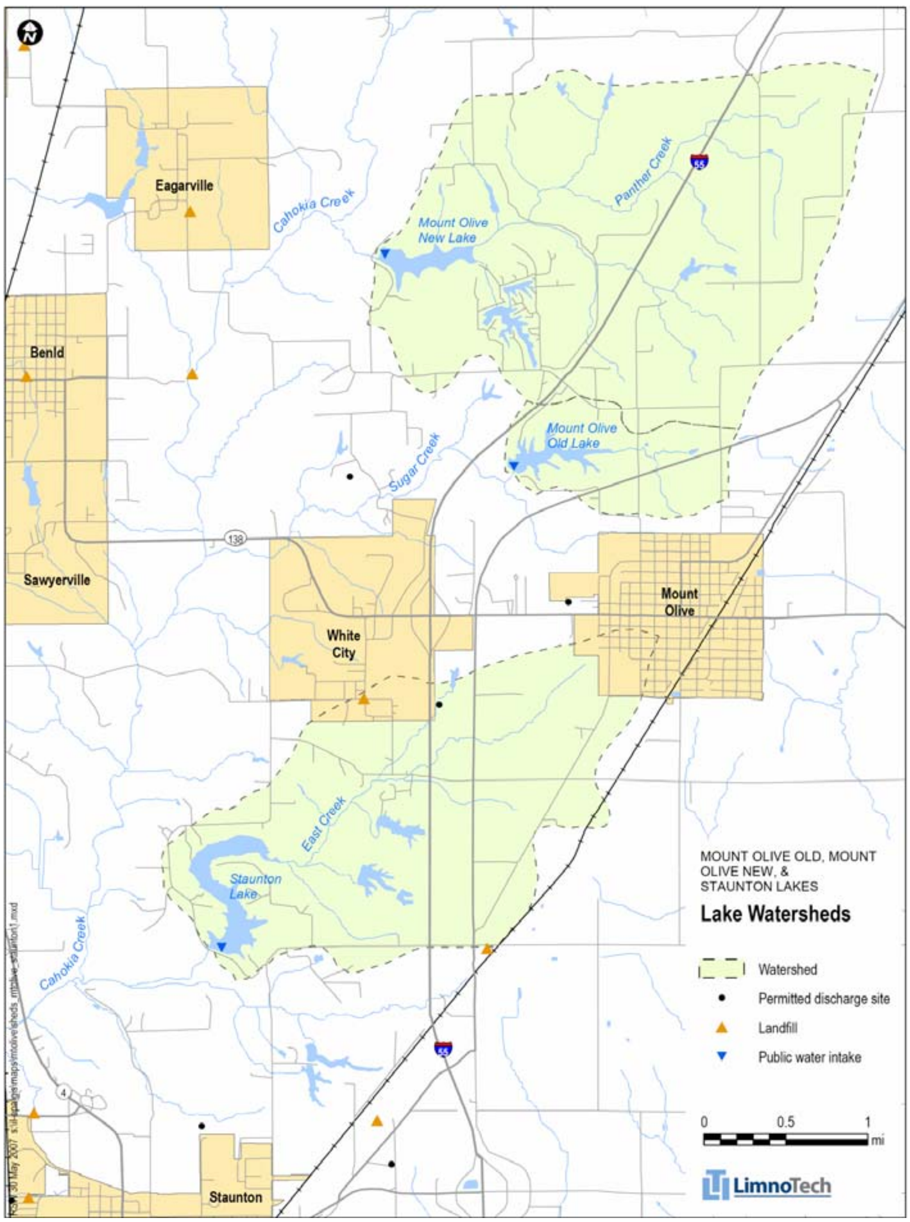
Illinois
Environmental
Protection Agency

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

August 2007

IEPA/BOW/07-015

Mt. Olive New Lake, Mt. Olive Old Lake and Staunton Lake Watersheds TMDL Report



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Mt Olives / Staunton

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

SEP 20 2007

REPLY TO THE ATTENTION OF:

WW-16J

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

RECEIVED
SEP 27 2007
Watershed Management Section
BUREAU OF WATER

Dear Ms. Willhite:

The United States Environmental Protection Agency (U.S. EPA) has reviewed the final Total Maximum Daily Loads (TMDL) from the Illinois Environmental Protection Agency (IEPA) for Mt. Olive Old Lake (RJF), Mt. Olive New Lake (RJG), and Staunton Lake (RJA) in Illinois. The TMDLs are for phosphorus, atrazine, and manganese, and address several impairments in these waterbodies.

Based on this review, U.S. EPA has determined that Illinois' TMDLs for phosphorus, atrazine, and manganese meet the requirements of Section 303(d) of the Clean Water Act and U.S. EPA's implementing regulations at 40 C.F.R. Part 130. Therefore, U.S. EPA hereby approves five TMDLs for nine impairments for Mt. Olive Old Lake (RJF), Mt. Olive New Lake (RJG), and Staunton Lake (RJA) in Illinois. 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 submitting this TMDL and look forward to future TMDL submissions by the State of Illinois. If you have any questions, please contact Dean Maraldo, TMDL Program Manager, at 312-353-2098.

Sincerely yours,

Kevin M. Pierard
Acting Director, Water Division

Enclosure

cc: Jennifer Clarke, IEPA

TABLE OF CONTENTS

TMDL Development for the Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake Watersheds

Stage One Report: Watershed Characterization and Water Quality Analysis

March 13, 2006

Submitted to:
Illinois Environmental Protection Agency
1021 N. Grand Avenue East
Springfield, IL 62702

Submitted by:
Tetra Tech, Inc.
Water Resources TMDL Center

CONTENTS

TABLES

FIGURES

Key Findings

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency has identified three waterbodies in the Cahokia Creek watershed as impaired:

- Mt. Olive New Lake (segment IL_RJF)
- Mt. Olive Old Lake (segment IL_RJG)
- Staunton Lake (segment IL_RJA)

The purpose of this report is to describe the watershed in which these waters are located and review the available water quality data to confirm the impairments. This report also identifies several potential options for proceeding with developing total maximum daily loads (TMDLs) for these waters.

- A previous study of Staunton Reservoir found high rates of sediment delivery from East Creek ranging from 10 kg/day to more than 100,000 kg/day, while sediment load at the spillway ranged from less than 1 kg/day to greater than 2,000 kg/day. Additionally, nitrogen and phosphorus loads from East Creek exceeded 1,000 kg/day and 10,000 kg/day, respectively. Additional problems identified were shoreline erosion, nutrient loading from birds, atmospheric nutrient loading, and lake sediment nutrient loading.

- A review of the Mt. Olive New lake data reveals that 100 percent of TP samples violated the water quality standard, including 100 percent of recent samples.

- All manganese samples from Mt. Olive New Lake are less than the 1000 µg/L manganese general use standard; however, all but one sample violates the 150 µg/L drinking water supply standard.

- A review of the Mt. Olive Old data reveals that nearly 100 percent of TP samples violated the water quality standard. However, no recent samples (data post-1997) were available to compare to the TP water quality standard.

- All Mt. Olive Old samples are less than the 1000 µg/L manganese general use standard, however, all samples violate the 150 µg/L drinking water supply standard.

- Only five atrazine samples are available for Mt. Olive Old Lake. These data were collected from April through October in 2003. One sample is greater than the 9.0 µg/L chronic atrazine general use standard, however, all but one sample violates the 3.0 µg/L drinking water supply standard.

- Additional atrazine data have been collected at the Mt. Olive raw water intake, which receives water from both Mt. Olive Old Lake and Mt. Olive New Lake. The raw water intake data indicate that 36 of 61 samples (59 percent) violated the 3.0 µg/L drinking water supply standard. The concentrations of atrazine also appear to be decreasing over time.

- A review of the Staunton Lake data reveals that nearly 67 percent of TP samples violated the water quality standard, and 79 percent of recent samples (data post-1997), exceed the TP water quality standard.

- A review of the Staunton Lake manganese data reveals that 70 percent of recent samples violated the water quality standard.

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1 Introduction

The Cahokia Creek watershed (ILJQ03) is located in southwest Illinois, trends in a southeasterly direction and drains approximately 70 square miles. Most of the watershed is in southeastern Macoupin County, and a smaller portion of the basin is located in southwestern Montgomery County.

As part of the Section 303(d) listing process, the Illinois Environmental Protection Agency (IEPA) has identified three waterbodies in the Cahokia Creek watershed as impaired (Table 1-1):

- Mt. Olive New Lake (segment IL_RJF)
- Mt. Olive Old Lake (segment IL_RJG)
- Staunton Lake (segment IL_RJA)

The potential causes of impairment for Mt. Olive New Lake are phosphorus, total suspended solids (TSS), atrazine, and manganese. The potential causes of impairment for Mt. Olive Old Lake are phosphorus, TSS, atrazine, and manganese. The potential cause of impairment for Staunton Lake is manganese.

The Clean Water Act and USEPA regulations require that states develop TMDLs for waters on the Section 303(d) lists. Illinois EPA is currently developing TMDLs for pollutants that have numeric water quality standards. Of the pollutants impairing these three lakes phosphorus, manganese, and atrazine are the only parameters with a water quality standard for lakes. Illinois EPA believes that addressing these impairments should lead to an overall improvement in water quality due to the interrelated nature of the other listed pollutants. For example, reducing loads of phosphorus should result in less algal growth and some of the management measures taken to reduce phosphorus loads (e.g., reducing shoreline erosion) should also reduce loads of suspended solids.

A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. 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 waterbodies 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 waterbodies 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 waterbodies.
- 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.

Table 1-1. 2004 303(d) List Information for the Cahokia Creek Watershed (ILJQ03)

Segment (Area)	Name	Designated Uses and Support Status	Causes of Impairment	Potential Sources of Impairment
IL_RJF (47.8 acres)	Mt. Olive New Lake	Aesthetic Quality	Phosphorus (Total)	Crop Production (Crop Land or Dry Land), Runoff from Forest/Grassland/Parkland
			Total Suspended Solids (TSS)	Crop Production (Crop Land or Dry Land), Littoral/shore Area Modifications (Non-riverine), Site Clearance (Land Development or Redevelopment)
		Public Water Supplies	Atrazine	Crop Production (Crop Land or Dry Land)
			Manganese	Source Unknown
IL_RJG (32.5 acres)	Mt. Olive Old Lake	Aesthetic Quality	Phosphorus (Total)	Livestock (Grazing or Feeding Operations), Runoff from Forest/Grassland/Parkland
			Total Suspended Solids (TSS)	Livestock (Grazing or Feeding Operations), Runoff from Forest/Grassland/Parkland, Site Clearance (Land Development or Redevelopment)
		Public Water Supplies	Atrazine	Crop Production (Crop Land or Dry Land)
			Manganese	Source Unknown
IL_RJA (78.8 acres)	Staunton Lake	Drinking Water Supply (Partial Support)	Manganese	Source Unknown

Source: Illinois EPA, 2006.

The project is being initiated in three stages. Stage One involves the characterization of the watershed, an assessment of the available water quality data, and identification of potential technical approaches. Stage Two will involve additional data collection, if necessary. Stage Three will involve model development and calibration, TMDL scenarios, and implementation planning. This report documents the results of Stage One.

2 Watershed Characteristics

The physical characteristics of Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake watersheds are described in the following sections. For the purposes of this characterization, the Cahokia Creek watershed was subdivided into three subwatersheds according to their respective Illinois water body segment identification. These subwatersheds correspond to the upstream contributing areas of Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA). The subwatersheds were defined using digital elevation data, and the delineation process is discussed in section 3.2.3. This type of watershed subdivision allows for a more pertinent discussion of land use and soils information impacting each of the water body segments.

2.1 Location

The Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds (Figure 2-1) are located within the Cahokia Creek watershed (ILJQ03) in southwestern Illinois in Macoupin County. Drainage for the Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake watersheds is provided by Panther Creek, Sugar Creek, and East Creek, respectively. Mt. Olive New Lake drains approximately 3,244 acres, Mt. Olive Old Lake drains approximately 462 acres, and Staunton Lake watersheds drains 2,398 acres.

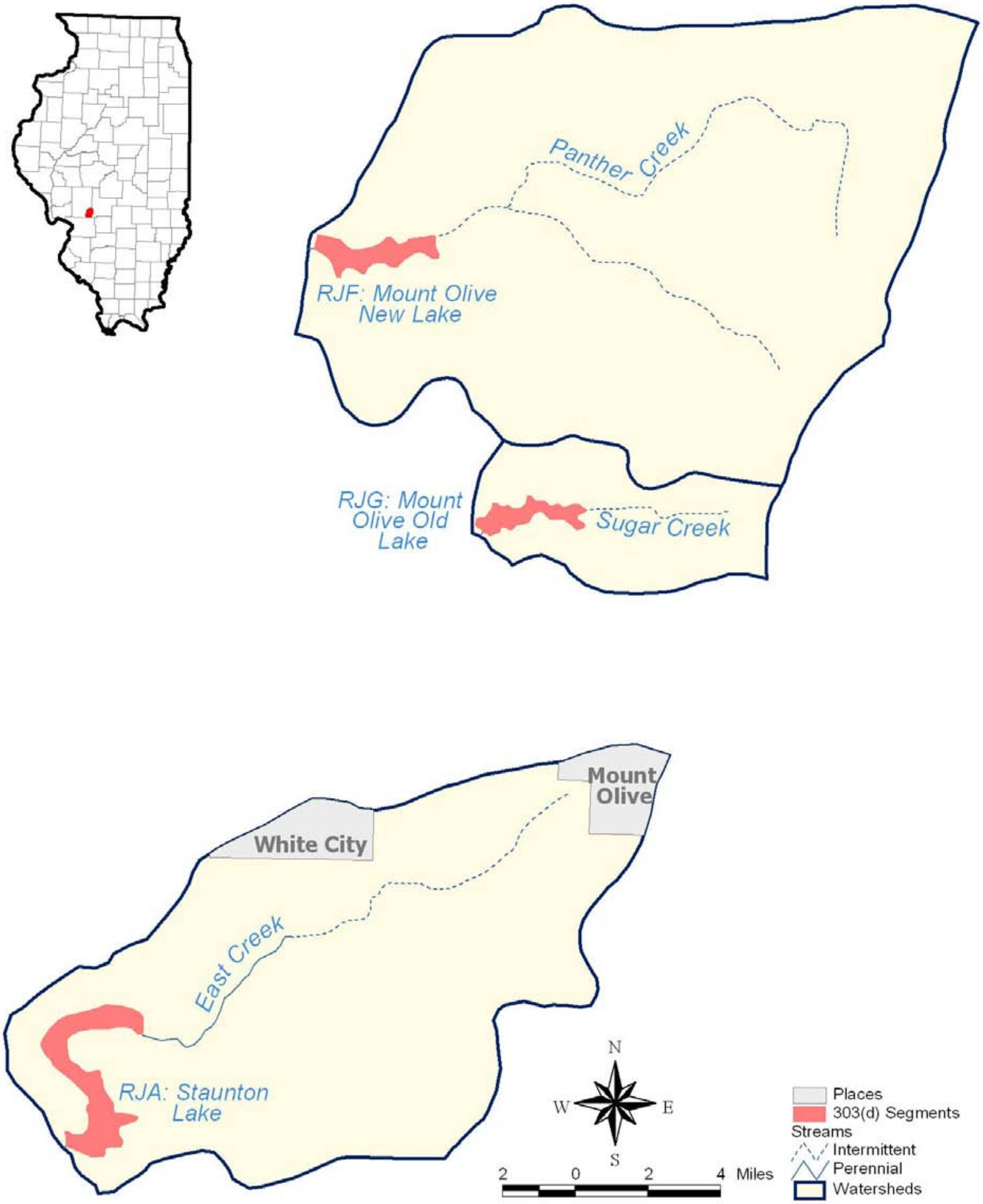

Figure 2-1. Location of the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds.

2.2 Topography

Topography is an important factor in watershed management because stream types, precipitation, and soil types can vary dramatically by elevation. Digital elevation models (DEM) containing 30-meter grid resolution elevation data are available from the USGS for each 1:24,000-topographic quadrangle in the United States. Elevation in the Mt. Olive New Lake (IL_RJF) watershed ranges from 700 feet above sea level in the headwaters to 589 feet at the lake outlet (Figure 2-3). The absolute elevation change is 111 feet over the 3.56-mile stream length of Panther Creek, which yields a stream gradient of 31.18 feet per mile. Elevation ranges from 689 feet in the headwaters of Mt. Olive Old Lake (IL_RJG) to 645 feet at the lake outlet. The stream gradient for the 1.26-mile Sugar Creek segment is approximately 35 feet per mile. The Staunton Lake (IL_RJA) watershed has an elevation change of 114 feet with a maximum elevation of 681 feet and a minimum elevation at the lake of 567 feet. East Creek has a stream gradient of 30.40 feet per mile along its 3.75-mile segment. The mean stream slopes and stream profiles for each creek are shown in Table 2-1 and Figure 2-2, respectively.

Table 2-1. Mean Stream Slope of Panther Creek, Sugar Creek, and East Creek.

Stream	Mean Slope
Panther Creek	0.0059
Sugar Creek	0.0066
East Creek	0.0058

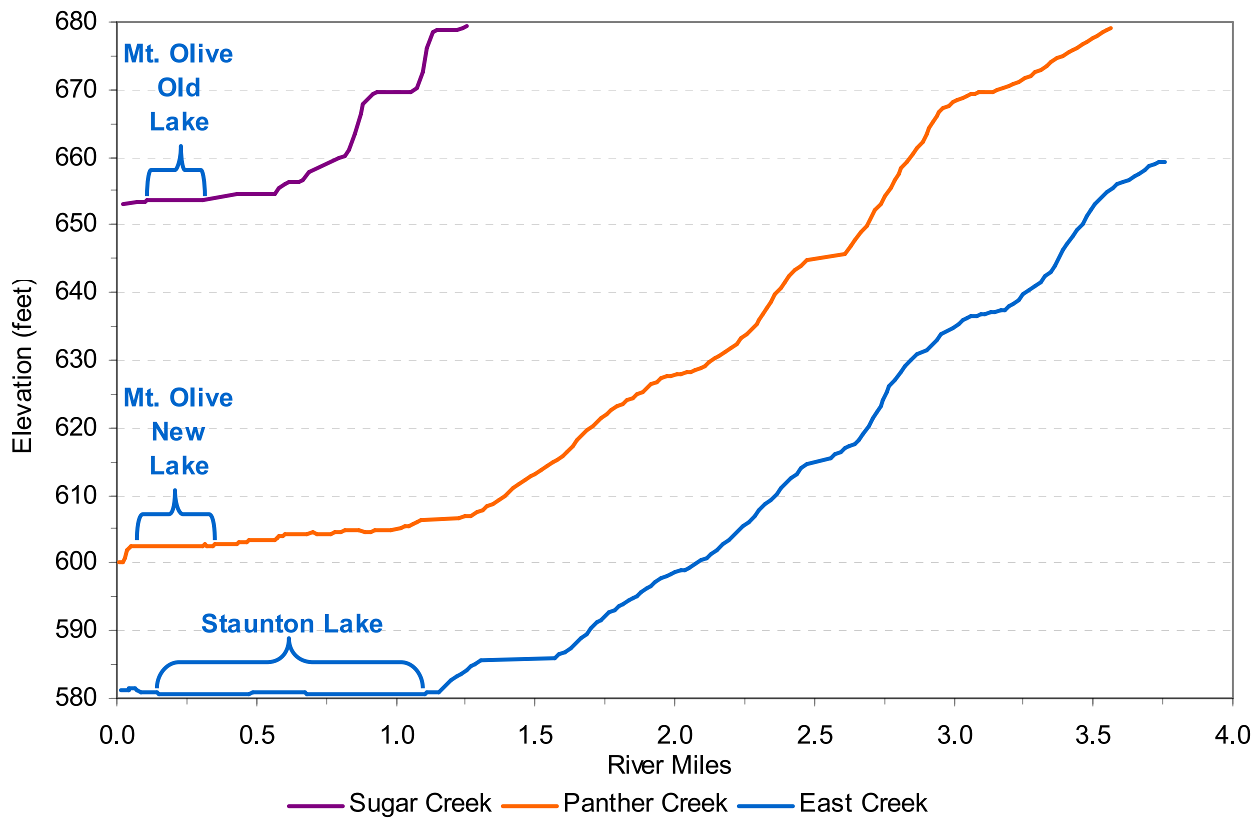

Figure 2-2. Stream Profiles of Panther Creek, Sugar Creek, and East Creek.

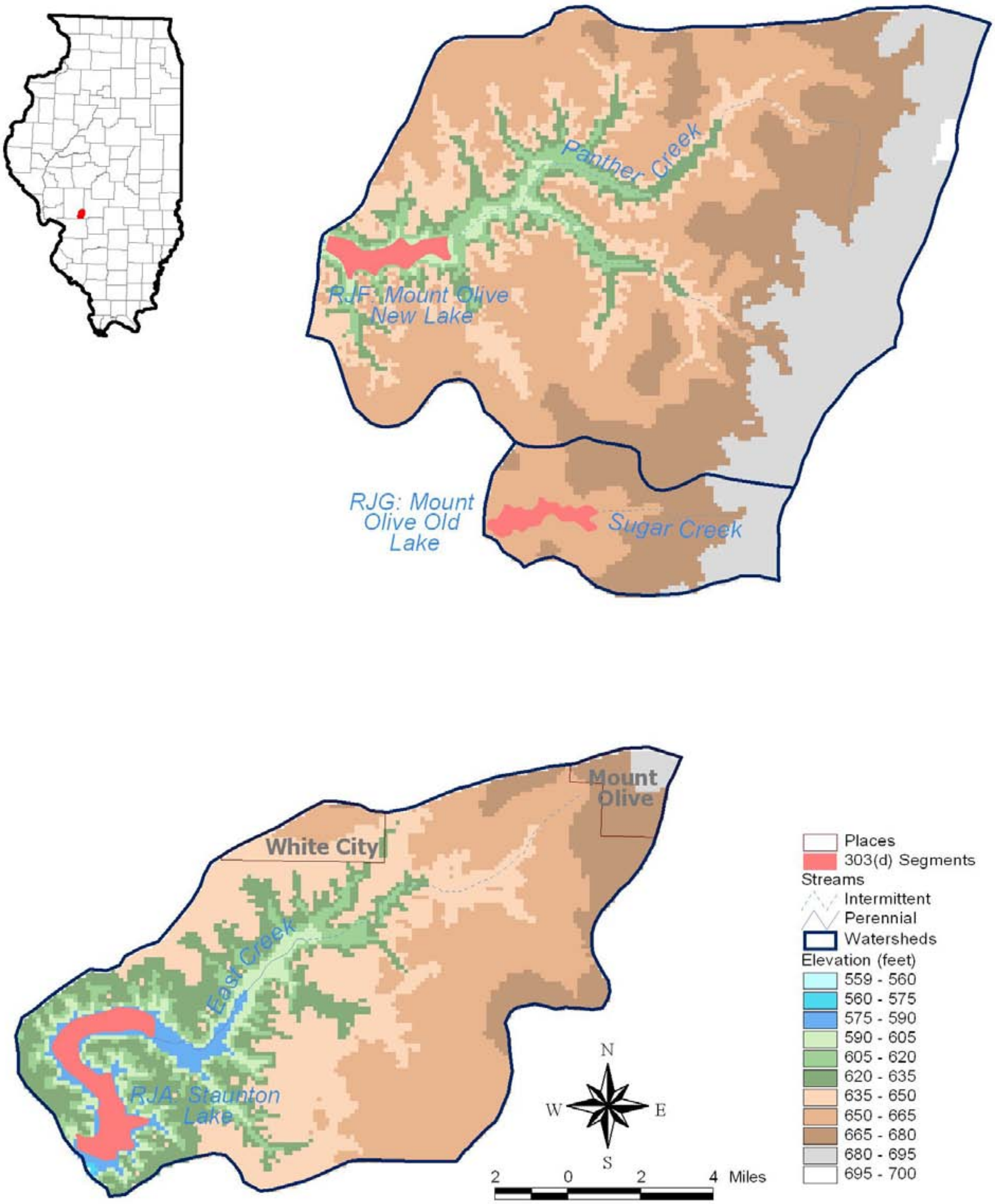

Figure 2-3. Elevation in the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds.

2.3 Land Use/Land Cover and Tillage Practices

General land cover data for the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds were extracted from the Illinois Natural History Survey's GAP Analysis Land cover database (INHS, 2003). This database was derived from satellite imagery taken during 1999 and 2000 and is the most current detailed land cover data known to be available. Each 98-foot by 98-foot pixel contained within the satellite image is classified according to its reflective characteristics. Figure 2-4 displays land use and land cover in the Sugar Creek watershed. A complete listing of the Illinois GAP land cover categories is given in Table A-1 in Appendix A.

The land cover data reveal that approximately 3,356 acres, representing nearly 55 percent of the total combined watershed area, are devoted to agricultural activities. Approximately 28 percent of the three watersheds is forested, and seven percent is devoted to urban land uses.

Tillage system practices are not available specifically for the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds; however, county-wide tillage system surveys have been undertaken by the Illinois Department of Agriculture (2000; 2002; 2004). It is assumed that the general tillage practice trends reported throughout the county are applicable to the three watersheds. The results of these surveys for Macoupin County are presented in Table 2-2. The table shows that the percentage of surveyed cornfields employing conventional tillage in Macoupin County increased from 2000 to 2002 then decreased from 2002 to 2004; conventional tillage is also the most common tillage type throughout the period. For soybean production within the county, reduced-till, mulch-till, and no-till practices generally account for greater percentages than conventional tillage practices in 2000, 2002, and 2004. Small grain production involved 100 percent no-till practices in 2004, while 100 percent of small grain production incorporated 100 percent conservation tillage practices.

Table 2-2. Percentage of Agricultural Fields Surveyed with Indicated Tillage System in Macoupin County, Illinois, in 2000, 2002 and 2004.

2000 Transect Survey				
	Tillage Practice			
Crop Field Type	**Conventional**	**Reduced-till**	**Mulch-till**	**No-till**
Corn	69	22	2	7
Soybean	15	40	15	29
Small Grain	0	0	0	100
2002 Transect Survey				
	Tillage Practice			
Crop Field Type	**Conventional**	**Reduced-till**	**Mulch-till**	**No-till**
Corn	91	4	2	4
Soybean	20	23	14	43
Small Grain	38	0	0	63
2004 Transect Survey				
	Tillage Practice			
Crop Field Type	**Conventional**	**Reduced-till**	**Conventional**	**No-till**
Corn	72	19	8	2
Soybean	8	18	26	47
Small Grain	100	0	0	0

Source: Illinois Dept. of Agriculture, 2000; 2002.

In the following sections, land use and land cover are described and summarized for each of the listed water bodies, and their respective subwatershed areas.

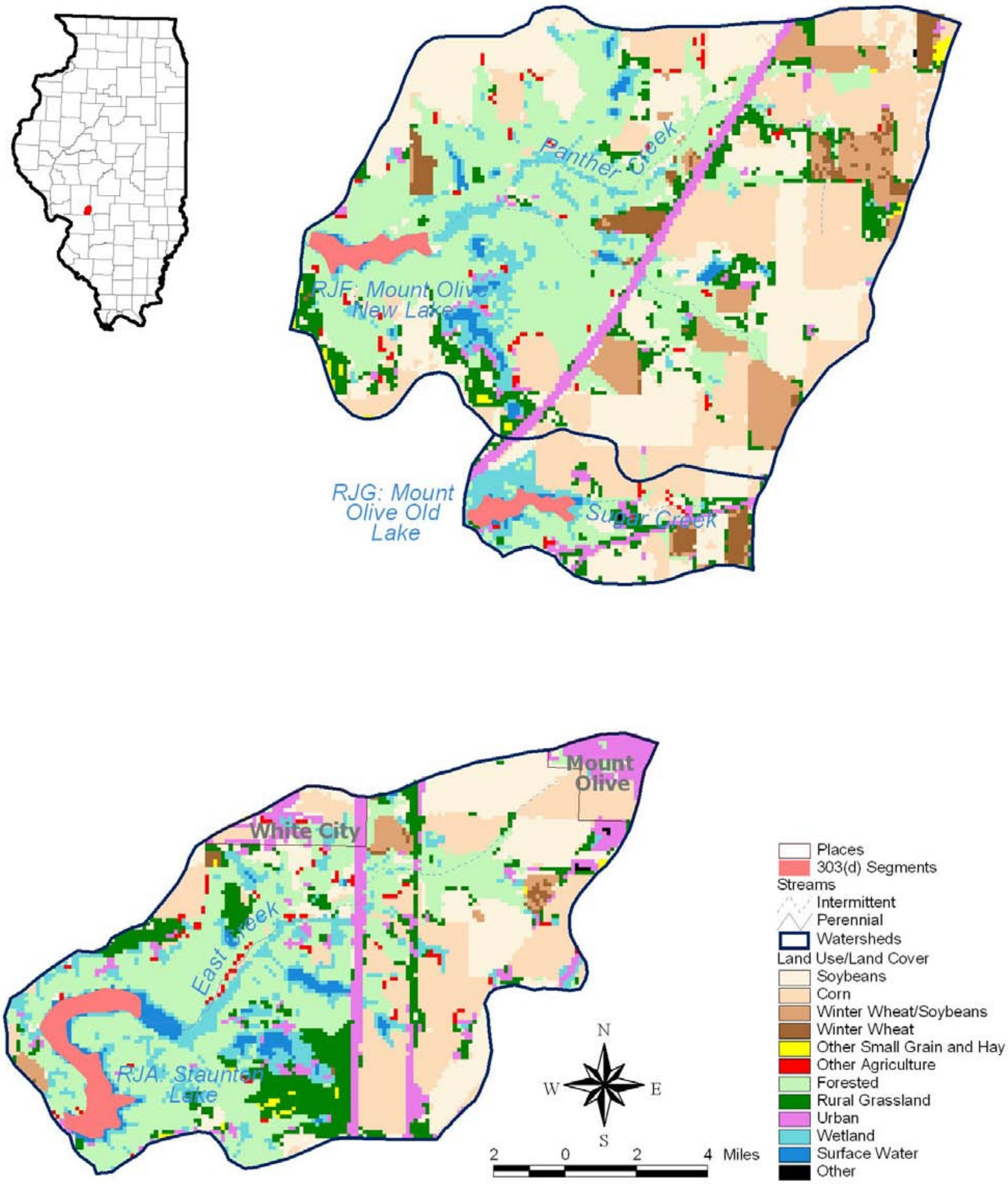

Figure 2-4. GAP land use/land cover in the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds.

2.3.1 Mt. Olive New Lake (Illinois Water Body Segment IL_RJF)

Land use and land cover in the Mt. Olive New Lake subwatershed is summarized in Table 2-3. The table shows that agricultural land uses account for 1,961 acres, representing nearly 61 percent of the subwatershed area. Corn and soybeans account for 23.38 and 20.54 percent of subwatershed area, respectively. Forested land accounts for roughly 940 acres (29 percent) of the subwatershed area. Rural grassland, winter wheat/soybeans, and wetlands represent 6.64, 6.40, and 5.4 percent of the subwatershed area, respectively. Urban lands (primarily roads) occupy 99 acres (3.06 percent) of the subwatershed area.

Table 2-3. Land Use and Land Cover in the Mt. Olive New Lake Subwatershed (Segment IL_RJF).

Land Use / Land Cover Description	Area		Percent of Watershed Area
	Acres	Square Miles	
Forested	940.7	1.47	29.08
Soybeans	756.1	1.18	23.38
Corn	664.5	1.04	20.54
Rural Grassland	214.6	0.34	6.64
Winter Wheat/Soybeans	207.0	0.32	6.40
Wetland	174.8	0.27	5.40
Urban	99.0	0.15	3.06
Winter Wheat	78.5	0.12	2.43
Surface Water	58.7	0.09	1.82
Other Agriculture	27.1	0.04	0.84
Other Small Grain and Hay	12.9	0.02	0.40
Other	0.4	<0.01	0.01
Total	**3,234.5**	**5.05**	**100.00**

2.3.2 Mt. Olive Old Lake (Illinois Water Body Segment IL_RJG)

Agricultural land use is the dominant land use type in the Mt. Olive Old Lake subwatershed and accounts for 62 percent (285 acres) of the total subwatershed area. As shown in Table 2-4, corn and soybeans are the dominant crops, representing 24 percent and 22 percent, respectively, of all subwatershed land use and land cover types. Additional agricultural land uses account for approximately 7.5 percent of all subwatershed land uses. Approximately 57.6 acres are devoted to forested land uses, representing 12.63 percent of the subwatershed area. Wetlands, rural grassland, urban land, and surface water represent approximately 11.61 percent, 8.93 percent and 7.56 percent, respectively, of the subwatershed area. Other land cover types represent less than one percent of the subwatershed area.

Table 2-4. Land Use and Land Cover in the Mt. Olive Old Lake Subwatershed (Segment IL_RJG).

Land Use / Land Cover Description	Watershed Area		Percent of Watershed Area
	Acres	Square Miles	
Corn	108.1	0.17	23.71
Soybeans	102.3	0.16	22.44
Forested	57.6	0.09	12.63
Wetland	52.9	0.08	11.61
Rural Grassland	39.4	0.06	8.63
Urban	34.5	0.05	7.56
Surface Water	25.8	0.04	5.66
Winter Wheat	24.9	0.04	5.46
Winter Wheat/Soybeans	5.3	0.01	1.17
Other Agriculture	4.7	0.01	1.02
Other	0.4	<0.01	0.10
Total	**455.9**	**0.71**	**100.00**

2.3.3 Staunton Lake (Illinois Water Body Segment IL_RJA)

Of the 2,384 acres draining the Staunton Lake subwatershed, approximately 47 percent is dedicated to agricultural activities. The dominant agricultural crop types are corn and soybeans (see Table 2-5), which represent 18.70 percent and 14.93 percent of the total subwatershed acreage, respectively. All other agricultural land uses account for approximately 81 acres (3 percent) of all subwatershed land uses. Forested lands account for 29.87 percent of the subwatershed area, more than any other individual land use land cover type. Rural grassland, wetlands, urban land, and surface water account for 9.57 percent, 9.40 percent, 8.77 percent and 5.30 percent of the subwatershed area, respectively.

Table 2-5. Land Use and Land Cover in the Staunton Lake Subwatershed (Segment IL_RJA).

Land Use / Land Cover Description	Watershed Area		Percent of Watershed Area
	Acres	Square Miles	
Forested	712.1	1.11	29.87
Corn	445.9	0.70	18.70
Soybeans	355.8	0.56	14.93
Rural Grassland	228.2	0.36	9.57
Wetland	224.2	0.35	9.40
Urban	209.1	0.33	8.77
Surface Water	126.3	0.20	5.30
Winter Wheat/Soybeans	34.0	0.05	1.43
Other Agriculture	26.5	0.04	1.11
Winter Wheat	12.0	0.02	0.50
Other Small Grain and Hay	8.2	0.01	0.35
Other	1.8	<0.01	0.07
Total	**2,384.1**	**3.73**	**100.00**

2.4 Soils

Soils data and GIS coverages from the Natural Resources Conservation Service (NRCS) were used to characterize soils in the Mt. Olive Old Lake, Mt. Olive New Lake, and Staunton Lake watersheds. General soils data and map unit delineations for the country are provided as part of the State Soil Geographic (STATSGO) database. GIS coverages provide 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. It should be noted that map units can be highly variable and the following maps are meant as general representations. Figure 2-5 displays the STATSGO soil map units in the three watersheds. Identification fields in the GIS coverage can be linked to a database that provides information on chemical and physical soil characteristics for each map unit. Of particular interest for water resource studies are the hydrologic soil group, the K-factor of the Universal Soil Loss Equation, and depth to water table. The following sections describe and summarize the specified soil characteristics for each of the listed water bodies, and their respective basins.

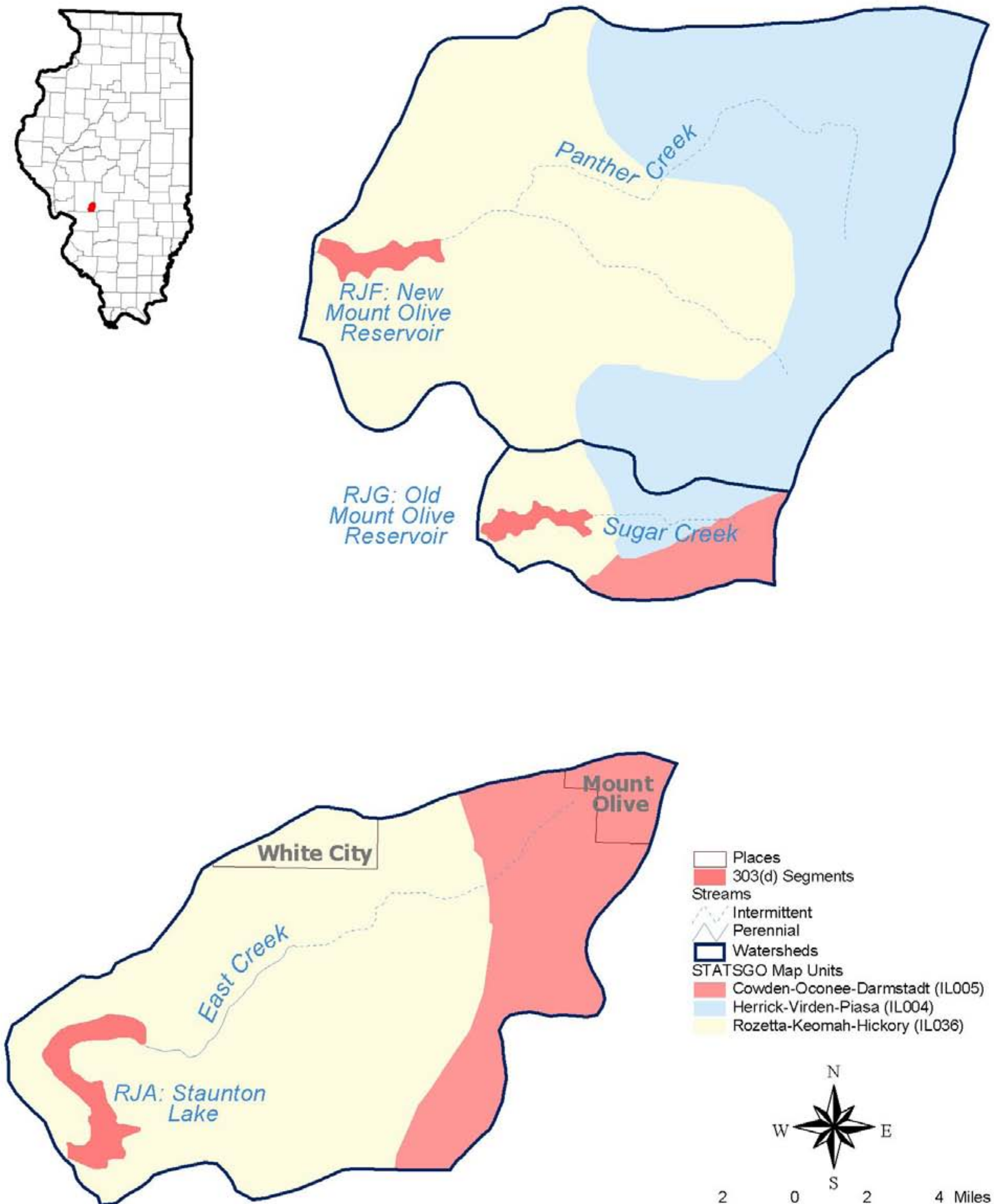

Figure 2-5. Distribution of STATSGO Map Units in the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds.

