
Source Water Protection and Watershed Management: A Rural and Water Supply Perspective

Jim Rutherford
Watershed Conservationist
McLean County SWCD

Rick Twait
Superintendent of Water Purification
City of Bloomington
Bloomington, IL

The City of Bloomington Water Treatment Plant produces an average of 11.5 million gallons per day and serves over 70,000 people. Bloomington uses lake water to supply the treatment plant. Activities in the predominately agricultural watersheds affect the conditions in the lakes and the quality of the water entering the plant.

The operating philosophy of the water plant considers the watershed part of the treatment train. The City has a long history on involvement in watershed management and has actively promoted cooperative efforts between various agencies, universities, private organizations, and landowners. A major cooperater in the efforts is the McLean County Soil and Water Conservation District.

Bloomington obtains its water from two man made reservoirs. The lakes, Bloomington and Evergreen, are located approximately 14 miles north of the city. The tributaries to the two reservoirs are part of the Mackinaw River drainage, which eventually enters the Illinois River.

Lake Bloomington is a 635 acre impoundment with a drainage area of 69.5 square miles for a 70 to 1 ratio of drainage area to lake surface area. The normal pool capacity for Lake Bloomington is 8,760 acre/feet of storage.

Evergreen Lake is a 900 acre impoundment with a 41.1 square mile drainage area for a 29 to 1 ratio of drainage area to lake surface area. At normal pool, Evergreen Lake has 15,480 acre/feet of storage. In response to the drought of 1988-89, the City of Bloomington raised the spillway at Evergreen Lake by five feet in 1992. This increased its storage capacity by 36%.

With Lake Bloomington having the 69% larger drainage area, but Evergreen Lake having the 77% larger storage capacity, the two lakes act very differently in the way they are affected by runoff.

The great majority of the watershed area for both lakes is used for agricultural production. In most years, McLean County leads the State of Illinois in both total corn production and total soybean production. Having lakes in these extremely fertile and highly cultivated agricultural areas has created problems for the City of Bloomington. The two main impacts have been the

effects of agricultural chemicals and the siltation that has occurred from erosion of agricultural lands.

In 1986, the City requested assistance from the Soil Conservation Service (SCS; now Natural Resource Conservation Service, NRCS) to perform an inventory and needs assessment for both lakes. A PL-566 sediment basin project was proposed for Evergreen Lake.

In 1988, a prolonged drought severely strained the water resources provided by the two reservoirs. When plans were made to raise the spillway at Evergreen Lake by five feet to increase storage capacity, the PL-566 project was then switched to Lake Bloomington. The SCS developed the Lake Bloomington Watershed Plan/Environmental Assessment during 1988-1991. The plan was approved and signed by the City, SCS, McLean County Soil and Water Conservation District (SWCD), and the Illinois Department of Agriculture.

The PL-566 project included two sediment basins for the tributaries feeding Lake Bloomington. The SCS agreed to design the structures and pay one half of the cost, estimated at 1.9 million dollars. Heavy flooding throughout the Midwest in 1993 resulted in the diversion of SCS resources from projects like the Bloomington sediment basin designs to more urgent tasks. The SCS then requested that the City perform the design work.

Since improvements in water quality and sedimentation of the lakes required working on a watershed scale basis, City staff knew they needed assistance from people and organizations that were currently dealing with the landowners and farm operators. In 1991, Jim Rutherford, a long time NRCS and McLean County Soil and Water Conservation District employee, was employed through the SWCD as Watershed Conservationist for both lakes. The Watershed Conservationist position is funded by the City to promote conservation within both watersheds and to act as liaison with the many people, agencies, and groups that form the local watershed community.

The City has had significant problems through the years with nitrates. Historically, nitrate levels have exceeded the EPA limit of ten parts per million almost every spring for as long as records have been kept. Prior to 1992, the City simply published public notice each spring when the nitrate limit was exceeded and removed the notification when the drinking water went below the maximum contaminant level.

In 1992, the City entered into a consent agreement with the Illinois EPA to eliminate the annual excursions above the ten parts per million limit for nitrates. The agreement basically required that the City either manage its facilities in such a way as to maintain the water supplied to the customers below the maximum contaminant level for nitrates or within five years add additional treatment processes to ensure that finished water nitrates stayed below the maximum contaminant level.

The City's consultant, Consoer Townsend Envirodyne, performed a study in 1993 that indicated it would cost approximately \$3,000,000.00 to add ion exchange equipment to the treatment process to guarantee that the nitrate level would stay within the EPA guidelines. The high cost of disposing the waste stream from the ion exchange process, along with the fact that the process would only be needed for limited times during the year, made the option unattractive. The City

decided to investigate the possibility of managing its lakes and their watersheds in such a fashion as to reduce nitrate levels to levels where ion exchange was unnecessary.

