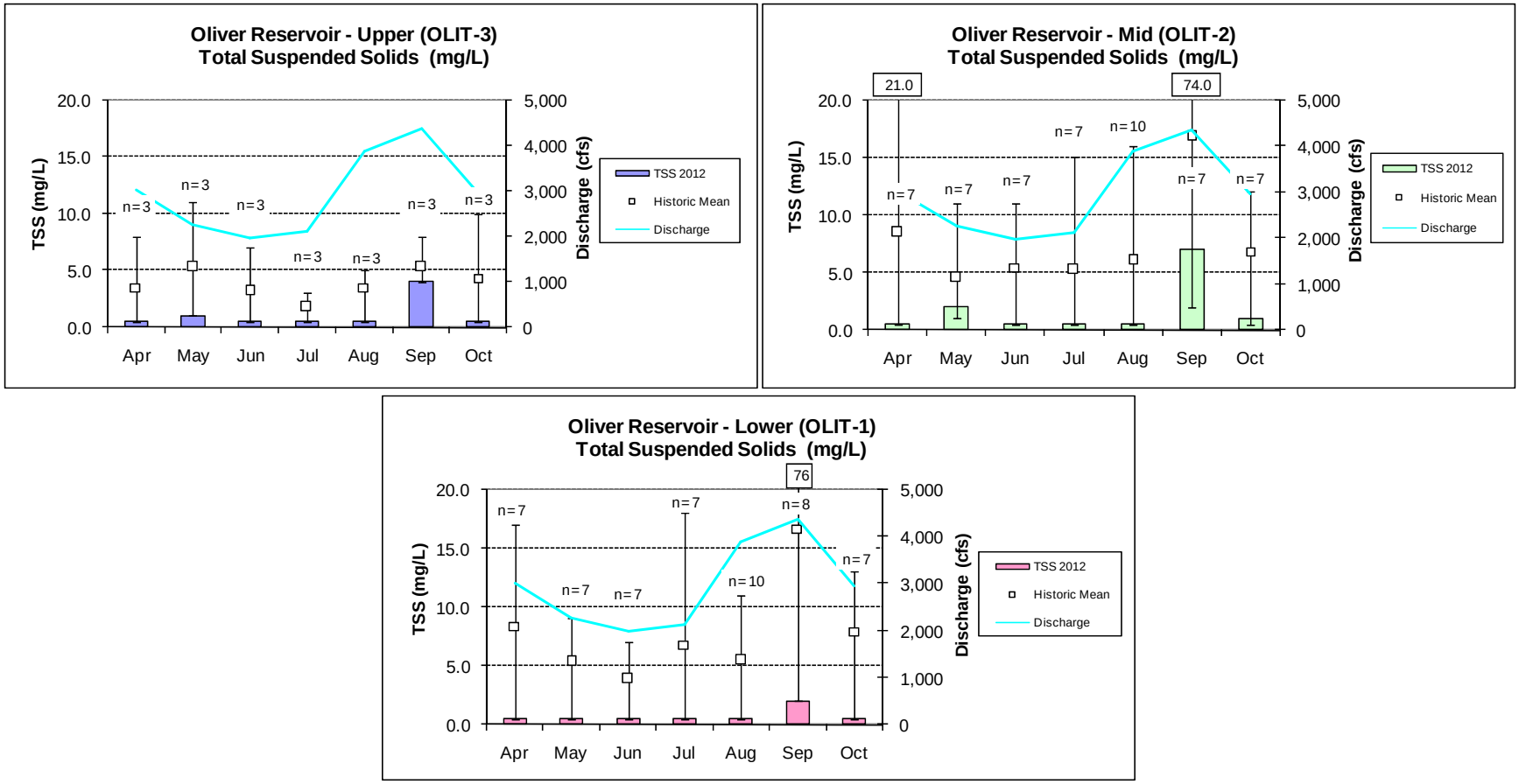


Figure 11. Monthly TSS concentrations measured in Holt Reservoir, April-October, 2012, vs. average monthly discharge. Discharge measured at Holt L&D, provided by APCO. Each bar graph depicts monthly changes in each station. The historic mean (1992-2012) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.

