Total Maximum Daily Load
Evaluation
for
Lake Allatoona
in the
Coosa River Basin
for
Chlorophyll *a*

Submitted to:
The U.S. Environmental Protection Agency
Region 4
Atlanta, Georgia

Submitted by:
The Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

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EXECUTIVE SUMMARY

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories, supporting designated use, not supporting designated use or assessment pending, depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* (Draft GA EPD, 2008 – 2009). This document is available on the Georgia Environmental Protection Division (GA EPD) website.

The subset of the water bodies that do not meet designated uses on the 305(b) list are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Although the 305(b) and 303(d) lists are two distinct requirements under the CWA, Georgia reports both lists in one combined format called the Integrated 305(b)/303(d) List, which is found in Appendix A of *Water Quality in Georgia*. Water bodies on the 303(d) list are denoted by Category 5, and are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. 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 in-stream water quality conditions. A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body.

The TMDLs in this document are based on the 2010 303(d) listing, which is available on the GA EPD website. The TMDL process establishes the allowable pollutant loadings or other quantifiable parameters for a water body based on the relationship between pollutant sources and instream water quality conditions. This allows water quality-based controls to be developed to reduce pollution and restore and maintain water quality.

The State of Georgia has identified two segments of Lake Allatoona located in the Coosa River Basin as not supporting their designated use due to chlorophyll *a* violations (Little River Embayment and Etowah River arm). One segment is listed as assessment pending (Allatoona Creek arm). A lake segment is placed on the not support list if during the last five-year assessment period, the chlorophyll *a* growing season (April through October) average exceeds the site-specific criteria two or more times. A segment is place on the assessment pending list if during the last five-year assessment period the site specific criteria are exceeded one time. Water quality samples collected monthly during the growing season are used to determine the growing season average. Chlorophyll *a* is a pigment in algae. It is used as an indicator of the potential presence of nutrients in a waterbody that causes excess algal growth. A TMDL for the Little River Embayment was done in 2004. This TMDL addresses the Etowah River arm in Cherokee County and the Allatoona Creek arm in Cobb and Bartow Counties. Lake Allatoona's water use classifications are Recreation and Drinking Water.

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are or may be discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulated nutrients that wash off land surfaces as a result of storm events.

The process of developing the chlorophyll *a* TMDLs for the Coosa River Basin listed segments includes using three computer models to determine the following:

- The current nutrient loads to the lake under existing conditions;
- The critical nutrient load to the lake under NPDES permits at full capacity;
- The TMDL for similar meteorological conditions to those under which the current critical load was determined; and
- The percent reduction in the current critical nutrient load necessary to achieve the TMDL.

A watershed model for Lake Allatoona was developed using the Loading Simulation Program in C++ (LSPC). The watershed model simulates the effects of surface runoff on both water quality and flow and was calibrated to available data. The model also included all major point sources of nutrients. The results of this model were used as tributary flow inputs to the lake hydrodynamic model, Environmental Fluid Dynamics Code (EFDC) and lake water quality model, Water Analysis Simulation Program (WASP). EFDC simulates the transport of water into and out of the lake and WASP simulates the fate and transport of nutrients into and out of the lake and the uptake of nutrients by phytoplankton, where the growth and death of phytoplankton is measured through the surrogate parameter chlorophyll *a*. The nutrient loads and required reductions are summarized in the table below.

Total Daily Nutrient Loads and Required Load Reductions

Stream Segment		**Lake Allatoona – Etowah River Arm**		**Lake Allatoona – Allatoona Creek Arm**	
		Total Nitrogen (lbs/day)	**Total Phosphorus (lbs/day)**	**Total Nitrogen (lbs/day)**	**Total Phosphorus (lbs/day)**
Current Load (lbs/day)		62,342	12,718	5465	907
TMDL Components	4,032	41	23	4	4
	422	77	943	154	154
	50,852	10,017	2,287	374	374
	Implicit	Implicit	Implicit	Implicit	Implicit
	55,300	10,136	3,253	532	532
Percent Reduction		14%	20%	40%	41%

Management practices that may be used to help reduce nutrient source loads include:

- Compliance with NPDES permit limits and requirements;
- Adoption of NRCS Conservation Practices; and
- Application of Best Management Practices (BMPs) appropriate to reduce nonpoint sources.

The amount of nutrients delivered to a stream is difficult to determine. However, by requiring and monitoring the implementation of these management practices, their effects will improve stream water quality, and represent a beneficial measure of TMDL implementation.

1.0 INTRODUCTION

1.1 Background

The State of Georgia assesses its water bodies for compliance with water quality standards criteria established for their designated uses as required by the Federal Clean Water Act (CWA). Assessed water bodies are placed into one of three categories, supporting designated use, not supporting designated use or assessment pending, depending on water quality assessment results. These water bodies are found on Georgia's 305(b) list as required by that section of the CWA that defines the assessment process, and are published in *Water Quality in Georgia* (Draft GA EPD, 2008 – 2009). This document is available on the Georgia Environmental Protection Division (GA EPD) website.

The subset of the water bodies that do not meet designated uses on the 305(b) list are also assigned to Georgia's 303(d) list, also named after that section of the CWA. Although the 305(b) and 303(d) lists are two distinct requirements under the CWA, Georgia reports both lists in one combined format called the Integrated 305(b)/303(d) List, which is found in Appendix A of *Water Quality in Georgia*. Water bodies on the 303(d) list are denoted by Category 5, and are required to have a Total Maximum Daily Load (TMDL) evaluation for the water quality constituent(s) in violation of the water quality standard. 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 in-stream water quality conditions. A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body.

Chlorophyll *a* is a pigment in algae. It is used as an indicator of the potential presence of nutrients in a waterbody that cause excess algal growth. In 2002, the Little River Embayment of Lake Allatoona was listed as impaired for chlorophyll *a,* and in 2004 a TMDL was finalized for this lake segment. Table 1 presents the segments of the Coosa River Basin included on the 2010 303(d) list for exceedances of the chlorophyll *a* criteria.

Table 1. Waterbodies Listed on the 2010 303(d) List for Chlorophyll *a* in the Lake Allatoona

Lake Segment	Location	Category	Segment Area (acres)	Designated Use
Allatoona Lake	Etowah River Arm (Cherokee County)	5	2,785	Recreation/ Drinking Water
Allatoona Lake	Allatoona Creek Arm (Cobb and Bartow Counties)	3	3,515	Recreation/ Drinking Water

1.2 Watershed Description

The Etowah River originates in Lumpkin County in the north Georgia mountains. The Etowah River flows southwest to Lake Allatoona. Lake Allatoona is located approximately 30 miles northeast of Atlanta. The Lake Allatoona watershed occupies a total area of about 1,120 square miles. Lake Allatoona is a US Army Corps of Engineers Lake, and was complete and has been operational since 1950. The lake has a summer pool elevation of 840 feet above mean sea level, and a winter pool elevation of 823 feet above mean sea level. Lake Allatoona is considered a multi-use reservoir, and its uses include: flood control, hydropower generation, water-supply, recreation, fish and wildlife management, and navigation. The City of Cartersville, Cherokee County Water and Sewer Authority, and the Cobb-Marietta Water Authority depend on the reservoir to meet their water usage needs. To help meet these needs, the City of Cartersville and Cobb-Marietta Water Authority maintain water intakes located on Lake Allatoona. The Lake Allatoona watershed lies within the Coosa River Basin, and is part of the Alabama-Coosa-Tallapoosa (ACT) River Basin that drains into Alabama and down to Mobile Bay. A total of 8 counties are located either completely or partially in the Lake Allatoona watershed, making the watershed very important to a wide-range of communities.

The Lake Allatoona watershed contains parts of the Blue Ridge, Piedmont, and Southern Appalachian Ridge and Valley physiographic provinces that extend throughout the south-eastern United States.

The United States Geologic Survey (USGS) has divided the Coosa basin into five sub-basins, or Hydrologic Unit Codes (HUCs). These are numbered as HUCs 03150101 through 03150105. Figure 1 shows the locations of these sub-basins. Lake Allatoona is located in HUC 03150104. Figure 2 shows the impaired segments within this sub-basin.

The landuse characteristics of the Lake Allatoona watershed were determined using data from the National Land Cover Dataset (NLCD) for Georgia. This coverage was produced from Landsat Thematic Mapper digital images developed in 2001. Landuse classification is based on a modified Anderson level one and two system. Table 2 lists the watershed land coverage distribution of the two segments.

1.3 Water Quality Standard

The water use classifications for the listed segments in Lake Allatoona are Recreation and Drinking Water. The criterion violated is listed as chlorophyll *a*. The potential causes listed include urban runoff, nonpoint sources, and municipal and industrial facilities. The site-specific criteria for Lake Allatoona, as stated in the *State of Georgia's Rules and Regulations for Water Quality Control*, Chapter 391-3-6-.03(17)(5)(i) (GA EPD, 2009), are:

(d) Lake Allatoona: Those waters impounded by Allatoona Dam and upstream to State Highway 5 on the Etowah River, State Highway 5 on Little River, the Lake Acworth Dam, and the confluence of Little Allatoona Creek and Allatoona Creek. Other impounded tributaries to an elevation of 840 feet mean sea level corresponding to the normal pool elevation of Lake Allatoona.

(i) Chlorophyll *a*: For the months of April through October, the average of monthly mid-channel photic zone composite samples shall not exceed the chlorophyll *a* concentrations at the locations listed below more than once in a five-year period:

1.	Upstream from the Dam	10 μg/L
2.	Allatoona Creek upstream from I-75	12 μg/L
3.	Mid-Lake downstream from Kellogg Creek	10 μg/L
4.	Little River upstream from Highway 205	15 μg/L
5.	Etowah River upstream from Sweetwater Creek	14 μg/L

(ii) pH: Within the range of 6.0-9.5 standard units.

(iii) Total Nitrogen: Not to exceed a growing season average of 4 mg/L as nitrogen in the photic zone.

(iv) Phosphorous: Total lake loading shall not exceed 1.3 pounds per acre-foot of lake volume per year.

(v) Fecal Coliform:

1. Etowah River, State Highway 5 to State Highway 20: Fecal coliform bacteria shall not exceed the Fishing Criterion as presented in 391-3-6.-03(6)(c)(iii).

2. Etowah River, State Highway 20 to Allatoona Dam: Fecal coliform bacteria shall not exceed the Recreation criterion as presented in 391-3-6.-03(6)(b)(i).

(vi) Dissolved Oxygen: A daily average of 5.0 mg/L and no less than 4.0 mg/L at all times at the depth specified in 391-3-6-.03(5)(g).

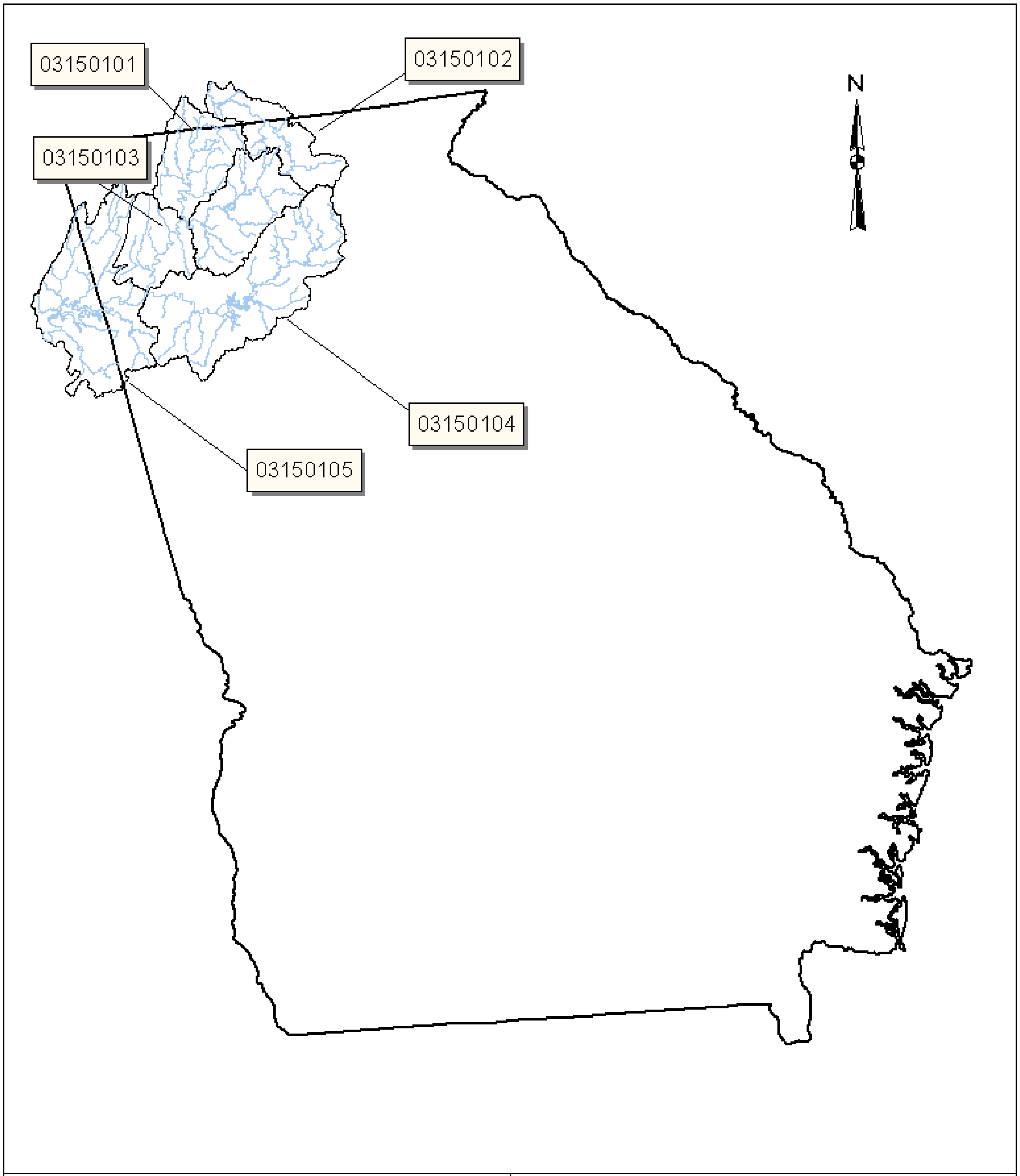
(vii) Temperature:

1. Etowah River, State Highway 5 to State Highway 20: Water temperature shall not exceed the Fishing criterion as presented in 391-3-6-.03(6)(c)(iv).

2. Etowah River State Highway 20 to Allatoona Dam: Water temperature shall not exceed the Recreation criterion as presented in 391-3-6-.03(6)(b)(iv).