The first step was to see if the two lakes, which have different drainage area to storage capacity ratios, had differing nitrate levels. Evergreen Lake tended to have water with significantly lower nitrate levels than Lake Bloomington, especially during spring runoff time. By pumping water from Evergreen Lake during periods when nitrate concentrations in Lake Bloomington exceed the 10 mg/l standard, the City has kept nitrate levels under the maximum contaminant level since 1992.

Examination of the existing historical nitrate data shows that the highest nitrate levels came after the drought of 1988-89. High levels of nitrates, due to lack of uptake by crops, accumulated in the soil and leached out quickly with the first significant rainfall after the drought. Low water levels provided little dilution for the high nitrate runoff entering the reservoirs. Future droughts may result in similar conditions.

City staff had assumed that the nitrate problem was mainly related to agricultural fertilizer. Other possible sources included onsite waste system discharges from villages and homes within the watershed and from residences around Lake Bloomington. Relative contributions of the various possible sources needed to be determined before any possible solutions could be implemented.

In 1992, the City asked the SWCD and Watershed Conservationist to locate sites and get permission to sample from different locations in the Money Creek watershed. Money Creek is the main tributary to Lake Bloomington. Samples were collected and analyzed for nitrate by City staff from drainage tile outlets, surface runoff, and from various points along Money Creek.

The sampling program expanded in 1993, when the City entered into an agreement with Dr. Ken Smiciklas, of the College of Agriculture at Illinois State University, to study the nitrate problem. Students from ISU collected samples from the expanded sites and delivered them to the water treatment plant for analysis. The results from the sampling program showed that the most of the nitrates entering Lake Bloomington came from field tiles (1). The City resumed sampling responsibilities in 2003.

In order to keep the watershed stakeholders involved and informed about the study, Professor Aaron Moore, also of the College of Agricultural at Illinois State University, sent out a semi-annual newsletter. He also performed annual surveys of the farm operators throughout the watershed for their current and intended farming practices, including details of their proposed nitrogen fertilizer application. Group meetings with people from the watershed have also been held to answer their questions and give them information about the study.

The next phase of with the study with Illinois State University was to determine if different agricultural practices could help reduce the amount of nitrates leaving the fields through the drainage tiles. In early spring, 1997, the City, with the McLean County Soil and Water Conservation District and ISU, installed individual tile drainage networks for six 5-acre test plots in a farm field next to City property at the upper end of Lake Bloomington. The test plots were developed on a privately owned field that was previously only minimally tiled.

The City entered into an agreement with the landowner and farm operator to continue the traditional corn/soybean planting rotation, but to vary the timing, rate, and use of nitrification inhibitors on individual test plots. The treatments are fall application of anhydrous ammonia, one field with and one field without inhibitor, spring applications with and without inhibitor, one post emergent side dress application, and a control plot which receives no anhydrous ammonia. Nitrate concentrations in tile drainage from each of the fields are measured, along with harvest quantities and plant conditions.

So far, the clearest results are that fields with fall application of anhydrous ammonia experience higher nitrate losses than from spring applications. Yields are drastically reduced from the field where no ammonia is applied. Since weather patterns exert such a large effect upon crop growth and harvest, and corn is only planted every other year, the City will continue to work with the landowner and farm operator on the study to get a better idea of the effects of soybean nitrogen fixation and carryover and the effectiveness of inhibitors on productivity and nitrate losses.

A third part of the City's study is to determine if there are natural ways to remove nitrates from the water between the discharge points of field tiles and the intakes for the Water Treatment Plant. In conjunction with the tile study, another study was started with Dr. Dave Kovacic of the Department of Landscape Architecture at the University of Illinois. Dr. Kovacic is studying the use of created wetlands nitrate removal and removal of other nutrients. Dr. Kovacic has done similar studies in other areas of Illinois and has documented 36% nitrogen removals from wetlands. He has also documented that buffer or filter strips alongside tributary streams can remove another 9% of the nitrogen from the water that flows across the strips (2).

City property along Money Creek adjoins the private land containing the experimental tile fields. Experimental wetlands were constructed on the City property in the fall of 1997. Tile flow from the experimental fields and surface flow from the fields is directed into the wetlands through control structures equipped with flow monitors and samplers. By knowing the exact quantity and quality of the water coming into the wetlands as well as the quantity and quality of water leaving the wetlands, the effectiveness of the wetland in removing nitrates can be determined. By knowing the exact area of agricultural land draining into the experimental wetlands, size requirements for additional wetlands can be determined. The wetlands were shown to be effective in removing both nitrogen and phosphorus from the inflowing drainage.