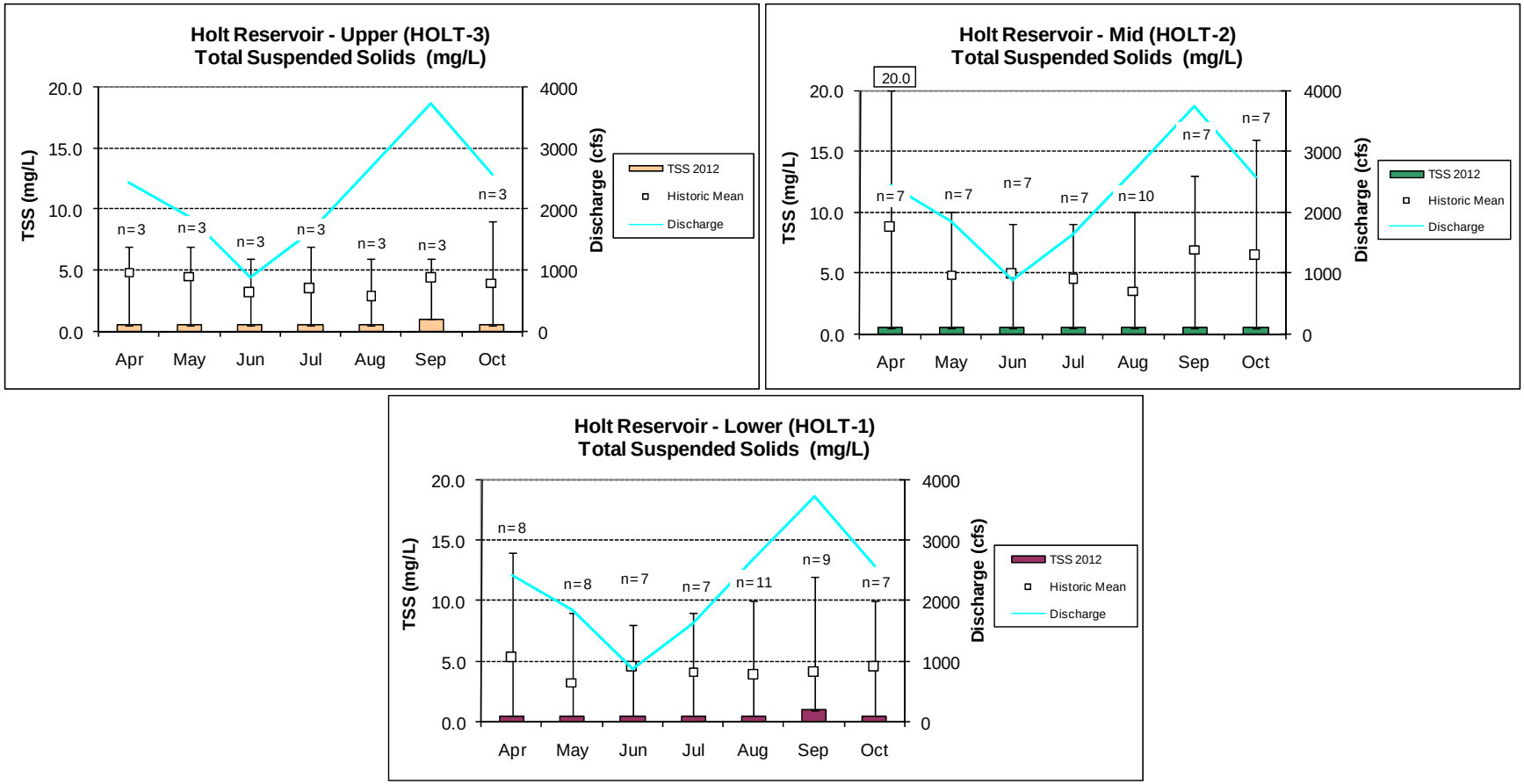
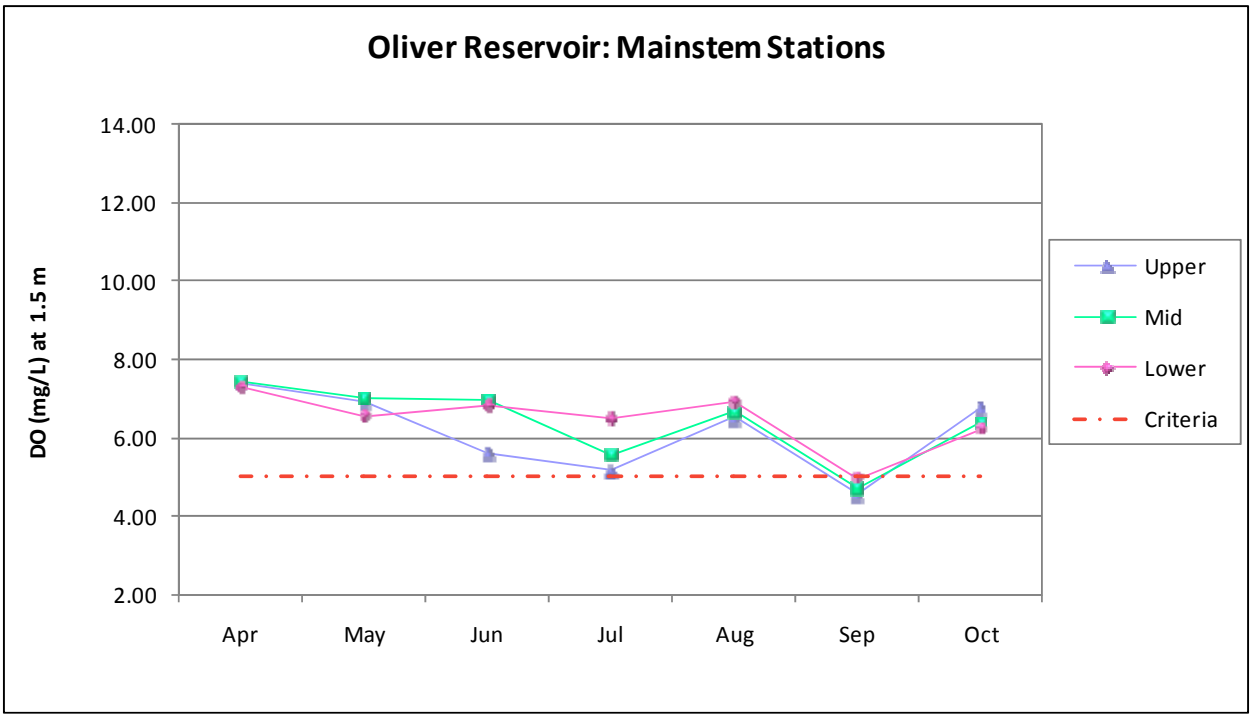


Table 2. Algal growth potential test results, Oliver and Holt Reservoirs, 1998-2012, (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers (Raschke and Schultz 1987).

Station	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
August 2012	28.35	Non-Limiting	23.97	Non-Limiting	6.78	Nitrogen	7.59	Co-limiting	9.01	Phosphorus	8.16	Co-limiting

Figure 12. Monthly DO concentrations at 1.5 m (5 ft) for Oliver and Holt Reservoir stations collected April-October, 2012. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/L at this depth (ADEM 2005).



