DREW CREEK MANAGEMENT PLAN

FOX LAKE, DODGE COUNTY, WISCONSIN

Prepared for:

Fox Lake Inland Lake Protection and Rehabilitation District
W10543 HWY F
Fox Lake WI 53933

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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 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.

Follow-up monitoring of Drew Creek was conducted in in the fall of 2008 and summer of 2009. The purpose of the follow-up monitoring was to collect additional data on sources of nitrogen, phosphorus and sediment entering Fox Lake from the Drew Creek watershed. The goal of the project was 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. The results of the follow-up monitoring are summarized in the report ***Drew Creek Monitoring Project: Final Report*** (Hey and Associates, Inc., 2009.

The 2008 /2009 Drew Creek monitoring identified the following conclusions (Appendix B):

- Most of the water that flows in Drew Creek is from groundwater flow and drain tile discharges. Surface runoff is a small component of the annual flow.

- High levels of nitrate/nitrite nitrogen (NO_2+NO_3) were found at all of the sampling sites. Nitrite/nitrate nitrogen levels ranged from 14.5 to 20.2 mg/l well above the state's drinking water standard of 10 mg/l. The high levels and similar concentrations of nitrate/nitrite nitrogen at all of the sampling sites, regardless of location in the watershed, indicate that groundwater contamination is a watershed wide problem and not isolated to a single farm or location.

- Sediment levels in the water were generally low ranging from 3.0 to 34.0 mg/l. The low levels of sediment confirm the conclusion that surface runoff is not a serious problem in the watershed and that groundwater is the major source of pollution in the watershed.

- 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. In Drew Creek levels at CTH F exceeded this value on more than half of the sampling dates, indicating an upstream source of animal waste, likely a local dairy farm.

In addition to the surface water monitoring indicating high levels of Nitrite/nitrate nitrogen levels, well sampling conducted by private home owners through the University of Wisconsin – Stevens Point, has indicated groundwater concentrations above the state drinking water standard.

The objective of this project is to develop a management strategy to reduce existing sources of pollution in the watershed and develop a clean-up strategy for the contaminated groundwater that is the result of decades of excessive nutrient inputs in the watershed.

PLANNING PROCESS

The preparation of this plan was conducted by Ecological Research Partners, LLC. and the Fox Lake Inland Lake Protection and Rehabilitation District (FLILPRD) utilizing a grant from the Federal Environmental Protection Agency (EPA) Great Lakes Restoration Imitative (GLRI)(Grant# LPL-1464-12). The project recommendations were guided by a technical advisory committee that includes the following individuals:

Name	Title	Agency
Neal O'Reilly - Ph.D.	Principal	Ecological Research Partners
Tim Ehlinger – Ph.D.	Principal	Ecological Research Partners & University of Wisconsin-Milwaukee
Timothy J. Grundl - Ph.D.	Professor	Geosciences Department and School of Freshwater Sciences University of Wisconsin-Milwaukee
Daniel H. Zitomer - Ph.D., P.E.	Professor	Professor of Civil, Construction and Environmental Engineering Marquette University.
Marc Bethke	County Conservationist	Dodge County, Land Conservation Department.
Nathian Fikkert	Resource Conservationist	Natural Resources Conservation Service
Dee Pettack	Chief of Staff	Senator Luther Olsen Office
Cindy Block	Legislative Aide	Senator Scott Fitzgerald's office
Michael Vollrath	Water Resources Management Specialist	Wisconsin Department of Natural Resources
Dan Heim	Water Resources Management Specialist	Wisconsin Department of Natural Resources
David Venard	Badger Industries	Wisconsin Department of Corrections
Kathy Rydquist	Clerk-Coordinator	Fox Lake Inland Lake Protection and Rehabilitation District
Dennis VanderWerff	Board Chairman	Fox Lake Inland Lake Protection and Rehabilitation District
Kurt Heckl	Board Member	Fox Lake Inland Lake Protection and Rehabilitation District
Timothy Meekma	Board Member	Fox Lake Inland Lake Protection and Rehabilitation District
Cheryl Witkowski	Board Member	Fox Lake Inland Lake Protection and Rehabilitation District
Julie Flemming	Board Member	Fox Lake Inland Lake Protection and Rehabilitation District
William O'Connor	Attorney	Wheller, Van Sickle & Anderson

Meeting agendas and minutes are located in Appendix A of this report.

The following report will provide an overview of the Drew Creek watershed, identify potential pollution sources through the preparation of a water and nutrient budget, identify potential management options and recommended future actions.

DREW CREEK WATERSHED

Drew Creek is one of three watersheds that feeds Fox Lake. The three watersheds include Alto Creek (13,693 ac), Cambra Creek (14,900 ac) and Drew Creek (3,650 ac) (Figure 1).

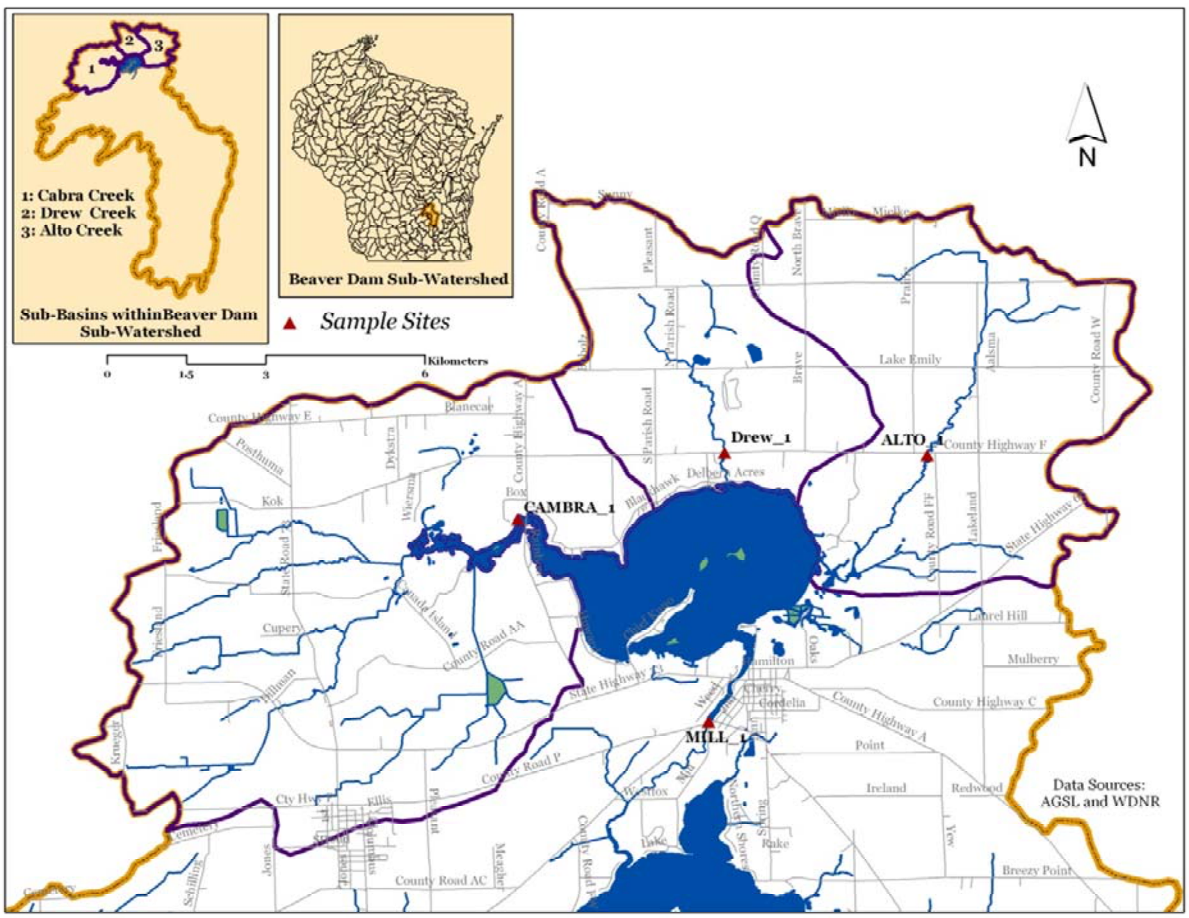

Figure 1 - Fox Lake Watersheds

Land use in the Drew Creek watershed is summarized in Table 1 and illustrated in Figure 2. As we see the majoring of the land use is agricultural crop land and pasture (87%). The commercial and high density residential classified land uses in the watershed are the Fox Lake Correctional Facility which owns approximately 1,200 acres in the watershed.

Table 1 Land Use in Drew Creek Watershed
(Source: Wisconsin LANSAT Land Use Data Base)

Land Use	Acres	Percent
Agriculture Crop Land	2,369.2	64.92
Grass/Pasture	791.5	21.69
Residential	194	5.32
Water/Wetland	154.3	4.23
Forest	121.9	3.34
Commercial	15.8	0.43
Industrial	2.9	0.08
Total	**3,649.6**	**100.00**

Soils in the Drew creek watershed are generally silt loams on the uplands and silty clay loam soils in the lowland areas. Figure 3 illustrates the soil distribution based on their hydrologic soil classification. The upland soils are predominantly well drained class B soils and the lowland wetlands are poorly drained class D soils.

Wetlands with in the Drew Creek watershed are illustrated on Figure 4. There are approximately 150 acres of wetland in the watershed that are generally associated with the stream corridor and a large marsh area north of Lake Emily Road, which includes a large open water area.

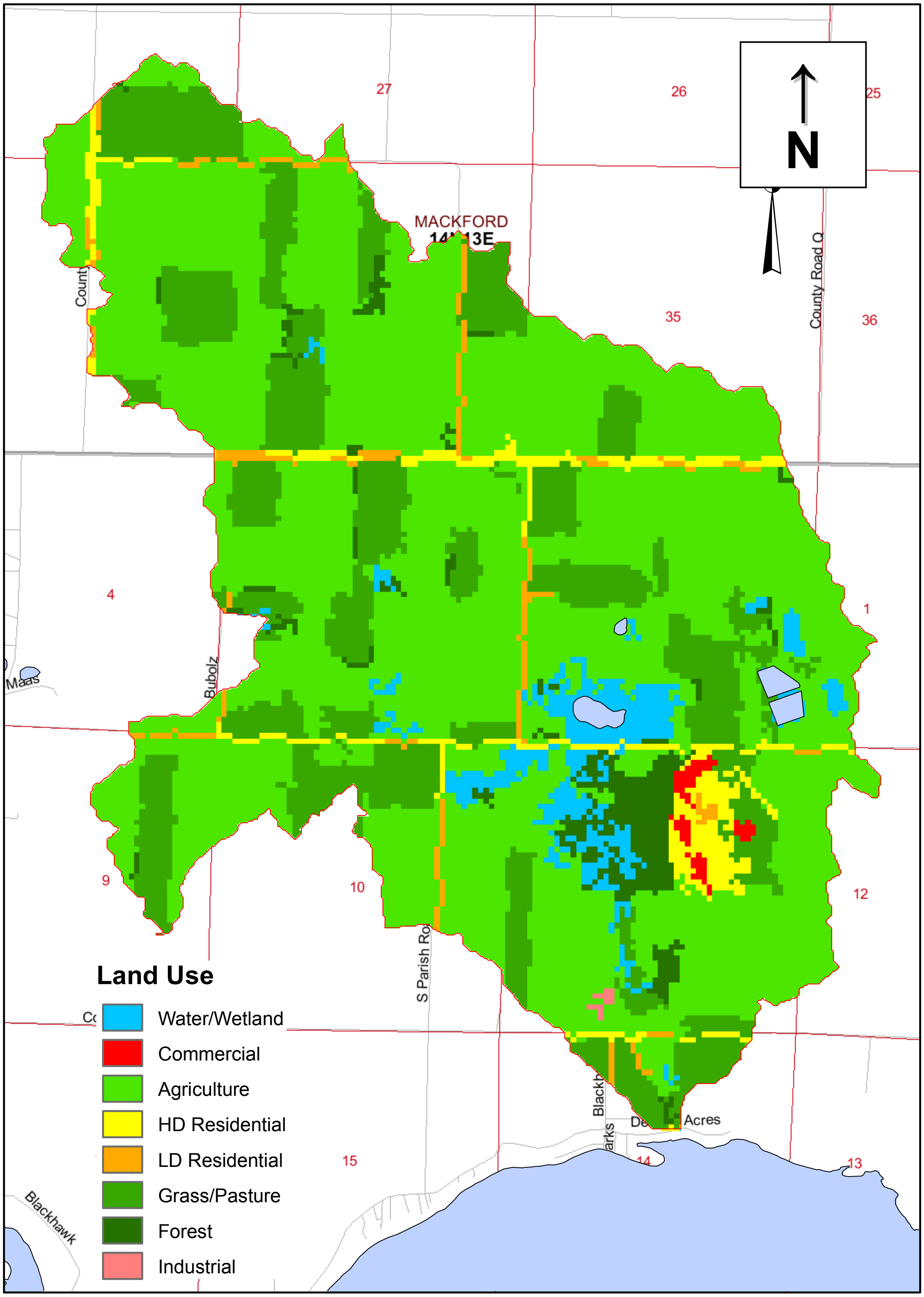

Figure 2 – Land Use in Drew Creek Watershed
(Source: ERP and Dodge County Land Record Department)

