VFC Index - Watershed (Plan)

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FOREWARD

This Final Draft of the Watershed Management Plan for the Upper Tippecanoe River Basin was released for agency submission, July 31, 2006.

Please submit technical comments, changes, suggestions and recommendations regarding the content of this document, in writing, to the contact listed below.

Tippecanoe Environmental Lake & Watershed Foundation
Holly LaSalle, Watershed Coordinator
P.O. Box 55
North Webster, IN 46555
Phone: 574-834-3242
Fax: 574-834-3929
Email: telwf@kconline.com

The First Draft of this Watershed Management Plan for was released for stakeholder comment and review from May 15, 2002 through August 15, 2002. Comments from stakeholders including agency staff resulted in the second updated Draft version dated January, 2006. The January Second Draft resulted in additional comments from the Indiana Department of Environmental Management (IDEM) that lead to this current and Final Plan.

ACKNOWLEDGEMENTS

The original Watershed Management Plan was drafted with funding from the Build Indiana Fund and Tippecanoe Environmental Lake and Watershed Foundation (TELWF). The team of J.F. New and Associates, Inc. and TELWF documented the historical information available, completed lake and tributary stream analysis nutrient and sediment loading, and modeled nutrient export to the lakes. Authors of the original draft report (including much of what remains in this current version) were Lynn Stevens at TELWF and Marianne Giolitto, Sara Peel, John Richardson, Cornelia Sawatzky, and Steve Zimmerman at J. F. New and Associates, Inc. Brian Majka of J.F. New and Associates, Inc. provided GIS maps of the study area. Updates to the Plan to meet the 2003 checklist were accomplished via the collaborative efforts of Holly LaSalle and Jan McGee at TELWF, Greg Bright and Melody Myers-Kinzie at Commonwealth Biomonitoring, Inc. Kathleen Hagan at IDEM, and primary authorship and organization by Jill Hoffmann of Williams Creek Consulting, Inc. Special thanks goes to all of the lake associations, volunteers, and public officials throughout the watershed who contributed to the information found in this report, as well as those who participated in public outreach activities and input sessions. It is our desire that these individuals adopt and update this plan annually to keep it relevant and current.

PLAN ADMINISTRATION

Everyone involved with the development of this Upper Tippecanoe Watershed Management Plan agrees that in order for this plan to be most effective, the watershed goals, strategies, and actions need to be driven by the local people taking local actions throughout the watershed.

This watershed management plan is intended to provide a starting point to improve the water quality and find accountable ways to measure its improvement. Hence, this document will require revisions and amendments as new information becomes available. The future revisions and amendments will occur over a long-term basis with key updates delivered to primary stakeholders at the annual Board meetings.

For more information regarding this document please contact Holly LaSalle at the Tippecanoe Environmental Lake & Watershed Foundation office:

Mailing Address: P.O. Box 55
Street Address: 405 South Main Street
North Webster, IN 46555
Phone: 574-834-3242
Fax: 574-834-3929
Email: telwf@kconline.com

The Tippecanoe Environmental Lake & Watershed Foundation Office, in cooperation with many other organizations, has agreed to maintain and monitor this watershed management plan until funding is secured to retain a part/full time watershed coordinator for the area.

WATERSHED MANAGEMENT PLAN DISTRIBUTION LIST

- Lake association board presidents
- Farm Bureau representative
- Soil and Water Conservation District representatives
- The Nature Conservancy representative
- Legislators
- Planning Commission representatives
- Drainage Board representatives
- County Commissioners from Kosciusko, Whitley and Noble Counties
- Natural Resources Conservation Service representatives
- TELWF's Board of Directors
- IDEM Watershed Management Section representative
- IDNR Division of Nature Preserves representatives
- IDNR Division of Fish and Wildlife representatives (Fisheries and LARE staff)
- County Health Department representatives
- ACRES representatives
- Edmund F. Ball Nature Preserve representatives

TABLE OF ACRONYMS

BOD	Biochemical oxygen demand
BMP	Best Management Practice
C	Celcius
cfs	cubic feet per second
CLP	Clean Lakes Program
C-BOD	Carbonaceous biochemical oxygen demand
COD	Chemical oxygen demand
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
F	Fahrenheit
ha	Hectares
HEL	Highly Erodible Land
HUA	Hydrologic Unit Area
HUC	Hydologic Unit Code
IAC	Indiana Administrative Code
IDEM	Indiana Department of Environmental Management
ITSI	Indiana Trophic State Index
kg/d	kilograms per day
m	meters
mg/l or mg/L	Milligrams per liter
μg/l	micrograms per liter
MWH	Modified warmwater habitat
New	J.F. New and Associates
NH_4^+-N	Ammonia-nitrogen
NO_3^--N	Nitrate-nitrogen
NRCS	Natural Resources Conservation Service
ppb	parts per billion
ppm	parts per million
SRP	Soluble Reactive Phosphorus
SWCD	Soil and Water Conservation District
TELWF	Tippecanoe Environmental Lake and Watershed Foundation
TKN	Total Kjeldahl nitrogen
TP	Total phosphorus
TSI	Trophic State Index
TSS	Total Suspended Solids
WMP	Watershed Management Plan
WWH	Warmwater habitat

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EXECUTIVE SUMMARY OF RECENT DEVEOPMENTS

In 2002 the Tippecanoe Environmental Lake and Watershed Foundation (TELWF) along with JF New & Associates worked to complete a draft Watershed Management Plan (WMP) for the Upper Tippecanoe River watershed. The WMP plan was funded by the Indiana Department of Environmental Management's (IDEM) 319 Program. Upon completion of the draft WMP IDEM's requirements for such a plan expanded. In effort to meet the new expanded checklist (2003), TELWF hired a watershed coordinator to facilitate and document on-going activities in the watershed and supply updated information to relevant chapters as required by the checklist. Sections of this final WMP were drafted with the assistance of staff at Williams Creek Consulting, Inc. and Commonwealth Biomonitoring, Inc.

This summary chapter serves as a synopsis of recent developments including:

- Public Participation Events and Outreach Activities,
- Revised Goals (based on current land use and water quality concerns as supported by the public participation process),
- Prioritization of Subwatersheds,
- Summary of Recent Best Management Practice (BMP) Project Initiatives and Coordination, and
- Projects for Future Implementation (based on updated data and new or previously stated goals)

Chapters or sections in the original draft document that were added or supplemented with current data include:

- Section 4.0 – Public Involvement
- Section 5.0, Sub-sections B.1 and B.2 – Sub-watershed Water Quality for Smalley and Ridinger/Robinson
- Section 5.0, C – 2005 Water Quality/Biological Assessment (within 11-digit HUC)
- Section 5.0, Sub-sections F.1 and F.2– Storm Drains Studies
- Section 6.0 – Goals and Objectives

E.1 Public Participation Events and Outreach Activities

Documentation of additional public meetings, resident surveys, and associated details were added to the public involvement section, Section 4.0 and Appendix F. The watershed coordinator continued to meet regularly with various local officials, special interest groups, and state personnel to further satisfy the requirements of IDEM's 2003 checklist. In addition, three educational events were hosted by TELWF to solicit public comment on the draft plan and to keep watershed stakeholders up to date with on-going projects or new developments/data. The most recent event also focused on improving participants' technical knowledge of water quality and biological communities within the watershed.

Workshop 1

The first watershed wide workshop was held in April of 2005. It was held in cooperation with the Kosciusko County SWCD. Mr. Dennis Shively (previous watershed coordinator) lead much of the presentation. The educational focus included watershed definition and delineation, the water cycle, and water paths across the landscape. This workshop also included a public involvement and input session.

Workshop 2

The second watershed wide workshop was held on January 14th, 2006. It focused on basic water quality understanding, as well as an increased awareness of the biological "treasures" found within the watershed. Participants engaged in hands-on activities such as water testing, nutrient cycling worksheets, freshwater fish and mussel identification (including rare or endangered species - otherwise known as “treasures.”), and habitat evaluations. The goals of the WMP were also reviewed with participants at this workshop and refinements were made as necessary to keep up with recent concerns. Individual participants were given the opportunity to rank the goals via a weighted number system. Comment cards with a return address were distributed to ensure that those participants uncomfortable vocalizing their concerns in a public forum had an alternative venue to provide input (Appendix F).

Taste of the Lakes Event

This public event was held as a fundraiser and education venue for watershed stakeholders on September 18th, 2005. Ten area businesses participated by catering various foods and drinks for approximately 150 participants. A table top display board with pictures and text describing TELWF, what they do, and their initiatives related to yard waste and fertilizer reduction were on display. One of TELWF’s educational videos was on continuous loop and brochures detailing what landowners can do as individuals to protect their lakes and streams were available. These brochures included topics such as septic maintenance, purple loosestrife & Eurasian watermilfoil alerts, phosphorus and yard care, and shoreline management. TELWF also gave a brief presentation on its organization and activities.

Community Leadership Activities

One of the strategies acknowledged in the WMP was to enroll more local citizens in volunteer monitoring efforts and to assist newly developing lake associations with their activities or organization. To this end, TELWF and its coordinator are working with six new volunteer monitors, as well as leading the formation of a new coalition of lake associations known as the Upper Tippecanoe River Lake Association (UTRLA). TELWF regularly attends the UTRLA meetings serving as the facilitator for their combined activities. This collaboration has lead TELWF and UTRLA to jointly seeking LARE funding in 2006 to fill in the missing water quality pieces associated with the Goose/Loon Lake subwatershed and the Crooked/Big Lake subwatershed as identified in the draft WMP. The grant also hopes to identify more current implementation projects in these subwatersheds since many of the recommendations detailed in this Plan are somewhat dated. A recent survey of members of UTRLA found that they shared similar concerns and goals already outlined in this WMP. UTRLA members have already committed to doing what is necessary to implement water quality improvements in their respective watersheds.

Lakes already involved in volunteer monitoring include:

Big Lake
Crooked Lake
Loon Lake
Goose Lake
Little Crooked Lake
Big Barbee
James Lake (Little Tippy)
Kuhn Lake
Oswego Lake
Ridinger Lake
Tippecanoe Lake
Webster Lake

Lakes newly involved in volunteer monitoring due to TELWF's outreach efforts include:

- New Lake
- Old Lake
- Little Barbee
- Sawmill
- Seachrist
- Irish

Newsletters

TELWF has distributed 14 versions of the News Splash Newsletter. The newsletter helps keep stakeholders aware of all watershed activities, as well as serves as an educational venue. Lake, watershed, or water quality topics are regularly featured in the newsletter. Copies of the newsletters can be found in Appendix F. This newsletter also welcomes public comment and provides contact information for the public to voice their concerns or volunteer to help with various activities.

Stakeholder Surveys

TELWF conducted a survey of over 8,000 lake resident households throughout Kosciusko County to help clarify local priorities and ensure all possible concerns were being addressed by the WMP efforts. This survey effort, in particular, resulted in the addition of a new goal for the WMP that focuses on development issues such as zoning and "funneling" that are affecting the lakes and overall water quality in the watershed. Funnel-type development occurs when a relatively small lakefront lot is used to provide lake access to a larger development located some distance away from the lake. Funneling allows a large number of individuals to gain access to a lake through a small corridor of property. Unregulated funnel-type development has the potential to create a number of problems including land use conflicts, unsafe and inadequate lake access, increased noise, lake and shoreland congestion, lake multi-use conflicts, ecological degradation, and diminished property values. This concern is growing rapidly around many watersheds in the natural lakes region of northern Indiana. In fact, the issue is currently being discussed/debated by the State's Lakes Management Work Group (LMWG) at the request of several state legislators. TELWF plans to stay involved in the activities of the LMWG to help address this growing concern.

E.2 Revised Goals / Strategic Planning

Such current and historic public input and review of recently acquired water quality data lead to the development of goals and implementation strategies. This evolution of thought is summarized in Table E1. Since the publication of the draft many of the original concerns and associated goals remained constant from the draft WMP; however, changing land use in the watersheds has raised the additional concern, discussed above, related to general development pressures, zoning, and "funneling." The goals listed in Table E1 are not in order of priority, but rather in the order they were developed as part of the original draft WMP.

A recent pole of workshop participants helped solidify the overall prioritization of the identified goals. The primary concern expressed by stakeholders at this workshop, as well as other various venues over the past two years, was declining water quality due to nutrient enrichment and bacterial pollution.

In summary, the priority goals based on current public input are as follows:

1.) Reduce total phosphorus, nitrogen, *E. coli, and sediment* loads in the Upper Tippecanoe River Watershed 20% by 2010.

2.) Fund watershed improvement projects.
3.) Address development issues such as zoning and "funneling."
4.) Document existing mIBI, IBI, water quality, and habitat in each subwatershed in order to set reasonable targets to improve biological integrity.
5.) Decrease the abundance and spread of exotic aquatic species.
6.) Implement plan for testing phosphorus and nitrogen in soils adjacent to tributaries and streams.
7.) Hire/Retain a Watershed Coordinator for the Upper Tippecanoe Watershed.
8.) Foster communication among all watershed stakeholders.

Board Meetings

Annual Advisory Board meetings were held to discuss recent changes, concerns, or new data in effort to plan for long-range implementation projects associated with the outlined goals. Currently, the Advisory Board is synonymous with the TELWF Board of Directors. Discussions about the WMP at annual Board meetings included members of the public that were present at each of these meetings. The WMP was the sole focus of the 2004 annual meeting. Notes from the 2003 planning session and 2004 Board Meeting are included in Appendix F. The following topic areas were identified and prioritized by the Board in 2004 as essential elements needed to meet the identified goals in the WMP.

Areas of proposed activity	**Priority ranking**
Education	7
Public relations	7
Funding sources	6
Publicize current and completed projects	5
Legal issues (including zoning)	4
Local government relationships	3
Representation in TELWF (geographical areas)	1
ID undeveloped property at risk for development	1
Drainage tiles through the watershed	0

Subsequent monthly meetings of the Board were use to check on the progress of various elements of the WMP's development, individual project progress, and upcoming stakeholder outreach activities. The coordinator regularly briefed the Board on current happenings and/or local initiatives at these meetings.

Certain members of the Board became actively involved in exploring the one of the public's largest concerns, and newly added WMP goal, related to zoning and development. As a result, TELWF has taken proactive steps to partner with various other lake and watershed groups to begin building a strong relationship with county planners in Kosicusko County. TELWF and other supporting groups hope to reduce the negative impacts that rapid, high density housing projects are having on the lakes and streams in the Upper Tippecanoe River Watershed. See Appendix F for a recently circulated brochure generated by TELWF to explain and foster support for the creation of a new "lake district" zoning category. This initiative is still under review at the county.

In general, the Board serves to help talk through the 'who,' 'what,' and 'how' so to speak of the outlined WMP goals. TELWF remains cognizant that their organizational goals are lockstep with those outlined in this WMP. The Board will continue its outreach activities to insure that all recent concerns are addressed and wrapped into the watershed management planning process.

Table E1 Goals and Strategies

Goal #	Goal	Public Concerns	Alternatives Considered	Selected Strategies	Indicator(s)
1	Reduce total phosphorus, nitrogen, *E. coli, and sediment* loads in the Upper Tippecanoe River Watershed 20% by 2010.	Increased weed growth Increased algae growth Lack of septic maintenance Lack of adequate sewage disposal and septic alternatives Increased number of ducks and geese Lack of cleaning/maintenance on existing storm drains, stormwater management Increased stream bank erosion Increased Nutrient loading Lack of scheduled street cleaning Increased number of channels filling in with organics loss of flood conservation areas Livestock productions; manure management septic capacity to handle increased residential growth yard care/fertilizer alternatives Increased E. coli contamination of lakes and streams Increased counts/violations at NPDES dischargers Increased sedimentation (Silt & Muck) Increased filling of wetlands Increased number of channels filling in with organics Lack of erosion control enforcement on new home construction Need for increased maintenance on legal drains without clearing the banks of all trees	Legislative rules Educate stakeholders Implement programs and projects	A. Promote the use of phosphorus free fertilizer/reduced fertilizer use. B. Implement 5-year watershed protection plan C. Assist in implement of filter strips/grassed waterways on 20,000 feet of waterways each year D. Restore 50 acres of wetlands over the next five years. E. Install sanitary sewer system throughout watershed by 2020. F. Assist in implement nutrient management plan on a significant acreage of planted agriculture land in all counties. G. Assist in implementation of conservation tillage on a significant acreage of planted acreage and 80% of all HEL acreage. H. Assist dairy/beef farms with implementing manure management plans. I. Promote compliance with Rule 5 plans in the watershed.	
2	Document existing mIBI, IBI, water quality, and habitat in each subwatershed in order to set reasonable targets to improve biological integrity.	Decrease in fish counts Loss of fish, wildlife, woodland habitat Fluctuation of water levels for fish and wildlife Increased seawall development	Review existing biological surveys Conduct surveys	A. Document biotic community B. Identify specific threats to local populations including riparian habitat conditions and riparian priority areas. C. Sample sub-basin water quality.	

3	Implement plan for testing phosphorus and nitrogen in soils adjacent to tributaries and streams.	Need to identify potential lands for acquisition or for enrollment in conservation programs	Obtain and use grant monies to hire a soil science consultant to conduct soil testing. Obtain and use grant monies to hire/fund university research on soil testing. Utilize NRCS expertise.	A. SWCD/NRCS to test soils for nitrogen and phosphorus in 25% of all active crop fields within a quarter mile of all waterways. B. SWCD/NRCS to utilize soil testing report in developing nutrient management plans.
4	Decrease the abundance and spread of exotic aquatic species.	Loss of native aquatic plants Lack of enforcement on lakes: boating, herbicides Increased exotic species including zebra mussels Need for aquatic plant management Lack of cleaning/spraying boats coming in/out of lakes	Legislate Rules regarding the mandatory use of boat cleaning and lake quarantine/closure. Educate boat and lake users on exotic aquatic species.	A. Assist in development of aquatic plant management plan for all lakes over 100 acres in watershed. B. Decrease the spread/introduction of new exotic aquatic species through education. C. Increase the awareness of beneficial native plants to the ecosystem.
5	Foster communication among all watershed stakeholders.	Increased number of boats and personal watercraft on lakes Protecting property rights/farmers rights Lack of enforcement on lakes: boating Lack of public knowledge and education about lake and watershed issues Lack of stewardship ethic Lack of communication/coordination within the groups Lack of flood awareness, impacts of flooding Lack of education regarding yard care Lack of education regarding aquatic plant removal Increased number of fishing tournaments	Educate stakeholders regarding each others' needs Facilitate the transfer of information among stakeholder groups	A. Form an Advisory Board of Directors to meet for annual review of watershed management plan beginning in 2006 and conduct strategic planning. B. Communicate goals of management plan to all Upper Tippecanoe River Watershed stakeholders. C. Educate stakeholders on watershed issues. D. Attend multiple lake associations meetings and events and exchange newsletters for the purposes of identifying educational opportunities. E. Assist in a liaison capacity to facilitate communication between watershed stakeholders and Federal and State representatives. F. Identify cites and towns, in addition to North Webster, that are affected by the Watershed Plan and work with the appropriate contacts within each unit of government. G. Provide workshop style venues for increased communication between lake owners associations, SWCD, FFA, 4-H, local schools, and the general public. H. Identify lakes where no association currently exists and/or assist in their development. I. Coordinate with SWCD educational staff to help promote schools and other individual volunteers to begin Hoosier RiverWatch Program in each of the 8 sub-basins.
6	Fund watershed improvement projects.	Lack of funding sources Need to promote Best Management Practices (BMP's) to homeowners and farmers	Raise local funds Seek outside grants	A. Develop listing of potential funding sources.
7	Hire/Retain a Watershed Coordinator for the Upper Tippecanoe Watershed.	Lack of communication/coordination within the groups	Hire a full time watershed coordinator. Enlist a volunteer watershed coordinator. Request that SWCD implement the plan.	A. Determine the duties and develop job description of a watershed coordinator. B. Seek grants to fund the position.

8	Address development issues such as zoning and "funneling."	Increased number of boats and personal watercraft on lakes Need to revise zoning ordinances Increased number of housing developments Loss of land to urban sprawl; land use issues Wetland destruction by development; increased filling of wetlands Loss of fish, wildlife, woodland habitat Increased sizes of homes being built and septic capability Lack of development control by county planning office number of boats, hours, boats coming from unknown waters	Provide voluntary plan review with area developers Get involved in area Plan Commission activities Review legal mechanisms for new rules on lakes Advise County Commissioners Get involved with IDNR rule-making (piers, ecozones, etc.)	A. Assist area Plan Commission on developing lake zoning ordinances. B. Evaluate eco-zone development/implementation for various lake areas C. Maintain active involvement in Lakes Management Work Group

E.3 Prioritization of Subwatersheds

Several smaller diagnostic studies were evaluated in the original draft to assist in ranking the subwatershed of the larger Upper Tippecanoe River Watershed. Water quality analysis in these smaller studies utilized historical data collected from all available sources, as well as current water chemistry and biological data at several sites throughout the smaller 14-digit watersheds. Since the draft WMP was prepared, local groups continued to collect additional water quality data from individual subwatersheds that previously lacked current inlet or outlet water quality data and/or data was patchy in its location throughout the subwatershed. Such data was added to the appropriate sections of this Plan, namely the Smalley Subwatershed and the Ridinger/Robinson Subwatershed stream water quality sections. At the time of the draft WMP subwatershed rankings in order of highest to lowest priority ranked as follows:

1) Smalley Subwatershed
2) Ridinger/Robinson Subwatershed
3) Goose/Loon Subwatershed
4) Elder Ditch Subwatershed
5) Barbee Lakes Subwatershed
6) Webster/Backwaters Subwatershed
7) Tippecanoe Subwatershed
8) Crooked/Big Subwatershed

Recent water quality data collected as part of the updates to this WMP included water quality and biological integrity assessments at the broader 11-digit watershed scale. This included at least one sample in each of the eight subwatershed and two additional data point locations in the previously identified priority watershed of Ridinger/Robinson. More complete results from this investigation can be found in Section 5.0, C and/or Appendix G which includes the full report. The analysis made use of several biological evaluations to arrive at the best possible conclusions from the limited number of samples. It can be concluded from the data that the subwatershed priorities in order of highest to lowest priority (from poorest water quality to best water quality) are as follows:

1) Ridinger/Robinson Subwatershed
2) Smalley Subwatershed
3) Barbee Lakes Subwatershed
4) Elder Ditch Subwatershed
5) Crooked/Big Subwatershed
6) Goose/Loon Subwatershed
7) Tippecanoe Subwatershed
8) Webster/Backwaters Subwatershed

These results show similar rankings among the top priorities. As landuse changes over time and/or groups or individuals are able to implement more watershed improvement projects, the rankings of these subwatersheds may change. However, current available data suggests that the top three priority subwatersheds for future implementation projects should include:

1) Ridinger/Robinson
2) Smalley
3) Elder Ditch

Table E2 details the individual water quality concerns of each subwatershed, as well as the associated pollution sources, priority areas, and suggested BMPs. This table summarizes the data collected in both historic and recent LARE diagnostic studies. The priority areas described are further identified in Section 5G of this report through a series of maps showing recommendations in each subwatershed.

Table E2 Water Quality Concerns and Priorities			
Water Quality Concern(s)	**Source(s)**	**Priority Areas**	**BMPs**
Smalley Subwatershed			**See Figure 61, page 5.82**
High Total Phosphorus (TP) concentrations	Farm fields fertilization runoff, residential runoff, agricultural practices	Scattered	Grassed waterways, no-till conservation tillage, filter strips, wetland restoration, and tile riser protection
Low clarity - Secchi disk depth less than average Indiana lakes and high turbidity in inlets	Erosion from stream banks, construction sites, and pasture land	Construction sites around Big Lake and Smalley Lake; along the Tippecanoe river from Big Lake west to Smalley Lake	Filter strips, cattle fencing, vegetative filter areas around unprotected risers, erosion control techniques on residential and commercial development sites.
High chlorophyll *a* concentrations	Nutrient loading – see sources for N & P	Scattered	Any/all nutrient management practices
High concentrations of nitrate-nitrogen	Cattle in stream, fertilizers, row crop practices	Northern inlet	Cattle fencing, alternative water source development if necessary, restoration of the riparian zone, constructed wetland development
High Ammonia levels	Decaying organic matter within streams		Restore riparian zones, filter strips along the Tippecanoe river and its tributaries
High E. coli levels	Livestock waste	Northern inlet and County Road 1050 W. and County Road 275 S	Fence cattle from the stream, construct watering pond as an alternative water source
Ridinger/Robinson Subwatershed			**See Figure 62, page 5.84**
Low clarity - Secchi disk depth less than average Indiana lakes; high TSS load	Erosion due to unstable banks in lakes' tributaries	Ridinger outlet, Shanton Ditch, and Elder Ditch	Streambank stabilization
High levels of chlorophyll *a* concentrations in Robinson and Ridinger Lakes.	Decaying organic matter due to nutrient loading	Scattered	Any/all nutrient management practices
High Total Phosphorus concentrations in lakes; High SRP in inlets	Residential and agricultural fertilizer run-off, wildlife and animal waste	Elder Ditch and Shanton Ditch	Wetland restoration, livestock exclusion, riparian restoration
Nitrate-nitrogen loading	Residential and agricultural fertilizer run-off, wildlife and animal waste	Downstream of Ridinger, Elder Ditch, and Shanton Ditch	Wetland construction
High Ammonia concentrations	Agricultural run-off, wildlife and animal waste	Shanton Ditch and Delano Ditch	Riparian corridor and stream bank restoration
High E. coli concentrations	Wildlife and human waste	Elder and Mathias Ditches; Troy Cedar Lake	Filter strips, livestock exclusion along Mathias Drain and Robinson Lake, riparian restoration
Goose/Loon Subwatershed			**See Figure 63, page 5.85**
Low clarity - Secchi disk depth less than average Indiana lakes	Streambank erosion,	Scattered	Filter strips, streambank stabilization
High levels of chlorophyll *a* concentrations	Nutrient loading – see sources for TP	Goose and Loon Lakes	Any/all nutrient management practices
High Total Phosphorus (TP) and SRP concentrations	Residential and agricultural fertilizer run-off, wildlife and animal waste	Loon Lake	Develop waste control storage structures, filter strips
NOTE: no recent stream data was available to determine full range of water quality concerns			
Elder Ditch Subwatershed			**See Figure 64, page 5.86**
Low clarity - Secchi disk depth on Troy Cedar less than average Indiana lakes	Agricultural practices, stream bank erosion from cattle	Cedar Lake Branch of Elder Ditch	Cattle fencing, CRP enrollment
High levels of chlorophyll a concentrations	Nutrient loading - – see sources for TP	Scattered	Any/all nutrient management practices
High Total Phosphorus (TP) and SRP concentrations	Animal waste, agricultural run-off	Near CR 550W, Scott Lake western tributary, Cedar Lake Branch of Elder Ditch, Smith Drain	Restore wetlands, install filter strips
NOTE: no recent stream data was available to determine full range of water quality concerns			
Barbee Lakes Subwatershed			**See Figure 67, page 5.92**
High Total Phosphorus (TP) and SRP concentrations	Urban storm water run-off, livestock waste	Big Barbee and Little Barbee Lakes, Putney Ditch	Filter strips, pasture fencing, storm water filters
High concentrations of nitrate-nitrogen	Urban storm water run-off, livestock waste	Big Barbee, Little Barbee, and Sawmill Lakes, Grassy Creek, tributaries of Kuhn Lake	Wetland restoration, install catch basins
High Ammonia concentrations	Livestock waste	Grassy Creek	Livestock fencing
High Total Suspended Solids; Low clarity in some lakes	Urban storm water run-off, nutrient loading	Grassy Creek, Putney Ditch	Riparian corridor and stream bank restoration

Water Quality Concern(s)	Source(s)	Priority Areas	BMPs
Webster/Backwaters Subwatershed			**See Figures 65 and 66, page 5.88 and 5.90**
High Total Phosphorus (TP) and SRP concentrations	Urban storm water run-off, agricultural practices	Gaff Ditch, Tippecanoe River, Ditch at CR 675 N and CR 925 E	Filter strips and wetland restoration along Gaff Dtich, urban stormwater BMPs
High Total Suspended Solids in inlet streams and storm connections; Low relative clarity in lakes	Urban storm water run-off, streambank erosion, agricultural practices	Gaff Ditch, Tippecanoe River at SR 5, Ditch at CR 675 N and CR 925 E, Town of North Webster	Streambank stabilization and stormwater outlet, storm drain retrofitting, grassed waterways,
High Ammonia concentrations	Decaying organic matter within streams	Webster Lake, Gaff Ditch, Ditch at CR 675 N and CR 925 E	Urban stormwater BMPs, filter strips
Tippecanoe Subwatershed			**See Figure 68 and 69, page 5.94 and 5.95**
High Total Phosphorus (TP) and SRP concentrations	Urban storm water run-off, livestock waste, agricultural practices	Kuhn Ditch, Town of North Webster	Urban stormwater BMPs, filter strips, wetland restoration
High Total Suspended Solids in inlet streams and storm connections	Urban storm water run-off, streambank erosion from cattle, agricultural practices	Indian Creek, Long Ditch, Kuhn Ditch, Town of North Webster	Urban stormwater BMPs, filter strips, stream restoration
High Total Nitrogen and nitrate-nitrogen	Urban storm water run-off, streambank erosion from cattle, agricultural practices	Long Ditch, Kuhn Ditch	Urban stormwater BMPs, filter strips
High E. coli levels	Septic systems, manure spreading near streams, livestock in stream	All greater than state standard, Kuhn w/ highest concentration	Cattle fencing, filter strips, septic education
Crooked/Big Subwatershed			**See Figure 70, page 5.97**
High Total Phosphorus (TP) and SRP concentrations	Agricultural pracitces, development, residential fertilizers	Green Lake tributary, Stuckman and Sell Drains	Conservation tillage, sediment basin, filter strips
High Total Nitrogen and nitrate-nitrogen	Agricultural pracitces, development, residential fertilizers	Green Lake tributary, Stuckman and Sell Drains	Conservation tillage, sediment basin, filter strips
High Ammonia concentrations	Agricultural practices, livesock waste	Big Lake	Sediment basins, filter strips
High Total Suspended Solids in inlet streams	Streambank erosion, agricultural practices	Stuckman and Sell Drains	Conservation tillage, sediment basin, filter strips, streambank/ravine stabilization
NOTE: no recent stream data was available to determine full range of water quality concerns; data was from small 1995 study			

Load Reduction Estimates

Load reductions associated with selected BMPs and various priority areas are noted below. A combination of practices will be necessary in order to reach the first goal of 20% reduction in phosphorus, nitrogen, *E. coli,* and sediment loads.

Table E3: Minimum reduction estimates for 100,000 feet of filter strips/grassed waterways

Filter strip width (ft)	Sediment Load Reduction (tons/year)	Phosphorus Load Reduction (lbs/year)	Nitrogen Load Reduction (lbs/year)
20	233	283	332
25	269	329	388
30	538	657	775

Table E4: Cropland, HEL, and Tillage data for Upper Tippecanoe Watershed

	Total Cropland (acres)[1]	Cropland in HEL (acres)[2]	Conventional tillage % (corn/soybeans)[3]	Estimated Cropland in Conventional Tillage (acres)	
				Corn	Soybeans
Kosciusko	10,927	148	8%/4%	386	228
Whitley	14,089	2,471	28%/5%	1,726	369
Noble	7,046	1,157	21%/7%	644	260
Watershed Total	**32,062**	**3,776**		**2,756**	**857**

Sources
1 2002, 2003 USDA National Agricultural Statistics Service
2 Digital Soil Surveys for Kosciusko, Whitley, and Noble Counties
3 2004 Tillage Transect report

Table E5: Reduction estimates for conservation tillage on a significant acreage of cropland acreage

		Sediment Load Reduction (tons/year)			Phosphorus Load Reduction (lbs/year)			Nitrogen Load Reduction (lbs/year)		
Increase in conservation tillage acreage		50%	75%	100%	50%	75%	100%	50%	75%	100%
Kosciusko	Soybeans	228	342	456	342	513	685	570	856	1,141
	Corn	386	578	771	578	867	1,157	964	1,446	1,928
Whitley	Soybeans	738	1,108	1,477	738	1,108	1,477	1661	2,492	3,323
	Corn	6,040	9,059	12,079	5,177	7,765	10,354	11216	16,825	22,433
Noble	Soybeans	520	780	1,040	520	780	1,040	1,040	1,560	2,080
	Corn	1,287	1,931	2,575	1,287	1,931	2,575	2,575	3,862	5,150

Table E6: Reduction estimates for conservation tillage on 80% of HEL cropland acreage

	80% of Cropland in HEL (acres)	Sediment Load Reduction (tons/year)	Phosphorus Load Reduction (lbs/year)	Nitrogen Load Reduction (lbs/year)
Kosciusko	118	474	474	947
Whitley	926	6,479	5,554	12,033
Noble	1,977	13,838	11,861	25,698
Watershed Total	**3,021**	**20,791**	**17,889**	**38,678**

Table E7: Reduction estimates for proposed streambank restoration projects (detailed below in E.4)

	Estimated feet stabilized	Sediment Load Reduction (tons/year)	Phosphorus Load Reduction (lbs/year)	Nitrogen Load Reduction (lbs/year)
Project 1 (Shanton Ditch)	3500	403	403	805
Project 2 (Troy Cedar Br.)	2084	240	240	479
Total	**5584**	**643**	**643**	**1284**

E.4 Summary of Recent BMP Project Initiatives and Coordination

Several implementation projects were initiated since the draft WMP through the efforts of the Watershed Coordinator. The proposed BMP projects (outlined below) are focused in previously identified priority subwatersheds and/or specific subwatershed hot spots as determined by various diagnostic studies. The projects range in cost, complexity, pollution source, and technique. Initial landowner outreach and preliminary design development have occurred for Projects 1,3, and 4. All associated landowners are willing participants and are simply awaiting necessary funding to implement the projects. Project 2 stills needs to secure all of the landowners prior to proceeding further; however, some landowners have been contacted and are agreeable. General project locations are shown on Figures E1 and E2.

Project 1 (Trump Wetland)

A potential water quality/stream restoration project was identified in the Ridinger subwatershed along Shaton Ditch. The property adjacent to the ditch is owned by Mr. Dennis Trump. Numerous conversations and preliminary design discussions have occurred with Mr. Trump. Mr. Trump is agreeable to the project and supportive of the intended results. TEWLF staff and staff from J.F. New and Associates have reviewed various cost share programs with Mr. Trump and secured his interest in participation. The project has applied for EQUIP funds; although, funding is not guaranteed . The estimated cost is between $50,000-$60,000.

The proposed project would include approximately 1950 feet of fencing preventing the access of animals to Shanton Ditch, approximately 3500 feet of ditch bank restoration, stone installations at key bank locations for erosion control, installation of an access culvert, installation of grass buffer, construction of a detention wetland (approximately 4 acres), berm elevation increase to enhance wetland, riparian restoration and wildlife habitat construction.

Project 2 (550W Animal Management)

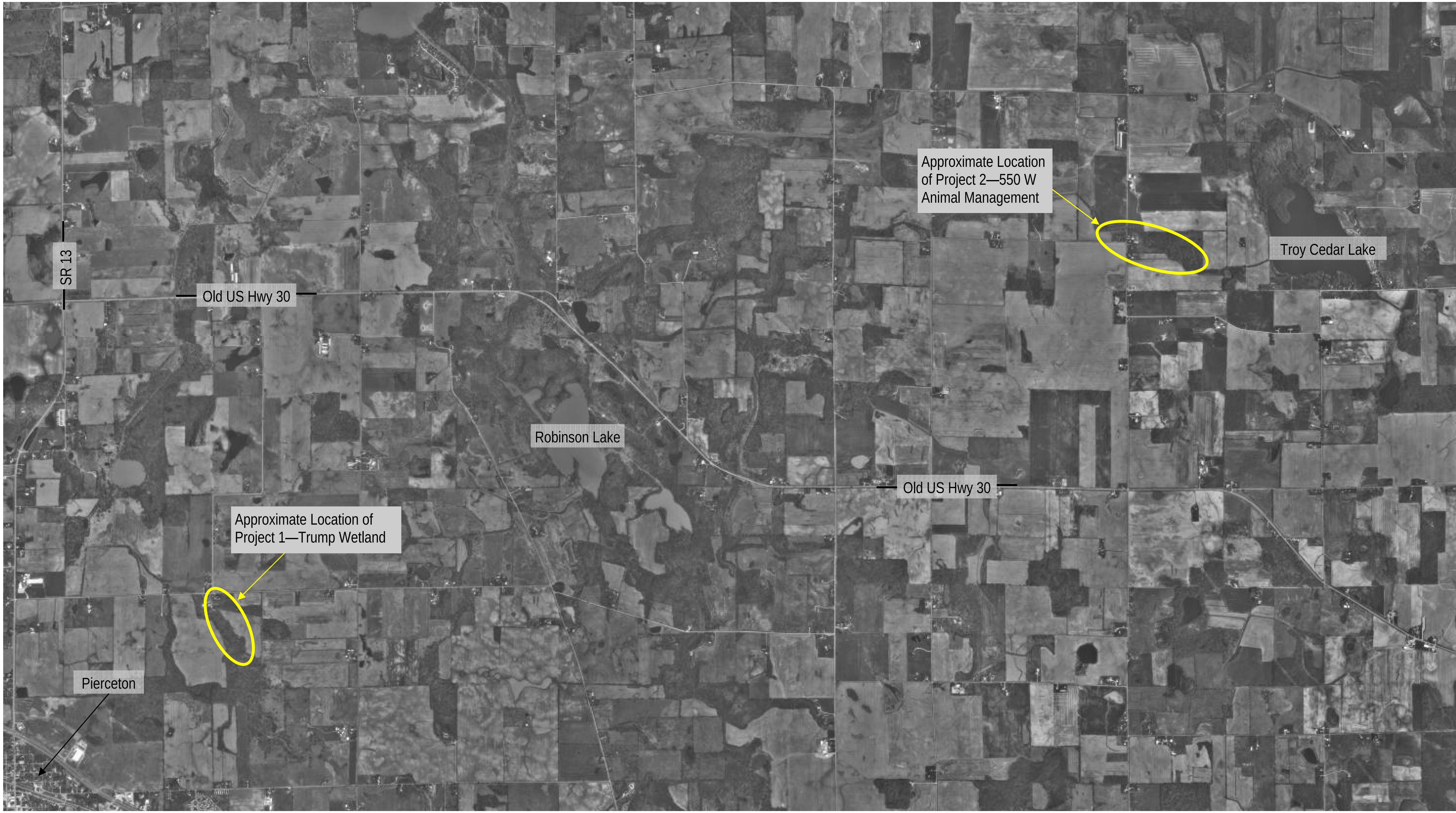
This project is located in the Elder Ditch subwatershed and would include approximately 2100 ft. of fencing to prevent animal access to Troy Cedar Branch of Elder Ditch, approximately 1900 ft. of ditch bank restoration, stone check dam installations, riffle installations, grass buffer strips, riparian restoration and the construction of an alternative water source for animals. This project involves 8 property owners and stakeholders. The estimated cost is $50,000-$60,000.

Project 3 (Schad Project)

This project would install a “rain garden” on a direct drainage ravine along Kalorama Road on the north shore of Lake Tippecanoe. This biorention feature (“rain garden”) would be placed in the landowner’s yard to filter storm water runoff from the street and other sources/adjacent landowners. The estimated cost is $3,500.

Project 4 (Paton Enterprises Project)

This project includes the installation of a sediment basin to collect and treat runoff along Kalorama Road. The project would also include a separate infiltration trench where street runoff would be collected. Presently the storm water discharges directly into a channel connected to Lake Tippecanoe. The infiltration trench would facilitate ground water recharge and make use of a fixed media filter to improve the water quality. The estimated cost is $20,000.



WILLIAMS CREEK CONSULTING

919 North East Street
Indianapolis, Indiana 46220
Tel: 317-423-0690
Fax: 317-423-0696

N

1" ≈ 1200'

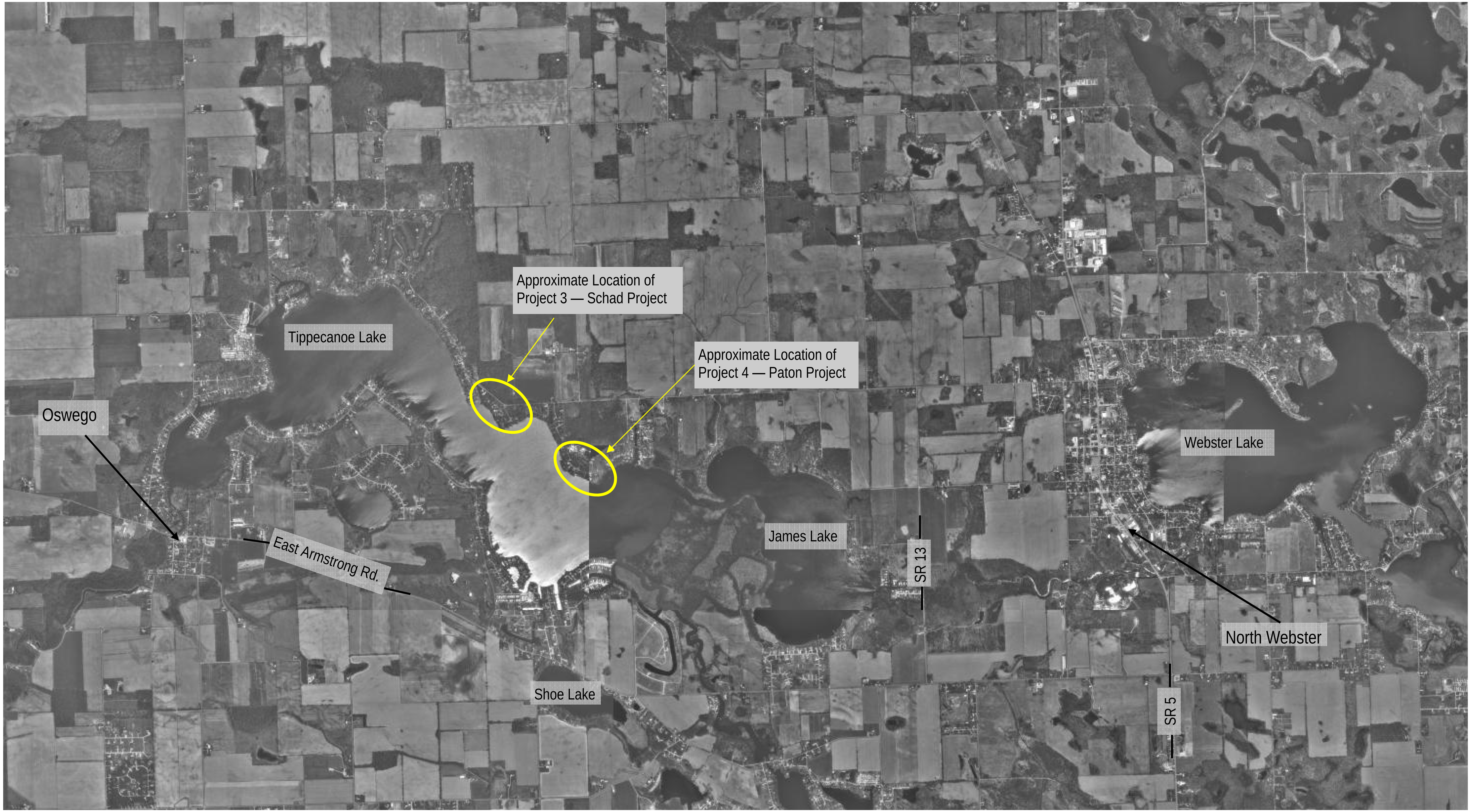
Figure E1 Recent BMP Project Initiatives
Projects 1 and 2

1998 (TerraServer Website)

Koscinsko and Whitely Counties

Prepared for:
Tippecanoe Environmental Lake and Watershed Foundation

Project No.	Date:	Figure E1
TIPP-45-001	July 2006	Page Exec. 14



WILLIAMS CREEK CONSULTING	919 North East Street Indianapolis, Indiana 46220 Tel: 317-423-0690 Fax: 317-423-0696	N 1" ≈ 1200'	Figure E2 Recent BMP Project Initiatives Projects 3 and 4 1998 (TerraServer Website) Kosciusko County, IN	Prepared for: Tippecanoe Environmental Lake and Watershed Foundation Project No. TIPP-45-001 Date: July 2006 Figure E2 Page Exec. 15

E.5 Projects for Future Implementation

Two section 319 grant applications were submitted to IDEM in 2005 for various projects in priority subwatersheds including two of the above projects. Various public input confirmed the need for area stakeholders to see projects implemented on the ground in a visible way. In order to address this and begin to affect change, the Board and the Watershed Coordinator have pulled together other various projects from several of the diagnostic study conclusions to arrive at the following list of future implementation projects.

Smalley Subwatershed

- Install buffer strips along the Tippecanoe River from Big Lake west to Smalley Lake.
- Fence cattle from the stream near County Road 1050 W. and County Road 275 S. and construct watering pond as an alternative water source.
- Restore riparian zones along the Tippecanoe River and its tributaries where possible; minimally, install filter strips along the Tippecanoe River and its tributaries.
- Restore as many wetlands as possible in the Smalley Lake watershed, focusing first on the Tippecanoe River subwatershed and targeting those areas shown in Figure 61, Section 5.0, G.
- Install fencing to protect Smalley Lake's northern inlet from grazing cattle. Install an alternative water source if necessary. Restore the riparian zone where grazing cattle have damaged the stream habitat. Consider directing drainage from an adjacent grazed field through a constructed wetland to reduce nitrate inputs to the northern inlet.
- Utilize the Conservation Reserve Program to implement grassed waterways and remove land mapped in highly erodible soils from agricultural production. Target areas shown in Figure 61 first.
- Plant vegetative filter areas around unprotected risers shown in Figure 61.

Ridinger/Robinson Subwatershed

- Create wetland habitat, install buffer strips/grassed waterways to reduce flow and retire agricultural land upstream of Rine Lake.
- Install filter strips along Mathias Ditch.
- Develop materials to distribute on "Lake Basics" to be given to tenants upon their arrival at Jellystone Park regarding trash, fertilizers, chemicals, automobile traffic, grass and leaves, boating, etc.
- Wetland restoration on Elder Ditch, north of Old 30 and East of 900 E.
- Restoration of the Elder Ditch corridor where ditch cleaning has been particularly damaging such as the area upstream and downstream of Elder Road. Restoration in this area includes stream bank stabilization through the use of bioengineering techniques and revegetation of the riparian corridor, preferably with woody vegetation.
- Restrict access of livestock to Robinson Lake. An alternate source of water should be created for the livestock, and the lake shoreline where the livestock have grazed should be restored. Ideally, a constructed wetland or other treatment of drainage from the livestock's pasture should be installed to limit nutrient input to Robinson Lake from runoff.
- Stabilization of the eroding ravine leading to the southeast corner of Ridinger Lake. Work at this site will include working with the property owner of the adjacent land to utilize grassed waterways or set aside a portion of the land in CRP.
- Restoration of Troy Cedar Lake's northern inlet's corridor where ditch cleaning has damaged the riparian zone. Restoration may include stream bank stabilization through the use of bioengineering techniques and revegetation of the riparian corridor, preferably with woody vegetation.
- Restrict livestock access to the Troy Cedar Branch of Elder Ditch on the east and west sides of CR 550W. An alternate source of water should be created for the livestock, and the stream bank where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks

using bioengineering techniques. If possible, drainage from the land where the livestock are pastured should be directed to flow through a constructed wetland to reduce pollutant loading particularly, nitrate-nitrogen loading, to the Troy Cedar Branch of Elder Ditch.
- Restore riparian zones along the streams in the Ridinger Lake watershed where possible; minimally, install filter strips along these streams. Stream corridors in the Shanton Ditch and Elder Ditch subwatersheds should receive high priority.
- Restore as many wetlands as possible in the Ridinger Lake watershed, targeting those areas shown in Figure 62 (Section 5.0, G). Watershed stakeholder should try to restore wetland acreage so that the percentage of the Ridinger Lake watershed covered by wetlands equals or exceeds the percentage of land in the greater Upper Tippecanoe River basin that is covered by wetlands.

Loon/Goose Subwatershed
- Work with livestock owners to develop waste storage structures throughout the Loon Lake Watershed.
- Conduct a current, more detailed diagnostic study of this subwatershed to develop site specific recommendations.

Elder Ditch Subwatershed
- Restore 120-acre wetland north of County Road 700 N. and east of County Road 550 W.
- Restore 40-60 acres of wetland south of County Road 750 N. and east of County Road 550 W.
- Install filter strips on the western tributary to Scott Lake.
- Install filter strips, fence cattle from the stream and stabilize the stream bank of the Cedar Lake Branch of Elder Ditch east of County Road 650 W to Troy Cedar Lake.
- Install filter strips west of County Road 650 W. on the Cedar Lake Branch of Elder Ditch.
- Enroll property south of Smith Drain along the west side of State Road 5 in CRP or WRP.
- Restore the wetland north of County Road 300 N. and east of County Road 650 W.

Webster/Backwaters Subwatershed
- Install buffer strips along Gaff Ditch from County Road 750 W. to its headwaters (New, 2000).
- Restore two wetland filters at the headwater of Gaff Ditch; County Road 750 N. and County Road 650 W.
- Restore wetland or tributary to Gaff Ditch between County Road 700 N. and County Road 750 N.
- Stabilize stormwater outlet and channel banks south of East Street on the northwest corner of Webster Lake.
- Install grassed waterways on agricultural land southeast of County Road 650 W. and County Road 750 N. (Cormany Farms).
- Install filter strips and grassed waterways on the unnamed tributary to Gaff Ditch east of County Road 750 W. at County Road 400 S.
- Install pollutant removal devices on the 18 stormwater drain complexes located in the city of North Webster and develop a maintenance plan for each of these filters.
- Stabilize banks adjacent to bridge abutments over Gaff Ditch at County Road 750 W. off of 750 N.
- Complete the installation of sanitary sewers.
- Selectively dredge the inlets to Webster Lake (work in progress, 2006).
- Work with the County on long range plan for County Road 750 N.
- Continue to work with the Town Council to ensure that a storm drain inspection and maintenance plan is implemented.

- Work with the Town Council to determine if drain retrofitting is desirable given available resources. Depending on available resources, other funding sources or grants should be secured to retrofit at least the high priority drain networks.
- Have a representative present at monthly town council meetings to ensure better long-term communication regarding the storm drain project and other lake conservation projects.
- Initiate an information and education program to inform town and lake residents about practices they can utilize to control sources of pollutants and debris before they are introduced into the storm drain system.

Barbee Lakes Subwatershed

- Install filter strips; fence pastures adjacent to Grassy Creek on Elder Ditch between Ridinger Lake and Putney ditch.
- Install grass/forested buffer at the southwest corner of County Road 650 E. and County Road 200 N.
- Install buffer strips east of County Road 650 E.
- Create wetland south of McKenna Road.
- Filter stormwater from drains east of State Road 13 and west of Big Barbee southern channel to remove road runoff and petroleum products.
- Install stormwater drains/catch basins on drains near Sechrist and Kuhn Lakes.
- Selectively dredge sediment in Little Barbee Lake and its channels (work in progress, 2006).
- Reduce phosphorus loading from Ridinger Lake.

Tippecanoe Subwatershed

- Install comprehensive sanitary sewer system.
- Address *E. coli*, phosphorus and nitrogen inputs from the northwest corner of County Road 500 E and County Road 650 N.
- Consider how to fund an implement a catch basin insert program for the 35 street storm drains around the lake.
- Encourage or cost share with local residents to incorporate rain gardens into their landscapes.
- Generate local consensus, design, and build two community rain gardens to treat storm water runoff in Bell Rohr Park and Russell Park neighborhoods. The land is already owned by the associations, so no additional land acquisition is needed.
- Seek design and implementation funding for other storm water BMPs as outline in Section 5.0, Table 49.

Crooked/Big Subwatershed

- Conduct a current, more detailed diagnostic study of this subwatershed to develop site specific recommendations.
- Incorporate measures to slow the water and sediment loss above the ravine (Tall Trees Memorial Grove) outside of the Nature Preserve.
- Enlist the agricultural field on south side of golf course in the conservation tillage program.
- Enlist the agricultural field located south of lake near Spear Road in the conservation tillage program.
- Create sediment retention structure at the outlet of Stuckman Drain, install filter strips, and stabilize the banks.
- Install a sediment trap on Sell Branch immediately upstream of County Road 600 N. along Airport Road.
- Install a sediment trap 600 feet upstream of State Road 109 in Sell Subwatershed.
- Install a sediment trap immediately upstream of County Line Road in Sell Subwatershed.

- Install filter strips within the Sell branch Subwatershed.
- Install filter strips on cropland east of County Road 250 W. in Crane Subwatershed.
- Reforest land along the southern bank of Crane Ditch.
- Install a sediment trap upstream of County Road 500 S. in Crane Subwatershed.
- Expand idle lands to the southeast of Green Lake and south of County Road 500 S.
- Protect and reforest land east of Haroff Lake in Green Lake Subwatershed.
- Install filter strips on the north side of County Road 500 S. in the Green Lake subwatershed.
- Continue in-lake water quality testing for phosphorus, nitrate, and turbidity and consider limited tributary samplings.

TELWF understands the limited nature of funding and the rather optimistic list of above projects. Given this, other initiatives/projects in the watershed are seeking implementation money through alternate funding sources or institutional avenues in addition to current and future requests from the 319 Program. Some concurrent efforts include:

- LARE funded diagnostic and planning project in the Crooked/Big and Goose/Loon subwatersheds
- Various LARE funded implementation projects in select subwatersheds
- Potential Zoning Ordinance modifications via Plan Commission collaboration and cooperation
- Privately funded property acquisition for restoration projects

TELWF and the watershed coordinator will continue with the current activities and initiatives as outlined in the Task Timeline, Section 6.0, C. Some tasks listed for 2006 can continue with current staff and Board leadership; however, others are dependent on grant funding decisions that are expected in the spring or summer of 2006.

1.0 INTRODUCTION

The Upper Tippecanoe River Watershed (Hydrologic Unit Code (HUC) 05120106010) is located northeast of Warsaw in portions of Kosciusko, Noble, and Whitley Counties, Indiana (Figure 1). The watershed drains approximately 72,846 acres (113.8 square miles) and encompasses eight U.S. Geological Survey fourteen-digit watersheds. The Upper Tippecanoe River Watershed is part of the larger Tippecanoe River Watershed (HUC 05120106). Water from the Tippecanoe River discharges into the Wabash River northeast of Lafayette, Indiana eventually converging with the Ohio River in southwestern Indiana.

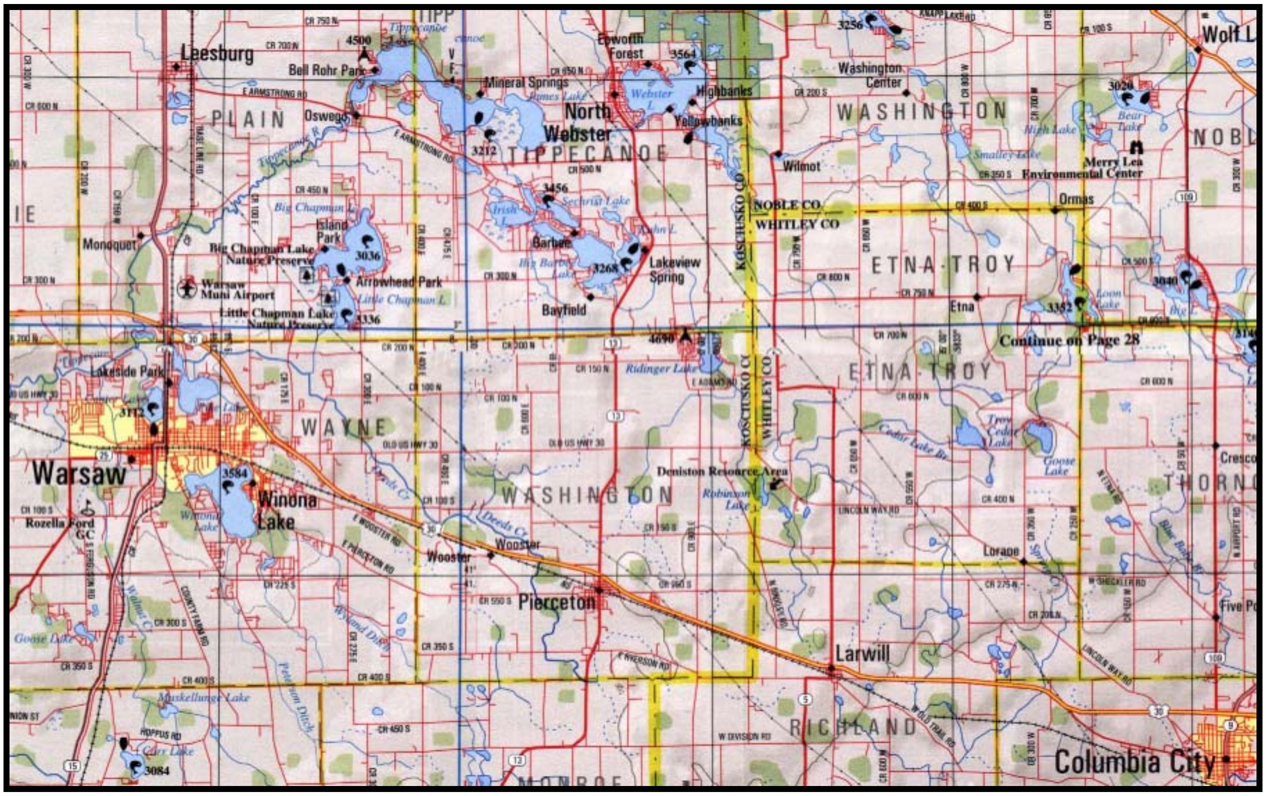


Figure 1. Upper Tippecanoe Watershed location map

The drainage basin of the Upper Tippecanoe River Watershed was formed during the most recent retreat of glaciers in the Pleistocene Era. The glacial advance and retreat of both the Huron-Saginaw Lobe and Ontario-Erie Lobe of the last Wisconsinian glaciations, which began about 70,000 years ago, formed much of the present topography within the watershed (Wayne, 1966). The watershed topography influences land surface form, potential natural vegetation, soils and land use. All of these factors can be used as general descriptors of larger areas or ecoregions. The Upper Tippecanoe River Watershed is located in the Northern Till Plain, an ecoregion consisting of extensive crop and livestock production. Its natural forest cover, high degree of urbanization and extensive quarrying distinguishes it from adjacent ecoregions (Simon, 1997). Channelized drainage ditches and streams as well as lakes are common.

Changes in land use have altered the watershed's natural landscape. Settlers to the region drained wet areas and cleared forests in order to farm soils rich in both nutrients and humic material. As technology has increased, farm production has also increased. Today 75% of the watershed is utilized for agricultural purposes. The clearing of forest land, the installation of subsurface tile drain networks, and excavation of drainage channels has contributed to the decline of water quality in the watershed. In addition to water quality impairments, landscape alteration for farming may impact the natural structure and function of aquatic systems (Menzel, 1983). The growth of development around the lakes, the transitioning of summer cottages to full time residences, and the lack of adequate sanitary waste treatment systems has also contributed to the deterioration of water quality in the watershed.

To address impairments to aquatic systems in the Upper Tippecanoe River Watershed the Tippecanoe Environmental Lake and Watershed Foundations (TELWF) obtained a Build Indiana Funding Grant from the State of Indiana. TELWF hired J.F. New & Associates to assist in the development of a watershed management plan for this three county area.

The purpose of this document is to provide an action plan endorsed by the majority of watershed stakeholders to follow that will create permanent improvements in the water quality of the Upper Tippecanoe Watershed. This plan includes recommendations from previous studies, summaries of communication with landowners, business owners and state and local regulatory agencies and field investigations identifying land use patterns and locations for best management practice (BMP) installations. The document also lists the watershed partners that developed the plan and notes how the public contributed to the plans creation. The plan concludes with a discussion of water quality goals and objectives and lists steps the community should take to move forward with the plan.

TELWF's mission and the subsequent mission of this plan is as follows:

"Our mission shall be to promote the understanding and management of our lakes and watersheds fostering their restoration and preservation for today and for the future."

2.0 WATERSHED DESCRIPTION AND CHARACTERISTICS

A. General Overview and Setting

The Upper Tippecanoe River Watershed (HUC 05120106010) is located northeast of Warsaw and south of Lake Wawasee in Kosciusko, Noble and Whitley Counties, Indiana (Figure 1). The watershed is part of the larger 8-digit Tippecanoe Watershed HUC 05120106 (Figure 2). Draining approximately 72,846 acres (113.8 square miles, 29,479 ha), the Upper Tippecanoe River Watershed encompasses eight 14-digit watersheds: the Tippecanoe Subwatershed (HUC 05120106010080), the Webster/Backwaters Subwatershed (HUC 0512010601080040), the Smalley Subwatershed (HUC 0512010601080030), the Barbee Lakes Subwatershed (HUC 0512010601080070), the Crooked/Big Subwatershed (HUC 0512010601080010), the Loon/Goose Subwatershed (HUC 0512010601080020), the Ridinger/Robinson Subwatershed (HUC 0512010601080060), and the Elder Ditch Subwatershed (HUC 0512010601080050) (Figure 3). Table 1 displays the acreage of each subwatershed and what percentage each subwatershed is of the Upper Tippecanoe River Watershed.

Figure 2. Tippecanoe River Basin. The green shaded area indicates the 8-digit Tippecanoe River Watershed; the grey shaded area is the 11-digit Upper Tippecanoe River Watershed.

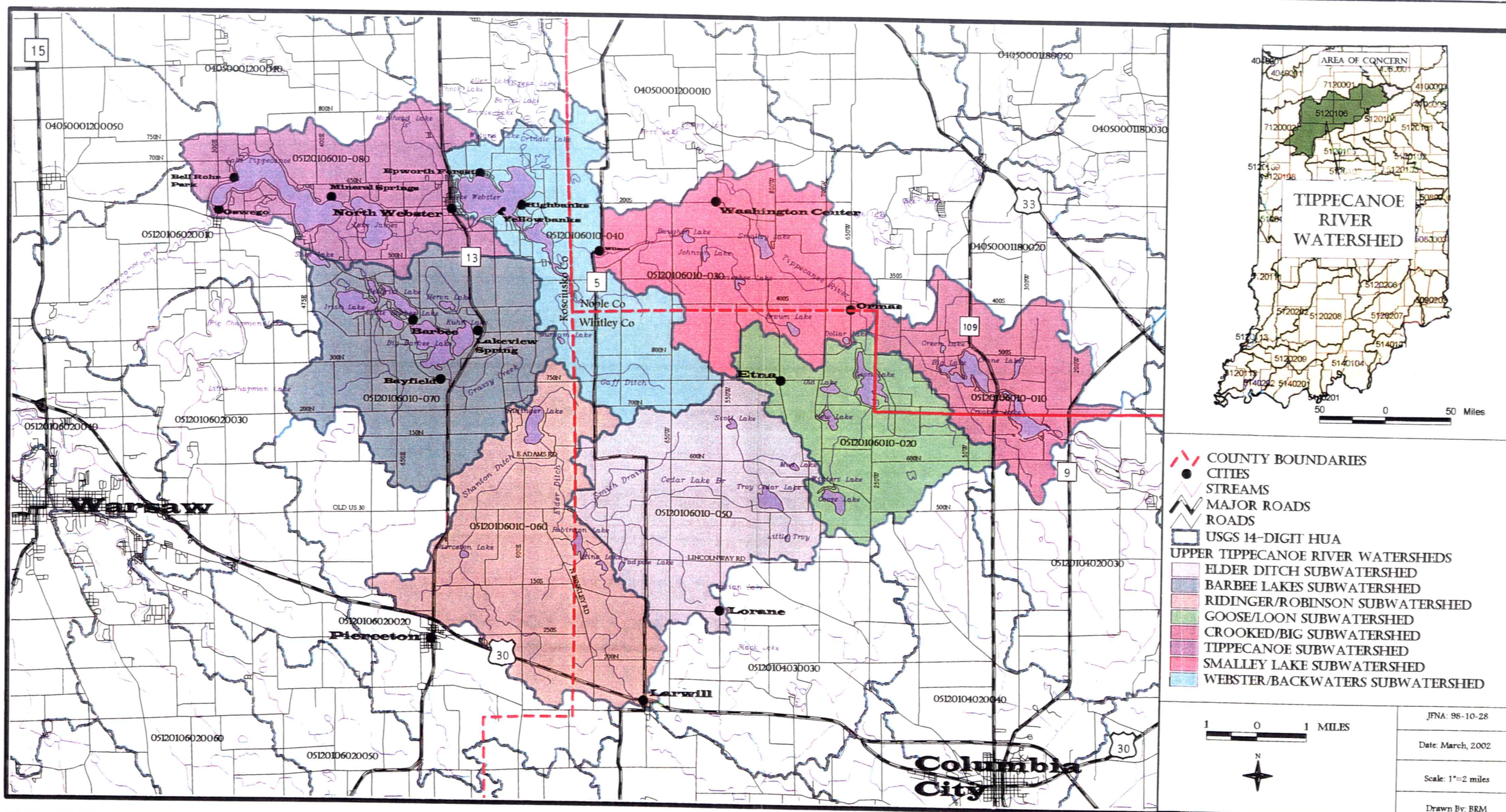


Figure 3
14 Digit Subwatersheds
Upper Tippecanoe River Watershed

Table 1. Subwatersheds within the Upper Tippecanoe River Watershed.

Hydrologic Unit Name	Area (acres)	Area (ha)	Percent of Watershed
Tippecanoe Subwatershed	8,193	3,315	11.2
Webster/Backwaters Subwatershed	8,941	3,618	12.3
Smalley Subwatershed	8,926	3,612	12.3
Barbee Lakes Subwatershed	11,041	4,468	15.2
Crooked/Big Subwatershed	6,333	2,563	8.7
Goose/Loon Subwatershed	7,259	2,938	10.0
Ridinger/Robinson Subwatershed	12,009	4,860	16.5
Elder Ditch Subwatershed	10,144	4,105	13.9
Tippecanoe Watershed	**72,846**	**29,479**	**100**

B. Topography

The drainage basin of the Tippecanoe River area was formed during the most recent glacial retreat of the Pleistocene or Quaternary Era. The advance and retreat of the Ontario-Erie Lobe of the last Wisconsian glaciation and the deposits left by the lobe shaped much of the landscape found in the northern two-thirds of Indiana (Wayne, 1966). In the study area, the receding glacier left nearly level to rolling topography characterized by "numerous lakes, kettle holes, sandy and gravelly knolls and ridges and outwash plains" (Ulrich, 1966).

The study watershed is located in the central portion of the Northern Lakes Natural Region (Homoya et al., 1985). The Northern Lakes Natural Region occupies the north central and northeastern area of the state and is bordered by the Eel River on the southeast and the western side of the Maxinkuckee Moraine on the west. Prior to European settlement, the region was a mixture of numerous natural community types including bog, fen, marsh, prairie, sedge meadow, swamp, seep spring, lake and deciduous forest (Homoya et al., 1985). The dry to dry-mesic uplands which dominated the landscape were likely forested with red oak, white oak, black oak, shagbark hickory, and pignut hickory. More mesic areas probably harbored beech, sugar maple, black maple, and tulip poplar with sycamore, American elm, red elm, green ash, silver maple, red maple, cottonwood, hackberry, and honey locust dominating the floodplain forests. The first plat of Indiana by the General Land Surveyors documented beech-maple forests as comprising 50% or more of the original vegetation of the state while oak-hickory forests comprised about 29% (Petty and Jackson, 1966). The Northern Lakes Natural Region also contains more bog habitat than any other region. The bogs are typically composed of a *Sphagnum* moss mat overlying a glacial depression.

C. Population and Demographics

Population sizes have dramatically increased in Kosciusko, Noble, and Whitley Counties since 1900 (STATS Indiana, 2001). The 2000 census recorded 9% more people living in Kosciusko County, 11% more people living in Noble County, and 14% more people living in Whitley County compared to 10 years ago. On average, about 109 people per square mile live in the six townships in the study watershed (Table 2).

Table 2. Population structure of the six townships that are either partly or fully encompassed by the Upper Tippecanoe River Watershed.

County	Township	Township Population	People/square mile
Kosciusko	Plain	7,194	200
Kosciusko	Tippecanoe	6,493	180
Noble	Noble	2,861	79
Noble	Washington	1,182	33
Whitley	Etna-Troy	1,833	51
Whitley	Thorncreek	3,925	109

Source: STATS Indiana, 1997.

D. Climate

Indiana's climate can be described as temperate with cold winters and warm summers. The National Climatic Data Center provides an excellent summary of Indiana weather in its 1976 Climatology of the United States document No. 60. "Imposed on the well known daily and seasonal temperature fluctuations are changes occurring every few days as surges of polar air move southward or tropical air moves northward. These changes are more frequent and pronounced in the winter than in the summer. A winter may be unusually cold or a summer cool if the influence of polar air is persistent. Similarly, a summer may be unusually warm or a winter mild if air of tropical origin predominates. The action between these two air masses of contrasting temperature, humidity, and density fosters the development of low-pressure centers that move generally eastward and frequently pass over or close to the state, resulting in abundant rainfall. These systems are least active in midsummer and during this season frequently pass north of Indiana" (National Climatic Data Center, 1976). Prevailing winds are generally from the southwest, but are more persistent and blow from a northerly direction during the winter months.

The climate of Kosciusko, Noble and Whitley Counties is such that enough snow falls in the cold winter to provide adequate soil moisture through the warmer growing season. Winters are cold, averaging 26º F (-3.3º C); winter lows average 17º F (-8.3º C) (Staley, 1989). The coldest temperature on record is -25º F (-31.7º C) recorded January 16, 1972. Summers are warm, averaging 70º F (21º C); summer highs average 82º F (27.8º C). The highest recorded temperature, 103º F (39.4º C), occurred July 17, 1976 (Staley, 1989). Mild drought conditions do occur occasionally during the summer when evaporation is greatest. Average relative humidity differs very little over the course of a day and is often 100 percent during summer months. In 2001, just over 48 inches (122 cm) of precipitation (Table 3) was recorded at North Webster in Kosciusko County; just over 41 inches (104 cm) of precipitation was recorded at Ligonier in Noble County; and just over 43 inches (109 cm) of precipitation was recorded at Columbia City in Whitley County Indiana (http://shadow.agry.purdue.edu/sc.index.html). The average annual precipitation in the watershed is 36.22 inches (92 cm). Although differences in 2001 precipitation and average precipitation are not great, there were periods that were wetter than normal and drier than normal throughout the year. These periods balance out the disparity. For example, two to three times the average amount of precipitation was recorded in all counties in October, but less than average precipitation was recorded in January and March.

Table 3. Monthly rainfall data for year 2001 as compared to average monthly rainfall. Averages are based on available weather observations taken during the years of 1961-1990 in Kosciusko, Noble, and Whitely Counties (http://shadow.agry.purdue.edu/sc.index.html).

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	TOTAL
Kosciusko	1.10	3.96	1.08	4.31	3.54	3.86	4.83	10.7	2.44	7.69	2.29	2.31	48.11
Noble	0.71	3.59	0.62	3.12	3.82	4.05	3.22	7.24	3.43	7.43	2.18	1.98	41.39
Whitley	1.02	3.34	0.70	5.30	3.63	5.77	5.39	5.57	2.66	8.58	3.16	2.39	43.88
Average	1.74	1.79	2.45	3.29	3.72	3.94	3.94	3.55	3.31	2.78	2.96	2.92	36.22

E. Physiography and Geology

The surficial physiography and geology of the study watershed area is the result of the most recent glacial period known as the Wisconsin Age that began about 70,000 years ago. Prior to the Wisconsin Age, Indiana had been glaciated twice, though the Wisconsinian glacier can be credited with building the topography in northeastern Indiana. During the main advance about 21,000 years ago, the Wisconsinian glacier covered two-thirds of the state. Numerous glacial advances and retreats resulted in moraine deposition and the formation of Indiana topography as it is known today.

The stalling of the Huron-Saginaw Lobe of the Wisconsin ice sheet deposited the Packerton Moraine (Figure 4) and established the current topography of the study watershed about 15,000 years ago. As the glacier retreated it left a thick, complex deposit of glacial material that is over 450 feet thick in some places (Homoya et al., 1985). Glacial topography of the area is also complex and varied composed of kettles, moraines, outwash plains, kames (irregular, short ridge or hill of stratified glacial drift), and valleys. Most of Indiana's natural lakes were formed during the advance and retreat of the Huron-Saginaw Lobe.

In physiographic terms, the Upper Tippecanoe River Watershed is part of the Steuben Morainal Lake Area (Schneider, 1966). The Steuben Morainal Lake Area is characterized by more physiographic and topographic variety than any other physiographic unit in Indiana. Knob and kettle end moraine topography can be found throughout the Packerton Moraine. The knob outcroppings are composed of ice-contact sand and gravel deposits (kame complexes) or glacial till material. The watershed streams themselves were probably glacial meltwater channels leading to the broad outwash plain currently occupied by the Tippecanoe River. Streams in the area typically are clear and of medium to low gradient with sandy gravel substrates (Homoya, 1985).

The glacial topography of the area is underlain by shale bedrock formed during the Devonian and Mississippian Ages about 20 to 60 million years ago (Gutschick, 1966). The bedrock slopes at about 30 ft/mi to the northeast and is part of the Michigan Basin (Arihood, 1998). Bedrock elevations vary between about 275-710 feet above sea level in the study area. Unconsolidated material directly above the bedrock contains aquifers which serve as the water source for the area.

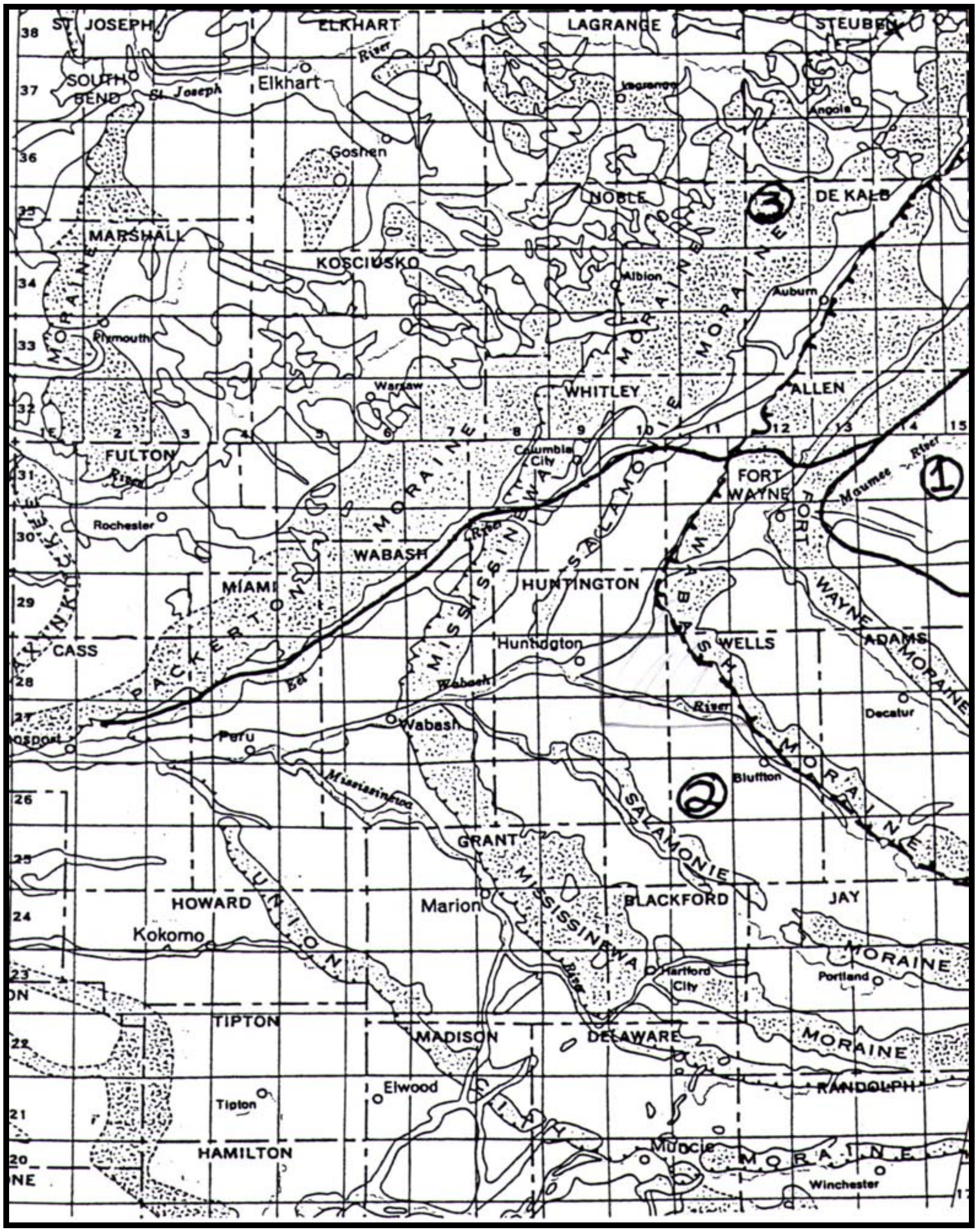


Figure 4. Moraine deposits in Northern Indiana from the Wisconsin glacial period.

F. Soils

The soil types found in Kosciusko, Noble, and Whitley Counties are a product of the original parent materials deposited by the glaciers that covered the area 12,000 to 15,000 years ago. The main parent materials found in the counties are glacial outwash and till, ice-contact sand and gravel deposits, alluvium, and organic materials that were left as the glaciers receded. The interaction of these parent materials with the physical, chemical, and biological variables found in the area, time, and the physical and mineralogical composition of the parent material formed the soils located in the three counties today.

Surficial Saginaw-Huron Lobe deposits are characteristically sand, sandy loams, and gravel within and west of the Packerton moraine (Figure 4). The deposits form nine dominant soil series (STATSGO soils) in the watershed (Figure 5). In order to provide a digital GIS coverage of soils for use with broad level planning, the Natural Resources Conservation Service developed the State Soil Geographic Database (STATSGO). The NRCS developed the coverage by generalizing detailed soils survey maps; if detailed maps were not available, the NRCS derived soils data from existing topographic, geologic, and vegetative information. Because the STATSGO soils were developed at a broad scale (1:250,000), they should only be used on multi-county or larger scales. Additionally, STATSGO soils are named by the soil series most accurately represented by the components of the soil. For example, a soil named "Elston" will have characteristics consistent with those of the Elston series. However, not all soils in the STATSGO series will be Elston soils. Table 4 contains information on these dominant soil series and where they may be found within the general topography. Table 5 identifies the distribution of dominant soil series in each subwatershed.

Table 4. Characteristics of major soil types found within the study watershed.

