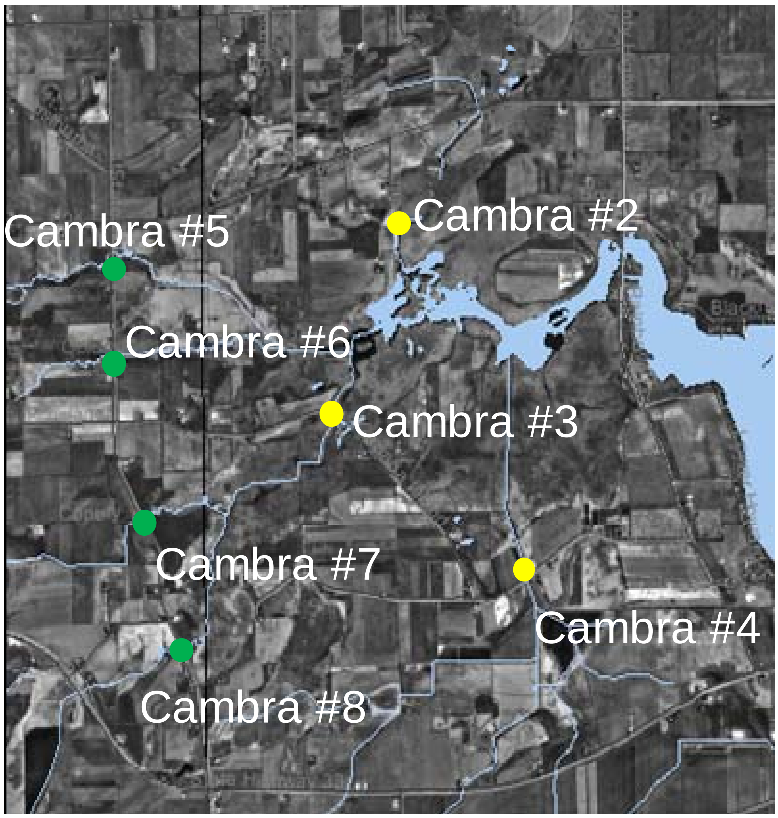
Hey and Associates, Inc.

CAMBRA CREEK MONITORING PROJECT
FINAL REPORT

FOX LAKE, DODGE COUNTY, WISCONSIN



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INTRODUCTION

Fox Lake is a 1,022-hectare (2,625-acre) lake located in northwestern Dodge County. In the 1980's and 1990's, Fox Lake experienced a rapid shift in water quality from a clear-water lake to one characterized by poor-water transparency, increased algae populations, loss of aquatic macrophytes, loss of wetland fringe, and declining sports fishery. In the mid 1990's, the Fox Lake Inland Lake Protection and Rehabilitation District (FLILPRD), in partnership with the Wisconsin Department of Natural Resources (WDNR) began implementation of a long-range management project to shift the lake back into a clear-water state. In 1995 a long-range management strategy for Fox Lake was developed by an advisory committee that included FLILPRD, WDNR, Dodge County, University of Wisconsin-Extension, Town of Fox Lake, City of Fox Lake, and civic and sportsman groups. The project management strategy is outlined in a report tilted, *Long Range Planning Strategy for the Rehabilitation of Fox Lake, Dodge County* (R. A. Smith and Associates, Inc. 1998).

To deal with the complex water quality problems at Fox Lake, the planning and rehabilitation process was broken down into the following components:

1. Watershed management to reduce sediment and nutrient inputs
2. Shoreline stabilization to reduce erosion
3. Aquatic plant management to restore rooted aquatic vegetation
4. Fishery Management (bio-manipulation to reduce rough fish and increase top predators)
5. Lake use management to protect sensitive areas
6. Public education

In 2005 and 2006 the University of Wisconsin-Milwaukee (UWM) and Hey and Associates, Inc. conducted an intensive lake and watershed monitoring program to evaluate the success of the above management strategy. The results of the monitoring are summarized in a report titled: *Fox Lake Management Strategy Evaluation and Recommendations for Future Action – 2008*, (Hey and Associates, Inc. and UW-Milwaukee, 2008). The monitoring documented that high levels of nitrogen and phosphorus were entering the lake from the lake's three tributaries. During the UWM study in 2004-2005, Cambra Creek was identified to contribute 35.9% of total annual water inflow to Fox Lake, making it the largest single source of water to the lake.

The purpose of this project was to collect additional data on sources of nitrogen, phosphorus and sediment entering Fox Lake from the Cambra Creek watershed. The work is a follow-up to sampling in 2005 and 2006 conducted by the UWM. The goal of the project is to narrow down which watershed activities, such as feedlots, animal waste storage and spreading, wastewater treatment, and tillage practices on specific properties are contributing to the high concentration of nitrogen and phosphorus being experienced in the previous sampling.

SAMPLING METHODS

Sampling was conducted at seven sites illustrated on Figure 1. Samples were collected on four dates in the fall of 2009 and summer of 2010. Samples were not collected at Cambra #1 (CC-1) in 2009-10 because previous sampling by UWM indicated that this site generally represented the lake environment. Samples were analyzed for the following parameters:

- TOTAL KJELDAHL NITROGEN
- NITRATE PLUS NITRITE-NITROGEN
- TOTAL PHOSPHORUS
- DISSOLVED PHOSPHORUS
- TOTAL SUSPENDED SOLIDS (SEDIMENT)
- FECAL COLIFORM (MFFCC) (BACTERIA)
- STREAM FLOW

All sampling was conducted using the methods outlined in:

- Edwards, T.K., and G.D. Glysson. 1999. *Field Methods for Measurement of Fluvial Sediment, Book 3, Chapter C2*. Techniques of Water-Resources Investigations of the United States Geological Survey, U.S. Government Printing Office, Washington, DC.

- Shelton, L. R., 1994. *Field Guide for Collecting and Processing Stream Water Samples for the National Water-Quality Assessment Program*, Open-File Report 94-455, United States Geological Survey, Sacramento, California.

- United States Geological Survey (USGS). 2005. *Techniques of Water Resources Investigations Reports. Book 3: Applications of hydraulics, Section A: Surface-water techniques.* (21 chapters). United States Department of Interior, U.S. Geological Survey. Washington D.C. http://water.usgs.gov/pubs/twri/.

All water quality and bacterial samples were iced upon collection and transported by cooler to the Wisconsin State Laboratory of Hygiene in Madison Wisconsin for analysis.

Flow velocities were measured using a Marsh McBerny FlowMate® flow meter.

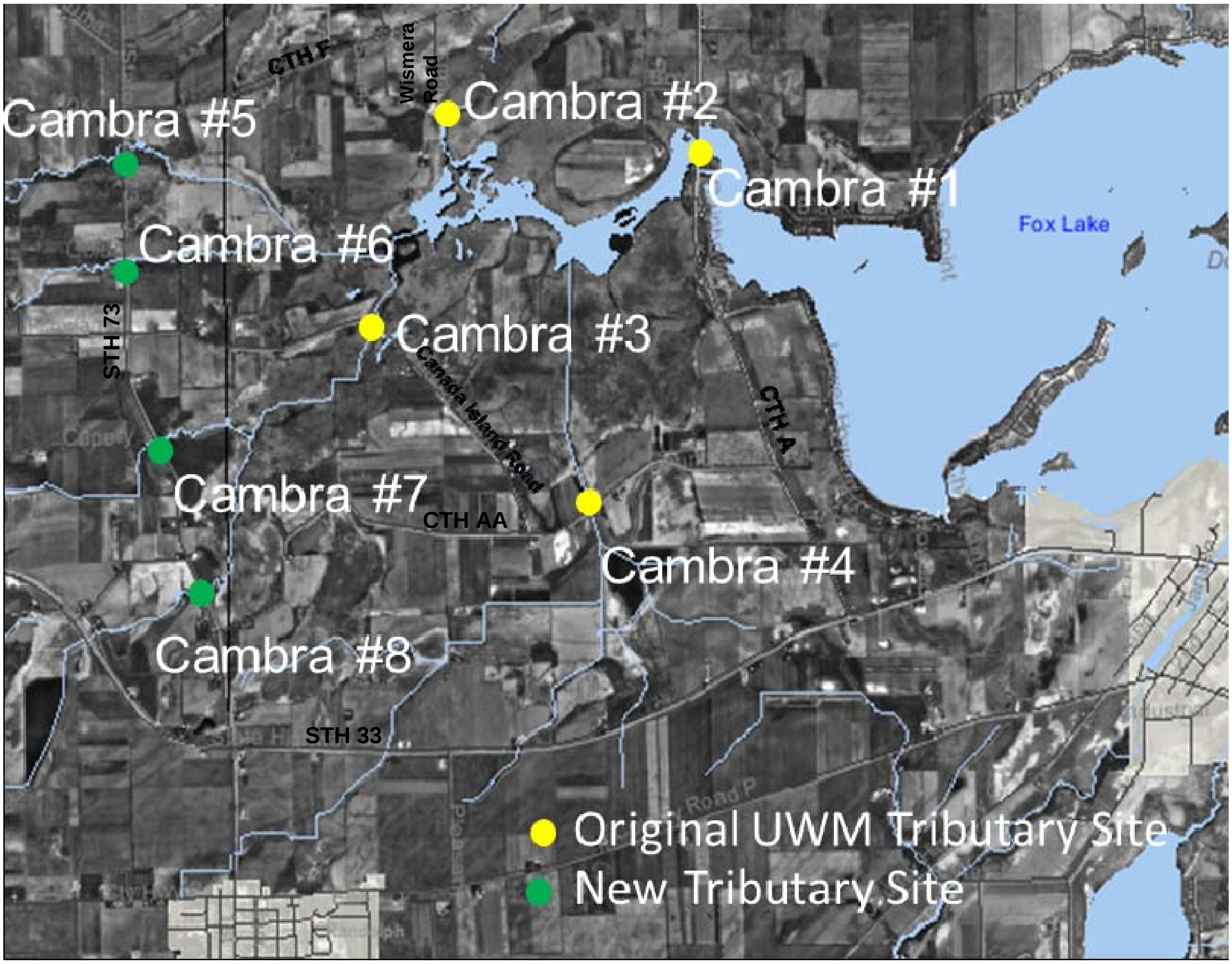

Figure 1
Location of Sampling Points

SUMMARY OF UW-MILWAUKEE 2006 SAMPLING

As discussed above, the University of Wisconsin-Milwaukee (UWM) conducted tributary monitoring of Cambra, Drew and Cambra Creeks in spring and summer of 2006. In the Cambra Creek watershed samples were collected at four sites, shown in yellow in Figure 1. The sites were CC-1 (CTH A) CC-2 (Wismera Road), CC-3 (Canada Island Road) and CC-4 (CTH-AA) illustrated on Figure 1. The mean values of the UWM sampling are summarized in Table 1. Included in the table for comparisons are statewide means and ranges for nitrogen and phosphorus based on data for 240 streams as part of the study, *Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin* (USGS, 2006). Values in bold text indicate mean concentrations above the state, ecoregion or environmental phosphorus zone averages as reported by USGS.

