The Lakes of Missouri Volunteer Program 2010 Data Report

Featuring water quality monitoring data from 91 sites on 32 public lakes. All samples were collected and processed by trained volunteers, then analyzed by University of Missouri staff.

The Lakes of Missouri Volunteer Program

Region VII, US Environmental Protection Agency, through the Missouri Department of Natural Resources, has provided partial funding for this project under Section 319 of the Clean Water Act.

The Lakes of Missouri Volunteer Program is also partially funded by the University of Missouri.

Nutrients and sediments are two of the top three pollutants in lakes, according to the EPA. These pollutants often enter our lakes as nonpoint source pollution, through runoff. The way to reduce the impact of excessive nutrients and sediments on our lakes is to reduce nonpoint source pollution in the watershed.

The Lakes of Missouri Volunteer Program, with the help of volunteer monitors, tracks nonpoint source pollution in Missouri's lakes by measuring chlorophyll (a measure of algal biomass), nitrogen and phosphorus (nutrients), suspended sediments (soil particles), and water clarity.

Preface

The following report is divided into two parts. The first part focuses on educating the reader about the Lakes of Missouri Volunteer Program, water quality and lake ecology. The second part of the report presents the data collected by volunteers in the program. Much of the emphasis is on the 2009 data, but some historical data is presented as well.

If you have any questions about the program or the data, call us at 1-800-895-2260. If nobody answers, leave a message and we will call you back. You can also email us at INFO@LMVP.ORG.

Let us know if you would like to receive our newsletter, The Water Line. The Water Line is published three times a year and is distributed through both email and postal mail. You can read previous issues of our newsletter at the Publications page of our web site, www.LMVP.org.

Acknowledgements

This report is the result of a lot of work by many people who should be acknowledged.

Above all are the volunteers, without whom none of this would be possible. Their enthusiasm, energy and dedication are truly inspiring.

We extend a sincere thank you to Jim Stetson and the Ozark Lakes Country Senior Center in Kimberling City for hosting our data reviews for the last several years and for allowing us to store samples for pickup. In addition, he makes very good coffee.

We would also like to thank the Jackson County Parks Department, the Mark Twain Lake Sailing Association, the U.S. Army Corps of Engineers, the City of Lamar, the City of Bowling Green, the City of Moberly, the City of Unionville, the City of Cameron, the Missouri Department of Natural Resources and the United States Coast Guard Auxiliary Flotillas 55, 57 and 5-3 for donating their time and their employees time to sampling.

Further thanks go to Baxter Marina, Jacomo Marina, and the Missouri Department of Conservation for loaning boats and gasoline to volunteer water samplers. Additional thanks to the Missouri Dept. of Conservation for allowing volunteers to drop samples off at their Camdenton office. Finally, thank you to the technicians in the University of Missouri's Limnology Laboratory for their exceptional work conducting the sample analyses.

Sincerely,

Tony Thorpe Dan Obrecht

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Coordinators of the Lakes of Missouri Volunteer Program

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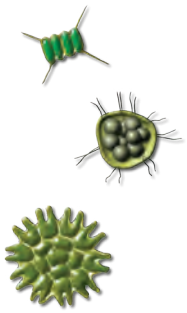
Introduction

Nonpoint Source Pollution and Lake Ecology

Energy captured from the sun through photosynthesis drives all life on this planet. This statement is true for both terrestrial and aquatic ecosystems.

The Algae

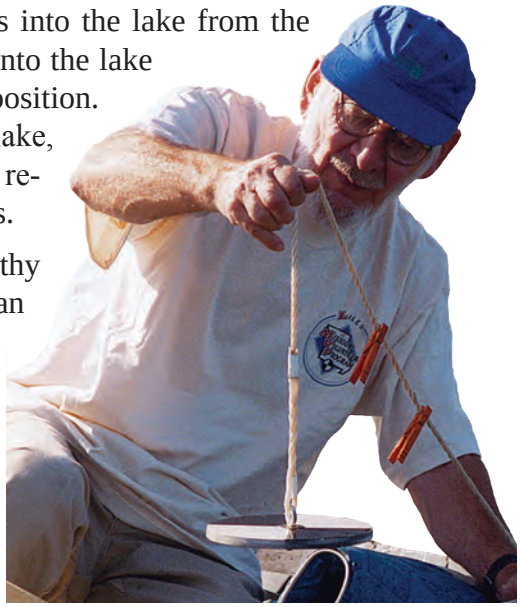
Algae are a diverse group of aquatic organisms that can be microscopic, or in the case of kelp, more than 50 feet long. Some algae are attached to rocks or other submerged structures. This is the slippery green stuff most people call "moss." Other algae live free-floating in the water, and many species can even "swim."



Algae, like plants, create their own food through photosynthesis, the process by which the sun's energy is captured by the pigment chlorophyll and used to combine carbon dioxide and water to form simple sugars. The algae can later break the sugar molecules apart, releasing the stored chemical energy for growth and reproduction. Other organisms are also welcome to those sugars; all they have to do is eat the algae.

Requirements for photosynthesis – light, CO2 and water

Algae have it pretty good when it comes to the requirements for photosynthesis. As long as they stay near the surface of the water, they can find plenty of sunlight. There generally isn't much shade out on the lake. The exception to this is when water clarity is reduced by suspended sediments or excessive algae. The second requirement for photosynthesis, carbon dioxide, readily diffuses into the lake from the atmosphere and is released into the lake via respiration and decomposition. There is plenty of water in a lake, which takes care of the final requirement for photosynthesis.



Algae are necessary for a healthy lake ecosystem, but there can be too much algae. When this happens, the grazers who feed on algae can't keep up. As the uneaten algae die off, they sink to the lake bottom and decay. The process of decay is

conducted by bacteria, which in turn require oxygen. If there is an abundance of dead algae, bacteria use up too much oxygen, and there isn't enough left over for aquatic creatures such as insects and fish. Too much algae can also give lakes an unpleasant green color, a surface scum, or (in the case of drinking water reservoirs) a "fishy" taste.

The Nutrients

While algae must photosynthesize to store energy, they also have further requirements for growth and reproduction. For these processes, algae draw resources from their environment. Chief among these requirements are nitrogen and phosphorus, nutrients often responsible for limiting algal growth. If nutrients in the water are insufficient, algal growth will slow or stop entirely until more nutrients become available. An increase in the concentration of nutrients in a lake will typically increase the amount of algae as well.

Nitrogen and phosphorus are natural components of soil but are also frequently applied on land as fertilizer. If these fertilizers are not taken up by terrestrial plants, the nutrients may be transported as nonpoint source pollution to our lakes. Nutrients, especially phosphorus, can also attach to soil particles, which wash into lakes as suspended sediment particles during rain events. To truly control algae in lakes, you must control the nutrients.

The Sediments

While nutrients encourage algal growth in a lake, suspended sediments can restrict growth. These soil materials decrease water clarity, limiting the amount of light available to algae. Suspended sediments make the lake look brown, reducing its aesthetic appeal. The suspended sediments must be removed from water intended for drinking. Additionally, as sediment settles out of suspension, it falls to the bottom of the lake, reducing the lake's volume. If the volume decreases enough, the lake will need to be dredged or abandoned. Dredging is the extremely expensive and disruptive process of mechanically removing the accumulated sediments from the bottom of the lake.

The sediments carried by runoff will eventually fill in every single Missouri lake

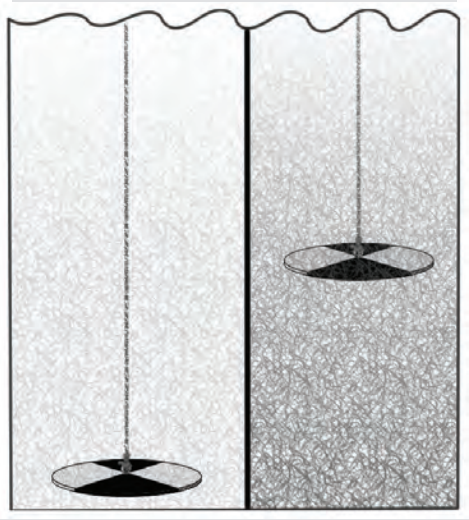
We can control how fast that happens by managing our watersheds wisely

The Watershed

To control nutrients and sediments within a lake, we must look to the watershed, the land area draining to a lake (or stream). All surface water bodies have a watershed, and all land is part of a complex network of watersheds. Tavern Creek and the Lake of the Ozarks each have watersheds. Their watersheds are part of the larger Osage River watershed. The Osage River watershed is a part of the much larger Missouri River watershed. The Missouri River's entire watershed is included in the even larger Mississippi River watershed.

Water (rain, snow melt, etc.) moves down the landscape before entering the lake as runoff. Along the way, runoff picks up nutrients, sediments and other pollutants from the watershed. Pollutants entering lakes and streams via runoff are called nonpoint source pollution. Nonpoint source pollution comes from a diffuse area in the watershed, rather than a single (point) source. To improve water quality anywhere, you start by addressing human activity in the watershed.

Suspended sediments and algae will reduce the clarity of lake water



Water clarity is measured using a Secchi disk. The Secchi disk is lowered into the water until it is no longer visible and the depth is recorded. Clear water has a greater Secchi depth than murky water

Parameter	Abbreviation	Unit of Measure
Water Clarity (using Secchi disk)	Secchi	Inches (“)
Total Phosphorus	TP	Micrograms per liter (µg/L) or parts per billion (ppb)
Total Nitrogen	TN	Micrograms per liter (µg/L) or parts per billion (ppb)
Chlorophyll	CHL	Micrograms per liter (µg/L) or parts per billion (ppb)
Inorganic Suspended Sediments	ISS	Milligrams per liter (mg/L) or parts per million (ppm)

This table shows the parameters measured by the Lakes of Missouri Volunteer Program, the abbreviations used in this document, and the units of measure that the numbers represent.

Land Use and Water Quality in Missouri Lakes

According to the EPA, nutrients (particularly phosphorus and nitrogen) are the top pollutants that impair the country's lakes and reservoirs. Some nutrients come from point sources such as sewage treatment plants, but the majority enter our lakes through nonpoint source runoff from urban areas and agriculture. In Missouri, the number of lakes that have point source pollution are few and generally limited to large reservoirs. Nutrient levels in most Missouri lakes are determined by nonpoint source impacts within the watershed.

Land Use

We once thought that differences in soil fertility (i.e. nutrient levels) explained regional differences in lake water quality in Missouri. Thin, nutrient-poor soils in the Ozark led to clear lakes with low nutrient levels. Deeper, nutrient-rich soils in northern Missouri equated to productive, nutrient-rich lakes. With continued analysis we identified the differences in land use across the regions of the state (the Ozarks have forest, while agriculture dominates in northern Missouri). The quality and amount of soil definitely helps determine land use, as nobody has much luck farming ridge tops in the Ozarks! But analysis indicates that if a watershed in northern Missouri is mostly forested, the lake will look like an Ozark lake.

Bowling Green Lake #1 is in northern Missouri where soils are nutrient-rich and yet has a mean Secchi transparency of 60 inches. Nearly half of the watershed of Bowling Green Lake #1 is forested.

We now realize that land cover within a lake's watershed plays a larger role in water quality than the background nutrients within soils. In Missouri (and elsewhere) more agriculture in a watershed leads to more nutrient inputs into the lake. In contrast, a forested watershed generally equates to less human impact and therefore lower nutrient inputs into the lake. Grass and pasture land do not show a strong relation to in-lake nutrients, probably because these land types range from low impact (e.g. Conservation Reserve Program land) to highly managed (litter/manure application).

Hydrology

But land use is not the only factor that plays a role in determining lake water quality in Missouri. The amount (and timing) of water that flows into a lake during a given year, or its hydrology, plays a much larger

role than we previously thought. If a lake has a large watershed relative to its lake volume, it will be more impacted by inflow from the watershed. On the other hand, if a lake has a small watershed relative to lake volume, inputs from the watershed will have less impact on water quality.

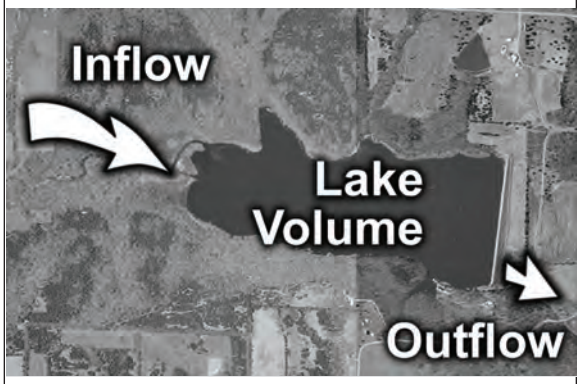
Residence Time

One way of looking at hydrology is by calculating what is known as residence time, a measure of how long water remains in the lake before new inflows replace it. If a lake has a volume of 100 acre/feet and the annual inflow is 200 acre/feet, then residence time equals 6 months. That means, on average, the volume of the lake is replaced every 6 months. Residence time is a theoretical measurement, but a valuable one all the same.

How much of a factor is residence time on lake water quality in Missouri? If a Missouri lake has 50% of its watershed in agriculture, the overall phosphorus concentrations within the lake may range from as low as 40 µg/L to as high as 150 µg/L. This large range occurs because the residence time of our lakes vary greatly. The lake with 40 µg/L of phosphorus might have a residence time of over 18 months. A lake with a residence time of 6 months might have 100 µg/L phosphorus, while a lake with a 3 month residence time could have 150 µg/L phosphorus.

The three factors that determine residence time are lake volume, watershed area, and the amount of precipitation. Of these, precipitation is not a constant. Dry years produce less inflow into the lake, so the residence time is, in effect, longer than normal. During wet years the opposite is true; more inflow leads to a shorter residence time. We find that dry years have lower than normal nutrient levels, while in wet years nutrient concentrations are higher. Differences in hydrology (residence time) from year to year can help explain why a lake's water quality varies over time.

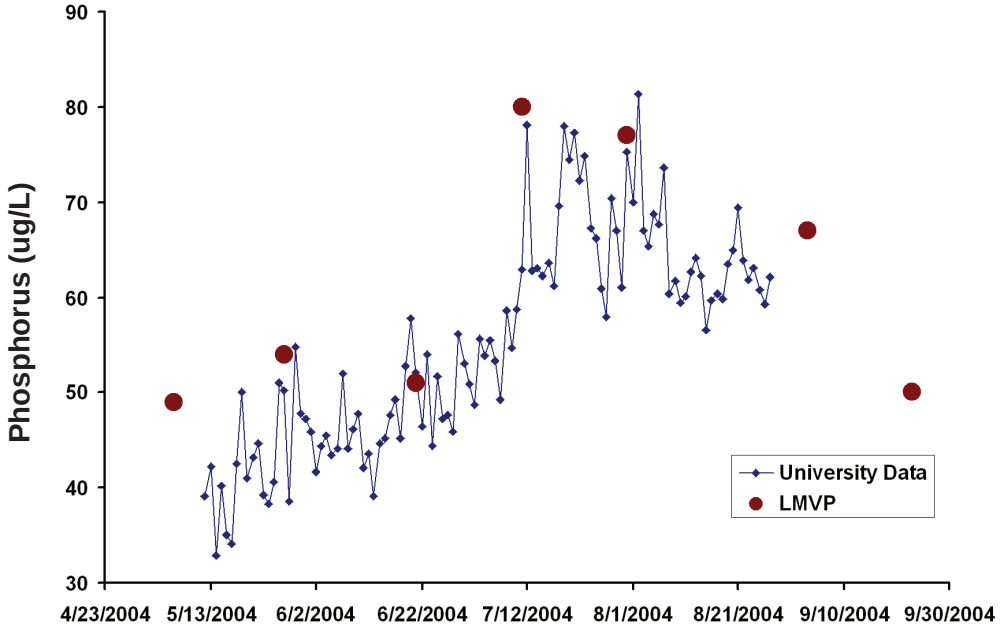
Inflowing water replaces the lake water, which leaves via the outflow. Residence time is a measure of how long the lake's water volume "resides" in the lake.



Lakes with a long residence time tend to have lower concentrations of nutrients than lakes with a short residence time.

The Quality of Volunteer Collected Data

LMVP volunteers monitor at 3-week intervals from late spring to early fall and process the samples in their homes. The processed samples are stored in volunteers' freezers until LMVP staff can pick them up. The samples are then analyzed at the University of Missouri's Limnology laboratory following accepted standard methods. LMVP data are "research quality", and have been used in several scientific journal articles. One study (Obrecht et al. 1998) shows LMVP data to be of comparable quality to data collected by employees of the University of Missouri.



Phosphorus concentrations in Little Dixie Lake from samples collected by an LMVP volunteer and by University of Missouri staff. All samples were analyzed in the same laboratory.

Regular sampling intervals give a good estimate of average conditions in a lake. Additionally, values obtained by LMVP volunteers are comparable to values obtained by "professionals".

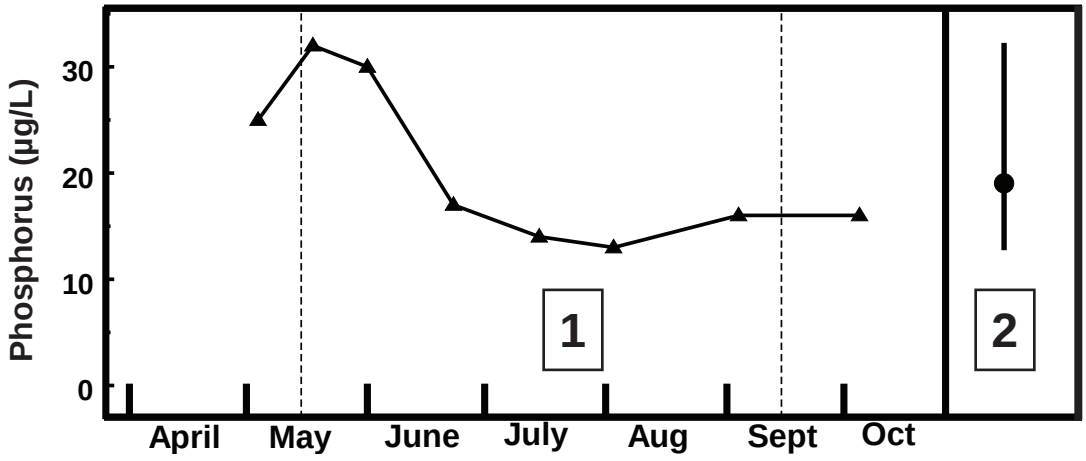
Understanding the Data Graphs

The data are typically graphed in three ways for the data report. The first of these is a simple line graph (See 1 below). These graphs are used if there are fewer than three years of data to report. The parameter represented is named on the vertical axis, which is may be on the left or right hand side of the graph. Use the legend to identify the symbols used for each parameter. These graphs will show all data collected last year, with the date of collection shown at the bottom of the graph.

Some data are shown as trend graphs. For these data we will show a stick plot (See 2 below). The stick plot features a "stick" that reaches from the high value to the low value and a dot that shows the geometric mean* for that year. Each stick plot represents data from a single season. These plots will always be shown with other stick plots for comparison among years.

When stick plots are shown, only the "summer" data are used. For our purposes, "summer" is defined as the period between May 15 and September 15. This period is shown in section 1 of the figure below with the dotted lines, so in this case the samples from early May and early October would not be used. Trimming the data like this lets us compare data from different years, regardless of whether the volunteer began sampling early or finished late.

In the stick plot below, the take home point is that the data range from a low of 13 to a high of 32 µg/L, but the values tended to be at the lower end of that range. You can tell this because the dot representing the mean is closer to the bottom of the line than the top.



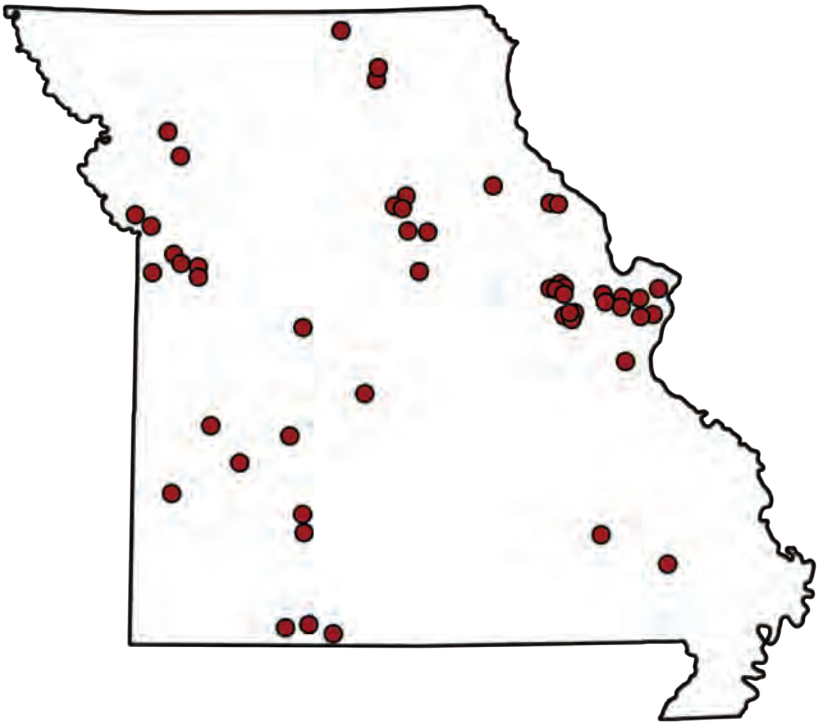
An example of a graph showing seasonal variation (1), a stick plot (2). The stick plot represents only the seasonal variation data from May 15 through September 15 (illustrated by the dotted lines).

* Geometric mean is used as a measure of the central tendency of the data and to reduce the influence of extreme values. In this report, the geometric mean is the average of the data when 'log10 transformed.'

2010 Lake Data
Lake by Lake Summary

In 2010, volunteers for the Lakes of Missouri Volunteer Program collected 845 samples from 120 sample sites on 58 Missouri lakes. To accomplish this, volunteers donated nearly 1200 hours and drove nearly 9000 miles.

The following pages represent the data from the 91 sampling sites on 32 public lakes monitored in 2010.



Lakes monitored by LMVP volunteers in 2010.

Blue Springs Lake

2010 DATA

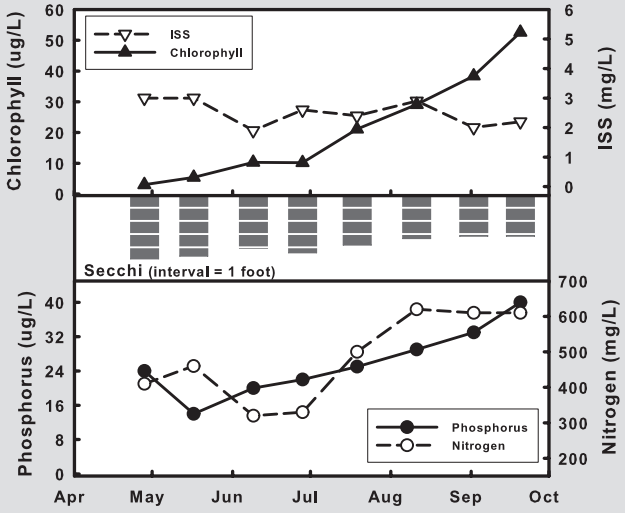
Jackson County
Latitude: 39.0164 Longitude: -94.3375

Date	4/28	5/17	6/9	6/28	7/19	8/11	9/2	9/20	Mean
Secchi (inches)	59	56	49	53	46	40	38	38	47
TP (µg/L)	24	14	20	22	25	29	33	40	25
TN (µg/L)	410	460	320	330	500	620	610	610	468
CHL (µg/L)	3.0	5.4	10.3	10.2	21.1	29.1	38.4	52.6	14.6
ISS (mg/L)	3.0	3.0	1.9	2.6	2.4	2.9	2.0	2.2	2.5

The pattern of increasing nutrient levels through the season is opposite that found in most Missouri lakes, where nutrient concentrations tend to peak during spring samples. Inorganic suspended sediment values remained fairly stable through the season, suggesting increased nutrients were not associated with erosional runoff from the watershed. The increase in algal chlorophyll concentrations during the sample season can only be partially attributed to the higher nutrient levels. The ratio of chlorophyll to phosphorus increased from 0.1 in April to >1.0 at the end of the season. These higher ratios indicate the algae were more efficient at using available phosphorus, possibly a result of shifts in the algal community or in grazing pressure.

There has been a shift in phosphorus concentrations in Blue Springs Lake overtime. Phosphorus values during 1992-1998 ranged from 30-58µg/L, with a predictable peak occurring most springs. Since 1999 the range has been lower, 20-40µg/L. Also, the predictable nature of the spring peak seemed to disappear, with many annual peaks occurring in the fall.

2010 GRAPHS



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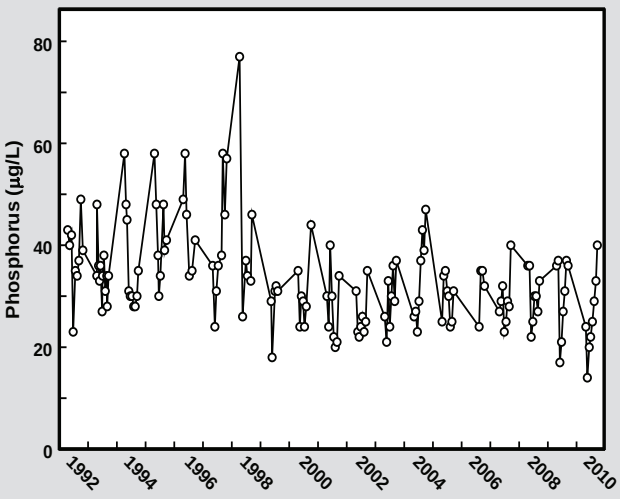


See pages 10-11 for help interpreting graphs

Bowling Green Lake #1

2010 DATA

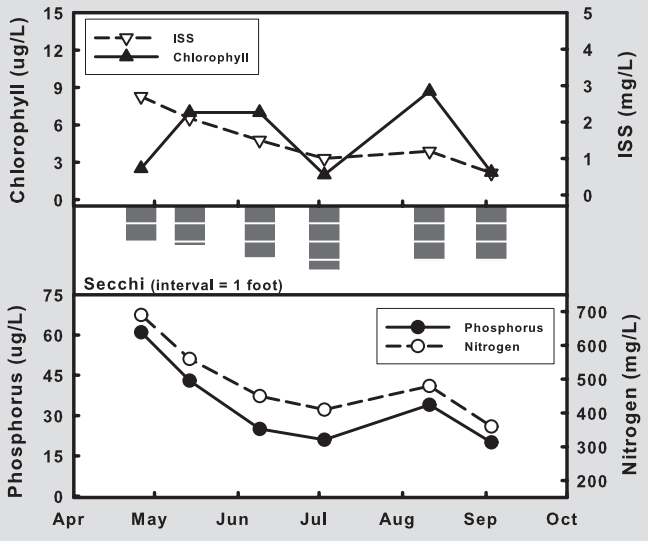
Pike County
Latitude: 39.3417 Longitude: -91.1532

Date	4/26	5/14	6/9	7/3	X	8/11	9/3	X	Mean
Secchi (inches)									
TP (µg/L)	61	43	25	21		34	20		31
TN (µg/L)	690	560	450	410		480	360		481
CHL (µg/L)	2.5	7.0	7.0	2.0		8.7	2.2		4.1
ISS (mg/L)	2.7	2.1	1.5	1.0		1.2	0.6		1.4

Water quality in Bowling Green Lake 1 followed a predictable pattern of higher nutrient and inorganic suspended sediment values early in the season, with a general decline in concentrations as the season progressed. This pattern reflects the influence of watershed runoff during spring, and the subsequent settling of sediment and nutrients over the course of summer (summertime inputs have a tendency to plunge into deeper water in the lake and not influence surface water quality). Algal chlorophyll showed moderate variability during the sample season, with no obvious pattern.

For a third summer in a row, phosphorus levels have been slightly higher than the long-term average. This increase in phosphorus does not seem to be a result of higher inorganic suspended sediment levels, as the last three summers have had values right at the long-term average. Other than the slightly higher phosphorus levels, none of the other parameters display any real trends.

2010 GRAPHS



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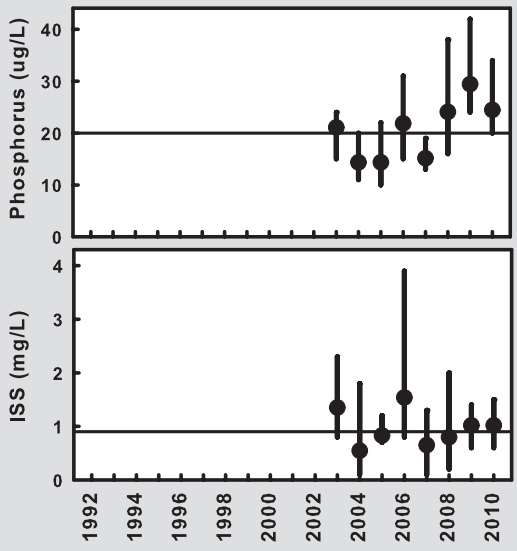


See pages 10-11 for help interpreting graphs

Bowling Green Lake #2

2010 DATA

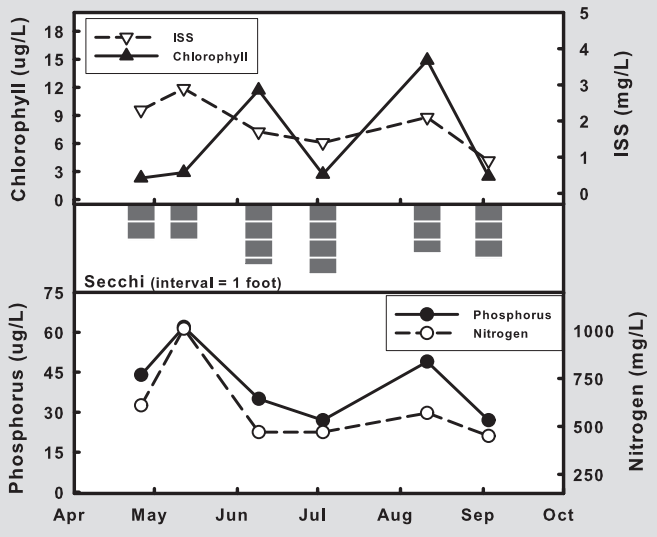
Pike County
Latitude: 39.3436 Longitude: -91.1615

Date	4/26	5/12	6/9	7/3	X	8/11	9/3	X	Mean
Secchi (inches)									
TP (µg/L)	44	62	35	27		49	27		39
TN (µg/L)	610	1010	470	470		570	450		572
CHL (µg/L)	2.3	2.9	11.7	2.7		14.9	2.5		4.5
ISS (mg/L)	2.3	2.9	1.7	1.4		2.1	0.9		1.8

The highest nutrient and suspended sediment values were measured in the May sample, which is a common pattern for Missouri lakes. Phosphorus, nitrogen and suspended sediment generally followed the same pattern through the season, while algal chlorophyll concentrations fluctuated with no real pattern. Even when chlorophyll levels peaked above 10µg/L, the ratio of chlorophyll to phosphorus remained below the Missouri average, suggesting the algae in Bowling Green Lake 2 were never efficient at using the available nutrients.

Phosphorus concentrations during the summer of 2010 were similar to levels measured during the period 2003-06. The higher values measured during the three year period of 2007-09 were related to water removal from the surface layer of the lake. Water was pumped from lake #2 into lake #1 to maintain the volume in lake #1. Chlorophyll levels were low during the summer of 2010, and comparable to values from previous years. While year-to-year fluctuations occur in water quality, there are no obvious trends in Bowling Green Lake 2.

2010 GRAPHS



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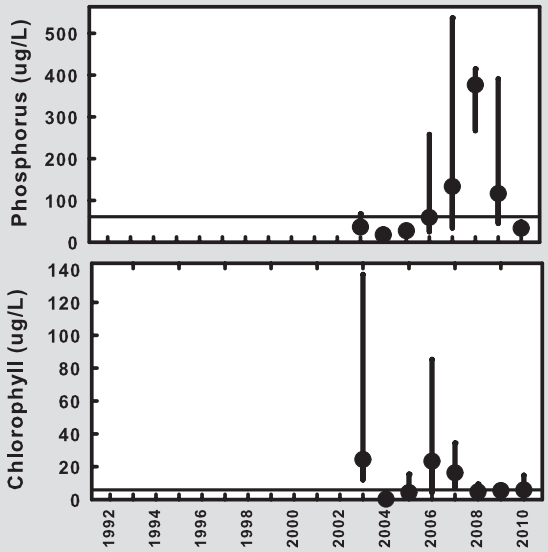
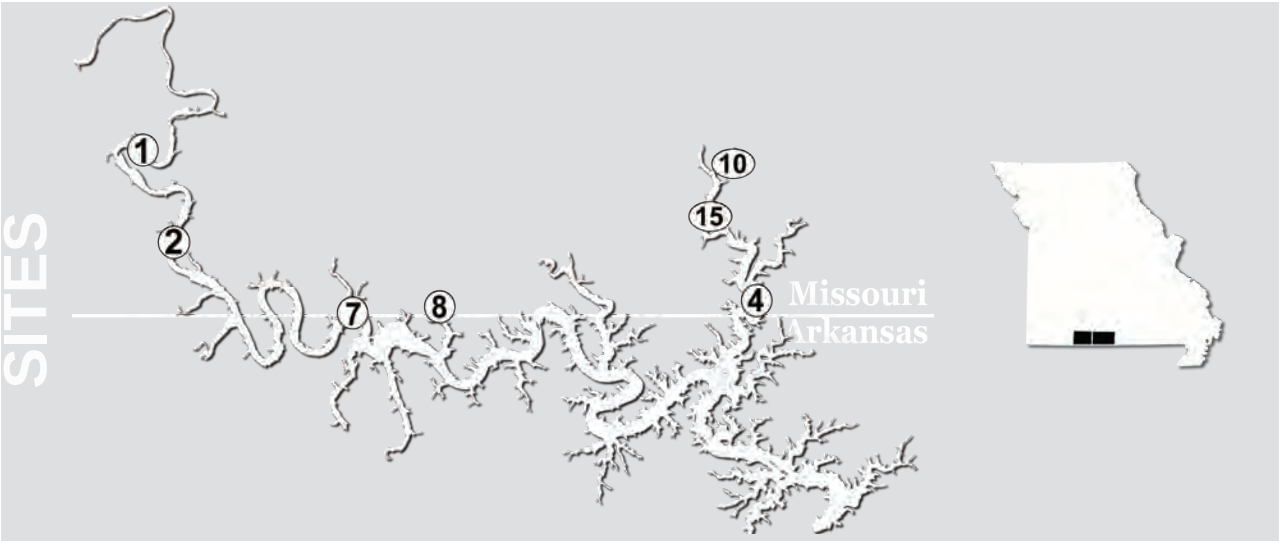


See pages 10-11 for help interpreting graphs

Bull Shoals Lake

Taney County and Ozark County



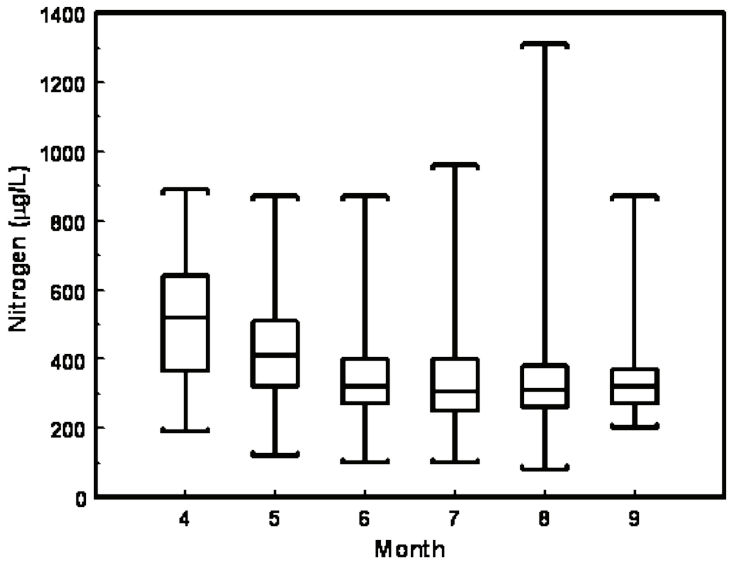
Seasonal Analysis

Nutrient concentrations in the main lake sites (1, 2, & 7) and Site 8 (located in a tributary of the main lake) all displayed similar patterns during the 2010 season. Nitrogen levels were highest during the early part of the season, then decreased by around 50% and remained stable during the second half of the sample season. Nitrogen concentrations were similar at all four sites. In comparison, phosphorus values were fairly stable across the whole sample season at the four sites. There was slightly more phosphorus at Site 1 than the other three sites, though the difference was minimal. Chlorophyll values showed a little more variability than phosphorus, but generally tracked phosphorus concentrations. While chlorophyll values at the four sites did not differ greatly, there were substantial differences in maximum water clarity readings. Minimum Secchi readings were similar for the sites, but sites 1 and 2 only ranged about 33 inches of clarity. Site 8 ranged by 99 inches while Site 7 had almost twice that range at 179 inches.

		Main Channel			Shoal Creek	North Fork Arm		
	SITE	**1**	**2**	**7**	**8**	**10**	**15**	**4**
	Number of Samples	5	5	8	8	8	8	7
Secchi (inches)	Mean	80	96	141	111	63	100	141
	Minimum	62	74	85	81	42	69	96
	Maximum	96	106	264	180	160	200	210
TP (µg/L)	Mean	14	11	9	10	24	13	7
	Minimum	12	9	7	7	14	8	5
	Maximum	17	13	11	13	40	23	13
TN (µg/L)	Mean	377	350	381	354	598	397	407
	Minimum	290	260	260	260	370	290	250
	Maximum	610	680	660	620	870	570	660
CHL (µg/L)	Mean	5.9	5.0	3.5	4.2	9.8	5.9	2.9
	Minimum	4.1	3.0	1.8	2.0	6.6	3.1	1.5
	Maximum	11.3	6.4	7.4	8.2	16.4	11.3	5.0

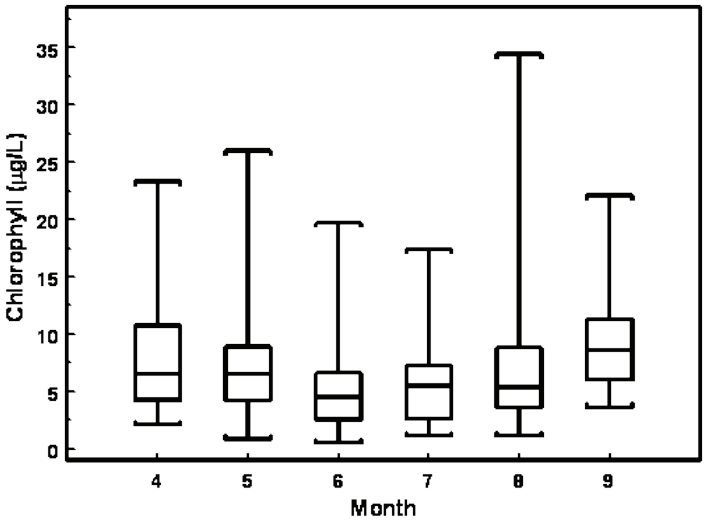
Seasonal Analysis (continued)

The three sites (10, 15 and 4) located within the Little North Fork River Arm of Bull Shoals Lake display the expected longitudinal gradient. Phosphorus and algal chlorophyll concentrations decrease as the site location moves down the tributary arm towards the main lake. In response to the lower chlorophyll levels, we find substantially clearer water at Site 4. While nitrogen levels were highest at the up-lake site, concentrations at the two lower sites were for the most part equal.



When nitrogen values from all years and all sites are grouped by month of sample collection and graphed using box plots we find a seasonal trend. The tendency is for higher nitrogen values in April, a decrease through May, and fairly stable conditions through the remainder of the sample season. [Compare the boxes, which represent the middle 50% of data and the bars within the boxes which are the median values.] The median nitrogen value for samples collected in April was 520µg/L, 410µg/L in May, and between 305 and 320µg/L in the other months. In contrast, phosphorus values did not show any seasonal trend, with monthly median values differing by only 3µg/L.