County	Series	Description	Texture	Formation Process	Location
Kosciusko, Noble, Whitley	Glynwood	silt loam	fine	in glacial till on till plains and moraines	over dense till
Kosciusko, Noble, Whitley	Houghton	muck, sandy clay loam, clay loam	fine	in herbaceous organic deposits	on lake plains, outwash plains, ground end moraines and floodplains
Kosciusko, Noble, Whitley	Riddles	sandy loam, sandy clay loam	fine	in loamy and sandy till	on uplands
Kosciusko, Noble, Whitley	Wawasee	sandy loam, sandy clay loam	fine	in glacial till	moraines and till plains
Kosciusko, Noble	Spinks	loamy sand, sandy loam, sand	moderate to coarse	in sandy outwash material	on moraines, till plains, beach plains
Kosciusko, Noble, Whitley	Crosier	loam, clay loam, sandy clay loam	fine	in glacial till	on till plains and moraines
Noble	Hoytville	silt loam, clay loam, loam	moderate	under mixed hardwoods in glacial till	on till plains and moraines
Noble	Kalamazoo	sandy loam	fine	in loamy outwash overlying sand, loamy sand or gravel outwash	on outwash plains or low-lying moraines
Kosciusko	Elston	sandy loam, gravel	fine to coarse	in glacial till	on outwash plains

Source: McCarter, 1977; Staley, 1989; Ruesh, 1990

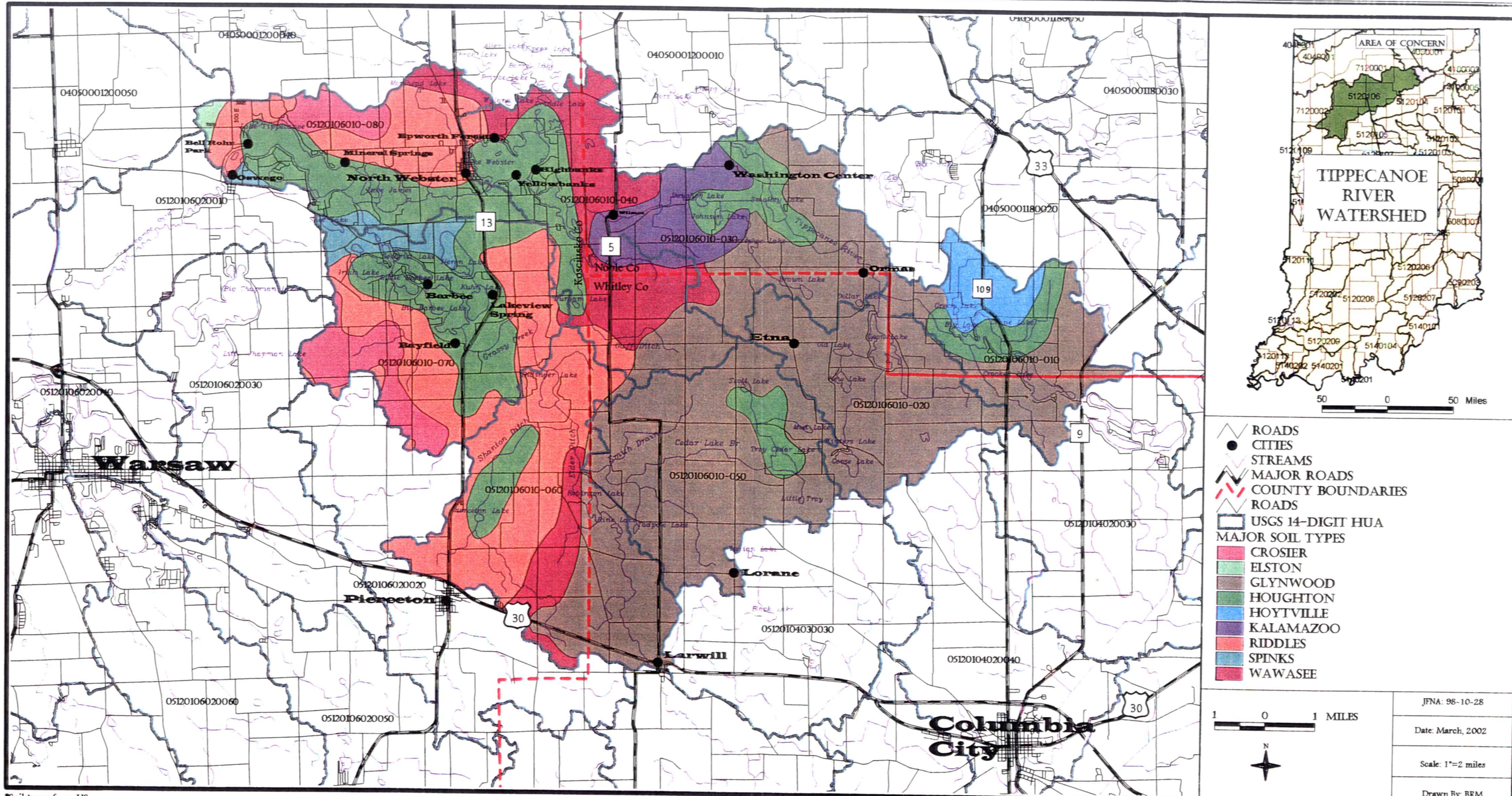


Figure 5
Major Soil Types
Upper Tippecanoe River Watershed

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Table 5. Dominant soil series and total area (acres) by subwatershed in the Upper Tippecanoe River Watershed.

Subwatershed	Glynwood	Houghton	Riddles	Wawasee	Spinks	Crosier	Hoytville	Kalamazoo	Elston
Tippecanoe	-	3264.8	3079.4	433.9	418.4	812.8	-	-	174.8
Webster/Backwaters	1282.1	2545.7	683.9	3874.3	-	-	-	549.8	-
Smalley	4707.7	1529.3	-	525.2	-	-	-	2163.5	-
Barbee Lakes	-	4150.5	3981.7	39.3	973.1	1896.3	-	-	-
Crooked/Big	3531.5	1356.2	-	-	-	-	1445.6	-	-
Goose/Loon	7259.3	-	-	-	-	-	-	-	-
Ridinger/Robinson	4045.9	957.6	5437.6	1568.2	-	-	-	-	-
Elder Ditch	9232.3	891	20.2	0.4	-	-	-	-	-

Highly Erodible Soils

Soils in the watersheds and their ability to erode or sustain certain land use practices can impact the water quality of the river systems in the watershed. For example, highly erodible soils are, as their name implies, easily erodible. Soils that erode from the landscape are transported to waterways where they impair water quality, interfere with recreational uses, and impair aquatic habitat. In addition, such soils carry attached nutrients, which further impair water quality by increasing plant and algae growth. Soil-associated chemicals like some herbicides and pesticides can kill aquatic life and damage water quality.

Table 6 lists the soil units considered highly erodible by the Natural Resources Conservation Service (NRCS). It is important to note that highly erodible soil designations are based on county-wide soil surveys, and the soils at various locations have not necessarily been field- checked. Kosciusko, Noble, and Whitley Counties contain 4, 29, and 12 highly erodible soil types respectively.

Table 6. Soil units within the watershed area considered highly erodible by the NRCS offices of Kosciusko, Noble, and Whitley Counties.

County	Soil Unit	Soil Name	Soil Description
Kosciusko	BoC	Boyer loamy sand	6-12% slopes
Kosciusko	MrD3	Miami clay loam	12-18% slopes, severely eroded
Kosciusko	MvC2	Morley loam	6-12% slopes, eroded
Kosciusko, Whitley	MxD3	Morley clay loam	12-20% slope, severely eroded
Noble	BlB2	Blount silt loam	2-4% slopes, eroded
Noble	BoD2	Boyer loamy sand	12-18% slopes, eroded
Noble	CcC3	Casco sandy clay loam	8-15% slopes, severely eroded
Noble	ChC	Chelsea fine sand	6-12% slopes
Noble	FoC2	Fox sandy loam	6-12% slopes, eroded
Noble	FsD2, FsE2	Fox-Casco sandy loam	12-25% slopes, eroded
Noble	MfB2-MfE2	Miami loam	2-25% slopes, eroded
Noble	MoD2	Miami loam	12-18% slopes, eroded
Noble	MgC3	Miami clay loam	6-18% slopes, severely eroded

Noble	MrB2-MrD2	Morley silt loam	2-18% slopes, eroded
County	**Soil Unit**	**Soil Name**	**Soil Description**
Noble	MsC3, MsD3	Morley silty clay loam	6-18% slopes, severely eroded
Noble, Whitley	MvC	Morley loam	6-12% slopes
Noble	MtE	Morley soils	18-25% slopes
Noble, Whitley	MvD2	Morley loam	12-20% slopes, eroded
Noble, Whitley	MvE2	Morley loam	20-30% slopes, eroded
Noble	MuC2	Morley, Miami, Rawson loams	6-12% slopes, eroded
Noble	OsC	Oshtemo loamy sand	6-12% slopes
Noble	RaC2	Rawson sandy loam	6-12% slopes, eroded
Noble	RbB	Rawson loam	2-6% slopes
Noble	RdB2	Rawson, Morley, Miami loams	2-6% slopes, eroded
Noble	RsC2, RsD2	Riddles sandy loam	6-18% slopes, eroded
Whitley	BvD	Boyer loamy sand	12-20% slopes
Whitley	HeG	Hennepin loam	25-50% slopes
Whitley	GtB3	Glynwood clay loam	3-8% slopes, severely eroded
Whitely	MmD2	Miami sandy loam	12-18% slopes, eroded
Whitley	MmE2	Miami sandy loam	18-25% slopes, eroded
Whitley	MoC3	Miami clay loam	6-12% slopes, severely eroded
Whitley	MoD3	Miami clay loam	12-20% slopes, severely eroded
Whitley	MxD3, MxE3	Morley clay loam	20-30% slope, severely eroded

Source: 1987 USDA/SCS Indiana Technical Guide Section II-C for Kosciusko County; 1987 USDA/SCS Indiana Technical Guide Section II-C for Noble County; 1987 USDA/SCS Indiana Technical Guide Section II-C for Whitley County.

Erosion is a major management concern for agricultural land mapped in the soil types listed in Table 6. Miami loam, clay loam, and sandy loam soils (MoD2, MrD3, MmD2-MmE2, MoC3-MoD3) are prone to erosion, and due to moderately slow permeability, runoff from these soils occurs rapidly. Although little land in the watershed is mapped in steeply sloped Miami loam (MoD2) and Miami clay loam (MrD3) soils, these soils are particularly erosion vulnerable. Though not well suited for crop cultivation, conservation practices are necessary if the land mapped in these soils is to be cultivated. Erosion is also the primary risk associated with farming Morley loam and clay loam soils (MvC, MxD3-MxE3). Due to soil compaction propensity, severe slopes, and moderately slow permeability, erosion of these Morley soils must be controlled by the incorporation of conservation practices on agricultural land.

Erosion, soil blowing, rapid runoff, and organic matter depletion are risks associated with the remaining soils listed in Table 6. Many of the soils are suited to cultivation as long as erosion is controlled with Best Management Practices (BMPs) and soil organic matter is maintained. However, Boyer loamy sand (BoD2), Casco sandy clay loam (CcC3), the Fox-Casco sandy loams (FsD2-FsE2), Glynwood clay loam (GtB3), Hennepin loam (HeG), Miami loams (MgC3, MmD2-MmE2, MoC3-MoD3), and Morley soils (MtE, MvC2-MvE2, MxD3-MxE3) are not suited for row crop cultivation under most circumstances.

Considerations for On-Site Wastewater Disposal Systems

Background Information

Nearly half of Indiana's population lives in residences with private waste disposal systems (Thomas, 1996). As is common in rural Indiana, many homes use septic tanks and septic tank absorption fields for wastewater treatment within the Upper Tippecanoe River Watershed. This type of wastewater treatment system relies on the septic tank for primary treatment to remove solids and the soil for secondary treatment to reduce the remaining pollutants in the effluent to levels that protect surface and groundwater from contamination.

A variety of factors can affect a soil's ability to function as a septic absorption field. Seven soil characteristics are currently used to determine soil suitability for on-site sewage disposal systems: position in the landscape, slope, soil texture, soil structure, soil consistency, depth to limiting layers, and depth to seasonal high water table (Thomas, 1996). The ability of soil to treat effluent (waste discharge) depends on four factors: the amount of accessible soil particle surface area, the chemical properties of the surfaces, soil conditions like temperature, moisture, and oxygen content, and the types of pollutants present in the effluent (Cogger, 1989).

The amount of accessible soil particle surface area depends both on particle size and porosity. Because they are smaller, clay particles have a greater surface area per unit volume than silt or sand and therefore, a greater potential for chemical activity. However, soil surfaces only play a role if wastewater can contact them. Soils of high clay content or soils that have been compacted often have few pores that can be penetrated by water and are not suitable for septic systems because they are too impermeable. Additionally, some clays swell and expand on contact with water, closing spaces and pores in the profile even more. On the other hand, very coarse soils may not offer satisfactory effluent treatment either because the water can travel rapidly through the soil profile. Soils located on sloped land also may have difficulty in treating wastewater due to reduced contact time.

Chemical properties of the soil surfaces are also important for wastewater treatment. For example, clay materials all have imperfections in their crystal structure which gives them a negative charge along their surfaces. Due to their negative charge, they can bond cations of positive charge to their surfaces. However, many pollutants in wastewater are also negatively charged and are not attracted to the clays. Clays can help remove and inactivate bacteria, viruses, and some organic compounds.

Environmental soil conditions influence the microorganism community which ultimately carries out the treatment of wastewater. Factors like temperature, moisture, and oxygen availability influence microbial action. Excess water or ponding saturates soil pores and slows oxygen transfer. The soil may become anaerobic if oxygen is depleted. Decomposition process (and therefore, effluent treatment) becomes less efficient, slower, and less complete if oxygen is not available.

Many of the nutrients and pollutants of concern are removed safely if a septic system is sited correctly. Most soils have a large capacity to hold phosphate. On the other hand, nitrate (the end product of nitrogen metabolism in a properly functioning septic system) is very soluble in soil solution and is often leached to the groundwater. Care must be taken in siting the system to avoid well contamination. Nearly all organic matter in wastewater is biodegradable as long as oxygen is present. Pathogens can be both retained and inactivated within the soil as long as conditions are right. Bacteria and viruses are much smaller than other pathogenic organisms associated with wastewater and therefore, have a much greater potential for movement through the soil. Clay minerals and other soil components may adsorb them, but retention is not necessarily permanent. During stormflows, they may become resuspended in the soil solution and transported in the soil profile. Inactivation and destruction of pathogens occurs more rapidly in soils containing oxygen because sewage organisms compete poorly with the natural soil microorganisms, which are obligate aerobes requiring oxygen for life. Sewage organisms live longer under anaerobic conditions without oxygen and at lower soil temperatures because natural soil microbial activity is reduced.

The Study Watershed Area

Soil conditions such as slow permeability and high water table, coupled with poor design, faulty construction, and lack of maintenance reduce the average life span of septic systems in Indiana to 7-10 years (Jones and Yahner, 1994). Likewise, several onsite systems located in morainal soils in other neighboring areas are known to perform poorly or to have failed completely (Indiana University/Purdue University, 1996). Localized soil-geologic conditions are responsible for most of the problems. In fact in Wells County, the Indiana State Department of Health and the Wells County Health Board have instituted a moratorium on residential development within the Wabash End Moraine in an area known as “Buttermilk Ridge”, a part of Union Township (Section 14, T28N, R11E). Although no extensive studies have been conducted within the Packerton Moraine of the immediate watershed area, soil types there share similar soil composition characteristics with soils found in the Wabash End Moraine.

The NRCS ranks each soil series in terms of its limitations for use as a septic tank absorption field. Each soil series is placed in one of three categories: slightly limited, moderately limited, or severely limited. Use of septic absorption fields on soils in the moderately or severely limited categories generally requires special designs, planning, or maintenance to overcome the limitations. Table 7 summarizes the dominant soil series located in the study watershed in terms of their suitability for use as a septic tank absorption field.

Table 7. Dominant soil series in the Upper Tippecanoe River Watershed and their suitability for on-site wastewater treatment systems.

County	Name	Depth to Water Table	Suitability for Septic Absorption Field
Kosciusko, Noble, Whitley	Crosier loam	1-3 ft	Severe: Slow percolation; wetness
Kosciusko, Noble, Whitley	Morley-Glynwood complex	2-3.5 ft	Severe: Slow percolation; wetness
Kosciusko, Noble Whitley	Houghton muck	+1-1 ft	Severe: Subsides; ponding; slow percolation
Kosciusko, Noble, Whitley	Riddles fine sandy loam	>6 ft	Moderate: Slow percolation Severe: Slope
Kosciusko, Noble, Whitley	Wawasee fine sandy loam	>6 ft	Moderate: Slow percolation; slope
Kosciusko	Elston sandy loam	>6 ft	Severe: Wetness
Noble	Hoytville sandy loam	1-3 ft	Severe: Poorly drained
Noble	Kalamazoo sandy loam	>6 ft	Severe: Wetness
Kosciusko, Noble	Spinks sandy loam	>6 ft	Severe: Wetness

Source: McCarter, 1977; Staley, 1989; Ruesh, 1990

None of the dominant soil series present in the study drainage possess a ranking of "slightly limited" for septic leachate treatment. All nine dominant soil series are moderately to severely limited for use as septic leach field and are generally not conducive to the satisfactory operation of conventional on-site treatment systems. Crosier loam, Riddles and Wawasee fine sandy loam, Elston, Spinks, Kalamazoo, and Hoytville sandy loam, and the Morley-Glynwood complex tend to be wet, poorly drained soils of slow permeability. High water tables especially during wet seasons can cause soil saturation and even ponding. Characteristic wetness can lead to anoxic conditions and improper treatment within leach fields. It is recommended that systems be: installed with perimeter subsurface drains to lower the water table, installed with an enlarged leach field to offset slow permeability, and constructed when the soil is dry to avoid soil sealing and compaction.

Due to ponding and low soil strength which causes subsidence, Houghton (Ht, Hx) muck soils are also severely compromised for septic effluent treatment. The water table is often within one foot of the surface, and because the water table is often at the same level as surface water features (like lakes and streams), achieving proper septic field drainage may be impossible (McCarter, 1977).

Many of the dominant soil types in the study watershed have severe limitations for septic suitability (Table 7). Geologic conditions in many parts of the diffuse moraine deposits are not likely to promote satisfactory septic system function resulting in surface and groundwater pollution. Although no septic inspections or sampling were conducted as part of this study, stream water quality sampling conducted by TELWF and the Kosciusko County Health Department in 2001 suggests improperly functioning systems are a possible cause of surface water pollution in the watershed. In some samples collected by these groups, *E. coli* concentrations in area streams following storm events exceeded 5,000 col/100ml. However, manure spreading for fertilizer is a common practice in the study area, and runoff from fields where manure has recently been spread can result in elevated stream *E. coli* levels as well.

To address these issues and concerns, residential development should proceed with caution especially in soils unsuited for conventional septic systems. Competent soil scientists that are familiar with conditions should evaluate potential development sites for evidence of poor water movement, soil development, or filtering ability. Alternative technology, like the mound system, the at-grade system, the pressure-dosed system, or wastewater wetlands may provide a solution in soils that are unsuitable. Some soils may be suitable for alternating field technology which requires that a second field be available to accept effluent while the primary field "rests". Enlarged septic fields should be installed to increase the area of absorption. It is important to note, however, that some soils are too wet, too shallow, too impermeable, too steep, or too well-drained for any type of system.

Once the proper technology has been installed, proper maintenance is very important. Depending on the size of the system and the loading to it, systems should be cleaned out every 2 to 5 years. Property owners should divert surface runoff away from absorption fields, keep a cover of vegetation over the field, and keep foot and vehicular traffic over the field to a minimum. Pressure on septic systems can also be reduced by common water conservation practices like shorter showers and less flushing and rinsing within reason.

Soil Discussion and Summary

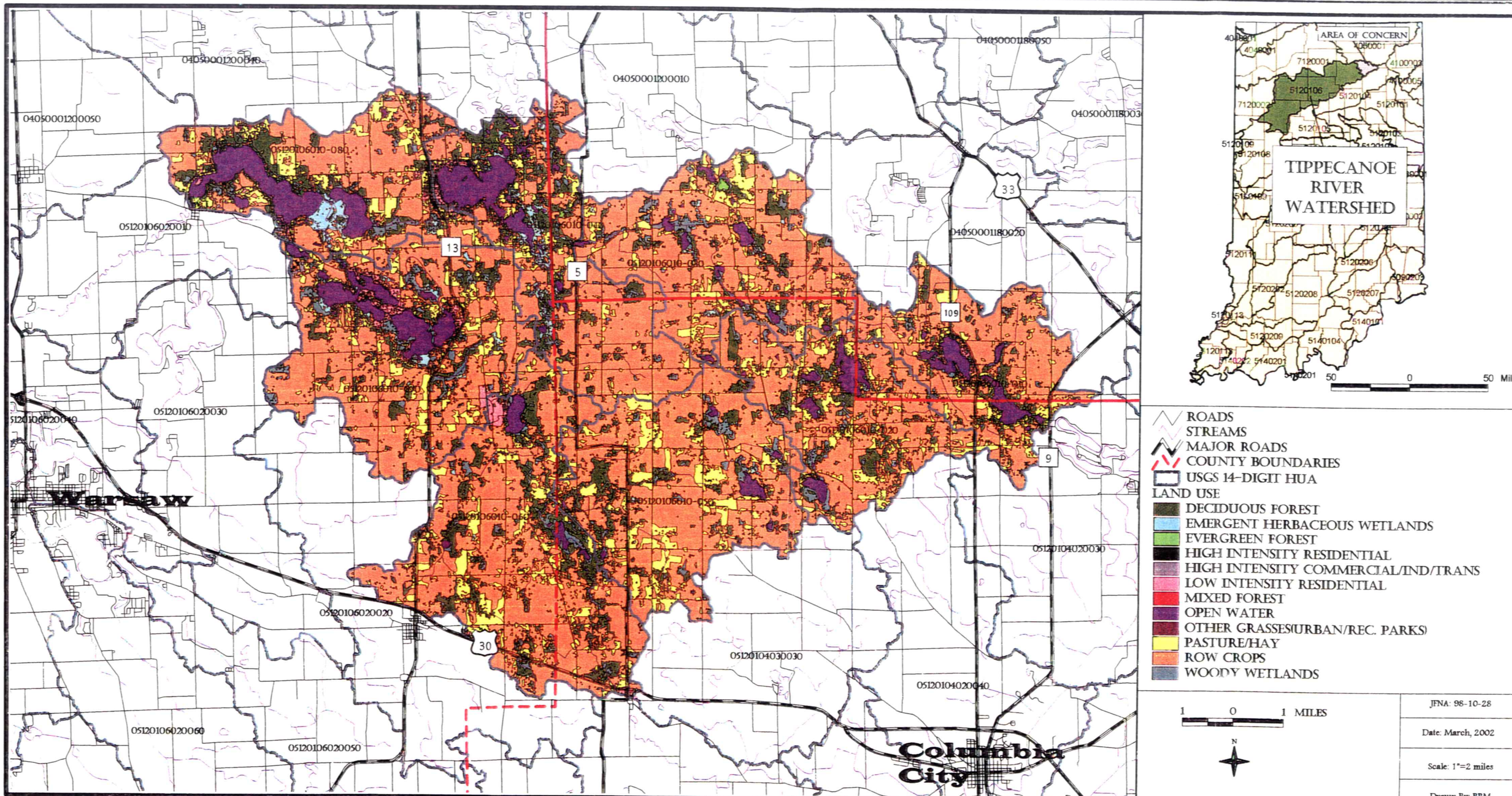
The type of soils in a watershed and the land uses practiced on those soils can impact the quality of the water in the watershed. Soil erosion contributes sediment to the rivers reducing water quality downstream, degrading aquatic habitat, and interfering with recreational uses. Nutrients attached to eroded soils fertilize and increase aquatic production. Additionally, soil eroding from the landscape accumulates in ditches and drainageways necessitating costly dredging maintenance projects. Not only does the sediment hinder water conveyance, it also provides a nutrient-rich substrate for rooted aquatic plant growth. Nutrients and nutrient-rich sediment can promote the growth of nuisance levels of algae and plants downstream in other waterbodies. Consequently, conservation methods and best management practices (BMPs) should be utilized when soils are disturbed in these areas. This includes residential development and farming practices in highly erodible soils.

Soil type should also be considered in siting septic systems. Some soils do not provide adequate treatment for septic tank effluent. Much of the land in the study watershed is mapped in soils that rate as severely limited for use as septic tank absorption fields. This is typical for much of Indiana, as research by Dr. Donald Jones suggests that 80% of the soils in Indiana are unsuitable for wastewater treatment (Grant, 1999).

Pollution from septic tank effluent can affect waterways, the life they support, and the waterbodies' users in a variety of ways. It can contribute to eutrophication (overproduction) and water quality impairment of lakes and other waterbodies in the watershed. In addition, septic tank effluent potentially poses a health concern for users of both surface and groundwater in the watershed. Swimmers, anglers, or boaters that have body contact with contaminated water may be exposed to waterborne pathogens. This is an issue of concern for the Upper Tippecanoe River, its tributaries, and its receiving waterbody, the Tippecanoe River, since according to Indiana State statutes, these waterbodies should support contact recreation as a beneficial use (IDEM, 2000; IAC, 2000). Fecal contaminants can be harmful to humans and cause serious diseases, such as infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illness. Additionally, nitrogen and pathogens may also leach into the groundwater compromising well water for drinking.

G. Land Use

Figure 6 and Table 8 present land use information for the Upper Tippecanoe River Watershed. Land use data was obtained from USGS/EROS Indiana land cover data. This data was corrected to reflect conditions present in December 1998. Land use data for each subwatershed is presented in Appendix A.



*Land use from USGS EROS Land Use Data, 1998

Figure 6
Land Use
Upper Tippecanoe River Watershed

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Table 8. Land use in the Upper Tippecanoe River Watershed.

Land Use	Area (acres)	Area (ha)	Percent of Watershed
Deciduous Forest	8322.0	3367.8	11.4%
Emergent Herbaceous Wetland	1126.0	455.7	1.5%
Evergreen Forest	90.0	36.4	0.1%
High Intensity Residential	80.0	32.4	0.1%
Low Intensity Residential	982.0	397.4	1.3%
High Intensity Commercial	149.0	60.3	0.2%
Mixed Forest	9.0	3.6	0.0%
Open Water	4609.0	1865.2	6.3%
Other Grasses (Urban/rec. parks)	35.0	14.2	0.0%
Pasture/Hay	9781.0	3958.2	13.4%
Row Crops	45255.0	18314.0	62.1%
Woody Wetlands	2444.0	989.0	3.4%
Total	72882.0	29494.3	100.0%

Source: USGS/EROS Indiana Land Cover Data Sheet, Version 98-12 (updated December 1998)

Approximately 76% of the watershed is used for agricultural purposes, including cropland, pasture, and agricultural woodlots. Sixty-two percent is used for row crop production. This percentage approximates those estimated by the U.S. Census of Agriculture (1997) for Kosciusko (72%), Noble (69%), and Whitley (77%) Counties. Because the watershed is located in a rural area, more land is used for agriculture than is average for the counties. Table 9 contains more detailed U.S. Census of Agriculture (1997) data for the three counties.

Table 9. Detailed 1997 U.S. Census of Agriculture data for Kosciusko, Whitley and Noble Counties.

County	# of Farms	Land in Farms (acres)	Total Land (acres)	Percent of County Farmed
Kosciusko	1,130	246,900	344,012	72%
Noble	942	182,000	263,125	69%
Whitley	787	165,067	214,720	77%

Source: U.S. Census of Agriculture, United States Department of Commerce (1997).

In general, row crop agriculture dominates land use throughout the subwatersheds (Figure 7). The Barbee Lakes Subwatershed is the most diverse with respect to different types of land use while Smalley Subwatershed is the least diverse. The Tippecanoe Subwatershed contains the only notable acreage of urban land use due to the municipality of North Webster.

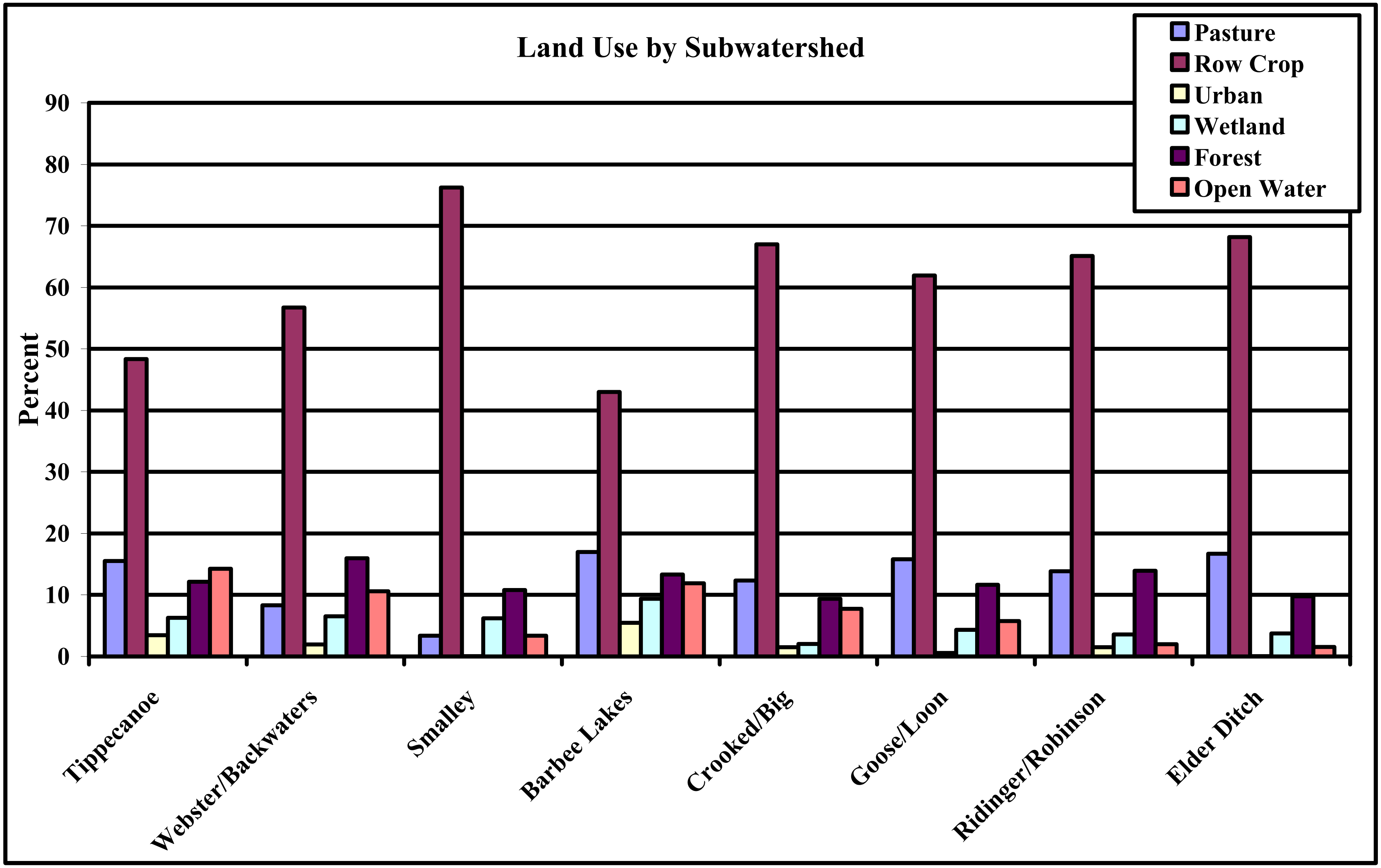

Figure 7. Lane use by subwatershed.

Wetlands

Wetlands provide a variety of functions for an ecosystem. These functions include filtering sediment and nutrients in runoff, detaining water and allowing for groundwater recharge and discharge, and providing nesting habitat for waterfowl and spawning sites for fish. By performing these roles, healthy, functioning wetlands often improve the water quality and biological health of streams and lakes located downstream of wetlands.

The land use table (Table 8) indicates that wetlands account for approximately 4.9% of the Upper Tippecanoe Watershed. Table 10 presents the acreage of wetlands by type. The IDNR (Indiana Wetland Conservation Plan, 1996) estimates that approximately 85% of the state's wetlands have been filled. The greatest loss has occurred in the northern counties of the state such as Kosciusko, Noble, and Whitley Counties. The last glacial retreat in these northern counties left level landscapes dotted with wetland and lake complexes. Development of the land in these counties for agricultural purposes altered much of the natural hydrology eliminating many of the wetlands. The 1978 census of agriculture found that drainage is artificially enhanced on 38%, 35% and 45% of the land in Kosciusko, Noble, and Whitley Counties, respectively (cited in Hudak, 1995).

Aside from agricultural uses, wetlands and forests represent the other notable land use within the study watershed (Figure 7). In some cases like along the Barbee Lakes or Lake Tippecanoe, these wetland natural areas directly border lakes and stream segments. Figure 8 further classifies the wetlands based on National Wetland Inventory (NWI) data. According to the NWI data, most wet areas are lacustrine and palustrine, emergent wetlands (Table 10). Due to the small remaining amount of forested land and wetland (only about 16% of the watershed) their protection is merited. Farmers should also be encouraged to route drainage tiles toward specified treatment wetlands or filter areas. Riparian buffer area filtration is drastically reduced when drainage tiles completely bypass them, carrying drainage waters directly to the downstream ditches and lakes.

Table 10. National Wetland Inventory (NWI) data for the Upper Tippecanoe River Watershed.

Wetland Type	Area (acres)	Area (ha)	Percent of Watershed
Lacustrine	4,031.1	1,631	5.5%
Palustrine emergent	2920	1,182	4.0%
Palustrine forested	2,386.2	965.7	3.3%
Palustrine scrub/shrub	971.7	393	1.3%
Palustrine submergent	11	4.5	0.1%
Ponds	574.2	232	0.8%
Riverine	23.4	9.5	0.3%
Upland	61,928.4	25,061	85.0%

H. Freshwater Mussels

During the past 30 year, numbers of both individual and species diversity of native mussels have declined throughout the United States. The high numbers of imperiled freshwater mussels in the United States, which harbors the most diverse fauna in the world, are on a path towards an extinction crisis, that if left unchecked, will severely impoverish one of the richest components

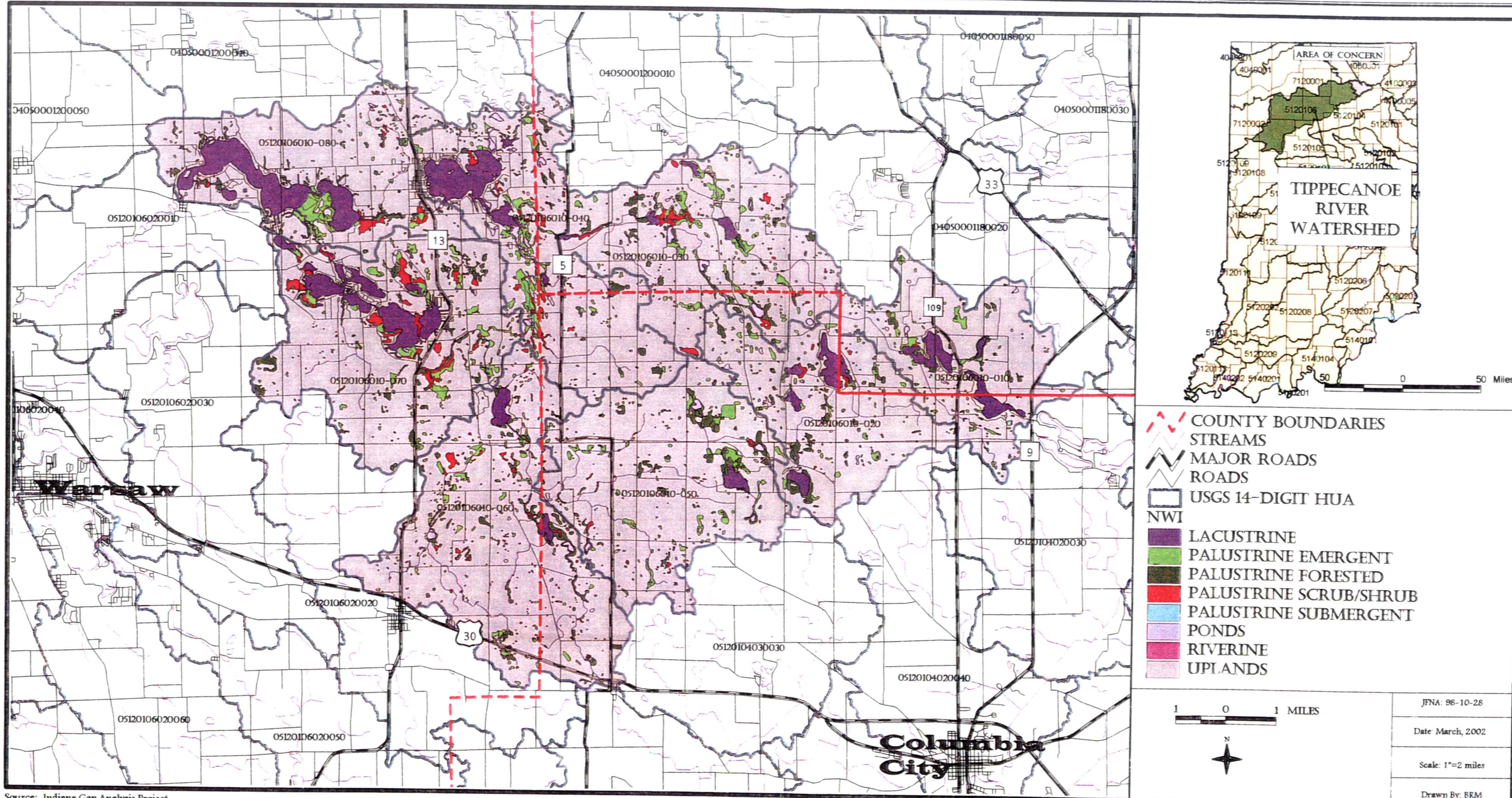

Figure 8
National Wetlands Inventory
Upper Tippecanoe River Watershed

J.F. New & Associates
wetland consultants / environmental engineers

of aquatic biodiversity. (Williams, et al., 1993). The Nature Conservancy recognized that 55 % of North America's mussels as extinct or imperiled compared to "only" 7 % of the continent's bird and mammal species (Master, 1990). This alarming decline is primarily the result of habitat destruction and degradation associated with adverse anthropogenic activities. The decline of freshwater mussels during the past century has involved a variety of threats, the single most important being destruction of habitat (Williams, et al., 1993). Mussels are sessile organisms and are considered good indicators of the health of aquatic ecosystems. They are dependent on good water quality, physical habitat conditions, and an environment that will support populations of host fish.

The Upper Tippecanoe River watershed provides ample habitat for unionid (freshwater mussel) species. Scott (1926) described the Upper Tippecanoe River as "the only stream in Indiana that remains approximately in natural condition". The unique, high quality habitat supported a diverse, widely distributed unionid population. Historical records (1903, 1987, and 1991) indicate that the Tippecanoe River sustained 57 species of freshwater mussels (Ecological Specialists, 1993). Today, land use changes, dredging and straightening of stream channels, increasingly silty substrates, and stagnant, slow flowing water threaten freshwater mussel populations. Despite current conditions, two recent surveys indicate that many of the original Tippecanoe River fauna are still in residence in limited distribution (Cummings et al., 1987; Ecological Specialist, 1993). A list of unionid species observed in the Upper Tippecanoe River Watershed is displayed in Table 11. Many of these species including the northern riffleshell (*Torulosa rangiana*), the wavyrayed lampmussel (*Lampsilis fasciola*), the kidneyshell (*Ptychobranchus fasciolaris*), and the purple lilliput (*Toxolasma lividus*) are state threatened or rare, while the clubshell (*Pleurobema clava*) is federally endangered. Preservation of the high quality mussel habitat in the headwaters of the Upper Tippecanoe River (Ormas to Smalley Lake) requires the maintenance of riparian areas and the limitation of sedimentation, along with continuing to monitor the water quality.

Table 11. Mussel species collected in the Upper Tippecanoe River watershed. X indicates the collection of mussel shells; Y indicates that species were collected during the sample.

Species	Scientific Name	North Webster*	Oswego**	1993
Clubshell	*Pleurobema clava*		3	Y
Creek heelsplitter	*Lasmigona compressa*		2	
Elk toe	*Alasmidonta marginata*		X	
Fat mucket	*Lampsilis radiata luteola*	4	5	Y
Fluted shell	*Lasmigona costata*		1	
Giant floater	*Anodonta grandis*	6		Y
Kidneyshell	*Ptychobranchus fasciolaris*	21	53	Y
Lady finger	*Elliptio dilatata*	20	8	
Little purple	*Toxolasma lividis*	1	X	
Northern riffleshell	*Epioblasma torulosa*	X	X	
Paper floater	*Anodonta imbecilis*		X	
Plain pocketbook	*Lampsilis cardium*	1	10	
Purple lilliput	*Strophitus undulatus undulatus*	14	7	
Rainbow shell	*Villosa iris iris*	1	22	Y
Round pig-toe	*Pleurobema sintoxia*	4	15	
Three ridge	*Amblema plicata*	96	X	Y
Wabash pig-toe	*Fusconaia flava*	14	23	Y
Wavy-rayed lampmussel	*Lampsilis fasciola*	1	3	Y

Total Number of Live Specimens	183	152	
Total Number of Live Species	12	12	
Total Number of Dead Species	1	5	
Total Number of Species	13	17	

Source: Illinois Natural History Survey, 1987; Ecological Specialists, 1993. *One-half mile southwest of North Webster at CR 750 E; **One mile southwest of Oswego

I. Fisheries

The Tippecanoe River fish fauna today is very similar to the early 1900's despite channelization of most tributaries, intensified agricultural practices and increased recreation and urbanization (Ecological Specialists, 1993).

Indiana Department of Natural Resources Fisheries Biologists conducted fish surveys on approximately 20 lakes in the Upper Tippecanoe River Watershed in 2001. Table 12 lists the species collected during these surveys. IDNR biologists collected a total of 51,645 fish representing 14 families and 54 species. Overall, nearly 80% of collected fish are game fish species. Game fish collected include largemouth bass (Micropterus salmoides), yellow perch (*Perca flavescens*), walleye (*Stizostedion vitreum*), muskellunge (*Esox masquinongy*), bluegill (*Lepomis macrochirus*), channel catfish (*Ictalurus punctatus*), rainbow trout (*Oncorhynchus mykiss*), white and black crappie (*Pomoxis annularis* and *P. nigromaculatus*), longear sunfish (*Lepomis megalotis*), northern pike (*Esox lucius*), rock bass (*Ambloplites rupestris*), white bass (*Morone chrysops*) and warmouth (*Lepomis gulosus*) (Pearson, personal communication). Bluegill dominated the survey comprising nearly 50% of the overall population. Largemouth bass (*Micropterus salmoides*), gizzard shad (*Dorosoma cepedianum*), yellow perch (*Perca flavescens*) and redear sunfish (*Lepomis microlophus*) were also important components of the community accounting for 9.8%, 8.7%, 6.0% and 5.2%, respectively.

The percentage of tolerant species and number of sensitive species in a system depends on the water quality and habitat conditions. Tolerant species are those that can tolerate a wide variety of environmental disturbances such as poor water quality or habitat degradation. Tolerant species, including white sucker (*Catostomus commersoni*), carp (*Cyprinus carpio*), and gizzard shad (*Dorosoma cepedianum*) comprised nearly 15% of the total population. Simon reports that if a lake's fish population is composed of less than 15% tolerant species, the fishery is of high quality (unpublished). Sensitive species are highly intolerant to a variety of environmental disturbances. IDNR biologists collected a total of eleven sensitive fish species. A population containing more than five sensitive species represents a high quality fishery (Simon, unpublished). The lakes of the Upper Tippecanoe River also contain a small population of hybrid sunfish (0.1% of the total population). Natural hybrids are common in sunfish, darter and minnow families in high quality systems (Simon, 1991). Overall, the lakes of the Upper Tippecanoe River possess a good quality fishery.

Table 12. Fish species (total number and total weight) collected in IDNR Fisheries Surveys conducted in the Upper Tippecanoe River Watershed in 2001.

County	Common Name	Scientific Name	Number	Weight (lb)
Kosciusko	Banded Killifish	*Fundulus diaphanous*	3	0.01
Kosciusko, Whitley	Black Bullhead	*Ameius nubulosus*	51	29
Kosciusko, Noble, Whitley	Black Crappie	*Pomoxis nigromaculatus*	1,231	337
Whitley	Blackchin Shiner	*Notropis heterodon*	1	0.00
Kosciusko	Blackside Darter	*Percina maculata*	1	0.01
Kosciusko, Noble, Whitley	Bluegill	*Lepomis macrochirus*	25,727	2,479
Kosciusko, Noble	Bluntnose Minnow	*Pimephales notatus*	79	0.39
Kosciusko, Noble, Whitley	Bowfin	*Amia calva*	126	506
Kosciusko, Noble, Whitley	Brook Silverside	*Labidesthes sicculus*	239	3
Kosciusko, Noble, Whitley	Brown Bulhead	*Ameiurus nebulosus*	517	534
Kosciusko, Noble, Whitley	Carp	*Cyprinus carpio*	175	1,148
Kosciusko	Central Mudminnow	*Umbra limi*	3	0.02
Kosciusko, Noble, Whitley	Channel Catfish	*Ictalurus punctatus*	397	894
Noble	Cisco	*Coregonus artedi*	3	5
Kosciusko	Common Shiner	*Luxilius cornutus*	5	28
Kosciusko	Fathead Minnow	*Pimephales promelus*	3	0.01
Kosciusko, Whitley	Gizzard Shad	*Dorosoma cepedianum*	4,531	1,886
Kosciusko	Golden Redhorse	*Moxostomata erythrurum*	25	40
Kosciusko, Noble, Whitley	Golden Shiner	*Notemigonus crysoleucas*	1,441	142
Kosciusko, Noble, Whitley	Grass Pickerel	*Esox americanus vermiculatus*	131	25
Kosciusko, Noble, Whitley	Green Sunfish	*Lepomis cyanellus*	26	2
Kosciusko, Noble, Whitley	Hybrid Sunfish	*Lepomis* species	50	11
Kosciusko	Johnny Darter	*Etheostoma nigrum*	3	0.00
Kosciusko, Noble, Whitley	Lake Chubsucker	*Erimyzon sucetta*	574	162
Kosciusko, Noble, Whitley	Largemouth Bass	*Micropterus salmoides*	5,090	2,703
Kosciusko, Noble, Whitley	Logperch	*Percina* species	237	1
Kosciusko	Longear Sunfish	*Lepomis megalotis*	299	29

County	Common Name	Scientific Name	Number	Weight (lb)
Kosciusko, Noble	Longnose Gar	*Lepisosteus platostomus*	40	158
Kosciusko, Noble	Muskellunge	*Esox masquinongy*	18	71
Kosciusko	Northern Hog Sucker	*Hypentelium nigricans*	4	4
Kosciusko, Noble	Northern Pike	*Esox lucius*	136	607
Kosciusko, Noble, Whitley	Pumpkinseed	*Lepomis gibbosus*	609	63
Kosciusko, Whitley	Quillback	*Carpoides cyprinus*	45	132
Kosciusko, Noble	Rainbow Trout	*Oncorhynchus mykiss*	26	22
Kosciusko, Noble, Whitley	Redear Sunfish	*Lepomis microlophus*	2,713	545
Kosciusko	River Redhorse	*Moxostomata carinatum*	4	11
Kosciusko, Noble	Rock Bass	*Amblioplites rupestris*	189	25
Kosciusko	Shorthead Redhorse	*Moxostomata macrolepidotum*	6	11
Whitley	Slender Madtom	*Notorus nocturnus*	3	0.02
Kosciusko, Noble	Smallmouth Bass	*Micropterus dolomieu*	7	5
Kosciusko	Spotfin Shiner	*Cyprinella spiloptera*	4	0.10
Kosciusko, Noble, Whitley	Spotted Gar	*Lepisosteus oculatus*	681	1,157
Kosciusko, Noble, Whitley	Spotted Sucker	*Minytrema melanops*	352	465
Whitley	Spotted Sunfish	*Lepomis puncatus*	1	0.05
Kosciusko	Starhead Topminnow	*Fundulus dispar*	1	0.00
Kosciusko	Steelcolor Shiner	*Cyprinella whipplei*	11	0.11
Kosciusko	Tadpole Madtom	*Notorus gyrinus*	2	0.02
Kosciusko	Walleye	*Stizostedion vitreum*	77	75
Kosciusko, Noble, Whitley	Warmouth	*Lepomis gulosus*	1,082	149
Kosciusko, Whitley	White Bass	*Morone chrysops*	289	189
Kosciusko, Whitley	White Crappie	*Pomoxis annularis*	73	32
Kosciusko, Noble, Whitley	White Sucker	*Catostomus commersoni*	683	982
Kosciusko, Noble, Whitley	Yellow Bullhead	*Ameiurus natalis*	573	353
Kosciusko, Noble, Whitley	Yellow Perch	*Perca flavescens*	3,048	743
		Total:	**51,645**	**16,766**

Source: Indiana Department of Natural Resources.

Fish Stocking

Fish stocking is a means of establishing naturally reproducing populations in a lake. Most stocking occurs to maintain game fish species. Species stocked are predominantly chosen based on public interest and fisheries management recommendations. Past stocking efforts that have been discontinued include channel catfish in Lake Tippecanoe and the Barbee Lakes and rainbow trout in Sechrist Lake. The Indiana

Department of Natural Resources (DNR) discontinued stocking these species for two reasons: 1) channel catfish established a naturally reproducing population in the Barbee Lakes and Lake Tippecanoe and 2) a fishery managers switched from stocking trout in Sechrist Lake to stocking muskellunge. Current stocking efforts in the watershed consist of only muskellunge in Webster Lake, Lake Tippecanoe, and the Barbee Chain of Lakes (Pearson, personal communication).

J. Endangered Species

The Indiana Natural Heritage Data Center database provides information on the presence of endangered, threatened, or rare species, high quality natural communities, and natural areas in Indiana. The IDNR developed the database was developed to assist in documenting the presence of special species and significant natural areas and to serve as a tool for setting management priorities in areas where special species or habitats exist. The database relies on observations from individuals rather than systematic field surveys by the IDNR. Because of this, it does not document every occurrence of special species or habitat. At the same time, the listing of a species or natural area does not guarantee that the listed species is currently present or that the listed area is in pristine condition. The database includes the date that the species or special habitat was last observed and reported in a specific location.

Appendix B presents the results from the database search for the Upper Tippecanoe River Watershed. (For additional reference, a listing of endangered, threatened, and rare species and high quality natural communities documented in Kosciusko, Noble, and Whitley Counties is included in Appendix C.) According to the database, the Upper Tippecanoe River Watershed and the area immediately adjacent to the watershed support a variety of endangered, threatened, and rare animals and plants. The listed animals include seven mollusks, five reptiles, three amphibians, fourteen birds, two fish, and two mammals. All of the thirty-five listed plants are hydrophytic plants, likely remnants from the original marshes that bordered the lakes in the watershed.

Several of the database entries are relatively recent. Cisco (*Coregonus artedi*) was last noted in 1997, the Blanding's turtle (*Emydoidea blandingii*) in 1992, the bigeye chub (*Hybopsis amblops*) in 1991, the marsh wren (*Cistothorus palustris*), the great blue heron (*Ardea herodias*) and the bobcat (*Lynx rufus*) in 1990. Multiple plant species were last noted in the 1990s. Most of the remaining entries in the database possess observed dates before 1985. Some observations date back to the 1910's and 1920's. Given the agricultural and residential development that has occurred in the watershed since the early part of the last century, it is unlikely that many of the endangered, threatened, and rare species listed in the database still inhabit the area.

K. Prior Studies

The Upper Tippecanoe River Watershed has been the focus of restoration efforts from numerous public and private agencies in the region due primarily to degraded stream and lake conditions caused by sedimentation and nutrient amplification. The following is a list of some of these restoration efforts/studies.

A. In 1989, the Tri-State University Department of Biology conducted a study entitled "Preliminary Investigation of the Lakes of Kosciusko County". The study examined 28 lakes within the St. Joseph River and Tippecanoe River Basins. The study authors analyzed various land use activities their impacts on the water quality of the lakes.

B. In 1990, the Agricultural Stabilization and Conservation Service, Purdue Cooperative Extension Service, and Soil Conservation Service completed a Water Quality Plan for the Upper

Tippecanoe River Watershed. The primary goal of the Water Quality Plan was to provide farmers with information regarding current or potential water quality problems.

C. In 1990, International Science and Technology, Inc. conducted a feasibility study for the restoration of Ridinger Lake. The study assessed current lake conditions, addressed potential threats to the lake and watershed, and developed mitigation strategies for improving the quality of the lake. No actions were taken on the recommendations.

D. In 1991, International Science and Technology, Inc. conducted the "Feasibility Study of Little Barbee Lake". The study recommended various watershed projects for improving water quality in Little Barbee Lake. Both streambank stabilization and sediment basin construction occurred following recommendations from this report.

E. In 1992, F.X. Browne Associates, Inc. conducted a feasibility study at Loon and Goose Lakes. The report presents water quality and modeling results for Indiana "T by 2000" Lake Enhancement Program Phase I. It also includes management alternatives for lake restoration and general recommendations. Design and construction of a wetland filter on Friskney Ditch followed report recommendations.

F. In 1993, Crisman conducted an assessment of watershed-lake interactions influencing the cultural eutrophication of Little Crooked & Crooked Lakes. The study examined current water quality and land use practices, delineated historical changes, and proposed management alternatives for controlling watershed loading of nutrients and sediments into the lakes and for management/restoration of the lakes. The local lake association proceeded with recommendations through the design and construction of a pond, wetland filter and ditch bank stabilization.

G. In 1995, the US Army Corps of Engineers released the first volume of a reconnaissance level investigation of water problems in the Upper Tippecanoe River Basin primarily in Kosciusko County, Indiana. The study focused on flooding issues around natural lakes in the county, measures to alleviate the problems, and environmental restoration opportunities.

H. In 1995, the Indiana Department of Natural Resources completed the Big Lake Diagnostic Study. The study characterized the lake and watershed, developed a list of concern areas, and identified multiple locations for watershed improvement projects.

I. In 1995, J.F. New and Associates, Inc. conducted the Loon Lake Wetland Design Study. The study authors determined the location for wetland restoration along Friskney Ditch, developed a planting plan, and completed the wetland restoration.

J. In 1997, J.F. New and Associates, Inc. conducted the Lake Tippecanoe Diagnostic Study. The study authors documented the extent of sedimentation, nutrient loading, and contamination within Lake Tippecanoe and its major tributaries.

K. In 2000, J.F. New and Associates, Inc. conducted the Lake Webster/Backwaters Area Diagnostic Study. The study authors assessed impacts to the lakes and their watershed, documented sediment and nutrient sources, and problem areas. Recommendations for improving water quality and aesthetics of the lakes and tributaries was also conducted.

L. In 2000, J.F. New and Associates, Inc. conducted the Barbee Lakes Diagnostic Study. The study assessed the ecological health of the Barbee Lakes Chain and the Grassy Creek Watershed, and documented sediment and nutrient sources. The study also included recommendations for improving water quality and aesthetics of the lakes and tributaries.

M. In 2001, The Indiana Chapter of the Nature Conservancy wrote the "Tippecanoe River Project Strategic Plan". The plan summarized historical events in and around the river, identified protection strategies for biological communities, prioritized stresses to the river system, and listed sources of stress.

N. In 2001, Donan Engineering instituted a project to determine the feasibility of the development and construction of a wetland/nutrient filter structure at the intersection of State Road 13 and Epworth Forest Road. The study will conclude with physical design of suggested projects and practices, and ensure project success.

O. In 2001, J.F. New and Associates initiated a stormwater treatment project for the stormwater drains in the town of North Webster that drain into Webster Lake. The project will include the collection of stormwater samples, determination of stormwater treatment solutions, and prioritization of the drains for stormwater treatment.

P. In 2001, J.F. New and Associates began a project to determine the feasibility of the development and construction of a wetland/nutrient filter along Putney Ditch about Little Barbee Lake. The project will include locating potential filter sites, surveying biological and habitat integrity, determining physical and social costs, and proposing a construction site.

Q. Multiple mussel and fish surveys, fisheries management plans and design studies for water quality improvement projects have also been completed. Contact the Kosciusko, Noble and Whitley SWCDs, TELWF or your local library for more information about your local lake or stream.

R. In 2002, J.F. New and Associates, Inc. conducted the North Webster storm drain engineering feasibility study. The project involved mapping and analysis of existing drains where sources of pollution may exist, suggesting maintenance and technology that may be used to address pollution, and examining the feasibility of project design and construction.

S. In 2004, J.F. New and Associates, Inc. conducted the Smalley Lake Diagnostic Study. The study assessed the ecological health of the lakes and the watershed, and documented sediment and nutrient sources. The study also included recommendations for improving water quality and aesthetics of the lakes and tributaries.

T. In 2004, J.F. New and Associates, Inc. conducted the Ridinger/Robinson Diagnostic Study. The study assessed the ecological health of the lake and the watershed, and documented sediment and nutrient sources. The study also included recommendations for improving water quality and aesthetics of the lakes and tributaries.

U. In 2005, Commonwealth Biomonitoring, Inc. conducted the Lake Tippecanoe Storm Drain Engineering Feasibility Study. This project was designed to map the location of existing storm drains around Tippecanoe Lake in Kosciusko County, Indiana and recommend solutions for addressing pollutants entering the lake in storm water runoff from streets surrounding the lake.

3.0 WATERSHED PARTERS/STAKEHOLDERS

A. State and Federal Agency Stakeholders

Indiana Department of Natural Resources (IDNR)
402 W. Washington Street
Indianapolis, IN 46204-2748

Division of Nature Preserves
Room W267
317-232-4052

Division of Fish & Wildlife
Room W273
317-232-4080

Division of Entomology & Plant Pathology
Room W290
317-232-4120

Division of Forestry
Room W296
317-232-4105

Division of Water
Room W264
317-232-4160

Division of Outdoor Recreation
Room W271
317-232-4070

Indiana Department of Environmental Management (IDEM)
100 N. Senate Avenue
P.O. Box 6015
Indianapolis, IN 46206-6015
317-233-8491
800-451-6027

Natural Resources Conservation Service (NRCS)
6013 Lakeside Boulevard
Indianapolis, IN 46278
317-290-3200

Farm Service Agency (FSA)
5981 Lakeside Boulevard
Indianapolis, IN 46278
317-290-3030

U.S. Army Corps of Engineers (USACE)
Louisville District
P.O. Box 59
Louisville, KY 40201-0059
502-582-5607

U.S. Environmental Protection Agency (USEPA)
Region 5
77 West Jackson Boulevard
Chicago, IL 60604-3590
800-632-8431

U.S. Fish & Wildlife Service (USFWS)
620 S. Walker Street
Bloomington, IN 47403-2121
812-334-4261

Indiana Association of Soil & Water Conservation Districts (IASWCD)
225 S. East Street, Suite 740
Indianapolis, IN 46202

Indiana Department of Transportation (INDOT)
100 N. Senate Avenue, Room N808
Indianapolis, IN 46204
317-232-5468

Indiana Chamber of Commerce
115 W. Washington Street #850 S.
Indianapolis, IN 46204
317-264-6881

Indiana State Department of Health
2 N. Meridian Street
Indianapolis, IN 46204
317-233-1325
Contact person: Gregory Wilson

Indiana Association of County Commissioners
County Office Building
20 N. 3rd Street
Lafayette, IN 47901-1214
765-423-9215
Contact person: Ruth Shedd

Indiana Association of Cities and Towns
150 W. Market Street, Suite 728
Indianapolis, IN 46204
317-237-6200
Contact person: Tonya Galbraith

Indiana Farm Bureau, Inc.
225 S. East Street
Indianapolis, IN 46202
317-692-7851

U.S. Senator Richard Lugar
(senator_lugar@lugar.senate.gov)
Federal Building Room 3158
1300 S. Harrison Street
Fort Wayne, IN 46802
260-422-1505

U.S. Senator Evan Bayh
(senator@bayh.senate.gov)
10 W. Market Street, Suite 1650
Indianapolis, IN 46204
317-554-0750

U.S. Representative Mark Souder
3105 Federal Building
1300 Harrison Street
Fort Wayne, IN 46802
260-424-3041

B. <u>Local Offices of State & Federal Agency Stakeholders</u>

Indiana Department of Environmental Management (IDEM)
220 W. Colfax Avenue
South Bend, IN 46601-1634
800-753-5519

Natural Resources Conservation Service (NRCS)

Kosciusko County
Contact Person: Sam St. Clair
217 E. Bell Drive
Warsaw, IN 46580
574-267-5726

Whitley County
Contact Person: Amy Lybarger
1911 E. Business 30
Columbia City, IN 46725
260-244-6780

Noble County
Contact Person: Wayne Stanger
100 E. Park Drive
Albion, IN 46701
260-636-7682

Farm Service Agency (FSA)

Kosciusko County
Contact Person: Leila Knoblock
217 E. Bell Drive
Warsaw, IN 46580
574-267-7445

Whitley County
Contact Person: Eric Mason
1911 E. Business 30
Columbia City, IN 46725
260-244-6780

Noble County
Contact Person: Karl Clark
100 E. Park Drive
Albion, IN 46701
260-636-7682

Indiana Department of Natural Resources (IDNR)

Division of Fish & Wildlife
Contact Person: Randy Millar, Property

Manager
Tri-County FWA
8432 N. 850 E.
Syracuse, IN 46567
574-834-4461

Division of Fish & Wildlife
Contact Person: Jed Pearson, Fisheries Biologist/Ed Braun, Fisheries Biologist
Tri-Lakes Fisheries Station
5570 N. Fish Hatchery Road
Columbia City, IN 46725

Soil & Water Conservation District

Kosciusko County
Contact Person: Wanda Bruner
217 E. Bell Drive
Warsaw, IN 46580
574-267-7445

Whitley County
Contact Person: Nadean Eldien
1919 E. Business 30
Columbia City, IN 46725
219-244-6266

Noble County
Contact Person: Stacey McGinnis
100 E. Park Drive
Albion, IN 46701
260-636-7682

C. State Government Stakeholders

Senator Harold Wheeler (s17@ai.org)
Route 1
Larwill, IN 46764
260-327-3332

Senator Kent Adams (s9@ai.org)
105 Beechwood Drive
Bremen, IN 46506
574-546-3119

Senator Robert Meeks (s13@ai.org)
5840 E. 25 N.
LaGrange, IN 46761
260-463-3198

Representative David Wolkins (r13@ai.org)
501 Pierceton Road
Winona Lake, IN 46590
574-269-6771

Representative Gary Dillion (r50@ai.org)
331 N. Chauncey Street
Columbia City, IN 46725
260-436-8000

Representative Robert Alderman (r83@ai.org)
5715 Kroemer Road
Fort Wayne, IN 46818
260-489-5349

D. County Government Stakeholders

Kosciusko County Commissioners
100 W. Center Street
Warsaw, IN 46580
574-372-2433
Contact Persons: Avis Gunter, Ronald Truex, Brad Jackson

Kosciusko County Council
100 W. Center Street
Warsaw, IN 46580
574-267-4444
Contact Persons: John Kinsey, Bradley Tandy, Harold Jones, Thomas Anglin, Larry Teghtmeyer, Maurice Beer

Kosciusko County Engineer
2936 E. Old Route 30
Warsaw, IN 46580
574-372-2356
Contact Person: Rob Ladson

Kosciusko County Health Department
100 W. Center Street
Warsaw, IN 46580
574-372-2349
Contact Person: Bob Weaver

Kosciusko County Area Planning Department
100 W. Center Street
Warsaw, IN 46580
574-372-2304
Contact Person: Dan Richards/Matt Sandy

Kosciusko County Solid Waste Management District
220 S. Union Drive
Warsaw, IN 46580
574-372-3087
Contact Person: Sue Studebaker

Kosciusko County Surveyor
100 W. Center Street
Warsaw, IN 46580
574-372-2366
Contact Person: Dick Kemper

Kosciusko County Extension Service
100 W. Center Street
Warsaw, IN 46580
574-372-2340
Contact Person: Kelly Easterday

Whitley County Commissioners
101 W. Van Buren Street
Columbia City, IN 46725
260-248-3100
Contact Persons: James Pettigrew, Thomas Rethlake, James Argerbright

Whitley County Council
101 W. Van Buren Street
Columbia City, IN 46725
260-248-3100
Contact Persons: James Bayman, Douglas Beer, Glen Larue, Thomas Cormany, Scott Darley, Kent Hoffman, Steven Hively

Whitley County Engineer/ Surveyor
101 W. Van Buren Street
Columbia City, IN 46725
260-248-3185
Contact Person: Brandon Forrester

Whitley County Highway Department
801 S. Line Street
Columbia City, IN 46725
260-248-3123
Contact Person: Randy Knach

Whitley County Health Department
101 W. Market Street, Suite A
Columbia City, IN 46725
260-248-3121
Contact Person: Scott Wagner

Whitley County Area Planning Department
101 W. Market Street, Suite B
Columbia City, IN 46725
260-248-3112
Contact Person: David Sewell

Whitley County Extension Service
115 S. Line Street
Columbia City, IN 46725
260-244-7615
Contact Person: Valynnda Slack

Whitley County Building Inspector
101 W. Market Street, Suite B
Columbia City, IN 46725
260-248-3112
Contact Person: Craig Wagner

Noble County Commissioners
101 N. Orange Street
Albion, IN 46701
(260) 636-7877
Contact Persons: Mark Pankop, Richard Winebrenner, J. Hal Stump

Noble County Council
101 N. Orange Street
Albion, IN 46701
260-636-7877
Contact Persons: Lee Boggs, Dick Coats, Bob Scott, Harold Uhl, Larry Holbrook, Dave Fiandt, Jack Frederick

Noble County Building Inspector
2090 S. State Road 9
Albion, IN 46701
260-636-2215
Contact Person: Richard Adair

Noble County Highway Department
1118 E. Main Street
Albion, IN 46701
260-636-2124
Contact Person: Keith Lytton

Noble County Health Department
2090 S. State Road 9, Suite C
Albion, IN 46701
260-636-2191
Contact Persons: Dr. Gerald Warrener-Health Officer/Jack Chronsiter-Septic Health Inspector

Noble County Area Planning Department
2090 S. State Road 9, Suite A
Albion, IN 46701
260-636-7217
Contact Person: Beth Shellman

Noble County Solid Waste District
2320 W. 800 N.
Ashley, IN 46705
260-587-3063
Contact Person: Steve Christman

Noble County Surveyor
2090 S. State Road 9, Suite B
Albion, IN 46701
260-636-2131
Contact Person: Scott Zeigler

Noble County Extension Service
2090 S. State Road 9, Suite D
Albion, IN 46701
260-636-2111
Contact Person: Beth Green
(beth.green@ces.purdue.edu)

E. <u>Upper Tippecanoe Watershed Stakeholders</u>

Acres Land Trust
200 N. Wells Street
Fort Wayne, IN 46808
219-422-1004
Contact Person: Carolyn McNagny

American Fisheries Society
P.O. Box 100
Seymour, IN 47274
Contact Person: Scott Shuler

Arrowhead Country RC & D
633 E. 13th Street
Winamac, IN 46996
Contact Person: Bruce Wilhelm

Backwater Lake
2220 Irvine Lane
Plainfield, IL 60544
815-254-9520
Contact Person: Bruce Whieting

Backwater Retriever Club
19341 County Road 16
Bristol, IN 46507
Contact Person: Ray Weaver

Edmund & Virginia Ball Nature Preserve
500 S. Mulberry Street
Muncie, IN 47305
765-288-4448
Contact Person: Martin Fink

Barbee Lakes Conservancy District
P.O. Box 407
North Webster, IN 46555
574-372-1670
Contact Person: Barry Hecker

Barbee Lakes Property Owners Association
P.O. Box 175
North Webster, IN 46555
574-834-2114
Contact Person: Dick Long

Big Lake Association
3871 W. Lake Shore Drive
Columbia City, IN 46725
Contact Person: David Smith

Big Lake Association
3994 W. Lake Shore Drive
Columbia City, IN 46725
260-691-2044
Contact Person: Mike Martin
(mdmart@netusa1.net)

Builders Association of Kosciusko-Fulton Counties
331 S. Buffalo Street
Warsaw, IN 46580
574-267-6125

Camp Good News
9491 E. Backwater Rd.
North Webster, IN 46555
574-834-2769
Contact Person: Herb Gaines

Clear Choice Tippy Lake Association
P.O. Box 39
Leesburg, IN 46538
574-834-2601
Contact Person: Phil Baskett

Crooked Lake Property Owners Association Inc.
465 E. Morsches Road
Columbia City, IN 46725
260-691-3577
Contact Person: Brooks Langeloh

Ducks Unlimited
6425 Oak Mill Place
Fort Wayne, IN 46835
260-486-2505
Contact Person: Clark Milestone

Ducks Unlimited
15784 Menominee
Plymouth, IN 46563
219-936-2405
Contact Person: Terry Jolly

Goose Lake Association
3445 W. Shoreline Drive
Columbia City, IN 46725
260-248-2508
Contact Person: Denise Heckman

Hoosier Audubon Council
6530 W. Wallen Road
Fort Wayne, IN 46818
260-489-5032
Contact Person: Paul McAfee

Hoosier Bass 'N Gals
600 Gentry
Frankfort, IN 46041
Contact Person: Linda Personette

Hoosier Environmental Council
520 E. 12th Street, Suite 14
P.O. Box 1145
Indianapolis, IN 46206-1145
317-685-8800
Contact Person: Tim Maloney

Hoosier Muskie Hunters
Webster Lake Musky Club No. 49
P.O. Box 670
North Webster, IN 46555
574-834-1669
Contact Person: Chae Dolsen
(chae@maplenet.net)

Indiana Audubon Society
Richardson Wildlife Sanctuary
64 West Road-Dune Acres
Chesterton, IN 46304
219-787-8983
Contact Person: John Thiele

Indiana Beef Cattle Association
8770 Guion Road, Suite A
Indianapolis, IN 46268
317-872-2333
Contact Person: Phillip Anderson
(pgaibca@iquest.net)

Indiana Chapter B.A.S.S. Federation
6911 Caledonia Circle
Indianapolis, IN 46254
Contact: Steve Cox

Indiana Corn Growers Association
225 S. East Street, Suite 737
Indianapolis, IN 46202
317-692-7151
Contact Person: Michael Aylesworth

Indiana Farm Bureau
225 S. East Street
Indianapolis, IN 46202
800-866-1160
Contact Persons :
Susan Lawrence (260-349-0402)
John Newsom (260-276-5378)
Brian Daggy (317692-7835)

Indiana Farmers Union, Inc.
3901 W. 86th Street
Indianapolis, IN 46268
Contact Person: Lawrence Dorrell

Indiana Forestry & Woodland Owners Association
Board of Directors
5578 S. 500 W.
Atlanta, IN 46031

Indiana Geological Survey
611 N. Walnut Grove
Bloomington, IN 47405-2208
812-855-7636
(igsinfo@indiana.edu)

Indiana Grain & Feed Association Inc.
Consolidated Grain & Barge
Box 547, Bluff Road
Mt. Vernon, IN 47620
800-669-0085
Contact Person: Don Smolek
(smolekd@cgb.com)

Indiana Hardwood Lumbermen's Association
3600 Woodview Trace, Suite 305
Indianapolis, IN 46268
317-875-3660
Contact Person: Vicki Carson

Indiana Lakes Management Society
207 S. Wayne, Suite B
Angola, IN 46703
574-842-3686
Contact Person: Tina Hissong

Indiana Plant Food & Agicultural Chemicals Association Inc.
Garrett Fertilizer
1622 County Road 52
Garrett, IN 46738
260-357-5432
Contact Person: Curt Custer
(custergrain@fwi.com)

Indiana Pork Producers Association
8902 Vincennes Circle, Suite F
Indianapolis, IN 46268
Contact Person: Terry Fleck

Indiana Rural Development
ISTA Center, Suite 414
150 W. Market Street
Indianapolis, IN 46204
317-232-8776 (wdant@commerce.state.in.us)
Contact Persons: Mary Henry 260-636-7682
Melissa Christiansen 574-936-9872
Enzley Mitchell III 260-248-8924

Indiana Rural Water Association
P.O. Box 679
Nashville, IN 47448
Contact Person: Marilyn Gambold

Indiana Seed Trade Association
Holdens Foundation Seeds LLC
RR1, Box 149
Franklin, IN 46131
317-535-8357
Contact Person: Scott Williams
(scott.Williams@holden.com)

Indiana Soybean Growers Association
423 W. South Street
Lebanon, IN 46052
Contact Person: Anita Stuever

Indiana Sportsman's Roundtable
500 Tamarack Lane
Noblesville, IN 46060
317-773-2944/317-575-4555
Contact Person: Bob Gerdenich II

Indiana State Dairy Association
208 Poultry Science Building
West Lafayette, IN 47907-1016
Contact Person: Robert Jones

Indiana State Poultry Association Inc.
Hy-Line International
1029 Mill Site Drive
Warren, IN 46792
Contact Person: Curt Schmidt

Izaak Walton League
2173 Pennsylvania Street
Portage, IN 46368-2448
219-762-4876
Contact Person: Charles Siar

Indiana Wildlife Federation
50 Rangeline Road, Suite A
Carmel, IN 46032
317-571-1220
Contact Person: Charlie O'Neill

Kosciusko Development Inc.
313 S. Buffalo Street
Warsaw, IN 46580
574-267-6311

Lake Tippecanoe Property Owners Association
P.O. Box 224
Leesburg, IN 46538
574-453-4716
Contact Person: Mike Lattimer

Lake Tippecanoe Women's Association
8 EMS T32 D Lane
Leesburg, IN 46538
574-453-4037
Contact Person: Carroll Chambers

Long Lake Association
2070 W. Long Lake Road
Pleasant Lake, IN 46779
Contact Person: Mike Kimmel

Loon Lake Property Owners Association
7543 N. Maple Lane
Columbia City, IN 46725
Contact Person: Mike Clapp

National Wild Turkey Federation
8818 N. 400 W.
Roann, IN 46974
765-982-7935
Contact Person: Randy Showalter

Nature Conservancy-Tippecanoe Project
P.O. Box 69
Winamac, IN
574-946-7491
Contact Person: Chad Watts (cwatts@tnc.org)

North American Lakes Management Society
P.O. Box 5443
Madison, WI 53705-5443
608-233-2386

North Webster-Tippecanoe Township Chamber of Commerce
P.O. Box 19
North Webster, IN 46555
574-834-7076
Contact: Connie Berry

Northwest Indiana Steelheaders, Inc.
P.O. Box 701
Chesterton, IN 46304
Contact Person: Mike & Janet Ryan

Pheasants Forever
420 Dawn Avenue
Danville, IL 61832
217-446-2958
Contact Person: Tom Kieschenmann

Pheasants Forever
3806 N. 925 E.
Pierceton, IN 46562
574-834-2283
Contact Person: Rich Wells

Purdue University Cooperative Extension Service
Agronomy 1150 Lilly Hall
Purdue University
West Lafayette, IN 47997
765-494-6134
Contact Person: John Peverly
(jpeverly@purdue.edu)

Quail Unlimited
Route 4, Box 152
Vincennes, IN 47592
812-886-6436
Contact Person: Ray McCormick

Ridinger Lake Property Owners Association
283 EMS R4 Lane
Pierceton, IN 46562
Contact Person: Holly Ousley

Sierra Club
212 W. 10th Street, Suite A-335
Indianapolis, IN 46202
317-972-1903
Contact Person: Susan Thomas

Tippecanoe Audubon Society
606 E. 7th Street
North Manchester, IN 46962
Contact Person: David Eiler

Town of North Webster
P.O. Box 95
North Webster, IN 46555
574-834-7894
Contact Person: Peg Lawrence

Tri-Lakes Regional Sewer District
5240 N. Old 102
Columbia City, IN 46725
260-691-2820

Waterfowl USA
1707 South Cline Avenue
Griffith, IN 46319
765-322-1545
Contact Person: Don Roberts

Webster Lake Conservation Association
606 N. Eckert Drive
North Webster, IN 46555
574-834-7144
Contact Person: Dawn Meyer
(ddmeyer@kconline.com)

Whitley County Economic Development Corporation
561 North Line Street, Suite F
Columbia City, Indiana 46725
260-244-5506
Contact Person: Dorinda Heiden
(www.whitleybiz.com)

Wood-Land-Lakes RC & D
214 W. North Street
Kendallville, IN 46755-1134
260-349-1433
Contact Person: Kathy Latz (woodland-lakes@in.rcdnet.org)

Yogi Bear Membership Corp. Jellystone Park
1916 N. 850 E.
Pierceton, IN 46562
574-594-2124
Contact Person: Larry Ladd

F. Media Stakeholders

Chronicle Tribune
610 S. Adams Street
Marion, IN 46952
765-664-5111

Elkhart Truth
103 S. 3rd Street
Goshen, IN 46526
574-533-8676

Fort Wayne Newspapers Inc.
600 W. Main Street
Fort Wayne, IN 46802
219-461-8516
Journal Gazette
215 E. Van Buren Street #204
Columbia City, IN 46725
260-244-3944

Journal-Gazette Bureau
3755 Lake City Highway, #9
Warsaw, IN 46580

Licensee
10129 N. 800 E.
Syracuse, IN 46567

Mail Journal
103 E. Main Street
Syracuse, IN 46567
574-457-3666

Post & Mail
927 W. Connexion Way
Columbia City, IN 46725
260-244-5153

Senior Life
206 S. Main St.
Milford, IN 46542

South Bend Tribune
122 W. Washington Street
Elkhart, IN 46516
800-220-7378

Sun & Evening Star
P.O. Box 39
Kendallville, IN 46755
260-347-0400

The Paper
114 W. Market Street
Warsaw, IN 46580
574-269-2932

Times Union
P.O. Box 1448
Warsaw, IN 46581-1448
574-267-3111

WNIT-Public Television
P.O. Box 3434
Elkhart, IN 46515-3434

4.0 PUBLIC INVOLVEMENT

Since January of 2001, the Tippecanoe Environmental Lake & Watershed Foundation has been gathering information on the fourteen-digit subwatersheds of the Upper Tippecanoe River Basin. This includes information from stakeholders, site visits, and water quality sampling efforts within the subwatersheds.

Appendix X includes a list of the many public meetings, lake association meetings, site visits and other miscellaneous meetings conducted throughout the planning period. Stakeholders involved in these meetings voiced a variety of common concerns. General public concerns and specific geographic areas of concern were complied throughout the many formal and informal meetings with the stakeholders (see below lists). These concerns were tabulated and grouped together to create major goals. Strategies were then considered for these broad and/or specific goals. The strategies were evaluated for their viability and practicality to arrive at "selected strategies." The results of this step by step train of thought are displayed in Table E1 (pages 4.4 – 4.5). Action items associated with the goals and subsequent strategies are outline in Section 6.0, A.

A. Concerns Noted

The following list outlines the general concerns and/or specific areas of concern as expressed by the Upper Tippecanoe Stakeholders during the many formal and informal meetings over the past several years. These concerns are in no particular order. Stakeholders repeated many of these themes in the meetings.

General Concerns

Increased weed growth
Loss of native aquatic plants
Decrease in fish counts
Increased algae growth
Increased sedimentation (silt & muck)
Increased number of muskrats and beavers
Increased number of boats and personal watercraft on lakes
Protecting property rights/farmers rights
Need to revise zoning ordinances
Lack of septic maintenance
Increased chlorination levels coming from dairy operations
Need to identify potential lands for acquisition/for CRP enrollment
Increased number of housing developments
Lack of enforcement on lakes: boating, herbicides
Increased zebra mussels
Increased exotic species; need for aquatic plant management
Lack of funding sources
Loss of land to urban sprawl; land use issues
Lack of public knowledge and education
Lack of erosion control enforcement on new home construction
Lack of access for some public lakes
Wetland destruction by development; increased filling of wetlands
Loss of fish, wildlife, woodland habitat
Lack of adequate sewage disposal; septic problems
Lack of stewardship ethic

Increased number of ducks and geese
Lack of cleaning/maintenance on existing storm drains; stormwater management
Increased filling of wetlands
Increased streambank erosion
Lack of communication/coordination within the groups
Increased Nutrient loading
Lack of scheduled street cleaning
Increased number of channels filling in with organics
Fluctuation of water levels for fish and wildlife
Lack of flood awareness and loss of flood conservation areas
Livestock productions; manure management
Increased sizes of homes being built; septic capacity to handle increased size
Lack of education regarding yard care
Lack of development control by county planning office
Homes being built on soils that will not support sanitary septic systems
Increased number of fishing tournaments: number of boats, hours, boats coming from unknown waters
Need for increased maintenance on legal drains without clearing the banks of all trees
Need to promote Best Management Practices (BMPs) to homeowners and farmers
Lack of education regarding aquatic plant removal
Increased *E. coli* contamination of lakes and streams
Increased counts/violations at NPDES dischargers
Increased seawall development
Lack of cleaning/spraying boats coming in/out of lakes

Specific Geographic Areas Mentioned:

Putney Ditch
Mouth of Grassy Creek at Big Barbee
Durham Lake Road
Mathias Ditch
North side of Webster Lake-Moore Property
East of Ridinger Lake-Ditch off Adams Road
Elder Ditch

B. Lake Resident Survey

TELWF conducted a survey of over 8,000 lake resident households throughout Kosciusko County to help clarify local priorities and ensure all possible concerns were being addressed by the WMP efforts. The results are provided below. Results of this survey as well as input received at watershed workshops and meetings lead to the inclusion of an additional goal related to land use development issues such as zoning and funneling practices. TELWF received approximate 25% of the distributed surveys back from area residents.