(viii) Major Lake Tributaries: For the following major tributaries, the annual total phosphorous loading to Lake Allatoona shall not exceed the following:

1.	Etowah River at State Highway 5 spur and 140, at the USGS gage	340,000 lbs/yr
2.	Little River at State Highway 5 (Highway 754)	42,000 lbs/yr
3.	Noonday Creek at North Rope Mill Road	38,000 lbs/yr
4.	Shoal Creek at State Highway 108 (Fincher Road)	12,500 lbs/yr



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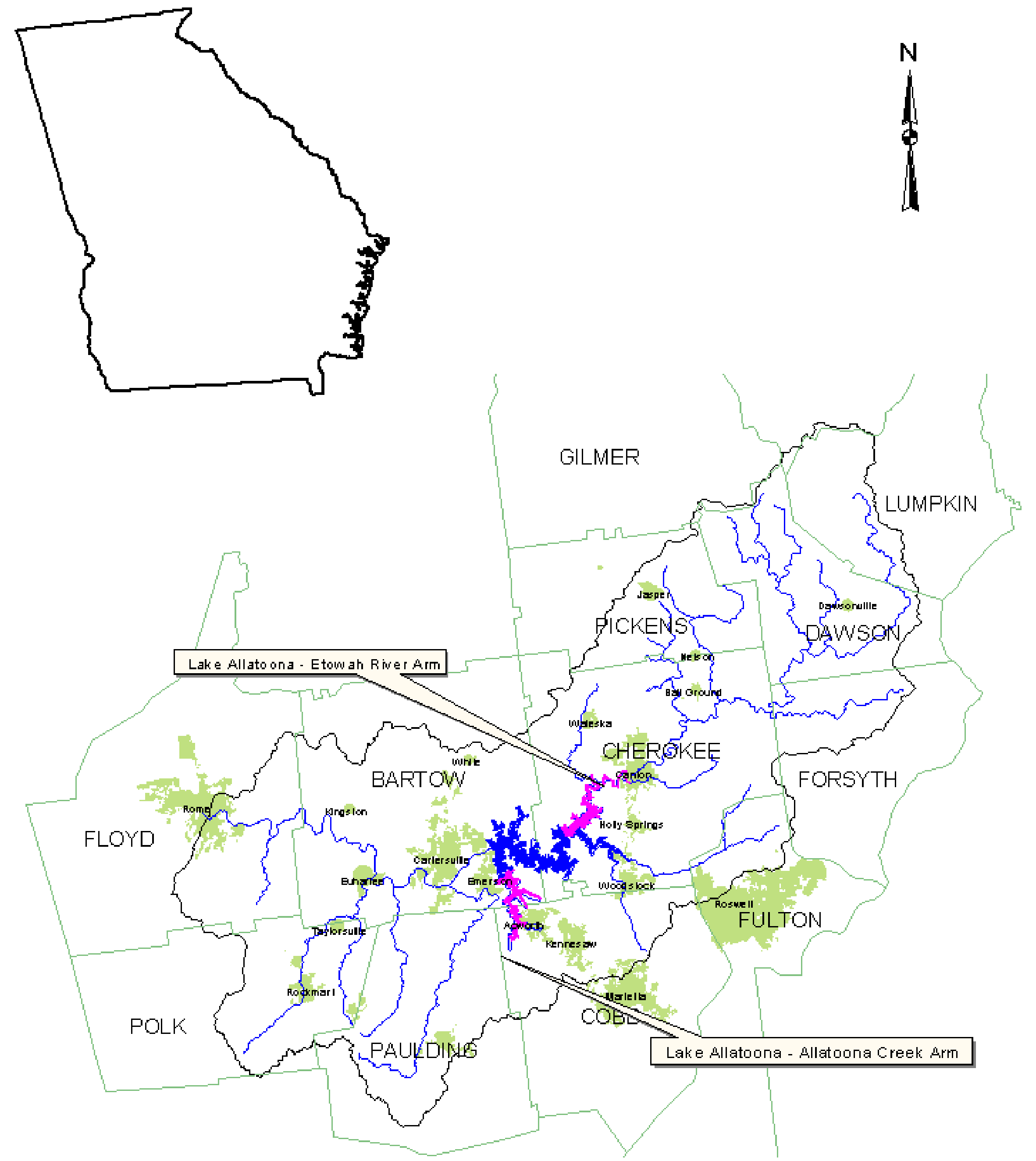
Coosa River Basin

Figure 1. USGS 8-digit HUCS for Coosa River Basin



TMDL Evaluation - Chlorophyll a
Coosa River Basin

Figure 2. 303d Listed Streams in HUC 03150104

Table 2. Coosa River Basin Land Coverage

Stream/Segment	Landuse Categories - Acres (Percent)																
	Open Water	Low Intensity Residential	High Intensity Residential	Medium Intensity	Developed High Intensity	Bare Rock	Deciduous Forest	Evergreen Forest	Mixed Forest	Deciduous Scrubland	Grassland/ Herbaceous	Pasture/Hay	Row Crops	Pasture-Chicken	Woody Wetlands	Emergent Herbaceous Wetlands	Total
Lake Allatoona -	3,210	34,907	6,736	1,391	326	2,340	279,835	55,924	18,207	6,013	13,194	23,276	463	20,048	2,610	2	468,482
Etowah River Arm	(0.69)	(7.45)	(1.44)	(0.30)	(0.07)	(0.50)	(59.73)	(11.94)	(3.89)	(1.28)	(2.82)	(4.97)	(0.10)	(4.28)	(0.56)	(0.00)	(100.00)
Lake Allatoona -	2,770	10,532	9,048	1,223	373	646	9,383	11,137	397	121	896	2,189	18	76	570	1	49,380
Allatoona Creek Arm	(5.61)	(21.33)	(18.32)	(2.48)	(0.76)	(1.31)	(19.00)	(22.55)	(0.80)	(0.25)	(1.81)	(4.43)	(0.04)	(0.15)	(1.15)	(0.00)	(100.00)
Lake Allatoona	14,640	81,250	35,914	6,742	2,794	5,254	353,659	97,781	25,296	8,226	17,894	38,765	547	22,644	5,155	6	716,567
Entire Watershed	(2.04)	(11.34)	(5.01)	(0.94)	(0.39)	(0.73)	(49.35)	(13.65)	(3.53)	(1.15)	(2.50)	(5.41)	(0.08)	(3.16)	(0.72)	(0.00)	(100.00)

2.0 WATER QUALITY ASSESSMENT

In lakes with nutrient and chlorophyll *a* standards, GA EPD collects water quality samples monthly during the growing season, which is from April through October. Lake Allatoona is sampled at five locations. Figure 3 shows the locations of the Lake Allatoona water quality stations. These data are used to assess water quality standards, see trends in nutrients and chlorophyll levels, and to assist in developing NPDES permits.

Stream segments are placed on the 303(d) list as not supporting their water use classification based on water quality sampling data. A lake segment is placed on the not support list if during the last five-year assessment period, the chlorophyll *a* growing season average exceeds the site-specific criteria two or more times.

GA EPD collected the chlorophyll *a* data used for the TMDLs developed in this document during calendar years 2000 through 2007. These data along with other water quality data collected as part of the lake standard monitoring program are presented in Appendix A. Appendix B shows plots of the average annual growing season chlorophyll *a* levels at the five monitoring stations.

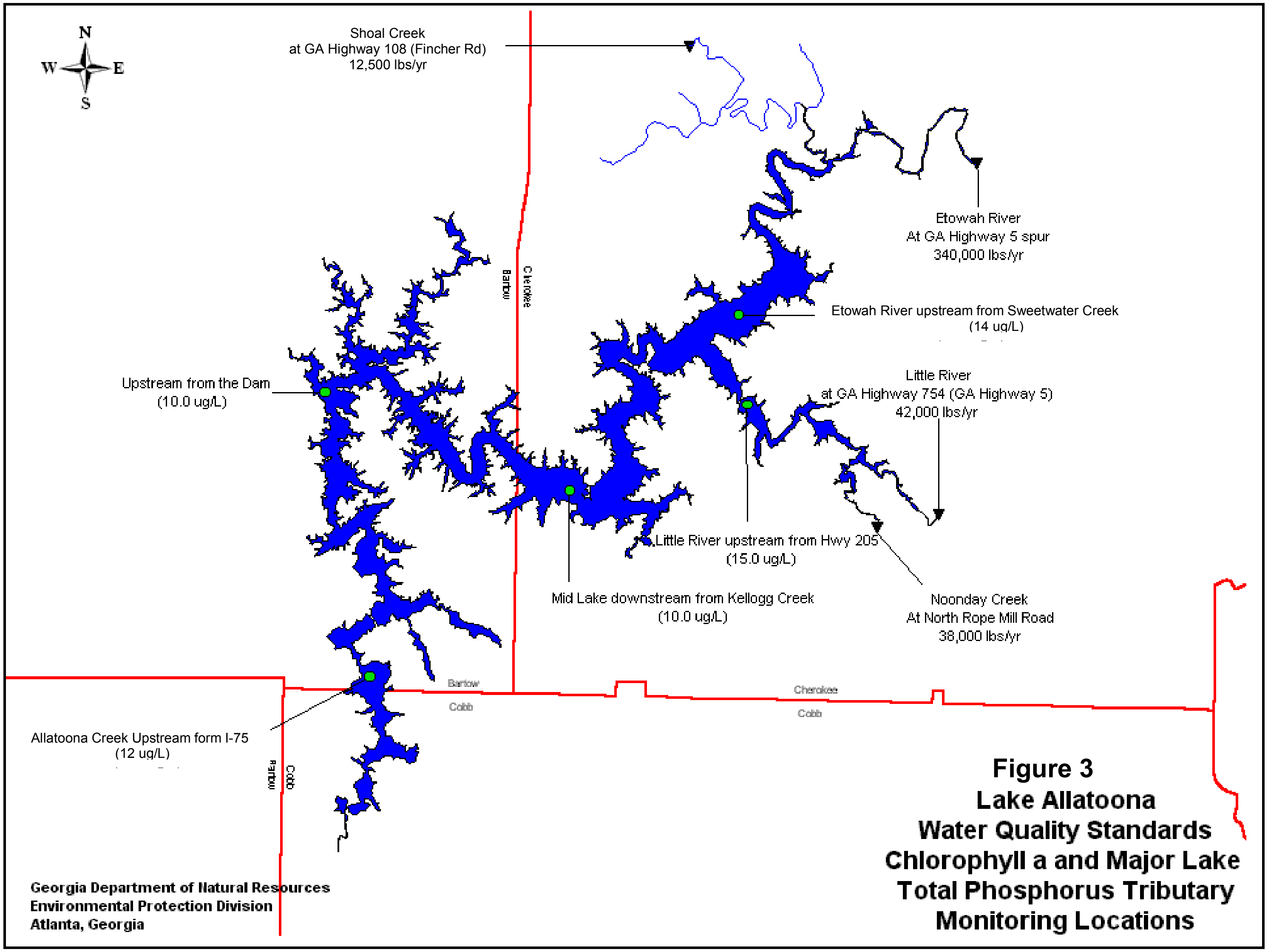


Figure 3
Lake Allatoona
Water Quality Standards
Chlorophyll a and Major Lake
Total Phosphorus Tributary
Monitoring Locations

Georgia Department of Natural Resources
Environmental Protection Division
Atlanta, Georgia

3.0 SOURCE ASSESSMENT

An important part of the TMDL analysis is the identification of potential source categories. Sources are broadly classified as either point or nonpoint sources. A point source is defined as a discernable, confined, and discrete conveyance from which pollutants are, or may be, discharged to surface waters. Nonpoint sources are diffuse, and generally, but not always, involve accumulation of nutrients on land surfaces that wash off as a result of storm events.

3.1 Point Source Assessment

Title IV of the Clean Water Act establishes the National Pollutant Discharge Elimination System (NPDES) permit program. Basically, there are two categories of NPDES permits: 1) municipal and industrial wastewater treatment facilities, and 2) regulated storm water discharges.

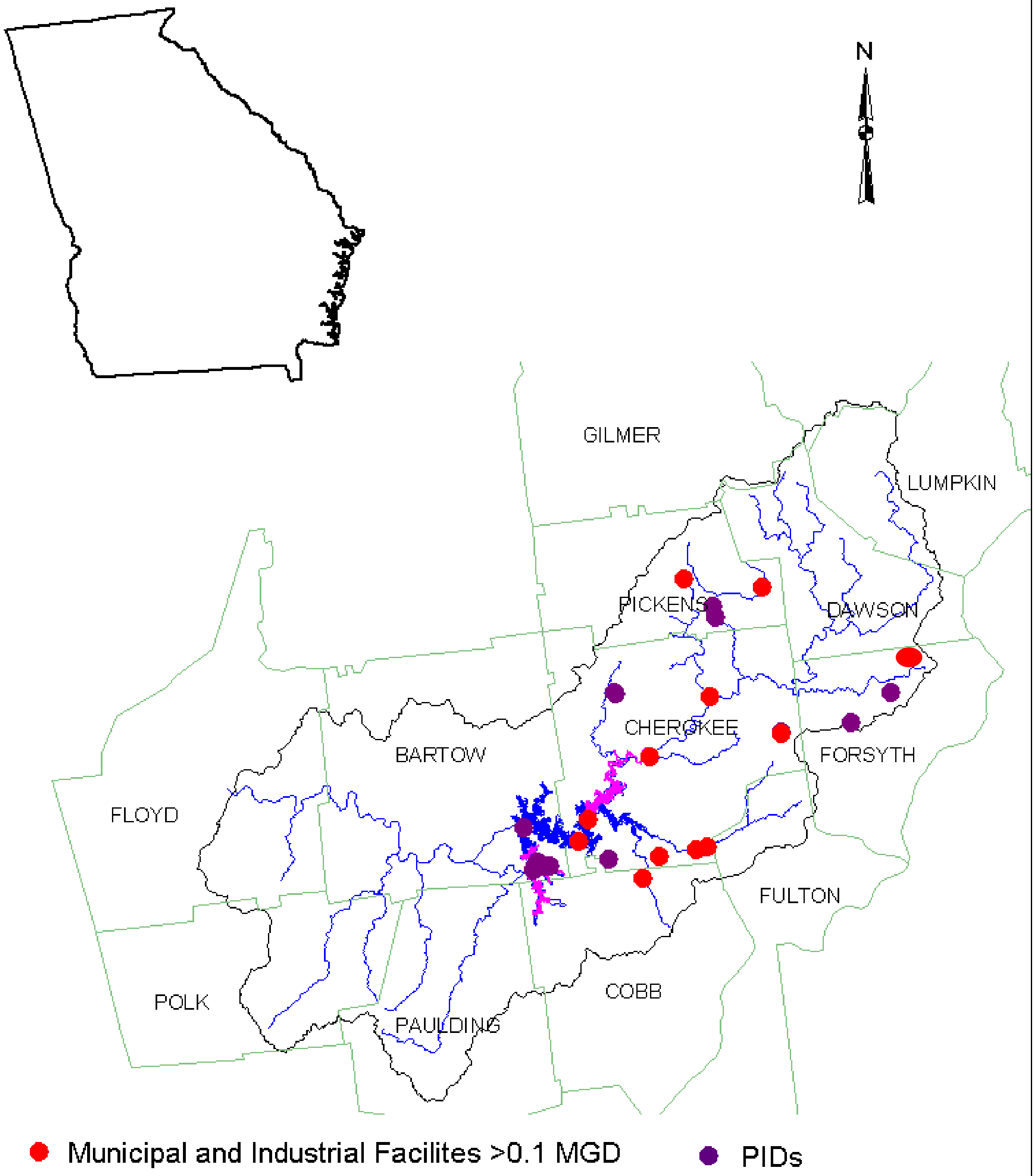
3.1.1 Wastewater Treatment Facilities

In general, industrial and municipal wastewater treatment facilities have NPDES permits with effluent limits. These permit limits are either based on federal and state effluent guidelines (technology-based limits) or on water quality standards (water quality-based limits).

