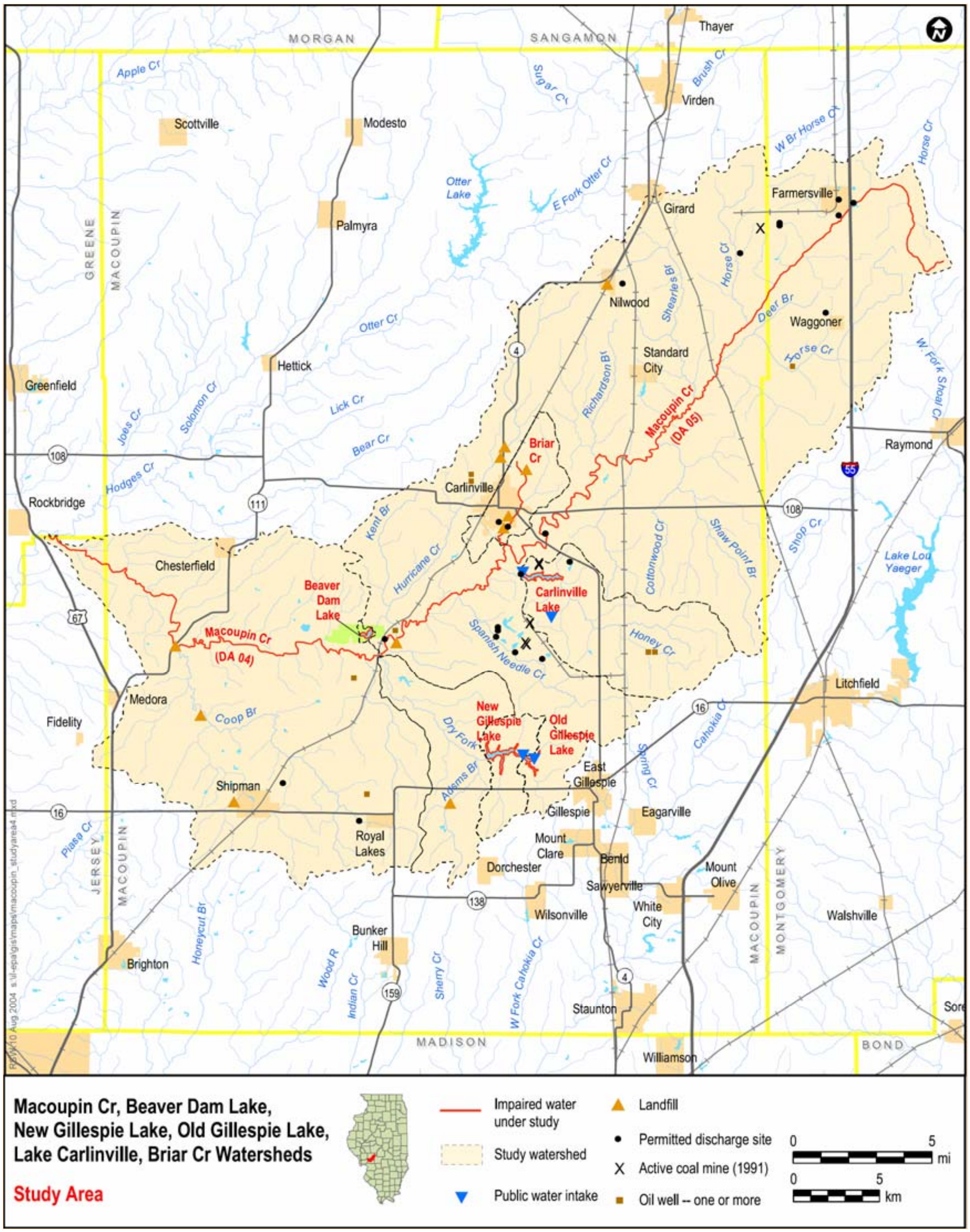
Illinois
Environmental
Protection Agency

Bureau of Water
P. O. Box 19276
Springfield, IL 62794-9276

August 2007

IEPA/BOW/07-007

Macoupin Creek Watershed TMDL Report



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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
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SEP 27 2006

REPLY TO THE ATTENTION OF:
WW-16J

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BUREAU OF WATER
BUREAU CHIEF'S OFF

Marcia T. Willhite, Chief
Bureau of Water
Illinois Environmental Protection Agency
1021 North Grand Ave. East
P.O. Box 19276
Springfield, IL 62794-9276

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Loads (TMDL) for the Macoupin Creek watershed including supporting documentation and follow up information. On September 7, 2006, Illinois Environmental Protection Agency (IEPA) submitted TMDL reports for Macoupin Creek (IL_DA-04 and IL_DA-05) for manganese (Mn), total phosphorus (TP) and total suspended solids (TSS) and Macoupin Creek IL_DA-04 addressing fecal coliform. The reports also addressed four lakes: Carlinville Lake (IL_RDG) and Old Gillespie Lake (IL_SDT) for TP, Mn, and TSS; New Gillespie Lake (IL_SDU) for TP and TSS; and Beaver Dam Lake (IL_RDH) for TP.

Based on this review, U.S. EPA has determined that the following seven Illinois TMDLs meet the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations:

- Macoupin Creek IL_DA-04 for fecal coliform and Mn;
- Macoupin Creek IL_DA-05 for Mn;
- Carlinville Lake IL_RDG for TP;
- Old Gillespie Lake IL_SDT for TP;
- New Gillespie Lake IL_SDU for TP; and
- Beaver Dam Lake for TP.

Except for Beaver Dam Lake, each of the waterbodies identified above are also identified in the reports as being impaired due to TSS. However, because Illinois does not have numerical water quality standard for TSS, Illinois has decided not to submit TMDLs for TSS impairment in those waterbodies. Nonetheless, the Mn TMDLs for the stream segments and the TP TMDLs for the lakes will address the TSS issue. Carlinville Lake and Old Gillespie Lake were also listed for Mn. Although IEPA does have water quality criteria for Mn a TMDL was not developed for this pollutant in these lakes. In the two lakes, Mn will be addressed through the implementation of the TMDLs for TP.

Therefore, U.S. EPA hereby approves Illinois's seven TMDL addressing 15 impairments for the Macoupin Creek watershed. The statutory and regulatory requirements for approval, and U.S. EPA's review of Illinois's compliance with each requirement, are described in the enclosed decision document.

The TMDL reports also addressed dissolved oxygen (DO) impairment in Macoupin Creek. However, IEPA determined that the DO impairments in the Macoupin Creek watershed are a result of flow-related conditions rather than a specific pollutant cause. Therefore, since TMDLs are required only for pollutants, and flow is not a pollutant, no TMDL for DO is required for Macoupin Creek watershed (Segments IL_DA-04 and IL_DA-05) under the Clean Water Act or U.S. EPA regulations.

The TMDL reports also addressed DO impairments in Briar Creek. However, during the data review, IEPA determined that Briar Creek is now meeting the DO water quality standard. As IEPA now intends to propose the delisting of Briar Creek from the Section 303(d) list in 2008, U.S. EPA is not approving a TMDL for Briar Creek at this time.

We wish to acknowledge Illinois's effort in submitting these TMDLs, and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Kevin Pierard, Chief of the Watersheds and Wetlands Branch at 312-886-4448.

Sincerely yours,

Jo Lynn Traub,
Director, Water Division

Enclosure

cc: Bruce Yurdin, IEPA
Jennifer Clarke, IEPA

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Final Stage1 Progress Report

Prepared for Illinois Environmental Protection Agency

May 2005

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New Gillespie Lake (SDU), and Old Gillespie Lake (SDT)

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First Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

May 2005

Macoupin Creek Watershed

Macoupin Creek (DA04, DA05), Briar Creek (DAZN),
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EXECUTIVE SUMMARY

This is the first in a series of quarterly status reports documenting work completed on the Macoupin Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a TMDL be completed for each pollutant listed for an impaired waterbody. A TMDL is a report that is submitted by the States to the EPA. In the TMDL report, a determination is made of the greatest amount of a given pollutant that a waterbody can receive without violating water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

Methods

The effort completed in the first quarter included: 1) two site visits and collection of information to complete a detailed watershed characterization; 2) development of a water quality database and data analyses; and 3) synthesis of the watershed characterization information and the data analysis results to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the draft 2004 303(d) list of impaired waterbodies.

Results

Based on work completed to date, the project team has concluded that TMDLs are warranted for the seven impaired waterbodies in this targeted watershed. Specifically:

- For **Segment DA 04 of Macoupin Creek**, data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese, dissolved oxygen and fecal coliform TMDLs are warranted. Potential sources of manganese are erosion and streambank erosion of soils naturally enriched in manganese. Potential sources contributing to low dissolved oxygen include algal respiration and decomposition, sediment oxygen demand, degradation of CBOD, nitrification of ammonia (from agricultural lands and failing septic systems), and municipal point sources. Additional data collection will be needed to confirm any potential sources. Potential sources of fecal coliform include municipal point sources, failing septic systems and agricultural runoff.
- For **Segment DA 05 of Macoupin Creek,** data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese and dissolved oxygen TMDLs are warranted. In addition, an analysis of available data revealed elevated fecal coliform levels. Because of an existing disinfection exemption, modeling will need to be used to determine if this segment is contributing to downstream fecal impairments in segment DA 04. Potential sources of manganese are erosion and streambank erosion of soils naturally enriched in manganese. Potential sources contributing to low dissolved oxygen include algal respiration and decomposition, sediment oxygen demand, degradation of CBOD, nitrification of ammonia (from agricultural lands and failing septic systems), and municipal point sources.
- For **Briar Creek (DAZN),** available data are sufficient to support the causes listed on the draft 2004 303(d) list. In addition, an analysis of available data revealed elevated fecal coliform levels. Because of an existing disinfection exemption, modeling will need to be used to determine if this segment is contributing to downstream fecal impairments in segment DA 04. Potential sources contributing to low dissolved oxygen include point source discharges, including CSOs, and agricultural runoff.
- For **Carlinville Lake (RDG),** data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese and total phosphorus TMDLs are warranted. Potential sources of manganese are erosion and streambank erosion of soils naturally enriched in manganese. Potential sources of total phosphorus include agricultural runoff, release from lake bottom sediments during seasonal hypolimnetic anoxia and algal decay.
- For **Beaver Dam Lake (RDH),** data are sufficient to support the causes listed on the draft 2004 303(d) list, and a total phosphorus TMDL is warranted. Potential sources of total phosphorus include agricultural runoff, point source discharge, and release from lake bottom sediments during seasonal hypolimnetic anoxia.
- For **New (SDU) and Old (SDT) Gillespie Lakes,** data are sufficient to support the causes listed on the draft 2004 303(d) list. Total phosphorus TMDLs are warranted for both lakes, and a manganese TMDL is warranted for Old Gillespie Lake. Potential sources of manganese to these two lakes include watershed erosion and streambank erosion of soils naturally enriched in manganese. Potential sources of total phosphorus include agricultural runoff and erosion, stream bank erosion,

release from lake bottom sediments during seasonal hypolimnetic anoxia and failing septic systems.

INTRODUCTION

This Stage 1 report describes initial activities related to the development of TMDLs for impaired waterbodies in the Macoupin Creek watershed. Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed. This section provides some background information on the TMDL process, and Illinois assessment and listing procedures. The specific impairments in waterbodies of the Macoupin Creek watershed are also described.

TMDL Process

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is called the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA 2004a), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review are presented in this first quarterly status report.

Next, the Illinois EPA, with assistance from consultants, will recommend an approach for the TMDL, including an assessment of whether additional data are needed to develop a defensible TMDL.

Finally, Illinois EPA and consultants will conduct the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired waterbodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) will be strictly voluntary.

Illinois Assessment and Listing Procedures

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of five generic designated use categories: public water supply, aquatic life, primary contact (swimming), secondary contact (recreation), and fish consumption (IEPA, 2004). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of three possible "use-support" levels:

- Fully supporting (the water body attains the designated use);
- Partially supporting (the water body attains the designated use at a reduced level); or
- Not supporting (the water body does not attain the designated use).

All water bodies assessed as partial or nonsupport attainment for any designated use are identified as "impaired." Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list of impaired waters. Potential causes and sources of impairment are also identified for impaired waters.

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units, to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2004).

List of Identified Watershed Impairments

The impaired waterbody segments included in the project watershed are listed in Table 1 below, with the parameters they are listed for, and the use impairments as identified in the draft 2004 303(d) list (IEPA, 2004). TMDLs are currently only being developed for pollutants that have numerical water quality standards. Sources that are listed for pollutants that exceed statistical guidelines are not subject to TMDL development at this time (IEPA, 2004). Table 1 provides information on the targeted waterbodies, including size, causes of impairment, and use support (partial support, full support, nonsupport). Those impairments that are the focus of this report are shown in bold font.

Table 1. Impaired Waterbodies in the Macoupin Creek Watershed (IEPA, 2004)

Waterbody Segment	Waterbody Name	Size (miles/acres)	Year Listed	Listed for[1]	Use Support[2]
DA04	Macoupin Creek	19.73	1998	**Manganese, dissolved oxygen, fecal coliform,** sedimentation/siltation, total phosphorus (statistical guideline)	Fish consumption (F) Aquatic life (P) Primary contact (N)
DA05	Macoupin Creek	43.89	1998	**Manganese, dissolved oxygen,** total nitrogen as N, other flow regime alterations, total phosphorus (statistical guideline)	Fish consumption (F) Aquatic life (P)
DAZN	Briar Creek	3.97	2002	**Dissolved oxygen**, habitat assessment, total phosphorus (statistical guideline)	Aquatic life (P)
RDG	Carlinville Lake	168	1996	**Manganese, total phosphorus**, total suspended solids, excess algal growth, total phosphorus (statistical guideline)	Aquatic life (F), Overall use (P), Primary contact (P), Secondary contact (P), Public water supply (P)
RDH	Beaver Dam Lake	56.5	1998	**Total phosphorus**, excess algal growth, total phosphorus (statistical guideline)	Aquatic life (F), fish consumption (F), overall use (P), primary contact (P), secondary contact (P),
SDT	Old Gillespie Lake	71	2002	**Manganese, total phosphorus**, TSS, excess algal growth, total phosphorus (statistical guideline)	Aquatic life (F), fish consumption (F), overall use (P), primary contact (P), secondary contact (P), public water supply (P)
SDU	New Gillespie Lake	207	2002	**Total phosphorus**, TSS, excess algal growth, total phosphorus (statistical guideline)	Aquatic life (F), fish consumption (F), public water supply (F), overall use (F), primary contact (P), secondary contact (P)

[1] Bold font indicates those parameters that are addressed in this report. The other parameters will not be included because they do not have a numeric water quality standard.

[2]F=full support, P=partial support, N=nonsupport

WATERSHED CHARACTERIZATION

The purpose of watershed characterization was to obtain information describing the watershed to support the identification of sources contributing to manganese, total phosphorus, low dissolved oxygen and fecal coliform impairments. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, land cover and uses, climate, and population growth. The methods used to characterize the watershed, and the findings are described below.

Methods

Watershed characterization was conducted by compiling and analyzing data and information from various sources. Where available, data were obtained in electronic or Geographic Information System (GIS) format to facilitate mapping and analysis. To develop a better understanding of land management practices in the watershed, calls were placed to local agencies to obtain information on crops, pesticide and fertilizer application practices, tillage practices and best management practices employed. Additionally, a meeting was held on December 11, 2003 with Regional and State-level IEPA staff and a site visit was conducted later that day. A second site visit was conducted on June 27-28, 2004 and a meeting was held with the Executive Director (Rhonda Koehne) and the District Conservationist (John Ford) at the Macoupin County Soil and Water Conservation District offices in Carlinville.

The first step in watershed characterization was to delineate the watershed boundaries for the impaired waterbodies (Table 1) in GIS using topographic and stream network (hydrography) information. Other relevant information obtained and processed for mapping and analysis purposes included:

- current land cover,
- current cropland,
- State and Federal lands,
- soils,
- point source dischargers,
- public water supply intakes,
- roads,
- railroads,
- state, county and municipal boundaries,
- landfills,
- oil and gas wells,
- coal mines, dams,
- data collection locations, and
- the location of 303(d) listed lakes and streams.

To better describe the watershed and obtain information related to active local watershed groups, data collection efforts, agricultural practices, and septic systems, calls were placed to county-level officials at the Natural Resources Conservation District (NRCS), Agricultural Extension Office, Health Department, Farm Services Agency (FSA). A valuable resource used in this effort was the *Upper Macoupin Creek Watershed Restoration Action Strategy* (WRAS), an in-depth report prepared by the Macoupin County Soil and Water Conservation District (Macoupin Creek SWCD) in 2003. Other information compiled for this task related to climate, population growth and urbanization. A list of data sources and calls is included in Appendix A.

Macoupin Creek Watershed General Characterization

The impaired waterbodies addressed in this report are in the Macoupin Creek watershed, located in West-Central Illinois approximately 45 miles south of Springfield, Illinois. The creek extends through four counties, but most of the watershed is located in Macoupin County. Macoupin Creek extends from its point of origin southeast of Farmersville to its confluence with the Illinois River, but the two impaired segments that are addressed in this report are the two most upstream segments. The watershed for these two segments is approximately 256,854 acres (400 square miles) in size, and there are about 227 miles of streams in the watershed (Macoupin County SWCD, 2003). Figure 1 shows a map of the watershed, and includes key features such as waterways, impaired waterbodies, and public water intakes. The map also shows the locations of point source discharges that have a permit to discharge under the National Permit Discharge Elimination System (NPDES).

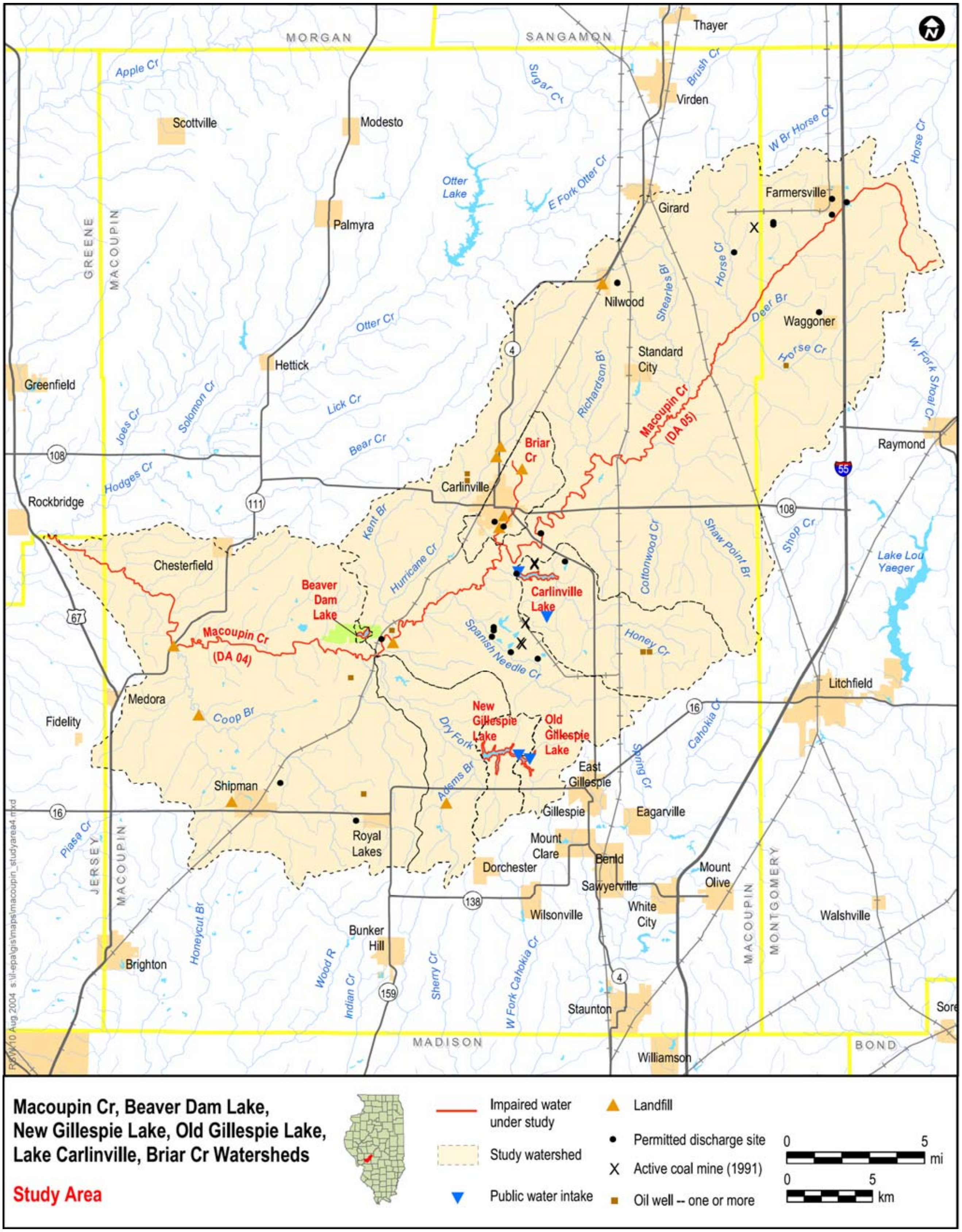

Figure 1. Base Map of Macoupin Creek Watershed

The following sections provide a broad overview of the characteristics of the Macoupin Creek watershed. Specific information about the smaller subwatersheds for impaired waterbodies follows the general overview.

Geology and Soils

Information on geology and soils was compiled in order to understand whether the soils are a potential source of manganese. During the Pleistocene era, the Macoupin Creek watershed was covered by glacier. After the glacier receded, the land was nearly level, so uplands in the Macoupin Creek watershed typically have low relief. The elevation at the point of origin (northeast of Farmerville) is 650 feet above mean sea level. The elevation drops to approximately 466 feet at the confluence with Hodges Creek (Macoupin Creek SWCD, 2003).

Figure 2 shows the major soil associations in the Macoupin Creek watershed. Each association has a distinctive pattern of soils, relief, and drainage. Typically, an association consists of one or more major soils and some minor soils (USDA, 1990). Deposits of glacial drift average 50 feet thick in Macoupin County, but in some areas, the drift is nearly 200 feet thick over bedrock valleys that trend east to west across the drainage. The loess or silt covering the drift is 50-100 inches thick and is highly erodible (USDA, 1990). There have been ongoing efforts to reduce erosion through various programs, as described below. The most common sediments found in the subsurface of the watershed are diamicton, consisting of a compact mixture of clay, silt, and sand particles. This dense, compact sediment, when exposed in stream banks, can be involved in slumping and minor landslides. Detail on the geology and soils in the Macoupin Creek watershed can be found in the Watershed Restoration Action Strategy Report (Macoupin County SWCD, 2003) and the Macoupin County Soil Survey (USDA, 1990).

Many of the soils in the Macoupin Creek watershed contain manganese and iron oxide concretions or accumulations and are also acidic. This could result in manganese and iron moving into solution and being transported in base flow and/or runoff, as discussed in later sections of this report.

Coal has been extensively mined throughout this portion of Illinois. Figure 1 shows the locations of active coal mines in the Lower Macoupin Creek watershed.

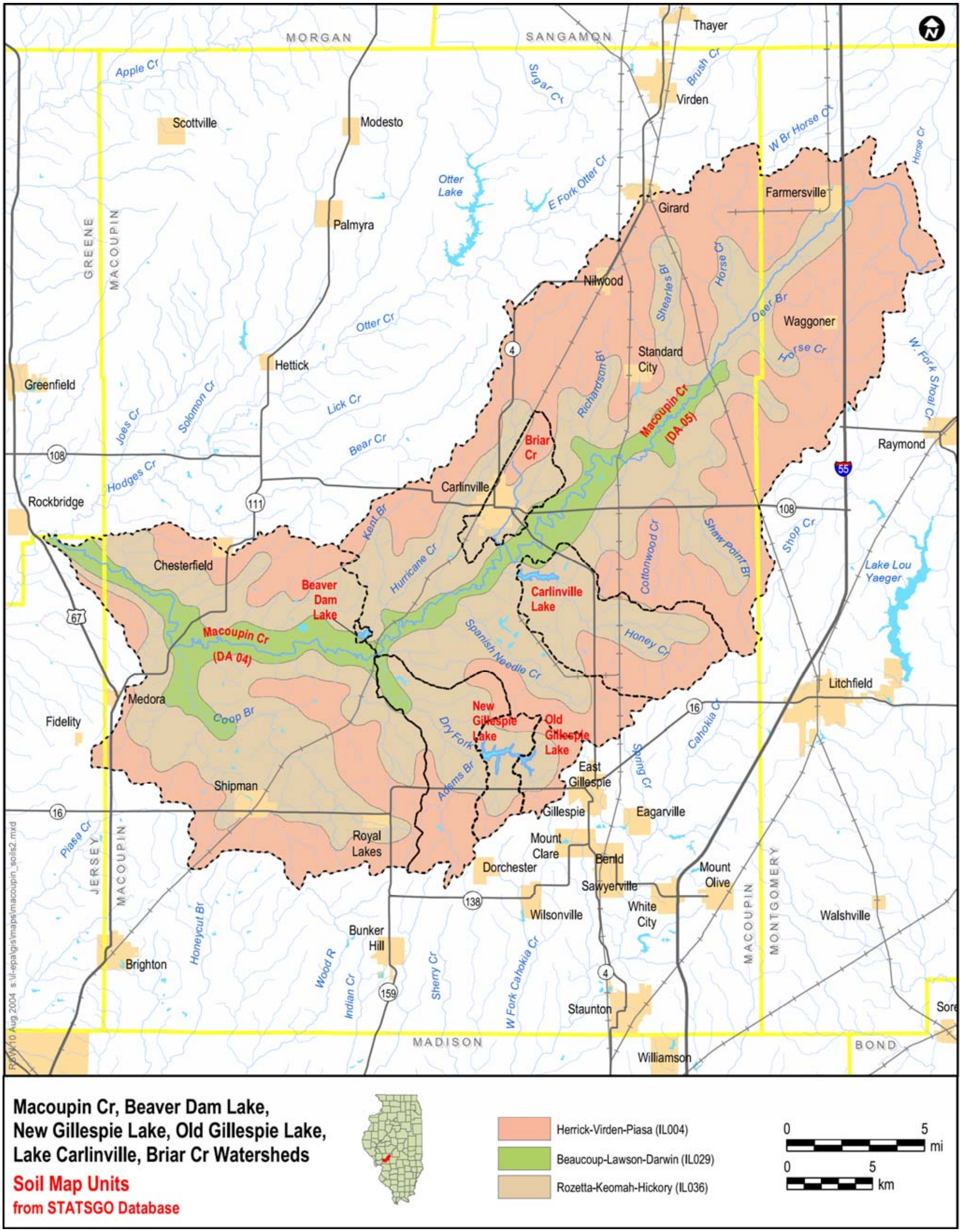

Figure 2. Soil Associations in the Macoupin Creek Watershed

Climate

Climate information was obtained and summarized to support the watershed characterization and gain an understanding of runoff characteristics for this study area. The Macoupin Creek watershed has a temperate climate with cold, snowy winters and hot summers. The National Weather Service (NWS) maintains a weather station at Carlinville through the Cooperative Observer Program (COOP). Climate data are archived at the National Climatic Data Center (NCDC) and summaries are available on the web page of the Illinois State Climatologist Office (Illinois Water Survey, 2004). The average long-term precipitation recorded at Carlinville (Station 111280) is approximately 39 inches. The maximum annual precipitation is 58.14 inches (1927) and the minimum annual precipitation is 21.94 inches (1976). On average there are 114 days with precipitation of at least 0.01 inches and 9 days with precipitation greater than 1 inch. Average snowfall is approximately 20.7 inches per year.

Average maximum and minimum temperatures recorded at Carlinville are 34.9^{o} F and 17.4^{o} F, in January and 87.3^{o} F and 66.6^{o} F in July. These averages are based on measurements collected between 1971 and 2000. The average temperature recorded in January is 26.2^{o} F and the average temperature recorded in July is 77.0^{o} F.

Hydrology

An understanding of hydrology helps with understanding the importance of different watershed transport and instream processes. There are no USGS streamflow gages in this watershed. The *Watershed Restoration Action Strategy* (Macoupin County SWCD, 2003) lists Macoupin Creek as a perennial stream, and Briar Creek is listed as an intermittent stream. Dry Fork (the Gillespie Lakes are impoundments on Dry Fork) is an intermittent stream. The *Watershed Restoration Action Strategy* also provides information on hydrological alterations. The report states that there are 14 miles of channelized stream (of the larger streams in the watershed), or 7% of the total stream miles. Approximately 1.2 miles of channelized stream are on Macoupin Creek. Channelization may be destabilizing, and lead to high rates of streambank erosion (Macoupin County SWCD, 2003).

Land Cover

Runoff from the land surface contributes pollutants to nearby receiving waters. In order to understand sources contributing to the waterbody impairments, it was necessary to characterize land cover in the watershed. Land cover in the Macoupin Creek watershed in 1999-2000 is shown in Figure 3, and listed in Table 2. The predominant land cover in the watershed is agriculture, shown in yellow on the map. Approximately 74% of the watershed is cropland. The second highest land cover is forest, which covers approximately 14% of the watershed.

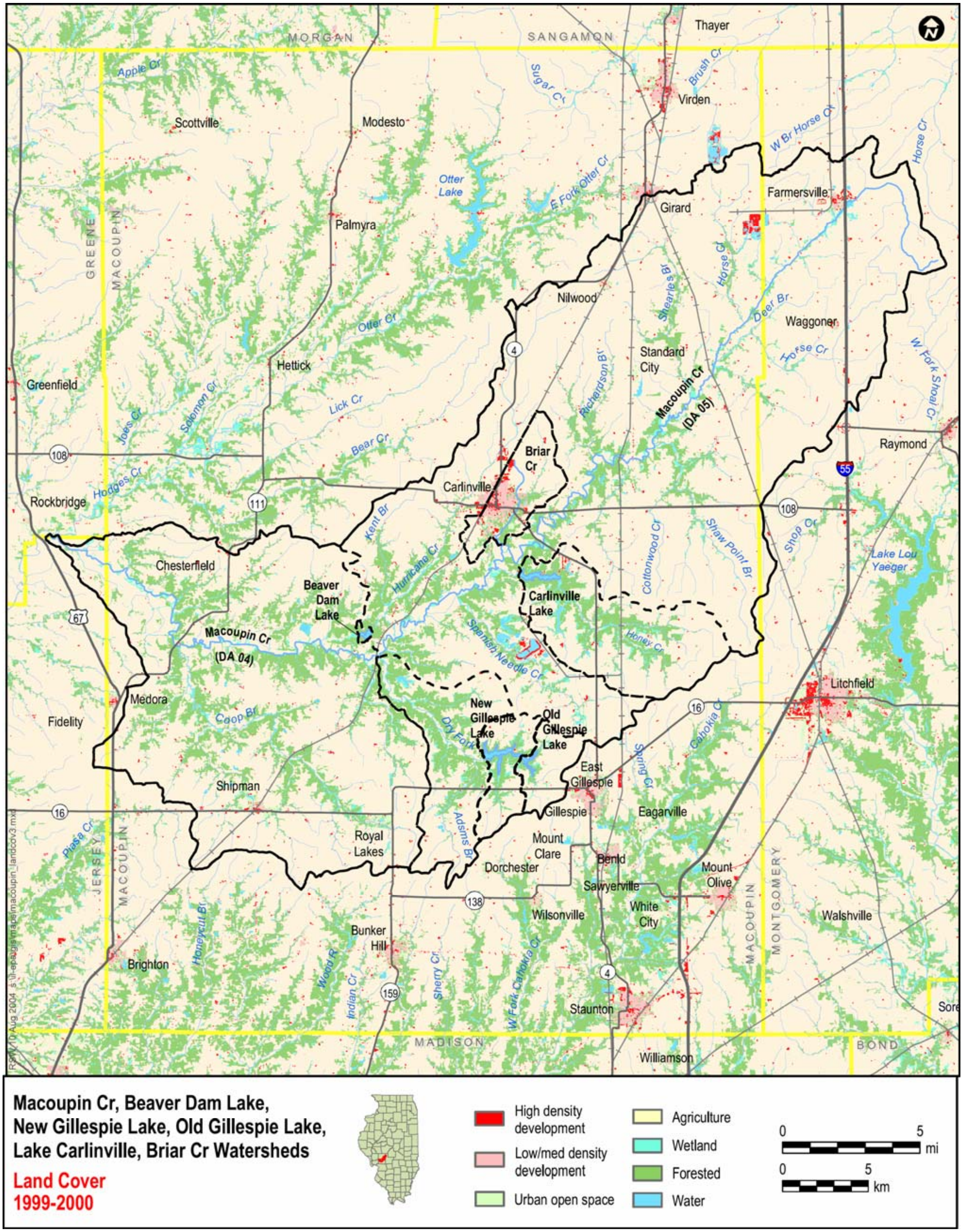

Figure 3. Land Cover in Macoupin Creek Watershed 1999-2000

Table 2. Land Cover in Macoupin Creek Watershed

Land Cover Type	Area (acres)	Percent of Watershed Area
Agriculture	190,458	74.2
Forest	36,630	14.3
Grassland	13,998	5.4
Urban	6,022	2.3
Water	1,386	0.55
Wetland	8,243	3.2
Barren Land	117	0.05
Totals	**256,854**	**100**

Most farms in the area have a corn-soybean rotation, and some farmers include wheat in their rotations. Tillage practices in the watershed were documented in an erosion survey in 2002 (Macoupin County SWCD, 2003). The survey found that approximately 29% of the cropland is tilled using tillage methods that leave little or no residue on the surface. Approximately 57% of the cropland is tilled by reduced tillage methods, which can reduce soil loss in comparison to conventional methods by 30%. The remaining 14% of cropland is planted without any tillage prior to planting, a process that can reduce soil loss by up to 75%.

A recent report by the Illinois Department of Agriculture (IDA, 2002) reports tillage practices by crop type for Macoupin County, as shown below in Table 3.

Table 3. Tillage Practices by Crop Type – Macoupin County

Percent of Fields, by crop, with indicated tillage system

	Conventional Till[1]	Reduced-Till[2]	Mulch-Till[3]	No-Till[3]
Corn	91	4	2	4
Soybean	20	23	14	43
Small grain	38	0	0	63

[1] Residue level 0 – 15%
[2] Residue level 16-30%
` [3] Residue level > 30%

Erosion is a problem in the Macoupin Creek Watershed. The *Watershed Restoration Action Strategy* reports the results of an erosion/sedimentation inventory that was conducted for the watershed. The study found that an estimated 883,096 tons of erosion occurs on an annual basis from sheet, rill, ephemeral, gully, and streambank erosion. Approximately 74 % of the erosion comes from sheet and rill erosion for all the different land covers in the watershed.

According to the Macoupin County NRCS District Conservationist, common fertilizers in Macoupin County are anhydrous ammonia, diammonium phosphate (DAP) and potash. Most anhydrous ammonia is applied to corn in the spring. Not much is done in the fall, but if it is done it is recommended that one use N-Serve to prevent nitrate migration.

The yellow areas on Figure 3 indicating agricultural land cover include livestock operations. A windshield survey in 2002 (Macoupin Creek SWCD, 2003) noted 221 cattle operations, 55 hog operations, and 6 farms with sheep in the watershed. These livestock operations are located throughout the Lower Macoupin Creek watershed.

The green areas on Figure 3 show forested lands (approximately 14% of the watershed), which are both upland (generally oak-hickory) and floodplain (mixed composition). Also shown on the map (in red) are areas of low/medium and high density development (approximately 2% of the watershed). These areas indicate the locations of the residential communities in the watershed. Carlinville is the largest urban area in Macoupin County.

Urbanization and Growth

Urbanization and growth are two factors that can affect the amount and quality of runoff from land surfaces and which also affect the demand on water and sewage treatment facilities. The Macoupin watershed encompasses portions of four counties (Green, Jersey, Macoupin and Montgomery) and ten small communities. These communities are: Chesterfield, Royal Lakes, Shipman, Carlinville, Farmersville, Girard, Nilwood, Standard City, Waggoner, and Dorchester. Carlinville is the largest urbanized area in the watershed with a population of nearly 7,000 in the greater Carlinville area (http://www.carlinville.com/).

Estimated current population in the Macoupin Creek watershed is 16,000. The State of Illinois Population Trends Report (State of Illinois, 1997) provides projected population trends by county. For Macoupin County, where most of the watershed is located, the population is expected to increase by approximately 9% between 2000 and 2020.

Point Source Discharges

Data are available for eleven entities that have NPDES permits. Seven of these are sewage treatment plant outfalls and are permitted to discharge treated wastewater to Macoupin Creek or its tributaries. One of these sewage treatment plants (Carlinville STP) also has a permit for a treated CSO (when flows exceed maximum design flow of 3.75 MGD) and a second CSO (Broad Street). All outfalls from the Carlinville STP discharge to Briar Creek. Two of the permitted dischargers are coal mines (one surface and one underground) and two are public water supplies. Table 4 provides a list of permittees and parameters that are permitted to be discharged from these outfalls, and permit expiration dates.

Table 4. NPDES Discharges and Parameters

NPDES ID	Facility name	Pipe description	Average design flow (MGD)	Permitted to Discharge	Permit expiration date
IL0004669 and IL0059471	Freeman United Coal-Crown 1 and Freeman United Coal-Crown 3	Acid-controlled surface mine drainage; domestic wastewater; acid mine drainage; alkaline mine drainage	N/A	Fecal coliform, $CBOD_5$, Flow, Iron, pH, Total suspended solids	01-Jul-93
IL0056022	Monterey Coal #1 Mine North	Acid mine drainage; alkaline mine drainage; reclamation area; sanitary wastewater	N/A	N/A	15-Sept-00
IL0022675	Carlinville STP	STP outfall; Treated CSO outfall for flows between 3.75 and 18.75 MGD; CSO-Broad St.	1.5	Fecal coliform, $CBOD_5$, BOD_5, Flow, Total and dissolved iron, Total manganese, Total ammonia nitrogen, pH, Total suspended solids	31-Dec-07
IL0045373	Lake Williamson Christian Cntr	STP outfall	0.032	Fecal coliform, BOD_5, $CBOD_5$, Flow, pH, Total suspended solids	31-Jul-09
IL0051390	Carlinville Waterworks System	Filter backwash and clarifier sludge bldwn	0.02	Flow, pH, Total suspended solids	31-Oct-07
IL0051454	Waggoner WTP	Iron filter backwash waste water	N/A	Flow, Total iron, chlorine, Total suspended solids	30-Nov-05
IL0063088	Shipman STP	STP outfall	0.08	BOD_5, $CBOD_5$, Flow, Total ammonia nitrogen, pH, Total suspended solids	30-Jun-05
IL0069175	Il DNR-Beaver Dam State Park Shower	STP outfall	0.0024	Fecal coliform, BOD_5, $CBOD_5$, Flow, Total ammonia nitrogen, pH, Total suspended solids	31-Dec-01
IL0071391	Royal Lakes STP	STP outfall	0.041	Fecal coliform, BOD_5, $CBOD_5$, Flow, pH, Total suspended solids	30-Apr-01
ILG580090	Nilwood STP	STP outfall	0.049	BOD_5, $CBOD_5$, Flow, pH, Total suspended solids	31-Dec-07
ILG580126	Farmersville STP	STP outfall	0.125	BOD_5, $CBOD_5$, Flow, pH, Total suspended solids	31-Dec-07

N/A = Not available

Watershed Activities

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. The Macoupin Creek Watershed Restoration Action Strategy (WRAS) prepared by the Macoupin County Soil and Water Conservation District (SWCD) in 2003 compiled information on agencies and organizations that are active in or near the Macoupin Creek watershed. State agencies currently active in the watershed are Illinois Department of Agriculture (IDA), Illinois Department of Natural Resources (IDNR), and the Illinois Environmental Protection Agency (IEPA). The USDA/NRCS in conjunction with the Macoupin County Soil and Water Conservation District offers landowners programs to cost-share for conservation plans and best management practices. These include programs such as the Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP). The Illini Valley Resource Conservation & Development Council (RC&D), which is not yet federally authorized and is currently in the formation process, will provide additional technical support for natural resource related practices in Macoupin County (and other counties). Volunteer programs currently active in the area include:

- RiverWatch (IDNR)
- Acres for Wildlife (IDNR)
- Volunteer Lake Monitoring Program (ILEPA)
- Conservation Practice Program – CPP (IDA)

In addition to the programs mentioned above, it should be noted that Heartland Ecosystem Services, Inc. has recently applied for 319 and Clean Lakes Study grant money to conduct watershed assessment and sampling for all tributaries to Carlinville Lake and to conduct water quality sampling in this lake.

Macoupin Creek (DA 04) Watershed Characterization

Macoupin Creek Segment DA 04 is 19.7 miles in length and its subwatershed is 256,854 acres in size. This segment of the creek flows through forest lands (14%) and open agricultural areas (74%). It receives water from Segment DA 05 of Macoupin Creek, and flows downstream to the confluence with Hodges Creek. Segment DA 04 flows through Macoupin County and the northeast corner of Jersey County. There are four small communities in this subwatershed: Chesterfield, Royal Lakes, Shipman, and Dorchester. The subwatershed for Segment DA 04 is the entire Macoupin Creek watershed (above Hodges Creek). Land cover information was provided above in Table 2. Photos are provided in Appendix B.

Macoupin Creek (DA 05) Watershed Characterization

Macoupin Creek Segment DA 05 is 43.9 miles in length and its subwatershed is 163,919 acres in size. It is the most upstream segment on Macoupin Creek, originating southeast of Farmersville in Montgomery County. Most of this segment is in Macoupin County, where it receives flow from Briar Creek and Carlinville Lake. This segment of Macoupin Creek flows through open agricultural areas and some forested lands. There are six communities in this subwatershed: Carlinville, Farmersville, Girard, Nilwood, Standard City, and Waggoner. Land cover for the Macoupin Creek DA 05 subwatershed is listed in Table 5. Approximately 79% of the land is used for agriculture, and approximately 10% is forested. Photos are provided in Appendix B.

Table 5. Land Cover in Segment DA05 Macoupin Creek Subwatershed

Land Cover	Area (acres)	Percent of Watershed Area
Agriculture	129,229	78.8
Forest	17,321	10.6
Grassland	7,130	4.3
Wetland	4,748	2.9
Urban	4,533	2.8
Water	890	0.5
Barren	68	0.04
Total	**163,919**	**100**

Briar Creek (DAZN) Watershed Characterization

Briar Creek is a small creek (4.0 miles in length) that flows through cropland and a hilly wooded residential neighborhood in Carlinville. In late June during the field visit, flow was very low, and the creek in the vicinity of Briar Creek Road was generally a series of standing water and small ponds. The watershed covers a total of 5,554 acres of Macoupin County (shown as a dotted line in Figure 3). The creek flows through forested and open agricultural areas. Land cover for Briar Creek is listed in Table 6. Approximately 60% of the land is used for agriculture, and 22% is urban development. Photos are provided in Appendix B.

Table 6. Land Cover in Briar Creek Subwatershed

Land Cover Type	Area (acres)	Percent of Watershed Area
Agriculture	3,313	59.6
Urban	1,247	22.5
Forest	634	11.4
Grassland	288	5.2
Wetland	56	1.0
Water	9	0.2
Barren	7	0.1
Total	**5,554**	**100**

Carlinville Lake (RDG) Watershed Characterization

Carlinville Lake is located in Macoupin County and it is 168 acres in size. Its subwatershed is 15,136 acres in size. The land surrounding the lake is forested, and the banks of the lake are steep. Some shoreline erosion was evident during the field visit. There is a dam and water treatment plant at the western end of the lake. Land cover for the Carlinville Lake subwatershed is listed in Table 7. Approximately 64% of the land is used for agriculture and 23% is forested. Photos of Carlinville Lake are provided in Appendix B.

Table 7. Land Cover in Carlinville Lake Subwatershed

Land Cover Type	Area (acres)	Percent of Watershed Area
Agriculture	9,744	64.4
Forest	3,441	22.7
Wetland	743	4.9
Grassland	739	4.9
Water	240	1.6
Urban	226	1.5
Barren	3	0.02
Total	**15,136**	**100**

Beaver Dam Lake (RDH) Watershed Characterization

Beaver Dam Lake, located in Macoupin County, is small (49 acres in size) and shallow (approximately 10 feet deep). It drains to a nearby open water marsh via a wide drainage that includes a settling pond. During the field visit in late June, the drainage and the marsh were thick with green algal growth. In addition to receiving drainage from the lake, the marsh receives drainage from the park's wastewater system. No algae were observed in the lake itself at the time of the field visit. The lake's watershed is small, about 185 acres in size. There is limited development including park roads in this subwatershed, and there is one permitted point source discharge (from park showers).

The Assistant Site Superintendent of Beaver Dam State Park, Mike Page, described how during rain events, stormwater runs through a wide gully from farm fields located at a higher elevation and north of the lake, through the campground and woods, under a road, and into the lake. The topography in this area is very steep. Mr. Page described how during very heavy rains, the water flows over a park road. He explained that the drainage ditch from the fields, as well as the lake bottom near the outlet of the ditch, needs to be cleaned out periodically to remove sediment from the fields. A smaller drainage to the lake was observed next to the visitor's center. Fishing is generally reported to be poor in the lake. It is sprayed every spring for curly leaf pondweed.

Land cover for the Beaver Dam Lake subwatershed is listed in Table 8. Approximately 56% of the land is forested. There are prairie restoration activities in Beaver Dam State Park near the lake. Photos are provided in Appendix B.

Table 8. Land Cover in Beaver Dam Lake Subwatershed

Land Cover	Area (acres)	Percent of Watershed Area
Forest	103	55.7
Water	49	26.7
Wetland	12	6.7
Agriculture	11	6.1
Urban	7	4.0
Grassland	2	0.8
Total	**185**	**100**

Old and New Gillespie Lakes (SDT and SDU) Watershed Characterization

A comprehensive report prepared in 1999 under the Illinois Clean Lakes Program (Crawford, 1999) provides valuable information on both Gillespie Lakes, including detailed information on land uses, nonpoint source loadings, and water quality problems in the lakes. The report includes a Feasibility Study directed at development of a restoration plan for the lakes. This section provides a brief overview of these characteristics, and, and the reader is referred to the report for more information.

Old and New Gillespie Lakes are impoundments on Dry Fork Creek. The primary land cover within the Gillespie Lakes watershed is cropland (corn, soybeans and wheat). The primary tillage system used to grow these crops is a chisel/disk system done in the spring before planting. The second largest acreage cover is the woodland acreage that is predominantly located along sloping areas adjacent to the lakes. There is little to no discharge of groundwater to the lakes or their tributaries. The region is characterized by flat to rolling ground. Slopes near the lakes are relatively steep, and soils in this area are susceptible to erosion. A recent study (Crawford and Associates, 1999) estimated that approximately 11,000 tons of soil are eroded and delivered to Old Gillespie Lake each year, and approximately 15,000 tons of soil are estimated to be eroded and delivered to New Gillespie Lake each year. This is due to runoff from land including farmland, and streambank erosion, which is reported to be severe along the creek.

Old Gillespie Lake (Segment SDT)

Old Gillespie Lake is located in Macoupin County and it is 71 acres in size. Its subwatershed is rolling terrain, and approximately 3,093 acres in size. There are no towns in this subwatershed, although the land immediately around the lake is developed with older small cottages and trailers. Land cover for the Old Gillespie Lake subwatershed is listed in Table 9. Approximately 77% of the land is used for agriculture. The land surrounding the lake is forested. Photos are provided in Appendix B.

Table 9. Land Cover in Old Gillespie Lake Subwatershed

Land Cover Type	Area (acres)	Percent of Watershed Area
Agriculture	2,371	76.7
Forest	277	9.0
Grassland	220	7.1
Wetland	148	4.8
Water	41	1.3
Urban	35	1.1
Barren	2	0.05
Total	**3,093**	**100**

New Gillespie Lake (SDU)

New Gillespie Lake is located in Macoupin County and it is 207 acres in size. In late June the water in the lake was dark, and algal blooms were apparent along the shore. At the time of the site visit, the swimming beach was fenced off with several signs posted. Some of the signs included regulations and hours the beach was open. One of the signs posted at the time of the site visit read “swimming area closed”.

The New Gillespie Lake subwatershed is 7,215 acres in size. Land cover for the New Gillespie Lake subwatershed is listed in Table 10. Approximately 68% of the land is used for agriculture, and 16% is forested. The land surrounding the lake is very wooded, and there are many older cottages and trailers. Several horses were observed in a campground near the lake, and at a nearby horse farm. Photos are found in Appendix B.

Table 10. Land Cover in New Gillespie Lake Subwatershed

Land Cover Type	Area (acres)	Percent of Watershed Area
Agriculture	4,883	67.7
Forest	1,132	15.7
Grassland	491	6.8
Wetland	424	5.9
Water	199	2.8
Urban	84	1.2
Barren	2	0.03
Total	**7,215**	**100**

DATABASE DEVELOPMENT AND DATA ANALYSIS

A water quality database was developed and the data were analyzed to confirm the sufficiency of the data to support both the listing decision and the sources of impairment that are included on the draft 2004 303(d) list.

Data Sources and Methods

All readily available existing data to describe water quality in the impaired waterbodies were obtained. IEPA data included IEPA ambient water quality monitoring data, facility-related stream survey data, and IEPA NPDES monitoring data. Data collected by the United Stated Geological Survey (USGS) through their routine monitoring program were also obtained. All available and relevant data were then compiled in electronic format along with sample location and depth information, in a project database. A list of data sources is included in Appendix A.

The water quality data were analyzed to confirm the cause of impairment for each waterbody and, in combination with the watershed characterization data, an assessment was made to confirm the sufficiency of the data to support the listing decision and the sources of impairment that are included on the draft 2004 303(d) list. Data were first compiled and basic statistics for each parameter were computed. The data were then compared to relevant water quality criteria based on beneficial use. Related parameters were also analyzed to understand sources of impairment (e.g., total phosphorus data were reviewed for waterbodies with dissolved oxygen impairments).

A summary of readily available water quality data for the watershed is presented in Table 11 below, including the period of record and data ranges. Sampling station locations are shown in Figure 4.

Table 11. Water quality data summary for the Macoupin Creek watershed

Waterbody Segment	Parameter	Sampling station	Period of record (#)	Minimum	Maximum	Average
Macoupin Creek DA 04	Dissolved oxygen (mg/l)	DA 03	7/1998-9/2001 (4 samples)	5.5	8.7	7.2
		DA 04	1/1990-5/2003 (117 samples)	3	15.4	8.8
	Manganese (ug/l)	DA 03	6/2001-9/2001 (3 samples)	250	1000	733
		DA 04	1/1990-5/2003 (92 samples)	120	9100	497
	Fecal coliform (cfu/100ml)	DA 04	1/1990-6/2004 (102 samples)	10	91000	2421
Macoupin Creek DA 05	Dissolved oxygen (mg/l)	DA 05	1/2000-12/2002 (25 samples)	4.5	15.8	9.5
		DA11	7/2001 (1 sample)	3.1	3.1	3.1
		DA-CV-C4	9/1998 (1 sample)	1.5	1.5	1.5
		DA-CV-D2	9/1998 (1 sample)	1.9	1.9	1.9
		05586645	8/1997 (1 sample)	5.8	5.8	5.8
	Manganese (ug/l)	DA 11	7/2001 (1 sample)	510	510	510
		DA-CV-C4	9/1998 (1 sample)	330	330	330
		DA-CV-D2	9/1998 (1 sample)	1500	1500	1500

Table 11. Water quality data summary for the Macoupin Creek watershed (Continued)

Waterbody Segment	Parameter	Sampling station	Period of record (#)	Minimum	Maximum	Average
Briar Creek DAZN	Dissolved oxygen (mg/l)	DAZN-CV-C1	9/1998 (1 sample)	4.5	4.5	4.5
		DAZN-CV-C2	9/1998 (1 sample)	0.3	0.3	0.3
		DAZN-CV-C3	9/1998 (1 sample)	2.7	2.7	2.7
Carlinville Lake RDG	Manganese (ug/l)	RDG-1	4/2002-10/2002 (5 samples)	46	200	95
	Total Phosphorus (mg/l)	RDG-1	4/1992-10/2002 (34 samples)	0.05	0.48	0.14
		RDG-2	4/1992-10/2002 (15 samples)	0.07	0.32	0.11
		RDG-3	4/1992-10/2002 (15 samples)	0.08	0.33	0.13
Beaver Dam Lake RDH	Total Phosphorus (mg/l)	RDH-1	5/1992-10/2002 (28 samples)	0.02	0.29	0.10
		RDH-2	4/1993-10/2002 (10 samples)	0.03	0.14	0.09
		RDH-3	4/1993-10/2002 (10 samples)	0.02	0.13	0.08
New Gillespie Lake SDU	Total Phosphorus (mg/l)	SDU-1	4/1996-10/2002 (39 samples)	0.059	0.94	0.206
		SDU-2	4/1996-10/2002 (27 samples)	0.072	0.31	0.147
		SDU-3	4/1996-10/2002 (23 samples)	0.063	0.32	0.162
Old Gillespie Lake SDT	Manganese (ug/l)	SDT-1	4/2001-10/2001 (5 samples)	59	310	178
	Total Phosphorus (mg/l)	SDT-1	4/1996-10/2001 (50 samples)	0.05	1.37	0.36
		SDT-2	4/1996-10/2001 (19 samples)	0.05	0.62	0.33
		SDT-3	4/1996-10/2001 (24 samples)	0.06	0.65	0.31

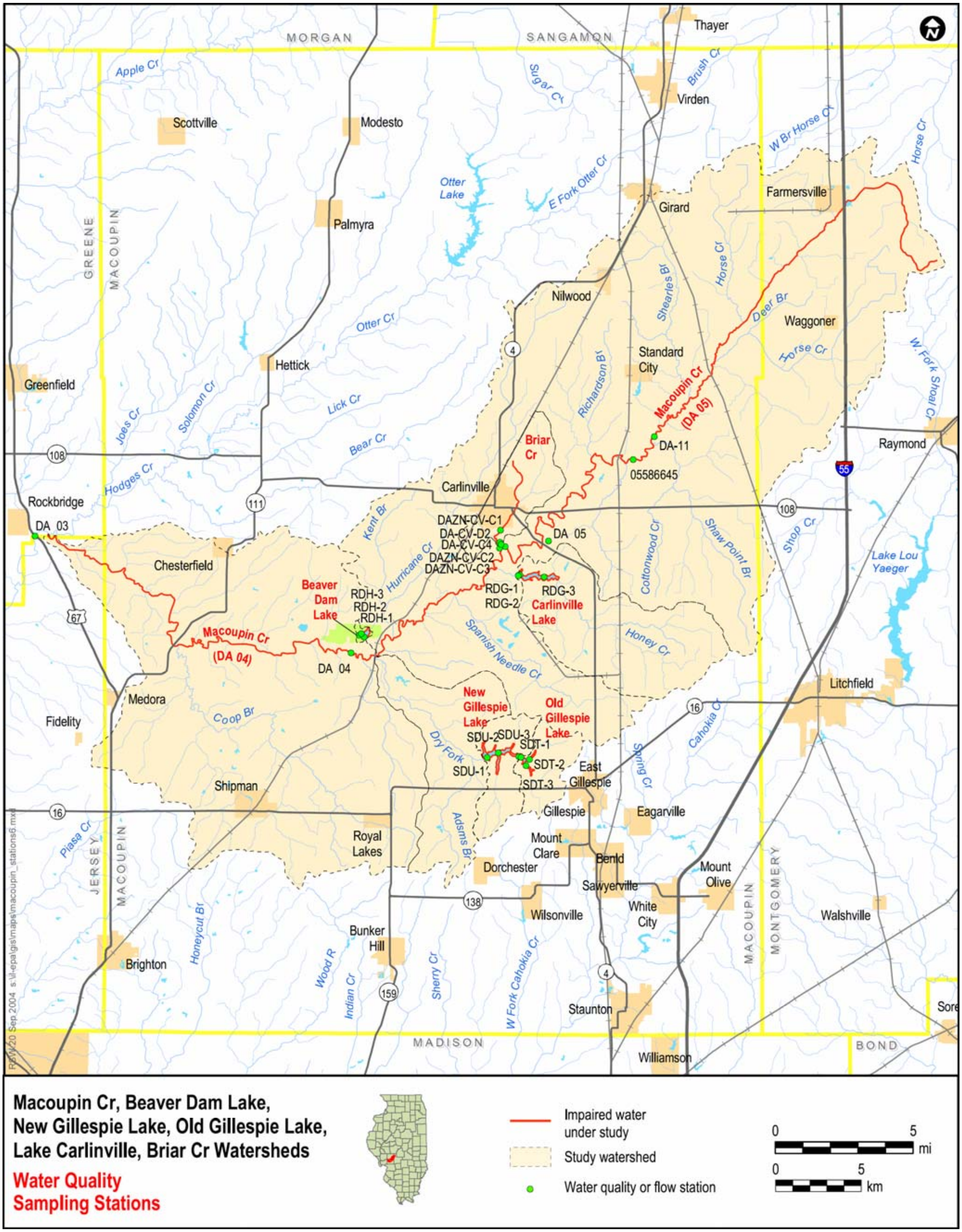

Figure 4. Sampling stations in the Macoupin Creek watershed

CONFIRMATION OF CAUSES AND SOURCES OF IMPAIRMENT

Water quality data were evaluated to confirm the cause of impairment for each waterbody in the Macoupin Creek watershed, and in combination with the watershed characterization data, the sufficiency of the data to support the sources of impairment that are included on the 2004 303(d) list was assessed. Table 12 lists the impaired waterbodies, the applicable water quality criteria, and the number of samples exceeding the criteria. These data are discussed by waterbody in the following sections.

Table 12. Water Quality Standards and Number of Exceedances

Sample Location/ Cause of Impairment	Applicable Illinois Nonspecific Use Designation	Water Quality Criterion	Number of Samples Exceeding Criterion
Macoupin Creek (DA 04)			
Manganese	General Use	1000 ug/l	3 of 95 samples > criteria
Dissolved oxygen	General Use	5 mg/l minimum	8 of 121 samples < criteria
Fecal coliform	General Use	400 cfu/100ml when TSS $\leq$ 50th percentile	9 of 42 samples > criteria
Macoupin Creek (DA 05)			
Manganese	General Use	1000 ug/l	1 of 3 samples > criteria
Dissolved oxygen	General Use	5 mg/l minimum	5 of 29 samples < criteria
Briar Creek (DAZN)			
Dissolved oxygen	General Use	5 mg/l minimum	3 of 3 samples < criteria
Carlinville Lake (RDG)			
Manganese	Public Water Supply	150 ug/l	1 of 5 samples > criteria
	General Use	1000 ug/l	0 of 5 samples > criteria
Total Phosphorus	General Use	0.05 mg/l	45 of 45 surface samples > criteria
Beaver Dam Lake (RDH)			
Total Phosphorus	General Use	0.05 mg/l	33 of 39 surface samples > criteria
Old Gillespie Lake (SDT)			
Manganese	Public Water Supply	150 ug/l	3 of 5 > criteria
	General Use	1000 ug/l	0 of 5 > criteria
Total Phosphorus	General Use	0.05 mg/l	76 of 78 surface samples > criteria
New Gillespie Lake (SDU)			
Total Phosphorus	General Use	0.05 mg/l	71 of 71 surface samples > criteria

The following sections also discuss potential sources of impairments. The Illinois EPA (IEPA, 2004) defines potential sources as known or suspected activities, facilities, or conditions that may be contributing to impairment of a designated use. The impairments identified by IEPA in the 305(b) report are listed in Table 13. These potential sources were supplemented with data reflecting point source discharges in the watershed, non-point pollution sources, and data and information collected as part of Stage 1 activities, as summarized in Table 14 and described in the following section.

Table 13. Waterbody Impairment Causes and Sources (from IEPA, 2004)

Waterbody	Cause of impairments	Potential Sources (from 305(b) Report)
Macoupin Creek (DA 04)		
	Manganese	Resource extraction
	Dissolved oxygen	Source unknown
	Fecal coliform	Source unknown
Macoupin Creek (DA 05)		
	Manganese	Resource extraction
	Dissolved oxygen	Municipal point sources
Briar Creek (DAZN)		
	Dissolved oxygen	Habitat modification (other than hydromodification)
Carlinville Lake (RDG)		
	Manganese	Agriculture; Crop-related sources; non-irrigated crop production; Habitat modification; Streambank modification/destabilization; Recreation and tourism activities; Forest/grassland/parkland; Source unknown
	Total Phosphorus	
Beaver Dam Lake (RDH)		
	Total Phosphorus	Agriculture; Crop-related sources; non-irrigated crop production; Forest/grassland/parkland
Old Gillespie Lake (SDT)		
	Manganese	Agriculture; Crop-related sources; non-irrigated crop production; Habitat modification; Streambank mod./destabilization; Forest/grassland/parkland; source unknown
	Total Phosphorus	
New Gillespie Lake (SDU)		
	Total Phosphorus	Agriculture; Crop-related sources; non-irrigated crop production; Habitat modification; Streambank modification/destabilization; Recreation and tourism activities; forest/grassland/parkland

Table 14. Other Impairment Causes and Sources

Waterbody	Cause of impairments	Potential Sources
Macoupin Creek (DA 04)		
	Manganese	Natural background sources
	Dissolved oxygen	Respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, low flow, municipal point sources
	Fecal coliform	Municipal point sources, agricultural runoff, failing septic systems
Macoupin Creek (DA 05)		
	Manganese	Natural background sources
	Dissolved oxygen	Respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, low flow, municipal point source discharge
Briar Creek (DAZN)		
	Dissolved oxygen	Point source discharges (including CSOs), agricultural runoff and low flows
Carlinville Lake (RDG)		
	Manganese	Natural background, seasonal hypolimnetic anoxia
	Total Phosphorus	Agricultural runoff, seasonal hypolimnetic anoxia, algal decay
Beaver Dam Lake (RDH)		
	Total Phosphorus	Agricultural runoff, seasonal hypolimnetic anoxia, point source
Old Gillespie Lake (SDT)		
	Manganese	Natural background, seasonal hypolimnetic anoxia
	Total Phosphorus	Agricultural runoff, stream bank erosion, seasonal hypolimnetic anoxia, failing septic systems
New Gillespie Lake (SDU)		
	Total Phosphorus	Agricultural runoff, stream bank erosion, seasonal hypolimnetic anoxia, failing septic systems

Macoupin Creek (DA 04)

Listed for: Dissolved Oxygen, Manganese, and Fecal Coliform

Dissolved oxygen, fecal coliform, and manganese data were collected at multiple stations (two, one, and two stations, respectively) located within this segment (DA 04). The data were collected between 1990 and 2004, as shown in Table 11.

Dissolved Oxygen

The IEPA guidelines (IEPA, 2004a) for identifying dissolved oxygen as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of the applicable standard (5.0 mg/l) or known fish kill resulting from dissolved oxygen depletion. For the available data, 8 of 121 (7%) dissolved oxygen measurements were below the general use water quality criterion of 5 mg/l. Excursions ranged from 0.04 to 2.0 mg/l below the criterion and have occurred throughout the sampling record, with the most recent occurrence in 2002. The 8 excursions occurred at the upstream station only (Station DA 04). The data compared to the general use criterion are shown in Figure 5. These data are considered representative of water quality in this segment, both temporally and spatially. Therefore the data are sufficient to support the causes listed on the draft 2004 303(d) list.

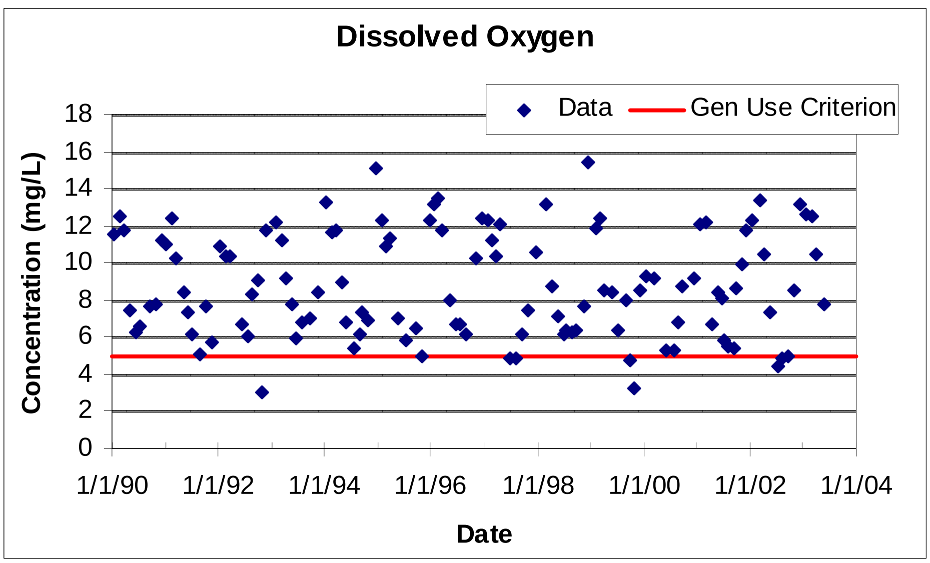

Figure 5. Macoupin Creek (DA04) Dissolved Oxygen Data Compared to General Use Criterion

Potential sources for the low dissolved oxygen in this segment were identified by reviewing the site characterization information and analyzing related data that provide information about photosynthesis and respiration, and other processes that may affect dissolved oxygen. While some excursions below the dissolved oxygen criterion occurred during summer months, others occurred in the late fall, indicating that other processes may be relevant. Data were not sufficient to explore the relationship between dissolved oxygen and ammonia and CBOD, and dissolved oxygen and chlorophyll. Potential sources of the low dissolved oxygen in this segment may include respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia and municipal point sources. Additional data collection will be needed to confirm any potential sources. Low flows may also contribute to low dissolved oxygen concentrations in this segment.

Manganese

The IEPA guidelines (IEPA, 2004a) for identifying manganese as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of applicable acute or chronic standards. For the available data, 3 of 95 manganese measurements exceeded the general use criterion. Exceedances ranged from 100 to 8,100 ug/l over the criterion, and these have occurred most recently in 2000. These data are considered representative of water quality in this segment, both temporally and spatially, and the data are considered sufficient to support the causes listed on the draft 2004 303(d) list.

Manganese is a naturally occurring element that is a component of over 100 minerals. Of the heavy metals, it is surpassed in abundance only by iron (Agency for Toxic Substances and Disease Registry (ATSDR) 1997). Because of the natural release of manganese into the environment by the weathering of manganese-rich rocks and sediments, manganese occurs ubiquitously at low levels in soil, water, air, and food (USEPA, 2003).

Many of the soils in the Macoupin Creek watershed contain naturally-occurring manganese concretions or accumulations and some soils are also acidic (USDA, 1990). The low pH could result in the manganese moving into solution and being transported through baseflow and/or runoff. A data analysis found that dissolved manganese accounts for approximately 90% of the total manganese. Streambank erosion of manganese-containing soils is also a likely source of manganese in the creek.

The observed levels of manganese are likely due to the natural geochemical environment and most likely reflect natural background conditions. For this reason, the general use standard may be difficult to attain. Manganese does not present any human health hazards, but may be responsible for offensive tastes and appearances in drinking water, as well as staining laundry and fixtures.

Fecal Coliform

The IEPA guidelines (IEPA, 2004a) for identifying fecal coliform as a cause in streams state that the primary contact use is not supported if the geometric mean is greater than 200/100 ml or if greater than 10% of the samples exceed 400/100 ml when TSS for that station is $\leq 50^{th}$ percentile. 42 fecal coliform samples were collected when TSS was $\leq 50^{th}$ percentile (41 mg/l). Of these, 9 (21%) of the fecal coliform samples were greater than 400 cfu/100 ml. For this subset of the fecal coliform data (where TSS $\leq$ 41 mg/l) the exceedances ranged from 80 to 11,600 cfu/100 mL over the criterion. Excursions were observed between 1990 and 2002. These data are considered representative of water quality in this segment, and the data are considered sufficient to support the causes listed on the draft 2004 303(d) list.

A comparison with total suspended solids (TSS) data indicates a positive relationship between fecal coliform and TSS (see Figure 6). This suggests there may be wet weather sources of fecal coliform, including runoff from agricultural operations. The Watershed Restoration Action Strategy (Macoupin County SWCD, 2003) indicates there are many livestock operations in the Macoupin Creek watershed, including in the vicinity of Macoupin Creek in this area and upstream in the watershed. There may be other sources of fecal coliform on Segment DA 05 of Macoupin Creek, which is immediately upstream of and flows into Segment DA 04. Potential sources include nonpoint sources including agricultural operations such as livestock operations. In addition, there are four point source discharges that are permitted to discharge fecal coliform in the watershed upstream of the Segment DA 04 sampling stations (see Table 4). Another potential source of fecal coliform is failing septic systems in the area including surrounding the Gillespie Lakes, which discharge to Dry Fork, which flows into Macoupin Creek upstream of the sampling station DA 04. Crawford & Associates (1999) reported that at the time of its study, there are many failed septic systems around Gillespie Lakes. Concentrations in failed septic systems range from 10,000 to 1,000,000 cfu/100 mL (Center for Watershed Protection, 1999).

The limited fecal coliform data available for Segment DA 05 (the segment upstream of Segment DA 04) suggests that this segment may be a source of fecal coliform to Segment DA 04. A facility-related stream survey (FRSS) conducted for the Carlinville Sewage Treatment Plant (IEPA, 1998), which discharges to Briar Creek, found high concentrations of fecal coliform in Briar Creek both upstream and downstream of the Carlinville STP (450,000 to 760,000 cfu/100 mL). The Carlinville has two combined sewer overflows, one of which is treated. Therefore, Briar Creek (and the Carlinville STP, including two combined sewer overflows) may be sources of fecal coliform to Segment DA 04 (via Segment DA 05), especially during wet weather. Fecal coliform was also measured at high concentrations in Macoupin Creek downstream of Briar Creek during the FRSS, as discussed in the following section. It should be noted that the Carlinville STP has a disinfection exemption that applies to the reach from the facility discharge to the confluence with Macoupin Creek, and from the confluence to the confluence with Hurricane Creek, a distance of 9.8 miles (personal communication, Scott Twait, IEPA). Because of this disinfection exemption, modeling will need to be conducted during the later TMDL stage to determine if these sources are contributing to DA 04 impairments.

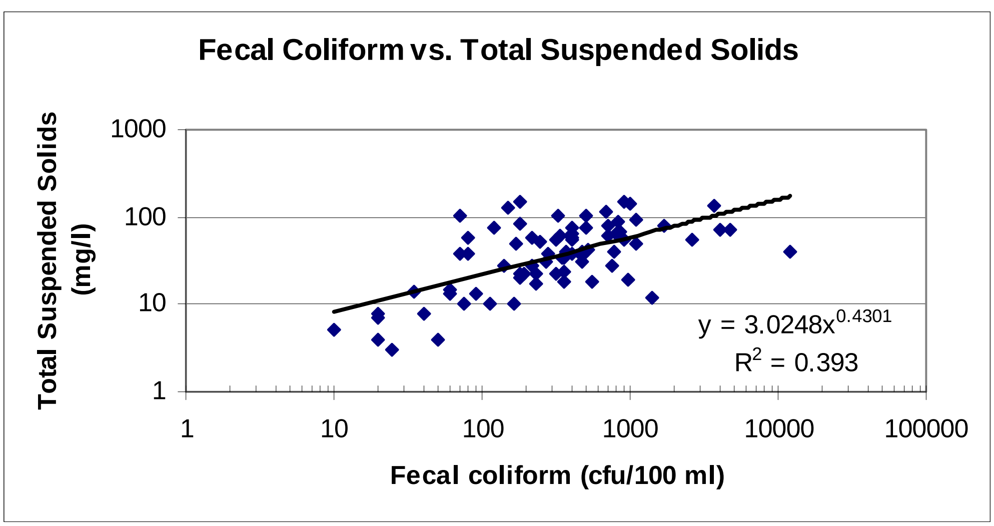

Figure 6. Relationship between Fecal Coliform and Total Suspended Solids (DA04)

Macoupin Creek (Segment DA 05)

Listed for: Dissolved Oxygen and Manganese

Dissolved oxygen and manganese data were collected at five and three stations, respectively. The stations were located in the middle and downstream ends of Segment DA 05. The data were collected between 1997 and 2001, as shown in Table 11.

Dissolved Oxygen

Dissolved oxygen data collected in this segment are compared to the general use water quality criterion in Figure 7. Five of 29 measurements are below the general use criterion of 5 mg/l. DO is also clearly inversely related to water temperature, and all five exceedances occurred on days with high water temperatures relative to the period of record. Two of the five exceedances are less than 0.5 mg/l below the 5 mg/l criterion. As stated previously, one exceedance of the dissolved oxygen criterion is sufficient to list dissolved oxygen as a cause for impairment of the aquatic life use (IEPA, 2004a).

Chlorophyll, CBOD and ammonia data are too limited to draw conclusions about the role of nutrients and algae. Based on the site characterization and available data, potential sources of low dissolved oxygen in this segment include point sources, sediment oxygen demand, CBOD degradation, ammonia nitrification and algal respiration. Additional data collection will be needed to confirm any potential sources.