Another key component for reducing levels of nitrogen, as well as other nutrients, from entering the lakes is a nutrient management program. In 2001, the Lake Bloomington watershed was selected as one of five in the state to receive IEPA funding for nutrient management cost share funding. The goal of the program was to minimize the loss of nutrients from farm fields by making field specific nutrient application plans that were based upon test results, thereby reducing the possibility of overapplication of fertilizer.

The two year program was extremely successful, enrolling 34% of the eligible (corn) acreage the first year and increasing to 50% of the second year's eligible acreage. The City added to the IEPA cost share payments for developing and following the nutrient plans. Reductions in

nitrogen, phosphorus, and potassium applied to the fields averaged around 9%, 20%, and 12%, respectively, over the two years.

In 2005, the Lake Bloomington watershed was selected by the University of Illinois Extension and the Illinois Department of Agriculture for a basin scale nutrient management program. The three year program is funded by the Sand County Foundation. The goal of the program is to see if nutrient loss from farm fields, nitrogen in particular, can be decreased through soil test based fertilizer application rates and by using nitrification inhibitors, spring or cold weather nitrogen applications. Additional activities for the project will include identifying potential created wetland sites. The Mclean County SWCD will perform much of the local work.

The City has decided not to pursue the PL-566 sediment basin project, and is proposing in its budgets starting FY2006/2007 to fund a similar three year nutrient project for Evergreen Lake.

In 2004, Evergreen Lake was designated a Total Maximum Daily Load (TMDL) watershed, with impairments due to sedimentation and phosphorus. The IEPA released a Stage 3 report in the fall of 2005. The IEPA is funding the development of a watershed plan through the Association of Illinois Soil and Water Conservation Districts (AISWCD) to achieve the allowable phosphorus loading for the lake. The Mclean County SWCD is the lead agency in the effort.

In addition to efforts to reduce the levels of nitrates and other nutrients from the water draining off agricultural lands, the City has undertaken efforts to reduce the amount of sediment that reaches the lakes. Since 1990, the City, along with McLean County SWCD and Pheasants Forever, is paying for the cost of installing filter strips along tributary streams where landowners and farm operators are willing to participate. The City pays the cost of seeding these filter strips and the farm operator obtains credit for set aside land under various U.S. Department of Agriculture programs.

In 1997, the Illinois Department of Agriculture applied Conservation 2000 Funds to a willow post method stream bank stabilization demonstration project on Six Mile Creek, the main tributary to Evergreen Lake. Since stream bank material is delivered directly to the stream, bank erosion can significantly affect the nutrient and sediment loads that reach the lakes (3).

As part of the TMDL process, the City hired a streambank erosion specialist to conduct inventories of the tributaries to both lakes. The inventories included identification and prioritization of problem areas and presented alternatives with projected costs for stabilizing the sites. The inventories will provide the basis for budgeting and implementing stream restoration work.

The City is participating in the Illinois Environmental Protection Agency's Clean Lakes Program. The City is currently in the data analysis phase of the Diagnostic/Feasibility study. The plan is to determine the nutrient and sediment loads that flow into the lakes during storm events as well as during the different seasons of the year. From the data developed in this first phase, an action plan will be developed to minimize the effects these nutrients and sediment's have on the lakes.

The City installed aeration/destratification equipment in both of the lakes to improve the water quality in the reservoirs. These units prevent thermal stratification and prevent depletion of dissolved oxygen in the lower depths of the lakes. By preventing the formation of an anaerobic zone in the lower elevations of the lakes, release of undesirable compounds, such as ammonia, iron, manganese, and hydrogen sulfide from the lake bottoms and accumulation of other taste and odor causing compounds is greatly reduced (4). Additionally, the release of nutrients, particularly phosphorus, from the sediments that could sustain algal blooms is also reduced (5). Adequate dissolved oxygen throughout the entire lake also greatly improves fish habitat.

Future plans revolve heavily around the TMDL designation for Evergreen Lake and the anticipated TMDL designation for Lake Bloomington in late 2005. The TMDL watershed planning process provides an excellent opportunity to expand existing efforts and bring more people and interests into the City's source water protection program.

Surface water supplies in agricultural watersheds face great challenges in maintaining water quality. The root causes for many of the water quality problems lay far beyond the treatment plant. The City of Bloomington's approach is to work with the communities, landowners and farm operators within the watershed as well as the larger agricultural and scientific community to first understand the problems and then work together to solve them.