The EPA has developed technology-based guidelines, which establish a minimum standard of pollution control for municipal and industrial discharges. These are based on Best Practical Control Technology Currently Available (BPT), Best Conventional Control Technology (BCT), and Best Available Technology Economically Achievable (BAT). The level of control required by each facility depends on the type of discharge and the pollutant.

The EPA and the states have also developed numeric and narrative water quality standards. Typically, these standards are based on the results of aquatic toxicity tests and/or human health criteria and include a margin of safety. Water quality-based effluent limits are set to protect the receiving stream. These limits are based on water quality standards that have been established for a stream based on its intended use and the prescribed biological and chemical conditions that must be met to sustain that use.

Discharges from municipal and industrial wastewater treatment facilities can contribute nutrients to receiving waters. There are 34 point source discharges located in the Lake Allatoona watershed. Of these point sources, nine are municipal facilities, 17 are private facilities such as schools and hospitals, and eight are industrial facilities. Seven of the eight industrial facilities are rock quarries and should not be a source of nutrients. Of the remaining 26 facilities, ten have National Pollutant Discharge Elimination System (NPDES) permitted discharges with flows greater than 0.1 MGD, which includes one Private Institutional Discharge (PID), Big Canoe, and one industrial facility, Goldkist Poultry Byproducts. The Hampton Reuse Facility received a permit on November 9, 2007, which allows for a seasonal discharge, from November through April, to Settingdown Creek. During the other times of the year, there is no discharge since the effluent is reused. The sixteen remaining PIDs have permitted discharges with flows less than 0.1 MGD. Six of these have ceased discharging since 2007. Figure 4 shows the locations of these point source discharges. Table 3 provides the monthly average discharge flows and nutrient concentrations (total phosphorus [Total P], ortho-phosphate [PO_4], ammonia [NH_3], and nitrate-nitrite [NO_2/NO_3]) for the municipal and industrial treatment facilities with permitted flows greater than 0.1 MGD. These data were obtained from calendar years 2000-2007 Discharge Monitoring Reports (DMRs). The permitted flow and nutrient concentrations for these facilities are also included in this table.



TMDL Evaluation - Chlorophyll a
Coosa River Basin

Figure 4. Location of
Point Source Discharges

Table 3. NPDES Facilities Discharging Nutrients into the Lake Allatoona

Facility Name	NPDES Permit No.	Receiving Stream	NPDES Permit Limits				Average Discharge					
			Average Monthly Flow (MGD)	BOD$_5$ (mg/L)	TP (mg/L)	NH$_3$ (mg/L)	Average Monthly Flow (MGD)	BOD$_5$ (mg/L)	TP (mg/L)	PO$_4$ (mg/L)	NH$_3$ (mg/L)	NO$_X$ (mg/L)
Cobb County Noonday Creek WPCP	GA0024988	Noonday Creek	20	6.0	10,960 lbs/yr	1.2	9.78	2.13	0.21	0.08	0.16	--
City of Canton WPCP	GA0025674	Etowah River	1.89	30.0	0.5	17.4	1.77	12.10	2.79	--	1.71	--
Woodstock Rubes Creek WPCP	GA0026263	Rubes Creek	2.50	5.0	28.6 kg/ mth	3.0	0.72	3.75	1.34	0.50	1.22	--
Big Canoe WPCP	GA0030252	East Branch Long Swamp Creek	0.25	10.0	1.0	--	0.021	4.86	0.51	--	1.37	--
Jasper WPCP	GA0032204	Polecat Branch	0.80	20.0	--	5.0	0.48	3.65	--	--	0.65	--
Fulton County Little River WPCP	GA0033251	Little River	1.0	8.5	0.5	1.7	0.74	1.31	0.23	--	0.24	--
Cherokee County Fitzgerald Creek	GA0038555	Little River	2.0	8.0	0.82	1.5	1.03	5.29	1.54	0.30	0.31	17.26
Hampton Reuse Facility (seasonal discharge Nov-Apr)	GA0038903	Settingdown Creek	0.45	5.0	0.16	1.0	-	-	-	-	-	-
Cherokee County Rose Creek	GA0046451	Lake Allatoona	6.0	6.7	0.36	1.3	3.50	3.62	0.17	--	0.32	--
Cobb County Northwest WPCP	GA0046761	Lake Allatoona	12.0	3.0	0.23	0.6	6.19	2.04	0.16	0.06	0.14	--
Goldkist Poultry Byproducts	GA0000728	Etowah River	--	40.0	--	134 lbs/day	0.16	12.79	1.79	--	27.56	--

Source: GA EPD

Combined sewer systems convey a mixture of raw sewage and storm water in the same conveyance structure to the wastewater treatment plant. These are considered a component of municipal wastewater treatment facilities. When the combined sewage exceeds the capacity of the wastewater treatment plant, the excess is diverted to a combined sewage overflow (CSO) discharge point. There are no permitted CSO outfalls in the Coosa River Basin.

3.1.2 Regulated Storm Water Discharges

Some storm water runoff is covered under the NPDES Permit Program. It is considered a diffuse source of pollution. Unlike other NPDES permits that establish end-of-pipe limits, storm water NPDES permits establish controls “to the maximum extent practicable”. Currently, regulated storm water discharges that may contain nutrients consist of those associated with industrial activities including construction sites disturbing one acre or greater, and large, medium, and small municipal separate storm sewer systems (MS4s) that serve populations of 50,000 or more.

Storm water discharges associated with industrial activities are currently covered under a General Storm Water NPDES Permit. This permit requires visual monitoring of storm water discharges, site inspections, implementation of Best Management Practices (BMPs), and record keeping.

Storm water discharges from MS4s are very diverse in pollutant loadings and frequency of discharge. At present, all cities and counties within the state of Georgia that had a population of greater than 100,000 at the time of the 1990 Census, are permitted for their storm water discharge under Phase I. This includes 60 permittees in Georgia.

Phase I MS4 permits require the prohibition of non-storm water discharges (i.e., illicit discharges) into the storm sewer systems and controls to reduce the discharge of pollutants to the maximum extent practicable, including the use of management practices, control techniques and systems, as well as design and engineering methods (Federal Register, 1990). A site-specific Storm Water Management Plan (SWMP) outlining appropriate controls is required by and referenced in the permit. There are five Phase I MS4s in the Lake Allatoona watershed (Table 4).

Table 4. Phase I Permitted MS4s in the Lake Allatoona Watershed

Name	Permit No.	Watershed
Acworth	GAS000101	Coosa
Cobb County	GAS000108	Chattahoochee, Coosa
Fulton County	GAS000117	Chattahoochee, Coosa, Flint, Ocmulgee
Forsyth County	GAS000300	Chattahoochee, Coosa
Kennesaw	GAS000121	Coosa

Source: Nonpoint Source Permitting Program, GA DNR, 2010

Small MS4s serving urbanized areas are required to obtain a storm water permit under the Phase II storm water regulations. An urbanized area is defined as an area with a residential population of at least 50,000 people and an overall population density of at least 1,000 people per square mile. Thirty counties and 56 communities in Georgia are permitted under the Phase

II regulations. There are eight counties or communities located in the Lake Allatoona watershed that are covered by the Phase II General Storm Water Permit (Table 5).

Table 5. Phase II Permitted MS4s in the Lake Allatoona Watershed

Name	Watershed
Bartow County	Coosa
Canton	Coosa
Cherokee County	Coosa
Holly Springs	Coosa
Mountain Park	Coosa
Paulding County	Chattahoochee, Coosa, Tallapoosa
Woodstock	Coosa

Source: Nonpoint Source Permitting Program, GA DNR, 2010

Those watersheds located within Phase I or Phase II MS4 city or county urbanized areas are listed in Table 6. The table provides the total area of each of these watersheds plus the total are of the Lake Allatoona watershed, and the percentage of the watersheds that is in a MS4 city or county urbanized area.

Table 6. Percentage of Watersheds in the Lake Allatoona Watershed Located in MS4 City or County Urbanized Areas

Location	Segment	Total Area (acres)	% in MS4 area
Lake Allatoona	Etowah River Arm (Cherokee County)	469,462	12.2
Lake Allatoona	Allatoona Creek Arm (Cobb and Bartow Counties)	49,380	94.1
Lake Allatoona	Entire Watershed	716,360	30.4

3.1.3 Concentrated Animal Feeding Operations

The NPDES program regulates the discharge of pollutants from point sources to waters of the United States. Concentrated Animal Feeding Operations (CAFOs) are point sources, as defined by the Federal Clean Water Act. To be considered a CAFO, a facility must first be defined as an Animal Feeding Operation (AFO).

AFOs are agricultural operations where animals are kept and raised in confined situations. AFOs generally congregate animals, feed, manure, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures. An AFO is a lot or facility (other than an aquatic animal production facility) where the following conditions are met:

- Animals have been, are, or will be stabled or confined and fed or maintained for a total of 45 days or more in any 12-month period, and
- Crops, vegetation, forage growth, or post-harvest residues are not sustained in the normal growing season over any portion of the lot or facility.

Animal feeding operations that are characterized by high animal densities result in large quantities of fecal material being concentrated in a limited area. Processed agricultural manure from confined hog, beef cattle, dairy cows, and select poultry operations is generally collected in lagoons. It is then applied to pastureland and cropland as a fertilizer, at rates that vary monthly. Animal waste and wastewater from these operations can enter waterbodies during rain events or because of accidents such as spills or breaks of waste storage areas near the waterbody.

From 1999 through 2001, Georgia adopted water quality rules for swine and non-swine feeding operation permits. Georgia rules require medium size animal feeding operations, those with more than 300 animal units (AU), but less than 1000 AU, to apply for a non-discharge Land Application System (LAS) waste disposal permit. LAS permits for AFOs are required and regulated by Georgia if any of the following criteria are met:

- 201 to 700 dairy cows
- 301 to 1000 beef cows
- 751 to 2500 hogs weighing 55 lbs or more

Large operations with more than 1000 AU must apply for a non-discharge NPDES permit as a CAFO. The rules specify that 1000 AU equals 1000 beef cows, 700 dairy cows, or 2500 swine. CAFO permit holders are required to develop and implement a nutrient management plan (NMP) for their operations. NPDES permits for CAFOs are required and regulated by Georgia if any of the following criteria are met:

- >700 dairy cows
- >1000 beef cows
- >2500 hogs weighing 55 lbs or more

In 2002, the USEPA greatly expanded NPDES permit regulations for CAFOs. Dry manure poultry operations larger than 125,000 broilers or 82,000 layers were added, as well as other changes, and accordingly, the Georgia rules were amended. The USEPA CAFO regulations were successfully appealed in 2005, and EPA revised their CAFO regulations effective December 20, 2008, to comply with the court decision. The Georgia rules must be revised within one year to incorporate these revisions. The two key changes in the EPA regulation are:

- Reducing the permitted community from all large CAFOs to only those that actually discharge to surface water, e.g. eliminating most dry manure poultry permitting
- Requiring a public participation opportunity for nutrient management plans (NMPs) prior to permit coverage.

Georgia has almost 5000 livestock and poultry farms. Permit applications for animal waste disposal have been submitted for about 800 of the largest farms. Of these, 185 use liquid manure handling with 44 as large operations that have NPDES CAFO permits, and 141 are medium operations that have LAS permits. There are four swine and non-swine (primarily dairies) liquid manure CAFOs located in the Coosa River Basin that are registered or have land application permits. None of these are located in the Lake Allatoona watershed.

Georgia is consistently among the top three states in the U.S. in terms of poultry operations. The majority of poultry farms are dry manure operations. These farms store and dispose of their animal waste as a solid material. This can be a nonpoint source for nutrients. Current federal regulations require that large poultry farms operate under NPDES permits, but this may not apply in the future. Large poultry farms include poultry operations with 82,000 laying hens or 125,000 chickens. There are over 500 large dry manure poultry farms that are NPDES CAFOs.

Table 7 presents the dry manure poultry operations in the Lake Allatoona watershed that have submitted an application for the General NPDES Permit GAG930000.

Table 7. Registered Dry Manure Poultry Operations in the Lake Allatoona Watershed

Name	County	Number of Animals (thousands)
Bok-Bok Poultry	Dawson	138
Buchanan Livestock #2	Pickens	176
Buchanan Livestock- Spring Farm	Pickens	155
Circle R	Dawson	140
Cumberland Pltry, Autum Farm, Cripple Creek	Cherokee	175.5
Danny Fausett #1,#2,#3	Dawson	223
Eagle Creek	Dawson	193.2
Git-R-Done#1 & Git-R-Done # 2	Dawson	157.8
Juno Farm	Dawson	146.4
Little Mtn, Jerry Waters, & J&B	Dawson	152.6
M & T Farm	Dawson	138
Pigeon Creek Laroge Rocky Ridge	Dawson	127
Powell Poultry#1/ Cochran Creek	Dawson	146.4
Won's Poultry (McPherson Poultry)	Forsyth	143.4
Yellow Creek Poultry Farm (1 & 2)	Forsyth	208

Source: GA Dept. of Agriculture, 2010

3.2 Nonpoint Source Assessment

In general, nonpoint sources cannot be identified as entering a waterbody through a discrete conveyance at a single location. Typical nonpoint sources of nutrients come from materials being washed into the rivers and streams during storm events. Constituents that have washed off of land surfaces in previous months or years have either flushed out of the system along with the water column flow or settled out and became part of the lake bottom. In this manner, settleable material accumulates and may release nutrients into the water column over time. Constituents of concern from surface washoff include the fractions of phosphorus and nitrogen that become an integral part of channel bottom sediments, thus becoming a potential source of nutrients for algae.

Typical nonpoint sources of nutrients include:

- Wildlife
- Agricultural Livestock
    - Application of manure to pastureland and cropland
    - Application of fertilizers
- Urban Development
    - Application of fertilizers
    - Septic systems
    - Land Application Systems
    - Landfills

In urban areas, a large portion of storm water runoff may be collected in storm sewer systems and discharged through distinct outlet structures. For large urban areas, these storm sewer discharge points may be regulated as described in Section 3.1.2.

3.2.1 Wildlife

The importance of wildlife as a source of nutrients in streams varies considerably, depending on the animal species present in the watersheds. Based on information provided by the Wildlife Resources Division (WRD) of GA DNR, the animals that spend a large portion of their time in or around aquatic habitats are the most important wildlife sources of nutrients. Waterfowl, most notably ducks and geese, are considered to potentially be the greatest contributors of nutrients. This is because they are typically found on the water surface, often in large numbers, and deposit their waste directly into the water, and their faeces contains high levels of nutrients. Other potentially important animals regularly found around aquatic environments include racoons, beavers, muskrats, and to a lesser extent, river otters and minks. Recently, rapidly expanding feral swine populations have become a significant presence in the floodplain areas of all the major rivers in Georgia. Population estimates of these animal species in Georgia are currently not available.

