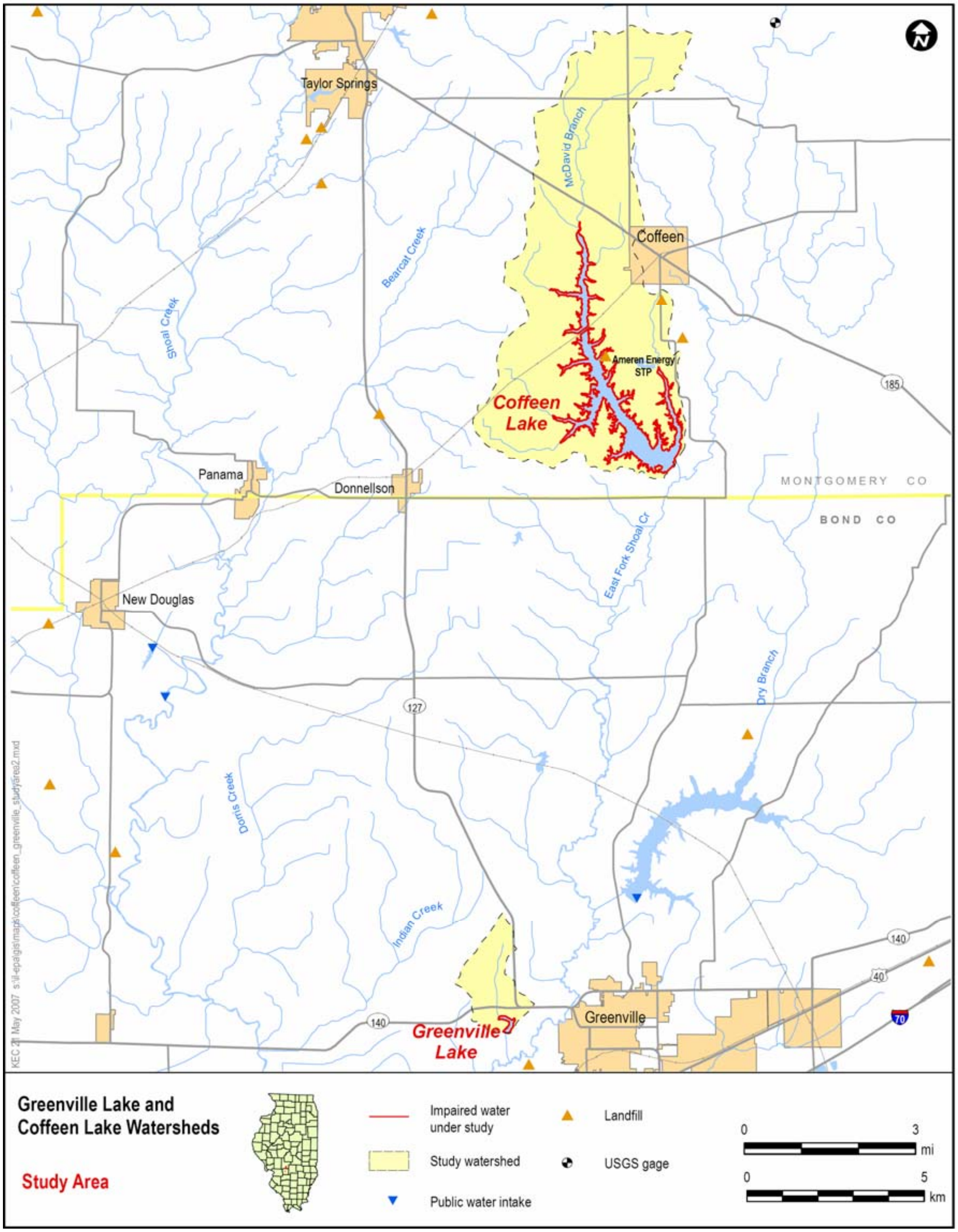
Illinois
Environmental
Protection Agency

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

August 2007

IEPA/BOW/07-014

Greenville Old Lake and Coffeen Lake Watersheds



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Greenville / Coffeen

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
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SEP 17 2007

REPLY TO THE ATTENTION OF:

WW-16J

RECEIVED
SEP 24 2007
Watershed Management Section
BUREAU OF WATER

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

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Loads (TMDLs) submittal for Greenville and Coffeen Lakes in the Shoal Creek Watershed, including supporting documentation and follow up information. IEPA's TMDLs address two lakes, Illinois identification ROY and ROG, respectively, in HUC 0717020304. Both lakes are impaired for aesthetic quality by excess algae, as a result of excess phosphorus loading to the lakes. Based on this review, U.S. EPA has determined that Illinois' TMDLs for phosphorus, addressing not only excess phosphorus but also aquatic plant/aquatic algae and total suspended solids impairments, meet the requirements of Section 303(d) of the Clean Water Act (CWA) and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves Illinois' 2 TMDLs addressing 6 impairments for Greenville and Coffeen Lakes. The statutory and regulatory requirements, and U.S. EPA's review of Illinois' compliance with each requirement, are described in the enclosed decision document.

We wish to acknowledge Illinois' effort in these submitted TMDLs, and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Mr. Dean Maraldo, TMDL Program Manager, at 312-353-2098.

Sincerely yours,

Kevin M. Pierard
Acting Director, Water Division

Enclosure

cc: Jennifer Clarke

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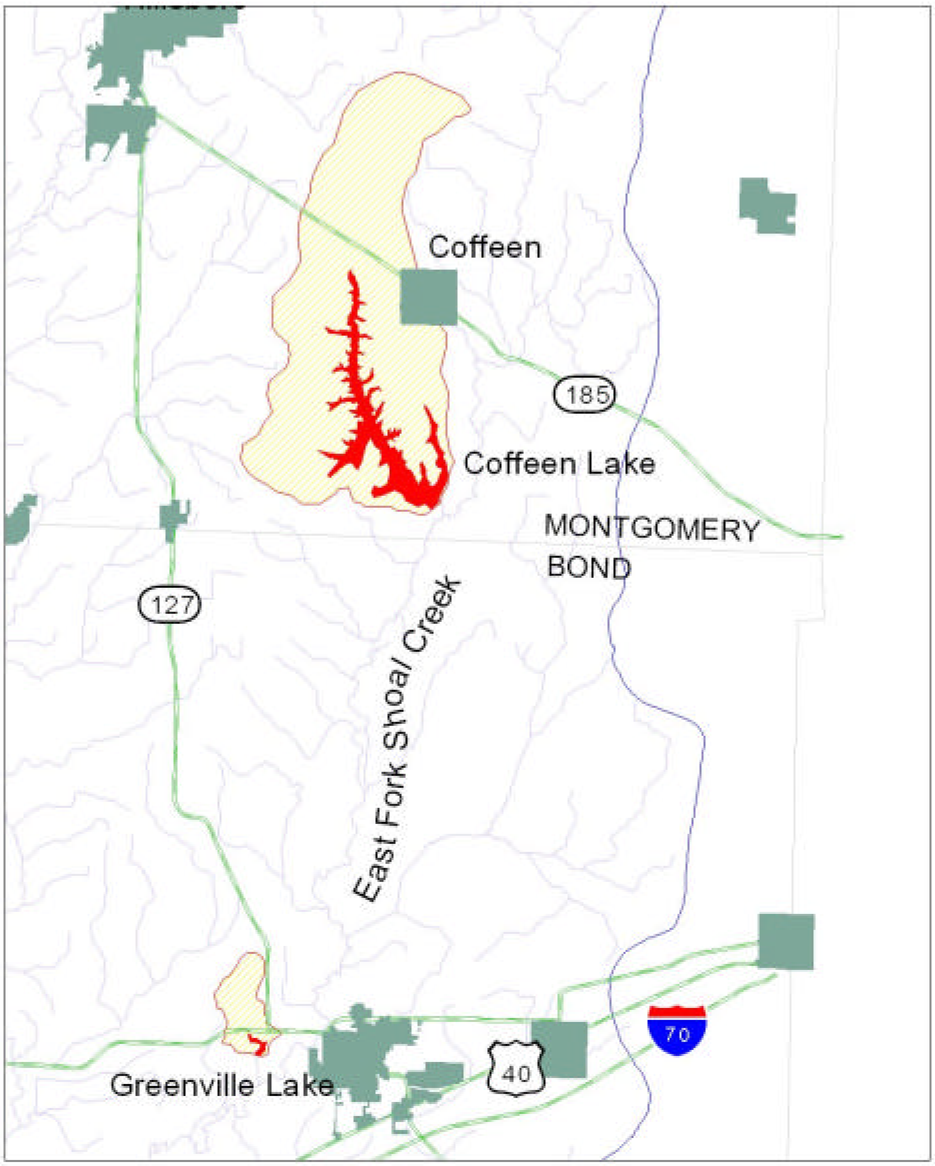
Greenville Lake and Coffeen Lake TMDL

Stage 1 Report: Watershed Characterization, Data Analysis, And Methodology selection

Submitted to:
Illinois Environmental Protection Agency



TETRA TECH EM INC.

March 8, 2006

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EXECUTIVE SUMMARY

The Illinois 2004 303(d) list identifies the following segments for impairment of designated uses:

- Greenville Lake (ROY)
- Coffeen Lake (ROG)

This report documents the analysis and findings in Stage 1 of the TMDL development for these two water segments – watershed characterization, including data analysis and methodology selection. The focus of this report is on the portions of the Shoal Creek watershed that drain into Greenville and Coffeen Lakes.

The Shoal Creek Watershed is located in southwestern Illinois. The watershed is predominantly located in Bond and Montgomery Counties, with portions extending to Clinton County. The entire Shoal Creek watershed drains approximately 922 square miles. Both Greenville Lake and Coffeen Lake drains to East Fork Shoal Creek. Greenville Lake is a manmade recreational lake located in Bond County near the center of the watershed. Coffeen Lake is a cooling reservoir for the coal-fired Coffeen Power Station. It is located in southeastern Montgomery County. The land use in the Shoal Creek watershed is predominantly agriculture cropland. The soil has medium potential for runoff and erosion.

Water quality data are gathered from IEPA, USGS NWIS and USEPA STORET database. The data analysis is performed for the listed segments. A review of the available water quality data confirms the impairments in ROY and ROG. Phosphorous concentration has violated the 0.05 mg/l Illinois standard in ROY and ROG.

The data verified that the total phosphorous is a limiting nutrient in Greenville and Coffeen Lakes and frequently exceeded the 0.05 mg/L water quality standard. The elevated phosphorous concentration results in excessive algal growth.

Both point sources and nonpoint source potentially contribute to impairments in Greenville and Coffeen Lakes. Potential nonpoint sources include agricultural runoff, crop related sources, habitat modification, streambank destabilization, and recreation and tourist activity

1.0 INTRODUCTION

Section 303(d) of the Clean Water Act (CWA) and the U.S. Environmental Protection Agency (USEPA) Water Quality Planning and Management Regulations (40 CFR Part 130) require states to identify water bodies that do not meet water quality standards and to determine the Total Maximum Daily Load (TMDL) for pollutants causing the impairment. A TMDL is the total amount of pollutant load that a water body can receive and still meet the water quality standards. It is the sum of the individual waste load allocation for point sources and load allocations for nonpoint sources and natural background with a margin of safety. The CWA establishes the process for completing TMDLs to provide more stringent, water-quality based controls when technology-based controls are not sufficient to achieve state water quality standards. A TMDL is also required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. The overall goals and objectives in developing the TMDLs include:

- Assess the water quality of the impaired water bodies and identify key issues associated with the impairments and potential pollutant sources.
- Use the best available science and available data to determine the maximum load the water bodies can receive and fully support all of their designated uses.
- Use the best available science and available data to determine current loads of pollutants to the impaired water bodies.
- If current loads exceed the maximum allowable load, determine the load reduction that is needed.
- Identify feasible and cost-effective actions that can be taken to reduce loads.
- Inform and involve the public throughout the project to ensure that key concerns are addressed and the best available information is used.
- Submit a final TMDL report to USEPA for review and approval.

Under Section 303(d) of the CWA, the State of Illinois prepared a list of waters that are not meeting state water quality standards (hereafter referred to as the “303(d) list”) in each 2-year cycle. The most recent list was reviewed and approved by USEPA in 2004. The 303(d) list identifies two water bodies as impaired:

- Greenville Lake (ROY)
- Coffeen Lake (ROG)

Greenville and Coffeen Lakes (watershed ID: 0714020304) discharge to East Fork Shoal Creek (Watershed HUC 07140203). The State of Illinois has assigned a high priority to the two listed water bodies for TMDL development.

This report documents the analysis and findings in the characterization of overall hydrology and water quality for Greenville and Coffeen Lakes watershed. The focus of this TMDL is on the portions of the Shoal Creek watershed that drain into Greenville and Coffeen Lakes. In this report, “Shoal Creek watershed” refers to the portions of the watershed that drain into Greenville and Coffeen Lakes, unless otherwise specified. The purposes of the watershed characterization and data analysis report are to (1) confirm impairments in listed water bodies by comparing observed data with water quality standards or appropriate targets; (2) evaluate spatial and temporal water quality variation; (3) evaluate any identifiable relationships between pollutants of concern and other environmental measurements and conditions (for example, water quality and stream flow condition); (4) provide a preliminary assessment of sources contributing to impairments; (5) describe potential TMDL development approaches; and (6) identify data needs and recommendations for additional data collection.

This chapter discusses the rationale for beneficial use designations and impairments for waters of the State of Illinois, and specifically, for the listed Greenville and Coffeen Lakes in southwestern Illinois.

Chapter 2 describes the characteristics of the watershed and water bodies, and chapter 3 addresses the climate and hydrology conditions. Chapter 4 describes the water quality standards and water quality assessment. Chapter 5 discusses the potential nonpoint and point sources that may cause the impairment. Chapter 6 describes the methodology selection for the TMDL development. Finally, chapter 7 identifies data gaps and provides recommendations for additional data collection.

All waters of Illinois are assigned one of the following four designations: general use waters, public and food processing water supplies, Lake Michigan, and secondary contact and indigenous aquatic life waters. All Illinois waters must meet general use water quality standards unless they are subject to another specific designation (CWA Section 302.201). The general use standards protect the state's water for aquatic life (except as provided in Illinois Water Quality Standard Section 302.213), wildlife, agricultural use, secondary contact use, and most industrial uses, and they ensure the aesthetic quality of the state's aquatic environment. Primary contact uses are protected for all general use waters where the physical configuration permits such use. Unless otherwise specifically provided for and in addition to the general use standards, waters of the state must meet the public and food processing water quality standards at the points of water withdrawal for treatment and distribution as a potable supply or for food processing.

The designated uses and the causes of impairment addressed in this TMDL are summarized in Tables 1-1. When a waterbody is assessed as partial support for a designated use, one violation of an applicable Illinois water quality standard at an Intensive Basin Surveys (IBS) or Facility-Related Stream Surveys (FRSS) site or one violation over three years at an Ambient Water Quality Monitoring Network (AWQMN) station is considered a basis for listing the violating parameter as a potential cause.

TABLE 1-1 DESIGNATED USES OF IMPAIRED SEGMENTS

Segment	Designated Use and Support Status (in parenthesis)	Causes of Impairment	Impairments addressed in TMDL
Coffeen Lake (ROG)	Aquatic life (full) Fish consumption (full) Primary contact (not assessed) Secondary contact (not assessed) Public water supply (not assessed) Aesthetic quality (not supporting)	Total phosphorous Habitat assessment (lake) Total suspended solids Excess algal growth	Phosphorous
Greenville Old Lake (ROY)	Aquatic life (full) Fish consumption (full) Primary contact (not assessed) Secondary contact (not assessed) Public water supply (not assessed) Aesthetic quality (not supporting)	Total phosphorous Total suspended solids Aquatic Algae	Phosphorous

Source: IEPA 2004 303(d) list

The Greenville and Coffeen Lake segments addressed in this report are designated as a general use water bodies. As specified under Title 35 of the Illinois Administrative Code, Subtitle C, Part 302, waters of the state shall be free from sludge or bottom deposits (narrative standard for siltation), visible oil, odor, plant or algal growth (narrative standards for nutrients, eutrophication, or noxious aquatic plants), and color or turbidity of other than natural origin. Aquatic life is fully supported in segments ROG and ROY. The aesthetic quality is not supported based on assessment. One purpose of this report is to verify the causes of impairment by comparing the available data to water quality standards.

2.0 WATERSHED AND WATER BODY CHARACTERISTICS

This chapter describes the general hydrological characteristics of the Greenville and Coffeen Lakes watershed and water bodies, including their location, population, land use and cover, topography and geology, and soils. The discussion of general watershed characteristics is followed by specific information for the listed segments of the river and the lake.

2.1 LOCATION

The entire Shoal Creek watershed is located in southwestern Illinois as shown on Figures 2-1 and 2-2. The watershed is predominantly located in Bond and Montgomery Counties, with portions extending to Christian, Clinton, Macoupin, and Madison Counties. The watershed drains about 922 square miles. The distribution of watershed area by county is shown in Table 2-1.

TABLE 2-1 WATERSHED AREA DISTRIBUTION BY COUNTY

County, State	Area of Watershed in County (Square Miles)	Percent of Watershed in County (Percent)
Bond County, Illinois	307.8	33.4
Montgomery County, Illinois	469.2	50.9
Clinton County, Illinois	139.0	15.1
Other Counties	5.7	0.6

Greenville Lake (ROY) is located in the central portion of the watershed, approximately 1.5 miles west of the City of Greenville. The Greeville Lake drains 1.3 square miles. Coffeen Lake (ROG) is located in the north central portion of the watershed, approximately 2 miles west southwest of the City of Coffeen. Coffeen Lake drains 19.2 square miles. This TMDL focuses on the watersheds that drain to the listed Greenville and Coffeen Lake segments. The characteristics of the watersheds will be used for the load allocation for each segment in the TMDL.

FIGURE 2-1 GREENVILLE LAKE WATERSHED

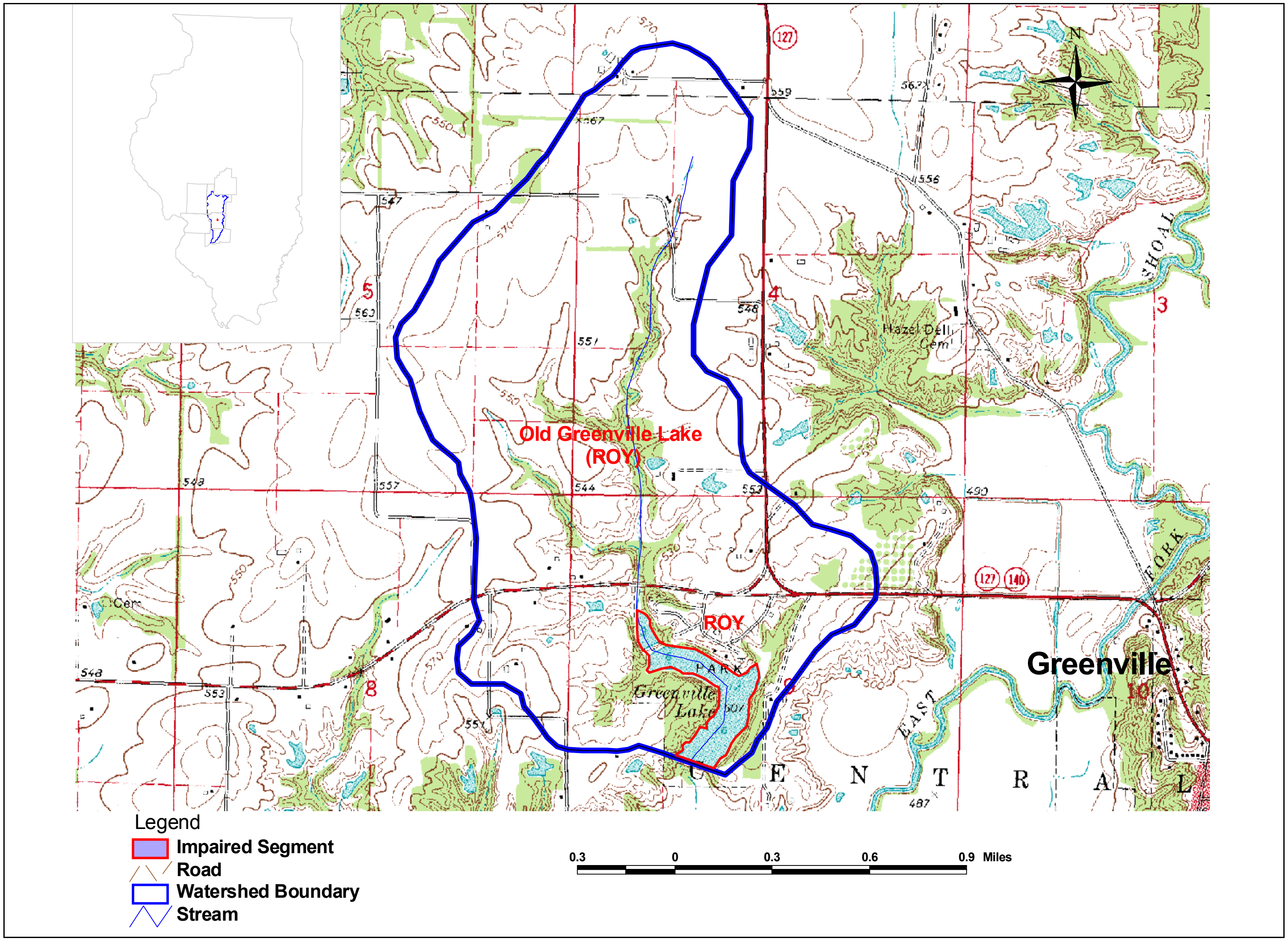
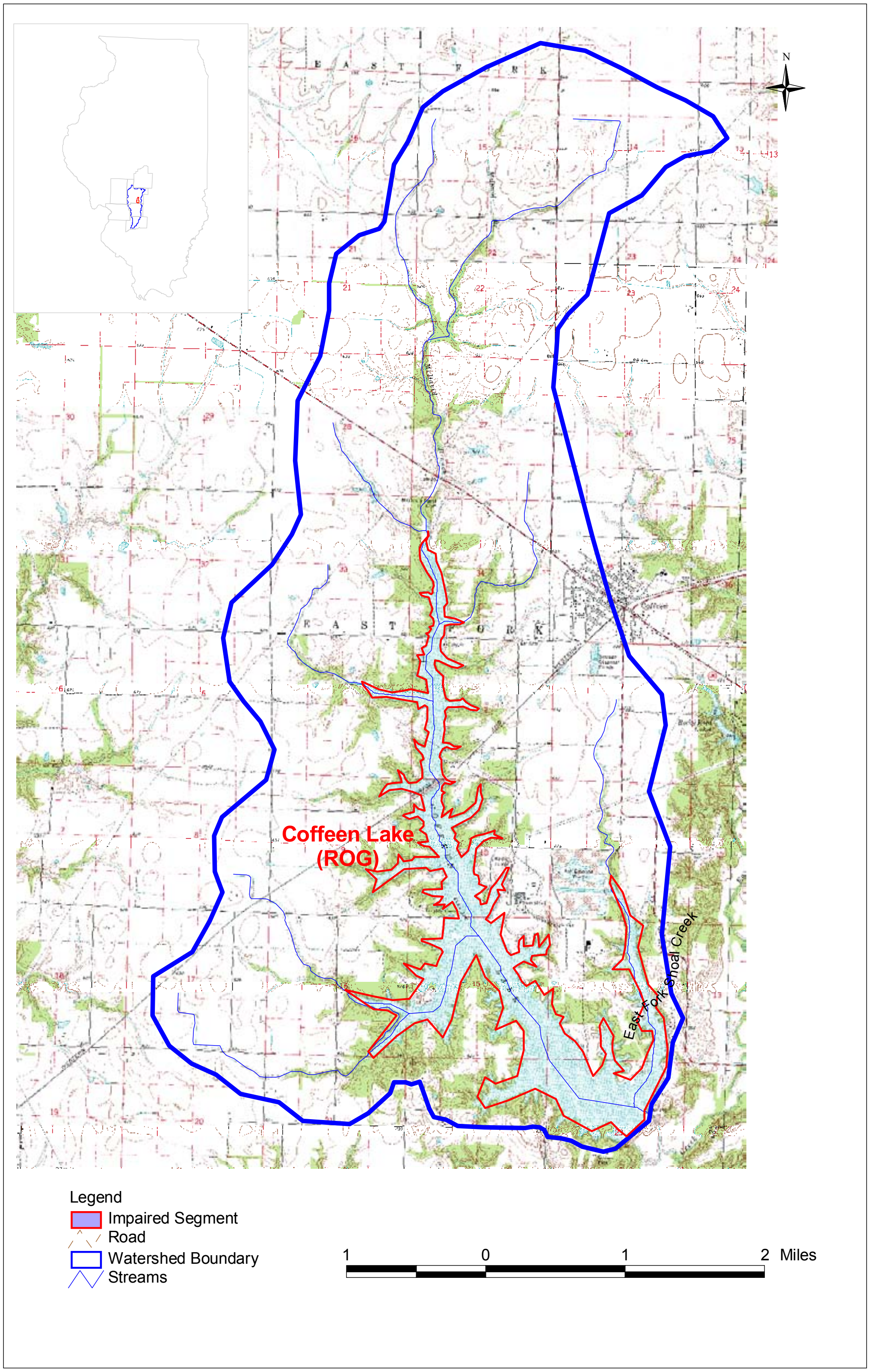


FIGURE 2-2 COFFEEN LAKE WATERSHED



2.2 POPULATION

Total watershed population data is not directly available but population estimates may be calculated from the 2000 U.S. Census data. The census data were downloaded for all towns, cities, and counties with boundaries that were fully or partially within the watershed (U.S. Census Bureau 2000). Urban and nonurban populations were estimated for the watershed area and were summed to obtain the total watershed population. This section describes how urban and nonurban population estimates were determined from town, city, and county census data.

The urban watershed population is the sum of the populations for all municipalities located entirely in the watershed. Table 2-2 presents urban population in the Greenville and Coffeen Lake watersheds. There are no municipalities in Greenville Lake Watershed. The urban population in Coffeen Lake watershed is obtained by the total population of the City of Coffeen multiplying the percentage of the city located within the watershed.

TABLE 2-2 MUNICIPALITY POPULATION IN THE GREENVILLE AND COFFEEN LAKES WATERSHED

Watershed	Municipality/County	Urban population
ROG	Coffeen/Montgomery	319[a]
ROY	NA	NA
Total		**319**

Notes:
NA Not applicable (no municipalities located in the watershed)
a Represents 45 percent of the total Coffeen population of 709; 45 percent of Coffeen is located in the watershed.
Source: U.S. Census Bureau 2000

The first step in calculating the nonurban watershed population was to subtract the county urban population from the total county population. The portion of nonurban population in each watershed was then calculated by multiplying the percent area of the county in the watershed by the nonurban population of the county. For example, the nonurban population of Montgomery County is 8,217. 2.7 percent of Montgomery County is in the Coffeen Lake watershed. Therefore, 2.7 percent of 8,217 (222) is assumed to be in the Coffeen Lake watershed. The results from these calculations for each watershed are shown in Table 2-3. These results are based on the assumption that nonurban populations are uniformly distributed throughout each county.

TABLE 2-3 WATERSHED POPULATION SUMMARIZED BY WATER BODY SEGMENT

Waterbody Segment	County	Urban population	Nonurban Population	Watershed Population
Coffeen Lake	Montgomery	319	222	541
Greenville Lake	Bond	0	25	25

Source: U.S Census Bureau 2000

Table 2-4 shows the population change between 1990 and 2000 for each county in the watershed. The population of Bond County increased by 17.6 percent while Montgomery decreased by 0.25 percent.

TABLE 2-4 POPULATION CHANGE

County in the Watershed	1990 Population	2000 Population	Absolute Change	Percent Change
Bond	14,991	17,633	2,642	17.60%
Montgomery	30,728	30,652	-76	-0.25%

Sources: U.S Census Bureau 1990 and 2000

2.3 LAND USE AND LAND COVER

The land use and land cover data for Greenville Lake and Coffeen Lake watershed are obtained from the Illinois Natural History Survey (INHS) Illinois Gap Analysis (GAP) Land Cover data. GAP data classifies vegetation according to the Illinois Natural Community Level, as outlined in the Illinois Natural Areas Inventory Technical Report (1978). An attempt was made, where possible, to classify the vegetation to the Alliance (Species) Level Classifications developed by the Nature Conservancy. Data is also generalized to the National Vegetation Classification Standard (NVCS) developed by the Federal Geographic Data Committee (FGDC). The Illinois GAP data is a raster, geo-referenced, categorized land cover data layer produced using satellite imagery. The data were derived from 1999 and 2000 Landsat 5 and Landsat 7 TM satellite imagery acquired between the dates of April 30, 1999 and October 10, 2000. The approximate scale is 1:100,000 with a ground resolution of 30 meters by 30 meters. Compared to other land use data, GAP data provide most recent and detailed land use information. Figure 2-3 and 2-4 presents land use and land cover for the two watershed.

FIGURE 2-3 GREENVILLE LAKE WATERSHED LAND USE AND LAND COVER MAP

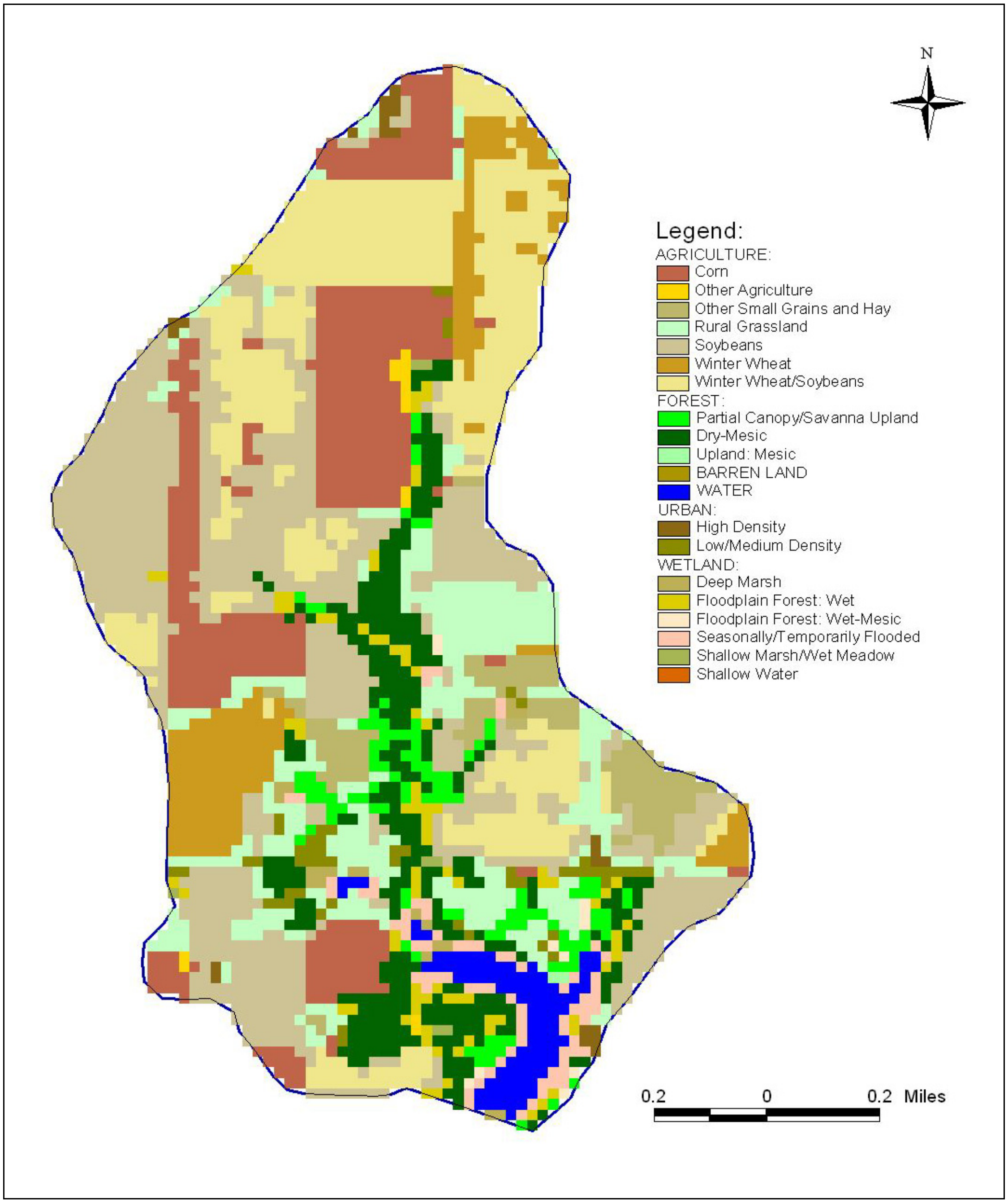
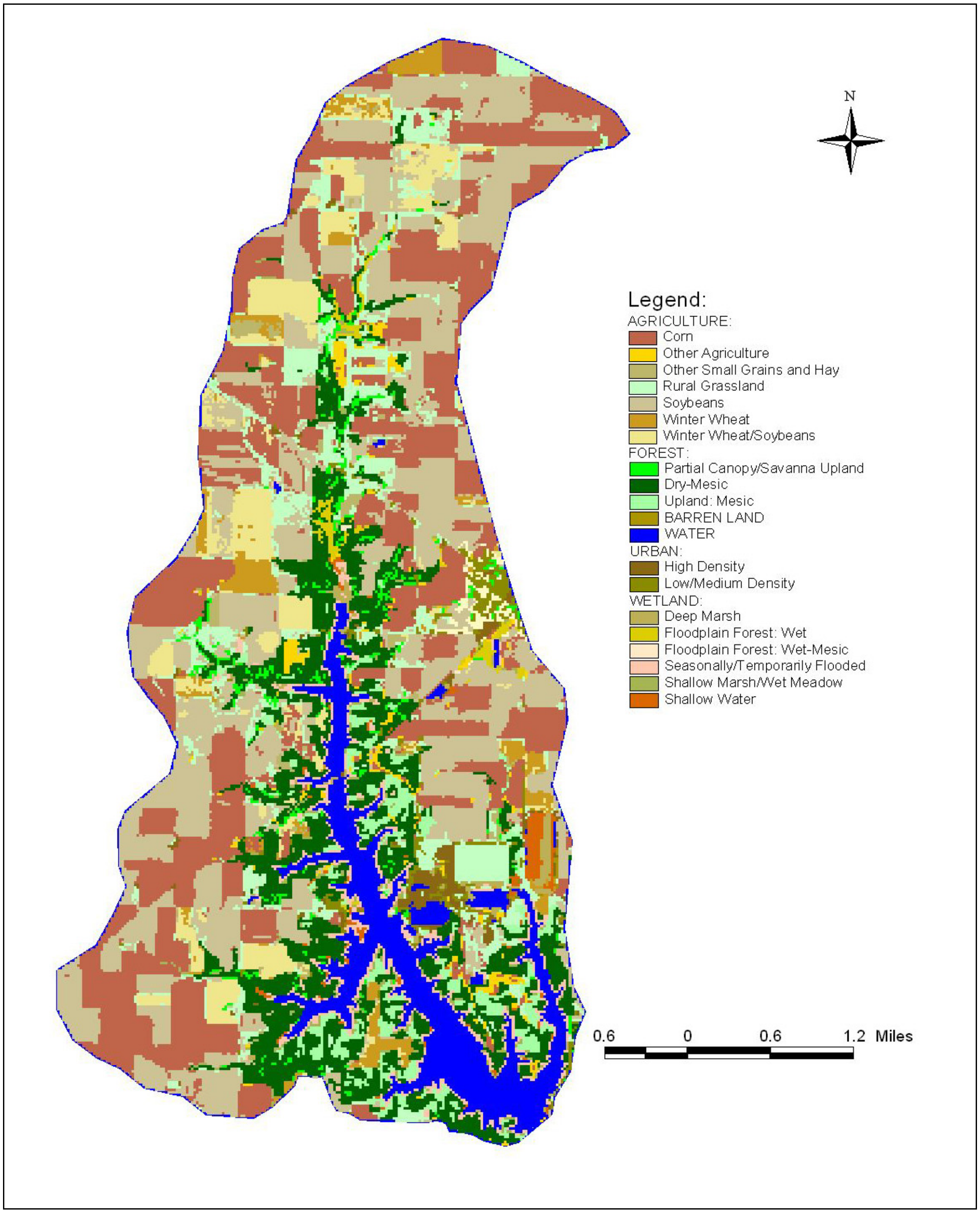


FIGURE 2-4 COFFEEN LAKE WATERSEHD LAND USE AND LAND COVER MAP



Land use distribution is calculated for watersheds contributing to each listed segment. Table 2-5 summarizes the land use for watershed of Greenville Lake watershed. It shows that the agriculture cropland account for about 78.5 percent of total 830-acre watershed. Forest land accounts for 11.9 percent; urban land (including farmstead) accounts for 2 percent, and wetland accounts for 5.1 percent, and water surface account for 2.6 percent.

TABLE 2-5 LAND USES IN LAKE GREENVILLE WATERSHED

Land Use	Area (acre)	Percentage
AGRICULTURAL:		
Soybeans	209.63	25.23
Winter Wheat/Soybeans	147.81	17.79
Corn	118.07	14.21
Rural Grassland	89.60	10.79
Winter Wheat	49.52	5.96
Other Small Grains and Hay	34.06	4.10
Other Agriculture	2.99	0.36
Subtotal	**651.68**	**78.44**
FOREST:		
Upland: Dry-Mesic	72.11	8.68
Partial Canopy/Savanna Upland	26.20	3.15
Upland: Mesic	0.44	0.05
Subtotal	**98.75**	**11.88**
URBAN:		
Low/Medium Density	11.36	1.37
High Density	4.92	0.59
Subtotal	**16.28**	**1.96**
WETLAND:		
Floodplain Forest: Wet	18.16	2.19
Seasonally/Temporarily Flooded	16.05	1.93
Deep Marsh	4.31	0.52
Floodplain Forest: Wet-Mesic	2.37	0.28
Shallow Marsh/Wet Meadow	1.37	0.16
Subtotal	**42.26**	**5.08**
OTHER: SURFACE WATER	21.76	2.62
Total	**830.73**	**100**

Table 2-6 shows the land uses for Coffeen Lake watershed. The agricultural land is dominant in the watershed, accounting for 66.5 percent. Forest land accounts 17.9 percent, urban land and farmstead 2.8 percent, wetland 5.2 percent. Because of Coffeen Lake, the water surface area accounts for 7.5 percent of total watershed.

TALBE 2-6 LAND USES IN WATERSHEDS OF COFFEEN LAKE WATERSHED

Land Use	Area (acre)	Percentage
AGRICULTURAL:		
Soybeans	3,085.7	25.13
Corn	2,916.2	23.75
Rural Grassland	962.3	7.84
Winter Wheat/Soybeans	679.2	5.53
Winter Wheat	311.8	2.54
Other Agriculture	133.2	1.08
Other Small Grains and Hay	82.3	0.67
Subtotal	**8,170.70**	**66.54**
FOREST:		
Upland: Dry-Mesic	1,681.5	13.69
Upland: Mesic	347.4	2.83
Partial Canopy/Savanna Upland	168.1	1.37
Subtotal	**2,197.00**	**17.89**
URBAN:		
Low/Medium Density (excluding TM Scene 2331)	162.6	1.32
High Density	126.1	1.03
Urban Open Space	54.5	0.44
Subtotal	**343.2**	**2.79**
WETLAND:		
Seasonally/Temporarily Flooded	301.3	2.45
Shallow Marsh/Wet Meadow	91.0	0.74
Deep Marsh	83.8	0.68
Floodplain Forest: Wet	78.7	0.64
Shallow Water	77.6	0.63
Floodplain Forest: Wet-Mesic	4.4	0.04
Subtotal	**636.8**	**5.18**
WATER	924.0	7.53
BARREN AND EXPOSED LAND	6.7	0.05
Total	12,278.4	100

Table 2-7 presents the 2004 tillage information for Bond and Montgomery Counties. It appears that large part of agriculture land in Bond County is current through conventional tillage while Montgomery County has significantly implemented conservation tillage practice. Tillage without conservation may contribute suspended solid and phosphorus load to water bodies.

TABLE 2-7 TILLAGE DATA 2004 (ILLINOIS DEPARTMENT OF AGRICULTURE, 2004)

County	Crop	Conventional	Reduced-tillage	Mulch-tillage	No-tillage
Bond	Soybean	67	0	0	33
	Corn	94	0	0	6
	Small Grain	77	0	0	23
Montgomery	Soybean	6	23	38	33
	Corn	76	9	8	7
	Small Grain	0	0	0	100

2.4 TOPOGRAPHY AND GEOLOGY

The Greenville and Coffeen Lakes watersheds are part of a belt of low ridges and hills that rise above a broad, flat, physiographic area called the Springfield Plain. The landscape was shaped largely by great, slow-moving continental masses of ice, called glaciers that covered much of Illinois repeatedly during the past million years or so. Glaciers left deposits of material on the irregular bedrock surface; these materials, generally unconsolidated, but sometimes dense as claystone, include pebbly clay (till), water-laid sand and gravel (outwash), and wind-laid silt (loess). The glacial deposits (drifts) are 150 feet thick or more in the Greenville area. The soils here, as well as in most of the rest of Illinois, are developed in the upper portion of the glacial deposits. The land in the area is gently rolling and ground elevations vary from about 670 feet NGVD at the watershed divide to 530 feet NGVD at the toe of dam.

