Watershed Plan and Phase 1 Diagnostic/Feasibility Study of Lake Carlinville, Macoupin County, Illinois

United States EPA
and
Illinois EPA
Section 319 Program

Prepared by:

HDR│CWI

CONSULTING ENGINEERS & SCIENTISTS

5201 South Sixth Street Road
Springfield, Illinois 62703
217-585-8300

in cooperation with

The City of Carlinville
Illinois Environmental Protection Agency
USDA - Natural Resources Conservation Service
Macoupin County Soil and Water Conservation District
Illinois Department of Natural Resources

December 2007

This report was prepared using United States Environmental Protection Agency funds under Section 319 of the Clean Water Act distributed through the Illinois Environmental Protection Agency. The findings and recommendations herein are not necessarily those of the funding agencies.

This page intentionally left blank

TABLE OF CONTENTS

TABLES

FIGURES

ACKNOWLEDGMENTS

The *Watershed Plan and Phase 1 Clean Lakes Diagnostic/Feasibility Study* was funded by the City of Carlinville and a grant from the U.S. Environmental Protection Agency (US EPA) (administered by Illinois EPA) under the Section 319 Nonpoint Source Pollution Control Program. The study was conducted by HDR | CWI.

Several HDR | CWI staff members contributed to this project and report. Peter Berrini was the project leader and coordinator. He provided internal review, quality control and quality assurance. Lorin Hatch also provided an internal review. Project research, analysis, and writing were performed by Ryan Keith and Meghan Oh. Eddie Cottone and Michael Grove conducted the lake sedimentation survey. Ryan Keith completed the shoreline erosion and aquatic macrophyte surveys. Meghan Oh, Joseph Bartletti, and Michael Grove drafted figures and diagrams for the Report using Geographic Information Systems (GIS) and Autocad.

The cooperation and assistance of the City of Carlinville, the Macoupin County Soil and Water Conservation District (SWCD), USDA – Natural Resource Conservation Service (NRCS), and private landowners within the Lake Carlinville watershed was much appreciated. Mary Beth Bellm and her staff were helpful throughout the project and were responsible for the volunteer monitoring and sampling. Dan McCandless of Macoupin County SWCD provided valuable information regarding the Lake Carlinville watershed. Ron Strohbeck, John Reid, and Keith Graham were all useful in evaluating potential watershed projects. Jeff Pontnack from the Illinois Department of Natural Resources provided fish population survey data and other important fisheries information. The phytoplankton analyses were completed by Dr. Lawrence O'Flaherty of Western Illinois University. Analyses of water samples were performed by the Prairie Analytical Systems, Inc. and Illinois EPA laboratories. Appreciation is also extended to all others who contributed to this project.

Special thanks to Amy Walkenbach, Gregg Good, Scott Tomkins, Teri Holland, and Tara Lambert of the Illinois Environmental Protection Agency for their assistance throughout the project. The critical review of Amy Walkenbach and Scott Tomkins was greatly appreciated.

PREFACE

The *Watershed Plan and Clean Lakes Phase 1 Diagnostic/Feasibility Study of Lake Carlinville* was the first project in the State of Illinois to combine detailed watershed planning with a Clean Lakes study. Implementing a watershed plan in conjunction with lake restoration activities will greatly enhance the benefits expected from proposed actions by identifying proactive restoration solutions in addition to retroactive restoration solutions. This holistic approach should enhance the outcome of recommendations from this report and help the Lake Carlinville community to understand that watershed management and lake restoration are truly interrelated.

The *Watershed Plan and Phase 1 Diagnostic/Feasibility Study of Lake Carlinville* addresses the Clean Lakes Program requirements for a Diagnostic/Feasibility Study and the Nine Elements of a Watershed Plan set forth by the U.S. EPA. The Diagnostic Section (Part 1) of a Phase 1 Clean Lakes Report documents existing and historical lake and watershed conditions and the Feasibility Section (Part 2) identifies impairments, evaluates lake and watershed restoration alternatives, describes benefits expected from implementation of proposed alternatives, and addresses how and when proposed alternatives can be implemented. The Nine Elements of a Watershed Plan include:

1. Identify the sources of nonpoint source (NPS) pollution that need to be controlled to achieve load reductions established in the Total Maximum Daily Load (TMDL) as approved by Illinois EPA or the goals identified in the local watershed plan.

2. Estimate the load reductions expected from the implementation of the best management practices (BMPs) listed in the application.

3. Describe the best management practices needed to reduce NPS pollution and identify the critical areas in which the BMPs will need to be implemented.

4. Describe the assistance (financial and technical) and which authorities the applicant anticipates having to rely on to implement the project. Estimate the amount of assistance that the project may need from the State and/or Federal Resources.

5. An information/education component, which enhances public understanding of the project and encourages public involvement in the control of NPS pollution.

6. A schedule for implementing the NPS management measures identified in the application and a general schedule for implementation for the local TMDL or watershed management plan.

7. A schedule of interim, measurable milestones that can be used to determine whether BMPs or other control actions are being implemented.

8. A set of criteria that can be used to determine whether substantial progress is being made toward meeting the water quality standards and, if not, criteria that will help to determine whether the TMDL or local watershed plan should be revised.

9. A monitoring component to evaluate how effective the implementation efforts are as measured against the set of criteria developed as described previously in Item 8.

In order to streamline the outcome of the project, the typical components of a Diagnostic/Feasibility Study and Watershed Plan were combined into one report that provides a detailed description of Lake Carlinville and its watershed, identifies and provides alternatives for impairments, and describes the process of implementing those alternatives. The table of contents for this report is similar to a typical Phase 1 Diagnostic/Feasibility Study and the Nine Elements of a Watershed Plan were included in Part 2 as follows:

Element 1 – Section A of Part 2
Element 2 – Section C of Part 2
Element 3 – Section C of Part 2
Element 4 – Sections C, G, & H of Part 2
Element 5 – Sections C & I of Part 2
Element 6 – Sections E of Part 2
Element 7 – Sections F of Part 2
Element 8 – Section D & F of Part 2
Element 9 – Section F of Part 2

EXECUTIVE SUMMARY

Introduction

In the fall of 2005, Cochran & Wilken, Inc. (now HDR│CWI) undertook a *Watershed Plan and Phase 1 Diagnostic/Feasibility Study of Lake Carlinville*. Funding for the project was provided by a U.S. EPA grant (administered by Illinois EPA) and the City of Carlinville. The major objectives of the study were to evaluate the current condition of the watershed and lake, investigate potential alternatives for restoring lake water quality and increasing lake storage capacity to maintain the public water supply, and to develop a Watershed Plan that the City of Carlinville and private landowners could use to meet the watershed and lake management objectives.

The *Watershed Plan and Phase 1 Diagnostic/Feasibility Study of Lake Carlinville* presented a unique opportunity. This project was the first in the State of Illinois to combine watershed planning with a Clean Lakes Phase 1 study to identify problems and impairment issues affecting the watershed and the lake. The *Watershed Plan and Phase 1 Diagnostic/Feasibility Study of Lake Carlinville* addresses the Clean Lakes Program requirements for a Diagnostic/Feasibility Study and the Nine Elements of a Watershed Plan set forth by the U.S. EPA. The Diagnostic Section (Part 1) documents existing and historical lake and watershed conditions and the Lake and Watershed Management Plan Section (Part 2) identifies watershed and lake impairments, evaluates watershed and lake restoration alternatives, addresses how and when proposed alternatives can be implemented, and describes benefits expected from implementation of proposed alternatives. Implementing a watershed plan in conjunction with lake restoration activities will greatly enhance the benefits expected from proposed actions by identifying proactive solutions in addition to retroactive solutions. This holistic approach should enhance the outcome of recommendations outlined within The *Watershed Plan and Phase 1 Diagnostic/Feasibility Study of Lake Carlinville* and help the Lake Carlinville community to understand that watershed management and lake restoration are truly interrelated.

Lake Carlinville is approximately 168 acres (68 hectares) and is impounded by an earth embankment with a concrete spillway. The lake is located in the east central portion of Macoupin County, Illinois. Lake Carlinville was constructed in 1939 as the public water supply for the City of Carlinville. Due to the excessive erosion and sediment transport from the watershed, lake siltation was documented early in the lake's history and decreased water storage capacity was noted. As a result, the City conducted several lake sediment removal projects in the 1970s and raised the dam and spillway three feet to an elevation of 573.0 feet above mean sea level in 1983.

The Lake Carlinville watershed is approximately 15,481 acres (6,265 hectares). The watershed to lake ratio is approximately 92:1. The major land uses within the watershed are comprised primarily of agriculture and forest land at 65 and 22 percent, respectively, with grasslands, wetlands, and surface water making up the remaining 13 percent of the watershed. Honey Creek is the major tributary that flows into the lake from the southeast. The City of Carlinville owns and manages Lake Carlinville. Figures 1 and 2 within Part 1 (pages 15 and 17) illustrate the Lake Carlinville watershed.

303(d) Listing and TMDL Status of Lake Carlinville

In 2006, Lake Carlinville (IL_RDG) was listed on Illinois Section 303(d) List of Impaired Waters as a water body not meeting its designated uses and numerical water quality standards for phosphorus and manganese (Illinois EPA, 2006). Other lake impairments identified included total suspended solids and algae, although there are no water quality standards for these parameters. As a result of the 303(d) listing, a Total Maximum Daily Load (TMDL) study was initiated for the Macoupin Creek watershed of which the Lake Carlinville watershed is included. The TMDL study determined that sources contributing to Lake Carlinville's impairments were natural background and seasonal hypolimnetic anoxia for manganese, and agricultural runoff and seasonal hypolimnetic anoxia for total phosphorus (Illinois EPA, 2006). While hypolimnetic anoxia is a contributor to manganese and phosphorus concentrations, it does not appear to be a major issue.

The water quality standard for total phosphorus to protect aquatic life and aesthetic quality uses in Illinois lakes is 0.05 mg/L. The water quality standard for manganese in Illinois waters designated as public and food processing water supplies is 150 µg/L. The TMDL target for manganese is set as a total phosphorus concentration of 0.05 mg/L. Since reduced phosphorus loading was determined as the best way to control the source of manganese, these standards were used as targets for the TMDL.

The TMDL established a load allocation for Lake Carlinville of 172.17 kg total phosphorus/month or 5.64 kg total phosphorus/day. These load allocations for total phosphorus represent an approximate 51 percent load reduction for Lake Carlinville. As of 2007, the Implementation Phase of the Macoupin Creek and Lake Carlinville TMDL was completed.

Brief Comparison of Phase 1 and Historical Lake Water Quality Data

Water samples were collected from three in-lake sampling sites (Sites 1, 2, and 3) during the Phase 1 monitoring period (i.e., April 2006 through March 2007) by the City of Carlinville and the Illinois EPA's Ambient Lake Monitoring Program (ALMP). Site 1 was located near the dam, Site 2 was located near the boat dock (mid-lake), and Site 3 was located at the upper end of the lake. The Phase 1 monitoring data were compared against historical ALMP data collected in 1979, 1981, 1988, 1994, 1999, and 2002, in order to determine how water quality conditions have changed over time. A variety of physical, chemical, and biological parameters were analyzed and the results are described within the larger report.

The Trophic State Index (TSI) (Carlson, 1977) provides a method to compare existing and historical lake conditions (i.e., the Phase 1 data vs. the historical data). The TSI includes physical (Secchi disk transparency), chemical (total phosphorus concentrations), and biological (chlorophyll a concentrations) indicators to quantitatively describe lake water quality and the degree of eutrophication or trophic state. Since the index was developed for lakes dominated by algal turbidity, the Secchi TSI may be artificially elevated due to sediment turbidity. The trophic condition for each of the three sampling sites within Lake Carlinville has been calculated according to the TSI for the Phase 1 monitoring period (2006-07) and historical monitoring years.

According to the Lake Assessment Criteria as listed in the 1994-95 Illinois Water Quality Report, lakes having a TSI greater than 50 and less than 70 are characterized as being eutrophic. Since the TSI values for each parameter during the Phase 1 sampling period for Sites 1, 2, and 3 were generally above 60 and below 80, Lake

Carlinville can be characterized as being eutrophic to slightly hyper-eutrophic. As the table below illustrates, TSI values have increased over time. This suggests that Lake Carlinville water quality has decreased over time, especially at Site 3.

Trophic State Index Values for Lake Carlinville

		Secchi Transparency TSI	Total Phosphorus TSI	Chlorophyll a TSI
Phase 1	Site 1	68.5	76.5	71.5
	Site 2	72	80	70.5
	Site 3	77	82.5	73.5
Historical	Site 1	69	71	64.5
	Site 2	70	71	64.5
	Site 3	74	72.5	68.5

Impairment Identification & Development of Management Objectives

Diagnostic lake and watershed information contained within Part 1 of the Report served as the basis for the identification of the following impairments identified within the Lake Carlinville watershed.

1. Soil Erosion and Excess Nutrient Loading
2. Excessive Lake Sedimentation
3. Degraded Water Quality
4. Unbalanced Aquatic Vegetative Community
5. Unbalanced Fishery

The goal of the Lake Carlinville Watershed Plan is to address the impairments listed above, to protect and enhance existing watershed and lake uses, to increase recreational access and opportunities, and to improve the lake water quality. The Lake Carlinville Watershed Plan objectives are as follows:

1. Improve Water Quality,
2. Enhance Lake Aesthetics and Recreational Opportunities, and
3. Promote Lake and Watershed Restoration.

Lake Carlinville Watershed Plan

The Lake Carlinville Watershed Plan (Table 28, page 113) contains recommended actions and management practices, a range of unit costs, units proposed, a range of estimated costs, estimated load reductions, and potential financial and technical assistance for the project implementation. Within the Watershed Plan, recommended actions and management practices are divided into two groups. Group #1 includes specific watershed and lake actions and management practices on City-owned property (i.e., Lake Carlinville and property surrounding the lake) and other areas located near Lake Carlinville where HDR | CWI was permitted to access private property. Group #2 consists of actions and practices that are proposed for the areas of the Lake Carlinville watershed that were not observed during field surveys.

General criteria are suggested for the implementation of the Watershed Plan (i.e., selecting and prioritizing projects). Priority should be given to projects located on publicly-owned lands or on lands in which private landowners are cooperative and willing to implement projects and/or management practices. Additional consideration should be given to those projects and management alternatives closest to the lake that will have the greatest impact on reducing sediment and nutrient (particularly phosphorus) loadings to the lake.

As the owner of Lake Carlinville, the City of Carlinville should take the lead by implementing watershed management alternatives and best management practices (BMPs) on City-owned land adjacent to Lake Carlinville. This action would send a message to the community that the City is serious about the restoration of Lake Carlinville and its watershed. Recommended actions and management practices for the City include:

- implementing various agricultural BMPs (including nutrient management plans, cover crops, conservation tillage, and conservation buffers) on publicly-owned lands;
- installing grade stabilization structures and sediment and water control basins to control gully erosion on publicly-owned lands;
- stabilizing eroded lake shoreline;

- removing accumulated sediment in the upper and lower portions of the lake;
- installing a sediment and nutrient control basin (similar to 1996 NRCS preliminary design) (lake sediment removal prerequisite);
- inspecting and upgrading (when necessary) septic and holding tanks on lake properties;
- installing a lake aeration system (lake sediment removal prerequisite); and
- restructuring lake fish population (lake sediment removal prerequisite).

Removing accumulated lake sediments will enhance and increase the longevity of several other lake restoration projects. Therefore, lake sediment removal is recommended before the following activities are considered: installation of a sediment and nutrient control basin, lake aeration, and restructuring the fish population. In order minimize maintenance of accumulated sediments and materials in the sediment control basin, the City should consider implementing various BMPs in the lower portion of the watershed, which is in close proximity to Lake Carlinville. For the other areas within the Lake Carlinville watershed, projects and practices should be implemented and completed as cooperative private landowners are identified and project match funds are available.

In addition to management practices, there are other recommended actions that need to be completed to insure that the Lake Carlinville Watershed Plan is a success. Developing and conducting informational and educational (I/E) programs in the community will improve and increase the public's perception and awareness of various lake and watershed issues. I/E programs can be implemented on various levels throughout the community (i.e., schools, scout groups, and local government). Developing and distributing informational pamphlets that summarize watershed and lake ecological issues and the Lake Carlinville Watershed Plan is another means of informing the public.

The prioritization, implementation, and completion of the projects listed within the Lake Carlinville Watershed Plan will require oversight and decision making by the City of Carlinville. Therefore, the identification of and establishment of a Watershed and Lake Coordinator may be the most critical action item to ensure the success and implementation of the overall Lake Carlinville Watershed Plan. It is recommended that the City assign or hire a dedicated person(s) to facilitate lake and watershed restoration activities. Options are described within the report.

Budgeting for implementation of the projects identified within the *Watershed Plan and Phase 1 Diagnostic/Feasibility Study of Lake Carlinville* will be important. Rather than committing to a fixed budget and schedule (where funding and restoration projects are specified beforehand), a more open and flexible budget and schedule approach is proposed. This more flexible approach will consist of preparing separate, individual 319-grant applications (annual August 1 deadline) that are based on the findings of this report and recommendations of the Lake Carlinville Watershed Plan. This method will allow watershed and lake restoration projects to be identified and grant applications submitted, as various match-funding sources become available. A ten-year implementation schedule was developed and will serve as a guideline for prioritizing projects listed in the Lake Carlinville Watershed Plan (Table 32, page 146).

Benefits Expected from the Implementation of the Watershed Plan

The ecological, social, and economic benefits of watershed management and lake restoration can extend over many generations. Continuous management of Lake Carlinville and its watershed can improve lake water quality, enhance recreational opportunities, reduce or prevent future increases in water treatment costs, and enhance habitat for game fish and other wildlife. Once implemented, the proposed actions from the Lake Carlinville Watershed Plan will reduce sediment and nutrient loadings to the lake and generate a wide range of water quality improvements. This will lead to recreational use benefits and enhance the public water supply. Specific benefits in relation to completion of each objective in the Lake Carlinville Watershed Plan are listed in Table 30 on page 142.

Part 1

Diagnostic Study of Lake Carlinville

Macoupin County, Carlinville, Illinois

INTRODUCTION

A Diagnostic Study was undertaken on Lake Carlinville to identify and quantify existing water quality problems and other factors affecting the reservoir's recreational, aesthetic, and ecological qualities. The United States Environmental Protection Agency (US EPA) funded 56 percent of the study and the Illinois Environmental Protection Agency (IL EPA) administered the project. The City of Carlinville contributed the remaining 44 percent to the project. The Illinois EPA was responsible for grant administration and program management. HDR│Cochran & Wilken, Inc. (HDR│CWI) conducted the research study with assistance from the City of Carlinville, Illinois Department of Natural Resources (IL DNR), the USDA Natural Resources Conservation Service (NRCS), Macoupin County Soil and Water Conservation Service, and the Illinois EPA.

A. LAKE AND WATERSHED IDENTIFICATION AND LOCATION

Lake Carlinville is a 168-acre reservoir located in central Macoupin County, Illinois, approximately 2.5 miles southeast of Carlinville. The lake was constructed in 1939 to provide a reliable water source for the City of Carlinville. The lake is impounded by an earth embankment structure, which is approximately 785 feet long with a 150-foot long concrete spillway located at the north end of the dam. When initially constructed, the spillway elevation was 570.0 feet above mean sea level. In 1983, the dam and spillway were raised three feet to an elevation of 573.0 feet above mean sea level to provide additional lake storage capacity (ISWS, 1987 and US COE, 1980). The current storage capacity of Lake Carlinville is approximately 1,810,035 m^3 (1,467 acre-ft.). Lake Carlinville has a maximum depth of 5.18 meters (17 ft.), and a mean depth of 2.74 meters (9 ft.). The average hydraulic retention time of the lake system was calculated to be approximately 0.110 years. While Honey Creek is the major drainage source from the watershed, several smaller inlet channels and storm drains enter the lake at various points along the 8.85 km (5.5 miles) of shoreline. Table 1 lists the specific lake and watershed information for Lake Carlinville.

The Lake Carlinville watershed is located in west central Illinois, approximately 65 miles northeast of St. Louis, MO and 50 miles southwest of Springfield, IL. It is a small portion of the Upper Macoupin Creek Watershed and covers approximately 6,265 hectares (15,481 acres) of Macoupin County. There is one main tributary, namely Honey Creek, and numerous unnamed tributaries to Honey Creek. Honey Creek originates in eastern Macoupin County and flows approximately 19.3 kilometers (12 miles) before entering the southeastern tip of Lake Carlinville. Other lakes in the watershed include Lake Carlinville II, Lake Williamson, Deer Run Lake, Gillespie Country Club Lake, and several small ponds. Figure 1 illustrates an aerial view of the Lake Carlinville watershed and its general location in Macoupin County.

Table 1. Identification and Location of Lake Carlinville

Parameter	Description
Name	Carlinville Lake
IEPA Storet Code	RDG
State	Illinois
County	Macoupin
Ownership	City of Carlinville
Nearest Municipality	Carlinville
Latitude	39 Degrees 14' 35" N
Longitude	89 Degrees 51' 52" W
Location	T9N, R7W, Section 10
USEPA Region	5
USEPA Major Basin	Upper Mississippi River
USEPA Minor Basin	Illinois River
Major Tributary	Honey Creek
Receiving Waterbody	Macoupin Creek
Applicable Water Quality Standards	State of Illinois Rules & Regulations, Title 35: Environmental Protection, Subtitle C: Water Pollution, Ch. 1: Pollution Control Board, Parts 302, Subpart B: General Use Water Quality Stds. And Subpart C: Public & Food Processing Water Supply Stds.
Surface Area	168 acres (68 hectares)
Watershed Area	15,481 acres (6,265 hectares)
Shoreline Length	5.5 miles (8.9 km)
Maximum Depth	17 feet (5.18 m)
Mean Depth	9 feet (2.74 m)
Normal Pool Elevation	573.0 feet ASL (174.7 m)
Hydraulic Retention Time	0.110 years
Storage Capacity	1,467 acre-feet (478,156,923 Gal)

Sources: Illinois EPA; ISWS, 1987; and Limno-Tech, Inc., 2005

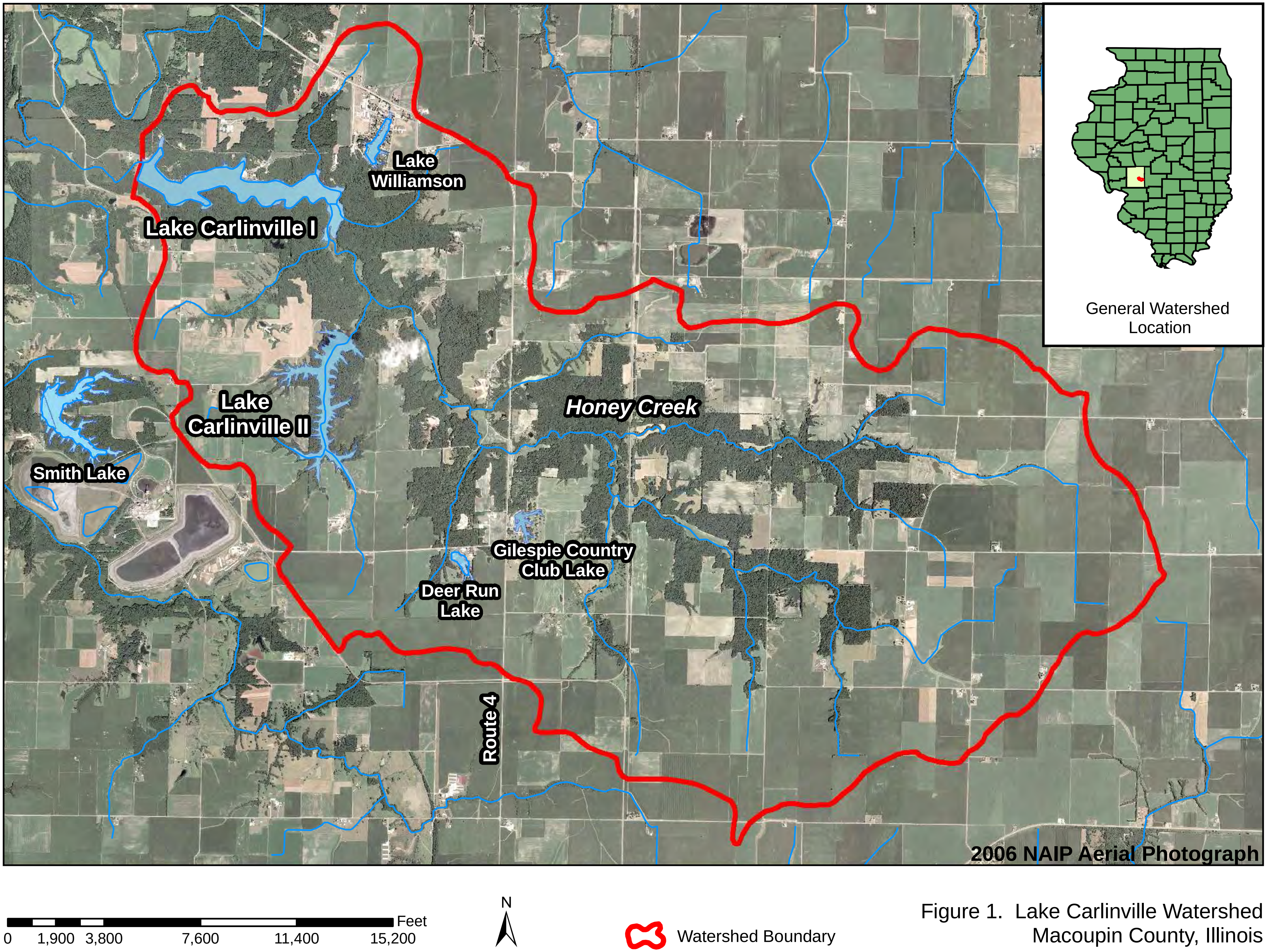


Figure 1. Lake Carlinville Watershed
Macoupin County, Illinois

B. GEOLOGICAL AND SOILS DESCRIPTION OF WATERSHED

1. Geological and Topographical Description

Lake Carlinville and its watershed are located within Macoupin County, Illinois (Figure 2). Upland soils within the Lake Carlinville watershed were formed from a base of loess and tend to be both poorly drained and droughty (i.e., porous and well drained). Soils in incised drainage courses were formed from alluvium with a base of glacial drift (USDA-NRCS, 2003).

During the Pleistocene era, the Illinoisan glacier covered all of Macoupin County. In most areas of the county, deposits of glacial drift average 50 feet thick with loess or silt covering the drift varying from 4 to 8 feet thick. After the glaciers receded, the land throughout the county was nearly level. However, as a result of geologic erosion, stream valleys and drainage ways dissected the landscape (USDA-NRCS, 1990). Elevations within the Lake Carlinville watershed range from approximately 573 feet above mean sea level at the lake to 675 feet above mean sea level (ISWS, 1987). The valleys within the watershed are relatively shallow, and streams have low gradients. The major tributary to the Lake Carlinville, Honey Creek, is a third-order stream. There are several other small, first-order streams that discharge directly to the lake. Figure 2 illustrates the topography of the Lake Carlinville Watershed.