Table 1

Results of UWM Tributary Monitoring
Mean Values from Five Sampling Dates in 2006

Watershed and Station No.	Total Suspended Solids (mg/l)	Organic Nitrogen (TKN) (mg/l)	Nitrate/Nitrite (mg/l)	Total Nitrogen (mg/l)	Total Phosphorus (mg/l)	Dissolved Phosphorus (SRP) (mg/l)
Cambra No. 1 (CTH – A)	5.750	***1.766***	1.315	***3.081***	***0.127***	0.057
Cambra No. 2 (Wismera Road)	7.667	***0.972***	0.027	0.999	***0.221***	***0.156***
Cambra No. 3 (Canada Island Road)	27.750	***1.342***	***4.304***	***5.646***	***0.138***	0.069
Cambra No. 4 (CTH-AA)	26.200	***1.598***	***4.218***	***5.816***	***0.169***	0.060
	Statewide Means (USGS, 2006)					
Mean	-	0.675	2.086	2.807	0.116	0.079
Median		0.563	1.048	1.695	0.085	0.050
Minimum	-	0.070	0.005	0.131	0.012	0.004
Maximum	-	2,350	20.550	21.260	1.641	1.495
Standard deviation	-	0.414	2.865	2.860	0.144	0.122

Source: University of Wisconsin-Milwaukee and Wisconsin Laboratory of Hygiene and USGS (2006)

As can be seen Cambra Creek has concentrations of organic nitrogen (TKN), and nitrate/nitrite that exceed the statewide means (bold text). Total phosphorus concentrations slightly exceed statewide mean and median levels.

RESULTS OF HEY SAMPLING

The results of the 2009-2010 sampling by Hey and Associates are summarized in Table 2 (field parameters) and Table 3 (laboratory parameters).

Concentrations highlighted in Table 3 are levels above statewide means for nitrogen and phosphorus based on data for 240 streams as part of the study, *Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin* (USGS, 2006), or above state water quality standards for total phosphorus and bacteria (E-coli).

Table 2
Results of Cambra Creek Tributary Monitoring 2009 -2010
Field Parameters

Site Location	Site No.	Date	Flow (cfs)	Flow (MGD)	Temp (^{0}F)	Dissolved Oxygen (mg/l)	Conductivity	pH
Cambra Creek – Wismera Road	CC-2	3/17/2010	6.40	4.13	0.04	4.32	560	8.01
		5/5/2010	2.39	1.55	15.7	7.02	701	7.91
		8/2/2010	TD > 10	TD	20.8	1.54	NA	NA
		8/22/2010	TD > 10	TD	20.0	0.77	NA	NA
		Mean	**4.40**	**2.84**	**14.14**	**3.41**	**630**	**7.96**
Cambra Creek – Canada Island Road	CC-3	3/17/2010	12.12	7.83	4.1	7.3	708	8.10
		5/5/2010	6.59	4.26	16.7	11.78	820	8.20
		8/2/2010	8.89	5.74	18.9	4.28	NA	NA
		8/22/2010	6.99	4.52	18.1	5.4	NA	NA
		Mean	**8.65**	**5.59**	**14.45**	**7.19**	**764**	**8.15**
Cambra Creek – CTH-AA	CC-4	3/17/2010	15.32	9.90	4.0	5.08	518	7.86
		5/5/2010	3.11	2.01	15.6	14.98	842	8.16
		8/2/2010	7.14	4.61	20.9	0.71	NA	NA
		8/22/2010	3.15	2.03	20.1	1.78	NA	NA
		Mean	**7.18**	**4.64**	**15.15**	**5.64**	**680**	**8.01**
Cambra Creek – STH 73 South of CTH-F	CC-5	3/17/2010	4.90	3.16	3.5	8.33	666	8.20
		5/5/2010	2.50	1.62	13.1	9.96	785	8.13
		8/2/2010	6.09	3.93	18.7	9.45	NA	NA
		8/22/2010	2.65	1.71	16.4	8.01	NA	NA
		Mean	**4.04**	**2.61**	**12.93**	**8.94**	**725**	**8.17**
Cambra Creek – STH 73 North of Canada Island Road	CC-6	3/17/2010	0.81	0.52	6.4	4.55	806	7.79
		5/5/2010	NF	NF	NF	NF	NF	NF
		8/2/2010	0.66	0.43	19.3	5.33	NA	NA
		8/22/2010	0.01	0.006	19.5	2.43	NA	NA
		Mean	**0.74**	**0.48**	**15.07**	**4.10**	**806**	**7.79**
Cambra Creek – STH 73	CC-7	3/17/2010	2.14	1.38	4.3	8.12	667	8.20
		5/5/2010	2.40	1.55	15.6	12.41	781	8.34
		8/2/2010	7.69	4.97	17.3	8.45	NA	NA
		8/22/2010	0.05	0.03	17.3	7.78	NA	NA
		Mean	**3.07**	**1.98**	**13.63**	**9.19**	**724**	**8.27**
Cambra Creek – STH 73 Just S of Dillman Rd	CC-8	3/17/2010	6.88	4.44	5.0	7.81	785	7.81
		5/5/2010	6.09	3.93	15.6	12.41	781	8.34
		8/2/2010	6.85	4.42	15.1	8.11	NA	NA
		8/22/2010	4.09	2.64	15.2	8.07	NA	NA
		Mean	**5.98**	**3.86**	**12.73**	**9.10**	**7830**	**8.08**

- TD = Flow too deep to measure
- NA = Not available
- NF = No Flow

Table 3
Results of Cambra Creek Tributary Monitoring 2009 -2010 Laboratory Parameters

Site Location	Site No.	Date	TP (mg/l)	SRP (mg/l)	TSS (mg/l)	TKN (mg/l)	NO2 NO3 (mg/l)	E-Coli (Counts/100 ml)
Cambra Creek – Wismera Road	CC-2	3/17/2010	0.066	0.038	2.8	**0.81**	1.590	5
		5/5/2010	0.095	**0.083**	2	**0.71**	ND	157
		8/2/2010	**0.307**	**0.272**	3	**0.79**	0.022	73
		8/22/2010	**0.223**	**0.208**	ND	**0.71**	0.021	167
		Mean	**0.173**	**0.150**	**2.6**	**0.76**	**0.544**	**101**
Cambra Creek – Canada Island Road	CC-3	3/17/2010	**0.228**	**0.107**	50	**1.06**	**8.140**	24
		5/5/2010	**0.113**	0.076	14	**0.98**	**4.950**	101
		8/2/2010	**0.199**	**0.188**	12	**1.30**	**3.730**	**330**
		8/22/2010	**0.161**	**0.125**	4	**1.07**	**4.480**	**517**
		Mean	**0.175**	**0.124**	**20**	**1.10**	**5.325**	**243**
Cambra Creek – CTH-AA	CC-4	3/17/2010	**0.250**	**0.191**	7	**1.16**	1.600	91
		5/5/2010	**0.125**	**0.085**	3	**1.36**	**2.790**	82
		8/2/2010	**0.587**	**0.485**	3	**1.61**	0.637	110
		8/22/2010	**0.227**	**0.162**	4	**1.85**	**2.630**	**488**
		Mean	**0.297**	**0.231**	**4.25**	**1.50**	**1.914**	**193**
Cambra Creek – STH 73 South of CTH-F	CC-5	3/17/2010	0.053	0.030	7	**0.85**	**5.780**	71
		5/5/2010	0.046	0.027	5	**0.85**	**5.030**	**261**
		8/2/2010	0.076	0.059	6	**0.84**	**5.610**	**610**
		8/22/2010	0.079	0.058	6	**1.15**	**5.250**	**272**
		Mean	**0.064**	**0.044**	**6**	**0.92**	**5.418**	**304**
Cambra Creek – North of Canada Island Road	CC-6	3/17/2010	0.095	0.077	ND	0.30	**6.850**	20
		5/5/2010	NF	NF	NF	NF	NF	NF
		8/2/2010	**0.322**	**0.321**	2	**0.75**	1.640	**490**
		8/22/2010	**0.536**	**0.345**	5	**1.34**	1.320	**326**
		Mean	**0.318**	**0.248**	**3.5**	**0.80**	**3.270**	**279**
Cambra Creek – STH 73	CC-7	3/17/2010	**0.106**	0.063	9	0.34	**4.630**	5
		5/5/2010	**0.129**	**0.084**	17	0.62	**4.520**	108
		8/2/2010	**0.117**	**0.088**	12	0.60	**6.680**	**580**
		8/22/2010	**0.138**	**0.113**	7	0.51	**5.690**	**387**
		Mean	**0.123**	**0.087**	**11.25**	**0.52**	**5.380**	**270**
Cambra Cr at St Rd 73 Just S of Dillman Rd	CC-8	3/17/2010	**0.200**	**0.159**	10	**1.16**	**13.500**	18
		5/5/2010	0.060	0.037	4	0.62	**7.650**	96
		8/2/2010	**0.115**	**0.098**	8	**0.77**	**8.090**	110
		8/22/2010	**0.104**	**0.083**	9	**0.87**	**7.970**	**345**
		Mean	**0.120**	**0.094**	**7.75**	**0.86**	**9.303**	**142**

- NF = No Flow
- ND – No detection

Stream Flow

Stream flow was measured on each of the sampling dates. Figure 2 illustrates the variability of flow by sample site and sample date. Most sites carried base flow on each sample date, with the exception of CC-6 which was dry on 5/5/2010 and 8/22/2010. Flows on 8/2/2010 and 8/22/2010 were too deep (> 6 feet deep) at CC-2 to measure with equipment available and were estimated to be approximately 10 cfs. Flows measured on 8/2/2010, right after a large storm event illustrate that flows did not increase dramatically over base flow conditions and that the watershed contains a large amount of storage which holds back water and releases it slowly over extended periods of time.