5/10/2005 Kosciusko County Lake Resident Survey Results				
	Yes	No	Yes %	No %
Is your lake home your year-round primary residence?	797	1167	40.58%	59.42%
Is your lake home your primary summer residence?	1125	839	57.28%	42.72%
Do you vote in Kosciusko County?	867	1097	44.14%	55.86%
Do you believe the quality of your lake is threatened by development?	1478	486	75.25%	24.75%
Do you believe the quality of your lake is threatened by greater numbers of motor boats?	1546	418	78.72%	21.28%
Is the environmental quality of Kosciusko County lakes a major concern?	1765	199	89.87%	10.13%
Should government take action to protect lake quality in Kosciusko County?	1539	425	78.36%	21.64%
May we contact you about this survey?	1691	273	86.10%	13.90%
Total Quantity of Kosciusko County lake property owners surveyed:	7723			
Total number of completed surveys received:	1964			
Survey response rate:	25.43%			

C. Goals and Strategies Train of Thought

See next page for table.

Table E1 Goals and Strategies Train of Thought

Goal #	Goal	Public Concerns	Alternatives Considered	Selected Strategies
1	Reduce total phosphorus, nitrogen, *E. coli, and sediment* loads in the Upper Tippecanoe River Watershed 20% by 2010.	Increased weed growth Increased algae growth Lack of septic maintenance Lack of adequate sewage disposal and septic alternatives Increased number of ducks and geese Lack of cleaning/maintenance on existing storm drains, stormwater management Increased stream bank erosion Increased Nutrient loading Lack of scheduled street cleaning Increased number of channels filling in with organics loss of flood conservation areas Livestock productions; manure management septic capacity to handle increased residential growth yard care/fertilizer alternatives Increased E. coli contamination of lakes and streams Increased counts/violations at NPDES dischargers Increased sedimentation (Silt & Muck) Increased filling of wetlands Increased number of channels filling in with organics Lack of erosion control enforcement on new home construction Need for increased maintenance on legal drains without clearing the banks of all trees	Legislative rules Educate stakeholders Implement programs and projects	A. Promote the use of phosphorus free fertilizer/reduced fertilizer use. B. Implement 5-year watershed protection plan C. Assist in implement of filter strips/grassed waterways on 20,000 feet of waterways each year D. Restore 50 acres of wetlands over the next five years. E. Install sanitary sewer system throughout watershed by 2020. F. Assist in implement nutrient management plan on a significant acreage of planted agriculture land in all counties. G. Assist in implementation of conservation tillage on a significant acreage of planted acreage and 80% of all HEL acreage. H. Assist dairy/beef farms with implementing manure management plans. I. Promote compliance with Rule 5 plans in the watershed.
2	Document existing mIBI, IBI, water quality, and habitat in each subwatershed in order to set reasonable targets to improve biological integrity.	Decrease in fish counts Loss of fish, wildlife, woodland habitat Fluctuation of water levels for fish and wildlife Increased seawall development	Review existing biological surveys Conduct surveys	A. Document biotic community B. Identify specific threats to local populations including riparian habitat conditions and riparian priority areas. C. Sample sub-basin water quality.
3	Implement plan for testing phosphorus and nitrogen in soils adjacent to tributaries and streams.	Need to identify potential lands for acquisition or for enrollment in conservation programs	Obtain and use grant monies to hire a soil science consultant to conduct soil testing. Obtain and use grant monies to hire/fund university research on soil testing. Utilize NRCS expertise.	A. SWCD/NRCS to test soils for nitrogen and phosphorus in 25% of all active crop fields within a quarter mile of all waterways. B. SWCD/NRCS to utilize soil testing report in developing nutrient management plans.

4	Decrease the abundance and spread of exotic aquatic species.	Loss of native aquatic plants Lack of enforcement on lakes: boating, herbicides Increased exotic species including zebra mussels Need for aquatic plant management Lack of cleaning/spraying boats coming in/out of lakes	Legislate Rules regarding the mandatory use of boat cleaning and lake quarantine/closure. Educate boat and lake users on exotic aquatic species.	A. Assist in development of aquatic plant management plan for all lakes over 100 acres in watershed. B. Decrease the spread/introduction of new exotic aquatic species through education. C. Increase the awareness of beneficial native plants to the ecosystem.
5	Foster communication among all watershed stakeholders.	Increased number of boats and personal watercraft on lakes Protecting property rights/farmers rights Lack of enforcement on lakes: boating Lack of public knowledge and education about lake and watershed issues Lack of stewardship ethic Lack of communication/coordination within the groups Lack of flood awareness, impacts of flooding Lack of education regarding yard care Lack of education regarding aquatic plant removal Increased number of fishing tournaments	Educate stakeholders regarding each others' needs Facilitate the transfer of information among stakeholder groups	A. Form an Advisory Board of Directors to meet for annual review of watershed management plan beginning in 2006 and conduct strategic planning. B. Communicate goals of management plan to all Upper Tippecanoe River Watershed stakeholders. C. Educate stakeholders on watershed issues. D. Attend multiple lake associations meetings and events and exchange newsletters for the purposes of identifying educational opportunities. E. Assist in a liaison capacity to facilitate communication between watershed stakeholders and Federal and State representatives. F. Identify cites and towns, in addition to North Webster, that are affected by the Watershed Plan and work with the appropriate contacts within each unit of government. G. Provide workshop style venues for increased communication between lake owners associations, SWCD, FFA, 4-H, local schools, and the general public. H. Identify lakes where no association currently exists and/or assist in their development. I. Coordinate with SWCD educational staff to help promote schools and other individual volunteers to begin Hoosier RiverWatch Program in each of the 8 sub-basins.
6	Fund watershed improvement projects.	Lack of funding sources Need to promote Best Management Practices (BMP's) to homeowners and farmers	Raise local funds Seek outside grants	A. Develop listing of potential funding sources.
7	Hire/Retain a Watershed Coordinator for the Upper Tippecanoe Watershed.	Lack of communication/coordination within the groups	Hire a full time watershed coordinator. Enlist a volunteer watershed coordinator. Request that SWCD implement the plan.	A. Determine the duties and develop job description of a watershed coordinator. B. Seek grants to fund the position.
8	Address development issues such as zoning and "funneling."	Increased number of boats and personal watercraft on lakes Need to revise zoning ordinances Increased number of housing developments Loss of land to urban sprawl; land use issues Wetland destruction by development; increased filling of wetlands Loss of fish, wildlife, woodland habitat Increased sizes of homes being built and septic capability Lack of development control by county planning office number of boats, hours, boats coming from unknown waters	Provide voluntary plan review with area developers Get involved in area Plan Commission activities Review legal mechanisms for new rules on lakes Advise County Commissioners Get involved with IDNR rule-making (piers, ecozones, etc.)	A. Assist area Plan Commission on developing lake zoning ordinances. B. Evaluate eco-zone development/implementation for various lake areas C. Maintain active involvement in Lakes Management Work Group

5.0 IDENTIFIED THREATS IN THE WATERSHED

The Upper Tippecanoe Watershed, which drains over 72,000 acres in northeast Indiana, has changed since the first Europeans settled the area. Before their arrival, an oak-hickory forest growing in rich organic soils dominated the landscape along with many streams, natural lakes, and expansive wetlands. Since the late 1800's, the watershed has suffered from the impacts of agriculture and urbanization. Today, water resource impairments and water quality threats are a constant or a reoccurring problem.

Water resource impairments and water quality threats come in the form of point and non-point sources. Pollution itself has been described and interpreted in many ways. For the purposes of this plan, the definition of pollution as stated in Clean Water Act of 1977 (PL 95-217) will suffice. The Clean Water Act defines pollution as the human-made or human-induced alteration of the chemical, physical, biological, and radiological integrity of water (Hocutt, 1981). Several studies have been conducted over the past 14 years in an attempt to identify know or suspected causes of water quality impairments and threats such as specific pollutants, changes in land use, and other human induced events.

An examination of the Upper Tippecanoe River Watershed reveals many potential sources or causes for the threats identified in the subsequent sections of this document. The following sections describe the existing condition of water resources in the watershed, identify potential pollutants and their sources, and locate priority areas for water resource improvement throughout the Upper Tippecanoe River Watershed.

IDEM 303(d) List

Section 303 (d) of the Clean Water Act requires states to identify waters that do not or are not expected to meet applicable water quality standards with federal technology-based standards alone. States area also required to develop a priority ranking for these waters taking into account the severity of the pollution and the designated uses of the waters. The EPA approved Indiana's initial 303 (d) list and once every two years, IDEM publishes and updates this initial list. The 303(d) list also includes a schedule for Total Maximum Daily Load (TMDL) development for the waterbodies on that list. The TMDL refers to the maximum load of point and nonpoint source pollutants (plus margin of safety that a waterbody may possess and still meet water quality standards.

Several lakes within the Upper Tippecanoe River Watershed appear on the 303(d) list (Figure 9). Crooked Lake, Loon Lake, Little Barbee Lake, Lake Webster, and Lake Tippecanoe are 303(d) listed for mercury contamination. Crooked Lake and Lake Tippecanoe are also listed for Impaired Biotic Communities. The segment of the Tippecanoe River within the watershed boundaries is listed for mercury, PCB, and *E. coli* contamination. Mercury originates from aerial sources; therefore lakes and streams not included on the 303(d) list could potentially suffer from mercury contamination as well, but simply have not been tested.

303(d) #	Major Basin	14 Digit Hydrologic Unit Code	County**	Segment ID Number	Waterbody Name	Parameters of Concern
4	UPPER WABASH	5120106010010	WHITLEY CO	INB06P1001_00	CROOKED LAKE	IMPAIRED BIOTIC COMMUNITIES
90	UPPER WABASH	5120106010080	KOSCIUSKO CO	INB06P1002_00	TIPPECANOE LAKE	IMPAIRED BIOTIC COMMUNITIES
92	UPPER WABASH	5120106030050	KOSCIUSKO CO	INB0635_T1040	TIPPECANOE RIVER	E. COLI
4	UPPER WABASH	05120106010010	WHITLEY CO	INB06P1001_00	CROOKED LAKE	FCA for Hg
90	UPPER WABASH	05120106010080	KOSCIUSKO CO	INB06P1002_00	TIPPECANOE LAKE	FCA for Hg
92	UPPER WABASH	05120106010070	KOSCIUSKO CO	INB0618_T1003	TIPPECANOE RIVER	FCA for PCBs and Hg
439	UPPER WABASH	05120106010070	KOSCIUSKO CO	INB06P1035_00	LITTLE BARBEE LAKE	FCA for Hg
443	UPPER WABASH	05120106010040	KOSCIUSKO CO	INB06P1034_00	WEBSTER LAKE	FCA for Hg
456	UPPER WABASH	05120106010020	WHITELY CO	INB06P1060_00	LOON LAKE	FCA for Hg

Figure 9. 303(d) listed waterbodies in the Tippecanoe River Basin.

A. Introduction to Water Quality Assessment Introduction

Before reviewing the results of the historical water quality assessments of Upper Tippecanoe River subwatershed lakes and streams, it may be useful to explore the way limnologists evaluate the ecological health of water bodies. In evaluating a lake or stream, a limnologist will measure a variety of water quality parameters. These include measurements of nutrient, sediment, and dissolved oxygen concentrations, and in lakes, water clarity and light penetration through the water column. Limnologists often evaluate lakes and streams based on these measurements alone or, for lakes, incorporate these measurements into an index to measure the parameters collectively. These parameters and indices indicate whether the lake or stream water is clear or turbid; whether it supports, or can support, diverse, native flora and fauna communities; and whether it can provide desired recreational opportunities for watershed residents. The following paragraphs describe the typical parameters measured during stream water quality assessments, additional parameters measured during lake water quality assessments, and how these parameters are incorporated in various ecological health indices to describe the condition of a lake's water quality.

Stream Water Quality Parameters

The comprehensive evaluation of stream chemistry requires collecting data on the different water quality parameters listed above. A brief description of each parameter follows:

Temperature

Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. Likewise, water temperature regulates the species composition and activity of life associated with the aquatic environment. Since essentially all aquatic organisms are 'cold-blooded' the temperature of the water regulates their metabolism and ability to survive and reproduce effectively (EPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits for Indiana streams. Temperatures during the month of May should not exceed 83°F (25.4°C) . June temperatures should not exceed 90°F (32.2°C). The Code also states that "the maximum temperature rise at any time or place…shall not exceed 5°F (2.8°C) in streams…".

Dissolved Oxygen (DO)

DO is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3-5 parts per million (ppm) of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The IAC sets minimum DO concentrations at 6 mg/L for coldwater fish. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with DO. Dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

Conductivity

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions: on their total concentration, mobility, and valence (APHA, 1995). During low discharge, conductivity is higher than during storm water runoff because the water moves more slowly across or through ion-containing soils and substrates during base flow. Carbonates and other charges particles dissolve into the slow-moving water, thereby increasing conductivity measurements.

pH

The pH of stream water describes the concentration of acidic ions (specifically H^+) present in the water. The pH also determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC establishes a range of 6-9 pH units for the protection of aquatic life.

Alkalinity

Alkalinity is a measure of the acid-neutralizing (or buffering) capacity of water. Certain substances, if present in water, like carbonates, bicarbonates, and sulfates can cause the water to resist changes in pH. A lower alkalinity indicates a lower buffering capacity or a decreased ability to resist changes in pH. During base flow conditions, alkalinity is usually high because the water picks up carbonates from the bedrock. Alkalinity measurements are usually lower during storm flow conditions because buffering compounds are diluted by rainwater and the runoff water moves across carbonate-containing bedrock materials so quickly that little carbonate is dissolved to add additional buffering capacity.

Turbidity

Turbidity (measured in Nephelometric Turbidity Units) is a measure of water coloration and particles suspended in the water itself. It is generally related to suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. According to the Hoosier Riverwatch, the average turbidity of an Indiana stream is 11 NTU with a typical range of 4.5-17.5 NTU (White, unpublished data). Turbidity measurements >20 NTU have been found to cause undesirable changes in aquatic life (Walker, 1978).

Nitrogen

Nitrogen is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80% of air is nitrogen gas. This nitrogen can diffuse into water where it can be "fixed", or converted, by blue-green algae for their use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia. Because of this, there is an abundant supply of available nitrogen to aquatic systems. The three common forms of nitrogen are:

> *Nitrate-Nitrogen (NO_3^--N)* – Nitrate is dissolved nitrogen that is converted to ammonia by algae. It is found in streams and runoff when dissolved oxygen is present, usually in the surface waters. Nitrogen applied to farmland is rapidly oxidized or converted to nitrate and usually enters surface and groundwater as nitrate. Nitrate is highly soluble in water and leaches readily into the groundwater. The Ohio EPA (1999) found that the median nitrate-nitrogen concentration in wadeable streams that support modified warmwater habitat (MWH) was 1.6 mg/L. Modified warmwater habitat was defined as: aquatic life use assigned to streams that have irretrievable, extensive, man-induced modifications that preclude attainment of the warmwater habitat use (WWH) designation; such streams are characterized by species that are tolerant of poor chemical quality (fluctuating dissolved oxygen) and habitat conditions (siltation, habitat amplification) that often occur in modified streams (Ohio EPA, 1999). Nitrate-nitrogen concentrations exceeding 10 mg/L in drinking water are considered hazardous to human health (Indiana Administrative Code IAC 2-1-6).

> *Ammonia-Nitrogen (NH_3-N)* – Ammonia is dissolved nitrogen that is the preferred form for algae use. Bacteria produce ammonia as they decompose dead plant and animal matter. Ammonia is the reduced form of nitrogen and is found where dissolved oxygen is lacking. Both temperature and pH govern the toxicity of ammonia for aquatic life. According to the IAC, maximum unionized ammonia

concentrations within the temperature and pH ranges measured for the study streams should range between approximately 0.13 and 0.22 mg/L.

Organic Nitrogen (Org N) – Organic nitrogen includes nitrogen found in plant and animal materials. It may be in dissolved or particulate form. In the analytical procedures, total Kjeldahl nitrogen (TKN) was analyzed. Organic nitrogen is TKN minus ammonia.

Phosphorus

Phosphorus is an essential plant nutrient, and the one that most often controls aquatic plant (algae and macrophyte) growth. It is found in fertilizers, human and animal wastes, and yard waste. There are few natural sources of phosphorus to streams other than that which is attached to soil particles, and there is no atmospheric (vapor) form of phosphorus. For this reason, phosphorus is often a **limiting nutrient** in aquatic systems. This means that the relative scarcity of phosphorus may limit the ultimate growth and production of algae and rooted aquatic plants. Therefore, management efforts often focus on reducing phosphorus inputs to receiving waterways because: (a) it can be managed and (b) reducing phosphorus can reduce algae production. Two common forms of phosphorus are:

Soluble reactive phosphorus (SRP) – SRP is dissolved phosphorus readily usable by algae. SRP is often found in very low concentrations in phosphorus-limited systems where the phosphorus is tied up in the algae themselves. Because phosphorus is cycled so rapidly through biota, SRP concentrations as low as 0.005 mg/L are enough to maintain eutrophic or highly productive conditions in lake systems (Correll, 1998). Sources of SRP include fertilizers, animal wastes, and septic systems.

Total phosphorus (TP) – TP includes dissolved and particulate phosphorus. TP concentrations greater than 0.03 mg/L (or 30 μg/L) can cause algal blooms. TP is often a problem in agricultural streams and drainages because TP concentrations for eutrophication control are an order of magnitude lower than those typically measured in soils used to grow crops (0.2-0.3 mg/L). The Ohio EPA (1999) found that the median TP in wadeable streams that support MWH for fish was 0.28 mg/L.

Total Suspended Solids (TSS)

A TSS measurement quantifies all particles suspended and dissolved in stream water. Closely related to turbidity, this parameter quantifies sediment particles and other solid compounds typically found in stream water. In general, the concentration of suspended solids is greater during high flow events due to increased overland flow. The increased overland flow erodes and carries more soil and other particulates to the stream. Although the State of Indiana sets no standard for TSS, total dissolved solids should not exceed 750 mg/L. In general, TSS >80 mg/L have been found to be deleterious to aquatic life (Waters, 1995).

E. coli Bacteria

E. coli is one member of the fecal coliform bacteria group. Biologists use *E. coli* as an indicator organism to identify the potential for the presence of pathogenic organisms in a water sample. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. *E. coli* can come from the feces of any warm-blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, previously contaminated sediments, and failing or improperly sited septic systems are common sources of the bacteria. The IAC sets the maximum standard at 235 *E. coli* colonies/100 ml in any one sample within a 30-day period. In general, fecal coliform bacteria have a die-off rate of 90% in 3-5 days (Gerba and McLeod, 1976). However, scientific literature suggests that suspended fine sediment and organic matter particles can result in life expectancy extensions for bacteria (Sherer et al., 1992). Sherer et al. (1992) found that fecal coliform bacteria lived an average of 17 days longer when incubated with sediment. Additionally, benthic sediments can harbor significantly higher concentrations of bacteria than the overlying water, and disturbance of the sediment can result in contamination of the water column.

Lake Water Quality Parameters

Lake water quality assessments require measurement of many of the parameters listed above. Additionally, water clarity and chlorophyll *a* measurements must also be collected to assess the water quality of a lake. A description of these additional parameters is listed below.

Chlorophyll a

While nutrient parameters suggest the *potential* for algae and rooted plant growth, **chlorophyll *a*** measurements are used to indicate the actual presence of algae in the water. Chlorophyll *a* is one of the pigments found in plant material. It plays a role in the plant's ability to photosynthesize. Because algae are plants, they, too, contain chlorophyll *a*. In general, chlorophyll *a* concentrations below 2 μg/L are considered low, while those exceeding 10 μg/L are considered high and indicative of poorer water quality.

Water Clarity

Because it affects both the inhabitants in the lake and those around the lake (homeowners), limnologists also commonly measure water clarity in lake assessments. Sedimentation (the input of dirt) to a lake decreases the lake's life span and creates deltas and sand bars that could affect recreational uses of the lake. On shallower lakes bottom sediments can be resuspended through boating activity or wave action, thereby inhibiting water clarity. Suspended sediments impact a lake's biota. Heavy silt loads can deteriorate fish spawning grounds and alter fish community composition by shifting dominance to more tolerant species. Sediment, algae, and other materials suspended in a lake also ruin the lake's aesthetic value. Few lake residents or visitors are attracted to murky water and silt covered lake bottoms.

Limnologists use a variety of methods to measure lake water clarity. **Secchi disk transparency** is the most common measure of water clarity. Secchi disk transparency is measured in the field by lowering a 20-cm diameter disk divided into alternating black and white quadrants into the lake until it can no longer be seen. The biologist performing the measurement records this depth. The disk is then raised until the biologist observes the disk again. The biologist records this second depth. The Secchi disk transparency depth is the average of these measurements. In general, lakes possessing Secchi disk transparency depths greater than 15 feet (4.5 m) have outstanding clarity. Lakes with Secchi disk transparency depths less than 5 feet (1.5 m) possess poor water clarity (ISBH, 1975; Carlson, 1977).

The ability of light to penetrate through the water column is another way to evaluate the lake's water clarity. Limnologists will measure **light transmission at 3 feet** (0.9 m) below the water surface and compare it to the light reaching the lake surface to obtain the percentage of the total light transmission at 3 feet (0.9 m). In clearer lakes, light travels unimpeded through the water column and a large percentage (> 70%) of it reaches 3 feet (0.9 m) into the lake's water column. In lakes with poorer clarity, a lower percentage of light reaches 3 feet (0.9 m) into the lake's water column as suspended particles in the light absorb or reflect the light before it reaches the 3-foot depth.

Finally, limnologists often measure the depth at which light transmission equals 1% of the light reaching the lake's surface. This depth, the 1% light level, marks the lower limit of the lake's photic zone. The photic zone is that portion of the lake that has sufficient light to support plant life. Lake's with large photic zones (deep 1% light levels) have the *potential* to support more algae than lake's with limited photic zones.

<u>*Ecological Health Indices*</u>
Once all water quality parameters are assessed, they can then be incorporated into various ecological health indices. Those most common type of indices utilized is an evaluation of trophic state. Additional evaluation can also be conducted by comparing current water quality measurements to median, or average, values collected in other studies. Two such examples, Vollenweider's data and Indiana Clean Lakes Program data, will be utilized for comparison of lakes in the Upper Tippecanoe River Watershed.

Trophic States
When considering the water quality of lakes, watershed residents are often more familiar with the terms *oligotrophic, mesotrophic, eutophic,* and *hypereutrophic* than many of the water quality parameters measured during lake evaluations. These terms describe a water body's trophic state (i.e. how productive the lake is, how much plant and algae growth is present, etc.). The terms categorize lakes with respect to productivity (amount of rooted plant and algae growth) and water quality. They are qualitative in nature, broadly defined, and lack rigid dividing lines separating individual categories. The following paragraphs briefly describe each of the terms.

Oligotrophic lakes are those with the highest water quality. These lakes possess low nutrient (phosphorus and nitrogen) concentrations and, as a consequence, do not typically support algae blooms or extensive rooted plant populations. Oligotrophic lakes have clear water transparency. They support less tolerant organisms such as cold-water fish which have higher oxygen requirements than warm water fish.

Mesotrophic lakes are characterized by intermediate nutrient concentrations and intermediate productivity. These lakes can support algae but the severe blooms associated with eutrophic and hypereutrophic lakes are not common in mesotrophic lakes. Similarly, mesotrophic systems support some rooted plants but not at nuisance levels.

Eutrophic lakes are productive systems. They possess high nutrient concentrations and are able to support algae blooms and extensive rooted plant populations. Eutrophic lakes and streams often exhibit a lack of oxygen in the bottom waters during summer stratification. This lack of oxygen limits the habitat potential of the system.

Hypereutrophic lakes are highly productive systems. These water bodies possess very high concentrations of nutrients and support nuisance populations of rooted plants and have severe algae blooms. Algal blooms are so severe that the term "pea-soup" is often used to characterize hypereutrophic lakes. Transparency is poor in these lakes. Oxygen levels are low in hypereutrophic lakes; fish kills associated with low oxygen are common in hypereutrophic lakes.

Trophic State Indices
Although the definitions listed above are qualitative, some limnologists have developed numerical criteria for placing lakes in one of the four trophic states. The primary way limnologists do this is through the use of a trophic state index. A trophic state index (TSI) evaluates several water quality parameters by condensing the parameters into a single number. The single number is then compared to numerical ranges for the four

trophic states. The most common TSI used to assess Indiana lakes is the Indiana Trophic State Index (ITSI).

Indiana Trophic State Index
Harold Bon Homme and the Indiana Stream Pollution Control Board developed the first Indiana TSI (or Eutrophication Index). The Indiana Department of Environmental Management later modified the index, creating the TSI in use today. The original ITSI differed slightly from the one in use today. Today's ITSI uses ten different water quality parameters to calculate a score. The following table shows the point values assigned for each parameter.

Table 13. The Indiana Trophic State Index

Parameter and Range			Eutrophy Points
I.	Total Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
II.	Soluble Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
III.	Organic Nitrogen (ppm)		
	A.	At least 0.5	1
	B.	0.6 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
IV.	Nitrate (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
V.	Ammonia (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.5	2
	C.	0.6 to 0.9	3
	D.	1.0 or more	4

VI. Dissolved Oxygen:
Percent Saturation at 5 feet from surface

A.	114% or less	0
B.	115% to 119%	1
C.	120% to 129%	2
D.	130% to 149%	3
E.	150% or more	4

VII. Dissolved Oxygen:
Percent of measured water column with at least 0.1 ppm dissolved oxygen

A.	28% or less	4
B.	29% to 49%	3
C.	50% to 65%	2
D.	66% to 75%	1
E.	76% 100%	0

VIII. Light Penetration (Secchi Disk)

A.	Five feet or under	6

IX. Light Transmission (Photocell):
Percent of light transmission at a depth of 3 feet

A.	0 to 30%	4
B.	31% to 50%	3
C.	51% to 70%	2
D.	71% and up	0

X. Total Plankton per liter of water sampled from a single vertical tow between the 1% light level and the surface:

A.	less than 3,000 organisms/L	0
B.	3,000 - 6,000 organisms/L	1
C.	6,001 - 16,000 organisms/L	2
D.	16,001 - 26,000 organisms/L	3
E.	26,001 - 36,000 organisms/L	4
F.	36,001 - 60,000 organisms/L	5
G.	60,001 - 95,000 organisms/L	10
H.	95,001 - 150,000 organisms/L	15
I.	150,001 - 500,000 organisms/L	20
J.	greater than 500,000 organisms/L	25
K.	Blue-Green Dominance: additional points	10

Values for each water quality parameter are totaled to obtain an ITSI score. Based on this score, lakes are then placed into one of five categories (Table 14). Four of these categories correspond to the qualitative lake productivity categories. The fifth category, dystrophic, is for lakes that possess high nutrient concentrations but have limited rooted plant and algal productivity (IDEM, 2000). In these lakes, plant productivity is controlled by a factor other than nutrient availability.

Table 14. Indiana Trophic State Index score related to water quality

TSI score	Water Quality (Productivity)
0-15	Oligotrophic
16-31	Mesotrophic
32-46	Eutrophic
47-75	Hypereutrophic
*	Dystrophic

* See explanation above

Vollenweider's Data

Results of studies conducted on numerous lakes by Richard Vollenweider in the 1970's are often used as guidelines for evaluating concentrations of water quality parameters. As a result of his studies, Vollenweider established general ranges for relating water quality parameters to lake productivity or trophic state. Lake managers often use Vollenweider's ranges as *general guidelines* for comparison with data collected on a specific lake. The mean values of each trophic state resulting from his work are given in Table 15 below. Remember that these are only general ranges to be used as a guideline; similar concentrations in a particular lake may not cause problems if something else is limiting the growth of algae or rooted plants.

TABLE 15. Mean values of some water quality parameters and their relationship to lake production (after Vollenweider, 1975).

PARAMETER	Oligotrophic	Mesotrophic	Eutrophic	Hypereutrophic
Total Phosphorus (mg/L)	0.008	0.027	0.084	>0.750
Total Nitrogen (mg/L)	0.661	0.753	1.875	-
Chlorophyll *a* (µg/L)	1.7	4.7	14.3	-

Clean Lakes Program Data

To put the Upper Tippecanoe River Watershed lakes in context, it is useful to compare the results to other Indiana lakes. Table 16 presents median, minimum, and maximum data from 355 Indiana lakes collected during July and August 1994-98 under the Indiana Clean Lakes Program. (The Indiana Clean Lakes Program samples all public freshwater lakes in the state on a 5 year rotating basis. The data set below represents one full rotation.) The set of data summarized in the table represent mean values of epilimnetic and hypolimnetic samples for the 355 lakes. It should be noted that a wide variety of conditions, including geography, morphometry, time of year, and watershed characteristics, could influence the water quality of lakes. Thus, it is difficult to predict or even explain the reasons for the water quality of a given lake.

TABLE 16. Water quality characteristics of 355 Indiana lakes sampled from 1994 thru 1998 by the Indiana Clean Lakes Program. Means of epilimnetic and hypolimnetic samples reported.

	Secchi Disk (m)	NO_3 (mg/L)	NH_4 (mg/L)	TP (mg/L)	SRP (mg/L)
Median	1.8	0.025	0.472	0.097	0.033
Maximum	9.2	9.303	11.248	4.894	0.782
Minimum	0.1	0.022	0.018	0.001	0.001

B. Subwatershed Water Quality (within 14-digit HUCs)

The Upper Tippecanoe River Watershed contains approximately 100 lakes. Lakes located in the same subwatershed will likely be impacted by the same general factors; therefore, New selected a representative lake or group of lakes for each of the eight subwatersheds to characterize the water quality of each subwatershed. A wide variety of factors such as basin morphometry, geography, watershed characteristics and the time of year all influence the water quality of a given lake. Water quality samples collected for a given lake produce a snapshot of a lake's water quality at the specific time that sample collection occurred. Although water quality samples can be regarded as a representative sample for each individual lake, similarly, this generalization may not always be valid.

The following sections include stream and ditch data collected by the Kosciusko, Noble, and Whitley County Health Departments, Indiana Department of Natural Resources, F.X. Browne, J.F. New and Associates and TELWF to supplement lake data, when available. Again, it is important to note that data collected from individual stream sites are a snapshot of the water quality at that particular point in time. Stream data analysis involved comparing concentrations of parameters through the year (if available) to account for variations due to base flow, storm flow, growing season, and non-growing season sample concentrations and loads. Concentrations express the mass of a substance per unit volume, for example milligrams of total suspended solids per liter. Data analysis included the calculation of mass loading (kg/day) for each site for each date, when flow measurements were available. Mass loading is a measure of the mass of a substance in the creek per unit time. Loading is important when comparing water quality parameters among sites and among sampling dates because: 1) Discharge can be highly variable; therefore, normalizing concentrations to discharge eliminates this variability. 2) Delivery of materials is important to consider. For example, a stream with high discharge but low pollutant concentration may deliver a larger portion of a pollutant to its receiving body than a stream with higher pollutant concentration but lower discharge.

Water quality analysis utilized historical data collected from all available sources to rank each subwatershed. As groups collect more water quality data in individual subwatersheds and implement more watershed improvement projects, these rankings could change. Subwatershed rankings, from poorest water quality to highest water quality are as follows:

1. Smalley Subwatershed
2. Ridinger/Robinson Subwatershed
3. Goose/Loon Subwatershed
4. Elder Ditch Subwatershed
5. Barbee Lakes Subwatershed
6. Webster/Backwaters Subwatershed
7. Tippecanoe Subwatershed
8. Crooked/Big Subwatershed

The following sections detail subwatershed water quality in the order of their ranking.

<u>Smalley Subwatershed</u>

Smalley Subwatershed Lake Water Quality

Smalley Lake was selected to represent the Smalley Subwatershed. The Smalley Subwatershed receives water from both the Crooked/Big Subwatershed and the Goose/Loon Subwatershed

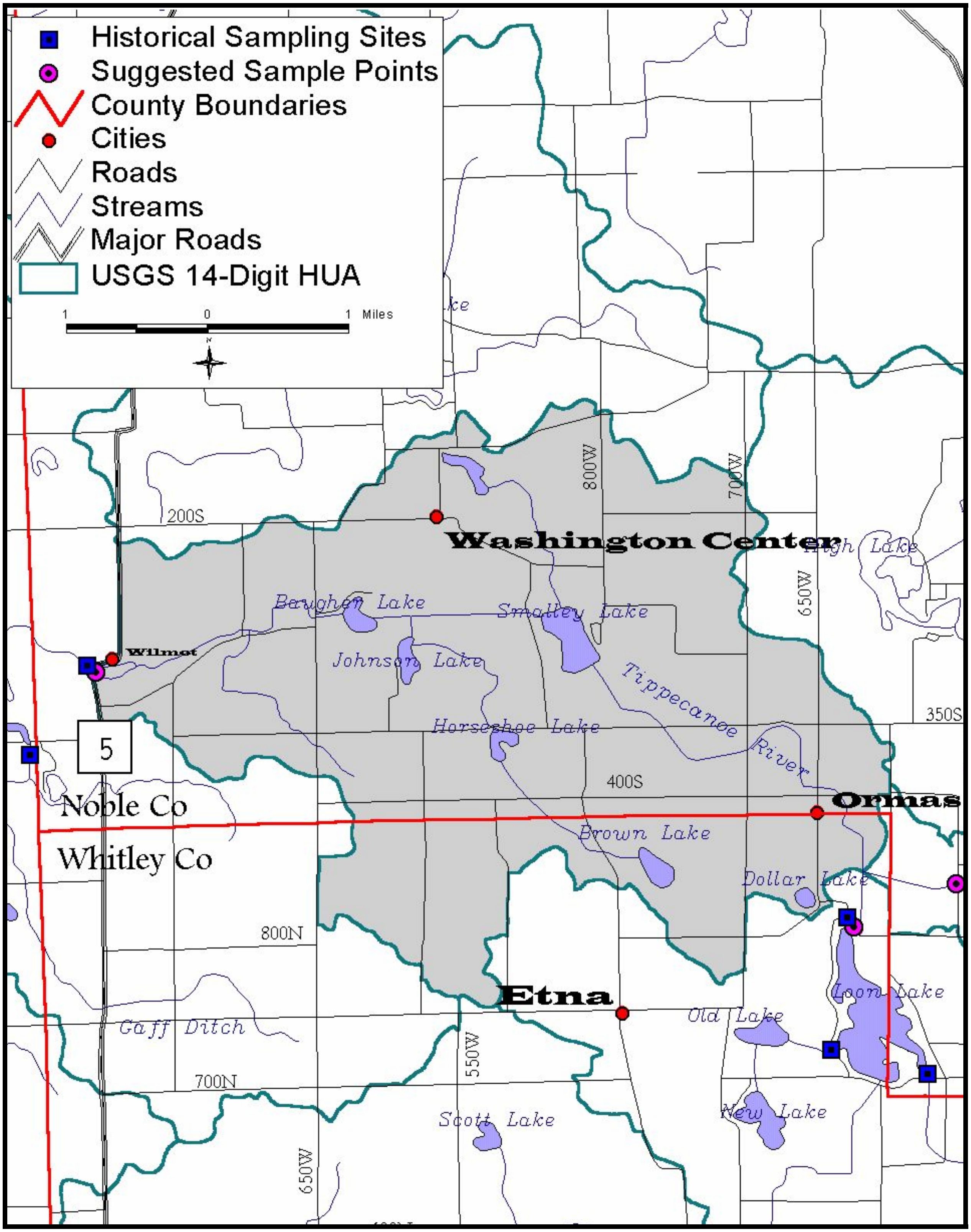

Figure 10. Smalley Subwatershed.

(Figure 10). The Indiana Clean Lakes Program measured water quality in Smalley Lake on three separate occasions, in 1989, 1993, and 1998. Table 17 lists Indiana trophic state and trophic index scores for Smalley Lake from these three samplings. While there is some variability in the year-to-year TSI values, there is no general increasing or decreasing trend. Water quality at Smalley Lake remained relatively constant based on three sampling efforts. On each occasion, Smalley Lake was classified as eutrophic, or productive.

Table 17. Smalley subwatershed Indiana trophic state index scores.

	1989	1993	1998
Smalley Lake Trophic Score	38	32	38
Smalley Lake Trophic State	Eutrophic	Eutrophic	Eutrophic

Table 18 displays historic mean total phosphorus concentrations for Smalley Lake. Total phosphorus concentrations show a generally increasing trend, with a sharp increase in 1998. This is the opposite trend needed for improving lake conditions. When total phosphorus values are compared to Vollenweider's guidelines above, all samples are above the mean value for eutrophic lakes, and in 1998, are well above the mean value for hypereutrophic lakes (0.750 mg/L). In fact, Smalley Lake recorded the highest total phosphorus concentration of all lakes sampled in the 1994 to 1998 rotation.

Table 18. Smalley Subwatershed total phosphorus concentrations.

	1989	1993	1998
Smalley Lake Concentration	0.313 mg/L	0.584 mg/L	4.894 mg/L
TP Score	Eutrophic	Eutrophic	Hypereutrophic

Results from the 1998 water quality sampling at Smalley Lake can also be compared to other Indiana lakes. Based on this comparison, Smalley Lake, in general, had worse water quality than most Indiana lakes (Figure 11). Smalley Lake's Secchi disk depth was less than the Secchi disk depth in most Indiana lakes, indicating that most Indiana lakes were clearer than Smalley Lake (Appendix D). In addition, Smalley Lake possessed higher concentrations of chlorophyll *a* than most Indiana lakes, and the highest total phosphorus concentration of all the samples collected in Indiana lakes. High chlorophyll *a* concentrations suggest Smalley Lake was more productive than most Indiana lakes; high total phosphorus concentrations suggest Smalley Lake has the potential to be even more productive.

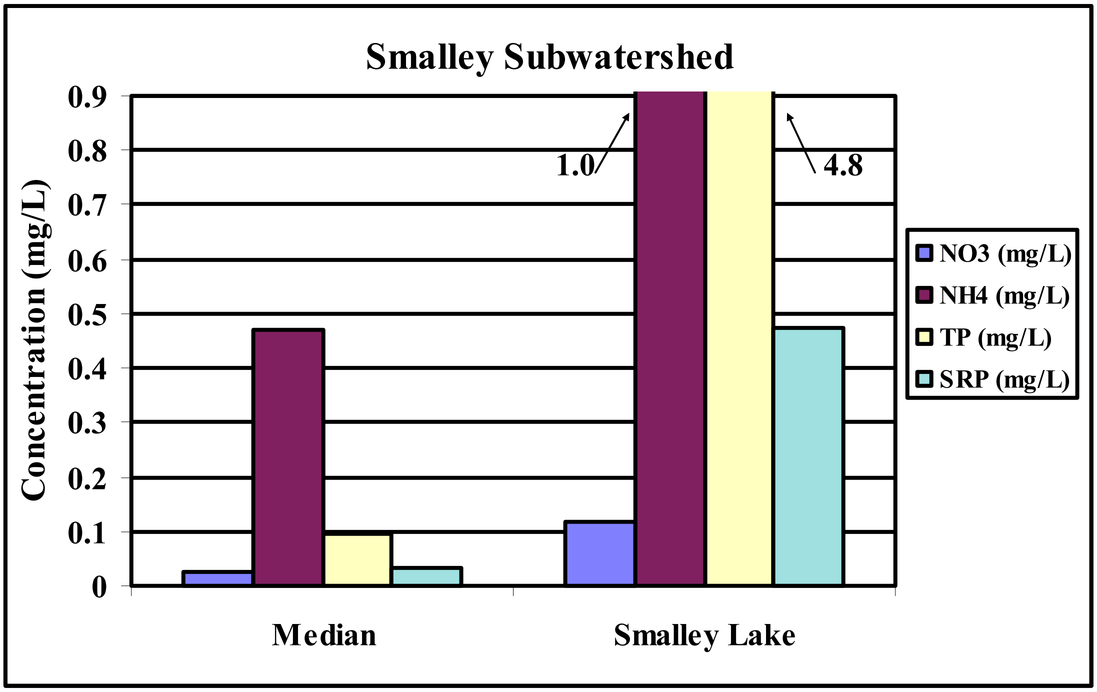

Figure 11. Comparison of Smalley Lake water quality data (1998) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

Smalley Subwatershed Stream Water Quality

Current stream water quality data associated with Smalley Lake was collected in 2003 as was recommended by the original draft version of this Watershed Management Plan. This data collection occurred as part of a Lake and River Enhancement (LARE) diagnostic study. Smalley Lake has two inlets (Sites 1 and 2) and one outlet (Site 3) (Figure 11a). The Tippecanoe River (Site 1) delivers significantly more pollutants to the lake than the northern inlet (Site 2). This is expected since the Tippecanoe River drains approximately 91% of the Smalley Lake watershed, while the northern inlet drains slightly less than 7% of the lake's watershed. However, when areal loading rates are examined, it is noticeable that the Tippecanoe River still contributes more pollutants per acre of subwatershed than the northern inlet. The exception to this is nitrate-nitrogen. The northern inlet contributes more nitrate nitrogen to Smalley Lake per acre of subwatershed than the Tippecanoe River. This suggests that, in general, management efforts should focus primarily on the Tippecanoe River subwatershed rather than the northern inlet subwatershed. However, management efforts to control nitrate-nitrogen in the northern inlet subwatershed, such as installing fencing to restrict cattle's access to the northern inlet, should be pursued.

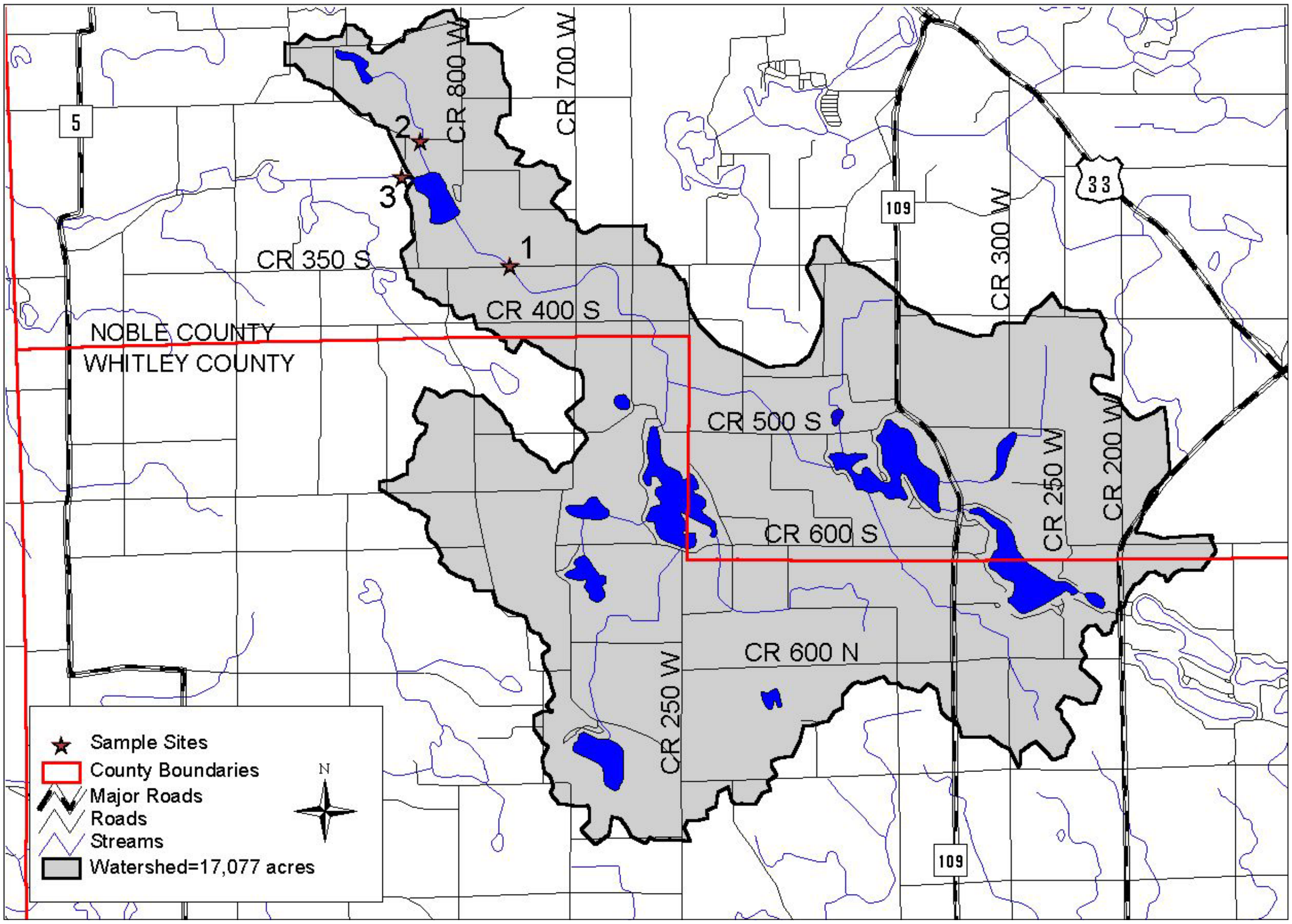

Figure 11a. LARE 2003 water quality sampling sites for Smalley Lake Watershed.

Physical Concentrations and Characteristics

None of the temperatures observed in the study streams violated the state water quality standards (Table 18a). With the exception of the results at the Smalley Lake outlet during base flow, the Tippecanoe River inlet (Site 1) and the Smalley Lake outlet (Site 3) exhibited dissolved oxygen concentrations within normal ranges for Indiana streams. Some turbidity levels were relatively high for Indiana streams and exceeded the target level recommended by the USEPA (USEPA, 2000).

Table 18a. Physical characteristics of the Smalley Lake watershed streams on 5/1/03 (storm flow) and 8/6/03 (base flow).

Site	Date	Timing	Flow (cfs)	Temp (°C)	D.O. (mg/L)	D.O. Sat. (%)	Cond. (µmhos)	TSS (mg/L)	Turbidity (NTU)
1	5/1/03	Storm	11.79	19.3	11.0	119.0	n/a	6.4	4.9
	8/6/03	Base	11.16	25.3	8.0	97.3	520	22.0	4.6
2	5/1/03	Storm	0.45	21.1	>20.0	n/a	n/a	11.8	5.1
	8/6/03	Base	0.00	23.8	2.7	31.0	500	20.4	17
3	5/1/03	Storm	14.81	17.1	11.8	123.0	n/a	4.7	3.1
	8/6/03	Base	14.18	26.7	11.8	147.6	393	6.0	2.9

Chemical and Bacterial Characteristics

In a recent study of 85 relatively undeveloped basins across the United States, the USGS reported the following median concentrations: ammonia (0.020 mg/L), nitrate (0.087 mg/L), total nitrogen (0.26 mg/L), soluble reactive phosphorus (0.010 mg/L), and total phosphorus (0.022 mg/L) (Clark et al., 2000). Nutrient concentrations, excluding soluble reactive phosphorus, in the Smalley Lake streams all exceeded these median concentrations, some parameters by an order of magnitude.

Nitrate concentrations in the study streams were average to slightly elevated for Indiana streams. The nitrate-nitrogen concentration at all sites exceeded the USEPA recommended target criterion of 0.3 mg/L for nitrate in streams. None of the streams exceeded the IAC standard of 10 mg/L. Both inlet streams, Sites 1 and 2, had relatively high concentrations of ammonia, 0.102 mg/L (storm) and 0.191 mg/L (base), respectively; likely this is due to decaying organic matter in the stream itself. Like nitrate concentrations, total Kjeldahl nitrogen levels in the Smalley Lake inlet and outlet streams were average to elevated for Indiana streams. Total phosphorus concentrations in the Smalley Lake watershed streams were average for Indiana streams. Soluble reactive phosphorus (SRP) concentrations were generally low; most of the SRP concentrations were at or below the method detection limit of 0.010 mg/L (Table 18b). Total suspended solid concentrations were low to moderate in the Smalley Lake watershed streams

Inlet and outlet streams were also sampled for E. coli concentrations in 2003. While all samples except the storm flow sample collected from the Smalley Lake outlet (Site 3) violated the Indiana state *E. coli* standard of 235 col/100ml, the *E. coli* concentrations were not generally high for Indiana (Table 18b). White (unpublished data) noted that the average *E. coli* concentration in Indiana waters is approximately 650 col/100ml. Most of the Smalley Lake watershed stream's *E. coli* concentrations were under 500 col/100ml. The base flow sample collected from the northern inlet is the exception to this. The *E. coli* concentration at this sampling location was 2700 col/100ml during base flow. The high *E. coli* concentration observed in the northern inlet (Site 2) during base flow likely resulted from livestock waste.

Table 18b. Chemical and bacterial concentrations of the Smalley Lake watershed streams on 5/1/03 (storm flow) and 8/6/03 (base flow).

Site	Date	Timing	pH	Alk. (mg/L)	NH3-N (mg/L)	NO3 --N (mg/L)	TKN (mg/L)	TP (mg/L)	SRP (mg/L)	*E. coli* (#/100 mL)
1	5/1/03	Storm	8.5	129	0.102	0.928	1.665	0.089	0.016	280
	8/6/03	Base	7.7	165	0.075	0.797	1.139	0.027	0.010*	490
2	5/1/03	Storm	8.7	238	0.075	3.556	1.342	0.058	0.010*	390
	8/6/03	Base	7.2	261	0.191	1.807	4.09	0.131	0.079	2,700
3	5/1/03	Storm	8.5	192	0.052	1.017	1.293	0.034	0.010*	9
	8/6/03	Base	8.5	156	0.064	0.735	1.343	0.084	0.010*	340

While pollutant concentration data provides an understanding of the water quality at a given time and the conditions to which stream biota are subjected, pollutant loading data provides an understanding of how much actual pollutant (mass) is delivered to a downstream waterbody per unit of time.

The pollutant load data for Smalley Lake's inlet and outlet streams (Table 18c) suggest that the lake serves as a sediment trap for particulate pollutants, especially during storm flow. Table 18b shows that more total suspended solids entered the lake than left the lake under both base and storm flow conditions. Similarly, particulate nutrient loading data indicate that Smalley Lake trapped a portion of the total phosphorus and total Kjeldahl nitrogen entering the lake during storm flow.

Table 18c. Chemical and sediment load characteristics of the Smalley Lake watershed streams on 5/1/03 (storm flow) and 8/6/03 (base flow).

Site	Date	Timing	NH3-N Load (kg/d)	NO3 --N Load (kg/d)	TKN Load (kg/d)	TP Load (kg/d)	SRP Load (kg/d)	TSS Load (kg/d)
1	5/1/03	Storm	0.10	0.95	1.70	0.09	0.02	6.52
	8/6/03	Base	0.07	0.77	1.10	0.03	bdl	21.21
2	5/1/03	Storm	0.00	0.14	0.05	0.00	bdl	0.45
	8/6/03	Base*	--	--	--	--	--	--
3	5/1/03	Storm	0.07	1.30	1.65	0.04	bdl	5.99
	8/6/03	Base	0.08	0.90	1.65	0.10	bdl	7.35

Ridinger/Robinson Subwatershed

Ridinger/Robinson Subwatershed Lake Water Quality

Robinson Lake and Ridinger Lake were selected to represent the Ridinger/Robinson Subwatershed. The Ridinger/Robinson Subwatershed forms the western headwaters of Elder Ditch. The Indiana Clean Lakes Program measured water quality at Robinson and Ridinger Lakes only one time, in 1998. Table 19 lists Indiana trophic state and index scores for the lakes. Robinson Lake, located upstream of Ridinger Lake, was eutrophic or very productive at the time of sampling. Water from Robinson Lake drains through Elder Ditch and combines with the Cedar Lake Branch and Shanton Ditch upstream of Ridinger Lake. Ridinger Lake was eutrophic/hypereutrophic at the time of sampling.

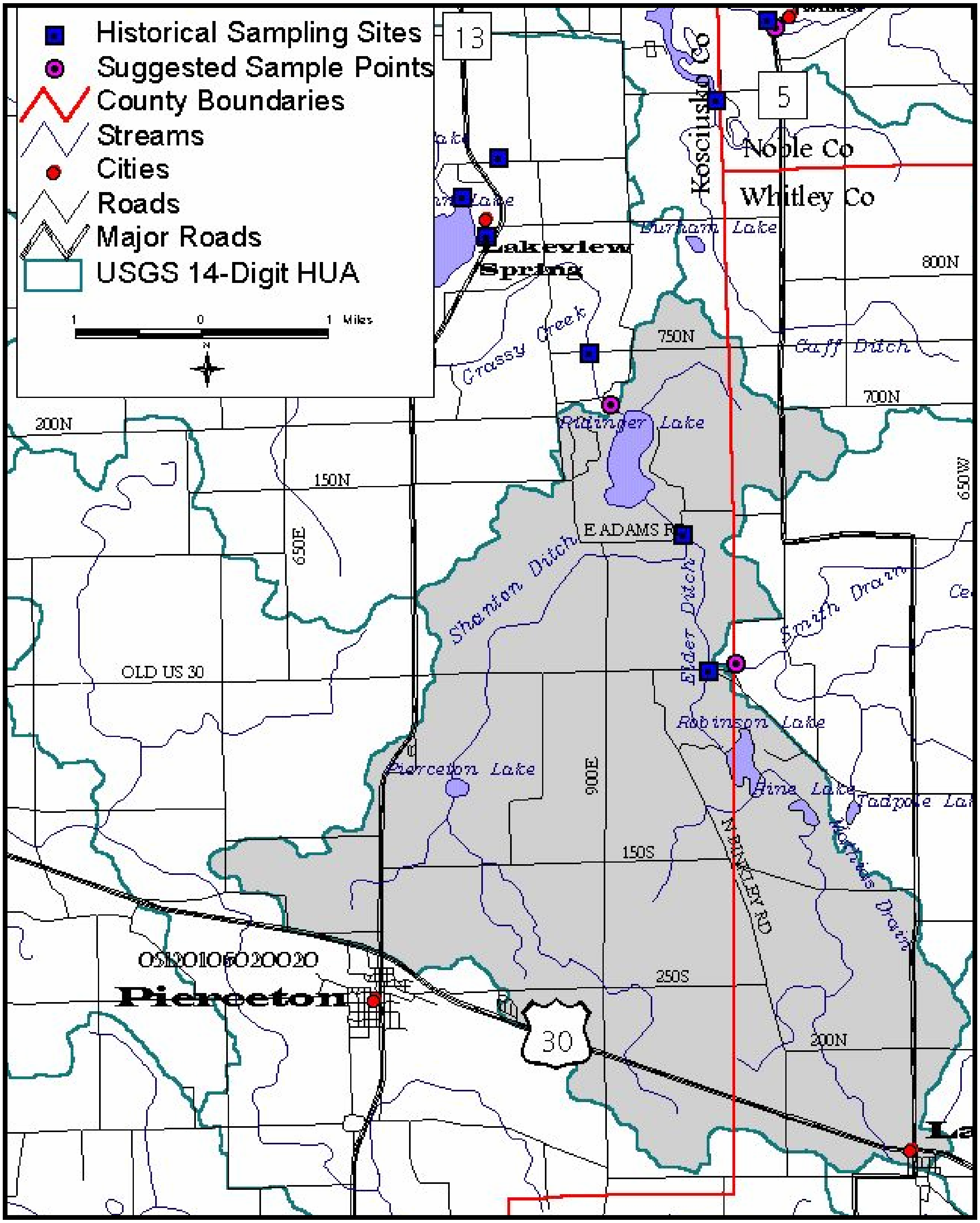

Figure 12. Ridinger/Robinson Subwatershed.

Table 19. Ridinger/Robinson Subwatershed Indiana trophic state index scores.

	1998
Ridinger Lake Trophic Score	46
Trophic Status	Eutrophic
Robinson Lake Trophic Score	38
Trophic Status	Eutrophic

Table 20 displays historic mean total phosphorus concentrations for Robinson Lake and Ridinger Lake. Total phosphorus concentrations increased from 1975 to 1998 in Ridinger Lake. Total phosphorus concentrations in Ridinger Lake remained lower than those measured in Robinson Lake at the time of sampling. When total phosphorus values are compared to Vollenweider's guidelines above, both lakes were above the mean value for hypereutrophic lakes.

Table 20. Ridinger/Robinson Subwatershed total phosphorus concentrations.

	1975	1988	1998
Ridinger Lake Concentration	0.050 mg/L	0.055 mg/L	0.216 mg/L
TP Score	Mesotrophic	Mesotrophic	Eutrophic
Robinson Lake Concentration	--	--	0.319 mg/L
TP Score	--	--	Eutrophic

Results from Robinson and Ridinger Lakes can also be compared to other Indiana lakes (Figure 13). Based on this comparison, both lakes had worse water quality than most Indiana lakes. Secchi disk depths were less than Secchi disk depths reported for most Indiana lakes, indicating that most Indiana lakes were clearer than Ridinger/Robinson Subwatershed lakes. Likewise, nitrogen, total phosphorus and chlorophyll *a* concentrations were higher than the samples collected from most Indiana lakes. High total phosphorus indicates that both Robinson and Ridinger Lakes have the potential to be more productive than most Indiana lakes; higher chlorophyll *a* concentrations suggest both that the lakes were more productive than most Indiana lakes.

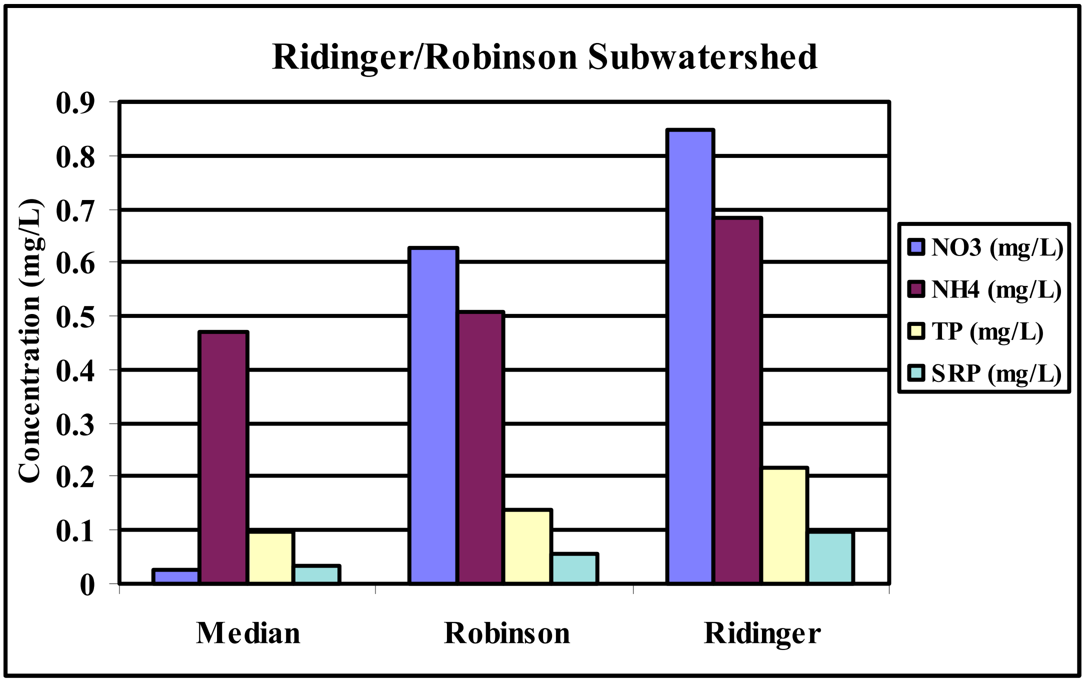

Figure 13. Comparison of Ridinger Lake and Robinson Lake water quality data (1998) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

Ridinger/Robinson Subwatershed Stream Water Quality

Health Department Data

The Kosciusko County Health Department collected three years of water quality monitoring data for Kosciusko County streams. The Ridinger/Robinson Subwatershed contains three of their sampling sites; one site on Grassy Creek at Kyle Drive (Site 1) and two sites on Elder Ditch, at Adams Road (Site 2) and Old Road 30 (Site 3) (Figure 12). Health department biologists collected water quality samples four times from November 1996 to June 1998, and twice yearly (May and October) in 2000 and 2001. Biologists analyzed the samples for dissolved oxygen, temperature change, nitrate-nitrogen, ammonia-nitrogen, total phosphorus, turbidity, total solids, BOD, and *E. coli* samples. Table 21 shows discharge for each site by date. Site 1 generally had the highest discharge. Site 3 generally had the lowest discharge.

Table 21. Discharge in cubic feet per second (cfs) for all sites by sampling date. A double dash (--) indicates that no sample was collected.

Date	Site 1	Site 2	Site 3
11/21/1996	136	5.2	--
4/22/1997	69.34	38.7	9.63
10/29/1997	26.43	9.62	8.05
5/13/1998	46.75	28.41	18.33
5/30/2000	101.79	182.99	--
10/24/2000	10.47	6.62	--
5/29/2001	33.18	14.66	--
10/17/2001	172.8	264.68	--

Source: Kosciusko County Health Department, 1998, 2000, and 2001.

Figures 14-15 display concentration and loading data for nitrate-nitrogen (NO_3^--N), a dissolved, inorganic form of nitrogen. Nitrate was below Indiana safe drinking water standards of 10 mg/L (327 IAC 2) for most collected samples. Typically, Site 1 had higher nitrate-nitrogen concentrations than those measured at the other two sites. Nitrate-nitrogen loading measured at Site 1 was nearly twice that measured at the other two sites. This indicates that some point or points downstream of the lake could be a potential source of nitrate to Elder Ditch.

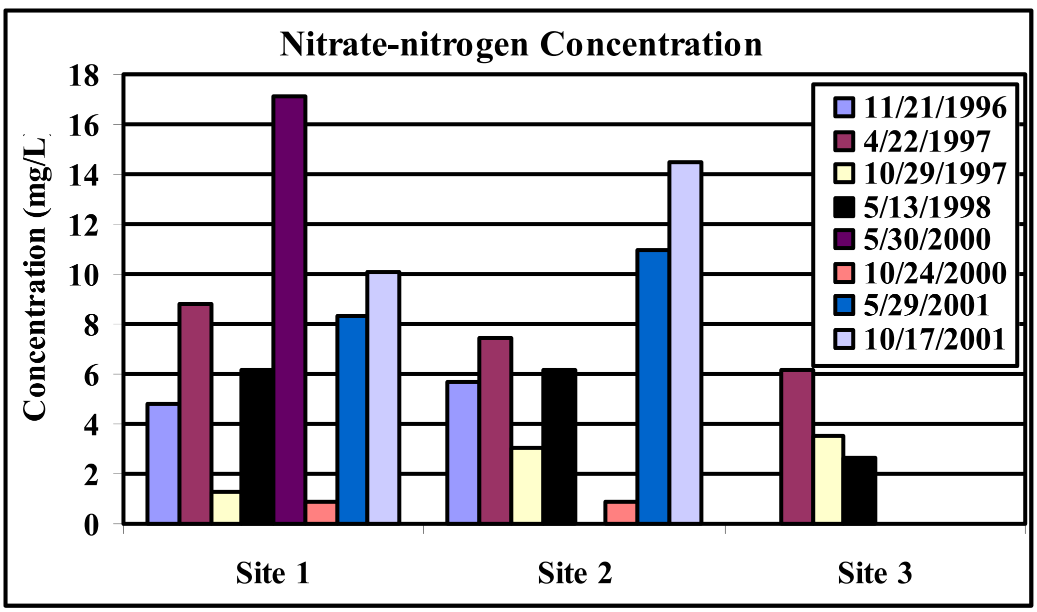

Figure 14. Nitrate-nitrogen concentrations in Ridinger/Robinson streams.

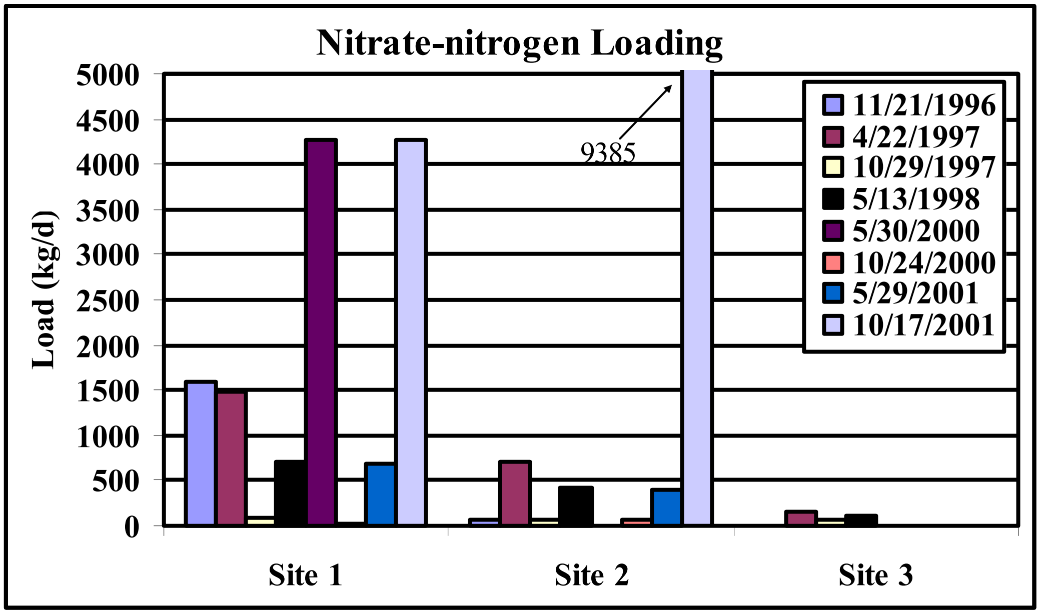

Figure 15. Nitrate-nitrogen loading in Ridinger/Robinson streams.

Figures 16 and 17 portray total phosphorus (TP) data for the three monitoring years. Total phosphorus concentrations exceeded the minimum level that causes eutrophication in temperate waterbodies (0.03 mg/L). Site 1 typically contained the highest total phosphorus concentration of all sample sites. Almost all samples contained total phosphorus concentrations below the 0.28 mg/L level acceptable for modified warmwater habitat (Ohio EPA, 1999). Site 1 consistently maintained higher flows than all other sample sites and generally carried the highest total phosphorus load.

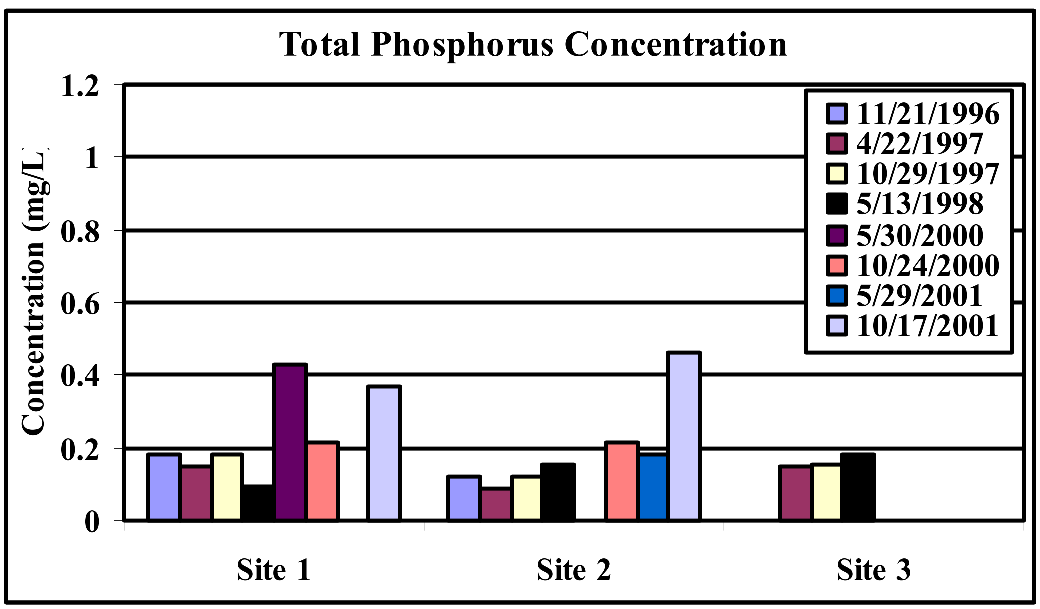

Figure 16. Total phosphorus concentration in Ridinger/Robinson streams.

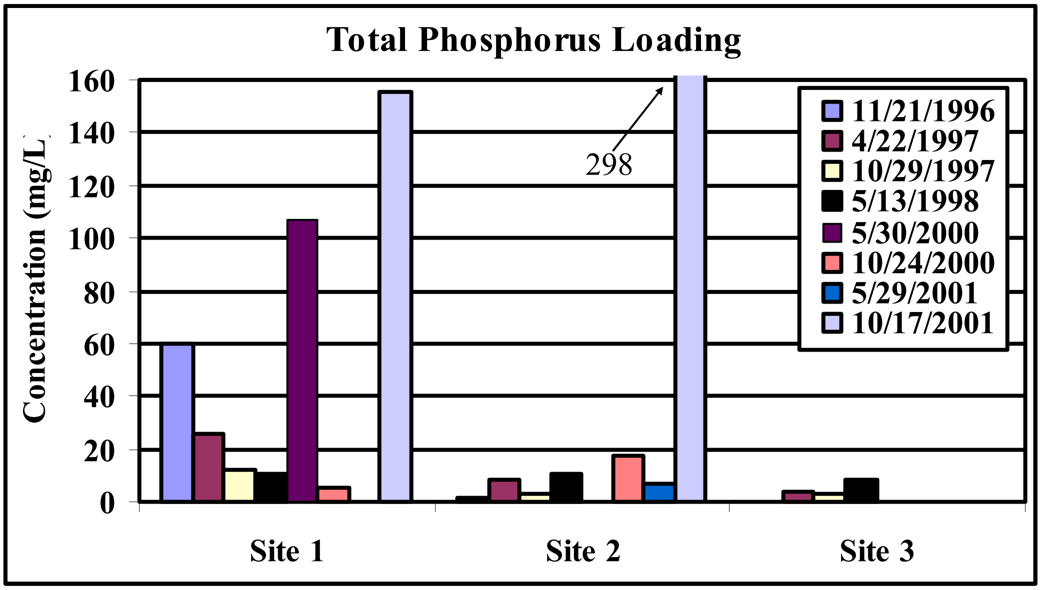

Figure 17. Total phosphorus loading in Ridinger/Robinson streams.

E. coli concentrations at most sites were generally less than 235 col/100 ml, the Indiana state standard for contact recreation (Figure 18). The April 1997 site 3 sample contained the highest concentrations of *E. coli*.

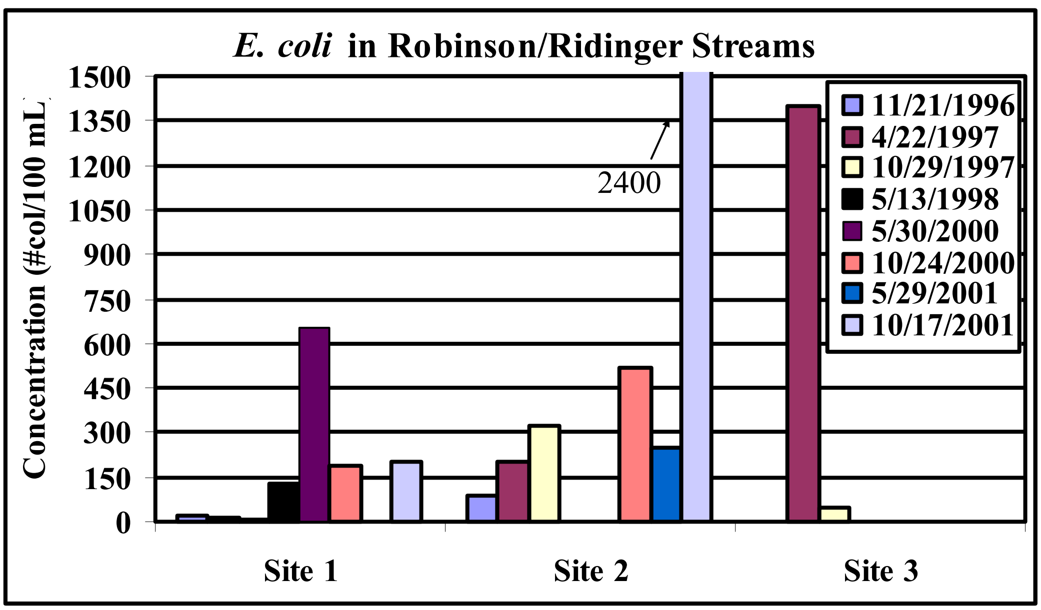

Figure 18. *E. coli* concentration in Ridinger/Robinson streams.

Lake and River Enhancement (LARE) Data

As a result of recommendations in the original draft version of this plan, as well as Ridinger/Robinson's overall poor ranking when compared to other subwatersheds a complete LARE diagnostic study was conducted on this subwatershed in 2003. As part of the diagnostic study, water samples were collected and analyzed for various parameters from seven streams in the Ridinger/Robinson Lake watershed (Figure 18a).

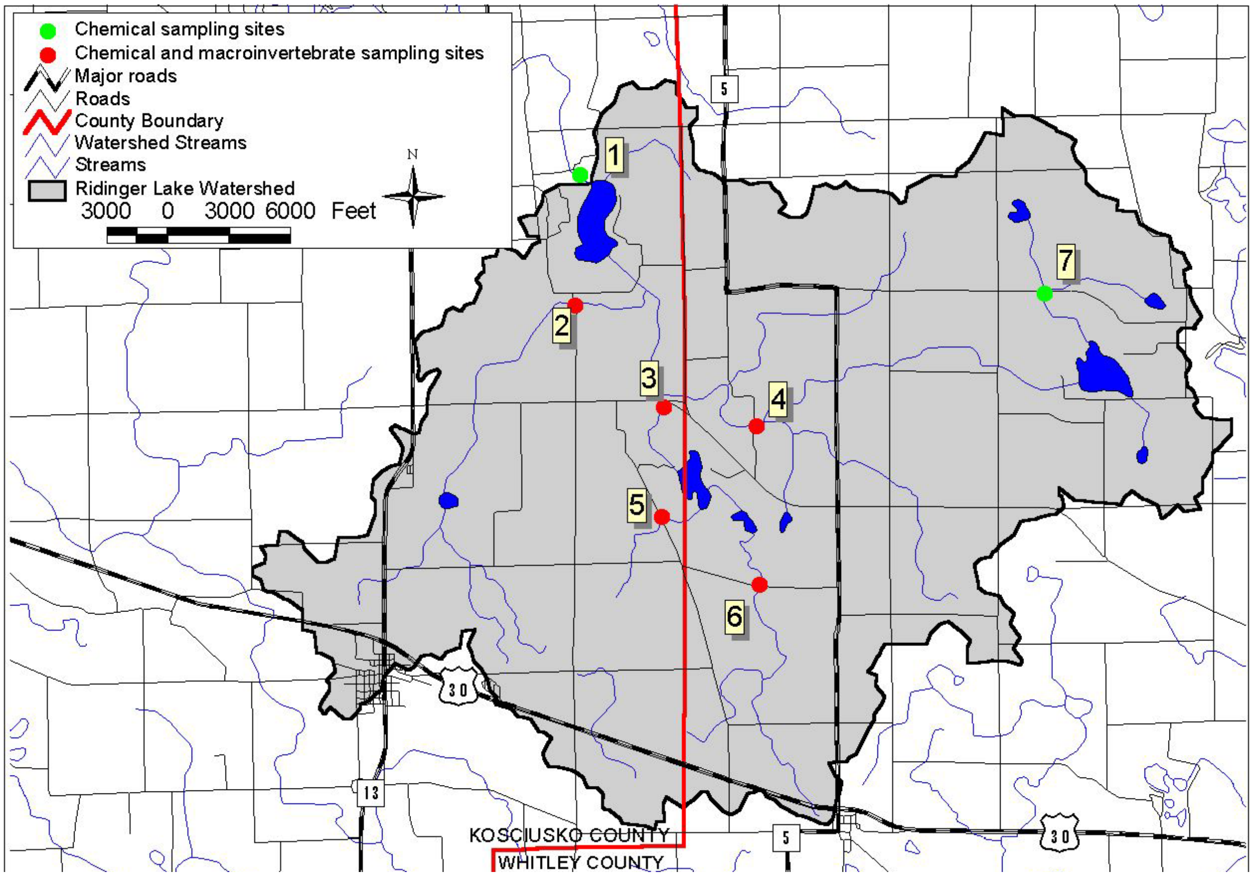

Figure 18a. LARE 2003 sample sites for Ridinger/Robinson

Physical Concentrations and Characteristics

Physical parameter results measured during base and storm flow sampling of the Ridinger Lake watershed streams are presented in Table 21a. Water temperatures in the Ridinger Lake watershed streams varied with season. As expected, stream temperatures in early Mary during storm flow conditions were lower than stream temperatures in August during storm flow conditions. None of the observed water temperatures exceeded the Indiana Administrative Code standard for the protection of aquatic life. Dissolved oxygen saturation levels at base flow were generally within the normal range for Indiana streams. Total suspended solids concentrations in the Ridinger Lake watershed streams ranged from 0.4 mg/L in Delano Ditch during base flow and Mathias Ditch during storm flow to 10.8 mg/L in Shanton Ditch during storm flow. None of the concentrations in the Ridinger Lake watershed streams exceeded 80 mg/L, the threshold at which Waters (1995) found to be deleterious to aquatic life. Turbidity concentrations in the Ridinger Lake watershed streams were generally low. None of the streams possessed turbidity concentrations above the USEPA recommended target of 9.9 NTU (USEPA, 2000a).

Table 21a. Physical characteristics of the Ridinger Lake watershed streams on 5/1/03 (storm flow) and 8/6/03 (base flow).

Site Name	Site #	Date	Event	Flow (cfs)	Temp (oC)	D.O.* (mg/L)	D.O. % Sat	TSS (mg/L)	Turbidity (NTU)
Ridinger Lake outlet	1	5/1/03	storm	12.0	18.8	11.4	121.0	4.2	2.5
		8/6/03	base	8.5	27.4	9.4	118.7	10.0	3.4
Shanton Ditch	2	5/1/03	storm	2.7	19.6	16.8	183.1	10.8	5.0
		8/6/03	base	1.5	26.1	6.6	81.1	7.8	4.0
Robinson Lake outlet	3	5/1/03	storm	1.7	20.2	10.6	117.7	6.5	5.5
		8/6/03	base	0.7	25.2	12.6	152.0	2.3	1.9
Elder Ditch	4	5/1/03	storm	2.2	18.9	12.8	136.9	5.9	5.8
		8/6/03	base	1.9	23.3	6.8	79.6	8.4	6.0
Doke Ditch	5	5/1/03	storm	0.5	18.0	11.1	116.6	4.2	8.0
		8/6/03	base	0.2	19.1	6.9	74.5	6.0	5.0
Mathias Ditch	6	5/1/03	storm	1.0	18.0	12.9	136.5	0.4	2.8
		8/6/03	base	0.6	19.3	8.9	96.5	4.6	4.6
Delano Ditch	7	5/1/03	storm	0.5	20.0	10.5	115.0	12.1	5.5
		8/6/03	base	0.4	23.2	7.5	92.7	0.4	4.3

Chemical and Bacterial Concentrations and Characteristics

The chemical and bacterial characteristics of the Ridinger Lake watershed streams during base and storm flow conditions are shown in Table 21b. In a recent study of 85 relatively undeveloped basins across the United States, the USGS reported the following median concentrations: ammonia (0.020 mg/L), nitrate (0.087 mg/L), total nitrogen (0.26 mg/L), soluble reactive phosphorus (0.010 mg/L), and total phosphorus (0.022 mg/L) (Clark et al., 2000). Nutrient concentrations in the Ridinger Lake streams all exceeded these median concentrations, some parameters by an order of magnitude (Table 21b).