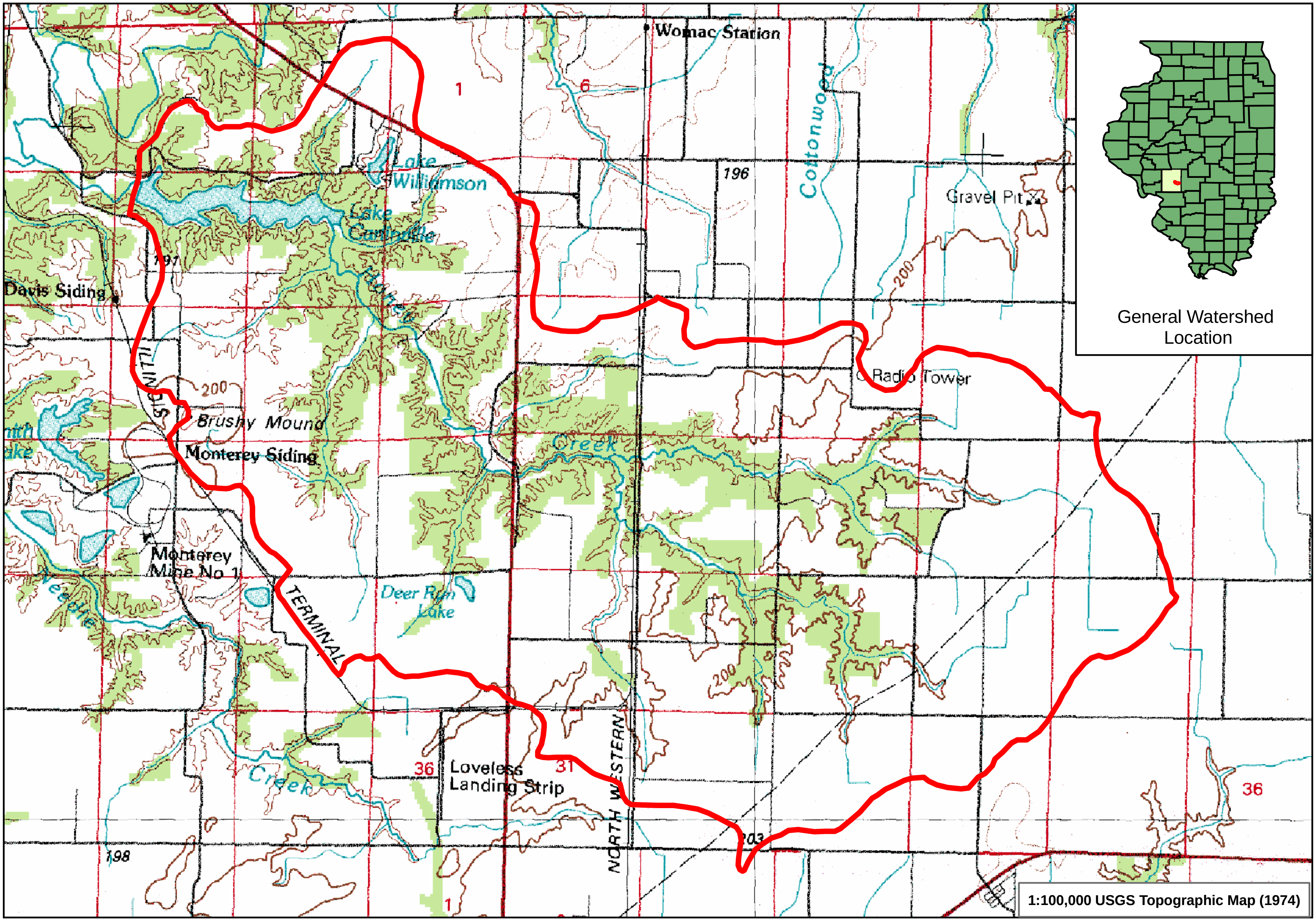


Figure 2. Lake Carlinville Watershed Topography
Macoupin County, Illinois

2. Groundwater Hydrology

The Illinois State Geological Survey (ISGS) publication entitled *Groundwater Geology In South-Central Illinois: A Preliminary Geologic Report* (1957) was referenced to help determine the occurrence of groundwater yielding strata present within the Lake Carlinville watershed. According to the ISGS publication, the Pennsylvanian formation, which includes shale, sandstone, limestone, and coal, is the primary geologic formation within the Lake Carlinville watershed study area.

The presence of groundwater bearing strata within Macoupin County is mixed, with some areas being poor and other areas having fair to good groundwater potential. The upland areas located near Lake Carlinville and its watershed have thin beds of sand and gravel within the glacial till that may yield enough water for small domestic wells. However, these localized sand and gravel deposits are generally found near the base of the till and due to their discontinuity, their locations cannot be easily predicted. (Personal communication ISGS, 2005). Generally, the geologic substrata within the region do not produce sufficient yields for public water supply wells. Thus Lake Carlinville was created as a public water supply source in 1939.

3. Description of Soils

The major soil types occurring in the Lake Carlinville watershed and surrounding area consist mainly of the Hickory-Marine-Hosmer Association, with the Herrick-Piasa-Virden Association occurring in the uppermost portions of the watershed (USDA-NRCS, 1990). The Hickory-Marine-Hosmer Association consist of nearly level to steep, well drained to somewhat poorly drained, moderately permeable, slowly permeable, or very slowly permeable soils formed in glacial till or in loess; on uplands. The Herrick-Piasa-Virden Association consist of nearly level, somewhat poorly drained and poorly drained, moderately permeable soils formed in alluvium; on flood plains.

An inventory of all soil types found in the Lake Carlinville watershed is listed in Table 2. The listing of soil types contains a numerical description (214C2) where the first number (214) indicates the soil name, the capital letter (C) provides a slope range and the third part (2) describes the degree of erosion. Detailed soil type descriptions are not provided herein but can be found in the USDA-NRCS Soil Survey for Macoupin County, Illinois, 1990.

Table 2. Watershed Soil Types

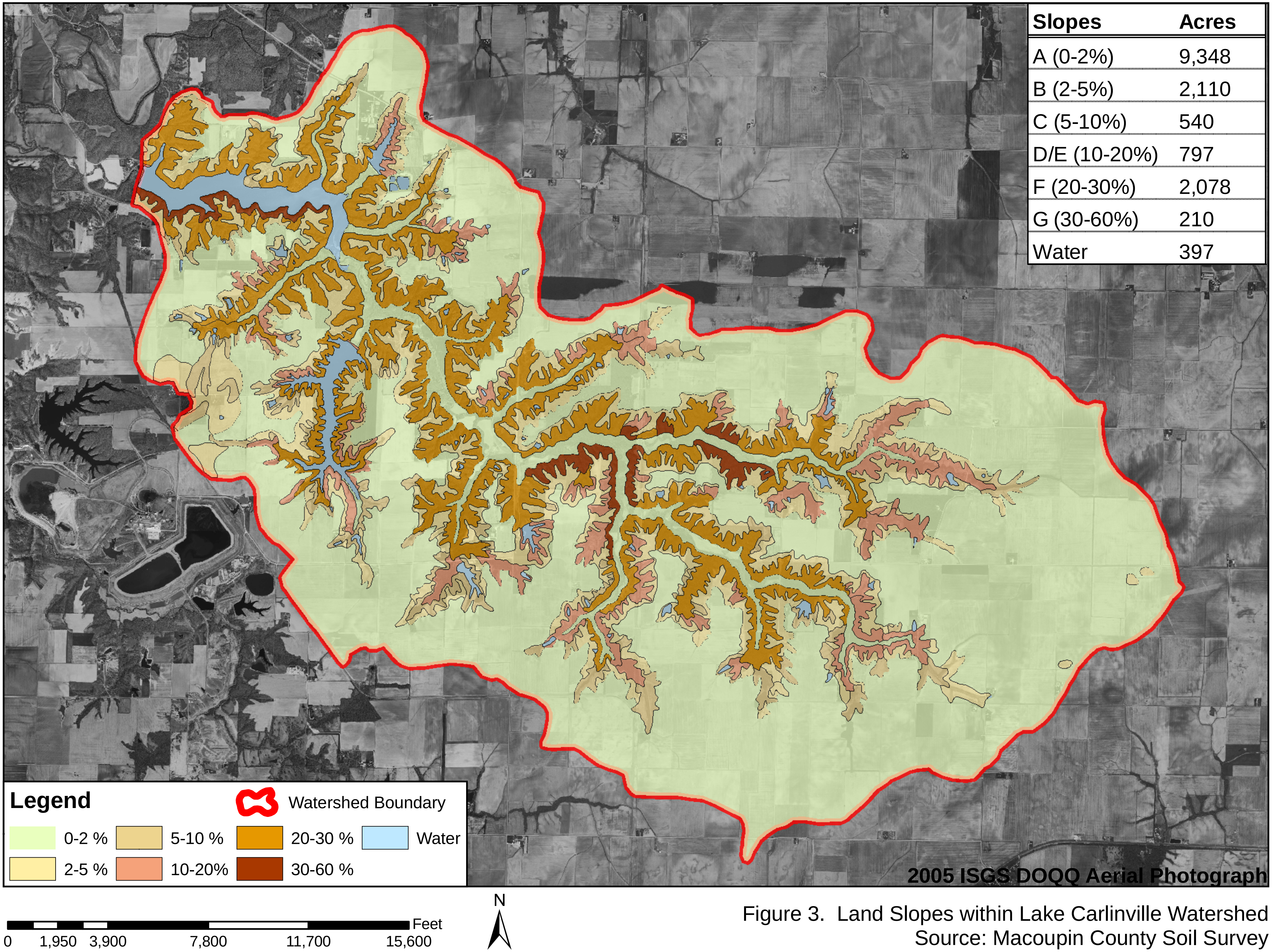
Acres	Soil Symbol	Soil Type	% of Watershed
245.8	112A	Cowden silt loam, 0 to 2 % slopes	1.59
479.5	113A	Oconee silt loam, 0 to 2 % slopes	3.10
5.5	113B	Oconee silt loam, 2 to 5 % slopes	0.04
5.7	119B2	Elco silt loam, 2 to 5 % slopes, eroded	0.04
184.4	119C2	Elco silt loam, 5 to 10 % slopes, eroded	1.19
27.0	119D2	Elco silt loam, 10 to 15 % slopes, eroded	0.17
10.4	127B	Harrison silt loam, 2 to 5 % slopes	0.07
478.4	16A	Rushville silt loam, 0 to 2 % slopes	3.09
22.7	259C2	Assumption silt loam, 5 to 10% slopes, eroded	0.15
649.5	3333A	Wakeland silt loam, 0 to 2 % slopes, freq. flooded	4.20
6.8	3451A	Lawson silt loam, 0 to 2 % slopes, freq. flooded	0.04
1,054.3	46A	Herrick silt loam, 0 to 2 % slopes	6.81
64.8	470B	Keller silt loam, 2 to 5 % slopes	0.42
900.1	50A	Virden silty-clay loam, 0 to 2 % slopes	5.81
2,352.1	517A	Marine silt loam, 0 to 2 % slopes	15.20
1,950.6	582B	Homen silt loam, 2 to 5% slopes	12.60
49.5	582C	Homen silt loam, 5 to 10% slopes	0.32
36.1	657A	Burksville silt loam, 0 to 2 % slopes	0.23
72.6	6B2	Fishhook silt loam, 2 to 5 % slopes, eroded	0.47
37.7	6C2	Fishhook silty clay loam, 5 to 10 % slopes, eroded	0.24
2.1	802E	Orthents, loamy, hilly	0.01
9.7	885A	Virden-Fosterburg silt loams, 0 to 2 % slopes	0.06
2,590.2	894A	Herrick-Biddle-Piasa silt loams, 0 to 2 % slopes	16.73
222.9	897C2	Bunkum-Atlas silt loams, 5 to 10% slopes, eroded	1.44
23.0	897C3	Bunkum-Atlas silty clay loams, 5 to 10% slopes, sev. eroded	0.15
233.2	897D2	Bunkum-Atlas silt loams, 10 to 18% slopes, eroded	1.51
535.1	8D2	Hickory loam, 10 to 15 % slopes, eroded	3.46
1,731.7	8F	Hickory silt loam, 15 to 30 % slopes	11.19
346.6	8F2	Hickory loam, 20 to 30 % slopes, eroded	2.24
210.4	8G2	Hickory silt loam, 30 to 60 % slopes	1.36
546.0	993A	Cowden-Piasa silt loams	3.53
396.9	W	Water	2.55
15,481.0			100.00

Source: USDA Soil Conservation Service, 1998

Figure 3 illustrates the land slopes in the Lake Carlinville Watershed. The majority of the watershed (11,458 acres) consists of A and B slopes (0-5% slopes), although there are approximately 2,000 acres with F slopes (20-30% slopes). Areas with F slopes and greater are generally located along Honey Creek, Lake Carlinville I and Lake Carlinville II. Land with slopes of C (5-10% slope) or greater is most susceptible to erosion and often targeted for best management practices. This accounts for 23% of the watershed, as listed in Table 3.

Table 3. Land Slopes within the Watershed

Slope Class	Acres	Percent
A (0-2%)	9,348	60.4 %
B (2-5%)	2,110	13.6 %
C (5-10%)	540	3.5 %
D/E (10-20%)	797	5.1 %
F (20-30%)	2,078	13.4 %
G (30-60%)	210	1.4 %
Water	397	2.6 %
Total	15,481	100.0 %



Slopes	Acres
A (0-2%)	9,348
B (2-5%)	2,110
C (5-10%)	540
D/E (10-20%)	797
F (20-30%)	2,078
G (30-60%)	210
Water	397

Figure 3. Land Slopes within Lake Carlinville Watershed
Source: Macoupin County Soil Survey

C. DESCRIPTION OF PUBLIC ACCESS

Public access to Lake Carlinville and the surrounding area is managed by the City of Carlinville. Lake Carlinville provides the following amenities: a beach, camping area, and access to one pavilion, restrooms, and a boat ramp. There are 23 facilities available for campers, including 9 sites on the lake front. Each site has access to electrical and water utilities. In addition, there are also 21 tent sites. Fees are $15 for campers and $10 for tent sites. If a camper stays for six days, the seventh day is free (Schaaff personal communication, 2006.)

The major roadway through the Lake Carlinville watershed is Illinois State Route 4, which runs north to south. The two primary access routes to the lake are from the east and west. From the east, Carlinville Lake Road can be accessed from Route 4. Carlinville Lake Road proceeds along the north side of the lake to Campground Road, where the lake's campground, boat launch, public beach, and main parking area are located. The other access route to the lake is from the west off of Brushy Mound Road, which proceeds south from of Carlinville. Brushy Mound Road then intersects with Carlinville Lake Road. An area just past the Carlinville Water Treatment Plant where the public can fish, picnic, and view the lake can be accessed from Carlinville Lake Road. There is no public transportation directly to the lake at this time. Figure 4 depicts the public access routes to and around Lake Carlinville.

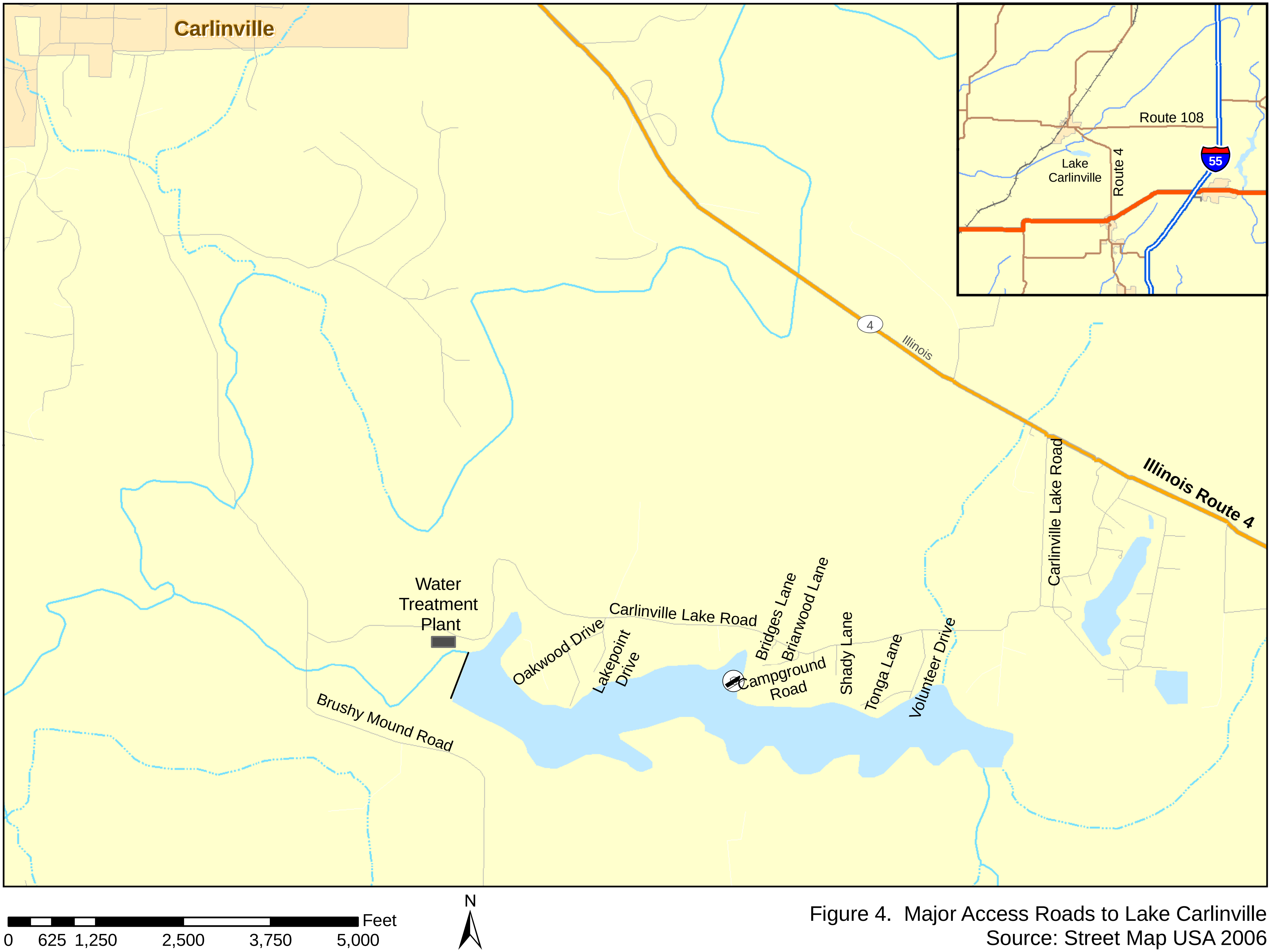


Figure 4. Major Access Roads to Lake Carlinville
Source: Street Map USA 2006

D. DESCRIPTION OF POPULATION SIZE AND ECONOMIC STRUCTURE

The major population center located within close proximity to Lake Carlinville is the City of Carlinville. In 2000, the total populations for Carlinville and Macoupin County were 5,685 and 49,019, respectively, and the median household income for Carlinville and Macoupin County were $34,259 and $36,190, respectively (US Census Bureau, 2005).

The largest industries for the Lake Carlinville area as of the 2000 U.S. Census were educational, health, and social services (25.7 percent); retail trade (16.5 percent); transportation, warehousing, and utilities (8.9 percent); public administration (7.4 percent); arts, entertainment, recreation, accommodation, and food services (7.3 percent); and manufacturing (7.0 percent). The industries making up the remaining 27.2 percent were other services (5.6 percent); professional, scientific, management, administrative, and waste management (4.9 percent); finance, insurance, and real estate (4.5 percent); construction (4.5 percent); information (2.5 percent); agriculture, forestry, fishing, hunting, and mining (3.7 percent); and wholesale trade (1.5 percent) (US Census Bureau, 2005).

E. SUMMARY OF HISTORICAL LAKE USES

Lake Carlinville was constructed in 1939 by the City of Carlinville as a public water supply. Today the lake serves as the primary water supply for the City of Carlinville, the Lake Williamson Christian Center, and the surrounding rural community. During drought conditions, the water treatment plant pumps from Lake Carlinville II. There are several residences and summer cottages along the north shore of the lake, although there is currently no development on the south shore. The lake is also used for recreation, mainly boating and fishing, with camping on adjacent grounds. Other lake uses include swimming, skiing, picnicking, and aesthetic enjoyment. Table 4 provides a list of the major recreational uses and associated facilities at Lake Carlinville.

Table 4. Major Recreational Uses and Facilities

Available Lake Uses	Available Recreational Facilities
Fishing	Entire lake
Camping	Facility on the west side of the lake, near the boat ramp
Motor Boating	Entire lake (75 Horsepower Limit)
Sailing/Canoeing	Entire Lake
Picnicking	Pavilion near the boat ramp
Swimming	Beach located on the north side of the lake

The following rules and regulations apply for recreational activities at Lake Carlinville (Schaaff personal communication, 2006).

- Swimming is prohibited outside of the beach area. The beach is open between Memorial Day and Labor Day and there is no lifeguard on duty. There is no fee to access the beach.
- Littering or polluting at Lake Carlinville or the surrounding area is prohibited.
- All boats are required to have a city boat license. There is a 75-horsepower limit on all boats and inboards are prohibited. Boaters are responsible for knowing rules and regulations.
- Fishermen must have an Illinois license and abide by IL DNR fishing regulations.
- The lake is available for recreation between April 1^{st} and October 31^{st}. Lake hours are 7 am to 10 pm daily.

In the *Lake Carlinville Watershed Plan and Environmental Assessment Report*, the NRCS estimated that the annual visitor-days to the Lake Carlinville area totaled approximately 52,900 (USDA-NRCS, 1996). The majority of those visitor-days were attributed to group activities. In 1999, the City of Carlinville hosted a lake festival at the Lake Carlinville boat ramp. Approximately 65 persons attended the festival, where they learned about lake ecosystems, the fishery at the lake, how the Illinois EPA assesses lake quality, and how the public could be better stewards of the lake and their environment. On an annual basis, Scout Camp Weyanna is used for Boy Scout and Girl Scout activities, Lake Williamson is used for camping, swimming, fishing, boating, waterfowl hunting, and family oriented activities, and the city park is used for a fireworks display on Independence Day (USDA-NRCS, 1996).

F. POPULATION SEGMENTS ADVERSELY AFFECTED BY LAKE DEGRADATION

Lake Carlinville, as mentioned previously, provides water for the City of Carlinville, the Lake Williamson Christian Center, and Central Macoupin County Rural Water District, which includes the rural areas near Carlinville and around Lake Carlinville, including approximately one-third of the watershed (Shaw personal communication, 2006). As of 2006, the lake served approximately 8,000 people, the average daily demand at the Carlinville water treatment plant was approximately 0.95 million gallons per day (MGD), and the peak daily demand was 1.45 MGD (Shaw personal communication, 2006). As the lake water quality continues to decline, all water customers will be affected by increasing water treatment costs and a higher likelihood of taste and odor issues. The water treatment plant will also be affected by reduced water storage capacity and the inconvenience of changing the water source when Lake Carlinville I lacks adequate volume to serve the community.

Overall, degraded lake water quality and decreased lake access adversely impacts the local communities that utilize the lake and adjacent areas (Kirschner, 1995). The entire watershed is affected by erosion and soil loss in fields, adjacent to streams, and along drainage ways that are unprotected. Property owners along the lake are losing land due to shoreline erosion and property values tend to decrease as water quality, recreational opportunities, and aesthetics degrade. Fishermen have limited opportunities due to lack of habitat and the fact that the IL DNR has discontinued the stocking program at Lake Carlinville until the quality of the lake is improved. Finally, all boaters are affected by shallow depths and inability to access the upper portion of the lake.

G. COMPARISON OF LAKE USES TO USES OF OTHER LAKES IN REGION

Table 5 lists information for public lakes greater than 20 acres that are located within an 80 km (50 mile) radius of Lake Carlinville. Figure 5 illustrates the area within 80 km (50 miles) of Lake Carlinville and gives approximate locations of some of the larger, public lakes in the area (i.e., greater than 550 acres.) Lake Carlinville is relatively small compared to many of the lakes in the region, but recreational opportunities are very comparable. About ten of the lakes listed are utilized as a public water supply.

Table 5. Publicly Owned Lakes within 50 Miles of Lake Carlinville

Lake	County	Area (acres)	Max Depth (ft.)	Public Access/ Launch Ramp	Recreational Facilities	Distance in Miles
Carlinville Lake	Macoupin	168	19	Y	B,F,C,P	
Carlinville Lake II	Macoupin	105	45	Y	B,F	2
Otter Lake	Macoupin	723	51	Y	B,F,C,P	13
Palmyra-Modesto Lake	Macoupin	40	30	Y	B,F	15
Beaver Dam Lake	Macoupin	57	9	Y	B,F,C,P	6
Gillespie New City Lake	Macoupin	207	30	Y	B,F,C,P	6
Gillespie Old City Lake	Macoupin	71	21	Y	B,F,C,P	7
Staunton Reservoir	Macoupin	84	32	Y	B,F	14
Mt. Olive New City Lake	Macoupin	36	14	Y	B,F	11
Mt. Olive Old City Lake	Macoupin	36	29	Y	B,F	12
Lake Glenn Shoals	Montgomery	1,085	25	Y	B,F,C,P	21
Lake Lou Yeager	Montgomery	1,304	31	Y	B,F,C,P	13
Lake Hillsboro	Montgomery	94	23	Y	B,F	21
Coffeen Lake	Montgomery	1,070	58	Y	B,F,P	28
Walton Park Lake	Montgomery	30	10	Y	B,F	12
White Hall Reservoir	Greene	34		Y	B,F	30
Greenfield City Reservoir	Greene	59	21	Y	B,F	19
Horseshoe Lake	Madison	2,107	6	Y	B,F,C,P	49
Highland Silver Lake	Madison	550	5	Y	B,F,C,P	33
Carlyle Lake	Clinton	24,580	35	Y	B,F,C,P	46
Governor Bond Lake	Bond	775	26	Y	B,F,P	33
Greenfield Old City Lake	Bond	22	17	Y	B,F,P	30
Ramsey Lake	Fayette	46	22	Y	B,F,C,P	37
Vandalia Lake	Fayette	660	30	Y	B,F,C,P	46
Lake Springfield	Sangamon	3,797	30	Y	B,F,SK,C,P,SW	40
Sangchris Lake	Christian	2,321	42	Y	B,F,C,P	33
Lake Taylorville	Christian	1,286	22	Y	B,F,C,P	40
Lake Pana	Christian	205	36	Y	B,F,P	46
Mauvaise Terre Lake	Morgan	172	11	Y	B,F,P	40
Lake Jacksonville	Morgan	442	31	Y	B,F,C,P	39
Waverly Lake	Morgan	112	15	Y	B,F	23

B = Boating; SK = Skiing; C = Camping; P = Picnicking; F = Fishing; SW = Swimming

Source: Illinois State Atlas, 1980 and Illinois Atlas & Gazetteer, 2002.