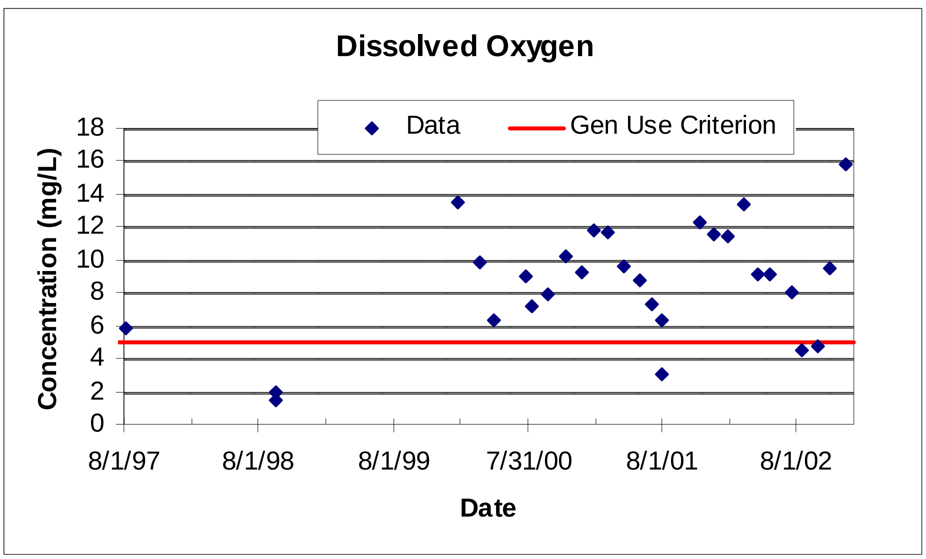

Figure 7. Dissolved oxygen data in Segment DA 05 Compared to General Use Criterion

Manganese

Three measurements are available for manganese for Segment DA 05 of Macoupin Creek. One of the three samples exceed the general use criterion of 1,000 ug/l by 500 ug/l. While manganese data for this segment are limited, they are considered representative of water quality in this segment, because data from nearby streams and lakes support that manganese is ubiquitous in this region. For this reason, and because the

IEPA guidelines state that one exceedance of the manganese criterion is sufficient to identify manganese as a cause of impairment, the data are considered sufficient to support manganese being listed on the draft 2004 303(d) list.

A discussion of background sources of manganese is provided above under Segment DA 04 of Macoupin Creek.

Fecal Coliform

Segment DA 05 is not listed for fecal coliform because there are not enough fecal coliform data available to assess the swimming use; however, an analysis of available data did reveal elevated fecal coliform levels. Two samples were collected in this segment during the 1998 FRSS for the Carlinville STP. Fecal coliform concentrations were relatively low upstream of the confluence with Briar Creek (140 cfu/100mL at Station DA-CV-D2) but downstream of Briar Creek at Station DA-CV-C4, fecal coliform was measured at 510,000 cfu/100mL. This concentration exceeds the general use criterion of 400 cfu/100 mL.

It should be noted, that the Carlinville STP, which discharges to Briar Creek, has a disinfection exemption that applies to the reach from the facility discharge to the confluence with Macoupin Creek, and from the confluence to the confluence with Hurricane Creek, a distance of 9.8 miles. The NPDES permit also indicates that there is a treated CSO outfall and an untreated CSO outfall (personal communication, Scott Twait, IEPA). Therefore modeling will need to be conducted during the later TMDL stage to determine if these sources are contributing to downstream fecal impairments in segment DA 04.

Briar Creek (DAZN)

Listed for: Dissolved Oxygen

The data available for Briar Creek were collected in September 1998 as part of a facility-related stream survey (FRSS) focused on the Carlinville STP. Dissolved oxygen data were collected at three stations on Briar Creek at and downstream of the Carlinville STP, and only one sample was collected at each station. The three samples were collected on the same day. All three measurements were below the dissolved oxygen criterion of 5 mg/l. The excursions range from 0.5 to 4.7 below the criterion. Recall that the IEPA guidelines (IEPA, 2004a) for identifying dissolved oxygen as a cause in streams state that the aquatic life use is not supported if there is at least one exceedance of the applicable standard (5.0 mg/l) or known fish kill resulting from dissolved oxygen depletion. Therefore these data are considered sufficient to support the listing of Briar Creek on the draft 2004 303(d) list for dissolved oxygen.

The FRSS report states that the dissolved oxygen (and total suspended solids) exceedances during the survey "may have been in response to levels of BOD and total suspended solids which may have been elevated due to the milky nature of the stream at the time of this survey." An observation was made that the Carlinville STP effluent and receiving stream was opaque and milky on the day of this survey. The operator reported that it was "cleaning day at Prairie Farms and this was a normal once a month occurrence." Ammonia and $CBOD_5$ at these sampling stations were measured during the

FRSS at high concentrations (4.0 mg/l to 7.5 mg/l and 12 mg/l to 23 mg/l, respectively). These data suggest that the Carlinville Sewage Treatment Plant (STP) may contribute to the low dissolved oxygen in this segment. During the time of the survey, the effluent comprised a large portion of the flow in the stream. The monthly discharge from the Carlinville STP reported in the FRSS report for September, 1998 was 1.37 mgd (2.12 cfs), and the flow in Briar Creek downstream of the outfall during the survey was reported as 1.40 cfs. This suggests that the treatment plant likely contributed to most of the flow in the stream.

The low flows in Briar Creek (observed during the FRSS), even in the absence of the STP, may also be a contributing factor to low dissolved oxygen levels. Very low flows were also observed in the creek during the June 2004 field visit, as discussed in the Site Characterization section above. Low flows can contribute to low dissolved oxygen levels because there is little reaeration in the creek. Runoff from agricultural lands in the watershed may also contribute nutrients and BOD to the stream and contribute to low instream dissolved oxygen.

Carlinville Lake (RDG)

Listed for: Manganese and Total Phosphorus

Carlinville Lake is a public water supply and is classified for both general use and public water supply. Available data for manganese and total phosphorus were therefore analyzed and compared to both the public water supply and general use water quality criteria.

Manganese

Five samples were collected at one station in Carlinville Lake between April and October, 2002. The samples were collected approximately mid-depth in the water column at the same station, so depth profiles are not available. One of the five samples exceeded the public water supply criterion (by 50 ug/l), supporting the listing of this waterbody for manganese. None of the manganese samples exceeded the general use criterion. While these data are limited, they are considered representative of water quality in the lake because data from nearby waterbodies supports that manganese is ubiquitous in this region. Profiles of dissolved oxygen in the lake indicate that the deeper waters go anoxic in the summer. Under anoxic conditions, manganese may be released from the sediments, contributing to elevated levels in the water column.

The oxidation-reduction chemistry of manganese (and the similar metal iron) is well studied in lakes. In the oxidized state, that is in lakes, in the aerobic epilimnion, manganese is in particulate form. During summer stagnation, manganese reduces (before iron does) and becomes dissolved in the water column (Cole, 1994). Limnologists have found that increases in water column profiles of dissolved manganese may be associated with the reduction of manganese as particles settle into the anoxic zones of lakes, or, from reduction and upward transport of dissolved manganese derived from lake bottom sediment (Davison, 1985). Hence, the measurements of manganese in mid-water samples from the lakes exceed the water quality criterion because of thermal stratification and the development of reducing conditions in the hypolimnion.

The previous discussion of the ubiquitous nature of manganese (see discussion under Segment DA 04 Macoupin Creek) describes how observed water column concentrations in this region most likely reflect natural background conditions. For this reason, the general use standard may be difficult to attain. Manganese does not present any human health hazards, but may be responsible for offensive tastes and appearances in drinking water, as well as staining laundry and fixtures.

Total Phosphorus

The IEPA guidelines (IEPA, 2004a) for identifying total phosphorus as a cause in lakes ≥ 20 acres in size, state that the aquatic life and secondary contact uses are not supported if there is at least one exceedance of the applicable standard (0.05 mg/l) in surface samples during the monitoring year. Available data were collected between 1992 and 2002. A total of 64 samples were collected at three stations and at various depths. Forty five (45) of these samples were collected at the lake surface. All total phosphorus samples collected at the surface (as well as at all depths) exceeded the general use criterion of 0.05 mg/l (see Figure 8) indicating that the aquatic life and secondary contact uses are not fully supported. There is no public water supply criteria for total phosphorus. At the lake surface, exceedances range from 0.008 mg/L to 0.285 mg/L over the criterion. These data are considered sufficient to support the listing of Carlinville Lake on the draft 2004 303(d) list for total phosphorus.

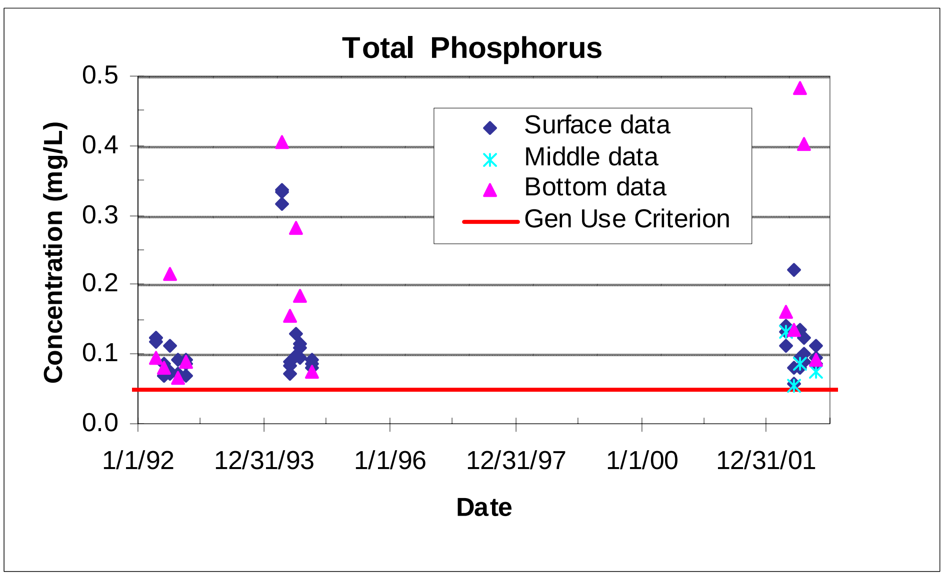

Figure 8. Comparison of Total Phosphorus Data for Carlinville Lake to General Use Criterion

An analysis of dissolved and particulate phosphorus data (see Figure 9) indicates that approximately 47% of total phosphorus is in dissolved form, therefore more than 50% of total phosphorus is in particulate form. The presence of particulate phosphorus suggests that there may be watershed sources of phosphorus. A plot of total suspended solids

(TSS) indicates that total phosphorus generally increases with TSS, supporting the potential for watershed sources, such as runoff from agricultural lands.

A portion of the observed dissolved phosphorus may originate from lake bottom sediments. An examination of data collected at Station RDG-1 in 2002 indicates that phosphorus concentrations increased in bottom waters in June and July, suggesting that phosphorus release from sediments may be occurring under anoxic conditions. Corresponding dissolved oxygen data for 2002 are not available, but depth profiles from 1994 indicate that the bottom waters of the lake became anoxic from before June until October. As shown in Figure 8, samples collected from deeper waters in summer months generally exhibit higher concentrations of total phosphorus, suggesting that sediment release of phosphorus is occurring under low hypolimnetic dissolved oxygen conditions. Another potential source of dissolved phosphorus is algae cell decomposition.

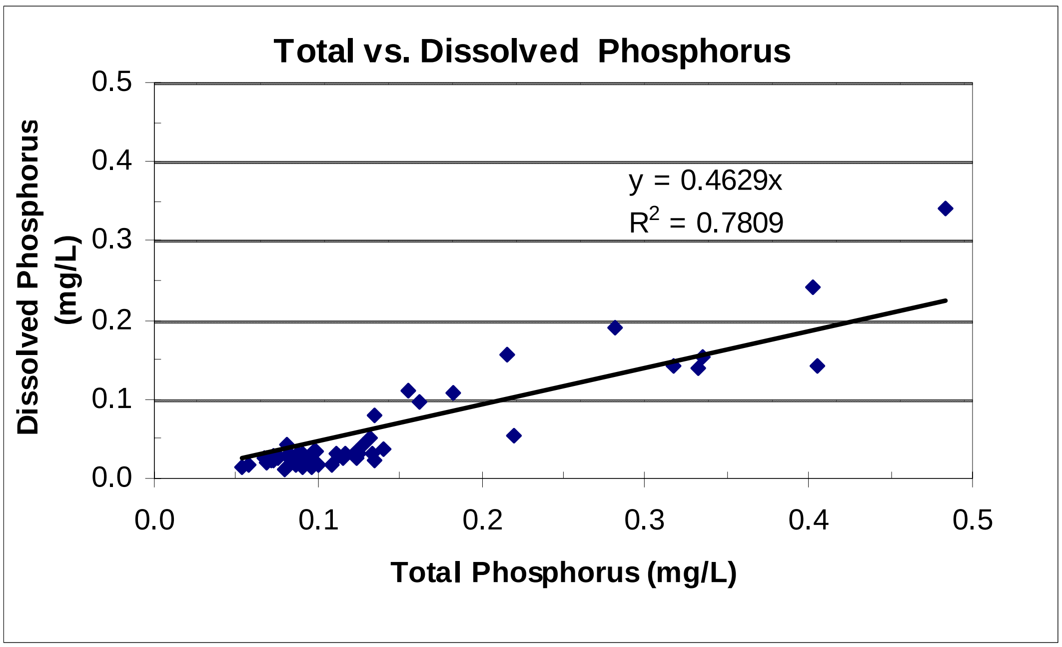

Figure 9. Total vs. Dissolved Phosphorus in Carlinville Lake

Beaver Dam Lake (RDH)

Listed for: Total Phosphorus

A total of 48 samples were collected at three stations in Beaver Dam Lake between 1992 and 2003. Samples were collected at up to three depths per station. Thirty nine of these samples were collected at the lake surface. Exceedances of the general use criterion for total phosphorus occurred in 33 of the 39 surface samples. Concentrations greater than 0.05 mg/l were also were noted at all depths, as shown in Figure 10. These data are considered sufficient to support the causes listed on the draft 2004 303(d) list, and they are supported by field observations. Based on a review of these data, neither the aquatic life nor secondary contact uses appear to be fully supported. During the field visit in late

June, 2004, the marsh that receives waters from Beaver Dam Lake was observed to be very eutrophic, likely due to these high phosphorus concentrations.

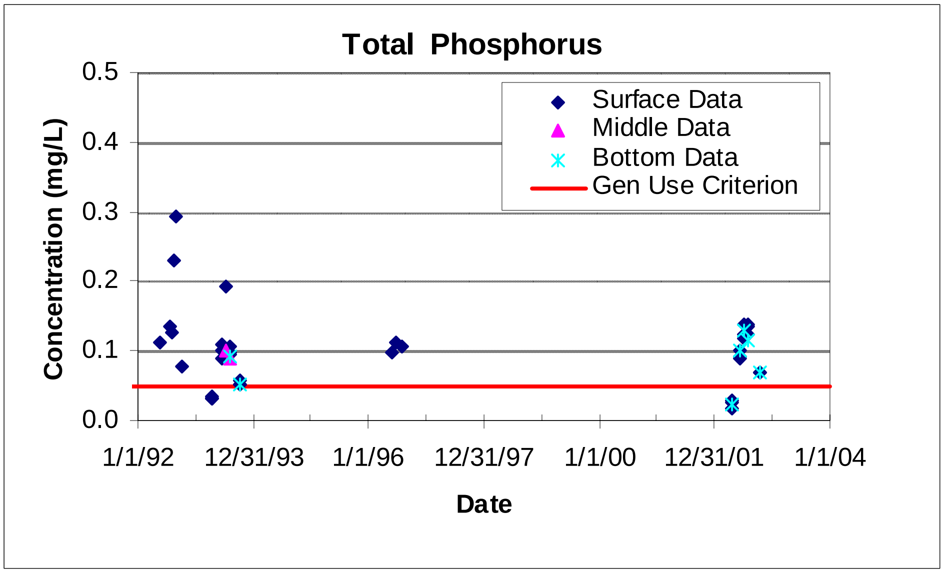

Figure 10. Total Phosphorus Concentrations in Beaver Lake Dam

Total and dissolved phosphorus were found to be weakly correlated, and the data indicate that particulate phosphorus comprises approximately 75% of the total phosphorus. A relatively strong correlation does exists between total suspended solids and total phosphorus (see Figure 11). These observations together indicate a watershed source of phosphorus. Release from the sediments is also a potential source of phosphorus. Dissolved oxygen data indicate that bottom waters become anoxic during summer months, and under anoxic conditions, phosphorus may be released in the dissolved form from lake sediments.

Beaver Dam Lake is shallow (about 10 feet deep) and the subwatershed is small. More than 50% of the subwatershed is forested, and only approximately 6% is used for agriculture. However, observations by park staff of significant runoff and sediment accumulation during wet-weather events suggest that phosphorus loadings from runoff from agricultural fields located north of the lake may be significant (see Site Characterization discussion). In summary, agricultural operations are potentially a source of phosphorus, as well as release from the sediments under anoxic conditions.

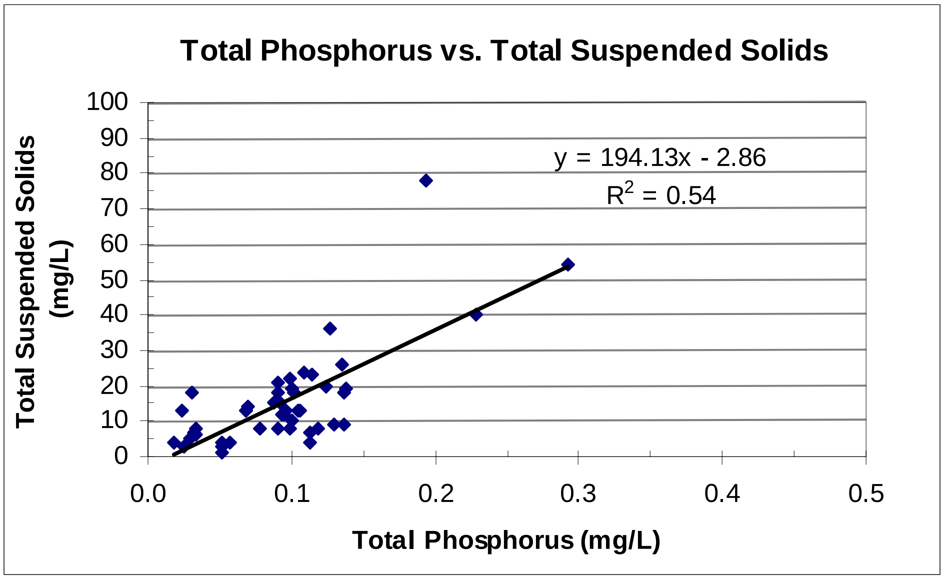

Figure 11. Total Phosphorus vs. Total Suspended Solids in Beaver Dam Lake

Old Gillespie Lake (SDT)

Listed for: Total Phosphorus and Manganese
Old Gillespie Lake serves the City of Gillespie and nearby communities as a public water supply. Samples were collected at three stations between 1996 and 2001.

Total Phosphorus

A total of 93 samples were collected at various water depths at three stations in the lake. 78 of these samples were collected at the lake surface, with 76 of these surface samples exceeding the total phosphorus general use criterion. The exceedances range from 0.005 mg/L to 0.603 mg/L over the 0.05 mg/l criterion, as shown in Figure 12. These data are considered sufficient to support the causes listed on the draft 2004 303(d) list as neither the aquatic life nor secondary contact uses appear to be fully supported.

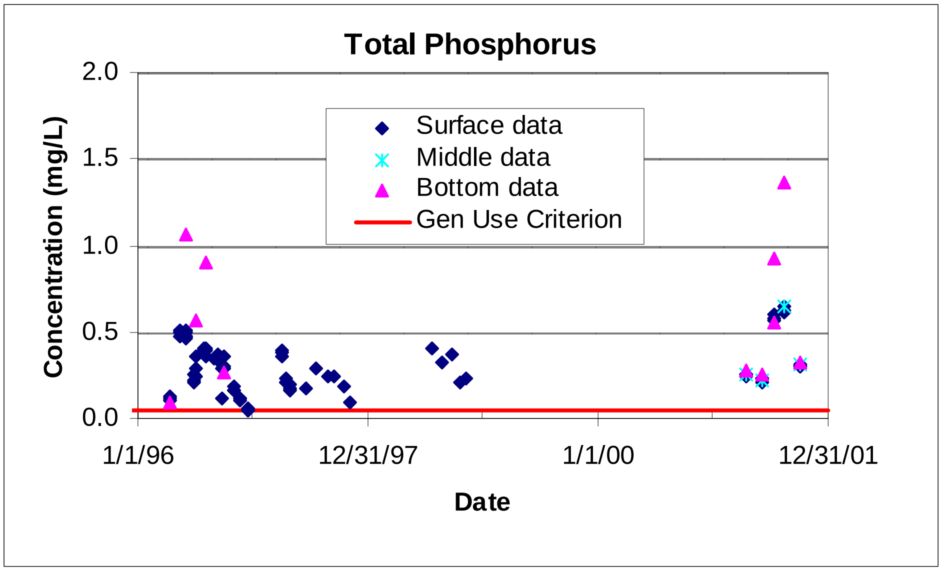

Figure 12. Total Phosphorus Data for Old Gillespie Lake Compared to General Use Criterion

Available data indicate that approximately 75% of total phosphorus is in the dissolved form. This dissolved phosphorus may originate from lake bottom sediments. An examination of data collected at Station SDT-1 (Figure 13) indicates that phosphorus increased in bottom waters in July and August, suggesting that release from sediments may be occurring under anoxic conditions. The dissolved oxygen data support that the bottom waters become anoxic in the late summer.

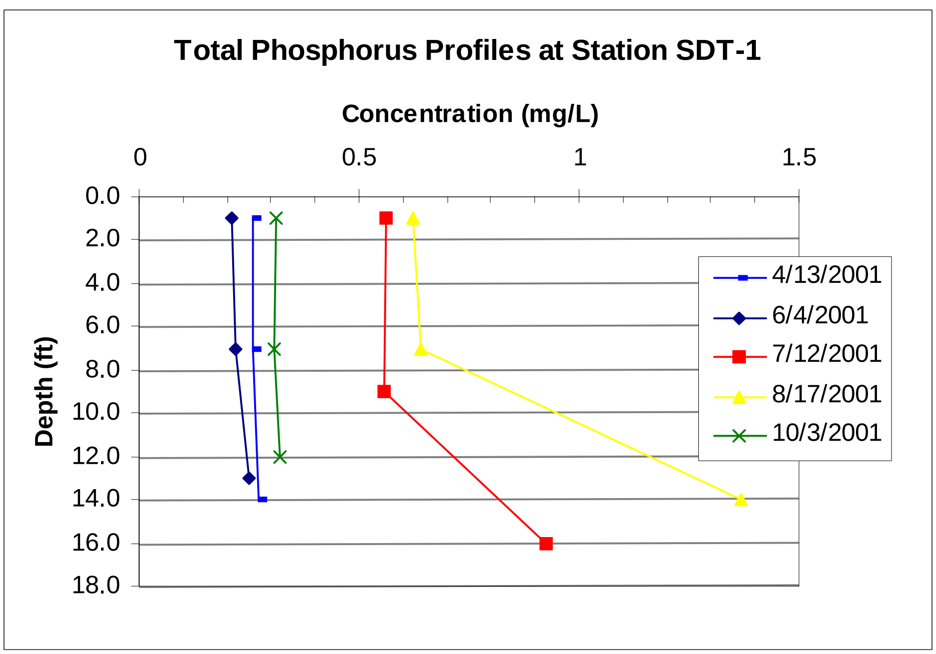

Figure 13. Total Phosphorus Profiles in Old Gillespie Lake

The phosphorus data are supported by strong evidence from other physical, chemical, and biological lake monitoring data that the Gillespie Lakes are eutrophic, as described in the Illinois Clean Lakes Program Phase I Diagnostic-Feasibility Study (Crawford & Associates, 1999). This report provides detailed information on sources of nutrients to the Gillespie Lakes. The authors describe the lakes as “eutrophic lakes subject to extended periods of summer stratification and internal nutrient recycling from bottom sediments.” The report provides a nutrient budget for the lake as shown in Table 15 below.

Table 15. Annual Phosphorus Budget for Gillespie Lakes

Influx	Total Phosphorus (tons/year)	Total Suspended Solids (tons/year)
Land Runoff	2.8	8,486
Lake Sediment	1.31	--
Atmosphere	0.1	9.7
Shoreline Erosion	--	512
Total Influx	4.21	9,007.7

Source: Crawford & Associates, 1999

There are no point source discharges to the Gillespie Lakes or tributaries to the lakes. As shown in Table 15, land runoff is the most significant source of phosphorus to the Gillespie Lakes, followed by lake sediment. The Crawford report breaks the land runoff influxes into categories by land use, as shown in Table 16. Based on these estimates, runoff from cropland appears to be the most significant source of phosphorus to the Gillespie Lakes, comprising 85% of the total load from land runoff. The report notes that under the “residence” category, septic tanks from residential housing could be a source of pollutant loading as “the majority of the tanks in the area do not operate properly.”

Table 16. Estimated Non-Point Source Phosphorus Loading from Land Runoff

Land Use	Area (hectares)	Percent of Watershed	Pollutant Load (tons/year)
Cropland	2170	66.5	2.387
Woodland	445	13.6	0.14685
Grassland	293	9	0.12892
Wetland	162	5	0.096228 (from atmosphere)
Residence	90	2.6	0.0495
Road	30	1	0.033
Wildlife	42	1.3	0.0231
Pasture/Hayland	32	1	0.01408

Source: Crawford & Associates, 1999

Manganese

Five samples were collected at one station in Old Gillespie Lake between April and October 2001. The samples were collected approximately mid-depth in the water column at the same station, so depth profiles are not available. Three of the five measurements exceeded the public water supply criterion, with concentrations ranging from 40 to 160 ug/l over the criterion. No sample concentrations exceeded the general use criterion. While manganese data for this waterbody are limited, they are considered representative of water quality in this segment, because data from nearby streams and lakes supports that manganese is ubiquitous in this region. For this reason, the data are considered sufficient to support the causes listed on the draft 2004 303(d) list.

Profiles of dissolved oxygen in the lake indicate that the deeper waters go anoxic in the summer. Under anoxic conditions, manganese may be released from the sediments, contributing to elevated levels in the water column. For a more detailed discussion of manganese in waters of this region, see the previous discussion under Macoupin Creek and Carlinville Lake.

New Gillespie Lake (SDU)

Listed for: Total Phosphorus

A total of 89 samples were collected at various water depths at three stations in the lake between 1996 and 2001. 71 of these samples were collected at the lake surface. All 71 surface samples (as well as all collected samples) exceeded the total phosphorus criterion. The exceedances range from 0.009 mg/L to 0.265 mg/L over the general use criterion of 0.05 mg/l, as shown in Figure 14. These data are considered sufficient to support the causes listed on the draft 2004 303(d) list, as neither the aquatic life nor secondary contact uses appear to be fully supported.   The phosphorus data are supported by strong evidence from other physical, chemical, and biological lake monitoring data that the Gillespie Lakes are eutrophic (Crawford & Associates, 1999).

For a discussion of potential sources of phosphorus to New Gillespie Lake, see the discussion above for Old Gillespie Lake.

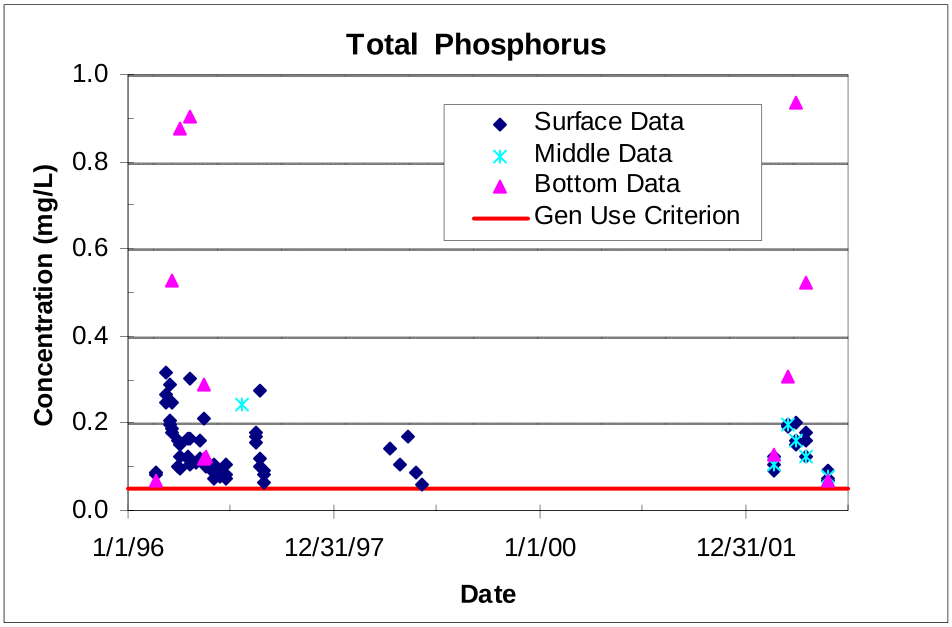

Figure 14. Total Phosphorus in New Gillespie Lake

CONCLUSIONS

Based on Stage I work, the project team has concluded that TMDLs are warranted for the seven impaired waterbodies in this targeted watershed. Specifically:

- For **Segment DA 04 of Macoupin Creek**, data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese, dissolved oxygen and fecal coliform TMDLs are warranted. Potential sources of manganese are erosion and streambank erosion of soils naturally enriched in manganese. Potential sources contributing to low dissolved oxygen include algal respiration and decomposition, sediment oxygen demand, degradation of CBOD, nitrification of ammonia (from agricultural lands and failing septic systems), and municipal point sources. Additional data collection will be needed to confirm any potential sources. Potential sources of fecal coliform include municipal point sources, failing septic systems and agricultural runoff.
- For **Segment DA 05 of Macoupin Creek,** data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese and dissolved oxygen TMDLs are warranted. In addition, an analysis of available data revealed elevated fecal coliform levels. Because of an existing disinfection exemption that applies to the reach from the facility discharge to the confluence with Macoupin Creek, and from the confluence to the confluence with Hurricane Creek (personal communication, Scott Twait, IEPA), modeling will need to be used to determine if this segment is contributing to downstream fecal impairments in segment DA 04. Potential sources of manganese are erosion and streambank erosion of soils naturally enriched in manganese. Potential sources contributing to low dissolved oxygen include algal respiration and decomposition, sediment oxygen demand,

degradation of CBOD, nitrification of ammonia (from agricultural lands and failing septic systems), and municipal point sources.

- For **Briar Creek (DAZN),** available data are considered sufficient to support the causes listed on the draft 2004 303(d) list. In addition, an analysis of available data revealed elevated fecal coliform levels. Because of an existing disinfection exemption that applies to the reach from the facility discharge to the confluence with Macoupin Creek, and from the confluence to the confluence with Hurricane Creek (personal communication, Scott Twait, IEPA), modeling will need to be used to determine if this segment is contributing to downstream fecal impairments in segment DA 04. Potential sources contributing to low dissolved oxygen include point source discharges, including CSOs, and agricultural runoff.
- For **Carlinville Lake (RDG),** data are sufficient to support the causes listed on the draft 2004 303(d) list, and manganese and total phosphorus TMDLs are warranted. Potential sources of manganese are erosion and streambank erosion of soils naturally enriched in manganese. Potential sources of total phosphorus include agricultural runoff, release from lake bottom sediments during seasonal hypolimnetic anoxia and algal decay.
- For **Beaver Dam Lake (RDH),** data are sufficient to support the causes listed on the draft 2004 303(d) list, and a total phosphorus TMDL is warranted. Potential sources of total phosphorus include agricultural runoff, point source discharge, and release from lake bottom sediments during seasonal hypolimnetic anoxia.
- For **New (SDU) and Old (SDT) Gillespie Lakes,** data are sufficient to support the causes listed on the draft 2004 303(d) list. Total phosphorus TMDLs are warranted for both lakes, and a manganese TMDL is warranted for Old Gillespie Lake. Potential sources of manganese to these two lakes include erosion and streambank erosion of soils naturally enriched in manganese. Potential sources of total phosphorus include agricultural runoff and erosion, stream bank erosion, release from lake bottom sediments during seasonal hypolimnetic anoxia and failing septic systems.

NEXT STEPS

In the upcoming quarter, methods, procedures and models that will be used to develop TMDLs for the project watershed will be identified and described. This description will include documentation of any important assumptions underlying the recommended approach (methods, procedures and models) and a discussion of data needed to support the development of a credible TMDL.

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APPENDIX A. DATA SOURCES AND LOCAL CONTACTS

Table A-1. Data sources

Data description	Agency	Website
Climate summaries	Illinois State Water Survey	http://www.sws.uiuc.edu/atmos/statecli/index.htm
NPDES permit limits	United States Environmental Protection Agency	http://www.epa.gov/enviro/html/pcs/pcs_query.html
Aerial photography	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/webdocs/doqs/graphic.html
Coal mines: active and abandoned - polygons part 1	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned - polygons part 2	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mines: active and abandoned – points	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Coal mine permit boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
County boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Cropland	United States Department of Agriculture, National Agricultural Statistics Service, via Illinois Department of Agriculture	http://www.agr.state.il.us/gis/pass/nassdata/
Dams	National Inventory of Dams (NID)	http://crunch.tec.army.mil/nid/webpages/nid.cfm
Elevation	United States Geological Survey	http://seamless.usgs.gov/viewer.htm
Federally-owned lands	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrologic cataloging units	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Hydrography	United States Geological Survey	http://nhd.usgs.gov/
Impaired lakes	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Impaired streams	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Land cover	Illinois Department of Agriculture	http://www.agr.state.il.us/gis/
Landfills	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Municipal boundaries	U.S. Census Bureau	
Municipal boundaries	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
National Pollutant Discharge Elimination System (NPDES) permitted sites	United States Environmental Protection Agency	
Nature preserves	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Oil wells	United States Geological Survey	http://energy.cr.usgs.gov/oilgas/noga/
Railroads	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/

Data description	Agency	Website
Roads – state highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads – U.S. highways	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Roads- detailed road network	U.S. Census Bureau	http://www.census.gov/geo/www/tiger/tigerua/ua_tgr2k.html
Survey-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/ssurgo.html
State-level soils	United States Department of Agriculture Natural Resources Conservation Service	http://www.il.nrcs.usda.gov/technical/soils/statsgo_inf.html - statsgo8
State boundary	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State conservation areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State forests	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State fish and wildlife areas	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
State parks	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangle index	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
Topographic map quadrangles	Illinois Natural Resources Geospatial Data Clearinghouse	http://www.isgs.uiuc.edu/nsdihome/
USGS stream gages	Illinois State Water Survey	
Watersheds	Illinois Environmental Protection Agency	http://maps.epa.state.il.us/website/wqinfo/
Water supply – Public water supply intakes	Illinois State Water Survey	
DMR data and information on NPDES permitted facilities; Gillespie Old and New water quality data; stream water quality data	IEPA Springfield Regional Office	Provided by e-mail from Tim Kelly and Phyllis Borland-Lau
Stream water quality data	USGS	http://waterdata.usgs.gov/nwis/qw
Hardcopy and electronic lake water quality data	IEPA	Provided by mail and e-mail
Stream and lake water quality data	STORET and STORET Modern	http://www.epa.gov/storet/dbtop.html

Table A-2. Local and State Contacts

Contact	Agency/ Organization	Contact Means	Phone #	Subject
Burke Davies	Marion Co. SWCD	Telephone	618-548-1337 x3	Manganese
Mike Page	Assistant Site Superintendent, Beaver Dam State Park	In person		Stormwater drainage to the lake
Rhonda Koehne	Executive Director. Macoupin County SWCD	In person	217-854-2628	Soils, farming practices, watershed characterization, SWCD programs
John Ford	District Conservationist, Macoupin County SWCD	In person	217-854-2628	Soils, farming practices, watershed characterization, SWCD programs
Rich Nickels	Illinois Department of Agriculture	Telephone	217-782-6297	Requested Cropland Transect Survey
Craig Bussmann	Macoupin County Health Department	Telephone		Surface wastewater discharges
Sue Ebetsch	Illinois State Data Center	Telephone	217-782-1381	Requested Population projection report
Laura Biewick	U.S. Geological Survey	Telephone	303-236-7773	GIS data for oil & gas wells
Kathy Brown	Illinois State Water Survey	Telephone	217-333-6778	USGS gage locations; water supply intakes
Sharie Heller	SW Illinois GIS resource Center		618-566-9493	Discussed CRP maps
Steve Sobaski	Illinois Department of National Resources		ssobaski@dnrmail.state.il.us	Formal request for conservation related GIS files
Don Pitts	United States Department of Agriculture Natural Resources Conservation Service	Telephone	217-353-6642	Potential sources of iron and manganese in south-central Illinois surface waters.
Tony Meneghetti	IEPA	Telephone and e-mail	217-782-3362 Anthony.Meneghetti@epa.state.il.us	Lake data and SWAPs
Dave Muir	IEPA Marion Regional office	Personal visit	618-993-7200	Assessment data used in 303(d) and 305(b) reports
Tim Kelly	IEPA Springfield Regional office	Telephone and e-mail	217/-786-6892 Tim.Kelly@epa.state.il.us	NPDES DMR data
Jeff Mitzelfelt	IEPA	e-mail	jeff.mitzelfelt@epa.state.il.us	Websites for GIS information
	Heartland Ecosystem Services, Inc.	Telephone	618-664-9749	Grants for Carlinville Lake and watershed sampling

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APPENDIX B. PHOTOGRAPHS

PHOTOGRAPHS FROM FIELD VISIT
JUNE 27-28, 2004

Lake Road east of Gillespie Lakes looking south showing rolling terrain, soy, corn

Unnamed road immediately to north of Gillespie lakes: Heavily forested on south side (around lakes) and fields to north

New Gillespie Lake

New Gillespie Lake: Fenced off beach with signs and algae

Old Gillespie Lake: Boat ramp and berm

Quarry Road: Stream that drains to Gillespie Lake
Low flow with ponding observed

Macoupin Creek from Shipman Road

Drainage from Beaver Lake to marsh from road

Beaver Lake from visitor's center

**Drainage in woods from fields in north end of
Beaver Dam Lake watershed – looking up from road**

Drainage to lake looking toward lake from road

View of marsh that receives water from Beaver Dam Lake (very eutrophic)

Drainage from fields through campgrounds located north of lake

View of farm fields located north of Beaver Dam Lake from campground

Briar Creek showing very low ponded flow

Residential neighborhood around Briar Creek (very hilly)

Carlinville Lake from campsite looking east showing eroding banks

Carlinville Lake looking at top of dam and water treatment plant

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Second Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

April 2005

Macoupin Creek Watershed

Macoupin Creek (DA04, DA05), Briar Creek (DAZN),
Carlinville Lake (RDG), Beaver Dam Lake (RDH),
New Gillespie Lake (SDU), and Old Gillespie Lake (SDT)

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EXECUTIVE SUMMARY

This is the second in a series of quarterly status reports documenting work completed on the Macoupin Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

The intent of this second quarterly status report is to:

- Identify and briefly describe the methodologies/procedures/models to be used in the development of TMDLs
- Document important assumptions underlying the recommended methodologies
- Identify the data needs for the methodologies to be used in TMDL development, including an assessment of whether additional data are needed to develop credible TMDLs

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the second quarter included: 1) summarizing potentially applicable model frameworks for TMDL development, 2) Recommending specific model frameworks for application to the Macoupin Creek watershed, and 3) Making a determination whether sufficient data exist to allow development of a credible TMDL. Selection of specific model frameworks was based upon consideration of three separate factors, consistent with the guidance of DePinto et al (2004):

- **Site-specific characteristics:** The characteristics define the nature of the watershed and water bodies. For the Macoupin Creek watershed, the relevant site-specific characteristics include a watershed with predominantly agricultural land use, stream segments impaired by manganese, dissolved oxygen and fecal coliform and several lakes impaired by manganese and total phosphorus.
- **Management objectives:** These objectives consist of the specific questions to be addressed by the model. For this application, the management objective is to define a credible TMDL.
- **Available resources:** This corresponds to the amount of time and data available to support TMDL development. Water quality data currently exist for all listed waterbodies in the Macoupin Creek watershed, however, some of the datasets are very limited. One aspect of this work is to define whether or not the existing data are sufficient to allow development of a credible TMDL.

Results

Several modeling frameworks potentially applicable for developing TMDLs were identified, spanning a range of detail from simple to complex. Selection of a specific modeling framework is complicated by the fact that the definition of a "credible" TMDL depends upon the level of detail to be contained in the implementation plan. If the goal of the TMDL implementation plan is to define the primary sources of impairment and quickly identify the general level of reduction required, relatively simple models can be used to develop a credible TMDL. If the goal of the TMDL implementation plan is to explicitly define the specific levels of controls required, more detailed models (and additional data) are required to develop a credible TMDL. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

Because of the wide range of impairment types and water bodies in the Macoupin Creek watershed, a range of modeling approaches is required. They are summarized here by individual water body segment and grouped together as appropriate.

The recommended modeling approach for Macoupin Creek segments DA04 and DA05 and Briar Creek (should IEPA determine that a TMDL is warranted for this creek which has insufficient data to support its listing), consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for the Macoupin Creek and Briar Creek segments will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads. The recommended approach to address fecal coliform impairments in segment DA04 consists of developing a load-duration curve. This will allow for determination of the degree of impairment under different flow conditions and the respective importance of dry weather and wet weather fecal coliform sources. Results from the load-duration curve can also be used to identify the approximate level of source control needed under each set of flow conditions.

The recommended modeling approach for Carlinville Lake, Old Gillespie Lake, Beaver Dam Lake and New Gillespie Lake consists of using the GWLF and BATHTUB models. Specifically, GWLF will be applied to calculate phosphorus loads to these reservoirs over a time scale consistent with their respective nutrient residence times. BATHTUB will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus (for all reservoirs) and dissolved oxygen concentrations (for Carlinville Lake and Old Gillespie Lake, where it assumed that the only controllable source of manganese is that which is released from lake sediments during periods of low dissolved oxygen.) This relationship will be used to define the dominant sources of phosphorus to the lakes, and the extent to which they must be controlled to attain water quality standards for phosphorus and manganese.

Alternative model frameworks are also provided in the event that a different level of detail is desired for the implementation plans. Some alternative approaches require no additional data collection; however, others have significantly greater data requirements, and their use would require additional data collection.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the Macoupin Creek watershed. Earlier Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed.

The remaining sections of this report include:

- **Identification of potentially applicable methodologies to be used in TMDL development:** This section describes the range of potentially applicable watershed loading and water quality methodologies that could be used to conduct the TMDL, and identifies their strengths and weaknesses.
- **Model selection process:** This section describes how management objectives, available resources and site-specific conditions in the Macoupin Creek watershed affect the recommendation of specific methodologies.
- **Selection of specific methodologies and future data requirements:** This section provides specific recommendation of methodologies for the Macoupin Creek watershed, along with the data needed to support application of the methodologies.

IDENTIFICATION OF POTENTIALLY APPLICABLE MODELS AND PROCEDURES TO BE USED IN TMDL DEVELOPMENT

Development of TMDLs requires: 1) a method to estimate the amount of pollutant load being delivered to the water body of interest from all contributing sources, and 2) a method to convert these pollutant loads into an in-stream (or in-lake) concentration for comparison to water quality targets. Both of these steps can be accomplished using a wide range of methodologies, ranging from simple calculations to complex computer models. This section describes the methodologies that are potentially applicable for the Macoupin Creek watershed, and is divided into separate discussions of watershed methodologies and receiving water quality model frameworks.

Watershed Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize watershed loads for TMDL development. These include:

- Empirical Approaches
- Unit Area Loads/Export Coefficients
- Universal Soil Loss Equation
- Watershed Characterization System (WCS) Sediment Tool
- Generalized Watershed Loading Functions (GWLF) Model
- Agricultural Nonpoint Source Pollution Model (AGNPS)
- Hydrologic Simulation Program - Fortran (HSPF)
- Better Assessment Science Integrating point and Nonpoint Sources (BASINS)/ Nonpoint Source Model (NPSM)
- Storm Water Management Model (SWMM)
- Soil & Water Assessment Tool (SWAT)

This section describes each of the model frameworks and their suitability for characterizing watershed loads for TMDL development. Table 1 summarizes some important characteristics of each of the models relative to TMDL application.

Table 1 Summary of Potentially Applicable Models for Estimating Watershed Loads

Model	Data Needs	Output Timescale	Potential Accuracy	Calibration	Applicability for TMDL
Empirical Approach	High	Any	High	N/A	Good for defining existing total load; less applicable for defining individual contributions or future loads
Unit Area Loads	Low	Annual average	Low	None	Acceptable when limited resources prevent development of more detailed model
USLE	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
WCS Sediment Tool	Low	Annual average	Low	Requires data describing annual average load	Acceptable when limited resources prevent development of more detailed model
GWLF	Moderate	Monthly average	Moderate	Requires data describing flow and concentration	Good for mixed use watersheds; compromise between simple and more complex models
SWMM	Moderate	Continuous	Moderate	Requires data describing flow and concentration	Primarily suited for urban watersheds
AGNPS	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available
HSPF	High	Continuous	High	Requires data describing flow and concentration	Good for mixed use watersheds; highly applicable if sufficient resources are available
SWAT	High	Continuous	High	Requires data describing flow and concentration	Primarily suited for rural watersheds; highly applicable if sufficient resources are available

Empirical Approaches

Empirical approaches estimate pollutant loading rates based upon site-specific measurements, without the use of a model describing specific cause-effect relationships. Time series information is required on both stream flow and pollutant concentration.

The advantage to empirical approaches is that direct measurement of pollutant loading will generally be far more accurate than any model-based estimate. The approach, however, has several disadvantages. The empirical approach provides information specific to the storms that are monitored, but does not provide direct information on conditions for events that were not monitored. Statistical methods (e.g., Preston et al., 1989) can be used to integrate discrete measurements of suspended solids concentrations with continuous flow records to provide estimates of solids loads over a range of conditions.

The primary limitation of empirical techniques is their inability to separate individual contributions from multiple sources. This problem can be addressed by collecting samples from tributaries serving single land uses, but most tributary monitoring stations reflect multiple land uses. The EUTROMOD and BATHTUB water quality models described below contain routines that apply the empirical approach to estimating watershed loads.

Unit Area Loads/Export Coefficients

Unit area loads (also called export coefficients) are routinely used to develop estimates of pollutant loads in a watershed. An export coefficient is a value expressing pollutant generation per unit area and unit time for a specific land use (Novotny and Olem, 1994).

The use of unit areal loading or export coefficients has been used extensively in estimating loading contributions from different land uses (Beaulac 1980, Reckhow et al. 1980, Reckhow and Simpson 1980, Uttormark et al. 1974). The concept is straightforward; different land use areas contribute different loads to receiving waters. By summing the amount of pollutant exported per unit area of land use in the watershed, the total pollutant load to the receiving system can be calculated.

These export coefficients are usually based on average annual loads. The approach permits estimates of current or existing loading, as well as reductions in pollutant export for each land use required to achieve a target TMDL pollutant load. The accuracy of the estimates is dependent on good land use data, and appropriate pollutant export coefficients for the region. EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, which can estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The FLUX module of the BATHTUB software program estimates nutrient loads or fluxes to a lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified.

Universal Soil Loss Equation

The Universal Soil Loss Equation (USLE), and variations of the USLE, are the most widely used methods for predicting soil loss. When applied properly, the USLE can be used as a means to estimate loads of sediment and sediment-associated pollutants for TMDLs. The USLE is empirical, meaning that it was developed from statistical regression analyses of a large database of runoff and soil loss data from numerous watersheds. It does not describe specific erosion processes. The USLE was designed to predict long-term average annual soil erosion for combinations of crop systems and management practices with specified soil types, rainfall patterns, and topography.

Required model inputs to the USLE consist of:

- Rainfall erosivity index factor
- Soil-erodibility factor
- Slope length factor reflecting local topography
- Cropping-management factor
- Conservation practice factor

Most of the required inputs for application of the USLE are tabulated by county Natural Resources Conservation Service (NRCS) offices.

There are also variants to the USLE: the Revised USLE (RUSLE) and the Modified USLE (MUSLE). The RUSLE is a computerized update of the USLE incorporating new data and making some improvements. The basic USLE equation is retained, but the technology for evaluating the factor values has been altered and new data introduced to evaluate the terms for specific conditions. The MUSLE is a modification of USLE, with the rainfall energy factor of the USLE replaced with a runoff energy factor. MUSLE allows for estimation of soil erosion on an event-specific basis.

While the USLE was originally designed to consider soil/sediment loading only, it is also commonly used to define loads from pollutants that are tightly bound to soils. In these situations, the USLE is used to define the sediment load, with the result multiplied by a pollutant concentration factor (mass of pollutant per mass of soil) to define pollutant load.

The USLE is among the simplest of the available models for estimating sediment and sediment-associated loads. It requires the least amount of input data for its application and consequently does not ensure a high level of accuracy. It is well suited for screening-level calculations, but is less suited for detailed applications. This is because it is an empirical model that does not explicitly represent site-specific physical processes. Furthermore, the annual average time scale of the USLE is poorly suited for model calibration purposes, as field data are rarely available to define erosion on an annual average basis. In addition, the USLE considers erosion only, and does not explicitly consider the amount of sediment that is delivered to stream locations of interest. It is best used in situations where data are available to define annual loading rates, which allows for site-specific determination of the fraction of eroded sediment that is delivered to the surface water.

Watershed Characterization System (WCS) Sediment Tool

The Watershed Characterization System (WCS) Sediment Tool was developed by EPA Region 4. The Watershed Characterization System is an ArcView-based application used to display and analyze GIS data including land use, soil type, ground slope, road networks, point source discharges, and watershed characteristics. WCS has an extension called the Sediment Tool that is specifically designed for sediment TMDLs. For each grid cell within the watershed, the WCS Sediment Tool calculates potential erosion using the USLE based on the specific cell characteristics. The model then calculates the potential sediment delivery to the stream grid network. Sediment delivery can be calculated using one of the four available sediment delivery equations: a distance-based equation, a distance slope-based equation, an area-based equation, or a WEPP-based regression equation.

The applicability of WCS for estimating sediment loads for TMDLs is similar to that of the USLE in terms of data requirements and model results; i.e., it is relatively simple to apply but has the potential to be inaccurate. It provides three primary enhancements over the USLE: 1) Model inputs are automatically incorporated into the model through GIS coverages; 2) Topographic factors are calculated in the model based on digital elevation data; and 3) The model calculates the fraction of eroded sediment that is delivered to the surface water. It is only applicable to sediment TMDLs whose target represents long-term loading conditions. Because its predictions represent average annual conditions, it is not suitable for predicting loads associated with specific storm events. Like the USLE, it is does not lend itself to model calibration unless data are available to define annual loading rates.

Generalized Watershed Loading Functions Model (GWLF)

The Generalized Watershed Loading Functions Model (GWLF) simulates runoff and sediment loadings from mixed-use watersheds. It is a continuous simulation model (i.e., predicts how concentrations change over time) that uses daily time steps for weather data and water balance calculations. Sediment results are provided on a monthly basis. GWLF requires the user to divide the watershed into any number of distinct groups, each of which is labeled as rural or urban. The model does not spatially distribute the source areas, but simply aggregates the loads from each area into a watershed total; in other words, there is no spatial routing. Erosion and sediment yield for rural areas are estimated using monthly erosion calculations based on the USLE (with monthly rainfall-runoff coefficients). A sediment delivery ratio based on watershed size and a transport capacity based on average daily runoff are then applied to the calculated erosion to determine how much of the sediment eroded from each source area is delivered to the watershed outlet. Erosion from urban areas is considered negligible.

GWLF provides more detailed temporal results than the USLE, but also requires more input data. Specifically, daily climate data are required as well as data on processes related to the hydrologic cycle (e.g., evapotranspiration rates, groundwater recession constants). By performing a water balance, it has the ability to predict concentrations at a watershed outlet as opposed to just loads. It lacks the ability to calculate the sediment delivery ratio that is present in the WCS sediment tool. Because the model performs on a continuous simulation basis, it is more amenable to site-specific calibration than USLE or the WCS sediment tool.

Agricultural Nonpoint Source Pollution Model (AGNPS)

The Agricultural Nonpoint Source Pollution Model (AGNPS) is a joint USDA-Agricultural Research Service and -Natural Resources Conservation Service system of computer models developed to predict nonpoint source pollutant loadings within agricultural watersheds. The sheet and rill erosion model internal to AGNPS is based upon RUSLE, with additional routines added to allow for continuous simulation and more detailed consideration of sediment delivery.

AGNPS was originally developed for use in agricultural watersheds, but has been adapted to allow consideration of construction sources.

AGNPS provides more spatial detail than GWLF and is therefore more rigorous in calculating the delivery of eroded sediment to the receiving water. This additional computational ability carries with it the cost of requiring more detailed information describing the topography of the watershed, as well as requiring more time to set up and apply the model.

Hydrologic Simulation Program – Fortran (HSPF)

The Hydrologic Simulation Program – Fortran (HSPF) uses continuous rainfall and other meteorologic records to compute stream flow hydrographs and pollutographs. HSPF is well suited for mixed-use (i.e., containing both urban and rural land uses) watersheds, as it contains separate sediment routines for pervious and impervious surfaces. HSPF is an integrated watershed/stream/reservoir model, and simulates sediment routing and deposition for different classes of particle size. HSPF was integrated with a geographical information system (GIS) environment with the development of Better Assessment Science Integrating point and Nonpoint Sources (BASINS). Although BASINS was designed as a multipurpose analysis tool to promote the integration of point and nonpoint sources in watershed and water quality-based applications, it also includes a suite of water quality models. One such model is Nonpoint Source Model (NPSM). NPSM is a simplified version of HSPF that is linked with a graphical user interface within the GIS environment of BASINS. HSPC is another variant of the HSPF model, consisting of the equations used by HSPF recoded into the C++ programming language.

HSPF provides a more detailed description of urban areas than AGNPS and contains direct linkage to a receiving water model. This additional computational ability carries with it the cost of requiring more detailed model inputs, as well as requiring more time to set up and apply the model. BASINS software can automatically incorporate existing environmental databases (e.g., land use, water quality data) into HSPF, although it is important to verify the accuracy of these sources before using them in the model.

Storm Water Management Model (SWMM)

The Storm Water Management Model (SWMM) is a comprehensive computer model for analysis of quantity and quality problems associated with urban runoff. SWMM is designed to be able to describe both single events and continuous simulation over longer periods of time. SWMM is commonly used to simulate urban hydraulics, although its sediment transport capabilities are not as robust as some of the other models described here.

Soil & Water Assessment Tool (SWAT)

The Soil & Water Assessment Tool (SWAT) is a basin-scale, continuous-time model designed for agricultural watersheds. It operates on a daily time step. Sediment yield is calculated with the Modified Universal Soil Loss Equation. It contains a sediment routing model that considers deposition and channel erosion for various sediment particle sizes. SWAT is also contained as part of EPA's BASINS software.

SWAT is a continuous time model, i.e., a long-term yield model. The model is not designed to simulate detailed, single-event flood routing. SWAT was originally developed strictly for application to agricultural watersheds, but it has been modified to include consideration of urban areas.

Water Quality Methodologies and Modeling Frameworks

Numerous methodologies exist to characterize the relationship between watershed loads and water quality for TMDL development. These include:

- Spreadsheet Approaches
- EUTROMOD
- BATHTUB
- WASP5
- CE-QUAL-RIV1
- CE-QUAL-W2
- EFDC

This section describes each of the methodologies and their suitability for defining water quality for TMDL development. Table 2 summarizes some important characteristics of each of the models relative to TMDL application.

Table 2. Summary of Potentially Applicable Models for Estimating Water Quality

Model	Time scale	Water body type	Spatial scale	Data Needs	Pollutants Simulated	Applicability for TMDL
Spreadsheet approaches	Steady State	River or lake	0- or 1-D	Low	DO, nutrients, algae, metals	Good for screening-level assessments
EUTROMOD	Steady State	Lake	0-D	Low	DO, nutrients, algae	Good for screening-level assessments
BATHTUB	Steady State	Lake	1-D	Moderate	DO, nutrients, algae	Good for screening-level assessments; can provide more refined assessments if supporting data exist
QUAL2E	Steady State	River	1-D	Moderate	DO, nutrients, algae, bacteria	Good for low-flow assessments of conventional pollutants in rivers
WASP5	Dynamic	River or lake	1-D to 3-D	High	DO, nutrients, metals, organics	Excellent water quality capability; simple hydraulics
CE-QUAL-RIV1	Dynamic	River	1-D	High	DO, nutrients, algae	Good for conventional pollutants in hydraulically complex rivers
HSPF	Dynamic	River or lake	1-D	High	DO, nutrients, metals, organics, bacteria	Wide range of water quality capabilities, directly linked to watershed model
CE-QUAL-W2	Dynamic	Lake	2-D vertical	High	DO, nutrients, algae, some metals	Good for conventional pollutants in stratified lakes or impoundments
EFDC	Dynamic	River or lake	3-D	High	DO, nutrients, metals, organics, bacteria	Potentially applicable to all sites, if sufficient data exist

Spreadsheet Approaches

A wide range of simple methods are available to describe the relationship between pollutant loads and receiving water quality, for a variety of situations including rivers and lakes. These methods are documented in Mills et al. (1985). These approaches do not require specific computer software, and are designed to be implemented on a hand calculator or computer spreadsheet. These approaches have the benefit of relatively low data requirements, as well as being easy to apply. Because of their simplistic nature, these approaches are best considered as screening procedures incapable of producing highly accurate results. They do provide good initial estimates of the primary cause-effect relationships.

EUTROMOD

EUTROMOD is a spreadsheet-based modeling procedure for estimating phosphorus loading and associated lake trophic state variables, distributed by the North American Lake Management Society (Reckhow 1990). The modeling system first estimates phosphorus loads derived from watershed land uses or inflow data using approaches developed by Reckhow et al. (1980) and Reckhow and Simpson (1980). The model accounts for both point and nonpoint source loads. Statistical algorithms are based on regression analyses performed on cross-sectional lake data. These algorithms predict in-lake phosphorus, nitrogen, hypolimnetic dissolved oxygen, chlorophyll, and trihalomethane precursor concentrations, and transparency (Secchi depth). The model also estimates the likelihood of blue-green bacteria dominance in the lake. Lake morphometry and hydrologic characteristics are incorporated in these algorithms. EUTROMOD also has algorithms for estimating uncertainty associated with the trophic state variables and hydrologic variability and estimating the confidence interval about the most likely values for the various trophic state indicators.

BATHTUB

BATHTUB is a software program for estimating nutrient loading to lakes and reservoirs, summarizing information on in-lake water quality data, and predicting the lake/reservoir response to nutrient loading (Walker 1986). It was developed, and is distributed, by the U.S. Army Corps of Engineers. BATHTUB consists of three modules: FLUX, PROFILE, and BATHTUB (Walker 1986). The FLUX module estimates nutrient loads or fluxes to the lake/reservoir and provides five different algorithms for estimating these nutrient loads based on the correlation of concentration and flow. In addition, the potential errors in loading estimates are quantified. PROFILE is an analysis module that permits the user to display lake water quality data. PROFILE algorithms can be used to estimate hypolimnetic oxygen depletion rates, area-weighted or mixed layer average constitutent concentrations, and similar trophic state indicators. BATHTUB is the module that predicts lake/reservoir responses to nutrient fluxes. Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

BATHTUB contains a number of regression equations that have been calibrated using a wide range of lake and reservoir data sets. It can treat the lake or reservoir as a continuously stirred, mixed reactor, or it can predict longitudinal gradients in trophic state variables in a reservoir or narrow lake. These trophic state variables include in-lake total and ortho-phosphorus, organic nitrogen, hypolimnetic dissolved oxygen, metalimnetic dissolved oxygen, and chlorophyll concentrations, and Secchi depth (transparency).

Uncertainty estimates are provided with predicted trophic state variables. There are several options for estimating uncertainty based on the distribution of the input and in-lake data. Both tabular and graphical displays are available from the program.

QUAL2E

QUAL2E is a one-dimensional water quality model that assumes steady-state flow, but allows simulation of diurnal variations in dissolved oxygen and temperature. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model simulates the following state variables: temperature, dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, inorganic phosphorus, organic phosphorus, algae, and conservative and non-conservative substances. QUAL2E also includes components that allow implementation of uncertainty analyses using sensitivity analysis, first-order error analysis, or Monte Carlo simulation. QUAL2E has been used for wasteload allocation purposes throughout the United States. QUAL2E is also linked into EPA's BASINS modeling system.

The primary advantages of using QUAL2E include its widespread use and acceptance, and ability to simulate all of the conventional pollutants of concern. Its disadvantage is that it is restricted to one-dimensional, steady-state analyses.

WASP5

WASP5 is EPA's general-purpose surface water quality modeling system. It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The model can be applied in one, two, or three dimensions and is designed for linkage with the hydrodynamic model DYNHYD5. WASP5 has also been successfully linked with other one, two, and three dimensional hydrodynamic models such as RIVMOD, RMA-2V and EFDC. WASP5 can also accept user-specified advective and dispersive flows. WASP5 provides separate submodels for conventional and toxic pollutants. The EUTRO5 submodel describes up to eight state variables in the water column and bed sediments: dissolved oxygen, biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, organic phosphorus, and phytoplankton. The TOXI5 submodel simulates the transformation of up to three different chemicals and three different solids classes.

The primary advantage of using WASP5 is that it provides the flexibility to describe almost any water quality constituent of concern, along with its widespread use and acceptance. Its primary disadvantage is that it is designed to read hydrodynamic results only from the one-dimensional RIVMOD-H and DYNHYD5 models. Coupling of WASP5 with multi-dimensional hydrodynamic model results will require extensive site-specific linkage efforts.

CE-QUAL-RIV1

CE-QUAL-RIV1 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. Water quality state variables consist of temperature, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, dissolved iron, and dissolved manganese. The effects of algae and macrophytes can also be included as external forcing functions specified by the user.

The primary advantage of CE-QUAL-RIV1 is its direct link to an efficient hydrodynamic model. This makes it especially suitable to describe river systems affected by dams or experiencing extremely rapid changes in flow. Its primary disadvantage is that it simulates conventional pollutants only, and contains limited eutrophication kinetics. In addition, the effort and data required to support the CE-QUAL-RIV1 hydrodynamic routines may not be necessary in naturally flowing rivers.

HSPF

HSPF (Hydrological Simulation Program - FORTRAN) is a one-dimensional modeling system for simulation of watershed hydrology, point and non-point source loadings, and receiving water quality for both conventional pollutants and toxicants (Bicknell et al, 1993). It is supported by the U.S. EPA Center for Exposure Assessment Modeling (CEAM) in Athens, Georgia. The water quality component of HSPF allows dynamic simulation of both conventional pollutants (i.e. dissolved oxygen, nutrients, and phytoplankton) and toxics. The toxics routines combine organic chemical process kinetics with sediment balance algorithms to predict dissolved and sorbed chemical concentrations in the upper sediment bed and overlying water column. HSPF is also linked into EPA's BASINS modeling system.

The primary advantage of HSPF is that it exists as part of a linked watershed/receiving water modeling package. Nonpoint source loading and hydrodynamic results are automatically linked to the HSPF water quality submodel, such that no external linkages need be developed.

CE-QUAL-W2

CE-QUAL-W2 is a linked hydrodynamic-water quality model, supported by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) in Vicksburg, Mississippi. CE-QUAL-W2 simulates variations in water quality in the longitudinal and lateral directions, and was developed to address water quality issues in long, narrow reservoirs. Water quality state variables consist of temperature, algae, dissolved oxygen, carbonaceous biochemical oxygen demand, ammonia, nitrate, organic nitrogen, orthophosphate, coliform bacteria, and dissolved iron.

The primary advantage of CE-QUAL-W2 is the ability to simulate the onset and breakdown of vertical temperature stratification and resulting water quality impacts. It will be the most appropriate model for those cases where these vertical variations are an important water quality consideration. In un-stratified systems, the effort and data required to support the CE-QUAL-W2 hydrodynamic routines may not be necessary.

EFDC

EFDC (Environmental Fluid Dynamics Code) is a three-dimensional hydrodynamic and water quality model supported by the U. S. EPA Ecosystems Research Division. EFDC simulates variations in water quality in the longitudinal, lateral and vertical directions, and was developed to address water quality issues in rivers, lakes, reservoirs, wetland systems, estuaries, and the coastal ocean. EFDC transports salinity, heat, cohesive or noncohesive sediments, and toxic contaminants that can be described by equilibrium partitioning between the aqueous and solid phases. Unique features of EFDC are its ability to simulate wetting and drying cycles, it includes a near field mixing zone model that is fully coupled with a far field transport of salinity, temperature, sediment, contaminant, and eutrophication variables. It also contains hydraulic structure representation, vegetative resistance, and Lagrangian particle tracking. EFDC accepts radiation stress fields from wave refraction-diffraction models, thus allowing the simulation of longshore currents and sediment transport.

The primary advantage of EFDC is the ability to combine three-dimensional hydrodynamic simulation with a wide range of water quality modeling capabilities in a single model. The primary disadvantages are that data needs and computational requirements can be extremely high.

MODEL SELECTION

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs for the impaired waterbodies in the Macoupin Creek watershed. This chapter presents the general guidelines used in the model selection process, and then applies these guidelines to make specific recommendations. In summary, two approaches are recommended for the listed waterbodies in the Macoupin Creek watershed, with several alternate approaches also provided. The final selection will be dependent upon the level of implementation to be immediately conducted for the TMDLs.

General Guidelines

A wide range of watershed and water quality modeling tools is available and potentially applicable to develop TMDLs. This section provides the guidelines to be followed for the model selection process, based upon work summarized in (DePinto et al, 2004). Three factors will be considered when selecting an appropriate model for TMDL development:

- **Management objectives:** Management objectives define the specific purpose of the model, including the pollutant of concern, the water quality objective, the space and time scales of interest, and required level or precision/accuracy.
- **Available resources:** The resources available to support the modeling effort include data, time, and level of effort of modeling effort
- **Site-specific characteristics:** Site-specific characteristics include the land use activity in the watershed, type of water body (e.g. lake vs. river), important transport and transformation processes, and environmental conditions.

Model selection must be balanced between competing demands. Management objectives typically call for a high degree of model reliability, although available resources are generally insufficient to provide the degree of reliability desired. Decisions are often required regarding whether to proceed with a higher-than-desired level of uncertainty, or to postpone modeling until additional resources can be obtained. There are no simple answers to these questions, and the decisions are often made using best professional judgment.

The required level of reliability for this modeling effort is one able to "support development of a credible TMDL". The amount of reliability required to develop a credible TMDL depends, however, on the degree of implementation to be included in the TMDL. TMDL implementation plans that require complete and immediate implementation of strict controls will require much more model reliability than an implementation plan based upon adaptive management which allows incremental controls to be implemented and includes follow-up monitoring of system response to dictate the need for additional control efforts.

The approach to be taken here regarding model selection is to provide recommendations which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date. Alternative methodologies are also provided that will support the development of differing levels of TMDL implementation plans. For each approach, the degree of implementation that can be supported to produce a credible TMDL will be provided. Specific recommendations are provided which correspond to the level of detail provided in other Illinois TMDL implementation plans conducted to date.

Model Selection for the Macoupin Creek Watershed

Tables 1 and 2 summarized the characteristics of the various watershed and water quality methodologies with potential applicability to TMDL development. This section reviews the relevant site-specific characteristics of the systems, summarizes the data available, and provides recommended approaches. Data needs, assumptions, and level of TMDL implementation support are provided for each of the recommended approaches.

Site Characteristics

Watershed characterization for the Macoupin Creek watershed was provided in the first quarterly status report (LTI, 2004). There are seven listed waterbodies located within the Macoupin Creek watershed discussed in the first quarterly status report. The most downstream Macoupin Creek segment (DA04) includes the drainages for all of the listed waterbodies. In summary, the Macoupin Creek watershed is located in West-Central Illinois approximately 45 miles south of Springfield, Illinois. The creek extends through four counties, but most of the watershed is located in Macoupin County. Macoupin Creek extends from its point of origin southeast of Farmersville to its confluence with the Illinois River, but the two impaired creek segments are the two most upstream segments. Macoupin Creek segments DA04 and DA05 are 19.73 and 43.89 miles in length, respectively. A third creek segment, Briar Creek, is listed as impaired for dissolved oxygen, but it was recommended in the first quarterly status report (LTI, 2004), that the available data do not support the listing of this segment for dissolved oxygen. In addition to the impaired creek segments, four lakes are impaired within the Macoupin Creek watershed. These range from 56.5 to 207 acres in size and are: Carlinville Lake, Beaver Dam Lake, Old Gillespie Lake and New Gillespie Lake. The causes and potential sources of impairments are summarized for all waterbodies (Table 3).

Additional information related to each of the seven listed waterbody segments follows below:

- Macoupin Creek (DA04). This is the most downstream segment in the watershed, with a drainage area of approximately 400 square miles. The watershed is predominantly agricultural (74%), with forest and grassland comprising approximately 14% and 5% of the watershed, respectively. There are eleven entities that have NPDES permits in the watershed. Surface discharge systems were also identified in this watershed. Impairments in this segment are low dissolved oxygen, fecal coliform bacteria and manganese.

- Macoupin Creek (DA05). This segment is located upstream of DA04. The watershed for this segment is mostly agricultural, with some forest. There are several point sources in this watershed. Two tributaries to this segment include Briar Creek and Carlinville Lake. Known impairments include low dissolved oxygen and manganese.
- Briar Creek (DAZN). The watershed for this creek is predominantly agricultural (60%) and urban (22%). Briar Creek is small (4 miles) and appears to be intermittent. Very low flows and standing water were noted during a site visit in June 2004. During the sampling period, the flow from the Carlinville STP comprised 98% of the creek flow downstream of the discharge. This STP also has permitted CSOs. This creek is listed for low dissolved oxygen, however, in the first quarterly status report, LTI determined that the available data were insufficient to confirm the listing.
- Carlinville Lake (RDG). Carlinville Lake is located in Macoupin County and it is 168 acres in size. Its watershed is 15,136 acres in size. The land surrounding the lake is forested, and the banks of the lake are steep. Some shoreline erosion was evident during the field visit. There is a dam and water treatment plant at the western end of the lake. Approximately 64% of the watershed is used for agriculture and 23% is forested. This lake is listed for manganese and total phosphorus.
- Beaver Dam Lake (RDH). This is a small shallow lake (49 acres, 10 ft deep) with a small watershed (185 acres). Approximately 56% of the land is forested. There are prairie restoration activities in Beaver Dam State Park near the lake. It drains to a nearby open water marsh via a wide drainage that includes a settling pond. During the field visit in late June, the drainage and the marsh were thick with green algal growth. In addition to receiving drainage from the lake, the marsh receives drainage from the park's wastewater system. No algae were observed in the lake itself at the time of the field visit. There is limited development in the watershed, which includes park roads. There is also one permitted point source discharge (from park showers). The Assistant Site Superintendent of Beaver Dam State Park, Mike Page, described how during rain events, stormwater runs through a wide gully from farm fields located at a higher elevation and north of the lake, through the campground and woods, under a road, and into the lake. The topography in this area is very steep. Mr. Page described how during very heavy rains, the water flows over a park road. He explained that the drainage ditch from the fields, as well as the lake bottom near the outlet of the ditch, needs to be cleaned out periodically to remove sediment from the fields. A smaller drainage to the lake was observed next to the visitor's center. Fishing is generally reported to be poor in the lake. The lake is sprayed every spring for curly leaf pondweed. This lake is listed for total phosphorus.
- Old Gillespie Lake (SDT). This lake is 71 acres in size and has a 3,093-acre watershed. There are no towns in this subwatershed, although the land immediately

around the lake is developed with older small cottages and trailers. The land use is primarily agricultural. A recent study (Crawford and Associates, 1999) found that soils in this area are susceptible to erosion and estimated that approximately 11,000 tons of soil are eroded and delivered to Old Gillespie Lake each year. This study also found that there is little to no discharge of groundwater to the lake or its tributaries. This lake is listed for total phosphorus and manganese.

- New Gillespie Lake (SDU). This lake is 207 acres in size with a 7,215-acre watershed. A recent study (Crawford and Associates, 1999) found that soils in this area are susceptible to erosion and estimated that approximately 15,000 tons of soil are estimated to be eroded and delivered to New Gillespie Lake each year. This study also found that there is little to no discharge of groundwater to the lake or its tributaries. Approximately 68% of the land is used for agriculture, and 16% is forested. The land surrounding the lake is very wooded, and there are many older cottages and trailers. Several horses were observed in a campground near the lake, and at a nearby horse farm. This lake is listed for total phosphorus.