References

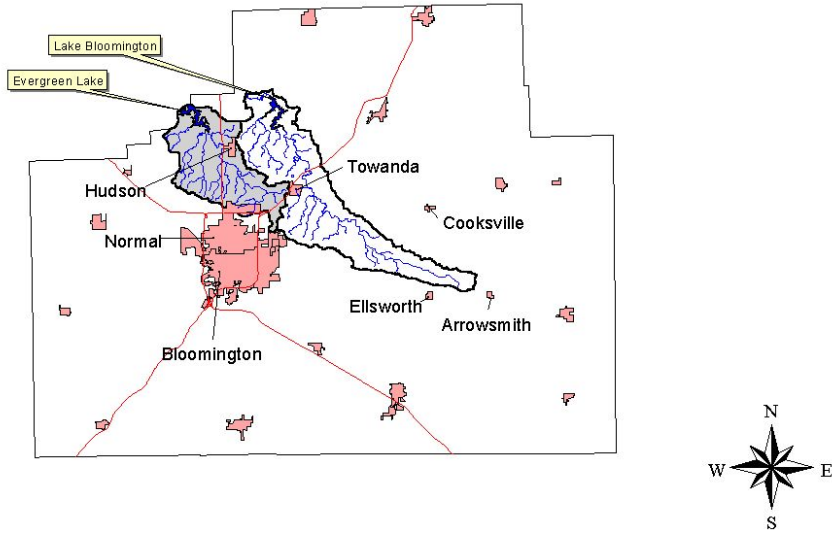
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- (2) Kovacic, D.A., and Mark B. David, Lowell E. Gentry, and Karen M. Starks. 1999. Use of Constructed Wetlands to Reduce Nitrogen and Phosphorus Export From Agricultural Tile Drainage. *Journal of Environmental Quality*.
- (3) Roseboom, Don, and Thomas Hill, Dr. Allan Felsot and Jon Rodsater. June 1990. Stream Yields From Agricultural Chemicals And Feedlot Runoff From An Illinois Watershed. Prepared for: Illinois Department of Energy and Natural Resources Office of Research and Planning, Project: 87/002. ILENR/RE-WR-90/11.
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Acknowledgements

Steve Stockton, Mayor, City of Bloomington
Bloomington City Council
Tom Hamilton, City Manager
Craig Cummings, Director of Water
Jill Mayes, Bloomington Water Treatment Plant
Roger Windhorn, USDA
Dr. Ken Smiciklas, Dr. Aaron Moore, Dr. Steve VanDerHoven, Diane Lamb, ISU
Dr. David Kovacic, Mike Wallace, University of Illinois
Robert Hoffman, Larry Troyer
McLean County SWCD, The Nature Conservancy, IEPA, IDNR, ICES, IDOA, USEPA, Illinois
Farm Bureau,
ISU, IWU, Heartland Community College Interns,
the Staff of the Bloomington Water Treatment Plant
George Drye (retired), Ron Schultz (retired), City of Bloomington Engineering & Water

Figures

Lake Bloomington and Evergreen Lake Watershed Map



Produced by the City of Bloomington Water Department using Illinois Department of Natural Resources data, 2000

Figure 1. Watershed map for Lake Bloomington and Evergreen Lake.

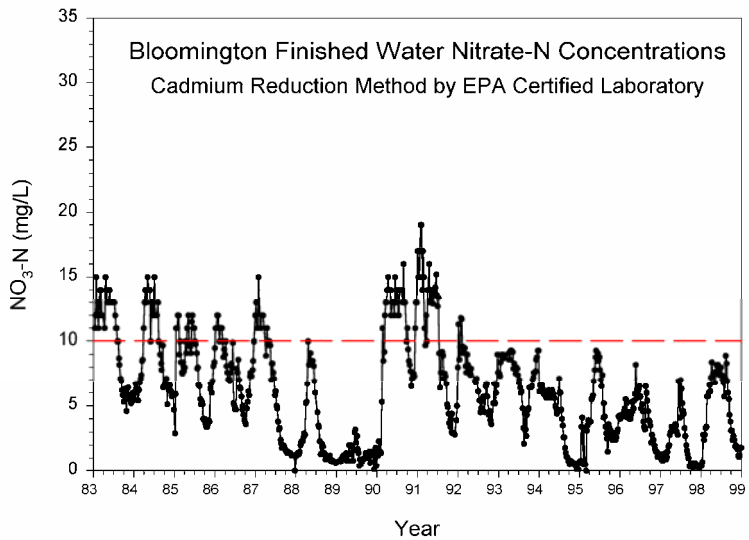


Figure 2. Nitrate-Nitrogen Concentrations for Bloomington finished water. Weekly samples were analyzed for nitrate by an EPA certified laboratory using the cadmium reduction method.