Alkalinity, pH, and conductivity values were within normal ranges for Indiana streams. Nitrate-nitrogen concentrations in the Ridinger Lake watershed streams were slightly elevated for Indiana streams. Ammonia concentrations ranged from below the laboratory detection limit in Mathias Ditch at base flow to 0.421 mg/L in Mathias Ditch during storm flow. Relatively high ammonia concentrations were also observed in Shanton Ditch during base flow and Delano Ditch during both base and storm flow conditions. Total Kjeldahl nitrogen levels in the Ridinger Lake watershed streams were roughly average for northern Indiana streams. Soluble reactive phosphorus (SRP) concentrations in the Ridinger Lake watershed streams were higher than desired for headwater streams. SRP concentrations in the Ridinger Lake watershed streams ranged from at or below the detection limit of 0.010 mg/L in the Ridinger Lake outlet during storm flow to 0.093 mg/L in Elder Ditch at storm flow. Elder Ditch also exhibited the highest base flow SRP concentration, which was higher than the SRP concentrations at all the other sites during base or storm flow. High SRP concentrations were also observed in Mathias Ditch and Delano Ditch during both base and storm flow. Elder Ditch, Mathias Ditch, and the Troy Cedar Lake also possessed relatively high *E. coli* concentrations during base and/or storm flow. Waste (wildlife and/or human) may be increasing the SRP concentrations in these streams. Management efforts should focus on reducing the waste reaching these streams. Nutrient (fertilizer) management should also be a priority on agricultural and residential land in these subwatersheds.

Like the TKN levels, total phosphorus concentrations in the Ridinger Lake watershed streams were average for northern Indiana streams. Despite the fact that the concentrations were relatively average for northern Indiana, the total phosphorus concentrations in some of the streams suggested that they were fairly productive streams and this high productivity has the potential to impair the streams' biotic communities. All of the streams, except Doke Ditch, possessed base and/or storm flow total phosphorus concentrations that would place the streams in the eutrophic, or highly productive, category using Dodd et al.'s (1998) criteria. Total phosphorus concentrations in all of the watershed streams at base and storm flow conditions exceeded the USEPA recommended target criterion of 0.033 mg/L (USEPA, 2000a).

E. coli concentrations in the Ridinger Lake watershed streams were relatively high. More than half of the water quality samples collected from the Ridinger Lake watershed streams contained *E. coli* concentrations that violated state water quality standards. In addition to violating the state standard, *E. coli* concentrations at four of the sampling sites were above the average *E. coli* concentration of 650 col/100mL found in Indiana waters (White, unpublished data).

Table 21b. Chemical and bacterial characteristics of the Ridinger Lake watershed streams on 5/1/03 (storm flow) and 8/6/03 (base flow).

Site	Site #	Date	Event	pH	Alk. (mg/L)	Cond (µmhos)	NO3-N (mg/L)	NH3-N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	*E. coli* (col/100 mL)
Ridinger Lake outlet	1	5/1/03	storm	8.7	188	n/a	2.430	0.044	1.292	0.010*	0.044	20
		8/6/03	base	8.4	147	440	1.647	0.101	1.557	0.021	0.118	34
Shanton Ditch	2	5/1/03	storm	8.4	217	n/a	2.088	0.056	1.673	0.022	0.096	200
		8/6/03	base	7.7	229	590	0.846	0.354	1.276	0.055	0.144	630
Robinson Lake outlet	3	5/1/03	storm	7.8	166	n/a	0.950	0.090	1.038	0.017	0.089	470
		8/6/03	base	7.7	173	550	0.600	0.108	0.745	0.045	0.091	23
Elder Ditch	4	5/1/03	storm	8.4	201	n/a	1.234	0.073	1.170	0.093	0.177	980
		8/6/03	base	8.2	203	415	1.528	0.064	0.896	0.069	0.064	950
Doke Ditch	5	5/1/03	storm	8.1	242	n/a	1.219	0.053	0.853	0.025	0.045	1,410
		8/6/03	base	7.6	317	600	0.893	0.068	0.545	0.021	0.064	380
Mathias Ditch	6	5/1/03	storm	8.3	213	n/a	1.666	0.421	1.130	0.051	0.178	210
		8/6/03	base	8.1	257	600	1.789	0.018*	0.958	0.066	0.097	13,100
Delano Ditch	7	5/1/03	storm	8.0	174	n/a	2.396	0.129	1.872	0.051	0.010#	1,390
		8/6/03	base	7.7	186	400	1.162	0.119	1.425	0.058	0.094	180

While pollutant concentration data provides an understanding of the water quality at a given time and the conditions to which stream biota are subjected, pollutant loading data provides an understanding of how much actual pollutant (mass) is delivered to a downstream waterbody per unit of time.

When each of the watershed streams is compared to one another (Table 21c), it is noticeable that the Ridinger Lake outlet possessed the highest loading rate for most of the pollutants measured. The only exception to this is Elder Ditch, which exhibited the highest SRP loading rate at storm flow. That the Ridinger Lake outlet had the greatest loading rates, particularly for sediment and particulate nutrient pollutants, is not surprising. This portion of the stream possesses the greatest watershed area and therefore has the greatest potential for pollutant delivery. Knowing that the Ridinger Lake outlet possessed the greatest pollutant loading rates does little to help direct watershed management efforts, so it is useful to consider which streams aside from the Ridinger Lake outlet possessed high pollutant loading rates. Of the remaining streams, Shanton Ditch and Elder Ditch generally exhibited the highest pollutant loading rates under both base and storm flow conditions. The only exception was Mathias Ditch, which possessed the highest ammonia-nitrogen loading rate during storm flow. The high pollutant loading rates measured in Shanton and Elder Ditches suggest that management efforts should be directed at these subwatersheds.

Table 21c. Areal pollutant loading rates for the Ridinger Lake watershed streams on 5/1/03 (storm flow) and 8/6/03 (base flow). Red shading indicates base and storm flow sites which possessed the highest load, while pink indicates those sites with the second highest load.

Site Name	Site #	Date	Event	NO3-N Load (kg/d)	NH3-N Load (kg/d)	TKN Load (kg/d)	SRP Load (kg/d)	TP Load (kg/d)	TSS Load (kg/d)
Ridinger Lake outlet	1	5/1/03	storm	2.516	0.046	1.338	bdl	0.046	4.348
		8/6/03	base	1.202	0.074	1.137	0.015	0.086	7.301
Shanton Ditch	2	5/1/03	storm	0.482	0.013	0.386	0.005	0.022	2.493
		8/6/03	base	0.111	0.046	0.168	0.007	0.019	1.021
Robinson Lake outlet	3	5/1/03	storm	0.137	0.013	0.150	0.002	0.013	0.939
		8/6/03	base	0.038	0.007	0.047	0.003	0.006	0.144
Elder Ditch	4	5/1/03	storm	0.237	0.014	0.225	0.018	0.034	1.137
		8/6/03	base	0.247	0.010	0.145	0.011	0.010	1.357
Doke Ditch	5	5/1/03	storm	0.049	0.002	0.034	0.001	0.002	0.170
		8/6/03	base	0.018	0.001	0.011	0.000	0.001	0.119
Mathias Ditch	6	5/1/03	storm	0.140	0.035	0.095	0.004	0.051	0.034
		8/6/03	base	0.099	bdl	0.053	0.004	0.005	0.253
Delano Ditch	7	5/1/03	storm	0.099	0.005	0.077	0.002	bdl	0.501
		8/6/03	base	0.036	0.004	0.044	0.002	0.003	0.012

<u>Goose/Loon Subwatershed</u>

Goose/Loon Subwatershed Lake Water Quality

Loon Lake and Goose Lake were selected to provide representative data for the Loon/Goose Subwatershed. The Loon/Goose Subwatershed forms the western headwaters of the Tippecanoe River. The Indiana Clean Lakes Program measured water quality at Loon and Goose Lakes on two separate occasions, in 1994 and 1998. Table 22 lists Indiana trophic state and index scores for Goose and Loon Lakes from these two sampling efforts. Water quality in both lakes decreased, rating as mesotrophic in 1994 and eutrophic in 1998.

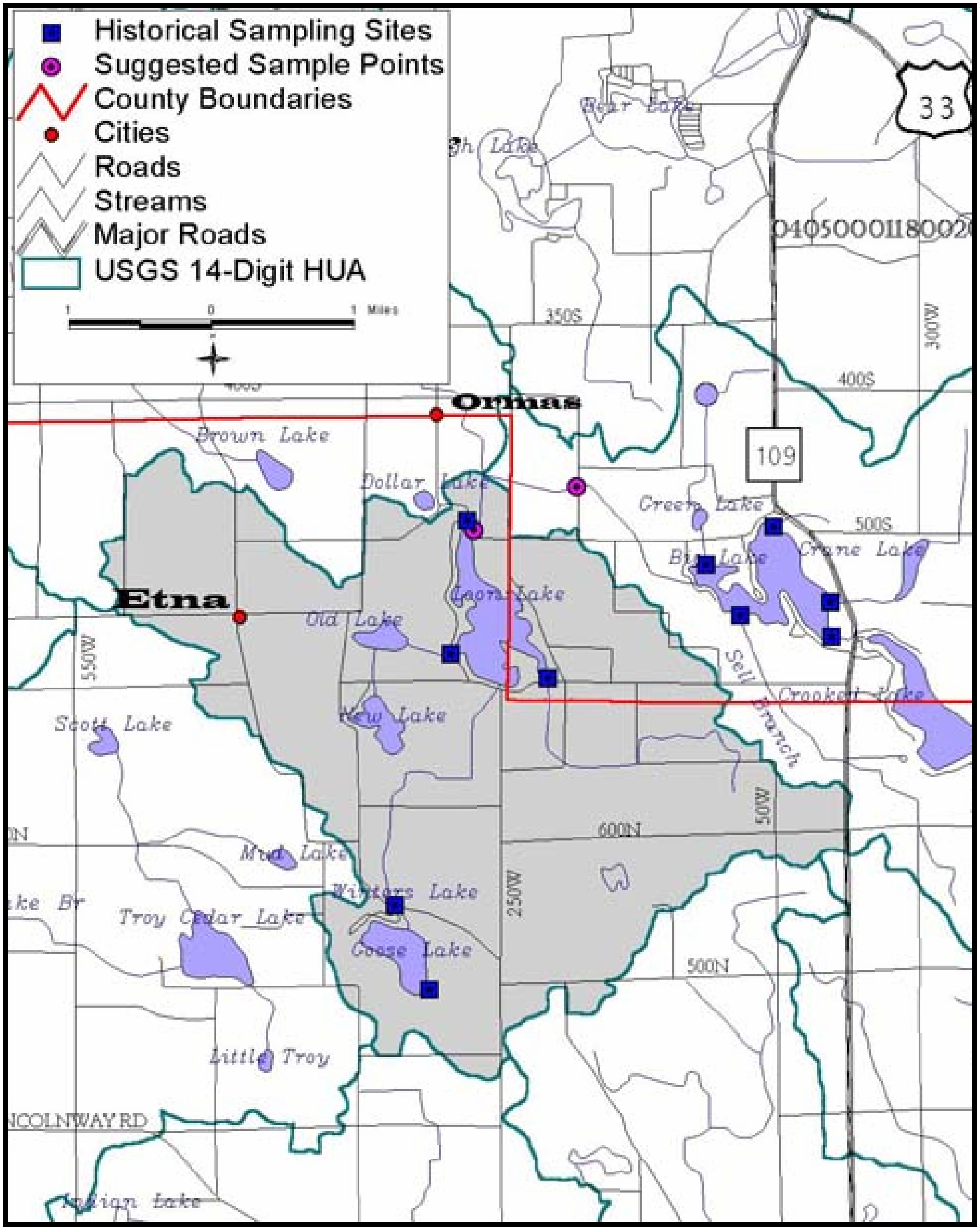

Figure 19. Goose/Loon Subwatershed.

Table 22. Goose/Loon Subwatershed Indiana trophic state index scores.

	1994	1998
Goose Lake Trophic Score	31	36
Trophic Status	Mesotrophic	Eutrophic
Loon Lake Trophic Score	27	41
Trophic Status	Mesotrophic	Eutrophic

Table 23 displays historic mean total phosphorus concentrations for Loon and Goose Lakes. Total phosphorus concentrations decreased from 1994 to 1998 suggesting an improvement in water quality. However, when total phosphorus values are compared to Vollenweider's guidelines above, the values exceed the mean value for eutrophic lakes.

Table 23. Goose/Loon Subwatershed total phosphorus concentrations.

	1994	1998
Goose Lake Concentration	0.243 mg/L	0.225 mg/L
TP Score	Eutrophic	Eutrophic
Loon Lake Concentration	0.359 mg/L	0.302 mg/L
TP Score	Eutrophic	Eutrophic

Results from Loon Lake and Goose Lake can also be compared to other Indiana lakes (Figure 20). Based on this comparison, Goose Lake and Loon Lake, in general, had poorer water quality than most Indiana lakes. Goose Lake's Secchi disk depth was less than Secchi disk depths measured in most Indiana lakes, indicating that most Indiana lakes are clearer than Goose Lake. Goose Lake also possessed higher concentrations of total phosphorus, soluble reactive phosphorus, and ammonia-nitrogen than the median concentration recorded for other Indiana lakes. However, low chlorophyll *a* concentrations indicate that although nutrients appear to be readily available, algae growth was limited in Goose Lake. Loon Lake had similar water quality to that measured in Goose Lake. Loon Lake's Secchi disk depth was less than Goose Lake's. Total phosphorus, soluble reactive phosphorus, and chlorophyll *a* concentrations measured in Loon Lake were higher than concentrations measured in Goose Lake and most Indiana lakes. This suggests that both Goose and Loon Lakes had poorer water quality than other Indiana lakes.

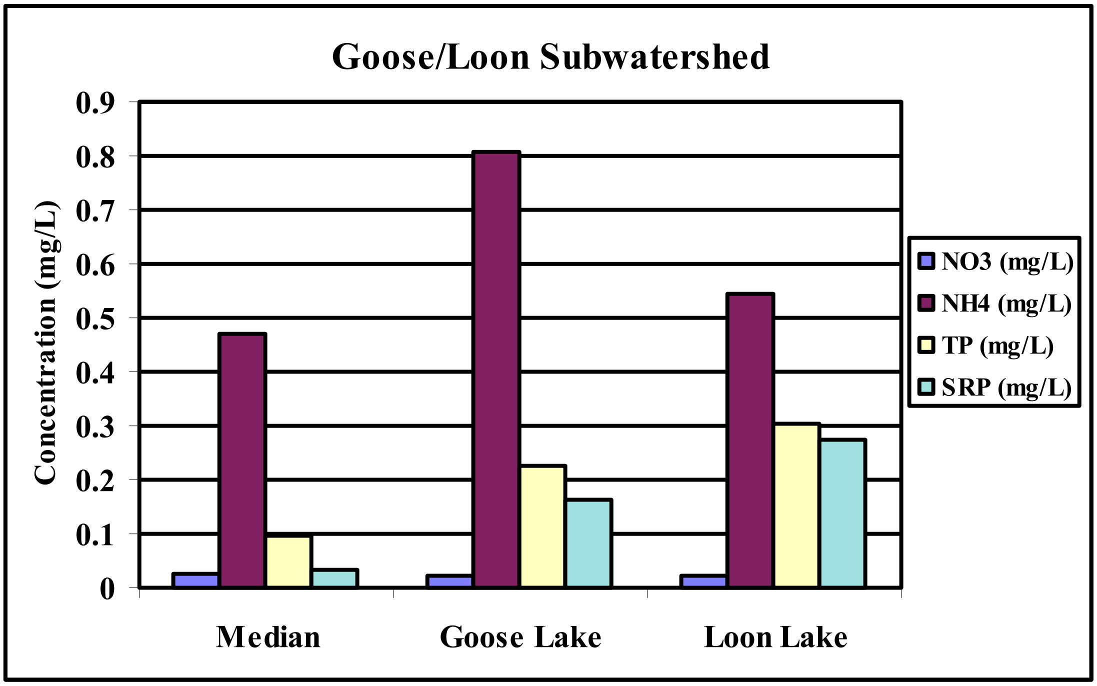

Figure 20. Comparison of Loon Lake and Goose Lake water quality data (1998) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

Goose/Loon Subwatershed Stream Water Quality

No published stream water quality data exists for the Loon/Goose Subwatershed. Further study of the Loon/Goose Subwatershed streams will allow for an analysis of background water quality conditions, problem area identification, and, ultimately, water quality improvement project completion.

Elder Ditch Subwatershed

Elder Ditch Subwatershed Lake Water Quality

Troy Cedar Lake was chosen to represent the Elder Ditch Subwatershed. The Elder Ditch Subwatershed forms the eastern headwaters of Elder Ditch. The Indiana Clean Lakes Program measured water quality at Troy Cedar Lake on three separate occasions, in 1990, 1994 and 1998. Table 24 lists Indiana trophic state and index scores for Troy Cedar Lake from these three samplings. While there was minor variability in the year-to-year TSI values, there was no general increasing or decreasing trend. Water quality at Troy Cedar Lake remained relatively constant from 1990 to 1998. The TSI scores suggest Troy Cedar Lake is slightly eutrophic.

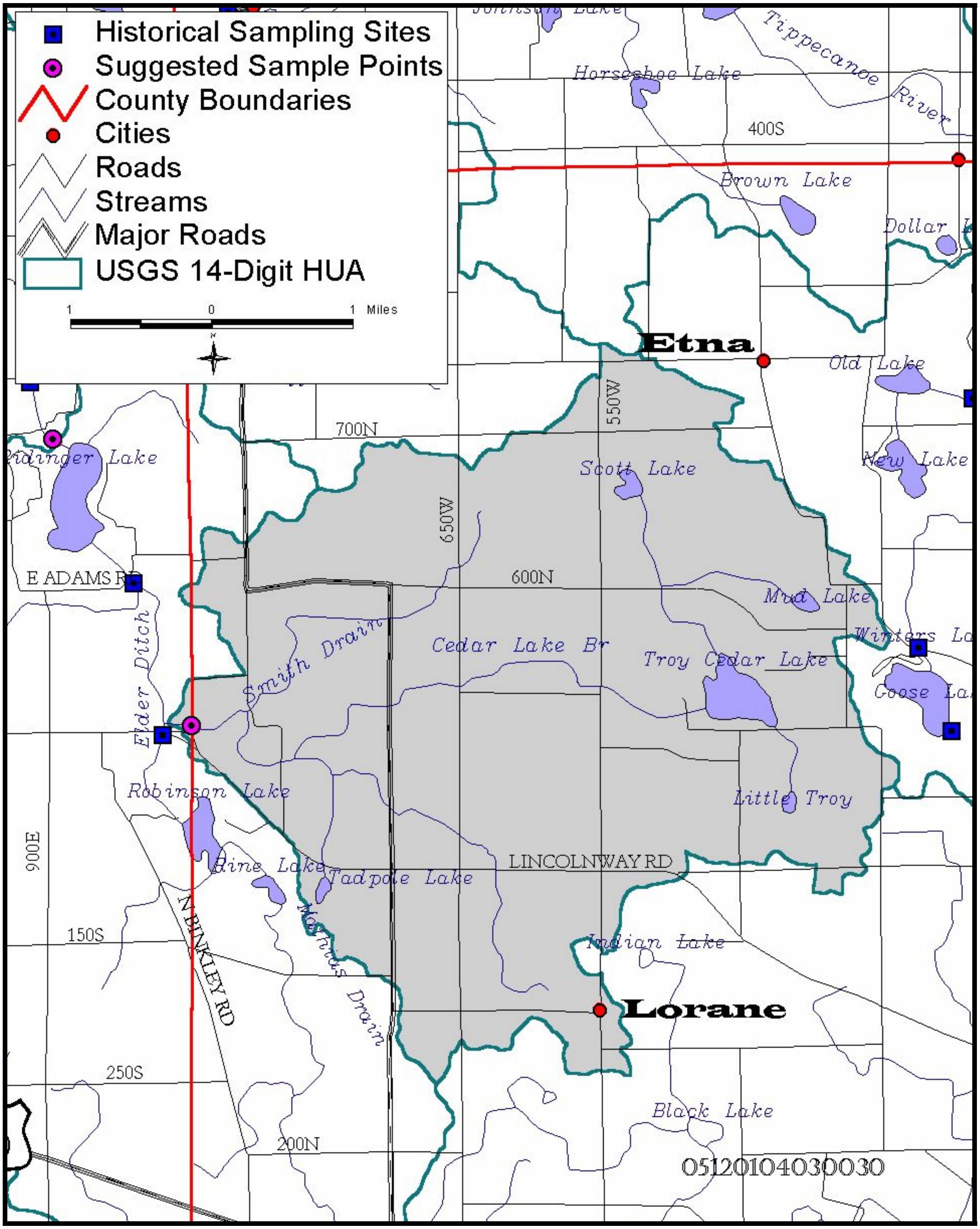

Figure 21. Elder Ditch Subwatershed.

Table 24. Elder Ditch Subwatershed Indiana trophic state index scores.

	1990	1994	1998
Troy Cedar Lake Trophic Score	39	39	31
Troy Cedar Lake Trophic Status	Eutrophic	Eutrophic	Mesotrophic

Table 25 displays historic mean total phosphorus concentrations for Troy Cedar Lake. Total phosphorus concentrations indicate no general trend from 1990 to 1998. The 1994 sample contained the highest concentration of total phosphorus. Total phosphorus concentrations declined slightly in 1998. When total phosphorus values are compared to Vollenweider's guidelines above, the 1994 and 1998 total phosphorus concentrations exceed the mean value for eutrophic lakes; the 1990 total phosphorus concentration is only slightly below eutrophic status.

Table 25. Elder Ditch Subwatershed total phosphorus concentrations.

	1990	1994	1998
Troy Cedar Lake Concentration	0.062 mg/L	0.225 mg/L	0.198 mg/L
TP Score	Mesotrophic	Eutrophic	Eutrophic

Results from Troy Cedar Lake can also be compared to other Indiana lakes (Figure 22). Based on this comparison, Troy Cedar Lake, in general, had worse water quality than most Indiana lakes. Troy Cedar Lake's Secchi disk depth was less than the Secchi disk depth observed in most Indiana lakes, indicating that most Indiana lakes are clearer than Troy Cedar Lake. In addition, Troy Cedar Lake possessed higher concentrations of chlorophyll *a* and total phosphorus than concentrations observed in most Indiana lakes. High chlorophyll *a* and total phosphorus concentrations suggest Troy Cedar Lake was more productive and has poorer water quality than most Indiana lakes.

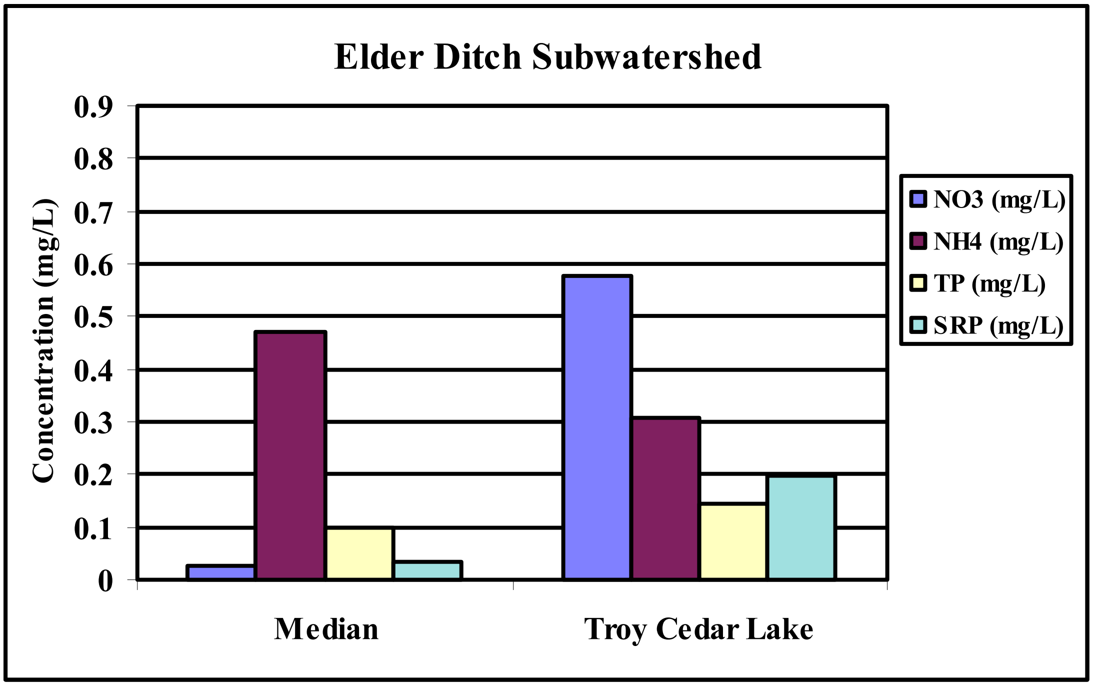

Figure 22. Comparison of Troy Cedar Lake water quality data (1998) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

Elder Ditch Subwatershed Stream Water Quality

No published stream water quality data exists for the Elder Ditch Subwatershed. Further study of the Elder Ditch Subwatershed streams will allow for an analysis of background water quality conditions, problem area identification, and, ultimately, water quality improvement project completion.

Barbee Lakes Subwatershed

Barbee Lakes Subwatershed Lake Water Quality

The Barbee Lake Chain (Big Barbee, Little Barbee, Irish, Banning, Sechrist, Sawmill and Kuhn Lakes) was selected to represent the Barbee Lakes Subwatershed and the downstream portion of Elder Ditch. The Indiana Clean Lakes Program measured water quality at the Barbee Lakes only four times, in 1990, 1994, 1998 and 1999. Table 26 lists Indiana trophic state and index scores for the lakes calculated from each of the four samplings. While there is much variability in the year-to-year TSI values, there is a general trend for decreasing TSIs (improved conditions). Caution must be used with the 1999 scores as “improved” lake conditions are often observed during drought years like 1999 (New, 2000). The lower scores for 1999 may be more related to the drought than to improving lake conditions. (Similarly, drought conditions should be considered for all samples collected in 1999.) Nonetheless, the overall trend of lower TSI values is encouraging.

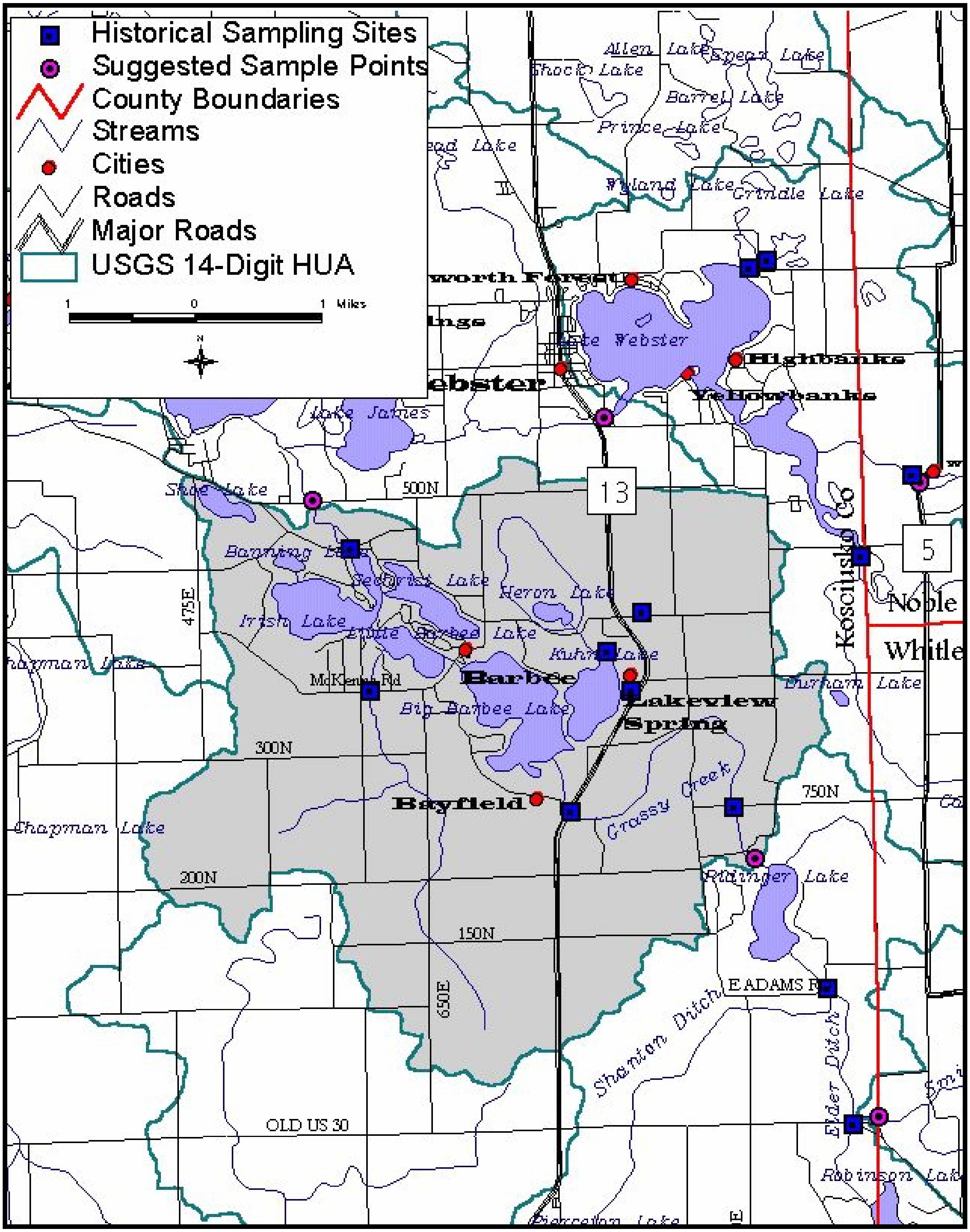

Figure 23. Barbee Lakes Subwatershed.

Table 26. Barbee Lakes Subwatershed Indiana trophic state index scores.

	1990	1994	1998	1999
Banning Lake Trophic Score	11	22	27	12
Trophic Status	Oligotrophic	Mesotrophic	Mesostrophic	Oligotrophic
Big Barbee Lake Trophic Score	36	39	35	20
Trophic Status	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic
Irish Lake Trophic Score	34	36	28	33
Trophic Status	Eutrophic	Eutrophic	Mesotrophic	Mesotrophic
Kuhn Lake Trophic Score	24	29	15	6
Trophic Status	Mesotrophic	Mesotrophic	Oligotrophic	Oligotrophic
Little Barbee Trophic Score	40	38	37	38
Trophic Status	Eutrophic	Eutrophic	Eutrophic	Eutrophic
Sawmill Lake Trophic Score	40	25	28	19
Trophic Status	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic
Sechrist Lake Trophic Score	27	29	21	17
Trophic Status	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic

Table 27 displays historic mean total phosphorus concentrations for the Barbee Chain of Lakes. In general, total phosphorus concentrations in 1999 were higher than in previous years. This is the opposite trend needed for improving lake conditions. When the 1999 values are compared to Vollenweider's guidelines above, Kuhn, Banning and Irish lakes were below the mean value for eutrophic lakes. The remaining lakes (Sechrist, Sawmill, Big Barbee, and Little Barbee) all have mean total phosphorus concentrations greater than the mean for eutrophic lakes in Vollenweider's data.

Table 27. Barbee Lakes Subwatershed total phosphorus concentrations.

	1983	1988	1990	1994	1998	1999
Banning Lake Concentration	--	--	0.040 mg/L	0.019 mg/L	0.063 mg/L	0.063 mg/L
TP Score	--	--	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic
Big Barbee Lake Concentration	0.090 mg/L	0.140 mg/L	0.060 mg/L	0.272 mg/L	0.232 mg/L	0.421 mg/L
TP Score	Eutrophic	Eutrophic	Mesotrophic	Eutrophic	Eutrophic	Eutrophic
Irish Lake Concentration	0.070 mg/L	0.090 mg/L	0.030 mg/L	0.073 mg/L	0.027 mg/L	0.082 mg/L
TP Score	Mesotrophic	Eutrophic	Mesotrophic	Mesotrophic	Eutrophic	Mesotrophic
Kuhn Lake Concentration	0.070 mg/L	0.140 mg/L	0.020 mg/L	0.016 mg/L	0.040 mg/L	0.033 mg/L
TP Score	Mesotrophic	Eutrophic	Mesotrophic	Oligotrophic	Mesotrophic	Mesotrophic
Little Barbee Lake Concentration	0.080 mg/L	0.120 mg/L	0.280 mg/L	0.373 mg/L	0.148 mg/L	0.334 mg/L
TP Score	Eutrophic	Eutrophic	Eutrophic	Eutrophic	Eutrophic	Eutrophic
Sawmill Lake Concentration	0.070 mg/L	0.120 mg/L	0.100 mg/L	0.168 mg/L	0.115 mg/L	0.214 mg/L
TP Score	Mesotrophic	Eutrophic	Eutrophic	Eutrophic	Eutrophic	Eutrophic
Sechrist Lake Concentration	0.070 mg/L	0.140 mg/L	0.070 mg/L	0.056 mg/L	0.044 mg/L	0.094 mg/L
TP Score	Mesotrophic	Eutrophic	Mesotrophic	Mesotrophic	Mesotrophic	Eutrophic

Figure 24 compares the mean of selected water quality parameters for the Barbee Chain of Lakes to the median value for all Indiana lakes. Kuhn was better in all parameters. Banning was better in all but the

Secchi disk transparency. Sechrist was better in three parameters. The other lakes (Big Barbee, Sawmill, Little Barbee, and Irish) had generally higher values for the water quality parameters when compared to all Indiana lakes. Little Barbee was worse in all parameters. Generally, Barbee Chain Lakes have poorer water quality than other Indiana lakes.

Barbee Lakes Subwatershed Stream Water Quality (From New, 2000a)
The major streams flowing into and out of the Barbee Lakes chain area were sampled once during at less than base flow conditions on 8/11/99 and once after a storm runoff event on 4/21/00. The area was experiencing a drought during late summer 1999. As a result, discharge could not be measured during base flow sampling. Site 5 was not sampled at base flow conditions as there was no water present at the time of sampling. Storm sampling followed a major storm on 4/20/00. Two to five inches (5 to 13 cm) of rain were reported for Kosciusko County that day. The eight sampling locations are included in Figure 23.

Tables 28 and 29 provide the base flow stream sampling results. Base flow sampling included measurements of common chemical and physical characteristics as well as nutrient and suspended sediment levels. Base flow sampling provides an understanding of typical conditions in the Barbee Lakes inlet streams. Storm water sampling focused on nutrient and sediment input to understand the influences of the watershed during runoff events.

TABLE 28. Nutrient and sediment concentration data from Barbee Inlet Streams.

Site	Date	Flow (cfs)	Timing	TKN (mg/L)	NH_4^+ (mg/L)	NO_3^- (mg/L)	TP (mg/L)	SRP (mg/L)	TSS (mg/L)
1	08/11/99	*	Base	1.031	0.034	0.660	0.130	0.115	5.75
1	04/21/00	126.6	Storm	1.10	<0.05	2.30	<0.05	<0.05	20
3	08/11/99	*	Base	0.344	0.018	2.923	0.027	0.043	4.22
3	04/21/00	0.25	Storm	3.00	0.05	4.60	0.17	0.09	3
4	08/11/99	*	Base	0.681	0.043	0.325	0.065	0.046	2
4	04/21/00	**	Storm	1.10	<0.05	2.30	0.12	0.06	30
5	04/21/00	0.55	Storm	3.10	0.12	6.00	0.07	0.06	2
6	08/11/99	*	Base	0.554	0.018	0.094	0.041	0.034	1.8
6	04/21/00	0.77	Storm	1.80	<0.05	1.80	0.08	0.08	15
7	08/11/99	*	Base	0.605	0.018	0.937	0.092	0.076	4
7	04/21/00	3.6	Storm	1.10	0.27	<0.10	0.27	0.12	68
8	08/11/99	*	Base	0.660	0.018	0.022	0.031	0.031	5
8	04/21/00	15.4	Storm	0.52	<0.05	<0.10	<0.05	<0.05	1

* Flows too low flow measure due to drought. ** Flow too high to measure. Source: New, 2000.

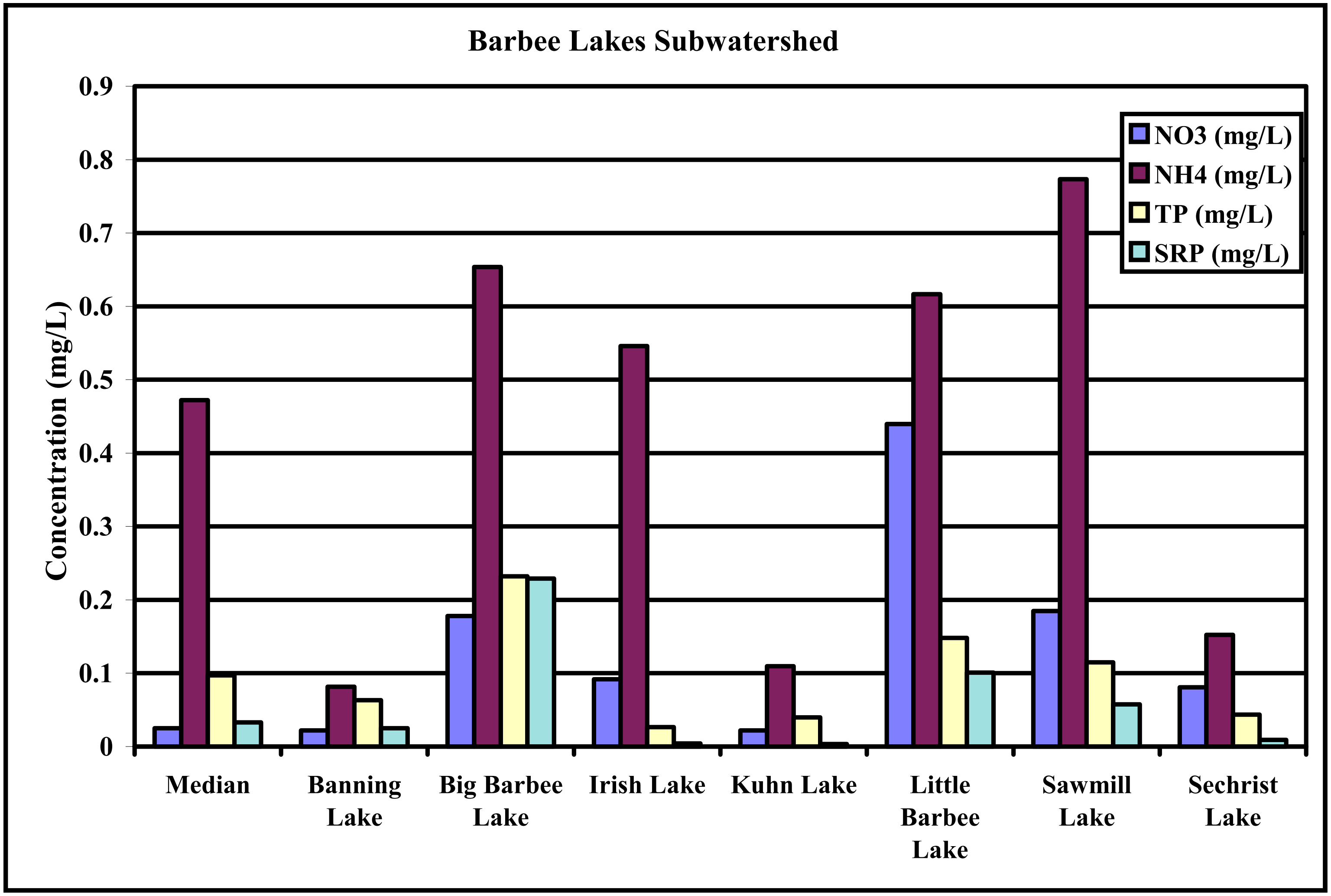

Figure 24. Comparison of the Barbee Chain Lakes water quality data (1999) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

TABLE 29. Physical and chemical characteristics of Barbee Inlet Streams at Base Flow.

Site	Date	Timing	pH	Alkalinity (mg/L)	Conductivity (µmhos)	Temperature (°C)	Dissolved O_2 (mg/L)
1	08/11/99	Base	8.4	238	411	26.7	7.3
3	08/11/99	Base	8.1	283	575	16.8	8.9
4	08/11/99	Base	7.7	230	465	18.6	6.1
6	08/11/99	Base	8.2	231	400	26.2	7.0
7	08/11/99	Base	8.3	243	365	22.1	8.1
8	08/11/99	Base	8.4	146	403	21.8	10.0

Source: New, 2000.

During base flow conditions, temperatures in the streams varied from 62° F (16.8° C) to 80 ° F (26.7° C). Those streams with cooler temperatures likely have a greater proportion of groundwater flowing in them. The high temperature for Grassy Creek likely reflects the lack of riparian shading along the creek. Stream temperatures are generally cooler than lake temperatures due to the groundwater influence and because there is less solar warming of shaded stream water.

Dissolved oxygen (DO) concentrations vary from 6.1 to 10.0 mg/L. Because DO varies with temperature (cold water can contain more oxygen than warm water), it is more appropriate to consider DO saturation values. This refers to the amount of oxygen dissolved in water compared to the maximum possible when the water is saturated with oxygen. The saturation value of water at 20° C is 9.1 mg/L. Stream dissolved oxygen concentrations that are less than this value suggest that: a) decomposition processes within the streams consume oxygen more quickly than it can be replaced by diffusion from the atmosphere, and b) flow in the streams is not turbulent enough to entrain sufficient atmospheric oxygen. Results from this sampling indicate that oxygen was sufficient in the inlet streams despite the low flows.

Alkalinity is lowest in the streams during storm events because during periods of high runoff, the alkalinity is diluted by rainwater and the runoff water moves across carbonate-containing bedrock materials so quickly that little carbonate is dissolved to add additional alkalinity. During low discharges, alkalinity is usually high because runoff water picks up carbonates from the bedrock. This accounts for the high alkalinity measurements recorded during low flow in Barbee Lakes inlet streams.

Total phosphorus concentrations were high at Sites 1 and 7. Nitrate-nitrogen was very high at Site 3. These streams could be important sources of these nutrients to the lakes. Total suspended solids (TSS) were expectedly low due to the low flow.

Table 28 exhibits the storm flow stream sampling results. Table 30 displays the loading data for the storm event sampling.

TABLE 30. Nutrient and sediment loading data from Barbee Inlet Streams during a storm event.

Site	Date	Flow (kg/d)	Timing	TKN Load (kg/d)	NH_3-N Load (kg/d)	NO_3-N Load (kg/d)	TP Load (kg/d)	SRP Load (kg/d)	TSS Load (kg/d)
1	4/21/2000	126.6	Storm	340.51	-	711.97	-	-	6191.04
3	4/21/2000	0.25	Storm	1.83	0.03	2.81	0.10	0.06	1.83
4	4/21/2000	*	Storm	-	-	-	-	-	-
5	4/21/2000	0.55	Storm	4.17	0.16	8.07	0.09	0.08	2.69
6	4/21/2000	0.77	Storm	3.39	-	3.39	0.14	0.14	28.24
7	4/21/2000	3.6	Storm	9.68	2.38	-	2.38	1.06	598.57
8	4/21/2000	15.4	Storm	19.58	-	-	-	-	37.65

* Flow too high to measure. Source: New, 2000.

The collection of discharge during the storm event allows for the relative comparison between the inlet streams. Grassy Creek (Site 1) delivered the greatest amount of total nitrogen, nitrate-nitrogen and total suspended solids to the lakes (Figures 25-28). This result is not surprising given the fact that Grassy Creek has the largest drainage area of the three inlets, providing the greatest potential for runoff. Grassy Creek also has the potential to deliver the greatest amount of the remaining nutrient parameters. Results for ammonia-nitrogen, total phosphorus and soluble reactive phosphorus were below detection levels. Despite this, even a very low concentration (one below the detect level) of these nutrients combined with the discharge of Grassy Creek would result in the delivery of more pollutant mass than delivery from other inlets.

Putney Ditch (Site 7) delivered the highest amounts of total phosphorus, soluble reactive phosphorus, and total suspended solids. Two unnamed tributaries of Kuhn Lake (Sites 3 and 5) recorded high loadings of nitrate-nitrogen. In addition, for its size, Site 6 delivered a relatively large amount of total suspended solids to Kuhn Lake.

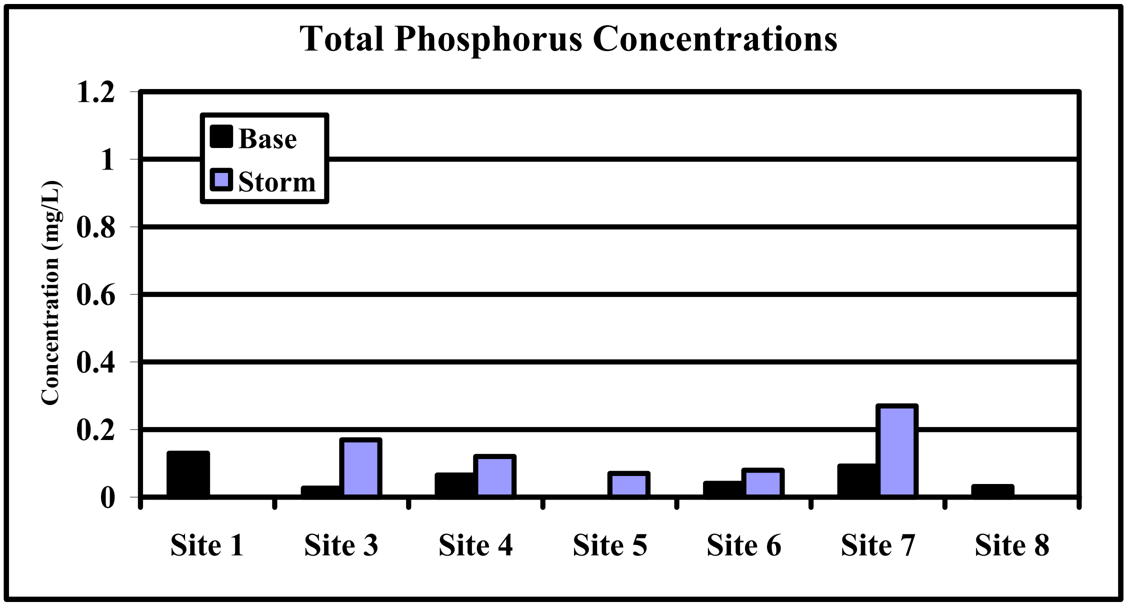

Figure 25. Total phosphorus concentrations in Barbee Lakes Streams.

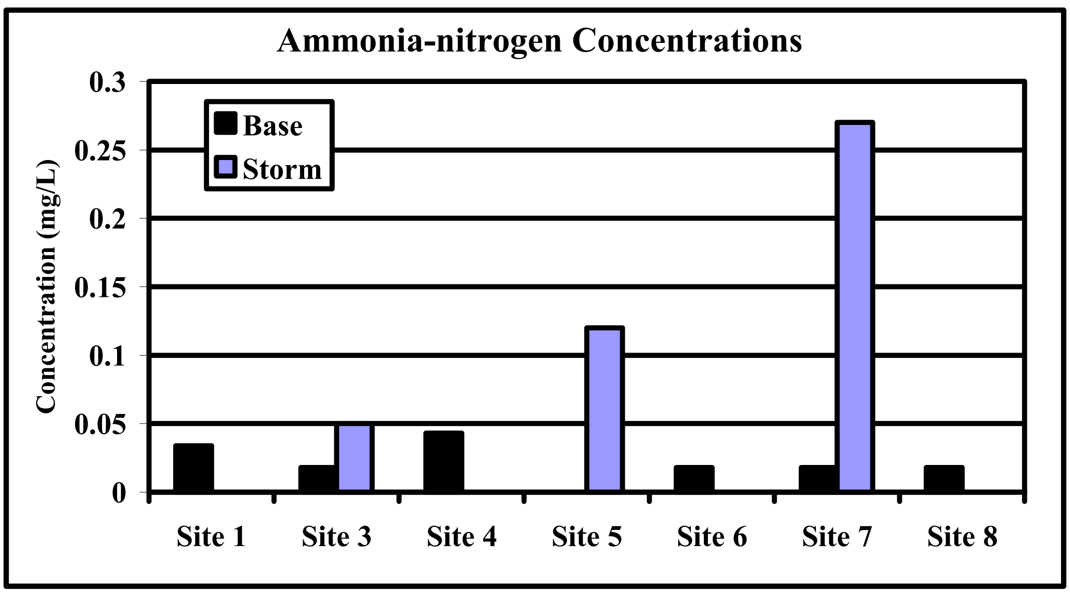

Figure 26. Ammonia-nitrogen concentrations in Barbee Lakes Streams.

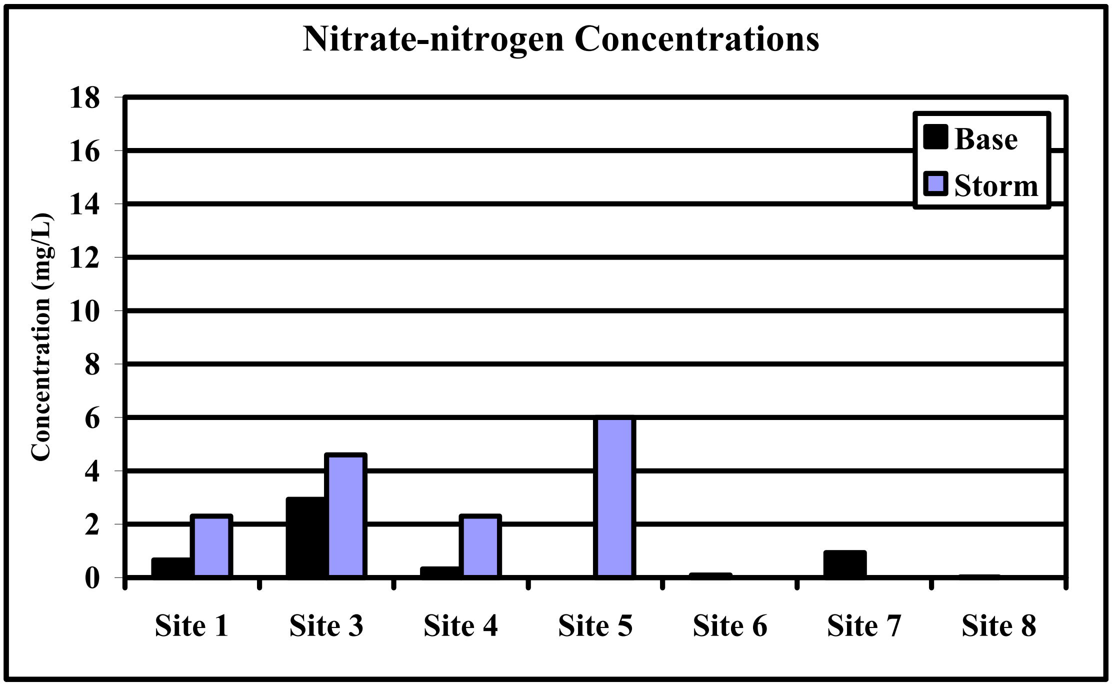

Figure 27. Nitrate-nitrogen concentrations in Barbee Lakes Streams.

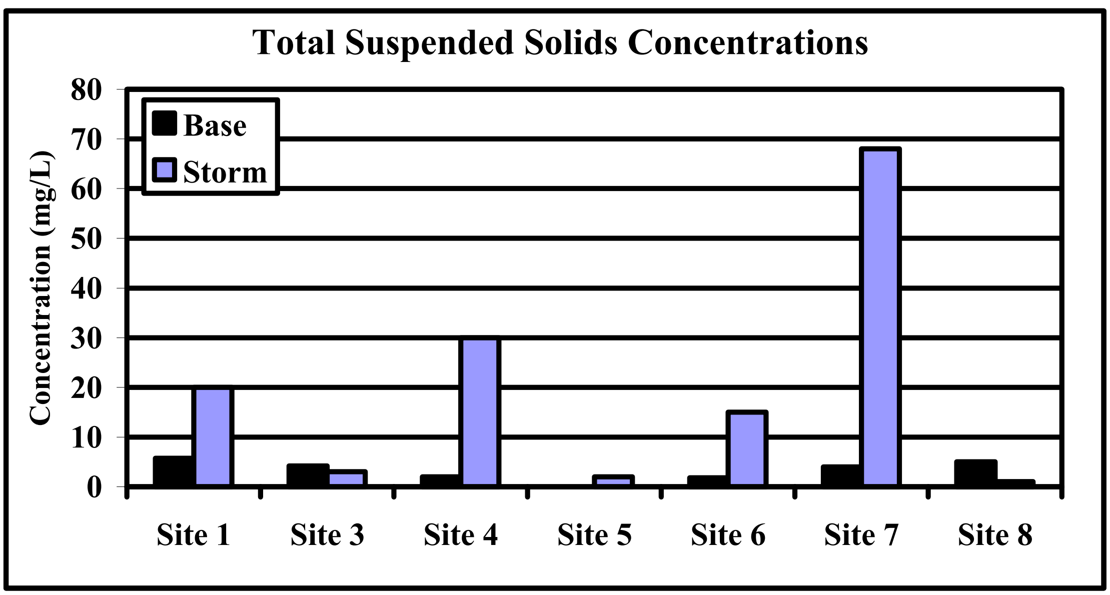

Figure 28. Total suspended solids concentrations in Barbee Lakes Streams.

<u>Webster/Backwaters Subwatershed</u>

Webster/Backwaters Lake Water Quality

Webster Lake and The Backwaters were chosen to represent the Webster/Backwaters Subwatershed. The Webster/Backwaters Subwatershed receives water via the Tippecanoe River from the Smalley Lake. The Indiana Clean Lakes Program measured water quality at Webster Lake and The Backwaters on three separate occasions, in 1994, 1998, and 1999. Table 31 lists Indiana trophic state and index scores for both lakes calculated from the three samplings. From 1994 to 1998, samples indicated a decrease in water quality for both Webster Lake and The Backwaters. Water quality samples collected in 1999 illustrated improved water quality. Further investigation of the data suggested that the Indiana trophic state index was not providing an accurate representation of the true conditions of either lake. New (2000) determined that the inaccuracy could be attributed to the unreliability of the Indiana TSI. The Indiana TSI depends heavily on algae and does not account for poor transparency or high nutrient concentrations in the final score. The "intermediate" TSI value calculated for Webster Lake was determined to be inconsistent with extensive macrophyte growth observed in the lake. However, over the sampling period Webster Lake generally scored in the eutrophic category, while The Backwaters was mesotrophic.

Table 31. Webster/Backwaters Subwatershed Indiana trophic state index scores.

	1994	**1998**	**1999**
Backwaters Trophic Score	16	20	16
Trophic Status	Mesotrophic	Mesotrophic	Mesotrophic
Lake Webster Trophic Score	24	36	28
Trophic Status	Mesotrophic	Eutrophic	Mesotrophic

Table 32 displays historic mean total phosphorus concentrations for Webster Lake and The Backwaters. Total phosphorus concentrations displayed no general trend in The Backwaters, and were exceptionally consistent in Lake Webster. When total phosphorus values are compared to Vollenweider's guidelines, samples from The Backwaters were below the eutrophic lake mean value while Webster Lake samples were above the eutrophic lake mean value.

Table 32. Webster/Backwaters Subwatershed total phosphorus concentrations.

	1994	**1998**	**1999**
Backwaters Concentration	0.039 mg/L	0.095 mg/L	0.072 mg/L
TP Score	Mesotrophic	Eutrophic	Mesotrophic
Lake Webster Concentration	0.150 mg/L	0.149 mg/L	0.149 mg/L
TP Score	Eutrophic	Eutrophic	Eutrophic

Results from The Backwaters and Lake Webster can also be compared to other Indiana lakes (Figure 30). Based on this comparison, The Backwaters and Lake Webster, in general, had similar water quality to most Indiana lakes. Secchi disk depths were less than Secchi disk depths recorded at most Indiana lakes, indicating that most Indiana lakes were clearer than Lake Webster or The Backwaters. Additionally, The Backwaters and Lake Webster possessed higher concentrations of chlorophyll *a* and total phosphorus than most Indiana lakes. High chlorophyll *a* and total phosphorus concentrations suggest both Lake Webster and The Backwaters have the potential to be more productive than most Indiana lakes.

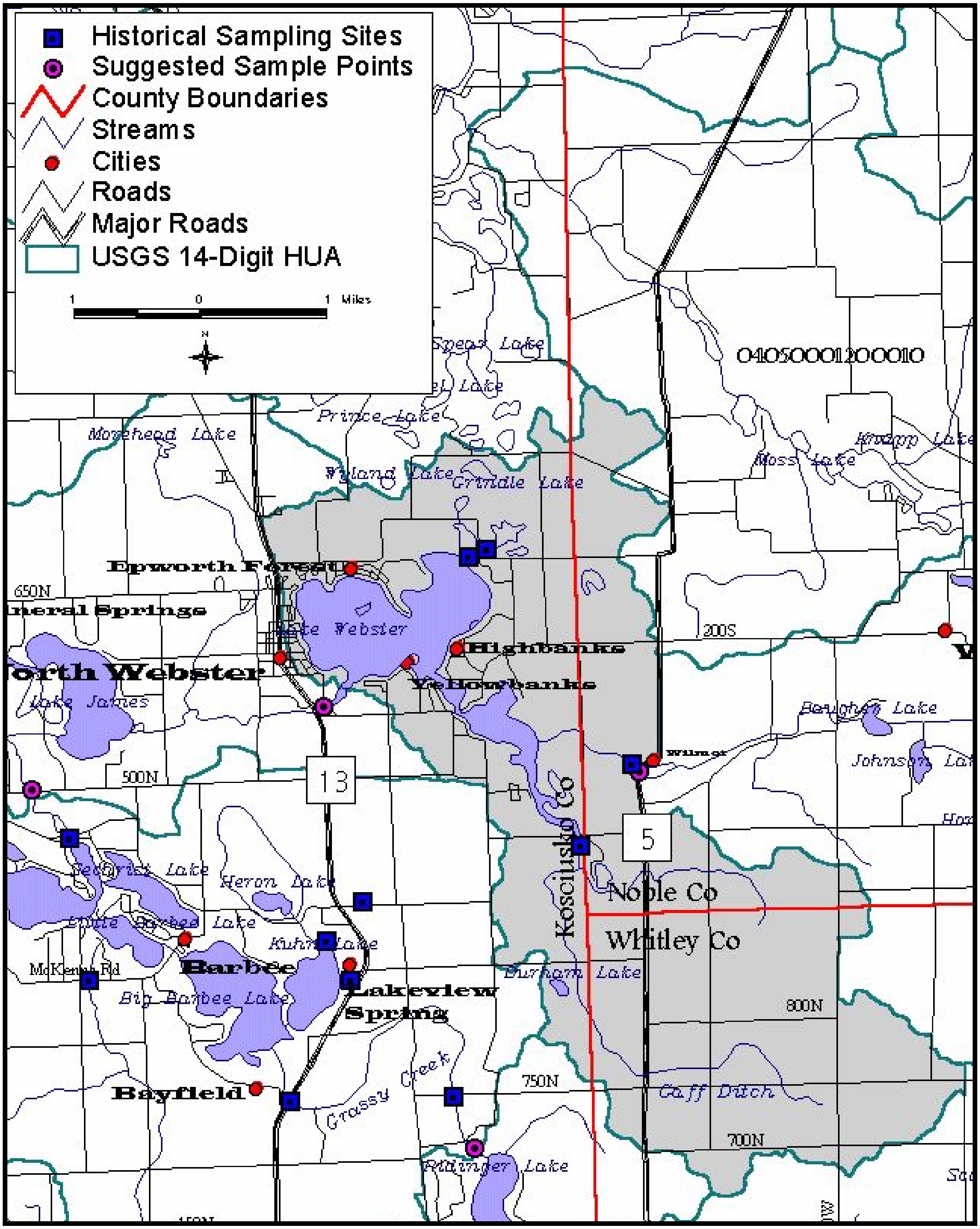

Figure 29. Webster/Backwaters Subwatershed.

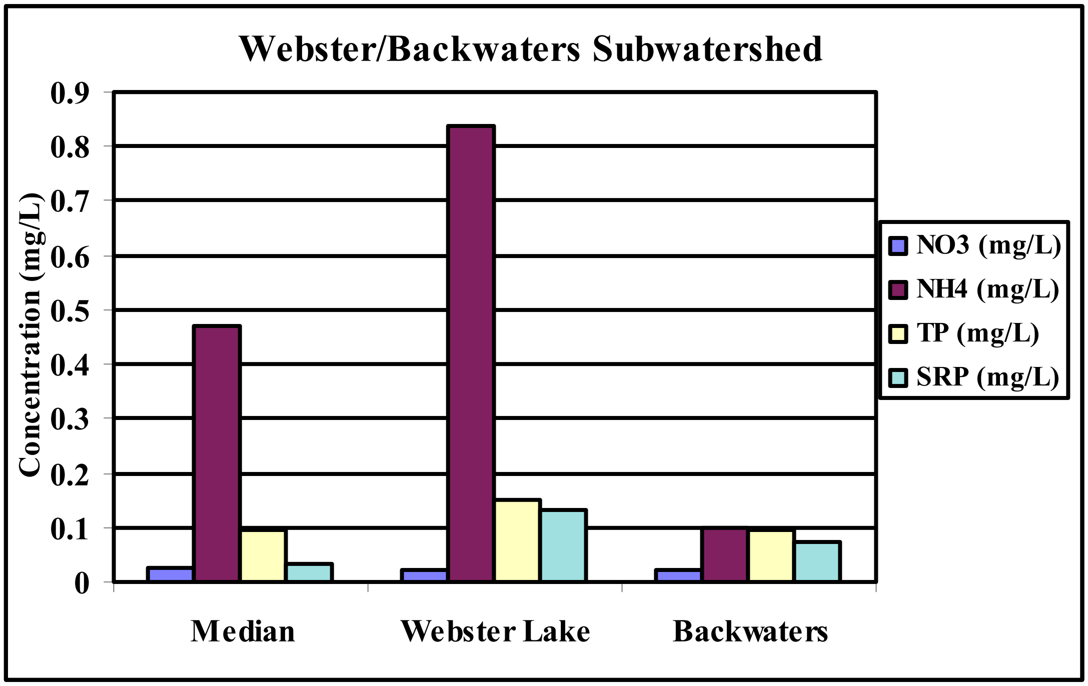

Figure 30. Comparison of Lake Webster and the Backwaters water quality data (1999) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

Webster/Backwaters Subwatershed Stream Water Quality (From New, 2000b)

The major streams flowing into and out of Lake Webster and the Backwaters area were sampled once at less than base flow conditions on 8/12/99 and once after a storm runoff event on 4/21/00. The area was experiencing a drought during late summer 1999. As a result, discharge could not be measured during base flow sampling. Storm sampling followed a major storm on 4/20/00. Two to five inches (5 to 13 cm) of rain were reported for Kosciusko County that day. Site 5 was not sampled during the storm event. The sampling locations included (Figure 29):

Site 1 Tippecanoe River outlet at SR 13
Site 2 Gaff Ditch at County Road 450 North
Site 3 Tippecanoe River at SR 5
Site 4 Ditch at County Road 675 North and County Road 925 East
Site 5 Ditch at County Road 700 North

Base flow stream sampling results are given in Table 33. Base flow sampling included measurements of common chemical and physical characteristics as well as nutrient and suspended sediment levels. Because there was so little water flowing in the streams at the time of base flow sampling, discharge was not measured. Thus, only concentrations are reported.

Table 33. Water quality characteristics of Webster Stream Inlets and Outlets (8/12/99).

Parameter	Site 1	Site 2	Site 3	Site 4	Site 5
PH	7.8	7.3	7.7	7.7	7.45
Alkalinity (mg/L)	185.9	299.6	200.2	242.0	262.1
Conductivity (mhos)	439	539	485	395	488
Temperature (°C)	22.4	19.0	22.5	18.4	20.0
Dissolved Oxygen (mg/L)	3.9	0.5	5.0	5.3	0.4
Total Phosphorus (mg/L)	0.034	0.623	0.123	0.096	0.060
Soluble Reactive Phos. (mg/L)	0.042	0.321	0.079	0.039	0.036
Nitrate-Nitrogen (mg/L)	0.078	0.028	0.024	0.806	0.013
Ammonia-Nitrogen (mg/L)	0.069	0.076	0.017	0.396	0.015
Organic Nitrogen (mg/L)	0.702	1.237	0.90	1.431	1.195
Total Suspended Solids (mg/L)	2.20	18.89	3.14	13.00	6.40

Source: New, 2000.

During base flow conditions, temperatures in the streams varied from 65 F (18.4° C) to 72.5 F (22.5° C). Those streams with cooler temperatures likely have a greater proportion of groundwater flowing in them. Stream temperatures are generally cooler than lake temperatures due to the groundwater influence and because there is less solar warming of shaded stream water.

Dissolved oxygen (DO) concentrations varied from 0.4 to 5.3 mg/L. Because DO varies with temperature (cold water can contain more oxygen than warm water), it is more appropriate to consider DO saturation values. This refers to the amount of oxygen dissolved in water compared to the maximum possible when the water is saturated with oxygen. The saturation value of water at 20° C is 9.1 mg/L. All of the stream dissolved oxygen concentrations are less than this value, indicating that: a) decomposition processes within the streams consume oxygen more quickly than it can be replaced by diffusion from the atmosphere, and b) flow in the streams is not turbulent enough to entrain sufficient atmospheric oxygen. Since the stream discharges at the time of sampling were somewhat less than base flow, the low oxygen concentrations are not unexpected.

Alkalinity is lowest in the streams during storm events because during periods of high runoff, the alkalinity is diluted by rainwater and the runoff water moves across carbonate-containing bedrock materials so quickly that little carbonate is dissolved to add additional alkalinity. During low discharges, alkalinity is usually high because groundwater flow picks up carbonates from the bedrock. This accounts for the high alkalinity measurements recorded during low flow in Lake Webster’s streams.

Total phosphorus concentrations are highest in Gaff Ditch (Site 2). The Tippecanoe River (Site 3) had the next highest phosphorus concentration. These could be significant sources of phosphorus loading to Lake Webster, depending on the volume of water discharged from these streams. Nitrogen concentrations in the streams are very different from the patterns observed for phosphorus. The Ditch at County Road 675 North (Site 4) has the highest concentrations of total nitrogen followed by Site 2. Gaff Ditch and the ditch at

County Road 675 North (Site 2 & Site 4) had the highest concentrations of total suspended solids during base flow.

Table 34 provides the storm flow stream sampling results.

Table 34. Water quality characteristics of Webster Stream Inlets and Outlets (4/21/00).

Parameter	Site 1		Site 2		Site 3		Site 4	
	Conc. (mg/L)	Mass* (kg/d)	Conc. (mg/L)	Mass (kg/d)	Conc. (mg/L)	Mass (kg/d)	Conc. (mg/L)	Mass (kg/d)
Total N (Kjeldahl)	0.64	134.7	0.98	389	1.5	146.8	0.64	0.36
Ammonia-N	<0.05	-	0.11	43.6	0.06	5.8	0.06	0.03
Nitrate + Nitrite-N	<0.1	-	0.14	55.5	2.3	225.2	0.74	0.41
Soluble React. Phos.	<0.1	-	0.14	55.5	<0.1	-	<0.1	-
Total Phosphorus	<0.05	-	0.27	107	0.11	10.8	0.25	0.14
Total Susp. Solids	3	631.7	6	2308	13	1273.3	1	0.56

* Mass loadings are based on discharge measurements of 86 cubic feet per second (cfs) at Site 1, 14 cfs at Site 2, 40 cfs at Site 3, 0.23 cfs at Site 4 (Source: New, 2000).

Typically, nutrient concentrations and total suspended solids are higher in streams following the runoff event because the increased water flow results in increased erosion of soil and nutrients from the land. The nutrient concentrations reported for the storm samples did not reflect this theory (Figures 31-33). One possible reason for this may be that base flow conditions actually represented stagnant water which may result in higher concentrations of some pollutants. In addition despite the fact that two to five inches (5 to 9 cm) of rain fell during the storm event, runoff may not have been typical for that amount of rain. The area was still recovering from the near draught conditions experienced during the latter half of 1999. It is unlikely that the soil was saturated prior to the rainfall. Thus, a larger portion of the rainfall may have been absorbed by the soil than would be typical if the soil was already saturated.

The collection of discharge during the storm event allows for relative comparison between the inlet streams. The Tippecanoe River (Site 3) delivers the greatest amount of pollutants to the lakes for every parameter measured. This result is not surprising given the fact that the Tippecanoe River has the largest drainage area of the three inlets, providing the greatest potential for runoff. Gaff Ditch (Site 2) recorded the highest concentration of phosphorus of all the inlet samples which is consistent with the measurements recorded for the base flow sampling. This high concentration results in the delivery of a similar mass of phosphorus to the lake by Gaff Ditch compared to the Tippecanoe River, despite the fact that the Tippecanoe River's discharge is nearly three times as great.

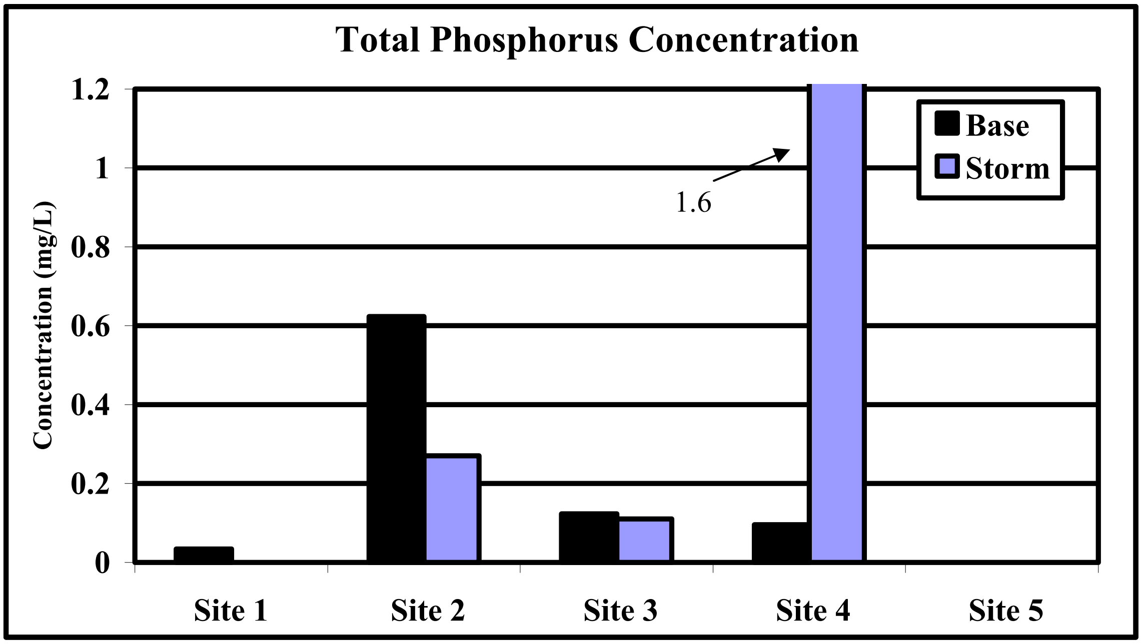

Figure 31. Total phosphorus concentrations in Webster/Backwater Streams.

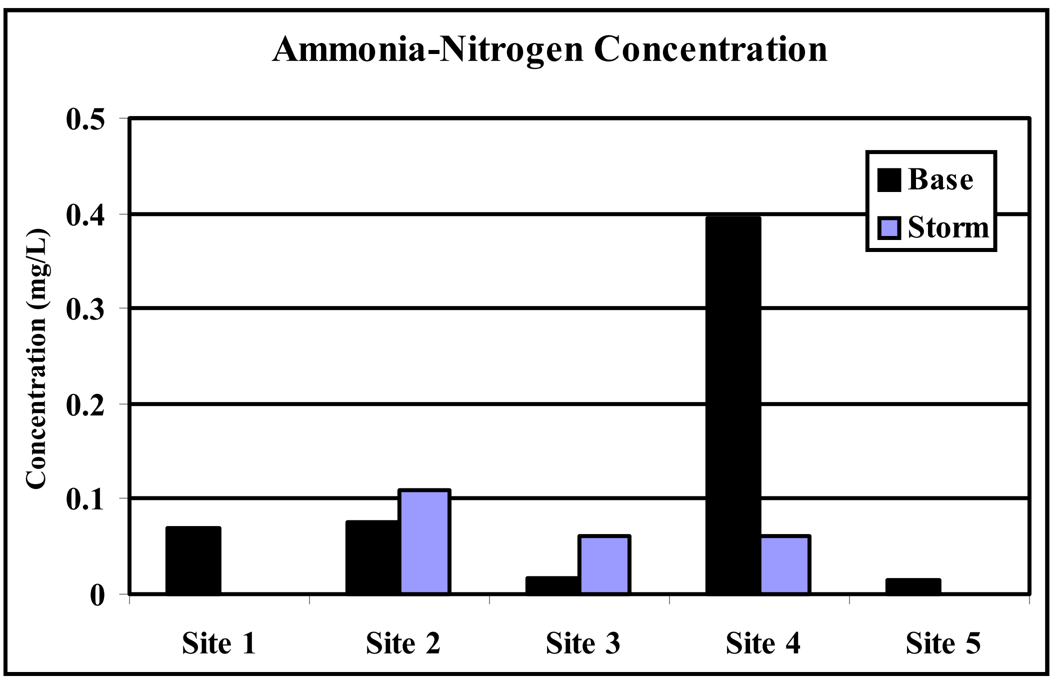

Figure 32. Ammonia-nitrogen concentrations in Webster/Backwater Streams.

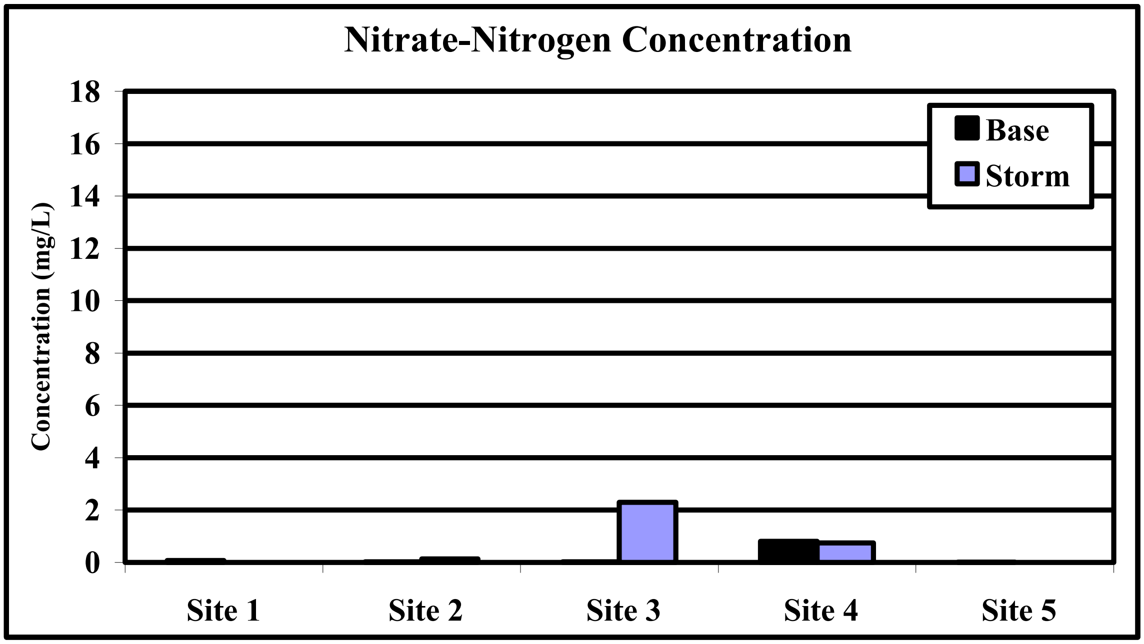

Figure 33. Nitrate-nitrogen concentrations in Webster/Backwater Streams.

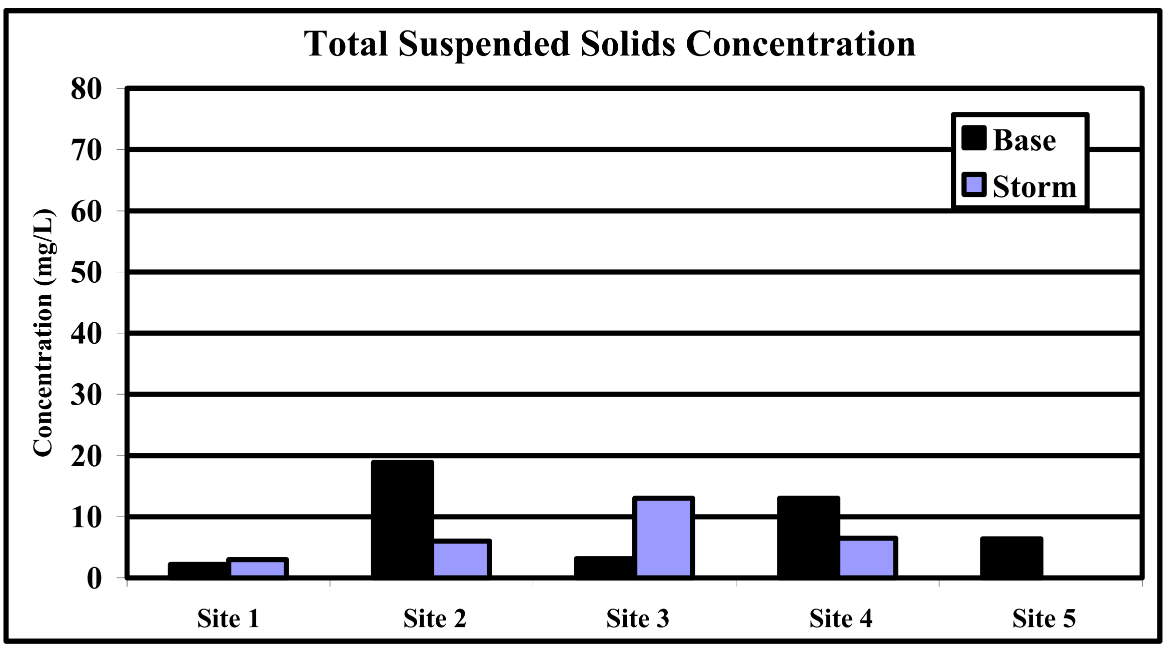

Figure 34. Total suspended solids concentrations in Webster/Backwater Streams.

<u>*Tippecanoe Subwatershed*</u>

Tippecanoe Subwatershed Lake Water Quality

James Lake, Oswego Lake and Tippecanoe Lake were chosen to represent the Tippecanoe Subwatershed. The Tippecanoe Watershed receives water from both the Webster/Backwaters and the Barbee Lakes Subwatersheds. The Indiana Clean Lakes Program measured water quality at James and Tippecanoe Lakes on three separate occasions, in 1989, 1994, and 1998 and at Oswego Lake in 1998. Table 35 lists Indiana trophic state and index scores for the lakes calculated from the three samplings.

Both James and Tippecanoe Lakes displayed a generally increasing water quality trend. James Lake improved from eutrophic to mesotrophic while Tippecanoe Lake improved from mesotrophic to oligotrophic in the 1998 sampling. (The oligotrophic rating for Tippecanoe Lake does not include a hypolimnetic total phosphorus sample in the calculation.)

Table 35. Tippecanoe Subwatershed Indiana trophic state index scores.

	1989	1994	1998
James Lake Trophic Score	37	32	27
Trophic Status	Eutrophic	Eutrophic	Mesotrophic
Tippecanoe Lake Trophic Score	23	29	8*
Trophic Status	Mesotrophic	Mesotrophic	Oligotrophic
Oswego Lake Trophic Score	--	--	27
Trophic Status	--	--	Mesotrophic

*Hypolimnetic total phosphorus sample was excluded from the calculation.

Table 36 displays historic mean total phosphorus concentrations for James Lake, Oswego Lake and Tippecanoe Lake. Total phosphorus concentrations increased from 1975 to 1998 in both James and Oswego Lakes. Tippecanoe Lake total phosphorus concentrations indicated no general trend from 1975 to 1994. When total phosphorus values are compared to Vollenweider's guidelines above, samples from James and Oswego Lake were below the mean value for Tippecanoe Lake total phosphorus concentrations were always below the mean eutrophic value, but in 1998 they were below the mean total phosphorus value in mesotrophic lakes as well.

Table 36. Tippecanoe Subwatershed total phosphorus concentrations.