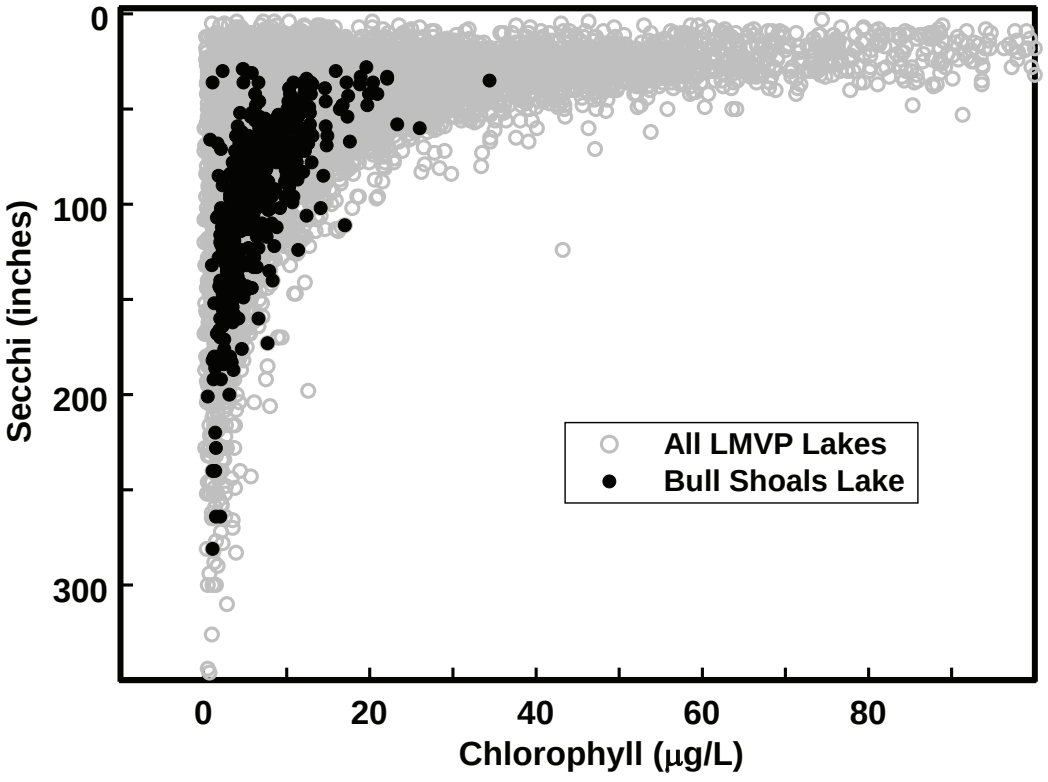
Chlorophyll concentrations were generally lowest in June (median of 4.5µg/L) and highest in September (median of 8.6µg/L), though the overlap in the boxes indicate differences were nominal. The other months of the sampling season tended to have intermediate chlorophyll levels. Because the fluctuations in algal chlorophyll across the season do not reflect changes in nutrients, another factor such as grazing by zooplankton may explain the slight suppression of algal chlorophyll in June.



Seasonal Analysis (continued)

When individual chlorophyll values are plotted against their corresponding Secchi readings from all LMVP lakes we find a non-linear relationship. Water clarity decreases dramatically as chlorophyll concentrations increase from near zero to about 7µg/L. After this point there is still a decrease in clarity as chlorophyll increases, but at a much slower rate. As chlorophyll levels approach 15µg/L the relationship flattens out with little change in Secchi transparency across a wide range of chlorophyll concentrations.

The majority of data from Bull Shoals Lake is located on the vertical portion of the relationship, where chlorophyll concentrations are low and water clarity high. Most of the data points that do fall into the flattened portion of the relationship are from sites 10 and 1. These two sites tend to have higher phosphorus concentrations than the other Bull Shoals sites, which translates to more algal growth and lower water clarity (note the samples from Site 1 that fall into the flattened portion of the Secchi-Chlorophyll relation were collected in the 1990s, before phosphorus reductions occurred).

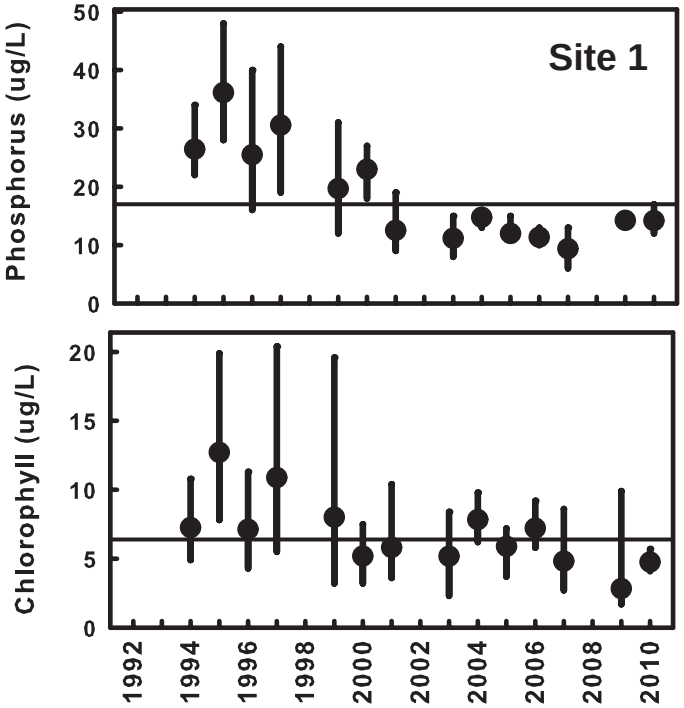


Bull Shoals Lake

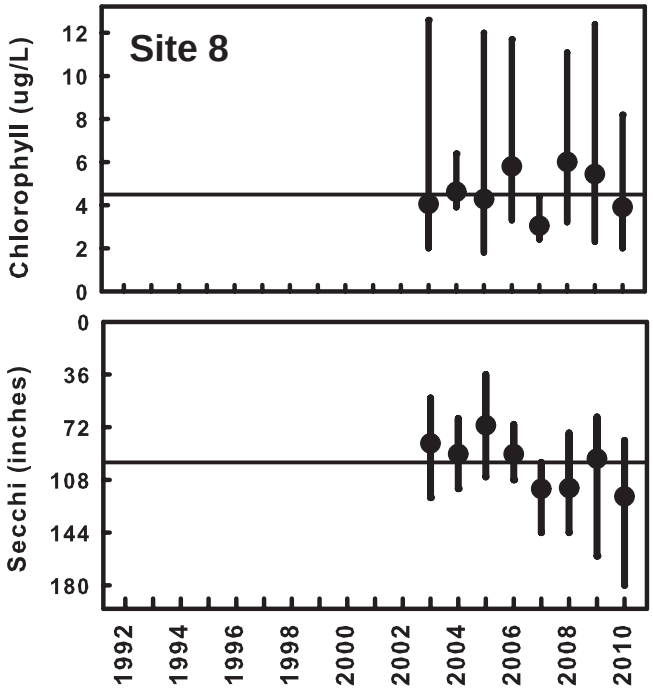
Main Lake Trend Data

Bull Shoals Trends

The long-term trend for phosphorus at Site 1 has been a decline through the 1990s, with low and stable values over the last decade. These lower phosphorus values reflect reductions in phosphorus inputs into Lake Taneycomo and Table Rock Lake, both located upstream. The algal chlorophyll concentrations have mimicked the phosphorus in terms of trends.



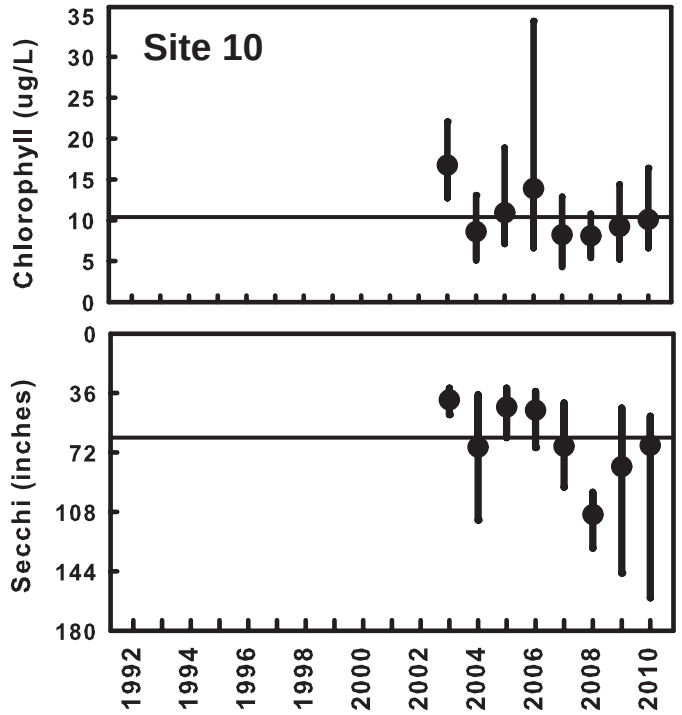
At Site 8 we have seen deeper Secchi transparency readings during the last four years. Three of the summertime mean values have been below the long-term average, and maximum Secchi readings have been deeper than previously measured. Algal chlorophyll values have not been consistently lower during these past four years, suggesting that improvements in water clarity may relate to a decline in suspended sediment at this site.

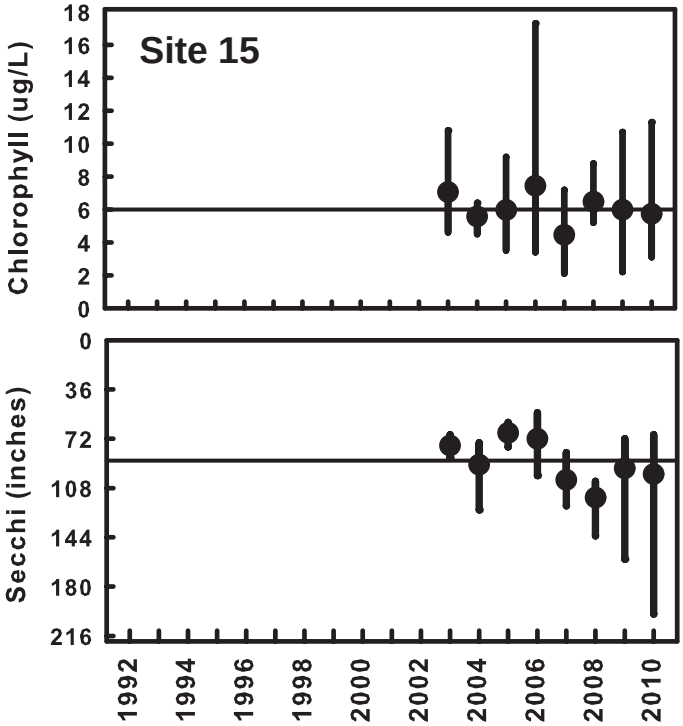


Bull Shoals Lake

Bull Shoals Trends

The same pattern (but over the last three years) of improved water clarity without a decrease in algal chlorophyll has been measured at the two upper most sites (10 and 15) in the Little North Fork River Arm. Again, these improvements in clarity do not seem to reflect shifts in algal chlorophyll concentrations. Improved clarity is the result of lower levels of suspended sediment or a shift in the algal community at these sites. If the algal community has shifted to species with larger bodies it is possible that the chlorophyll concentrations would remain the same, while clarity would improve (many smaller algae would reduce clarity more than fewer large algae).





Cameron City Lake #3

2010 DATA

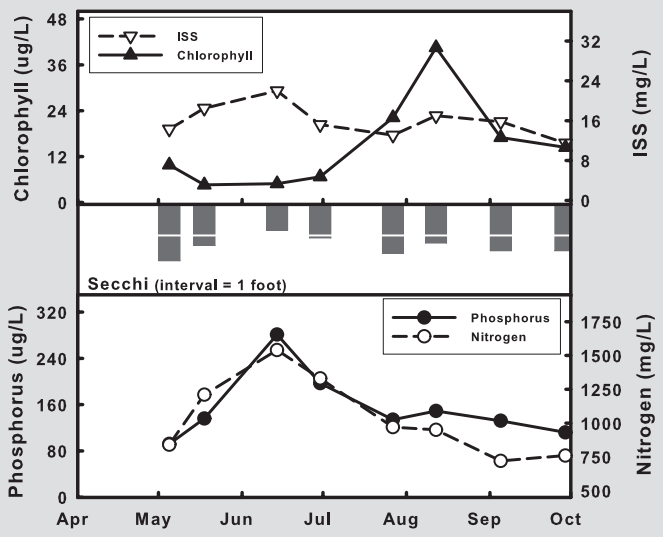
Dekalb County
Latitude: 39.7734 Longitude: -94.2717

Date	5/5	5/18	6/14	6/30	7/27	8/12	9/5	9/29	Mean
Secchi (inches)	22	16	10	13	19	15	18	18	16
TP (µg/L)	92	136	281	197	134	149	132	112	146
TN (µg/L)	840	1210	1540	1330	970	950	720	760	1006
CHL (µg/L)	9.8	4.6	4.9	6.7	22.2	40.5	17.0	14.4	11.6
ISS (mg/L)	14.3	18.5	22.0	15.2	13.1	17.0	15.8	11.5	15.6

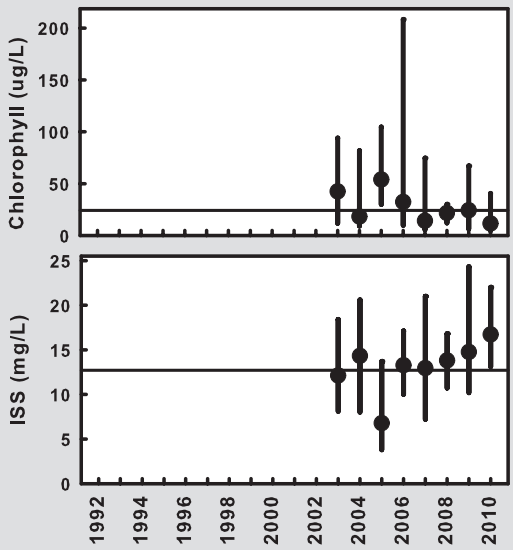
Water quality parameters in Cameron City Lake #3 followed different patterns over the course of the 2010 sample season. Both nutrients peaked in mid-June with concentrations decreasing consistently during the remainder of the season. In contrast, algal chlorophyll levels were low in the early part of the sample season and peaked in August. In many Missouri lakes a mid to late-season peaks in chlorophyll relates to a decline in the suspended sediment concentrations. This was not the case in Cameron #3, as inorganic suspended sediment values were high throughout the sample season.

The average inorganic suspended sediment concentration during the summer of 2010 was the highest we have measured (highest average, but not the highest individual value). These higher levels of suspended sediment may help explain the lower levels of algal chlorophyll measured in 2010.

2010 GRAPHS

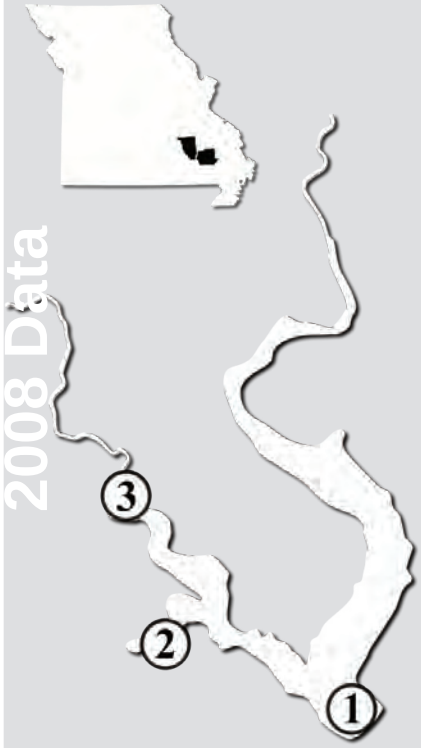


TREND GRAPHS



See pages 10-11 for help interpreting graphs

Clearwater Lake



Reynolds and Wayne County

Site 1

Latitude 37.1376 Longitude -90.7744

Date	Secchi (inches)	TP (µg/L)	TN (µg/L)	CHL (µg/L)	ISS (mg/L)
5/3	57	9	140	5.3	2.3
5/23	71	8	110	4.1	1.6
6/9	79	6	110	3.2	1.1
7/7	60	13	120	6.3	2.5
7/28	78			8.8	0.6
8/19	70	15	170	6.6	1.5
9/12	58	13	190	8.0	2.1
10/4	30	15	270	9.2	6.9

Site 2

Latitude 37.1478 Longitude -90.8069

Date	Secchi (inches)	TP (µg/L)	TN (µg/L)	CHL (µg/L)	ISS (mg/L)
5/3	31	21	280	6.3	9.6
5/23	51	12	150	5.0	2.8
6/9	28	20	170	5.2	8.4
7/7	25	33	280	10.5	10.1
7/28	20	33	250	10.2	11.6
8/19	24	30	230	7.3	11.4
9/12	30	23	190	8.2	8.6
10/4	40	10	100	0.6	3.8

Site 3

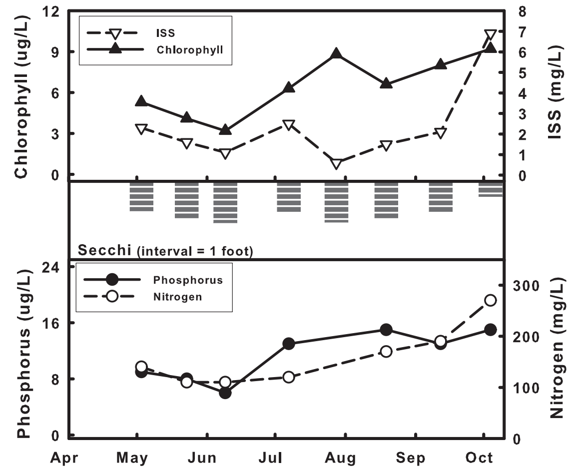
Latitude 37.1664 Longitude -90.8116

Date	Secchi (inches)	TP (µg/L)	TN (µg/L)	CHL (µg/L)	ISS (mg/L)
5/3	24	15	230	4.9	6.5
5/23	40	14	190	6.5	4.6
6/9	21	20	160	10.8	7.9
7/7	24	31	240	8.9	10.8
7/28	18	24	200	5.4	6.1
8/19	18	42	220	7.7	23.3
9/12	26	14	190	7.2	5.0
10/4	54	6	120	0.5	3.5

Site 1

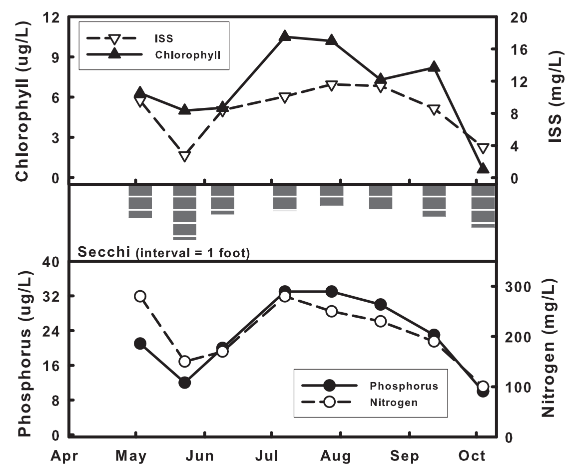
The three sites monitored in Clearwater Lake differ in their 2010 seasonal patterns, which probably reflect the difference in their location within the lake. Water quality at Site 1 at the dam was consistent during the season, with slight increases in the nutrients and chlorophyll during the second half of the season. High inorganic suspended sediment and nitrogen values were measured on the last sample day of the season, October 4. These higher values were probably a result of the lake surface cooling off and the lake water mixing deeper, incorporating water from the lower layer of the lake.

2010 Seasonal Graphs



Site 2

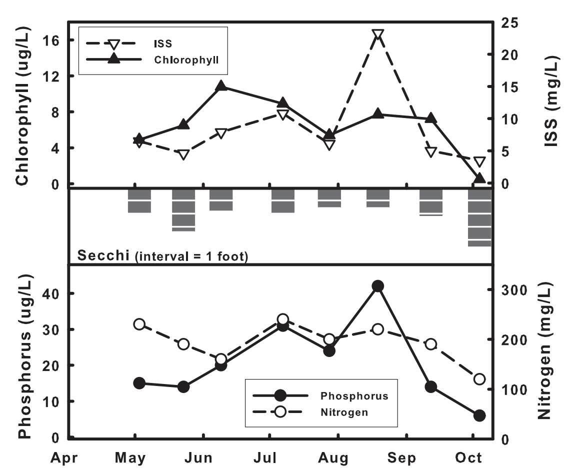
The water quality parameters at Site 2, located in a tributary flowing into the Logan Creek Arm of the lake, all followed the same general pattern during the 2010 season. Nutrients, algal chlorophyll and inorganic suspended sediment all decreased from the first to second sample, followed by an increase to peak values in July, and another decrease through fall. Secchi transparency reflects the seasonal changes in chlorophyll and suspended sediment, with the deepest readings occurring in late-May and October.



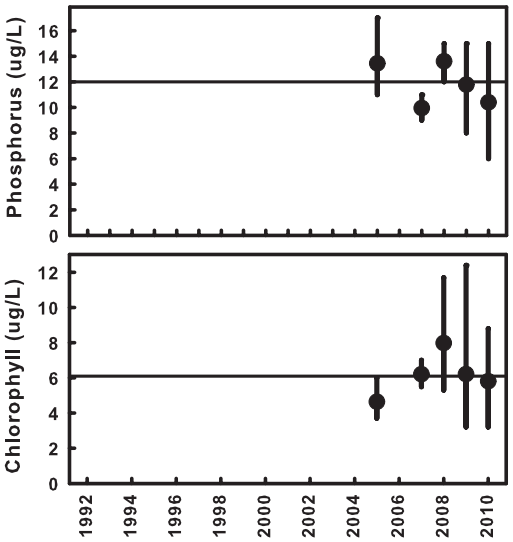
Site 3

At Site 3, located in the upper portion of the Logan Creek Arm, there was not the synchronization of parameters seen at the other two sites. There was a very strong relation between phosphorus and inorganic suspended sediment values at this site. This is common as phosphorus tends to bind to soil materials and enter the lake as part of erosional runoff.

Water quality at sites 2 and 3 (both located in a tributary of the lake) differed from that of Site 1, but the differences were not consistent among the water quality parameters. The most notable difference was inorganic suspended sediment levels were about four times higher in the tributary sites compared to the dam. The higher levels of suspended sediment were accompanied by more phosphorus, though levels at tributary sites were only 2 times higher than at the dam. Nitrogen was only slightly higher at tributary sites. Water clarity at tributary sites was about half of that measured at the dam. Increased clarity at the dam relate to lower levels of suspended sediment and not differences in chlorophyll levels, as all three sites had similar chlorophyll levels.



Long-Term Trend Graphs

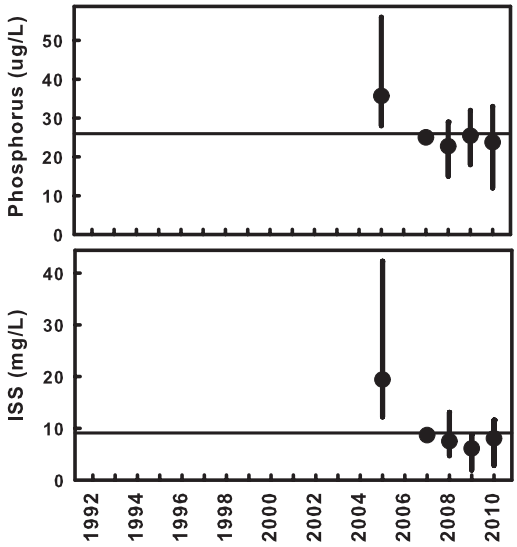


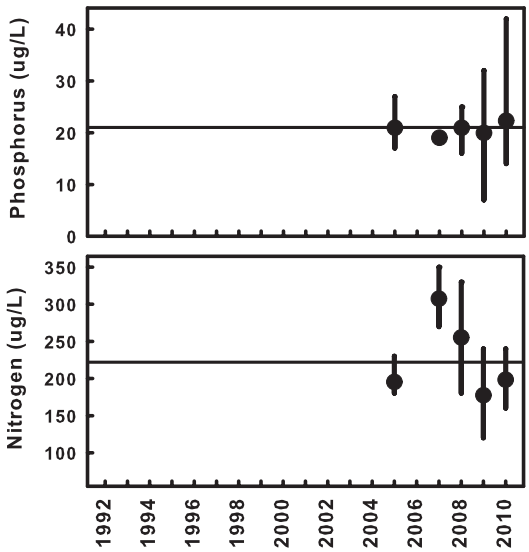
Site 1

The year-to-year shifts in average chlorophyll values at Site 1 have mimicked the annual fluctuations in phosphorus over the last four summers. Values from 2005 do not fit the pattern, as phosphorus levels were higher than the long-term average and chlorophyll was lower than average. During the summer of 2005 the nitrogen concentrations were extremely low, and nitrogen probably limited the production of algal chlorophyll. There are no obvious trends in water quality at Site 1.

Site 2

The long-term graphs for Site 2 show just how tight the parameters phosphorus and inorganic suspended sediment relate to each other. Values from the last four years have been stable relative the higher levels measured in 2005. Phosphorus is often bound to soil particles, explaining this strong relationship. Water clarity as measured with the Secchi disk also trends with suspended sediment. Currently there are no long-term trends in water quality at Site 2.





Site 3

The year-to-year trends in phosphorus and nitrogen differ at Site 3 in Clearwater Lake. Summertime averages for phosphorus have been very similar for the five years of monitoring, while average nitrogen values have varied from roughly 174 to 300µg/L. This range in nitrogen is common in Missouri lakes, and it is the stability of the phosphorus concentrations that is unusual. None of the parameters show obvious long-term trends.

Creve Coeur Lake

2010 DATA

Saint Louis County
Latitude: 38.7222 Longitude: -90.4911

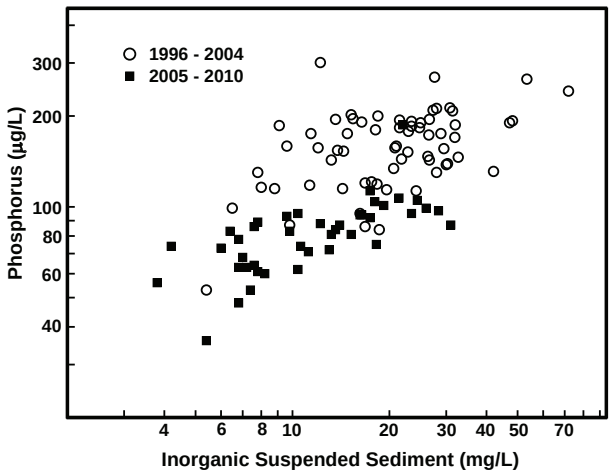
Date	5/2	X	6/8	6/29	7/18	8/12	9/3	9/25	Mean
Secchi (inches)	17		16	22	16	23	13	19	18
TP (µg/L)	99		105	93	94	68	113	83	92
TN (µg/L)	680		710	570	730	660	760	750	691
CHL (µg/L)	57.8		25.4	26.6	27.1	25.6	83.8	50.7	38.0
ISS (mg/L)	26.0		24.4	9.6	16.4	7.0	17.4	6.4	13.4

Water quality in Creve Coeur Lake did not show any seasonal patterns during the 2010 season. Both nutrients fluctuated slightly, with only minimal variation. Phosphorus concentrations did seem to track the inorganic suspended sediment levels, especially during the second half of the season. Given the high levels of inorganic suspended sediment in Creve Coeur Lake, algal chlorophyll concentrations were notably high. On three sample occasions the ratio of chlorophyll to phosphorus was >0.5, indicating the algae were fairly efficient at using available nutrients (generally high suspended sediment levels limit light and reduce the chlorophyll–phosphorus ratio).

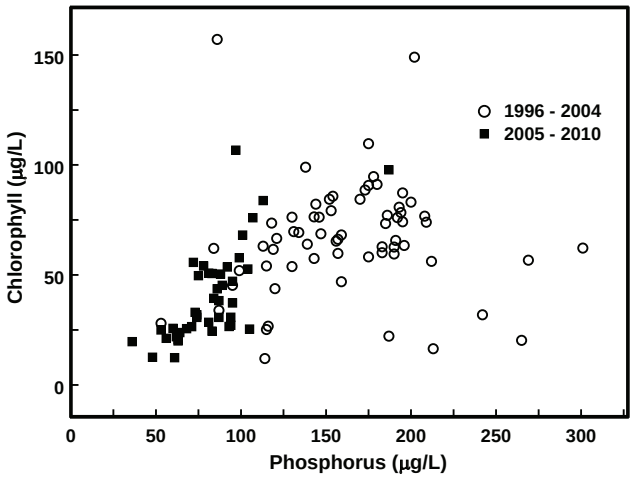
As noted in previous data reports, there has been a substantial change in water quality in Creve Coeur Lake since implementation of lake management (including dredging and creation of another lake up-stream of Creve Coeur). Review of the data shows that while there is some overlap in inorganic suspended sediment levels, there has been a notable decrease in concentrations (median value for pre- and post-dredge are 21 and 11mg/L, respectively). Along with lower levels of suspended sediment, we find a substantial decline in phosphorus concentrations (median 159 vs 83µg/L).

The decrease in nutrients (including nitrogen) has led to a reduction in the amount of algal chlorophyll measured in Creve Coeur Lake. While we still have some high chlorophyll readings measured in the lake, the overall chlorophyll concentrations have dropped from a median of 66µg/L to 33µg/L.

Pre and Post Dredging
Phosphorus and ISS



Pre and Post Dredging
Chlorophyll and Phosphorus



Fellows Lake

2010 DATA

Greene County
Latitude: 37.3147 Longitude: -93.2280

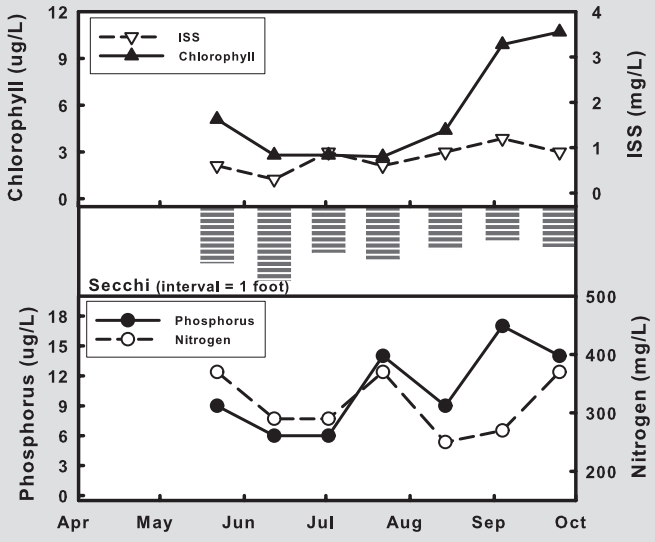
Date	X	5/22	6/12	7/2	7/22	8/14	9/4	9/25	Mean
Secchi (inches)		112	146	91	104	84	67	80	95
TP (µg/L)		9	6	6	14	9	17	14	10
TN (µg/L)		370	290	290	370	250	270	370	312
CHL (µg/L)		5.1	2.8	2.8	2.7	4.4	9.9	10.7	4.7
ISS (mg/L)		0.6	0.3	0.9	0.6	0.9	1.2	0.9	0.7

Phosphorus and nitrogen concentrations followed the same general pattern through the 2010 sample season. While the fluctuations of nutrient concentrations suggest that inputs into the lake were affecting water quality, the shifts in nutrient levels were relatively small. Algal chlorophyll values were stable through the majority of the season, with a late peak during September that corresponded to higher phosphorus levels. Inorganic suspended sediment values were low, with only one value exceeding 1mg/L.

Fellows Lake was also sampled in 2008, with water quality that was similar to that measured in 2010. Continued sampling will help define the expected variability of water quality within seasons, year to year variation, and identify any long-term trends in water quality.

2010 GRAPHS

TREND GRAPHS



See pages 10-11 for help interpreting graphs

Forest Lake

Site 1

2010 DATA

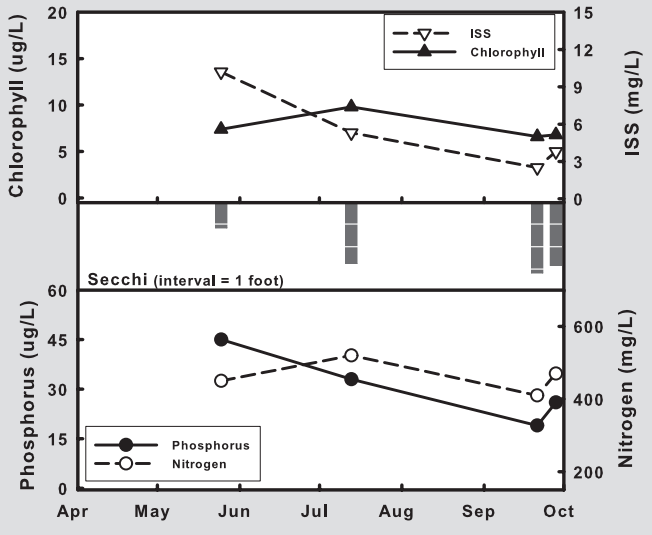
Adair County
Latitude: 40.1706 Longitude: -92.6556

Date	X	5/25	X	X	7/13	X	9/21	9/28	Mean
Secchi (inches)		14			33		38	34	28
TP (µg/L)		45			33		19	26	29
TN (µg/L)		450			520		410	470	461
CHL (µg/L)		7.4			9.8		6.6	6.8	7.6
ISS (mg/L)		10.2			5.3		2.5	3.8	4.8

The limited data collected in 2010 hinders seasonal analysis. The sample collected in May had substantially higher levels of inorganic suspended sediment and phosphorus than samples collected later in the season. This is a common occurrence as turbid inflows into the lake early in the year carry suspended sediment (which often has phosphorus bound to it) and influence surface water quality. Inflows that occur later in the year tend to plunge into deeper lake layers, having minimal influence on surface water quality. The fluctuations in nitrogen and chlorophyll values during 2010 were relatively small.

Comparison of the inorganic suspended sediment and phosphorus long-term graphs (especially the last 6 years) shows how strongly these two parameters relate to each other in Forest Lake. Sediment coming into the lake as early season runoff also brings the nutrient phosphorus into the lake. It would seem that efforts to reduce inorganic suspended sediment inputs into the lake (via watershed management) would also reduce the amount of phosphorus entering the lake.

2010 GRAPHS



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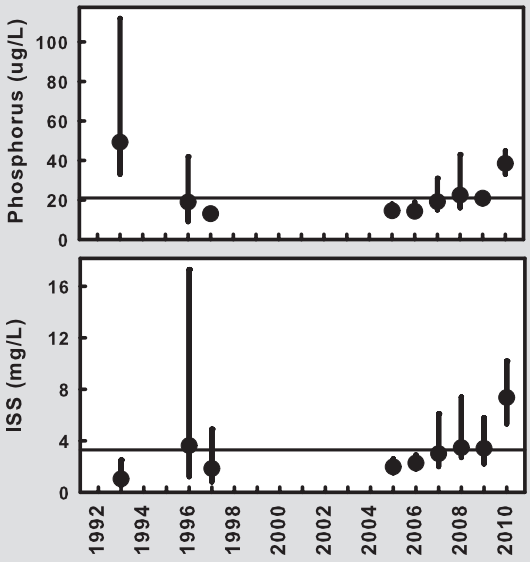


See pages 10-11 for help interpreting graphs

Forest Lake

Site 2

2010 DATA

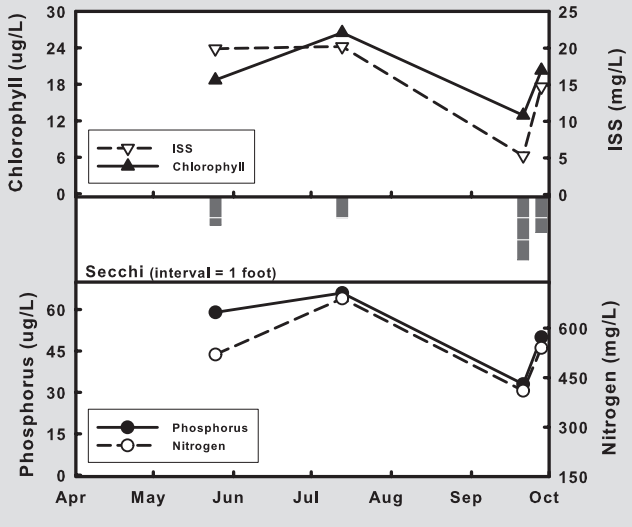
Adair County
Latitude: 40.1697 Longitude: -92.637

Date	X	5/25	X	X	7/13	X	9/21	9/28	Mean
Secchi (inches)		16			12		35	20	19
TP (µg/L)		59			66		33	50	50
TN (µg/L)		520			690		410	540	531
CHL (µg/L)		18.7			26.5		12.9	20.3	19.0
ISS (mg/L)		19.9			20.2		5.3	14.7	13.3

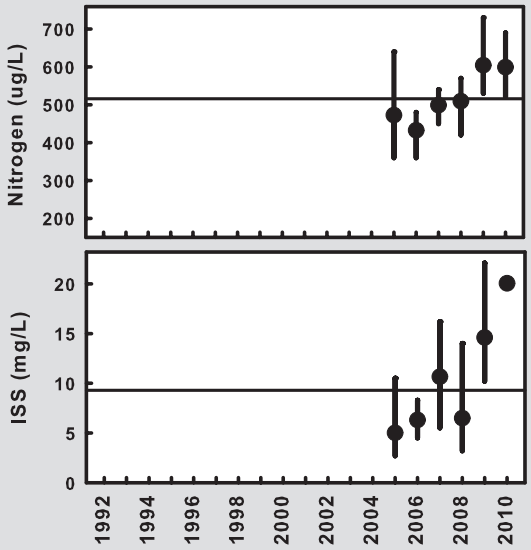
Site 2 is located in a tributary arm of Forest Lake and because it is closer to watershed inputs than Site 1, it tends to have higher nutrient, algal chlorophyll and inorganic suspended sediment values. Similar to Site 1, all of the parameters tracked each other during the 2010 sample season. The most interesting part of the 2010 data are the last two samples collected in September. These samples were collected only a week apart, but display considerably different water quality. The surface water temperature had decreased by 7˚ F between these two samples. It is very likely that the lake was mixing a little deeper on the last sample date, and higher nutrients, suspended sediment and chlorophyll reflect this deeper mixing of the lake.

Average summertime nitrogen values from the last two years have been higher than those measured in the previous four years. The same pattern was seen for phosphorus, inorganic suspended sediment, chlorophyll and Secchi transparency (lower Secchi readings). It would be erroneous to suggest that these data represent a trend in water quality as data collection in 2009 and 2010 have been limited (3 and 2 summer samples, respectively). Differences in sample numbers among the summers may affect the comparability of the data.

2010 GRAPHS



TREND GRAPHS



See pages 10-11 for help interpreting graphs

Grindstone Lake

2010 DATA

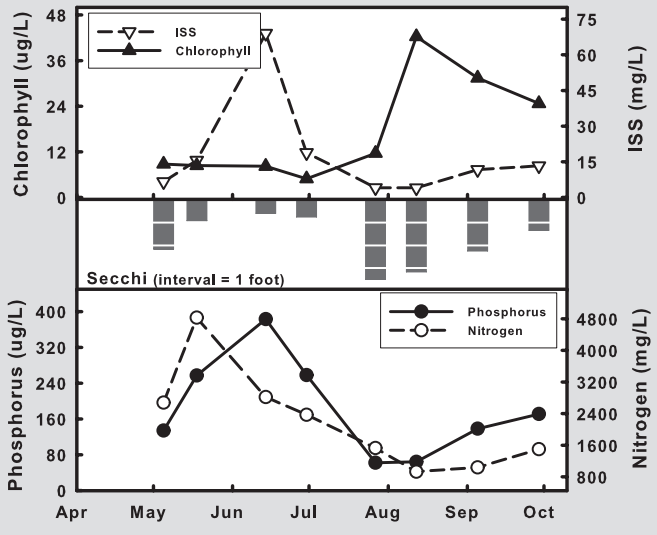
Dekalb County
Latitude: 39.7744 Longitude: -94.2952

Date	5/5	5/18	6/14	6/30	7/27	8/12	9/5	9/29	Mean
Secchi (inches)	26	11	7	9	42	38	27	16	18
TP (µg/L)	134	257	383	258	62	64	138	171	154
TN (µg/L)	2680	4830	2820	2370	1530	930	1040	1500	1929
CHL (µg/L)	8.8	8.4	8.2	4.9	11.6	42.3	31.4	24.7	13.5
ISS (mg/L)	6.6	15.6	69.0	18.8	4.1	4.0	11.7	13.3	11.7

The two nutrients follow similar seasonal patterns, though nitrogen peaks in the middle of May while phosphorus reaches its maximum in mid-June. Both nutrients decrease through the summer with a slight increase during the last two sampling dates. The same general pattern is observed in the inorganic suspended sediment data. In contrast, the seasonal pattern of algal chlorophyll was the reverse of suspended sediment, remaining low early in the season and peaking in August when suspended sediment values were at their lowest. The deepest Secchi transparency reading came in late July, when both suspended sediment and chlorophyll were relatively low.

Summertime chlorophyll levels have been comparable during all years with the exception of 2005 & 2006, when average chlorophyll concentrations were notably higher. In most Missouri lakes high chlorophyll concentrations would directly relate to either higher nutrient levels or lower inorganic suspended sediment values (lower sediment levels would increase light availability). This was not the case in Grindstone Lake, where neither increased nutrient levels or decreased suspended sediment accompanied the higher chlorophyll levels.