2.4.1 Hydrologic Soil Group

The hydrologic soil group classification is a means for grouping soils by 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 has defined four hydrologic groups for soils as listed in Table 2-6. In addition, soils with tile drainage in Illinois should be designated as Class B soils (i.e., due to the presence of tile drainage the soil takes on the attribute of a Class B soil ((McKenna, personal communications, December 15, 2004)). Figure 2-6 presents the general distribution of hydrologic soil groups. The figure shows the dominant hydrologic groups in the basin are B and D. Hydrologic soil group B composes soils in the entire Mt. Olive New Lake watershed and lower and middle reaches of the Mt. Olive Old Lake and Staunton Lake watersheds. The headwaters region of Mt. Olive Old Lake and Staunton Lake contain soils classified as hydrologic soil D.

Table 2-6. NRCS Hydrologic Soil Groups

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.

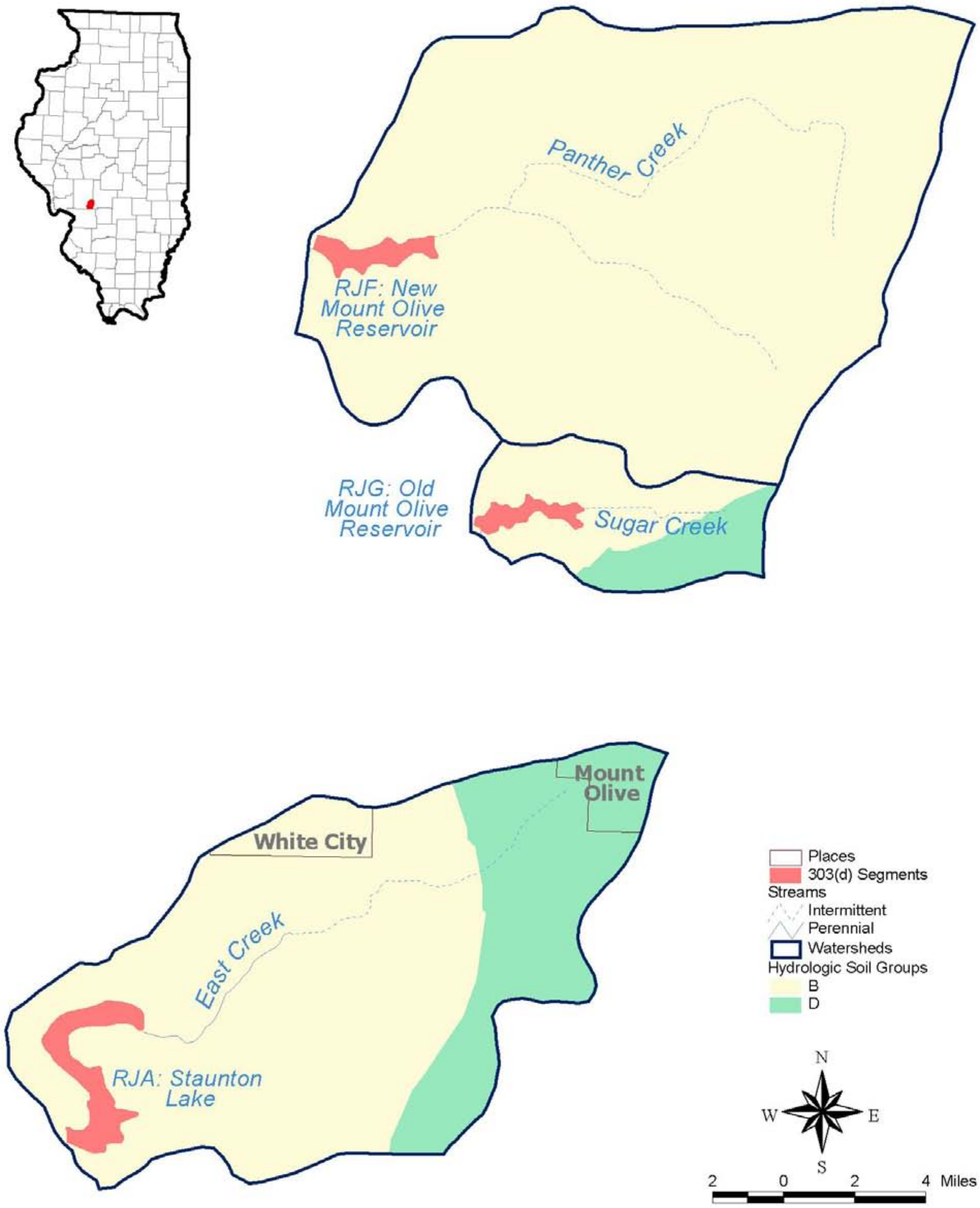

Figure 2-6. Hydrologic soil group distribution.

2.4.2 K-Factor

A commonly used soil attribute is the K-factor, a component of the USLE (Wischmeier and Smith, 1978). The K-factor is a dimensionless measure of a soil's natural susceptibility to erosion, and 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 inherent soil erodibility. The distribution of K-factor values is shown in Figure 2-7. The figure indicates that soils with moderate erosion potential (e.g., K-factors that range in value from 0.20 to 0.37) comprise 100 percent of the soils in each of the three watersheds.

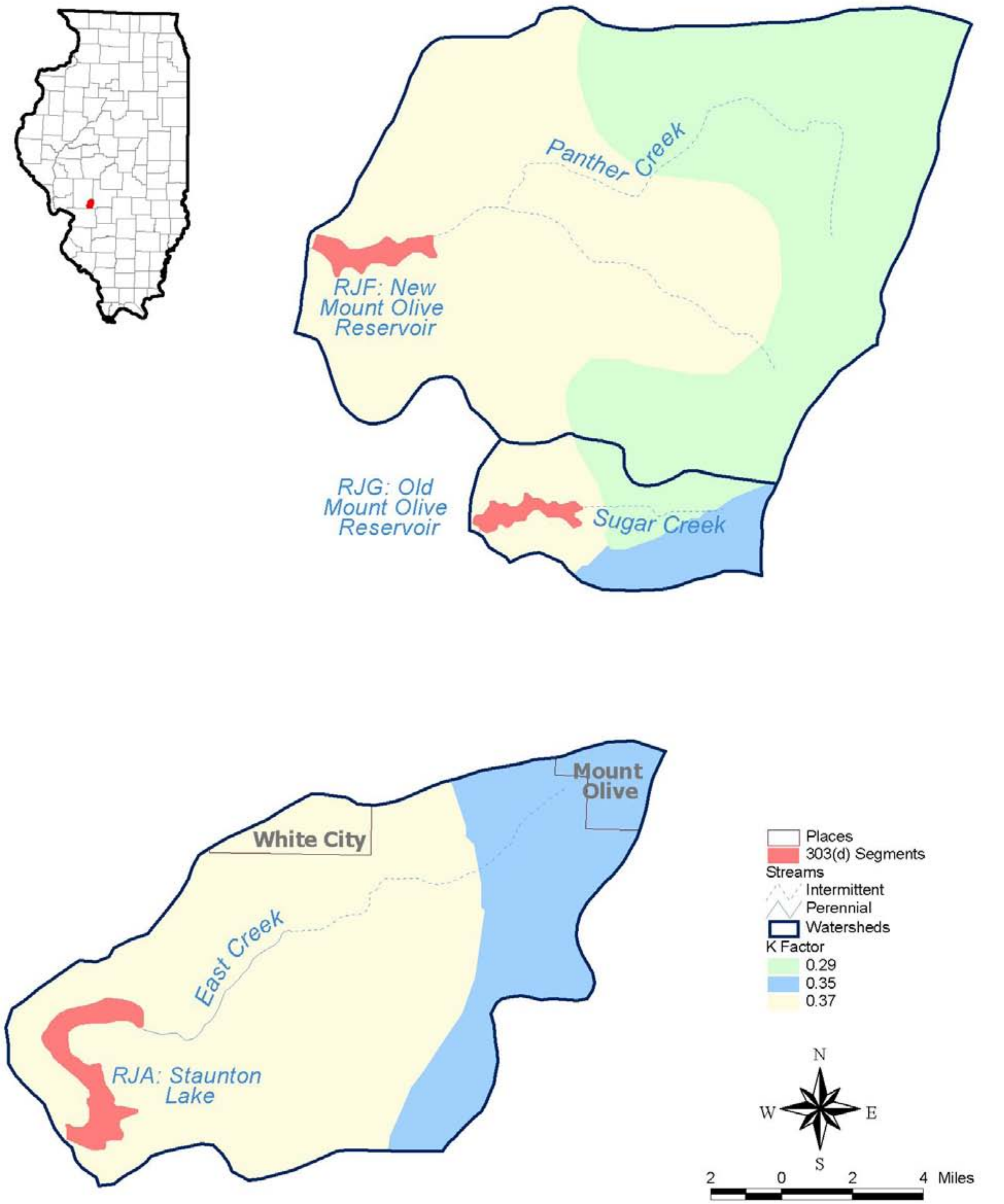

Figure 2-7. USLE K-Factor distribution in the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds.

2.4.3 Depth to Water Table

Water table depth as described in the STATSGO database is the range in depth to the seasonally high water table level for a specified month. The STATSGO database reports depth to water table as both a minimum and maximum depth. Values were summarized to reflect the weighted sum of the minimum depth to water table for the surface layer of all soil sequences composing a single STATSGO map unit. Figure 2-8 displays the distribution of depth to water table for the basin and shows that depths range from 1.7 foot to 5.2 feet. Minimum depths occur in the headwaters region of the Mt. Olive New Lake watershed, while maximum depths occur in the lower reaches of all three drainages.

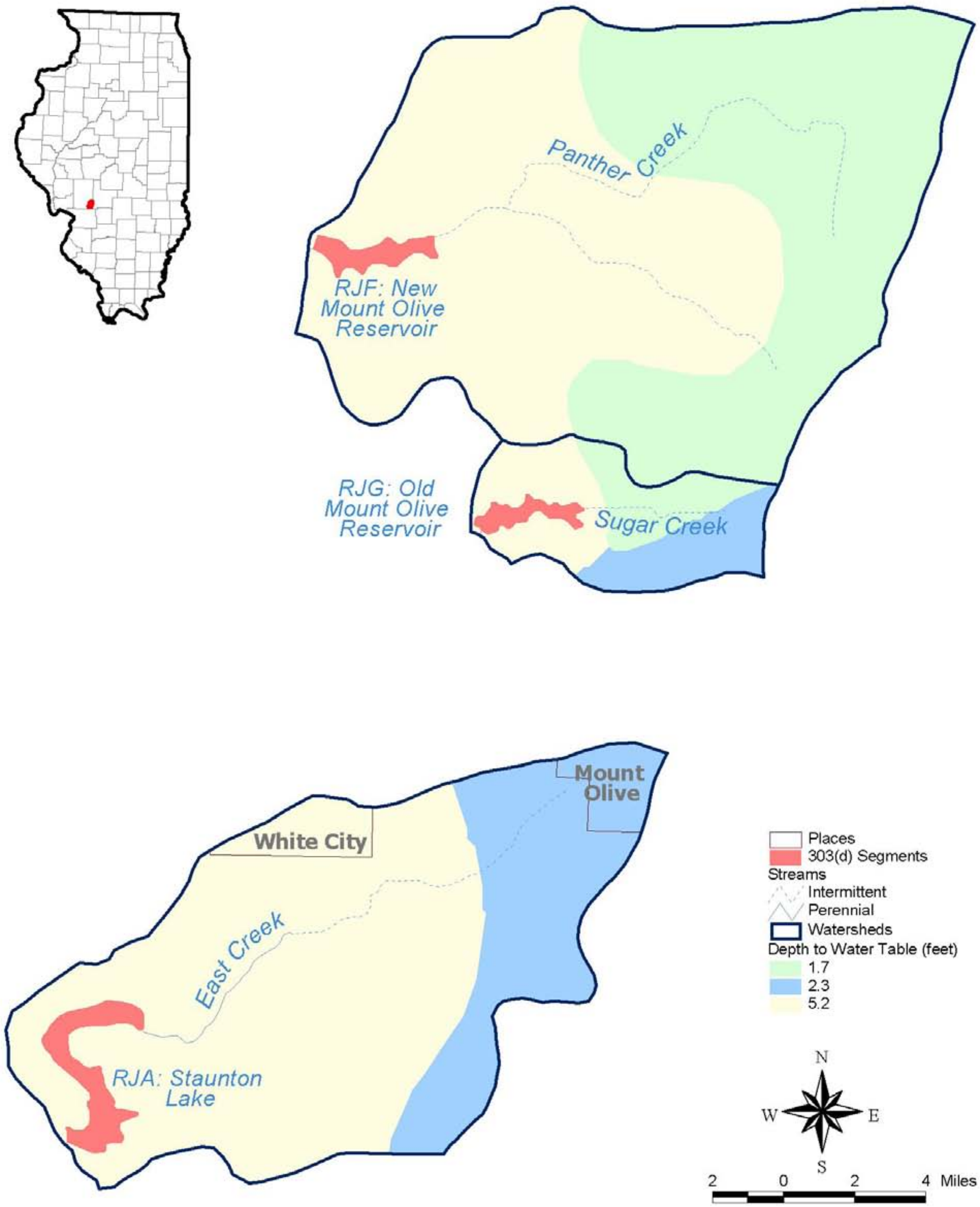

Figure 2-8. Depth to water table in the Mt. Olive New Lake (IL_RJF), Mt. Olive Old Lake (IL_RJG), and Staunton Lake (IL_RJA) watersheds.

2.5 Population

Total watershed population is not directly available but may be estimated from the 2000 U.S. Census data. The 2000 U.S. Census data were downloaded for all towns, cities, and counties whose boundaries lie wholly or partially in the watershed (Census, 2000). Urban and nonurban populations were estimated for the watershed area and were summed to obtain an estimate of total watershed population. The following paragraphs describe how urban and nonurban population estimates were determined from town, city, and county Census data.

Urban watershed population is the sum of population for all towns and cities located entirely in the watershed. In the instance where a city or town is located partially in the watershed, a population weighting method was used to estimate a place's contribution to urban watershed population. First, the proportion of the place's area in the watershed was determined using spatial overlay of the town and city boundaries with the watershed boundary in a geographic information system (GIS). Assuming an even distribution of population throughout each place, the city and town populations were multiplied by the proportion of the place encompassed by the watershed. The product was assumed to reflect an urban area's contribution to total watershed population. Finally, contributing population for each place was summed to obtain total urban watershed population.

Nonurban watershed population is defined as the portion of watershed population excluding urban population. Nonurban population for each county was determined by first subtracting the total county urban population from the total county population. Some cities and towns are not entirely included in a single county and their contribution to total county urban population was estimated using the same method described in the previous paragraph. Since only portions of counties are found in the watershed, a nonurban population weighting method was also used to estimate each county's contribution of nonurban population to the total watershed population. The proportion of county to watershed nonurban area was determined from spatial overlay of county boundaries and the watershed boundary in a GIS. Nonurban area for each county and watershed were calculated by subtracting the total urban area from the total area, respectively. It is assumed that the nonurban population for each county is uniformly distributed throughout the nonurban portion of the county. The nonurban county population was multiplied by the county's nonurban proportional watershed area and the product was assumed to reflect the county's contribution to the nonurban watershed population.

2.5.1 Watershed Population

Watershed population is summarized in Table 2-7 for each watershed. Figure 2-1 displays the locations of counties, cities, and towns. Approximately 100 people reside in the Mt. Olive New Lake watershed, with 100 percent of the population residing in nonurban areas. The Mt. Olive Old Lake watershed population is also 100 percent nonurban with approximately 14 people. The Staunton Lake watershed has the largest population of the three watersheds with approximately 680 people. Table 2-7 indicates that about 10 percent of the population live in nonurban areas and 90 percent live in urban areas. These urban areas include small portions of White City and Mt. Olive.

Table 2-7. Population Summarized by Watershed.

Waterbody Segment	Watershed Population	Nonurban Population	Percent Nonurban Population	Urban Population	Percent Urban Population
Mt. Olive New Lake (IL_RJF)	98	98	100.00	0	0.00
Mt. Olive Old Lake (IL_RJG)	14	14	100.00	0	0.00
Staunton Lake (IL_RJA)	680	67	9.82	613	90.18

Source: U.S. 2000 Census and GIS analysis.

2.5.2 Population Growth

Table 2-8 demonstrates population change, calculated for the ten-year period between 1990 and 2000, for nonurban and urban populations in the Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake watersheds. Nonurban populations increased by 5.84 percent during this period for each of the watersheds. The population in White City decreased by approximately one person while Mt. Olive had a population increase of 1.12 percent.

Table 2-8. Population Change in Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake Watersheds.

Waterbody Segment	Municipality	1990 Population	2000 Population	Absolute Change	Percent Change
IL_RJF	Nonurban	92	98	6	5.84
	Total	**92**	**98**	**6**	**5.84**
IL_RJG	Nonurban	13	14	1	5.84
	Total	**13**	**14**	**1**	**5.84**
IL_RJA	Nonurban	63	67	4	5.84
	White City	31	30	-1	-4.32
	Mount Olive	305	308	3	1.12
	Total	**399**	**405**	**6**	**1.49**

3 Climate and Hydrology

3.1 Climate

Southwest Illinois has a temperate climate with hot summers and cold winters. Average annual precipitation is 38.7 inches. On average there are 110 days with at least 0.01 inches of precipitation. Annual average snowfall is 20.8 inches. Monthly variation of total precipitation, snowfall, and temperature is presented for the Mt. Olive station (Cooperative ID 115917) in Figure 3-1. The figure shows that although precipitation occurs throughout the year, May is the month with the most precipitation per month. Much of the annual snowfall occurs in the months of December and January, with the greatest snowfalls occurring in January. (Note that average monthly temperature data was not available for the Mt. Olive station and the temperature data presented in Figure 3-1 was collected at the Hillsboro 2 SSW station (Cooperative ID 114108)).

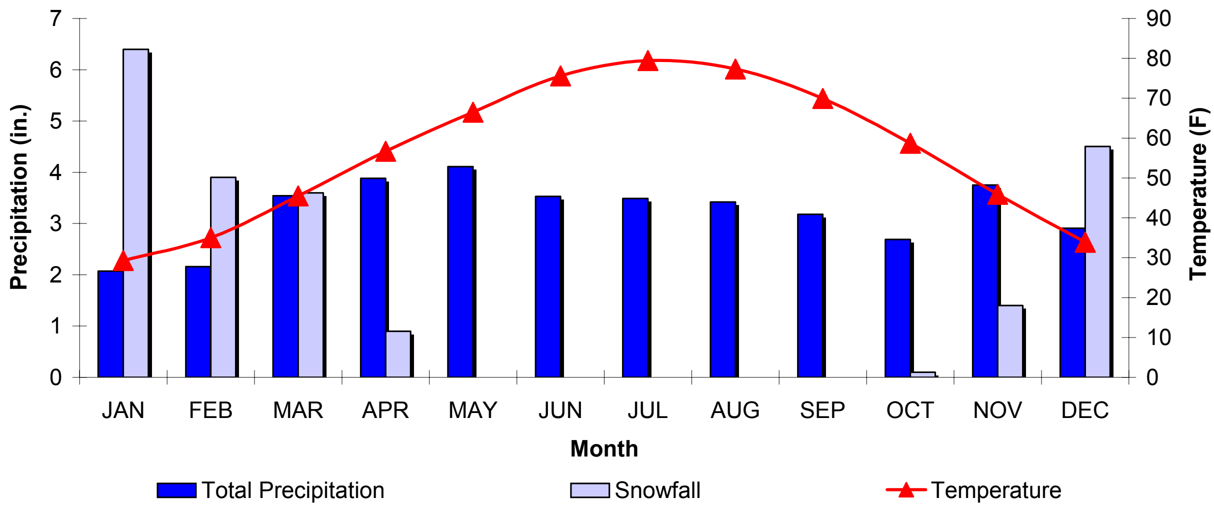

Figure 3-1. Climate summary for the Mt. Olive 1 E station (115917) (based on data from 1970 through 2000).

3.2 Hydrology

This section presents information related to the general hydrology, streams types, and subbasins found in the Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake watersheds.

3.2.1 Reservoir Hydrology

An annual water budget was calculated for Staunton Lake as part of a Clean Lakes study (IEPA, 2005). To determine the amount of water entering and leaving the Staunton Lake, a stream staff gauge was placed in the main tributary as close to the lake as possible as well as at the spillway. Lake inflow from tributaries and discharge were calculated using the cross-sectional area at the staff gage and flow measurements. The Staunton Lake 2001–2002 hydrologic budget is shown in Table 3-1.

Table 3-1. Staunton Lake 2001–2002 Hydrologic Budget.

	Inflow			Outflow			
Month	Tributaries (acre*feet)	Rainfall (acre*feet)	Total Inflow (acre*feet)	Drinking Water Supply (acre*feet)	Flow over spillway (acre*feet)	Evaporation (acre*feet)	Total Outflow (acre*feet)
May	94	39	133	55	113	55	223
Jun	1,414	30	1,444	53	0	63	116
July	0	21	21	55	0	71	126
Aug	0	50	50	55	0	60	115
Sep	17	29	46	53	0	40	93
Oct	478	96	574	55	0	27	82
Nov	324	42	366	53	0	13	66
Dec	1,417	46	1,463	55	381	6	442
Jan	393	0	393	55	103	6	164
Feb	276	0	276	51	175	10	236
Mar	1,953	23	1,976	55	486	22	563
Apr	499	45	544	53	527	39	619
Total	**6,865**	**421**	**7,286**	**648**	**1,785**	**412**	**2,845**

3.2.2 Stream Types

The National Hydrography Data (NHD) provided by USEPA and USGS identified two different stream types in the Mt. Olive Lakes and Staunton Lake watersheds (Figure 2-1) (NHD, 2003). Most streams were classified as intermittent streams (Table 3-2). Intermittent streams have flow only for short periods during the course of a year, which is usually initiated by rainfall. All streams contributing flowing into the Mt. Olive New and Mt. Olive old lakes are classified as intermittent. Perennial streams are only found in the Staunton Lake drainage. Artificial paths are the NHD line features in the basin that designate the location of a lake.

Table 3-2. Summary of Stream Types in the Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake Watersheds.

Stream Type	Stream Length (m)	Percent
Intermittent Streams	10,964.5	66.95
Perennial Streams	1,633.3	9.97
Artificial Paths	3,779.0	23.08
Total	**16,376.8**	**100.00**

3.2.3 Subbasin Delineation

Subbasins were delineated using spatial overlay of digital elevation data (DEM) and the National Hydrography Data set (NHD) spatial database of stream reaches in ArcView GIS. Thirty-meter DEM data, representing 7.5 minute U.S. Geological Survey (USGS) quadrangle maps, were downloaded from the GEOCommunity <www.geocomm.com> web site. Subbasins were delineated by overlaying NHD streams on the DEM data and manually appending the Illinois 12-digit Hydrologic Unit Codes (HUCs). This approach ensures that the subbasin boundaries conform to topographic characteristics while requiring that catalogued stream segments connect in the proper order and direction. The delineated subbasins are shown in Figure 2-1 and will be useful for implementation planning.

3.2.4 Tile Drainage

The Cahokia Creek watershed, as with many other watersheds in Illinois, is underlain by drain tile designed to remove standing water from the soil surface for agricultural purposes. The water table level is controlled through a series of drainage pipes (tile or tubing) that are installed below the soil surface, usually just below the root zone. In Illinois, subsurface drainage pipes are typically installed at a depth of 3 to 4 feet and at a spacing of 80 to 120 feet. The subsurface drainage network generally outlets to an open ditch or stream.

Researchers at the University of Illinois and elsewhere have studied the impact of tile drainage on hydrology and water quality. Some impacts are relatively well understood while others are not. Zucker and Brown (1998) provided the following summary of the impacts (statements compare agricultural land with subsurface drainage to that without subsurface drainage):

- The percentage of rain that falls on a site with subsurface drainage and leaves the site through the subsurface drainage system can range up to 63 percent.
- The reduction in the total runoff that leaves the site as overland flow ranges from 29 to 65 percent.
- The reduction in the peak runoff rate ranges from 15 to 30 percent.
- Total discharge (total of runoff and subsurface drainage) is similar to flows on land without subsurface drainage, if flows are considered over a sufficient period of time before, during, and after the rainfall/runoff event.
- The reduction in sediment loss by water erosion from a site ranges between 16 to 65 percent. This reduction relates to the reduction in total runoff and peak runoff rate.
- The reduction in loss of phosphorus ranges up to 45 percent, and is related to the reductions in total runoff, peak runoff rate, and soil loss. However, in high phosphorus content soils, dissolved phosphorus levels in tile flow can be high.
- In terms of total nutrient loss, by reducing runoff volume and peak runoff rate, the reduction in soil-bound nutrients is 30 to 50 percent.
- In terms of total nitrogen losses (sum of all nitrogen species), there is a reduction. However, nitrate-N, a soluble nitrogen ion, has great potential to move wherever water moves. Numerous studies throughout the Midwest and southeast U.S., and Canada document that the presence of a subsurface drainage system enhances the movement of nitrate-N to surface waters. Proper management of drainage waters along with selected in-field best management practices helps reduce this potential loss.

3.2.5 Flow Data

There are no USGS stream flow monitoring stations within any of the three watersheds. No other sources of continuous stream flow data have been identified.

4 Inventory and Assessment of Water Quality Data

This section presents the draft 2006 303(d) list information for all listed waterbodies in the Cahokia Creek watershed. A description of the parameters of concern and the applicable water quality standards is presented. Additionally, an analysis of the available water quality (or other watershed monitoring) data to confirm the impairment and a summary of existing water quality conditions is provided. A complete listing of the water quality data is provided in Appendix B.

4.1 Illinois 303(d) List Status

The Illinois 303(d) list for the ILJQ03 watershed is given in Table 1-1. The table shows that Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake are listed for impairments related to nutrients, total suspended solids, atrazine, and/or manganese.

4.2 Previous Studies

A Phase I Diagnostic Feasibility Study of Staunton Reservoir (Illinois EPA, 2005) was completed under the USEPA Clean Lakes Program in 2005. The Phase I study investigated the physical and social characteristics of the Staunton Lake drainage, established a hydrologic budget, and assessed nutrient and sediment loading to the lake. The study found high rates of sediment delivery from East Creek ranging from 10 kg/day to more than 100,000 kg/day, while sediment load at the spillway ranged from less than 1 kg/day to greater than 2,000 kg/day. Additionally, nitrogen and phosphorus loads from East Creek exceeded 1,000 kg/day and 10,000 kg/day, respectively. Additional problems identified were shoreline erosion, nutrient loading from birds, atmospheric nutrient loading, and lake sediment nutrient loading.

4.3 Parameters of Concern

The following sections provide a summary of the parameters identified on Illinois 303(d) list as causing impairments to Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake watersheds. The purpose of these sections is to provide an overview of the parameters, units, sampling methods, and potential sources. The relevance of the parameter to the various beneficial uses is also briefly discussed.

4.3.1 Nutrients/Organic Enrichment/Low DO/Excessive Algal Growth

The term *nutrients* usually refers to the various forms of nitrogen and phosphorus found in a waterbody. Both nitrogen and phosphorus are necessary for aquatic life, and both elements are needed at some level in a waterbody to sustain life. The natural amount of nutrients in a waterbody varies depending on the type of system. A pristine mountain spring might have little to almost no nutrients, whereas a lowland, mature stream flowing through wetland areas might have naturally high nutrient concentrations. Various forms of nitrogen and phosphorus can exist at one time in a waterbody, although not all forms can be used by aquatic life. Common phosphorus sampling parameters are total phosphorus (TP), dissolved phosphorus, and orthophosphate.

The dissolved phosphorus component of total phosphorus is the form that is most readily available to plants. It consists of soluble phosphorus that is not bound to particulates. In waterbodies with relatively short residence times, such as fast-flowing streams, dissolved phosphorus is of greater interest than TP because it is the only form that is readily available to support algal growth. However, in lakes and reservoirs, where residence times are much longer, particulate phosphorus can be transformed to dissolved phosphorus through microbial action. TP is therefore considered an adequate estimation of bioavailable phosphorus (USEPA, 1999).

Nutrients generally do not pose a direct threat to the beneficial uses of a waterbody. However, excess nutrients can cause an undesirable abundance of plant and algae growth. This process is called eutrophication or organic enrichment. Organic enrichment can have many effects on a stream or lake. One possible effect of eutrophication is low dissolved oxygen concentrations. Aquatic organisms need oxygen to live and they can experience lowered reproduction rates and mortality with lowered dissolved oxygen concentrations. Dissolved oxygen concentrations are measured in the field and are typically reported in milligrams per liter. Ammonia, which is toxic to fish at high concentrations, can be released from decaying organic matter when eutrophication occurs. Recreational uses can be impaired because of eutrophication. Nuisance plant and algae growth can interfere with swimming, boating, and fishing. Nutrients generally do not pose a threat to agricultural uses.

Nitrogen and phosphorus exist in rocks and soils and are naturally weathered and transported into waterbodies. Organic matter is also a natural source of nutrients. Systems rich with organic matter (e.g., wetlands and bogs) can have naturally high nutrient concentrations. Phosphorus and nitrogen are potentially released into the environment through different anthropogenic sources including septic systems, wastewater treatment plants, fertilizer application, and animal feeding operations.

4.3.2 Sedimentation/Siltation

Extreme sedimentation can impair aquatic life, drinking water, and recreational designated uses. Excessive sediments deposited on the bottom of streams and lakes can choke spawning gravels, thereby reducing fish survival and growth rates, impair fish food sources, and reduce habitat complexity in stream channels. Furthermore, high sediment levels can clog fish gills, causing direct physical harm. Related to drinking water supply, sediments can cause taste and odor problems, block water supply intakes, foul treatment systems, and fill reservoirs. High levels of sediment can impair swimming and boating by altering channel form, creating hazards due to reductions in water clarity, and adversely affecting the general aesthetics of the waterbody.

Sediment is delivered to a receiving waterbody through various erosional processes such as sheetwash, gully and rill erosion, wind, landslides, and human excavation. Additionally, sediments are often produced through the stream channel and stream bank erosion, and by channel disturbance.

4.3.3 Manganese

Manganese is a naturally occurring substance found in low levels in many types of rock, soil, water, air, and food. Additionally, manganese can be released by steel production, power plants, and coke ovens (EPA, 1996). For humans, manganese is essential for normal physiologic function and low levels of manganese in the diet are essential. However, chronic exposure to high levels of manganese may result in central nervous system disorders.

The vertical distribution of manganese concentrations in lakes is controlled primarily by thermal stratification and dissolved oxygen concentrations. In oxygenated and well-circulated lakes, manganese concentrations are usually very low (Wetzel, 2001). Under these conditions manganese exists in the oxidized Mn^{3+} particulate form. In anoxic lake waters, however, insoluble manganese is reduced to the soluble Mn^{2+} state. This typically occurs during summer stratification in the hypolimnion of eutrophic lakes where oxygen concentrations are low. Dissolved manganese is released into the water column and migrates toward the surface. Manganese solubility also decreases as pH increases. The fluctuation of manganese in the water column is also influenced by microbial utilization. In strongly stratified eutrophic lakes, specialized bacteria utilize oxidized manganese and produce soluble manganese.

4.3.4 Atrazine

Atrazine is a commonly used herbicide applied for corn and sorghum production. Heavy atrazine use occurs in a large portion of Illinois with unit area applications of approximately 66 $lbs/mi^2/year$ (USEPA, 2001). It is applied directly to soil during pre-planting and/or pre-emergence applications and is transported indirectly to soil by incomplete interception during application and wash-off. Recent studies indicate that atrazine is only moderately susceptible to degradation in soil under aerobic conditions with reported half-lives between three and four months with much longer half-lives under anaerobic conditions (USEPA, 2001).

Atrazine can be transported to surface water via runoff, spray drift, and atmospheric transport. It has been widely detected in rainfall in the mid western corn-belt region during the application season (mid-April through mid- July) (USEPA, 2002). Additionally, atrazine is only moderately susceptibility to biodegradation and is persistent in ground water and surface waters with relatively long residence times. This is a result of atrazine's resistance to abiotic hydrolysis and to direct aqueous photolysis, its moderate susceptibility to biodegradation, and its limited volatilization potential.

4.4 Applicable Water Quality Standards

A description of the designated use support for waters within Illinois and a narrative of IEPA's water quality standards are presented in this section. Additionally, numerical water quality criteria for the parameters of interest in this TMDL are listed as well.

4.4.1 Use Support Guidelines

To assess the designated use support for Illinois waterbodies the Illinois EPA uses rules and regulations adopted by the Illinois Pollution Control Board (IPCB). The following are the use support designations provided by the IPCB:

a. *General Use Standards* - These standards protect for aquatic life, wildlife, agricultural, primary contact (where physical configuration of the waterbody permits it, any recreational or other water use in which there is prolonged and intimate contact with the water involving considerable risk of ingesting water in quantities sufficient to pose a significant health hazard, such as swimming and water skiing), secondary contact (any recreational or other water use in which contact with the water is either incidental or accidental and in which the probability of ingesting appreciable quantities of water is minimal, such as fishing, commercial and recreational boating, and any limited contact incident to shoreline activity), and most industrial uses. These standards are also designed to ensure the aesthetic quality of the state's aquatic environment.

   Aesthetic quality is a new use for the 2006 assessment cycle and is associated with all waterbodies in the state. However, methods for assessing aesthetic quality have only been developed to date for inland lakes; aesthetic quality is therefore not assessed in other waterbody types.

   The assessment methodology previously used to assess secondary contact recreation in lakes was determined to be more appropriate for assessing aesthetic quality. All previous assessments of secondary contact in lakes have been changed to assessments of aesthetic quality use.

The Recreation Use Index (RUI) is the primary tool used to assess aesthetic quality. RUI represents the extent to which pleasure boating, canoeing, and aesthetic enjoyment are attained at a lake. The mean Trophic State Index (TSI), the percent surface-area macrophyte coverage during the peak growing season (June through August), and the median concentration of nonvolatile suspended solids are used to calculate the RUI score. Higher RUI scores indicate increased impairment.

b. *Public and Food Processing Water Supply Standards* - These standards protect for any water use in which water is withdrawn from surface waters of the state for human consumption or for processing of food products intended for human consumption.

4.4.2 Numeric Standards

Numeric water quality standards for the State of Illinois for general use and Public and food processing and water supply are presented in Table 4-2.

Table 4-2. Illinois Numeric Water Quality Standards.

Parameter	Units	General Use	Public and Food Processing Water Supply
Nutrients/Organic Enrichment/Excessive Algal Growth			
Total Phosphorus[1]	mg/L	0.05	None
Chlorophyll-a		None	None
Sedimentation/Siltation			
Sedimentation/Siltation		None	None
Total Suspended Solids			
Total Suspended Solids		None	None
Manganese			
Total Manganese	µg/L	1000	150
Atrazine			
Atrazine	µg/L	82.0 acute/ 9.0 chronic	3.0

[1] The total phosphorus standard only applies to lakes.

4.5 Water Quality Assessment

Water quality data for Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake were downloaded from the STORET database and were also provided by IEPA. Figure 4-1 displays the monitoring stations located in Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake. Summary statistics, including the period of record, for all available water quality data are presented in this section, and are organized by impaired waterbody segment. The individual results of each sampling event are provided in Appendix B.

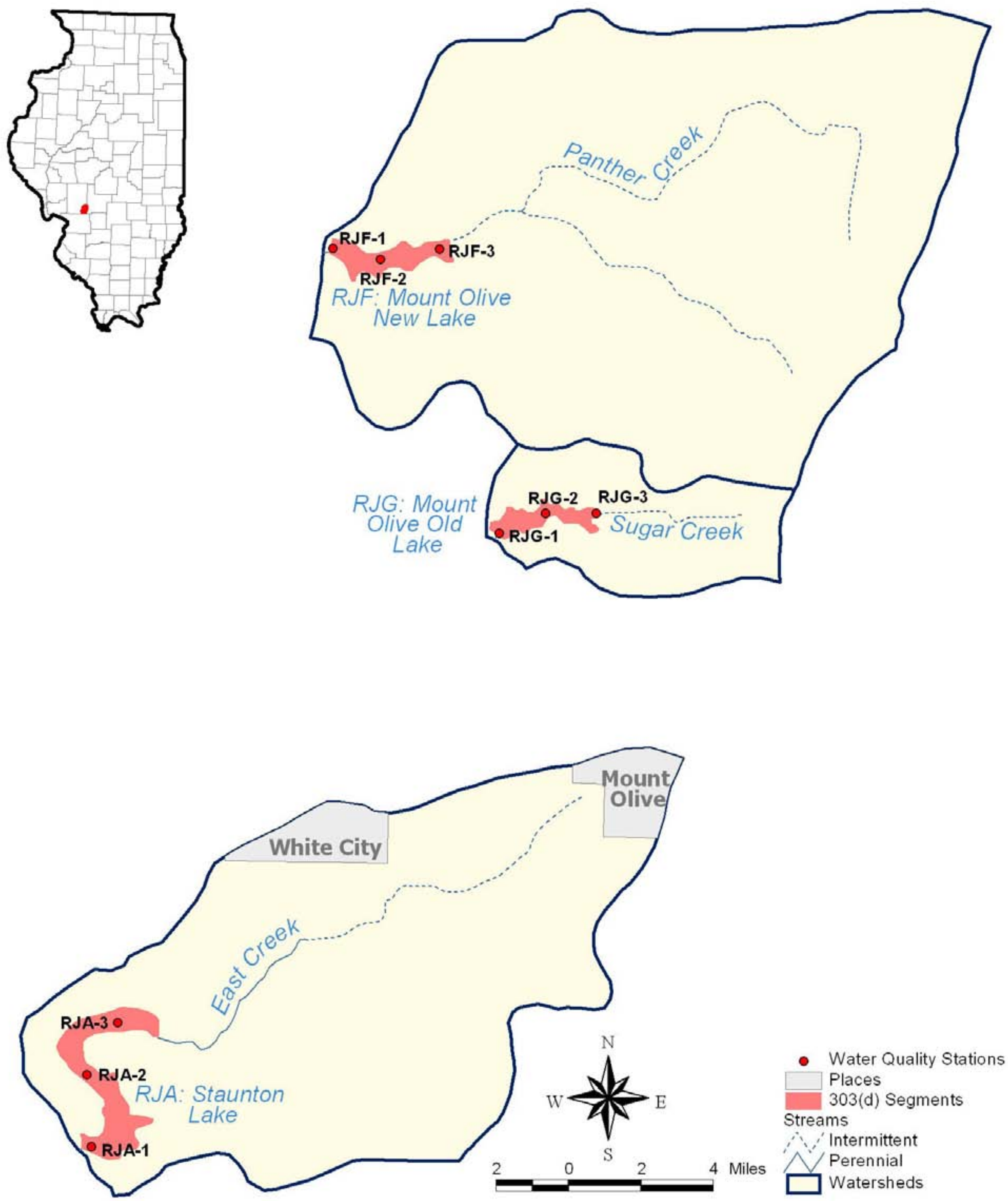

Figure 4-1. Water quality sampling stations in the Mt. Olive Old, Mt. Olive New, and Staunton Lakes.