	1975	1988	1989	1994	1998
James Lake Concentration	0.040 mg/L	0.060 mg/L	0.065 mg/L	0.076 mg/L	0.122 mg/L
TP Score	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Eutrophic
Tippecanoe Lake Concentration	0.050 mg/L	0.040 mg/L	0.051 mg/L	0.056 mg/L	0.010 mg/L *
TP Score	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic	Mesotrophic
Oswego Lake Concentration	0.040 mg/L	0.060 mg/L	--	--	0.110 mg/L
TP Score	Mesotrophic	Mesotrophic	--	--	Eutrophic

*Hypolimnetic total phosphorus sample was excluded from the calculation.

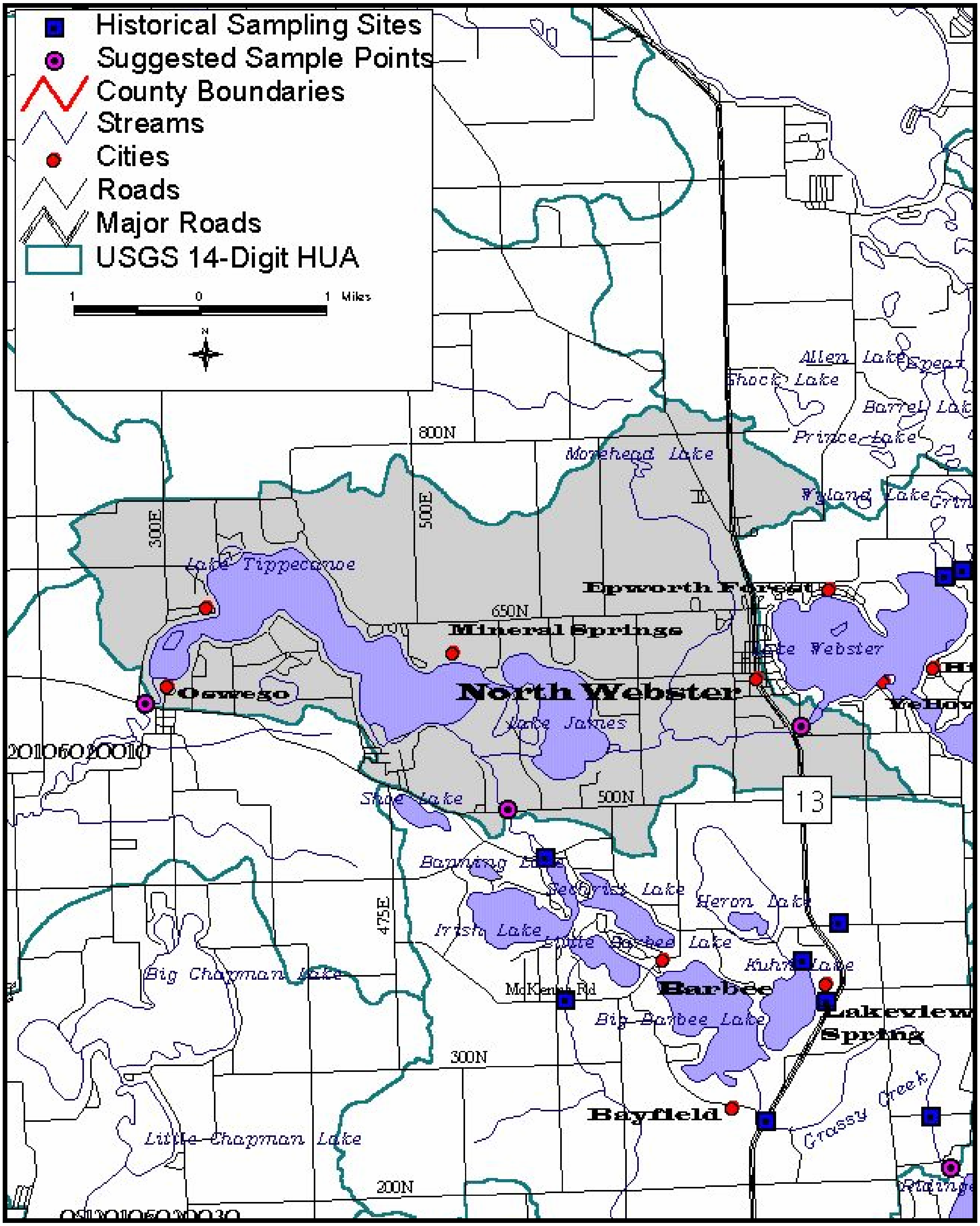

Figure 35. Tippecanoe Subwatershed.

Results from James, Oswego and Tippecanoe Lakes can also be compared to other Indiana lakes (Figure 36). Based on this comparison, James, Oswego and Tippecanoe Lakes, in general, had worse water quality than most Indiana lakes. Secchi disk depths were better than Secchi disk depths recorded in most Indiana lakes, indicating that most Indiana lakes were not as clear as the James/Tippecanoe Subwatershed lakes. Conversely, soluble reactive phosphorus, total phosphorus, nitrate-nitrogen and ammonia-nitrogen were higher than most Indiana lakes. High total phosphorus concentrations suggested that all three of the lakes were more productive than most Indiana lakes.

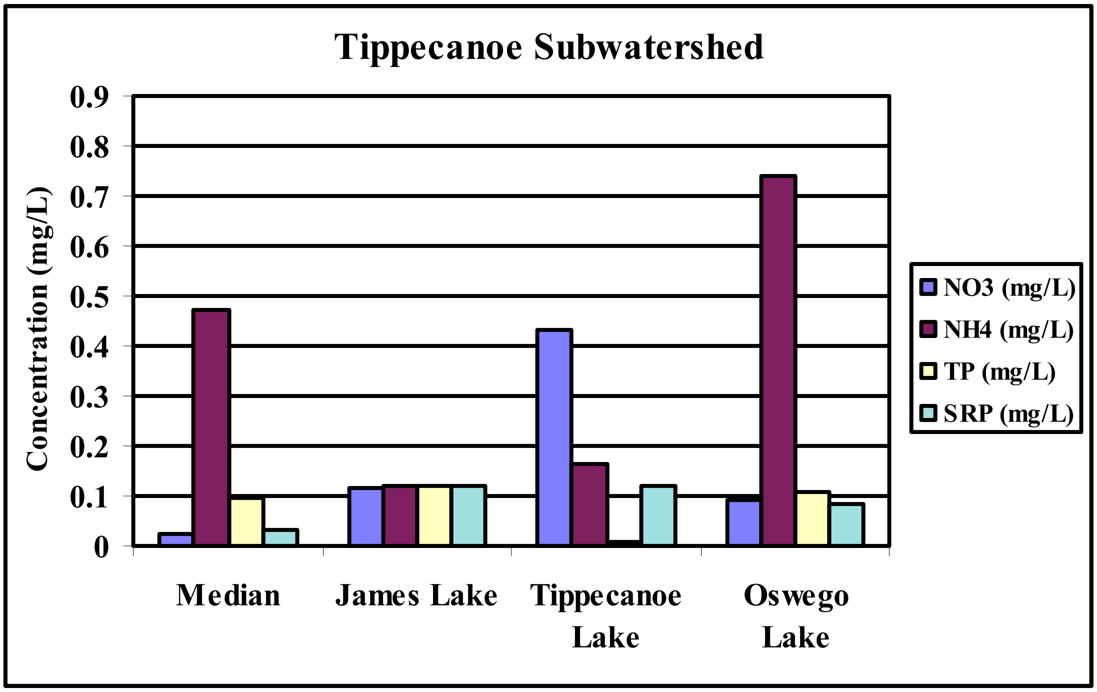

Figure 36. Comparison of James Lake, Oswego Lake and Tippecanoe Lake water quality data (1999) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

Tippecanoe Watershed Stream Water Quality

From 1999 to 2001, TELWF collected monthly water quality monitoring data at twelve sites in the tributaries to Lake Tippecanoe (Figure 37; Table 37). TELWF analyzed the samples for the following parameters: dissolved oxygen, temperature, nitrate-nitrogen, ammonia-nitrogen, total Kjeldahl nitrogen, total phosphorus, soluble reactive phosphorus and *E. coli* samples were collected all three years. In 2001, TELWF also measured flow at each site. Water quality sampling included collection from twelve sample sites. Four of the twelve sites will be used for tributary comparability. Sites 1, 5, 6, and 7 are located closest to the Lake Tippecanoe; therefore they represent all upstream concentrations and loads from individual tributaries. For individual site data please refer to Appendix D.

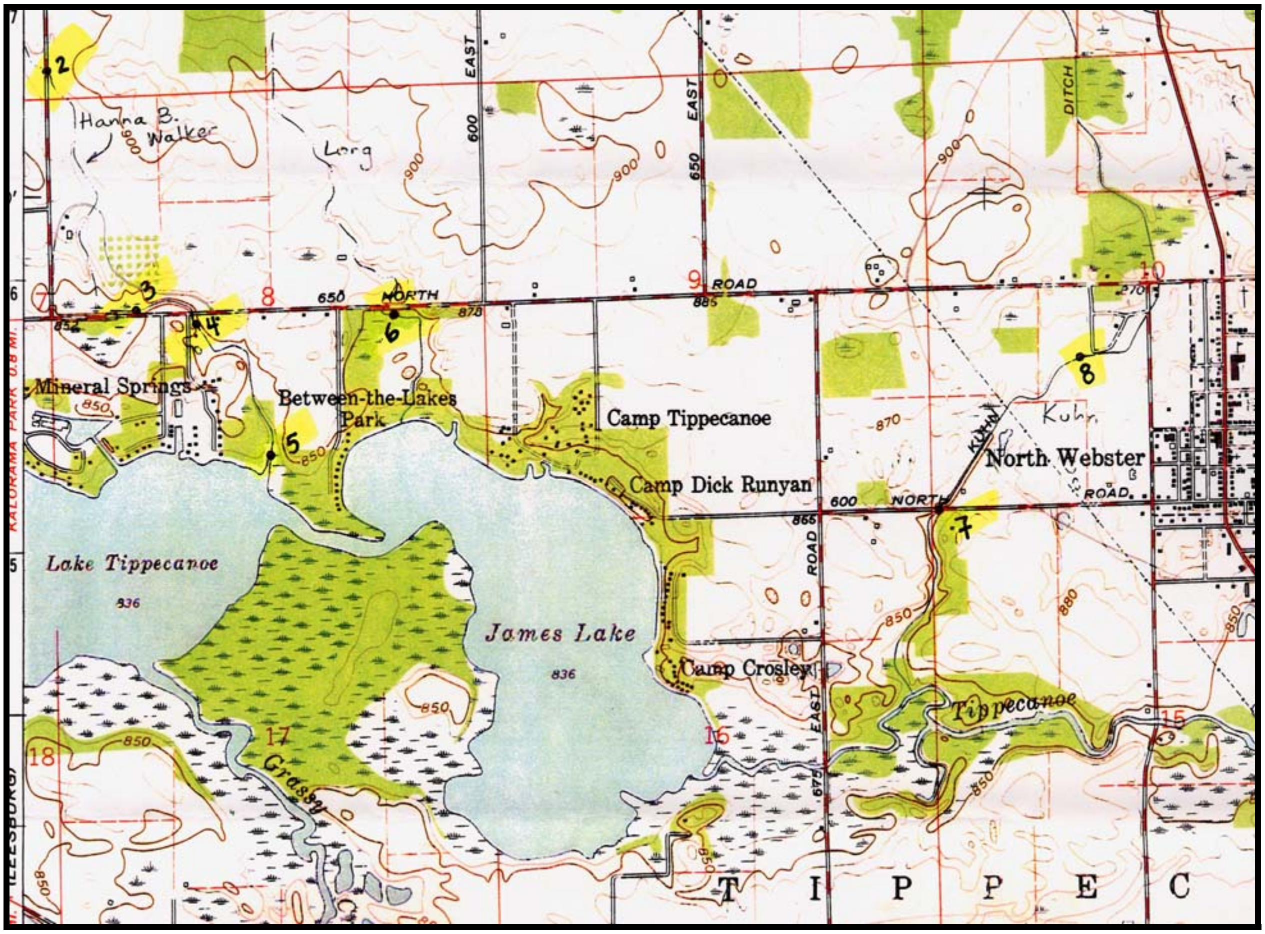

Figure 37. Water quality sampling sites (Site 2-Site 8). Site 9-12 are located on the grounds of the Tippecanoe Country Club on the north side of Lake Tippecanoe.

Table 37. Water quality sampling site locations. Bold sites are those utilized for comparison of tributary concentration and loading.

Sampling Site	Site Location
Site 1	**Indian Creek at outlet to Lake Tippecanoe**
Site 2	Hanna B. Walker Drain at County Road 550 East
Site 3	Hanna B. Walker Drain on the north side of Country Road 650 North
Site 4*	**Hanna B. Walker Drain south of Country Road 650 North**
Site 5	**Hanna B. Walker Drain at the outlet to Lake Tippecanoe**
Site 6	**Long Ditch at County Road 650 North**
Site 7	**Kuhn Ditch between County Road 600 N and County Road 650 N**
Site 8	Kuhn Ditch at County Road 600 North
Site 9	Tippecanoe Country Club Hole 1 Inlet Stream
Site 10	Tippecanoe Country Club Hole 2 Inlet Stream
Site 11	Tippecanoe Country Club Hole 1 Outlet Stream
Site 12	Tippecanoe Country Club Hole 2 Outlet Stream

*No flow measurements were collected at Site 5, therefore Site 4 was utilized for loading comparison.

Table 38 shows flow for each site by date. Sites 2, 3, 6, and 9-12 had very low flows. Site 5 is located adjacent to the lake, generally experienced backflows. The remaining four sites had higher discharge rates. Flows peaked during the December sampling due to nearly 1.04" of rain during the preceding days.

Table 38. Discharge in cubic feet per second (cfs) for all sites by sampling date for the 1999-2001 monitoring seasons. A double dash (--) indicates that no sample was collected due to stagnant or non-flowing water.

Date	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12
2/15/01	0.84	1.00	0.00	1.34	--	0.62	0.40	3.59	0.11	0.12	0.01	0.03
3/15/01	0.86	0.00	--	--	--	0.62	3.43	3.36	0.01	0.03	0.01	--
4/11/01	--	--	--	--	--	--	--	--	--	--	--	--
5/14/01	0.21	0.03	0.00	0.28	--	--	3.58	1.75	0.00	0.01	0.21	--
6/12/01	0.40	0.56	0.00	--	--	0.09	3.27	1.56	0.07	--	0.00	--
7/16/01	0.26	0.55	--	0.00	--	--	2.19	0.87	0.05	--	--	0.08
8/16/01	1.06	--	0.29	0.60	--	--	3.38	8.23	--	--	--	--
9/20/01	0.91	0.00	0.34	0.63	--	--	2.15	5.24	0.00	--	--	--
10/24/01	1.11	--	1.44	2.45	--	0.32	6.11	6.21	--	--	--	0.15
11/19/01	1.32	1.08	1.76	3.76	--	0.41	4.32	3.50	0.01	--	0.05	0.01
12/17/01	3.79	5.14	17.35	5.84	--	10.17	8.99	9.67	0.49	--	1.19	2.81

Source: TELWF, 2001.

Figures 38-41 display concentration and loading data for two forms of nitrogen: nitrate-nitrogen (NO_3^-) a dissolved, inorganic form of nitrogen and total Kjeldahl nitrogen (TKN) an organic form of nitrogen which includes ammonia and is found in plant and animal material. Nitrate was below Indiana safe drinking water standards of 10 mg/L (327 IAC 2) at all sites in 2001 except Site 7 (September). Typically, Long Ditch (Site 6) had higher nitrate-nitrogen and TKN concentrations than those measured at the other stream sites. Conversely, Kuhn Ditch (Site 7) had the highest NO_3^--N and TKN loading fates of the four streams.

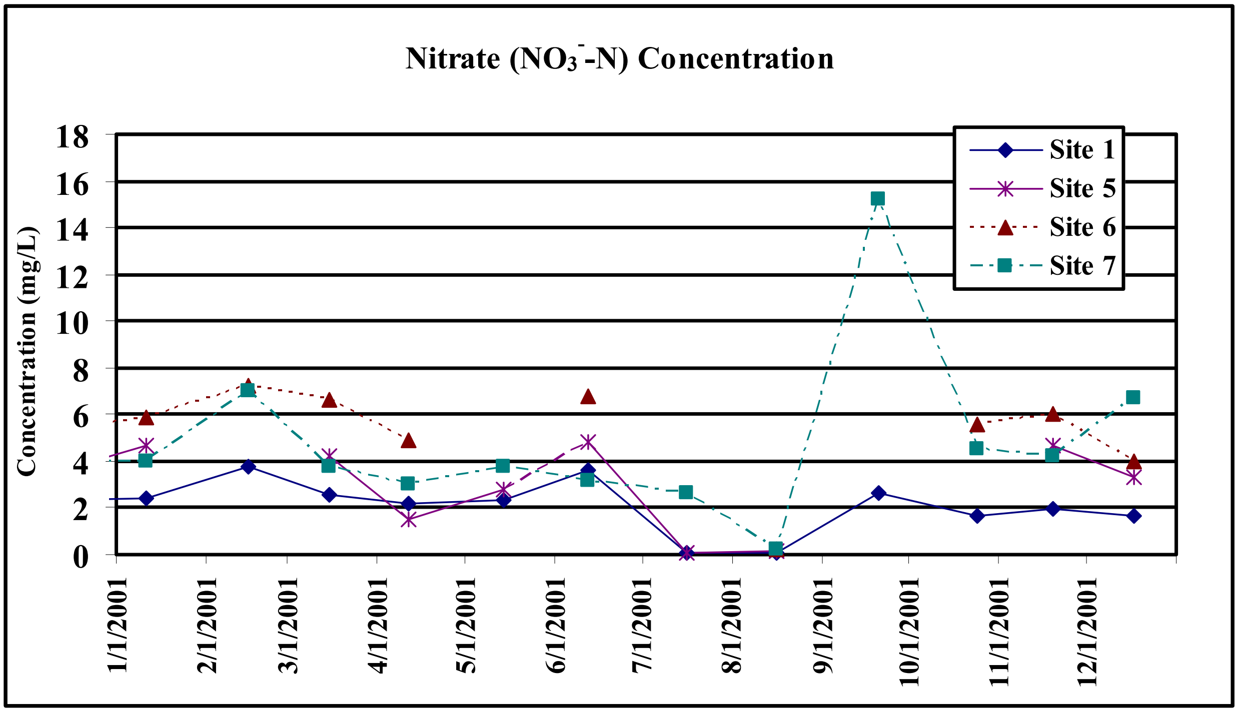

Figure 38. Nitrate-nitrogen concentration data for 1999-2001 water quality monitoring seasons.

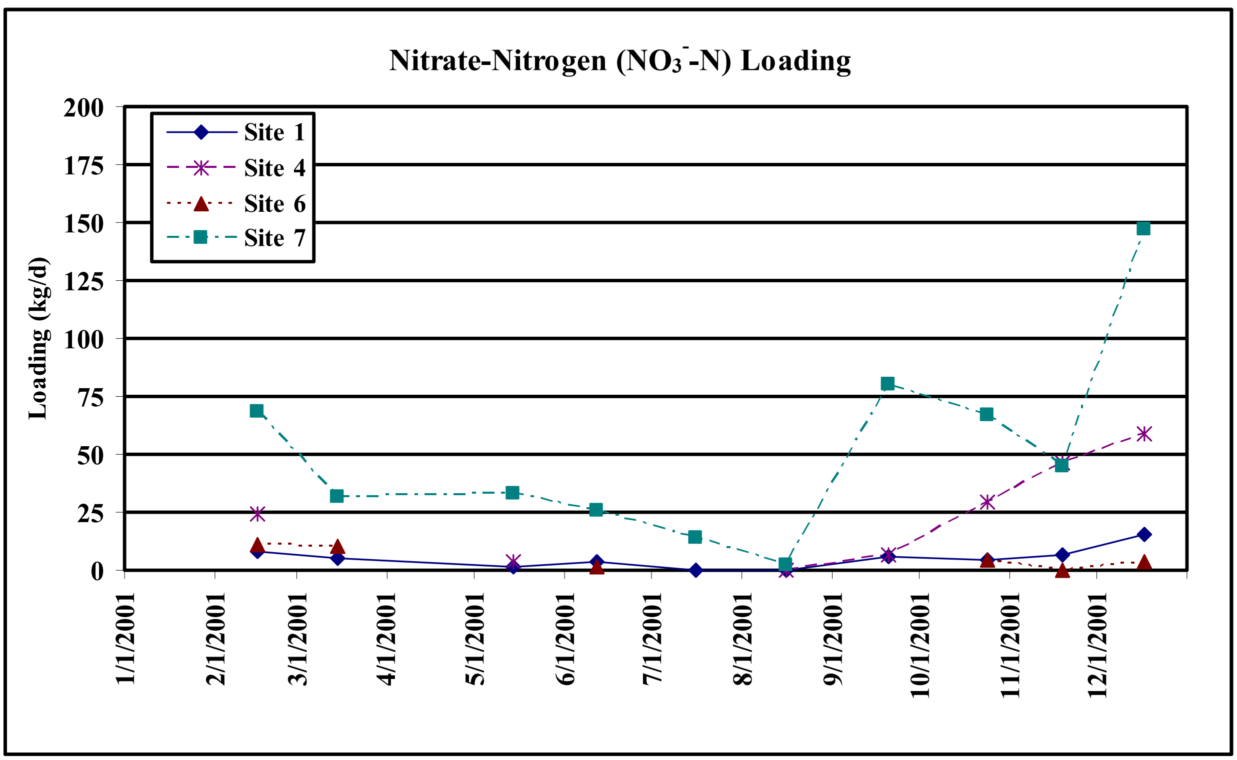

Figure 39. Nitrate-nitrogen loading data for the 2001 water quality monitoring season.

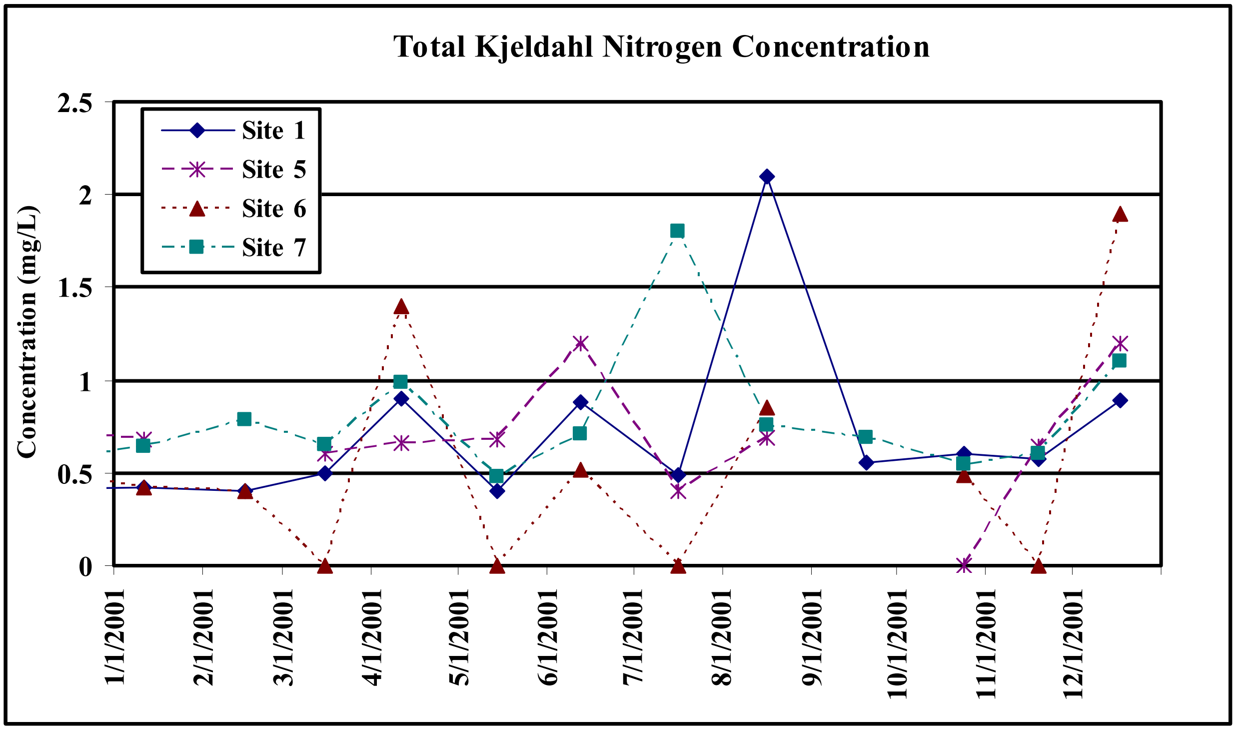

Figure 40. Total Kjeldahl nitrogen concentration data for the 2001 water quality monitoring seasons.

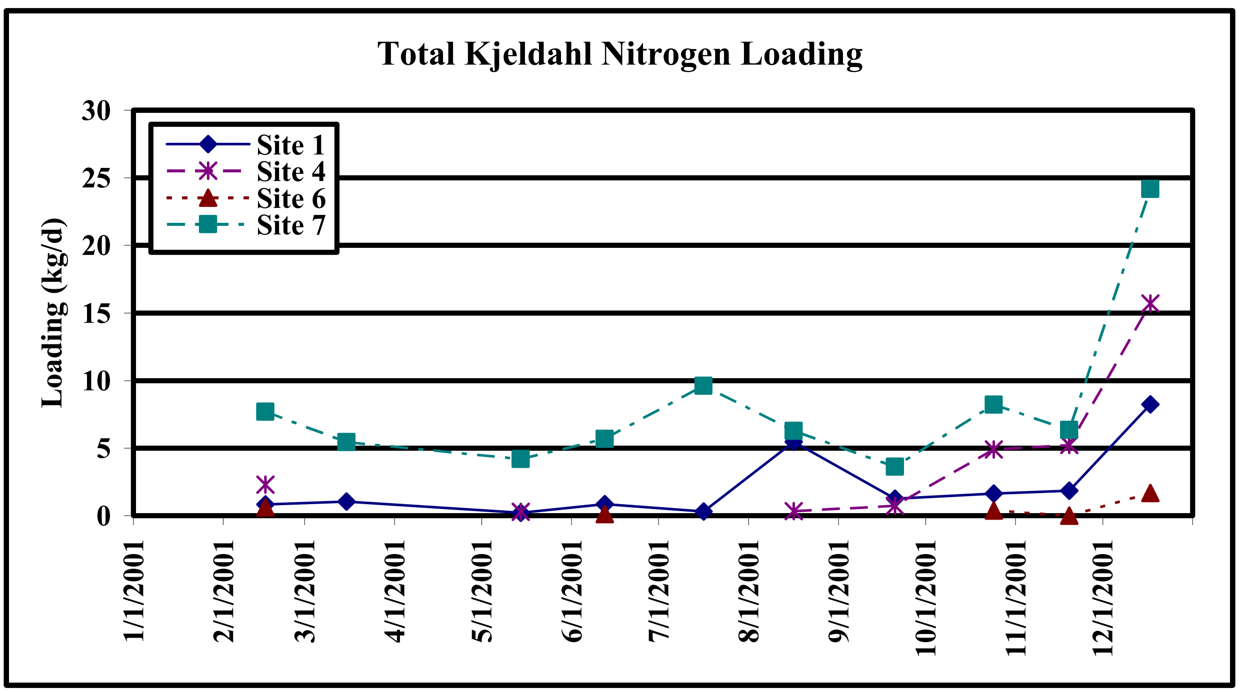

Figure 41. Total Kjeldahl nitrogen loading data for the 2001 water quality monitoring season.

Figures 42 and 43 portray total phosphorus (TP) data for the 2001 monitoring. Total phosphorus concentrations exceeded the minimum level that causes eutrophication in temperate waterbodies (0.03 mg/L) on only one occasion (Long Ditch in August). Site 9 typically contained the highest total phosphorus concentration of all sample sites. All streams maintained total phosphorus concentrations below the 0.28 mg/L level acceptable for modified warmwater habitat (Ohio EPA, 1999). Generally, total phosphorus concentrations measured in all four streams were similar, therefore no particular stream can be identified as containing the highest TP concentration. Site 7 (Kuhn Ditch) consistently maintained higher flows than all other sample sites and generally contributed the highest total phosphorus load to Lake Tippecanoe.

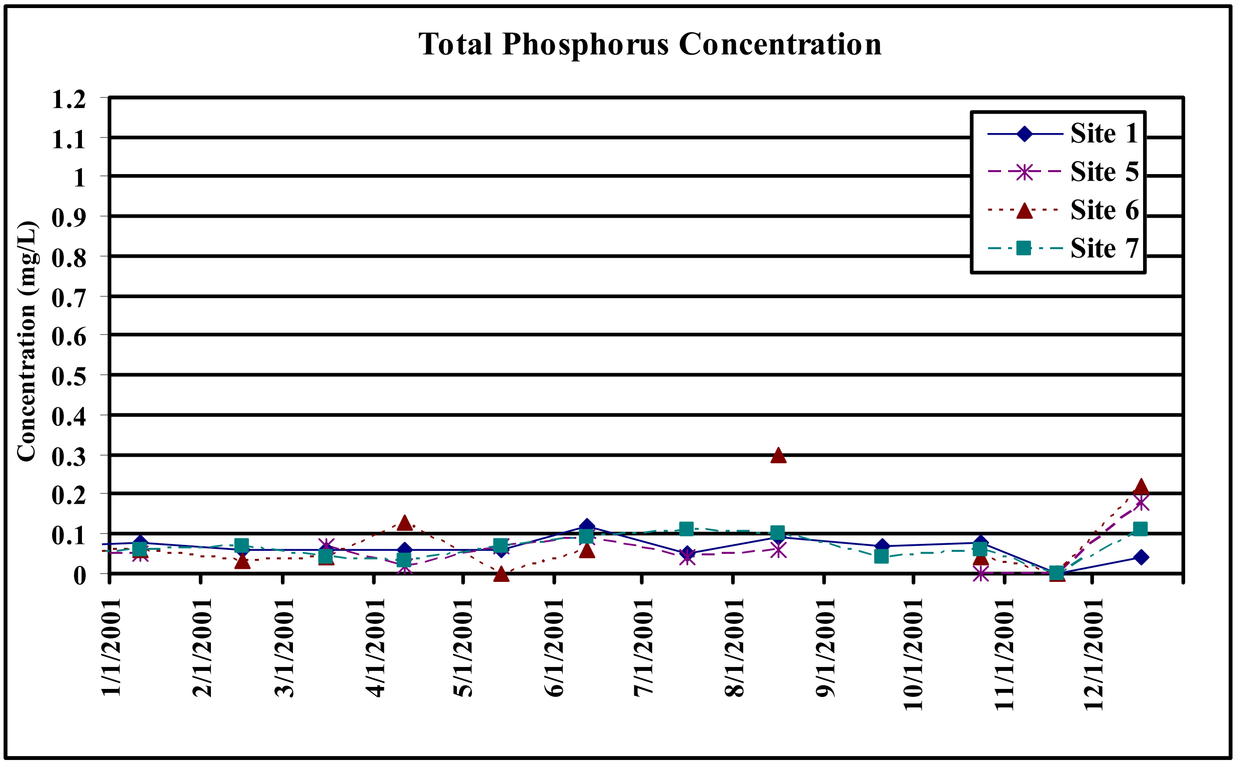

Figure 42. Total phosphorus concentration data for the 2001 water quality monitoring seasons.

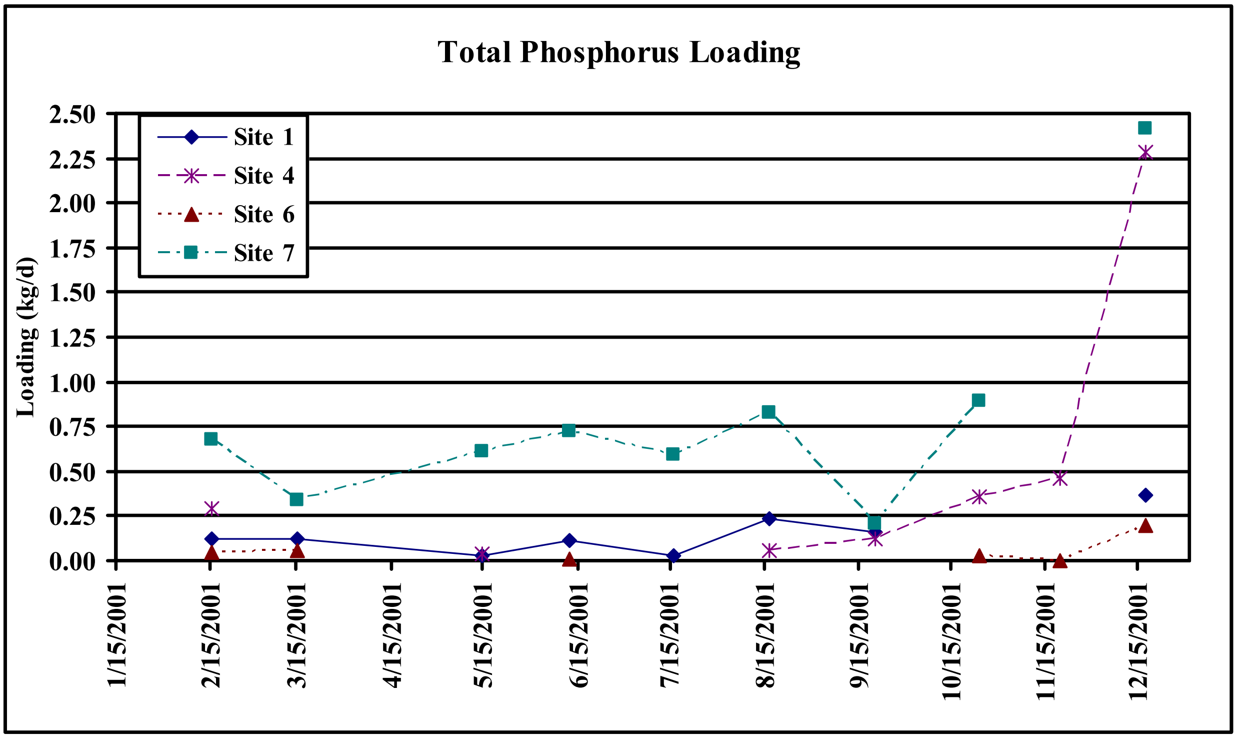

Figure 43. Total phosphorus loading data for the 2001 water quality monitoring season.

Figures 44 and 45 portray total suspended solids (TSS) data for the 2001 monitoring. At multiple points throughout the sampling season suspended solid concentrations reached levels deleterious to lithotrophic fish (90 mg/L) in both Indian Creek (Site 1) and Long Ditch (Site 6). TSS concentrations were generally highest at these two sites. Conversely, Kuhn Ditch (Site 7) had the highest TSS loading rates throughout the year.

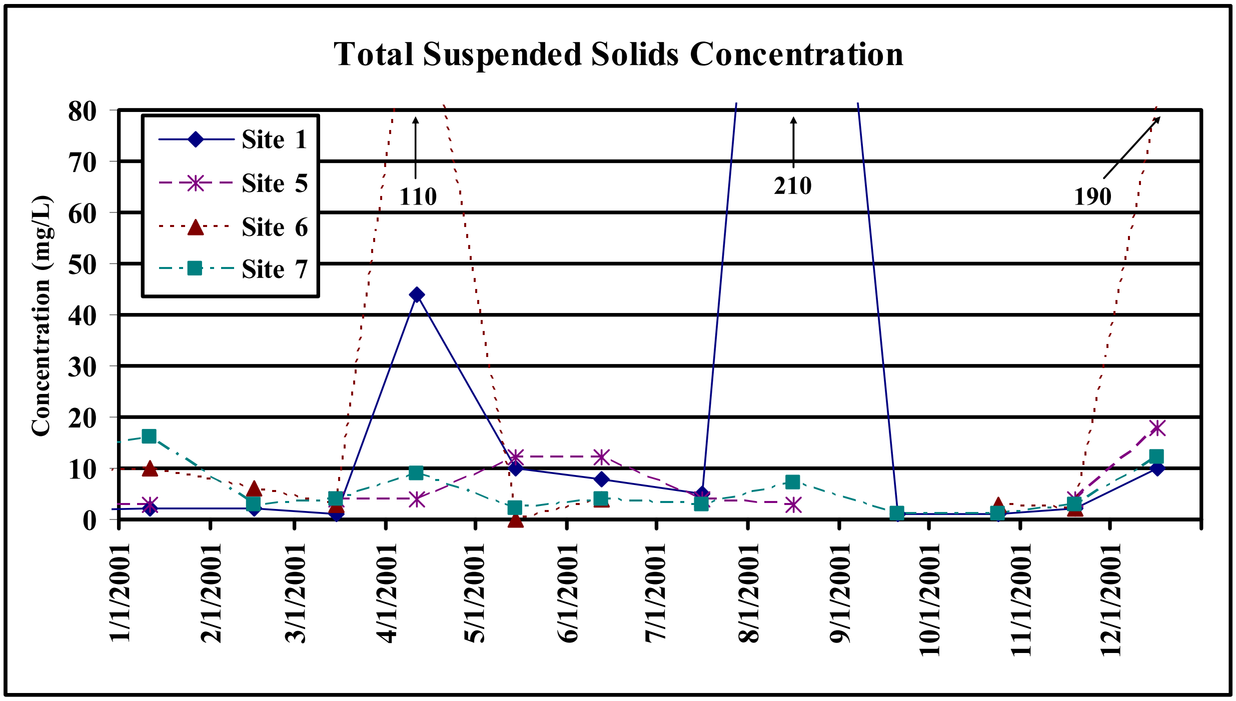

Figure 44. Total suspended solids concentration data for the 1999-2001 water quality monitoring seasons.

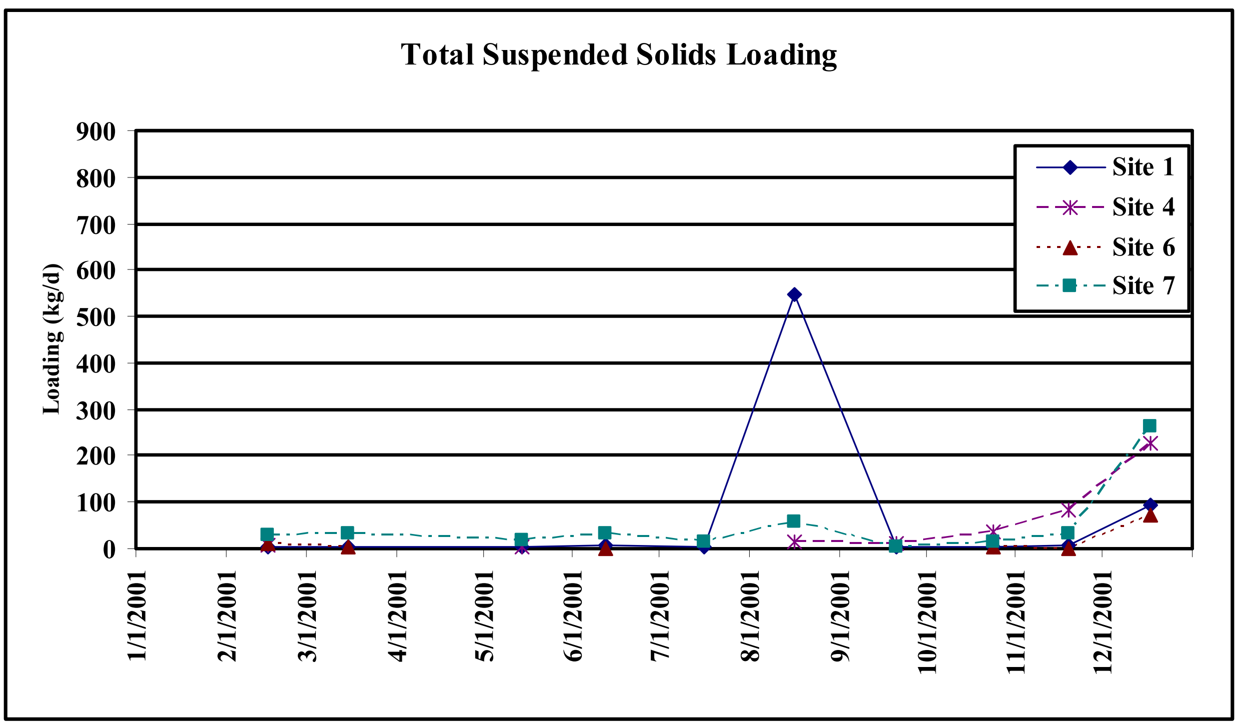

Figure 45. Total suspended solids loading data for the 2001 water quality monitoring season.

E. coli concentrations were elevated in Tippecanoe Subwatershed streams during 2001 monitoring (Figure 46). *E. coli* concentrations at most sites were greater than 235 col/100 ml, the Indiana state standard for contact recreation; concentrations peaked at 32,560 col/100 ml in Kuhn Ditch. No one stream can be identified as containing the highest E. coli concentration throughout the year. Potential sources of *E. coli* contamination include failing or poorly sited septic systems, manure spreading near stream banks, and feces of other animals that may be introduced to the stream.

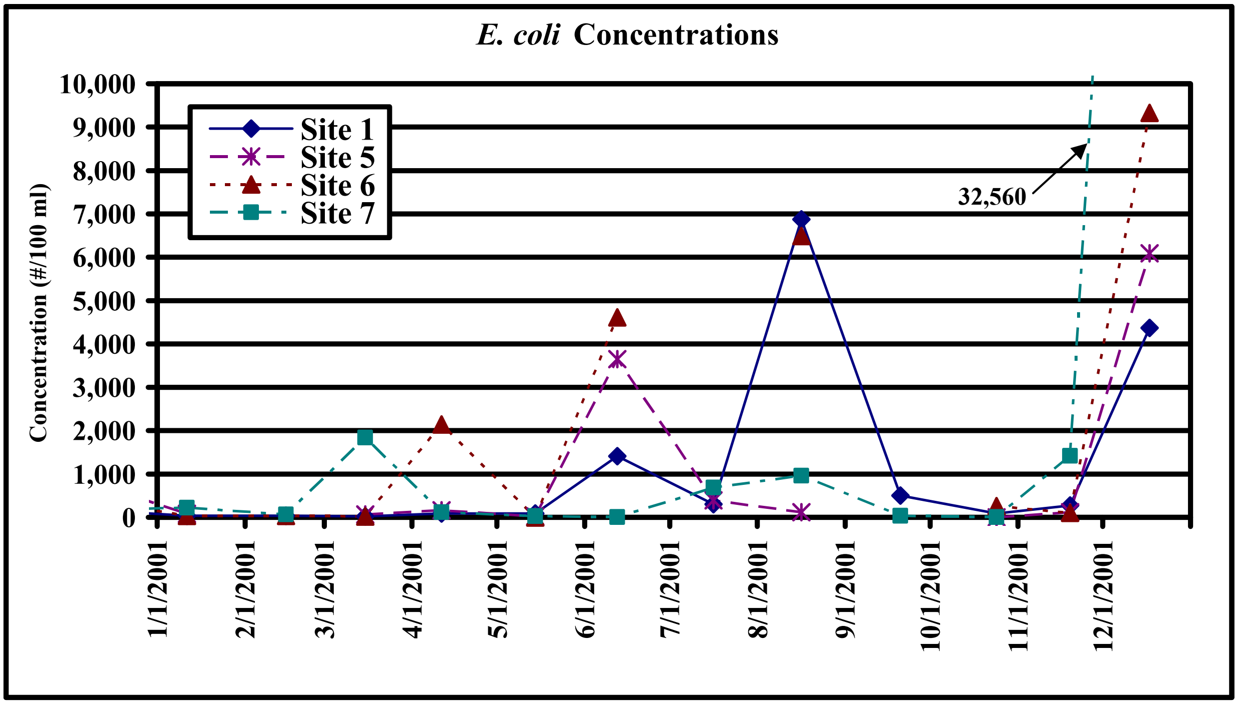

Figure 46. *E. coli* data concentration for the 2001 water quality monitoring seasons. The Indiana state standard for recreational water bodies is 235 colonies/100 ml.

<u>*Crooked/Big Subwatershed*</u>

Crooked/Big Subwatershed Lake Water Quality

Crooked and Big Lakes were selected to represent the Crooked/Big Subwatershed. The Crooked/Big Subwatershed forms the eastern headwaters of the Tippecanoe River. The Indiana Clean Lakes Program measured water quality at Crooked Lake on two separate occasions, in 1994 and 1998, and Big Lake on three occasions, in 1990, 1994, and 1998. Table 39 lists Indiana trophic state and index scores for the two Crooked Lake and three Big Lake sampling efforts. Water quality in Crooked Lake decreased over time, rating as oligotrophic in 1994 and mesotrophic in 1998. Indiana trophic state index scores rate Big Lake eutrophic in 1990, mesotrophic in 1994, and eutrophic in 1998. Ultimately Big Lake does not display any particular water quality trend based on the Indiana trophic state index scores. On average, the Crooked/Big Subwatershed contains mesotrophic lakes.

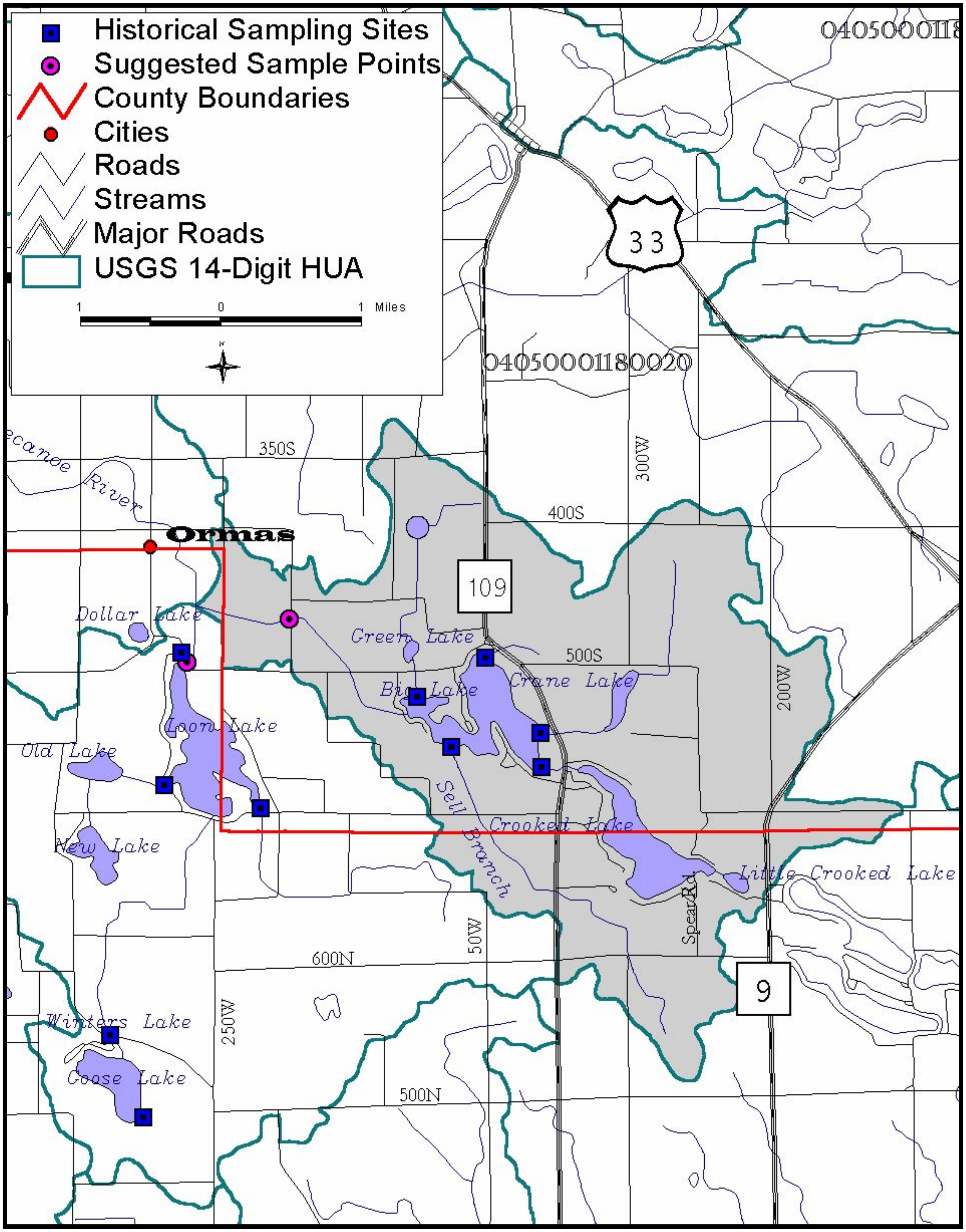

Figure 47. Crooked/Big Subwatershed.

Table 39. Crooked/Big Subwatershed Indiana trophic state index scores.

	1990	1994	1998
Crooked Lake Trophic Score	--	11	18
Trophic Status		Oligotrophic	Mesotrophic
Big Lake Trophic Score	42	27	37
Trophic Status	Eutrophic	Mesotrophic	Mesotrophic

Table 40 displays historic mean total phosphorus concentrations for Crooked and Big Lakes. Total phosphorus concentrations in both lakes show a generally increasing trend from 1990 to 1998. This is the opposite trend needed for improving lake conditions. When total phosphorus values are compared to Vollenweider's guidelines above, all samples are above the mean value for eutrophic lakes.

Table 40. Crooked/Big Subwatershed total phosphorus concentrations.

	1990	1994	1998
Crooked Lake Concentration	0.070 mg/L	0.119 mg/L	0.122 mg/L
TP Score	Mesotrophic	Eutrophic	Eutrophic
Big Lake Concentration	0.058 mg/L	0.142 mg/L	0.242 mg/L
TP Score	Mesotrophic	Eutrophic	Eutrophic

Results from Crooked and Big Lakes can also be compared to other Indiana lakes (Figure 48). Based on this comparison, Crooked Lake, in general, had worse water quality than most Indiana lakes. Crooked Lake's Secchi disk depth was greater than most Indiana lakes, indicating that most Indiana lakes are not as clear as Crooked Lake. Conversely, Crooked Lake possessed higher concentrations of total phosphorus, soluble reactive phosphorus, and nitrate-nitrogen than most Indiana lakes. However, low chlorophyll *a* concentrations indicate that although nutrients appear to be readily available, Crooked Lake was not extremely productive. Big Lake possesses poorer water quality than most Indiana lakes. Big Lake contains higher total phosphorus, nitrate-nitrogen and ammonia-nitrogen than that observed at most Indiana lakes. However, the Secchi depth recorded at Big Lake is higher than most Indiana lakes.

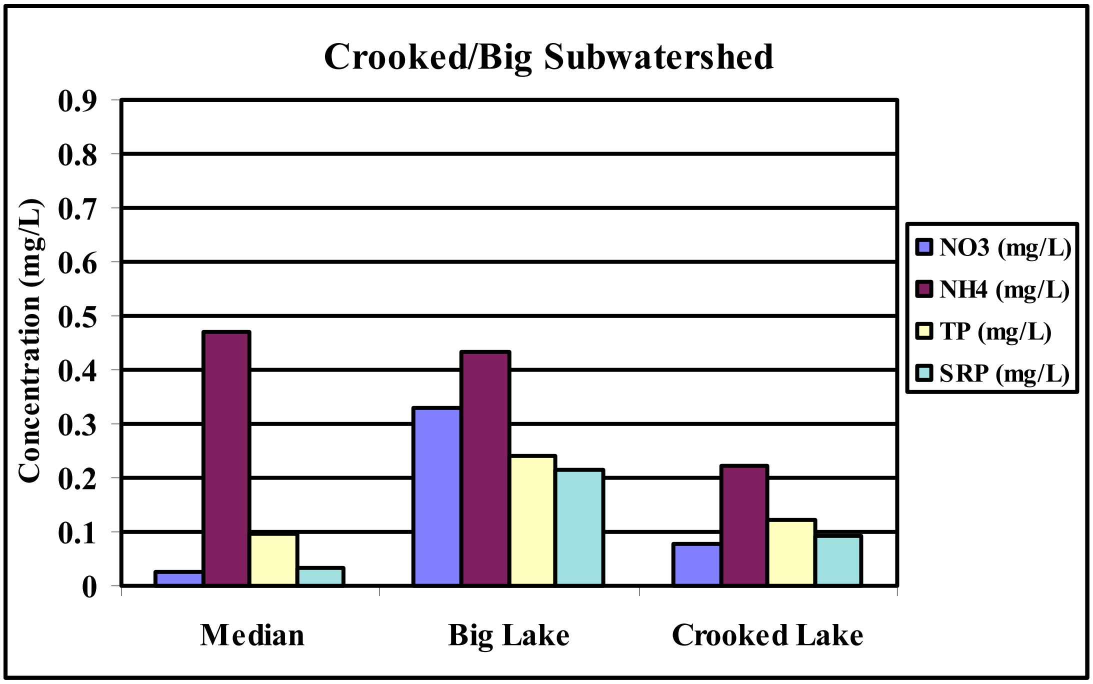

Figure 48. Comparison of Crooked Lake water quality data (1998) with Indiana Clean Lakes Program data (1994-1998). Median represents the median value of all lakes sampled from 1994-1998 by the Indiana Clean Lakes Program. Individual lakes with values below the median value are considered to have better water quality than most Indiana lakes; lakes with values above the median value for Indiana lakes are considered to have poorer water quality than most Indiana lakes.

Crooked/Big Subwatershed Stream Water Quality

The IDNR collected water quality samples from the major streams flowing into and out of Big Lake at base flow conditions on 4/8/92 and once after a storm runoff event on 6/17/92 (IDNR, 1995). The sampling locations included the five tributaries to Big Lake: the tributary from Crooked Lake, the tributary from Crane Lake, the tributary from Green Lake, Stuckman Drain, and Sell Drain (Figure 47).

Base flow and storm flow sampling included measurements of common chemical and physical characteristics as well as nutrient and suspended sediment levels. IDNR did not record discharge during either base or storm flow sampling. Because of this, the following paragraphs detail the results as only concentrations.

Figure 49 portrays total phosphorus (TP) data for the two collected samples. Total phosphorus concentrations were the highest in the Green Lake tributary during base flow and in the Crane Lake tributary and Stuckman Drain during storm flow. All sites maintained total phosphorus concentrations below the 0.28 mg/L level acceptable for modified warmwater habitat (Ohio EPA, 1999).

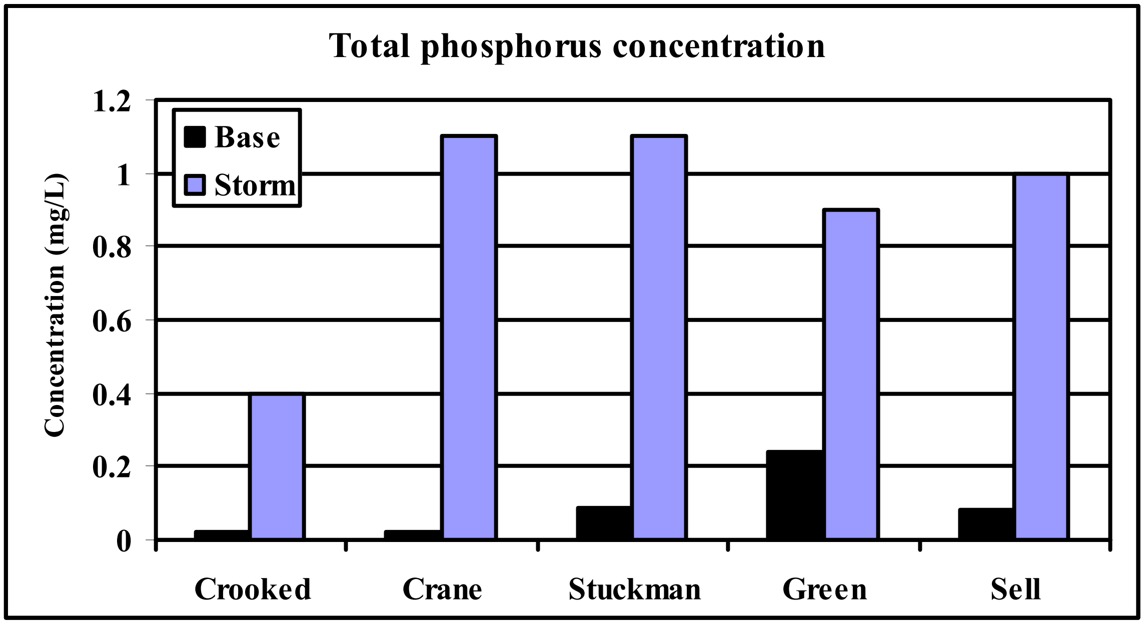

Figure 49. Total phosphorus concentrations measured in Big Lake tributaries. (Source: IDNR, 1995)

Total Kjeldahl nitrogen (TKN) concentrations in the streams are somewhat similar to those patterns observed for phosphorus. TKN concentrations in storm flow samples were double those measured in base flow samples. The Green Lake tributary, Stuckman Drain and Sell Drain had the highest concentrations during both base flow and storm flow (Figure 50). Following the storm event, Stuckman Drain contained concentrations nearly double TKN concentrations measured in other tributaries.

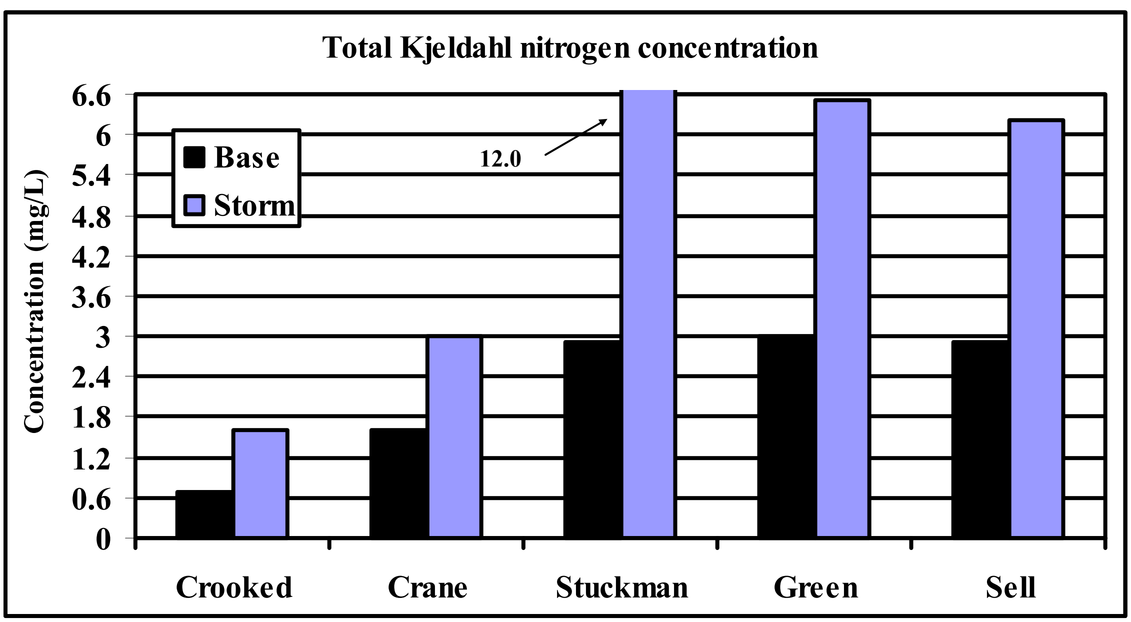

Figure 50. Total Kjeldahl nitrogen concentrations measured in Big Lake tributaries. (Source: IDNR, 1995)

Total suspended solids concentrations varied similarly to nitrogen and phosphorus concentrations. Sell Drain contained the highest concentration of total suspended solids during base flow, while Stuckman Drain had the highest storm flow concentration (Figure 51). TSS concentrations did not increase in storm flow samples in two of the five tributaries. Total suspended solids concentrations in the Stuckman Drain storm flow sample were nearly 125 times greater than those measured in the base flow sample. Both Stuckman and Sell Drains may be significant sources of sediment and nutrients to Big Lake.

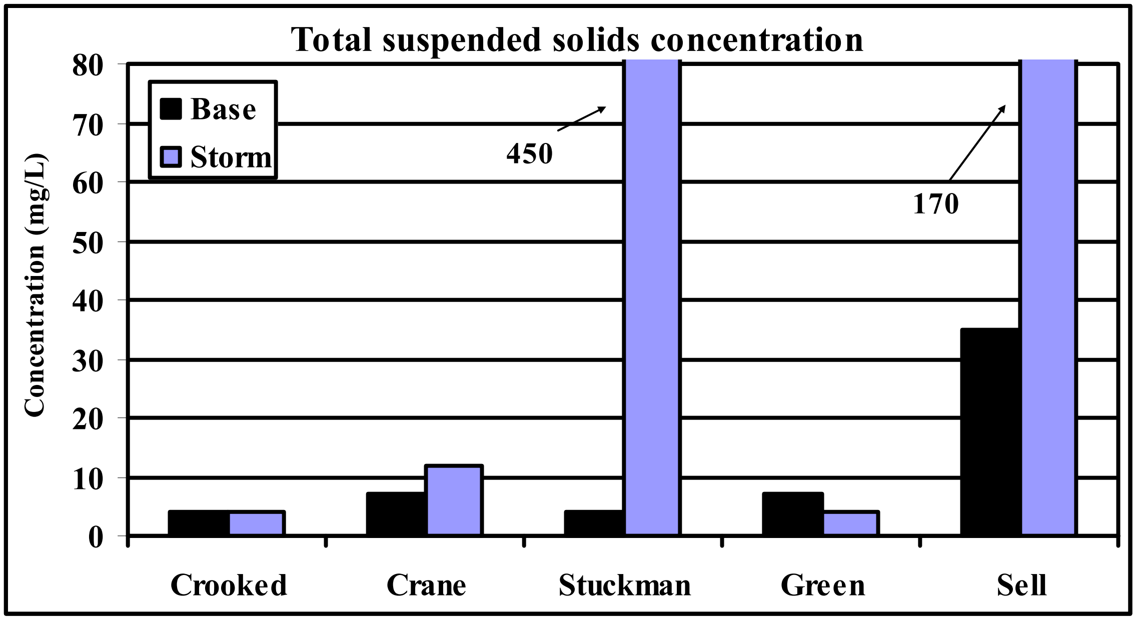

Figure 51. Total suspended solids concentrations measured in Big Lake tributaries. (Source: IDNR, 1995)

C. 2005 Water Quality/Biological Assessment (within 11-digit HUC)

Recent water quality data collected as part of the updates to this WMP included water quality and biological integrity assessments at the broader 11-digit watershed scale. This included at least one sample in each of the eight subwatershed and two additional data point locations in the previously identified priority watershed of Ridinger/Robinson. The full report is included Appendix G. A Quality Assurance Project Plan (QAPP) was completed for data collected as part of this assessment. The approved QAPP is included as Appendix H. The analysis made use of several biological evaluations and limited water chemistry data to arrive at the best possible conclusions from the limited number of samples. It can be concluded from the data that the subwatershed priorities in order of highest to lowest priority (from poorest water quality to best water quality) are as follows:

1. Ridinger/Robinson Subwatershed
2. Smalley Subwatershed
3. Barbee Lakes Subwatershed
4. Elder Ditch Subwatershed
5. Crooked/Big Subwatershed
6. Goose/Loon Subwatershed
7. Tippecanoe Subwatershed
8. Webster/Backwaters Subwatershed

Figure 52 shows the location of chemical and biological study sites associated with this recent water quality assessment. Table 41 links these sites to specific subwatersheds and their relative priority ranking.

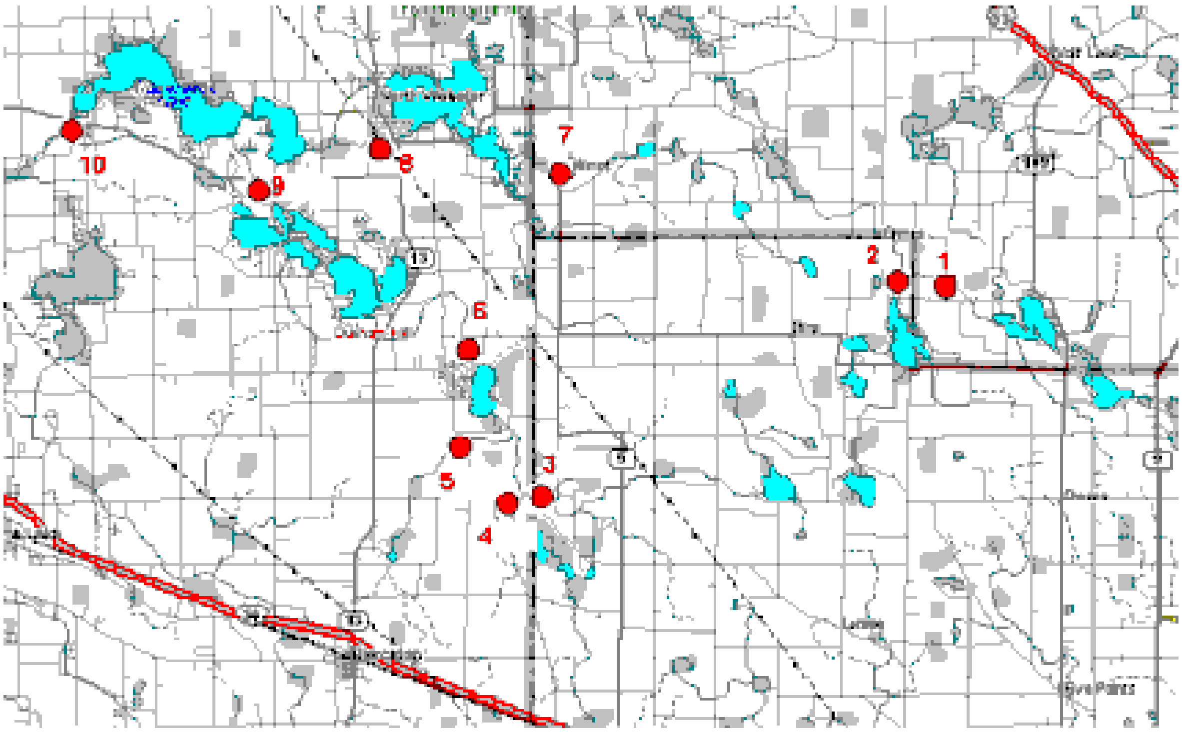

Figure 52. Sample site locations in the 11-digit watershed

Table 41 Site locations, subwatersheds, and priorities in the 11-digit watershed

Site Location No.	Site Description	Subwatershed	Priority
1	Outlet of Big Lake	Crooked/Big	7
2	Outlet of Loon Lake	Goose/Loon	8
3	Elder Ditch at Kosciusko/Whitley County line	Elder Ditch	4
4	Outlet of Robinson Lake	Ridinger/Robinson	5
5	Shanton Ditch CR 900 E	Ridinger/Robinson	1
6	Outlet of Ridinger Lake	Ridinger/Robinson	6
7	Tippecanoe River below Wilmot Mill Pond	Smalley	2
8	Tippecanoe River below Webster Lake	Webster	10
9	Grassy Creek inlet to Tippecanoe Lake	Barbee	3
10	Tippecanoe River below Tippecanoe Lake	Tippecanoe	9

One of the most useful aspects of biological monitoring is that it can be used to diagnose a reoccurring problem because of the way aquatic animals respond to different types of environmental stress. For example, degraded biotic integrity can often be directly related to degraded habitat. Macroinvertebrates cannot thrive where habitat is lacking. When the two values are compared against one another, causative factors for low biological scores can be weeded out. When habitat score are graphed in relation to biotic integrity scores, a measurement error of plus or minus 10% can be added to the graph to give a range in which biotic integrity degradation is explained simply by a lack of adequate habitat (Bright, 2006, Appendix G). When values fall outside this range, however, water quality problems are suspected. A comparison of biotic integrity to habitat is shown in Figure 53.

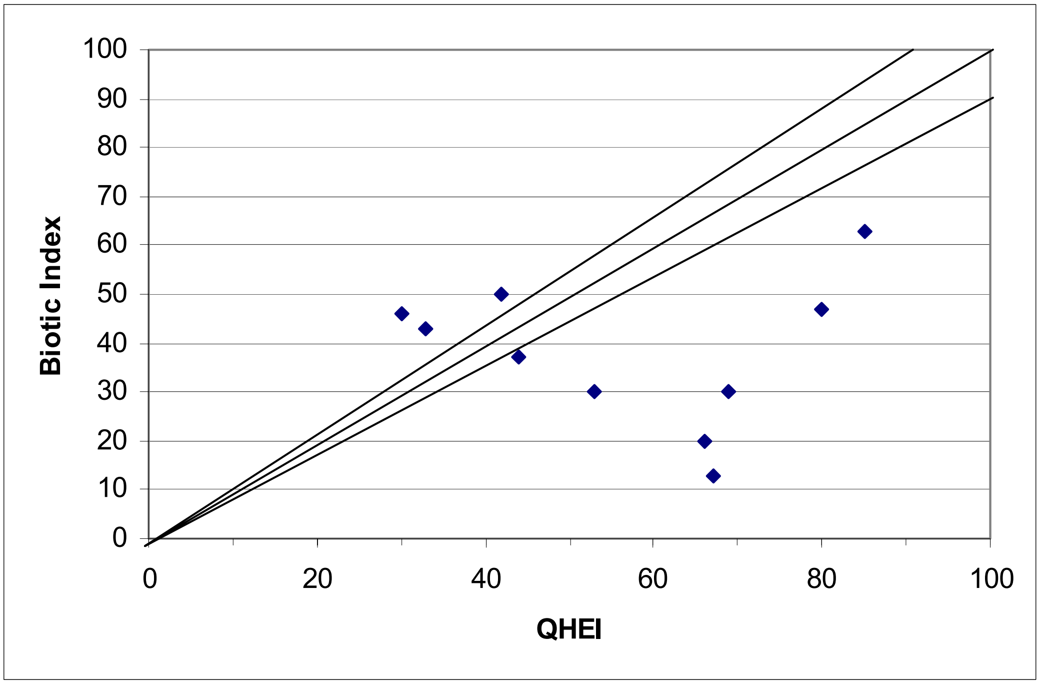

Figure 53. Relationship of Aquatic Habitat Value to Biotic Integrity at the Ten Study Sites

All of the sites showed some degree of impairment. This impairment was most apparent at Site 7, which despite a habitat score of 67, only had a macroinvertebrate biotic integrity score of 13. The macroinvertebrate community was dominated by amphipods, and there was a complete lack of mayflies. There was an abundance of algal growth at this site, which is evidence of nutrient enrichment.

Sites 4 and 5 had fish and macroinvertebrate community biotic integrity scores lower than what would be indicated by their habitat scores. The macroinvertebrate collection at Site 4 had no mayflies and was dominated by isopods. The fish community was dominated by tolerant creek chubs. Site 5 had poor biotic integrity for macroinvertebrates and a very poor IBI for fish. The macroinvetebrate community was dominated by isopods, with very few mayflies or caddisflies. There were low numbers and variety of fish.

Sites 1, 2. 3, and 6 were limited by degraded habitat, primarily from channelization. At Site 6, the substrate was very soft from siltation, and the fish IBI was 16, with only six species being collected. However, this site had fair biotic integrity for macroinvertebrates, with both mayflies and caddisflies being present. In addition, evidence of six freshwater mussel species was observed, including one uncommon species.

Sites 8 and 10 on the Tippecanoe River both had excellent habitat. Of these two, Site 8 was in the best ecological health, with the highest mayfly and caddisfly diversity of any of the sites. The macroinvertebrate collection at Site 10 was dominated (61%) by the net-spinning caddisfly *Cheumatopsyche*, and there were no darters or suckers in the fish collection.

Site 9 had a macroinvertebrate biotic integrity score of only 20, despite a habitat score of 66. There were no mayflies or caddisflies, and dipterans dominated the collection. This site is near an impoundment, and macroinvertebrate communities are affected by alterations to the flow regime.

The above listed subwatershed priorities were arrived at though the consideration of the above biological evaluations and interpretation, as well as one time water chemistry data collected at the ten sites. Water chemistry data was taken concurrently with biological data collected on October 31, 2005. Results of the water chemistry are included in Table 42.

Table 42. Water Chemistry Data for the 11-digit Watershed Sampling Sites

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10
Time	1140	1210	1310	1330	1410	1440	1240	1510	1540	1600
Temp.(C)	11.6	12.3	13.9	12.2	10.5	15.0	12.0	12.1	14.7	13.2
Dissolved Oxygen (mg/L)	10	8.7	14.9	6.6	6.0	11.8	8.9	7.7	10.2	8.3
pH (S.U.)	7.3	7.1	8.2	7.6	7.4	8.1	7.4	7.7	8.0	7.8
Conductivity (μs/cm)	715	840	660	630	670	500	500	440	440	410
Flow (cfs)	0.3	0.4	1.1	0/2	1.5	5	5	7	20	45
E.coli (cfu/100 ml)	26	52	74	10	104	16	6	44	190	58
TSS (mg/L)	11	1.2	1.7	2.2	43	3.8	1.2	1.5	2.0	< 1
NH_3-N	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.4	0.4	0.5
BOD (mg/L)	3.1	2.2	3.1	0.8	1.4	3.2	2.7	1.5	0.6	0.4

D. <u>Phosphorus Modeling</u>

Since phosphorus is the limiting nutrient in most lakes and reservoirs, watershed management programs often target phosphorus as a nutrient to control. Because of this, a phosphorus model was used to estimate the dynamics of this important nutrient in these subwatersheds.

The limited scope of this study did not allow analysts to determine phosphorus inputs and outputs outright. Therefore, a standard phosphorus model was used to estimate the phosphorus budget. Reckhow et al. (1980) compiled phosphorus loss rates from various land use activities as determined by a number of different studies and calculated phosphorus export coefficients for each land use in the watershed. Mid-range estimates of these phosphorus export coefficient values were used for most watershed land uses (Table 43).

Table 43. Phosphorus export coefficients (units are kg/hectare-yr except the septic category, which are kg/capita-yr).

Estimate Range	Row Crop	Non-Row	Pasture	Forest	Precipitation	Urban
High	5.0	1.5	2.5	0.3	0.6	3.0
Mid	2.0	0.8	0.9	0.2	0.3	1.0
Low	1.0	0.5	0.1	0.1	0.15	0.5

Source: Reckhow et al. (1980)

Table 43 lists phosphorus export coefficients in kilograms of phosphorus lost per hectare of land per year. These coefficients were multiplied by the amounts of land in each of the land use category to derive an estimate of annual phosphorus export (as kg/year) for each land use per watershed (Table 44).

Because row crop agriculture is the dominant land use within each of the subwatersheds, the proportional mass of phosphorus estimated from row cropland is also high, accounting for over 88% of the total estimated phosphorus loss from the watershed. The percentage of phosphorus loss due to row crops ranges from a low of 78% in the Barbee Lakes Subwatershed to a high of 96% in the Smalley Subwatershed. When the data have been normalized for subwatershed area, all upper watershed sub-basins, Smalley, Loon/Goose, Crooked/Big, Ridinger/Robinson, and Elder Ditch, contribute almost even amounts of phosphorus, approximately 1.5 kg/ha-yr, while lower subwatershed basins such as Tippecanoe, Barbee Lakes and Webster/Backwaters contribute only about 1.2 kg/ha-yr (Table 45). According to the model, the Ridinger/Robinson Subwatershed loaded the most phosphorus per unit area. The model estimates that 38,560 kilograms (42.5 tons) of phosphorus is lost from lands within the project area each year. Significant reduction of phosphorus loading to local streams and lakes will necessitate additional management of agricultural sources.

Table 44. Results of phosphorus export modeling by subwatershed given in kg/yr.

	P-Export Coefficient[a]	Tippecanoe	Webster/ Backwaters	Smalley	Barbee Lakes	Crooked / Big	Goose / Loon	Ridinger/ Robinson	Elder Ditch	Total	Percent of Total
Deciduous Forest	0.2	79.5	112.5	68.2	83.1	47.3	68.2	134.8	80.1	673.6	0.0175
Emergent Herbaceous Wetland	0.1	11.2	13.3	4.5	8.0	1.0	2.7	2.5	2.3	45.6	0.0012
Evergreen Forest	0.15	0.6	2.0	1.4	0.3	0.6	0.2	0.3	0.1	5.5	0.0001
High Intensity Residential	1.9	15.7	13.6	0.3	24.0	3.7	0.9	3.5	0.0	61.7	0.0016
Low Intensity Residential	1.0	65.8	57.8	1.2	141.0	32.5	14.9	66.9	1.0	381.1	0.0099
High Intensity Commercial/Industrial	1.5	40.7	8.0	0.1	26.2	5.9	2.4	7.4	0.0	90.8	0.0024
Mixed Forest	0.2	0.1	0.4	0.1	0.0	0.0	0.0	0.1	0.0	0.7	0.0000
Open Water	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0000
Other Grasses (Parks)	0.6	8.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.5	0.0002
Pasture Hay	0.9	463.0	270.1	98.8	478.3	285.0	417.3	606.3	617.1	3235.9	0.0839
Row Crops	2.0	3206.2	4103.8	4954.2	2694.3	3434.5	3639.1	6327.4	5598.1	33957.7	0.8806
Woody Wetlands	0.1	9.7	10.2	15.5	21.3	4.2	10.0	15.0	13.1	98.9	0.0026
TOTAL		**3,900.9**	**4,591.7**	**5,144.3**	**3,476.5**	**3,814.8**	**4,155.6**	**7,164.2**	**6,311.8**	**38,559.9**	**1.0000**

[a]From Reckhow et al. (1980)

Table 45. Results of phosphorus export modeling by subwatershed given in kg/ha-yr.

Subwatershed	Phosphorus Export (lb/ac-yr)	Phosphorus Export (kg/ha-yr)
Tippecanoe Subwatershed	1.05	1.18
Webster/Backwaters Subwatershed	1.12	1.27
Smalley Subwatershed	1.41	1.58
Barbee Lakes Subwatershed	0.98	1.11
Crooked/Big Subwatershed	1.32	1.49
Loon/Goose Subwatershed	1.26	1.42
Ridinger/Robinson Subwatershed	1.31	1.47
Elder Ditch Subwatershed	1.37	1.54
Upper Tippecanoe River Subwatershed	**1.23**	**1.38**

E. <u>Potential Pollutants in the Watershed</u>

A number of substances can contribute to water pollution. Sources of these pollution-causing substances are divided into two broad categories: point sources and nonpoint sources. Point sources are typically piped discharges from wastewater treatment plants, large urban and industrial stormwater systems and other facilities. Nonpoint sources can include atmospheric deposition, groundwater inputs and runoff from urban areas, agricultural lands and others.

Total Suspended Solids

Total suspended solids refers to all particles suspended and dissolved in aquatic ecosystems. Particles are generally comprised of clay, silt, fine organic and inorganic matter, plankton and other microscopic organisms. Sediment is the most common type of suspended solid. Sediment originates from many sources included eroding stream banks, tilled land lacking vegetative cover and other disturbed areas.

Suspended solids impact streams in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the lake or creek bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals reproductive success. Solids that settle to lake bottoms can impair recreational uses of the lake. The accumulation of suspended solids in shallow areas create new substrate for nuisance macrophyte growth further impairing recreational uses of the lake. Suspended sediments also degrade the aesthetic and recreational value of the creek. In addition, pollutants attached to sediment impair water quality. (These pollutants are discussed in greater detail below.)

Nutrients

The term nutrients are referred to the two major plant nutrients: phosphorus and nitrogen and are an essential component of aquatic ecosystems. Nitrogen is found in fertilizers, human and animal wastes, yard waste and the air. Nitrogen enters aquatic systems as inorganic nitrogen or ammonia or is “fixed” by blue green algae for their use. While there is no atmospheric form of phosphorus, it enters aquatic systems through atmospheric deposition or is washed in attached to soil particles. Nutrients are essential for the growth of primary producers, namely algae and plants. Growth of primary producers supports the remainder of the food web. Insufficient nutrient levels in stream and lake water can limit the size and complexity of biological communities living in the aquatic ecosystem. Ohio EPA found that the median nitrate-nitrogen concentration in wadeable streams that support modified warmwater habitat (MWH) was 1.6 mg/L (Ohio EPA, 1999). Modified warmwater habitat was defined as: aquatic life use assigned to stream that have irretrievable, extensive, man-induced modifications that preclude attainment of the warmwater habitat use (WWH) designation; such streams are characterized by species that are tolerant of poor chemical quality and habitat conditions that commonly occur in modified streams (Ohio EPA, 1999). In contrast, excessive levels of nutrients in lakes or streams alter biological communities by promoting nuisance species growth. For example, high concentration of total phosphorus in lake water (>0.03 mg/L) create ideal conditions for nuisance algae growth. In extreme cases lake algae growth can exclude rooted macrophyte growth and shift fish community composition.