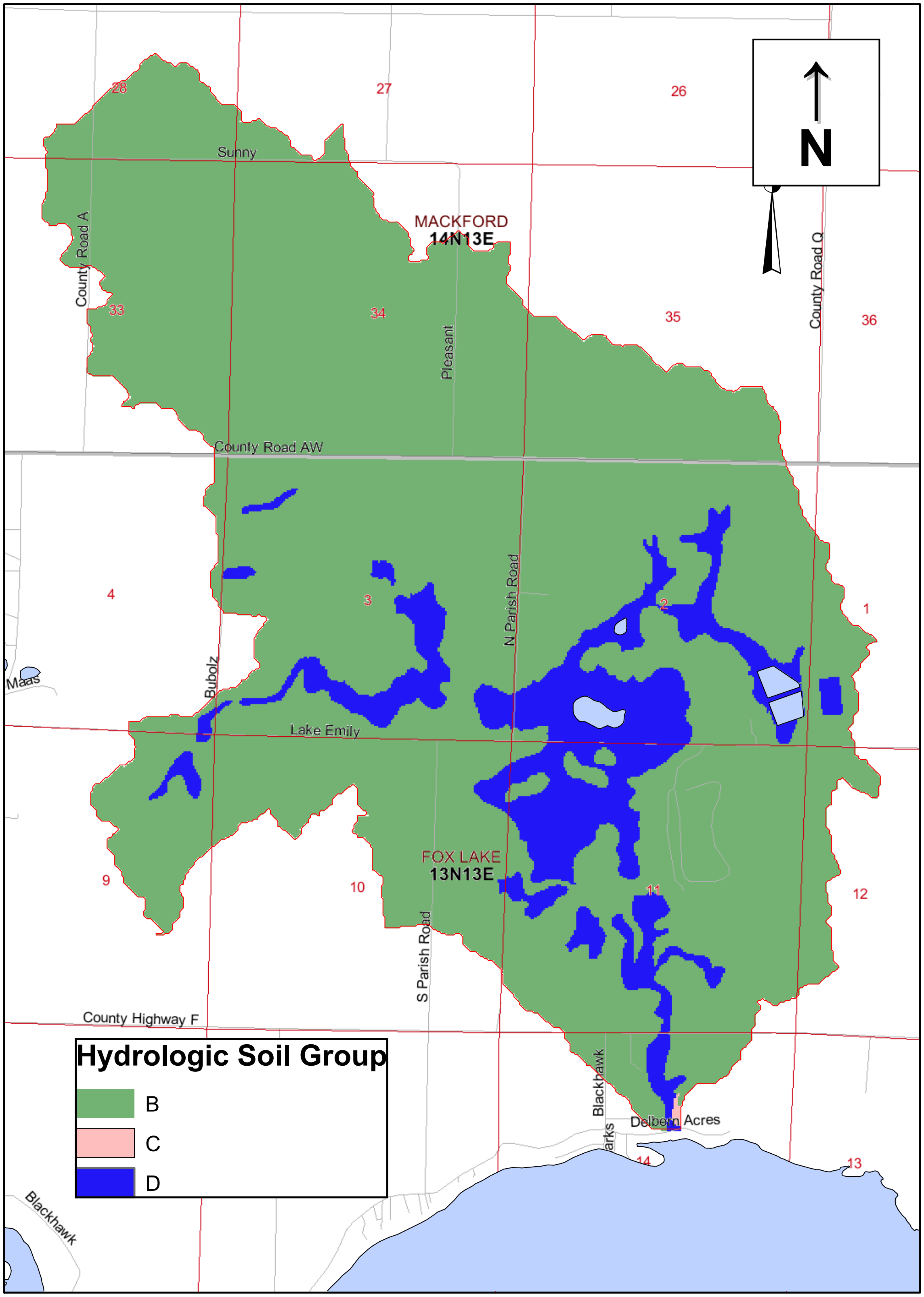

Figure 3 – Hydrologic Soil Groups in Drew Creek Watershed
(Source: ERP and Natural Resource Conservation Service)

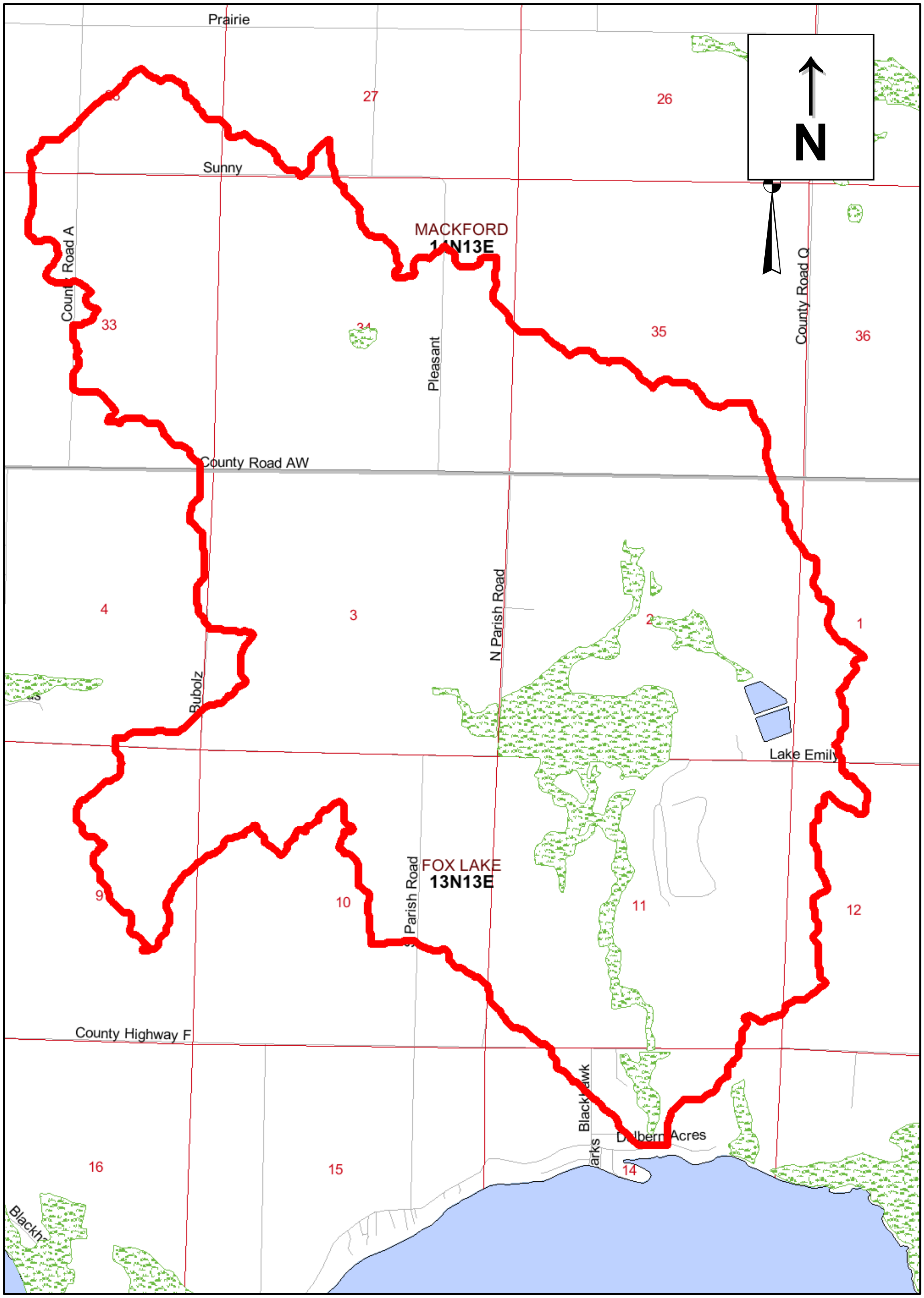

Figure 4 – Existing Wetlands in Drew Creek Watershed

(Source: Wisconsin Department of Natural Resource and Dodge County)

DREW CREEK WATER BUDGET

To understand the sources of water in the Drew Creek watershed an annual water budget was prepared using the Long Term Hydrologic Impact Analysis (L-THIA), developed by Purdue University. A water budget is an estimate of the water inputs and outputs in the watershed. On a long term basis inputs and outputs equal. The L-THIA model utilizes the NRCS TR-55 methodology to estimate surface runoff based on annual rainfall, land cover and soil hydrological classification. Table 2 summarizes the watershed input data to the L-THIA TR-55 model.

Table 2 Land Use and Soil Input Data to L-THIA TR-55 Model

Land	Soil Type	Area (ac)
Water/Wetland	B	43.2
Water/Wetland	D	111.1
Commercial	B	15.8
Agriculture	B	2134.8
Agriculture	D	234.4
HD-Residential	B	122
HD-Residential	D	5.9
LD-Residential	B	62.9
LD-Residential	D	3.2
Grass/Pasture	B	751.8
Grass/Pasture	C	1.2
Grass/Pasture	D	38.5
Forest	B	89.4
Forest	C	0.2
Forest	D	32.3
Industrial	B	2.9
Total	**Area**	**3649.6**

The L-THIA modeling was supplemented with records of land applied treated wastewater from the Fox Lake Correctional Facility (Figure 5). Wastewater from the Correctional Faculty is treated on site in an activated sludge treatment plant and the treated wastewater is stored in several surface lagoons and land applied during the summer months. Data from 2012 only represented one half of the application season. The data indicates that the average water use per inmate and staff at the Fox Lake Correctional Facility is 101 gal/cap/day (66 MG/yr/1800 people). Typical Domestic Water Use in US is 40 to 130 gal/cap/day.

