2010 Jordan Reservoir Report

Rivers and Reservoirs Monitoring Program

Alabama Department of Environmental Management

Field Operations Division
Environmental Indicators Section
Aquatic Assessment Unit
December 2012

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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
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

Jordan Reservoir is a 6,800 acre impoundment of the Coosa River located about 20 miles north of Montgomery in central Alabama. The reservoir is created by two dams: Jordan dam, completed in 1928, and Bouldin dam, completed in 1967 to increase generating capacity. The reservoir is managed by the Alabama Power Company (APCO) for hydroelectric power generation and recreation.

The Alabama Department of Environmental Management (ADEM) monitored Jordan Reservoir as part of the 2010 assessment of the Alabama, Coosa, and Tallapoosa River (ACT) 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 2010, the ADEM implemented a specific water quality criterion for nutrient management at the lower Jordan Reservoir station, which has been monitored by ADEM since 1990. This criterion represents the maximum growing season mean (April-October) chlorophyll *a* (chl *a*) concentration allowable while still fully supporting Jordan Reservoir's Swimming and Fish & Wildlife (S, F&W) use classifications.

The purpose of this report is to summarize data collected at five stations in Jordan Reservoir during the 2010 growing season and to evaluate growing season trends in lake trophic status and nutrient concentrations using ADEM's fourteen-year dataset. Monthly and/or mean concentrations of nutrients [total nitrogen (TN); total phosphorus (TP)], algal biomass/productivity [chl *a*; algal growth potential testing (AGPT)], sediment [total suspended solids (TSS)], and trophic state [Carlson's trophic state index (TSI)] were compared to ADEM's historical data and established criteria.

METHODS

Sampling stations were selected using historical data and previous assessments (Fig. 1). Specific location information can be found in Table 1. Jordan Reservoir was sampled in the dam forebay and upper reservoir. Three tributary embayment stations were also monitored, Shoal Creek, Weoka Creek and Sofkahatchee Creek.

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 2010), Surface Water Quality Assurance Project Plan (ADEM 2008), 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 APCO flow data and ADEM's previously collected data to help interpret the 2010 results.

Figure 1. Jordan Reservoir with 2010 sampling locations.

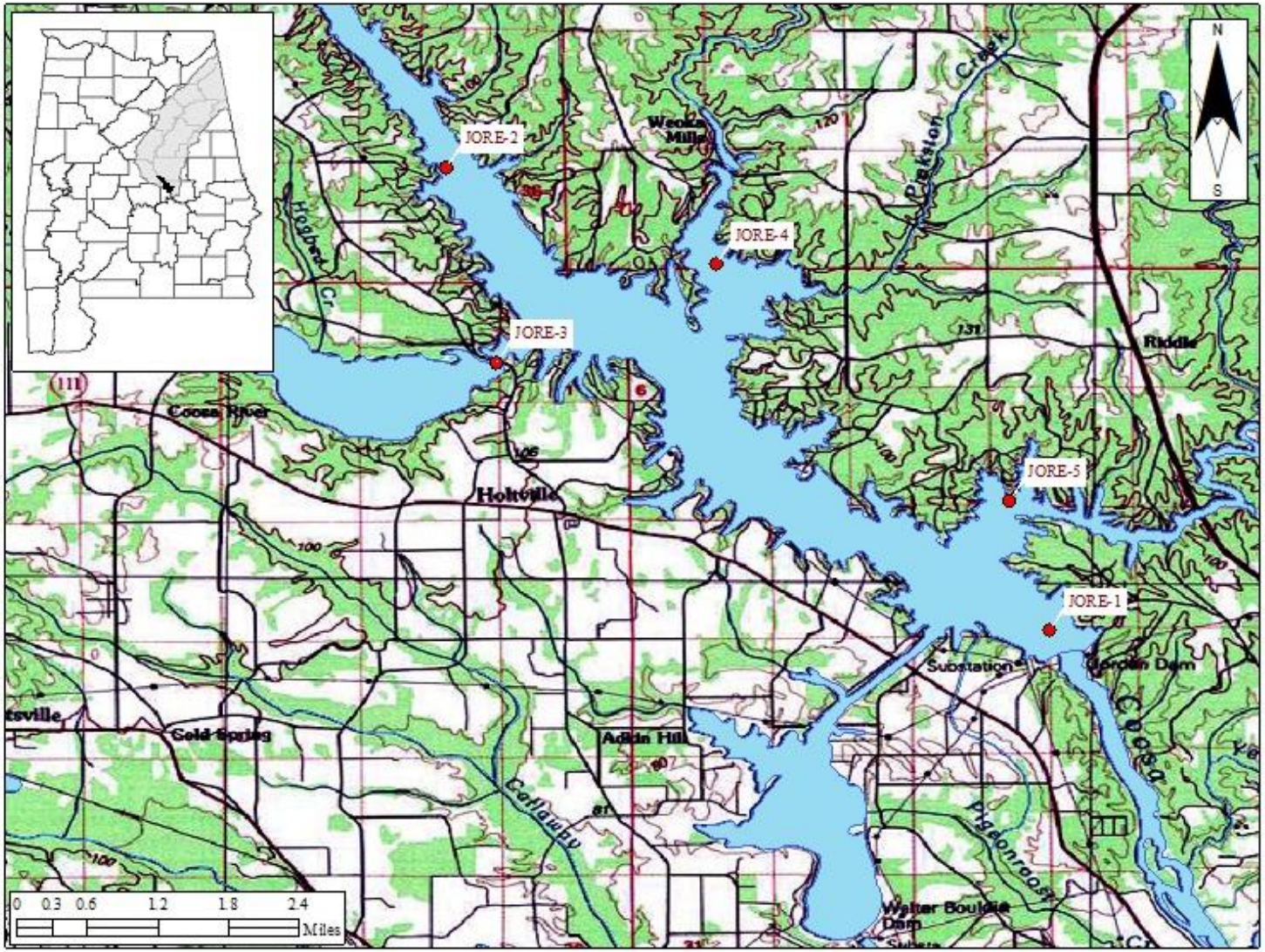


Table 1. Descriptions of the 2010 monitoring stations in Jordan Reservoir.

HUC	County	Station Number	Report Designation	Waterbody	Station Description	Chl *a* Criteria	Latitude	Longitude
031501070906	Elmore	JORE-1*	Lower	Coosa R	Deepest point, main river channel, dam forebay.	14 ug/L	32.6213	-86.2595
031501070906	Elmore	JORE-2	Upper	Coosa R	Deepest point, main river channel, upstream of Weoka Ck / Coosa River confluence.		32.6783	-86.3338
031501070902	Elmore	JORE-3	Shoal Ck	Shoal Ck	Deepest point, main creek channel, Shoal Ck embayment, immediately upstream of Elmore Co. Rd. 23 bridge.		32.6542	-86.3277
031501070904	Elmore	JORE-4	Weoka Ck	Weoka Ck	Deepest point, main creek channel, Weoka Ck embayment, approximately 0.5 miles upstream of lake confluence.		32.6664	-86.3006
031501070905	Elmore	JORE-5	Sofkahatchee Ck	Sofkahatchee Ck	Deepest point, main creek channel, Sofkahatchee Ck embayment, approximately 0.5 miles upstream of lake confluence.		32.6372	-86.2645

*Growing season mean chl *a* criteria implemented at this station in 2010.

RESULTS

Growing season mean graphs for TN, TP, chl *a*, and TSS are provided in this section (Figs. 2 and 3). Monthly graphs for TN, TP, chl *a*, TSS, DO, and TSI are also provided (Figs. 4-8 and 11). Mean monthly discharge is included in monthly graphs for TN, TP, chl *a*, TSS, and TSI as an indicator of flow and retention time in the months sampled. AGPT results appear in Table 2. Depth profile graphs of temperature, DO, and conductivity appear in Figures 9 and 10. Summary statistics of all data collected during 2010 are presented in Appendix Table 1. The table contains the minimum, maximum, median, mean, and standard deviation of each parameter analyzed.