Table 3. Causes and Sources of Waterbody Impairment

Waterbody	Cause of impairments	Potential Sources
Macoupin Creek (DA 04)		
	Manganese	Natural background sources
	Dissolved oxygen	Respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, low flow, municipal point sources
	Fecal coliform	Municipal point sources, agricultural runoff, failing septic systems
Macoupin Creek (DA 05)		
	Manganese	Natural background sources
	Dissolved oxygen	Respiration, sediment oxygen demand, degradation of CBOD, nitrification of ammonia, low flow, municipal point source discharge
Briar Creek (DAZN)		
	Dissolved oxygen	Point source discharges (including CSOs), agricultural runoff and low flows
Carlinville Lake (RDG)		
	Manganese	Natural background, seasonal hypolimnetic anoxia
	Total Phosphorus	Agricultural runoff, seasonal hypolimnetic anoxia, algal decay
Beaver Dam Lake (RDH)		
	Total Phosphorus	Agricultural runoff, seasonal hypolimnetic anoxia, point source
Old Gillespie Lake (SDT)		
	Manganese	Natural background, seasonal hypolimnetic anoxia

Waterbody	Cause of impairments	Potential Sources
	Total Phosphorus	Agricultural runoff, stream bank erosion, seasonal hypolimnetic anoxia, failing septic systems
New Gillespie Lake (SDU)		
	Total Phosphorus	Agricultural runoff, stream bank erosion, seasonal hypolimnetic anoxia, failing septic systems

Data Available

Table 4 provides a summary of available water quality data from the first quarterly status report (LTI, 2004).

This amount of data is sufficient to confirm the presence of water quality impairments for all waterbodies except Briar Creek. Only three dissolved oxygen measurements were collected from Briar Creek (upstream and downstream of the Carlinville STP) and it was noted that the STP effluent was milky white and that that was because it was cleaning day at Prairie Farms (a unique event).

While sufficient to confirm the waterbody listings (except Briar Creek), the data are not sufficient to support development of a rigorous watershed or water quality model.

Specific items lacking in this data set include tributary loading data for all pollutants of concern, data describing the distribution of manganese, total phosphorus and fecal coliform throughout the watershed, and chlorophyll a data to better define the processes controlling dissolved oxygen throughout the lakes. A USGS gage is located on Macoupin Creek, but it is located downstream of the project study area and the flows at this gage (drainage area = 868 mi^2) are expected to be approximately twice those at the downstream end of the project study area (drainage area = 401 mi^2). It should be noted that some additional data may be collected in the future. Heartland Ecosystem Services, Inc. has recently applied for 319 and Clean Lakes Study grant money to conduct watershed assessment and sampling for all tributaries to Carlinville Lake and to conduct water quality sampling in this lake.

Table 4. Water Quality Data Summary for Macoupin Creek Watershed

Waterbody Segment	Parameter	Sampling station	Period of record (#)	Minimum	Maximum	Average
Macoupin Creek DA 04	Dissolved oxygen (mg/l)	DA 03	7/1998-9/2001 (4 samples)	5.5	8.7	7.2
		DA 04	1/1990-5/2003 (117 samples)	3	15.4	8.8
	Manganese (ug/l)	DA 03	6/2001-9/2001 (3 samples)	250	1000	733
		DA 04	1/1990-5/2003 (92 samples)	120	9100	497
	Fecal coli. (cfu/100ml)	DA 04	1/1990-6/2004 (102 samples)	10	91000	2421
Macoupin Creek DA 05	Dissolved oxygen (mg/l)	DA 05	1/2000-12/2002 (25 samples)	4.5	15.8	9.5
		DA11	7/2001 (1 sample)	3.1	3.1	3.1
		DA-CV-C4	9/1998 (1 sample)	1.5	1.5	1.5
		DA-CV-D2	9/1998 (1 sample)	1.9	1.9	1.9
		05586645	8/1997 (1 sample)	5.8	5.8	5.8
	Manganese (ug/l)	DA 11	7/2001 (1 sample)	510	510	510
		DA-CV-C4	9/1998 (1 sample)	330	330	330
		DA-CV-D2	9/1998 (1 sample)	1500	1500	1500
Briar Creek DAZN	Dissolved oxygen (mg/l)	DAZN-CV-C1	9/1998 (1 sample)	4.5	4.5	4.5
		DAZN-CV-C2	9/1998 (1 sample)	0.3	0.3	0.3
		DAZN-CV-C3	9/1998 (1 sample)	2.7	2.7	2.7
Carlinville Lake RDG	Manganese (ug/l)	RDG-1	4/2002-10/2002 (5 samples)	46	200	95
	Total Phosphorus (mg/l)	RDG-1	4/1992-10/2002 (34 samples)	0.05	0.48	0.14
		RDG-2	4/1992-10/2002 (15 samples)	0.07	0.32	0.11
		RDG-3	4/1992-10/2002 (15 samples)	0.08	0.33	0.13
Beaver Dam Lake RDH	Total Phosphorus (mg/l)	RDH-1	5/1992-10/2002 (28 samples)	0.02	0.29	0.10
		RDH-2	4/1993-10/2002 (10 samples)	0.03	0.14	0.09
		RDH-3	4/1993-10/2002 (10 samples)	0.02	0.13	0.08

Waterbody Segment	Parameter	Sampling station	Period of record (#)	Minimum	Maximum	Average
New Gillespie Lake SDU	Total Phosphorus (mg/l)	SDU-1	4/1996-10/2002 (39 samples)	0.059	0.94	0.206
		SDU-2	4/1996-10/2002 (27 samples)	0.072	0.31	0.147
		SDU-3	4/1996-10/2002 (23 samples)	0.063	0.32	0.162
Old Gillespie Lake SDT	Manganese (ug/l)	SDT-1	4/2001-10/2001 (5 samples)	59	310	178
	Total Phosphorus (mg/l)	SDT-1	4/1996-10/2001 (50 samples)	0.05	1.37	0.36
		SDT-2	4/1996-10/2001 (19 samples)	0.05	0.62	0.33
		SDT-3	4/1996-10/2001 (24 samples)	0.06	0.65	0.31

Recommended Approaches

This section provides recommendations for specific modeling approaches to be applied for the Macoupin Creek watershed TMDLs. One and two alternative sets of approaches are provided in Tables 5 and 6 for the creek and lake segments, respectively, with each approach having unique data needs and resulting degree of detail.

Table 5. Recommended Modeling Approaches for the Macoupin Creek (DA04 and DA05) and Briar Creek (DAZN)

Modeling Approach	Waterbody	Pollutants considered	Watershed Model	Water Quality Model	Additional data needs	Level of TMDL implementation supported
Recommended						
	Macoupin Creek (DA04)	Fecal coliform	Load duration curve		None	Identify whether sources occur during dry or wet weather; and identify approximate level of control needed
	Macoupin Creek (DA04)	Dissolved Oxygen	Empirical approach	QUAL2E	Low flow stream surveys	Identify primary sources to be controlled, and approximate level of control needed
	Macoupin Creek (DA05)					
	Briar Creek (DAZN)					
	Macoupin Creek (DA04)	Manganese	Empirical approach	Spreadsheet approach	Low flow stream surveys	Identify manmade versus natural sources
	Macoupin Creek (DA05)					
Alternative						
	Macoupin Creek (DA04)	Fecal coliform	HSPF	HSPF	Tributary flow and coliform concentrations at multiple locations	Define specific sources of bacteria and detailed control strategies

The recommended approach for Macoupin Creek (DA04) consists of developing a load-duration curve to address fecal coliform impairments. A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. Such a graph can be developed by 1) developing a flow duration curve by ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results as shown in Figure 1; 2) translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard as shown in Figure 2; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph as shown in Figure 3.

% Exceed	Flow
99	694.2
95	803.3
90	920.2
85	1213.3
80	1629.7
75	2081.3
70	2692.9
65	3130.3
60	3583.3
55	4177.9
50	5092.2
45	6074.7
40	7068.8
35	8398.1
30	9801.8
25	11617.5
20	13838.5
15	17136.8
10	22281.1

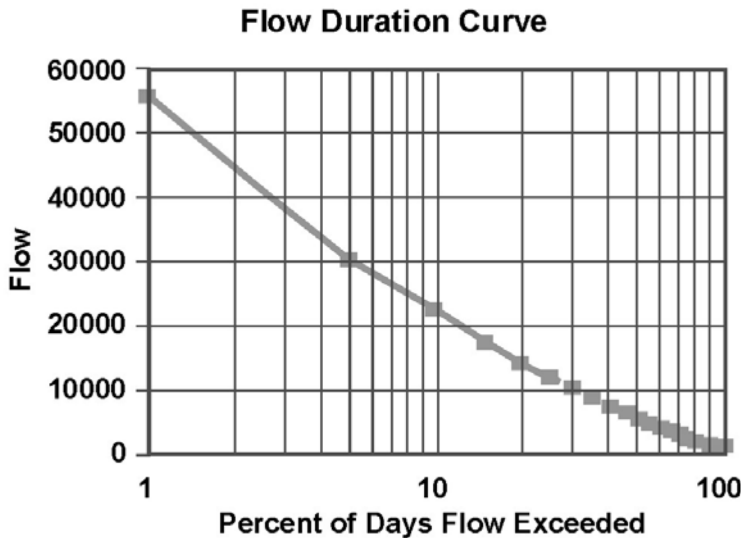

Figure 1. Calculation of a Flow Duration Curve (from Freedman et al., 2003)

% Exceed	Flow	Atrazine (lbs/day)
99	694.2	11.50
95	803.3	13.31
90	920.2	15.25
85	1213.3	20.10
80	1629.7	27.00
75	2081.3	34.49
70	2692.9	44.62
65	3130.3	51.87
60	3583.3	59.38
55	4177.9	69.23
50	5092.2	84.38
45	6074.7	100.66
40	7068.8	117.13
35	8398.1	139.16
30	9801.8	162.42
25	11617.5	192.50
20	13838.5	229.30
15	17136.8	283.96
10	22281.1	369.20
5	30245.9	501.17
1	55562.3	920.67

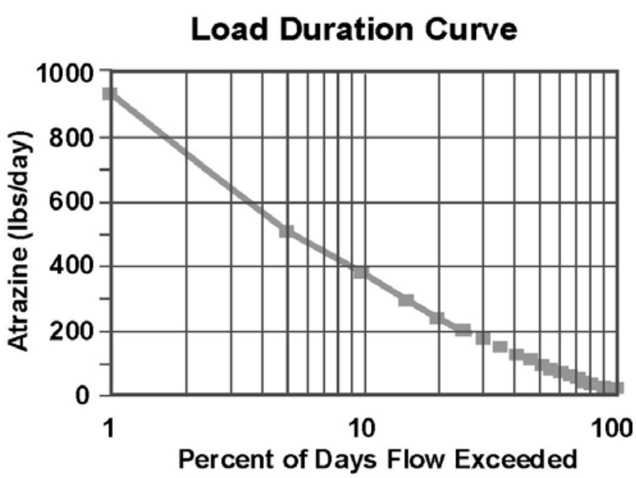

Figure 2. Calculation of a Load Duration Curve (from Freedman et al., 2003)

% Exceed	Flow	Atrazine (lbs/day)	Atrazine Load
99	694.2	11.50	4.33
95	803.3	13.31	
90	920.2	15.25	
85	1213.3	20.10	12.92
80	1629.7	27.00	
75	2081.3	34.49	
70	2692.9	44.62	122.91
65	3130.3	51.87	
60	3583.3	59.38	95.87
55	4177.9	69.23	
50	5092.2	84.38	
45	6074.7	100.66	
40	7068.8	117.13	
35	8398.1	139.16	
30	9801.8	162.42	
25	11617.5	192.50	
20	13838.5	229.30	
15	17136.8	283.96	154.43
10	22281.1	369.20	804.32
5	30245.9	501.17	
1	55562.3	920.67	

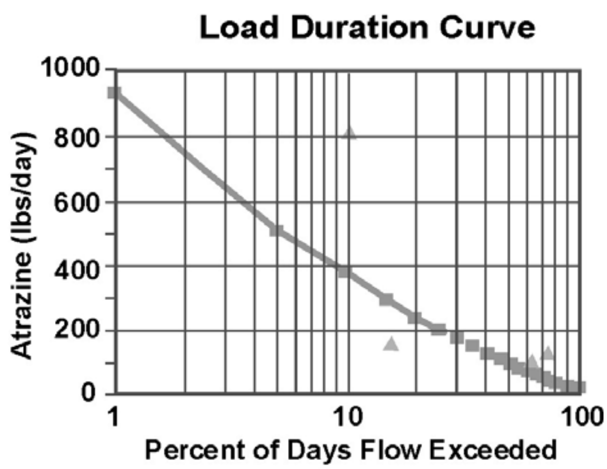

Figure 3. Load Duration Curve with Observed Loads (from Freedman et al., 2003)

The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below), and duration (potentially how long the deviation is present) questions; and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

The location of loads that plot above the load duration curve is meaningful. Loads which plot above the curve in the area of the plot defined as being exceeded 85-99 percent of the time are considered indicative of point source influences on the water quality. Those loads plotting above the curve over the range of 10-70 percent exceedence likely reflect nonpoint source load contributions. NPS loads are pollution associated with runoff or snowmelt from numerous, dispersed sources over an extended area. Some combination of the two source categories lies in the transition zone of 70-85 percent exceedence. Those loads plotting above the curve at exceedences less than 10 percent or more than 99 percent reflect extreme hydrologic conditions of flood or drought (Freedman et al, 2003).

The load duration curve approach will identify broad categories of coliform sources and the extent of control required from these sources to attain water quality standards.

The alternative approach for Macoupin Creek (DA04) consists of applying the HSPF model to define watershed loads for all fecal coliform sources and using the water quality component of this model to simulate in-stream concentrations and water quality response. This approach, coupled with intensive monitoring, would define specific sources of bacteria and identify detailed control strategies necessary to attain water quality standards.

To address dissolved oxygen problems, the recommended approach for Macoupin Creek (DA04 and DA05) and Briar Creek (DAZN) consists of using the water quality model QUAL2E. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for this segment will be defined using an empirical approach. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing dissolved oxygen for low flow conditions. Because problems appear to be restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment. For this reason, an empirical approach was selected for determining watershed loads. The recommended approach (in conduction with additional monitoring described below) will identify the primary sources of dissolved oxygen to be controlled, as well as the level of control needed.

Table 6. Recommended Modeling Approaches for Carlinville Lake, Beaver Dam Lake, Gillespie Old Lake and Gillespie New Lake

<table>
<tr><th>Modeling Approach</th><th>Waterbody</th><th>Pollutants considered</th><th>Watershed Model</th><th>Water Quality Model</th><th>Additional data needs</th><th>Level of TMDL implementation supported</th></tr>
<tr><td colspan="7">Recommended</td></tr>
<tr><td></td><td>Carlinville Lake (RDG)</td><td rowspan="2">Total phosphorus, Manganese</td><td rowspan="4">GWLF</td><td rowspan="4">BATHTUB</td><td rowspan="4">None</td><td rowspan="4">Identify primary sources to be controlled; and approximate level of control needed</td></tr>
<tr><td></td><td>Old Gillespie Lake (SDT)</td></tr>
<tr><td></td><td>Beaver Dam Lake (RDH)</td><td rowspan="2">Total phosphorus</td></tr>
<tr><td></td><td>New Gillespie Lake (SDU)</td></tr>
<tr><td colspan="7">Alternative 1</td></tr>
<tr><td></td><td>Carlinville Lake (RDG)</td><td rowspan="2">Total phosphorus, Manganese</td><td rowspan="4">None</td><td rowspan="4">BATHTUB</td><td rowspan="4">None</td><td rowspan="4">Identify approximate level of control needed</td></tr>
<tr><td></td><td>Old Gillespie Lake (SDT)</td></tr>
<tr><td></td><td>Beaver Dam Lake (RDH)</td><td rowspan="2">Total phosphorus</td></tr>
<tr><td></td><td>New Gillespie Lake (SDU)</td></tr>
<tr><td colspan="7">Alternative 2</td></tr>
<tr><td></td><td>Carlinville Lake (RDG)</td><td rowspan="2">Total phosphorus, Manganese</td><td rowspan="4">SWAT</td><td rowspan="4">CE-QUAL-W2</td><td rowspan="4">Tributary flow and concentrations; lake concentrations</td><td rowspan="4">Define detailed control strategies</td></tr>
<tr><td></td><td>Old Gillespie Lake (SDT)</td></tr>
<tr><td></td><td>Beaver Dam Lake (RDH)</td><td rowspan="2">Total phosphorus</td></tr>
<tr><td></td><td>New Gillespie Lake (SDU)</td></tr>
</table>

The recommended approach for the four Macoupin reservoirs consists of using the GWLF and BATHTUB models to address total phosphorus in all four reservoirs (Carlinville Lake, Beaver Dam Lake, and Old and New Gillespie Lakes) and manganese problems in Carlinville Lake and Old Gillespie Lake. Specifically, GWLF will be applied to calculate phosphorus loads to the reservoir from different land uses, over a time scale consistent with its residence time in the four lakes. BATHTUB will then be used to predict the relationship between phosphorus load and resulting in-lake phosphorus and dissolved oxygen concentrations, and resulting potential for manganese release from sediments. This relationship will be used to define the dominant sources of phosphorus to the lake, and the extent to which they must be controlled to attain water quality standards. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. GWLF was selected as the watershed model because it can provide loading information on the time-scale required by BATHTUB, with moderate data requirements that can be satisfied by existing data. This approach will identify the primary sources to be controlled, as well as the approximate level of control needed.

The first alternative approach for Carlinville Lake, Beaver Dam Lake and Old and New Gillespie Lakes would not include any watershed modeling for phosphorus, but would focus only on determining the pollutant loading capacity of the lake. Determination of existing loading sources and prioritization of restoration alternatives would be conducted by local experts as part of the implementation process. Based upon their recommendations, a voluntary implementation plan would be developed that includes both accountability and the potential for adaptive management.

The second alternative approach for Carlinville Lake, Beaver Dam Lake and Old and New Gillespie Lakes would consist of applying the SWAT watershed model to define watershed loads of phosphorus, coupled with application of the reservoir models CE-QUAL-W2 to describe in-lake water quality response. CE-QUAL-W2 would be applied to define hydrodynamics and eutrophication processes.

Assumptions Underlying the Recommended Methodologies

The recommended approach is based upon the following assumptions:

- The only controllable source of manganese to Carlinville Lake and Old Gillespie Lake is that which enters from lake sediments during periods of low dissolved oxygen; this source can be (partially) controlled by reducing phosphorus loads and increasing hypolimnetic dissolved oxygen concentrations.
- A credible TMDL implementation plan can be developed based upon relatively simple models

LTI believes that these assumptions are appropriate.

DATA NEEDS FOR THE METHODOLOGIES TO BE USED

The recommended modeling approach and the first alternative approach for Carlinville Lake, Beaver Dam Lake and Old and New Gillespie Lakes can be applied without collection of any additional data. However, follow-up monitoring is strongly recommended after controls are implemented, to verify their effectiveness in reducing loads and documenting lake response.

Application of the recommended modeling approaches for the two Macoupin Creek segments and Briar Creek will require conduct of additional field sampling to support TMDL development for dissolved oxygen (Macoupin Creek, and if determined necessary for by IEPA, Briar Creek) and manganese (Macoupin Creek segments only). The existing data, while sufficient to document impairment in Macoupin Creek, are not sufficient to define the cause-effect relationships. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances and manganese in Macoupin Creek, and oxygen demanding substances in Briar Creek.

Should the alternative approach be selected for Macoupin Creek or the second alternative approach selected for the four reservoirs, extensive data collection efforts would be required in order to calibrate the watershed and water quality models. The purpose of the detailed data collection is as follows:

1) define the distribution of specific loading sources throughout the watershed,
2) define the extent to which these loads are being delivered to the river or lake, and
3) define important reaction processes in Carlinville Lake, Beaver Dam Lake, Old Gillespie Lake and New Gillespie Lake.

To satisfy objective one, for the four lakes, wet weather event sampling of phosphorus and manganese (Carlinville and Old Gillespie lakes only) at multiple tributary and mainstem locations in the watershed will be needed. To satisfy objective one for Macoupin Creek, wet weather event sampling of fecal coliform at multiple tributary and mainstem locations in the watershed will be needed. To satisfy objective two, routine monitoring of loads to the lake and to the creek will be needed. Flows could be estimated using the USGS gage on Macoupin Creek near Kane, Illinois (05587000), however, the drainage area at this gage is approximately twice the size of the study area. Therefore, it is recommended that flows be measured in the watershed at the mouth of Macoupin Creek, and on several tributaries to reflect watershed-specific flow conditions. It is also recommended that flows be measured on the primary tributaries to each of the four lakes. Water quality sampling and analyses would be required for several wet and dry weather events for the lakes for: total suspended solids, manganese, total phosphorus, and ortho-phosphorus. Water quality sampling and analyses would be required for several wet and dry weather events for Macoupin Creek (DA04) for total suspended solids and fecal coliform. To satisfy the third objective, routine in-lake monitoring will be needed. In the four lakes, bi-monthly sampling would need to be conducted for water temperature, in addition to total suspended solids, manganese (Carlinville and Old Gillespie Lakes only), total phosphorus, ortho-phosphorus, dissolved oxygen, and chlorophyll a.

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Third Quarterly Progress Report

Prepared for Illinois Environmental Protection Agency

October 2004

Macoupin Creek Watershed

Macoupin Creek (DA04, DA05), Briar Creek (DAZN),
Carlinville Lake (RDG), Beaver Dam Lake (RDH),
New Gillespie Lake (SDU), and Old Gillespie Lake (SDT)

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EXECUTIVE SUMMARY

This is the third in a series of quarterly status reports documenting work completed on the Macoupin Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

Background

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the draft 2004 303(d) list (IEPA, 2004), which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. The Clean Water Act requires that a Total Maximum Daily Load (TMDL) be completed for each pollutant listed for an impaired water body. TMDLs are prepared by the States and submitted to the U.S. EPA. In developing the TMDL, a determination is made of the greatest amount of a given pollutant that a water body can receive without exceeding water quality standards and designated uses, considering all known and potential sources. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation.

As part of the TMDL process, the Illinois Environmental Protection Agency (IEPA) and several consultant teams have compiled and reviewed data and information to determine the sufficiency of available data to support TMDL development. As part of this review, the data were used to confirm the impairments identified on the 303(d) list and to further identify potential sources causing these impairments. The results of this review were presented in the first quarterly status report.

In a second quarterly status report, the methodologies/procedures/models to be used in the development of TMDLs were identified and described and models were recommended for application to the project watershed.
The intent of this third quarterly status report is to:

- Identify the amount of data needed to support the modeling (if additional data collection is recommended);
- Provide a general data collection plan; and
- Identify, to the extent possible, the responsible parties for additional data collection.

In future phases of this project, Illinois EPA and consultants will develop the TMDLs and will work with stakeholders to implement the necessary controls to improve water quality in the impaired water bodies and meet water quality standards. It should be noted that the controls for nonpoint sources (e.g., agriculture) would be strictly voluntary.

Methods

The effort completed in the third quarter included summarizing additional data needs to support the recommended methodologies/procedures/models to be used in the development of TMDLs, and where needed, providing general information related to the data collection.

Results

The recommended modeling approach for Macoupin Creek segments DA04 and DA05 and Briar Creek (should IEPA determine that a TMDL is warranted for this creek which has insufficient data to support its listing), consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for the Macoupin Creek and Briar Creek segments will be defined using an empirical approach. The recommended approach to address fecal coliform impairments in segment DA04 consists of developing a load-duration curve. Application of the recommended modeling approaches for the two Macoupin Creek segments and Briar Creek will require conduct of additional field sampling to support TMDL development for dissolved oxygen (Macoupin Creek, and if determined necessary for by IEPA, Briar Creek) and manganese (Macoupin Creek segments only).

The recommended modeling approach for Carlinville Lake, Old Gillespie Lake, Beaver Dam Lake and New Gillespie Lake consists of using the GWLF and BATHTUB models. The recommended modeling approaches for Carlinville Lake, Beaver Dam Lake and Old and New Gillespie Lakes can be applied without collection of any additional data.

INTRODUCTION/PURPOSE

This Stage 1 report describes intermediate activities related to the development of TMDLs for impaired water bodies in the Macoupin Creek watershed. Earlier Stage 1 efforts included watershed characterization activities and data analyses, to confirm the causes and sources of impairments in the watershed, and the recommendation of models to support TMDL development.

The remaining sections of this report include:

- **Description of additional data collection, if any, to support modeling:** This section describes the amount (temporal and spatial) of data, if any, to be collected, and also includes a general description of a data collection plan. Potential parties that may be responsible for additional data collection are also identified.
- **Next steps**

DESCRIPTION OF ADDITIONAL DATA COLLECTION TO SUPPORT MODELING

In the second quarterly progress report for the Macoupin Creek watershed (LTI, 2004), modeling approaches were recommended. The recommended modeling approach for Macoupin Creek segments DA04 and DA05 and Briar Creek (should IEPA determine that a TMDL is warranted for this creek which has insufficient data to support its listing), consists of using the water quality model QUAL2E to address dissolved oxygen problems. Manganese impairments will be addressed via spreadsheet calculations. Watershed loads for the Macoupin Creek and Briar Creek segments will be defined using an empirical approach. The recommended approach to address fecal coliform impairments in segment DA04 consists of developing a load-duration curve.

The recommended modeling approach for Carlinville Lake, Old Gillespie Lake, Beaver Dam Lake and New Gillespie Lake consists of using the GWLF and BATHTUB models. Application of the recommended modeling approaches for Carlinville Lake, Beaver Dam Lake and Old and New Gillespie Lakes can be applied without collection of any additional data.

As noted in the second quarterly status report, the recommended modeling approaches described above will require conduct of additional field sampling to support TMDL development. The existing data, while sufficient to document impairment in all segments except Briar Creek, are not sufficient to define the cause-effect relationships. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances and manganese in Macoupin Creek, and oxygen demanding substances in Briar Creek.

No additional data collection is recommended for the four reservoirs.

Data Collection Plan

The data collection plan outlined in general terms below, will support development of the recommended approaches for TMDL development. One low-flow survey is recommended to synoptically measure sources and receiving water concentrations of manganese at the twelve essential stations in the Macoupin Creek watershed shown in Figure 1. Two low- to medium-flow surveys are recommended to synoptically measure sources and receiving water concentrations of oxygen demanding substances at these twelve stations. No additional data collection is recommended for the four reservoirs.

Sample collection

Twelve essential monitoring stations and one discretionary station are shown in Figure 1. It is recommended that the twelve essential stations be sampled during low- to medium-flow conditions to support model development and application. Five of these stations are located along the mainstem of Macoupin Creek (including DA 03, DA 04, DA 05, DA 11 and a headwater station) and seven are located on tributaries that are either significant contributors or which have a point source discharge.

Essential monitoring

Two low- to medium-flow surveys are recommended to provide data to support model development and calibration. At each of the essential stations shown in Figure 1, it is recommended that the measurements shown in Table 1 be collected on the same day, under low- to medium- river flow conditions.

Table 1. Sampling recommendations

Measurement	Number of low flow surveys recommended
Dissolved oxygen	2
Water temperature	2
Biochemical oxygen demand (BOD),	2
Ammonia	2
Total manganese	1
Channel morphometry	2

In addition, it is recommended that depth and velocity be measured at four of the mainstem sites, at the same time as the water quality sampling, to support flow calculation.

Finally, at a station determined to be representative of the river based on a field survey, it is recommended that sediment oxygen demand (SOD) be measured, in addition to either continuous dissolved oxygen measurements or dissolved oxygen measurements collected in the morning and afternoon. The purpose of these dissolved oxygen measurements is to assess the effect of algae on instream dissolved oxygen concentrations. The SOD only needs to be measured during one survey.

Discretionary monitoring

One discretionary monitoring station is shown in Figure 1. This station is located on a large tributary to Macoupin Creek. Dissolved oxygen, water temperature, BOD, ammonia, flow, manganese, and channel morphometry measurement at this station would improve the modeling and contributions of watershed sources to instream dissolved oxygen and manganese. However, data collection at this station is not required to support development of a credible model and, as such, this station would only be sampled at the discretion of the agency.

Potential parties that may be responsible for additional data collection

Both Baetis Environmental Services, Inc. and Limno-Tech, Inc. are qualified to conduct the recommended data collection in the Macoupin Creek watershed.

NEXT STEPS

In the upcoming month, the IEPA will confer with the Scientific Advisory Committee to discuss the work presented in the three quarterly status reports. A public meeting will also be scheduled and held in the watershed to present the conclusions and recommendations of Stage 1 to local stakeholders and to obtain feedback on the work completed to date.

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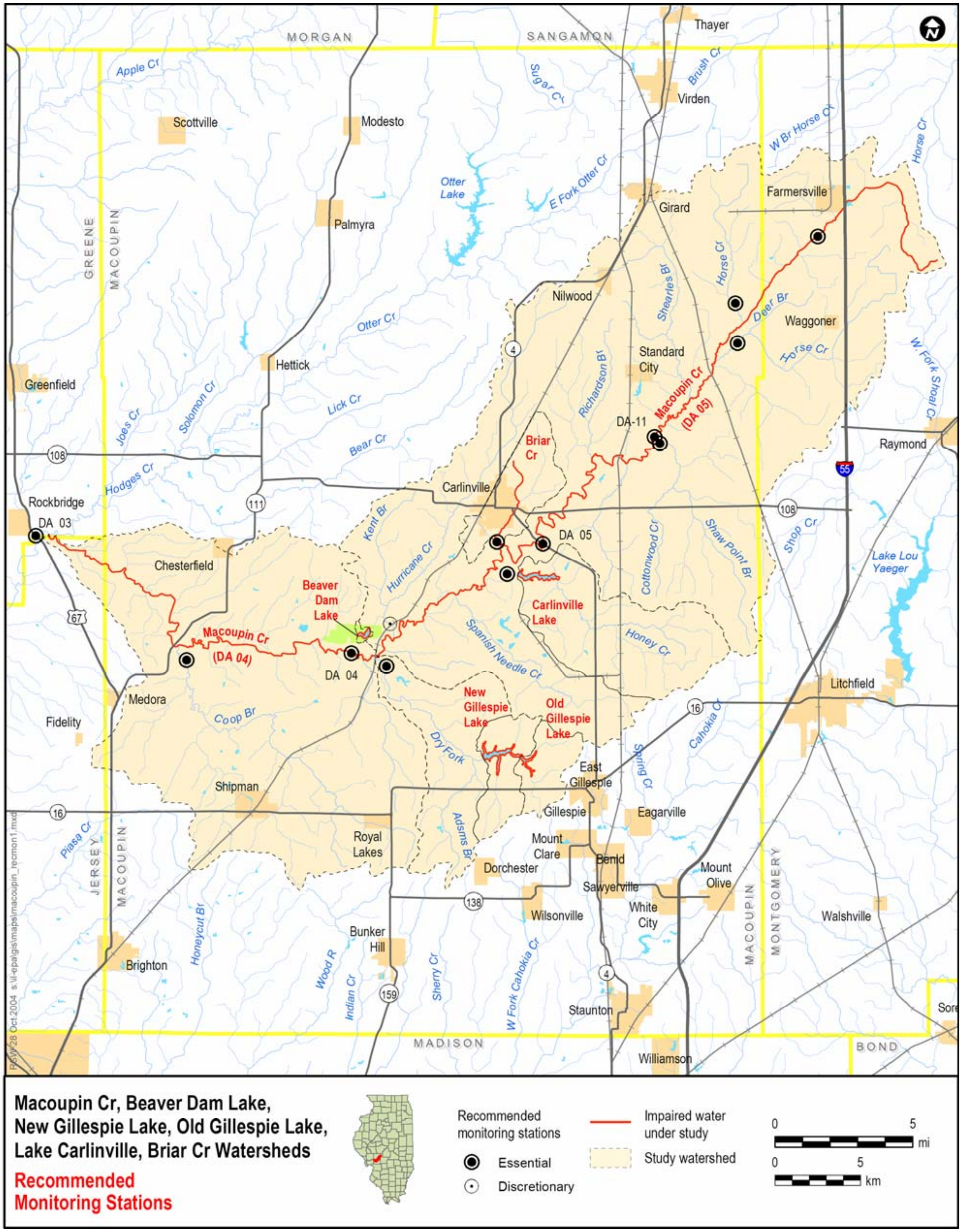

Figure 1. Recommended Stage 2 Sampling Locations

Final Stage1 Progress Report

Prepared for Illinois Environmental Protection Agency

May 2005

Macoupin Creek Watershed

Macoupin Creek (DA04, DA05), Briar Creek (DAZN),
Carlinville Lake (RDG), Beaver Dam Lake (RDH),
New Gillespie Lake (SDU), and Old Gillespie Lake (SDT)

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PUBLIC PARTICIPATION

Stage 1 included opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in Summer 2004 to initiate Stage 1. As quarterly progress reports were produced, the Agency posted them to their website.

In February 2005, a public meeting was announced for presentation of the Stage 1 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Monday, March 21, 2005 in Carlinville, Illinois at the Carlinville High School cafeteria. In addition to the meeting's sponsors, nine individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

The Agency entertained questions and concerns from the public through April 22, 2005. At the meeting, there were several general questions, including questions about schedule and process, and concerns that the TMDL will bring new regulations for farmers. In response, the voluntary nature of the program with respect to nonpoint sources was emphasized. Some attendees expressed skepticism that manganese TMDLs could be conducted, given their prevalence in the soils in the watershed. A statement was made that the Carlinville STP adds ammonia to wastewater and that this could contribute to the dissolved oxygen problem. Some observed that streambank erosion in Macoupin Creek is a major problem. The creek is very dynamic, with a great deal of sloughing. IL-EPA discussed recent flyovers to identify areas of erosion in the watersheds. A question related to whether dissolved and particulate phosphorus would be broken out in the site characterization, and LTI responded that this was done. One attendee noted that there are many confined animal feeding operations (CAFOs) in the watershed. A resident expressed concerns about long wall coal mining in the area, and its effect on water quality.

This is the fourth in a series of quarterly status reports documenting work completed on the Macoupin Creek project watershed. The objective of this report is to provide a summary of Stage 1 work that will ultimately be used to support Total Maximum Daily Load (TMDL) development in the project watershed.

REFERENCES

Illinois Environmental Protection Agency, 2004. Final Draft Illinois Water Quality Report 2004 Illinois Environmental Protection Agency Bureau of Water. IEPA/BOW/04-006. May 2004

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FINAL

March 2006

Macoupin Creek Watershed

Hodges Creek Watershed

North Fork Kaskaskia River Watershed

Skillet Fork Watershed

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INTRODUCTION

Limno-Tech, Inc. (LTI) completed surface water sampling in the summer and fall of 2005 to support Total Maximum Daily Load (TMDL) development for impaired water bodies in four State of Illinois watersheds. This report describes the field investigations and results of the sampling program completed in 2005. This report is divided into sections describing:

- Field investigation overview
- Water sample collection and field measurements
- Discharge measurements
- Sediment oxygen demand and continuous dissolved oxygen monitoring
- Quality assurance review
- Conclusions

FIELD INVESTIGATION OVERVIEW

TMDL streams and their tributaries were sampled during the summer and fall of 2005 to collect data needed to support water quality modeling and TMDL development. The sampled waterbodies are all located within the following watersheds:

- Macoupin Creek (Figure 1),
- Hodges Creek (Figure 2),
- North Fork Kaskaskia River (Figure 3), and
- Skillet Fork (Figure 4).

Sampling was initially planned for six watersheds, as described in the IEPA-approved Quality Assurance Project Plan (LTI, 2005); however, weather conditions did not permit completion of sampling in two of the project watersheds (Mauvaise Terre and East Fork Kaskaskia River). Sampling in these two watersheds will be completed in 2006 and documented separately.

Data were collected during two low-flow periods in accordance with an Illinois EPA-approved QAPP (Appendix 1; LTI, 2005). In each of the sampled watersheds, the 303(d)-listed stream segment(s) had water present, although tributaries to these segments were not always flowing. Samples were collected from the tributaries if water was present.

Table 1 presents a summary of the sampling completed by watershed, field observations, and any changes in station location.

The sampling and analysis activities included:

- collection of water samples for laboratory analysis;
- measurement of in-stream water quality and channel morphology parameters;
- stream discharge measurements;
- continuous dissolved oxygen (DO) monitoring; and
- sediment oxygen demand (SOD) measurements.

Water samples and stream measurements were collected from the selected locations in each watershed during both events. Discharge measurements, SOD and 24-hour continuous DO measurements were conducted at a subset of locations in each watershed. In accordance with the QAPP, sample collection and field measurement activities (quality, morphometry and discharge) were conducted during two separate dry weather periods and continuous DO and SOD monitoring were conducted only during one dry weather period.

Following the completion of field investigation and laboratory analysis activities, the generated data were compiled and a quality assurance review was conducted to assess data quality and usability.

Table 1. Sampling summary

Site ID	IEPA Station ID	Station Description	Location Change From QAPP Listing	DO, NH_3, BOD_5, Water Temp, channel morphometry		Flow (depth & velocity)		SOD & diurnal DO	Fe		Mn		Round 1 Notes	Round 2 Notes
				Round 1	Round 2	Round 1	Round 2	Round 1	Round 1	Round 2	Round 1	Round 2		
Macoupin Creek Watershed													**8/22-25/2005**	**10/11/2005**
MAC-1	DA 03	Macoupin Ck at US 67		✔	✔	✔	✔				✔	✔	Water flowing; Sampled u.s. side of bridge	Same as Round 1
MAC-2		Coop Branch at Victory Rd											Upstream - dry; Downstream - pooled water covered with duckweed; Not sampled	Same as Round 1
MAC-3	DA 04	Macoupin Ck at Shipman Rd		✔	✔	✔	✔				✔	✔	Water present; Sampled u.s. side of bridge	Same as Round 1
MAC-4		Dry Fork at Lake Catatoga Rd											Dry; Not sampled	Same as Round 1
MAC-5		Honey Ck at Brushy Mount Rd		✔	✔						✔	✔	Water present, no apparent flow; Sampled u.s. side of bridge	Same as Round 1
MAC-6	DAZN	Briar Ck at Crumystone Rd		✔	✔						✔	✔	Water flowing; 3 8' circular c.s. culverts; discharge from W. culvert; Sampled ~20' d.s. of W. culvert; flow measurements ~80 d.s. of culverts and beyond sand bar	Water present; flow from all 3 culverts; Sampled ~80 d.s. of culverts and beyond sand bar
MAC-7	DA 05	Macoupin Ck at Illinois Rte 4		✔	✔	✔	✔	✔			✔	✔	Water present; Sampled u.s. side of bridge	Water present; Sampled d.s. side of bridge
MAC-8		Shaw Point Branch at Sumpter Rd			✔							✔	Dry with pools of water 100'-200' upstream and downstream; Not sampled	Upstream - water under bridge and ~50 u.s., then dry channel for ~75', then water present beyond; Downstream - water present for ~15' d.s., then ~10' of dry bed, then water present beyond; Sampled u.s. side of bridge
MAC-9	DA 11	Macoupin Ck at Coops Mound Rd		✔	✔	✔	✔				✔	✔	Water present; Sampled d.s. side of bridge	No flow, low water levels, duckweed covered
MAC-10		Horse Ck (East) at Sulphur Springs Road		✔	✔						✔	✔	Dry under bridge with water upstream and downstream; Sampled 50' d.s. of bridge & ~10' below u.s. edge of water	Same as Round 1
---			Additional observation: Macoupin Ck at Sulphur Springs Rd										Upstream - dry; Downstream - water present	
---			Additional observation: Macoupin Ck at Boston Chapel Rd										Water present upstream and downstream, duckweed covered	
MAC-11		Horse Ck (West) at Boston Chapel Road		✔							✔		Upstream - dry; Downstream and under bridge - pooled with duckweed cover; sampled d.s. side of bridge	Dry with small pool under bridge; Not sampled
---			Additional observation: Macoupin Ck at Macoupin Rd./Co. Rd. 2725N Rd										Dry under bridge with pooled water upstream and downstream	
---			Additional observation: Macoupin Ck at East 1st Rd./Co. Rd. 100E										Dry under bridge with puddled water upstream and downstream	
---			Pasture Rd./Co. Rd. 2850N										Water present	
MAC-12		Macoupin Ck at East 2nd Rd/County Rd. 200E		✔	✔		✔				✔	✔	Dry under bridge with moist sediments and small puddle, water present `10' upstream and ~25' downstream; Sampled d.s. side of bridge	Pools u.s. and d.s. with slow trickle of water between under bridge; Sampled
---			Additional observation: Macoupin Ck at I-55										Upstream and under bridge - very little water with trickle flow under bridge; Downstream - duckweed covered pool	
---			Additional observation: Mine Ave./Co. Rd. 3050N (E. of I-55)										Upstream - very little water; Downstream - dry	

Table 1. Sampling Summary Continued

Site ID	IEPA Station ID	Station Description	Location Change From QAPP Listing	DO, NH_3, BOD_5, Water Temp, channel morphometry		Flow (depth & velocity)		SOD & diurnal DO	Fe		Mn		Round 1 Notes	Round 2 Notes
				Round 1	Round 2	Round 1	Round 2	Round 1	Round 1	Round 2	Round 1	Round 2		
Hodges Creek Watershed													**8/22-25/2005**	**10/11/2005**
HOD-1	DAG 03	Hodges Ck at Co. Hwy. 24/Co. Rd. 1050N/Chesterfield Rd.		✓	✓	✓	✓	✓					Water present, ~40' wide, narrows to ~10' under bridge with flow observed; Sampled channel (10' width) and measured flows (20' width) under d.s. side of bridge	Pooled water, very low flow
HOD-2		Joes Ck. At Joes Ck Rd.											Dry with small puddle at upstream side of bridge	Same as Round 1
---			Additional observation: Joes Cr at Illinois Rte 108										Upstream - water present; Downstream - dry	
HOD-3		Hodges Ck at Illinois Route 108	Otter Cr. incorrectly referenced in QAPP	✓	✓	✓	✓						Shallow, narrow 1-4' wide stream widening to a ~50' pool ~50' downstream of bridge; Sampled 2' wide channel under d.s. side of bridge	Water pooled u.s. and d.s. and connected by small trickle of water
HOD-4		Solomon Ck at Boyscout Rd (d/s of Hettick STP)											Dry with small puddle downstream	Same as Round 1
HOD-5		Solomon Ck East off of Goshen Rd., no bridge (d.s. of Palmyra STP)											Dry, 2.5-3' c.s. culvert, no bridge	Same as Round 1
HOD-6		Nassa Ck near end of Wildcat Ln, no bridge											Dry with pool ~60' upstream (pool size: 12'x12'x2-6" deep), no bridge	Dry, small puddles, no flow
HOD-7		East Fork Otter Ck at Henry Rd (W of Girard)		✓	✓	✓	✓						Water present, narrows to <1' under bridge, no apparent flow; Sampled d.s. side of bridge	Similar to Round 1
North Fork Kaskaskia River Watershed													**8/26/05-9/2/05**	**10/13/2005**
NFK-1		N.F. Kaskaskia R. at Boulder Rd/Co. Rd 300E/2700E		✓	✓	✓	✓		✓	✓	✓	✓	Water present; Sampled u.s. side of bridge	Water present; Sampled d.s. side of bridge
NFK-2		Louse Run at Co. Rd. 2150/Co. Rd. 475E/Co. Rd. 450E		✓	✓				✓	✓	✓	✓	Water present, flow observed; Sampled u.s. side of bridge	Same as Round 1
NFK-3		N.F. Kaskaskia R. at Co. Rd 100N		✓	✓			✓	✓	✓	✓	✓	Water present, duckweed covered u.s.; Sampled d.s. side of bridge	Same as Round 1; deer carcass observed in water
NFK-4		Unnamed tributary 600' S of Bond Ave., no bridge. D/S of Patoka STP											Dry, ~5' wide shallow channel, no bridge; Not sampled	Same as Round 1
NFK-5	OKA 01	N.F. Kaskaskia R at US 51		✓	✓	✓	✓		✓	✓	✓	✓	Water present; Sampled u.s. side of bridge	Water present; Sampled u.s. side of bridge; flow measurements d.s. side of bridge
NFK-6		N.F. Kaskaskia R at Griffin Rd.		✓	✓	✓	✓		✓	✓	✓	✓	Water present; Sampled u.s. side of bridge	Same as Round 1
NFK-7		N.F. Kaskaskia R at Hadley Rd.		✓	✓				✓	✓	✓	✓	Upstream - water present; Downstream - only small puddles present for ~50' d.s. of bridge, then water; Sampled u.s. side of bridge	Sampled from u.s. side of bridge; water present u.s., under bridge & ~6' d.s., then dry for ~15' d.s., then a 20' long puddle, then dry for ~5', then water present

Table 1. Sampling Summary Continued

Site ID	IEPA Station ID	Station Description	Location Change From QAPP Listing	DO, NH_3, BOD_5, Water Temp, channel morphometry		Flow (depth & velocity)		SOD & diurnal DO	Fe		Mn		Round 1 Notes	Round 2 Notes
				Round 1	Round 2	Round 1	Round 2	Round 1	Round 1	Round 2	Round 1	Round 2		
Skillet Fork Watershed													**8/26/05-9/1/05**	**10/12/2005**
SKIL-1		Skillet Fork at Neal Road/Faye Road		✓	✓								Upstream - water pooled from under bridge to ~50' u.s.; Downstream - dry for ~75', then a pool; Sampled	Similar to Round 1
SKIL-2		Dums Cr. at Williams Road		✓	✓								Water present, not continuous u.s., no flow; Sampled	Similar to Round 1
SKIL-3		Sutton Cr. At Co. Rd. 050E/Scotch Pine Rd.		✓	✓								Water present; Sampled	Same as Round 1
SKIL-4	CA 09	Skillet Fork at Wilcoxen Rd.		✓	✓	✓	✓	✓					Water present; Sampled	Same as Round 1
SKIL-5		Dums Cr. At Bee Branch Rd.		✓	✓								Upstream and under bridge - dry for ~50' u.s., then pooled; Downstream - dry for ~20', then pooled; Sampled	Similar to Round 1
SKIL-6		Skillet Fork at Allen Rd/Kirby Rd		✓	✓								Water present; skinned animal carcass observed in water on 8/26/05; Sampled	Same as Round 1
SKIL-7	CAW 04	Dums Cr at end of Landmark Rd (no bridge)		✓	✓	✓	✓	✓					Water present, duckweed covered; Sampled	Same as Round 1
SKIL-8	CA 08	Skillet Fork at River Rd.	Difficult access at end of Blank Rd., no bridge, moved d.s. to nearest bridge	✓	✓								Water present; Sampled	Same as Round 1
SKIL-9		Brush Cr. at Co. Rd 2200N		✓	✓						✓		Water present; Sampled	no visible flow, pooled water u.s. and d.s.; 50 gal. drum and trash in water; Sampled u.s. side of culvert
SKIL-10		Fulton Cr at Landmark Rd.		✓	✓								Water on u.s. side of bridge; pool of water on d.s. side, then dry d.s.; concreted wash over culvert; Sampled u.s. side of culvert	no visible flow, pooled water u.s. and d.s.; Sampled u.s. side of culvert
SKIL-11		Nickolson Cr at Dago Hill Rd.		✓	✓								Water present, flow observed; Sampled	Small pond under bridge, no flow
SKIL-12		Skillet Fork beyond end of Seed House Rd.		✓	✓								Water present, flowing, no bridge; Sampled	Same as Round 1
SKIL-13		Bob Branch Co. Rd 1900N											Water present on 8/26/05 after heavy thunderstorms, Dry on 9/1/05; 2 4' culverts; Not sampled u.s. side	Dry with very small pools u.s.; water level ~1' below culverts; Not sampled
SKIL-14		Brush Cr at Co. Hwy 16/Co. Rd. 1825 N		✓	✓								Water present; Sampled	
SKIL-15	CA 06	Skillet Fork at State Route 161		✓	✓	✓	✓	✓			✓		Water present; Sampled u.s. side of bridge	Same as Round 1
SKIL-16	CAR 01	Brush Creek at Co. Hwy. 27/Co. Rd. 1500N		✓	✓	✓	✓	✓			✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-17		Skillet Fork at Co. Hwy. 13/Co. Rd 250E		✓	✓						✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-18		Horse Creek beyond end of Moonbeam Ln		✓	✓						✓		Water present, small 6" wide trickle of water flowing between pools u.s. and d.s., no bridge; Sampled	Pools u.s. and d.s., no flow between; Sampled pool, no morphometry measurements recorded
---			Additional observation: Horse Cr at Harmony Rd./Co. Rd. 1900E										Water present	
SKIL-19		Horse Cr at Malecki R./Co. Rd. 2050N		✓	✓						✓		Water present; no observable flow; Sampled u.s. side of bridge	Same as Round 1
SKIL-20		Skillet Fork at Co. Rd. 900N		✓	✓			✓ SOD only					Water present; flow observed; Sampled u.s. side of bridge	Same as Round 1
SKIL-21	CAN 01	Horse Cr at Co. Rd. 200E		✓	✓	✓	✓	✓			✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-22		Puncheon Cr at Co. Rd. 000E/2400E		✓	✓								Water present; slight flow observed; Sampled u.s. side of bridge	Same as Round 1
SKIL-23	CA 05	Skillet Fork at Illinois Route 15		✓	✓			✓ DO only			✓		Water present; Sampled u.s. side of bridge	Same as Round 1
SKIL-24		Skillet Fork at Co. Rd. 100N at corner with 1500 E	No access at Co. Rd. 1225E, no bridge, moved d.s. to nearest bridge	✓	✓						✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-25	CA 02	Skillet Fork at Co. Rd. 800E		✓	✓						✓		Water present; Sampled d.s. side of bridge	Same as Round 1; deer carcass observed in water
SKIL-26		Limekiln Cr at Co. Rd. 2000N		✓	✓								Water present; Sampled u.s. side of bridge	Same as Round 1
SKIL-27	CA 03	Skillet Fork at Co. Hwy 1/Co. Rd. 1125E/1150E		✓	✓	✓	✓	✓			✓		Water present; Sampled d.s. side of bridge	Same as Round 1
SKIL-28		Sevenmile Cr. At Co. Rd. 750E (N. of Co. Rd. 1800N)	No access, private land, no bridge at original location, moved u.s. to nearest bridge	✓	✓								Water present; Sampled u.s. side of bridge	Same as Round 1

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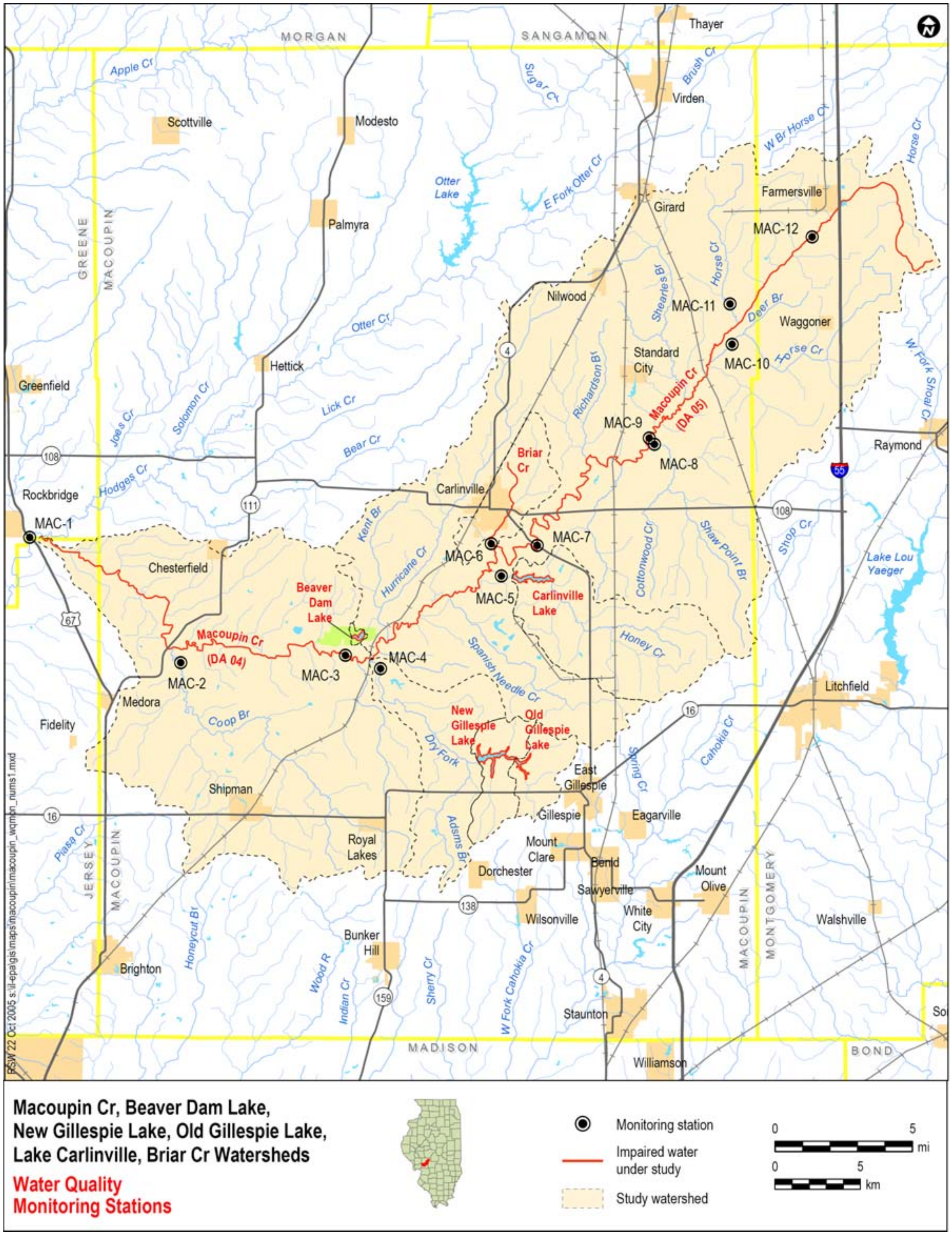

Figure 1. Macoupin Creek Watershed Sampling Locations

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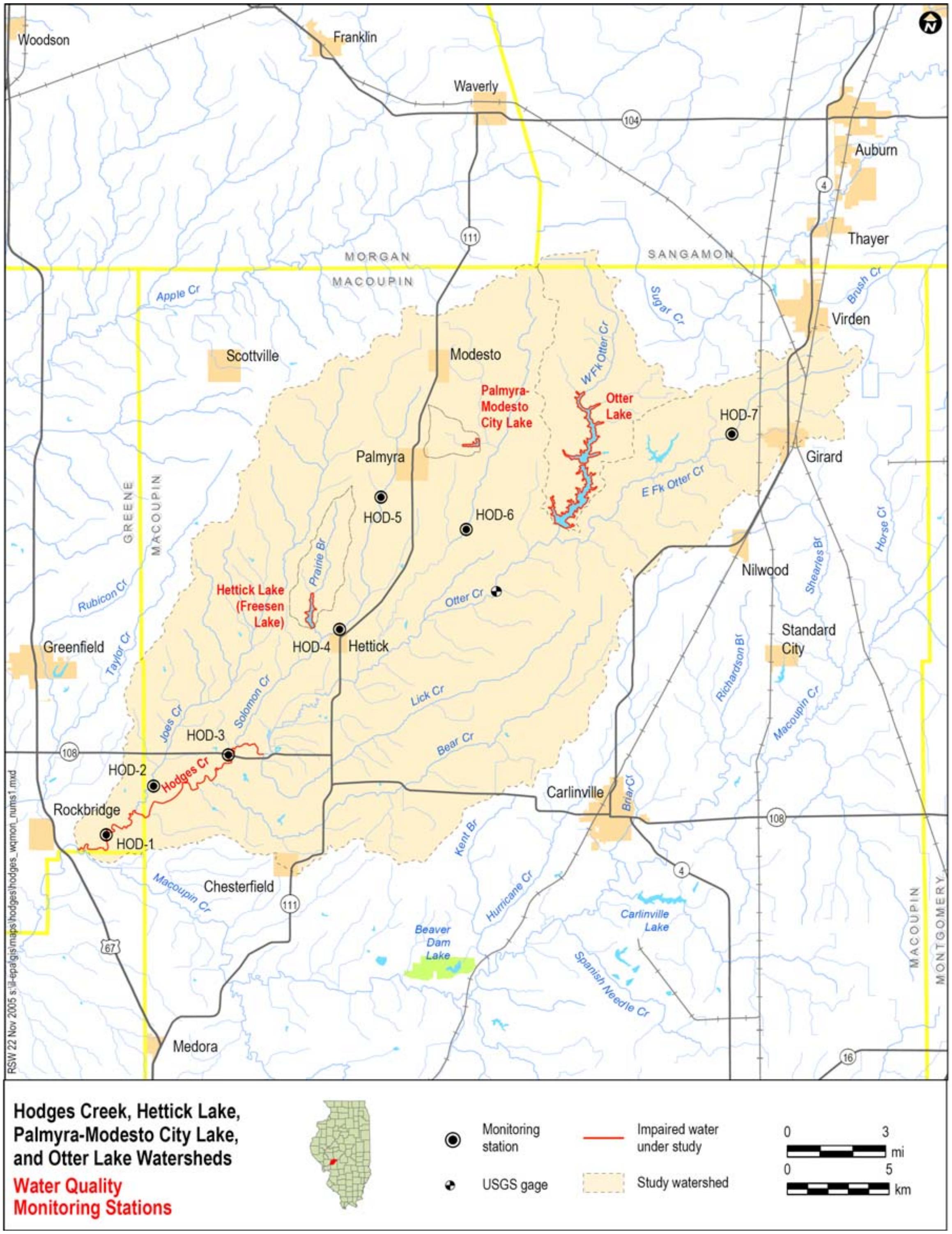

Figure 2. Hodges Creek Watershed Sampling Locations

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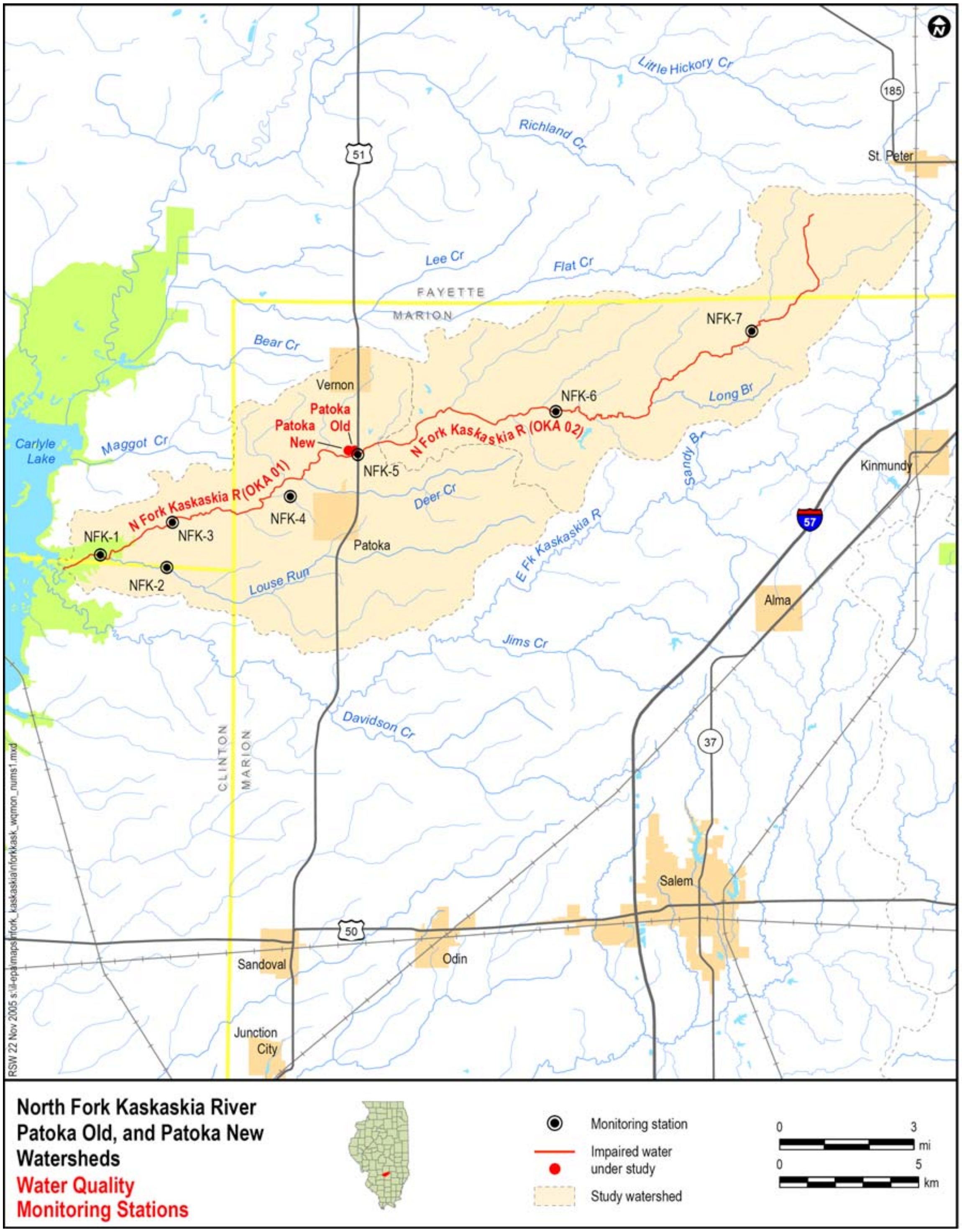

Figure 3. North Fork Kaskaskia River Watershed Sampling Locations

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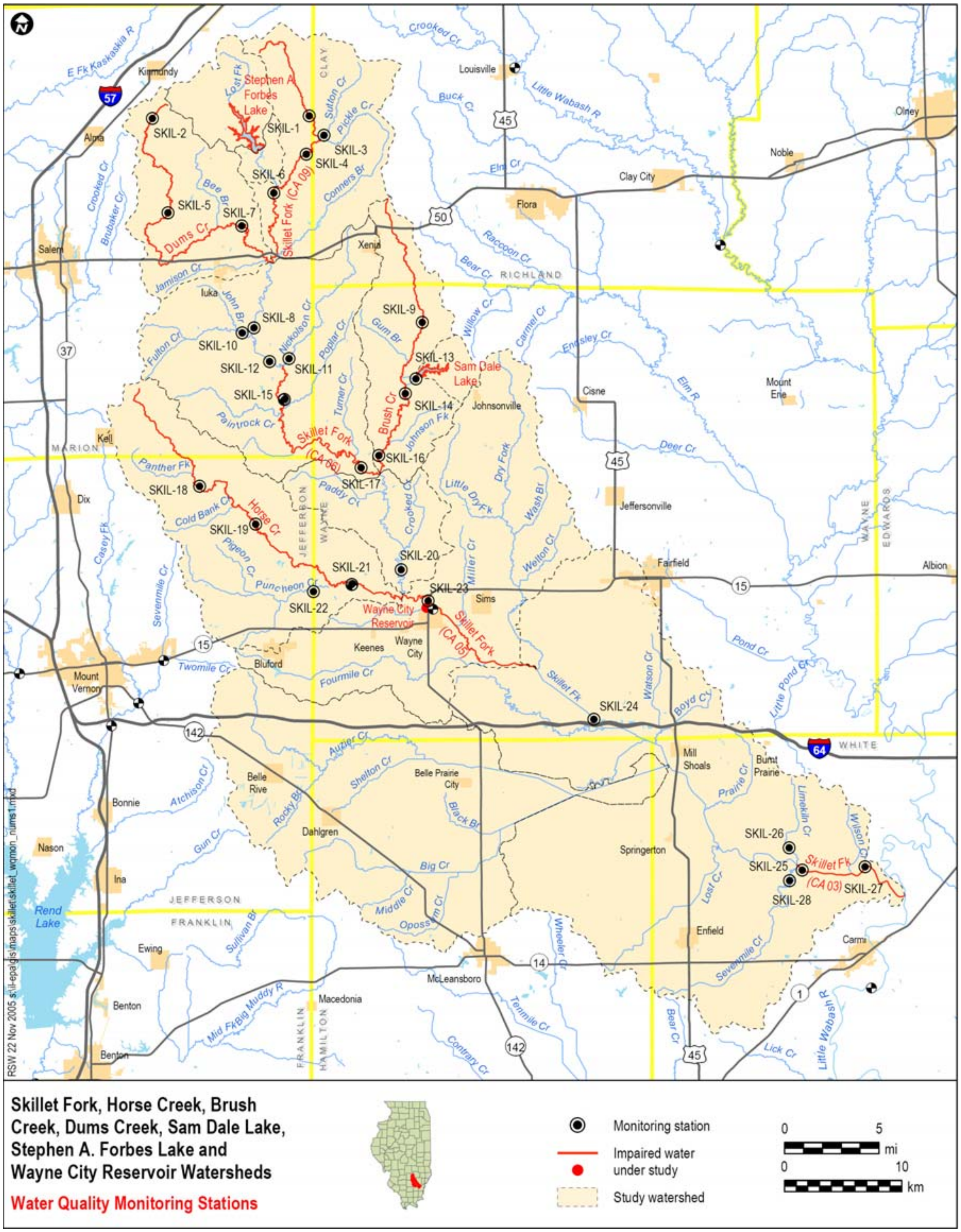

Figure 4. Skillet Fork Watershed Sampling Locations

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WATER SAMPLE COLLECTION AND FIELD MEASUREMENTS

Sampling activities were conducted in accordance with the QAPP during low flow conditions on two separate occasions (Round 1 and Round 2) for each watershed, as noted in Table 1. Surface water samples and field measurements were collected by LTI at 45 stream locations (out of a possible 54 planned locations) in four watersheds; nine locations were not sampled because there was insufficient water present. For some streams, alternating reaches of water-filled and "dry" channels were observed. In these locations, it appears that the stream went underground for a short stretch, resurfacing further downstream. A small number of locations were sampled from standing pools of water such as these, which had no observable surface hydraulic connection to upstream or downstream sampling locations. Water level conditions observed in the field are noted in Table 1.

Table 1 presents a summary of the parameters analyzed at each location. Analytes were based on the causes of impairment identified in the 303(d) list. Field instruments were used to measure in-situ water quality parameters, and Brighton Analytical, Inc. conducted all laboratory analyses. At all locations, water samples were collected for laboratory analysis of ammonia and 5-day biochemical oxygen demand (BOD_5), while field measurements included dissolved oxygen (DO), water temperature (T), and channel morphometry (water depth and width). In addition, iron samples and pH measurements were collected at all locations in the North Fork Kaskaskia watershed, and manganese samples and pH measurements were collected at a subset of locations in the Skillet Fork watershed.

The analytical and field measurement results for Round 1 and Round 2 sampling are presented in Tables 2 through 4.

Table 2. Round 1 Laboratory and Field Measurement Results

Sample ID	Colletion Date/Time	Ammonia (mg/L)	BOD_5 (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)		Temp (degC)	DO (mg/L)	pH (s.u.)
Hodges Creek Watershed									
HOD-1	8/24/05 8:25	<0.01	<2				23.00	5.00	
HOD-3	8/24/05 9:55	0.14	<2				22.40	8.60	
HOD-7	8/24/05 10:45	0.07	<2				19.40	4.35	
Macoupin Creek Watershed									
MAC-1	8/23/05 8:15	<0.01	2.7		0.57	J	25.80	4.28	
MAC-1 Dup	8/23/05 8:15	<0.01	3.2						
MAC-3	8/23/05 10:05	<0.01	2.9		0.52	J	25.30	4.65	
MAC-5	8/23/05 11:40	0.02	<2		0.06	J	27.00	13.10	
MAC-6	8/23/05 12:10	<0.01	<2		0.03	J	19.00	8.65	
MAC-7	8/23/05 12:50	0.01	4.8		0.5	J	24.50	4.15	
MAC-9	8/23/05 14:25	0.31	<2		0.65	J	25.00	3.90	
MAC-10	8/23/05 15:30	0.16	5.5		0.95	J	22.00	6.60	
MAC-11	8/23/05 15:50	0.22	4.9		1.9	J	21.80	1.50	
MAC-12	8/23/05 16:25	0.06	2.8		0.19	J	22.00	9.40	
North Fork Kaskaskia River Watershed									
NFK-1	8/31/05 12:05	0.08	3.2	0.88	0.47		26.00	3.50	7.90
NFK-1 Dup	8/31/05 12:05	0.09	3.2	0.89					
NFK-2	8/31/0511:40	0.24	<2	1.5	0.47		23.10	2.30	7.50
NFK-3	8/31/05 11:10	0.07	3.2	1.7	1.7		23.10	0.50	7.50
NFK-5	8/31/05 9:40	0.51	<2	0.93	1.2		22.10	1.85	7.60
NFK-6	8/31/05 8:40	0.3	<2	1.6	1.1		21.50	1.65	7.60
NFK-7	8/31/05 7:55	0.2	<2	0.85	1.4		21.50	1.40	7.60
Skillet Fork Watershed									
SKIL-1	9/1/05 14:55	0.66	<2				24.00	4.10	
SKIL-2	9/1/05 15:40	0.04	<2				28.00	10.20	
SKIL-3	9/1/05 14:10	0.72	<2				25.00	2.20	
SKIL-4	9/1/05 13:30	0.03	6.7				21.00	0.40	
SKIL-5	9/1/05 12:00	0.41	<2				22.80	5.00	
SKIL-6	9/1/05 11:25	0.02	<2				23.90	2.50	
SKIL-6 Dup	9/1/05 11:25	<0.01	<2						
SKIL-7	9/1/05 10:40	0.13	<2				22.00	3.00	
SKIL-8	9/1/05 9:50	0.27	<2				22.90	3.10	7.28
SKIL-9	9/1/05 9:35	0.25	<2		2.3		21.20	1.56	
SKIL-10	9/1/05 7:45	1.2	<2				19.90	2.36	
SKIL-11	9/1/05 9:00	0.06	<2				20.70	4.74	
SKIL-12	9/1/05 8:20	0.51	<2				22.20	1.78	
SKIL-14	9/1/05 10:00	0.15	<2				21.80	3.25	
SKIL-15	9/1/05 7:50	0.16	<2		0.69		22.50	3.50	7.22
SKIL-16	9/1/05 7:55	0.16	<2		1.2		21.55	2.10	6.67
SKIL-17	9/1/05 8:50	0.12	<2		0.6		22.96	3.51	6.78

Sample ID	Colletion Date/Time	Ammonia (mg/L)	BOD_5 (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)	pH (s.u.)
SKIL-18	9/1/05 11:55	0.14	<2		0.98	23.50	6.74	
SKIL-19	9/1/05 12:20	0.08	<2		0.58	22.40	3.75	
SKIL-19 Dup	9/1/05 12:20	0.09	<2		0.61			
SKIL-20	9/1/05 13:30	0.09	<2			24.60	5.03	
SKIL-21	9/1/05 9:20	0.16	<2		1.2	21.96	3.20	6.92
SKIL-22	9/1/05 12:55	0.03	<2			22.60	3.60	
SKIL-23	9/1/05 10:35	0.15	<2		0.6	24.36	3.15	7.12
SKIL-24	9/1/05 11:20	0.2	<2		0.75	25.26	6.06	7.32
SKIL-25	9/1/05 12:40	<0.01	<2		0.3	24.89	5.54	7.23
SKIL-26	9/1/05 12:15	0.12	<2			22.35	4.20	6.89
SKIL-27	9/1/05 13:30	<0.01	<2		0.26	25.94	8.12	7.61
SKIL-27 Dup	9/1/05 13:30	<0.01	<2		0.26			
SKIL-28	9/1/05 13:00	0.07	<2			22.47	4.19	6.85
Rinse Blank	9/1/05 16:00	<0.01	<2		<0.02			
Rinse Blank 2	9/1/05 16:30	0.04	<2		<0.02			

Notes: J = Value is considered estimated based on quality control/quality assurance deficiencies. The nature of the deficiency and its significance are discussed in the QA section of this report.