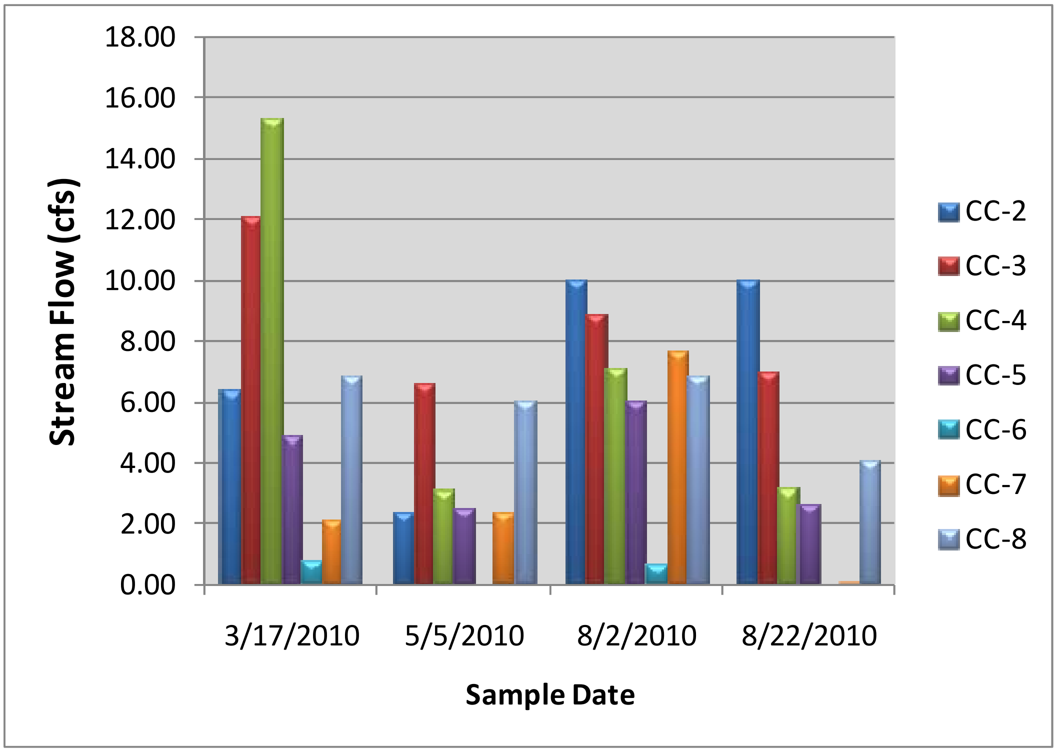

Figure 2
Relationship of Stream Flow by Sample Site and Sample Date

Total Suspended Solids

Total suspended solids (TSS) include all particles suspended in water which will not pass through glass-fiber filter disk. Suspended solids are associated with nonpoint source pollution, such as soil erosion from agricultural and construction sites. As levels of TSS increase, a water body begins to lose its ability to support a diversity of aquatic life. Suspended solids absorb heat from sunlight, which increases water temperature and subsequently decreases levels of dissolved oxygen. Warmer water holds less oxygen than cooler water. Photosynthesis also decreases, since less light penetrates the water causing less oxygen to be produced by plants and algae. TSS can also destroy fish habitat because suspended solids settle to the bottom and cover coarse bottom materials. Suspended solids can smother the eggs of fish and aquatic insects, and can suffocate newly-hatched insect larvae. Suspended solids can also harm fish by clogging gills, reducing growth rates, and lowering resistance to disease. As suspended solids settle in the calm waters of the lake, they fill in bays impacting recreational use. Levels above 40 mg/l cause water to become cloudy and above 100 mg/l begin to damage aquatic life.

In 2009-2010 sampling, TSS values ranged from 3 to 50 mg/l, with most samples below 10 mg/l, indicating low levels of suspended sediment. The sampling indicates that surface erosion on the sampling dates was not a major problem. Figure 3 illustrates the relationship of TSS concentrations by sample date and site.

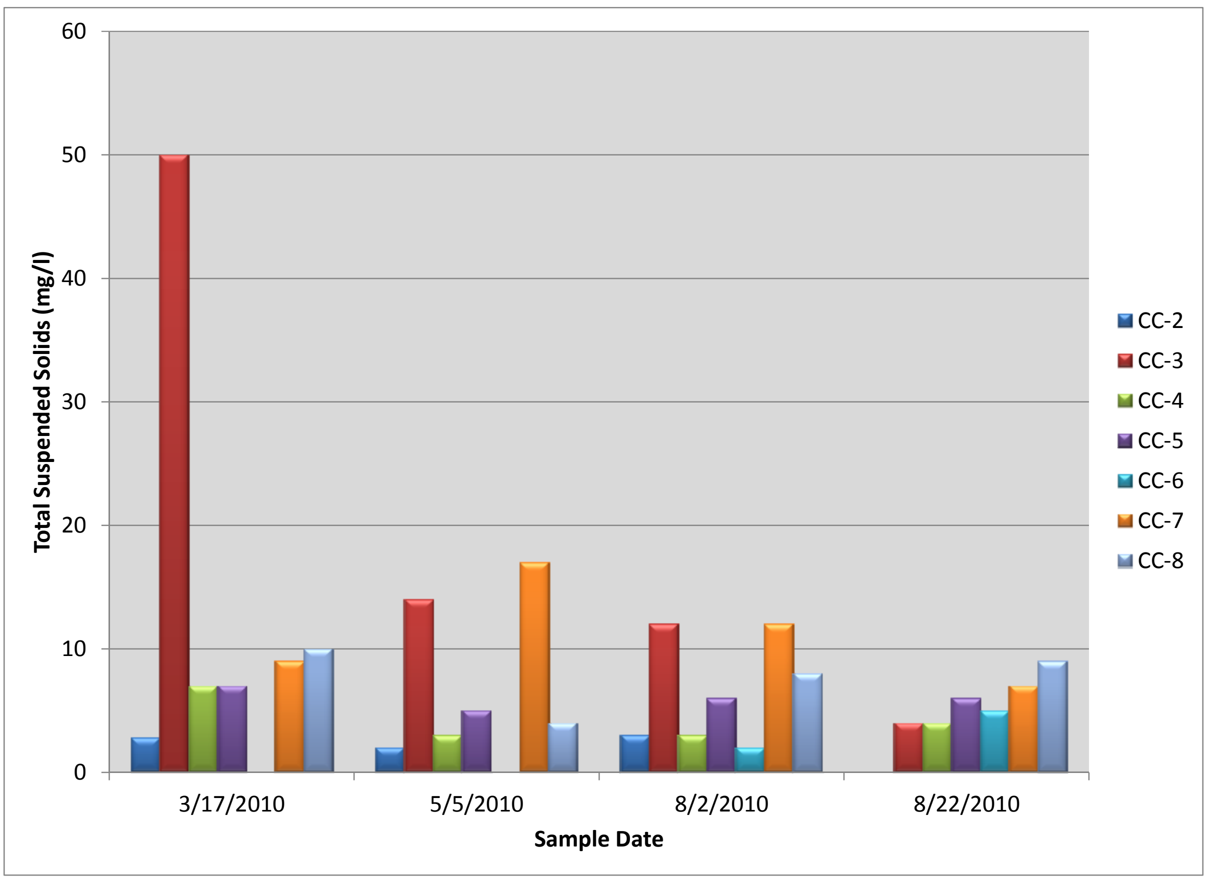

Figure 3
Relationship of Total Suspended Solids Concentrations by Sample Site and Date

Figure 4 illustrates the loadings of TSS by sample site and date. Loading is the total mass in pounds that enters the lake per day. Multiplying the measured stream flow times the pollutant concentration you can estimate daily pounds of a given pollutant that has entered the lake at that moment. As we see, with the exception of sample site CC-3, most sites provide little loading of TSS. CC-3 only had high TSS loadings on March 17, 2010. It should be noted that sample sites CC-7 and CC-8, which feed this site, on that same date had very low TSS readings. The sources of high TSS loadings at CC-3 on March 17, 2010 maybe do to carp activity in the marsh on that date.