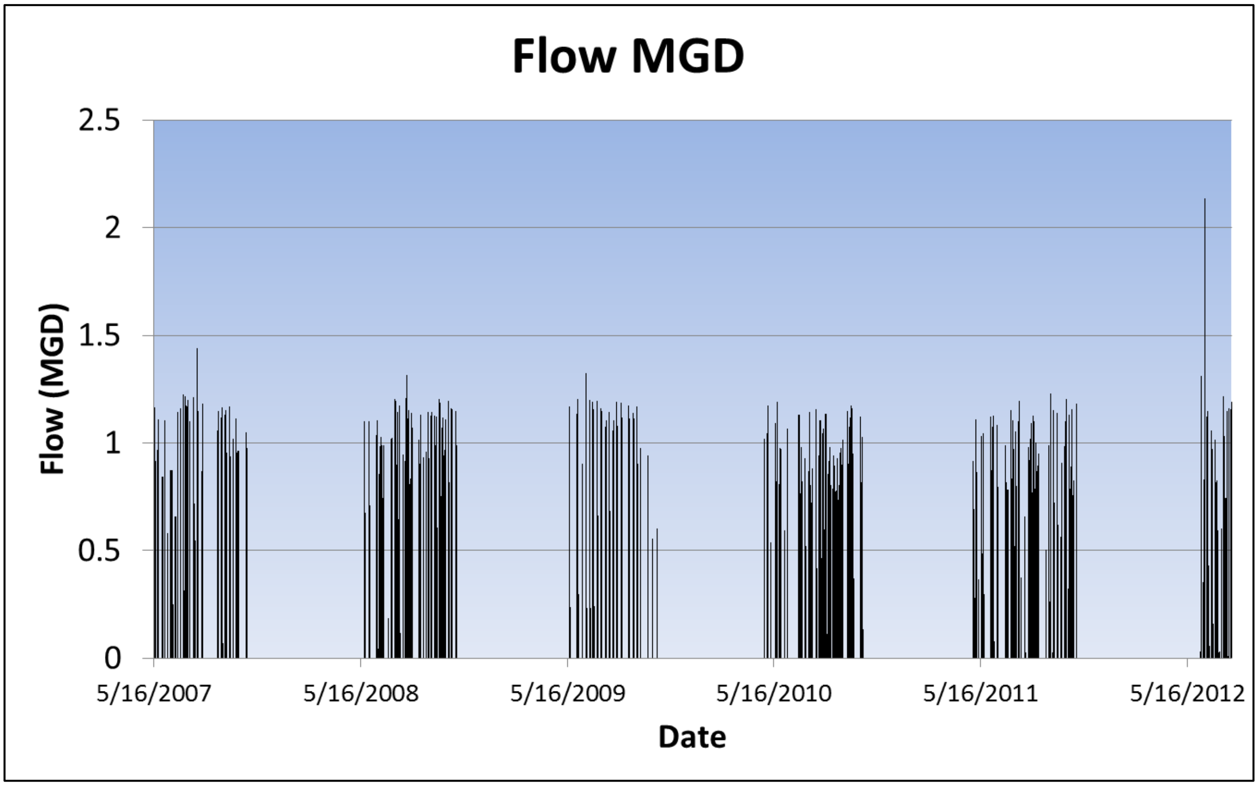

Figure 5 – Daily Discharge of Land Applied Treated Wastewater at Fox Lake Correctional Facility (MGD)

Table 3 Annual Daily Discharge of Land Applied Treated Wastewater at Fox Lake Correctional Facility (MGY)

Year	Flow MG/yr
2007	59.102
2008	73.986
2009	47.293
2010	76.480
2011	73.252
2012 (First half of season)	27.027
Mean 2007-11	**66.023**

Table 4 summarizes the annual water budget for the Drew Creek watershed. Annual rainfall measured at the NOAA weather station at Beaver Dam is 35.10 inches per year (1995 – 2012). Of this rainfall 10.14 inches becomes surface runoff, which is equivalent to 1,060 million gallons per year (Mg/yr). Based on the water budget analysis we see that the Fox Lake Correctional Facility Wastewater Treatment Plant contributes only 66 MG/yr or 1.8% of the annual input of water to Drew Creek. Flow in Drew Creek is estimated to be only 29% of the annual water output. The largest output of water is the combination of groundwater recharge and evaporation.

Table 4 Water Budget Drew Creek Watershed

Parameter	Average
Average Annual Rainfall (in/yr)	35.10
Inputs	
Rainfall Volume (MG/yr)	3,480
Fox Lake Corrections (MG/yr)	66
Total Input (MG/yr)	**3,546**
Outputs	
Drew Creek Flow (UWM) (MG/yr)	1,273*
Surface Runoff (LTHIA)(MG/yr)	1,060
Groundwater/Evaporation (MG/yr)	2,396
Total Output (MG/yr)	**3,546**

*Estimated based on ratio of stream flow/rainfall from UWM 2004/05 data.

DREW CREEK NUTRIENT BUDGET

A nutrient budget for Nitrogen and phosphorus was developed for the Drew Creek watershed to understand what the significant sources of these nutrients were. First a L-THIA TR-55 Model was developed to estimate surface runoff of these nutrients based on estimated surface runoff volumes and literature values. The results of the L-THIA TR-55 modeling are summarized in Table 6. The results illustrate that agricultural runoff is the largest source of surface water runoff for both total nitrogen and total phosphorus.

Table 6 Annual Runoff Pollution Estimates L-Thia Model

Land Use	Nitrogen (Lbs/yr)	Phosphorus (Lbs/yr)	Suspended Solids (Lbs/yr)	BOD (Lbs/yr)	COD (Lbs/yr)	Fecal Coliform (millions of coliform)
Commercial	102	24	4,248	1,760	8,878	52,813
Agricultural	23,698	7,001	576,295	21,543	0	14,003,432
Agricultural	3,584	1,058	87,163	3,258	0	2,117,995
High Density Residential	771	241	17,383	10,811	20,987	847,976
High Density Residential	52	16	1,171	728	1,414	57,163
Low Density Residential	251	78	5,656	3,517	6,828	275,910
Low Density Residential	20	6	455	283	550	22,242
Grass/Pasture	906	12	1,294	647	0	25,886
Grass/Pasture	2	0	2	1	0	58
Grass/Pasture	79	1	113	56	0	2,277
Forest	89	1	128	64	0	2,570
Forest	0	0	0	0	0	8
Forest	60	1	86	43	0	1,724
Industrial	14	3	698	161	525	11,192
Total Surface Runoff	**29,628**	**8,442**	**694,692**	**42,872**	**39,182**	**17,421,246**

The L-THIA TR-55 modeling results are only for surface runoff and do not represent the additional artificial input from the Fox Lake Correctional Facility treatment plant spray irrigation system. To estimate the impacts of the treatment plant discharge data from records provided by the facility to the WDNR were used to calculate annual loadings of total nitrogen, total suspended solids (sediment) and total phosphorus. The results are summarized in Table 7. We see from these results that the treatment plant contributes very little nutrients and solids as compared to surface runoff.

Table 7 Estimated Annual Total Nitrogen, Total Suspended Solids and Total Phosphorus Exports from Fox Lake Correctional Facility Treatment Plant

Year	Flow MG	Mean TN (mg/l)	Loading TN (lbs/yr)	Mean TSS (mg/l)	Loading TSS (lbs/yr)	Assumed TP (mg/l)	Loading TP (lbs/yr)
2007	59.10	5.109	2,518.16	12.250	6,038.16	1.000	492.91
2008	73.99	4.730	2,918.61	22.120	13,649.00	1.000	617.04
2009	47.29	2.654	1,046.80	15.692	6,189.42	1.000	394.42
2010	76.48	1.759	1,122.18	19.966	12,734.87	1.000	637.84
2011	73.25	4.457	2,722.97	11.464	7,003.78	1.000	610.92
2012	27.03	1.250	281.76	11.861	2,673.63	1.000	225.41
Mean 2007-11	**66.02**	**3.742**	**2,065.74**	**16.298**	**9,123.04**	**1.000**	**550.63**

To understand the potential sources of nutrients in the agricultural runoff an estimate of how much nitrogen and phosphorus fertilizer used in the watershed was prepared. Assuming that each farm was following a nutrient management plan and were following the nutrient application rates recommended in ***Nutrient Application Guidelines for Field, Fruit and Vegetable Crops in Wisconsin*** (Carrie Laboski and John Peter, A2809), Table 8 was prepared to summarize the annual total application of total Nitrogen and total phosphorus in the Drew Creek watershed.

Table 8 Estimated Annual Fertilizer Application Rates in Drew Creek Watershed

Land Use	Acres	Percent	TN Application (lbs/yr/ac)	TN Application (lbs/yr)	TP Application Rate (lbs/ac/yr)	TP Application Rate (lbs/yr)
Agriculture	2,369.2	64.92	150	355,380	50	118,460
Grass/Pasture	791.5	21.69	50	39,575	40	31,660
Residential	194	5.32	0	0	0	0
Water	154.3	4.23	0	0	0	0
Forest	121.9	3.34	0	0	0	0
Commercial	15.8	0.43	0	0	0	0
Industrial	2.9	0.08	0	0	0	0
Total	**3,649.6**	**100.00**		**394,955**		**150,120**

Table 9 summarizes the external sources of total nitrogen and total phosphorus in te Drew Crew watershed from fertilizer applications and spay irrigation of treated wastewater. From the results we see that the Fox Lake Correctional Facility wastewater treatment plant (WPT) is a very minor source of nitrogen and phosphorus to the watershed.

Table 9 Estimated Annual Total Nitrogen and Phosphorus Inputs to Drew Creek Watershed

Source	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)
Agriculture	355,380	118,460
Grass/Pasture	39,575	31,660
Fox Lake Correctional Facility WTP	1,826	551
Total Input	**396,781**	**150,671**

Table 10 summarizes the estimated export of total nitrogen and total phosphorus from the Drew Creek watershed. From the data we see that the 66% of the total nitrogen measured in Drew Creek by UWM is likely from groundwater sources. While Drew Creek carries large amounts of total nitrogen and total phosphorus, larger amounts are being exported into groundwater and soil storage. This is resulting in a large reservoir of nutrients in the watershed that may take years to decades to drain from the system.

Figure 6 illustrates the farms in the Dodge County portion of the Drew Creek watershed that have active nutrient management plans. A similar distribution exists in the Green Lake County portion of the watershed. The stream monitoring data illustrates that while local farmers are implementing nutrient management planning, it is not protecting local surface and groundwater quality.

Table 10 Estimated Annual Total Nitrogen and Phosphorus Outputs from Drew Creek Watershed

Source	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)
Runoff (L-Thia)	29,628	8,442
Measured Drew Creek Output (UWM 2004/05)	47,472	3,266
Estimated Drew Creek (Adjusted to Mean Rainfall)	89,000	6,123
Groundwater and Soil Storage	307,781	144,548
Total Output	**396,781**	**150,671**