4.5.1 Mt. Olive New Lake (IL_RJF)

Water quality data collected in the Mt. Olive New Lake at monitoring stations RJF-1, RJF-2, and RJF-3 are available from 1989 to 2002. A summary of these data is presented in the sections below. Data from these stations are included in Appendix B.

4.5.1.1 Total Phosphorus

The applicable water quality standard for total phosphorus (TP) in Illinois lakes is 0.05 mg/L. Table 4-3 presents the period of record and a statistical summary for all available TP and other nutrient-related parameters. Additionally, Figure 4-2 presents a graphical representation of the TP sampling activity in Mt. Olive New Lake. A review of the data reveals that 100 percent of TP samples violated the water quality standard, including 100 percent of recent samples (Table 4-4). TP concentrations at the surface (one foot depth) are typically similar to TP concentrations at deeper samples, probably due to the shallowness of the lake.

Table 4-3. Summary of total phosphorus parameters for Mt. Olive New Lake (Segment IL_RJF).

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Total Phosphorus	40	8/1/1989	8/7/2002	0.06	0.37	2.77	1.28
Dissolved Phosphorus	28	8/1/1989	8/7/2002	0.02	0.25	2.70	1.87

*CV = standard deviation/average

Table 4-4. Violations of the total phosphorus standard in Mt. Olive New Lake (Segment IL_RJF).

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 2000 to Present	Violations (Count), 2000 to present	Percent Violating, 2000 to Present
Total Phosphorus (All Depths)	40	40	100.00	19	19	100.00
Total Phosphorus (1-foot Depth)	28	28	100.00	12	12	100.00

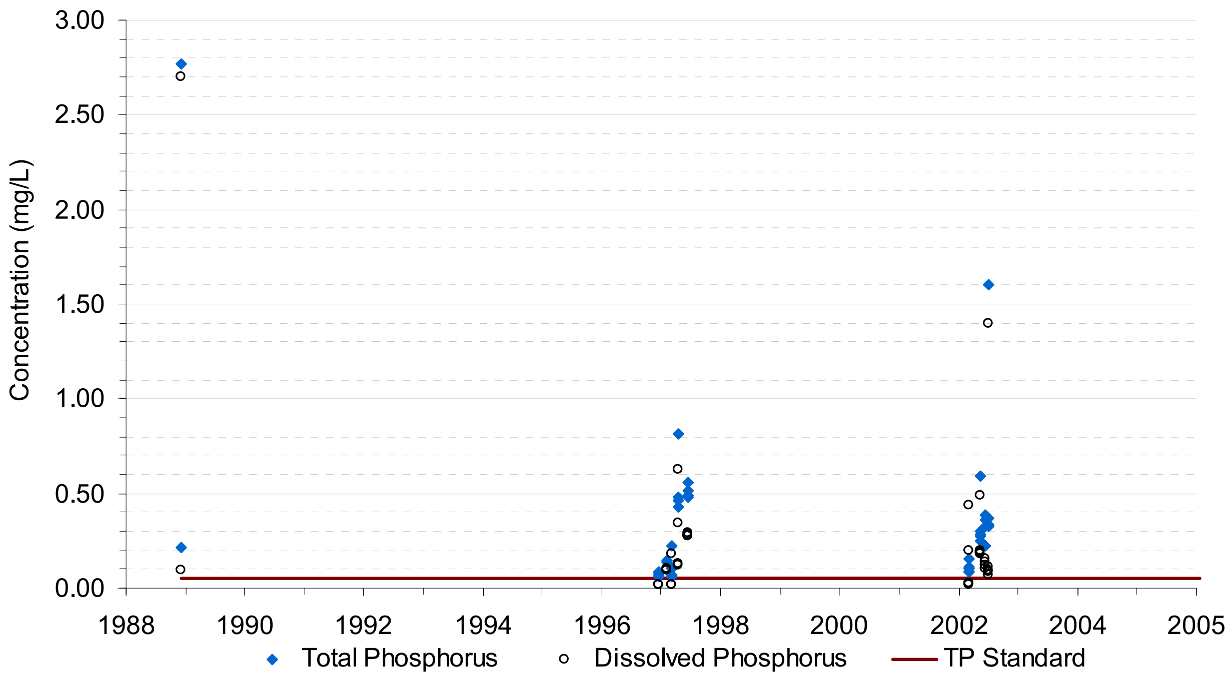

Figure 4-2. Total phosphorus and dissolved phosphorus observations in the Mt. Olive New Lake (Segment IL_RJF).

Monthly median and mean TP concentrations for the period of record are presented in Figure 4-3. Data are not available for the months of January, February, March, May, September, November, and December. The figure shows that the water quality standard of 0.05 mg/L is exceeded in all months. TP concentrations increase from April through October.

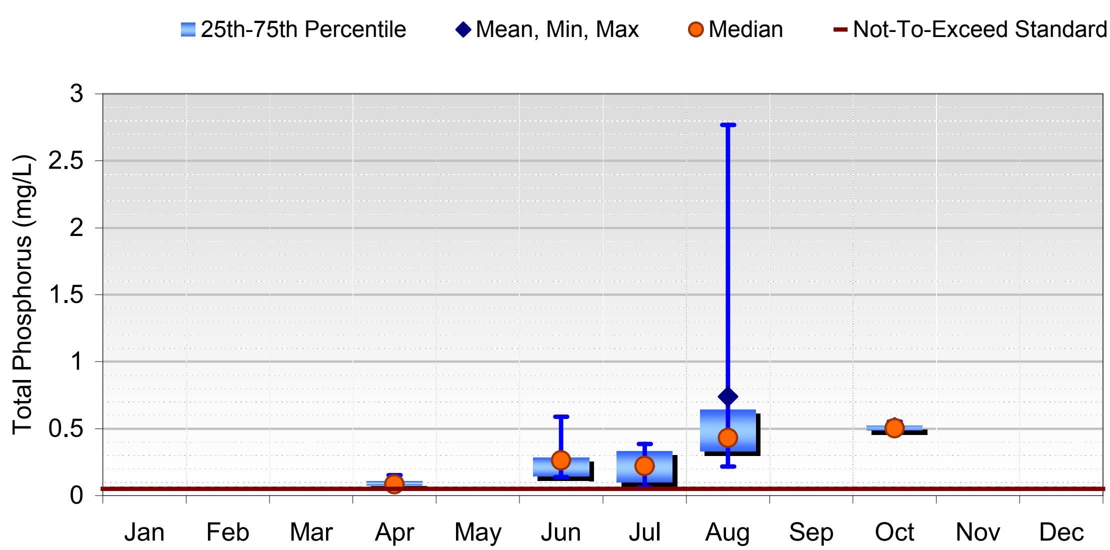

Figure 4-3. Monthly statistics for total phosphorus in the Mt. Olive New Lake (Segment IL_RJF), 1989–2002.

4.5.1.2 Dissolved Phosphorus

As stated in section 4.3.1, dissolved phosphorus (DP) is an important component of the total phosphorus (TP) measure. Mean and median dissolved phosphorus concentrations sampled in Mt. Olive New Lake are shown in Figure 4-4. DP data are available for April, June, July, August, and October. Mean DP concentrations are significantly greater in August, which leads to greater variability of dissolved phosphorus concentrations in this month. Furthermore, mean DP concentrations exceed the total phosphorus criteria in August.

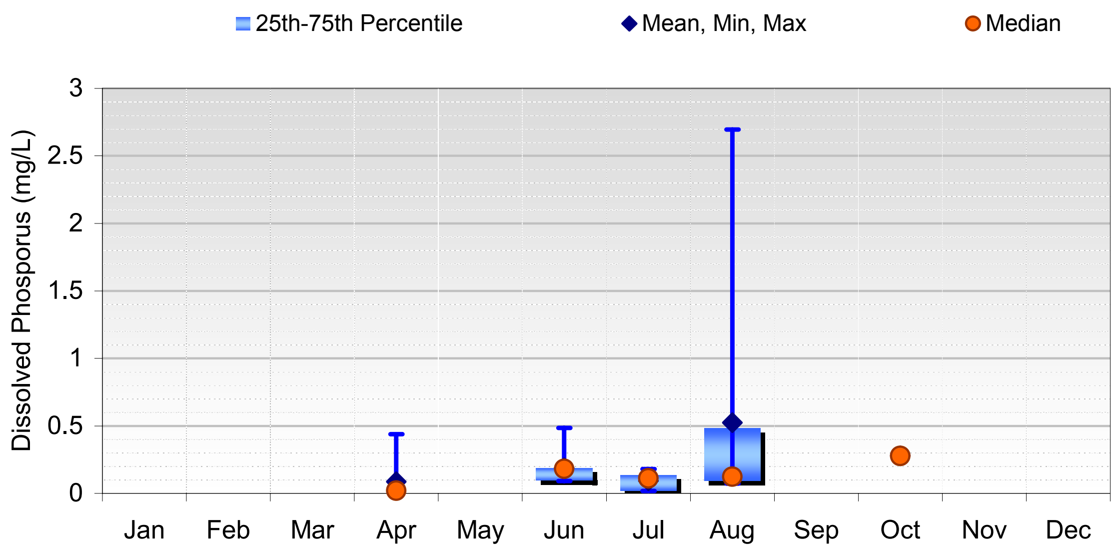

Figure 4-4. Dissolved phosphorus monthly statistics in Mt. Olive New Lake (Segment IL_RJF), 1989–2002.

The proportion of DP to TP is quite variable over the period of record as shown in Figure 4-5. The percentage of DP ranges from approximately twenty percent to almost 100 percent. Many observations record dissolved phosphorus contributions greater than 50 percent of TP in Mt. Olive New Lake.

The monthly percent contribution of DP to TP is quite variable, yet the greatest monthly contributions occur in June, as illustrated in Figure 4-6.

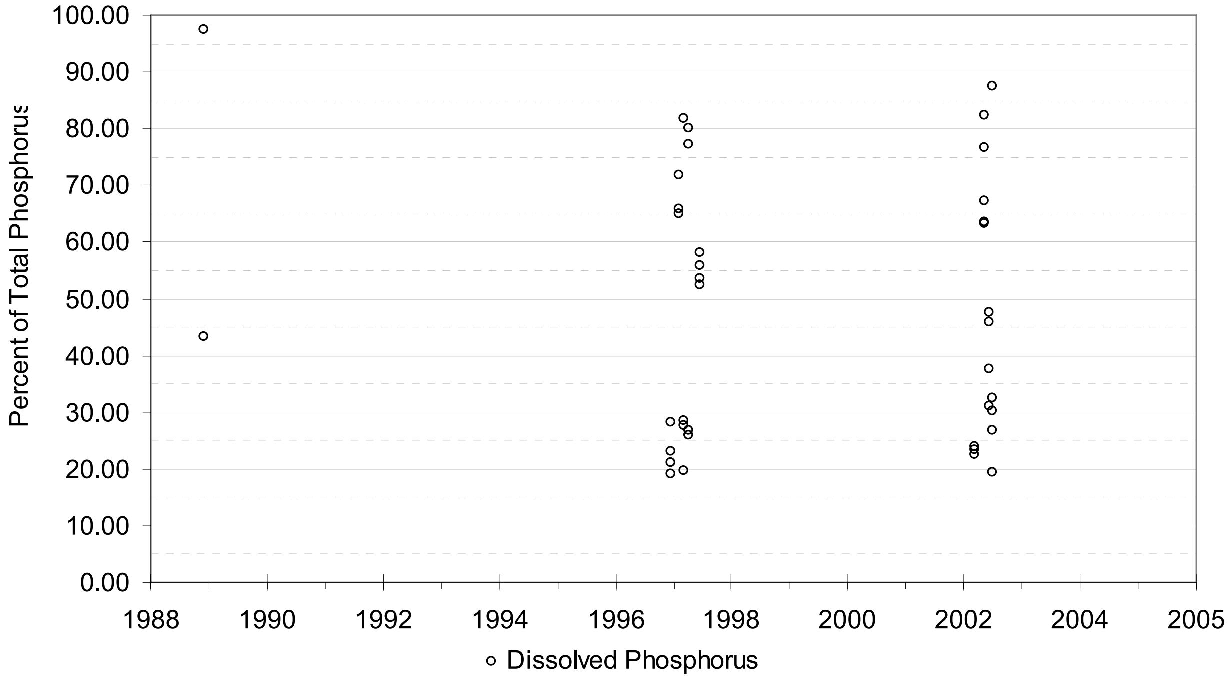

Figure 4-5. Proportion of dissolved phosphorus in total phosphorus for Mt. Olive New Lake (Segment IL_RJF).

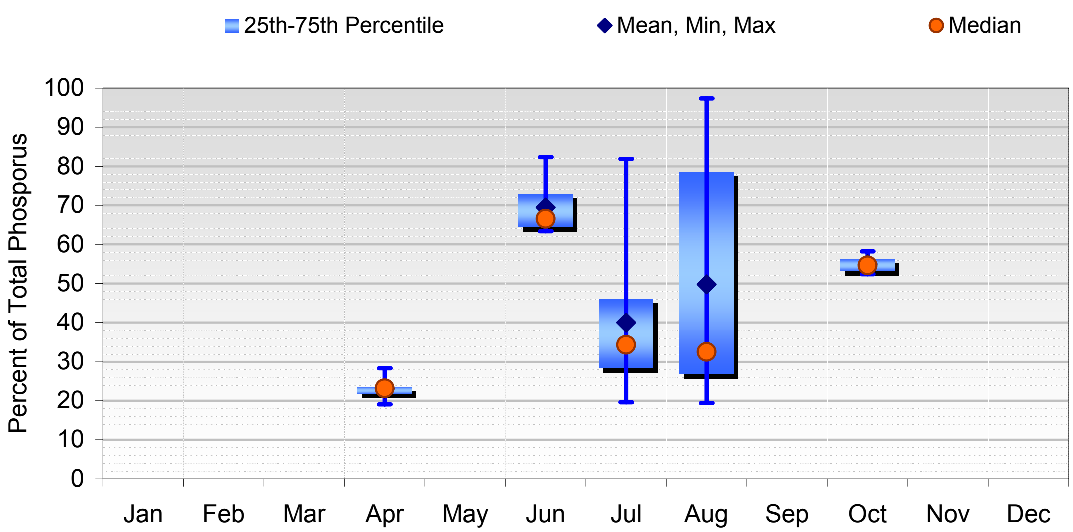

Figure 4-6. Monthly mean and median percentage of dissolved phosphorus comprising total phosphorus for Mt. Olive New Lake (Segment IL_RJF), 1989–2002.

4.5.1.3 Total Nitrogen (TN)-to-Total Phosphorus (TP) Ratio

Eutrophication in freshwater systems is typically controlled by either nitrogen or phosphorus. The limiting nutrient is defined as the nutrient that limits plant growth when it is not available in sufficient quantities. Controlling this nutrient can often slow the rate of eutrophication and improve conditions in the waterbody. An initial identification of the limiting nutrient can be made by comparing the levels of nutrients in the waterbody with the plant stoichiometry. The ratio of nitrogen to phosphorus in biomass is approximately 7.2:1. Therefore, a nitrogen:phosphorus ration in water that is less than 7.2 suggests that nitrogen is limiting. In contrast, a ratio greater than 7.2 suggests that phosphorus is the limiting nutrient (Chapra, 1997).

The variability of the TN:TP ratios in Mt. Olive New Lake are presented in Figure 4-7. Figure 4-8 illustrates that TN:TP ratios are quite variable over the period of record, as well as over the course of a year. Most TN:TP ratios are greater than 7.2, suggesting that phosphorus is the limiting nutrient in the Mt. Olive New Lake.

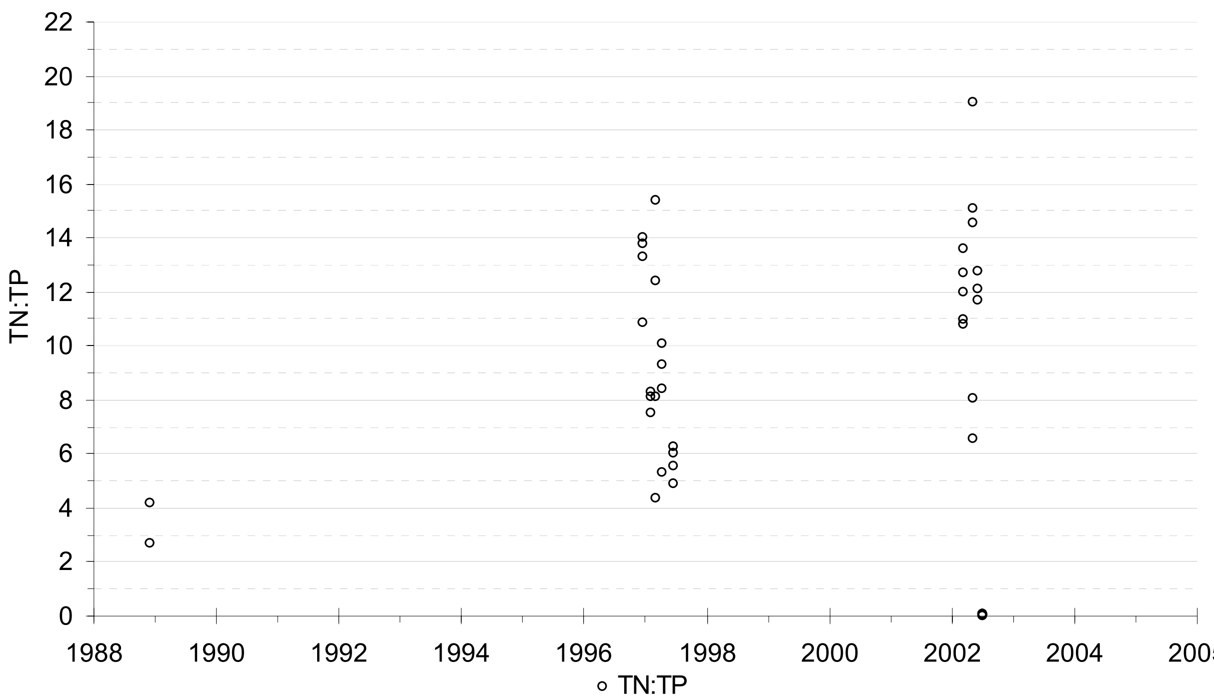

Figure 4-7. TN:TP ratios over the period of record in Mt. Olive New Lake (Segment IL_RJF).

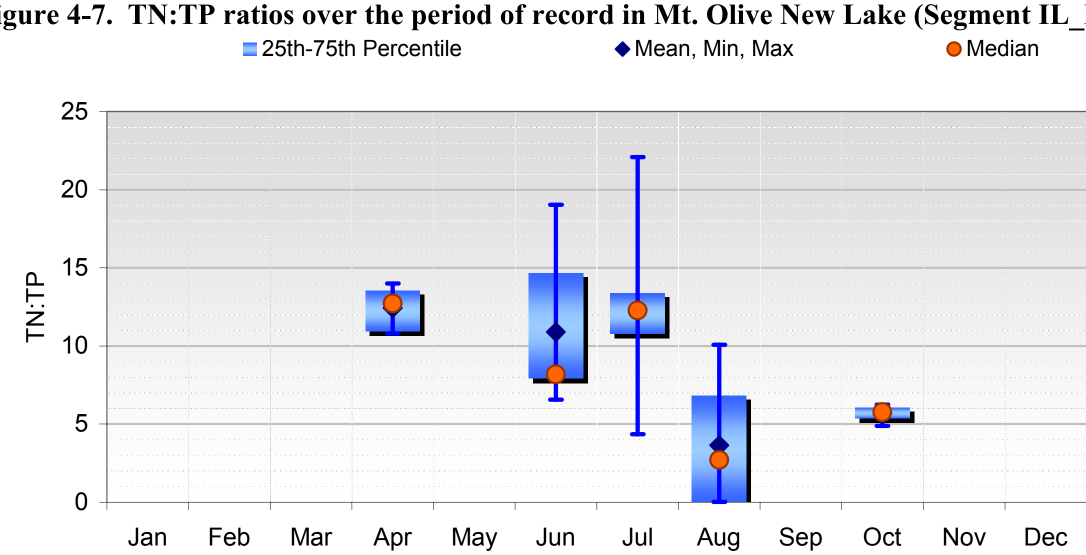

Figure 4-8. Monthly median and mean TN:TP ratios in Mt. Olive New Lake (Segment IL_RJF), 1989–2002.

4.5.1.4 Total Suspended Solids

A summary of the total suspended solids (TSS) data collected in Mt. Olive New Lake is given in Table 4-5. Data are not available for the months of January, February, March, May, September, November, and December. Figure 4-9 displays the sampling frequency for TSS in Mt. Olive New Lake, and indicates that TSS concentrations are highly variable over the period of record. Monthly median and mean TSS concentrations are presented in Figure 4-10. The figure shows that median and mean TSS concentrations are slightly lower in the months April and June, then increase in July and remain fairly constant throughout the remaining months of the year.

Table 4-5. Summary Statistics for Total Suspended Solids in Mt. Olive New Lake (Segment IL_RJF).

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Suspended Solids	40	8/1/1989	8/7/2002	2.0	22.2	44.0	0.53

*CV = standard deviation/average

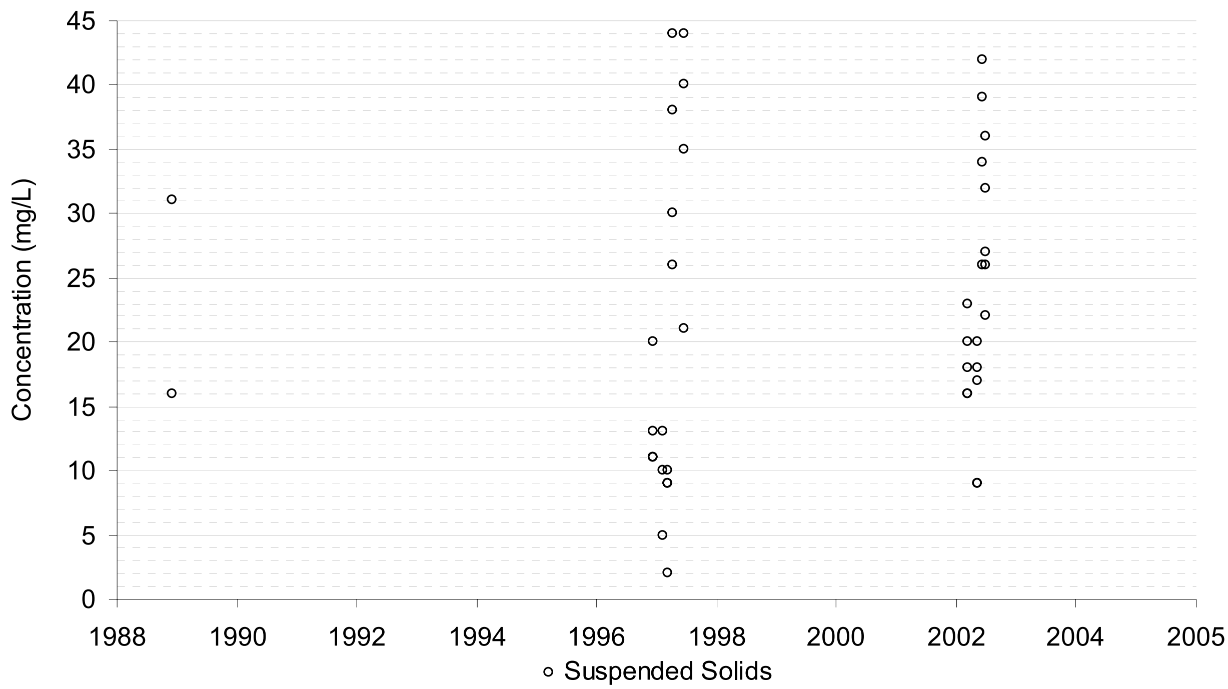

Figure 4-9. Total suspended solids sampling observations in the Mt. Olive New Lake (Segment IL_RJF).

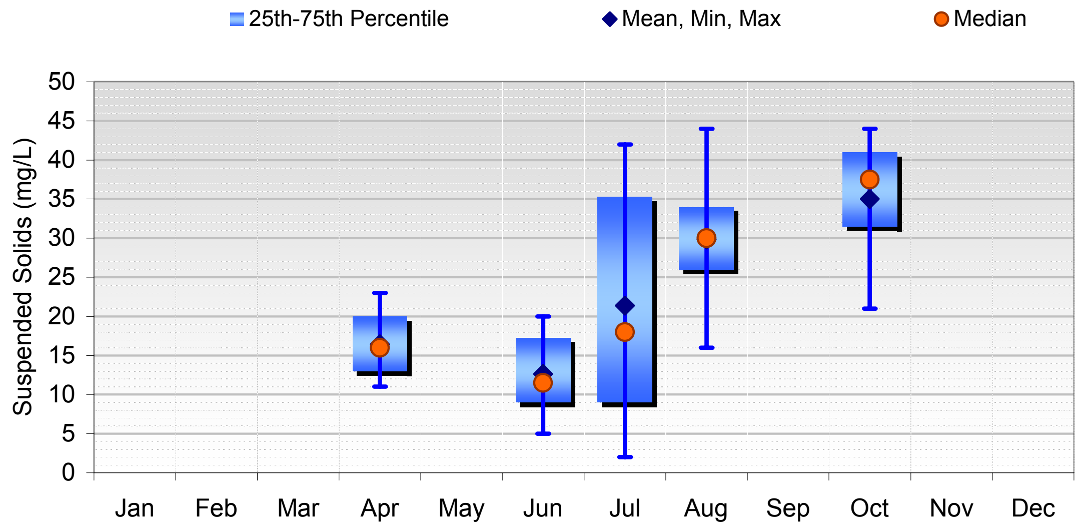

Figure 4-10. Monthly mean and median total suspended solids concentrations in Mt. Olive New Lake (Segment IL_RJF), 1989–2002.

4.5.1.5 Manganese

A summary of the manganese data collected in Mt. Olive New Lake is given in Table 4-6 and Table 4-7. The tables show that only five samples were collected from April through August in 2002. All samples are less than the 1000 µg/L manganese general use standard, however, all but one sample violates the 150 µg/L drinking water supply standard.

Table 4-6. Summary Statistics for Manganese in Mt. Olive New Lake (Segment IL_RJF).

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Manganese	5	4/17/2002	10/1/2002	140.00	246.00	360.00	0.38

*CV = standard deviation/average

Table 4-7. Manganese Observations in Mt. Olive New Lake (Segment IL_RJF).

StationID	Date	Sample Depth (feet)	Manganese (µg/L)
IL_RJF-2	4/17/2002	5.0	170
IL_RJF-2	6/17/2002	5.0	310
IL_RJF-2	7/16/2002	5.0	140
IL_RJF-2	8/7/2002	3.0	250
IL_RJF-2	10/1/2002	5.0	360

4.5.1.6 Atrazine

Atrazine data have been collected at the Mt. Olive raw water intake and the data are summarized in Table 4-8 and Table 4-9. The tables show that 61 samples were collected and 36 samples (59 percent) exceeded the 3.0 µg/L drinking water supply standard. Figure 4-11 shows that observed atrazine concentrations generally decrease throughout the sampling period.

Because these data were collected at the Mt. Olive raw water intake (which includes water from both Mt. Olive Old Lake and Mt. Olive New Lake), it is not possible to associate the data directly with either lake. As a result, data collected at the intake are presented for the Mt. Olive New Lake and the Mt. Olive Old Lake and were used by IEPA in making the use support determination.

Table 4-8. Summary Statistics for Atrazine in Mt. Olive Raw Water Intake.

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Atrazine	57	4/21/2003	12/20/2004	0.05	5.88	18.78	0.95

*CV = standard deviation/average

Table 4-9. Violations of the atrazine Drinking Water Standard in Mt. Olive Raw Water Intake.

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 2000 to Present	Violations (Count), 2000 to present	Percent Violating, 2000 to Present
Atrazine	57	32	56%	57	32	56%

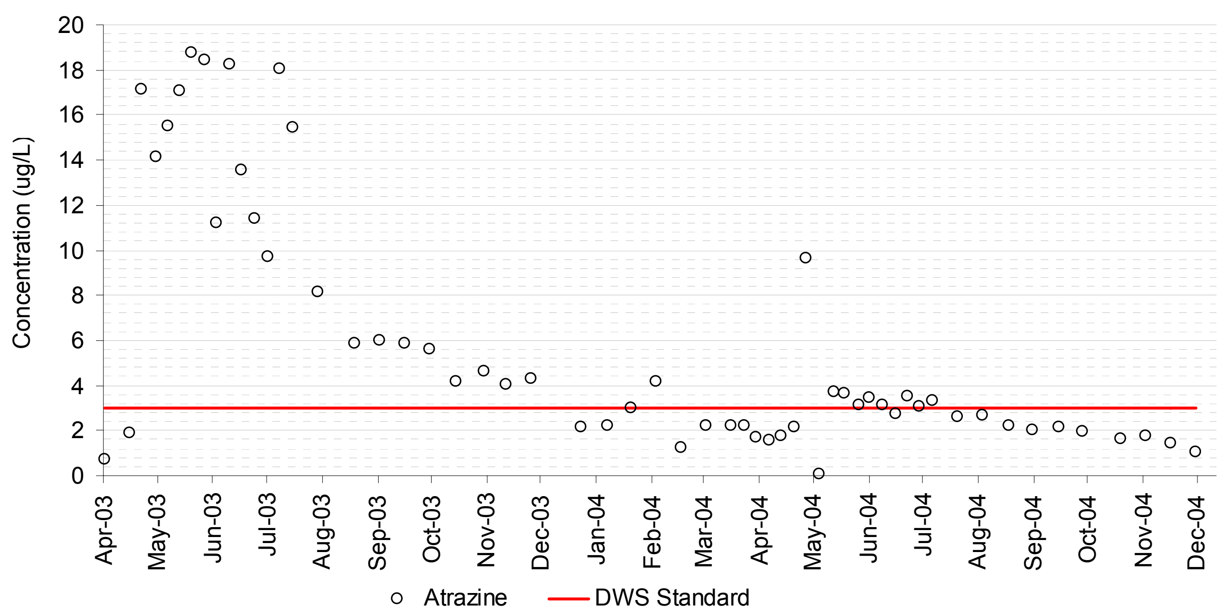

Figure 4-11. Atrazine Sampling Observations in the Mt. Olive Raw Water Intake.

4.5.2 Mt. Olive Old Lake (IL_RJG)

As stated in Section 4.1, Mt. Olive Old Lake is impaired due to phosphorus, excessive algal growth, suspended solids, manganese, and atrazine. Water quality data collected in the Mt. Olive Old Lake at monitoring stations RJG-1, RJG-2, and RJG-3 are available from 1977 to 1997. A summary of these data is presented in the sections below. Data from these stations are included in Appendix B.

4.5.2.1 Total Phosphorus

The applicable water quality standard for TP in Illinois is 0.05 mg/L. Table 4-10 and Table 4-11 present the period of record and a statistical summary for all available TP data. Additionally, Figure 4-12 presents a graphical representation of the TP sampling activity in Mt. Olive Old Lake. A review of the data reveals that nearly 100 percent of TP samples violated the water quality standard, and no recent samples (data post-1997), were available to compare to the TP water quality standard. There does not appear to be a significant increasing or decreasing trend represented by the data. TP concentrations at the surface (one foot depth) are typically similar to TP concentrations at deeper samples.

Table 4-10. Summary of total phosphorus parameters in Mt. Olive Old Lake (Segment IL_RJG).

Parameter	Samples (Count)	Start	End	Minimum	Average	Maximum	CV*
Total Phosphorus	31	8/20/1977	10/6/1997	0.08	0.46	2.10	1.14
Dissolved Phosphorus	24	5/26/1982	10/6/1997	0.01	0.40	2.02	1.34

*CV = standard deviation/average

Table 4-11. Violations of the total phosphorus standard in Mt. Olive Old Lake (Segment IL_RJG).

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 2000 to Present	Violations (Count), 2000 to present	Percent Violating, 2000 to Present
Total Phosphorus (All Depths)	31	31	100.00	0	0	0.00
Total Phosphorus (1-Foot Depth)	24	24	100.00	0	0	0.00

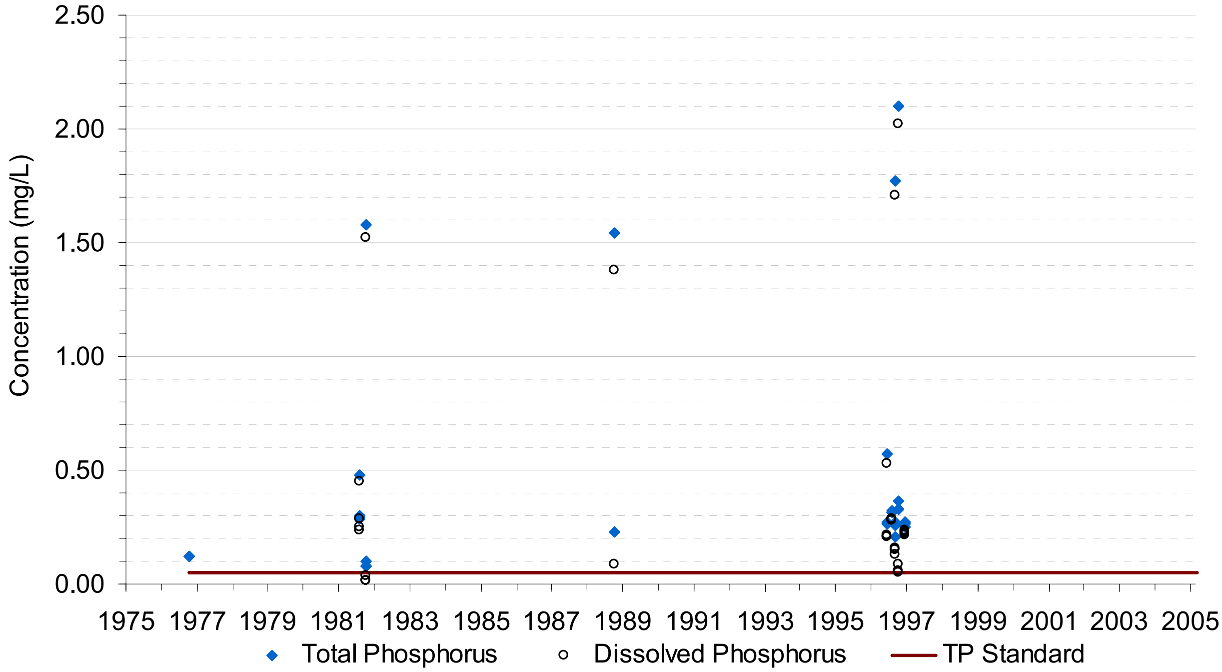

Figure 4-12. Total phosphorus and dissolved phosphorus observations in Mt. Olive Old Lake (Segment IL_RJG).

Monthly median and mean TP concentrations for the period of record are presented in Figure 4-13. Data are not available for the months of January, February. March, September, November, and December. The figure shows that the water quality standard of 0.05 mg/L is exceeded in all months. Additionally, median and mean monthly TP concentrations are similar in all months.

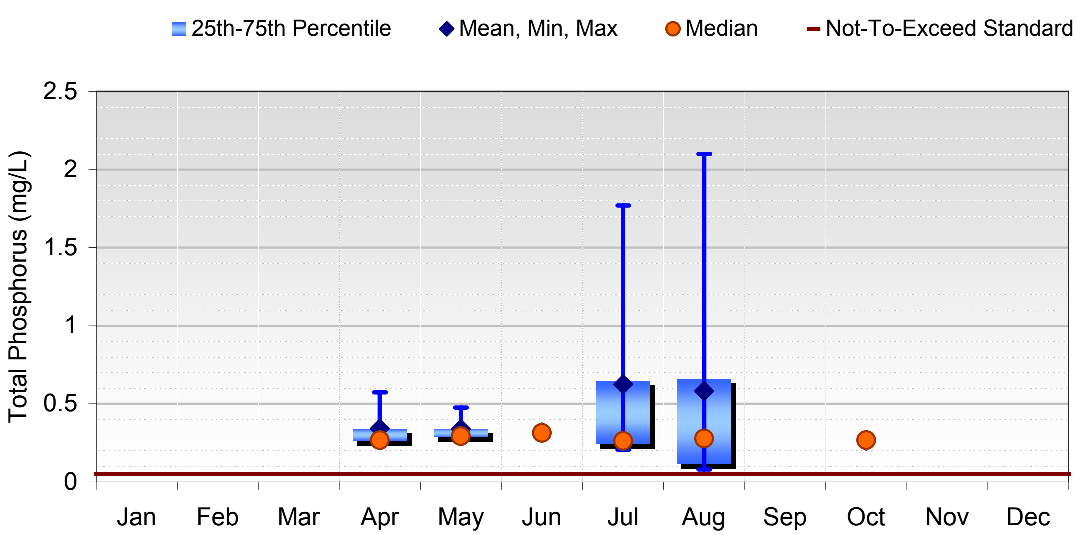

Figure 4-13. Monthly total phosphorus statistics in the Mt. Olive Old Lake (Segment IL_RJG), 1977–1997.