Curious features are found on the Illinoisan till plain in the Greenville and adjacent areas: elongated ridges and knolls that trend primarily north-northeast. The elongated ridges are composed largely of sand and gravel, and the knolls scattered across the landscape contain gravel, glacial till, and blocks of ice-thrusted bedrock. The origin of these features has been the object of much debate throughout this century, but the latest research indicated that they are the result of deposition from glaciers that, for the most part, were stagnant. These deposits have been of considerable interest for many years because they are one of the most important sources of building and road materials in southern Illinois.

The relatively loose Quaternary deposits in the Greenville area are underlain by consolidated, layered bedrock strata of the Pennsylvanian age that were deposited in shallow seas that some 275 million years ago repeatedly covered this part of what is now the Mid-continent Region of North America. Relatively thin layers of rock, such as shale, limestone, coal, and sandstone, are exposed only at a few places along stream banks and in quarries and roadcuts. Older strata, known from water, oil, and gas prospect wells, have an aggregate thickness here of between 6,000 and 7,000 feet. These strata dip down gently to the south and east into the deeper parts of the Illinois Basin forming a broad, shallow, spoon-shaped bedrock depression that underlies much of southern Illinois and adjacent portions of southwestern Indiana and western Kentucky.

Groundwater in this area is obtained from underground reservoirs occurring in beds of saturated glacial sand and gravel or stream alluvium, or in porous or creviced bedrock layers. Groundwater is released slowly into creeks, lakes, and ponds during dry periods, replenishing water lost through evaporation, outflow, and well water and other withdraws. Exfiltration is not a significant source of water exflow from Greenville Lake.

The original municipal water supply for Greenville was obtained from shallow sand and gravel wells located in the southern part of the city that tapped the Hagarstown Member of the Glasford Formation. In 1923, this location was abandoned when eight new wells ranging from 45 to 60 feet deep were put into service just north of the depot between Second and Third Streets (in Greenville). The combined yield of these new wells was about 195 gallons per minute (gpm). In 1927, seven new wells, with an average depth of 62 feet below ground surface, were opened north of the stockyard and had a total yield of about 300 gpm. Additional exploration, only partially successful, for sand and gravel well sites was undertaken as water demands increased in the 1940s and 1950s. In the late 1960s, damming the Kingsbury Branch north of Greenville formed Governor Bond Lake. This lake covers 775 acres and provides drinking water for the city and surrounding communities. Greenville Lake has never been a municipal raw water source.

The topography of the watershed ranges from nearly level to gently rolling hills, which become increasingly steep in proximity to streams. Nearly 70% of the land area in the watershed is in agricultural production. Three percent of the watershed, occurring mostly along streams, is forested. The remainder is either pasture, residential, or open water.

2.5 SOILS

Major soil associations found within the Greenville watershed include:

- Oconee-Darmstadt Association (~54%): Nearly level or gently sloping, somewhat poorly drained soils that have a slowly permeable or very slowly permeable subsoil and formed in loess; on uplands
- Ava-Hickory-Parke Association (~41%): Gently sloping to steep, moderately well drained or well drained soils that have a very slowly permeable or moderately permeable subsoil and formed in glacial till or in loess and glacial drift; on uplands
- Pisa Cowden Association (~5%): Nearly level, poorly drained soils that have a very slowly permeable or slowly permeable subsoil and formed in loess; on uplands

Soil Types in Greenville Lake Watershed			
Type	Percent	Slope	Eroded
Cowden Silt Loam	1.19	0-5	No
Cowden-Piasa Silt Loam	30.44	0-5	No
Oconee Silt Loam	0.59	0-2	No
Oconee Silt Loam	1.19	2-5	No
Oconee Silt Loam	3.57	2-5	Yes
Oconee-Darmstadt Silt Loam	5.95	0-3	No
Oconee-Darmstadt Silt Loam	7.25	2-5	Yes
Hosmer Silt Loam	1.1	2-5	No
Stoy Silt Loam	8.44	0-2	No
Stoy Silt Loam	10.58	2-5	No
Stoy Silt Loam	2.62	2-5	Yes
Pike Silt Loam	4.28	2-5	No
Wakeland Silt Loam	0.71	0-2	No
Percent of Total	77.91		
Percent Eroded Soil Type	13.44		
Atlas Silty Clay Loam	5.11	5-10	Yes
Parke Silt Loam	1.31	5-12	Yes
Hosmer Silt Loam	1.9	5-10	Yes
Percent of total	8.32		
Percent Eroded Soil Type	8.32		
Hickory Silt Loam	13.79	15-30	No
Percent of total	13.79		
Percent eroded soil type	13.79		

Soil types were measured with a digital planimeter, within a watershed boundary super-imposed on a soils map. Information on erosion is taken from the general soil description, and is not derived from site-specific inventory or other measured means. .

GIS soil data from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Greenville and Coffeen Lakes watershed. General soils data and map unit delineations for the country are provided as part of the State Soil Geographic (STATSGO) database. GIS coverage provides locations for the soil map units at a scale of 1:250,000 (USDA, 1995). A map unit is composed of several soil series having similar properties. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics. The STATSGO database contains many soil characteristics associated with each map unit. Of particular interest are the hydrologic soil group, the K-factor of the Universal Soil Loss Equation (USLE), and depth to water table.

The hydrologic soil group classification identifies soil groups with similar infiltration and runoff characteristics during periods of prolonged wetting. Typically, clay soils that are poorly drained have lower infiltration rates, while well-drained sandy soils have the greatest infiltration rates. NRCS (2001) has defined four hydrologic groups for soils as listed in Table 2-10.

TABLE 2-10 NRCS HYDROLOGIC SOIL GROUP

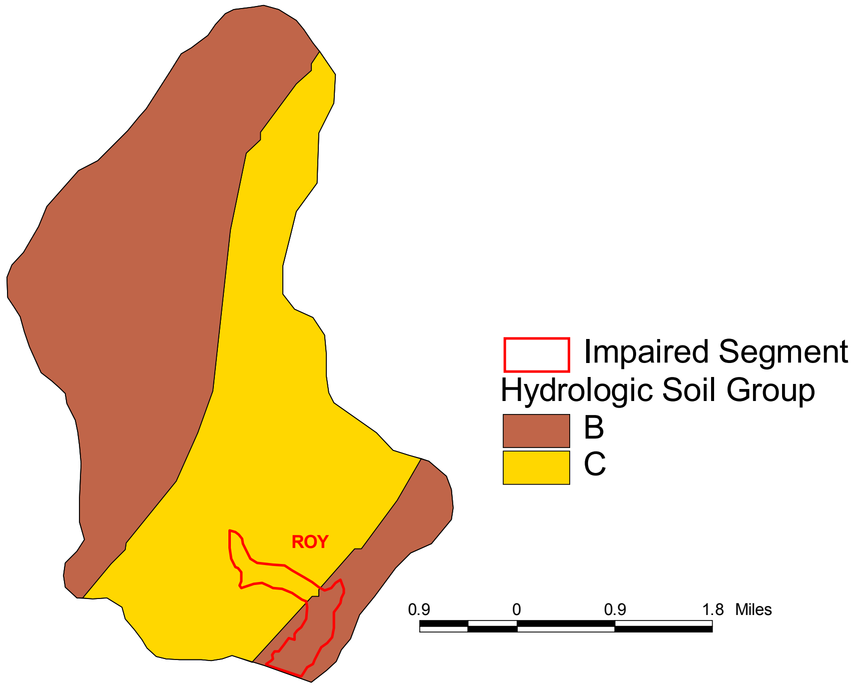
Hydrologic Soil Group	Description
A	Soils with high infiltrations rates. Usually deep, well drained sands or gravels. Little runoff.
B	Soils with moderate infiltration rates. Usually moderately deep, moderately well drained soils.
C	Soils with slow infiltration rates. Soils with finer textures and slow water movement.
D	Soils with very slow infiltration rates. Soils with high clay content and poor drainage. High amounts of runoff.

Dual hydrologic groups, A/D, B/D, and C/D, are given for certain wet soils that can be adequately drained. The first letter applies to the drained condition, the second to the undrained. Only soils that are rated D in their natural condition are assigned to dual classes. Soils may be assigned to dual groups if drainage is feasible and practical. Figure 2-3 displays the STATSGO hydrologic soil group map for the Greenville and Coffeen Lakes watershed.

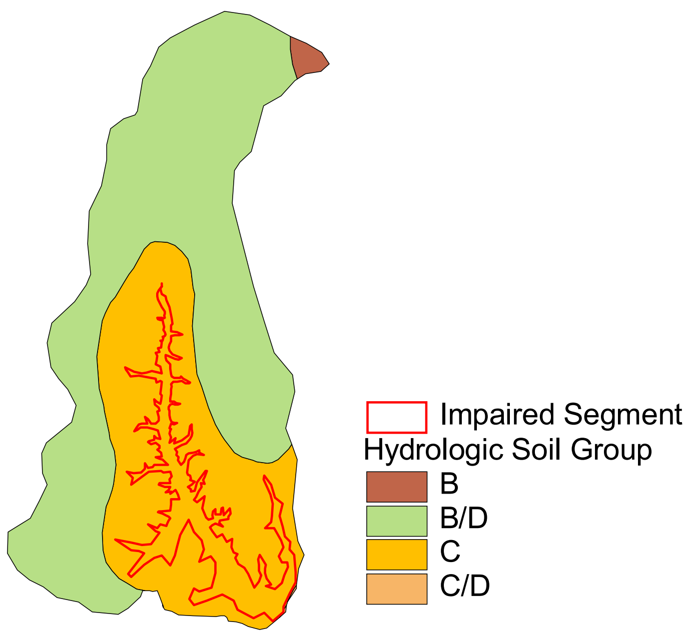
A commonly used soil attribute of interest is the K-factor, a coefficient used in the USLE (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion. Factor values may range from 0 for water surfaces to 1.00 (although in practice, maximum factor values do not generally exceed 0.67). Large K-factor values reflect greater potential soil erodibility. The distribution of K-factor values in the Coffeen and the Greenville Lakes watershed is shown in Figure 2-4.

The depth to the groundwater table determines the groundwater flow contribution to the two lakes. When the depth is shallower, there is a better chance for groundwater to discharge to the lakes. The depth to the water table varies seasonally. The estimated depth to the water table is based on NRCS Soil Survey. Each soil unit has an estimated depth to the water table associated with it. Figure 2-5 presents the distribution of depth to the seasonal high water table in the watershed.

FIGURE 2-3 HYDROLOGIC SOIL GROUP MAP

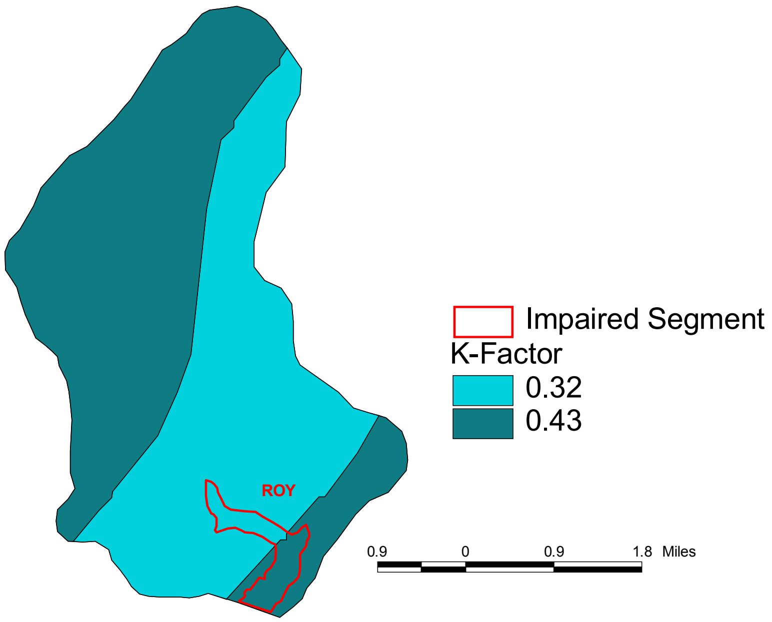


Greenville Lake Watershed

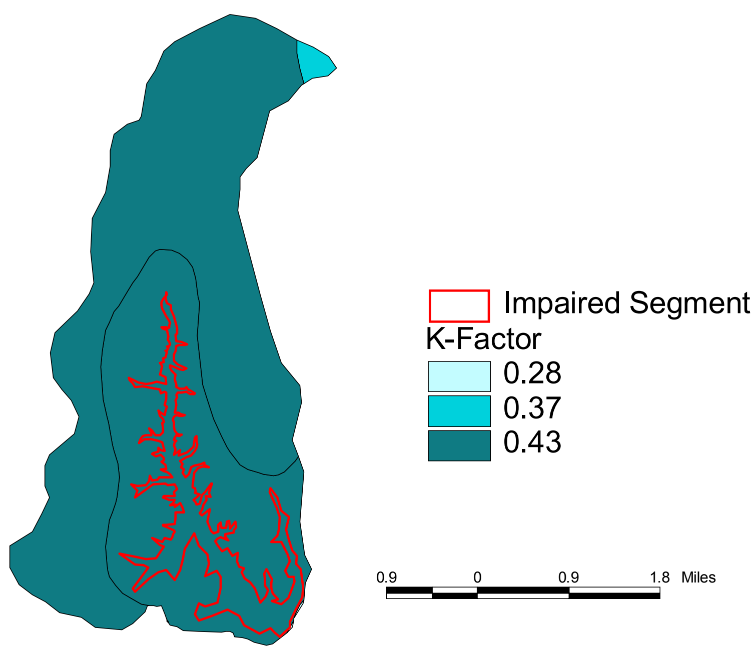


Coffeen Lake Watershed

FIGURE 2-4 SOIL EROSION K-FACTOR MAP

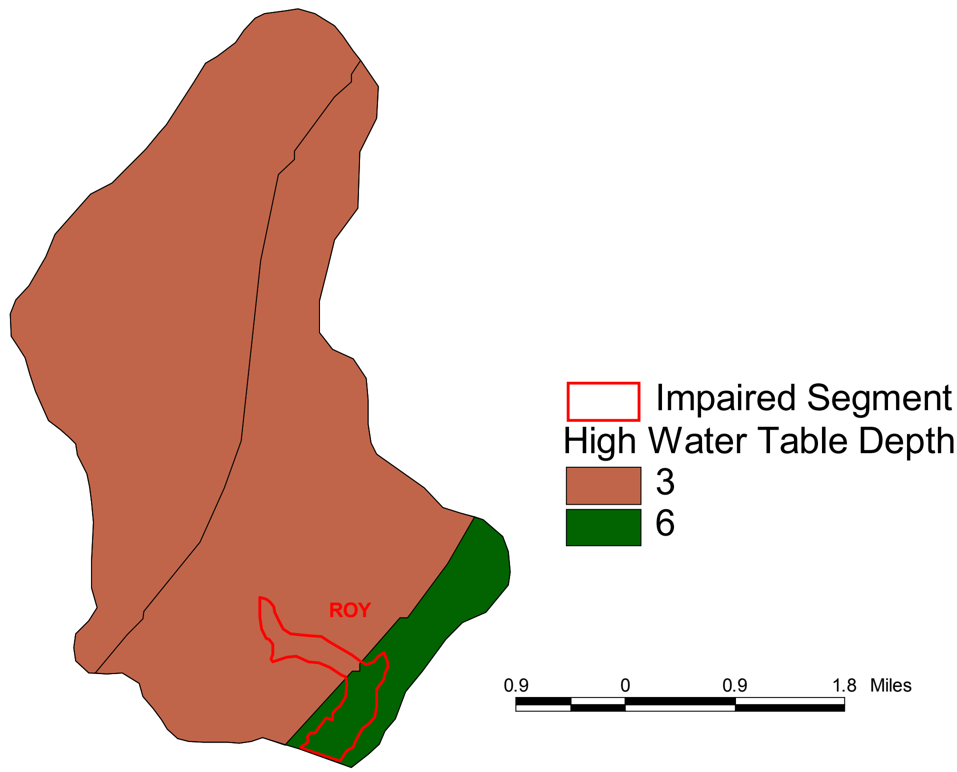


Greenville Watershed

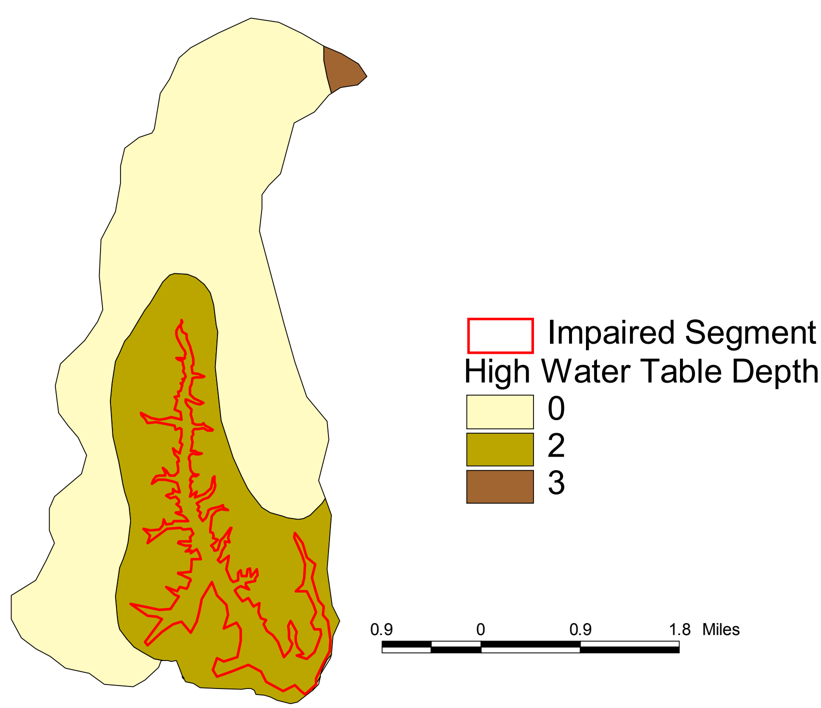


Coffeen Lake Watershed

FIGURE 2-6 DEPTH TO SEASONAL HIGH WATER TABLE



Greenville Lake Watershed



Coffeen Lake Watershed

2.6 WATERBODY CHARACTERISTICS

This section discusses waterbody characteristics for Greenville and Coffeen Lakes.

2.6.1 Greenville Lake

Greenville Lake is located west of Greenville, Illinois. The Kingsbury Park District manages the lake. Greenville Lake has been used as a recreational resource since its construction in 1933. The construction of the surrounding park in its original configuration was completed in 1940. In 1952, the shelter house north of the main drive was added. The facility remains today, and is one of the most frequently used facilities at the lake. The band shelter near the west end of the park was constructed in 1960. The shelter and amphitheater received less use in the 1970s, and the shelter covering was torn down in 1980. Recently, electricity was added to the amphitheater area and this facility has experienced a revitalization of use for community theater and other events. Prior to the 1970s, swimming was one of the primary recreational activities enjoyed at Patriot's Park and all municipal swimming lessons were held at Patriot's Park prior to construction of the municipal swimming pool. Swimming in Patriot's Park was discontinued in approximately 1974 by the Bond County Health Department due to poor water quality.

Fishing and lakeside recreation are two major activities that occur on the lake. Other activities include boating, camping, cross-country skiing, horseback riding, hiking, picnicking and various educational activities.

TABLE 2-11 GREENVILLE LAKE CHARACTERISTICS

Characteristic	Value
Drainage area	830 acres
Water surface	26 acres[b]
Emergency spillway elevation	Unknown
Maximum storage	224.4 acre-feet[a]
Normal storage	224.4 acre-feet[a]
Maximum pool length	3.6 miles[a]
Shoreline length	1.5 miles[a,b]
Average depth	9.12 feet[a,b]
Maximum depth	16 feet[b]
Dam length	600 feet[b]
Designed maximum discharge	Unknown
Average hydraulic retention time	0.2 year

Notes:
NGVD National Geodetic Vertical Datum
a Source: Illinois State Water Survey 1999
b Source: Illinois Natural History Survey 1993

2.6.2 Coffeen Lake

Coffeen Lake is located on McDavid Branch about 0.25 miles from its confluence with Shoal Creek. The Central Illinois Public Service Company built a 75-foot high earthen dam on a branch of the East Fork of Shoal Creek in 1963. The lake was completely filled by 1966 and now serves as cooling water for the coal-fired Coffeen Power Station. The power station has a generating capacity of 945 megawatts of electricity, with the first unit coming into operation in 1965 and the larger, second unit in 1972. The heated discharge affects 73% of the surface water. The cooling loop is 4.1 miles.

Coffeen Lake Dam is an earthfill structure with spill way. A pump station pumps water from the downstream channels to the lake during dry season. The preliminary design report estimated an average annual loss in capacity to by 0.08% per year, resulting from the sediment load from the watershed. The lake surface area is 1,096 acres, about 9 percent of the drainage area. A railroad embankment crosses the lake about 1.6 mile from the dam. About 57 percent of the watershed area drains to the waterway opening under the embankment. In 1982, an intake channel with weir between the East Fork Shoal Creek and the Coffeen Lake Dam spillway was contracted to divert water from East Fork Shoal Creek to Coffeen Lake. This diversion may potentially contribute sediment and phosphorus load to the Lake. The diversion structure and flow will be further discussed when the information becomes available.

TABLE 2-11 LAKE COFFEEN CHARACTERISTICS

Characteristic	Value
Drainage area	4,452 hectares[a]
Water surface	1,096 acres[a]
Emergency spillway elevation	590 feet NGVD[b]
Maximum storage	35,800 acre-feet[a]
Normal storage	22,000 acre-feet[a]
Maximum pool length	6.3 miles[a]
Shoreline length	47.9 miles[a]
Average depth	18.7 feet[a]
Maximum depth	58 feet[a]
Dam length	1,300 feet[a]
Designed maximum discharge	12200 ft^3/s[a]
Average hydraulic retention time	2.1 years[a]

Notes:
NGVD National Geodetic Vertical Datum
a Source: Illinois Natural History Survey 1993

3.0 CLIMATE AND HYDROLOGY

This section discusses the climate of the watershed and its hydrology.

3.1 CLIMATE

The western portion of Illinois has a continental climate with cold, rather dry winters, and warm humid summers. Table 3-1 summarizes climate characteristics near Coffeen, Illinois, based on the climate records up to 2001. The average annual precipitation at Coffeen, Illinois is about 40 inches. Monthly average precipitation is about 3.3 inches. Months from March through August are wet months, with average precipitation between 3.4 and 4.3 inches per month. Months from September through February are relatively dry, with average precipitation of 2.2 to 3.2 inches per month. On average, there are 110 days with precipitation each year. The average annual temperature at Coffeen, Illinois is approximately 55.6° F. The maximum and minimum average temperatures are 66.0° F and 45.2° F, respectively.

TABLE 3-1 CLIMATE CHARACTERISTICS NEAR COFFEEN, ILLINOIS

Climate Variable	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
Average temp. (°F)	28.6	34.2	44.7	56.0	65.9	75.0	78.8	76.7	69.4	58.0	45.3	33.3	55.6
High temperature (°F)	36.7	43.3	54.8	67.2	77.3	86.3	90.0	88.3	81.6	70.0	54.3	41.2	66.0
Low temperature (°F)	20.4	25.1	34.6	44.6	54.5	63.7	67.6	65.2	57.1	46.0	36.3	25.5	45.2
Precipitation (in)	2.2	2.1	3.5	4.0	4.3	4.1	3.6	3.4	3.2	2.9	3.8	2.9	40.0 (total)
Days with Precip	9	8	11	11	11	9	9	8	8	8	9	9	9.2
Wind speed (mph)	11.4	11.5	12.4	12.1	10.2	9.2	8.1	7.7	8.4	9.5	11.2	11.1	10.2
Morning humidity (%)	81	80	80	78	81	82	84	87	87	83	82	82	82.3
Afternoon humidity (%)	69	67	63	59	59	59	61	62	61	59	66	77	63
Sunshine (%)	49	52	53	56	61	67	69	67	65	61	47	43	57.5
Days clear of clouds	7	7	6	7	7	7	9	10	11	12	8	7	8.2
Partly cloudy days	7	6	8	8	9	10	11	11	8	7	7	7	8.3
Cloudy days	17	15	17	15	14	12	10	10	10	11	16	18	13.8
Snowfall (in)	5.7	5.1	3.9	0.6	0.0	0.0	0.0	0.0	0.0	0.0	1.6	4.5	1.8

Notes:

°F Degrees Fahrenheit
in Inch
mph Miles per hour
% Percent

Source: City-Data.Com 2005

3.2 HYDROLOGY

Hydrology in Greenville and Coffeen Lake watershed is mostly affected by glacial processes and deposits that cover the watershed. The principal source of surface runoff is precipitation that enters the stream as overland flow, which is rainwater or snowmelt that flows over the land surface toward stream channels. In agricultural areas, there is more infiltration and much less overland flow compared to urban areas. The average annual runoff accounts for about 35 percent of annual precipitation. Groundwater discharge to the lakes affects the flow and water quality of the stream. The actual groundwater contribution can be determined by a water balance in the river.

Greenville Lake, also named Patriot's Park Lake, constructed in 1933, is a centerpiece resource for the Kingsbury Park District (KPD). In February of 2001, the Kingsbury Park District was awarded funding for the study of Patriot's Park Lake through the IEPA Clean Lakes Program. Work on the study began in May of 2001 and included extensive field sampling, water quality analyses and data interpretation. The results of this effort are documented in a diagnostic report (Sauerwein and others, 2001). The following discussion on the lake characteristics is extracted from this report.

An annual water budget was calculated for Greenville Lake using established IEPA and state water survey protocol. To determine the amount of water entering the lake, a staff gauge was placed in the major tributary at site ROY-2, south of Illinois Route 140. Kingsbury Park District staff members recorded the stream height on the staff gauge on a daily basis. Cross-sections of the stream were measured at the gauge site. A relationship was established for the area of the cross-section in relation to staff gauge height and flow velocity in feet-per-second was measured using a Global Water flow measuring instrument. Flow and area measurements were combined to establish a relationship between staff height and stream discharge at the cross-section. Calculations were then used to determine the volume of water, in acre-feet, entering the lake each day from the tributary. In addition to water flowing in from the watershed, direct precipitation onto the lake surface was calculated from daily rain amounts recorded at the caretaker's house located on the north shore of the lake.

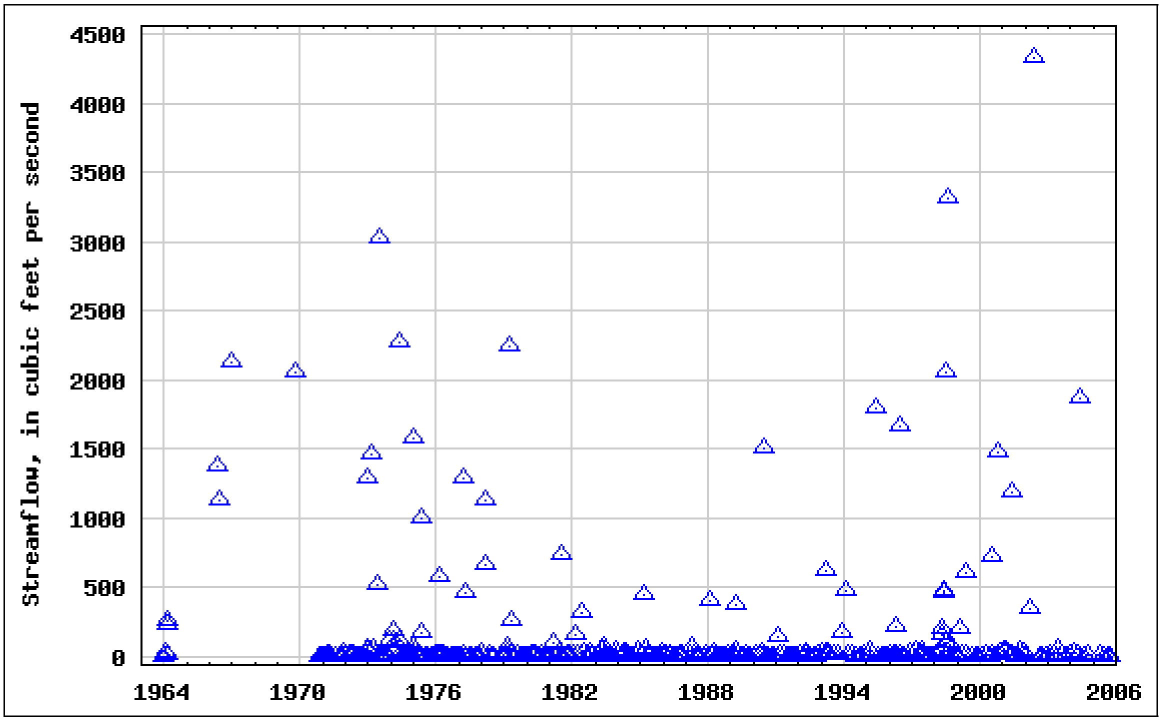
The outflow from the lakes included evaporation from the lake and discharge over the spillways, and potential seepage through the dams. The capacity of the lake's spillway was determined through use of the weir equation: $Q = C L H^{(3/2)}$, where Q is the outflow rate in cubic feet-per-second, C is the weir coefficient based on H, L is the length of the outlet in feet, and H is the headwater depth in feet Evaporation was calculated using 50 years of historical evaporation rates in Illinois. Multiplying the area of the lake by the inches of evaporation, a volume of evaporation was calculated. The difference between the outflow and the inflow is a net hydrologic loading that indicates either a greater inflow or greater outflow. The water budget is presented in Table 3-2, indicating that from May 2001 to April 2002, there was a net inflow of approximately 1,133 acre-feet (Sauerwein and others, 2001).

TABLE 3-2 WATER BUDGET FOR GREENVILLE LAKE

	In Flow			Out Flow		
Month	Tributaries (ac-ft)	Lake precipitation (ac-ft)	Inputs monthly (ac-ft)	Spillway discharge (ac-ft)	Lake evaporation (ac-ft)	Outputs monthly
May-01	131.5333	8.385	140.2408	10.6	10.5975	21.1975
Jun-01	149.0776	4.637	153.8926	85.9	12.375	98.275
Jul-01	58.94669	6.63	65.83169	0.3	14.175	14.475
Aug-01	0	7.085	7.3575	0.1	11.655	11.755
Sep-01	0	5.547	5.76	0	8.2575	8.2575
Oct-01	72.73393	10.877	84.02893	0.4	5.2425	5.6425
Nov-01	147.9371	5.395	153.5396	5.1	2.5875	7.6875
Dec-01	741.3402	7.215	748.8327	948.8	1.2375	950.038
Jan-02	378.1444	3.748	382.0369	243.4	1.2375	244.6375
Feb-02	607.4504	2.08	609.6104	355	1.9125	356.9125
Mar-02	1240.825	5.763	1246.81	86.8	4.0725	90.8725
Apr-02	1166.926	10.183	1177.501	1822.5	7.425	1829.925
Annual Total	4694.915	77.548	4772.463	3558.9	80.775	3639.675

The observed flow data for Coffeen Lake has not been identified at the time the report is prepared. A USGS gage (05593900) on East Fork Shoal Creek near Coffeen, IL recorded flows from time to time since 1964. Figure 3-1 presents the observed stream flows in East Fork Shoal Creek. The data may be used to extrapolate the inflow to Coffeen Lake if there is no data for the Lake.

FIGURE 3-1 FLOW DATA AT USGS STATION 05593900 EAST FORK SHOAL CREEK NEAR COFFEEN, IL



4.0 WATER QUALITY

This chapter discusses applicable water quality standards and the pollutants-of-concern in Greenville and Coffeen Lakes. The available water quality data is evaluated to verify impairments in listed segments by comparing observed data with water quality standards or appropriate targets. The spatial and temporal water quality variations as well as the correlation among the constituents are assessed.

4.1 WATER QUALITY STANDARDS AND END POINTS

This section describes applicable water quality standards for Greenville and Coffeen Lakes. Based on the standards, TMDL endpoints were identified as numeric water quality targets.

4.1.1 Lake Water Quality Standards

Greenville and Coffeen Lakes are listed on the Illinois 303(d) list for use impairment caused by phosphorous, suspended solids, and excessive algal growth. The water quality standard associated with the listing is total phosphorus.

Table 4-1 summarizes the applicable water quality standard for both Greenville and Coffeen Lakes.

TABLE 4-1 WATER QUALITY STANDARD FOR GREENVILLE AND COFFEEN LAKES

Parameter	Standard
Total Phosphorus	Phosphorus as TP shall not exceed 0.05 mg/L in any reservoir or lake with a surface area of 8.1 hectares (20 acres) or more or in any stream at the point where it enters any such reservoir or lake

Excessive algal growth is listed as a cause of impairment in Greenville and Coffeen Lakes. Algal biomass is commonly measured through a surrogate, Chlorophyll-a (Chl-a), which is a plant pigment. The abundance of Chl-a in water highly correlates with the amount of algae present. The State of Illinois does not have a numeric standard for Chl-a. The algal growth is directly related to excessive amount of limiting nutrients and light availability for photosynthesis. Phosphorus is identified as a limiting nutrient in this report. Consequently, TP can be considered a surrogate indicator for excessive algal growth. Sources of TP in the lakes' water can be the result of erosion of sediments, by direct discharge or, in limited cases, from phosphate-rich runoff water (e.g., from heavy land application of fertilizers and animal manure). Generally, land-applied phosphorus is in the mineralized fertilizer form (inorganic phosphate) that is easily adsorbed to soil particles (that is why phosphorus mobility is limited to soil movement). Because of that controlling soil erosion is imperative in controlling particulate phosphorus. However, soils reaching phosphate adsorption capacity such as in areas with heavy applications of organic (manure, plant residue) and inorganic phosphate-rich fertilizers, inorganic phosphates will enter waterways even if soil erosion is controlled.

4.1.2 TMDL Endpoints

To meet all designated uses, a water body must meet the standards identified for its most sensitive use. TMDL endpoints are the numeric target values of pollutants and parameters for a water body that represent the conditions that will attain water quality standards and restore the water body to its designated uses. The most stringent standards are chosen as the endpoints for the TMDL analysis. Usually, if an applicable numeric water quality standard violation is the basis for 303(d) listing, the numeric criterion is selected as the TMDL endpoint. If the applicable water quality standard or guideline is narrative or is not protective of the designated use, a numeric water quality target must be established or adopted from site-specific water quality and biologic assessment. Table 4-2 summarizes the endpoints that will be used in the TMDL development for Greenville and Coffeen Lakes.

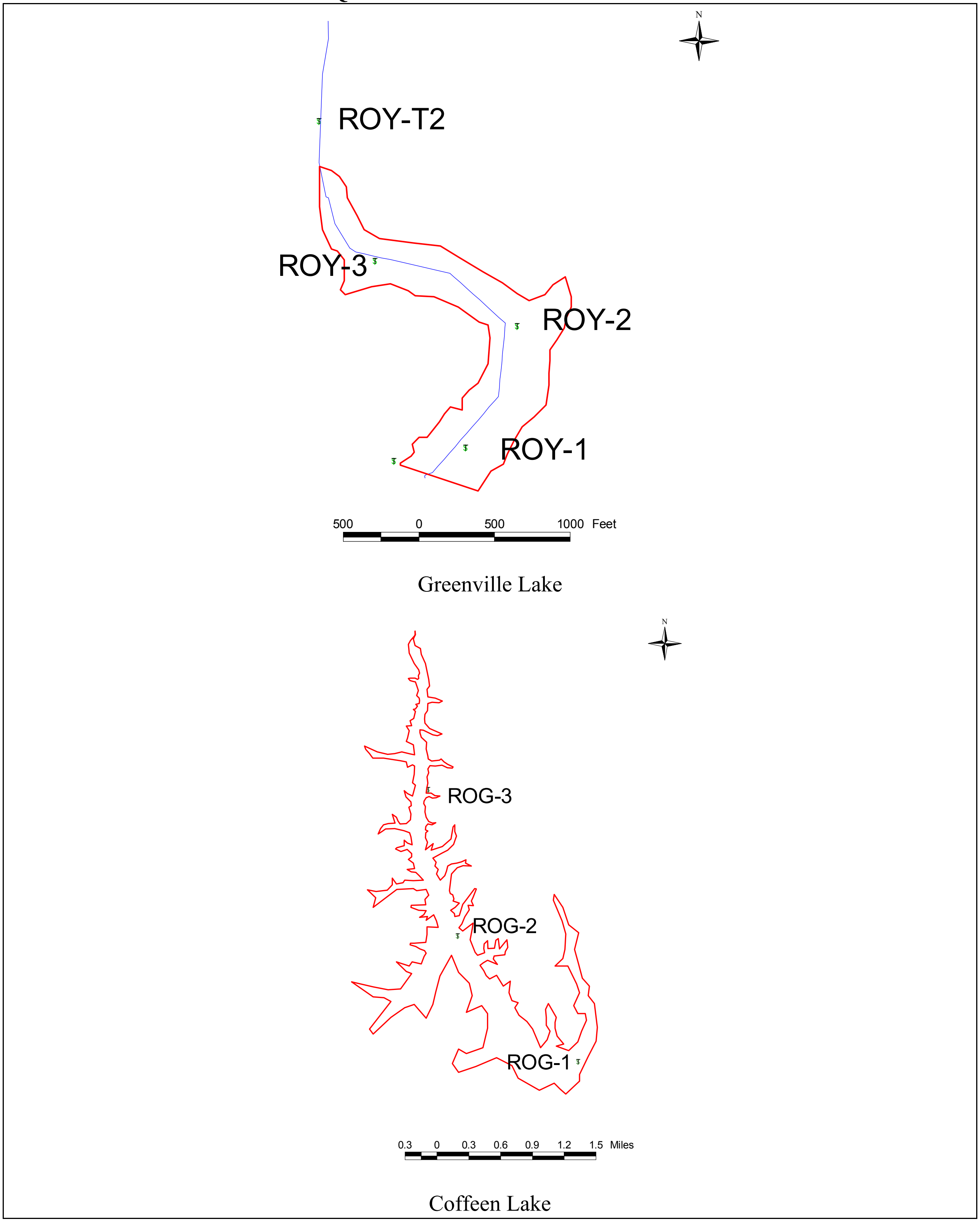
TABLE 4-2 TMDL ENDPOINTS

Parameter	TMDL Endpoint		Indicator
	Greenville Lake	Coffeen Lake	
Total Phosphorus (mg/L)	<0.05	<0.05	Direct measurement Surrogate for excessive algal growth

4.2 DATA AVAILABILITY

From 2001 to 2002, IL EPA collected monthly water samples at three locations in both lakes. At Greenville Lake the sampling locations were chosen at approximately 0.2 miles of each other covering the full length of the bow-shaped lake. The three sampling points at Coffeen Lake are spaced at about 1.5 miles of each other covering the main body of the lake. Figure 4-1 presents the waster quality sampling sites at Greenville Lake and Coffeen Lake. The available water quality data before 1999 was obtained from US EPA STORET database. Water quality parameters include TP, dissolved phosphorus (DP), ammonia nitrogen, nitrite and nitrate, and Chlorophyll- a. This report primarily assessed the parameters that are related to the listed causes for two lakes, phosphorus, chlorophyll-a, and total suspended solids. The water quality data are include in Appendix B.

FIGURE 4-1 WATER QUALITY SAMPLING SITES IN GREENVILLE LAKE



4.3 ASSESSMENT OF WATER QUALITY DATA

This section discusses the pollutants of concern for the listed segments, Lake Greenville (ROY) and Lake Coffeen (ROG). The available water quality data is analyzed and assessed to verify the impairments of listed segments by comparing observed data with water quality standards or appropriate targets. The potential spatial and temporal variation of water quality conditions is evaluated for both lakes.

4.3.1 Lake Greenville (ROY)

This section presents the water quality assessment for Greenville Lake using the available data.

4.3.1.1 Phosphorus

Phosphorus is an important component of organic matter. As a constituent of nucleic acids in all cells, it is vital for all organisms. In streams and rivers, phosphorus is usually the limiting nutrient in photosynthetic production in algae. Phosphorus enters the lake not only through stormwater runoff, but also through natural mineralization of phosphates in the soil and rock and man-made sources. Phosphorus is measured in two ways: as TP and as DP phosphorus. Streams with high TP and low DP levels usually have the most phosphorus input from nonpoint source pollution, such as agriculture runoff. Since phosphorus can be bound to sediments such as clay, phosphorus is measured through the suspended solids potency. DP measurements provide insights into how much of the phosphorus entering a stream is potentially from point sources and diffusive sources such as livestock operations and animal feedlots or septic systems. Untreated wastewater can have phosphorus concentrations as high as 10 mg/L and feedlot overflow can contribute up to 4 to 5 mg/L. Phosphorous was listed as a cause of impairment in the 2004 IEPA 303(d) list. Phosphorous is also used as an indicator for excessive algal growth in Greenville Lake.

Figure 4-2 presents the monthly descriptive statistics for TP in the Greenville Lake. The months of March through June have relatively lower TP, and then TP starts to increase through the summer growing season reaching a higher level in October. TP decreases slightly in late fall and early winter. The average annual concentration goes up and down, likely attributed to the precipitation change and activities in the watershed. The average annual concentrations exceed the lake phosphorus standard of 0.05 mg/l in every month, which confirm the list of phosphorus as cause for impairment in 2004 303(d) list.