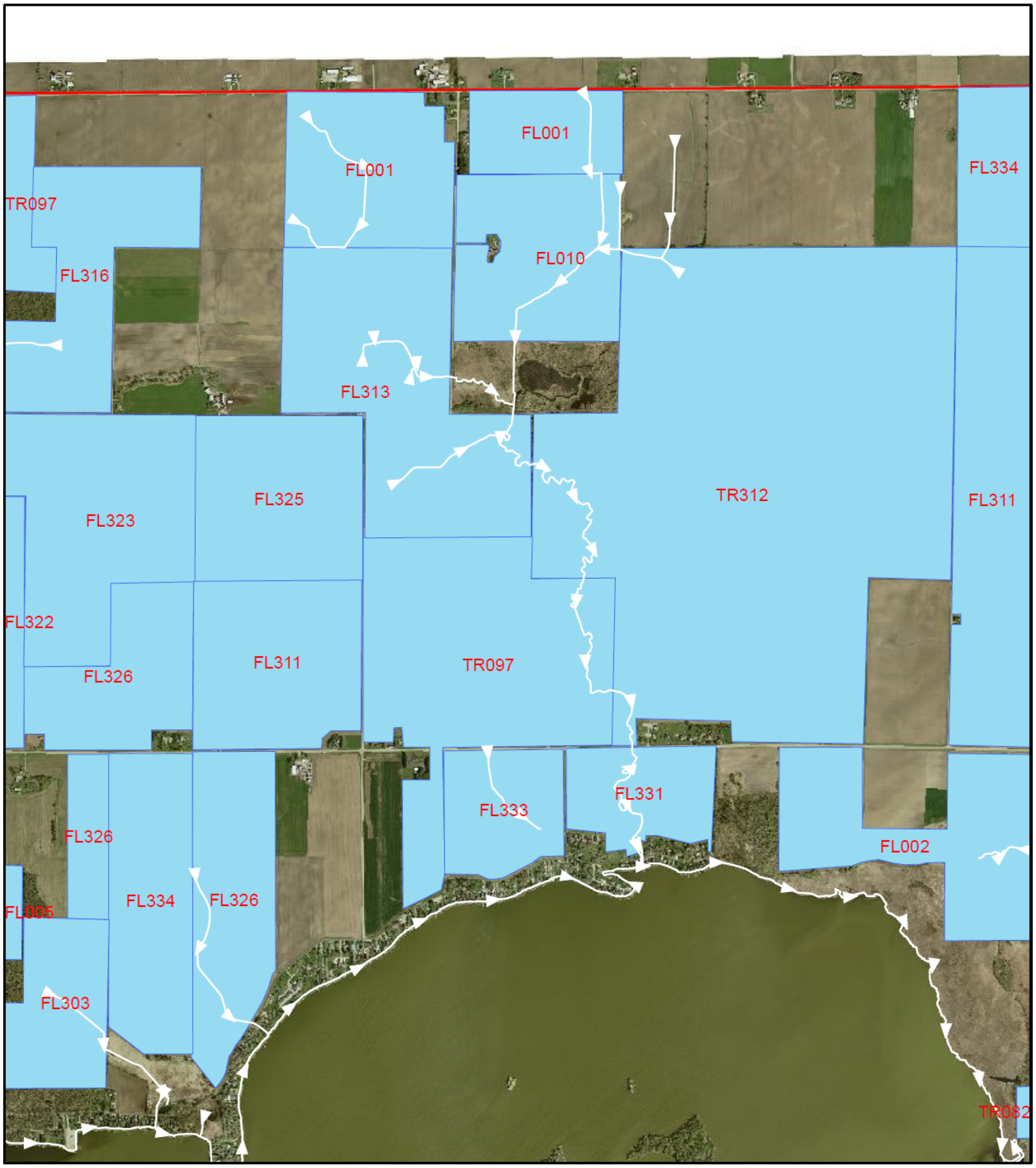

Figure 6 – Farms with Nutrient Management Plans in the Dodge County Portion of the Drew Creek Watershed (Source: Dodge County Land Conservation Department)

PROJECT GOALS AND OBJECTIVES

The Drew Creek Management Plan has two broad goals:

1. To reduce nutrient inputs to Fox Lake from the Drew Creek watershed through the implementation of agricultural management practices to reduce nutrient export. The purpose is to reduce the frequency of in-lake algae blooms on the lake.

2. Reduce potential public health impacts of high nitrite levels in the local drinking water supply, which are predominantly shallow private groundwater wells.

To achieve the above goals several objectives need to be meet:

1. New agricultural practices for nutrient management need to be developed. Current nutrient management planning is not protecting Fox Lake.

2. Current nutrient management planning is not protecting the shallow groundwater that is being used as the local drinking water supply, measures need to be taken to reduce nitrate/nitrite inputs to the shallow water table.

3. Public education of the potential of groundwater contamination in the Drew Creek watershed needs to take place to inform the public of potential health issues and what they can do to protect their families.

Monitoring data of Drew Creek illustrate that most of the nitrogen and phosphorus is in soluble forms, likely being discharged from local drain tiles and springs. To reduce nitrogen loss from watersheds G. Philip Robertson and Peter M. Vitousek (2009) have recommended the following actions to reduce nitrogen export:

1. Improve N capture by crops,

2. Providing farmers with decision support tools for better predicting crop fertilizer N requirements,

3. Improving methods for optimizing fertilizer timing and placement, and,

4. Developing watershed-level strategies to recapture N lost from fields.

The following alternatives section will explore options available to meet the above recommendations.

ALTERNATIVES TO REDUCE NUTRIENT EXPORT

INTRODUCTION

Nitrogen cycling in agricultural soils is complex. Figure 7 illustrates the nitrogen cycle on cultivated fields. Nitrogen is lost from the soil system in several ways including:

- Leaching
- Denitrification
- Volatilization
- Crop removal
- Soil erosion and runoff

The goal of any agricultural nutrient management plan is minimize the application of nutrients to only the immediate needs of the crops and to tie up any excess nutrients to prevent leaching from the soil into local surface or groundwater. The following alternative management practices are designed to meet the recommendations of Robertson and Vitousek (2009) discussed above.

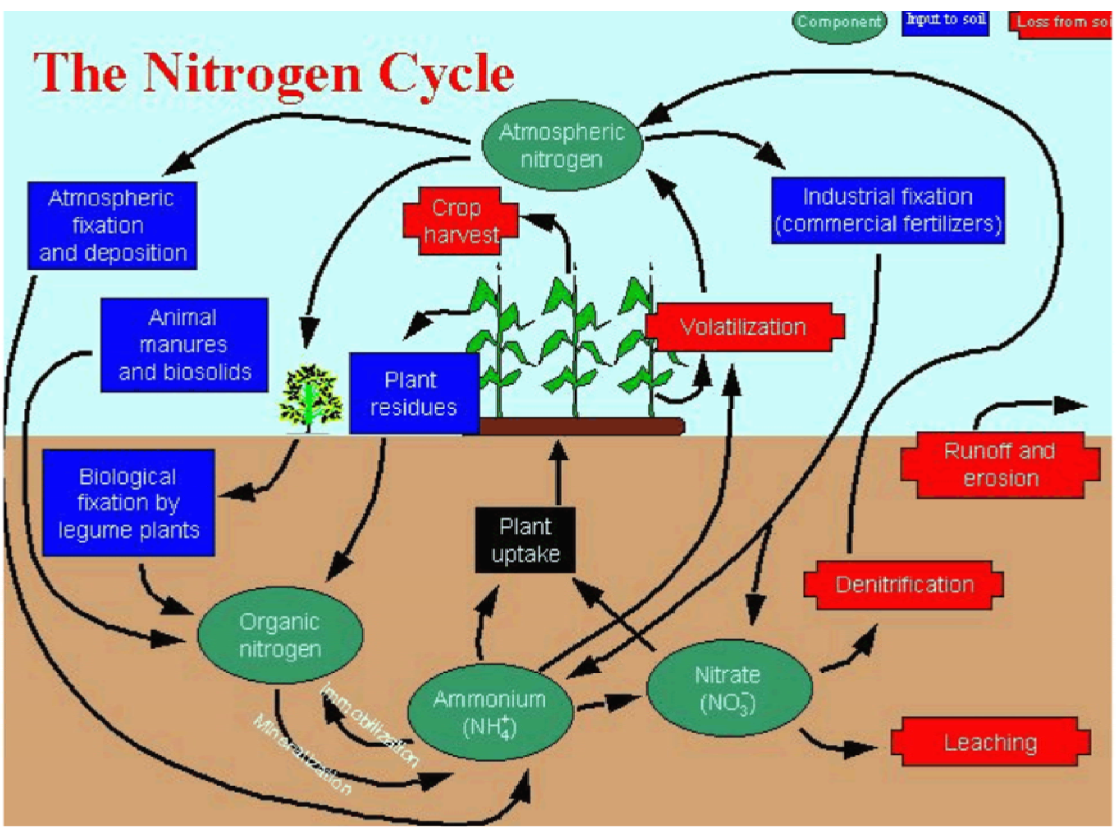

Figure 7 - The Nitrogen cycle on Agricultural Fields

Within the Drew Creek watershed the primary agricultural crops are corn, soybean and alfalfa. Therefore the following management alternative will focus on nutriment export reduction for these crops. The alternatives will be divided into the following groups:

- Methods to improve capture of nutrients on the agricultural fields.
- Methods to trap nutrients before they leave the agricultural fields.

IMPROVE NUTRIENTS CAPTURE

The concept of nitrogen capture by crops is to assure that the nitrogen applied to the field will be captured by the crops and will be removed during the crop harvest process and will not leach into local surface or groundwater. Methods that are being studied by the U. S. Department of Agriculture include cover crops, nitrogen trading and wetland treatment (nutrient farming).

Cover Crops

Winter Cover Crops

Crops planted in the fall can capture nitrogen left over from the summer crop before it can be washed into the surrounding watershed by fall and winter rains or spring snowmelt. The next crop can use the captured nitrogen when the cover crop is killed prior to spring planting. Some grain crops such as winter wheat can also be planted in the fall.

Winter cover crops are planted into or after harvest of a cash grain, oilseed, or vegetable crop before the next crop is planted the following spring. In this context, winter cover crops are not grown for harvest. Table 11 outlines some of the benefits and risks of planting a winter cover crop (Kristine Moncada and Craig Sheaffer, 2013).

The first step in selecting a cover crop species is to determine the main goal of the cover crop (Table 12). From Table 12 we see for the purpose of nitrogen scavenging and erosion control winter rye is the recommended crop by the Midwest Cover Crops Council (MCCC).

Table 11- Potential Benefits and Risks of Winter Cover Crops (Source: Midwest Cover Crops Council)

Benefits	Risks
Nutrient enhancement	Additional management and labor
Soil nutrient capture	Additional expense for seed cost
Soil moisture retention	Interference with primary crop establishment
Erosion protection	Soil moisture depletion (if cover crop actively growing in spring)
Weed control	Cooler soil temperatures in spring because of plants on surface
Improved soil structure	Competition with primary crop
Disease control	Nutrient depletion by non-legumes
Nematode control	Nutrient availability not timely for subsequent crop
Increased soil organic matter	Allelopathic effects on primary crop

Table 12 - Important Functions of Winter Cover Crops in Cropping Systems. (These cover crops are recommended for the Upper Midwest.) (Source: Midwest Cover Crops Council)

Function	Winter cover crops
Nitrogen source	Hairy vetch
Nitrogen scavenging	Winter rye
Provide soil organic matter	Winter rye
Erosion control	Winter rye
Improved soil structure	Brassicas
Control weeds	Winter rye, annual ryegrass, oats
Control diseases	Brassicas

Living Mulches (Cover Crop between Planted Rows)

Living mulches are an extension of cover crops used to decrease soil erosion, suppress weeds, improve soil structure and nutrient cycling, and in the case of legumes, supply nitrogen to a grain crop. Unlike cover crops that are killed before planting the grain crop, living mulches co-exist with the crops during the growing season and continue to grow after the crop is harvested. The living mulch can be an annual or perennial plant interseeded with a grain crop, or it can be an existing perennial grass or legume stand into which another crop is planted.

The integration of living mulch cover crops into a cropping system by relay cropping, over-seeding, inter-seeding, and double cropping may serve to provide and conserve nitrogen for grain crops, reduce soil erosion, reduce weed pressure, and increase soil organic matter content (Hartwig and Hoffman 1975). Before 1945, cover crops were used for these purposes and as a source of forage in integrated agricultural systems. Since 1945, the development of relatively inexpensive inorganic fertilizers and the concurrent widespread use of herbicides have caused a dramatic decline in the use of winter cover crops (Frye et al. 1985). Much of the research on cover crops has centered on the use of legumes to supply nitrogen for future grain crops (Ebelhar et al. 1984; Hargrove 1986; Mitchell and Teel 1977). But long before nitrogen was recognized as a problem in the environment, Morgan et al. (1942) documented the ability of cereal grain cover crops to reduce the leaching of nitrate and other nutrients from the root zone. A study by the National Soil Tilth Laboratory in Ames, Iowa found that planting a cover crop such as Rye grass between the rows of corn or soybeans can reduce nitrate export by 74%. Thus, the use of living mulches can address two distinctly different issues. In the case of legumes, cover crops supply organic nitrogen but also may use available soil nitrogen. Recent advances in soil testing permit the measurement of soil nitrogen with good correlation to crop growth needs that may allow us to reduce or even eliminate nitrogen applications when they are not needed (Fox et al. 1989; Griffin and Laine 1983; Magdoff et al. 1984; Ruby and Griffin 1985).