Table 3. Round 2 Laboratory and Field Measurement Results

Sample ID	Collection Date/TIme	Ammonia (mg/L)	BOD_5 (mg/L)	Dissolved Fe (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)	pH (s.u.)
Hodges Creek Watershed									
HOD-1	10/11/05 8:55	<0.01	2.7				14.85	5.77	
HOD-3 DUP1	10/11/05 9:50	0.23	<2				14.60	5.67	
HOD-3 DUP2	10/11/05 9:50	0.23	<2						
HOD-7	10/11/05 11:45	0.02	<2				14.17	6.96	
Rinse Blank H	10/11/05 7:00	0.06	<2						
Macoupin Creek Watershed									
MAC-1	10/11/05 9:20	<0.01	<2			0.35 J	14.69	8.39	
MAC-3	10/11/05 10:15	<0.01	<2			0.34 J	13.56	7.92	
MAC-5	10/11/05 12:20	0.01	3.5			1.1 J	15.67	8.73	
MAC-6	10/11/05 12:50	0.05	<2			<0.02 J	18.42	8.57	
MAC-7 DUP1	10/11/05 14:00	0.02	2.6			0.21 J	14.42	5.59	
MAC-7 DUP2	10/11/05 14:00	0.03	<2						
MAC-8	10/11/05 14:45	0.02	<2			0.2 J	14.02	4.27	
MAC-9	10/11/05 13:45	0.2	6			1.6 J	13.85	0.67	
MAC-10	10/11/05 13:10	0.36	<2			0.39 J	14.25	4.05	
MAC-12	10/11/05 12:30	1.8	16			0.47 J	13.18	2.57	
Rinse Blank MAC	10/11/05 7:00	0.05	<2						
North Fork Kaskaskia River Watershed									
NFK-1	10/13/05 8:35	0.13	<2	0.06	1.9	0.31	16.41	3.88	6.57
NFK-2	10/13/05 12:00	0.41	5.1	0.34	2.3	1.3	14.40	1.74	7.24
NFK-3	10/13/05 10:10	0.44	3.8	0.34	3.6	1.8	14.41	0.57	6.90
NFK-5 DUP1	10/13/05 10:55	0.25	3.7	0.6	2.6	0.89	13.92	2.26	6.89
NFK-5 DUP2	10/13/05 10:55	0.22	4.5	0.55	2.8				
NFK-6	10/13/05 12:45	0.43	4.3	1.4	3.8	1.9	13.67	0.49	6.64
NFK-7	10/13/05 13:25	0.33	4.5	0.48	2.8	1.6	15.85	1.25	7.19
Rinse Blank	10/13/05 8:00	0.09	<2	0.06	0.11				
Skillet Fork Watershed									
SKIL-1	10/12/05 13:20	0.03	<2				14.67	3.40	
SKIL-2	10/12/05 12:45	0.15	3				16.34	9.01	
SKIL-3	10/12/05 13:40	0.47	<2				14.03	2.22	
SKIL-4	10/12/05 14:00	0.02	17				13.54	1.02	
SKIL-5	10/12/05 11:40	1.5	<2				14.37	2.65	
SKIL-6 DUP1	10/12/05 14:35	0.16	3.7				14.94	2.74	
SKIL-6 DUP2	10/12/05 14:35	0.02	3						
SKIL-7	10/12/05 11:10	0.18	<2				13.73	1.73	
SKIL-8	10/12/05 10:30	0.24	4.8				13.72	2.65	
SKIL-9	10/12/05 9:30	0.16	<2				14.18	3.64	7.78
SKIL-10	10/12/05 8:20	1.2	<2				13.64	4.07	7.95
SKIL-11	10/12/05 9:05	0.06	<2				13.87	5.29	7.89
SKIL-12	10/12/05 8:45	0.19	<2				14.55	2.93	7.78
SKIL-14	10/12/05 9:50	0.08	<2				14.19	6.17	7.82
SKIL-15	10/12/05 8:15	0.14	<2				14.42	3.69	7.41

Sample ID	Collection Date/TIme	Ammonia (mg/L)	BOD_5 (mg/L)	Dissolved Fe (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)	Temp (degC)	DO (mg/L)	pH (s.u.)
SKIL-16	10/12/05 8:20	0.18	<2				13.85	3.43	7.09
SKIL-17	10/12/05 9:10	0.08	<2				14.62	5.94	7.32
SKIL-18	10/12/05 10:50	0.09	<2				15.26	4.82	7.80
SKIL-19 DUP1	10/12/05 11:05	0.32	<2				14.19	2.42	7.57
SKIL-19 DUP2	10/12/05 11:05	0.36	<2						
SKIL-20	10/12/05 11:40	0.12	<2				16.54	7.36	7.66
SKIL-21	10/12/05 9:40	0.08	<2				14.47	3.48	7.24
SKIL-22	10/12/05 12:05	0.12	<2				15.15	7.37	7.59
SKIL-23	10/12/05 10:35	0.03	8.1				16.71	4.22	7.00
SKIL-24	10/12/05 11:30	0.05	4.8				17.07	8.76	7.23
SKIL-25	10/12/05 12:55	0.05	<2				18.80	6.85	7.60
SKIL-26	10/12/05 12:35	0.07	2.5				16.00	6.60	7.60
SKIL-27 DUP1	10/12/05 15:00	<0.01	4.1				19.71	7.21	7.91
SKIL-27 DUP2	10/12/05 15:00	0.03	4						
SKIL-28	10/12/05 13:35	0.09	5.8				15.39	3.35	7.25
RB-1	10/12/05 7:00	0.07	<2						
RB-2	10/12/05 7:00	0.04	<2						
RB-3	10/12/05 7:00	0.07	<2						

Notes: J = Value is considered estimated based on quality control/quality assurance deficiencies. The nature of the deficiency and its significance are discussed in the QA section of this report.

Table 4. Stream Morphometry Results

	Round 1			Round 2		
Site ID	Time	River Width (ft)	Avg. Water Depth (ft)	Time	River Width (ft)	Avg. Water Depth (ft)
Macoupin Watershed						
	8/23/2005			10/11/2005		
MAC-1	8:15	48	1.09	9:00	48	1.11
MAC-2	9:40	dry	dry	9:45	dry	dry
MAC-3	10:05	60	3.34	10:15	60	3.30
MAC-4	11:15	dry	dry	11:55	dry	dry
MAC-5	11:40	14	0.28	12:15	14	0.33
MAC-6	12:10	14	0.55	12:50	10	0.72
MAC-7	10:05	58	1.83	14:00	55	1.03
MAC-8	14:10	dry	dry	14:45	15	0.27
MAC-9	14:25	41	1.42	13:45	31	0.84
MAC-10	15:30	10.5	0.39	13:05	6	0.40
MAC-11	15:50	22	1.42	12:50	dry	dry
MAC-12	16:25	18	0.28	12:45	5	0.20
Hodges Watershed						
	8/24/2005			10/11/2005		
HOD-1	10:45	20	0.78	8:55	20	0.76
HOD-2	na	dry	dry	9:30	dry	dry
HOD-3	9:55	2	0.20	9:55	2	0.15
HOD-4	na	dry	dry	10:10	dry	dry
HOD-5	na	dry	dry	10:30	dry	dry
HOD-6	na	dry	dry	11:15	dry	dry
HOD-7	8:25	15	0.48	11:45	13	0.86
N. Fork Kaskaskia Watershed						
	8/31/2005			10/13/2005		
NFK-1	12:05	104	4.87	8:35	105	4.89
NFK-2	11:40	20.5	1.43	12:00	19	1.21
NFK-3	11:10	31	1.06	10:10	28	1.22
NFK-4	10:40	dry	dry	10:45	dry	dry
NFK-5	12:05	42	1.77	10:55	38	1.39
NFK-6	8:40	17.5	0.75	12:45	18.5	0.73
NFK-7	7:55	14	0.57	13:25	16	0.61
Skillet Fork Watershed						
	9/1/2005			10/12/2005		
SKIL-1	14:55	16	0.68	13:20	16	0.79
SKIL-2	15:40	6	0.33	12:45	4	0.15
SKIL-3	14:10	22	1.14	13:40	23	1.07
SKIL-4	13:30	24	1.30	14:00	25	1.19
SKIL-5	12:00	13.5	0.41	11:40	13	0.37
SKIL-6	11:25	67	2.30	14:35	65	2.29
SKIL-7	10:30	30	0.71	11:10	29	0.68
SKIL-8	9:50	18	1.05	10:30	14	0.71
SKIL-9	9:35	20	1.10	9:30	14.5	1.32

	Round 1			Round 2		
Site ID	**Time**	**River Width (ft)**	**Avg. Water Depth (ft)**	**Time**	**River Width (ft)**	**Avg. Water Depth (ft)**
SKIL-10	7:45	6	0.81	8:20	7.5	0.40
SKIL-11	9:00	31	1.51	9:05	28	1.65
SKIL-12	8:20	13.5	0.24	8:45	10.5	0.13
SKIL-13	9:55	dry	dry	9:40	dry	dry
SKIL-14	10:00	33	1.73	9:50	24	1.76
SKIL-15	10:30	70	4.75	8:15	60	5.03
SKIL-16	7:55	40	1.36	8:20	38	1.45
SKIL-17	8:50	59	2.56	9:10	59	2.32
SKIL-18	11:55	0.5	0.04	10:50	dry	dry
SKIL-19	12:20	46	1.97	11:05	39	1.54
SKIL-20	13:30	52	0.81	11:40	10	0.25
SKIL-21	9:20	57	1.71	9:40	55	1.91
SKIL-22	12:55	23	1.44	12:05	23	1.36
SKIL-23	10:35	82	5.92	10:35	81	5.81
SKIL-24	11:20	60	2.32	11:30	60	1.70
SKIL-25	12:40	90	3.49	12:55	88	3.29
SKIL-26	12:15	23	0.71	12:30	19	0.46
SKIL-27	13:30	92	5.01	15:00	90	5.20

DISCHARGE MEASUREMENTS

Discharge measurements were conducted at a subset of locations representative of the water bodies in each watershed. Discharge measurements were recorded using standard USGS techniques employing an electromagnetic point velocity meter (Marsh–McBirney Flo-Mate 2000) and a bridgeboard or a wading rod. Information supporting flow calculation was recorded in field notebooks and included:

- Site location,
- Date and time,
- Measurement monitoring point,
- Distance between measurement points,
- Depth at each measurement point,
- Velocities at each measurement point,
- Angle of flow at each measurement point,
- Angle of bridge with respect to river channel (where measurements were conducted from bridges), and
- Any significant observations of monitoring procedures or river conditions

The discharge measurement results are presented in Table 5.

Table 5. Discharge Results

Macoupin Creek Watershed												
Site ID:	MAC-1		MAC-3		MAC-7		MAC-9		MAC-12			
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**		
8/23/05	8:15	1.67	10:05	0*	12:50	0.28	14:25	0.09				
10/11/05	9:00	0.76	10:15	0*	12:50	1.27	13:45	0*	12:45	0*		
Hodges Creek Watershed							**North Fork Kaskaskia Watershed**					
Site ID:	HOD-1		HOD-3		HOD-7		NFK-1		NFK-5		NFK-6	
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**
8/24/05	10:35	0.067	9:55	0.008	8:25	0*	12:05	1.62	12:05	1.33	8:40	0.2
10/11/05	8:55	0*	9:55	0.0006	11:45	0.13	8:35	0*	10:55	0*	12:45	0*
Skillet Fork Watershed												
Site ID:	SKIL-4		SKIL-7		SKIL-15		SKIL-16		SKIL-21		SKIL-27	
Date	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**	**Time**	**Q (cfs)**
9/1/05	13:30	0*	10:30	0*	10:30	0.74	7:55	0*	9:20	0.08	13:30	35.07
10/12/05	14:00	0*	11:10	0*	8:15	0*	8:20	1.05	9:40	0.82	15:00	3.81

Notes: Q = discharge
*No observable and/or measured downstream current

SEDIMENT OXYGEN DEMAND AND CONTINUOUS DO MONITORING

Sediment oxygen demand and continuous dissolved oxygen were measured at select locations representative of river conditions in each watershed. SOD respirometer chambers were installed in accordance with the QAPP, and DO measurements during SOD testing were manually recorded in the field notes for a period of 2 hours or until DO dropped by 2 mg/L or to zero mg/L. The data were used to calculate SOD rates for use in the DO modeling activities. The SOD rate results are presented in Table 6.

In-Situ Mini-Troll multi-parameter data-logging sondes were used for continuous DO measurements. The sondes were deployed for at least 24 hours at each of the selected locations. Calibration of the sondes for DO using the Winkler titration method was conducted before deployment and again after deployment to check the system for drift in DO values over time. Calibration and drift-check results were recorded in the field notes and are presented in Table 7. DO and temperature data were recorded at 15 minute intervals during sonde deployment, after which the sonde was removed and data were downloaded to a laptop computer. The continuous DO and temperature data are presented in Figures 5 through 14 and are also presented in Appendix 2.

Table 6. Sediment Oxygen Demand Results

Date	Site ID	<=SOD, g/m2/day @ 20c
8/25/2005	HOD1	1.24
8/25/2005	MAC7	0.78
8/31/2005	NFK3	0.38
8/28/2005	SKIL4	0.95
8/28/2005	SKIL7	0.63
8/28/2005	SKIL15	0.31
8/29/2005	SKIL16	0.56
8/29/2005	SKIL21	0.025
8/30/2005	SKIL20	0.32
8/29/2005	SKIL27	0.99

Table 7. Continuous DO Sonde Calibration Values and Drift Check Results

		Pre-Deployment Calibration	Post-Deployment Drift Check						
Station	Sonde ID	Winkler DO (mg/L)	Water Sample DO (mg/L)	Winkler DO (mg/L)	DO Drift (mg/L)	DO Drift (%)	Hours Deployed	Average Drift/hr (mg/L)	Average Drift/hr (%)
HOD-1	40813	5.3	6.42	6.75	-0.33	-5.0%	26	-0.0127	-0.19%
MAC-7	SS0002	5.425	5.16	6.65	-1.49	-25.2%	27.02	-0.0552	-0.93%
SKIL-4	40813	0.45	0.48	0.6	-0.12	-22.2%	24.75	-0.0048	-0.90%
SKIL-7	40067	4.4	3.23	3.05	0.18	5.7%	42.05	0.00428	0.14%
SKIL-15	SS0002	4.8	3.5	4.2	-0.7	-18.2%	26.58	-0.0263	-0.68%
SKIL-23	40813	3.4	3.74	3.45	0.29	8.1%	23.77	0.0122	0.34%
SKIL-16	40067	3.55	2.41	2.75	-0.34	-13.2%	27.08	-0.0126	-0.49%
SKIL-21	SS0002	5.3	3.72	3.6	0.12	3.3%	26.58	0.00451	0.12%
SKIL-27	40813	4.05	10.37	10.2	0.17	1.7%	44.75	0.0038	0.04%
NFK-3	SS0002	4.15	1.29	0.95	0.34	30.4%	40.58	0.00838	0.75%

Notes: Sonde deployed was Hydrolab MiniSonde 4a

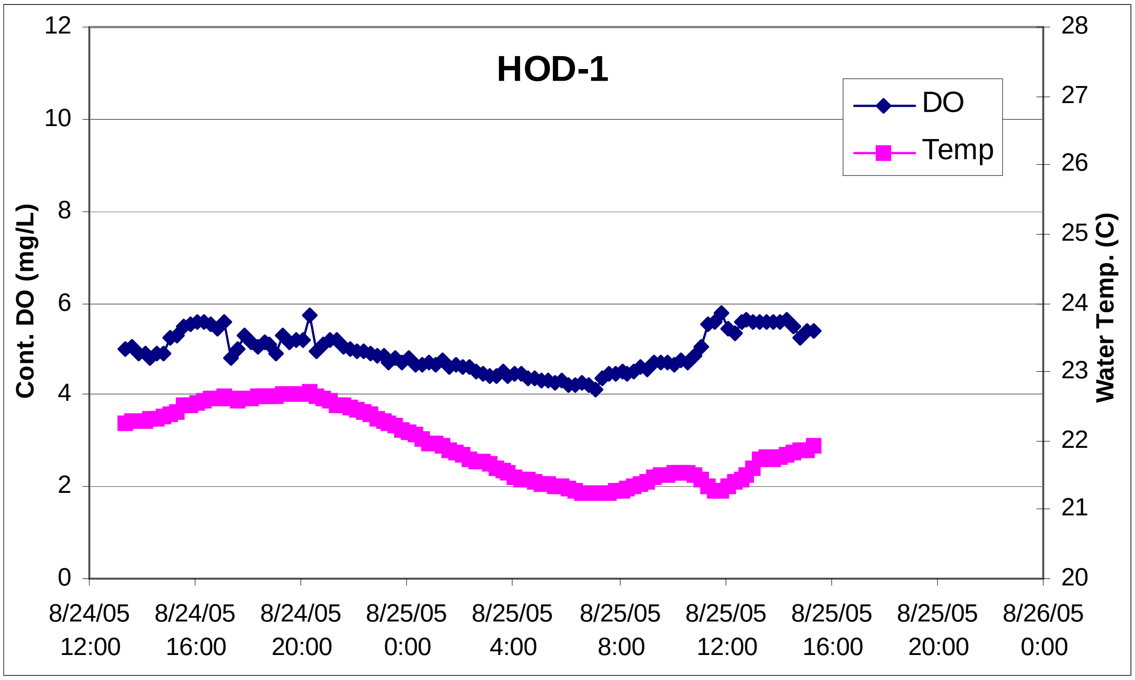

Figure 5. Continuous DO and Temperature at Hodges Creek Station HOD-1

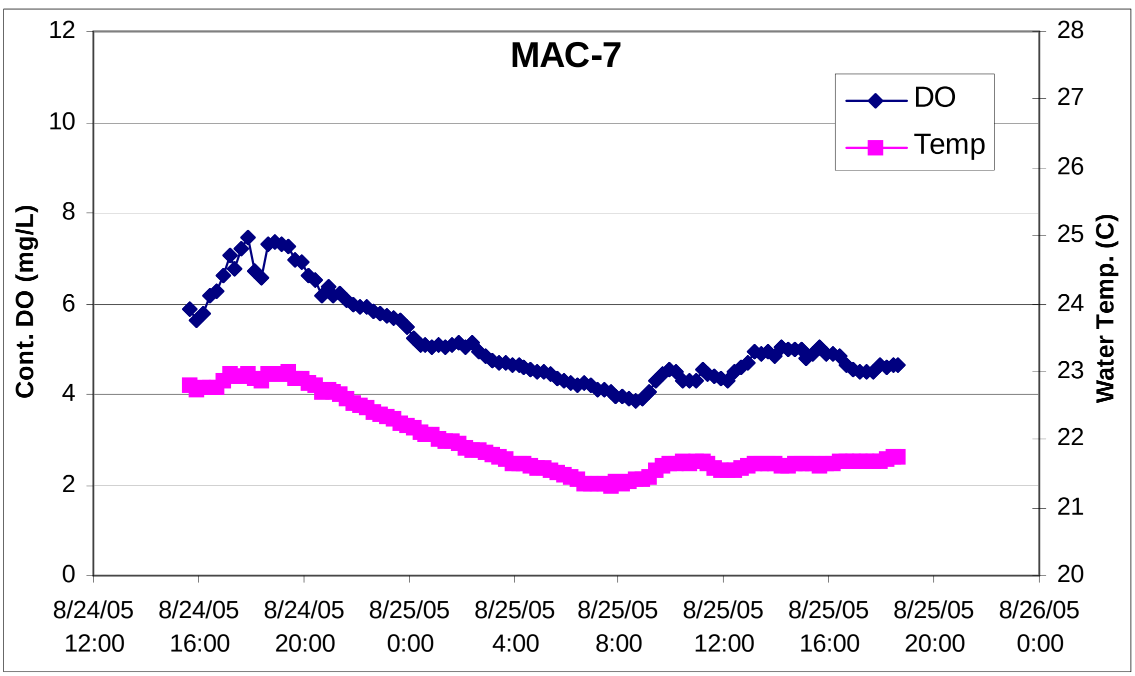

Figure 6. Continuous DO and Temperature at Macoupin Creek Station MAC-7

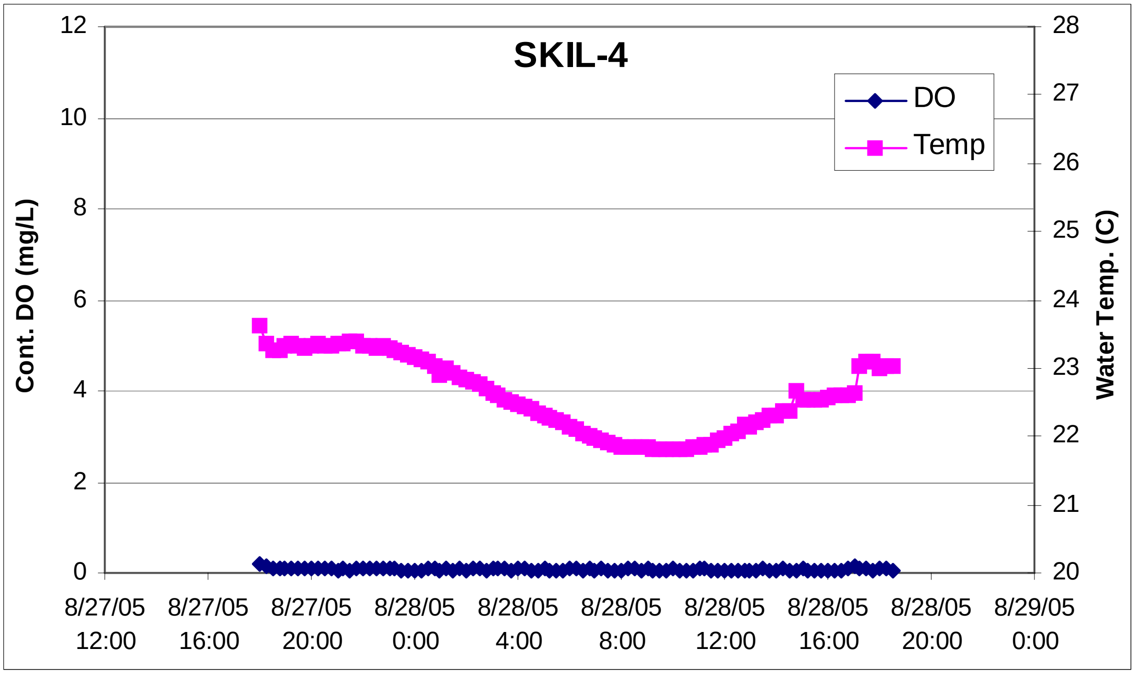

Figure 7. Continuous DO and Temperature at Skillet Fork Station SKIL-4

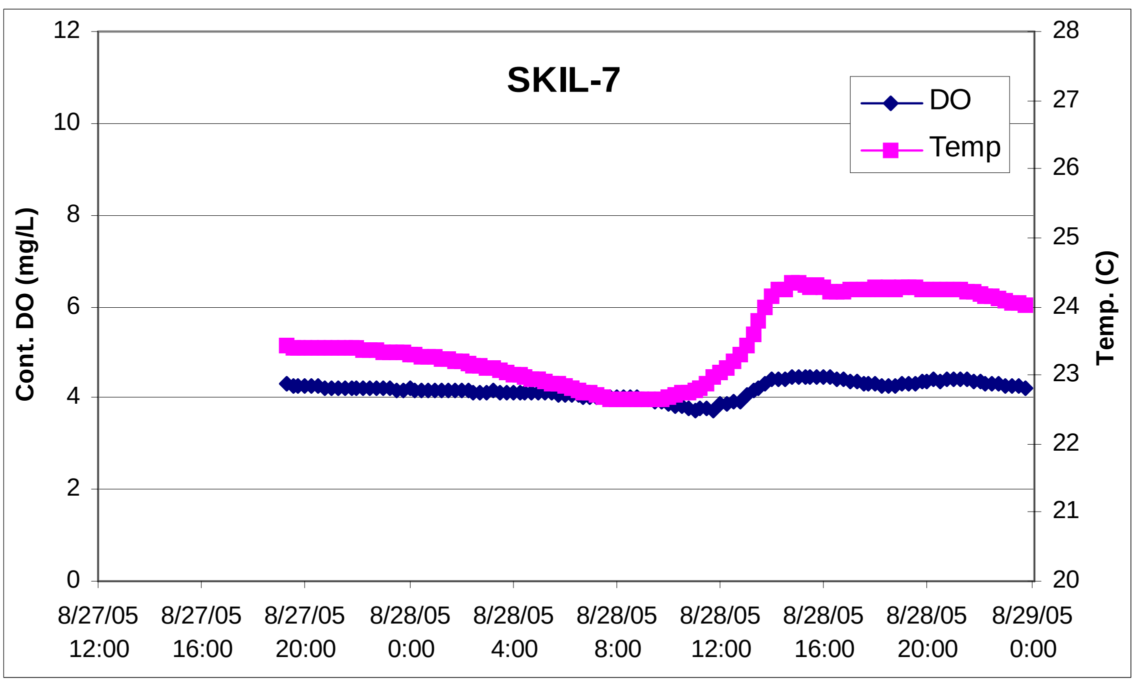

Figure 8. Continuous DO and Temperature at Dums Creek Station SKIL-7

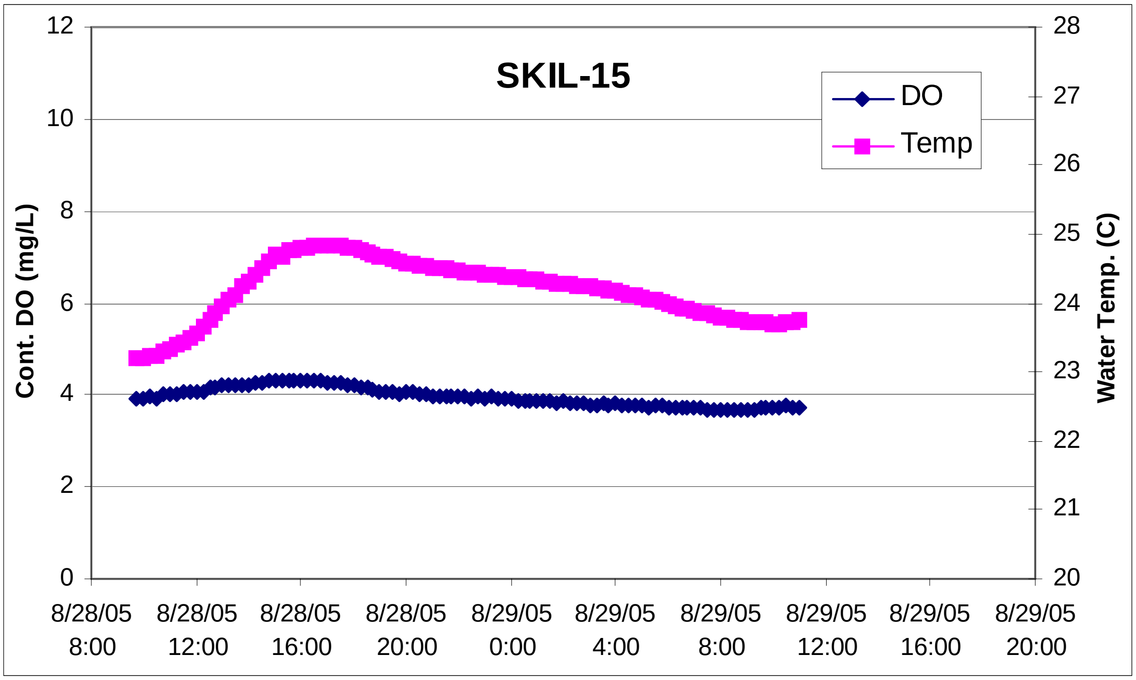

Figure 9. Continuous DO and Temperature at Skillet Fork Station SKIL-15

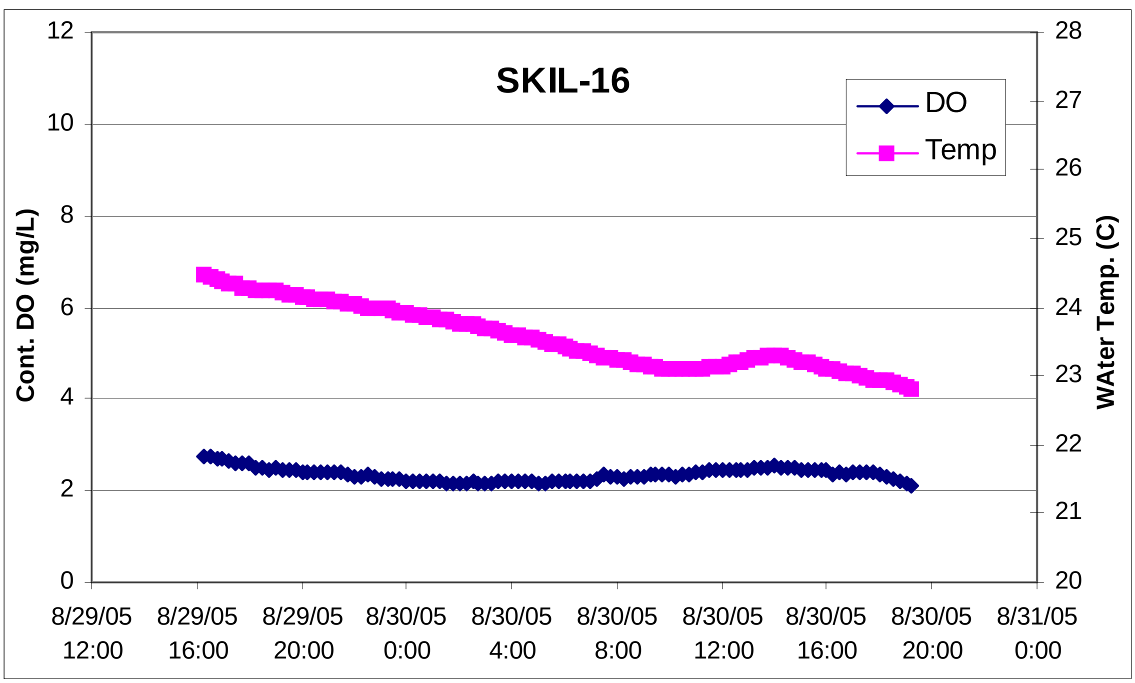

Figure 10. Continuous DO and Temperature at Brush Creek Station SKIL-16

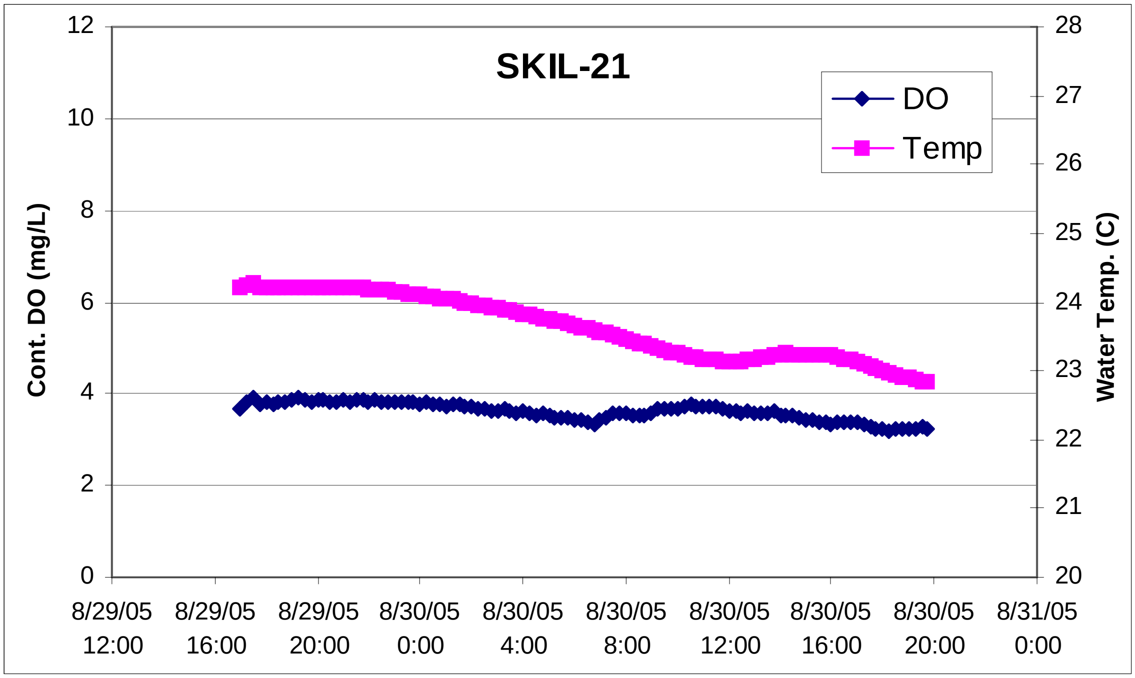

Figure 11. Continuous DO and Temperature at Horse Creek Station SKIL-21

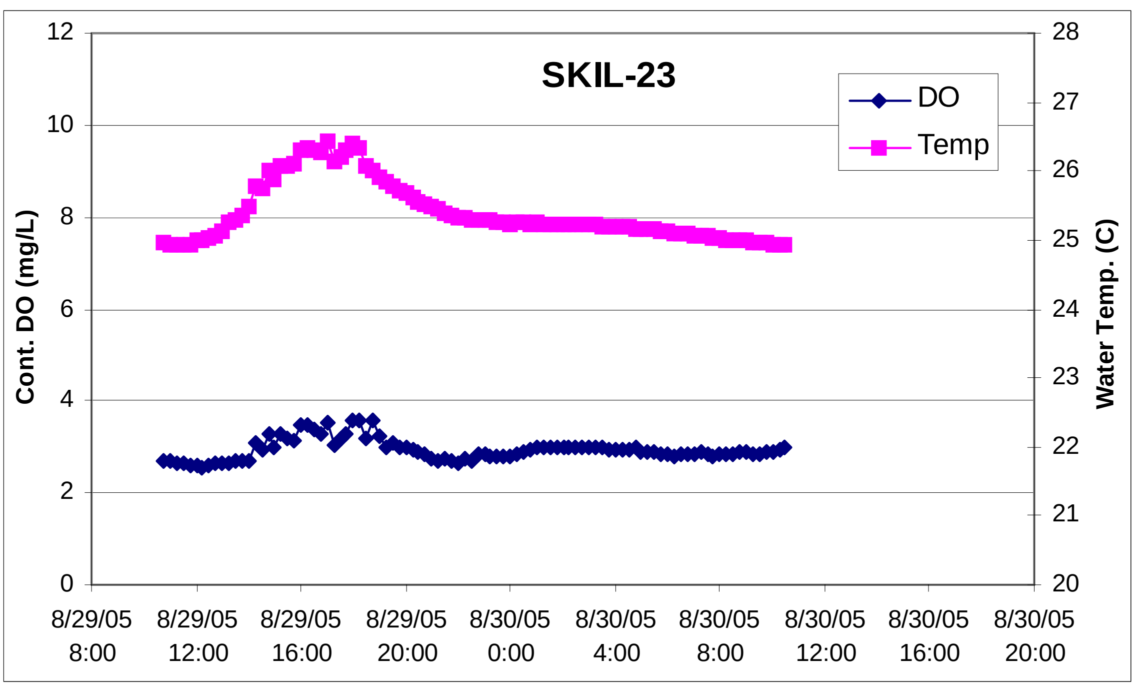

Figure 12. Continuous DO and Temperature at Skillet Fork Station SKIL-23

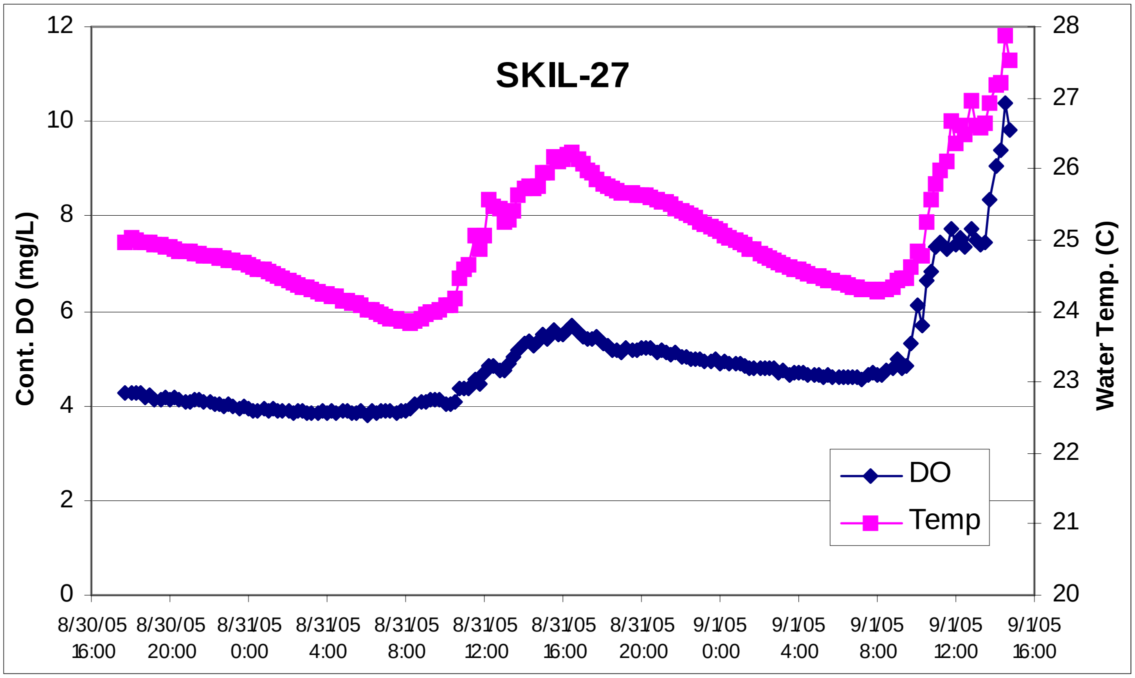

Figure 13. Continuous DO and Temperature at Skillet Fork Station SKIL-27

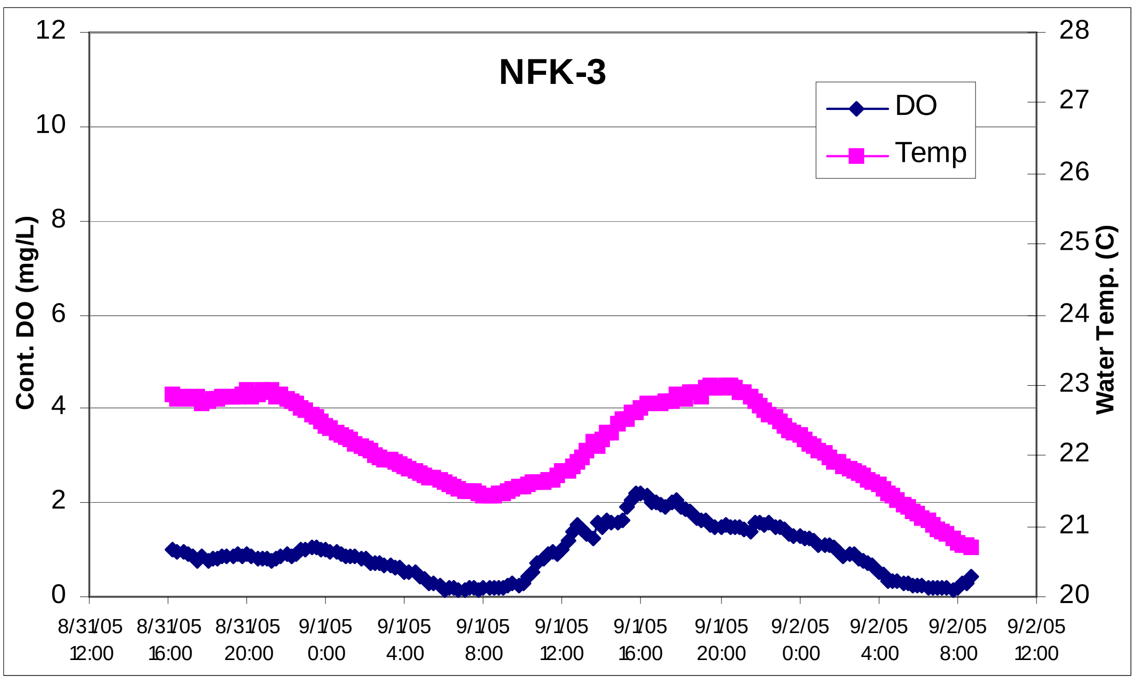

Figure 14. Continuous DO and Temperature at North Fork Kaskaskia River Station NFK-3

QUALITY ASSURANCE REVIEW

A review was conducted to assess the quality and usability of data generated from implementation of the work activities and to assess adherence to protocols specified in the QAPP. Field and laboratory methods were reviewed and found to be in accordance with the QAPP; however, certain changes to sampling and analysis activities were implemented that deviated from the sampling plan presented in the QAPP and are documented in the remainder of this section. Field measurement data and laboratory analytical data were verified and validated in accordance with the QAPP.

Overall, the data generated are of satisfactory quality and suitable for the intended uses, which include stream characterization and modeling for TMDL development. Some of the data, though acceptable for use, are qualified because of deficiencies in field or laboratory quality control procedures or conditions. Other data, though not specifically flagged with a data qualifier, are associated with uncertainties that prompt caution in their use. These are discussed in this section.

The following subsections of this document present the deviations, deficiencies and cautions associated with the data generated during the investigations. These subsections include the sampling plan changes implemented during the course of the investigation and the results of the data verification and data validation activities.

Changes from Sampling Plan (QAPP)

Certain changes were made to the sampling plan or sampling protocols specified in the QAPP as noted in the following list.

- A number of Round 1 BOD_5 samples were frozen at the lab upon receipt. The result is that the BOD_5 analysis was initiated six days after sample collection. Based on discussions with the lab, which has commonly followed this practice and which has conducted studies to assess the impact of this practice, the effect of freezing the samples has a minimal effect on the results.
- A number of sampling locations were changed from those presented in the QAPP because of difficult access conditions noted during field reconnaissance. The location changes made are documented in Table 1.
- Samples were not collected at stations that were dry. Locations not sampled due to dry conditions are identified in Table 1.
- The QAPP describes one round of pH measurements in the North Fork Kaskaskia River and Skillet Fork watersheds. A second round of pH field measurements was added to the sampling plan to provide additional data for assessment of this parameter at the sampled locations. The Round 1 pH measurements in the North Fork Kaskaskia River watershed were performed by the laboratory using samples submitted for BOD_5 analysis, rather than in the field. pH measurements are presented in Table 3.
- The QAPP describes one round of total iron sampling in the North Fork Kaskaskia River watershed. To better compare iron measurements to the Illinois Water Quality Criteria for iron, which are based on the dissolved fraction, both total and dissolved iron samples were added to Round 2 sampling and analysis

activities. The total iron samples were collected to enable correlation between the solid and dissolved fractions. Iron results are presented in Table 3.

- Manganese measurements were not originally outlined in the QAPP for the Macoupin Creek and North Fork Kaskaskia River watersheds. After discussions with the IL-EPA project manager, the lab was contacted on 10/24/05 and authorized to complete manganese analyses from samples already at the lab. Manganese was analyzed for the North Fork Kaskaskia River using the samples submitted for iron analysis, which were properly preserved with nitric acid. Samples submitted for BOD_5 analysis, which contained no chemical preservative, were used for the Macoupin Creek watershed manganese analyses after discussions with the laboratory regarding the effects of analyzing manganese from improperly preserved samples. The manganese results are presented in Tables 2 and 3.

Data Verification and Validation

The data generated are of overall good quality and acceptable for use with some qualifications as discussed below.

Discharge data. There is uncertainty associated with discharge values generated from flow data for many locations. Results that are negative and very near zero accurately represent the fact that little to no downstream discharge was present, but should be used with caution in terms of defining a specific magnitude of flow. Drought conditions in southern Illinois during summer and fall 2005 created very low water levels and stream velocities. Field observations of “no apparent flow” were common. Uncertainties in the data may be associated with the following:

- Recorded water velocities were very low or negative, often below the sensitivity of the velocity meter (±0.05 feet per second),
- Stream flow was often insufficient to overcome measurement system inertia and accurately orient the velocity sensor in the direction of flow, resulting in inaccurate recordings of flow angle when using a bridgeboard,
- Stream flow was often insufficient to overcome water currents induced by the presence of sampling personnel when measuring velocities while wading in the stream, and
- At the SKIL-15 sampling location, hydraulic conditions were observed that may have been associated with the presence of underwater springs.

The knowledge that little to no downstream discharge was present will be sufficient to satisfy modeling requirements.

Laboratory data. There is uncertainty associated with some of the laboratory data based on results of quality control procedures that are outside of control limits. These data were qualified as estimated (J flag), and are described in additional detail below.

- ***BOD_5 holding times*** - BOD_5 samples arrived at the lab in time for analysis, however, due to arrival on a holiday weekend, the laboratory froze the samples, and analyzed them 6 days after the samples were collected. The holding time for these frozen samples exceeded the method specified holding time of 48 hours from sample collection to analysis. The samples affected are presented below.

- All Round 1 samples collected on 9/1/05 from the Skillet Fork watershed (SKIL-1, SKIL-2, SKIL-3, SKIL-4, SKIL-5, SKIL-6 DUP1, SKIL-6 DUP2, SKIL-7, SKIL-8, SKIL-9, SKIL-10, SKIL-11, SKIL-12, SKIL-14, SKIL-15, SKIL-16, SKIL-17, SKIL-18, SKIL-19 DUP1, SKIL-19 DUP2, SKIL-20, SKIL-21, SKIL-22, SKIL-23, SKIL-24, SKIL-25, SKIL-26, SKIL-27 DUP1, SKIL-27 DUP2, SKIL-28, Rinse Blank, Rinse Blank 2)

The laboratory indicated that they have commonly frozen BOD_5 samples and have previously conducted analyses on split samples to determine the impact of freezing on results. The potential error introduced is between 10 and 30 percent and no significant bias was observed. Because this is consistent with the precision measurement objective as stated in the QAPP and as such these results were not flagged. Furthermore, a review of the BOD_5 results between Round 1 and Round 2, found that the BOD_5 results are similar for the majority of Skillet Fork locations. If appropriate, the BOD_5 inputs to the model may be adjusted within the estimated range of uncertainty, to calibrate the water quality model.

- ***Manganese sample preservation*** – As discussed previously, manganese analyses were added to the project scope after field sampling had been completed. The laboratory was contacted and asked to analyze manganese from the Macoupin watershed water samples remaining from previous BOD_5 analyses. Because these samples were collected for BOD_5 analyses, they did not meet the field preservation specifications for metals (using nitric acid). As a result, these manganese results (detected and non-detected) were qualified as estimated (J flag). It should be noted that the samples were analyzed for manganese within method specified holding times (6 months) for properly preserved samples and the laboratory sample preparation procedures of acid digestion brought back into solution any manganese that was precipitated or adsorbed to the container. However, it is possible that other processes such as volatilization or microbial breakdown may have been present to affect analytical results. The analytical method does not discuss procedures for unpreserved samples. The samples affected are presented below.

  - All Round 1 samples collected on 8/23/05 from the Macoupin Creek watershed (MAC-1, MAC-3, MAC-5, MAC-6, MAC-7, MAC-9, MAC-10, MAC-11, MAC-12)

  - All Round 2 samples collected on 10/11/05 from the Macoupin Creek watershed (MAC-1, MAC-3, MAC-5, MAC-6, MAC-7, MAC-8, MAC-9, MAC-10, MAC-12)

  The effect of the change in sample preservation is expected to be minimal and these data are considered sufficient to support model and TMDL development.

Field QC data. Field quality control (QC) samples were collected to assess bias associated with field and laboratory methods. The field QC samples included 11 field duplicate sample pairs and eight rinse blank samples. The results of these analyses are presented below.

- ***Ammonia contamination in rinse blanks*** - Ammonia was detected in 7 out of 8 rinse blanks analyzed from the Round 1 and Round 2 sampling events. Although no qualifications were made to the sample results based on the presence of rinse blank contamination, the possibility must be acknowledged that sample results with levels near or below those detected in blanks may be attributable to contamination introduced during field sampling and rinsing procedures and not representative of stream quality. Sample containers were all rinsed using station stream water prior to sample collection, rather than the deionized water used for preparation of the rinse blanks; however, caution is indicated. Positive ammonia results for rinse blanks ranged 0.04-0.09 mg/L while positive sample results ranged 0.01-1.8 mg/L.

  Because the sample bottles were all rinsed with stream water prior to sample collection, the ammonia detected in the rinse blanks is not expected to affect the results and the data are suitable for use in model and TMDL development. Additionally, the magnitude of ammonia concentrations observed in the rinse blanks is small, relative to the management concern (i.e., ammonia concentration < 1.0 mg/l isn't considered a problem).

- ***Field Duplicates*** - Eleven field duplicate pairs were analyzed with the monitoring data. Positive sample results and relative percent differences (RPD) are presented in Table 8 along with the criteria for precision (relative percent difference values). All duplicate recoveries were within acceptable ranges.

Table 8. Field Duplicate Pair Sample Results

Sample ID	Ammonia (mg/L)	BOD_5 (mg/L)	Dissolved Iron (mg/L)	Total Fe (mg/L)	Total Mn (mg/L)
Round 1 Results					
MAC-1 DUP1	<0.01	2.7			0.57 J
MAC-1 DUP2	<0.01	3.2			
RPD (%)		**4.2 b**			
NFK-1 DUP1	0.08	3.2		0.88	0.47
NFK-1 DUP2	0.09	3.2		0.89	
RPD (%)	**2.9 b**	**0.0 b**		**0.3 a**	
SKIL-6 DUP1	0.02	<2 J			
SKIL-6 DUP2	<0.01	<2 J			
RPD (%)	**16.7 b**				
SKIL-19 DUP1	0.08	<2 J			0.58
SKIL-19 DUP2	0.09	<2 J			0.61
RPD (%)	**2.9 b**				**1.3 a**
SKIL-27 DUP1	<0.01	<2 J			0.26
SKIL-27 DUP2	<0.01	<2 J			0.26
RPD (%)					**0.0 a**
Round 2 Results					
HOD-3 DUP1	0.23 J	<2			
HOD-3 DUP2	0.23 J	<2			
RPD (%)	**0.0 b**				
MAC-7 DUP1	0.02 J	2.6			0.21 J
MAC-7 DUP2	0.03 J	<2			
RPD (%)	**10.0 b**	**6.5 b**			
NFK-5 DUP1	0.25	3.7	0.6	2.6	0.89
NFK-5 DUP2	0.22	4.5	0.55	2.8	
RPD (%)	**3.2 b**	**4.9 b**	**2.2 a**	**1.9 a**	
SKIL-6 DUP1	0.16	3.7			
SKIL-6 DUP2	0.02	3			
RPD (%)	**38.9 b**	**5.2 b**			
SKIL-19 DUP1	0.32	<2			
SKIL-19 DUP2	0.36	<2			
RPD (%)	**2.9 b**				
SKIL-27 DUP1	0.01 U	4.1			
SKIL-27DUP2	0.03	4			
RPD (%)	**25.0 b**	**0.6 b**			

a Acceptable metal duplicate; sample results are within +/- the laboratory reporting limit or <= 20% RPD (for aqueous samples).

b Acceptable organic duplicate; sample results are within +/- the laboratory reporting limit or <= 20% RPD (for aqueous samples) or the difference is < a factor of 5X in the concentration.

c One or both results should be considered estimated and have been flagged with a J in the data tables due to the disparity observed between the field duplicate results.

*RPD= |S-D| x100 / (S+D)/2 where S: original sample; D: Duplicate sample

Conformance to Data Quality Objectives. Overall, the data generated during the investigation conformed to the project data quality objectives (DQOs) and are suitable for their intended uses. The monitored parameters were evaluated in terms of minimum measurement criteria, minimum measurement objectives, required detection limits, accuracy, precision and completeness using the DQOs presented in the project QAPP. Table 9 summarizes the results of the DQO quality assurance (QA) check.

The QA check shows apparent deficiencies with minimum measurement criteria for iron results and with completeness criteria for DO, temperature, ammonia and BOD_5. In the case of iron, the method detection limit (0.02 mg/L) did meet its criterion and this value is essentially rounded up to one significant digit from the minimum measurement criterion for iron (0.017 mg/L). The completeness criteria reflect the number of samples and measurements that were originally planned; however, as noted previously, the drought conditions prevalent during the investigations precluded sampling at tributary locations that were dry or had insufficient water. Adjusting the completeness criterion to reflect actual field conditions by eliminating locations that were not possible to sample results in the criterion being met at 100%. The completeness value for pH monitoring exceeds 100% because measurements were obtained during the second round of sampling and at a number of additional locations not present in the original sampling plan.

Table 9. Measurement Objectives and Criteria Check

					MS/MSD *				LCS *			
Parameter	**Minimum Measurement Criteria**	**Minimum Measurement Objectives**	**Method*; MDL[1]**	**QA check**	**Accuracy (% recovery)**	**QA check**	**Precision (RPD)**	**QA check**	**Accuracy (% recovery)**	**QA check**	**Completeness Criteria**	**QA check**
Dissolved Oxygen	NA	0.1 mg/l [s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S[3] (83%)
Water Temperature	NA	0.1 degree C [s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S[3] (83%)
pH	NA	0.1 pH unit[s]	Field; NA	S	NA	NA	NA	NA	NA	NA	90%	S (162%)
Ammonia	15.0 mg/l[G]	3.0 mg/l	EPA 350.1/ 350.3; 0.01/0.03 mg/l	S (0.01 mg/l)	80-120%	S	20%	S	80-120%	S	90%	S[3] (88%)
BOD_5	No Standard	No Standard	EPA 405.1/ SM5210 B; 2 mg/l	S (2 mg/l)	NA	NA	20%	S	NA	NA	90%	S[3] (88%)
Iron, Total & Dissolved	0.017 mg/l[G, 2]	0.005 mg/l	EPA 200.8; 0.02 mg/l	S (0.02 mg/l)	70-130%	S (80-120%)	20%	S	80-120%	S	90%	S (97%)
Manganese, Total	1 mg/l[G]	0.2 mg/l	EPA 200.8 0.02 mg/l	S (0.02 mg/l)	70-130%	S (80-120%)	20%	S	80-120%	S	90%	S (98%)

Notes

1 Method Detection Limit (MDL) from SM and EPA.
2 Calculated acute standard based on a minimum water hardness of 100 mg/L as CaCO3
* Limits are subject to change based upon capabilities of contract labs
G State of Illinois General Use Water Quality Standard
s Required sensitivity
EPA U.S. EPA Methods for Chemical Analysis of Water and Wastes, March 1983
NA Not Applicable
SM Standard Methods of the Examination of Water and Wastewater, 20th Edition
S QA check is satisfactory, criteria met
S[3] QA check is satisfactory for adjusted criteria

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Appendix 1. Quality Assurance Project Plan

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Appendix 2. Continuous Data

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Continuous Dissolved Oxygen (DO) Data - Hodges, Macoupin, North Fork Kaskaskia and Skillet Fork Watersheds

HOD-1			MAC-7			NFK-3			SKIL-4		
Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]	Date / Time	Temp [°C]	DO [mg/l]
8/24/2005 13:20	22.26	5.01	8/24/2005 15:40	22.79	5.9	8/31/2005 16:15	22.87	1	8/27/2005 18:00	23.61	0.19
8/24/2005 13:35	22.27	5.03	8/24/2005 15:55	22.72	5.65	8/31/2005 16:30	22.82	0.96	8/27/2005 18:15	23.36	0.14
8/24/2005 13:50	22.28	4.88	8/24/2005 16:10	22.76	5.77	8/31/2005 16:45	22.83	0.94	8/27/2005 18:30	23.26	0.12
8/24/2005 14:05	22.29	4.91	8/24/2005 16:25	22.77	6.17	8/31/2005 17:00	22.79	0.91	8/27/2005 18:45	23.26	0.11
8/24/2005 14:20	22.31	4.78	8/24/2005 16:40	22.78	6.25	8/31/2005 17:15	22.8	0.88	8/27/2005 19:00	23.33	0.09
8/24/2005 14:35	22.33	4.9	8/24/2005 16:55	22.87	6.6	8/31/2005 17:30	22.85	0.77	8/27/2005 19:15	23.35	0.09
8/24/2005 14:50	22.35	4.89	8/24/2005 17:10	22.97	7.07	8/31/2005 17:45	22.75	0.86	8/27/2005 19:30	23.32	0.11
8/24/2005 15:05	22.39	5.25	8/24/2005 17:25	22.94	6.75	8/31/2005 18:00	22.77	0.77	8/27/2005 19:45	23.29	0.1
8/24/2005 15:20	22.42	5.3	8/24/2005 17:40	22.94	7.22	8/31/2005 18:15	22.79	0.79	8/27/2005 20:00	23.34	0.08
8/24/2005 15:35	22.51	5.48	8/24/2005 17:55	22.97	7.44	8/31/2005 18:30	22.82	0.8	8/27/2005 20:15	23.36	0.08
8/24/2005 15:50	22.5	5.55	8/24/2005 18:10	22.89	6.72	8/31/2005 18:45	22.85	0.84	8/27/2005 20:30	23.31	0.09
8/24/2005 16:05	22.56	5.59	8/24/2005 18:25	22.88	6.59	8/31/2005 19:00	22.84	0.88	8/27/2005 20:45	23.34	0.08
8/24/2005 16:20	22.58	5.59	8/24/2005 18:40	22.97	7.29	8/31/2005 19:15	22.83	0.87	8/27/2005 21:00	23.37	0.07
8/24/2005 16:35	22.62	5.52	8/24/2005 18:55	22.97	7.35	8/31/2005 19:30	22.84	0.93	8/27/2005 21:15	23.36	0.09
8/24/2005 16:50	22.62	5.44	8/24/2005 19:10	22.97	7.33	8/31/2005 19:45	22.88	0.88	8/27/2005 21:30	23.4	0.07
8/24/2005 17:05	22.63	5.58	8/24/2005 19:25	22.98	7.27	8/31/2005 20:00	22.92	0.89	8/27/2005 21:45	23.39	0.09
8/24/2005 17:20	22.6	4.82	8/24/2005 19:40	22.91	6.94	8/31/2005 20:15	22.85	0.88	8/27/2005 22:00	23.33	0.09
8/24/2005 17:35	22.58	5.01	8/24/2005 19:55	22.89	6.89	8/31/2005 20:30	22.87	0.8	8/27/2005 22:15	23.34	0.09
8/24/2005 17:50	22.6	5.29	8/24/2005 20:10	22.83	6.62	8/31/2005 20:45	22.92	0.82	8/27/2005 22:30	23.3	0.08
8/24/2005 18:05	22.61	5.12	8/24/2005 20:25	22.8	6.5	8/31/2005 21:00	22.9	0.81	8/27/2005 22:45	23.31	0.09
8/24/2005 18:20	22.65	5.04	8/24/2005 20:40	22.71	6.16	8/31/2005 21:15	22.92	0.76	8/27/2005 23:00	23.28	0.09
8/24/2005 18:35	22.66	5.13	8/24/2005 20:55	22.73	6.37	8/31/2005 21:30	22.85	0.82	8/27/2005 23:15	23.25	0.09
8/24/2005 18:50	22.65	5.07	8/24/2005 21:10	22.7	6.19	8/31/2005 21:45	22.86	0.85	8/27/2005 23:30	23.23	0.06
8/24/2005 19:05	22.65	4.9	8/24/2005 21:25	22.67	6.2	8/31/2005 22:00	22.82	0.9	8/27/2005 23:45	23.2	0.06
8/24/2005 19:20	22.68	5.3	8/24/2005 21:40	22.61	6.06	8/31/2005 22:15	22.76	0.85	8/28/2005 0:00	23.16	0.07
8/24/2005 19:35	22.67	5.13	8/24/2005 21:55	22.54	5.96	8/31/2005 22:30	22.73	0.92	8/28/2005 0:15	23.12	0.06
8/24/2005 19:50	22.69	5.19	8/24/2005 22:10	22.51	5.94	8/31/2005 22:45	22.69	0.99	8/28/2005 0:30	23.09	0.08
8/24/2005 20:05	22.69	5.18	8/24/2005 22:25	22.47	5.93	8/31/2005 23:00	22.64	1.02	8/28/2005 0:45	23.04	0.09
8/24/2005 20:20	22.7	5.75	8/24/2005 22:40	22.41	5.81	8/31/2005 23:15	22.58	1.06	8/28/2005 1:00	22.9	0.06
8/24/2005 20:35	22.65	4.97	8/24/2005 22:55	22.37	5.78	8/31/2005 23:30	22.54	1.03	8/28/2005 1:15	22.98	0.09
8/24/2005 20:50	22.61	5.1	8/24/2005 23:10	22.33	5.75	8/31/2005 23:45	22.49	1.02	8/28/2005 1:30	22.92	0.07
8/24/2005 21:05	22.57	5.19	8/24/2005 23:25	22.29	5.7	9/1/2005 0:00	22.43	1	8/28/2005 1:45	22.88	0.09
8/24/2005 21:20	22.53	5.18	8/24/2005 23:40	22.24	5.62	9/1/2005 0:15	22.38	0.96	8/28/2005 2:00	22.83	0.06
8/24/2005 21:35	22.5	5.06	8/24/2005 23:55	22.2	5.47	9/1/2005 0:30	22.34	0.94	8/28/2005 2:15	22.8	0.08
8/24/2005 21:50	22.48	4.99	8/25/2005 0:10	22.16	5.23	9/1/2005 0:45	22.3	0.93	8/28/2005 2:30	22.76	0.08
8/24/2005 22:05	22.44	4.97	8/25/2005 0:25	22.11	5.1	9/1/2005 1:00	22.25	0.87	8/28/2005 2:45	22.69	0.06
8/24/2005 22:20	22.41	4.94	8/25/2005 0:40	22.08	5.1	9/1/2005 1:15	22.22	0.84	8/28/2005 3:00	22.64	0.08
8/24/2005 22:35	22.37	4.91	8/25/2005 0:55	22.06	5.05	9/1/2005 1:30	22.18	0.85	8/28/2005 3:15	22.6	0.09
8/24/2005 22:50	22.33	4.85	8/25/2005 1:10	22.01	5.09	9/1/2005 1:45	22.15	0.8	8/28/2005 3:30	22.54	0.09
8/24/2005 23:05	22.29	4.86	8/25/2005 1:25	21.99	5.06	9/1/2005 2:00	22.11	0.82	8/28/2005 3:45	22.5	0.07
8/24/2005 23:20	22.25	4.69	8/25/2005 1:40	21.96	5.09	9/1/2005 2:15	22.06	0.74	8/28/2005 4:00	22.46	0.08
8/24/2005 23:35	22.21	4.8	8/25/2005 1:55	21.94	5.16	9/1/2005 2:30	22.02	0.74	8/28/2005 4:15	22.43	0.09
8/24/2005 23:50	22.17	4.72	8/25/2005 2:10	21.88	5.05	9/1/2005 2:45	21.99	0.74	8/28/2005 4:30	22.39	0.06
8/25/2005 0:05	22.12	4.81	8/25/2005 2:25	21.85	5.12	9/1/2005 3:00	21.96	0.66	8/28/2005 4:45	22.35	0.07
8/25/2005 0:20	22.08	4.67	8/25/2005 2:40	21.86	4.96	9/1/2005 3:15	21.93	0.68	8/28/2005 5:00	22.3	0.09
8/25/2005 0:35	22.03	4.65	8/25/2005 2:55	21.82	4.83	9/1/2005 3:30	21.9	0.63	8/28/2005 5:15	22.27	0.06
8/25/2005 0:50	21.96	4.71	8/25/2005 3:10	21.78	4.74	9/1/2005 3:45	21.87	0.63	8/28/2005 5:30	22.24	0.07
8/25/2005 1:05	21.97	4.67	8/25/2005 3:25	21.74	4.69	9/1/2005 4:00	21.84	0.54	8/28/2005 5:45	22.19	0.06
8/25/2005 1:20	21.92	4.74	8/25/2005 3:40	21.7	4.67	9/1/2005 4:15	21.82	0.51	8/28/2005 6:00	22.15	0.08
8/25/2005 1:35	21.87	4.62	8/25/2005 3:55	21.66	4.64	9/1/2005 4:30	21.79	0.51	8/28/2005 6:15	22.1	0.08
8/25/2005 1:50	21.83	4.65	8/25/2005 4:10	21.66	4.62	9/1/2005 4:45	21.76	0.45	8/28/2005 6:30	22.05	0.07
8/25/2005 2:05	21.79	4.59	8/25/2005 4:25	21.63	4.59	9/1/2005 5:00	21.73	0.39	8/28/2005 6:45	22.01	0.08
8/25/2005 2:20	21.74	4.59	8/25/2005 4:40	21.6	4.56	9/1/2005 5:15	21.69	0.3	8/28/2005 7:00	21.97	0.06
8/25/2005 2:35	21.7	4.5	8/25/2005 4:55	21.59	4.49	9/1/2005 5:30	21.68	0.27	8/28/2005 7:15	21.94	0.09
8/25/2005 2:50	21.69	4.45	8/25/2005 5:10	21.57	4.49	9/1/2005 5:45	21.65	0.22	8/28/2005 7:30	21.9	0.06
8/25/2005 3:05	21.65	4.43	8/25/2005 5:25	21.54	4.42	9/1/2005 6:00	21.61	0.15	8/28/2005 7:45	21.88	0.07
8/25/2005 3:20	21.61	4.41	8/25/2005 5:40	21.52	4.34	9/1/2005 6:15	21.58	0.19	8/28/2005 8:00	21.86	0.07
8/25/2005 3:35	21.56	4.49	8/25/2005 5:55	21.49	4.29	9/1/2005 6:30	21.56	0.17	8/28/2005 8:15	21.85	0.08
8/25/2005 3:50	21.53	4.41	8/25/2005 6:10	21.46	4.24	9/1/2005 6:45	21.53	0.13	8/28/2005 8:30	21.84	0.08
8/25/2005 4:05	21.48	4.46	8/25/2005 6:25	21.42	4.2	9/1/2005 7:00	21.51	0.16	8/28/2005 8:45	21.84	0.06
8/25/2005 4:20	21.45	4.45	8/25/2005 6:40	21.36	4.23	9/1/2005 7:15	21.49	0.17	8/28/2005 9:00	21.83	0.08
8/25/2005 4:35	21.43	4.38	8/25/2005 6:55	21.35	4.21	9/1/2005 7:30	21.49	0.18	8/28/2005 9:15	21.82	0.07
8/25/2005 4:50	21.4	4.36	8/25/2005 7:10	21.35	4.12	9/1/2005 7:45	21.47	0.14	8/28/2005 9:30	21.82	0.06
8/25/2005 5:05	21.38	4.33	8/25/2005 7:25	21.34	4.12	9/1/2005 8:00	21.45	0.19	8/28/2005 9:45	21.82	0.06
8/25/2005 5:20	21.36	4.33	8/25/2005 7:40	21.33	4.06	9/1/2005 8:15	21.45	0.18	8/28/2005 10:00	21.82	0.08
8/25/2005 5:35	21.35	4.26	8/25/2005 7:55	21.37	3.97	9/1/2005 8:30	21.44	0.18	8/28/2005 10:15	21.81	0.07
8/25/2005 5:50	21.33	4.31	8/25/2005 8:10	21.36	3.93	9/1/2005 8:45	21.46	0.2	8/28/2005 10:30	21.82	0.07
8/25/2005 6:05	21.32	4.19	8/25/2005 8:25	21.39	3.9	9/1/2005 9:00	21.47	0.17	8/28/2005 10:45	21.83	0.05
8/25/2005 6:20	21.27	4.23	8/25/2005 8:40	21.4	3.85	9/1/2005 9:15	21.5	0.23	8/28/2005 11:00	21.84	0.08
8/25/2005 6:35	21.24	4.24	8/25/2005 8:55	21.41	3.9	9/1/2005 9:30	21.54	0.28	8/28/2005 11:15	21.87	0.08
8/25/2005 6:50	21.24	4.21	8/25/2005 9:10	21.46	4.05	9/1/2005 9:45	21.56	0.26	8/28/2005 11:30	21.89	0.06
8/25/2005 7:05	21.23	4.1	8/25/2005 9:25	21.56	4.31	9/1/2005 10:00	21.55	0.3	8/28/2005 11:45	21.93	0.07
8/25/2005 7:20	21.24	4.37	8/25/2005 9:40	21.6	4.44	9/1/2005 10:15	21.59	0.43	8/28/2005 12:00	21.98	0.05
8/25/2005 7:35	21.25	4.44	8/25/2005 9:55	21.64	4.54	9/1/2005 10:30	21.61	0.54	8/28/2005 12:15	22.03	0.07
8/25/2005 7:50	21.26	4.45	8/25/2005 10:10	21.65	4.47	9/1/2005 10:45	21.63	0.71	8/28/2005 12:30	22.06	0.07
8/25/2005 8:05	21.27	4.52	8/25/2005 10:25	21.68	4.32	9/1/2005 11:00	21.63	0.82	8/28/2005 12:45	22.17	0.07
8/25/2005 8:20	21.29	4.48	8/25/2005 10:40	21.66	4.3	9/1/2005 11:15	21.66	0.91	8/28/2005 13:00	22.15	0.07
8/25/2005 8:35	21.33	4.49	8/25/2005 10:55	21.68	4.31	9/1/2005 11:30	21.67	0.94	8/28/2005 13:15	22.19	0.05
8/25/2005 8:50	21.38	4.59	8/25/2005 11:10	21.68	4.52	9/1/2005 11:45	21.72	0.93	8/28/2005 13:30	22.24	0.08
8/25/2005 9:05	21.42	4.56	8/25/2005 11:25	21.63	4.43	9/1/2005 12:00	21.78	1	8/28/2005 13:45	22.29	0.06
8/25/2005 9:20	21.46	4.72	8/25/2005 11:40	21.59	4.4	9/1/2005 12:15	21.8	1.21	8/28/2005 14:00	22.32	0.07
8/25/2005 9:35	21.49	4.7	8/25/2005 11:55	21.56	4.35	9/1/2005 12:30	21.86	1.4	8/28/2005 14:15	22.36	0.08
8/25/2005 9:50	21.51	4.69	8/25/2005 12:10	21.56	4.29	9/1/2005 12:45	21.9	1.51	8/28/2005 14:30	22.37	0.07
8/25/2005 10:05	21.52	4.64	8/25/2005 12:25	21.55	4.48	9/1/2005 13:00	21.99	1.43	8/28/2005 14:45	22.68	0.07
8/25/2005 10:20	21.53	4.74	8/25/2005 12:40	21.57	4.6	9/1/2005 13:15	22.06	1.34	8/28/2005 15:00	22.55	0.08
8/25/2005 10:35	21.53	4.7	8/25/2005 12:55	21.61	4.7	9/1/2005 13:30	22.19	1.26	8/28/2005 15:15	22.55	0.07
8/25/2005 10:50	21.51	4.86	8/25/2005 13:10	21.65	4.96	9/1/2005 13:45	22.12	1.6	8/28/2005 15:30	22.53	0.05
8/25/2005 11:05	21.45	5.04	8/25/2005 13:25	21.64	4.9	9/1/2005 14:00	22.22	1.49	8/28/2005 15:45	22.55	0.05
8/25/2005 11:20	21.34	5.52	8/25/2005 13:40	21.63	4.96	9/1/2005 14:15	22.34	1.62	8/28/2005 16:00	22.56	0.07
8/25/2005 11:35	21.26	5.59	8/25/2005 13:55	21.64	4.84	9/1/2005 14:30	22.33	1.59	8/28/2005 16:15	22.59	0.05
8/25/2005 11:50	21.27	5.8	8/25/2005 14:10	21.62	5.05	9/1/2005 14:45	22.44	1.56	8/28/2005 16:30	22.61	0.07
8/25/2005 12:05	21.35	5.43	8/25/2005 14:25	21.61	4.97	9/1/2005 15:00	22.51	1.63	8/28/2005 16:45	22.6	0.11
8/25/2005 12:20	21.39	5.34	8/25/2005 14:40	21.65	5.01	9/1/2005 15:15	22.53	1.93	8/28/2005 17:00	22.62	0.17
8/25/2005 12:35	21.44	5.58	8/25/2005 14:55	21.63	4.97	9/1/2005 15:30	22.61	2.04	8/28/2005 17:15	23.04	0.12
8/25/2005 12:50	21.5	5.62	8/25/2005 15:10	21.63	4.79	9/1/2005 15:45	22.62	2.22	8/28/2005 17:30	23.08	0.09
8/25/2005 13:05	21.6	5.59	8/25/2005 15:25	21.63	4.9	9/1/2005 16:00	22.68	2.22	8/28/2005 17:45	23.11	0.07
8/25/2005 13:20	21.72	5.57	8/25/2005 15:40	21.61	5.03	9/1/2005 16:15	22.73	2.16	8/28/2005 18:00	22.98	0.08
8/25/2005 13:35	21.75	5.6	8/25/2005 15:55	21.63	4.89	9/1/2005 16:30	22.75	2.01	8/28/2005 18:15	23.04	0.08
8/25/2005 13:50	21.73	5.57	8/25/2005 16:10	21.63	4.87	9/1/2005 16:45	22.75	2	8/28/2005 18:30	23.04	0.07
8/25/2005 14:05	21.77	5.58	8/25/2005 16:25	21.68	4.83	9/1/2005 17:00	22.74	1.98			
8/25/2005 14:20	21.8	5.63	8/25/2005 16:40	21.68	4.64	9/1/2005 17:15	22.76	1.91			
8/25/2005 14:35	21.82	5.47	8/25/2005 16:55	21.68	4.54	9/1/2005 17:30	22.78	2.03			
8/25/2005 14:50	21.85	5.24	8/25/2005 17:10	21.68	4.49	9/1/2005 17:45	22.86	2.07			
8/25/2005 15:05	21.86	5.4	8/25/2005 17:25	21.69	4.47	9/1/2005 18:00	22.83	1.92			
8/25/2005 15:20	21.93	5.39	8/25/2005 17:40	21.69	4.5	9/1/2005 18:15	22.8	1.88			
			8/25/2005 17:55	21.68	4.62	9/1/2005 18:30	22.9	1.82			
			8/25/2005 18:10	21.7	4.61	9/1/2005 18:45	22.9	1.65			
			8/25/2005 18:25	21.73	4.66	9/1/2005 19:00	22.83	1.64			
			8/25/2005 18:40	21.75	4.64	9/1/2005 19:15	22.97	1.61			
						9/1/2005 19:30	23	1.52			
						9/1/2005 19:45	22.98	1.47			
						9/1/2005 20:00	22.96	1.48			
						9/1/2005 20:15	23	1.55			
						9/1/2005 20:30	23	1.5			
						9/1/2005 20:45	22.96	1.5			
						9/1/2005 21:00	22.89	1.46			
						9/1/2005 21:15	22.89	1.43			
						9/1/2005 21:30	22.83	1.41			
						9/1/2005 21:45	22.77	1.59			
						9/1/2005 22:00	22.71	1.59			
						9/1/2005 22:15	22.66	1.52			
						9/1/2005 22:30	22.59	1.56			
						9/1/2005 22:45	22.55	1.5			
						9/1/2005 23:00	22.48	1.46			
						9/1/2005 23:15	22.43	1.42			
						9/1/2005 23:30	22.37	1.36			
						9/1/2005 23:45	22.32	1.27			
						9/2/2005 0:00	22.28	1.27			
						9/2/2005 0:15	22.23	1.25			
						9/2/2005 0:30	22.17	1.23			
						9/2/2005 0:45	22.12	1.19			
						9/2/2005 1:00	22.08	1.11			
						9/2/2005 1:15	22.03	1.12			
						9/2/2005 1:30	21.98	1.09			
						9/2/2005 1:45	21.92	1.05			
						9/2/2005 2:00	21.9	0.96			
						9/2/2005 2:15	21.86	0.86			
						9/2/2005 2:30	21.81	0.92			
						9/2/2005 2:45	21.77	0.91			
						9/2/2005 3:00	21.74	0.81			
						9/2/2005 3:15	21.71	0.77			
						9/2/2005 3:30	21.67	0.7			
						9/2/2005 3:45	21.62	0.66			
						9/2/2005 4:00	21.58	0.52			
						9/2/2005 4:15	21.53	0.47			
						9/2/2005 4:30	21.48	0.35			
						9/2/2005 4:45	21.43	0.35			
						9/2/2005 5:00	21.38	0.35			
						9/2/2005 5:15	21.32	0.29			
						9/2/2005 5:30	21.27	0.31			
						9/2/2005 5:45	21.22	0.26			
						9/2/2005 6:00	21.17	0.25			
						9/2/2005 6:15	21.11	0.25			
						9/2/2005 6:30	21.07	0.17			
						9/2/2005 6:45	21.01	0.18			
						9/2/2005 7:00	20.96	0.2			
						9/2/2005 7:15	20.92	0.19			
						9/2/2005 7:30	20.89	0.2			
						9/2/2005 7:45	20.84	0.16			
						9/2/2005 8:00	20.78	0.19			
						9/2/2005 8:15	20.74	0.28			
						9/2/2005 8:30	20.72	0.3			
						9/2/2005 8:45	20.69	0.43			