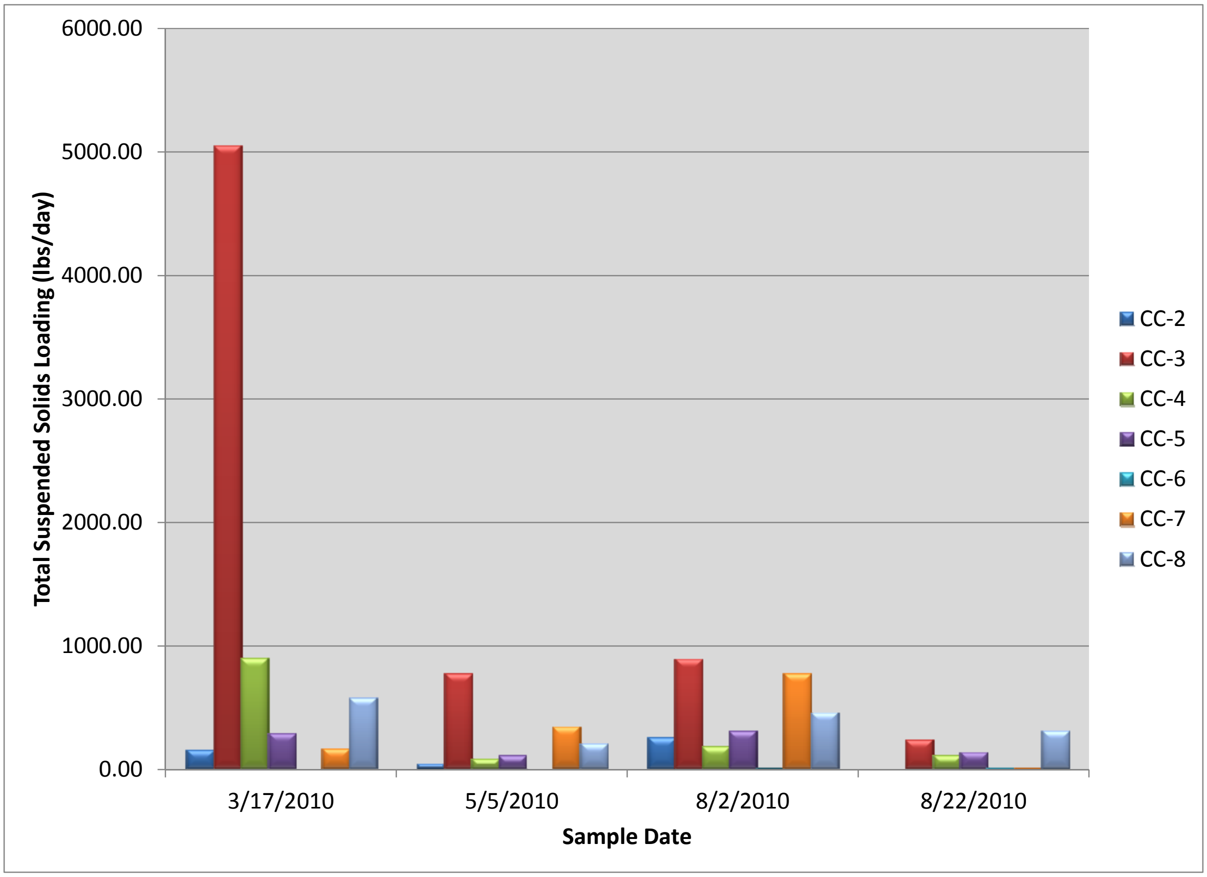

Figure 4
Relationship of Total Suspended Solids Loadings
by Sample Site and Date

Phosphorus

Aquatic plants and algae require nutrients such as phosphorus, nitrogen, carbon, calcium, chlorides, iron, magnesium, sulfur, and silica for growth. In lakes where the supply of one or more of these nutrients is limited, plant and algae growth may also be limited. The two nutrients that most often limit and control the growth of plants are nitrogen and phosphorus. In nutrient limited lakes, if you add more nitrogen or phosphorus, you will get more plant or algae growth. Under Wisconsin Administrative Code NR 102.06 the State of Wisconsin has established a total phosphorus standard of 100 ug/L (0.10 mg/l) for unidirectional flowing waters (streams) and 30 ug/L (0.03 mg/l) for lakes that are both drainage and stratified lakes.

Two types of phosphorus were sampled; total phosphorus (TP) and dissolved phosphorus also known as soluble reactive phosphorus (SRP).

Phosphorus is found in natural environments in several forms including (Snoeyink and Jenkins, 1980):

- Orthophosphate (H_3PO_4, $H_2PO_4^-$, HPO_4^-, HPO_4^{2-}, HPO_4^{2-} complexes)
- Polyphosphates ($H_4P_2O_7$, $H4P_2O_7^-$, $H_4P_2O_7^{2-}$, $H_4P_2O_7^{3-}$, $H_4P_2O_7^{4-}$, $H_4P_2O_7^{3-}$complexes)
- Metaphosphate ($HP_3O_9^{2-}$, $HP_3O_9^{3-}$)
- Organic phosphates (phosphorus tied up in organic matter)

A test for total-phosphorus (TP) will identify the combined concentration of all of the above compounds. Orthophosphate and the other complexes of phosphorus found in the natural environment are generally not very soluble and typically bind with various cations such as calcium (Ca), magnesium (Mg), aluminum (Al) or iron (Fe). The most common complexes include the following:

- Calcium hydrogen phosphate $CaHPO4_{(s)}$ (pK_{so} +6.66)
- Calcium dihydrogen phosphate $Ca(H_2PO_4)_{2(s)}$ (pK_{so} +1.14)
- Hydroxyapatite $Ca_5(PO_4)_2OH_{(s)}$ (pK_{so} +55.9)
- Ferric phosphate $FePO_4$ (pK_{so} +21.9)
- Aluminum phosphate $AlPO_4$ (pK_{so} +21.0)

The solubility of these complexes in fresh water is defined by a solubility equilibrium constant (pK_{so}). The smaller the solubility constant the less soluble the compound is in water. Other complexes with sodium (Na), magnesium (Mg), manganese (Mn), and orthophosphate, pyrophosphate and tripophosphate also exist, making phosphorus equilibrium chemistry very complex.

The soluble reactive phosphorus (SRP) consists largely of the inorganic orthophosphate (PO_4) form of phosphorus. Orthophosphate is the phosphorus form that is directly taken up by algae, and the concentration of this fraction constitutes an index of the amount of phosphorus immediately available for algal growth. The presence of soluble phosphorus in high concentrations is unusual in areas with hard water and high calcium levels as found throughout Southern Wisconsin.

The test results show high concentration of total phosphorus on sampling dates after each rainfall event. Nineteen of the 27 samples (70%) were above the NR 102.06 standard of 0.10 mg/l. Six of the seven sampling sites had total phosphorus concentrations above the statewide mean on more than half the sampling dates. Figures 5 and 6 illustrate concentrations of total phosphorus and soluble reactive phosphorus by site and sample date respectively. Between 47% and 99% the total phosphorus is in the form of soluble reactive phosphorus depending on the sample date and site. As outlined above this is unusual in the hard water of Southern Wisconsin. This indicates that the source of the phosphorus is not soil erosion where most phosphorus is typically bound to the soil particles, but is due a soluble source of phosphorus such as contamination of groundwater by sources such as treated wastewater, septic system waste or animal manure.