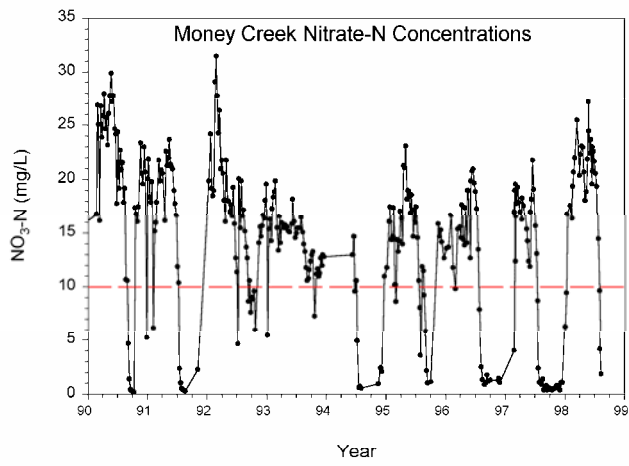


Figure 3. Nitrate-nitrogen concentrations for Money Creek, the main tributary to Lake Bloomington. Weekly grab samples were analyzed for nitrate using an ion specific electrode.

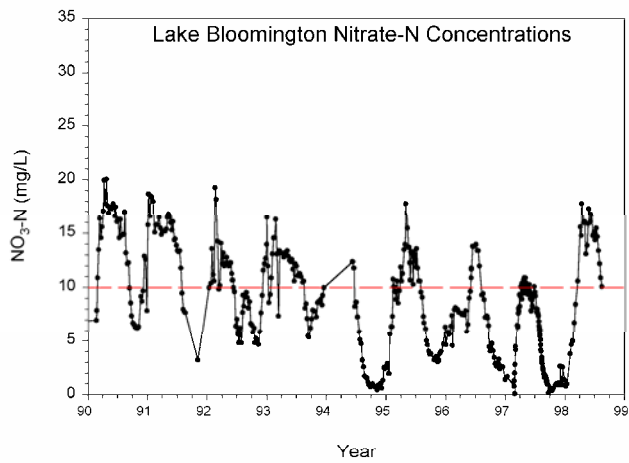


Figure 4. Nitrate-nitrogen concentrations for Lake Bloomington. Weekly grab samples were analyzed for nitrate using an ion specific electrode.

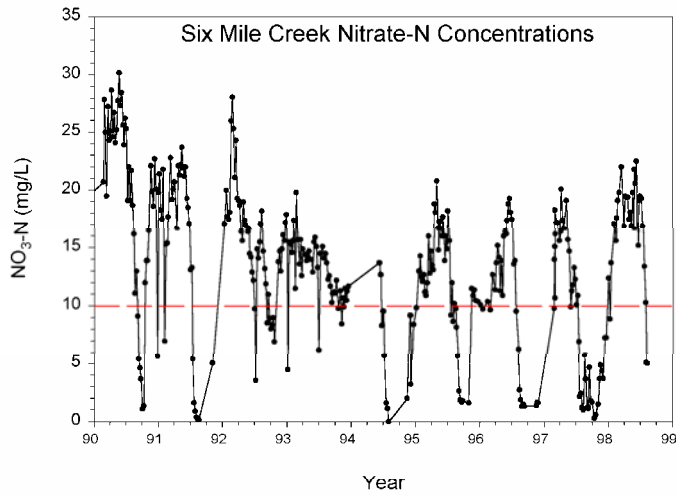


Figure 5. Nitrate-nitrogen concentrations for Six Mile Creek, the main tributary to Lake Evergreen. Weekly grab samples were analyzed for nitrate using an ion specific electrode.

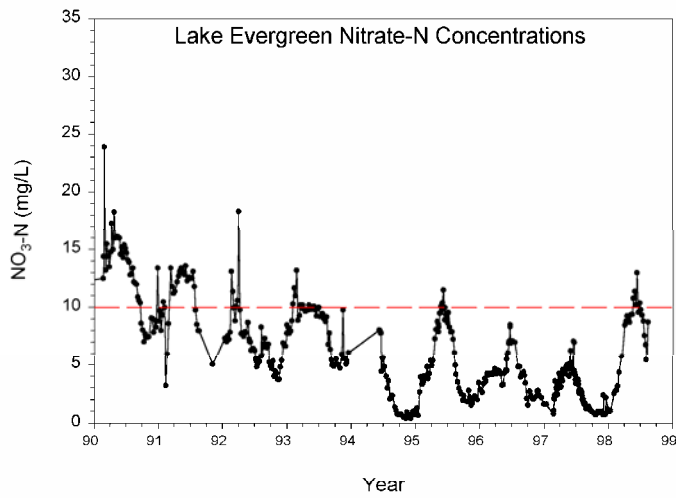


Figure 6. Nitrate-nitrogen concentrations for Lake Evergreen. Weekly grab samples were analyzed for nitrate using an ion specific electrode.