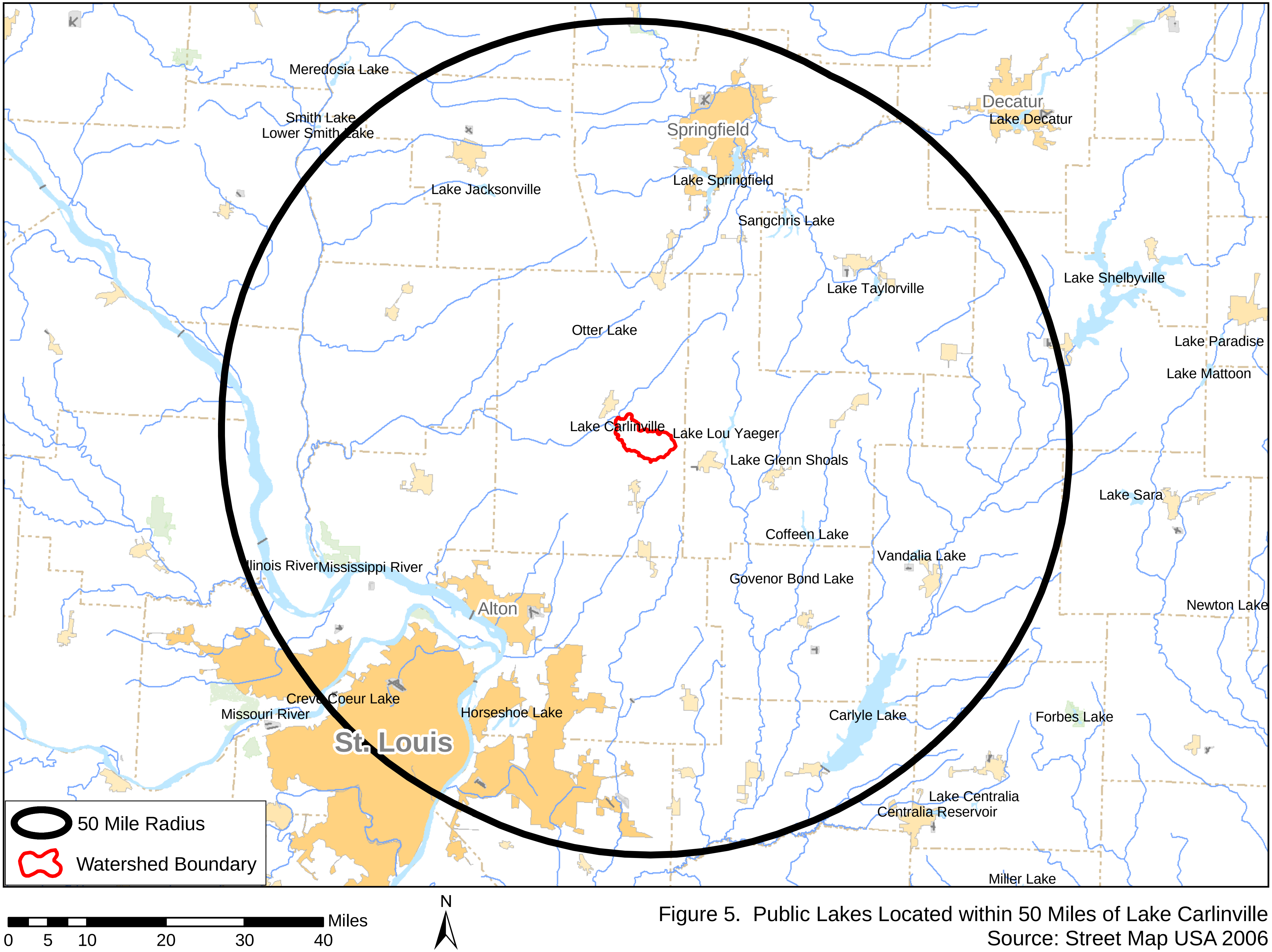


Figure 5. Public Lakes Located within 50 Miles of Lake Carlinville
Source: Street Map USA 2006

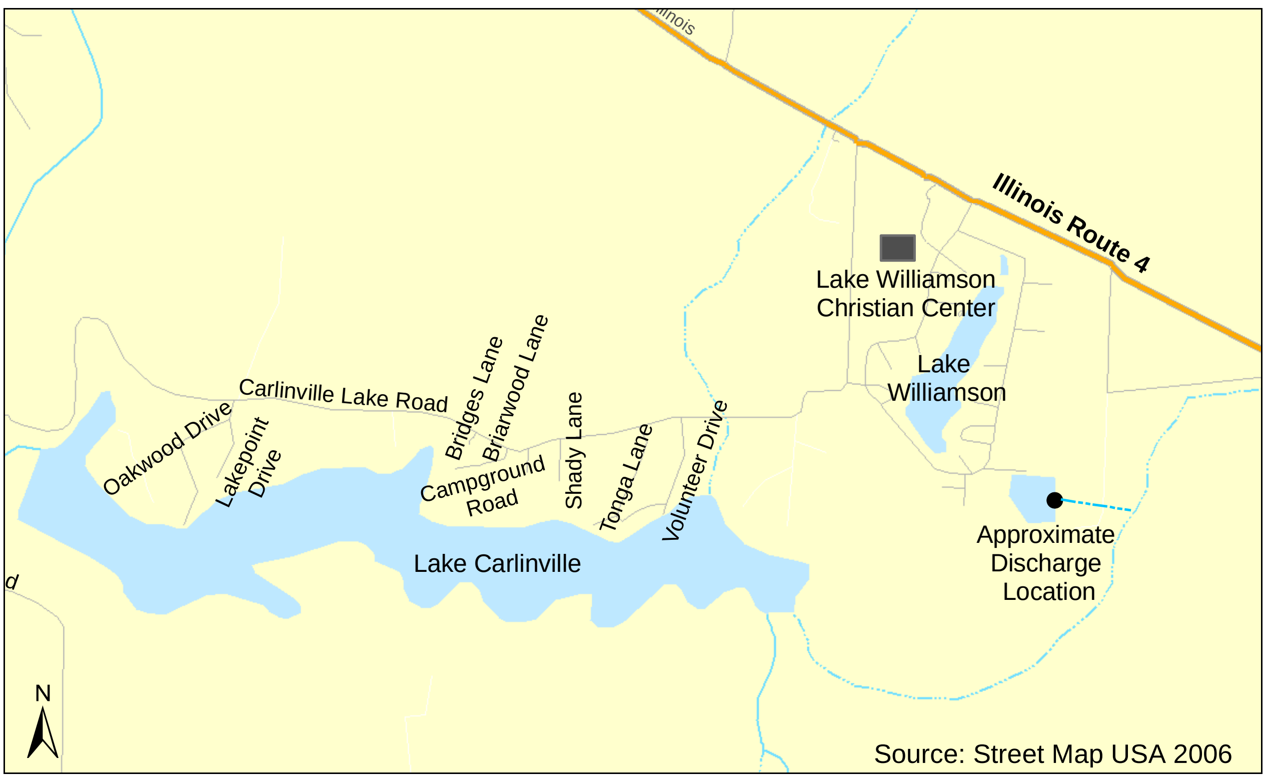
H. DESCRIPTION OF POINT SOURCE POLLUTION DISCHARGES WITHIN WATERSHED

The Lake Williamson Christian Center is the only facility with a National Pollution Discharge Elimination System (NPDES) Permit located within the Lake Carlinville watershed (Table 6). A review of the Illinois EPA discharge monitoring report (DMR) data, facility inspection reports, and conversations with the Macoupin County Health Department suggest that the Lake Williamson Christian Center is currently in compliance and has historically complied with the permit limitations (Bussman personal communication, 2006.)

Table 6. Point Source Pollution within the Lake Carlinville Watershed

NPDES Permit ID	Facility Name	Pipe Description	Avg. Design Flow (MGD)	Permitted to Discharge	Permit Expiration Date
IL0045373	Lake Williamson Christian Center	STP outfall	0.032	Fecal Coliform, $CBOD_5$, BOD_5, Flow, pH & Total Suspended Solids	Jul. 31, 2009

Figure 6. Approximate Location of Point Source Pollution Discharge

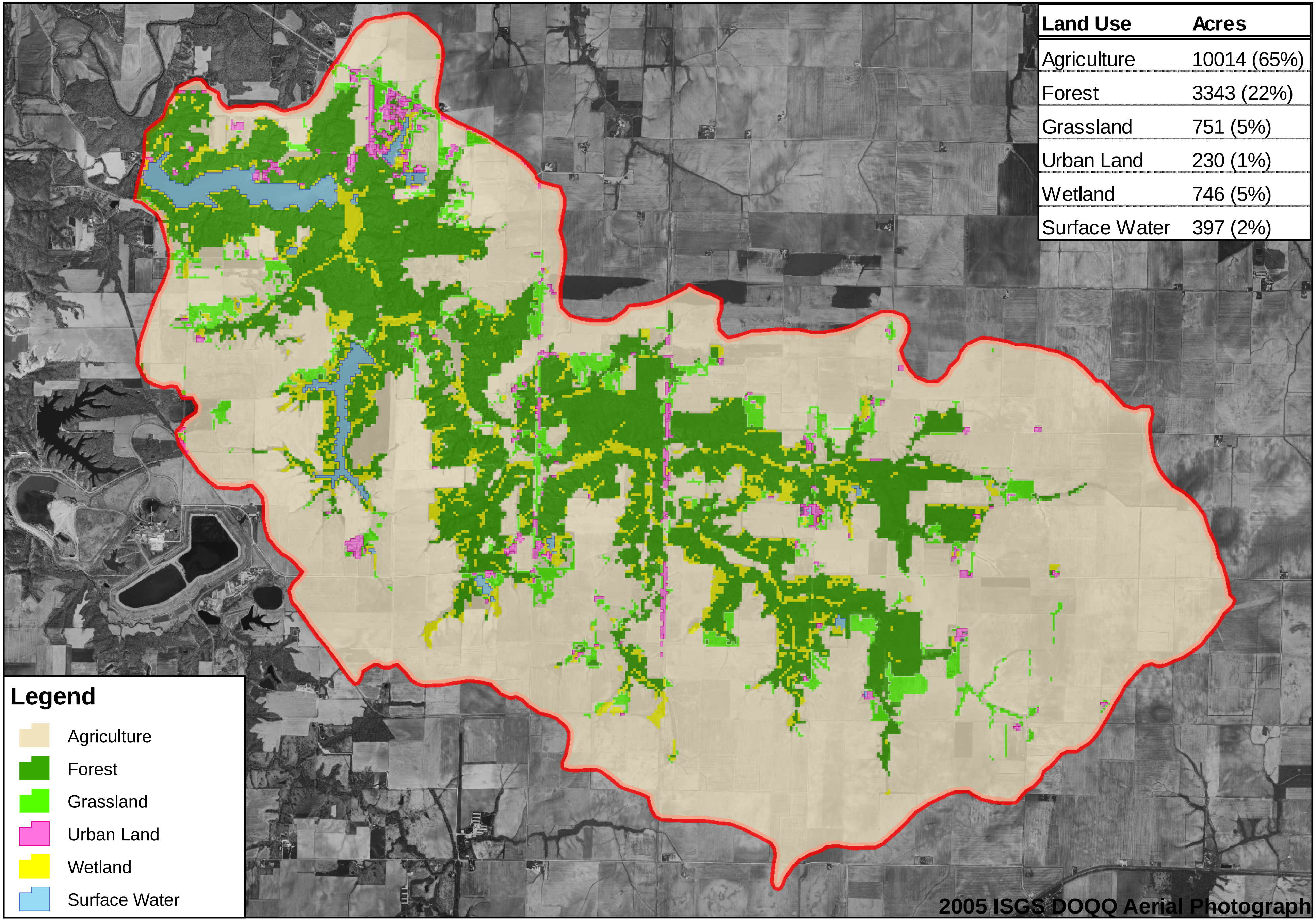


I. LAND USES AND NONPOINT SOURCE POLLUTION LOADINGS

The Lake Carlinville watershed encompasses approximately 6,265 hectares (15,481 acres) of land in central Macoupin County. The major land use in the watershed is agriculture (65 percent) (Figure 7). Other land uses include forest (22%), grassland (5%), wetland (5%), surface water (2%), and urban (1%). At 168 acres, Lake Carlinville represents 1.1 percent of the total watershed. The watershed to lake ratio for Lake Carlinville is 92:1.

The predominant land cover within the Lake Carlinville watershed is a consistent agricultural rotation of corn, soybeans, and small amounts of cover crops (i.e., winter wheat and other small grains). Due to the flat topography within the farmed portions of the watershed, the majority of the farmland within the watershed continues to be conventionally tilled (i.e., 0 to 10 percent residue left on the fields) (USDA-NRCS and Macoupin County SWCD, 2006). Some areas within the watershed utilize conservation tillage practices - mulch till (i.e., 30 percent residue) and no till (i.e., 50 percent residue). The soil conservation tillage practices within Macoupin County tend to be reserved for soybean production, some small grain rotations and steeper sloping or highly erodable areas (USDA-NRCS personal communication, 2006 and Limno-Tech, 2004). Conservation tillage is an important tool used to reduce sheet and rill erosion on cropland. Using continuous no till methods of farming can reduce soil loss by 75 percent over conventional methods. The NRCS (2003) recommends that row crops grown on slopes greater than 5 percent (i.e., C slopes or greater) should be no tilled.

The District Conservationist for Macoupin County indicated that few individuals within the watershed have participated in the Conservation Reserve Program (CRP) (McCandless personal communication, 2006). As of 2006, approximately 160 acres of land were enrolled in CRP, accounting for 11 different farms. It is possible that others have participated in the program in the past and are maintaining BMPs but are not currently enrolled. In addition to land enrolled in CRP, approximately 550 acres within the watershed consist of grassed waterways or field borders. In order to secure funding through CRP, the USDA requires that the farm manager develop and comply with a conservation plan (McCandless personal communication, 2007). It is likely that many agricultural fields have conservation plans, especially if the soil is highly erodable.



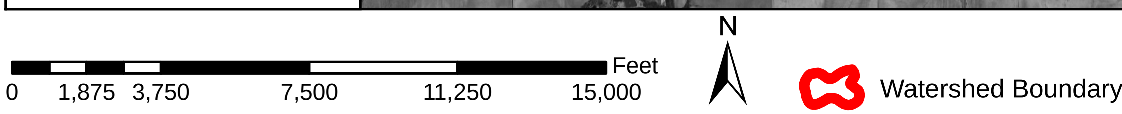


Figure 7. Land Uses within Lake Carlinville Watershed
Soucre: IL GAP (Macoupin County, Illinois)

Numerous nonpoint sources of pollution have been identified in the Lake Carlinville watershed including sheet and rill erosion, ephemeral gully erosion, gully erosion, stream bank erosion, shoreline erosion, and roadside erosion (USDA-NRCS, 1996). Soil erosion from the watershed and subsequent delivery rates to the lake were estimated by the NRCS within a 1996 report entitled *Lake Carlinville Watershed Plan and Environmental Assessment* and are included in Tables 7 and 8 below.

Table 7 summarizes the estimated annual rates of gross erosion and annual sediment delivery to Lake Carlinville, as related to the specific acreage of land use type within the watershed.

Table 7. Estimated Nonpoint Sediment Sources

Erosion Sources	Acres	Gross Erosion Rates (tons/ac/yr)	Gross Sediment Delivered (tons)	Sediment Delivery Rate (SDR)	Net Sediment Delivered (tons)
Sheet & Rill Erosion					
Agriculture	10,016	9.2	92,147	0.43	39,623
Grassland	753	2.8	2,108	0.45	949
Forest	3,480	1.5	5,220	0.35	1,827
Urban	230	6.5	1,495	0.20	299
Water & Wetland	1,002				
Total Acres	15,481				
Total Sheet & Rill Erosion			*100,971*		*42,698*
Ephemeral Erosion			3,435	0.80	2,748
Upper Gully Erosion			3,672	0.75	2,754
Adjacent Gully Erosion			3,005	0.90	2,705
Streambank & Shoreline Erosion			4,205	1.00	4,205
Total Erosion Yields			*115,288*		*55,110*
Watershed Transport Factor (STF)					0.29
Subtotal - Suspended Sediment					*15,982*
Estimated Bedload (10%)					1,598
Total Sediment Delivered					*17,580*

Source: USDA-NRCS, 2003

Table 8 lists the estimated annual nutrient loadings for total phosphorus and nitrogen within the Lake Carlinville watershed. Approximately, 17,580 tons/yr

(15,948,312 kg/yr) of sediment, 14.4 tons/yr (13,063 kg/yr) of total nitrogen, and 4.4 tons/yr (3,992 kg/yr) of total phosphorus could be annually delivered to Lake Carlinville. Sediment and nutrient budgets are discussed later in the Report and are included in Table 16 – 18. However, the actual measured concentrations from the Phase 1 (2006-07) sampling period (i.e., the sediment and nutrient budgets) yielded different results, suggesting inaccuracy of the loading estimates in Tables 5 and 6. The annual loading estimates in Table 7 do not account for nonpoint sources generated from eroded stream bank and lake shoreline erosion.

Similar problems involving large discrepancies between estimated loading rates and those derived from watershed monitoring were reported for lake restoration studies conducted in Illinois by CWI (1991) on Paris Twin Lakes, by Kothandaraman and Evans (1983) on Johnson Sauk Trail Lake and Lake Le-Aqua-Na, and by Kirschner and Sefton (1983) on the Skokie Lagoons. These studies reported that estimated loading rates gave results much different than those derived from stream monitoring data. These differences are probably related to the spatial distribution of land use in the watershed, stormwater management practices, and the problems related to predicting average export rates for a non-homogeneous watershed.

Table 8. Estimated Nonpoint Nutrient Sources

	Land Area		Total Nitrogen		Total Phosphorus	
Estimated Annual Loading	Acres	Hectares	Export/Input Rate (kg/ha/yr)	Annual Loading (kg/yr)	Export/Input Rate (kg/ha/yr)	Annual Loading (kg/yr)
Agriculture	10,016	4,053	10.1	40,938.8	3.3	13,376.038
Grassland	753	305	3.1	944.7	0.4	121.892
Forest	3,480	1,408	1.8	2,535.0	0.1	154.914
Other	230	93	6.5	605.0	1.2	111.694
Water & Wetland	1,002	405	NA	NA	NA	NA
	15,481	2,535				
Watershed Transport Factor				0.29		0.29
Total kg				13,056.8		3,991.7
Total tons				14.4		4.4

Source: Reckhow et al. (1980)

J. CURRENT AND PAST LAKE AND WATERSHED RESTORATION ACTIVITIES

Sedimentation impacts within Lake Carlinville were discovered not long after the lake was constructed in 1939. The first sedimentation survey, completed by the Illinois State Water Survey (ISWS) in 1949, determined that the lake's volume loss was nearly 24 acre-feet (38,720 cubic yards) per year or 1.4% of its original storage capacity. In an attempt to restore the lake to its original storage capacity, the City of Carlinville dredged the lake between 1968 and 1971. During this period, an estimated 100 acre-feet (approximately 161,000 cubic yards) of sediment were removed from the lake. To further increase lake storage capacity, the city began a construction program in 1978 that led to raising the spillway level of the lake. In 1982, the project was completed with the addition of a three-foot lip across the existing concrete spillway, which raised the spillway elevation to 573.0 feet above mean sea level. Overall, the project increased the lake's storage capacity by nearly 600 acre-feet (968,000 cubic yards).

In 2003, shoreline stabilization was completed to reduce the amount of sediment being transferred to the lake from the shoreline. The City of Carlinville obtained a Priority Lake and Watershed Implementation Program (PLWIP) grant from the State of Illinois' Conservation 2000 Program, which was administered by the Illinois EPA. The PLWIP grant was for $10,000 and was matched with $4,000 from the City of Carlinville. The funds were used to stabilize approximately 275 linear feet of eroded shoreline near the lake's main picnic area and boat ramp.

The USDA-NRCS, SWCD, and Farm Service Agency (FSA) continuously encourage landowners to implement BMPs and aid in identifying matching funds for qualifying projects throughout the Lake Carlinville watershed. There are numerous landowners within the watershed that have implemented conservation buffers, grassed waterways, and water and sediment control basins to reduce soil and nutrients from entering the lake (McCandless personal communication, 2007). This was evident when HDR│CWI personnel toured the watershed from public roadways.

K. BASELINE AND CURRENT LIMNOLOGICAL DATA

Baseline (historical) and current (Phase 1) limnological data for Lake Carlinville was obtained with assistance from the Illinois EPA Ambient Lake Monitoring Program

(ALMP) and the Illinois Clean Lakes Program (ILCP). Current data corresponds to samples collected during the Lake Carlinville Phase 1 monitoring year (bi-monthly, April 2006 through March 2007 with several exceptions). ALMP samples were collected monthly, when possible, rather than bi-monthly. All data reported prior to the Phase 1 monitoring year are considered historical data. Historical data were obtained from the US EPA STORET Computerized Environmental Data System (1979, 1981, 1988, and 1994) and the Illinois EPA (1999 and 2002). Four to five sampling dates were reported for each year, with the exception of 1979 and 1981, which only had two sampling dates reported. Specific sampling months were not consistent between data sets. Monthly data were evaluated by parameter for months occurring during the Illinois EPA ambient sampling period (May through October). Current and historical water quality data are provided in Appendix A and comparisons of the data are presented in the following paragraphs. Based on the above information, it is important to note that monthly means are sometimes representative of only one sampling event. Specifically, May and September historical data were limited and conductivity, pH, total alkalinity, and dissolved phosphorus Phase 1 data were limited.

The water quality data analyzed by the Illinois EPA laboratories for this Phase 1 study period was distributed by the Illinois EPA with two disclaimers (Appendix A). In addition to the disclaimers, information regarding data quality from the Illinois EPA laboratories during this time period is provided in the biannual update to the Integrated Report. The most recent Integrated Report, the *Illinois Integrated Water Quality Report and Section 303(d) list – 2006* is available on the Illinois EPA website at www.epa.state.il.us/water/water-quality/report-2006/2006-report.pdf.

> *Based on Illinois EPA's review of surface-water results analyzed by Illinois EPA laboratories, some data failed to meet quality control criteria or failed to meet data quality objectives. For these analytes, the Illinois EPA intends to further review the results of samples collected after 12/31/2003, and therefore does not intend to use the data until a complete review of samples has been conducted. Data sets not used were: ammonia collected from 01/01/1997 through 12/31/1999 and 10/01/2002 through 12/31/2003; phenols and total Kjeldahl nitrogen data collected from 01/01/1999 through 12/31/2003; and phosphorus, nitrate/nitrite, chloride, alkalinity,*

sulfate, cyanide, chlorophyll, total suspended solids, volatile suspended solids and total dissolved solids collected from 10/01/2002 through 12/31/2003.

Based on the information provided in the 2006 Integrated Report and the specific disclaimer for surface water data (Appendix A), the results obtained for the following parameters analyzed by Illinois EPA laboratories during the Phase 1 study period are to be interpreted with caution: chlorophyll.

1. Historical and Current Lake Water Quality

The Illinois EPA ambient lake water quality monitoring at Lake Carlinville began in 1979. This monitoring program provides an intensive analysis of the limnological characteristics and includes a wide range of water quality parameters. The City of Carlinville's participation in the Volunteer Lake Monitoring Program (VLMP) lasted for a three year period (1982-84). VLMP sampling has not occurred since the 1980s (Nickel personal communication, 2006).

The Illinois EPA Ambient Lake Monitoring Program has three (3) in-lake sampling sites (RDG-1, RDG-2, and RDG-3) for Lake Carlinville. RDG-1 (Site 1) is the deepest sampling station and is located in the western portion of the lake near the spillway and dam. RDG-2 (Site 2) is located near the boat dock in the center of the lake, and RDG-3 (Site 3) is located in the upper, eastern portion of the lake. In addition to the in-lake monitoring sites, two (2) tributary sampling sites (RDG-T1 and RDG-T2) were designated within the watershed. RDG-T1 (tributary Site 1) is located at the spillway and RDG-T2 (tributary Site 2) is located at Honey Creek at the Old Route 4 bridge crossing. Figure 8 illustrates the in-lake and tributary monitoring locations within Lake Carlinville and its watershed.

Water quality and lake sediment sampling was conducted at in-lake Sites 1, 2, and 3 in order to establish current limnological conditions. Samples collected in conjunction with the ambient monitoring program were collected monthly by Illinois EPA personnel during May through October (with the exception of July and September) and additional samples were collected bi-monthly (with the exception of September and November through March) by City of Carlinville personnel. Surface samples were collected at 0.30 meters (1.0 ft.) at all three sampling locations in the lake. In addition to surface water samples, intermediate and bottom samples were collected at depths of approximately 7 feet (depth of public water supply intake) and two feet from the bottom at Site 1, respectively. Sampling procedures for each trip also included a water transparency reading (Secchi transparency depth), a depth-integrated chlorophyll sample (obtained by lowering the sampling apparatus between the surface and a depth of approximately twice the Secchi depth), and a dissolved oxygen and temperature profile (DO/temperature). A screening for metals and organics (in lake water and lake bottom sediment) was also included in the analysis of ambient monitoring samples.

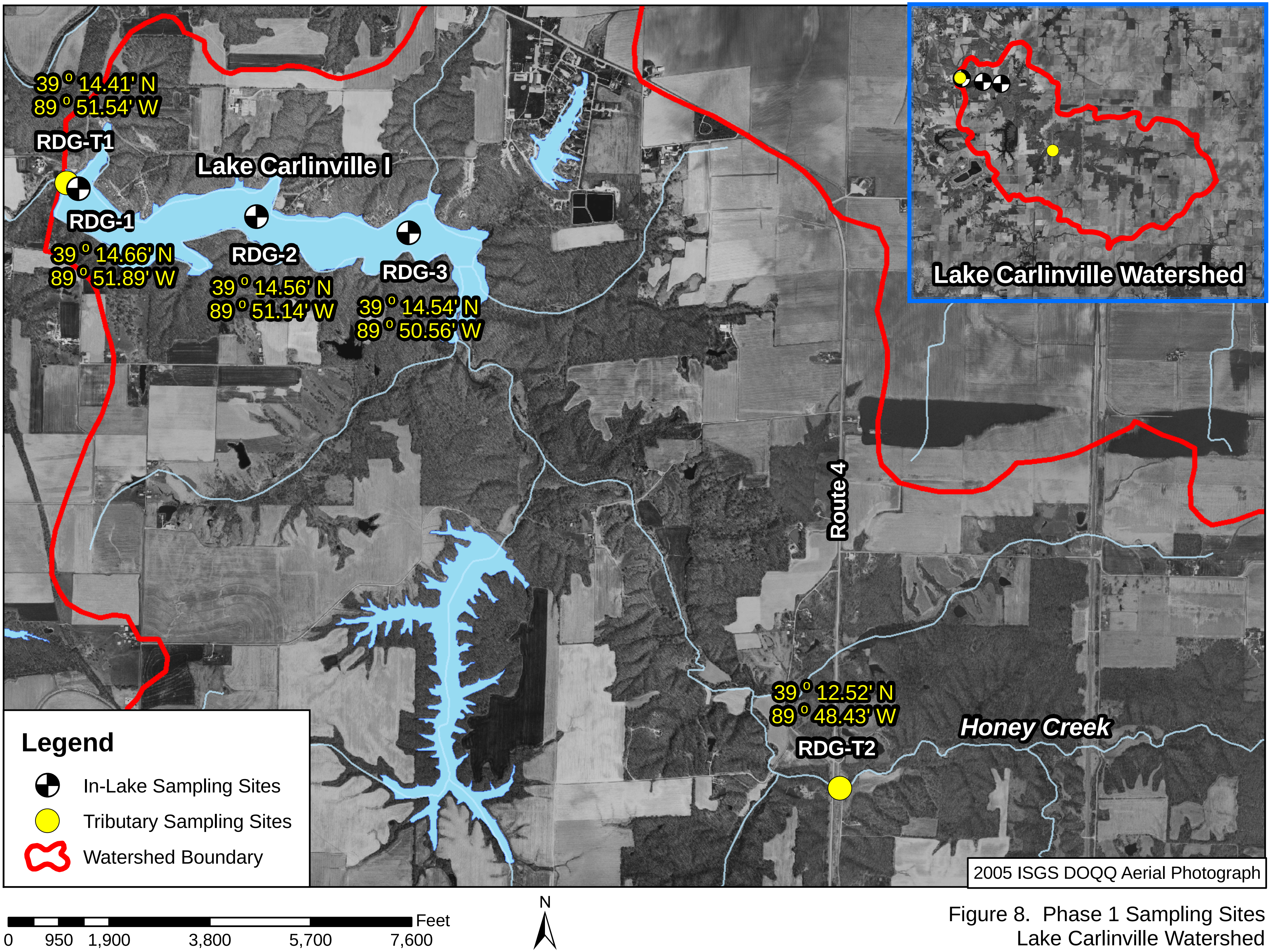


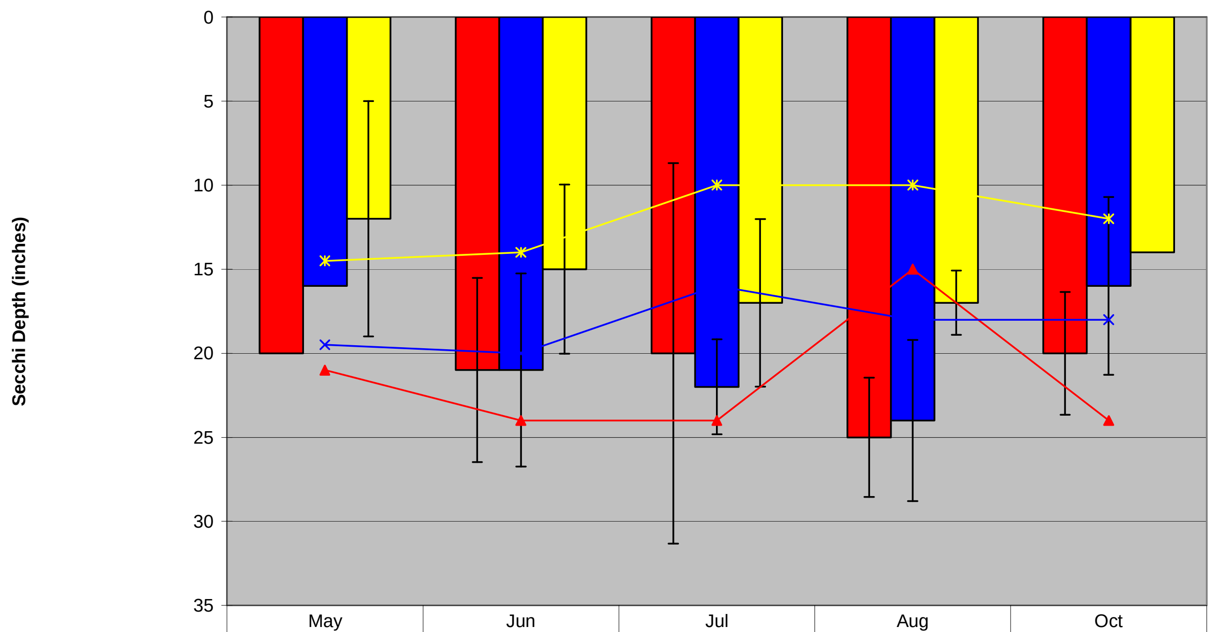
Figure 8. Phase 1 Sampling Sites
Lake Carlinville Watershed

a. Water Transparency

Lake water transparency was measured using a simple, inexpensive device known as a Secchi disk. The Secchi disk is a 20.0 cm (7.9 inch) round disk with alternating black and white patterns that is lowered into the water column until it disappears. The corresponding depth at which the disk is no longer visible with the naked eye is known as the Secchi transparency depth. An increase in algal productivity or an increase in suspended solids may negatively correlate with Secchi depth measurements due to a decrease in light penetration.