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

In 2010 mean growing season TN values in Jordan Reservoir mainstem stations were higher in the upper station than the lower (Fig. 2). Mean growing season TN values have shown an overall increase in the upper and lower mainstem stations and the Shoal Creek embayment station. Values in the Weoka Creek and Sofkahatchee Creek stations have been variable. During a high flow period in May a historic high TN concentration was measured in the upper station (Fig. 4). All other monthly TN concentrations were within the range of previous values.

In 2010 mean growing season TP values in Jordan Reservoir mainstem stations were higher in the upper station than the lower (Fig. 2). Mean growing season TP values in Jordan Reservoir mainstem stations have generally declined since monitoring began. Values in the tributary stations have varied. Monthly TP concentrations in the lower and upper stations were below historic means all months monitored (Fig. 5). Highest monthly TP concentrations in the lower and upper stations were measured in May during a high flow period. Historic low TP concentrations were measured in the lower and upper stations July, September and October.

Specific water quality criterion for nutrient management has been established for the lower station in Jordan Reservoir. The growing season mean chl *a* value calculated in the lower

station during 2010 was in compliance with the criteria limit (Fig. 3). Mean growing season chl *a* values in all Jordan Reservoir mainstem and tributary embayment stations monitored were the lowest since monitoring began and have declined overall at most locations in the years monitored. A historic high concentration was measured in May in the upper station during a high flow period (Fig. 6). Historic low chl *a* concentrations were measured in the lower station in April, June and September and in the upper station in June and July.

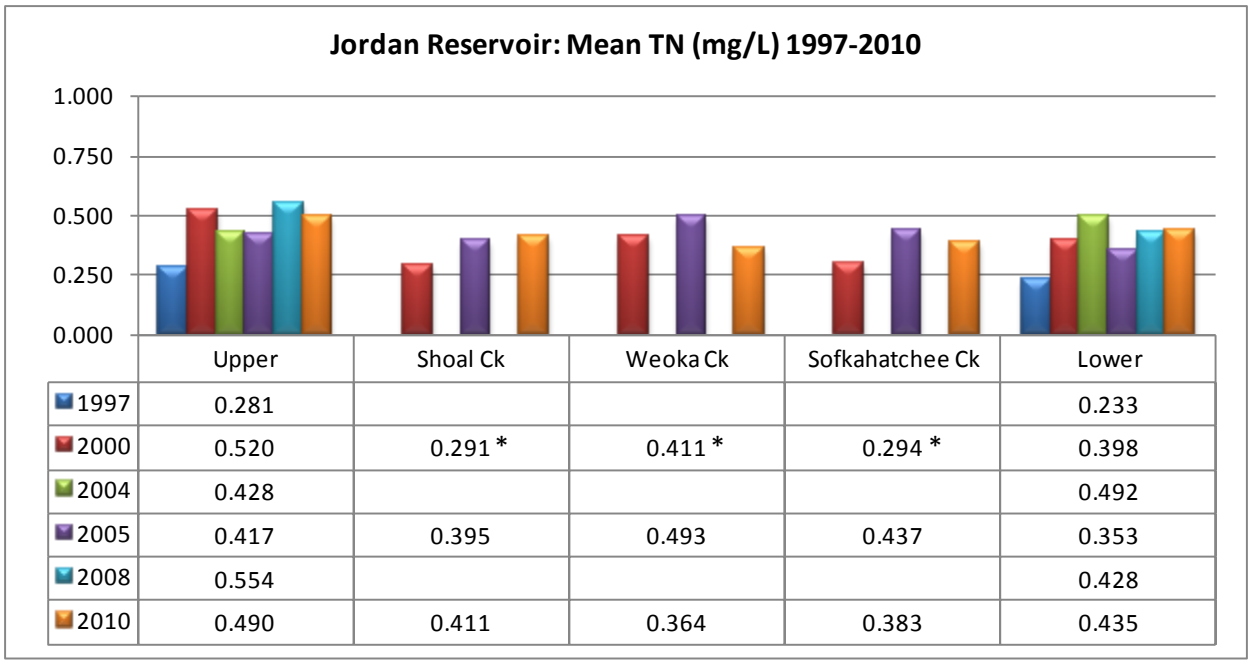
With the exception of the lower station, mean growing season TSS values in all Jordan Reservoir stations were the lowest since monitoring began in 1997 and have declined overall in the years monitored (Fig. 3). Historic low TSS concentrations were measured in the lower and upper stations during June, July and September (Fig. 7). Historic low TSS concentrations were measured in the lower station in April and August as well.

AGPT results for Jordan Reservoir have varied between phosphorus limited and nitrogen limited in the years monitored (Table 2). With the exception of 1997, MSC values in the lower and upper stations have remained below 5.0 mg/L, the value that Raschke et al. (1996) defined as protective of reservoir and lake systems.

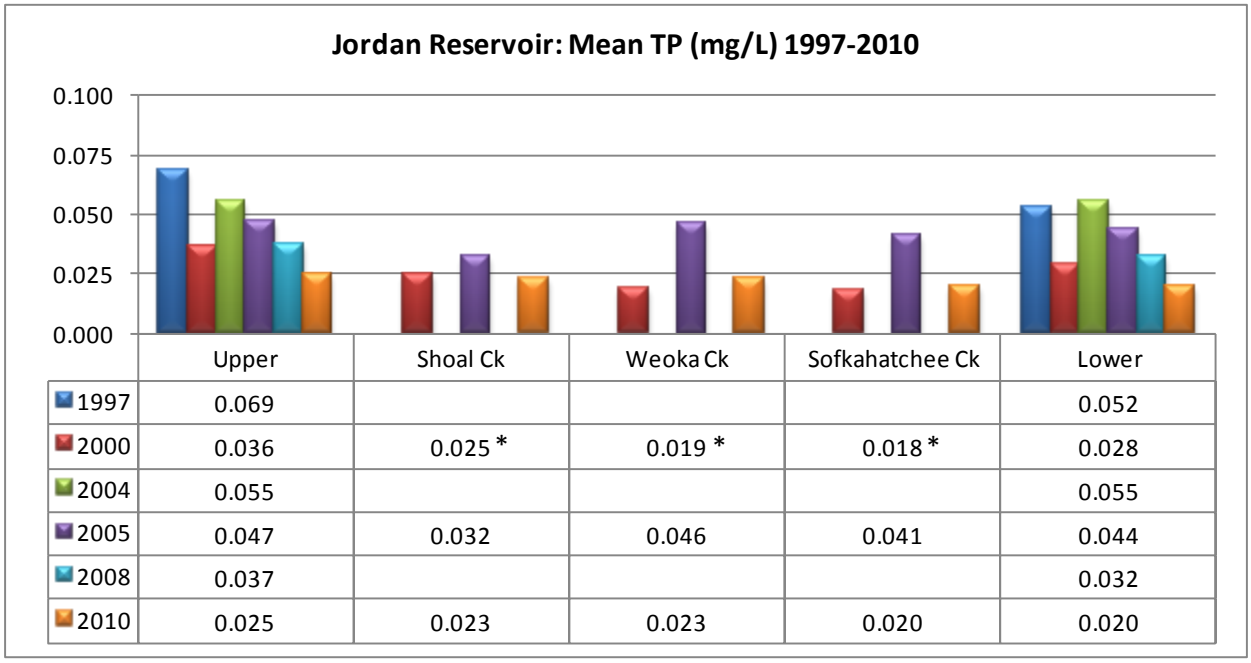
All measurements of dissolved oxygen (DO) concentrations in Jordan Reservoir mainstem and tributary stations were above the ADEM Criteria (ADEM Admin. Code R. 335-6-10-.09) limit of 5.0 mg/L at 5.0 ft (1.5 m) (Fig. 8). However, DO concentrations in the lower station were below 5.0 mg/L at depths greater than 3 m during the June and September station visits (Fig. 9).