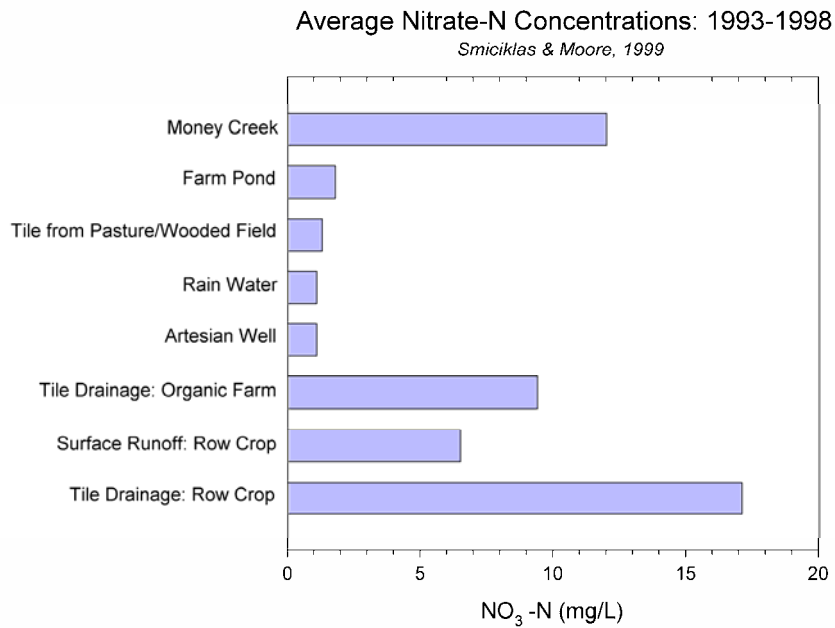


Figure 7. Average nitrate-nitrogen concentrations for weekly grab samples from various sources entering Money Creek, the main tributary to Lake Bloomington from 1993-1999 (ref. 1). The samples were analyzed for nitrate using an ion specific electrode.



Figure 8. Anhydrous ammonia is the main form of nitrogen fertilizer in the watersheds of Lakes Bloomington and Evergreen.

Nitrogen Transformation Pathways

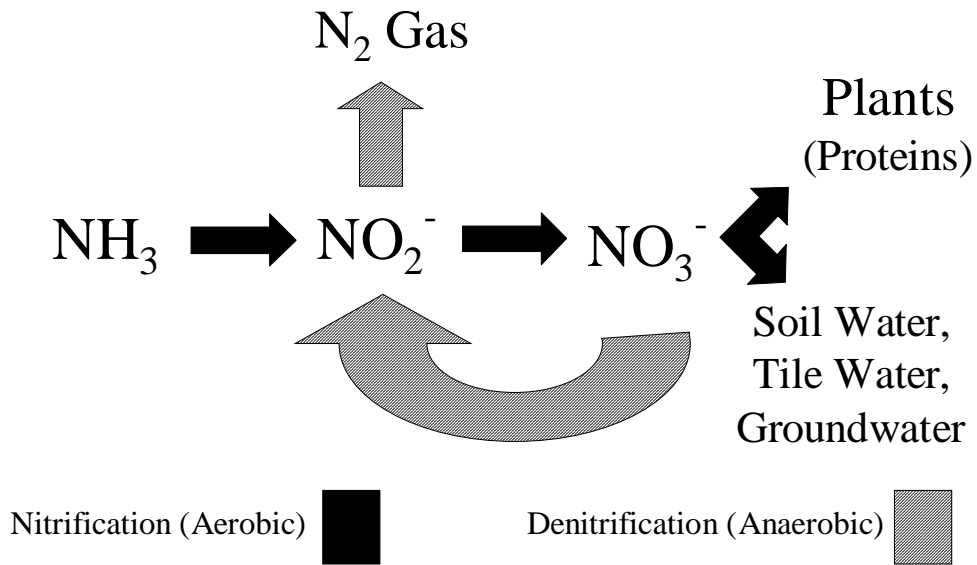


Figure 9. Simplified diagram of nitrogen pathways.



Figure 10. Jim Rutherford, watershed Conservationist (left), with Robert Hoffman, landowner of the experimental field tile site, October 1996.



Figure 11. Aerial view of experimental field tile site and created wetlands. The wetlands can be seen at the top (north) of the picture A farm pond is at the right of the field.



Figure 12. Aerial view of the tile site shortly after tile installation in 1997. The individual tile drainage networks for the six 5 acre treatment plots can be seen. This view is to the southwest, with the farm pond in the background. The wetlands were later built on City property adjoining the field at the left side of the photo.