The beneficial effects of legume cover crops on nonlegume crops are not just the direct effect of nitrogen fixation. LaRue and Patterson (1981) showed the value of green manures in adding nitrogen to the soil and suggested that the cost of the fertilizer saved may serve as an indication of the economic value of nitrogen fixation. Frye et al. (1985) conducted an experiment to determine if growing a legume cover crop during the winter and using no-till practices for corn production could increase profits through higher grain yields or lower production costs. They found that the combination of hairy vetch and 100 kg N ha^{-1} of fertilizer nitrogen consistently gave the highest grain yields and economic returns. When compared with corn grown in corn residue, hairy vetch resulted in additional net returns of $199, $91, and $157 for the 0, 50, and 100 kg ha^{-1} fertilizer nitrogen rates. Thus, they concluded that hairy vetch with 100 kg ha^{-1} nitrogen was potentially more economical than corn grown in corn residue with 150 kg ha^{-1} fertilizer nitrogen.

From an agronomic perspective, high nitrate levels in groundwater due to leaching of nitrogen from the crop root zone represents a loss of a resource required for crop production. For corn grain production, recommended nitrogen fertilizer rates are based on utilization efficiencies of approximately 60%; however, suboptimal growing conditions can reduce this percentage to much lower levels (Chichester and Smith 1978; Stanford 1973). The relatively inefficient use of nitrogen in crop production has been recognized for some time (Allison 1955), but until the recent environmental concerns, the unused portion of applied nitrogen was largely ignored or assumed to be lost as a gas.

There are many legume species that could be considered for use in living mulch systems. They include:

- Alfalfa
- Kura clover
- Birdsfoot trefoil
- White clover

Fertilizer Applications Timing and Rates

Because nitrate is mobile and subject to leaching losses, and all forms of N are subject to conversion to nitrate, the longer the time that elapses between application of N and crop uptake, the greater the risk of nitrate loss. Applying N close to when the maximum N demand occurs reduces N loss risk (Meisinger and Delgado, 2002; Dinnes et al., 2002).

Figure 8 illustrates the typical uptake of nitrogen by corn. As we see rapid nitrogen uptake does not take place until the sixth week of growth. Fertilizer applied at the time of planting has a high potential to leach due to the inactivity of the young plant. Options to reduce nitrogen loss is to either time the major fertilizer application until the plants are actively growing or apply the fertilizer in several smaller applications throughout the growing season.

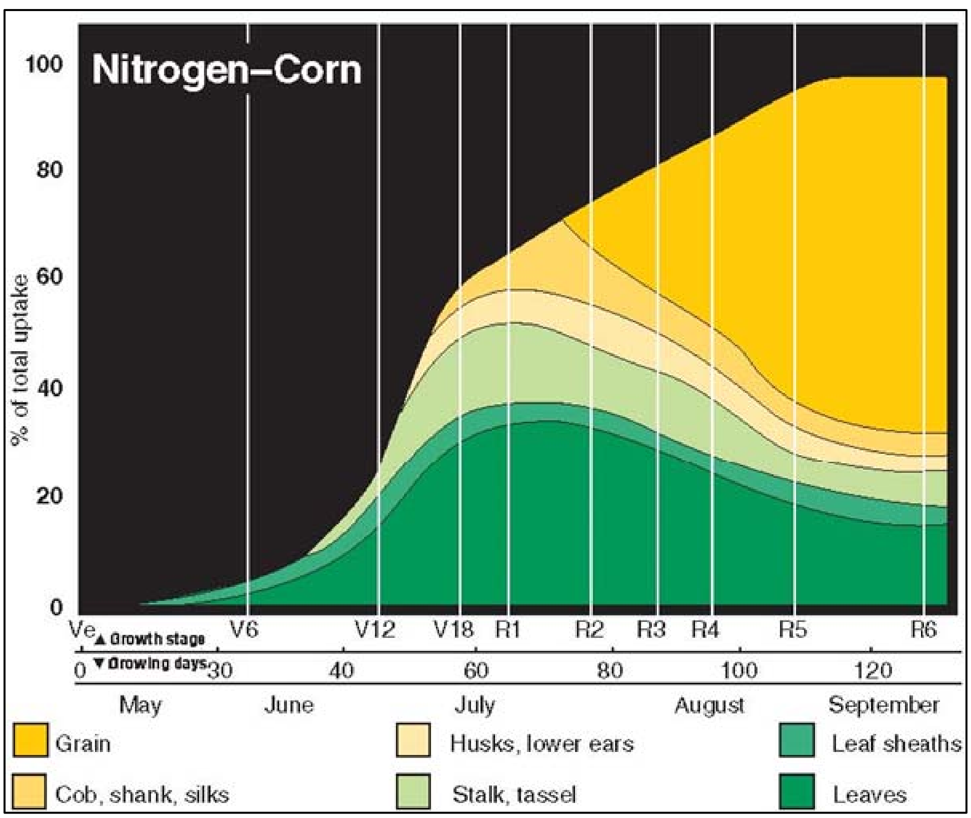

Figure 8 – Seasonal Uptake of Nitrogen Uptake by Corn

A later season fertilizer application is called a sidedressing. Sidedress application, usually made about four to six weeks after planting crops, provides N just prior to the time of most rapid N uptake by crops, reducing the risk of N loss through leaching or denitrification. There are some risks with sidedress application. If sidedress applications are delayed due to weather or labor and equipment shortage, yields may be reduced. Or if N is applied to dry soil that stays dry, N may not be adequately available, reducing yields (Voss et al. 1988) Applying N in split applications involving preplant application of part of crop N needs, followed by sidedress applications, allows efficient use of applied N and reduces some risk of yield reduction should sidedress applications be delayed. Split applications and sidedress applications also allow the use of better soil tests and tissue tests to better determine crop N needs.

Variable rate fertilizer applications promise to improve N use efficiency and reduce nitrate losses. Recent studies have documented that the optimal N rate for corn (Mamo et al., 2003; Scharf et al., 2005) and wheat (Fiez et al., 1994) vary spatially within fields. Historically, fields have been managed as a unit, with fertilizer rates uniform across the entire field. Due to variations in yield potential due to factors such as soil type (Oberle and Keeney, 1990), and variations in N availability due to factors such as soil organic matter (Clay et al., 1997; Soon and Malhi, 2005) or previous cropping or manure application differences, some areas of fields may receive too much N fertilizer, while other areas may receive too little. Using precise maps of soil variables and/or localized N needs determined from soil, tissue tests and remote sensing in season, N fertilizer can be applied at a variable rate to match the soil productivity potential or crop needs (Wiese et al. 2000; Redulla et al. 1996). Less leaching of nitrate below the root zone was documented in Washington potato production with variable rate N application (Whitley et al. 2000).

Nitrogen Trading

Nutrient trading programs are market based programs that involve the exchange of pollution allocations between sources. Most programs involve exchanges between different point sources. Less common are programs that allow point source (treatment plants) to nonpoint source trades. The concept is to pay farmers to grow crops that have lower nitrogen requirements (alfalfa, oats, peas, etc.)(Agricultural Research Service (ARS). Efforts have been established in Pennsylvania and Ohio, with municipalities and state environmental agencies trying the approach.

Wetland Treatment

The Wetlands Initiative, a not-for-profit organization whose charter, in part, is to restore and increase the area of wetlands that cover the Mississippi watershed, has coined the term “Nutrient Farming” where wetland treatment systems are used to strip nitrogen from stream water.

A constructed wetland is considered to be a complex bioreactor. A number of physical, chemical, and biological processes with microbial communities, emergent plants, soil, and sediments accumulated in the lower layer take place in the systems. Nitrogen removal is achieved by two major processes, physicochemical and biological treatment techniques. Biological nitrogen removal is primarily composed of a combination of aerobic nitrification and anaerobic denitrification (Figure 9). Phosphorus removal in wetland treatment systems is primarily through plant uptake and settling of solids.

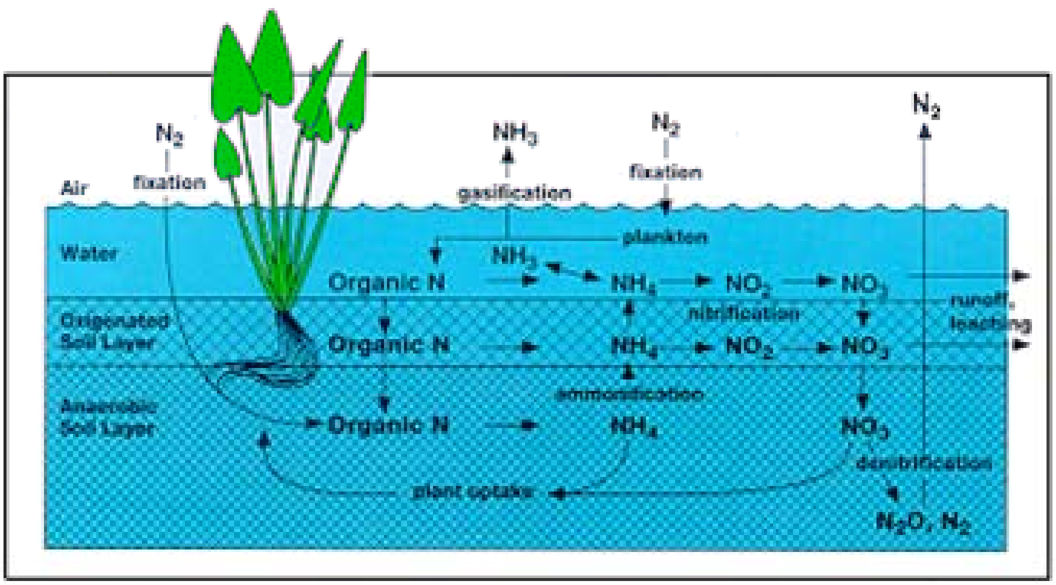

Figure 9 – Nitrogen Cycling in Treatment Wetlands

The FLILPRD in the early 2000's created four wetland treatment areas on Alto Creek. As outlined ***Alto Creek Monitoring Project Final Report: Fox Lake Dodge County*** (Hey and Associates, Inc. 2010), the largest treatment wetland at CTH F produced the following treatment results in Table 13 based on nine pair upstream and downstream samples.

Table 13- Mean Pollutant Removal at CTH F Treatment Wetland Based on Nine Pairs of Upstream and Downstream Samples

Pollutant	Mean Removal
Total suspended solids	66.1 %
Total Kjeldahl Nitrogen (TKN)	76.8%
NO_2/NO^3	35.9%
Total Phosphorus	61.1%
Dissolved Phosphorus	65.5%

Based on work by the Wetland Initiative (1999), treatment wetland systems needs to be about 3% to 5% of the watershed area. For the Dew Creek watershed (3.650 ac) as a whole we would need approximately 109 to 182 acres of treatment surface.

END OF DRAIN TILE TREATMENT SYSTEMS (BIOREACTORS)

To make farming operations productive and viable, most agricultural land located in in the Drew Creek watershed is artificially drained or tiled. As a result of the tile systems, high concentrations of soluble nutrients like nitrate-nitrogen are reaching the local stream and Fox Lake.

Edge-of-field treatment systems, such as buffer strips, have been installed in many places throughout the country to reduce contaminant loads in receiving waters. However, as research is showing, outside of large rain events, most water leaving drained agricultural fields is through subsurface tile flow and is never coming in contact with these filter systems at the surface. To capture subsurface flow, current practices such as wetlands and retention ponds exist, but in addition to their large costs they also require land to be taken out of production. A new practice gaining interest is the use of bioreactors to reduce the amount of nitrate-nitrogen reaching surface waters.

A bioreactor is essentially a buried trench or tank filled with a carbon source (commonly wood chips), through which tile water is allowed to flow. The carbon source provides material upon which microorganisms can colonize. Using wood chips as a food source, the microorganisms begin breaking down nitrate in the water and expelling the nitrate as di-nitrogen gas (N_2), a primary atmospheric component.