2010 GRAPHS



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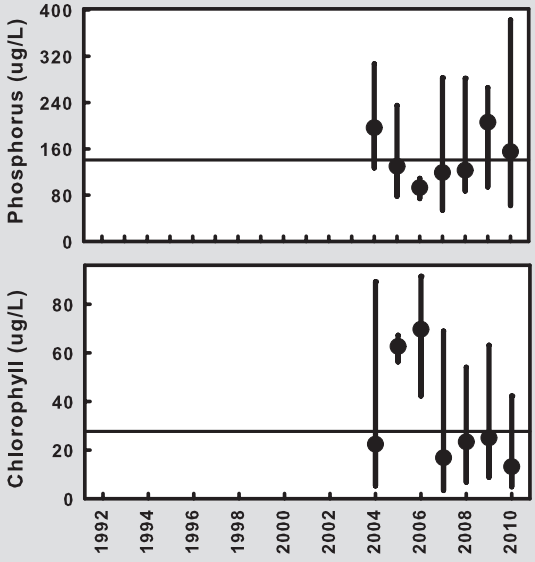


See pages 10-11 for help interpreting graphs

Hazel Creek Lake

Site 1

2010 DATA

Adair County
Latitude: 40.2985 Longitude: -92.628

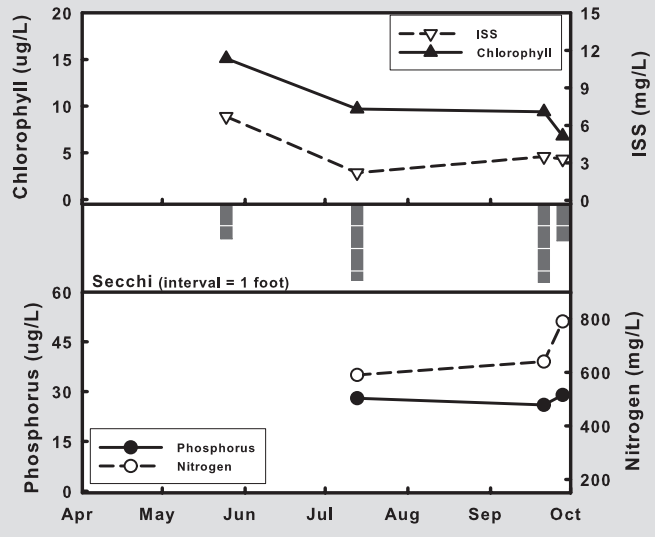
Date	X	5/25	X	X	7/13	X	9/21	9/28	Mean
Secchi (inches)		19			41		42	20	28
TP (µg/L)		.			28		26	29	28
TN (µg/L)		.			590		640	790	668
CHL (µg/L)		15.1			9.7		9.4	6.8	9.8
ISS (mg/L)		6.7			2.2		3.5	3.3	3.6

The limited data collected in 2010 hinders seasonal analysis. The data that were collected suggest fairly stable water quality during the 2010 season, with slightly higher inorganic suspended sediment and chlorophyll data in the May sample.

The number of samples collected each summer from Hazel Creek Lake has ranged from two in 2010 to six in 2005 and 2008. Differences in sample numbers and the distribution of data from across the summer can influence results, making comparisons of long-term data a challenge.

The average Secchi transparency in 2010 was the lower than previous years, which suggests increased levels of either algal chlorophyll or inorganic suspended sediment. Review of the data indicate that chlorophyll was lower and suspended sediment slightly higher than normal in 2010. This fairly small increase in suspended sediment values would account for the decreased water clarity.

2010 GRAPHS



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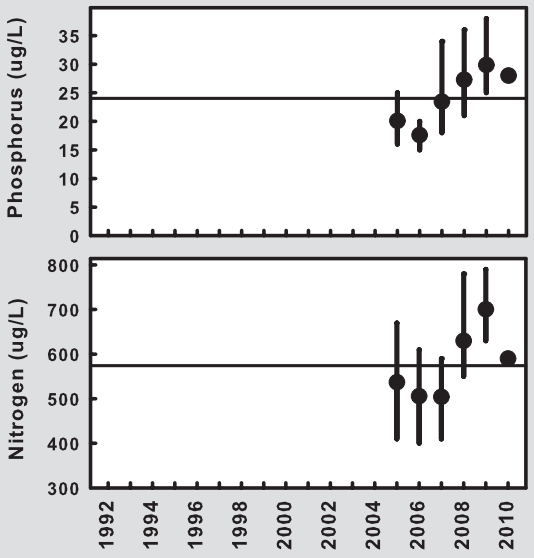


See pages 10-11 for help interpreting graphs

Hazel Creek Lake

Site 2

2010 DATA

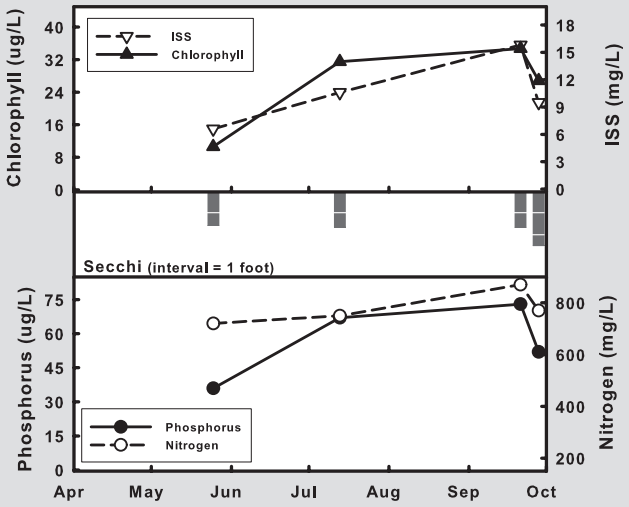
AdairCounty
Latitude: 40.2805 Longitude: -92.6045

Date	X	5/25	7/13	X	7/13	X	9/21	9/28	Mean
Secchi (inches)		19	20		20		20	30	22
TP (µg/L)		36	67		67		73	52	55
TN (µg/L)		720	750		750		870	770	776
CHL (µg/L)		10.6	31.5		31.5		34.7	26.8	23.6
ISS (mg/L)		6.6	10.6		10.6		15.8	9.5	10.1

The nutrients, algal chlorophyll and inorganic suspended sediment concentrations all followed the same pattern during the 2010 sampling season. Values increased (at different rates) from the first sample in May till the third sample on September 21. The fourth sample was conducted a week after the third, with the parameters showing a decline in concentration. Secchi transparency remained stable at 20 inches and increases by ten inches on the last sample date.

Both average phosphorus and nitrogen concentrations have increased since 2005. While this suggests declining water quality at Site 2, minimal data collection during some of the summers limits our ability to identify this as a trend. Continued monitoring (with full seasonal collections) will be needed to determine if there is a trend for changing water quality.

2010 GRAPHS



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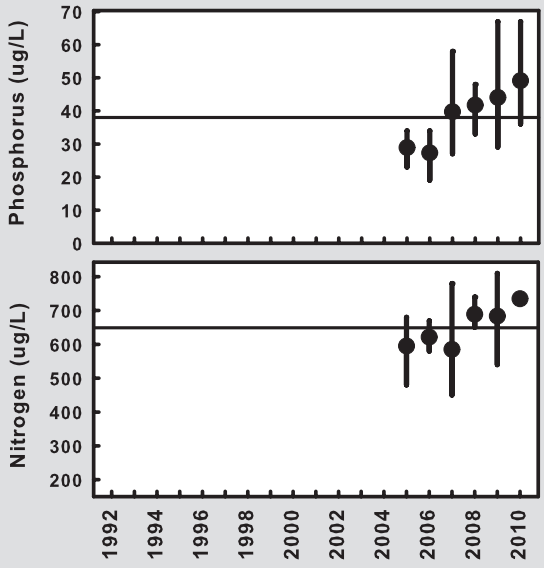


See pages 10-11 for help interpreting graphs

Hazel Creek Lake

Site 3

2010 DATA

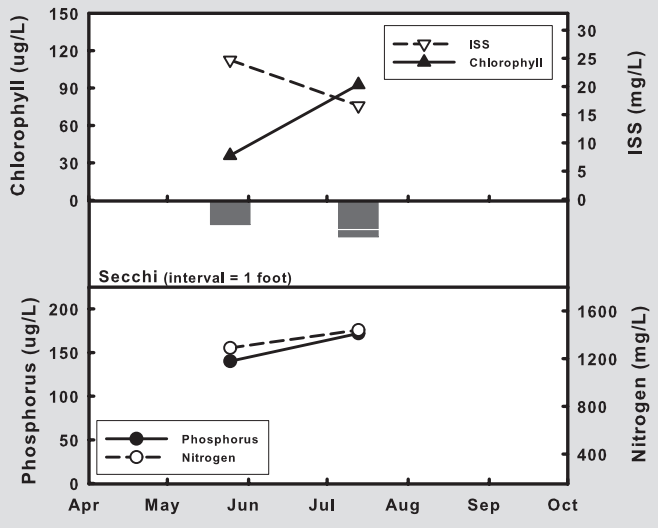
Adair County
Latitude: 40.2772 Longitude: -92.6092

Date	X	5/25	X	X	7/13	X	X	X	Mean
Secchi (inches)		10			15				12
TP (µg/L)		140			172				155
TN (µg/L)		1290			1440				1363
CHL (µg/L)		35.9			92.7				57.7
ISS (mg/L)		24.7			16.6				20.2

Due to limited sampling, seasonal trends cannot be addressed for the 2010 season. Site 3 on Hazel Creek Lake has very different water quality than the other two sites. It is to be expected that the dam site (#1) would be different from the other sites as it is not directly influenced from inflows. What is somewhat surprising is the difference in water quality between sites 2 and 3. These sites are both located on the far southeastern end of the lake, in inflowing coves. The difference in water quality between these sites is related to differences in the watersheds that drain into these two sites. There is about three times as much watershed flowing into Site 3 than Site 2 (≈1550 versus 540 acres).

As observed at Site 2, both phosphorus and nitrogen concentrations have increased over the last two summers. Again, we have limited data from this site during some of the summers which inhibits our ability to analyze and determine if there is a trend for changing water quality at this site.

2010 GRAPHS



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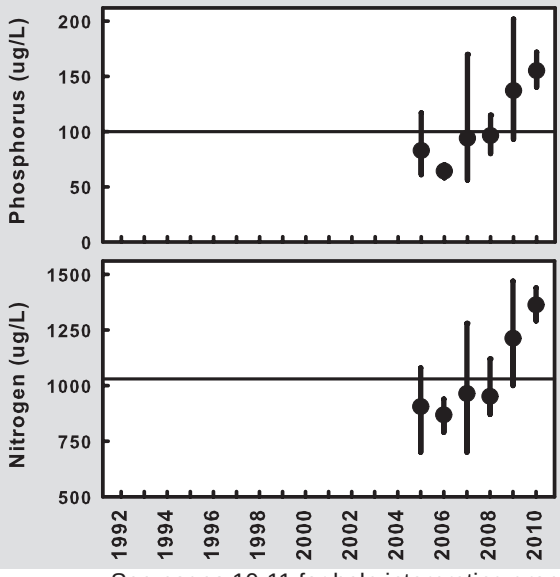


See pages 10-11 for help interpreting graphs

Jennings Park Lake (Koeneman Park Lake)

2010 DATA

St. Louis County
Latitude: 38.7384 Longitude: -90.2583

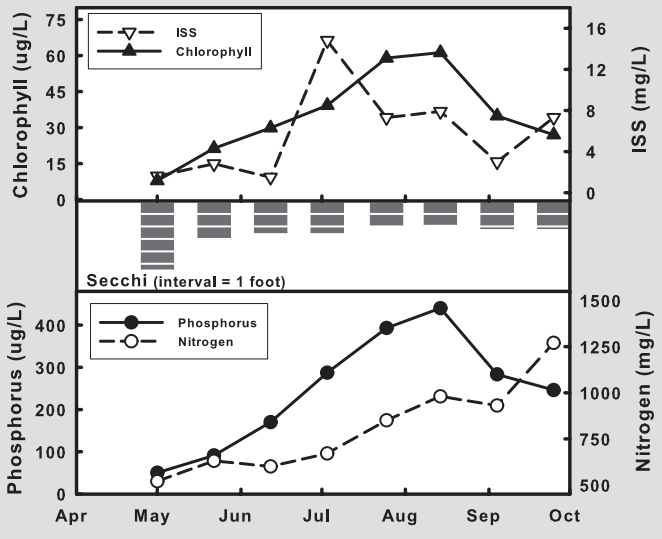
Date	5/1	5/22	6/12	7/3	7/25	8/14	9/4	9/25	Mean
Secchi (inches)	65	36	30	30	23	22	26	26	30
TP (µg/L)	50	91	170	287	393	440	283	246	201
TN (µg/L)	520	630	600	670	850	980	930	1270	775
CHL (µg/L)	7.9	21.4	29.9	39.3	59.0	61.3	34.9	27.0	30.1
ISS (mg/L)	1.6	2.8	1.5	14.8	7.3	7.9	3.0	7.3	4.3

Jennings Lake once again displayed lower levels of nutrients, algal chlorophyll and inorganic suspended sediment at the beginning of the sample season, with increases through the summer. This differs from the normal seasonal pattern found in most Missouri lakes, which is dominated by inflows entering the lake during the springtime. This reversal of the normal Missouri pattern suggest that water quality in Jennings Lake may be dominated by internal loading as opposed to inputs from the watershed. Internal loading involves nutrients migrating from the lake sediment into the overlying water.

The nitrogen concentrations in Jennings Lake are low relative to phosphorus values, indicating that algae in the lake are limited in growth by nitrogen. This is important because some forms of algae are able to use atmospheric nitrogen, making Jennings Lake a perfect place for their growth. These algae are often found in large clumps at the lake's surface, making them very undesirable to lake users.

Both the average and maximum phosphorus concentrations have increased over the last few summers in Jennings Lake. The average phosphorus concentration during the summer of 2010 was nearly twice the long-term average. In most Missouri lakes this increase in phosphorus would be mimicked by an increase in inorganic suspended sediments coming from the watershed. Review of data from Jennings Lake shows the inorganic suspended sediment values have not increased over the last few years. Phosphorus is the only water quality parameter that shows a trend.

2010 GRAPHS



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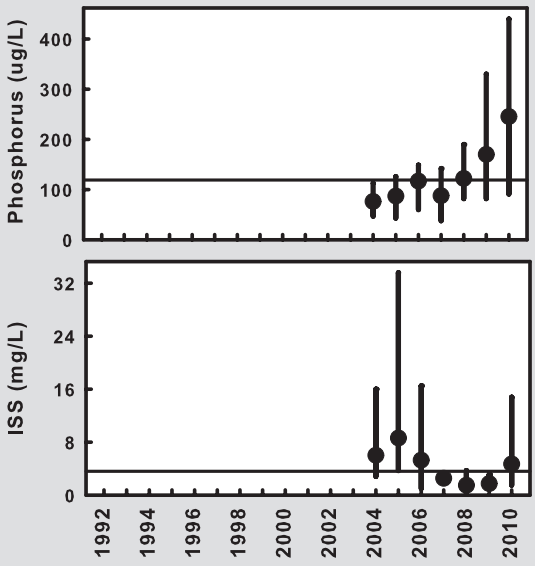
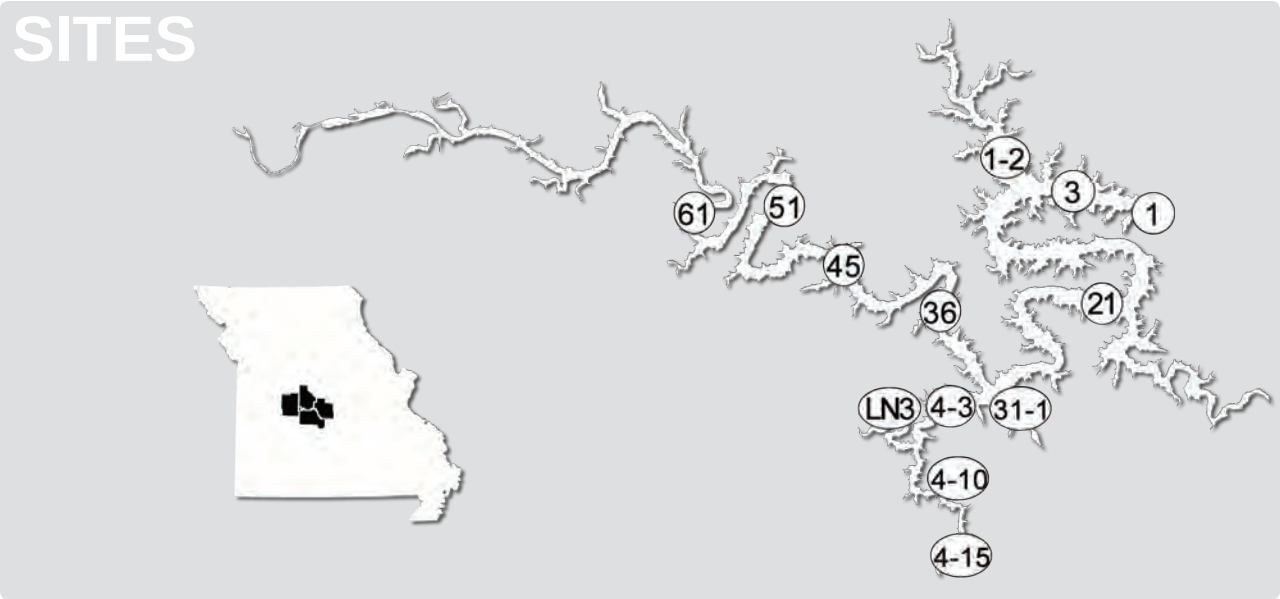


See pages 10-11 for help interpreting graphs

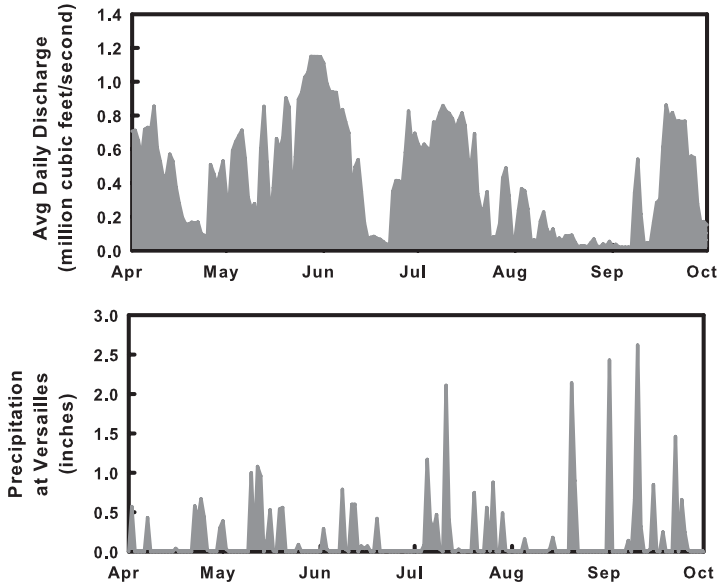
Lake of the Ozarks

Benton, Camden, Miller and Morgan Counties



In the lower lake near Bagnell Dam, nutrients were low and clarity was high (about 9 feet) early in the 2010 season. Turbidity was high during the early season in the upper Osage portion of the lake, causing reduced water clarity relative the remainder of the season.

At all but a few sites there was an increase in nutrients and sediments at the end of September. If the suspended sediments remained below approximately 7, there was an increase in algal chlorophyll on the same day. For those sites where the suspended sediment values exceeded 7 mg/L there was a decrease in algal chlorophyll due to shading. In the main lake, this happened at the sites between Truman Dam and the 21 mile marker (Site 21).



The two graphs above reflect the influence of rainfall and runoff. The first graph is the the average daily discharge from Bagnell Dam into the Osage River. The second (bottom) graph shows total daily precipitation at Versailles.

On August 31 samples were collected at both Site 1.2 and Site 3 by different volunteers. This duplication of effort allows for a cursory quality control examination. Secchi was similar among the 2 samples, differing by about 20% at each site. The variation between samplers could be explained by differences in time of observation. Because of the influence of the angle of the sun, we ask volunteers to sample at approximately the same time each visit. All other measurements were essentially identical. For the purposes of this report, the two samples were averaged to produce a single daily value.

LOWA
our lake - one voice

Many of the LMVP volunteers at the Lake of the Ozarks are also active in the Lake of the Ozarks Watershed Alliance (LOWA). Visit the LOWA website at www.soslowa.org.

Lake of the Ozarks

Benton, Camden, Miller and Morgan Counties

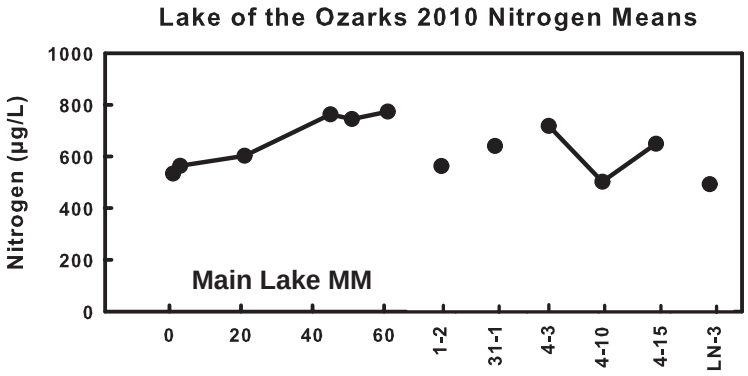
2010 SUMMARY DATA TABLE

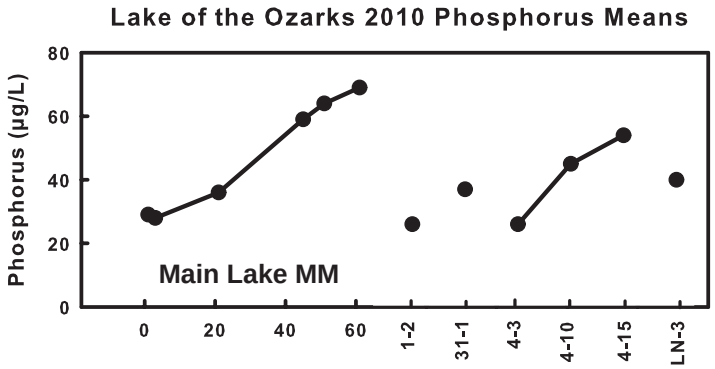
Site	# of samples		Secchi (inches)	TP (µg/L)	TN (µg/L)	CHL (µg/L)	ISS (mg/L)	Site Description
1	**6**	**Mean**	**59**	**29**	**534**	**14.8**	**1.2**	Bagnell Dam
		Minimum	45	19	430	1.6	0.7	
		Maximum	83	48	690	32.1	2.3	
3	**8**	**Mean**	**64**	**28**	**564**	**15.3**	**1.6**	Main Lake, 3 mile marker
		Minimum	45	15	400	2.0	1.0	
		Maximum	110	52	970	43.5	3.3	
21	**7**	**Mean**	**53**	**36**	**603**	**13.5**	**1.3**	Main lake, 13 mile marker
		Minimum	32	23	480	6.1	0.1	
		Maximum	67	48	990	23.5	4.1	
45	**6**	**Mean**	**32**	**59**	**763**	**20.6**	**4.9**	Main lake, 45 mile marker
		Minimum	21	41	610	9.0	2.2	
		Maximum	44	77	1430	32.4	8.6	
51	**8**	**Mean**	**25**	**64**	**745**	**21.9**	**9.3**	Main lake, 51 mile marker
		Minimum	12	44	570	7.5	2.6	
		Maximum	40	92	1350	33.4	19.2	
61	**6**	**Mean**	**13**	**69**	**774**	**17.8**	**17.7**	Main lake, 61 mile marker
		Minimum	8	58	520	7.4	9.0	
		Maximum	21	100	1300	29.5	26.4	
1-2	**8**	**Mean**	**70**	**26**	**563**	**14.3**	**1.3**	Gravois Arm, 2 miles from main channel
		Minimum	57	15	480	2.3	0.7	
		Maximum	112	43	760	34.5	2.3	
31-1	**7**	**Mean**	**39**	**37**	**641**	**27.9**	**2.6**	Linn Creek Arm cove site, 1 mile from main channel
		Minimum	28	26	530	17.9	1.0	
		Maximum	48	52	970	41.2	5.9	
4-3	**6**	**Mean**	**52**	**26**	**718**	**13.1**	**1.2**	Niangua Arm, 3 miles from main channel
		Minimum	42	19	640	10.5	0.7	
		Maximum	63	29	870	16.0	2.0	
4-10	**7**	**Mean**	**38**	**45**	**502**	**19.5**	**2.6**	Niangua Arm, 10 miles from main channel
		Minimum	13	31	330	2.3	1.4	
		Maximum	58	64	710	47.6	17.1	
4-15	**6**	**Mean**	**24**	**54**	**649**	**18.4**	**11.1**	Niangua Arm, 15 miles from main channel
		Minimum	14	36	410	5.0	6.6	
		Maximum	34	136	1230	41.6	21.0	
		Mean	**35**	**40**	**493**	**17.4**	**2.8**	Little Niangua, 3 miles from the Niangua
LN3	5	Minimum	18	32	400	9.3	1.3	
		Maximum	51	68	620	26.5	12.4	

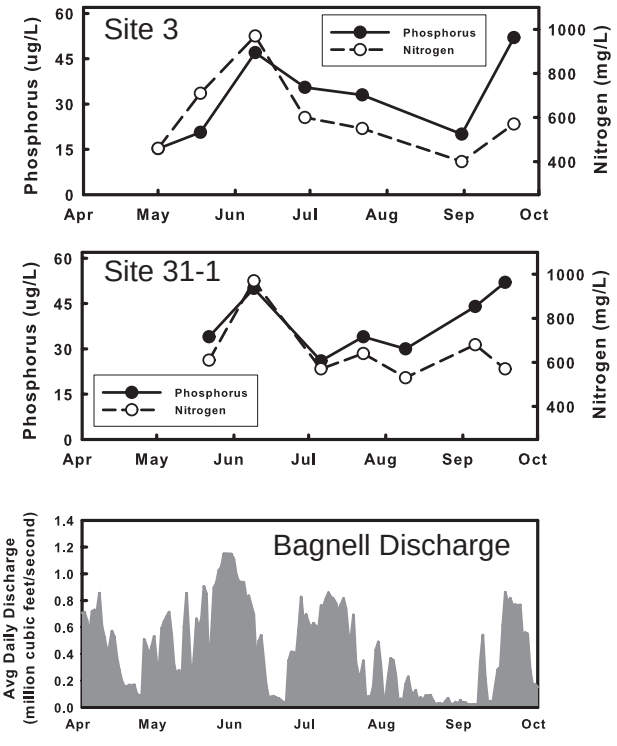
Lake of the Ozarks
Benton, Camden, Miller and Morgan Counties

Nitrogen concentrations only varied by about 30% from the 61 mile marker (Site 61) to Bagnell Dam. Sites within the Niangua Arm showed approximately the same variability as the main lake. The lowest mean 2010 nitrogen value was measured in the Little Niangua, though lake-wide nitrogen values varied little.

As is typical of reservoirs, the up-lake sites had higher concentrations of phosphorus than the lower lake sites. Phosphorus values at Bagnell Dam averaged just over a third of the phosphorus values measured up-lake at Site 61. This phenomenon was also observable in the Niangua Arm, as Site 4-3 had about half the phosphorus measured 12 miles up the arm near Ha Ha Tonka (Site 4-15).

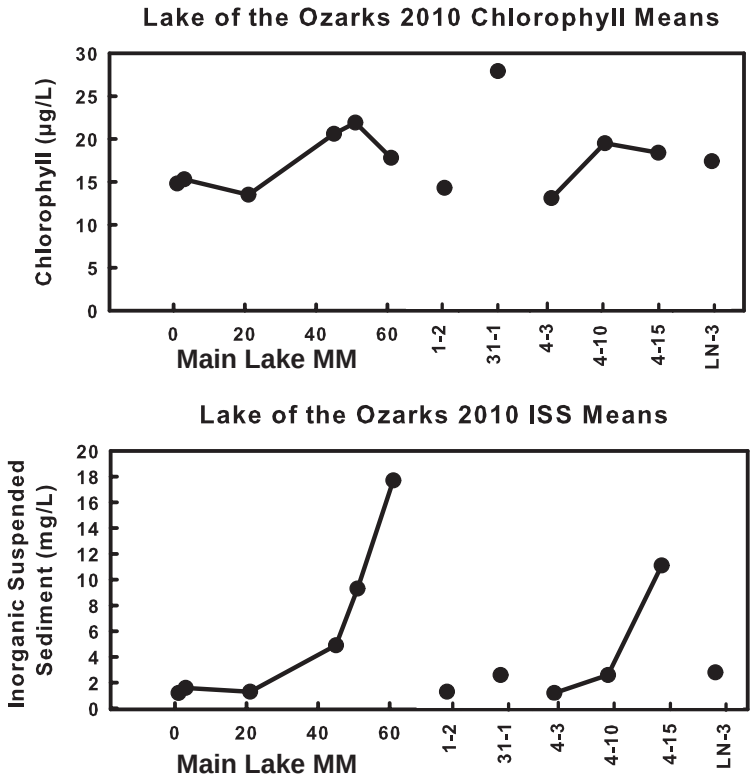






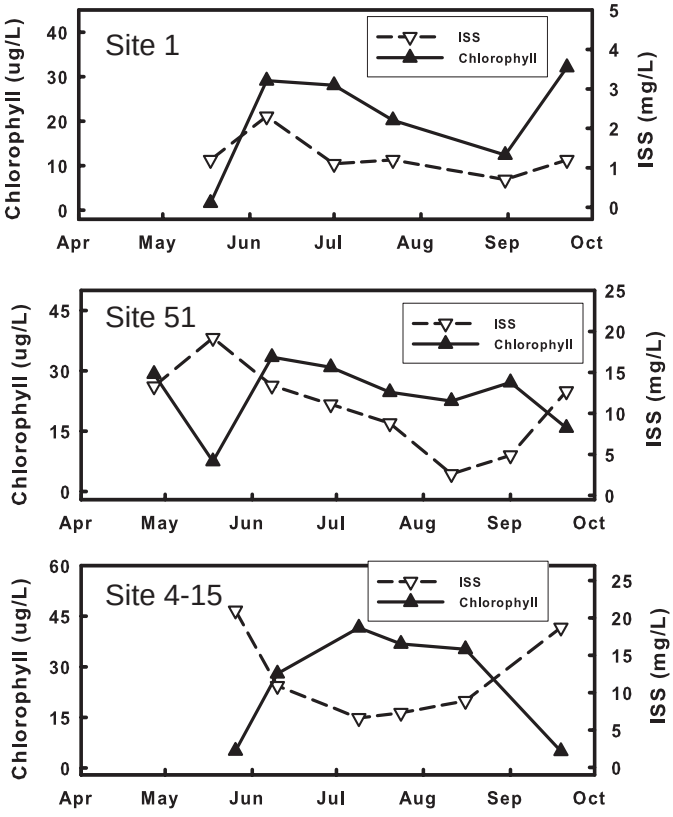
Across the 2010 sampling season, nutrient concentrations varied roughly with discharge from Bagnell Dam (bottom left). The discharge reflects the accumulated rain and runoff from the surrounding landscape and the Osage River. At many sites (e.g. Site 3, top left), there were two nutrient peaks in 2010, one in late May or early June and another in early or mid September. At other sites (e.g. Site 31-1, middle left) there was a smaller mid season bump in nutrient concentrations that more or less coincides with the Bagnell discharge data from July.

Lake of the Ozarks
Benton, Camden, Miller and Morgan Counties



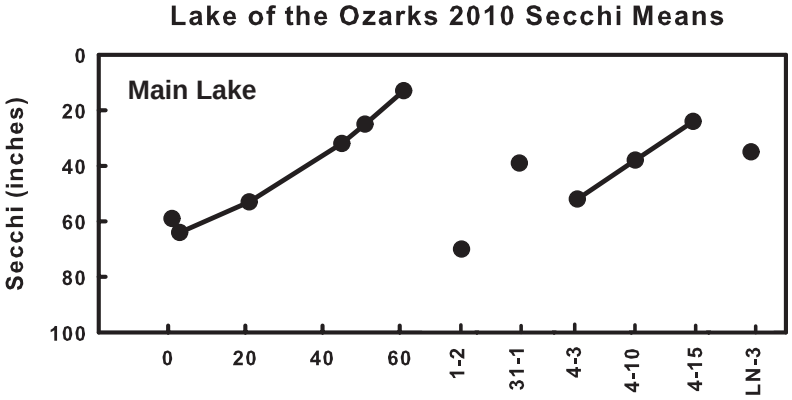
The abundance of algae, as measured by chlorophyll concentration, in the main lake was highest mid-lake at the 45 and 51 mile marker sites. Sites in the Niangua showed a similar pattern, with higher values mid-arm. This pattern reflects the abundance of inorganic suspended sediment materials present at the uppermost sites. Inflowing water carries sediment that shades the water column, inhibiting algal growth. As the water flows through the lake (or lake arm) the velocity slows and the particles settle to the bottom, allowing sunlight to penetrate deeper into the water column. The additional sunlight promotes algae growth and higher measured chlorophyll concentrations. Site 31-1 had the highest measured chlorophyll value in 2010. This site is located at the mouth of a cove on the Linn Creek arm.

At Bagnell Dam (Site 1, top) inorganic suspended sediment (ISS) concentrations were low, with the maximum measured ISS value less than 2 mg/L. At Site 51 (51 mile marker, center) and Site 4-15 (upper Niangua arm, near Ha Ha Tonka, bottom) ISS values were an order of magnitude higher and showed roughly the same seasonal pattern. At Sites 51 and 4-15 the highest ISS values were associated with the lowest concentrations of chlorophyll, illustrating the inhibition of algal growth due to shading by sediment particles.



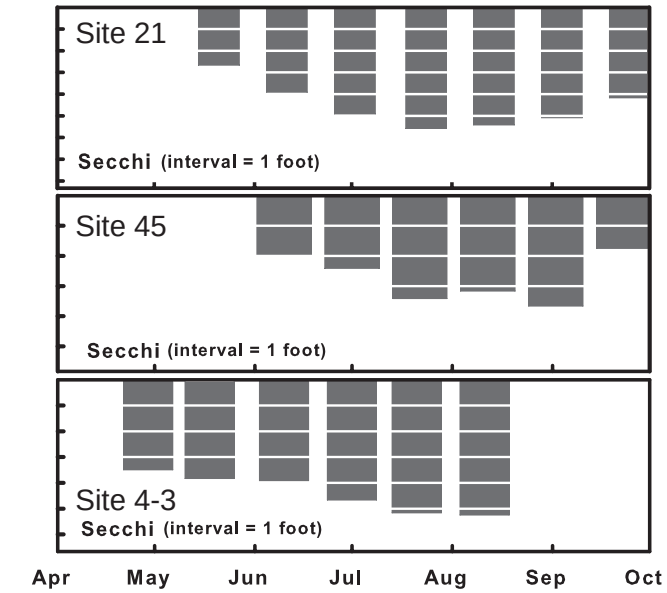
Lake of the Ozarks

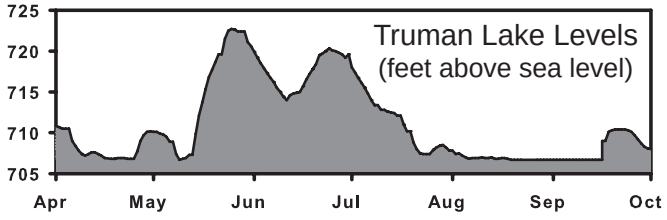
Benton, Camden, Miller and Morgan Counties



Water clarity is highest near the dam and decreases nearer to the source of inflowing water. In the main lake, Bagnell Dam (Site 1) and the 3 mile marker (Site 3) water clarity averaged about 5 feet, while clarity barely cleared one foot at mile marker 61 (Site 61). Within the Niangua Arm, the same spatial trend is clearly apparent, with clarity at the mouth of the arm similar to the main lake nearby. Water clarity at the head of the Niangua Arm (Site 4-15) averaged 2 feet in 2010. The Linn Creek and Little Niangua sites (31-1 and LN-3, respectively) each had about 3 feet of clarity on average. Water at the Gravois site (1-2) was somewhat clearer than at Bagnell Dam, with a 2010 average Secchi transparency of nearly 6 feet.

At all but a few down-lake sites (graphs not shown) water clarity was highest mid-season, during the latter part of July through August. The graphs to the right show water clarity, as measured via Secchi disk, at mile markers 21 (site 21) and 45 (Site 45) and at the Highway 5 bridge over the Niangua (Site 4-3). The period of higher 2010 water clarity roughly coincides with a 6-week period of comparatively low flow in the Osage River channel, as indicated by Truman Lake levels (bottom right) and discharge data from Bagnell Dam (page 35). In most reservoirs, lower flow (or greater "residence time") results in lower concentrations of suspended sediment materials and particulate phosphorus, as these materials will settle to the lake bottom, given enough time.





Lake of the Ozarks

Benton, Camden, Miller and Morgan Counties

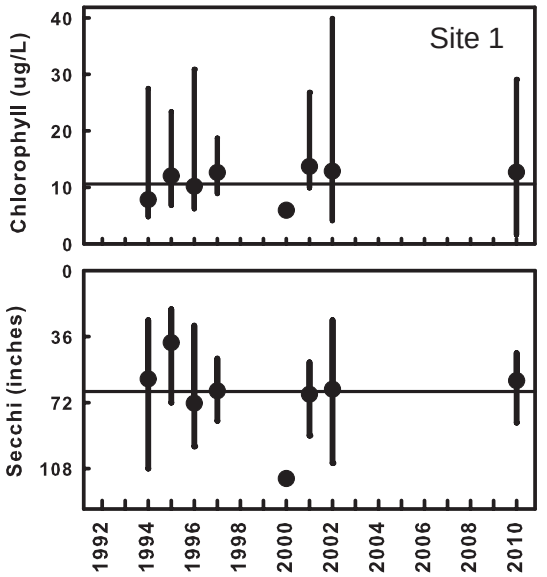
Lake of the Ozark Trends
Main Channel

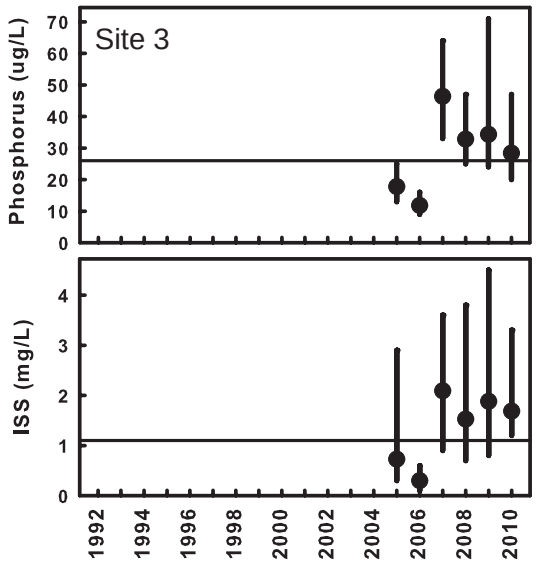
Nutrient, chlorophyll and sediment concentrations across the Lake of the Ozarks were typical, with very few exceptions. Water clarity, as measured by Secchi disk, was typical also, varying only slightly around the mean across the lake.

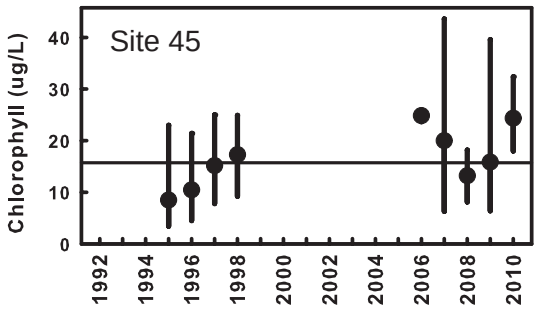
Data from Site 1 (Bagnell Dam) show chlorophyll concentrations in 2010 were very similar to the values measured before 2002, when this site was last sampled. This was the case for all water quality measurements at Site 1.

Site 3 has been monitored more consistently in recent years, but has no sampling history prior to 2005. These data are interesting in that they imply a trend in the past 4 years of higher nutrient concentrations, greater algal biomass, increased suspended sediments and reduced water clarity. However, 2005 and 2006 were dry years and the data from other sites show unusually low concentrations of nutrients, chlorophyll and sediment, resulting in higher than average water clarity lake-wide.

Chlorophyll concentrations were roughly 50% higher than the long-term average at the 45 mile marker (Site 45) in the summer of 2010. Lower than average suspended sediment concentrations during the summer of 2010 (graph not shown) likely encouraged algal growth by allowing sunlight deeper into the water column. Despite the greater algal biomass, the net effect was that the water clarity was higher than average in 2010.



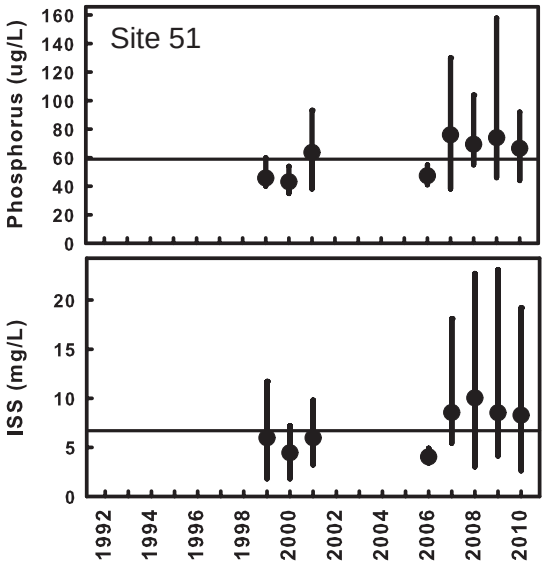




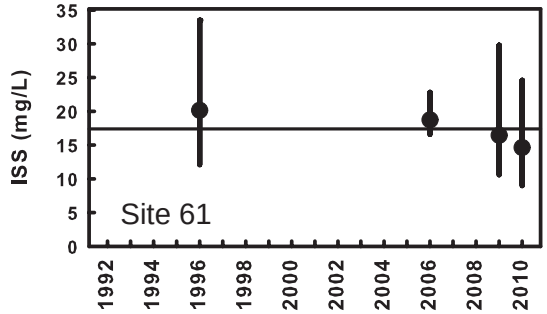
Lake of the Ozarks

Benton, Camden, Miller and Morgan Counties

Conditions at the 51 mile marker (Site 51) are dependent upon the water released from Truman, reflecting the inorganic suspended sediment (ISS) and nutrients passed through Truman Dam and scoured from the bottom and the shoreline below Truman Dam. Phosphorus and ISS data from this site show slightly higher than average concentrations in the past 4 years.