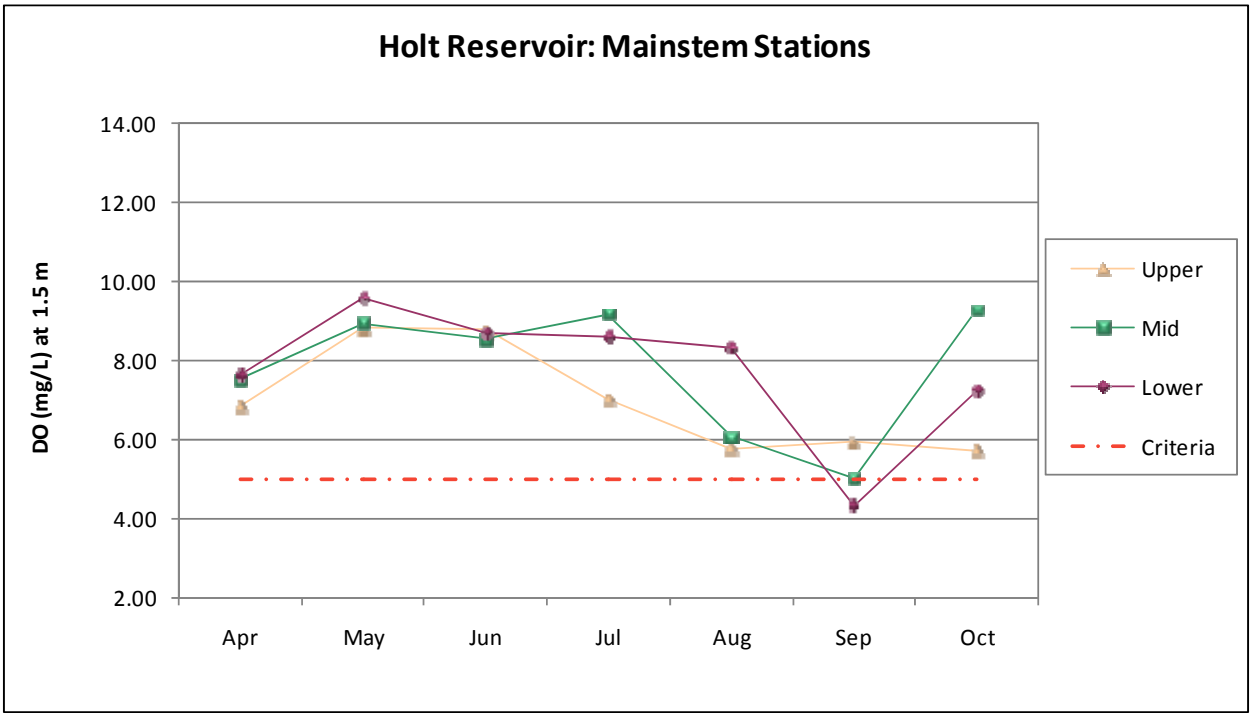


Figure 13. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C) and conductivity (umhos) in the lower Oliver Reservoir station, April-October, 2012.