The bioreactor has no adverse effects on crop production and is designed in a way that it does not restrict drainage. A control structure determines the amount of tile flow that is diverted into the bioreactor. During periods of high flow, excess water bypasses the bioreactor and continues to flow through the existing field tile.

Placement of wood chips or other organic carbon sources around the tile to provide a media for de-nitrification (breakdown of nitrates) can reduce nitrate export by 65%.

When used as part of a suite of solutions for achieving water quality goals in an agricultural watershed, the bioreactor offers many advantages for treating sub-surface drainage:

- In most locations, does not necessitate taking any land out of production, as it can be installed below filter strips at the edge of the field.
- Begins removing nitrate immediately upon completion with the first water flow.
- Can be targeted for placement to optimize impact.
- Is readily accepted by producers.
- Can be installed in landscapes in which wetlands cannot be built.
- Offers a cost savings compared with wetland installation, so, combined with targeted wetlands, can reduce the cost of subsurface drainage treatment in a watershed.

Challenges for these types of systems are:

- Finding available land.
- Cost of installation.
- Understanding of the effective period for the carbon source and when it needs to be replaced.
- Knowing under what environmental conditions they work and don't work.

An important factor to consider in any end of pipe system will be the performance under different flow rates. As hydraulic residence time decreases, removal rates decline. The first step to explore this option is to identify locations of critical tiles.

Figure 10 illustrates the concept of a field tile bioreactor.

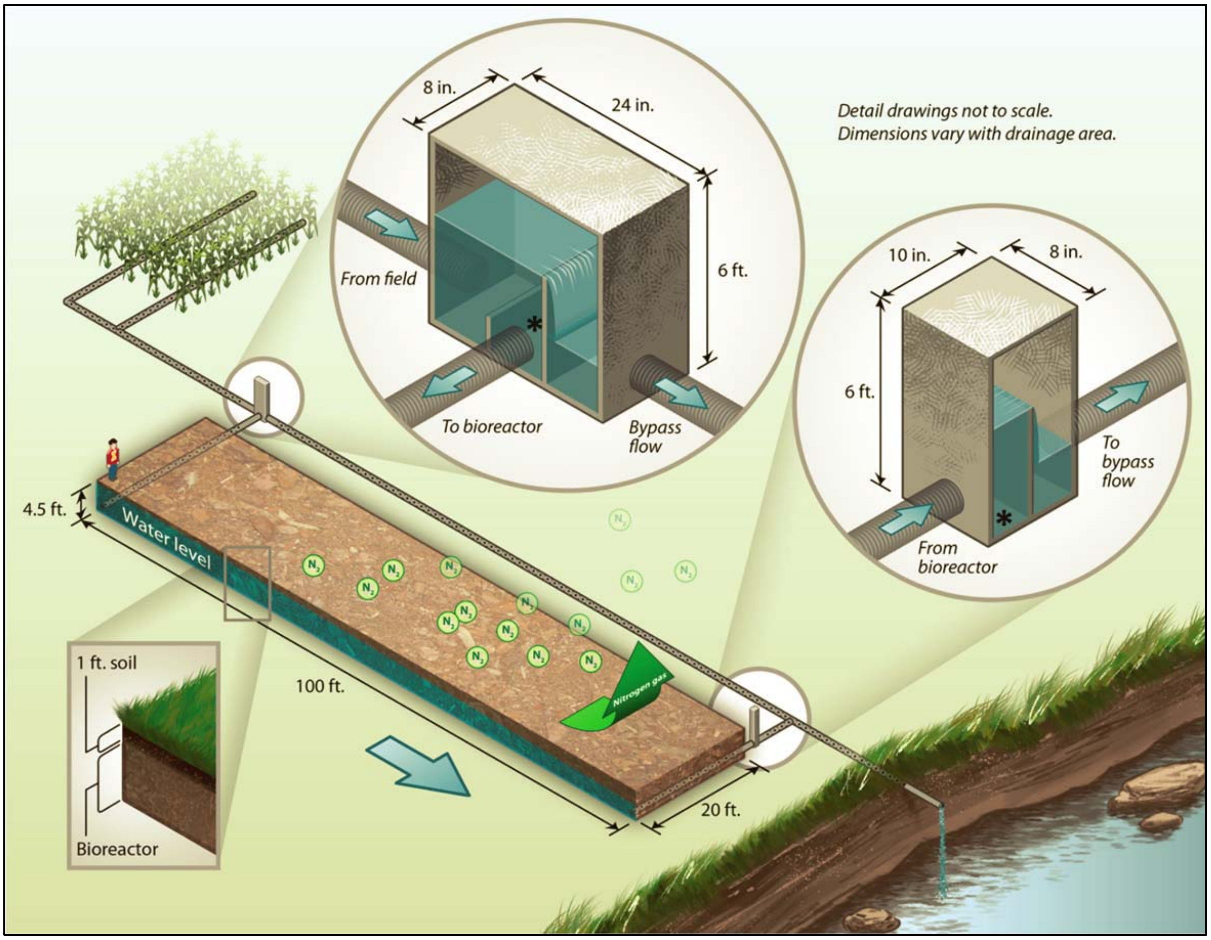

Figure 10 - Illustration of the Concept of a Field Tile Bioreactor.
(Diagram courtesy of Matt Helmers and Laura Christianson, Iowa State University. Illustration by John Peterson.)

The wood chips in the bioreactor should last for 10 to 20 years. At that time the wood chips can be replaced to restore the bioreactor function, or if the producer chooses not to replace the chips, the stop logs can be removed from the control structures and drainage will continue normally. The average cost of field scale bioreactors installed by the Iowa Soybean Association for 40 to 80 acre drainage areas have averaged $8,000.

The USDA NRCS in Iowa has an interim conservation practice standard for denitrifying bioreactors (Interim IA-747) that provides some design criteria. A standard for Wisconsin is not yet available. The Iowa interim standard calls for a design capacity to treat a flow equivalent to a drainage coefficient of 1/8″ per day or 20% of the calculated peak flow from the drainage system. Bioreactors should be designed to meet the capacity requirements with a hydraulic retention time (the time it takes for water to pass through the bioreactor) sufficient to achieve the desired nitrate reduction. Current recommendations are for a retention time of 4 to 8 hours.

RECOMMENDATIONS FOR FUTURE ACTION

INTRODUCTION

Based on monitoring data, Drew Creek carries high concentrations and loadings of nitrogen and phosphorus. While most local farmers are practicing nutrient management planning, these practices are not protecting the surface and groundwater in the Drew Creek Watershed. To meet the goals of this plan to protect Fox Lake and the local shallow groundwater drinking supply, new techniques for crop management need to be implemented. The alternatives section of this report outlines some of the innovative approaches that are being explored by the U. S. Department of Agriculture. However, many of these practices are not at the point of being generally accepted by the local farming community. Therefore, the advisory committee came up with a phased approach to nutrient management. The first phase would be implement known practices on local farms and install two wetland filters to reduce pollutants until better practices are available. Second would be to conduct a private well sampling programs to further understand the extent of groundwater contamination with nitrites in the watershed and conduct a public education program of local residents. Third, is to use the Fox Lake Correctional Facility farm as a demonstration site to explore new cropping and tile management practices.

IMPLEMENTATION OF EXISTING PRACTICES

Under this element, the Dodge County Land Conservation Wisconsin Department of Natural Resources (DNR), and Natural Resource Conservation Service (NRCS) will continue to work with local farmers to implement existing conservation practice such as nutrient management planning, manure management, buffer strips, and conservation tillage. To protect Fox Lake from the existing sources of nutrients, two wetland treatment systems would be installed on the upper branches of the watershed.

Figure 11 illustrates the location of the upper East and West Tributaries of Drew Creek. Areas of the tributaries that include existing wetland and hydric soils are shown in Figure 12. These areas could be converted to treatment wetlands by using ditch plugs similar to those used in the Alto Creek Watershed. Tables 14 and 15 summarize the land use and soil types in the East and West Tributaries of Drew Creek.

Table 14 – Land Use and Soils in Drew Creek West Tributary

Land use	Soil group	Area(acres)
Water	B	7.6
Water	D	3.7
Agriculture	B	973.3
Agriculture	D	71.8
HD-Residential	B	38.2
LD-Residential	B	29.3
LD-Residential	D	0.7
Grass/Pasture	B	448.5
Grass/Pasture	D	7.9
Forest	B	21.2
Forest	D	0.4
Total Area		**1602.6**

Table 15– Land Use and Soils in Drew Creek East Tributary

Land use	Soil group	Area(acres)
Water	B	8.8
Water	D	49.6
Agriculture	B	744.2
Agriculture	D	61
HD-Residential	B	24.2
LD-Residential	B	20.5
LD-Residential	D	0.4
Grass/Pasture	B	160.7
Grass/Pasture	D	16.7
Forest	B	10.8
Forest	D	0.9
Total Area		**1097.8**