Monthly TSI values were calculated using monthly chl *a* concentrations and Carlson's Trophic State Index. TSI values calculated for the lower Jordan Reservoir station were oligotrophic in April and eutrophic May through October (Fig. 11). TSI values in the upper station varied between oligotrophic and eutrophic throughout the growing season. All Jordan Reservoir tributary stations monitored were mesotrophic in April and eutrophic most other months monitored.

Figure 2. Mean growing season TN and TP measured in Jordan Reservoir, April-October, 1997-2010. Stations are illustrated from upstream to downstream as the graph is read from left to right.



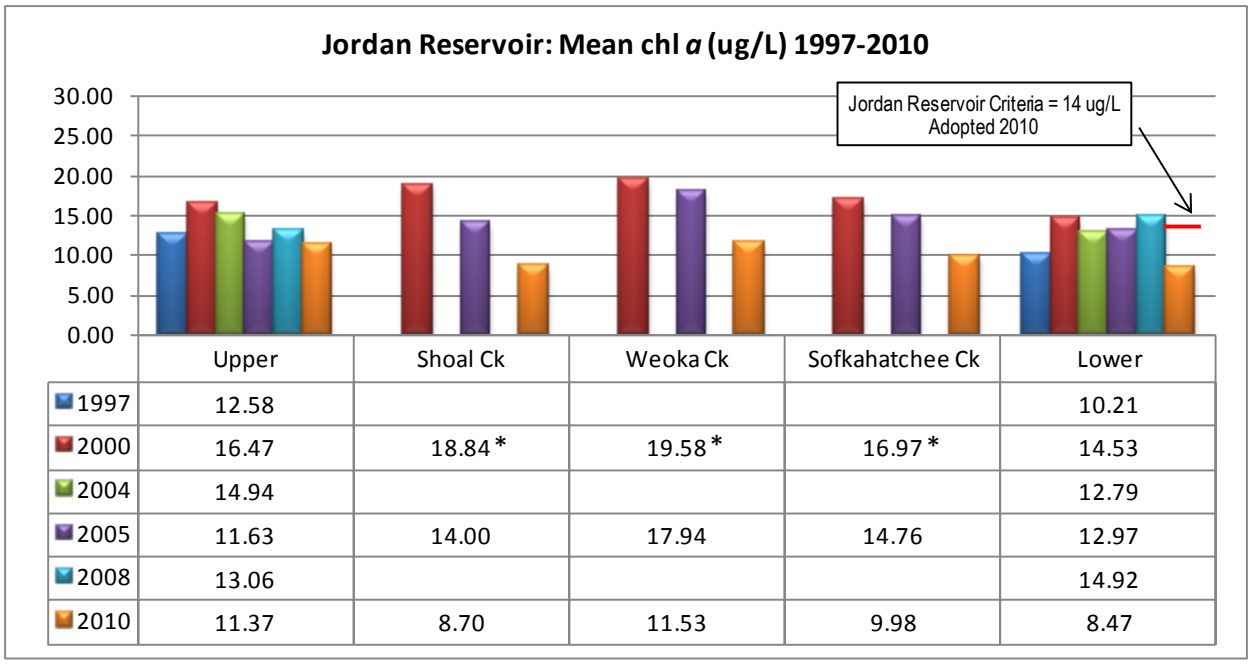
	Upper	Shoal Ck	Weoka Ck	Sofkahatchee Ck	Lower
1997	0.281				0.233
2000	0.520	0.291 *	0.411 *	0.294 *	0.398
2004	0.428				0.492
2005	0.417	0.395	0.493	0.437	0.353
2008	0.554				0.428
2010	0.490	0.411	0.364	0.383	0.435



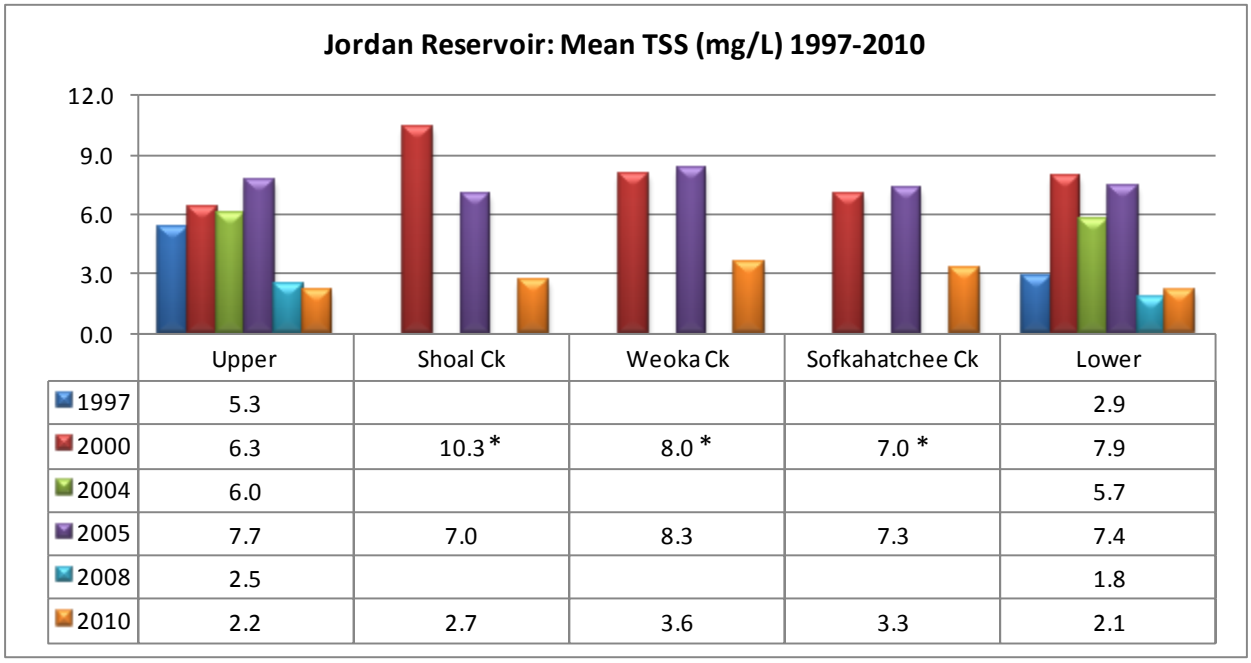
	Upper	Shoal Ck	Weoka Ck	Sofkahatchee Ck	Lower
1997	0.069				0.052
2000	0.036	0.025 *	0.019 *	0.018 *	0.028
2004	0.055				0.055
2005	0.047	0.032	0.046	0.041	0.044
2008	0.037				0.032
2010	0.025	0.023	0.023	0.020	0.020

*Mean of April/June/August only.

Figure 3. Mean growing season chl *a* and TSS measured in Jordan Reservoir, April-October, 1997-2010. 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 station.