Trash and Organic Debris
Materials such as household garbage, grass clippings, leaves and lawn wastes, unwanted furniture, automotive parts, toys or ornaments not only effects the aesthetic value of the water resources, but also contributes to the loss of natural flow and the depletion of the oxygen needed for a balanced aquatic system.

Pathogens
Bacteria, viruses, and other pathogens are contaminants of concern in both urban and agricultural areas of the watershed. Common sources of these pathogens include human and wildlife waste, fertilizers containing manure, previously contaminated sediments, septic tank leachate, combined sewer overflows, and illicit connections to stormwater sewers. *E. coli* is a member of the fecal coliform bacteria group typically utilized as an indicator organism to identify the presence of pathogenic organisms in a water sample. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis and other gastrointestinal illnesses. Thus, pathogens can impair the recreational value of a stream. Some pathogens can also impair biological communities.

Oxygen Demand
Like their terrestrial counterparts, aquatic fauna require oxygen to live. During respiration, aquatic fauna consume oxygen in the water column. The degradation of certain organic substances also utilizes oxygen in the water. In addition to quantifying specific pollutants, water quality analyses often include a measurement of the potential for oxygen depletion by these oxygen demanding substances. A variety of sources contribute oxygen demanding organic wastes to a stream, including soil erosion, human and animal wastes, vehicle emission, household or industrial chemicals, lawn clippings, and pesticides (Horner et al., 1994).

Toxic Substances
A toxic substance is defined as substances that are or may become harmful to plant or animal life or to food chains when present in sufficient concentration or combinations. Toxic substances include, but are not limited to, those pollutants identified as toxic under the Clean Water Act. Toxic substances frequently encountered include chlorine, ammonia, organics (hydrocarbons and pesticides), heavy metals, PCBs and pH. These materials are toxic to different organisms in varying amounts, and the effects may be evident immediately or may only be manifested after long-term exposure or accumulation in living tissue. Toxins can also be found in compounds that people use everyday, such as: household cleaning compounds, paints, varnishes and lacquers, paint thinners, degreasers and other solvents, gasoline, anti-freeze, battery acid and motor oils, de-icing compounds and road salt. Each of the substances below can be toxic in sufficient quantity or concentration.

Ammonia ($NH3$)
Point source dischargers are one of the major sources of ammonia. In addition, discharge of untreated septic effluent, decaying organisms which may come from nonpoint source runoff and bacterial decomposition of animal waste also contribute to the levels of ammonia.

Polychlorinated biphenyls (PCBs)
PCBs were first created in 1881 and subsequently began to be used commercially manufactured around 1929 (Bruce, 1994). Because of their fire-resistant and insulating properties, PCBs were widely used in transformers, capacitors and in hydraulic and heat transfer systems. In addition, PCBs were used in products such as plasticizers, rubber, ink and wax. In 1966, PCBs were first detected in wildlife and were soon found to be ubiquitous in the environment (Bruce, 1994). PCBs entered the environment through unregulated disposal of products such as waste oils, transformers, capacitors, sealants, paints and carbonless copy paper. In 1977, production of PCBs in North America was halted. Subsequently, the PCB contamination present in the surface waters and environment today is the result of historical waste disposal practices.

Metals (Zinc, Copper, Nickel, Lead, Arsenic, Cadmium, Mercury and Chromium)
Metals are a pollutant of concern in the more urban areas of the watershed. Metals can impair a stream's biological community and, in extreme cases, its recreational potential. Like hydrocarbons, metals can be acutely and chronically toxic to all forms of life (aquatic and human). Metals also have the capacity to bioaccumulate in the food web. In Indiana, mercury contamination in fish has cause the need to post widespread fish consumption advisories. The source of the mercury is unclear; however, atmospheric sources are suspected and are currently being studied. Municipal and industrial dischargers are one of the main sources of metal contamination in surface water. Point source dischargers are controlled through the NPDES permit process. Municipalities with significant industrial users discharging waste to their treatment facilities limit the heavy metals through a pretreatment program. Source reduction and wastewater recycling at wastewater treatment plants (WWTP) also reduces the amount of metals being discharged to a stream. Vehicle use/wear (worn metal parts, tires, leaking fluids, etc.) and exhaust is another primary source of metals to the urban landscape. For example, applying the brakes to slow a car results in the deposition of copper laden dust on roads and parking lots. At the same time, tire wear caused by the braking action contributes cadmium, copper, lead, and zinc to the landscape. Paints and the weathering of steel structures add additional metals to the watershed.

Hydrocarbons
The category "hydrocarbons" encompasses a broad range of substances. Because of the diversity of substances, researchers may test water quality samples for oil and grease, total hydrocarbons, polyaromatic hydrocarbons (PAHs), polynuclear aromatic hydrocarbons (PNAs), phenols, or specific hydrocarbons. Some of the more common toxic hydrocarbons found in runoff include bis(2-ethylhexl)phthalate, a-hexachorocyclohexane, phenanthrene, pyrene, chrysene, and fluorathene. The most common sources of hydrocarbons are fuels, oils, and the combustion of fuels and oils. Given this, Schueler (2000a) found that gas/service stations, convenience store and fast food restaurant parking lots, and commuter parking lots contributed significantly greater amounts of hydrocarbons to runoff compared to other developed areas in the watershed.

Hydrocarbons impair aquatic biological communities and the aesthetic value of a waterbody. For example, some hydrocarbons are directly toxic to aquatic life. Specific hydrocarbons are also toxic to humans. Hydrocarbons are oxygen demanding substances that lower the dissolved oxygen content of a waterbody.

Thus, hydrocarbons may indirectly impact biological communities. In addition, many hydrocarbons have the ability to bioaccumulate in the food web, impacting more species than solely aquatic ones. Lastly, some hydrocarbons, specifically oil and grease, form visible sheens on a water's surface, detracting from the aesthetic value of the waterbody.

Pesticides

Pesticides are a necessary component of conventional agricultural practices. Additionally, pesticides are applied to roughly half the urban lawns in the United States annually (Schueler, 2000b). While researchers have detected pesticides in urban lakes and streams, concentrations are typically much lower than levels that are toxic for aquatic and land organisms (Schueler, 2000b). Testing for pesticides can be difficult and expensive without specific knowledge of the pesticides used in the watershed. Although the use of pesticides may contribute to the degradation of the watershed, their effects are likely minimal in comparison to the effects of other pollutants.

F. Potential Pollution Sources in the Watershed

An examination of the Upper Tippecanoe River Watershed reveals many potential sources or causes for the threats identified in the previous sections of this document. As discussed previously, sources of water pollution are divided into two broad categories: point sources and nonpoint sources. The following paragraphs explore the potential for pollutants from each of these to degrade water quality, thereby limiting the potential use of the Upper Tippecanoe River Watershed.

Permitted Discharges

Three separate facilities currently hold permits from the state to discharge specified loads of certain pollutants into streams within the study watershed area. The state requires permitted facilities to monitor their discharge and submit compliance reports on a monthly basis. A facility that exceeds their permitted pollutant discharge levels are in violation and must correct the problem in a timely manner. The Environmental Protection Agency (EPA) Envirofacts Warehouse database can be queried to determine if facilities within the Upper Tippecanoe River Watershed consistently meet or violate standard criteria set for discharge effluent.

The North Webster Municipal Sewage Treatment Plant treats wastewater from the North Webster area and currently holds a permit to discharge treated water into Kuhn Ditch. The plant is located northwest of the intersection of State Road 13 and County Road 650 North. The plant staff monitors the plants effluent for dissolved oxygen (DO), pH, total suspended solids (TSS), ammonia-nitrogen (NH_3-N), residual chlorine, carbonaceous biological oxygen demand (C-BOD), total phosphorus (TP), and flow. Table 46 lists the number of times and the percentage of time that the North Webster Sewage Treatment Plant was in violation of its permit for chemical parameters from January 1998 to September 2001. Of the parameters monitored, the North Webster Municipal Sewage Treatment Plant violated its ammonia-nitrogen concentration limit (1.7 mg/L) most frequently. When in violation, the plant reported maximum ammonia-nitrogen concentrations ranging from 6.7 mg/L to 13.2 mg/L. The majority of ammonia-nitrogen violations occurred during late spring, summer, and early fall months. The North Webster Municipal Sewage Treatment Plan was in violation of its permitted ammonia-nitrogen level in 24% of the samples taken from January 1998 to September 2001.

Table 46. Number of times and percentage of time North Webster Sewage Treatment Plant was in violation of its permit for chemical discharge from January 1998-September 2001.

Parameter	Number of Times Violation Occurred	% of Time Plant was in Violation
DO	0	--
pH	1	2.2%
TSS	0	--
NH_3	11	24.4%
E. coli	0	--
C-BOD	1	2.2%

Source: U.S. Environmental Protection Agency Envirofacts Warehouse database, 2002.

The Yogi Bear's Jellystone Park—Pierceton located at 1916 N. County Road 850 E. currently holds a permit to discharge by-products of municipal waste treatment to Elder Ditch. Treatment effluent must meet certain standards for: DO, pH, TSS, NH_3-N, residual chlorine, flow, and C-BOD. Table 47 contains data similar to that reported for the North Webster Municipal Sewage Treatment Plant in Table 46. Yogi Bear's Jellystone Park violated its discharge limits (5 mg/L) for total suspended solids approximately 20% of the time (monitored during the summer months only). Concentrations of TSS in violation ranged from 25.3-38.6 mg/L.

Table 47. Number of times and percentage of time Yogi Bear's Jellystone Park was in violation of its permit for chemical discharge from April 1999-July 2001.

Parameter	Number of Times Violation Occurred	% of Time Plant was in Violation
DO	0	--
pH	0	--
TSS	9	19.9%
NH_3	0	--
E. coli	0	--
C-BOD	0	--

Source: EPA's Envirofacts Warehouse database, 2002.

The Etna-Troy School located at 4905 N. 550 W. also holds a permit to discharge treated water. Although the facility has a permit to discharge, no discharge data could be located. The school could choose to discharge in the future; therefore continued monitoring of the Envirofacts Warehouse database should occur.

Residential Areas

Activities on residential properties in the watershed play a role in contributing nutrients, sediment, pesticides, and pathogens to streams within the watershed. Residential property owners typically fertilize their lawns. Fertilizer not absorbed by plants dissolves in rainwater and may eventually reach the Tippecanoe River, adding nutrients, particularly nitrate, to the stream. In addition, research suggests that approximately half of all urban residents apply pesticides to their lawns (Schueler, 2000). Thus, pesticide use is likely in the Upper Tippecanoe River Watershed too. Animal waste left on lawns may contribute pathogens to streams, and ultimately, to the Tippecanoe River. Lastly, construction of new residential areas in the watershed without appropriate erosion control can release sediments and attached nutrients into waterways.

Commercial Areas and Roads

Commercial areas and roads typically export a greater quantity of pollutants to receiving waterbodies than residential areas. Several state roads pass through the Upper Tippecanoe Watershed offering examples of areas where impervious surfaces predominate. Impervious surfaces (parking lots, rooftops, etc.) cover many areas along State Roads 5, 13, and 9. The large percentage of impervious surface associated with these land use types and their connectivity to storm drains create ideal conditions for the export of pollutants. Without any infiltration capacity, stormwater transports pollutants to the Tippecanoe River following even very small storm events. Commercial facilities and roads contribute all of the pollutants listed in the **Potential Pollutants** section. These pollutants originate from atmospheric deposition, vehicular exhaust and fluid leakage, or other means.

Failing Septic Systems and Straight Pipe Discharges

Local county health departments and other stakeholders have identified failing or poorly sited septic systems and straight pipe discharges from septic tanks as significant sources of water pollution in the Upper Tippecanoe River Watershed. Straight pipe discharges from septic tanks and septic tanks connected to drainage tiles are illegal (327 IAC 5-1-1.5); however these practices still exist in the watershed.

Construction Activities

Construction activities that involve excavation, grading or filling can release a significant amount of sediment from a site if not properly controlled. Sediment release from developing urban areas can be a major source of pollution due to the cumulative number of acres disturbed in the watershed. Construction of single family homes in rural areas can also be a source of sediment release to waterbodies when homes are placed in or near stream corridors. As a pollution source, construction activities are typically temporary, but the impacts on water quality can be severe and long lasting.

Streambank Erosion

The cutting and erosion of streambanks within the Upper Tippecanoe River Watershed is a major concern. This cutting and erosion increases the sediment load in waterbodies and directly impacts the scenic and recreational values of these waterbodies. Streambank cutting and erosion is often a function of many factors that include: stream energy and velocity, flooding and land management. Increased drainage of headwater areas increases stream energies during rainfall events and often leads to increased streambed and bank erosion downstream. Land clearing and urban development using stormwater discharge pipes also increases the volume and velocity of runoff.

Agricultural Areas

Approximately 65% of the Upper Tippecanoe River Watershed is utilized for agricultural row crop production. This land use, particularly on highly erodible soils and in other environmentally sensitive areas, can impact the water quality downstream. Runoff from farm fields can contain a variety of pollutants including nutrients (nitrogen and phosphorus), pesticides, sediment, and bacteria (*E. coli*). In addition, the original creation of agricultural land involved draining low wet areas with tiles and ditches. This decreased the storage capacity of the land and increased peak flows in streams and channels in the watersheds. An increase in both the volume and velocity of peak flows typically leads to increases in bank erosion and ultimately increases in sediment and sediment-associated pollutant loading to the receiving waterbody.

According to the National Research Council (1993), non-point source pollution by contaminants in agricultural runoff is a major cause of poor surface water quality in the United States.

Storm Drains

Runoff from storm water frequently contains pollutants such as phosphorus, nitrogen, oil, and sediment that can cause impairment to lakes and streams. Regulated city drains and other residential run-off collection systems carry organic and inorganic debris into the lakes and streams during storm events. Storm drains are a direct conduit for polluted stormwater to enter the aquatic environment. Given this, management of pollutants associated with storm water and storm drains must be considered as both point source and non-point source pollution.

F.1 North Webster Storm Drains

A recent storm drain study (New, 2002) examined the feasibility of retrofitting town-regulated storm drains with pollutant filtration devices. To be deemed feasible, the technology needed to be: 1) installable; 2) acceptable to and permitted by the North Webster Town Council and their utilities contractor, STS; 3) economically justifiable; and 4) maintainable. The project area includes land drained by town-regulated storm drains to the east of State Road 13 in North Webster. The estimated watershed area contributing to the storm drains is about 200 acres (80 ha or 0.32 miles).

The area of the watershed draining directly to the Lake Webster on its west side is currently high intensity residential and commercial development. State Road 13, a busy, state-maintained highway, passes through North Webster's downtown and receives heavy sand and gravel applications during the winter. The Town of North Webster is responsible for maintenance of the other roadways within incorporated town limits. Litter from these commercial and transportation areas also finds its way into storm drains. Residential runoff also carries yard waste, fertilizers, and other debris to the lake via the drains. Town maps were modified and updated to include 18 drainage networks (Figure 56). (Please note that the most westward street marked on the figure as Center Street is actually Albert Eckert Drive. The other street marked as Center Street is Center Street West. Finally, the street marked as Albert Eckert Drive is actually Center Street East.) A variety of drainage infrastructure exists as part of the networks (Figure 54 and 55).

Figure 54. Sample Storm Drain Infrastructure

Figure 55. Sample Storm Drain Infrastructure

Field surveys of the storm drains indicated that the current drain structure and/or maintenance schedule was not sufficient to protect Webster Lake water quality. Alternatives considered for remedying the existing situation included: 1) adopt a rigorous maintenance plan to ensure that the existing infrastructure performs as intended; 2) install two or three expensive “swirl collector style” Continuous Deflective Separation systems or other similar manufactured product for storm water inlets at the bottom of the highest priority drainage networks; 3) tear out the existing infrastructure at the base of the highest priority drainage networks and install sand filters, water quality inlets (also commonly called oil/grit or oil/water separators), or similar underground chamber device; 4) retrofit existing storm drain inlets with disposable, replaceable, inexpensive catch basin inserts like the Stream Guard sediment insert. Due to financial and other resource constraints, it was decided that the most feasible option is a combination of items one and four above (New, 2002). Regardless of the selected option reducing inputs from storm water runoff is an important management goal for lake associations as they seek to improve water quality.

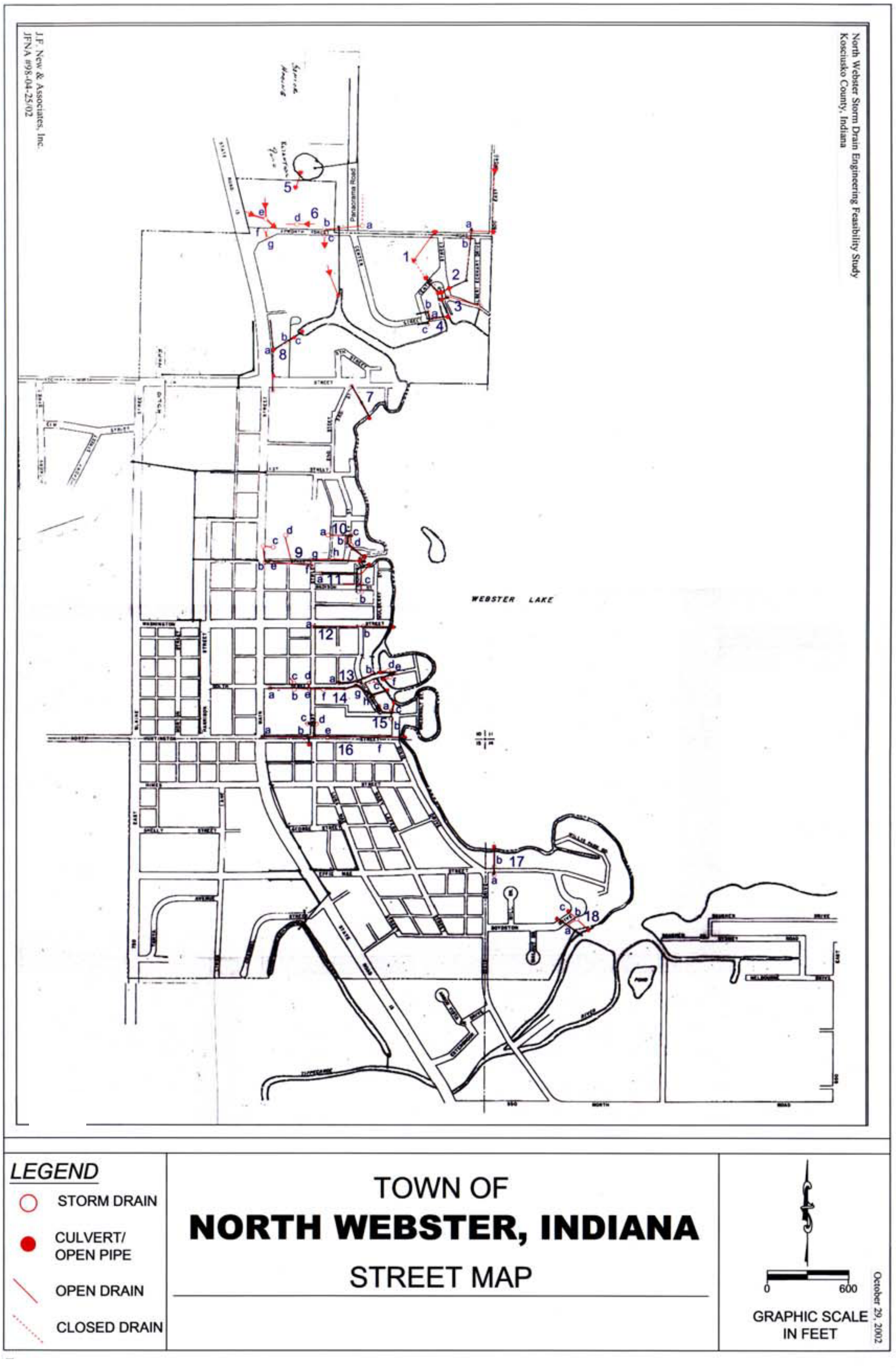

Figure 56. North Webster Drainage Networks

F.2 <u>Lake Tippecanoe Storm Drains</u>

As part of a recent storm drain study conducted by Commonwealth Biomonitoring, 2005, storm drains were located around Lake Tippecanoe by driving around each subdivision on the lake, looking for inlets on streets. After the inlets were located and mapped, fluorescent dye was placed in each inlet and water samples were collected at pipes draining into the lake. The dye was detected by a hand-held field fluorometer. Once located, the storm drain inlets and outlets were mapped on a geographic information system (GIS) database.

After the mapping was completed, the project included an analysis of potential effects of pollutants from storm drains. Computer modeling showed that runoff from approximately 10 hectares of impervious road and parking lot surfaces near Lake Tippecanoe account for approximately 10 kg of phosphorus, 50 kg of nitrogen, and 10000 kg of sediment each year. Eliminating this amount of loading will reduce total nutrient concentrations in the lake by about 2%.

There were 39 storm water inlet pipes like the ones shown in Figure 57 identified in the study. Locations of the inlet pipes are shown in Figure 59. About 65% of all storm water pipes were attached to a street drain inlet. One pipe no longer carries storm water flow. Instead of street runoff, several pipes carry roof drain water or other types of storm-related runoff. Pipe number 33 carries the overflow from Stanton Lake, which includes street runoff

.

Figure 57. Sample Storm Water Inlet on Lake Tippecanoe

During the survey, 40 street drains like the one shown in Figure 58 were identified and mapped. Generalized locations of all street drains are shown in Figure 60. About 90% of all street drains flowed directly into Tippecanoe Lake through an attached outlet pipe. A few drains were not attached to a pipe but instead flowed to a vegetated area before discharging to a lake. The Kosciusko County Highway Department has maintenance responsibilities for 75% of the street drain inlets. The remainder are private or are the responsibility of a local property owner's association.

Figure 58. Typical Street Drain to Lake Tippecanoe

In addition to mapping and modeling, the project also included a plan to reduce pollutant loading from storm drains. Plans developed as part of this project include installation of catch basin inserts, construction of vegetative swales, construction of wetlands, and construction of bioretention filters or "rain gardens." Several local property owners expressed interest in pursuing construction options and preliminary drawings for these potential projects.

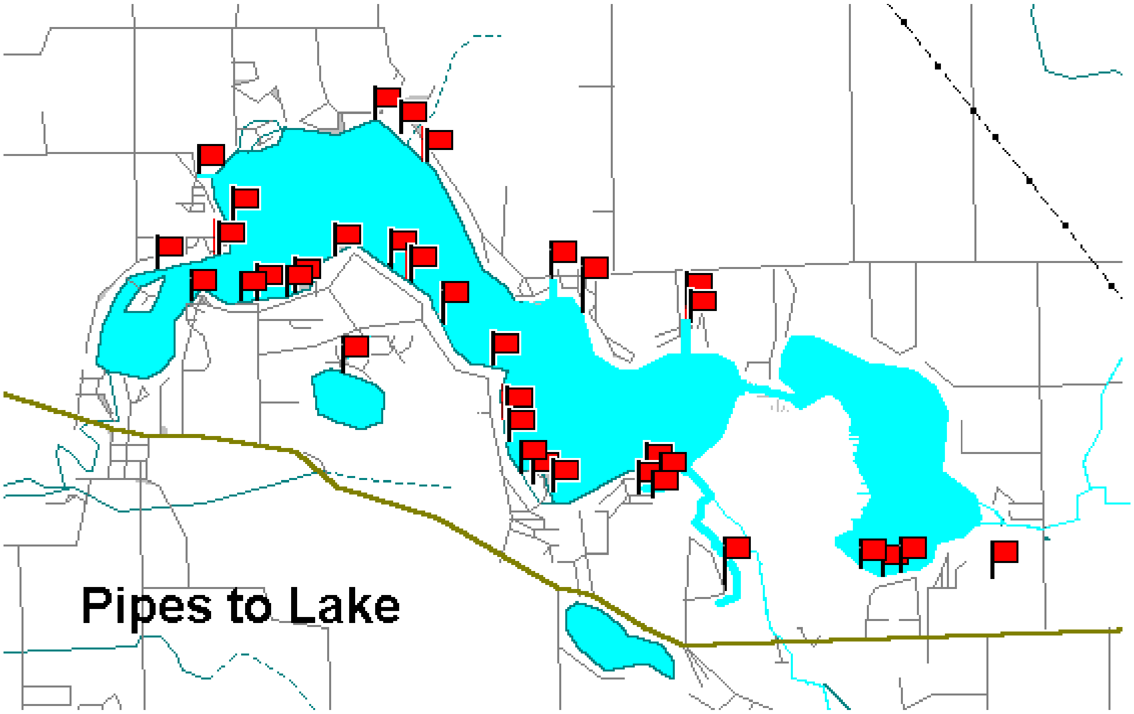

Figure 59. Storm Inlet Pipes to Lake Tippecanoe

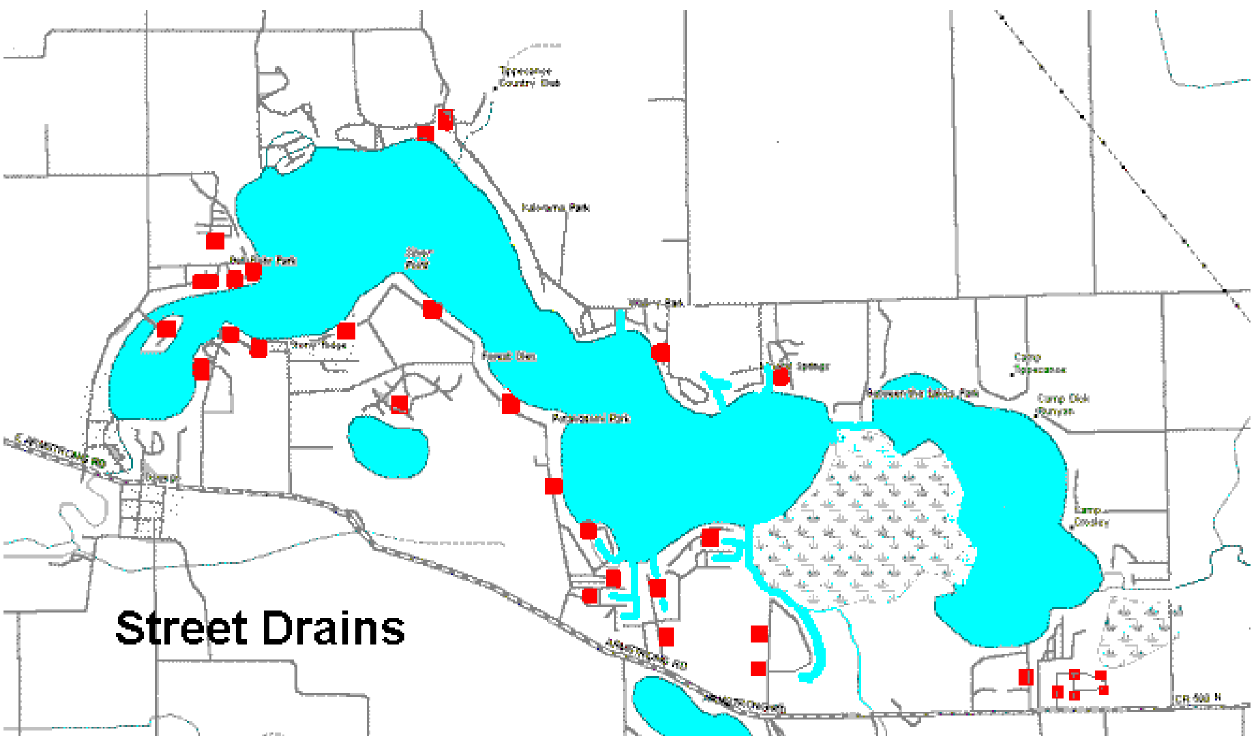

Figure 60. Street Drains with Inlets to Lake Tippecanoe

G. Priority Areas

Many areas throughout the Upper Tippecanoe River Watershed have been identified in previous studies as priority areas. During the development of this plan, additional priority areas were identified and incorporated into the following lists. Many of locations identified in the subwatersheds could benefit from the installation of sanitary sewers, the development of plant and nutrient management plans, and the use of agricultural and homeowners Best Management Practices (Appendix E). Figures 61-70 map the locations of more specific priority areas by subwatershed.

Smalley Subwatershed

- Install buffer strips along the Tippecanoe River from Big Lake west to Smalley Lake (New, 2000).
- Fence cattle from the stream near County Road 1050 W. and County Road 275 S. and construct watering pond as an alternative water source (New, 2000).
- Restore riparian zones along the Tippecanoe River and its tributaries where possible; minimally, install filter strips along the Tippecanoe River and its tributaries. Target areas shown on Figure 61 (New, 2004).
- Restore as many wetlands as possible in the Smalley Lake watershed, focusing first on the Tippecanoe River subwatershed and targeting those areas shown in Figure 61. Watershed stakeholders should try to restore wetland acreage so that the percentage of the Smalley Lake watershed covered by wetlands equals or exceeds the percentage of land in the greater Upper Tippecanoe River basin that is covered by wetlands (New, 2004).
- Install fencing to protect Smalley Lake's northern inlet from grazing cattle. Install an alternative water source if necessary. Restore the riparian zone where grazing cattle have damaged the stream habitat. Consider directing drainage from an adjacent grazed field through a constructed wetland to reduce nitrate inputs to the northern inlet (New, 2004).
- Increase the usage of no-till conservation tillage on corn fields in the Smalley Lake watershed (New, 2004).
- Utilize the Conservation Reserve Program to implement grassed waterways and remove land mapped in highly erodible soils from agricultural production. Target areas shown in Figure 61 first (New, 2004).
- Monitor and improve erosion control techniques on residential and commercial development sites. Bring areas of concern to appropriate authorities. Management efforts should focus on Big Lake and Smalley Lake where the active construction sites exist and lack of erosion control techniques were observed (New, 2004).
- Plant vegetative filter areas around unprotected risers shown in Figure 61 (New, 2004).

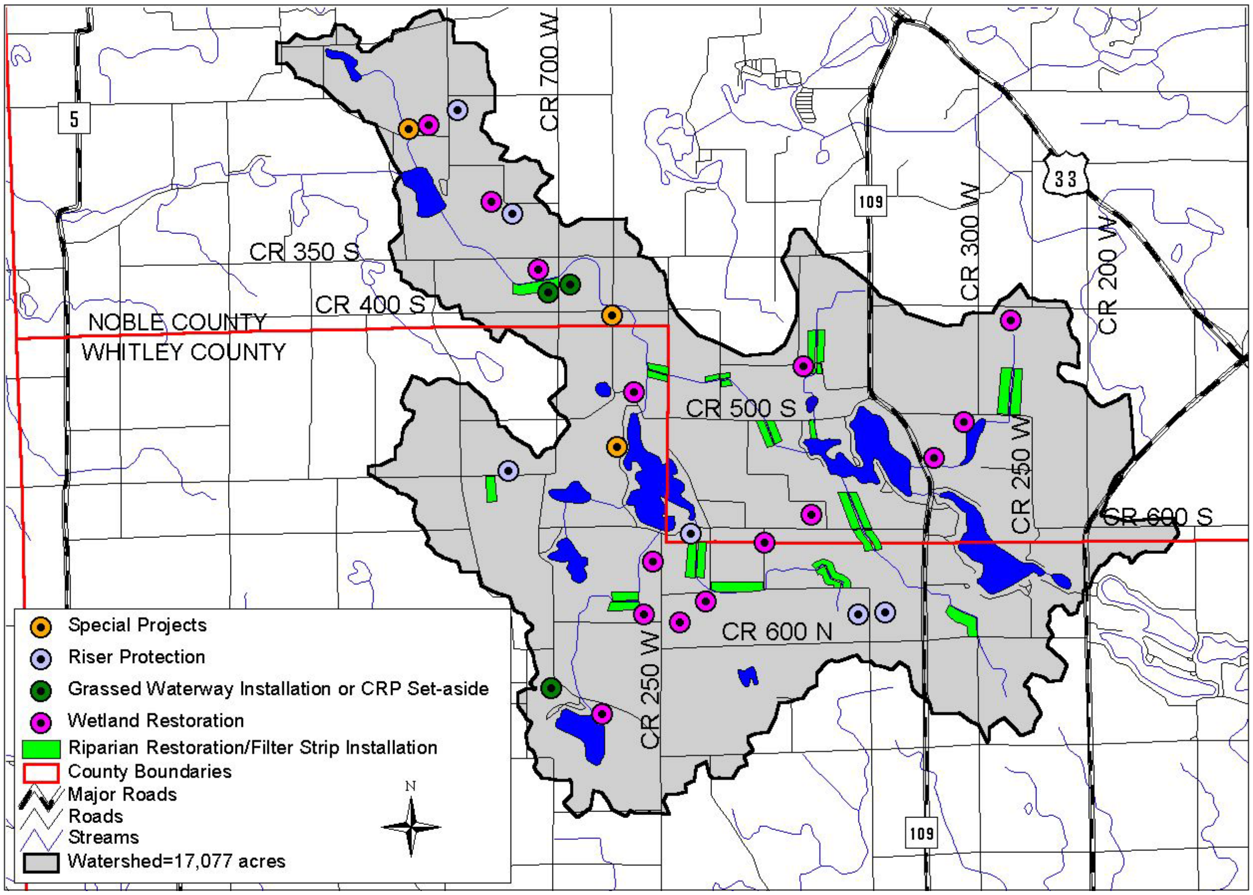

Figure 61. Priority areas in the Smalley Subwatershed.

Ridinger/Robinson Subwatershed

- Create wetland habitat, install buffer strips/grassed waterways to reduce flow and retire agricultural land upstream of Rine Lake (New, 2000).
- Selectively dredge the sandbars near mouths of both major inlets at Ridinger Lake (International Science and Technology (IST), 1990).
- Install filter strips along Mathias Ditch (St. Clair, personal communication).
- Develop materials to distribute on "Lake Basics" to be given to tenants upon their arrival at Jellystone Park regarding trash, fertilizers, chemicals, automobile traffic, grass and leaves, boating, etc. (IST, 1990).
- Wetland restoration on Elder Ditch, north of Old 30 and East of 900 E. (USACE, 1995)
- Identify sources of high cadmium levels in Ridinger tributaries (IST, 1990)
- Restoration of the Elder Ditch corridor where ditch cleaning has been particularly damaging such as the area upstream and downstream of Elder Road. Restoration in this area includes stream bank stabilization through the use of bioengineering techniques and revegetation of the riparian corridor, preferably with woody vegetation (New, 2004).
- Restricting access of livestock to Robinson Lake. An alternate source of water should be created for the livestock, and the lake shoreline where the livestock have grazed should be restored. Ideally, a constructed wetland or other treatment of drainage from the livestock's pasture should be installed to limit nutrient input to Robinson Lake from runoff (New, 2004).
- Stabilization of the eroding ravine leading to the southeast corner of Ridinger Lake. Work at this site will include working with the property owner of the adjacent land to utilize grassed waterways or set aside a portion of the land in CRP (New, 2004).
- Restoration of Troy Cedar Lake's northern inlet's corridor where ditch cleaning has damaged the riparian zone. Restoration may include stream bank stabilization through the use of bioengineering techniques and revegetation of the riparian corridor, preferably with woody vegetation (New, 2004).
- Restricting access of livestock to Shanton Ditch's headwaters tributaries. An alternate source of water should be created for the livestock, and the stream bank where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks using bioengineering techniques. If possible, drainage from the land where the livestock are pastured should be directed to flow through a constructed wetland to reduce pollutant loading particularly, nitrate-nitrogen loading, to the adjacent stream (New, 2004).
- Restrict livestock access to the Troy Cedar Branch of Elder Ditch on the east and west sides of CR 550W. An alternate source of water should be created for the livestock, and the stream bank where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks using bioengineering techniques. If possible, drainage from the land where the livestock are pastured should be directed to flow through a constructed wetland to reduce pollutant loading particularly, nitrate-nitrogen loading, to the Troy Cedar Branch of Elder Ditch (New, 2004).
- Restore riparian zones along the streams in the Ridinger Lake watershed where possible; minimally, install filter strips along these streams. Stream corridors in the Shanton Ditch and Elder Ditch subwatersheds should receive high priority (New, 2004).
- Restore as many wetlands as possible in the Ridinger Lake watershed, targeting those areas shown in Figure 62. Watershed stakeholder should try to restore wetland acreage so that the percentage of the Ridinger Lake watershed covered by wetlands equals or exceeds the percentage of land in the greater Upper Tippecanoe River basin that is covered by wetlands (New, 2004).

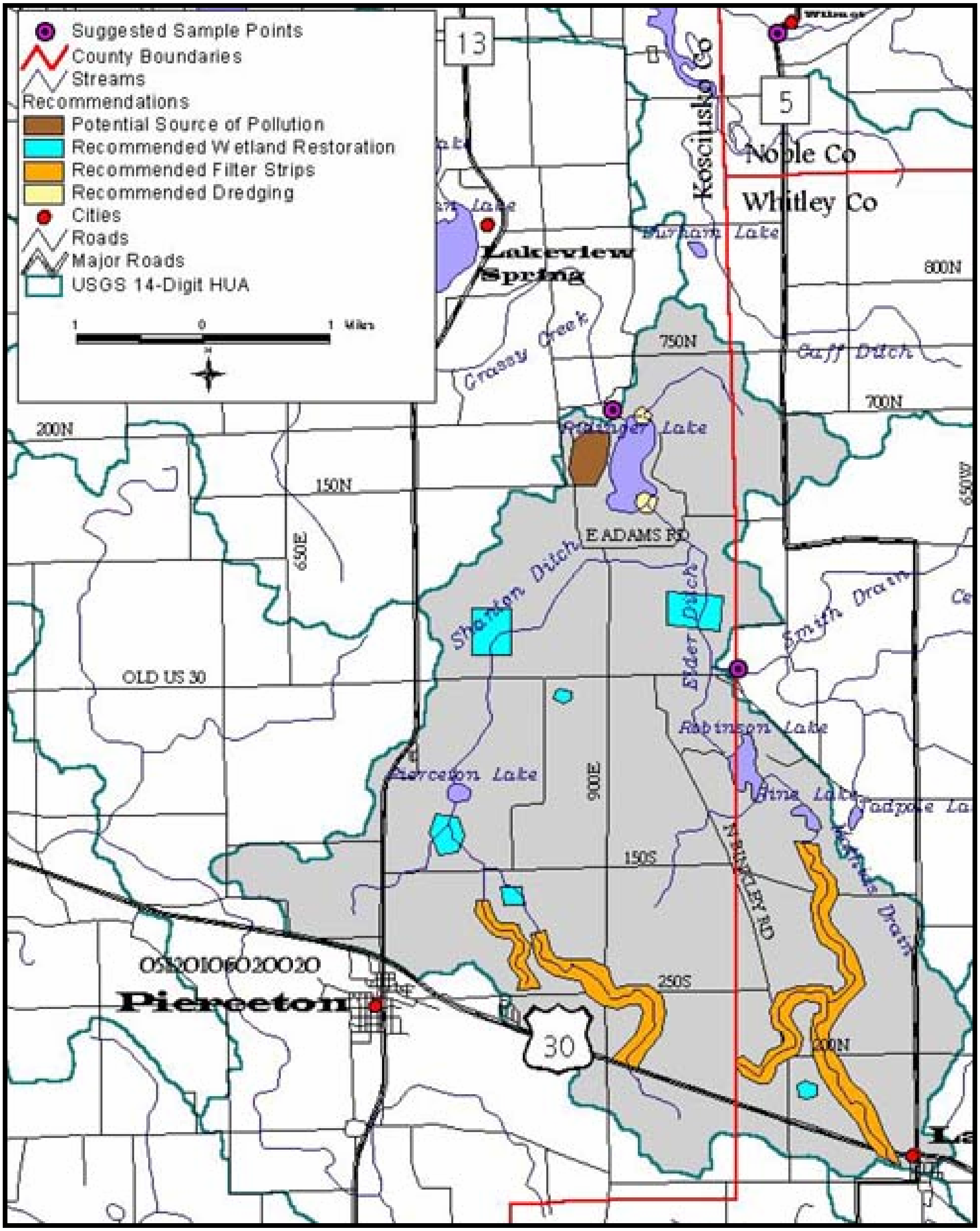

Figure 62. Priority areas in the Ridinger/Robinson Subwatershed.

Loon/Goose Subwatershed

- Work with livestock owners to develop waste storage structures throughout the Loon Lake Watershed (Browne, 1992).
- Conduct a current, more detailed diagnostic study of this subwatershed to develop site specific recommendations (Williams Creek, 2005).

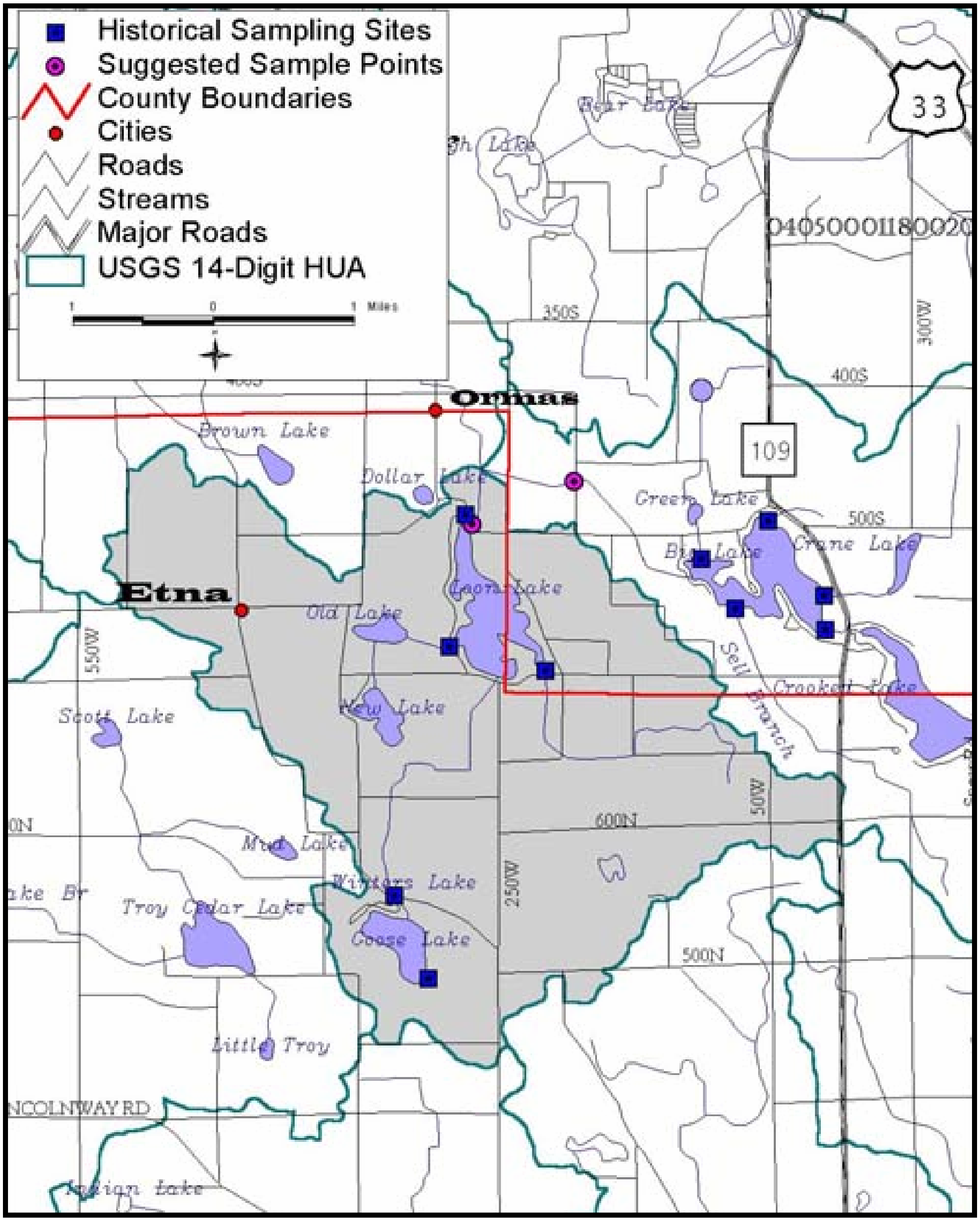

Figure 63. Priority areas in the Loon/Goose Subwatershed.

Elder Ditch Subwatershed

- Restore 120-acre wetland north of County Road 700 N. and east of County Road 550 W.
- Restore 40-60 acres of wetland south of County Road 750 N. and east of County Road 550 W.
- Install filter strips on the western tributary to Scott Lake.
- Install filter strips, fence cattle from the stream and stabilize the stream bank of the Cedar Lake Branch of Elder Ditch east of County Road 650 W to Troy Cedar Lake.
- Install filter strips west of County Road 650 W. on the Cedar Lake Branch of Elder Ditch.
- Enroll property south of Smith Drain along the west side of State Road 5 in CRP or WRP.
- Restore the wetland north of County Road 300 N. and east of County Road 650 W.

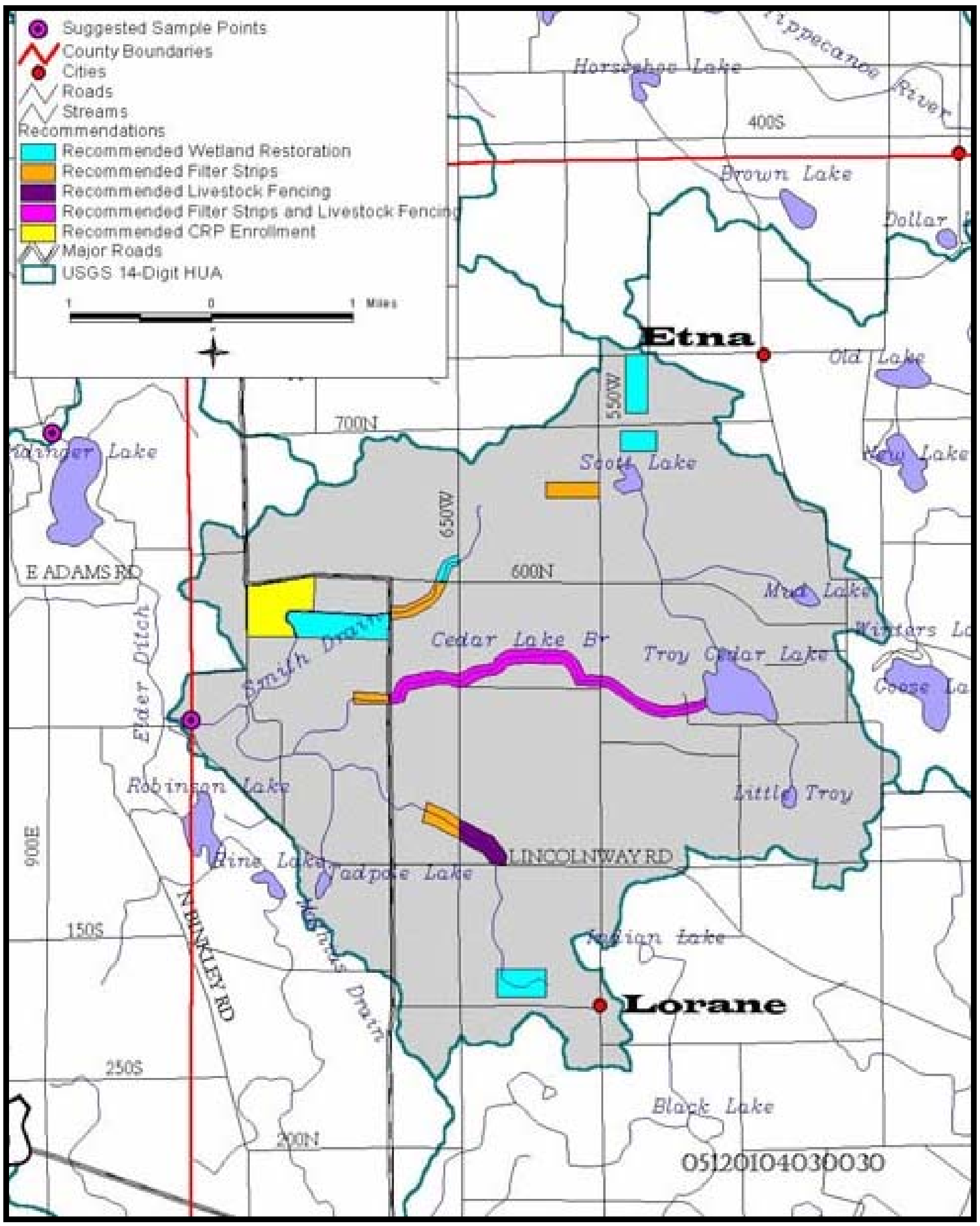

Figure 64. Priority areas in the Elder Ditch Subwatershed.

Webster/Backwaters Subwatershed

- Install buffer strips along Gaff Ditch from County Road 750 W. to its headwaters (New, 2000).
- Restore two wetland filters at the headwater of Gaff Ditch; County Road 750 N. and County Road 650 W. (New, 2000).
- Restore wetland or tributary to Gaff Ditch between County Road 700 N. and County Road 750 N.
- Stabilize stormwater outlet and channel banks south of East Street on the northwest corner of Webster Lake.
- Install grassed waterways on agricultural land southeast of County Road 650 W. and County Road 750 N. (Cormany Farms).
- Install filter strips and grassed waterways on the unnamed tributary to Gaff Ditch east of County Road 750 W. at County Road 400 S.
- Install pollutant removal devices on the 18 stormwater drain complexes located in the city of North Webster and develop a maintenance plan for each of these filters (New, 2000 and 2002). See detailed recommendations in below Table and Figure.
- Stabilize banks adjacent to bridge abutments over Gaff Ditch at County Road 750 W. off of 750 N. (New, 2000).
- Complete the installation of sanitary sewers (New, 2000).
- Selectively dredge the inlets to Webster Lake (New, 2000) – work in progress, 2006.
- Work with the County on long range plan for County Road 750 N. (New, 2000).
- Continue to work with the Town Council to ensure that a storm drain inspection and maintenance plan is implemented (New, 2002).
- Work with the Town Council to determine if drain retrofitting is desirable given available resources. Depending on available resources, other funding sources or grants should be secured to retrofit at least the high priority drain networks (New, 2002).
- Have a representative present at monthly town council meetings to ensure better long-term communication regarding the storm drain project and other lake conservation projects (New, 2002).
- Initiate an information and education program to inform town and lake residents about practices they can utilize to control sources of pollutants and debris before they are introduced into the storm drain system (New, 2002).

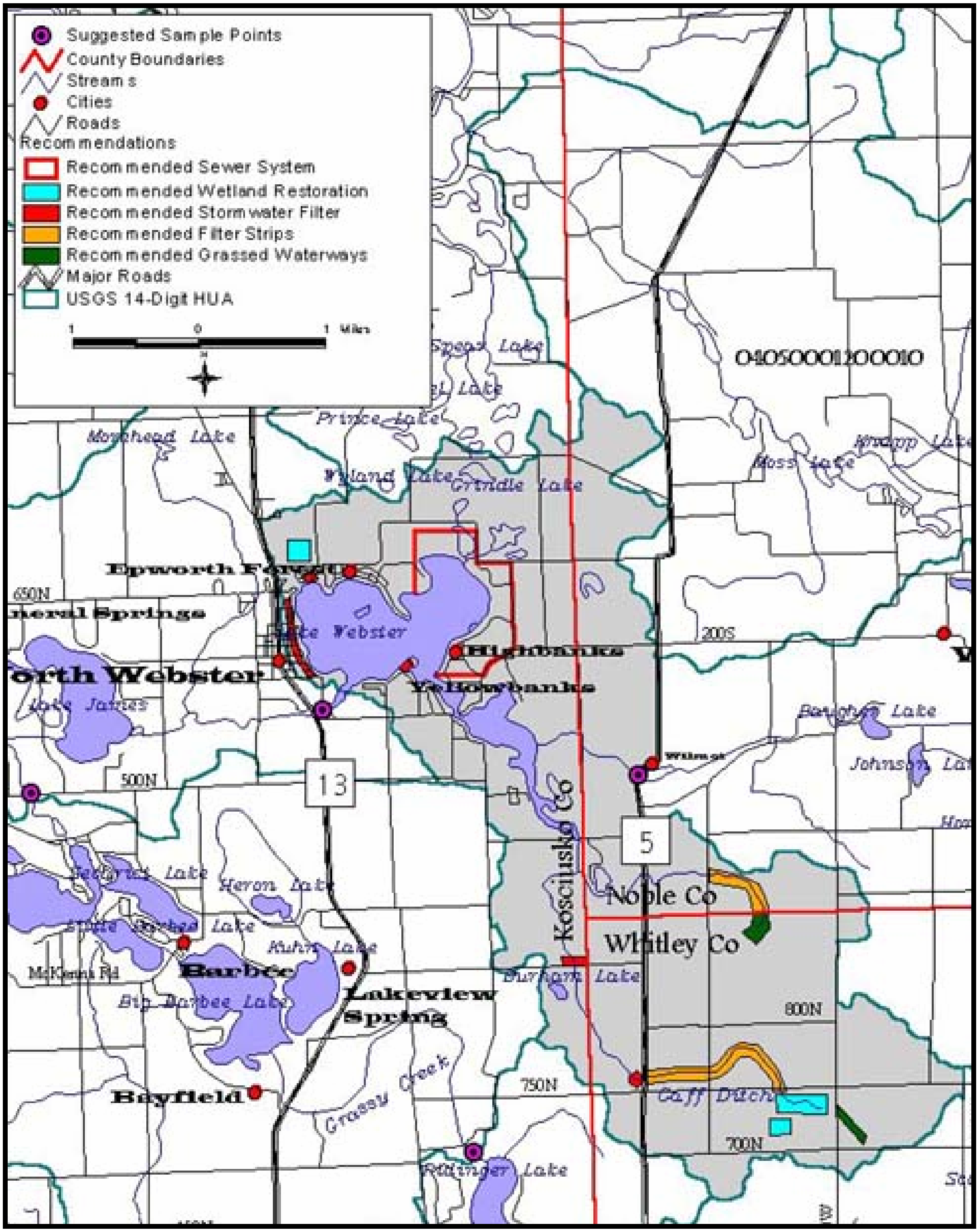

Figure 65. Priority areas in the Webster/Backwaters Subwatershed.

Storm Drain Projects in North Webster

Prioritization of the 18 storm drain networks around North Webster was based on watershed observation, consideration of storm water volumes conducted by each network, input from lake residents, runoff event observation, and estimation of pollutant loading severity (New, 2002). Table 48 and Figure 66 summarize the prioritization. (The same disclaimer mentioned earlier regarding Center Street and Albert Eckert Drive also applies to this figure.) It is important to note that BMPs relevant for treatment of drain network #1 do not involve retrofitting technologies. Additionally at this time, no actions are recommended for drain network #5 other than regular sediment basin maintenance which is the responsibility of the property owner at the site. Since retrofitting technologies do not apply to these drains, they are not included in the prioritization.

Table 48. Storm drain network prioritization

Drain	Priority	Drain Network Description	Recommended Project
#4	High	3-basin complex draining southern bend of Albert Eckert Drive	Maintain and retrofit catch basins a, b, and c; it was noted that water bypasses catch basin c almost completely and travels over the road to the lake
#6	High	7-basin complex draining Panorama and Epworth Forest Roads	Maintain and retrofit catch basins a-g
#9	High	8-basin complex draining North Street from SR 13	Maintain and retrofit catch basins a-h
#12	High	2-basin complex draining the Washington Street area	Maintain and retrofit catch basins a and b
#14	High	8-basin complex draining South and Mulberry Streets	Maintain and retrofit catch basins a-h
#15	High	3-basin complex draining Mulberry St.	Maintain and retrofit catch basins a, b, and c
#2	Medium	2-basin and open ditch complex draining Hoss Hill and Epworth Forest Roads	Maintain and retrofit catch basins a and b
#3	Medium	Basin draining an area of Center Street East and West	Maintain and retrofit inlet catch basin
#7	Medium	Basin draining 3rd and 4th Streets	Maintain and retrofit inlet catch basin
#8	Medium	Series of basins, culverts, and open swales draining SR 13 and a graveled trailer park area	Maintain and retrofit catch basin b
#10	Medium	4-basin complex draining Stanley St	Maintain and retrofit catch basins a-d
#11	Medium	4-basin complex draining Short Street	Maintain and retrofit catch basins b and c
#13	Medium	6-basin complex draining an island and portion of South Street	Maintain and retrofit catch basins a-f
#16	Medium	6-basin complex draining a portion of Mulberry Street	Maintain and retrofit catch basins a-f
#17	Low	2-basin complex draining Effie May St	Maintain and retrofit catch basins a and b
#18	Low	3-basin complex draining Boydston Drive	Maintain and retrofit catch basins a and b

Figure 66. Storm drain network prioritization

Barbee Lakes Subwatershed

- Install filter strips; fence pastures adjacent to Grassy Creek on Elder Ditch between Ridinger Lake and Putney ditch (New, 2000).
- Install grass/forested buffer at the southwest corner of County Road 650 E. and County Road 200 N. (New, 2000).
- Install buffer strips east of County Road 650 E. (New, 2000).
- Create wetland south of McKenna Road (New, 2000).
- Filter stormwater from drains east of State Road 13 and west of Big Barbee southern channel to remove road runoff and petroleum products (New, 2000).
- Install stormwater drains/catch basins on drains near Sechrist and Kuhn Lakes (New, 2000).
- Selectively dredge sediment in Little Barbee Lake and its channels (Hippensteel, 1988) – work in progress, 2006.
- Reduce phosphorus loading from Ridinger Lake (Hippensteel, 1988).
- Install comprehensive sanitary sewer system (New, 2000).

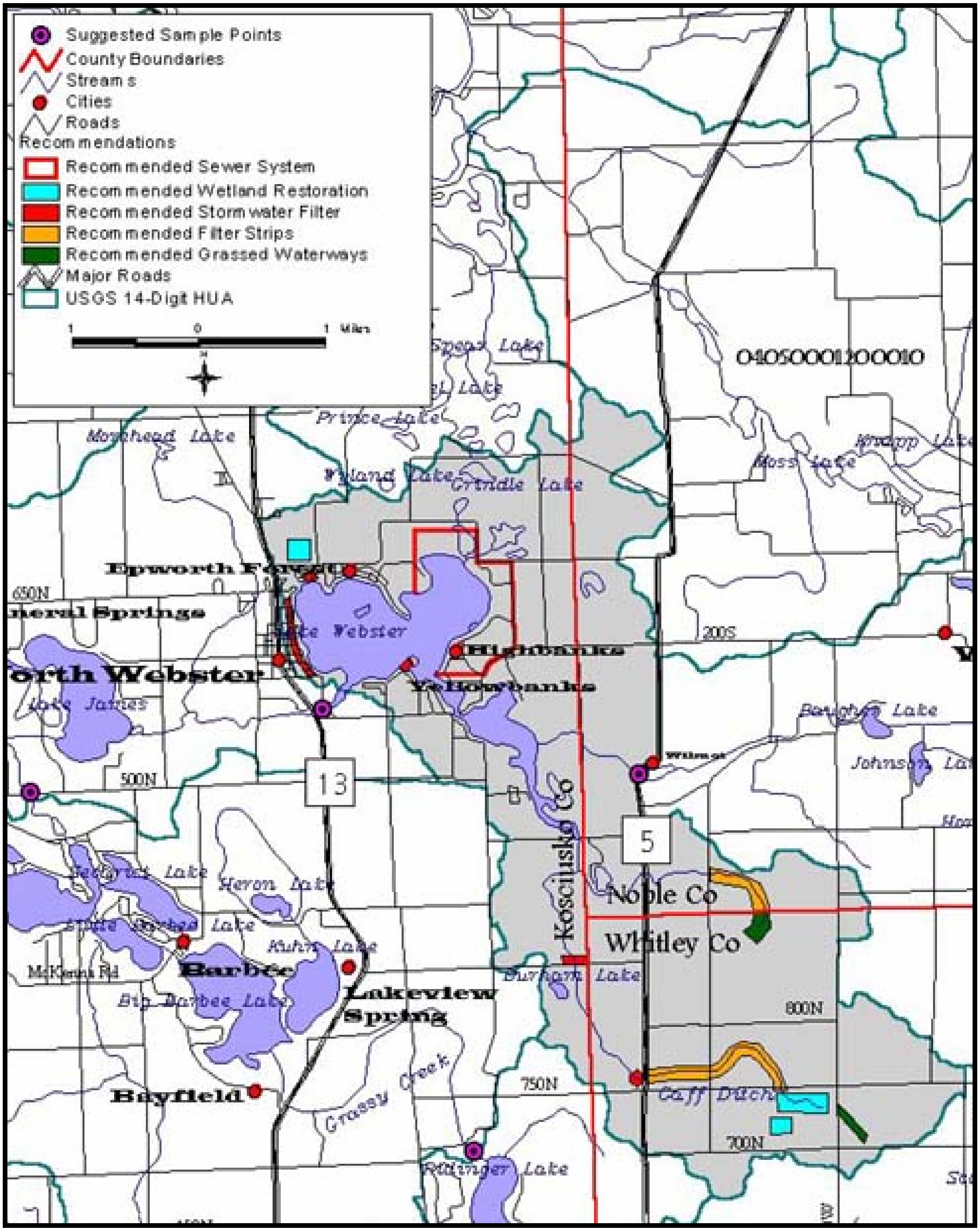

Figure 67. Priority areas in the Barbee Lakes Subwatershed.

Tippecanoe Subwatershed

- Install comprehensive sanitary sewer system (New, 1997).
- Address *E. coli*, phosphorus and nitrogen inputs from the northwest corner of County Road 500 E and County Road 650 N (New, 1997)
- Consider how to fund an implement a catch basin insert program for the 35 street storm drains around the lake (Bright, 2005).
- Encourage or cost share with local residents to incorporate rain gardens into their landscapes (Bright, 2005).
- Generate local consensus, design, and build two community rain gardens to treat storm water runoff in Bell Rohr Park and Russell Park neighborhoods. The land is already owned by the associations, so no additional land acquisition is needed (Bright, 2005).
- Seek design and implementation funding for other storm water BMPs as outline in Table 49 below (Bright, 2005).

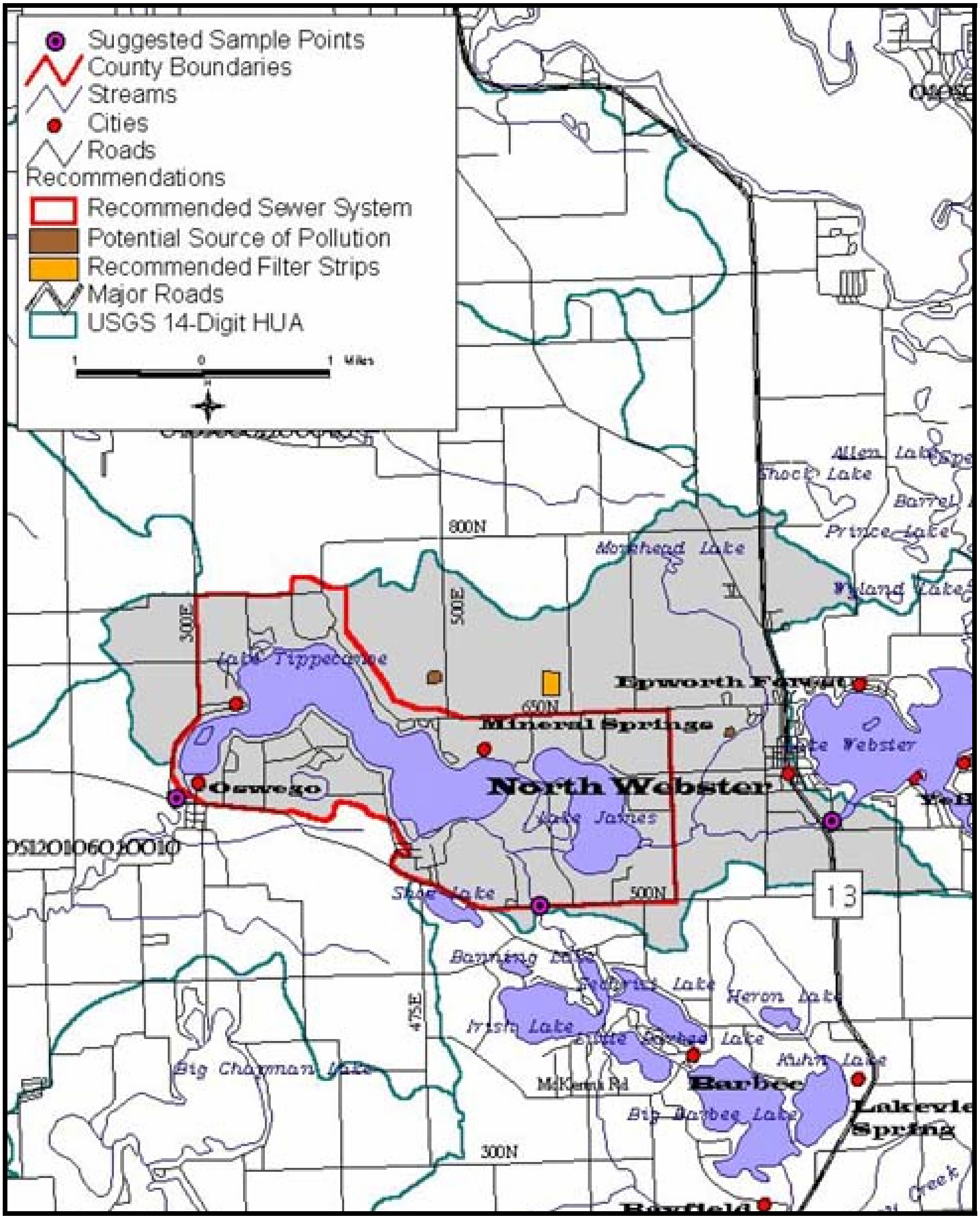

Figure 68. Priority areas in the Tippecanoe Subwatershed.

Lake Tippecanoe Storm Drain Projects

Storm drain inlets on Tippecanoe Lake are widely scattered over an area of almost 8 square miles. Therefore, a centralized treatment system to treat all storm water in the watershed would be impractical. Instead, the best solution for improving runoff quality to the lake is to use small, localized treatment systems. During the past 20 years there has been an increasing emphasis on finding ways to improve water quality in storm water runoff. Many “best management practices” (BMPs) have been proposed and tested for both urban and agricultural runoff. Some of those found to be most effective for storm water runoff from streets and parking lots, as well as suited to implementation at Lake Tippecanoe include those outlines in Table 49.

Table 49. Potential Storm Water BMP Implementation Projects

Proposed BMP	Removal Efficiency for TSS	Site Shown in Figure 69
Rain garden	65%	5, 6
Catch basin insert	75-90%	N/A
Sediment basin	70%	1
Infiltration trench	95%	2.4
Wetland enhancement	80%	3

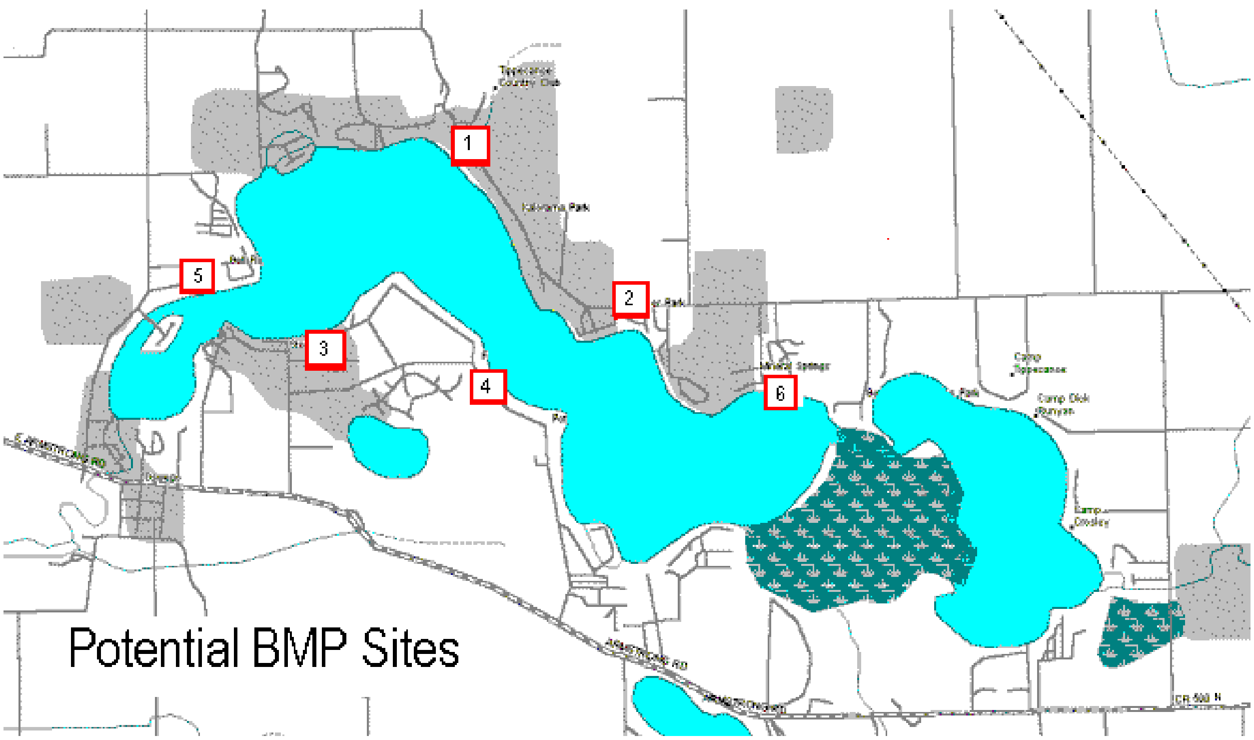

Figure 69 Potential Storm Water BMP Implementation Project Sites

Crooked/Big Subwatershed

- Conduct a current, more detailed diagnostic study of this subwatershed to develop site specific recommendations.
- Incorporate measures to slow the water and sediment loss above the ravine (Tall Trees Memorial Grove) outside of the Nature Preserve (Crisman, 1993).
- Enlist the agricultural field on south side of golf course in the conservation tillage program (Crisman, 1993).
- Enlist the agricultural field located south of lake near Spear Road in the conservation tillage program (Crisman, 1993).
- Create sediment retention structure at the outlet of Stuckman Drain, install filter strips, and stabilize the banks (IDNR, 1995).
- Install a sediment trap on Sell Branch immediately upstream of County Road 600 N. along Airport Road (IDNR, 1995).
- Install a sediment trap 600 feet upstream of State Road 109 in Sell Subwatershed (IDNR, 1995).
- Install a sediment trap immediately upstream of County Line Road in Sell Subwatershed (IDNR, 1995).
- Install filter strips within the Sell branch Subwatershed (IDNR, 1995).
- Install filter strips on cropland east of County Road 250 W. in Crane Subwatershed (IDNR, 1995).
- Reforest land along the southern bank of Crane Ditch (IDNR, 1995)
- Install a sediment trap upstream of County Road 500 S. in Crane Subwatershed (IDNR, 1995).
- Expand idle lands to the southeast of Green Lake and south of County Road 500 S. (IDNR, 1995).
- Protect and reforest land east of Haroff Lake in Green Lake Subwatershed (IDNR, 1995).
- Install filter strips on the north side of County Road 500 S. in the Green Lake subwatershed (IDNR, 1995).
- Continue in-lake water quality testing for phosphorus, nitrate, and turbidity and consider limited tributary samplings (IDNR, 1995).

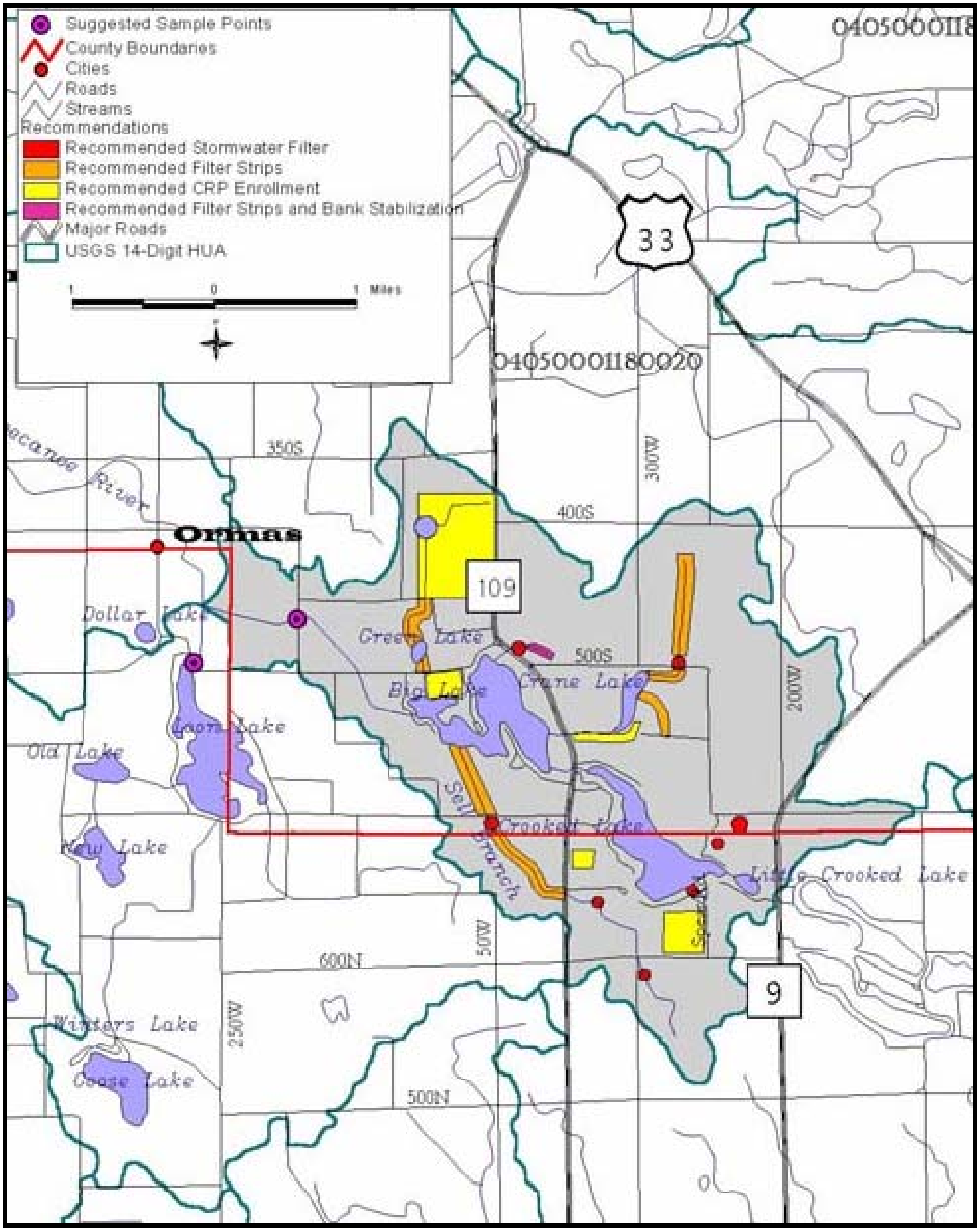

Figure 70. Priority areas in the Crooked/Big Subwatershed.

6.0 GOALS AND OBJECTIVES

A. Water Quality Goals, Strategies, Actions, Identified Alternatives, and Impacts

Purpose of the Plan: To coordinate the actions and efforts of the majority of stakeholders that will lead to permanent improvement to water quality in the Upper Tippecanoe River Basin.

Goals:

1) Reduce total phosphorus, nitrogen and *E. coli* loads in the water column of Tippecanoe River and Grassy Creek by 20% by 2010.
2) Document existing mIBI and IBI in each subwatershed in order to set reasonable targets to improve invertebrate and fish biological integrity.
3) Implement plan for testing phosphorus and nitrogen in soils adjacent to tributaries and streams.
4) Decrease the abundance and spread of exotic aquatic species including Eurasian watermilfoil, curly-leaf pondweed, and zebra mussels.
5) Foster communication among all watershed stakeholders.
6) Fund watershed improvement projects via grant funding.
7) Hire a Watershed Coordinator for the Upper Tippecanoe Watershed.
8) Address development issues such as zoning and funneling.

- **GOAL: REDUCE TOTAL PHOSPHORUS, NITROGEN AND *E. COLI* LOADS IN THE WATER COLUMN OF TIPPECANOE RIVER AND GRASSY CREEK BY 20% BY 2010.**

  Potential Alternatives:
  1. Legislate rules.
  2. Educate Stakeholders.
  3. Implement programs and projects

  Selected Strategy: Promote the use of phosphorus free fertilizer/reduced fertilizer use.

  Action Item:

  A. TELWF to educate property owners on fertilizer issues through newsletters and presentations at public meetings.
  B. TELWF to monitor phosphorus free fertilizer sales at local vendors yearly.
  C. TELWF to market to one new vendor each year.

  Selected Strategy: Document river corridor habitat by 2008.

  Action Item:

  A. TELWF to work with IDNR Division of Nature Preserves personnel to document corridor habitat protection areas and potential restoration areas in 2007.
  B. TELWF or SWCD to secure grant and hire consultant for mapping stream corridor habitat characteristics in each subwatershed using the QHEI protocol.
  C. TELWF to develop master list of property owners of potential protection and restoration areas by the end of 2007.

Selected Strategy: Implement 5-year watershed protection plan.

Action Item:

A. Continue identifying areas needing protection
B. TELWF to approach 25% of landowners with identified protection areas (Years 2, 3, 4, and 5).
C. Each year, TELWF and SWCD to implement two restoration/protection projects previously identified (Years 2, 3, 4, and 5).

Selected Strategy: Implement filter strips/grassed waterways on 20,000 feet of waterways each year.

Action Item:

A. TELWF to develop prioritized list of property owners along waterways based on survey (Strategy: Document river corridor habitat by 2007).
B. SWCD to access database for current buffer/filter strip locations and create map of existing buffer/filter strips.
C. SWCD and TELWF to target a total of 10 individuals per year for land treatment and LARE project implementation in identified priority areas.
D. SWCD to review 10% of constructed buffer/filter strips annually.

Selected Strategy: Restore 50 acres of wetlands each year over the next five years.

Action Item:

A. Develop prioritized list and map locations of property owners with drained wetlands.
B. NRCS to access database for current WRP locations and create map of existing WRPs.
C. TELWF to assist NRCS in finding participants for WRP projects for priority areas.
D. TELWF to pursue one wetland restoration project per year for the next five years.

Strategy: Install sanitary sewer system throughout watershed by 2020.

Action Item:

A. Watershed Coordinator to assist existing Conservancy Districts and assist in developing new Conservancy Districts.
B. Watershed Coordinator to begin discussion with town of Leesburg in 2006.
C. Watershed Coordinator to begin discussion with county engineers in 2006.
D. Watershed Coordinator to begin discussion with state senators and representatives in 2006.
E. TELWF to identify potential funding sources for feasibility studies in 2007.
F. TELWF to apply for feasibility grants in 2007.

Selected Strategy: Implement nutrient management plan on a significant acreage of planted agriculture land in all counties.

Action Item:

A. Contact and work with the SWCD offices to develop reasonable strategies and action items.

Selected Strategy: Implement conservation tillage on a significant acreage of planted acreage and 80% of all HEL acreage.

Action Item:

A. Contact and with work the SWCD offices to develop reasonable strategies and action items.

Selected Strategy: Assist 100% of dairy/beef farms with implementing manure management plans.

Action Item:

A. Contact and work with the SWCD offices to develop reasonable strategies and action items.

Selected Strategy: Promote compliance on all submitted Rule 5 plans.

Action Item:

A. Contact and work with the ISDA County Resource Specialist to develop reasonable strategies and action items.

The negative impacts of the recommended alternatives include potential extra equipment purchases for agricultural operations, potential loss of crop land for the preservation of wetlands, buffer strips and grasses waterways, potential lower crop yield from different tillage methods or reduced nutrient application, the potential out-of-pocket expense for sewer installation, additional erosion control expenses, permanent or temporary loss of property, infringement on individuals privacy, potential for reduced abundance of game fish in cleaner waters, disturbances during construction, and increased chemical use on no-till ground. The positive impacts of the recommended alternatives include increased property values near the clean water, greater business opportunities due to increased visitation to the area, increased recreational opportunities especially swimming and wading, increased aesthetic value, more diversity of riparian and aquatic fish and wildlife species and less risk of groundwater contamination.