4.5.2.2 Dissolved Phosphorus

Dissolved phosphorus (DP) is an important component of the total phosphorus (TP) measure (see section 4.3.1). Mean and median dissolved phosphorus concentrations sampled in the Mt. Olive Old Lake are shown in Figure 4-14. DP data are available from April through August, and October. The figure shows that mean DP concentrations follow the general seasonal trend as TP presented in the previous section: mean DP concentrations are greatest in July and August. Mean DP concentrations exceed the total phosphorus criteria of 0.05 mg/L in July and August. Additionally, DP concentrations are highly variable in July and August.

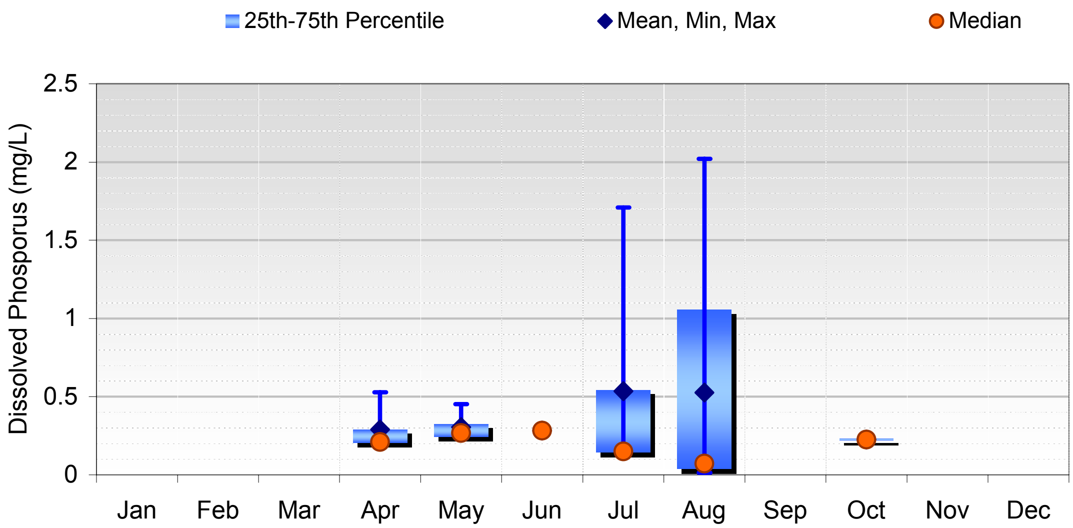

Figure 4-14. Dissolved phosphorus monthly statistics in the Mt. Olive Old Lake (Segment IL_RJG), 1982–1997.

The proportion of DP to TP is quite variable over the period of record as shown in Figure 4-15. The percentage of DP comprising the TP load ranges from less than 15 percent to more than 95 percent. A significant number of observations record dissolved phosphorus contributions greater than 50 percent of the TP in the Mt. Olive Old Lake.

The monthly percent contribution of DP to TP varies greatly, yet the greatest monthly contributions occur in April, May, June, and October as illustrated in Figure 4-16.

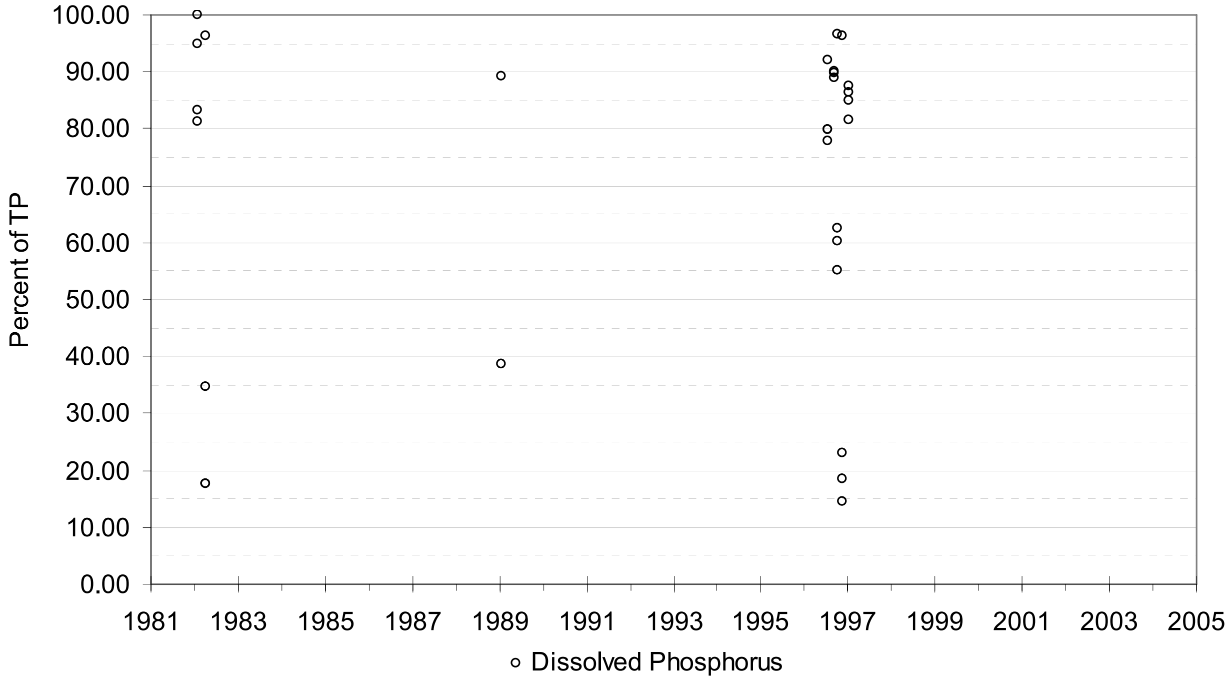

Figure 4-15. Proportion of dissolved phosphorus in total phosphorus for the Mt. Olive Old Lake (Segment IL_RJG).

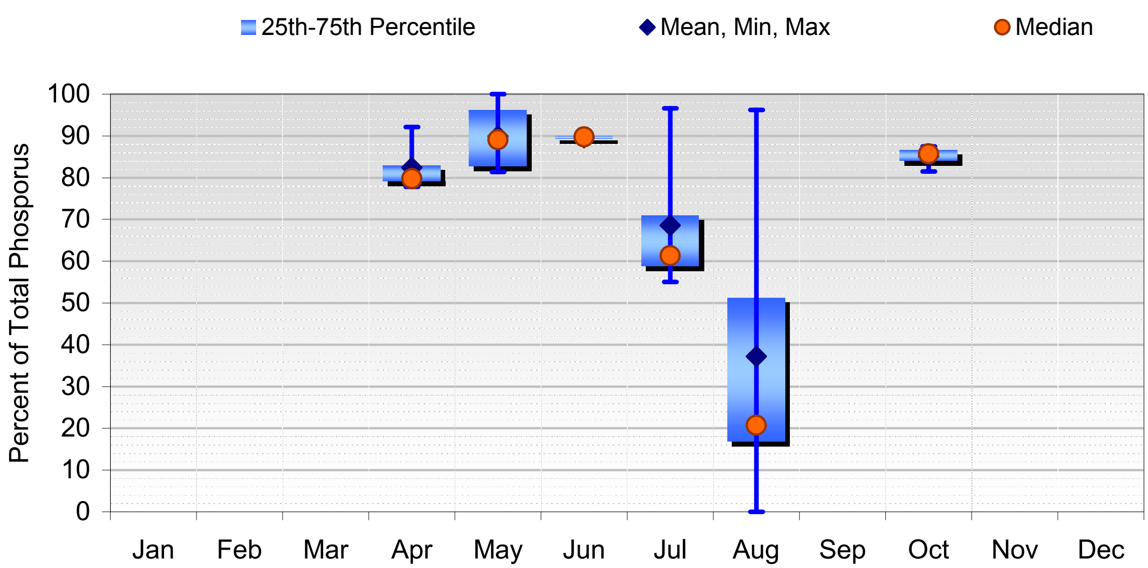

Figure 4-16. Monthly mean and median percentage of dissolved phosphorus comprising total phosphorus for the Mt. Olive Old Lake (Segment IL_RJG), 1982–1997.

4.5.2.3 Total Nitrogen (TN)-to-Total Phosphorus (TP) Ratio

The importance of the TN:TP ratio is discussed in section 4.5.1.3. The variability of the TN:TP ratios in Mt. Olive Old Lake is presented in Figure 4-17, and monthly median and mean TN:TP ratios are shown in Figure 4-18. These figures illustrate that TN:TP ratios are quite variable over the period of record, as well as over the course of a year. Mean TN:TP ratios are greater than 7.2 in August and October, suggesting that phosphorus is the limiting nutrient. However, for the months April through July TN:TP is less than 5.0, which demonstrates a shift from nitrogen to phosphorus as the limiting nutrient. This could be due to different seasonal loading rates for the two nutrients.

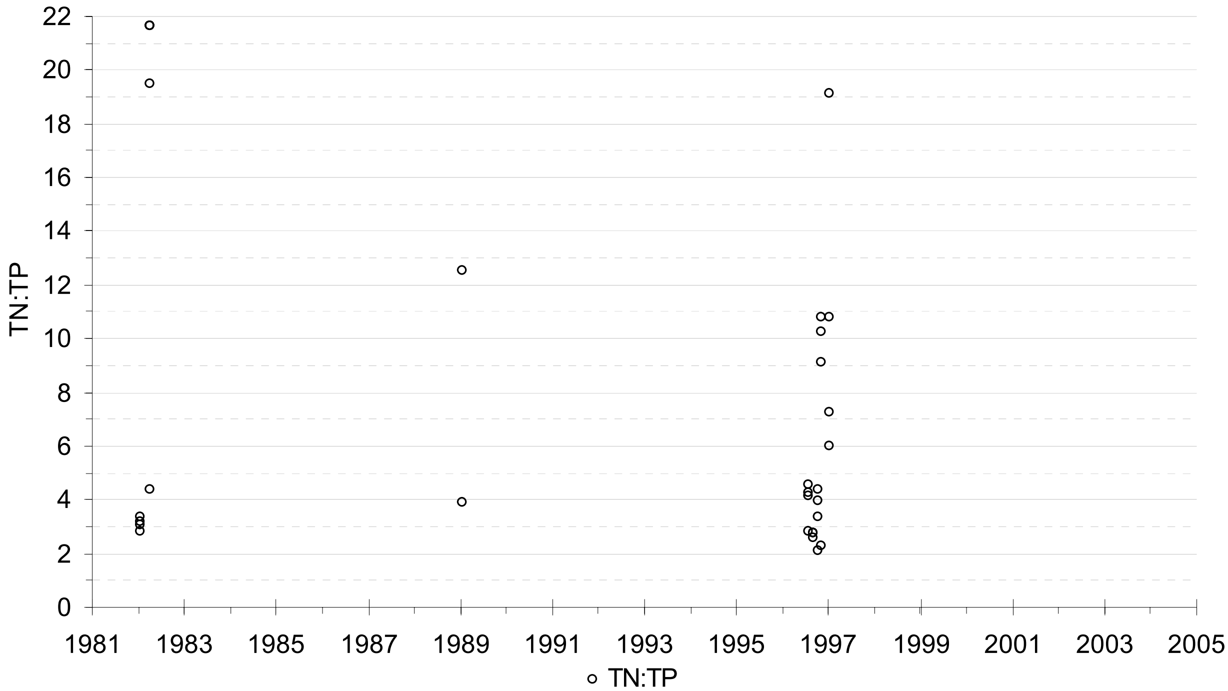

Figure 4-17. TN:TP ratios over the period of record in the Mt. Olive Old Lake (Segment IL_RJG).

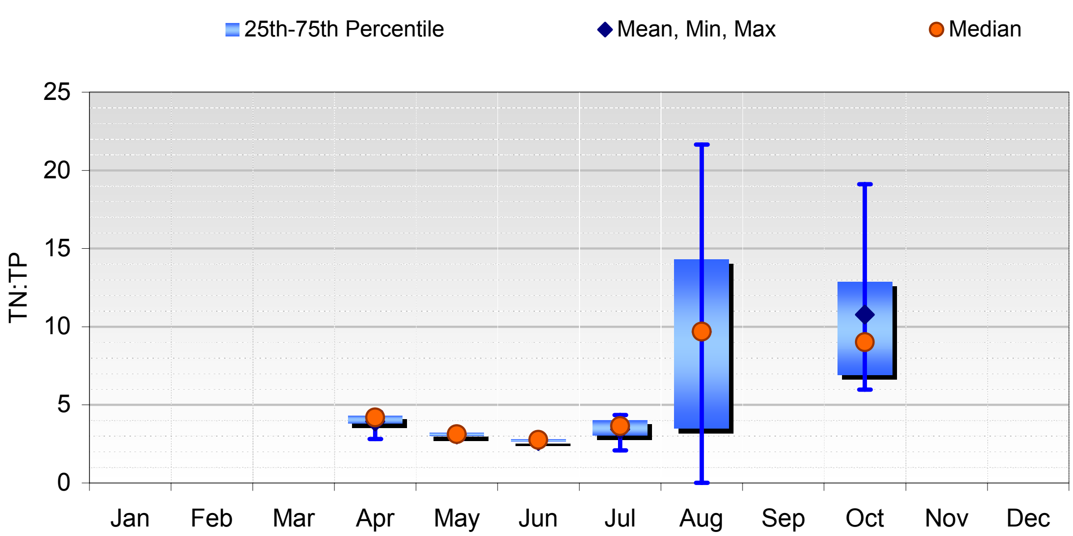

Figure 4-18. Monthly median and mean TN:TP ratios in the Mt. Olive Old Lake (Segment IL_RJG), 1982–2002.

4.5.2.4 Excessive Algal Growth

The dominant pigment in algal cells is chlorophyll-*a*, which is easy to measure and is a valuable surrogate measure for algal biomass. Chlorophyll-*a* is desirable as an indicator because algae are either the direct (e.g. nuisance algal blooms) or indirect (e.g. high/low dissolved oxygen, pH, and high turbidity) cause of most problems related to excessive nutrient enrichment. Both seasonal mean and instantaneous maximum concentrations can be used to determine impairments. The Illinois water quality standard for general use states that "waters of the state shall be free from algal growth of other than natural origin" (Section 302.203).

Table 4-12 presents a summary of the chlorophyll-*a* collected in Mt. Olive Old Lake. Data are not available for the months of January, February, March, September, November, and December. Figure 4-19 displays the sampling frequency for chlorophyll-*a* in Mt. Olive Old Lake. Monthly median and mean chlorophyll-*a* concentrations are presented in Figure 4-20, which shows that median and mean chlorophyll-*a* increase in magnitude and variability during the summer month of August and remain relatively low throughout the remainder of the year. The relationship between chlorophyll-*a* and TP is graphically displayed in Figure 4-21. The figure shows only a weak positive relationship between TP and chlorophyll *a*.

Table 4-12. Summary Statistics for Chlorophyll-*a* in the Mt. Olive Old Lake (Segment IL_RJG).

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Chlorophyll-a	21	5/26/1982	10/6/1997	7.62	39.51	191.35	1.40

*CV = standard deviation/average

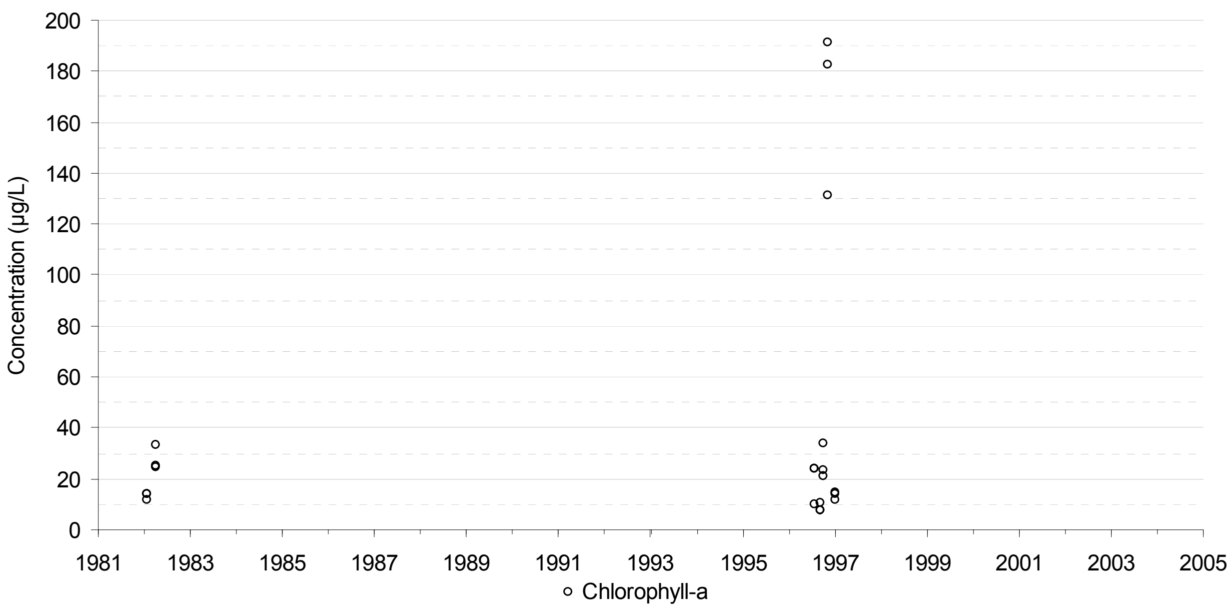

Figure 4-19. Chlorophyll-*a* sampling observations in the Mt. Olive Old Lake (Segment IL_RJG).

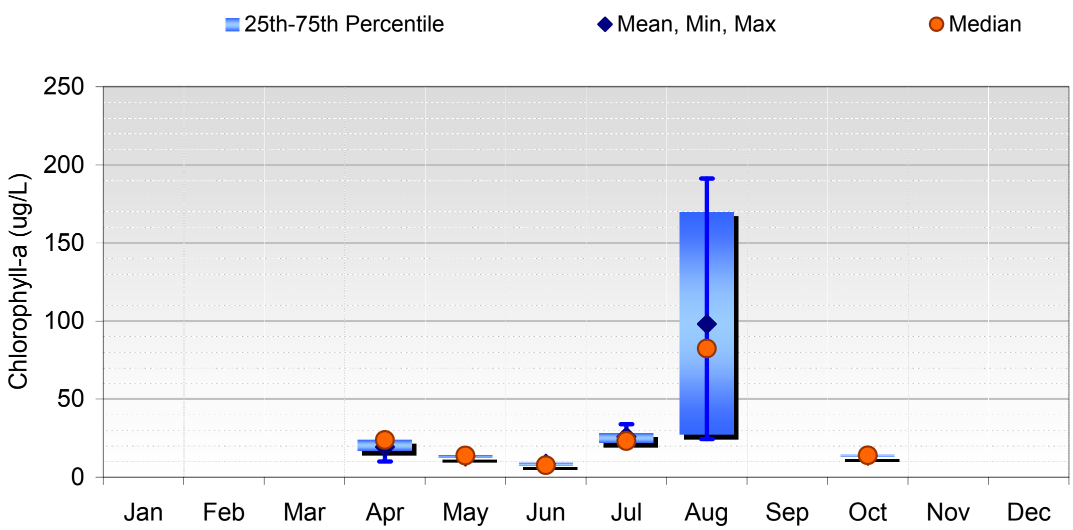

Figure 4-20. **Monthly mean and median chlorophyll-*a* concentrations in the Mt. Olive Old Lake (Segment IL_RJG), 1982–1997.**

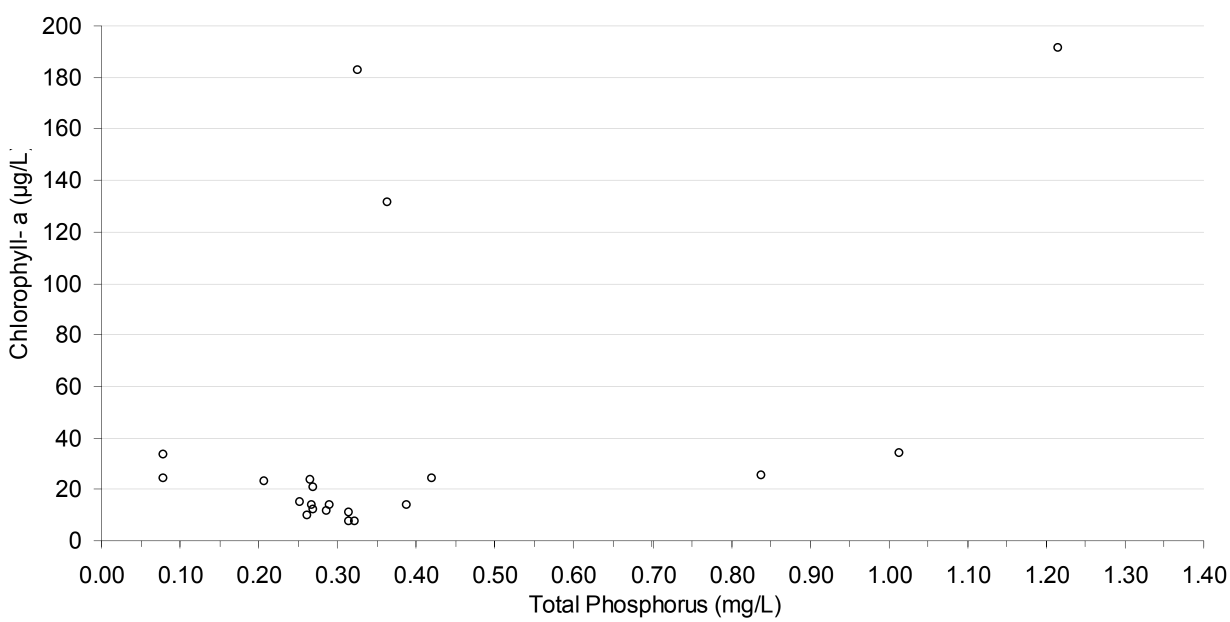

Figure 4-21. **Relationship between chlorophyll-a concentration and TP concentration in the Mt. Olive Old Lake (Segment IL_RJG), 1982–1997.**

4.5.2.5 Total Suspended Solids

A summary of the total suspended solids (TSS) data collected in Mt. Olive Old Lake is given in Table 4-13. Data are not available for the months of January, February, March, September, November, and December. Figure 4-22 displays the sampling frequency for TSS in Mt. Olive Old Lake, and indicates that TSS concentrations are highly variable over the period of record. Monthly mean and median TSS concentrations are presented in Figure 4-23. The figure shows that mean and median TSS concentrations increase from May through August where they reach their maximum.

Table 4-13. Summary Statistics for Total Suspended Solids in the Mt. Olive Old Lake (Segment IL_RJG).

Parameter	Samples (Count)	Start	End	Minimum (mg/L)	Average (mg/L)	Maximum (mg/L)	CV*
Suspended Solids	31	8/20/1977	10/6/1997	1.00	8.84	7	26.00
*CV = standard deviation/average							

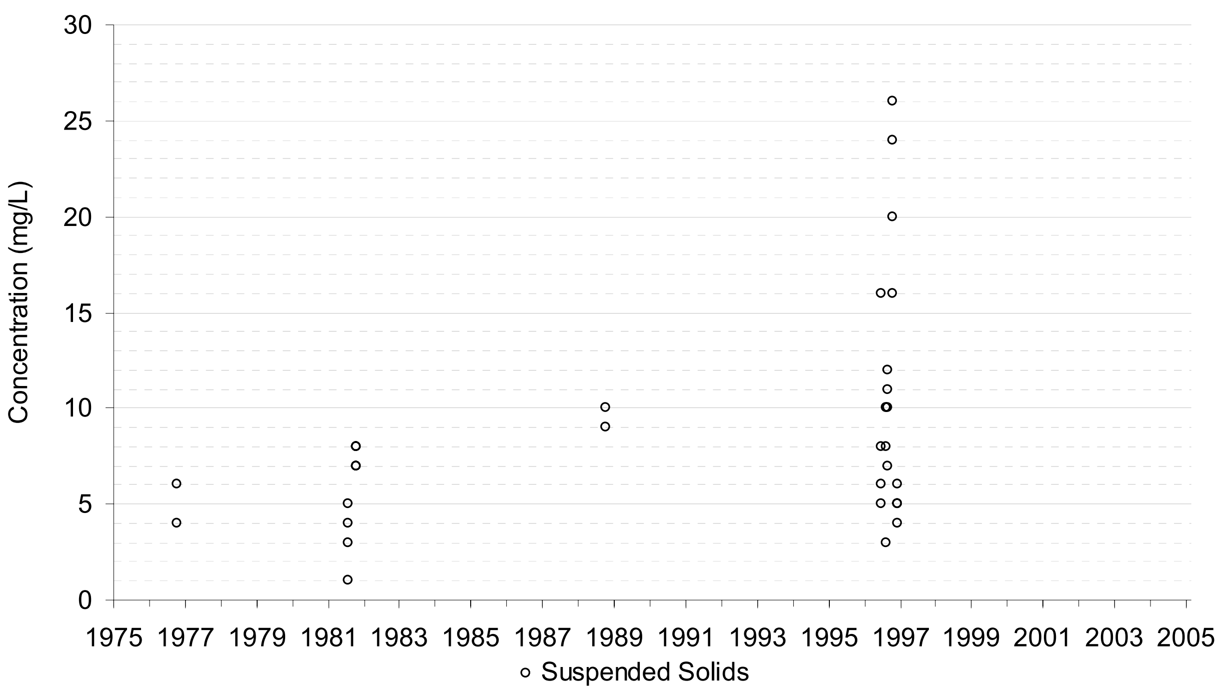

Figure 4-22. Total suspended solids sampling observations in the Mt. Olive Old Lake (Segment IL_RJG).

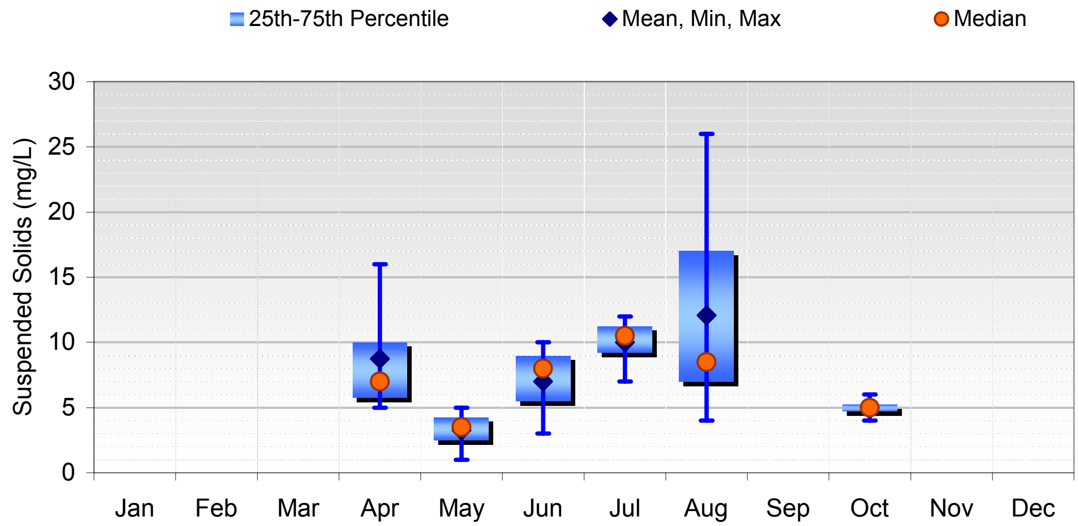

Figure 4-23. Monthly mean and median suspended solids concentrations in the Mt. Olive Old Lake (Segment IL_RJG), 1977–1997.

4.5.2.6 Manganese

A summary of the manganese data collected in Mt. Olive Old Lake is given in Table 4-14 and Table 4-15. The tables show that only four samples were collected from April through October in 2003. All samples are less than the 1000 µg/L manganese general use standard, however, all samples violate the 150 µg/L drinking water supply standard.

Table 4-14. Summary Statistics for Manganese in Mt. Olive Old Lake (Segment IL_RJG).

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Manganese	4	4/16/2003	10/3/2003	190.00	545.00	900.00	0.53

*CV = standard deviation/average

Table 4-15. Manganese Observations in Mt. Olive Old Lake (Segment IL_RJG).

StationID	Date	Sample Depth (feet)	Manganese (µg/L)
RJG-1	4/16/2003	13.0	190
RJG-1	6/3/2003	13.0	560
RJG-1	7/11/2003	11.0	900
RJG-1	10/3/2003	7.0	530

4.5.2.7 Atrazine

A summary of atrazine data collected in Mt. Olive Old Lake is given in Table 4-16 and Table 4-17. The tables show that only five samples were collected from April through October in 2003. One sample is greater than the 9.0 µg/L chronic atrazine general use standard, however, all but one sample violates the

3.0 μg/L drinking water supply standard. Additional atrazine data collected at the Mt. Olive raw water intake are presented in section 4.5.1.6 and were used in making the use support determination.

Table 4-16. Summary Statistics for Atrazine in Mt. Olive Old Lake (Segment IL_RJG).

Parameter	Samples (Count)	Start	End	Minimum (μg/L)	Average (μg/L)	Maximum (μg/L)	CV*
Atrazine	5	4/16/2003	10/3/2003	0.42	6.06	11.00	0.73

*CV = standard deviation/average

Table 4-17. Atrazine Observations in Mt. Olive Old Lake (Segment IL_RJG).

StationID	Date	Sample Depth (feet)	Atrazine (μg/L)
IL_RJG-1	4/16/2003	13.0	0.42
IL_RJG-1	6/3/2003	13.0	11.0
IL_RJG-1	7/11/2003	11.0	9.8
IL_RJG-1	8/13/2003	13.0	3.4
IL_RJG-1	10/3/2003	7.0	5.7

4.5.3 Staunton Lake (IL_RJA)

As discussed in Section 4.1 Staunton Lake is impaired for excessive algal growth and manganese. Water quality data collected in Staunton Lake at IEPA monitoring stations RJA-1, RJA-2, and RJA-3, are available from 1983 to 2002. A summary of these data is presented in the sections below and data from these stations are included in Appendix B.

4.5.3.1 Excessive Algal Growth

The importance of algal growth, and specifically chlorophyll-*a* is discussed in section 4.5.2.4. Table 4-18 presents a summary of the chlorophyll-*a* collected in Staunton Lake. Figure 4-24 displays the sampling frequency for chlorophyll-*a* in Staunton. Monthly median and mean chlorophyll-*a* concentrations are presented in Figure 4-25, which shows that median and mean chlorophyll-*a* concentrations are variable throughout the year. A weak relationship exists between TP concentrations and chlorophyll-a concentrations, as displayed in Figure 4-26. Chlorophyll-*a* is a commonly used surrogate measure of algal biomass. Typically, as TP concentrations increase, concentrations of chlorophyll-*a* increase as well. Figure 4-26 shows that as TP concentrations increase in the Staunton Lake, chlorophyll-*a* concentrations do not always correspondingly increase. Thus, the relationship between chlorophyll-*a* and TP concentrations is characterized as weak for the Staunton Lake.

Table 4-18. Summary Statistics for Chlorophyll-*a* in the Staunton Lake (Segment IL_RJA).

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Chlorophyll-a	102	5/17/1983	8/7/2002	0.18	22.24	101.95	0.86

*CV = standard deviation/average

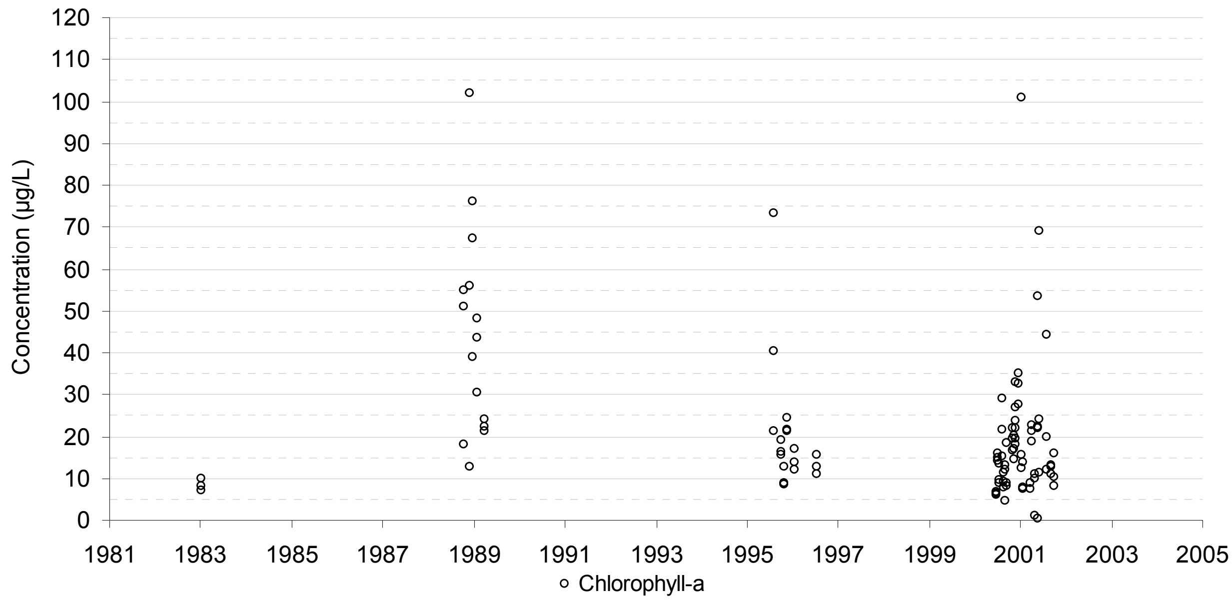

Figure 4-24. Chlorophyll-*a* sampling observations in Staunton Lake (Segment IL_RJA).

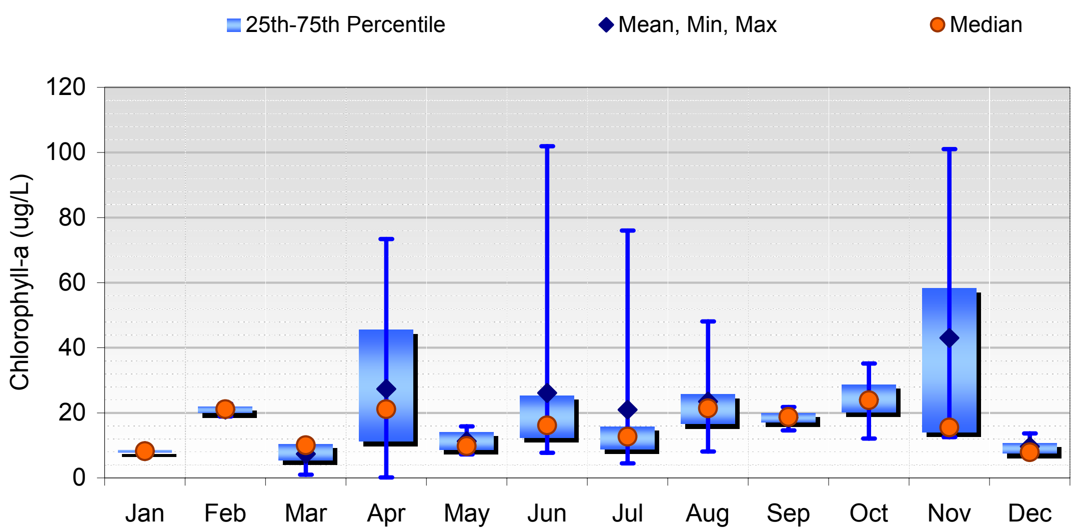

Figure 4-25. Monthly mean and median chlorophyll-*a* concentrations in Staunton Lake (Segment IL_RJA), 1983–2002.

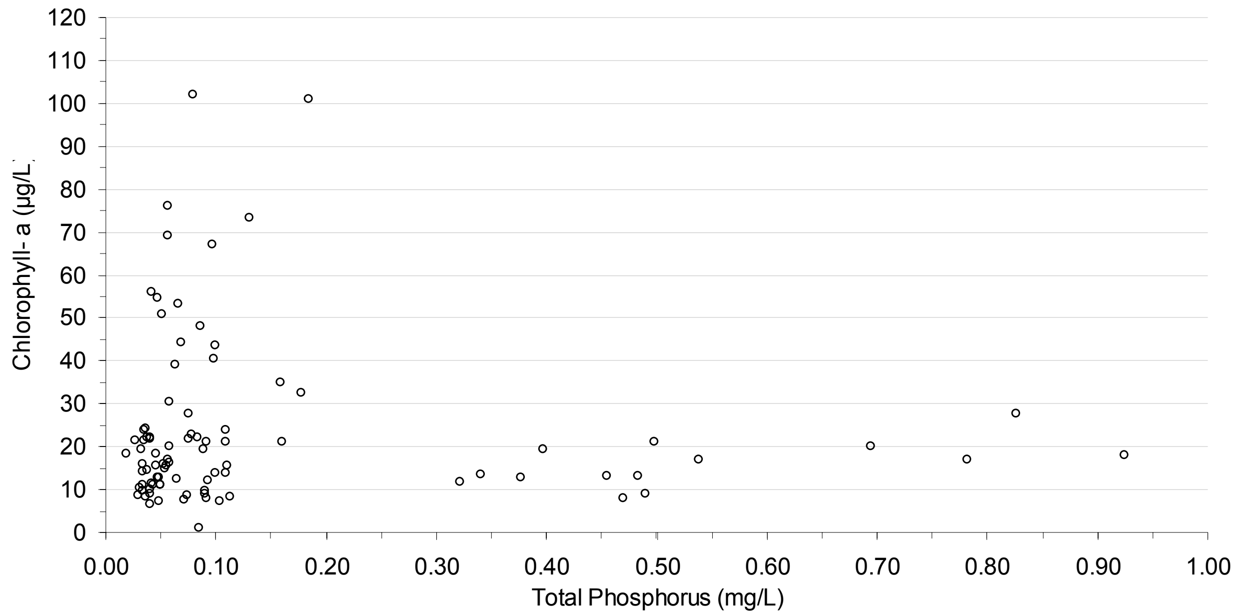

Figure 4-26. Relationship between chlorophyll-a concentration and TP concentration in the Staunton Lake (Segment IL_RJA), 1983-2002.