Continuous Dissolved Oxygen (DO) Data - Hodges, Macoupin, North Fork Kaskaskia and Skillet Fork Watersheds

SKIL-7

Date / Time	Temp [°C]	DO [mg/l]
8/27/2005 19:15	23.42	4.33
8/27/2005 19:30	23.41	4.28
8/27/2005 19:45	23.41	4.28
8/27/2005 20:00	23.41	4.26
8/27/2005 20:15	23.41	4.25
8/27/2005 20:30	23.41	4.25
8/27/2005 20:45	23.41	4.23
8/27/2005 21:00	23.41	4.23
8/27/2005 21:15	23.4	4.22
8/27/2005 21:30	23.4	4.22
8/27/2005 21:45	23.39	4.21
8/27/2005 22:00	23.38	4.21
8/27/2005 22:15	23.37	4.2
8/27/2005 22:30	23.36	4.2
8/27/2005 22:45	23.36	4.19
8/27/2005 23:00	23.34	4.19
8/27/2005 23:15	23.33	4.2
8/27/2005 23:30	23.32	4.17
8/27/2005 23:45	23.32	4.18
8/28/2005 0:00	23.31	4.19
8/28/2005 0:15	23.29	4.17
8/28/2005 0:30	23.28	4.16
8/28/2005 0:45	23.27	4.17
8/28/2005 1:00	23.25	4.15
8/28/2005 1:15	23.24	4.16
8/28/2005 1:30	23.22	4.14
8/28/2005 1:45	23.2	4.15
8/28/2005 2:00	23.19	4.15
8/28/2005 2:15	23.17	4.15
8/28/2005 2:30	23.15	4.13
8/28/2005 2:45	23.13	4.12
8/28/2005 3:00	23.1	4.12
8/28/2005 3:15	23.09	4.14
8/28/2005 3:30	23.07	4.13
8/28/2005 3:45	23.04	4.11
8/28/2005 4:00	23.02	4.11
8/28/2005 4:15	23.01	4.1
8/28/2005 4:30	22.97	4.09
8/28/2005 4:45	22.95	4.12
8/28/2005 5:00	22.93	4.11
8/28/2005 5:15	22.9	4.1
8/28/2005 5:30	22.87	4.1
8/28/2005 5:45	22.86	4.07
8/28/2005 6:00	22.83	4.05
8/28/2005 6:15	22.8	4.07
8/28/2005 6:30	22.77	4.08
8/28/2005 6:45	22.75	4.04
8/28/2005 7:00	22.73	4.04
8/28/2005 7:15	22.7	4.03
8/28/2005 7:30	22.68	4.03
8/28/2005 7:45	22.66	4.03
8/28/2005 8:00	22.65	4.03
8/28/2005 8:15	22.64	4.03
8/28/2005 8:30	22.63	4.02
8/28/2005 8:45	22.63	4.01
8/28/2005 9:00	22.63	3.99
8/28/2005 9:15	22.63	3.96
8/28/2005 9:30	22.64	3.93
8/28/2005 9:45	22.66	3.91
8/28/2005 10:00	22.69	3.88
8/28/2005 10:15	22.71	3.83
8/28/2005 10:30	22.74	3.81
8/28/2005 10:45	22.75	3.79
8/28/2005 11:00	22.78	3.74
8/28/2005 11:15	22.8	3.77
8/28/2005 11:30	22.86	3.76
8/28/2005 11:45	22.98	3.74
8/28/2005 12:00	23.04	3.86
8/28/2005 12:15	23.09	3.89
8/28/2005 12:30	23.21	3.94
8/28/2005 12:45	23.31	3.91
8/28/2005 13:00	23.44	4.05
8/28/2005 13:15	23.58	4.14
8/28/2005 13:30	23.78	4.21
8/28/2005 13:45	23.97	4.33
8/28/2005 14:00	24.15	4.43
8/28/2005 14:15	24.26	4.43
8/28/2005 14:30	24.26	4.42
8/28/2005 14:45	24.33	4.45
8/28/2005 15:00	24.33	4.44
8/28/2005 15:15	24.3	4.46
8/28/2005 15:30	24.29	4.46
8/28/2005 15:45	24.32	4.44
8/28/2005 16:00	24.27	4.44
8/28/2005 16:15	24.21	4.46
8/28/2005 16:30	24.2	4.4
8/28/2005 16:45	24.22	4.42
8/28/2005 17:00	24.23	4.37
8/28/2005 17:15	24.23	4.36
8/28/2005 17:30	24.25	4.33
8/28/2005 17:45	24.25	4.32
8/28/2005 18:00	24.28	4.32
8/28/2005 18:15	24.26	4.28
8/28/2005 18:30	24.27	4.27
8/28/2005 18:45	24.26	4.28
8/28/2005 19:00	24.27	4.31
8/28/2005 19:15	24.27	4.3
8/28/2005 19:30	24.27	4.33
8/28/2005 19:45	24.26	4.35
8/28/2005 20:00	24.25	4.35
8/28/2005 20:15	24.25	4.39
8/28/2005 20:30	24.24	4.38
8/28/2005 20:45	24.24	4.41
8/28/2005 21:00	24.24	4.4
8/28/2005 21:15	24.23	4.42
8/28/2005 21:30	24.22	4.39
8/28/2005 21:45	24.2	4.35
8/28/2005 22:00	24.18	4.36
8/28/2005 22:15	24.16	4.33
8/28/2005 22:30	24.14	4.32
8/28/2005 22:45	24.13	4.29
8/28/2005 23:00	24.09	4.27
8/28/2005 23:15	24.06	4.26
8/28/2005 23:30	24.04	4.24
8/28/2005 23:45	24.02	4.2

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Date / Time	Temp [°C]	DO [mg/l]
8/28/2005 9:45	23.2	3.93
8/28/2005 10:00	23.21	3.92
8/28/2005 10:15	23.23	3.97
8/28/2005 10:30	23.24	3.93
8/28/2005 10:45	23.3	4
8/28/2005 11:00	23.32	4
8/28/2005 11:15	23.38	4.01
8/28/2005 11:30	23.44	4.06
8/28/2005 11:45	23.5	4.07
8/28/2005 12:00	23.55	4.07
8/28/2005 12:15	23.66	4.08
8/28/2005 12:30	23.75	4.15
8/28/2005 12:45	23.85	4.15
8/28/2005 13:00	23.96	4.19
8/28/2005 13:15	24.04	4.22
8/28/2005 13:30	24.11	4.19
8/28/2005 13:45	24.25	4.22
8/28/2005 14:00	24.31	4.2
8/28/2005 14:15	24.41	4.24
8/28/2005 14:30	24.51	4.26
8/28/2005 14:45	24.59	4.29
8/28/2005 15:00	24.7	4.3
8/28/2005 15:15	24.68	4.31
8/28/2005 15:30	24.76	4.3
8/28/2005 15:45	24.78	4.31
8/28/2005 16:00	24.81	4.31
8/28/2005 16:15	24.81	4.3
8/28/2005 16:30	24.83	4.32
8/28/2005 16:45	24.84	4.3
8/28/2005 17:00	24.84	4.28
8/28/2005 17:15	24.83	4.27
8/28/2005 17:30	24.82	4.24
8/28/2005 17:45	24.8	4.19
8/28/2005 18:00	24.79	4.19
8/28/2005 18:15	24.76	4.15
8/28/2005 18:30	24.74	4.16
8/28/2005 18:45	24.71	4.11
8/28/2005 19:00	24.67	4.08
8/28/2005 19:15	24.66	4.05
8/28/2005 19:30	24.63	4.06
8/28/2005 19:45	24.6	4.02
8/28/2005 20:00	24.57	4.05
8/28/2005 20:15	24.56	4.05
8/28/2005 20:30	24.55	4
8/28/2005 20:45	24.53	4
8/28/2005 21:00	24.52	3.99
8/28/2005 21:15	24.49	3.97
8/28/2005 21:30	24.49	3.98
8/28/2005 21:45	24.47	3.97
8/28/2005 22:00	24.46	3.95
8/28/2005 22:15	24.44	3.95
8/28/2005 22:30	24.44	3.94
8/28/2005 22:45	24.43	3.95
8/28/2005 23:00	24.41	3.94
8/28/2005 23:15	24.4	3.96
8/28/2005 23:30	24.4	3.93
8/28/2005 23:45	24.37	3.9
8/29/2005 0:00	24.37	3.92
8/29/2005 0:15	24.36	3.88
8/29/2005 0:30	24.35	3.88
8/29/2005 0:45	24.34	3.88
8/29/2005 1:00	24.33	3.86
8/29/2005 1:15	24.31	3.87
8/29/2005 1:30	24.3	3.85
8/29/2005 1:45	24.29	3.82
8/29/2005 2:00	24.28	3.85
8/29/2005 2:15	24.27	3.84
8/29/2005 2:30	24.26	3.82
8/29/2005 2:45	24.23	3.81
8/29/2005 3:00	24.23	3.79
8/29/2005 3:15	24.21	3.79
8/29/2005 3:30	24.2	3.8
8/29/2005 3:45	24.19	3.77
8/29/2005 4:00	24.17	3.81
8/29/2005 4:15	24.15	3.76
8/29/2005 4:30	24.12	3.77
8/29/2005 4:45	24.11	3.77
8/29/2005 5:00	24.08	3.75
8/29/2005 5:15	24.06	3.74
8/29/2005 5:30	24.04	3.76
8/29/2005 5:45	24.01	3.76
8/29/2005 6:00	23.98	3.74
8/29/2005 6:15	23.95	3.74
8/29/2005 6:30	23.92	3.74
8/29/2005 6:45	23.92	3.73
8/29/2005 7:00	23.88	3.72
8/29/2005 7:15	23.86	3.7
8/29/2005 7:30	23.84	3.69
8/29/2005 7:45	23.82	3.69
8/29/2005 8:00	23.8	3.68
8/29/2005 8:15	23.78	3.68
8/29/2005 8:30	23.75	3.67
8/29/2005 8:45	23.75	3.67
8/29/2005 9:00	23.73	3.67
8/29/2005 9:15	23.72	3.69
8/29/2005 9:30	23.71	3.7
8/29/2005 9:45	23.71	3.72
8/29/2005 10:00	23.7	3.71
8/29/2005 10:15	23.7	3.7
8/29/2005 10:30	23.71	3.75
8/29/2005 10:45	23.71	3.7
8/29/2005 11:00	23.74	3.71

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Date / Time	Temp [°C]	DO [mg/l]
8/29/2005 16:15	24.48	2.72
8/29/2005 16:30	24.44	2.73
8/29/2005 16:45	24.4	2.7
8/29/2005 17:00	24.37	2.68
8/29/2005 17:15	24.34	2.63
8/29/2005 17:30	24.33	2.62
8/29/2005 17:45	24.29	2.59
8/29/2005 18:00	24.27	2.61
8/29/2005 18:15	24.26	2.51
8/29/2005 18:30	24.25	2.5
8/29/2005 18:45	24.24	2.47
8/29/2005 19:00	24.23	2.48
8/29/2005 19:15	24.21	2.46
8/29/2005 19:30	24.19	2.45
8/29/2005 19:45	24.18	2.43
8/29/2005 20:00	24.16	2.42
8/29/2005 20:15	24.15	2.42
8/29/2005 20:30	24.13	2.4
8/29/2005 20:45	24.12	2.39
8/29/2005 21:00	24.1	2.41
8/29/2005 21:15	24.08	2.42
8/29/2005 21:30	24.07	2.38
8/29/2005 21:45	24.06	2.35
8/29/2005 22:00	24.05	2.31
8/29/2005 22:15	24.03	2.31
8/29/2005 22:30	24	2.34
8/29/2005 22:45	24	2.3
8/29/2005 23:00	23.99	2.27
8/29/2005 23:15	23.97	2.25
8/29/2005 23:30	23.95	2.24
8/29/2005 23:45	23.93	2.24
8/30/2005 0:00	23.91	2.22
8/30/2005 0:15	23.9	2.21
8/30/2005 0:30	23.88	2.21
8/30/2005 0:45	23.86	2.2
8/30/2005 1:00	23.84	2.21
8/30/2005 1:15	23.83	2.18
8/30/2005 1:30	23.81	2.15
8/30/2005 1:45	23.79	2.15
8/30/2005 2:00	23.77	2.16
8/30/2005 2:15	23.75	2.16
8/30/2005 2:30	23.74	2.18
8/30/2005 2:45	23.71	2.17
8/30/2005 3:00	23.7	2.15
8/30/2005 3:15	23.68	2.16
8/30/2005 3:30	23.65	2.19
8/30/2005 3:45	23.63	2.2
8/30/2005 4:00	23.6	2.19
8/30/2005 4:15	23.58	2.19
8/30/2005 4:30	23.56	2.19
8/30/2005 4:45	23.55	2.18
8/30/2005 5:00	23.53	2.17
8/30/2005 5:15	23.5	2.17
8/30/2005 5:30	23.47	2.18
8/30/2005 5:45	23.45	2.18
8/30/2005 6:00	23.42	2.2
8/30/2005 6:15	23.4	2.18
8/30/2005 6:30	23.37	2.18
8/30/2005 6:45	23.36	2.19
8/30/2005 7:00	23.33	2.22
8/30/2005 7:15	23.3	2.26
8/30/2005 7:30	23.28	2.33
8/30/2005 7:45	23.26	2.29
8/30/2005 8:00	23.24	2.28
8/30/2005 8:15	23.22	2.27
8/30/2005 8:30	23.2	2.29
8/30/2005 8:45	23.18	2.3
8/30/2005 9:00	23.17	2.32
8/30/2005 9:15	23.14	2.36
8/30/2005 9:30	23.12	2.36
8/30/2005 9:45	23.1	2.34
8/30/2005 10:00	23.1	2.36
8/30/2005 10:15	23.1	2.32
8/30/2005 10:30	23.09	2.33
8/30/2005 10:45	23.1	2.34
8/30/2005 11:00	23.09	2.38
8/30/2005 11:15	23.1	2.42
8/30/2005 11:30	23.12	2.44
8/30/2005 11:45	23.13	2.45
8/30/2005 12:00	23.14	2.45
8/30/2005 12:15	23.16	2.46
8/30/2005 12:30	23.19	2.47
8/30/2005 12:45	23.19	2.45
8/30/2005 13:00	23.22	2.47
8/30/2005 13:15	23.25	2.49
8/30/2005 13:30	23.27	2.51
8/30/2005 13:45	23.29	2.52
8/30/2005 14:00	23.29	2.53
8/30/2005 14:15	23.29	2.52
8/30/2005 14:30	23.26	2.5
8/30/2005 14:45	23.23	2.49
8/30/2005 15:00	23.21	2.47
8/30/2005 15:15	23.2	2.45
8/30/2005 15:30	23.16	2.45
8/30/2005 15:45	23.14	2.43
8/30/2005 16:00	23.1	2.44
8/30/2005 16:15	23.09	2.37
8/30/2005 16:30	23.06	2.4
8/30/2005 16:45	23.05	2.36
8/30/2005 17:00	23.03	2.4
8/30/2005 17:15	23.02	2.4
8/30/2005 17:30	22.97	2.41
8/30/2005 17:45	22.95	2.4
8/30/2005 18:00	22.94	2.34
8/30/2005 18:15	22.93	2.29
8/30/2005 18:30	22.9	2.24
8/30/2005 18:45	22.86	2.19
8/30/2005 19:00	22.84	2.15
8/30/2005 19:15	22.81	2.11

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Date / Time	Temp [°C]	DO [mg/l]
8/29/2005 17:00	24.22	3.66
8/29/2005 17:15	24.23	3.82
8/29/2005 17:30	24.29	3.91
8/29/2005 17:45	24.21	3.76
8/29/2005 18:00	24.2	3.8
8/29/2005 18:15	24.2	3.79
8/29/2005 18:30	24.2	3.84
8/29/2005 18:45	24.2	3.83
8/29/2005 19:00	24.22	3.87
8/29/2005 19:15	24.22	3.9
8/29/2005 19:30	24.22	3.88
8/29/2005 19:45	24.21	3.8
8/29/2005 20:00	24.22	3.88
8/29/2005 20:15	24.22	3.89
8/29/2005 20:30	24.22	3.83
8/29/2005 20:45	24.21	3.84
8/29/2005 21:00	24.21	3.85
8/29/2005 21:15	24.21	3.81
8/29/2005 21:30	24.21	3.86
8/29/2005 21:45	24.2	3.85
8/29/2005 22:00	24.19	3.83
8/29/2005 22:15	24.18	3.85
8/29/2005 22:30	24.18	3.83
8/29/2005 22:45	24.17	3.84
8/29/2005 23:00	24.15	3.8
8/29/2005 23:15	24.14	3.82
8/29/2005 23:30	24.13	3.8
8/29/2005 23:45	24.11	3.82
8/30/2005 0:00	24.1	3.78
8/30/2005 0:15	24.09	3.8
8/30/2005 0:30	24.07	3.78
8/30/2005 0:45	24.05	3.77
8/30/2005 1:00	24.04	3.73
8/30/2005 1:15	24.04	3.79
8/30/2005 1:30	24.02	3.76
8/30/2005 1:45	23.99	3.74
8/30/2005 2:00	23.98	3.71
8/30/2005 2:15	23.96	3.67
8/30/2005 2:30	23.95	3.68
8/30/2005 2:45	23.93	3.64
8/30/2005 3:00	23.91	3.62
8/30/2005 3:15	23.9	3.65
8/30/2005 3:30	23.87	3.63
8/30/2005 3:45	23.85	3.59
8/30/2005 4:00	23.82	3.62
8/30/2005 4:15	23.81	3.59
8/30/2005 4:30	23.79	3.55
8/30/2005 4:45	23.77	3.57
8/30/2005 5:00	23.75	3.55
8/30/2005 5:15	23.73	3.46
8/30/2005 5:30	23.72	3.5
8/30/2005 5:45	23.69	3.47
8/30/2005 6:00	23.67	3.44
8/30/2005 6:15	23.64	3.43
8/30/2005 6:30	23.62	3.37
8/30/2005 6:45	23.6	3.33
8/30/2005 7:00	23.57	3.44
8/30/2005 7:15	23.55	3.47
8/30/2005 7:30	23.53	3.56
8/30/2005 7:45	23.49	3.58
8/30/2005 8:00	23.46	3.57
8/30/2005 8:15	23.43	3.55
8/30/2005 8:30	23.4	3.53
8/30/2005 8:45	23.38	3.54
8/30/2005 9:00	23.36	3.59
8/30/2005 9:15	23.32	3.67
8/30/2005 9:30	23.3	3.67
8/30/2005 9:45	23.27	3.68
8/30/2005 10:00	23.25	3.69
8/30/2005 10:15	23.23	3.74
8/30/2005 10:30	23.21	3.75
8/30/2005 10:45	23.19	3.74
8/30/2005 11:00	23.18	3.73
8/30/2005 11:15	23.16	3.74
8/30/2005 11:30	23.16	3.71
8/30/2005 11:45	23.15	3.69
8/30/2005 12:00	23.15	3.63
8/30/2005 12:15	23.15	3.64
8/30/2005 12:30	23.15	3.59
8/30/2005 12:45	23.16	3.63
8/30/2005 13:00	23.17	3.6
8/30/2005 13:15	23.19	3.59
8/30/2005 13:30	23.2	3.58
8/30/2005 13:45	23.22	3.61
8/30/2005 14:00	23.23	3.54
8/30/2005 14:15	23.25	3.53
8/30/2005 14:30	23.24	3.52
8/30/2005 14:45	23.23	3.48
8/30/2005 15:00	23.23	3.44
8/30/2005 15:15	23.23	3.41
8/30/2005 15:30	23.24	3.4
8/30/2005 15:45	23.23	3.37
8/30/2005 16:00	23.22	3.35
8/30/2005 16:15	23.21	3.39
8/30/2005 16:30	23.17	3.36
8/30/2005 16:45	23.16	3.4
8/30/2005 17:00	23.14	3.37
8/30/2005 17:15	23.11	3.32
8/30/2005 17:30	23.08	3.29
8/30/2005 17:45	23.05	3.21
8/30/2005 18:00	23.02	3.22
8/30/2005 18:15	22.98	3.2
8/30/2005 18:30	22.95	3.24
8/30/2005 18:45	22.92	3.21
8/30/2005 19:00	22.9	3.25
8/30/2005 19:15	22.88	3.24
8/30/2005 19:30	22.85	3.26
8/30/2005 19:45	22.83	3.23

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Date / Time	Temp [°C]	DO [mg/l]
8/29/2005 10:45	24.95	2.69
8/29/2005 11:00	24.94	2.69
8/29/2005 11:15	24.92	2.63
8/29/2005 11:30	24.93	2.63
8/29/2005 11:45	24.94	2.59
8/29/2005 12:00	24.98	2.6
8/29/2005 12:15	24.99	2.57
8/29/2005 12:30	25.03	2.6
8/29/2005 12:45	25.07	2.63
8/29/2005 13:00	25.14	2.64
8/29/2005 13:15	25.26	2.64
8/29/2005 13:30	25.29	2.7
8/29/2005 13:45	25.34	2.69
8/29/2005 14:00	25.47	2.71
8/29/2005 14:15	25.77	3.08
8/29/2005 14:30	25.76	2.96
8/29/2005 14:45	26	3.28
8/29/2005 15:00	25.89	2.97
8/29/2005 15:15	26.07	3.26
8/29/2005 15:30	26.06	3.18
8/29/2005 15:45	26.09	3.13
8/29/2005 16:00	26.29	3.46
8/29/2005 16:15	26.34	3.46
8/29/2005 16:30	26.29	3.39
8/29/2005 16:45	26.28	3.28
8/29/2005 17:00	26.42	3.51
8/29/2005 17:15	26.15	3.05
8/29/2005 17:30	26.2	3.17
8/29/2005 17:45	26.31	3.28
8/29/2005 18:00	26.39	3.57
8/29/2005 18:15	26.33	3.6
8/29/2005 18:30	26.07	3.17
8/29/2005 18:45	26.01	3.58
8/29/2005 19:00	25.9	3.22
8/29/2005 19:15	25.83	3.01
8/29/2005 19:30	25.79	3.09
8/29/2005 19:45	25.72	3
8/29/2005 20:00	25.68	2.98
8/29/2005 20:15	25.62	2.92
8/29/2005 20:30	25.56	2.89
8/29/2005 20:45	25.51	2.84
8/29/2005 21:00	25.49	2.75
8/29/2005 21:15	25.44	2.71
8/29/2005 21:30	25.4	2.73
8/29/2005 21:45	25.36	2.7
8/29/2005 22:00	25.33	2.65
8/29/2005 22:15	25.31	2.73
8/29/2005 22:30	25.3	2.7
8/29/2005 22:45	25.3	2.83
8/29/2005 23:00	25.3	2.83
8/29/2005 23:15	25.28	2.81
8/29/2005 23:30	25.27	2.79
8/29/2005 23:45	25.26	2.8
8/30/2005 0:00	25.24	2.8
8/30/2005 0:15	25.25	2.84
8/30/2005 0:30	25.25	2.9
8/30/2005 0:45	25.24	2.93
8/30/2005 1:00	25.25	2.99
8/30/2005 1:15	25.24	2.97
8/30/2005 1:30	25.24	2.98
8/30/2005 1:45	25.24	2.99
8/30/2005 2:00	25.23	3
8/30/2005 2:15	25.23	3.01
8/30/2005 2:30	25.23	2.98
8/30/2005 2:45	25.22	2.97
8/30/2005 3:00	25.22	2.98
8/30/2005 3:15	25.21	2.98
8/30/2005 3:30	25.2	2.98
8/30/2005 3:45	25.19	2.92
8/30/2005 4:00	25.19	2.93
8/30/2005 4:15	25.19	2.94
8/30/2005 4:30	25.18	2.92
8/30/2005 4:45	25.17	2.97
8/30/2005 5:00	25.16	2.9
8/30/2005 5:15	25.16	2.91
8/30/2005 5:30	25.15	2.89
8/30/2005 5:45	25.13	2.84
8/30/2005 6:00	25.12	2.82
8/30/2005 6:15	25.11	2.81
8/30/2005 6:30	25.11	2.82
8/30/2005 6:45	25.08	2.85
8/30/2005 7:00	25.07	2.85
8/30/2005 7:15	25.06	2.87
8/30/2005 7:30	25.06	2.82
8/30/2005 7:45	25.04	2.8
8/30/2005 8:00	25.02	2.84
8/30/2005 8:15	25	2.83
8/30/2005 8:30	25.01	2.84
8/30/2005 8:45	24.98	2.87
8/30/2005 9:00	24.98	2.88
8/30/2005 9:15	24.96	2.86
8/30/2005 9:30	24.95	2.85
8/30/2005 9:45	24.95	2.91
8/30/2005 10:00	24.93	2.87
8/30/2005 10:15	24.93	2.96
8/30/2005 10:30	24.92	2.99

SKIL-27

Date / Time	Temp [°C]	DO [mg/l]
8/30/2005 17:45	24.97	4.27
8/30/2005 18:00	25.02	4.25
8/30/2005 18:15	25.01	4.29
8/30/2005 18:30	24.98	4.28
8/30/2005 18:45	24.95	4.18
8/30/2005 19:00	24.95	4.23
8/30/2005 19:15	24.92	4.14
8/30/2005 19:30	24.92	4.14
8/30/2005 19:45	24.9	4.17
8/30/2005 20:00	24.89	4.12
8/30/2005 20:15	24.86	4.17
8/30/2005 20:30	24.85	4.11
8/30/2005 20:45	24.85	4.1
8/30/2005 21:00	24.84	4.08
8/30/2005 21:15	24.81	4.13
8/30/2005 21:30	24.81	4.12
8/30/2005 21:45	24.79	4.06
8/30/2005 22:00	24.78	4.07
8/30/2005 22:15	24.76	4.02
8/30/2005 22:30	24.74	4.01
8/30/2005 22:45	24.73	3.99
8/30/2005 23:00	24.7	4.01
8/30/2005 23:15	24.7	4
8/30/2005 23:30	24.68	3.93
8/30/2005 23:45	24.67	3.97
8/31/2005 0:00	24.65	3.93
8/31/2005 0:15	24.62	3.9
8/31/2005 0:30	24.59	3.91
8/31/2005 0:45	24.57	3.94
8/31/2005 1:00	24.55	3.91
8/31/2005 1:15	24.52	3.92
8/31/2005 1:30	24.49	3.88
8/31/2005 1:45	24.46	3.9
8/31/2005 2:00	24.43	3.89
8/31/2005 2:15	24.39	3.83
8/31/2005 2:30	24.36	3.88
8/31/2005 2:45	24.33	3.87
8/31/2005 3:00	24.32	3.82
8/31/2005 3:15	24.29	3.86
8/31/2005 3:30	24.27	3.84
8/31/2005 3:45	24.25	3.89
8/31/2005 4:00	24.23	3.84
8/31/2005 4:15	24.21	3.88
8/31/2005 4:30	24.19	3.86
8/31/2005 4:45	24.15	3.88
8/31/2005 5:00	24.13	3.87
8/31/2005 5:15	24.11	3.84
8/31/2005 5:30	24.1	3.86
8/31/2005 5:45	24.07	3.89
8/31/2005 6:00	24.03	3.81
8/31/2005 6:15	24.03	3.88
8/31/2005 6:30	23.99	3.83
8/31/2005 6:45	23.96	3.88
8/31/2005 7:00	23.93	3.88
8/31/2005 7:15	23.9	3.89
8/31/2005 7:30	23.88	3.84
8/31/2005 7:45	23.86	3.87
8/31/2005 8:00	23.86	3.91
8/31/2005 8:15	23.84	3.94
8/31/2005 8:30	23.86	4.01
8/31/2005 8:45	23.88	4.06
8/31/2005 9:00	23.94	4.08
8/31/2005 9:15	23.97	4.12
8/31/2005 9:30	23.99	4.11
8/31/2005 9:45	24.03	4.13
8/31/2005 10:00	24.08	4.05
8/31/2005 10:15	24.08	4.02
8/31/2005 10:30	24.16	4.09
8/31/2005 10:45	24.45	4.34
8/31/2005 11:00	24.58	4.35
8/31/2005 11:15	24.65	4.37
8/31/2005 11:30	25.07	4.55
8/31/2005 11:45	24.87	4.45
8/31/2005 12:00	25.07	4.69
8/31/2005 12:15	25.56	4.82
8/31/2005 12:30	25.47	4.84
8/31/2005 12:45	25.44	4.76
8/31/2005 13:00	25.25	4.76
8/31/2005 13:15	25.28	4.88
8/31/2005 13:30	25.41	5.04
8/31/2005 13:45	25.63	5.19
8/31/2005 14:00	25.73	5.29
8/31/2005 14:15	25.77	5.36
8/31/2005 14:30	25.71	5.26
8/31/2005 14:45	25.74	5.34
8/31/2005 15:00	25.95	5.52
8/31/2005 15:15	25.95	5.42
8/31/2005 15:30	26.16	5.6
8/31/2005 15:45	26.11	5.52
8/31/2005 16:00	26.13	5.5
8/31/2005 16:15	26.2	5.62
8/31/2005 16:30	26.24	5.69
8/31/2005 16:45	26.13	5.53
8/31/2005 17:00	26.06	5.46
8/31/2005 17:15	25.99	5.4
8/31/2005 17:30	25.96	5.43
8/31/2005 17:45	25.86	5.45
8/31/2005 18:00	25.8	5.33
8/31/2005 18:15	25.74	5.28
8/31/2005 18:30	25.71	5.19
8/31/2005 18:45	25.68	5.17
8/31/2005 19:00	25.67	5.11
8/31/2005 19:15	25.66	5.21
8/31/2005 19:30	25.67	5.16
8/31/2005 19:45	25.64	5.16
8/31/2005 20:00	25.63	5.24
8/31/2005 20:15	25.62	5.22
8/31/2005 20:30	25.6	5.2
8/31/2005 20:45	25.58	5.13
8/31/2005 21:00	25.54	5.17
8/31/2005 21:15	25.52	5.14
8/31/2005 21:30	25.49	5.09
8/31/2005 21:45	25.44	5.11
8/31/2005 22:00	25.4	5.05
8/31/2005 22:15	25.36	5.05
8/31/2005 22:30	25.35	4.99
8/31/2005 22:45	25.3	4.99
8/31/2005 23:00	25.26	4.98
8/31/2005 23:15	25.22	4.92
8/31/2005 23:30	25.17	4.92
8/31/2005 23:45	25.14	4.96
9/1/2005 0:00	25.11	4.89
9/1/2005 0:15	25.07	4.91
9/1/2005 0:30	25.03	4.89
9/1/2005 0:45	24.99	4.9
9/1/2005 1:00	24.96	4.88
9/1/2005 1:15	24.93	4.82
9/1/2005 1:30	24.88	4.78
9/1/2005 1:45	24.86	4.8
9/1/2005 2:00	24.82	4.78
9/1/2005 2:15	24.78	4.8
9/1/2005 2:30	24.74	4.79
9/1/2005 2:45	24.72	4.77
9/1/2005 3:00	24.69	4.71
9/1/2005 3:15	24.66	4.72
9/1/2005 3:30	24.62	4.66
9/1/2005 3:45	24.6	4.71
9/1/2005 4:00	24.58	4.71
9/1/2005 4:15	24.55	4.69
9/1/2005 4:30	24.53	4.67
9/1/2005 4:45	24.5	4.67
9/1/2005 5:00	24.49	4.66
9/1/2005 5:15	24.46	4.62
9/1/2005 5:30	24.44	4.66
9/1/2005 5:45	24.42	4.61
9/1/2005 6:00	24.41	4.62
9/1/2005 6:15	24.38	4.62
9/1/2005 6:30	24.37	4.6
9/1/2005 6:45	24.34	4.61
9/1/2005 7:00	24.32	4.59
9/1/2005 7:15	24.31	4.56
9/1/2005 7:30	24.3	4.63
9/1/2005 7:45	24.29	4.69
9/1/2005 8:00	24.28	4.63
9/1/2005 8:15	24.29	4.64
9/1/2005 8:30	24.3	4.74
9/1/2005 8:45	24.34	4.81
9/1/2005 9:00	24.43	4.99
9/1/2005 9:15	24.45	4.81
9/1/2005 9:30	24.47	4.85
9/1/2005 9:45	24.63	5.32
9/1/2005 10:00	24.84	6.11
9/1/2005 10:15	24.77	5.67
9/1/2005 10:30	25.26	6.66
9/1/2005 10:45	25.56	6.82
9/1/2005 11:00	25.78	7.36
9/1/2005 11:15	25.97	7.47
9/1/2005 11:30	26.11	7.3
9/1/2005 11:45	26.67	7.75
9/1/2005 12:00	26.36	7.38
9/1/2005 12:15	26.6	7.52
9/1/2005 12:30	26.49	7.36
9/1/2005 12:45	26.97	7.72
9/1/2005 13:00	26.61	7.48
9/1/2005 13:15	26.58	7.4
9/1/2005 13:30	26.65	7.46
9/1/2005 13:45	26.93	8.34
9/1/2005 14:00	27.18	9.08
9/1/2005 14:15	27.22	9.37
9/1/2005 14:30	27.86	10.37
9/1/2005 14:45	27.51	9.84

Macoupin Creek Watershed TMDL
Final Approved TMDL

Prepared for Illinois Environmental Protection Agency

September 2006

Macoupin Creek Watershed

Macoupin Creek (DA-04, DA-05)

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INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the 2006 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Macoupin Creek (Segments IL_DA-04 and IL_DA-05) and Briar Creek (IL_DAZN) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they have been targeted as high priority waterbodies for TMDL development. This document presents the TMDLs designed to allow these waterbodies to fully support their designated uses. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Adaptive Implementation Process

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1 PROBLEM IDENTIFICATION

The impairments in waters of the Macoupin Creek watershed addressed in this report are summarized below, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). Those causes that are the focus of this report are shown in bold font. TMDLs are currently only being developed for pollutants that have numerical water quality standards. A TMDL for fecal coliform in Segment DA-04 of Macoupin Creek was submitted separately (LTI, 2006).

While TMDLs are currently only being developed for pollutants that have numerical water quality standards, many controls that are implemented to address TMDLs for these pollutants will reduce other pollutants as well. For example, any controls to reduce manganese loads from watershed sources such as stream bank erosion would also serve to reduce phosphorus loads to the creek.

Stage 2 (data collection) was completed for the Briar Creek segment in 2005. These results are presented in the Stage 2 data report. The new data indicate that Briar Creek is not impaired by low dissolved oxygen. Dissolved oxygen will be delisted as an impairment and this will be reflected in the 2008 integrated report. For this reason, the TMDLs described in this report do not explicitly address Briar Creek.

Macoupin Creek	
Assessment Unit ID	IL_DA-04
Length (miles)	19.74
Listed For	**Manganese, dissolved oxygen,** fecal coliform, sedimentation/siltation, total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (F), Primary contact (N), Secondary contact (X), Aesthetic quality (X)
Assessment Unit ID	IL_DA-05
Length (miles)	43.89
Listed For	**Manganese, dissolved oxygen,** total nitrogen, other flow regime alterations[2], total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (F), Primary contact (X), Secondary contact (X), Aesthetic quality (X)

[1]F = Fully supporting, N=not supporting, X= not assessed

[2] Not a pollutant; listed in category 3

Briar Creek	
Assessment Unit ID	IL_DAZN
Length (miles)	3.98
Listed For	**Dissolved oxygen**, habitat assessment[2], total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (X), Primary contact (X), Secondary contact (X), Aesthetic quality (X)

[1]F=fully supporting, N=not supporting, X=not assessed

[2] Not a pollutant; listed in category 3

2 REQUIRED TMDL ELEMENTS

USEPA Region 5 guidance for TMDL development requires TMDLs to contain eleven specific components. Each of these components is summarized below.

Macoupin Creek (Segment IL_DA_04)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Macoupin Creek, HUC 07130012. The causes of concern addressed in this TMDL are dissolved oxygen and manganese. Potential sources contributing to the listing of these segments of Macoupin Creek include: natural background sources, streambank erosion, groundwater, creek bottom sediments, runoff from lawns and agricultural lands, failing septic systems and permitted point sources. Additional information is provided in the Stage 1 Report.

   Macoupin Creek is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Because this watershed has a public water supply use impaired (Carlinville and Old Gillespie Lakes, discussed in LTI, 2006), it was ranked as high priority on the 303(d) list for TMDL development.

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **dissolved oxygen** in Illinois waters designated for aquatic life specifies that dissolved oxygen shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time. For Macoupin Creek, the TMDL target was set based upon the water quality criterion for minimum dissolved oxygen of 5 mg/l. The QUAL2E model used to calculate the TMDL predicts a daily average dissolved oxygen and does not directly predict daily minimum. QUAL2E results can be translated into a form comparable to a daily minimum, by subtracting the observed difference between daily average and daily minimum dissolved oxygen from the model output. For QUAL2E model runs, a modeling target of 6.0 mg/l was used to consider diurnal variation and ensure that the 5.0 mg/l TMDL target water quality standard is met. The water quality standard for **manganese** in streams is 1,000 ug/l to protect the aquatic life use. The TMDL target for manganese is therefore a total manganese concentration of 1,000 ug/l.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Loading capacity was determined for each impairment cause and creek segment, as presented below.

   Dissolved Oxygen

   Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Because TMDLs cannot be written to control flow, the focus of this TMDL was instead on SOD, as its effect on dissolved oxygen is dominant under low flow conditions. QUAL2E simulations show that SOD must be reduced by 84% during low flow conditions to meet the TMDL target for dissolved oxygen, assuming that other sources are maintained at existing loads. To achieve this, an 84% reduction of particulate organic carbon loading to the stream is required.

Ammonia and CBOD5 are the other oxygen-demanding substances addressed in this TMDL. Because their effects on DO during critical conditions was determined to be insignificant compared to SOD, the load capacity for CBOD5 and ammonia was set to current background loads during critical low flow conditions.

The load capacity is presented below.

CBOD5 Load Capacity (lb/day)	Ammonia Load Capacity (lb/day))
0.011	0.00066

Manganese

A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the total manganese standard under a range of flow conditions:

DA_04 Flow (cfs)	DA_04 Load Capacity (lb/day)
5	27.0
10	53.9
20	107.9
50	269.7
100	539.4
200	1,078.7
400	2,157.5
1000	5,393.7

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Dissolved oxygen:

IL_DA-04 CBOD5 LA (lb/day)	IL_ DA-04 Ammonia LA (lb/day)
0.01	0.0006

Manganese:

DA_04 Flow (cfs)	DA_04 Load Allocation (lb/day)
5	24.3
10	48.5
20	97.1
50	242.7
100	485.4
200	970.9
400	1,941.7
1000	4,854.3

5. **Wasteload Allocations (WLA):** Point source discharges to segment DA_04 were determined not to contribute significantly to low dissolved oxygen. The two point sources that discharge to this segment, Shipman STP (IL0063088) and Royal Lakes STP (IL0071391), are small facilities that discharge to unnamed tributaries of Coop Branch, in which no flow was observed during the field surveys. Because of their negligible contribution to low dissolved oxygen levels, a WLA does not need to be calculated.

   Point sources have been determined not to contribute significantly to manganese levels instream, and thus, a WLA does not need to be calculated.

6. **Margin of Safety:** The margin of safety for the dissolved oxygen and manganese TMDLs is discussed below.

   Dissolved oxygen

   The dissolved oxygen TMDL contains an explicit margin of safety of 10% of the load allocation, corresponding to the values shown below. A 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL based upon the generally good agreement between the QUAL2E water quality model predicted values and the observed values. In particular, model predictions of minimum dissolved oxygen match very well with both the continuous dissolved oxygen measurements and the grab sampling that was conducted in 2005. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available.

CBOD5 MOS (lb/day)	Ammonia MOS (lb/day)
0.001	0.00006

Manganese

The TMDL for segment IL_DA_04 contains an implicit margin of safety and an explicit MOS. The implicit MOS is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the creek, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also includes an explicit MOS of 10% of the loading capacity. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed as new data are developed. The following table provides the MOS for manganese:

DA_04 Flow (cfs)	Margin of Safety (10%)
5	2.7
10	5.4
20	10.8
50	27.0
100	53.9
200	107.9
400	215.7
1000	539.4

7. **Seasonal Variation:** The TMDLs were conducted with consideration of seasonal variation. The TMDL for manganese was calculated for a range of flow conditions that are expected to be observed throughout the year. The entire range of conditions was evaluated for the dissolved oxygen TMDL, but it was determined that the low flow period is critical for dissolved oxygen. Furthermore, the dissolved oxygen TMDL requires an 84% reduction in watershed particulate organic carbon loadings, which are expected to be delivered to the stream during wet weather conditions. This fully takes seasonal effects into account by focusing on the TMDL on both the critical low flow period and the higher flow conditions when DO isn't a problem. The load allocation to BOD and ammonia during dry weather accounts for critical conditions where DO effects are seen. The reductions to particulate organic carbon loading reflect the higher flow conditions where DO isn't a problem.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA administers the NPDES permitting program for wastewater treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years) to ensure that they are consistent with the applicable wasteload allocation.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   The involvement of local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** Monitoring will continue to be conducted as part of IEPA's ambient monitoring program to track the effectiveness of the TMDL.

10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. Two public meetings were conducted in Carlinville, Illinois to present the Stage 1 watershed characterization work (March 2005) and the Stage 3 TMDL findings (July 2006). One additional public meeting is planned to present the implementation plan.

Macoupin Creek (Segment IL_DA_05)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Macoupin Creek, HUC 07130012. The causes of concern addressed in this report are **dissolved oxygen and manganese**. Potential sources contributing to low dissolved oxygen include algal respiration and decomposition, sediment oxygen demand, degradation of CBOD, nitrification of ammonia (from agricultural lands and failing septic

systems), and municipal point sources. Potential sources of manganese are erosion and streambank erosion of soils naturally enriched in manganese. Additional information is provided in the Stage 1 Report.

Segment IL_DA_05 is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006). Because this watershed has a public water supply use impaired (Carlinville and Old Gillespie Lakes, discussed in LTI, 2006), it was ranked as high priority on the 303(d) list for TMDL development.

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **dissolved oxygen** in Illinois waters designated for aquatic life specifies that dissolved oxygen shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time. For Macoupin Creek, the TMDL target was set based upon the water quality criterion for minimum dissolved oxygen of 5 mg/l. The QUAL2E model used to calculate the TMDL predicts a daily average dissolved oxygen and does not directly predict daily minimum. QUAL2E results can be translated into a form comparable to a daily minimum, by subtracting the observed difference between daily average and daily minimum dissolved oxygen from the model output. For QUAL2E model runs, a modeling target of 6.0 mg/l was used to consider diurnal variation and ensure that the 5.0 mg/l TMDL target water quality standard is met. The water quality standard for **manganese** in streams is 1,000 ug/l to protect the aquatic life use. The TMDL target for manganese is therefore a total manganese concentration of 1,000 ug/l.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** Loading capacity was determined for each impairment cause, as presented below.

Dissolved Oxygen

Based on a review of all available data, dissolved oxygen violations of the water quality standard were observed to occur only during low flow conditions. QUAL2E water quality model simulations for low flow conditions showed that, even with external BOD and ammonia loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit and that DO standards could only be attained via reduction of SOD. Although SOD is the overwhelming oxygen sink, the true cause of low DO is a lack of base flow (which greatly exacerbates the effect of SOD). Because TMDLs cannot be written to control flow, the focus of this TMDL was instead on SOD, as its effect on dissolved oxygen is dominant under low flow conditions. QUAL2E simulations show that SOD must be reduced by 84% during low flow conditions to meet the TMDL target for dissolved oxygen, assuming that other sources are maintained at existing loads. To achieve this, an 84% reduction of particulate organic carbon loading to the stream is required.

Ammonia and CBOD5 are the other oxygen-demanding substances addressed in this TMDL. Because their effects on DO during critical conditions was determined to be insignificant compared to SOD, the load capacity for CBOD5 and ammonia was set to current background loads during critical low flow conditions.

CBOD5 Load Capacity (lb/day)	Ammonia Load Capacity (lb/day)
0.05	0.0022

Manganese:

A load capacity calculation was completed to determine the maximum manganese loads that will maintain compliance with the total manganese standard under a range of flow conditions:

DA_05 Flow (cfs)	DA_05 Load Capacity (lb/day)
3	17.3
6	34.5
13	69.0
32	172.6
64	345.2
128	690.4
256	1,380.8
640	3,451.9

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDLs are as follows:

Dissolved oxygen:

IL_DA-05 CBOD5 LA (lb/day)	IL_ DA-05 Ammonia LA (lb/day)
0.045	0.002

Manganese:

DA_05 Flow (cfs)	DA_05 Load Allocation (lb/day)
3	15.5
6	31.1
13	62.1
32	155.3
64	310.7
128	621.3
256	1,242.7
640	3,106.7

5. **Wasteload Allocations (WLA):** Most of the point sources that discharge to this segment, including the Farmersville (ILG580126) and Nilwood (ILG580090) STPs and the Beaver Dam State Park Shower facility (IL0069175), are small facilities that were determined not to contribute to low dissolved oxygen. The Farmersville STP is a lagoon system that does not discharge during dry weather; it was not discharging at the time that violations of water quality criteria were observed in Segment DA_05 during the 2005 field monitoring. The Nilwood STP is located on a tributary to Macoupin Creek, a substantial distance from the mainstem, and IEPA records indicate that it discharges only approximately four times per year. The State Park shower discharge is located downstream of the observed violations of the dissolved oxygen criteria and is therefore not believed to contribute to observed low D.O.

   The Carlinville STP (IL0022675) is by far the largest point source, discharging to Briar Creek with a design average flow of 1.5 mgd. This discharge substantially increases the flow in Macoupin Creek under critical conditions, and water quality modeling demonstrated that the increased flow improved dissolved oxygen in the creek, despite the BOD load from the STP. Because of their negligible contributions during critical conditions a wasteload allocation was not calculated for this segment.

   Point sources have been determined not to contribute significantly to manganese levels instream, and thus, a WLA was not calculated

6. **Margin of Safety**: The margin of safety for the dissolved oxygen and manganese TMDLs is discussed below.

   Dissolved oxygen

   The dissolved oxygen TMDL contains an explicit margin of safety of 10% of the load allocation, corresponding to the values shown below. A 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL based upon the generally good agreement between the

QUAL2E water quality model predicted values and the observed values. In particular, model predictions of minimum dissolved oxygen match very well with both the continuous dissolved oxygen measurements and the grab sampling that was conducted in 2005. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available.

CBOD5 MOS (lb/day)	Ammonia MOS (lb/day)
0.005	0.0002

Manganese

The TMDL for segment IL_DA_05 contains an implicit margin of safety and an explicit MOS. The implicit MOS is provided via the use of a conservative model to define load capacity. The model assumes no loss of manganese that enters the creek, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also includes an explicit MOS of 10%. This 10% MOS was included in addition to the implicit MOS to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed as new data are developed.

DA_05 Flow (cfs)	Margin of Safety (10%)
3	1.7
6	3.5
13	6.9
32	17.3
64	34.5
128	69.0
256	138.1
640	345.2

7. **Seasonal Variation:** The TMDLs were conducted with consideration of seasonal variation. The TMDL for manganese was calculated for a range of flow conditions that are expected to be observed throughout the year. The entire range of conditions was evaluated for the dissolved oxygen TMDL, but it was determined that the low flow period is critical for dissolved oxygen. Furthermore, the dissolved oxygen TMDL requires an 84% reduction in watershed particulate organic carbon loadings, which are expected to be delivered to the stream during wet weather conditions. This fully takes seasonal effects into account by focusing on the TMDL on both the critical low flow period and the higher flow conditions when DO isn't a problem. The load allocation to BOD and ammonia during dry weather accounts for critical conditions where DO effects are seen. The

reductions to particulate organic carbon loading reflect the higher flow conditions where DO isn't a problem.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA administers the NPDES permitting program for wastewater treatment plants, stormwater permitting and CAFO permitting. The permits for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years), to ensure that they are consistent with the applicable wasteload allocation.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   The involvement of local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** Monitoring will continue to be conducted as part of IEPA's ambient monitoring program to track the effectiveness of the TMDL.

10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.

11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. Two public meetings were conducted in Carlinville, Illinois to present the Stage 1 watershed characterization work (March 2005) and the Stage 3 TMDL findings (July 2006). One additional public meeting is planned to present the implementation plan.

3 WATERSHED CHARACTERIZATION

A description of the Macoupin Creek watershed to support the identification of sources contributing to the listed impairments is provided in the Stage 1 Report. Within the Stage 1 Report, watershed characterization is discussed in the First Quarterly Progress Report. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

The impaired waterbodies addressed in this report are in the Macoupin Creek watershed, located in West-Central Illinois approximately 45 miles south of Springfield, Illinois. The creek extends through four counties, but most of the watershed is located in Macoupin County. Macoupin Creek extends from its point of origin southeast of Farmersville to its confluence with the Illinois River, but the two impaired segments that are addressed in this report are the two most upstream segments. The watershed for these two segments is approximately 256,854 acres (400 square miles) in size, and there are about 227 miles of streams in the watershed (Macoupin County SWCD, 2003). Figure 1 shows a map of the watershed, and includes key features such as waterways, impaired waterbodies, and public water intakes. The map also shows the locations of point source discharges that have a permit to discharge under the National Permit Discharge Elimination System (NPDES).

In August and October 2005, additional low-flow sampling was conducted in the Macoupin Creek watershed. During the first survey, dissolved oxygen concentrations were observed below 5 mg/l at four of the five Macoupin Creek stations and three of the tributary locations were dry (Coop Branch, Dry Fork and Shaw Point Branch). During the second field survey, dissolved oxygen concentrations were observed below 5 mg/l at two Macoupin Creek stations and two tributary stations (Horse Creek at Sulphur Springs Rd. and Shaw Point Branch). Two other tributary locations (Coop Branch and Horse Creek at Boston Chapel Rd.) were dry. Manganese concentrations were observed to exceed the aquatic life use criteria at one location along Macoupin Creek and in two tributaries (Honey Creek and Horse Creek). The data are summarized in the Stage 2 data report.

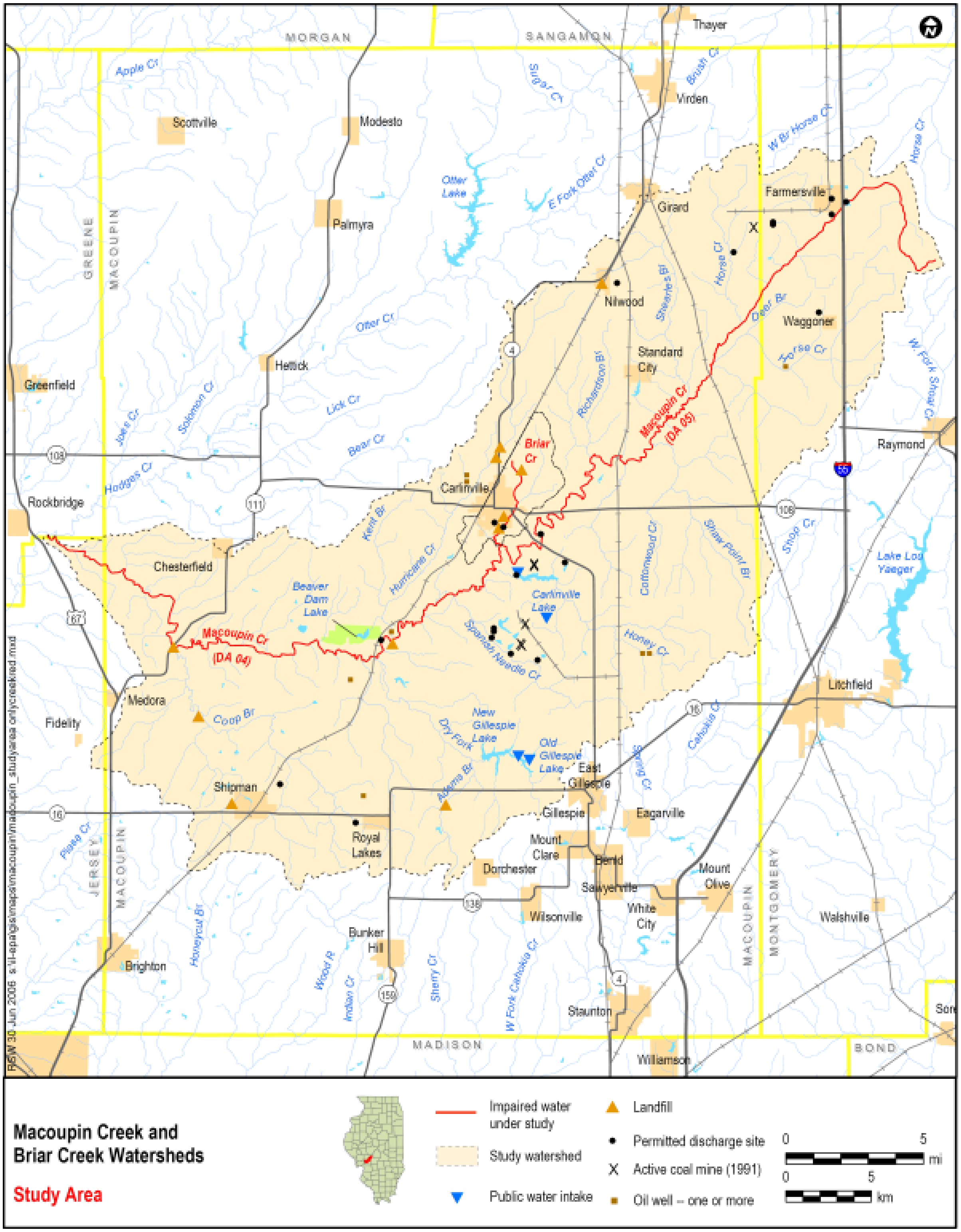

Figure 1. Map of the Macoupin Creek Watershed

4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

The ultimate goal of TMDL development is to achieve attainment with water quality standards. A water quality standard consists of the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. Water quality criteria are sometimes in a form that is not directly amenable for use in TMDL development and may need to be translated into target values for TMDLs. This section discusses the applicable designated uses, use support, criteria and TMDL targets for waterbodies in the Macoupin Creek watershed that are addressed in this report.

4.1 DESIGNATED USES AND USE SUPPORT

Water quality assessments in Illinois to determine attainment of designated uses are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of seven designated uses: aquatic life, aesthetic quality, indigenous aquatic life (for specific Chicago-area waterbodies), primary contact (swimming), secondary contact, public and food processing water supply, and fish consumption (IEPA, 2006). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully Supporting (the water body attains the designated use); or
- Not Supporting (the water body does not attain the designated use).

Water bodies assessed as "Not Supporting" for any designated use are identified as impaired. Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters (IEPA, 2006).

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2006).

4.2 WATER QUALITY CRITERIA

Illinois has established water quality criteria and guidelines for allowable concentrations of dissolved oxygen and manganese under its CWA Section 305(b) program, as summarized below.

4.2.1 Dissolved oxygen

The water quality standard for dissolved oxygen in Illinois waters designated for aquatic life is a minimum of 5.0 mg/l at any time, and not less than 6.0 mg/l during at least 16 hours of any 24-hour period. The aquatic life guideline for streams indicates impairment if more than 10% of the observations measured in the last five years are below 5 mg/l. The available data confirmed that the listing of Macoupin Creek (Segments IL_DA_04 and IL_DA_05) for dissolved oxygen is appropriate based on IEPA's guidelines (see Stage 1 Report).

4.2.2 Manganese

The water quality standard for total manganese in Illinois waters designated for the aquatic life use is 1,000 ug/l. The aquatic life guideline for streams indicates impairment if more than 10% of the observations measured in the last five years exceed 1,000 ug/l. The available data confirm that the listing of the Macoupin Creek (Segments DA_04 and DA_05) for total manganese is appropriate based on IEPA's guidelines (see Stage 1 Report).

4.3 DEVELOPMENT OF TMDL TARGETS

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric criteria do not exist, surrogate parameters must be selected to represent the designated use.

4.3.1 Dissolved oxygen

The water quality standard for dissolved oxygen in Illinois waters designated for aquatic life is that dissolved oxygen shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time. For Macoupin Creek (Segments DA_04 and DA_05), the target was based upon the water quality criterion for minimum dissolved oxygen of 5 mg/l. The QUAL2E model used to calculate the TMDL predicts a daily average dissolved oxygen and does not directly predict daily minimum. QUAL2E results can be translated into a form comparable to a daily minimum, by subtracting the observed difference between daily average and daily minimum dissolved oxygen from the model output. For Macoupin Creek, the diurnal variation in dissolved oxygen, as measured during the August 2005 field survey, was determined to be approximately 2 mg/l. The target used for modeling, therefore, equals 6.0 (5.0 mg/l plus half of the diurnal variation), to ensure that the 5.0 mg/l water quality standard is met.

4.3.2 Manganese

For Macoupin Creek (Segments IL_DA_04 and IL_DA_05), the target was set to the water quality criterion for total manganese of 1,000 ug/l.

5 DEVELOPMENT OF WATER QUALITY MODELS

Water quality models are used to define the relationship between pollutant loading and the resulting water quality. The dissolved oxygen TMDLs are based on the QUAL2E model. The TMDL for manganese apples the Load Duration Curve approach in conjunction with a load capacity calculation. The development of these approaches is described in the following sections, including information on:

- Model selection
- Modeling approach
- Model inputs
- Model calibration/analysis

5.1 QUAL2E MODEL

The QUAL2E water quality model was used to define the relationship between external oxygen-demanding loads and the resulting concentrations of dissolved oxygen in Macoupin Creek. QUAL2E is a one-dimensional stream water quality model applicable to dendritic, well-mixed streams. It assumes that the major pollutant transport mechanisms, advection and dispersion, are significant only along the main direction of flow. The model allows for multiple waste discharges, water withdrawals, tributary flows, and incremental inflows and outflows.

5.1.1 Model Selection

A detailed discussion of the model selection process for the Macoupin Creek watershed is provided in the Stage 1 Report.

Of the models discussed, the QUAL2E model (Brown and Barnwell, 1987) was selected to address dissolved oxygen impairments in Macoupin Creek. QUAL2E was selected for dissolved oxygen modeling because it is the most commonly used water quality model for addressing low flow conditions. Because problems are restricted to low flow conditions, watershed loads are not expected to be significant contributors to the impairment during low flow periods. For this reason, an empirical approach was selected for determining watershed loads.

5.1.2 Modeling Approach

The approach selected for the dissolved oxygen TMDL is based upon discussions with IEPA and their Scientific Advisory Committee. The approach consists of using existing empirical data to define current loads to the creek, and using the QUAL2E model to define the extent to which loads must be reduced to meet water quality standards. This is the recommended approach presented in the detailed discussion of the model selection process provided in the Stage 1 Report. The dominant land use in the watershed is agriculture. Implementation plans for nonpoint sources will consist of voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, which required little additional data collection and was conducted over a relatively short time period, will expedite these implementation efforts.

Determination of existing loading sources and prioritization of restoration alternatives may be conducted by local experts as part of the implementation process (see Section 8). Based upon their recommendations, a voluntary implementation plan could be developed that includes both accountability and the potential for adaptive management.

5.1.3 Model Inputs

This section provides an overview of the model inputs required for QUAL2E application, and how they were derived. The following categories of inputs are required for QUAL2E:

- Model options (title data)
- Model segmentation
- Hydraulic characteristics
- Initial conditions
- Incremental inflow conditions
- Point source loads

5.1.3.1 Model options

This portion of the input file defines the specific water quality parameters to be simulated. QUAL2E was set up to simulate biochemical oxygen demand, the nitrogen series, and dissolved oxygen.

5.1.3.2 Model Segmentation

The QUAL2E model divides the river being simulated into discrete segments (called "reaches") that have constant channel geometry and hydraulic characteristics. Reaches are further divided into "computational elements", which define the interval at which results are provided. The Macoupin Creek QUAL2E model consists of twelve reaches, which are comprised of a varying number of computational elements. Computational elements have a fixed length of 0.4 miles. Model segmentation is presented below in Table 1. The modeled portion of Macoupin Creek extended beyond the lower boundary of impaired segment DA_04 to incorporate an IEPA monitoring location in segment DA_03; this location was also monitored during the field surveys, and thus was included in the model.

Table 1. QUAL2E Segmentation

Reach	River miles	Number of computational elements	Other features
1	64.0 – 57.6	16	
2	57.6 – 51.6	15	
3	51.6 – 44.4	18	Horse Creek W.; Horse Creek E.
4	44.4 – 37.2	18	Shaw Point Branch
5	37.2 – 30.4	17	
6	Briar Creek	7	
7	Briar Creek	3	Carlinville STP
8	30.4 – 24.0	16	Junction with Briar Creek
9	24.0 – 20.0		Honey Creek End of DA_05
10	20.0 – 16.0		
11	16.0 – 8.0	20	Coop Branch
12	8.0 – 0.0	20	Hodges Creek (segment extends past DA_04 to include monitoring point in DA_03)

5.1.3.3 Hydraulic Characteristics

A functional representation was used to describe the hydraulic characteristics of the system. For each reach, velocity and depth were specified, based on measurements taken during the two field surveys.

5.1.3.4 Initial Conditions

Initial model conditions were based on field observations taken during the two surveys.

5.1.3.5 Incremental Inflow Conditions

Incremental inflows were not included in the model. Flows during the two surveys were extremely low, and incremental inflows were determined to be insignificant.

5.1.3.6 Point Source Loads

The only point source included in the model was the Carlinville STP discharge. Most of the other NPDES permitted discharges in the watershed are very small and many are not continuous discharges. Tributaries with observed flow during the field surveys were included as point source inputs. These included Horse Creek West, Horse Creek East, Shaw Point Branch, Honey Creek, and Hodges Creek.

5.1.4 QUAL2E Calibration

QUAL2E model calibration consisted of:

1. Applying the model with all inputs specified as above
2. Comparing model results to dissolved oxygen data collected during two surveys
3. Adjusting model coefficients to provide the best comparison between model predictions and observed dissolved oxygen data.

The QUAL2E dissolved oxygen calibration for the entire length of Macoupin Creek (Segments DA_04 and DA_05) is discussed below.

The QUAL2E model was initially applied with the model inputs as specified above. Observed data for two dry weather surveys were used for calibration purposes. These surveys were conducted on August 23, 2005 and October 11, 2005.

QUAL2E was calibrated to match the observed dissolved oxygen concentrations measured along the mainstem of the creek. Model reaction rate coefficients (BOD decay rate coefficient, rate coefficient for ammonia oxidation, and reaeration rate) were adjusted during the calibration process to provide a reasonable match between model results and data collected during the two field surveys.

The resulting dissolved oxygen predictions compared well to the measured concentrations, as shown in Figure 2. This comparison represents an acceptable model calibration. Model verification was completed using the data collected during the second field survey. Again, the resulting dissolved oxygen predictions compared well to the measured concentrations (Figure 3). A complete listing of all the observed data used for calibration and verification purposes, as well as a comparison between model predictions and observed data, is provided in Attachment1 and the Stage 2 Data Report.

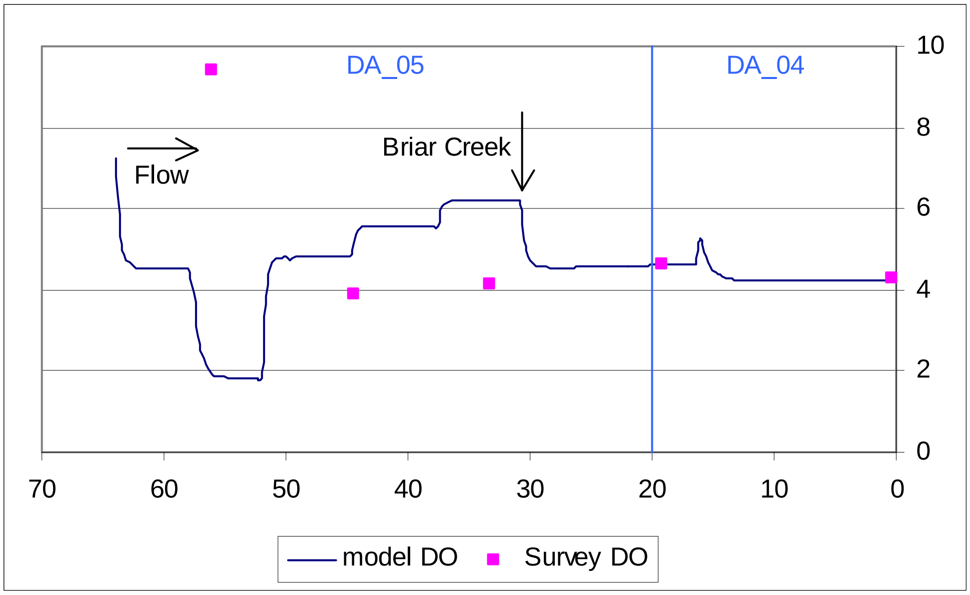

Figure 2. Model Calibration Results for August 2005 Survey Data

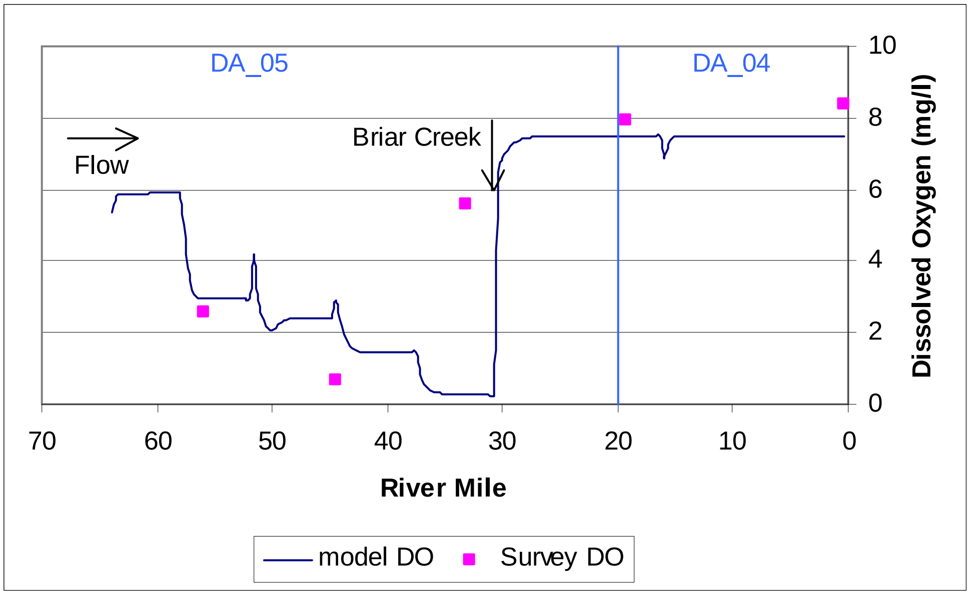

Figure 3. Model Verification Results for October 2005 Survey Data

5.2 MANGANESE ANALYSIS

A load capacity analysis and empirical approach were used to assess manganese for Macoupin Creek. The available data on observed manganese load were compared to the assimilative capacity of Macoupin Creek to determine the level of reduction needed to meet the water quality standard. An empirical approach was used for Segment DA_05 due to the sparse data set, while a load-duration curve was developed for Segment DA_04, for which more data were available. A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

5.2.1 Model Selection

A detailed discussion of the model selection process for Macoupin Creek is provided in the Stage 1 Report. The load capacity approach was selected because it is a simpler approach that can be supported with the available data and still support the selected level of TMDL implementation for this TMDL. The load-duration curve approach identifies broad categories of manganese sources and the extent of control required from these source categories to attain water quality standards; the empirical approach used for Segment DA_05 also identifies the extent of control needed to meet water quality standards.

5.2.2 Approach

A load duration curve was developed for Segment DA_04. The load duration curve approach uses stream flows and observed concentrations for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results in what is called a flow duration curve; 2) translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. A more complete description of the load duration curve approach is provided in the Stage 1 Report.

An empirical approach was used for Segment DA_05, due to the sparse data set. The level of reduction needed was determined based on the extent to which observed manganese concentrations exceeded the water quality criterion.

5.2.3 Data inputs

This section describes the flow and water quality data used to support development of the load duration curve for total manganese in Segment DA_04.

5.2.3.1 Flow

Daily average flows measured at the USGS gage on Macoupin Creek near Kane, IL (Station 05587000) were used in the analysis. Flows at this gage are available for the period 1921 through 2005 (the last year of data are listed as "provisional" as they have not yet received final USGS approval). This station is located downstream of Segment DA-04, so the flows measured at Kane were adjusted for the size of the drainage area (i.e., they were multiplied by 0.34 because the watershed for IL_DA-04 is 66% smaller than the watershed for the Kane gage).

5.2.3.2 Manganese

Total manganese data collected by IEPA as part of their ambient water quality monitoring program between 1990 and 2005 were used in the analysis. Total manganese data collected by Limno-Tech, Inc. during the 2005 dry weather surveys were also used in the analysis. All available data were used. In total, 94 samples were available for Segment DA_04, while nine samples were available for Segment DA_05.

5.2.4 Analysis

A flow duration curve for Segment DA_04 was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for manganese for this segment was then generated by multiplying the flows in the duration curve by the water quality standard of 1,000 ug/l for total manganese. The load duration curve is shown with a solid line in Figure 4. Observed pollutant loads of manganese were calculated using available concentration data paired with corresponding flows, and were plotted on the same graphs. The worksheet for this analysis is provided in Attachment 2.

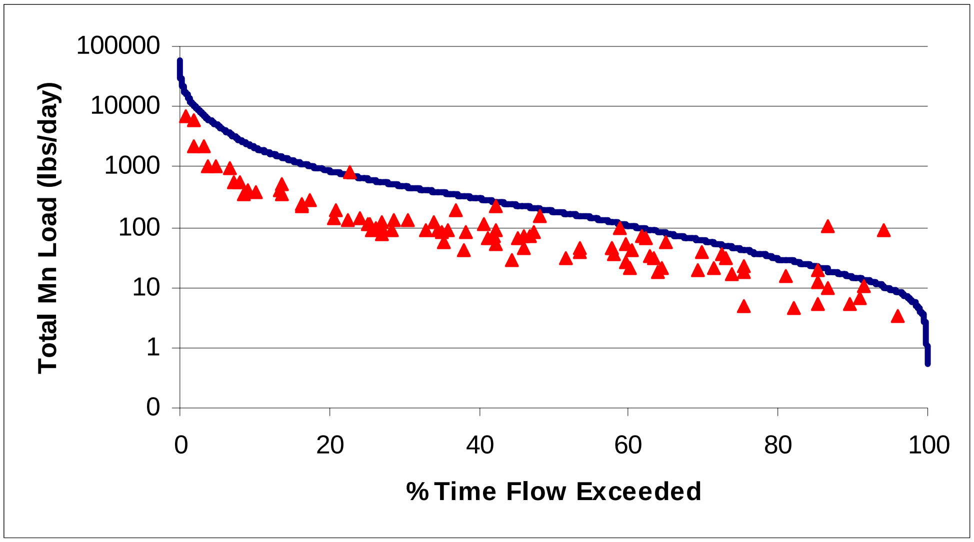

Figure 4. Load Duration Curve for Manganese with Observed Loads (triangles)

The load duration curve shows that the most significant exceedances of the water quality standard occurred under low flow conditions, suggesting that natural sources (soils and groundwater) are the primary cause of the observed impairment.