Figure 4-3 presents TP data by sites based the data from 1989 to 2002. The figure indicates that at all locations, TP concentrations (total 138 samples) exceed the water quality standard of 0.05 mg/L. The TP concentrations at ROY-2 are slightly higher than other two locations. One possible explanation is that TP concentrations site are affected by direct inflow from a nearby tributaries, which may provide sufficient phosphorus load to elevate the concentration locally.

FIGURE 4-2 MONTHLY AVERAGE TOTAL PHOSPHORUS CONCENTRATION IN GREENVILLE LAKE (ALL SAMPLING SITES)

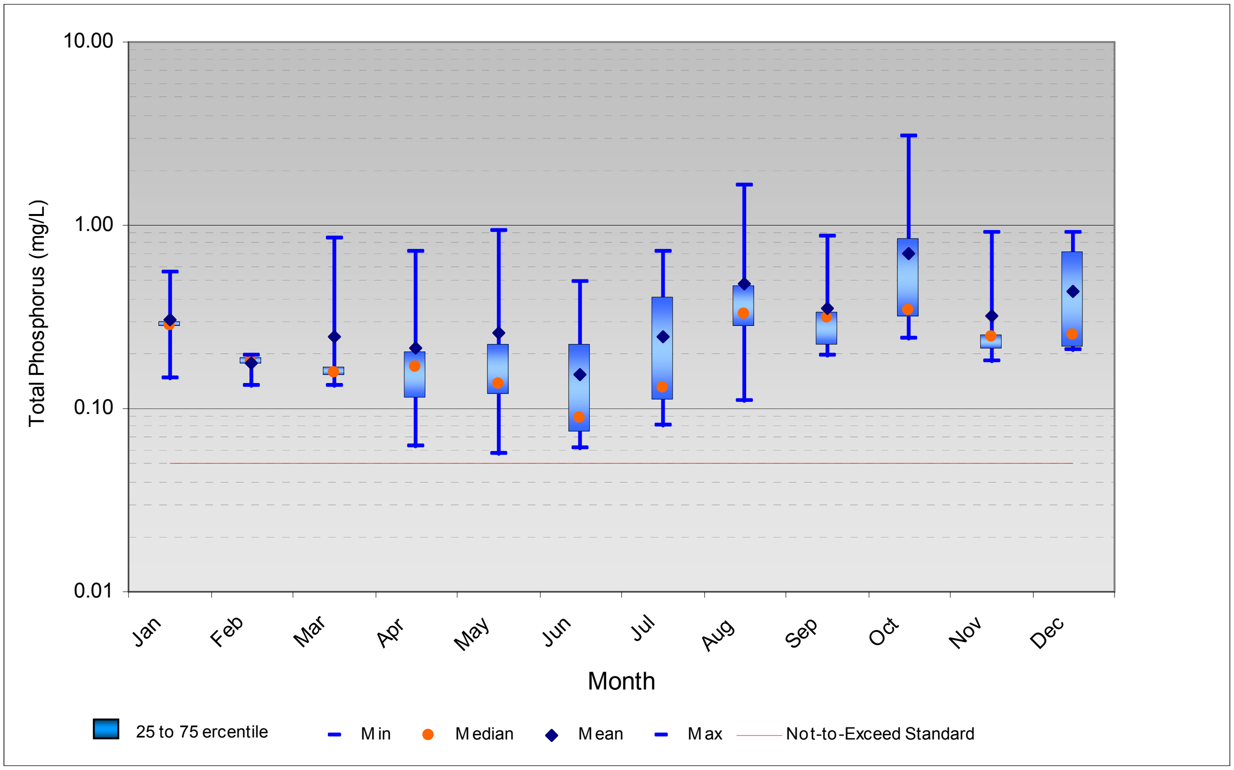


FIGURE 4-3 TOTAL PHOSPHORUS CONCENTRATION AT SAMPLING SITES IN GREENVILLE LAKE

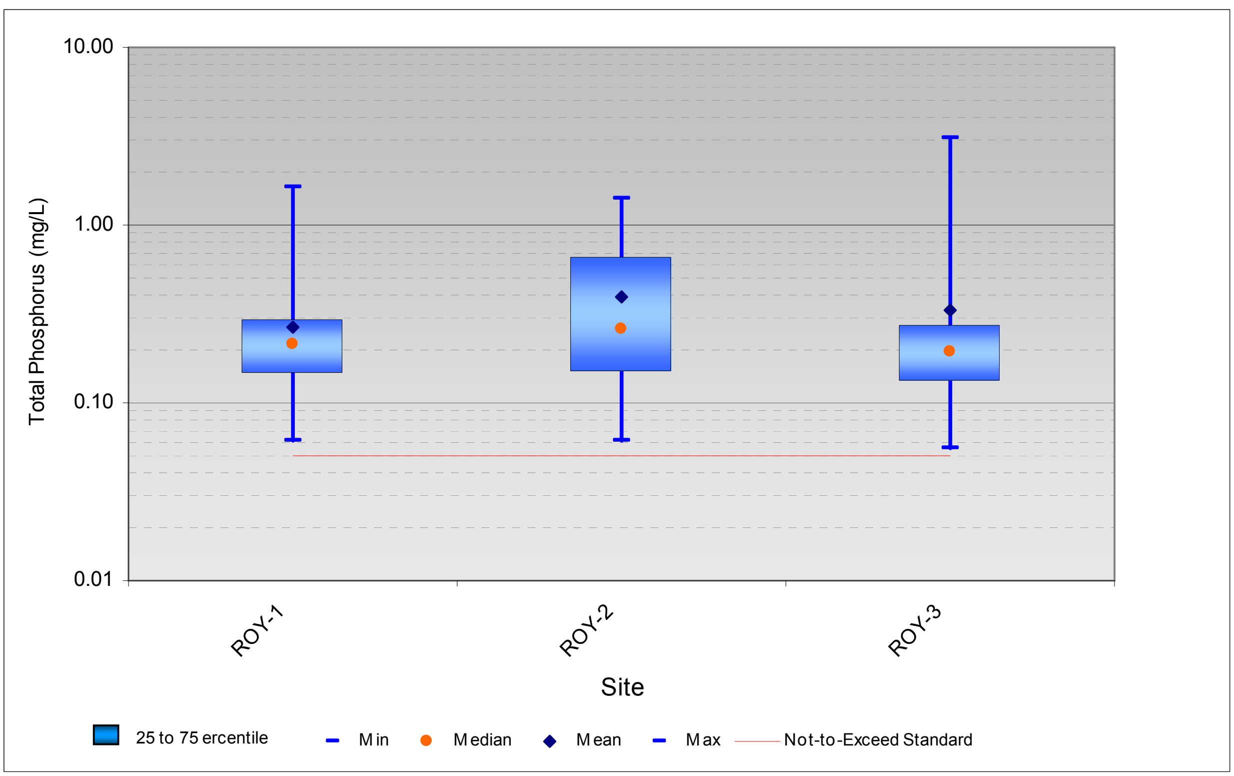


Figure 4-3 presents the dissolved phosphorus (DP) at three sampling locations. Similar to TP, the DP concentration is higher at Site ROY-2. As shown by the data points at ROY-1, TP is elevated where the water is deeper. This indicated that the phosphorus bound in the sediments on the bottom of the lake may contribute to the nutrient loading to the lake water column. When the dissolved oxygen concentration within about 3 of the bottom of the lake is less than 1mg/L, phosphorus trapped in the sediments is released to the lake water.

FIGURE 4-3 DISSOLVED PHOSPHORUS CONCENTRATIONS IN GREENVILLE LAKE

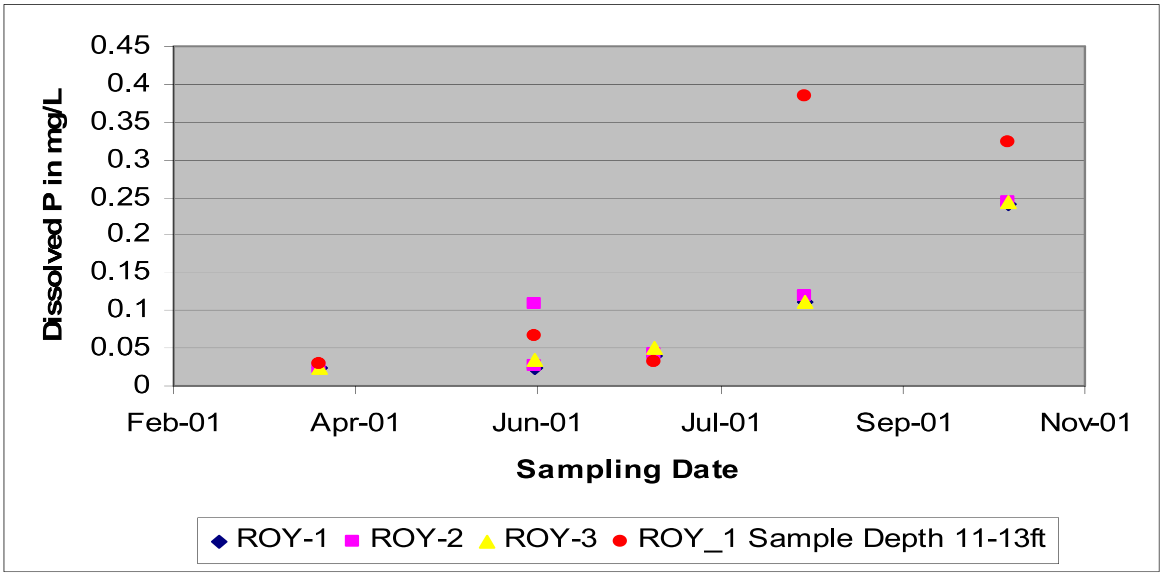


Table 4-5 summarizes the monthly average DP and TP concentrations in the lake. In average, 38 percent of TP is dissolved while the rest is in particulate form. The particulate phosphorus load is often associated with the suspended solids in the surface water runoff while the dissolve P is contributed by organic matter. Lake mixing dynamics can greatly affect water quality in terms of chemical (nutrient) availability and the concentrations, location, and forms in which chemicals are present. Phosphorus settles out of the water column to the lake bottom as particulate-phosphorus and is bound to the lake bottom sediment. This phosphorus generally is not available for aquatic plant growth and is not a water quality problem. However, anoxic conditions at the lake bottom can result in the release of bound phosphorus. If no subsequent mixing occurs in the water column, the dissolved phosphorus will remain at the lake bottom. On the other hand, when mixing does occur, the dissolved phosphorus is brought up to the surface, where it is available for algal uptake.

TABLE 4-3 MONTHLY AVERAGE DISSOLVED PHOSPHORUS AND TOTAL PHOSPHORUS CONCENTRATIONS IN GREENVILLE LAKE ROY-1 SAMPLING STATION

Month	DP	TP	Percent DP
Apr-01	0.025	0.09	28%
Jun-01	0.024	0.13	18%
Jul-01	0.04	0.20	20%
Aug-01	0.11	0.28	40%
Sep-01	0.04	0.28	14%
Oct-01	0.242	0.30	82%
Average	0.08	0.21	38%

4.3.1.2 Limiting Nutrients

A limiting nutrient is a nutrient or trace element that is essential for plants to grow but that is available in smaller quantities than are required by the plants and algae to increase in abundance. Therefore, if more of a limiting nutrient is added to an aquatic ecosystem, larger algal populations will develop until nutrient limitation or another environmental factor (such as light or water temperature) curtails production at a higher threshold than previously possible. Reducing the limiting nutrient can lower the eutrophication level in the lake and improve the water quality. The stoichiometry ratio of nitrogen to phosphorus (TN:TP) in phytoplankton biomass is about 7.2:1. If the N:P ratio in a water body is less than 7.2, nitrogen is the limiting nutrient. Otherwise, phosphorus is the limiting nutrient. Table 4-4 summarizes the average TN:TP ratio in the Greenville Lake, based on the 2001-2002 sampling data. The average TN:TP ratio is varies, with average monthly N:P ratio above 7.2 at Roy 1 for July, April, May and June at ROY -2 and June at ROY-3. Therefore, phosphorus can be considered the limiting nutrient for plant growth in Greenville Lake at these sections of the lake during those periods. TP contributes to lake eutrophication (fertility) and algal blooms. Nitrogen is also an essential nutrient for plant growth; however, it is often so abundant that it does not limit algae growth, especially in water systems with low retention times (fast-flowing systems). Some species of algae can also “fix” their own atmospheric nitrogen and do not need another nitrogen source. With nitrogen abundant and available, an increase in limiting nutrient, TP, results in rapid algal growth. It is safe to surmise that an imbalance in the N:P ratio during the high temperature and long sunlight days of the summer time can be a major factor in lake eutrophication.

TABLE 4-4 MONTHLY AVERAGE TOTAL PHOSPHORUS AND TOTAL NITROGEN CONCENTRATIONS IN GREENVILLE LAKE

Month-Year	TN NO_3-NO_2	TP	N:P ROY-1	TN NO_3-NO_2	TP	N:P ROY-2	TN NO_3-NO_2	TP	N:P ROY-3
Apr-01	0.16	0.09	1.78	3.2	0.37	8.7	0.16		
May-01	0.24	0.27	0.90	3.8	0.26	14.9	0.105		
Jun-01	0.84	0.13	6.27	2.7	0.20	13.6	1.96	0.18	11.14
Jul-01	2.13	0.20	10.88	1.3	0.36	3.7		0.20	
Aug-01	0.08	0.28	0.29		0.32			0.13	
Sep-01		0.28			0.27			0.10	
Oct-01	0.13	0.30	0.43	0.4	0.78	0.5	0.03	0.11	0.29
Nov-01	0.31	0.23	1.35	0.6	0.58	1.0	0.18	0.35	0.51
Dec-01	0.35	0.23	1.50	1.0	0.71	1.4	0.36	0.20	1.84
Jan-02	0.51	0.29	1.75	0.3	0.33	0.8	0.46	0.30	1.51
Feb-02	0.98	0.19	5.11	0.6	0.16	3.4	0.87	0.35	2.52
Mar-02	0.80	0.15	5.36	0.9	0.36	2.5	0.74	0.23	3.27
Apr-02	0.40	0.19	2.17	0.4	0.49	0.8	0.415	0.68	0.61
Average	0.58	0.22	2.66	1.38	0.40	3.95	0.53	0.26	2.71

All values are in mg/L

4.3.1.3 Trophic Index

Trophic status (or “fertility” status) is often used to describe the nutrient enrichment status of a lake ecosystem. Higher trophic status is associated with more nutrient availability and higher productivity. Generally, mesotrophic to eutrophic lakes are considered to be the best environments for supporting a variety of uses, including fishing, aquatic life support, swimming, boating, and other uses. Excessive nutrient loads can result in nuisance algal blooms and excessive turbidity. Very low nutrient status also can limit the support of aquatic life. Carlson Trophic State Index (TSI) values are used as indicators of trophic status, which can be calculated using TP concentrations, Chl-a concentrations, or Secchi disk depth respectively (Carlson 1977). Generally, TP is considered the best indicator of *potential* trophic status, especially when the TP is the limiting nutrient. The diagram in Figure 4-4 depicts the relationship between the TSI, trophic status, and nutrient status.

Table 4-5 shows the TSI value at the three sampling location, calculated from TP and Chlorophyll-a concentrations. The TSI value based on TP indicate the lake is hypereutrophic while TSI value based on Chl-a indicates the lake is eutrophic.

FIGURE 4-4 TSI RELATIONSHIP TO LAKE FERTILITY

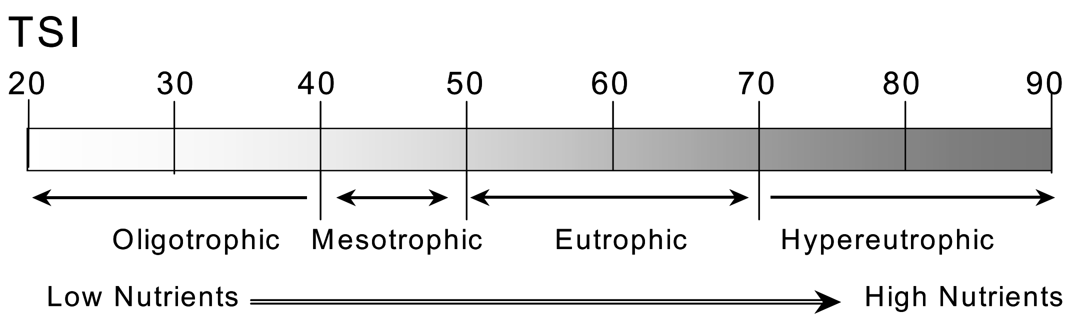


TABLE 4-5 TROPHIC STATE INDEX FOR GREENVILLE LAKE

Location	TSI (for Total Phosphorus)	TSI (for Chl-a)
ROY-1	84.7	70.5
ROY-2	90.4	70.3
ROY-3	88.0	73.4
Average	87.7	71.4

4.3.1.4 Excessive Algal Growth/Chlorophyll-a

Greenville is listed for impairment of excessive algal growth. No TMDL will be development for algae since there is no numeric water quality standard for this constituent. The Algal is discussed in this report as it is a contributor to TP. Chl-a, as an indicator for algal growth, is the dominant pigment in the algae cell, which is commonly used as a surrogate for algae. Algae blooms are also an indirect cause of low DO related to organic enrichment. The narrative water quality standard for general use in the State of Illinois requires that waters of the state shall be free from algal growth of other than natural origin.

Figure 4-5 shows monthly variation of Chl-a concentrations at three sampling locations in Greenville Lake. Chl-a concentrations are higher in August and September that other months. This phenomena seems to follow the similar monthly trend for TP. Chl-a concentrations do not show large spatial variation as shown in Figure 4-6.

FIGURE 4-5 GREENVILLE LAKE MONTHLY CHLOROPHYLL-A CONCENTRATIONS

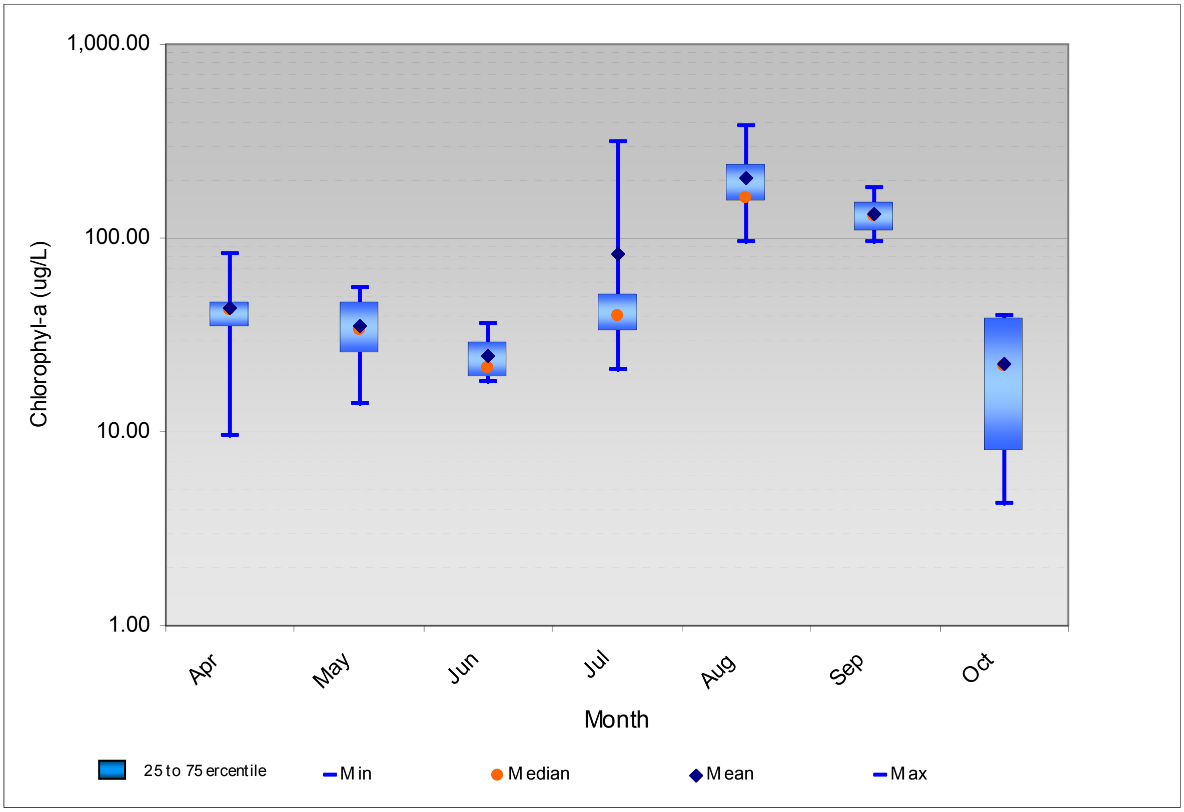
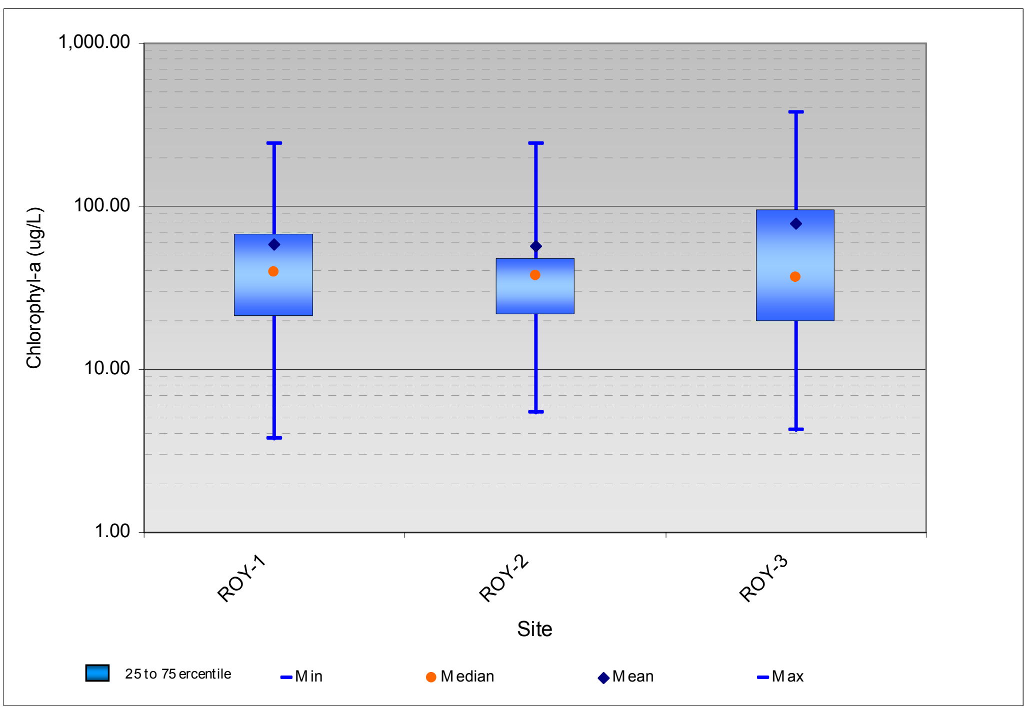


FIGURE 4-6 GREENVILLE LAKE CHLOROPHYLL-A STATISTICS BY SAMPLING SITES



4.3.2 Lake Coffeen (ROG)

This section presents the water quality assessment in Coffeen Lake using the available data.

4.3.2.1 Phosphorus

Phosphorous was listed as a cause of impairment in the 2004 IEPA 303(d) list. Phosphorous is also used as an indicator for excessive algal growth in Greenville Lake. Figure 4-7 presents the monthly variation of TP concentrations in the Coffeen Lake. It appears that TP does not show significant monthly variation within a year. The average annual concentrations exceed the lake phosphorus standard of 0.05 mg/l in every month, which confirm the list of phosphorus as cause for impairment in 2004 303(d) list.

Figure 4-8 presents TP data by sites based the data from 1989 to 2002. The figure indicates that at all locations, TP concentrations exceed the water quality standard of 0.05 mg/L. The average TP concentrations at ROG-1 and ROG-3 are slightly higher than that at ROG-2.

FIGURE 4-7 COFFEEN LAKE MONTHLY TOTAL PHOSPHORUS CONCENTRATIONS

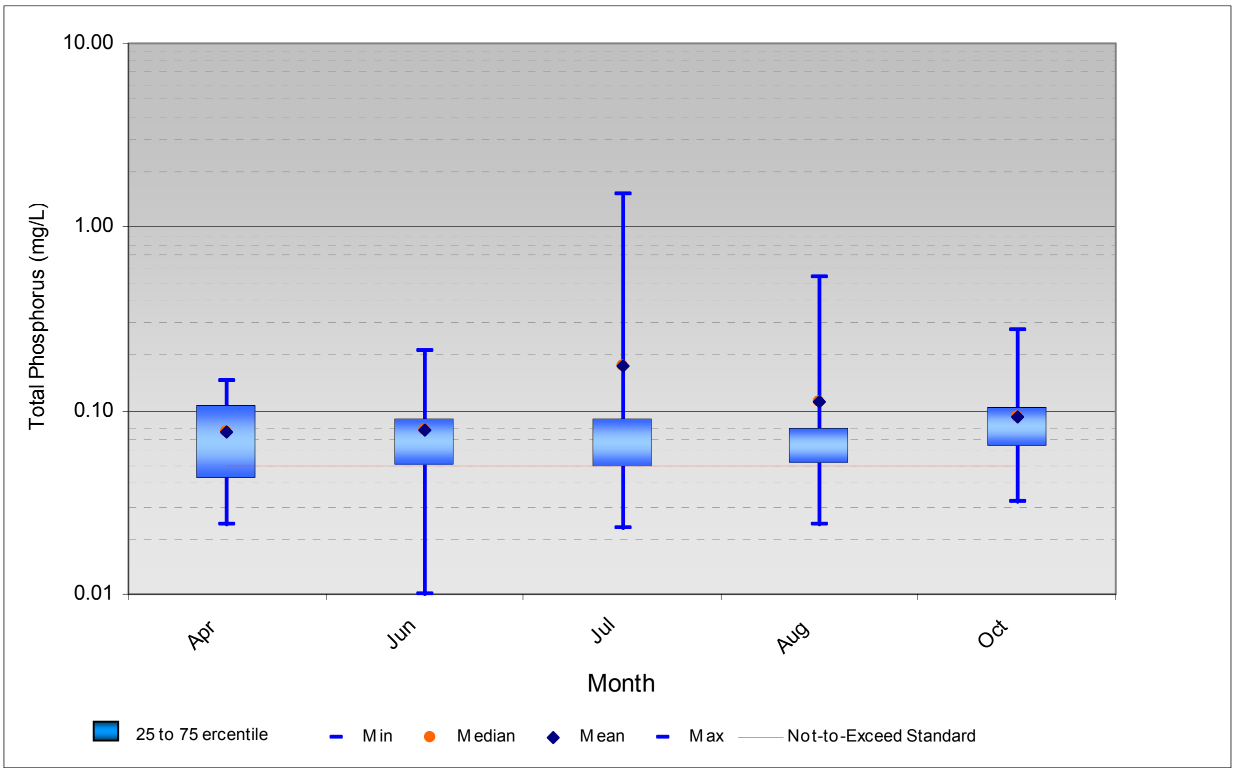


FIGURE 4-8 COFFEEN LAKE TP CONCENTRATION BY SAMPLING SITE

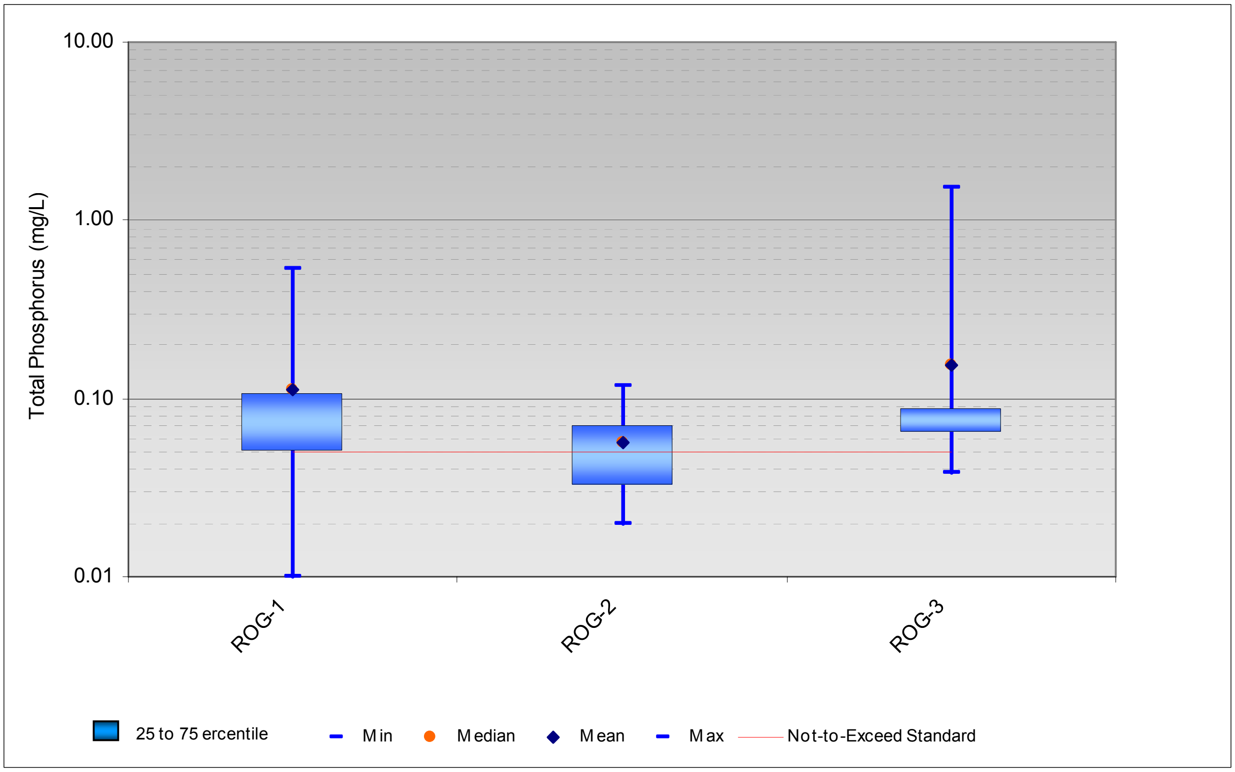


Table 4-6 summarizes the monthly average DP and TP concentrations in Coffeen Lake. In average, 60 percent of TP is dissolved while the rest is in particulate form. It indicates that the organic TP sources are dominant. This observation will be further verified and evaluated in the Stage 3 – TMDL development.

TABLE 4-6 MONTHLY AVERAGE DISSOLVED PHOSPHORUS AND TOTAL PHOSPHORUS CONCENTRATIONS IN COFFEEN LAKE

Station	Date	Sample Depth (ft)	Total -P (mg/L)	Dissolved-P (mg/L)	Percent DP
ROG-1	Apr-02	1	0.041	0.015	37%
ROG-1	Jul-02	1	0.144	0.069	48%
ROG-1	Aug-02	1	0.098	0.05	51%
ROG-1	Oct-02	1	0.088	0.084	95%
ROG-2	Apr-02	1	0.121	0.014	12%
ROG-2	Jun-02	1	0.096	0.053	55%
ROG-2	Jul-02	1	0.08	0.048	60%
ROG-2	Aug-02	1	0.087	0.036	41%
ROG-2	Oct-02	1	0.081	0.046	57%
ROG-3	Apr-02	1	0.065	0.051	78%
ROG-3	Jun-02	1	0.075	0.037	49%
ROG-3	Jul-02	1	0.099	0.047	47%
ROG-3	Aug-02	1	0.068	0.039	57%
ROG-3	Oct-02	1	0.063	0.034	54%
ROG-1	Aug-02	21	0.081	0.065	80%
ROG-1	Oct-02	27	0.103	0.086	83%
ROG-1	Jul-02	41	0.368	0.308	84%
ROG-1	Apr-02	43	0.066	0.044	67%
ROG-1	Jun-02	43	0.212	0.185	87%
Average			0.107	0.069	60%

4.3.2.2 Limiting Nutrients

Table 4-7 summarizes the average TN:TP ratio in the Greenville Lake, based on the 2001-2002 sampling data. The average TN:TP ratio varies, with average monthly N:P ratio above 7.2 at ROG-1 for April and June. Therefore, phosphorus can be considered the limiting nutrient for plant growth in Greenville Lake at that section of the lake during those periods. TP contributes to lake eutrophication (fertility) and algal blooms. Nitrogen is also an essential nutrient for plant growth; however, it is often so abundant that it does not limit algae growth, especially in water systems with low retention times (fast-flowing systems). Some species of algae can also "fix" their own atmospheric nitrogen and do not need another nitrogen source. With nitrogen abundant and available, an increase in limiting nutrient, TP, results in rapid algal growth. The general trend in water quality at the lake indicates poorer water quality at ROG-2 and ROG-3 sampling location therefore it is safe to assume that phosphorus may be a limiting nutrient at these sections at lest during the April- June period for which there is data available at ROG-1.

TABLE 4-4 MONTHLY AVERAGE TOTAL PHOSPHORUS AND TOTAL NITROGEN CONCENTRATIONS IN COFFEEN LAKE

ROG-1	Average NO3NO2	TP	TN:TP
Apr-02	0.336	0.041	8.2
Jun-02	0.365	0.041	8.9
Jul-02	0.06	0.144	0.42
Aug-02	0.02	0.098	0.20
Oct-02	0.04	0.088	0.45

4.3.2.3 Trophic Index

Table 4-7 shows the TSI value at the three sampling location in Coffeen Lake, calculated from TP and Chlorophyll-a concentrations. The TSI value based on TP indicate the lake is hypereutrophic while TSI value based on Chl-a indicate the lake is eutrophic.

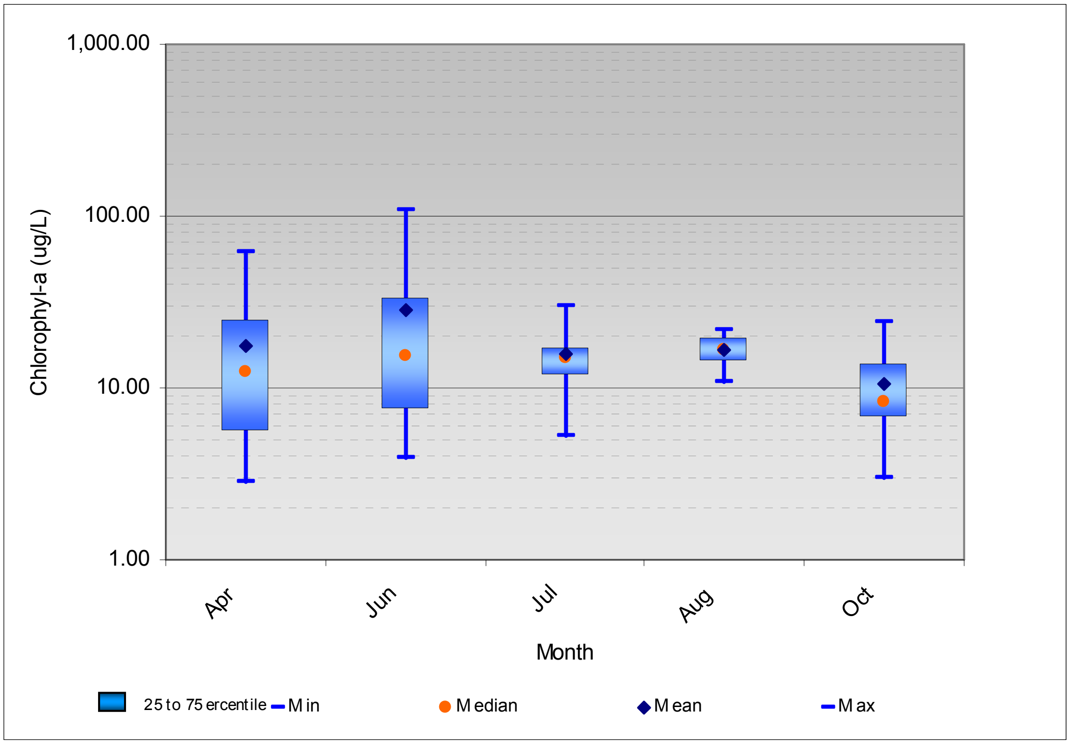
TABLE 4-7 TROPHIC STATE INDEX FOR COFFEEN LAKE

Location	TSI (for Total Phosphorus)	TSI (for Chl-a)
ROG-1	72.6	52.9
ROG-2	62.3	59.4
ROG-3	76.8	62.0
Average	70.6	58.1

4.3.2.4 Excessive Algal Growth/Chlorophyll-a

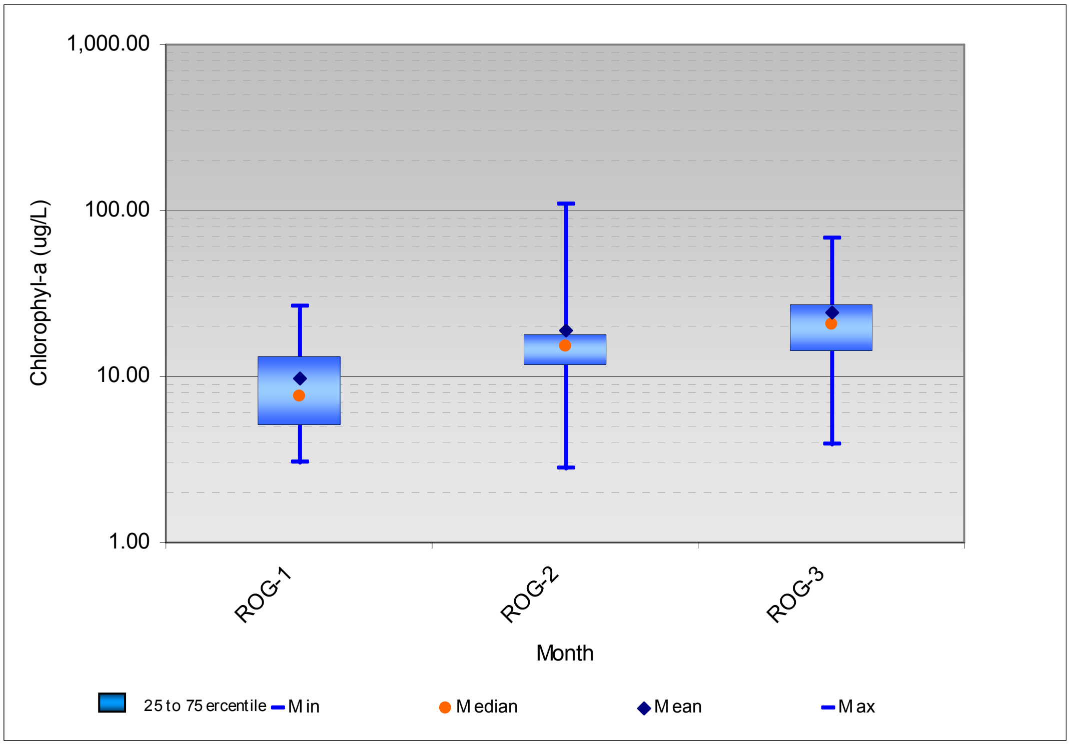
The narrative water quality standard for general use in the State of Illinois requires that waters of the state shall be free from algal growth of other than natural origin. Figure 4-13 shows Chl-a concentration at three sampling locations. Chl-a concentrations do not show large spatial variation. The maximum Chl-a concentration of about 100 ug/L occurred at Coffeen Lake sampling site ROG-2.

FIGURE 4-13 CHLOROPHYLL-A CONCENTRATIONS IN COFFEEN LAKE



Chlorophyll-a concentration at each sampling site is presented in Figure 4-14. The average Chlorophyll-a concentration increase from ROG-1 near the dam to ROG-3 at the upstream site of the Lake.

FIGURE 4-14 COFFEEN LAKE CHLOROPHYLL-A STATISTICS BY SAMPLING SITES



5.0 SOURCE ASSESSMENT

This section discusses point and nonpoint sources that potentially contribute to the impairment of the Lake Coffeen and Lake Greenville.

5.1 NONPOINT SOURCES

The Illinois 2004 303(d) List identified agriculture (crop related, non-irrigated crop production), habitat/streambank modification, recreation and tourist activity, and forest/grassland/parkland as sources of nutrient and solids loads to Greenville and Coffeen Lakes. Row crop agriculture is a common source of sediment and nutrient loads and is prevalent in the watershed. Fertilizers commonly used in the watershed include anhydrous ammonia, ammonium phosphate, and potash. Fertilizers are applied in the fall and spring with a variety of application methods.

The primary concerns of nonpoint pollution in the watershed are eroded soils and nutrients from agricultural areas. Private septic systems are prevalent in the area and are another potential source of nutrient, sediment, and pathogen loads. Septic systems can potentially leach nutrients into the groundwater and can contaminate surface water if the system is not functioning properly. The potential influence of septic tank effluent on the lake will be investigated, based site-specific information.

Runoff from agricultural land can contribute significantly to the sediment and nutrient loads for a lake. Sediments bring fertilizers and pesticides that are deposited into the lake. High amounts of phosphorus and nitrogen run off contribute to the eutrophication of the lake by increasing algae growth. This algae growth also contributes to turbidity and lack of water clarity. Residential activities in the watershed can also contribute to sedimentation and nutrient loading of the lake. Lawn fertilizers from homes as well as nutrients from septic systems contribute to the nutrients entering the lake. Nutrients from nonpoint pollution sources consist of nitrogen and phosphorous which originate primarily from the fertilized fields in the watershed.