4.5.3.2 Total Phosphorus

The applicable water quality standard for TP in Illinois is 0.05 mg/L. Table 4-10 presents the period of record and a statistical summary for all available TP data. Additionally, Figure 4-12 presents a graphical representation of the TP sampling activity in Staunton Lake. A review of the data reveals that nearly 67 percent of TP samples violated the water quality standard, and 79 percent of recent samples (data post-1997), exceed the TP water quality standard. There appears to be an increasing trend represented by the data over the period of record. TP concentrations at the surface (one foot depth) are typically similar to TP concentrations at deeper samples.

Table 4-19. Summary of total phosphorus parameters in Staunton Lake (Segment IL_RJA).

Parameter	Samples (Count)	Start	End	Minimum	Average	Maximum	CV*
Total Phosphorus	176	5/17/1983	8/7/2002	0.02	0.23	4.65	2.16
Dissolved Phosphorus	77	5/17/1983	8/7/2002	0.01	0.23	7.00	3.34

*CV = standard deviation/average

Table 4-20. Violations of the total phosphorus standard in Staunton Lake (Segment IL_RJA).

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 1998 to Present	Violations (Count), 1998 to present	Percent Violating, 1998 to Present
Total Phosphorus (All Depths)	176	117	66.48	124	79	63.71
Total Phosphorus (1-Foot Depth)	133	77	57.89	94	53	56.38

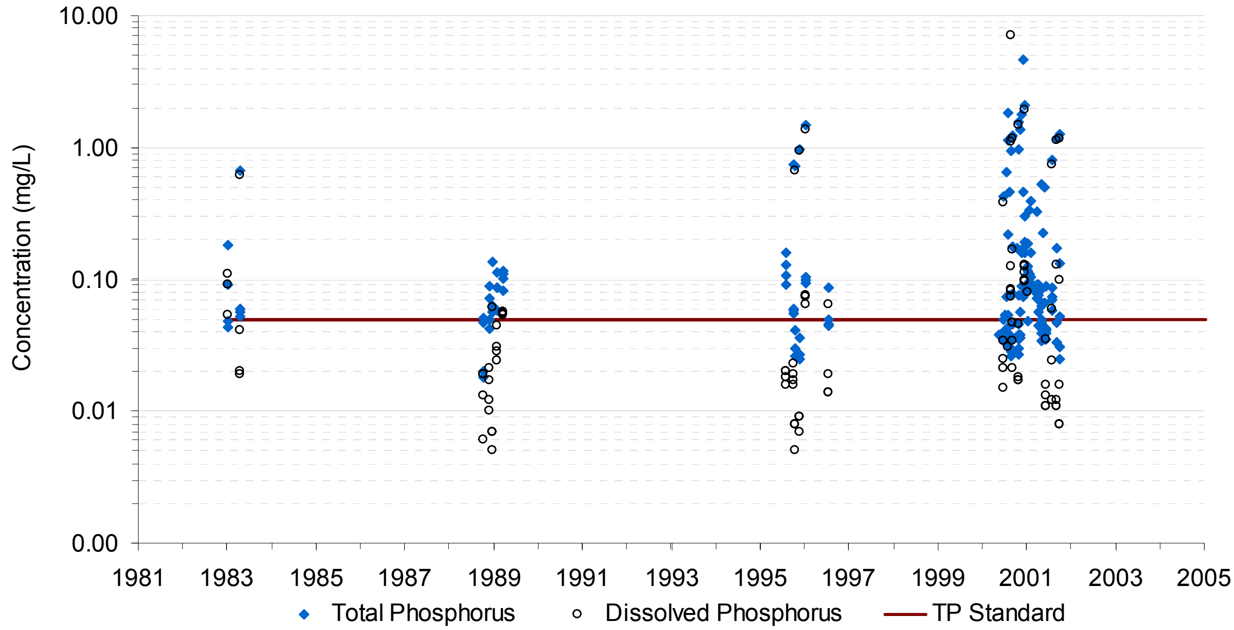

Figure 4-27. Total phosphorus and dissolved phosphorus observations in Staunton Lake (Segment IL_RJA).

Monthly median and mean TP concentrations for the period of record are presented in Figure 4-13. The figure shows that the water quality standard of 0.05 mg/L is exceeded in all months and mean monthly TP concentrations display seasonal variability. Mean monthly TP concentrations are greatest in October, and then steadily decrease from February through April. Mean and median concentrations increase steadily from May through October.

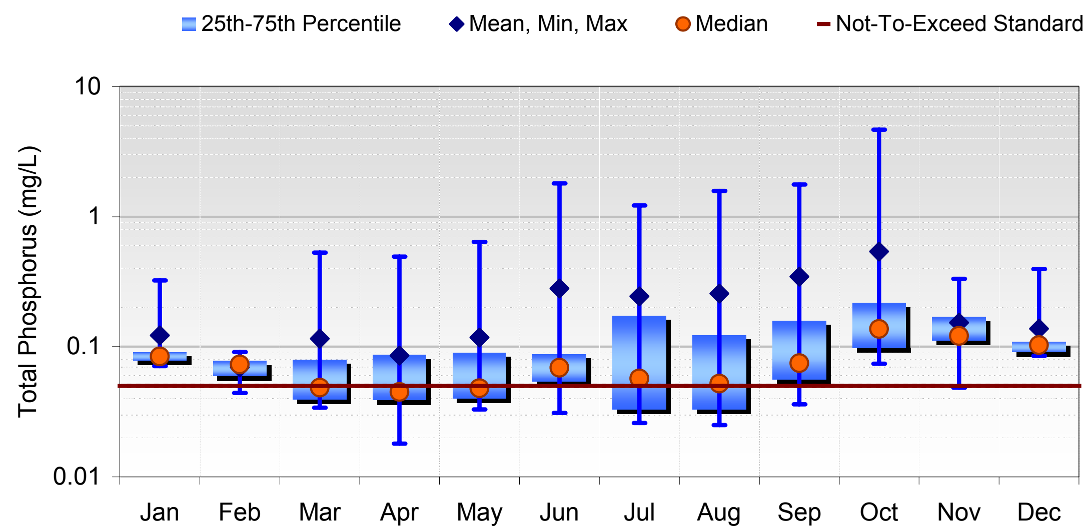

Figure 4-28. Monthly total phosphorus statistics in the Staunton Lake (Segment IL_RJA), 1983–2002.

4.5.3.3 Dissolved Phosphorus

Dissolved phosphorus (DP) is an important component of the total phosphorus (TP) measure (see section 4.3.1). Mean and median dissolved phosphorus concentrations sampled in the Staunton Lake are shown in Figure 4-14. DP data are available from April through November. Mean DP concentrations increase from the minimum in April through July. After the maximum occurs in July, concentrations steadily decrease through the remainder of the year. Mean DP concentrations exceed the total phosphorus criteria of 0.05 mg/L in all months. Additionally, DP concentrations are highly variable for most months.

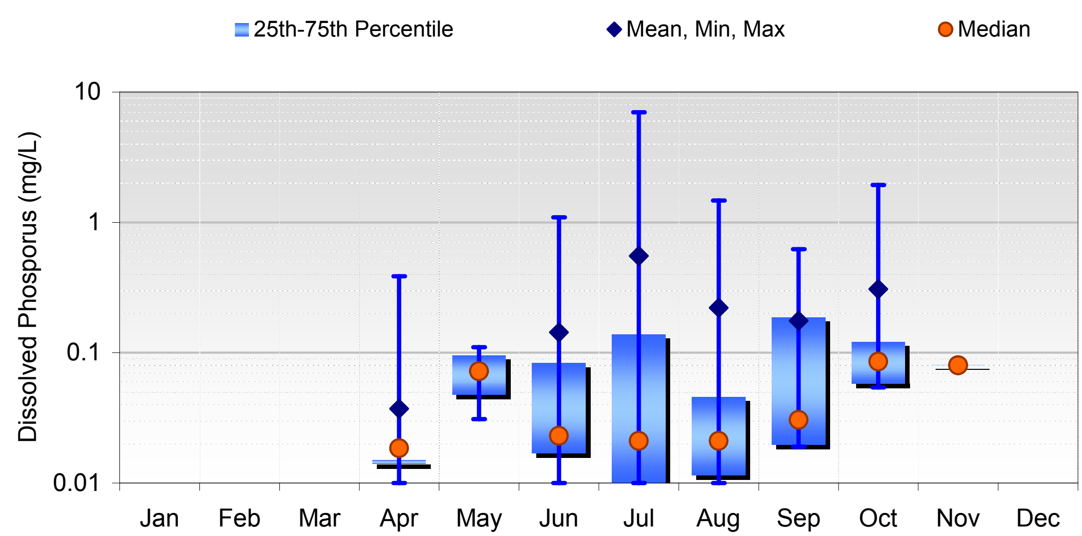

Figure 4-29. Dissolved phosphorus monthly statistics in the Staunton Lake (Segment IL_RJA), 1983–2002.

The proportion of DP to TP is quite variable over the period of record as shown in Figure 4-15. The percentage of DP comprising the TP load ranges from less than five percent to greater than 95 percent. A significant number of observations record dissolved phosphorus contributions greater than 30 percent of the TP.

The monthly percent contribution of DP to TP varies greatly, yet the greatest monthly contributions occur in May and October as illustrated in Figure 4-16. Indeed, the mean DP contribution to TP exceeds 40 percent all months except June.

Figure 4-30. Proportion of dissolved phosphorus in total phosphorus for the Staunton Lake (Segment IL_RJA).

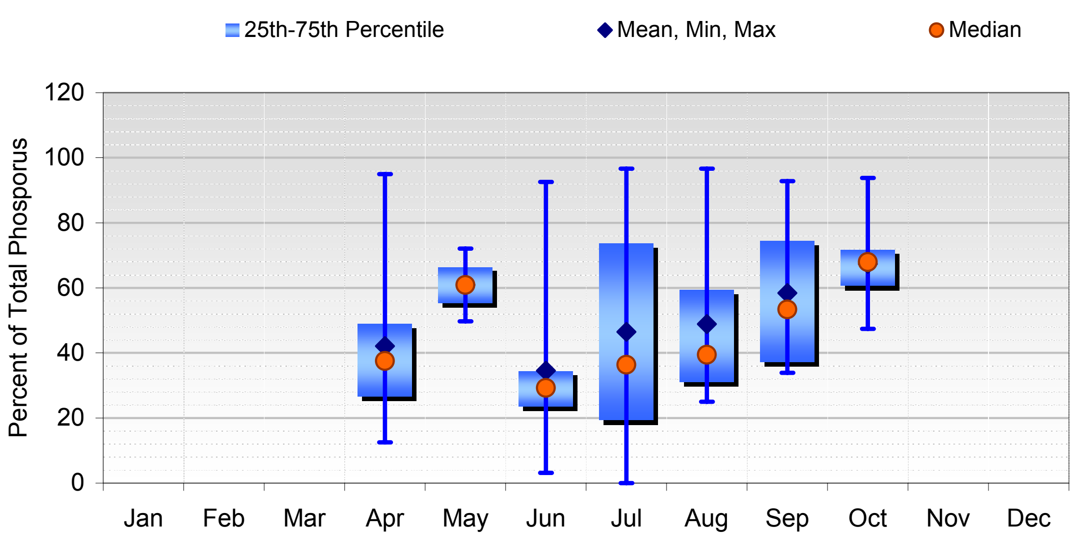

Figure 4-31. Monthly mean and median percentage of dissolved phosphorus comprising total phosphorus for the Staunton Lake (Segment IL_RJA), 1983–2002.

4.5.3.4 Total Nitrogen (TN)-to-Total Phosphorus (TP) Ratio

The importance of the TN:TP ratio is discussed in section 4.5.1.3. The variability of the TN:TP ratios is presented in Figure 4-17, and monthly median and mean TN:TP ratios are shown in Figure 4-18. These figures illustrate that TN:TP ratios are quite variable over the period of record, as well as over the course of a year. Mean TN:TP ratios are greater than 10 for all months, strongly suggesting that phosphorus is the limiting nutrient in the Staunton Lake.

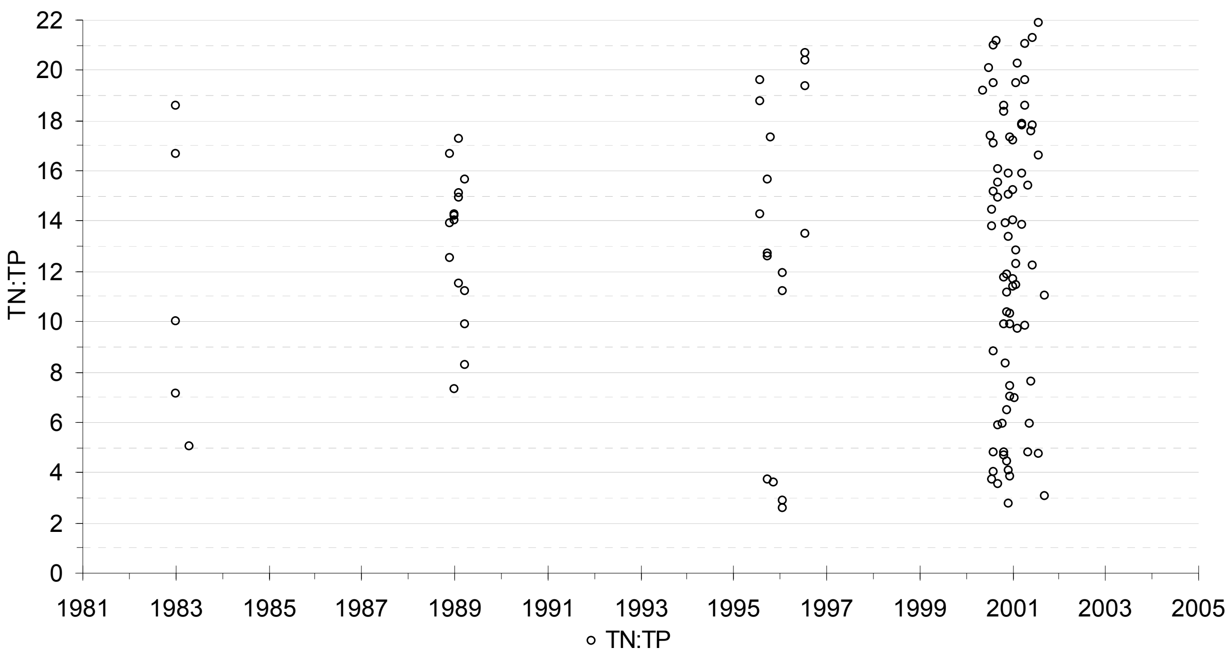

Figure 4-32. TN:TP ratios over the period of record in the Staunton Lake (Segment IL_RJA).

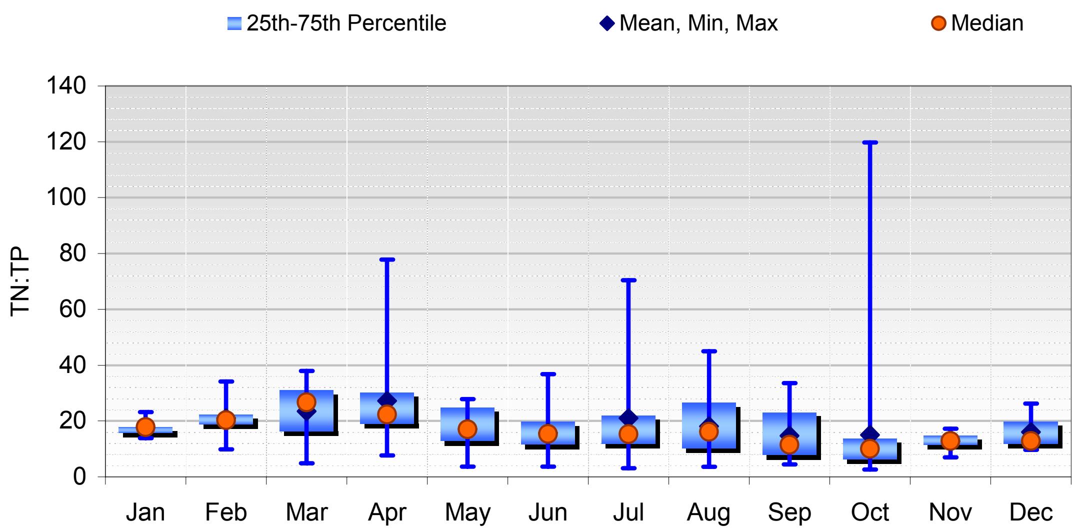

Figure 4-33. Monthly median and mean TN:TP ratios in the Staunton Lake (Segment IL_RJA), 1983–2002.

4.5.3.5 Manganese

The applicable water quality standard for manganese in Illinois lakes is 1000 µg/L. Table 4-21 presents the period of record and a statistical summary for all available manganese observations. Additionally, Figure 4-34 presents a graphical representation of the manganese sampling activity in Staunton Lake. A review of the data reveals that 70 percent of recent samples violated the water quality standard (Table 4-22).

Table 4-21. Summary of manganese sampling for Staunton Lake (Segment IL_RJA).

Parameter	Samples (Count)	Start	End	Minimum (µg/L)	Average (µg/L)	Maximum (µg/L)	CV*
Manganese	10	4/27/2001	10/1/2002	18.00	450.50	1700.00	1.16

*CV = standard deviation/average

Table 4-22. Violations of the manganese standard in Staunton Lake (Segment IL_RJA).

Parameter	Samples (Count)	Violations (Count)	Percent Violating	Samples (Count), 2000 to Present	Violations (Count), 2000 to present	Percent Violating, 2000 to Present
Manganese	10	7	70%	10	7	70%

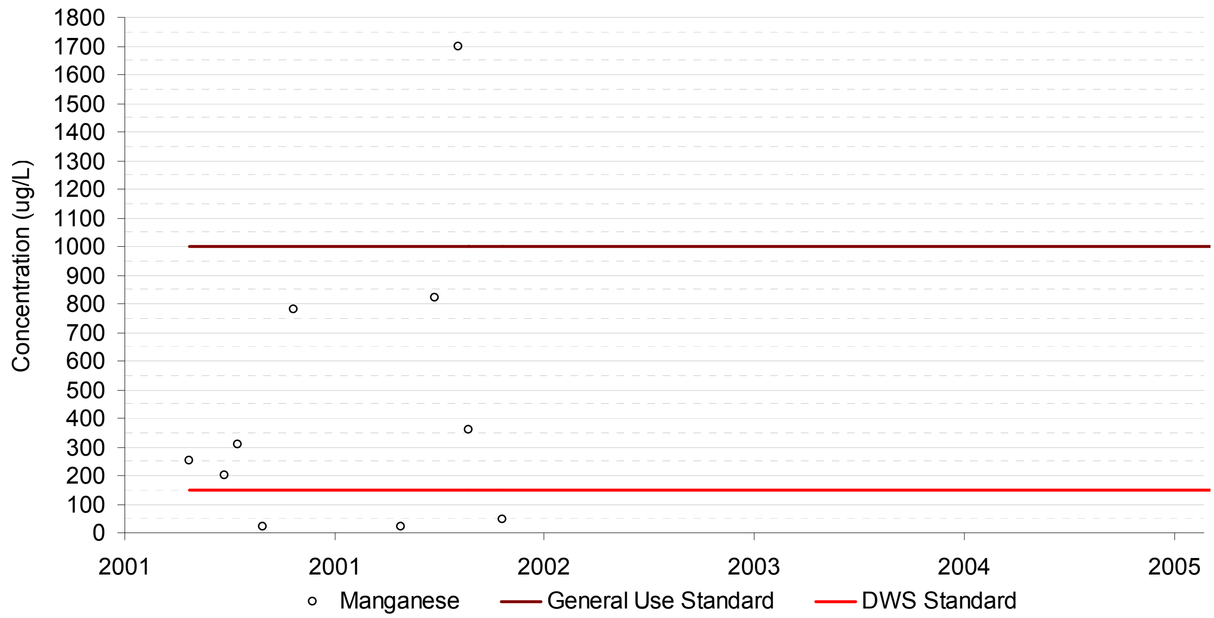

Figure 4-34. Manganese sampling observations in Staunton Lake (Segment IL_RJA).

4.5.4 Potential Pollutant Sources

Both point and nonpoint sources represent potential sources of pollutants in the Staunton Lake watershed is discussed below.

4.5.4.1 Point Source Discharges

A query of the National Pollution Discharge Elimination System (NPDES) database revealed one point source discharger in the Staunton Lake watershed. The White City sewage treatment plant (STP) (NPDES ID: ILG580229) reported monthly total suspended solids (TSS), ammonia, and flow from 1998 to 2004.

4.5.4.2 Nonpoint Sources

Potential nonpoint sources of sediments and nutrients in the Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake watersheds include sheet and rill erosion, lake shoreline erosion, stream channel erosion, fertilizer and pesticide use, failing septic systems, storm water runoff, atmospheric deposition, internal lake recycling, and natural sources.

5 Identification of Data Gaps and Sampling Plan

A review of the Mt. Olive Old Lake data reveals that no recent (data post-1997) total phosphorus data are available to compare to the water quality standard. Limited manganese (4 samples) and atrazine (5 samples) are also available, although they are relatively recent. Based on these considerations it is recommended that Stage 2 sampling be conducted for Mt. Olive Old Lake. In addition, no atrazine data are directly available for Mt. Olive New Lake (the listing is based on raw water intake sampling that includes water from both Mt. Olive New Lake and Mt. Olive Old Lake. Stage 2 sampling of atrazine is therefore recommended for Mt. Olive New Lake.

Water quality sampling in Mt. Olive Old Lake and Mt. Olive New Lake should be conducted at the historical Illinois EPA monitoring stations (Figure 4-1). The lake should be sampled two times a month from April through October. This schedule will capture the expected seasonal variation in water quality parameters related to nutrient and pesticide loading, eutrophication and oxygen-demanding processes. Water samples for Mt. Olive Old Lake should be analyzed to determine concentrations of TP, soluble reactive phosphorus, chlorophyll *a*, nitrate/nitrite nitrogen, total Kjeldahl nitrogen, manganese, and atrazine (Table 5-1). Water samples for Mt. Olive New Lake should be analyzed to determine concentrations of atrazine. In the field, measurements should be made throughout the water column of both lakes to obtain vertical profiles of pH, temperature and dissolved oxygen. Profiles should be collected at additional lake stations if reconnaissance shows vertical profiles vary according to lake location. Secchi depth should also be measured at each lake sampling station. Nutrient samples should be collected at three depths at each station in Mt. Olive Old Lake if stratification is observed. Single mid-depth samples should be collected at each station when the lakes are not stratified. Chlorophyll-a should be measured in a composite sample of water collected within the photic zone, from the water surface to twice the Secchi depth.

Table 5-1. Identification of parameters to be analyzed in Mt. Olive Old Lake.

Parameter	Water column profiles	Lake samples	Tributary	Lake Sediment
Temperature	x			
pH	x			
Dissolved Oxygen	x			
Secchi disk depth	x			
Total Phosphorus		x	x	x
Soluble Reactive P		x	x	
Nitrate/nitrite N		x		
Total Kjeldahl N		x		
Chlorophyll a		x		
TOC				x
Manganese		X		x
Atrazine		x		

Sufficient data are available to proceed with Stage 3 TMDL development for the Mt. Olive New Lake and Staunton Lake manganese and phosphorus impairments. It is recognized that limited manganese data are available for Mt. Olive New Lake (5 samples collected from April through October in 2002). However, the data are recent and detailed modeling of manganese is not expected to be necessary (refer to Section 6.0).

6 Technical Approach

Technical approaches for developing phosphorus and manganese TMDLs for Mt. Olive New Lake and Staunton Lake are presented in this section. Both simple and more advanced technical approaches are presented.

It should be noted that the phosphorus and manganese TMDLs would be linked in that the only controllable source of manganese to the lakes is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to the effects of nutrient enrichment. For this reason, attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.

6.1 Simple Approach

A simple approach to TMDL development for phosphorus and manganese would be to estimate loadings to the lakes using surrogate flow and water quality data from a nearby stream (flows and loads would be pro-rated based on drainage area). The BATHTUB model could then be used to estimate the load reductions necessary to meet the TP target of 0.05 mg/L. BATHTUB performs steady-state water and nutrient balance calculations in a spatially segmented hydraulic network and has previously been used for TMDL development in Illinois.

A simple approach to TMDL development for atrazine would be to estimate the allowable in-lake loads by multiplying the lake volumes by the water quality standard. Existing loads could be calculated based on multiplying the lake volumes by the observed data and the necessary reduction could be based on the difference between the existing and allowable loads. A delivery factor could also be identified from the literature to relate watershed application rates to loads delivered to the lakes. For example, a delivery ratio of 3 percent was used in the West Lake, Iowa TMDL based on research performed at Iowa State University (Baker and Mickelson, 2002).

The advantages of the simple approach are that it would be easy to apply and therefore could be done quickly. The disadvantages are that limited information would be available on the source of pollutants. The impact of excessive algal growth on dissolved oxygen concentrations would also not be simulated using the simple approach.

6.2 Detailed Approach

Under a more detailed approach both a watershed and a lake model would be developed and applied for the TMDLs. The Soil Water Assessment Tool (SWAT) model would be used to estimate watershed loadings, and the LAKE2K model would be used to evaluate conditions in the two lakes. A watershed model would provide the following added information:

1) Help estimate existing inflows to the lakes (due to the lack of flow data).
2) Help estimate existing sediment, nutrient, and atrazine loads to the lakes instead of relying on data from a separate watershed.
3) Provide additional perspective on the relative magnitude of the various sediment, nutrient, and atrazine sources.
4) Assess the potential benefit of various best management practices.

The SWAT model, version 2000A, is proposed for the Mt. Olive New Lake and Staunton Lake watersheds. The SWAT model was designed specifically to address loadings from rural, agriculture dominated watersheds. It is able to predict the impact of land management practices, such as vegetative changes, conservation practices, and groundwater withdrawals, on water quality and sediment. SWAT can analyze large watersheds and river basins (greater than 100 square miles) by subdividing the area into subwatersheds. SWAT simulates hydrology, pesticide and nutrient cycling, erosion and sediment transport.

SWAT is proposed because it:

- models the constituents of concern (TP, nitrate and nitrite, atrazine, and sediments)
- is designed for primarily agricultural watersheds
- provides daily output to link to a lake model
- provides the ability to directly evaluate management practices (such as altering fertilizer application rates, tillage practices, and erosion control structures)
- has been used elsewhere in Illinois for TMDL development
- can incorporate multiple point sources, such as flow from waste water treatment facilities
- has a greater level of acceptance with the agricultural community because it was developed by the U.S. Department of Agriculture, Agricultural Research Service.

The issue of tile drainage will be addressed in the SWAT model by using the model's tile drainage module and making other parameter adjustments to reflect known hydrologic and water quality impacts.

The LAKE2K model could be linked to SWAT output to estimate the load reductions necessary to meet water quality standards. LAKE2K is a model that is designed to compute seasonal trends of water quality in stratified lakes (Chapra and Martin, 2004). A beta version of the model has recently been released and is supported by the U.S. EPA Office of Research and Development. LAKE2K is implemented within the Microsoft Windows environment and uses Microsoft Excel as the graphical user interface. The model requires information on lake elevation, area, volume, inflows, meteorology, and initial water quality conditions. Daily water quality output is provided for three vertical layers (epilminion, metalimnion, and hypolimnion), including daily predictions of TP, dissolved oxygen, and three phytoplankton groups. LAKE2K also includes a sediment diagenesis model for nutrient release during low dissolved oxygen Conditions LAKE2K is recommended because it is sufficiently detailed to provide the output necessary to compare to numeric water quality standards, and yet is not so complex as to require an extensive amount of data to set up and run. It falls between the less complex BATHTUB model and the more rigorous and dataintensive CE-QUAL-W2 or Environmental Fluid Dynamics Code (EFDC) models. A comparison of the BATHTUB and LAKE2K models is provided in Table 6-1.

Table 6-1. Comparison of the BATHTUB and LAKE2K models.

	BATHTUB	**LAKE-2K**
Model Basis	Empirical	Physically -based (complicated water quality kinetics, no hydrodynamics)
Time Step	Steady State	Dynamic
Vertical Segmentation	Depth Averaged	Vertically segmented into 3 layers (each constituent simulated for each layer, epi, meta, hypo)
Longitudinal Segmentation	Spatially segmented network	Cannot represent spatially segmented network (may not be appropriate if data show spatial variablity in the lake)
Chlorophyll-a Simulation	Can only provide seasonal average predictions; unable to evaluate maximums. Cannot simulate more than one species	Able to simulate 3 types of phytoplankton.
DO Simulation	Meta and Hypolimnetic Depletion Rate	Predicts for each vertical layer
Sediment Diagenisis	No	Yes
Predictive Capability/Scenario Testing	Short-term responses and effects related to structural modifications or responses to variables other than nutrients cannot be evaluated	Represents whole-lake as one box. Model may not be predictive of local impacts due to loadings or in-lake management measures are to be evaluated

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Appendix A: Illinois GAP Land Cover Description

Table A-1. Values and class names in the Illinois Gap Analysis Project Land Cover 1999-2000 Arc/Info GRID coverage.

GRID VALUE	LAND COVER CATEGORY
	AGRICULTURAL LAND
11	Corn
12	Soybeans
13	Winter Wheat
14	Other Small Grains and Hay
15	Winter Wheat/Soybeans
16	Other Agriculture
17	Rural Grassland
	FORESTED LAND
22	Dry Upland
23	Dry-Mesic Upland
24	Mesic Upland
25	Partial Canopy/Savannah Upland
26	Coniferous
	URBAN LAND
31	High Density
32	Low/Medium Density (excluding TM Scene 2331)
33	Medium Density (TM Scene 2331)
34	Low Density (TM Scene 2331)
35	Urban Open Space
	WETLAND
41	Shallow Marsh/Wet Meadow
42	Deep Marsh
43	Seasonally/Temporarily Flooded
45	Mesic Floodplain Forest
46	Wet-Mesic Floodplain Forest
47	Wet Floodplain Forest
48	Swamp
49	Shallow Water
	OTHER
51	Surface Water
52	Barren and Exposed Land
53	Clouds
53	Cloud Shadows

Appendix B: Water Quality Data for the Sugar Creek Watershed

<<Attached Electronically on CD>>

Final Approved TMDL

Mt. Olive New Lake (RJF)

Mt. Olive Old Lake (RJG)

Staunton Lake (RJA)

Prepared for: **Illinois Environmental Protection Agency**

August 2007

Mt. Olive New Lake (RJF): Total Phosphorus, Atrazine, Manganese

Mt. Olive Old Lake (RJG): Total Phosphorus, Atrazine, Manganese

Staunton Lake (RJA): Manganese

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ATTACHMENTS

EXECUTIVE SUMMARY

Section 303(d) of the 1972 Clean Water Act requires States to define impaired waters and identify them on a list, which is referred to as the 303(d) list. The State of Illinois 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).

Mt. Olive Old Lake, Mt. Olive New Lake, and Staunton Lake are listed on the 2006 Illinois Section 303(d) List of Impaired Waters (IEPA, 2006) as waterbodies that are not meeting their designated uses. As such, these lakes have been targeted as high priority waters for TMDL development. This document presents the TMDLs designed to allow these three lakes to fully support their designated uses. The report covers each step of the TMDL process and is organized as follows:

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

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1. PROBLEM IDENTIFICATION

The three 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 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 Table 1 in bold font.

Table 1. Summary of Impairment Causes and Sources (IEPA, 2006)

Segment (Area)	Name	Designated Uses	Causes of Impairment
IL_RJF (47.8 acres)	Mt. Olive New Lake	Aesthetic Quality	**Phosphorus (Total)**
			Total Suspended Solids (TSS)
		Public Water Supplies	**Atrazine**
			Manganese
IL_RJG (32.5 acres)	Mt. Olive Old Lake	Aesthetic Quality	**Phosphorus (Total)**
			Total Suspended Solids (TSS)
		Public Water Supplies	**Atrazine**
			Manganese
IL_RJA (78.8 acres)	Staunton Lake	Public Water Supply	**Manganese**

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2. REQUIRED TMDL ELEMENTS

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

Mt. Olive New Lake

1. **Identification of Waterbody, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Mt. Olive New Lake, HUC 0714010101. The pollutants of concern addressed in the Mt. Olive New Lake TMDL are manganese, total phosphorus, and atrazine. Pollutant sources of phosphorus include runoff from lawns and agricultural lands (fertilized cropland and agricultural land with livestock), failing private sewage disposal systems (septic and surface discharge systems), and release from lake bottom sediments under hypolimnetic anoxic conditions. Pollutant sources for manganese are natural background sources including runoff and soil erosion, and release from lake bottom sediments under hypolimnetic anoxic conditions. Pollutant sources of atrazine include runoff from agricultural lands (cropland). Mt. Olive New Lake is ranked high priority on the 2006 Illinois EPA 303(d) list.

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for phosphorus to protect the aesthetic quality use in Illinois lakes is 0.05 mg-P/l. For the Mt. Olive New Lake TMDL, the numeric target was set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

   The water quality standard for manganese in Illinois waters designated as public water supply is 150 ug/l, and the general use standard is 1,000 ug/l. The primary source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, release from the lake sediments is considered a controllable source, and attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese and phosphorus is therefore set as a total phosphorus concentration of 0.05 mg-P/L.

   The water quality standard for atrazine in Illinois waters designated as public water supply is 3.0 ug/l, and the general use standard is 82.0 ug/L for acute exposure and 9.0 ug/L for chronic exposure. Mt. Olive New Lake is designated for drinking water supply and the TMDL target was set at the 3.0 ug/l atrazine criteria.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the average allowable phosphorus load that will meet the 0.05 mg-P/l water quality target is 0.87 kg/day between April and August, with the total load not to exceed 133 kg over this period. This corresponds to a 67 percent reduction of existing tributary loads. The same allowable loads are applied to meet the manganese water quality goal.

   A loading capacity calculation was completed to determine the maximum atrazine loads that will maintain compliance with the atrazine target under a range of flow conditions:

Flow (cfs)	Allowable Load (lbs/day)
0.07	0.0011
0.70	0.0113
3.50	0.0566
7.00	0.1133
14.00	0.2265
35.00	0.5663
70.00	1.1327
140.00	2.2653
350.00	5.6633

4. **Load Allocations (LA):** Load allocations are described below.

   The phosphorus load allocation given to non-point source loads from watershed sources is 0.78 kg/day between April and August.

   The load allocation designed to achieve compliance with the atrazine TMDL is:

Flow (cfs)	Load allocation (lbs/day)
0.07	0.0010
0.70	0.0102
3.50	0.0510
7.00	0.1019
14.00	0.2039
35.00	0.5097
70.00	1.0194
140.00	2.0388
350.00	5.0970

5. **Wasteload Allocations (WLA):** No point sources of manganese, phosphorus, or atrazine exist in the Mt. Olive New watershed, so wasteload allocations do not need to be calculated.

6. **Margin of Safety:** Both explicit and implicit margins of safety were incorporated into this TMDL as described below.

   The phosphorus and manganese TMDLs contain an explicit margin of safety (MOS) corresponding to 10% of the loading capacity, which equals 0.087 kg/day. This value was set to reflect the uncertainty in the BATHTUB model.

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

Flow (cfs)	MOS (lbs/day)
0.07	0.0001
0.70	0.0011
3.50	0.0057
7.00	0.0113
14.00	0.0227
35.00	0.0566
70.00	0.1133
140.00	0.2265
350.00	0.5663

7. **Seasonal Variation:** Seasonal variation is considered within the TMDL as described below:

   The phosphorus and manganese TMDLs were conducted with an explicit consideration of seasonal variation for phosphorus. The BATHTUB model used for this TMDL is designed to evaluate seasonal to annual loads. Model results indicate that the phosphorus residence time in Mt. Olive New Lake is one to three months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

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

8. **Reasonable Assurances:** There are no permitted point sources in the Mt. Olive New Lake watershed, so reasonable assurances for point sources are not discussed. In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:

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

9. **Monitoring Plan to Track TMDL Effectiveness:** Ongoing IEPA lake monitoring activities are sufficient to determine the effectiveness of the TMDL implementation program at restoration of designated uses.

10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.

11. **Public Participation:** A public meeting was held on Tuesday, April 25, 2006 to present the findings of the Stage 1 report. A second public meeting was held on July 17, 2007 within the watershed to present the TMDLs in this report. At this same meeting, the implementation plan was also presented.

Mt. Olive Old Lake

1. **Identification of Water body, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Mt. Olive Old Lake, HUC 0714010101. The pollutants of concern addressed in the Mt. Olive Old Lake TMDL are manganese, total phosphorus, and atrazine. Pollutant sources of phosphorus include runoff from lawns and agricultural lands (fertilized cropland and agricultural land with livestock), failing private sewage disposal systems (septic and surface discharge systems), and release from lake bottom sediments under hypolimnetic anoxic conditions. Pollutant sources for manganese are natural background sources including runoff and soil erosion, and release from lake bottom sediments under hypolimnetic anoxic conditions. Pollutant sources of atrazine include runoff from agricultural lands (cropland). Mt. Olive Old Lake is ranked high priority on the 2006 Illinois EPA 303(d) list.

2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for phosphorus to protect the aesthetic quality use in Illinois lakes is 0.05 mg-P/l. For the Mt. Olive Old Lake TMDL, the numeric target was set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

   The water quality standard for manganese in Illinois waters designated as public water supply is 150 ug/l, and the general use standard is 1,000 ug/l. The primary source of manganese to the lake is the release of manganese from lake sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, release from the lake sediments is considered a controllable source, and attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese and phosphorus is therefore set as a total phosphorus concentration of 0.05 mg-P/L.

The water quality standard for atrazine in Illinois waters designated as public water supply is 3.0 ug/l, and the general use standard is 82.0 ug/L for acute exposure and 9.0 ug/L for chronic exposure. Mt. Olive New Lake is designated for drinking water supply and the TMDL target was set at the 3.0 ug/l atrazine criteria.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the average allowable phosphorus load that will meet the 0.05 mg-P/l water quality target is 0.18 kg/day between April and August, with the total load not to exceed 27 kg over this period. This corresponds to an 80 percent reduction of existing tributary loads. The same allowable loads are applied to meet the manganese target.

   A loading capacity calculation was completed to determine the maximum atrazine loads that will maintain compliance with the atrazine target under a range of flow conditions:

Flow (cfs)	Allowable Load (lbs/day)
0.01	0.0002
0.10	0.0016
0.50	0.0081
1.00	0.0162
2.00	0.0324
5.00	0.0809
10.00	0.1618
20.00	0.3236
50.00	0.8090

4. **Load Allocations (LA):** Load allocations are described below:

   Phosphorus

   The phosphorus load allocation given to non-point source loads from watershed sources is 0.16 kg/day between April and August.