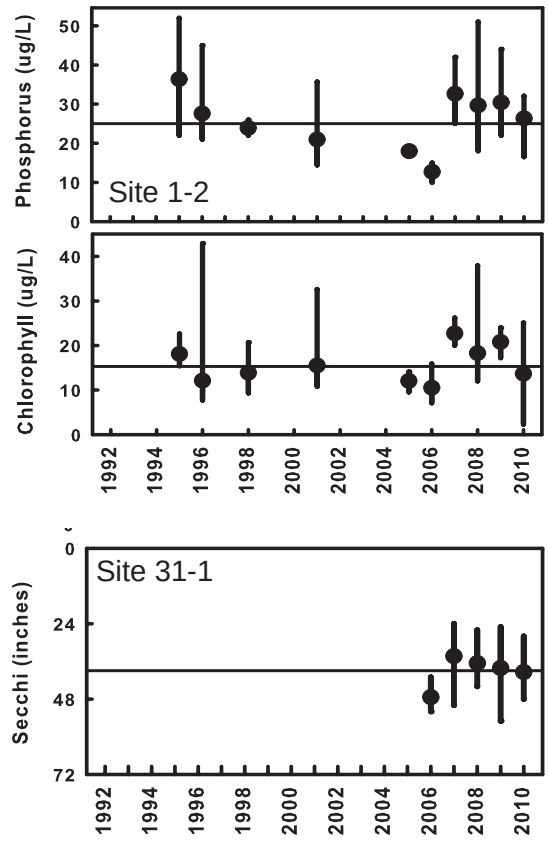
Site 61 (at the 61mile marker) was monitored for the second consecutive year in 2010, following a lengthy period of sporadic sampling. The mean 2009 and 2010 inorganic suspended sediment concentrations were lower, on average, than in either of the previous years.



In both the Gravois Arm and the Linn Creek Arm phosphorus concentrations were lower during 2010 than the previous 3 years. At Site 1-2 in the Gravois Arm, reduced algal biomass in the lake was the result.

Algal biomass was slightly higher at Site 31-1 in the Linn Creek Arm, possibly due to increased light penetration through the water column. Linn Creek's suspended sediment values were lower during 2010 than measured in the previous two years.

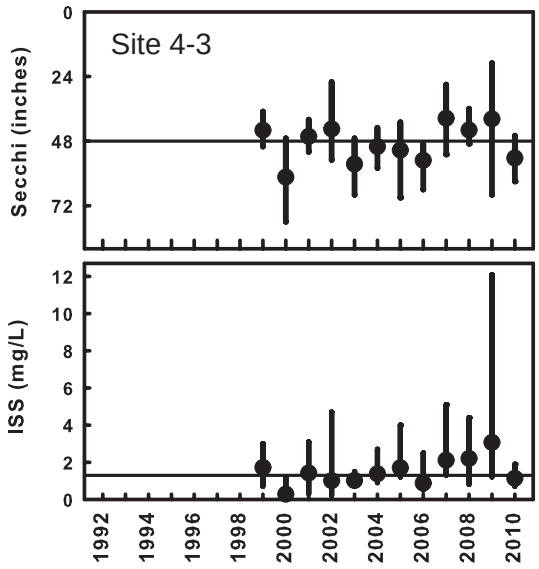
Water clarity was marginally improved at both sites.



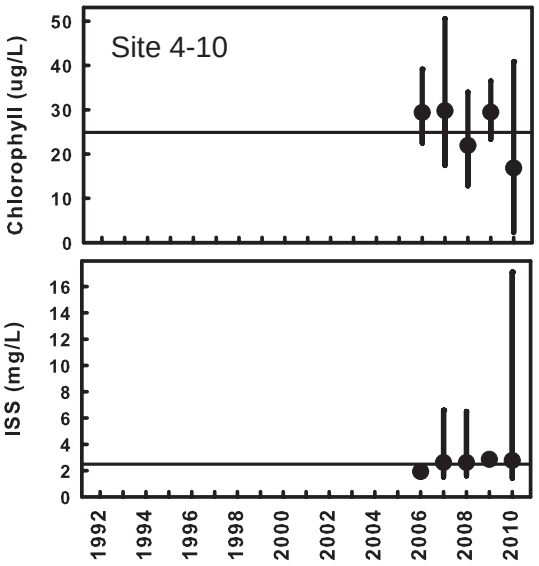
Lake of the Ozarks

Benton, Camden, Miller and Morgan Counties

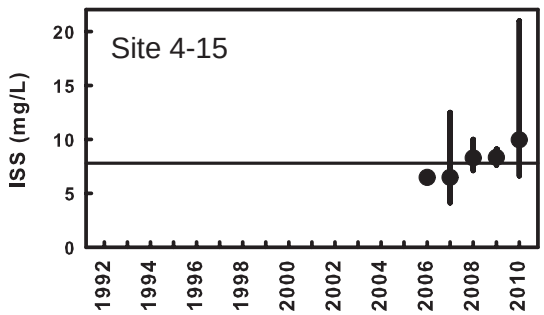
The water at Site 4-3 was clearer than average in 2010. The mean 2010 Secchi value was 14 inches greater than measured in 2009, largely due to the presence of less suspended sediment in 2010. Long-term data show 2010 ISS concentrations were very near the overall mean but just a third of the 2009 values.



The 2010 data show that there was less algae at Site 4-10, near Bridal Cave, than in recent years. The mean 2010 chlorophyll value was the lowest recorded to data, though the range of values observed was quite high. While the 2010 mean inorganic suspended sediment value was near the long-term mean, the range of values measured was quite high. The maximum ISS value measured in 2010 was nearly 10 times higher than the mean and more than double the next highest value. The high ISS value was measured on the same day as the lowest chlorophyll value. This illustrates the effect of light limitation on algal biomass. When ISS concentrations are high (typically at or above 10 mg/L) the soil particles in the water scatter enough light to inhibit algae growth.



Summer ISS concentrations were higher in 2010 than measured previously at Site 4-15. The maximum 2010 ISS value was more than double the second highest value (measured in 2007).



Lamar City Lake

Site 1

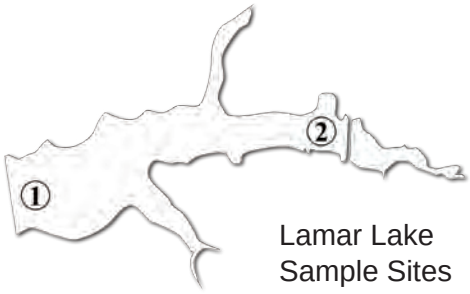
Barton County
Latitude: 37.4801 Longitude: -94.2602

2010 DATA

Date	4/30	5/21	6/11	7/2	7/23	8/16	8/31	9/20	Mean
Secchi (inches)	42	18	30	24	24	32	24	30	27
TP (µg/L)	85	117	77	98	115	98	90	60	91
TN (µg/L)	950	640	1040	890	1320	1590	1240	960	1044
CHL (µg/L)	13.4	11.3	43.9	76.7	45.5	57.7	31.5	19.8	30.9
ISS (mg/L)	3.7	17.1	2.1	1.7	2.3	1.1	3.2	1.9	2.8

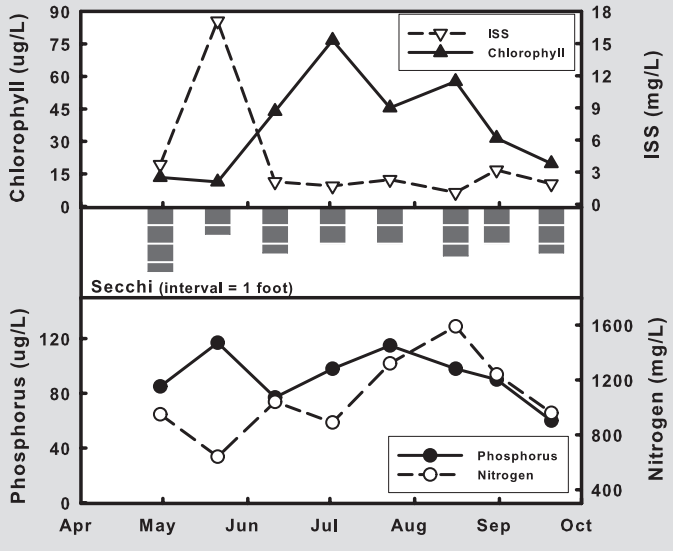
Similar to the pattern observed in previous years, nitrogen levels in Lamar City Lake generally increased as the sampling season progressed. This differs from the pattern observed in most Missouri lakes, where nitrogen concentrations decrease through the summer. Lamar City Lake tends to have high levels of phosphorus relative to nitrogen, creating a situation where blue-green algae that have the ability to fix atmospheric nitrogen may have a competitive advantage over other types of algae. These algae will create floating mats across the surface of the lake and are not desirable due to aesthetic issues, potential taste and odors problems and their general poor quality as a food item for aquatic life.

Inorganic suspended sediment values have been low in Lamar City Lake, with an overall average of around 2mg/L. This is a low level of suspended sediment for a lake located in the Osage Plains Region of the state (regional average of 6.8 mg/L). The two high values that have been measured (6/10/2008 and 5/21/2010) in Lamar City Lake were samples collected on days preceding substantial rain events (1.9" and 2.3", respectively). Average phosphorus values for the last four summers have been higher than the long-term average (and higher than those measured between the years 2003-06). None of the other parameters reflect this pattern.



Lamar Lake
Sample Sites

2010 GRAPHS



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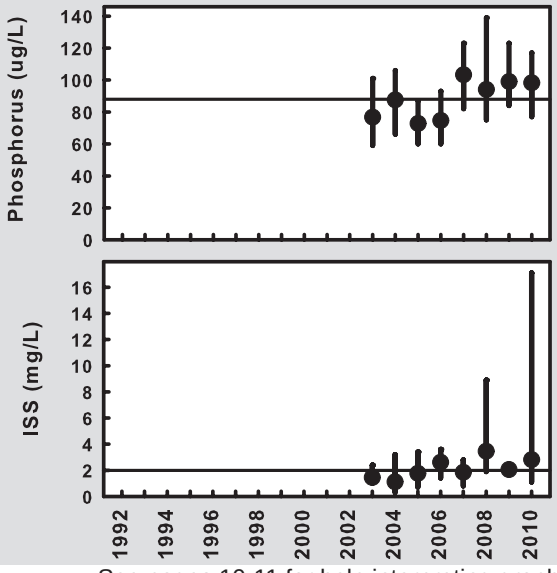


See pages 10-11 for help interpreting graphs

Lamar City Lake

Site 2

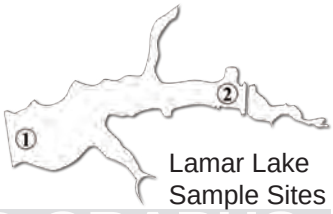
2010 DATA

Barton County
Latitude: 37.483 Longitude: -94.2451

Date	4/30	5/21	6/11	7/2	7/23	8/16	8/31	9/20	Mean
Secchi (inches)	42	18	28	24	24	36	24	32	28
TP (µg/L)	72	106	102	147	103	85	82	65	92
TN (µg/L)	1010	630	1400	1110	1160	1050	1180	810	1018
CHL (µg/L)	18.0	21.1	89.2	71.9	69.0	43.7	38.6	30.9	41.5
ISS (mg/L)	3.7	10.6	2.0	2.2	1.9	2.4	1.6	1.1	2.5

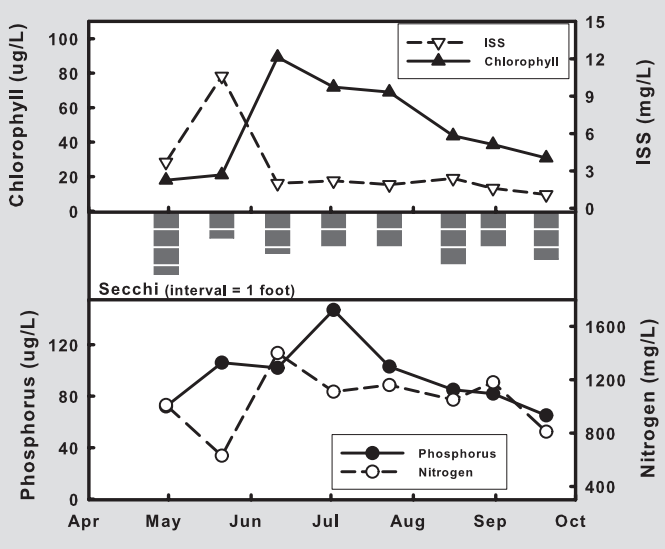
Water quality at Site 2 followed the same general seasonal pattern observed at Site 1. Comparison of the two sites is interesting in that the expected spatial trend of higher nutrient and inorganic suspended sediments concentrations at the up-lake site do not always hold true in this lake. In half the samples (especially in the second half of the season) nutrient levels at Site 1 were higher than at Site 2. Inorganic suspended sediments levels were fairly low at both sites, so the small differences between sites on most sample dates are not significant. The exception would be the May sample when inorganic suspended sediment at the down-lake site was 17.1mg/L compared to 10.6mg/L at the up-lake site. This represents a notable difference that goes against the norm. Algal chlorophyll was the one parameter that showed a tendency for higher values at the up-lake site (though not always). On two occasions the chlorophyll up-lake was twice the level at the dam (May and June).

Chlorophyll levels at Site 2 have fluctuated both within and among years. Comparison of the long-term chlorophyll and long-term nitrogen graphs show similar trends. Site 2 in Lamar City Lake tends to have nitrogen concentrations that are low relative to phosphorus values. The ratio of nitrogen to phosphorus, which is useful in gauging which nutrient limits algal growth, tends to range from 11 to 15 units of nitrogen for each unit of phosphorus. This ratio suggests that both nutrients are important in determining algal growth (depending on the species of algae present at any given time). This may explain why chlorophyll mimics nitrogen in the long-term graphs.

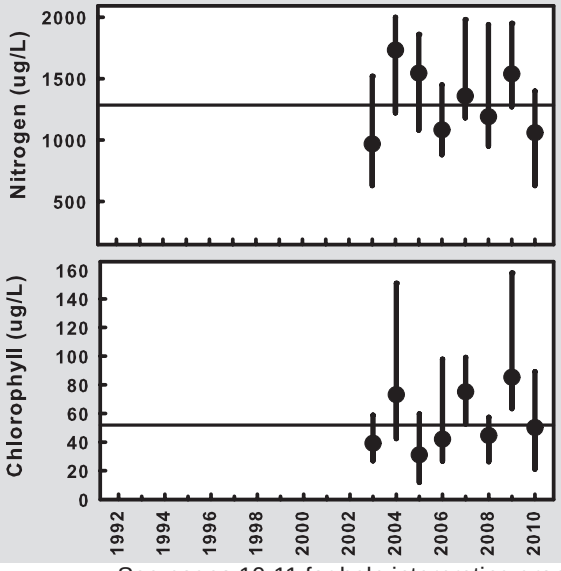


Lamar Lake
Sample Sites

2010 GRAPHS



TREND GRAPHS



See pages 10-11 for help interpreting graphs

Lick Creek Lake

2010 DATA

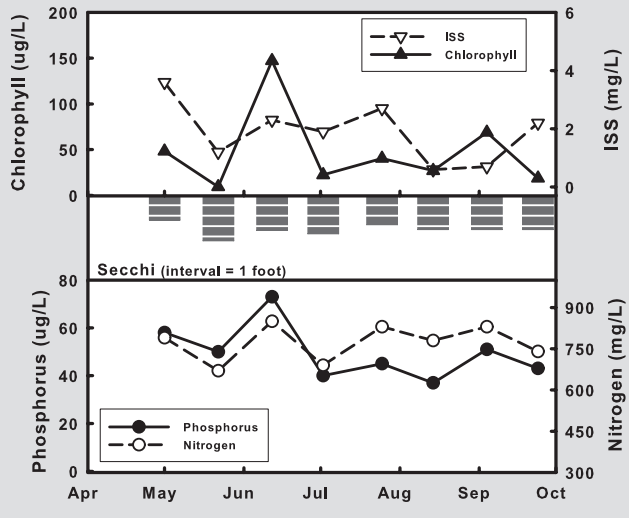
Boone County
Latitude: 39.1510 Longitude: -92.3852

Date	5/1	5/22	6/12	7/2	7/25	8/14	9/4	9/24	Mean
Secchi (inches)	29	53	41	45	35	40	40	40	40
TP (µg/L)	58	50	73	40	45	37	51	43	49
TN (µg/L)	790	670	850	690	830	780	830	740	770
CHL (µg/L)	48.3	9.4	147.1	22.4	40.4	27.0	68.8	18.7	34.7
ISS (mg/L)	3.6	1.2	2.3	1.9	2.7	0.6	0.7	2.2	1.6

The nutrients tended to fluctuate in a similar fashion during the 2010 season, with no real trend towards increasing or decreasing levels. Relative to most Missouri lakes, the amount of variation in the nutrients was considerably low. In contrast, algal chlorophyll values ranged from a low of 9.4µg/L to a maximum concentration of 147.1µg/L. This represents the highest chlorophyll concentration measured in Lick Creek Lake. The previous maximum had been 38.0ug/L in 2008, in contrast there were four values that exceeded 38µg/L this past year, and the average for 2010 was 34.7µg/L.

Phosphorus concentrations during the summer of 2010 were notably higher than in the past two summers. While it is common for year to year variations in Missouri lakes, we normally see other parameters also fluctuating. There was slightly more nitrogen in Lick Creek Lake in 2010, but the difference from previous years is relatively small. There was not a notable increase in the inorganic suspended sediment in 2010, an occurrence we might expect to see tie into the higher phosphorus levels. Relative to many Missouri lakes, the levels of suspended sediment in Lick Creek Lake are extremely low, reflecting the lake's forested watershed.

2010 GRAPHS



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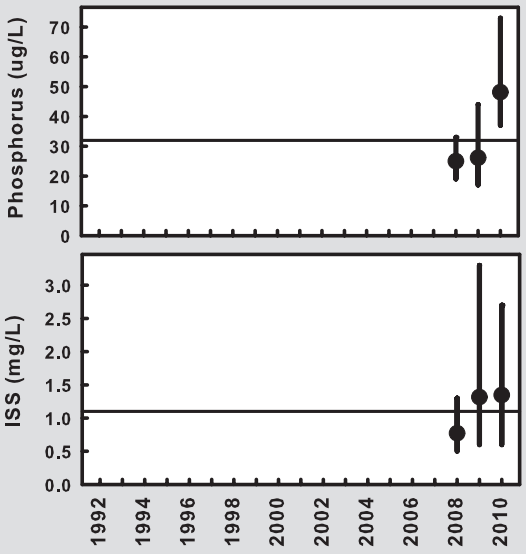


See pages 10-11 for help interpreting graphs

Longview Lake

2010 DATA

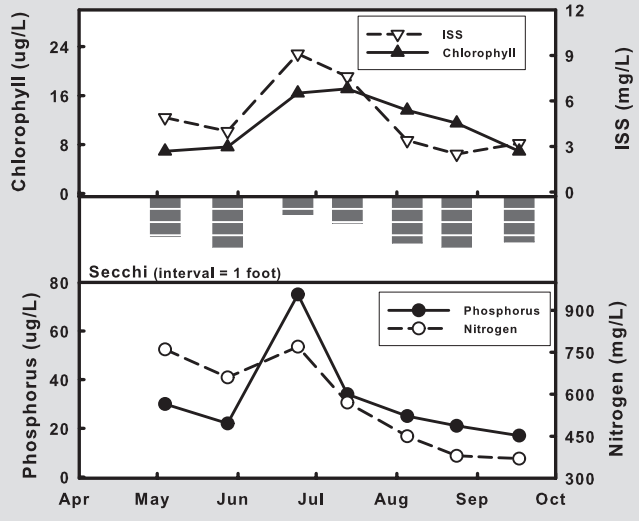
Jackson County
Latitude: 38.9210 Longitude: -94.4661

Date	X	5/4	5/28	6/24	7/13	8/5	8/24	9/17	Mean
Secchi (inches)		37	47	17	25	43	47	42	35
TP (µg/L)		30	22	75	34	25	21	17	28
TN (µg/L)		760	660	770	570	450	380	370	543
CHL (µg/L)		6.9	7.6	16.4	17.1	13.6	11.5	6.9	10.7
ISS (mg/L)		4.9	4.0	9.1	7.6	3.4	2.5	3.2	4.5

Nutrients, inorganic suspended sediment and algal chlorophyll all followed the same general pattern during the 2010 sample season, all peaking to maximum levels in June. The amount of variation in the data was normal, with nitrogen ranging about 2-fold, phosphorus 4-fold, and suspended sediment about 4-fold. Chlorophyll was more stable than we normally find, with only a 2.5-fold difference between the minimum and maximum.

Longview Lake has been monitored in 18 of the last 19 years. Water quality in this lake has always displayed notable variability, both within individual years and among years. The accompanying graphs show how nitrogen and chlorophyll have fluctuated during the last two decades. The symbols represent values from individual sample dates, with the thin line connecting data points in chronological order. The thicker line shows the general long-term pattern within the data. Nitrogen levels in Longview Lake declined through the mid-1990s and have been fairly stable since. In contrast, chlorophyll concentrations have shown a slight long-term increase. None of the other water quality parameters displayed any long-term trends.

2010 GRAPHS



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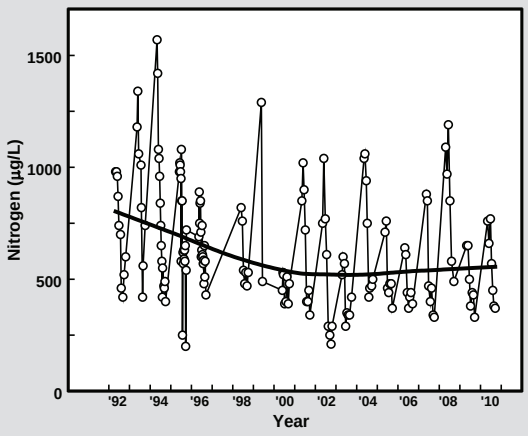
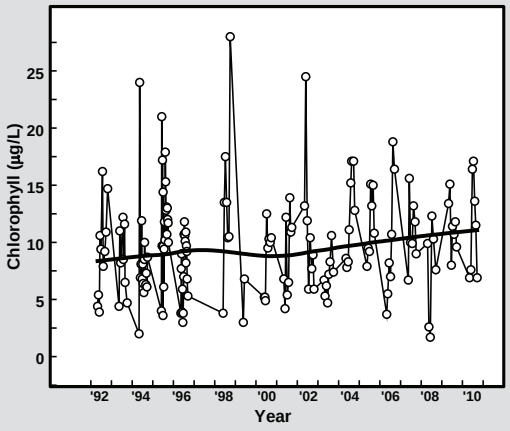




See pages 10-11 for help interpreting graphs

Mahoney Lake

Site 1

Putnam County
Latitude: 40.4997 Longitude: -93.0244

2010 DATA

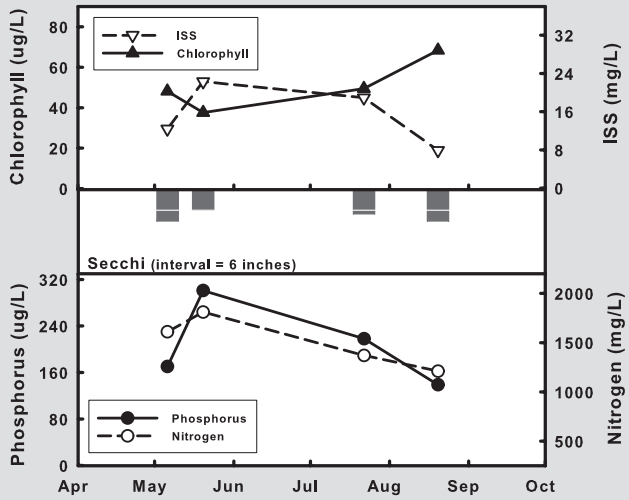
Date	X	5/6	5/20	X	X	7/22	8/20	X	Mean
Secchi (inches)		9	6			7	9		8
TP (µg/L)		170	301			218	139		198
TN (µg/L)		1610	1810			1370	1210		1483
CHL (µg/L)		48.1	37.6			49.4	68.4		49.7
ISS (mg/L)		12.4	22.3			18.9	7.9		14.3

Mahoney Lake sampling sites

The four samples collected at Site 1 in Mahoney Lake indicate extremely high nutrient, algal chlorophyll and inorganic suspended sediment concentrations. Because both algal chlorophyll and suspended sediment levels were high, water clarity was remarkably low (~20% of the statewide average). The nutrient and suspended sediment concentrations tracked each other across the sample season, while fluctuations in chlorophyll differed. The changes in chlorophyll reflect shifts in suspended sediment, with the lowest chlorophyll measurement occurring the day suspended sediment was highest and the maximum chlorophyll being measured when suspended sediment dipped below 10mg/L.

While summertime phosphorus concentrations in Mahoney Lake have historically been elevated compared to state and regional averages, phosphorus levels during the last four summers have been extremely high with all values exceeding 100µg/L and ranging up to 300µg/L. Often times we find elevated phosphorus concentrations accompanied by higher inorganic suspended sediment levels (phosphorus tends to bind to the sediment particles). In three of the past four years suspended sediment levels have been moderate, with only the 2010 values being elevated. Nitrogen levels (not shown) have only been high during the last two summers, with 2007 and 2008 values being below the long-term average.

2010 GRAPHS



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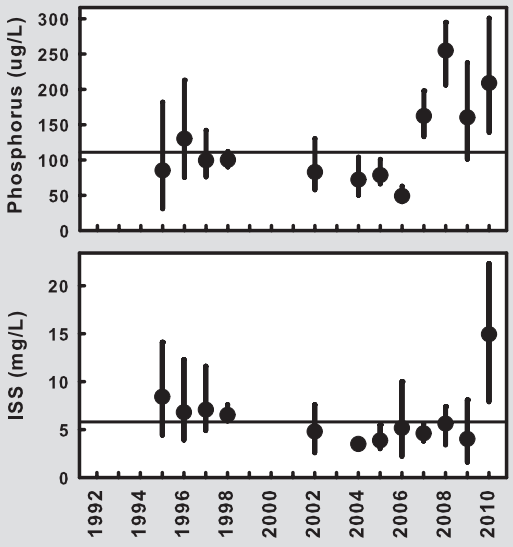


See pages 10-11 for help interpreting graphs

Mahoney Lake

Site 2

2010 DATA

Putnam County
Latitude: 40.4956 Longitude: -93.0236

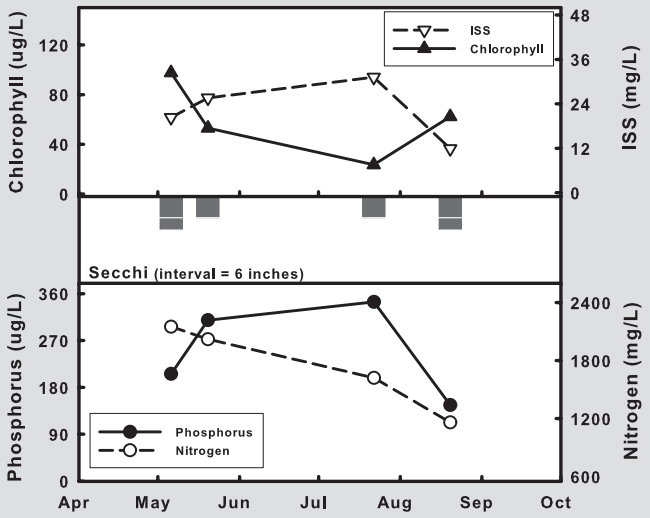
Date	X	5/6	5/20	X	X	7/22	8/20	X	Mean
Secchi (inches)		9	6			6	9		7
TP (µg/L)		206	309			344	146		238
TN (µg/L)		2150	2020			1620	1160		1690
CHL (µg/L)		97.6	53.0			23.5	62.2		52.4
ISS (mg/L)		20.3	25.6			31.2	11.9		21.0

Site 2 is located approximately 500 yards up-lake from Site 1, and predictably has higher concentrations of nutrients and suspended sediment. When data from individual sample dates are compared we find the strength of this gradient can vary, with similar water quality at both sites on some sample dates. Water clarity was always similar at the two sites due to the high levels of both algae and suspended sediment.

Average summer chlorophyll concentrations have been higher than the long-term mean during the last three years. These higher chlorophyll levels generally correspond to higher nutrient values. A result of the increased chlorophyll concentrations is lower Secchi transparency readings. Not only have the last three summers found water clarity at Site 2 being low, but also very stable with very little variations from sample to sample within individual summers.

Mahoney Lake sampling sites

2010 GRAPHS



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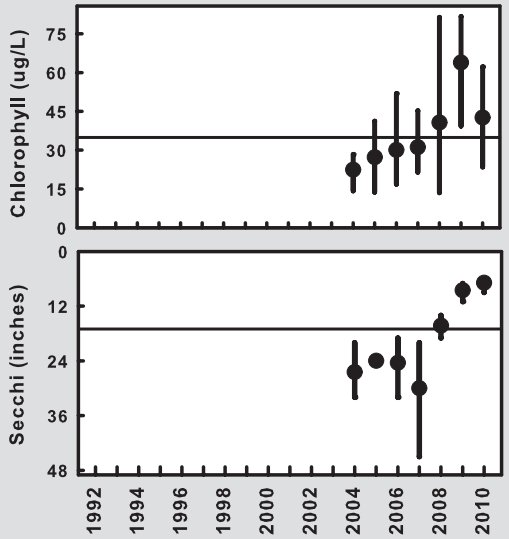


See pages 10-11 for help interpreting graphs

Mark Twain Lake

Site 1

2010 DATA

Monroe and Ralls County
Latitude: 39.524 Longitude: -91.6478

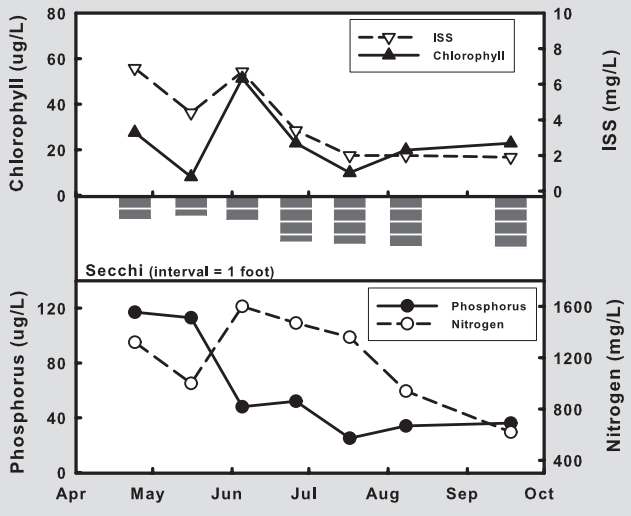
Date	4/24	5/16	6/5	6/26	7/17	8/8	X	9/18	Mean
Secchi (inches)	21	18	22	42	44	46		48	32
TP (µg/L)	117	113	48	52	25	34		36	47
TN (µg/L)	1320	1000	1600	1470	1360	940		620	1137
CHL (µg/L)	27.6	8.1	51.3	22.9	9.9	19.9		22.9	19.8
ISS (mg/L)	6.9	4.4	6.7	3.4	2.0	2.0		1.9	3.4

Mark Twain Lake sampling sites

The sample season can be divided into two portions based on water quality at Site 1. The April to early June sample dates had water clarity averaging 20 inches, with the remainder of the season averaging 45 inches of clarity. The shift in Secchi transparency can be attributed to a decrease in inorganic suspended sediment concentrations. The first three sample dates average 6.0mg/L of suspended sediment compared to an average of 2.3mg/L for the second half of the season. Algal chlorophyll was highly variable in the early season and fairly stable during the second half of the season. The nutrients showed a general trend of decreasing values over the season

Average summertime inorganic suspended sediment and nitrogen levels have been higher than the long-term average during the last three years. These elevated values relate to the last three years having substantially more rainfall than normal. Average annual rainfall in the watershed is around 39 inches. Annual rainfall for the years 2008-2010 ranged from 47 to 67 inches, depending on the weather station. More rainfall equates to increased runoff from the watershed that can carry more inorganic suspended sediment into the lake. Increased rainfall also transports nitrogen from the watershed, usually through the movement of groundwater. Interestingly, only one of the last three years had an average phosphorus value that was substantially higher than the long-term mean (graph not shown).

2010 GRAPHS



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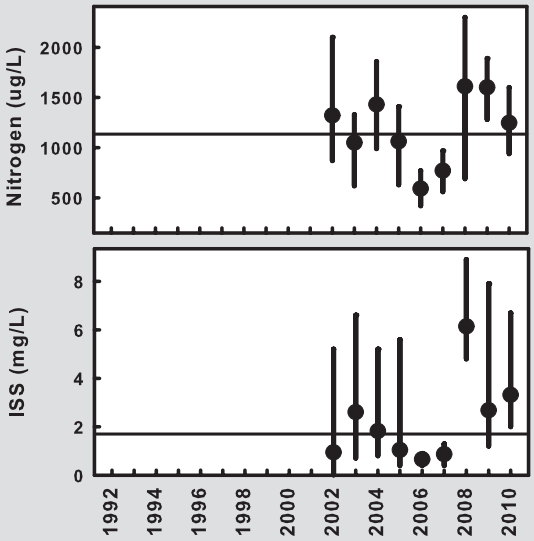


See pages 10-11 for help interpreting graphs

Mark Twain Lake

2010 DATA Site 2

Latitude: 39.5395 Longitude: -91.6972

Date	4/24	5/16	6/5	6/26	7/17	8/8	X	9/18	Mean
Secchi (inches)	22	17	19	38	34	54		59	31
TP (µg/L)	113	115	75	35	30	26		42	53
TN (µg/L)	1340	1600	1410	1760	1170	900		730	1223
CHL (µg/L)	57.4	19.2	48.8	15.3	6.3	10.4		27.6	20.4
ISS (mg/L)	10.2	4.3	6.0	3.0	4.5	1.8		2.1	3.9

Site 2, located in the Indian Creek Arm of Mark Twain, had water quality in 2010 that was very similar to that observed at Site 1. The same general trend of higher inorganic suspended sediment values during the early season, followed by lower levels during the second half of the season were observed. In response to shifts in suspended sediment, water clarity improved throughout the season with the September Secchi reading being roughly three times deeper than values measured earlier in the season. Algal chlorophyll was quite variable, with a nine-fold difference between the minimum and maximum measured value.

Water quality at Site 5 was very comparable to that found at Site 2 in Indian Creek Arm and Site 1 at the dam. Along with similar mean values, the seasonal trends of clearer water, lower nutrient concentrations and lower suspended sediment values during the second half of the season was also identified at Site 5. The biggest differences among sites were slightly higher suspended sediment values at Site 5, which led to shallower Secchi readings.

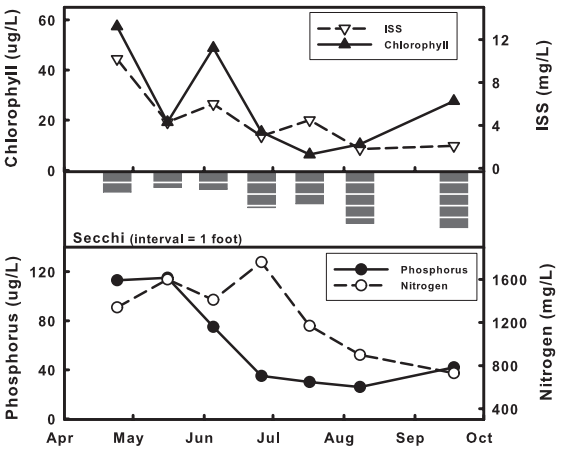
Mark Twain Lake sampling sites

2010 DATA Site 5

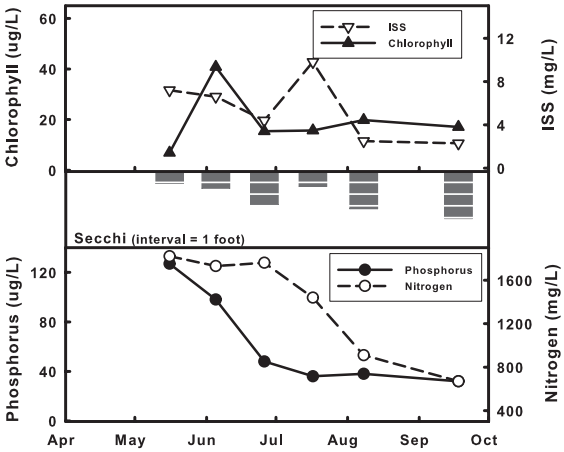
Latitude: 39.5066 Longitude: -91.7679

Date	X	5/16	6/5	6/26	7/17	8/8	X	9/18	Mean
Secchi (inches)		13	18	35	16	39		49	25
TP (µg/L)		127	98	48	36	38		32	54
TN (µg/L)		1820	1730	1760	1440	910		670	1302
CHL (µg/L)		6.9	40.8	15.4	15.7	19.8		17.1	16.9
ISS (mg/L)		7.2	6.6	4.4	9.8	2.5		2.3	4.8

Site 2: 2010 Data



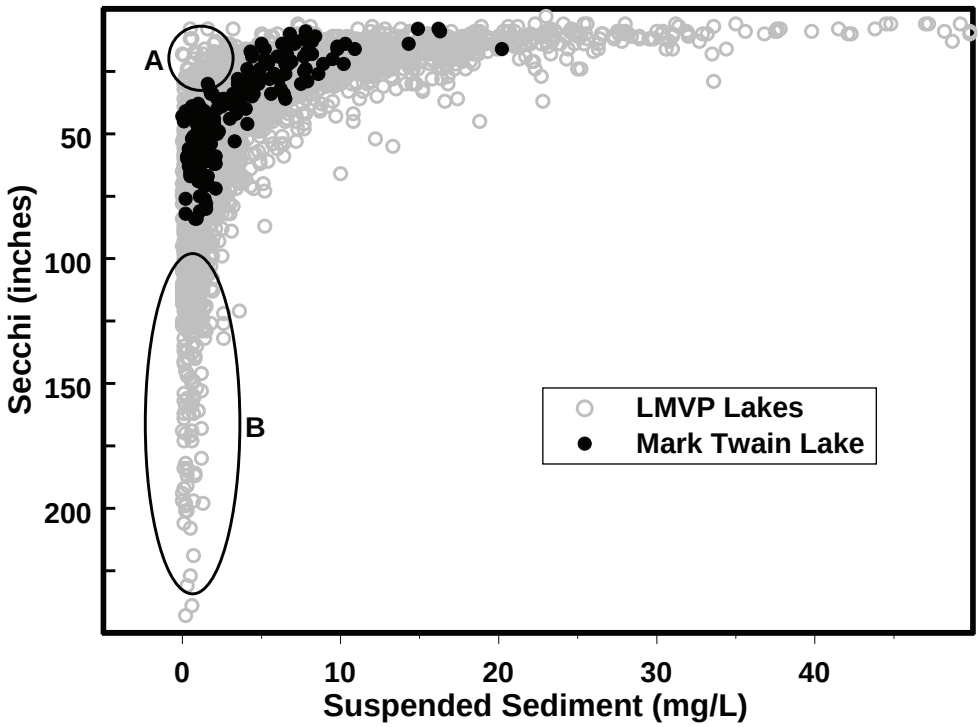
Site 5: 2010 Data



Mark Twain Lake Trends

In Missouri lakes the two factors that dictate water clarity readings are inorganic suspended sediment (soil particles) and algae (estimated via the photosynthetic pigment chlorophyll). While clarity in some Missouri lakes is a function of only one of these factors, in most lakes both suspended sediment and algae combine to dictate water clarity. The following graphs compare these parameters to Secchi transparency, showing data from all LMVP lakes (grey symbols) and Mark Twain sites 1, 2 and 5 (solid, black symbols). Where Mark Twain data points fall within the relationship is informative, as is the areas of the relation where data don't fall.