5.2 POINT SOURCES

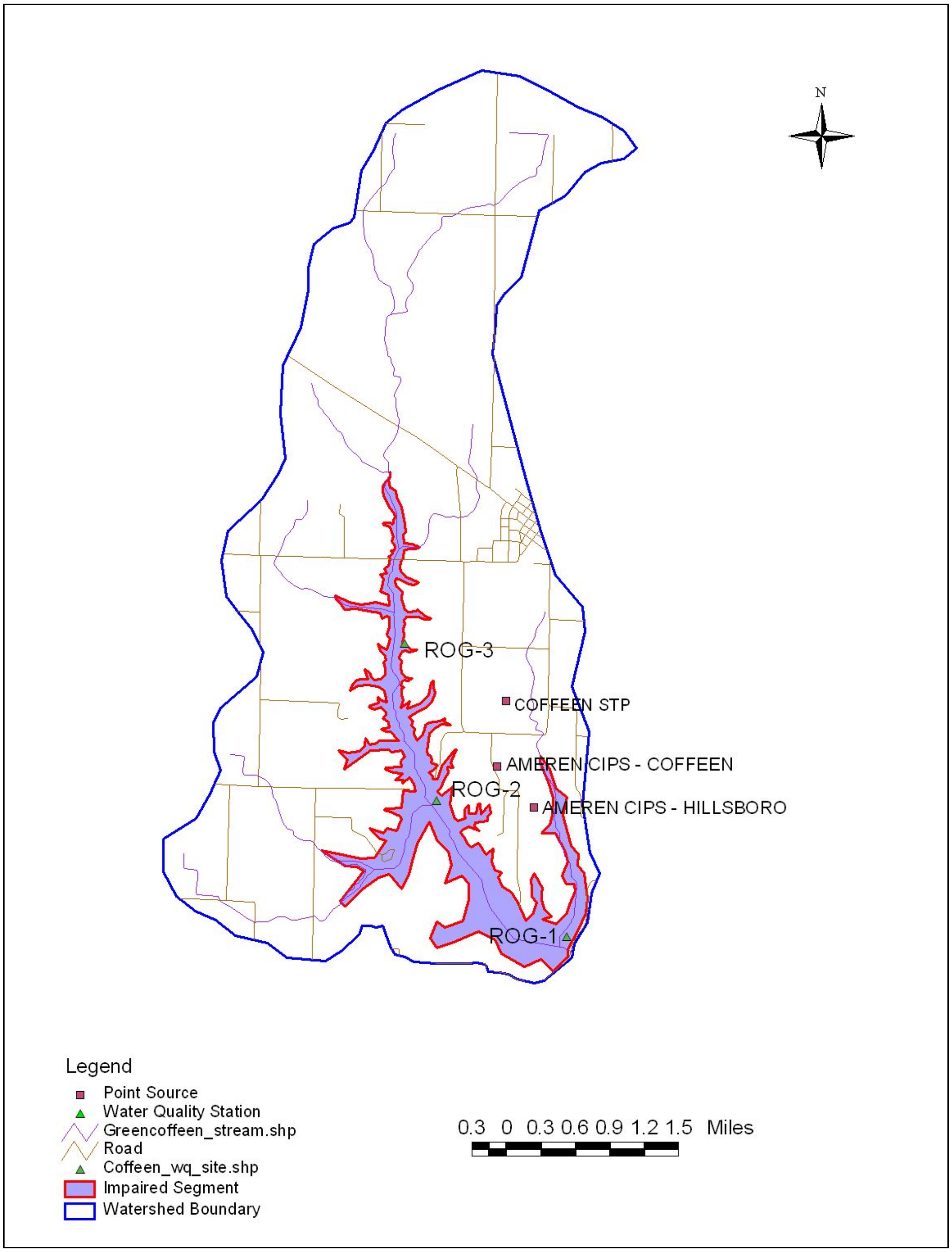
There is no point source in Greenville Lake watershed. There are three point sources in Coffeen Lake watershed; Coffeen Sewage Treatment plant, Ameren Energy Coffeen, and Ameren Energy Hillsboro (See Figure 5-1). Table 5-1 summarizes the information about these point sources. There is no TP data in discharge monitory record for the point sources.

TABLE 5-1 POINT SOURCES DISCHARGER IN COFFEEN LAKE WATERSHED

Facility Name	NPDES No.	Description	Status	Average TP discharge (NPDES data)	Average Discharge (MGD)
AMEREN Energy, Coffeen	IL0000108	ELECTRICAL SERVICES	Active	Unknown	404.7
AMEREN Engergy, Hillsboro	IL0026549	BITUMINOUS COAL & LIG, SURFACE	Inactive	Unknown	Unknow
Coffeen STP	IL0020745	SEWERAGE SYSTEMS	Active	11.5	0.1

In addition, the pumped water from East Fork Shoal Creek to Coffeen Lake acts as a point source. The load from the Shoal Creek will be estimated based on pumped flow volume and water quality information in the creek.

FIGURE 5-1 POINT SOURCE LOCATION MAP COFFEEN LAKE



6.0 METHODOLGY SELECTIONT

This chapter discusses the methodology to be used for the development of TMDLs for Greenville and Coffeen Lakes. Both a simple approach and a modeling approach are considered. The final selection of a methodology will be based on following factors:

1) Meeting minimum requirements of defensible and approvable TMDL
2) Data Availability
3) Fund availability
4) Public acceptance
5) Complexity of water body

A simpler approach shall be used as long as it meets TMDL requirement since it is more economic. Models are often used to establish a scientific link between the pollutant sources and the water quality indicators for the attainment of designated uses. Models enable the prediction of water body response to the pollutant loads and comparison of the various reduction scenarios. The linkage allows for the evaluation of management options and the selection of the option that will achieve the desired load reductions.

Section 6.1 discusses the simple approach. Section 6.2 discusses the sophisticated approach, describes the criterion for the model selection and preliminary model selection, followed by brief descriptions of each model. Sections 6.3 and 6.4 discuss model calibration and sensitivity analysis. Section 6.3 discusses sensitivity analysis.

6.1 MODEL SELECTION

Generally, the TMDL modeling approach will consist of two steps: (1) use of a watershed model to simulate hydrology and estimate pollutant loads to each water body as a function of land use and pollutant export, and (2) use of a water quality model to predict pollutant concentrations and other responses in the water body as a function of pollutant loads. A simpler technique has also been identified and is discussed below. The water quality model often involves a hydrodynamic model to determine the flow and velocity in a waterbody. This section describes the criterion for the model selection and preliminary model selection, followed by brief descriptions of each model. Sections 6.2 and 6.3 discuss model calibration and sensitivity analysis. Section 6.3 discusses sensitivity analysis.

The following criteria were used to select watershed and water body models for developing TMDLs:

- Capable of simulating watershed hydrology and loading process
- Capable of simulating pollutant (particularly phosphorus) transport and water quality
- Capable of simulating best management practices (BMP) scenarios
- Ease of use and calibration
- Well tested and documented

6.2 NON-MODELING SIMPLE APPROACH

A simple approach such as a flow duration curve may be considered for the Greenville and Coffeen Lakes' TMDL development provide that adequate data and information is available. In order to use a duration curve, a large amount of flow and water quality data is needed through intensive sampling to trace where the major sources of pollution are coming from. The method may not be a good tool to use alone in TMDL development. More importantly, unlike widely used modeling approaches, the flow duration approach is not capable of allocating loads to specific sources and considering pollutant transport mechanisms. While a flow duration approach appears to be a good tool for screening and gaining an overall picture of watershed conditions, a more complex modeling should be used for TMDL development to better represent watershed processes and calculate more accurate load allocations (Miller-McClellan, 2003). In both lakes continuous flow and water quality data, which can be used to develop a duration curve and a loading curve and subsequently calculate the total loads do not cover the watershed. However, a watershed model (even a simple one), has to be used to establish load allocation. Therefore, a simple duration curve approach may be used in combination with other watershed models to develop defensible TMDL for Greenville and Coffeen Lakes.

6.3 WATERSHED MODEL SOPHISTICATED MODELING APPROACH

The Hydrologic Simulation System in Fortran (HSPF) is another technical approach that can be used to develop a detailed linkage between load and water quality targets. HSPF is a watershed model that simulates nonpoint source runoff and pollutant loadings for a watershed, combines these with point source contributions, and performs flow and water quality routing in reaches. HSPF is embedded in USEPA BASINS (EPA 2000) to provide an integrating framework that facilitates watershed and water quality studies. HSPF can simulate hydrologic and associated water quality for extended periods of time. Simulations can be conducted on multiple pervious and impervious land surfaces and in streams and well-mixed impoundments. It simulates canopy interception, soil moisture, surface runoff, interflow, base flow, snowpack depth and water content, snowmelt, evapotranspiration, ground-water recharge, fecal coliform, channel and reservoir routing, constituent routing, phosphorus, and phytoplankton. The interflow scheme in HSPF provides a conceptual representation of subsurface tile drainage in the Shoal Creek Watershed. Tile drainage can have an important influence on storm hydrographs in the upper zone soil layer. In HSPF, the inflows to the Tile drain system can be routed as outflow from the land segment.

Tetra Tech has recently adapted the original HSPF model and created a TMDL friendly program, Loading Simulation Program in C++ (LSPC). LSPC includes the HSPF algorithms for simulating hydrology, sediment, and general water quality on land as well as a simplified stream pollutant transport model. The attractive feature is that LSPC includes a module to assist TMDL calculation and sources allocation. For each model run, LSPC automatically generates flow and load output by watersheds for all land uses, streams, and simulated modules used in a specified time interval. It makes load reduction and scenario comparisons much easier. LSPC will be considered an alternative for the HSPF model.

The water quality model has to be able to simulate pollutant fate and transport in the Greeenville and Coffeen Lakes areas. Water Quality Analysis Simulation Program (WASP) is selected to simulate the water quality for the both Lakes. WASP is a dynamic compartment-modeling program for aquatic systems such as river, estuary, and lakes, widely used throughout the Unite States for the development of TMDL and load allocations. WASP enables the 1-, 2-, or 3-D analysis of eutrophication and toxicants to meet the need to understand the water quality kinetics in the river and lake. The model includes the algorithms for simulating eutrophication, and temperature. The time varying processes of advection, dispersion, point and diffuse mass loading and boundary exchange are represented in the model. The WASP can be linked with a hydrodynamic model that can provide flows, depth, velocities, and temperature for lake circulation. WASP model is superior to BATHTUB, another simple water quality model, in that it provides better temporal and spatial resolution, which is needed to represent the water quality variation within the two water bodies. With compartment segmentation, WASP represents spatial nutrient gradient in the lake. It also accounts for seasonal variation in nutrient concentration at various monitoring locations. WASP allows for the simulation of vertical DO trends observed in both Lakes. The combination of HSPF watershed model and WASP water quality model not only provide the framework for TMDL development but also has a potential to be enhanced into a management tool for both lakes.

6.4 MODEL CALIBRATION AND VALIDATION

Calibration involves minimizing the deviation between measured and simulated water quality indicators output by adjusting model parameters. Data required for calibration include a set of known input values along with corresponding field observations. Although model calibration is critical, Tetra Tech believes that significant effort should be focused on sound source characterization and sensitivity analysis. A good characterization of source loadings results in a more efficient, scientifically sound, and justifiable calibration process. Tetra Tech will identify data sets for water quality calibration, identify model adjustment needs based on past experience, and work closely with IEPA to fully characterize sources and address calibration issues and their impacts on final TMDL allocations. The performance of model calibration will be assessed based on statistic method and professional judgments.

Validation involves the use of a second set of independent information to check model calibration. Data used for model validation consist of field measurements of the same type as the data output from the model. Models are tested based on their predictions of mean values, variability, extreme values, and all predicted values. If the model is calibrated properly, model predictions should be acceptably close to field observations.

6.5 SENSITIVITY ANALYSIS

A thorough sensitivity analysis provides a number of benefits, including the following:

- Assistance on proper parameter selection
- Improve understanding of the model and related assumptions
- Evaluation of different TMDL scenarios
- Evaluation of model accuracy.
- Justification of selection of Margin of Safety

The results of a sensitivity analysis will provide information regarding parameters with the greatest effect on outputs. Tetra Tech will perform a sensitivity analysis based on multiple model runs based on selected parameter range and load range. In addition to evaluating the sensitivity of the technical approach to the different sources, it is also important to estimate (either qualitatively or quantitatively) the accuracy or reliability of model predictions. This estimate of the model's accuracy will be an important factor in deciding how to use the model results in estimating the TMDL values.

An important step in the TMDL process is to evaluate the relative significance of the various source-loading estimates on model results. For example, potential sources of phosphorus contributing to the impairment of the water body include municipal treatment plant, failing septic systems, livestock operations, agricultural and urban runoff. It will be important to evaluate the sensitivity of the model to loadings from each of these sources. For example, there is no known relationship that can be used to predict the contribution of failing septic systems to a stream. If the analysis indicates that the model is especially sensitive to this source, it might be necessary to revise the loading estimates to a daily or seasonal basis.

7.0 IDENTIFICATION OF DATA GAPS

TMDL development relies on pollutant- and site-specific data and sometimes it can become data intensive. Sufficient flow and water quality data are required to evaluate current water conditions and calibrate model parameters. To a certain degree, data availability dictates the modeling approach used for the Greenville and Coffeen Lake watersheds. Five types of data are crucial for the TMDL development:

- Flow and Water Stage data
- Meteorological data
- Water quality data
- Watershed and water body physical parameters
- Sources characteristic data

A considerable amount of climatic, hydrologic, and water quality data is available for both lakes. Climate Stations provide continuous precipitation and climatic data needed for developing a calibrated, predictive hydrologic model, which is essential to a water quality model. The regional evaporation, wind speed, solar radiation, dew point, and cloud cover can be obtained form Midwest Climate Center. Discharge records at Coffeen Lake are available for water balance in the lake.

The available flow and water quality data for both Lakes appear to meet the basic needs for this TMDL. IEPA, however, may consider collecting some current total Phosphorus and dissolved Phosphorus and total nitrogen data at a temporal interval of at least one-samples-per-month (as stated in Illinois Water Quality Standards) to further verify the limiting nutrient through out the year.

Based on a review of data collected for this Stage I report and discussion in previous chapters, the following information and data gaps have been identified in order to facilitate the TMDL development for two water bodies.

- Flow and Stage Data
- Septic tank investigation (distribution, upgrade, failure incidents)
- Drain tile data (existing condition, distribution, and density)
- Groundwater discharge and quality data
- Live stock assessment
- Wildlife assessment
- Channel geometry
- Point Sources Discharge Monitory Record
- Livestock operations and feedlot permits

More data is needed to cover time and space data gaps for various critical water quality parameters. In both lakes there is more data available on various water quality parameters at the first sampling station and less data is available at the down “stream” data where the limited water quality data indicate a poorer water quality than at the first sampling station. Additionally, more data on point sources are needed along with the discharged water quality.

The data gaps are mainly related to sources characteristics. Obtaining these data does not always require on-site sampling; instead, coordination with local governments, agencies, and watershed groups may help the gathering of the needed data. In consultation with IEPA, Tetra Tech will determine the efforts to be included as part of actual TMDL Development.

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APPENDIX A. LIST OF CONTACTS

Organization	Contact Name	Phone Number	e-mail
Illinois Department of Natural Resources			coffeenlake@dnrmail.state.il.us
Illinois State Water Survey - Surface Water Monitoring and Stream Gauging Data	Laura Keefer	217-333-3468	lkeefer@uiuc.edu
Illinois State Water Survey - Center for Watershed Science	Bill Saylor	217-333-0447	
Kingsbury Park District			kingsburyparkdistrict@hotmail.co
Coffeen Lake State Fish & Wildlife Area		217-537-3351	
Illinois Department of Natural Resources	Brad Tedrick, Site Superintendent	217-537-3351	coffeenlake@dnrmail.state.il.us
Natural Resources Conservation Services, Department of Agriculture			

APPENDIX B. WATER QUALITY DATA

Station ID	Date	Parameter	Value	Unit
ROY-2	06/07/01	SOLIDS, TOT. SUS.	6	MG/L
ROY-2	06/07/01	SOLIDS, TOT. SUS.	19	MG/L
ROY-2	06/15/01	SOLIDS, TOT. SUS.	365	MG/L
ROY-2	06/25/01	SOLIDS, TOT. SUS.	11	MG/L
ROY-2	06/25/01	SOLIDS, TOT. SUS.	21	MG/L
ROY-2	07/10/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-2	07/24/01	SOLIDS, TOT. SUS.	290	MG/L
ROY-2	07/25/01	SOLIDS, TOT. SUS.	26	MG/L
ROY-2	07/25/01	SOLIDS, TOT. SUS.	12	MG/L
ROY-2	08/20/01	SOLIDS, TOT. SUS.	26	MG/L
ROY-2	08/27/01	SOLIDS, TOT. SUS.	29	MG/L
ROY-2	09/04/01	SOLIDS, TOT. SUS.	22	MG/L
ROY-2	09/20/01	SOLIDS, TOT. SUS.	29	MG/L
ROY-2	10/12/01	SOLIDS, TOT. SUS.	47	MG/L
ROY-2	10/15/01	SOLIDS, TOT. SUS.	12	MG/L
ROY-2	10/24/01	SOLIDS, TOT. SUS.	460	MG/L
ROY-2	10/27/01	SOLIDS, TOT. SUS.	16	MG/L
ROY-2	10/27/01	SOLIDS, TOT. SUS.	24	MG/L
ROY-2	11/24/01	SOLIDS, TOT. SUS.	7	MG/L
ROY-2	11/30/01	SOLIDS, TOT. SUS.	55	MG/L
ROY-2	12/13/01	SOLIDS, TOT. SUS.	68	MG/L
ROY-2	12/14/01	SOLIDS, TOT. SUS.	75	MG/L
ROY-2	12/15/01	SOLIDS, TOT. SUS.	13	MG/L
ROY-2	12/15/01	SOLIDS, TOT. SUS.	39	MG/L
ROY-2	12/16/01	SOLIDS, TOT. SUS.	410	MG/L
ROY-2	12/17/01	SOLIDS, TOT. SUS.	75	MG/L
ROY-2	01/17/02	SOLIDS, TOT. SUS.	9	MG/L
ROY-2	01/17/02	SOLIDS, TOT. SUS.	9	MG/L
ROY-2	01/30/02	SOLIDS, TOT. SUS.	177	MG/L
ROY-2	02/19/02	SOLIDS, TOT. SUS.	49	MG/L
ROY-2	02/23/02	SOLIDS, TOT. SUS.	30	MG/L
ROY-2	02/23/02	SOLIDS, TOT. SUS.	11	MG/L
ROY-2	03/02/02	SOLIDS, TOT. SUS.	72	MG/L
ROY-2	03/09/02	SOLIDS, TOT. SUS.	413	MG/L
ROY-2	03/19/02	SOLIDS, TOT. SUS.	32	MG/L
ROY-2	03/19/02	SOLIDS, TOT. SUS.	20	MG/L
ROY-2	04/01/02	SOLIDS, TOT. SUS.	22	MG/L
ROY-2	04/01/02	SOLIDS, TOT. SUS.	21	MG/L
ROY-2	04/08/02	SOLIDS, TOT. SUS.	465	MG/L
ROY-2	04/23/02	SOLIDS, TOT. SUS.	13	MG/L
ROY-3	04/09/01	CHLOROPHYL-A UNCO	43.2	UG/L
ROY-3	05/15/01	CHLOROPHYL-A UNCO	27	UG/L
ROY-3	05/29/01	CHLOROPHYL-A UNCO	55.1	UG/L
ROY-3	06/07/01	CHLOROPHYL-A UNCO	20.6	UG/L
ROY-3	06/25/01	CHLOROPHYL-A UNCO	31.3	UG/L
ROY-3	07/10/01	CHLOROPHYL-A UNCO	310	UG/L
ROY-3	07/25/01	CHLOROPHYL-A UNCO	32.6	UG/L
ROY-3	08/20/01	CHLOROPHYL-A UNCO	159	UG/L
ROY-3	08/27/01	CHLOROPHYL-A UNCO	376	UG/L
ROY-3	09/04/01	CHLOROPHYL-A UNCO	132	UG/L
ROY-3	09/20/01	CHLOROPHYL-A UNCO	128	UG/L

Station ID	Date	Parameter	Value	Unit
ROY-2	02/23/02	CHLOROPHYL-A UNCO	40.3	UG/L
ROY-2	03/19/02	CHLOROPHYL-A UNCO	39.9	UG/L
ROY-2	04/01/02	CHLOROPHYL-A UNCO	47.3	UG/L
ROY-2	04/23/02	CHLOROPHYL-A UNCO	19.3	UG/L
ROY-2	04/06/01	PHOSPHORUS-P, TOTAL	0.66	MG/L
ROY-2	04/09/01	PHOSPHORUS-P, TOTAL	0.073	MG/L
ROY-2	05/15/01	PHOSPHORUS-P, TOTAL	0.073	MG/L
ROY-2	05/29/01	PHOSPHORUS-P, TOTAL	0.127	MG/L
ROY-2	07/25/01	PHOSPHORUS-P, TOTAL	0.137	MG/L
ROY-2	08/27/01	PHOSPHORUS-P, TOTAL	0.328	MG/L
ROY-2	09/04/01	PHOSPHORUS-P, TOTAL	0.227	MG/L
ROY-2	09/20/01	PHOSPHORUS-P, TOTAL	0.321	MG/L
ROY-2	10/12/01	PHOSPHORUS-P, TOTAL	0.982	MG/L
ROY-2	10/24/01	PHOSPHORUS-P, TOTAL	1.4	MG/L
ROY-2	10/27/01	PHOSPHORUS-P, TOTAL	0.343	MG/L
ROY-2	10/27/01	PHOSPHORUS-P, TOTAL	0.85	MG/L
ROY-2	11/24/01	PHOSPHORUS-P, TOTAL	0.245	MG/L
ROY-2	11/30/01	PHOSPHORUS-P, TOTAL	0.917	MG/L
ROY-2	12/13/01	PHOSPHORUS-P, TOTAL	0.915	MG/L
ROY-2	12/14/01	PHOSPHORUS-P, TOTAL	0.864	MG/L
ROY-2	12/15/01	PHOSPHORUS-P, TOTAL	0.211	MG/L
ROY-2	12/15/01	PHOSPHORUS-P, TOTAL	0.639	MG/L
ROY-2	12/16/01	PHOSPHORUS-P, TOTAL	0.868	MG/L
ROY-2	12/17/01	PHOSPHORUS-P, TOTAL	0.743	MG/L
ROY-2	01/17/02	PHOSPHORUS-P, TOTAL	0.276	MG/L
ROY-2	02/23/02	PHOSPHORUS-P, TOTAL	0.179	MG/L
ROY-2	03/02/02	PHOSPHORUS-P, TOTAL	0.281	MG/L
ROY-2	03/09/02	PHOSPHORUS-P, TOTAL	0.855	MG/L
ROY-2	03/19/02	PHOSPHORUS-P, TOTAL	0.162	MG/L
ROY-2	03/19/02	PHOSPHORUS-P, TOTAL	0.157	MG/L
ROY-2	04/01/02	PHOSPHORUS-P, TOTAL	0.115	MG/L
ROY-2	04/01/02	PHOSPHORUS-P, TOTAL	0.146	MG/L
ROY-2	04/08/02	PHOSPHORUS-P, TOTAL	0.721	MG/L
ROY-2	04/23/02	PHOSPHORUS-P, TOTAL	0.188	MG/L
ROY-2	04/23/02	PHOSPHORUS-P, TOTAL	0.201	MG/L
ROY-2	06/07/01	PHOSPHORUS-P,TOTAL	0.075	MG/L
ROY-2	06/07/01	PHOSPHORUS-P,TOTAL	0.221	MG/L
ROY-2	06/15/01	PHOSPHORUS-P,TOTAL	0.485	MG/L
ROY-2	06/25/01	PHOSPHORUS-P,TOTAL	0.062	MG/L
ROY-2	07/10/01	PHOSPHORUS-P,TOTAL	0.081	MG/L
ROY-2	08/20/01	PHOSPHORUS-P,TOTAL	0.321	MG/L
ROY-2	10/15/01	PHOSPHORUS-P,TOTAL	0.317	MG/L
ROY-2	04/06/01	SOLIDS, TOT. SUS.	658	MG/L
ROY-2	04/09/01	SOLIDS, TOT. SUS.	7	MG/L
ROY-2	05/15/01	SOLIDS, TOT. SUS.	16	MG/L
ROY-2	05/15/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-2	05/19/01	SOLIDS, TOT. SUS.	20	MG/L
ROY-2	05/21/01	SOLIDS, TOT. SUS.	561	MG/L
ROY-2	05/29/01	SOLIDS, TOT. SUS.	21	MG/L
ROY-2	05/29/01	SOLIDS, TOT. SUS.	10	MG/L
ROY-2	05/30/01	SOLIDS, TOT. SUS.	18	MG/L

Station ID	Date	Parameter	Value	Unit
ROY-1	10/15/01	SOLIDS, TOT. SUS.	16	MG/L
ROY-1	10/24/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-1	10/27/01	SOLIDS, TOT. SUS.	18	MG/L
ROY-1	10/27/01	SOLIDS, TOT. SUS.	19	MG/L
ROY-1	10/27/01	SOLIDS, TOT. SUS.	11	MG/L
ROY-1	11/24/01	SOLIDS, TOT. SUS.	7	MG/L
ROY-1	11/24/01	SOLIDS, TOT. SUS.	9	MG/L
ROY-1	11/24/01	SOLIDS, TOT. SUS.	4	MG/L
ROY-1	11/30/01	SOLIDS, TOT. SUS.	7	MG/L
ROY-1	12/13/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-1	12/14/01	SOLIDS, TOT. SUS.	6	MG/L
ROY-1	12/15/01	SOLIDS, TOT. SUS.	6	MG/L
ROY-1	12/15/01	SOLIDS, TOT. SUS.	4	MG/L
ROY-1	12/15/01	SOLIDS, TOT. SUS.	6	MG/L
ROY-1	12/16/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-1	12/17/01	SOLIDS, TOT. SUS.	25	MG/L
ROY-1	01/17/02	SOLIDS, TOT. SUS.	6	MG/L
ROY-1	01/17/02	SOLIDS, TOT. SUS.	9	MG/L
ROY-1	01/17/02	SOLIDS, TOT. SUS.	7	MG/L
ROY-1	01/30/02	SOLIDS, TOT. SUS.	21	MG/L
ROY-1	02/19/02	SOLIDS, TOT. SUS.	11	MG/L
ROY-1	02/23/02	SOLIDS, TOT. SUS.	16	MG/L
ROY-1	02/23/02	SOLIDS, TOT. SUS.	11	MG/L
ROY-1	02/23/02	SOLIDS, TOT. SUS.	15	MG/L
ROY-1	03/02/02	SOLIDS, TOT. SUS.	19	MG/L
ROY-1	03/19/02	SOLIDS, TOT. SUS.	24	MG/L
ROY-1	03/19/02	SOLIDS, TOT. SUS.	20	MG/L
ROY-1	03/19/02	SOLIDS, TOT. SUS.	23	MG/L
ROY-1	04/01/02	SOLIDS, TOT. SUS.	17	MG/L
ROY-1	04/01/02	SOLIDS, TOT. SUS.	20	MG/L
ROY-1	04/01/02	SOLIDS, TOT. SUS.	22	MG/L
ROY-1	04/08/02	SOLIDS, TOT. SUS.	19	MG/L
ROY-1	04/23/02	SOLIDS, TOT. SUS.	57	MG/L
ROY-1	04/23/02	SOLIDS, TOT. SUS.	12	MG/L
ROY-1	04/23/02	SOLIDS, TOT. SUS.	23	MG/L
ROY-2	04/09/01	CHLOROPHYL-A UNCO	34.5	UG/L
ROY-2	05/15/01	CHLOROPHYL-A UNCO	14	UG/L
ROY-2	05/29/01	CHLOROPHYL-A UNCO	48.9	UG/L
ROY-2	06/07/01	CHLOROPHYL-A UNCO	22.4	UG/L
ROY-2	06/25/01	CHLOROPHYL-A UNCO	35.8	UG/L
ROY-2	07/10/01	CHLOROPHYL-A UNCO	32.4	UG/L
ROY-2	07/25/01	CHLOROPHYL-A UNCO	46.6	UG/L
ROY-2	08/20/01	CHLOROPHYL-A UNCO	154	UG/L
ROY-2	08/27/01	CHLOROPHYL-A UNCO	241	UG/L
ROY-2	09/04/01	CHLOROPHYL-A UNCO	183	UG/L
ROY-2	09/20/01	CHLOROPHYL-A UNCO	94.8	UG/L
ROY-2	10/15/01	CHLOROPHYL-A UNCO	8.41	UG/L
ROY-2	10/27/01	CHLOROPHYL-A UNCO	39.8	UG/L
ROY-2	11/24/01	CHLOROPHYL-A UNCO	24.9	UG/L
ROY-2	12/15/01	CHLOROPHYL-A UNCO	8.91	UG/L
ROY-2	01/17/02	CHLOROPHYL-A UNCO	5.38	UG/L

Station ID	Date	Parameter	Value	Unit
ROY-1	04/23/02	PHOSPHORUS-P, TOTAL	0.236	MG/L
ROY-1	04/23/02	PHOSPHORUS-P, TOTAL	0.109	MG/L
ROY-1	04/23/02	PHOSPHORUS-P, TOTAL	0.221	MG/L
ROY-1	08/18/93	PHOSPHORUS-P,TOTAL	1.650	MG/L
ROY-1	08/18/93	PHOSPHORUS-P,TOTAL	0.111	MG/L
ROY-1	04/09/01	PHOSPHORUS-P,TOTAL	0.09	MG/L
ROY-1	06/07/01	PHOSPHORUS-P,TOTAL	0.229	MG/L
ROY-1	06/15/01	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROY-1	06/25/01	PHOSPHORUS-P,TOTAL	0.061	MG/L
ROY-1	06/25/01	PHOSPHORUS-P,TOTAL	0.096	MG/L
ROY-1	06/25/01	PHOSPHORUS-P,TOTAL	0.224	MG/L
ROY-1	07/10/01	PHOSPHORUS-P,TOTAL	0.081	MG/L
ROY-1	07/10/01	PHOSPHORUS-P,TOTAL	0.111	MG/L
ROY-1	08/20/01	PHOSPHORUS-P,TOTAL	0.297	MG/L
ROY-1	08/20/01	PHOSPHORUS-P,TOTAL	0.505	MG/L
ROY-1	10/15/01	PHOSPHORUS-P,TOTAL	0.309	MG/L
ROY-1	10/15/01	PHOSPHORUS-P,TOTAL	0.243	MG/L
ROY-1	08/18/93	SOLIDS, TOT. SUS.	17	MG/L
ROY-1	04/06/01	SOLIDS, TOT. SUS.	60	MG/L
ROY-1	04/09/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-1	04/09/01	SOLIDS, TOT. SUS.	15	MG/L
ROY-1	05/15/01	SOLIDS, TOT. SUS.	10	MG/L
ROY-1	05/15/01	SOLIDS, TOT. SUS.	5	MG/L
ROY-1	05/19/01	SOLIDS, TOT. SUS.	7	MG/L
ROY-1	05/21/01	SOLIDS, TOT. SUS.	2	MG/L
ROY-1	05/29/01	SOLIDS, TOT. SUS.	30	MG/L
ROY-1	05/29/01	SOLIDS, TOT. SUS.	4	MG/L
ROY-1	05/29/01	SOLIDS, TOT. SUS.	10	MG/L
ROY-1	05/30/01	SOLIDS, TOT. SUS.	55	MG/L
ROY-1	06/07/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-1	06/07/01	SOLIDS, TOT. SUS.	4	MG/L
ROY-1	06/07/01	SOLIDS, TOT. SUS.	26	MG/L
ROY-1	06/15/01	SOLIDS, TOT. SUS.	20	MG/L
ROY-1	06/25/01	SOLIDS, TOT. SUS.	10	MG/L
ROY-1	06/25/01	SOLIDS, TOT. SUS.	11	MG/L
ROY-1	06/25/01	SOLIDS, TOT. SUS.	36	MG/L
ROY-1	07/10/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-1	07/10/01	SOLIDS, TOT. SUS.	9	MG/L
ROY-1	07/24/01	SOLIDS, TOT. SUS.	21	MG/L
ROY-1	07/25/01	SOLIDS, TOT. SUS.	9	MG/L
ROY-1	07/25/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-1	07/25/01	SOLIDS, TOT. SUS.	13	MG/L
ROY-1	08/20/01	SOLIDS, TOT. SUS.	23	MG/L
ROY-1	08/20/01	SOLIDS, TOT. SUS.	18	MG/L
ROY-1	08/27/01	SOLIDS, TOT. SUS.	17	MG/L
ROY-1	08/27/01	SOLIDS, TOT. SUS.	23	MG/L
ROY-1	09/04/01	SOLIDS, TOT. SUS.	20	MG/L
ROY-1	09/04/01	SOLIDS, TOT. SUS.	24	MG/L
ROY-1	09/20/01	SOLIDS, TOT. SUS.	30	MG/L
ROY-1	09/20/01	SOLIDS, TOT. SUS.	29	MG/L
ROY-1	10/15/01	SOLIDS, TOT. SUS.	10	MG/L

Station ID	Date	Parameter	Value	Unit
ROY-1	04/06/01	PHOSPHORUS-P, TOTAL	0.356	MG/L
ROY-1	04/09/01	PHOSPHORUS-P, TOTAL	0.083	MG/L
ROY-1	05/15/01	PHOSPHORUS-P, TOTAL	0.627	MG/L
ROY-1	05/15/01	PHOSPHORUS-P, TOTAL	0.067	MG/L
ROY-1	05/19/01	PHOSPHORUS-P, TOTAL	0.145	MG/L
ROY-1	05/21/01	PHOSPHORUS-P, TOTAL	0.127	MG/L
ROY-1	05/29/01	PHOSPHORUS-P, TOTAL	0.222	MG/L
ROY-1	05/29/01	PHOSPHORUS-P, TOTAL	0.162	MG/L
ROY-1	05/29/01	PHOSPHORUS-P, TOTAL	0.113	MG/L
ROY-1	05/30/01	PHOSPHORUS-P, TOTAL	0.938	MG/L
ROY-1	07/24/01	PHOSPHORUS-P, TOTAL	0.453	MG/L
ROY-1	07/25/01	PHOSPHORUS-P, TOTAL	0.124	MG/L
ROY-1	07/25/01	PHOSPHORUS-P, TOTAL	0.123	MG/L
ROY-1	07/25/01	PHOSPHORUS-P, TOTAL	0.39	MG/L
ROY-1	08/27/01	PHOSPHORUS-P, TOTAL	0.648	MG/L
ROY-1	08/27/01	PHOSPHORUS-P, TOTAL	0.256	MG/L
ROY-1	09/04/01	PHOSPHORUS-P, TOTAL	0.196	MG/L
ROY-1	09/04/01	PHOSPHORUS-P, TOTAL	0.874	MG/L
ROY-1	09/20/01	PHOSPHORUS-P, TOTAL	0.36	MG/L
ROY-1	09/20/01	PHOSPHORUS-P, TOTAL	0.327	MG/L
ROY-1	10/24/01	PHOSPHORUS-P, TOTAL	0.295	MG/L
ROY-1	10/27/01	PHOSPHORUS-P, TOTAL	0.348	MG/L
ROY-1	10/27/01	PHOSPHORUS-P, TOTAL	0.347	MG/L
ROY-1	10/27/01	PHOSPHORUS-P, TOTAL	0.245	MG/L
ROY-1	11/24/01	PHOSPHORUS-P, TOTAL	0.256	MG/L
ROY-1	11/24/01	PHOSPHORUS-P, TOTAL	0.249	MG/L
ROY-1	11/24/01	PHOSPHORUS-P, TOTAL	0.179	MG/L
ROY-1	11/30/01	PHOSPHORUS-P, TOTAL	0.193	MG/L
ROY-1	12/13/01	PHOSPHORUS-P, TOTAL	0.208	MG/L
ROY-1	12/14/01	PHOSPHORUS-P, TOTAL	0.208	MG/L
ROY-1	12/15/01	PHOSPHORUS-P, TOTAL	0.217	MG/L
ROY-1	12/15/01	PHOSPHORUS-P, TOTAL	0.214	MG/L
ROY-1	12/15/01	PHOSPHORUS-P, TOTAL	0.212	MG/L
ROY-1	12/16/01	PHOSPHORUS-P, TOTAL	0.229	MG/L
ROY-1	12/17/01	PHOSPHORUS-P, TOTAL	0.319	MG/L
ROY-1	01/17/02	PHOSPHORUS-P, TOTAL	0.286	MG/L
ROY-1	01/17/02	PHOSPHORUS-P, TOTAL	0.303	MG/L
ROY-1	01/17/02	PHOSPHORUS-P, TOTAL	0.295	MG/L
ROY-1	01/30/02	PHOSPHORUS-P, TOTAL	0.284	MG/L
ROY-1	02/19/02	PHOSPHORUS-P, TOTAL	0.195	MG/L
ROY-1	02/23/02	PHOSPHORUS-P, TOTAL	0.193	MG/L
ROY-1	02/23/02	PHOSPHORUS-P, TOTAL	0.173	MG/L
ROY-1	02/23/02	PHOSPHORUS-P, TOTAL	0.189	MG/L
ROY-1	03/02/02	PHOSPHORUS-P, TOTAL	0.15	MG/L
ROY-1	03/19/02	PHOSPHORUS-P, TOTAL	0.153	MG/L
ROY-1	03/19/02	PHOSPHORUS-P, TOTAL	0.145	MG/L
ROY-1	03/19/02	PHOSPHORUS-P, TOTAL	0.133	MG/L
ROY-1	04/01/02	PHOSPHORUS-P, TOTAL	0.144	MG/L
ROY-1	04/01/02	PHOSPHORUS-P, TOTAL	0.149	MG/L
ROY-1	04/01/02	PHOSPHORUS-P, TOTAL	0.185	MG/L
ROY-1	04/08/02	PHOSPHORUS-P, TOTAL	0.146	MG/L

Station ID	Date	Parameter	Value	Unit
ROG-3	04/27/89	SOLIDS, TOT. SUS.	4	MG/L
ROG-3	06/15/89	SOLIDS, TOT. SUS.	4	MG/L
ROG-3	07/11/89	SOLIDS, TOT. SUS.	9	MG/L
ROG-3	08/08/89	SOLIDS, TOT. SUS.	10	MG/L
ROG-3	10/12/89	SOLIDS, TOT. SUS.	8	MG/L
ROG-3	04/28/93	SOLIDS, TOT. SUS.	15	MG/L
ROG-3	06/16/93	SOLIDS, TOT. SUS.	13	MG/L
ROG-3	08/19/93	SOLIDS, TOT. SUS.	8	MG/L
ROG-3	04/14/97	SOLIDS, TOT. SUS.	13	MG/L
ROG-3	06/02/97	SOLIDS, TOT. SUS.	17	MG/L
ROG-3	07/01/97	SOLIDS, TOT. SUS.	7	MG/L
ROG-3	08/04/97	SOLIDS, TOT. SUS.	10	MG/L
ROG-3	10/02/97	SOLIDS, TOT. SUS.	12	MG/L
ROG-3	04/18/02	SOLIDS, TOT. SUS.	27	MG/L
ROG-3	06/19/02	SOLIDS, TOT. SUS.	17	MG/L
ROG-3	07/22/02	SOLIDS, TOT. SUS.	12	MG/L
ROG-3	08/22/02	SOLIDS, TOT. SUS.	7	MG/L
ROG-3	10/11/02	SOLIDS, TOT. SUS.	5	MG/L
ROY-02	05/15/01	PHOSPHORUS-P, TOTAL	0.217	MG/L
ROY-02	05/19/01	PHOSPHORUS-P, TOTAL	0.383	MG/L
ROY-02	05/21/01	PHOSPHORUS-P, TOTAL	0.752	MG/L
ROY-02	05/29/01	PHOSPHORUS-P, TOTAL	0.117	MG/L
ROY-02	05/30/01	PHOSPHORUS-P, TOTAL	0.126	MG/L
ROY-02	07/24/01	PHOSPHORUS-P, TOTAL	0.724	MG/L
ROY-02	07/25/01	PHOSPHORUS-P, TOTAL	0.493	MG/L
ROY-02	01/17/02	PHOSPHORUS-P, TOTAL	0.147	MG/L
ROY-02	01/30/02	PHOSPHORUS-P, TOTAL	0.552	MG/L
ROY-02	02/19/02	PHOSPHORUS-P, TOTAL	0.133	MG/L
ROY-02	02/23/02	PHOSPHORUS-P, TOTAL	0.175	MG/L
ROY-02	06/25/01	PHOSPHORUS-P,TOTAL	0.155	MG/L
ROY-1	08/18/93	CHLOROPHYL-A UNCO	151.0	UG/L
ROY-1	04/09/01	CHLOROPHYL-A UNCO	42.4	UG/L
ROY-1	05/15/01	CHLOROPHYL-A UNCO	24.5	UG/L
ROY-1	05/29/01	CHLOROPHYL-A UNCO	39.4	UG/L
ROY-1	06/07/01	CHLOROPHYL-A UNCO	18.5	UG/L
ROY-1	06/25/01	CHLOROPHYL-A UNCO	18	UG/L
ROY-1	07/10/01	CHLOROPHYL-A UNCO	20.7	UG/L
ROY-1	07/25/01	CHLOROPHYL-A UNCO	53.7	UG/L
ROY-1	08/20/01	CHLOROPHYL-A UNCO	95.3	UG/L
ROY-1	08/27/01	CHLOROPHYL-A UNCO	240	UG/L
ROY-1	09/04/01	CHLOROPHYL-A UNCO	158	UG/L
ROY-1	09/20/01	CHLOROPHYL-A UNCO	100	UG/L
ROY-1	10/15/01	CHLOROPHYL-A UNCO	7.83	UG/L
ROY-1	10/27/01	CHLOROPHYL-A UNCO	39.7	UG/L
ROY-1	11/24/01	CHLOROPHYL-A UNCO	27.2	UG/L
ROY-1	12/15/01	CHLOROPHYL-A UNCO	5.97	UG/L
ROY-1	01/17/02	CHLOROPHYL-A UNCO	3.72	UG/L
ROY-1	02/23/02	CHLOROPHYL-A UNCO	36.8	UG/L
ROY-1	03/19/02	CHLOROPHYL-A UNCO	35.2	UG/L
ROY-1	04/01/02	CHLOROPHYL-A UNCO	67.1	UG/L
ROY-1	04/23/02	CHLOROPHYL-A UNCO	42.2	UG/L