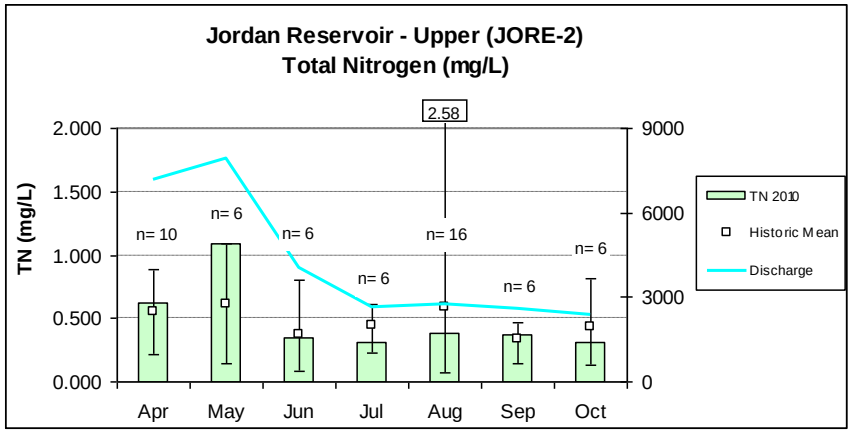
	Upper	Shoal Ck	Weoka Ck	Sofkahatchee Ck	Lower
1997	12.58				10.21
2000	16.47	18.84*	19.58*	16.97*	14.53
2004	14.94				12.79
2005	11.63	14.00	17.94	14.76	12.97
2008	13.06				14.92
2010	11.37	8.70	11.53	9.98	8.47



	Upper	Shoal Ck	Weoka Ck	Sofkahatchee Ck	Lower
1997	5.3				2.9
2000	6.3	10.3*	8.0*	7.0*	7.9
2004	6.0				5.7
2005	7.7	7.0	8.3	7.3	7.4
2008	2.5				1.8
2010	2.2	2.7	3.6	3.3	2.1

*Mean of April/June/August only.

Figure 4. Monthly TN concentrations measured in Jordan Reservoir, April-October 2010 vs. average monthly discharge. Discharge provided by APCO. Each bar graph depicts monthly changes in each station. The historic mean (1990-2010) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.



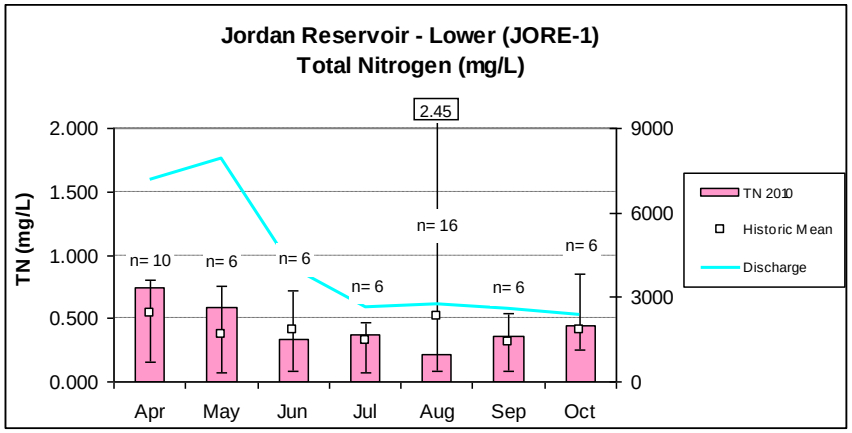
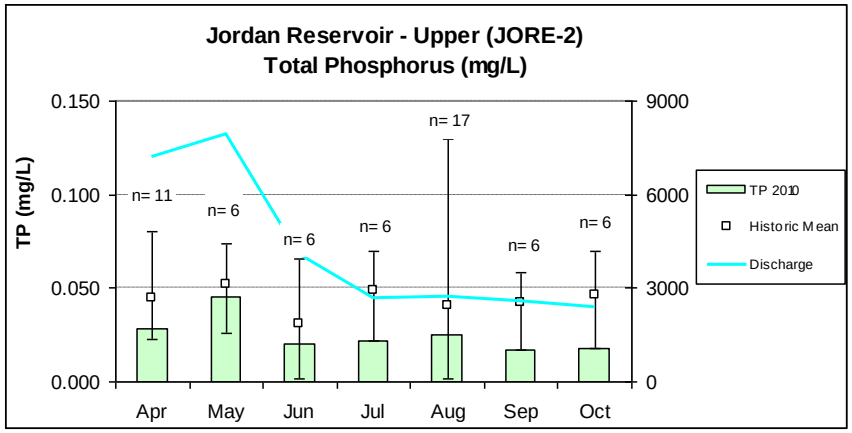


Figure 5. Monthly TP concentrations measured in Jordan Reservoir, April-October 2010 vs. average monthly discharge. Discharge provided by APCO. Each bar graph depicts monthly changes in each station. The historic mean (1990-2010) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.



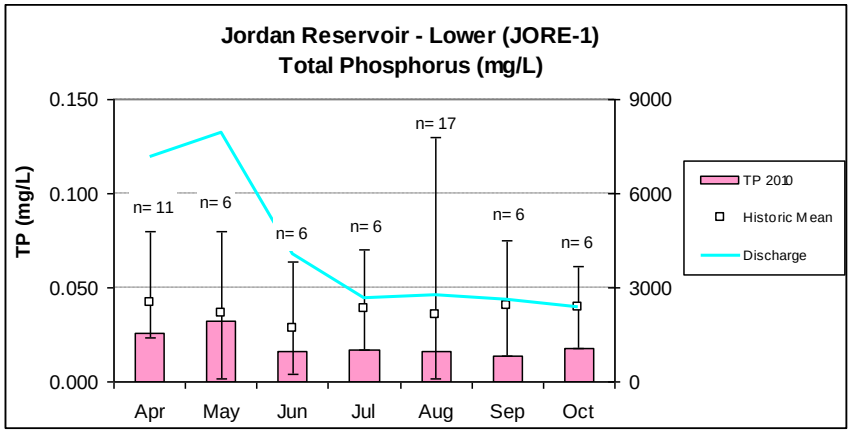
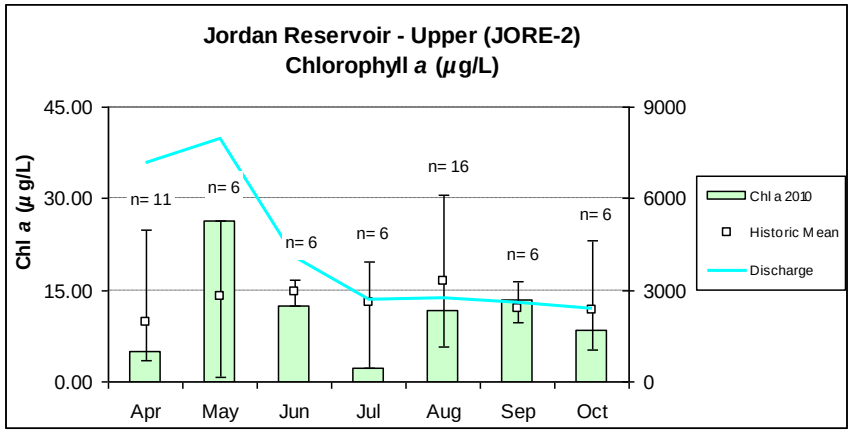


Figure 6. Monthly chl a concentrations measured in Jordan Reservoir, April-October 2010 vs. average monthly discharge. Discharge provided by APCO**.** Each bar graph depicts monthly changes in each station. The historic mean (1990-2010) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.