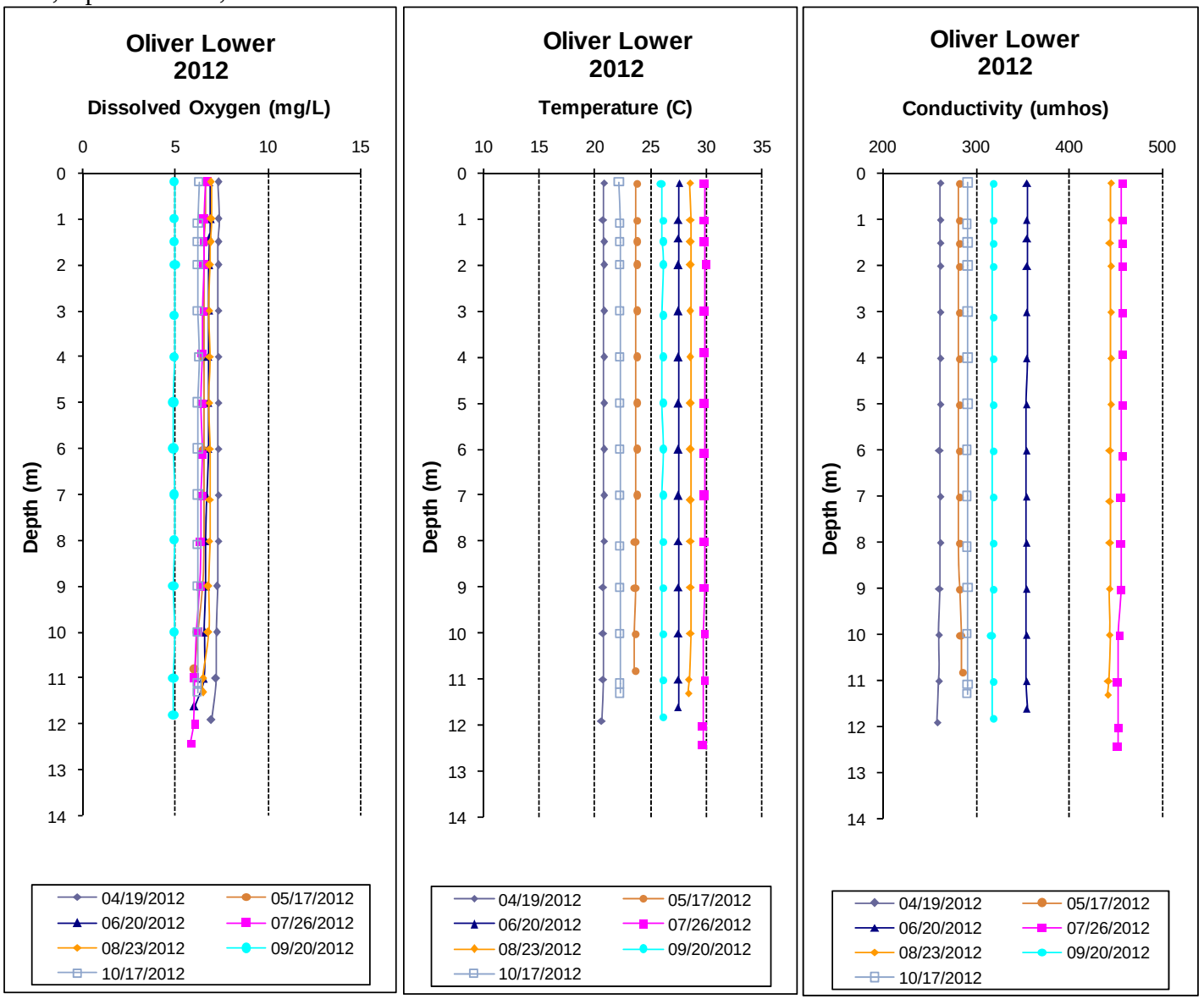


Figure 14. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C) and conductivity (umhos) in the upper Oliver Reservoir station, April-October, 2012.

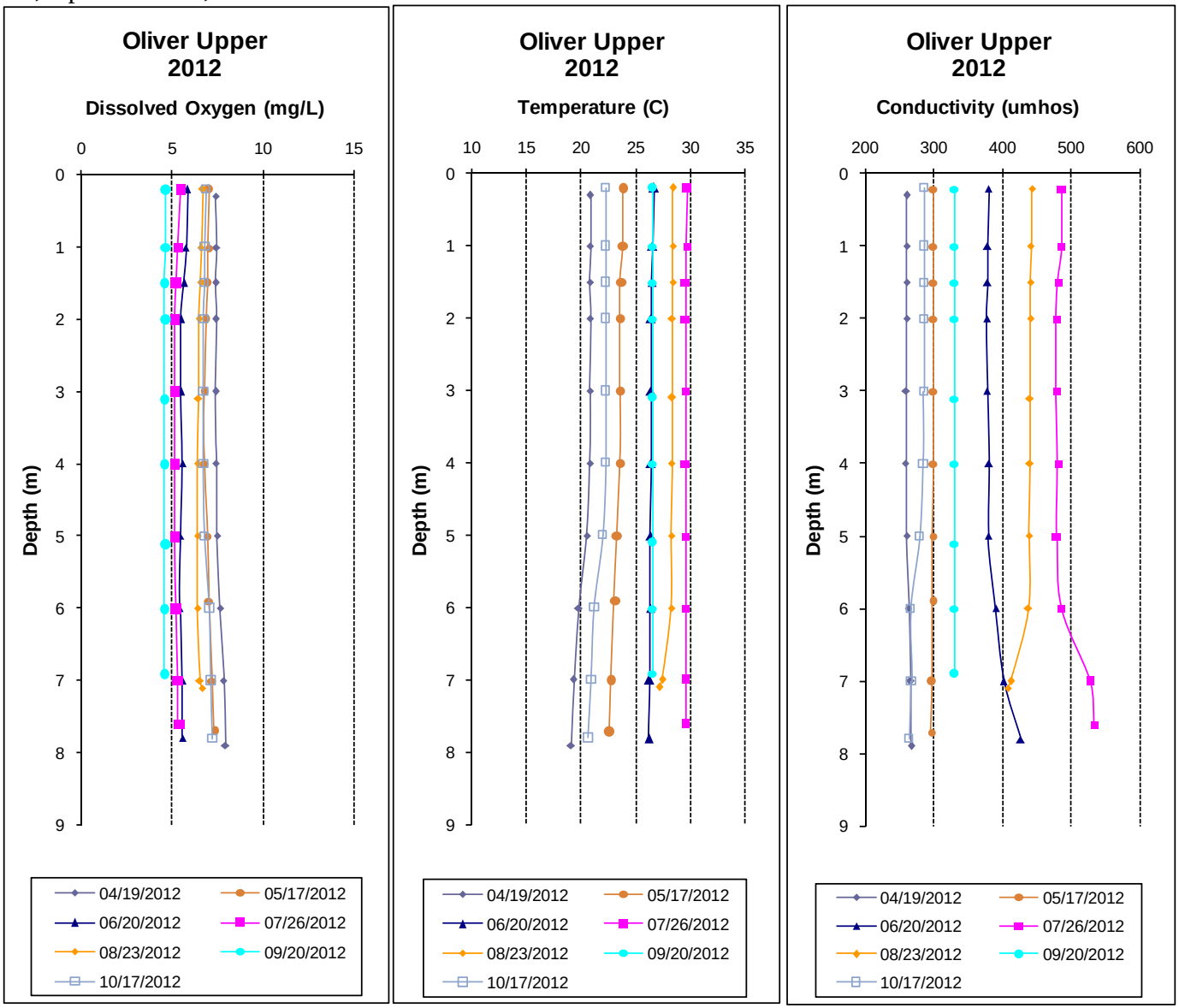


Figure 15. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C) and conductivity (umhos) in the lower Holt Reservoir station, April-October, 2012.