White-tailed deer populations are significant throughout the Coosa River Basin. Nutrient contributions from deer to water bodies are generally considered less significant than that of waterfowl, racoons, and beavers. This is because a greater portion of their time is spent in terrestrial habitats. This also holds true for other terrestrial mammals such as squirrels and rabbits, and for terrestrial birds (GA WRD, 2007). However, waste deposited on the land surface that contains nutrients can result in additional nutrient loads to streams during runoff events.

3.2.2 Agricultural Livestock

Manure from agricultural livestock is a potential source of nutrients to streams in the Lake Allatoona watershed. The animals grazing on pastureland deposit their feces, which contain nutrients, onto land surfaces, where it can be transported during storm events to nearby streams. Animal access to pastureland varies monthly, resulting in varying nutrient loading rates throughout the year. Beef cattle spend all of their time in pastures, while dairy cattle and hogs are periodically confined. In addition, agricultural livestock will often have direct access to streams that pass through their pastures, and can thus impact water quality in a more direct manner (USDA, 2002).

Table 8 provides the annual estimated number of beef cattle, dairy cattle, goats, horse, swine, sheep, and chickens reported by county. The Natural Resources Conservation Service (NRCS) provided these data.

Table 8. Estimated Agricultural Livestock Populations in the Lake Allatoona Watershed

County	**Livestock**							
	Beef Cattle	**Dairy Cattle**	**Swine**	**Sheep**	**Horses**	**Goats**	**Chickens Layers**	**Chickens-Broilers Sold**
Bartow	15,000	130	250	225	4,925	1,600	220,000	32,175,000
Cherokee	3,000	100	-	-	3,000	1,000	-	18,161,000
Cobb	-	-	-	-	1,320	-	-	-
Dawson	3,700	-	-	75	950	300	40,000	22,687,500
Forsyth	1,600	-	-	-	2,700	50	72,000	9,052,800
Fulton	3,000	-	-	24	560	350	-	-
Gilmer	5,500	800	-	-	510	100	400,000	72,192,000
Lumpkin	3,300	200	-	80	390	329	140,000	12,531,200
Paulding	3,000	45	-	250	1,200	650	-	7,865,000
Pickens	3,330	-	240	30	735	345	80,000	23,000,000

Source: NRCS, 2008

3.2.3 Urban Development

Nutrients from urban areas are attributable to multiple sources, including: domestic animals, leaks and overflows from sanitary sewer systems, illicit discharges, septic systems, runoff from lawns where fertilizers have been applied, and leachate from both operational and closed landfills.

Urban runoff can contain high concentrations of nutrients from domestic animals and urban wildlife. Nutrients enter streams by direct washoff from the land surface, or the runoff may be diverted to a storm water collection system and discharged through a discrete outlet structure. For large, medium, and small urban areas (populations greater than 50,000), the storm water outlets are regulated under MS4 permits (see Section 3.1.2). For smaller urban areas, the storm water discharge outlets currently remain unregulated.

In addition to urban animal sources of nutrients, there may be illicit connections to the storm sewer system. As part of the MS4 permitting program, municipalities are required to conduct dry-weather monitoring to identify and then eliminate these illicit discharges. Nutrients may also enter streams from leaky sewer pipes, or during storm events when sanitary sewer overflows discharge.

3.2.3.1 Septic Systems

A portion of the nutrient contributions in the Lake Allatoona watershed may be attributed to septic systems and illicit discharges of raw sewage. Table 9 presents the number of septic systems in each county of the Lake Allatoona watershed existing in 2001 and the number existing in 2006, based on data from the Georgia Department of Human Resources, Division of Public Health. In addition, an estimate of the number of septic systems installed and repaired during the five-year period from 2001 through 2006 is given. These data show that a substantial increase in the number of septic systems has occurred in some counties. Often, this is a reflection of population increases outpacing the expansion of sewage collection systems, which results in a large number of septic systems being installed to contain and treat the sanitary waste.

Table 9. Number of Septic Systems in the Lake Allatoona Watershed

County	Existing Septic Systems (2001)	Existing Septic Systems (2006)	Number of Septic Systems Installed (2001 to 2006)	Percent Increase (2001 to 2006)	Number of Septic Systems Repaired (2001 to 2006)
Bartow	19,074	21,369	2295	10.3%	800
Cherokee	33,925	37,390	3465	9.7%	631
Cobb	32,105	33,558	1453	4.3%	1417
Dawson	7,212	8,524	1312	15.4%	151
Forsyth	26,915	31,428	4513	11.0%	1106
Fulton	25,385	27,009	1624	5.4%	512
Gilmer	12,308	15,012	2704	21.6%	123
Lumpkin	8,582	10,118	1536	18.0%	78
Paulding	29,405	36,205	6800	23.0%	1237
Pickens	9,714	11,534	1820	17.4%	214

Source: The Georgia Dept. of Human Resources, Division of Public Health, 2007

3.2.3.2 Land Application Systems

Many smaller communities use land application systems (LAS) for treatment and disposal of their sanitary wastewater. These facilities are required through LAS permits to treat all their wastewater by land application and are to be properly operated as non-discharging systems that contribute no runoff to nearby surface waters. However, runoff during storm events may carry surface residual containing nutrients to nearby surface waters. Some of these facilities may also exceed the ground percolation rate when applying the wastewater, resulting in surface runoff from the field. If not properly bermed, this runoff, which probably contains nutrients, may be discharged to nearby surface waters. There are 18 permitted LAS systems located in the Lake Allatoona watershed (Table 10).

Table 10. Permitted Land Application Systems in the Lake Allatoona Watershed

LAS Name	County	Permit No.	Type	Flow (MGD)
Amicalola Falls State Park	Dawson	GA02-045	Municipal	0.0143
Bent Tree Community Golf Course	Pickens	GA03-782	Private	0.018
Chapel Knoll	Cherokee	GA03-944	Private	0.010
Cherokee Co. WSA Rose Creek	Cherokee	GA02-015	Municipal	4.0
Cherokee Little River/Fitzgerald (closed)	Cherokee	GA02-278	Municipal	0.33

LAS Name	County	Permit No.	Type	Flow (MGD)
Dawson Forest Water Reclamation Facility	Dawson	GA02-232	Municipal	1.0
Dawsonville LAS	Dawson	GA02-179	Municipal	0.12
DNR Red Top Mountain State Park	Bartow	GA02-237	Municipal	0.0221
DIM Vastgoed NV	Cherokee	GA03-848	Private	0.016
Forsyth Co. Manor WRF	Forsyth	GA03-921	Municipal	0.5
Fulton Co. Settingdown Creek	Cherokee	GA02-170	Municipal	0.2
Gold Creek Urban Water Reuse Facility	Dawson	GA02-025	Municipal	0.5
Hampton Reuse Facility	Forsyth	GA0038903	Municipal	0.45
Lake Arrowhead Utility Co.	Cherokee	GA03-819	Private	0.3
Parkstone at the Bridges	Forsyth	GA03-936	Municipal	0.1
USA Camp Frank D. Merrill	Lumpkin	GA03-727	Municipal	NA
Village at Mountain Ridge	Forsyth	GA03-769	Private	0.06
Young Life Inc.	Pickens	GA03-954	Private	0.017

Source: Permitting Compliance and Enforcement Program, GA EPD, Atlanta, Georgia, 2010

3.2.3.3 Landfills

Leachate from landfills might contain nutrients that may at some point seep into surface waters. Sanitary (or municipal) landfills are the most likely to be a source of nutrients. These types of landfills receive household wastes, animal manure, offal, hatchery and poultry processing plant wastes, dead animals, and other types of wastes. Older sanitary landfills were not lined and most have been closed. Those that remain active and have not been lined operate as construction/demolition landfills. Currently active sanitary landfills are lined and have leachate collection systems. All landfills, excluding inert landfills, are now required to install environmental monitoring systems for groundwater and methane sampling. There are 43 known landfills in the counties within the Lake Allatoona watershed (Table 11). Of these, 7 are active landfills, 2 are in the process of being closed, and 34 are inactive or closed. As shown in Table 11, many of the older, inactive landfills were never permitted.

Table 11. Landfills in the Lake Allatoona Watershed

Name	County	Permit No.	Type	Status
3 - Way Campers	Cobb		NA	Inactive
Anglin-Francis Rd	Forsyth	058-005D(L)	Construction and Demolition Landfill	Closed
Ballground	Cherokee		NA	Inactive
Brookfield West - Mtn. Park	Fulton		NA	Inactive
Brown-SR 92 W Woodstock	Cherokee	028-012D(L)	Dry Trash Landfill	Closed
Camp Merrill-US ARMY	Lumpkin	093-004D(SL)	Sanitary Landfill	Closed
Canton - Ridge Road	Cherokee	028-004D(SL)	Sanitary Landfill	Closed
Canton - Ridge Rd Phase 2	Cherokee	028-014D(SL)	Sanitary Landfill	Inactive
Carter - Bascomb Road	Cherokee		NA	Closed
Chadwick Rd Landfill, Inc.	Fulton	060-072D(L)	Construction and Demolition Landfill	Inactive
Cheatham Road Balefill (area 1) & Phase 2	Cobb	033-027D(SL)	Sanitary Landfill	Closed
Cherokee Co. - Woodstock - Blalock Rd.	Cherokee	028-006D(SL)	Sanitary Landfill	Operating
Cherokee Co. - Blalock Rd Phase 3	Cherokee	028-015D(SL)	Sanitary Landfill	Inactive

Name	County	Permit No.	Type	Status
Cherokee Co. - Blalock Rd Phase 4	Cherokee	028-017D(SL)	Sanitary Landfill	Closed
Cherokee Co. - Blalock Rd. Phase 6	Cherokee	028-041D(SL)	Sanitary Landfill	Inactive
Cherokee C & D Landfill	Cherokee	028-043D(C&D)	Construction and Demolition Landfill	Operating
Cherokee Co. - Pine Bluff landfill, Inc.	Cherokee	028-039D(SL)	Municipal Solid Waste Landfill	Operating
Cherokee Co. - SWIMS - SR 92 Phase 4	Cherokee	028-040D(L)	Construction and Demolition Landfill	Operating
Cherokee Co. - SWIMS - SR 92 Phase 5	Cherokee	028-040D(C&D)	Construction and Demolition Landfill	Operating
Cherokee Co. - Univeter Rd	Cherokee	028-007D(L)	Dry Trash Landfill	Closed
Cove Rd	Pickens		NA	Inactive
Cobb Co. - Cheatham Rd Phase 2	Cobb	033-038D(SL)	Sanitary Landfill	Closed
Dawson Co. (Hwy. 19)	Dawson		NA	Inactive
Dawson Co. - Shoal Hole Rd	Dawson	042-002D(SL)	Sanitary Landfill	Closed
Eagle Point Landfill	Forsyth	058-012D(MSWL)	Municipal Solid Waste Landfill	Operating
Forsyth Co. - Hightower Rd Phase 1	Forsyth	058-006D(L)	Sanitary Landfill	Closed
Forsyth Co. - Hightower Rd Phase 3	Forsyth	058-009D(SL)	Sanitary Landfill	Closed
Forsyth Co. - Hightower Rd Phase 4	Forsyth	058-010D(SL)	Municipal Solid Waste Landfill	Closed
Gravely - Bells Ferry Road	Cherokee		NA	Inactive
Honea-C & R Landfill Francis Rd	Fulton	060-059D(L)	Dry Trash Landfill	Closed
Hwy 92, Old Acworth site	Cobb		NA	Inactive
Jasper - Hood Rd.	Pickens		NA	Inactive
Kendrick - Arnold Mill Rd Phase 1	Cherokee	028-013D(L)	Dry Trash Landfill	Closed
Kuykendall - Earney Rd	Cherokee	028-032D(L)	Dry Trash Landfill	Closed
O.E. Matlock – Hwy 41	Cobb		NA	Inactive
Pickens Co. – Jasper	Pickens		NA	Inactive
R.B. Ingram - Old Hwy 41	Cobb		NA	Inactive
SWIMS-SR 92 (Dixie) PH 1&2	Cherokee	028-030D(L)	Dry Trash Landfill	Closed
SWIMS-SR 92 (Dixie) PH 3	Cherokee	028-034D(L)	Construction and Demolition Landfill	In-Closure
U S ARMY-Camp Merrill #6	Lumpkin	093-005D(SL)	Sanitary Landfill	In-Closure
Voyles - Hwy 5	Cherokee		NA	Inactive
Woodstock	Cherokee		NA	Inactive

Source: Land Protection Branch, GA DNR, 2008

4.0 ANALYTICAL APPROACH

The process of developing the chlorophyll *a* TMDLs for Lake Allatoona included developing three computer models for the lake and its embayments. The models were run for calendar years 2001 through 2007, when water quality data were collected in the lake. A watershed model of the Lake Allatoona watershed was developed, using LSPC that included all major point sources of nutrients. The watershed model simulates the effects of surface runoff on both water quality and flow and was calibrated to available data. The results of this model were used as tributary flow inputs to the hydrodynamic model EFDC, which simulated the transport of water into and out of the embayment. The EPA WASP model was used to simulate the fate and transport of nutrients into and out of the lake and the uptake by phytoplankton, where the growth and death of phytoplankton is measured through the surrogate parameter chlorophyll *a*. Figure 5 shows how the three models interact with one another and what outputs each model provides. The computer models used to develop this TMDL are described in the following sections.

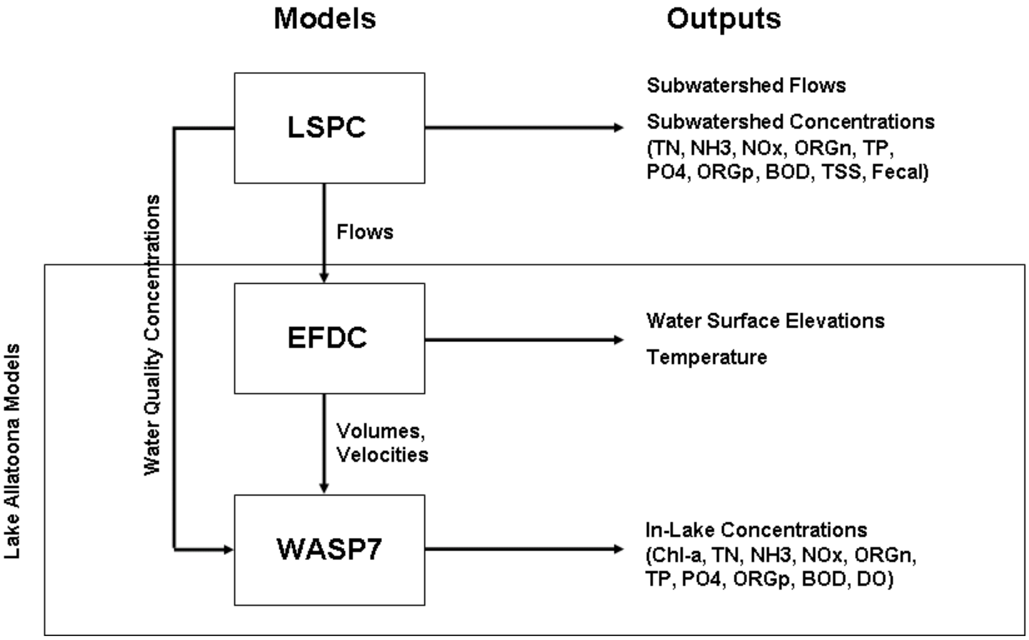


Figure 5. Linkage between LSPC, EFDC, and WASP

4.1 Watershed Modeling (LSPC)

LSPC is a system designed to support TMDL development for areas impacted by both point and nonpoint sources. It is capable of simulating land-to-stream transport of flow, sediment, metals, nutrients, and other conventional pollutants, as well as temperature and pH. LSPC is a comprehensive data management and modeling system that simulates pollutant loading from nonpoint sources. LSPC utilizes the hydrologic core program of the Hydrological Simulation Program Fortran (HSPF, EPA 1996b), with a custom interface of the Mining Data Analysis System (MDAS), and modifications for non-mining applications such as nutrient and pathogen modeling.