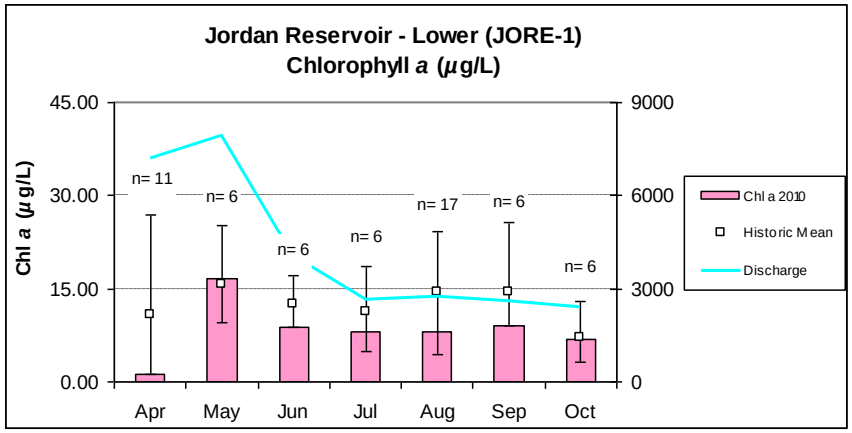
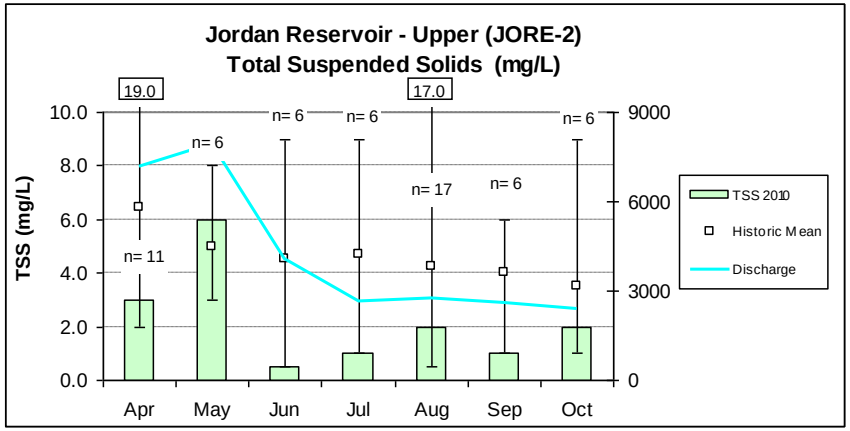


Figure 7. Monthly TSS concentrations measured in Jordan Reservoir, April-October 2010 vs. average monthly discharge. Discharge provided by APCO. Each bar graph depicts monthly changes in each station. The historic mean (1990-2010) and min/max range are also displayed for comparison. The "n" value equals the number of datapoints included in the monthly historic calculations.



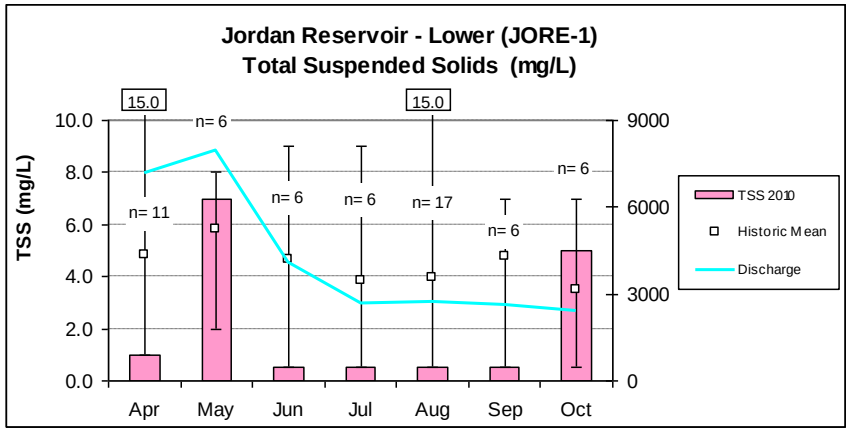
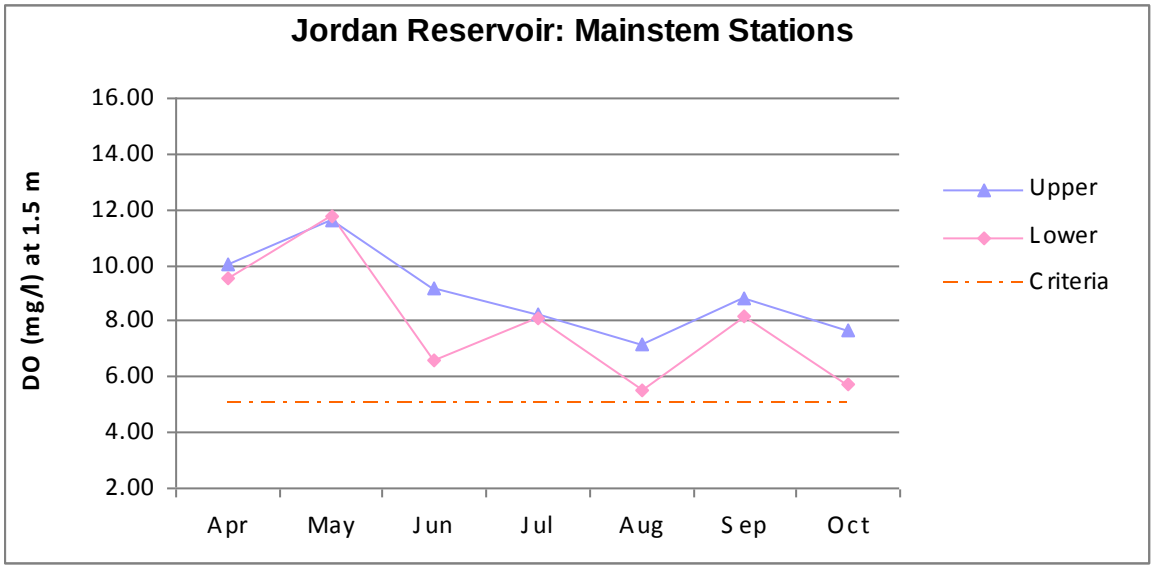


Table 2. Algal growth potential test results, Jordan Reservoir, 1997-2010 (expressed as mean Maximum Standing Crop (MSC) dry weights of Selenastrum capricornutum in mg/L) and limiting nutrient status. MSC values below 5 mg/L are considered to be protective in reservoirs and lakes; values below 20 mg/L MSC are considered protective of flowing streams and rivers. (Raschke and Schultz 1987).

Station	Upper		Lower	
	MSC	Limiting Nutrient	MSC	Limiting Nutrient
August 1997	6.80	Nitrogen	6.28	Phosphorus
August 2000	1.79	Phosphorus	2.41	Phosphorus
August 2005	2.86	Co-limiting	2.74	Nitrogen
August 2010	2.53	Phosphorus	-	-

Figure 8. Monthly DO concentrations at 1.5 m (5 ft) for Jordan Reservoir stations collected April-October 2010. ADEM Water Quality Criteria pertaining to reservoir waters require a DO concentration of 5.0 mg/L at this depth (ADEM 2010).