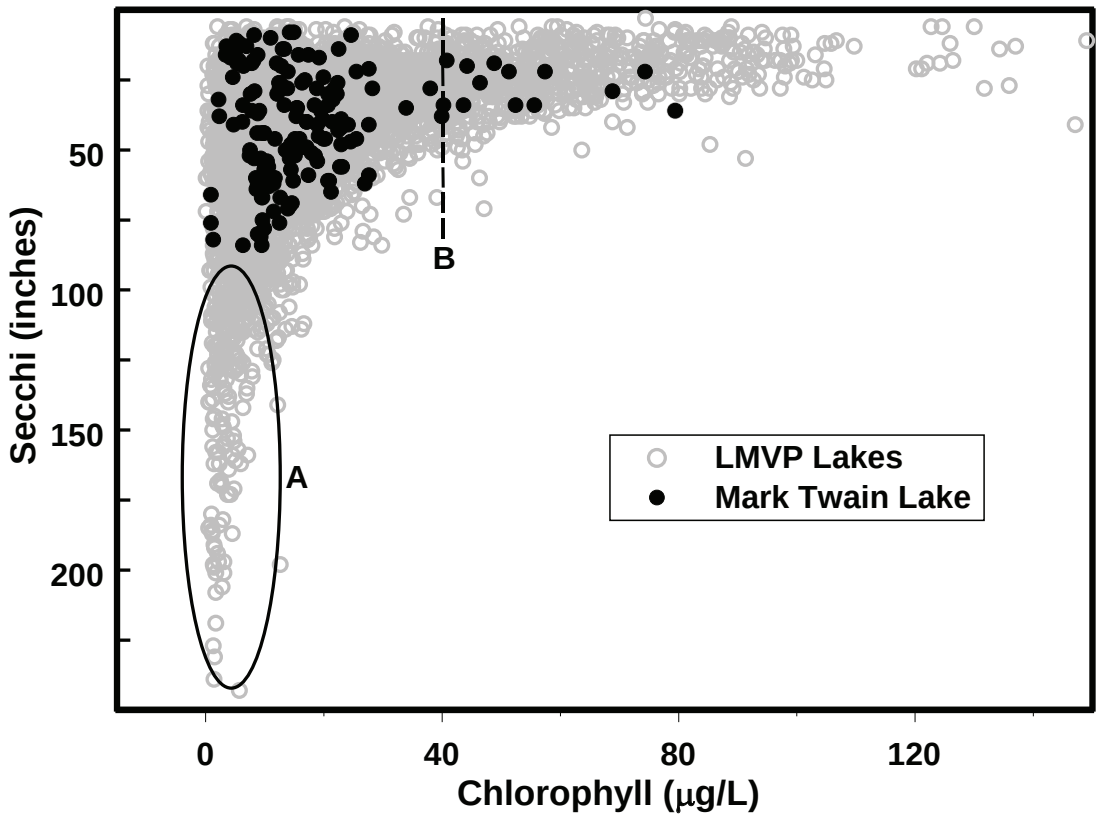
Note a large portion of Mark Twain Lake's watershed is located in an area known as the claypan till plains. Simply put, there is a notable layer of clay in the soil profile, and where erosion is occurring the clay is transported via streams and rivers into Mark Twain Lake. Some of these clay particles are very small in size, and are able to pass through the suspended sediment filter. This means the LMVP inorganic suspended sediment readings actually under-estimate the total amount of suspended sediment in the water column. Also, the small size of the clay particle allows them to remain suspended in the water longer than large particles that would easily settle out.



There is a predictable relation between inorganic suspended sediment values and water clarity in Missouri lakes, with Mark Twain Lake fitting within the relationship. The lack of Mark Twain data in region A of the graph indicates that extremely low Secchi transparency readings associated only with high algal biomass do not occur in Mark Twain Lake. Put in another way, if we are getting very low Secchi readings (<25 inches) the

suspended sediment levels are at least 4mg/L (plus any small particles too small to be captured on our filters). The lack of data points in region B of the graph indicates that Mark Twain Lake does not achieve water clarity that exceeds 85 inches, even when measured suspended sediment values are low. The failure of water clarity to exceed 85 inches reflects a combination of algal biomass and the smaller clay particles that are not being measured.

The algal chlorophyll-Secchi transparency data from Mark Twain Lake also fits within the statewide relation. As previously noted, water clarity does not exceed 85 inches (region A in graph), even on the few days when chlorophyll levels are quite low (<4µg/L). This indicates that on these days suspended sediment was the major determinant of water clarity (low clarity due to suspended sediment may have led to low chlorophyll levels by limiting light availability). Another indication that suspended sediments limit algal growth in Mark Twain Lake is the fact that only 8% of the individual chlorophyll values were >40µg/L, a level that indicates extreme algal biomass in Missouri lakes (also referred to as hypereutrophic, and identified on graph by line B). In contrast, 20% of individual phosphorus values and 47% of nitrogen measurements were in the hypereutrophic zone.



Pomme de Terre Lake

Site 1

2010 DATA

Hickory and Polk County
Latitude: 37.892 Longitude: -93.3108

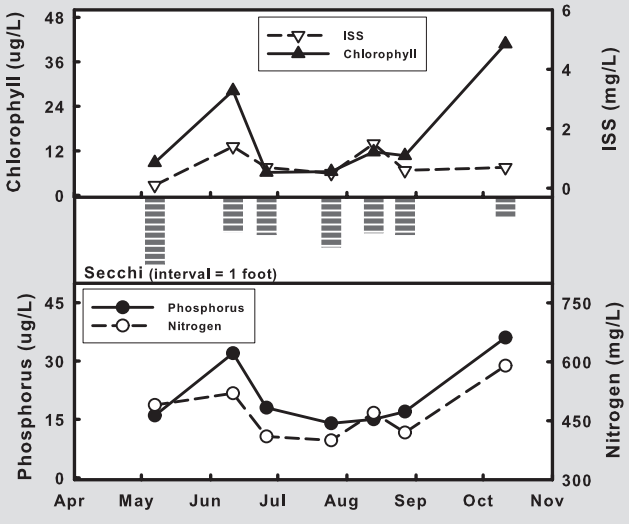
Date	X	5/7	6/11	6/26	7/25	8/13	8/27	10/11	Mean
Secchi (inches)		115	60	65	86	62	65	36	66
TP (µg/L)		16	32	18	14	15	17	36	20
TN (µg/L)		490	520	410	400	470	420	590	467
CHL (µg/L)		8.8	28.2	6.2	6.4	11.7	10.7	40.8	12.6
ISS (mg/L)		0.1	1.4	0.7	0.5	1.5	0.6	0.7	0.6

Pomme de Terre Lake sampling sites

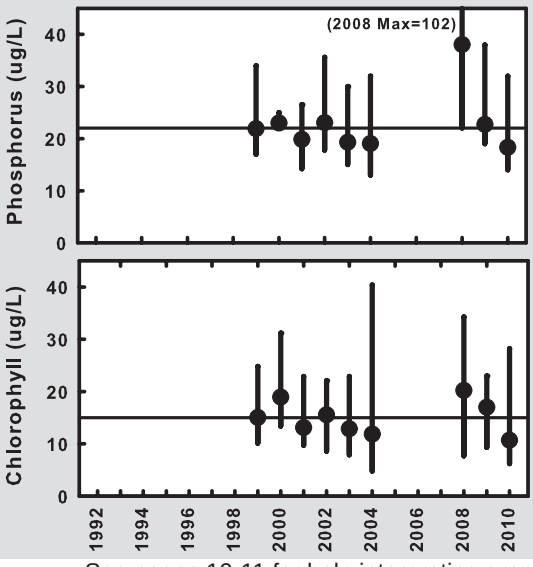
Phosphorus, nitrogen and algal chlorophyll tracked each other across the sample season, with peaks in early June and October. The ratio of chlorophyll to phosphorus (a measure of how efficient algae are at using the nutrient) ranged from 0.34 to 1.13, with a 0.68 average. Statewide this ratio tends to be around 0.40, suggesting the algal community in Pomme de Terre Lake was exceptionally efficient in 2010. One explanation for the high chlorophyll to phosphorus ratio is the low levels of inorganic suspended sediments. The average suspended sediment concentation in 2010 for Site 1 was 0.6mg/L, a value that was 40% of the regional average (1.5mg/L) and only 11% of the statewide average (5.5mg/L). Lower levels of suspended sediment translate to increased sunlight penitartaion and improved photosynthesis by the algae.

With the exception of 2008, phosphorus concentrations at Site 1 have shown nominal variation within indidiual summers (phosphorus ranges about 15µg/L most summers) and similar mean values among sampling seasons (range of summer means = 18 - 23µg/L). Comparison of phosphorus and chlorophyll data show similar year-to-year fluctuations. On average, chlorophyll values vary about 19µg/L during individual summers, a value that is close to that seen in phosphorus. Mean values for chlorophyll range from 10.7 – 18.9µg/L. none of the parameters displayed long-term trends.

2010 GRAPHS



TREND GRAPHS



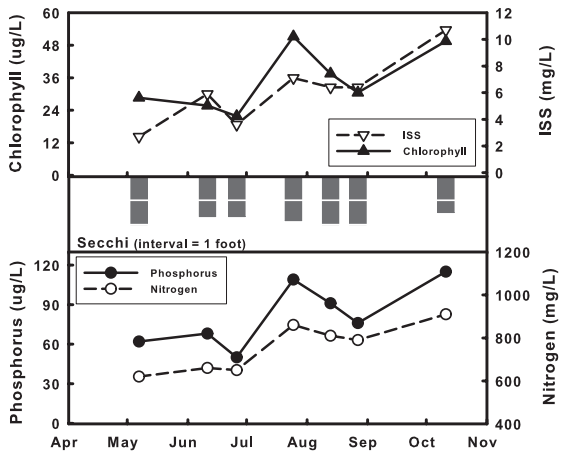
See pages 10-11 for help interpreting graphs

Pomme de Terre Lake

Site 3 2010 DATA

Hickory and Polk County
Latitude: 37.8357 Longitude: -93.2636

Date	X	5/7	6/11	6/26	7/25	8/13	8/27	10/11	Mean
Secchi (inches)		24	20	20	22	24	24	18	22
TP (µg/L)		62	68	50	109	91	76	115	78
TN (µg/L)		620	660	650	860	810	790	910	750
CHL (µg/L)		28.6	25.7	21.8	51.2	37.5	30.5	49.5	33.4
ISS (mg/L)		2.7	5.9	3.6	7.1	6.4	6.4	10.7	5.6

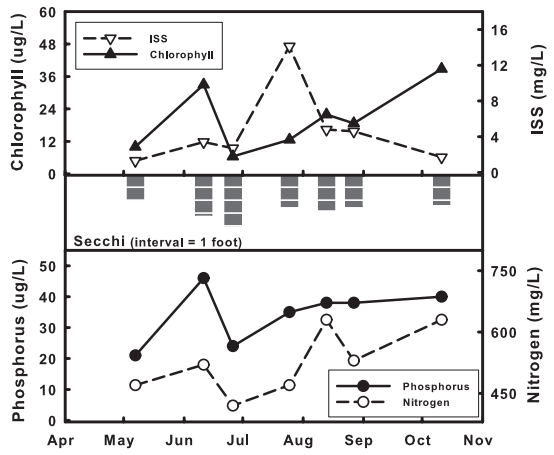


Phosphorus, nitrogen, chlorophyll and inorganic suspended sediment all showed a general trend of increasing concentrations as the sample season progressed. The other Pomme de Terre sites displayed fluctuations in water quality as the season progressed, but not the distinct pattern observed at Site 3. This pattern differs from most Missouri lakes which display a seasonal pattern of highest nutrient and suspended sediment values in the spring time, with decreasing levels as the summer progresses. Because algal chlorophyll and inorganic suspended sediment values levels were consistently moderate to high, Secchi transparency never exceeded 24 inches during the course of the 2010 sample season.

Site 4 2010 DATA

Hickory and Polk County
Latitude: 37.8337 Longitude: -93.3629

Date	X	5/7	6/11	6/26	7/25	8/13	8/27	10/11	Mean
Secchi (inches)		24	38	48	30	33	30	28	32
TP (µg/L)		21	46	24	35	38	38	40	33
TN (µg/L)		470	520	420	470	630	530	630	519
CHL (µg/L)		10.0	33.0	6.4	12.6	21.9	18.7	38.8	17.1
ISS (mg/L)		1.3	3.4	2.7	14.1	4.8	4.6	1.7	3.5



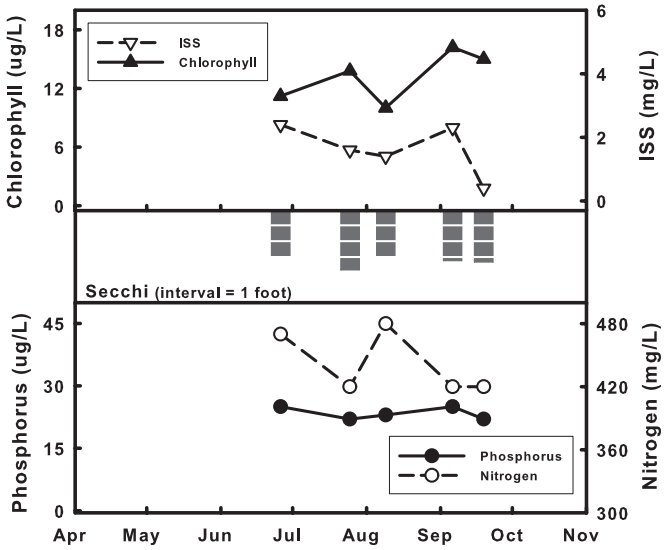
The same seasonal fluctuations in water quality were observed at sites 1 and 4, suggesting a strong link between these two sites. The only real difference between the two site in terms of patterns was a July peak in suspended sediment at Site 4, which showed up at Site 1 in August. While the patterns were the same, nutrient, suspended sediment and chlorophyll concentrations at Site 4 were higher than those measured at Site 1. The lower concentrations at the dam site reflect the loss of suspended materials and nutrients to sedimentation.

Pomme de Terre Lake

Site 5 2010 DATA

Hickory and Polk County
Latitude: 37.8573 Longitude: -93.3183

Date	X	X	X	6/26	7/25	8/9	9/6	9/19	Mean
Secchi (inches)				36	46	36	39	40	39
TP (µg/L)				25	22	23	25	22	23
TN (µg/L)				470	420	480	420	420	441
CHL (µg/L)				11.2	13.8	10.0	16.2	15.0	13.0
ISS (mg/L)				2.4	1.6	1.4	2.3	0.4	1.4



Site 5 is located in the tributary located between the much larger arms of the lake. The watershed that drains into this area is relatively small, with a fair amount of forest land cover. This site was only sampled during the last half of the season, so we are limited in commenting on seasonal trends. Water quality at Site 5 was extremely stable during the four months of sampling, with only minor fluctuations in nutrient, chlorophyll and suspended sediment concentrations. Nutrient levels were similar to those measured at Site 1, as were chlorophyll concentrations. Site 5 did have slightly more suspended sediment, leading to Secchi transparency readings that were about 50% of those measured at the dam.

Pomme de Terre Lake

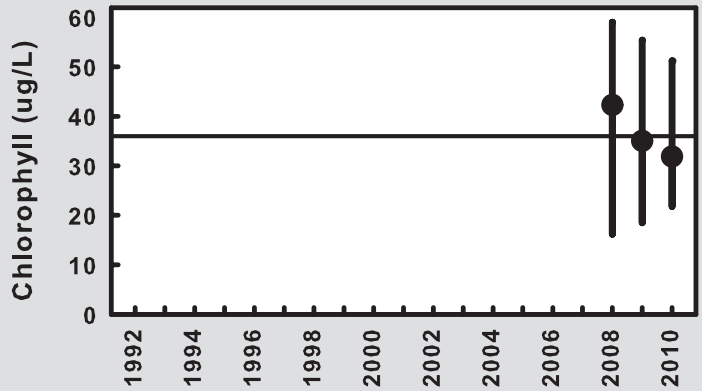
Trends (Sites 3, 4 and 5)

Sites 3 and 4 have been monitored for three years while 2010 was the first season for Site 5. We do not have enough data to truly evaluate for long-term trends, but we can start to identify the normal variation that can be expected at these sites. Phosphorus concentrations at both sites have shown the same year-to-year pattern of decreasing average values since 2008. The difference in phosphorus levels among years probably relates to differences in rainfall. Total rainfall in 2008 was 56.1 inches, 53.1 inches in 2009 and 43.1 inches in 2010. More rainfall generally equates to more nutrient inputs from the watershed. Site 3 had the same long-term pattern, with values that were twice those measured at Site 4. Chlorophyll concentrations follow the same pattern as phosphorus (this nutrient usually limits algal growth). Again, there were higher values at Site 3 than Site 4.

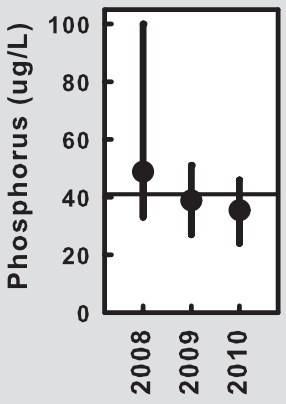
Not only is water quality at these sites related to the overall rainfall within the watershed, these sites can also respond to short-term events. The inorganic suspended sediment data from Site 4 show higher values in 2010 compared to the two previous summers. The maximum value of 14.1 mg/L was measured a week after it had rained 3 inches in a single day. This extreme rain event led to an abnormal suspended sediment measurement that skews the data (the next two sample dates had the second and third highest suspended sediment values, respectively).

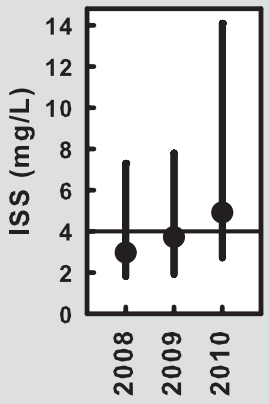
TRENDS

Site 3



Site 4





Prairie Lee Lake

2010 DATA

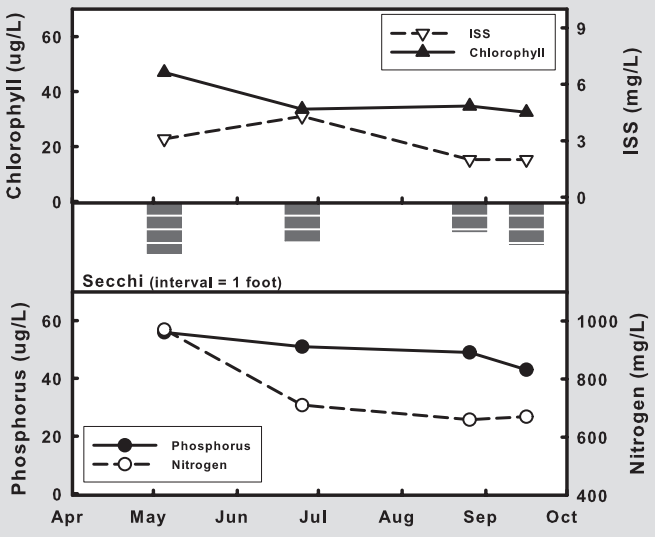
Jackson County
Latitude: 38.9436 Longitude: -94.3294

Date	X	5/5	X	6/25	X	X	8/26	9/16	Mean
Secchi (inches)		45		34			26	37	35
TP (µg/L)		56		51			49	43	50
TN (µg/L)		970		710			660	670	743
CHL (µg/L)		47.0		33.6			34.7	32.5	36.5
ISS (mg/L)		3.1		4.3			2.0	2.0	2.7

The limited number of samples collected during 2010 in Prairie Lee Lake hinders our ability to identify seasonal trends. Variations among the four samples were generally low for all water quality parameters. Chlorophyll concentrations were high relative to phosphorus levels, with the average ratio of chlorophyll to phosphorus of .74, a ratio that is about twice the statewide average. This indicates that the algae are efficient at using the nutrients within the lake.

Chlorophyll levels during the last two summers of sampling have been above the long-term average. Note that there were only two samples collected during each summer (May 15 – Sept. 15) in 2004 and 2010. The limited number of samples during these two years disallows us to call this a true trend. The phosphorus levels during these last two years of monitoring were higher than all of the other years except 1993, when average phosphorus was 62µg/L. Mean phosphorus values from 1992-1999 (sans 1993) ranged from 32 - 44µg/L.

2010 GRAPHS



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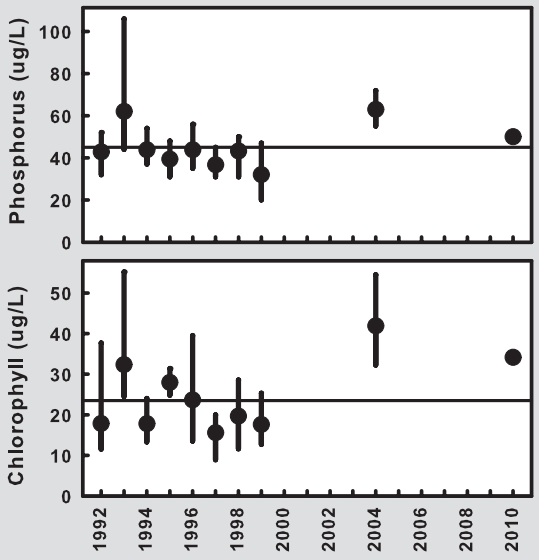


See pages 10-11 for help interpreting graphs

Rothwell Lake

2010 DATA

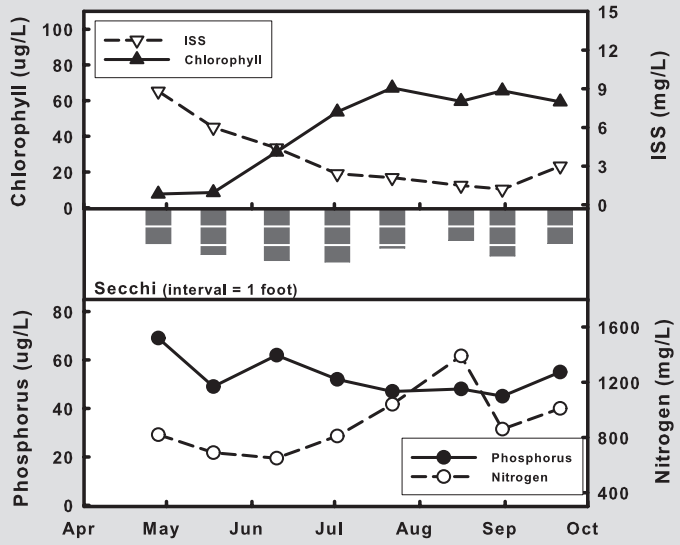
Randolph County
Latitude: 39.4184 Longitude: -92.4616

Date	4/28	5/18	6/10	7/2	7/22	8/16	8/31	9/21	Mean
Secchi (inches)	24	30	34	35	26	21	31	23	28
TP (µg/L)	69	49	62	52	47	48	45	55	53
TN (µg/L)	820	690	650	810	1040	1390	860	1010	884
CHL (µg/L)	7.7	8.6	31.3	53.7	67.1	59.6	65.5	59.3	33.9
ISS (mg/L)	8.8	6.0	4.4	2.4	2.1	1.5	1.2	3.0	3.0

Suspended sediment concentrations in Rothwell Lake decreased through the 2010 season from an all-time high of 8.8mg/L in April (7.4mg/L in April, 2009 was second highest measured value). Chlorophyll concentrations increased as suspended sediment concentrations decreased, indicating probable light limitation of algae. In the 7 years of monitoring, just 6 Secchi observations have resulted in readings of less than 27 inches. Four of those observations were from 2010. Not surprisingly, the 2010 mean Secchi value (28 inches) was the lowest to date, though only marginally lower than 2009 and 2006 (31 inches). Phosphorus concentrations were high, but did not vary considerably during the season. Nitrogen concentrations increased in late summer, but dropped during early autumn.

The long-term trends show Secchi transparency has been below average for 2 consecutive years. No Secchi measurement in 2010 exceeded 36 inches, the statewide mean. Concentrations of suspended sediment are at least partly to blame for the diminished water clarity values. The 2010 mean ISS value was higher than any previous year, with the highest single "summer" value to date (6.0 mg/L)

2010 GRAPHS



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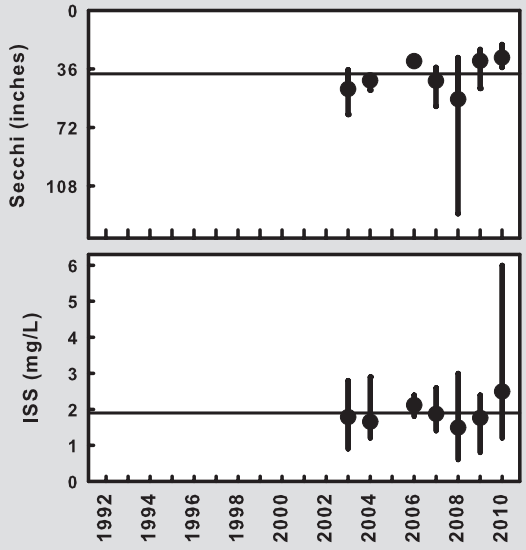


See pages 10-11 for help interpreting graphs

Simpson Lake

2010 DATA

St. Louis County
Latitude: 38.5571 Longitude: -90.4691

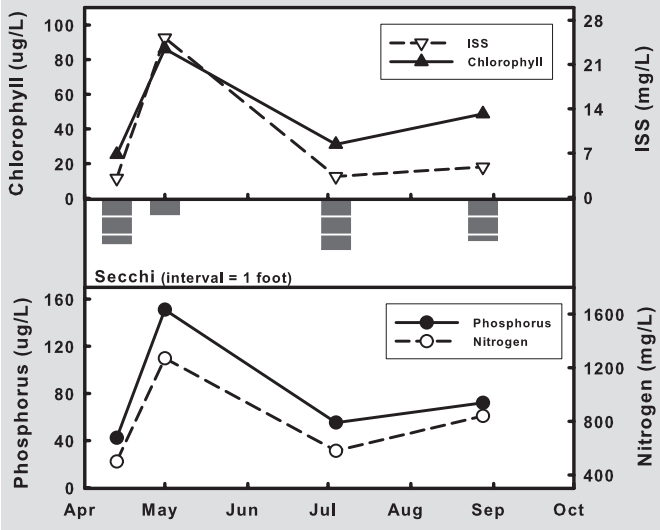
Date	4/13	5/1	X	X	7/4	X	8/28	X	Mean
Secchi (inches)	30	11			34		28		24
TP (µg/L)	42	151			55		72		71
TN (µg/L)	500	1270			580		840		746
CHL (µg/L)	25.3	86.2			31.2		48.7		42.7
ISS (mg/L)	3.0	25.2			3.3		4.8		5.9

Simpson Lake is a shallow reservoir along a side channel of the Meramec River. During heavy rains, flow through the lake increases dramatically and water tops the lake's low dam. In this way, Simpson Lake can behave like a lake or a river, depending upon the Meramec River stage.

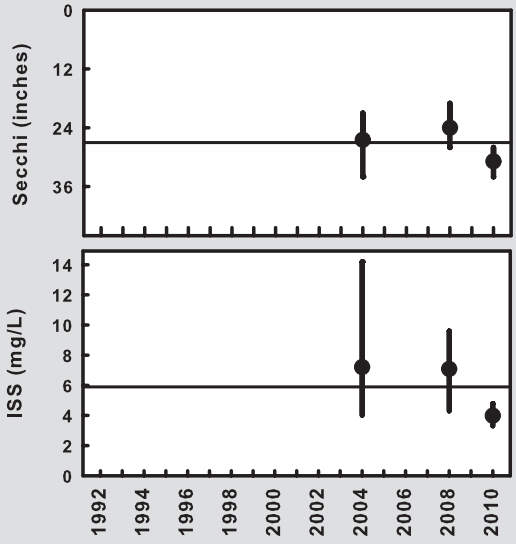
The 4 samples collected in 2010 mark the third year of sampling at Simpson Lake. Heavy rains were recorded 48 hours prior to the May 1 sample event, and the associated runoff and increased river flow are likely responsible for the high concentrations of suspended sediment and nutrients and low water clarity observed. Water quality was comparable among the remaining 3 sample dates.

Secchi transparency values were higher in 2010 than in either of the previous years. The improved water clarity can be at least partially attributed to the lower concentrations of suspended sediment in the lake. The 2010 mean ISS value was just over 42% lower than observed in either previous sampling season.

2010 GRAPHS



TREND GRAPHS



See pages 10-11 for help interpreting graphs

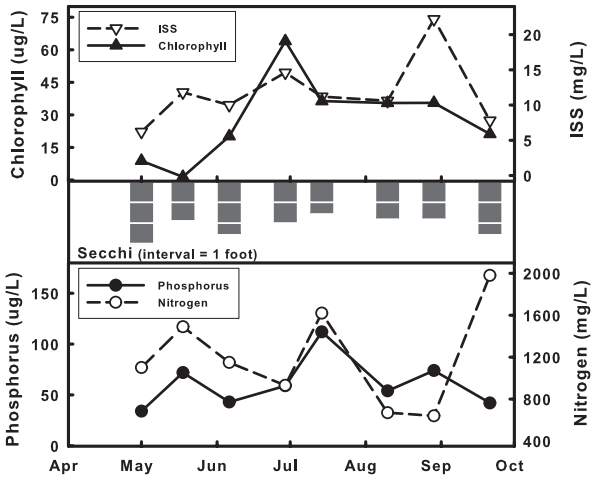
Lake Springfield

Site 1 2010 Data

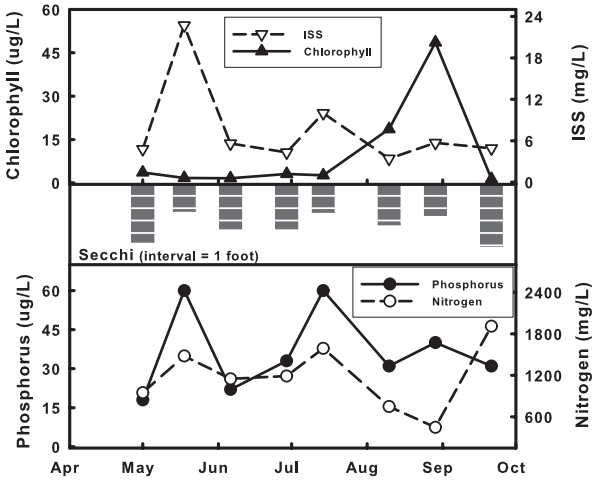
Greene County
Latitude: 37.1122 Longitude: -93.2608

Date	5/1	5/18	6/6	6/29	7/14	8/10	8/29	9/21	Mean
Secchi (inches)	36	22	30	24	18	21	21	30	25
TP (µg/L)	34	72	43	59	112	54	74	42	57
TN (µg/L)	1100	1490	1150	930	1620	670	640	1980	1116
CHL (µg/L)	8.9	1.5	20.2	64.0	36.4	35.5	35.6	21.2	19.0
ISS (mg/L)	6.2	11.8	10.0	14.6	11.2	10.6	22.2	7.8	11.0

Site 1



Site 2



The shift in water quality across Lake Springfield's two sites is interesting in that it differs from the norm. Missouri lakes tend to have lower levels of nutrients and inorganic suspended sediment near the dam compared to up-lake sites due to sedimentation. In Lake Springfield we find higher phosphorus and inorganic suspended sediment at Site 1. Interestingly, nitrogen concentrations were very similar on sample dates for the two sites (though variable from sample to sample).

Lake Springfield Sites

Site 2 2010 Data

Greene County
Latitude: 37.1263 Longitude: -93.2256

Date	5/1	5/18	6/6	6/29	7/14	8/10	8/29	9/21	Mean
Secchi (inches)	57	27	44	44	28	40	31	61	40
TP (µg/L)	18	60	22	33	60	31	40	31	34
TN (µg/L)	950	1480	1150	1190	1590	750	450	1910	1089
CHL (µg/L)	3.6	1.7	1.6	3.1	2.6	18.6	48.6	1.3	4.2
ISS (mg/L)	4.8	22.7	5.6	4.3	10.0	3.4	5.7	4.9	6.3

Lake Springfield (continued)

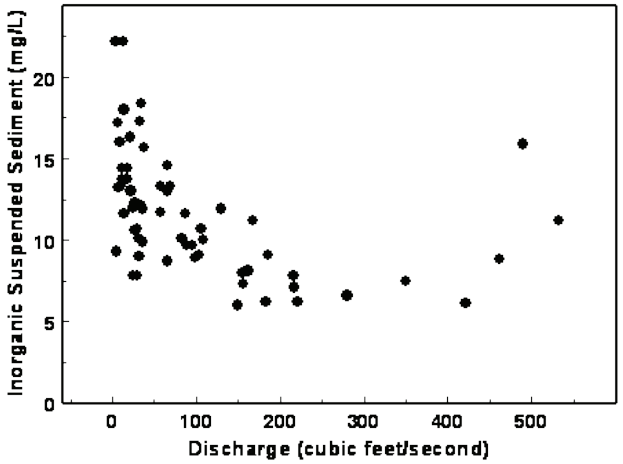
Lake Springfield differs from the average Missouri lake in two ways. First, the lake water is used to cool a nearby power plant. Warm water from the power plant re-enters the lake near the dam and the physical mixing caused by this input prevents sediment from settling to the lake bottom and acts to re-suspend any material that had settled.

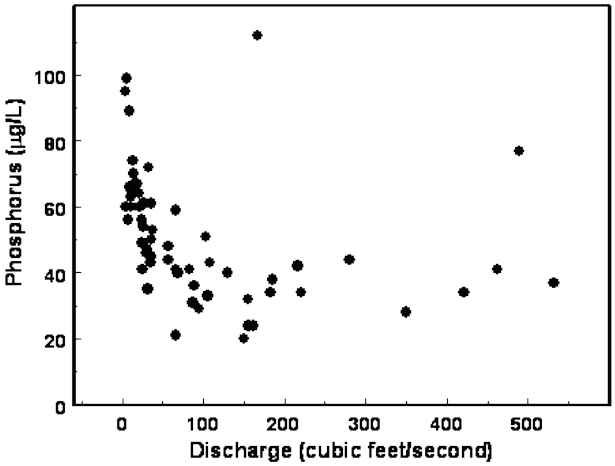
The other factor that makes Lake Springfield different is its extremely high flushing rate. On average, the lake's volume is replaced every 5-6 days (actual time varies with flow in the James River). For comparison, other similar sized lakes in Missouri take 12 months to replace their volume! Lake Springfield's extremely high flushing rate limits the amount of sedimentation that can occur within the lake.

Combined, these two factors make Lake Springfield unique among LMVP lakes. The two adjoining graphs show how inorganic suspended sediment and phosphorus at Site 1 relate to flow within the James River. Discharge data were collected at a USGS gauging station located about 5 miles up-stream from Lake Springfield Dam.

In most Missouri lakes suspended sediment levels peak when turbid inflows into the lake are the highest. When inflows are low (during dry periods) there is less sediment coming into the lake, and the sediment that is in the lake has time to settle. Lake Springfield behaves the opposite in that an increase in up-stream discharge actually lowers the suspended sediment levels. This tells us that the majority of suspended sediment that is being measured during low discharge periods is being re-suspended from the lake bottom and not coming into the lake as turbid inflow. The decrease in suspended sediment values during high discharge reflects the movement of these materials out of the lake and down the James River. There is a slight hint of increasing suspended sediment when discharge values in the James River are>400cfs, a result of high flow in the river carrying eroded sediment from the watershed.

Phosphorus concentrations fluctuate with discharge in a fashion similar to suspended sediment. This is not surprising as phosphorus tends to bind to sediment particles. In contrast, nitrogen concentrations (graph not shown) do not decrease with increasing discharge, but show a tendency to increase. The nutrients behave differently because nitrogen has a gas phase and is probably lost to the atmosphere during periods of low discharge (thus it does not accumulate the same way phosphorus does). Also, groundwater readily picks up and transports nitrogen. As discharge in the James River increases there is probably an increase in nitrogen inputs into the lake.





Spring Fork Lake

Site 1

Pettis County
Latitude: 38.5678 Longitude: -93.2429

2010 DATA

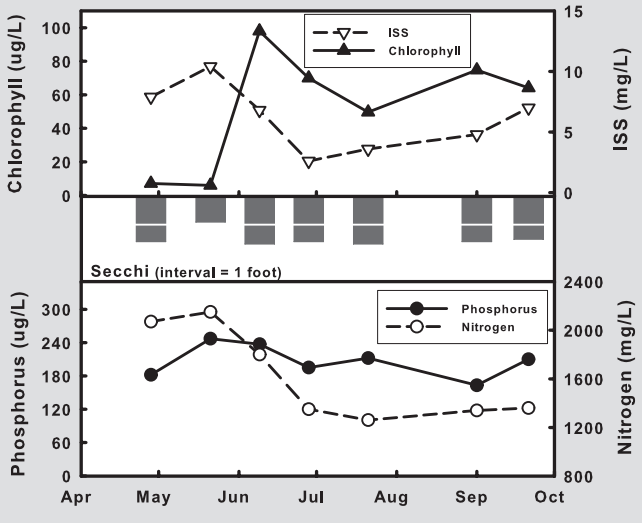
Date	4/28	5/21	6/9	6/28	7/21	X	9/1	9/21	Mean
Secchi (inches)	19	11	20	19	20		19	18	18
TP (µg/L)	182	247	237	195	212		163	210	205
TN (µg/L)	2070	2150	1800	1350	1260		1340	1360	1582
CHL (µg/L)	7.2	6.0	98.0	70.0	49.7		74.8	64.1	35.5
ISS (mg/L)	7.9	10.4	6.8	2.6	3.6		4.8	7.0	5.6

The algal community was apparently quite pleased with its environment in mid June. Chlorophyll concentrations were 7.2 and 6.0 µg/L for the first two sample dates, but exploded by more than an order of magnitude to a seasonal high of 98.0 µg/L in less than 3 weeks. Nutrient concentrations did not increase over the same time frame. A closer examination of the data shows high phosphorus concentrations relative to the amount of algae we see in the first two samples of 2010. In other words, based on the amount of phosphorus in the lake, we would expect high algal chlorophyll values. For some reason the algal community was suppressed during the early season. Secchi transparency was unaffected by the variability in algal chlorophyll, with the lowest water clarity measured on the date with the lowest chlorophyll concentration. The comparatively high suspended sediment concentration was at least partly responsible for the low (11 inch) clarity reading.

The "summer" 2010 mean chlorophyll concentration is slightly lower than was measured in 2009, while the Secchi transparencies from the same period are comparable. Chlorophyll concentrations show a history of high variability, ranging from a minimum of around 20 to a maximum of 100 µg/L each of the last 4 seasons sampled. Secchi shows much less variability, as is typical of turbid water bodies.

Spring Fork Lake Sites

2010 GRAPHS



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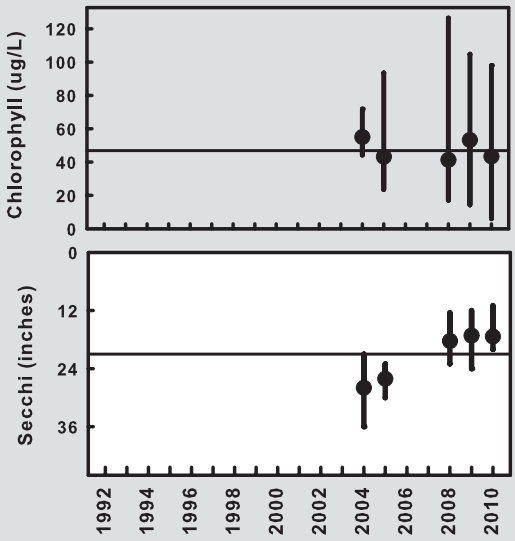


See pages 10-11 for help interpreting graphs

Spring Fork Lake

Site 2

2010 DATA

Pettis County
Latitude: 38.5605 Longitude: -93.2440

Date	4/28	5/21	6/9	6/28	7/21	X	9/1	9/21	Mean
Secchi (inches)	16	12	20	16	15		22	19	17
TP (µg/L)	203	283	207	232	203		179	206	214
TN (µg/L)	2070	2160	1400	1310	1150		1390	1320	1503
CHL (µg/L)	7.0	20.4	33.2	81.0	49.4		67.0	54.7	35.4
ISS (mg/L)	8.3	11.6	6.9	5.7	5.2		4.0	6.2	6.5

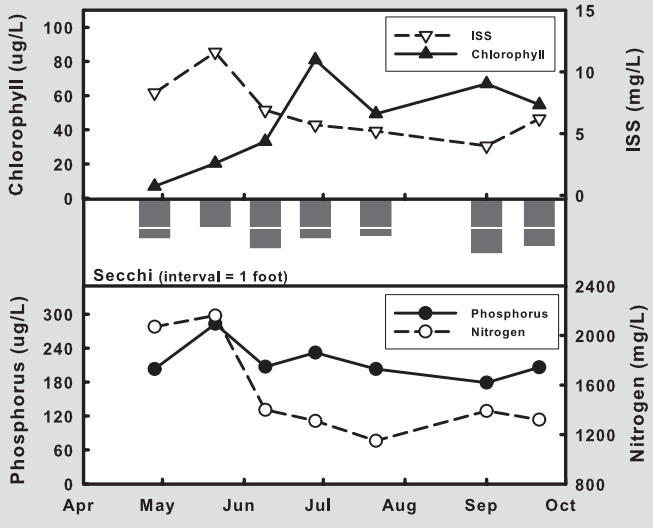
The peak 2010 chlorophyll concentration at Site 2 occurred later in the season than at Site 1, but values were otherwise similar. In fact, the 2010 geometric mean values for all parameters were nearly indistinguishable from those of Site 1. While average suspended sediment concentrations at Site 2 were nearly identical to those of Site 1, individual Site 2 concentrations were slightly less variable.