LSPC was used to calculate runoff and hydrologic transport of pollutants based on historic precipitation data. LSPC was configured for the Lake Allatoona watershed to simulate the watershed as a series of hydrologically connected sub-watersheds. Configuration of the model involved sub-dividing the Lake Allatoona watershed into 225 modeling sub-watersheds, which are shown in Figure 6. Sub-basin delineations were based on elevation data (30 meter National Elevation Dataset from USGS), and stream connectivity from the National Hydrography Dataset. Potential pollutant loadings were determined from mass-balance predictions of available pollutants on the land surface for the land cover distribution in each sub-watershed.

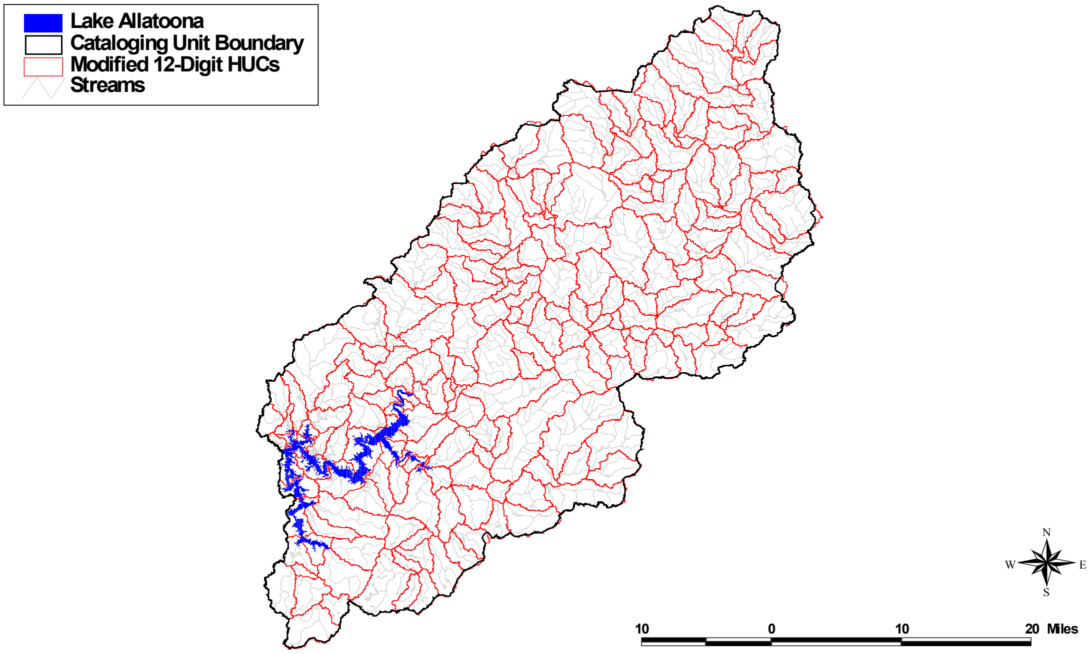


Figure 6. Subdelineated 12-Digit HUC Coverage for the Lake Allatoona Watershed

The Lake Allatoona watershed LSPC model performed a continuous simulation of flow and water quality for these sub-watersheds using the following data:

- Meteorological data
- Land cover
- Soils
- Stream lengths and slopes
- Point source discharge data
- Water withdrawal data
- USGS flow data
- Water quality data

<u>Meteorological Data</u>

Nonpoint source loadings and hydrological conditions are dependent on weather conditions. Hourly data from weather stations within the boundaries of, or in close proximity to, the sub-watersheds were applied to the watershed model. An ASCII file was generated for each meteorological station used in the hydrological evaluations in LSPC. Each meteorological file contains precipitation and potential evapotranspiration data used in modeling the hydrological processes. Precipitation data for the Lake Allatoona watershed were gathered from meteorological stations listed in Table 12.

Table 12. Available Meteorological Stations in the Lake Allatoona Watershed

Station ID	Station Name	Elevation (ft)	County	Latitude	Longitude
090181	Allatoona Dam 2	975	Bartow	34.165	-84.730
090603	Ball Ground	1270	Cherokee	34.330	-84.471
091585	Canton	876	Cherokee	34.236	-84.496
091665	Cartersville	786	Bartow	34.226	-84.785
092408	Cumming 1 ENE	1306	Forsyth	34.208	-84.131
092485	Dallas 7 NE	1100	Paulding	33.988	-84.748
092578	Dawsonville	1343	Dawson	34.421	-84.104
094648	Jasper 1 NNW	1465	Pickens	34.496	-84.459
099077	Waleska	1196	Cherokee	34.311	-84.538
099524	Woodstock	1052	Cherokee	34.110	-84.515

The Lake Allatoona watershed was subdivided into Thiessen polygons, using the precipitation stations as centers, to determine the precipitation station that would be used for each sub-watershed. After the initial calibration of the watershed hydrology model, the precipitation data were further analyzed to determine the best combination of precipitation stations that should be used to model the measured flow data. After performing a number of model runs by varying the precipitation station assignments for the watersheds, it was determined that the two meteorological stations most representative from January 1, 1997, through December 31, 2007, were 091585 (Canton) and 092578 (Dawsonville). The Dawsonville gage was applied to the northern section of the watershed model, while the Canton gage was applied to the southern portion of the watershed model (see Figure 7).

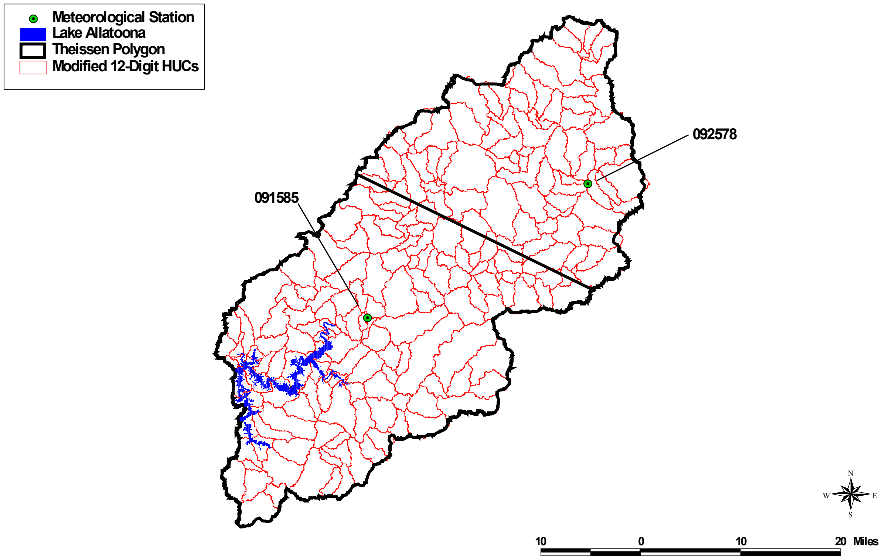


Figure 7. Precipitation Stations Used in the Lake Allatoona Watershed Model

Land Cover

The watershed model uses land cover data as the basis for representing hydrology and nonpoint source loading. Landuse data were used from both the National Landuse Classification Dataset (NLCD) dataset and the Atlanta Regional Commission (ARC) dataset, and included built-up, forest, cropland, pasture, and wetlands. The NLCD and ARC data represented conditions in Year 2005. The ARC dataset did not cover the entire Lake Allatoona watershed, so in those areas, the NLCD data were used. Land cover categories for modeling were selected based on the NLCD landuse classification, and included open water, urban, barren or mining, cropland, pasture, forest, grassland, and wetlands. Figure 8 presents the distribution of land cover within the Lake Allatoona watershed, and a breakdown of each landuse is given in Table 2.

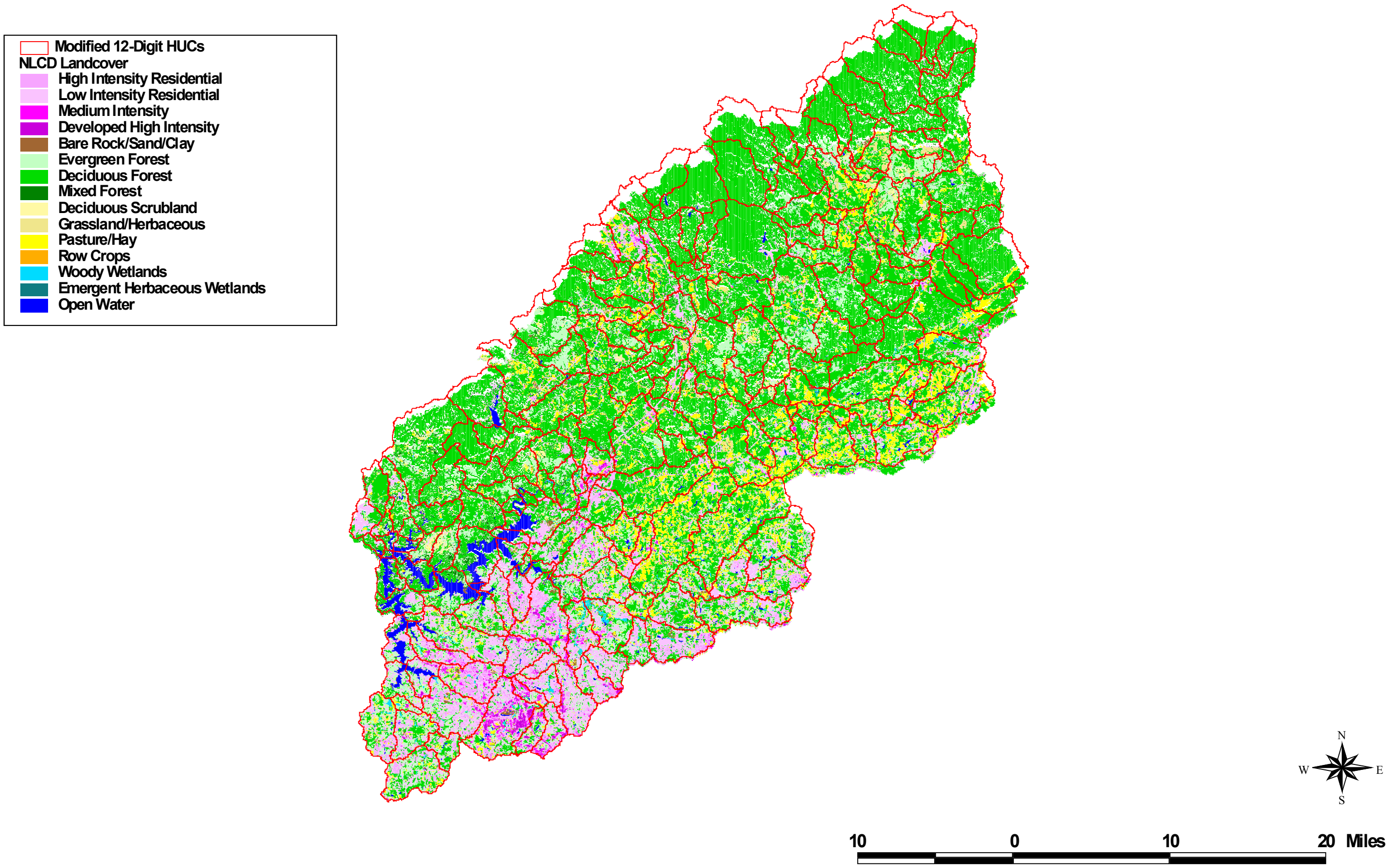


Figure 8. Lake Allatoona Watershed 2005 Land Cover from ARC/NLCD

The LSPC model requires division of land cover into pervious and impervious land units. For each land cover, this division can be made based on typical imperviousness percentages from individual landuse categories, such as those used in the Soil Conservation Service's TR-55 method (see Table 13). For modeling purposes, the percent impervious and pervious of a given land category can be calculated as an area-weighted average of landuse classes encompassing the modeling land category.

Table 13. Land Cover Percent Impervious and Pervious

Land Categories Represented in the Model	Land Use Code	NLCD Landuse Category	% Impervious	% Pervious
Water	11	Reservoirs	0	100
Urban	21	Low Intensity Residential	19	81
Urban	22	High Intensity Residential	65	35
Urban	23	High Intensity Commercial/Industrial/Transportation	80	20
Urban	24	Developed High Intensity	85	15
Urban	33	Transitional	10	90
Barren & Mining	31	Bare Rock/Sand/Clay	0	100
Barren & Mining	32	Quarries/Strip Mines/Gravel Pits	0	100
Forest	41	Deciduous Forest	0	100
Forest	42	Evergreen Forest	0	100
Forest	43	Mixed Forest	0	100
Forest	52	Deciduous Scrubland	0	100
Grassland	71	Grassland/Hervaceous	0	100
Cropland	82	Row Crops	0	100
Pasture	81	Pasture/Hay	0	100
Pasture	83	Small Grains	0	100
Pasture	85	Other Grass (Urban/Recreational; e.g., parks, lawns)	0	100
Pasture Chicken		-	0	100
Wetlands	90	Woody Wetlands	0	100
Wetlands	95	Emergent Herbaceous Wetlands	0	100

Chicken Houses

Using aerial photographs, 923 broiler houses, either currently active or historic houses, were identified in the Lake Allatoona watershed (Figure 9). These broiler chicken houses are buildings that currently house or in the past housed a large number of birds. It is common for chicken manure to be applied to pasture land. A study conducted by the University of Georgia (UGA) showed pasture land within a 0.75 km radius of a chicken house typically received applications of broiler manure (Lin 2008). To distinguish regular pasture land from pasture land that receives or has received broiler manure, a 0.75 km radius was drawn around each broiler chicken house, and all pasture land contained within that radius was converted to a new landuse type known as “Pasture-Chicken” (Figure 10).