- **GOAL: DOCUMENT EXISTING BIOLOGICAL INTEGRITY AND WATER QUALITY IN EACH SUBWATERSHED**

Potential Alternatives:

1. Review existing biological surveys.
2. Conduct biological and water quality surveys.

Selected Strategy: Document biotic community**.**

Action Item:

A. Watershed Coordinator to identify one stream reach within each subwatershed for volunteer sampling.
B. Watershed Coordinator to find grant and hire consultant to identify and map all mussel beds in Upper Tippecanoe River Basin with The Nature Conservancy's coordination.
C. Watershed Coordinator to link map to GIS database listing individual sites, species composition and density by 2008.

D. Watershed Coordinator to find grant to hire biologist/consultant or individual volunteer to conduct annual macroinvertebrate survey in each of the eight subwatersheds; calculate mIBI.
E. TELWF to work with IDNR Division of Fish & Wildlife to a develop baseline report for each of the eight subwatersheds and prepare plan for future sampling.
F. Watershed Coordinator to update WMP with biotic community information on an annual basis.

Selected Strategy: Identify specific threats to local populations including riparian habitat conditions and priority riparian areas.

Action Item:

A. Watershed Coordinator to document potential threats to populations in conjunction with survey biologist.
B. Watershed Coordinator to include potential threats in annual report to be shared with SWCD.
C. Document river corridor habitat by 2008 using the QHEI or cQHEI method

Selected Strategy: Sample sub-basin water quality.

Action Item:

A. TELWF to collect water quality data as needed for projects and success measurements.
B. TELWF to organize Hoosier RiverWatch volunteer monitors – at least one regularly sampled site in each subwatershed.
C. Crooked Lake, Big Lake, Loon Lake, Goose Lake, Webster Lake, Lake Tippecanoe, James Lake, Oswego Lake, and Barbee Chain of Lakes (7) to continue participating in the Indiana Clean Lakes Volunteer Monitoring Program.
D. TELWF to assist Robinson Lake, Smalley Lake, Troy Cedar Lake and others with starting Indiana Clean Lakes Volunteer Monitoring Program.

The selected alternative will have a few negative impacts associated with trespass on private property to get the information and costs of hiring a consultant. The positive benefits include the compilation of a biological inventory and assessment of the biological integrity of the watershed. This inventory and assessment will form the basis for protecting and enhancing the existing biological communities.

- **GOAL: IMPLEMENT PLAN FOR TESTING PHOSPHORUS AND NITROGEN IN SOILS ADJACENT TO TRIBUTARIES AND STREAMS.**

  Potential Alternatives:

  1. Obtain and use grant monies to hire a soil science consultant to conduct soil testing.
  2. Obtain and use grant monies to hire/fund university research on soil testing.
  3. Utilize NRCS expertise.

Selected Strategy: SWCD/NRCS to test soils for nitrogen and phosphorus in 25% of all active crop fields within a quarter mile of all waterways once each year.

Action Item:

A. Coordinate with NRCS to pursue employee responsible for soil testing (potential Purdue internship) in 2007.
B. TELWF to assist NRCS/SWCD with grant funding to support soil testing by soil scientist in 2007.
C. Soil scientist to obtain permission to access properties for testing purposes annually.
D. Soil scientist to provide an annual report to include location of samples take, sample results, and highlights of nutrient hot spots.

Selected Strategy: SWCD/NRCS to utilize soil testing report in developing nutrient management plans.

Action Item:

A. District Conservationist to review annual report and identify areas in need of nutrient management plan.
B. District Conservationist to have a representative contact targeted properties and assist with the development of a plan.
C. Soil scientist to address and monitor success of nutrient management plan in each annual soil testing report.

The negative impact associated with the collection of nutrient samples and the development of nutrient management plans on specific farms is the potential infringement on private property rights. The positive impact of the sample collection and analysis is being able to better assist property owners in determining the proper level of fertilizers sufficient to maximum yields.

- **GOAL: DECREASE THE ABUNDANCE AND SPREAD OF EXOTIC AQUATIC SPECIES INCLUDING EURASIAN WATERMILFOIL, CURLY-LEAF PONDWEED AND ZEBRA MUSSELS.**

Potential Alternatives:

1. Legislate Rules regarding the mandatory use of boat cleaning and lake quarantine/closure.
2. Educate boat and lake users on exotic aquatic species.

Selected Strategy: Develop aquatic plant management plan for all lakes in watershed.

Action Item:

A. TELWF to work with LARE program on grant to assist each lake in developing a plant management plan.
B. TELWF to highlight the completed reports in newsletters.

Selected Strategy: Decrease the spread/introduction of new exotic aquatic species.

Action Item:

A. TELWF newsletter to address exotic aquatic species in two newsletters per year.
B. TELWF to show Sea Grant video on exotics at annual Lake Association Meetings.
C. DNR to post and maintain signs at public boat ramps.
D. TELWF to team up with lake association boards of directors to conduct a field event at each public access within the watershed one time per year.

Selected Strategy: Increase the awareness of beneficial native plants to the ecosystem.

Action Item:

A. TELWF to highlight one beneficial aquatic plant in two newsletters per year with a picture and description of its benefits.
B. TELWF to host an annual workshop at a different lake each year which highlights the benefits of shoreline vegetation.

The negative impacts of attempting to control exotics and promote native vegetation are primarily economic. It will cost approximately $5,000 – $10,000 to develop the signage for boat ramps; it will take considerable staff time to facilitate the inclusion of the sea grant video and plant articles in all conservation newsletters; and a quality aquatic plant survey and management plan could cost up to $30,000 per lake. The positive benefits of controlling exotics are primarily economic but also social. Reducing the dominance of exotic aquatic species will result in lower plant management costs, more recreational opportunities including boating, swimming and fishing, increased property values and increased native plant and fish diversity.

- **GOAL: FOSTER COMMUNICATION BETWEEN ALL WATERSHED STAKEHOLDERS.**

Potential Alternatives:

1. Educate stakeholders regarding each others' needs
2. Facilitate the transfer of information among stakeholder groups.

Selected Strategy: Form an Advisory Board of Directors (Advisory Board) containing the following representatives to meet for annual review of watershed management plan beginning in 2006.

Plan administrators:

A. Lake associations board presidents
B. Farm Bureau representatives
C. Soil and Water Conservation Districts
D. The Nature Conservancy
E. Legislators
F. Planning Commissions
G. Drainage Board representatives
H. County Commissioners from Kosciusko, Whitley and Noble Counties
I. Natural Resources Conservation Service representatives
J. TELWF's Watershed Planning Committee Chair
K. IDEM Watershed Management Section representative
L. IDNR Division of Nature Preserves
M. IDNR Division of Fish and Wildlife
N. County Health Departments
O. ACRES/Ball Nature Preserve representatives

Selected Strategy: Communicate goals of management plan to all Upper Tippecanoe River Watershed stakeholders.

Action Item:

A. Watershed Coordinator to develop list of all stakeholders owning 40 acres.
B. Watershed Coordinator to update major stakeholder list annually.

C. Watershed Coordinator to develop list of all stakeholders (master stakeholder list) by 2007.
D. Watershed Coordinator to send yearly mailings regarding the management plan's goals and updates to individuals listed on master stakeholder list.
E. TELWF to distribute copies of final watershed management plan to all major stakeholders, all Upper Tippecanoe River Watershed lake associations, libraries, schools, SWCD offices, and Advisory Board members as updates occur.
F. TELWF to inform all watershed stakeholders of plan updates and availability.

Selected Strategy: Educate stakeholders on watershed issues.

Action Item:

A. Send educational mailing to all watershed stakeholders once per year.
B. Highlight best management practices or watershed projects at public event once per year.
C. TELWF to publish quarterly newsletter regarding watershed issues to stakeholders.
D. SWCD to publish bimonthly newsletter regarding watershed issues to stakeholders.
E. Watershed Coordinator to develop relationships with local outdoor/environmental reporters to ensure that credible watershed stories are published. (Good/Bad Attributes)
F. TELWF to send press releases to local media regarding watershed issues.
G. TELWF to maintain scrapbook of watershed related publications and project articles in local newspapers and natural magazines.
H. TELWF to conduct/compile annual survey of watershed stakeholders on water quality concerns for use in updating watershed management plan.
I. SWCD to utilize space in Times Union to publish watershed related articles.
J. Watershed Coordinator to incorporate identified stakeholder water quality concerns into plan.

Selected Strategy: TELWF to attend multiple lake association meetings and events for purposes of identifying educational opportunities.

Action Item:

A. TELWF to contact all area lake associations and establish a master list of meetings and planned activities in Spring 2006.
B. Determine if any of the planned activities can be utilized as watershed outreach/educations events.
C. TELWF and SWCD to help fund or mentor the development of newsletters for other organizations including SWCD, Farmers Exchange and lake associations.
D. TELWF to summarize excerpts from various newsletters concerning water quality related projects in their newsletters.
E. Each identified stakeholder organization to summarize and print watershed plan updates in their newsletters.

Selected Strategy: Regular communication of Plan goals to Noble, Whitley and Kosciusko County governments.

Action Item:

A. Watershed Coordinator to meet with planning commission, building inspectors, and drainage board of watershed strategies and action items (i.e. Erosion control, LESA planning assessment tool)
B. Watershed Coordinator to attend monthly meeting of planning commission, drainage board, board of zoning appeals.
C. TELWF to invite Engineering and Health to TELWF goal meeting each quarter.
D. TELWF to invite all government agencies to TELWF annual meeting.
E. TELWF and SWCD to send newsletters to representatives.

Selected Strategy: Assist in a liaison capacity to facilitate communication between Watershed Stakeholders and Federal and State representatives.

Action Item:

A. SWCD and TELWF to attend Annual Legislative Breakfast hosted by IASWCD in January.
B. SWCD/TELWF to hold annual tour of actual watershed projects co-sponsored/coordinated by TELWF, lake associations and/or SWCD.
C. TELWF and SWCD to send newsletter to representatives.
D. SWCD/TELWF to track new legislation that affects water quality issues in the district.
E. TELWF to include legislative information, Lakes Management Workgroup and ILMS information in quarterly newsletter.
F. TELWF and SWCD to develop action agenda for each legislative session.

Selected Strategy: Identify cites and towns, in addition to North Webster, that are affected by the Watershed Plan and work with the appropriate contacts within each unit of government.

Action Item:

A. TELWF to list those cities and towns that are in watershed or discharge stormwater/wastewater in watershed.
B. TELWF to identify officials from cities and towns for inclusion in plan.

Selected Strategy: Provide workshop style venues for increased communication between lake owners associations, SWCD, Future Farmers of America, 4-H, local schools, and the general public.

Action Item:

A. TELWF and SWCD to send newsletters or postcards to all identified stakeholders informing them of upcoming events.
B. TELWF to host at least two workshops a year for various stakeholder organizations.

Selected Strategy: Identify lakes where no association currently exists and/or assist in their development.

Action Item:

A. TELWF to develop and maintain list of lakes with active associations.
B. TELWF to contact landowners around lakes with newly forming associations to assist in their understanding of lake issues.

Selected Strategy: Coordinate with SWCD educational staff, schools, and other individuals to begin Hoosier Riverwatch Program in each of the 8 sub-basins.

Action Item:

A. SWCD to host teacher trainings for area schools one time per year.
B. SWCD to identify list of schools serving people in watershed in 2006.
C. SWCD and TELWF to identify and assist Hoosier Riverwatch Coordinator to train one teacher from identified schools in becoming Hoosier Riverwatch volunteer in 2007.
D. SWCD or TELWF to assist educators in applying for Hoosier Riverwatch grants for equipment in 2006.
E. SWCD or TELWF to work with Hoosier Riverwatch Area Trainer to educate and develop lead instructors for 8 Riverwatch sampling sites (a minimum of one site per subwatershed) by 2007.
F. Lead instructors to begin sampling one site by 2007.

The impacts of fostering communication and supporting all the conservation groups in the watershed will be primarily social. Negative impacts may include receiving feedback from specific stakeholders, while the positive impacts include the education of all stakeholder groups on each other's needs and desires for the water quality and an increase potential to work together.

- **GOAL: FUND WATERSHED IMPROVEMENT PROJECTS VIA GRANT FUNDING.**

Potential Alternatives:

1. Raise local funds
2. Seek outside grants

Selected Strategy: Develop listing of potential funding sources and needed information.

Action Item:

A. TELWF to examine history of Foundation's donations and encourage continued donations through public relations, mailings, director solicitations.
B. TELWF/Watershed Coordinator to identify and apply for yearly state and local grants including LARE, IDEM 319, 205j, WRP, CRP, NIPSCO, Community Foundations, and Hoosier Riverwatch.
C. TELWF/Watershed Coordinator to work with the SWCDs regarding Clean Water Indiana project grants.
D. Watershed Coordinator to work with The Nature Conservancy to identify national grants to document biotic (macroinvertebrates, fish, mussels) communities during 2006.
E. Advisory board to set financial goals and identify funding sources for protection easements during 2007.

- **GOAL: HIRE/RETAIN A WATERSHED COORDINATOR FOR THE UPPER TIPPECANOE WATERSHED.**

Potential Alternatives:

1. Hire/retain a full time watershed coordinator.
2. Enlist a volunteer watershed coordinator.

3. Request that SWCD implement the plan.

Selected Strategy: Determine the duties and develop job description of a watershed coordinator.

Action Item:
A. SWCD, TELWF and ABOD to work together to identify these tasks.

Selected Strategy: Seek grants to continue funding the position.
Action Item:
A. SWCD and TELWF to request an IDEM 319 Grant in October 2005 (completed).
B. SWCD and TELWF to look for more permanent funding to make permanent position.

- **GOAL: ADDRESS DEVELOPMENT ISSUES SUCH AS ZONING AND "FUNNELING"**

Potential Alternatives:
1. Provide voluntary plan review with area developers.
2. Get involved in area Plan Commission activities.
3. Review legal mechanisms for new rules on lakes.
4. Advise County Commissioners on environmental zoning alternatives.
5. Get involved with IDNR rule-making (piers, ecozones, etc.)

Selected Strategy: Assist area Plan Commission on developing lake zoning ordinances.
Action Item:
A. Send Watershed Coordinator and other Board members to Plan Commission meetings.
B. Hire consultant to generate language or ideas for an environmental overlay or draft zoning ordinance for presentation or submission to the Commission.

Selected Strategy: Evaluate eco-zone development/implementation for various lake areas.
Action Item:
A. Begin discussion with IDNR staff about critical habitat areas
B. Hire technical expertise to assess various lake areas for community composition, habitat value, eco-zone development and public palatability. Engage in outreach activities that generate support for such lake zoning.

Selected Strategy: Maintain active involvement in the Lakes Management Work Group.
Action Item:
A. Attend all meetings.
B. Relay information back to watershed stakeholders and generate "calls to action" when appropriate legislation is being considered.

B. Load Reduction Estimates

Sediment, phosphorus, and nitrogen load reductions for selected strategies and BMPs were estimated using the IDEM/USEPA Region 5 Pollutant Load Reduction Model and are summarized below:

Goal 1: Reduce total phosphorus, nitrogen, E. coli, and sediment loads in the Upper Tippecanoe Watershed 20% by 2010.

Selected Strategies:

C. Assist in the implementation of filter strips/grassed waterways on 20,000 feet of waterways each year (through 2010 for a total of 100,000 feet)

Table 50: Minimum reduction estimates for 100,000 feet of filter strips/grassed waterways

Filter strip width (ft)	Sediment Load Reduction (tons/year)	Phosphorus Load Reduction (lbs/year)	Nitrogen Load Reduction (lbs/year)
20	233	283	332
25	269	329	388
30	538	657	775

G. Assist in the implementation of conservation tillage on a significant acreage of planted acreage and 80% of all HEL acreage.

Table 51: Cropland, HEL, and Tillage data for Upper Tippecanoe Watershed

	Total Cropland (acres)[1]	Cropland in HEL (acres)[2]	Conventional tillage % (corn/soybeans)[3]	Estimated Cropland in Conventional Tillage (acres) Corn	Soybeans
Kosciusko	10,927	148	8%/4%	386	228
Whitley	14,089	2,471	28%/5%	1,726	369
Noble	7,046	1,157	21%/7%	644	260
Watershed Total	**32,062**	**3,776**		**2,756**	**857**

Sources
1 2002, 2003 USDA National Agricultural Statistics Service
2 Digital Soil Surveys for Kosciusko, Whitley, and Noble Counties
3 2004 Tillage Transect report

Table 52: Reduction estimates for conservation tillage on significant acreage of cropland

		Sediment Load Reduction (tons/year)			Phosphorus Load Reduction (lbs/year)			Nitrogen Load Reduction (lbs/year)		
	Increase in conservation tillage acreage	50%	75%	100%	50%	75%	100%	50%	75%	100%
Kosciusko	Soybeans	228	342	456	342	513	685	570	856	1,141
	Corn	386	578	771	578	867	1,157	964	1,446	1,928
Whitley	Soybeans	738	1,108	1,477	738	1,108	1,477	1661	2,492	3,323
	Corn	6,040	9,059	12,079	5,177	7,765	10,354	11216	16,825	22,433
Noble	Soybeans	520	780	1,040	520	780	1,040	1,040	1,560	2,080
	Corn	1,287	1,931	2,575	1,287	1,931	2,575	2,575	3,862	5,150

Table 53: Reduction estimates for conservation tillage on 80% of HEL cropland acreage

	80% of Cropland in HEL (acres)	Sediment Load Reduction (tons/year)	Phosphorus Load Reduction (lbs/year)	Nitrogen Load Reduction (lbs/year)
Kosciusko	118	474	474	947
Whitley	926	6,479	5,554	12,033
Noble	1,977	13,838	11,861	25,698
Watershed Total	**3,021**	**20,791**	**17,889**	**38,678**

Reductions for Proposed BMP Projects (see E.4)

Table 54: Reduction estimates for streambank restoration projects

	Estimated feet stabilized	Sediment Load Reduction (tons/year)	Phosphorus Load Reduction (lbs/year)	Nitrogen Load Reduction (lbs/year)
Project 1 (Shanton Ditch)	3500	403	403	805
Project 2 (Troy Cedar Br.)	2084	240	240	479
Total	**5584**	**643**	**643**	**1284**

C. Task Timeline

This task timeline below provides a framework for implementation of the tasks outlined as goals and strategies within the Upper Tippecanoe River Watershed management plan.

Winter 2006

- Publish Watershed Management Plan and distribute to listed stakeholders.
- Continue contact with landowners associated with pending projects and firm up details and funding.
- Continue participation in the Lakes Management Work Group.
- Continue coordination with the Kosciusko County Plan Commission regarding zoning issues.
- Contact The Nature Conservancy about grant opportunities, ideas, and grant schedules.
- Assist SWCDs in applying for RiverWatch equipment grants.

Spring 2006

- Organize and hold an Advisory Board of Directors review meeting. Review this document and its findings with the advisory board and other stakeholders present. A list of watershed stakeholders can be found in the Watershed Partners/Stakeholders section.
- Begin one-on-one visits to potential project site to discuss options with landowners.
- Contact other lake associations to get information about newsletter capabilities, meeting schedules, and grant submittals. Crate a large calendar of all related watershed activities and meetings. Look for educational opportunities and mentoring opportunities based on this information.
- Submit WMP updates/articles to other lake association newsletters for publication.
- Contact DNR regarding the posting of exotic species signs at public boat ramps.
- Assist in consultant selection and scope development for all LARE funded aquatic plant management plans and activities.
- Continue participation in the Lakes Management Work Group.

- Include LMWG activities and summaries in the newsletter.
- Prepare newsletter material on individual exotic species and individual beneficial aquatic plants for future newsletters.
- Continue coordination with the Kosciusko County Plan Commission regarding zoning issues.
- Update listing of all watershed stakeholders owning 40+ acres (major stakeholder list)
- Prepare new Clean Lakes Program Volunteers for summer monitoring on their lakes.

Summer 2006

- Develop a current job description for the watershed coordinator assuming 319 grant is awarded. Identify funding sources for permanent position.
- Conduct an aquatic plant management and/or wetland workshop.
- Conduct septic system workshop highlighting various technologies, maintenance, and alternatives.
- Contact local SWCDs and NRCS staff to assist in developing an organized approach and standard method for soil nutrient testing on 25 % of land adjacent to waterways each year.
- Identify one individual to become involved in volunteer water quality monitoring in each of the subwatersheds. Contact Hoosier Riverwatch for training in Fall 2006 or Spring of 2007.
- Contact all volunteer lake monitors to check on their progress and results over the summer sampling period. Insure they have what they need and feel encouraged.
- Develop a scope of service for future mussel bed surveys and stream habitat assessments. Determine who will perform the habitat assessments (consultant, coordinator, or volunteer). Begin discussions with IDNR and identify funding sources.
- Prepare 319 grants for priority projects. Assist area lake and watershed groups with their grant efforts in a coordinated way.
- Contact SWCDs regarding Clean Water Indiana grant ideas/coordination.

Fall 2006

- Develop a list of cities/towns in the watershed discharging stormwater utilities into streams or lakes. Get involved in their planning efforts.
- Update or complete master stakeholder and/or watershed landowner list(s).
- Host first annual legislative breakfast to discuss legislation that impacts the watershed.
- Educate property owners on the use of phosphorus free fertilizers and monitor phosphorus free fertilizer sales.
- Conduct a fertilizer workshop including hands on demonstrations of application and other residential maintenance issues.
- Prepare LARE grants for BMP projects and watershed wide eco-zone evaluation
- Assist area lake and watershed groups with their grant efforts in a coordinated way.
- Identify grant funding for annual position (possible summer internship position) to conduct soil testing.
- Continue seeking donations through direct mailers and personal solicitations.
- Continue to attend LMWG meetings and report outcomes in the newsletter.

2007

- Consultant to assist with developing environmental overlays and/or new zoning categories and make recommendations to area Plan Commissions.

- Conduct annual management plan review and update soil testing information, water quality data, biotic sampling data; and aquatic plant management and nutrient plans in order to identify areas where restoration or protection of stream habitat, shoreline, and/or wetland areas occurred.
- Consultant or trained volunteer to document river corridor habitat and identify hotspots for protection or restoration.
- Work with IDNR Division of Nature Preserves to document potential protection/restoration areas critical to listed species.
- Develop master list of property owners along waterways and those associated with any of the specific recommendations identifies in this Plan. Identify and prioritize individuals who own potential restoration areas, particularly wetland sites.
- Consultant and Coordinator to evaluate priority areas for in-lake ecozone development based on habitat and water quality (pending funding).
- Develop location map and master list of property owners with prior converted wetland sites. Prioritize listing for restoration potential and pursue one wetland restoration project each year for the next five years (2011).
- Implement two on the ground construction projects with educational elements (if appropriate).
- Begin sanitary sewer implementation process by opening communication with the town of Leesburg, the County Engineers, State Senators, and State Representatives. Identify potential funding sources for sanitary sewer feasibility studies.
- Consultant to begin survey and mapping of all watershed mussel beds with The Nature Conservancy. Listing of each site should include GPS coordinates, general location, site description, and listing of species identified.
- Consultant to conduct macroinvertebrate and fish surveys in Goose/Loon and Crooked/Big subwatersheds and post-construction evaluations as appropriate. Compare any data collected with baseline/historic data to allow for refinement of water quality goals. Following sampling efforts, associated report will be added as addendums to this Plan.
- Coordinate with NRCS to pursue employee responsible for testing phosphorus and nitrogen content of soils in fields adjacent to streams via grant funds or intermittent/intern positions in the local USDA offices. Begin annual sampling. Concluded with annual report of sample locations, results and identification of nutrient hot spots. Encourage District Conservationist to begin development of individual nutrient management plans based on soil sampling results.
- Host annual legislator tour of watershed projects.
- Insure Hoosier Riverwatch monitors are organized and have the equipment they need. Begin to synthesis data collected to date
- Board to set financial goals and identify funding sources for protection easements and project implementation for the next three years.
- Host annual workshop highlighting benefits of aquatic shoreline vegetation and residential landscaping alternatives for habitat and stormwater treatment at several of the individual lakes.
- Maintain scrap book containing all newsletters, public mailings and press releases associated with the management plan, its goals and implementation.
- Seek opportunities to showcase recent watershed projects and efforts. Consider local Rotary Clubs, professional organizations, SWCD conferences, media contacts, etc.
- Plan for press releases and draft promotional material as appropriate.
- Plan for and instigate residential surveys on hot topics as appropriate.
- Attend IASWCD events including Annual Conference and the Legislative Breakfast.

2008+

- Implement two river corridor restoration projects each year for the next three years. Projects initiated should be from those identified in corridor habitat surveys conducted in 2007.
- Complete mussel surveys and link survey data and mapping information database with GIS for master listing of site location, species composition and density (coordinate with IDNR).
- Conduct annual management plan review and update incorporating soil testing information, water quality data, biotic sampling reviews, updates to aquatic plant management and nutrient plans, and identifying areas where restoration or protection of stream habitat, shoreline, and/or wetland areas occurred.
- Send stakeholder surveys on topics/issues and specific watershed management plan strategies.
- Continue contact with landowners regarding project implementation (contact 25% of landowners associated with listed implementation projects each year during years 2006-2009).
- Insert cities/towns' stormwater management plans into this WMP as appropriate.
- Continue monitoring water quality and biotic community.
- Continue process of sanitary sewer implementation by applying for and obtaining feasibility study funding and by continuing to develop a new Conservancy District.
- Encourage CLP and Hoosier Riverwatch volunteers to continue monitoring water quality.
- Consultant to do follow-up water quality and biological testing to document improvements in select project areas.
- Continue quarterly newsletter and annual educational mailings to stakeholders.
- Continue monitoring of phosphorus free fertilizer sales.
- Continue soil testing of phosphorus and nitrogen content of fields near streams, and coordinate with NRCS staff on subsequent nutrient management plan development.
- Continue hosting annual workshops highlighting watershed issues.
- Continue lake association outreach and development.
- Host annual legislative breakfast and legislator tour of watershed projects.
- Maintain scrap book containing all newsletters, public mailings and press releases associated with the management plan, its goals and implementation.
- Update master stakeholder list, major stakeholder list, waterway stakeholder list and lake association list.

D. Plan Costs and Funding Resources

Funding and other resources are important for the actual implementation of recommended management practices in a watershed. There are numerous sources of funding for all types of water quality projects. The sources of funding include federal and state agencies, non-profits and private funding. Additionally, both human and material resources may be available in the watershed.

Plan Costs

The estimated costs for implementing the plan are for the first two years. The costs do not include actual labor hours associated with volunteers or the watershed coordinator. However, the cost to employ a watershed coordinator is included in the total. If a watershed coordinator is not employed, it is assumed that the salary and benefits will be redistributed among the tasks to employ other sources of labor.

Goal: Reduce total phosphorus, nitrogen, and E.coli loads in the water column of Tippecanoe River and Grassy Creek by 20% by 2010.
Match assistance for potential Clean Water Indiana BMP projects.. $5,000 - 10,000
Sewer feasibility study $35,000
Restoring one wetland each year $60,000
Annual BMP projects (including 20,000 feet of filter strips or grassed waterways/year) $40,000

Goal: Document existing biological integrity in each subwatershed.
Mussel survey of entire watershed $6,000
QHEI survey $10,000

Goal: Implement plan for testing phosphorus and nitrogen in soils adjacent to tributaries and streams.
Employ intern for soil nutrient testing... $12,000

Goal: Decrease the abundance and spread of exotic aquatic species including Eurasian watermilfoil, curly-leaf pondweed and zebra mussels.
Develop aquatic plant management plan for 8 lakes $160,000
Post signs at each public landing $8,000

Goal: Foster communication among all watershed stakeholders.
Reproduce and distribute copies of WMP to stakeholder list... $10,000
Quarterly newsletter production and distribution cost $12,000
Mileage reimbursement for meeting attendance.. $4,000
Speakers and other resources for technical workshops $10,000

Goal: Hire/Retain a Watershed Coordinator for the Upper Tippecanoe Watershed.
Salary and benefits.. $80,000

Goal: Address Zoning and Funneling Issues.
Assist area Plan Commission on developing lake zoning ordinances……………………………...……$20,000
Evaluate/Recommend eco-zone development/implementation for various lake areas……………......$50,000
Maintain active involvement in Lakes Management Work Group……………………………………….$5,000

Funding Sources

There are several cost-share grants available from both state and federal government agencies specific to watershed management. Watershed groups, local governments, lake associations and/or Soil and Water Conservation Districts (SWCDs) can apply for the majority of these grants. The main goal of these grants and other funding sources is to improve water quality though specific BMPs. As public awareness shifts towards watershed management, these grants will become more and more competitive. Therefore, any association interested in improving water quality through the use of grants must become active soon. Once an association is recognized as a "watershed management activist" it will become easier to obtain these funds repeatedly. The following are some of the possible major funding sources available to lake and watershed associations for watershed management.

State Conservation and Watershed Programs

Lake and River Enhancement Program (LARE)

LARE is administered by the Indiana Department of Natural Resources, Division of Fish and Wildlife. The program's main goals are to control sediment and nutrient inputs to lakes and streams and prevent or reverse degradation from these inputs through the implementation of corrective measures. Under present policy, the LARE program may fund lake and watershed specific construction actions up to $100,000 for a specific project or $300,000 for all projects on a specific lake or stream. Cost-share approved projects require a 0-25% cash or in-kind match, depending on the project. LARE also has a "watershed land treatment" component that can provide grants to SWCDs for multi-year projects. The funds are available on a cost-sharing basis with farmers who implement various BMPs.

State Resolving Fund

The state resolving fund program is available to municipalities and counties for facilities development through IDEM's Office of Water Management.

State Nature Preserve Dedication

The state nature preserve program is available through the IDNR Division of Nature Preserves for the acquisition and management of threatened habitat.

Classified Wildlife Habitat Program/Wildlife Habitat Cost-Share Program

These programs are offered to individual landowners to foster private wildlife habitat management through tax reduction and technical assistance. Landowners need 15 acres or more of habitat to be eligible and IDNR provides management plans and assistance through the District Wildlife Managers.

Classified Forest Program

This program is offered to individual landowners to foster private forest management through tax reduction and technical assistance. Landowners need 10 acres of more of woods to be eligible. IDNR provides the management plans and assistance through the District Foresters.

Classified Windbreak Act

The classified windbreak act provides tax incentives, technical assistance through IDNR District Foresters on newly established windbreaks at least 450 feet long adjacent to tillable land.

Forest Stewardship Program/ Stewardship Incentives Program

These programs offer individuals cost share and technical assistance to encourage responsibly managed and productive private forests.

Federal Conservation and Watershed Programs

Clean Water Act Section 319(h) Nonpoint Source Pollution Management Grant

The 319 Grant Program is administered by the Indiana Department of Environmental Management (IDEM), Office of Water Management, Watershed Management Section. The 319 (h) Grant is a federal grant made available by the Environmental Protection Agency (EPA) on an annual basis to fund projects that target nonpoint source water pollution. Nonpoint source pollution (NPS) refers to pollution originating from general sources rather than specific discharge points (Olem and Flock, 1990). Sediment, animal and human waste, nutrients, pesticides, and other chemicals resulting from land use activities such as mining, farming, logging, construction, and septic fields are considered NPS pollution. According to the EPA, NPS pollution is the number one contributor to water pollution in the United States. To qualify for funding, the water body must be listed in the state's 305(b) report as a high priority water body or be identified by a diagnostic study as being impacted by NPS pollution. Funds can be requested for up to $300,000 for individual projects. There is a 25% cash or in-kind match requirement. Actual funding depends on approval from EPA and the yearly congressional appropriations.

Section 104(b)(3) NPDES Related State Program Grants

Section 104(b)(3) of the Clean Water Act gives authority to a grant program called the National Pollutant Discharge Elimination System (NPDES) Related State Program Grants. These grants provide money for developing, implementing, and demonstrating new concepts or requirements that will improve the effectiveness of the NPDES permit program that regulates point source discharges of water pollution. Projects that qualify for Section 104(b)(3) grants involve water pollution sources and activities regulated by the NPDES program, including developing storm water management plans by small municipalities, projects involving a watershed approach to municipal separate sewer systems and projects that directly promote community based environmental protection. The awarded amount can vary by project and there is a required 5% match.

Section 205(j) Water Quality Management Planning Grants

Funds allocated by Section 205(j) of the Clean Water Act are granted for water quality management planning and design. Grants are given to municipal governments, county governments, regional planning commissions, and other public organizations for researching point and non-point source pollution problems and developing plans to deal with the problems. According to the IDEM Office of Water Quality website: "The Section 205(j) program provides for projects that gather and map information on non-point and point source water pollution, develop recommendations for increasing the involvement of environmental and civic organizations in watershed planning and implementation activities, and implement watershed management plans. No match is required. For more information on the 310, 104(b)(3), and 205(j) grants, please see the IDEM website http://www.in.gov/idem/water/planbr/wsm/Section205j_main.html.

Other Federal Grant Programs

The USDA and EPA award research and project initiation grants through the US National Research Initiative Competitive Grants Program and the Agriculture in Concert with the Environment Program.

Watershed Protection and Flood Prevention Program

The Watershed Protection and Flood Prevention Program is funded by the U.S. Department of Agriculture (USDA) and is administered by the Natural Resources Conservation Service (NRCS). Funding targets a variety of watershed activities including watershed protection, flood prevention, erosion and sediment control, water supply, water quality, fish and wildlife habitat enhancement, wetlands creation and restoration, and public recreation in small watersheds (250,000 or fewer acres). The program covers 100% of flood prevention construction costs or 50% of construction costs for agricultural water management, recreational, or fish and wildlife projects.

Conservation Reserve Program (CRP)

The Conservation Reserve Program is funded by the USDA and administered by the Farm Service Agency (FSA), with technical assistance from the NRCS. CRP is a voluntary, competitive program designed to encourage farmers to establish vegetation on their property in an effort to decrease erosion, improve water quality, or enhance wildlife habitat. The program targets farmed areas that have a high potential for degrading water quality under traditional agricultural practices or areas that might make good wildlife habitat if they were not farmed. Such areas include highly erodible land, riparian zones, and farmed wetlands. Participants in the program receive cost share assistance for any plantings or construction as well as annual payments for any land set aside.

Wetlands Reserve Program (WRP)
The Wetlands Reserve Program is funded by the USDA, administered by the NRCS and is a subsection of the Conservation Reserve Program. This voluntary program provides funding for the restoration of wetlands on agricultural land. To qualify for the program, land must be restorable and suitable for wildlife benefits. This includes farmed wetlands, prior converted cropland, farmed wet pasture, farmland that has become a wetland as a result of flooding, riparian areas which link protected wetlands, and the land adjacent to protected wetlands that contribute to wetland functions and values. Landowners can establish conservation easements of either permanent or 30 year duration, or can enter into restoration cost-share agreements where no easement is involved. In exchange for establishing a permanent easement, the landowner received payment up to the agricultural value of the land and 100 percent of the restoration costs for restoring the wetlands. The 30 year easement payment is 75 percent of the restoration cost. The voluntary agreements are for a minimum 10-year duration and provide for 75 percent of the cost of restoring the involved wetlands. Easements and restoration cost-share agreements establish wetland protection and restoration as the primary land use for the duration of the easement or agreement. In all instances, landowners continue to control access to their land.

North American Wetland Conservation Act Grant Program
The North American Wetland Conservation Act Grant Program (NAWCA) is funded and administered by the U.S. Department of Interior. This program provides support for projects that involve long-term conservation of wetland ecosystems and their inhabitants including waterfowl, migratory birds, fish and other wildlife. The match for this program is on a 1:1 basis.

Wildlife Habitat Incentive Program (WHIP)
The Wildlife Incentive Program provides financial incentives to develop habitat for fish and wildlife on private lands. Participants agree to implement a wildlife habitat development plan and the USDA agrees to provide cost-share assistance for the initial implementation of the wildlife habitat development practices. USDA and program participants must enter into a cost-share agreement for the wildlife habitat. Support includes technical assistance as well cost sharing payments. Those lands already enrolled in WRP are not eligible for WHIP. The match is 25% and the agreement is generally not shorter than ten years from the date that the contract is signed.

Environmental Quality Incentives Program (EQIP)
The Environmental Quality Incentives Program is a voluntary program designed to provide technical, educational and financial assistance to producers to establish conservation practices in target areas where significant natural resource concerns exist. Eligible land includes cropland, rangeland, pasture, and forestland, and preference is given to applications which propose BMP installation that benefits wildlife. EQIP, funded by the EPA and administered by the NRCS, offers cost share and technical assistance on tracts that are not eligible for continuous CRP enrollment. Certain BMPs receive up to 75% cost share. In return, the producer agrees to withhold the land from production for five years. Practices that typically benefit wildlife include: grassed waterways, grass filter strips, conservation cover, tree planting, pasture and hay planting, and field borders. Best fertilizer and pesticide management practices are also eligible for EQIP cost-share.

Conservation Technical Assistance (CTA)

The purpose of the program is to assist land users, communities, units of state and local government and other Federal agencies in planning and implementing conservation systems. The purpose of the conservation systems are to reduce erosion, improve soil and water quality, improve and conserve wetlands, enhance fish and wildlife habitat, improve air quality, improve pasture and range condition, reduce upstream flooding and improve woodlands. The objective of the CTA program is to assist individual landowners, communities, conservation districts and other units of state and local government and Federal agencies to meet their goals for resource stewardship and assist individuals to comply with state and local requirements. NRCS assistance is provided to individual landowners through conservation district offices.

Conservation of Private Grazing Land Initiative (CPGL)

The conservation of private grazing land initiative will ensure that technical, educational and related assistance is provided to those who own private grazing lands. It is not a cost-share program. This technical assistance will offer opportunities for: better grazing land management; protecting soil from erosive wind and water; using more energy-efficient ways to produce food and fiber; conserving water; providing habitat for wildlife; sustaining forage and grazing plants; using plants to sequester greenhouse gases and increase soil organic matter and using grazing lands as a source of biomass energy and raw materials for industrial products.

Farmland Protection Program (FPP)

The Farmland Protection Program provides funds to help purchase development rights in order to keep productive farmland in use. The goals FPP are: to protect valuable, prime farmland from unruly urbanization and development; to preserve farmland for future generations; to support a way of life for rural communities; and to protect farmland for long-term food security.

Forestry Incentive Program (FIP)

The Forestry Incentive Program, administered by the NRCS, provides cost-share money to assist private landowners in forest management.

Debt for Nature

Debt for Nature is a voluntary program that allows certain FSA borrowers to enter into 10-year, 30-year, or 50-year contracts to cancel a portion of their FSA debts in exchange for devoting eligible acreage to conservation, recreation, or wildlife practices. Eligible acreage includes: wetlands, highly erodible lands, streams and their riparian areas, endangered species, or significant wildlife habitat, land in 100-year floodplains, areas of high water quality or scenic value, aquifer recharge zones, areas containing soil not suited for cultivation, and areas adjacent or within administered conservation areas.

Private Funding Sources

Non-Profit Conservation Advocacy Group Grants

Various non-profit conservation advocacy groups provide funding for projects and land purchases that involve resource conservation. Examples of these organization include: Ducks Unlimited, Pheasants Forever, and Quail Unlimited.

Land Trusts

Acres Inc. and Oxbow Inc.

National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation, established in 1984 by Congress, awards challenge grants for natural resource conservation. Federally appropriated funds are used to match private sector funds. Six program areas include wetland conservation, conservation education, fisheries, migratory bird conservation, conservation policy and wildlife habitat. For more information: 1120 Connecticut Avenue, NW Suite 900, Washington DC, 20036.

Indianapolis Power and Light Company (IPALCO) Golden Eagle Environmental Grant
The IPALCO Golden Eagle Grant awards grant of up to $10,000 to projects that seek, improve, preserve and protect the environment and natural resources in the state of Indiana. The award is granted to approximately 10 projects each year. Deadline for funding is typically in January. More information is available at
http://www.ipalco.com/ABOUTIPALCO/Environmet/Golden_Eagle/Golden_Eagle_Application.html.

Nina Mason Pulliam Charitable Trust (NMPCT)
The NMPCT awards various dollar amounts to projects that help people in need, protect the environment and enrich community life. Prioritization is given to projects in the greater Phoenix, Arizona and Indianapolis, Indiana areas, with secondary priority being assigned to projects throughout Indiana and Arizona. The trust awarded nearly $20,000,000 in funds in the year 2000. More information is available at http://www.nmpct.org.

NIPSCO Environmental Challenge Funds

Watershed Resources
An important but often overlooked factor in accomplishing goals and completing projects in any watershed is resources within the watershed itself. These resources may be people giving of their time, local schools participating in projects, companies giving materials for project construction, or other donations. This study documents some of these available resources for the Upper Tippecanoe River Watershed. It is important to note that this list is not all-inclusive, and some groups and donors may have been missed.

Watershed Coordinator
The Indiana Department of Environmental Management (IDEM) employs four regional watershed specialist positions. The watershed specialist is an advocate for watershed-level work in the region. Watershed specialists can help direct actions of groups and stakeholders who are interested in working together to address problems in their watershed. They can help with everything from structuring public meetings to assisting with the compilation of a Watershed Management Plan. Their wealth of knowledge includes ideas about how to work with and respect all stakeholders in order to find the best plan for natural resource conservation within a given watershed. The regional watershed conservationist for the northeastern portion of Indiana is currently vacant. However, general contact information is listed below.

Regional Watershed Specialist
Indiana Department of Environmental Management
Office of Water Quality
Watershed Planning Branch
100 North Senate Avenue, IGCN 1255
Indianapolis, IN 46204-2251
(317) 234-3312

Coordinated Resource Management
The Coordinated Resource Management (CRM) process is an organized approach to identification of local concerns, evaluation of natural resources, development of alternative actions, assistance from technical specialists, implementation of a selected alternative, evaluation of implementation activities, and involvement of all interested parties who wish to participate in watershed action. The goal is an effective Watershed Management Plan through the establishment of common goals and actions to achieve those goals. Further CRM information and its complementary Watershed Action Guide can be downloaded from the USDA/NRCS website at http://www.in.nrcs.gov. The CRM gives guidance on how to plan with people to maximize benefits to the greatest number of people while enhancing or maintaining the natural resource.

Conservation Technology Information Center (CTIC)
Know your Watershed educational materials are available.

Hoosier Riverwatch
The Hoosier Riverwatch Program was started in 1994 by the State of Indiana to increase public awareness of water quality issues and concerns. Riverwatch is a volunteer stream monitoring program sponsored by the IDNR Division of Soil Conservation in cooperation with Purdue University Agronomy Department. Any citizen interested in water quality may volunteer to take a short training session held from May through October. Water monitoring equipment may be supplied to nonprofit organizations, schools, or government agencies by an equipment grant. Additionally, many SWCD offices (including the Kosciusko, Noble, and Whitley County SWCDs) have loaner equipment that can be borrowed. Several groups in the three counties actively participate in the Riverwatch Program. Table 46 contains information about groups that have conducted volunteer monitoring in the three counties. Because neither the Upper Tippecanoe River nor any of its tributaries have been monitored through the Hoosier Riverwatch Program, more participation should be advocated within the study watershed especially since loaner equipment is readily available. More detailed information is available via the Hoosier Riverwatch web site at http://www.state.in.us/dnr/soilcons/riverwatch/.

Table 55. Groups that have participated in the Hoosier Riverwatch volunteer monitoring program in Kosciusko, Noble, and Whitley Counties.

County	Organization	City
Kosciusko	Kosciusko County SWCD	Warsaw
Kosciusko	Wawasee Area Conservancy Foundation	Syracuse
Kosciusko	Warsaw Community High School	Warsaw
Noble	Noble County SWCD	Albion
Noble	High Lake Conservation Club	Albion
Noble	East Noble High School	Kendallville

Source: Hoosier Riverwatch, 2002.

Indiana Hardwood Lumbermen's Association
Indiana Tree Farm Program

Volunteer Groups
Volunteer groups can be instrumental in planning projects, implementing projects, and monitoring projects once they are installed. Although no streams in the study watershed have been monitored by Hoosier Riverwatch participants, both the Warsaw and East Noble High Schools have participated in the program.

The two schools are located in Warsaw and Kendallville. Involving the people living in the watershed, especially school-age children, is a good way to promote natural resource awareness and a good way to get data collected and projects completed. Oftentimes, data collected by volunteer groups may be the only available data for a watershed. This data is very valuable in helping to establish baseline trends with which to compare future samples.

Purdue Agricultural Center (PAC) Research and Demonstration Projects
The Pinney and Northeast Purdue Agricultural Centers (PACs) participate in on-going agricultural research that is relevant to challenges producers face in northern Indiana. The Pinney PAC is located in Wanatah the Northeast PAC in Columbia City. Brian McGowan studies forestry and natural resource issues at the Northeast Center. Mr. McGowan is currently investigating the effects of filter strips on crop production via alterations in the community dynamics of arthropods, small mammals, and birds. He has also hosted demonstrations of windbreak and wetland planting possibilities at the center in Wanatah. His research may provide insight on future management techniques that could be applicable to the Solomon Creek area.

E. Impediments to Meeting Goals

Although no previous studies have directly identified obstacles or special challenges for watershed-level projects in the Upper Tippecanoe River Watershed, data collected during a phone survey of hundreds of producers in the 21 Rural Clean Water Program (RCWP) project areas provides some information with respect to the most typical obstacle encountered in watershed projects: private landowner willingness to participate. The purpose of the survey was to evaluate difference between farmers who chose to participate in the RCWP projects and those who did not (Gale et al., 1995). Participation was positively correlated with the following factors: total acreage farmed, farm sales, property/equipment values, water pollution awareness, access to water quality/conservation materials and information, education level, willingness to take risks, availability of financial (cost-share) incentives, and level/frequency of one-to-one contact between project personnel and farmers (Osmond and Gale, 1995). (An example of a positive correlation would be that more producers participated if more cost-share incentives were available.) The study found that producers who were tenant farmers or were employed off-farm were less likely to participate in conservation programs. The main reason landowners did not participate was that they did not believe water quality to be a problem.

7.0 PLAN IMPLEMENTATION AND PROGRESS EVALUATION

A. Monitoring

An active water quality monitoring plan for the larger watershed will continue into the future. The plan and associated process will consist of water quality sampling and laboratory testing by a consultant and volunteers with the RiverWatch program. Both chemical and biological parameters will be analyzed. Monitoring will include water quality sampling associated with pre-construction and post-construction conditions of various future implementation projects as they get built or installed. At a minimum, sampling will include at least one site in each of the 8 sub watersheds that comprise the Upper Tippecanoe River Watershed. Implementation projects will also be monitored by visual assessment and post-construction inspection annually.

During the monitoring phase, watershed stakeholders should hold regular meetings to discuss the results of monitoring and to refine the watershed management plan. At each meeting, constituents should consider:

1. Have the best management practices that were implemented been effective in improving the health of the watershed?
2. Can adjustments be made to the selected best management practices to be more effective in improving the health of the watershed?
3. Have the water quality goals that were set been attained?
4. Have the water quality goals changed? If so, how?
5. Have the macroinvertebrate and fish community goals that were set been attained?
6. Have the biotic community goals changed? If so, how?
7. What are the results of soil nutrient testing?
8. Are nutrient management plans being developed and implemented?
9. Have the population and density of exotic species goals been attained?
10. Have the density and distribution of exotic species changed? If so, how?
11. Have watershed stakeholders become more informed about watershed issues?
12. Have the methods for informing stakeholders changed? If so, how?
13. Have more natural resource-oriented groups become active in the Upper Tippecanoe River Watershed?
14. Have the desired uses of the Upper Tippecanoe River been attained?
15. Have the desired uses of the Upper Tippecanoe River changed? If so, how?
16. What funding sources have been utilized in improving the watershed? Are others available that can be used?
17. Has the role of the Watershed Coordinator changed? If so, how?
18. What other activities should the coordinator pursue?

Answers to these and other relevant questions should be documented and added as revisions to the watershed management plan. If the answers to these questions suggest that new projects be implemented, the watershed group must return to the steps outlined in the timeline.

B. Follow-Up Practices

The Upper Tippecanoe River Watershed management plan identifies projects to be implemented throughout the subwatersheds. Each type of project falls under different jurisdictions. For example, most buffer/filter strip installation will predominantly occur through the Farm Service Agency or the SWCD offices, while stream corridor protections will occur through the IDNR Division of Nature Preserves or The Nature Conservancy. Annual maintenance and inspection of a percentage of the implemented projects is included in the management plan and will be carried out by the watershed coordinator. To ensure that all projects are being properly maintained, landowner assistance is required. Therefore, the primary follow-up monitoring activity will be an annual inspection of construction areas by existing property owners. The inspection should note any signs of erosion, movement of protection structures, trouble with plant survival rates, and any other problems. Landowners involved in the project will need to agree to perform annual maintenance inspections prior to project implementation. Each landowner will also be required to submit an annual inspection form to the watershed coordinator. Upon receipt of the form, the coordinator will review the inspection form and follow up with the landowner if problems are noted.

C. Re-evaluation and Revising

An Advisory Board of Directors (ABOD) composed of watershed stakeholders will be formed for watershed management plan review upon acceptance of this plan by IDEM. Members from the following organizations will be contact again and asked to serve on the ABOD: lake association board presidents, Farm Bureau representatives, Soil and Water Conservation Districts personnel, The Nature Conservancy member/staff, legislators, planning commissions members/staff, Drainage Board representatives, Kosciusko, Noble and Whitley County Commissioners, Natural Resources Conservation Service representatives, TELWF's watershed planning committee chairperson, IDEM representatives, IDNR representatives from the Division of Nature Preserves and the Division of Fish and Wildlife, ACRES, Inc., and County Health Departments staff. Other members may be added at a later date. The Board will meet annually for review of the Upper Tippecanoe River Watershed management plan. Review will include, but not be limited to the following:

- Discussion of water quality sampling results
- Discussion of biotic community sampling (mIBI; IBI; mussel distribution and density)
- Review of phosphorus-free fertilizer usage
- Update on corridor habitat protection areas (mapping; protection project implementation)
- Review of agricultural BMP implementation
    - Number and acreage of filter/buffer strip installations
    - Number and acreage of wetland restorations
    - Number and acreage of fields utilizing conservation tillage
    - Number of nutrient management plans developed and implemented
    - Number of manure management plans developed and implemented
- Report on the progress of sanitary sewer implementation
- Status of phosphorus modeling
- Review of annual soil testing results and report
- Review of distribution and density of exotic species
- Status of aquatic plant management plan development
- Status of stakeholder, county government, lake association, and federal and state government education and communication
- Status of the development of lake associations
- Review of the status of volunteer water quality monitoring
- Status of grant funding opportunities and review of grants received
- Review and evaluation of the watershed coordinator position
- Refinement of goals, strategies and action items

Following the annual review meeting the Upper Tippecanoe River Watershed management plan will be updated. All water quality and biotic monitoring data, agricultural BMP installation information, aquatic plant and nutrient management plans will be added as addendums to the report. Report sections will be examined and updated information will be added following the annual meeting. In order to track information flow, each stakeholder will be required to return the prior year's report before a copy of the updated report will be issued.

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INDIANA DEPARTMENT OF ENVIRONMENTAL MANAGEMENT
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October 31, 2005

Holly LaSalle, Watershed Coordinator
Tippecanoe Environmental Lake and Watershed Foundation
P.O. Box 55
North Webster, IN 46555

Dear Ms. LaSalle:

Re: QAPP Approval
FFY 2003 Section 319 Project
ARN 305-3-3757

This letter is to inform you that the Quality Assurance Project Plan (QAPP) for the *Upper Tippecanoe River Watershed* in Indiana has been approved by our office. Enclosed you will find a copy of the completed signature page.

Thank you for your interest in furthering Indiana's nonpoint source (NPS) pollution goals by facilitating water quality monitoring efforts in your watershed. We appreciate your work and anticipate that much good will come from your efforts. Please remember to address quality assurance (QA) activities as required by the QAPP in the Quarterly Progress Reports for your project. If you have any questions or if we can be of further assistance, do not hesitate to contact your Project Manager, Kathleen Hagan, at 317/233-8801 or QA Manager, Betty Ratcliff, at 317/234-2997.

Sincerely,

Betty Ratcliff

Betty Ratcliff, QA Manager
Watershed Management Section
Office of Water Quality

Cc: Greg R. Bright
Commonwealth Biomonitoring, Inc.
8061 Windham Lake Drive
Indianapolis, IN 46214

Enclosure

QUALITY ASSURANCE PROJECT PLAN
FOR
Upper Tippecanoe River Watershed Monitoring

Prepared by:

Greg R. Bright
Commonwealth Biomonitoring
8061 Windham Lake Drive
Indianapolis, Indiana 46214

Prepared for

Indiana Department of Environmental Management
Office of Water Management
Watershed Management Section

Tippecanoe Environmental Lake and Watershed Foundation
P.O. Box 55
North Webster, IN 46555

September 2005

Water Quality Data Manager	Greg R. Bright Greg Bright	9/14/05 Date
Watershed Coordinator	Holly LaSalle Holly LaSalle	9/9/05 Date
IDEM Project Manager	Kathleen T. Hagan Kathleen Hagan	10/19/05 Date
QA Project Manager:	Betty Ratcliff Betty Ratcliff	10/19/05 Date
WMS Section Chief:	Linda Schmidt Linda Schmidt	10/26/05 Date
Planning Branch Chief:	Martha Clark Martha Clark	10/26/05 Date

Copies of the QAPP have been distributed to Greg Bright, Holly LaSalle, and Betty Ratcliff, all of whom have responsibility for implementation of various tasks in the project.

QUALITY ASSURANCE PROJECT PLAN

FOR

Upper Tippecanoe River Water Quality Monitoring
ARN: A305 - 3 - 3757

Prepared by

Greg R. Bright
Commonwealth Biomonitoring, Inc.
8061 Windham Lake Drive
Indianapolis, Indiana 46214

Prepared for

Indiana Department of Environmental Management
Office of Water Management
Watershed Management Section

Tippecanoe Environmental Lake and Watershed Foundation
P.O. Box 55
North Webster, IN 46555

September 2005

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1.0 INTRODUCTION

The Tippecanoe River in northern Indiana is one of the most biologically important streams in the United States. It supports numerous fish and freshwater mussel species that are rare or extirpated from other streams. A grant was awarded to the Tippecanoe River Environmental Lake and Watershed Foundation by the Indiana Department of Environmental Management to prepare a watershed management plan to help protect and enhance the river's water quality and biological diversity upstream from Tippecanoe Lake. Although in relatively good ecological condition, some of the Upper Tippecanoe River watershed's lakes [e.g. Crooked, Oswego, Webster, Loon, and Tippecanoe] appear on the state's 303[d] list for mercury contamination. A preliminary study of the watershed [TELWF, 2002] identified additional threats in the watershed, including suspended solids, nutrients, ammonia, E.coli, and BOD.

One of the tasks in the project is to monitor water quality using biological and chemical methods and use the information to make decisions that may be used to help prepare the watershed management plan. This document presents quality assurance plans for monitoring.

2.0 PROJECT DESCRIPTION

2.1 General Overview:

The water quality assessment will use macroinvertebrate monitoring and aquatic habitat assessment to measure an Index of Biotic Integrity (IBI) at ten sites in the upper Tippecanoe River watershed. The biological information will be supplemented by collecting water chemistry data at these sites as well. The information will be used to diagnose water quality problems and propose solutions.

2.2 Project Objectives:

The objectives of this project are to characterize the biological, physical, and chemical integrity of the upper Tippecanoe River and its tributaries and to make recommendations to solve any identified problems.

In association with routine chemical measurements, bioassessments are extremely valuable tools in determining the ecological health of a waterbody. An accurate and reproducible measure of the ecological health of a stream can be made by comparing the number and kinds of animals present at a study site with those from an unimpacted "reference" site. The bioassessment technique results in a single biotic index value: the higher the value, the more ecologically healthy the site.

In addition, bioassessments can diagnose problems. Healthy streams have good aquatic habitat. However, if habitat is good but the stream doesn't support a healthy aquatic community, a diagnosis of poor water quality can be made.

Finally, the aquatic community can even help in the diagnosis of particular type of water quality problems. Certain animals are sensitive to different types of stresses. Comparison of the numbers and kinds of animals present can give important clues about degraded water quality due to toxic substances, excessive sedimentation, excessive nutrient inputs, or low dissolved oxygen concentrations.

Macroinvertebrates respond more quickly to changes in environmental conditions than fish. They also have more "indicator species" value than fish, because their responses to different environmental stresses are more predictable. Because they are exposed to conditions 24 hours a day for up to a year, macroinvertebrates can detect water quality problems that occasional grab samples for chemical analysis may not discover. Fish communities are also important because many ordinary citizens are familiar with fish and they are frequently economically important as well.

2.3 Sampling Design:

The overall experimental design is to conduct targeted sampling of the biological community, the physical integrity of the stream's habitat, and basic water chemistry to answer the following questions:

1) What is the overall ecological health of the watershed?
2) Are the problems primarily from water quality or degraded habitat?
3) Are water chemistry parameters (dissolved oxygen, pH, temperature, nutrients, and sediments) within normal ranges for aquatic life?
4) Are E.coli concentrations high enough to pose a risk to human health?
5) What can be done to make the identified problems better?

Fig. 1. Eight subwatersheds to be investigated. The 14-digit names and numbers are listed in Appendix I.

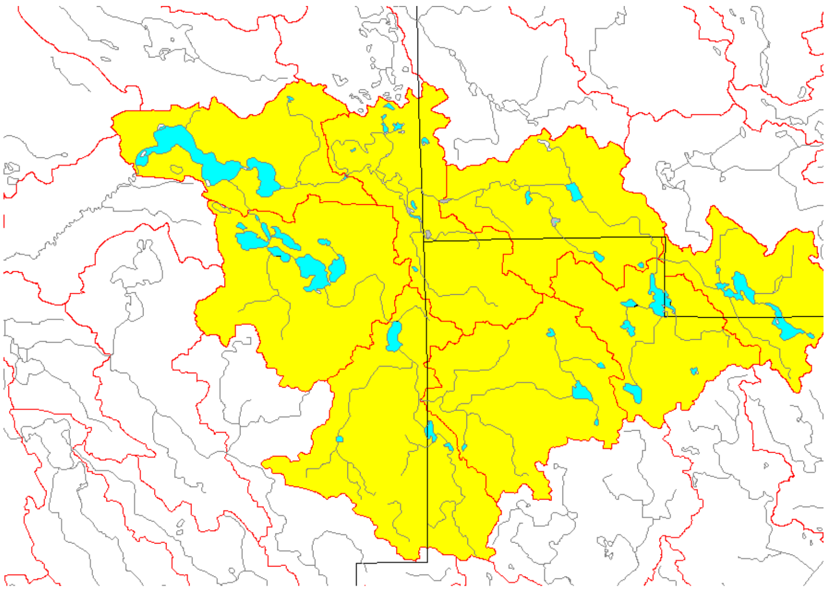

Fig 2. Sites to be investigated. Sampling sites are also listed in Appendix I.

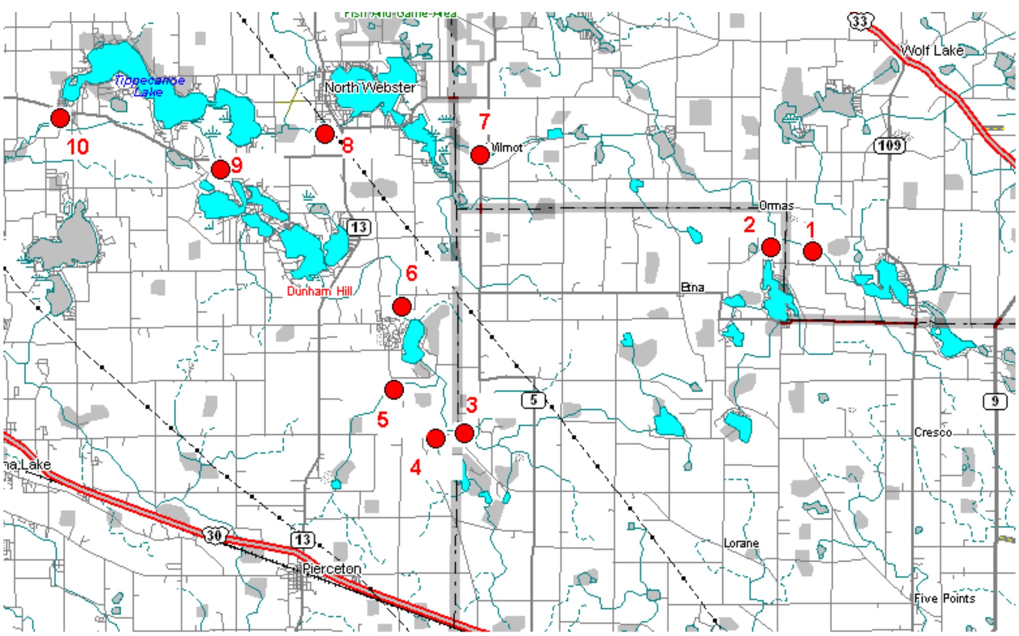

Table 1. Physical, chemical and biological parameters to be measured at each site

Habitat
Qualitative Habitat Evaluation Index at 10 sites

Biological
Macroinvertebrate IBI - 10 sites
Fish IBI - 10 sites

Physical and Chemical
Dissolved oxygen, pH, temperature, flow, ammonia,
TSS, BOD5, E.coli, and flow - 10 sites

2.4 Project Timetable:

The project will be conducted during October 2005 with final manuscript preparation and completion by January 2006.

QAPP approved	September 2005
Biological Sampling	October 2005
Chemical Sampling	October 2005
Data Analysis	November and December 2005
Final Report	February 2006

3.0 PROJECT ORGANIZATION AND RESPONSIBILITY

The study will be conducted by Commonwealth Biomonitoring, The following people will be responsible for carrying out the project:

The Water Quality Data Project Manager (Greg R. Bright) is responsible for quality assurance, management of the project field logistics, the collection, analysis, and interpretation of chemical and biological data, identification of biological specimens, and writing the report. A copy of the lab's Standard Operating Procedures is attached in the Appendix.

Aquatic Biologists (Melody Myers-Kinzie and Andrew Kennedy) are responsible for assisting in sample collections and analyzing the data.

The Watershed Coordinator (Holly LaSalle) is responsible for coordinating the project with Commonwealth Biomonitoring, IDEM, and the Tippecanoe Environmental Lake and Watershed Foundation.

The IDEM project manager (Kathleen Hagan) is responsible for oversight of the grant.

The IDEM QA manager (Betty Ratcliff) is responsible for approval of the QAPP..

4.0 DATA QUALITY OBJECTIVES

4.1 Accuracy/Bias

Accuracy and bias in biological and chemical analyses are dependent on maintenance of standard procedures for sample processing, labeling, sorting, identification, counts, and chemistry laboratory procedures. A definitive measurement of accuracy in biological assessments cannot be made because there is no "true" value for reference. However, by stressing conformance with the procedures outlined in this plan, we expect a high degree of accuracy and a low degree of bias.

For the field chemical measurements, we expect the following accuracies, based on the equipment specifications:

Temperature	plus or minus 0.1 degree C of true value
pH	plus or minus 0.1 SU of true value
Dissolved oxygen	plus or minus 0.3 mg/l of true value

For the laboratory chemical measurements, we expect accuracies within 10% of the true value, based on previous results obtained by laboratories participating in performance evaluations.

Bias is evaluated by the use of field and laboratory blanks.

4.2 Precision

Precision of biological sampling will be evaluated by performing analyses on field duplicates of biological community measurements at 10% of the sites. The data quality objective for precision is IBI scores of duplicates within 10% of the mean score.

Sample 1 IBI / (Sample 1 IBI + Sample 2 IBI / 2) is less than 0.1

Habitat assessments are conducted at each site by the same crew member. At one site a duplicate assessment will be conducted by a second trained biologist. If data differs by more than 10% in total QHEI assessment scores, then biologists will discuss and attempt to reach a consensus. Adjustments to assessment scores are then documented and made in the data set.

Precision of the field chemical analyses, as given by the manufacturer of the equipment to be used is:

pH	0.1 SU
Temperature	0.5 degrees C
Dissolved Oxygen	0.1 mg/l

Precision of the laboratory chemical analyses is expected to result in chemical recoveries of 95 to 105%. Precision will be measured by analyzing the results of duplicate samples collected in the field and measuring the relative percent difference.

4.3 Completeness

Completeness for IBI and chemical measurements should be 90% or 9 valid samples for each sampling period.. Completeness is defined as:

Completeness = v/n * 100

where: v = number of samples determined to be valid;
n = total number of measurements necessary to achieve project objectives.

4.4 Representativeness

The samples collected for chemical and biological analysis should be representative of the biological health of the site where the sample is collected. To assure representativeness, all samples will be collected on the same day, using the same collection technique from the same habitat. The sites that have been selected for analysis represent the entire watershed.

4.5 Comparability

Comparability is ensured through the use of identical sampling techniques at each sample site. There are no historical samples of water quality to compare the results to.

5.0 FIELD PROCEDURES

Fish will be collected by D.C. electrofishing, using methods outlined in the attached Standard Operating Procedures. All fish collected will be retained and kept in a live well until the zone is completed. Individuals will be counted, batch weighed by species, and minimum and maximum lengths recorded. Each sampling zone will consist of a distance of at least 100 m.

Benthic macroinvertebrates will be collected by dipnet from riffle areas using EPA Rapid Bioassessment Protocol III (U.S.EPA, 1999).

Chemical sampling will consist of grab samples collected from pooled areas. High density plastic containers will be used to collect the samples. The containers for E.coli will be pre-sterilized. Samples for ammonia analysis will be preserved with sulfuric acid. All samples will be placed on ice for transport to Commonwealth Biomonitoring’s lab. Table 2 summarizes the sampling conditions to be used.

Table 2. Summary of sampling methods, containers, preservatives, and holding times.

Parameter	Method	Containers	Preservative	Holding Time

E.coli	SM 9223 B	Sterile, plastic	None	6 hours
Total Suspended Solids	SM 2540	Plastic	None	seven days
CBOD	SM 5210 B	Plastic	None	48 hours
Ammonia	SM 4500 NH3	Plastic	H2SO4	28 days

Sample conditions

Biological sampling will be conducted during low- to moderate-stable periods. Periods of high flow will be avoided. Chemical sampling will occur within 24 hours of the biological sampling.

Habitat

Qualitative habitat will be measured using the protocol developed by Ohio EPA (1989).

Field Chemistry and Physical Measurements

Dissolved oxygen, pH, temperature, and flow will be measured in the field. A Hanna Instruments multiprobe meter will be used for pH and temperature. A YSI Model 54A D.O. meter will be used for dissolved oxygen. A current velocity meter will be used to estimate flow.

6.0 LABORATORY PROCEDURES

Laboratory Chemistry

The remaining water quality parameters not measured in the field will be measured in the laboratory, using standard operating procedures outlined in Appendix 2.

Macroinvertebrates

Macroinvertebrate samples will be preserved with 70% isopropanol and returned to the lab. In the lab, each sample will be spread onto a grid and randomly selected grids will be completely picked until a 100 organism subsample is obtained. All macroinvertebrates in the subsample will be identified to genus or species (if possible).

7.0 CUSTODY PROCEDURES

Sample custody will begin with the crew chief and samples are to remain in the custody of the field team until the samples are returned to the appropriate laboratory shipping and receiving room for entering into the sample tracking system. A chain-of-custody form will be completed for all samples. This form will include the sample date, sample time, sample site, and ther name of the person collecting the sample. An example chain-of-custody form is attached in the appendix.

All sample sites will be assigned a designated number. Sites will be consecutively numbered and all standardized data forms generated from a site will be indexed and computerized according to that number.

Containers will be preserved, labeled, and placed in a sealed cooler for transport to the laboratory. Samples will be retained in the laboratory under chain-of-custody procedures. Samples will be inspected for leakage or damage from transport weekly. Loss of fluid preservatives for community samples will be replaced. Taxonomic composition and relative abundance information is submitted to the Project Manager.

All raw data (including data forms, logbooks, etc.) are retained by the Project Manager in an organized fashion and archived for future reference.

8.0 CALIBRATION PROCEDURES AND FREQUENCY

Instruments for field chemical measurements (D.O., temperature, and pH) will be calibrated at the beginning of each day they are used, according to the manufacturer's instructions.

9.0 PREVENTATIVE MAINTENANCE

The field crew leader is responsible for maintaining all files for all field equipment. Individual team members may be given responsibility for different equipment and its deployment in the field. All nets will be inspected at the completion of each site for holes caused by snagging or other damage. The nets will be repaired immediately.

A list of critical spare parts that should always accompany field sampling surveys to minimize downtime follows:

- DC electrofisher and gear
- 70% isopropanol
- Dipnet
- Macroinvertebrate sample containers

- Macroinvertebrate sieve
- All equipment required in Standard Operating Procedures.
- QAPP

10.0 DATA REDUCTION, REVIEW AND REPORTING

10.1 Raw Data

Raw data for fish and macroinvertebrates will be in the form of species or genus names and numbers for the biological assessment and in appropriate quantitative values for the habitat assessment.

10.2 Data Reduction

The macroinvertebrate data will be analyzed using Ohio EPA metrics (Ohio EPA, 1989) for the Eastern Corn Belt Ecoregion (Omernick, 1987).. The IBI metrics for this study are shown in Table 2.

Table 2. SCORING VALUES FOR METRICS
Adapted from Ohio EPA and U.S. EPA RBA Protocol III.

	6 points	4 points	2 points	0 points
# of Genera	**>20**	**14 - 20**	**7 - 13**	**<7**
# Mayfly Taxa	**> 6**	**4 - 6**	**2 - 4**	**<2**
# Caddisfly Taxa	**> 4**	**3 - 4**	**1 - 2**	**0**
# Diptera Taxa	**>12**	**8 - 12**	**4 - 7**	**<4**
% Tanytarsini	**>25**	**11 - 25**	**1 - 10**	**0**
% Mayflies	**>25**	**11 - 25**	**1 - 10**	**0**
% Caddisflies	**>20**	**11 - 19**	**1 - 10**	**0**
% Tolerant Species	**0-10**	**11 - 20**	**21 - 30**	**>30**
% non-Tanytarsids & non-insects	**<25**	**25 - 45**	**46 - 65**	**>65**
% Dominant Taxon	**<20**	**21-29**	**30-39**	**>40**

The scores for each metric (0 to 6) will be added (10 metrics) to calculate an IBI score for each site (a range of scores from 0 to 60).

The fish data will be used to calculate an Index of Biotic Integrity score using the scoring technique developed by Simon and Dufour for the Eastern Corn Belt Plain of Indiana.

10.3 Data Review

All chemical data will be checked for completeness before leaving a site. Data collected in the laboratory will be checked to assure that the required metrics can be calculated. Data sheets from each site are checked by the field crew leader to verify accuracy and completeness.

10.4 Data Reporting

Biological data will be reported by the names and numbers of the species collected. The IBI will be reported as a value between 0 and 100 Habitat data will be reported as a number between 0 and 100.

Chemical data will be turned over to the watershed coordinator so it can be incorporated into the watershed management plan.

11.0 QUALITY CONTROL PROCEDURES

Standard quality control procedures described by Cuffney et al. (1993) for biological assessments will be employed in this study. These include checks of identification and enumeration of macroinvertebrates by two different experts at one site during each sampling season.

Voucher specimens of all macroinvertebrate species collected will be retained and placed in the Purdue University Entomology collection for future reference and inspection by qualified biologists, for checks on species identifications, if necessary

Habitat assessments are conducted at each site by the same crew member. At one site a duplicate assessment will be conducted by a second trained biologist. If data differs by more than 10% in total QHEI assessment scores, then biologists will discuss and attempt to reach a consensus. Adjustments to assessment scores are then documented and made in the data set.

Field chemistry quality control procedures include the analysis of duplicate samples at ten percent of all sample sites.

Laboratory quality control procedures include the analysis of spikes, duplicates, and method blanks every tenth sample (see Appendix 2). A single field blank for each parameter will be prepared and analyzed for the one chemistry sampling event [a 10% field blank frequency].

12.0 DATA QUALITY ASSESSMENT

Specific procedures for assessment of precision and accuracy on a routine basis are outlined and described in section 4.0. The data will be evaluated after each sampling event to assure that the data quality objectives are being met. If data fall outside the project goals of the Data Quality Objectives in Section Four, the laboratory will take corrective action, as stated in Section Fourteen.

13.0 PERFORMANCE AND SYSTEMS AUDITS

Internal performance and system audits required to monitor the capability and performance of the laboratories will be conducted on appropriate log sheets, data sheets, verification sheets, and calibration equipment log sheets at each site in the field and after each of the two sampling seasons after all data have been collected.. All laboratory audits will be conducted by the Project Manager. Calibration logs will be made available to IDEM staff upon request for an external audit.

14.0 CORRECTIVE ACTION

Most of the biological samples will be analyzed by one taxonomic expert (the project manager) to provide consistency between samples. One sample each sampling period will be analyzed by two different people. If there is more than 10% variance in sample numbers, identifications, or IBI scores, the samples will be analyzed again by the project manager. Discrepancies in identification and counts will be noted for that sample. Differences in identification of a particular organism will be discussed between the two to arrive at a consensus. Consultation of an outside taxonomist may be necessary. Changes will be made based on the consensus conclusion.

If water chemistry analyses fall outside the objectives listed in Section Four or if field blanks indicate contamination, the lab or field personnel will not analyze any additional samples until a cause for the discrepancy has been identified. Sample results collected during this time will not be discarded but will be identified as potentially suspect. If field blanks indicate contamination, the data reports will identify the contamination. Field blank results that indicate contamination greater than the following limits will result in data being rejected:

E.coli	3 cfu/100 ml
TSS	3 mg/l
CBOD	3 mg/l
Ammonia	0.5 mg/l

15.0 QUALITY ASSURANCE REPORTS

A single report will be prepared by the project manager and will include all pertinent information relating to measurement data accuracy, precision, and completeness, as outlined in the Standard Operating Procedures and this Quality Assurance Program Plan.

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U.S. EPA, 1999. Rapid bioassessment protocols: 2nd edition. EPA 841-B-99-002.

Simon, T.P. and R. Dufour, 1998. Development of index of biotic integrity expectations for the ecoregions of Indiana. V. Eastern Corn Belt Plain. EPA 905-R96-004. EPA Region 5, Chicago, IL.

TELWF, 2002. Upper Tippecanoe River Watershed Management Plan. Tippecanoe Lake and Watershed Foundation, North Webster, IN.

APPENDIX I.

Sampling Sites

Site 1 - outlet of Big Lake
Site 2 - outlet of Loon Lake
Site 3 - Elder Ditch at the Kosciusko/Whitley County line
Site 4 - outlet of Robinson Lake
Site 5 - Shanion Ditch at CR 900 E
Site 6 - outlet of Ridinger Lake
Site 7 - Tippecanoe River below the Wilmot Mill Pond
Site 8 - Tippecanoe River below Webster Lake
Site 9 - Grassy Creek inlet to Tippecanoe Lake
Site 10 - Tippecanoe River below Tippecanoe Lake

14-digit Subwatersheds

05120106010010	Crook Lake/Big Lake outlet
05120106010020	Loon Lake outlet
05120106010030	Smalley Lake outlet
05120106010040	Webster Lake outlet
05120106010050	Elder Ditch/Cedar Lake outlet
05120106010060	Grassy Creek/Robinson Lake outlet
05120106010070	Grassy Creek/Big Barbee Lake outlet
05120106010080	Tippecanoe Lake outlet

APPENDIX 2. - Standard Operating Procedures for Laboratory Water Chemistry

Ammonia
Total Suspended Solids
E.coli
BOD5

Total Suspended Solids (TSS)

Reference

Standard Method 18th Edition for the Examination of Water and Wastewater, 2540; A, B, or C.

Sample Handling and Preservation

Samples are to be collected without any preservatives being added to them.

Apparatus and Materials

Analytical Balance
Drying Oven
Desiccator
Vacuum pump
Connection Tubing
Baking pans used in drying oven
Pre-weighed paper filters, with trays
Suction Flask
Membrane Filter
Membrane Filter Funnel
Clamp
Metal or Plastic tweezers

Reagents

Deionzied Water

Procedures

Assemble the suctioning apparatus to filtering apparatus.

Place the membrane filter inside the suction flask

On the TSS record sheet write down the pre-weighed filter number and weight in the correct spaces provided. Place that filter on top of the membrane filter, then place the membrane funnel and clamp the funnel down to the suction flask.

Shake the sample to have a representative sample.

Pour off 100 ml of sample into the filtering apparatus

Pump air out of the filtering appratus.

Rinse the sides of the beaker with deionzied water getting all particles off the walls of the beaker. Pour that into the membrane funnel with the rest of the sample. Once the sample has gone through the pre-weighed filter, rinse the funnel for any remaining particles.

After all water has been suctioned through the pre-weighed filter, turn off air manifold valve. Release the clamp. Remove the membrane funnel. Use the tweezers to remove the pre-weighed filter and place that filter in its original tray.

Before placing the next clean pre-weighed filter on the membrane filter, remember to clean the membrane funnel before the next sample is analyzed.

Place the tray in a baking pan that can be placed in the drying oven once the baking pan is full or all of the samples have been analyzed.

Weigh the filter after drying. Calculate TSS as the dry weight of the filter after drying minus then original weight of the filter.

Quality Assurance/Quality Control

There should be a duplicate analyzed every tenth sample.

E. coli

Location

This procedure is performed in the bacteriological laboratory.

Purpose

This method is used to determine the Most Probable Number of Escherichia coli (E. coli) in wastewater, potable waters, and all other water matrixes.

Scope

This procedure uses the m-coliblue medium to determine the MPN for the E. coli present.

Reference

Standard Methods 20th Edition – Method 9223 B

Sample Handling and Preservation

Samples are to be collected in a sterile bottle provide by the lab.

Apparatus and Materials

m-coliblue media
petri dish with sterile pad
Incubator
Sterile filter
Sterile filtering mechanism
Vacuum pump

Procedures

Place a sterile filter on the sterile filtering mechanism
Pour 100 ml of sample into the filtering mechanism
Draw the sample through the filtering mechanism with a vacuum pump
Remove the filter and place in a Petri dish with m-coliblue media
Place dish into incubator at 35 degrees C and wait 24 hours.
Count the number of blue colonies, which is equivalent to CFU/mL

Quality Assurance/Quality Control

A blank sample is analyzed with every batch, to provide assurance of a contamination free work area for that day. Duplications are analyzed every tenth sample.

CBOD5

Location

This procedure is performed in the chemistry laboratory.

Purpose

This method is used to determine the five-day carbonaceous biological oxygen demand of a water sample.

Scope

This procedure uses measurements of oxygen in an enclosed water sample at the beginning and end of a five-day monitoring period.

Reference

Standard Methods 20th Edition – Method 5210 B

Sample Handling and Preservation

Samples are collected in a plastic bottle supplied by the lab. No preservatives are used.

Apparatus and Materials

BOD bottles
oxygen meter
water bath

Reagents

BOD seed

Procedures

Pour the sample into a BOD bottle. Add BOD seed. Determine initial dissolved oxygen concentration. Incubate the sample at 20 degrees C for five days. Determine the final dissolved oxygen concentration.

Quality Assurance/Quality Control

A blank sample is analyzed with every batch. A seed control is measured with every batch. Duplications are analyzed every tenth sample.

Ammonia

Location

This procedure is performed in the chemistry laboratory.

Purpose

This method is used to determine the concentration of total ammonia as nitrogen.

Scope

This procedure uses a specific ion probe to measure ammonia in water.

Reference

Standard Methods 20th Edition – Method 4500 NH3

Sample Handling and Preservation

Samples are collected in a plastic bottle with sulfuric acid preservative.

Apparatus and Materials

Specific ion probe and meter
30 ml beaker
magnetic stir bar and stirrer
sodium hydroxide

Calibration

Calibrate the probe each day using ammonia standards of 0.1, 1, and 10 mg/l.

Procedures

Pour the sample into the 30 ml beaker. Place a stir bar in the beaker and start mixing. Place the specific ion probe in the water above the stir bar. Add sodium hydroxide to raise pH to greater than 12. Record the meter mv reading after it stabilizes. Calculate ammonia concentration from calibration lines.