Station ID	Date	Parameter	Value	Unit
ROG-2	08/19/93	SOLIDS, TOT. SUS.	10	MG/L
ROG-2	10/14/93	SOLIDS, TOT. SUS.	1	MG/L
ROG-2	04/14/97	SOLIDS, TOT. SUS.	8	MG/L
ROG-2	06/02/97	SOLIDS, TOT. SUS.	8	MG/L
ROG-2	07/01/97	SOLIDS, TOT. SUS.	5	MG/L
ROG-2	08/04/97	SOLIDS, TOT. SUS.	8	MG/L
ROG-2	10/02/97	SOLIDS, TOT. SUS.	5	MG/L
ROG-2	04/18/02	SOLIDS, TOT. SUS.	8	MG/L
ROG-2	06/19/02	SOLIDS, TOT. SUS.	17	MG/L
ROG-2	07/22/02	SOLIDS, TOT. SUS.	6	MG/L
ROG-2	08/22/02	SOLIDS, TOT. SUS.	4	MG/L
ROG-2	10/11/02	SOLIDS, TOT. SUS.	3	MG/L
ROG-3	04/27/89	CHLOROPHYL-A UNCO	20.83	UG/L
ROG-3	06/15/89	CHLOROPHYL-A UNCO	53.12	UG/L
ROG-3	07/11/89	CHLOROPHYL-A UNCO	29.62	UG/L
ROG-3	08/08/89	CHLOROPHYL-A UNCO	20.84	UG/L
ROG-3	10/12/89	CHLOROPHYL-A UNCO	20.01	UG/L
ROG-3	04/28/93	CHLOROPHYL-A UNCO	5.78	UG/L
ROG-3	06/16/93	CHLOROPHYL-A UNCO	27.18	UG/L
ROG-3	07/08/93	CHLOROPHYL-A UNCO	14.94	UG/L
ROG-3	10/14/93	CHLOROPHYL-A UNCO	24.52	UG/L
ROG-3	04/14/97	CHLOROPHYL-A UNCO	26.83	UG/L
ROG-3	06/02/97	CHLOROPHYL-A UNCO	3.91	UG/L
ROG-3	07/01/97	CHLOROPHYL-A UNCO	11.02	UG/L
ROG-3	08/04/97	CHLOROPHYL-A UNCO	21.71	UG/L
ROG-3	10/02/97	CHLOROPHYL-A UNCO	7.10	UG/L
ROG-3	04/18/02	CHLOROPHYL-A UNCO	61.4	UG/L
ROG-3	06/19/02	CHLOROPHYL-A UNCO	67.4	UG/L
ROG-3	07/22/02	CHLOROPHYL-A UNCO	16.9	UG/L
ROG-3	08/22/02	CHLOROPHYL-A UNCO	20.2	UG/L
ROG-3	10/11/02	CHLOROPHYL-A UNCO	12.7	UG/L
ROG-3	06/23/77	PHOSPHORUS-P,TOTAL	0.09	MG/L
ROG-3	04/27/89	PHOSPHORUS-P,TOTAL	0.04	MG/L
ROG-3	06/15/89	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROG-3	07/11/89	PHOSPHORUS-P,TOTAL	1.52	MG/L
ROG-3	08/08/89	PHOSPHORUS-P,TOTAL	0.05	MG/L
ROG-3	10/12/89	PHOSPHORUS-P,TOTAL	0.07	MG/L
ROG-3	04/28/93	PHOSPHORUS-P,TOTAL	0.12	MG/L
ROG-3	06/16/93	PHOSPHORUS-P,TOTAL	0.06	MG/L
ROG-3	07/08/93	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROG-3	08/19/93	PHOSPHORUS-P,TOTAL	0.07	MG/L
ROG-3	06/02/97	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROG-3	07/01/97	PHOSPHORUS-P,TOTAL	0.06	MG/L
ROG-3	08/04/97	PHOSPHORUS-P,TOTAL	0.07	MG/L
ROG-3	10/02/97	PHOSPHORUS-P,TOTAL	0.05	MG/L
ROG-3	04/18/02	PHOSPHORUS-P,TOTAL	0.144	MG/L
ROG-3	06/19/02	PHOSPHORUS-P,TOTAL	0.121	MG/L
ROG-3	07/22/02	PHOSPHORUS-P,TOTAL	0.087	MG/L
ROG-3	08/22/02	PHOSPHORUS-P,TOTAL	0.075	MG/L
ROG-3	10/11/02	PHOSPHORUS-P,TOTAL	0.063	MG/L
ROG-3	06/23/77	SOLIDS, TOT. SUS.	47	MG/L

Station ID	Date	Parameter	Value	Unit
ROG-2	06/15/89	CHLOROPHYL-A UNCO	14.5	UG/L
ROG-2	07/11/89	CHLOROPHYL-A UNCO	22.0	UG/L
ROG-2	08/08/89	CHLOROPHYL-A UNCO	15.7	UG/L
ROG-2	10/12/89	CHLOROPHYL-A UNCO	9.0	UG/L
ROG-2	04/28/93	CHLOROPHYL-A UNCO	13.6	UG/L
ROG-2	06/16/93	CHLOROPHYL-A UNCO	11.1	UG/L
ROG-2	07/08/93	CHLOROPHYL-A UNCO	11.8	UG/L
ROG-2	07/08/93	CHLOROPHYL-A UNCO	11.8	UG/L
ROG-2	08/19/93	CHLOROPHYL-A UNCO	12.7	UG/L
ROG-2	08/19/93	CHLOROPHYL-A UNCO	16.4	UG/L
ROG-2	10/14/93	CHLOROPHYL-A UNCO	10.0	UG/L
ROG-2	04/14/97	CHLOROPHYL-A UNCO	2.8	UG/L
ROG-2	06/02/97	CHLOROPHYL-A UNCO	108.3	UG/L
ROG-2	07/01/97	CHLOROPHYL-A UNCO	16.8	UG/L
ROG-2	08/04/97	CHLOROPHYL-A UNCO	17.9	UG/L
ROG-2	10/02/97	CHLOROPHYL-A UNCO	5.2	UG/L
ROG-2	04/18/02	CHLOROPHYL-A UNCO	23.9	UG/L
ROG-2	06/19/02	CHLOROPHYL-A UNCO	16.8	UG/L
ROG-2	07/22/02	CHLOROPHYL-A UNCO	24	UG/L
ROG-2	08/22/02	CHLOROPHYL-A UNCO	18.9	UG/L
ROG-2	10/11/02	CHLOROPHYL-A UNCO	17.7	UG/L
ROG-2	06/23/77	PHOSPHORUS-P,TOTAL	0.020	MG/L
ROG-2	04/27/89	PHOSPHORUS-P,TOTAL	0.024	MG/L
ROG-2	06/15/89	PHOSPHORUS-P,TOTAL	0.055	MG/L
ROG-2	07/11/89	PHOSPHORUS-P,TOTAL	0.024	MG/L
ROG-2	08/08/89	PHOSPHORUS-P,TOTAL	0.024	MG/L
ROG-2	10/12/89	PHOSPHORUS-P,TOTAL	0.064	MG/L
ROG-2	04/28/93	PHOSPHORUS-P,TOTAL	0.117	MG/L
ROG-2	06/16/93	PHOSPHORUS-P,TOTAL	0.066	MG/L
ROG-2	07/08/93	PHOSPHORUS-P,TOTAL	0.055	MG/L
ROG-2	08/19/93	PHOSPHORUS-P,TOTAL	0.070	MG/L
ROG-2	10/14/93	PHOSPHORUS-P,TOTAL	0.098	MG/L
ROG-2	04/14/97	PHOSPHORUS-P,TOTAL	0.077	MG/L
ROG-2	06/02/97	PHOSPHORUS-P,TOTAL	0.045	MG/L
ROG-2	07/01/97	PHOSPHORUS-P,TOTAL	0.023	MG/L
ROG-2	08/04/97	PHOSPHORUS-P,TOTAL	0.048	MG/L
ROG-2	10/02/97	PHOSPHORUS-P,TOTAL	0.032	MG/L
ROG-2	04/18/02	PHOSPHORUS-P,TOTAL	0.041	MG/L
ROG-2	06/19/02	PHOSPHORUS-P,TOTAL	0.088	MG/L
ROG-2	07/22/02	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROG-2	08/22/02	PHOSPHORUS-P,TOTAL	0.065	MG/L
ROG-2	10/11/02	PHOSPHORUS-P,TOTAL	0.068	MG/L
ROG-2	06/23/77	SOLIDS, TOT. SUS.	6	MG/L
ROG-2	04/27/89	SOLIDS, TOT. SUS.	1	MG/L
ROG-2	06/15/89	SOLIDS, TOT. SUS.	2	MG/L
ROG-2	07/11/89	SOLIDS, TOT. SUS.	4	MG/L
ROG-2	08/08/89	SOLIDS, TOT. SUS.	4	MG/L
ROG-2	10/12/89	SOLIDS, TOT. SUS.	4	MG/L
ROG-2	04/28/93	SOLIDS, TOT. SUS.	16	MG/L
ROG-2	06/16/93	SOLIDS, TOT. SUS.	7	MG/L
ROG-2	07/08/93	SOLIDS, TOT. SUS.	3	MG/L

Station ID	Date	Parameter	Value	Unit
ROG-1	04/18/02	PHOSPHORUS-P,TOTAL	0.041	MG/L
ROG-1	06/19/02	PHOSPHORUS-P,TOTAL	0.212	MG/L
ROG-1	06/19/02	PHOSPHORUS-P,TOTAL	0.098	MG/L
ROG-1	07/22/02	PHOSPHORUS-P,TOTAL	0.096	MG/L
ROG-1	07/22/02	PHOSPHORUS-P,TOTAL	0.368	MG/L
ROG-1	08/22/02	PHOSPHORUS-P,TOTAL	0.081	MG/L
ROG-1	08/22/02	PHOSPHORUS-P,TOTAL	0.081	MG/L
ROG-1	10/11/02	PHOSPHORUS-P,TOTAL	0.103	MG/L
ROG-1	10/11/02	PHOSPHORUS-P,TOTAL	0.099	MG/L
ROG-1	06/23/77	SOLIDS, TOT. SUS.	6	MG/L
ROG-1	04/27/89	SOLIDS, TOT. SUS.	10	MG/L
ROG-1	04/27/89	SOLIDS, TOT. SUS.	4	MG/L
ROG-1	06/15/89	SOLIDS, TOT. SUS.	2	MG/L
ROG-1	06/15/89	SOLIDS, TOT. SUS.	4	MG/L
ROG-1	07/11/89	SOLIDS, TOT. SUS.	13	MG/L
ROG-1	07/11/89	SOLIDS, TOT. SUS.	35	MG/L
ROG-1	08/08/89	SOLIDS, TOT. SUS.	100	MG/L
ROG-1	08/08/89	SOLIDS, TOT. SUS.	7	MG/L
ROG-1	10/12/89	SOLIDS, TOT. SUS.	7	MG/L
ROG-1	10/12/89	SOLIDS, TOT. SUS.	9	MG/L
ROG-1	04/28/93	SOLIDS, TOT. SUS.	5	MG/L
ROG-1	04/28/93	SOLIDS, TOT. SUS.	6	MG/L
ROG-1	06/16/93	SOLIDS, TOT. SUS.	12	MG/L
ROG-1	06/16/93	SOLIDS, TOT. SUS.	6	MG/L
ROG-1	07/08/93	SOLIDS, TOT. SUS.	2	MG/L
ROG-1	07/08/93	SOLIDS, TOT. SUS.	7	MG/L
ROG-1	08/19/93	SOLIDS, TOT. SUS.	11	MG/L
ROG-1	08/19/93	SOLIDS, TOT. SUS.	8	MG/L
ROG-1	10/14/93	SOLIDS, TOT. SUS.	1	MG/L
ROG-1	10/14/93	SOLIDS, TOT. SUS.	4	MG/L
ROG-1	10/14/93	SOLIDS, TOT. SUS.	3	MG/L
ROG-1	04/14/97	SOLIDS, TOT. SUS.	10	MG/L
ROG-1	04/14/97	SOLIDS, TOT. SUS.	12	MG/L
ROG-1	06/02/97	SOLIDS, TOT. SUS.	11	MG/L
ROG-1	07/01/97	SOLIDS, TOT. SUS.	5	MG/L
ROG-1	07/01/97	SOLIDS, TOT. SUS.	7	MG/L
ROG-1	08/04/97	SOLIDS, TOT. SUS.	4	MG/L
ROG-1	08/04/97	SOLIDS, TOT. SUS.	4	MG/L
ROG-1	10/02/97	SOLIDS, TOT. SUS.	6	MG/L
ROG-1	10/02/97	SOLIDS, TOT. SUS.	7	MG/L
ROG-1	04/18/02	SOLIDS, TOT. SUS.	12	MG/L
ROG-1	04/18/02	SOLIDS, TOT. SUS.	8	MG/L
ROG-1	06/19/02	SOLIDS, TOT. SUS.	20	MG/L
ROG-1	06/19/02	SOLIDS, TOT. SUS.	12	MG/L
ROG-1	07/22/02	SOLIDS, TOT. SUS.	9	MG/L
ROG-1	07/22/02	SOLIDS, TOT. SUS.	7	MG/L
ROG-1	08/22/02	SOLIDS, TOT. SUS.	3	MG/L
ROG-1	08/22/02	SOLIDS, TOT. SUS.	3	MG/L
ROG-1	10/11/02	SOLIDS, TOT. SUS.	3	MG/L
ROG-1	10/11/02	SOLIDS, TOT. SUS.	3	MG/L
ROG-2	04/27/89	CHLOROPHYL-A UNCO	11.5	UG/L

Station ID	Date	Parameter	Value	Unit
ROG-1	04/27/89	CHLOROPHYL-A UNCO	7.63	UG/L
ROG-1	06/15/89	CHLOROPHYL-A UNCO	8.23	UG/L
ROG-1	07/11/89	CHLOROPHYL-A UNCO	11.30	UG/L
ROG-1	10/12/89	CHLOROPHYL-A UNCO	7.43	UG/L
ROG-1	04/28/93	CHLOROPHYL-A UNCO	4.61	UG/L
ROG-1	06/16/93	CHLOROPHYL-A UNCO	5.36	UG/L
ROG-1	07/08/93	CHLOROPHYL-A UNCO	5.20	UG/L
ROG-1	08/19/93	CHLOROPHYL-A UNCO	10.82	UG/L
ROG-1	10/14/93	CHLOROPHYL-A UNCO	3.80	UG/L
ROG-1	04/14/97	CHLOROPHYL-A UNCO	4.26	UG/L
ROG-1	06/02/97	CHLOROPHYL-A UNCO	4.68	UG/L
ROG-1	07/01/97	CHLOROPHYL-A UNCO	13.17	UG/L
ROG-1	08/04/97	CHLOROPHYL-A UNCO	13.26	UG/L
ROG-1	10/02/97	CHLOROPHYL-A UNCO	3.01	UG/L
ROG-1	04/18/02	CHLOROPHYL-A UNCO	26.6	UG/L
ROG-1	06/19/02	CHLOROPHYL-A UNCO	16.3	UG/L
ROG-1	07/22/02	CHLOROPHYL-A UNCO	16.2	UG/L
ROG-1	08/22/02	CHLOROPHYL-A UNCO	15.3	UG/L
ROG-1	10/11/02	CHLOROPHYL-A UNCO	7.44	UG/L
ROG-1	06/23/77	PHOSPHORUS-P,TOTAL	0.01	MG/L
ROG-1	04/27/89	PHOSPHORUS-P,TOTAL	0.04	MG/L
ROG-1	04/27/89	PHOSPHORUS-P,TOTAL	0.06	MG/L
ROG-1	06/15/89	PHOSPHORUS-P,TOTAL	0.04	MG/L
ROG-1	06/15/89	PHOSPHORUS-P,TOTAL	0.09	MG/L
ROG-1	07/11/89	PHOSPHORUS-P,TOTAL	0.19	MG/L
ROG-1	07/11/89	PHOSPHORUS-P,TOTAL	0.04	MG/L
ROG-1	08/08/89	PHOSPHORUS-P,TOTAL	0.03	MG/L
ROG-1	08/08/89	PHOSPHORUS-P,TOTAL	0.53	MG/L
ROG-1	10/12/89	PHOSPHORUS-P,TOTAL	0.28	MG/L
ROG-1	10/12/89	PHOSPHORUS-P,TOTAL	0.06	MG/L
ROG-1	04/28/93	PHOSPHORUS-P,TOTAL	0.11	MG/L
ROG-1	04/28/93	PHOSPHORUS-P,TOTAL	0.11	MG/L
ROG-1	06/16/93	PHOSPHORUS-P,TOTAL	0.12	MG/L
ROG-1	06/16/93	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROG-1	07/08/93	PHOSPHORUS-P,TOTAL	0.06	MG/L
ROG-1	07/08/93	PHOSPHORUS-P,TOTAL	0.06	MG/L
ROG-1	08/19/93	PHOSPHORUS-P,TOTAL	0.26	MG/L
ROG-1	08/19/93	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROG-1	10/14/93	PHOSPHORUS-P,TOTAL	0.11	MG/L
ROG-1	10/14/93	PHOSPHORUS-P,TOTAL	0.10	MG/L
ROG-1	10/14/93	PHOSPHORUS-P,TOTAL	0.12	MG/L
ROG-1	04/14/97	PHOSPHORUS-P,TOTAL	0.08	MG/L
ROG-1	04/14/97	PHOSPHORUS-P,TOTAL	0.09	MG/L
ROG-1	06/02/97	PHOSPHORUS-P,TOTAL	0.05	MG/L
ROG-1	07/01/97	PHOSPHORUS-P,TOTAL	0.04	MG/L
ROG-1	07/01/97	PHOSPHORUS-P,TOTAL	0.05	MG/L
ROG-1	08/04/97	PHOSPHORUS-P,TOTAL	0.21	MG/L
ROG-1	08/04/97	PHOSPHORUS-P,TOTAL	0.04	MG/L
ROG-1	10/02/97	PHOSPHORUS-P,TOTAL	0.13	MG/L
ROG-1	10/02/97	PHOSPHORUS-P,TOTAL	0.04	MG/L
ROG-1	04/18/02	PHOSPHORUS-P,TOTAL	0.066	MG/L

Station ID	Date	Parameter	Value	Unit
ROY-3	10/15/01	CHLOROPHYL-A UNCO	4.24	UG/L
ROY-3	10/27/01	CHLOROPHYL-A UNCO	35.6	UG/L
ROY-3	11/24/01	CHLOROPHYL-A UNCO	16.5	UG/L
ROY-3	12/15/01	CHLOROPHYL-A UNCO	12.7	UG/L
ROY-3	01/17/02	CHLOROPHYL-A UNCO	4.21	UG/L
ROY-3	02/23/02	CHLOROPHYL-A UNCO	36.9	UG/L
ROY-3	03/19/02	CHLOROPHYL-A UNCO	47.3	UG/L
ROY-3	04/01/02	CHLOROPHYL-A UNCO	83.4	UG/L
ROY-3	04/23/02	CHLOROPHYL-A UNCO	9.52	UG/L
ROY-3	04/09/01	PHOSPHORUS-P, TOTAL	0.062	MG/L
ROY-3	05/15/01	PHOSPHORUS-P, TOTAL	0.056	MG/L
ROY-3	05/29/01	PHOSPHORUS-P, TOTAL	0.137	MG/L
ROY-3	07/25/01	PHOSPHORUS-P, TOTAL	0.141	MG/L
ROY-3	08/27/01	PHOSPHORUS-P, TOTAL	0.352	MG/L
ROY-3	09/04/01	PHOSPHORUS-P, TOTAL	0.196	MG/L
ROY-3	09/20/01	PHOSPHORUS-P, TOTAL	0.304	MG/L
ROY-3	10/27/01	PHOSPHORUS-P, TOTAL	0.345	MG/L
ROY-3	11/24/01	PHOSPHORUS-P, TOTAL	0.226	MG/L
ROY-3	12/15/01	PHOSPHORUS-P, TOTAL	0.275	MG/L
ROY-3	01/17/02	PHOSPHORUS-P, TOTAL	0.272	MG/L
ROY-3	02/23/02	PHOSPHORUS-P, TOTAL	0.184	MG/L
ROY-3	03/19/02	PHOSPHORUS-P, TOTAL	0.168	MG/L
ROY-3	04/01/02	PHOSPHORUS-P, TOTAL	0.196	MG/L
ROY-3	04/23/02	PHOSPHORUS-P, TOTAL	0.197	MG/L
ROY-3	06/07/01	PHOSPHORUS-P,TOTAL	0.069	MG/L
ROY-3	06/25/01	PHOSPHORUS-P,TOTAL	0.082	MG/L
ROY-3	07/10/01	PHOSPHORUS-P,TOTAL	0.107	MG/L
ROY-3	08/20/01	PHOSPHORUS-P,TOTAL	0.274	MG/L
ROY-3	10/15/01	PHOSPHORUS-P,TOTAL	3.07	MG/L
ROY-3	04/09/01	SOLIDS, TOT. SUS.	7	MG/L
ROY-3	05/15/01	SOLIDS, TOT. SUS.	10	MG/L
ROY-3	05/29/01	SOLIDS, TOT. SUS.	13	MG/L
ROY-3	06/07/01	SOLIDS, TOT. SUS.	8	MG/L
ROY-3	06/25/01	SOLIDS, TOT. SUS.	13	MG/L
ROY-3	07/10/01	SOLIDS, TOT. SUS.	11	MG/L
ROY-3	07/25/01	SOLIDS, TOT. SUS.	15	MG/L
ROY-3	08/20/01	SOLIDS, TOT. SUS.	25	MG/L
ROY-3	08/27/01	SOLIDS, TOT. SUS.	16	MG/L
ROY-3	09/04/01	SOLIDS, TOT. SUS.	17	MG/L
ROY-3	09/20/01	SOLIDS, TOT. SUS.	30	MG/L
ROY-3	10/15/01	SOLIDS, TOT. SUS.	9	MG/L
ROY-3	10/27/01	SOLIDS, TOT. SUS.	18	MG/L
ROY-3	11/24/01	SOLIDS, TOT. SUS.	5	MG/L
ROY-3	12/15/01	SOLIDS, TOT. SUS.	6	MG/L
ROY-3	01/17/02	SOLIDS, TOT. SUS.	9	MG/L
ROY-3	02/23/02	SOLIDS, TOT. SUS.	21	MG/L
ROY-3	03/19/02	SOLIDS, TOT. SUS.	27	MG/L
ROY-3	04/01/02	SOLIDS, TOT. SUS.	26	MG/L
ROY-3	04/23/02	SOLIDS, TOT. SUS.	15	MG/L

FINAL Approved TMDL

Coffeen Lake (ROG)
Greenville Lake (ROY)

Shoal Creek Watershed

Prepared for: **Illinois Environmental Protection Agency**

August 2007

Coffeen Lake (ROG): Phosphorus
Greenville Lake (ROY): Phosphorus

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INTRODUCTION

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

Coffeen and Greenville Lakes are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as water bodies that are not meeting their designated uses. Because these lakes are nonsupporting of the aesthetic quality use only, they are considered low priority waters for TMDL development.[1] This document presents the TMDLs designed to allow these two lakes to fully support their designated uses. This report covers each step of the TMDL process and is organized as follows:

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

[1] When TMDL development began (e.g., Stage 1 Report), this watershed had a high priority rating based on Governor Bond Lake's public water supply impairment. Because Governor Bond Lake has since had a TMDL completed, this watershed now has a lower priority rating.

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1 PROBLEM IDENTIFICATION

The two impaired waterbody segments addressed in this TMDL are listed below, with the parameters they are listed for, and the use impairments as identified in the 2006 303(d) list (IEPA, 2006). TMDLs are currently only being developed for pollutants that have numerical water quality standards. Those impairments that are the focus of this report are shown in bold font.

Coffeen Lake	
Waterbody Segment	ROG
Size (Acres)	1,038
Listed For	**Phosphorus (Total)**, Total Suspended Solids, Habitat Assessment
Use Support	Aesthetic Quality (Not Supporting)

Greenville Lake	
Waterbody Segment	ROY
Size (Acres)	25.1
Listed For	**Phosphorus (Total)**, Total Suspended Solids, Excess Aquatic Algae
Use Support	Aesthetic Quality (Not Supporting)

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2 REQUIRED TMDL ELEMENTS

U.S. EPA Region 5 guidance (USEPA, 1991) for TMDL development requires TMDLs to contain specific components. Each of those components is summarized here, by waterbody.

Coffeen Lake

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Coffeen Lake, HUC 0717020304. The pollutant of concern addressed in this TMDL is total phosphorus. Pollutant sources are listed as crop production (cropland or dry land), and industrial point source discharges (IEPA, 2006). Coffeen Lake is ranked as a low priority on the 2006 Illinois EPA 303(d) list for TMDL development.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target**: The water quality standard for **total phosphorus** to protect the aesthetic quality use in Illinois lakes is 0.05 mg-P/l. For the Coffeen Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.
3. **Loading Capacity - Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine the maximum tributary phosphorus load that will maintain compliance with the phosphorus standard is 0.16 kg-P/day between April 1 and August 31, with the total load not to exceed 25 kg during this period.
4. **Load Allocations (LA)**: The load allocation designed to achieve compliance with the above TMDL is 0.139 kg-P/day for the period April 1 through August 31.
5. **Wasteload Allocations (WLA)**: There is one point source discharger[2] in the Coffeen Lake watershed (Ameren Energy). This facility has both cooling water and treated wastewater effluent. A WLA was calculated for the treated wastewater effluent and set as estimated existing loading conditions (0.005 kg-P/d).
6. **Margin of Safety**: The TMDL contains an explicit margin of safety corresponding to 10% of the loading capacity, or 0.016 kg-P/day, that reflects the uncertainty in the BATHTUB model predictions.
7. **Seasonal Variation**: The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The April - August duration for the seasonal loading was determined based on a

[2] Three point sources were mentioned in the Stage 1 report, but one was determined to be inactive and the other was mentioned in error. This WLA is therefore based on only one point source discharger.

calculation of a phosphorus residence time in Coffeen Lake on the order of weeks to months.

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

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

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

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report (TetraTech 2006).

9. **Monitoring Plan to Track TMDL Effectiveness**: A monitoring plan is included as part of the implementation plan.

10. **Transmittal Letter**: A letter will be included with the transmittal of this TMDL to US EPA Region V.

11. **Public Participation**: Public participation is an important step in the development of an applicable and effective TMDL. The Stage 1 report involved contacts with several state agencies, as described in Appendix A of the Stage 1 report (TetraTech 2006). IEPA and its consultants will provide other necessary opportunities for public involvement to support the development and completion of the TMDL and implementation plan as well. A public meeting was held previously to present the results of the watershed characterization and data analysis (Stage 1). A second public meeting was conducted within the watershed on July 12, 2007 to present the TMDL and Implementation Plan. The purpose of this meeting was to involve the general public, local municipalities, affected industrial clients, and others to review the TMDL and implementation plan, comment on its contents and recommendations, and actively participate in the TMDL process.

Greenville Lake

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Greenville Lake, HUC 0717020304. The pollutant of concern addressed in this TMDL is total phosphorus. Pollutant sources are listed as crop production (cropland or dry land), and runoff from forest/grassland/parkland, crop production (cropland or dryland). Greenville Lake is ranked as a low priority on the 2006 Illinois EPA 303(d) list for TMDL development (IEPA 2006).

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for **total phosphorus** to protect the aesthetic quality use in Illinois lakes is 0.05 mg-P/l. For the Greenville Lake phosphorus TMDL, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.
3. **Loading Capacity - Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine the maximum tributary phosphorus load that will maintain compliance with the phosphorus standard is 0.53 kg-P/day between April 1 and August 31, with the total load not to exceed 81 kg during this period.
4. **Load Allocations (LA)**: The load allocation designed to achieve compliance with the above TMDL is 0.47 kg/day between April 1 and August 31.
5. **Wasteload Allocations (WLA)**: There are no permitted point sources in the Greenville Lake watershed so the WLA did not need to be calculated.
6. **Margin of Safety**: The TMDL contains an explicit margin of safety corresponding to 10% of the loading capacity, or 0.053 kg-P/day to reflect the uncertainty in the BATHTUB model predictions.
7. **Seasonal Variation**: The TMDL was conducted with an explicit consideration of seasonal variation. The BATHTUB model used for the phosphorus TMDL is designed to evaluate seasonal to annual loads. The seasonal loading analysis that was used is appropriate due to the long response time between phosphorus loading and biotic response. The April - August duration for the seasonal loading was determined based on a calculation of a phosphorus residence time in Greenville Lake on the order of weeks to months
8. **Reasonable Assurances**: There are no permitted point sources in the watershed and so reasonable assurances for point sources are not discussed.

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

   Local agencies and institutions with an interest in watershed management will be important for successful implementation of this TMDL. Detail on watershed activities is provided in the Stage 1 Report (TetraTech 2006).
9. **Monitoring Plan to Track TMDL Effectiveness**: A monitoring plan is included as part of the implementation plan.
10. **Transmittal Letter**: A letter will be included with the transmittal of this TMDL to US EPA Region V.

11. **Public Participation**: Public participation is an important step in the development of an applicable and effective TMDL. The Stage 1 report involved contacts with several state agencies, as described in Appendix A of the Stage 1 report (TetraTech 2006). IEPA and its consultants will provide other necessary opportunities for public involvement to support the development and completion of the TMDL and implementation plan as well. A public meeting was held previously to present the results of the watershed characterization and data analysis (Stage 1). A second public meeting was conducted within the watershed on July 12, 2007 to present the TMDL and Implementation Plan. The purpose of this meeting was to involve the general public, local municipalities, affected industrial clients, and others to review the TMDL and implementation plan, comment on its contents and recommendations, and actively participate in the TMDL process.

3 WATERSHED CHARACTERIZATION

The Stage 1 Report (TetraTech 2006) presents and discusses information describing the watersheds of the impaired waterbodies to support the identification of sources contributing to total phosphorus and total suspended solids impairments. Watershed characterization activities were focused on gaining an understanding of key features of the watersheds, including geology and soils, climate, land cover, hydrology, urbanization and population growth, point source discharges, and watershed activities.

The impaired waterbodies addressed in this report are located within the Shoal Creek watershed, which is located in southwestern Illinois. The Greenville Lake watershed is 3.36 square kilometers in size, located within Bond County and lands are primarily agricultural and forested. The Coffeen Lake watershed is 46.7 square kilometers in size, located within Montgomery County and lands are primarily agricultural and forested. Figure 3.1 depicts a map of the Coffeen Lake and Greenville Lake watersheds, and includes key features such as waterways, watershed boundaries and impaired waterbodies. The map also shows the location of the point source discharge in the Coffeen Lake watershed.

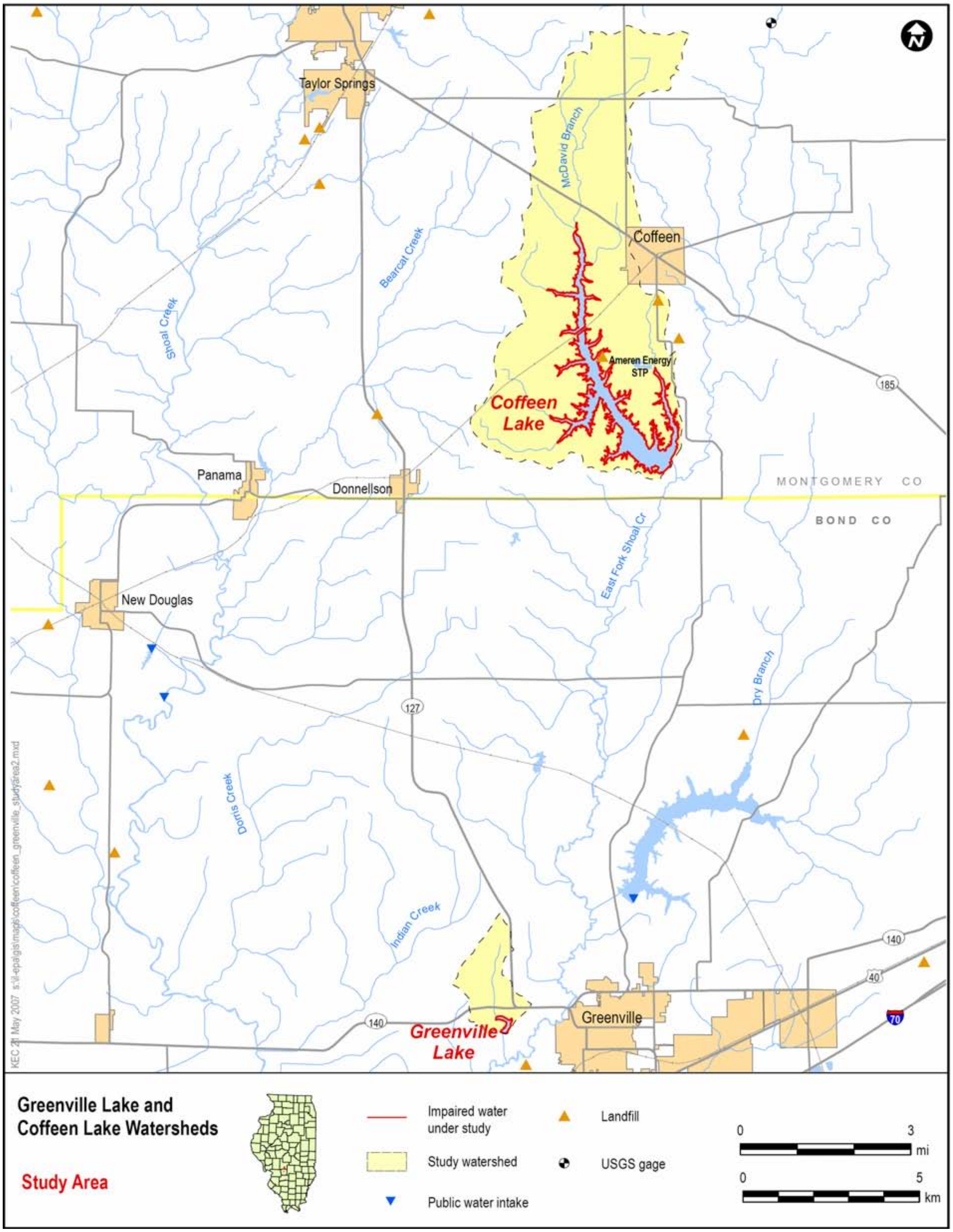

Figure 3-1. Base Map of Coffeen Lake and Greenville Lake Watersheds

4 DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

A water quality standard includes the designated uses of the waterbody, water quality criteria to protect designated uses, and an antidegradation policy to maintain and protect existing uses and high quality waters. This section discusses the applicable designated uses, use support, and criteria for Coffeen and Greenville Lakes.

4.1 DESIGNATED USES AND USE SUPPORT

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

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

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

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

4.2 WATER QUALITY CRITERIA

Illinois has established water quality criteria and guidelines for allowable concentrations of total phosphorus under its CWA Section 305(b) program, as summarized below. A comparison of available water quality data to the phosphorus criteria is provided in the Stage 1 Report (TetraTech 2006).

The IEPA guidelines (IEPA, 2006) for identifying total phosphorus as a cause of impairment in lakes (for lakes $\geq$ 20 acres) states that the *Aesthetic Quality* use is not supported if the surface phosphorus concentration exceeds the applicable numeric standard of 0.05 mg/l in at least one sample during a recent monitoring year.

4.3 DEVELOPMENT OF TMDL TARGETS

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

For the Coffeen Lake and Greenville Lake phosphorus TMDLs, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

5 DEVELOPMENT OF WATER QUALITY MODEL

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

- summarize the model selection process,
- provide an overview of the BATHTUB model,
- present the model inputs used in BATHTUB, and
- describe the model application and comparison of model output to data.

5.1 MODEL SELECTION

A detailed discussion of the model selection process for the Shoal Creek watershed is provided in the Stage 1 Report. Of the models discussed, the BATHTUB model was selected for application to Coffeen Lake and Greenville Lake.

The BATHTUB model was selected to estimate the loading capacity of the lakes. The model was used to predict the relationship between phosphorus load and resulting in-lake phosphorus concentrations for the lakes. The BATHTUB model was selected because it does not have extensive data requirements (and can therefore be applied with existing data), yet still provides the capability for calibration to observed lake data. BATHTUB has been used extensively for reservoir TMDLs in Illinois, and has been cited as an effective tool for lake and reservoir water quality assessment and management, particularly where data are limited (Ernst et al., 1994).

5.1.1 Selected Modeling Approach

The approach used in the development of this TMDL is based upon discussions with IEPA and the Scientific Advisory Committee. The approach consists of using existing empirical data to define current loads to the lakes, and using the BATHTUB model to define the extent to which these loads must be reduced to meet water quality standards. This approach was taken because phosphorus concentrations in both lakes exceed the TMDL targets by several fold. This indicates that phosphorus loads will need to be reduced to a small fraction of existing loads in order to attain water quality standards. The dominant land use in both watersheds is agriculture. This level of load reduction is likely not attainable in the near future. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, which requires no additional data collection, can be conducted immediately and will expedite the implementation efforts.

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

5.2 MODEL OVERVIEW

BATHTUB is a software program for predicting the lake/reservoir response to nutrient loading (Walker, 1986). Because reservoir ecosystems typically have different characteristics than many natural lakes, BATHTUB was developed to specifically account for some of these differences, including the effects of non-algal turbidity on transparency and algae responses to phosphorus.

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

5.3 BATHTUB MODEL INPUTS

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

- Model options
- Global variables
- Reservoir segmentation
- Tributary loads

5.3.1 Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were applied as shown in Table 5-1 for Coffeen Lake and Table 5-2 for Greenville Lake, with the rationale for these options discussed as follows. No conservative substance was being simulated for any of the lakes, so this option was not needed. The second order available phosphorus option was selected for phosphorus in both lakes, as it is the default option for BATHTUB. Nitrogen was not simulated in either lake because phosphorus is the nutrient of concern. Chlorophyll a and transparency were not simulated for any of the lakes. The Fischer numeric dispersion model was selected for both lakes, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations for both lakes. No nitrogen calibration was required. Finally, the use of availability factors was not required for any of the lakes, and estimated concentrations were used to generate mass balance tables for the lakes.

Table 5-1. BATHTUB Model Options for Coffeen Lake

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

Table 5-2. BATHTUB Model Options for Greenville Lake

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

5.3.2 Global Variables

The global variables required by BATHTUB consist of:

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

BATHTUB is a steady state model, whose predictions represent concentrations averaged over a period of time. A key decision in the application of BATHTUB is the selection of the length of time over which inputs and outputs should be modeled. The length of the appropriate averaging period for BATHTUB application depends upon what is called the nutrient residence time, i.e. the average length of time that phosphorus spends in the water column before settling or flushing out of the lake. Guidance for the BATHTUB model recommends that the averaging period used for the analysis be at least twice as large as nutrient residence time for the lake of interest. For lakes with a nutrient residence time on the order of 1 to 3 months, a seasonal (e.g. spring-summer) averaging period is recommended. The nutrient residence time for both Coffeen and Greenville Lakes were calculated as several weeks to three months, so the averaging period used for this analysis was set to the seasonal period April - August.

Precipitation inputs were taken from the observed long term April - August precipitation data. This resulted in precipitation inputs of 19.4 inches for each lake during the averaging period. Evaporation within Greenville Lake was set equal to precipitation and there was no assumed increase in storage during the modeling period, to represent steady state conditions.

Evaporation in Coffeen Lake exceeds precipitation due to the evaporative losses related to the operation of the Ameren Energy facility, which uses the lake for cooling water. To maintain water levels in this lake for purposes of power generation and temperature requirements, water is pumped to the lake from East Fork Shoal Creek. The evaporation for the cooling water supplementation was estimated at 4.6 inches during the averaging period, based on 2002 pumping estimates (Pers. Comm. Smallwood 2007).