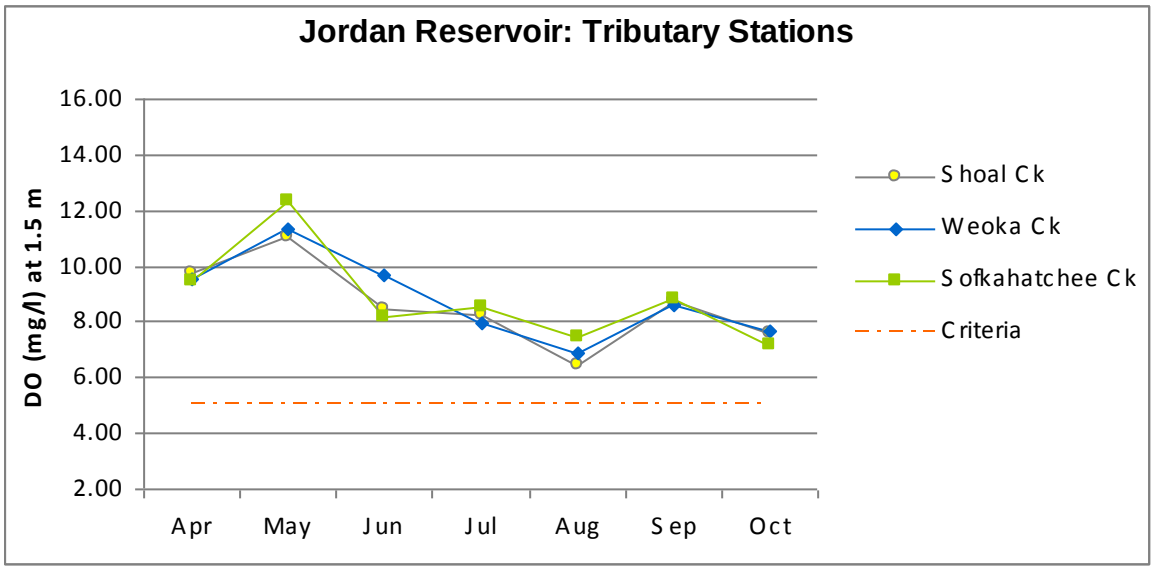


Figure 9. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the lower Jordan Reservoir station, April-October 2010.

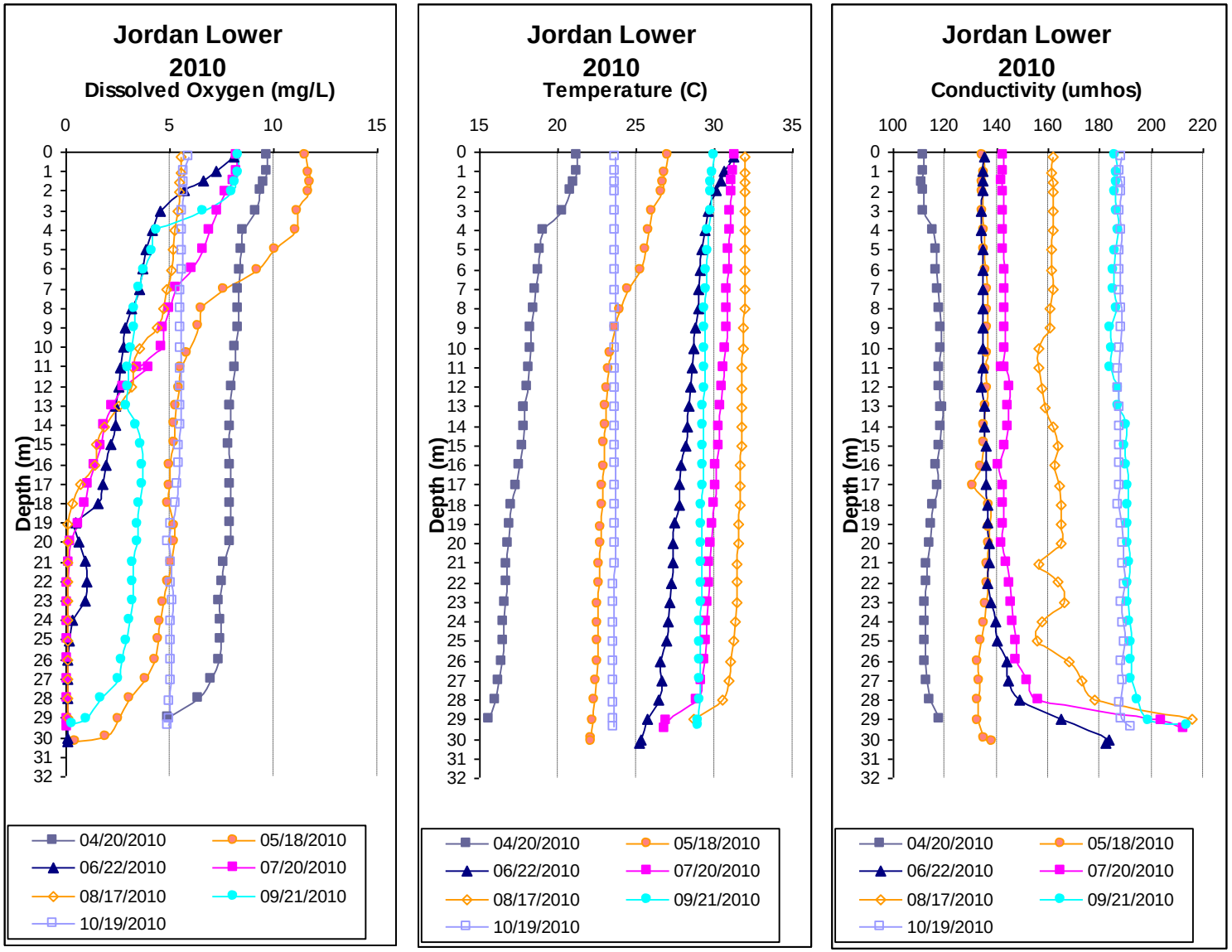


Figure 10. Monthly depth profiles of dissolved oxygen (mg/L), temperature (C), and conductivity (umhos) in the upper Jordan Reservoir station, April-October 2010.