For Segment DA_05, insufficient data were available to develop a load-duration curve. Only nine sample results were available for this segment, collected at four different locations. There was no apparent relationship between manganese concentration and stream flow, as shown in Figure 5. Because of the limited data set, a simple empirical approach was employed. The load reduction needed to meet the water quality target was determined by averaging the samples that exceeded the target, and calculating the necessary reduction using that average exceedance concentration.

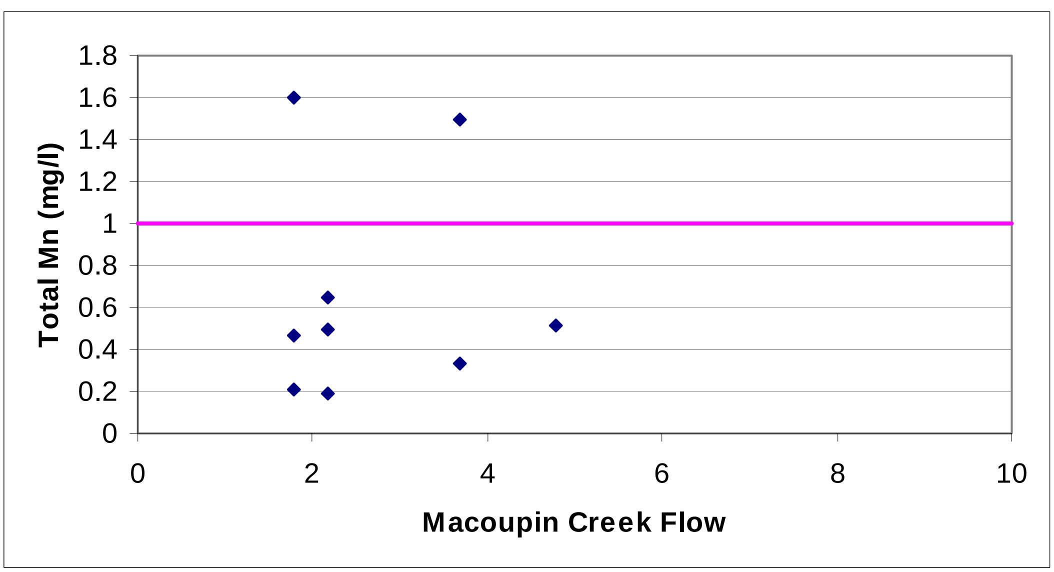

Figure 5. Manganese Concentrations in Segment DA_05

6 TMDL DEVELOPMENT

This section presents the development of the total maximum daily load for the Macoupin Creek watershed for dissolved oxygen and manganese. Included in this section are descriptions of how the total loading capacity was calculated, and a discussion on how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 DISSOLVED OXYGEN TMDL

A dissolved oxygen TMDL was developed for both segments of Macoupin Creek. The specific steps followed in developing this TMDL are described below.

6.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The first step in determining the loading capacity was to reduce external sources of oxygen-demanding substances (BOD and ammonia) to determine whether these reductions would result in the river attaining the TMDL target of 5.0 mg/l. QUAL2E simulations showed that, even with external loads set to zero, compliance with the dissolved oxygen standards was not attained. Examination of model results indicated that sediment oxygen demand (SOD) was the dominant source of the oxygen deficit, and that DO standards could only be attained via reduction of SOD[1]. To determine the loading capacity, QUAL2E model was run repeatedly, uniformly reducing SOD until model results demonstrated attainment of TMDL targets. The maximum SOD that results in compliance with water quality standards was used as the basis for determining the creek's loading capacity.

Model simulations determined that it was necessary to reduce sediment oxygen demand by 84% to meet the TMDL target for dissolved oxygen. It is difficult to accurately predict the necessary reductions in organic solids necessary to achieve specific SOD reductions; however, a TMDL assessment of SOD reductions for a watershed in Michigan estimated that SOD rates would respond proportionally to reductions in total suspended solids (TSS) loads (Suppnick, 1992). This response appears reasonable if the appropriate solids are targeted for reduction. As such, a 84% reduction of particulate organic carbon loading to the stream (which occurs primarily during higher flow periods), is required.

Model results were used to calculate the TMDL load allocation (Tables 2 through 5), which is a component of the loading capacity. The load capacity was calculated as the sum of the load allocation, the wasteload allocation for point sources, and the margin of safety, which are described in the next section.

[1] Although SOD is the dominant source of the oxygen deficit, the true cause of low dissolved oxygen is a lack of base flow (which greatly exacerbates the effect of SOD). Because TMDLs cannot be written to control flow, the focus of this TMDL was instead on SOD, as its effect on dissolved oxygen is dominant under low flow conditions.

6.1.2 Allocation

A TMDL consists of point source/wasteload allocations (WLAs), nonpoint sources/load allocations (LAs), and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

The following section presents the allocations for Macoupin Creek Segments DA_04 and DA_05.

6.1.2.1 Macoupin Creek (DA_04)

Point source discharges to segment DA_04 were determined not to contribute significantly to low dissolved oxygen during critical periods when low dissolved oxygen is observed. The two point sources that discharge to this segment, Shipman STP (IL0063088) and Royal Lakes STP (IL0071391), are small facilities that discharge to unnamed tributaries of Coop Branch, in which no flow was observed during the field surveys. Because of their negligible contribution, the WLAs for these discharges were not calculated.

The load allocation was calculated for nonpoint sources under low flow conditions because this is the period when dissolved oxygen problems have been observed. The load allocation representing low flow periods was based on the estimated tributary inflow to segment DA_04 and measured concentrations, because these are considered background conditions and do not significantly contribute to dissolved oxygen problems. The load allocations presented below in Tables 2 and 3 were reduced by 10%, which was designed to serve as a margin of safety (discussed below). The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall oxygen demand.

Table 2. CBOD5 Allocation for Segment DA_04[1]

Loading Capacity (lb/day)	Load Allocation (lb/day)	Margin of Safety (lb/day)
0.011	0.01	0.001

[1]WLA was not calculated [1]

Table 3. Ammonia Allocation for Segment DA_04[1]

Loading Capacity (lb/day)	Load Allocation (lb/day)	Margin of Safety (lb/day)
0.00066	0.0006	0.00006

[1]WLA was not calculated

6.1.2.2 Macoupin Creek (DA_05)

Point source discharges to segment DA_05 were determined not to contribute significantly to low dissolved oxygen. Most of the point sources that discharge to this segment, including the Farmersville (ILG580126) and Nilwood (ILG580090) STPs and the Beaver Dam State Park Shower facility (IL0069175), are small facilities that discharge only intermittently (design average flows 0.125, 0.049, and 0.0024, respectively). The Farmersville STP is a lagoon system that does not discharge during dry weather; it was not discharging at the time that violations of water quality criteria were observed in Segment DA_05 during the 2005 field monitoring. The Nilwood STP is located on a tributary to Macoupin Creek, a substantial distance from the mainstem, and IEPA records indicate that it discharges only approximately four times per year. The State Park shower discharge is located downstream of the observed violations of the dissolved oxygen criteria and is therefore not believed to contribute to observed low D.O. Because of their negligible contribution, the WLA for these discharges were not calculated.

The Carlinville STP (IL0022675) is by far the largest point source, discharging to Briar Creek with a design average flow of 1.5 mgd. This discharge substantially increases the flow in Macoupin Creek under critical conditions, and the QUAL2E model demonstrated that the increased flow improved dissolved oxygen in the creek, despite the BOD load from the STP. Carlinville STP loads do not contribute to low D.O. in Macoupin Creek, so the WLA for this facility was not calculated.

In addition to the point source discharges described above, the Carlinville STP also has a permit for two combined sewer overflows (CSOs) that may discharge under wet weather conditions. Because low dissolved oxygen is a low flow problem and CSOs discharge during wet weather, the WLA for the CSOs was not calculated.

The load allocation was calculated for nonpoint sources under low flow conditions because this is the period when dissolved oxygen problems have been observed. The load allocation during low flow periods was based on the estimated tributary inflow to segment DA_04 and measured concentrations, because these are considered background conditions and do not significantly contribute to low dissolved oxygen. The load allocations presented below in Tables 4 and 5 were reduced by 10%, which was designed to serve as a margin of safety (discussed below). The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall oxygen demand.

Table 4. CBOD5 Allocation for Segment DA_05[1]

Loading Capacity (lb/day)	Load Allocation (lb/day)	Margin of Safety (lb/day)
0.05	0.045	0.005

[1] WLA was not calculated

Table 5. Ammonia Allocation for Segment DA_05[1]

Loading Capacity (lb/day)	Load Allocation (lb/day)	Margin of Safety (lb/day)
0.0022	0.002	0.0002

[1] WLA was not calculated

6.1.3 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. A review of available dissolved oxygen data for Macoupin Creek showed that low dissolved oxygen occurs during low flow conditions. To effectively consider critical conditions, this TMDL is based upon the flows measured during the October 2005 low flow survey (0.76 cfs at the most downstream location) and temperatures measured during the warmer August 2005 survey.

6.1.4 Seasonality

The TMDL was conducted with an explicit consideration of seasonal variation. A range of flow conditions that are expected to be observed throughout the year was evaluated, including low flow periods when dissolved oxygen is typically the lowest. It was determined that low dissolved oxygen is only a problem under low flow conditions, and thus the TMDL is only expressed for low flows. Furthermore, this TMDL requires an 84% reduction in watershed loadings of particulate organic carbon, which are expected to be delivered to the stream during wet weather conditions.

6.1.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The dissolved oxygen TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the QUAL2E water quality model predicted values and the observed values. In particular, model predictions of dissolved oxygen concentrations correctly predict the presence of standards violations for all six measured violations across two surveys. The average error in predicted dissolved oxygen concentration is less than 0.85 mg/l. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit CBOD5 and ammonia loads allocated to the margin of safety were presented in Tables 2 through 5.

6.2 MANGANESE TMDL

A load capacity calculation approach was applied to support development of a manganese TMDL for Macoupin Creek.

6.2.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected flows for the watershed. The allowable loading capacity was computed by multiplying flow at the downstream end of each segment by the manganese water quality standard (1,000 ug/l). The manganese loading capacity is presented in Table 6.

Table 6. Macoupin Creek Manganese Loading Capacity

DA_04 Flow (cfs)	DA_04 Load Capacity (lb/day)
5	27.0
10	53.9
20	107.9
50	269.7
100	539.4
200	1,078.7
400	2,157.5
1000	5,393.7

DA_05 Flow (cfs)	DA_05 Load Capacity (lb/day)
3	17.3
6	34.5
13	69.0
32	172.6
64	345.2
128	690.4
256	1,380.8
640	3,451.9

For Segment DA_04, the mean of the manganese exceedances observed under low flow conditions was calculated and compared to the 1,000 ug/l standard for aquatic life, to estimate the percent reduction needed. For Segment DA_05, the mean of the two manganese exceedances was calculated and compared to the 1,000 ug/l standard to determine the reductions needed. These results are presented for both segments of Macoupin Creek (Table 7). Because point sources are not believed to be significant contributors to manganese levels, the reductions presented in Table 7 apply solely to nonpoint sources.

Table 7. Manganese Reductions for Macoupin Creek

Segment	Average concentration of samples exceeding target (ug/l)	Percent reduction needed
DA_04	1,550	35%
DA_05	7,300	86%

6.2.2 Allocation

A TMDL consists of wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

Point sources are not believed to contribute significantly to manganese concentrations in Macoupin Creek; high manganese levels in local soils has been identified as the primary source. A WLA thus did not need to be calculated.

With no WLA, the full loading capacity is given to the load allocation for nonpoint sources and to the margin of safety, as presented in Tables 8 and 9. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall manganese load.

Table 8. Manganese TMDL for Segment DA_04[1]

DA_04 Flow (cfs)	DA_04 Load Capacity (lb/day)	Margin of Safety (10%)	Load Allocation (lb/day)
5	27.0	2.7	24.3
10	53.9	5.4	48.5
20	107.9	10.8	97.1
50	269.7	27.0	242.7
100	539.4	53.9	485.4
200	1,078.7	107.9	970.9
400	2,157.5	215.7	1,941.7
1000	5,393.7	539.4	4,854.3

[1] WLA was not calculated

Table 9. Manganese TMDL for Segment DA_05

DA_05 Flow (cfs)	DA_05 Load Capacity (lb/day)	Margin of Safety (10%)	Load Allocation (lb/day)
3	17.3	1.7	15.5
6	34.5	3.5	31.1
13	69.0	6.9	62.1
32	172.6	17.3	155.3
64	345.2	34.5	310.7
128	690.4	69.0	621.3
256	1,380.8	138.1	1,242.7
640	3,451.9	345.2	3,106.7

[1] WLA was not calculated

6.2.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

6.2.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The manganese standard will be met regardless of flow conditions in any season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in the creek.

6.2.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The manganese TMDL contains an explicit margin of safety of 10% to address potential uncertainty in the effectiveness of load reduction calculations. A relatively low margin of safety was chosen by IEPA because the load duration curve (LDC) analysis, used to develop the loadings, provides good information on the relationship between pollutant loadings and the receiving water quality. The LDC method has few assumptions in it, compared to more complex models. It provides a simple context for evaluating monitoring data across the entire range of flow conditions, thus reducing the uncertainty in the flows (and related loads). Since duration curves calculated loads at various flows and used the WQS as the TMDLs target, the method allowed IEPA to have a better understanding of when the exceedences occurred in the waterbody and under what conditions. This will help reduce uncertainty in the effectiveness of the implementation efforts, and the likelihood of meeting the appropriate WQS/designated use. This margin of safety can be reviewed in the future as new data are developed.

7 PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included numerous opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in Summer 2004 to notify stakeholders about the upcoming TMDLs, and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (see Stage 1 Report). As quarterly progress reports were produced during the first stage of the TMDL process, the Agency posted them to their website for public review.

In February 2005, a public meeting was announced for presentation of the findings of the first stage of the Macoupin Creek TMDL project, including the watershed characterization, model selection, and recommendations for additional data collection. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Monday, March 21, 2005 in Carlinville, Illinois at the Carlinville High School cafeteria. In addition to the meeting's sponsors, nine individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage One findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

In July 2006, a public meeting was announced for presentation of the Stage 3 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:00 pm on Tuesday, July 25, 2006 in Carlinville, Illinois at Carlinville City Hall. In addition to the meeting's sponsors, two individuals attended the meeting. Attendees registered and listened to a presentation on the Stage 3 findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

Illinois EPA will prepare another report that discusses implementation actions for the watershed. This report will be presented at another public meeting and will be posted on the IEPA website for review prior to the meeting. This implementation plan will describe effective and ongoing actions such as 319 watershed projects, conservation efforts, formation of a watershed group and other ways that local people can improve their waters. If you are not on the mailing list to receive notice of this meeting, please call or email Sarah Tadla (Illinois EPA) at (217) 782-5562, Sarah.Tadla@epa.state.il.us .

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8 ADAPTIVE IMPLEMENTATION PROCESS

The approach to be taken for TMDL implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lake can assimilate and still attain water quality standards
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. Finally, the adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps 1-3 correspond to TMDL development and have been completed, as described in Section 5 of this document. Steps 4 and 5 correspond to implementation.

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Attachment 1

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Attachment 2

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Data for Manganese Load Duration Curves

Macoupin Creek (DA_04) Flow (cfs)	% of Time Exceeded	Mn Load (lbs/day)
0.0	100.00	0.00
0.5	99.61	2.75
0.7	99.26	3.67
0.8	98.91	4.40
0.9	98.55	4.77
1.0	98.20	5.50
1.1	97.85	5.87
1.2	97.50	6.42
1.3	97.14	6.97
1.4	96.79	7.34
1.5	96.09	8.25
1.6	95.73	8.80
1.7	95.03	9.17
1.8	94.68	9.72
1.9	94.32	10.09
2.0	93.62	11.00
2.1	93.27	11.37
2.2	92.91	11.92
2.3	92.56	12.29
2.4	91.50	13.02
2.5	91.15	13.57
2.6	90.80	14.12
2.7	90.44	14.49
2.8	89.74	15.04
2.9	89.39	15.59
3.0	89.03	16.14
3.1	88.33	16.69
3.2	87.98	17.42
3.3	87.62	17.97
3.4	87.27	18.34
3.7	85.51	20.17
4.1	85.16	22.01
4.4	83.04	23.84
4.8	82.69	25.67
5.1	80.92	27.51
5.4	80.57	29.34
5.8	79.51	31.18
6.1	78.46	33.01
6.5	78.10	34.84
6.8	77.05	36.68
7.1	76.34	38.51
7.5	75.99	40.34
7.8	75.28	42.18
8.2	74.93	44.01
8.5	73.8716502	45.85
8.8	73.5190409	47.68
9.2	72.461213	49.51
9.5	72.1086037	51.35
9.9	71.7559944	53.18
10.2	71.0507757	55.02
10.5	70.3455571	56.85
10.9	69.9929478	58.68
11.2	69.6403385	60.52
11.6	69.2877292	62.35
11.9	68.9351199	64.18
12.2	67.877292	66.02
12.6	67.5246827	67.85
12.9	67.1720733	69.69

Observed Data

Date	Macoupin Creek (DA_04) Flow (cfs)	Manganese, total (ug/l)	Percentile	Mn Load (lb/day)
1/18/1990	4.76	180	82.0	4.6
2/27/1990	66.98	240	35.7	86.7
3/27/1990	59.84	260	38.2	83.9
5/10/1990	63.58	540	36.9	185.2
6/14/1990	76.16	210	32.8	86.3
7/17/1990	22.44	360	57.7	43.6
9/24/1990	14.62	730	64.9	57.6
10/25/1990	11.22	330	69.4	20.0
12/6/1990	102.00	220	27.1	121.0
1/7/1991	190.40	270	17.5	277.3
2/19/1991	265.20	250	13.7	357.6
3/21/1991	1190.00	160	3.6	1027.0
5/8/1991	149.94	240	20.9	194.1
6/10/1991	22.10	300	58.0	35.8
7/10/1991	15.98	360	63.4	31.0
8/29/1991	36.72	770	48.2	152.5
10/7/1991	15.64	210	63.8	17.7
11/20/1991	132.60	1100	22.8	786.7
1/8/1992	30.94	190	51.6	31.7
2/20/1992	94.86	250	28.6	127.9
3/26/1992	95.54	170	28.3	87.6
6/9/1992	19.04	410	60.3	42.1
7/21/1992	7.48	540	75.5	21.8
8/18/1992	3.74	590	85.3	11.9
9/30/1992	1.53	410	96.1	3.4
4/8/1993	107.10	170	26.3	98.2
5/20/1993	110.84	150	25.7	89.7
6/24/1993	70.04	230	34.6	86.9
8/5/1993	68.00	150	35.3	55.0
9/23/1993	2947.80	430	0.9	6836.7
2/22/1994	121.04	210	24.2	137.1
3/21/1994	85.34	280	30.4	128.9
5/4/1994	445.40	170	9.0	408.4
6/2/1994	72.08	320	34.0	124.4
7/18/1994	8.84	630	73.0	30.0
8/31/1994	20.74	850	58.9	95.1
9/22/1994	2.41	800	91.4	10.4
11/1/1994	17.00	720	62.2	66.0
12/21/1994	40.80	330	45.9	72.6
1/26/1995	272.00	280	13.3	410.8
3/6/1995	510.00	210	8.1	577.7
3/29/1995	112.20	190	25.5	115.0
5/17/1995	1961.80	560	1.8	5925.5
7/20/1995	16.66	370	62.8	33.2
9/18/1995	5.10	570	80.9	15.7
10/31/1995	3.74	940	85.3	19.0
12/27/1995	8.50	350	73.7	16.0
1/25/1996	209.44	210	16.2	237.2
2/14/1996	38.08	400	47.4	82.2
35138	69.02	220	34.9	81.9
5/6/1996	1285.2	310	3.3	2148.9
6/27/1996	28.56	250	53.5	38.5
7/23/1996	49.64	260	42.0	69.6
3/25/1997	102	180	27.1	99.0
35537	39.1	340	46.9	71.7
36194	479.4	140	8.5	362.0

Data for Manganese Load Duration Curves

Macoupin Creek (DA_04) Flow (cfs)	% of Time Exceeded	Mn Load (lbs/day)					
13.3	66.819464	71.52	36235	102.34	140	27.0	77.3
13.6	66.1142454	73.35	36262	113.9	180	25.2	110.6
13.9	65.7616361	75.19	5/25/1999	60.18	130	38.0	42.2
14.3	65.4090268	77.02	7/7/1999	19.72	240	59.7	25.5
14.6	65.0564175	78.86	8/30/1999	3.74	260	85.3	5.2
15.0	64.7038082	80.69	9/27/1999	2.584	490	90.8	6.8
15.3	64.3511989	82.52	11/3/1999	3.4	5500	86.5	100.9
15.6	63.9985896	84.36	36502	7.48	430	75.5	17.3
16.0	63.6459803	86.19	36551	1.87	9100	94.2	91.8
16.3	63.2933709	88.02	6/5/2000	19.72	500	59.7	53.2
16.7	62.9407616	89.86	7/31/2000	918	200	4.9	990.3
17.0	62.235543	91.69	36768	43.86	120	44.5	28.4
17.7	61.8829337	95.36	9/21/2000	14.96	260	64.5	21.0
18.0	61.5303244	97.19	12/20/2000	51	230	41.2	63.3
90.4	29.4111425	487.80	1/25/2001	49.3	190	42.1	50.5
92.8	29.0585331	500.64	3/7/2001	151.98	170	20.7	139.4
94.2	28.7059238	507.97	36993	656.2	270	6.7	955.6
95.5	28.3533145	515.31	37042	134.64	180	22.6	130.7
97.9	28.0007052	528.15	37074	52.7	390	40.6	110.9
100.3	27.6480959	540.98	37103	7.48	120	75.5	4.8
102.0	27.2954866	550.15	37152	49.3	820	42.1	218.0
102.7	26.9428773	553.82	11/6/2001	17.68	740	61.7	70.6
105.4	26.590268	568.49	37238	265.2	360	13.7	514.9
107.4	26.2376587	579.49	37280	42.16	280	45.2	63.7
109.5	25.8850494	590.50	37326	584.8	170	7.3	536.2
112.2	25.5324401	605.17	4/8/2002	387.6	180	10.0	376.3
114.6	25.1798307	618.00	5/16/2002	1958.4	210	1.9	2218.2
117.6	24.8272214	634.51	7/9/2002	28.56	290	53.5	44.7
119.3	24.4746121	643.68	8/12/2002	22.44	360	57.7	43.6
122.1	24.1220028	658.35	37518	10.88	640	69.8	37.6
125.1	23.7693935	674.85	37557	19.38	200	60.1	20.9
127.5	23.4167842	687.69	37600	9.86	400	71.5	21.3
130.6	23.0641749	704.20	37651	9.18	700	72.5	34.7
134.0	22.7115656	722.53	37685	40.8	210	45.9	46.2
136.0	22.3589563	733.54	37718	48.96	350	42.2	92.4
139.1	22.006347	750.04	37763	210.12	200	16.2	226.7
142.8	21.6537377	770.21	38587	3.4	520	86.5	9.5
145.9	21.3011283	786.72	38636	2.788	340	89.7	5.1
149.6	20.948519	806.89					
153.0	20.5959097	825.23					
156.4	20.2433004	843.57					
159.8	19.8906911	861.91					
164.2	19.5380818	885.75					
168.6	19.1854725	909.59					
172.4	18.8328632	929.76					
176.8	18.4802539	953.60					
181.6	18.1276446	979.27					
186.3	17.7750353	1004.95					
192.1	17.422426	1036.12					
198.2	17.0698166	1069.13					
203.7	16.7172073	1098.47					
207.4	16.364598	1118.64					
214.5	16.0119887	1157.15					
221.0	15.6593794	1192.00					
227.8	15.3067701	1228.67					
235.3	14.9541608	1269.02					
242.1	14.6015515	1305.70					
250.2	14.2489422	1349.71					
259.1	13.8963329	1397.39					
268.3	13.5437236	1446.90					

Data for Manganese Load Duration Curves

Macoupin Creek (DA_04) Flow (cfs)	% of Time Exceeded	Mn Load (lbs/day)
277.8	13.1911142	1498.25
288.0	12.8385049	1553.26
298.5	12.4858956	1610.11
306.0	12.1332863	1650.46
319.6	11.780677	1723.81
330.8	11.4280677	1784.33
340.0	11.0754584	1833.84
353.6	10.7228491	1907.20
370.6	10.3702398	1998.89
391.0	10.0176305	2108.92
408.0	9.66502116	2200.61
428.4	9.31241185	2310.64
448.8	8.95980254	2420.67
472.6	8.60719323	2549.04
503.2	8.25458392	2714.09
530.4	7.90197461	2860.79
561.0	7.5493653	3025.84
598.4	7.19675599	3227.56
639.2	6.84414669	3447.62
680.0	6.49153738	3667.68
717.4	6.13892807	3869.41
775.2	5.78631876	4181.16
829.6	5.43370945	4474.57
887.4	5.08110014	4786.33
952.0	4.72849083	5134.76
1020.0	4.37588152	5501.53
1088.0	4.02327221	5868.29
1183.2	3.67066291	6381.77
1281.8	3.3180536	6913.58
1394.0	2.96544429	7518.75
1543.6	2.61283498	8325.64
1727.2	2.26022567	9315.92
1921.0	1.90761636	10361.21
2169.2	1.55500705	11699.91
2522.8	1.20239774	13607.11
2971.6	0.84978843	16027.78
3706.0	0.49717913	19988.88
5406.0	0.14456982	29158.08

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Attachment 3

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Macoupin Responsiveness Summary

1. We face great loss of natural water supplies, and pollution of what is left if longwall mining is allowed in Illinois. What is EPA doing to combat mining pollution and water losses from mining, in Illinois? I know longwall mining has occurred in Macoupin Co. and Southern Illinois. I have a farm in Illinois where longwall mining has been proposed and I am seriously worried about the repercussions.

Response: For underground mining operations, whether they be longwall or conventional (room-and-pillar), Illinois EPA only permits the surface facilities of such operations. The actual underground mining operation is outside the scope of our authority as granted under 35 Ill. Adm. Code. Subtitle D (mining regulations). The underground mining operations are handled through a mining permit issued by Illinois Department of Natural Resources (IDNR)/Office of Mines and Minerals.

2. My research for a LUMP (Lands Unsuitable for Mining Petition) tells me of complete changes in watershed, and losses of waters in Southeastern Pennsylvania, and Ohio. Illinois is the heart of the breadbasket of the world. Why is EPA allowing destructive mining practices to remove a nonrenewable resource (coal) while destroying renewable resources (water and land)?

Response: As the permitting activities for actual mining operation fall outside of the regulatory scope of Illinois EPA, these impacts should be sent to the IDNR/ Office of Mines and Minerals.

3. Tributaries of Shoal Creek and Macoupin Creek supply water in pastures so farmers can raise livestock. These tributaries may be destroyed by longwall mining, causing billions of dollars damage in the next century, because livestock cannot be raised without water. Is EPA aware of its future damage? Has it happened in Macoupin County? If so, what is EPA doing about it?

Response: Longwall mining has been conducted under tributaries to Honey Creek in Macoupin County and Illinois EPA is not aware of any damage occurring to the streams.

4. Longwall mining, with its earthquake like damage, when 95 percent of the coal is removed, can damage dams on the four major lakes in Montgomery County, as well as farm ponds. Is the EPA aware of this type of damage in Macoupin County? How has it affected lakes in that area?

Response: Illinois EPA is not aware of this type of damage being caused by longwall mining in Macoupin County.

5. Bottomland is turned into wetlands by longwall mining because when that much coal is removed, the ground sinks four or five feet. Has that happened in Macoupin

County, and how has it affected the watershed? Has it happened in other counties where longwall mining is going on?

Response: Illinois EPA is not aware of any permanent damage done by longwall mining in Illinois.

6. Is there an increase in arsenic, mercury and sulfur in Macoupin County waterways, as has happened with longwall mining in Pennsylvania?

Response: Illinois EPA is not aware of any increase in arsenic, mercury and sulfur resulting from subsidence caused by longwall mining in Macoupin County.

7. Longwall mining, if it happens to 200,000 acres, which is the major part of the southern half of Montgomery County, will cause many tributaries of Shoal Creek to dry up. Has the EPA anticipated how this mining in Montgomery and Macoupin counties will eventually affect the Kaskaskia and the Mississippi Rivers?

Response: Illinois EPA is not aware of any streams in Illinois drying up as a result of longwall mining.

8. My LUMP has been turned down twice by Natural Resources Mining and Minerals because they say the Strip Mining Act of 1977 does not apply to "underground mining". I submitted it under the Bill of Rights, Amendment 1 of the U.S. Constitution...a citizen's right to petition the government for grievances, and it was turned down again. Is the EPA aware of where a citizen might submit a petition aimed at protecting the environment, especially the loss and pollution of water by longwall mining?

Response: The Surface Coal Mining Land Conservation and Reclamation Act, including provisions dealing with lands unsuitable for mining petitions, is administered by IDNR/Office of Mines and Minerals. Questions related to that Act are best directed to IDNR.

Macoupin Creek Watershed TMDL
Final Approved TMDL

Prepared for Illinois Environmental Protection Agency

September 2006

Macoupin Creek (IL_DA-04): Fecal Coliform

Carlinville Lake (IL_RDG): Total Phosphorus, Manganese

Beaver Lake Dam (IL_RDH): Total Phosphorus

Old Gillespie Lake (IL_SDT): Total Phosphorus, Manganese

New Gillespie Lake (IL_SDU): Total Phosphorus

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INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois recently issued the 2006 303(d) list, which is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for water bodies that are not meeting designated uses under technology-based controls. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and instream conditions. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (USEPA, 1991).

Macoupin Creek (IL_DA-04), Carlinville Lake (IL_RDG), Beaver Dam Lake (IL_RDH), Old Gillespie Lake (IL_SDT), and New Gillespie Lake (IL_SDU) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they have been targeted as high priority waterbodies for TMDL development. This document presents the TMDLs designed to allow these waterbodies to fully support their designated uses. The report covers each step of the TMDL process and is organized as follows:

- Problem Identification
- Required TMDL Elements
- Watershed Characterization
- Description of Applicable Standards and Numeric Targets
- Development of Water Quality Model
- TMDL Development
- Public Participation and Involvement
- Adaptive Implementation Process

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1 PROBLEM IDENTIFICATION

The impairments in waters of the Macoupin Creek Watershed addressed in this report are summarized below, with the parameters (causes) that they are listed for, and the impairment status of each designated use, as identified in the 303(d) list (IEPA, 2006). TMDLs are currently only being developed for pollutants that have numerical water quality standards. Those causes that are the focus of this report are shown in bold font. For Macoupin Creek, TMDLs for dissolved oxygen and manganese will be conducted in a separate TMDL report.

While TMDLs are currently only being developed for pollutants that have numerical water quality standards, many controls that are implemented to address TMDLs for these pollutants will reduce other pollutants as well. For example, any controls to reduce phosphorus loads from watershed sources (stream bank erosion, runoff, etc.) would also serve to reduce sediment loads to a lake (phosphorus is usually attached to the soil), as phosphorus Best Management Practices (BMPs) are often the same or similar to sediment BMPs. Furthermore, any reduction of phosphorus loads, either through implementation of watershed controls or dredging of lake sediments, is expected to work towards reducing algae concentrations, as phosphorus is the nutrient most responsible for limiting algal growth.

Macoupin Creek	
Assessment Unit ID	IL_DA-04
Length (miles)	19.74
Listed For	**Fecal coliform**, dissolved oxygen, manganese, sedimentation/siltation, total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (F), Primary contact (N), Secondary contact (X), Aesthetic quality (X)

[1]F = Fully supporting, N=not supporting, X= not assessed

Carlinville Lake	
Assessment Unit ID	IL_RDG
Size (Acres)	168
Listed For	**Manganese, total phosphorus**, total suspended solids, aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (X), Public and food processing water supplies (N), Primary contact (X), Secondary contact (X), Aesthetic quality (N),

[1]F=fully supporting, N=not supporting, X=not assessed

[2] Not a pollutant; listed in category 3

Beaver Dam Lake	
Assessment Unit ID	IL_RDH
Size (Acres)	56.5
Listed For	**Total phosphorus**, Aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (F), Primary contact (X), Secondary contact (X), Aesthetic quality (N)

[1]F=fully supporting, N=not supporting, X=not assessed

[2] Not a pollutant; listed in category 3

Old Gillespie Lake	
Assessment Unit ID	IL_SDT
Size (Acres)	71
Listed For	**Manganese, total phosphorus**, Total suspended solids, Aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (F), Public and food processing water supplies (N), Primary contact (X), Secondary contact (X), Aesthetic Quality (N)

[1]F=fully supporting, N=not supporting, X=not assessed

[2] Not a pollutant; listed in category 3

New Gillespie Lake	
Assessment Unit ID	IL_SDU
Size (Acres)	207
Listed For	**Total phosphorus**, Total suspended solids, Aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (F), Public and food processing water supplies (F), Primary contact (X), Secondary contact (X), Aesthetic quality (N)

[1]F=fully supporting, N=not supporting, X=not assessed

[2] Not a pollutant; listed in category 3

2 REQUIRED TMDL ELEMENTS

USEPA Region 5 guidance for TMDL development requires TMDLs to contain eleven specific components. Each of those components is summarized below, by waterbody.

Macoupin Creek (IL_DA-04)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Macoupin Creek, HUC 0713001201. The pollutant of concern addressed in this TMDL is fecal coliform. Potential sources contributing to the listing of Macoupin Creek include: runoff from pastureland and animal feeding operations, failing septic systems, and municipal point sources. Macoupin Creek is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006).

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 cfu/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml. For the Macoupin Creek TMDL for fecal coliform, the target is set at meeting 200 cfu/100 ml across the entire flow regime during May through October.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** A load capacity calculation was completed to determine the maximum fecal coliform loads that will maintain compliance with the fecal coliform target for May through October under a range of flow conditions:

Flow percentile range	Median Macoupin Creek Flow (cfs)	Load Capacity (cfu/day)
66 - 100	4.8	2.33E+10
33 - 66	34	1.68E+11
0-33	206	1.01E+12

4. **Load Allocations (LA):** Load allocations designed to achieve compliance with the above TMDL are calculated for the May-October period by the following equation:

$$\text{Load allocation} = \text{load capacity} - \text{MOS} - \Sigma\text{WLAs}$$

Flow percentile range	Median Macoupin Creek Flow (cfs)	Load Allocation (LA) (cfu/day)
66 - 100	4.8	9.34E+09
33 - 66	34	1.54E+11
0-33	206	9.85E+11

5. **Wasteload Allocations (WLA):** The WLA for the eight point source dischargers of fecal coliform in the Macoupin Creek (IL_DA-04) watershed was calculated from the current permitted flow and a fecal coliform concentration consistent with meeting the TMDL target (200 cfu/100 ml) (see Table 4 in Section 6.2.2), at the downstream end of the dischargers' exempted reaches. The WLA for these facilities equals 1.39E +10 cfu/day during periods of no CSO discharge. The Carlinville CSOs have a combined WLA of 7.49E+09 cfu/day during periods when the CSOs are discharging. This is calculated using average reported flow volumes per overflow event and a fecal coliform concentration consistent with the TMDL target (200 cfu/100 ml).
6. **Margin of Safety:** The TMDL contains an implicit margin of safety for fecal coliform, through the use of multiple conservative assumptions. The TMDL target (no more than 200 cfu/100 ml at any time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load.
7. **Seasonal Variation:** This TMDL was conducted with an explicit consideration of seasonal variation. The approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur at any given point in the season where the standard applies.
8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA has the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. The permit for the point source dischargers in the watershed will be modified if necessary as part of the permit review process (typically every 5 years) to ensure that they are consistent with the applicable wasteload allocation.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. Two public meetings were conducted in Carlinville, Illinois to present the Stage 1 watershed characterization work (March 2005) and Stage 3 TMDL findings (July 2006). One additional public meeting is planned to present the implementation plan.

Carlinville Lake (RDG)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Carlinville Lake, HUC 0713001201. The pollutants of concern addressed in this report are **manganese** and **total phosphorus**. Potential sources contributing to the listing of Carlinville Lake include: natural background and seasonal hypolimnetic anoxia for manganese, and agricultural runoff and seasonal hypolimnetic anoxia for total phosphorus. Carlinville Lake is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006).
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus** to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg-P/l. For the Carlinville Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

The water quality standard for **manganese** in Illinois waters designated as public and food processing water supplies is 150 ug/l. For the Carlinville Lake TMDL, the objective is to maintain hypolimnetic dissolved oxygen concentrations above zero, because the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to sediment oxygen demand resulting from the effects of nutrient enrichment, as there are no point source discharges to the lake. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is 191.3 kg-P/month (6.38 kg-P/day) between March 1 and August 31, with the total load not to exceed 1,147.8 kg phosphorus over this period.
4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is 172.17 kg-P/month (5.742 kg-P/day) for the period March 1 –August 31.
5. **Wasteload Allocations (WLA):** There are no point source dischargers in the Carlinville Lake watershed. The wasteload allocation does not need to be calculated.
6. **Margin of Safety:** The TMDL contains an explicit margin of safety of 10%, corresponding to 19.13 kg-P/month (0.638 kg-P/day). This value was set to reflect the uncertainty in the BATHTUB model predictions, as discussed in section 6.1.5.
7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus and manganese TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The March 1 –August 31 duration for the seasonal loading was determined based on a calculation of a phosphorus residence time in Carlinville Lake on the order of several weeks.
8. **Reasonable Assurances:** There are no permitted point sources in this watershed, so reasonable assurances for point sources are not discussed. In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:
    - Convene local experts familiar with nonpoint sources of pollution in the watershed

- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. Two public meetings were conducted in Carlinville, Illinois to present the Stage 1 watershed characterization work (March 2005) and Stage 3 TMDL findings (July 2006). One additional public meeting is planned to present the implementation plan.

Beaver Dam Lake (IL_RDH)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Beaver Dam Lake, HUC 0713001201. The pollutant of concern addressed in this TMDL is **total phosphorus**. Potential sources contributing to the listing of Beaver Dam Lake include: agricultural runoff and seasonal hypolimnetic anoxia. Beaver Dam Lake is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006).
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus** to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg-P/l. For the Beaver Dam Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is 2.35 kg/month (0.078 kg-P/day) between March 1 and August 31, with the total load not to exceed 14.1 kg over this period.

4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is 2.115 kg-P/month (0.070 kg-P/day) for the period March 1-August 31.
5. **Wasteload Allocations (WLA):** There are no point source dischargers in the Beaver Dam Lake watershed. The WLA does not need to be calculated.
6. **Margin of Safety:** The TMDL contains an explicit margin of safety of 10% for total phosphorus, corresponding to 0.235 kg-P/month (0.008 kg-P/day). This value was set to reflect the uncertainty in the BATHTUB model predictions, as discussed in section 6.1.5.
7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The March 1-August 31 duration for the seasonal loading was determined based on a calculation of a phosphorus residence time on the order of several months in Beaver Dam Lake.
8. **Reasonable Assurances:** There are no permitted point source dischargers in the Beaver Dam Lake watershed; therefore, reasonable assurances for point sources are not discussed.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:
   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.
9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report. As quarterly progress reports were produced, the Agency posted them to their website. Two public

meetings were conducted in Carlinville, Illinois to present the Stage 1 watershed characterization work (March 2005) and Stage 3 TMDL findings (July 2006). One additional public meeting is planned to present the implementation plan.

Old Gillespie Lake (IL_SDT)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Old Gillespie Lake, HUC 0713001201. The pollutants of concern addressed in this TMDL are **total phosphorus** and **manganese**. Potential sources contributing to the listing of Old Gillespie Lake include: natural background and seasonal hypolimnetic anoxia for manganese, and agricultural runoff, stream bank erosion, seasonal hypolimnetic anoxia, and failing septic systems for total phosphorus. Old Gillespie Lake is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006).
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus** to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg-P/l. For the Old Gillespie Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

   The water quality standard for **manganese** in Illinois waters designated as public and food processing water supplies is 150 ug/l. For the Old Gillespie Lake TMDL, the objective is maintenance of hypolimnetic dissolved oxygen concentrations above zero, because the only controllable source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to sediment oxygen demand resulting from the effects of nutrient enrichment, as there are no point source discharges to the lake. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is 16.32 kg-P/month (0.544 kg-P/day) between March 1 and August 31, with the total load not to exceed 97.9 kg over this period.
4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is 14.69 kg-P/month (0.49 kg-P/day) for the period March 1-August 31.

5. **Wasteload Allocations (WLA):** There are no point source dischargers in the Old Gillespie Lake watershed. The WLA does not need to be calculated.
6. **Margin of Safety:** The TMDL contains an explicit margin of safety of 10% for total phosphorus, corresponding to 1.632 kg-P/month (0.054 kg-P/day). This value was set to reflect the uncertainty in the BATHTUB model predictions, as discussed in section 6.1.5.
7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The March 1-August 31 duration for the seasonal loading was determined based on a calculation of a phosphorus residence time on the order of weeks to months in Old Gillespie Lake.
8. **Reasonable Assurances:** There are no permitted point source dischargers in the Old Gillespie Lake watershed, therefore reasonable assurances for point sources are not discussed.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:
   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.
9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. Two public meetings were conducted in Carlinville, Illinois to present the Stage 1 watershed characterization work (March 2005) and Stage 3 TMDL findings (July 2006). One additional public meeting is planned to present the implementation plan.

New Gillespie Lake (SDU)

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** New Gillespie Lake, HUC 0713001201. The pollutant of concern addressed in this TMDL is **total phosphorus**. Potential sources contributing to the listing of New Gillespie Lake include: agricultural runoff, seasonal hypolimnetic anoxia, stream bank erosion, and failing septic systems. New Gillespie Lake is reported on the 2006 303(d) list as being in category 5, meaning available data and/or information indicate that at least one designated use is not being supported or is threatened, and a TMDL is needed (IEPA, 2006).
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus** to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg-P/l. For the New Gillespie Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.
3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the maximum phosphorus load that will maintain compliance with the phosphorus standard is 91.18 kg/month (3.04 kg/day) between March 1 and August 31, with the total load not to exceed 547.1 kg over this period.
4. **Load Allocations (LA):** The Load Allocation designed to achieve compliance with the above TMDL is 82.06 kg-P/month (2.74 kg-P/day) for the period March 1-August 31.
5. **Wasteload Allocations (WLA):** There are no point source dischargers in the New Gillespie Lake watershed. The WLA does not need to be calculated.
6. **Margin of Safety:** The TMDL contains an explicit margin of safety of 10% for total phosphorus, corresponding to 9.118 kg-P/month (0.304 kg-P/day). This value was set to reflect the uncertainty in the BATHTUB model predictions, as discussed in section 6.1.5.
7. **Seasonal Variation:** The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The April-August duration for the seasonal loading was determined based on a calculation of a phosphorus residence time on the order of weeks to months in New Gillespie Lake.
8. **Reasonable Assurances:** There are no NPDES permitted dischargers in the New Gillespie Lake watershed and so reasonable assurances for point sources are not discussed.

   In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability.

Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report.

9. **Monitoring Plan to Track TMDL Effectiveness:** A monitoring plan will be prepared as part of the implementation plan.
10. **Transmittal Letter:** A transmittal letter has been prepared and is included with this TMDL.
11. **Public Participation:** Numerous opportunities were provided for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in summer 2004 to gather and share information and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (listed in the Stage 1 Report). As quarterly progress reports were produced, the Agency posted them to their website. Two public meetings were conducted in Carlinville, Illinois to present the Stage 1 watershed characterization work (March 2005) and Stage 3 TMDL findings (July 2006). One additional public meeting is planned to present the implementation plan.

3 WATERSHED CHARACTERIZATION

A description of the Macoupin Creek watershed to support the identification of sources contributing to the listed impairments is provided in the Stage 1 Report. The watershed characterization is discussed in the First Quarterly Progress Report. Watershed characterization activities were focused on gaining an understanding of key features of the watershed, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges and watershed activities.

The impaired waterbodies addressed in this report are in the Macoupin Creek watershed, located in West-Central Illinois approximately 45 miles south of Springfield, Illinois. The creek extends through four counties, but most of the watershed is located in Macoupin County. Macoupin Creek extends from its point of origin southeast of Farmersville to its confluence with the Illinois River, but the impaired segments that are addressed in this report are at the upstream end of the watershed. Figure 1 shows a map of the watershed, and includes key features such as waterways, impaired waterbodies, and public water intakes. The map also shows the locations of point source discharges that have a permit to discharge under the National Permit Discharge Elimination System (NPDES).

Macoupin Creek Segment IL_DA-04 is 19.74 miles in length and its subwatershed is 256,854 acres in size. Carlinville Lake is located in Macoupin County and it is 168 acres in size. Its subwatershed is 15,136 acres in size. Beaver Dam Lake, located in Macoupin County, is small (49 acres) and shallow (approximately 10 feet deep). The lake’s watershed is small, about 185 acres in size. Old Gillespie Lake is located in Macoupin County and it is 71 acres in size. New Gillespie Lake is located in Macoupin County and it is 207 acres in size.

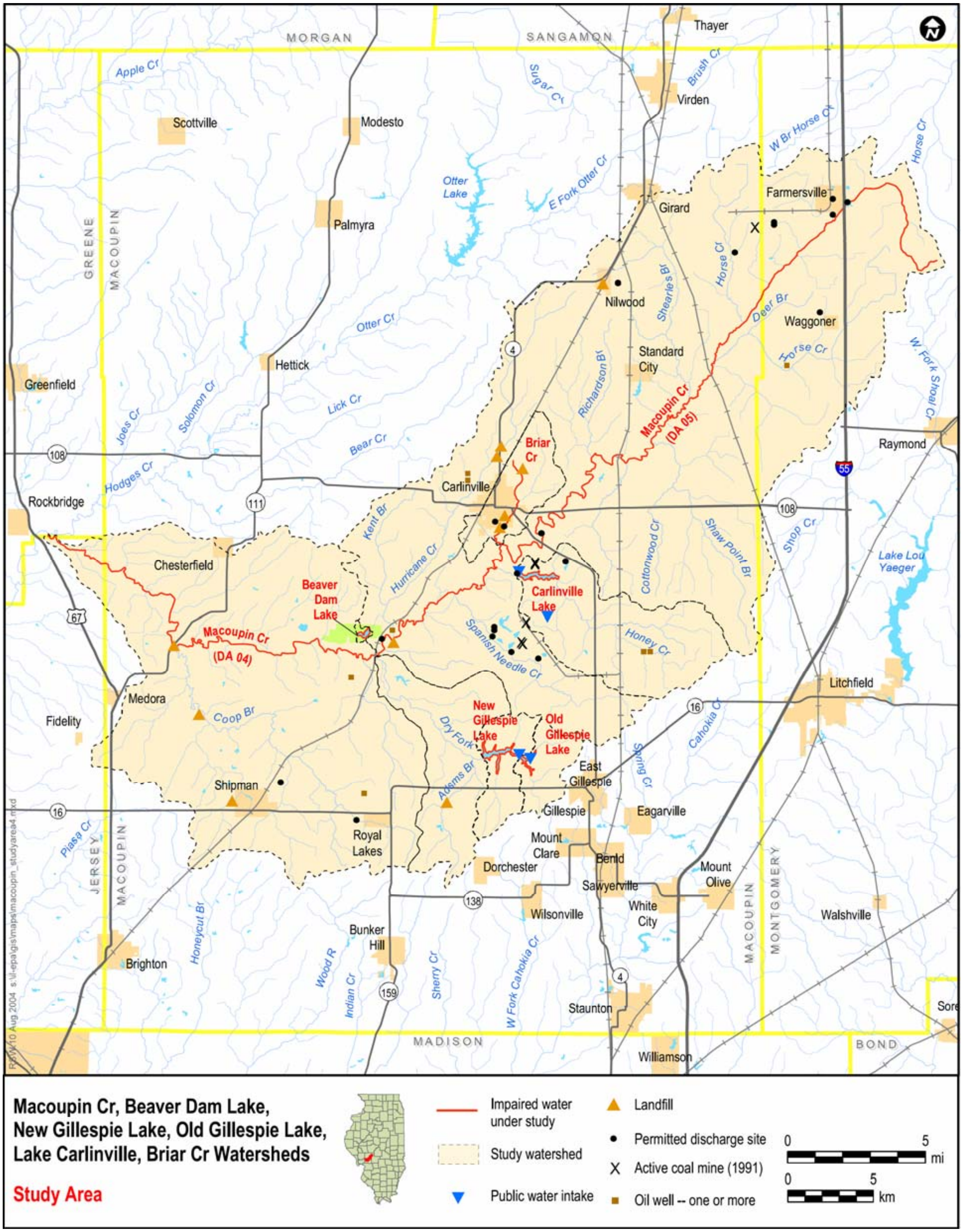

Figure 1. Base Map of Macoupin Creek Watershed

4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

The ultimate goal of TMDL development is to achieve attainment with water quality standards. A water quality standard consists of the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. Water quality criteria are sometimes in a form that are not directly amenable for use in TMDL development and may need to be translated into a target value for TMDLs. This section discusses the applicable designated uses, use support, criteria and TMDL targets for waterbodies in the Macoupin Creek watershed that are addressed in this report.

4.1 DESIGNATED USES AND USE SUPPORT

Water quality assessments in Illinois are based on a combination of chemical (water, sediment and fish tissue), physical (habitat and flow discharge), and biological (macroinvertebrate and fish) data. Illinois EPA conducts its assessment of water bodies using a set of seven designated uses: aquatic life, aesthetic quality, indigenous aquatic life (for specific Chicago-area waterbodies), primary contact (swimming), secondary contact, public and food processing water supply, and fish consumption (IEPA, 2006). For each water body, and for each designated use applicable to the water body, Illinois EPA's assessment concludes one of two possible "use-support" levels:

- Fully Supporting (the water body attains the designated use); or
- Not Supporting (the water body does not attain the designated use).

Water bodies assessed as "Not Supporting" for any designated use are identified as impaired. Waters identified as impaired based on biological (macroinvertebrate, macrophyte, algal and fish), chemical (water, sediment and fish tissue), and/or physical (habitat and flow discharge) monitoring data are placed on the 303(d) list. Potential causes and sources of impairment are also identified for impaired waters (IEPA, 2006).

Following the U.S. EPA regulations at 40 CFR Part 130.7(b)(4), the Illinois Section 303(d) list was prioritized on a watershed basis. Illinois EPA watershed boundaries are based on the USGS ten-digit hydrologic units to provide the state with the ability to address watershed issues at a manageable level and document improvements to a watershed's health (IEPA, 2006).

4.2 WATER QUALITY CRITERIA

Illinois has established water quality criteria and guidelines for allowable concentrations of fecal coliform, manganese, and total phosphorus under its CWA Section 305(b) program, as summarized below. A comparison of available water quality data to these criteria is provided in the Stage 1 Report.

4.2.1 Fecal Coliform

The IEPA guidelines (IEPA, 2006) for identifying fecal coliform as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through

October (minimum five samples) is greater than 200 cfu/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml. The available data support the listing of fecal coliform as a cause of impairment in Macoupin Creek, as discussed in the Stage 1 Report.

4.2.2 Manganese

The water quality standard for manganese in Illinois waters designated as public and food processing water supplies is 150 ug/l. The public and food processing water supply guideline for inland lakes indicates impairment if more than 10% of the observations measured since 1999 exceed 150 ug/L. The available data confirm that the listings of Carlinville Lake and Old Gillespie Lake for manganese are appropriate based on IEPA's guidelines as discussed in the Stage 1 Report.

4.2.3 Total Phosphorus

The IEPA guidelines (IEPA, 2006) for identifying total phosphorus as a cause of impairment in lakes greater than 20 acres in size state that phosphorus is a potential cause of impairment of the aesthetic quality use if there is at least one exceedance of the applicable standard (0.05 mg/L) during the most recent year of data from the Ambient Lake Monitoring Program or the Illinois Clean Lakes Program. The available data support the listing of phosphorus as a cause of impairment in Carlinville, Beaver Dam, Old Gillespie, and New Gillespie Lakes, as discussed in the Stage 1 Report.

4.3 DEVELOPMENT OF TMDL TARGETS

The TMDL target is a numeric endpoint specified to represent the level of acceptable water quality that is to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist, surrogate parameters must be selected to represent the designated use.

4.3.1 Fecal Coliform

For Macoupin Creek (IL_DA-04), the target was set to fecal coliform concentration of 200 cfu/100 ml.

4.3.2 Total Phosphorus

For the Carlinville, Beaver Dam, Old Gillespie, and New Gillespie Lake phosphorus TMDLs, the targets are set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

4.3.3 Manganese

For the Carlinville and Old Gillespie Lake manganese TMDLs, a surrogate parameter (total phosphorus concentration) was selected as the TMDL target for manganese. The linkage between the TMDL target (total phosphorus) and manganese is explained as follows. First, phosphorus loadings to lakes can stimulate excess algal growth. When the algae die and decompose, they then settle to the lake bottom where they contribute to anoxic (i.e. lacking dissolved oxygen) conditions at depth. Under anoxic conditions, manganese is released from the lake sediments.

The primary sources of manganese are naturally elevated concentrations in groundwater and release from lake bottom sediments during anoxic conditions. The only controllable source of manganese to the lakes is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. Therefore, the goal for the lakes is maintenance of hypolimnetic dissolved oxygen concentrations above zero. The lack of dissolved oxygen in lake bottom waters is presumed to be due to sediment oxygen demand resulting from the effects of nutrient enrichment, as there are no point source discharges in the watershed. Additionally, no other significant sources of oxygen demanding materials identified in the watershed characterization (LTI, 2004). For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.

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5 DEVELOPMENT OF WATER QUALITY MODELS

Water quality models are used to define the relationship between pollutant loading and the resulting water quality. The TMDLs for phosphorus and manganese are based upon the BATHTUB model. The TMDL for fecal coliform applies the Load Duration Curve approach in conjunction with a load capacity calculation. The development of the BATHTUB model and Load Duration Curve approach is described in the following sections, including information on:

- Model selection
- Modeling approach
- Model inputs
- Model calibration (only for BATHTUB)/analysis (load duration)

5.1 BATHTUB MODEL

The BATHTUB water quality model was used to define the relationship between external phosphorus loads and the resulting concentrations of total phosphorus and manganese in the four lakes.

5.1.1 Model Selection

A detailed discussion of the model selection process for the Macoupin Creek watershed is provided in the Stage 1 Report.

Of the models discussed, the BATHTUB model (Walker, 1985) was selected to address phosphorus and manganese impairments to the four lakes. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used previously for several reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

The BATHTUB model does not directly model manganese concentrations, but it is still appropriate for TMDL application. The only controllable source of manganese to the lakes is that which enters from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. This source of manganese can be controlled by reducing phosphorus loads to the lake, which will reduce algal growth and increase hypolimnetic dissolved oxygen concentrations.

The model was used to predict the relationship between phosphorus load and resulting in-lake phosphorus concentrations, as well as the resulting potential for oxygen depletion and manganese release from sediments.

5.1.2 Modeling Approach

The approach selected for the manganese and phosphorus TMDLs is based upon discussions with IEPA and their Scientific Advisory Committee. The approach consists of using existing empirical data to define current loads to the lake, and using the

BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach corresponds to Alternative 1 in the detailed discussion of the model selection process provided in the Stage 1 Report. The dominant land use in the watershed is agriculture. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, which requires no additional data collection and can be conducted immediately, will expedite these implementation efforts.

Determination of existing loading sources and prioritization of restoration alternatives may be conducted by local experts as part of the implementation process (see Section 8). Based upon their recommendations, a voluntary implementation plan could be developed that includes both accountability and the potential for adaptive management.

5.1.3 Model Inputs

This section provides an overview of the model inputs required for BATHTUB application, and how they were derived. The following categories of inputs are required for BATHTUB:

- Model Options
- Global Variables
- Reservoir Segmentation
- Tributary Loads

5.1.3.1 Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 1, with the rationale for these options discussed below. No conservative substance was being simulated, so this option was not needed. The second order available phosphorus option was selected for phosphorus, as it is the default option for BATHTUB. Nitrogen was not simulated, because phosphorus is the nutrient of concern. Similarly, chlorophyll a and transparency were not simulated. The Fischer numeric dispersion model was selected, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations. No nitrogen calibration was required. The use of availability factors was not required, and estimated concentrations were used to generate mass balance tables.

Table 1. BATHTUB Model Options for Carlinville, Beaver Dam, Old Gillespie, and New Gillespie Lakes

MODEL	MODEL OPTION
Conservative substance	Not computed
Total phosphorus	2nd order, available phosphorus
Total nitrogen	Not computed
Chlorophyll-a	Not computed
Transparency	Not computed
Longitudinal dispersion	Fischer-numeric
Phosphorus calibration	Concentrations
Nitrogen calibration	None
Error analysis	Not computed
Availability factors	Ignored
Mass-balance tables	Use estimated concentrations

5.1.3.2 Global Variables

The global variables required by BATHTUB consist of:

- The averaging period for the analysis
- Precipitation, evaporation, and change in lake levels
- Atmospheric phosphorus loads

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. A key decision in the application of BATHTUB is the selection of the length of time over which inputs and outputs should be modeled. The length of the appropriate averaging period for BATHTUB application depends upon what is called the nutrient residence time, i.e. the average length of time that phosphorus spends in the water column before settling or flushing out of the lake. Guidance for the BATHTUB model recommends that the averaging period used for the analysis be at least twice as large as nutrient residence time for the lake of interest. For lakes with a nutrient residence time on the order of weeks to a few months, a seasonal (e.g. spring-summer) averaging period is recommended. The nutrient residence times for the four lakes were calculated as follows:

- Carlinville Lake: several weeks
- Beaver Dam Lake: several months
- Old Gillespie Lake: weeks to months
- New Gillespie Lake: weeks to months

For these lakes, the averaging period used for this analysis was set to the seasonal period March 1-August 31.

Precipitation inputs were taken from the observed long-term annual average precipitation data and scaled for the March 1-August 31 simulation period. This resulted in a precipitation value of 29.7 inches for Carlinville Lake, Beaver Dam Lake and New Gillespie Lake, and 17.8 for Old Gillespie Lake. The differences relate to the year selected for model calibration (2002 vs. 2001). Evaporation was set equal to precipitation and there was no assumed increase in storage during the modeling period, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB.

5.1.3.3 Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of the reservoir. The segmentation scheme selected for Carlinville, Beaver Dam, Old Gillespie, and New Gillespie Lakes was designed to provide one segment for each of the primary lake sampling stations. The lakes were divided into the segments as shown in Figures 2 through 4. The areas of segments and watersheds for each segment were determined by Geographic Information System (GIS).

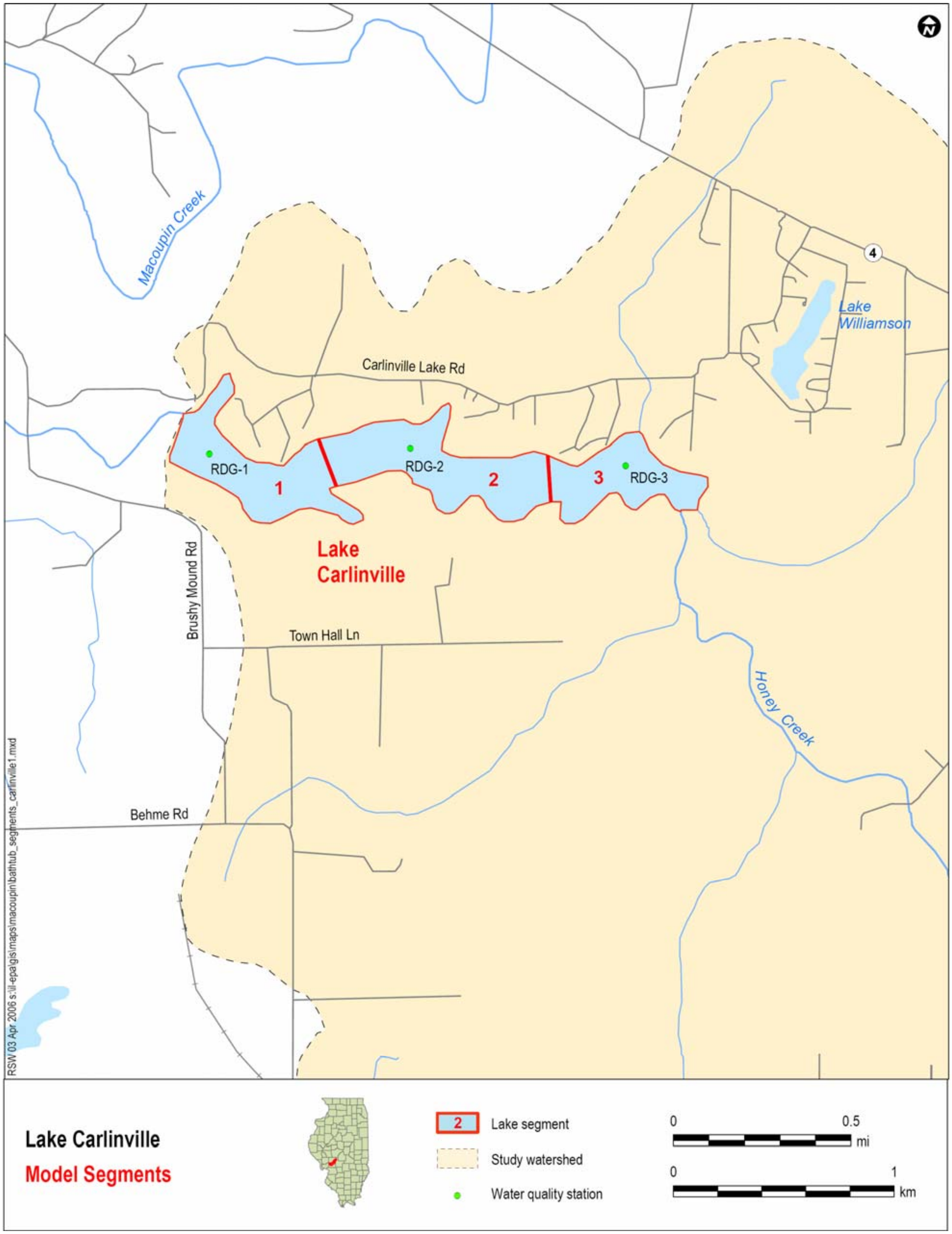

Figure 2. Carlinville Lake Segmentation Used in BATHTUB

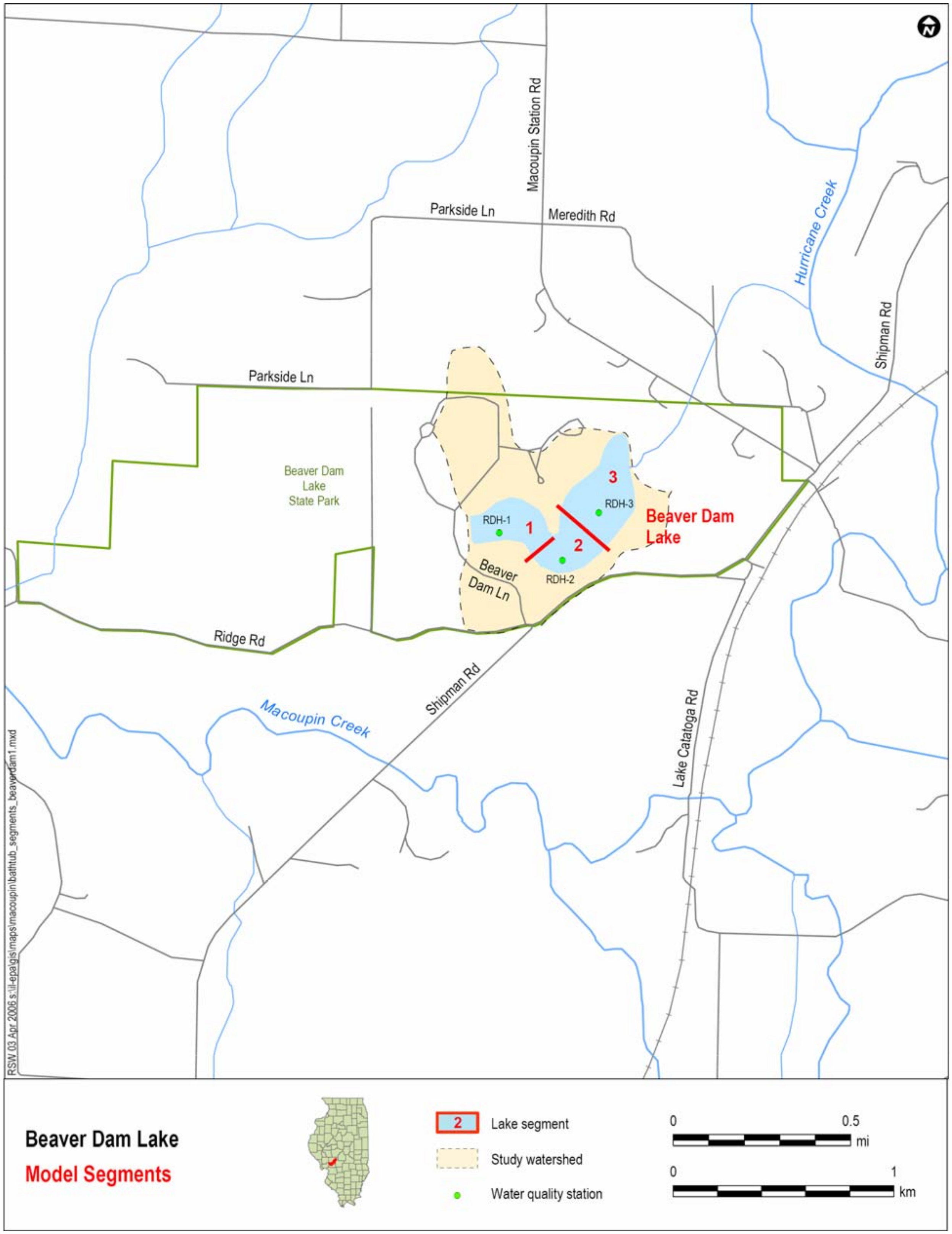

Figure 3. Beaver Dam Lake Segmentation Used in BATHTUB

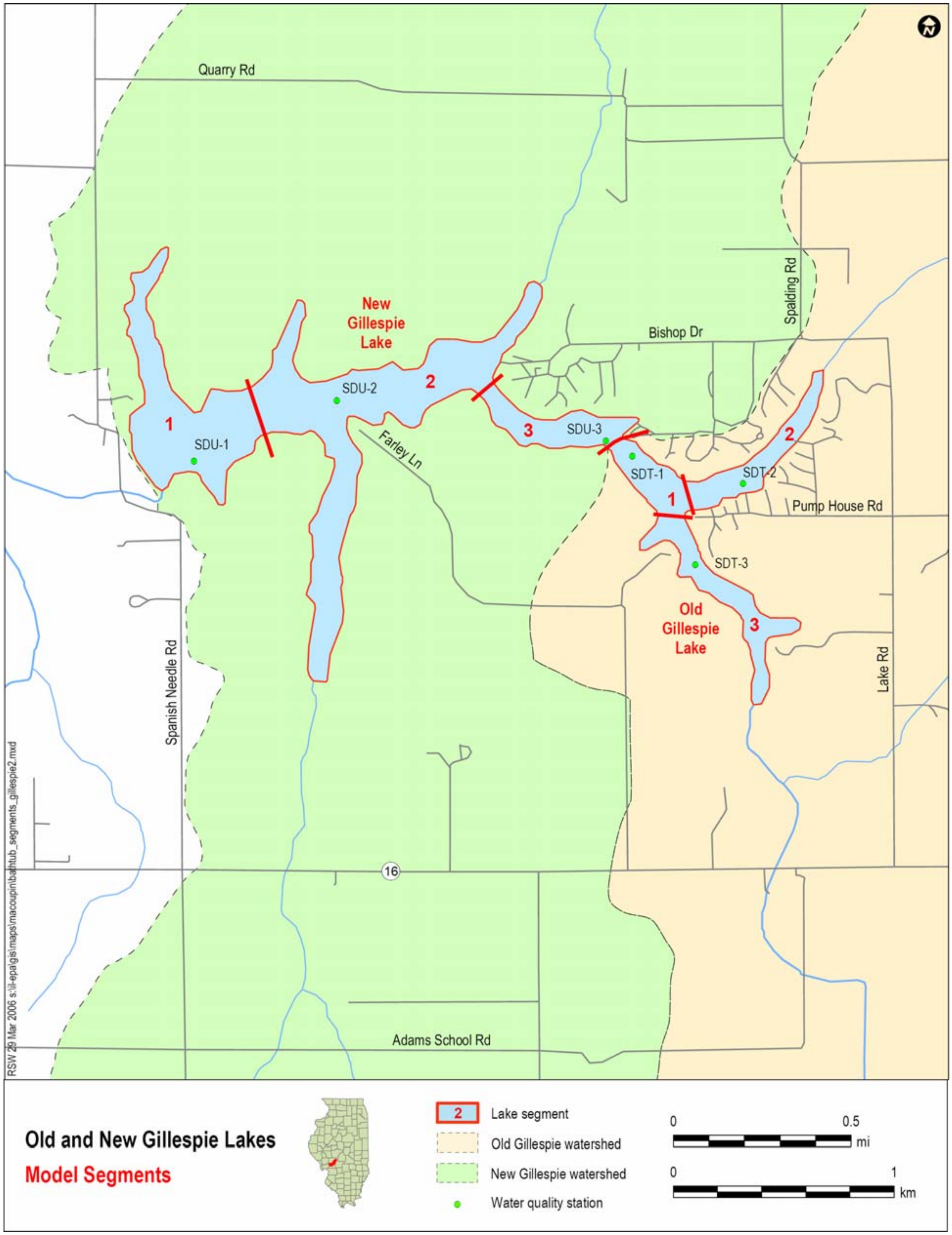

Figure 4. Old and New Gillespie Lake Segmentation Used in BATHTUB

BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths were calculated from lake monitoring data, while segment lengths and surface areas were calculated using GIS. A complete listing of all segment-specific inputs is provided in Attachments 1 through 4.

5.1.3.4 Tributary Loads

BATHTUB requires information describing tributary flow and nutrient concentrations into each reservoir segment. The approach used to estimate flows is described below. Total phosphorus concentrations for each major lake tributary were based upon springtime measurements taken near the headwaters of the lake. Concentrations for small tributaries were set equal to the assumed concentration for the major tributary. A complete listing of all segment-specific flows and tributary concentrations is provided in Attachments 1 through 4.

Average flows to each segment for the averaging period were estimated using observed flows at USGS gaging stations adjusted through the use of drainage area ratios as follows:

Flow into segment = Flow at USGS gage x Segment-specific drainage area ratio

$$\text{Drainage area ratio} = \frac{\text{Drainage area of watershed contributing to model segment}}{\text{Drainage area of watershed contributing to USGS gage}}$$

The USGS gage (#05577500) on Spring Creek at Springfield was used for all four lakes. Segment-specific drainage area ratios were calculated using watershed boundaries provided in GIS.

5.1.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above
2. Comparing model results to observed phosphorus data
3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

Separate discussions of the BATHTUB model calibration for Lake Carlinville, Beaver Dam Lake, Old Gillespie Lake and New Gillespie Lake are provided below.

5.1.4.1 Carlinville Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2002 were used for calibration purposes, as this year provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. The default calibration coefficients in BATHTUB provided an acceptable fit to the observed data in segments 2 and 3 (inlet of the lake), and no additional calibration activities were required. Model results in segment 1 initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical "net settling rate" (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 120 mg-P/m^2/day in segment 1. The resulting predicted lake average total phosphorus concentration was 154.2 ug-P/l, compared to an observed average of 154.8 ug-P/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 1.

5.1.4.2 Beaver Dam Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2002 were used for calibration purposes, as this year provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. Using default calibration coefficients, model results initially under-predicted the observed phosphorus data in all lake segments. Phosphorus loss rates in BATHTUB rates reflect a typical "net settling rate" (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 2.7 mg-P/m^2/day to each segment. The resulting predicted lake average total phosphorus concentration was 124.9 ug-P/l, compared to an observed average of 124.5 ug-P/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 2.

5.1.4.3 Old Gillespie Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2001 were used for calibration purposes, as this year provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. Using default calibration coefficients, model results initially under-predicted the observed phosphorus data in all lake segments. Phosphorus loss rates in BATHTUB rates reflect a typical "net settling rate" (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 600 mg-P/m^2/day in segment 1 and 300 mg-P/m^2/day in segments 2 and 3. The resulting predicted lake average total phosphorus concentration was 703.8 ug-P/l, compared to an observed average of 692.5 ug-P/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 3.