Finally, atmospheric phosphorus loads were specified for each lake using default values (30 mg/m^2-yr.) provided by BATHTUB.

5.3.3 Reservoir Segmentation

BATHTUB provides the capability to divide the reservoir under study into a number of individual segments, allowing prediction of the change in phosphorus concentrations over the length of each reservoir. The segmentation schemes selected for the two lakes were designed to provide one segment for each of the three primary lake sampling stations. Coffeen and Greenville Lakes were divided into three segments, as shown in Figure 5.1 and Figure 5.2 with the areas of the lake segments and watersheds for each segment determined by Geographic Information System (GIS).

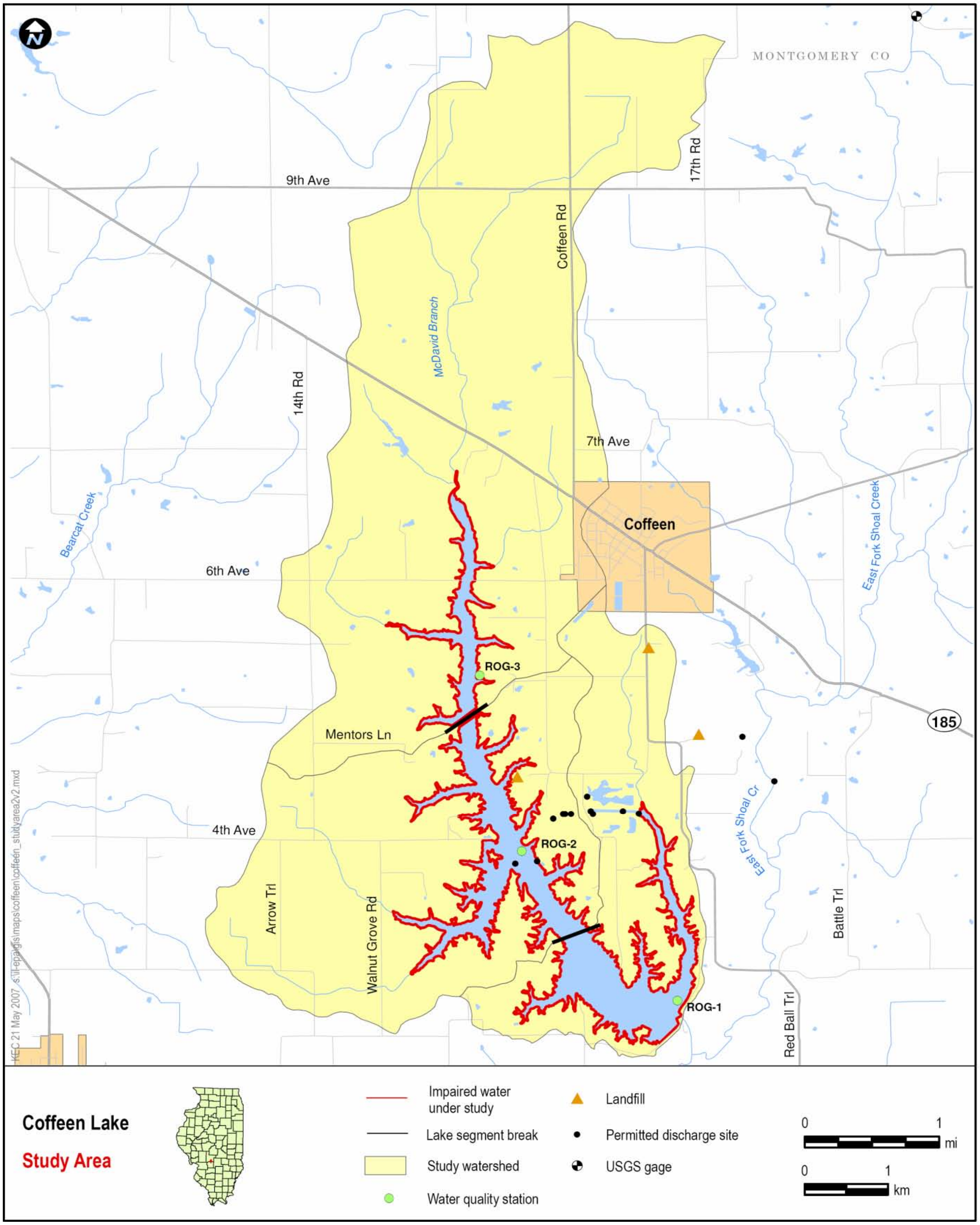

Figure 5-1 Coffeen Lake watershed and segmentation used in BATHTUB modeling.

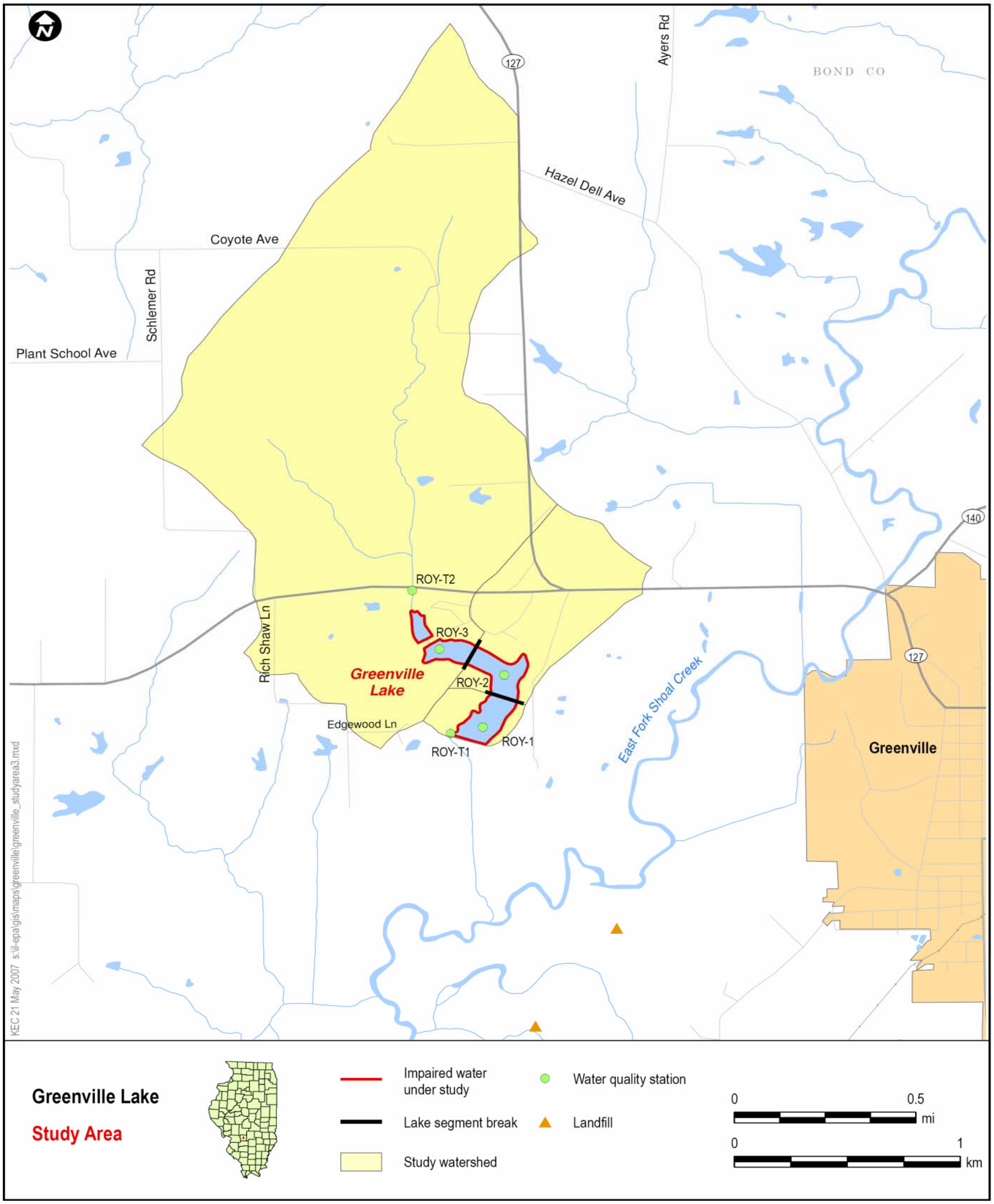

Figure 5-2. Greenville Lake watershed and segmentation used in BATHTUB modeling.

BATHTUB requires that a range of inputs be specified for each segment. These include segment surface area, length, total water depth, and depth of thermocline and mixed layer. Segment-specific values for segment depths were calculated from the lake monitoring data from 2002 for Coffeen Lake and 2001 for Greenville Lake. The monitoring periods represent the most recent and robust monitoring data for phosphorus within the lakes. Segment lengths and surface areas were calculated using GIS. A complete listing of all segment-specific inputs is provided in Attachment 1.

5.3.4 Tributary Loads

BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Flows to each segment were estimated using observed flows at a nearby USGS gaging station (East Fork Shoal Creek, near Coffeen, IL (05593900)). This station was selected because it was relatively close to the lakes, and was the most similar in terms of watershed size and land use. For Coffeen and Greenville Lake, flows into each lake segment were calculated through the use of drainage area ratios as follows:

Flow into segment = Average flow at USGS gages x Segment-specific drainage area ratio

$$\text{Drainage area ratio} = \frac{\text{Drainage area of watershed contributing to model segment}}{\text{Average drainage area of watersheds contributing to USGS gages}}$$

Segment-specific drainage area ratios were calculated via GIS information.

For Coffeen Lake, the phosphorus concentration for each major tributary was based upon springtime measurements taken near the headwaters of the lake. Concentrations for small tributaries were set equal to the assumed concentration for the major tributary. For Greenville Lake, tributary phosphorus loads were based on tributary phosphorus measurements taken at station ROY-T2. These concentrations were adjusted downward to account for phosphorus loss in the detention basin located at the upstream end of the lake. A complete listing of all segment-specific flows and tributary concentrations is provided in Attachment 1.

In addition to tributary loads from the two lakes' watersheds, East Fork Shoal Creek was also included as a tributary load of phosphorus to Coffeen Lake. As discussed previously, the cooling water operations of the facility results in an increase in lake evaporation that requires supplemental flow inputs from East Fork Shoal Creek to maintain lake levels as well as temperature needs for recreation resources. East Fork Shoal Creek drains a primarily agricultural dominated watershed. The phosphorus concentration for water pumped from East Fork Shoal Creek was estimated from measured concentrations in similar streams within the region.

5.3.5 Point Source Loads

Three point sources were mentioned in the Stage 1 report, but one was determined to be inactive and the other was mentioned in error. As such, the Ameren Energy facility is the sole NPDES permitted discharger in the Coffeen Lake watershed. Ameren Energy operates its coal-fired power plant on the lake and operates its discharges under NPDES Permit No. IL0000108. Within this permit is a discharge for a small sewage treatment facility (D01). The phosphorus load from this facility is accounted for in the model and is estimated from the permitted flow rate and an effluent phosphorus concentration reported for this facility on its permit application.

There are no point source discharges in the Greenville Lake watershed.

5.4 BATHTUB CALIBRATION

BATHTUB model calibration consists of:

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

Separate discussions of the BATHTUB model calibration for both Coffeen Lake and Greenville Lake are provided below.

5.4.1 Coffeen Lake

The BATHTUB model was initially applied with the model inputs as specified above, considering the effects of a bridge crossing in Segment 1. Within Segment 1, sedimentation is expedited by the flow interruptions created by the 6th Street and railroad bridge crossings. Dispersion and sedimentation rates were adjusted within this segment to reflect these conditions.

Observed data from Coffeen Lake for the year 2002 were used for calibration purposes, as this year provided the most recent and robust phosphorus data set. The August, 2002 observed lake data were used for calibration, as this data best reflects the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations and the physical conditions observed within the lake. Model results in all three segments initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical "net settling rate" (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected during the calibration process via the addition of an internal phosphorus load of 1.8 mg-P/m^2-day to Segment 1, 1.2 mg-P/m^2-day to Segment 2 and 3.7 mg-P/m^2-day to Segment 3. The resulting predicted lake average total phosphorus concentration was 72.3 ug-P/l, compared to an observed average of 72.8 ug-P/l. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 1.

5.4.2 Greenville Lake

The BATHTUB model was initially applied with the model inputs as specified above, considering a small basin located at the lake headwaters. As shown in Figure 5.2, this basin is located immediately upstream of Greenville Lake. The main tributary into Greenville Lake flows through this basin, which likely settles phosphorus from upstream sources. The effects of this basin were accounted for in the modeling by reducing tributary phosphorus concentrations by 20%.

Observed data from Greenville Lake for the year 2001 were used for calibration purposes, as this year provided the most recent and robust phosphorus data set. The August observed lake data were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. Model results in all three segments initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical “net settling rate” (i.e. settling minus sediment release) observed over a range of reservoirs. Under-prediction of observed phosphorus concentrations can occur in cases of elevated phosphorus release from lake sediments. The mismatch between model and data was corrected during the calibration process via the addition of an internal phosphorus load of 408.6 mg/m^2-day to Segment 3. The resulting predicted lake average total phosphorus concentration was 361.2 ug-P/l, compared to an observed average of 361.9 ug-P/l. A complete listing of all the observed data used for calibration purposes, as well as a comparison between model predictions and observed data, is provided in Attachment 1.

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6 TMDL DEVELOPMENT

This section presents the development of the Total Maximum Daily Load for Coffeen and Greenville Lakes. It begins with a description of how the total loading capacity was calculated for each lake, and then describes how the loading capacity is allocated among point sources, non-point sources, and the margin of safety. A discussion of critical conditions and seasonality considerations is also provided.

6.1 CALCULATION OF LOADING CAPACITY

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

6.1.1 Coffeen Lake

The level of Coffeen Lake is proposed to increase in the future to meet increasing production needs for the Ameren Energy facility (personal communication K. Reynolds 2007 and B. Tedrick, 2007). To account for the proposed future increase in lake volume, the lake level was conservatively increased by three feet and the surface area and volume were recalculated for the TMDL runs.

Initial BATHTUB load reduction simulations indicated that Coffeen Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from long-term storage within lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, eventually reverting back to more typical conditions reflective of decreased phosphorus inputs. This reduction in future sediment phosphorus release was assumed to respond linearly to reductions in tributary phosphorus loads. The resulting tributary phosphorus load that led to compliance with water quality standards was 0.16 kg phosphorus/day between April and August, with the total load for the April-August period not to exceed 25 kg. This allowable load corresponds to an approximate 64% reduction of existing loads (estimated as 70 kg for the April-August season). Internal phosphorus loads were also reduced by 64% to meet the target concentration.

6.1.2 Greenville Lake

Initial BATHTUB load reduction simulations indicated that Greenville Lake phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, eventually reverting back to more typical phosphorus level conditions resulting from decreased phosphorus inputs. This reduction in future sediment phosphorus release was represented in the model by reducing the internal sediment phosphorus sources for Segment 3, which contains greatest potential volume of sediment derived phosphorus within the lake. This reduction coincides with tributary reductions to 192 kg/year from their existing condition of 1477 kg/year. The resulting phosphorus load that led to compliance with water quality standards was 0.53 kg-P/day between April and August, with the total load not to exceed 81 kg over this period. This allowable load corresponds to an approximately 87% reduction below existing loads (estimated as 619 kg over the April – August period).

6.2 ALLOCATION

6.2.1 Coffeen Lake

The Ameren Energy Generating Company is the sole NPDES permitted point source discharger in the Coffeen Lake watershed. This facility does not have a permit limit for phosphorus, so loads from this plant were calculated using the permitted flow rate and a phosphorus concentration of 0.072 mg/l as recorded on this facility's permit application. The estimated current phosphorus load for this facility comprises less than 0.1% of the current total phosphorus load to the lake and the WLA for this facility is set equal to the current estimated load of 0.005 kg-P/day.

The permit for this facility will not be changed at this time. Nonpoint sources are responsible for the majority of the phosphorus load; therefore, phosphorus will not be added to the permit limit for this facility until substantial work has been done to decrease nonpoint source loads.

The remainder of the loading capacity is given to the load allocation for nonpoint sources and the margin of safety. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load. Given a total loading capacity of 0.16 kg/day, a WLA of 0.005 kg/day, and an explicit margin of safety of 10% (discussed below), the load allocation for Coffeen Lake is 0.139 kg-P/day.

6.2.2 Greenville Lake

No point sources of phosphorus exist in the Greenville Lake watershed. Therefore, the waste load allocation for this TMDL was not calculated. The remainder of the loading capacity is allocated to non-point sources and the margin of safety. Given a loading capacity of 0.53 kg-P/day, a 10% margin of safety (discussed below in Section 6.4), the load allocation for Greenville Lake is 0.477 kg/day. The loading capacity is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load.

6.3 CRITICAL CONDITION

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

6.4 SEASONALITY

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

6.5 MARGIN OF SAFETY

The TMDL contains an explicit margin of safety of 10%. The 10% margin of safety is considered an appropriate value based upon the generally good agreement between the BATHTUB water quality model predicted values and the observed values. Since the model reasonably reflects the conditions in the watershed, a 10% margin of safety is considered to be adequate to address the uncertainty in the TMDL, based upon the data available. This margin of safety can be reviewed in the future as new data are developed. The resulting explicit loads allocated to the margin of safety are 0.016 kg-P/day for Coffeen Lake and 0.053 kg-P/day for Greenville Lake.

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7 PUBLIC PARTICIPATION AND INVOLVEMENT

Public participation is an important step in the development of an applicable and effective TMDL. The Stage 1 report involved contacts with several state agencies (TetraTech 2006) and Stage 1 results were previously presented at a public meeting held in the watershed. Illinois EPA and its consultants will provide other necessary opportunities for public involvement to support the development and completion of the TMDL and implementation plan as well. Another public meeting was held on July 12, 2007 to present the TMDL and Implementation Plan. The purpose of this meeting was to involve the general public, local municipalities, affected industrial clients, and others to review the TMDL and implementation plan, comment on its contents and recommendations, and actively participate in the TMDL process.

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8 IMPLEMENTATION PLAN

Total Maximum Daily Loads (TMDLs) have been developed for Coffeen Lake and Greenville Lake to address phosphorus impairments. These TMDLs determined that significant reductions in existing phosphorus loads were needed to meet water quality objectives.

This document presents the implementation plan for the Coffeen and Greenville Lake TMDLs. It is divided into sections describing the implementation approach, discussing alternatives to reduce the existing loadings of phosphorus, describing reasonable assurances that the measures will be implemented, and outlining future monitoring and adaptive management.

8.1 IMPLEMENTATION APPROACH

The approach to be taken for TMDL development and implementation is based upon discussions with Illinois EPA and its Scientific Advisory Committee. The approach consists of the following steps, with the first three steps corresponding to TMDL development and the latter two steps corresponding to implementation:

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

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives. The Association of Illinois Soil and Water Conservation Districts, using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies. The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

Steps one through three described above have been completed, as described in the earlier sections of this report. This implementation plan represents step four of the process. Step five is briefly described in the last section of this document, and will be conducted as implementation proceeds.

8.2 EXISTING CONTROLS

The local Natural Resource Conservation Service (NRCS), Farm Service Agency (FSA), and Soil and Water Conservation District (SWCD) offices have information on existing best management practices within the watershed, and can be contacted to understand what efforts have been made or are planned to control nonpoint sources. Discussions with local NRCS and SWCD staff during the early stages of TMDL development identified some ongoing control efforts within affected watersheds, as summarized briefly below.

A majority of the lands immediately surrounding each lake are forested. These forested areas also extend along much of the mainstem, primary tributaries to the lakes but become narrower moving upstream. These forested areas can serve as buffers to surface inputs from crop production lands where surface flows have not been modified, increasing the transport capacity of nutrients via perennial, intermittent or ephemeral streams, or drainage ditches that lead to the lakes (USEPA, 1997). Buffers are particularly important where land on steeper slopes and erosive soils have been disturbed, increasing the potential for transporting sediment and nutrients from upland areas to the lakes.

Local NRCS, FSA, and SWCD units continue to educate landowners on opportunities to participate in state and federal cost-share programs to implement sediment removal and nutrient reduction practices into their current land management strategies (Pers. Comm. Reynolds 2007).

Within the Coffeen Lake watershed, two Conservation Reserve Program (CRP) units are in place – Cranfill Unit and Theis Unit. These plots are primarily taken out of crop production and converted to wildlife program enhancement lands where phosphorus supplementation will no longer be used. The Cranfill Unit (313 acres) has been in the CRP program for over ten years and the Theis Unit (180 acres) is a recent addition to the program.

8.3 IMPLEMENTATION ALTERNATIVES

No comprehensive inventory of BMPs was identified in preparing this plan and it is not known whether any study of the effectiveness of the BMPs has been undertaken.

Implementation alternatives for this TMDL are focused on those sources suspected of contributing phosphorus loads to the lakes, although some are not specifically identified (agricultural sources, release from existing lake bottom sediments under anoxic conditions, streambank and shoreline erosion, and failing private sewage disposal systems). Since the TMDL targets are total phosphorus levels in the lakes, potential phosphorus reduction alternatives may be considered for identified priority areas (section 8.4) or other areas where phosphorus reductions may be effective and implementable. These alternatives include:

- Sediment Control Basins
- Conservation Buffers

- Grassed Waterways
- Nutrient Management
- Animal Waste Management
- Conservation Tillage
- Shoreline Enhancement and Protection
- Erosion Control Measures for New Development
- Private Sewage Disposal System Inspection and Maintenance Program
- Aeration/Destratification
- Dredging
- Phosphorus Inactivation

Each of these alternatives is described briefly below, including information about their costs and effectiveness in reducing phosphorus inputs.

8.3.1 Sediment Control Basins

Sediment control basins trap sediments (and nutrients bound to that sediment) before they reach surface waters (USEPA, 2003). Such basins could be installed within focused areas of the watersheds, particularly within areas selected to minimize disruption to existing croplands. This could be particularly useful in the upstream portions of the Coffeen Lake watershed, where sediment deposition appears to be actively occurring. In the Greenville Lake watershed, a basin already exists that appears to be serving as a sediment control basin. This basin could be enlarged or dredged to increase its effectiveness.

Low water sediment control basins can be effective at reducing phosphorus loads to the lakes. State of Illinois, Section 319 funding has been obtained previously for sediment control basins in other Illinois watersheds. Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin with a sediment trapping efficiency of up to 75%. (Zahniser Institute, undated). Interest in a cost-share approach to designing and constructing these basins has been high in other watersheds, as determined from discussions at other Illinois TMDL public meetings.

Storm water detention wetlands are another alternative as these wetlands can trap sediments and nutrients (e.g., phosphorus) at up to 45% effectiveness (Zahniser Institute, undated). However, wetlands generally have low to moderate effectiveness at reducing particulate phosphorus, and low to negative effectiveness at reducing dissolved phosphorus (NRCS, 2006a), so the appropriateness of this type of treatment should be evaluated cautiously.

8.3.2 Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants (NRCS, 1999) by slowing the rate of runoff and filtering sediment and nutrients. Other benefits may include the creation of wildlife habitat, improved aesthetics, and potential economic benefits from marketing specialty forest crops (Trees Forever, 2005). This category of controls includes buffer strips, field borders, filter strips, vegetative barriers, riparian buffers, etc. (NRCS, 1999).

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (USEPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 2006a).

Costs of conservation buffers vary from about $200/acre for filter strips of introduced grasses or direct seeding of riparian buffers, to approximately $360/acre for filter strips of native grasses or planting bare root riparian buffers, to more than $1,030/acre for riparian buffers using bare root stock shrubs (NRCS, 2005).

The Conservation Practices Cost-Share Program (CPP), part of the Illinois Conservation 2000 Program, provides cost sharing for conservation practices including field borders and filter strips (http://www.agr.state.il.us/Environment/conserv/index.html). The Department of Agriculture distributes funding for the cost-share program to Illinois' soil and water conservation districts (SWCDs), which prioritize and select projects.

The Illinois Buffer Partnership offers cost sharing for installation of streamside buffer plantings at selected sites. An additional program that may be of interest is the Visual Investments to Enhance Watersheds (VIEW), which involves a landscape design consultant in the assessment and design of targeted BMPs within a watershed. Sponsored by Trees Forever (www.treesforever.org), VIEW guides a committee of local stakeholders through a watershed landscape planning process (Trees Forever, 2005). Additional funding for conservation buffers may be available through other sources such as the Conservation Reserve Program.

8.3.3 Grassed Waterways

A grassed waterway is a natural or constructed channel that is planted with suitable vegetation to reduce erosion (NRCS, 2000). Grassed waterways are used to convey runoff without causing erosion or flooding, to reduce gully erosion, and to improve water quality. They may be used in combination with filter strips, and are effective at reducing soil loss, with typical reductions between 60 and 80 percent (Lin et al, 1999). Grassed waterways cost approximately $1,800/acre, not including costs for tile or seeding (MCSWCD, 2006).

8.3.4 Nutrient Management

Nutrient management plans are designed to minimize nutrient losses from agricultural lands, and therefore minimize the amount of phosphorus transported to the lakes. Because agriculture is the most widespread land use within the watersheds, controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the lakes. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (USEPA, 2003). The majority of phosphorus lost from agricultural land is transported via surface runoff (vs. leaching through the soil, as occurs for nitrogen), mostly in particulate form attached to eroded soil particles. A nutrient management plan identifies the amount, source, time of application, and placement of each nutrient needed to produce each crop grown on each field each year, to optimize efficient use of all sources of nutrients (including soil reserves, commercial fertilizer, legume crops, and organic sources) and minimize the potential for losses that lead to degradation of soil and water quality (UIUC, 2005).

Steps in developing a nutrient management plan include (UIUC, 2005):

- Assess the natural nutrient sources (soil reserves and legume contributions).
- Identify fields or areas within fields that require special nutrient management precautions.
- Assess nutrient needs for each field by crop.
- Determine quantity of nutrients that will be available from organic sources, such as manure or industrial or municipal wastes.
- Allocate nutrients available from organic sources.
- Calculate the amount of commercial fertilizer needed for each field.
- Determine the ideal time and method of application.
- Select nutrient sources that will be most effective and convenient for the operation.

Costs of developing nutrient management plans have been estimated at $6 to $20/acre (USEPA, 2003). These costs are often offset by the savings associated with using less fertilizer. For example, a study in Iowa showed improved nutrient management on corn fields led to a savings of about $3.60/acre (USEPA, 2003).

A U.S. Department of Agriculture study reported that average annual phosphorus application rates were reduced by 36 lb/acre when nutrient management practices were adopted (EPA, 2003). Nutrient management is generally effective, but for phosphorus, most fertilizer is applied to the surface of the soil and is subject to transport (NRCS, 2006a). In an extensively cropped watershed, the loss of even a small fraction of the fertilizer-applied phosphorus can have a significant impact on water quality.

8.3.5 Animal Waste Management

It is uncertain if or where there may be animal feeding operations within the watersheds so the purpose of including waste management is for general information. From other Illinois studies, land application tends to be the preferred disposal option and can contribute nutrients (as well as pathogens) to the lakes. Waste handling and storage, disposal methods and application timing and rates should all be considered in relation to their effect on nutrient contributions to area lakes. Manure can also be tested for nutrient content, and soil sampling and nutrient management planning should be incorporated into waste management planning. Specific activities might include construction of waste storage facilities to hold waste until it can be properly applied. Feedlot waste control has been estimated to cost approximately $9,500 per year for every 50 animals, while manure storage averages $3,600 per storage facility (Lin et al, 1999). Additional information regarding practices, effectiveness, and costs, is available from the U.S. EPA (2003) (http://www.epa.gov/owow/nps/agmm/chap4d.pdf).

8.3.6 Conservation Tillage

The objective of conservation tillage is to provide profitable crop production while minimizing soil loss (UIUC, 2005). A reduction in soil loss also reduces the amount of phosphorus lost from lands that are potentially delivered to lakes. The Natural Resources

Conservation Service (NRCS) has replaced the term conservation tillage with the term crop residue management, year-round management of residue to maintain the level of cover needed for adequate control of erosion. This often requires more than 30% residue cover after planting (UIUC, 2005). Conservation tillage/crop residue management systems are recognized as cost-effective means of significantly reducing soil erosion and maintaining productivity. Currently, most landowners in the watershed use conventional tillage (NRCS, 2004). The most recent Illinois Soil Transect Survey (IDOA, 2004) suggests that 92% of land under soybean production in Macoupin County is farmed using reduced till, mulch till, or no-till, while 72% of cornfields and 100% of lands producing small grain are farmed with conventional methods. Expanding conservation tillage measures should be considered as part of this implementation plan, particularly for cornfields.

Conservation tillage practices have been reported to reduce total phosphorus loads by 45% (USEPA, 2003). In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006a). A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre in capital costs (USEPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $36 to $66/ acre, depending on the farm size and planting methods used (UIUC, 2005). In general, the total cost per acre for machinery and labor decreases as the amount of tillage decreases and farm size increases (UIUC, 2005).

8.3.7 Streambank and Shoreline Enhancement and Protection

Streambank and shoreline erosion are a problem in Illinois watersheds. Sediment derived from erosion not only increases solids in the lakes and decreases lake volume, but also can increase nutrient loads to the lakes. Shoreline enhancement efforts, such as planting deep-rooted vegetation or installing rip-rap in the unprotected shoreline areas, will protect against erosion and the associated increased pollutant loads.

The Illinois EPA, in cooperation with the U.S. Department of Agriculture and the U.S. Geological Survey have conducted aerial stream assessments for several TMDL watersheds. These aerial stream assessments found that aerial flyover DVDs, either alone or in conjunction with boat surveys, could be used to identify areas of severe streambank erosion and help to prioritize sites for restoration.

8.3.8 Erosion Control Measures for New Development

There is a considerable amount of development occurring within Illinois (LTI, 2004). Although it is unclear if planned developments are proposed within the Coffeen of Greenville Lake watersheds, residential development near and around lakes can cause significant erosion to lakes. Erosion control measures for new developments are therefore recommended as part of TMDL implementation, as applicable. A permit is required for construction activities disturbing more than one acre, under the NPDES Phase II storm water regulations (information on Illinois EPA's construction general permit is available at http://www.epa.state.il.us/water/permits/storm-water/construction.html). Additional erosion control measures can be implemented at the local level to reduce loads delivered to the lakes. Such measures could include new or revised local ordinances, as well as increased local planning and enforcement of ordinances. Development of ordinances would be relatively inexpensive; the primary cost of this alternative would be the additional resource staff time that might be needed to review and approve plans and enforce the ordinances.

8.3.9 Private Sewage Disposal System Inspection and Maintenance Program

In rural Illinois, many unsewered areas use individual surface discharging sewage disposal systems (generally either sand filters with chlorination, or aerobic systems). These systems, if not inspected and properly maintained, are prone to failure, resulting in a discharge of raw sewage. It has been estimated that statewide, between 20 and 60 percent of surface discharging systems are failing or have failed (IEPA, 2004), suggesting that such systems may be a significant source of pollutants.

A proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems. This alternative would require the commitment of staff time for County Health Department personnel; cost depends on whether the additional inspection activities could be accomplished by existing Health Department staff or would require additional personnel (there are limited personnel in County Health Departments currently).

8.3.10 Aeration/Destratification

Sediment within both lakes are a significant source of phosphorus. When dissolved oxygen is absent in the hypolimnion (deep layer) of the lakes, phosphorus is released from the sediments. Control of this internal load (that is, deep sediments) requires either removal of phosphorus from the lake bottom (such as through dredging), or preventing oxygen-deficient conditions from occurring. Aeration of portions of the lake might be considered as an effective alternative to increase mixing and improve oxygen levels. Destratifiers have been installed in other Illinois lakes to prevent thermal stratification and increase oxygen concentrations in the deeper lake waters. Studies have indicated that such systems can significantly improve water quality (Raman et. al, 1998). A destratification system installed in Lake Evergreen in McLean County was effective in improving dissolved oxygen levels throughout the lake, up to the depth of its operation (Raman et al, 1998). The destratifier used on Lake Evergreen cost approximately $72,000 (Raman et al, 1998). The cost of a destratifier or an aeration system has been estimated for a smaller Illinois lake at $65,000 (CMT, 2004).

8.3.11 Dredging

Deep water sediments have been identified as significant sources of phosphorus. In addition, sedimentation reduces the water volume of the lake, with a corresponding reduction in the lake's assimilative capacity. Dredging of sediments is one alternative to reducing this source of phosphorus. However, it is an expensive alternative and would only serve as a temporary solution if sediment and phosphorus loads are not reduced in the watershed. Without watershed sediment controls, it is likely that sedimentation and nutrient flux from the sediments would continue as a problem in the future. 1998 (USEPA) estimates for lake dredging range from $6 to $20 per cubic yard of sediment removed for hydraulic dredging (IEPA, 1998).

8.3.12 Phosphorus Inactivation

Phosphorus inactivation involves application of aluminum salts or calcium compounds to the lake to reduce phosphorus in the water column and slow its release from sediments (McComas, 1993). This can be an effective means of mitigating excess phosphorus in lakes and reservoirs (NALMS, 2004). Addition of aluminum sulfate (alum) is most common, but compounds such as calcium carbonate and calcium hydroxide (lime) can also be used (McComas, 1993). When alum is added to lake water, a series of chemical hydrolysis steps leads to the formation of a solid precipitate that has a high capacity to absorb phosphates. This flocculent material settles to the lake bottom, removing the phosphorus from the water column and providing a barrier that retards release of phosphorus from the sediments (NALMS, 2004). Aluminum concentrations in lake water are usually at acceptable levels for drinking water shortly after alum application (NALMS, 2004).

This alternative is best used in combination with a reduction in phosphorus inputs from watershed sources. If the external phosphorus load is being addressed, and most of the phosphorus comes from in-place sediments, a single dose treatment will likely be sufficient (Sweetwater, 2006). However, if watershed sources are not controlled, repeated treatments will be needed at a continued and added expense. Studies have indicated that the effectiveness of alum at controlling internal phosphorus loading in stratified lakes averaged 80% over several years of observation (Welch and Cooke, 1999). Costs for phosphorus inactivation are approximately $1,000 to $1,300 per acre (Sweetwater, 2006). This translates to costs of over $1,000,000 for Coffeen Lake and $25,000 to $33,000 for Greenville Lake.

8.3.13 Summary of Alternatives

Table 8-1 summarizes the alternatives identified for the Coffeen Lake and Greenville Lake TMDLs. These alternatives should be evaluated by the local stakeholders to identify those most likely to provide the necessary load reductions, based on site-specific conditions in the watersheds

Table 8-1. Summary of Implementation Alternatives

Alternative	Estimated Cost	Notes
Sediment Control Basins	$1,200 to $229,000 per basin, depending on size	May be able to provide cost-share with State 319 funds
Conservation Buffers	$200 - $360/acre	Dependant on size and location of buffer
Grassed Waterways	$1,800/acre	
Nutrient Management Plans	$6 to $20/acre	May lead to long-term production cost savings
Animal Waste Management	$9,500/50 animals for feedlot waste control $3,600 per manure storage facility	
Conservation Tillage	$12 to $83/acre	
Streambank and Shoreline Enhancement & Protection	$5,100 each for tree cutting and tree planting $47,700 for rip-rapping severely eroded areas $5/linear foot for plantings $67-$73/ton for rip-rap	
Erosion Control for New Development	Variable	Low cost to develop ordinances; additional staff costs are likely
Private Sewage Disposal System Inspection & Maintenance	Variable	Cost would be low if existing staff could accomplish
Aeration/Destratification	$65,000 - $72,000	Aeration/Destratification
Dredging	$6 - $20/cubic yard removed	Only effective when combined with watershed reductions
Phosphorus Inactivation	$1,000,000 for Coffeen Lake; $25,000 to $33,000 for Greenville Lake.	Only in concert with watershed reductions; best for smaller lakes

8.4 IDENTIFYING PRIORITY AREAS FOR CONTROLS

Priority areas for locating controls were identified through a GIS-based assessment. Additional data collection is also recommended in the monitoring and adaptive management section to help focus control efforts.

8.4.1 GIS Analysis

GIS soils, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated phosphorus loads. Within the GIS, maps were generated to show areas with steep slopes, defined as slopes greater than 9%, and highly erodible soils. Finally, priority areas for best management practices (BMPs) were defined as agricultural areas that have both steep slopes and highly erodible soils. These maps serve as a good starting point for selecting areas to target for implementing control projects, to maximize the benefit of the controls. Other locations that should be investigated for control projects are those that have either erodible soils or steep slopes, because both of these characteristics make soil more prone to erosion.

Based on GIS landcover analysis for years 1999-2000, approximately 57 percent of the Coffeen Lake watershed was under some type of crop rotation (Figure 8.1). Within the Coffeen Lake watershed, steeply sloped land is located along the shoreline and drainages that flow directly to the lake (Figure 8.2). Highly erodible soils are shown in Figure 8.3. Areas with steeply sloped land, highly erodible soils, and agricultural uses are identified as potential priority areas in the Coffeen Lake watershed, which should be investigated for BMP implementation (Figure 8.4).

Based on GIS landcover analysis for 1999-2000, approximately 69 percent of the Greenville Lake watershed was under some type of crop rotation (Figure 8.5). Within the Greenville Lake watershed, steeply sloped land is located along the shoreline and drainages that flow directly to the lake (Figure 8.6). Highly erodible soils are shown in Figure 8.7. Areas with steeply sloped land, highly erodible soils, and agricultural uses are identified as potential priority areas in the Greenville Lake watershed (Figure 8.8), which should be investigated for BMP implementation.