Limnologists often look at comparative ratios when considering lake conditions. One such ratio is that of nitrogen to phosphorus (N:P). In Missouri, the median 2010 N:P ratio was 19, meaning that for every unit of phosphorus, there are 19 units of nitrogen. The N:P ratio at both sites on Spring Fork Lake were rather low, only exceeding 10:1 on one date and more typically around 7:1. This indicates an abundance of phosphorus relative to the amount of nitrogen present. Excess phosphorus is often correlated with blooms of blue green algae.

The mean summer phosphorus concentration in 2010 was the highest recorded to date, with a only a single value falling below 200 µg/L. Water clarity was lower in 2010 than in previous years at Site 2, though the 2010 summer mean (17) was only 3 inches less than that of 2009 (20).

Spring Fork Lake Sites

2010 GRAPHS



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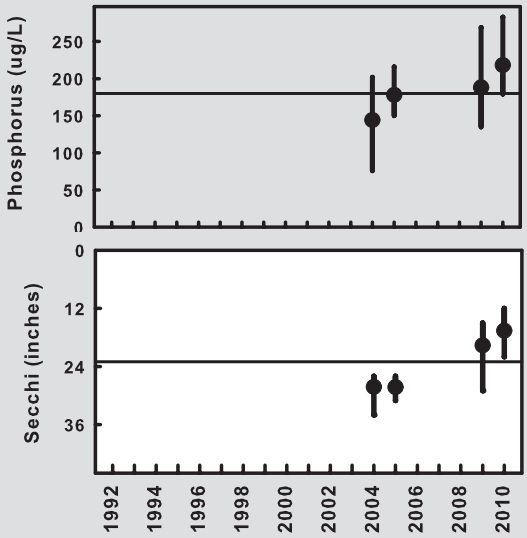


See pages 10-11 for help interpreting graphs

Stockton Lake

Site 1

2010 DATA

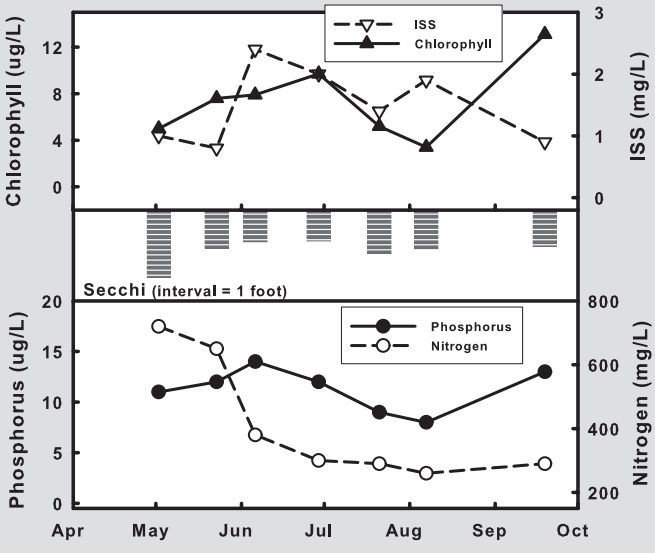
Cedar, Dade and Polk County
Latitude: 37.6863 Longitude: -93.7652

Date	5/2	5/23	6/6	6/29	7/21	8/7	X	9/19	Mean
Secchi (inches)	161	92	77	75	105	94		88	96
TP (µg/L)	11	12	14	12	9	8		13	11
TN (µg/L)	720	650	380	300	290	260		290	381
CHL (µg/L)	5.0	7.6	7.9	9.7	5.2	3.4		13.1	6.8
ISS (mg/L)	1.0	0.8	2.4	2.0	1.4	1.9		0.9	1.4

During 2010, the seasonal patterns of phosphorus and nitrogen at Site 1 differed from one another. Phosphorus remained fairly stable, with only minor fluctuations during the season. In contrast, nitrogen started out at 720µg/L, decreased by more than half by mid-season and remained low. While fluctuations in phosphorus were minor, they were enough to influence algal chlorophyll levels, which tracked the phosphorus across the season.

The summertime phosphorus mean has been slightly higher than the long-term mean for 5 consecutive years at Site 1. Above average precipitation and the increased runoff associated with it during the last three years may explain some of these higher values. During the sample seasons (April-September) of 2010, 2009 and 2008, rainfall was 9, 13 and 8.6 inches above average (based on last 40 years). Increased runoff in the watershed means more sediment (and attached phosphorus) coming into the lake. Not surprisingly, water clarity has suffered in the recent years with Secchi transparency measurements below average for the last 5 years.

2010 GRAPHS



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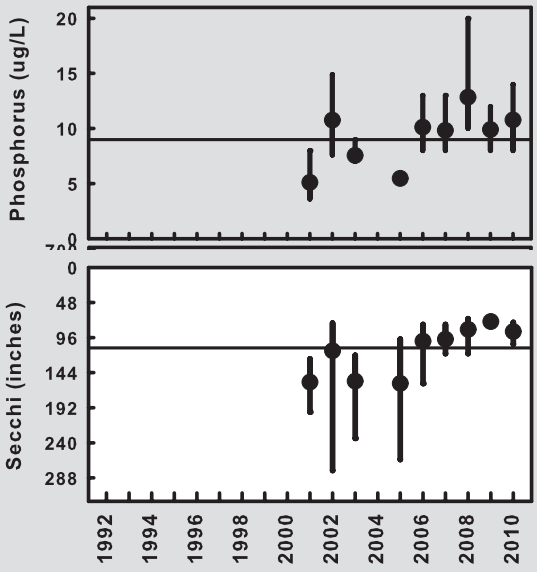
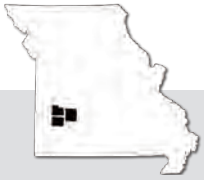


See pages 10-11 for help interpreting graphs

Stockton Lake



Site 2

2010 DATA

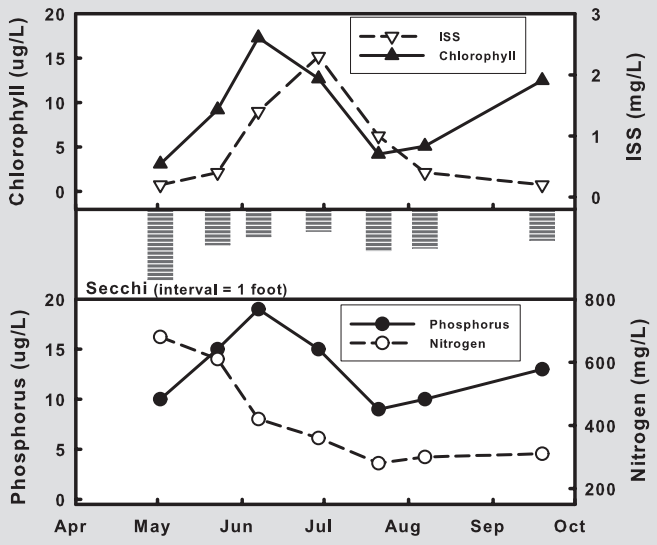
Cedar, Dade and Polk County
Latitude: 37.6248 Longitude: -93.7365

Date	5/2	5/23	6/7	6/29	7/21	8/7	X	9/19	Mean
Secchi (inches)	201	103	80	65	119	112		90	104
TP (µg/L)	10	15	19	15	9	10		13	13
TN (µg/L)	680	610	420	360	280	300		310	400
CHL (µg/L)	3.1	9.2	17.3	12.7	4.2	5.1		12.5	7.7
ISS (mg/L)	0.2	0.4	1.4	2.3	1.0	0.4		0.2	0.6

Water quality at Site 2 was quite similar to that at Site 1 during 2010. The average Secchi reading for the two sites differed by only 8 inches. As seen at the dam, chlorophyll concentrations tracked phosphorus closely. Nitrogen exhibited a typical pattern, high in the spring and decreasing as the season progressed. As at the dam site, suspended sediments were low, exceeding 2 mg/L on only one sample day.

The past 3 years have seen higher than average chlorophyll concentrations at Site 2. While the 2010 summer mean is the nearer to the long-term mean than any of the last 3 years' values, it was the most variable. The higher chlorophyll concentrations and slightly higher levels of suspended sediment (graph not shown) have led to a decrease in the average summertime Secchi reading as well as a decrease in the variability in water clarity during the last three years.

2010 GRAPHS



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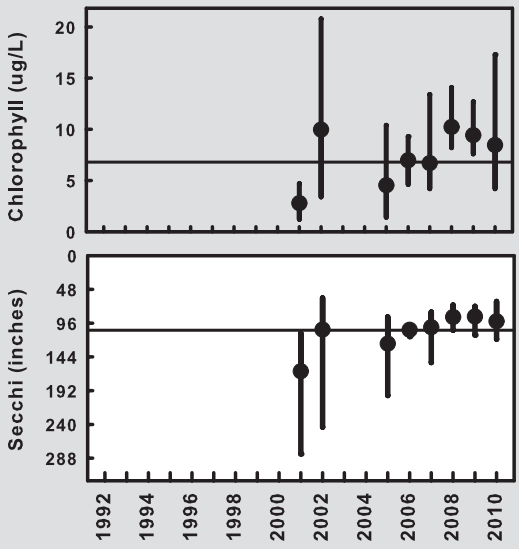


See pages 10-11 for help interpreting graphs

Stockton Lake

Site 215

2010 DATA

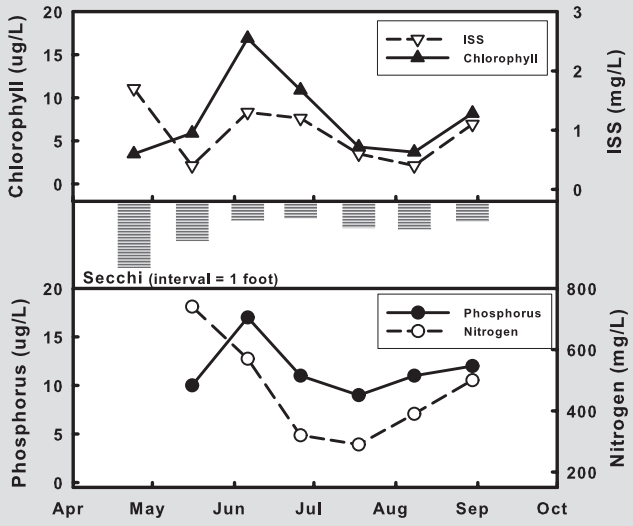
Cedar, Dade and Polk County
Latitude: 37.6219 Longitude: -93.7794

Date	4/24	5/16	6/6	6/26	7/18	8/8	8/30	X	Mean
Secchi (inches)	270	162	80	73	110	115	84		115
TP (µg/L)	.	10	17	11	9	11	12		11
TN (µg/L)	.	740	570	320	290	390	500		444
CHL (µg/L)	3.5	5.9	16.9	10.9	4.3	3.7	8.2		6.5
ISS (mg/L)	1.7	0.4	1.3	1.2	0.6	0.4	1.1		0.8

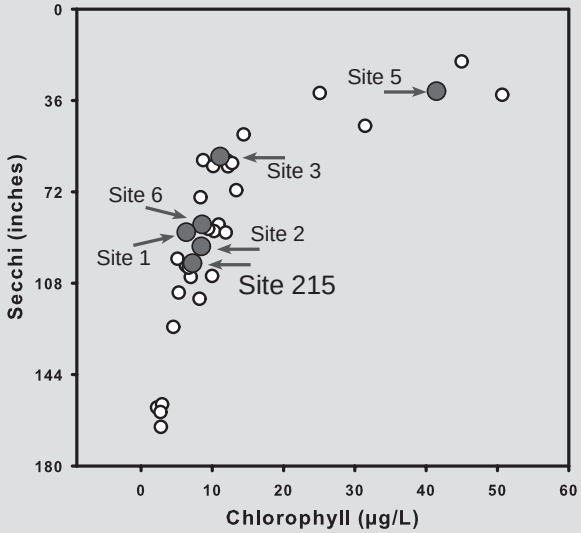
Site 215, at the Highway 215 Bridge over the Sac River Arm, was sampled on 7 occasions in 2010. Average concentrations and seasonal patterns of phosphorus and nitrogen at Site 215 were similar to that seen at sites 1 and 2. Chlorophyll levels tracked phosphorus values during the season, indicating that phosphorus limits algal growth. While inorganic suspended sediment values varied over the sample season, they were generally low. Moderate levels of chlorophyll and low suspended sediment explain why the average Secchi transparency reading at Site 215 was about three times deeper than the state average.

When 2010 average chlorophyll and Secchi are plotted against past averages from Stockton Lake we find four of the sites have very similar water quality. Sites in the mid to upper portion of the Sac River Arm have higher chlorophyll and subsequently lower clarity. We also find that 2010 was only an average year in terms of water clarity.

2010 GRAPHS

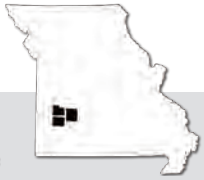


The Chlorophyll/Secchi Relationship in Stockton Lake, 2010



See pages 10-11 for help interpreting graphs

Stockton Lake



Site 3

2010 DATA

Cedar, Dade and Polk County
Latitude: 37.5547 Longitude: -93.7832

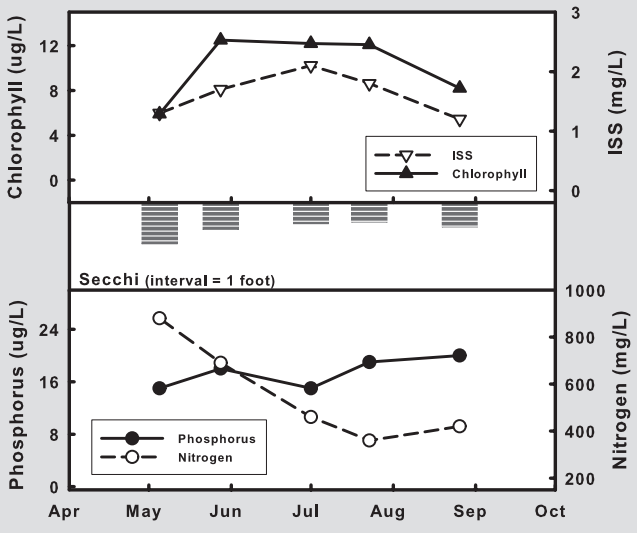
Date	5/5	5/28	X	7/1	7/23	8/26	X	X	Mean
Secchi (inches)	103	68		54	50	62			65
TP (µg/L)	15	18		15	19	20			17
TN (µg/L)	880	690		460	360	420			531
CHL (µg/L)	5.9	12.5		12.2	12.1	8.2			8.8
ISS (mg/L)	1.3	1.7		2.1	1.8	1.2			1.7

Site 3 is located near the Mutton Creek Public Use Area on the Sac River arm of Stockton Lake and was monitored on 5 occasions in 2010.

Chlorophyll and inorganic suspended sediment values varied only two-fold during the course of the season and were low compared to most Missouri lakes. Water clarity was a little deeper during the first sample date, corresponding to low levels of both chlorophyll and suspended sediment. Similar to the other Stockton Lake sites, phosphorus concentrations were low and stable during the season, while nitrogen levels were high in spring and low during the second half of the season.

The long-term mean algal chlorophyll value is skewed by the high measurements in 2003. As a result, all other seasons have had lower than average chlorophyll concentrations. Nonetheless, there was less measured algal biomass in 2010 than any year since 2006. Average water clarity in 2010 was typical of the site. Overall, the average values of water clarity have been consistent at Site 3, with the exception of 2003. Maximum summertime Secchi values have varied, with 2008 showing a high clarity value (over 8 feet) compared to 2010 (less than 6 feet).

2010 GRAPHS



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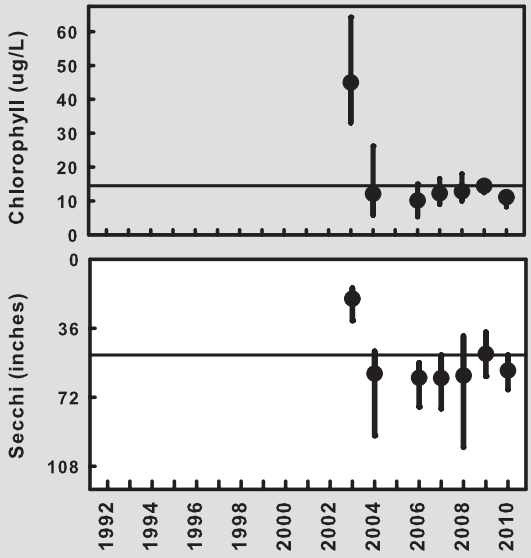
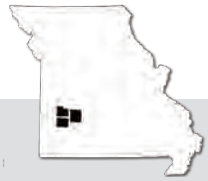


See pages 10-11 for help interpreting graphs

Stockton Lake



Site 5

Cedar, Dade and Polk County
Latitude: 37.4532 Longitude: -93.7773

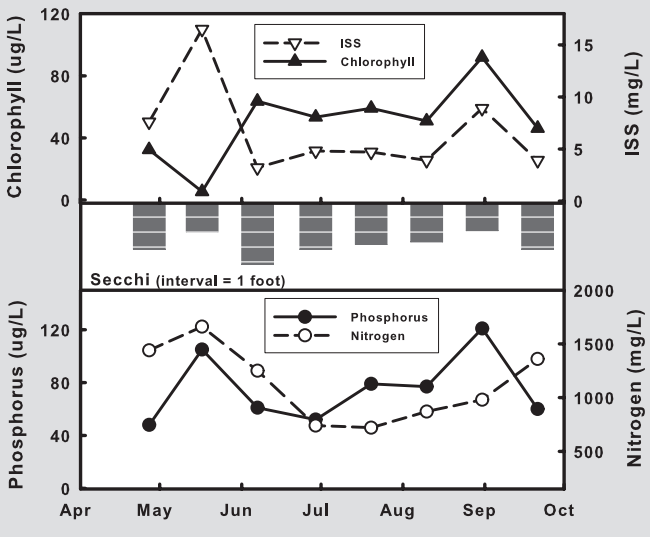
2010 DATA

Date	4/27	5/17	6/7	6/29	7/20	8/10	8/31	9/21	Mean
Secchi (inches)	38	24	50	38	34	32	23	38	34
TP (µg/L)	48	105	61	52	79	77	121	60	72
TN (µg/L)	1440	1660	1250	740	720	870	980	1360	1080
CHL (µg/L)	32.4	5.4	63.6	53.4	59.1	50.9	91.9	46.2	40.7
ISS (mg/L)	7.6	16.5	3.2	4.8	4.7	3.9	8.9	3.9	5.8

Site 5 had substantially higher levels of phosphorus, nitrogen, algal chlorophyll and inorganic suspended sediment than the other sites. This is to be expected given the location of Site 5, up-lake in the Sac River Arm of Stockton. This site is closer to inflows coming off of the watershed, which means nutrients and suspended sediment are not diluted out or settled out of the water column. Along with higher average values, Site 5 displays much larger variations in water quality. There were no real seasonal patterns for any of the parameters, though phosphorus values over the season mimicked the suspended sediment levels. This is not surprising as phosphorus often binds to sediment particles.

During the last three summers there have been high levels (>10mg/L) of inorganic suspended sediment measured at Site 5. The higher amounts of suspended sediment have resulted in low and stable Secchi transparency readings at this site.

2010 GRAPHS



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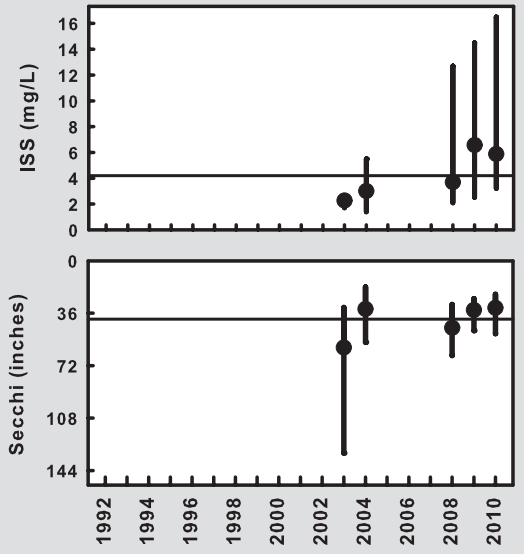


See pages 10-11 for help interpreting graphs

Stockton Lake

Site 6

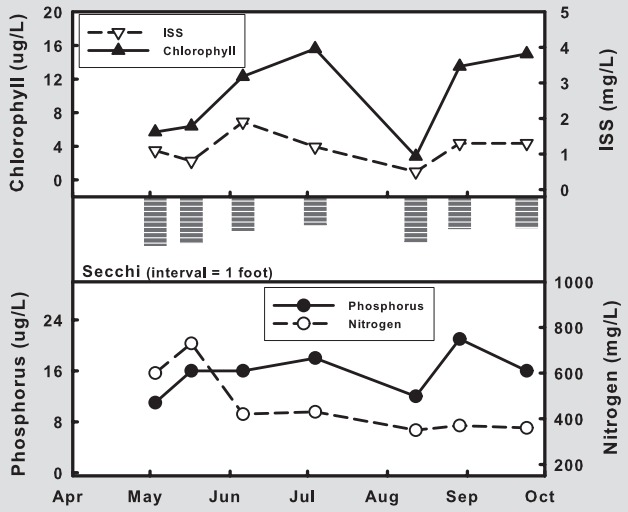
2010 DATA

Cedar, Dade and Polk County
Latitude: 37.4532 Longitude: -93.7773

Date	5/3	5/17	6/6	7/4	X	8/12	8/29	9/24	Mean
Secchi (inches)	113	107	79	66		105	75	73	87
TP (µg/L)	11	16	16	18		12	21	16	15
TN (µg/L)	600	730	420	430		350	370	360	449
CHL (µg/L)	5.7	6.4	12.3	15.6		2.8	13.5	15.0	8.8
ISS (mg/L)	1.1	0.8	1.9	1.2		0.5	1.3	1.3	1.1

Site 6 is located about 2/3 of the way up the Little Sac River Arm of the lake, approximately 6.3 miles up-lake of Site 2. Comparing 2010 data from the two sites show marginally higher levels of nutrients, algal chlorophyll and inorganic suspended sediment at Site 6. This slight gradient within the arm is expected as nutrients and sediment are generally highest up-lake, and settle out of the water column as sites move down-lake. As observed at the other Stockton Lake sites, nitrogen started the season high, decreased and remained low during the second half of the sample season. None of the other water quality parameters displayed any true seasonal pattern.

2010 GRAPHS



TREND GRAPHS

See pages 10-11 for help interpreting graphs

Sugar Creek Lake

Site 1

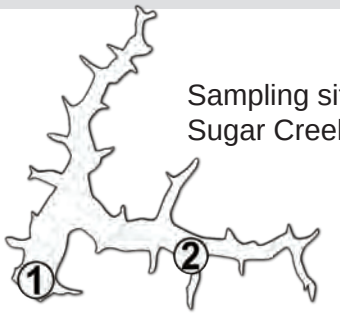
2010 DATA

Randolph County
Latitude: 39.4740 Longitude: -92.4783

Date	5/1	5/21	6/13	7/5	7/24	8/15	9/6	9/30	Mean
Secchi (inches)	21	21	21	39	26	30	27	26	26
TP (µg/L)	83	74	68	44	62	50	55	60	61
TN (µg/L)	1240	1250	850	590	830	840	730	860	874
CHL (µg/L)	7.8	13.2	24.2	18.3	46.8	38.5	27.9	24.1	22.0
ISS (mg/L)	12.9	9.4	9.4	4.5	6.8	2.9	5.2	5.7	6.5

Phosphorus and nitrogen generally follow the same trend over the course of the sample season, a decrease to minimal values in July, followed by a nominal increase and stable conditions during the remainder of the season. Inorganic suspended sediment also follows the same general trend. In contrast, chlorophyll starts the season at its minimal value and increases to a peak in late July. Chlorophyll values then slowly but steadily decline across the next three sample dates. The lower chlorophyll values early in the season were a result of suspended sediment being high enough to cause light limitation of the algae

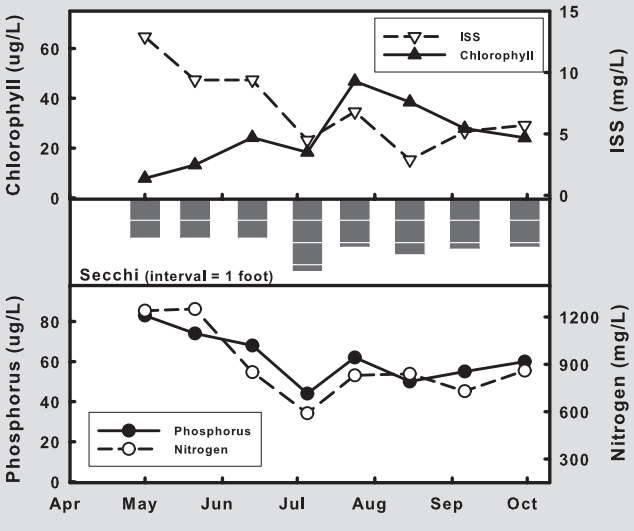
After 8 years of geometric mean phosphorus values that ranged between 43-48µg/L, the summer mean for 2010 was 58µg/L. This represents nominally higher phosphorus levels after



Sampling sites at Sugar Creek Lake

extremely consistent conditions over an extended period of time. This shift in phosphorus concentrations would not be notable except for the consistent conditions that preceded 2010. During this same period, summertime nitrogen means have ranged from 605 - 852µg/L, with this last year having an average of 827µg/L. The year-to-year variations in nitrogen levels in Sugar Creek Lake have been similar to that seen in most Missouri lakes.

2010 GRAPHS



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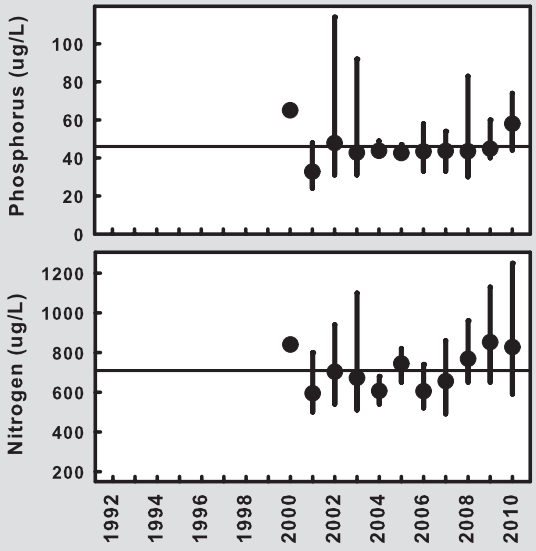


See pages 10-11 for help interpreting graphs

Sugar Creek Lake

Site 2

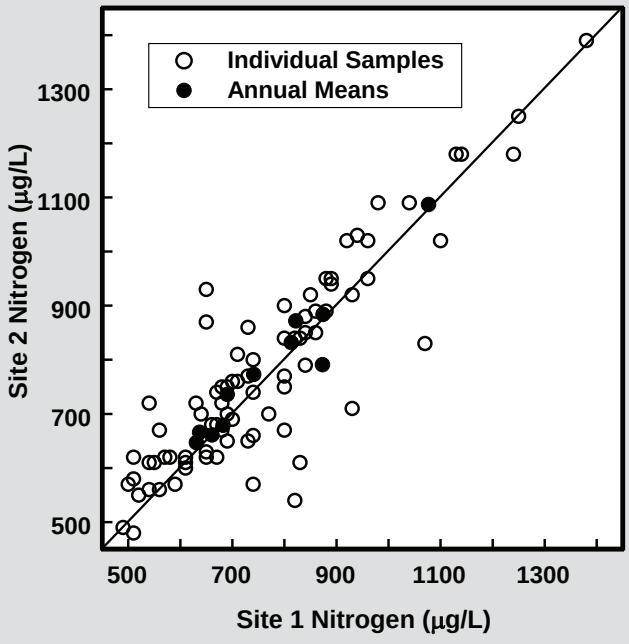
2010 DATA

Randolph County
Latitude: 39.4766 Longitude: -92.4619

Date	5/1	5/21	6/13	7/5	7/24	8/15	9/6	9/30	Mean
Secchi (inches)	17	22	18	41	28	27	26	26	25
TP (µg/L)	89	70	80	40	50	64	66	62	63
TN (µg/L)	1180	1250	920	570	840	880	770	850	884
CHL (µg/L)	21.0	17.7	49.2	13.6	29.4	45.5	28.3	29.5	26.9
ISS (mg/L)	11.4	9.3	10.6	3.3	4.5	4.9	10.6	6.7	7.0

Long-term patterns in water quality at Site 2 are similar to those at Site 1, even though Site 2 is located in an arm that drains a large portion of the lake's watershed. It is normal for down-lake sites to have lower nutrients and inorganic suspended sediment values than up-lake sites due to sedimentation. In past years the water quality at these two sites has been very comparable.

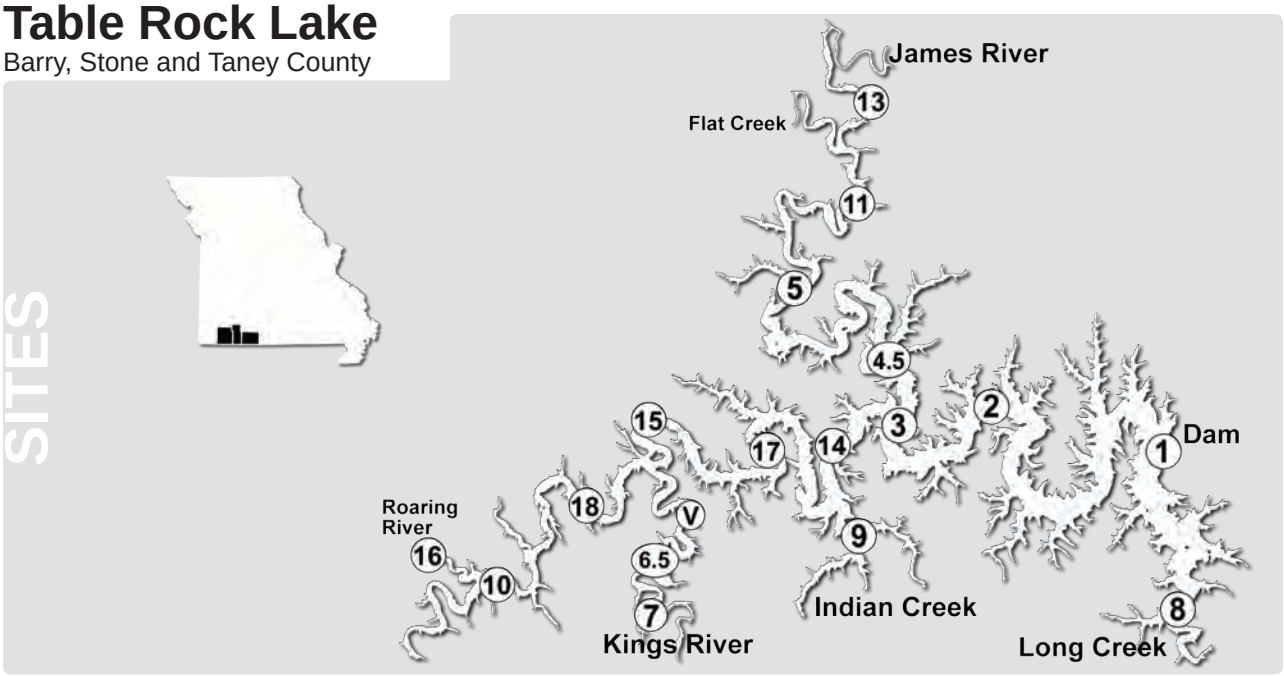
The graph below compares results from Site 1 directly to Site 2 results, with both the horizontal and vertical scales being equal. Both data from individual sample events as well as annual mean values are shown. The diagonal line is the 1:1 line, if the same measurement was collected at both sites on a given day, the symbol would fall on the line. Symbols located above the line indicate higher concentrations at Site 2 and symbols below the line represent higher concentrations at Site 1.



In 61% of the individual sample events nitrogen levels at Site 2 were higher than at Site 1. The average difference was 66µg/L, with a maximum difference of 280µg/L. It is somewhat surprising that in a third of the samples, the Site 1 nitrogen concentration exceeded that measured at Site 2, with an average difference of 77µg/L and a maximum difference of 280µg/L. When annual mean values are calculated, Site 2 was equal to or higher than Site 1 in all but one case (2009). The differences between sites were much lower, with the average difference being 12µg/L and a maximum difference of 82µg/L. This indicates that while water quality, on average, is very similar for these two sites, there can be notable differences on any individual day.

Table Rock Lake

Barry, Stone and Taney County



In the Table Rock Lake basin, the months of May and September received more rainfall than normal. For the city of Ozark, the month of September was the wettest measured to date (1946-2010), with 15.9 inches of rain (nearly 12 inches above normal). As a result, high concentrations of nutrients and chlorophyll as well as low clarity were recorded at many sites for either the late-May sample or the late-September sample or (in some cases) both.

In general, 2010 marks the long-awaited return to normal following the flooding of 2008. Phosphorus concentrations at most sites were similar to or less than the long-term mean. Chlorophyll concentrations were back down near the long-term mean following record highs at some sites over the last 2 years. Secchi transparency was improved across most of the lake, with only 4 sites showing less water clarity than the long-term mean.

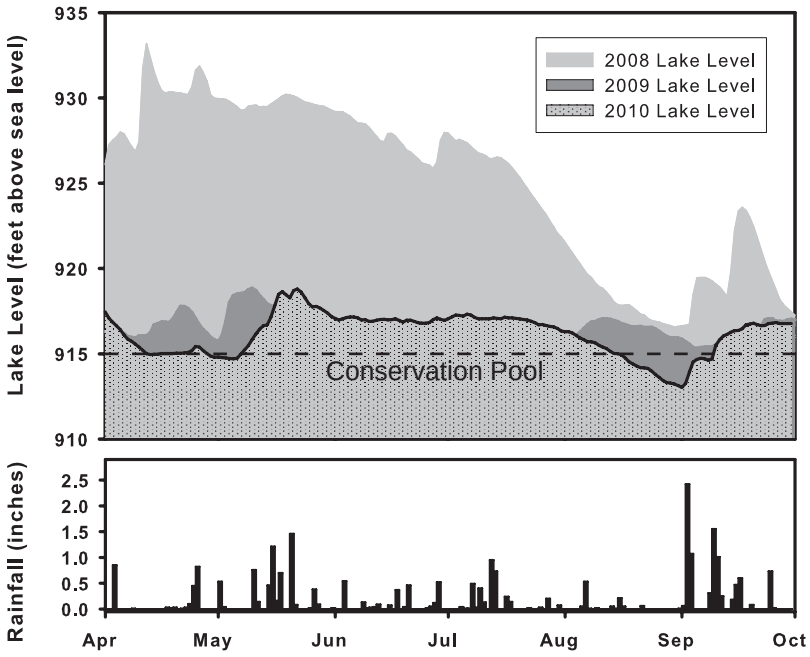


Table Rock Lake Levels
2008, 2009, 2010
(top - feet above sea level)

Basin-wide rainfall
(bottom - inches)

Table Rock Lake

Barry, Stone and Taney County

2009 Table Rock Lake Summary Data

TP = Total Phosphorus
TN = Total Nitrogen
CHL = Chlorophyll

Main Lake Sites

	SITE #	10	18	15	17	14	3	2	1
	# of Samples	8	8	7	8	8	4	7	8
SECCHI (inches)	Mean	115	118	100	118	125	120	115	113
	Minimum	85	107	88	104	99	92	60	67
	Maximum	180	130	126	157	182	141	192	166
TP (µg/L)	Mean	9	9	9	9	8	11	7	5
	Minimum	7	6	7	8	6	9	5	3
	Maximum	11	11	11	10	14	15	11	9
TN (µg/L)	Mean	344	309	369	419	477	567	542	446
	Minimum	250	220	240	270	270	460	300	230
	Maximum	630	680	720	690	780	670	1050	960
CHL (µg/L)	Mean	3.8	4.2	3.3	4.9	4.9	7.4	4.5	4.4
	Minimum	1.4	2.2	2.0	2.9	1.6	4.2	2.1	2.5
	Maximum	11.4	6.9	5.9	7.2	13.7	11.4	9.4	12.3

Tributary Sites

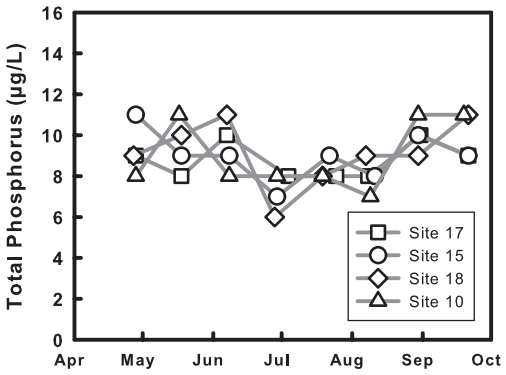
		James River Arm				Kings River Arm			Indian Creek	Roaring River	Long Creek
	SITE #	13	11	5	4.5	7	6.5	Viola	9	16	8
	# of Samples	9	10	8	8	7	7	8	8	8	8
SECCHI (inches)	Mean	31	48	79	121	34	45	75	110	40	86
	Minimum	17	37	56	94	26	26	24	76	36	53
	Maximum	36	56	142	166	62	84	108	162	45	186
TP (µg/L)	Mean	69	44	21	11	42	24	20	10	29	14
	Minimum	45	32	13	7	33	18	14	8	19	9
	Maximum	114	60	45	16	49	46	61	12	37	33
TN (µg/L)	Mean	966	787	683	523	505	366	380	397	812	592
	Minimum	540	430	280	270	330	290	240	230	550	360
	Maximum	2080	1770	1630	1370	1000	660	900	690	2100	1150
CHL (µg/L)	Mean	30.3	26.9	13.2	5.9	16.9	13.0	7.7	5.2	8.9	9.4
	Minimum	4.3	16.5	8.1	3.0	1.2	7.4	5.0	3.1	3.7	3.1
	Maximum	73.0	39.5	36.4	8.5	53.8	22.1	40.1	6.8	37.3	17.9

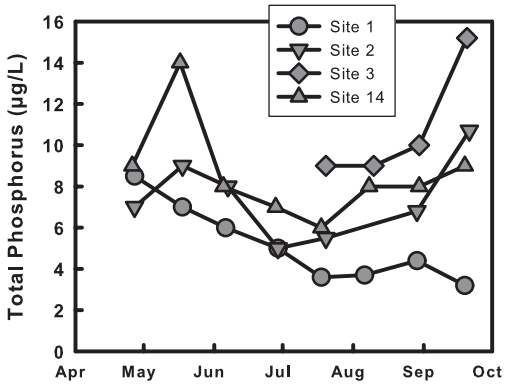
Table Rock Lake

Barry, Stone and Taney County

Phosphorus in the Main Channel

Phosphorus concentrations throughout the main channel were between 5 and 11 µg/L, with half of the sites at 9 µg/L. The lowest mean concentration was at the dam, where phosphorus concentrations started at just over 8 µg/L and dropped to 3 µg/L by the season's end. No other site behaved in this way. Phosphorus concentrations at the other main lake sites were higher, especially late in the season. Many sites showed a phosphorus increase during September, when rainfall was well above average. In aggregate, the phosphorus data from the main lake show a "U-shaped" pattern more or less conforming to the seasonal basin-wide rainfall data.

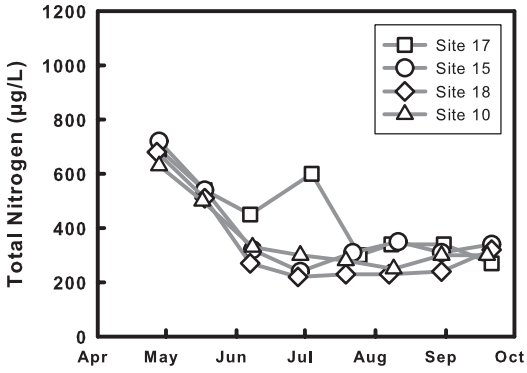




Nitrogen in the Main Channel

Nitrogen values in the main channel started the 2010 sampling season high and ended the season low. This is a typical pattern in lakes, reflecting the inflow of nitrogen with spring rains and the eventual decline of nitrogen concentrations as algal uptake occurs. All main lake nitrogen concentrations measured in late April or early May were above 600 µg/L (note: there are no Site 3 samples for the first half of the season). By July, all nitrogen concentrations were below 600 µg/L. At the end of September, nitrogen values at all sites (except Site 3) were below 400 µg/L.

Sites below the Indian Creek confluence had higher mean nitrogen concentrations than sites above the confluence. This distinction is particularly strong in the early season. Nitrogen data from Site 9 don't indicate Indian Creek to be the source.