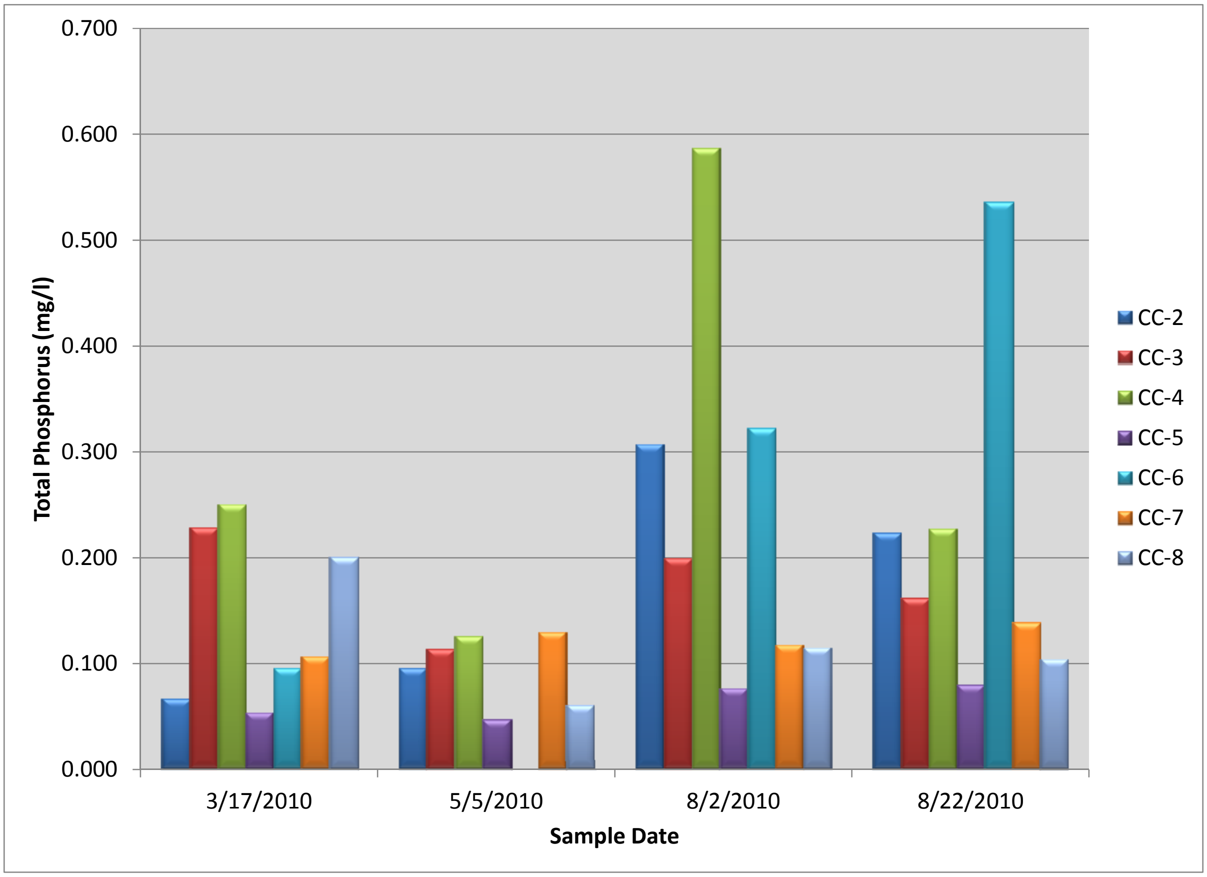

Figure 5
Relationship of Total Phosphorus Concentrations by Sample Site and Date

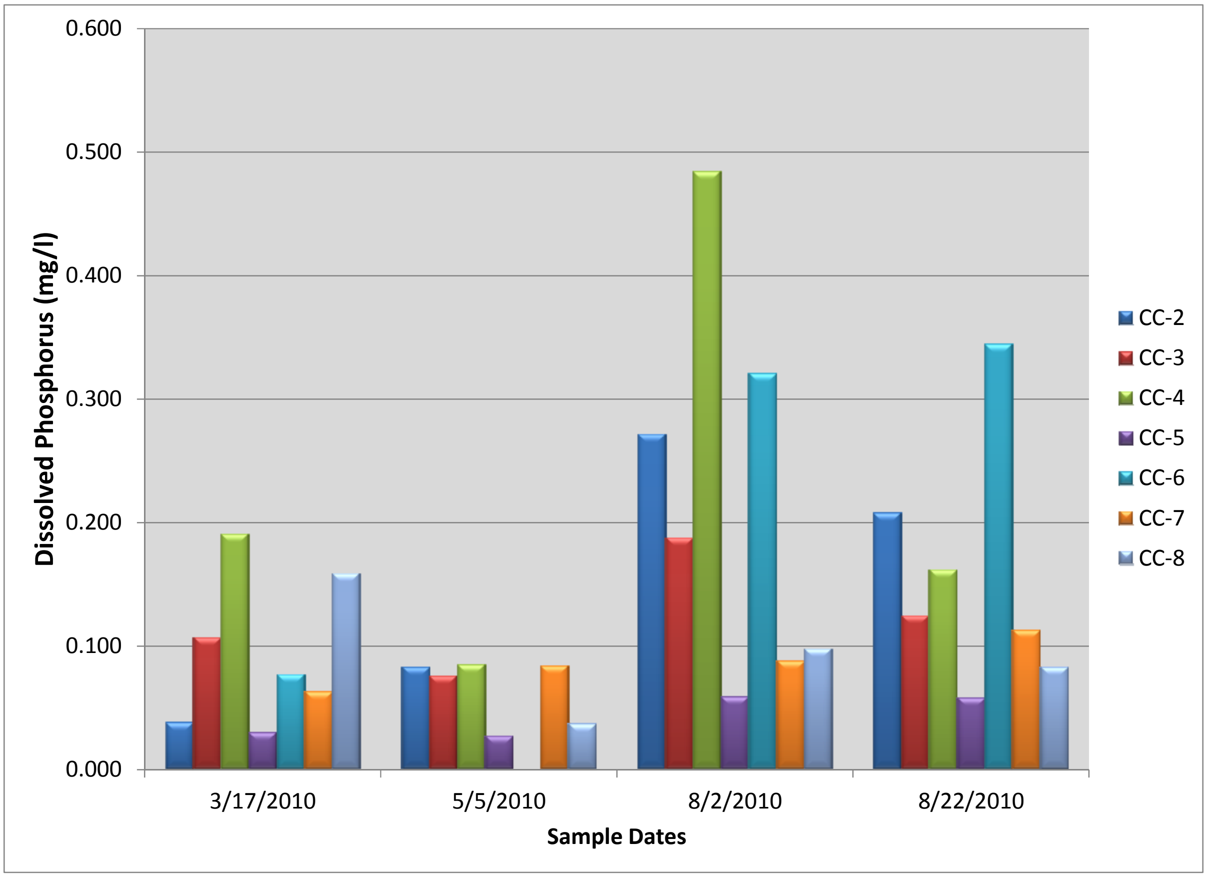

Figure 6
Relationship of Dissolved Phosphorus Concentrations by Sample Site and Date

Figures 7 and 8 illustrate the loadings of total phosphorus and dissolved phosphorus by sample site and date. We see that watersheds represented by stations CC-2, CC-3 and CC-4 carry the largest amount phosphorus into Fox Lake. Note on Figure 1, station CC-3 represents the combined flows of CC-7 and CC-8.

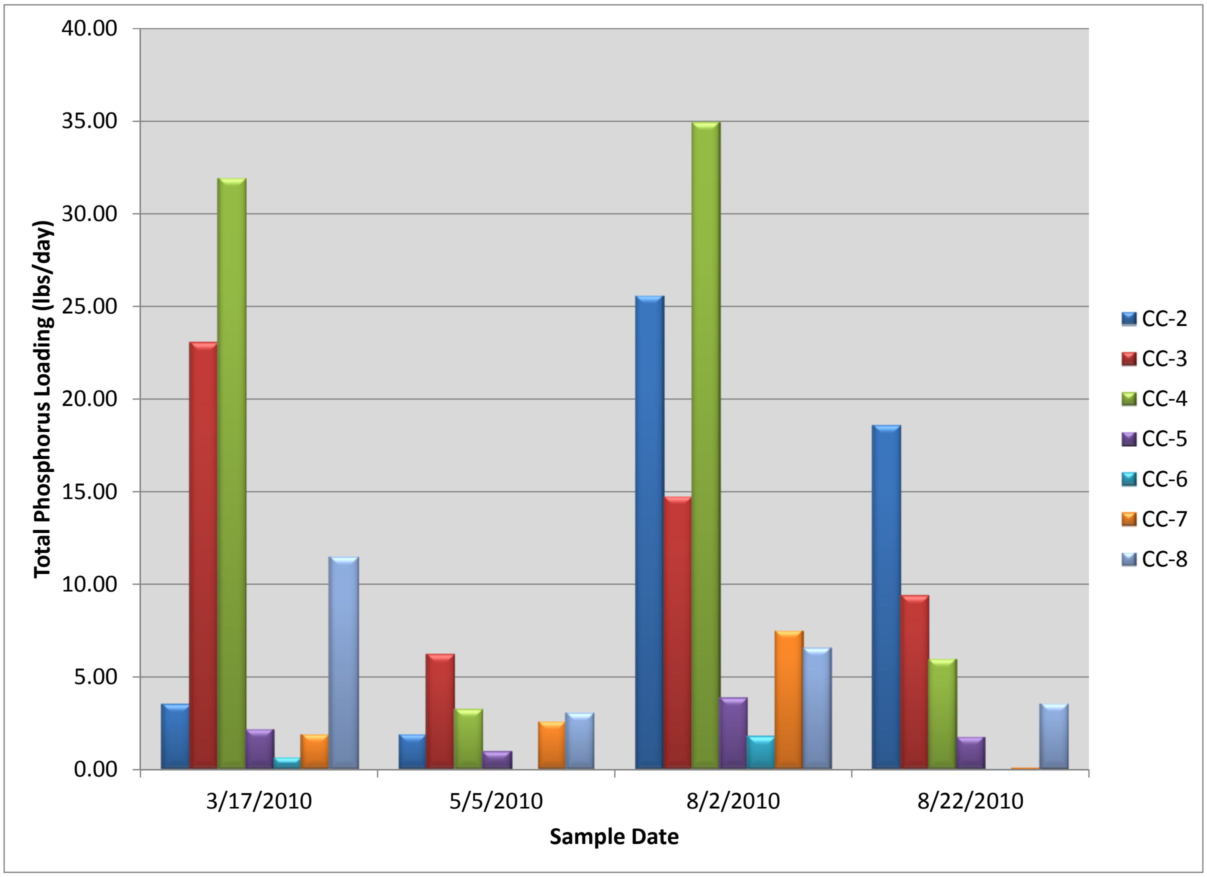

Figure 7
Relationship of Total Phosphorus Loadings
by Sample Site and Date

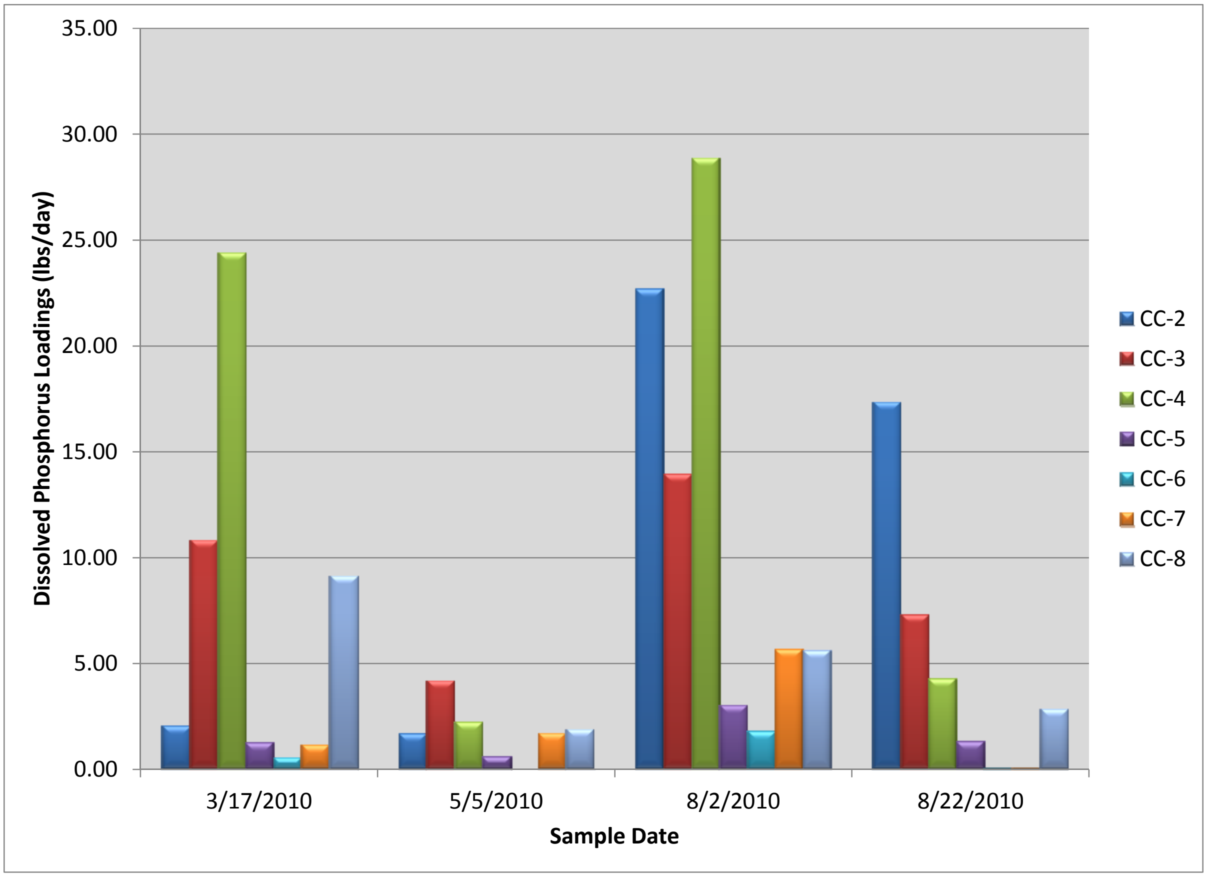

Figure 8
Relationship of Dissolved Phosphorus Loadings
by Sample Site and Date

Nitrogen

Nitrogen can be found in many different organic and inorganic forms in our environment. The air we breathe is composed of 78 percent nitrogen. Nitrogen can also be found in many varied forms in the soil. Plants need nitrogen from the soil for proper growth and development but are only able to use very specific forms of nitrogen. Plants cannot use the form of nitrogen found in the atmosphere.