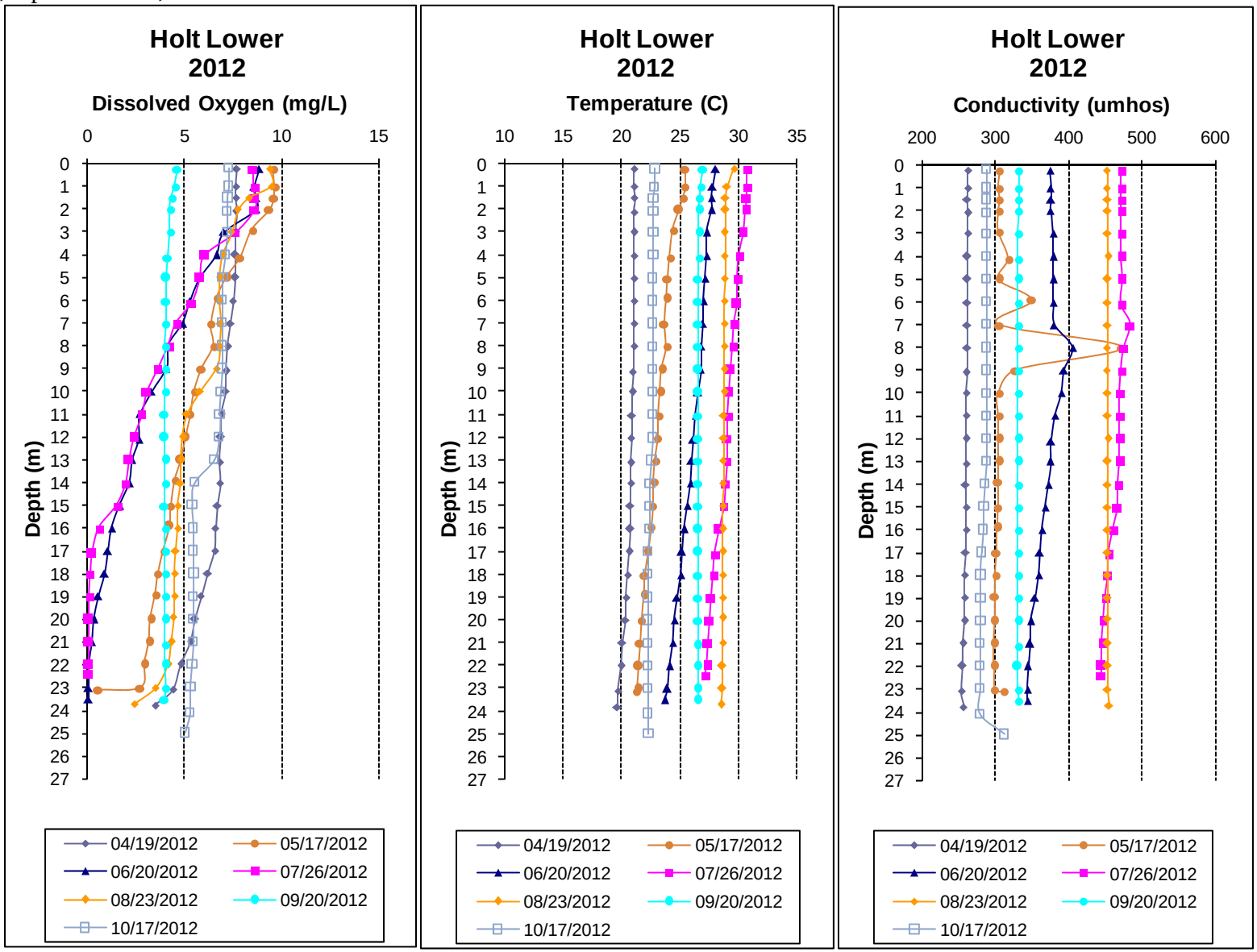


Figure 16. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C) and conductivity (umhos) in the upper Holt Reservoir station, April-October, 2012.