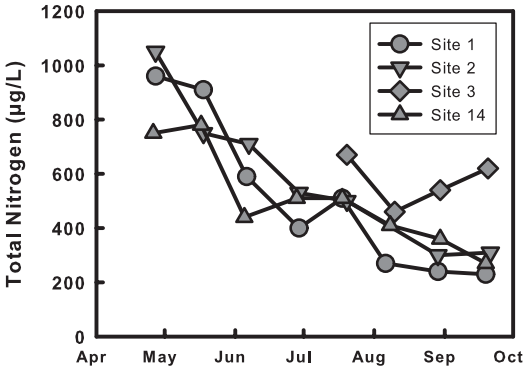


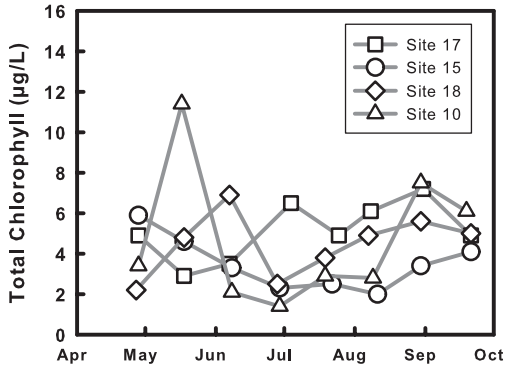
Table Rock Lake

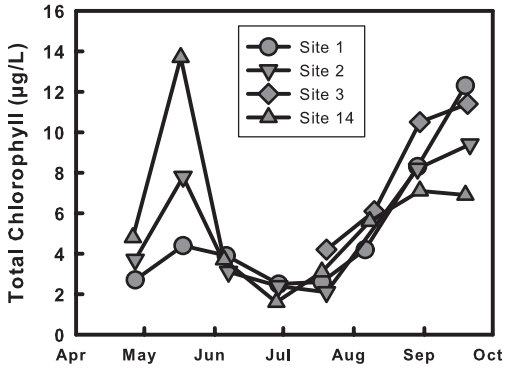
Barry, Stone and Taney County

Chlorophyll in the Main Channel

Mean 2010 chlorophyll concentrations in the main channel were below 5 µg/L at all sites except Site 3. The deviation of Site 3 is related to sample timing rather than water quality, as the early season, low chlorophyll samples were not collected. For the most part, chlorophyll concentrations mimic phosphorus in the main channel.

In the lower main lake there was a tendency toward peak values in both May and September with lower values occurring mid-season. Chlorophyll values at the down-lake sites were nearly identical from June through August. The upper-lake sites' chlorophyll values varied considerably more during this period.

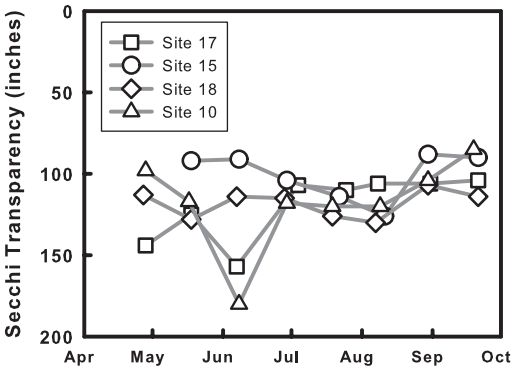




Water Clarity in the Main Channel

The upper main lake had rather consistent water clarity throughout the sample season. The only noteworthy variation was an early June peak in water clarity (>150 inches) at two sites. During the late June and mid July sample periods, water clarity at all lower main lake sites was virtually identical, varying by about a foot (range: 118 to 104 inches).

Like the upper main lake, water clarity among the lower main lake sites was virtually identical in late June. However, the lower sites' water clarity differed from the upper main lake by about 4 feet (range: 150 to 159 inches). The lower main lake sites' water clarity was similar throughout the season, with all 4 sites showing a sharp decrease in water clarity in May and a gradual decrease from July through September. All 3 of the lower main lake sites monitored in April had water clarity exceeding 150 inches.



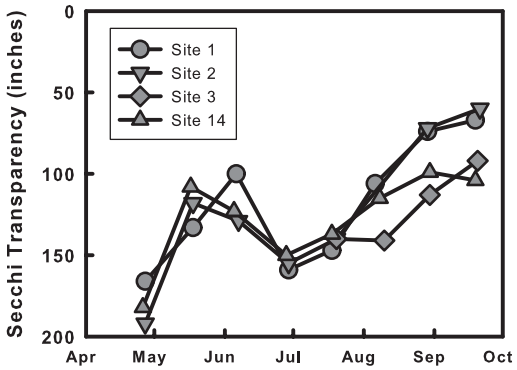
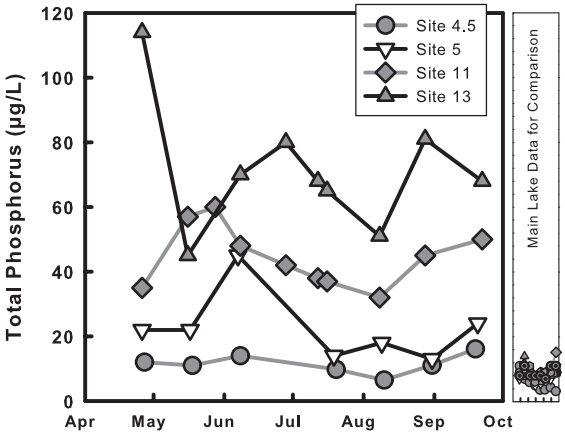


Table Rock Lake

Barry, Stone and Taney County

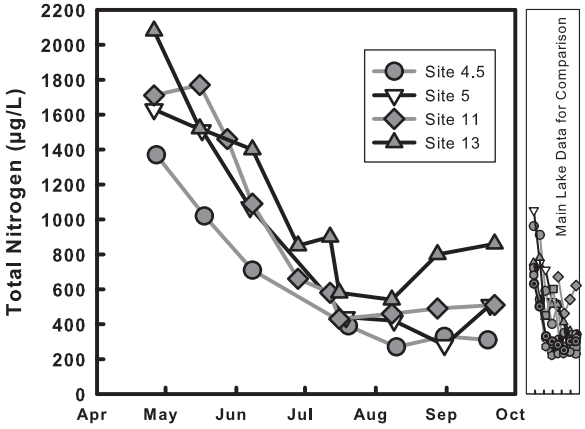
James River Phosphorus



It is no surprise that phosphorus concentrations in the upper James River arm (Site 13) are higher than concentrations near the main channel (Site 4.5). The gradual decrease in phosphorus with proximity to the main lake reflects the sedimentation of phosphorus to the lake bottom. The range of observed values at a given site also decreases with proximity to the main lake. Site 13 phosphorus concentrations varied by 69 µg/L, while phosphorus varied at Site 4.5 by only 9 µg/L.

Relative to phosphorus, nitrogen concentrations were comparatively similar throughout the James River Arm, with Site 13 having an average nitrogen value that was not quite double the average measured at Site 4.5. There was a strong seasonal trend of decreasing nitrogen with time. This seasonal nitrogen trend

James River Nitrogen

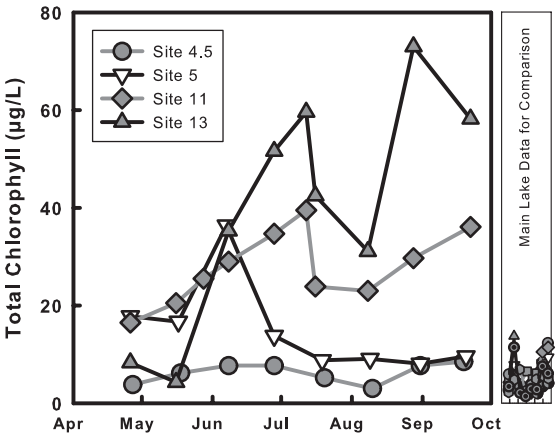


is very common in Missouri lakes.

As expected, chlorophyll concentrations were higher in the upper James than near the main channel. There was an increase in chlorophyll concentrations at the 3 uppermost sites that began in early June. Site 5 chlorophyll values dropped significantly by late June, and sites 11 and 13 followed suit in mid July. Site 4.5 behaved much like the main lake.

Water clarity, like the nutrients and chlorophyll, varied with distance to the main lake. Sites in the upper arm had low water clarity (31 inches at Site 13), and Secchi values varied little throughout the season. Water clarity at Site 4.5 was, on average, virtually indistinguishable from that of the main lake.

James River Chlorophyll



James River Water Clarity

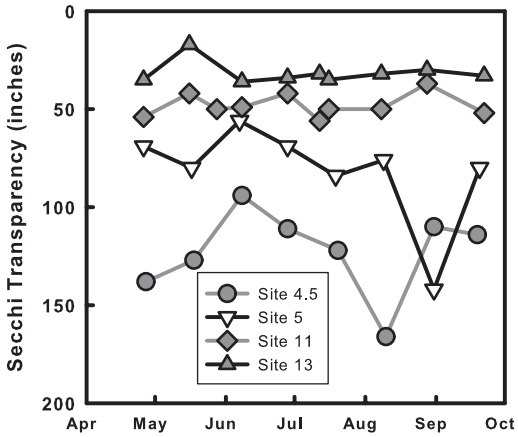
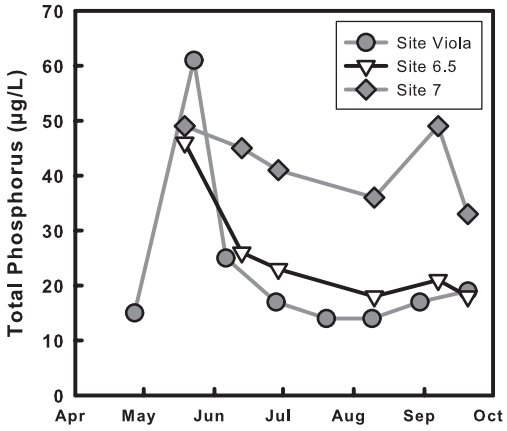


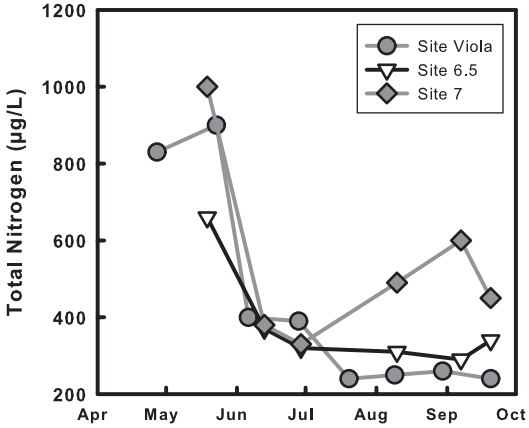
Table Rock Lake

Barry, Stone and Taney County

Kings River Phosphorus



Kings River Nitrogen

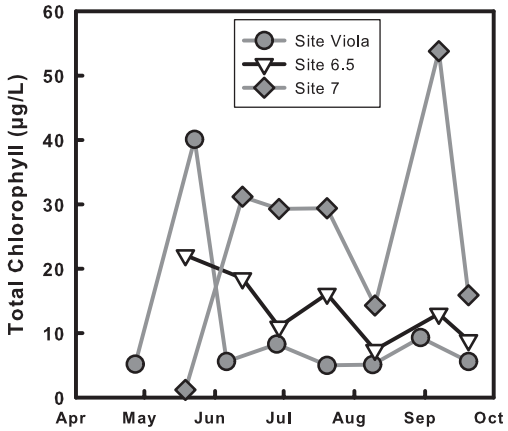


Phosphorus concentrations in the Kings River Arm were considerably higher than the main lake, even at the Viola Access, just 2 miles from the confluence. Nutrient levels (both phosphorus and nitrogen) were high at all Kings River sites in late May, a typical seasonal trend associated with spring rainfall. Nutrients, particularly nitrogen, generally decreased as the season progressed. Mean nitrogen concentrations were comparable at all Kings River sites, and similar to the main channel.

Chlorophyll concentrations in the Kings River Arm were higher than at most Table Rock sites, though they were comparable to the James River Arm. Site 7, the uppermost Kings River site, averaged 17 µg/L, but had a maximum value of 54 µg/L. The minimum value at Site 7 was remarkably low at 1.2 µg/L, likely due to suspended sediment from runoff reducing the algae community's access to sunlight. The maximum 2010 chlorophyll value at the Viola Access was similar to Site 7, though Viola averaged less than half the chlorophyll of Site 7 as a seasonal mean.

Water clarity was low in the upper Kings (average 34 inches) and doubled nearer the main lake at the Viola Access (average 75 inches). In the main lake just below the confluence of the Kings River, water clarity was three times greater than at Site 7 (average 100 inches).

Kings River Chlorophyll



Kings River Water Clarity

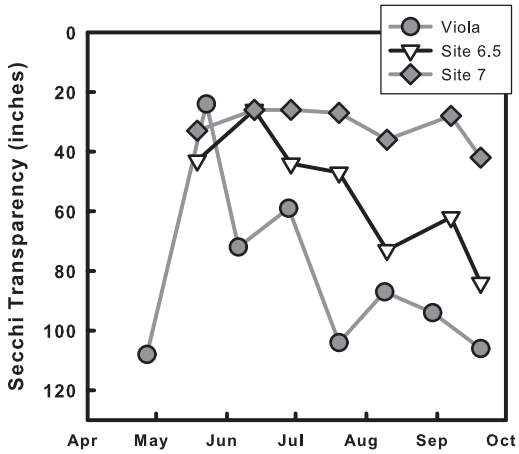


Table Rock Lake

Barry, Stone and Taney County

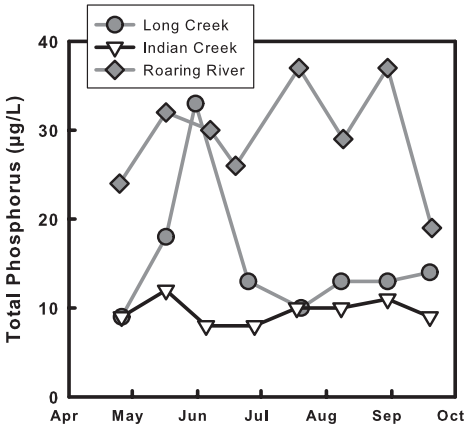
Long Creek, Indian Creek and Roaring River 2010 Data

Of the 3 remaining tributary sites at Long Creek (Site 8), Indian Creek (Site 9) and Roaring River (Site 16), phosphorus concentrations were highest at Site 16. This is not unexpected, as Site 16 is far up the Roaring River Arm, nearly in the river itself and the particulate phosphorus has not yet settled. Phosphorus concentrations at the other two sites were comparable to the main lake, with a May 31 peak at Long Creek being the only exception. Nitrogen concentrations at Site 9 in Indian Creek were slightly lower than those of the main lake and values at Site 8 in Long Creek values were slightly higher. Roaring River average nitrogen values were more than double those of the main lake, similar to those of the James River Arm.

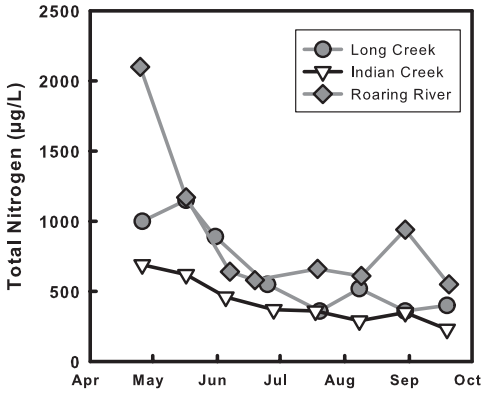
Mean chlorophyll values at Long Creek and Roaring River were similar in 2010 at approximately 9 µg/L. Roaring River had a higher maximum value, double that of Long Creek. Indian Creek was similar to the main lake Site 14 (at the confluence) but varied less during the season with less than a third of the range (maximum to minimum).

The water clarity (Secchi) at Roaring River varied by only 9 inches during 2010. At 40 inches the 2010 mean was comparable to the statewide mean but was low for Table Rock Lake. Indian Creek water clarity was more typical of the lake, with a mean of 100 inches and a maximum of 162 inches. Water clarity was generally better in the early season at Indian Creek. Long Creek's mean 2010 Secchi was low, having roughly a third of the main lake's clarity. An April 26 measurement of over 15 feet was a standout, with the remainder of the season's Secchi values below 100 inches.

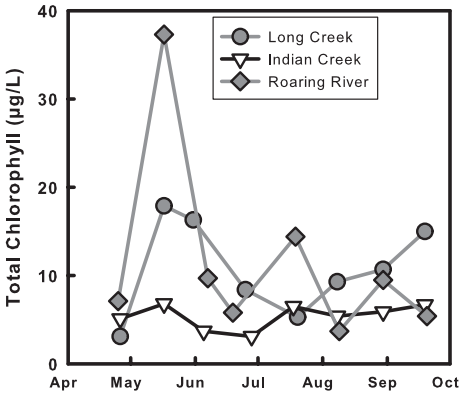
Phosphorus



Nitrogen



Chlorophyll



Water Clarity

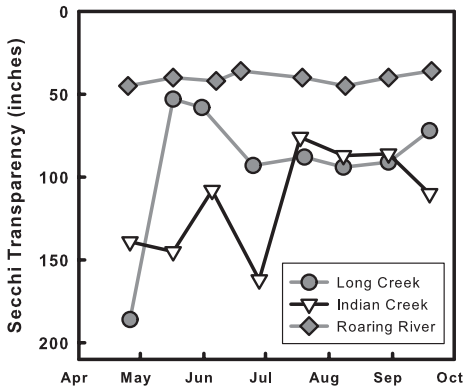


Table Rock Lake

Barry, Stone and Taney County

Roaring River Sampling – Above and Below

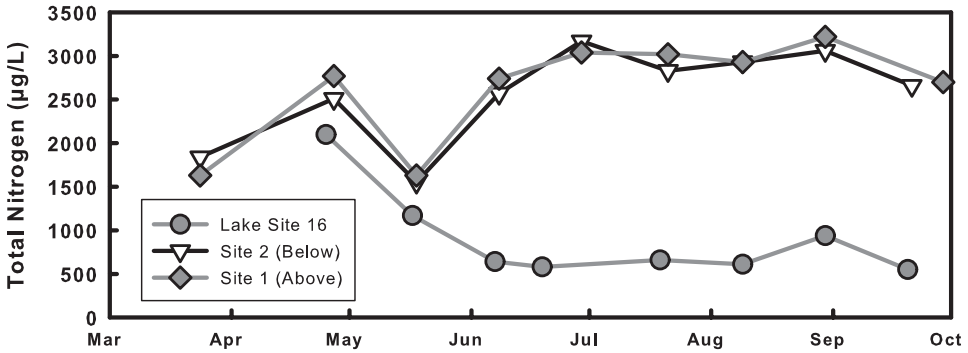
To address concerns regarding the construction of a confined animal feeding operation (CAFO) in the Roaring River watershed, a volunteer has been monitoring river sites.

Site 1 is located above the inflowing stream draining the CAFO, Site 2 is located below. For reference, Site 16 on the Roaring River Arm of the lake is included in the graphs.

Nitrogen concentrations did not vary between river sites. Both sites had higher nitrogen values than the lake site, particularly in June and beyond.

Phosphorus concentrations were similar at both river sites, though Site 1 had slightly higher values during July and August. The lake site had higher phosphorus concentrations than the river, by comparison.

The data do not show any negative influence associated with the tributary draining the CAFO prperty.



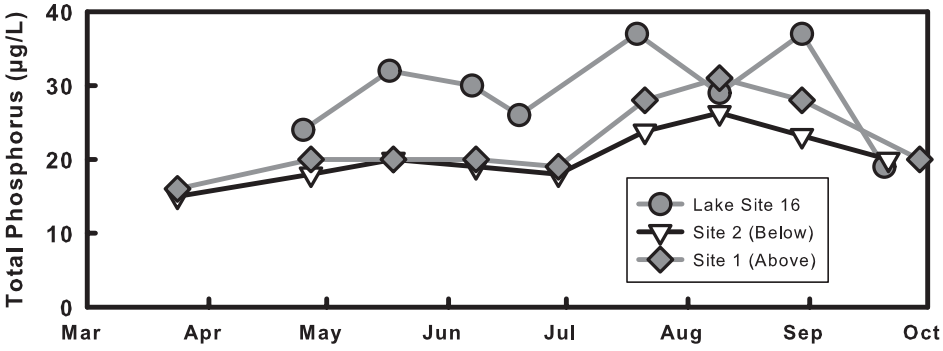


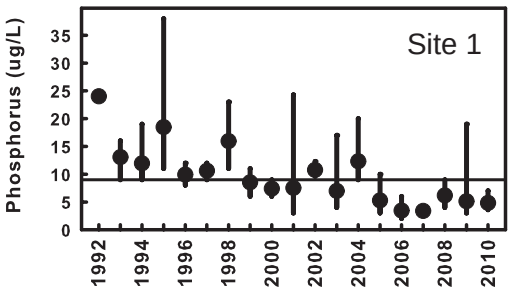
Table Rock Lake

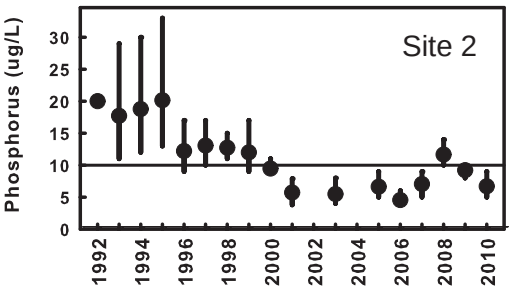
Barry, Stone and Taney County

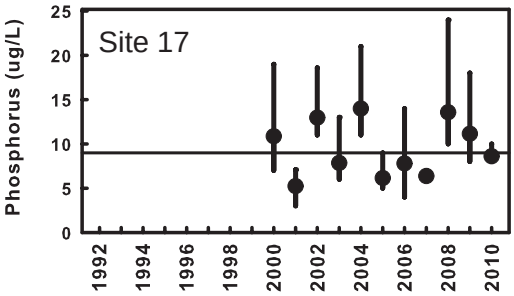
Main Lake Trends

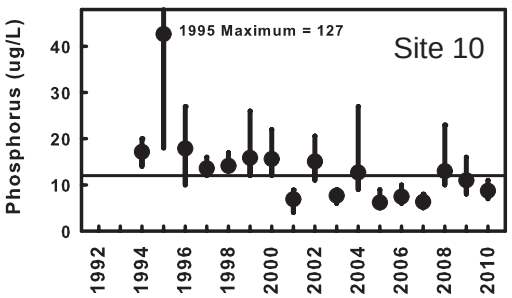
Phosphorus

Phosphorus concentrations remained low at the main lake sites below the James River confluence, likely related to phosphorus removal from wastewater treatment plant effluent in the James River watershed. Sites 17, 15 and 18 (above the James confluence) were not sampled prior to 2000, though average 2010 summer phosphorus concentrations at all main lake sites were still below the long-term means and generally displayed low variability. Phosphorus at Site 10 have been slowly trending downward since 1993, when sampling began, though the pattern is not as distinct as that of the lower main lake.



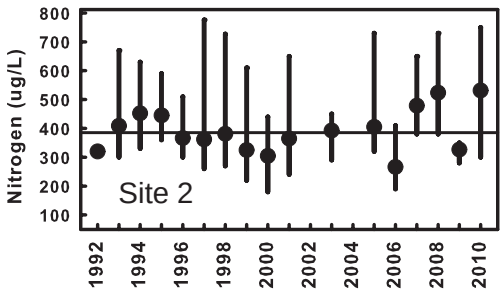


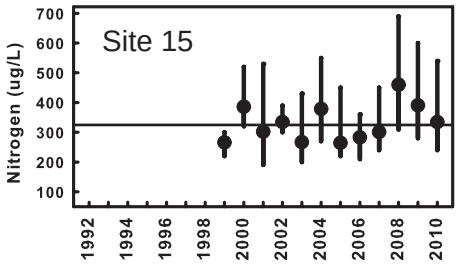




Nitrogen

In contrast to the below average phosphorus concentrations throughout the lake in 2010, summer nitrogen concentrations were higher than normal across the lake. In the main lake during 2010, only sites 10 and 18 (the most up-lake sites) did not have summer mean nitrogen concentrations in excess of the long-term mean. For the sites below Shell Knob, 2010 nitrogen values were among the highest in the last decade. Site 15 (at the 39 bridge) had a 2010 mean nitrogen value just above the long-term mean, but the 2010 summer maximum was among the highest to date.





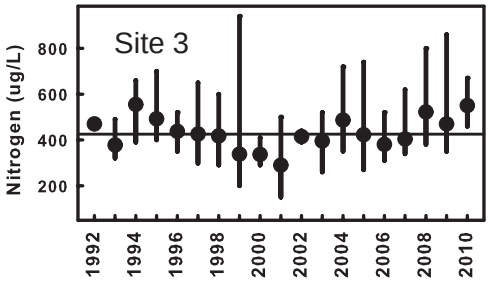


Table Rock Lake

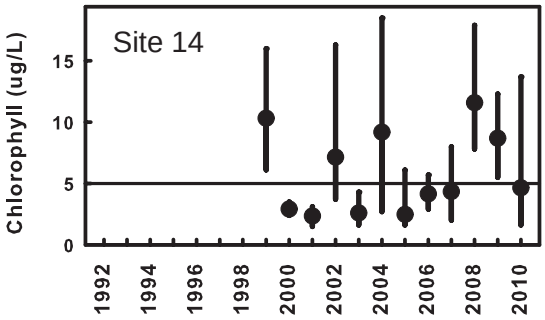
Barry, Stone and Taney County

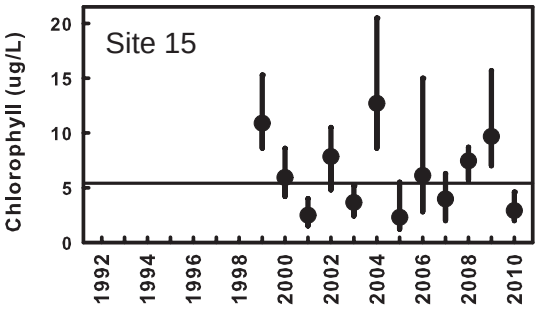
Main Lake Trends

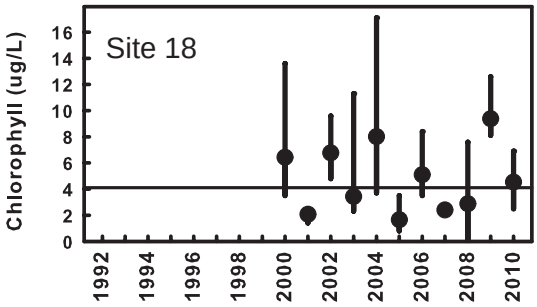
Chlorophyll

Average 2010 summer chlorophyll concentrations were below the long-term mean at all but two sites.

These two sites (Site 3 and Site 18) had average values that were only marginally higher than the long-term mean.

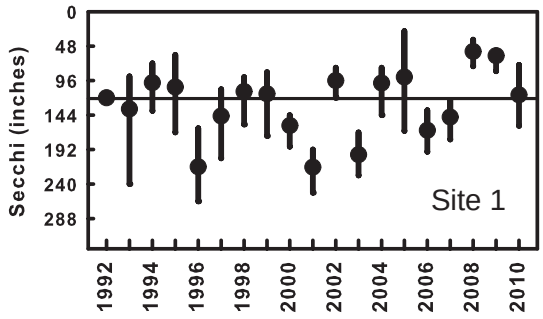


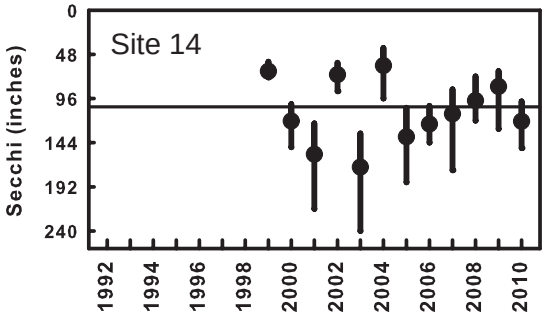


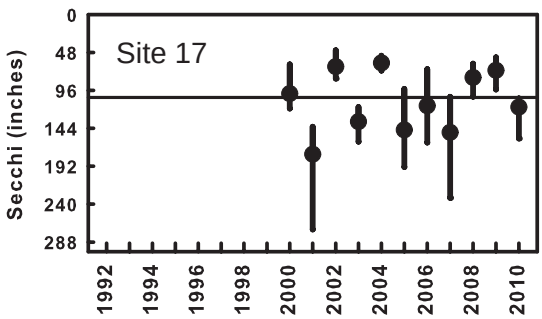


Secchi

Water clarity at the dam was slightly lower on average in 2010. On the other end of the main lake at Site 10 water clarity was nearly 3 feet above average. The other main lake sites had very typical summer water clarity in 2010, with a welcome return to the Secchi transparency values measured prior to the 2008 flooding.







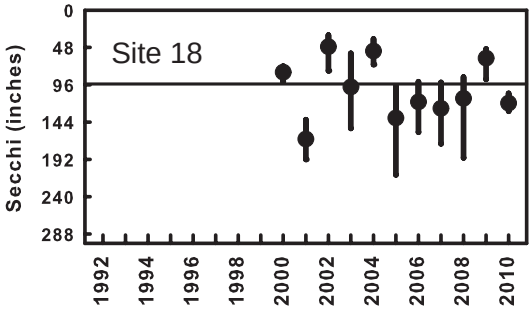
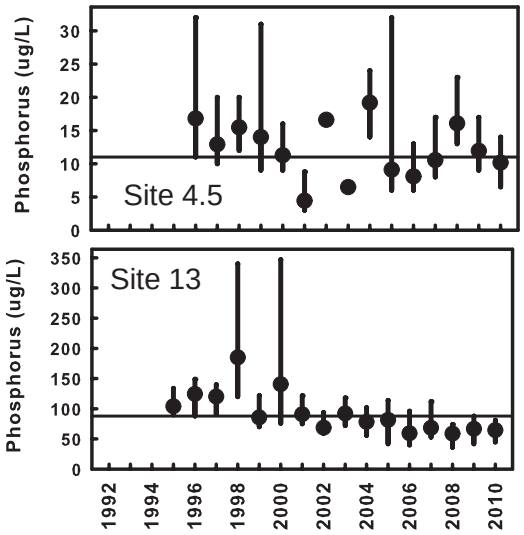


Table Rock Lake

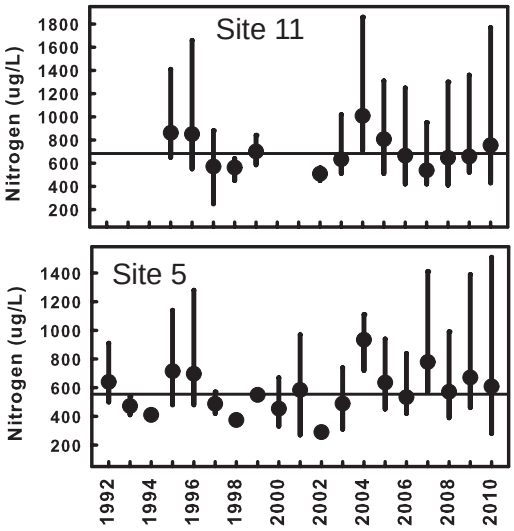
Barry, Stone and Taney County

James River Arm Trends

Phosphorus



Nitrogen



The 2010 summer mean phosphorus value measured at every James River site was at or below the long-term mean. As reported before, phosphorus values throughout the James River, the main lake below the James as well as Taneycomo and Bull Shoals, have been lower in the years since 2001, largely thanks to phosphorus removal operations at an upstream City of Springfield wastewater treatment plant. Though the pattern is somewhat diffuse at Site 11 and 4.5, sites 13 and 5 show this pattern nicely.

Average nitrogen concentrations in the summer of 2010 were higher than usual at 3 of the James River Arm sites. Site 13 nitrogen concentrations have remained, as an average, unchanged in the last 3 years. Summer 2010 nitrogen values at sites 11, 4.5 and 5 ranged widely, with near-record maximum and minimum values at all 3 sites.

James River Arm Trends

Chlorophyll

The mean chlorophyll concentration at all James River sites was lower than the long-term average. At Site 13 the summer 2010 average was 33% lower than the long-term mean, though the range of values observed was similar those measured in previous years. Chlorophyll concentrations at Site 4.5 remain variable across years, with summertime means ranging from 2.9 to 15.4 µg/L.

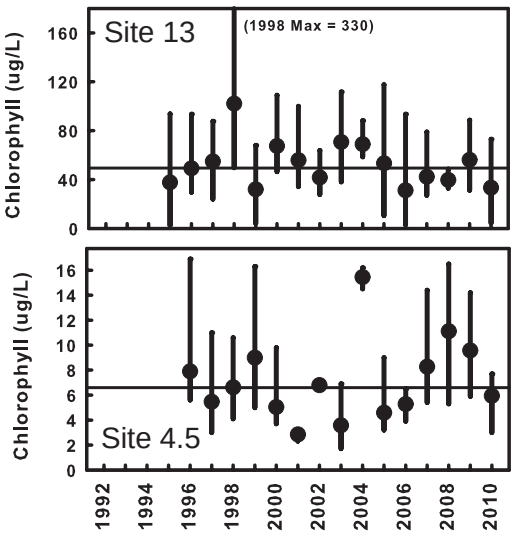


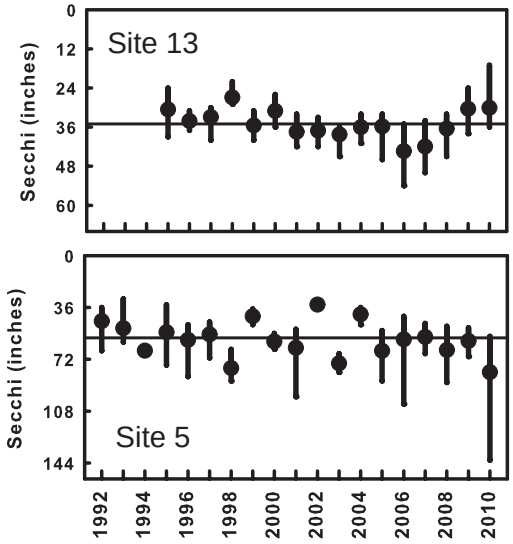
Table Rock Lake

Barry, Stone and Taney County

James River Arm Trends

Secchi

Site 13 had below average water clarity, and a record minimum Secchi transparency measured in 2010. However, summer 2010 Secchi transparency means at the remaining 3 James River sites were greater than the long-term average. For Site 5, this equated to record water clarity for 2010. Site 4.5 had its greatest summer water clarity measured to date (166 inches) during the dry month of August.

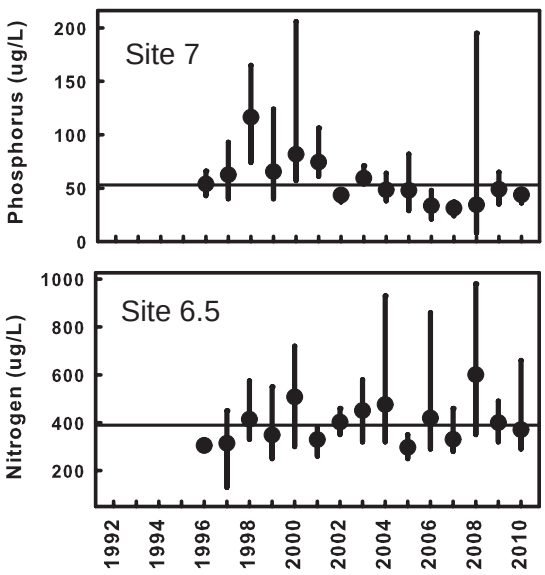


Kings River Arm Trends

2010 was the first year that nutrient and chlorophyll data were available for the Viola Access, though 8 years of Secchi data are available.

Summer mean phosphorus concentrations at Site 7 have been near or below the long-term mean since 2002, indicating a decline in phosphorus since sampling began in 1996. Nitrogen concentrations measured in the summer of 2010 were virtually identical to those of 2009. The primary difference was that the range of values was slightly higher in 2010. At Site 7 the mean 2010 summer chlorophyll concentration was lower than the long-term mean, though there was considerable range between the maximum and minimum values. At Site 6.5, the mean 2010 value was slightly higher than the long-term mean, with a typical range of values measured.

Water clarity was (on average) at or below the long-term mean at all 3 sites during the summer of 2010. The 2010 values at the Viola Access site were collected by a new volunteer. When combined with the long-term data at Viola, the data the match the pattern seen at Site 6.5, indicating that good data continuity was maintained.



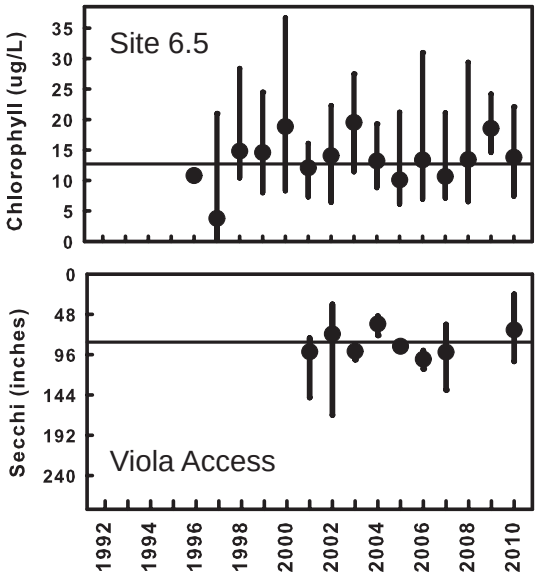
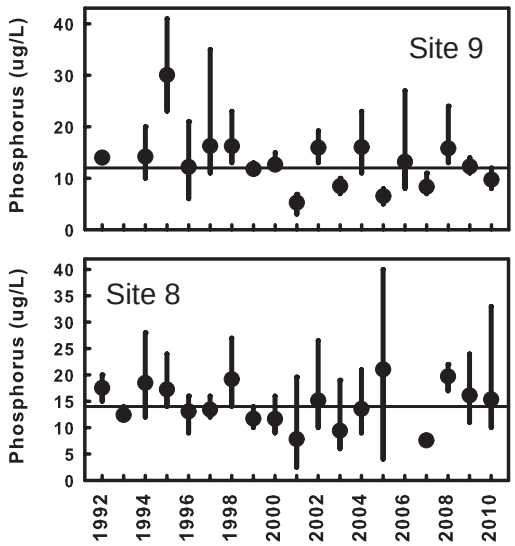


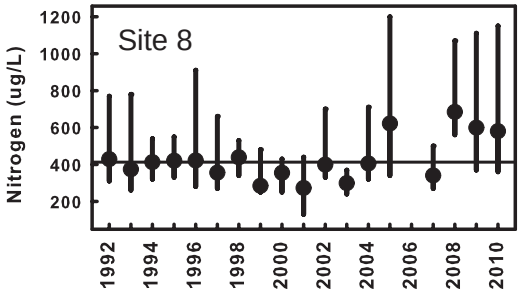
Table Rock Lake

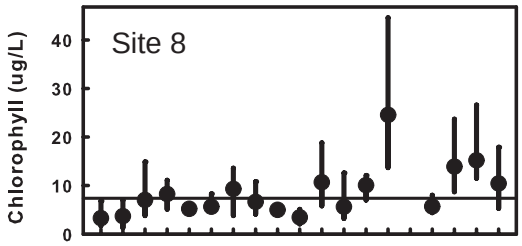
Barry, Stone and Taney County

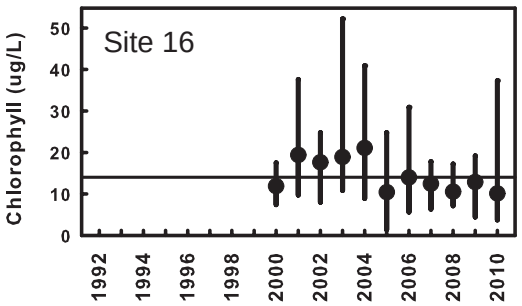
Long Creek, Indian Creek, Roaring River Trends

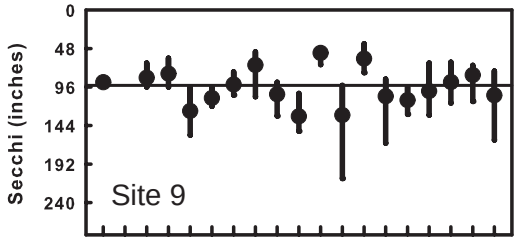
Only two sites on Table Rock Lake, Site 8 (Long Creek) and Site 16 (Roaring River) had mean 2010 summer phosphorus concentrations greater than the long-term mean. In both cases, the difference from the mean was marginal (7%). Summer nitrogen concentrations for these 3 sites were either at or above the long-term means in 2010. Site 8 2010 nitrogen values were lower than the previous 2 years, but still greater than the long-term mean. The mean summer 2010 Long Creek chlorophyll concentration was higher than the long-term average, while Site 9 and Site 16 were at and below the long-term value, respectively. While no site displayed a long-term trend, 2010 values were lower than in the previous 2 years for all 3 sites, if only marginally. Water clarity was better than average in Indian Creek in 2010, with an additional foot of clarity. Both Site 8 and Site 16 had lower than average water clarity in 2010, though by only 9 and 10 inches, respectively.