Natural biological process carried out by microorganisms in the soil convert organic nitrogen to inorganic forms, which plants are able to use. Organic nitrogen is a common component in plant residues and organic matter. Ultimately, organic nitrogen is converted to inorganic ammonium (NH-). Nitrate is the form of nitrogen that is most used by plants for growth and development. Where crops are grown, nitrates can also emanate from nitrogen fertilizers, and manure.

Nitrogen becomes a concern to water quality when nitrogen in the soil is converted to the nitrate (NO_3) form. This is because nitrate is very mobile and easily moves with water. The concern of nitrates and water quality is generally directed at groundwater. However, nitrates can also enter surface waters such as ponds, streams and rivers. Nitrates in the soil result from natural biological processes associated with the decomposition of plant residues and organic matter. Nitrates can also come from animal manure, treated human waste effluents and nitrogen fertilizers.

Whether nitrates actually enter groundwater depends on underlying soil and/or bedrock conditions, as well as depth to groundwater. If depth to groundwater is shallow and the underlying soil is sandy, the potential for nitrates to enter groundwater is relatively high.

Two of the major problems with excess levels of nitrogen in the environment are:

- Excess nitrogen can cause overstimulation of growth of aquatic plants and algae. Excessive growth of these organisms, in turn, can clog water intakes, use up dissolved oxygen as they decompose, and block light to deeper waters. This seriously affects the respiration of fish and aquatic invertebrates, leads to a decrease in animal and plant diversity, and affects our use of the water for fishing, swimming, and boating.
- Too much nitrate in drinking water can be harmful to young infants or young livestock.

The two forms of nitrogen measured as part of this study were:

- Total Kjeldahl Nitrogen (TKN), a measurement of organic nitrogen and ammonia, and
- Nitrite/nitrate nitrogen which measures nitrogen in the forms of NO_2 and NO_3.

Total Kjeldahl Nitrogen (TKN) concentration ranged from 0.30 to 1.85 mg/l. As illustrated in Figure 9, 21 of the 27 samples were above the statewide mean identified by USGS in *Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin* (USGS, 2006). On one site was consistently below the statewide mean, station CC-7.

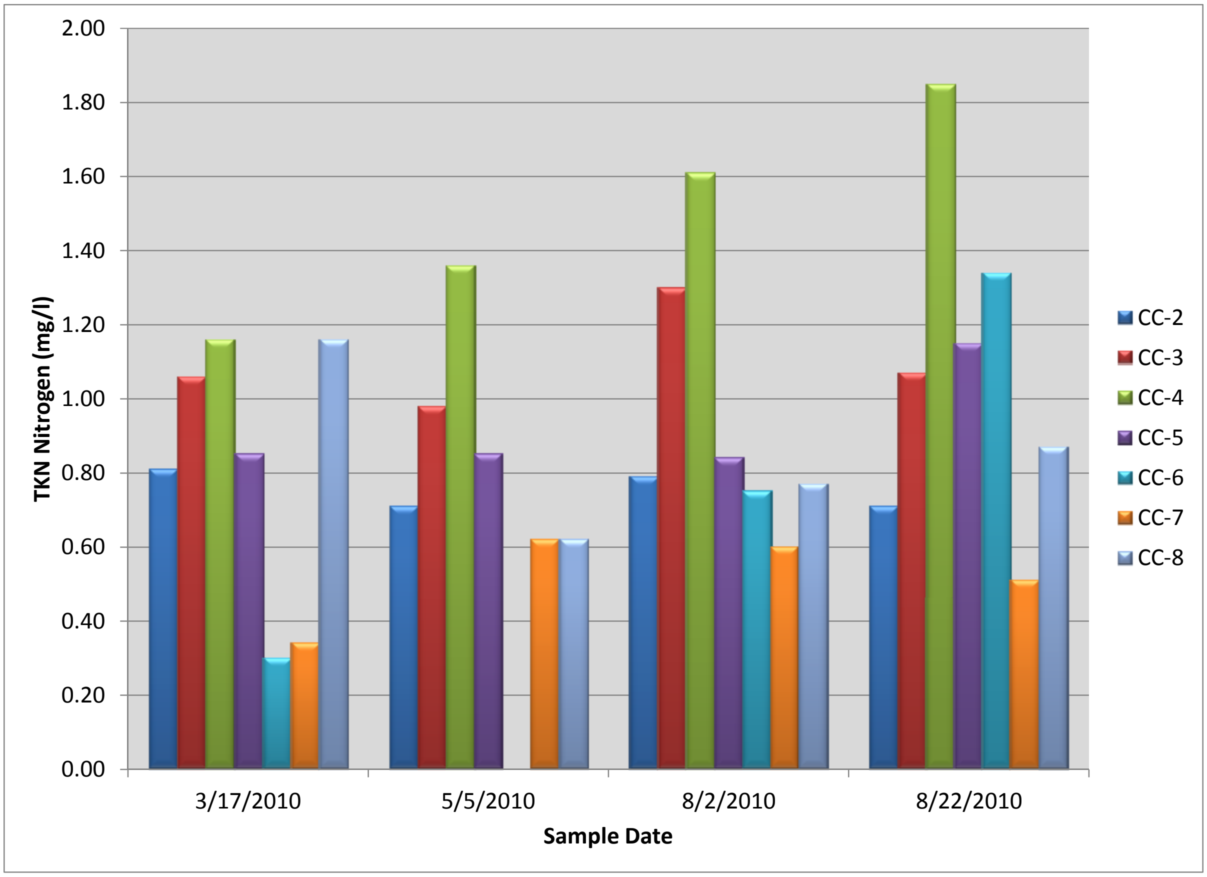

Figure 9
Relationship of Total Kjeldahl Nitrogen (TKN) Concentrations by Sample Site and Date

Nitrite/nitrate nitrogen (NO_2 & NO_3) levels ranged from non-detectable to 13.5 mg/l (Figure 10). 19 of the 27 samples were above the statewide mean as measured by USGS. The highest Nitrite/nitrate nitrogen concentrations were found at station CC-8. State and Federal laws set the maximum allowable level of nitrate-nitrogen in public drinking water at 10 milligrams per liter (10 parts per million). Nitrate-contaminated water should never be fed to an infant less than 6 months of age. In young infants, ingestion of nitrate can reduce the blood's ability to carry oxygen. In severe cases it can cause a condition that doctors call methemoglobinemia also called "blue baby syndrome" because the infant's skin appears blue-gray or lavender in color. This skin color change is caused by a lack of oxygen in the blood. An infant suffering from "blue baby syndrome" needs immediate medical care because the condition can lead to coma and death if it is not treated promptly. Some scientific studies have also found evidence suggesting that women who drink nitrate contaminated water during pregnancy are more likely to have babies with birth defects. People who have heart or lung disease, certain inherited enzyme defects or cancer may be more sensitive to the toxic effects of nitrate than healthy individuals. Some researchers also suspect that consuming nitrate-contaminated water may increase the risk of certain types of cancer (WDNR Publication: PUB-DG-001 2006).