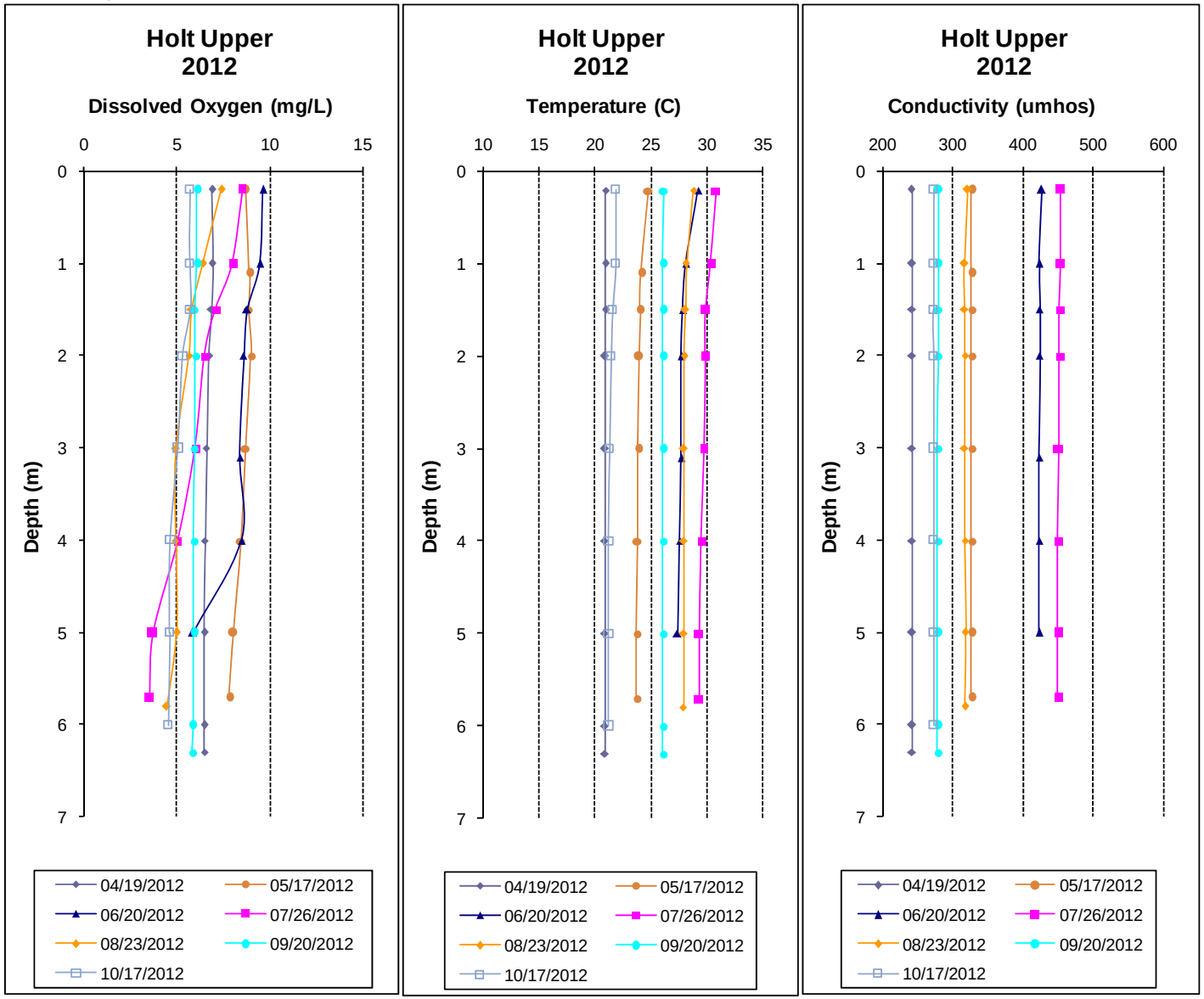
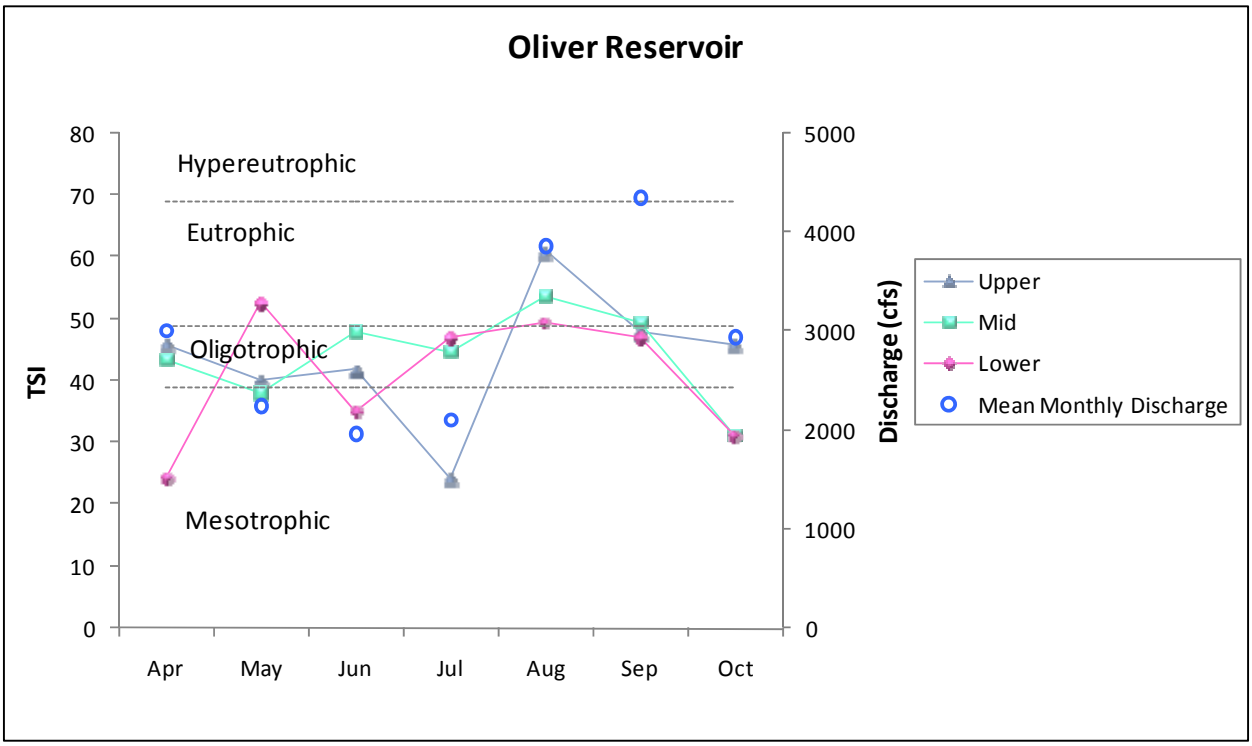
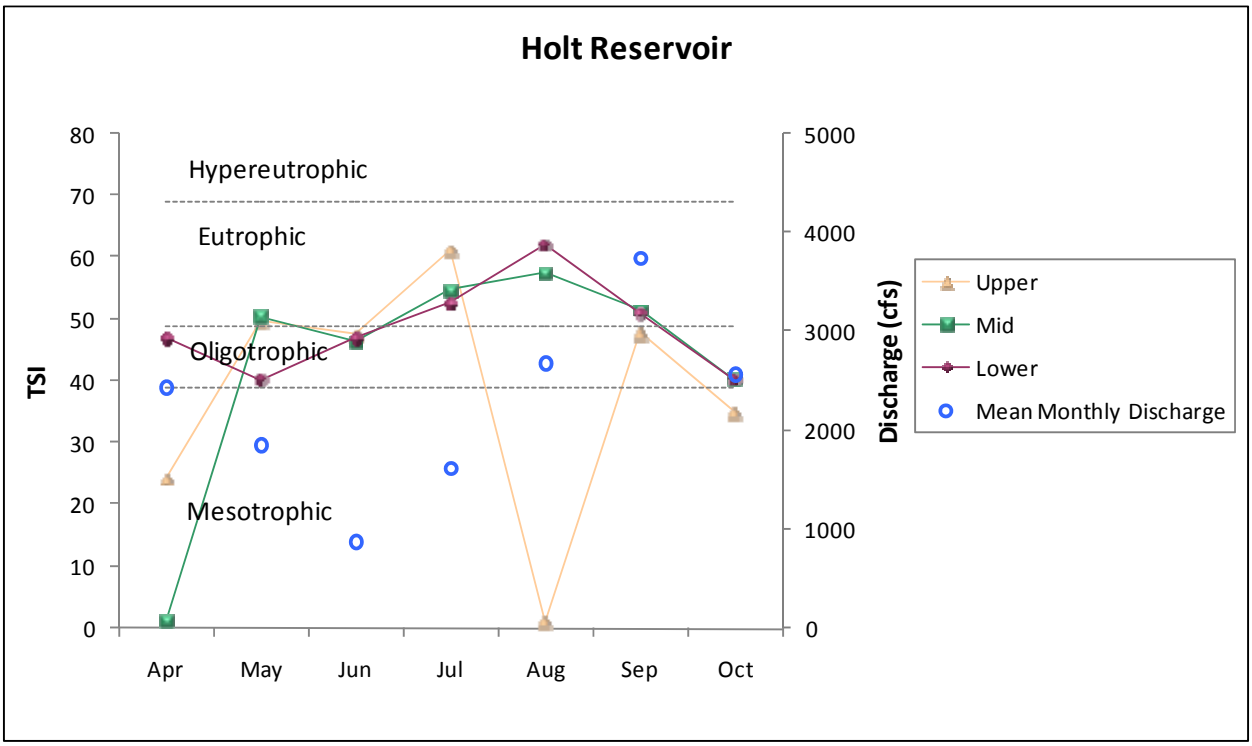