It is well known that chicken manure is very high in phosphorus and nitrogen. It was assumed that the pasture land within the 0.75 km radius received 6.73 mg hectares per year of broiler litter (Lin, 2008), which translates to an average of 16.45 pounds of broiler litter per day. Of the 16.45 lbs per day of broiler litter, 1.3% (Radcliffe, 2008a) was assumed to be total phosphorus (0.214 lbs per day), of which 90% was inorganic and 10% was organic (Lin, 2008). It was assumed that 0.214 pounds per day was the accumulation rate and the maximum storage was 0.214 pounds, indicating an “instant build-up.”

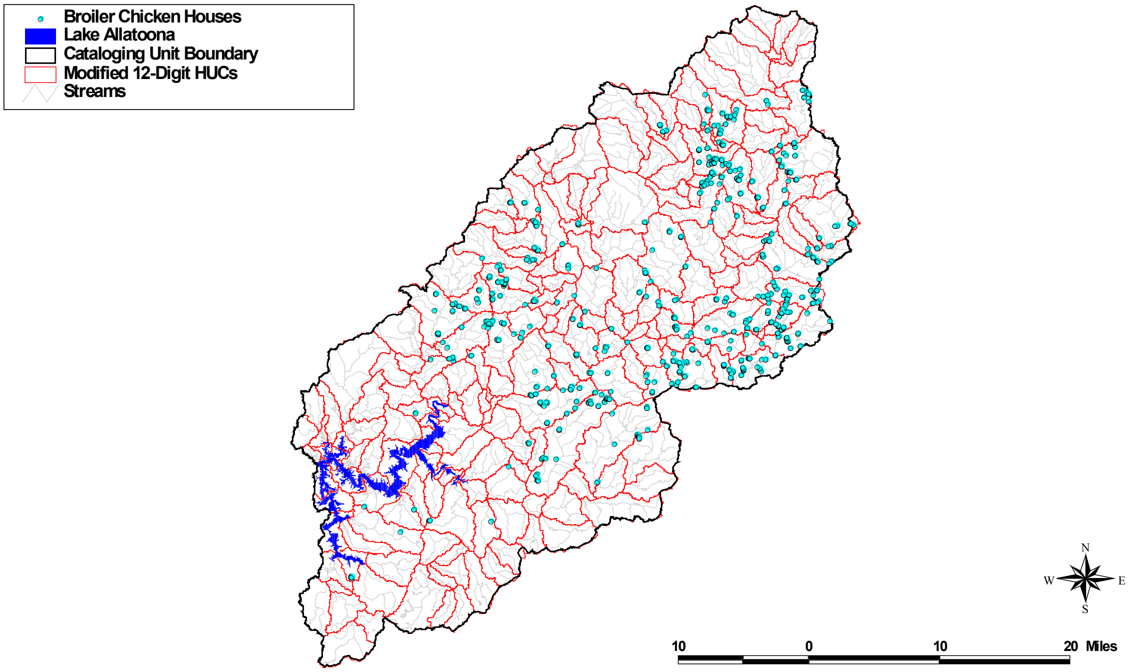


Figure 9. Location of Broiler Chicken Houses in the Lake Allatoona Watershed

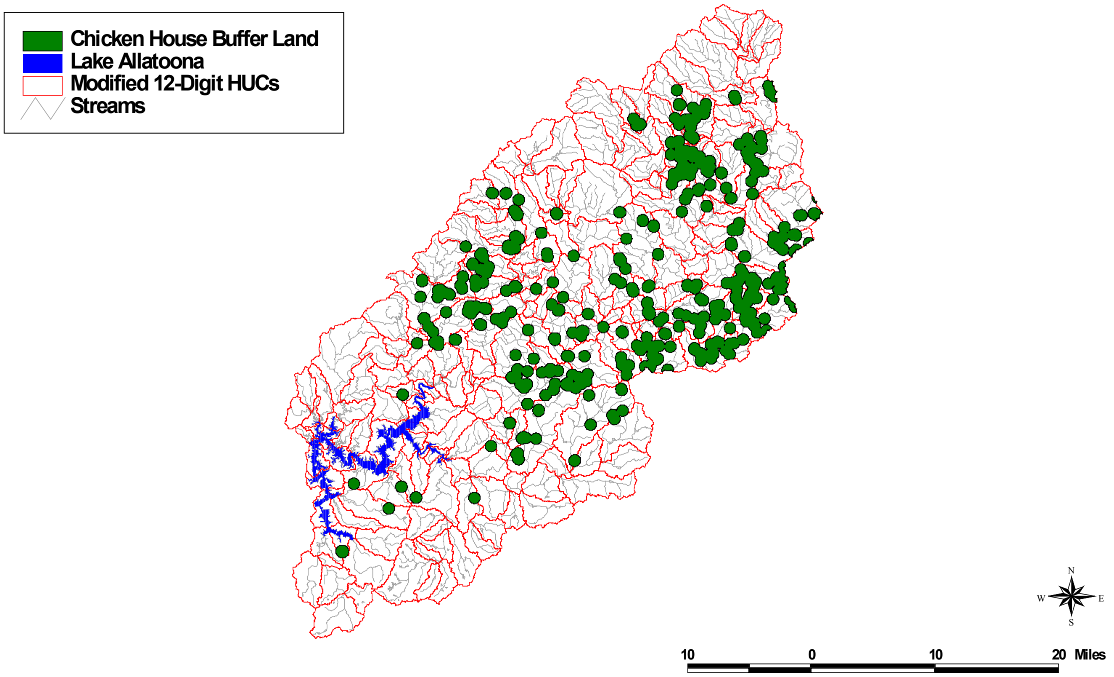


Figure 10. 0.75 km Pasture-Chicken Land around Chicken Houses in the Lake Allatoona Watershed

To calculate the amount of nitrogen applied to the pasture-chicken land, it was assumed that of the 16.45 lbs per day of broiler litter, total nitrogen makes up 3.13% (0.515 lbs per day). Ratios of ammonia, nitrate plus nitrite, and organic nitrogen were developed using data collected from Station 004 (see Table 22) in 2006 and 2007, since this was the station with the largest percentage of pasture-chicken land. Of the 0.515 lbs per day of total nitrogen, 34% was assumed to be organic nitrogen, 5% was assumed to be ammonia, and 61% was assumed to be nitrate+nitrite. Similar to total phosphorous, it was assumed that the load of total nitrogen, ammonia, nitrate+nitrite, and organic nitrogen was equal between the accumulation rate and the maximum storage value, indicating an "instant build-up". Since it was assumed there was "instant build-up," the wash-off rate was the main calibration parameter for this landuse. The hydrologic parameters of pasture-chicken land were assumed to be the same as regular pasture land.

It is acknowledged that the estimation of chicken houses based on aerial photography includes facilities that are no longer in production. Thus, the number of active houses in the watershed and the corresponding pasture land within 0.75-km radius that manure, as currently applied, has been overestimated. Additionally, the model does not account for the significant amount of manure that is transferred out of the watershed for use as a fertilizer in other parts of the state.

Soils

Soil data for the Lake Allatoona watershed were obtained from the State Soil Geographic Data Base (STATSGO). There are four main Hydrologic Soil Groups (Group A, B, C and D). The different soil groups range from soils that have a low runoff potential to soils that have a high runoff potential. The four soils groups are described below:

> Group A Soils Low runoff potential and high infiltration rates even when wet. They consist chiefly of sand and gravel and are well to excessively drained.
> Group B Soils Moderate infiltration rates when wet and consist chiefly of soils that are moderately deep to deep, moderately to well drained, and moderately to moderately course textures.
> Group C Soils Low infiltration rates when wet and consist chiefly of soils having a layer that impedes downward movement of water with moderately fine to fine texture.
> Group D Soils High runoff potential, very low infiltration rates and consist chiefly of clay soils.

There are two main Hydrologic Soil Groups, Groups B and C, in the Lake Allatoona watershed. Figure 11 shows the soil groups coverage for the watershed. The total area that each hydrologic soil group covered within each sub-watershed was determined. The hydrologic soil group that had the highest percent of coverage within each sub-watershed represented that sub-watershed in LSPC.

Stream Lengths and Slopes

Each sub-watershed must have a representative reach defined for it. The characteristics for each reach include the length and slope of the reach, the channel geometry, and the connectivity between the sub-watersheds. Length and slope data for each reach was obtained using the Digital Elevation Maps (DEM) and the National Hydrography Dataset (NHD). The channel geometry is described by a bank full width and depth (the main channel), a bottom width factor, a flood plain width factor, and the slope of the flood plain.

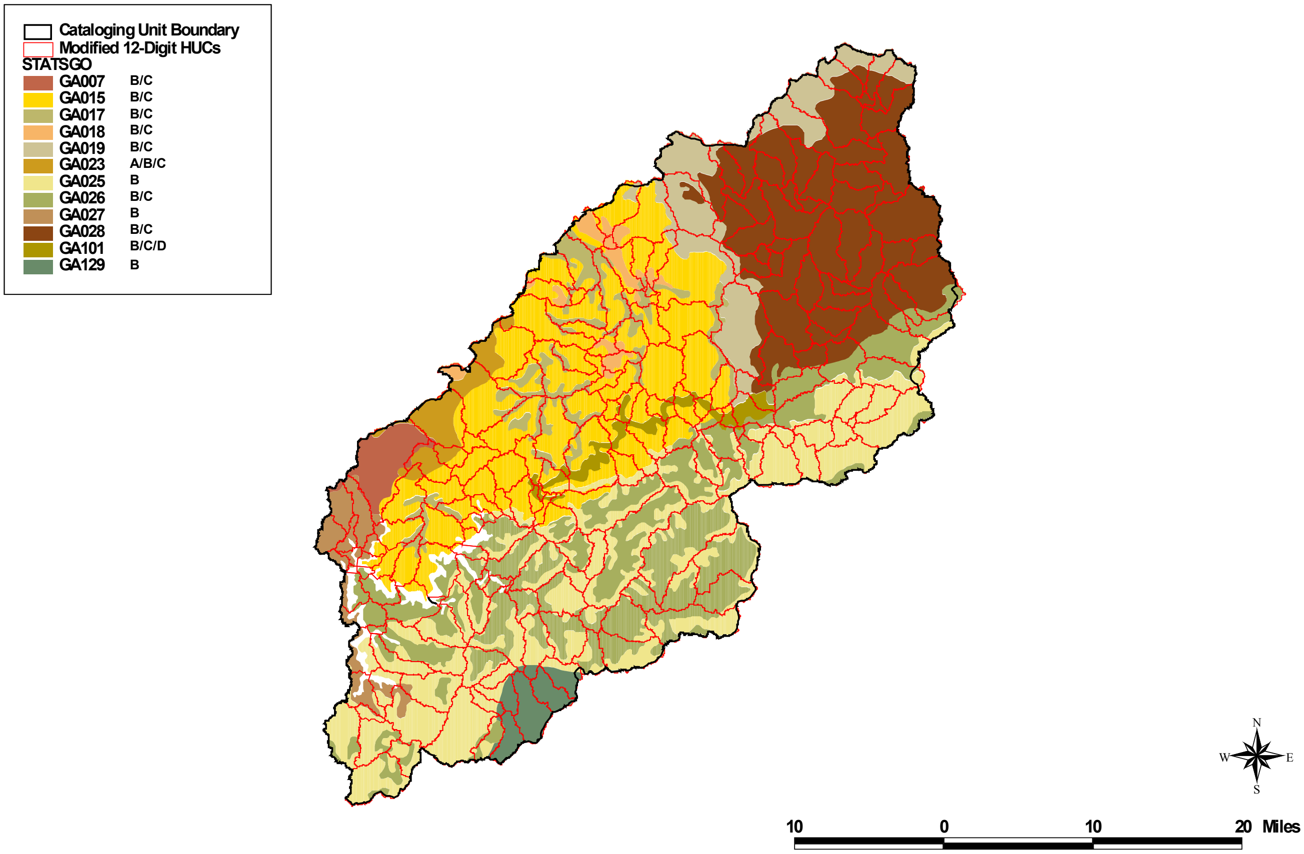


Figure 11. Lake Allatoona Watershed Soil Hydrologic Group

Point source discharge data

There are 26 point source discharges located in the Lake Allatoona watershed that have NPDES permits. Flows and water data for these point source discharges were obtained from either the Discharge Monitoring Reports (DMR) or Operating Monitoring Reports (OMR). Data obtained from these reports were input directly into the LSPC model. The subwatershed that each facility was assigned and the frequency of the DMR or OMR data are given in Table 14. Six of these facilities have ceased discharging since 2007.

Table 14. Summary of Point Source Discharges to the Lake Allatoona Watershed

Number	Facility Name	Data Frequency	Sub-Watershed
GA0000477	Georgia Marble Company	Monthly	610
GA0000485	Georgia Marble Company (Nelson)	Single	523
GA0000728	GoldKist Poultry ByProducts	Monthly	513
GA0000787	Vulcan Materials Kennesaw Quarry	Monthly	334
GA0001261	Georgia Marble Company	Monthly	607
GA0022292	Eastgate MHP	Monthly	319
GA0024228	Reinhardt College (ceased discharging)	Monthly	414
GA0024988	Cobb County Noonday Creek WPCP	Daily	326

NPDES Number	Facility Name	Data Frequency	Sub-Watershed
GA0026263	Woodstock WPCP	Monthly	344
GA0029955	Tate Housing Authority	Monthly	607
GA0030252	Big Canoe STP	Monthly	610
GA0031461	Oak Grove Elementary School (ceased discharging)	Single	318
GA0032204	Jasper	Monthly	527
GA0033251	Fulton Co. Little River WPCP	Daily	347
GA0034185	Free Home Elementary School	Monthly	602
GA0034193	Chapman Elementary School (ceased discharging)	Single	326
GA0034363	Little River Elementary School (ceased discharging)	Single	349
GA0034959	Mountain Brook Center WPCP (R.M. Moore Elementary School)	Single	414
GA0035254	Haven Hill MHP (ceased discharging)	Single	207
GA0035866	Sawnee Elementary School (ceased discharging)	Single	712
GA0035971	Forsyth Consolidated School (ceased discharging)	Monthly	719
GA0036986	Vulcan Materials	Constant	307
GA0037036	J.M. Huber Corp.	Constant	209
GA0037451	J.M. Huber Corp.	Monthly	610
GA0038555	Cherokee County Fitzgerald Creek	Daily	349
GA0048518	Tate Elementary School	Monthly	607

Phosphorus data were available for five minor point sources. These data were collected by GAEPD to better understand phosphorus output from the facility, as well as the breakdown of orthophosphate and organic phosphorus in the discharger's effluent. The data are given in Table 15.