During the Phase 1 monitoring period, Secchi transparencies ranged from a low of 10 inches at Site 3 to a high of 24 inches at Site 1. A comparison between Phase 1 and historical data indicates that Secchi depths recorded during the Phase 1 monitoring period were less (i.e., more turbid) than the historical Secchi depths, but were generally within one standard deviation of the historical mean for each site. Although, Secchi depths at Site 3 were significantly less in July and August when compared to historical depths. This is most likely due to resuspension of accumulated sediment in the upper end of the lake. During the Phase 1 monitoring period, Secchi depths were typically indicative of lower turbidity in the spring and higher turbidity in the summer months when algal productivity is known to be highest. Historical Secchi transparency depths appeared to peak in August, which differs from Phase 1 data showing a peak in June. Average monthly Secchi readings for Lake Carlinville are displayed in Figure 9.

Figure 9. Secchi Depth Comparison



	May	Jun	Jul	Aug	Oct
Site 1 - Historical	20	21	20	25	20
Site 2 - Historical	16	21	22	24	16
Site 3 - Historical	12	15	17	17	14
Site-1 - Phase I	21	24	24	15	24
Site 2 - Phase I	19.5	20	16	18	18
Site 3 - Phase I	14.5	14	10	10	12

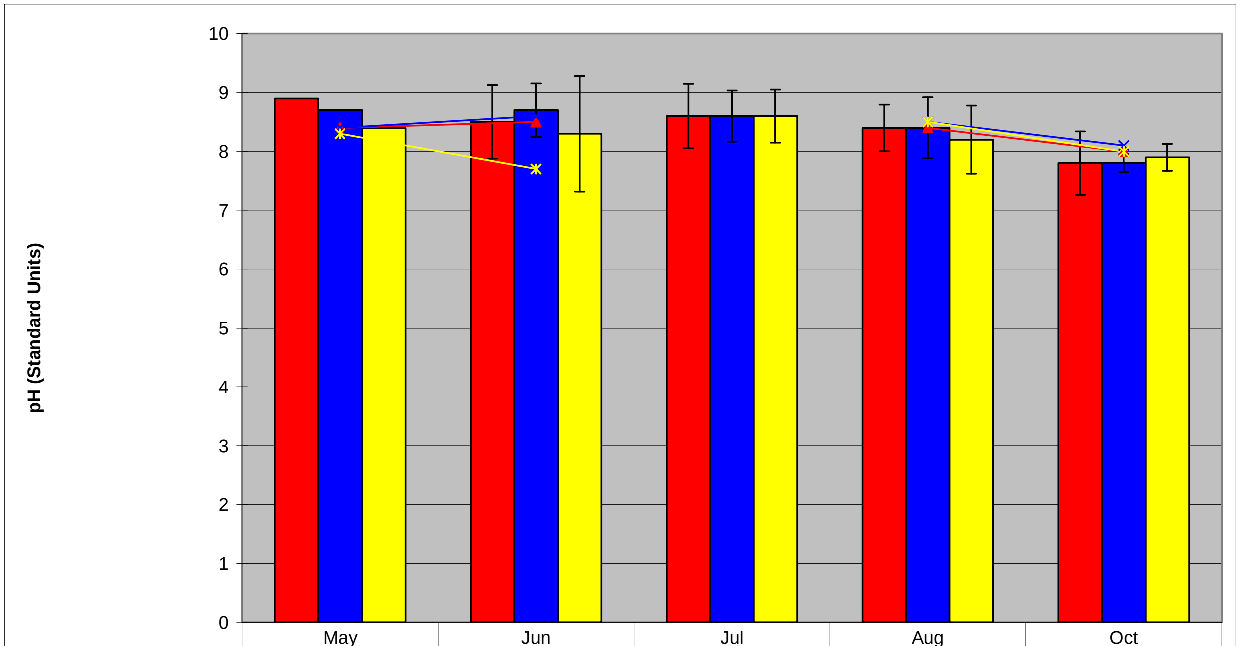
Note: Standard deviation is not shown for months where only one value was reported

b. pH and Alkalinity

When measuring the degree of acidity in a waterbody, a logarithmic scale ranging from 0 to 14 is used to measure the concentration of hydrogen ions. This scale is known as the pH scale. A pH value within the lower portion of the scale, 0 to 7, indicates the degree of acidity and a pH value within the upper portion, 7 to 14, indicates the degree of alkalinity. A 7 on the pH scale indicates the water is neutral. Generally, lakes in Illinois are well buffered by limestone bedrock, which may neutralize acidic activity. These lakes typically range from 6 to 9 on the pH scale.

During Phase 1 sampling, surface measurements of pH at Lake Carlinville ranged from a low of 7.7 at Site 3 to a high of 8.6 at Site 2. Overall, pH readings during the Phase 1 monitoring period were within one standard deviation of the historical mean for each site (Figure 10). Changes in pH during the season may be attributed to algal productivity, increased CO_2 from respiration accompanying decomposition, or nitrogen assimilation in the water column. Based on available data, pH measurements exhibited normal fluctuations and remained similar to other Illinois lakes.

Figure 10. pH Comparison



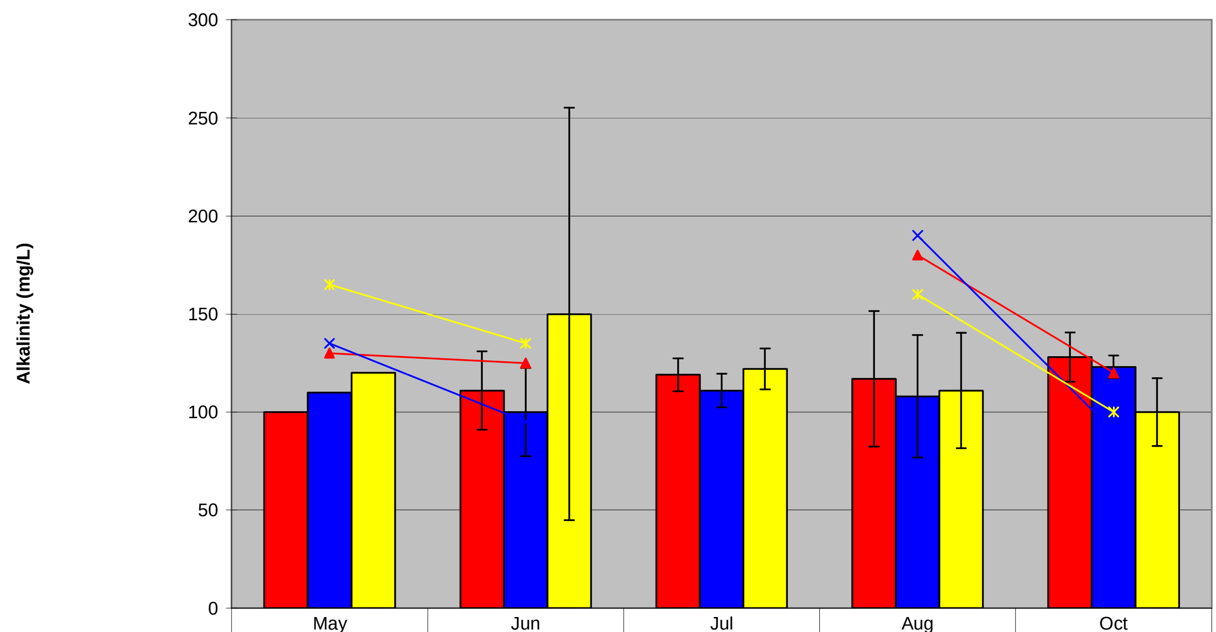
	May	Jun	Jul	Aug	Oct
Site 1 - Historical	8.9	8.5	8.6	8.4	7.8
Site 2 - Historical	8.7	8.7	8.6	8.4	7.8
Site 3 - Historical	8.4	8.3	8.6	8.2	7.9
Site-1 - Phase I	8.4	8.5		8.4	8
Site 2 - Phase I	8.4	8.6		8.5	8.1
Site 3 - Phase I	8.3	7.7		8.5	8

Note: Standard deviation is not shown for months where only one value was reported

Buffering capacity, also known as alkalinity, is defined by the ability of water to neutralize acid. Total alkalinity measures the amount of acid needed to lower the pH of water to 4.5. A high alkalinity concentration indicates a stronger ability to neutralize pH and resist changes, whereas a low alkalinity concentration indicates that a water body is vulnerable to changes in pH. In general, Lake Carlinville remained well buffered throughout the Phase 1 monitoring period. Total alkalinity measurements during the Phase 1 sampling period ranged from a low of 90 mg/L to a high of 190 mg/L at Site 2 (Figure 11). Historical and Phase 1 data were similar; however, historical alkalinity values were more consistent and slightly lower in some months when compared to

Phase 1 values. For example, there is an unexplained peak during August at all three sampling sites.

Figure 11. Total Alkalinity Comparison



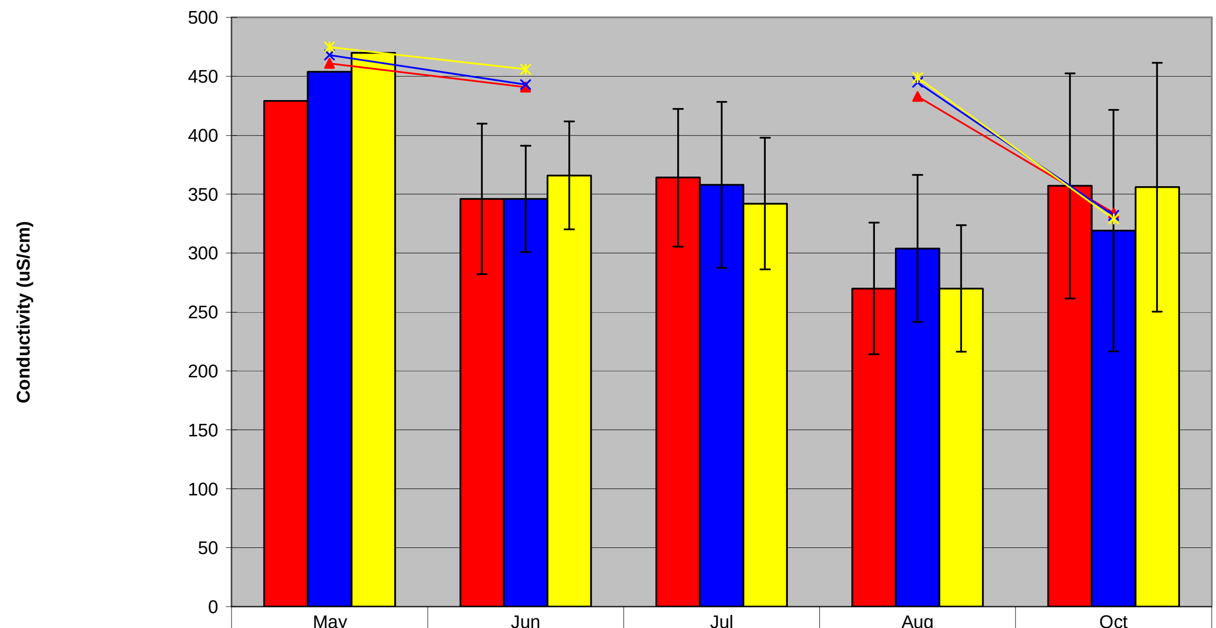
	May	Jun	Jul	Aug	Oct
Site 1 - Historical	100	111	119	117	128
Site 2 - Historical	110	100	111	108	123
Site 3 - Historical	120	150	122	111	100
Site-1 - Phase I	130	125		180	120
Site 2 - Phase I	135	95		190	90
Site 3 - Phase I	165	135		160	100

Note: Standard deviation is not shown for months where only one value was reported

c. Conductivity

Conductivity is a measure of water's ability to conduct an electrical current. The ability to carry a current is driven by the dissolved materials present in the water. These materials can include dissolved ions and other materials in the water and thus are directly proportional to the concentration of total dissolved solids (TDS) present in the water column. Typically, TDS concentrations represent 50-65 percent of the conductivity measurements. Lake Carlinville conductivity measurements ranged from a low of 329 μmhos/cm to a high of 475 μmhos/cm at Site 3 during the Phase 1 monitoring period. Measurements from the Phase 1 monitoring period were slightly higher than the historical data collected. With the exception of conductivity readings during August, concentrations remained within one standard deviation of the historical average and also remained similar to other Illinois lakes. Figure 12 portrays the Phase 1 conductivity measurements and the historical means for each site.

Figure 12. Conductivity Comparison



	May	Jun	Jul	Aug	Oct
Site 1 - Historical	429	346	364	270	357
Site 2 - Historical	454	346	358	304	319
Site 3 - Historical	470	366	342	270	356
Site-1 - Phase I	461	441		433	334
Site 2 - Phase I	468	443		445	332
Site 3 - Phase I	475	456		449	329

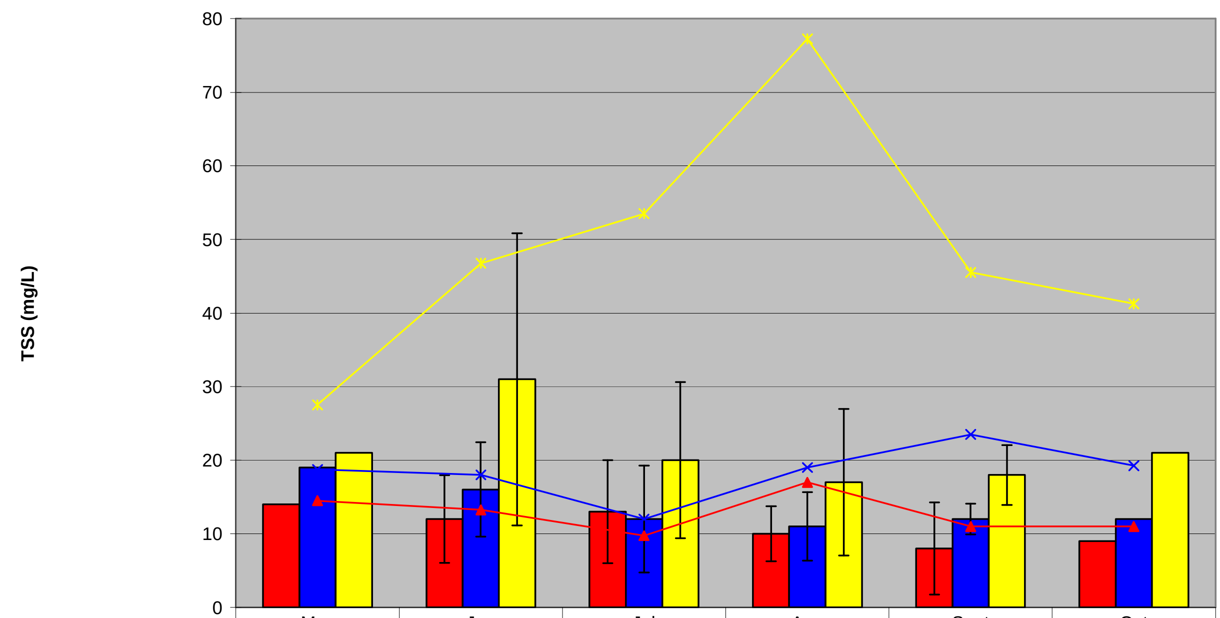
Note: Standard deviation is not shown for months where only one value was reported

d. Suspended Solids

Suspended solids in a lake most often consist of soil particles, organic material, and other debris floating in the water column. These concentrations can be an important indicator of the type and degree of turbidity in a lake as it relates to water quality. Secchi transparency depth measurements and total suspended solids (TSS) concentrations are inversely proportional. As TSS concentrations increase, the Secchi transparency depths decrease. In order to more accurately determine the types and amounts of suspended solids in the lake, a volatile suspended solids (VSS) analysis is often performed in conjunction with the TSS analysis. The VSS concentration mainly represents the organic portion of the total suspended solids concentration. Organic constituents often include plankton and additional plant and animal debris that is present in the water column.

TSS and VSS concentrations were measured to assess the average concentration of suspended material in the water column at each sampling location. The TSS concentration represents inorganic and organic, non-volatile particles and the VSS concentration represents mainly organic volatile particles present in the water column (Figures 13 and 14). The Phase 1 TSS data were significantly higher at Site 3 when compared to the historical data, and Site 3 TSS concentrations are typically higher than Site 1 and 2 concentrations. This is due to continued accumulation of sediment, which causes shallow depths and an increased likelihood of sediment being suspended by wind or wave action. The high TSS concentration in August 2007 is not typical and could have been caused by high flows or wind during the sampling event.

Figure 13. TSS Concentrations

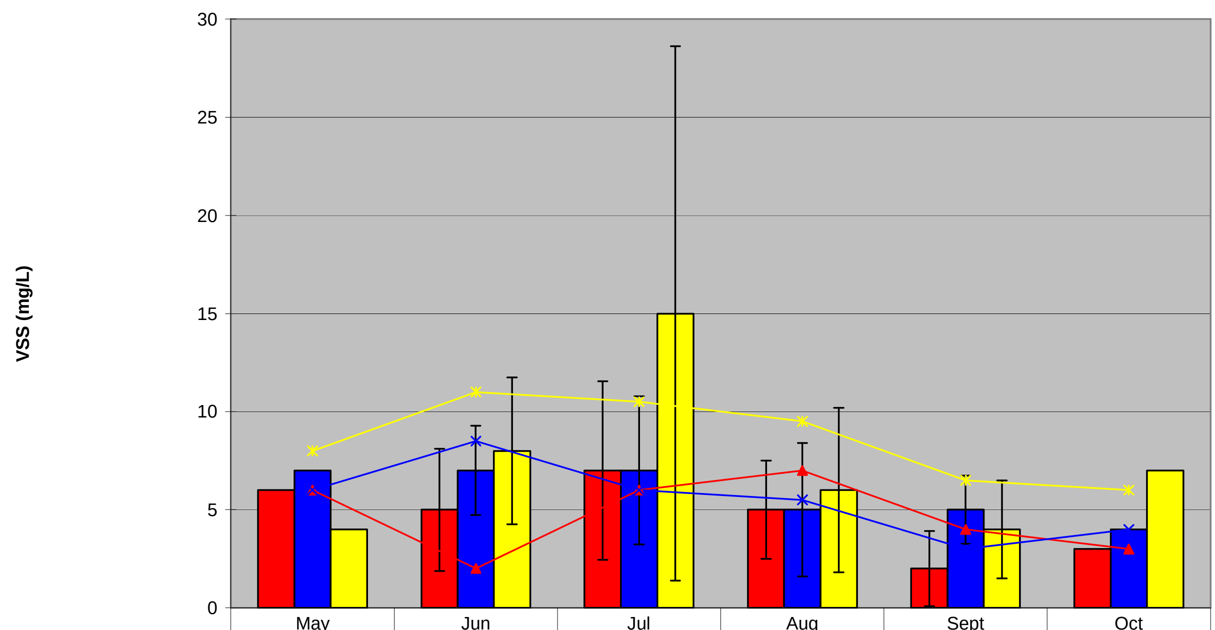


	May	Jun	Jul	Aug	Sept	Oct
Site 1 - Historical	14	12	13	10	8	9
Site 2 - Historical	19	16	12	11	12	12
Site 3 - Historical	21	31	20	17	18	21
Site-1 - Phase I	15	13	10	17	11	11
Site 2 - Phase I	19	18	12	19	24	19
Site 3 - Phase I	28	47	54	77	46	41

Note: Standard deviation is not shown for months where only one value was reported

The Phase 1 VSS data were similar to historical data; however, several concentrations varied more than one standard deviation. Specifically, the VSS concentration at Site 3 in July appears to be historically elevated but the large standard deviation demonstrates that data during this month may be inconsistent. Overall, Phase 1 VSS concentrations were slightly higher than historical values. According to the Phase 1 monitoring data, the mean VSS concentration was approximately 31 percent of the TSS concentration, ranging from 20 percent at Site 3 to 39 percent at Site 1. This indicates that a relatively high inorganic component was present, which correlates with the high algal productivity and chlorophyll levels present.

Figure 14. VSS Concentrations



	May	Jun	Jul	Aug	Sept	Oct
Site 1 - Historical	6	5	7	5	2	3
Site 2 - Historical	7	7	7	5	5	4
Site 3 - Historical	4	8	15	6	4	7
Site-1 - Phase I	6	2	6	7	4	3
Site 2 - Phase I	6	9	6	6	3	4
Site 3 - Phase I	8	11	11	10	7	6

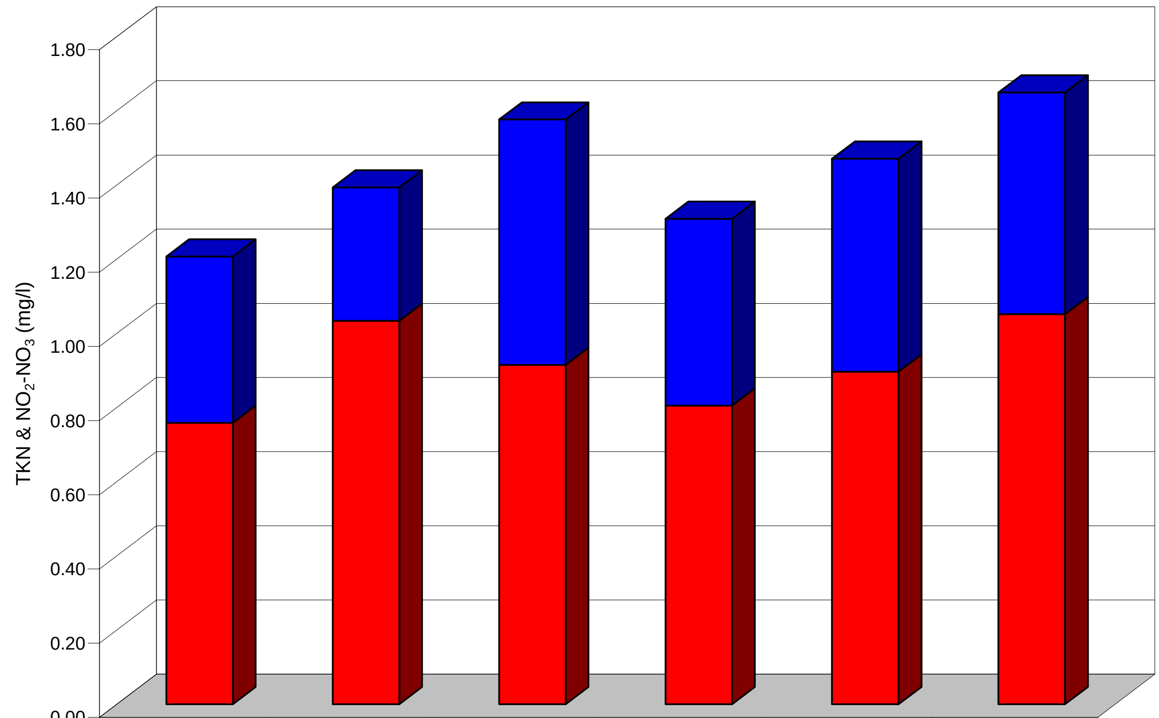
Note: Standard deviation is not shown for months where only one value was reported

e. Nitrogen

Nitrogen is one of several chemicals that are essential in freshwater ecosystems. Biota in the lake greatly depend upon the presence of nitrogen for daily activities and the diversity of species within a water body is often influenced by the degree of available nitrogen forms. These forms include gaseous nitrogen (N_2), nitrate (NO_3^-), nitrite (NO_2^-), ammonia nitrogen (NH_3-N), ammonium (NH_4^+), and dissolved organic nitrogen. Nitrate and nitrite concentrations are often measured together due to the fact that these forms readily change depending on the amount of available oxygen. The NH_3-N concentration represents unionized nitrogen and the NH_4^+ represents ionized nitrogen. Inorganic forms of nitrogen such as nitrate-nitrite and ammonia found in excess may be detrimental to lake ecosystems. For example, Sawyer (1952) indicated that inorganic nitrogen concentrations in excess of 0.30 mg/L are considered sufficient to stimulate excessive algal growth. Also, high concentrations of ammonia can be toxic to many fish and other aquatic organisms.