5.1.4.4 New Gillespie Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2002 were used for calibration purposes, as this year provided the most robust data set. The August in-lake data from this year were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. Using default calibration coefficients, model results initially under-predicted the observed phosphorus data in all lake segments. Phosphorus loss rates in BATHTUB rates reflect a typical "net settling rate" (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data were corrected during the calibration process via the addition of an internal phosphorus load of 30 mg-P/m^2/day in segments 1, 2 and 3. The resulting predicted lake average total phosphorus concentration was 146.1 ug-P/l, compared to an observed average of 142.7 ug-P/l. This comparison represents an acceptable model calibration. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 4.

5.2 LOAD DURATION CURVE ANALYSIS

A load duration curve approach was used in the fecal coliform analysis for Macoupin Creek (IL_DA-04). A load-duration curve is a graphical representation of observed pollutant load compared to maximum allowable load over the entire range of flow conditions. The load duration curve provides information to:

- Help identify the issues surrounding the problem and differentiate between point and nonpoint source problems, as discussed immediately below;
- Address frequency of deviations (how many samples lie above the curve vs. those that plot below); and
- Aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards for different flow conditions.

5.2.1 Model Selection

A detailed discussion of the model selection process for Macoupin Creek (IL_DA-04) is provided in the Stage 1 Report. The alternative approach considered for this TMDL consists of applying the HSPF model to define watershed loads for all fecal coliform sources and using the water quality component of this model to simulate in-stream concentrations and water quality response. This approach, coupled with intensive monitoring, would define specific sources of bacteria and identify detailed control strategies necessary to attain water quality standards. The load-duration curve approach was selected over HSPF because it is a simpler approach that requires less data, while supporting the selected level of TMDL implementation for this TMDL. The load-duration curve approach identifies broad categories of coliform sources and the extent of control required from these source categories to attain water quality standards.

5.2.2 Approach

The load duration curve approach uses stream flows and observed concentrations for the period of record to gain insight into the flow conditions under which exceedances of the water quality standard occur. A load-duration curve is developed by: 1) ranking the daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results in what is called a flow duration curve; 2) translating the flow duration curve into a load duration curve by multiplying the flows by the water quality standard; and 3) plotting observed pollutant loads (measured concentrations times stream flow) on the same graph. Observed loads that fall above the load duration curve exceed the maximum allowable load, while those that fall on or below the line do not exceed the maximum allowable load. An analysis of the observed loads relative to the load duration curve provides information on whether the pollutant source is point or nonpoint in nature. A more complete description of the load duration curve approach is provided in the Stage 1 Report.

5.2.3 Data inputs

Fecal coliform data collected by IEPA between 1990 and 2004 were used in the analysis. The data were collected as part of IEPA's ambient water quality monitoring program. Only data for the months of May-October were used because the water quality standard applies only during this period. Daily average flows measured at the USGS gage on Macoupin Creek near Kane, Illinois (05587000) were used in the analysis. Flows are available for the period 1921-2004. This station is located downstream of segment IL_DA-04, so the flows measured at Kane were adjusted for the size of the drainage area (i.e., they were multiplied by 0.34 because the watershed for IL_DA-04 is 66% smaller than the watershed for the Kane gage).

5.2.4 Analysis

A flow duration curve was generated by ranking daily flow data from lowest to highest, calculating the percent of days these flows were exceeded, and graphing the results. A load duration curve for fecal coliform was generated by multiplying the flows in the duration curve by the TMDL target of 200 cfu/100 ml for fecal coliform bacteria. This is shown with a solid line in Figure 5. Observed pollutant loads for the May through October period (measured concentrations multiplied by corresponding stream flow), were plotted on the same graph. The worksheet for this analysis is provided in Attachment 5.

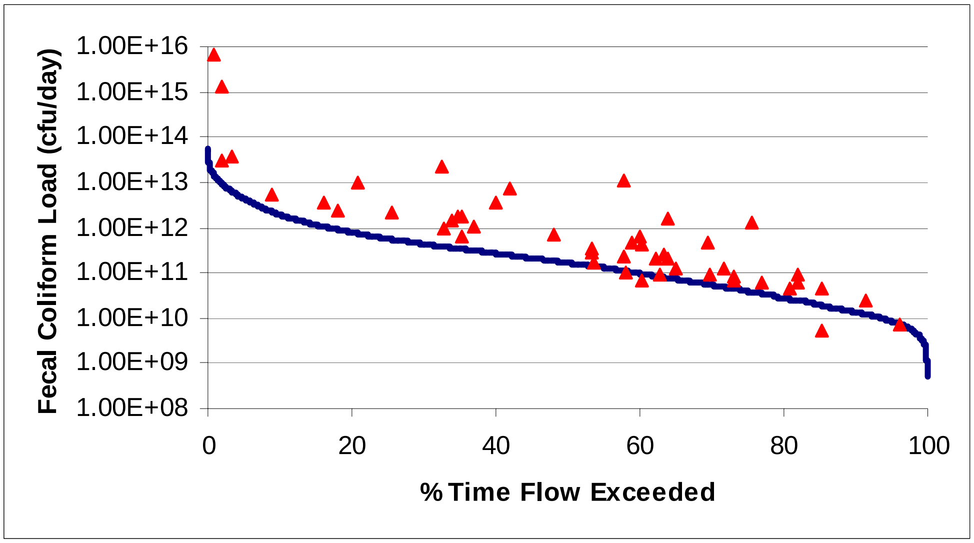

Figure 5. Load duration curve for Macoupin Creek with observed loads (triangles)

While data are somewhat limited during low flow periods, Figure 5 indicates that observed loads at low flows (in the area of the plot defined as being exceeded 85-99 percent of the time) fall near or below the line, suggesting that dry weather point sources are not major contributors to fecal coliform exceedances in segment IL_DA-04 of Macoupin Creek. In the range of 50-85 percent exceedance, the observed loads fall on or above the line, and these loads represent some combination of nonpoint and point sources. All of the loads in the range of 10-50 percent exceedance fall above the curve, indicating that wet weather sources contribute to fecal coliform exceedances. Those loads plotting above the curve at exceedances less than 10 percent or more than 99 percent reflect extreme hydrologic conditions of flood or drought (Freedman et al, 2003). The exceedances in the 0% to 10% range may be considered to represent unique high flow problems that may exceed feasible management remedies.

6 TMDL DEVELOPMENT

This section presents the development of the total maximum daily loads for the impaired waterbodies in Macoupin Creek watershed. It begins with a description of how the total loading capacity was calculated, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 PHOSPHORUS AND MANGANESE TMDLS FOR LAKES

Total phosphorus TMDLs were developed for Carlinville Lake, Beaver Dam Lake, Old Gillespie Lake, and New Gillespie Lake. Manganese TMDLs were developed for Carlinville Lake and Old Gillespie Lake.

6.1.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards.

The loading capacity was determined by running the BATHTUB model repeatedly, reducing the tributary nutrient concentrations for each simulation until model results demonstrated attainment of TMDL targets. The maximum tributary concentration that results in compliance with water quality standards was used as the basis for determining the lake's loading capacity. The tributary concentration was then converted into a loading rate through multiplication with the tributary flow.

Specific results are discussed below by waterbody.

6.1.1.1 Carlinville Lake

Initial BATHTUB load reduction simulations indicated that Carlinville Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for scenarios where tributary phosphorus concentrations were less than 65 ug/l. The resulting tributary phosphorus load that led to compliance with water quality standards was 191.3 kg phosphorus/month (6.38 kg-P/day) between March 1 and August 31, with the total load for this period not to exceed 1,147.8 kg. This allowable load corresponds to an approximately 51% reduction from existing tributary loads (estimated as 2,349 kg phosphorus over the March 1 to August 31 period). Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in Carlinville Lake is on the order of several weeks. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.1.2 Beaver Dam Lake

Initial BATHTUB load reduction simulations indicated that Beaver Dam Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. Because the watershed for this lake is very small and the phosphorus concentrations measured in the spring are relatively low (April concentrations are all below 50 ug/l), reductions in watershed loads will not have much of an effect on in-lake concentrations. The internal phosphorus flux that occurs when the lake is stratified and anoxic near the bottom will need to be addressed before in-lake phosphorus concentrations will meet water quality standards.

If the internal phosphorus flux is eliminated, then the lake will be in compliance with water quality standards without any reductions in tributary loads. The calculated tributary load that leads to compliance with the TMDL target for Beaver Dam Lake is 2.35 kg-P/month (0.078 kg-P/day) between March 1 and August 31, with the total load for this period not to exceed 14.1 kg phosphorus. Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in Beaver Dam Lake is on the order of months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis. Current loads are estimated to be in compliance with the load capacity, such Beaver Dam Lake is expected to eventually attain standards once sediment loads reach equilibrium with external loads. Implementation options, to be discussed in a separate report, include waiting for natural attenuation of sediment sources to occur or active remediation of internal sediment load.

6.1.1.3 Old Gillespie Lake

Initial BATHTUB load reduction simulations indicated that Old Gillespie Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for scenarios where tributary phosphorus concentrations were less than 65 ug/l. The resulting tributary phosphorus load that led to compliance with water quality standards was 16.32 kg-P/month (0.544 kg-P/day) between March 1 and August 31, with the total load for this period not to exceed 97.9 kg. This allowable load corresponds to an approximately 74% reduction from existing tributary loads (estimated as 370.6 kg phosphorus over the March 1 to August 31 period). Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in Old Gillespie Lake is on the order of weeks to months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.1.4 New Gillespie Lake

Initial BATHTUB load reduction simulations indicated that New Gillespie Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for scenarios where tributary phosphorus concentrations are less than 65 ug/l. The resulting tributary phosphorus load that led to compliance with water quality standards was 91.18 kg-P/month (3.04 kg-P/day) between March 1 and August 31, with the total load for this period not to exceed 547 kg. This allowable load corresponds to an approximately 48% reduction from existing tributary loads (estimated as 1043.7 kg phosphorus over the March 1 to August 31 period). Loads are expressed on a seasonal basis because model results indicate that the phosphorus residence time in New Gillespie Lake is on the order of weeks to months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.2 Allocation

A TMDL consists of point source/waste load allocations (WLAs), nonpoint sources/load allocations (LAs), and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$\text{TMDL} = \text{WLA} + \text{LA} + \text{MOS}$$

The following section presents the allocations for Carlinville, Beaver Dam, Old Gillespie, and New Gillespie Lakes.

6.1.2.1 Carlinville Lake

There are no NPDES permitted point source dischargers in the Carlinville Lake watershed. Therefore the WLA does not need to be calculated. The loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 191.3 kg-P/month (6.38 kg-P/day), a WLA of 0 kg/month, and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Carlinville Lake of 172.17 kg-P/month (5.742 kg-P/day).

6.1.2.2 Beaver Dam Lake

There are no NPDES permitted point source dischargers in the Beaver Dam Lake watershed. Therefore the WLA does not need to be calculated. The loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 2.35 kg-P/month (0.078 kg-P/day), a WLA of 0 kg/month, and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Beaver Dam Lake of 2.115 kg-P/month (0.07 kg-P/day).

6.1.2.3 Old Gillespie Lake

There are no NPDES permitted point source dischargers in the Old Gillespie Lake watershed. Therefore the WLA does not need to be calculated. The loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 16.32 kg-P/month (0.544 kg-P/day), a WLA of zero, and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Old Gillespie Lake of 14.69 kg-P/month (0.49 kg-P/day).

6.1.2.4 New Gillespie Lake

There are no NPDES permitted point source dischargers in the New Gillespie Lake watershed. Therefore the WLA does not need to be calculated. The loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a loading capacity of 91.18 kg-P/month (3.04 kg-P/day), a WLA of zero, and an explicit margin of safety of 10% (discussed below), this results in a load allocation for New Gillespie Lake of 82.06 kg-P/month (2.74 kg-P/day).

6.1.3 Critical Conditions

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Critical conditions were taken into account in the development of this TMDL. In terms of loading, spring runoff periods are considered critical because wet weather events can transport significant quantities of nonpoint source loads to lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon a seasonal period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

6.1.4 Seasonality

These TMDLs were conducted with an explicit consideration of seasonal variation. The BATHTUB model used for these TMDLs is designed to evaluate loads over a seasonal to annual averaging period. Model results indicate that the phosphorus residence time in the four lakes ranges from weeks to several months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.5 Margin of Safety

The phosphorus TMDL for the protection of phosphorus and manganese contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit phosphorus loads allocated to the margin of safety are:

- 19.13 kg/month (0.638 kg/day) for Carlinville Lake
- 0.235 kg/month (0.008 kg/day) for Beaver Dam Lake
- 1.632 kg/month (0.054 kg/day) for Old Gillespie Lake
- 9.118 kg/month (0.304 kg/day) for New Gillespie Lake

6.2 FECAL COLIFORM TMDL FOR MACOUPIN CREEK

A load capacity calculation approach was applied to support development of a fecal coliform TMDL for Macoupin Creek.

6.2.1 Calculation of Loading Capacity

The loading capacity is defined as the maximum pollutant load that a waterbody can receive and still maintain compliance with water quality standards. The loading capacity was defined over a range of specified flows based on expected flows for the watershed. The allowable loading capacity was computed by multiplying flow by the TMDL target (200 cfu/100 ml). The fecal coliform loading capacity is presented in Table 2.

Table 2. Macoupin Creek Fecal Coliform Loading Capacity

Flow percentile range	Median Macoupin Creek Flow (cfs)	Load Capacity (cfu/day)
66 - 100	4.8	2.33E+10
33 - 66	34	1.68E+11
0 - 33	206	1.01E+12

The maximum observed fecal coliform concentration was determined for different flow intervals (Table 3) and compared to the 200 cfu/100 ml target to estimate the percent reduction needed to meet the water quality target. A 99% reduction in fecal coliform loading is required to meet the TMDL target during high flow periods. A 98% and 94% reduction in fecal coliform loading is required to meet the TMDL target during moderate and low flow periods, respectively.

Table 3. Required Reductions in Existing Loads under Different Flow Conditions

Flow Percentile Interval	Macoupin Creek Flow (cfs)	Maximum fecal concentration (cfu/100 ml)	Percent Reduction to Meet Target
0-33	76 - 11,100	91,000	99%
33 - 66	14 - 76	20,000	98%
66 - 100	0 - 14	7,000	94%

6.2.2 Allocation

A TMDL consists of wasteload allocations (WLAs) for point sources, load allocations (Las) for nonpoint sources, and a margin of safety (MOS). This definition is typically illustrated by the following equation:

$$TMDL = WLA + LA + MOS$$

The WLA for the eight point source discharges in the watershed that for segment IL_DA-04 was calculated using their permitted flow rates and a concentration consistent with meeting the TMDL target (200 cfu/100 ml) at the downstream end of their exempted reach. Wasteload allocations for these facilities are presented in Table 4. The total WLA for these facilities equals 1.39E +10 cfu/day.

In addition to the dischargers presented in Table 4, the Carlinville STP also has a permit for two combined sewer overflows (CSOs) that may discharge under wet weather conditions. One CSO is treated and the other is not. The WLA for the CSOs was calculated based on reported 2001 average overflow volume per event for the two overflows and a concentration of 200 cfu/100ml, consistent with water quality standards. The WLA for the CSOs equals 7.49E+09 cfu/day.

Table 4. Point Source Dischargers and WLAs

NPDES ID	Facility name	Disinfection exemption?	Average Design Flow (MGD)	Permit expiration date	WLA (cfu/day)
IL0056022	Monterey Coal #1 Mine North	Year-round	N/A	15-Sept-00	9.09E+07
IL0022675	Carlinville STP	Year-round	1.5	31-Dec-07	1.14E+10
IL0045373	Lake Williamson Christian Center	Seasonal	0.032	31-Jul-09	2.42E+08
IL0063088	Shipman STP	Year-round	0.08	30-Jun-05	6.06E+08
IL0069175	Il DNR-Beaver Dam State Park Shower	Year-round	0.0024	31-Jan-10	1.82E+07
IL0071391	Royal Lakes STP	Year-round	0.041	31-Aug-09	3.11E+08
ILG580090	Nilwood STP	Year-round	0.049	31-Dec-07	3.71E+08
ILG580126	Farmersville STP	Year-round	0.125	31-Dec-07	9.47E+08

The remainder of the loading capacity is given to the load allocation for nonpoint sources and to the margin of safety, as presented in Table 5. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall fecal coliform load.

Table 5. Fecal Coliform TMDL for Segment IL_DA-04 Macoupin Creek[3]

Flow Percentile Range	Median Observed Macoupin Creek Flow (cfs)	Load Capacity (cfu/day)	Observed Load (cfu/day)[1]	WLA for Table 4 dischargers (cfu/day)	CSO WLA (cfu/day)[2]	Load allocation (cfu/day)	Percent reduction for CSOs
66 - 100	4.8	2.33E+10	8.15E+11	1.39E+10	0	9.34E+09	0
33 - 66	34	1.68E+11	1.68E+13	1.39E+10	0	1.54E+11	0
0-33	206	1.01E+12	4.58E+14	1.39E+10	7.49E+09	9.85E+11	99.9%

[1] Observed load calculated using maximum observed fecal concentration and median observed flows in the stated flow percentile range
[2] For purposes of this table, CSOs discharge only during high flows
[3] An implicit MOS is used in this TMDL

As shown in Table 5, a 99.9% reduction in CSO loads is required during higher flows, when CSOs are discharging. This percent reduction is based on fecal measurements from the Carlinville treated CSO outfall (2001 – 2005 data) and fecal measurements from untreated CSO outfalls for numerous other facilities. No WLA reduction is required at lower flows, as the eight permitted dischargers listed in Table 4 all have disinfection exemptions.

6.2.3 Critical Condition

TMDLs must take into account critical environmental conditions to ensure that the water quality is protected during times when it is most vulnerable. Figure 5 provides a graphical depiction of the data compared to the load capacity, showing that exceedances of the TMDL target occur over the full range of flow conditions. TMDL development utilizing the load-duration approach applies to the full range of flow conditions; therefore critical conditions were addressed during TMDL development.

6.2.4 Seasonality

This TMDL was conducted with an explicit consideration of seasonal variation. The Load Duration Curve approach used for the TMDL evaluated seasonal loads because only May through October water quality data were used in the analysis, consistent with the specification that the standard only applies during this period. The fecal coliform standard will be met regardless of flow conditions in the applicable season because the load capacity calculations specify target loads for the entire range of flow conditions that are possible to occur in any given point in the season where the standard applies.

6.2.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The fecal coliform TMDL contains an implicit margin of safety, through the use of multiple conservative assumptions. First, the TMDL target (no more than 200 cfu/100 ml at any point in time) is more conservative than the more restrictive portion of the fecal coliform water quality standard (geometric mean of 200 cfu/100 ml for all samples collected May through October). An additional implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no decay of bacteria that enter the river, and therefore represents an upper bound of expected concentrations for a given pollutant load. This margin of safety can be reviewed in the future as new data are developed.

7 PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included numerous opportunities for local watershed institutions and the general public to be involved. The Agency and its consultant met with local municipalities and agencies in Summer 2004 to notify stakeholders about the upcoming TMDLs, and initiate the TMDL process. A number of phone calls were made to identify and acquire data and information (see Stage 1 Report). As quarterly progress reports were produced during the first stage of the TMDL process, the Agency posted them to their website for public review.

In February 2005, a public meeting was announced for presentation of the Stage 1 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:30 pm on Monday, March 21, 2005 in Carlinville, Illinois at the Carlinville High School cafeteria. In addition to the meeting's sponsors, nine individuals attended the meeting. Attendees registered and listened to an introduction to the TMDL Program from Illinois EPA and a presentation on the Stage 1 findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

In July 2006, a public meeting was announced for presentation of the Stage 3 findings. This announcement was mailed to everyone on the previous TMDL mailing list and published in local newspapers. The public meeting was held at 6:00 pm on Tuesday, July 25, 2006 in Carlinville, Illinois at Carlinville City Hall. In addition to the meeting's sponsors, two individuals attended the meeting. Attendees registered and listened to a presentation on the Stage 3 findings by Limno-Tech, Inc. (LTI). This was followed by a general question and answer session.

Illinois EPA will prepare another report that discusses implementation actions for the watershed. This report will be presented at another public meeting and will be posted on the IEPA website for review prior to the meeting. This implementation plan will describe effective and ongoing actions such as 319 watershed projects, conservation efforts, formation of a watershed group and other ways that local people can improve their waters. If you are not on the mailing list to receive notice of this meeting, please call or e-mail Sarah Tadla (Illinois EPA) at (217) 782-5562, Sarah.Tadla@epa.state.il.us.

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8 ADAPTIVE IMPLEMENTATION PROCESS

The approach to be taken for TMDL implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lake can assimilate and still attain water quality standards
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. Finally, the adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps 1-3 correspond to TMDL development and have been completed, as described in Section 5 of this document. Steps 4 and 5 correspond to implementation.

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Attachment 1

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Carlinville Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment:	**4**	**Area-Wtd Mean**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	154.2		90.3%	154.8		90.4%
CHL-A MG/M3				47.1		98.2%
SECCHI M				0.5		14.8%
ANTILOG PC-1				2398.8		95.9%
ANTILOG PC-2				10.2		81.2%
TURBIDITY 1/M	1.9		90.0%	1.9		90.0%
ZMIX * TURBIDITY	5.0		72.1%	5.0		72.1%
ZMIX / SECCHI				5.9		63.7%
CHL-A * SECCHI				22.5		86.9%
CHL-A / TOTAL P				0.4		83.3%
FREQ(CHL-a>10) %				98.5		98.2%
FREQ(CHL-a>20) %				85.4		98.2%
FREQ(CHL-a>30) %				65.8		98.2%
FREQ(CHL-a>40) %				47.9		98.2%
FREQ(CHL-a>50) %				34.1		98.2%
FREQ(CHL-a>60) %				24.2		98.2%
CARLSON TSI-P	76.6		90.3%	75.7		90.4%
CARLSON TSI-CHLA				68.3		98.2%
CARLSON TSI-SEC				70.7		85.2%

Segment:	**1**	**Segment 1**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	189.1		93.6%	247.0		96.6%
CHL-A MG/M3				42.0		97.4%
SECCHI M				0.6		20.7%
ANTILOG PC-1				1718.0		93.1%
ANTILOG PC-2				11.0		84.7%
TURBIDITY 1/M	1.6		87.1%	1.6		87.1%
ZMIX * TURBIDITY	7.1		85.2%	7.1		85.2%
ZMIX / SECCHI				7.4		77.6%
CHL-A * SECCHI				24.4		89.1%
CHL-A / TOTAL P				0.2		41.2%
FREQ(CHL-a>10) %				97.7		97.4%
FREQ(CHL-a>20) %				81.2		97.4%
FREQ(CHL-a>30) %				59.2		97.4%
FREQ(CHL-a>40) %				40.8		97.4%
FREQ(CHL-a>50) %				27.7		97.4%
FREQ(CHL-a>60) %				18.8		97.4%
CARLSON TSI-P	79.7		93.6%	83.6		96.6%
CARLSON TSI-CHLA				67.3		97.4%
CARLSON TSI-SEC				67.8		79.3%

Carlinville Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 2 Segment 2

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	137.9		88.0%	100.0		79.3%
CHL-A MG/M3				47.0		98.2%
SECCHI M				0.5		16.2%
ANTILOG PC-1				2154.9		95.2%
ANTILOG PC-2				10.7		83.5%
TURBIDITY 1/M	1.4		81.9%	1.4		81.9%
ZMIX * TURBIDITY	4.3		65.7%	4.3		65.7%
ZMIX / SECCHI				6.2		67.5%
CHL-A * SECCHI				24.0		88.6%
CHL-A / TOTAL P				0.5		91.5%
FREQ(CHL-a>10) %				98.6		98.2%
FREQ(CHL-a>20) %				85.7		98.2%
FREQ(CHL-a>30) %				66.1		98.2%
FREQ(CHL-a>40) %				48.0		98.2%
FREQ(CHL-a>50) %				34.1		98.2%
FREQ(CHL-a>60) %				24.1		98.2%
CARLSON TSI-P	75.2		88.0%	70.6		79.3%
CARLSON TSI-CHLA				68.4		98.2%
CARLSON TSI-SEC				69.7		83.8%

Segment: 3 Segment 3

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	134.6		87.5%	123.0		85.3%
CHL-A MG/M3				54.0		98.8%
SECCHI M				0.3		5.9%
ANTILOG PC-1				3688.6		98.1%
ANTILOG PC-2				8.4		69.4%
TURBIDITY 1/M	3.0		96.6%	3.0		96.6%
ZMIX * TURBIDITY	3.2		50.8%	3.2		50.8%
ZMIX / SECCHI				3.2		24.8%
CHL-A * SECCHI				17.8		78.5%
CHL-A / TOTAL P				0.4		89.8%
FREQ(CHL-a>10) %				99.2		98.8%
FREQ(CHL-a>20) %				90.2		98.8%
FREQ(CHL-a>30) %				73.8		98.8%
FREQ(CHL-a>40) %				56.9		98.8%
FREQ(CHL-a>50) %				42.6		98.8%
FREQ(CHL-a>60) %				31.6		98.8%
CARLSON TSI-P	74.8		87.5%	73.5		85.3%
CARLSON TSI-CHLA				69.7		98.8%
CARLSON TSI-SEC				76.0		94.1%

Carlinville Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**		**Segment:**	**1**	**Segment 1**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
3	1	Segment 1 Direct Drainage	1.1	3.0%	141.0	1.0%	133
PRECIPITATION			0.3	0.9%	6.3	0.0%	20
INTERNAL LOAD			0.0	0.0%	9204.3	65.6%	
TRIBUTARY INFLOW			1.1	3.0%	141.0	1.0%	133
ADVECTIVE INFLOW			34.0	96.1%	4686.0	33.4%	138
***TOTAL INFLOW			35.3	100.0%	14037.6	100.0%	397
ADVECTIVE OUTFLOW			35.0	99.1%	6623.7	47.2%	189
NET DIFFUSIVE OUTFLOW			0.0	0.0%	2768.5	19.7%	
***TOTAL OUTFLOW			35.0	99.1%	9392.2	66.9%	268
***EVAPORATION			0.3	0.9%	0.0	0.0%	
***RETENTION			0.0	0.0%	4645.4	33.1%	

Hyd. Residence Time = 0.0270 yrs
Overflow Rate = 166.8 m/yr
Mean Depth = 4.5 m

Component:		**TOTAL P**		**Segment:**	**2**	**Segment 2**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
2	1	Segment 2 Direct Drainage	0.6	1.8%	83.8	1.2%	133
PRECIPITATION			0.4	1.1%	7.8	0.1%	20
TRIBUTARY INFLOW			0.6	1.8%	83.8	1.2%	133
ADVECTIVE INFLOW			33.3	97.0%	4489.0	65.7%	135
NET DIFFUSIVE INFLOW			0.0	0.0%	2256.9	33.0%	
***TOTAL INFLOW			34.4	100.0%	6837.6	100.0%	199
ADVECTIVE OUTFLOW			34.0	98.9%	4686.0	68.5%	138
***TOTAL OUTFLOW			34.0	98.9%	4686.0	68.5%	138
***EVAPORATION			0.4	1.1%	0.0	0.0%	
***RETENTION			0.0	0.0%	2151.6	31.5%	

Hyd. Residence Time = 0.0243 yrs
Overflow Rate = 130.7 m/yr
Mean Depth = 3.2 m

Component:		**TOTAL P**		**Segment:**	**3**	**Segment 3**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1	1	Inlet Tributary	33.3	99.3%	4434.2	89.6%	133
PRECIPITATION			0.2	0.7%	4.8	0.1%	20
TRIBUTARY INFLOW			33.3	99.3%	4434.2	89.6%	133
NET DIFFUSIVE INFLOW			0.0	0.0%	511.6	10.3%	
***TOTAL INFLOW			33.6	100.0%	4950.6	100.0%	147
ADVECTIVE OUTFLOW			33.3	99.3%	4489.0	90.7%	135
***TOTAL OUTFLOW			33.3	99.3%	4489.0	90.7%	135
***EVAPORATION			0.2	0.7%	0.0	0.0%	
***RETENTION			0.0	0.0%	461.6	9.3%	

Hyd. Residence Time = 0.0056 yrs
Overflow Rate = 208.4 m/yr
Mean Depth = 1.2 m

Carlinville Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.50 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	3	Inlet Tributary	58.3	33.3	0.00E+00	0.00	0.57
2	1	2	Segment 2 Direct Drainage	1.1	0.6	0.00E+00	0.00	0.57
3	1	1	Segment 1 Direct Drainage	1.9	1.1	0.00E+00	0.00	0.57
PRECIPITATION				0.6	1.0	0.00E+00	0.00	1.51
TRIBUTARY INFLOW				61.2	35.0	0.00E+00	0.00	0.57
***TOTAL INFLOW				61.9	36.0	0.00E+00	0.00	0.58
ADVECTIVE OUTFLOW				61.9	35.0	0.00E+00	0.00	0.57
***TOTAL OUTFLOW				61.9	35.0	0.00E+00	0.00	0.57
***EVAPORATION					1.0	0.00E+00	0.00	

Overall Mass Balance Based Upon Component: **Predicted TOTAL P** — **Outflow & Reservoir Concentrations**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	3	Inlet Tributary	4434.2	31.9%	0.00E+00		0.00	133.0	76.1
2	1	2	Segment 2 Direct Drainage	83.8	0.6%	0.00E+00		0.00	133.0	75.5
3	1	1	Segment 1 Direct Drainage	141.0	1.0%	0.00E+00		0.00	133.0	75.8
PRECIPITATION				18.9	0.1%	0.00E+00		0.00	19.9	30.0
INTERNAL LOAD				9204.3	66.3%	0.00E+00		0.00		
TRIBUTARY INFLOW				4659.0	33.6%	0.00E+00		0.00	133.0	76.1
***TOTAL INFLOW				13882.2	100.0%	0.00E+00		0.00	385.8	224.4
ADVECTIVE OUTFLOW				6623.7	47.7%	0.00E+00		0.00	189.1	107.1
***TOTAL OUTFLOW				6623.7	47.7%	0.00E+00		0.00	189.1	107.1
***RETENTION				7258.5	52.3%	0.00E+00		0.00		

Overflow Rate (m/yr)	55.6	Nutrient Resid. Time (yrs)	0.0217
Hydraulic Resid. Time (yrs)	0.0559	Turnover Ratio	23.0
Reservoir Conc (mg/m3)	154	Retention Coef.	0.523

Carlinville Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	35.0	0.0270	166.8	31.3	54.5	13.2	0.0
2	Segment 2	1	34.0	0.0243	130.7	44.1	98.8	23.6	54.1
3	Segment 3	2	33.3	0.0056	208.4	136.5	534.2	51.9	155.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.2	4.5	4.3	0.8	0.9	0.2	3.4
2	Segment 2	0.3	3.2	3.2	1.1	0.8	0.2	4.4
3	Segment 3	0.2	1.2	1.1	0.8	0.2	0.2	3.6
Totals		0.6	3.1			2.0		

Carlinville Lake

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 1 Direct Drainage	Type:	Monitored Inflow
--------Segment:	2	Segment 2		
Outflow Segment:	1	Segment 1		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3		
Outflow Segment:	2	Segment 2		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow

Carlinville Lake

Description:

Single reservoir (155.5 acres (from GIS))
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.5	0.0
Precipitation (m)	0.755	0.0
Evaporation (m)	0.755	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.21	4.51	0.845	4.3	0.12	2.44	0	1.65	0	0	0	120	0	0	0
2	Segment 2	1	1	0.26	3.17	1.07	3.17	0.12	2.13	0	1.36	0	0	0	0	0	0	0
3	Segment 3	2	1	0.16	1.16	0.76	1.06	0.12	0	0	3.02	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	247	0	0	0	42	0	0.58	0	0	0	0	0	0	0	0	0
2	0	0	100	0	0	0	47	0	0.51	0	0	0	0	0	0	0	0	0
3	0	0	123	0	0	0	54	0	0.33	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Carlinville Lake

Tributary Data

Trib	Trib Name	Segment	Type	Dr Area km^2	Flow (hm^3/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	3	1	58.27	33.34	0	0	0	133	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	1.11	0.63	0	0	0	133	0	0	0	0	0	0	0
3	Segment 1 Direct Drainage	1	1	1.86	1.06	0	0	0	133	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	**Trib Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Inlet Tributary	32.44	1.8	2.51	0.23	0.53	0.45	0	0
2	Segment 2 Direct Drainage	4.26	0.35	1.26	0.09	0.28	0.67	0	0
3	Segment 1 Direct Drainage	1.16	0.21	0.51	0.13	0.29	0.6	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Attachment 2

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Beaver Dam Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	124.9		85.7%	124.5		85.6%
CHL-A MG/M3				100.7		99.9%
SECCHI M				0.4		8.2%
ANTILOG PC-1				5920.9		99.2%
ANTILOG PC-2				14.1		93.2%
TURBIDITY 1/M	1.9		89.9%	1.9		89.9%
ZMIX * TURBIDITY	4.6		68.8%	4.6		68.8%
ZMIX / SECCHI				6.6		70.9%
CHL-A * SECCHI				37.8		96.8%
CHL-A / TOTAL P				0.8		98.7%
FREQ(CHL-a>10) %				100.0		99.9%
FREQ(CHL-a>20) %				98.9		99.9%
FREQ(CHL-a>30) %				94.9		99.9%
FREQ(CHL-a>40) %				87.9		99.9%
FREQ(CHL-a>50) %				79.2		99.9%
FREQ(CHL-a>60) %				69.8		99.9%
CARLSON TSI-P	73.8		85.7%	73.7		85.6%
CARLSON TSI-CHLA				75.8		99.9%
CARLSON TSI-SEC				74.1		91.8%

Segment: 1 Segment 1

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	121.3		84.9%	130.0		86.6%
CHL-A MG/M3				107.0		99.9%
SECCHI M				0.4		8.5%
ANTILOG PC-1				6188.7		99.3%
ANTILOG PC-2				14.9		94.4%
TURBIDITY 1/M	1.8		89.4%	1.8		89.4%
ZMIX * TURBIDITY	4.7		70.1%	4.7		70.1%
ZMIX / SECCHI				6.8		73.0%
CHL-A * SECCHI				40.7		97.5%
CHL-A / TOTAL P				0.8		98.8%
FREQ(CHL-a>10) %				100.0		99.9%
FREQ(CHL-a>20) %				99.2		99.9%
FREQ(CHL-a>30) %				95.9		99.9%
FREQ(CHL-a>40) %				89.9		99.9%
FREQ(CHL-a>50) %				82.0		99.9%
FREQ(CHL-a>60) %				73.3		99.9%
CARLSON TSI-P	73.3		84.9%	74.3		86.6%
CARLSON TSI-CHLA				76.4		99.9%
CARLSON TSI-SEC				73.9		91.5%

Beaver Dam Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 2 Segment 2

Variable	Predicted Mean	Predicted CV	Predicted Rank	Observed Mean	Observed CV	Observed Rank
TOTAL P MG/M3	125.7		85.8%	138.0		88.0%
CHL-A MG/M3				106.0		99.9%
SECCHI M				0.4		7.4%
ANTILOG PC-1				6450.8		99.4%
ANTILOG PC-2				14.2		93.3%
TURBIDITY 1/M	2.0		91.0%	2.0		91.0%
ZMIX * TURBIDITY	5.0		72.2%	5.0		72.2%
ZMIX / SECCHI				7.0		74.3%
CHL-A * SECCHI				38.2		96.9%
CHL-A / TOTAL P				0.8		98.4%
FREQ(CHL-a>10) %				100.0		99.9%
FREQ(CHL-a>20) %				99.1		99.9%
FREQ(CHL-a>30) %				95.8		99.9%
FREQ(CHL-a>40) %				89.7		99.9%
FREQ(CHL-a>50) %				81.6		99.9%
FREQ(CHL-a>60) %				72.8		99.9%
CARLSON TSI-P	73.9		85.8%	75.2		88.0%
CARLSON TSI-CHLA				76.3		99.9%
CARLSON TSI-SEC				74.7		92.6%

Segment: 3 Segment 3

Variable	Predicted Mean	Predicted CV	Predicted Rank	Observed Mean	Observed CV	Observed Rank
TOTAL P MG/M3	126.9		86.0%	114.0		83.2%
CHL-A MG/M3				94.0		99.9%
SECCHI M				0.4		8.5%
ANTILOG PC-1				5472.8		99.1%
ANTILOG PC-2				13.6		92.3%
TURBIDITY 1/M	1.8		89.6%	1.8		89.6%
ZMIX * TURBIDITY	4.3		66.0%	4.3		66.0%
ZMIX / SECCHI				6.2		67.5%
CHL-A * SECCHI				35.7		96.2%
CHL-A / TOTAL P				0.8		98.8%
FREQ(CHL-a>10) %				100.0		99.9%
FREQ(CHL-a>20) %				98.6		99.9%
FREQ(CHL-a>30) %				93.7		99.9%
FREQ(CHL-a>40) %				85.7		99.9%
FREQ(CHL-a>50) %				76.1		99.9%
FREQ(CHL-a>60) %				66.1		99.9%
CARLSON TSI-P	74.0		86.0%	72.4		83.2%
CARLSON TSI-CHLA				75.2		99.9%
CARLSON TSI-SEC				73.9		91.5%

Beaver Dam Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P — **Segment: 1 Segment 1**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Inlet Tributary	0.2	72.2%	15.7	19.3%	67
PRECIPITATION			0.1	27.8%	1.8	2.2%	20
INTERNAL LOAD			0.0	0.0%	59.2	72.6%	
TRIBUTARY INFLOW			0.2	72.2%	15.7	19.3%	67
NET DIFFUSIVE INFLOW			0.0	0.0%	4.8	5.9%	
***TOTAL INFLOW			0.3	100.0%	81.5	100.0%	250
ADVECTIVE OUTFLOW			0.2	72.2%	28.5	35.0%	121
***TOTAL OUTFLOW			0.2	72.2%	28.5	35.0%	121
***EVAPORATION			0.1	27.8%	0.0	0.0%	
***RETENTION			0.0	0.0%	53.0	65.0%	

Hyd. Residence Time = 0.6616 yrs
Overflow Rate = 3.9 m/yr
Mean Depth = 2.6 m

Component: TOTAL P — **Segment: 2 Segment 2**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
2	1	Segment 2 Direct Drainage	0.1	18.4%	4.7	5.6%	67
PRECIPITATION			0.1	19.9%	1.5	1.8%	20
INTERNAL LOAD			0.0	0.0%	49.3	58.5%	
TRIBUTARY INFLOW			0.1	18.4%	4.7	5.6%	67
ADVECTIVE INFLOW			0.2	61.8%	28.5	33.8%	121
NET DIFFUSIVE INFLOW			0.0	0.0%	0.3	0.3%	
***TOTAL INFLOW			0.4	100.0%	84.2	100.0%	222
ADVECTIVE OUTFLOW			0.3	80.1%	38.3	45.5%	126
***TOTAL OUTFLOW			0.3	80.1%	38.3	45.5%	126
***EVAPORATION			0.1	19.9%	0.0	0.0%	
***RETENTION			0.0	0.0%	45.9	54.5%	

Hyd. Residence Time = 0.4117 yrs
Overflow Rate = 6.1 m/yr
Mean Depth = 2.5 m

Component: TOTAL P — **Segment: 3 Segment 3**

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
3	1	Segment 3 Direct Drainage	0.1	21.9%	8.4	5.9%	67
PRECIPITATION			0.1	25.0%	2.8	2.0%	20
INTERNAL LOAD			0.0	0.0%	93.7	65.4%	
TRIBUTARY INFLOW			0.1	21.9%	8.4	5.9%	67
ADVECTIVE INFLOW			0.3	53.1%	38.3	26.7%	126
***TOTAL INFLOW			0.6	100.0%	143.3	100.0%	250
ADVECTIVE OUTFLOW			0.4	75.0%	54.6	38.1%	127
NET DIFFUSIVE OUTFLOW			0.0	0.0%	5.0	3.5%	
***TOTAL OUTFLOW			0.4	75.0%	59.6	41.6%	139
***EVAPORATION			0.1	25.0%	0.0	0.0%	
***RETENTION			0.0	0.0%	83.6	58.4%	

Hyd. Residence Time = 0.5209 yrs
Overflow Rate = 4.5 m/yr
Mean Depth = 2.4 m

Beaver Dam Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.50 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	1	Inlet Tributary	0.4	0.2	0.00E+00	0.00	0.57
2	1	2	Segment 2 Direct Drainage	0.1	0.1	0.00E+00	0.00	0.58
3	1	3	Segment 3 Direct Drainage	0.2	0.1	0.00E+00	0.00	0.57
PRECIPITATION				0.2	0.3	0.00E+00	0.00	1.51
TRIBUTARY INFLOW				0.8	0.4	0.00E+00	0.00	0.57
***TOTAL INFLOW				1.0	0.7	0.00E+00	0.00	0.77
ADVECTIVE OUTFLOW				1.0	0.4	0.00E+00	0.00	0.45
***TOTAL OUTFLOW				1.0	0.4	0.00E+00	0.00	0.45
***EVAPORATION					0.3	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	1	Inlet Tributary	15.7	6.6%	0.00E+00		0.00	67.0	38.4
2	1	2	Segment 2 Direct Drainage	4.7	2.0%	0.00E+00		0.00	67.0	39.0
3	1	3	Segment 3 Direct Drainage	8.4	3.5%	0.00E+00		0.00	67.0	38.3
PRECIPITATION				6.2	2.6%	0.00E+00		0.00	19.9	30.0
INTERNAL LOAD				202.2	85.2%	0.00E+00		0.00		
TRIBUTARY INFLOW				28.8	12.2%	0.00E+00		0.00	67.0	38.4
***TOTAL INFLOW				237.2	100.0%	0.00E+00		0.00	320.5	248.3
ADVECTIVE OUTFLOW				54.6	23.0%	0.00E+00		0.00	126.9	57.2
***TOTAL OUTFLOW				54.6	23.0%	0.00E+00		0.00	126.9	57.2
***RETENTION				182.6	77.0%	0.00E+00		0.00		

Overflow Rate (m/yr)	2.1	Nutrient Resid. Time (yrs)	0.2661
Hydraulic Resid. Time (yrs)	1.1736	Turnover Ratio	1.9
Reservoir Conc (mg/m3)	125	Retention Coef.	0.770

Beaver Dam Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	2	0.2	0.6616	3.9	1.0	1.1	0.1	1.1
2	Segment 2	3	0.3	0.4117	6.1	1.0	2.0	0.1	4.2
3	Segment 3	0	0.4	0.5209	4.5	1.0	3.6	0.1	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.1	2.6	2.6	0.4	0.2	0.2	2.4
2	Segment 2	0.1	2.5	2.5	0.2	0.1	0.2	1.2
3	Segment 3	0.1	2.4	2.4	0.3	0.2	0.3	1.3
Totals		0.2	2.5			0.5		

Beaver Dam Lake

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	2	Segment 2		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow
--------Segment:	2	Segment 2		
Outflow Segment:	3	Segment 3		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 3 Direct Drainage	Type:	Monitored Inflow

Beaver Dam Lake

Description:

Single reservoir (50.1 acres (from GIS))
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.5	0.0
Precipitation (m)	0.755	0.0
Evaporation (m)	0.755	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	2	1	0.06	2.59	0.38	2.59	0.12	1.524	0	1.83	0	0	0	2.7	0	0	0
2	Segment 2	3	1	0.05	2.51	0.24	2.51	0.12	1.524	0	1.98	0	0	0	2.7	0	0	0
3	Segment 3	0	1	0.095	2.36	0.35	2.36	0.12	1.524	0	1.84	0	0	0	2.7	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	130	0	0	0	107	0	0.38	0	0	0	0	0	0	0	0	0
2	0	0	138	0	0	0	106	0	0.36	0	0	0	0	0	0	0	0	0
3	0	0	114	0	0	0	94	0	0.38	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Beaver Dam Lake

Tributary Data

Trib	Trib Name	Segment	Type	Dr Area km^2	Flow (hm^3/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	1	1	0.41	0.2349	0	0	0	67	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	0.12	0.0699	0	0	0	67	0	0	0	0	0	0	0
3	Segment 3 Direct Drainage	3	1	0.22	0.1256	0	0	0	67	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	Trib Name	1	2	3	4	5	6	7	8
1	Inlet Tributary	32.44	1.8	2.51	0.23	0.53	0.45	0	0
2	Segment 2 Direct Drainage	4.26	0.35	1.26	0.09	0.28	0.67	0	0
3	Segment 3 Direct Drainage	1.16	0.21	0.51	0.13	0.29	0.6	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Attachment 3

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Gillespie Old Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	703.8		99.9%	692.5		99.9%
CHL-A MG/M3				50.3		98.5%
SECCHI M				0.5		16.3%
ANTILOG PC-1				2291.4		95.6%
ANTILOG PC-2				11.3		85.9%
TURBIDITY 1/M	1.6		86.4%	1.6		86.4%
ZMIX * TURBIDITY	5.1		73.2%	5.1		73.2%
ZMIX / SECCHI				6.3		68.7%
CHL-A * SECCHI				26.1		90.7%
CHL-A / TOTAL P				0.1		6.1%
FREQ(CHL-a>10) %				98.8		98.5%
FREQ(CHL-a>20) %				87.5		98.5%
FREQ(CHL-a>30) %				69.4		98.5%
FREQ(CHL-a>40) %				52.0		98.5%
FREQ(CHL-a>50) %				38.0		98.5%
FREQ(CHL-a>60) %				27.6		98.5%
CARLSON TSI-P	98.7		99.9%	98.3		99.9%
CARLSON TSI-CHLA				69.0		98.5%
CARLSON TSI-SEC				69.7		83.7%

Segment: 1 Segment 1

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	800.9		99.9%	878.0		99.9%
CHL-A MG/M3				59.0		99.2%
SECCHI M				0.6		22.6%
ANTILOG PC-1				2263.0		95.5%
ANTILOG PC-2				14.4		93.7%
TURBIDITY 1/M	1.2		78.0%	1.2		78.0%
ZMIX * TURBIDITY	5.5		76.1%	5.5		76.1%
ZMIX / SECCHI				7.5		77.9%
CHL-A * SECCHI				36.0		96.3%
CHL-A / TOTAL P				0.1		4.6%
FREQ(CHL-a>10) %				99.5		99.2%
FREQ(CHL-a>20) %				92.4		99.2%
FREQ(CHL-a>30) %				78.3		99.2%
FREQ(CHL-a>40) %				62.4		99.2%
FREQ(CHL-a>50) %				48.3		99.2%
FREQ(CHL-a>60) %				36.8		99.2%
CARLSON TSI-P	100.6		99.9%	101.9		99.9%
CARLSON TSI-CHLA				70.6		99.2%
CARLSON TSI-SEC				67.1		77.4%

Gillespie Old Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 2 Segment 2

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	697.5		99.9%	617.0		99.8%
CHL-A MG/M3				51.0		98.6%
SECCHI M				0.5		16.2%
ANTILOG PC-1				2328.6		95.7%
ANTILOG PC-2				11.3		86.0%
TURBIDITY 1/M	1.6		86.1%	1.6		86.1%
ZMIX * TURBIDITY	4.2		64.7%	4.2		64.7%
ZMIX / SECCHI				5.2		56.4%
CHL-A * SECCHI				26.0		90.7%
CHL-A / TOTAL P				0.1		8.7%
FREQ(CHL-a>10) %				99.0		98.6%
FREQ(CHL-a>20) %				88.5		98.6%
FREQ(CHL-a>30) %				70.7		98.6%
FREQ(CHL-a>40) %				53.3		98.6%
FREQ(CHL-a>50) %				39.0		98.6%
FREQ(CHL-a>60) %				28.4		98.6%
CARLSON TSI-P	98.6		99.9%	96.8		99.8%
CARLSON TSI-CHLA				69.2		98.6%
CARLSON TSI-SEC				69.7		83.8%

Segment: 3 Segment 3

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	655.9		99.8%	653.0		99.8%
CHL-A MG/M3				45.0		97.9%
SECCHI M				0.5		13.1%
ANTILOG PC-1				2276.6		95.6%
ANTILOG PC-2				9.6		77.8%
TURBIDITY 1/M	1.8		89.6%	1.8		89.6%
ZMIX * TURBIDITY	5.6		77.2%	5.6		77.2%
ZMIX / SECCHI				6.6		71.4%
CHL-A * SECCHI				20.7		84.1%
CHL-A / TOTAL P				0.1		5.0%
FREQ(CHL-a>10) %				98.3		97.9%
FREQ(CHL-a>20) %				84.1		97.9%
FREQ(CHL-a>30) %				63.5		97.9%
FREQ(CHL-a>40) %				45.2		97.9%
FREQ(CHL-a>50) %				31.6		97.9%
FREQ(CHL-a>60) %				21.9		97.9%
CARLSON TSI-P	97.7		99.8%	97.6		99.8%
CARLSON TSI-CHLA				67.9		97.9%
CARLSON TSI-SEC				71.2		86.9%

Gillespie Old Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:	**TOTAL P**			**Segment:**	**1**	**Segment 1**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
3	1	Segment 1 Direct Drainage	0.0	1.3%	9.5	0.1%	246
PRECIPITATION			0.1	1.8%	1.8	0.0%	33
INTERNAL LOAD			0.0	0.0%	15340.5	88.1%	
TRIBUTARY INFLOW			0.0	1.3%	9.5	0.1%	246
ADVECTIVE INFLOW			2.9	97.0%	2057.7	11.8%	698
***TOTAL INFLOW			3.0	100.0%	17409.5	100.0%	5722
ADVECTIVE OUTFLOW			3.0	98.2%	2393.6	13.7%	801
NET DIFFUSIVE OUTFLOW			0.0	0.0%	1.1	0.0%	
***TOTAL OUTFLOW			3.0	98.2%	2394.7	13.8%	801
***EVAPORATION			0.1	1.8%	0.0	0.0%	
***RETENTION			0.0	0.0%	15014.8	86.2%	

Hyd. Residence Time = 0.0994 yrs
Overflow Rate = 49.8 m/yr
Mean Depth = 4.9 m

Component:	**TOTAL P**			**Segment:**	**2**	**Segment 2**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
2	1	Segment 2 Direct Drainage	1.3	42.6%	317.3	2.8%	246
PRECIPITATION			0.1	2.7%	2.7	0.0%	33
INTERNAL LOAD			0.0	0.0%	9861.8	87.5%	
TRIBUTARY INFLOW			1.3	42.6%	317.3	2.8%	246
ADVECTIVE INFLOW			1.7	54.8%	1088.9	9.7%	656
NET DIFFUSIVE INFLOW			0.0	0.0%	1.1	0.0%	
***TOTAL INFLOW			3.0	100.0%	11271.7	100.0%	3719
ADVECTIVE OUTFLOW			2.9	97.3%	2057.7	18.3%	698
***TOTAL OUTFLOW			2.9	97.3%	2057.7	18.3%	698
***EVAPORATION			0.1	2.7%	0.0	0.0%	
***RETENTION			0.0	0.0%	9214.0	81.7%	

Hyd. Residence Time = 0.0815 yrs
Overflow Rate = 32.8 m/yr
Mean Depth = 2.7 m

Component:	**TOTAL P**			**Segment:**	**3**	**Segment 3**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1	1	Inlet Tributary	1.7	94.4%	408.4	3.3%	246
PRECIPITATION			0.1	5.6%	3.3	0.0%	33
INTERNAL LOAD			0.0	0.0%	12053.3	96.7%	
TRIBUTARY INFLOW			1.7	94.4%	408.4	3.3%	246
***TOTAL INFLOW			1.8	100.0%	12464.9	100.0%	7085
ADVECTIVE OUTFLOW			1.7	94.4%	1088.9	8.7%	656
***TOTAL OUTFLOW			1.7	94.4%	1088.9	8.7%	656
***EVAPORATION			0.1	5.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	11376.1	91.3%	

Hyd. Residence Time = 0.2021 yrs
Overflow Rate = 15.1 m/yr
Mean Depth = 3.0 m

Gillespie Old Lake

Overall Water & Nutrient Balances

Overall Water Balance

Averaging Period = **0.50** years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	3	Inlet Tributary	7.0	1.7	0.00E+00	0.00	0.24
2	1	2	Segment 2 Direct Drainage	5.4	1.3	0.00E+00	0.00	0.24
3	1	1	Segment 1 Direct Drainage	0.2	0.0	0.00E+00	0.00	0.24
PRECIPITATION				0.3	0.2	0.00E+00	0.00	0.90
TRIBUTARY INFLOW				12.5	3.0	0.00E+00	0.00	0.24
***TOTAL INFLOW				12.8	3.2	0.00E+00	0.00	0.25
ADVECTIVE OUTFLOW				12.8	3.0	0.00E+00	0.00	0.23
***TOTAL OUTFLOW				12.8	3.0	0.00E+00	0.00	0.23
***EVAPORATION					0.2	0.00E+00	0.00	

Overall Mass Balance Based Upon Component: Predicted TOTAL P — Outflow & Reservoir Concentrations

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance $(kg/yr)^2$	%Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	3	Inlet Tributary	408.4	1.1%	0.00E+00		0.00	246.0	58.7
2	1	2	Segment 2 Direct Drainage	317.3	0.8%	0.00E+00		0.00	246.0	58.7
3	1	1	Segment 1 Direct Drainage	9.5	0.0%	0.00E+00		0.00	246.0	59.2
PRECIPITATION				7.8	0.0%	0.00E+00		0.00	33.3	30.0
INTERNAL LOAD				37255.5	98.0%	0.00E+00		0.00		
TRIBUTARY INFLOW				735.2	1.9%	0.00E+00		0.00	246.0	58.7
***TOTAL INFLOW				37998.5	100.0%	0.00E+00		0.00	11789.7	2971.0
ADVECTIVE OUTFLOW				2393.6	6.3%	0.00E+00		0.00	800.9	187.1
***TOTAL OUTFLOW				2393.6	6.3%	0.00E+00		0.00	800.9	187.1
***RETENTION				35604.9	93.7%	0.00E+00		0.00		

Overflow Rate (m/yr)	11.5	Nutrient Resid. Time (yrs)	0.0162
Hydraulic Resid. Time (yrs)	0.2921	Turnover Ratio	30.9
Reservoir Conc (mg/m3)	704	Retention Coef.	0.937

Gillespie Old Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	3.0	0.0994	49.8	4.4	2.1	1.0	0.0
2	Segment 2	1	2.9	0.0815	32.8	10.9	4.9	4.9	0.0
3	Segment 3	2	1.7	0.2021	15.1	5.1	2.3	2.6	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.1	4.9	4.6	0.4	0.3	0.1	3.2
2	Segment 2	0.1	2.7	2.7	0.9	0.2	0.1	8.8
3	Segment 3	0.1	3.0	3.0	1.0	0.3	0.1	9.6
Totals		0.3	3.4			0.9		

Gillespie Old Lake

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 1 Direct Drainage	Type:	Monitored Inflow
--------Segment:	2	Segment 2		
Outflow Segment:	1	Segment 1		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3		
Outflow Segment:	2	Segment 2		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow

Gillespie Old Lake

Description:

Single reservoir (64.8 acres (from GIS))
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.5	0.0
Precipitation (m)	0.451	0.0
Evaporation (m)	0.451	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.06	4.95	0.44	4.55	0.12	3.51	0	1.2	0	0	0	700	0	0	0
2	Segment 2	1	1	0.09	2.67	0.89	2.67	0.12	1.98	0	1.58	0	0	0	300	0	0	0
3	Segment 3	2	1	0.11	3.05	1.03	3.05	0.12	0	0	1.84	0	0	0	300	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	878	0	0	0	59	0	0.61	0	0	0	0	0	0	0	0	0
2	0	0	617	0	0	0	51	0	0.51	0	0	0	0	0	0	0	0	0
3	0	0	653	0	0	0	45	0	0.46	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Gillespie Old Lake

Tributary Data

Trib	Trib Name	Segment	Type	Dr Area km²	Flow (hm³/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	3	1	6.96	1.66	0	0	0	246	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	5.41	1.29	0	0	0	246	0	0	0	0	0	0	0
3	Segment 1 Direct Drainage	1	1	0.16	0.0385	0	0	0	246	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km²)

		Land Use Category--->							
Trib	**Trib Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Inlet Tributary	32.44	1.8	2.51	0.23	0.53	0.45	0	0
2	Segment 2 Direct Drainage	4.26	0.35	1.26	0.09	0.28	0.67	0	0
3	Segment 1 Direct Drainage	1.16	0.21	0.51	0.13	0.29	0.6	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m²/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Attachment 4

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Gillespie New Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	146.1		89.2%	142.7		88.7%
CHL-A MG/M3				49.7		98.5%
SECCHI M				0.6		24.7%
ANTILOG PC-1				1907.8		94.1%
ANTILOG PC-2				13.1		91.2%
TURBIDITY 1/M	1.2		78.4%	1.2		78.4%
ZMIX * TURBIDITY	5.3		74.9%	5.3		74.9%
ZMIX / SECCHI				6.9		74.0%
CHL-A * SECCHI				31.1		94.3%
CHL-A / TOTAL P				0.3		81.3%
FREQ(CHL-a>10) %				98.4		98.5%
FREQ(CHL-a>20) %				86.1		98.5%
FREQ(CHL-a>30) %				67.7		98.5%
FREQ(CHL-a>40) %				50.6		98.5%
FREQ(CHL-a>50) %				37.1		98.5%
FREQ(CHL-a>60) %				27.0		98.5%
CARLSON TSI-P	76.0		89.2%	75.6		88.7%
CARLSON TSI-CHLA				68.8		98.5%
CARLSON TSI-SEC				66.5		75.3%

Segment: 1 Segment 1

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	140.1		88.3%	124.0		85.5%
CHL-A MG/M3				38.0		96.5%
SECCHI M				0.8		32.2%
ANTILOG PC-1				1214.4		88.9%
ANTILOG PC-2				12.7		90.2%
TURBIDITY 1/M	1.0		72.5%	1.0		72.5%
ZMIX * TURBIDITY	5.5		76.4%	5.5		76.4%
ZMIX / SECCHI				7.0		74.8%
CHL-A * SECCHI				28.9		92.9%
CHL-A / TOTAL P				0.3		75.9%
FREQ(CHL-a>10) %				96.7		96.5%
FREQ(CHL-a>20) %				76.6		96.5%
FREQ(CHL-a>30) %				52.8		96.5%
FREQ(CHL-a>40) %				34.7		96.5%
FREQ(CHL-a>50) %				22.6		96.5%
FREQ(CHL-a>60) %				14.8		96.5%
CARLSON TSI-P	75.4		88.3%	73.7		85.5%
CARLSON TSI-CHLA				66.3		96.5%
CARLSON TSI-SEC				64.0		67.8%

Gillespie New Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 2 Segment 2

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	147.0		89.4%	150.0		89.8%
CHL-A MG/M3				54.0		98.8%
SECCHI M				0.6		22.6%
ANTILOG PC-1				2080.6		94.9%
ANTILOG PC-2				13.6		92.2%
TURBIDITY 1/M	1.2		78.8%	1.2		78.8%
ZMIX * TURBIDITY	5.3		74.7%	5.3		74.7%
ZMIX / SECCHI				7.0		74.8%
CHL-A * SECCHI				32.9		95.1%
CHL-A / TOTAL P				0.4		83.0%
FREQ(CHL-a>10) %				99.2		98.8%
FREQ(CHL-a>20) %				90.2		98.8%
FREQ(CHL-a>30) %				73.8		98.8%
FREQ(CHL-a>40) %				56.9		98.8%
FREQ(CHL-a>50) %				42.6		98.8%
FREQ(CHL-a>60) %				31.6		98.8%
CARLSON TSI-P	76.1		89.4%	76.4		89.8%
CARLSON TSI-CHLA				69.7		98.8%
CARLSON TSI-SEC				67.1		77.4%

Segment: 3 Segment 3

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	159.5		90.9%	161.0		91.1%
CHL-A MG/M3				62.0		99.3%
SECCHI M				0.5		13.1%
ANTILOG PC-1				3085.7		97.3%
ANTILOG PC-2				11.9		88.0%
TURBIDITY 1/M	1.7		88.0%	1.7		88.0%
ZMIX * TURBIDITY	4.8		70.5%	4.8		70.5%
ZMIX / SECCHI				6.1		66.2%
CHL-A * SECCHI				28.5		92.7%
CHL-A / TOTAL P				0.4		85.6%
FREQ(CHL-a>10) %				99.6		99.3%
FREQ(CHL-a>20) %				93.5		99.3%
FREQ(CHL-a>30) %				80.5		99.3%
FREQ(CHL-a>40) %				65.4		99.3%
FREQ(CHL-a>50) %				51.5		99.3%
FREQ(CHL-a>60) %				39.8		99.3%
CARLSON TSI-P	77.3		90.9%	77.4		91.1%
CARLSON TSI-CHLA				71.1		99.3%
CARLSON TSI-SEC				71.2		86.9%

Gillespie New Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**		**Segment:**	**1**	**Segment 1**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
3	1	Segment 1 Direct Drainage	1.2	7.3%	154.5	2.7%	124
PRECIPITATION			0.4	2.4%	8.1	0.1%	20
INTERNAL LOAD			0.0	0.0%	2958.5	51.2%	
TRIBUTARY INFLOW			1.2	7.3%	154.5	2.7%	124
ADVECTIVE INFLOW			15.4	90.3%	2271.8	39.3%	147
NET DIFFUSIVE INFLOW			0.0	0.0%	385.8	6.7%	
***TOTAL INFLOW			17.1	100.0%	5778.8	100.0%	338
ADVECTIVE OUTFLOW			16.7	97.6%	2339.4	40.5%	140
***TOTAL OUTFLOW			16.7	97.6%	2339.4	40.5%	140
***EVAPORATION			0.4	2.4%	0.0	0.0%	
***RETENTION			0.0	0.0%	3439.3	59.5%	

Hyd. Residence Time = 0.1025 yrs
Overflow Rate = 61.8 m/yr
Mean Depth = 6.3 m

Component:		**TOTAL P**		**Segment:**	**2**	**Segment 2**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
2	1	Segment 2 Direct Drainage	7.6	47.0%	942.4	12.8%	124
PRECIPITATION			0.7	4.4%	14.1	0.2%	20
INTERNAL LOAD			0.0	0.0%	5150.0	70.0%	
TRIBUTARY INFLOW			7.6	47.0%	942.4	12.8%	124
ADVECTIVE INFLOW			7.8	48.6%	1252.3	17.0%	160
***TOTAL INFLOW			16.2	100.0%	7358.8	100.0%	455
ADVECTIVE OUTFLOW			15.4	95.6%	2271.8	30.9%	147
NET DIFFUSIVE OUTFLOW			0.0	0.0%	332.1	4.5%	
***TOTAL OUTFLOW			15.4	95.6%	2604.0	35.4%	169
***EVAPORATION			0.7	4.4%	0.0	0.0%	
***RETENTION			0.0	0.0%	4754.9	64.6%	

Hyd. Residence Time = 0.1391 yrs
Overflow Rate = 32.9 m/yr
Mean Depth = 4.6 m

Component:		**TOTAL P**		**Segment:**	**3**	**Segment 3**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1	1	Inlet Tributary	7.8	98.3%	973.4	49.6%	124
PRECIPITATION			0.1	1.7%	2.7	0.1%	20
INTERNAL LOAD			0.0	0.0%	986.2	50.3%	
TRIBUTARY INFLOW			7.8	98.3%	973.4	49.6%	124
***TOTAL INFLOW			8.0	100.0%	1962.3	100.0%	246
ADVECTIVE OUTFLOW			7.8	98.3%	1252.3	63.8%	160
NET DIFFUSIVE OUTFLOW			0.0	0.0%	53.6	2.7%	
***TOTAL OUTFLOW			7.8	98.3%	1306.0	66.6%	166
***EVAPORATION			0.1	1.7%	0.0	0.0%	
***RETENTION			0.0	0.0%	656.3	33.4%	

Hyd. Residence Time = 0.0321 yrs
Overflow Rate = 87.2 m/yr
Mean Depth = 2.8 m

Gillespie New Lake

Overall Water & Nutrient Balances

Overall Water Balance

Averaging Period = 0.50 years

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance $(hm3/yr)^2$	CV -	Runoff m/yr
1	1	3	Inlet Tributary	13.7	7.8	0.00E+00	0.00	0.57
2	1	2	Segment 2 Direct Drainage	13.3	7.6	0.00E+00	0.00	0.57
3	1	1	Segment 1 Direct Drainage	2.2	1.2	0.00E+00	0.00	0.57
PRECIPITATION				0.8	1.3	0.00E+00	0.00	1.51
TRIBUTARY INFLOW				29.2	16.7	0.00E+00	0.00	0.57
***TOTAL INFLOW				30.0	17.9	0.00E+00	0.00	0.60
ADVECTIVE OUTFLOW				30.0	16.7	0.00E+00	0.00	0.56
***TOTAL OUTFLOW				30.0	16.7	0.00E+00	0.00	0.56
***EVAPORATION					1.3	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations

Component: TOTAL P

Trb	Type	Seg	Name	Load kg/yr	Load %Total	Load Variance $(kg/yr)^2$	Load Variance %Total	CV	Conc mg/m^3	Export $kg/km^2/yr$
1	1	3	Inlet Tributary	973.4	8.7%	0.00E+00		0.00	124.0	70.9
2	1	2	Segment 2 Direct Drainage	942.4	8.4%	0.00E+00		0.00	124.0	70.9
3	1	1	Segment 1 Direct Drainage	154.5	1.4%	0.00E+00		0.00	124.0	70.9
PRECIPITATION				24.9	0.2%	0.00E+00		0.00	19.9	30.0
INTERNAL LOAD				9094.7	81.3%	0.00E+00		0.00		
TRIBUTARY INFLOW				2070.3	18.5%	0.00E+00		0.00	124.0	70.9
***TOTAL INFLOW				11189.9	100.0%	0.00E+00		0.00	623.4	372.7
ADVECTIVE OUTFLOW				2339.4	20.9%	0.00E+00		0.00	140.1	77.9
***TOTAL OUTFLOW				2339.4	20.9%	0.00E+00		0.00	140.1	77.9
***RETENTION				8850.5	79.1%	0.00E+00		0.00		

Overflow Rate (m/yr)	20.1	Nutrient Resid. Time (yrs)	0.0537
Hydraulic Resid. Time (yrs)	0.2463	Turnover Ratio	9.3
Reservoir Conc (mg/m3)	146	Retention Coef.	0.791

Gillespie New Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	0	16.7	0.1025	61.8	6.4	23.0	2.1	0.0
2	Segment 2	1	15.4	0.1391	32.9	8.2	38.7	4.7	55.7
3	Segment 3	2	7.8	0.0321	87.2	21.4	15.4	7.4	4.3

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.3	6.3	5.3	0.7	1.7	0.4	1.6
2	Segment 2	0.5	4.6	4.3	1.1	2.1	0.4	2.8
3	Segment 3	0.1	2.8	2.8	0.7	0.3	0.1	5.3
Totals		0.8	5.0			4.1		

Gillespie New Lake

Segment & Tributary Network

--------Segment:	1	Segment 1		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 1 Direct Drainage	Type:	Monitored Inflow
--------Segment:	2	Segment 2		
Outflow Segment:	1	Segment 1		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3		
Outflow Segment:	2	Segment 2		
Tributary:	1	Inlet Tributary	Type:	Monitored Inflow

Gillespie New Lake

Description:

Single reservoir (204.5 acres (from GIS))
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.5	0.0
Precipitation (m)	0.755	0.0
Evaporation (m)	0.755	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.00
Total N	0	0.00
Ortho P	0	0.00
Inorganic N	0	0.00

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	0	NONE
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1	0	1	0.27	6.34	0.654	5.35	0.12	3.74	0	1.03	0	0	0	30	0	0	0
2	Segment 2	1	1	0.47	4.572	1.145	4.29	0.12	2.74	0	1.23	0	0	0	30	0	0	0
3	Segment 3	2	1	0.09	2.8	0.688	2.8	0.12	0	0	1.71	0	0	0	30	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	124	0	0	0	38	0	0.76	0	0	0	0	0	0	0	0	0
2	0	0	150	0	0	0	54	0	0.61	0	0	0	0	0	0	0	0	0
3	0	0	161	0	0	0	62	0	0.46	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Gillespie New Lake

Tributary Data

Trib	Trib Name	Segment	Type	Dr Area km^2	Flow (hm^3/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	3	1	13.72	7.85	0	0	0	124	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	13.29	7.6	0	0	0	124	0	0	0	0	0	0	0
3	Segment 1 Direct Drainage	1	1	2.18	1.246	0	0	0	124	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	**Trib Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Inlet Tributary	32.44	1.8	2.51	0.23	0.53	0.45	0	0
2	Segment 2 Direct Drainage	4.26	0.35	1.26	0.09	0.28	0.67	0	0
3	Segment 1 Direct Drainage	1.16	0.21	0.51	0.13	0.29	0.6	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.331	0	0	0	140	0	0	0	0	0	0	0
2	Grassland	0.331	0	0	0	140	0	0	0	0	0	0	0
3	Forest	0.331	0	0	0	140	0	0	0	0	0	0	0
4	Urban	0.331	0	0	0	140	0	0	0	0	0	0	0
5	Wetland	0.331	0	0	0	140	0	0	0	0	0	0	0
6	Other	0.331	0	0	0	140	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.007	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Attachment 5

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Data for fecal coliform load duration curves

Macoupin Creek Flow (cfs)	% of Time Exceeded	Load (cfu/day)
0.0	100.00	0.00E+00
19.4	60.26	9.48E+10
95.2	28.40	4.66E+11
97.6	28.04	4.78E+11
99.6	27.68	4.88E+11
101.7	27.32	4.97E+11
102.3	26.97	5.01E+11
105.1	26.61	5.14E+11
107.1	26.25	5.24E+11
109.1	25.89	5.34E+11
112.2	25.54	5.49E+11
114.6	25.18	5.61E+11
117.3	24.82	5.74E+11
119.3	24.46	5.84E+11
121.7	24.11	5.96E+11
125.1	23.75	6.12E+11
127.5	23.39	6.24E+11
130.9	23.03	6.41E+11
134.0	22.68	6.56E+11
136.0	22.32	6.66E+11
139.4	21.96	6.82E+11
142.8	21.60	6.99E+11
146.2	21.25	7.15E+11
149.9	20.89	7.34E+11
153.0	20.53	7.49E+11
156.4	20.17	7.65E+11
160.1	19.81	7.84E+11
164.9	19.46	8.07E+11
169.7	19.10	8.30E+11
173.4	18.74	8.49E+11
177.8	18.38	8.70E+11
183.3	18.03	8.97E+11
187.7	17.67	9.18E+11
193.8	17.31	9.48E+11
199.6	16.95	9.77E+11
204.0	16.60	9.98E+11
209.4	16.24	1.02E+12
216.6	15.88	1.06E+12
223.4	15.52	1.09E+12
231.2	15.17	1.13E+12
238.0	14.81	1.16E+12
245.1	14.45	1.20E+12
253.6	14.09	1.24E+12
264.2	13.74	1.29E+12
272.0	13.38	1.33E+12
282.5	13.02	1.38E+12
292.4	12.66	1.43E+12
302.6	12.31	1.48E+12
313.5	11.95	1.53E+12
325.7	11.59	1.59E+12
340.0	11.23	1.66E+12
350.2	10.87	1.71E+12

Observed Data

Date	Macoupin Creek Flow (cfs)	Concentration (cfu/100 ml)	Percentile	Load (cfu/day)
5/10/90	64	700	36.84	1.09E+12
6/14/90	76	500	32.82	9.32E+11
7/17/90	22	400	57.70	2.20E+11
9/24/90	15	340	64.95	1.22E+11
10/25/90	11	1700	69.44	4.67E+11
5/8/91	150	2700	20.88	9.91E+12
6/10/91	22	180	58.00	9.73E+10
7/10/91	16	680	63.47	2.66E+11
8/29/91	37	800	48.11	7.19E+11
10/7/91	16	520	63.81	1.99E+11
6/9/92	19	900	60.34	4.19E+11
7/21/92	7	7000	75.62	1.28E+12
8/18/92	4	480	85.28	4.39E+10
9/30/92	2	190	96.02	7.11E+09
5/20/93	111	790	25.68	2.14E+12
6/24/93	70	1000	34.60	1.71E+12
8/5/93	68	1100	35.26	1.83E+12
9/23/93	2948	91000	0.86	6.56E+15
5/4/94	445	500	8.98	5.45E+12
6/2/94	72	820	33.98	1.45E+12
7/18/94	9	370	73.10	8.00E+10
8/31/94	21	900	58.88	4.57E+11
9/22/94	2	400	91.30	2.36E+10
5/17/95	1962	27000	1.83	1.30E+15
7/20/95	17	220	62.81	8.97E+10
9/18/95	5	360	80.97	4.49E+10
10/31/95	4	60	85.28	5.49E+09
5/6/96	1285	1200	3.29	3.77E+13
6/27/96	29	400	53.44	2.80E+11
7/23/96	50	6000	41.88	7.29E+12
8/26/96	54	2600	39.96	3.46E+12
6/24/97	17	480	62.24	2.00E+11
8/14/97	7	360	76.91	5.99E+10
9/24/97	5	760	82.01	8.85E+10
5/20/98	68	400	35.26	6.66E+11
7/7/98	77	12000	32.63	2.26E+13
9/1/98	16	4000	63.81	1.53E+12
9/24/98	5	550	82.01	6.41E+10
5/16/02	1958	600	1.84	2.88E+13
7/9/02	29	480	53.44	3.35E+11
8/12/02	22	20000	57.70	1.10E+13
9/19/02	11	350	69.84	9.32E+10
10/28/02	19	1390	60.07	6.59E+11
5/22/03	210	700	16.23	3.60E+12
7/8/03	19	150	60.34	6.99E+10
8/12/03	9	320	73.10	6.92E+10
9/18/03	10	520	71.56	1.25E+11
6/1/04	181	520	18.16	2.30E+12
6/22/04	28	250	53.73	1.73E+11

Data for fecal coliform load duration curves

Macoupin Creek Flow (cfs)	% of Time Exceeded	Load (cfu/day)
360.4	10.52	1.76E+12
380.8	10.16	1.86E+12
401.2	9.80	1.96E+12
421.6	9.44	2.06E+12
442.0	9.09	2.16E+12
462.4	8.73	2.26E+12
493.0	8.37	2.41E+12
516.8	8.01	2.53E+12
550.8	7.66	2.70E+12
584.8	7.30	2.86E+12
622.2	6.94	3.04E+12
669.8	6.58	3.28E+12
707.2	6.23	3.46E+12
765.0	5.87	3.74E+12
816.0	5.51	3.99E+12
870.4	5.15	4.26E+12
938.4	4.80	4.59E+12
1006.4	4.44	4.93E+12
1077.8	4.08	5.27E+12
1162.8	3.72	5.69E+12
1275.0	3.37	6.24E+12
1380.4	3.01	6.76E+12
1526.6	2.65	7.47E+12
1713.6	2.29	8.39E+12
1897.2	1.93	9.28E+12
2152.2	1.58	1.05E+13
2495.6	1.22	1.22E+13
2947.8	0.86	1.44E+13
3672.0	0.50	1.80E+13
5406.0	0.15	2.65E+13

Attachment 6

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Macoupin Responsiveness Summary

1. We face great loss of natural water supplies, and pollution of what is left if longwall mining is allowed in Illinois. What is EPA doing to combat mining pollution and water losses from mining, in Illinois? I know longwall mining has occurred in Macoupin Co. and Southern Illinois. I have a farm in Illinois where longwall mining has been proposed and I am seriously worried about the repercussions.