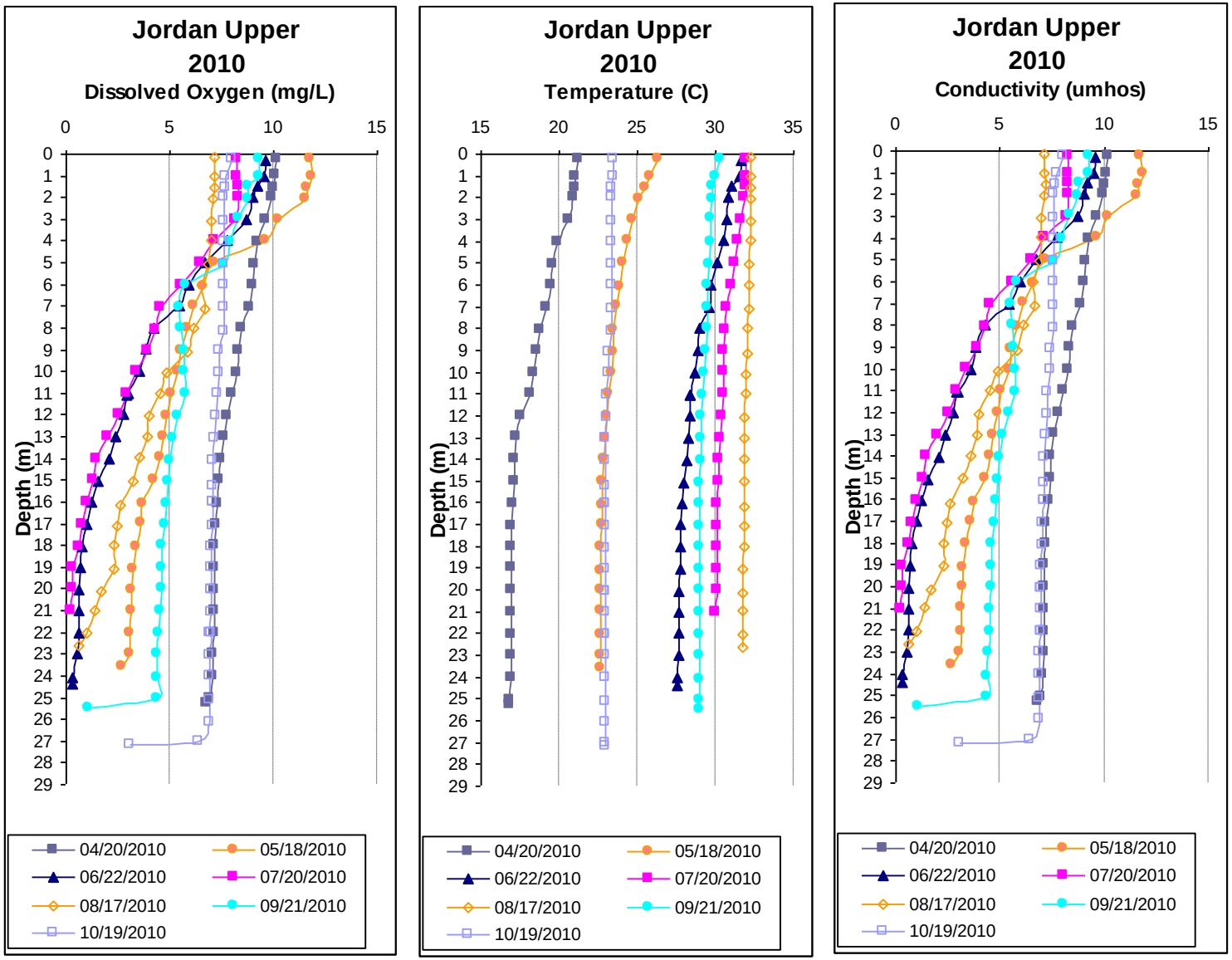
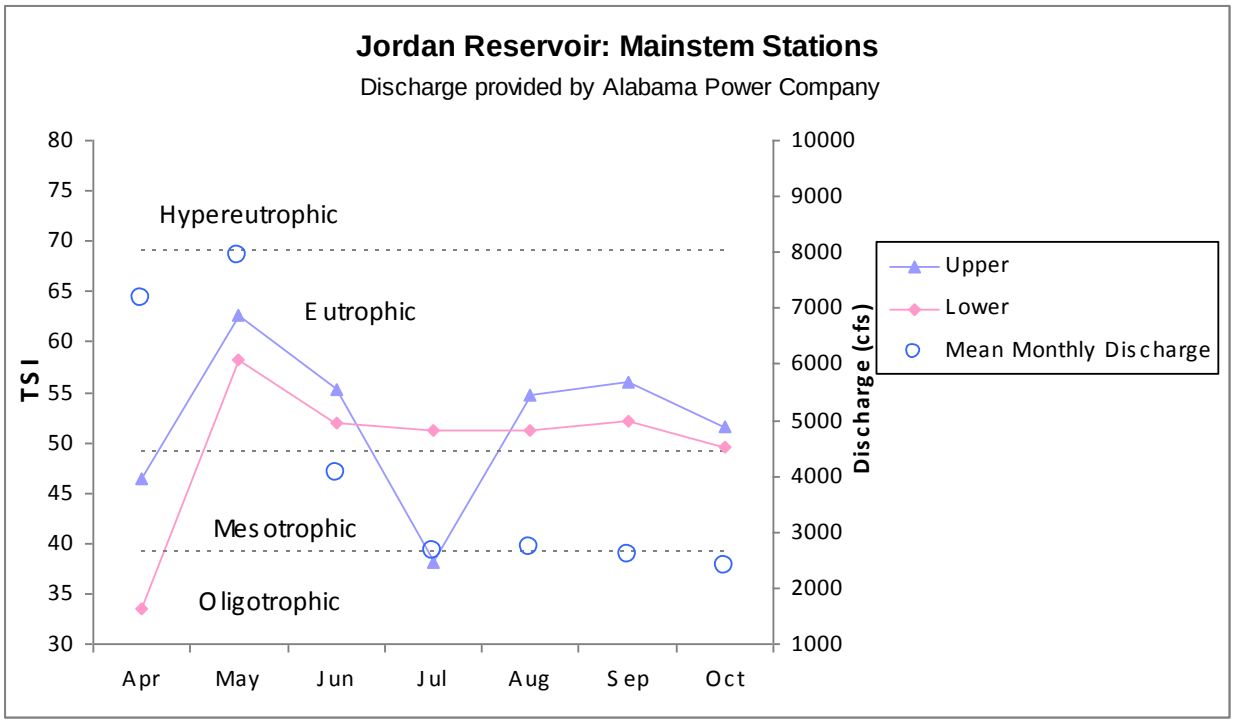
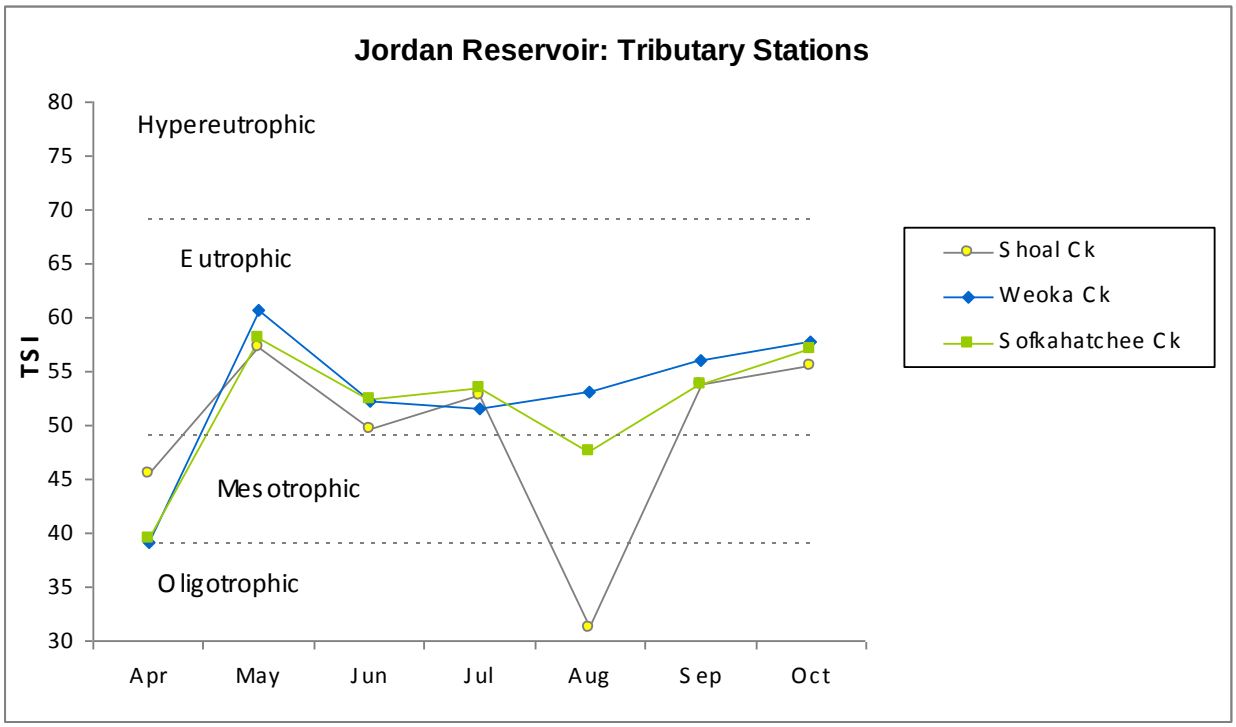


Figure 11. Mean growing season TSI values calculated for mainstem Jordan Reservoir stations using chl *a* concentrations and Carlson's Trophic State Index calculation. Discharge provided by APCO.