Nitrogen measurements conducted at Lake Carlinville included NH_3-N, NO_2-NO_3, and total Kjeldahl nitrogen (TKN). TKN is a measurement of both organic and ammonia-nitrogen. A total nitrogen concentration can be obtained by adding the TKN to the NO_2-NO_3 measurements. Figure 15 graphically portrays the mean total nitrogen measurements for each of the monitoring sites during both the Phase 1 and historical monitoring periods. In general, the total nitrogen percentages provide a relationship of the sources of nitrogen in the water body. Based on the historical data available, approximately 66% of the nitrogen in Lake Carlinville has been comprised of organic and ammonia nitrogen (measured by TKN). During the Phase 1 monitoring period, the ammonia and organic nitrogen components represented approximately 61% of the nitrogen in Lake Carlinville. Sources of organic nitrogen may include algae and macrophyte growth, while sources of ammonia nitrogen may be fish waste, atmospheric input and decomposing organic material in the lake.

Figure 15. Total Nitrogen Comparison

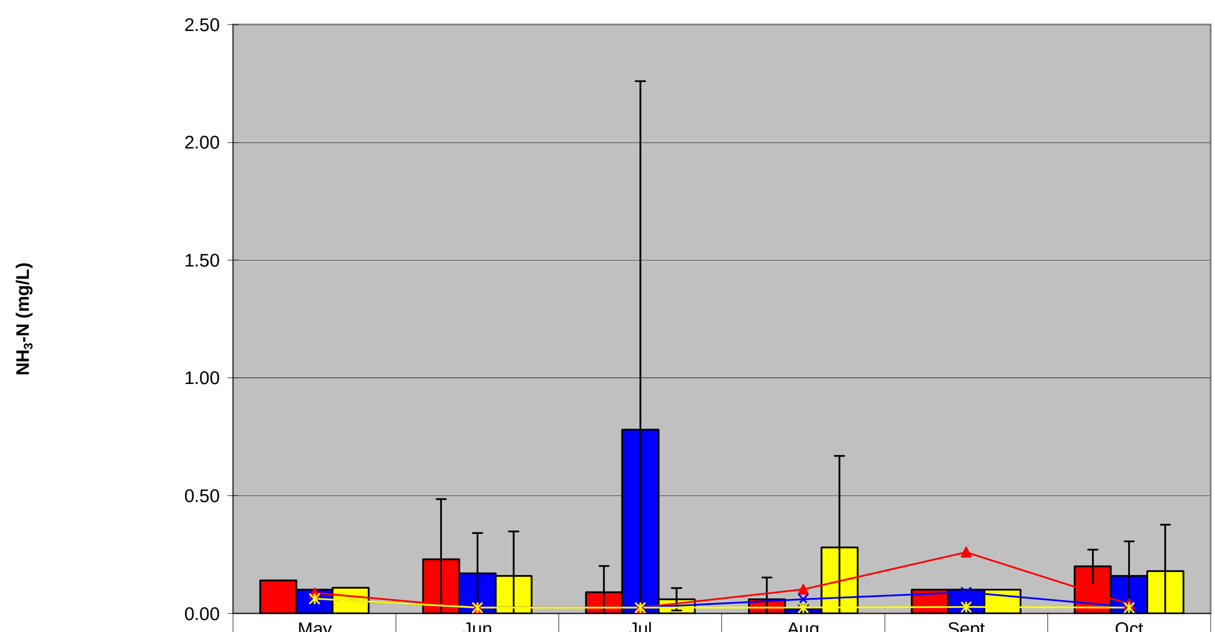


	Site-1 - Phase I	Site-1 - Historical	Site-2 - Phase I	Site-2 - Historical	Site-3 - Phase I	Site-3 - Historical
NO2-NO3	0.45	0.36	0.66	0.50	0.57	0.60
TKN	0.76	1.03	0.92	0.81	0.90	1.05

The Illinois General Water Quality Standards for ammonia-nitrogen vary according to water temperature and pH, with the allowable concentrations decreasing as temperature and pH increase. The allowable concentration of ammonia-nitrogen varies from 1.5 mg/L to 13.0 mg/L. As mentioned above, sources of ammonia-nitrogen include bacterial decomposition of organic material, atmospheric nitrogen, and fish excretion. Elevated ammonia (unionized) concentrations may be toxic to fish and other aquatic organisms and must be converted to ammonium (NH_4^+) through the formation of (NH_3OH) or nitrate (NO_3^-) before uptake by plants can occur. In contrast, ammonium (ionized) is not toxic to aquatic organisms and is readily available for uptake by phytoplankton and macrophytes. The total amount of ammonia and ammonium in the water column at any certain time is dependent upon the balance between pH, animal excretion, plant uptake, and activity of bacteria. Due to the high degree of variability possible, data should be interpreted carefully.

The Phase 1 data suggests that ammonia levels did not approach the toxic level and were lower compared to the historical mean concentrations (Figure 16). In the pH range characteristic of Lake Carlinville, as temperature rises, a higher percentage of ammonia is present in the water compared to that at lower pH and temperature ranges. The overall importance of this trend is that NH_3 dissolves and forms NH_4OH. Ultimately, as pH and temperature decrease, ammonium hydroxide disassociates and forms NH_4^+. This source of nitrogen is often referred to as a "regenerated" nitrogen source as compared to anthropogenic sources commonly found in lakes with higher inflows. This "regenerated" nitrogen source is readily taken up by phytoplankton and macrophytes in the lake thus contributing to a higher biomass.

Figure 16. Un-Ionized Ammonia (NH_3-N) Comparison

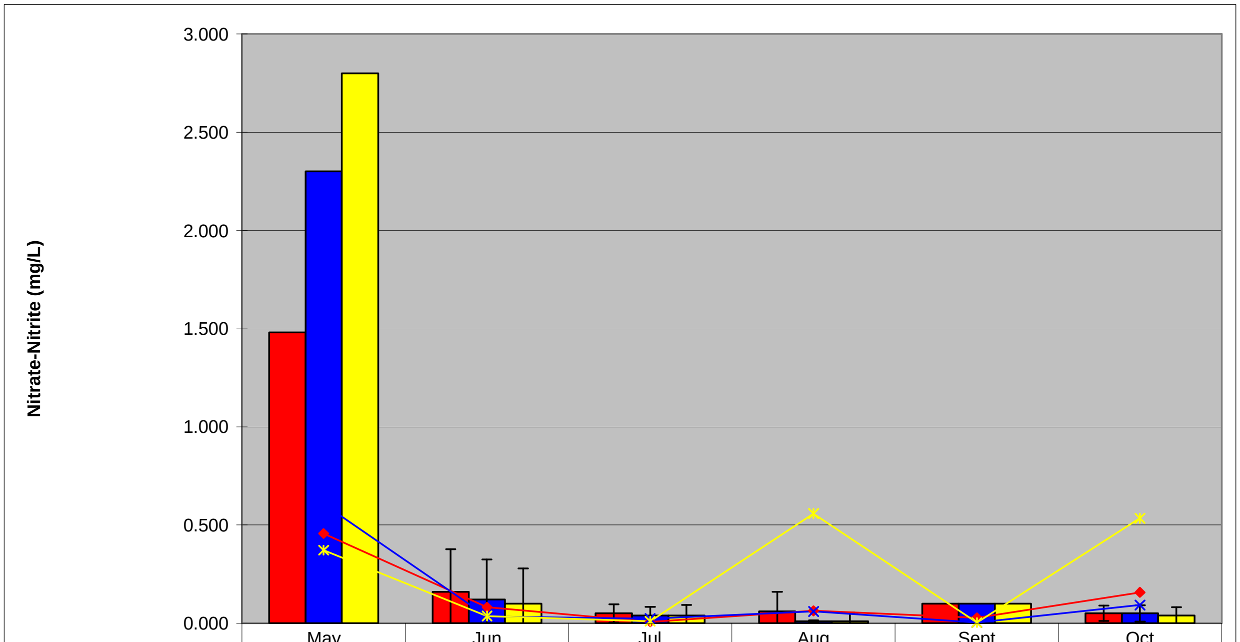


	May	Jun	Jul	Aug	Sept	Oct
Site 1 - Historical	0.14	0.23	0.09	0.06	0.10	0.20
Site 2 - Historical	0.10	0.17	0.78	0.02	0.10	0.16
Site 3 - Historical	0.11	0.16	0.06	0.28	0.10	0.18
Site-1 - Phase I	0.09	0.02	0.02	0.10	0.26	0.04
Site 2 - Phase I	0.06	0.02	0.02	0.06	0.09	0.03
Site 3 - Phase I	0.06	0.02	0.02	0.02	0.03	0.02

Note: Standard deviation is not shown for months where only one value was reported

In addition to ammonia, nitrate and nitrite were also analyzed as sources of nitrogen. In typical surface waters, nitrate-nitrite is often discussed as the combined inorganic portion of the nitrogen cycle since the nitrite concentration is typically minimal under aerobic conditions. Figure 17 graphically portrays the nitrate-nitrite concentrations for Lake Carlinville. NO_2-NO_3 concentrations ranged from a low of 0.003 mg/l to a high of 0.606 mg/l at Site 2. Concentrations observed during the Phase 1 period were lower than the historical average but were often within one standard deviation of the historical mean, indicating that this change in water quality is likely not statistically significant. It is interesting to note the elevated concentrations in May. This corresponds with the average monthly rainfall, which peaks in May. Due to the predominant agricultural land use in the watershed, NO_2-NO_3 concentrations peak in May as a result of applied nitrogen carried to the lake via runoff. This effect may be compounded if rainfall during the previous months is low.

Figure 17. NO_2-NO_3 Comparison



	May	Jun	Jul	Aug	Sept	Oct
Site 1 - Historical	1.480	0.160	0.050	0.060	0.100	0.050
Site 2 - Historical	2.300	0.120	0.040	0.010	0.100	0.050
Site 3 - Historical	2.800	0.100	0.040	0.010	0.100	0.040
Site-1 - Phase I	0.457	0.081	0.007	0.063	0.028	0.157
Site 2 - Phase I	0.606	0.034	0.023	0.060	0.003	0.093
Site 3 - Phase I	0.372	0.037	0.010	0.558	0.003	0.535

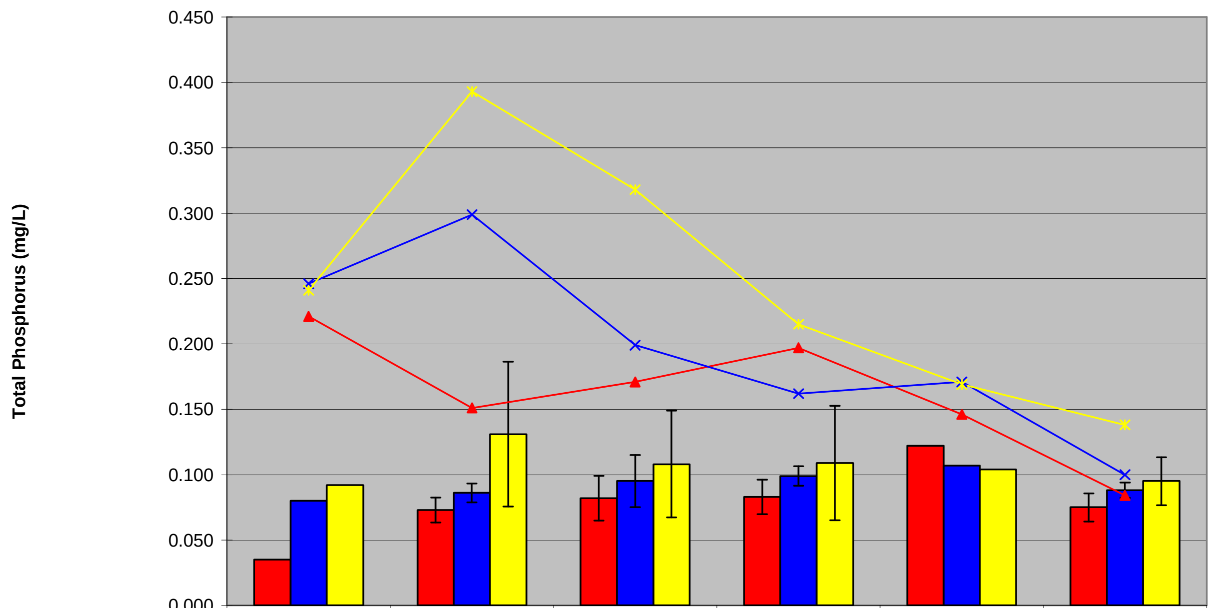
Note: Standard deviation is not shown for months where only one value was reported

f. Phosphorus

Phosphorus may be found in low concentrations in Illinois lakes throughout all seasonal periods of the year. Phosphorus is typically the limiting nutrient in a lake ecosystem and an elevated loading of phosphorus will generally stimulate additional plant and algae growth (Horne and Goldman, 1994). As a result, the control of phosphorus within a lake ecosystem is typically a primary focus for lake restoration and protection efforts. Often, the majority of phosphorus delivered to streams and lakes is tightly bound to sediment particles that originate from agricultural fields in the watershed. Additional sources of phosphorus may include internal recycling from anaerobic decomposition of organic matter at the bottom of the lake, leaking septic systems, waterfowl, atmospheric deposition, and point source pollution. According to the Illinois General Water Use Standards, phosphorus as “P” should not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more (IEPA, 1990).

Total phosphorus concentrations for Lake Carlinville are shown in Figure 18. Phosphorus concentrations during the Phase 1 period ranged from a low of 0.084 mg/L at Site 1 to a high of 0.393 mg/L at Site 3. Historical total phosphorous concentrations remained fairly consistent for each site on a monthly basis; however, concentrations measured during the Phase 1 monitoring period fluctuated from month to month. Phase 1 phosphorus concentrations were significantly higher than the historical mean. While the cause of elevated concentrations during the Phase 1 period is unknown, one possibility could be a change in the laboratory test method. Elevated concentrations may also be an indicator that the sediment accumulation is becoming a larger problem, especially during the wet season when frequent storm events occur. The excess runoff could be resuspending bottom sediments and distributing phosphorus throughout the lake.

Figure 18. Total Phosphorus Comparison

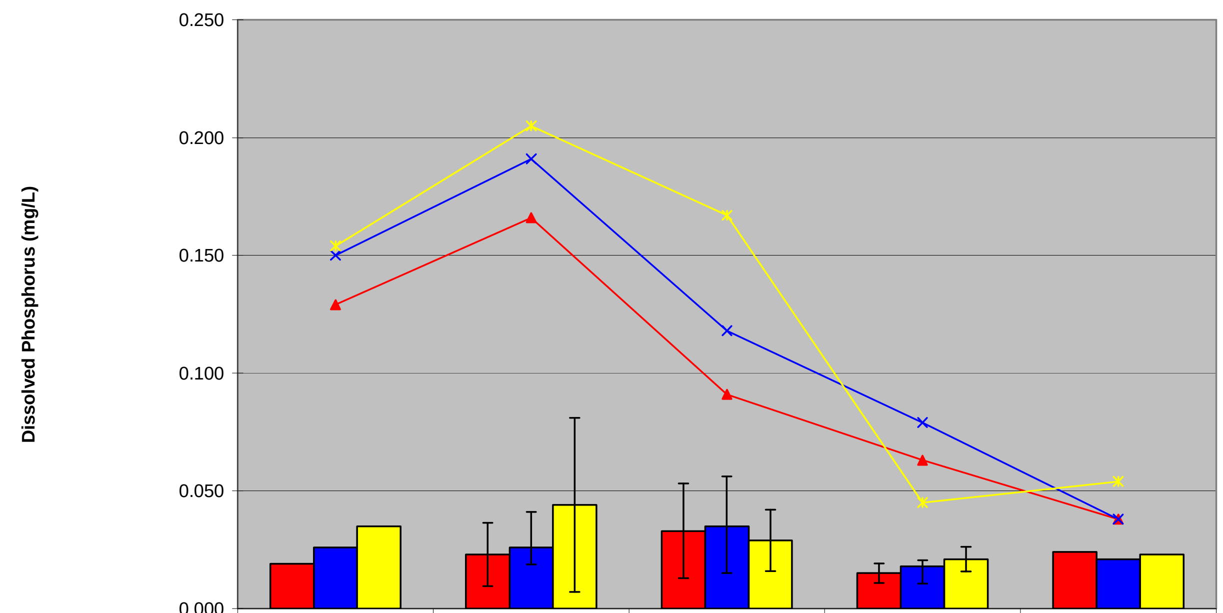


	May	Jun	Jul	Aug	Sept	Oct
Site 1 - Historical	0.035	0.073	0.082	0.083	0.122	0.075
Site 2 - Historical	0.080	0.086	0.095	0.099	0.107	0.088
Site 3 - Historical	0.092	0.131	0.108	0.109	0.104	0.095
Site-1 - Phase I	0.221	0.151	0.171	0.197	0.146	0.084
Site 2 - Phase I	0.246	0.299	0.199	0.162	0.171	0.100
Site 3 - Phase I	0.241	0.393	0.318	0.215	0.169	0.138

Note: Standard deviation is not shown for months where only one value was reported

Dissolved phosphorus is generally found in much smaller concentrations than total phosphorus and a portion of dissolved phosphorus is readily available for uptake by biota. For this reason, dissolved phosphorus concentrations are variable and difficult to use as an indicator of nutrient availability. Figure 19 displays the Phase 1 and historical data available for dissolved phosphorus in Lake Carlinville. Dissolved phosphorus concentrations during the Phase 1 period ranged from a low of 0.038 mg/L at Sites 1 and 2 to a high of 0.205 mg/L at Site 3. On average, dissolved phosphorus concentrations represented approximately 56% of the total phosphorous at each site during the Phase 1 monitoring period and approximately 32% based on the historical mean. Higher concentrations of dissolved phosphorus can be indicative of their source, which is often anaerobic degeneration of organic matter from lake bottoms (Kothandaraman and Evans, 1983). When compared to the historical mean, dissolved phosphorus concentrations the monitoring period were significantly elevated. Similaly to total phosphorus concentrations, the cause of elevated concentrations during the Phase 1 period is unknown but could be due to a change in the laboratory test method.

Figure 19. Dissolved Phosphorus Comparison



	May	Jun	Jul	Aug	Oct
Site-1 - Historical	0.019	0.023	0.033	0.015	0.024
Site 2 - Historical	0.026	0.026	0.035	0.018	0.021
Site 3 - Historical	0.035	0.044	0.029	0.021	0.023
Site-1 - Phase I	0.129	0.166	0.091	0.063	0.038
Site 2 - Phase I	0.150	0.191	0.118	0.079	0.038
Site 3 - Phase I	0.154	0.205	0.167	0.045	0.054

Note: Standard deviation is not shown for months where only one value was reported

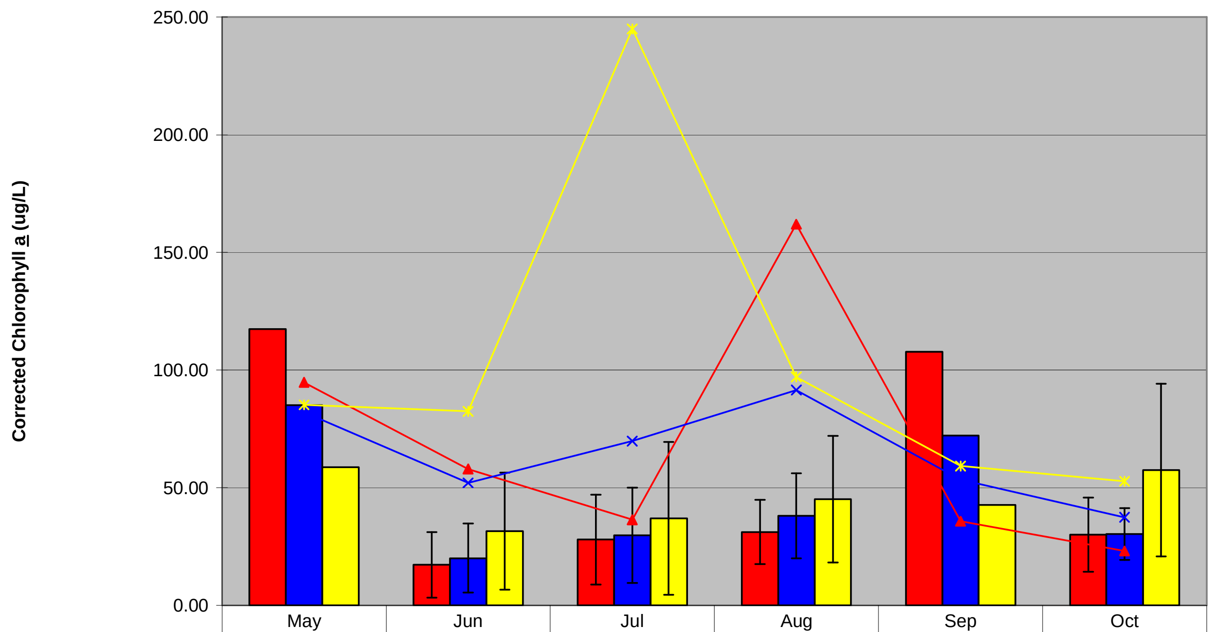
g. Chlorophyll

Chlorophyll measurements can be used to estimate the type and amount of algal productivity present in a lake. The chlorophyll a pigment is present in green algae, blue-green algae, and also in diatoms. This photosynthetic pigment is responsible for growth in the species that are typically found in Illinois. Chlorophyll a is often used to indicate the degree of eutrophication in a lake. For example, concentrations of chlorophyll a that exceed 20 µg/l indicate that a lake may be exhibiting eutrophic conditions (Illinois EPA, 1996).

In addition to the chlorophyll a concentrations, chlorophyll b, chlorophyll c, and phaeophytin can also be measured to further estimate the extent of algal diversity and productivity. Chlorophyll b is most common in the green species and serves as an auxiliary pigment for photosynthesis. Chlorophyll c is most common in diatom species and also serves as an auxiliary pigment. Algal productivity and diversity can be estimated by determining the concentrations of each pigment in the sample. For example, since green algal species contain both chlorophyll a and chlorophyll b, higher levels of both a and b may result if green algal species are dominant. Blue-green species contain only chlorophyll a pigments and lack chlorophyll b and c. High concentrations of only chlorophyll a may indicate that blue-green algal species are dominant. Diatom species contain both chlorophyll a and chlorophyll c pigments. Higher concentrations of both chlorophyll a and c may indicate that diatom species are dominant. Phaeophytin results from the breakdown of chlorophyll a, and a high concentration indicates a stressed algal population and/or recent algal die-off. Phaeophytin has an absorption peak in the same spectral region as chlorophyll a and can sometimes cause chlorophyll a values to appear higher than the actual concentration. Corrected chlorophyll a values refer to a concentration determined by a modified laboratory method, which adjusts the chlorophyll a concentration when phaeophytin concentrations become significantly high.

The chlorophyll a concentrations during the Phase 1 period ranged from 23.1 µg/l at Site 1 in October to 245.0 µg/l at Site 3 in July (Figure 20). The highest concentrations of chlorophyll a occurred in July and August, when algal productivity is high. This differs from historical chlorophyll a peaks, which occur in May and September at Lake Carlinville. The apparent peak at Site 3 in July is unexplained. Since chlorophyll a concentrations far exceeded chlorophyll b and c concentrations, it was evident that blue-green algae were the dominant algal species (Table 9).

Figure 20. Corrected Chlorophyll a Comparison



	May	Jun	Jul	Aug	Sep	Oct
Site 1- Historical	117.48	17.24	27.99	31.19	107.81	30.04
Site 2- Historical	85.05	20.09	29.82	38.04	72.25	30.28
Site 3- Historical	58.74	31.57	36.97	45.14	42.72	57.51
Site 1- Phase I	94.8	57.9	36.4	162.0	35.7	23.1
Site 2 - Phase I	82.2	52.1	69.8	91.5	53.4	37.4
Site 3 - Phase I	85.2	82.4	245.0	97.1	59.2	52.7

Note: Standard deviation is not shown for months where only one value was reported

Table 9. Mean Chlorophyll Summary

	chlorophyll a	chlorophyll b	chlorophyll c	phaeophytin
Site 1 - Phase 1	70.4	7.4	5.3	5.1
Site 2 - Phase 1	62.2	3.7	4.9	7.1
Site 3 - Phase 1	93.9	11.5	6.2	9.0
Site 1 - Historical	40.6	6.3	6.0	4.3
Site 2 - Historical	40.4	6.9	7.0	6.9
Site 3 - Historical	53.3	6.3	4.8	3.7

All results reported in µg/l (ppb).

h. Dissolved Oxygen and Temperature

According to the Illinois General Use Water Quality Standards, dissolved oxygen (DO) concentrations should not fall below 5.0 mg/L at any given time and should be at least 6.0 mg/L during 16 hours of any 24-hour period. Most aquatic organisms, including fish, require adequate concentrations of dissolved oxygen in the water column in order to survive. In temperate lakes with sufficient water depth (i.e., generally greater than 1.8 to 2.4 meters (6.0 to 8.0 ft)), there is a seasonal variation in temperature throughout the water column and thus a seasonal variation in DO concentrations.

As air temperatures rise in early spring, the upper layers become warmer and mix with the cooler water below as a result of wind and rain. Gradually, this mixing process diminishes and the lake begins to thermally stratify or separate into distinctly different layers. The upper layer of warmer water is known as the epilimnion and it is separated from the lower cooler layer, known as the hypolimnion. The thermocline is a zone of transition, which is located between the epilimnion and hypolimnion. The most important aspect of thermal stratification in relation to lake eutrophication is the summer stratification period when the hypolimnion becomes anoxic (i.e., devoid of dissolved oxygen) due to the increase in highly oxidizable material and the extended isolation from the epilimnion and atmosphere. When dissolved oxygen levels remain consistently below 5.0 mg/l and approach 0.0 mg/l, the conditions for chemical reduction become more favorable and the nutrient rich bottom sediments begin releasing nutrients such as ammonia and phosphorus, and minerals such as iron, manganese, and copper to the overlying waters.

Dissolved oxygen is an important component for respiration of aquatic life and thus is important for the overall health of the lake. Sources of oxygen can include inflow from tributaries, exchange with the atmosphere, and photosynthetic activity by aquatic plants and phytoplankton. Oxygen consumption on the other hand, can deplete valuable oxygen from the water column. Sources of oxygen consumption may include outflow, such as water discharge from the lake, respiration by fish and other oxygen consuming organisms, and biological consumption, such as the decomposition of dead plant and animal material.

DO concentrations and temperature profiles were developed for the Phase 1 sampling period at Site 1. Dissolved oxygen and temperature data for Sites 1, 2, and 3 are located in the Appendix A. Isopleth charts developed for dissolved oxygen in mg/l (ppm) and temperature (degrees Centigrade) reflect the seasonal variations for Site 1 during the 2006-07 Phase 1 monitoring period (Figures 21A and 21B).

Dissolved oxygen levels for Site 1 ranged from a high of 14.5 mg/l near the surface to a low of 0.1 mg/l near the bottom during the summer months. Areas below a depth of 3.35 m (11 ft.) exhibited anaerobic conditions (DO less than 1.0 mg/l) at various times between the months of June and September. This condition normally occurs due to a high oxygen demand as a result of decomposing material in the nutrient rich sediment. Thermal stratification at Site 1 was evident in some months but did not appear to be consistent. This suggests that Site 1 does not develop a strong thermocline. Based on the Phase 1 data, it appears as if hypolimnetic anoxia is somewhat limited; however, it is possible that anoxia has been more apparent in previous years. During 1999, anoxia was apparent at Site 1 during the months of June and July. DO profile data was not obtained for any other years. The apparent absence of a strong barrier (i.e., thermocline) allows nutrients within the lake bottom sediments to mix throughout the water column.