   The atrazine load allocation designed to achieve compliance with the atrazine TMDL is:

Flow (cfs)	Load allocation (lbs/day)
0.01	0.000146
0.10	0.001456
0.50	0.007281
1.00	0.014563
2.00	0.029126
5.00	0.072814
10.00	0.145629
20.00	0.291257
50.00	0.728143

5. **Waste load Allocations (WLA):** No point sources of manganese, phosphorus, or atrazine exist in the Mt. Olive Old watershed, so wasteload allocations do not need to be calculated.

6. **Margin of Safety:** Both explicit and implicit margins of safety were incorporated into this TMDL as described below.

   The phosphorus and manganese TMDLs contain an explicit margin of safety (MOS) corresponding to 10% of the loading capacity. For the phosphorus and manganese TMDLs, this corresponds to 0.018 kg P/day. This value was set to reflect the uncertainty in the BATHTUB model predictions.

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

Flow (cfs)	MOS (10%) (lbs/day)
0.01	0.00002
0.10	0.00016
0.50	0.00081
1.00	0.00162
2.00	0.00324
5.00	0.00809
10.00	0.01618
20.00	0.03236
50.00	0.08090

7. **Seasonal Variation:** Seasonal variation is considered within the TMDL as described below:

The phosphorus and manganese TMDLs were conducted with an explicit consideration of seasonal variation. The BATHTUB model used for this TMDL is designed to evaluate seasonal to annual loads. Model results indicate that the phosphorus residence time in Mt. Olive Old Lake is one to three months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

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

8. **Reasonable Assurances:** There are no permitted point sources in the Mt. Olive Old Lake watershed, so reasonable assurances for point sources are not discussed. In terms of reasonable assurances for nonpoint sources, Illinois EPA is committed to:
   - Convene local experts familiar with nonpoint sources of pollution in the watershed
   - Ensure that they define priority sources and identify restoration alternatives
   - Develop a voluntary implementation plan that includes accountability.
9. **Monitoring Plan to Track TMDL Effectiveness:** Ongoing IEPA lake monitoring activities are sufficient to determine the effectiveness of the TMDL implementation program at restoration of designated uses.
10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.
11. **Public Participation:** A public meeting was held on Tuesday, April 25, 2006 to present the findings of the Stage 1 report. A second public meeting was held on July 17, 2007 within the watershed to present the TMDLs in this report. At this same meeting, the implementation plan was also presented.

Staunton Lake

1. **Identification of Water body, Pollutant of Concern, Pollutant Sources, and Priority Ranking:** Staunton Lake, HUC 0714010101. The pollutant of concern addressed in this TMDL for Staunton Lake is manganese. Pollutant sources for manganese are natural background sources including runoff and soil erosion, and release from sediments under hypolimnetic anoxic conditions. Staunton Lake is ranked high priority on the 2006 Illinois EPA 303(d) list.
2. **Description of Applicable Water Quality Standards and Numeric Water Quality Target:** The water quality standard for manganese in Illinois waters designated as public water supply is 150 ug/l, and the general use standard is 1,000 ug/l. The primary source of manganese to the lake is the release of

manganese from lake bottom sediments during periods when there is no dissolved oxygen in lake bottom waters. The lack of dissolved oxygen in lake bottom waters is presumed to be due to the effects of nutrient enrichment, as there are no significant sources of oxygen demanding materials to the lake. For this reason, release from the lake sediments is considered a controllable source, and attainment of the total phosphorus standard is expected to result in oxygen concentrations that will reduce sediment manganese flux to natural background levels. The TMDL target for manganese is therefore set as a total phosphorus concentration of 0.05 mg-P/l.

3. **Loading Capacity – Linking Water Quality and Pollutant Sources:** The water quality model BATHTUB was applied to determine that the average allowable phosphorus load that will meet the 0.05 mg-P/l water quality target is 0.81 kg P/day between April and August, with the total load not to exceed 123 kg over this period. This corresponds to a 66 percent reduction of existing tributary loads.

4. **Load Allocations (LA):** The phosphorus load allocation given to non-point source loads from watershed sources is 0.629 kg P/day between April and August.

5. **Waste load Allocations (WLA):** The White City Sewage Treatment Facility (WCSTP) is the sole NPDES permitted point source discharge in the watershed. The WLA was set at estimated existing loading conditions of 0.1 kg P/day.

6. **Margin of Safety:** The TMDL contains an explicit margin of safety corresponding to 10% of the loading capacity, or 0.081 kg P/day. This value was set 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 this TMDL is designed to evaluate seasonal to annual loads. Model results indicate that the phosphorus residence time in Staunton Lake is one to three months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

8. **Reasonable Assurances:** In terms of reasonable assurances for point sources, Illinois EPA administers the NPDES permitting program for treatment plants, storm water permitting and CAFO permitting. The permits for the sole point source discharger in the watershed will be modified if necessary as part of the permit review process (typically every 5 years), to ensure that it is consistent with the applicable waste load allocation.

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

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

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

9. **Monitoring Plan to Track TMDL Effectiveness:** Ongoing IEPA lake monitoring activities are sufficient to determine the effectiveness of the TMDL implementation program at restoration of designated uses.

10. **Transmittal Letter:** A transmittal letter accompanies the final TMDL report.

11. **Public Participation:** A public meeting was held on Tuesday, April 25, 2006 to present the findings of the Stage 1 report. A second public meeting was held on July 17, 2007 within the watershed to present the TMDLs in this report. At this same meeting, the implementation plan was also presented.

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3. WATERSHED CHARACTERIZATION

The Stage 1 Report (TetraTech, 2006) presents and discusses information describing the watersheds of the impaired water bodies to support the identification of sources contributing to manganese, total phosphorus, and atrazine impairments, as applicable. 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 water bodies addressed in this report are located within the Cahokia watershed, which is located in southwest Illinois. The majority of the watershed is in Macoupin County, with a small portion extending into southwestern Montgomery County. Figure 1 shows a map of the watershed, and includes key features such as waterways, impaired water bodies, and public water intakes.

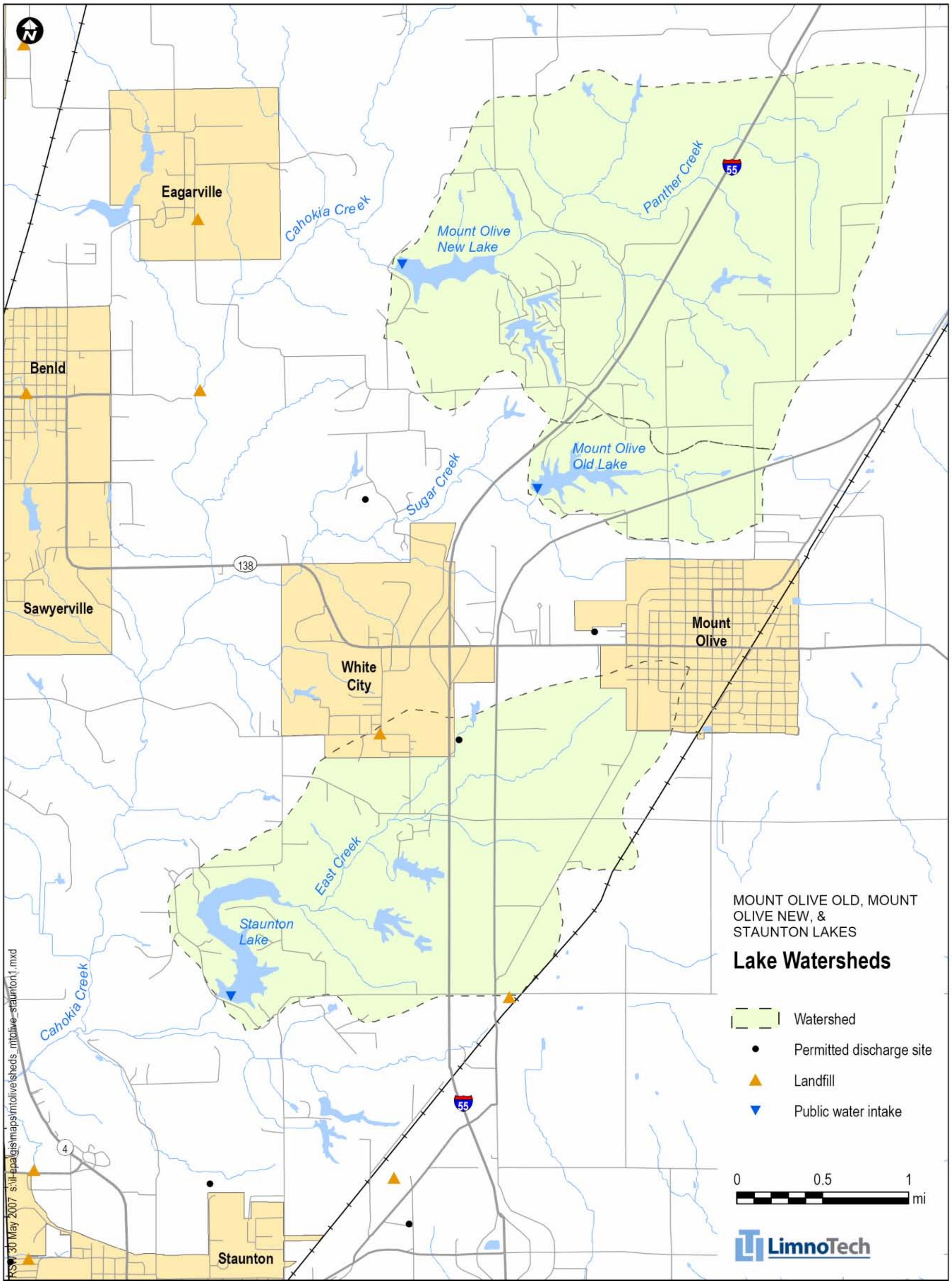

Figure 1. Base Map of Mt. Olive Old Lake, Mt. Olive New Lake and Staunton Lake Watershed

4. DESCRIPTION OF APPLICABLE STANDARDS AND NUMERIC TARGETS

A water quality standard includes the designated uses of the water body, water quality criteria to protect designated uses, and an anti-degradation policy to maintain and protect existing uses and high quality waters. This section discusses the applicable designated uses, use support, and criteria for Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake.

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 water bodies), 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 manganese, total phosphorus, and atrazine in the CWA Section 305(b) program, as summarized below. A comparison of available water quality data to these criteria is provided in the Stage 1 Report (TetraTech 2006).

4.2.1 Manganese

Mt. Olive Old Lake, Mt. Olive New Lake and Staunton Lake are all designated for drinking water supply. The water quality standard for manganese in Illinois waters designated as public and food processing water supplies is 150 ug/l. The public and food processing water supply guideline for inland lakes indicates impairment if more than 10% of the observations measured since 1999 exceed 150 ug/L.

4.2.2 Total Phosphorus

The IEPA guidelines (IEPA, 2006) for identifying total phosphorus as a cause of impairment in lakes greater than 20 acres in size, state that phosphorus is a potential cause of impairment of the aesthetic quality use if there is at least one exceedance of the applicable standard (0.05 mg-P/L) during the most recent year of data from the Ambient Lake Monitoring Program or the Illinois Clean Lakes Program.

4.2.3 Atrazine

The IEPA guidelines (IEPA, 2006) for identifying atrazine as a cause of impairment in lakes, state that atrazine is a potential cause of impairment of the public and food processing water supply use if: greater than 10% of observations in untreated water exceed the 3.0 ug/l criteria for water samples collected in 1999 or later and for which results are readily available; or if at least one violation of the 3.0 ug/l Maximum Contaminant Level (MCL) occurs during the most recent three years of readily available data; or if the public water supply uses a treatment approach, beyond conventional, without which a violation of at least one Maximum Contaminant Level (3.0 ug/l for atrazine) is expected during the most recent three years of readily available data.

4.3 DEVELOPMENT OF TMDL TARGETS

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

4.3.1 Manganese

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

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

4.3.2 Total Phosphorus

For the Mt. Olive Old Lake, Mt. Olive New Lake and Staunton Lake phosphorus TMDLs, the target is set at the water quality criterion for total phosphorus of 0.05 mg-P/l.

4.3.3 Atrazine

For the Mt. Olive New Lake and Mt. Olive Old Lake atrazine TMDLs, the target is set at the water quality criterion for atrazine of 3.0 ug/L.

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5. DEVELOPMENT OF WATER QUALITY MODELS

Water quality models are used to define the relationship between pollutant loading and the resulting water quality. The TMDLs for phosphorus and manganese are based upon the BATHTUB model. The TMDL for atrazine applies a loading capacity approach. The development of the BATHTUB model and loading capacity approach are described in the following sections, including information on:

- Model selection
- Modeling approach
- Model inputs
- Model calibration

5.1 BATHTUB MODEL

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

5.1.1 Model Selection

A discussion of the model selection process for the Mt. Olive New, Mt. Olive Old, and Staunton Lake watersheds is provided in the Stage 1 Report. Of the models discussed, the BATHTUB model was selected for application to all three lakes to develop the phosphorus and manganese TMDLs.

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

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

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

5.1.2 Modeling Approach

This approach for 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 Mt. Olive New and Old 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 all three watersheds is agriculture. This level of load reduction is likely not attainable in the near future, if at all. Implementation plans for agricultural sources will require voluntary controls, applied on an incremental basis. The approach taken for these TMDLs, which requires no additional data collection and can be conducted immediately, will expedite these implementation efforts.

5.1.3 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

5.1.3.a Model Options

BATHTUB provides a multitude of model options to estimate nutrient concentrations in a reservoir. Model options were entered as shown in Table 2 for Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake, with the rationale for these options discussed below. No conservative substance was simulated for any of the lakes, so this option was not needed. The second order available phosphorus option was selected for phosphorus in all three lakes, as it is the default option for BATHTUB. Nitrogen was not simulated in any of the lakes, 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 all three lakes, which is the default approach in BATHTUB for defining mixing between lake segments. Phosphorus calibrations were based on lake concentrations for all three lakes. No nitrogen calibration was required. The use of availability factors was not required for any of the lakes, and estimated concentrations were used to generate mass balance tables for all three lakes.

Table 2. BATHTUB Model Options for Mt. Olive New Lake, Mt. Olive Old Lake and Staunton 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

5.1.3.b 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 long as the nutrient residence time. 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 all three lakes was calculated as one to two months. Therefore, the averaging period used for this analysis was set to the seasonal period April – August for all three lakes.

Precipitation inputs were taken from the observed long term April - August precipitation data. This resulted in precipitation inputs of 16 inches for all three lakes. Evaporation was set equal to precipitation and there was no assumed increase in storage during the modeling period for either lake, to represent steady state conditions. The values selected for precipitation and change in lake levels have little influence on model predictions. Atmospheric phosphorus loads were specified using default values provided by BATHTUB (30 mg-P/m^2/yr).

5.1.3.c 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 three lakes were designed to provide one segment for each of the primary lake sampling stations. All three of the lakes were divided into three sections as shown in Figures 2, 3 and 4. The area of each segment was determined using a Geographic Information System (GIS).

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, while segment lengths and surface areas were calculated via GIS. Available dissolved oxygen data were used to calculate the depth of the thermocline during periods of stratification. Rapid changes in summer DO with depth indicate incomplete mixing of the surface and bottom layers due to thermal stratification. A complete listing of all segment-specific inputs is provided in Attachments 1, 2 and 3 for the three lakes.

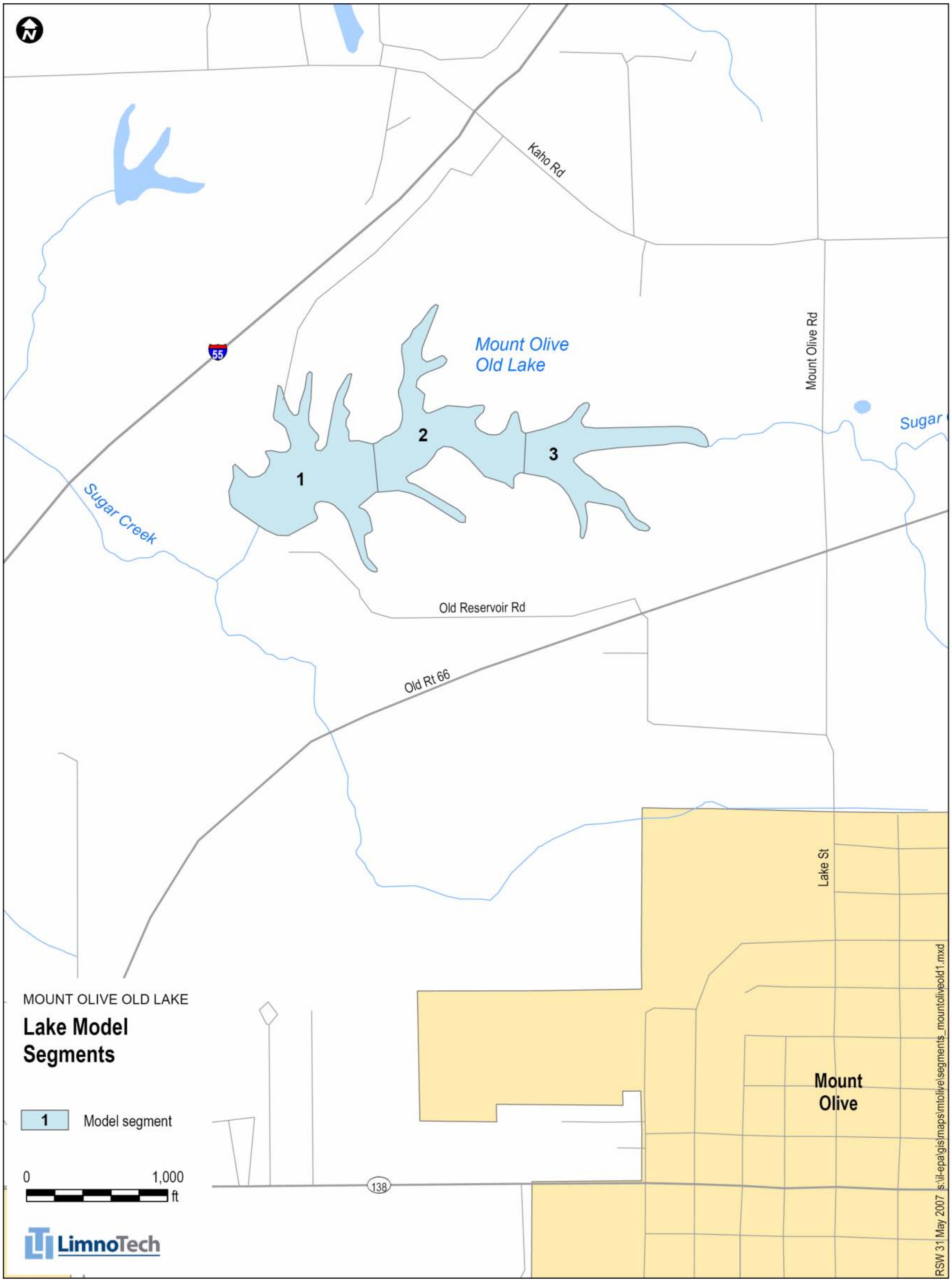

Figure 2. Mt. Olive New Lake Segmentation Used in BATHTUB

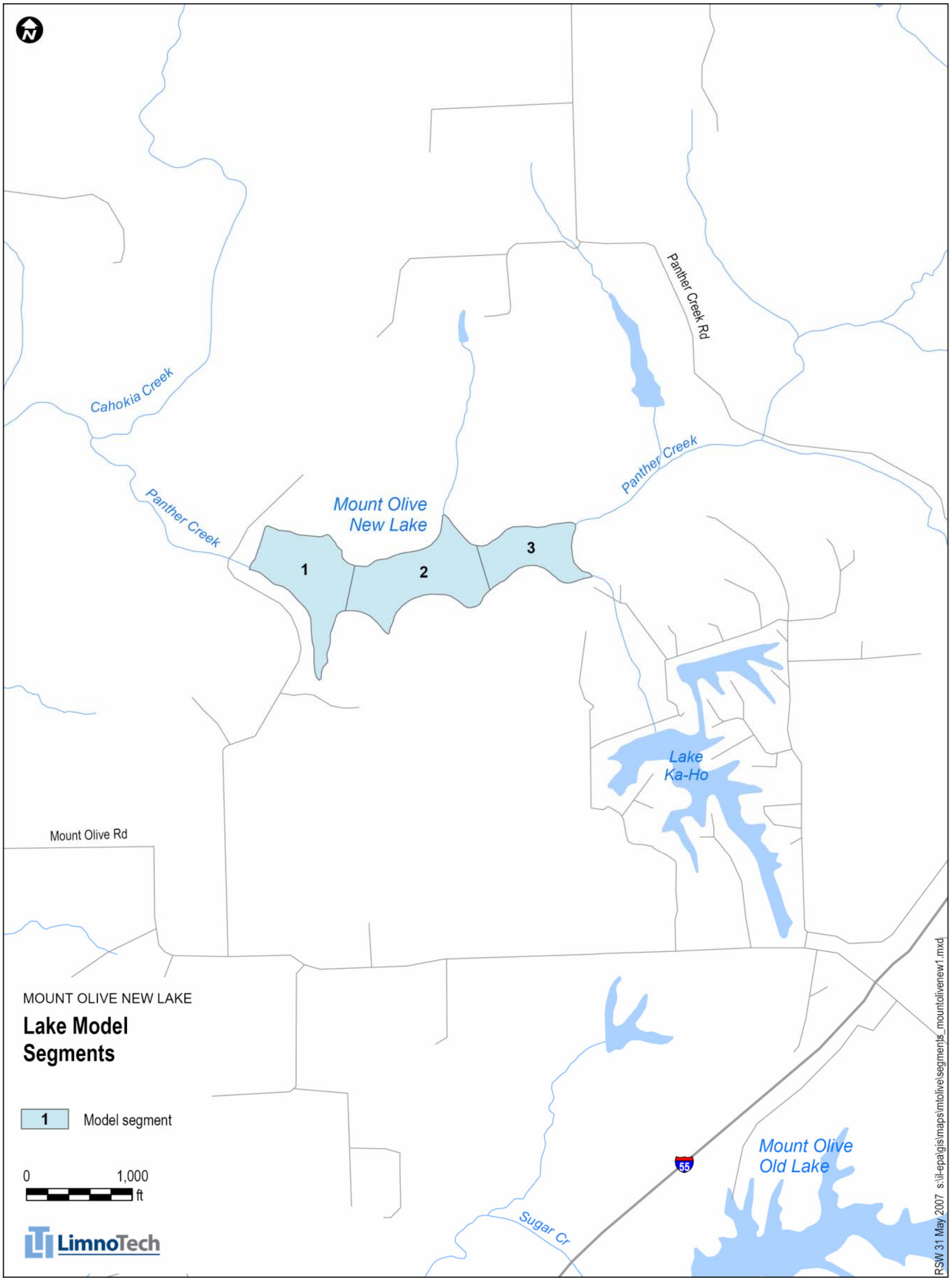

Figure 3. Mt. Olive Old Lake Segmentation Used in BATHTUB

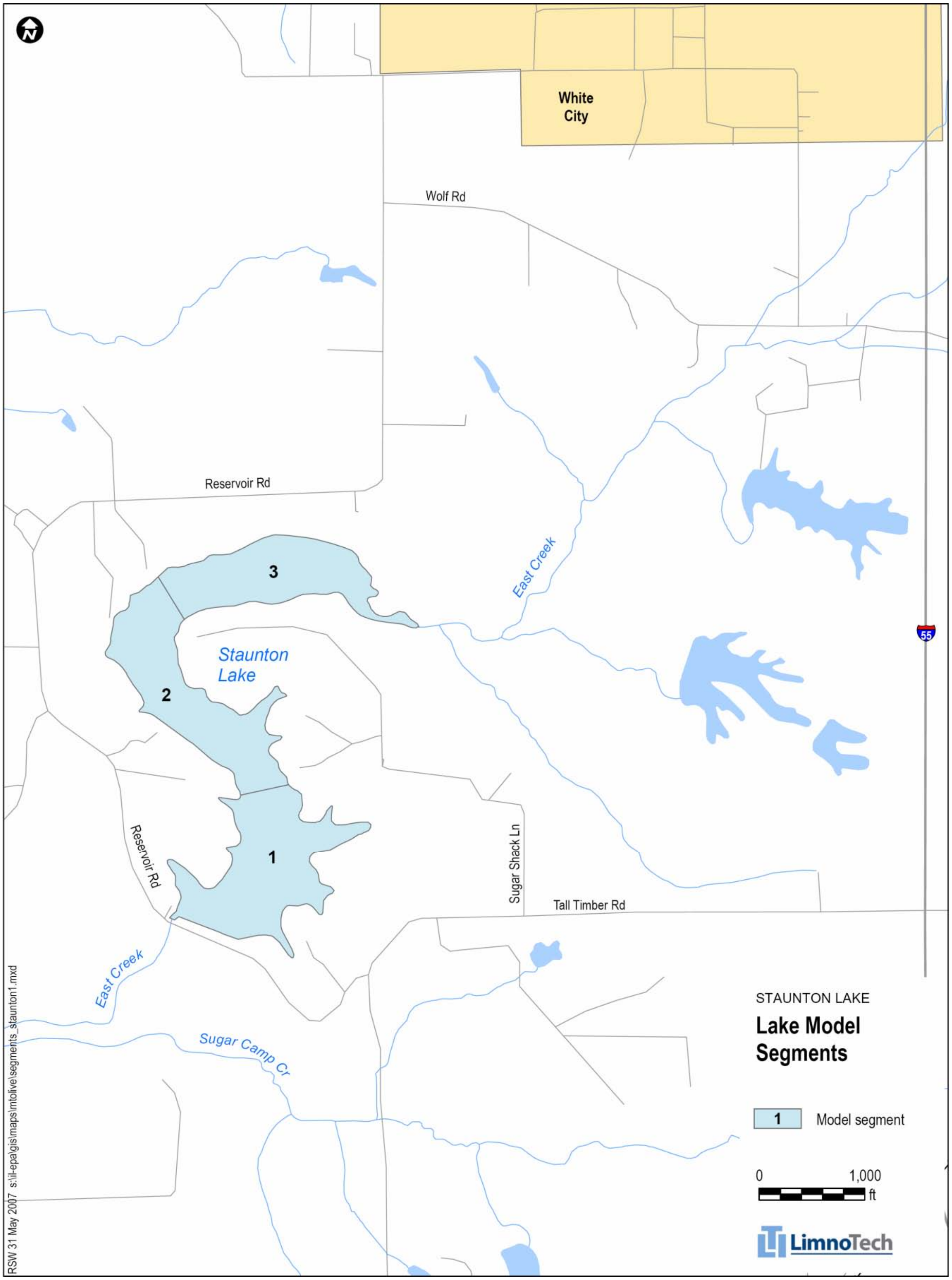

Figure 4. Staunton Lake Segmentation Used in BATHTUB

5.1.3.d Tributary Loads

Due to the nature of the watersheds for each lake, all inflows were input at the head of the lake. BATHTUB requires tributary flow and nutrient concentrations for each reservoir segment. Flows to each segment were estimated using the average of the observed flows at two nearby USGS gaging stations: East Fork of Shoal Creek (05593900), and Spring Creek (05577500). These were selected because they were the most similar in terms of watershed size and land use and were located nearby. Flows into each lake segment were calculated through the use of drainage area ratios as follows:

Flow into segment = Average flow at USGS gages over the April to August period x Segment-specific drainage area ratio

$$\text{Drainage area ratio} = \frac{\text{Drainage area of watershed contributing to the lake}}{\text{Drainage area of watershed contributing to USGS gages}}$$

Drainage area ratios were calculated via information obtained from GIS.

Total phosphorus concentrations for each major lake tributary were based upon springtime measurements taken near the headwaters of each lake. A complete listing of all flows and tributary concentrations is provided in the Stage 1 report.

5.1.3.e Point Source Loads

There is one permitted point source discharger in the Staunton Lake watershed (White City STP) which serves less than 200 people within the village limits of White City, IL. Flow records for the plant (available from the EPA PCS system) reveal that the plant only discharges 1 to 3 months of the year. If it is conservatively assumed that the STP discharges at design capacity (0.0252 MGD) for three full months with an effluent concentration of 4 mg/l, then the plant contributes less than 1% of the total phosphorus load to the lake. This facility was not included as a direct load of phosphorus to the lake due to its negligible contribution.

5.1.4 BATHTUB Calibration

BATHTUB model calibration consists of:

1. Applying the model with all inputs specified as above

2. Comparing model results to observed phosphorus data

3. Adjusting model coefficients to provide the best comparison between model predictions and observed phosphorus data.

Separate discussions of the BATHTUB model calibration for Mt Olive New Lake, Mt. Olive Old Lake, and Staunton Lake are provided below. 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 Attachments 1, 2 and 3.

5.1.4.a Mt. Olive New Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2002 were used for calibration purposes, as this year provided the most robust data set. Phosphorus data from 1997 were used as confirmation of model calibration. The observed total phosphorus lake data from August were used for calibration, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was first calibrated to match the observed reservoir-average total phosphorus concentrations. The default calibration coefficients in BATHTUB provided an acceptable fit to the observed data in segments 1 and 2, and no additional calibration activities were required. Model results in segment 3 initially under-predicted the observed phosphorus data. Phosphorus loss rates in BATHTUB rates reflect a typical “net settling rate” (i.e. settling – sediment release) observed in 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 via the addition of an internal phosphorus load of 600 mg/m^2/day in segment 3. The resulting predicted lake average (area-weighted mean) total phosphorus concentration was 481 ug/l, compared to an observed average (area-weighted mean) of 479 ug/l in August 2002.

5.1.4.b Mt. Olive Old Lake

The BATHTUB model was initially applied with the model inputs as specified above. The average of observed data from 1997 were used to develop model inputs. The average August observed lake data were used for calibration purposes, as these data best reflect the steady state conditions assumed for the BATHTUB model.

BATHTUB was calibrated to match the observed reservoir-average total phosphorus concentrations. An internal sediment phosphorus load of 15 mg/m^2/day was added to model segments 1 and 2, and an internal load of 900 mg/m^2/day was added to segment 3 to provide the best comparison between model predictions and observed data. The resulting predicted lake average (area-weighted mean) total phosphorus concentration was 487 ug/l, compared to an observed average (area-weighted mean) of 484 ug/l.

5.1.4.c Staunton Lake

The BATHTUB model was initially applied with the model inputs as specified above. Observed data for the year 2001 and 2002 were used for calibration purposes, as these years provided the most robust 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 calibrated to match the observed reservoir-average total phosphorus concentrations. An internal sediment phosphorus load of 80 mg/m^2/day was added to model segment 3 to provide the best comparison between model predictions and observed data. The resulting predicted lake average (area-weighted mean) total phosphorus concentration was 150 ug/l, compared to an observed average (area-weighted mean) of 152 ug/l.

5.2 LOADING CAPACITY ANALYSIS - ATRAZINE

A loading capacity approach was used in the atrazine analysis for Mt. Olive Old Lake and Mt. Olive New Lake. A loading capacity analysis defines the maximum allowable pollutant load that will result in compliance with water quality standards over the entire range of flow conditions. The loading capacity analysis also provides information to aid in establishing the level of implementation needed, by showing the magnitude by which existing loads exceed standards.

5.2.1 Model Selection

A detailed discussion of the model selection process for Mt. Olive New and Mt. Olive Old Lakes is provided in the Stage 1 Report. The loading capacity analysis (a component of the load-duration curve approach) was selected because it is a simpler approach that can be supported with the available data and still support the selected level of TMDL implementation for this TMDL.

Atrazine is a herbicide that is weakly adsorbed to soils and is very persistent in the environment. These characteristics allow it to be easily washed off of agricultural fields, remain dissolved in surface waters, and degrade slowly in lakes and reservoirs. From a mass balance standpoint, the only mechanisms that can reduce atrazine concentrations in a lake over a reasonable time frame are dilution and washout (outflow).

The amount of atrazine that enters the lake in any given year is a function of the amount applied to fields within the watershed, the method of application, soil type and conditions at time of application, rainfall intensity and duration, and the timing of rainfall. The hydraulic residence time of the reservoir will determine how fast the reservoir can recover from a rapid influx of atrazine during peak application periods (primarily in the spring months). A large rain event following atrazine application may wash a substantial amount of atrazine into a reservoir, but it may be washed out of the reservoir rather quickly if another large rain event occurs.

Monitoring data from 2003 to 2004 at the raw water intake for the Mt. Olive water treatment plant (Figure 5) clearly shows the characteristic wash-in of atrazine in June of 2003 and the subsequent washout over the next several months. Discussions with the operator of the plant indicated that spring 2003 was a “wet” spring and most farmers in the area planted corn. This would lead to a larger than usual application of atrazine during spring 2003. In 2004, planting of corn was less and it is assumed that atrazine application rates were less. A smaller peak in atrazine concentrations is observed in June of 2004. The operator also indicated that Mt. Olive pulls water almost exclusively from Mt. Olive Old Lake, so all of the water concentrations shown in Figure 5 apply to Mt. Olive Old Lake.

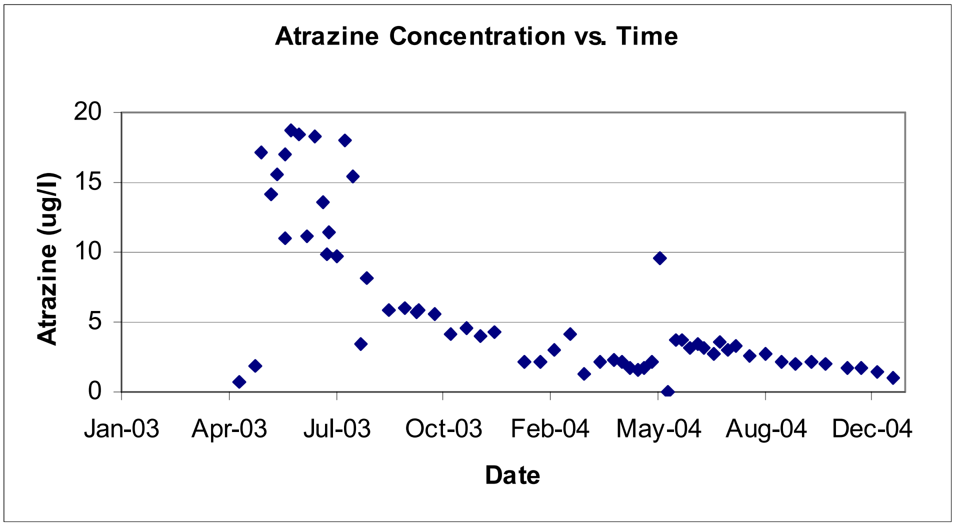

Figure 5. Atrazine concentrations in the raw water intake of the Mt. Olive water treatment plant from 2003 and 2004.

The data for Mt. Olive New Lake (Figure 6) are more limited than for Mt. Olive Old Lake, but demonstrate a similar temporal pattern of concentration peaking between late spring and early summer and then declining through the remainder of the year.

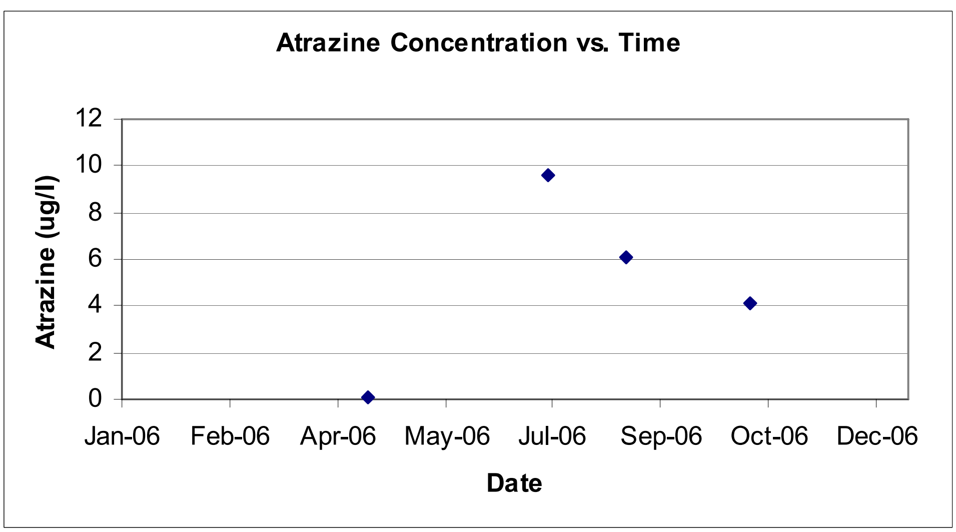

Figure 6. Atrazine concentrations in the raw water intake of the Mt. Olive New Lake from 2006.

This loading capacity approach was selected over the full load-duration curve approach because the available atrazine data were collected from within the lakes themselves and do not represent daily loads.

5.2.2 Approach

The loading capacity approach is based on the assumption that water quality standards will be attained in each lake if the tributary concentrations entering each lake are in compliance with the water quality standard. This approach considers loads from tributaries and from direct drainage to the lake, because inflows to the lake are adjusted for the size of the entire lake watershed (see section 5.2.3.a). The approach defines the maximum allowable loading by multiplying the daily stream flow by the water quality standard. This approach is identical to what is done for a load duration curve analysis. The only difference between the two approaches is how the existing data are analyzed to estimate the required level of loading reduction. The load duration curve approach provides load reduction estimates for a range of seasonal conditions, while the loading capacity approach provides a single estimate of required reduction that applies for all time periods.

5.2.3 Data Inputs

This section describes the flow and water quality data used to support development of the loading capacity approach for atrazine.

5.2.3.a Flow

Daily flow measurements are not available within the Mt. Olive New or Mt. Olive Old Lake watersheds. Daily flows to each of the lakes were estimated based on measured flows at that East Fork of Shoal Creek gage (USGS 05593900). The gaged flows were adjusted for the size of the drainage area for the two lakes. The adjustment ratio for each lake is as follows:

- Mt. Olive New Lake - multiplied by 0.091 because the watershed for Mt. Olive Old Lake is 0.091 times the size of the watershed at the East Fork Shoal Creek gage.
- Mt. Olive Old Lake - multiplied by 0.013 because the watershed for Mt. Olive Old Lake is 0.013 times the size of the watershed at the East Fork Shoal Creek gage.