Figure 13. Track hoe and auger that was used to install dormant willow post streambank stabilization demonstration site on Money Creek in March, 1997.



Figure 14. Dormant willow posts after installation.



Figure 15. Roger Windhorn, Soil Scientist with the NRCS, conducts intensive soil sampling at the tile/wetland experimental sites to better understand the behavior of nitrogen and water at the site.

**Stratified vs. Destratified Lakes:
Temperature and Dissolved Oxygen Profiles**
August 6, 2002

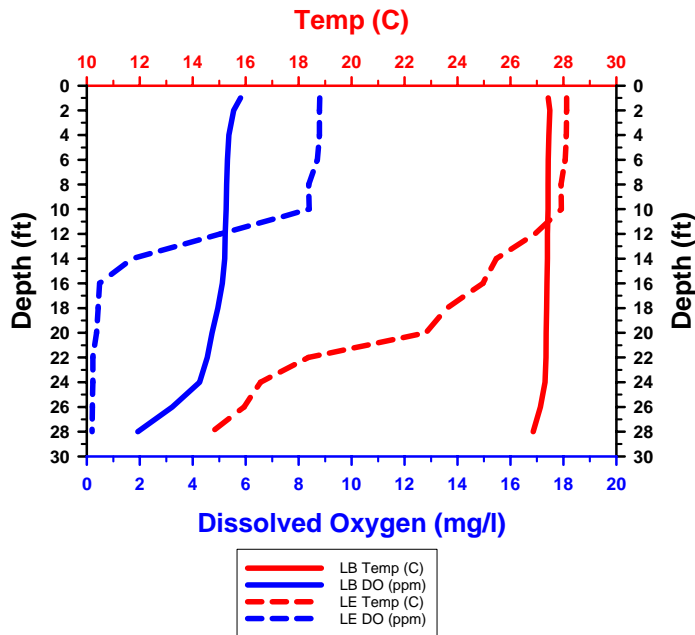


Figure 16. Graph showing the effect of a destratifier on the temperature and dissolved oxygen profiles in Lake Bloomington (LB) versus Evergreen Lake (LE). The destratifier in Evergreen Lake was not operating during the summer of 2002.

Appendix 1: Abbreviated Timeline of Watershed Activities

- 1986: City of Bloomington concerned about both lakes—watershed sizes—Lake Bloomington 43,000 + acres, Evergreen Lake, 26,000+ acres
- The City requested assistance from SCS (Soil Conservation Service), now NRCS (National Resource Conservation Service)
- SCS did an inventory on both lakes to determine needs.
- SCS & City reviewed needs and it was decided that a PL-566 project would be desirable.
- SCS & City selected Evergreen Lake to be the initial project.
- The drought of '88 came along and it was decided that Evergreen Lake spillway would need to be raised so they switched the planning process to Lake Bloomington.
- 1988-1991: SCS developed PL-566 Lake Bloomington Watershed Plan/Environmental Assessment.
- 1991: Plan agreed on and signed by City, SCS, SWCD, and IL Dept. of Ag. Dept of Ag.
- Two sediment structures planned at an estimated cost of \$1.9 millions. SCS was going to do the designs and pay ½ the cost.
- 1991, July: SWCD employed Watershed Conservationist funded by the City through grant process to promote conservation in the watershed of both Lakes and act as a liaison between City/SWCD/NRCS/TNC/IL Dept. of Ag/Extension/IL Dept. of Natural Resources/Pheasants Forever, etc.
- 1992: High nitrate levels. The City asked the SWCD and Watershed Conservationist to locate and get permission to do sampling at different locations on Money Creek on the tile outlets, surface samples, etc, which they did. The City did the sampling and also did the lab work.
- 1993-1996: Flood came and SCS didn't have time to do the design work on PL-566. They, then, asked the City to do the design.
- 1993-1994: High nitrate levels. City entered into agreement with ISU to expand sampling process, which would include organic pasture, additional field, plus putting information from City's lab into computer, etc.