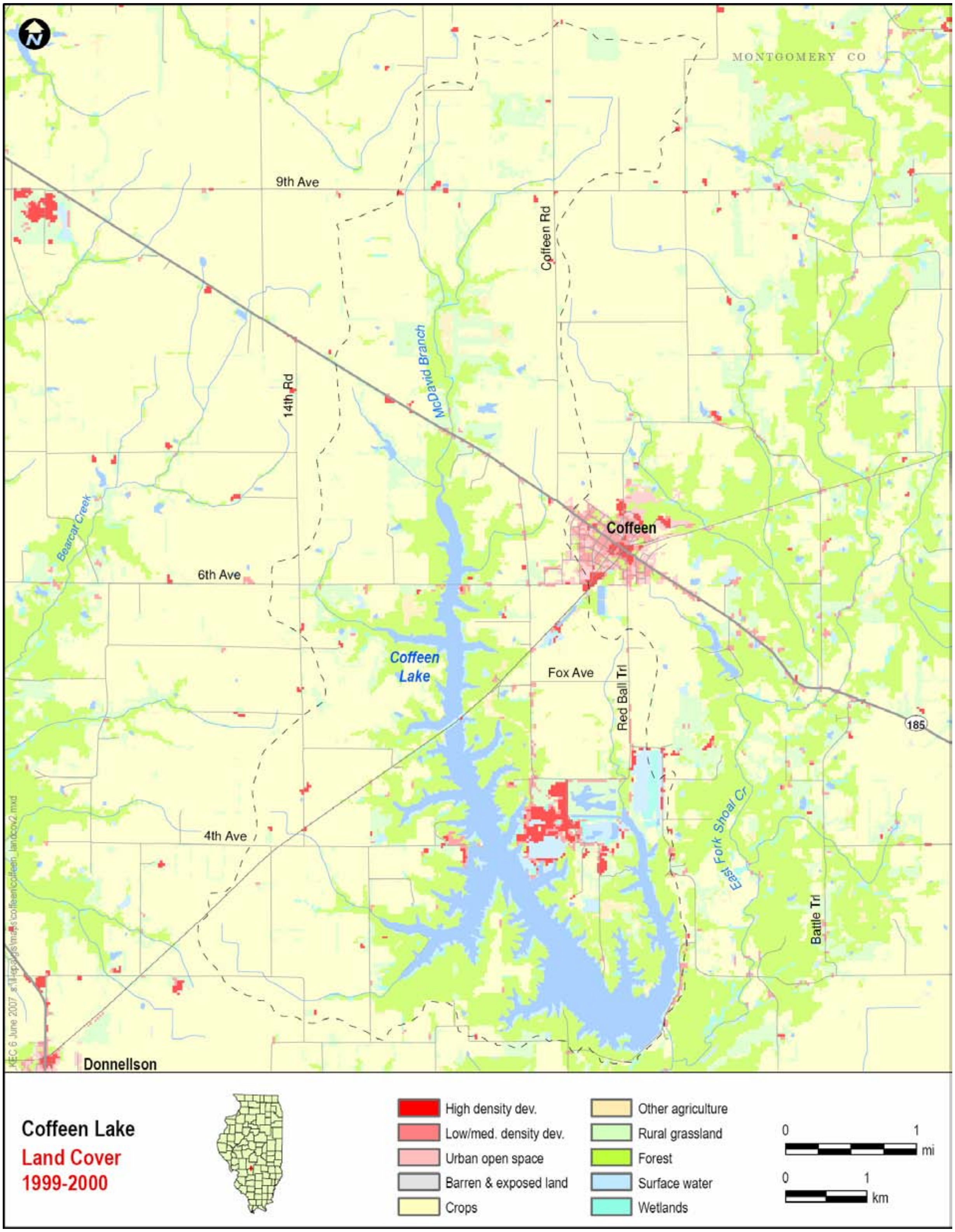

Figure 8-1. Coffeen Lake Land Cover (1999-2000)

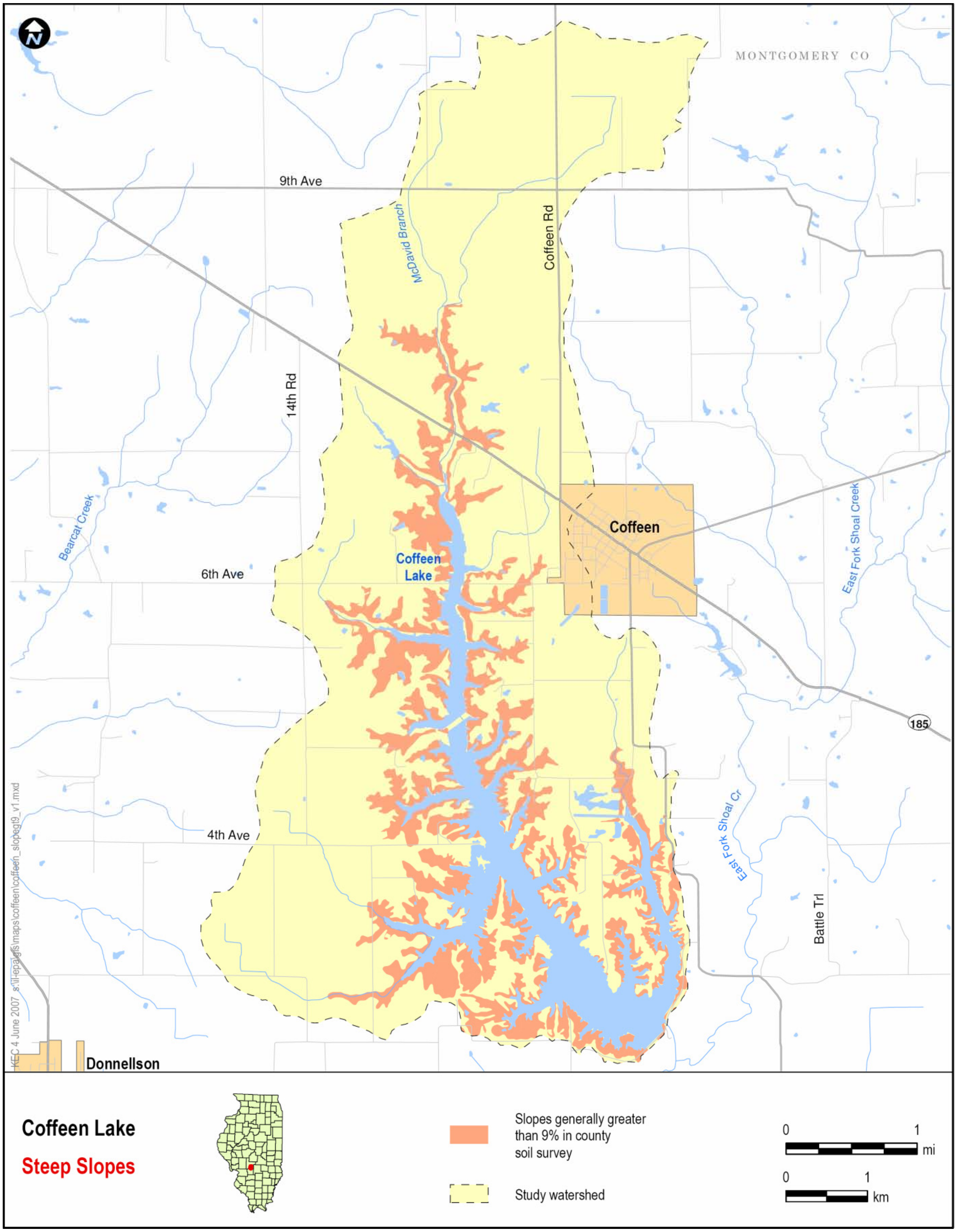

Figure 8-2. Coffeen Lake Steeply Sloped Land

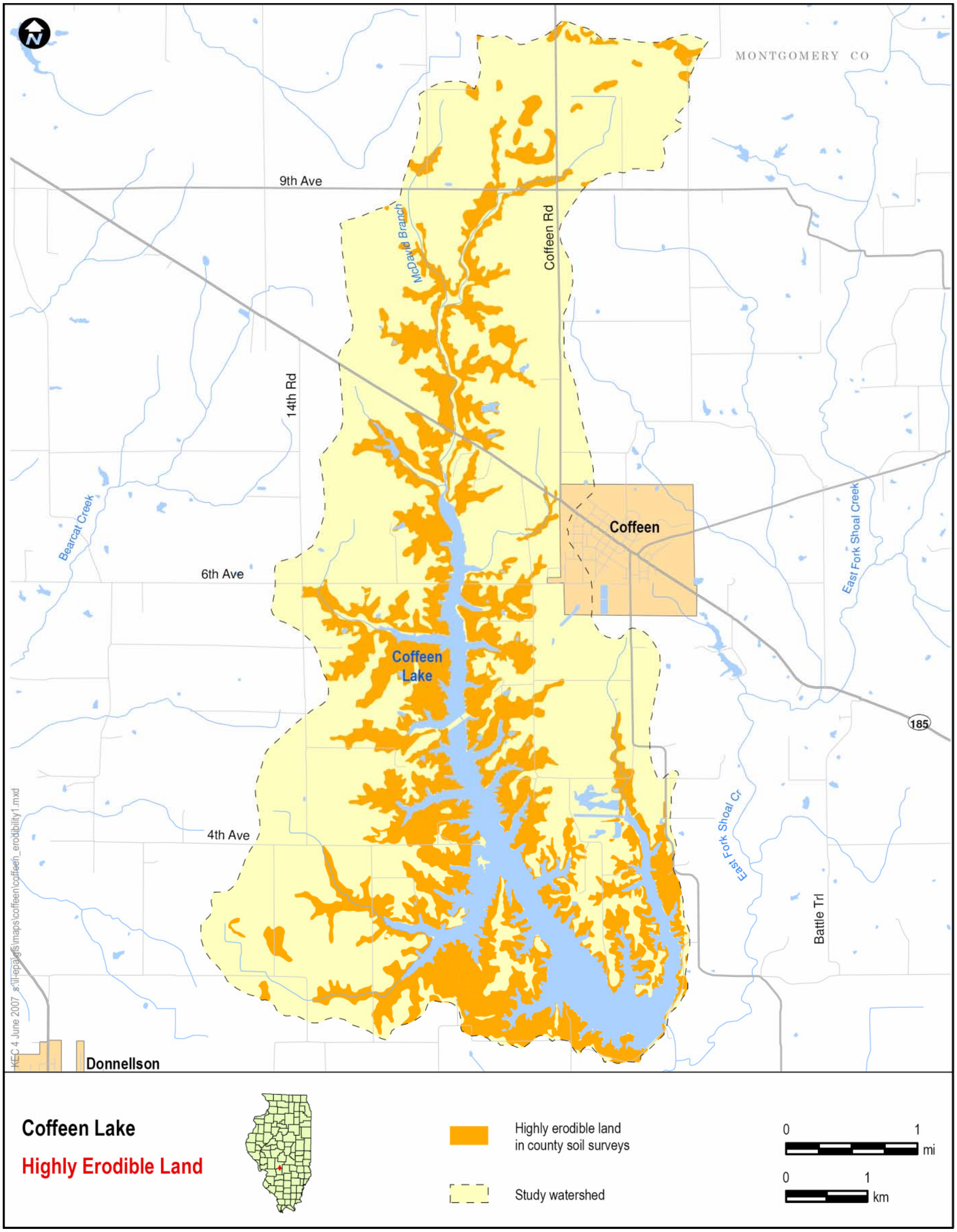

Figure 8-3. Coffeen Lake Highly Erodible Land

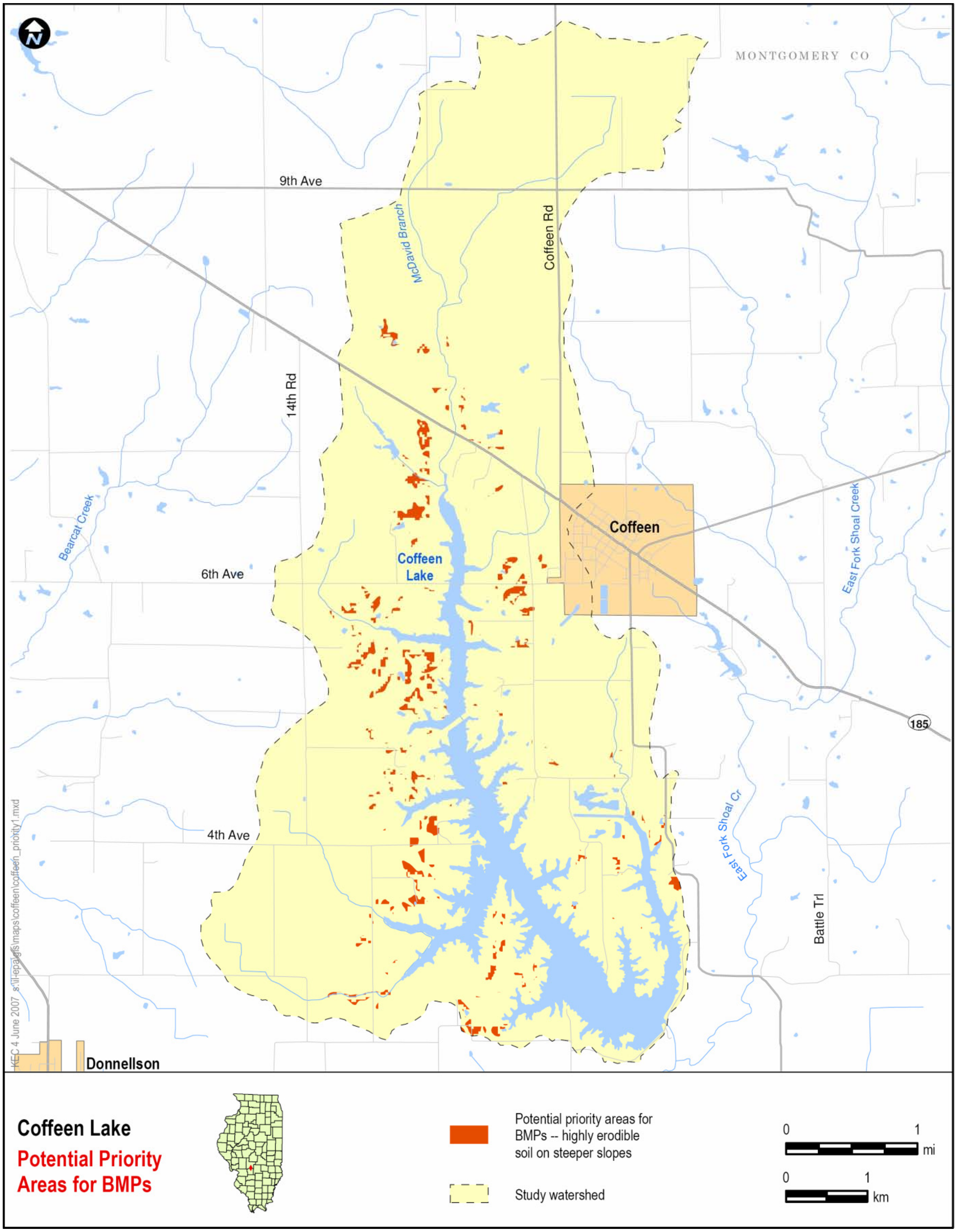

Figure 8-4. Coffeen Lake Potential Priority Areas for BMPs

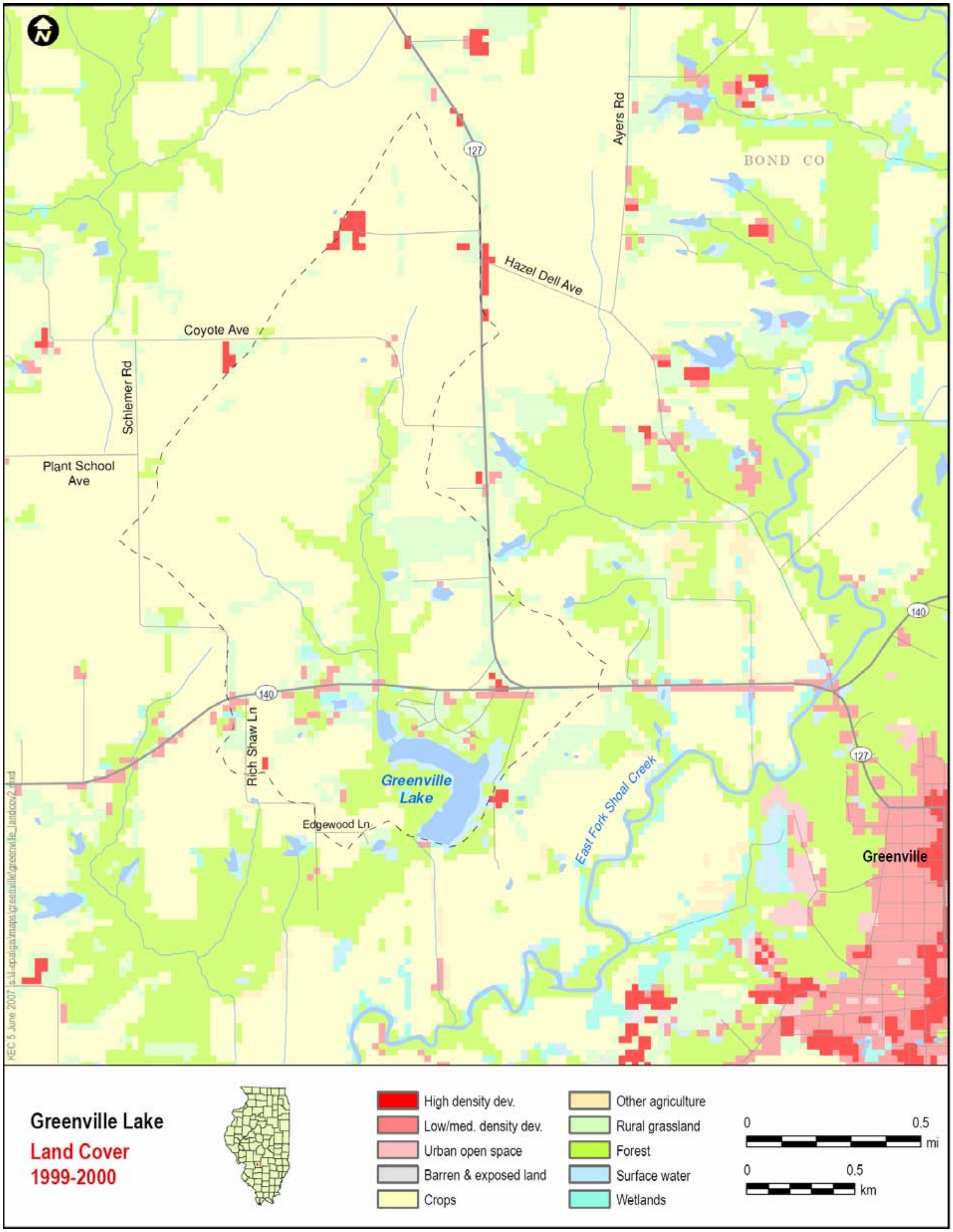

Figure 8-5. Greenville Lake Land Cover (1999-2000)

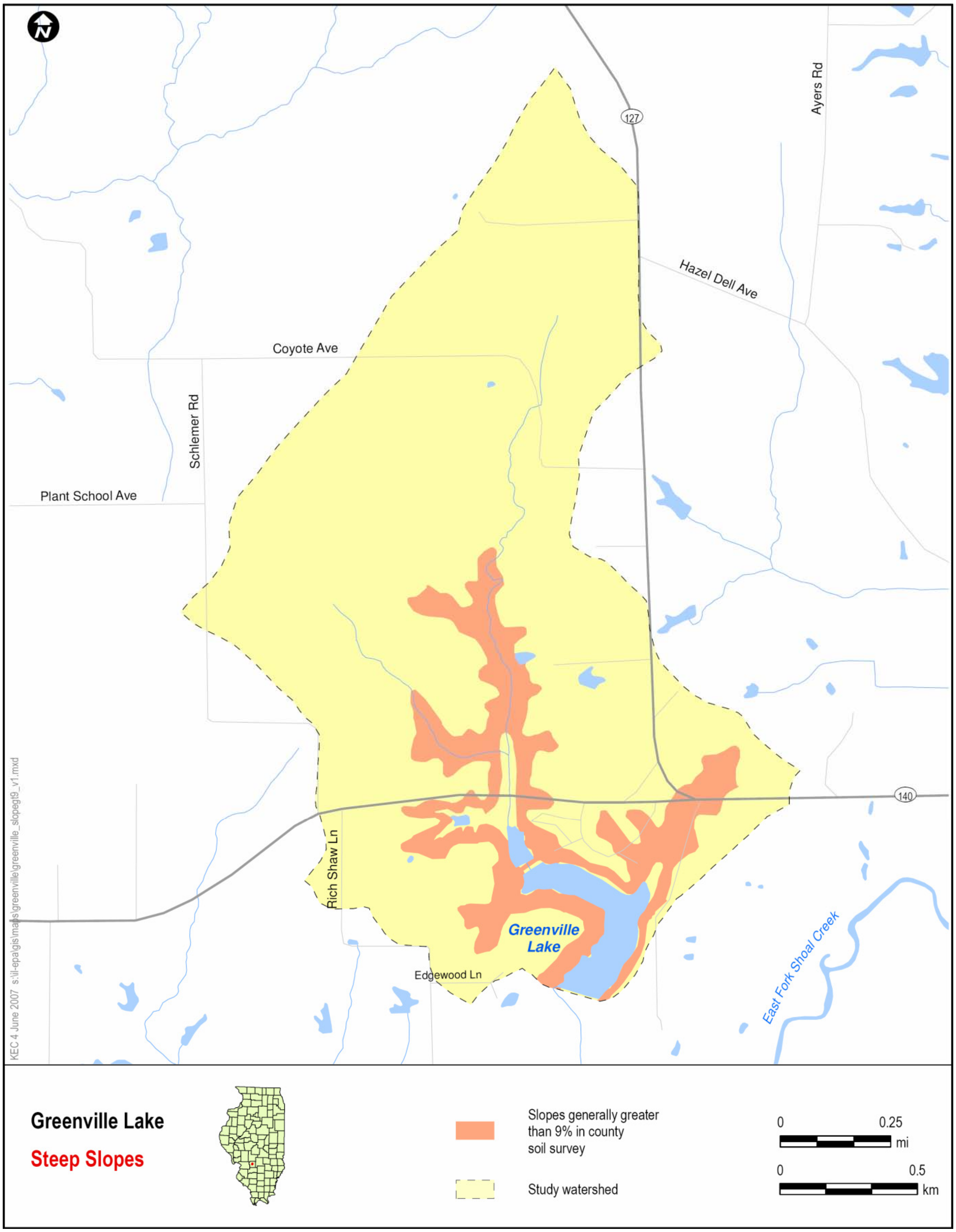

Figure 8-6. Greenville Lake Steeply Sloped Land

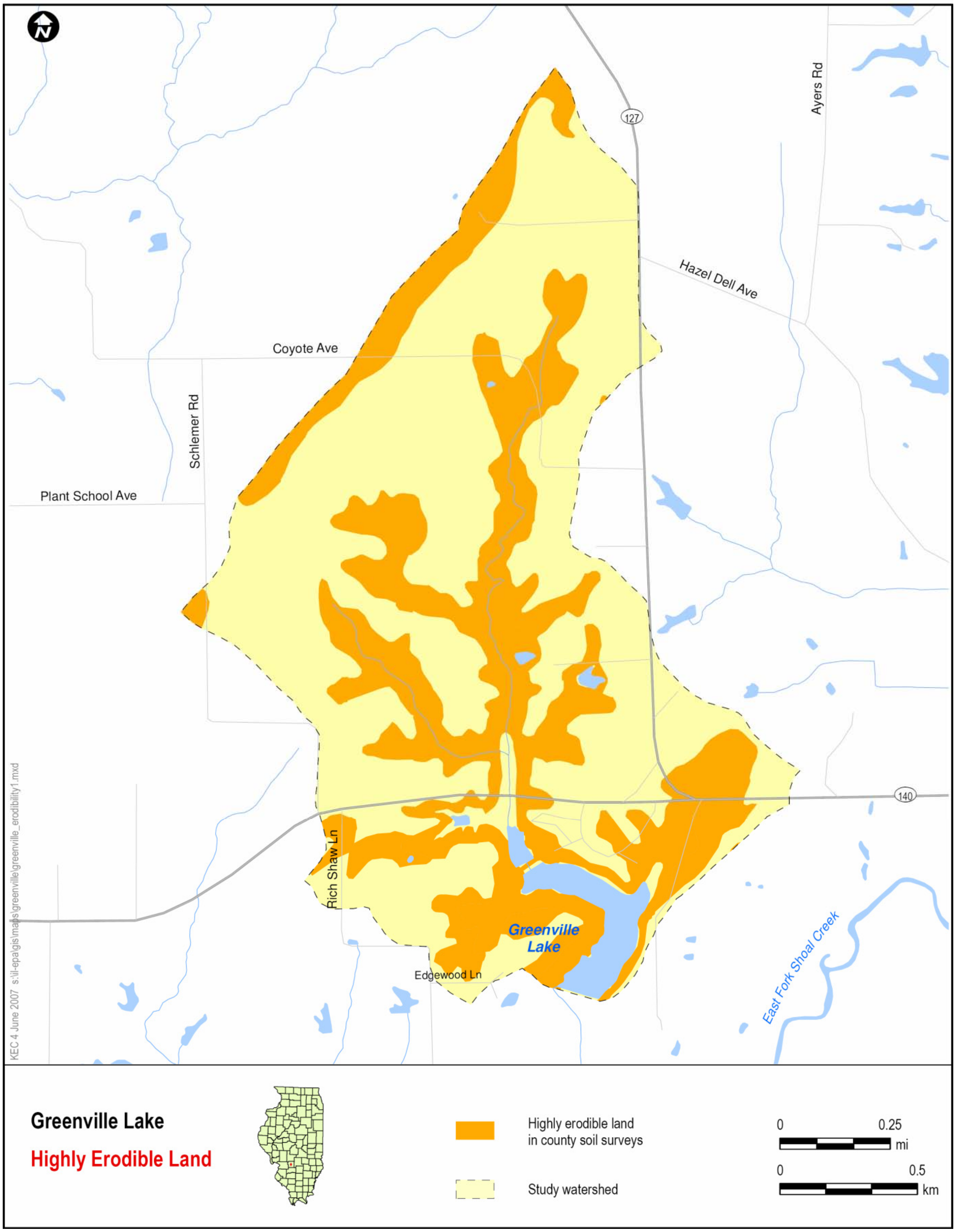

Figure 8-7. Greenville Lake Highly Erodible Land

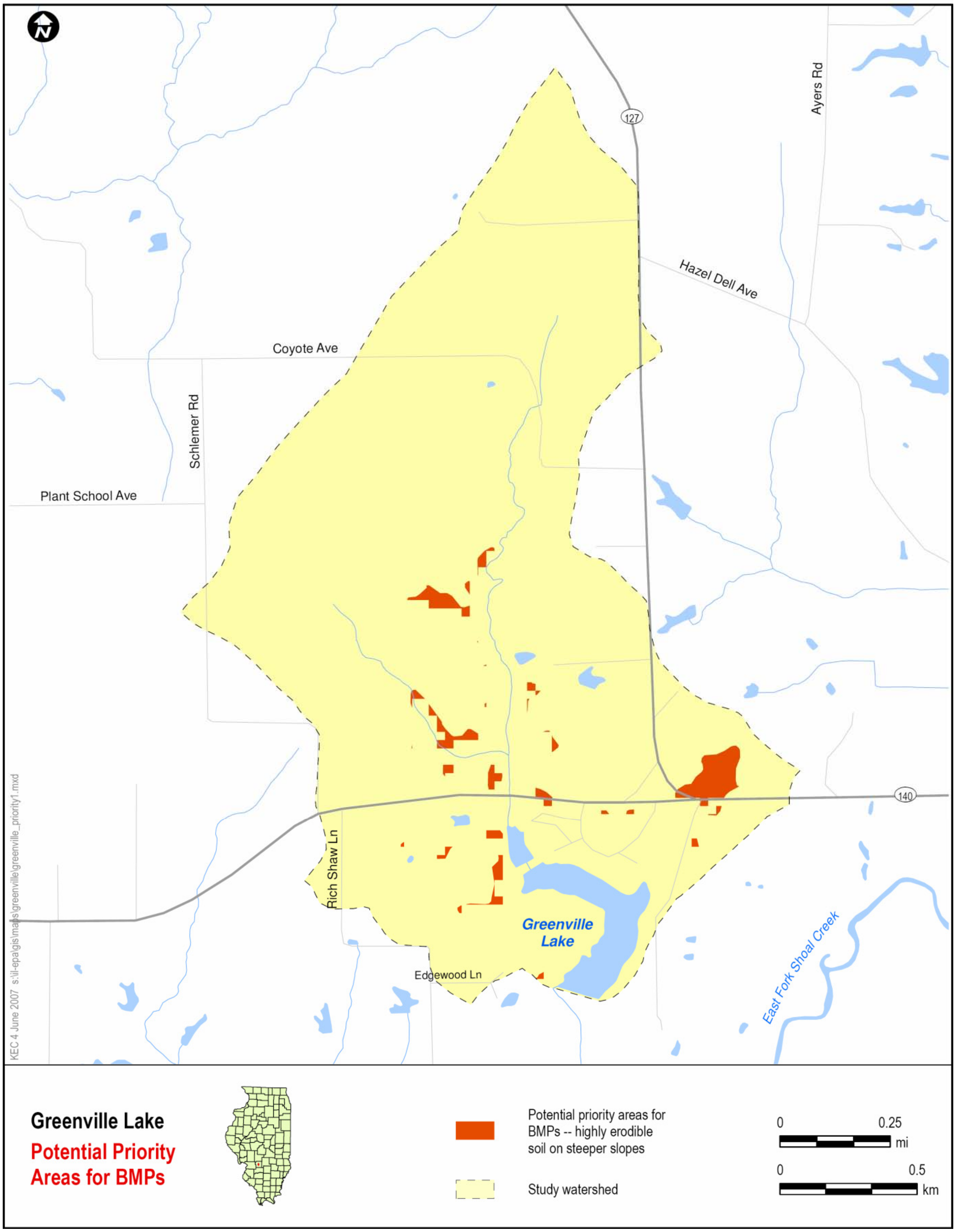

Figure 8-8. Greenville Lake Potential Priority Areas for BMPs

8.5 REASONABLE ASSURANCE

The U.S. EPA requires states to provide reasonable assurance that the load reductions identified in the TMDL will be met. In terms of reasonable assurance for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, stormwater permitting and CAFO permitting. Reasonable assurance for point sources means that NPDES permits will be consistent with any applicable wasteload allocation contained in the TMDL. The permit for the only point source discharger in the watershed, Ameren Energy, located in the Coffeen Lake watershed, will be modified as necessary to ensure it is consistent with the developed wasteload allocation from the Bathtub modeling.

For nonpoint sources, reasonable assurance means that nonpoint source controls are specific to the pollutant of concern (that is, phosphorus), implemented according to an expeditious schedule and supported by reliable delivery mechanisms and adequate funding (USEPA, 1999).

One of the most important aspects of implementing nonpoint source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including those listed below. It should be noted that the programs listed are based on the 2002 Farm Bill, which expires on September 30, 2007. It is currently unknown what conservation programs will be included in a future farm bill.

- *Illinois Nutrient Management Planning Program*, cosponsored by the Illinois Department of Agriculture (IDOA) and IEPA (http://www.agr.state.il.us/Environment/LandWater/tmdl.html). This program targets funding to Soil and Water Conservation Districts (SWCDs) for use in impaired waters. The nutrient management plan practice cost share is only available to landowners/operators with land in TMDL watersheds. The dollar amount allocated to each eligible SWCD is based on their portion of the total number of cropland acres in eligible watersheds.
- *Clean Water Act Section 319 grants* to address nonpoint source pollution (http://www.epa.state.il.us/water/financial-assistance/non-point.html). Section 319 of the Clean Water Act provides Federal funding for states for the implementation of approved nonpoint source (NPS) management programs. Funding under these grants has been used in Illinois to finance projects that demonstrate cost-effective solutions to NPS problems. Projects must address water quality issues relating directly to NPS pollution. Funds can be used for the implementation of watershed management plans, including the development of information/education programs, and for the installation of best management practices.
- *Conservation 2000* (http://www.epa.state.il.us/water/conservation-2000/), which funds nine programs across three state natural resource agencies (IEPA, IDOA, and the Department of Natural Resources). Conservation 2000 is a six-year, $100 million initiative designed to take a broad-based, long-term ecosystem approach to conserving, restoring, and managing Illinois' natural lands, soils, and water resources while providing additional high-quality

opportunities for outdoor recreation. This program includes the Priority Lake and Watershed Implementation Program and the Clean Lakes Program

- *Conservation Practices Cost-Share Program* (http://www.agr.state.il.us/Environment/conserv/index.html). Another component of Conservation 2000, the Conservation Practices Program (CPP) focuses on conservation practices, such as terraces, filter strips and grass waterways, that are aimed at reducing soil loss on Illinois cropland to tolerable levels. IDOA distributes funding for the cost-share program to Illinois' SWCDs, which prioritize and select projects. Construction costs are divided between the state and landowners.
- *Conservation Reserve Program* administered by the Farm Service Agency (http://www.nrcs.usda.gov/programs/crp/). The Conservation Reserve Program (CRP) provides technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. CRP is administered by the Farm Service Agency, with NRCS providing technical land eligibility determinations, conservation planning and practice implementation.
- *Wetlands Reserve Program* (http://www.nrcs.usda.gov/programs/wrp/). NRCS's Wetlands Reserve Program (WRP) is a voluntary program offering landowners the opportunity to protect, restore, and enhance wetlands on their property. The NRCS provides technical and financial support to help landowners with their wetland restoration efforts. This program offers landowners an opportunity to establish long-term conservation and wildlife practices and protection.
- *Environmental Quality Incentive Program* sponsored by NRCS (general information at http://www.nrcs.usda.gov/PROGRAMS/EQIP/; Illinois information and materials at http://www.il.nrcs.usda.gov/programs/eqip/). The Environmental Quality Incentives Program (EQIP) provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to eligible participants to install or implement structural and management practices on eligible agricultural land. EQIP may cost-share up to 75 percent of the costs of certain conservation practices. Incentive payments may be provided for up to three years to encourage producers to carry out management practices they may not otherwise use without the incentive.
- *Wildlife Habitat Incentives Program* (WHIP) (http://www.il.nrcs.usda.gov/programs/whip/index.html). WHIP is a NRCS program for developing and improving wildlife habitat, primarily on private lands. It provides both technical assistance and cost-share payments to help establish and improve fish and wildlife habitat.

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

- Convene local experts familiar with nonpoint sources of pollution in the watershed

- Ensure that they define priority sources and identify restoration alternatives
- Develop a voluntary implementation plan that includes accountability
- Use the results of future monitoring to conduct adaptive management.

8.6 MONITORING AND ADAPTIVE MANAGEMENT

Future monitoring is needed to assess the effectiveness of the various restoration alternatives and conduct adaptive management. The Illinois EPA conducts a variety of lake and stream monitoring programs (IEPA, 2002). Ongoing stream monitoring programs include: a statewide 213-station Ambient Water Quality Monitoring Network; an Intensive Basin Survey Program that covers all major watersheds on a five-year rotation basis; and a Facility-Related Stream Survey Program that conducts approximately 20-30 stream surveys each year. The ongoing Illinois EPA Lake Monitoring Program includes: an Ambient Lake Monitoring Program that samples approximately 50 lakes annually; and a Volunteer Lake Monitoring Program that encompasses over 170 lakes each year. Beyond this IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lakes.

Beyond the IEPA monitoring, local agencies and watershed organizations are encouraged to conduct additional monitoring to assess sources of pollutants and evaluate changes in water quality in the lake. In particular, wet and dry weather monitoring for phosphorus is recommended at the following locations:

Coffeen Lake

- McDavid Branch at the route 185 bridge crossing,
- Other small tributaries to the lake, near the point where they enter the lake.
- East Fork Shoal Creek at the point where water is pumped from this creek, to measure phosphorus concentrations.

Greenville Lake

- Concurrent sampling at the inlet and outlet to the basin located at the headwaters of the lake, to measure the efficiency of this basin at reducing phosphorus to the lake.

These ongoing efforts will provide the basis for assessment of the effectiveness of the TMDLs, as well as future adaptive management decisions. As various alternatives are implemented, the monitoring will determine their effectiveness and identify which alternatives should be expanded, and which require adjustments to meet the TMDL goals.

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Attachment 1

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Greenville

Variable = TOTAL P MG/M3 **R^2 = -212.04**
Global Calibration Factor = 1.60 CV = 0.45

Seg	Group	Name	Calibration Factor Mean	Calibration Factor CV	Predicted Mean	Predicted CV	Observed Mean	Observed CV	Log (Obs/Pred) Mean	Log (Obs/Pred) SE	Log (Obs/Pred) t
1	1	Segment 1(ROY3)	1.00	0.00	48.6	0.00	313.0	0.00	1.86	0.00	0.00
2	1	Segment 2 (ROY2)	1.00	0.00	46.9	0.00	325.0	0.00	1.94	0.00	0.00
3	1	Segment 3 (ROY 1)	1.00	0.00	45.4	0.00	427.0	0.00	2.24	0.00	0.00
4	1	Area-Wtd Mean			46.7	0.00	361.9	0.00	2.05	0.00	0.00

Variable = CHL-A MG/M3 **R^2 = -101.06**
Global Calibration Factor = 1.00 CV = 0.26

Seg	Group	Name	Calibration Factor Mean	Calibration Factor CV	Predicted Mean	Predicted CV	Observed Mean	Observed CV	Log (Obs/Pred) Mean	Log (Obs/Pred) SE	Log (Obs/Pred) t
1	1	Segment 1(ROY3)	1.00	0.00	24.3	0.00	276.0	0.00	2.43	0.00	0.00
2	1	Segment 2 (ROY2)	1.00	0.00	23.0	0.00	197.0	0.00	2.15	0.00	0.00
3	1	Segment 3 (ROY 1)	1.00	0.00	22.0	0.00	163.0	0.00	2.00	0.00	0.00
4	1	Area-Wtd Mean			22.9	0.00	201.5	0.00	2.17	0.00	0.00

Greenville

T Statistics Compare Observed and Predicted Means Using the Following Error Terms:
1 = Observed Water Quality Error Only
2 = Error Typical of Model Development Dataset
3 = Observed & Predicted Error

Segment: **Area-Wtd Mean**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	361.9	0.00	46.7	0.00	7.75		7.61	
CHL-A	MG/M3	201.5	0.00	22.9	0.00	8.80		6.28	

Segment: **1** **Segment 1(ROY3)**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	313.0	0.00	48.6	0.00	6.43		6.92	
CHL-A	MG/M3	276.0	0.00	24.3	0.00	11.35		7.02	

Segment: **2** **Segment 2 (ROY2)**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	325.0	0.00	46.9	0.00	6.93		7.20	
CHL-A	MG/M3	197.0	0.00	23.0	0.00	8.55		6.20	

Segment: **3** **Segment 3 (ROY 1)**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	427.0	0.00	45.4	0.00	9.41		8.33	
CHL-A	MG/M3	163.0	0.00	22.0	0.00	7.41		5.79	

Greenville

Segment	Name
1	Segment 1(ROY3)
2	Segment 2 (ROY2)
3	Segment 3 (ROY 1)
Mean	Area-Wtd Mean

PREDICTED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	48.6	46.9	45.4	46.7
CHL-A MG/M3	24.3	23.0	22.0	22.9
ORGANIC N MG/M3	717.2	688.1	664.2	685.4
TP-ORTHO-P MG/M3	41.1	38.8	36.9	38.6
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.1	0.1	0.1	0.1
CHL-A / TOTAL P	0.5	0.5	0.5	0.5
FREQ(CHL-a>10) %	86.9	85.0	83.2	84.7
FREQ(CHL-a>20) %	50.2	46.7	43.7	46.3
FREQ(CHL-a>30) %	25.8	23.1	20.9	22.8
FREQ(CHL-a>40) %	13.3	11.5	10.1	11.4
FREQ(CHL-a>50) %	7.0	5.9	5.1	5.9
FREQ(CHL-a>60) %	3.9	3.2	2.7	3.1
CARLSON TSI-P	60.2	59.6	59.2	59.6
CARLSON TSI-CHLA	61.9	61.4	60.9	61.3

OBSERVED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	313.0	325.0	427.0	361.9
CHL-A MG/M3	276.0	197.0	163.0	201.5
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.1	0.1	0.1	0.1
CHL-A / TOTAL P	0.9	0.6	0.4	0.6
FREQ(CHL-a>10) %	100.0	100.0	100.0	100.0
FREQ(CHL-a>20) %	100.0	100.0	99.9	99.9
FREQ(CHL-a>30) %	99.9	99.7	99.2	99.6
FREQ(CHL-a>40) %	99.7	98.8	97.5	98.5
FREQ(CHL-a>50) %	99.3	97.1	94.5	96.6
FREQ(CHL-a>60) %	98.4	94.6	90.4	93.8
CARLSON TSI-P	87.0	87.6	91.5	89.0
CARLSON TSI-CHLA	85.7	82.4	80.6	82.4

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	6.4	6.9	9.4	7.8
CHL-A MG/M3	11.4	8.6	7.4	8.8
TURBIDITY 1/M	1.0	1.0	1.0	1.0
ZMIX * TURBIDITY	1.0	1.0	1.0	1.0
CHL-A / TOTAL P	1.8	1.2	0.8	1.2
FREQ(CHL-a>10) %	1.2	1.2	1.2	1.2
FREQ(CHL-a>20) %	2.0	2.1	2.3	2.2
FREQ(CHL-a>30) %	3.9	4.3	4.8	4.4
FREQ(CHL-a>40) %	7.5	8.6	9.6	8.7
FREQ(CHL-a>50) %	14.1	16.4	18.5	16.5
FREQ(CHL-a>60) %	25.5	29.7	33.7	29.9
CARLSON TSI-P	1.4	1.5	1.5	1.5
CARLSON TSI-CHLA	1.4	1.3	1.3	1.3

OBSERVED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

PREDICTED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

Greenville

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	46.7		48.9%	361.9		98.8%
CHL-A MG/M3	22.9		87.7%	201.5		100.0%
ORGANIC N MG/M3	685.4		76.5%			
TP-ORTHO-P MG/M3	38.6		60.4%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%	0.1		0.0%
CHL-A / TOTAL P	0.5		92.5%	0.6		95.6%
FREQ(CHL-a>10) %	84.7		87.7%	100.0		100.0%
FREQ(CHL-a>20) %	46.3		87.7%	99.9		100.0%
FREQ(CHL-a>30) %	22.8		87.7%	99.6		100.0%
FREQ(CHL-a>40) %	11.4		87.7%	98.5		100.0%
FREQ(CHL-a>50) %	5.9		87.7%	96.6		100.0%
FREQ(CHL-a>60) %	3.1		87.7%	93.8		100.0%
CARLSON TSI-P	59.6		48.9%	89.0		98.8%
CARLSON TSI-CHLA	61.3		87.7%	82.4		100.0%

Segment: 1 Segment 1(ROY3)

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	48.6		50.7%	313.0		98.1%
CHL-A MG/M3	24.3		89.2%	276.0		100.0%
ORGANIC N MG/M3	717.2		79.2%			
TP-ORTHO-P MG/M3	41.1		62.9%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%	0.1		0.0%
CHL-A / TOTAL P	0.5		92.9%	0.9		99.1%
FREQ(CHL-a>10) %	86.9		89.2%	100.0		100.0%
FREQ(CHL-a>20) %	50.2		89.2%	100.0		100.0%
FREQ(CHL-a>30) %	25.8		89.2%	99.9		100.0%
FREQ(CHL-a>40) %	13.3		89.2%	99.7		100.0%
FREQ(CHL-a>50) %	7.0		89.2%	99.3		100.0%
FREQ(CHL-a>60) %	3.9		89.2%	98.4		100.0%
CARLSON TSI-P	60.2		50.7%	87.0		98.1%
CARLSON TSI-CHLA	61.9		89.2%	85.7		100.0%

Segment: 2 Segment 2 (ROY2)

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	46.9		49.0%	325.0		98.3%
CHL-A MG/M3	23.0		87.8%	197.0		100.0%
ORGANIC N MG/M3	688.1		76.8%			
TP-ORTHO-P MG/M3	38.8		60.7%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%	0.1		0.0%
CHL-A / TOTAL P	0.5		92.6%	0.6		96.2%
FREQ(CHL-a>10) %	85.0		87.8%	100.0		100.0%
FREQ(CHL-a>20) %	46.7		87.8%	100.0		100.0%
FREQ(CHL-a>30) %	23.1		87.8%	99.7		100.0%
FREQ(CHL-a>40) %	11.5		87.8%	98.8		100.0%
FREQ(CHL-a>50) %	5.9		87.8%	97.1		100.0%
FREQ(CHL-a>60) %	3.2		87.8%	94.6		100.0%