5.2.3.b Atrazine

Atrazine data collected by IEPA during 2006 were used for the Mount Olive New Lake analysis.

For the Mount Olive Old Lake analysis, atrazine data collected at the water intake in 2003 and 2004 were used, as discussions with the water treatment plant operator revealed water was exclusively withdrawn from Mt. Olive Old Lake during this period.

6. TMDL DEVELOPMENT

This section presents the development of total maximum daily loads for Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake. 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. A separate section is provided for the atrazine TMDL for Mt. Olive New and Mt. Olive Old Lakes.

6.1 PHOSPHORUS AND MANGANESE (MT. OLIVE NEW, MT. OLIVE OLD AND STAUNTON LAKES)

6.1.1 Calculation of Loading Capacity

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

Initial BATHTUB load reduction simulations indicated that Mt. Olive New Lake total phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for all future scenarios where tributary phosphorus loads averaged 100 ug/l or less. This results in a total average allowable load of 0.87 kg/day between April and August, with the total load not to exceed 133 kg over this period. This allowable load corresponds to an approximately 67% reduction from existing tributary loads (estimated as 402 kg for the April-August season). Loads are expressed on a seasonal basis because model results indicate that the average phosphorus residence time in the three lakes is on the order of a few months. Loads entering the lake in the fall through early spring period do not directly affect summer phosphorus concentrations, and therefore were excluded from the TMDL analysis.

6.1.1.b Mt. Olive Old Lake

Initial BATHTUB load reduction simulations indicated Mt. Olive Old Lake total phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for all future scenarios where tributary phosphorus loads averaged 100 ug/l or less. The resulting total average allowable load was 0.18 kg/day between April and August, with the total load not to exceed 27 kg over this period. This allowable load corresponds to an approximately 80% reduction from existing tributary loads (estimated as 135 kg over the April – August period).

6.1.1.c Staunton Lake

Initial BATHTUB load reduction simulations indicated Staunton Lake total phosphorus concentrations would exceed the water quality standard regardless of the level of tributary load reduction, due to the elevated internal phosphorus loads from lake sediments. This internal phosphorus flux is expected to decrease in the future in response to external phosphorus load reductions, reverting back to more typical conditions. This reduction in future sediment phosphorus release was represented in the model by eliminating the additional sediment phosphorus source for all future scenarios where tributary phosphorus loads averaged 100 ug/l or less. The resulting total average allowable load was 0.81 kg/day between April and August, with the total load not to exceed 123 kg over this period. This allowable load corresponds to an approximately 66% reduction from existing tributary loads (estimated as 365 kg over the April – August period).

6.1.2 Allocation

6.1.2.a Mt. Olive New Lake

There are no NPDES permitted point source dischargers in the Mt. Olive New Lake watershed. Therefore the WLA is not calculated. The loading capacity is allocated to non-point sources and the margin of safety. Given a 10% margin of safety (discussed below), this corresponds to a load allocation of 0.78 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.

6.1.2.b Mt. Olive Old Lake

There are no NPDES permitted point source dischargers in the Mt. Olive Old Lake watershed. Therefore the WLA is not calculated. The remainder of the loading capacity is allocated to non-point sources and the margin of safety. Given a 10%

margin of safety (discussed below), this corresponds to a load allocation of 0.16 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.

6.1.2.c Staunton Lake

One NPDES permitted discharger exists in the watershed (White City Sewage Treatment Plant). The effluent from this facility, when discharging, is not monitored for phosphorus. In order to determine if this facility merits a reduction in phosphorus loads, a conservative estimate of upper bound load from this facility was calculated. This calculation shows that facility, at most contributes 10% of the loading capacity and doesn't merit reduction. This conservative estimate was calculated using the permitted average design flow rates (0.0252 MGD), an assumption that this facility discharges 3 months of the year, and an average estimated phosphorus concentration in the effluent of 4 mg/l (Litke, 1999). This corresponds to a wasteload allocation of 0.1 kg/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 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. Given a loading capacity of 0.81 kg-P/day, a WLA of 0.1 kg-P/day, and an explicit margin of safety of 10% (discussed below), this results in a load allocation for Staunton Lake of 0.629 kg-P/day. The load allocation is not divided into individual source categories for purposes of this TMDL, as it is the intent of the implementation plan to provide detail on the contributions of specific sources to the overall phosphorus load.

6.1.3 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 lake. However, the water quality ramifications of these nutrient loads are most severe during middle or late summer. This TMDL is based upon a seasonal period that takes into account both spring loads and summer water quality in order to effectively consider these critical conditions.

6.1.4 Seasonality

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

6.1.5 Margin of Safety

The 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 reasonable 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 0.087 kg/day for Mt. Olive New Lake, 0.018 kg/day for Mt. Olive Old Lake, and 0.081 kg/day for Staunton Lake.

6.2 ATRAZINE TMDL (MT. OLIVE NEW AND MT. OLIVE OLD LAKES)

A load capacity calculation was applied to support development of an atrazine TMDL for Mt. Olive New Lake and Mt. Olive Old Lake.

6.2.1 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.

6.2.1.a Mt. Olive New Lake

The loading capacity for Mt. Olive New Lake was defined over a range of specified flows, based on expected flows to the lake. The allowable loading capacity was computed by multiplying flow by the TMDL target (3 ug/l). The atrazine loading capacity for Mt. Olive New Lake is presented in Table 3.

Table 3. Mt. Olive New Lake Load Capacity

Mt. Olive New Lake Flow (cfs)	Allowable Atrazine Load (lbs/day)
0.07	0.0011
0.70	0.0113
3.50	0.0566
7.00	0.1133
14.00	0.2265
35.00	0.5663
70.00	1.1327
140.00	2.2653
350.00	5.6633

The maximum measured atrazine concentration was examined to estimate the percent reduction in existing loads required to meet the 3 ug/l target. Based on the limited data available, up to a 69% reduction in atrazine loads is needed.

6.2.1.b Mt. Olive Old Lake

The loading capacity for Mt. Olive Old Lake was defined over a range of specified flows, based on expected flows to the lake. The allowable loading capacity was computed by multiplying flow by the TMDL target (3 ug/l). The atrazine loading capacity for Mt. Olive Old Lake is presented in Table 4.

Table 4. Mt. Olive Old Lake Load Capacity

Mt. Olive Old Lake Flow (cfs)	Allowable Atrazine Load (lbs/day)
0.01	0.0002
0.10	0.0016
0.50	0.0081
1.00	0.0162
2.00	0.0324
5.00	0.0809
10.00	0.1618
20.00	0.3236
50.00	0.8090

The maximum measured atrazine concentration was examined to estimate the percent reduction in existing loads required to meet the 3 ug/l target. Based on the data available, up to a 96% reduction in atrazine loads is needed.

6.2.2 Allocation

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

$$TMDL = WLA + LA + MOS$$

6.2.2.a Mt. Olive New Lake

There are no NPDES permitted point source dischargers in the Mt. Olive New Lake watershed. Therefore the WLA does not need to be calculated. The loading capacity is given to the load allocation for non-point sources and the margin of safety (Table 5). 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 atrazine load.

Table 5. Atrazine TMDL for Mt. Olive New Lake

Flow (cfs)	Allowable Load (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load allocation (LA) (lbs/day)
0.07	0.0011	-	0.0010
0.70	0.0113	-	0.0102
3.50	0.0566	-	0.0510
7.00	0.1133	-	0.1019
14.00	0.2265	-	0.2039
35.00	0.5663	-	0.5097
70.00	1.1327	-	1.0194
140.00	2.2653	-	2.0388
350.00	5.6633	-	5.0970

6.2.2.b Mt. Olive Old Lake

There are no NPDES permitted point source dischargers in the Mt. Olive Old Lake watershed. Therefore the WLA does not need to be calculated. The loading capacity is given to the load allocation for non-point sources and the margin of safety (Table 6). 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 atrazine load.

Table 6. Atrazine TMDL for Mt. Olive Old Lake

Flow (cfs)	Allowable Load (lbs/day)	Wasteload Allocation (WLA) (lbs/day)	Load allocation (LA) (lbs/day)
0.01	0.0002	-	0.000146
0.10	0.0016	-	0.001456
0.50	0.0081	-	0.007281
1.00	0.0162	-	0.014563
2.00	0.0324	-	0.029126
5.00	0.0809	-	0.072814
10.00	0.1618	-	0.145629
20.00	0.3236	-	0.291257
50.00	0.8090	-	0.728143

6.2.3 Critical Condition

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

6.2.4 Seasonality

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

6.2.5 Margin of Safety

Total maximum daily loads are required to contain a Margin of Safety (MOS) to account for any uncertainty concerning the relationship between pollutant loading and receiving water quality. The MOS can be either implicit (e.g., incorporated into the TMDL analysis through conservative assumptions), or explicit (e.g., expressed in the TMDL as a portion of the loading), or expressed as a combination of both. The atrazine TMDLs contain a combination of both types. An implicit Margin of Safety is provided via the use of a conservative model to define load capacity. The model assumes no loss of atrazine that enters the lake, and therefore represents an upper bound of expected concentrations for a given pollutant load. The TMDL also contains an explicit margin of safety of 10%. This 10% margin of safety was included in addition to the implicit margin of safety to address potential uncertainty in the effectiveness of load reduction alternatives. This margin of safety can be reviewed in the future as new data are developed. The explicit MOS for Mt. Olive New Lake and Mt. Olive Old Lake is presented for the expected range of flows to these lakes, in Tables 7 and 8.

Table 7. Margin of Safety – Mt. Olive New Lake

Flow (cfs)	MOS (10%) (lbs/day)
0.07	0.0001
0.70	0.0011
3.50	0.0057
7.00	0.0113
14.00	0.0227
35.00	0.0566
70.00	0.1133
140.00	0.2265
350.00	0.5663

Table 8. Margin of Safety – Mt. Olive Old Lake

Flow (cfs)	MOS (10%) (lbs/day)
0.01	0.00002
0.10	0.00016
0.50	0.00081
1.00	0.00162
2.00	0.00324
5.00	0.00809
10.00	0.01618
20.00	0.03236
50.00	0.08090

7. PUBLIC PARTICIPATION AND INVOLVEMENT

The TMDL process included several opportunities for local watershed institutions and the general public to be involved. A public meeting was conducted in Mt. Olive, Illinois on April 26, 2006 to present the results of Stage 1 work. A second meeting was held on July 17, 2007 to present and discuss the TMDL and implementation plan.

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8. IMPLEMENTATION PLAN

Total Maximum Daily Loads (TMDLs) were developed for the Mt. Olive New Lake, Mt. Olive Old Lake, and Staunton Lake in West-Central Illinois, to address a number of water quality impairments in the lakes. Specifically, TMDLs were developed for manganese for all three lakes, total phosphorus for the Mt. Olive Lakes, and for atrazine for the Mt. Olive Lakes. These TMDLs determined that significant reductions in existing pollutant loadings were needed to meet water quality objectives. The next steps in the TMDL process is to develop a implementation plan that includes both accountability and the potential for adaptive management. This section identifies a number of alternative actions to be considered by local stakeholders for phosphorus and manganese TMDL implementation; these are summarized in the table below. Atrazine alternatives are summarized separately in Section 8.4.

Table 9. 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 319 funds
Conservation Buffers	$200 - $360/acre	
Grassed Waterways	$1,800/acre	
Nutrient Management Plans	$6 to $20/acre	May lead to 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	
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	Shoreline erosion has been identified as a problem previously
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 in concert with watershed reductions
Phosphorus Inactivation	$1,000 to $1,300 per acre	Only in concert with watershed reductions; best for smaller lakes

*Costs expressed in 2006 dollars

8.1 APPROACH

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

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

This approach is designed to accelerate the pace at which TMDLs are being developed for sites dominated by nonpoint sources, which will allow implementation activities (and water quality improvement) to begin sooner. The approach also places decisions on the types of nonpoint source controls to be implemented at the local level, which will allow those with the best local knowledge to prioritize sources and identify restoration alternatives.

The Association of Illinois Soil and Water Conservation Districts, using Section 319 grant funding, have made available a Watershed Liaison to provide educational, informational, and technical assistance to local agencies and communities. The liaison can assist in establishing local watershed planning groups, as well as acting as an overall facilitator for coordination between local, state, and Federal agencies. The adaptive management approach to be followed recognizes that models used for decision-making are approximations, and that there is never enough data to completely remove uncertainty. The adaptive process allows decision-makers to proceed with initial decisions based on modeling, and then to update these decisions as experience and knowledge improve.

The first three steps described above have been completed as part of the TMDL. This section 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.

Based on the objectives for the TMDLs, discussions with local personnel, information obtained at the public meetings, and experience in other watersheds, a number of alternatives have been identified for the implementation phase of these TMDLs.

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 these agencies indicated that there are no existing controls or planned controls within the watershed. It was indicated by the NRCS that they are willing to provide assistance in watershed planning and implementation of BMPs; however there have been no local sponsors within the watershed to coordinate efforts. Examples of existing programs within Macoupin County can be found in the TMDL implementation plan for Hodges Creek and Macoupin Creek (LimnoTech, 2006).

8.3 IMPLEMENTATION ALTERNATIVES FOR PHOSPHORUS

Implementation alternatives for this TMDL are focused on those sources suspected of contributing phosphorus loads to the lake (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 lake. The 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 (EPA, 2003). Such basins could be installed throughout the watershed, in areas selected to minimize disruption to existing croplands. In addition to controlling sediment, these basins would reduce phosphorus loads to the lakes. Costs for these basins can vary widely depending on location and size; estimates prepared for another Illinois watershed range from $1,200 to more than $200,000 per basin (Zahniser Institute, undated). This same study estimated a trapping efficiency for sediment of 75%.

Storm water detention wetlands might also warrant consideration. These wetlands would trap sediments and nutrients; a study prepared for another Illinois watershed provides an estimated phosphorus removal rate of 45% (Zahniser Institute, undated). Wetlands generally have low to moderate effectiveness at reducing particulate phosphorus, and low to negative effectiveness at reducing dissolved phosphorus (NRCS, 2006a).

8.3.2 Conservation Buffers

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

Filter strips and similar vegetative control methods can be very effective in reducing nutrient transport. The relative gross effectiveness of filter strips in reducing total phosphorus has been reported as 75% (EPA, 2003). Reduction of particulate phosphorus is moderate to high, while effectiveness for dissolved phosphorus is low to negative (NRCS, 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 common land use in the watershed, controls focused on reducing phosphorus loads from these areas are expected to help reduce phosphorus loads delivered to the lakes. The focus of a nutrient management plan is to increase the efficiency with which applied nutrients are used by crops, thereby reducing the amount available to be transported to both surface and ground waters (EPA, 2003). The majority of phosphorus lost from agricultural land is transported via surface runoff (vs. leaching through the soil, as occurs for nitrogen), mostly in particulate form attached to eroded soil particles. A nutrient management plan identifies the amount, source, time of application, and placement of each nutrient needed to produce each crop grown on each field each year, to optimize efficient use of all sources of nutrients (including soil reserves, commercial fertilizer, legume crops, and organic sources) and minimize the potential for losses that lead to degradation of soil and water quality (UIUC, 2005).

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

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

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.

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

8.3.5 Animal Waste Management

While land application of animal waste is the preferred disposal option, it can contribute nutrients (as well as pathogens) to the lake. Waste handling and storage; disposal methods; and application timing and rates should all be considered. Manure should be tested for nutrient content, and soil sampling and nutrient management planning should be incorporated. Specific activities might include construction of waste storage facilities to hold waste until they 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 erosion (UIUC, 2005). This reduction in erosion also reduces the amount of phosphorus lost from the land and delivered to the lake. 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% (EPA, 2003). In general, conservation tillage and no-till practices are moderate to highly effective at reducing particulate phosphorus, but exhibit low or even negative effectiveness in reducing dissolved phosphorus (NRCS, 2006a). A wide range of costs has been reported for conservation tillage practices, ranging from $12/acre to $83/acre in capital costs (EPA, 2003). For no-till, costs per acre provided in the Illinois Agronomy Handbook for machinery and labor range from $36 to $66/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 Aeration/Destratification

The existing sediments in the lakes are a significant source of both phosphorus and manganese. When dissolved oxygen is absent in the hypolimnion (deep layer) of the lakes, phosphorus and manganese are released from the sediments. Control of this internal load requires either removal of phosphorus (and manganese) from the lake bottom (such as through dredging), or preventing oxygen-deficient conditions from occurring. Aeration of portions of the lake might be considered as an alternative to increase mixing and improve oxygen levels. Destratifiers have also been installed in other Illinois lakes to prevent thermal stratification, and thus increase oxygen concentrations in the deeper lake waters. Studies have indicated that such systems can significantly improve water quality (Raman et. al, 1998). A destratification system installed in Lake Evergreen 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).

8.3.8 Streambank and Shoreline Enhancement and Protection

Streambank and shoreline erosion have been problems in these 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 provide protection against erosion and the associated increased pollutant loads.

The Clean Lakes Study for Otter Lake, a lake in northern Macoupin County, recommended tree cutting ($5,100 over four years), tree planting ($5,100 over four years), and rip-rapping ($47,700 for the severely eroded areas) (Lin et al, 1999). Rip-rapping has been an on-going effort on Otter Lake, with plans to continue. Bald cypress trees have also been planted (OLWC, 2006). Cost estimates for rip-rapping are approximately $67-$73/ton (NRCS, 2005), while estimates for plantings at another Illinois lake suggest a cost of approximately $5/linear foot (CMT, 2004).

8.3.9 Erosion Control Measures for New Development

There is a considerable amount of development occurring in this region, (LTI, 2004). Erosion control measures for new developments are therefore recommended as part of TMDL implementation. A permit is required for construction activities disturbing more than one acre, under the NPDES Phase II storm water regulations (information on IEPA'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.

8.3.10 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.

Although it is unknown whether development is occurring in the study area watersheds, there is quite a bit of development occurring in the county, with Macoupin County being one of the top counties in Illinois issuing permits for individual disposal systems (LTI, 2004). Macoupin County has approximately 3,000 surface systems. 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. A more proactive program to maintain functioning systems and address nonfunctioning systems could be developed to minimize the potential for releases from private sewage disposal systems; however, the local health departments currently do not have sufficient staff nor funding to take on new inspection duties. The U.S. EPA has developed guidance for managing private sewage disposal systems (USEPA, 2005). This guidance includes procedures for assessing existing conditions, assessing public health and environmental risks, selecting a management approach, and implementing a management program (including funding information).

This alternative would require the commitment of staff time for County Health Department personnel to administer the program and conduct inspections; cost depends on the level of staffing needed. Illinois EPA has proposed a draft general permit for Surface Discharging Private Sewage Disposal Systems (http://www.epa.state.il.us/public-notices/2006/general-private-sewage/draft-permit.pdf). The intent of this permit is to ensure that effluent discharge from private sewage disposal systems to waters of the state comply with water quality standards. This will reduce the risk to public health and the environment, which is associated with failing systems. IEPA held public hearings on January 8, 10 and 11, 2007 to receive oral and written comments on the draft general permit.

Costs for annual maintenance agreements have been estimated at $200/year per household (IEPA, 2006a).

8.3.11 Dredging

In-place sediments have been identified as significant sources of phosphorus and manganese. In addition, sedimentation reduces the water volume of the lake, with a corresponding reduction in the lake's assimilative capacity. Dredging of the existing sediments is one alternative to address this source. It is, however, an expensive alternative, and would be only a temporary solution; if sediment and phosphorus loads are not reduced in the watershed, it is likely that sedimentation and nutrient flux from the sediments will continue to be a problem in the future. Costs for dredging have been estimated at $6 to $20 per cubic yard of sediment removed for hydraulic dredging (IEPA, 1998).

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). If watershed sources are not controlled, repeated treatments will be needed. Often, it is possible to do repeat dosing over several years, giving a partial dose every three to five years (Sweetwater, 2006). Studies have indicated that the effectiveness of alum at controlling internal phosphorus loading in stratified lakes averaged 80% over several years of observation (Welch and Cooke, 1999). Costs for phosphorus inactivation are approximately $1,000 to $1,300 per acre (Sweetwater, 2006).

8.3.13 Point Source Controls

There is one NPDES permitted point source discharger in the Staunton Lake watershed. This is the White City STP. This facility has a small average design flow (0.0252 MGD), does not discharge continuously and does not have a permit limits for phosphorus. IEPA will evaluate the need for additional point source controls through the NPDES permitting program; permits might need to be modified to ensure consistency with the WLA.

8.4 IMPLEMENTATION ALTERNATIVES FOR ATRAZINE

The Kansas State University Agricultural Experiment Station and Cooperative Extension Service (KSU) lists 12 best management practices that are effective at reducing the amount of atrazine that enters waterways (Devlin et. al. 2000).

1. Incorporate atrazine into the top 2 inches of soil. This will not only improve weed control, but can reduce runoff by 60 to 75% compared to surface application.

2. Use fall or early spring applications. Runoff can be reduced by 50% if atrazine is applied during lower rain periods that occur in the fall and early spring.

3. Use post-emergence atrazine premix products. These mixtures contain less atrazine, but may be more expensive to apply. This can reduce atrazine runoff by 50 to 67%.

4. Reduce soil-applied atrazine application rates. Follow the recommended application rate and use alternatives to atrazine when available. This can reduce atrazine runoff by 33%.

5. Apply atrazine in split applications. For example apply one-half of the atrazine prior to April 15 and the other half immediately following planting. This can reduce atrazine runoff by 25%.

6. A combination of BMPS such as reducing the amount of soil-applied atrazine followed by a post-emergence herbicide application. This can reduce atrazine runoff by 25%.

7. Use non-atrazine herbicides. This can reduce atrazine runoff by 100%.

8. Use integrated pest management strategies. By properly managing a field, weed infestation levels can be managed with non-herbicide alternatives. This can reduce atrazine runoff by 0 or 100%.

9. Band herbicides when applying. By only applying atrazine in the areas where needed (directly over the row) you can reduce atrazine application rates by 50 to 67% compared to a broadcast surface application.

10. Establish vegetative and riparian buffer areas. These areas will prevent water from directly flowing into a lake or river and allow the water to infiltrate into the soil. This can reduce atrazine runoff by 10% to 35%

11. Follow proper atrazine application rates, mixing, loading, and disposal practices.

12. Utilize conservation practices and structures.

According to KSU, Atrazine BMPs are designed to: reduce the amount of atrazine available for runoff, reduce the impact of the first runoff event on atrazine loss rates, provide a mechanism for atrazine loss (deposition) before it leaves the field and enters the surface water supply.

8.5 IDENTIFYING PRIORITY AREAS FOR CONTROLS

Preliminary identification of priority areas for siting of implementation alternatives was accomplished through a review of available information including a previous study, tributary monitoring data and GIS analyses. It should be noted that additional, more detailed evaluation may be necessary to refine the site selection. Furthermore, additional analysis will be required to prioritize implementation activities.

8.5.1 Tributary Monitoring

Available water quality data obtained as part of the Stage 1 Watershed Characterization work were reviewed and tributary monitoring data from 2001-2002 were identified for the Lake Staunton watershed. As discussed in the Clean Lakes Study (IEPA, 2005) high tributary phosphorus loads enter Staunton Lake from East Creek.

No recent tributary monitoring data were identified for Mt. Olive New or Mt. Olive Old Lakes. Additional tributary monitoring data for the Mt. Olive Lakes would help target particular areas for implementation efforts. Specific data collection recommendations are provided in the Monitoring and Adaptive Management Section later in this Implementation Plan.

8.5.2 Previous studies

In addition to phosphorus loads from East Creek, phosphorus sources to Staunton Lake identified as part of the Phase I Diagnostic/Feasibility Study included: shoreline erosion, nutrient loading from birds, atmospheric nutrient loading, and lake sediment nutrient loading (IEPA, 2005).

8.5.3 GIS Analysis

Soil type, land use and topography data were analyzed to identify areas that are expected to generate the highest sediment and associated phosphorus and manganese loads. From the available data, maps were generated in GIS to show areas with steep slopes, defined as slopes greater than 9% (Figure 6), highly erodible soils, classified within the SSURGO GIS soils as HEL (highly erodible land) (Figure 7), and finally, priority areas for BMPs (Figure 8). The priority areas are defined as cropland areas that have both steep slopes and highly erodible soils. Priority areas are logical locations for targeting 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. BMPs that would be applicable for the locations shown in Figure 8 include: conservation buffers, stream bank enhancement and protection, sediment control basins, grassed waterways and conservation tillage.

GIS analysis was also used to investigate the presence of hydric soils in the watershed to determine whether wetland restoration or creation is a viable option within this watershed. To support this analysis, areas having hydric soils, which are not already developed, forested, or covered by water or wetlands were identified. A significant proportion of the watersheds were identified as being potentially suitable for wetland restoration or creation. These areas are shown in Figure 9.

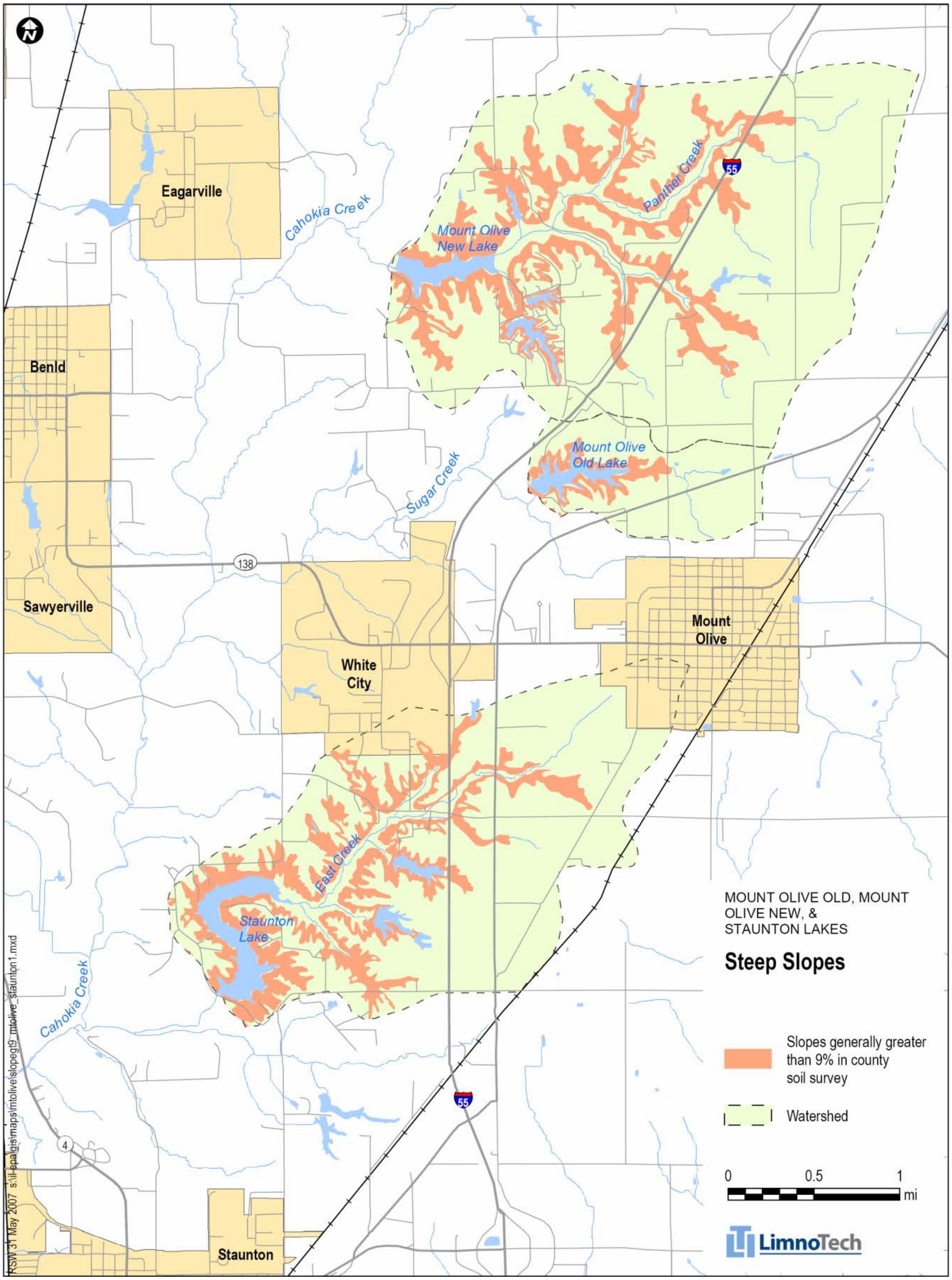

Figure 7. Areas with Steep Slopes

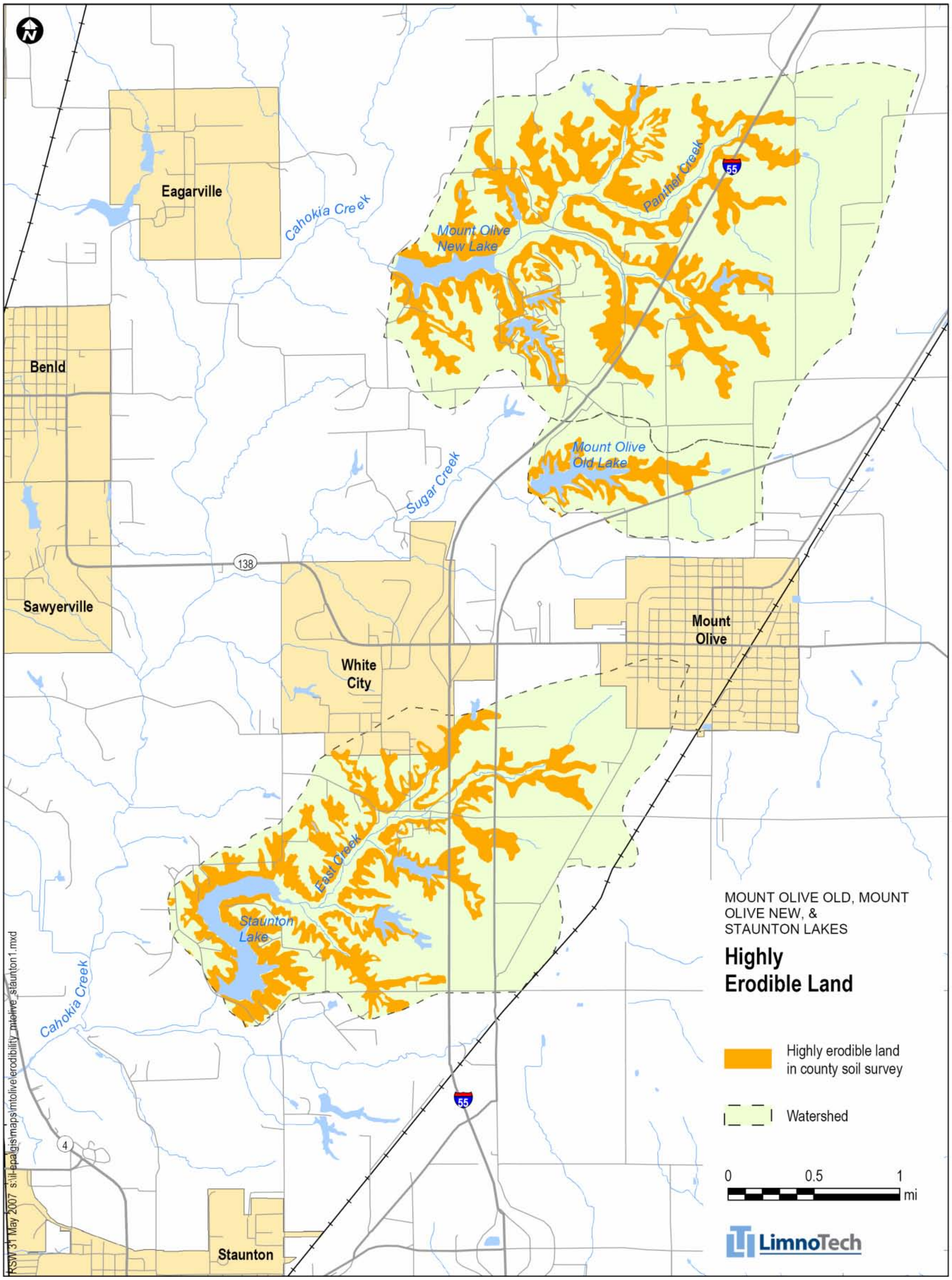

Figure 8. Areas with Highly Erodible Soils

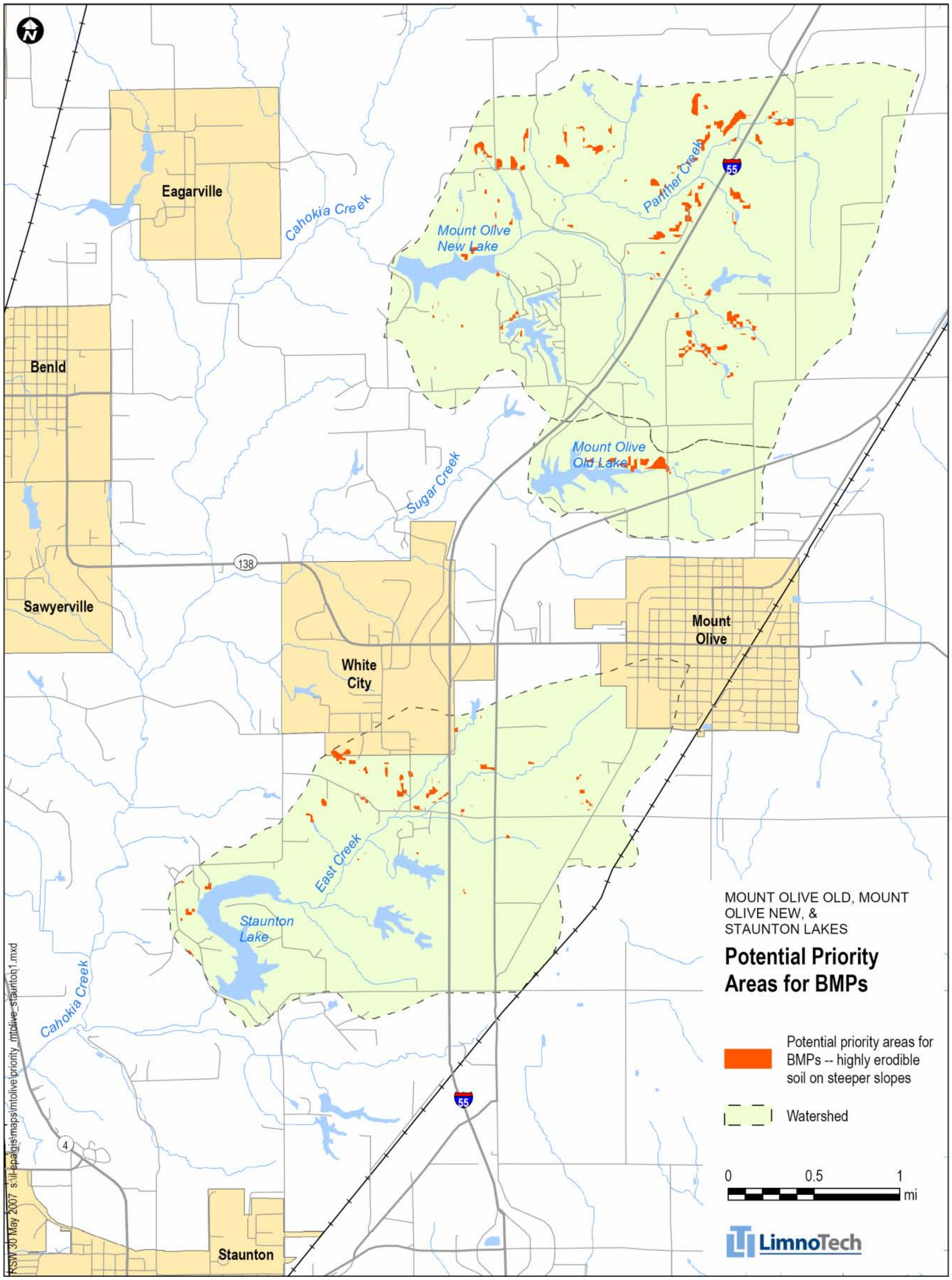

Figure 9. Potential Priority Areas for Best Management Practices

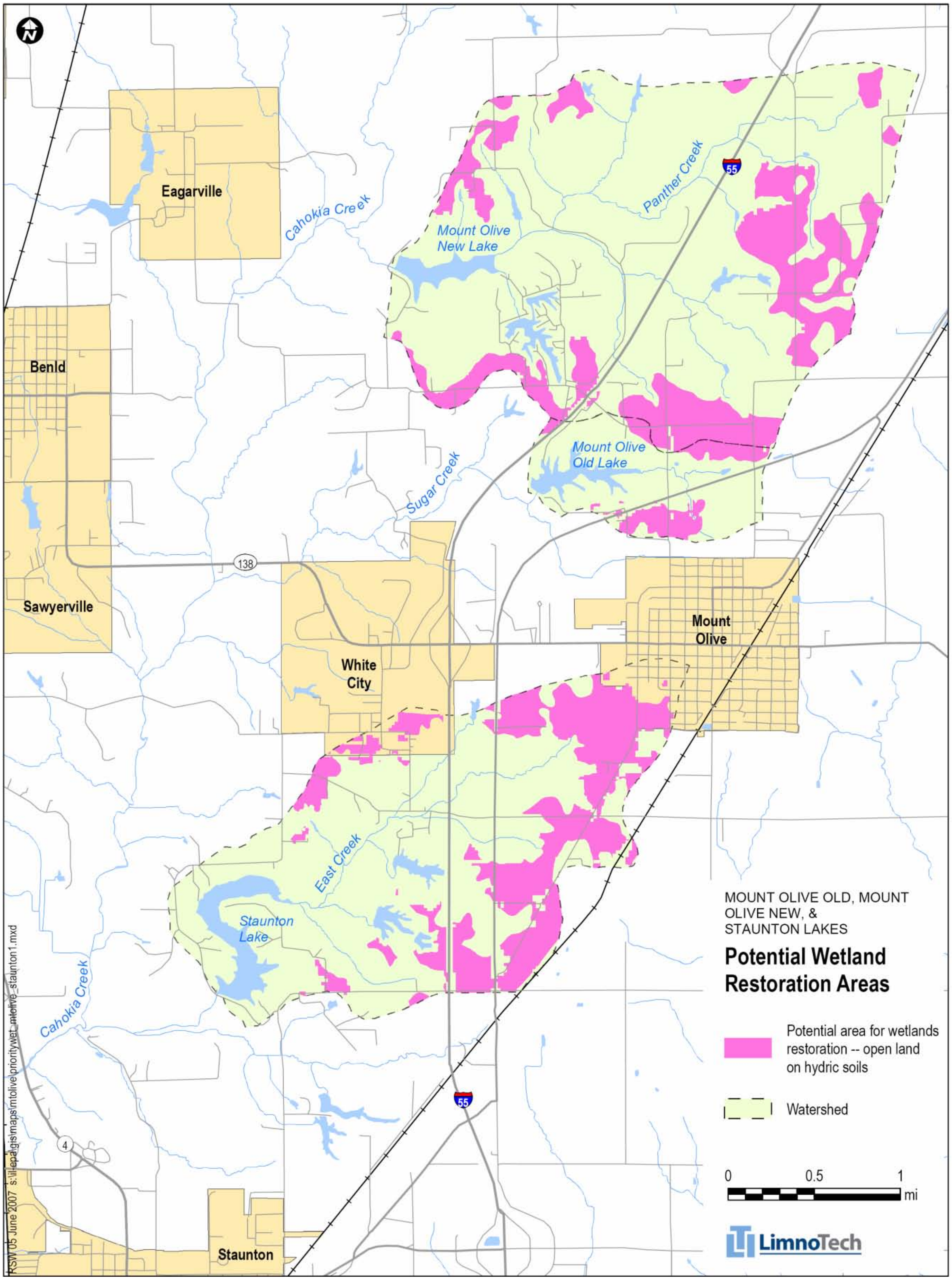

Figure 10. Potential Priority Areas for Wetland Restoration

8.6 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 (White City STP), located in the Staunton Lake watershed) will be modified if necessary to ensure it is consistent with the applicable wasteload allocation.