- 1995-2000: City and Watershed Conservationist worked with Pheasants Forever in promoting filter strips; also, City contributed dollars per acres toward filter strip establishment.
- 1997: City entered into agreement with ISU in 1997 to continue sampling Money Creek and proposed tile research and wetlands.
- 3/97: Tile research project. City entered into agreement with landowners to install field tile—6 different fields, 5 acres each, 2500' of 5" tile per field. Each field monitored 24/7. Samples collected by ISU, City did lab work, total cost of field tile installed was \$24,210.00
- 9/97: City developed wetlands below tile research project on City property. Wetlands collect all tile subsurface and surface water from the tile research project. Everything is monitored—11 different monitors. Wetland construction cost \$25,854.00, monitor(s), cost \$41,988.00.
- The U of I also is involved. They are monitoring the amount of water that is moving beneath the wetlands earthen fills.
- 1997-2005: Monitoring is on going.
- 2001-2002: Nutrient management plan program, due to high nitrate levels. Funding by IEPA, City of Bloomington through the AISWCD & McLean County SWCD. Lake Bloomington was one of five watersheds selected in the state.
- 2001: See additional sheet
- 2002: See additional sheet.
- 2004-2005: Evergreen Lake stamped Total Maximum Daily Load (TMDL). In process of developing watershed plan funded by IEPA through the AISWCD with McLean County SWCD being the lead agency in the planning process.
- 2005: Lake Bloomington watershed was selected by the U of I Extension/IL Dept of Ag to have a Nutrient Management program. The reason Lake Bloomington watershed was selected was due to the outstanding job McLean County SWCD did in 2001 and 2002 promoting a similar program. This is a three year program, which will be funded by the Sand County Foundation. Year #1 of the program is approved for '05-'06; Year #2 '06 – '07 & Year #3 '07-'08 are subject to funding.
- 2005: The City of Bloomington decided not to pursue the PL-566 and instead devote funding toward a three year nutrient project for Evergreen Lake.

Appendix 2. Information sheets for the 2001-2002 Nutrient Management Program.

WATERSHED NEWS

Jim Rutherford

Lake Bloomington Watershed Nutrient Management Program

The producers in the Lake Bloomington Watershed had a new program they could take advantage of this past fall. The Nutrient Management Plan Program provided producers in the watershed the opportunity to earn \$5.00/acre for corn planted in the crop year 2001. Producers signed up for the new program at the McLean County Soil & Water Conservation District office. Once the producer's application was approved, a nutrient plan was developed following the University of Illinois fertilizer recommendations. The plans, which were written by third party vendors (fertilizer dealers and certified crop advisors) and approved by NRCS, included recommendations on rate, timing, and placement of nitrogen, phosphorus and potassium.

There is approximately 40,000 acres of cropland (corn and soybeans) in the Lake Bloomington watershed. There have been 83 farms, representing 6,773 acres that have signed up for the Nutrient Management Program in the watershed for 2001 crop year.

If the plans are implemented as written, we anticipate the following reduction in nutrient loading in the Lake Bloomington water supply:

Nitrogen—reduced from 174.4 lb/ac. to 158.1lb/ac. or a 9.4% reduction.

Phosphorus—reduced from 87.9 lb/ac. to 70.9 lb/ac. or a 19% reduction.

Potassium—reduced from 121.1 lb/ac. to 94 lb/ac. or a 22% reduction.

Summer/fall of 2001, the producers in the Lake Bloomington watershed will again have the opportunity to sign up for the Nutrient Management Program. The payment will be increased from \$5.00 per acre to \$7.00 per acre for the producer for corn planted in the crop year 2002, and the third party vendors will receive \$2.00 per acre for writing the plan for the producer. The sign up period will be from August 9th to September 14th.

The goal of the program, which is funded by IEPA (Illinois Environmental Protection Agency) and the City of Bloomington, is to increase the number of acres being farmed to an approved Nutrient Management Plan in areas that contribute to public water supplies.

For additional information or questions regarding the Nutrient Management Program, contact Jim Rutherford at McLean County SWCD (309)452-0830, ext. 3.

WATERSHED NEWS

Jim Rutherford

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Again, the producers in the Lake Bloomington Watershed had a program they could take advantage of this past fall. The Nutrient Management Plan Program provides producers in the watershed the opportunity to earn \$7.00/acre for corn planted in the crop year 2002. Producers signed up for the program at the McLean County Soil & Water Conservation District office. Once the producer's application was approved, a nutrient plan was developed following the University of Illinois fertilizer recommendations. The plans, which were written by third party vendors (fertilizer dealers and certified crop advisors) and approved by NRCS, included recommendations on rate, timing, and placement of nitrogen, phosphorus and potassium.

There is approximately 40,000 acres of cropland (corn and soybeans) in the Lake Bloomington watershed. There have been 117 farms, representing 10,081.3 acres, that have signed up for the Nutrient Management Program in the watershed for 2002 crop year.

If the plans are implemented as written, we anticipate the following reduction in nutrient loading in the Lake Bloomington water supply:

Nitrogen—reduced from 171.2 lb/ac. to 156.1 lb/ac. or a 9.1% reduction.

Phosphorus—reduced from 90.1 lb/ac. to 70.2 lb/ac. or a 22.1% reduction.

Potassium—reduced from 116.3 lb/ac. to 108.1 lb/ac. or a 7% reduction.

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