Greenville

Predicted & Observed Values Ranked Against CE Model Development Dataset

CARLSON TSI-P	59.6		49.0%	87.6		98.3%
CARLSON TSI-CHLA	61.4		87.8%	82.4		100.0%

Segment: **3** **Segment 3 (ROY 1)**

	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	45.4		47.6%	427.0		99.2%
CHL-A MG/M3	22.0		86.5%	163.0		100.0%
ORGANIC N MG/M3	664.2		74.6%			
TP-ORTHO-P MG/M3	36.9		58.7%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%	0.1		0.0%
CHL-A / TOTAL P	0.5		92.3%	0.4		85.3%
FREQ(CHL-a>10) %	83.2		86.5%	100.0		100.0%
FREQ(CHL-a>20) %	43.7		86.5%	99.9		100.0%
FREQ(CHL-a>30) %	20.9		86.5%	99.2		100.0%
FREQ(CHL-a>40) %	10.1		86.5%	97.5		100.0%
FREQ(CHL-a>50) %	5.1		86.5%	94.5		100.0%
FREQ(CHL-a>60) %	2.7		86.5%	90.4		100.0%
CARLSON TSI-P	59.2		47.6%	91.5		99.2%
CARLSON TSI-CHLA	60.9		86.5%	80.6		100.0%

Greenville

Water Balance Terms (hm3/yr) **Averaging Period = 0.43 Years**

Seg	Name	External	Inflows Precip	Advect	Storage Increase	Outflows------> Advect	Disch.	Downstr Exchange	Evap
1	Segment 1(ROY3)	5	0	0	0	5	0	9	0
2	Segment 2 (ROY2)	1	0	5	0	6	0	9	0
3	Segment 3 (ROY 1)	0	0	6	0	6	0	0	0
Net		6	0	0	0	6	0	0	0

Mass Balance Terms (kg/yr) Based Upon Predicted Reservoir & Outflow Concentrations Component: TOTAL P

Seg	Name	Inflows--> External	Atmos	Advect	Storage Increase	Outflows-----> Advect	Disch.	Net Exchange	Net Retention
1	Segment 1(ROY3)	166	1	0	0	243	0	17	-94
2	Segment 2 (ROY2)	22	1	243	0	265	0	-3	4
3	Segment 3 (ROY 1)	4	1	265	0	263	0	-14	21
Net		192	3	0	0	263	0	0	-68

Greenville

Segment Mass Balance Based Upon Predicted Concentrations

Component:		**TOTAL P**		**Segment:**	**1**	**Segment 1(ROY3)**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1	1	Inlet Tributary (ROY-T2)	5.0	99.6%	165.9	99.6%	33
PRECIPITATION			0.0	0.4%	0.6	0.4%	30
TRIBUTARY INFLOW			5.0	99.6%	165.9	99.6%	33
***TOTAL INFLOW			5.0	100.0%	166.5	100.0%	33
ADVECTIVE OUTFLOW			5.0	99.6%	243.2	146.1%	49
NET DIFFUSIVE OUTFLOW			0.0	0.0%	16.9	10.2%	
***TOTAL OUTFLOW			5.0	99.6%	260.1	156.2%	52
***EVAPORATION			0.0	0.4%	0.0	0.0%	
***RETENTION			0.0	0.0%	-93.6	-56.2%	

Hyd. Residence Time = 0.0060 yrs
Overflow Rate = 255.1 m/yr
Mean Depth = 1.5 m

Component:		**TOTAL P**		**Segment:**	**2**	**Segment 2 (ROY2)**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
2	1	Segment 2 Direct Drainage	0.7	11.6%	21.9	8.1%	33
PRECIPITATION			0.0	0.6%	1.0	0.4%	30
TRIBUTARY INFLOW			0.7	11.6%	21.9	8.1%	33
ADVECTIVE INFLOW			5.0	87.8%	243.2	90.2%	49
NET DIFFUSIVE INFLOW			0.0	0.0%	3.4	1.3%	
***TOTAL INFLOW			5.7	100.0%	269.5	100.0%	47
ADVECTIVE OUTFLOW			5.7	99.4%	265.2	98.4%	47
***TOTAL OUTFLOW			5.7	99.4%	265.2	98.4%	47
***EVAPORATION			0.0	0.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	4.3	1.6%	

Hyd. Residence Time = 0.0164 yrs
Overflow Rate = 167.4 m/yr
Mean Depth = 2.7 m

Component:		**TOTAL P**		**Segment:**	**3**	**Segment 3 (ROY 1)**	
			Flow	**Flow**	**Load**	**Load**	**Conc**
Trib	**Type**	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
3	1	Segment 3 Direct Drainage	0.1	2.2%	4.3	1.5%	33
PRECIPITATION			0.0	0.6%	1.0	0.4%	30
TRIBUTARY INFLOW			0.1	2.2%	4.3	1.5%	33
ADVECTIVE INFLOW			5.7	97.2%	265.2	93.4%	47
NET DIFFUSIVE INFLOW			0.0	0.0%	13.5	4.8%	
***TOTAL INFLOW			5.8	100.0%	284.1	100.0%	49
ADVECTIVE OUTFLOW			5.8	99.4%	262.8	92.5%	45
***TOTAL OUTFLOW			5.8	99.4%	262.8	92.5%	45
***EVAPORATION			0.0	0.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	21.3	7.5%	

Hyd. Residence Time = 0.0232 yrs
Overflow Rate = 170.8 m/yr
Mean Depth = 4.0 m

Greenville

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.43 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Inlet Tributary (ROY-T2)	3.2	5.0	0.00E+00	0.00	1.56
2	1	2	Segment 2 Direct Drainage	0.4	0.7	0.00E+00	0.00	1.57
3	1	3	Segment 3 Direct Drainage	0.1	0.1	0.00E+00	0.00	1.62
PRECIPITATION				0.1	0.1	0.00E+00	0.00	0.99
TRIBUTARY INFLOW				3.7	5.8	0.00E+00	0.00	1.56
***TOTAL INFLOW				3.8	5.9	0.00E+00	0.00	1.55
ADVECTIVE OUTFLOW				3.8	5.8	0.00E+00	0.00	1.52
***TOTAL OUTFLOW				3.8	5.8	0.00E+00	0.00	1.52
***EVAPORATION					0.1	0.00E+00	0.00	

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

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Inlet Tributary (ROY-T2)	165.9	85.2%	0.00E+00		0.00	33.2	51.7
2	1	2	Segment 2 Direct Drainage	21.9	11.2%	0.00E+00		0.00	33.2	52.1
3	1	3	Segment 3 Direct Drainage	4.3	2.2%	0.00E+00		0.00	33.2	53.7
PRECIPITATION				2.6	1.3%	0.00E+00		0.00	30.2	30.0
TRIBUTARY INFLOW				192.1	98.7%	0.00E+00		0.00	33.2	51.8
***TOTAL INFLOW				194.7	100.0%	0.00E+00		0.00	33.1	51.3
ADVECTIVE OUTFLOW				262.8	135.0%	0.00E+00		0.00	45.4	69.2
***TOTAL OUTFLOW				262.8	135.0%	0.00E+00		0.00	45.4	69.2
***RETENTION				-68.1		0.00E+00		0.00		

Overflow Rate (m/yr)	66.3	Nutrient Resid. Time (yrs)	0.0616
Hydraulic Resid. Time (yrs)	0.0444	Turnover Ratio	6.9
Reservoir Conc (mg/m3)	47	Retention Coef.	-0.350

Greenville

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1(ROY3)	2	5.0	0.0060	255.1	37.5	20.2	4.2	9.5
2	Segment 2 (ROY2)	3	5.7	0.0164	167.4	17.4	10.5	2.5	9.1
3	Segment 3 (ROY 1)	0	5.8	0.0232	170.8	14.3	4.7	2.4	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1(ROY3)	0.0	1.5	0.9	0.2	0.0	0.1	2.6
2	Segment 2 (ROY2)	0.0	2.7	0.9	0.3	0.1	0.1	2.4
3	Segment 3 (ROY 1)	0.0	4.0	1.1	0.3	0.1	0.1	3.2
Totals		0.1	2.9			0.3		

Greenville

Segment & Tributary Network

--------Segment:	1	Segment 1(ROY3)		
Outflow Segment:	2	Segment 2 (ROY2)		
Tributary:	1	Inlet Tributary (ROY-T2)	Type:	Monitored Inflow
--------Segment:	2	Segment 2 (ROY2)		
Outflow Segment:	3	Segment 3 (ROY 1)		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3 (ROY 1)		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 3 Direct Drainage	Type:	Monitored Inflow

Greenville
Description:

Single reservoir, three segments.
Tributary flowing into sedimentation pond at inlet of lake.

Global Variables	Mean	CV
Averaging Period (yrs)	0.4267	0.0
Precipitation (m)	0.4234	0.0
Evaporation (m)	0.4234	0.0
Storage Increase (m)	0	0.0

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

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	6	P, CARLSON TSI
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	1	DECAY RATES
Error Analysis	0	NOT COMPUTED
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1(ROY3)	2	1	0.0196	1.524	0.224	0.914	0	0	0	0.08	0	0	0	0	0	0	0
2	Segment 2 (ROY2)	3	1	0.0338	2.743	0.285	0.914	0	2.4384	0	0.08	0	0	0	0	0	0	0
3	Segment 3 (ROY 1)	0	1	0.0339	3.9624	0.331	1.12776	0	2.7432	0	0.08	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	313	0	0	0	276	0	0	0	0	0	0	0	0	0	0	0
2	0	0	325	0	0	0	197	0	0	0	0	0	0	0	0	0	0	0
3	0	0	427	0	0	0	163	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

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

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Inlet Tributary (ROY-T2)	1	1	3.21	5.0004	0	0	0	33.18	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	0.42	0.6592	0	0	0	33.18	0	0	0	0	0	0	0
3	Segment 3 Direct Drainage	3	1	0.08	0.1294	0	0	0	33.18	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Categ	Land Use Name	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Row Crop	0.2596	0	0	0	493	0	0	0	0	0	0	0
2	Grassland	0.2596	0	0	0	493	0	0	0	0	0	0	0
3	Forest	0.2596	0	0	0	493	0	0	0	0	0	0	0
4	Urban	0.2596	0	0	0	493	0	0	0	0	0	0	0
5	Wetland	0.2596	0	0	0	493	0	0	0	0	0	0	0
6	Other	0.2596	0	0	0	493	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.600	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	1.000	0
Avail. Factor - Ortho P	0.000	0
Avail. Factor - Total N	0.000	0
Avail. Factor - Inorganic N	0.000	0

Coffeen Lake

Variable = CONSERVATIVE SUB **R^2 = 1.00**
Global Calibration Factor = 1.00 CV = 0.70

			Calibration Factor		Predicted		Observed		Log (Obs/Pred)		
Seg	**Group**	**Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**SE**	**t**

Variable = TOTAL P MG/M3 **R^2 = 0.98**
Global Calibration Factor = 1.00 CV = 0.45

			Calibration Factor		Predicted		Observed		Log (Obs/Pred)		
Seg	**Group**	**Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**SE**	**t**
1	1	Segment 1 (ROG3)	2.00	0.00	75.9	0.17	75.0	0.00	-0.01	0.17	-0.07
2	1	Segment 2 (ROG2)	1.00	0.00	63.9	0.22	65.0	0.00	0.02	0.22	0.08
3	1	Segment 3 (ROG1)	1.00	0.00	80.6	0.21	81.0	0.00	0.01	0.21	0.02
4	1	Area-Wtd Mean			72.3	0.21	72.8	0.00	0.01	0.21	0.03

Variable = CHL-A MG/M3 **R^2 = -3.09**
Global Calibration Factor = 1.00 CV = 0.26

			Calibration Factor		Predicted		Observed		Log (Obs/Pred)		
Seg	**Group**	**Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**SE**	**t**
1	1	Segment 1 (ROG3)	1.00	0.00	57.0	0.32	35.7	0.00	-0.47	0.32	-1.48
2	1	Segment 2 (ROG2)	1.00	0.00	29.4	0.30	20.3	0.00	-0.37	0.30	-1.23
3	1	Segment 3 (ROG1)	1.00	0.00	43.9	0.30	16.4	0.00	-0.99	0.30	-3.25
4	1	Area-Wtd Mean			39.6	0.31	21.3	0.00	-0.62	0.31	-2.02

Coffeen Lake

T Statistics Compare Observed and Predicted Means Using the Following Error Terms:
1 = Observed Water Quality Error Only
2 = Error Typical of Model Development Dataset
3 = Observed & Predicted Error

Segment:		**Area-Wtd Mean**							
		Observed		**Predicted**		**Obs/Pred**	**T-Statistics ---->**		
Variable		**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P	MG/M3	72.8	0.00	72.3	0.21	1.01		0.03	0.03
CHL-A	MG/M3	21.3	0.00	39.6	0.31	0.54		-1.79	-2.02

Segment:		**1**	**Segment 1 (ROG3)**						
		Observed		**Predicted**		**Obs/Pred**	**T-Statistics ---->**		
Variable		**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P	MG/M3	75.0	0.00	75.9	0.17	0.99		-0.04	-0.07
CHL-A	MG/M3	35.7	0.00	57.0	0.32	0.63		-1.35	-1.48

Segment:		**2**	**Segment 2 (ROG2)**						
		Observed		**Predicted**		**Obs/Pred**	**T-Statistics ---->**		
Variable		**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P	MG/M3	65.0	0.00	63.9	0.22	1.02		0.06	0.08
CHL-A	MG/M3	20.3	0.00	29.4	0.30	0.69		-1.08	-1.23

Segment:		**3**	**Segment 3 (ROG1)**						
		Observed		**Predicted**		**Obs/Pred**	**T-Statistics ---->**		
Variable		**Mean**	**CV**	**Mean**	**CV**	**Ratio**	**T1**	**T2**	**T3**
TOTAL P	MG/M3	81.0	0.00	80.6	0.21	1.01		0.02	0.02
CHL-A	MG/M3	16.4	0.00	43.9	0.30	0.37		-2.85	-3.25

Coffeen Lake

Segment	Name
1	Segment 1 (ROG3)
2	Segment 2 (ROG2)
3	Segment 3 (ROG1)
Mean	Area-Wtd Mean

PREDICTED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	75.9	63.9	80.6	72.3
CHL-A MG/M3	57.0	29.4	43.9	39.6
SECCHI M	0.7	1.2	0.8	1.0
ORGANIC N MG/M3	1463.5	833.4	1163.2	1064.8
TP-ORTHO-P MG/M3	99.3	50.1	75.9	68.2
HOD-V MG/M3-DAY	707.4			707.4
MOD-V MG/M3-DAY	377.4			377.4
ANTILOG PC-1	2024.9	609.3	1254.0	1092.0
ANTILOG PC-2	15.0	15.5	15.3	15.3
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.1	0.3	0.2	0.2
ZMIX / SECCHI	1.4	2.7	2.5	2.4
CHL-A * SECCHI	37.9	36.1	37.3	36.8
CHL-A / TOTAL P	0.8	0.5	0.5	0.5
FREQ(CHL-a>10) %	99.4	92.4	98.1	95.7
FREQ(CHL-a>20) %	91.6	62.2	83.1	75.1
FREQ(CHL-a>30) %	76.6	36.6	61.9	53.0
FREQ(CHL-a>40) %	60.4	21.0	43.6	36.2
FREQ(CHL-a>50) %	46.1	12.2	30.1	24.7
FREQ(CHL-a>60) %	34.8	7.2	20.7	17.0
CARLSON TSI-P	66.6	64.1	67.4	65.8
CARLSON TSI-CHLA	70.3	63.8	67.7	66.4
CARLSON TSI-SEC	65.9	57.1	62.3	60.6

OBSERVED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	75.0	65.0	81.0	72.8
CHL-A MG/M3	35.7	20.3	16.4	21.3
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.1	0.3	0.2	0.2
CHL-A / TOTAL P	0.5	0.3	0.2	0.3
FREQ(CHL-a>10) %	95.9	79.6	68.6	78.1
FREQ(CHL-a>20) %	73.4	38.6	26.3	39.6
FREQ(CHL-a>30) %	48.9	17.3	9.9	19.7
FREQ(CHL-a>40) %	31.1	8.0	4.0	10.3
FREQ(CHL-a>50) %	19.7	3.9	1.7	5.7
FREQ(CHL-a>60) %	12.6	2.0	0.8	3.3
CARLSON TSI-P	66.4	64.3	67.5	65.9
CARLSON TSI-CHLA	65.7	60.1	58.0	60.2

Coffeen Lake

Segment	Name
1	Segment 1 (ROG3)
2	Segment 2 (ROG2)
3	Segment 3 (ROG1)
Mean	Area-Wtd Mean

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	1.0	1.0	1.0	1.0
CHL-A MG/M3	0.6	0.7	0.4	0.5
TURBIDITY 1/M	1.0	1.0	1.0	1.0
ZMIX * TURBIDITY	1.0	1.0	1.0	1.0
CHL-A / TOTAL P	0.6	0.7	0.4	0.5
FREQ(CHL-a>10) %	1.0	0.9	0.7	0.8
FREQ(CHL-a>20) %	0.8	0.6	0.3	0.5
FREQ(CHL-a>30) %	0.6	0.5	0.2	0.4
FREQ(CHL-a>40) %	0.5	0.4	0.1	0.3
FREQ(CHL-a>50) %	0.4	0.3	0.1	0.2
FREQ(CHL-a>60) %	0.4	0.3	0.0	0.2
CARLSON TSI-P	1.0	1.0	1.0	1.0
CARLSON TSI-CHLA	0.9	0.9	0.9	0.9

OBSERVED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

PREDICTED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	13.3	14.3	16.8	15.0
CHL-A MG/M3	18.0	8.9	13.3	12.1
SECCHI M	0.2	0.4	0.3	0.3
ORGANIC N MG/M3	446.9	226.7	333.5	303.8
TP-ORTHO-P MG/M3	35.4	17.6	26.2	23.8
HOD-V MG/M3-DAY	151.1			151.1
MOD-V MG/M3-DAY	115.7			115.7
ANTILOG PC-1	1194.4	338.1	705.3	620.3
ANTILOG PC-2	1.2	1.2	1.2	1.2
ZMIX / SECCHI	0.4	0.8	0.7	0.7
CHL-A * SECCHI	3.8	3.8	3.8	3.8
CHL-A / TOTAL P	0.2	0.1	0.1	0.1
FREQ(CHL-a>10) %	0.9	6.8	2.2	4.0
FREQ(CHL-a>20) %	7.6	18.3	12.0	14.1
FREQ(CHL-a>30) %	15.3	18.3	18.3	17.8
FREQ(CHL-a>40) %	19.4	14.1	19.1	16.9
FREQ(CHL-a>50) %	20.1	10.0	17.0	14.3
FREQ(CHL-a>60) %	18.8	6.8	14.0	11.5
CARLSON TSI-P	2.5	3.3	3.0	3.0
CARLSON TSI-CHLA	3.1	2.9	2.9	3.0
CARLSON TSI-SEC	4.5	4.2	4.3	4.3

Coffeen Lake

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment:	**4**	**Area-Wtd Mean**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	72.3	0.21	67.6%	72.8		67.9%
CHL-A MG/M3	39.6	0.31	96.9%	21.3		85.7%
SECCHI M	1.0	0.29	45.4%			
ORGANIC N MG/M3	1064.8	0.29	94.4%			
TP-ORTHO-P MG/M3	68.2	0.35	80.6%			
HOD-V MG/M3-DAY	707.4	0.21	99.9%			
MOD-V MG/M3-DAY	377.4	0.31	99.2%			
ANTILOG PC-1	1092.0	0.57	87.3%			
ANTILOG PC-2	15.3	0.08	95.1%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.2		0.0%	0.2		0.0%
ZMIX / SECCHI	2.4	0.30	12.2%			
CHL-A * SECCHI	36.8	0.10	96.5%			
CHL-A / TOTAL P	0.5	0.26	94.5%	0.3		74.3%
FREQ(CHL-a>10) %	95.7	0.04	96.9%	78.1		85.7%
FREQ(CHL-a>20) %	75.1	0.19	96.9%	39.6		85.7%
FREQ(CHL-a>30) %	53.0	0.34	96.9%	19.7		85.7%
FREQ(CHL-a>40) %	36.2	0.47	96.9%	10.3		85.7%
FREQ(CHL-a>50) %	24.7	0.58	96.9%	5.7		85.7%
FREQ(CHL-a>60) %	17.0	0.68	96.9%	3.3		85.7%
CARLSON TSI-P	65.8	0.05	67.6%	65.9		67.9%
CARLSON TSI-CHLA	66.4	0.04	96.9%	60.2		85.7%
CARLSON TSI-SEC	60.6	0.07	54.6%			

Segment:	**1**	**Segment 1 (ROG3)**				
	Predicted Values--->			**Observed Values--->**		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	75.9	0.17	69.5%	75.0		69.1%
CHL-A MG/M3	57.0	0.32	99.0%	35.7		95.9%
SECCHI M	0.7	0.31	26.1%			
ORGANIC N MG/M3	1463.5	0.31	98.6%			
TP-ORTHO-P MG/M3	99.3	0.36	89.6%			
HOD-V MG/M3-DAY	707.4	0.21	99.9%			
MOD-V MG/M3-DAY	377.4	0.31	99.2%			
ANTILOG PC-1	2024.9	0.59	94.7%			
ANTILOG PC-2	15.0	0.08	94.7%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.1		0.0%	0.1		0.0%
ZMIX / SECCHI	1.4	0.31	1.6%			
CHL-A * SECCHI	37.9	0.10	96.8%			
CHL-A / TOTAL P	0.8	0.26	98.3%	0.5		91.9%
FREQ(CHL-a>10) %	99.4	0.01	99.0%	95.9		95.9%
FREQ(CHL-a>20) %	91.6	0.08	99.0%	73.4		95.9%
FREQ(CHL-a>30) %	76.6	0.20	99.0%	48.9		95.9%
FREQ(CHL-a>40) %	60.4	0.32	99.0%	31.1		95.9%
FREQ(CHL-a>50) %	46.1	0.44	99.0%	19.7		95.9%
FREQ(CHL-a>60) %	34.8	0.54	99.0%	12.6		95.9%
CARLSON TSI-P	66.6	0.04	69.5%	66.4		69.1%
CARLSON TSI-CHLA	70.3	0.04	99.0%	65.7		95.9%
CARLSON TSI-SEC	65.9	0.07	73.9%			

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Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 2 Segment 2 (ROG2)

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	63.9	0.22	62.6%	65.0		63.3%
CHL-A MG/M3	29.4	0.30	93.1%	20.3		84.1%
SECCHI M	1.2	0.29	56.7%			
ORGANIC N MG/M3	833.4	0.27	86.6%			
TP-ORTHO-P MG/M3	50.1	0.35	70.6%			
ANTILOG PC-1	609.3	0.55	75.7%			
ANTILOG PC-2	15.5	0.08	95.3%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.3		0.1%	0.3		0.1%
ZMIX / SECCHI	2.7	0.29	16.9%			
CHL-A * SECCHI	36.1	0.10	96.3%			
CHL-A / TOTAL P	0.5	0.27	91.0%	0.3		76.7%
FREQ(CHL-a>10) %	92.4	0.07	93.1%	79.6		84.1%
FREQ(CHL-a>20) %	62.2	0.29	93.1%	38.6		84.1%
FREQ(CHL-a>30) %	36.6	0.50	93.1%	17.3		84.1%
FREQ(CHL-a>40) %	21.0	0.67	93.1%	8.0		84.1%
FREQ(CHL-a>50) %	12.2	0.82	93.1%	3.9		84.1%
FREQ(CHL-a>60) %	7.2	0.94	93.1%	2.0		84.1%
CARLSON TSI-P	64.1	0.05	62.6%	64.3		63.3%
CARLSON TSI-CHLA	63.8	0.05	93.1%	60.1		84.1%
CARLSON TSI-SEC	57.1	0.07	43.3%			

Segment: 3 Segment 3 (ROG1)

	Predicted Values--->			Observed Values--->		
Variable	**Mean**	**CV**	**Rank**	**Mean**	**CV**	**Rank**
TOTAL P MG/M3	80.6	0.21	71.8%	81.0		72.0%
CHL-A MG/M3	43.9	0.30	97.7%	16.4		76.5%
SECCHI M	0.8	0.29	37.6%			
ORGANIC N MG/M3	1163.2	0.29	96.1%			
TP-ORTHO-P MG/M3	75.9	0.35	83.6%			
ANTILOG PC-1	1254.0	0.56	89.4%			
ANTILOG PC-2	15.3	0.08	95.0%			
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.2		0.0%	0.2		0.0%
ZMIX / SECCHI	2.5	0.30	13.4%			
CHL-A * SECCHI	37.3	0.10	96.6%			
CHL-A / TOTAL P	0.5	0.27	94.6%	0.2		51.9%
FREQ(CHL-a>10) %	98.1	0.02	97.7%	68.6		76.5%
FREQ(CHL-a>20) %	83.1	0.14	97.7%	26.3		76.5%
FREQ(CHL-a>30) %	61.9	0.30	97.7%	9.9		76.5%
FREQ(CHL-a>40) %	43.6	0.44	97.7%	4.0		76.5%
FREQ(CHL-a>50) %	30.1	0.56	97.7%	1.7		76.5%
FREQ(CHL-a>60) %	20.7	0.68	97.7%	0.8		76.5%
CARLSON TSI-P	67.4	0.04	71.8%	67.5		72.0%
CARLSON TSI-CHLA	67.7	0.04	97.7%	58.0		76.5%
CARLSON TSI-SEC	62.3	0.07	62.4%			

Coffeen Lake

Water Balance Terms (hm3/yr) **Averaging Period = 0.42 Years**

Seg	Name	External	Inflows Precip	Advect	Storage Increase	Outflows------> Advect	Disch.	Downstr Exchange	Evap
1	Segment 1 (ROG3)	3	1	0	0	3	0	0	1
2	Segment 2 (ROG2)	1	2	3	0	4	0	8	2
3	Segment 3 (ROG1)	1	2	4	0	5	0	0	2
Net		6	4	0	0	5	0	0	5

Mass Balance Terms (kg/yr) Based Upon Predicted Reservoir & Outflow Concentrations Component: CONSERVATIVE SUBST.

Seg	Name	Inflows--> External	Atmos	Advect	Storage Increase	Outflows-----> Advect	Disch.	Net Exchange	Net Retention
1	Segment 1 (ROG3)	0	0	0	0	0	0	0	0
2	Segment 2 (ROG2)	0	0	0	0	0	0	0	0
3	Segment 3 (ROG1)	0	0	0	0	0	0	0	0
Net		0	0	0	0	0	0	0	0

Mass Balance Terms (kg/yr) Based Upon Predicted Reservoir & Outflow Concentrations Component: TOTAL P

Seg	Name	Inflows--> External	Atmos	Advect	Storage Increase	Outflows-----> Advect	Disch.	Net Exchange	Net Retention
1	Segment 1 (ROG3)	91	21	0	0	198	0	0	-86
2	Segment 2 (ROG2)	48	57	198	0	243	0	-130	190
3	Segment 3 (ROG1)	63	49	243	0	402	0	130	-177
Net		203	127	0	0	402	0	0	-73

Coffeen Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component:	**CONSERVATIVE SUBST.**		**Segment:**	**1**	**Segment 1 (ROG3)**	
		Flow	**Flow**	**Load**	**Load**	**Conc**
Trib Type	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
PRECIPITATION		0.7	20.9%	0.0	0.0%	
TRIBUTARY INFLOW		2.7	79.1%	0.0	0.0%	
***TOTAL INFLOW		3.4	100.0%	0.0	0.0%	
ADVECTIVE OUTFLOW		2.6	76.6%	0.0	0.0%	
***TOTAL OUTFLOW		2.6	76.6%	0.0	0.0%	
***EVAPORATION		0.8	23.4%	0.0	0.0%	
***RETENTION		0.0	0.0%	0.0	0.0%	

Hyd. Residence Time = 0.8988 yrs
Overflow Rate = 3.7 m/yr
Mean Depth = 3.4 m

Component:	**TOTAL P**		**Segment:**	**1**	**Segment 1 (ROG3)**	
		Flow	**Flow**	**Load**	**Load**	**Conc**
Trib Type	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
1 1	Segment 1 Direct Drainage	2.7	79.1%	91.4	16.0%	34
PRECIPITATION		0.7	20.9%	21.0	3.7%	30
INTERNAL LOAD		0.0	0.0%	460.2	80.4%	
TRIBUTARY INFLOW		2.7	79.1%	91.4	16.0%	34
***TOTAL INFLOW		3.4	100.0%	572.6	100.0%	168
ADVECTIVE OUTFLOW		2.6	76.6%	198.2	34.6%	76
***TOTAL OUTFLOW		2.6	76.6%	198.2	34.6%	76
***EVAPORATION		0.8	23.4%	0.0	0.0%	
***RETENTION		0.0	0.0%	374.4	65.4%	

Hyd. Residence Time = 0.8988 yrs
Overflow Rate = 3.7 m/yr
Mean Depth = 3.4 m

Component:	**CONSERVATIVE SUBST.**		**Segment:**	**2**	**Segment 2 (ROG2)**	
		Flow	**Flow**	**Load**	**Load**	**Conc**
Trib Type	**Location**	**hm^3/yr**	**%Total**	**kg/yr**	**%Total**	**mg/m^3**
PRECIPITATION		1.9	32.4%	0.0	0.0%	
TRIBUTARY INFLOW		1.4	23.8%	0.0	0.0%	
ADVECTIVE INFLOW		2.6	43.8%	0.0	0.0%	
***TOTAL INFLOW		6.0	100.0%	0.0	0.0%	
ADVECTIVE OUTFLOW		3.8	63.8%	0.0	0.0%	
***TOTAL OUTFLOW		3.8	63.8%	0.0	0.0%	
***EVAPORATION		2.2	36.2%	0.0	0.0%	
***RETENTION		0.0	0.0%	0.0	0.0%	

Hyd. Residence Time = 4.7619 yrs
Overflow Rate = 2.0 m/yr
Mean Depth = 9.5 m

Coffeen Lake

Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P — **Segment: 2 Segment 2 (ROG2)**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
2	1	Segment 2 Direct Drainage	1.4	23.8%	48.1	3.8%	34
PRECIPITATION			1.9	32.4%	57.0	4.5%	30
INTERNAL LOAD			0.0	0.0%	832.8	65.8%	
TRIBUTARY INFLOW			1.4	23.8%	48.1	3.8%	34
ADVECTIVE INFLOW			2.6	43.8%	198.2	15.7%	76
NET DIFFUSIVE INFLOW			0.0	0.0%	130.1	10.3%	
***TOTAL INFLOW			6.0	100.0%	1266.1	100.0%	212
ADVECTIVE OUTFLOW			3.8	63.8%	242.8	19.2%	64
***TOTAL OUTFLOW			3.8	63.8%	242.8	19.2%	64
***EVAPORATION			2.2	36.2%	0.0	0.0%	
***RETENTION			0.0	0.0%	1023.3	80.8%	

Hyd. Residence Time = 4.7619 yrs
Overflow Rate = 2.0 m/yr
Mean Depth = 9.5 m

Component: CONSERVATIVE SUBST. — **Segment: 3 Segment 3 (ROG1)**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
PRECIPITATION			1.7	24.2%	0.0	0.0%	
TRIBUTARY INFLOW			0.8	11.8%	0.0	0.0%	
POINT-SOURCE INFLOW			0.6	8.5%	0.0	0.0%	
ADVECTIVE INFLOW			3.8	55.5%	0.0	0.0%	
***TOTAL INFLOW			6.8	100.0%	0.0	0.0%	
ADVECTIVE OUTFLOW			5.0	72.9%	0.0	0.0%	
***TOTAL OUTFLOW			5.0	72.9%	0.0	0.0%	
***EVAPORATION			1.9	27.1%	0.0	0.0%	
***RETENTION			0.0	0.0%	0.0	0.0%	

Hyd. Residence Time = 4.5134 yrs
Overflow Rate = 3.1 m/yr
Mean Depth = 13.8 m

Component: TOTAL P — **Segment: 3 Segment 3 (ROG1)**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
3	1	Segment 3 Direct Drainage	0.8	11.8%	27.3	1.1%	34
4	3	IL0000108 (Coal Fired PP)	0.0	0.4%	2.0	0.1%	72
5	3	EF Shoal Creek Recharge	0.6	8.1%	33.7	1.3%	61
PRECIPITATION			1.7	24.2%	48.9	1.9%	30
INTERNAL LOAD			0.0	0.0%	2202.8	86.1%	
TRIBUTARY INFLOW			0.8	11.8%	27.3	1.1%	34
POINT-SOURCE INFLOW			0.6	8.5%	35.8	1.4%	62
ADVECTIVE INFLOW			3.8	55.5%	242.8	9.5%	64
***TOTAL INFLOW			6.8	100.0%	2557.6	100.0%	374
ADVECTIVE OUTFLOW			5.0	72.9%	402.1	15.7%	81
NET DIFFUSIVE OUTFLOW			0.0	0.0%	130.1	5.1%	
***TOTAL OUTFLOW			5.0	72.9%	532.2	20.8%	107
***EVAPORATION			1.9	27.1%	0.0	0.0%	
***RETENTION			0.0	0.0%	2025.5	79.2%	

Hyd. Residence Time = 4.5134 yrs
Overflow Rate = 3.1 m/yr
Mean Depth = 13.8 m

Coffeen Lake

Overall Water & Nutrient Balances

Overall Water Balance — **Averaging Period = 0.42 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	Segment 1 Direct Drainage	25.6	2.7	0.00E+00	0.00	0.11
2	1	2	Segment 2 Direct Drainage	13.5	1.4	0.00E+00	0.00	0.11
3	1	3	Segment 3 Direct Drainage	7.6	0.8	0.00E+00	0.00	0.11
4	3	3	IL0000108 (Coal Fired PP)		0.0	0.00E+00	0.00	
5	3	3	EF Shoal Creek Recharge		0.6	0.00E+00	0.00	
PRECIPITATION				4.2	4.3	0.00E+00	0.00	1.02
TRIBUTARY INFLOW				46.7	4.9	0.00E+00	0.00	0.11
POINT-SOURCE INFLOW					0.6	0.00E+00	0.00	
***TOTAL INFLOW				50.9	9.8	0.00E+00	0.00	0.19
ADVECTIVE OUTFLOW				50.9	5.0	0.00E+00	0.00	0.10
***TOTAL OUTFLOW				50.9	5.0	0.00E+00	0.00	0.10
***EVAPORATION					4.8	0.00E+00	0.00	

Overall Mass Balance Based Upon Predicted Outflow & Reservoir Concentrations
Component: CONSERVATIVE SUBST.

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr

Overflow Rate (m/yr)	1.2	Nutrient Resid. Time (yrs)	0.0000
Hydraulic Resid. Time (yrs)	8.6107	Turnover Ratio	0.0
Reservoir Conc (mg/m3)	0	Retention Coef.	0.000

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

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	Segment 1 Direct Drainage	91.4	2.4%	0.00E+00		0.00	33.9	3.6
2	1	2	Segment 2 Direct Drainage	48.1	1.3%	0.00E+00		0.00	33.9	3.6
3	1	3	Segment 3 Direct Drainage	27.3	0.7%	0.00E+00		0.00	33.9	3.6
4	3	3	IL0000108 (Coal Fired PP)	2.0	0.1%	0.00E+00		0.00	72.0	
5	3	3	EF Shoal Creek Recharge	33.7	0.9%	0.00E+00		0.00	61.0	
PRECIPITATION				126.9	3.3%	0.00E+00		0.00	29.5	30.0
INTERNAL LOAD				3495.8	91.4%	0.00E+00		0.00		
TRIBUTARY INFLOW				166.8	4.4%	0.00E+00		0.00	33.9	3.6
POINT-SOURCE INFLOW				35.8	0.9%	0.00E+00		0.00	61.5	
***TOTAL INFLOW				3825.2	100.0%	0.00E+00		0.00	390.4	75.1
ADVECTIVE OUTFLOW				402.1	10.5%	7.03E+03		0.21	80.6	7.9
***TOTAL OUTFLOW				402.1	10.5%	7.03E+03		0.21	80.6	7.9
***RETENTION				3423.1	89.5%	7.03E+03		0.02		

Overflow Rate (m/yr)	1.2	Nutrient Resid. Time (yrs)	0.8122
Hydraulic Resid. Time (yrs)	8.6107	Turnover Ratio	0.5
Reservoir Conc (mg/m3)	72	Retention Coef.	0.895

Coffeen Lake

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1 (ROG3)	2	2.6	0.8988	3.7	3.4	0.0	5.3	0.0
2	Segment 2 (ROG2)	3	3.8	4.7619	2.0	1.0	5.4	1.1	7.8
3	Segment 3 (ROG1)	0	5.0	4.5134	3.1	1.0	8.9	0.4	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1 (ROG3)	0.7	3.4	0.9	3.1	2.3	0.2	13.5
2	Segment 2 (ROG2)	1.9	9.5	3.3	3.2	18.1	0.6	5.3
3	Segment 3 (ROG1)	1.6	13.8	2.1	1.8	22.5	0.9	2.0
Totals		4.2	10.2			43.0		

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Segment & Tributary Network

--------Segment:	1	Segment 1 (ROG3)		
Outflow Segment:	2	Segment 2 (ROG2)		
Tributary:	1	Segment 1 Direct Drainage	Type:	Monitored Inflow
--------Segment:	2	Segment 2 (ROG2)		
Outflow Segment:	3	Segment 3 (ROG1)		
Tributary:	2	Segment 2 Direct Drainage	Type:	Monitored Inflow
--------Segment:	3	Segment 3 (ROG1)		
Outflow Segment:	0	Out of Reservoir		
Tributary:	3	Segment 3 Direct Drainage	Type:	Monitored Inflow
Tributary:	4	IL0000108 (Coal Fired PP)	Type:	Point Source
Tributary:	5	EF Shoal Creek Recharge	Type:	Point Source

Coffeen Lake

Description:

Single Reservoir w/ 3 segments.

Reduced the dispersion rate and increased TP settling within Segment 1 based on site specific information describing sedimentationupstream of 6th Ave and the railroad crossings.

Global Variables	Mean	CV
Averaging Period (yrs)	0.4167	0.0
Precipitation (m)	0.4234	0.0
Evaporation (m)	0.4737	0.0
Storage Increase (m)	0	0.0

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

Model Options	Code	Description
Conservative Substance	1	COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	2	P, LIGHT, T
Secchi Depth	1	VS. CHLA & TURBIDITY
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1 (ROG3)	2	1	0.7	3.3528	3.077	0.91	0	2.1336	0	0.08	0	0	0	1.8	0	0	0
2	Segment 2 (ROG2)	3	1	1.9	9.525	3.174	3.35	0	5.4864	0	0.08	0	0	0	1.2	0	0	0
3	Segment 3 (ROG1)	0	1	1.63	13.8166	1.817	2.13	0	6.096	0	0.08	0	0	0	3.7	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	75	0	0	0	35.72	0	0	0	0	0	0	0	0	0	0	0
2	0	0	65	0	0	0	20.26	0	0	0	0	0	0	0	0	0	0	0
3	0	0	81	0	0	0	16.37	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0.001	0	2	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
2	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
3	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Segment 1 Direct Drainage	1	1	25.6	2.6957	0	0	0	33.9	0	0	0	0	0	0	0
2	Segment 2 Direct Drainage	2	1	13.47	1.4186	0	0	0	33.9	0	0	0	0	0	0	0
3	Segment 3 Direct Drainage	3	1	7.64	0.8049	0	0	0	33.9	0	0	0	0	0	0	0
4	IL0000108 (Coal Fired PP)	3	3	0	0.0282	0	0	0	72	0	0	0	0	0	0	0
5	EF Shoal Creek Recharge	3	3	0	0.553	0	0	0	61	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Attachment 2

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Attachment 2: Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from July 19, 2007 through August 11, 2007 postmarked, including those from the July 12, 2007 public meeting discussed below.

What is a TMDL?

A Total Maximum Daily Load (TMDL) is the sum of the allowable amount of a pollutant that a water body can receive from all contributing sources and still meet water quality standards or designated uses. This TMDL is for Greenville Lake and Coffeen Lake watersheds. This report details the watershed characteristics, impairment, sources, load and wasteload allocations, and reductions for each segment. The Illinois EPA implements the TMDL program in accordance with Section 303(d) of the federal Clean Water Act and regulations there under.

Background

Greenville Lake drains 832 acres and Coffeen Lake drains 12,288 acres. Land use in the Greenville Lake watershed is 78 percent agriculture, 12 percent forest, five percent wetland, and two percent urban. Land use in the Coffeen Lake watershed is 67 percent agriculture, 18 percent forest, five percent wetland and three percent urban. Greenville and Coffeen Lakes are listed on the Illinois EPA 2004 Section 303(d) List as being impaired for aesthetic quality use with the potential causes of phosphorus and suspended solids. The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) List.

Public Meetings

Public meetings were held in Greenville on April 27, 2006 and July 12, 2007. The Illinois EPA provided public notices for all meetings by placing display ads in two local newspapers in the watershed; the Greenville Advocate and the Litchfield News Herald. These notices gave the date, time, location, and purpose of the meetings. It also provided references to obtain additional information about this specific site, the TMDL Program and other related issues. Individuals and organizations were also sent the public notice by first class mail. The draft TMDL Report was available for review at the Greenville Public Library and also on the Agency's web page at http://www.epa.state.il.us/water/tmdl .

The first public meeting on April 27 started at 6:00 p.m. and was attended by one person. The second public meeting on July 12, 2007, started at 6:00 p.m. and was attended by three people. The meeting record remained open until midnight, August 11, 2007.

There were no comments or question pertaining to the TMDL at the meeting on July 12, 2007.