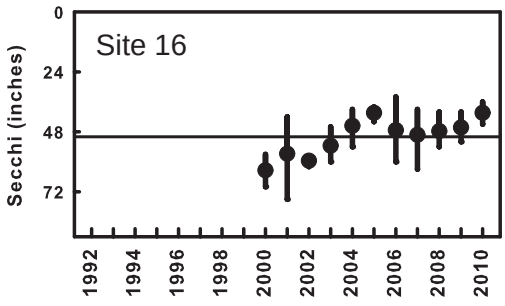












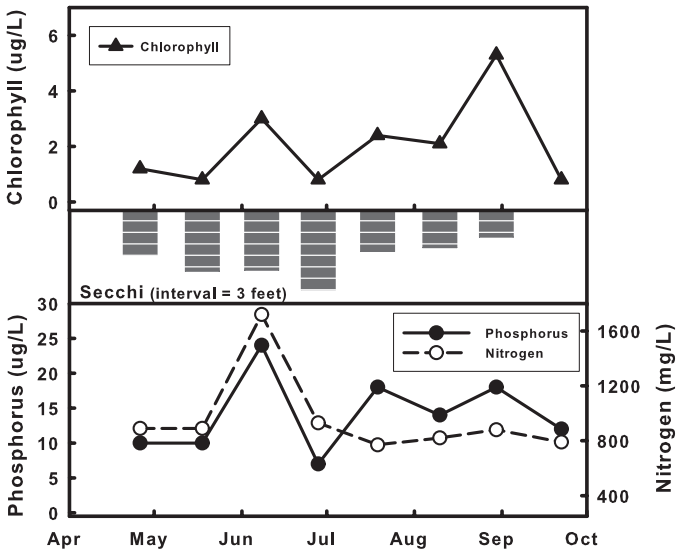
Lake Taneycomo

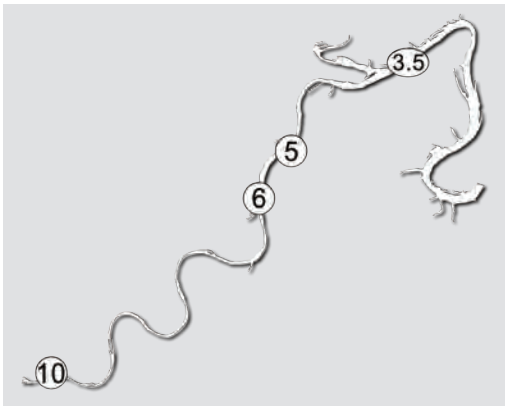
Site 3.5

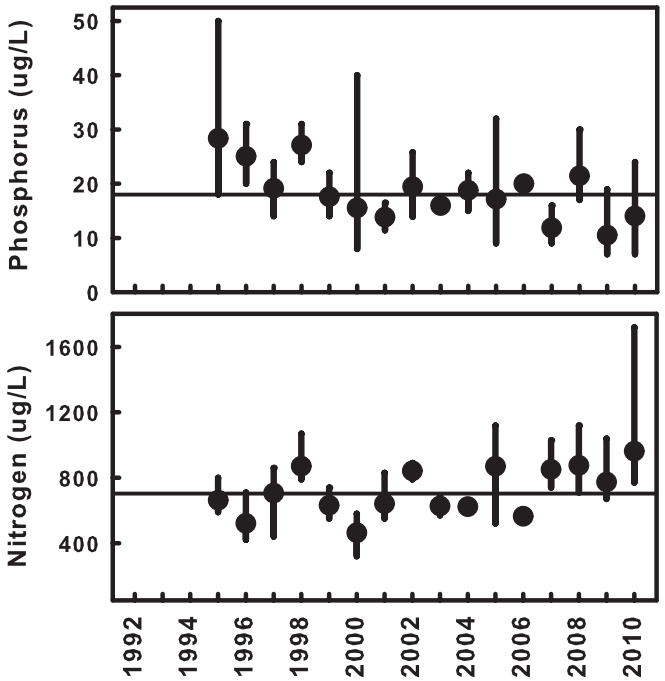
2010 DATA

Taney County
Latitude: 36.6963 Longitude: -93.1583

Date	X	5/18	6/8	6/28	7/19	8/10	8/30	9/22	Mean
Secchi (inches)		194	191	252	132	120	87	.	152
TP (µg/L)		10	24	7	18	14	18	12	13
TN (µg/L)		890	1720	930	770	820	880	790	929
CHL (µg/L)		0.8	3.0	0.8	2.4	2.1	5.3	0.8	1.6







Phosphorus, nitrogen and algal chlorophyll all followed the same general pattern through the 2010 sample season, with minor peaks in early June and again in late September. Secchi transparency increased through the first half of the sample season, reaching a depth of 21 feet at the end of June, and then decreased as the summer progressed. The Secchi hit the bottom of the lake on 9/22, so no value is reported.

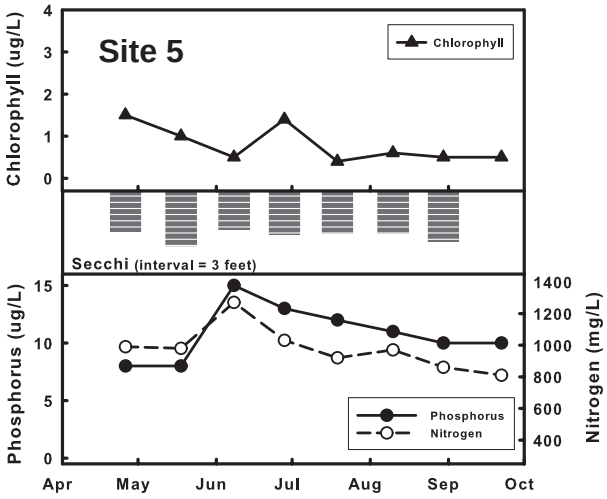
Long-term trends at Site 3.5 in Lake Taneycomo are for lower phosphorus concentrations relating to reduced inputs. In contrast, summertime nitrogen levels have been above the long-term average during the last four summers.

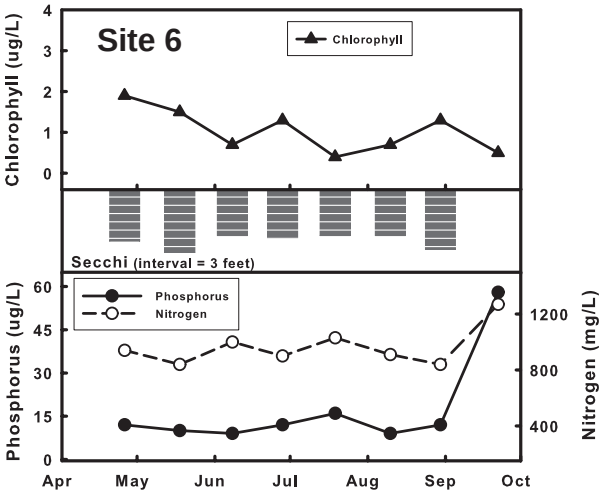
Lake Taneycomo Site 5

Taney County
Latitude: 36.6722 Longitude: -93.1986

Date	4/26	5/18	6/8	6/28	7/19	8/10	8/30	9/22	Mean
Secchi (inches)	242	326	229	259	252	252	300	.	264
TP (µg/L)	8	8	15	13	12	11	10	10	11
TN (µg/L)	990	980	1270	1030	920	970	860	810	728
CHL (µg/L)	1.5	1.0	0.5	1.4	0.4	0.6	0.5	0.5	0.7

In general, water quality in the mid-lake section of Lake Taneycomo was fairly stable across the 2010 sample season. Site 5 saw only minor fluctuations in the parameters, while Site 6 was stable except for the last sample date on September 22. On this day concentrations of both nutrients showed a sharp increase over the previous sample date. As we have seen in the past, short-term nutrient increases in Lake Taneycomo do not always translate to higher levels of algal chlorophyll. At both sites the Secchi transparency was deeper than normal during the season, with clarity exceeding lake depth on the last sample date.





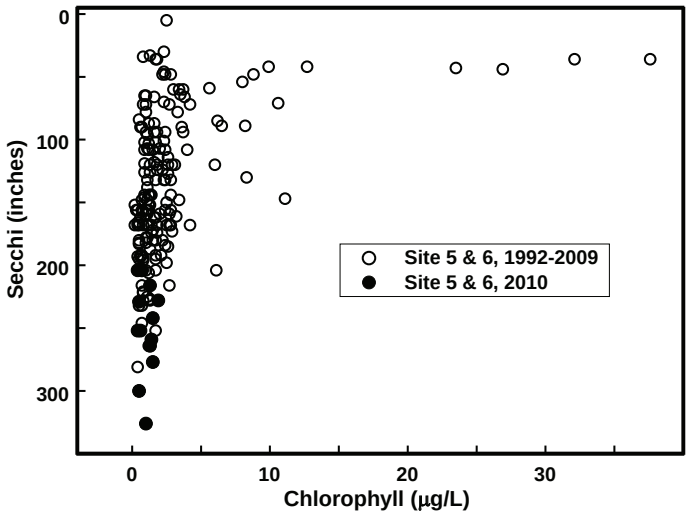
Lake Taneycomo Site 6

Taney County
Latitude: 36.6519 Longitude: -93.2133

Date	4/26	5/18	6/8	6/28	7/19	8/10	8/30	9/22	Mean
Secchi (inches)	228	277	204	216	204	204	264	.	226
TP (µg/L)	12	10	9	12	16	9	12	58	14
TN (µg/L)	940	840	1000	900	1030	910	840	1270	958
CHL (µg/L)	1.9	1.5	0.7	1.3	0.4	0.7	1.3	0.5	0.9

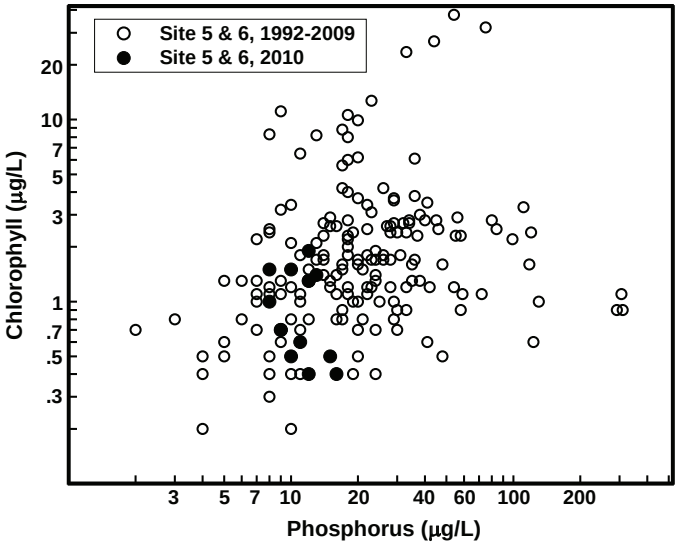
Lake Taneycomo (continued)

Secchi measurements at sites 5 and 6 were quite clear during the 2010 sample season. Readings taken in late September hit bottom at both sites and are not represented in the accompanying graph. Looking back at old field sheets, Secchi readings bottomed out at these sites only one other time, June 2002. Review of the graph shows that while chlorophyll levels in 2010 were low, they were not lower than previously measured values.



The cause of the improved clarity at these mid-lake sites during the 2010 season is not obvious. There may have been decreased levels of inorganic suspended sediment in the lake, which would improve clarity.

When we plot 2010 chlorophyll concentrations against phosphorus for sites 5 and 6 we find that the two parameters related to each other in a fashion similar to previous years. While chlorophyll levels were on the low end of the range (note both phosphorus and chlorophyll are log-scaled, which spreads values out at low end and compresses values on the high end), they were comparable to past values. Phosphorus concentrations are also on the low end of what has historically been measured at these sites, but not as low as some past values.



Lake Taneycomo

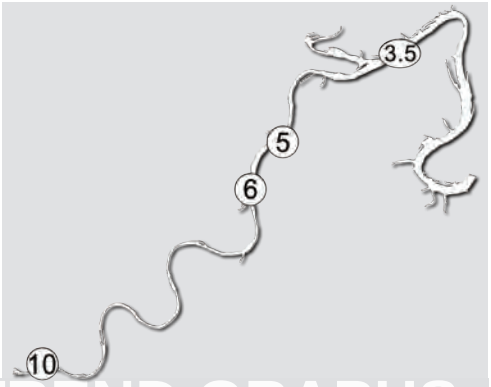
Site 10

2010 DATA

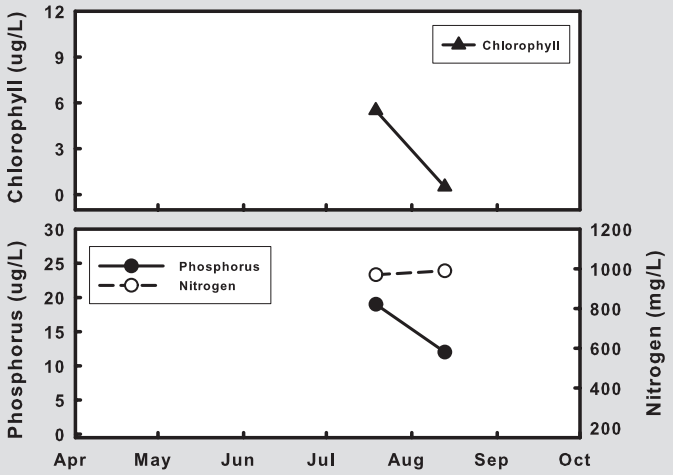
Taney County
Latitude: 36.5967 Longitude: -93.2950

Date	X	X	X	X	7/19	8/14	X	X	Mean
Secchi (inches)					Secchi on bottom				
TP (µg/L)					19	12			15
TN (µg/L)					970	990			980
CHL (µg/L)					5.5	0.5			1.7

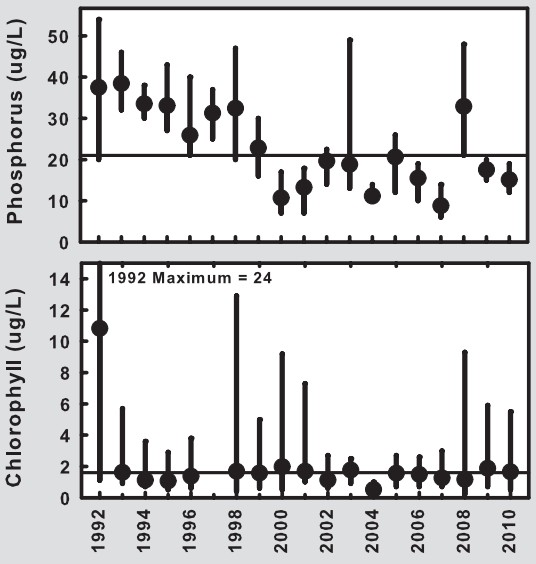
Not much can be said about the water quality at Site 10 in 2010 due to limited sampling. Long-term data show the decline of phosphorus at this site, relating to reduced inputs in the Table Rock Lake watershed. Chlorophyll levels are generally low (<3µg/L) with concentrations that occasionally peak above 5 µg/L.



2010 GRAPHS



TREND GRAPHS



See pages 10-11 for help interpreting graphs

Tri City Lake

2010 DATA

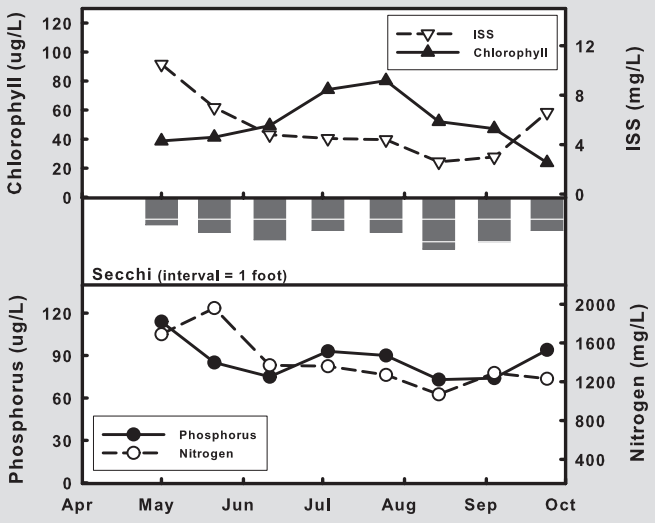
Boone County
Latitude: 39.1904 Longitude: -92.2085

Date	5/1	5/21	6/11	7/3	7/25	8/14	9/4	9/24	Mean
Secchi (inches)	15	19	23	18	19	28	24	18	20
TP (µg/L)	114	85	75	93	90	73	74	94	86
TN (µg/L)	1690	1960	1370	1360	1270	1070	1290	1230	1382
CHL (µg/L)	38.7	41.3	49.3	74.2	80.3	52.1	47.2	23.8	47.8
ISS (mg/L)	10.5	7.0	4.8	4.5	4.4	2.6	3.0	6.6	4.9

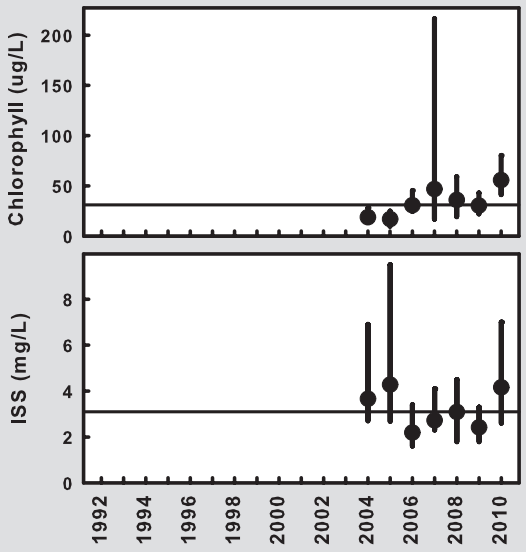
While maximum phosphorus and nitrogen values were measured early in the sample season, Tri City Lake did not display the normal pattern seen in many Missouri lakes where these springtime maximum values are followed by decreasing values during the sample season. During 2010, phosphorus remained fairly stable across the whole of the season. Chlorophyll values were generally high, with peak values in July. The seasonal pattern of chlorophyll reflects the inorganic suspended sediment levels, with the highest chlorophyll measurements coming when suspended sediment concentrations dropped below 5 mg/L. Water clarity was low throughout the season due to the moderate to high levels of both suspended sediment and algae (as estimated by chlorophyll).

Summertime inorganic suspended sediment values in 2010 were similar to those measured in 2004 and 2005, and higher than levels during the last four summers. Please note, the highest suspended sediment value in 2010 was collected on the first sample date and is not included in the long-term graph. The higher than average suspended sediment value is not as surprising as the higher than normal chlorophyll levels that were also measured in 2010. In most Missouri lakes higher suspended sediment reduces light available for algal growth. While the summertime suspended sediment values are not extreme by any means, they are high enough to have some influence on algal growth. Even with suspended sediment values over 4mg/L Tri City Lake supported chlorophyll levels in the hypereutrophic range.

2010 GRAPHS



TREND GRAPHS



See pages 10-11 for help interpreting graphs

Lake Wappapello

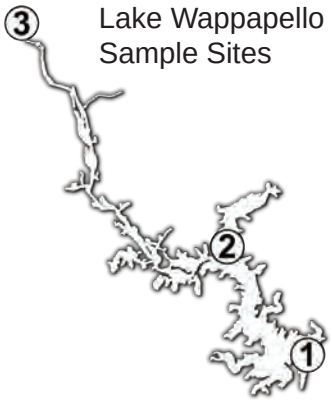
Site 1

Butler and Wayne County
Latitude: 36.9337 Longitude: -90.2833

2010 DATA

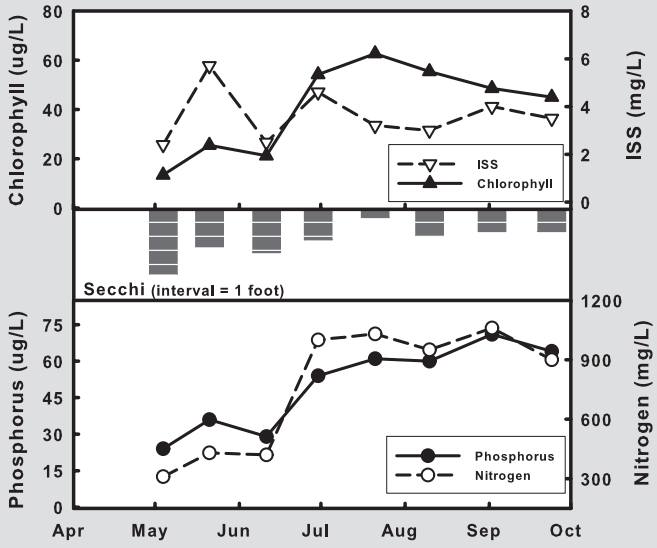
Date	5/4	5/21	6/11	6/30	7/21	8/10	9/2	9/24	Mean
Secchi (inches)	56	33	38	27	8	24	20	20	25
TP (µg/L)	24	36	29	54	61	60	71	64	47
TN (µg/L)	310	430	420	1000	1030	950	1060	900	691
CHL (µg/L)	13.4	25.5	21.2	54.2	62.7	55.4	48.6	45.0	36.3
ISS (mg/L)	2.4	5.7	2.5	4.6	3.2	3.0	4.0	3.5	3.5

The 2010 sample season is the first in which a full complement of samples was collected. This monitoring effort allows us to document the seasonal pattern that previous monitoring in Lake Wappapello had suggested. While most Missouri lakes have maximum nutrient levels during spring and decreasing values through summer, Site 1 on Lake Wappapello displays the opposite seasonal pattern. Previous data has suggested, and 2010 data support, the pattern of low nutrients early in the season, with increasing values as summer progresses. The algal chlorophyll values mimicked the nutrients, with end of the season values that were three times higher than early season values.



Lake Wappapello
Sample Sites

2010 GRAPHS

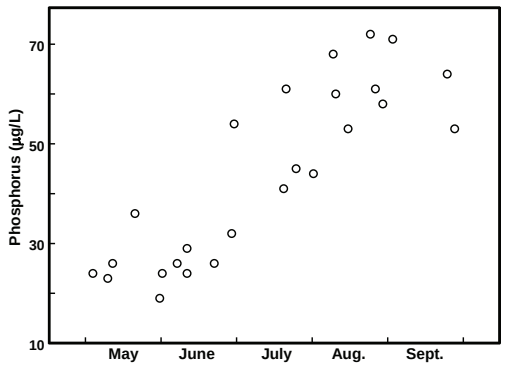


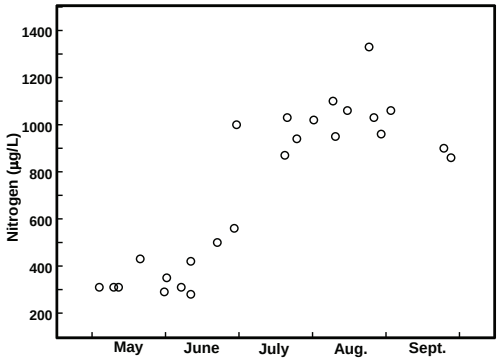
TREND GRAPHS

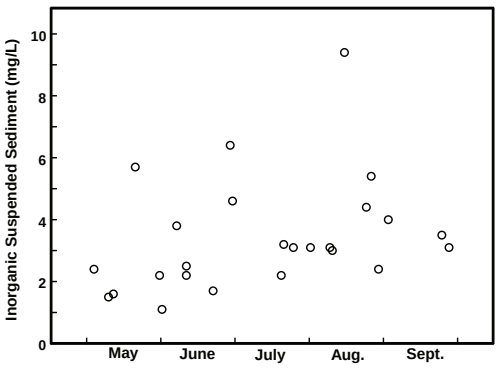
With the strong and predictable seasonality that we find in Lake Wappapello, (as shown on the next page) care needs to be taken when analyzing for long-term trends. The timing of the sample collection during each summer is very important as May and June sampling one year would result in a very different water quality assessment compared to July and August sampling the following year. In order to make a valid trend analysis the data from all years would need to represent comparable time periods.

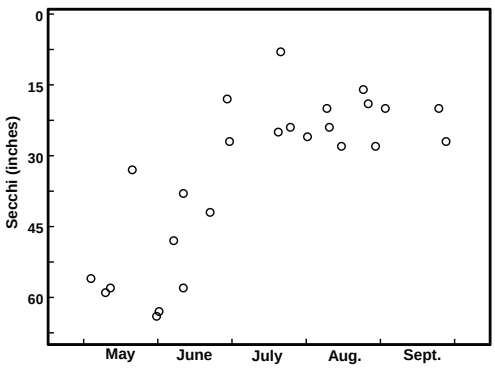
See pages 10-11 for help interpreting graphs

Lake Wappapello Site 1

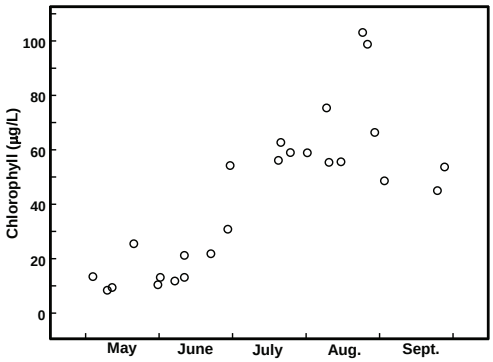








When we plot all of the data from Site 1 by the day of year in which the sample was collected, we find a distinct seasonal pattern in phosphorus concentrations. Most samples in May and June had phosphorus values that ranged between 20-30µg/L, while values during the second half of the season ranged between 40-72µg/L. The same pattern is observed when nitrogen and chlorophyll concentrations are plotted against sample date. Nitrogen and chlorophyll during the first half of the season ranged from 300-600µg/L and 8-32µg/l, respectively. During the second half of the season values ranged 850-1350µg/L and 45-105µg/L for nitrogen and chlorophyll.



The seasonal pattern observed in nutrient concentrations is not reflected by inorganic suspended sediment values. There is a slight increase in the minimum values measured across the season, but enough overlap in the data to suggest no true seasonal pattern. The difference in seasonal patterns between suspended sediment and nutrients suggest the increased nutrients during late summer/fall are not a result of erosional runoff from the watershed, as phosphorus inputs associated with nonpoint sources (i.e. runoff) is strongly correlated to suspended sediment concentrations.

Secchi transparency values at Site 1 in Lake Wappapello also show a seasonal pattern which reflects algal chlorophyll concentrations. During the early season, when chlorophyll levels are low, water clarity exceeds 30 inches and extends to past 60 inches. During the second half of the season Secchi transparency ranges from 8-28 inches.

Lake Wappapello

Site 2

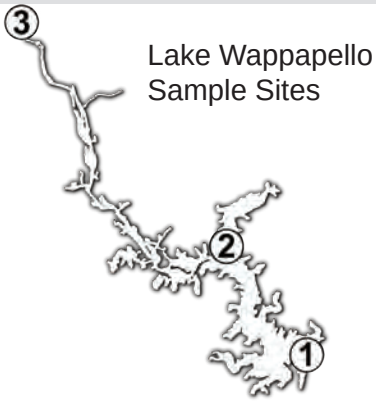
Butler and Wayne County
Latitude: 36.9888 Longitude: -90.3351

2010 DATA

Date	5/4	5/21	6/11	6/30	7/21	8/10	9/2	9/24	Mean
Secchi (inches)	29	28	21	16	10	18	14	20	19
TP (µg/L)	30	46	48	73	81	.	93	62	58
TN (µg/L)	250	420	410	750	860	.	1140	640	573
CHL (µg/L)	17.6	27.9	32.3	55.1	58.0	47.1	134.3	44.6	44.1
ISS (mg/L)	3.7	9.4	8.1	34.4	12.8	9.4	9.3	6.4	9.6

Site 2, located in the Lost Creek Arm of Lake Wappapello, followed the same general seasonal patterns that were observed at Site 1. Phosphorus and inorganic suspended sediment levels were slightly higher at Site 2 compared to Site 1, a trend we expect given its up-lake location (up-lake sites tend to have higher nutrient and suspended sediment levels). Nitrogen concentrations did not follow this trend, with values at Site 2 that were equal to or lower than Site 1. The amount of algal chlorophyll at Site 2 ranged from 17.6 to 134.3µg/L. These chlorophyll values represent high levels relative to the nutrients. This was especially true given the suspended sediment concentrations that were high enough to cause some light limitation.

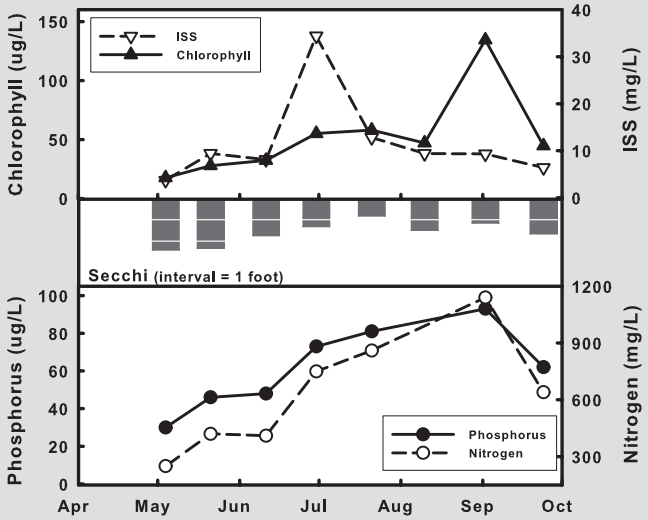
Site 2 generally followed the same seasonal trend observed at Site 1, with low nutrient, chlorophyll and suspended sediment concentrations during May and June.



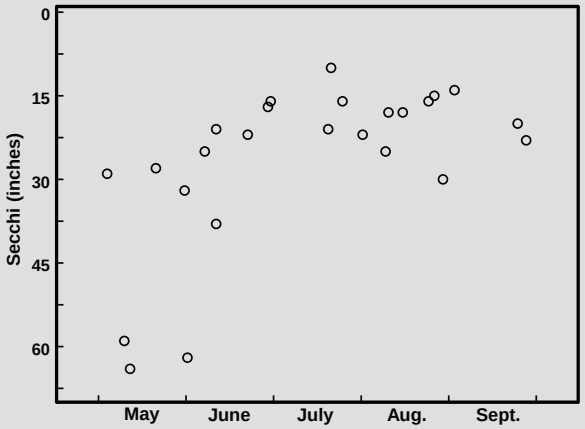
Lake Wappapello Sample Sites

The seasonal trend of Secchi transparency at Site 2 did differ from that observed at Site 1 as shallow Secchi readings were collected throughout the sample season. The slightly higher levels of chlorophyll and suspended sediment at Site 2 limit clarity in most samples.

2010 GRAPHS



TREND GRAPHS



See pages 10-11 for help interpreting graphs

Lake Wappapello

Site 3

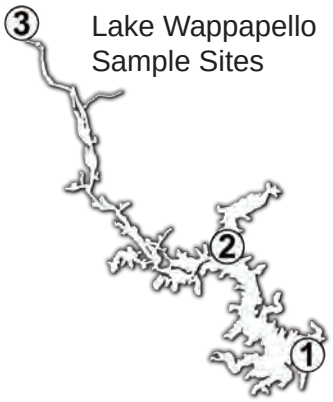
Butler and Wayne County
Latitude: 37.1945 Longitude: -90.5037

2010 DATA

Date	5/4	5/21	6/11	6/30	7/21	8/10	X	9/24	Mean
Secchi (inches)	.	.	.	.	.	.		.	.
TP (µg/L)	17	51	23	19	24	25		22	24
TN (µg/L)	350	440	250	150	230	240		150	241
CHL (µg/L)	2.5	6.9	17.6	9.4	7.5	5.8		3.0	6.2
ISS (mg/L)	2.4	19.9	5.2	.	6.5	1.7		0.1	3.4

The seasonal pattern of nutrient concentrations at Site 3, located in the St. Francois River, was for maximum values early in the season, followed by low and relatively stable levels throughout the remainder of the year. Chlorophyll does not reach maximum until the sample after nutrients peak, even though algal growth is directly tied to nutrient levels. During high flow periods, when nutrients levels are greatest, water movement through Site 3 is probably fast enough to keep algal cells from fully utilizing the available nutrients.

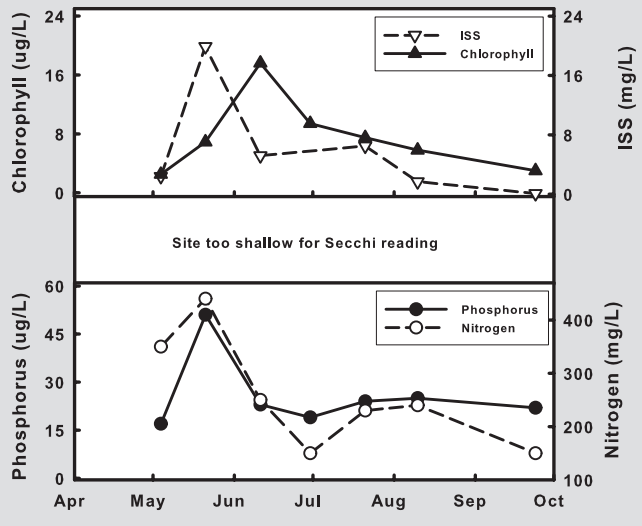
Site 3 does not display the same seasonal trend as the other sites. This is to be expected as Site 3 is a river site and water quality is directly related to flow, while water quality at the lake sites is greatly influenced by internal loading. The highest phosphorus and nitrogen values measured at Site 3 occur during the early part of the season, when runoff from the watershed tends to be highest. Data from the USGS stream gauge located at the site indicates a 10-fold difference in average discharge between April and August (2400 cubic feet/second versus 242 cubic feet/second, respectively).



Lake Wappapello Sample Sites

Review of the data indicate that the five highest nitrogen measurements at Site 3 occurred when discharge was >1500cfs. For comparison, the normal range of discharge is 50-300cfs. The four highest phosphorus values were also measured during these high flow periods (one high flow phosphorus value was 17µg/L, a value comparable to the normal range).

2010 GRAPHS



Waterworks Lake

Randolph County
Latitude: 39.4162 Longitude: -92.4646

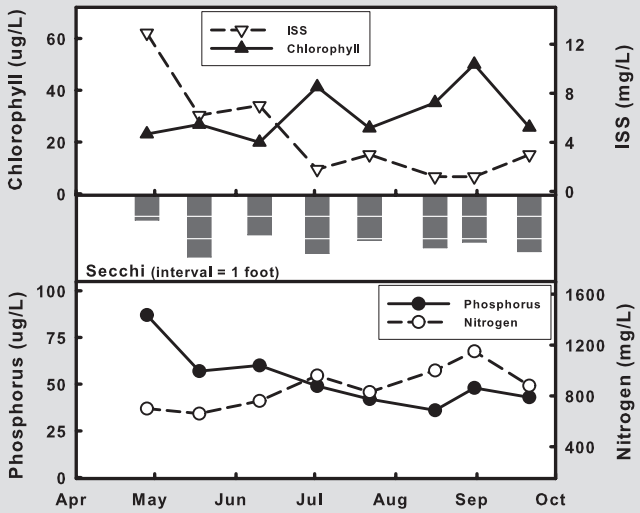
2010 DATA

Date	4/28	5/18	6/10	7/2	7/22	8/16	8/31	9/21	Mean
Secchi (inches)	14	34	22	32	25	29	26	31	26
TP (µg/L)	87	57	60	49	42	36	48	43	51
TN (µg/L)	700	660	760	960	830	1000	1150	880	854
CHL (µg/L)	23.1	26.8	19.9	41.3	25.4	35.2	50.0	25.7	29.6
ISS (mg/L)	12.9	6.2	7.0	1.8	3.0	1.2	1.2	3.0	3.3

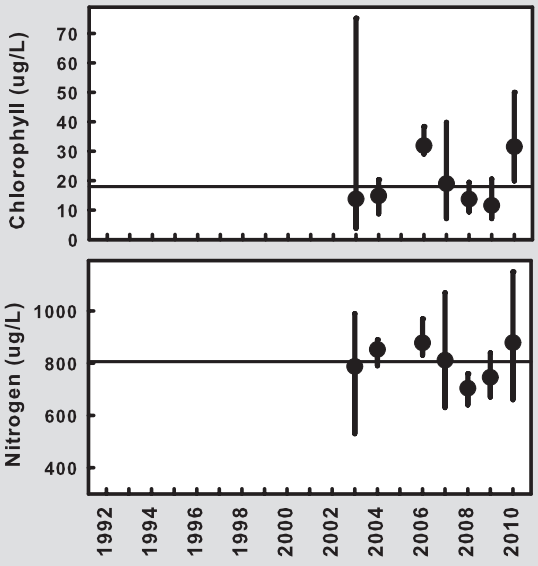
The nutrients displayed different patterns across the sample season. Phosphorus was 87µg/L on the first sample date and declined to values that hovered near 40µg/L during the last four sample dates. In contrast, nitrogen concentrations were near 700µg/L at the beginning of the season and increased to a maximum value of 1150µg/L on the second to last sample day. This difference in seasonal patterns had not been observed in Waterworks Lake during previous monitoring. Inorganic suspended sediment tracked the same seasonal pattern as phosphorus, which is common as sediment particles often have phosphorus bond to them. Algal chlorophyll values fluctuated during the season in unison with nitrogen. When chlorophyll concentrations were >30µg/L the nitrogen values always approached 1000µg/L.

The average chlorophyll value during the summer of 2010 was the highest recorded in seven years of monitoring (31.9µg/L compared to 2006's 31.5µg/L), and was substantially higher than the long-term average of 17.6µg/L. Both 2006 and 2010 also had the highest nitrogen concentrations out of the seven summers, though their values of 877 and 878µg/L were not substantially higher than the long-term average of 800µg/L. Both of these years also had the highest ratio of chlorophyll to phosphorus, which is one way of gauging how efficient algae within the lake are using the nutrients. Ratios during the other five summers ranged from 0.33 - 0.46, while the ratios for 2006 and 2010 were .71 and .58 respectively.

2010 GRAPHS



TREND GRAPHS



See pages 10-11 for help interpreting graphs

Whitecliff Park Lake

St. Louis County
Latitude: 38.5561 Longitude: -90.3688

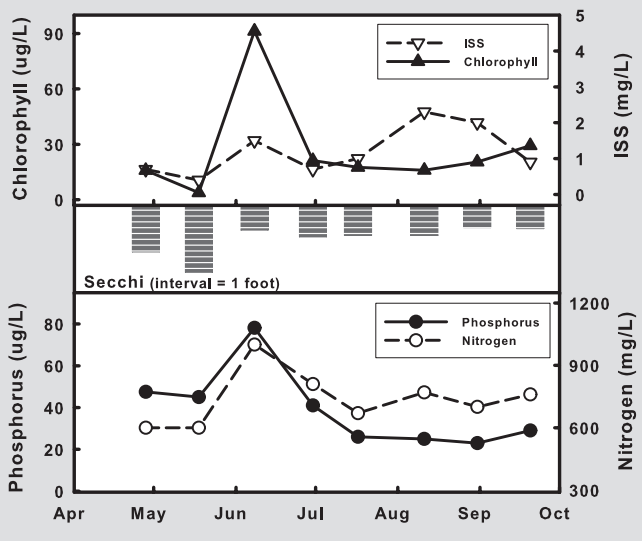
2010 DATA

Date	4/28	5/18	6/8	6/30	7/17	8/11	8/31	9/20	Mean
Secchi (inches)	98	140	53	67	64	64	48	50	68
TP (µg/L)	48	45	78	41	26	25	23	29	36
TN (µg/L)	600	600	1000	810	670	770	700	760	729
CHL (µg/L)	15.9	3.8	91.3	21.2	17.6	16.0	20.5	29.3	19.4
ISS (mg/L)	0.7	0.4	1.5	0.7	1.0	2.3	2.0	0.9	1.0

The two nutrients generally followed the same seasonal pattern of fluctuations, though the ratio of nitrogen to phosphorus changed over the season. During the first three samples there was approximately 13 units of nitrogen for each unit of phosphorus. This ratio suggests that neither nutrient was in excess relative to algal requirements. By the end of the season the ratio was around 30 units of nitrogen to each unit of phosphorus. This ratio indicates excess nitrogen and that phosphorus was probably the limiting nutrient. Chlorophyll mimicked the nutrients, peaking when nutrients were at their maximum. Inorganic suspended sediment levels were generally low and fairly stable across the season.

There has been a decrease in average summertime nitrogen concentrations in Whitecliff Lake over the four years of monitoring. In 2007 the summertime mean was 1119µg/L with four of five samples exceeding 1000µg/L. In contrast, the summertime mean in 2010 was 748µg/L with only one of six samples exceeding 1000µg/L. The only other water quality parameter that seems to be trending is Secchi transparency, but care needs to be taken when reviewing this graph. While the mean Secchi readings have improved from 42 inches in 2007 to 68 inches in 2010, the maximum values shown in the graph are somewhat misleading. Both 2007 and 2008 had water clarity readings that exceeded 150 inches, they just occurred prior to May 15th, the day we use to represent the beginning of the summer. When all values from each year are used to generate a geometric mean value, the difference from 2007 to 2010 is smaller (54 versus 68 inches).

2010 GRAPHS



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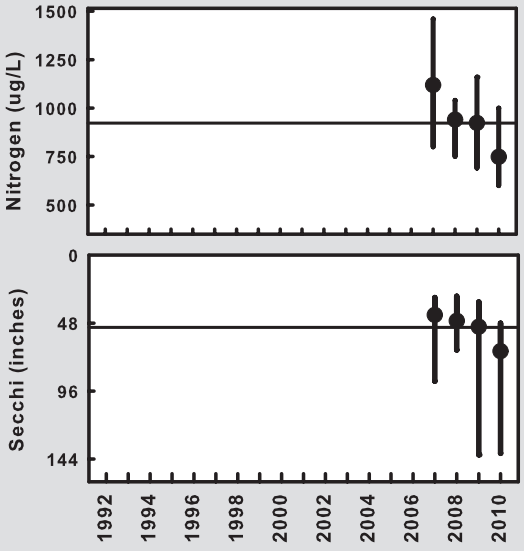

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