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

One of the most important aspects of implementing non-point source controls is obtaining adequate funding to implement voluntary or incentive-based programs. Funding is available from a variety of sources, including those listed below. It should be noted that the Federal 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. Figure 9 shows potential priority areas for wetland restoration.
- *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.

8.7 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. 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.

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. In particular, the following monitoring is recommended:

Mt. Olive New Lake – phosphorus, atrazine and manganese sampling during wet and dry weather at:

- Panther Creek at Panther Creek Road
- Panther Creek near the I-55 bridge crossing
- Downstream of the Lake Ka-Ho outlet

Mt. Olive Old Lake - phosphorus, atrazine and manganese sampling during wet and dry weather at:

- Sugar Creek at the Mt. Olive Road crossing

Staunton Lake – phosphorus and manganese sampling during wet and dry weather at:

- East Creek near the point where it enters the lake
- East Creek at the Wolf Road crossing

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ATTACHMENT 1. BATHTUB MODEL FILES MT. OLIVE NEW LAKE

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Mt. Olive New
File: **S:\IL-EPA5\MtOlives&Staunton\Model\Mt_olive_new\MT_OLIVE_NEW_2.btb**

Segment & Tributary Network

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

Mt. Olive New
File: **S:\IL-EPA5\MtOlives&Staunton\Model\Mt_olive_new\MT_OLIVE_NEW_2.btb**
Description:
Single reservoir
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.42	0.0
Precipitation (m)	0.41	0.0
Evaporation (m)	0.41	0.0
Storage Increase (m)	0	0.0

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

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	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

Internal Loads (mg/m2-day)

Seg	Name	Outflow Segment	Group	Area km²	Depth m	Length km	Mixed Depth (m) Mean	CV	Hypol Depth Mean	CV	Non-Algal Turb (m^{-1}) Mean	CV	Conserv. Mean	CV	Total P Mean	CV	Total N Mean	CV
1	Segment 1	2	1	0.057	1.05	0.32	0.93	0	0.68	0	0.2	0	0	0	0	0	0	0
2	Segment 2	3	1	0.065	2.01	0.4	2.01	0	1.05	0	0.1	0	0	0	0	0	0	0
3	Segment 3	0	1	0.036	3.96	0.31	3.85	0	1.41	0	0.08	0	0	0	600	0	0	0

Segment Observed Water Quality

Seg	Conserv Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Chl-a (ppb) Mean	CV	Secchi (m) Mean	CV	Organic N (ppb) Mean	CV	TP - Ortho P (ppb) Mean	CV	HOD (ppb/day) Mean	CV	MOD (ppb/day) Mean	CV
1	0	0	332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	327	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	986	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

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

Trib	Trib Name	Segment	Type	Dr Area km^2	Flow (hm^3/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	1	1	13.13	9.05	0	0	0	106	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.2596	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

Mt. Olive New
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Variable = TOTAL P MG/M3 **R^2 = 0.59**
Global Calibration Factor = 1.60 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	1.00	0.00	412.0	0.00	332.0	0.00	-0.22	0.00	0.00
2	1	Segment 2	1.00	0.00	449.6	0.00	327.0	0.00	-0.32	0.00	0.00
3	1	Segment 3	1.00	0.00	647.5	0.00	986.0	0.00	0.42	0.00	0.00
4	1	Area-Wtd Mean			481.1	0.00	479.0	0.00	0.00	0.00	0.00

Mt. Olive New
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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	479.0	0.00	481.1	0.00	1.00		-0.02	

Segment: **1** **Segment 1**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	332.0	0.00	412.0	0.00	0.81		-0.80	

Segment: **2** **Segment 2**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	327.0	0.00	449.6	0.00	0.73		-1.18	

Segment: **3** **Segment 3**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	986.0	0.00	647.5	0.00	1.52		1.56	

Mt. Olive New
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Segment	Name
1	Segment 1
2	Segment 2
3	Segment 3
Mean	Area-Wtd Mean

PREDICTED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	412.0	449.6	647.5	481.1
TURBIDITY 1/M	0.2	0.1	0.1	0.1
ZMIX * TURBIDITY	0.2	0.2	0.3	0.2
CARLSON TSI-P	91.0	92.2	97.5	93.0

OBSERVED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	332.0	327.0	986.0	479.0
TURBIDITY 1/M	0.2	0.1	0.1	0.1
ZMIX * TURBIDITY	0.2	0.2	0.3	0.2
CARLSON TSI-P	87.9	87.6	103.6	91.3

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	0.8	0.7	1.5	1.0
TURBIDITY 1/M	1.0	1.0	1.0	1.0
ZMIX * TURBIDITY	1.0	1.0	1.0	1.0
CARLSON TSI-P	1.0	1.0	1.1	1.0

OBSERVED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

PREDICTED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

Mt. Olive New
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Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: 4 Area-Wtd Mean

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	481.1		99.5%	479.0		99.5%
TURBIDITY 1/M	0.1		4.1%	0.1		4.1%
ZMIX * TURBIDITY	0.2		0.0%	0.2		0.0%
CARLSON TSI-P	93.0		99.5%	91.3		99.5%

Segment: 1 Segment 1

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	412.0		99.2%	332.0		98.4%
TURBIDITY 1/M	0.2		10.3%	0.2		10.3%
ZMIX * TURBIDITY	0.2		0.0%	0.2		0.0%
CARLSON TSI-P	91.0		99.2%	87.9		98.4%

Segment: 2 Segment 2

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	449.6		99.4%	327.0		98.4%
TURBIDITY 1/M	0.1		2.0%	0.1		2.0%
ZMIX * TURBIDITY	0.2		0.0%	0.2		0.0%
CARLSON TSI-P	92.2		99.4%	87.6		98.4%

Segment: 3 Segment 3

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	647.5		99.8%	986.0		100.0%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.3		0.1%	0.3		0.1%
CARLSON TSI-P	97.5		99.8%	103.6		100.0%

Mt. Olive New

File: **S:\IL-EPA5\MtOlives&Staunton\Model\Mt_olive_new\MT_OLIVE_NEW_2.btb**

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	9	0	0	0	9	0	82	0
2	Segment 2	0	0	9	0	9	0	29	0
3	Segment 3	0	0	9	0	9	0	0	0
Net		9	0	0	0	9	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	959	2	0	0	3729	0	-3067	299
2	Segment 2	0	2	3729	0	4069	0	-2614	2276
3	Segment 3	0	1	4069	0	5859	0	5681	-7471
Net		959	5	0	0	5859	0	0	-4895

Mt. Olive New
File: S:\IL-EPA5\MtOlives&Staunton\Model\Mt_olive_new\MT_OLIVE_NEW_2.btb
Segment Mass Balance Based Upon Predicted Concentrations

Component: TOTAL P | **Segment: 1** | **Segment 1**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Inlet Tributary	9.1	99.4%	959.3	23.8%	106
PRECIPITATION			0.1	0.6%	1.7	0.0%	31
TRIBUTARY INFLOW			9.1	99.4%	959.3	23.8%	106
NET DIFFUSIVE INFLOW			0.0	0.0%	3067.0	76.1%	
***TOTAL INFLOW			9.1	100.0%	4028.0	100.0%	442
ADVECTIVE OUTFLOW			9.1	99.4%	3728.6	92.6%	412
***TOTAL OUTFLOW			9.1	99.4%	3728.6	92.6%	412
***EVAPORATION			0.1	0.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	299.4	7.4%	

Hyd. Residence Time = 0.0066 yrs
Overflow Rate = 158.8 m/yr
Mean Depth = 1.0 m

Component: TOTAL P | **Segment: 2** | **Segment 2**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
PRECIPITATION			0.1	0.7%	1.9	0.0%	31
ADVECTIVE INFLOW			9.1	99.3%	3728.6	58.8%	412
NET DIFFUSIVE INFLOW			0.0	0.0%	2614.1	41.2%	
***TOTAL INFLOW			9.1	100.0%	6344.6	100.0%	696
ADVECTIVE OUTFLOW			9.1	99.3%	4068.7	64.1%	450
***TOTAL OUTFLOW			9.1	99.3%	4068.7	64.1%	450
***EVAPORATION			0.1	0.7%	0.0	0.0%	
***RETENTION			0.0	0.0%	2275.9	35.9%	

Hyd. Residence Time = 0.0144 yrs
Overflow Rate = 139.2 m/yr
Mean Depth = 2.0 m

Component: TOTAL P | **Segment: 3** | **Segment 3**

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
PRECIPITATION			0.0	0.4%	1.1	0.0%	31
INTERNAL LOAD			0.0	0.0%	7889.4	66.0%	
ADVECTIVE INFLOW			9.1	99.6%	4068.7	34.0%	450
***TOTAL INFLOW			9.1	100.0%	11959.2	100.0%	1316
ADVECTIVE OUTFLOW			9.1	99.6%	5859.4	49.0%	647
NET DIFFUSIVE OUTFLOW			0.0	0.0%	5681.1	47.5%	
***TOTAL OUTFLOW			9.1	99.6%	11540.5	96.5%	1275
***EVAPORATION			0.0	0.4%	0.0	0.0%	
***RETENTION			0.0	0.0%	418.7	3.5%	

Hyd. Residence Time = 0.0158 yrs
Overflow Rate = 251.4 m/yr
Mean Depth = 4.0 m

Mt. Olive New
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Overall Water & Nutrient Balances

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

Trb	Type	Seg	Name	Area km²	Flow hm³/yr	Variance (hm3/yr)²	CV -	Runoff m/yr
1	1	1	Inlet Tributary	13.1	9.1	0.00E+00	0.00	0.69
PRECIPITATION				0.2	0.2	0.00E+00	0.00	0.98
TRIBUTARY INFLOW				13.1	9.1	0.00E+00	0.00	0.69
***TOTAL INFLOW				13.3	9.2	0.00E+00	0.00	0.69
ADVECTIVE OUTFLOW				13.3	9.1	0.00E+00	0.00	0.68
***TOTAL OUTFLOW				13.3	9.1	0.00E+00	0.00	0.68
***EVAPORATION					0.2	0.00E+00	0.00	

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

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)²	Load Variance %Total	CV	Conc mg/m³	Export kg/km²/yr
1	1	1	Inlet Tributary	959.3	10.8%	0.00E+00		0.00	106.0	73.1
PRECIPITATION				4.7	0.1%	0.00E+00		0.00	30.5	30.0
INTERNAL LOAD				7889.4	89.1%	0.00E+00		0.00		
TRIBUTARY INFLOW				959.3	10.8%	0.00E+00		0.00	106.0	73.1
***TOTAL INFLOW				8853.4	100.0%	0.00E+00		0.00	961.8	666.3
ADVECTIVE OUTFLOW				5859.4	66.2%	0.00E+00		0.00	647.5	441.0
***TOTAL OUTFLOW				5859.4	66.2%	0.00E+00		0.00	647.5	441.0
***RETENTION				2994.0	33.8%	0.00E+00		0.00		

Overflow Rate (m/yr)	57.3	Nutrient Resid. Time (yrs)	0.0181
Hydraulic Resid. Time (yrs)	0.0368	Turnover Ratio	23.0
Reservoir Conc (mg/m3)	481	Retention Coef.	0.338

Mt. Olive New
File: S:\IL-EPA5\MtOlives&Staunton\Model\Mt_olive_new\MT_OLIVE_NEW_2.btb

Hydraulic & Dispersion Parameters

			Net	Resid	Overflow		Dispersion-------->		
		Outflow	Inflow	Time	Rate	Velocity	Estimated	Numeric	Exchange
Seg	Name	Seg	hm^3/yr	years	m/yr	km/yr	km^2/yr	km^2/yr	hm^3/yr
1	Segment 1	2	9.1	0.0066	158.8	48.4	147.4	7.7	81.6
2	Segment 2	3	9.1	0.0144	139.2	27.7	40.7	5.5	28.7
3	Segment 3	0	9.1	0.0158	251.4	19.7	8.4	3.1	0.0

Morphometry

		Area	Zmean	Zmix	Length	Volume	Width	L/W
Seg	Name	km^2	m	m	km	hm^3	km	-
1	Segment 1	0.1	1.0	0.9	0.3	0.1	0.2	1.8
2	Segment 2	0.1	2.0	2.0	0.4	0.1	0.2	2.5
3	Segment 3	0.0	4.0	3.8	0.3	0.1	0.1	2.7
Totals		0.2	2.1			0.3		

ATTACHMENT 2. BATHTUB MODEL FILES MT. OLIVE OLD LAKE

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Mt. Olive Old
File: S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb

Variable = TOTAL P MG/M3 **R^2 = 1.00**
Global Calibration Factor = 1.60 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	1.00	0.00	292.3	0.00	286.0	0.00	-0.02	0.00	0.00
2	1	Segment 2	1.00	0.00	296.0	0.00	298.0	0.00	0.01	0.00	0.00
3	1	Segment 3	1.00	0.00	1123.7	0.00	1115.0	0.00	-0.01	0.00	0.00
4	1	Area-Wtd Mean			488.2	0.00	484.2	0.00	-0.01	0.00	0.00

Mt. Olive Old

File: **S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb**

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	484.2	0.00	488.2	0.00	0.99		-0.03	

Segment: **1** **Segment 1**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	286.0	0.00	292.3	0.00	0.98		-0.08	

Segment: **2** **Segment 2**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	298.0	0.00	296.0	0.00	1.01		0.02	

Segment: **3** **Segment 3**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	1115.0	0.00	1123.7	0.00	0.99		-0.03	

Mt. Olive Old
File: **S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb**

Segment	Name
1	Segment 1
2	Segment 2
3	Segment 3
Mean	Area-Wtd Mean

PREDICTED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	292.3	296.0	1123.7	488.2
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.3	0.4	0.5	0.4
CARLSON TSI-P	86.0	86.2	105.4	90.6

OBSERVED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	286.0	298.0	1115.0	484.2
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.3	0.4	0.5	0.4
CARLSON TSI-P	85.7	86.3	105.3	90.5

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	1.0	1.0	1.0	1.0
TURBIDITY 1/M	1.0	1.0	1.0	1.0
ZMIX * TURBIDITY	1.0	1.0	1.0	1.0
CARLSON TSI-P	1.0	1.0	1.0	1.0

OBSERVED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

PREDICTED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

Mt. Olive Old

File: **S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb**

Predicted & Observed Values Ranked Against CE Model Development Dataset

Segment: **4** **Area-Wtd Mean**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	488.2		99.5%	484.2		99.5%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.4		0.3%	0.4		0.3%
CARLSON TSI-P	90.6		99.5%	90.5		99.5%

Segment: **1** **Segment 1**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	292.3		97.8%	286.0		97.6%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.3		0.1%	0.3		0.1%
CARLSON TSI-P	86.0		97.8%	85.7		97.6%

Segment: **2** **Segment 2**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	296.0		97.8%	298.0		97.9%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.4		0.4%	0.4		0.4%
CARLSON TSI-P	86.2		97.8%	86.3		97.9%

Segment: **3** **Segment 3**

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	1123.7		100.0%	1115.0		100.0%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.5		0.9%	0.5		0.9%
CARLSON TSI-P	105.4		100.0%	105.3		100.0%

Mt. Olive Old
File: S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb

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

		Inflows			Storage	Outflows------>		Downstr	
Seg	**Name**	**External**	**Precip**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Evap**
1	Segment 1	1	0	0	0	1	0	6	0
2	Segment 2	0	0	1	0	1	0	1	0
3	Segment 3	0	0	1	0	1	0	0	0
Net		1	0	0	0	1	0	0	0

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

		Inflows-->			Storage	Outflows----->		Net	Net
Seg	**Name**	**External**	**Atmos**	**Advect**	**Increase**	**Advect**	**Disch.**	**Exchange**	**Retention**
1	Segment 1	337	2	0	0	377	0	-21	-18
2	Segment 2	0	1	377	0	382	0	-625	622
3	Segment 3	0	1	382	0	1450	0	646	-1713
Net		337	4	0	0	1450	0	0	-1109

Mt. Olive Old
File: S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb
Segment Mass Balance Based Upon Predicted Concentrations

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

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
1	1	Inlet Tributary	1.3	95.7%	336.7	49.3%	261
PRECIPITATION			0.1	4.3%	1.8	0.3%	31
INTERNAL LOAD			0.0	0.0%	323.2	47.4%	
TRIBUTARY INFLOW			1.3	95.7%	336.7	49.3%	261
NET DIFFUSIVE INFLOW			0.0	0.0%	20.9	3.1%	
***TOTAL INFLOW			1.3	100.0%	682.6	100.0%	506
ADVECTIVE OUTFLOW			1.3	95.7%	377.0	55.2%	292
***TOTAL OUTFLOW			1.3	95.7%	377.0	55.2%	292
***EVAPORATION			0.1	4.3%	0.0	0.0%	
***RETENTION			0.0	0.0%	305.6	44.8%	
Hyd. Residence Time =			0.1473	yrs			
Overflow Rate =			21.9	m/yr			
Mean Depth =			3.2	m			

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

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
PRECIPITATION			0.0	3.6%	1.5	0.1%	31
INTERNAL LOAD			0.0	0.0%	268.5	21.1%	
ADVECTIVE INFLOW			1.3	96.4%	377.0	29.6%	292
NET DIFFUSIVE INFLOW			0.0	0.0%	625.2	49.1%	
***TOTAL INFLOW			1.3	100.0%	1272.2	100.0%	951
ADVECTIVE OUTFLOW			1.3	96.4%	381.9	30.0%	296
***TOTAL OUTFLOW			1.3	96.4%	381.9	30.0%	296
***EVAPORATION			0.0	3.6%	0.0	0.0%	
***RETENTION			0.0	0.0%	890.3	70.0%	
Hyd. Residence Time =			0.2150	yrs			
Overflow Rate =			26.3	m/yr			
Mean Depth =			5.7	m			

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

Trib	Type	Location	Flow hm³/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m³
PRECIPITATION			0.0	2.5%	1.0	0.0%	31
INTERNAL LOAD			0.0	0.0%	10847.9	96.6%	
ADVECTIVE INFLOW			1.3	97.5%	381.9	3.4%	296
***TOTAL INFLOW			1.3	100.0%	11230.8	100.0%	8492
ADVECTIVE OUTFLOW			1.3	97.5%	1449.6	12.9%	1124
NET DIFFUSIVE OUTFLOW			0.0	0.0%	646.2	5.8%	
***TOTAL OUTFLOW			1.3	97.5%	2095.8	18.7%	1625
***EVAPORATION			0.0	2.5%	0.0	0.0%	
***RETENTION			0.0	0.0%	9135.0	81.3%	
Hyd. Residence Time =			0.2218	yrs			
Overflow Rate =			39.1	m/yr			
Mean Depth =			8.7	m			

Mt. Olive Old
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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	Inlet Tributary	1.9	1.3	0.00E+00	0.00	0.69
PRECIPITATION				0.1	0.1	0.00E+00	0.00	0.98
TRIBUTARY INFLOW				1.9	1.3	0.00E+00	0.00	0.69
***TOTAL INFLOW				2.0	1.4	0.00E+00	0.00	0.71
ADVECTIVE OUTFLOW				2.0	1.3	0.00E+00	0.00	0.64
***TOTAL OUTFLOW				2.0	1.3	0.00E+00	0.00	0.64
***EVAPORATION					0.1	0.00E+00	0.00	

Overall Mass Balance Based Up 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	336.7	2.9%	0.00E+00		0.00	261.0	181.0
PRECIPITATION				4.2	0.0%	0.00E+00		0.00	30.5	30.0
INTERNAL LOAD				11439.6	97.1%	0.00E+00		0.00		
TRIBUTARY INFLOW				336.7	2.9%	0.00E+00		0.00	261.0	181.0
***TOTAL INFLOW				11780.5	100.0%	0.00E+00		0.00	8246.2	5887.3
ADVECTIVE OUTFLOW				1449.6	12.3%	0.00E+00		0.00	1123.7	724.4
***TOTAL OUTFLOW				1449.6	12.3%	0.00E+00		0.00	1123.7	724.4
***RETENTION				10330.9	87.7%	0.00E+00		0.00		

Overflow Rate (m/yr)	9.1	Nutrient Resid. Time (yrs)	0.0312
Hydraulic Resid. Time (yrs)	0.5841	Turnover Ratio	13.3
Reservoir Conc (mg/m3)	488	Retention Coef.	0.877

Mt. Olive Old
File: S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb

Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	2	1.3	0.1473	21.9	2.0	3.0	0.3	5.6
2	Segment 2	3	1.3	0.2150	26.3	1.7	0.7	0.3	0.8
3	Segment 3	0	1.3	0.2218	39.1	1.9	0.2	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	0.1	3.2	3.2	0.3	0.2	0.2	1.5
2	Segment 2	0.0	5.7	5.0	0.4	0.3	0.1	2.8
3	Segment 3	0.0	8.7	6.3	0.4	0.3	0.1	5.3
Totals		0.1	5.3			0.8		

Mt. Olive Old
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S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb
Segment & Tributary Network

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

Mt. Olive Old
File: **S:\IL-EPA5\MtOlives&Staunton\Model\Mt_Olive_Old\Mt_Olive_Old.btb**
Description:
Single reservoir
3 segments

Global Variables	Mean	CV
Averaging Period (yrs)	0.4	0.0
Precipitation (m)	0.4	0.0
Evaporation (m)	0.4	0.0
Storage Increase (m)	0	0.0

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

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	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	2	1	0.059	3.22	0.3	3.22	0	1.87	0	0.08	0	0	0	15	0	0	0
2	Segment 2	3	1	0.049	5.66	0.37	4.98	0	2.2	0	0.08	0	0	0	15	0	0	0
3	Segment 3	0	1	0.033	8.67	0.42	6.34	0	1.73	0	0.08	0	0	0	900	0	0	0

Segment Observed Water Quality

Seg	Conserv Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Chl-a (ppb) Mean	CV	Secchi (m) Mean	CV	Organic N (ppb) Mean	CV	TP - Ortho P (ppb) Mean	CV	HOD (ppb/day) Mean	CV	MOD (ppb/day) Mean	CV
1	0	0	286	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	298	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	1115	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

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

Trib	Trib Name	Segment	Type	Dr Area km^2	Flow (hm^3/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	1	1	1.86	1.29	0	0	0	261	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.2596	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

ATTACHMENT 3. BATHTUB MODEL FILES STAUNTON LAKE

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Staunton Reservoir
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Variable = TOTAL P **R^2 = 0.84**
Global Calibration Factor = 1.60 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	1.00	0.00	75.6	0.00	57.0	0.00	-0.28	0.00	0.00
2	1	Segment 2	1.00	0.00	80.1	0.00	45.0	0.00	-0.58	0.00	0.00
3	1	Segment 3	1.00	0.00	326.2	0.00	406.0	0.00	0.22	0.00	0.00
4	1	Area-Wtd Mean			148.8	0.00	152.6	0.00	0.03	0.00	0.00

Staunton Reservoir
File: **S:\IL-EPA5\MtOlives&Staunton\Model\Staunton\Staunton.btb**

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	152.6	0.00	148.8	0.00	1.03		0.09	

Segment: **1** **Segment 1**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	57.0	0.00	75.6	0.00	0.75		-1.05	

Segment: **2** **Segment 2**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	45.0	0.00	80.1	0.00	0.56		-2.14	

Segment: **3** **Segment 3**

Variable		Observed Mean	CV	Predicted Mean	CV	Obs/Pred Ratio	T-Statistics ----> T1	T2	T3
TOTAL P	MG/M3	406.0	0.00	326.2	0.00	1.24		0.81	

Staunton Reservoir
File: **S:\IL-EPA5\MtOlives&Staunton\Model\Staunton\Staunton.btb**

Segment	Name
1	Segment 1
2	Segment 2
3	Segment 3
Mean	Area-Wtd Mean

PREDICTED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	75.6	80.1	326.2	148.8
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.2	0.4	0.5	0.4
CARLSON TSI-P	66.5	67.4	87.6	72.8

OBSERVED CONCENTRATIONS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	57.0	45.0	406.0	152.6
TURBIDITY 1/M	0.1	0.1	0.1	0.1
ZMIX * TURBIDITY	0.2	0.4	0.5	0.4
CARLSON TSI-P	62.5	59.0	90.8	69.4

OBSERVED/PREDICTED RATIOS:

Variable Segment-->	1	2	3	Mean
TOTAL P MG/M3	0.8	0.6	1.2	1.0
TURBIDITY 1/M	1.0	1.0	1.0	1.0
ZMIX * TURBIDITY	1.0	1.0	1.0	1.0
CARLSON TSI-P	0.9	0.9	1.0	1.0

OBSERVED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

PREDICTED STANDARD ERRORS

Variable Segment-->	1	2	3	Mean

Staunton Reservoir
File:
S:\IL-EPA5\MtOlives&Staunton\Model\Staunton\Staunton.btb
Predicted & Observed Values

Segment: 4 Area-Wtd Mean

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	148.8		89.6%	152.6		90.1%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.4		0.3%	0.4		0.3%
CARLSON TSI-P	72.8		89.6%	69.4		90.1%

Segment: 1 Segment 1

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	75.6		69.4%	57.0		57.7%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.2		0.0%	0.2		0.0%
CARLSON TSI-P	66.5		69.4%	62.5		57.7%

Segment: 2 Segment 2

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	80.1		71.6%	45.0		47.2%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.4		0.6%	0.4		0.6%
CARLSON TSI-P	67.4		71.6%	59.0		47.2%

Segment: 3 Segment 3

Variable	Predicted Values---> Mean	CV	Rank	Observed Values---> Mean	CV	Rank
TOTAL P MG/M3	326.2		98.3%	406.0		99.1%
TURBIDITY 1/M	0.1		1.1%	0.1		1.1%
ZMIX * TURBIDITY	0.5		1.1%	0.5		1.1%
CARLSON TSI-P	87.6		98.3%	90.8		99.1%

Staunton Reservoir
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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	7	0	0	0	7	0	27	0
2	Segment 2	0	0	7	0	7	0	2	0
3	Segment 3	0	0	7	0	7	0	0	0
Net		7	0	0	0	7	0	0	0

Mass Balance Terms (kg/yr) Based Up(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	314	4	0	0	506	0	-120	-67
2	Segment 2	0	3	506	0	536	0	-339	313
3	Segment 3	0	3	536	0	2183	0	460	-2104
Net		314	10	0	0	2183	0	0	-1858

Staunton Reservoir
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Segment Mass Balance Based Upon Predicted Concentrations

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

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
1	1	Inlet Tributary	6.7	98.2%	314.4	71.7%	47
PRECIPITATION			0.1	1.8%	3.8	0.9%	31
TRIBUTARY INFLOW			6.7	98.2%	314.4	71.7%	47
NET DIFFUSIVE INFLOW			0.0	0.0%	120.3	27.4%	
***TOTAL INFLOW			6.8	100.0%	438.5	100.0%	64
ADVECTIVE OUTFLOW			6.7	98.2%	506.0	115.4%	76
***TOTAL OUTFLOW			6.7	98.2%	506.0	115.4%	76
***EVAPORATION			0.1	1.8%	0.0	0.0%	
***RETENTION			0.0	0.0%	-67.5	-15.4%	

Hyd. Residence Time = 0.0506 yrs
Overflow Rate = 53.5 m/yr
Mean Depth = 2.7 m

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

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
PRECIPITATION			0.1	1.7%	3.5	0.4%	31
ADVECTIVE INFLOW			6.7	98.3%	506.0	59.6%	76
NET DIFFUSIVE INFLOW			0.0	0.0%	339.5	40.0%	
***TOTAL INFLOW			6.8	100.0%	848.9	100.0%	125
ADVECTIVE OUTFLOW			6.7	98.3%	535.7	63.1%	80
***TOTAL OUTFLOW			6.7	98.3%	535.7	63.1%	80
***EVAPORATION			0.1	1.7%	0.0	0.0%	
***RETENTION			0.0	0.0%	313.2	36.9%	

Hyd. Residence Time = 0.1153 yrs
Overflow Rate = 58.2 m/yr
Mean Depth = 6.7 m

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

Trib	Type	Location	Flow hm^3/yr	Flow %Total	Load kg/yr	Load %Total	Conc mg/m^3
PRECIPITATION			0.1	1.4%	2.9	0.0%	31
INTERNAL LOAD			0.0	0.0%	5259.6	90.7%	
ADVECTIVE INFLOW			6.7	98.6%	535.7	9.2%	80
***TOTAL INFLOW			6.8	100.0%	5798.2	100.0%	855
ADVECTIVE OUTFLOW			6.7	98.6%	2182.6	37.6%	326
NET DIFFUSIVE OUTFLOW			0.0	0.0%	459.8	7.9%	
***TOTAL OUTFLOW			6.7	98.6%	2642.4	45.6%	395
***EVAPORATION			0.1	1.4%	0.0	0.0%	
***RETENTION			0.0	0.0%	3155.9	54.4%	

Hyd. Residence Time = 0.1392 yrs
Overflow Rate = 69.7 m/yr
Mean Depth = 9.7 m

Staunton Reservoir
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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	Inlet Tributary	9.7	6.7	0.00E+00	0.00	0.69
PRECIPITATION				0.3	0.3	0.00E+00	0.00	0.98
TRIBUTARY INFLOW				9.7	6.7	0.00E+00	0.00	0.69
***TOTAL INFLOW				10.0	7.0	0.00E+00	0.00	0.70
ADVECTIVE OUTFLOW				10.0	6.7	0.00E+00	0.00	0.67
***TOTAL OUTFLOW				10.0	6.7	0.00E+00	0.00	0.67
***EVAPORATION					0.3	0.00E+00	0.00	

Overall Mass Balance Based Up 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	314.4	5.6%	0.00E+00		0.00	47.0	32.4
PRECIPITATION				10.1	0.2%	0.00E+00		0.00	30.5	30.0
INTERNAL LOAD				5259.6	94.2%	0.00E+00		0.00		
TRIBUTARY INFLOW				314.4	5.6%	0.00E+00		0.00	47.0	32.4
***TOTAL INFLOW				5584.1	100.0%	0.00E+00		0.00	795.4	556.2
ADVECTIVE OUTFLOW				2182.6	39.1%	0.00E+00		0.00	326.2	217.4
***TOTAL OUTFLOW				2182.6	39.1%	0.00E+00		0.00	326.2	217.4
***RETENTION				3401.6	60.9%	0.00E+00		0.00		

Overflow Rate (m/yr)	19.9	Nutrient Resid. Time (yrs)	0.0544
Hydraulic Resid. Time (yrs)	0.3052	Turnover Ratio	7.7
Reservoir Conc (mg/m3)	149	Retention Coef.	0.609

Staunton Reservoir
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Hydraulic & Dispersion Parameters

Seg	Name	Outflow Seg	Net Inflow hm^3/yr	Resid Time years	Overflow Rate m/yr	Velocity km/yr	Dispersion--------> Estimated km^2/yr	Numeric km^2/yr	Exchange hm^3/yr
1	Segment 1	2	6.7	0.0506	53.5	10.5	25.2	2.8	27.0
2	Segment 2	3	6.7	0.1153	58.2	6.1	3.3	2.1	1.9
3	Segment 3	0	6.7	0.1392	69.7	5.7	1.2	2.3	0.0

Morphometry

Seg	Name	Area km^2	Zmean m	Zmix m	Length km	Volume hm^3	Width km	L/W -
1	Segment 1	0.1	2.7	2.7	0.5	0.3	0.2	2.2
2	Segment 2	0.1	6.7	5.5	0.7	0.8	0.2	4.3
3	Segment 3	0.1	9.7	6.7	0.8	0.9	0.1	6.7
Totals		0.3	6.1			2.0		

Staunton Reservoir
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Segment & Tributary Network

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

Staunton Reservoir
File: **S:\IL-EPA5\MtOlives&Staunton\Model\Staunton\Staunton.btb**
Description:

Global Variables	Mean	CV
Averaging Period (yrs)	0.4167	0.0
Precipitation (m)	0.4096	0.0
Evaporation (m)	0.4096	0.0
Storage Increase (m)	0	0.0

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

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	1	2ND ORDER, AVAIL P
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	2	CONCENTRATIONS
Nitrogen Calibration	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

							Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	**Name**	**Outflow Segment**	**Group**	**Area km^2**	**Depth m**	**Length km**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	Segment 1	2	1	0.125	2.71	0.53	2.71	0	2.03	0	0.08	0	0	0	0	0	0	0
2	Segment 2	3	1	0.115	6.71	0.7	5.53	0	2.63	0	0.08	0	0	0	0	0	0	0
3	Segment 3	0	1	0.096	9.7	0.8	6.67	0	2.96	0	0.08	0	0	0	150	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	57	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	406	0	0	0	0	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

Trib	Trib Name	Segment	Type	Dr Area km^2	Flow (hm^3/yr) Mean	CV	Conserv. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Inlet Tributary	1	1	9.70436	6.69	0	0	0	47	0	0	0	0	0	0	0

Non-Point Source Export Coefficients

Categ	Land Use Name	Runoff (m/yr) Mean	CV	Conserv. Subs. Mean	CV	Total P (ppb) Mean	CV	Total N (ppb) Mean	CV	Ortho P (ppb) Mean	CV	Inorganic N (ppb) Mean	CV
1	Row Crop	0.2596	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

ATTACHMENT 4. RESPONSIVENESS SUMMARY

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Attachment 4: Responsiveness Summary

This responsiveness summary responds to substantive questions and comments received during the public comment period from June 19, 2007 through August 16, 2007 postmarked, including those from the July 17, 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. The TMDL is for Mt. Olive New Lake, Mt. Olive Old Lake and Staunton 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

Mt. Olive New Lake drains 3,244 acres, Mt. Olive Old Lake drains 462 acres and Staunton Lake drains 2,398 acres. Land use in the watershed is 55 percent agriculture, 28 percent forest and seven percent urban. Mt. Olive Old and New 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. They are also impaired for public water supply use with the potential causes of manganese and atrazine. Staunton Lake is impaired for public water supply use with the potential cause of manganese. 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 Staunton on April 25, 2006 and July 17, 2007. The Illinois EPA provided public notices for all meetings by placing display ads in two newspapers in the watershed; the Staunton Star-Times and the Mount Olive 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 Mt. Olive Public Library, the Staunton 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 25 started at 6:00 p.m. and was attended by one person. The second public meeting on July 17, 2007, started at 6:00 p.m. and was attended by three people. The meeting record remained open until midnight, August 16, 2007.

Questions and Comments

1. There may be failing septic systems on Lake Ka-ho that are causing problems into Mt. Olive New Lake since Lake Ka-ho is upstream. Is there any way to determine this? Can Illinois EPA inspect systems? Does EPA sample Lake Ka-ho?

   Response
   In Illinois, private septic systems are regulated by the Illinois Department of Health (IDPH). IDPH generally contracts with the local Health Department. The normal procedure for local health departments is to permit repairs or installs for new septic systems. Most local Health Departments respond (with inspection or site visit) when complaints are received about a specific system. Illinois EPA does not monitor Lake Ka-ho.

2. The only source of atrazine is the farm fields. What incentives to farmers are there to reduce atrazine? What can the community do about this? How can we get farmers to put in wetlands and other practices?

   Response
   Besides the incentive of reducing pollution in the waters, if less atrazine is applied, costs will be reduced. Illinois EPA has no regulatory control over nonpoint sources of pollution. Runoff from farm fields is considered a nonpoint source and voluntary efforts from local landowners are the only way of controlling nonpoint pollution. We have recommended implementation actions for atrazine in the TMDL report and also included different programs that can provide cost shares. One of the best ways the community can start work in their watershed is to develop a watershed group with local stakeholders. This group can decide what their priorities are in the watershed and where they want to direct their efforts.

3. With corn prices so high, farmers are extending out nearer to the streams, which causes erosion and runoff. Many of the hedgerows and filter strips are being taken out. Is there anything that can be done about this?

   Response
   At this point in time, there is nothing that the state can do from a regulatory (or enforcement) standpoint. However, Illinois EPA in cooperation with the local, state and federal agencies works with the agricultural community to educate them on ways to reduce the impact of farming on the environment. Besides educating people on how this causes erosion, there is not a lot we can do.

4. As for Mt. Olive Old Lake, where does Sugar Creek flow into the lake?

   Response
   Sugar Creek flows from east to west and enters Mt. Olive Old Lake at the east end of the lake. There is a small tributary that flows into Sugar Creek from the south before it gets to the lake. Then Sugar Creek flows from the west side of the lake and eventually into Cahokia Creek.

5. By reducing the impairments in the watershed, will this help increase the life of the water treatment plant?

   Response
   No, it will not increase the life of the plant, but it can reduce the costs of treatment.

6. Mount Olive New Lake has filled in over the years. Wouldn't dredging be the best action for this lake?

   Response
   Dredging will definitely take sediments out of the lake, but should be used with a watershed approach. Unless there is a reduction in the sediment coming into the lakes, sediment build-up will occur again. Dredging is also a very expensive practice and estimates range from $6 to $20 per cubic yard of sediment removed.