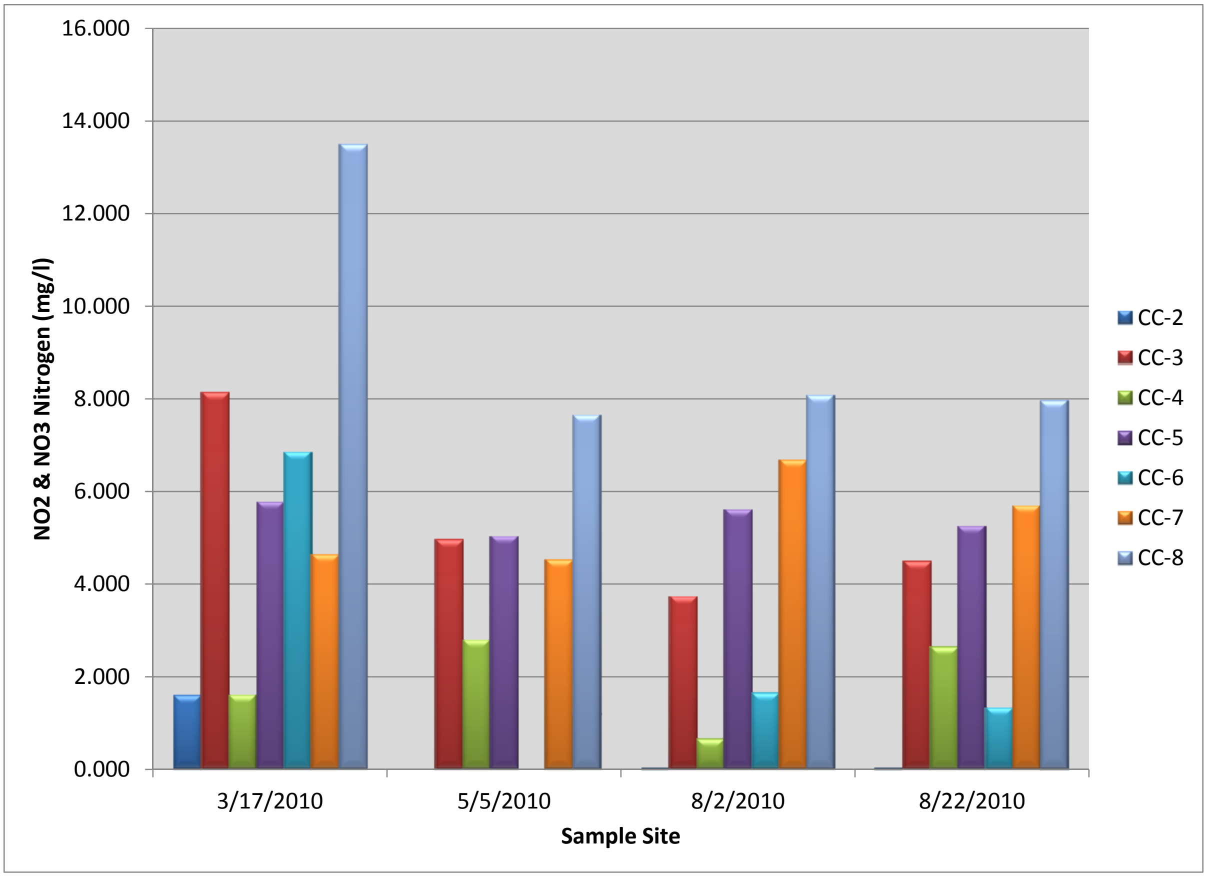

Figure 10
Relationship of NO_2/NO_3 Concentrations
by Sample Site and Date

Loadings of Total Kjeldahl Nitrogen (TKN) and Nitrite/nitrate nitrogen (NO_2 & NO_3) are illustrated by sample site and date in Figures 11 and 12.

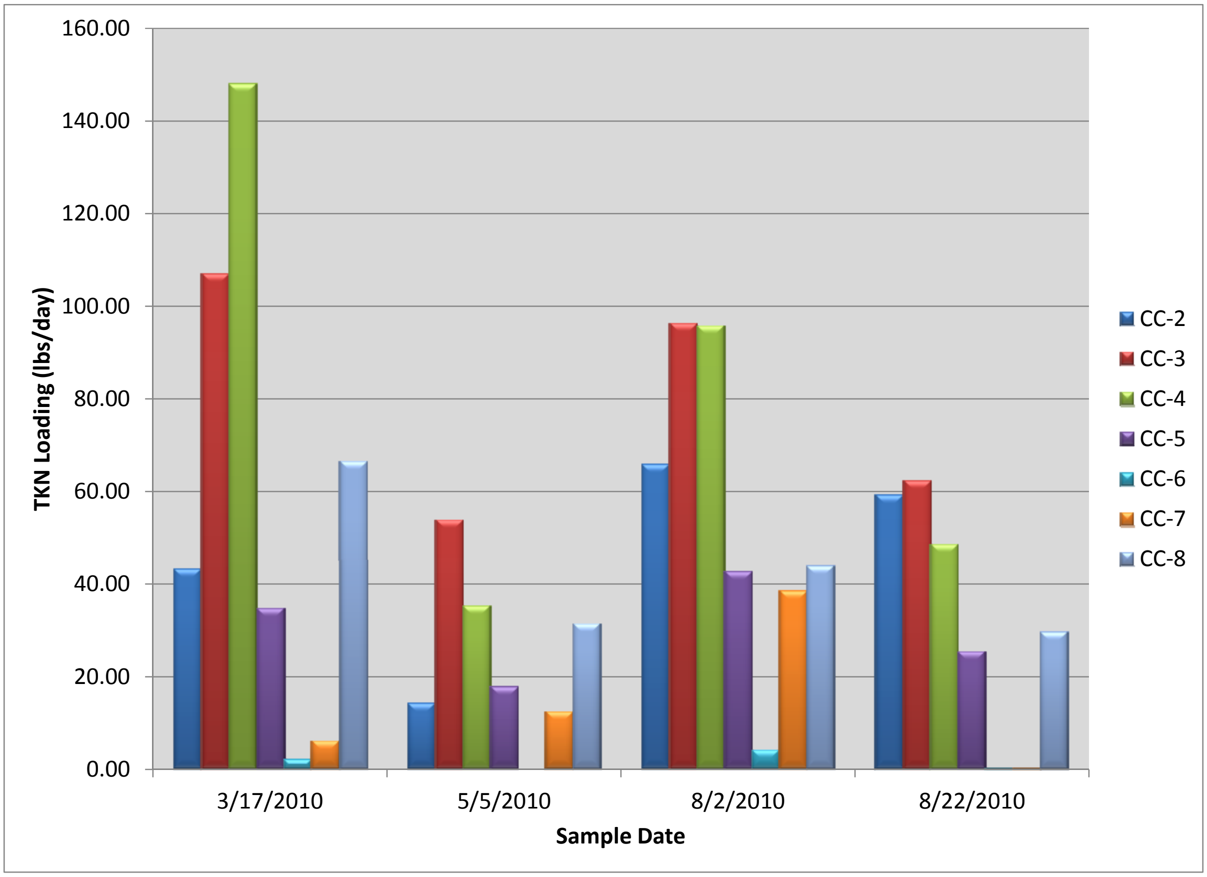

Figure 11
Relationship of Total Kjeldahl Nitrogen (TKN) Loadings by Sample Site and Date

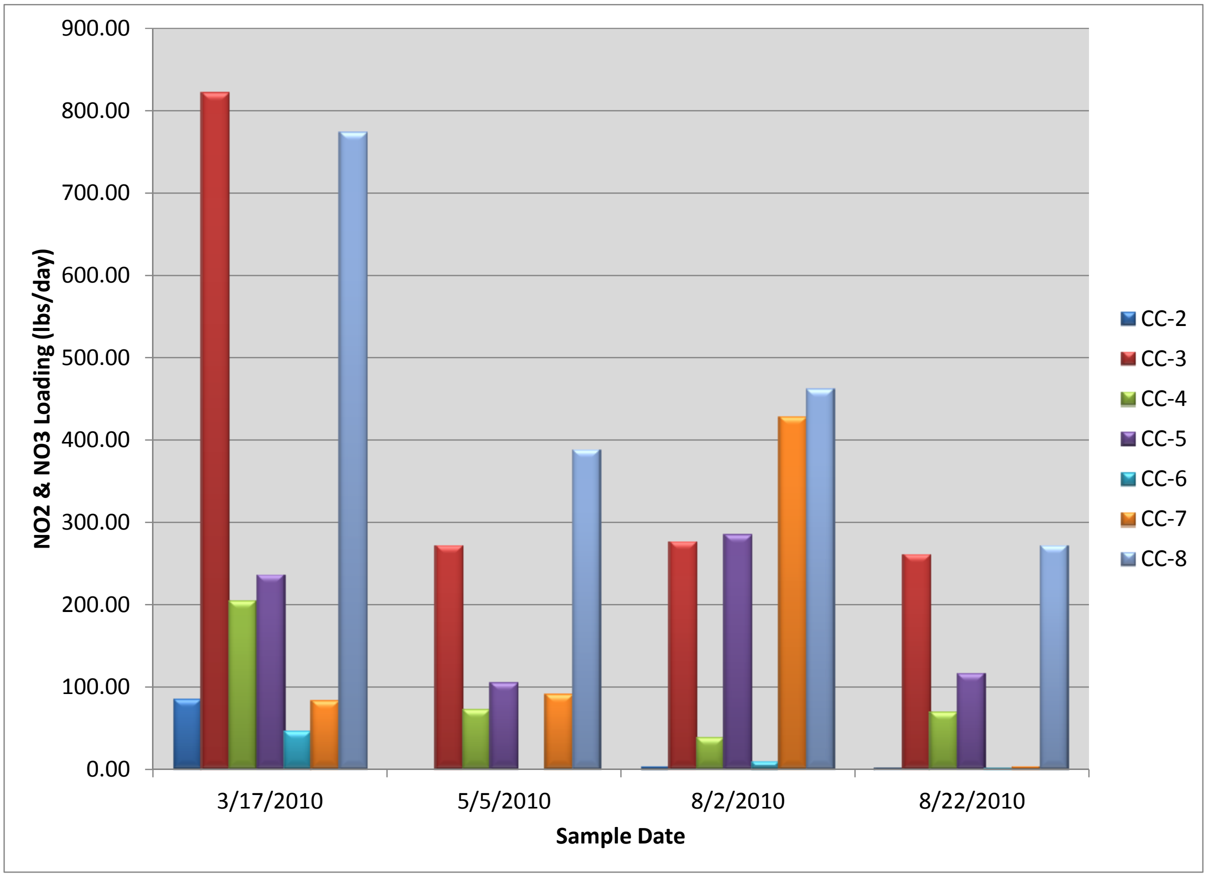

Figure 12
Relationship of NO_2/NO_3 Loadings
by Sample Site and Date

Fecal Bacteria

Fecal bacteria are bacteria that grow in the intestines of warm blooded animals and are found in fecal matter. E-coli (Escherichia coli) are a specific form of the fecal coliform group. E-coli have been associated with making humans sick through ingestion. The U. S. Environmental Protection Agency (USEPA) has recommended that E- coli be used to measure the safety of public beaches. The USEPA recommends that beaches be posted with an advisory sign informing the public of increased health risk when a water sample exceeds 235 colony-forming units of E. coli per 100 milliliters of water.

E-coli counts on the sample dates ranged from 5 to 610 counts per 100 milliliters (Figure 13). Eleven of the 27 samples exceeded the USEPA beach standard. Most of the high concentrations were seen on August 2, and 22, 2010 right after two large storm events. The bacterial counts indicate either runoff from local barn yards or agricultural fields recent spread with animal waste.