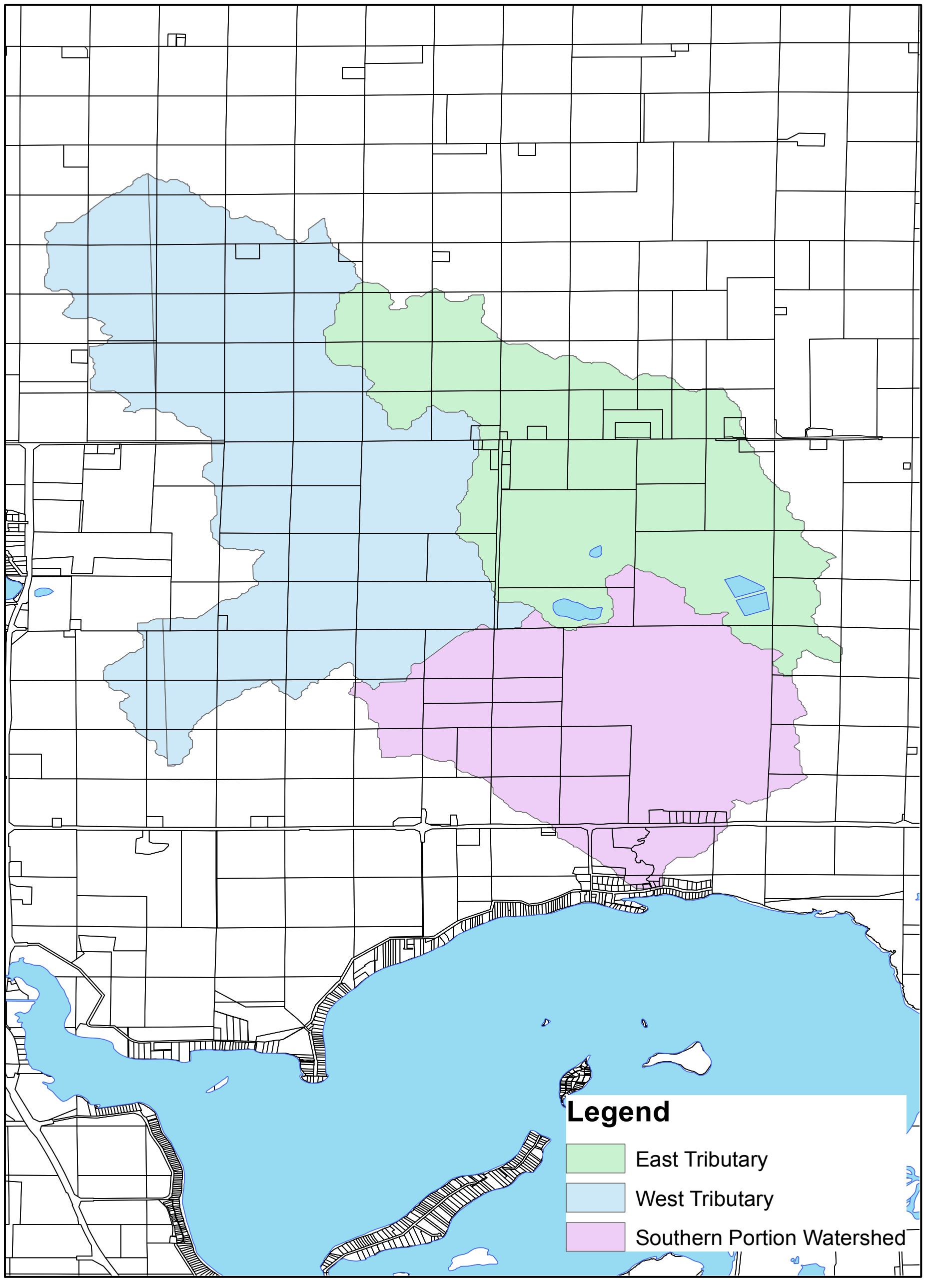

Figure 11 – Locations of Upper East and West Tributaries of Drew Creek

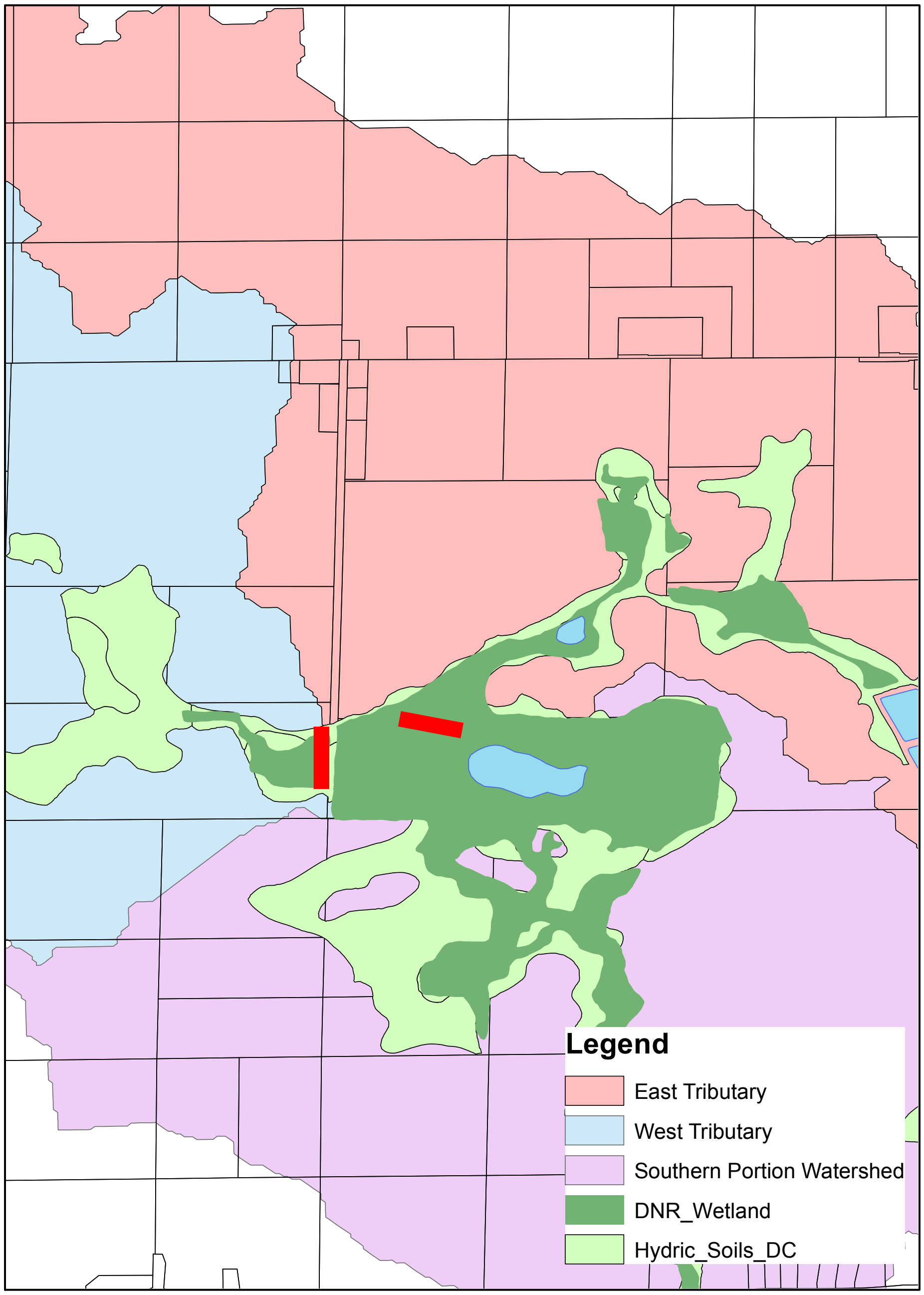

Figure 12 – Potential Locations for Wetland Treatment Systems Drew Creek Upper East and West Tributaries.

PRIVATE WELL TESTING PROGRAM

Nitrite levels, well are above the state drinking water standard have been documented in Drew Creek and the private wells near Fox Lake that have been tested. With this knowledge, the advisory committee recommended that additional sampling of private wells be conducted to determine the full geographic extent of the contamination and public health risk. The sampling would be conducted by asking local residents to voluntarily sample their wells and bring samples to FLILPRD for analysis at the University of Wisconsin – Stevens Point Lab.

FOX LAKE CORRECTIONAL FACILITY DEMONSTRATION FARM

To identify and demonstrate the nutrient management practices that will be feasible in the Drew Creek Watershed and throughout Dodge County, it is recommended that the Fox Lake Correctional Facility Farm be used as a demonstration site. As a demonstration site the farm has several advantages:

1. It is state owned property and could be used to show that the state of Wisconsin is a leader in farm management.
2. As state owned property easements would not be necessary, only intergovernmental agreements between the parties.
3. The property is already managed by a professional staff from Badger Industries, a division of the State Department of Corrections who could implement the various management practices.
4. The property is internally drained through a single drain tile which could be easily be monitored.

The site would be set up as a partnership between the Department of Corrections, University of Wisconsin, Dodge County Land Conservation Department and the Natural Resource Conservation Service. The farm would evaluate innovative nutrient management practices and document their success and failure. The project would monitor crop yields, nutrient application rates, and surface runoff and groundwater inputs to document the cost and benefits of the targeted practices.

PLAN IMPLEMENTATION

Table 16 summarizes the estimated first three year costs to implement the demonstration farm and private well sampling program. Cost for the wetland treatment systems will need to be developed through further specific site planning.

Responsible parties for the project implementation and their responsibilities are as follows:

- Department of Corrections:
  - Allow use of Fox Lake Correctional Facility Farm for demonstration projects.

- Natural Resources Conservation Service and Dodge County Land Conservation Department:
  - Technical Assistance
  - Public Education

- Wisconsin Department of Natural Resources:
  - Technical Assistance
  - Financial Assistance (Grants)
    - TRM
    - Lake Protection

- Fox Lake Inland Lake Protection and Rehabilitation District:
  - Assistance with grant applications
  - Potential funding opportunities
  - Public education
  - Wetland construction

- University of Wisconsin:
  - Monitoring
  - Private well and soil testing
  - Technical assistance

- Dodge County Land Conservation Department
  - Technical Assistance
  - Public Education

POTENTIAL FUNDING SOURCES FOR MANAGEMENT

Wisconsin DNR Grants

- Lake Planning Grant (max: $25,000)
- Lake Protection Grant (max:
- Targeted Runoff Management Grant (max: $1 million)
- River Protection Planning grants (max: $10,000)
- River Protection Management (max: $50,000)
- Urban Nonpoint Source and Storm Water Grants (max: Planning: $85,000; Construction: $150,000)

Federal Grant Programs

- Stewardship Incentive Program (SIP)
- Environmental Quality Incentives Program (EQIP)
- Conservation Security Program (CSP)
- Partners for Fish & Wildlife
- Land & Water Resource Management (LWRM) Plan Implementation
- Watershed Rehabilitation Program
- Targeted Watershed Grants Program
- Mississippi River Initiative Program

Table 16 – Estimated Costs to Implement Proposed Recommendations for a Three Year Period

Activity	Organization									Sub-Total	Total
	Dept. of Corrections		UWM		ERP	SLOH	FLLPRD	Extension	Contractor		
	Capital	O&M	Capital	O&M	O&M						
1. Demonstration Nutrient Management											
* The demonstration planting	$14,400									$14,400	
* Monitoring of nutrient applications rates		$2,000								$2,000	
* Monitoring of crop yields and plant health	$10,000	$2,000								$12,000	
* Soil chemistry (consulting)									$8,000	$8,000	
* Monitoring of the tile outlet from the field demonstration area(s)			$12,000	$15,000		$13,000				$40,000	
* Monitoring of the shallow groundwater			$12,000	$10,000		$6,500				$28,500	$104,900
2. Installation of a bio-filter on the main tile system											
* Design of bio-filter					$6,000					$6,000	
* Installation of bio-filter									$30,000	$30,000	
* Monitoring of the bio-filter's performance (inflow/outflow)			$12,000	$15,000		$13,000				$40,000	$76,000
* Maintenance											
3. Stream monitoring											
* Sonde CTH-F / upstream			$8,000	$15,000		$26,000				$49,000	
* Grad samples (5 sites)			$1,000	$10,000		$28,800				$39,800	$88,800
4. Drinking water sampling			$500							$500	$500
5. Weather (precipitation/wind)											
6. Annual Reports											
* Water budget					$5,000					$5,000	
* Nutrient budget				$5,000						$5,000	
* Crop production	$5,000									$5,000	
* Report				$5,000	$5,000					$10,000	$25,000
7. Public Education								$8,000		$8,000	$8,000
* Newsletters											
* Local tours											
* Technical Publications											
* Coordination with other groups											
Sub-Totals	$29,400.00	$4,000.00	$45,500.00	$75,000.00	$16,000.00	$87,300.00	$0.00	$8,000.00	$38,000.00	$303,200.00	

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APPENDIX A

Agendas and Minutes of Advisory Committee Meetings

Agenda

Drew Creek Watershed Management Plan

Date: July 11, 2012
Time: 10:00 AM till Noon
Location: Fox Lake Inland Lake Protection and Rehabilitation District Office (Fox Lake Town Hall), W10543 HWY F, Fox Lake, WI 53933

<u>Agenda:</u>

1. Introductions.

2. Overview of watershed, historic water quality data and past management activities.

3. Overview of planning process and goals of project.

4. Identification of potential watershed management alternatives to evaluate as part of plan.

5. Identification of team assignments.

6. Set potential date for second meeting.

Agenda Second Meeting

Drew Creek Watershed Management Plan

Date: November 14, 2012
Time: 10:00 AM till Noon
Location: Fox Lake Inland Lake Protection and Rehabilitation District Office (Fox Lake Town Hall), W10543 HWY F, Fox Lake, WI 53933

Agenda:

1. Introductions.
2. Overview of the results of stream tour on October 17, 2012.
3. Identification of recommended watershed management activities.
4. Review potential locations for some management activities.
5. Identify potential funding sources for management.
6. Set date for third meeting.