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APPENDIX

Appendix Table 1. Summary of Jordan Reservoir water quality data collected April-October, 2010. 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
JORE-1	**Physical**							
	Turbidity (NTU)	7		1.5	3.9	2.2	2.7	1.0
	Total Dissolved Solids (mg/L)[J]	7		68.0	128.0	86.0	89.7	20.0
	Total Suspended Solids (mg/L)	7	<	1.0	7.0	0.5	2.1	2.7
	Hardness (mg/L)	4		44.0	70.5	54.6	55.9	11.2
	Alkalinity (mg/L)	7		45.0	76.8	58.3	62.2	12.0
	Photic Zone (m)	7		3.55	6.50	6.15	5.56	1.07
	Secchi (m)	7		1.44	3.54	2.59	2.47	0.77
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.021	0.021	0.010	0.010	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.003	0.139	0.035	0.047	0.050
	Total Kjeldahl Nitrogen (mg/L)	7		0.209	0.604	0.364	0.388	0.150
	Total Nitrogen (mg/L)[J]	7	<	0.214	0.743	0.372	0.435	0.177
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.003	0.009	0.004	0.004	0.003
	Total Phosphorus (mg/L)	7		0.014	0.032	0.017	0.020	0.007
	CBOD-5 (mg/L)	7	<	2.0	2.3	1.0	1.2	0.5
	Chlorides (mg/L)	7		3.0	6.2	3.8	4.3	1.1
	Biological							
	Chlorophyll a (ug/L)	7		1.34	16.73	8.19	8.47	4.51
	E. coli (mpn/100mL)[J]	3		1	1	1	1	0
JORE-2	**Physical**							
	Turbidity (NTU)	7		2.0	4.8	2.6	2.9	1.1
	Total Dissolved Solids (mg/L)[J]	7		18.0	110.0	72.0	69.4	31.4
	Total Suspended Solids (mg/L)	7	<	1.0	6.0	2.0	2.2	1.9
	Hardness (mg/L)	4		44.6	72.2	56.0	57.2	12.2
	Alkalinity (mg/L)	7		46.8	77.2	59.9	61.3	11.3
	Photic Zone (m)	7		3.28	6.34	5.48	5.29	1.00
	Secchi (m)	7		1.17	2.36	2.10	2.02	0.39
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.021	0.021	0.010	0.010	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.002	0.142	0.010	0.030	0.051
	Total Kjeldahl Nitrogen (mg/L)	7		0.292	1.059	0.365	0.460	0.271
	Total Nitrogen (mg/L)[J]	7	<	0.307	1.095	0.367	0.490	0.288
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.003	0.005	0.004	0.004	0.001
	Total Phosphorus (mg/L)	7		0.017	0.045	0.022	0.025	0.010
	CBOD-5 (mg/L)	7	<	2.0	2.0	1.0	1.0	0.0
	Chlorides (mg/L)	7		3.1	6.5	3.8	4.5	1.3
	Biological							
	Chlorophyll a (ug/L)	7		2.14	26.29	11.75	11.37	7.75
	E. coli (mpn/100mL)[J]	3		1	1	1	1	0

Station	Parameter	N		Min	Max	Med	Mean	SD
JORE-3	**Physical**							
	Turbidity (NTU)	7		2.8	10.4	3.1	4.5	2.8
	Total Dissolved Solids (mg/L)[J]	7		32.0	110.0	78.0	77.4	26.0
	Total Suspended Solids (mg/L)[J]	7		1.0	4.0	3.0	2.7	1.0
	Hardness (mg/L)	4		37.3	70.0	51.0	52.3	13.6
	Alkalinity (mg/L)	7		38.3	74.8	56.4	58.1	13.7
	Photic Zone (m)	7		4.45	5.50	5.04	4.99	0.34
	Secchi (m)	7		1.67	2.17	1.91	1.88	0.16
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.021	0.021	0.010	0.010	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.002	0.116	0.015	0.026	0.041
	Total Kjeldahl Nitrogen (mg/L)	7		0.225	0.537	0.379	0.385	0.107
	Total Nitrogen (mg/L)[J]	7	<	0.247	0.591	0.380	0.411	0.130
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.003	0.007	0.004	0.004	0.002
	Total Phosphorus (mg/L)	7		0.018	0.028	0.023	0.023	0.004
	CBOD-5 (mg/L)	7	<	2.0	2.1	1.0	1.2	0.4
	Chlorides (mg/L)	7		3.0	6.5	3.8	4.3	1.3
	Biological							
	Chlorophyll a (ug/L)	7		1.07	15.13	9.61	8.70	4.85
	E. coli (mpn/100mL)	3		2	15	3	7	7
JORE-4	**Physical**							
	Turbidity (NTU)	7		2.2	7.5	3.2	3.8	1.9
	Total Dissolved Solids (mg/L)[J]	7		66.0	116.0	92.0	92.9	18.2
	Total Suspended Solids (mg/L)[J]	7		1.0	8.0	3.0	3.6	2.5
	Hardness (mg/L)	4		35.9	70.1	49.6	51.3	15.1
	Alkalinity (mg/L)	7		39.7	76.3	55.9	58.0	14.0
	Photic Zone (m)	7		3.65	6.25	5.12	4.98	0.93
	Secchi (m)	7		1.37	2.44	1.97	1.89	0.45
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.021	0.021	0.010	0.010	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.002	0.092	0.005	0.020	0.033
	Total Kjeldahl Nitrogen (mg/L)	7		0.159	0.523	0.360	0.344	0.126
	Total Nitrogen (mg/L)[J]	7	<	0.160	0.538	0.362	0.364	0.141
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.003	0.012	0.005	0.005	0.003
	Total Phosphorus (mg/L)	7		0.017	0.032	0.021	0.023	0.005
	CBOD-5 (mg/L)	7	<	2.0	2.5	1.0	1.5	0.7
	Chlorides (mg/L)	7		3.0	6.2	3.6	4.2	1.2
	Biological							
	Chlorophyll a (ug/L)	7		2.40	21.36	9.97	11.53	6.07
	E. coli (mpn/100mL)[J]	3		1	1	1	1	0

Station	Parameter	N		Min	Max	Med	Mean	SD
JORE-5	**Physical**							
	Turbidity (NTU)	6		2.0	4.3	2.6	2.9	1.0
	Total Dissolved Solids (mg/L)[J]	7		18.0	108.0	74.0	78.0	31.4
	Total Suspended Solids (mg/L)[J]	7		1.0	7.0	2.0	3.3	2.6
	Hardness (mg/L)	4		32.9	70.6	53.1	52.4	16.0
	Alkalinity (mg/L)	7		35.9	76.1	56.8	59.1	14.2
	Photic Zone (m)	7		4.73	7.35	6.08	5.80	0.92
	Secchi (m)	7		1.40	2.94	2.32	2.29	0.54
	Chemical							
	Ammonia Nitrogen (mg/L)	7	<	0.021	0.021	0.010	0.010	0.000
	Nitrate+Nitrite Nitrogen (mg/L)[J]	7	<	0.002	0.071	0.011	0.023	0.027
	Total Kjeldahl Nitrogen (mg/L)	7	<	0.080	0.630	0.398	0.360	0.190
	Total Nitrogen (mg/L)[J]	7	<	0.066	0.701	0.407	0.383	0.202
	Dissolved Reactive Phosphorus (mg/L)[J]	7	<	0.003	0.011	0.004	0.005	0.003
	Total Phosphorus (mg/L)	7		0.015	0.030	0.019	0.020	0.006
	CBOD-5 (mg/L)	7	<	2.0	2.9	1.0	1.3	0.7
	Chlorides (mg/L)	7		2.8	6.3	3.7	4.3	1.2
	Biological							
	Chlorophyll a (ug/L)	7		2.49	16.47	10.32	9.98	4.87
	E. coli (mpn/100mL)[J]	3		1	1	1	1	0

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