Figure 17. Monthly TSI values calculated for Oliver and Holt Reservoir stations, April-October, 2012, using chl *a* concentrations and Carlson's Trophic State Index calculation. Discharge for Oliver Reservoir measured at USGS gage 02465000, Black Warrior R at Northport AL. Discharge for Holt Reservoir measured at Holt L&D, provided by APCO.





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APPENDIX

Appendix Table 1. Summary of Oliver and Holt Reservoir water quality data collected April-October, 2012. 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
HOLT-1	Physical						
	Turbidity (NTU)	7	2.6	5.3	3.9	3.8	1.0
	Total Dissolved Solids (mg/L)	7	178.0	396.0	208.0	228.6	75.4
	Total Suspended Solids (mg/L)	7	<1.0	1.0	0.5	0.6	0.2
	Hardness (mg/L)	4	85.5	115.0	92.4	96.4	13.5
	Alkalinity (mg/L)	7	51.4	100.0	73.8	74.2	18.7
	Photic Zone (m)	7	3.72	6.03	4.90	5.01	0.83
	Secchi (m)	7	1.06	2.62	1.76	1.79	0.52
	Chemical						
	Ammonia Nitrogen (mg/L)	7	<0.007	0.008	0.004	0.004	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<0.002	0.406	0.249	0.200	0.163
	Total Kjeldahl Nitrogen (mg/L)[J]	7	0.137	0.575	0.302	0.308	0.136
	Total Nitrogen (mg/L)[J]	7	<0.334	0.715	0.492	0.508	0.126
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<0.005	0.014	0.002	0.005	0.004
	Total Phosphorus (mg/L)	7	0.015	0.039	0.025	0.024	0.009
	CBOD-5 (mg/L)[J]	7	<2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	7.4	15.4	10.5	11.3	2.7
	Biological						
	Chlorophyll a (ug/L)	7	2.67	25.10	5.34	8.39	7.80
	E. coli (col/100mL)	3	1	27	12	13	13
HOLT-2	Physical						
	Turbidity (NTU)	7	2.7	5.6	3.7	4.0	1.1
	Total Dissolved Solids (mg/L)	7	168.0	370.0	204.0	222.6	67.1
	Total Suspended Solids (mg/L)	7	<1.0	1.0	0.5	0.5	0.0
	Hardness (mg/L)	4	21.2	133.0	87.6	82.4	46.0
	Alkalinity (mg/L)	7	52.9	104.0	72.9	75.7	17.3
	Photic Zone (m)	7	3.22	5.84	5.25	4.74	1.04
	Secchi (m)	7	1.36	2.63	1.64	1.76	0.43
	Chemical						
	Ammonia Nitrogen (mg/L)[J]	7	<0.008	0.025	0.004	0.009	0.009
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	0.004	0.438	0.294	0.260	0.151
	Total Kjeldahl Nitrogen (mg/L)[J]	7	0.090	0.557	0.267	0.291	0.170
	Total Nitrogen (mg/L)[J]	7	0.409	0.629	0.561	0.551	0.073
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<0.005	0.017	0.002	0.006	0.005
	Total Phosphorus (mg/L)	7	0.016	0.042	0.025	0.027	0.009
	CBOD-5 (mg/L)[J]	7	<2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7	6.7	12.5	10.2	10.1	2.2
	Biological						
	Chlorophyll a (ug/L)	7	<0.10	15.49	7.48	7.28	5.29
	E. coli (col/100mL)	3	<1	<1	<1	<1	0