Agenda Third Meeting

Drew Creek Watershed Management Plan

Date: November 14, 2012
Time: 10:00 AM till Noon
Location: Fox Lake Inland Lake Protection and Rehabilitation District Office (Fox Lake Town Hall), W10543 HWY F, Fox Lake, WI 53933

Agenda:

1. Introductions.

2. Overview of the results of the stream tour on October 17, 2012.

3. Identification of recommended watershed management activities (Group Discussion).
   a. Management practices
   b. Locations of demonstration sites
   c. Monitoring activities
   d. Public education needs
   e. Agency roles
   f. Funding opportunities

4. Set date for final meeting (If needed).

Minutes:
Second Drew Creek Watershed Management Plan Advisory Committee Meeting September 12, 2012

Potential Sources of Nitrogen and Phosphorus in Drew Creek Watershed

1. Fox Lake Correctional Facility WTP contributes only 1.5% of the annual input of water and less than 0.5% of the total nitrogen inputs to the watershed.
2. Major source of nutrients appears to be agricultural inputs, including private farms and the Fox Lake Correctional Facility farmland.
3. Groundwater sources appear to be 2/3 of the annual nutrient inputs to Drew Creek.
4. While many farms maybe utilizing nutrient management plans today, we may have large amounts of legacy nutrients in the system that may take decades to leach out of the system.
5. The soil test laboratory at the University of Wisconsin has published summaries of soil test data for 1968 to 1994. These data include the University data plus the certified private laboratories in the state. The data show that the state mean for Bray P has increased from 34 ppm for 1968-73 to 50 ppm for 1990-94. The 1990-94 data show one county with a mean value of more than 150 ppm and 4 counties with mean values in the range of 75-150 (the four counties includes Dodge County).
6. It is well known that soils will retain phosphorus for long periods of time.
7. Nitrates and nitrites are very soluble in water and tend to be easily depleted for surface soils.
8. So the question is where is all of the nitrogen being retained? Are the high nitrogen concentrations being measured in Drew Creek from recent applications or legacy pollution form past decades?

Review of Existing Data and Identification of Missing Information

Existing Data:

1. Stream data UWM 2004/05
2. Stream data FLILPRD 2008
3. Private well data UW-Stevens Point
4. Effluent discharge data Fox Lake Correctional Facility
5. Fox Lake Correctional Facility groundwater data
6. NRCS soils mapping (to 5-feet)
7. Private well data
8. 2-foot contour maps
9. Existing wetland maps
10. Parcels maps

Missing Data:

1. Well Boring Logs Fox Lake Correctional Facility Monitoring Wells
2. Nutrient Management Plans / Conservation Plans
3. Fox Lake Correctional Facility
4. Private Farms
5. Locations of Drain Tiles
6. Land spreading of municipal waste, Industrial waste

Identification of Potential Watershed Management Alternatives

These include adding rotational complexity to cropping systems to:

- improve N capture by crops,
- providing farmers with decision support tools for better predicting crop fertilizer N requirements,
- improving methods for optimizing fertilizer timing and placement,
- and developing watershed-level strategies to recapture N lost from fields.

Management alternatives fall into the following categories:

1. **"Cover Crops"** - A study by the National Soil Tilth Laboratory in Ames, Iowa found that planting a cover crop such as Rye grass between the rows of corn or soybeans can reduce nitrate export by 74%.
2. **"Nitrogen Trading"** - The concept is to pay farmers to grow crops that have lower nitrogen requirements (alfalfa, oats, peas, etc.)(Agricultural Research Service (ARS).
3. **"Nitrogen Reuse"** - The stream flow is high in nitrogen, why not reuse this nitrogen by capturing the water in small reservoirs and spray irrigating it back onto the fields.
4. **"Nutrient Farming"** - The Wetlands Initiative, a not-for-profit organization whose charter, in part, is to restore and increase the area of wetlands that cover the Mississippi watershed, has coined the term "Nutrient Farming" where wetland treatment systems are used to strip nitrogen from stream water. Other forms of nitrogen farming may include planting crops that take up large amounts of nitrogen such as popular trees.
5. **"End of Pipe Treatment Systems"** - Placement of wood chips or other organic carbon sources around the tile to provide a media for de-nitrification (breakdown of nitrates) can reduce nitrate export by 65%.
6. "**Nutrient Management Based on Nitrogen not Phosphorus and on Nitrogen Soil Sampling**" - Using soil samples to determine nitrogen needs not an assumption that each year you start with zero in the soil.
7. **"Split Nitrogen Applications" –** Appling annual nitrogen over several applications during the growing season.
8. **" Biological Treatment Plant" –** Use of a biological de-nitrification plant at the outlet of Drew Creek.

A group of committee members agreed to tour Drew Creek in Mid-October to look for potential locations to try some of the above alternatives.

Identify Potential Funding Sources for Management

Wisconsin DNR Grants:

1. Lake Planning Grant (max: $25,000)
2. Lake Protection Grant (max:
3. Targeted Runoff Management Grant (max: $1 million)
4. River Protection Planning grants (max: $10,000)
5. River Protection Management (max: $50,000)
6. Urban Nonpoint Source and Storm Water Grants (max: Planning: $85,000; Construction: $150,000)

Federal Grant Programs:

1. Stewardship Incentive Program (SIP)
2. Environmental Quality Incentives Program (EQIP)
3. Conservation Security Program (CSP)
4. Partners for Fish & Wildlife
5. Land & Water Resource Management (LWRM) Plan Implementation
6. Watershed Rehabilitation Program
7. Targeted Watershed Grants Program
8. Mississippi River Initiative Program

Next Meeting: November 14, 2012 10:00 AM till Noon

APPENDIX B

University of Wisconsin-Milwaukee and Hey and Associates, Inc.
Drew Creek Monitoring Data: 2005 - 2009

Site	Site No.	Source	Date	Flow (MGD)	Concentration (mg/l)						Loadings (lbs/day)					E-Coli
					TP	SRP	TSS	TKN	NO2+ NO3	TN	TP	SRP	TSS	TKN	NO_2+N O_3	
Drew Creek at HWY F	DR1	UWM	5/18/2006	2.81	**0.163**	0.112	13	0.78	**14.40**	15.18	3.82	2.63	304.79	18.29	428.76	
		UWM	5/25/2006	2.39	**0.057**	0.041	5	0.31	**18.00**	18.31	1.14	0.82	99.82	6.19	123.54	
		UWM	5/31/2006	2.40	**0.097**	0.062	9	0.29	**18.70**	18.99	1.94	1.24	180.30	5.81	116.38	
		UWM	6/13/2006	2.16	**0.068**	0.041	7	0.34	**21.40**	21.74	1.22	0.74	125.84	6.11	109.88	
		UWM	6/19/2006	1.96	**0.087**	0.056	9	0.56	**21.50**	22.06	1.42	0.92	147.41	9.17	150.23	
		Hey	8/5/2008	7.00	**0.102**	0.07	7.00	0.55	**15.90**	16.45	5.95	4.14	408.49	32.10	1872.96	**866.00**
		Hey	9/9/2008	6.66	**0.071**	0.04	7.00	0.52	**18.10**	18.62	3.94	2.00	388.93	28.89	1605.26	129.00
		Hey	10/9/2008	4.45	**0.090**	0.05	13.00	0.67	**14.50**	15.17	3.34	1.74	482.35	24.86	922.39	**2419.00**
		Hey	7/14/2009	1.80	**0.067**	0.04	8.00	0.27	**16.70**	16.97	1.01	0.54	120.10	4.05	60.85	
			Mean	3.51	**0.089**	0.06	8.67	0.48	**17.69**	18.17	2.64	1.64	250.89	15.05	598.92	1138.00
Drew Creek at Lake Emily Road	DR2	UWM	5/18/2006	3.58	**0.078**	0.05	6	0.52	**16.30**	16.82	2.33	1.49	179.27	15.54	464.23	
		UWM	5/25/2006	2.51	**0.037**	0.026	4	0.48	**21.30**	21.78	0.77	0.54	83.69	10.04	210.10	
		UWM	5/31/2006	2.48	**0.299**	0.066	35.5	1.64	**19.80**	21.44	6.20	1.37	735.72	33.99	704.39	
		UWM	6/13/2006	1.65	**0.042**	0.025	3	0.34	**23.80**	24.14	0.58	0.34	41.28	4.68	64.37	
		UWM	6/19/2006	5.10	**0.033**	0.049	2	0.49	**24.00**	24.49	1.40	2.08	85.03	20.83	885.65	
		Hey	8/5/2008	12.44	**0.084**	0.06	7.00	0.38	**18.30**	18.68	8.72	5.81	726.41	39.43	4092.18	**225.00**
		Hey	9/9/2008	7.50	**0.058**	0.03	10.00	0.35	**19.20**	19.55	3.63	1.69	625.53	21.89	1369.49	70.00
		Hey	10/9/2008	4.74	**0.062**	0.03	4.00	0.48	**16.10**	16.58	2.45	1.34	158.18	18.98	750.65	133.00
		Hey	7/14/2009	0.00	**0.066**	0.03	13.00	0.15	**17.80**	17.95	0.00	0.00	0.00	0.00	0.00	
			Mean	4.45	**0.084**	0.04	9.39	0.54	**19.62**	20.16	2.90	1.63	292.79	18.38	949.01	142.67
Drew Creek at	DR3	UWM	5/18/2006	0.96	**0.180**	0.115	10	0.78	**18.90**	19.68	1.44	0.92	79.73	6.22	49.59	

Site	Site No.	Source	Date	Flow (MGD)	Concentration (mg/l)						Loadings (lbs/day)					E-Coli
					TP	SRP	TSS	TKN	NO2+ NO3	TN	TP	SRP	TSS	TKN	NO_2+NO_3	
Parish Rd.		UWM	5/25/2006	0.94	**0.074**	0.048	6	0.41	**20.40**	20.81	0.58	0.38	47.06	3.22	25.22	
		UWM	5/31/2006	0.55	**0.626**	0.032	198	3.4	**21.70**	25.10	2.85	0.15	901.74	15.48	70.52	
		UWM	6/13/2006	0.17	**0.054**	0.0378	2	0.24	**21.10**	21.34	0.08	0.05	2.87	0.34	0.49	
		UWM	6/19/2006	0.55	**0.066**	0.04	2	0.54	**21.60**	22.14	0.30	0.18	9.20	2.48	11.42	
		Hey	8/5/2008	1.94	**0.197**	0.27	3.00	0.58	**13.70**	14.28	3.18	4.40	48.48	9.37	151.44	196.00
		Hey	9/9/2008	1.52	**0.127**	0.03	29.40	0.63	**17.70**	18.33	1.61	0.43	371.68	7.96	100.69	167.00
		Hey	10/9/2008	2.54	**0.063**	0.05	3.00	0.52	**16.50**	17.02	1.34	0.95	63.65	11.03	234.09	32.00
		Hey	7/14/2009	0.00	**0.078**	0.04	10.00	0.30	**15.30**	15.60	0.00	0.00	0.00	0.00	0.00	
			Mean	1.02	**0.163**	0.07	29.27	0.82	**18.54**	19.37	1.26	0.83	169.38	6.24	71.50	131.67
Prison Creek	DR4	Hey	8/5/2008	2.00	**0.071**	0.04	22.00	0.29	**19.30**	19.59	1.19	0.68	367.29	4.84	80.83	121
		Hey	9/9/2008	5.98	**0.055**	0.03	14.00	0.45	**20.20**	20.65	2.74	1.35	698.52	22.45	1120.24	111.00
		Hey	10/9/2008	0.86	**0.062**	0.03	20.00	0.36	**18.10**	18.46	0.44	0.21	142.95	2.57	18.39	34.00
		Hey	7/14/2009	0.90	**0.068**	0.03	34.00	0.21	**19.10**	19.31	0.51	0.21	255.20	1.58	11.83	
			Mean	2.44	**0.064**	0.03	22.50	0.33	**19.18**	19.50	1.22	0.61	365.99	7.86	307.82	88.67
Drew Creek on Prison Grounds	DR6	Hey	9/9/2008	6.06	**0.058**	0.03	8.00	0.22	**18.90**	19.12	2.93	1.62	404.13	11.11	561.41	88.00
		Hey	10/9/2008	1.81	0.079	0.04	16.00	0.62	**15.50**	16.12	1.19	0.57	240.92	9.34	140.57	**517.00**
		Hey	7/14/2009	1.20	0.055	0.03	7.00	0.14	**17.70**	17.84	0.55	0.33	70.06	1.40	14.02	
			Mean	3.02	0.064	0.03	10.33	0.33	**17.37**	17.69	1.56	0.84	238.37	7.28	238.67	302.50

Sample Locations: