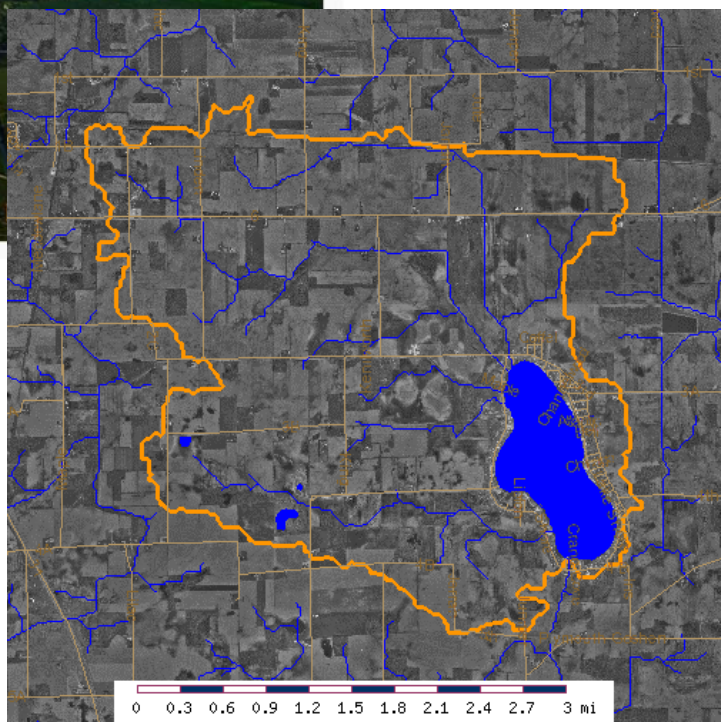
Lake of the Woods, Marshall County, Indiana
Watershed Management Plan

Photo credit: Lowell Michaels

Map source: Purdue University



-- FINAL DRAFT --

Prepared for:
Kankakee River Basin Commission

by: D. J. Case & Associates
317 E Jefferson Blvd.
Mishawaka, IN 46545
574-258-0100

with: JFNew
708 Roosevelt Road,
Walkerton, Indiana 46574
574-586-3400

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Executive Summary

This Watershed Management Plan (WMP) was developed for the watershed encompassing the Lake of the Woods (LOW) in Marshall County, which is located in the area designated by the 14-digit Hydrologic Unit Code (HUC) #07120001050090. These subwatersheds draining to the lake and the lake surface area total 6,418.7 acres with the entire area in Marshall County in north central Indiana. There are two perennial streams, four intermittent streams, roadside ditches and other waterways leading into the 416-acre lake.

Currently, the area surrounding Lake of the Woods is largely rural in character with no towns located in the watershed. Of the total land and water area draining to the dam, 74.4% is managed for row crop production, 10.9% is in grass, pasture or hay, 4.6% is covered by forest, 2.2% percent consists of residential or commercial development, and 7.9% is water. Over the past three decades, the lake has demonstrated average to below average water quality compared to most other natural lakes in Indiana.

Urban development accelerated around most lakes in the post-war years of the late 1940s and 1950s. Many lakes are again experiencing a sharp increase in housing construction and public use, especially in areas where sewers, public ramps and other amenities have been installed. The future may bring an even greater flow of nonresident recreational users and additional urban development to Lake of the Woods, if U.S. Highway 31 is upgraded to an interstate and development continues at the intersection with State Road 6 and in nearby cities and towns. As urban development and year-round residency increase, water quality problems associated with residential construction and recreational use will require strategic action.

This plan sets a course for soil and water conservation in the future as defined by the community vision and mission for these actions.

Vision: *Profitable farmland, achievable water quality, and continuing education in support of sustainable agriculture, recreational lake use, and property values.*

Mission: *The watershed planning committee, representing a broad range of interests, will foster communication, collaboration, education, and scientific understanding to develop practical conservation strategies that will maintain and improve watershed resources for sustainable agricultural production, recreational benefits, property values, and a cooperative community atmosphere.*

During 2004-2005, the community around Lake of the Woods and its watershed participated in a long-term planning process sponsored by the Kankakee River Basin Conservancy and the Lake of the Woods Property Owners Association in cooperation with the Marshall County SWCD, County Surveyors Office, and other community participants.

Key issues were identified and actions proposed for the following topics:

1. Erosion and sediment control
2. Hydrology and drainage
3. Nutrient loading
4. Long term, representative watershed management planning
5. Channel maintenance
6. Conservation practices
7. Education on stewardship topics
8. Invasive species
9. Watercraft safety and ecological impacts
10. Highway development
11. Law enforcement
12. Native fisheries resources

The associated management strategies focus on improving water quality to optimize recreational and aesthetic benefits of the lake in support of the various land uses in the watershed, including agricultural production and lake residential use. Implementation of these management practices will be evaluated against the interim lake water quality goal.

Water quality goal: *Improve average summer water clarity to 4.5 feet which would bring the lake up to water quality more typical of other Northern Indiana lakes. For example, the lake would have ranked 49th out of 79 northern Indiana lakes rather than 68th, according to samples taken in 2003.*

As conditions change in the future, the plan will be reviewed and updated to reflect the ongoing needs for continuous improvement in land and water management in Lake of the Woods and its watershed. Key to the long term implementation of this plan will be establishment of a watershed committee that includes representatives from a broad range of people who have an interest in water quality and water use in the lake and its watershed.

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Lake of the Woods, Marshall County, Indiana Watershed Management Plan

1.0 Introduction

The purpose of a watershed management plan is to identify ways to maintain or improve water quality in the lake and conserve healthy natural resources in the surrounding watershed. Through the process of developing the plan, a community identifies issues, proposes a range of solutions and prioritizes actions for future effort. Communities with approved plans are eligible to apply for continued funding from state and federal agencies for soil and water conservation practices.

Nonpoint source pollution is the primary water quality issue that will be addressed in this watershed management plan. A watershed serves as a logical landscape unit for environmental management for two reasons: 1) the area can be outlined on a map; and 2) working within a watershed makes sense for connecting water quality problems with their sources. Nonpoint source pollution—specifically sediment, nutrients, and bacteria (pathogens)—in the Lake of the Woods originate from several sources in the entire area outlined within the watershed, including the lake itself, the shoreline and areas that drain into the streams and ditches leading to the lake.

This Watershed Management Plan (WMP) was developed for the watershed encompassing the Lake of the Woods (LOW) in Marshall County and the area drained by tributaries leading into the lake, which lies within the 14-digit HUC #07120001050090 (Figure 1). These subwatersheds draining to the lake and the lake surface area total 6,418.7 acres with the entire area in Marshall County in north central Indiana. There are two perennial streams, four intermittent streams, roadside ditches and other waterways leading into the lake. The lake itself has a water surface area of 416 acres with a maximum depth of 47.9 ft and mean depth of 15.7 ft. The lake outlet was historically located along the eastern shore; the present-day outlet was dug in 1904.

Currently, the area surrounding Lake of the Woods is largely rural in character with no towns located in the watershed. However, the lake is located at a driving distance of just under five miles from a major intersection at U.S. Highway 31 and State Road 6 to the west and just over four miles from the edge of the town of Bremen on the east. State Road 6 runs east to west across the north side of the watershed with several county roads throughout the watershed.

Indiana farmers own and operate about 65% of the land in the state (NRCS, 2004). In comparison, of the total land and water area draining to the dam, 74.4% is managed for row crop production, 10.9% is in grass, pasture or hay, 4.6% is covered by forest, 2.2% percent consists of residential or commercial development, and 7.9% is water. Residential or commercial development occupies the majority of the lake shoreline with a

small wetland on the north side and some undeveloped areas scattered around the lake.

The lake lies in the headwaters of the Yellow River watershed, which drains into the Kankakee River. Water chemistry and algal populations suggest Lake of the Woods has been moderately eutrophic (affected by sediment and nutrient runoff and chemical recycling within the lake) with water clarity typical of glacially formed lakes in the agricultural and developed landscapes of northern Indiana. Measurements taken between 1975 and 2004 showed that the IDEM Indiana Trophic State Index has consistently scored around 40 points with a high of 50 points in 1990 and return to the mid-40s since 1995. (Lakes measuring 32-46 points are considered eutrophic with lakes rating 47-75 points being hypereutrophic, or severely affected by runoff from the watershed.)

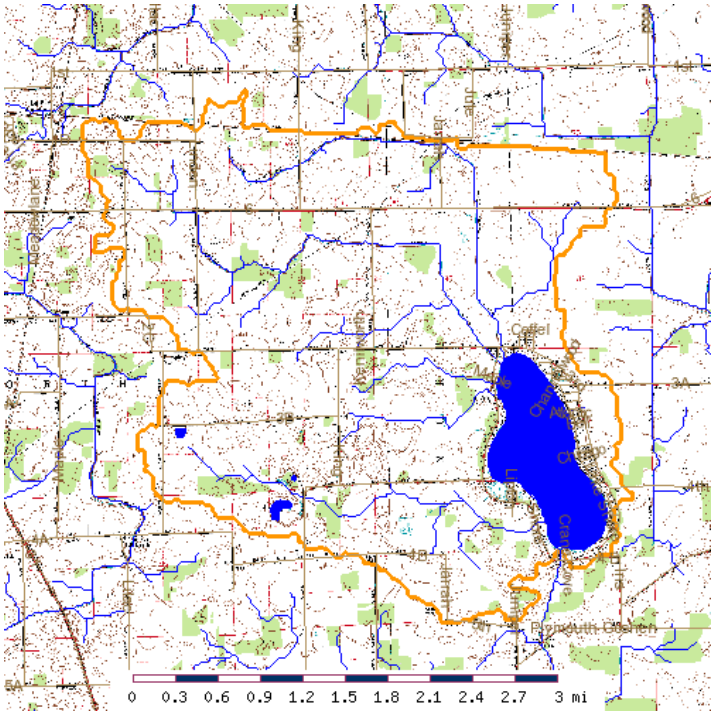


Figure 1. Location of the watershed and lake covered by this plan with the watershed outlined in orange and the water in blue. (Source: Purdue University online delineation tool)

1.1 Watershed partnerships

Many agencies, organizations and individuals are interested in and have been working on conservation issues in and around the lake and its surrounding watershed. Many of these groups participated in this planning process.

The Kankakee River Basin Commission (KRBC) served as the official local sponsor of the Lake of the Woods Watershed Management Plan project and provides guidance for watershed management and drainage projects to the larger surrounding region. Following a number of discussions between members of the community, the KRBC agreed to guide and administer the project and associated contracts.

After a competitive bid process, the KRBC selected D. J. Case and Associates (DJ Case), in partnership with J.F. New & Associates (JFNew), to facilitate development of the watershed management plan. DJ Case was responsible for the coordination, facilitation, development and implementation of the planning process. JFNew conducted the water

quality, habitat and biological assessments.

The Lake of the Woods Property Owners Association (POA) was instrumental in developing the original Lake and River Enhancement (LARE) funding proposal and securing a matching contribution. The Marshall County Soil and Water Conservation District (SWCD) provided leadership through the transition in sponsorship from the POA to the KRBC. The Indiana Department of Natural Resources LARE program provided 90% of the funding for this project ($36,000) with 10% matching funds contributed by the Lake of the Woods Property Owners Association (POA) as in-kind and cash contributions. The LARE funds are derived exclusively from fees assessed on boats registered for use in the state of Indiana. The Lake of the Woods project was initiated in July 2004 for a period lasting up to 18 months.

Early administrative dialogues with staff from the KRBC, Indiana Department of Natural Resources (IDNR), SWCD, POA, subcontractors, Marshall County Surveyor, and others provided input for a beginning list of potential stakeholders in the watershed. Organizations and individuals with a demonstrated interest in the planning activity were added to the list as were state, local and private agencies or organizations that are stakeholders or represent stakeholders in the watersheds. Local organizations that provided input during initial planning stages included the Lake of the Woods POA officers, Marshall County SWCD supervisors, a local group of about a dozen farmers and other landowners in the watershed. A list of agency staff and 86 participants who were involved in the development of this process ("Project Reviewers") is in Appendix I.

The list of contacts included the POA, Bremen Conservation Club, IDNR Agriculture Conservation Specialist, IDNR Division of Soil Conservation Resource Specialist, IDNR Conservation Officers, Marshall County Soil and Water Conservation District, Farm Services Agency, IDNR Division of Fish and Wildlife, Marshall County Commissioners, Marshall County Extension Service, Marshall County Farm Bureau Inc., Marshall County Health Department, and others.

These individuals and organizations were encouraged to participate in a set of focus groups to help guide design of the public participation process, collect background information and identify potential issues. During the initial focus group meetings, participants were asked to identify additional stakeholders who were not present but who should be included in the process.

A representative stakeholders group met on January 24, 2005, to:

- review issues and concerns identified by the focus groups in advance of public meetings;
- develop mission, goals, and objectives; and
- to solicit and coordinate public involvement in the watershed management planning process.

Individuals were invited to participate by distributing information about the process in organizational meetings, letters, newsletters, and through the project website.

Stakeholders included over 400 people residing in the watershed and around the lake, including all members of the lake association and conservation club, over 120 landholders in the watershed, county, state and federal agency staff, and any others who expressed an interest in the use and quality of the land and water in the area.

1.2 Public participation

A true watershed management process must consist of a broad discussion regarding all areas of concern related to effects of land management on water quality. Therefore, the watershed plan includes strategies for all lake and land users, including those who live immediately near the shoreline, property owners and land managers in the upper watershed areas, and recreational users who visit the lake.

There has been a lot of discussion in the community about lake levels and other drainage issues, beginning several years prior to the development of this planning process. Therefore, the IDNR Division of Soil Conservation and Kankakee River Basin Commission expressed a strong interest in establishing a professionally facilitated experience that would be productive for everyone involved in local land and water management. To help acquire input, the facilitators recognized that the process would need to start by meeting with groups of people in settings less prone to unproductive confrontation than general public meetings can be.

Facilitators asked for input from each perspective, recognizing that there would be differences of opinion. Facilitators sought out community perceptions of local issues in order to represent all perspectives and develop a sound strategy for protecting water quality and healthy land use.

Over the course of several months from July 2004 through January 2005, facilitators met with small groups of individuals in the area to further develop a sense of community objectives specific to LOW and its watershed managers. The first round of meetings documented the broad range of issues that affect each group individually (e.g., farmers, lake residents, drainage board, SWCD) as they manage their land or are affected by land and water management decisions of others. The facilitator recorded comments for use in development of short and long-term strategies, guided by community input. Numerous individuals discussed concerns, issues, and potential solutions through electronic mail, individual contact, and telephone conversations both before and after focus group meetings. A list of meetings, mailings and presentations is provided in Table 1.

Table 1. Meetings, mailings and presentations to develop an understanding of the issues affecting the Lake of the Woods and its watershed.

1. July 31 – met with LOTW POA officers
2. August 11 – presented introduction to Marshall County SWCD board meeting
3. September 4 – presented introduction at LOTW POA monthly meeting
4. September 8 – presented introduction at farmers meeting
5. October 18 – presented introduction to Marshall County Drainage Board

6. November 3 – onsite meeting with an area farmer to discuss conservation practices

7. November 3 – meeting with lake focus group to identify alternatives for lake conservation
8. November 18 – present progress update to KRBC
9. November 22 – posted announcement and first draft of Watershed Plan to website
10. December 1 – mailed announcement to 30 agricultural landowners
11. January 5 – meeting with farmers to identify alternatives for agricultural conservation
12. January 12 – update for the Marshall County SWCD board meeting
13. January 18 – attended annual meeting of the Marshall County SWCD
14. January 24 – facilitated stakeholders meeting
15. January 27 – prepared a progress update for KRBC meeting
16. March 11 – mailed announcement to all 128 landholders known to be in the watershed
17. March 21 – first public meeting
18. April 4 – presentation to the Plymouth Lions Club
19. June 4 – second public meeting

During focus group meetings, participants discussed the timing, location and preparation for general public meetings to achieve maximum potential for productive community planning.

After meeting several times with groups representing particular interests, a representative stakeholder meeting was held on January 24, 2005, to convene 18 people, at Shiloh Wesleyan Church near Plymouth, to reach some consensus on a vision, mission, priority goals and alternative actions. A public meeting followed on March 21, 2005, in anticipation of preparing a complete draft plan for public distribution in May of that year. There were 56 people who traveled to Plymouth County Building for this meeting. A public meeting was held on June 4, 2005, to solicit comments on the draft and discuss implementation. Of the 46 people who attended this public meeting at the Lake of the Woods Community Center near Bremen, 28 submitted written comments on implementation of the draft plan. Complete meeting notes and attendance were recorded at each meeting for use in developing the plan and preparing for implementation.

Community outreach regarding development of the WMP included the development and distribution of materials for the community that described the project. Information on the status of the project was provided throughout the duration of plan development on a project website, at meetings and through targeted mailings. Project managers prepared monthly progress reports, which were emailed to focus group members and any other interested parties. Articles in the lake association newsletter provided periodic updates; over 550 copies of newsletters were printed with 75 copies mailed directly to property owners' association members. A direct mailing announcing the project and public meetings was sent to all known landholders in the watershed. Multiple presentations were given in person or through handouts to members of the Kankakee River Basin

Commission, Marshall County Soil and Water Conservation District, Plymouth Lions Club, and Marshall County Drainage Board.

All stakeholders and the general public were invited and encouraged to attend public meetings. An announcement for the public meetings was provided to local news outlets, including those in Bremen, Plymouth, South Bend, Argos, and Bourbon. Over a dozen focus group meetings and presentations, along with one stakeholder meeting and two public meetings were held over the course of one year to insure that all stakeholders' needs and perspectives were considered in the development of the WMP.

1.3 Community concerns

During these meetings and through direct contact with facilitators, members of the public were able to voice their concerns and receive information on the progress and preliminary results of the planning process. These comments were documented and included for consideration throughout the planning process.

> Note that these concerns were recorded as members of the community identified them. They do not necessarily represent commonly held or mutually agreed upon beliefs or understandings and have not been verified through scientific or other examination, but reflect the values and concerns of various individuals as stakeholders in the early stages of this planning effort.

Members of the community voiced initial concerns about water quality and related conditions in the lake and watershed in regard to a variety of issues. These issues are loosely categorized below, recognizing that many of these issues are interrelated. Neither the category nor the order is intended to confer any relative prioritization. The community prioritized issues later in the process.

1.3.1 Planning process

Concerns were expressed about the watershed management planning process. These included:

- Groups meeting at times that were inconvenient to several sectors of the community, in particular the seasonality of farming operations and lake residency.
- Groups meeting "behind the back" of other sectors in the community.
- Time commitment to the process required of people in the community.
- Concerns that the watershed management plan or other studies would cause more controversy than already exists in the community.
- Having adequate representation of groups not associated with a formal entity, such as the lake association or conservation club.
- Complete the process in a year rather than 18 months, as originally scheduled.
- Officers of the lake association may not adequately represent community and watershed interests.

- Use of the lake association newsletter as a campaign venue for incumbent officers without providing equal space for other candidates who are running for office to express their views.
- The watershed management plan is an attempt to place blame exclusively on the farmers for the condition of the lake.
- The purpose of the original funding request for the plan was to use the process to produce additional information to be used in the lake level court cases.
- Recognize that all uses around lake can affect water quality, including farming, the golf course, and lakeshore residents.
- Welcome the planning effort as a third party opportunity to allow all residents in the area to express their opinions and concerns about how to protect water quality and land uses in the lake and watershed.
- Make sure the study includes comparisons of water quality in LOW as compared to water quality in other lakes and compared to State Water Quality Standards.

1.3.2 Drainage modification proposals

The following issues are associated with lake levels, stream re-routing and related drainage modification proposals. In order to make progress on a number of other issues related to water quality and conservation practices, this plan will not make specific recommendations on proposals related to drainage and water level manipulation. Therefore, this section will document issues raised during the process of developing this plan and describes possible studies that could be conducted to determine the impact of these possible projects.

The IDNR has indicated that additional impact study would be necessary to make further permit or other decisions regarding lake levels. Local organizations may choose to pursue funding through the Lake and River Enhancement program or other sources for hydrologic impact studies to address the effects of lake levels. No additional recommendations or statements regarding which level is most appropriate for the lake will be considered within this management plan. Those are issues that will be decided outside of this process.

1.3.2.1 Water levels

Stakeholders have voiced concerns about the effects of changing water levels on the streams and lake. These comments are provided below to document what the community has said about these issues in the information gathering stage of this planning process. Input is described within categories of impact that are listed below in alphabetical order (i.e., no priority is implied by the naming of categories or order of occurrence).

Boating

- Recreational use of the lake has increased in recent years.
- Dam manipulation at Lake of the Woods implies a boating season of May 15 to September 15 even though the recreational season for aquatic use in Indiana is

recognized in State Water Quality Standards as April 1 through October 31 (327 I.A.C. 2-1-6(d)).

- There is disagreement about how long it takes to return the lake level after the dam is closed on May 15 with estimates varying from 7 to 21 days, depending on precipitation.
- In 2005, the lake level had not returned to the sill of the raised dam within 5 weeks of closing the structure. If 8% of the total lake volume is in the top foot of the lake, it is not likely that the lake will fill to the spillway in years with unusually low rainfall due to dryness of surrounding soils.
- When the dam is opened in the fall, water levels rarely drop to below the sill, resulting in less than a 12-inch reduction in water level due to dam manipulation.
- Boating season is affected by lowering of lake level in the fall and spring.
- Engineering is more complicated for a handicapped-accessible pier for fluctuating lake levels; the pier must be designed as a floating structure to accommodate periodic changes in lake level.
- Water depth in the west bay the bay just north of Rt. 4b on the lake's west side is shallow for a distance well in excess of 200 ft from the shoreline. This requires that the propeller be raised on boats to get to the shore, and when the lake is lowered, it becomes impossible to even get to a 75' long dock or boatlift.

Fisheries and wildlife

- Loss of fish when the dam is opened.
- Lowering of lake level may destroy fish spawning areas in shallow water.
- Effect of lake level changes on habitat for waterfowl and shoreline birds.
- Drawdown may concentrate fish in shallower water, enhancing predation and reducing the number of stunted fish in the population.
- When the lake is filling after the dam is raised in spring, water in the lake becomes stagnant due to lack of flow through the outlet.

Flooding and drainage

- Inability to control flooding if the water level were kept permanently at the higher elevation.
- Hydrologic effects of control structure compared to fluctuations imposed by rainfall and runoff.
- Seasonal drawdown started in 1986, but the 1991 feasibility study did not discuss impacts of dual lake levels.
- After sewer installation, concerns about effects of high water levels on septic system operation are less significant or nonexistent.
- Foundations along the eastern shore of the lake are close to the water table and benefit from drying out when lake levels are lowered in the winter.
- The ground shifts when the lake level is down and it freezes, causing property damage.
- Drainage has improved through the increased use of tiles in agricultural land.
- Use available one-foot contour mapping of the watershed to identify exactly how much land is not tillable when the lake is high.

- With higher water level in winter, loss of drainage from 13 tiles set at elevations below the high water level (according to the county surveyor's report).
- A series of wet years between 1990 and 1999 may skew residents' perception of typical water levels.
- Lake level appears to be dropping since 1991.
- Raising and lowering the lake level by one foot may have little impact on the lake, considering that most lakes vary naturally than Lake of the Woods varies on purpose. Bass Lake, Pretty Lake and Lake Maxinkuckee have all varied as much as 3 feet and more in the past several years. Lake of the Woods was about 7 inches low the day before the dam was opened in September of 1999, which was the lowest noticed since the mid-1960s drought.
- The old dam that was in place prior to the new one being built in 1986 also had a gate, and the lake level was lowered in the winter.
- Dual lake levels may be affecting the water table in the watershed.
- Dewatering at a nearby landfill near Wyatt, Indiana, may be affecting groundwater tables, wells, and hydrology in the lake and watershed.
- Runoff may be affected by changes in the water table of the watershed due to opening of the dam, pumping in ditches leading to the lake, effects of tile drainage, and irrigation of farm fields in the watershed.
- When the lake level is dropped rapidly, water velocity and sediment transport increases in the streams leading into the lake; this sediment may accumulate in the lake at the mouths of inlets.

Pier and shoreline maintenance

- Pier removal, maintenance and installation are easier when lake levels are lowered in the fall and spring.
- Lower water level may facilitate shoreline repairs.

Shoreline erosion and ice damage

- Shoreline erosion is not as severely focused along one shoreline contour when water levels vary.
- Ice damage may be reduced when lake levels are lower in the winter; some northern states encourage lake level regulation to reduce shoreline damage.
- Opinions vary regarding the relative level of ice damage with some stakeholders indicating that ice is not as severe on Lake of the Woods as it is on some other lakes, while others indicate that significant heaving occurs in a normal winter, causing movement of concrete seawalls and sod.

Social impact of court cases

- Amount of money spent on court cases related to lake level is costly for both sides; money spent on the court case could have been used to fund conservation practices and other activities.
- Negative impacts of continued community dissension on quality of life and property values, particularly for individuals who made a long-term investment in retirement property at the lake or who intend to be multi-generational farm property owners.

- Removing the dam and allowing the lake to develop a natural channel and flush itself would be preferable to continued dissension over lake levels.
- Property taxes have increased for residents around the lakeshore and channels, yet residents do not have access to the lake due to annual drawdown.
- Property values for agricultural landowners are dependent on drainage and the dual lake level to maintain crop yields and land productivity.
- Landowners purchased property, knowing that the lake was managed as a dual level lake.
- Many recommendations for conservation practices in the watershed will be the same, regardless of court decisions on the lake level; conflict over dual lake level should not be allowed to impede implementation of soil and water conservation around the lake and in the watershed.
- Farmers may have been willing to compromise and shift the fall drawdown date to later in the year, if the lake residents would have dropped the court case; the spring date for closing the dam cannot be any earlier due to the planting season.
- Individuals on "both sides" of the dual lake level issue agree that a hydraulic impact study would be beneficial.
- Lake of the Woods is only as good as the people who live around it. Community residents are the most important natural resource there. Instead of worrying about the contaminants of the water, residents should be looking at the purity of their hearts.

Water quality and ecology

- Changes in water level may affect water quality and the aquatic environment.
- In an unregulated lake (no dam or control structure), water levels may fluctuate around a single level, consistent with the bed of an outlet stream, and would vary with rainfall and drought.
- Lakes in Indiana have historically been subject to variation in depth due to periodic construction of beaver dams along the outlet stream.
- Nutrient detention and hydrologic turnover rates.
- Flow regime in the outlet stream.
- Consolidation (compaction) of sediments when water level is drawn down.

Wetlands and aquatic plants

- Fluctuating water levels may affect the spatial distribution and acreage of emergent wetlands.
- Wetland plants may be more diverse in areas with fluctuating water levels.
- Nutrient absorption may be enhanced in wetlands with fluctuating water levels.
- Invasive plants in areas where water levels are held more constant may dominate wetlands or submerged aquatic plant beds in shallow waters.
- Invasive plants along the shoreline and in the channels may be controlled somewhat by drying and freezing when water levels are dropped in the winter
- Drying and freezing during drawdown may negatively affect native shallow water plants such as bulrush.

- In dry years such as 2005, the wetland at the northwest corner of the lake dries up, allowing grasses to grow and crowd out wetland plants.

Online resources:
Appeal from the Marshall County Circuit Court, February 22, 2005
http://www.mcgb.com/forum/archive/05-02-22/50A03-0405-CV-207.html

1.3.2.2 Stream re-routing

In the 1990s, permits were requested from the IDNR to allow re-routing of several streams from the west side of the lake, so that the water would drain into the outlet stream, rather than draining into the lake. The intent was to allow these streams to drain independent of lake level.

As with lake level impacts, the IDNR has indicated that additional engineering study would be necessary to make further permitting or other decisions in regard to stream re-routing. Local organizations may choose to pursue funding through the Lake and River Enhancement program or other sources for Engineering Feasibility studies to address impacts of those proposals.

Stakeholders voiced concerns about the effects of re-routing streams on streams and the lake. Specifically:

- Changes in stream re-routing may affect water quality and the aquatic environment.
- May divert nutrients away from the lake and improve water quality.
- May divert water away from the lake and reduce water quantity to maintain the higher lake level and flush the lake of excess nutrients, if water input were diverted from Seltenright, Bohmer and Kuntz ditches. It would also cut off a source of water for the lake, extending the amount of time it takes to refill the lake.
- Kuntz Ditch should not be bypassed around the lake because it would potentially lower the ground water table and become a de facto uncontrolled outlet from the lake.
- To date, no hydraulic study has been conducted to model the predicted effect of rerouting streams on lake level, the hydraulic budget and nonpoint pollution transport, in part due to the lack of funds for such a study.

1.3.3 Land and water management

The following issues are typical of lake management regardless of lake levels.

1.3.3.1 Erosion and sedimentation

Stakeholders voiced concerns about sediment input to the streams and lake. Specifically:

- Sedimentation has reduced access to the channel leading to the dam, causing bad odor from the rotting sediment; fishing used to be the best in this channel but now it is almost nonexistent.
- Lack of maintenance of existing sediment traps in Martin and Stephey ditches which are now completely filled and probably not functioning optimally.
- Existing sediment traps may have been sized too small or too close to the lake; basins must be properly designed and engineered to achieve adequate detention and treatment of sediment and nutrients.
- Farm runoff should be filtered by wetlands in Martin Ditch, Stephey Ditch and other ditches that pass through wetlands in channels on the northwest side of the lake. A distribution ditch wide enough to act as a silt trap should be constructed across the upstream edge of the wetlands to permit flows to percolate across wetlands before reaching the lake. The current channel should be obstructed to force water into the distribution ditch. This would require a series of culverts under West Shore drive to permit distributed flow to reach the lake.
- A wetlands area should be purchased to permit filtration of nutrients from Kuntz Ditch. The field just west of West Shore Drive appears to have been former wetlands and may quickly revert to wetlands if left in its natural state.
- Shoreline erosion has increased in recent years, possibly due to increase in use of high-speed boating, loss of trees along the shoreline or other factors.
- Shoreline erosion along the community building property, possibly using a seawall or other stabilization methods.
- Channels were excavated from muck soils over 40 years ago and have never been dredged; several properties are landlocked after the dam is lowered in September.
- Dredging channels may not improve boat access to the lake if the lakebed at the entrance to the channel is also too shallow; some channels are currently as deep or deeper than the lakebed due to siltation along the shoreline.
- The majority of the channels have concrete seawalls that stabilize the channel banks.
- The northeast side of the lake is shallow (waste deep) for a great distance from shore into the lake; siltation follows currents from the inlets on the north, along the northern and eastern shorelines.
- The bottom consists of a very fine silty sand approximately 4” thick with a cemented gravely base under that. Water quality is affected when boat propellers stirs up sediment on the lake bottom.
- Dredge the bay on the west side and other shallow shore areas of the lake. Channels around the lake should be dredged because they are inaccessible for anything except very small boats or pontoons.
- Consider an engineering study to determine if boulders in streams [drop structures] are appropriate to reduce erosion in some tributaries.
- Filter strips may work well on upland areas with greater topography, but are less useful in flat muck ground where most of the water flow goes through tiles in much of the watershed.
- The golf course installed filter strips along waterways.

- Other conservation practices may be more effective, but may be less well known to the lake community.
- The depth of the lake has decreased in the past 14 years.
- Alum treatment may be a waste of money due to wind and propeller wash, as well as continued transport of sediment into the lake.
- After herbicides kill weeds on cropland, nutrients and sediment transport may increase to the lake.
- A lack of rain over the past year resulted in the lake being very clear; this year, consistent rain was related to muddy water that did not clear up until drier weather.

1.3.3.2 Health

Stakeholders voiced concerns about health factors in the watershed and lake. Specifically:

- Amount of fecal coliforms entering the lake; two of six ditches sampled by Riverwatch volunteers showed levels that were twice the allowable level in state water quality standards; IDEM testing showed *E. coli* higher than the water quality standard in five of six inlet ditches.
- Testing of common swimming areas around the lake for bacteria that may impair aquatic recreation.
- Interpretation of test data collected by volunteers may be used for stewardship and education but cannot be interpreted as professionally collected data.

1.3.3.3 Information and education

Stakeholders voiced concerns about the amount of education and information available to the general public. Specifically:

- Familiarity with farming, engineering, and soil and water conservation practices.
- Understanding of general lake ecology and contributors to aquatic plant overgrowth.
- Lack of publicly available historical information on trends in water quality.
- Need education of landowners along channels to understand consequences of siltation, shoreline stabilization and dredging.

1.3.3.4 Land use

Stakeholders voiced concerns about land use in the watershed and lake. Specifically:

- Effect of sewer installation on increased residential and commercial development around the lake.
- Several septic systems have not been filled with pea gravel, stone or other suitable material, in violation of ordinances.

- Some grey water pipes may drain through crawl spaces under homes and are not connected to the sewer system, as required.
- Cost of conversion of productive farmland to wetlands.
- Over the next 5-10 years, pressure is likely to increase to convert farmland to residential areas, commercial development and other uses.
- Farmers were supposed to put in silt traps after sewers were installed.

1.3.3.5 Nuisance aquatic plants and animals

Stakeholders voiced concerns about nuisance aquatic plants and nuisance animals in the lake and associated wetlands. Specifically:

- Runoff and nutrient loading may accelerate the growth of Eurasian watermilfoil.
- High nutrient loading can create increased bluegreen algae blooms.
- Die-off of weed growth and decomposition can reduce depth.
- Silt build-up in shallow areas can increase water temperatures and stimulate bluegreen algae growth.
- Decomposition of algae can increase biological oxygen demand (BOD) and deprive aquatic life of oxygen.
- Need some plant growth to produce oxygen levels and support fish and wildlife.
- Obtain funding from the state LARE program to help with control of invasive plants, such as Eurasian watermilfoil.
- Studies will not improve weed growth, which is caused by typical conditions of a shallow muck-bottom lake.
- Nickname of "Lake of the Weeds" due to overabundant aquatic plant growth.
- There was a moratorium on weed killing by the lake association about 3-4 years ago; some individuals did spot treatments of weeds in the lake; last year, the lake association hired a company to treat the aquatic weeds; there have been more weeds in the lake this year than over the past 10 years.
- Need to control nutrients coming into the lake for long-term control of Eurasian watermilfoil and nuisance plants.
- Growth and spread of invasive purple loosestrife around the lakeshore and in the tributary streams; loosestrife is growing at the public access site, by the campground, and in wetlands; individuals can control loosestrife by digging and removing isolated pockets of it on their properties.
- Lakeshore areas are currently fogged for mosquitoes; some would like to have more mosquito control.
- Wetland development may increase the number of mosquitoes as vectors for West Nile virus; natural wetlands may increase populations of animals that control mosquitoes.
- Control the Canada goose population by extending the hunting season.
- Prairie View Landfill, about 10 miles north of the lake, may attract seagulls to the region; about 5,000-10,000 seagulls flock on Lake of the Woods, possibly exacerbating nutrient problems; could the landfill be covered to reduce the seagull population.

1.3.3.6 Nutrients

Stakeholders voiced concerns about nutrient input to the streams and lake. Specifically:

- Nutrients applied for several different land uses in the watershed including farming, lawn maintenance, golf course maintenance and other uses.
- Farmers have integrated technological advances in measurement and application of soil nutrients to avoid the cost of over-applying nutrients.
- Nutrient build-up in the lake sediments from years of septic use and runoff may be resuspended and impair water quality.
- Boat traffic in shallow water may resuspend nutrients.
- Dumping autumn leaves into the lake or burning them in ditches connecting to the lake can introduce nutrients.
- Leaves, debris, and muck blow into the lake due to prevailing winds from the southwest.
- The lake needs water running off farmland to keep the lake full and flush nutrients, as long as the water carries a benign amount of silt and nutrients.
- Soil and associated nutrients are valuable to farmers, who use conservation practices to hold them on farmland and maintain agricultural productivity.
- Application of fertilizers on lawns and the golf course, especially where inlet streams drain through the area.
- Several farmers practice conservation tillage, improving the quality of water entering the lake from the watershed.
- One farmer reports having installed over 20 acres of filter strips in the past two years.
- Another farmer has raised pumping stations off the bottom of nearby ditches, which results in sediment and associated nutrients settling along the bed of the ditch rather than being conveyed downstream to the lake.
- When ditches are dredged, sediments and nutrients may be resuspended and transported to the lake.
- Channelization through wetlands on the north side of the lake may accelerate transport of sediment and nutrients to the lake.
- Water quality testing in ditches shows that filter strips work to reduce nutrients and sediment in streams.
- When nutrient testing in streams indicated a source of high nutrients near a dairy, the broken tile drain was repaired, fixing the nutrient problem.
- The lake has been described as being among the top five lakes with poor water quality in northern Indiana due to hypereutrophic status and decreased water clarity.
- The golf course may use a lot of chemicals, but is economically motivated not to over fertilize.

1.3.3.7 Point sources

There are no known large point sources of pollution in the Lake of the Woods watershed. The outfall from the sewage treatment facilities drains to the stream below the lake outlet.

1.3.3.8 Property values and other social concerns

Stakeholders voiced concerns about economic and aesthetic values of properties around the watershed and the lake. Specifically:

- Aesthetics and property values. Could be a declining resale value for properties (relative to water quality).
- The number of full-time residents investing in properties around the lake has increased in recent years.
- Values of lake properties have increased after installation of the sewer system in 1993.
- Higher tax revenues have been generated by lake properties in recent years.
- Increasing number of building permits has been issued over the last ten years.
- Offensive odor in the channels.
- Perception that it is difficult to sell a house on the lake, especially in areas with a muck shoreline.
- A large amount of money has been spent on controlling aquatic weeds.
- Where residents live on the lake can affect their perception of lake quality, depending on the conditions along the shoreline in front of their property.
- A small number of people serve on boards and associations in the area; more people should serve, so that representation is more diverse.
- All owners of the golf course must understand how management decisions affect water quality; having several owners may complicate leadership on this issue.
- Addition of a pavilion to the LOW POA building to provide a covered outdoor facility for weddings and other functions; cost of the existing structure was $18,000.

1.3.3.9 Recreation

Stakeholders voiced concerns about recreational opportunities and responsibilities in the watershed and lake. Specifically:

Fisheries and wildlife

- Effects of seawalls and shoreline development on wetlands and shallow water habitat.
- Maintenance of aquatic plant habitat for northern pike.
- Identify potential wetland sites in the watershed that could be purchased and reverted to wetlands to benefit water quality and migratory bird habitats.
- Fish consumption advisories.

- Safety and rights of waterfowl hunters during duck and goose seasons; incidents of hunter harassment can be reported to the local sheriff for referral to conservation officers with fines as high as $500.
- Establish a ban on feeding geese and ducks to avoid concentrating them on lots near feeding areas. These waterfowl foul lawns and contribute to fecal contamination of the lake.

Boating and ice activities

- Safety of boaters in shallow water areas, especially when the lake is lowered.
- Safety of ice skaters, ice anglers and snowmobiles going on the ice before adequate ice thickness has formed (at least four inches of ice for foot traffic).
- More boaters from out-of-state are using the lake, resulting in increased recreational use.
- Construct a dock at the public access site that complies with ADA requirements, regardless of lake level (may be a floating dock to accommodate dual lake levels).
- As long as the lake is lowered, a second lane is needed at the public access site to facilitate traffic.

Off-road vehicles

- Off-road or all-terrain recreational vehicles (ATVs) are used in some areas where filter strips were installed, destroying the vegetation and crops, and deterring installation of additional filter strips.

1.3.4 Plan implementation

The following issues are related to implementation phases of the watershed management plan, including design and installation of best management practices, development and application of regulations, and monitoring of progress towards implementing actions described by the plan.

1.3.4.1 Best management practices

Stakeholders voiced concerns about implementing best management practices in the watershed and lake. Specifically:

- Use tax money wisely.
- Studies have been done in past years; doing another study would be a waste of money.
- Develop a special committee to foster building a stronger, closer community again, focusing on developing events, including fund raising, fun water and land activities to celebrate community resources, and community building efforts.
- Establish an Agricultural District Director on the POA board to represent agricultural watershed interests and recommendations.
- Hold POA membership drives and events to introduce new community members to open opportunities for larger community input through issue discussions and brainstorming sessions with community leaders and representatives.
- Need support from landowners in farming areas and from residents around the lake to implement best management practices throughout the watershed.
- Need additional funding to install filter strips, silt ponds, and other conservation practices in agricultural areas.
- Getting people to buy in and change cultural mentality so everyone does their fair share.
- Remedies to fix problems may be cost-prohibitive compared to the lower cost of preventive measures.
- Decisions affecting land management and water quality protection should be based on sound science.

1.3.4.2 Regulations

Stakeholders voiced concerns about regulation of land and water management. Specifically:

- Instituting regulations or expectations of agricultural practices that are not appropriate for the soil types, topography and farming systems used in the watershed.
- Regulation of boat size, speed and numbers may be needed for safety and water quality protection.

1.3.4.3 Monitoring of results

Stakeholders voiced concerns about evaluating the results of the project in the watershed and lake. Specifically:

- Monitoring conducted by volunteers should be crosschecked with periodic professional monitoring.

2.0 Watershed description

This Watershed Management Plan (WMP) was developed for the watershed encompassing the Lake of the Woods (LOW) in Marshall County which is located in the 14-digit HUC #07120001050090 (Figure 2). These subwatersheds draining to the lake and the lake surface area total 6,418.7 acres with the entire area in Marshall County in north central Indiana.

There are two perennial streams, four intermittent streams, roadside ditches and other waterways leading into the lake. The original outlet for the glacially formed lake was along the eastern shore, but was moved to the southwest side in the late 1800s with a channel reportedly established by 1904. The control structure and dam were constructed around 1958.

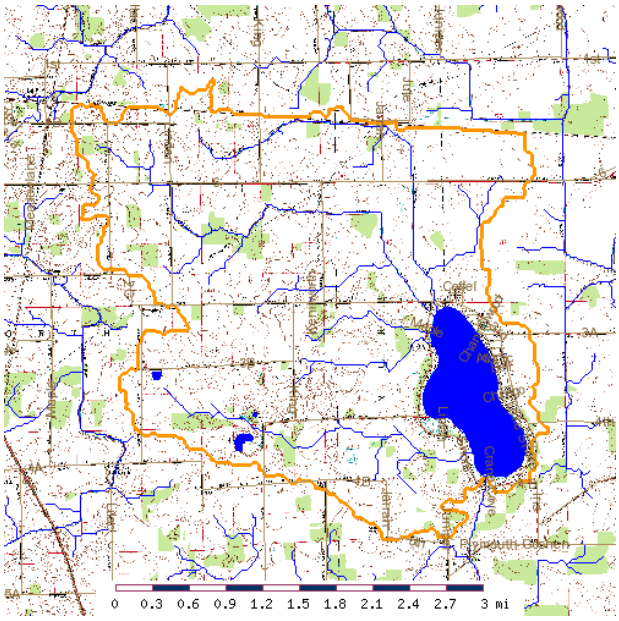


Figure 2. Watershed boundary for the Lake of the Woods outlet with the boundary outlined in orange and water in blue. (Source: Purdue University)

Online resources:

Watershed Delineation, Agricultural and Biological Engineering Department, Purdue University http://pasture.ecn.purdue.edu/~jychoi/wd_home

2.1 Demographics and local history

Marshall County was formally organized in 1836 and named after U.S. Chief Justice John Marshall. The territory previously belonged to the Menominee tribe of Potowatomi Indians, and was purchased by the government in 1832 under the treaty of Tippecanoe River.

Population statistics for the county generally fall midway between nearby Kosciusko and Starke counties. Marshall County had 104.3 residents per square mile and ranked 32nd in population size with 45,128 people in 2000, which was an increase of 7% over 1990 (ranking 54th in percent change). The county consists of rural areas with over 44 percent of the population living in small cities and towns. Plymouth was home to 22.9% of the population (10,607 residents) and an additional 22% of the population resided in Argos, Bourbon, Bremen, Culver, and La Paz.

In 2002, 95.4% of residents were employed in nonfarm industries with the largest single sector in manufacturing (28.6%) and retail trade as the next largest at 10.2%. Highest earnings per job were for manufacturing at $39,476. Farm income for county residents totaled over $4.4 million. Income from nonfarm industries was over $693 million. Median household income was $42,581 (31st), which was higher than the state median of $41,567, in comparison with Kosciusko County at $43,939 and Starke County income of $37,243.

In 2003, 179 residential building permits were filed in Marshall County with a total value of $23 million and consisting exclusively of single family residences (95.5%) or two family residences with no construction for multi-family dwellings. In 2000, median home value was $88,100 (ranking 38th) in comparison with $95,500 for Kosciusko County and $80,000 for Starke County. In 1999, Marshall County ranked 9th in the state for assessed agricultural property value and 32nd for each of residential and commercial and industrial property categories.

Water frontage and lake access typically increases property values and may be affected by water quality, availability of recreational amenities, lake management, and other factors. Slightly over two percent of the watershed consists of residential or commercial development; nearly all of this development is located at or near the lake shoreline. An appraisal report comparing housing values from 1980 to 2002 at Lake of the Woods to trends at five similar lakes in northern Indiana (Simonton, Heaton, Chapman, Dewart, and Koontz Lakes) not including vacant land sales, sales of lots with mobile homes or channel sales (Grove, 2002). The trend line showed that the price per front foot of land has tripled over that time period for these lakes with Lake of the Woods homes selling at or below the trend line through 1995, below trend in 1996 to 1998, above the trend in 1999 to 2001 and well below the trend line in 2002. Sales prices and trends per square foot were similar with housing prices increasing from under $30 per square foot in 1977 to $120 per square foot in 2002. Lake of the Woods was at or below the trend line for the time period with the exception of being above the trend in 1981, 1988, 1999, and 2001.

The population around Lake of the Woods has been gradually increasing over the past several decades. In the 1981 study, two sources of data resulted in lake population estimates of 1,068-1,170 residents. By the 1991 study, Dynamac Corporation used census data to estimate that there were about 455 dwellings occupied year-round and 51 seasonal dwellings with a total of about 1,386 residents at Lake of the Woods.

Racial and language diversity was generally greater in Marshall County than in Starke County, but lower than Kosciusko County and the state as a whole. Race was reported as 95.5% white, compared to 87.5% for the state with a fairly even distribution among other races (African-American, Asian, and American Indiana and Alaska Native at 0.3% each, other at 2.6% and 2 or more races at 1%). In Marshall County, 9.8% of households spoke a language other than English at home with 3.3% speaking Spanish. This was a higher number of bilingual homes than in either of the other two counties (8.4% and 5.1% for Kosciusko and Starke) or in the state (6.4% of households). Over the past 10 years, there has been a tripling of county residents who were born outside the United States, which

was three times greater than the state percent change and seven times greater than Starke County.

According to the Marshall County website, Bremen has a long history of a strong manufacturing industry with over 48 such factories operating currently. A combination of factors including the availability of skilled labor, proximity to major markets and the cost of doing business supports the advantages of Bremen business climate.

Most of the information presented below on the history of the town and surrounding area is from the Bremen Historical Society website. Early industries in the area were associated with agricultural production. One of the first industries established in the area was the Bremen Clay Products Company, a manufacturer of brick and drain tile in the late 1800s. The William Leman Company was established in 1911 as a mint farm and processing plant. Mint is a crop that grows prolifically on soils associated with wetlands, reflecting the predominance of wet flat landscapes through the county.

Access to and development of recreational amenities proceeded through the 1930s and 1940s. A new interstate highway marked as U.S. 6 "from Cape Cod to Colorado" was initially christened the Roosevelt Highway in 1932. Lake of the Woods welcomed visitors to a new park in 1936, to be called "Birchwood" as a result of a naming contest sponsored by the Bremen Conservation Club, which owned much of the north end of the lake. Entertainment at the time included two dance halls and a brothel. Where the public access site is located today, there was a Boy Scout camp. In the latter part of the 1940s and through the 1950s, the area around the town of Bremen experienced a surge in the population, jumping from 2,179 in the '40s, to 3,062 by the end of the '50s. A significant jump in development occurred at that time around many of northern Indiana's lakes. Businesses near Lake of the Woods continued to play a role in the area economy through the next several decades. The Sprig O' Mint golf course opened on the west edge of Bremen in 1963, bordering two streams that flow towards Lake of the Woods. In the fall of 1977, Bremen paid tribute to its German heritage by presenting the first Oktoberfest.

Since the late 1800s, flooding has been an issue for agricultural production. Area farmers periodically petition state environmental agencies to allow dredging of the Yellow River to alleviate flooding of farm fields. A group of farmers met with representatives from the government agencies at St. Isidore Hall in Bremen in October 1996. The IDNR Division of Water did not approve the project. The IDNR also indicated that dredging this stretch may increase downstream flooding. The IDNR allowed farmers to remove logjams, or fallen trees, that were clogging the flow of water, but did not permit dredging the river.

Drainage concerns also drove continuing discussions between the lake residents and farmers regarding the dual lake level that was set by the county courts under an agreed order entered in 1986. The order declared that the lake was to be maintained at two levels; 803.85' mean sea level datum (the original level set for the lake) during the four months commencing May 15, and 802.85' during the eight months commencing September 15. A petition brought by the Lake of the Woods Property Owners sought to eliminate the September draw down, and maintain the lake at the level originally set in

1948, 803.85' MSLD, throughout the year. Upstream agricultural interests filed their remonstrance opposing the petition, which was upheld by the court in early 2005. At the time of this report, the case remains in litigation after several actions of the circuit and appellate courts since the year 2000.

Online resources:
Population statistics were from the 2000 United States census, unless otherwise specified.
http://www.stats.indiana.edu/c2k/c2kframe.html

County economic statistics
http://www.stats.indiana.edu/profiles/pr18099.html

Marshall County online
http://www.co.marshall.in.us/

Historical information on the Town of Bremen and surrounding area is from conversations with local residents, the Marshall County website and the Bremen Historical Society website: http://www.bremenhistoricalsociety.org/decades5.htm.

2.2 Climate

The climate of northern Indiana tends to be somewhat cooler and drier than southern Indiana. Between 1971 and 2000 the mean temperature for north central Indiana ranged from a low of 23.3 degrees Fahrenheit in January to a high of 73 degrees in July. The average annual temperature is approximately 49.7 degrees. Similarly, between 1971 and 2000 the monthly normal precipitation ranged from a high of over 4.11 inches in June to a low of less than 1.81 inches in February for north central Indiana. The average annual precipitation is approximately 38.38 inches.

Online resources:
Climatological data
http://shadow.agry.purdue.edu/.

2.3 Land use

There has been virtually no change in the land use at the regional level between 1980 and 2000. Some small areas around Plymouth appear to have been converted to urban use (NRCS, 2000). The surrounding area is largely rural.

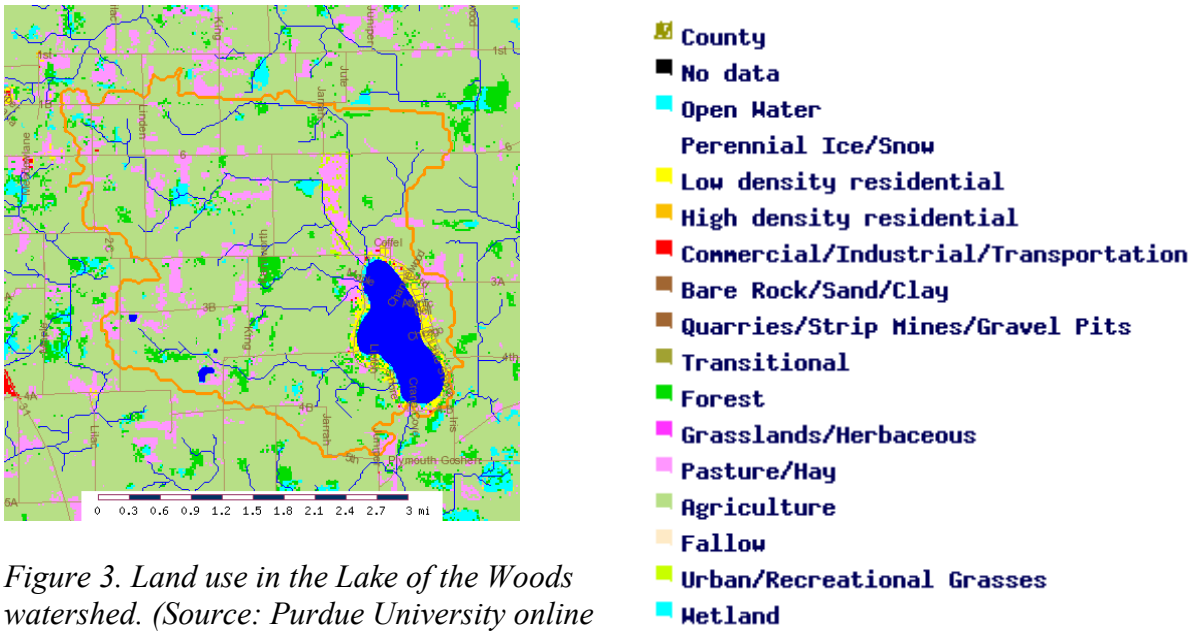


Figure 3. Land use in the Lake of the Woods watershed. (Source: Purdue University online delineation tool)

Agricultural production is the predominant use of the Lake of the Woods watershed by land area. Over 74% of the watershed is managed for row crop production with 10.9% in grass, pasture or hay production and 4.6% covered by forest (Figure 3; Table 2).

Table 2. Current land use in the Lake of the Woods watershed by acreage and percentage (Source: Purdue University).

land use	acres	percent
agriculture	4773.9	74.4%
grass/pasture	699.2	10.9%
water	505.8	7.9%
forest	297.5	4.6%
residential	137.8	2.1%
commercial	3.6	0.1%
impervious surface	133.2	2.7%

Online resources:

Land use data and maps from the Watershed Delineation tools, Agricultural and Biological Engineering Department, Purdue University at:
http://pasture.ecn.purdue.edu/~jychoi/wd_home/

NRCS - The Changing Midwest Assessment
http://ncrs.fs.fed.us/4153/deltawest/landcover/LCChange.asp

2.4 Soils, topography and wetlands

The Natural Resources Conservation Service (NRCS) describes the soils around Lake of the Woods as deep, nearly level and poorly drained. The soil associations in the area are the Rensselaer-Whitaker, characterized by swales on nearly level or depressional outwash plains, lake plains and terraces, and the Houghton-Adrian-Palms Association, typical of depressional areas commonly found in bogs and old glacial lakebeds (USDA, 1980; Figure 4).

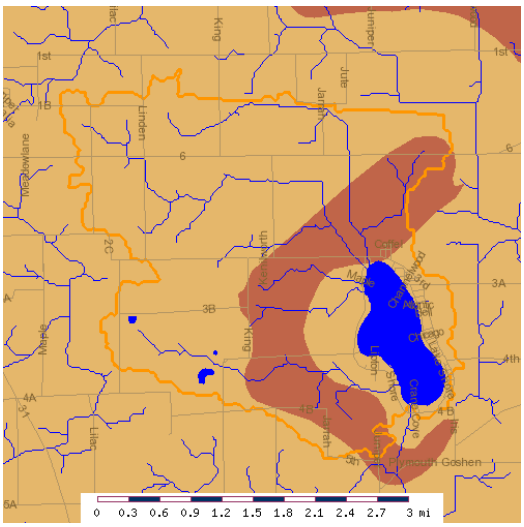


Figure 4. Distribution of general soil associations in the Lake of the Woods watershed. The Houghton-Adrian-Palms Association is represented in dark color and Rensselaer-Whitaker in light color. (Source: Purdue University online delineation tool)

A more detailed description and digitized information on soil types found in the watershed are available from the Marshall County Soil and Water Conservation District (Figure 5).

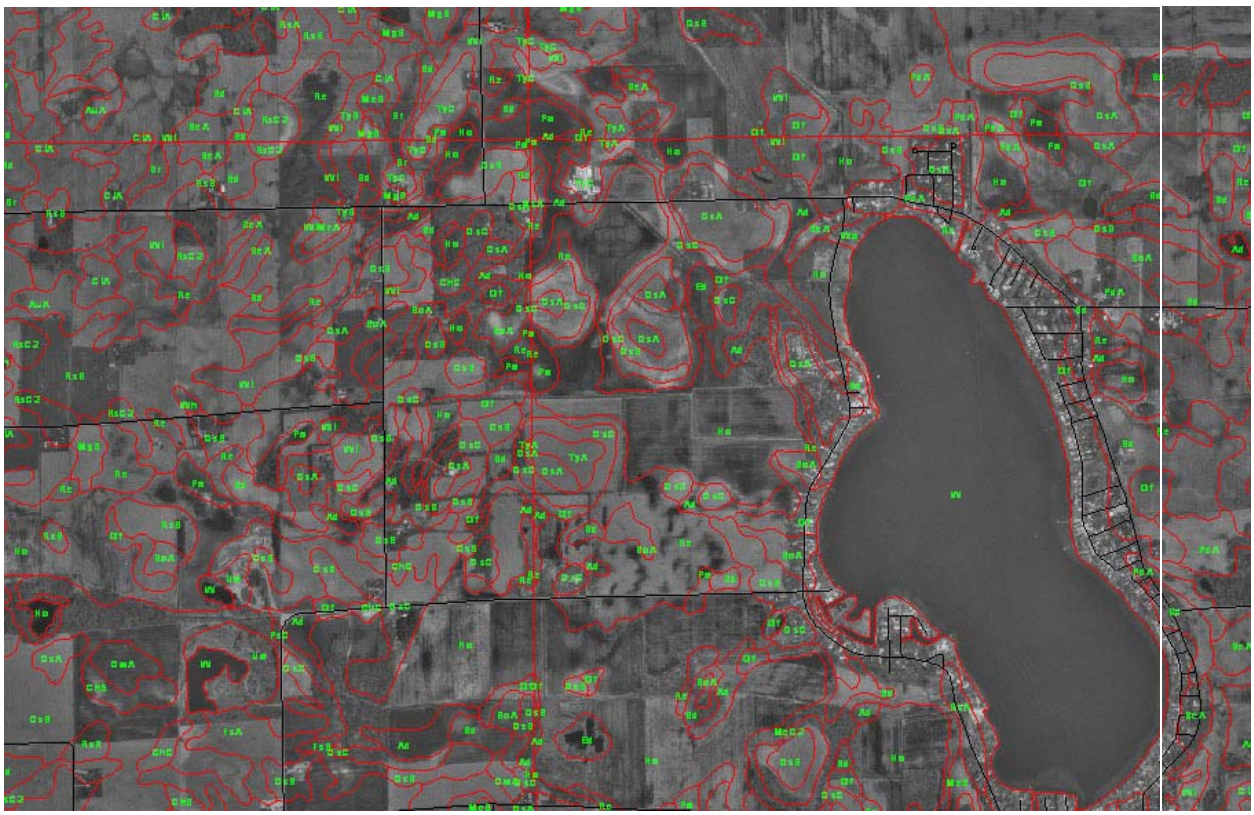


Figure 5. Example of digitized soil survey data for the Lake of the Woods watershed. (Source: NRCS, 1999-2000)

Most of the Lake of the Woods watershed is relatively flat with an average slope of 1.7% and having some variation in slope around the near west and northwest sides of the lake with a maximum slope of 8.5% in a hilly region west of the lake between East 3D and East 4th Roads (Figure 6).

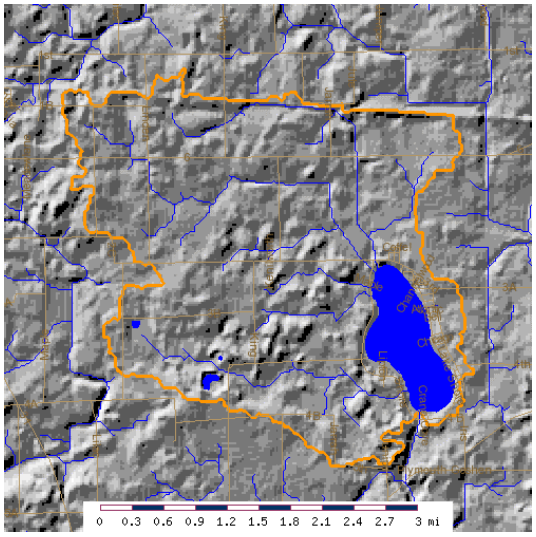


Figure 6. Topography (slope) as shown by digital elevation in the Lake of the Woods watershed. (Source: Purdue University)

Soil types and slopes are pertinent for the purposes of this document to the extent that they affect the identification of best management practices to control erosion and nutrient runoff. Knowing the location and extent of major soil associations, hydric soils and highly erodible soils can guide planning decisions as they affect runoff coeffients, erodibility and selection of appropriate measures at particular sites.

Highly erodible soils and steep slopes comprise very little of the Lake of the Woods watershed, indicating that soil erosion can be readily controlled with proper management techniques in most areas. Additional information on soils is included in the 1991 Feasibility Study.

Nearly 50% of the soils in the watershed are classified as "hydric," having characteristics of wetland or frequently flooded areas. Most of these soils are presently drained for agricultural use. Wetland habitat is present on the immediate northwest side of the lake near the mouth of Martin and Stephey Ditches and in smaller, scattered locations around the upper watershed that could total from 20 to 100 acres of wetlands (1991 Feasibility Study; Figure 7). Wetlands in the watershed provide a variety of benefits including flood control, groundwater recharge, nutrient filtration, and wildlife habitat associated with forested and emergent vegetation.

Sediment testing in the lakebed indicated that sand was the dominant particle size, comprising 85 percent of the total sediment composition (Dynamac, 1991). As a result, activities that stir the bottom, such as boating and dredging may have relatively minimal and short-term effects on water quality due to suspended sediment in the water column. However, resuspension could increase the availability of nutrients (i.e., phosphorus attached to sediment) and subsequent growth of unwanted algae and plants.

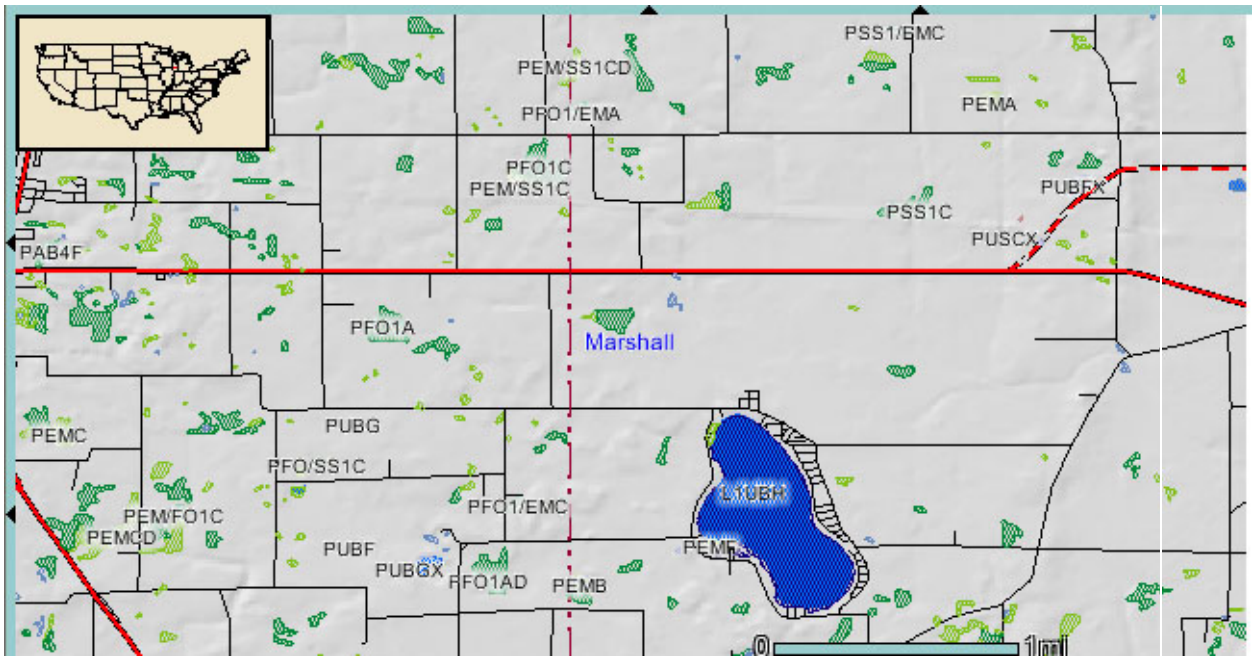


Figure 7. Major wetlands in the area including the Lake of the Woods watershed, according to the National Wetlands Inventory. (Source: US Fish & Wildlife Service)

Online resources:
U.S. Fish and Wildlife Service Wetlands Mapper
http://wetlandsfws.er.usgs.gov/wtlnds/viewer.htm

2.5 Hydrology and water use

The lake has a hydraulic retention time of 0.935 years, meaning that on average, the entire lake volume can be replaced by inflowing water every 360 days; this retention time suggests that the lake will respond relatively slowly to reductions in external nutrient inputs (Dynamac, 1991). Lake of the Woods is dependent on tributary streams and its watershed for water supply and flushing of nutrients. Runoff supplies 263 million cubic feet of water annually or 83% of the inputs; precipitation supplies 55.6 million cubic feet. Groundwater inflow, including spring flow in the lake, was assumed to be zero due to unavailability of data.

Lake of the Woods is one of four lakes in Indiana with a dual legal lake level. The dam is lowered 12 inches to 802.85 ft MSL from September 15 to May 15. The other dual level lakes are: Crooked Lake, Steuben County, (raised six inches from May through November), Lake Tippecanoe, Kosciusko County, (lowered six inches, November 1 to April 1) and Winona Lake (lowered 12 inches, November 1 to May 1).

Reasons for lowering Indiana lake levels during the winter vary. At Winona Lake, water level is dropped to reduce ice damage to the seawalls and to the control mechanisms of the dam. Lake of the Woods water levels are lowered primarily to aid drainage of agricultural fields in a relatively flat, low-lying landscape. Some of the farmland in the watershed is at or below lake level during the summer, resulting in the use of pumps to lower the water table in several fields. It is likely that pumping of water from farm fields would increase if the water level were maintained at the higher level year-round.

The dam at Lake of the Woods generally has continuous flow over the sill, even when the lake is lowered. According to conclusions filed by court case reviewers, the water level of the lake during the late summer of 1999 and in early summer of 2005 was lower than the set May to September elevation of 803.85 feet MSL due to a lack of rainfall. The low water level condition was consistent with other lakes throughout the area.

All tributaries to Lake of the Woods on the west side of the lake are regulated drains along most or all of their length (Figure 8). This legal designation allows the county drainage board to generate revenue from land benefiting from drain construction, repair, evaluation or maintenance according to regulations associated with state Drainage Law (IC 36-9-27). The county surveyor, the board, or an authorized representative of the surveyor or the board acting under this chapter has the right of entry upon land lying within seventy-five (75) feet of any regulated drain.

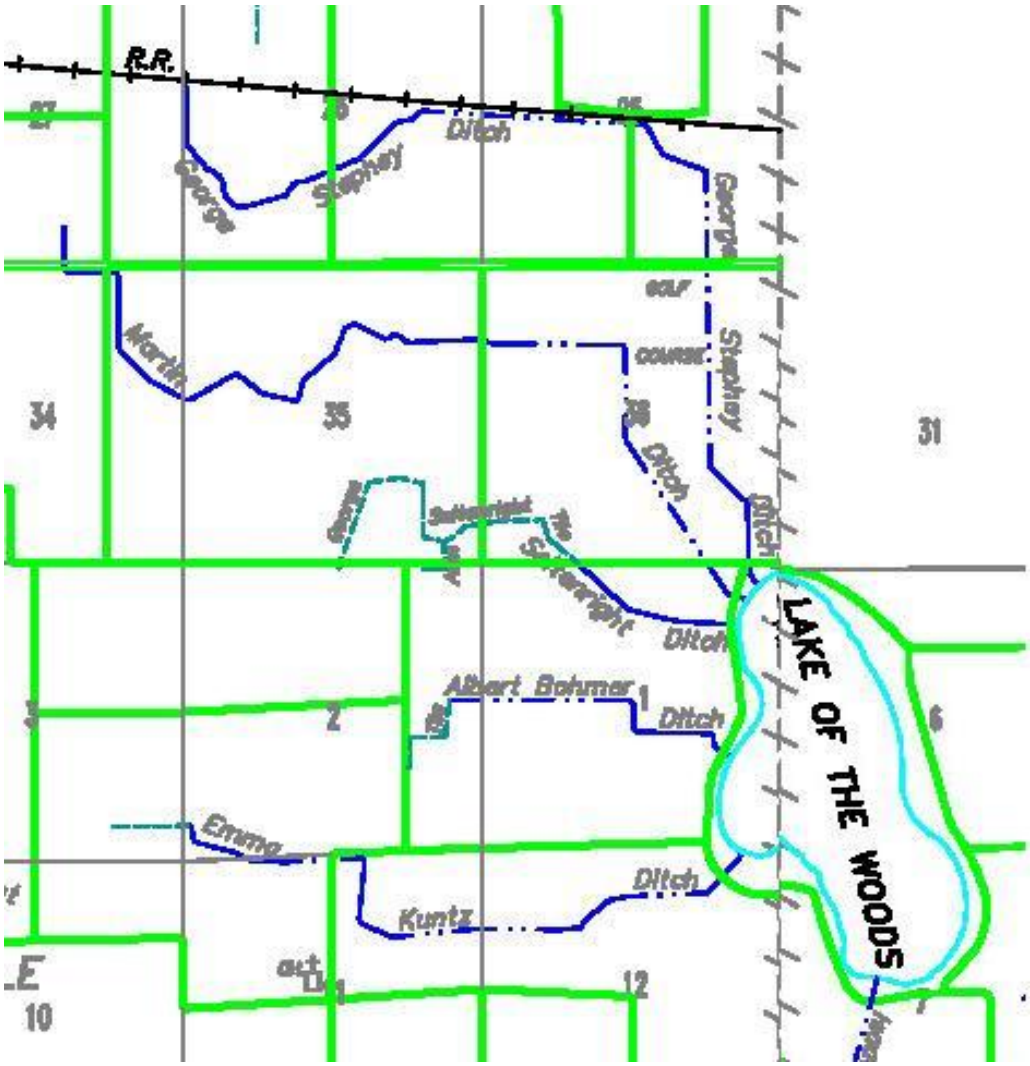


Figure 8. Regulated drains leading to and from Lake of the Woods (Source: Office of the Marshall County Surveyor).

Online resources:
Map of regulated drains in Marshall County
http://www.co.marshall.in.us/Surveyor/Map.pdf

According to IDNR Division of Water records, agriculture was the largest user of surface water in the county. Agricultural withdrawals of surface water in Marshall County increased steadily from about 50 million gallons in 1986 to 300 million in 1991, then tapered off to 150 million in 1997. Surface water withdrawals for energy production were greatest from 1998-1992 at about 150 million gallons. Industrial use went from 50 million gallons in 1986 to 250 million in 1993, before tapering to zero from 1994-1998.

Public water supply was the largest user of groundwater in the county. Groundwater withdrawals for agriculture fluctuated from year to year, ranging from a low of about 50 million gallons in 1990 to a high of 600 million in 1991 and averaging about 300-400

million gallons. In comparison, groundwater use for public water supplies in the county ranged from 900 million gallons in 1986, peaking at about 1.35 billion in 1988 before tapering to an average use just over 1.1 billion gallons in 1997. Industrial use of groundwater went from about 80 million gallons per year in 1986 to over 200 million in 1992 and stayed at about that level through 1997.

Online resources:
IDNR Division of Water: Public freshwater lake legal and average normal water levels
http://www.in.gov/dnr/water/surface_water/lake_levels/

IDNR Division of Water county-wide water withdrawal data
http://www.in.gov/dnr/water/water_availability/trends/pdf/k-m.pdf

2.6 Land ownership

Most of the land in the State of Indiana is in private ownership. The Lake of the Woods watershed is no exception and contains no known park properties or natural areas belonging to the county or state other than the area around the IDNR public access site. County roads and other easements typical of a rural and suburban landscape in Indiana are in the area. The property containing the Lake of the Woods community center includes land along the lake.

2.7 Cultural resources

There are no Indiana properties located in the watershed listed on the State and National Historic Registers.

Online resources:
State and National Historic Register
http://www.in.gov/dnr/historic/common/listingnationalregister.html#IM

2.8 Endangered species

According to the Indiana Department of Natural Resources there are a number of Endangered and Threatened animal and plant species that may be in Marshall County. Many of the state endangered, threatened, and federally endangered species that have been found in the county are associated with lakes and wetlands. These species may occur in habitats around the Lake of the Woods watershed. The 1991 Feasibility Study listed only one historical entry. Broadwing sedge (*Carex alata*) is a rare species that was collected in 1922 along the sandy border on the east side of the lake.

Online resources:
IDNR List of endangered, threatened and rare species by county
http://www.in.gov/dnr/naturepr/species/#L

2.9 Organizational resources

A thorough assessment of the organizations that may be available to implement land and water conservation practices is useful in determining current organizational capacity, feasibility of various solutions and to project community needs for the future.

2.9.1 Governmental organizations

Several regional and local governmental organizations provide services to the Lake of the Woods and watershed residents. These organizations are described in more detail below.

2.9.1.1 Kankakee River Basin Commission

The Kankakee River Basin Commission was created by the Indiana General Assembly in 1977. The Commission has responsibility for eight counties in Northwestern Indiana (Jasper, Lake, LaPorte, Marshall, Newton, Porter, Starke, and St. Joseph). The Commission is composed of 24 members: a representative from each of the eight county commissioner boards, the eight county surveyors or their employee, and a supervisor of the eight Soil and Water Conservation Districts

The commission was established to coordinate development in the Basin and has, since established, sought to plan and coordinate the many environmental demands placed upon the Kankakee River, its tributaries, and all the land around it. This includes flood control and drainage, as well as recreation, water quality and supply, hunting and fishing, wetlands preservation, and upland soil erosion. The Kankakee Basin in Indiana comprises 1.9 million acres of which almost 1.6 million has been used as cropland.

The commission has worked since its inception with many levels of government; federal, state, and local. It has maintained good relationships with the Natural Resources Conservation Service and the Indiana Department of Natural Resources. The KRBC remains in close working contact with all eight Soil and Water Conservation Districts and with the local government of the eight counties.

Online resources:
Northwest Indiana Regional Planning Commission
http://www.nirpc.org/

2.9.1.2 Marshall County Soil & Water Conservation District

According to their website, the Marshall County Soil and Water Conservation District is a legal subdivision of state government responsible for the conservation of soil and water

resources within its boundaries. It is an independent body formed under and subject only to the Indiana Soil and Water Conservation District Law.

The SWCD was organized by landowners of Green, Polk, Union, Walnut, and West Townships in May of 1955. In December of 1961 Bourbon, Center, German, North, and Tippecanoe Townships were added to the District. The District is controlled by a board of five local supervisors - three elected by the landowners in the district and two appointed by the State Soil and Water Conservation Board. The supervisors meet 12 to 15 times a year to conduct the district's business and attend other meetings in and out of the county. They serve their community without pay.

Supervisors are responsible for providing leadership in the conservation and development of soil, water and related resources within the district's boundaries. The major purpose of the district is to analyze needs and develop and carry out both short and long range programs aimed at solving resource problems, primarily dealing with soil and water resources. The ultimate district objective is to cause soil and water conservation practices and systems to be implemented upon the land.

Supervisors and staff work with both rural and urban dwelling landowners or occupiers, groups, local agencies and others to prevent resource problems, correct existing soil and water conservation problems and help utilize the county's natural resource capabilities. Through the district, local people are also better able to organize and coordinate their efforts in obtaining technical and financial assistance from state and federal agencies with responsibilities and expertise in natural resource use and development.

Online resources:
Marshall County SWCD
http://www.marshallcountyswcd.iaswcd.org/

2.9.1.3 Marshall County Drainage Board

The Marshall County Drainage Board meets on the third Thursday of the month. The County Surveyor is an ex-officio, non-voting member of the County Drainage Board. In this capacity the County Surveyor is the technical authority on the construction, reconstruction, and maintenance of all regulated drains or proposed regulated drains in the county. The Board and Surveyor have jurisdiction over regulated drains. Regulated drains are drains established by either the Commissioners Court or Circuit Court of each county prior to 1965 or the Drainage Board since 1965. These drains are open ditches or tile drains or a combination. These can also be municipal storm sewers. The County Surveyor also is normally a member of the County Plan Commission. As a member of the Commission they attend the monthly meeting and hear and make decisions on subdivisions and planning and often advise on technical review of plats. The County Surveyor also administers a filter strip tax abatement program under I.C. 6-1.1-6.7. The drainage board generally meets on the third Monday of the month.

Online resources:

Marshall County Surveyor's Office
http://www.co.marshall.in.us/Surveyor.htm

2.9.1.4 Other Marshall County offices

Marshall County offices provide a number of planning and assistance services to citizens in the county. The Marshall County Board of Commissioners meet several times per month, often immediately after county drainage board meetings. The County Plan Commission generally meets on the fourth Thursday of the month. Purdue University Cooperative Extension Service maintains offices in Marshall County with staff dedicated to the education of Indiana citizens through the application of land-grant university research and knowledge base to develop youth and strengthen agriculture, families and communities.

Online resources:
Marshall County Commissioners meeting schedule
http://www.co.marshall.in.us/Commissioners/Commissioners.htm

Marshall County Plan Commission meeting schedule
http://www.co.marshall.in.us/Plan/Plan%20Meetings.htm

Purdue Cooperative Extension
http://www.ces.purdue.edu/marshall/

2.9.1.5 State and federal agencies associated with water quality issues

Several state and federal agencies provide services to the Lake of the Woods watershed residents, including the Indiana Department of Natural Resources (IDNR), Indiana Department of Environmental Management (IDEM), Natural Resources Conservation Service (NRCS), and Purdue Extension Service.

2.9.1.6 Lake of the Woods Regional Sewer District

The board for the Lake of the Woods Regional Sewer District (LOWRSD) consists of five members, two of whom are elected, one appointed by the town of Bremen, one by the Marshall County Commissioners, and one by the Marshall County Council. The board typically meets the evening of the fourth Tuesday of the month at the sewer department offices. The district services just under 500 accounts for properties in an area extending 1500 feet out from the lakeshore. Sewers have been in operation since 1993. The last household was connected to sewers in 2004, putting the entire district on sewer service.

In 2004, the LOWRSD met with the Marshall County Building Department and reached an agreement requiring that a sewer permit be issued before a building permit can be issued. The requirement ensures that sewers are properly installed and meet codes. The system must pass inspection by the LOWRSD prior to issuance of an occupancy permit

by the building department. Concerns about the condition of residential sewer systems can be addressed to the district office at (574) 546-2318.

2.9.2 Nongovernmental organizations

Several nongovernmental organizations (NGOs) serve the community around Lake of the Woods.

2.9.2.1 Lake of the Woods Property Owners Association

The Lake of the Woods Property Owners Association (POA) has existed for several decades and typically has around 350 members. Monthly meetings and continental breakfast are held on the first Saturday of every month, generally in the Community Center. Officers include a four-member executive committee and two representatives from each of five districts around the lakeshore, which are elected through a majority vote of members present on the first Saturday in August and serve for a twelve-month period, starting September 1. Officers of the POA regularly attend meetings of related state and local organizations including the SWCD, drainage board, KRBC, State Soil and Water Conservation Board, and others.

The Mission Statement defines the intent and focus of the organization as:

> *It is the mission of the Lake of the Woods Property Owners Association to distinguish itself as the community's leader by providing resource, direction, and service that results in superior lake quality and superior lake living. To achieve this we must:*
>
> - *Continuously improve our Association and the Lake's environment.*
> - *Provide information and education to keep our members informed on the priorities and goal.*
> - *Place equal emphasis on all Lake of the Woods' priorities: ecology, conservation, property values, recreation, and safety.*
>
> *Lake of the Woods Property Owners Association's goal is to be the best, not because we say we are, but because our residents and visitors tell us we are.*

The POA sponsors a variety of community events, several of which are fundraisers, including:

- Fundraising breakfast and supper events
- Children's Halloween Party
- German Festival (two days), approximately 450 guests
- Firemens' Festival booth

Public services provided by the POA include:

- Treatment of aquatic nuisance plants in the lake

- Clean-up activities
- Placement of a streetlight at
- Installation of welcome signs around the lake
- Cost-share for the 1991 feasibility study, 2003 aquatic plant control survey, and 2004 watershed management plan.
- Participation in the Indiana Volunteer Lake Monitoring Program

The POA obtains funds from a variety of sources, including annual membership dues of $20, sale of Entertainment® books, sale of clothing with the logo, and other contributions.

2.9.2.2. Bremen Conservation Club

The Bremen Conservation Club (BCC) meets on the third Tuesday of every month, usually at the community Center. In 2004, the BCC received a $2,000 grant to restore the old Conservation Club Building. Funds were used to repair brickwork and sidewalk areas around the building, which was constructed in the early 1930's as part of the WPA program. The building is considered unique because of its distinct shape and design.

The DNR awarded the BCC custodial conservancy for the property located at 4th Road and East Shore Drive. The property extends from the road to the lakeshore and will remain as a sanctuary and natural habitat conservation area.

Public services provided by the BCC include:

- Participation in the IDNR Riverwatch volunteer stream monitoring program.
- Annual Raffle and Ice Fishing Derby (started in 2004)

3.0 State and regional benchmarks for water quality

State and regional reports provide benchmarks for water quality in Indiana lakes and streams by identifying how the Lake of the Woods watershed fits into the overall state and regional picture.

3.1 Previous lake and watershed basin studies

Two lake diagnostic studies were completed for Lake of the Woods: an EPA study in 1982 and an IDNR LARE study in 1991. Data from these studies is summarized in the sections of this plan regarding water quality.

3.2 Statewide impaired waters 303(d) list

The Section 303(d) list, named after enabling legislation in the federal Clean Water Act, provides a listing of waters that do not or are not expected to meet applicable water quality standards. The hydrologic unit #7120001050150 contains Lake of the Woods and is known as the Yellow River-Milner Seltenright Ditch. Like other sections of the Yellow River through Marshall County, it is listed for *E. coli* levels. The hydrologic unit #7120001050160 and known as the Elmer Seltenright Ditch headwaters is listed for impaired biotic communities. Designation on the 303(d) list is significant because IDEM Section 319 funds are primarily targeted to these areas.

Online resources:
IDEM 2004 303(d) list of impaired waters
http://www.in.gov/idem/water/planbr/wqs/303d.html

3.3 Fish Consumption Advisories

A number of Indiana lakes, including Lake of the Woods, are listed on the 2003 fish consumption advisory for mercury and polychlorinated biphenyls (PCBs) in fish. The ISDH provides information about the sources and effects of these persistent chemicals as follows.

Mercury is a naturally occurring as a result of normal breakdown of minerals in the earth's crust. Inorganic mercury enters the air from the burning of coal or garbage and from the emissions of factories that use mercury. Once in water, methyl mercury is very persistent in lakes and streams. Long or short-term exposure to either organic or inorganic mercury can damage the brain, kidney, and developing fetuses.

Like mercury, PCBs remain in aquatic systems long after their introduction. They have excellent electric conductive properties were used industrially as coolants, insulating materials, and lubricants in electrical equipment. The United States stopped making them in 1977 because of a range of potential health effects demonstrated in laboratory animals.

In the state *Fish Consumption Advisory*, Group 1 fish show low to no risk of contamination and consumption is not restricted. Group 2 is recommended at not more than one meal per week. Group 3 is recommended at not more than one meal per month. Fish in Group 5 should not be eaten. Note that advisories may be more restrictive for women who are nursing or intend to become pregnant and for children under the age of 15 years.

The fish consumption advisory at Lake of the Woods is for mercury contamination in largemouth bass over 14 inches (Group 2) and for contamination by PCBs in white bass over 13 inches (Group 2). Testing of bluegill up to 9 inches indicates that there is low to no risk of contamination for consumption (Group 1). For comparison, another lake listed on the advisory for Marshall County is Lake Maxinkuckee with recommendations due to mercury and PCBs in channel catfish 16-21 inches (Group 2) and over 21 inches (Group

3), and by mercury in largemouth bass over 6-17 inches (2) and over 17 inches (Group 3) and in walleye 22-23 inches (Group 2) and over 23 inches (Group 3).

Carp in Lake of the Woods showed contamination by PCBs with advisories in fish up to 22 inches (Group 2) and over 22 inches (Group 3). Generally, carp are contaminated with mercury and PCBs with the following advisory for all Indiana rivers and streams unless otherwise noted: over 25 inches (Group 5); 20-25 inches (Group 4); and 15-20 inches (Group 3).

Online resources:
Indiana State Department of Health Fish Consumption Advisories
http://www.ai.org/isdh/programs/environmental/fa_links.htm

3.4 Unified Watershed Assessments (UWA)

Lake of the Woods and its watershed are located within the priority areas in the 2001 Unified Watershed Assessment that described watersheds in need of financial or technical assistance for maintenance and improvement of water quality.

Online resources:
Map of priority areas for 2001 within the Unified Watershed Assessment.
http://www.in.gov/idem/water/img/prioritywatersheds.jpg

3.5 Volunteer water quality monitoring

Residents in the Lake of the Woods area have been active participants in volunteer water quality monitoring programs administered by two agencies in the state of Indiana. Records on Secchi depth, and later phosphorus and chlorophyll-a have been prepared and sent to the Volunteer Lake Monitoring program jointly run by Indiana University and the IDEM. Local residents also participate in the IDNR Riverwatch program, which provides citizens with educational materials and training on stream water quality monitoring, including chemical, physical and biological aspects.

As indicated in program materials, Hoosier Riverwatch promotes stewardship of Indiana's waterways through a volunteer stream monitoring and water quality education program. Riverwatch is supported by the Indiana Department of Natural Resources, Division of Soil Conservation in cooperation with Purdue University. Values stored in the Riverwatch databases result from volunteer monitoring efforts and were not obtained by scientific professionals. Both programs provide quality control training to volunteers and maintain statewide databases of information that can be used to identify areas that merit further professional study to determine more precisely what water quality problems may exist and their potential sources.

4.0 Documented water quality problems

Summaries of past data on water quality in Lake of the Woods and its tributaries provide information to guide the need and location of best management practices and education

for soil and water conservation. It is critical to remember that this is a planning document based on a review of long-term trends in water quality information from a number of sources. Available data can provide a guide to potential impacts on water quality as it affects resource management at a large scale (e.g., sediment and erosion control, nutrient management, fecal contamination, stream bank stabilization, fish and wildlife habitat improvement).

Best management practices optimize productivity of land and protection of natural resources by reducing soil erosion and transport of excess nutrients and other pollutants. Property owners base selection of appropriate practices on land use, erodibility of soils, nutrient requirements, slopes, and economic feasibility in the watershed and around the lake.

To provide an update on current water quality in the major streams around Lake of the Woods, JFNew conducted water quality, habitat, and biological assessments during the late summer and fall of 2004. These samples included stream water chemistry, macroinvertebrates, habitat assessment, interpretation of data, and technical assistance in integrating the data into the plan. Two water chemistry sampling events were taken in the fall of 2004 (baseflow on September 22, and stormflow on November 2) were analyzed at each of four sites: Martin Ditch; Stephey (also known as Walt Kimble) Ditch; Kuntz Ditch; and the lake outlet (maps in Figure 9-10; photos in Figure 11). One macroinvertebrate sample was taken and habitat condition was evaluated in the fall of 2004 at each of the two perennial stream sites (Martin and Stephey Ditches). All samples were taken after the dam was opened on September 15.

Sampling methods are used to distinguish between the need for soil and water management practices that filter overland flow of water (stormwater samples) and practices that control subsurface nutrients, such as septic system contributions (baseflow samples). All procedures were carried out according to standard LARE protocols for conducting sampling and quality assurance in a WMP process. Standard baseflow samples are taken when streams are flowing at a rate typical for time periods with little precipitation. These samples are indicative of water quality contributions from groundwater in the surrounding area. Stormflow samples are taken immediately after a rainfall event and indicate contributions from soil erosion and nutrient runoff from the surrounding landscape.

Online resources:
Indiana State Water Quality Standards (327 I.A.C. 2)
http://www.in.gov/legislative/iac/title327.html

Indiana Volunteer Lake Monitoring program
http://www.spea.indiana.edu/clp/Volunter%20Monitoring.htm

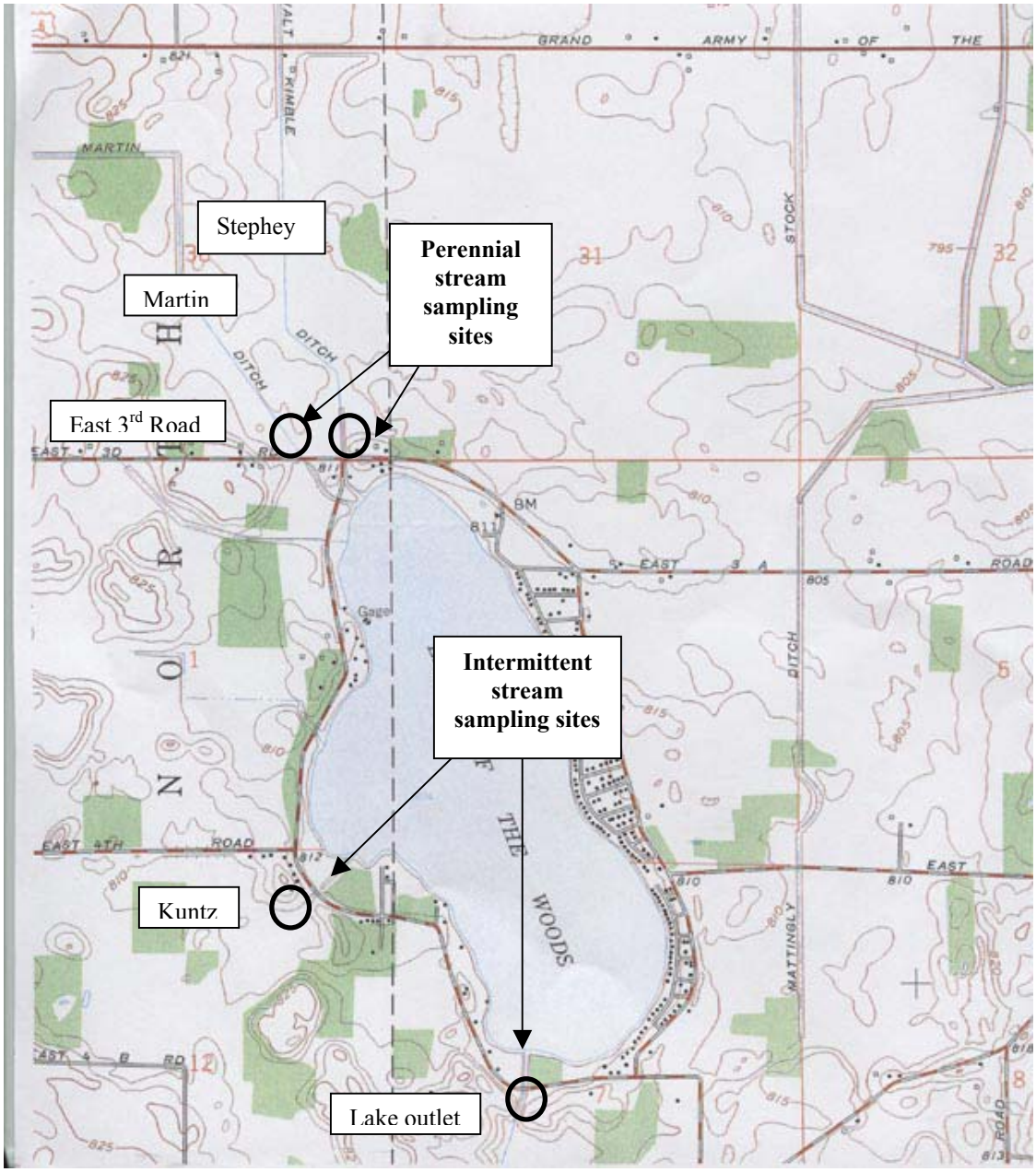


Figure 9. Location of fall 2004 sampling sites to update water quality information for Martin, Stephey (Walt Kimble), and Kuntz Ditches and the lake outlet (Isaac Sells Ditch).

Figure 10. Drainage areas for subwatersheds sampled at Lake of the Woods during 2004 (top right to bottom left: Stephey Ditch, Martin Ditch, Kuntz Ditch).

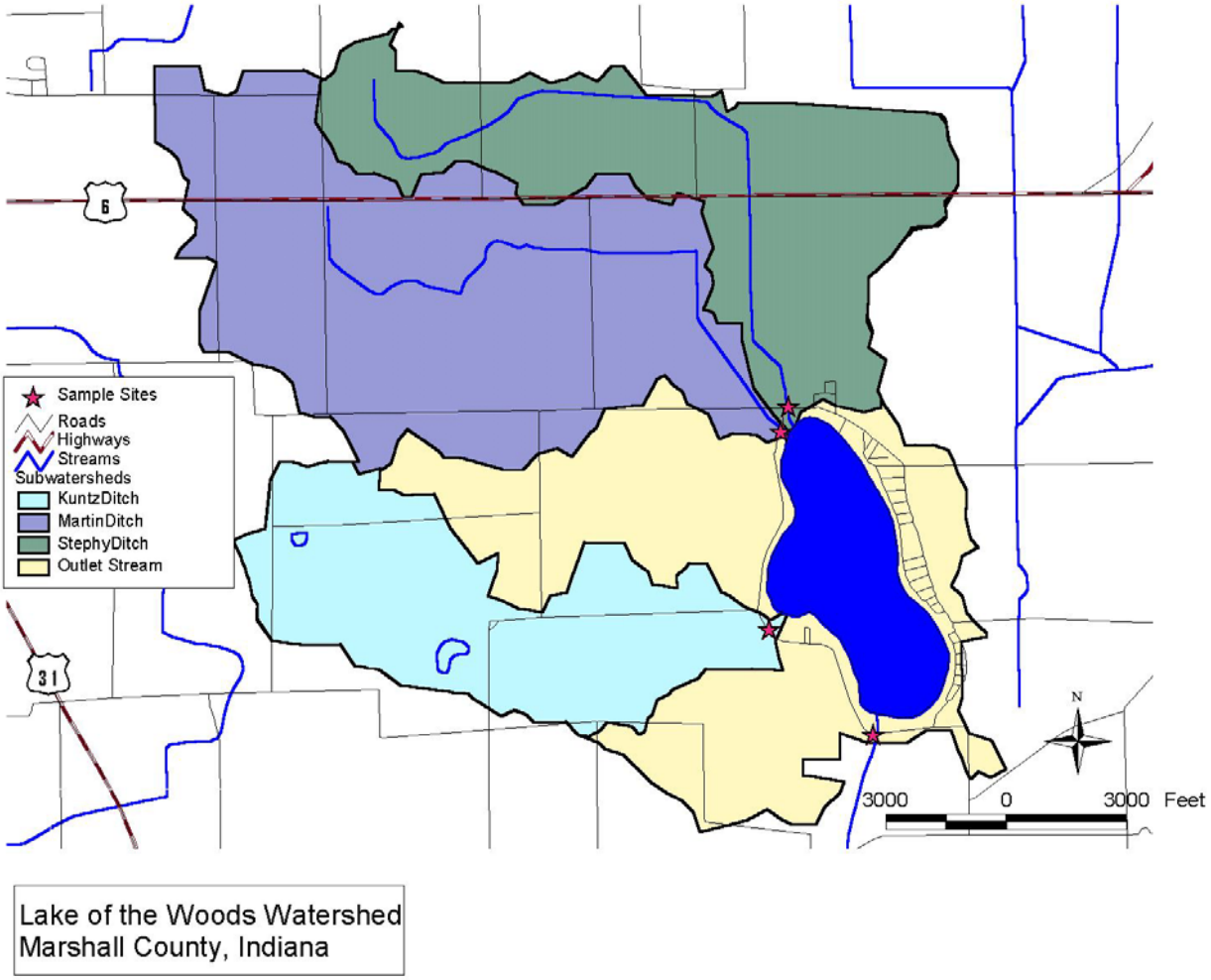


Figure 11. Photographs of sampling sites at Lake of the Woods, 2004.

Figure 11 (cont.). Photographs of sampling sites at Lake of the Woods, 2004, cont.

4.1 Lake quality

Lake water quality is a combination of a number of factors, including water clarity, algae abundance and species composition, and nutrient levels. Each of these factors will be described in this study, as they pertain to prioritization and planning for water quality protection.

4.1.1 Indiana Trophic State Index (ITSI)

The Indiana Trophic State Index (ITSI; formerly called the Eutrophication Index, or EI) was developed by the Indiana Department of Health in the early 1970s by combining measurements for several factors to create one score that can be compared with some statistical validity to other natural lakes across northern Indiana. Water quality monitoring functions were transferred to the IDEM when it was established in 1987.

The IDEM Lake Assessment Program uses the ITSI to provide basic information on the status and trends of the trophic state (enrichment levels) of Indiana's public inland lakes and reservoirs (IDEM, 2004). Physical, chemical, and biological data gathered on each lake are combined into a multi-metric index that indicates eutrophication, or productivity of the lake as a response to nutrient and sediment inputs. Eutrophy points are assigned to each parameter and totaled for a final ITSI score ranging from 0 to 75 (Table 3). The lower the score, the lower the levels and effects of nutrients.

Table 3. IDEM Lake Classes used in the 305(b) report after 1999. (IDEM, 2004).

Indiana TSI Scores	EPA Trophic Class
0-15	Oligotrophic (low nutrient effects)
16-31	Mesotrophic (average nutrient effects)
32-46	Eutrophic (high nutrient effects)
47-75	Hypereutrophic (very high nutrient effects)

As described by the IDEM lake classification scheme, Lake of the Woods has scored consistently in the range for a eutrophic lake with one sample taken in 1990 that entered the range for a hypereutrophic lake. The ITSI for Lake of the Woods fluctuated consistently around 40 points over nearly three decades from 1975 through 2004, changing little in the past 10 years and is currently virtually the same as it was in 1975 (Figure 12).

Progress: Samples taken in 2004 showed little change the overall lake water quality over the past 10 years and was virtually the same as a reading take 30 years ago, as indicated by the Indiana Trophic State Index.

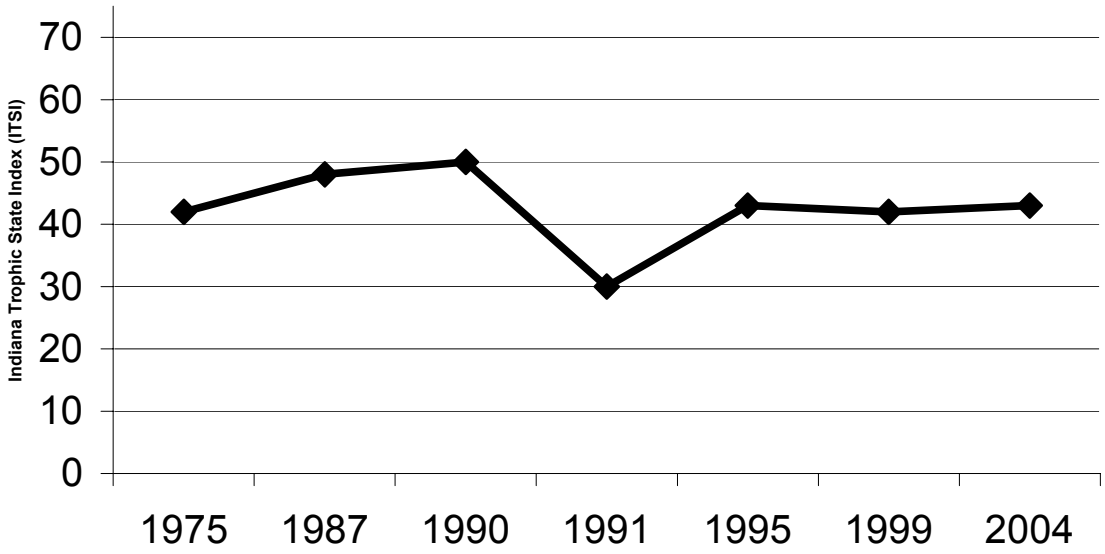


Figure 12. Indiana Trophic State Index (ITSI) taken periodically during the summer from 1975-2004. The 2004 calculation was completed for water chemistry and estimated for bluegreen algae dominance, which had not been tabulated as of the date of this study. Source: IDEM Lake Water Quality Assessment Program.

4.1.2 Lake water clarity

Average summer water clarity, as measured by Secchi depth, was 2.2 ft in data taken from 1989-2004 (Figure 13). Water clarity has generally fluctuated between 1.3 and 2.8 ft over these years, but was greatest in 1989 and 1995 at over 3 ft and was lowest in 1999-2000. Water clarity is typically greatest in drought years due to reduction in rainfall and associated runoff of sediment and nutrients into the lake. Cool and cloudy weather also can diminish growth of the algae that impair water clarity.

Lake of the Woods was compared to a database of 79 northern Indiana lakes that participate in this program. Volunteers who are trained to follow protocols designed by the IDEM and IU regularly sample these lakes. According to this data, Lake of the Woods ranked 68th out of 79 northern Indiana lakes for water clarity (a ranking of 1 is the highest water quality), as measured by mean summer Secchi depth of 2.8 feet at Lake of the Woods in 2003. In comparison, the median Secchi depth for these lakes was 5.7 ft. (A median value is the number for which there are an equal number of lakes with a larger number and an equal number of lakes with a smaller number. This statistic is a more accurate picture of a "typical" reading where there are a number of readings at one end or the other of the range of values.)

Figure 13. July-August mean Secchi depth in feet from 1989-2004. Source: Indiana University Lake Volunteer Monitoring Program.

Carlson's Trophic State Index (TSI) is another means of scoring eutrophication or biological condition of a lake. The TSI is largely based on water clarity, fertility and algal production and ranges from 0 to 100. The Secchi depth for Lake of the Woods converted to a TSI score of 62 in the year 2003. The TSI for chlorophyll-a and for Total Phosphorus were lower and similar to each other at 58 and 54, respectively. This difference suggests that in the year the data were taken, sediment or other particles in the water may have contributed somewhat more to negative impacts on water clarity than nutrients and algal growth did.

Individual values for chlorophyll-a, Secchi depth and total phosphorus and the collective TSI place Lake of the Woods squarely in the classification of eutrophic, but are not high enough to classify the lake as hypereutrophic. A TSI score in the range of 50-60, such as that found at Lake of the Woods for two of the three factors, indicates water quality supportive of warmwater fisheries but not as amenable to more sensitive species such as walleye or trout (Carlson and Simpson 1996). Lower reaches of lakes with these scores tend to be without oxygen during the summer and aquatic plants may become more abundant. The Lake of the Woods scores were approaching 60-70 points, a range in which bluegreen algae may dominate the lake enough to discourage recreational use due to taste and odor problems and excessive aquatic plant growth. Above 70 TSI points, a lake is considered to be hypereutrophic with an increasing likelihood of impaired recreational uses.

Progress: Water clarity in 2004 showed little change since 2002 and possible improvement over the past five years. In 2004, volunteer water clarity measurements were at their shallowest with a reading of 1.9 ft Secchi depth and averaged 2.6 ft. This would represent a trend towards better water clarity than in the past 10 years, but may also be related to weather, temperature and precipitation cycles.

In general, drought conditions tend to correlate with better water clarity in areas where sedimentation and/or watershed nutrient input degrade clarity due to the corresponding decrease in runoff in dry years. This pattern is somewhat discernable in the Lake of the Woods data for 1989 (drier), 1992-96 (wetter), and lower precipitation from 2000-2003. Warmer winters can also contribute to increased plant and algae growth, especially early in the spring.

Online resources:
Indiana Volunteer Lake Monitoring program
http://www.spea.indiana.edu/clp/Volunter%20Monitoring.htm

4.2 Nutrients

Nutrient levels in the 1991 study were below average in comparison to typical Indiana streams for total phosphorus, nitrate, *E. coli* and turbidity. In comparison to nationwide EPA levels, the authors of the 1991 study characterized nutrient concentrations in the two major Lake of the Woods tributaries as "moderately high" and turbidity as "very low." Updated sampling results taken in the fall of 2004 are shown in Table 4. A series of figures summarize water quality data taken from various streams in the watershed in comparison to each other, to historical levels, and to typical Indiana streams (Figures 14-16).

Table 4. Physical and chemical characteristics during low flow (September 22, 2004) and stormflow (November 2, 2004) sampling at four sites on Lake of the Woods. (All ammonia-nitrogen concentration are below the detection level during base flow.)

Stream Name	Drainage Area (acres)	Event	Flow (cfs)	Flow (l/s)	Temp (deg C)
Stephey Ditch	1,398	base	0.065	1.8	12.7
Martin Ditch	2,056	base	0.396	11.2	14.1
Kuntz Ditch	1,087	base	2.023	57.3	12.6
Lake of the Woods Outlet	7,150	base	15.868	449.1	20.9
Stephey Ditch	1,398	storm	1.053	29.8	11.5
Martin Ditch	2,056	storm	0.683	19.3	11.1
Kuntz Ditch	1,087	storm	2.311	65.4	12.1
Lake of the Woods Outlet	7,150	storm	3.570	101.0	12.3

Stream Name	DO (mg/l)	% Sat	pH	Conductivity (mmohs/cm)	Turbidity (NTU)
Stephey Ditch	1.9	17.2	7.6	713.0	2.6
Martin Ditch	3.0	29.0	7.7	865.0	8.7
Kuntz Ditch	9.2	86.1	8.2	683.0	1.7
Lake of the Woods Outlet	8.3	94.3	9.2	425.0	10.5
Stephey Ditch	5.9	54.5	7.8	657.0	5.2
Martin Ditch	2.3	21.2	7.7	821.0	2.3
Kuntz Ditch	7.9	73.4	7.5	742.0	2.4
Lake of the Woods Outlet	9.5	89.1	8.4	466.0	7.9
minimum	1.85	17.2	7.50	425	1.70
maximum	9.50	94.3	9.23	865	10.50

Stream Name	NH3-N (mg/l)	NO3--N (mg/l)	TKN (mg/l)	SRP (mg/l)	TP (mg/l)
Stephey Ditch	0.050	0.130	0.820	0.062	0.200
Martin Ditch	0.050	1.100	0.780	0.075	0.170
Kuntz Ditch	0.050	8.600	0.100	0.010	0.010
Lake of the Woods Outlet	0.050	0.100	0.930	0.040	0.050
Stephey Ditch	0.300	1.100	1.100	0.030	0.030
Martin Ditch	0.100	0.380	0.760	0.030	0.070
Kuntz Ditch	0.200	7.800	0.400	0.030	0.030
Lake of the Woods Outlet	0.850	0.180	1.600	0.030	0.030
minimum	0.05	0.10	0.10	0.01	0.01
maximum	0.85	8.60	1.60	0.08	0.20

Table 4 (cont.). Physical and chemical characteristics in fall 2004

Stream Name	**TSS**	***E. coli***
	(mg/l)	**(col/100ml)**
Stephey Ditch	2	314
Martin Ditch	16	268
Kuntz Ditch	5	540
Lake of the Woods Outlet	6	138
Stephey Ditch	3	370
Martin Ditch	2	350
Kuntz Ditch	1	134
Lake of the Woods Outlet	4	830
minimum	1.0	134
maximum	16.0	830

Figure 14. Water quality at a glance: comparison of water quality trends in Lake of the Woods and its tributaries compared to other similar waters in Indiana. Unless otherwise indicated, water quality data is for streams.

Definition of "typical" lake and stream values:

- Throughout this section, the phrase "typical northern Indiana lakes" will refer to a comparison with values in the epilimnion from up to 79 northern Indiana lakes in 2003 (Source: Indiana Volunteer Lake Monitoring Program. Protocols for the program are set by IDEM with training from IU-SPEA.)
- Where data is available, ranges are given for chemical concentrations in Indiana streams, based on data collected by IDEM at fixed monitoring stations in 1995-2000 (Source: JFNew) or ranges based on two standard deviations from the mean for IDEM data from 1991-2002 (Source: Hoosier Riverwatch Manual).
- Where IDEM analyses were not available, comparable statistics are provided from USEPA data sets by Level III ecoregion 56, which contains Lake of the Woods, from STORET for the years 1990-1999 (Source: JFNew).

Water clarity in the lake

Typical northern Indiana lakes:

- 2003: range of summer mean Secchi depths 0.5-22.5 ft
- 2003: median of all lakes 5.7 ft

Lake of the Woods:

- 2003: mean Secchi depth 2.8 ft
- 1989-2004: range of annual mean Secchi depths 1.3-3.5 ft.
- 1964-1977: range 2.0-3.8 ft

Turbidity (TSS or NTU)

Aquatic life impairment (Waters, 1995):

- Turbidity (TSS) 80-90 mg/l

Typical Indiana streams (IDEM 1995-2000):

- TSS range 2-836 mg/l
- TSS median 19 mg/l
- TSS average 37 mg/l

Lake of the Woods:

- 2004 TSS 1-16 mg/l (1.7-10.5 NTU)
- 1990 TSS < 4.0 mg/l
- 1981 Turbidity 15-50 NTU

Sedimentation on the lakebed

Typical freshwater lake in the United States:

- EPA 1990: range of 0.10-0.50 inches per year

Lake of the Woods:

- 1955-1990: range 0.17-0.53 inches per year

Figure 14 (cont.). Water quality at a glance: Phosphorus.

Total Phosphorus (TP) in the lake

Typical northern Indiana lakes:

- 2003: Total Phosphorus (TP) range 0.01-0.16 mg/l
- 2003: TP median 0.03 mg/l

Lake of the Woods:

- 2003: TP range 0.02-0.08 mg/l
- 2003: TP average 0.03 mg/l
- 1990: TP range 0.1-0.42 mg/l
- 1981: TP range 0.03-0.19 mg/l
- 1975: TP average 0.09 mg/l

Total Phosphorus (TP) in streams

IN water quality standards:

- Total Phosphorus (TP) - none

Typical Indiana streams (1995-2000):

- TP range 0.03-38.4 mg/l
- TP median 0.14 mg/l
- TP median 0.2 mg/l

Lake of the Woods:

- 2004 TP 0.01-0.2 mg/l
- 1990 TP 0.05-0.07 mg/l
- 1981 TP 0.02-0.20 mg/l
- 1975 TP 0.01-0.26 mg/l

Soluble Reactive Phosphorus (SRP)

IN water quality standard:

- SRP - none

Typical Indiana streams (regional EPA data):

- SRP range 0.005-0.17 mg/l.
- SRP median 0.02 mg/l.

Lake of the Woods:

- 2004 SRP 0.01-0.08 mg/l
- 1990 SRP not available
- 1981 SRP 0.01-0.18 mg/l
- 1975 SRP 0.01-0.12 mg/l

Figure 14 (cont.). Water quality at a glance: Nitrogen.

Nitrate (NO_3)

IN water quality standard:

- Nitrate (NO_3) 10 mg/l

Typical Indiana streams (1995-2000) for Nitrite + Nitrate (designated below as NO_3):

- NO_3 range 0.04-32 mg/l
- NO_3 median 2.1 mg/l
- NO_3 average 2.9 mg/l

Lake of the Woods:

- 2004 NO_3 0.1-8.6 mg/l
- 1990 NO_3 3.6-5.7 mg/l
- 1981 NO_3 1.5-13.0 mg/l
- 1975 NO_3 0.2-8.0 mg/l

Ammonia (NH_3)

IN water quality standard:

- NH_3 5.9 mg/L at a temperature of 20 degrees C and a pH of 8.0 to exceed the state standard for unionized ammonia (0.2135 mg/L; depends on temperature and pH).

Typical Indiana streams (1995-2000):

- NH_3 range 0-13 mg/l
- NH_3 median 0.2 mg/l
- NH_3 average 0.3 mg/l

Lake of the Woods:

- 2004 NH_3 0.05-0.85 mg/l
- 1981 NH_3 0.02-0.30 mg/l
- 1990 NH_3 not available
- 1975 NH_3 0.10-0.50 mg/l

Organic Nitrogen (TKN)

Water quality standard:

- TKN - none

Typical Indiana streams (1995-2000):

- TKN range 0-16 mg/l
- TKN median 0.7 mg/l
- TKN average 0.86 mg/l

Lake of the Woods:

- 2004 TKN 0.10-1.60 mg/l
- 1981 TKN 5.0-36.1 mg/l
- 1990 TKN 0.95-1.78 mg/l
- 1975 TKN 0.7-2.7 mg/l

Bacteria (*E. coli*)

IN water quality standard:

- *E. coli* 235 CFU/100ml

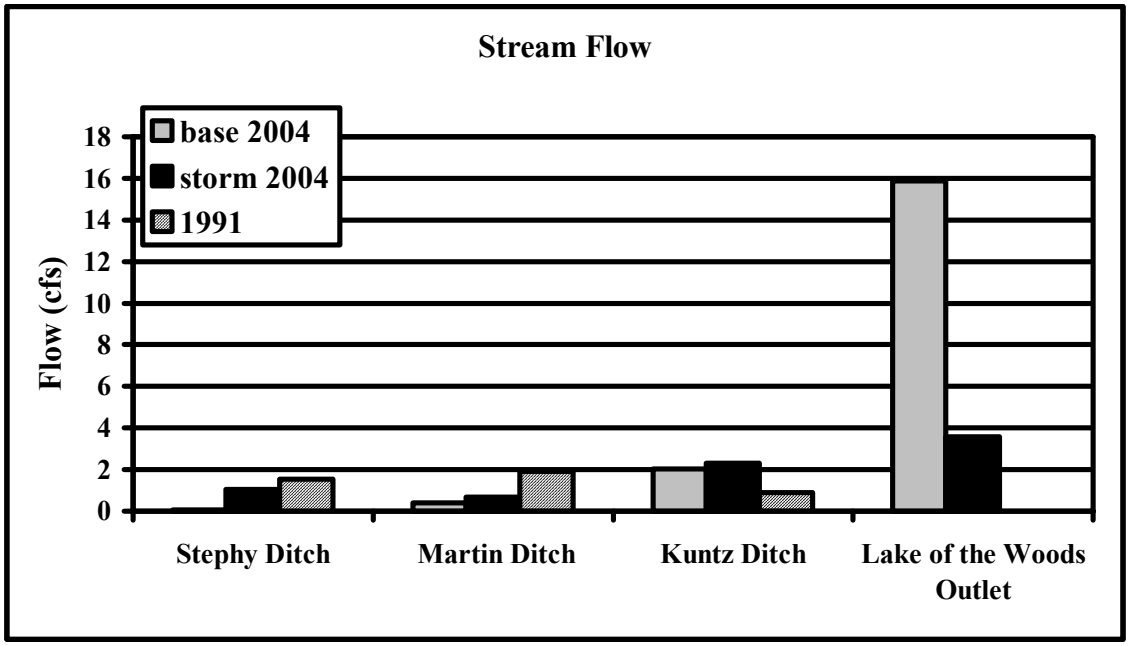
Typical Indiana streams (1991-2002):

- *E. coli* range 133-1,157 CFU/100ml
- *E. coli* average 645 CFU/100ml

Lake of the Woods:

- 2004 *E. coli* 134-830 CFU/100ml
- 2003 *E. coli* 25-600 CFU/100ml
- 1990 *E. coli* 0-7 CFU/100ml
- 1981 *E. coli* 17-2,420 CFU/100ml

Figure 15. Stream flow, concentration of various nutrients and bacterial counts (E. coli) during fall 2004 water quality sampling in Lake of the Woods tributaries and the outlet. Where available, the 2004 data is compared to historical data from either the 1981 or 1991 state water quality studies and for bacteria, 2003 Hoosier Riverwatch data. (TP = Total Phosphorus; SRP = Soluble Reactive Phosphorus; NH3 = ammonia; NO3 = nitrate; TKN = Total Kjeldahl Nitrogen; cfs = cubic feet per second; mg/l = milligrams per liter; where indicated, a solid line indicates the state water quality standard)



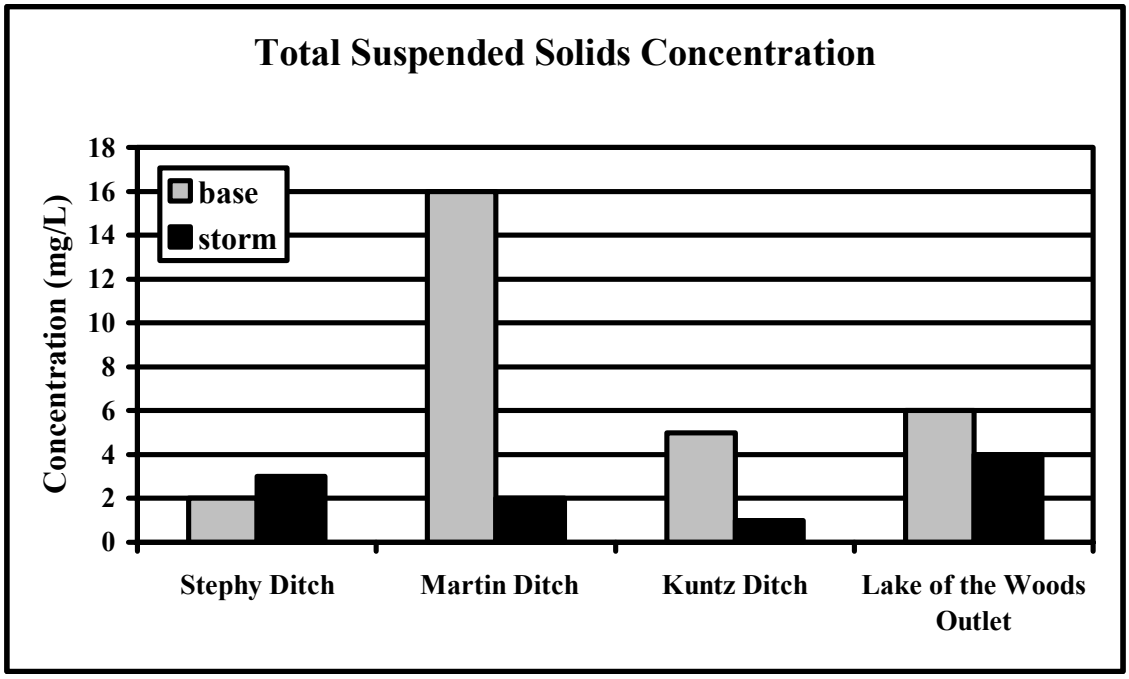
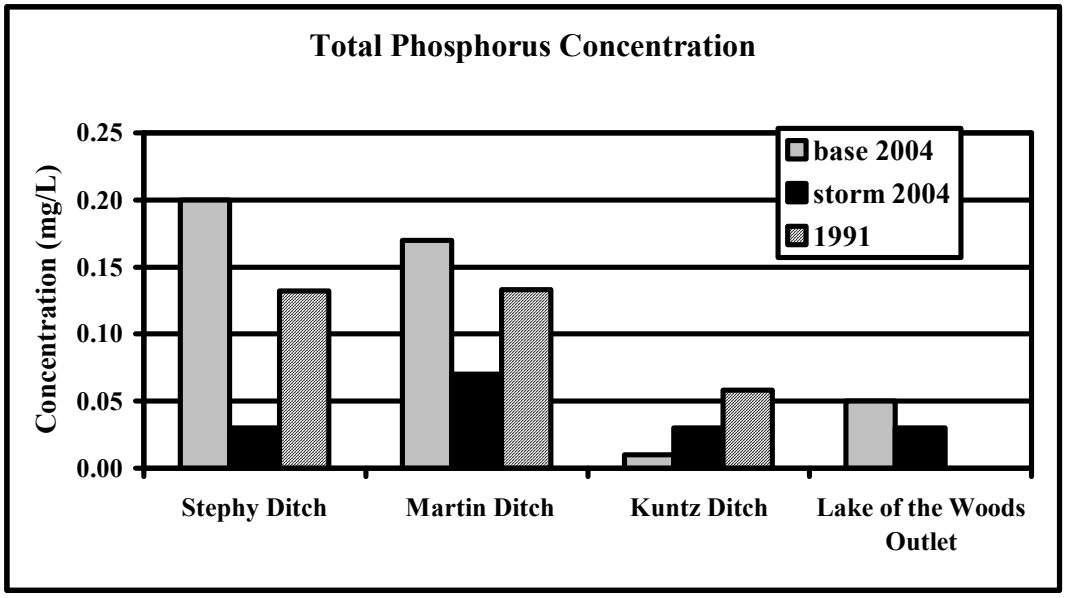


Figure 15 (cont.). Results of 2004 water quality sampling in Lake of the Woods.



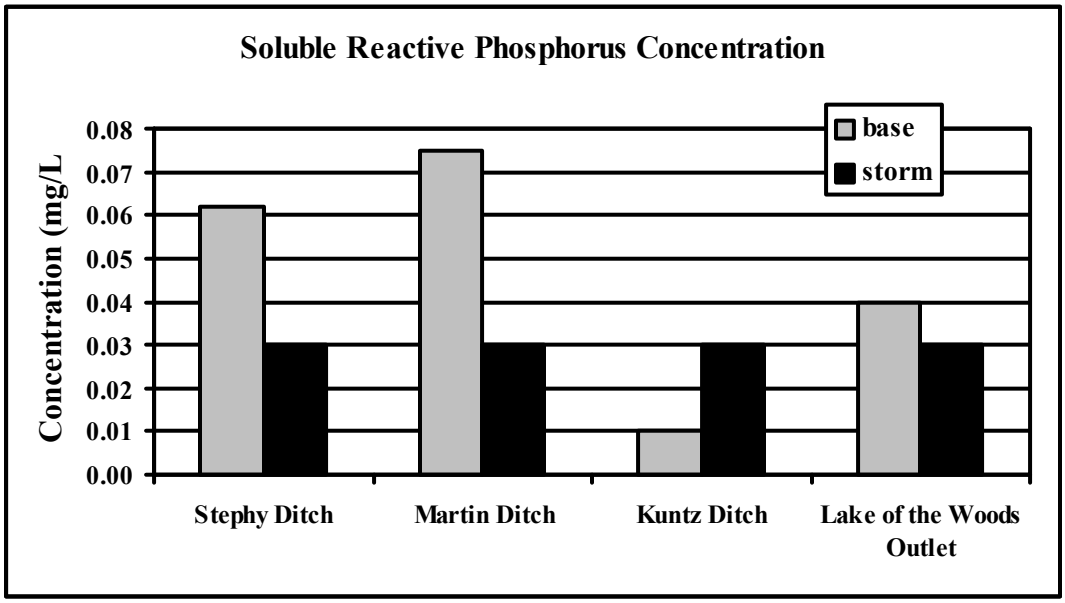
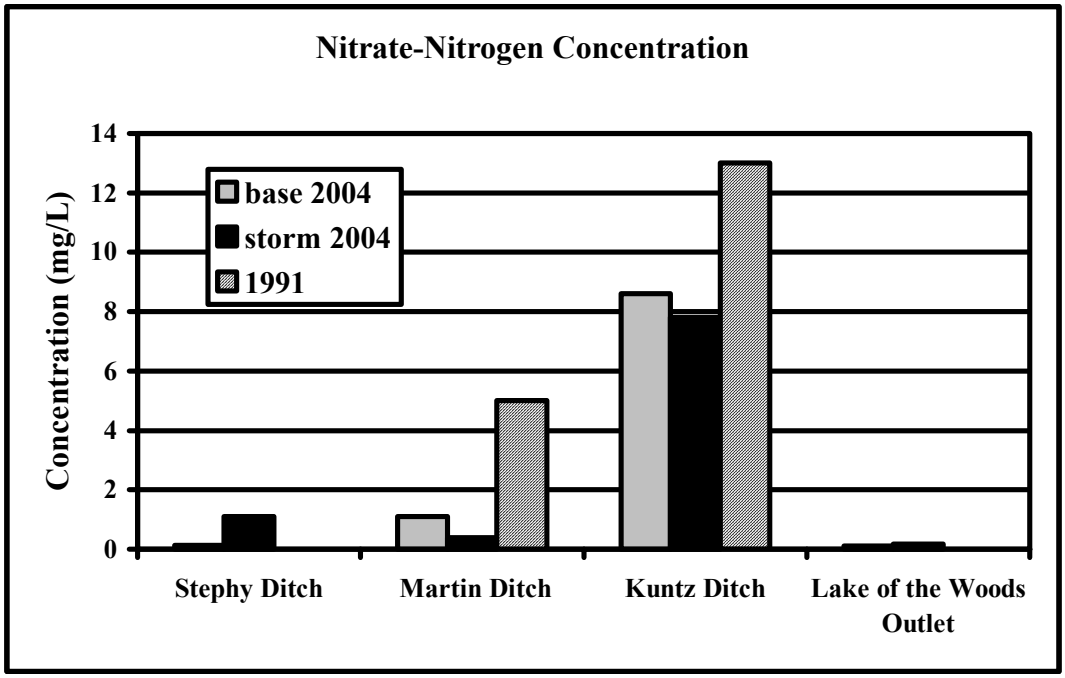


Figure 15 (cont.). Results of 2004 water quality sampling in Lake of the Woods.



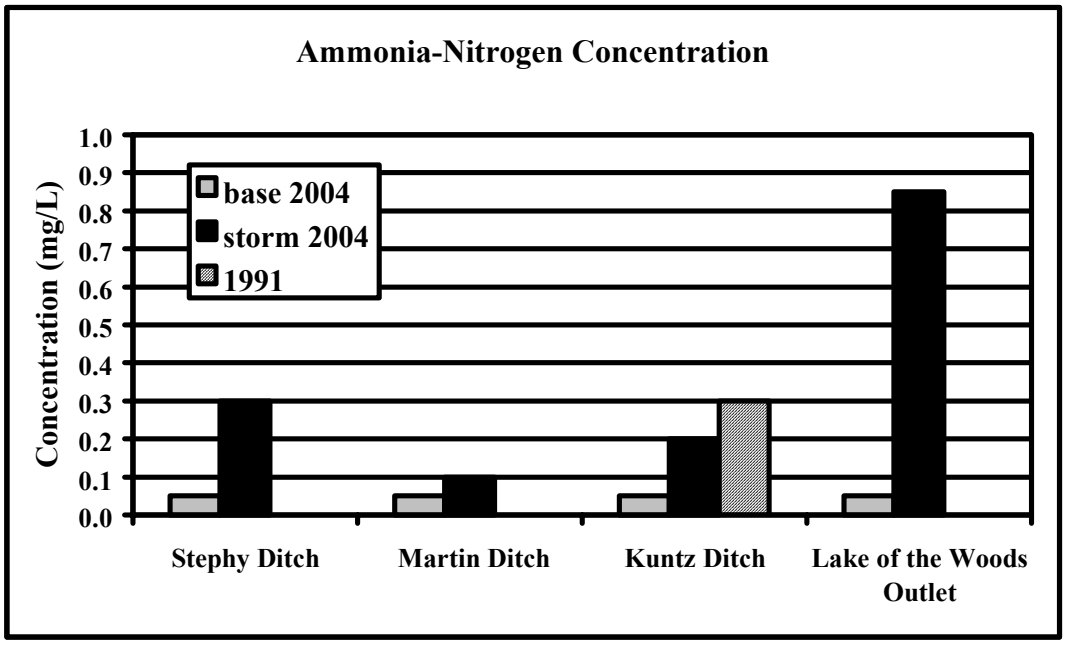
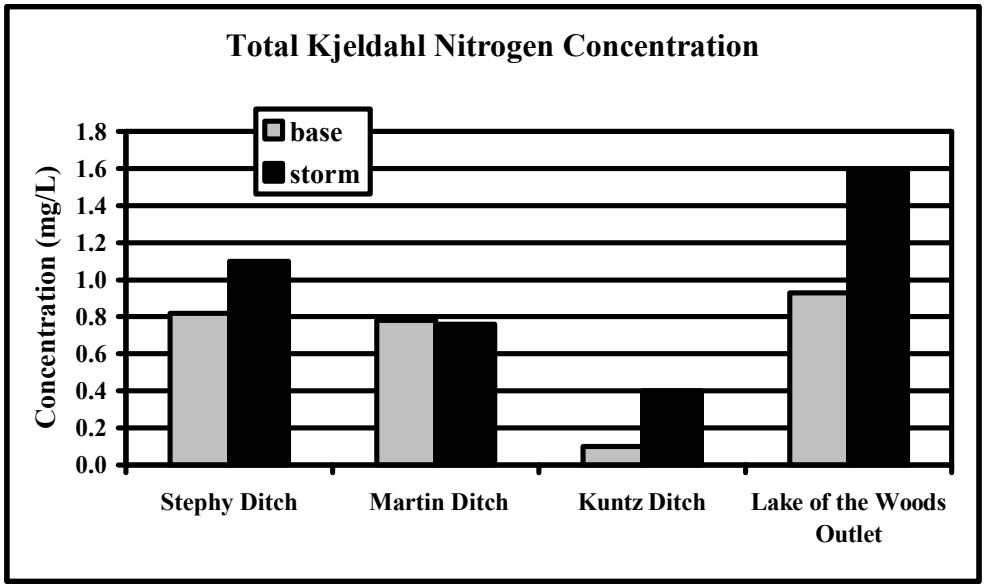


Figure 15 (cont.). Results of 2004 water quality sampling in Lake of the Woods.



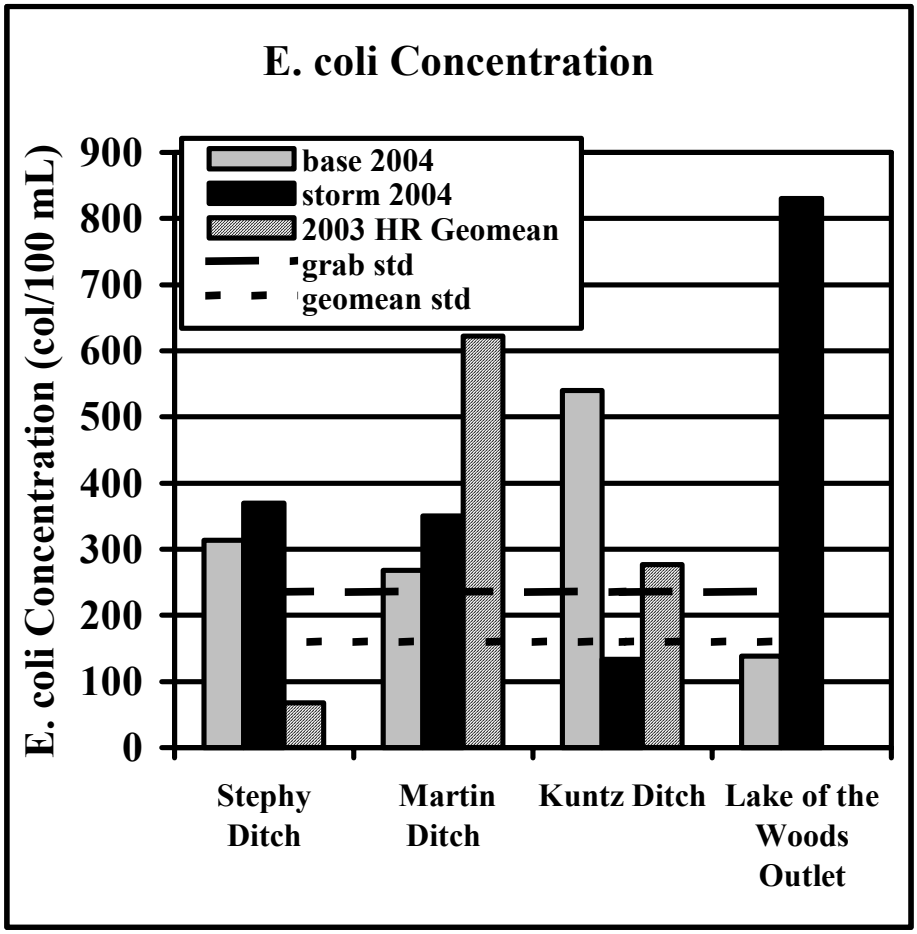
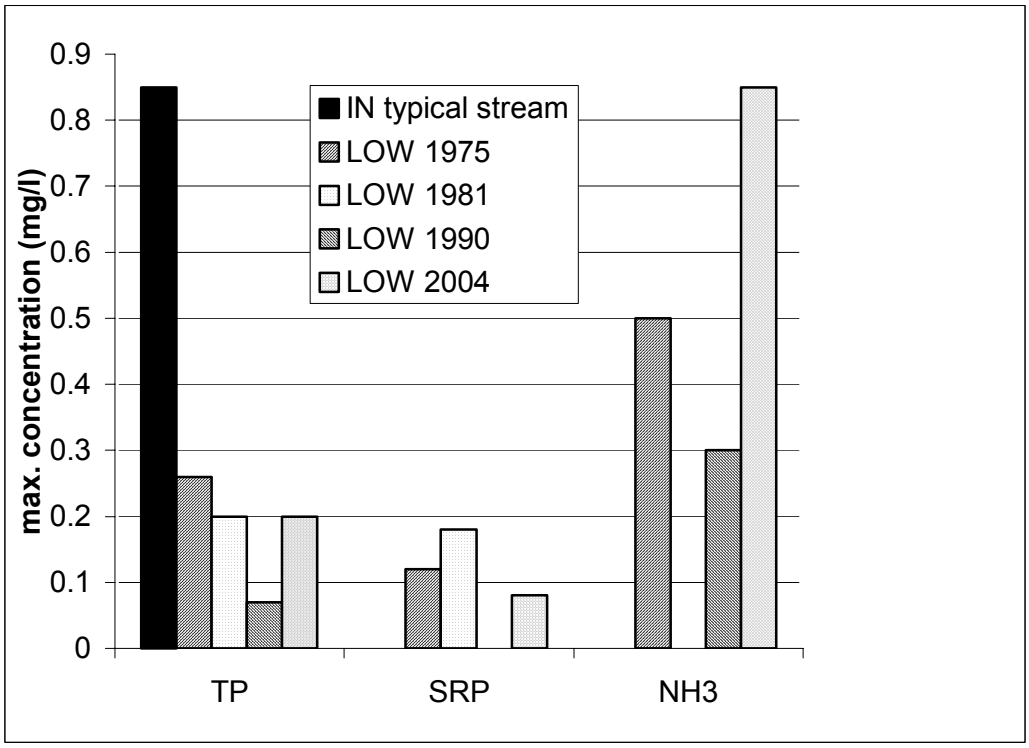


Figure 16. Trends in the maximum concentration of nutrients in tributaries to Lake of the Woods, 1975-2004, compared to a "typical" Indiana stream (TP = Total Phosphorus; SRP = Soluble Reactive Phosphorus; NH3 = ammonia nitrogen; NO3 = nitrate nitrogen; TKN = Total Kjeldahl Nitrogen).



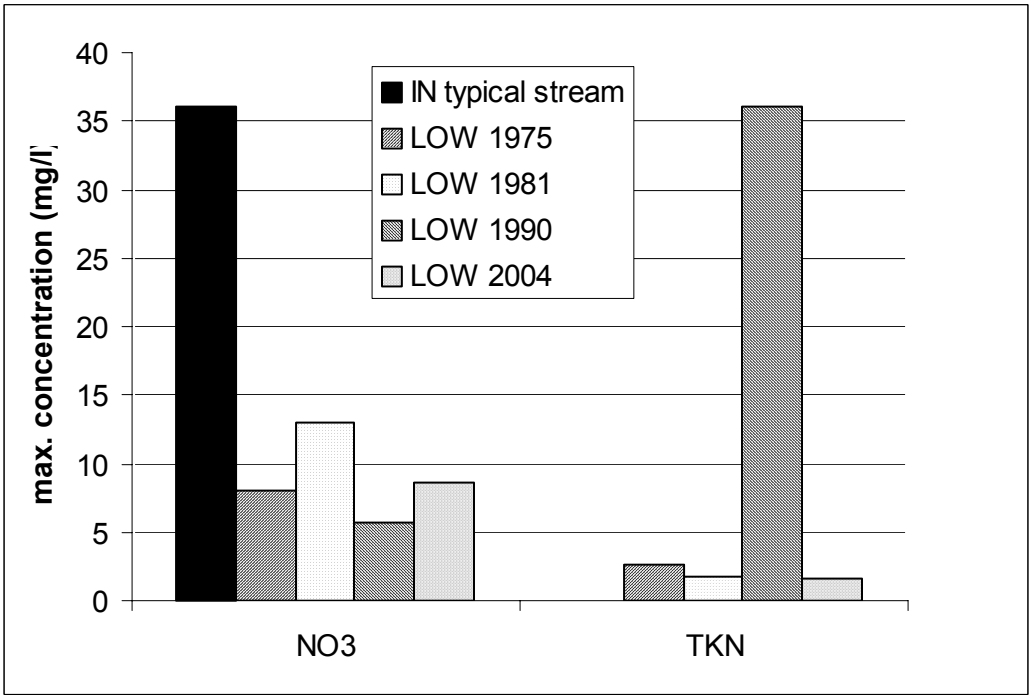
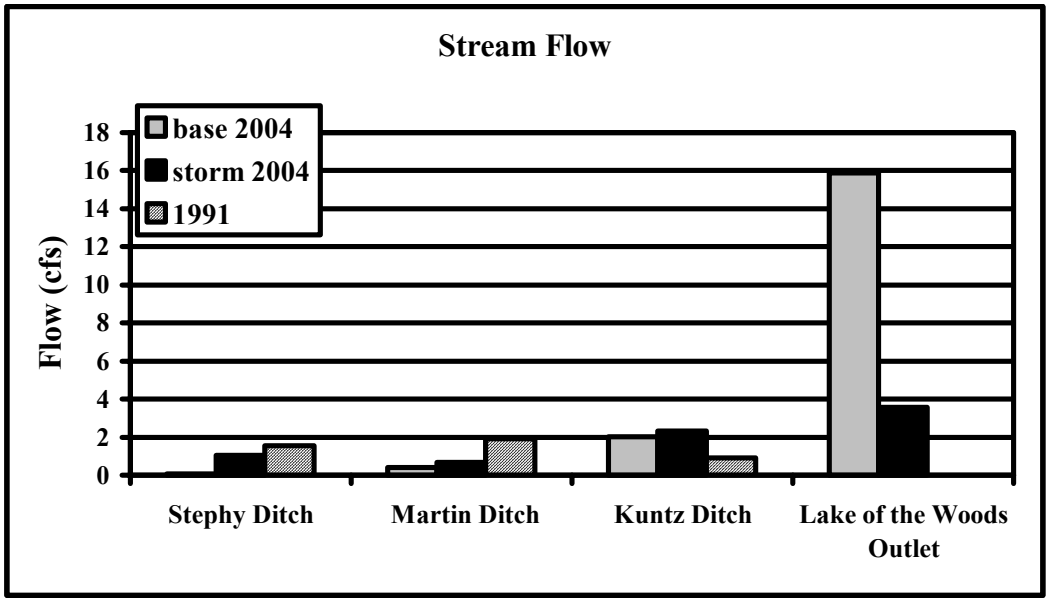


Figure 17. Areal loadings for nutrients based on fall 2004 water quality sampling in Lake of the Woods tributaries and the outlet. (TP = Total Phosphorus; SRP = Soluble Reactive Phosphorus; NH3 = ammonia; NO3 = nitrate; TKN = Total Kjeldahl Nitrogen; kg/d = kilograms per day)



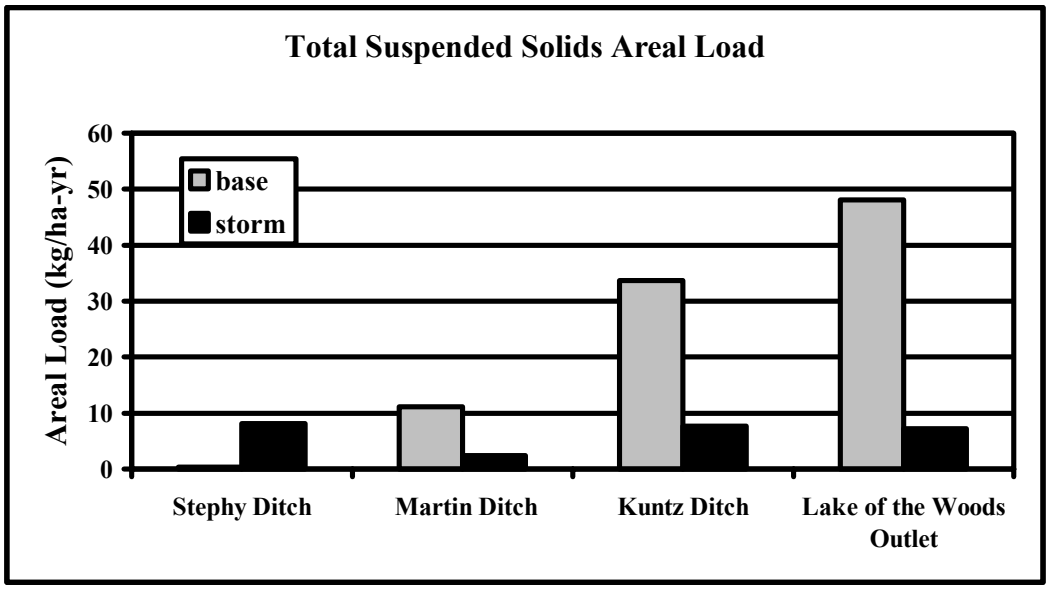
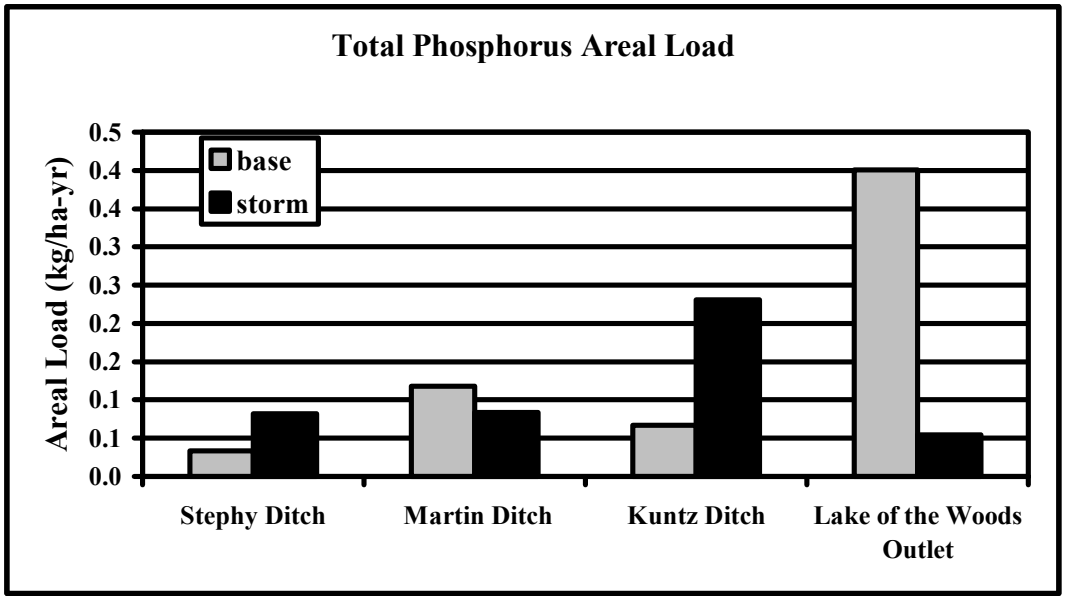


Figure 17 (cont.). Areal loadings for nutrients based on fall 2004 water quality sampling.



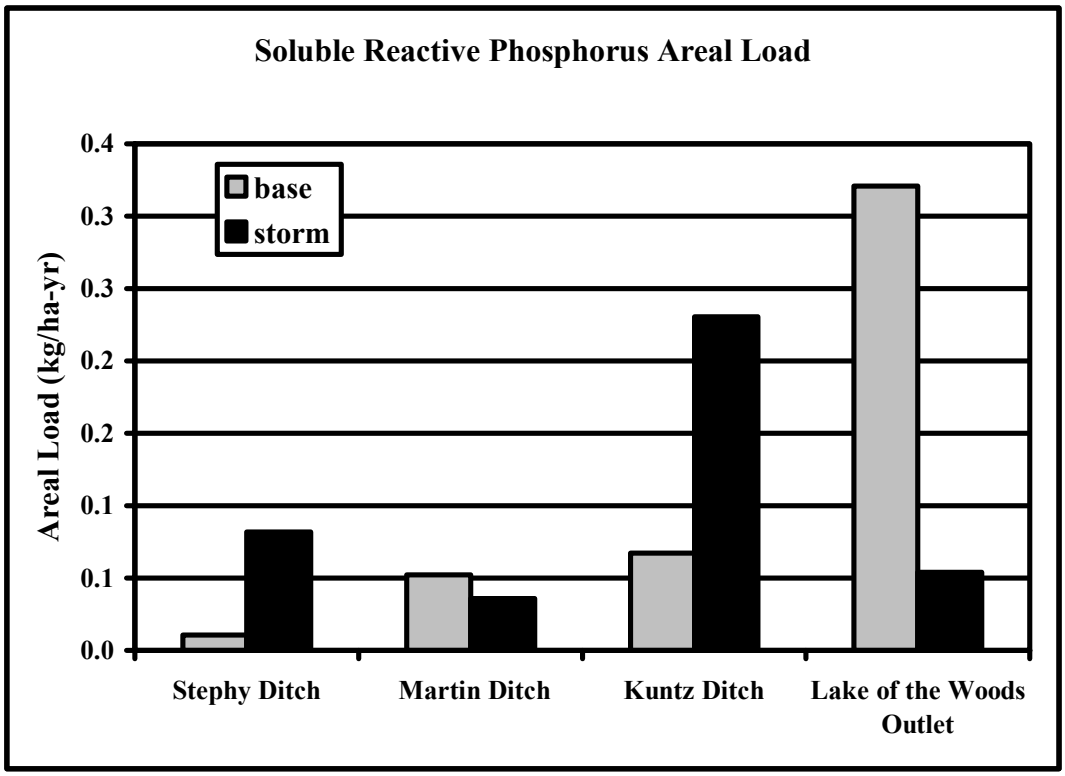
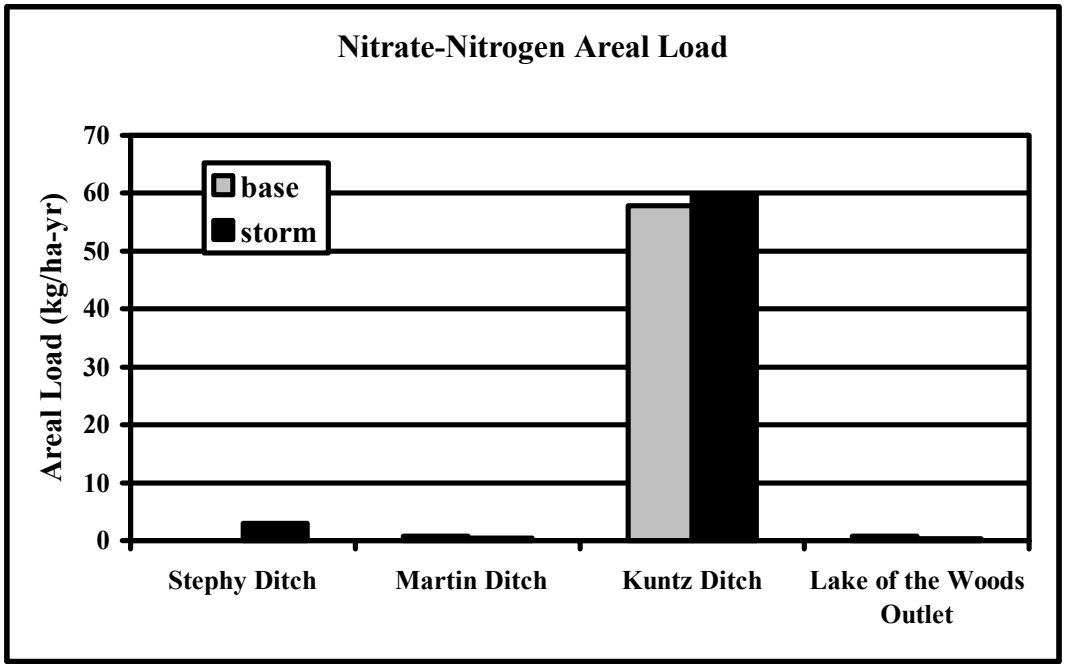


Figure 17 (cont.). Areal loadings for nutrients based on fall 2004 water quality sampling.



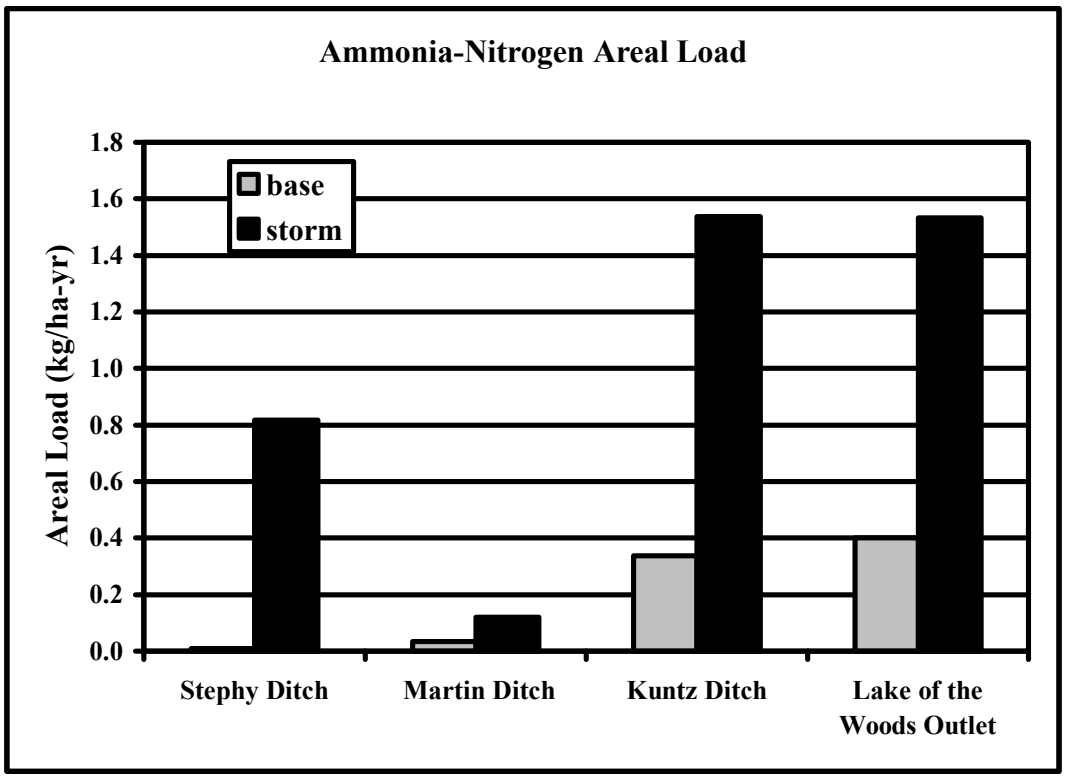
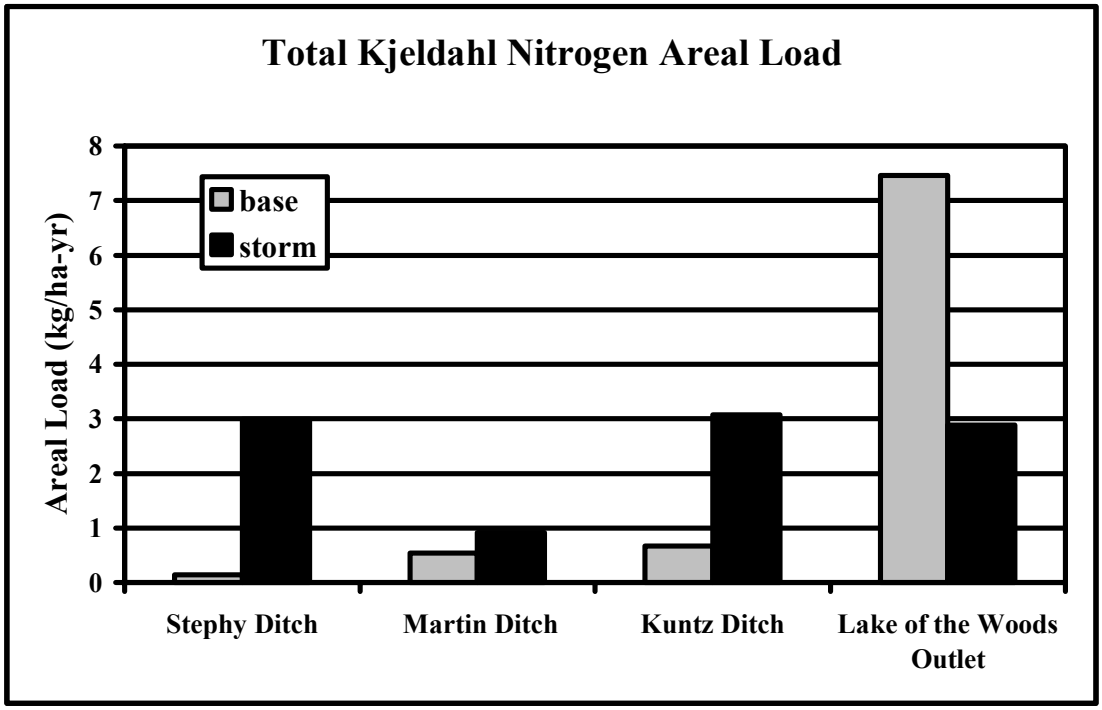


Figure 17 (cont.). Areal loadings for nutrients based on fall 2004 water quality sampling.



4.2.1 Phosphorus and algae

Phosphorus is generally the limiting nutrient in aquatic systems and provides the primary fuel for production of algal blooms in lakes. Nitrogen is less of a controlling factor because some forms of algae can obtain nitrogen from the air and do not rely strictly on water sources for population growth.

4.2.1.1. Phosphorus in the lake

Volunteer monitoring data for total phosphorus levels in the lake showed that Lake of the Woods ranked 8th out of 28 lakes in northern Indiana (a ranking of 1 is the highest water quality) with a mean July-August 2003 Total Phosphorus level of 27.1 ug/L and a TSI of 54. Total Phosphorus levels in the lake showed no overall trend, averaging 59.4 ug/l over the time period from 1991-2001. Readings fluctuated from year to year, ranging from a lows of 23.7 ug/l in 1993 and 34.9 ug/l in 1998 to highs of 76.7 in 1996 ug/l and 79.1 ug/l in 1999 (Figure 18).

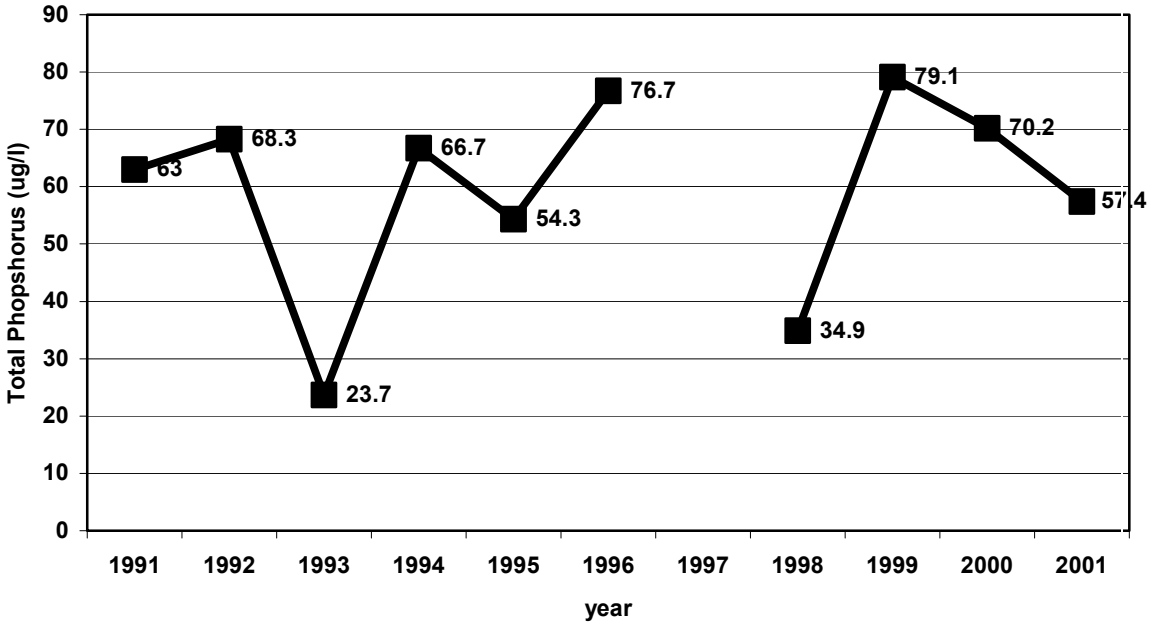


Figure 18. Mean Total Phosphorus in micrograms per liter taken from Lake of the Woods during July-August 1991-2001. Source: Indiana University Lake Volunteer Monitoring Program.

4.2.1.2 Phosphorus in the tributaries

In 1991, total phosphorus was less than the state average in Walt Kimble and Martin Ditches (0.045 and 0.047 mg/l, respectively) and slightly higher in the lake outlet (0.065 mg/l). For comparison, in 1975 total phosphorus in four inlets and the outlet averaged somewhat higher at 0.13 mg/l with a maximum of 0.26 mg/l.

Progress: In 2004, Stephey and Martin Ditches had the highest total phosphorus (TP) concentrations at base flow. Although these elevated TP concentrations are of concern since the streams are lake inlet streams, the TP concentrations are not extremely unusual for northern Indiana streams, particularly modified streams such as agricultural ditches.

All of the streams had soluble reactive phosphorus (SRP) concentrations that were below the laboratory detection limit following a storm event. Kuntz Ditch possessed a SRP concentration below the laboratory detection limit at base flow as well. Stephey and Martin Ditches exhibited the highest SRP concentrations during base flow.

4.2.1.3 Chlorophyll-a in the lake

Chlorophyll-a is a compound contained in plant cells that provides an indication of the amount of algae growing in the lake. Algal growth is affected by nutrients in the water column, temperature, currents, and light. In 1990, Chlorophyll-a in the lake ranged from 3-50.7 ug/l. In 2003, Lake of the Woods ranked 25rd place out of 31 lakes in northern

Indiana (a ranking of 1 is the highest water quality) with a mean July-August Chlorophyll-a level of 14.1 ug/l and a TSI of 58. A Chlorophyll-a reading of 3.5 ug/l would rank Lake of the Woods in the middle of these lakes.

4.2.2 Nitrogen

In 1991, nitrate in all three streams was lower than average (5.2 mg/l in Walt Kimble Ditch, 5.7 mg/l in Martin Ditch, and 3.6 mg/l in the outlet). For comparison, in 1975 total nitrate in four inlets and the outlet averaged somewhat lower at 2.68 mg/l, but with a maximum of 8.0 mg/l.

Progress: In 2004 ammonia-nitrogen concentrations were below the laboratory detection limit during the base flow sampling. During storm flow, all of the streams exhibited ammonia-nitrogen concentrations below the Indiana state water quality standard. Stephey Ditch and the outlet stream possessed the highest ammonia-nitrogen concentrations during storm flow. The elevated ammonia-nitrogen concentrations likely reflect decomposition occurring within Stephey Ditch and Lake of the Woods.

Nitrate-nitrogen concentrations were all below the Indiana state standard (10 mg/L). However, Kuntz Ditch possessed elevated nitrate-nitrogen concentrations during both the base and storm flow sampling events. Nitrate-nitrogen concentrations present within Kuntz Ditch exceeded the concentration (3-4 mg/L) considered to impair aquatic life according to Ohio EPA methods. The other streams exhibited nitrate-nitrogen concentrations similar to those found in other Indiana streams.

All of the Lake of the Woods' inlet and outlet streams exhibited total Kjeldahl nitrogen (TKN) concentrations that are relatively normal for Indiana streams. The outlet stream and Stephey Ditch possessed the highest TKN concentrations.

4.3 Fecal contamination

IDEM test results for *E. coli* during the fall of 2003 showed lower levels than the typical statewide average (645 CFU/100ml), but above the state water quality standard with a range of 250-350 colony forming units (CFU) per 100ml in Bohmer, Kuntz, public access ditch, and Seltenright Ditch. Martin Ditch had just over 600 CFU/100ml. Levels were below the state water quality standard of 235 CFU/100ml in inlet ditch #1, Stephey Ditch, the Isaac Sells outlet ditch and at the beach along the lakeshore (25 CFU/100ml).

In 1991 data, *E. coli* were very low in Walt Kimble (7 CFU/100ml) and absent in Martin Ditch and the lake outlet. In 1981, E. coli counts in tributary streams ranged from a low of 17 CFU in Stephey Ditch to 2,420 CFU/100ml in Seltenright and Martin Ditches.

Progress: In 2004, *E. coli* concentrations observed within the inlet streams were relatively low for Indiana streams. All of the *E. coli* concentrations in the inlet streams fell below the average *E. coli* concentration for Indiana streams (650 colonies/100 ml). Nonetheless, all *E. coli* concentrations in the inlet streams except the concentration

observed in Kuntz Ditch following a storm flow exceeded the Indiana state standard (235 colonies/100 ml). The *E. coli* concentrations in the outlet stream are surprisingly high *for a lake outlet stream*. Only the sample taken following the storm event exceeds the state standard, but the sample taken at base flow is still relatively high *for a lake outlet stream*.

4.4 Erosion, sedimentation and turbidity

In 1991, turbidity (TSS) was below measurable limits at <4.0 mg/L in all three streams.

Progress: In 2004, turbidity and total suspended solids concentrations in the inlet streams were relatively normal for Indiana streams. All of the turbidity concentrations in the inlet streams were below the concentration (20 NTU) at which undesirable changes in aquatic life have been known to occur. The slightly elevated concentrations observed in Martin Ditch may be due to heavy duckweed cover. Both Martin and Stephey Ditches have flocculent, organic substrates that can easily be suspended with little force.

Unexpectedly, the outlet stream exhibited the highest turbidity during both sampling events. The factors responsible for this may include the release of plankton from the lake (base flow) or the vicinity of the sampling site to the lake outfall. (The kinetic energy of the water and the consequent ability of the water to suspend substrate sediments is greater at the outlet sampling site than at the inlet streams' sampling sites.)

4.5 Polychlorinated biphenyls (PCBs)

Similar to a number of other lakes in Northern Indiana, the fish consumption advisory indicates some level of contamination from polychlorinated biphenyls (PCBs) in larger and longer-lived species in Lake of the Woods. These chemicals generally originated from manufacturing or waste disposal processes that are no longer permitted in the United States. However, PCBs remain in aquatic systems long after their introduction.

Progress: The State of Indiana conducts routine periodic sampling to determine the levels of PCBs in lake fish species and issues advisories that describe how to lessen any risk that may be associated with consuming larger, older fish that may have accumulated these persistent toxic chemicals.

4.6 Other toxic substances

No data was found that would indicate that other toxic substances are a problem in Lake of the Woods or its tributaries.

4.7 Other physical and chemical factors

For sampling done in 2004, water temperatures varied with season. As expected water temperatures measured in September exceeded those measured in November. None of the temperatures exceeded the Indiana Administrative Code standard for the protection of aquatic life.

Martin Ditch possessed dissolved oxygen concentrations below the Indiana Administrative

Code (IAC) standard of 5 mg/L during both base and storm flow events, while Stephey Ditch exhibited a dissolved oxygen concentration below the IAC standard during base flow. Kuntz Ditch and the outlet stream maintained dissolved oxygen concentrations greater than 7.9 mg/L during both sampling events.

All streams were undersaturated with dissolved oxygen. Kuntz Ditch and the outlet stream were 73-94% saturated, which is normal for Indiana streams. Stephey and Martin Ditches were 21-55% saturated. Undersaturated conditions could be attributed to a) decomposition processes within the stream consuming oxygen more quickly than it can be replaced and/or b) flow in the stream not being turbulent enough to entrain sufficient oxygen.

Conductivity and pH levels were within normal ranges for Indiana streams. The pH measured in the outlet stream (9.2) during base flow exceeds the IAC standard. The elevated pH could be attributed to natural fluctuations from photosynthesis within Lake of the Woods. Although given the time of year, this hypothesis should be viewed with some caution.

4.8 Overall stream water quality and aerial loading

Comparisons over time and to other Indiana streams indicated that the inlets and outlet stream measured in these studies had typical water quality or were better than many streams in Indiana. However, like many Indiana streams, the values did not indicate desirable conditions in some cases, particularly ammonia levels. In general, water quality in tributaries showed some improvement since the 1970s.

By comparing the relative contribution of various nutrients to the contribution to flow, it may be possible to determine where nutrients are disproportionately transported. In 1981, contributions from the tributaries were fairly proportionate to the flow, indicating that one other ditch is not clearly a problem relative to the others (Table 5).

Table 5. Nutrient loads relative to annual discharge to Lake of the Woods from tributaries in 1981 (N = nitrogen; P = phosphorus).

Tributary	%Flow	%Nitrogen	%Phosphorus
Martin	30.2	28	21
Stephey	24.4	24	17
Seltenright	12.3	18	12
Kuntz	14.0	14	4
Bohmer	2.9	4	1
NE unnamed	3	1	

Comparing the inlet streams illustrates that Martin and Stephey Ditches generally possessed the highest pollutant *concentrations* (Table 4). However, Kuntz and Martin Ditches delivered the greatest amount of pollutants (*loading rate*) to Lake of the Woods during base flow conditions, while Kuntz and Stephey Ditches delivered the greatest amount of pollutants to the lake following a storm event (Table 6; Figure 17).

Table 6. Areal loading rates for tributaries to Lake of the Woods.

Stream Name	NH3 Load (kg/day)	NO3 Load (kg/day)	TKN Load (kg/day)	SRP Load (kg/day)	TP Load (kg/day)	TSS Load (kg/day)
Stephey Ditch	0.1	0.2	1.3	0.1	0.3	3.2
Martin Ditch	0.5	10.7	7.6	0.7	1.6	154.9
Kuntz Ditch	2.5	425.4	4.9	0.5	0.5	247.3
Lake of the Woods Outlet	19.4	38.8	360.8	15.5	19.4	2327.9
Stephey Ditch	7.7	28.3	28.3	0.8	0.8	77.2
Martin Ditch	1.7	6.3	12.7	0.5	1.2	33.4
Kuntz Ditch	11.3	440.8	22.6	1.7	1.7	56.5
Lake of the Woods Outlet	74.2	15.7	139.7	2.6	2.6	349.2
Total	20.7	475.4	63.6	3.0	3.6	167.1

Stream Name	**NH3 Aerial Load**	**NO3 Aerial Load**	**TKN Aerial Load**	**SRP Aerial Load**	**TP Aerial Load**	**TSS Aerial Load**
Stephey Ditch	0.008	0.022	0.138	0.010	0.034	0.336
Martin Ditch	0.035	0.765	0.543	0.052	0.118	11.134
Kuntz Ditch	0.336	57.836	0.673	0.067	0.067	33.626
Lake of the Woods Outlet	0.401	0.802	7.458	0.321	0.401	48.113
Stephey Ditch	0.817	2.994	2.994	0.082	0.082	8.165
Martin Ditch	0.120	0.456	0.912	0.036	0.084	2.400
Kuntz Ditch	1.537	59.924	3.073	0.230	0.230	7.683
Lake of the Woods Outlet	1.533	0.325	2.887	0.054	0.054	7.216

With the exception of nitrate, the outlet stream exhibited pollutant loading rates higher than the loading rates observed in the inlet streams. The outlet's pollutant loading rates were often an order of magnitude higher than the loading rates observed in the inlet streams.

Dividing pollutant loading rates by drainage size yields areal loading rates (pollutant rate per unit area of drainage). Areal loading rates neutralize the effect of drainage on the pollutant loading rates. (Higher loading rates are typically expected with larger drainages.) Of the inlet streams, Kuntz Ditch possessed the greatest areal loading rates for the measured pollutants during both base and storm flow conditions. During base flow conditions, Martin Ditch possessed the second greatest areal loading rate of the inlet streams, while Stephey Ditch exhibited the second greatest areal loading rate of the inlet streams following storm events.

During base flow conditions, the outlet stream possessed a greater areal loading rate for most pollutants than the inlet streams. However, following a storm event, Kuntz and Stephey Ditches exhibited higher areal loading rates than the outlet stream for all parameters except ammonia-nitrogen.

For the purposes of prioritizing subwatersheds on the basis of nonpoint source pollutants:

- During base flow, Martin and Kuntz Ditches had the highest pollutant loads.
- Temperature, conductivity, turbidity, and pH were all within normal levels.
- Martin Ditch (base and storm) and Stephey Ditch (base) exhibited dissolved oxygen levels below the IAC standard
- During storm flow, Martin and Stephey Ditches had the highest pollutant loads.

4.9 Habitat quality in streams

When evaluated with the Qualitative Habitat Evaluation Index, the three inlet streams scored very poorly (26-38; Table 7). Scores were within the range that definite negative biotic impacts are expected and the streams would not be generally supportive of aquatic life (scores below 51). The outlet ditch possessed a higher (55) QHEI score. This score would fall within IDEM's "partially supporting" category (scores of 51-64) if used to assess the satisfaction of Clean Water Act designated uses.

Shallow riffle substrate (sand and gravel stream bed material with less overlying sediment) was of higher quality in the outlet compared to all other streams. None of the streams had pool habitats, which are valuable as protective refuges for fish and other aquatic animals. Pools are cooler in the summer and deeper with slower flow. In contrast, riffles are shallow areas with faster flow that tend to have sand and cobble with less sedimentation. A combination of pools and riffles presents the most diverse and valuable habitat for aquatic animals in streams.

Riparian cover (trees and bushes along the stream) was of highest quality along Martin Ditch and similar along other streams. Trees along a stream bank provide many positive benefits to streams by reducing temperature on hot days (shading), stabilizing banks (roots and logs), and provide food from falling leaves and insects.

To summarize, the 2004 data indicated that:

- Habitat quality was poor within Stephey, Martin, and Kuntz Ditches.
- Only the outlet stream appeared to rate as partially supporting for its aquatic life use designation.

Table 7. Qualitative Habitat Evaluation Index scores for three inlet streams and the outlet at Lake of the Woods. The chart provides the maximum possible score for a high quality habitat compared to scores for three inlets and the outlet.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible Score	**20**	**20**	**20**	**10**	**10**	**10**	**10**	**100**
Stephey Ditch	1	10	6	3.25	0	0	6	**26**
Martin Ditch	2	11	6	7.5	0	0	8	**35**
Kuntz Ditch	7	10	7	4	0	0	10	**38**
Lake of the Woods outlet	14	12	8	4	0	7	10	**55**

4.10 Biological quality in streams

Both good water quality (chemistry) and habitat are required to support diverse aquatic life in streams. The results of the macroinvertebrate sampling in Stephey and Martin Ditches suggest that the biotic integrity of the macroinvertebrate communities in both ditches is severely impaired (Table 8). Pollution and disturbance tolerant organisms dominated the samples collected from both sample sites. Only 23 organisms were collected from Martin Ditch suggesting substantial impairment of the biotic community. As noted above, the habitat in each of these ditches is also very poor. Poor habitat is likely to be the primary influence on biotic community health.

Table 8. Macroinvertebrate results for Stephey and Martin Ditches.

Site Number: Stephey Ditch (Site 1)

Scientific Name	#	EPT	Tolerance (t)	# x t	%
Arthropoda					
Talitridae	53		8	424	46.49
Coleoptera					
Dytiscidae	3				2.63
Haliplidae	2		7	14	1.75
Hydrophilidae	1		5	5	0.88
Diptera					
Ceratopogonidae	1		6	6	0.88
Chironomidae	20		6	120	17.54
Ephemeroptera					
Caenidae	5	5	7	35	4.39
Odonata					
Coenagrionidae	27		9	243	23.68
Libellulidae	1		9	9	0.88
Trichoptera					
Leptoceridae	1	1	4	4	0.88
	114	**6**		**7.7**	
	10	2		**HBI**	
				111	

Site Number: Martin Ditch (Site 2)

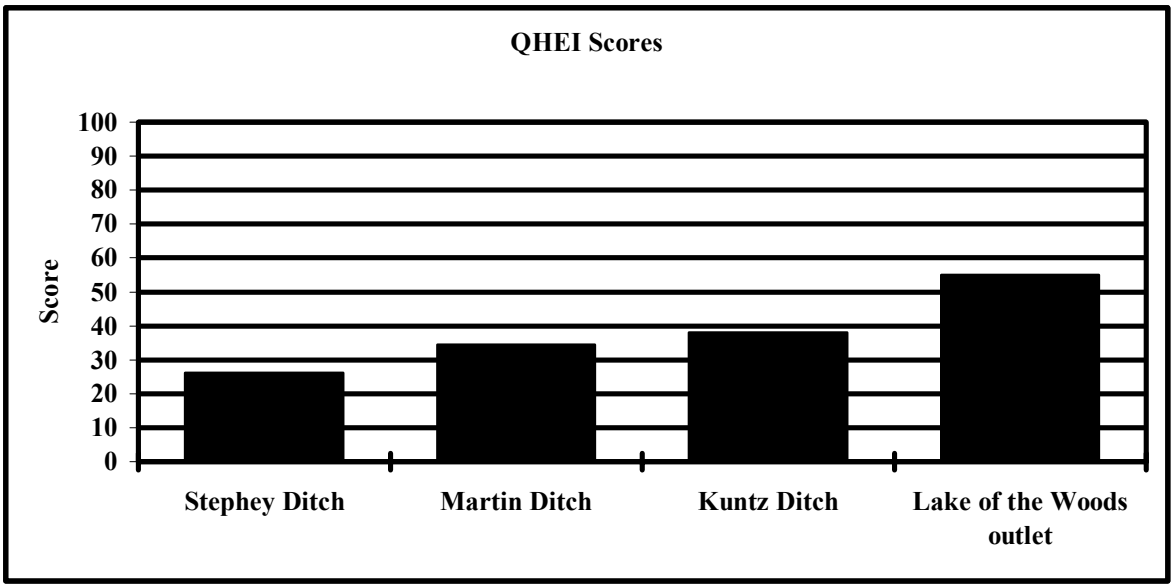
Scientific Name	#	EPT	Tolerance (t)	# x t	%
Arthropoda					
Aphididae	2				40.00
Talitridae	8		8	64	160.00
Coleoptera					
Elmidae	1		4	4	20.00
Helodidae	2				40.00
Diptera					
Chironomidae	6		6	36	120.00
Odonata					
Coenagrionidae	4		9	36	80.00
	23	**0**		**6.7**	
	6	0		**HBI**	
				21	

Table 8 (cont.). Macroinvertebrate results for Stephey and Martin Ditches.

Site 1 (Stephey Ditch)		**Metric Score**
HBI	7.75	0
No. Taxa (family)	10	2
No. Individuals	114	2
% Dominant Taxa	46.5	2
EPT Index	2	2
EPT Count	6	0
EPT Count/Total Count	0.05	0
EPT Abun./Chir. Abun.	0.30	0
No. Indiv. Per Square	16.29	0
Chironomid Count	20.00	4
mIBI Score		1.2

Site 2 (Martin Ditch)		**Metric Score**
HBI	6.7	0
No. Taxa (family)	6	0
No. Individuals	23	0
% Dominant Taxa	160	4
EPT Index	0	0
EPT Count	0	0
EPT Count/Total Count	0	0
EPT Abun./Chir. Abun.	0	0
No. Indiv. Per Square	0.3	0
Chironomid Count	6	8
mIBI Score		1.2

Figure 19. Qualitative Habitat Evaluation Index scores for three inlet streams and the outlet at Lake of the Woods. The chart provides the maximum possible score for a high quality habitat compared to scores for three inlets and the outlet.



5.0 Impacts on Water Quality and Feasibility Study Recommendations

Two major studies have been conducted on Lake of the Woods, culminating in management recommendations in a 1991 Feasibility Study by Dynamac Corporation. In this section, existing management practices are compared to the prior feasibility study recommendations to determine which actions have already been taken. This information is available for consideration in developing current priorities for implementation.

5.1 Point sources of pollution

The State of Indiana's efforts to control the direct discharge of pollutants to waters of the State were inaugurated by the passage of the Stream Pollution Control Law of 1943. The vehicle currently used to control direct discharges to waters of the State is the NPDES (National Pollutant Discharge Elimination System) Permit Program, made possible by the passage of the Federal Water Pollution Control Act Amendments of 1972 (also referred to as the Clean Water Act). These permits place limits on the amount of pollutants that may be discharged to waters of the State by each discharger. These limits are set at levels to protect both the aquatic life in the receiving waters and human health.

As of July 2004, NPDES permits were issued in Marshall County for Municipal Sewage Treatment Plants at small towns such as Argos, Bourbon, Bremen, Culver, and Lapaz, the Lake of the Woods Regional Sewer District, a Red-D-Mart Store in Plymouth, and some recreational facilities, such as the Swan Lake Golf Resort and Yogi Bear's Jellystone Park west of Plymouth.

Online resources:
IDEM Database of NPDES Permits
http://www.in.gov/idem/water/data/#npdes

Progress: The only facility within the Lake of the Woods watershed that requires an NPDES permit is the Lake of the Woods Regional Sewer District which discharges to Yellow River through Stock Ditch.

5.2 Nonpoint sources of pollution and existing management practices

A number of best management practices for lakeside residents and agricultural areas were recommended in the 1991 study to control negative effects of nonpoint sources of pollution.

5.2.1 Agricultural practices

The 1991 study indicated that phosphorus from row crops contributed over 90 percent of the loading from all runoff land uses combined, reflecting the large percentage of land area in the watershed that is used for agriculture.

5.2.1.1 Crop production

Agricultural commodities in the Lake of the Woods watershed consist almost exclusively of row crops, including corn, wheat and soybeans. Production of crops can affect water quality, depending upon use of nutrient application, pest management, drainage, and erosion control practices.

5.2.1.1.1 Nutrients

According to data from the office of the Indiana State Chemist in 2003 there were 25,376.83 tons of fertilizer and plant nutrients applied in Marshall County with most nutrient application occurring in the first half of the year (Table 9).

Table 9. Fertilizer and nutrients (tonnage) applied by county in the first and last half of 2003 and total for the year in Marshall, Kosciusko and Starke Counties.

January - June, 2003				
County	Total fertilizer	Total N	Total P205	Total K20
Marshall	17,888.27	5,923.27	1,486.02	2,734.79
Kosciusko	31,236.31	7,648.72	1,203.28	3,157.88
Starke	17,133.35	5,009.13	1,104.71	3,123.49
July - December, 2003				
County	Total fertilizer	Total N	Total P205	Total K20
Marshall	7,488.56	1,461.35	792.65	2,101.13
Kosciusko	7,460.05	875.42	246.29	1,961.62
Starke	3,621.53	484.44	228.28	1,210.81
Total for 2003				
County	Total fertilizer	Total N	Total P205	Total K20
Marshall	25,376.83	7,384.62	2,278.67	4,835.92
Kosciusko	38,696.36	8,524.14	1,449.57	5,119.50
Starke	20,754.88	5,493.57	1,332.99	4,334.30

Progress: Several farmers in the Lake of the Woods watershed are using sophisticated soil sampling and yield maps are plotted using GPS systems to analyze soil types, uptake of nutrients by plants in order to apply fertilizers sparingly. Equipment is calibrated annually. Use of land for commercial purposes provides a strong economic motivation for controlling fertilizer over application.

Barriers: As crop yields increase, plants take up additional nutrients, which are then removed by harvesting rather than being transported through groundwater and surface runoff. Calculation of fertilizer rates is done early in the year, so that fertilizers can be applied during planting. When crops are flooded out and yields drop, excess nutrients may be exported from the field.

Technology can provide more accurate application of fertilizers, pesticides and herbicides, but it is used at an added cost to the producer. For example, soil sampling is done approximately every three years and costs about $625 per acre if done by a crop consultant.

Opportunities: Maintenance of drainage in fields planted to row crops can increase uptake of nutrients by high-yielding crops. Similarly, conservation programs that minimize planting of row crops in areas that are likely to be flooded can save money and protect water quality.

Online resources:
Fertilizer and Nutrients by County, Indiana Fertilizer Tonnage data from:
http://www.isco.purdue.edu/fert_report_2003.pdf

5.2.1.1.2 Pesticides and herbicides

Pesticide and herbicide use in agricultural areas has changed dramatically over the past decade with introduction of new or improved chemicals, genetically modified crops, and computerized mapping of weed infestations in fields

Modern chemicals are formulated to increase their effectiveness while reducing environmental impacts. All chemicals used on farms are regulated by the U.S. Environmental Protection Agency and must be applied according to rates and uses stipulated on the chemical label. Several chemicals that were used in the past to control pests and weeds are no longer used due to persistent toxicity.

Progress: Agricultural producers use sophisticated mapping tools to locate weed and pest problems in fields. This information is used to program equipment to apply pesticides and herbicides at rates and locations where problems were identified. The kind of chemical and timing of the application are selected according to the soil type, target weed or pest species, cost, and environmental impact (use restrictions).

Herbicide selection by farmers in the Lake of the Woods watershed reflects a trend toward increased use of post-emergent herbicides that work well with conservation tillage and narrow row spacing. These chemicals are only effective in contact with green plants, reducing their effect on non-target plants. They also bind tightly to the soil until it biodegrades through bacterial activity, lessening their transport to groundwater. Landowners in the Lake of the Woods watershed report that one of the most commonly used agricultural herbicide is RoundUp® (glyphosate), which is commonly applied at 12-28 ounces per acre over RoundUp Ready® soybeans and other crops.

5.2.1.1.3 Erosion and sedimentation

The 1991 study indicated that the volume of the lake in 1990 was 6,163 acre-feet, which represented a loss of three percent since the 1955 bathymetric survey, when the volume was 6,373 acre-feet. Over the 35-year period, the most likely annual sedimentation rate was calculated at 0.17 inches per year with a possible maximum rate of up to 0.53 inches per year.

Results of an AGNPS model were provided in the 1991 study. Most of the landscape is relatively flat, providing significant opportunity for sediment and nutrients to be filtered in overland transport. Modeling indicated that the highest erosion rates were on land slopes ranging from 5.3% to 8.5% that were used predominantly for row crop agriculture.

5.2.1.1.4 Tillage practices

Tillage practices have changed dramatically over the past few decades. Historically, all cropland was plowed in the spring and fall to prepare the soil and reduce weed growth. As a consequence, bare ground eroded easily, sending sediment into streams and lakes. Conservation tillage leaves residue on the ground in the form of roots, stems and leaves that are very effective in reducing soil erosion and sedimentation. By reducing soil loss, transport of phosphorus bound to the soil is also reduced.

According to Purdue University, no-till refers to any direct seeding system, including strip preparation, with minimal soil disturbance. Mulch till is any tillage system leaving greater than 30% crop residue cover after planting, excluding no-till. Conventional tillage is any system leaving less than 30% crop residue cover after planting. Reduced till leaves less residue than mulch till but employs some system for decreasing the amount of tillage used.

In the state as a whole, percent of total cropland in a conservation tillage system increased steadily from 1990 to 2000, then leveled off or dropped slightly through 2003. This pattern is reflected in Marshall County with the exception that no till has increased slightly over this time period in cornfields.

> *The single most important land management practice that a farmer can use to protect water quality in the Lake of the Woods watershed is no-till plowing; successful use of this tillage method would reduce soil loss and associated phosphorus transport by more than 90%* (Senft and Roberts, 1982).

From 1984 through 1989, the percentage of active corn cropland in which conservation tillage practices were used increased from 34 percent to 58 percent; in 1989, no till was practiced on 7.5% of corn acreage in the county (CTIC 1989). Conservation practices were greater for soybeans in Marshall County.

Progress: At the county level, farmers in Marshall County do not use conservation tillage in corn and soybean fields as much as farmers in most other counties around the state, including comparisons with nearby counties. In contrast, farmers in the Lake of the Woods watershed estimate that they manage around 90 percent of cropland using conservation tillage. Research continues to improve tillage practices.

The Purdue University Cooperative Extension Service and IDNR Division of Soil Conservation 2003 Cropland Tillage Data show that 69% of corn in Marshall County was conventional till with 9% no-till (7,718 acres), 5% mulch till and 18% reduced till, which ranked the county 51st out of 56 counties for percentage of no-till corn acres (higher ranking numbers indicate lower use of conservation tillage). Nearby producers used conservation tillage at a higher rate with Kosciusko County ranking 22nd while Fulton County ranked 44th.

In 2003, Marshall County farmers used no-till methods over 28% of the area in soybean production (17,751 acres) with 24% in mulch till and 21% in reduced till. About one-quarter (26%) of soybean acreage was in conventional till, ranking the county 54th out of 56 counties for percentage of no till soybeans. In adjacent counties, producers used more conservation tillage with Kosciusko County ranking 28th and Fulton County ranking 43rd. Relative to 1989, no till soybean acreage has increased by over 5 times (in 1989, 5% of soybeans were no till; 37% mulch till; CTIC 1989).

Despite the relatively low use of conservation tillage in the county, Purdue University's 2002 Indiana Soil Loss Data map showed that over 80 percent of Marshall County is conserving soil by displaying soil loss at or below T (tolerable limit of loss to maintain agricultural production), which was better than the 2002 state average of 74%. Erosion rates are higher in sandy soils and hilly areas, neither of which typifies the watershed around Lake of the Woods.

The SWCD has a truax no-till drill that has the capability to plant warm season grasses (e.g., big blue stem, little blue stem), cool season grasses (e.g., orchard grass, timothy), and small seed (e.g., alfalfa and clover). The no-till drill will seed an 8-foot width with the rows 8 inches apart. The SWCD is renting it to landowners and operators to establish small acreage for wildlife habitat, hay seeding, or conservation cover. A tractor that is at 40 horsepower and has external hydraulic is needed to operate the drill. Once it is set up for a specific field, it should be able to cover about 3.5 acres per hour. The drill rents for $5 an acre for non-commercial plantings and $10 an acre for commercial plantings.

Online resources:
Purdue and IDNR cropland conservation and soil loss data
http://www.agry.purdue.edu/swq/publications.htm

Marion County SWCD no-till drill rental
http://www.marshallcountyswcd.iaswcd.org/products.htm

5.2.1.1.5 Conservation buffers

Both the 1982 and 1991 studies recommended use of vegetated streamside management and buffer strips as an extremely effective practice for reducing both nutrient and sediment input and for protecting habitat near aquatic systems. Factors that determine effectiveness of filter strips include filter width, slope, vegetation type, and application rate of fertilizers. To be effective, vegetated buffer strips should be at least 20-30 feet wide (Senft and Roberts, 1982).

Progress: A total of 91 acres of filter strips have been installed along waterways in or near the Lake of the Woods watershed over the past several years with state and federal program assistance (Beth Forsness, IDNR Division of Soil Conservation, pers. comm.). On July 12, 2001, the SWCD offered a workshop and funding for installation of filter strips in the watershed; two of the three farmers in attendance participated in the program, installing 14 filter strips on 44.3 acres.

The County Surveyor also administers a program under I.C. 6-1.1-6.7 in which filter strips can be classified for tax purposes to reduce the tax on those strips of land to $1/acre, similar to the forest and wildlife classification programs. Filter strips are strips of vegetation, such as grass, along open streams and ditches. To qualify for this program, filter strips must be a minimum of 20 feet in width to a maximum of 75 feet in width. The purpose of the strip is to filter silt out of surface water runoff so that the silt does not enter the stream or ditch. Landowners have not used this program in the county, most likely because a parallel program sponsored by the USDA provides a much greater financial incentive for enrollment (Larry Fisher, pers. comm.).

Barriers:
1. All terrain vehicle use on filter strips: Landowners in the area report that unauthorized use of all terrain and/or off-road vehicles has caused damage to filter strips and adjacent crop fields in some areas, resulting in increased erosion in these areas and decreased landowner interest in installing these buffers.

2. Cost-share for filter strips: Farm Bill programs will not provide federal cost-share to install filter strips in areas that have not been actively farmed in the past five years or in areas that are not classified as highly erodible. This gap may leave some areas unprotected if the farmer cannot afford to pay for installation of riparian buffer strips.

Opportunities:
1. Increase enforcement of trespass laws, signage and education of area residents on appropriate use of such off-road vehicles and associated impacts on water quality and landowner relationships.

2. Identify local or state sources of cost-share for filter strips in areas where federal programs do not apply.

Online resources:

Land and Water Conservation Program Forms
http://www.in.gov/dnr/soilcons/programs/lare/manual.html

5.2.1.2 Livestock production

Best management practices for livestock production can include manure management and erosion control in areas subject to trampling by livestock. There are no large livestock operations in the watershed and none require a Confined Animal Feeding Operation (CAFO) nutrient management plan from IDEM. There are a number of pleasure horses in the watershed and a few very small herds of cattle (several dozen cattle in all). This small number of livestock is unlikely to have significant impact on offsite water quality.

5.2.1.2.1 Manure management, bacteria and pathogens

Water quality data taken since the early 1990s showed average to low levels of fecal coliforms, as represented by *E. coli* in inlet and outlet streams around Lake of the Woods. Several readings were above the state water quality standard, but none exceeded 700 CFU/100ml. Therefore, no unusual problems were indicated.

The 1991 study recommended use of roof gutters and water collection systems to detain and treat runoff and wash down water at feed lots and holding facilities, location of facilities at a distance of 98-393 feet, grading of confinement areas to direct runoff away from waterways, proper maintenance of manure storage lagoons, and proper use and timing of manure applications as fertilizer on pasture and cropland.

Progress: Unknown. Due to the small number of livestock, best management practices are useful to protect water quality for the immediate and adjacent landowners, but may have less impact on lake water quality. See also *6.2.1.1.5 Conservation buffers.*

5.2.1.2.2 Pasture and access to waterways

According to the 1991 study, pastureland should be managed to prevent overgrazing and resulting soil erosion, as well as compaction and increased runoff. Rotation of livestock through a series of fenced areas, terracing and soil stabilization can be effective in reducing erosion in areas used for pasture.

Fencing to remove animals from streams or to allow limited access to water can decrease erosion and sedimentation caused by trampling of stream banks and beds. The distance where ample opportunity is provided for pollution filtration was estimated to be 98 to 393 feet, depending on soil characteristics, grass type and density of cover (Novotny and Chesters 1981). The 1991 study recommended fencing no closer than the top of the grade with vegetation on ditch slopes.

Progress: Unknown. Due to the small number of livestock, best management practices are useful to protect water quality for the immediate and adjacent landowners, but may have less impact on lake water quality. See also *6.2.1.1.5 Conservation buffers.*

5.2.1.3 Wetlands, sediment detention basins, and ditch dredging

Reliance on sediment detention basins and dredging of ditches as a primary means of preventing sediment transport from streams to the lake can be prohibitively costly. The 1982 Diagnostic Study indicated that use of sediment retention basins to reduce siltation and phosphorus loading from surface streams was not a viable strategy due to the cost and logistical problems involved with excavating the large volumes of soil and the subsequent dredging that would be required to maintain storage volume (i.e., basins ranging from 2.9 to 7.1 acres in size on each tributary).

Instead, they recommended use of land cover systems, such as conservation tillage, riparian buffers and wetlands. They strongly urged the establishment and protection of wetlands in the Lake of the Woods watershed, especially along streams and ditches, as natural biological filters that remove sediments and nutrients from surface runoff (Senft and Roberts, 1982). The latter approach retains soil in fields where it can contribute to crop productivity, rather than inefficiently allowing soil to be deposited in streams and incurring the high cost of periodically dredging the material back out and disposing it on farmland or other rural areas.

According to the AGNPS model from the 1991 Feasibility Study, over half of the overland flow in the watershed drains into one 25-acre cell that contains the mouth of both the Martin and Walt Kimble Ditches. As a consequence of this large input area and agricultural use in the watershed, this cell had the highest sediment yield in the model. Other cells with high sediment transport were situated along the golf course and fields northwest of the lake.

The two large streams flow through a wetland prior to entering the lake. This wetland most likely plays a significant role in reducing sediment delivery to the lake. Additionally, Kuntz Ditch flows through an area with old marl pits that may detain water and sediment.

Progress: The county surveyor reports that there are several older sediment basins upstream of this wetland that have not been maintained and may no longer fulfill their intended function of filtering sediments and associated nutrients.

Barriers: Drainage tile throughout the watershed suggests that subsurface flow may be carrying dissolved nutrients (e.g., nitrate) that would not be intercepted by surface wetlands and detention. Muck soils and wetland areas can also export nitrogen and other nutrients due to high organic content and productivity in these systems.

The 1991 study and the current county surveyor both indicate that soils in this area are unstable and not suited to construction activities (Larry Fisher, county surveyor, pers. comm.). Therefore, maintenance of the existing wetland is likely to be more successful than attempted construction of new wetlands or reconstruction of detention basins in soils near the lake and associated wetlands.

Proper disposal locations would have to be identified to spread dredged spoil from sediment basins during maintenance dredging. Soils may contain a seed bank of weeds and excess nutrients that may create problems for crop production in areas where material is spread on farm fields.

Opportunities: Wetland restoration or detention basins in areas higher in the watershed may be beneficial as habitat and local water quality, although they may not be immediately essential for the lake itself due to the flat landscape and opportunity for onsite nutrient and sediment detention in depressions throughout the watershed. Over half of the land area consists of hydric soils, indicating that areas may be amenable to wetland restoration.

Proposed construction along the Highway 31 corridor may provide some opportunity for wetland mitigation in the area around Lake of the Woods at some point in the future. It would be premature to entertain the notion of a feasibility study before initiating discreet discussions about the potential to actually acquire sizeable parcels of land from willing landowners. Pursuit of an engineering feasibility study in the watershed plan would have to be focused on very specific water quality needs in areas where there is significant potential for landowner participation.

5.2.2Urban development

Urban development accelerated around most lakes in the post-war years of the late 1940s and 1950s. Many lakes are again experiencing a sharp increase in housing construction and recreational use, especially in areas where sewers, public ramps, acquisition of large and high-powered watercraft, and other amenities have been installed. By 1982, virtually all of the shoreline of Lake of the Woods had been developed for residential usage (Senft and Roberts, 1982).

The future may bring an even greater flow of recreational users and urban development to Lake of the Woods, especially if U.S. Highway 31 is upgraded to an interstate and development continues in surrounding towns and at the intersection with State Road 6. Increased accessibility may result in pressure to convert prime farmland and open space from agricultural and rural uses to residential and commercial development.

> *The 1982 Diagnostic Study strongly urged that future development along Lake of the Woods be severely curtailed (Senft and Roberts, 1982).*

As urban development and year-round residency increase, water quality problems associated with residential and commercial construction, more intense recreational use and loss of open space may require additional attention.

5.2.2.1 Human and animal waste

Human and animal waste can be a source of nutrients and other chemical and physical additives that may impair water quality and uses. Several of the potential factors are described below for the Lake of the Woods and its watershed.

5.2.2.1.1 Failing septic systems

As recommended by the 1991 study, the following septic system maintenance practices should be employed:

a. Residents in the watershed who are on septic systems should ensure that their systems are properly placed, installed, inspected and maintained through periodic pumping with material discharged at a treatment plant.
b. Trees should not be allowed to grow on the drain field and vehicle traffic should be prevented to avoid soil compaction over the site.
c. Solids, greases and toxic materials should not be flushed into septic systems to avoid clogging pipes or killing the beneficial bacteria that break down waste.
d. Under most circumstances, additives are not needed.

The 1991 study indicated that Lake of the Woods received approximately 466 pounds of total phosphorus annually from septic systems used by households adjacent to the lake.

The 1981 data showed that fecal coliform levels in the tributaries were in excess of the IDEM standard for whole body contact recreation (i.e., 400 CFU / 100 ml) throughout most of the summer. No pattern was determined, but the contamination was thought to be from a combination of human and animal wastes. In 1986, surveys were conducted by the Marshall County Health Department in response to a potential septic system overflow into the lake. Samples were taken mostly from the southwest side of the lake contained high levels of fecal coliforms and fecal streptococcus.

Progress: Presumably, septic system inputs ended around the lake with installation of the sewer system in the early 1990s. Septic systems remain in use in other areas of the watershed. Maintenance regimes for those systems are not known.

5.2.2.1.2 Wildlife and pet waste

The 1991 study did not reference wildlife or pet waste, although pets and geese are known to create water quality problems due to nutrient and coliform runoff in and near waters in other areas.

Progress: Unknown.

5.2.2.2 Household and yard waste

As recommended by the 1991 study, the following household and yard waste maintenance practices should be employed:

a. grass clipping and leaves should not be placed in or near water;
b. trash cans and dumpsters must be sufficient to handle trash, not have drain holes that could leach toxic chemicals or nutrients and be placed as far as possible from the lake;

Progress: Unknown.

Barriers: Rural landowners around Lake of the Woods report finding piles of discarded leaves and other yard waste dumped and burning on their property without permission.

Opportunities: Education may be needed to communicate to area residents that yard waste must be disposed of properly and not in violation of private property.

5.2.2.2.1 Toxic materials disposal

As recommended by the 1991 study, the following household and yard waste maintenance practices should be employed:

a. stormwater runoff along roads and parking lots should be situated so as not to channel runoff directly into the lake or tributaries due to high metal, hydrocarbon and nutrient content of exhaust from internal combustion engines.

Progress: Unknown.

Opportunities:
1. Direct gutter and storm drains away from the lake into areas where water from rooftops, driveways and other hard surfaces can filter through soil or vegetation.
2. Reduce use of salt in the winter in areas where runoff goes to the lake and divert road runoff to areas that will not go directly to the lake.

5.2.2.3 Lawn, garden and park practices

As recommended by the 1991 study, the following lawn, garden and park maintenance practices should be employed:

a. use of fertilizers, pesticides, herbicides and other lawn care chemicals should be avoided or minimized on properties adjacent to the lake, stream or other drainage areas;

These recommendations may apply to maintenance of landscaped areas on residential properties and other recreational facilities, such as the golf courses and campground and resort. Mechanisms for education and regulation differ between private property owners and managers of commercial facilities. Information on management practices that affect *water quality* are described according to the type of property affected.

Progress: Unknown.

5.2.2.3.1 Residential lawn and garden practices

Landowners may personally apply pesticides and fertilizers on their lawns and gardens or they may elect to hire a landscaping company to apply chemicals. Residential property owners may be unfamiliar with proper selection and application of chemicals, especially in areas where the risk of runoff to water bodies is greater.

Progress: Unknown.

Barriers: Licensing of pesticide applicators only applies to commercial use. Therefore, many landowners may lack the training necessary to properly select and apply herbicides and pesticides. In addition, the economic motivation for reducing or restricting over application may be less for residential property owners due to the relatively low cost of chemicals used in an area totaling only a few acres.

Opportunities:
1. Provide education on the proper use of lawn and garden chemicals in areas near streams and lakes in regard to application rates and treatment selection.
2. Provide information on sources of low or no phosphate lawn fertilizers.
3. Encourage residents to use vegetation in landscaping that requires little or no use of fertilizers and pesticides.
4. Allow taller vegetation to grow in a strip along the lakeshore to increase infiltration of stormwater, reduce use of the shoreline by unwanted geese, and provide habitat for wildlife (do not mow grass immediately adjacent to the lake shore).

5.2.2.3.2 Golf course practices

State regulations require commercial pesticide applicators to be licensed through the State Chemists' Office. Chemicals are registered by the U.S. Environmental Protection Agency and must be used according to directions on the package label.

***Progress*:** The golf course supervisor maintains a schedule of nutrient sampling to determine proper rates of fertilizer and pesticide applications on golf course areas. Water testing is conducted four times per year in accordance with requirements from the IDEM.

5.2.2.3.3 Campground and resort practices

A campground and resort borders the northwest side of the lake and provides amenities for short-term use. The area includes a landscape of turf, trees, and several hundred feet of shoreline with boat moorings and a swimming beach.

Progress: Unknown.

5.2.3 Land use policies

Land use planning can affect change equally for a large number of landowners and include educational and regulatory approaches. As indicated above, additional access to the lake and improvements in associated amenities may enhance the need for development and implementation of long-term strategic planning policies.

5.2.3.1 Land use planning

Rural areas in Indiana that have natural amenities, such as Lake of the Woods, can expect a growing influx of residents into homes for year-round, vacation and retirement occupancy.

Progress: Marshall County is one of several counties in Indiana that employs a land use planner, allowing for land use planning that anticipates and addresses needs in the area as the population and demand for services increase in rural areas around lakes.

5.2.3.2 Erosion and sediment control at construction sites

The 1991 study recommended implementation of an ordinance for erosion control on sties with land disturbing activities, which would typically be instituted at the county level.

Other recommendations for areas under construction included:

a. phased construction to avoid clearing large land areas at one time;
b. stabilization of graded road surfaces to diminish transport of sediment on tires of construction vehicles;
c. streamside vegetated buffer or filter strips;
d. sediment barriers, especially protecting storm drain inlets;
e. construction and maintenance of temporary sediment traps and basins;
f. quickly stabilizing disturbed areas with straw mulch, vegetation or other means;
g. diversion of runoff from roof gutters, paved lots and other hard (impervious) surfaces to ponds, filters or other water collection systems to avoid direct runoff into the lake; and
h. management of all other sources of runoff at construction and developed sites.

Progress: See also *6.2.1.1.5 Conservation buffers* for applications in agricultural areas. Unknown in residential areas near Lake of the Woods.

A Storm Drainage and Sediment Control Ordinance Number 1993-7 was adopted on October 4, 1993, as an amendment to the Marshall County Zoning Ordinance, Article 4, Section 435, to address drainage concerns as land is converted in open or agricultural areas to urban uses. The ordinance discusses compliance with other ordinances and permits for construction in a floodway and presents design standards for storm sewers, open channels, stormwater detention, and other drainage structures. The ordinance recognizes that "…deposits from sediment during and after construction can reduce capacities of storm sewers and drainage systems and result in damages to receiving lakes and streams."

Therefore, the release rate of storm water from all new development and any redevelopment or other new construction in Marshall County must be designed to be equal to or less than the release rate from the land area prior to the construction project. Designs must be submitted to the Plan Commission for review. The Marshall County Plan Director and Surveyor are authorized to review engineering summaries of projects and grant exemptions or waive requirements of this ordinance. Their decisions can be appealed to the Plan Commission.

Online resources:
Storm Drainage and Sediment Control Ordinance:
http://www.co.marshall.in.us/Surveyor/ORDINANCE.pdf.

Since the 1991 study, statewide requirements also were developed under "Rule 5" (327 IAC 15-5) for erosion and sediment control on construction sites greater than five acres. Over the past year, the jurisdictional area has been further reduced to sites with land disturbance affecting areas at least one acre in size. The Phase II Version of 327 IAC 15-5 became effective as of November 26, 2003. Significant changes associated with the Phase II version of 327 IAC 15-5 include:

- The land disturbance threshold for regulated projects has been reduced to affected areas of 1 acre or more.
- Construction Plans must be submitted to the reviewing authority at least 28 days in advance of the proposed start date of construction.
- Construction plans must be approved by the reviewing authority prior to submitting the Notice of Intent (NOI) to the Indiana Department of Environmental Management (IDEM)
- Submittal of the NOI to IDEM must include documentation from the reviewing authority that the construction plans meet the requirements of the rule or did not receive a formal evaluation prior to the expiration of the 28 day review period. The NOI must be submitted to the Indiana Department of Environmental Management at least 48 hours in advance of land disturbance with a copy to the reviewing authority.
- NOIs must include latitude/longitude in addition to Section, Township & Range

location information
- NOIs must include an estimation of the proposed impervious surface area associated with the project
- Within 48 hours of initiating construction activities, the project site owner must notify IDEM of the actual project start date.
- Regulated projects are to be inspected by a representative of the project site owner at least weekly and again within 24 hours following a ½ inch precipitation event. Written records must be kept for each inspection and made available to IDEM or their representative upon request.
- Areas that are scheduled or likely to remain inactive for 15 days or more must have temporary surface stabilization measures in place.

The Indiana Department of Environmental Management provided Section 319 base funds for a project titled, "Land Use Changes and Nonpoint Source Pollution Prevention (01-252)." Funds would enable the Michiana Area Council of Governments (MACOG) to develop a computer CD and corresponding printed material to educate builders and developers regarding land use changes and relative impacts on nonpoint source pollution (NPS). The focus was to be on construction site maintenance, sequencing of construction activities, erosion control, and general site design. MACOG will consult with the homebuilders associations, planning departments, and local Soil and Water Conservation Districts before developing the material. MACOG will also be developing, in cooperation with local health departments, a video highlighting the care and maintenance of on-site sewage disposal systems. The video will be distributed throughout the St. Joseph River Basin and Marshall County including libraries, health departments, title companies, real estate offices, and other agencies involved in land transfer and land development within the St. Joseph River basin.

The SWCD has a 16 hp Briggs & Stratton Pro-Chopper Bale Chopping/Mulching machine with seed attachment for rent by Marshall County residents/contractors. It rents for $40 (plus tax) for up to four hours and $75 (plus tax) for five to eight hours.

Online resources:
Rule 5 update
http://www.hancockswcd.org/Rule%205.htm

IDEM Watershed Management Section
http://www.state.in.us/idem/water/planbr/wsm/319sumrg.html

Marshall County SWCD Products/Services Available
http://www.marshallcountyswcd.iaswcd.org/products.htm

5.2.3.3 Riparian corridors

The 1991 study also recommendations erosion control and stormwater management in developed areas, including the use of:

a. stabilization of graded road surfaces to diminish erosion and sediment transport to ditches;
b. maintenance of permanent sediment traps and basins, where feasible and necessary;
c. streamside vegetated buffer or filter strips; and
d. sediment barriers, especially protecting storm drain inlets.

Approval from the IDNR Division of Water is required under the Flood Control Act (IC 14-28-1) and regulations in 312 IAC 10 for Construction in a Floodway along streams and rivers, including bridges, dams, levees, walls, piers, stabilization, excavation, fill and other activities. Permit review must address potential impacts of the proposed structure, obstruction, deposit, or excavation that will do any of the following:

> (a) adversely affect the efficiency of or unduly restrict the capacity of the floodway; or
> (b) by virtue of the nature, design, method of construction, state of maintenance, or physical condition do any of the following:
>
> > (i) constitute an unreasonable hazard to the safety of life or property; or
> > (ii) result in unreasonably detrimental effects upon the fish, wildlife, or botanical resources.

Permits also may be required under the Lowering of Ten Acre Lakes Act, otherwise known as the Ditch Act (IC 14-26-5) for construction in channels having a bottom depth lower than the normal water level of a lake within one-half (1/2) mile of a public freshwater lake of 10 acres or more in surface area. The IDNR shall issue the permit if the proposed project is not found to endanger the legally established water level of a lake; or the normal water level of a lake whose water level has not been legally established; or result in unreasonably detrimental effects upon fish, wildlife, or botanical resources.

<u>Permit requests for stream construction:</u> Two permits submitted under the Flood Control (FW designation) and Ditch Reconstruction (DR designation) Acts were identified in the IDNR online database for the following actions:

1. Sediment trap maintenance (Permit # DR 197): remove accumulated sediment from a trap in an inlet channel, submitted November 13, 1989, by the county surveyor with DNR approval action not indicated.

2. Reroute a stream (Permits # DR 398; FW-22076): Three existing regulated drains would be diverted south of their present alignment to form a new 5000' long drain was proposed for construction to divert the drainage of an

Unnamed Tributary to Lake of the Woods, locally known as Emma Kuntz Ditch. The proposed by-pass ditch will divert the drainage of the tributary from entering Lake of the Woods with the downstream end of the project beginning at Isaac Sells Ditch, approximately 1,700' downstream of the outlet of Lake of the Woods and continuing northwest for 5,000' to a point approximately 1000' upstream from the inlet of an unnamed tributary into the lake, locally known as Emma Kuntz Ditch. A 48" pipe will be installed at a .1% grade in the lower 2,100' of the new ditch and the remaining 2,883' of the project will be an open ditch having a .05% grade and a 4' bottom with 1.5:1 side slopes. Spoil materials will be side cast, leveled, and seeded along the overbanks. In addition, an existing culvert, located about 700' upstream of the mouth of the Unnamed Tributary of Lake of the Woods, will be removed and backfilled. The permit was submitted August 19, 2002, by the Marshall County Drainage Board. A public hearing was held on February 6, 2003, and the application was terminated on June 30, 2003. Details of the project are contained in information and plans received at the IDNR Division of Water.

3. Dredging of an inlet stream and ditch rerouting: Two DNR permit hearings were held at the community center on June 3, 2005, to review proposals under permits # DR-444 and DR-446. Under permit # DR-444, submitted on February 22, 2005, a new private drain would be constructed to carry storm runoff from agricultural fields. An open drainage ditch approximately 300' long would be connected to an existing private ditch that currently empties into the lake. At the landward end of the new ditch 2100' of 24" drainage tiles would be placed below ground and would drain into Sells Ditch. The existing pump would be removed and the lakeward end of the existing drain would be capped to prevent backflow into the lake. Under Permit # DR-446, submitted on March 10, 2005, approximately 1250' of a private ditch would be dredged 1.5' to a depth 6' below the high water elevation of the lake. The channel would be restored to an average width of 12'.

Progress: Unknown in residential areas. See also *6.2.1.1.5 Conservation buffers* for applications in agricultural areas.

Barriers:

1. Lake residents need accessible information on when the various laws apply and which permits are required for work on streams, ditches and lake shorelines. The IDNR Division of Water Public Information & Education staff has indicated that they will work with the Division of Soil Conservation and Division of Fish & Wildlife to produce a resource on permits in lake areas.

2. No comprehensive study has been done on the impacts to water quality, lake level and retention time (flushing), drainage, and crop yields if streams on the west side of the lake were to be re-routed.

Online resources:

IDNR Division of Water Statutes and Rules

http://www.in.gov/dnr/water/statute_rules/index.html

IDNR Division of Water Permit Application Database query
http://www.in.gov/serv/dnr_water_permit_query

5.2.3.4 Impervious areas and stormwater management in developed areas

The 1991 study and other DNR Division of Soil Conservation materials recommend erosion control and stormwater management in developed areas, including:

a. stabilize all bare areas with vegetation or other means;
b. reduce the amount of impervious area by using alternatives to pavement and other hard surfaces;
c. divert runoff from roofs, paved lots and other hard (impervious) surfaces to ponds or filters to avoid direct runoff into the lake;
d. use natural vegetation, glacial stone, or bioengineered materials rather than concrete or steel sheetpile seawalls, where feasible to stabilize eroding lake shorelines; and
e. manage all other sources of erosion and runoff at developed sites.

Progress: Unknown.

5.2.3.5 Information and education

As population and demand for services increases around lakes in rural areas, new residents may be unfamiliar with lifestyle differences in rural areas, including application of ecological principles, natural resource management, maintenance of well water and septic systems, and standard agricultural practices that may affect perceptions of quality of life, aesthetics and recreational resources. Additionally, residents who are new to the lake have a different perspective on the historical conditions in and around the lake than residents who have recently purchased housing at the lake or who use the lake for recreational purposes.

The 1991 study and other DNR Division of Soil Conservation materials recommend erosion control and stormwater management in developed areas, including:

a. educate recreational users on issues surrounding the lake and its care, including broad-based nature exhibits or storyboards on specific problems, such as why fishermen should not clean their catch in or near the lake.
b. place exhibits at public access sites to the lake.

Progress:

1. Recommendations for lake property owners have been published in the POA newsletter, including: Leave filter strips of vegetation along the lake shoreline;
    a. Don't burn leaves near the lake;
    b. Keep garbage out of ditches;

   c. Don't apply fertilizers within 15 feet of the lakeshore; and
   d. Fertilize lawns sparingly and use low or no phosphorus fertilizers.
2. Conducted an annual raffle and ice fishing derby, which drew 70 people in 2004 and 120 anglers in 2005, including almost 20 children (sponsored by the Bremen Conservation Club).

Opportunities:
1. Provide information on historical trends and conditions of the lake and watershed, including land use, water quality, and development of soil and water conservation practices.
2. Develop additional community events and projects that facilitate positive interactions among residents.
3. Specify positions in community organizations (e.g., lake association officers; conservation club) that are designated to represent particular stakeholder groups (e.g., agriculture, business, lake residents).

5.2.4 In-lake remediation

Implementation of best management practices is essential to the long-term health of the lake. However, in-lake remediation can provide an interim solution that will have longer lasting effects if lake and watershed practices are in place before conducting expensive remediation.

Years of historical inputs from poorly sited and maintained septic systems and overuse of fertilizers on lawns and in agricultural areas has resulted in high nutrient levels in lake sediments. When these sediments are churned up into the water column, these "legacy nutrients" become available to aquatic plants and can cause overgrowth of weeds and algae.

5.2.4.1 Alum treatment

Negative impacts from these nutrients can be reduced by phosphorus precipitation or inactivation by using aluminum sulfate (alum) to remove phosphorus from the water column and cap phosphorus in the lakebed. In the early 1990s, costs for a whole-lake alum treatment ranged from $96,000-$136,500.

Use of alum is not without risk. Treatment must be done carefully to avoid potential toxicity of dissolved aluminum to fish and other aquatic animals. Improved water clarity can lead to increased plant growth, as light penetrates into areas with deeper water. Proper dosage and monitoring of pH are essential.

Progress: To date, an alum treatment has not been conducted, nor have specific costs been determined through recent contractor estimates.

5.2.4.2 Boat traffic in shallow water areas

Boating in shallow water areas can have detrimental effects on recreational equipment and ecological health of the lake (see inset on "Environmental Considerations"). Reducing boat traffic over shallow water is a less expensive way of keeping phosphorus out of the water column than alum treatments or dredging. Sediments resuspension increases with boat speed and horsepower.

According to residents, boat number, size and horsepower have steadily increased over the past few decades in northern Indiana lakes, including Lake of the Woods. There may be shallow areas in the lake outside the 200-foot idle zone where sediments and nutrients can be resuspended by high-speed boat traffic. Wave runners (jet skis) are increasing in horsepower and may be used more commonly in shallow water areas.

Progress: In 2000, a law (HEA 1075) was enacted that provides the IDNR with authority to limit boat traffic in specific areas of lakes to protect water quality and ecological resources in addition to safety of recreational lake users. The same law modified the regulatory terminology to read that all watercraft may not go faster than idle speed within 200 feet of the lake shoreline or channel. This modification reduced the possibility of wakes that may be associated with big boats with a large draft that may still push a lot of water even though they are moving at slow speeds (e.g., 10 mph).

To date, the IDNR has completed lake zoning to protect wetlands and water quality in response to a request from Lake Wawasee. A similar petition has not been contemplated for Lake of the Woods but may apply to shallow muck-bottom areas with fine silt, particularly along northern and eastern shore lines of the lake.

Environmental Considerations

Source: IDNR Division of Law Enforcement

When operating your PWC always be considerate of the effect you may have on the environment.

- Do not operate a PWC in shallow water (less than 24 inches deep). Bottom sediments or aquatic vegetation can be sucked into the water pump and damage your PWC and the environment.
- Avoid creating a wake which can cause erosion when operating near shore or in narrow streams or rivers.
- Maintain idle speed when within 200 feet of shore.
- Do not dock or beach your PWC in reeds and grasses. This could damage fragile environments.
- Take extra care when fueling your PWC in or near the water. Oil and gasoline spills are very detrimental to the aquatic environment. Fuel on land if possible.
- Never use your PWC to chase wildlife such as birds feeding near shore, waterfowl or other animals.

Another mechanism for addressing high speed boating and nutrient resuspension in shallow waters would be through increased education of lake residents and visitors.

Barriers: The number, size and times of use have not been quantified for Lake of the Woods.

Opportunities:
1. Limit boat size and speed that can be used on the lake.
2. Set certain hours that motorized boats can be used on the lake to allow the lake to settle out after being churned by boat motors.
3. Establish idle zones in all shallow areas by petitioning the IDNR.

5.2.4.3 Aquatic plant control

The 1991 study suggested that a significant "weed problem" did not exist at the time for Lake of the Woods, but that aquatic plants may need to be periodically removed from most lakes. No chemical control program had been recommended by IDNR biologists at the time.

Information from residents suggests that a variety of methods have been used for aquatic plant control over the past several decades. Copper sulfate was reportedly applied to the lake in the early 1970s, using aerial spraying from a helicopter, and a weed harvester was used on the lake during the 1980s when plant growth was very weedy. Residents report that "trailer loads" of weeds were removed from the lake at that time. More recently, herbicides have been used for aquatic plant control—especially in shallow areas—resulting in more manageable plant growth. Concerns have also periodically been raised that overuse of herbicides can deplete plant beds needed as habitat for fish. Longtime residents of the lake indicate that plant growth has fluctuated widely in cycles over time. More recently, plant growth has again been heavy.

The study recommended aquatic plant harvesting and removal of associated internal nutrient loads by cutting aquatic plants from the lake with a mechanical weed harvester. Contract costs for weed harvesting were estimated at $135 - $300 per acre in the early 1990s.

The downside of aquatic plant harvesting is that weed regrowth can be rapid, providing only temporary relief. In addition, harvesting of plants that disperse through fragmentation, such as the invasive exotic Eurasian watermilfoil, can actually cause the plant to spread throughout the lake. Reduced sedimentation or decreased algae growth, associated with improved water clarity in the lake may also lead to increased growth of rooted aquatic plants. Chemical control of Eurasian watermilfoil can be achieved through use of 2,4-D or fluridone (Sonar®).

Progress: In 2004, the Lake of the Woods Property Owners Association successfully applied for a LARE grant to develop an aquatic plant management plan. Strategies and actions for that plant management plan have been included in this watershed plan (e.g., Goal 8).

Online resources:

Aquatic plant control regulations
http://www.ai.org/legislative/ic/code/title14/ar22/ch9.html#IC14-22-9-10

5.2.4.4 Nuisance animal control

Residents complain of nuisance levels of seagulls around the lake and indicate that no other wildlife presents a regular nuisance. Research conducted along the Lake Michigan shoreline indicates that seagulls may be a significant source of coliforms in aquatic recreation areas (Haack, et. al, 2001; Whitman and Nevers, 2003). However, they did not suggest any methods for controlling these animals.

5.2.4.5 Fisheries management

From 1978 through the 1980s, Lake of the Woods traditionally supported a satisfactory fishery for crappie, yellow perch and stocked channel catfish with fewer large bass and bluegill than desired. Statewide establishment of a 14-inch minimum size limit seemed to improve the overall bass population. Invasive gizzard shad became abundant in the late-1980s, constituting 58% of the fish caught in that survey.

According to a 1996 IDNR fisheries survey, bluegill abundance rose dramatically from 1987 to 1996, producing very good bluegill fishing. Bass fishing continued to be mediocre compared to other northern Indiana lakes. A tiger muskellunge stocking did not produce a fishery, but later stocking of walleye in the early 1990s appears to be creating good fishing opportunities for that species. Walleye seemed to be controlling the shad population. However, appearance of introduced white bass—most likely due to illegal stocking—was disappointing as they could be disruptive to the walleye fishery.

Based on an average fishing trip length, the IDNR estimated that 2,272 fishing trips occurred at Lake of the Woods during a six-month creel period in 1997, resulting in an estimated $49,984 contribution to the local economy. Nearly 43% of anglers were fishing primarily for walleye, 13% for crappie, 11% for largemouth bass, 7.5% for bluegill, and over 24% for "anything." Of participants in the survey, 48% of the anglers were from Marshall County. Other anglers were from St. Joseph, Porter and Lake counties. Over 29% of anglers were residents at the lake in comparison to out of state residents, who constituted only 1.8%.

Progress: Fish management practices will be unable to improve the lake's fishery without improvements in water quality. Such improvements are expected in the near future due to the installation of the sewer system and increased use of agricultural conservation practices is expected to positively affect fish and other aquatic life.

Barriers: Introduction of exotic species can nullify other efforts to improve a fishery through water quality management. Additional education of lake residents regarding the economic and recreational value of the fishery and potential negative impacts of illegal stocking of invasive exotic fish and transport of other nuisance species may help prevent

introduction of destructive species. Once these species are in the lake, adequate control can be expensive or impossible.

5.2.4.6 Stabilization and dredging along the lake shoreline and channels

Residents perceive that certain areas around the lake shorelines and in some channels around the lake have become shallower due to historical and continuing sedimentation from watershed sources, eroding shorelines and decomposition of plant materials. Spot dredging could be used to restore access for boating and other recreational activities.

Locations that were previously identified for potential dredging included:

a. Channel leading to the dam; and
b. Shorelines along the northeast side of the lake.

A project to restore and maintain original depth contours along the shoreline and in channels could include:

a. Stabilizing eroding shorelines using sound engineering techniques that are environmentally sensitive;
b. Controlling runoff around the channel mouth to avoid additional sedimentation;
c. Dredging along the channel to re-establish the original depth contours; and
d. Limitations on watercraft speed within 200 feet of shore to reduce scouring and erosion of the lakebed.

<u>Permit requests for lake construction:</u> The Lakes Preservation Act (IC 14-26-2) and associated rules in 312 IAC 11 regulate similar activities along channels and lake shorelines of public freshwater lakes, including Lake of the Woods. A search of the online database revealed 98 permit applications have been submitted to the IDNR Division of Water since November 1989. Permits were approved for construction projects along a cumulative 7,800 linear feet of shoreline since October 1992.

Since November 1989, permit requests and IDNR decisions included in-lake construction of:

a) A geothermal pump (1 denied);
b) Seawall installations or refaces (5 denied; 83 approved with 2 in review);
c) Boat well (1 denied for 7,000 square feet of fill; 2 approved, one for 323 square feet and the other did not have the area indicated in the database);
d) Boat ramp construction (1 approved for the IDNR boat ramp; 1 action not indicated); and
d) Channel dredging (1 denied; 4 approved), including one permit each for:
    i) 2,500 square feet (50 linear feet) at Lot 13, Marks Park, approved May 26, 1995,
    ii) 1,800 square feet (90 linear feet) at Lot 12, Marks Park, approved June 30, 1995

iii) 9,000 square feet (225 linear feet) at 4118 West Shore Drive, approved May 30, 2001; and
iv) Area and location not available, approved November 13, 1989 (issued to County Surveyor and probably associated with the Ditch Reconstruction permit sediment trap submitted on the same date).

Progress: Private landowners have received permits from the IDNR Division of Water for dredging projects in several channels around the lake. In 1989, the County Surveyor applied for permits under the Lake Preservation and Ditch Reconstruction Act for maintenance dredging of a sediment trap on an inlet to the lake. Local residents along the channel near the dam obtained quotes from two dredging companies, which were in a price range of $20-30,000, but have not been able to raise funds to apply for permits and hire a contractor to do the work.

Barriers: Most of the residents along the channel are older and live on fixed incomes, preventing them from financing the project. When the DNR, as owner of the dam, was contacted the reply reported by property owners was that financial assistance from the State could only be considered if sedimentation interfered significantly with the function of the dam.

Online resources:
IDNR Division of Water Statutes and Rules
http://www.in.gov/dnr/water/statute_rules/index.html

Lakeshore Protection in Indiana, IDNR Division of Soil Conservation
http://www.in.gov/dnr/soilcons/pdfs/seawall.pdf

6.0 Identifying critical areas for action

The community defined their vision and mission for watershed management as follows:

Vision: Profitable farmland, achievable water quality, and continuing education in support of sustainable agriculture, recreational lake use, and property values.

Mission: The watershed planning committee, representing a broad range of interests, will foster communication, collaboration, education, and scientific understanding to develop practical conservation strategies that will maintain and improve watershed resources for sustainable agricultural production, recreational benefits, property values, and a cooperative community atmosphere.

On the basis of these overarching statements, historical information, and updated water quality data, the community developed a long-term management plan that identifies critical areas for action.

6.1 Prioritization of water quality issues by the community

Community leaders identified 12 issues as top priority concerns for the Lake of the Woods and its watershed, based on areas of concern identified through public input. During and after the public meeting on March 21, 2005, 49 people identified their top three highest priority issues. Votes are provided below as an indication of the relative significance of these issues to the individuals who responded.

Issues will be addressed in the following order throughout the document. This process is not a scientific survey, but a means of identifying key community concerns at this point in time. Feasibility of taking action on any particular issue, connections between topics, and changes in social and scientific understanding of these issues are likely to affect future prioritization.

Rankings were as follows:

Rank	Issue	Votes
1.	Erosion and sediment control	26
2.	Hydrology and drainage	24
3.	Nutrient loading	23
4.	Long term, representative watershed management planning	15
5.	Channel maintenance	12
6. (tie)	Conservation practices	8
6. (tie)	Education on stewardship topics	8
7. (tie)	Invasive species	7
7. (tie)	Watercraft safety and ecological impacts	7
8. (tie)	Highway development	1
8. (tie)	Law enforcement	1
8. (tie)	Native fisheries resources	1

For the purposes of prioritizing the largest subwatersheds on the basis of nonpoint source pollutants, the sampling data indicated that:

- During base flow, Martin and Kuntz Ditches had the highest pollutant loads.
- Temperature, conductivity, turbidity, and pH were all within normal levels.
- Martin Ditch (base and storm) and Stephey Ditch (base) exhibited dissolved oxygen levels below the IAC standard
- During storm flow, Martin and Stephey Ditches had the highest pollutant loads.

However, water quality in these streams was similar when adjusted for flow rates. Therefore, the data does not suggest clear prioritization exclusively on the basis of water quality. Other factors such as the feasibility of applying conservation practices in particular areas will be more likely to drive the choices leading to prioritization of efforts.

6.2 Feasibility analysis

The most recent year for which water clarity information is available for 79 northern

Indiana lakes that participate in the statewide volunteer monitoring program was 2003. In that year, the median Secchi depth for these lakes was 5.7 ft (average of 7.0 ft) with a range of 0.5 ft at Town Lake (Fulton County) to 22.5 ft at Saugany Lake (Porter County). The collection of this data is managed by a quality control process through the Indiana Department of Environmental Management in association with the School for Public and Environmental Affairs, Indiana University.

While a reasonable long-term goal for water quality improvement could be 5.7 ft, the potential for improvement at Lake of the Woods is currently hampered by historical loadings of sediment and nutrients. In comparisons with lakes of similar size and land use in the region, the lake association suggested that 5.9 feet might be achievable over the long term.

The 1991 feasibility study presented an analysis of the potential impacts on water clarity of various management and restoration actions; most of these conservation measures were predicted to lead to water clarity between 2.8 and 4.5 feet (Table 10). This information was considered as community stakeholders determined the level of water quality that could be achieved through practical and feasible soil and water conservation measures.

For the purposes of implementing this watershed management plan, community stakeholders agreed to an interim water clarity goal of 4.5 feet.

Problem Statement: Water quality in Lake of the Woods is consistently below average for glacially formed lakes in Northern Indiana. As an indicator of current water quality, Lake of the Woods ranked 66th out of 77 northern Indiana lakes for water clarity, as measured by mean Secchi depth of 2.8 feet, according to statewide volunteer monitoring data in 2003.

Water quality goal: Improve average summer water clarity to 4.5 feet which would bring the lake up to water quality more typical of other Northern Indiana lakes. For example, the lake would have ranked 49th out of 79 northern Indiana lakes rather than 68th, according to samples taken in 2003.

This water quality goal provides a benchmark by which to measure progress in implementing this plan.

6.3 Resources to address concerns and monitor impacts

The community has access to a number of agencies and organizations with a long history of addressing issues and monitoring effects of actions taken. These organizations are described in earlier parts of this document and will be identified as appropriate to address specific tasks in the Action Plan.

7.0 Goals and indicators

The following water quality improvement or protection goals were developed through a series of discussions with a range of stakeholders, culminating in a public meeting on March 21, 2005. To be implemented effectively, it is necessary for goals to include specific, realistic targets (indicators) for reducing pollutants or mitigating impacts, and to identify timeframes for accomplishment.

These timeframes are guidelines for implementation and provide a sense for the amount time that may be involved in addressing each goal. The timelines may be altered, as resources become available or community conditions change.

Goal 1. **Erosion and sediment control:** By 2015, control erosion and sediment transport from the watershed to the lake from both agricultural and urban land uses by reducing soil erosion below T for all land areas currently in production or under development.

Goal 2. **Hydrology and drainage:** By 2010, manage hydrology in Lake of the Woods and its watershed to maintain adequate water quality, depth and agricultural drainage that: a) allows full recreational use of the lake; and b) maintains current crop productivity.

Goal 3. **Nutrient loading:** By 2015, decrease nutrient loading, both externally (from tributaries) and internally (from lake sediments).

Goal 4. **Long term, representative watershed management planning:** By 2006, ensure that watershed management planning is an ongoing process that includes broad representation and continually improves stewardship of the land and water resources in the community.

Goal 5. **Channel maintenance:** By 2010, maintain and improve channels for recreational use by restoring the channels to their original dimensions.

Goal 6. **Conservation practices:** By 2010, obtain adequate funding for installation of conservation practices in all lakeshore and watershed areas that demonstrate need.

Goal 7. **Education on stewardship topics:** By 2008, provide education on stewardship at least 5 high priority topics that will encourage responsible lake and watershed management.

Goal 8. **Invasive species:** By 2008, reduce or eradicate invasive species that impair native fish and wildlife habitat in the lake and its watershed.

Goal 9. **Watercraft safety and ecological impacts:** By 2008, control watercraft to reduce safety and ecological risks by ensuring that all watercraft operators are aware of and follow state regulations.

Goal 10. **Highway development:** By 2025, minimize any negative impacts of highway development on the watershed such that water quality, quantity and hydrology in the lake and its watershed are not adversely affected.

Goal 11. **Native fisheries resources:** By 2015, maintain and improve native fisheries resources by ensuring that new and existing stocking and management practices maintain or improve angler satisfaction.

Goal 12. **Law enforcement:** By 2010, ensure effective law enforcement to promote safe recreation and minimize impacts on water quality and quality of life by accessing all available resources to support awareness of state and local laws among all recreational users and adequate enforcement presence on the lake and in the watershed.

8.0 Management practices, resources, and cost

For each goal, the community suggested strategies and actions that they felt were feasible to achieve. This input was then used by project managers to recommend a set of specific steps that would be required to implement these actions, including management practices, resources, and an estimated cost.

Actual costs may vary greatly depending upon conditions at the time of implementation. These ranges are provided to assist in the planning effort. Prior to carrying out any action or applying for grant funds, project managers would need to acquire a specific set of bids for the desired actions.

Goal 1. Erosion and sediment control: Control erosion and sediment transport from the watershed to the lake from both agricultural and urban land uses.

Strategy 1.1 Implement soil conservation practices in *developing areas around the lake*, including control of shoreline erosion and management of bare ground during construction projects.

Actions

1. Implement voluntary conservation practices among waterfront property owners along shorelines.
    a. Identify lakefront property owners and developers who are using soil conservation practices along the lakeshore, including:
        1. Use of decorative native and non-invasive plants to stabilize and beautify shorelines.
        2. Installation of bioengineered seawalls (e.g., stone and plants).
        3. Reface of existing concrete seawalls with stone or other bioengineering materials.
    b. Facilitate interaction between those individuals and other property owners interested in adopting those practices.
    c. Identify technical and financial resources to implement practices.
    d. Conduct field days or other workshops to demonstrate practices for lake residents, developers and those involved in lake real estate transactions.

Strategy 1.2 Implement soil conservation practices in *rural areas in the watershed*, including use of conservation tillage, grassed waterways, vegetated stream buffers, and as needed.

Actions

a. Implement voluntary conservation practices among private property owners on agricultural land.
    i. Identify agricultural producers who are using no-till and other conservation practices.
    ii. Facilitate interaction between those producers and other landowners interested in adopting those practices.
    iii. Locate areas that are eroding and need soil stabilization; determine appropriate practices.
    iv. Apply for cost-share funding to install practices.
    v. Conduct field days to demonstrate practices for agricultural landowners and lake residents.
b. Dredge sediment from inlet streams on a routine maintenance schedule.
    i. Locate areas needing maintenance.
    ii. Ensure adequate funding through ditch assessment revenue.
    iii. Acquire permits and hire contractors.

Resources

- *Technical:* Landowners, NRCS, SWCD, KRBC, County Surveyors' Office (regulated drain maintenance), Purdue Cooperative Extension Service, IDNR District Fisheries Biologists (shoreline construction practices), Conservation Tillage Information Center (CTIC).
- *Financial:* IDNR Watershed Land Treatment funding through LARE program; IDEM 319 Nonpoint Source Implementation Grant, local ditch assessment revenue, corporate sponsorships, POA.

Cost: Relatively low cost ($10,000-$50,000 for each strategy)

Goal 2. Hydrology and drainage: Manage hydrology in Lake of the Woods and its watershed to maintain adequate water quality and agricultural drainage.

Strategy 2.1 Re-route streams (drainage ditches) and manage lake level patterns to maintain agricultural drainage and improve water quality.

Actions

a. Obtain funding for the impact and engineering feasibility study from external sources.
b. Conduct a study examining the ecological and economic impacts of existing hydrology, including the dual lake level, drainage and stream rerouting, on the streams, the lake, and downstream in the Yellow River.
c. Propose alternative solutions and determine cost-effective methods for addressing verifiable water quality and drainage problems, including:
    i. i. Rerouting the un-named inlet at the public access site; and/or
    ii. ii. Rerouting Kuntz Ditch to bypass the lake and drain into the outlet.
d. Complete design and construction for recommended actions, including obtaining permits, landowner easements or land purchase, and hiring contractors.

Resources

- *Technical:* KRBC; County Surveyors' Office; IDEM Office of Water Quality (permits); IDNR Division of Water (engineering requirements, permits); District Fisheries Biologists (permit review, ecological impacts)
- *Financial:* Landowners; IDNR engineering feasibility and construction funding for erosion and sediment control through LARE program (potential, depending on state policies, priorities and funding availability).

Cost: Strategy 2.1 – Relatively high cost ($30,000-60,000 for studies; $100,000-$500,000 for construction).

Goal 3. Nutrient loading: Decrease nutrient loading, both externally (from transport through tributaries) and internally (from lake sediments).

Note: Any modifications to hydrology, such as rerouting streams or altering lake level may affect nutrient loading. Therefore, those actions in Goal 2 may need to logically be completed before addressing Goal 3.

Strategy 3.1 Decrease external nutrient loading by filtering nutrients that pass through the tributaries.

Actions

a. Obtain funding for the engineering feasibility study from external sources.

b. Conduct an engineering feasibility study to enhance natural wetlands or create artificial detention basins for the purposes of nutrient filtration by:
    i. Focus on inlets where wetland filtration has the greatest potential benefit and where soils, slope and other environmental conditions may be suitable for construction (e.g., Martin, Seltenright, Stephey, and Kuntz Ditches).
    ii. Identify available properties with willing owners amenable to construction of wetland filtration or sediment detention basins.
    iii. Predict water quality impacts of wetland functions and construction processes at particular inlets and potential construction sites in the watershed.
    iv. Develop preliminary design for size, placement, and construction plans.
    v. If recommended, establish preliminary agreements with willing owners amenable to construction and sediment disposal.
c. Design and construct the wetland and/or detention basins, including obtaining permits, establishing landowner easements or land purchase, and hiring contractors.
d. Conduct long-term monitoring to measure water quality impacts.
e. Provide for long-term maintenance of basins (periodic dredging).

Strategy 3.2 Decrease internal nutrient loading from the lake sediments.

Actions

a. Identify areas of the lake that may require dredging (e.g., north, east and south shores), after controlling erosion and sediment inputs to those areas.
b. Obtain funding for in-lake dredging.
c. Remove sediments and associated nutrients by dredging selected areas of the lake, using methods that are environmentally appropriate.
d. Limit resuspension of sediments and associated nutrients by restricting boat speed in shallow areas.
e. Determine the advisability and cost of an alum treatment after watercraft operation, watershed and shoreline conservation practices are in place.

Resources

- *Technical:* Engineering and dredging consultants; KRBC; County Surveyors' Office; IDEM Office of Water Quality (permits); IDNR Division of Water (engineering requirements, permits); IDNR Division of Law Enforcement (boat regulation over shallow areas); District Fisheries Biologists (permit review, ecological impacts of construction and boating).
- *Financial:* Landowners; IDNR engineering feasibility and construction funding for erosion and sediment control through LARE program (depending on state policies, priorities and funding availability).

Cost: Strategy 3.1, 3.2(a,c) Relatively high cost ($50,000-90,000 for studies;

$100,000-$500,000 for construction, dredging or alum treatment).
Strategy 3.2(b) Minimal cost.

Goal 4. **Long term, representative watershed management planning: Ensure that watershed management planning is an ongoing process that includes broad representation and continually improves stewardship of the land and water resources in the community.**

Note: *Although this goal ranked lower than those above, establishing a long term planning entity will be essential to effectively carry out any of the goals in this plan with the necessary community support.*

Strategy 4.1 Ensure broad representation on the watershed planning committee. A number of representatives have participated in the development of this plan.

Actions

a. Identify all interest areas that need representation for long-term watershed management. In addition to those involved in development of this plan, additional representation may be necessary for the following interest areas:
    - Water-based recreation
    - Recreational users who do not live on the lake and use the public access site.
    - Tournament anglers (e.g., walleye, bass)
    - Watershed residents who do not belong to the POA.
    - Nonconsumptive users who do not boat, but enjoy the nature and tranquility of the lake.

b. Meet at neutral, mutually acceptable and publicly accessible locations on a periodic schedule to review the Watershed Management Plan, determine feasible actions for implementation, acquire technical and financial resources, and conduct periodic updates of the plan.

Strategy 4.2 Examine the relationship between soil and water conservation practices, water quality, soil productivity, and real estate values on farm ground and in lake residential areas.

Strategy 4.3 Examine the economic and social impact of lake level lawsuits, such as diversion of funds that could be used for conservation and effects on community collaboration.

Actions

a. Determine the questions to be addressed, prepare a scope of services, acquire funding, and select a consultant to conduct the study(s).

Resources

- *Technical:* Economic impact consultants, Chamber of Commerce, County Planner, other agencies as needed to support the watershed management steering committee.
- *Financial:* Landowners, Indiana Economic Development Corporation (depending on policies and funding availability).

Cost: Strategy 4.1. Minimal cost.
Strategy 4.2, 4.3. Moderate cost ($30,000-50,000 for studies).

Goal 5. Channel maintenance: Maintain and improve channels for recreational use.

Strategy 5.1 Dredge channels to improve access for recreational boating.

Actions:

a. Identify channel areas where sedimentation impairs boat access and obtain bids on dredging operations. Concerns have been raised for the following channels:
    i. Liberty Street channel.
    ii. West side channels, including bay just north of Rt. 4b.
    iii. Channel near the dam (width and depth).
    iv. North side channels.
b. Determine appropriate depths (e.g., a slope of about 5% extending to a depth of about 4' would permit access to most docks even when the lake is lowered) and timing (e.g., conduct dredging activities over winter by lowering the lake to the invert of the Isaac Sells outlet ditch).
c. Determine where dredging and deposit of spoil is feasible.
d. Obtain funds, permits, bids, and contractors for dredging projects.

Strategy 5.2 Improve oxygenation and reduce algae overgrowth in inlet streams and channels.

Actions:

a. Install aerators in channels, as needed to increase water circulation, including obtaining cost estimates, purchase, installation, and maintenance.
b. Maintain trees along one side of stream banks (west or south) during dredging operations to increase shading and oxygenation of inlet streams.
c. Design and construct drop structures, low flow channels, gravel runs, or other grade control structures in inlets to increase stream flow rates and mixing.

Resources

- *Technical:* Engineering and dredging consultants; KRBC; County Surveyors' Office; IDEM Office of Water Quality (permits); IDNR Division of Water (engineering requirements, permits); District Fisheries Biologists (permit review, ecological impacts of dredging).

- *Financial:* Landowners; IDNR funding for sediment control through LARE program (depending on state policies, priorities and funding availability; in general LARE funds are not available for channels that are not associated with inlets to the lake).

Cost: Strategy 5.1. High cost ($50,000-90,000 for studies; $30,000-$100,000 for dredging).
Strategy 5.2. Moderate cost ($10,000-50,000 for design and installation).

Goal 6. Conservation practices: Obtain adequate funding for installation of conservation practices.

Strategy 6.1 Identify potential external sources of funding, determine applicability and eligibility, and raise local cost-share amounts, as needed.

Actions: *This goal is closely associated with a number of other goals that call for implementation of conservation practices. See related goals for action items (e.g., Goal 3).*

Resources

- *Technical:* Landowners, NRCS, SWCD, KRBC, County Surveyors' Office, Purdue Cooperative Extension Service, IDNR District Fisheries Biologists (streambank, channel, shoreline and in-lake practices), Conservation Tillage Information Center (CTIC).
- *Financial:* IDNR Watershed Land Treatment funding and other LARE program funds; IDEM 319 Nonpoint Source Implementation Grant, local ditch assessment revenue, corporate sponsorships, POA.

Cost: Relatively low cost, depending on practices ($10,000-$50,000 for each strategy)

Goal 7. Education on stewardship topics: Provide education on stewardship topics for responsible lake and watershed management.

Strategy 7.1 Encourage proper application of Best Management Practices (BMPs) for soil and water conservation with special emphasis on techniques that are practical, cost-effective and easy to install or use.

Actions

a. Provide education on a variety of topics through a strategic communications, possibly including workshops, guest speakers, and printed materials. The following list includes topics *in no particular order* that have been suggested by community residents:

- Watercraft safety and impacts of boating on nutrient suspension, water quality and shallow water habitats.
- Agricultural production and conservation practices, including trends and values of soil conservation methods, agricultural economics, and direct and indirect impacts of cost-share programs on landowners, and trends in crop and livestock production in the watershed.
- Fish consumption advisories and risk reduction.
- Function and values of aquatic systems,
- Hydrology of lake systems, including how water cycle through a watershed, current flows and historical patterns in lake levels, and historical and proposed changes in inlets and outlets that affect hydrology.
- Nutrient cycling in lake systems, including annual chemical effects of lake stratification (lack of oxygen deeper parts of the lake due to summer heating), past and present sources of nutrients, changes in loads from various sources, fertilizer and land use impacts on nutrient transport, and relative impacts of resuspension of residual nutrients from the lakebed.
- Off-road vehicle use, including trespassing laws and impacts on erosion and water quality.
- Waterfowl hunter safety.
- Permitting requirements under the Public Freshwater Lake Act.
- Effects of seawalls and shoreline development on aquatic habitat and water quality, along with shoreline habitat protection and restoration methods. May include sale or distribution of native or non-invasive decorative plants as a buffer to control erosion and runoff from yards.
- Function and values of sensitive areas and wetlands, including flood control, filtration, groundwater recharge, impacts on peak flow and erosion rates, and as habitat for fish and wildlife.
- Ecology and management of aquatic plants, including long term trends and cycles of plant abundance, relationships between algae and rooted plants, and effects of nutrients and water clarity on plant growth.

Actions

a. Select workshop topics, identify speakers, seek funding where needed; and
b. Conduct workshops and evaluate results of participation.

Resources

- *Technical:* IDNR and IDEM staff; consultants; other agencies as needed to supply workshop presenters.
- *Financial:* Landowners, IDEM 319 Grant (depending on policies and funding availability).

Cost: Minimal cost ($0-$10,000 per workshop, depending on topic).

Goal 8. Invasive species: Reduce or eradicate invasive species that impair native fish and wildlife habitat.

Strategy 8.1 According to the *Lake of the Woods Aquatic Vegetation Management Plan*, goals for managing aquatic plants in this lake are:

- Develop or maintain a stable, diverse aquatic plant community that supports a good balance of predator and prey fish and wildlife species, good water quality and is resistant to minor habitat disturbances and invasive species.
- Direct efforts to preventing and/or controlling the negative impacts of aquatic invasive species.
- Provide reasonable public recreational access while minimizing the negative impacts on plant and wildlife resources.

Actions A comprehensive treatment plan for aquatic plants was developed in 2005 for the Lake of the Woods. The plan outlines methods of reducing invasive aquatic plants (Eurasian watermilfoil) to promote recovery of native plant beds and without harming fish species.

Three rounds of treatment were recommended from 2005-2008, including whole lake and spot treatments. Treatment would consist of the following steps:

i. Pretreatment survey;
ii. Application of herbicides;
iii. Post-treatment vegetation surveys; and
iv. Plan updates.

For more detailed information, see *Lake of the Woods Aquatic Vegetation Management Plan.*

Resources

- *Technical:* Aquatic plant control consultants (surveys, herbicide treatment); IDNR LARE staff (technical and grant review); IDNR District Fisheries Biologists (permit review).

- *Financial:* Landowners, IDNR aquatic plant control grant (depending on policies and funding availability).

Cost: Moderate cost ($40,000-$50,000 over 4 years, depending on survey and treatment protocols).

Strategy 8.2 Control nuisance wildlife populations to decrease social impacts and a possible source of fecal coliforms.

Actions

a. Conduct a bacterial DNA study to determine the sources of fecal coliforms in the Lake of the Woods and its tributaries, including obtaining funding, sample collection, and laboratory services. This study may also provide information on bacterial contamination from septic systems, wildlife and other sources.

b. If warranted, develop and implement a scientifically based and socially acceptable plan for control of nuisance wildlife, including seagulls, at the Lake of the Woods. The plan would outline methods of reducing nuisance seagull or other wildlife populations without harming fish species.

   Three rounds of treatment were recommended from 2005-2008, including whole lake and spot treatments. Each treatment would consist of the following steps:

   i. pretreatment survey of seagull populations;
   ii. review and selection of control methods;
   iii. post-control population surveys; and
   iv. plan updates.

Resources

- *Technical:* Water quality testing laboratories (coliform DNA testing); nuisance animal control consultants (surveys, treatment); IDNR LARE staff (technical review); IDNR District Wildlife Biologists (technical and permit review, depending on control methods); IDEM Office of Water Management (bacterial sampling protocols, grant review).
- *Financial:* Landowners, IDEM Office of Water Management (depending on policies and funding availability).

Cost: Strategy 8.2(a) Moderate cost ($10,000-50,000 for analysis and interpretation of DNA sampling).
Strategy 8.2(b) Moderate cost (unknown, depending on survey and treatment protocols).

Goal 9. Watercraft safety and ecological impacts: Control boating to reduce safety and ecological risks.

Strategy 9.1 Consider alternative methods of controlling watercraft, if indicated by safety and ecological impacts.

Actions

a. Conduct a study to determine watercraft impacts on safety and lake ecology, including an examination of impacts on:
    i. habitat (spatterdock, water lilies) of boat traffic in emergent plant beds;
    ii. water quality of re-suspending nutrient-laden sediments in shallow area; and
    iii. safety risks associated with particular locations within the lake or time periods of use.
b. Identify possible mechanisms for restricting high speed boating in particular high-risk (shallow) areas of the lake.
c. If indicated, petition the DNR to establish ecological protection zones over shallow areas of the lake.
d. Hold public hearings and follow the rule-making process.

Resources

- *Technical:* IDNR Division of Law Enforcement (regulatory petitions; lake patrol reserve officers); District Fisheries Biologists (ecological impacts)
- *Financial:* Landowners; IDNR Division of Law Enforcement (potential, depending on state policies, priorities and funding availability).

Cost: Strategy 9.1(a,b) – Moderate cost ($10,000-30,000 for boating impact studies).
Strategy 9.2(c,d) - Minimal cost.

Goal 10. Highway development: Minimize any negative impacts of highway development on the watershed.

Strategy 10.1 Examine the impacts of modifying the Highway 31 bypass on watershed size, hydrology, and infiltration.

Strategy 10.2 Identify opportunities for wetland mitigation associated with road development.

Actions

a. Request notification of Indiana Department of Transportation (InDOT) actions related to Highway 31 development near Lake of the Woods.
b. Ask InDOT to include a study to determine watercraft impacts on safety and lake ecology, including an examination of impacts on watershed size, hydrology, and infiltration.
c. If indicated, recommend that InDOT review sites within the Lake of the Woods

watershed for potential purchase and enhancement as wetland mitigation sites.

d. Hold public hearings and follow the legal process.

Resources

- *Technical:* Indiana Department of Transportation (public hearings, permits, mitigation); District Fisheries Biologists (permit review; ecological impacts).
- *Financial:* Landowners; InDOT (potential, depending on state policies, priorities and funding availability).

Cost: Strategy 10.1, 10.2 - Minimal cost (incurred by InDOT).

Goal 11 Law enforcement: Ensure effective enforcement of existing laws to promote safe recreation and minimize impacts on water quality and quality of life.

Strategy 11.1 Ensure effective enforcement of boating regulations. *See Goal 9 for other water-related law enforcement actions.*

Actions

a. Conduct educational campaigns among residents and nonresident recreational boaters.
b. Increase law enforcement patrols at peak hours of high-speed use or violations.
c. Purchase, position and maintain buoys around the lake within 200 feet of the legal shoreline.

Strategy 11.2 Increase compliance with trespassing and property rights laws.

Actions

a. Conduct educational campaigns among residents regarding:
    i. private property rights in rural areas; and
    ii. local codes on trespassing, off road vehicle use, dumping, and burning.
b. Increase reporting and law enforcement patrols in areas subject to violations.

Resources

- *Technical:* County Sheriff; IDNR Division of Law Enforcement; District Fisheries Biologists (ecological impacts)
- *Financial:* Landowners; local law enforcement; IDNR Division of Law Enforcement (potential, depending on state policies, priorities and funding availability).

Cost: Strategy 11.1(a) – Moderate cost ($0-30,000 for educational campaign development and materials)
Strategy 11.1(b) – Moderate cost (depending on use of reserve law enforcement services)
Strategy 11.1(c) – Moderate cost (depending on purchase, placement and maintenance of buoys).
Strategy 11.2(a) – Moderate cost ($0-30,000 for educational campaign development and materials).
Strategy 11.2(b) - Minimal cost.

Goal 12. Native fisheries resources: Maintain and improve native fisheries resources.

Strategy 12.1 Emphasize fisheries management for native species.

Actions

a. Determine the ecological and fiscal impacts of walleye stocking.
b. Reduce or eliminate invasive species such as white bass and carp.

Strategy 12.2 Prevent illegal stocking of nonnative fish.

Actions

a. Conduct an educational campaign on invasive species regulations, prevention and control among residents and recreational users.

Resources

- *Technical:* IDNR Division of Law Enforcement (boater education); IDNR District Fisheries Biologists (fisheries management; ecological impacts; aquatic nuisance species information); IDNR Lake and River Enhancement (ANS information, grant review); Illinois-Indiana Sea Grant; Great Lakes Commission; national *Stop Aquatic Hitchhikers!* campaign at www.protectyourwaters.net. (ANS information).
- *Financial:* IDNR Division of Fish & Wildlife (fisheries management); IDNR invasive species control grants from LARE program (depending on policies and funding availability).

Cost: Strategy 11.1(a) – Moderate to high cost (use of state funds for fisheries management in public waters; local cost-share not required)
Strategy 11.1(b) – Moderate cost ($0-30,000 for educational campaign development and materials)

9.0 Estimated improvement in water quality

Ecological systems are complex. Land use is constantly changing. Therefore, predictions of water quality impacts can be used to prioritize actions and identify cost-effective solutions. They should not be used as exact representations of future conditions.

The 1982 Diagnostic Study outlined two methods for estimating the impact of phosphorus reduction on lake water quality. The Chlorphyll-a concentration may be related to total phosphorus in the following manner (Jones and Bachmann, 1976):

$$\log \text{Chl. A} = -1.09 + 1.46(\log \text{TP})$$

where chlorophyll-a and total phosphorus concentrations are given in ug /liter.

Likewise, water clarity may improve with reductions in total phosphorus in the following relationship (Carlson, 1977):

$$\ln \text{Secchi depth} = 3.876 - 0.98\ (\ln \text{TP})\ \textit{or}\ \text{Secchi depth} = 48\ (1 / \text{TP})$$

where Secchi depth is given in meters and total phosphorus concentration in ug/liter.

The authors predicted that reductions in phosphorus loading resulting from elimination of septic systems could result in an average Secchi depth of 0.84 m (2.76 ft), a slight improvement over the water quality value taken in 1981. In comparison, elimination of phosphorus resuspension from the lakebed would result in Secchi depth of 1.26 m (4.13 ft), or a significant improvement.

The 1982 Diagnostic Study provided a set of proposed management strategies for Lake of the Woods for consideration by outlining the goals, timing, cost and indicators of effectiveness (Table 10). This table has been expanded to include proposals from the 1991 Feasibility study and strategies that have been contemplated more recently.

Table 10. Proposed management strategies for Lake of the Woods and predicted impact on water quality (Adapted from Senft and Roberts, 1982).

Strategy	Nature	Cost	Effectiveness
Chemical	Short	$40,000-$50,000	75-100% invasive plant control by 2008
Lake management workshops	Short-intermediate	Variable	Unknown
Sewage diversion	Long	$5 million	Sewage diversion was completed in early 1990s; - at 100% septic seepage elimination, predicted to result in a Secchi depth of 2.8 ft (at 2.4 ft in 1981; water clarity has been 2.6-2.8 ft since 2002)
Development restrictions	Long	Unknown	Unknown; at 10-15% impervious surface, water quality begins to lose integrity.
Hydraulic modification	Long	$50,000-$90,000 for impact study; unknown for design and construction	Estimate 5% removal for Kuntz and Bohmer ditches and 12% phosphorus removal for Kuntz, Bohmer and Seltenright ditches. - prediction not calculated at less than 50% removal.
Grassed waterways and buffer zones	Long	Unknown	Estimate 25-75% phosphorus removal. - at 50% stream flow load reduction, Secchi depth predicted at 3.5 ft (in combination with septic system elimination)
No till agriculture	Long	Unknown	Estimate 80-90% reduction in stream phosphorus concentration. - at 100% stream flow load reduction, Secchi depth predicted at 4.5 ft (in combination with septic system elimination)
Wetlands	Long	Unknown	Estimate up to 95% reduction in stream phosphorus concentration; - at 100% stream flow load reduction, Secchi depth predicted at 4.5 ft (in combination with septic system elimination)
Alum treatment and/or reduction in boat traffic over shallow areas, use of stone and bioengineered shorelines and other techniques to sediment resuspension	Intermediate	High	Estimate 50-80% inlake phosphorus reduction. - at 50% sediment source reduction, Secchi depth predicted at 3.1 ft; - at 100% sediment source reduction, Secchi depth at 4.1ft; - at 100% sediment source reduction, Secchi depth predicted at 22.5 ft (in combination with septic system elimination and stream flow load reduction),

10.0 Action Plan and timeline for implementation

The initial Action Plan provides a calendar for implementation of the soil and water conservation practices recommended in this Watershed Management Plan over the next four years (2005-2009). These timelines will be used as general guidelines, but are subject to change depending on land and water management conditions and availability of resources. The Action Plan is presented in Table 11.

Table 11. Action Plan (2005-2009) for the Lake of the Woods Watershed Management Plan. (TBD = to be determined later, based on the schedule for highway development)

Year	Goal	Strategy	Activity
Annual	Long term planning	4.1	Review Watershed Management Plan and update short-term Action Plan.
TBD	Highway development	10.1	Examine the impacts of modifying the Highway 31 bypass.
	Highway development	10.2	If indicated, identify potential mitigation sites for the Highway 31 bypass.
2005	Long term planning	4.1	Establish a representative committee to implement the Action Plan.
	Erosion & sediment control	1.1 & 1.2(a)	Identify lakefront and agricultural property owners using conservation practices.
	Hydrology and drainage	2.1	Obtain funding for the impact and engineering feasibility study.
	Channel maintenance	5.2	Install aerators in channels, as needed.
	Channel maintenance	5.2	Maintain trees along one side of stream banks where feasible.
	Construction practices	6.1	*See Goal 1 Erosion & sediment control.*
	Education on stewardship	7.1	Select workshop topics, identify speakers, seek funding as needed.
	Invasive species	8.1	Plant survey, whole lake herbicide, survey, and plan update.
2006	Erosion & sediment control	1.1 & 1.2	Facilitate interaction between individuals.
	Erosion & sediment control	1.1 & 1.2	Identify technical and financial resources.
	Erosion & sediment control	1.2(b)	Dredge sediment from inlet streams.
	Channel maintenance	5.2	Design and construct structures to increase stream flow rates and mixing.
	Hydrology and drainage	2.1	Conduct a study examining the ecological and economic impacts of hydrology.
	Education on stewardship	7.1	Conduct workshops and evaluate results
	Law enforcement	11.1 & 11.2	Conduct outreach campaigns on boating and trespass laws.
2007	Erosion & sediment	1.1 & 1.2	Conduct field days or other workshops.

	control		
	Hydrology and drainage	2.1	Complete design and construction for stream rerouting, if recommended.
	Invasive species	8.1	Herbicide to regrowth areas, spot treatment.
	Watercraft safety	9.1	Conduct a study to determine watercraft impacts on safety and ecology.
2008	Nutrient loading	3.1	Obtain funding for an engineering feasibility study for wetlands.
	Channel maintenance	5.1	Identify channel areas for dredging and acquire cost estimates.
	Invasive species	8.1	Pretreatment survey, herbicide to regrowth areas, spot treatment.
	Invasive species	8.2	Conduct a bacterial DNA study to determine sources of coliforms.
	Watercraft safety	9.1	Petition the DNR to establish ecological zones with reduced boat speed.
2009	Nutrient loading	3.1	Conduct an engineering feasibility study to enhance filtration wetlands.
	Channel maintenance	5.1	Dredging channels, obtain permits, hire contractor.
	Invasive species	8.2	If warranted, plan for control of nuisance wildlife, including seagulls.
	Watercraft safety	9.1	Conduct public hearings to establish ecological zones.

11.0 Measuring progress

Implementation of soil and water conservation practices comes at a cost. It will be important to evaluate these activities and their effectiveness in improving the water quality in Lake of the Woods and its watershed.

11.1 Progress Indicators

The Lake of the Woods community has demonstrated a long-term consistent interest in monitoring the trends in water quality. Direct and indirect effects of improving water quality on recreational use and aesthetic value of the lake can be measured by monitoring the following factors:

- Chemical, physical, and biological conditions in the lake and tributaries.
- Growth of aquatic weeds.

In addition to monitoring water quality, other indicators may be used to measure success in implementing soil and water conservation practices. These may include:

- Awareness and adoption of conservation practices by landowners.
- Community collaboration and stakeholder participation rates.
- Human population and recreational use.
- Economic impacts such as property values and agricultural productivity.

All monitoring efforts must take into take into consideration:

- Use of professional and state guidelines in collecting and interpreting data.
- Use of protocols and sampling sites that are as similar as possible to prior data collection to facilitate the detection of long-term trends.
- Comparison to similar lakes in the region through professional and volunteer involvement in state monitoring programs, as appropriate.

Indicators of water quality improvement can include measurement to determine long-term large-scale trends in water quality and use. Specific monitoring regimes would also be designed in association with implementation of particular conservation goals and actions. For example, IDNR Watershed Land Treatment projects, which are funded through the LARE program, have a required component for measuring water quality before and after implementation.

11.2 Monitoring Strategy

The 1991 study recommended design of a monitoring program to measure the impacts of implementing the best management practices, chemical treatment or biological control projects. Analytical methodologies, quality control/quality assurance requirements and estimates of laboratory costs were included in that study.

The IDEM Clean Lakes Program contracts with Indiana University School of Public and Environmental Affairs to conduct lake water quality sampling on northern Indiana lakes,

including Lake of the Woods. Because more than 1,200 natural lakes and reservoirs are located in Indiana, most lakes are only tested on a 5-year rotation. The Clean Lakes Program at IDEM (and formerly the State Department of Health) in coordination with Indiana University will continue to periodically test water quality in Lake of the Woods, as it has since 1975.

In between these sample periods, volunteer lake monitors will continue to participate in the Clean Lakes Volunteer Monitoring program by checking water clarity (Secchi depths) and taking samples to be tested for chlorophyll-a (algae) and nutrients.

Progress: Water quality at Lake of the Woods and its tributaries will continue to be monitored through several ongoing programs.

- The most recent data for Lake of the Woods was collected by the Indiana Clean Lakes Program in 2004 and will likely be examined again in 2009, given the standard five-year rotation for lake sampling.
- Volunteer lake monitoring data was available from 2003 and will continue to be taken yearly, as long as volunteers are available and the program continues to have funding.
- Streams have been monitored through participation in the state volunteer Riverwatch program and will continue to be taken yearly, as long as volunteers are available and the program continues to have funding.
- Other types of sampling, such as testing of *E. coli* at beaches or in other public waters, are available periodically through county and state agencies.
- Water quality is not tested regularly by professional monitoring at the lake or in its tributaries between the sampling events described above.

Online resources:
Indiana Volunteer Lake Monitoring program
http://www.spea.indiana.edu/clp/Volunter%20Monitoring.htm

Hoosier Riverwatch
http://www.in.gov/dnr/soilcons/riverwatch/

12.0 Plan Evaluation

Watershed management plans are not intended to be static documents. They must be incorporated into the community development process as a tool for science-based decision-making. Therefore, impacts of plan implementation must be periodically evaluated and updated to accommodate changing expectations for land and water use.

12.1 Responsibility for evaluation

A steering committee with the specific responsibility of implementing, evaluating and updating this plan will be established with adequate representation across the range of interests affected by soil and water conservation. Adequate representation was identified as a significant issue for planning processes at Lake of the Woods and among watershed residents. Representative of the

following entities may be particularly useful contribution to the steering committee:

- Lake of the Woods Property Owners Association
- Bremen Conservation Club
- Marshall County Soil & Water Conservation District
- Kankakee River Basin Commission
- Purdue Extension Service
- Marshall County Drainage Board and Surveyors Office
- Marshall County Commissioners
- Marshall County Health Office
- State Legislators
- Indiana Department of Natural Resources
- Indiana Department of Environmental Management
- Agricultural producers
- Golf course managers
- Campground and retreat center managers
- Water-based recreation
- Recreational users who do not live on the lake and use the public access site.
- Tournament anglers (e.g., walleye, bass)
- Watershed residents who do not belong to the POA.
- Nonconsumptive users who do not boat, but enjoy the nature and tranquility of the lake.
- Any others, as indicated by interest.

A core planning team of 12-15 people can operate effectively if a broad range of interests is represented and power is equal and mutually shared. Additional work groups can be organized to address particular topics, such as agriculture, lake recreation, or commercial uses. Use of electronic media to allow access to meeting notes and planning documents can provide the rest of the community with an opportunity to identify issues in which they would like to become involved.

By maintaining an open, orderly and cooperative process, implementation of this plan will become an effective means of sustaining the resources upon which the future of community growth and development depends.

12.2 Timeline for evaluation and adaptation

This document will be reviewed annually in order to track progress and create annual work plans, based on actions identified in the *Watershed Management Plan*. These reviews must be coordinated with:

- Funding cycles for state grants (e.g., pre-proposals are due to the IDNR LARE program by January 31).
- Planning processes of major community organizations.
- Planning processes for local government entities, especially county government.

Results of this annual evaluation and update will be presented to stakeholders in the community in SWCD board meetings, newsletters, direct mailing, articles in the local press, and/or at other local events.

12.3 Contact Information

Questions regarding the intent or content of this plan may be directed to:

- Kankakee River Basin Commission, 219-763-0696.
- IDNR Lake and River Enhancement Program, 317-232-3870.
- D.J. Case & Associates, 574-258-0100, www.djcase.com.

12.4 Distribution list

Hard copies and electronic versions of this watershed management plan are available through the IDNR Lake and River Enhancement program and will have been provided to the following:

- Kankakee River Basin Commission
- Marshall County Soil and Water Conservation District
- Lake of the Woods Property Owners Association

13.0 References and additional resources

Carlson, R.E. and J. Simpson. 1996. A Coordinator's Guide to Volunteer Lake Monitoring Methods. North American Lake Management Society. 96 pp. http://dipin.kent.edu/tsi.htm

Grove, I.C. 2002. An Appraisal Report: Change of Established Level of Lake of the Woods. Cause No.: 50C01-9909-CP-114. Prepared for Lake of the Woods Property Owners Association. Elkhart, Indiana.

Haack, Sheridan K., Lisa A. Reynolds, Mark J. Wolcott, and Richard L. Whitman. 2001. DNA fingerprinting to determine the influence of seagulls on *Escherichia coli* populations at the 63rd Street Beach, Chicago, IL. Great Lakes Beach Conference, Chicago, IL, Feb 5-8, 2001. RTS# MI-0106 http://wwwdmilns.er.usgs.gov/reports/RTSMI-0106.html

Indiana Department of Environmental Management (IDEM). 2004. Lake Water Quality Assessment. Fact Sheet. IDEM's Surface Water Quality Assessment Program, Assessment Branch, Office of Water Quality.

Natural Resources Conservation Service. 1992-2000. Marshall County, Indiana, May 2003: Soil Survey Geographic Database. ESRI.

Whitman, R.L., and M.B. Nevers. 2003. Foreshore sand as a source of *Escherichia coli* in nearshore water of a Lake Michigan beach. Applied and Environmental Microbiology 69(9):5555-5562. www.sourcemolecular.com/whitman2.pdf

Appendix I. Project Reviewers

Review comments were received from the following individuals throughout various stages of the watershed management plan development. We are grateful to these participants for their constructive engagement in the process.

The following agency technical staff provided assistance to the project:

Larry Fisher, Marshall County Surveyor
Beth Forsness, IDNR Division of Soil Conservation
Jody Melton, Kankakee River Basin Commission
Carol Newhouse, IDEM Lake Water Quality Assessment Program
Eric Oliver, IDEM Watershed Management Section
Sam Purvis, IDNR Division of Law Enforcement
Jim Ray, IDNR Division of Soil Conservation
Cecil Rich, IDNR Division of Soil Conservation

The following 86 individuals attended a public meeting and/or submitted written or verbal review comments (transcribed from sign-in sheets; in alphabetical order):

Harold & Bonnie Bagley
Richard R. Bean
Deitrick Behrens
Tim & Joan Bemish
Greg Bollenbacher
Kenneth Boren
Joan Boren
Jack Borsodi
John Bretz
JoAnn Chrzan
Travis Coles
Frank Collins
Ryan Colvin
Lou Earles
Rick Farrell
L. Filewics
Jim & Shirley Gallagher
John & Sharon Galminas
John Glingle
Randy Glingle
Sherry Gorden
Lance Gould
Cliff Graybill
Gordon Guntner
Lin Hall
Terry Hall
Martha & Noble Hand
Jeannine Hartman
Jim Hartman
Al & Estelle Hatkevich
Virgil Hess
Kevin Hines
Kim Hochstetler
Charlie Houin
Diane Houin
Marvin Houin
Richard Hundt
Bob Ivanov
John Karris
Brian Kaser
Rick Keller
Eric Kessler
Rick Keyser
Lon Kipfer
Rita Kopala
Marc Laudeman
Don Lynch
Terri Mendlik
Lowell Michaels
Tim Nelson
Jon & Joan Oswald
Seth Owens
Tom Power
Calvin Ralston
Sandy Read
John Rhodes
Mary Rhodes
Vicky Rupert
Tom Rzepka
Barb Rzepka
Dave Schrock
Homer Seltenright
Mike Siefer
Carol Skelton
Joe Skelton
Dan and Charlotte Smith
Betty Spruit
Bob Spruit
Bill Tegeler
Joe Toth
Maxine Tyson
Chris Van Laere
James Van Laere
Tim Ward
Ernie Yockey
Barb Yocum
Joe Yocum
Bob Yoder

Along with other stakeholders who reviewed documents or visited the project website.

Appendix II. Financial and Technical Resources

Program	Agency	Phone	Website
LARE Watershed Land Treatment	IDNR	317-233-3870	http://www.in.gov/dnr/soilcons/
LARE Design & Construction Funds	IDNR	317-233-3870	http://www.in.gov/dnr/soilcons/
LARE Aquatic Plant Control Funds	IDNR	317-233-3870	http://www.in.gov/dnr/soilcons/
Resource Specialist	Dept of Ag	574-223-3220	http://www.in.gov/dnr/soilcons/
Section 319	IDEM	317-232-0019	http://www.in.gov/idem/water/planbr/
Section 205(j)	IDEM	317-232-0019	http://www.in.gov/idem/water/planbr/
Section 104(b)(3)	IDEM	317-232-0019	http://www.in.gov/idem/water/planbr/
EQIP	NRCS	317-290-3200	http://www.in.nrcs.usda.gov/
CRP	NRCS	317-290-3200	http://www.in.nrcs.usda.gov/
CSP Conservation Security Program	NRCS	317-290-3200	http://www.in.nrcs.usda.gov/
State Revolving Loan Fund (SRF)	IDEM	317-232-8655	http://www.state.in.us/idem/srf/
Marshall County SWCD	MC	574-936-2024	http://marshallcountyswcd.iaswcd.org/
Marshall County Surveyor's Office	MC	574-935-8530	http://www.co.marshall.in.us/
Marshall County Health Department	MC	574-935-8565	http://www.co.marshall.in.us/
Marshall County Planning Commission	MC	574-935-8540	http://www.co.marshall.in.us/

Appendix III. Acronyms

IDEM: Indiana Department of Environmental Management
IDNR: Indiana Department of Natural Resources
ISDH: Indiana State Department of Health
KRBC: Kankakee River Basin Commission
MC: Marshall County
NRCS: Natural Resources Conservation Service
POA: Property Owners Association (at Lake of the Woods)
SWCD: Soil and Water Conservation District
WMP: Watershed Management Plan