Table 15. Additional Phosphorus Data Collected at Minor Point Sources

NPDES Number	Facility Name	Permitted Flow (MGD)	Total Phosphorus (mg/L)	Ortho Phosphorus (mg/L)	Ortho Phosphorus/ Total Phosphorus Ratio
GA0024228	Reinhardt College (ceased discharging)	0.024	6.05	3.0	0.50
GA0029955	Tate Housing Authority	0.010	3.40	3.4	1.00
GA0032204	Jasper WPCP	0.800	3.40	3.4	1.00
GA0035866	Sawnee Elementary School (ceased discharging)	0.030	8.40	8.2	0.98
GA0045818	Tate Elementary School	0.007	1.50	1.4	0.93
				Average Ratio	**0.88**

Using this data, the following equations were applied to minor discharges (< 1.0 MGD) that did not have available ortho phosphorus data:

Organic Phosphorus = Total Phosphorous * 0.12

Orthophosphate = Total Phosphorous * 0.88

For major dischargers with permitted flows greater than 1.0 MGD, the total phosphorus and orthophosphate data collected at the Cobb County Northwest WRF were used to determine the breakdown of the total phosphorus. From November 2004 through December 2006, there were 784 values of total phosphorus and orthophosphate data collected. The average ratio of orthophosphate data to total phosphorus was 0.66. Therefore, the following equations were used for major discharges that did not have available phosphorus data:

Organic Phosphorus = Total Phosphorous * 0.34

Orthophosphate = Total Phosphorous * 0.66

Table 16 provides the water quality concentrations that were input when no data was available for water quality parameters in a point source.

Table 16. Assumed Water Quality Concentrations for Point Sources without Data

Parameter	Concentration (mg/L)
BOD5	10.00
TN	29.40
NH3	17.40
NO3/NO2	10.00
ORG-N	2.00
TP	5.00
PO4	3.3 (majors) / 4.4 (minors)
ORG-P	1.7 (majors) / 0.6 (minors)
TSS	10.00

Septic Tanks

Septic tanks were also considered in the watershed model. The number of septic tanks in each subwatershed was determined through an area weighting method. Each subwatershed was assigned to a county based on where the outlet of the watershed lies. The ratio of the area of the subwatershed to the area of the county was determined, and this ratio was applied to the total number of septic tanks in the county to determine a number for each subwatershed. Not all septic tanks were considered to be contributing flow to the system. It was assumed that 85% of the septic tanks were non-failing and 15% of the septic tanks were failing. For the non-failing septic tanks, these were treated as a source of nutrients through subsurface flow. This was represented as a direct input into the stream, assuming a decay rate and an average 60-day travel time from the septic tank to the stream. To represent the non-failing septic tank flow, it was assumed that each septic tank serves a household of 2.8 people and that each person accounts for 70 gallons/day of flow in the septic tank. The failing septic tanks were treated as a source of nutrients through surface flow. These were represented as a landuse and only contributed to the stream during rain events.

Table 17. Septic Tank Water Quality Concentrations

Parameter	Effluent Concentration (mg/L)	Decay Rate (1/day)	Concentration at Stream (mg/L)**
BOD_5	105.0	0.16	0.562
Total Nitrogen	70.26	0.25	0.0125
Organic Nitrogen	0.46	0.25	0.0001
Ammonia	10.5	0.25	0.0019
Nitrate+Nitrite	59.3	0.25	0.0106
Total Phosphorus*	9.37	0.014	0.614
Organic Phosphorus*	9.37	0.014	0.614
Ortho-Phosphate*	0.0	0.014	0.000
TSS	10.0	0	1.0
Fecal coliform	--	--	10000***

* It was assumed that 90% of phosphorus is sorbed to sediment.
** Assumes Septic Flow takes an average of 60 days to reach stream
*** Fecal coliform concentration obtained from EPA (2001) "Protocol for Developing Pathogen TMDLs"

Water Withdrawal Data

There are nine water withdrawals located in the Lake Allatoona watershed that were represented in the LSPC model. Average monthly water withdrawal data were obtained. For Bent Tree Community withdrawals, the 2000 through 2001 data were not separated into individual withdrawals from Chestnut Cove Creek or Lake Tamarack. Therefore, the monthly flow data that were obtained were divided evenly for the two permits for the 2000 and 2001 time period. For the USA-Camp Frank D. Merrill withdrawal, data were only available for 2000 and 2001. Average monthly values were calculated and were input into the model from 2002 through 2007. The source water, subwatershed, and permitted withdrawal for each withdrawal are given in Table 18.

Table 18. Summary of Water Withdrawals in the Lake Allatoona Watershed

Permit Number	Withdrawal	Source Water	Sub-Watershed	Permitted Withdrawal 24-Hour Limit (MGD)	Permitted Withdrawal Monthly Average (MGD)
112-1417-03	Bent Tree Community, Inc.	Chestnut Cove Creek	615	0.25	0.23
112-1417-04	Bent Tree Community, Inc.	Lake Tamarack	615	0.25	0.23
112-1417-05	Big Canoe Utilities Co, Inc.	Lake Pettit	610	1.00	1.00
028-1491-04	City of Canton	Etowah River	509	5.45	5.45
028-1416-01	Cherokee County Water & Sewerage Authority	Etowah River	600	43.20	36.00
042-1415-01	Etowah Water & Sewer Authority	Etowah River	911	5.50	4.40
028-1491-03	Gold Kist, Inc	Etowah River	513	5.00	4.50
112-1417-02	City of Jasper	Long Swamp Creek	614	1.00	1.00
N/A	USA-Camp Frank D. Merrill	Etowah River	930	N/A	N/A

Modeling Parameters

Pollutants simulated by LSPC were biochemical oxygen demand (BOD), total nitrogen (Total N), and total phosphorus (Total P). LSPC requires land cover specific accumulation and washoff rates for each of the modeled water quality parameters. Table 19 provides the rates developed during model calibration for BOD, total nitrogen, and total phosphorus for each land cover type.

Table 19. LSPC Modeling Parameters

Landuse	Water Quality Parameter	Rate of Accumulation (lb/acre/day)	Maximum Storage (lb/acre)	Rate Of Surface Runoff Which Will Remove 90% (in/hr)	Concentration In Interflow Outflow (mg/L)	Concentration In Active Groundwater Outflow (mg/L)
Barren	BOD	0.269	0.783	0.8	1.5420	1.5000
	Total N	0.108	0.431	0.8	0.0820	0.1040
	Total P	0.018	0.071	0.8	0.0040	0.0048
Cropland	BOD	0.608	1.825	0.8	1.7500	1.5000
	Total N	0.318	1.270	0.8	0.6120	0.3020
	Total P	0.024	0.095	0.8	0.1000	0.1200
Forest	BOD	0.232	0.464	0.8	1.5420	1.5000
	Total N	0.108	0.431	0.8	0.0820	0.1690
	Total P	0.018	0.071	0.8	0.0040	0.0048
Pasture	BOD	0.261	0.783	0.8	2.0000	1.5000
	Total N	0.318	1.270	0.8	0.4620	0.4690
	Total P	0.024	0.095	0.8	0.1000	0.1200
Grassland	BOD	0.261	0.783	0.8	0.2000	1.5000
	Total N	0.061	0.245	0.8	0.3030	0.3010
	Total P	0.035	0.139	0.8	0.0001	0.0001
Urban Pervious	BOD	0.261	0.783	0.8	5.0825	1.5000
	Total N	0.106	0.430	0.8	0.4620	0.4690
	Total P	0.018	0.071	0.8	0.0100	0.0012
Wetlands	BOD	0.261	0.783	0.8	1.5420	1.5000
	Total N	0.108	0.431	0.8	0.2100	0.2810
	Total P	0.018	0.071	0.8	0.0040	0.0048
Pasture Chicken	BOD	0.261	0.783	0.8	0.2000	1.5000
	Total N	0.515	0.515	0.8	0.5030	2.2010
	Total P	0.214	0.214	0.8	0.0001	0.0001
Urban Impervious	BOD	0.261	0.783	0.8	5.0825	1.5000
	Total N	0.106	0.430	0.8	0.1950	0.2810
	Total P	0.018	0.071	0.8	0.0100	0.0120

Model Calibration

Historical flow data collected at USGS stations located in the Lake Allatoona watershed (Table 20) were used to calibrate, validate, and verify the LSPC watershed hydrology model. During the hydrology calibration, it was observed that the simulated baseflow was consistently lower than the measured baseflow, particularly in the upper portions of the watershed. An adjustment of the hydrologic parameters was unable to increase the simulated baseflow to be in line with the measured data.

Therefore, to determine the source of missing baseflow, an assessment of potential water sources was conducted. Based on the assessment, it was determined that there are a significant number of natural springs in the areas around Amicalola Creek and the Etowah River upstream of State Road 9. To account for this missing baseflow, 38 cfs was added to the Amicalola Creek watershed (Station 013) and 28 cfs was added to the Etowah River upstream of State Road 9 (Station 016). These flows were area weighted to the subwatersheds located in these watersheds.

Table 20. Flow Stations Used to Calibrate LSPC Hydrology

Station Name	Station Number	USGS Stations	Drainage Area (mi^2)	Calibration / Validation / Verification
Etowah River at Hwy 140 near Canton	002	02392000	613	Validation
Little River at SR 5 near Woodstock	003	02392780	139	Calibration
Long Swamp Creek at Reavis Mountain Road	006	02390475	67.6	Calibration
Shoal Creek at SR 108 near Waleska	007	02392360	56.8	Calibration
Board Tree Creek at Newt Green Road	008	-	3.0	Calibration
Noonday Creek at Shallowford Road near Woodstock	009	02392975	33.6	Verification
Noonday Creek at Hawkins Store Road	011	02392950	24.3	Verification
Etowah River at SR 9 near Dawsonville	012	02389150	131	Calibration
Amicalola Creek near SR 53	013	02390000	88.5	Calibration
Etowah River at SR 9 Lumpkin County	016	02388900	70.3	Calibration

To represent the water quality from the natural springs, data collected at Stations 013 and 016 in 2006 and 2007 were used. The 25th percentile of each of the modeled constituents was calculated and applied as a constant value to the natural springs in each watershed. In addition, each modeled parameter was assigned a 1st order decay rate. Table 21 presents a summary of water quality data input for the baseflow and springs contributing to Stations 013 and 016 and the decay rate for each parameter.

Table 21. Water Quality Inputs for Baseflow and Natural Springs Watersheds and the Decay for Each Parameter

Parameter	Concentration (mg/L)			Decay Rate (1/day)
	Baseflow	Watershed Station 013	Watershed Station 016	
BOD_5	1.50	2.00	2.00	0.16
Total Nitrogen	0.15	0.32	0.20	0.25
Organic Nitrogen	0.05	0.08	0.08	0.25
Ammonia	0.01	0.02	0.02	0.25
Nitrate+Nitrite	0.10	0.24	0.06	0.25
Total Phosphorus	0.01	0.014	0.011	0.014
Organic Phosphorus	0.01	0.002	0.001	0.014
Ortho-Phosphate	0.01	0.010	0.010	0.014
Total Suspended Solids	7.00	3.00	2.85	N/A

The 2006 through 2007 flow data from the seven USGS gages were used to calibrate the hydrology of the LSPC model. These gages were used because they contained flow during the intense data collection effort conducted by the Lake Allatoona/Upper Etowah Watershed

Partnership. The flow data from the USGS gage (02392000) on the Etowah River at Canton, GA, were used to validate the model, and the flow data from the two USGS gages on Noonday Creek (02392975 and 02392950) were used to verify the model. Figure 12 shows the location of the various flow gages that were used for the hydrologic calibrations. Figure 13 shows a graph of the flow calibration for Etowah River at Canton, GA from 2001 through 2007 and Figure 14 shows graphs of the average monthly flows observed and modeled.

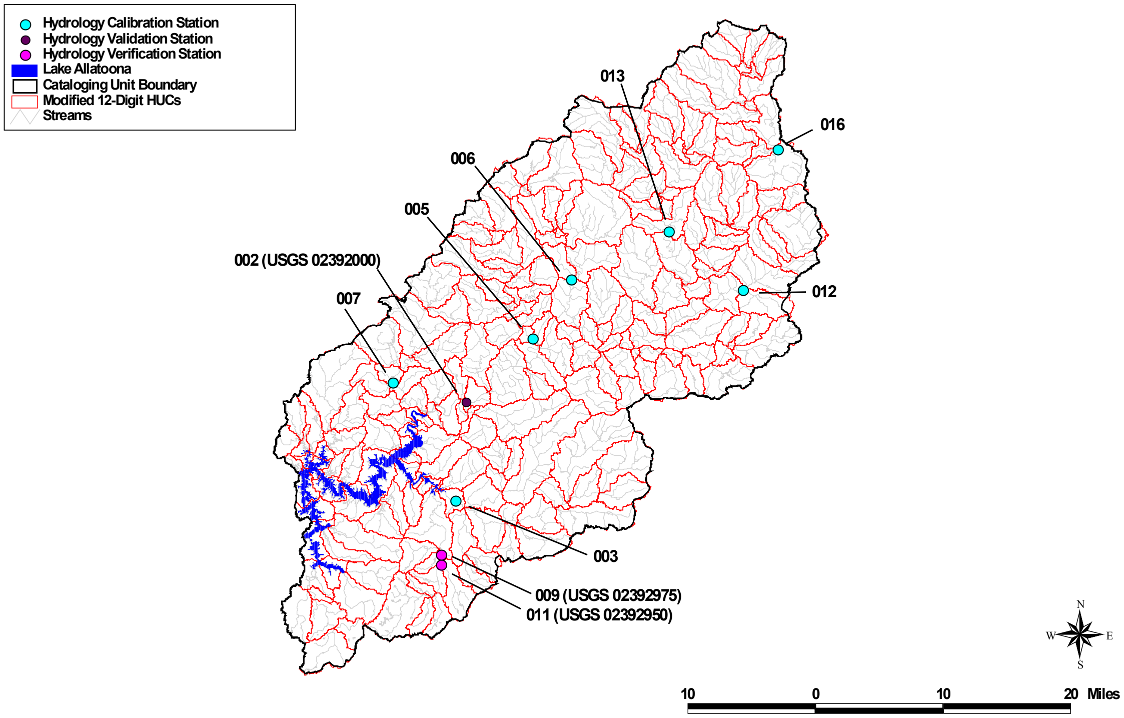


Figure 12. Flow Stations Used in the Hydrologic Calibration of LSPC

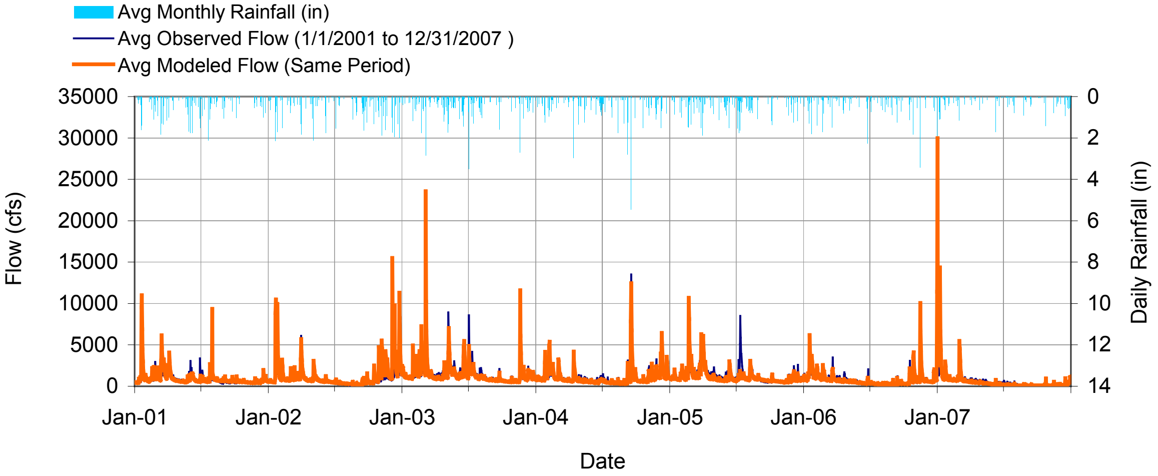


Figure 13. Flow Calibration for USGS 02392000 Etowah River near Canton, GA from the LSPC Watershed Model for 2001 –2007