Station	Parameter	N		Min	Max	Med	Mean	SD
HOLT-3	**Physical**							
	Turbidity (NTU)	7		3.1	3.6	3.3	3.3	0.2
	Total Dissolved Solids (mg/L)	7		148.0	372.0	190.0	210.3	77.6
	Total Suspended Solids (mg/L)	7	<	1.0	1.0	0.5	0.6	0.2
	Hardness (mg/L)	4		10.7	138.0	86.7	80.5	52.5
	Alkalinity (mg/L)	7		54.1	108.0	66.9	75.3	18.9
	Photic Zone (m)	7		3.44	5.50	4.72	4.41	0.78
	Secchi (m)	7		1.31	1.98	1.71	1.66	0.24
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.008	0.004	0.004	0.000
	Nitrate+Nitrite Nitrogen (mg/L)	7	<	0.002	0.505	0.367	0.299	0.185
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.076	0.717	0.391	0.415	0.231
	Total Nitrogen (mg/L)	7	<	0.503	0.843	0.747	0.714	0.112
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.009	0.005	0.005	0.003
	Total Phosphorus (mg/L)	7		0.022	0.040	0.029	0.029	0.007
	CBOD-5 (mg/L)[J]	7	<	2.0	2.2	1.0	1.2	0.4
	Chlorides (mg/L)	7		5.2	10.2	8.3	8.0	1.7
	Biological							
	Chlorophyll a (ug/L)	7	<	0.10	22.96	5.72	6.26	7.89
	E. coli (col/100mL)	3		<1	5	1	2	2
OLIT-1	**Physical**							
	Turbidity (NTU)	7		4.3	7.6	5.9	5.8	1.0
	Total Dissolved Solids (mg/L)	7		168.0	360.0	184.0	215.4	68.2
	Total Suspended Solids (mg/L)	7	<	1.0	2.0	0.5	0.7	0.6
	Hardness (mg/L)	4		84.1	125.0	98.8	101.6	18.6
	Alkalinity (mg/L)	7		50.0	97.5	69.0	70.5	17.9
	Photic Zone (m)	7		2.43	4.29	4.03	3.68	0.70
	Secchi (m)	7		0.61	1.54	1.49	1.34	0.33
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.008	0.004	0.004	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7		0.014	0.426	0.249	0.231	0.162
	Total Kjeldahl Nitrogen (mg/L)	7		0.152	0.550	0.388	0.358	0.155
	Total Nitrogen (mg/L)[J]	7		0.454	0.895	0.525	0.589	0.154
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.012	0.002	0.005	0.004
	Total Phosphorus (mg/L)	7		0.015	0.030	0.019	0.020	0.005
	CBOD-5 (mg/L)[J]	7	<	2.0	2.4	1.0	1.2	0.5
	Chlorides (mg/L)	7		7.2	15.6	9.7	10.9	2.7
	Biological							
	Chlorophyll a (ug/L)	7		0.53	9.61	5.34	4.35	3.40
	E. coli (col/100mL)	3		2	17	11	10	8

Station	Parameter	N		Min	Max	Med	Mean	SD
OLIT-2	**Physical**							
	Turbidity (NTU)	7		3.3	7.5	4.5	4.8	1.5
	Total Dissolved Solids (mg/L)	7		154.0	360.0	186.0	211.1	72.8
	Total Suspended Solids (mg/L)	7	<	1.0	7.0	0.5	1.7	2.4
	Hardness (mg/L)	4		80.2	132.0	99.8	103.0	23.0
	Alkalinity (mg/L)	7		47.2	106.0	69.6	71.3	22.5
	Photic Zone (m)	7		2.69	4.76	4.05	3.88	0.70
	Secchi (m)	7		1.00	1.92	1.55	1.51	0.31
	Chemical							
	Ammonia Nitrogen (mg/L)[J]	7	<	0.007	0.018	0.004	0.006	0.005
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.026	0.383	0.243	0.220	0.139
	Total Kjeldahl Nitrogen (mg/L)[J]	7		0.059	0.545	0.334	0.309	0.177
	Total Nitrogen (mg/L)[J]	7		0.362	0.717	0.475	0.529	0.140
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.013	0.002	0.005	0.004
	Total Phosphorus (mg/L)	7		0.013	0.038	0.019	0.020	0.009
	CBOD-5 (mg/L)[J]	7	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7		6.8	15.8	10.1	10.8	3.0
	Biological							
	Chlorophyll a (ug/L)	7		1.07	10.68	4.27	4.96	3.23
	E. coli (col/100mL)	3		4	5	5	5	1
OLIT-3	**Physical**							
	Turbidity (NTU)	7		3.0	6.5	5.3	5.1	1.3
	Total Dissolved Solids (mg/L)	7		190.0	312.0	198.0	216.9	44.7
	Total Suspended Solids (mg/L)	7	<	1.0	4.0	0.5	1.1	1.3
	Hardness (mg/L)	4		84.4	121.0	100.4	101.6	18.2
	Alkalinity (mg/L)	7		49.6	95.8	72.3	71.4	18.4
	Photic Zone (m)	7		2.83	4.92	3.82	3.91	0.77
	Secchi (m)	7		1.06	2.42	1.48	1.55	0.44
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.007	0.022	0.004	0.006	0.007
	Nitrate+Nitrite Nitrogen (mg/L)	7		0.028	0.401	0.245	0.234	0.142
	Total Kjeldahl Nitrogen (mg/L)[J]	7		0.091	0.554	0.352	0.309	0.155
	Total Nitrogen (mg/L)[J]	7		0.392	0.955	0.527	0.544	0.193
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.005	0.014	0.002	0.005	0.004
	Total Phosphorus (mg/L)	7		0.013	0.033	0.024	0.022	0.007
	CBOD-5 (mg/L)[J]	7	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7		7.1	16.0	10.1	11.0	2.9
	Biological							
	Chlorophyll a (ug/L)	7		0.53	22.43	4.81	6.33	7.31
	E. coli (col/100mL)	3		3	46	11	20	23

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