Response: For underground mining operations, whether they be longwall or conventional (room-and-pillar), Illinois EPA only permits the surface facilities of such operations. The actual underground mining operation is outside the scope of our authority as granted under 35 Ill. Adm. Code. Subtitle D (mining regulations). The underground mining operations are handled through a mining permit issued by Illinois Department of Natural Resources (IDNR)/Office of Mines and Minerals.

2. My research for a LUMP (Lands Unsuitable for Mining Petition) tells me of complete changes in watershed, and losses of waters in Southeastern Pennsylvania, and Ohio. Illinois is the heart of the breadbasket of the world. Why is EPA allowing destructive mining practices to remove a nonrenewable resource (coal) while destroying renewable resources (water and land)?

Response: As the permitting activities for actual mining operation fall outside of the regulatory scope of Illinois EPA, these impacts should be sent to the IDNR/ Office of Mines and Minerals.

3. Tributaries of Shoal Creek and Macoupin Creek supply water in pastures so farmers can raise livestock. These tributaries may be destroyed by longwall mining, causing billions of dollars damage in the next century, because livestock cannot be raised without water. Is EPA aware of its future damage? Has it happened in Macoupin County? If so, what is EPA doing about it?

Response: Longwall mining has been conducted under tributaries to Honey Creek in Macoupin County and Illinois EPA is not aware of any damage occurring to the streams.

4. Longwall mining, with its earthquake like damage, when 95 percent of the coal is removed, can damage dams on the four major lakes in Montgomery County, as well as farm ponds. Is the EPA aware of this type of damage in Macoupin County? How has it affected lakes in that area?

Response: Illinois EPA is not aware of this type of damage being caused by longwall mining in Macoupin County.

5. Bottomland is turned into wetlands by longwall mining because when that much coal is removed, the ground sinks four or five feet. Has that happened in Macoupin

County, and how has it affected the watershed? Has it happened in other counties where longwall mining is going on?

Response: Illinois EPA is not aware of any permanent damage done by longwall mining in Illinois.

6. Is there an increase in arsenic, mercury and sulfur in Macoupin County waterways, as has happened with longwall mining in Pennsylvania?

Response: Illinois EPA is not aware of any increase in arsenic, mercury and sulfur resulting from subsidence caused by longwall mining in Macoupin County.

7. Longwall mining, if it happens to 200,000 acres, which is the major part of the southern half of Montgomery County, will cause many tributaries of Shoal Creek to dry up. Has the EPA anticipated how this mining in Montgomery and Macoupin counties will eventually affect the Kaskaskia and the Mississippi Rivers?

Response: Illinois EPA is not aware of any streams in Illinois drying up as a result of longwall mining.

8. My LUMP has been turned down twice by Natural Resources Mining and Minerals because they say the Strip Mining Act of 1977 does not apply to "underground mining". I submitted it under the Bill of Rights, Amendment 1 of the U.S. Constitution...a citizen's right to petition the government for grievances, and it was turned down again. Is the EPA aware of where a citizen might submit a petition aimed at protecting the environment, especially the loss and pollution of water by longwall mining?

Response: The Surface Coal Mining Land Conservation and Reclamation Act, including provisions dealing with lands unsuitable for mining petitions, is administered by IDNR/Office of Mines and Minerals. Questions related to that Act are best directed to IDNR.

TMDL Implementation Plan

Macoupin Creek Watershed

Prepared for Illinois Environmental Protection Agency

February 2007

Macoupin Creek (IL_DA-04): Fecal Coliform, Manganese, Dissolved Oxygen

Macoupin Creek (IL_DA-05): Manganese and Dissolved Oxygen

Carlinville Lake (IL_RDG): Total Phosphorus, Manganese

Beaver Lake Dam (IL_RDH): Total Phosphorus

Old Gillespie Lake (IL_SDT): Total Phosphorus, Manganese

New Gillespie Lake (IL_SDU): Total Phosphorus

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SUMMARY

Total Maximum Daily Loads (TMDLs) were developed and approved by the U.S. EPA in September 2006 for Macoupin Creek, Carlinville Lake, Beaver Dam Lake, New Gillespie Lake and Old Gillespie Lake, within the Macoupin Creek watershed in West-Central Illinois, to address a number of water quality impairments. Specifically, TMDLs were developed for fecal coliform in Macoupin Creek (IL_DA-04), manganese and phosphorus in Carlinville Lake, and for phosphorus in Beaver Dam Lake, New Gillespie Lake and Old Gillespie Lake. These TMDLs, which determined that significant reductions in existing pollutant loadings were needed to meet water quality objectives, have been approved by the U.S. EPA. A separate TMDL report was developed and submitted to U.S. EPA in September 2006 for Macoupin Creek to address manganese and low dissolved oxygen. The TMDL for manganese was approved by U.S. EPA. The Macoupin Creek TMDL for dissolved oxygen will not be approved by U.S. EPA (although it is considered completed by Illinois EPA) because the low dissolved oxygen levels were determined to be due to low flow and not pollutants; TMDLs cannot be written to control flow.

The next step in the TMDL process it to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. This document identifies a number of alternative actions to be considered by local stakeholders for TMDL implementation, identifies priority areas for controls and provides monitoring recommendations.

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INTRODUCTION

Section 303(d) of the 1972 Clean Water Act requires States to define waters that are not meeting designated uses under technology-based controls and identify them on a list of impaired waters, which is referred to as the 303(d) list. The Illinois Environmental Protection Agency's (IEPA) 2004 303(d) list is available on the web at: http://www.epa.state.il.us/water/tmdl/303d-list.html. Section 303(d) of the Clean Water Act and EPA's Water Quality Planning and Management Regulations (40 CFR Part 130) require states to develop Total Maximum Daily Loads (TMDLs) for these impaired water bodies. The TMDL process establishes the allowable loading of pollutants or other quantifiable parameters for a water body based on the relationship between pollution sources and conditions in the water body. This allowable loading represents the maximum quantity of the pollutant that the waterbody can receive without exceeding water quality standards. The TMDL also takes into account a margin of safety, which reflects scientific uncertainty, as well as the effects of seasonal variation. By following the TMDL process, States can establish water quality-based controls to reduce pollution from both point and nonpoint sources, and restore and maintain the quality of their water resources (U.S. EPA, 1991).

Macoupin Creek (IL_DA-04 and IL_DA-05), Carlinville Lake (IL_RDG), Beaver Dam Lake (IL_RDH), Old Gillespie Lake (IL_SDT), and New Gillespie Lake (IL_SDU) are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, they were targeted as high priority waterbodies for TMDL development. TMDLs for these waterbodies have been developed (LTI, 2006) and approved by the U.S. EPA. Briar Creek (IL_DAZN) is a tributary to Macoupin Creek and was also listed in the 303(d) list. Recently collected data indicate that Briar Creek is not impaired by low dissolved oxygen. Dissolved oxygen will be delisted as an impairment and Briar Creek is not addressed in this implementation plan. The next step in the TMDL process is to develop a voluntary implementation plan that includes both accountability and the potential for adaptive management. Adaptive management recognizes that proceeding with some initial improvement efforts is better than waiting to find a "perfect" solution. In an adaptive management approach, the TMDL and the watershed to which it applies are revisited over time to assess progress and make adjustments that continue to move toward achieving the TMDL's goals. Adaptive management may be conducted through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This document presents the implementation plan for the Macoupin Creek watershed TMDLs. It is divided into sections describing the watershed, summarizing the allowable loads and needed reductions identified in the TMDL, describing the implementation strategy, describing existing controls, discussing alternatives to reduce the existing loadings of the pollutants of concern, identifying priority areas for controls, describing reasonable assurances that the measures will be implemented, and outlining future monitoring and adaptive management.

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WATERSHED DESCRIPTION

The Macoupin Creek watershed is located in West-Central Illinois, approximately 45 miles south of Springfield, Illinois. The creek extends through four counties, but most of the watershed is located in Macoupin County. Macoupin Creek extends from its point of origin southeast of Farmersville to its confluence with the Illinois River, but the two impaired segments that are addressed in this report are the two most upstream segments. The watershed for these two segments is approximately 256,854 acres (400 square miles) in size, and there are about 227 miles of streams in the watershed (Macoupin County SWCD, 2003).

Figure 1 shows a map of the watershed, and includes key features such as waterways, impaired waterbodies, and public water intakes. The map also shows the locations of point source discharges that have a permit to discharge under the National Pollutant Discharge Elimination System (NPDES).

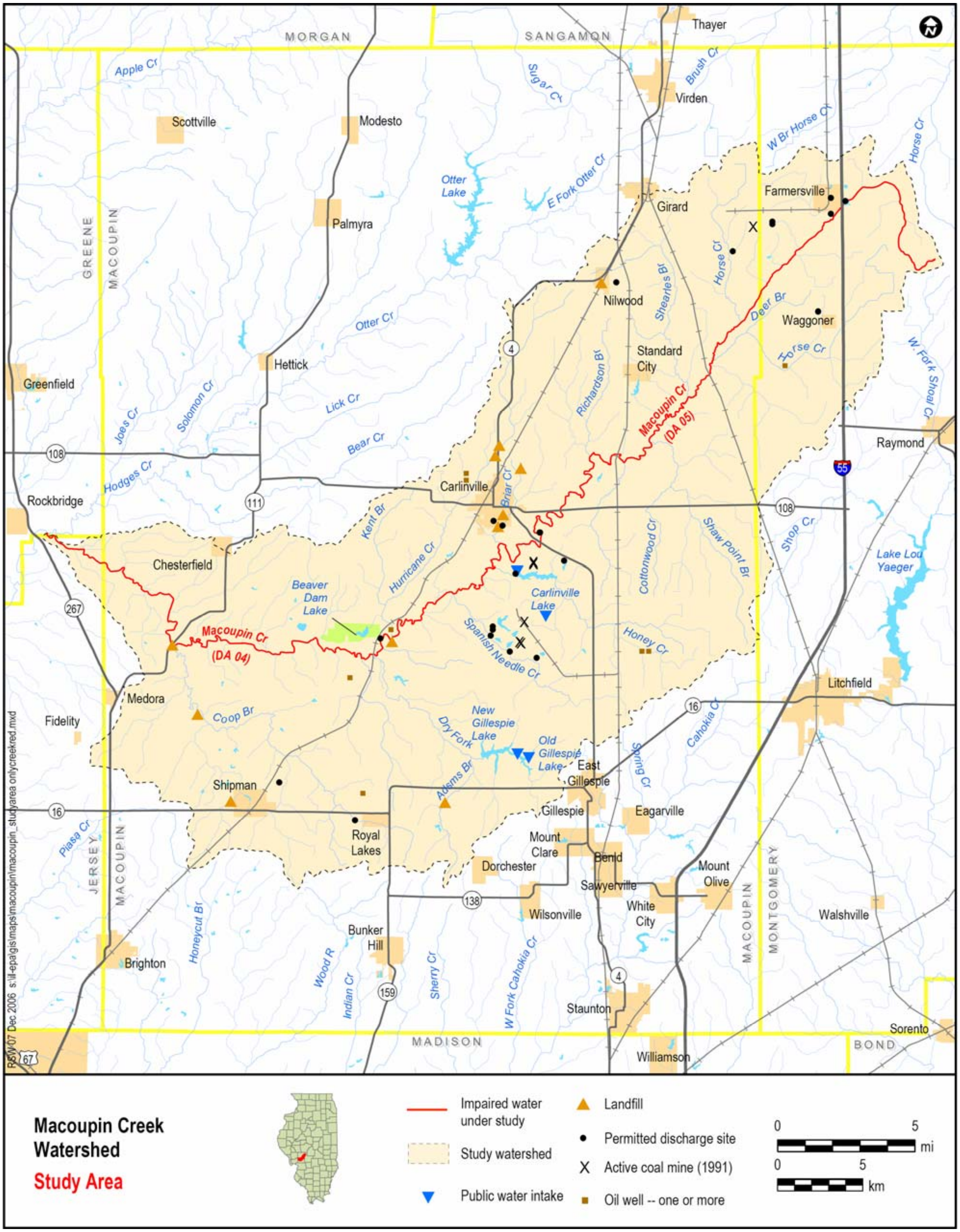

Figure 1. Macoupin Creek Watershed

TMDL SUMMARY

The following waterbodies are listed on the Illinois 303(d) list for various impairments:

- Macoupin Creek (IL_DA-04): Fecal Coliform, Manganese and Dissolved Oxygen
- Macoupin Creek (IL_DA-05): Manganese and Dissolved Oxygen
- Carlinville Lake (IL_RDG): Total Phosphorus, Manganese
- Beaver Lake Dam (IL_RDH): Total Phosphorus
- Old Gillespie Lake (IL_SDT): Total Phosphorus, Manganese
- New Gillespie Lake (IL_SDU): Total Phosphorus

Additional information on these impairment listings is summarized in Table 1.a (for Macoupin Creek) and Table 1.b (for lakes in the Macoupin Creek watershed).

Table 1.a. Summary of Impairment Listing for Macoupin Creek

Macoupin Creek	
Assessment Unit ID	IL_DA-04
Length (miles)	19.74
Listed For	**Fecal coliform**, **dissolved oxygen, manganese**, sedimentation/siltation, total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (F), Primary contact (N), Secondary contact (X), Aesthetic quality (X)
Assessment Unit ID	IL_DA-05
Length (miles)	43.89
Listed For	**Manganese, dissolved oxygen,** total nitrogen, other flow regime alterations[2], total phosphorus
Use Support[1]	Aquatic life (N), Fish consumption (F), Primary contact (X), Secondary contact (X), Aesthetic quality (X)

[1]F=fully supporting, N=not supporting, X=not assessed

[2] Not a pollutant; listed in category 3

Table 1.b. Summary of Impairment Listings for Lakes in the Macoupin Creek Watershed

Carlinville Lake	
Assessment Unit ID	IL_RDG
Size (Acres)	168
Listed For	**Manganese, total phosphorus**, total suspended solids, aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (X), Public and food processing water supplies (N), Primary contact (X), Secondary contact (X), Aesthetics (N),

Beaver Dam Lake	
Assessment Unit ID	IL_RDH
Size (Acres)	56.5
Listed For	**Total phosphorus**, Aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (F), Primary contact (X), Secondary contact (X), Aesthetic quality (N)

Old Gillespie Lake	
Assessment Unit ID	IL_SDT
Size (Acres)	71
Listed For	**Manganese, total phosphorus**, Total suspended solids, Aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (F), Public and food processing water supplies (N), Primary contact (X), Secondary contact (X), Aesthetic Quality (N)

New Gillespie Lake	
Assessment Unit ID	IL_SDU
Size (Acres)	207
Listed For	**Total phosphorus**, Total suspended solids, Aquatic algae[2]
Use Support[1]	Aquatic life (F), Fish consumption (F), Public and food processing water supplies (F), Primary contact (X), Secondary contact (X), Aesthetic quality (N)

[1]F=fully supporting, N=not supporting, X=not assessed

[2] Not a pollutant; listed in category 3

Potential sources contributing to the impairment listing of waterbodies in the Macoupin Creek watershed are summarized in Tables 2.a and 2.b.

Table 2.a. Sources of Impairment for Macoupin Creek

Waterbody	Cause of Impairments	Potential Sources
Macoupin Creek (IL_DA-04)		
	FECAL COLIFORM	Runoff from pastureland and animal feeding operations, failing private sewage disposal systems (septic and surface discharge systems), municipal point sources, combined sewer overflows
	MANGANESE	Natural background sources including groundwater, surface runoff and soil erosion
	DISSOLVED OXYGEN	Sediment oxygen demand; Conditions exacerbated during low flow; Non-point sources of oxygen-demanding substances; crop fertilization with commercial fertilizers or manure; animal feeding operations and pastureland runoff; runoff from fertilized lawns; lakeshore and streambank erosion*
Macoupin Creek (IL_DA-05)		
	MANGANESE	Natural background sources; ground surface and streambank erosion of soils naturally enriched with manganese
	DISSOLVED OXYGEN	Sediment oxygen demand; Conditions exacerbated during low flow; Non-point sources of oxygen-demanding substances; crop fertilization with commercial fertilizers or manure; animal feeding operations and pastureland runoff; runoff from fertilized lawns; lakeshore and streambank erosion*

*Modeling showed that these are not a cause of low dissolved oxygen in Macoupin Creek

Table 2.b. Sources of Impairment for Lakes in the Macoupin Creek Watershed

Waterbody	Cause of Impairments	Potential Sources
Carlinville Lake (IL_RDG)		
	TOTAL PHOSPHORUS	Release from lake bottom sediments during anoxic conditions; failing septic systems; runoff from watershed; crop fertilization; animal feeding operations; pastureland; lakeshore and streambank erosion; runoff from fertilized lawns
	MANGANESE	Streambank and lakeshore erosion of soils naturally enriched with manganese; release from lake bottom sediments during anoxic conditions
Beaver Dam Lake (IL_RDH)		
	TOTAL PHOSPHORUS	Release from lake bottom sediments during anoxic conditions; failing septic systems; runoff from watershed; crop fertilization; animal feeding operations; pastureland; lakeshore and streambank erosion; runoff from fertilized lawns
Old Gillespie Lake (IL_SDT)		
	TOTAL PHOSPHORUS	Release from lake bottom sediments during anoxic conditions; failing septic systems; runoff from watershed; crop fertilization; animal feeding operations; pastureland; lakeshore and streambank erosion; runoff from fertilized lawns
	MANGANESE	Streambank and lakeshore erosion of soils naturally enriched with manganese; release from lake bottom sediments during anoxic conditions
New Gillespie Lake (IL_SDU)		
	TOTAL PHOSPHORUS	Release from lake bottom sediments during anoxic conditions; failing septic systems; runoff from watershed; crop fertilization; animal feeding operations; pastureland; lakeshore and streambank erosion; runoff from fertilized lawns

TMDLs require targets, numeric endpoints specified to represent the level of acceptable water quality to be achieved by implementing the TMDL. Where possible, the water quality criterion for the pollutant of concern is used as the numeric endpoint. When appropriate numeric standards do not exist or are not practical for TMDL implementation, surrogate parameters must be selected to represent the designated use. TMDL targets were developed to represent each pollutant addressed in these TMDLs. The target parameters for the TMDLs discussed in this implementation plan are discussed further below and are summarized in Table 3.

The IEPA guidelines (IEPA, 2006) for identifying **fecal coliform** as a cause of impairment in streams state that fecal coliform is a potential cause of impairment of the primary contact use if the geometric mean of all samples collected during May through October (minimum five samples) is greater than 200 cfu/100 ml, or if greater than 10% of all samples exceed 400 cfu/100 ml. For the Macoupin Creek TMDL for fecal coliform, the target was set at meeting 200 cfu/100 ml across the entire flow regime during May through October. Reduction of fecal coliform loading from point and non-point sources is targeted for the Macoupin Creek fecal coliform TMDL.

The water quality standard for **manganese** in streams is 1,000 ug/l to protect the aquatic life use. The TMDL target for manganese is therefore a total manganese concentration of 1,000 ug/l. For Macoupin Creek, direct reductions in manganese loading are targeted to meet the TMDL. For Carlinville and Old Gillespie Lakes, elevated manganese is attributed to release of manganese from sediments, which occurs when dissolved oxygen is depressed in the bottom waters of the lakes. This oxygen depletion is attributed to excessive loading of phosphorus, so phosphorus reduction is targeted to address the manganese TMDLs for Carlinville and Old Gillespie Lakes.

The water quality standard for **dissolved oxygen** in Illinois waters designated for aquatic life specifies that dissolved oxygen shall not be less than 6.0 mg/l during at least 16 hours of any 24 hour period, nor less than 5.0 mg/l at any time. For Macoupin Creek, the TMDL target was set based upon the water quality criterion for minimum dissolved oxygen of 5 mg/l.

The water quality standard for **phosphorus** to protect aquatic life and secondary contact uses in Illinois lakes is 0.05 mg-P/l. For this reason, attainment of the total phosphorus standard is expected to result in attainment of the dissolved oxygen standard. The TMDL target for dissolved oxygen is therefore a total phosphorus concentration of 0.05 mg-P/l. Phosphorus load reductions from non-point sources are targeted to meet the phosphorus TMDLs for Carlinville, Beaver Dam, Old Gillespie, and New Gillespie Lakes. As discussed above, phosphorus reduction is also targeted to address the manganese TMDLs for Carlinville and Old Gillespie Lakes.

Table 3. Target Parameters for Macoupin Creek Watershed TMDLs

Waterbody	TMDL	Parameter Targeted for Load Reduction
Macoupin Creek	Fecal coliform Manganese Dissolved Oxygen	Fecal coliform Manganese N/A*
Carlinville Lake	Total Phosphorus Manganese	Phosphorus Phosphorus
Beaver Dam Lake	Total Phosphorus	Phosphorus
Old Gillespie Lake	Total Phosphorus Manganese	Phosphorus Phosphorus
Beaver Dam Lake	Total Phosphorus	Phosphorus

*Modeling showed low dissolved oxygen is caused by low flow, not a pollutant.

The TMDLs determined the total allowable load for each lake and Macoupin Creek, as well as the level of reduction needed to achieve the TMDL targets. Table 4.a through 4.d summarize the TMDL allocations.

Table 4.a. Summary of Macoupin Creek Lake TMDLs (kg P/day)

Lake	Allowable Load [1]	Waste Load Allocation	Load Allocation	Margin of Safety	Percent Reduction Needed
Carlinville	6.38	--	5.742	0.638	51%
Beaver Dam	0.078	--	0.070	0.008	0%[2]
Old Gillespie	0.544	--	0.49	0.054	74%
New Gillespie	3.04	--	2.74	0.304	48%

[1] Phosphorus loads are for March 1-August 31 (critical period)

2 Current loads are estimated to be in compliance with the load capacity, such Beaver Dam Lake is expected to eventually attain standards once sediment loads reach equilibrium with external loads. Implementation options include waiting for natural attenuation of sediment sources to occur or active remediation of internal sediment load.

Table 4.b. Summary of Macoupin Creek (IL_DA-04) Fecal Coliform TMDL (cfu/day)[1]

Macoupin Creek Flow (cfs)	Allowable Load	Waste Load Allocation	Load Allocation	Percent Reduction Needed
4.8	2.33E+10	1.39E +10	9.34E+09	94%
34	1.68E+11	1.39E +10	1.54E+11	98%
206	1.01E+12	1.39E +10	9.85E+11	99%

[1]An implicit MOS is used in this TMDL

In addition to the WLA presented above, the Carlinville STP also has a permit for two combined sewer overflows (CSOs) that may discharge under wet weather conditions. The WLA for the CSOs equals 7.49E+09 cfu/day.

Table 4.c. Summary of Macoupin Creek IL_DA-04 Manganese TMDL (lbs/day)

Macoupin Creek Flow (cfs)	Allowable Load	Waste Load Allocation	Load Allocation	Margin of Safety
5	27.0	--	24.3	2.7
10	53.9	--	48.5	5.4
20	107.9	--	97.1	10.8
50	269.7	--	242.7	27.0
100	539.4	--	485.4	53.9
200	1,078.7	--	970.9	107.9
400	2,157.5	--	1,941.7	215.7
1000	5,393.7	--	4,854.3	539.4

A 35% reduction in manganese load is required. Violations were observed only during low flows, suggesting natural sources (e.g., groundwater) are the primary cause of the observed impairment.

Table 4.d. Summary of Macoupin Creek IL_DA-05 Manganese TMDL (lbs/day)

Macoupin Creek Flow (cfs)	Allowable Load	Waste Load Allocation	Load Allocation	Margin of Safety
3	17.3	--	15.5	1.7
6	34.5	--	31.1	3.5
13	69.0	--	62.1	6.9
32	172.6	--	155.3	17.3
64	345.2	--	310.7	34.5
128	690.4	--	621.3	69.0
256	1,380.8	--	1,242.7	138.1
640	3,451.9	--	3,106.7	345.2

An 85% reduction in manganese load is required over the range of flows.

The TMDL for Macoupin Creek (IL_DA-04 and IL_DA-05) dissolved oxygen determined that sediment oxygen demand is the dominant cause of the oxygen deficit; however, the true cause of low dissolved oxygen is a lack of base flow (which greatly exacerbates the effect of sediment oxygen demand). TMDLs cannot be written to control flow. Some of the implementation options in this implementation plan will improve baseflow and/or reduce water temperatures, both of which will help improve dissolved oxygen during low flows.

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IMPLEMENTATION APPROACH

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

1. Use existing data to define overall existing pollutant loads, as opposed to developing a watershed model that might define individual loading sources.
2. Apply relatively simple models (e.g. BATHTUB) to define the load-response relationship and define the maximum allowable pollutant load that the lakes can assimilate and still attain water quality standards.
3. Compare the maximum allowable load to the existing load to define the extent to which existing loads must be reduced in order to meet water quality standards.
4. Develop a voluntary implementation plan that includes both accountability and the potential for adaptive management.
5. Carry out adaptive management through the implementation of a long-term monitoring plan designed to assess the effectiveness of pollution controls as they are implemented, as well as progress towards attaining water quality standards.

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. The Association of Illinois Soil and Water Conservation Districts, using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies. The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

The first three steps described above have been completed, as documented in the TMDL reports for the Macoupin Creek watershed (LTI, 2006a and 2006b). This plan represents Step Four of the process. Step Five is briefly described in the last section of this document, and will be conducted as implementation proceeds.

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EXISTING CONTROLS

A number of past initiatives and projects have been implemented to improve water quality in the water bodies discussed in this implementation plan. Several of these were discussed in the 2003 Watershed Restoration Action Strategy for Upper Macoupin Creek, prepared by the Natural Resource Conservation Service (NRCS, 2003), including the following:

- *Old and New Gillespie Lakes.* A 1995 planning effort was undertaken to address inflow of sediment, nutrients, and agricultural chemicals to the lakes and farmers were encouraged to implement conservation tillage practices. In addition, Section 319 grant funds have been obtained to implement sediment control basins and for public education. The Macoupin County Soil and Water Conservation District has also obtained funding for implementation of best management practices (BMPs) and ongoing lake monitoring (through Blackburn College).
- *Carlinville Lake.* In 1993, a resource planning effort was initiated to address a number of natural resource issues, including water quality. One of the recommendations of the initiative was construction of a sedimentation basin, but that project had not been constructed as of the 2003 report. Land terraces and ponds have been built in the watershed and conservation tillage is being used.
- *Beaver Dam State Park.* According to the 2003 report, five aerators were planned for Beaver Dam Lake as part of overall improvements to Beaver Dam State Park to aerate and mix the water column and prevent summer fish kills.

In addition to the lake-specific efforts described above, the NRCS report lists several USDA/NRCS programs available to farmers including the Conservation Reserve Program, the Conservation Reserve Enhancement Program, the Wetlands Incentive Program, the Wildlife Habitat Incentive Program, the Environmental Quality Incentive Program, and the Wetland Quality Incentive Program. These programs are described later in this plan, but specific information on the extent to which they have been utilized in the Macoupin Creek watershed is not available. The local Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), and Soil and Water Conservation District (SWCD) offices have information on existing best management practices within the watershed, and can be contacted to understand what efforts have been made or are planned to control nonpoint sources.

In 2005, the Illinois Department of Agriculture conducted an “aerial assessment” of Macoupin Creek from Coops Mound (just south of Standard City), downstream to Rockbridge (IDOA, 2005). The assessment involved collection of aerial-based digital video of stream channel conditions in Macoupin Creek, for purposes of identifying sites for stream bank or channel stabilization, as a means of reduction erosion and sedimentation problems in the watershed. The report recommended bank stabilization and grade control measures throughout the watershed, but did not suggest any means or strategy to prioritize these measures. None of the recommended work appears to have been completed.

In 2005, the City of Carlinville received a grant from the Illinois EPA under the State's section 319 grant program to conduct a project titled "Lake Carlinville Watershed Plan". The project involves performance of a Phase I diagnostic feasibility study of Carlinville Lake and preparation of an improvement plan for the Carlinville Lake watershed. The final project deliverables are scheduled for completion by December 2007.

IMPLEMENTATION ALTERNATIVES

Based on the objectives for the TMDLs, information obtained at the public meetings, and experience in other watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs. As discussed earlier in this plan, a number of BMPs, including water and sediment control systems, terracing, and conservation tillage, have been implemented in this watershed (NRCS, 2003). No comprehensive inventory of BMPs was identified in preparing this plan and it is not known whether any study of the effectiveness of the BMPs has been undertaken.

Implementation alternatives are focused on one or more the following source categories:

- Sources suspected of contributing fecal coliform to Macoupin Creek: runoff from pastureland and animal feeding operations; failing private sewage disposal systems (septic and surface discharge systems); municipal point sources; and combined sewer overflows.
- Sources suspected of contributing phosphorus loads to the lakes: failing septic systems; runoff from watershed; crop fertilization; animal feeding operations; pastureland; lakeshore and streambank erosion; and runoff from fertilized lawns.

For manganese, the primary source appears to be naturally high levels in groundwater, which cannot be addressed by the BMPs described herein. However, BMPs designed to reduce erosion are expected to provide secondary benefits in reducing manganese, given that manganese concentrations in local soils are often elevated (LTI, 2005).

Non-structural BMPs identified for this watershed include:

- Nutrient Management
- Conservation Tillage
- Conservation Buffers
- Private Sewage Disposal System Inspection and Maintenance Program
- Restriction of Livestock Access

Structural BMPs identified for this watershed include:

- Sediment Control Basins
- Streambank and Shoreline Stabilization
- Wetland Restoration
- Grassed Waterways
- Combined Sewer Overflow Controls
- Point Source Controls

In-lake phosphorus controls include:

- Aeration
- Dredging
- Phosphorus Inactivation

Each of these alternatives is described briefly in this section, including information about their costs and effectiveness in reducing loadings of the constituents of concern. Costs have been updated from their original sources, based on literature citations, to 2006 costs using the Engineering News Record Construction Cost Index, as provided by the Natural Resource Conservation Service (NRCS)[1]. Some of the measures described below are most applicable to a single pollutant, while others will have broader applicability. Table 5 summarizes the implementation alternatives and the pollutants which each is expected to reduce.

It should be noted that there is usually a wide range in the effectiveness of the various practices; this is largely due to variations in climate, soils, crops, topography, design, construction, and maintenance of the practices (NRCS, 2006).

[1] http://www.economics.nrcs.usda.gov/cost/priceindexes/index.html

Table 5. Applicability of Implementation Alternatives (BMPs)

Alternative	Fecal Coliform	Manganese (loading to creek)	Phosphorus
Non-Structural BMPs			
Nutrient Management			●
Conservation Tillage		*	●
Conservation Buffers	●	*	●
Private Sewage Disposal System Inspection and Maintenance Program	●		●
Restriction of Livestock Access	●	*	●
Combined Sewer Overflow Controls	●		
Point Source Controls	●		
Structural BMPs			
Sediment Control Basins		*	●
Streambank and Shoreline Stabilization		*	●
Wetland Restoration	●	*	●
Grassed Waterways		*	●
In-Lake Controls			
Aeration			●
Dredging			●
Phosphorus Inactivation			●

* While not directly tied to primary sources of manganese, BMPs designed to reduce erosion are expected to provide secondary benefits in reducing manganese, given that manganese concentrations in local soils are often elevated.

NUTRIENT MANAGEMENT

Nutrient management plans are designed to minimize nutrient losses from agricultural lands, and therefore minimize the amount of phosphorus transported to the lakes. Because agriculture is the most common land use in the watershed, controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the lakes. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (EPA, 2003). The majority of phosphorus lost from agricultural land is transported via surface runoff (vs. leaching through the soil, as occurs for nitrogen), mostly in particulate form attached to eroded soil particles. A nutrient management plan identifies the amount, source, time of application, and placement of each nutrient needed to produce each crop grown on each field each year, to optimize efficient use of all sources of nutrients (including soil reserves, commercial fertilizer, legume crops, and organic sources) and minimize the potential for losses that lead to degradation of soil and water quality (UIUC, 2005).

Steps in developing a nutrient management plan include (UIUC, 2005):

- Assess the natural nutrient sources (soil reserves and legume contributions).
- Identify fields or areas within fields that require special nutrient management precautions.
- Assess nutrient needs for each field by crop.
- Determine quantity of nutrients that will be available from organic sources, such as manure or industrial or municipal wastes.
- Allocate nutrients available from organic sources.
- Calculate the amount of commercial fertilizer needed for each field.
- Determine the ideal time and method of application.
- Select nutrient sources that will be most effective and convenient for the operation.

Local NRCS staff have indicated that the vast majority (on the order of 90%) of farmers in the area are using soil testing to determine the amount and type of fertilizer to apply to the soil. This suggests that some nutrient management is already occurring in the watershed. A U.S. Department of Agriculture study reported that average annual phosphorus application rates were reduced by 36 lb/acre when nutrient management practices were adopted (EPA, 2003). Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil and is subject to transport (NRCS, 2006). In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality.

Costs of developing nutrient management plans have been estimated at \$6 to \$20/acre (EPA, 2003). These costs are often offset by the savings associated with using less fertilizer. For example, a study in Iowa showed improved nutrient management on cornfields led to a savings of about \$3.60/acre (EPA, 2003).

CONSERVATION TILLAGE

The objective of conservation tillage is to provide profitable crop production while minimizing soil erosion (UIUC, 2005). This reduction in erosion also reduces the amount of nutrients, particularly phosphorus, lost from the land and delivered to surface waters. The Natural Resources Conservation Service (NRCS) has replaced the term conservation tillage with the term crop residue management, or the year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognized as cost-effective means of significantly reducing soil erosion and maintaining productivity. The most recent Illinois Soil Transect Survey (IDOA, 2004) suggests that 91% of land under soybean production in Macoupin County is farmed using reduced till, mulch till, or no-till, while all of the land in small grain production and 72% of corn fields are farmed with conventional methods. In Montgomery County, 99% of land under soybean production and all of the land in small grain production is farmed using reduced till, mulch till, or no-till, while 76% of corn fields are farmed with conventional methods. Additional conservation tillage measures should be considered as part of this implementation plan, particularly for cornfields and for small grain fields in Macoupin County.

Conservation tillage practices have been reported to reduce total phosphorus loads by 45%, and total nitrogen (including organic nitrogen, ammonia, and nitrate) loads by 55% (EPA, 2003). In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006). A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre in capital costs (EPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $36 to $66 per acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

CONSERVATION BUFFERS

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999), generally by slowing the rate of runoff, while filtering sediment and nutrients. Additional benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999).

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (EPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 2006). Vegetated filter strips and riparian buffers can also be used to reduce bacteria; riparian buffer zones have bacteria removal efficiencies of 43-57% (Commonwealth of Virginia, 2003).

Costs of conservation buffers vary from about $200/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $360/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,030/acre for riparian buffers using bare root stock shrubs (NRCS, 2005).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Conservation 2000 Program, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/Environment/conserv/index.html). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects. The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (www.treesforever.org), VIEW guides a committee of local stakeholders through a watershed landscape planning process (Trees Forever, 2005). Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

PRIVATE SEPTIC SYSTEM INSPECTION AND MAINTENANCE PROGRAM

A number of municipal wastewater treatment plants exist in the Macoupin Creek watershed including Carlinville, Farmersville, Nilwood, Chesterfield, Shipman, Waggoner, and Beaver Dam State Park (NRCS, 2003). However, private septic systems are common in rural areas and around lakes. A more proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. The U.S. EPA has developed guidance for managing private sewage disposal systems (EPA, 2005). This guidance includes procedures for assessing existing conditions, assessing public health and environmental risks, selecting a management approach, and implementing a management program (including funding information).

This alternative would require the commitment of staff time for County Health Department personnel; cost depends on whether the additional inspection activities could be accomplished by existing staff or would require additional personnel.

RESTRICT LIVESTOCK ACCESS TO LAKE AND TRIBUTARIES

It has been noted that there a many livestock operations in the Macoupin Creek watershed (LTI, 2005) and, in some cases, livestock have access to Macoupin Creek and its tributaries. Livestock are a potential source of nutrients and fecal coliform that are the focus of this TMDL. In addition, livestock can cause or exacerbate streambank erosion and trample riparian buffers.

One potential component of TMDL implementation could be to restrict livestock access to Macoupin Creek, its tributaries, and the lakes in the watershed. This could be accomplished by fencing and installation of alternative systems for livestock watering. Livestock exclusion and other grazing management measures have been shown to reduce phosphorus loads on the order of 49%, (EPA, 2003). The principal direct costs of providing grazing practices vary from relatively low variable costs of dispersed salt blocks to higher capital and maintenance costs of supplementary water supply improvements. Improving the distribution of grazing pressure by developing a planned grazing system or strategically locating water troughs, salt, or feeding areas to draw cattle away from riparian zones can result in improved utilization of existing forage, better water quality, and improved riparian habitat. Fencing costs are estimated as $3,500 to $4,000 per mile (USEPA, 2003). Capital costs for pipeline watering range from $0.32 to $2.60 per foot, while watering tanks and troughs range from $291 to $1,625 each (EPA, 2003).

SEDIMENT CONTROL BASINS

Sediment control basins trap sediments (and nutrients bound to that sediment) before they reach surface waters (EPA, 2003). That is not only important for reducing sedimentation of lakes, but also for reducing loading of nutrients and oxygen-demanding substances. Although sediment control basins have been proposed in various parts of the watershed, documentation of actual basin construction was not identified for this plan.

Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin (Zahniser Institute, undated). This same study estimated a trapping efficiency for sediment of 75%. Sediment control basins may be implemented as relatively small basins distributed throughout the watershed, or larger regional sediment control basins can be implemented near lake inlets. This latter type of regional sedimentation basin would be similar to the one recently constructed on Otter Lake, which had an estimated cost of $750,000. Siting considerations and costs are driven mainly by the size of the basin required, land availability, and land acquisition costs.

STREAMBANK STABILIZATION

Erosion of the banks and beds of tributary streams is recognized as a significant source of sediment loading lakes in the Macoupin Creek watershed. This sediment load not only causes sedimentation in the lakes, but also contributes to loading of phosphorus and manganese. Streambank stabilization (including grade stabilization to reduce erosive velocities and shear stresses) is a key measure in reducing erosion and the resulting sediment loads.

A recent aerial assessment report concluded that Macoupin Creek is experiencing "extensive streambank erosion" (IDOA, 2005). This study recommends rock riffle grade control and stone toe protection to counter bed erosion and stabilize banks along the length of Macoupin Creek. The report estimates that the cost for installing rock riffles and stone toe protection for streambank stabilization along 44 miles of Macoupin Creek would be $2,635,500 to $3,289,500. This estimate does not include the cost of repairing or stabilizing upper bank erosion or geotechnical failures along the creek, not does it address bank erosion in tributaries.

Because of the high potential cost of stabilizing streambanks throughout the watershed, additional study is recommended to prioritize sites for streambank stabilization. Such study should include direct observation of bank conditions, as well as an assessment of stream hydraulics and geomorphology to support identification and design of effective stabilization measures.

SHORELINE ENHANCEMENT AND PROTECTION

Shoreline erosion was observed on Carlinville Lake during a field visit for watershed characterization (LTI, 2005). The existence or extent of shoreline erosion on Old Gillespie, New Gillespie, or Beaver Dam Lakes is not known. Sediment derived from shoreline erosion not only increases solids in the lakes and decreases lake volume, but also can increase nutrient loads to the lakes. Shoreline enhancement efforts, such as planting deep-rooted vegetation or installing rip-rap in the unprotected shoreline areas, will provide protection against erosion and the associated increased pollutant loads. Estimates for rip-rapping are approximately \$67-\$73/ton (NRCS, 2005), while estimates for plantings at another Illinois lake suggest a cost of approximately \$5/linear foot (CMT, 2004).

WETLAND RESTORATION

Wetland restoration is defined as rehabilitation of a drained or degraded wetland to its natural condition, to the extent practicable (NRCS, 1998). Wetland restoration can be effective BMP for reducing loading of sediments, nutrients, and oxygen-demanding substances. It has been estimated that approximately 79,000 acres of wetlands existed in Macoupin County prior to settlement. Currently there are approximately 20,000 acres of hydric soils in the Macoupin Creek watershed that are not developed, forested or wetland. These are potential areas where wetlands could be restored. This is discussed in more detail later in this Implementation Plan. The work required to implement a restoration project may involve simply breaking drain tiles and blocking drain ditches, or it may require more engineering effort and replanting. In addition to improving water quality, wetland restoration provides additional benefits for flood control, habitat, and recreation. Costs for wetland restoration vary widely, depending on the size of the wetland, the work needed for restoration, and land costs. However, a general unit cost of \$500 to \$1200 per acre has been suggested (FWS, 2006) for restoration projects in Illinois.

GRASSED WATERWAYS

Grassed waterways are another alternative to consider for this watershed. A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately \$1,800/acre, not including costs for tile or seeding (MCSWCD, 2006b).

COMBINED SEWER OVERFLOW CONTROLS

The Carlinville sewage treatment plant has a permit for two combined sewer overflows (CSOs) that may discharge under wet weather conditions. These CSOs are a source of fecal coliform to Macoupin Creek. The City is required under its NPDES permit to conduct a CSO Assessment, and to develop a Long-Term Control Plan (LTCP) by

January 1, 2007, if the CSO Assessment indicates that the CSO outfalls cause or contribute to violations of water quality standards. The City prepared a pollution prevention plan for the CSO collection/treatment system, as well as an operation and maintenance plan; these were approved by the Illinois EPA. These plans were designed to comply with the National CSO control Policy and reduce pollutant loadings.

POINT SOURCE CONTROLS

There are eight NPDES permitted point source dischargers of fecal coliform in the Macoupin Creek watershed: Monterey Coal #1 Mine North, Carlinville STP, Lake Williamson Christian Center, Shipman STP, Il DNR-Beaver Dam State Park, Royal Lakes STP, Nilwood STP, and Farmersville STP. The Lake Williamson Christian Center has a seasonal disinfection exemption and the rest have year-round disinfection exemptions, and are not required to remove fecal coliform from their discharges. IEPA will examine disinfection exemptions as part of TMDL implementation. IEPA intends to remove disinfection exemptions for point sources discharging directly to impaired waterbodies, and will require point sources discharging upstream of impaired segments to demonstrate that their discharge has no reasonable potential to exceed water quality standards in applicable stream reaches. IEPA will evaluate the need for additional point source controls through the NPDES permitting program; permits might need to be modified to ensure consistency with the WLA.

AERATION/DESTRATIFICATION

As noted in the report on TMDLs for Carlinville, Old Gillespie, New Gillespie, and Beaver Dam Lakes (LTI, 2006), existing lake sediments are a significant source of both phosphorus and manganese. When dissolved oxygen is absent in the hypolimnion (deep layer) of the lake, phosphorus and manganese are released from the sediments. Control of this internal load requires either removing phosphorus (and manganese) from the lake bottom (such as through dredging), or preventing oxygen-deficient conditions from occurring. Aeration of portions of the lake might be considered as an alternative to increase mixing and improve oxygen levels. Destratifiers have also been installed in other Illinois lakes to prevent thermal stratification, and thus increase oxygen concentrations in the deeper lake waters. Studies have indicated that such systems can significantly improve water quality (Raman et. al, 1998). A destratification system installed in Lake Evergreen (754 acres) in McLean County was effective in improving dissolved oxygen levels throughout the lake, up to the depth of its operation (Raman et al, 1998). The destratifier used on Lake Evergreen cost approximately $72,000 (Raman et al, 1998). The cost of a destratifier or an aeration system has been estimated for a smaller Illinois lake at $65,000 (CMT, 2004).

DREDGING

As discussed above, lake sediments have been identified as a significant source of phosphorus and manganese to lakes in the Macoupin Creek watershed. In addition, sedimentation reduces the water volume of the lake, with a corresponding reduction in the lake’s assimilative capacity. Dredging of the existing sediments is one alternative to address this source. It is, however, an expensive alternative, and would be only a temporary solution; if sediment and phosphorus loads are not reduced in the watershed, it is likely that sedimentation and nutrient flux from the sediments will continue to be a problem in the future. Costs for dredging have been estimated at $6 to $20 per cubic yard of sediment removed for hydraulic dredging (IEPA, 1998).

PHOSPHORUS INACTIVATION

Phosphorus inactivation involves application of aluminum salts or calcium compounds to the lake to reduce phosphorus in the water column and slow its release from sediments (McComas, 1993). This can be an effective means of mitigating excess phosphorus in lakes and reservoirs (NALMS, 2004). Addition of aluminum sulfate (alum) is most common, but compounds such as calcium carbonate and calcium hydroxide (lime) can also be used (McComas, 1993). When alum is added to lake water, a series of chemical hydrolysis steps leads to the formation of a solid precipitate that has a high capacity to absorb phosphates. This flocculent material settles to the lake bottom, removing the phosphorus from the water column and providing a barrier that retards release of phosphorus from the sediments (NALMS, 2004). Aluminum concentrations in lake water are usually at acceptable levels for drinking water shortly after alum application (NALMS, 2004).

This alternative is best used in combination with a reduction in phosphorus inputs from watershed sources. If the external phosphorus load is being addressed, and most of the phosphorus comes from in-place sediments, a single dose treatment will likely be sufficient (Sweetwater, 2006). Repeated treatments will be needed if watershed sources are not controlled. Often, it is possible to do repeat dosing over several years, giving a partial dose every three to five years (Sweetwater, 2006). Studies have indicated that the effectiveness of alum at controlling internal phosphorus loading in stratified lakes averaged 80% over several years of observation (Welch and Cooke, 1999). Costs for phosphorus inactivation are approximately $1,000 to $1,300 per acre (Sweetwater, 2006). This translates to a cost of $168,000 to $218,400 for Carlinville Lake; $71,000 to $92,300 for Old Gillespie Lake; $207,000 to $269,100 for New Gillespie Lake; and $49,000 to $63,700 for Beaver Dam Lake.

SUMMARY OF ALTERNATIVES

Table 6 summarizes the implementation alternatives identified for the Macoupin Creek watershed. These alternatives should be evaluated by the local stakeholders to identify those most likely to provide the necessary load reductions, based on site-specific conditions in the watershed.

Table 6. Summary of Implementation Alternatives

Alternative	Estimated Cost	Notes
Non-Structural BMPs		
Nutrient Management	$6 to $20/acre	May lead to cost savings
Conservation Tillage	$12 to $83/acre	
Conservation Buffers	$200 - $360/acre	
Private Sewage Disposal System Inspection and Maintenance Program	Variable	Cost would be low if existing staff could accomplish
Restriction of Livestock Access	Fencing: $3,500 to $4,000 per mile Pipeline watering: $0.32 - $2.60 per foot Watering tanks and troughs: $291 - $1,625 each	
Structural BMPs		
Sediment Control Basins	$1,200 to more than $200,000 per basin, depending on size	
Streambank and Shoreline Stabilization	$2,635,500 to $3,289,500 for grade and toe stabilization alone in Macoupin Creek Other streambank stabilization projects at priority sites, cost varies depending on nature and size of site	Recommended by IL Dept. of Agriculture Additional study required to identify priority sites
Wetland Restoration	$500 to $1200/acre estimated	Costs may be higher, depending on size, work required, and land costs
Grassed Waterways	$1,800/acre	
In-Lake Controls		
Aeration/Destratification	$50,000 to $100,000	
Dredging	$6 - $20/cubic yard removed	Only in concert with watershed reductions
Phosphorus Inactivation	$550,000 - $715,000 per lake	Only in concert with watershed reductions

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IDENTIFYING PRIORITY AREAS FOR CONTROLS

Preliminary identification of priority areas for siting of implementation alternatives was accomplished through a review of available information. It should be noted that additional, more detailed, evaluation may be necessary to refine the site selection. Furthermore, additional analysis will be required to prioritize implementation activities.

Information reviewed for this preliminary evaluation included: tributary water quality data (no recent nutrient or bacteria data were identified); an aerial assessment report; and GIS-based data. Based on this review, it is recommended that streambank stabilization be initiated to reduce bank erosion, and that this work occur concurrently with watershed controls in priority areas. Additional evaluation of potential wetland restoration sites is also recommended. Tributary monitoring to better assess current conditions and monitor improvement as controls are implemented is recommended as well.

TRIBUTARY MONITORING

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and no recent tributary monitoring data were identified. Manganese measured during the 2005 Stage 2 monitoring work showed manganese concentrations exceeding water quality standards (1,000 mg/l) in Horse Creek and Honey Creek. These are tributaries to IL_DA-05).

AERIAL ASSESSMENT REPORT

A 2005 report (IDOA, 2005) examined streambank conditions along Macoupin Creek and identified extensive stream bed and bank erosion. The report recommended installation of rock riffle grade controls, but suggested that additional analysis may reveal that the standard spacing of 6 bankfull widths may not be required, which would reduce costs. Additional, more detailed analysis is required to refine costs and to prioritize stabilization efforts.

GIS ANALYSIS

GIS soils, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated phosphorus loads. Within the GIS, maps were generated to show areas with steep slopes (Figure 2), highly erodible soils (Figure 3), and finally, priority areas for BMPs (Figure 4). The priority areas are defined as agricultural areas that have both steep slopes and highly erodible soils. Priority areas are logical locations for targeting phosphorus control projects, to maximize the benefit of the controls. Other locations that should be investigated for control projects are those that have either erodible soils or steep slopes, because both of these characteristics make soil more prone to erosion.

GIS analysis was also used to investigate the presence of hydric soils in each lake’s watershed to determine whether wetland restoration or creation is a viable option within this watershed. To support this analysis, areas having hydric soils, which are not already developed, forested, or covered by water or wetlands were identified. A significant proportion (8%) of the Macoupin Creek watershed was identified as being potentially suitable for wetland restoration or creation. These areas are shown in Figure 5.

PRIORITIZATION OF IMPLEMENTATION ACTIVITIES

The preliminary assessment presented above and the aerial assessment conducted by the Illinois Department of Agriculture identified many locations and opportunities for BMP implementation in the Macoupin Creek watershed. Some additional analysis is required to confirm these preliminary assessments and to prioritize implementation efforts. The following activities are recommended to prioritize efforts and facilitate effective water quality improvements:

- Tributary Monitoring – Additional tributary monitoring is recommended to provide better spatial and temporal understanding of tributary water quality and watershed loading. Specific data collection recommendations are provided in the Monitoring and Adaptive Management Section later in this Implementation Plan.
- Stream Erosion Assessment – Further, more detailed, analysis is recommended to prioritize implementation of streambank and grade stabilization projects. This analysis should include a hydrologic and hydraulic analysis of the creek, field observation to document erosion problems in more detail, a geomorphic assessment of the creek, and additional review of land use and land ownership. Such analysis will not only support prioritization of stabilization activities, but will provide useful information for design of stabilization projects.
- BMP Inventory – As discussed above, it has been reported that a number of BMPs, including water and sediment control systems, terracing, and conservation tillage, have been implemented in the Macoupin Creek watershed (NRCS, 2003). However, no inventory of BMPs was identified in preparing this plan and it is not known whether any study of the effectiveness of the BMPs has been undertaken. An inventory of existing BMPs would inform BMP site selection in the future. Such an inventory should not only include identification of what was implemented and where, but field-checks of BMPs to verify their existence and condition.
- BMP Implementation Assessment – It appears that meeting water quality goals for the Macoupin Creek watershed will require widespread BMP implementation. Implementation efforts should be prioritized to maximize effectiveness and optimize resources. Information gathered in the activities listed above should be utilized in identifying and prioritizing future BMPs. In addition, further watershed assessment based on that information should be conducted to support a comprehensive strategy for BMP implementation. Such assessment might include watershed modeling, more detailed spatial analysis using GIS, or other measures.

Potential funding sources for these activities are summarized in the following section.

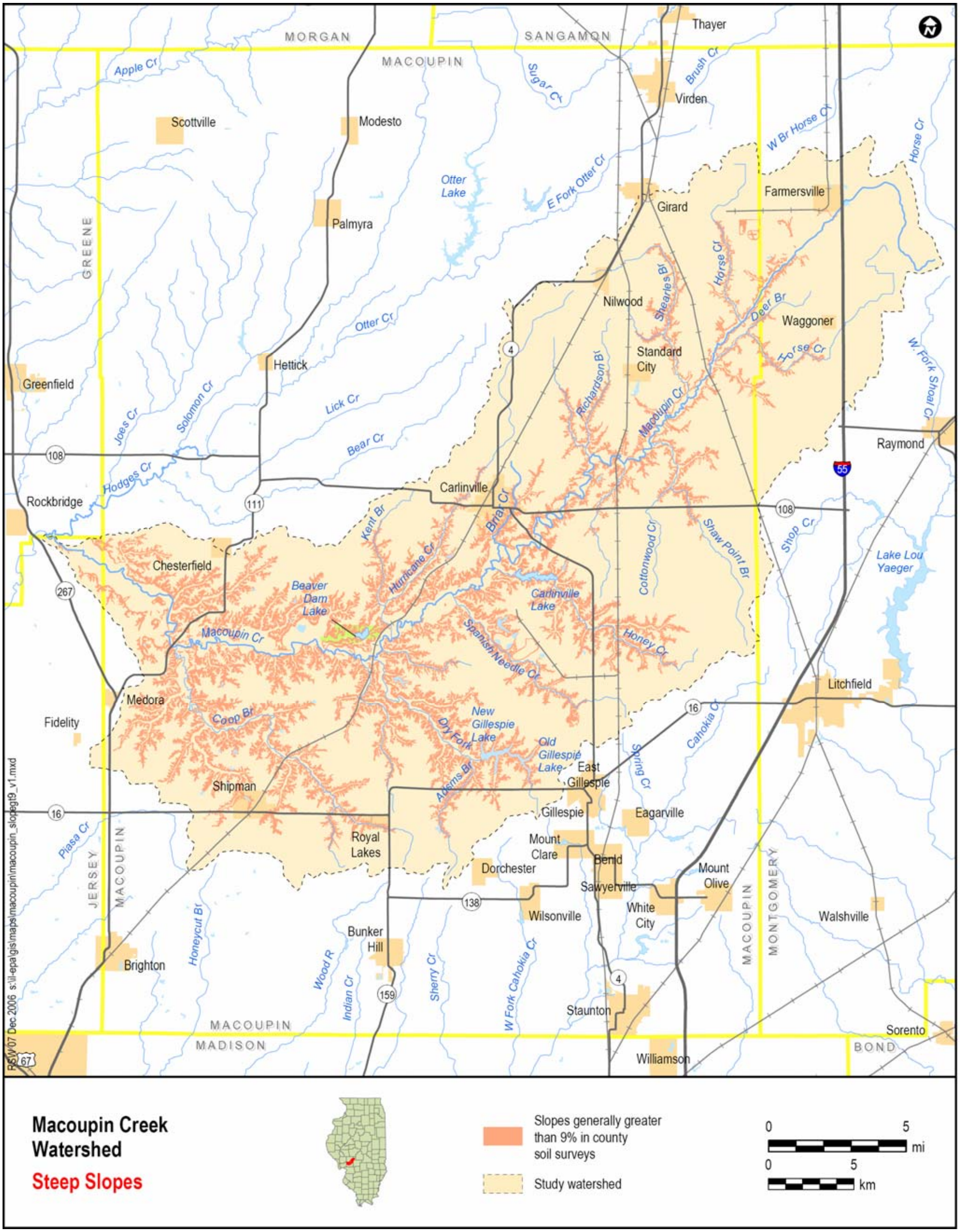

Figure 2. Areas with Steep Slopes

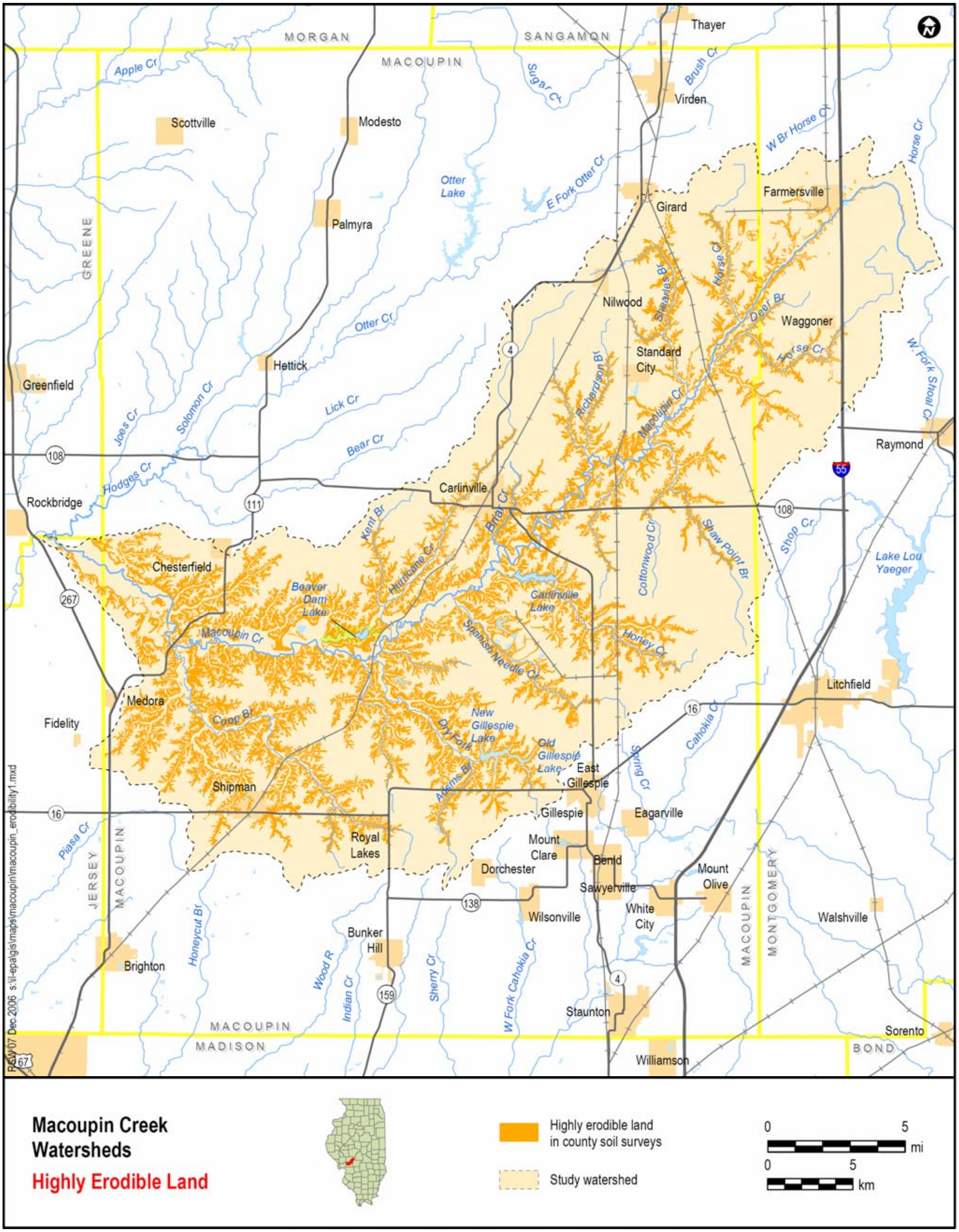

Figure 3. Areas with Highly Erodible Soils

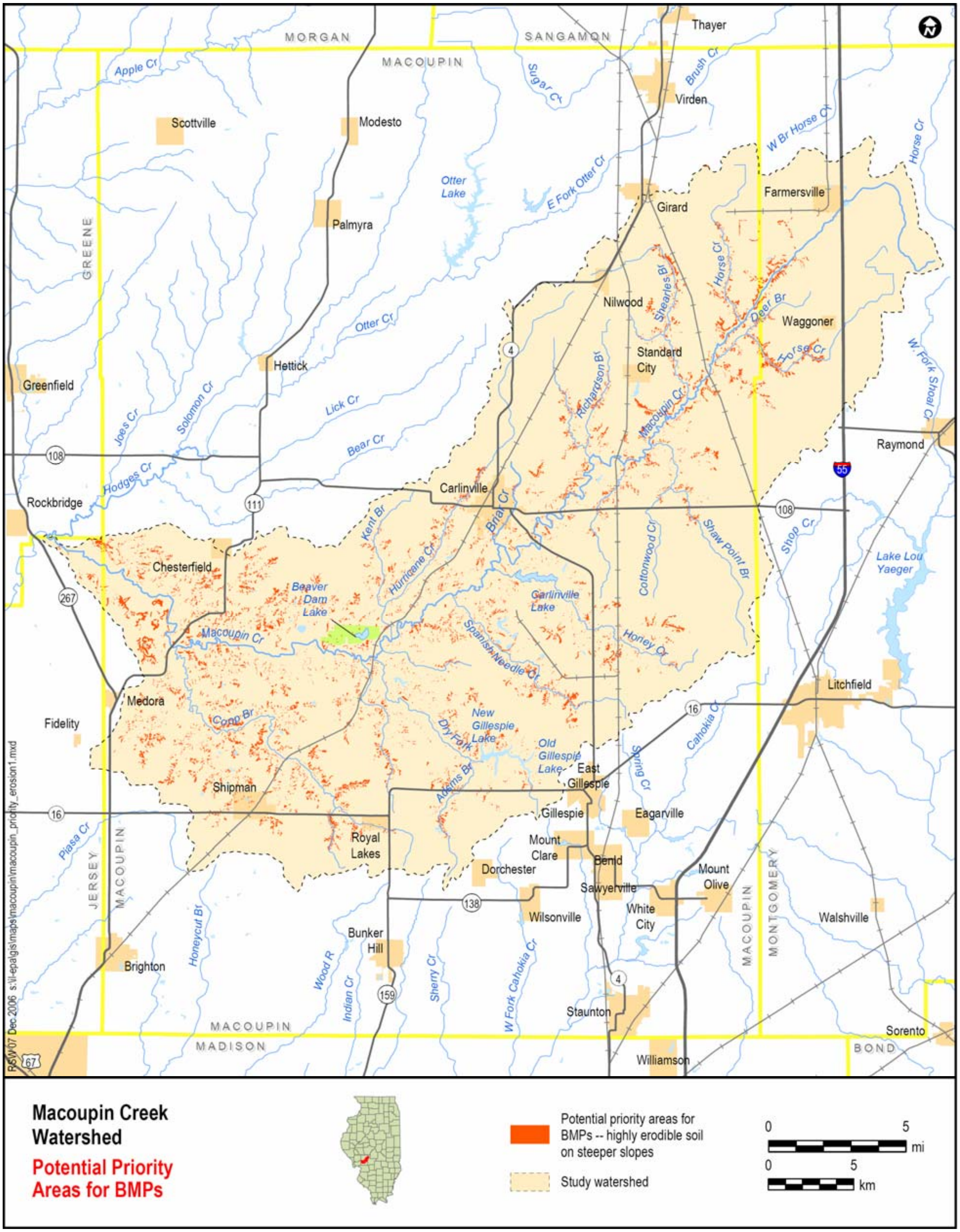

Figure 4. Potential Priority Areas for Best Management Practices

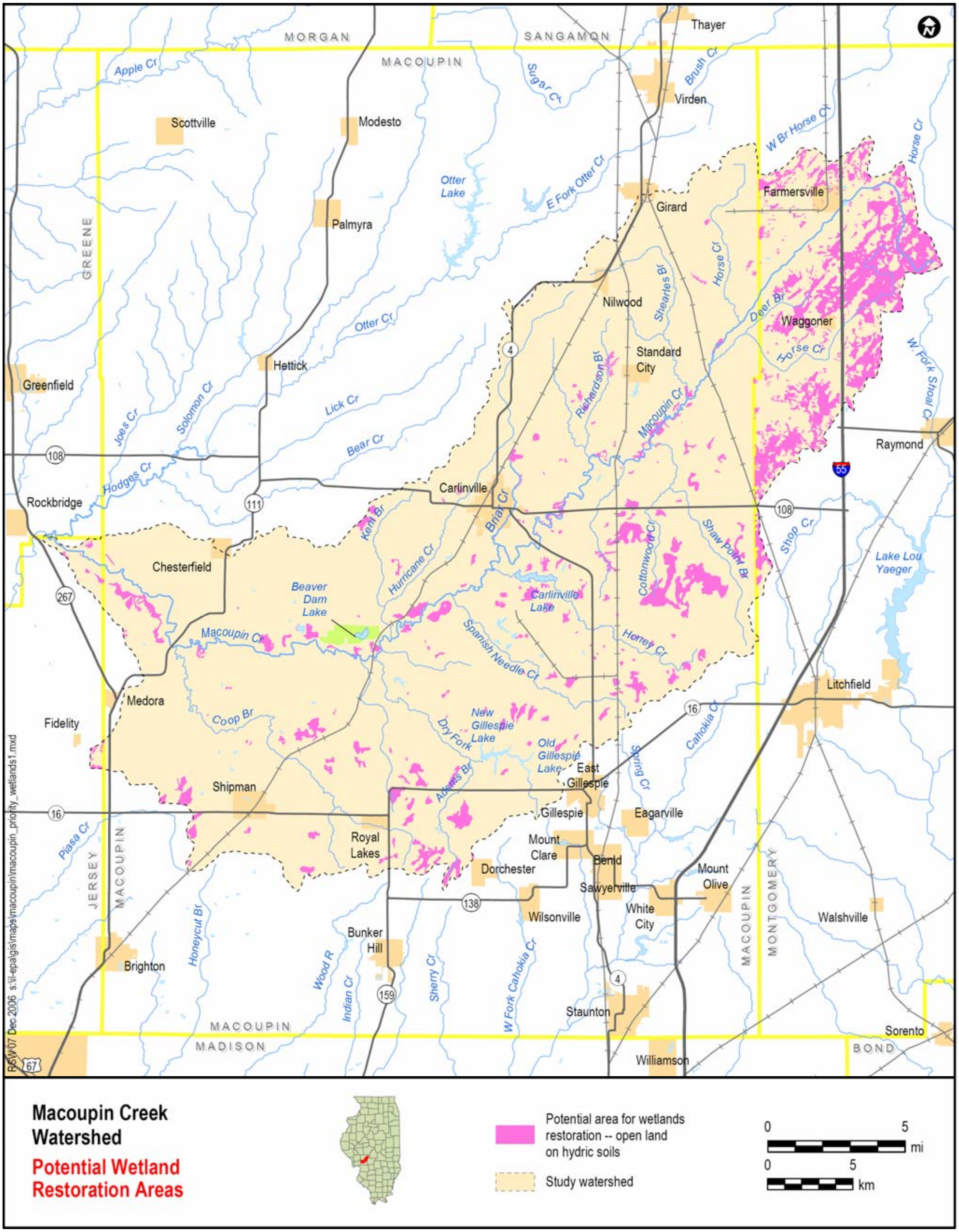

Figure 5. Potential Wetland Restoration Areas

REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting, and CAFO permitting. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. The permit for point source dischargers in the watershed will be modified if necessary to ensure it is consistent with the applicable wasteload allocation.

For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern, implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (U.S. EPA, 1999).

One of the most important aspects of implementing non-point source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including the following:

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://www.agr.state.il.us/Environment/LandWater/tmdl.html). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.
- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.
- *Conservation 2000* (http://www.epa.state.il.us/water/conservation-2000/), which funds nine programs across three state natural resource agencies (IEPA, IDOA, and the Department of Natural Resources). Conservation 2000 is a six-year, $100 million initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality opportunities for outdoor recreation. This program includes the Priority Lake and Watershed Implementation Program and the Clean Lakes Program.
- *Conservation Practices Cost-Share Program* (http://www.agr.state.il.us/Environment/conserv/index.html). Another component

of Conservation 2000, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways, that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.

- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation. It has been suggested that participation in this program could be increased if local sources such as the City of Highland provided some additional funding to supplement the CRP funds and encourage greater participation (MCSWCD, 2006a).

- *Wetlands Reserve Program* (http://www.nrcs.usda.gov/programs/wrp/). NRCS's Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection. Madison County SWCD staff indicated that there probably is land eligible for this program in the Highland Silver Lake watershed, although there has not been interest in the program (MCSWCD, 2006a). Figure 5 shows potential wetland restoration areas. These are areas with hydric soils that are not currently developed, covered by water or forested.

- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive.

- *Wildlife Habitat Incentives Program* (WHIP) (http://www.il.nrcs.usda.gov/programs/whip/index.html). WHIP is a NRCS program for developing and improving wildlife habitat, primarily on private lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.

In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

- Convene local experts familiar with nonpoint sources of pollution in the watershed
- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Using the results of future monitoring to conduct adaptive management

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MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and conduct adaptive management. The Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network; an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program that conducts approximately 20-30 stream surveys each year. The ongoing Illinois EPA Lake Monitoring Program includes: an Ambient Lake Monitoring Program that samples approximately 50 lakes annually; and a Volunteer Lake Monitoring Program that encompasses over 170 lakes each year. Beyond this IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lakes.

These ongoing efforts will provide the basis for assessment of the effectiveness of the TMDLs, as well as future adaptive management decisions. As various alternatives are implemented, the monitoring will determine their effectiveness and identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

In particular, monitoring for phosphorus and suspended solids is recommended in major tributaries upstream of each of the four lakes, to better understand where loads are being generated in the watersheds. This monitoring should be conducted during both wet and dry weather. This monitoring is described in more detail below.

Preliminary recommended locations in the Carlinville Lake watershed include:

- Honey Creek at the Reeder Lane crossing to characterize water quality near the mouth of this creek.
- Continued monitoring on Honey Creek at the Route 4 bridge crossing to assess if there are spatial differences in water quality in Honey Creek compared to the downstream location. This location is currently being sampled as part of the Lake Carlinville Watershed Planning Study and sampling is planned through February 2007. The status of the sampling is not known.

Preliminary recommended locations in the Old Gillespie and New Gillespie lakes watershed to characterize water quality entering the lake include:

- Dry Fork Creek at the Route 16 bridge, and
- Monitoring of other unnamed tributaries to the lakes, upstream of any lake influence.

Preliminary recommended locations in the Beaver Dam Lake watershed include:

- Wet and dry (if possible) weather sampling of water entering the lake from a gully draining nearby farm fields.
- Monitoring of the small drainage ditch near the visitor’s center.

For Macoupin Creek, monitoring for suspended solids is recommended during wet weather to assess the relative contribution of tributaries to sediment load in the creek. Preliminary recommended locations in the Macoupin Creek watershed include:

- Horse Creek (East) at Sulphur Springs Road
- Horse Creek (West) at Boston Chapel Road
- Shaw Point Branch at Sumpter Road
- Briar Creek at Crumystone Road
- Honey Creek at Brushy Mount Road
- Dry Fork at Lake Catatoga Road
- Coop Branch at Victory Road

Periodic low flow dissolved oxygen and water temperature monitoring of Macoupin Creek is also recommended at the Route 4 crossing in Carlinville and at the Shipman Road crossing to provide feedback on the effect that improvement projects have on instream dissolved oxygen.

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