Quality Assurance/Quality Control

A blank sample is analyzed with every batch. Duplicates are analyzed every tenth sample.

Commonwealth Biomonitoring, Inc
8061 Windham Lake Drive
Indianapolis, IN 46214
317-297-7713

SAMPLE SUMMARY AND CHAIN OF CUSTODY

PROJECT NAME:

PURPOSE OF SAMPLE:

SAMPLE IDENTIFICATION NUMBERS:

DESCRIPTION:

DATE SAMPLE COLLECTED:

NAME OF PERSON COLLECTING SAMPLE:______________________

VOLUME OF SAMPLE:

SAMPLE CONTAINER:

NUMBER OF CONTAINERS:

SAMPLE STORAGE:

PRESERVATIVES:

Relinquished by:____

Date:_________________________
Time:_________________________

Received by:____

Date:_________________________
Time:_________________________

COMMENTS:

STANDARD OPERATING PROCEDURE

FOR

BENTHIC MACROINVERTEBRATES

Commonwealth Biomonitoring
Indianapolis, Indiana

April 2005

Sampling Procedure: **Dependent on the study objectives and habitat**

Sorting Procedure:

The sample is first thoroughly rinsed in a 500 micron screen or a sampling net to remove fine sediments. Any large organic material (whole leaves, twigs, algal and macrophyte mats) should rinsed thoroughly, visually inspected, and discarded from the sample.

The sample contents are placed in a large, flat pan (approximately 30x45 cm or so) with a light colored bottom. The bottom of the pan will be marked with a numbered grid pattern. Each grid will measure 5x5 cm. Organisms should be evenly distributed in the pan. Samples too large to be effectively sorted in a single pan may be thoroughly mixed in a container with some water, half of the homogenized sample placed in each of two gridded pans. Each half of the sample must be composed of the same kinds and quantity of debris and an equal number of grids must be sorted from each pan, in order to ensure a representative subsample. Also since the samples will be preserved in alcohol it will be necessary to soak the sample contents in water for about 15 minutes to hydrate the benthic organisms, preventing them from floating on the water surface during sorting. Use only enough water to allow complete dispersion of the sample within the pan. An excessive amount of water will allow sample material to shift within the grid during sorting.

A random numbers table is used to select a number corresponding to a square within the gridded pan. Remove all organisms from within that square and proceed with the process of selecting squares and removing organisms until the total number sorted from the sample is within 10% of 100. Any organism which is lying over a line separating two squares is considered to be in the square containing its head. In those cases where it is not possible to determine the location of the head (e.g. worms), the organism is considered to be in the square containing the largest portion of its body. Any square sorted must be sorted in its entirety, even after the 100-organism count has been reached. If many of the organisms are very small use an illuminated 5X magnifier to facilitate sorting.

Organism Identification:

All benthic macroinvertebrates in the subsample should be identified to the lowest positively identified taxonomic level (generally genus or species), enumerated, and recorded on the laboratory bench sheet. This accomplished in two phases. Phase I consists of Family level identification of the organisms for a sample and tallying the counts for the families on the computer generated bench sheet for that sample. Organisms are put in alcohol filled 5 dram vials by taxonomic Order and placed in large alcohol filled jars labelled with their respective Orders. HBI and EPT:Chironomiidae calculations are made for preliminary site assessment. Also the preliminary number of taxa, number of individuals in the sample, taxonomist, date and number of vials forwarded are also recorded.

Phase II is for final organism identification to genus/species level (if possible). Each Order has been assigned to a "biologist" and he/she is responsible for identification of all samples in that order. Phase II tallying is recorded on the back side of the above laboratory bench sheet for that sample. Taxonomic Order, Family, organism name, count, life stage, taxonomist and date are recorded. Based on the taxonomic identifications, functional feeding group classifications can be assigned for most aquatic insects using a reference such as Merritt and Cummins (1984). Once a functional feeding group classification list has been established, it can be incorporated into the computer analysis for computation of the metrics. Care should be taken to note the presence of early instars which may represent different functional feeding groups from later instars. The scraper and filtering collector functional groups are considered the important indicators in the riffle/run community; numbers of individuals representing each of these two groups are recorded on the laboratory bench sheet (Figure).

CPOM Functional Feeding Group Determination:

The CPOM sample was collected to provide data on the relative abundance of the shredders at the site. Shredders of large particulate material are important in forested areas of stream ecosystems ranging from stream orders 1 through 4 (Minshall et al., 1985). The absence of large particulate shredders is characteristic of unstable, poorly retentive headwater streams in disturbed watersheds or in dry areas where leaf material processing is accomplished by terrestrial detritivores (Minshall et al., 1985).

CPOM samples are processed separately from the riffle/run samples and used for Functional Feeding Group characterization.

Taxonomic identification is not necessary for this component. Sorted organisms (see above) are classified by functional feeding group. Numbers of individuals representing the shredder functional group, as well as total number of macroinvertebrates collected in this sample, are recorded on the CPOM laboratory bench sheet.

Mounting Chironomidae:

Members of this family are mounted directly from the 80% alcohol preservative in which they have been stored in the initial phase I taxonomy. Two drops of mounting medium is placed on each slide allowing enough room for a label on the left end of the slide. Working under the dissection microscope if necessary a group of approximately 10 larvae are gathered up and picked up with a pair of forceps. While holding them firmly with the forceps touch them lightly to a paper towel to remove excess alcohol. This is accomplished by capillary action and there is no need to release the larvae from the forceps. The 10 larvae are then placed into a drop of medium on the microscope slide. This is repeated again to deliver larvae into the other drop of medium previously placed on the slide. The next step is to place the slide under the microscope and pull the larvae into parallel lines within the drop of medium orienting the heads in the same direction (to the right if you are right handed). Once both drops have had their respective larvae arranged the operator should, larvae by larvae, with two minuten needles pop the heads off and orient them ventral side up and tap the head to spread the mandibles. These slides should then have a microscope slide label attached to it containing all the information found on the vial label. Always label all slides with a label prior to processing another sample. This avoids all possibility of mislabeled slides due to sample manipulations.

SAFETY AND WASTE HANDLING

Preserved specimens are handled carefully to avoid skin contact. Waste preservatives are discarded in the sink and flushed with generous amounts of water.

LABORATORY QA/QC

INTRODUCTION:

Comprehensive QA/QC is an end product of careful expediting both the field and laboratory components of the overall project. The whole QA/QC of such a project, particularly when several people of various levels of experience are directly involved in its completion, starts with comprehensive record keeping of all activities. Many such projects compromise the integrity of the final data sets by poor record keeping including inaccurate site descriptions, unreliable labeling of samples, unreliable tracking of specimens, improper curation of samples, lack of voucher specimens, inconsistent taxonomic identifications, absence of cross-checks on data entry and retrieval, etc.

LAB DUPLICATES--Laboratory duplicates are to be carried out on all samples collected at sites where field duplicates were acquired. The two field samples, one being a field duplicate, are each subsampled one additional time in the laboratory to create 2 laboratory duplicates. The staff person performing the subsample must enter certain information into the record in the Laboratory Notebook.

SAMPLE LABELING- Consistent and conscientious record keeping in the field was the foundation for proper sample identification. This is especially critical when large numbers of samples are being taken over a relatively short period of time. The value of any field collection is contingent on the accuracy of the label associated with that sample relative to the where, when, who, and how of its collection. Samples are collected into 1/2 gallon jars and a pre-printed label is filled out by the investigators and placed inside the jar. A tape label is placed on the lid telling the stream name and date. The internal label is the official sample label.

TAXONOMIC IDENTIFICATIONS--Accurate and consistent taxonomic identifications for benthos is critical for correct implementation of metrics associated with biocriteria. The lab supervisor is responsible for all QA/QC procedures and ultimate data consistency and uniformity. This project has resulted updating and standardizing taxonomic references within the laboratory. All staff have been given copies of these sources or have had copies made available to them.

METRICS CALCULATIONS

Each metric result is given a score based on percent comparability to a reference station or database. Scores are totaled and a Biological Condition Category is assigned based on percent comparability with the reference station score. Values obtained may sometimes be intermediate to established ranges and require some subjective judgment as to assessment of biological condition. In these instances, habitat assessment, physical characterization, and water quality data may aid in the evaluation process.

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STANDARD OPERATING PROCEDURE

FOR

FISH COMMUNITY SAMPLING

Commonwealth Biomonitoring
Indianapolis, Indiana

April 2005

Fish Collections

Fish are normally collected by DC electrofishing. All fish sampling gear types are generally considered selective to some degree; however, electrofishing has proven to be the most comprehensive and effective *single* method for collecting stream fishes. Pulsed DC (direct current) electrofishing is the method of choice to obtain a representative sample of the fish assemblage at each sampling station. As with any fish sampling method, the proper scientific collection permit(s) must be obtained before commencement of any electrofishing activities. The accurate identification of each fish collected is essential, and species-level identification is required (including hybrids in some cases).

Field identifications are acceptable; however, voucher specimens must be retained for laboratory verification, particularly if there is any doubt about the correct identity of the specimen. Because the collection methods used are not consistently effective for young-of-the-year fish and because their inclusion may seasonally skew bioassessment results, fish less than 20 millimeters total length will not be identified or included in standard samples.

***All field team members must be trained in electrofishing safety precautions and unit operation procedures identified by the electrofishing unit manufacturer.* Each team member must be insulated from the water and the electrodes; therefore, chest waders and rubber gloves are required. Electrode and dip net handles must be constructed of insulating materials (e.g., woods, fiberglass). Electrofishers/electrodes must be equipped with functional safety switches (as installed by virtually all electrofisher manufacturers). Field team members must not reach into the water unless the electrodes have been removed from the water or the electrofisher has been disengaged.**

***Many* options exist for electrofisher configuration and field team organization; however, procedures will always involve pulsed DC electrofishing and a minimum 2-person team for sampling streams and wadeable rivers. Examples include:**

- **Backpack electrofisher with 2 hand-held electrodes mounted on fiberglass poles, one positive (anode) and one negative (cathode). One crew member, identified as the electrofisher unit operator, carries the backpack unit and manipulates both the anode and cathode poles. The anode may be fitted with a net ring (and shallow net) to allow the unit operator to net specimens. The remaining 1 or 2 team members net fish with dip nets and are responsible for specimen transport and care in buckets or livewells.**

- **Backpack electrofisher with 1 hand-held anode pole and a trailing or floating cathode. The electrofisher unit operator manipulates the anode with one hand, and has a second hand free for use of a dip net. The remaining 1 or 2 team members also aid in the netting of specimens, and in addition are responsible for specimen transport in buckets or livewells.**

- **Tote barge (pramunit) electrofisher with 2 hand-held anode poles and a trailing/floating cathode (recommended for large streams and wadeable rivers). Two team members are each equipped with an anode pole and a dip net. Each is responsible for electrofishing and the netting of specimens. The remaining team member will follow, pushing or pulling the barge through the sample reach. A livewell is maintained within the barge and/or within the sampling reach but outside the area of electric current.**

The safety of all personnel and the quality of the data is assured through the adequate education, training, and experience of all members of the fish collection team. At least 1 biologist with training and experience in electrofishing techniques and fish taxonomy *must* be involved in each sampling event. Laboratory analyses are conducted and/or supervised by a fisheries professional trained in fish taxonomy. Quality assurance and quality control must be a continuous process in fisheries monitoring and assessment, and must include all program aspects (i.e., field sampling, habitat measurement, laboratory processing, and data recording).

Field Sampling Procedures

FIELD EQUIPMENT/SUPPLIES NEEDED FOR FISH SAMPLING--ELECTROFISHING

- **appropriate scientific collection permit(s)**
- **backpack or tote barge-mounted electrofisher**
- **dip nets**
- **block nets (i.e., seines)**
- **elbow-length insulated waterproof gloves**
- **chest waders (equipped with wading cleats, when necessary)**
- **polarized sunglasses**
- **buckets/livewells**
- **jars for voucher/reference specimens**
- **waterproof jar labels**

- **10% buffered formalin (formaldehyde solution)**
- **measuring board (500 mm minimum, with 1 mm increments)[a]**
- **balance (gram scale)[b]**
- **tape measure (100 m minimum)**
- **fish Sampling Field Data Sheet[c]**
- **applicable topographic maps**
- **copies of field protocols**
- **pencils, clipboard**
- **first aid kit**
- **Global Positioning System (GPS) Unit**

[a] Needed only if program/study requires length frequency information
[b] Needed only if total biomass and/or the Index of Well-Being are included in the assessment process (see Section 8.3.3, Metric 13).
[c] It is helpful to copy fieldsheets onto water-resistant paper for use in wet weather conditions.

A representative stream reach (see Alternatives for Stream Reach Designation, next page) is selected and measured such that primary physical habitat characteristics of the stream are included within the reach (e.g., riffle, run and pool habitats, when available). The sample reach should be located away from the influences of major tributaries and bridge/road crossings (e.g., sufficiently upstream to decrease influences on overall habitat quality). The exact location (i.e., latitude and longitude) of the downstream limit of the reach must be recorded on each field data sheet. (If a Global Positioning System unit is used to provide location information, the accuracy or design confidence of the unit should be noted.) A habitat assessment and physical/ chemical characterization of water quality should be performed within the same sampling reach (see Chapter 5: Habitat Assessment and Physicochemical Characterization).

Collection via electrofishing begins at a shallow riffle, or other physical barrier at the downstream limit of the sample reach, and terminates at a similar barrier at the upstream end of the reach. In the absence of physical barriers, block nets should be set at the upstream and downstream ends of the reach prior to the initiation of any sampling activities.

Fish collection procedures commence at the downstream barrier. A minimum 2-person fisheries crew proceeds to electrofish in an upstream direction using a side-to-side or bank-to-bank sweeping technique to maximize area

coverage. All wadeable habitats within the reach are sampled via a single pass, which terminates at the upstream barrier. Fish are held in livewells (or buckets) for subsequent identification and enumeration.

- **Sampling efficiency is dependent, at least in part, on water clarity and the field team's ability to see and net the stunned fish. Therefore, each team member should wear polarized sunglasses, and sampling is conducted only during periods of optimal water clarity and flow.**

- **All fish (greater than 20 millimeters total length) collected within the sample reach must be identified to species (or subspecies). Specimens that cannot be identified with certainty in the field are preserved in a 10% formalin solution and stored in labeled jars for subsequent laboratory identification (see Section 8.2). A representative voucher collection must be retained for unidentified specimens, very small specimens, new locality records, and/or a particular region. In addition to the unidentified specimen jar, a voucher collection of a subsample of each species identified in the field should be preserved and labeled for subsequent laboratory verification, if necessary. Obviously, species of special concern (e.g., threatened, endangered) should be noted and released *immediately* on site. Labels should contain (at a minimum) location data (verbal description and coordinates), date, collectors' names, and sample identification code and/or station numbers for the particular sampling site. Young-of-the-year fish less than 20 millimeters (total length) are not identified or included in the sample, and are released on site. Specimens that can be identified in the field are counted, examined for external anomalies (i.e., deformities, eroded fins, lesions, and tumors), and recorded on field data sheets. Space is available for optional fish length and weight measurements, should a particular program/study require length frequency or biomass data. However, these data *are not required* for the standard multimetric assessment. Space is allotted on the field data sheets for the *optional* inclusion of measurements (nearest millimeter total length) and weights (nearest gram) for a subsample (to a maximum 25 specimens) of each species. Although fish length and weight measurements are optional, recording a range of lengths for species encountered may be a useful routine measure. Following the data recording phase of the procedure, specimens that have been identified and processed in the field are released on site to minimize mortality.**

QUALITY CONTROL (QC) IN THE FIELD

Quality control must be a continuous process in fish bioassessment and should include all program aspects, from field collection and preservation to habitat assessment, sample processing, and data recording. Field validation should be conduced at selected sites and will involve the

collection of a duplicate sample taken from an adjacent reach upstream of the initial sampling site. The adjacent reach should be similar to the initial site with respect to habitat and stressors. Sampling QC data should be evaluated following the first year of sampling in order to determine a level of acceptable variability and the appropriate duplication frequency.

Field identifications of fish *must* be conducted by qualified/trained fish taxonomists, familiar with local and regional ichthyofauna. Questionable records are prevented by: (a) requiring the presence of at least one experienced/trained fish taxonomist on every field effort, and (b) preserving selected specimens. Specimens must be properly preserved and labeled. When needed, chain-of-custody forms must be initiated following sample preservation, and must include the same information as the sample container labels.

All field equipment must be in good operating condition, and a plan for routine inspection, maintenance, and/or calibration must be developed to ensure consistency and quality of field data. Field data must be complete and legible, and should be entered on standardized field data forms and/or digital recorders. While in the field, the field team should possess sufficient copies of standardized field data forms and chains-of-custody for all anticipated sampling sites, as well as copies of all applicable Standard Operating Procedures (SOPs).

The data collection phase includes the completion of the top portion of the "Fish Sampling Field Data Sheet", which duplicates selected information from the physical/chemical field sheet. Information regarding the sample collection procedures must also be recorded. This includes method of fish capture, start time, ending time, duration of sampling, maximum and mean stream widths. The percentage of each habitat type in the reach is estimated and documented on the data sheet. Comments should include sampling conditions, e.g., visibility, flow, difficult access to stream, or anything that may prove to be valuable information to consider for future sampling events or by personnel unfamiliar with the site.

LABORATORY IDENTIFICATION AND VERIFICATION

QUALITY CONTROL (QC) FOR TAXONOMY

A representative voucher collection must be retained for unidentified specimens, small specimens, and new locality records.

Voucher collections should be verified by a second qualified fish taxonomist, i.e., a professional other than the taxonomist responsible for the original field identifications. The word "validated" and the name of the taxonomist that validated the identification should be added to each voucher label.

A library of taxonomic literature is essential for the aid and support of identification/verification activities, and must be maintained (and updated as needed) in the laboratory.

Fish records of questionable quality are prevented by preserving specimens (that cannot be readily identified in the field) for laboratory examination and/or a voucher collection for laboratory verification. Specimens will be properly preserved (e.g., 10% formalin for tissue fixing and 70% ethanol for long-term storage) and labeled. Labels will contain site location data (i.e., verbal description and site coordinates), collection date, collector's names, species identification (for fishes identified in the field), and sample site number. Laboratory fisheries professionals *will* be capable of identifying fish to the lowest possible taxonomic level (i.e., species or subspecies) and will have access to suitable regional taxonomic references to aid in the identification process. Taxonomic nomenclature *will* kept consistent and current.

DELT [Deleterious Lesions and Anomalies] and Hybridization

All fish weighed individually or subsampled are examined for the presence of gross external anomalies and their presence recorded on the data sheets. Incidence is defined as the presence of externally visible morphological disorders (i.e. diseases, eroded fins, lesions, and tumors) and is expressed as percent (i.e. based percent incidence) weighted of afflicted fish.

Incidence of occurrence is computed for all anomalies for every species at each segment. A total percent occurrence for a specific anomaly can be calculated for the entire study area. Incidence is computed as a weighted number (i.e. based on percent incidence in weighed fish times the total number of the fish species in the sample).

Specific anomalies include: fin rot; Aeromonas (causes ulcers, lesions, and skin growth, and formation of pus-producing surface lesions accompanied by scale erosion); dropsy (puffy body); swollen eyes; fungus; ich; curved spine; and swollen

bleeding mandible or opercle. Deformed fishes should be photographed or preserved in 10% formalin to be available for confirmation of deformity.

Hybrid species encountered in the field should be documented as weighted averages for particular taxonomic groups (e.g. centrarchids, cyprinids). Hybrids are recorded on the data sheet and if possible potential parental combinations recorded.

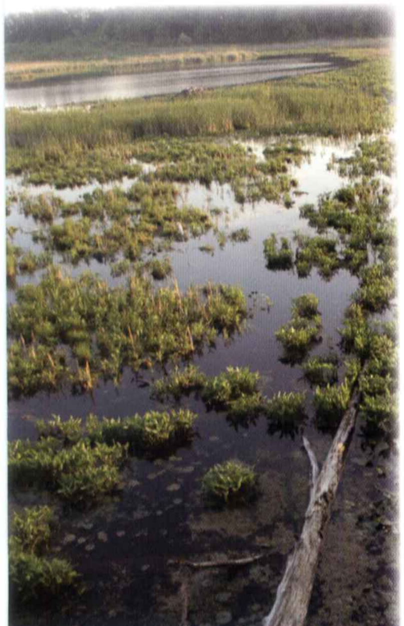
Protecting Our Lakes Benefits You

Protecting the quality of Kosciusko County's lakes provides direct benefits to you, your neighbors and your community.

The natural beauty of our lakes helps entice economic development to Kosciusko County. Economic development means more jobs, more revenue, lower taxes and greater opportunity for all.

Local lake protection:

- Maintains property values
- Provides recreational opportunities
- Drives economic development
- Attracts businesses
- Creates jobs
- Protects the county's greatest fiscal asset
- Results in a higher quality of life



"A lake is the landscape's most beautiful and expressive feature."

Henry David Thoreau

Join Us in Protecting Kosciusko County's Lakes

Organizations such as the following are working to protect and preserve Kosciusko County's lakes and waterways for you and for your children. Please join us.

- Barbee Lake Property Owners Association
- Beaver Dam Lake Conservation Club
- Center Lake Conservation Association
- Chapman Lakes Conservation Association
- Dewart Lake Protective Association
- Lake Tippecanoe Property Owners
- Pike Lake Conservation Association
- Silver Lake Conservation Association
- Tippecanoe Environmental Lake & Watershed Foundation
- Yellow Creek Lake Conservation Club
- Winona Lake Preservation Association
- Webster Lake Conservation Association
- Wawasee Area Conservancy Foundation

For more information about how you can help protect our lakes, please contact us:

LAKE TIPPECANOE

Lake Tippecanoe Property Owners
P.O. Box 224
Leesburg, IN 46538
www.ltpo.org
(574) 453-3560

Chapman Lakes Conservation Association
www.chapmanlake.com

Kosciusko County Lakes Need Our Protection

Kosciusko County residents have a plan to save our lakes!

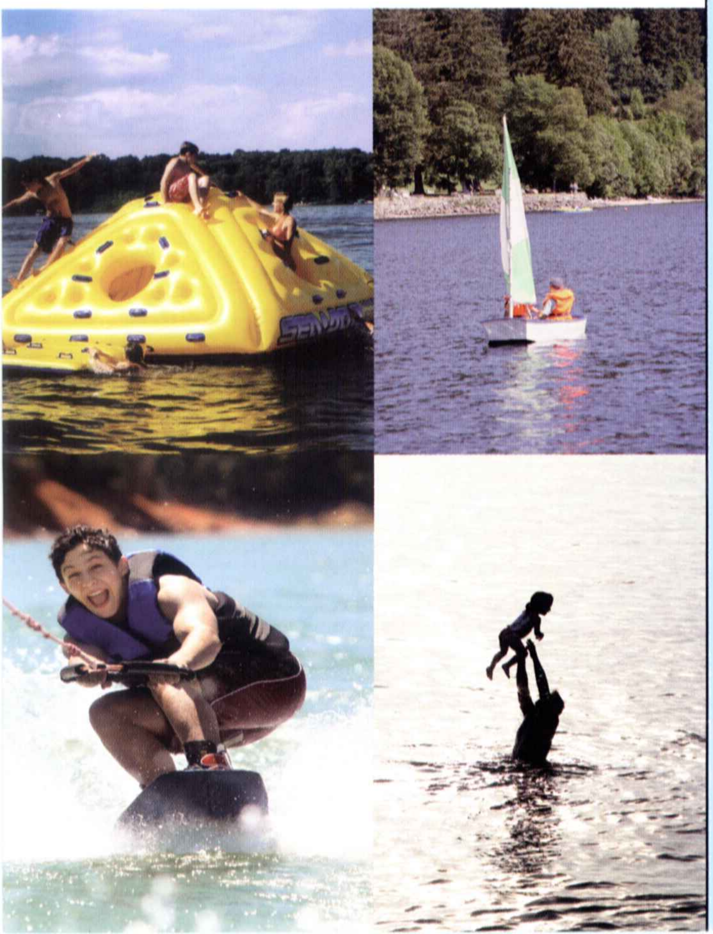
LAKE TIPPECANOE

The Lakes of Kosciusko County

Kosciusko County lakes contribute directly to the great life we all enjoy.

Today, our lakes face environmental threats as never before.

Now is the time to protect them!



Protecting Our Lake Heritage

A coalition of Kosciusko County residents is working to preserve and protect our lake heritage. These groups are concerned about damage caused by pollution, overdevelopment, overuse, erosion and non-native aquatic species.

A recent survey of thousands of local lakefront property owners found that 75 percent believe the environmental quality of their lakes is threatened by development. It also found that 78 percent believe that government should take action to protect lake quality.

Key to this effort is the adoption of a new county zoning ordinance, which will preserve and protect our lakes now and in the future.

This ordinance will not impact current property owners, nor will it cost the county or county residents tax dollars.

Today, Kosciusko County's lakes face the potential for unprecedented deterioration.

The watershed is bearing increasing population, pollution and traffic. Water quality problems associated with direct lakeshore development have the potential to dramatically damage our lakes.

Recent studies in Maine and Minnesota have explored the relationship between lake water quality and economics. Those studies show that local quality of life sinks when the quality of local lakes declines. *

Since 1975, Kosciusko County has had a single zoning classification for residential property, whether on a lake or not. While adequate in most circumstances, it does not recognize the special importance and heritage of our riparian life.

A new Lake Residential zoning ordinance will recognize that unfettered development, overuse, pollution and noise pose a threat to the quality of Kosciusko County's lakes.

The new ordinance would establish a lakefront property zone that would apply to all property now zoned Residential and located within one-half mile of the shoreline of natural public lakes greater than 10 acres in size.

The new zoning category would limit new housing to single-family and duplex homes with minimums on lot size and lake frontage. Additional commercial development within the new lake residential district would not be permitted.

The quality of our lives is closely linked to the quality of our lakes.

* The Economics of Lakes; Maine Department of Environmental Protection; March 2000. Lakeshore Property Values and Water Quality; Legislative Commission on Minnesota Resources; June 2003.

2011 Addendum to the Upper Tippecanoe Watershed Management Plan

In 2008, the Tippecanoe Environmental Lake and Watershed Foundation (TELWF) revised its name to the Tippecanoe Watershed Foundation (TWF).

In 2006, the Tippecanoe Watershed Foundation received a Lake and River Enhancement (LARE) grant from the Indiana Department of Natural Resources (IDNR) for the development of a Watershed Management Plan (WMP)/Diagnostic Study for the seven lakes in the uppermost part of the Tippecanoe watershed. The lakes include Big, Crane, Crooked, Old, New, Goose, and Loon. These lakes are represented by the Upper Tippecanoe River Lakes Association (UTRLA). In the 2006 WMP, many Loon, Goose, Crooked and Big lakes sites were incorporated into the Smalley Watershed's critical areas list. The addendum strives to more accurately reflect the true location of the critical areas within smaller demographical subwatersheds.

The UTRLA Watershed Management Plan was completed by Williams Creek Consulting, Inc. in cooperation with Commonwealth Biomonitoring and Empower Results, LLC in July 2008. This plan resulted in the development of site specific recommendations for critical areas in two subwatersheds (Loon/Goose and Big/Crooked).

In addition, TWF developed a Technical Advisory Committee (TAC) in 2008 to provide annual review of the Watershed Management Plan, develop a reporting process, and make revisions. The TAC met in December 2008 and December 2009 (participant list attached). TAC participants provided updates on conservation practices and projects that had been recently completed in the watershed. They reviewed the critical areas, suggested projects for removal or addition, and recommend priority projects from among the list.

Given this new data, analysis and feedback, the Tippecanoe Watershed Foundation is prepared to update Section 5.0 G "Priority Areas" from the 2006 Watershed Management Plan. This document replaces pages 5.81-5.88 and 5.91-5.97 of the WMP written by JF New and approved by IDEM in 2006.

Projects to be Removed from Critical Areas List

Several BMP implementation projects from the 2006 Watershed Management Plan (WMP) have been completed by TWF or partner organizations and agencies and shall be removed from the critical areas list. In addition, several of the projects listed in the 2006 WMP do not meet the specifications for a critical area and will be removed from the list.

Smalley Subwatershed (HUC 051201060103 (northwestern portion)) (WMP2006 p5.81)

- No changes

Ridinger / Robinson Subwatershed (HUC 051201060102) (WMP2006 p5.83)

- Identify sources of high cadmium levels in Ridinger tributaries (IST, 1990) (6^{th} bullet) - *not applicable*
- Restricting access of livestock to Robinson Lake. An alternate source of water should be created for the livestock, and the lake shoreline where the livestock have grazed should be restored. Ideally, a

constructed wetland or other treatment of drainage from the livestock's pasture should be installed to limit nutrient input to Robinson Lake (JFNew, 04) (8th bullet) – *completed*

- Restoration of Troy Cedar Lake's northern inlet's corridor where ditch cleaning has damaged the riparian zone. Restoration may include stream bank stabilization through the use of bioengineering techniques and revegetation of the riparian corridor, preferably with woody vegetation (New, 2004) (10th bullet). – *Moved to Elder Subwatershed*

Loon / Goose Subwatershed (HUC 051201060103(southwestern portion)) (WMP2006 p5.85)

- Conduct a current, more detailed diagnostic study of this subwatershed to develop site specific recommendations (Williams Creek, 2005). (2nd bullet)- *completed*

Elder Ditch Subwatershed (HUC 051201060101) (WMP2006 p5.86)

- Restore the wetland north of County Road 300 N. and east of County Road 650 W. (7th bullet) – *completed*
- Restrict livestock access to the Troy Cedar Branch of Elder Ditch on the east and west sides of CR 550W. An alternate source of water should be created for the livestock, and the stream bank where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks using bioengineering techniques. (New, 2004) (Ridinger Robinson 12th bullet)- *completed*

Webster / Backwaters Subwatershed (HUC 051201060105(eastern portion)) (WMP2006 p5.87)

- Restore two wetland filters at the headwater of Gaff Ditch; CR 750 N & CR 650 W (New, 2000) (2nd bullet)- *completed*
- Install filter strips and grassed waterways on the unnamed tributary to Gaff Ditch east of CR 750 W. at CR 400 S. (6th bullet) - *completed*
- Selectively dredge the inlets to Webster Lake (New, 2000) (10th bullet)- *completed*

Barbee Lakes Subwatershed (HUC 051201060104) (WMP2006 p5.91)

- Install filter strips; fence pastures adjacent to Grassy Creek between Ridinger and Barbee Lakes (New, 2000) (1st bullet). - *completed*
- Install grass/forested buffer at the southwest corner of County Road 650 E. and County Road 200 N. (New, 2000) (2nd bullet). - *completed*
- Selectively dredge sediment in Little Barbee Lake and its channels (Hippensteel, 1988) (7th bullet) – *completed*
- Reduce phosphorus loading from Ridinger Lake (Hippensteel, 1988) – *refers to areas in the Ridinger/Robinson and Elder Subwatersheds*
- Install comprehensive sanitary sewer system (New, 2000). (9th bullet) – *in progress*

Lake Tippecanoe Subwatershed (HUC 051201060105(western portion)) (WMP2006 p5.93)

- Address E. coli, phosphorus and nitrogen inputs from the northwest corner of County Road 500 E and County Road 650 N (New, 1997) (2nd bullet). – *completed*

Crooked / Big Subwatershed (HUC 051201060103(eastern portion)) (WMP2006 p5.96)

- Conduct a current, more detailed diagnostic study of this subwatershed to develop site specific recommendations. (1st bullet)- *completed*

Critical Areas to be Completed

The critical areas are focused in previously-identified priority subwatersheds and/or specific subwatershed hot spots as determined by various diagnostic studies and technical expert advisement.

This current updated list includes critical areas identified in the 2006 Watershed Management Plan, as well as new areas identified by TWF, natural resource professionals, or members of the Technical Advisory Committee (TAC).

Smalley Subwatershed (HUC 051201060103(northwestern portion)) (WMP2006 p5.81)

S1) Install buffer strips along the Tippecanoe River from Big Lake west to Smalley Lake (JFNew, 2000) (1st bullet).

S2) Fence cattle from the stream near County Road 1050 W. and County Road 275 S. and construct watering pond as an alternative water source (JFNew, 2000) (2nd bullet).

S3) Restore riparian zones along the Tippecanoe River and its tributaries where possible; minimally, install filter strips along the Tippecanoe River and its tributaries. Target areas shown on subwatershed map first. (JFNew, 2004) (3rd bullet).

S4) Restore as many wetlands as possible in the Smalley Lake watershed, focusing first on the Tippecanoe River subwatershed and targeting those areas shown on subwatershed map first. Watershed stakeholders should try to restore wetland acreage so that the percentage of the Smalley Lake watershed covered by wetlands equals or exceeds the percentage of land in the greater Upper Tippecanoe River basin that is covered by wetlands. (JFNew, 2004) (4th bullet).

S5) Install fencing to protect Smalley Lake's northern inlet from grazing cattle. Install an alternative water source if necessary. Restore the riparian zone where grazing cattle have damaged the stream habitat. Consider directing drainage from an adjacent grazed field through a constructed wetland to reduce nitrate inputs to the northern inlet. (JFNew, 2004) (5th bullet).

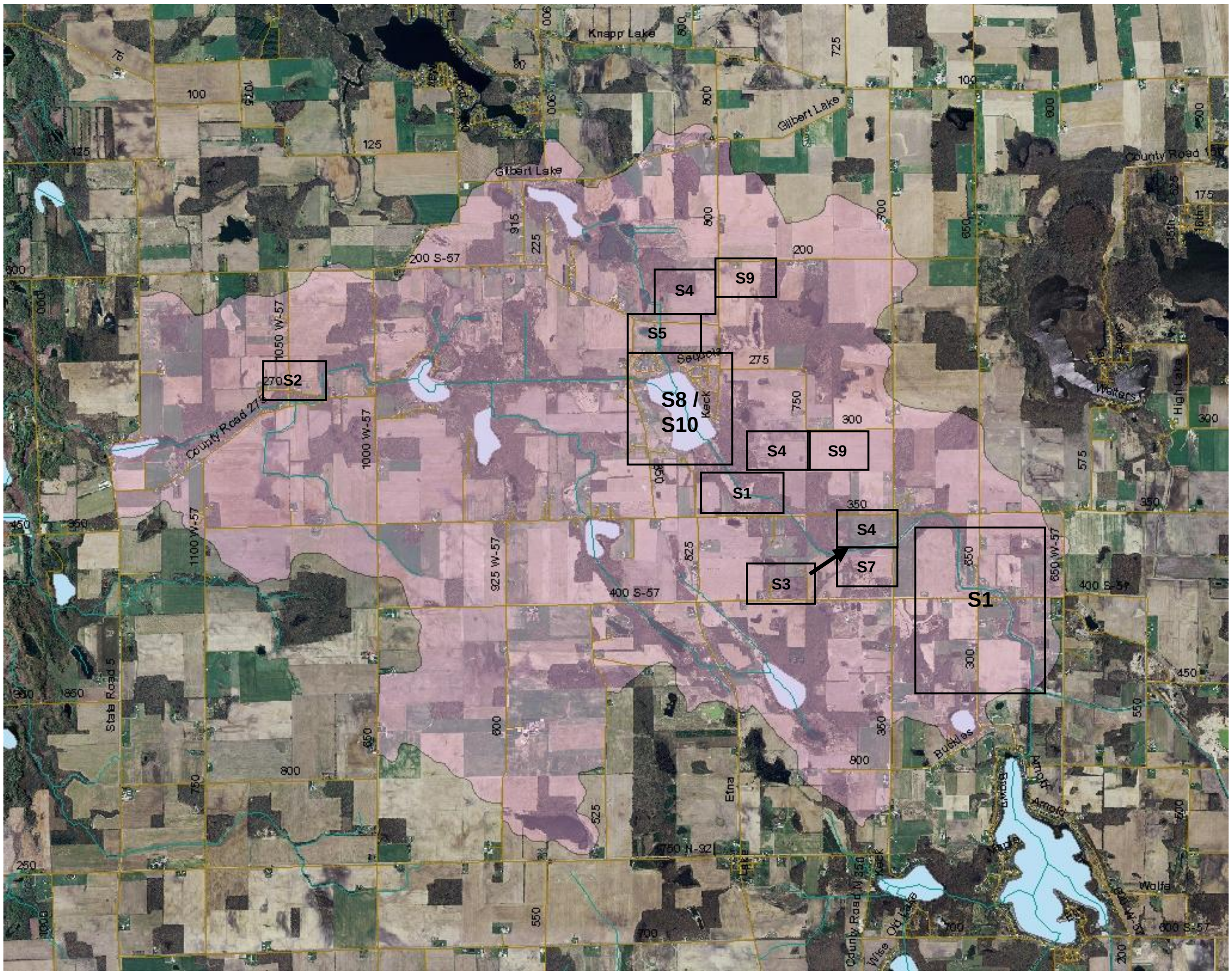
S6) Increase the usage of no-till conservation tillage on corn fields in the Smalley subwatershed. (New, 2004) (6th bullet)

S7) Implement grassed waterways and remove land mapped in highly erodible soils from agricultural production. Target areas shown on subwatershed map first (JFNew, 2004) (7th bullet). - ***Modified to remove "CRP" as the only technique.***

S8) Monitor and improve erosion control techniques on residential and commercial development sites less than one acre in size. Bring areas of concern to appropriate authorities. Work with landowners to install BMP's such as silt fences, berms, diversions, and construction drives. Management efforts should focus on Smalley Lake where the active construction sites exist and lack of erosion control techniques were observed (JFNew, 2004) (8th bullet).

S9) Plant vegetative filter areas around unprotected risers shown on subwatershed map first. (JFNew, 2004) (9th bullet).

S10) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers. (TAC, 2009) – ***NEW AREA***



Smalley Subwatershed Critical Areas

Ridinger / Robinson Subwatershed (HUC 051201060102) (WMP2006 p5.83)

RR1) Create wetland habitat, install buffer strips/grassed waterways to reduce flow and retire agricultural land upstream of Rine Lake (New, 2000) (1st bullet).

RR2) Selectively dredge the sandbars near mouths of both major inlets at Ridinger Lake (International Science and Technology(IST), 1990) (2nd bullet).

RR3) Install filter strips along Mathias Ditch (St. Clair, personal communication) (3rd bullet).

RR4) Develop materials to distribute on “Lake Basics” to be given to tenants upon their arrival at Jellystone Park regarding trash, fertilizers, chemicals, automobile traffic, grass and leaves, boating, etc. (IST, 1990) (4th bullet).

RR5) Wetland restoration on Elder Ditch, north of Old 30 and East of 900 E. (USACE, 1995) (5th bullet)

RR6) Restoration of the Elder Ditch corridor where ditch cleaning has been particularly damaging such as the area upstream and downstream of Elder Road. Restoration in this area includes stream bank stabilization through the use of bioengineering techniques and re-vegetation of the riparian corridor, preferably with woody vegetation (JFNew, 2004) (7th bullet).

RR7) Stabilization of the eroding ravine leading to the southeast corner of Ridinger Lake. Work at this site will include working with the property owner of the adjacent land to utilize grassed waterways or set aside a portion of the land in CRP (JFNew, 2004) (9th bullet).

a) Install grade stabilization and grassed waterway on the Ivan Wertsler property at the gully on the N. side of Adams Rd, West of Co. Line (Personal correspondence from Sam St.Clair, NRCS, 2010)

RR8) Restricting access of livestock to Shanton Ditch’s headwaters tributaries. An alternate source of water should be created for the livestock, and the stream bank where the livestock have grazed should be restored. This may include stabilizing or reconstructing the banks using bioengineering techniques. If possible, drainage from the land where the livestock are pastured should be directed to flow through a constructed wetland to reduce pollutant loading particularly, nitrate-nitrogen loading, to the adjacent stream (New, 2004) (11th bullet).

RR9) Restore riparian zones along the streams in the Ridinger Lake watershed where possible; minimally, install filter strips along these streams. Stream corridors in the Shanton Ditch and Elder Ditch subwatersheds should receive high priority (JFNew, 2004) (13th bullet).

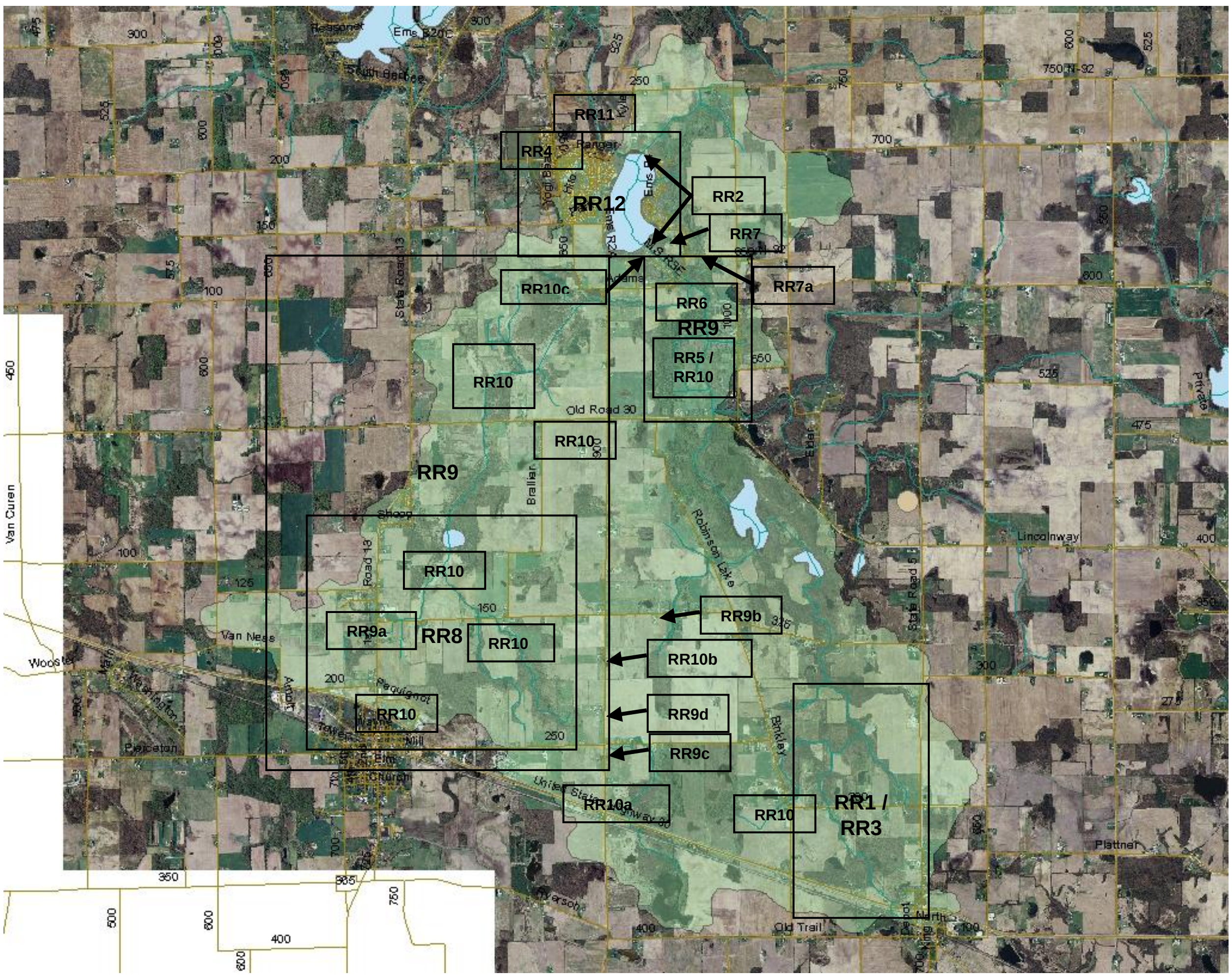
a) Install bank stabilization and buffer or two stage ditch on Shanton Ditch (Personal correspondence from Sam St.Clair, NRCS, 2010)
b) Encourage or cost-share Wascob repair, cover crop, or critical areas re-vegetation along Doke Ditch (Personal correspondence from Sam St.Clair, NRCS, 2010)
c) Encourage or cost-share grassed waterway or similar BMP near 900 E & 250S on Shanton Ditch (Personal correspondence from Sam St.Clair, NRCS, 2010)
d) Encourage or cost-share grassed waterway or similar BMP near 900 E & south of 150 S (Personal correspondence from Sam St.Clair, NRCS, 2010)

RR10) Restore as many wetlands as possible in the Ridinger Lake watershed, targeting those areas shown on subwatershed map first. (JFNew, 2004) (14th bullet).

a) Restore wetland near 900 E & US 30 on Shanton Ditch. (Personal correspondence from Sam St.Clair, NRCS, 2010)
b) Restore wetland on the Jim Argerbrite property (Personal correspondence from Sam St.Clair, NRCS, 2010)
c) Restore wetland on the SE Corner of Ridinger (Personal correspondence from Sam St.Clair, NRCS, 2010)

RR11) Reduce phosphorus loading into Ridinger Lake (Hippensteel, 1988) (***Barbee Lakes 8th bullet***).

RR12) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers. (TAC, 2009) – ***NEW AREA***



Ridinger / Robinson Subwatershed Critical Areas

Loon / Goose Subwatershed (HUC 051201060103(southwestern portion)) (WMP2006 p5.85)(UTRLA2008 Fig 49, Fig50) *(In the 2006 WMP, priority areas identified the Smalley Watershed's critical areas list were actually in the Loon / Goose Subwatershed**)**

LG1) Work with livestock owners to develop waste storage structures throughout the Loon Lake Watershed (Browne, 1992) (1st bullet).

LG2) Restore riparian zones along the Tippecanoe River and its tributaries where possible; minimally, install filter strips along the Tippecanoe River and its tributaries. Target areas shown on subwatershed map first. (JFNew, 2004) (***Smalley Watershed 3rd bullet***).

LG3) Restore as many wetlands as possible in the Smalley Lake watershed, focusing first on the Tippecanoe River subwatershed and targeting those areas shown on subwatershed map first. (JFNew, 2004) (***Smalley Watershed 4th bullet***).

LG4) Implement grassed waterways and remove land mapped in highly erodible soils from agricultural production. Target areas shown on subwatershed map first. (JFNew, 2004) (***Smalley Watershed 7th bullet***). – *Modified to remove "CRP" as the only technique*

LG5) Plant vegetative filter areas around unprotected risers shown on subwatershed map first. (JFNew, 2004) (***Smalley Watershed 9th bullet***).

LG6) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers (TAC, 2009) – ***NEW AREA***

LG7) Construct grassed waterways starting with the areas indicated on the map first. *(UTRLA WMP p.116,117 and Fig 53, 54) –* ***NEW AREA***

LG8) Construct a sediment trap along the Old Lake north inlet. *(UTRLA WMP p.116,117 and Fig 53) –* ***NEW AREA***

LG9) Construct a buffer area and bio retention filter / raingarden on north inlet to Loon Lake. *(UTRLA WMP p.116,117 and Fig 54) –* ***NEW AREA***

LG10) Work with livestock owners to encourage rotational grazing starting with area indicated on the map first. *(UTRLA WMP p.116,117 and Fig 54) –* ***NEW AREA***

LG11) Work with landowner to enroll property in a conservation easement starting with the areas indicated on the map first. *(UTRLA WMP p.116,117 and Fig54) –* ***NEW AREA***

LG12) Install buffer strips along both sides of Winter's Ditch between 625 N and 700 N. and 3 WASCOBs *(UTRLA WMP p.116,117 and Fig 54) –* ***NEW AREA***

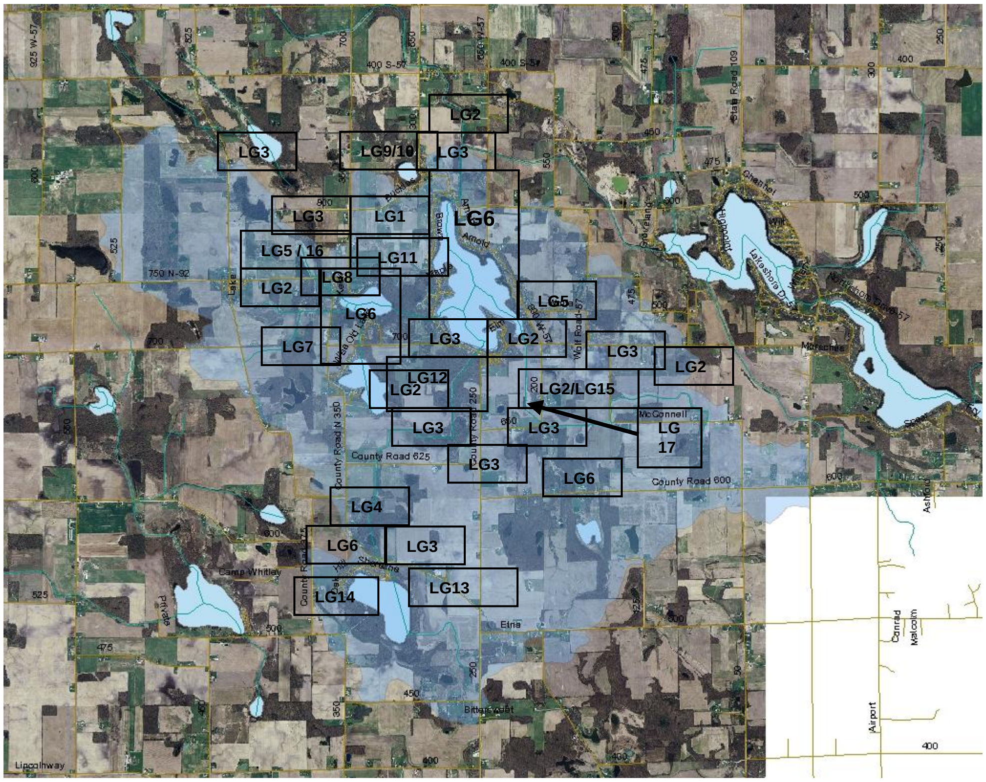
LG13) Install buffer strips along Goose Lake inlet on east shore. *(UTRLA WMP p.116,117 and Fig 54) –* ***NEW AREA***

LG14) Install buffer strips along Goose Lake's southwestern shore. *(UTRLA WMP p.116,117 and Fig 54) –* ***NEW AREA***

LG15) Construct buffer strips on Friskney Ditch to the west of the 90 degrees bend on McConnell Road. *(UTRLA WMP p.116,117 and Fig 55) –* ***NEW AREA***

LG16) Install streambank stabilization on the north inlet to Old Lake. (TAC, 2009) – ***NEW AREA***

LG17) Install and maintain a sediment trap along the south inlet to Loon Lake. *(UTRLA WMP p.116,117 and Fig 55) –* ***NEW AREA***



Loon / Goose Subwatershed Critical Areas

Elder Ditch Subwatershed (HUC 051201060101) (WMP2006 p5.86)

ED1) Restore 120-acre wetland north of County Road 700 N. and east of County Road 550 W (1^{st} bullet).

ED2) Restore 40-60 acres of wetland south of County Road 750 N. and east of County Road 550 W. (2^{nd} bullet).

ED3) Install filter strips on the western tributary to Scott Lake (3^{rd} bullet).

ED4) Install filter strips, fence cattle from the stream and stabilize the stream bank of the Cedar Lake Branch of Elder Ditch east of County Road 650 W to Troy Cedar Lake. (4^{rd} bullet).

ED5) Install filter strips west of County Road 650 W. on the Cedar Lake Branch of Elder Ditch (5^{th} bullet).

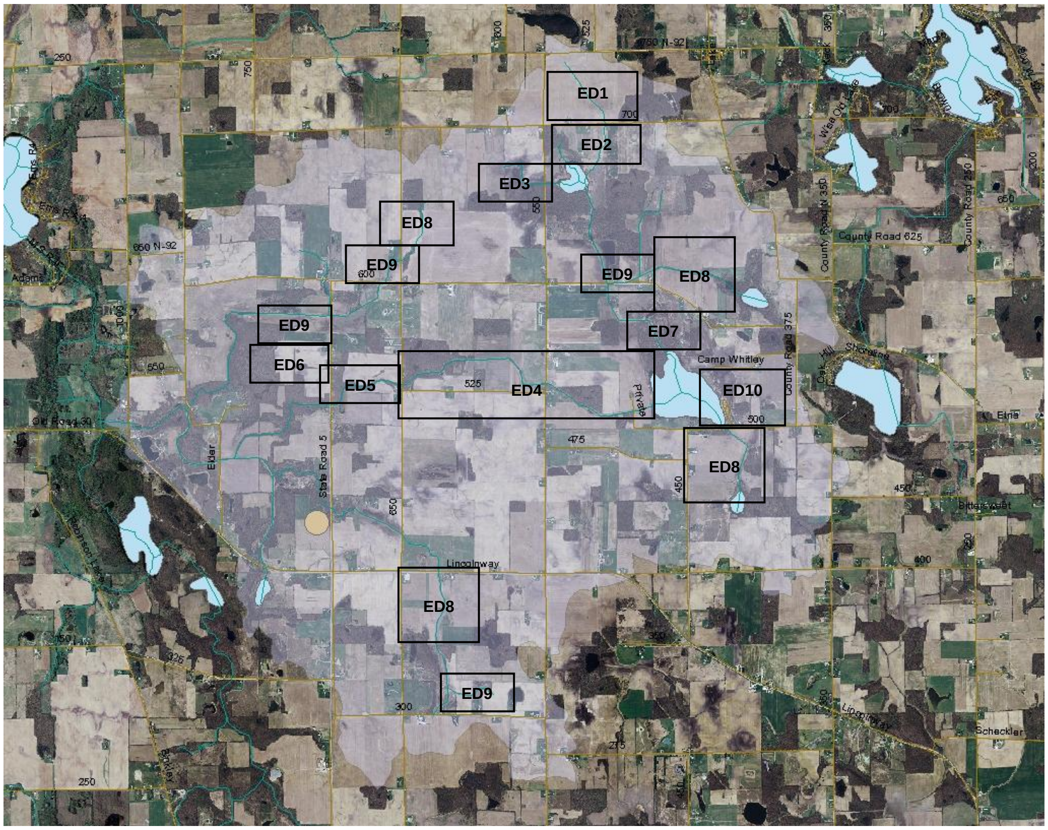
ED6) Enroll property south of Smith Drain along the west side of SR 5 in CRP or WRP. (6^{th} bullet)

ED7) Restoration of Troy Cedar Lake's northern inlet's corridor where ditch cleaning has damaged the riparian zone. Restoration may include stream bank stabilization through the use of bioengineering techniques and re-vegetation of the riparian corridor, preferably with woody vegetation (JFNew, 2004) (***Ridinger/Robinson 10^{th} bullet***).

ED8) Reduce phosphorus loading into Ridinger Lake (Hippensteel, 1988) (***Barbee Lakes 8^{th} bullet***).

ED9) Restore as many wetlands as possible in the Elder Ditch subwatershed. (TAC, 2009) – ***NEW AREA***

ED10) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers. (TAC, 2009) – ***NEW AREA***



Elder Ditch Subwatershed Critical Areas

Webster / Backwaters Subwatershed (HUC 051201060105 (eastern portion)) (WMP2006 p5.87)

WB1) Install buffer strips along Gaff Ditch from County Road 750 W. to its headwaters (New, 2000) (1st bullet).

WB2) Restore wetland or tributary to Gaff Ditch between County Road 700 N and County Road 750 N (3rd bullet).

WB3) Stabilize stormwater inlets, outlet, and channel banks south of East Street on the northwest corner of Webster Lake. (4th bullet)

WB4) Install grassed waterways on agricultural land southeast of County Road 650 W and County Road 750 N (Cormany Farms). (5th bullet)

WB5) Install pollutant removal devices on the 18 stormwater drain complexes located in the city of North Webster and develop a maintenance plan for each of these filters (New, 2000 and 2002) (7th bullet).

WB6) Stabilize banks adjacent to bridge abutments over Gaff Ditch at County Road 750 W off of 750 N (New, 2000) (8th bullet).

WB7) Complete the installation of sanitary sewers along east side of Webster Lake. (New, 2000) (9th bullet).

WB8) Work with the County on long range plan for County Road 750 N (New, 2000) (11th bullet).

WB9) Continue to work with the Town Council to ensure that a storm drain inspection and maintenance plan is implemented (New, 2002) (12th bullet).

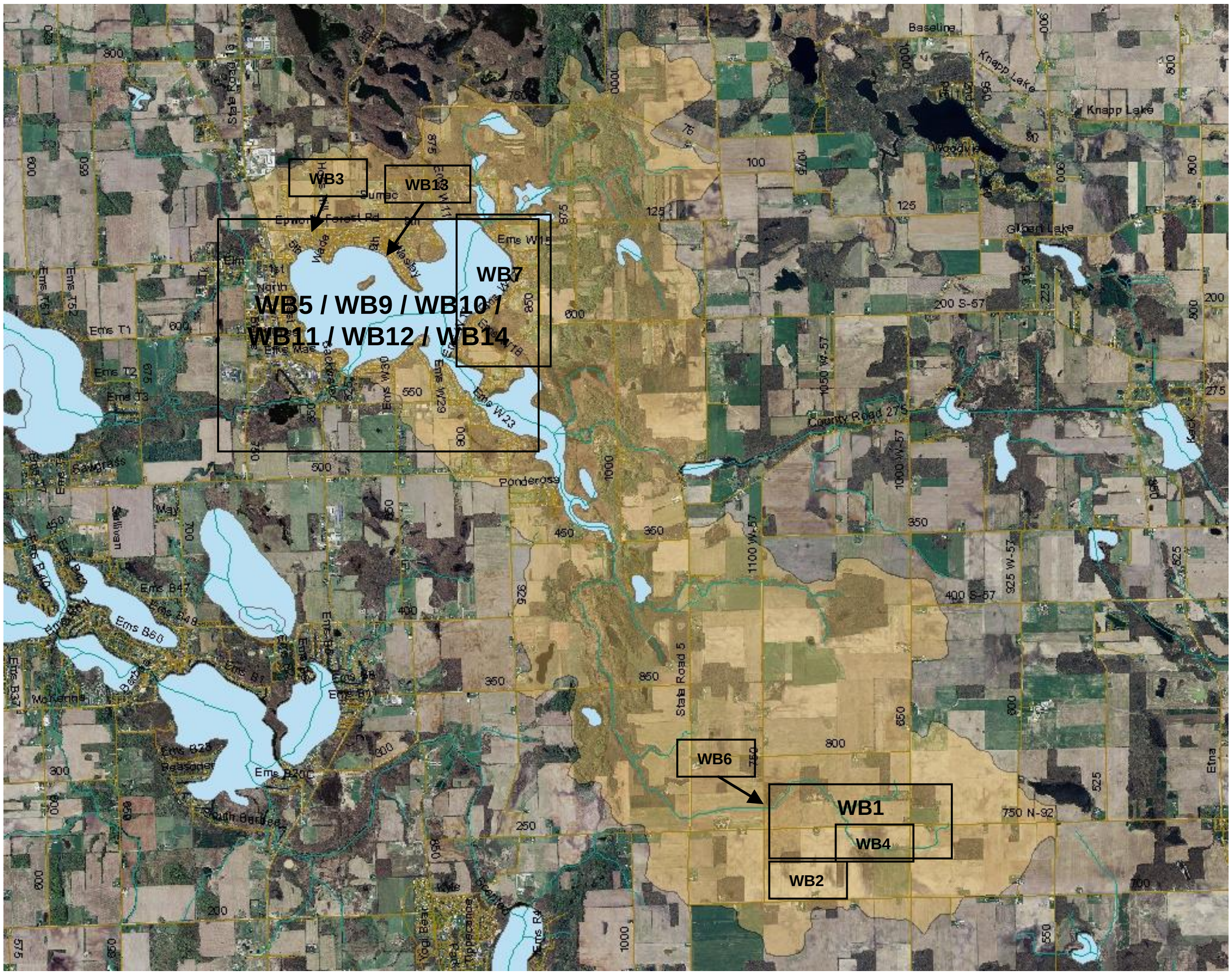
WB10) Work with the Town Council to determine if drain retrofitting is desirable given available resources. Depending on available resources, other funding sources or grants should be secured to retrofit at least the high priority drain networks (New, 2002) (13th bullet).

WB11) Have a representative present at monthly town council meetings to ensure better long-term communication regarding the storm drain project and other lake conservation projects (New, 2002) (14th bullet).

WB12) Initiate an information and education program to inform town and lake residents about practices they can utilize to control sources of pollutants and debris before they are introduced into the storm drain system (New, 2002) (15th bullet).

WB13) Stabilize shoreline and hillside at 8587 Wesleyan Lane, North Webster to reduce sediment loading. (TAC, 2009) – ***NEW AREA***

WB14) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers. (TAC, 2009) – ***NEW AREA***



Webster / Backwater Subwatershed Critical Areas

Barbee Lakes Subwatershed (HUC 051201060104) (WMP2006 p5.91)

B1) Install buffer strips east of County Road 650 E. (New, 2000) (3^{th} bullet).

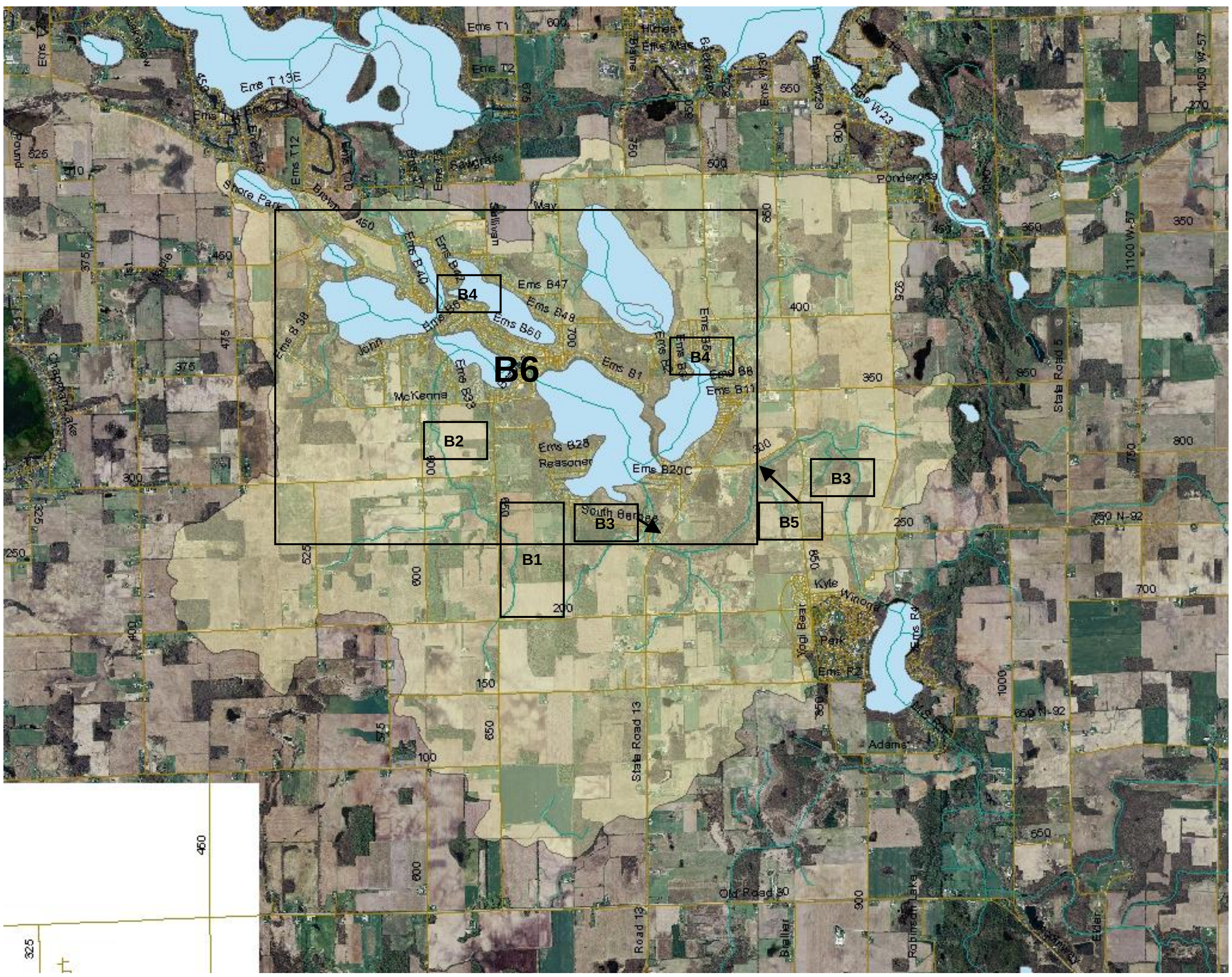
B2) Create wetland south of McKenna Road (New, 2000) (4^{th} bullet).

B3) Create wetland or bioretention practice to manage run-off from drains east of State Road 13 and west of Big Barbee southern channel to remove road runoff and petroleum products (New, 2000) (5^{th} bullet).

B4) Create wetland or bioretention practice to manage run-off from drains near Sechrist and Kuhn Lakes (New, 2000) (6^{th} bullet).

B5) Restore wetland north of CR300N and east of CR650E. (TAC, 2009) – ***NEW AREA***

B6) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers. (TAC, 2009) – ***NEW AREA***



Barbee Lakes Subwatershed Critical Areas

Lake Tippecanoe Subwatershed (HUC 051201060105(western portion)) (WMP2006 p5.93)

T1) Install comprehensive sanitary sewer system in residential areas surrounding the lake. (New, 1997) (1st bullet).

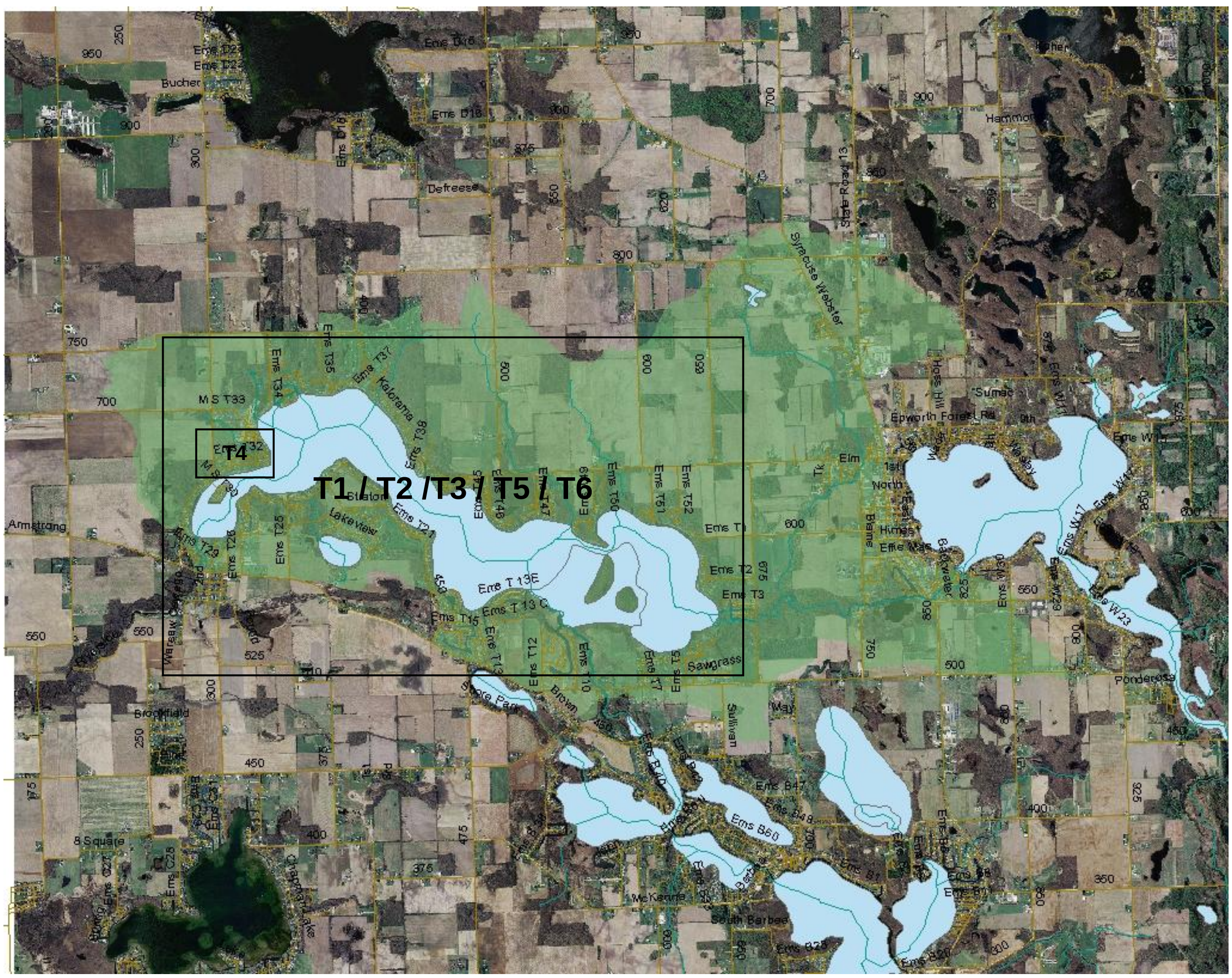
T2) Reduce sediments and nutrients from the 35 street drains around the lake (Figure 60 below)(Bright, 2005) (3rd bullet) - *Modified to allow the use of other BMP's.*

T3) Encourage or cost share with local residents to incorporate rain gardens into their landscapes (Bright, 2005) (4th bullet).

T4) Generate local consensus, design, and build two community rain gardens to manage storm water runoff in Bell Rohr Park and Russell Park neighborhoods. The land is already owned by the associations, so no additional land acquisition is needed (Bright, 2005) (5th bullet).

T5) Seek design and implementation funding for other storm water BMPs as outline in Table 49 pg.5.95 of the 2006 TWF WMP. (Bright, 2005) (6th bullet)

T6) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers. (TAC, 2009) – ***NEW AREA***



Lake Tippecanoe Subwatershed Critical Areas

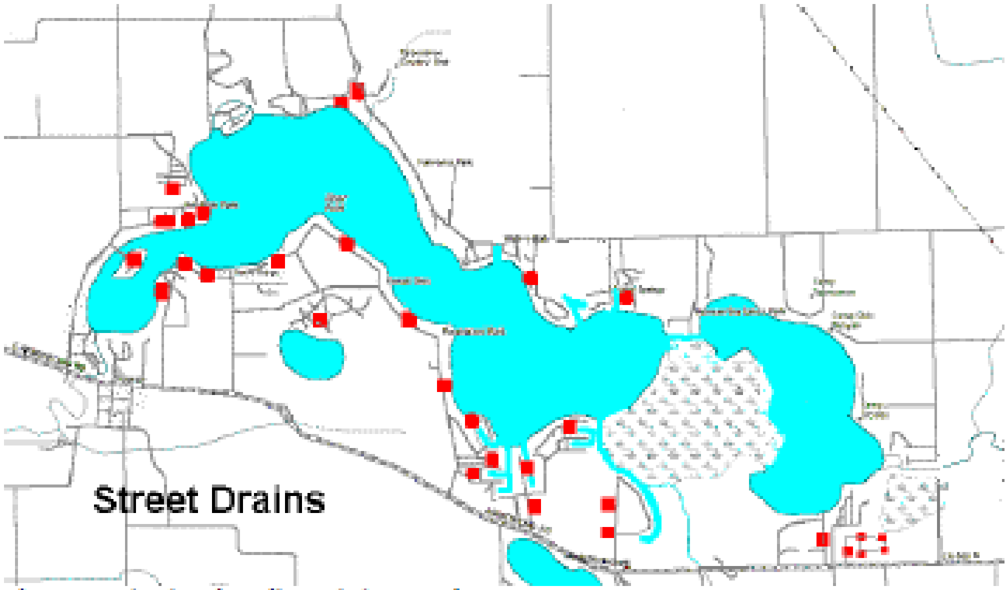


Figure 60. Street Drains with Inlets to Lake Tippecanoe

Crooked / Big Subwatershed (HUC 051201060103(eastern portion)) (WMP2006 p5.96) *(In the 2006 WMP, priority areas identified the Smalley Watershed's critical areas list were actually in the Crooked / Big Subwatershed**)**

CB1) Incorporate measures to slow the water and sediment loss above the ravine (Tall Trees Memorial Grove) outside of the Nature Preserve (Crisman, 1993) (2nd bullet).

CB2) Enlist the agricultural field on south side of golf course in the conservation tillage program (Crisman, 1993) (3rd bullet).

CB3) Enlist the agricultural field located south of lake near Spear Road in the conservation tillage program (Crisman, 1993) (4th bullet).

CB4) Decrease sediment at the outlet of Stuckman Drain, and stabilize the banks (IDNR, 1995). (5th bullet). - *Modified to allow the use of other BMP's.*

CB5) Decrease sediment on Sell Branch immediately upstream of County Road 600 N. along Airport Road (IDNR, 1995) (6th bullet). - *Modified to allow the use of other BMP's.*

CB6) Decrease sediment 600 feet upstream of State Road 109 in Sell Subwatershed (IDNR, 1995) (7th bullet). - *Modified to allow the use of other BMP's.*

CB7) Decrease sediment immediately upstream of County Line Rd in Sell Subwatershed (IDNR, 1995) (8th bullet). - *Modified to allow the use of other BMP's.*

CB8) Install filter strips within the Sell branch Subwatershed (IDNR, 1995) (9th bullet).

CB9) Install filter strips on cropland east of County Road 250 W in Crane Subwatershed (IDNR, 1995) (10th bullet).

CB10) Reforest land along the southern bank of Crane Ditch (IDNR, 1995) (11th bullet).

CB11) Decrease sediment upstream of County Road 500 S. in Crane Subwatershed (IDNR, 1995) (12th bullet) - *Modified to allow the use of other BMP's.*

CB12) Increase the acreage of land committed to conservation set aside to the southeast of Green Lake and south of County Road 500 S (IDNR, 1995). (13th bullet) - *Modified to allow the use of other BMP's.*

CB13) Vegetate or reforest land between Haroff Lake and SR109. (IDNR, 1995) (14th bullet) - *Modified to allow the use of other BMP's.*

CB14) Install filter strips on the north side of County Road 500 S (IDNR, 1995) (15th bullet).

CB15) Continue in-lake water quality testing for phosphorus, nitrate, and turbidity and consider limited tributary samplings (IDNR, 1995) (16th bullet).

CB16) Restore riparian zones along the Tippecanoe River and its tributaries where possible; minimally, install filter strips along the Tippecanoe River and its tributaries. Target areas shown on subwatershed map first. (JFNew, 2004) (***Smalley Watershed 3rd bullet***).

CB17) Restore as many wetlands as possible in the Smalley Lake watershed, focusing first on the Tippecanoe River subwatershed and targeting those areas shown on subwatershed map first. Watershed stakeholders should try to restore wetland acreage so that the percentage of the watershed covered by wetlands equals or exceeds the percentage of land in the greater Upper Tippecanoe River basin that is covered by wetlands (JFNew, 2004). (***Smalley Watershed 4th bullet***).

CB18) Plant vegetative filter areas around unprotected risers shown on subwatershed map first. (JFNew, 2004) (***Smalley Watershed 9th bullet***).

CB19) Reduce phosphorus and sediment inputs from high density residential and commercial areas through installation of rain barrels, rain gardens, and riparian/shoreline buffers. (TAC, 2009) – ***NEW AREA***

CB20) Install buffer strips along the Tippecanoe River and its tributaries. Target areas shown on subwatershed map first. *(UTRLA WMP p.117,118 and Fig 56,57) –* ***NEW AREA***

CB21) Work with landowner adjacent to Haroff ditch near CR 475 to develop a nutrient management plan. *(UTRLA WMP p.117,118 and Fig 56,57) –* ***NEW AREA***

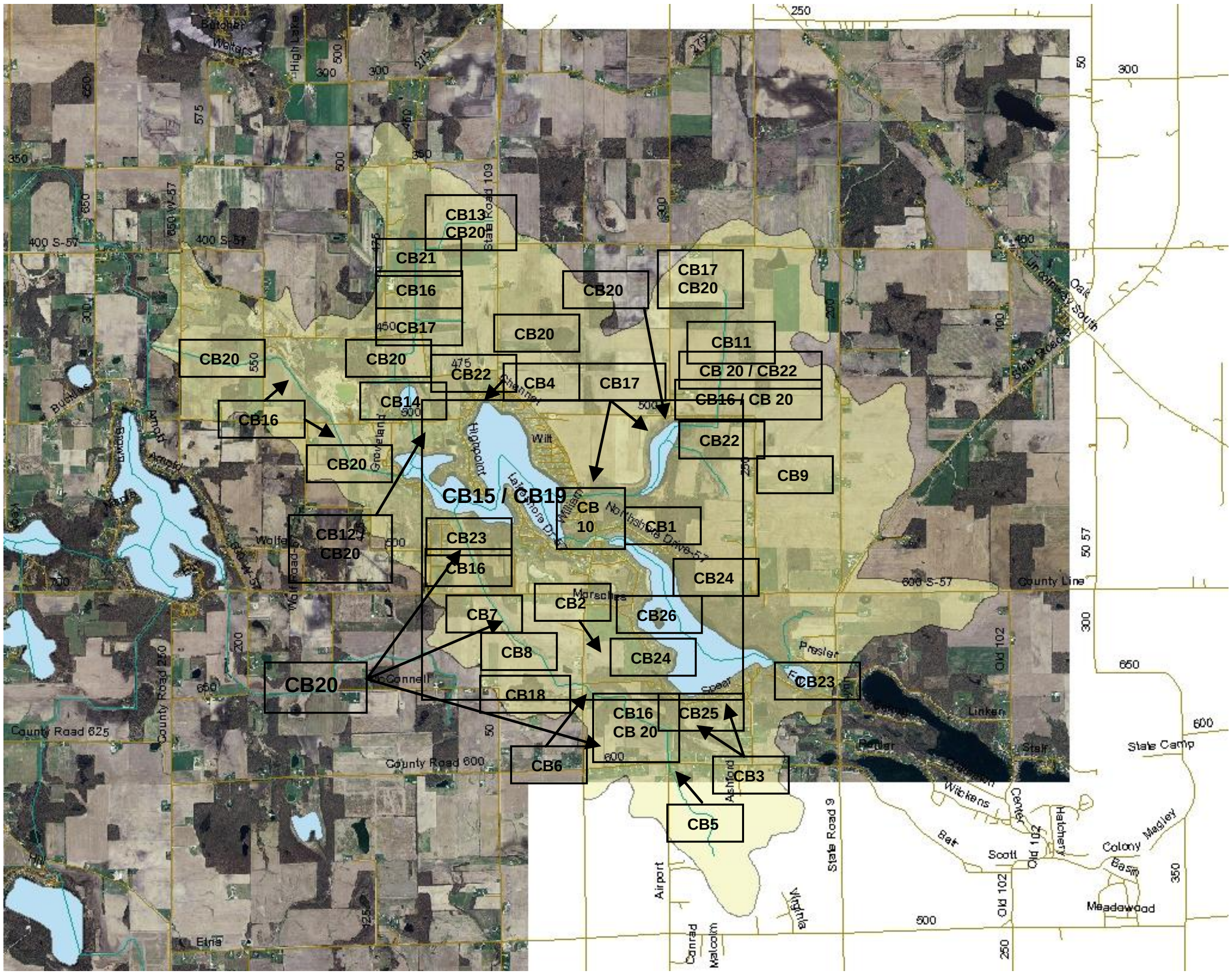
CB22) Install grassed waterways along the Tippecanoe River and its tributaries. Target areas shown on subwatershed map first. *(UTRLA WMP p.117,118 and Fig 56,57) –* ***NEW AREA***

CB23) Construct a sediment trap or two stage ditch on Sell Ditch upstream of Big Lake and upstream of Little Crooked Lake. *(UTRLA WMP p.117,118 and Fig 56,57) –* ***NEW AREA***

CB24) Address grade stabilization issues on the northeast and southwest sides of Crooked Lake. *(UTRLA WMP p.118 and Fig 56,57) –* ***NEW AREA***

CB25) Construct bioretention filter along the southern inlet to Crooked Lake. *(UTRLA WMP p.118 and Fig 56,57) –* ***NEW AREA***

CB26) Stabilize the shore of the island located in the western portion of Crooked Lake. *(UTRLA WMP p.118 and Fig 56,57) –* ***NEW AREA***



Crooked / Big Subwatershed Critical Areas