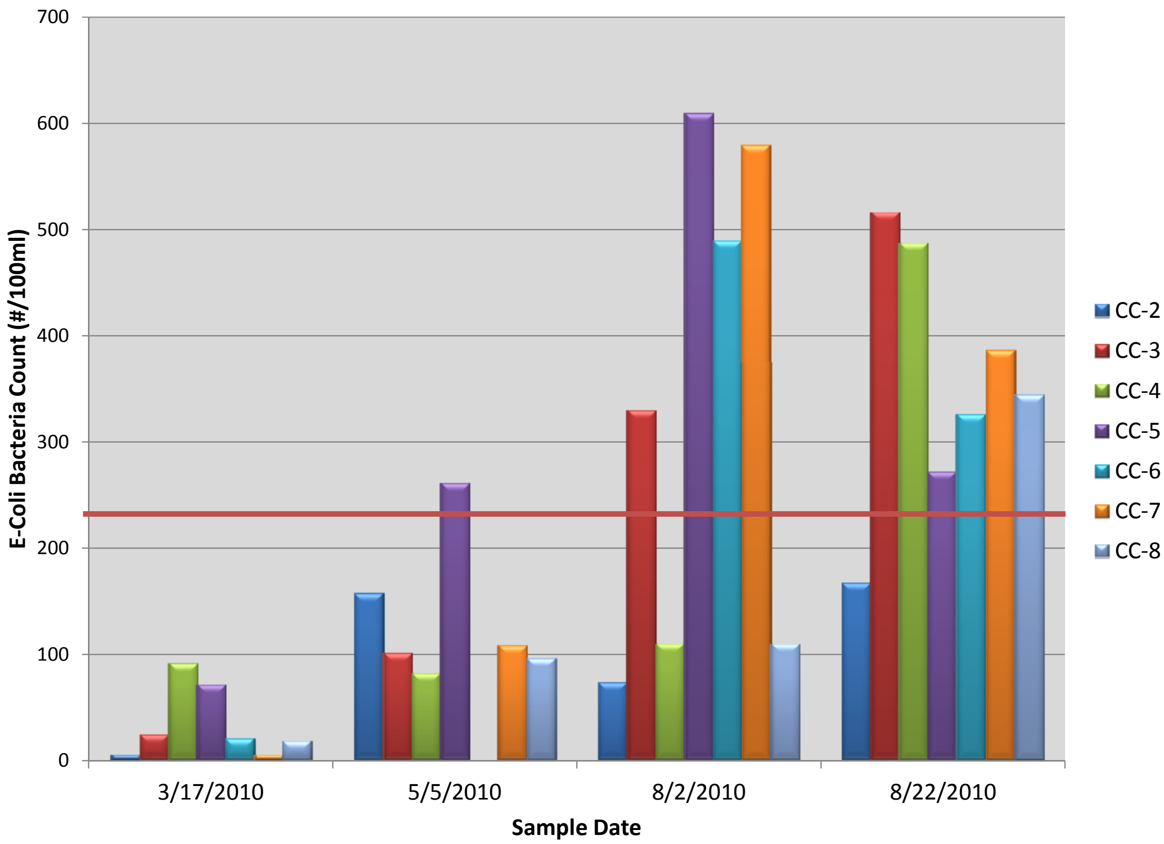

Figure 13
Relationship of Fecal E-Coli Bacteria Counts
by Sample Site and Date

CONCLUSIONS

It's been stated that "A lake is a Reflection of its Watershed". In the case of Fox Lake that reflection is one of high levels of pollution. Based on the 2004-2006 UWM monitoring, Cambra Creek contributes to Fox Lake:

- 35.9% of the annual water input
- 43.3 % of the annual TSS input
- 10.9 % of the annual nitrogen input
- 9.0 % of the total phosphorus input

To identify the sources of the sediment and nutrients entering Fox Lake a sampling program of the Cambra Creek watershed was conducted in 2009 and 2010. Development of conclusions from the data is hampered by the loss of approximately half of the samples by the Wisconsin State Laboratory of Hygiene. Based on the available data the following conclusions can be reached.

Total Kjeldahl Nitrogen (TKN) concentration ranged from 0.30 to 1.85 mg/l. As illustrated in Figure 9, 21 of the 27 samples were above the statewide mean identified by USGS in *Nutrient Concentrations and Their Relations to the Biotic Integrity of Wadeable Streams in Wisconsin* (USGS, 2006). On one site was consistently below the statewide mean, station CC-7.

Nitrite/nitrate nitrogen (NO_2 & NO_3) levels ranged from non-detectable to 13.5 mg/l (Figure 10). 19 of the 27 samples were above the statewide mean as measured by USGS. The highest Nitrite/nitrate nitrogen concentrations were found at station CC-8. State and Federal laws set the maximum allowable level of nitrate-nitrogen in public drinking water at 10 milligrams per liter (10 parts per million).

In the 2009-2010 sampling, TSS values ranged from 2 to 50 mg/l, indicating low levels of suspended sediment. The sampling indicates that surface erosion on the sampling dates was not a major problem.

The State of Wisconsin has established under Wisconsin Administrative Code NR 102.06 a total phosphorus standard of 100 ug/L (0.10 mg/l) for "unidirectional flowing waters" (streams) and 30 ug/L (0.03 mg/l) for lakes that are both drainage and stratified lakes. The test results show high concentration of total phosphorus on all of the sampling dates and at all of the sampling locations. Nineteen of the 27 samples (70%) were above the NR 102.06 standard of 0.10 mg/l. Approximately 75% of the total phosphorus is in the form of soluble reactive phosphorus. As outlined above this is unusual in the hard water of Southern Wisconsin. This indicates that the source of the phosphorus is not soil erosion where most phosphorus is typically bound to the soil particles, but is due a soluble source of phosphorus such as contamination of groundwater by sources such as treated wastewater, septic system waste or animal manure.

E-coli bacteria (Escherichia coli) are bacteria that live in the digestive track of warm blooded animals including man and livestock. The presence of e-coli bacteria in the water is an indication of animal waste. To protect public health the U. S. Environmental Protection Agency has recommended that beaches be closed when e-coli levels exceed 235 CFU/100 ml. Eleven of the 27 samples exceeded the USEPA beach standard. Most of the high concentrations were seen on August 2, and 22, 2010 right after two large storm events. The bacterial counts indicate either runoff from local barn yards or agricultural fields recent spread with animal waste.

The results of the 2009-2010 sampling indicate that groundwater contamination is the largest problem in the Cambra Creek watershed. Most pollutants enter Cambra Creek via groundwater discharges along the entire stream length. The best management practices to reduce pollutant discharges to the stream are those that prevent movement of pollutants into the groundwater.

RECOMMENDATIONS FOR FUTURE ACTION

The Cambra Creek watershed has been identified as an area with high potential for groundwater contamination by the U. S. Geological Survey. Nitrate/nitrate and phosphorus sampling of Cambra Creek has demonstrated that this contamination has already taken place. Likely sources of the contamination include barnyard runoff, and spreading of manure and other industrial waste.

Based on the existing problems the following things should take place:

a. No new sources of animal or human waste should be imported into the watershed. Only animal waste generated within the watershed should be spread.

b. Existing land applications of animal or human waste should be minimized. The Wisconsin Legislature should explore new regulations for the land application of waste in areas with high potential for groundwater contamination.

c. All animal waste storage facilities, such as manure storage pits of tanks, should be inspected to assure that they are not leaking and are in compliance with Dodge County's Manure Storage and Nutrient Utilization Ordinance (Ordinance No. 794) and Columbia County Animal Waste Management Ordinance (Title 15).

d. All applications of fertilizers in the watershed should be based on a Comprehensive Nutrient Management Plan (CNMP). The plan is based on realistic crop yield goals, soil tests to determine the nutrients available in fields, and taking credit for nutrients from legumes and manure applications. The plan may also identify areas of special concern such as flood plains and steep slopes. Nutrients are applied at the proper time using the appropriate application method. Sound nutrient management reduces fertilizer costs and protects water quality.

e. The monitoring data indicates that the highest loadings of total phosphorus and TKN nitrogen are found at sample sites CC-2, CC-3 and CC-4. CC-2 is at Wismera Road, CC-4 is at CTH AA. CC-3, at Canada Island Road, includes the combined drainage from CC-7 and CC-8. About 50% of the loading of total phosphorus at CC-3 comes from CC-8. The Dodge and Columbia County Land Conservation Departments Farms should contact landowners upstream of these sites to explore potential opportunities for use of conservation practices to reduce phosphorus and nitrogen contamination of groundwater and surface runoff.

REFERENCES

Edwards, T.K., and G.D. Glysson. (1999). Field Methods for Measurement of Fluvial Sediment, Book 3, Chapter C2. Techniques of Water-Resources Investigations of the United States Geological Survey, U.S. Government Printing Office, Washington, DC.

Hey and Associates, Inc. and UW-Milwaukee (2008). *Fox Lake Management Strategy Evaluation and Recommendations for Future Action – 2008*, Brookfield, WI.

R. A. Smith and Associates, Inc. (1998). *Long Range Planning Strategy for the Rehabilitation of Fox Lake, Dodge County*, Brookfield, WI

Robertson, D.M., Graczyk, D.J., Garrison, P.J., Wang, L., LaLiberte, G., and Bannerman, R., (2006). *Nutrient concentrations and their relations to the biotic integrity of wadeable streams in Wisconsin: U.S. Geological Survey Professional Paper 1722*, 139 p. Madison, WI.

Shelton, L. R., (1994). Field Guide for Collecting and Processing Stream Water Samples for the National Water-Quality Assessment Program, Open-File Report 94-455, United States Geological Survey, Sacramento, California.

United States Geological Survey (USGS). (2005). Techniques of Water Resources Investigations Reports. Book 3: Applications of hydraulics, Section A: Surface-water techniques. (21 chapters). United States Department of Interior, U.S. Geological Survey. Washington D.C. http://water.usgs.gov/pubs/twri/.