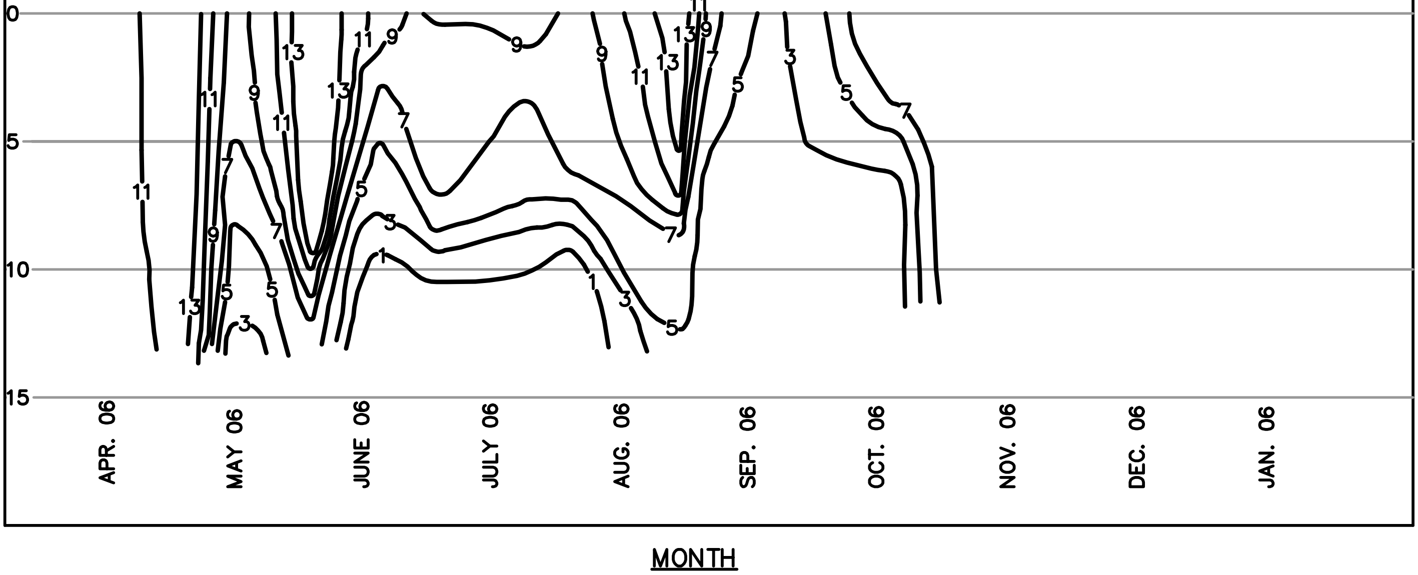


Figure 21-A – Dissolved Oxygen (mg/L) for Lake Carlinville – Site 1 (RDG-1)

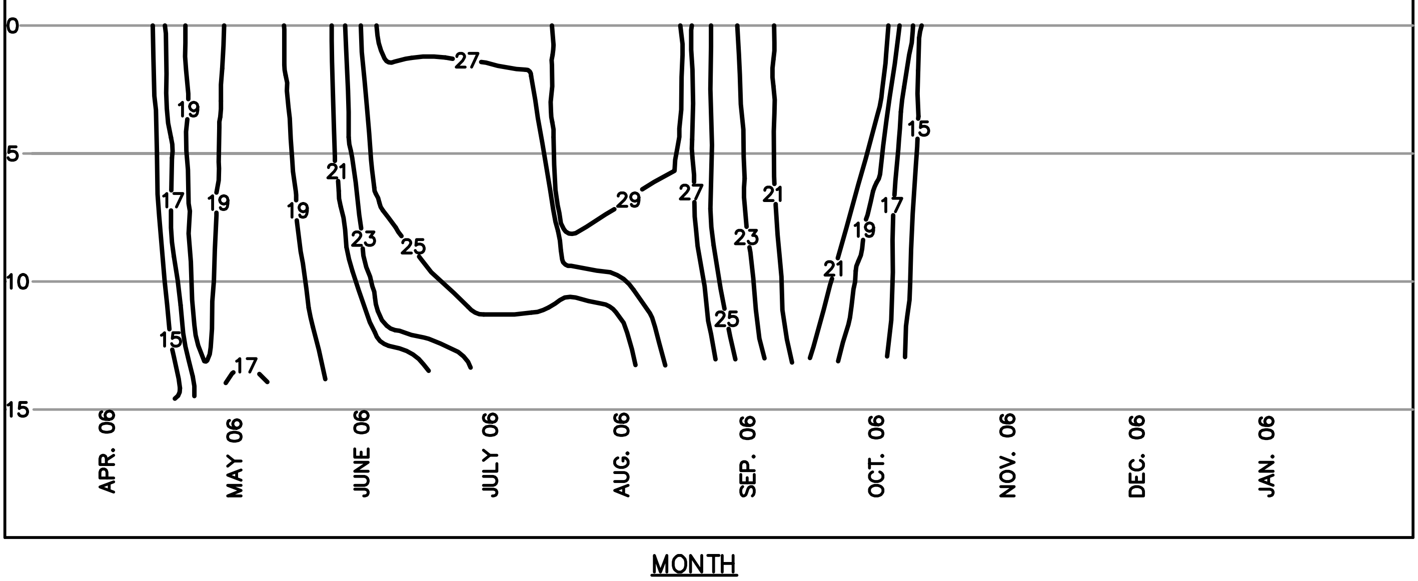


Figure 21-B – TEMP °C for Lake Carlinville – Site 1 (RDG-1)

i. Metals and Organics

Analysis of various metals and organic compounds was conducted during the 2006 IEPA monitoring year (May- October). Monthly water samples were collected mid-depth at Site 1. Results are included in Tables 10 and 11.

Table 10. Metals Concentrations

Date Sampled	Units	05/04/06	06/20/06	07/19/06	08/24/06	10/17/06
Sample ID		RDG-1I	RDG-1I	RDG-1I	RDG-1I	RDG-1I
Depth of Sample		7	7	7	7	7
Depth of Site		15	15	15	15	15
Arsenic, T	ug/l	<12	4.2	5.7	9	2
Lead, T	ug/l	<6	<5	<5	<5	<5
Selenium, T	ug/l	<10		<2	<2	
Calcium, T	mg/l	44	41	44	39	36
Magnesium, T	mg/l	18	20	20	19	15
Sodium, T	mg/l	20.0	22.0	22.0	23.0	15.0
Potassium, T	mg/l	4.7	5.1	5.2	5.6	5.4
Aluminum, T	ug/l	180	150	240	140	400
Barium, T	ug/l	64	53	55	57	69
Boron, T	ug/l	32	28	37	37	34
Beryllium, T	ug/l	<1	<1	<1	<1	<1
Cadmium, T	ug/l	<3	<3	<3	<3	<3
Chromium, T	ug/l	<5	<5	<5	<5	<5
Copper, T	ug/l	10	5	<10	<10	3.4
Cobalt, T	ug/l	<10	<10	<10	<10	<10
Iron, T	ug/l	220	170	240	290	540
Manganese, T	ug/l	140	120	140	340	150
Nickel, T	ug/l	<5	<5	<5	<5	<5
Silver, T	ug/l	<5	<5	<3	<3	<3
Strontium, T	ug/l	130	110	130	130	110
Vanadium, T	ug/l	<5	<5	<5	3	<5
Zinc, T	ug/l	3.8	6.2	9.3	4.2	8.5
Hardness Calc.	mg/l	690	180	190	180	150

Table 11. Organic Compound Concentrations

Date Sampled	Units	05/04/06	06/20/06	07/19/06	08/24/06	10/17/06
Sample ID		RDG-1I	RDG-1I	RDG-1I	RDG-1I	RDG-1I
Depth of Sample		7	7	7	7	7
Depth of Site		15	15	15	15	15
Hexachlorobenzene	ug/l	<0.01	<0.01	<0.01	0.0016	<0.01
Trifluralin	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Alpha-BHC	ug/l	<0.01	<0.01	<0.01	<0.01	0.0013
Gamma-BHC (Lindane)	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Atrazine	ug/l	0.75	1.9	1.8	1.1	0.43
Heptachlor	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Aldrin	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Acetochlor	ug/l	0.029	0.35	0.11	0.024	<0.1
Alachlor	ug/l	<0.02	<0.02	<0.02	<0.02	<0.02
Metribuzin	ug/l	<0.05	0.01	0.026	0.044	<0.05
Metalochlor	ug/l	<0.1	0.56	0.42	0.12	0.087
Heptachlor Epoxide	ug/l	<0.01	<0.01	<0.01	<0.01	0.00097
Pendimethalin	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05
Gamma-Chlordane	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Alpha-Chlordane	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Tot. Alpha and Gamma Chlordane	ug/l	<0.1	<0.1	<0.1	<0.1	<0.01
Dieldrin	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Captan	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05
Cyanazine	ug/l	<0.1	<0.1	<0.1	<0.1	0.16
Endrin	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
P,P'-DDE	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
P,P'-DDD	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
P,P'-DDT	ug/l	<0.01	<0.01	<0.01	<0.01	<0.01
Total DDT	ug/l	<0.1	<0.1	<0.1	<0.1	<0.01
Methoxychlor	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05
Total PCBs	ug/l	<0.1	<0.1	<0.1	<0.1	<0.1
2,4-D	ug/l	<1	0.33	<1	0.31	0.2
Pentchlorophenol (PCP)	ug/l	<0.1	<0.2	<0.1	<0.1	<0.1
2,4,5,TP (Silvex)	ug/l	<5	<5	<5	<5	<1.0
Dalapon	ug/l	<20	<20	<20	<20	<5
Dicamba	ug/l	<0.25	<0.25	<0.25	<0.25	<0.25
Dinoseb	ug/l	<0.7	<0.7	<0.7	<0.7	<0.7
Picloram	ug/l	<50	<50	<50	<50	<1
Acifluorfen	ug/l	<0.5	<0.5	<0.5	<0.5	<0.5
Toxaphene	ug/l	<1	<1	<1	<1	<1.0
EPTC	ug/l	<0.5	<0.5	<0.5	<0.5	<0.5
Butylate	ug/l	<0.2	<0.2	<0.2	<0.2	<0.2
Phorate	ug/l	<0.25	<0.25	<0.25	<0.25	<0.25
Terbufos	ug/l	<0.1	<0.1	<0.1	<0.1	<0.1
Fonofos	ug/l	<0.1	<0.1	<0.1	<0.1	<0.1
Diazinon	ug/l	<0.05	<0.05	<0.05	<0.05	<0.05
Methyl Parathion	ug/l	<0.1	<0.1	<0.1	<0.1	<0.1
Malathion	ug/l	<0.15	<0.15	<0.15	<0.15	<0.15
Chlorpyrifos	ug/l	<0.1	<0.1	<0.1	<0.1	<0.1
Atrazine	ug/l	0.48	1.5	1.7	1.4	0.68
Ethyl parathion	ug/l	<0.15	<0.15	<0.15	<0.15	<0.10
Simazine	ug/l	0.36	0.33	0.33	0.27	0.11

2. Trophic Condition

The physical, chemical, and biological data obtained from baseline sampling are used to quantitatively describe the degree of eutrophication, or the trophic state, through the calculation of an index number. The trophic state index (TSI) number is of great value to the lake manager (or consultant) and the user population. The TSI number, when properly interpreted, allows for comparison of previous and existing lake conditions. Carlson (1977) has developed a useful TSI for lakes with algal turbidity and minimal aquatic vegetation (Table 12).

This index was based on the amount of algal biomass in surface water, using a scale of 0 to 100. The scale uses a log transformation of Secchi disk transparency values as a measure of algal biomass. However, the accuracy of Carlson's index may vary as a result of water coloration or suspended materials other than algae. For example, Lake Carlinville is heavily impacted by sediment, which could elevate the Secchi TSI values. Since chlorophyll a and total phosphorus concentrations are often correlated with transparency, an index number can also be calculated from these parameters. The following table correlates TSI numbers with the associated Secchi transparency depths, surface phosphorus and chlorophyll a concentrations.

Table 12. Carlson's Completed Trophic State Index

TSI	Secchi Depth (m)	Secchi Depth (ft)	Surface Phos. (mg/m3)	Surface Chloro. (mg/m3)
0	64	220	0.75	0.04
10	32	106	1.5	0.12
20	16	52.5	3	0.34
30	8	26	6	0.94
40	4	13	12	2.6
50	2	6.6	24	6.4
60	1	3.3 (39")	48	20
70	0.5	1.6 (20")	96	56
80	0.25	0.8 (10")	192	154
90	0.13	0.4 (5")	384	427
100	0.06	0.2 (2.5")	768	1,183

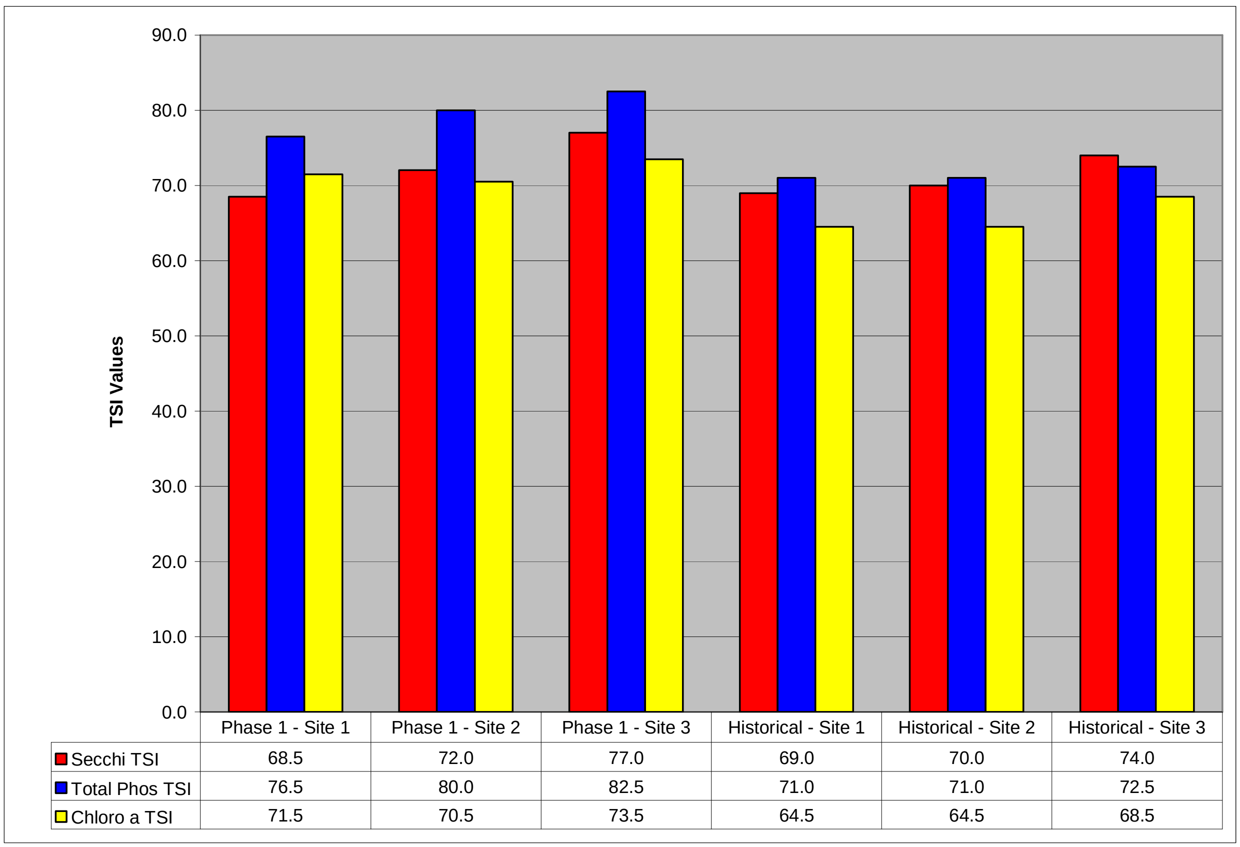
Source: Carlson, 1977

The trophic condition for each sampling site at Lake Carlinville has been calculated according to the Trophic State Index as shown above. The calculated TSI values for Sites 1 through 3 are shown in Table 13 and graphically represented in Figure 22.

Table 13. TSI Values

		Secchi TSI	Total Phos TSI	Chloro a TSI
Phase 1	Site 1	68.5	76.5	71.5
	Site 2	72.0	80.0	70.5
	Site 3	77.0	82.5	73.5
Historical	Site 1	69.0	71.0	64.5
	Site 2	70.0	71.0	64.5
	Site 3	74.0	72.5	68.5

Figure 22. Calculated TSI Comparison



According to the Lake Assessment Criteria as listed in the 1994-95 Illinois Water Quality Report (Carlson, 1977), lakes having a TSI greater than 50.0 and less than 70.0 are characterized as being eutrophic. Since the TSI values for each parameter during the Phase 1 sampling period for Sites 1, 2, and 3 were generally above 60 and below

80, Lake Carlinville can be characterized as being eutrophic to slightly hyper-eutrophic. Generally, the Phase 1 TSI values have increased compared to the historical TSI values (Table 13), which may indicate increased total phosphorus and chlorophyll a concentrations. These changes have likely led to increases in lake algal productivity.

3. Limiting Algal Nutrient

The weight to volume ratio of total nitrogen (mg/l) to total phosphorus (mg/l) is often used to determine which nutrient is limiting algal growth in a lake or reservoir. Since the nitrogen to phosphorus ratio (by weight in mg/l) in algal cell tissue is typically 7 to 1, it is assumed that when the ratio of total nitrogen (mg/l) to total phosphorus (mg/l) is greater than 10 to 1, phosphorus is generally the limiting nutrient (Horne, 1994). When ratios are less than 10 to 1, nitrogen is generally the limiting nutrient.

The total nitrogen to total phosphorus (TN:TP) ratios for Lake Carlinville during the Phase 1 monitoring year are listed in Table 14. The TN to TP ratios for Sites 1, 2, and 3 during the Phase 1 monitoring year range from a mean value of 5 at Site 3, to a mean value of 7 at Sites 1 and 2. This data indicates that Lake Carlinville is a nitrogen-limited lake; however, this is unusual due to the agricultural land use throughout the majority of the watershed. It is possible that this relationship is skewed by the elevated phosphorus concentrations during the Phase 1 monitoring period. The raw data indicates that nitrogen concentrations are sometimes low and phosphorus concentrations are always very high. When nitrogen concentrations are slightly lower, the TN:TP ratio is shifted enough to indicate that a nitrogen-limited environment is present in Lake Carlinville. Historically, nitrogen values were similar or higher when compared to Phase 1 data but historical phosphorus values were lower when compared with Phase 1 data. Thus, Lake Carlinville has historically been a phosphorus-limited lake. The mean calculated values for historical TN:TP ratios range from 13 to 22.

Table 14. Nitrogen to Phosphorus Ratios

Monitoring Site	Sample Date	TKN mg/l	NO_2-NO_3 mg/l	Tot Nitrogen mg/l	Tot Phos mg/l	TN : TP Ratio
Site 1	04/10/06	0.270	2.100	2.37	0.200	12
	04/24/06	1.060	1.290	2.35	0.096	24
	05/04/06	0.896	0.853	1.75	0.216	8
	05/23/06	0.797	0.060	0.86	0.225	4
	06/07/06	0.213	0.121	0.33	0.109	3
	06/20/06	0.260	0.040	0.30	0.193	2
	07/12/06	0.785	0.003	0.79	0.184	4
	07/19/06	1.560	0.010	1.57	0.157	10
	08/16/06	1.220	0.003	1.22	0.202	6
	08/24/06	0.512	0.122	0.63	0.191	3
	09/19/06	0.230	0.028	0.26	0.146	2
	10/04/06	0.213	0.199	0.41	0.068	6
	10/17/06	0.213	0.115	0.33	0.100	3
	11/21/06	0.213	0.320	0.53	0.113	5
	12/13/06	1.030	2.490	3.52	0.341	10
Site 2	04/10/06	1.770	2.910	4.68	0.220	21
	04/24/06	0.559	1.120	1.68	0.126	13
	05/04/06	1.110	0.744	1.85	0.250	7
	05/23/06	0.480	0.772	1.25	0.242	5
	06/07/06	0.750	0.003	0.75	0.108	7
	06/20/06	0.213	0.064	0.28	0.490	1
	07/12/06	2.550	0.043	2.59	0.214	12
	07/19/06	0.666	0.003	0.67	0.184	4
	08/16/06	0.490	0.003	0.49	0.173	3
	08/24/06	0.460	0.117	0.58	0.150	4
	09/19/06	0.213	0.003	0.22	0.171	1
	10/04/06	0.310	0.106	0.42	0.072	6
	10/17/06	0.213	0.080	0.29	0.127	2
	11/21/06	0.501	0.344	0.85	0.134	6
	12/13/06	0.923	2.890	3.81	0.505	8
Site 3	04/10/06	0.878	2.950	3.83	0.207	18
	04/24/06	0.500	0.731	1.23	0.191	6
	05/04/06	0.711	0.681	1.39	0.259	5
	05/23/06	0.970	0.063	1.03	0.223	5
	06/07/06	0.310	0.003	0.31	0.134	2
	06/20/06	0.213	0.070	0.28	0.652	0
	07/12/06	2.290	0.017	2.31	0.345	7
	07/19/06	1.260	0.003	1.26	0.291	4
	08/16/06	0.562	1.000	1.56	0.248	6
	08/24/06	1.190	0.116	1.31	0.182	7
	09/19/06	0.320	0.003	0.32	0.169	2
	10/04/06		0.037	0.04	0.131	0
	10/17/06	0.480	0.077	0.56	0.145	4
	11/21/06	0.490	0.662	1.15	0.243	5
	12/13/06	0.770	2.170	2.94	0.687	4

4. Sediment Quality and Sedimentation

a. Chemical Characteristics

As previously mentioned, lake sediment grab samples were collected at Sites 1, 2, and 3 during the Phase 1 monitoring period. Samples were analyzed for metals and organics in the sediment. The Phase 1 sampling period results for metals and organics for Sites 1, 2, and 3 are listed in Tables 15 and 16. Most of the parameters at Sites 1, 2, and 3 were found to be within the normal range for Illinois lake sediment (Table 17). All metal concentrations were within the normal range, although Kjeldahl-N, copper, and manganese were approaching an elevated concentration. Laboratory analyses of the lake sediment grab samples indicate that the lake sediment would not likely require disposal in a special hazardous facility, if any sediment were to be removed.

Table 15. Sediment Core Analysis for Metals

Date Sampled	Units	07/19/06	07/19/06	07/19/06
Time		9:23	10:03	10:17
Sample ID		RDG-1	RDG-2	RDG-3
Collector		PBL	PBL	PBL
Depth of Sample		13	10	3
Sample Matrix		Soil	Soil	Soil
Date Received		07/21/06	07/21/06	07/21/06
Phosphorus-P	mg/kg	559	531	276
TOC	%	9,088.00	11,102.00	8,123.00
Kjeldahl-N	mg/kg	5,620	4,000	3,490
% Solids	%	20.3	35.7	20.3
Soilds, Vol	%	8.0	9.3	5.8
Mercury	mg/kg	0.030	0.029	0.032
Potassium	mg/kg	1,400	1,600	860
Barium	mg/kg	160	190	88
Cadmium	mg/kg	0.17	0.11	<0.3
Chromium	mg/kg	18	21	12
Copper	mg/kg	94	66	33
Iron	mg/kg	25,000	25,000	13,000
Lead	mg/kg	18	20	12
Manganese	mg/kg	1,100	960	530
Nickel	mg/kg	25	21	12
Silver	mg/kg	<0.5	<0.5	<0.5
Zinc	mg/kg	75	80	47
Arsenic	mg/kg	9	8	4

Table 16. Sediment Core Analysis for Organics

	Units	RDG-1	RDG-2	RDG-3
Total PCBs	µg/kg	<10	<10	<10
Hexachlorobenzene	µg/kg	3.3	<1	3.3
Trifluralin	µg/kg	>10	>10	>10
Alpha-BHC	µg/kg	<0.2	<0.2	<0.2
Gamma-BHC (Lindane)	µg/kg	<1	<1	<1
Atrazine	µg/kg	<50	<50	<50
Heptachlor	µg/kg	<1	<1	<1
Aldrin	µg/kg	<1	<1	<1
Alachlor	µg/kg	<10	1.8	<10
Metribuzin	µg/kg	<10	<10	<10
Metolachlor	µg/kg	<25	<25	<25
Heptachlor Epoxide	µg/kg	<1	<1	<1
Pendimethalin	µg/kg	<10	<10	<10
Gamma-Chlordane	µg/kg	0.27	<2	<2
Alpha-Chlordane	µg/kg	0.82	0.82	0.82
Total Alpha and Gamma Chlordane	µg/kg	<2	<2	<2
Dieldrin	µg/kg	0.3	0.32	<1
Captan	µg/kg	<10	<10	<10
Cyanazine	µg/kg	9.9	11	11
Endrin	µg/kg	<1	<1	<1
P,P'-DDE	µg/kg	<1	<1	<1
P,P'-DDD	µg/kg	<1	<1	<1
P,P'-DDT	µg/kg	<1	<1	<1
Total DDT	µg/kg	<5	<5	<5
Methoxychlor	µg/kg	<5	<5	<5
Acetochlor	µg/kg	<25	<25	<25

Table 17. Classification of Illinois Lake Sediment

Parameter	Unit	Low	Normal	Elevated	Highly Elevated
PCB's	µg/kg	n/a	less than 10	10 to <89	89 or greater
Aldrin	µg/kg	n/a	less than 10	1 to <1.2	1.2 or greater
Diedrin	µg/kg	n/a	less than 3.4	3.4 to <15	15 or greater
DDT	µg/kg	n/a	less than 10	10 to 180	180 or greater
Chlordane	µg/kg	n/a	less than 5	5 to 12	12 or greater
Endrin	µg/kg	n/a	less than 1	n/a	1 or greater
Methoxychlor	µg/kg	n/a	less than 5	n/a	5 or greater
alpha-BHC	µg/kg	n/a	less than 1	n/a	1 or greater
gamma-BHC	µg/kg	n/a	less than 2	n/a	1 or greater
HCB	µg/kg	n/a	less than 3	n/a	1 or greater
Heptachlor Epoxide	µg/kg	n/a	less than 4	1 to <1.6	1.6 or greater
Phosphorus	mg/kg	less than 394	394 to <1115	1115 to <2179	2179 or greater
Total Kjeldahl Nit.	mg/kg	less than 1300	1300 to <5357	5357 to <11700	11700 or greater
Cadmium	mg/kg	n/a	less than 5	5 to <14	14 or greater
Copper	mg/kg	less than 16.7	16.7 to <100	100 to <590	590 or greater
Lead	mg/kg	less than 14	14 to <59	59 to <339	339 or greater
Mercury	mg/kg	n/a	less than 0.15	0.15 to <0.701	0.701 or greater
Cyanide	mg/kg	n/a	n/a	n/a	n/a
Arsenic	mg/kg	less than 4.1	4.1 to <14	14 to <95.5	95.5 or greater
Chromium	mg/kg	less than 13	13 to <27	27 to <49	49 or greater
Iron	mg/kg	less than 16000	16000 to <37000	37000 to <56000	56000 or greater
Manganese	mg/kg	less than 500	500 to <1700	1700 to <5500	5500 or greater
Zinc	mg/kg	less than 59	59 to <145	145 to <1100	1100 or greater
Nickel	mg/kg	less than 14.3	14.3 to <31	31 to 43	43 or greater
Silver	mg/kg	n/a	less than 0.1	0.1 to <1	1 or greater
Potassium	mg/kg	less than 410	410 to <2100	2100 to <2797	2797 or greater
Barium	mg/kg	less than 94	94 to <271	271 to <397	397 or greater

Source: Illinois EPA, Mitzelfelt, 1996

b. Sedimentation

Erosion and sedimentation are natural geophysical processes that allow fine-grained silts, clays, and detritus to be delivered to lakes and reservoirs. Sedimentation can lead to a significant loss of original water depth and may be considered detrimental if allowed to progress. The average rate of reservoir capacity loss in Illinois has been reported to be approximately 0.6 percent per year (Roseboom et al., 1979). Lakes and reservoirs often act as sediment traps and are capable of trapping as much as 90 percent of the sediments that are carried from agricultural fields and unprotected constructions sites. In addition to causing a loss in water depth and storage capacity, accumulated sediments can contribute to internal nutrient recycling from resuspension and/or anaerobic decomposition.

In order to determine the storage and sedimentation conditions of the lake, the Illinois State Water Survey (ISWS) completed sedimentation surveys of Lake Carlinville in 1949, 1954, 1959, and 1986. The ISWS-sedimentation surveys divided the lake into segments and cross-section transects mark the boundaries of each segment. In 1986, the Lake Carlinville basin capacity was shown to have been reduced from its original lake capacity of 2,350 acre-feet to 1,650 acre-feet. The 700 acre-feet (1,129,331 cubic yard) loss equated to an approximate 30 percent loss in total lake volume from 1939 to 1986. These figures include the additional capacity reclaimed through dredging (1968-71) and the raising of the spillway (1982).

In the fall of 2006, HDR | CWI completed a sedimentation survey using the same lake segments and transect locations as the previous ISWS surveys. A copy of the 2006 sedimentation survey and a bathymetric map of Lake Carlinville are shown in Figures 23 and 24. Water depth measurements were located horizontally in terms of X-Y coordinates using a global position system (GPS) unit. Actual water depths (Z-coordinates) were determined using a flat steel disk (eight-inches in diameter), attached to a graduated rod, where depth-to-sediment measurements were determined. This method allowed accurate water depth determination over soft bottom materials, as the flat disk rests on the sediment surface, rather that penetrating the material. After the water depths were determined at each point, the sediment depths were also measured and recorded. Sediment depths were determined using a one-inch diameter aluminum range pole. The range pole was pushed through the soft sediment until the hard, original lake bottom was reached. The total length of pole at the water surface was then determined, and this length, less the water depth, yielded the actual sediment depth at each of the respective points.

The data were plotted as cross-sections so that a profile of the existing sediment and the original lake bottom could be developed (Appendix C). The average end-area-method was applied to each of the cross sections to calculate the quantity of accumulated sediment and remaining water volume. The results of the 2006 sedimentation survey for Lake Carlinville are presented in Table 18. The results suggested that approximately 1,425,009 cubic yards of sediment have been deposited across the fifteen segments of Lake Carlinville. This volume represents approximately a 37.6 percent water storage capacity loss over the lake's 67-year history. This suggests that the current mean rate of sediment deposition is approximately 21,269 cubic yards per year, which is consistent with Roseboom's suggested capacity loss in Illinois reservoirs of 0.6 percent per year.

Table 18. Lake Sedimentation Survey Results

Lake Segments	Original Capacity (cubic yards)	Existing Capacity (cubic yards)	Amount of Sediment (cubic yards)	Percent of Capacity Loss
1	29,362	19,646	9,716	33.1%
2	607,147	398,173	208,974	34.4%
3	486,887	315,251	171,636	35.3%
4	731,687	482,677	249,010	34.0%
5	327,354	218,875	108,479	33.1%
6	547,369	355,605	191,764	35.0%
7	430,762	257,513	173,249	40.2%
8	221,566	126,392	95,174	43.0%
9	177,961	90,603	87,358	49.1%
10	41,494	17,656	23,838	57.4%
11	60,184	29,847	30,337	50.4%
12	77,182	26,612	50,570	65.5%
13	16,945	5,139	11,806	69.7%
14	50,171	35,153	15,018	29.9%
15	15,740	7,943	7,797	49.5%
Total	3,792,448	2,367,439	1,425,009	37.6%

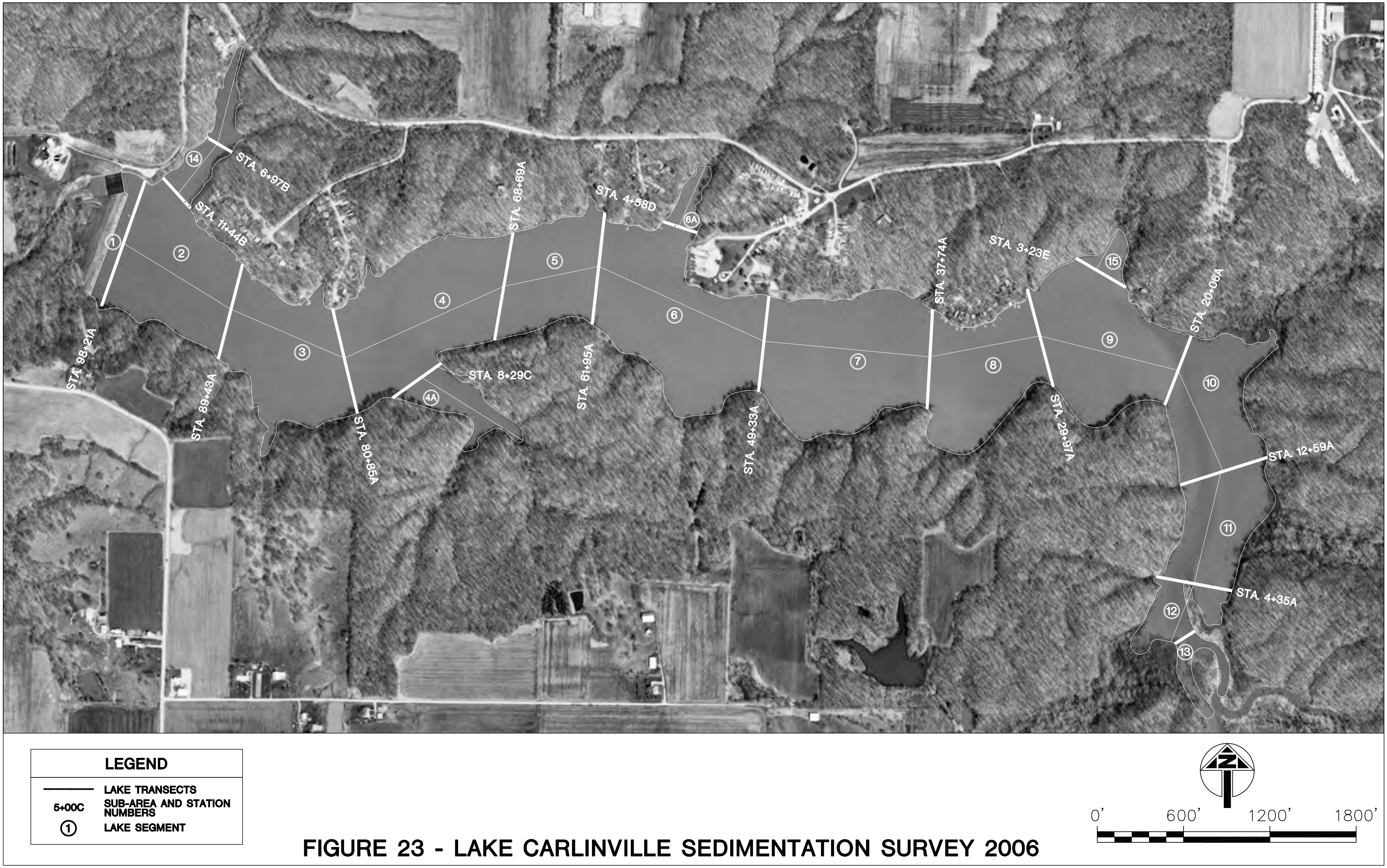


FIGURE 23 - LAKE CARLINVILLE SEDIMENTATION SURVEY 2006

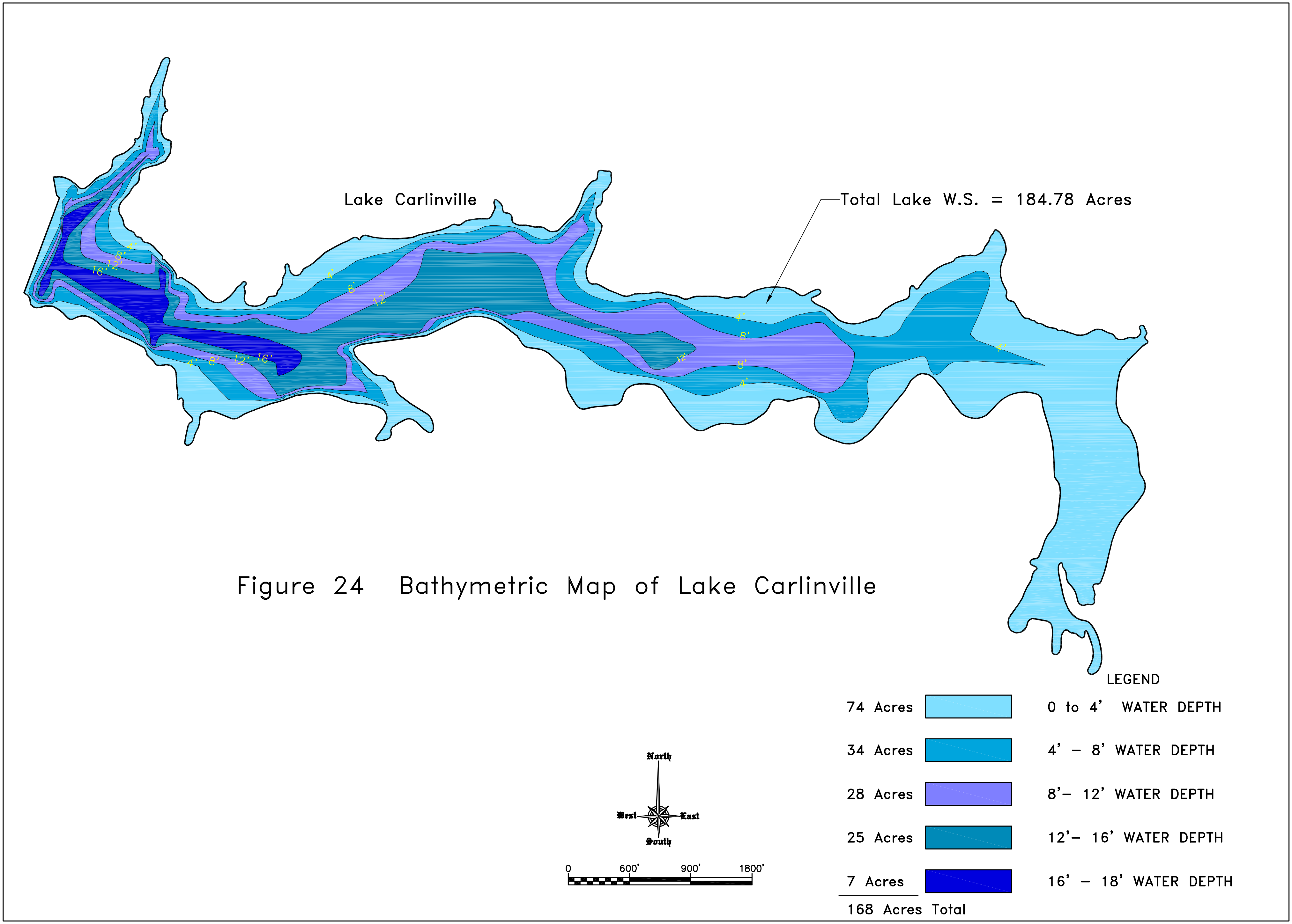


Figure 24 Bathymetric Map of Lake Carlinville

c. Shoreline Erosion

In the summer of 2006, HDR│CWI personnel completed a shoreline erosion survey of Lake Carlinville in order to determine the extent of shoreline erosion's contribution to lake water degradation. Eroded shoreline impairs lake usage and access by adding turbidity and decreasing storage capacity due to accumulating sediment. Shoreline erosion is most commonly attributed to wave action from strong winds and boats and fluctuating water levels. The loss of shoreline soils in severe cases may also jeopardize the stability of infrastructure including bridges, roads, and docks. In addition, shoreline loss reduces the overall aesthetic appeal of the lake. As previously mentioned, the spillway elevation was raised in 1983 by three feet. This increase in normal lake pool elevation, over the last two decades, has accelerated shoreline erosion at Lake Carlinville.

The methodologies used during the survey rated erosion severity by vertical measurements of the eroded zones. An estimate was made to determine the horizontal length of each eroded zone and a vertical measurement was recorded and applied to the following criteria: bank heights of less than 1 foot were classified as having no erosion; bank heights of 1 to 3 feet were classified as having slight erosion; bank heights greater than 3 feet and less than 8 feet were classified as having moderate erosion; and bank heights greater than 8 feet were classified as having severe erosion. An estimated 54.4% or 5,703 meters (18,709 feet) of the 10,490 meters (34,417 feet) of shoreline were classified as eroded during the 2006 survey. The largest classification of eroded shoreline was 4,068 meters (13,348 feet) of slight shoreline erosion, which represented 71.3% of the total eroded shoreline length. Moderate shoreline erosion accounted for 1,293 meters (4,243 feet) or 12.3% of the total eroded shoreline and severe erosion made up 6.0% of the total eroded shoreline with 341 meters (1,118 feet). There was an area at the upper end of the lake that was not surveyed because the lake was too shallow for a boat to navigate. It is probable that this area is characterized by low bank heights due to minimal wind and wave action in this area. Figure 25 illustrates the results of the 2006 shoreline erosion survey.

From the spillway elevation in 1983 through 2006, an estimated 23,073 cubic yards of soil has eroded from the shoreline of Lake Carlinville. The eroded shoreline length contributed approximately 31,149 tons (28,257,906 kg) of delivered soil to Lake Carlinville. The total tons of delivered soil were calculated using a dry unit weight of 100 pounds per cubic-ft. This estimated loading was calculated by extending the eroded bank into the lake at a projected slope of 3:1 (3 foot horizontal to 1 foot vertical) to form a typical triangular end area. Then, the length of the eroded shoreline in linear feet was multiplied by the projected end area for each degree of classification of erosion.

Approximately 3,238 linear feet of riprap has been placed along the shoreline in several locations in an attempt to stabilize the shoreline and reduce erosion (Figure 25). Most of the existing riprap was installed along the dam, boat launch area, and at several private cabins and leased lots throughout the lake. Most of these locations were considered to be reasonably successful stabilization measures. In addition to the general observations and measurements, areas in greatest need of remediation were documented (Appendix D).

Figure 25. Shoreline Erosion Survey

This page intentionally left blank

5. Hydrologic Budget

A hydrologic budget was developed in order to account for the total inflow and outflow of water for the Lake Carlinville system during the Phase 1 (2006-07) monitoring period. The budget accounts for the inflows from the tributaries entering the lake, total precipitation to the watershed, direct precipitation to the lake, as well as outflows consisting of evaporation, water withdrawals for the public water supply, and flow over the spillway. The hydrologic budget is a critical component and the basis for developing subsequent nutrient and sediment budgets. In general, the lake hydrologic budget for the Lake Carlinville system was calculated based on the following formula:

Change in Storage Capacity = Inflows – Outflows *

* Unaccounted flows are assumed to be caused from fluctuations in the groundwater inflows and outflows.

The hydrologic budget was developed by using rainfall and runoff from daily precipitation readings collected from an Illinois State Water Survey (ISWS) weather station located in Carlinville and average annual runoff (inches) throughout the watershed. In addition, water level readings were also taken at the spillway. The spillway outfall readings were used with the dam's spillway-rating curve to develop lake discharges. The daily precipitation and spillway discharge readings were found to occur at more regular intervals and to be more reliable and accurate in developing the hydrologic budget than the dozen or less flow measurements collected from the tributary sampling sites during the Phase 1 (2006-07) monitoring period.

Daily and monthly precipitation (rainfall) readings were applied to the lake and the watershed. Runoff coefficients were used to model and predict the potential watershed inflows to the lake. Monthly evaporation rates and average monthly pumping rates at the Carlinville water plant were also used to calculate outflows from the lake. Evaporation was determined using the methods described in "Lake Evaporation in Illinois" (Roberts and Stall, 1967). During the Phase 1 period, the ISWS weather station collected 34.66 inches of precipitation, which is low compared to the annual mean of

38.59 inches. The watershed experienced 10.2 percent less rain compared to the annual average rainfall.

The total calculated inputs for the Phase 1 monitoring year were 17,469,934 cubic-meters (14,168.6 acre-ft). Approximately 16,006,025 cubic-meters (12,981.4 acre-ft) of water left the lake and were delivered as outputs. An average outflow of 8.38% of the total hydrologic budget was unaccounted for and could be potentially attributed to groundwater outflows. The volume of water estimated to either enter or exit the Lake Carlinville as a result of each of the above components was compiled monthly during the monitoring year that occurred from April 2006 to March 2007 (see Table 19).

Table 19. Hydrologic Budget Summary

		Inputs			Outputs				
Month	Avg. Pool Level	Precip. from Watershed	Direct Lake Precip.	Net Inputs	Lake Evapor.	Public Water Supply	Spillway Outflow	Net Outputs	Unaccounted Outflow
	Ft-ASL	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft	Ac-Ft
Apr-06	572.3	890.8	33.0	923.9	35.9	78.9	0.0	114.8	809.1
May-06	573.2	1,566.5	58.1	1,624.6	61.2	81.5	1,154.4	1,297.2	327.5
Jun-06	572.8	430.3	16.0	446.3	70.1	86.8	0.0	156.8	289.5
Jul-06	572.6	755.0	28.0	783.0	72.9	97.8	0.0	170.7	612.2
Aug-06	572.4	1,623.3	75.0	1,698.3	62.5	97.8	0.0	160.3	1,538.1
Sep-06	573.2	1,542.0	60.9	1,602.9	48.9	86.8	1,635.9	1,771.6	-168.6
Oct-06	573.1	1,532.6	56.8	1,589.4	23.0	81.5	877.2	981.7	607.7
Nov-06	573.2	1,092.8	36.8	1,129.6	18.2	78.9	1,535.9	1,633.0	-503.4
Dec-06	573.1	739.9	27.4	767.3	17.0	81.5	777.2	875.7	-108.4
Jan-07	573.2	1,234.4	45.8	1,280.1	16.4	81.5	1,484.3	1,582.1	-302.0
Feb-07	573.3	1,087.0	25.5	1,112.5	27.6	73.6	1,947.2	2,048.5	-936.0
Mar-07	573.3	1,188.9	21.8	1,210.7	33.8	81.5	2,073.8	2,189.0	-978.3
Sum	**acre-feet**	**13,683.4**	**485.2**	**14,168.6**	**487.4**	**1,008.0**	**11,486.0**	**12,981.4**	**1,187.3**
	cubic meters	16,871,633	598,301	17,469,934	601,023	1,242,813	14,162,189	16,006,025	1,463,909
Avg.	**acre-feet**	**1,140.3**	**40.4**	**1,180.7**	**40.6**	**84.0**	**957.2**	**1,081.8**	**98.9**
	cubic meters	1,405,969	49,858	1,455,828	50,085	103,568	1,180,182	1,333,835	121,992
Percent		**96.58%**	**3.42%**	**100.00%**	**3.75%**	**7.76%**	**88.48%**	**100.00%**	**8.38%**

6. Phosphorus and Nitrogen Budgets

Nitrogen and phosphorus are generally considered to be the two main nutrients involved in algal growth and the lake eutrophication process. The inputs of phosphorus and nitrogen were calculated on a monthly basis for the Phase 1 monitoring period using tributary samples collected during April 2006 through March 2007 (see Appendix A). The methodologies for the collection and calculation of nutrient inputs and outputs were similar to those used in the hydraulic budget with the exception of internal regeneration calculation, which was calculated as an additional input.

Data was collected during the monitoring year and then concentrations were estimated using a flow weighted average method. The total amount of a specific nutrient transported over a given period of time was calculated using the following equation (along with conversion factors):

$$T_i = (Q_i \times C_i)$$

where:

T_i = Total amount of nutrient transported during a particular period

Q_i = Total flow of water entering or leaving the lake during a period

C_i = Concentration of nutrients for the period being calculated

The calculated numbers were correlated with the hydrologic budget estimates for water movement and then converted to kilograms and tons in order to estimate the total amount of nutrients flowing into and out of the lake during the monitoring period. The estimated releases of ammonia-nitrogen and phosphorus from sediment were based on rates determined by Keeney (1973) and Nurnberg (1984), respectively. A rate of 120.0 $mg/m^2/day$ (1.07 lbs/acre/day) for ammonia-nitrogen and 12.0 $mg/m^2/day$ (0.107 lbs/acre/day) for phosphorus was used to calculate an approximate internal nutrient load for the period of time that dissolved oxygen levels were less than 1.0 mg/l. The regeneration values for anaerobic conditions were multiplied by the approximate area of the lake bottom that had summertime dissolved oxygen levels below 1.0 mg/l in order to arrive at a daily loading rate. This rate was used to determine nutrient loadings during the time the lake was anoxic. Atmospheric inputs were derived from regional concentrations obtained through the National Atmospheric Deposition Program (NADP) and applied to precipitation totals.

Tables 20 and 21 display monthly estimates for the phosphorus and nitrogen budgets, respectively. The total gross loading to the lake from all sources was estimated to be 4,850 kg (5.3 tons) of phosphorus and 47,847 kg (52.7 tons) of nitrogen. Internal regeneration accounted for approximately 6.9 percent of the total phosphorus load and 7.0 percent of the total nitrogen load. A net load of 2,380 kg (2.62

tons) of phosphorus and 29,507 kg (32.5 tons) of nitrogen was retained within Lake Carlinville during the Phase 1 sampling period. As is typical for Midwestern lakes, the net nitrogen load was much greater than the phosphorus load on a monthly basis. This loading estimate indicates that phosphorus is the limiting nutrient, although both nutrients are in abundant concentrations. Although water quality data previously indicated a nitrogen-limited lake, it is more likely that the lake is phosphorus-limited.

Table 20. Phosphorus Budget Summary

Month	Atmospheric Inflow		Watershed & Tributary Site 2 Inflows		Internal Regeneration		Watershed & Tributary Site 1 Outflows		Net Phosphorus Load	
	kg	tons	kg	tons	kg	tons	kg	tons	kg	tons
Apr-06	0.3	0.000	148.1	0.163	0.0	0.000	31.3	0.034	117.2	0.129
May-06	1.1	0.001	599.2	0.660	0.0	0.000	340.8	0.376	259.5	0.286
Jun-06	0.1	0.000	115.6	0.127	80.4	0.089	0.0	0.000	196.1	0.216
Jul-06	0.3	0.000	195.6	0.216	87.8	0.097	0.0	0.000	283.6	0.313
Aug-06	1.8	0.002	471.3	0.520	87.8	0.097	45.3	0.050	515.7	0.568
Sep-06	1.2	0.001	662.4	0.730	80.4	0.089	566.0	0.624	178.0	0.196
Oct-06	1.0	0.001	421.5	0.465	0.0	0.000	350.0	0.386	72.6	0.080
Nov-06	0.4	0.000	429.1	0.473	0.0	0.000	205.8	0.227	223.8	0.247
Dec-06	0.2	0.000	276.4	0.305	0.0	0.000	230.1	0.254	46.5	0.051
Jan-07	0.7	0.001	452.0	0.498	0.0	0.000	206.9	0.228	245.8	0.271
Feb-07	0.2	0.000	379.1	0.418	0.0	0.000	245.1	0.270	134.2	0.148
Mar-07	0.2	0.000	270.3	0.298	0.0	0.000	248.4	0.274	22.0	0.024
Sum	**92.6**	**0.008**	**4,420.6**	**4.873**	**336.4**	**0.371**	**2,469.5**	**2.722**	**2,380.1**	**2.624**

Annual Totals	Total kg	Total Tons	Percent of Total
Atmospheric Inflow	92.6	0.008	1.9%
Watershed & Tributary Site 2 Inflows	4,420.6	4.873	91.2%
Internal Regeneration	336.4	0.371	6.9%
Total Inflow	**4,849.6**	**5.252**	
Total Outflow (Site 1)	**2,469.5**	**2.722**	
Net Phosphorus Load	**2,380.1**	**2.624**	

Table 21. Nitrogen Budget Summary

Month	Atmospheric Inflow		Watershed & Tributary Site 2 Inflows		Internal Regeneration		Watershed & Tributary Site 1 Outflows		Net Nitrogen Load	
	kg	tons	kg	tons	kg	tons	kg	tons	kg	tons
Apr-06	31	0.03	2,079	2.29	0	0.00	293	0.32	1,817	2.00
May-06	54	0.06	9,039	9.96	0	0.00	2,346	2.59	6,746	7.44
Jun-06	15	0.02	711	0.78	804	0.89	0	0.00	1,530	1.69
Jul-06	26	0.03	1,375	1.52	878	0.97	0	0.00	2,279	2.51
Aug-06	70	0.08	3,292	3.63	878	0.97	93	0.10	4,147	4.57
Sep-06	56	0.06	2,108	2.32	804	0.89	530	0.58	2,438	2.69
Oct-06	53	0.06	3,568	3.93	0	0.00	3,718	4.10	-97	-0.11
Nov-06	34	0.04	5,348	5.90	0	0.00	3,092	3.41	2,291	2.52
Dec-06	25	0.03	3,795	4.18	0	0.00	3,910	4.31	-89	-0.10
Jan-07	42	0.05	3,804	4.19	0	0.00	1,668	1.84	2,178	2.40
Feb-07	24	0.03	2,964	3.27	0	0.00	1,314	1.45	1,674	1.84
Mar-07	20	0.02	1,583	1.74	0	0.00	1,377	1.52	226	0.25
Sum	**4,817**	**0.50**	**39,666**	**43.72**	**3,364**	**3.71**	**18,341**	**20.22**	**29,506**	**32.53**

Annual Totals	Total kg	Total Tons	Percent of Total
Atmospheric Inflow	4,817	0.50	10.1%
Watershed & Tributary Site 2 Inflows	39,666	43.72	82.9%
Internal Regeneration	3,364	3.71	7.0%
Total Inflow	**47,847**	**52.74**	
Total Outflow (Site 1)	**18,341**	**20.22**	
Net Nitrogen Load	**29,506**	**32.53**	

7. Sediment Budget

Water volume data from the hydrologic budget were used to develop a sediment budget (Table 22), which indicates the amount of sediment entering the lake system. The flow values in the hydrologic budget and the corresponding tributary sample total suspended solids (TSS) concentrations were used to calculate sediment inputs and outputs for the lake. An estimate of 10 percent for bed load transport (Fitzpatrick and Harbison, 1986) was added to the monitored tributary inputs. Tributary samples collected typically do not account for nutrients and sediment transported along the bottom of the tributary, which cannot be accurately monitored.

Out of the 3,356,430 kg (3,699 tons) of sediment estimated to have entered Lake Carlinville during the Phase 1 monitoring year, 2,582,087 kg (2,846 tons) were deposited in the lake. This resulted in an overall trapping efficiency of 86.0 percent. Shoreline erosion contributes an estimated 465 tons of sediment to the lake each year, or 13.8 percent of the total annual sediment load.

The 2006 sedimentation survey completed by HDR|CWI estimated that approximately 1,425,009 cubic yards have been deposited within the lake over its 67-year history. The average dry-bulk density of lake sediment is estimated to be 50.0 lbs/cubic foot. (i.e., 1,350 pounds per cubic yard). Based on this estimation, there has been approximately 961,881 tons of sediment deposited in the lake over its history. Therefore, the average annual rate of deposition during the 67-year period was approximately 14,356 tons per year.

The net sediment load of 2,846 tons in the Sediment Budget Summary during the Phase 1 monitoring year appeared to be a 80.1 percent underestimate compared to the 2006 lake sedimentation survey, which suggested that the historical average annual sediment loading was 14,356 tons per year. The decreased sediment load during the Phase 1 period could have been a result of 1) a lack of significant rainfall events during the Phase 1 period, and/or 2) reduced gross erosion and sediment delivery rates associated with improved land use practices within the Lake Carlinville watershed over time.

Table 22. Sediment Budget Summary

Month	Watershed & Tributary Site 2 Inflows		Shoreline Erosion		Watershed & Tributary Site 1 Outflows		Net Sediment Load	
	kg	tons	kg	tons	kg	tons	kg	tons
Apr-06	110,564	121.9	35,147	38.7	4,991	5.5	140,719	155.1
May-06	543,400	599.0	35,147	38.7	42,301	46.6	536,246	591.1
Jun-06	56,287	62.0	35,147	38.7	0	0.0	91,434	100.8
Jul-06	95,837	105.6	35,147	38.7	0	0.0	130,984	144.4
Aug-06	531,767	586.2	35,147	38.7	7,265	8.0	559,648	616.9
Sep-06	448,205	494.1	35,147	38.7	70,473	77.7	412,879	455.1
Oct-06	156,209	172.2	35,147	38.7	49,950	55.1	141,406	155.9
Nov-06	243,615	268.5	35,147	38.7	55,141	60.8	223,621	246.5
Dec-06	69,609	76.7	35,147	38.7	25,114	27.7	79,641	87.8
Jan-07	144,196	158.9	35,147	38.7	56,182	61.9	123,161	135.8
Feb-07	125,313	138.1	35,147	38.7	72,741	80.2	87,718	96.7
Mar-07	104,537	115.2	35,147	38.7	85,055	93.8	54,629	60.2
Sum	**2,629,540**	**2,898.6**	**421,760**	**464.9**	**469,213**	**517.2**	**2,582,087**	**2,846.3**

Annual Totals	Total kg	Total Tons	Percent of Total
Watershed & Tributary Site 2 Inflows	2,629,540	2,898.6	86.2%
Shoreline Erosion	421,760	464.9	13.8%
Bedload Transport	305,130	336.3	10.0%
Total Inflow	**3,356,430**	**3,699.8**	
Total Outflow (Site 1)	469,213	517.2	
Net Sediment Load	**2,582,087**	**2,846.3**	

L. BIOLOGICAL RESOURCES AND ECOLOGICAL RELATIONSHIPS

1. Phytoplankton

Phytoplankton analyses were completed by Dr. Larry O'Flaherty of Western Illinois University (WIU) in order to quantify the species present in the water column (see Appendix B). O'Flaherty reports that all samples were analyzed using the Sweep Method (Sedgewick-Rafter counting cell). Selected historical phytoplankton analyses were conducted on available sample data from Site 1 in 1988 and 2002. During the

2006-Phase 1 monitoring period, samples were collected from Sites 1, 2, and 3 on the following dates: May 4, June 20, July 19, August 24, and October 17 (Table 23).

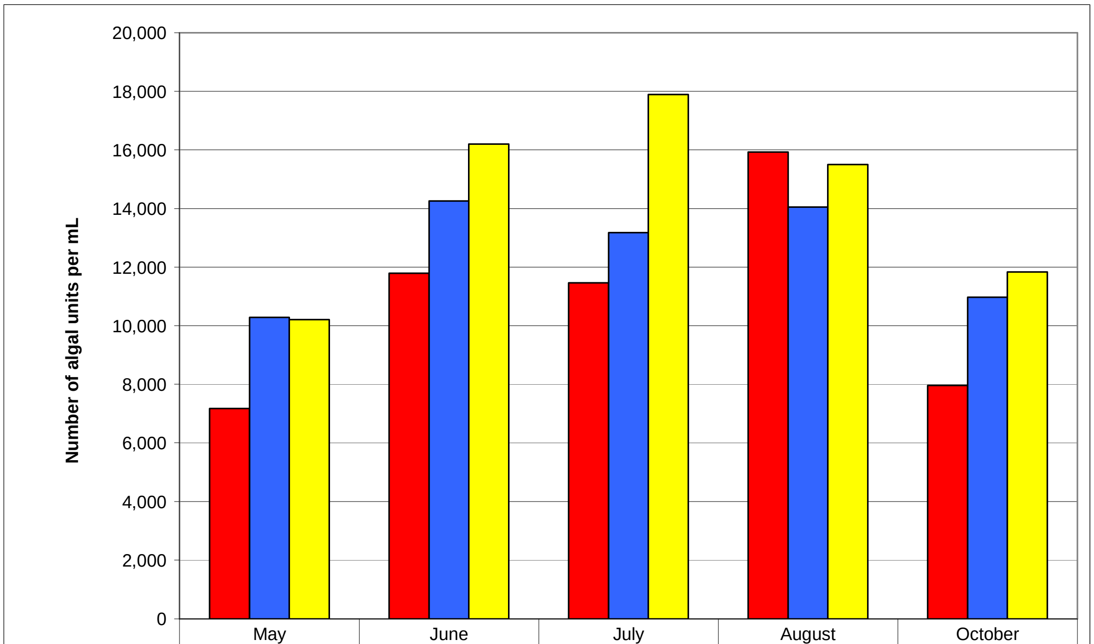
Table 23. Site 1 Phytoplankton Summary

Phylum	May	June	July	August	October
Bacillariophyta	836	907	489	2,375	754
Chlorophyta	2,140	3,526	2,354	6,278	856
Chrysophyta	10	20	0	71	10
Cryptophyta	31	245	214	2,854	10
Cyanophyta	3,914	6,951	8,205	3,475	6,136
Euglenophyta	245	102	173	662	183
Pyrrhophyta	0	20	0	163	0
Xanthophyta	0	20	20	51	10
Totals	7,175	11,792	11,456	15,930	7,960

Source: O'Flaherty, 2007
All values represent the number of algal units per milliliter.

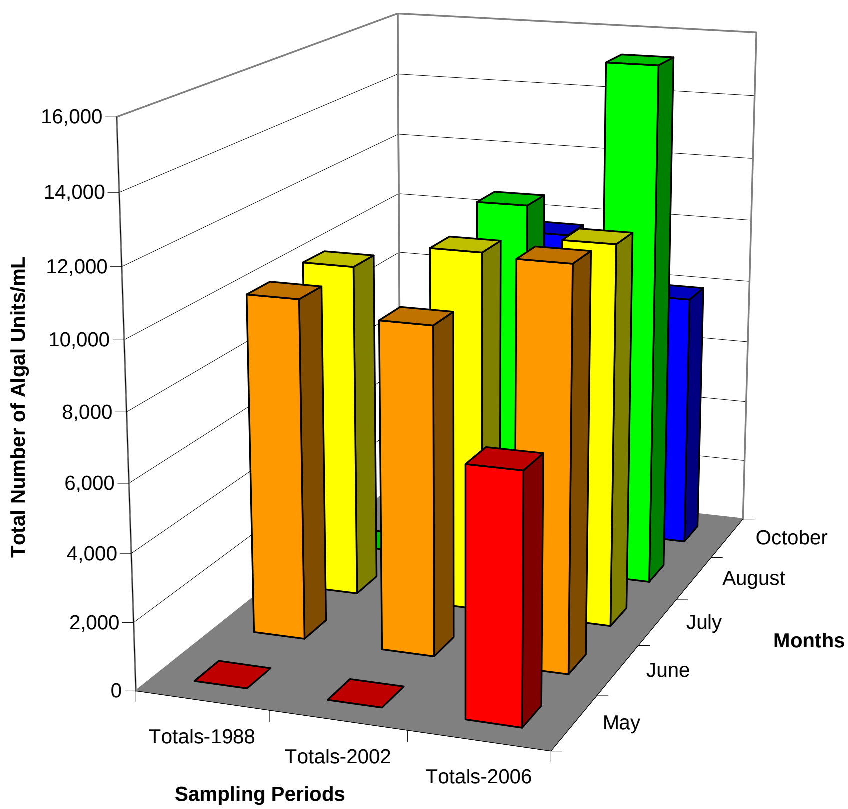
Phytoplankton analyses at Site 1 during the Phase 1 monitoring period showed that the total algal population ranged from a low of 7,175 (number of algal units/mL) in May to a high of 15,930 (number of algal units/mL) in August. Sites 2 and 3 were also similar in terms of total number of algal units and distribution of individual taxa with the dominant algal division being Cyanophyta (blue-greens) and Chlorophyta (greens). Figure 26 shows the similarity of total phytoplankton for Sites 1, 2, and 3 for the Phase 1 (2006) samples. A comparison of the Phase 1 (2006) Site 1 sample data with historical 1988 and 2002 data shows that there has been a significant increase in total algal productivity in Lake Carlinville particularly in the spring and fall (Figure 27).

Figure 26. Phytoplankton Comparison



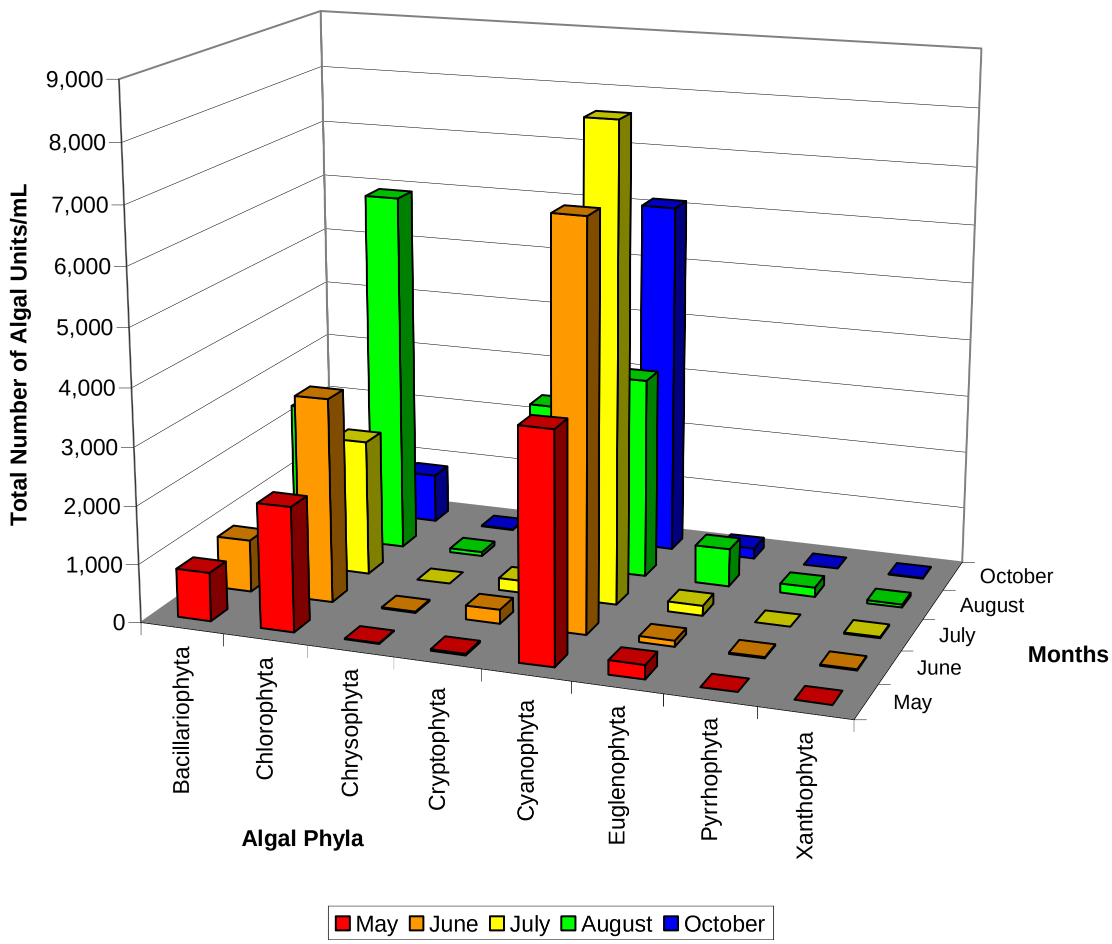
	May	June	July	August	October
Totals-Site 1	7,175	11,792	11,456	15,930	7,960
Totals-Site 2	10,284	14,259	13,178	14,045	10,967
Totals-Site 3	10,212	16,195	17,887	15,492	11,833

Figure 27. Historical Site 1 Total Phytoplankton Comparison



In addition to the increased algal productivity and blue-green dominance found in the Phase 1 (2006) samples (Figure 28), it is apparent that the phylum Cyanophyta (blue-green algae) becomes abundant in Lake Carlinville during the summer months. This algal species is a nuisance blue-green that is generally indicative of highly eutrophic conditions.

Figure 28. Site 1 Dominant Phytoplankton Comparison



2. Fisheries Population

a. History and Population Surveys

The sport fish population within Lake Carlinville has been sporadic due to diminished water quality and the quality of fish habitat, which have been attributed to heavy siltation and shallow water depths in the upper end of the lake (Pontnack personal communication, 2005 and 2006).

IL DNR has documented twelve fish species occurring within Lake Carlinville (Table 24). Fish population surveys for Lake Carlinville have historically been completed in the fall of every third year (i.e., 1995, 1999, and 2002) by the District 14 IL DNR fisheries biologist; however, recent population surveys are now completed every three to five years due to State budget constraints (Pontnack personal communication, 2006). In addition, Lake Carlinville is a low priority lake due to impairments listed above.

Table 24. Common Fish Species

ID Code	Species	Scientific Name
BLB	Black Bullhead Catfish	*Ictalurus melas*
BLC	Black Crappie	*Pomoxis nigromaculatus*
BLG	Bluegill Sunfish	*Lepomis macrochirus*
CAP	Common Carp	*Cyprinus carpio*
CCF	Channel Catfish	*Ictalurus punctatus*
GSF	Green Sunfish	*Lepomis cyanellus*
GZS	Gizzard Shad	*Dorosoma cepedianum*
LMB	Largemouth Bass	*Micropterus salmoides*
WAM	Warmouth	*Lepomis gulosus*
WHC	White Crappie	*Pomoxis annularis*
YEB	Yellow Bullhead Catfish	*Ameiurus natalis*
YLB	Yellow Bass	*Morone mississippiensis*

Source: Pontnack, 2000 and 2003

The fish population surveys for Lake Carlinville have typically included electrofishing with three, half-hour sessions during the day and gill netting sampling during the night. The fish population survey data is compiled into the Lake Management Status Reports for Lake Carlinville. Fish population survey summaries from Status Reports are summarized in Table 25 (Pontnack, 2000 and 2003).

Table 25. Fish Population Survey Summaries

Species	Parameter	1995	1999	2002	LMP Objective
LMB	No. Collected	65	173	70	> 90
	YAR	0	3	1	1 - 5
	PSD	38	44	17	40 - 60
	PSD 15	18	23	5	20 - 30
	PSD 18	5	10	0	5 - 10
	WR	103	97	100	90 - 110
	CPUE	43	115	47	> 60
BLG	No. Collected	296	364	117	> 200
	YAR	0	0	0	1 - 5
	PSD	15	37	34	20 - 40
	PSD 7	0	1	7	10 - 20
	PSD 8	0	0	0	5 - 15
	WR	91	94	87	90 - 110
	CPUE	197	243	78	> 133
WHC	No. Collected	28	113	40	> 50
	PSD	30	11	100	40 - 60
	PSD 9	19	10	90	20 - 30
	PSD 10	11	10	72	5 - 15
	PSD 12	4	3	21	1 - 10
	WR	85	90	97	90 - 110
	CPUE	19	75	27	> 33
CCF	No. Collected	1	1	0	> 25
	PSD	100	0		40 - 60
	PSD 18	100	0		10 - 20
	PSD 20	100	0		1 - 10
	WR		85		90 - 110
	CPUE	1	1		> 17
BLC	No. Collected	1	3	8	> 25
	PSD			75	40 - 60
	PSD 9			75	20 - 30
	PSD 10			63	5 - 15
	PSD 12				1 - 10
	WR			101	90 - 110
	CPUE	1	2	5	> 16
GZS	No. Collected	139	90	44	> 80
	WR	93	104	98	90 - 110
	CPUE	93	60	29	> 53
CAP	No. Collected		22	11	
GSF	No. Collected		131	15	
WAM	No. Collected		1	1	
YEB	No. Collected		17	2	
YLB	No. Collected		8	20	
BLB	No. Collected			2	

Source: Pontnack, 2000 and 2003

IL DNR fisheries biologists use various terms to assess the health and condition of surveyed fish populations. The terms for the abbreviations used within the IL DNR fisheries Lake Management Status Reports and Table 25 are as follows:

YAR – "Young-to-Adult Ratio" is the proportion of young-of-year fish in relation to adult or "quality-size" fish within a particular population.

PSD – Proportional Stock Density is a way of representing the size structure of fish populations. It represents the percentage of "quality-size" fish that are at sexual maturity with a given population. The greater the PSD value, the greater percentage of "quality" fish there is within a particular population.

RSD7 (or 8,9,14,16,18) – Relative Stock Density is another way of representing the size structure of fish populations that corresponds to the percentage of fish of a given length or larger within a population. Hence, an RSD14 reading 25 for LMB indicates that 25 percent of the sexually mature LMB are at least 14-inches in length.

Wr – Weight Relative (to length) is a way of stating "plumpness" or "body condition" of a particular fish species. The higher the Wr value, the better the condition.

CPUE – Catch Per Unit of Effort is a way of representing the density of a species population. The higher the CPUE means there are a greater number of fish present.

LMP Objective – A Lake Management Plan Objective is indicated in the Status Reports for each parameter assessed.

General summaries, reported by Pontnack, of the major species sampled in the 1999 and 2002 fish population surveys are as follows:

Largemouth Bass (LMB) – The LMB population within Lake Carlinville has historically been sporadic, as the CPUE has varied greatly in recent sampling years. These observations are believed to be due to the weather and its impact on fish location within the lake. In 2002, a greater number of smaller fish were sampled and the YAR reflects this trend. Fewer larger fish were sampled in 2002, with only 43% of the fish sampled being greater than 15-inches. The LMB flesh condition in 2002 remained average to good with a Wr of 100.2.

Bluegill (BLG) – Numbers of BLG collected in 2002 were considerably lower (65% reduction) compared to the last two sampling events. Reproduction and recruitment for BLG remained at zero, as indicated by the YAR over the past sampling events. In 2002, only 4.3% of the BLG collected were less than 3.1-inches. However, BLG size structure did improve some in 2002, as a larger number of bigger fish (i.e., greater than 7-inches) were sampled. The weight relative to length ratio (Wr) for BLG fell below average in 2002 with 87.2.

White Crappie (WHC) - Like the LMB population, the WHC population within Lake Carlinville has been variable. The WHC numbers sampled in 2002 dropped 43% compared to the previous sampling event in 1999. Size structure improved in 2002 with a greater number of larger fish sampled (60% greater than 11-inches and 20% greater than 12-inches). In 2002, the mean Wr for WHC was reported as good at 97.4. Since 1995, good numbers of 10-inch plus WHC have been found in Lake Carlinville.

Black Crappie (BLC) – The BLC population in Lake Carlinville is small, with only 8 fish collected in the 2002 sampling effort. However, the fish sampled indicated that size structure is good and 63% of the fish sampled were at least 10.2-inches. The Wr for BLC is also good (101.3).

Channel Catfish (CCF) – Due to time constraints, netting gear was not used in 2002 fish population survey and no CCF were sampled in the electroshocking sampling efforts. One fish was collected during each of the prior electroshocking surveys (1995 and 1999) and five CCF were collected via gill nets in 1999. The fish collected were in fair condition (Wr = 88.8) and were quality size (PSD = 66.7%)

Undesirable Fish Species – Several undesirable fish species were collected during the 1999 and 2002 sampling efforts. These species included: hybrid bluegill, drum, black bullhead catfish, warmouth, yellow bullhead catfish, common carp, yellow bass, and green sunfish. Undesirable fish species accounted for approximately 19% and 15% of the total fish collected during 1999 and 2002, respectively.

b. Fish Contaminant Monitoring

Fish flesh samples were collected in 2006 during the Phase 1 sampling period to determine the level of toxicity present in Lake Carlinville fishes. The results of the 2006 fillet analyses were not available at the time this report was finalized (December 2007).

c. Fisheries Management

Poor water quality and heavy siltation within Lake Carlinville may have diminished the sport fish habitat and population. Due to these conditions, IL DNR has not stocked any fish within the lake since 1994. This has allowed less desirable (riverine) fish species such as black bullhead catfish, warmouth, yellow bullhead catfish, common carp, yellow bass, and green sunfish to become well established within the lake, according to the District 14 Fisheries Biologist (Pontnack personal communication, 2006). These occurrences of undesirable, riverine fish species have caused some to suggest "starting over" by removing the existing fish population and restocking the lake. The District 14 Fisheries Biologist recommends this practice only after the existing sediment and other lake water quality issues have been addressed (Pontnack personal communication, 2005 and 2006). Table 26 provides a listing of the current regulations, as set forth by the IL DNR. These fishing regulations will likely need to be updated and revised as the new fish population is established within the lake (Pontnack personal communication, 2005 and 2006).

Table 26. Sport Fishing Regulations for Lake Carlinville

Species	Regulation
All Fish	2 Pole and Line Fishing Only
Channel Catfish	6 Fish Dailt Creel Limit

Source: Pontnack, 2003

The fisheries management report evaluated 1999 and 2002 survey data and compared that data to the historical averages for the lake. Generally, considering observed fluctuations in certain fish populations, the 2002 survey data did not vary from the historical averages. There appeared to be, however, a 64% decline the fish population when comparing fish sampled in 2002 versus 1999. The current sport fish regulations in effect for Lake Carlinville continue to be maintained in order to assist in achieving IL DNR management goals and to ensure a more balanced fishery.

3. Aquatic Vegetation

In the summer of 2006, HDR | CWI conducted an aquatic macrophyte survey at Lake Carlinville. Due to the turbid water conditions of the lake, aquatic plants were only encountered along the shoreline. Aquatic plant species encountered were identified and approximate locations of each species were marked on aerial photographs. Approximate locations of aquatic macrophyte species identified at Lake Carlinville are indicated in Figure 29. A detailed survey of the upper end of the lake was not possible due to restricted boat access in shallow depths; however, the shallow depth and turbidity in this area would not promote dense plant growth or diversity. While the density is unknown, it is likely that some water willow is present in this area.

A total of two aquatic emergent macrophyte species were noted during the plant survey at Lake Carlinville (Table 27) in areas with water depths of less than 2.0 feet. Water willow (*Decodon verticillatus*) was the most abundant species encountered, while creeping water primrose (*Jussiaea repens var. glabrescens*) was encountered only along the dam. No species were found at depths or more than 2.0 feet. The aquatic macrophyte population within Lake Carlinville lacks diversity and is poor, due to poor water clarity and quality.

Table 27. Aquatic Macrophyte Species

Common Name	Scientififc Name	Type	Status
Water Willow	*Decodon verticillatus*	Emergent	Native
Creeping Water Primrose	*Jussiaea repens var. glabrescens*	Emergent	Native

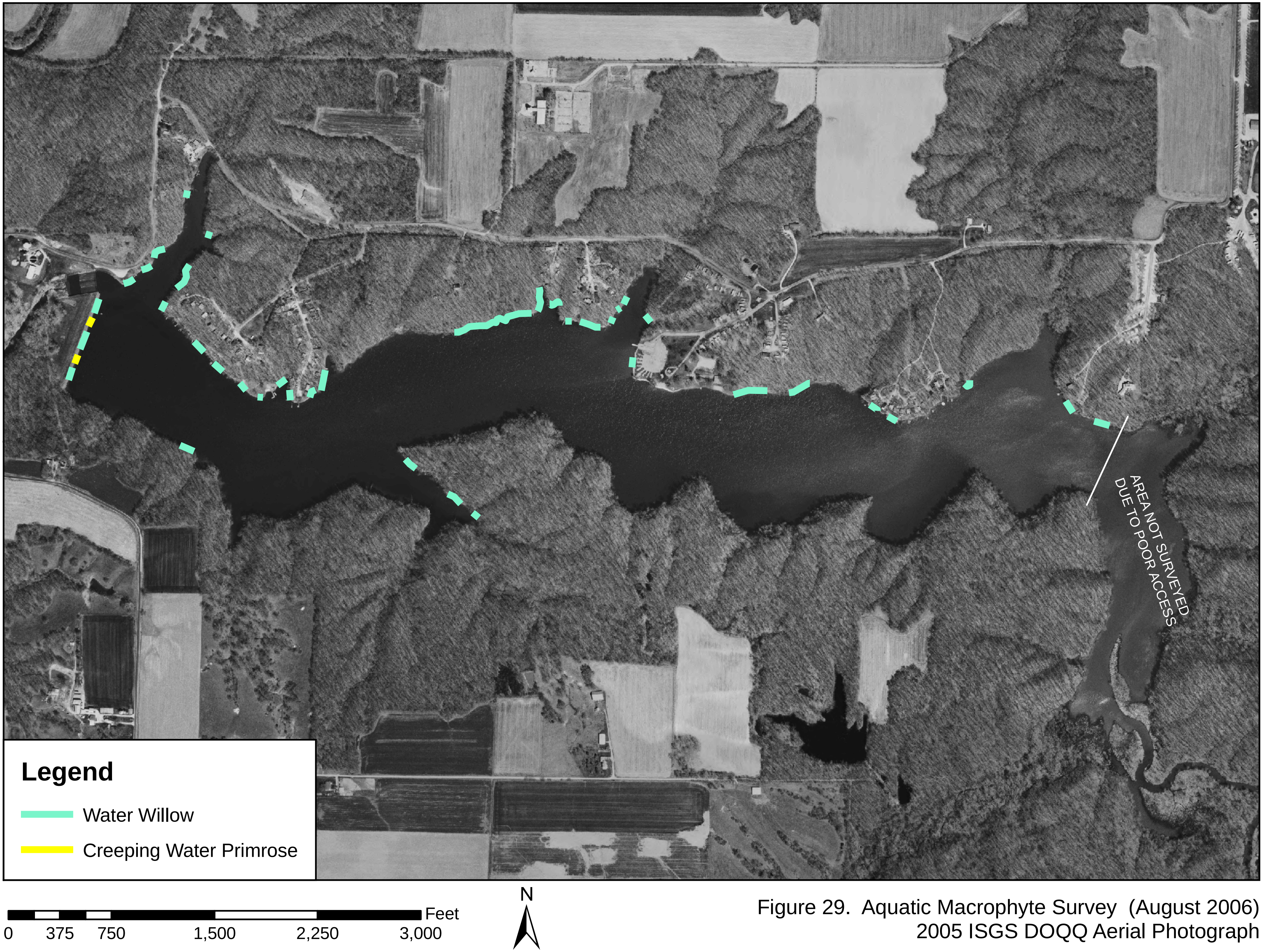


Figure 29. Aquatic Macrophyte Survey (August 2006)
2005 ISGS DOQQ Aerial Photograph