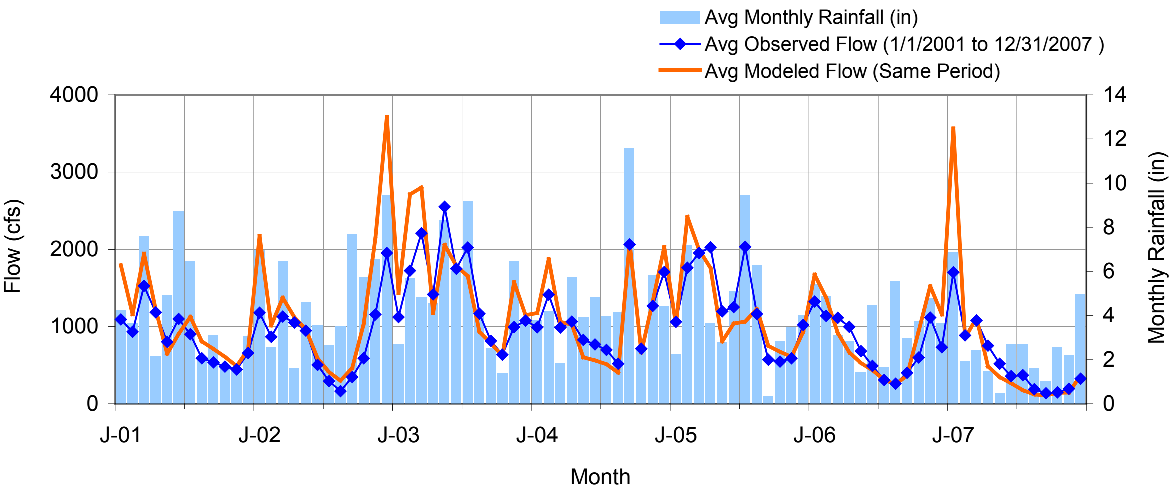


Figure 14. Average Monthly Modeled Flow vs. Observed Flow at USGS 02392000 Etowah River near Canton, GA

As previously mentioned, to represent watershed loadings and resulting pollutant concentrations in individual stream segments, the Lake Allatoona watershed was divided into 225 sub-watersheds. Listed reaches, tributary confluences, and the locations of water quality monitoring sites defined these sub-watersheds, representing hydrologic boundaries. Delineation at water quality monitoring sites allowed comparison of model output to measured data. The Lake Allatoona LSPC model was calibrated, validated, and verified to discrete instream water quality data measured at several stations in the Lake Allatoona watershed (Table 22).

Table 22. Monitoring Stations Used to Calibrate LSPC Water Quality

Station Name	Station Number	Calibration / Validation / Verification
Lake Allatoona/Upper Etowah Partnership		
Etowah River at Hwy 140 near Canton	002	Calibration
Little River at SR 5 near Woodstock	003	Calibration
Settingdown Creek at Hwy 369	004	Calibration
Sharp Mountain Creek at SR 5 near Ball Ground	005	Calibration
Long Swamp Creek at Reavis Mountain Road	006	Calibration
Shoal Creek at SR 108 near Waleska	007	Calibration
Board Tree Creek at Newt Green Road	008	Calibration
Noonday Creek at Shallowford Road near Woodstock	009	Calibration
Allatoona Creek at Old Stilesboro Road	010	Calibration
Noonday Creek at Hawkins Store Road	011	Calibration
Etowah River at SR 9 near Dawsonville	012	Calibration
Amicalola Creek near SR 53	013	Calibration
Shoal Creek upstream of Sweetwater Road	014	Calibration
Etowah River at Old Federal Road	015	Calibration
Etowah River at SR 9 Lumpkin County	016	Calibration
Etowah River at Castleberry Bridge Road	017	Calibration
Upper Etowah River at County Road P211	018	Calibration
Sharp Mountain Creek downstream of Rock Creek	019	Calibration

Station Name	Station Number	Calibration / Validation / Verification
USGS Stations		
Etowah River at Canton	02392000	Validation
Little River at GA 5 near Woodstock	02392780	Verification
Shoal Creek at GA 108 near Waleska	02392360	Verification
Noonday Creek at GA 92	02393000	Verification
Cherokee County Water Quality Stations		
Chicken Creek	CHC	Verification
Kellogg Creek @ Kemp Drive	KC	Verification
Little River above Fitz	LR4	Verification
Mill Creek @ Tripp Road	MC3	Verification
Mill Creek @ confluence near HWY 5	MC4	Verification
Rubes Creek @ confluence near HWY 5	RC2	Verification
Cobb County Water Quality Stations		
Allatoona Creek, County Line Road	AL4	Verification
Little Noonday Creek, Noonday Park	LND3	Verification
Proctor Creek, Highway 293	PC3	Verification
Rubes Creek, Jamerson Road East	RB3	Verification
Rubes Creek, Jamerson Road West	RB4	Verification

The model was calibrated using the water quality data from 18 locations sampled by the Upper Etowah/Lake Allatoona Partnership during 2006-2007. The water quality data included total nitrogen, nitrate+nitrite, ammonia, total Kjeldahl nitrogen (TKN), total phosphorus, orthophosphate, BOD_5, and total suspended sediment (TSS). Data from 2000-2007, collected by USGS, at the Etowah River at Canton station were used to validate the model. Data from the other three USGS monitoring stations, as well as from the Cobb County and Cherokee County water quality monitoring stations, were used to verify the model. Figure 15 shows the location of the various monitoring stations that were used for water quality calibration, validation, and verification. Figure 16 shows the total phosphorus calibration for the Etowah River at Canton during 2001 through 2007.

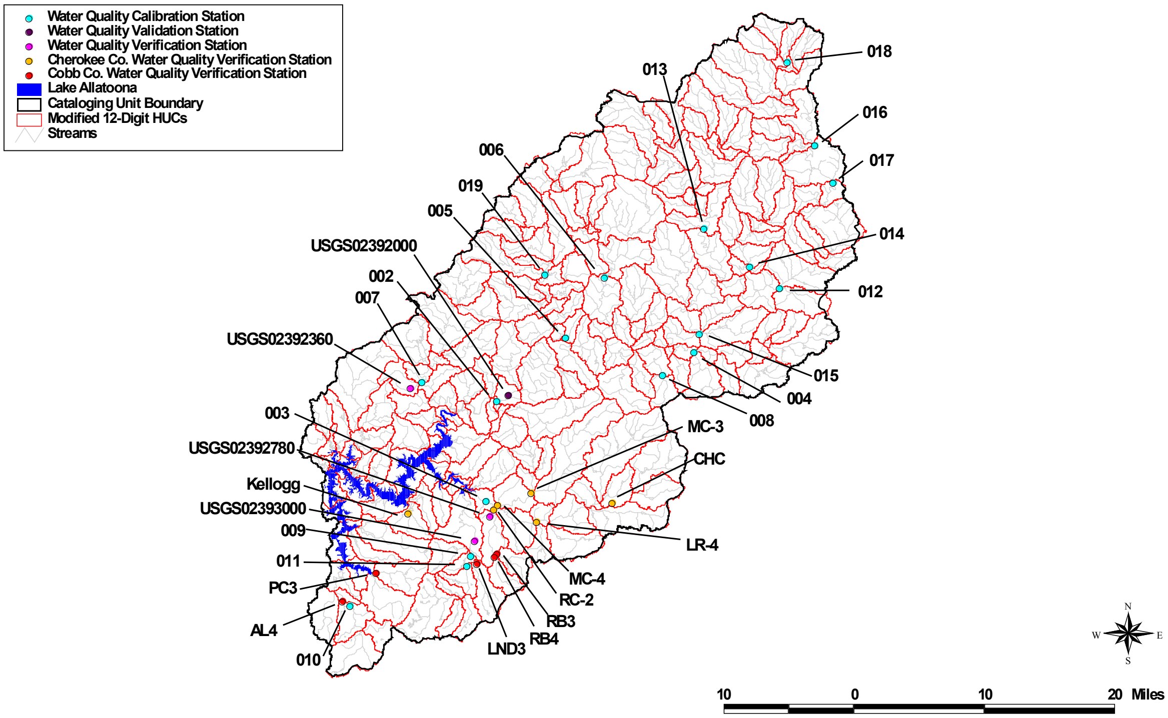
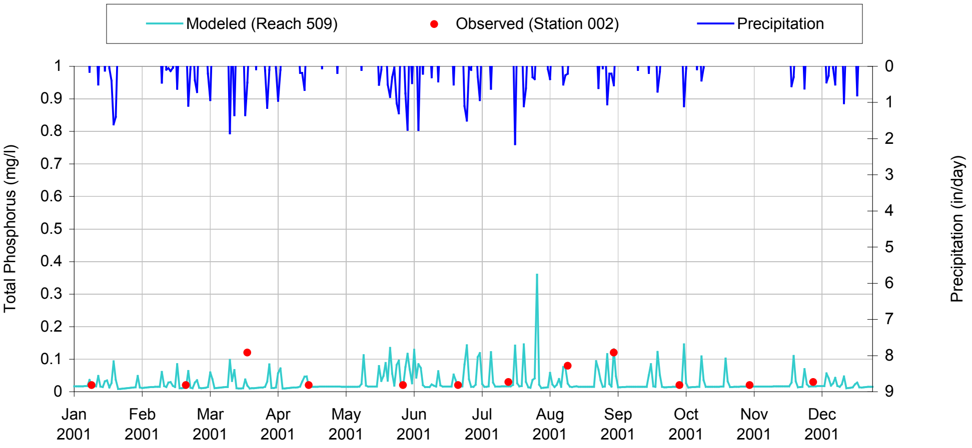
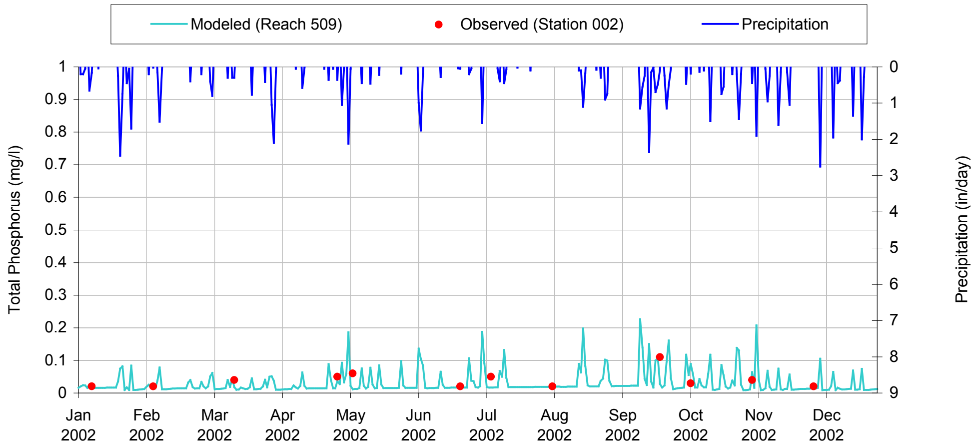
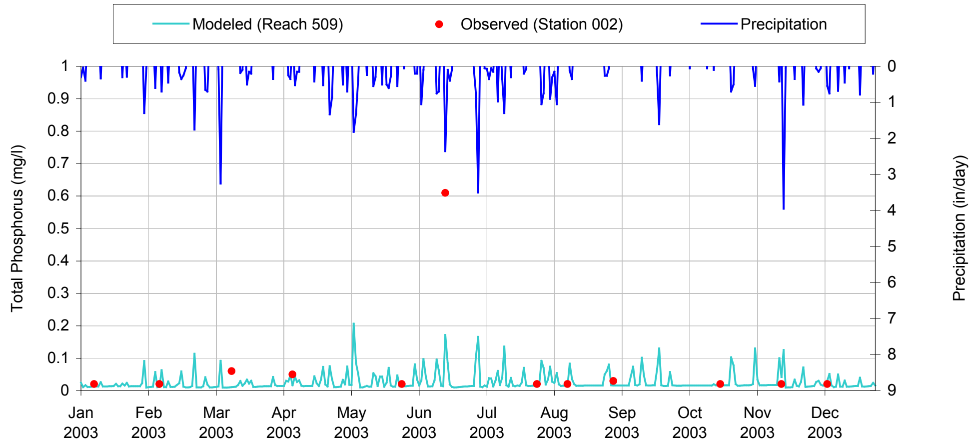
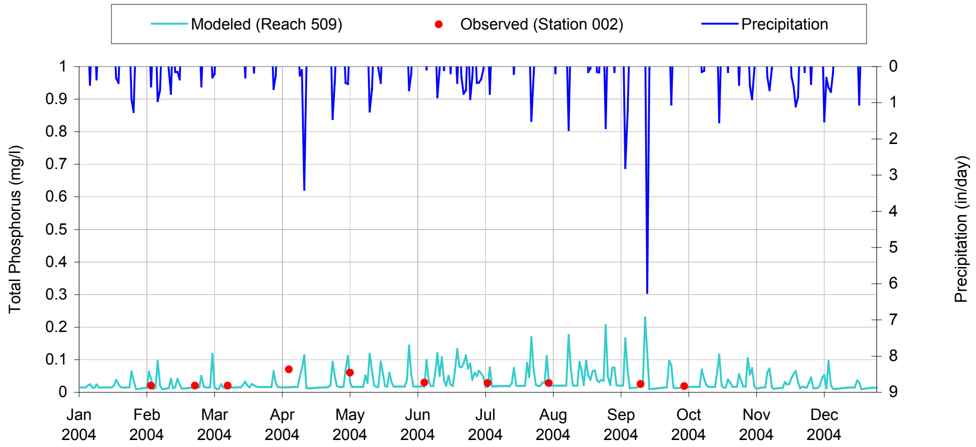


Figure 15. Monitoring Stations Used in the Water Quality Calibration of LSPC




Modeled (Reach 509)
Observed (Station 002)
Precipitation
Total Phosphorus (mg/l)
Precipitation (in/day)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
1
2
3
4
5
6
7
8
9
Jan 2002
Feb 2002
Mar 2002
Apr 2002
May 2002
Jun 2002
Jul 2002
Aug 2002
Sep 2002
Oct 2002
Nov 2002
Dec 2002


Modeled (Reach 509)
Observed (Station 002)
Precipitation
Total Phosphorus (mg/l)
Precipitation (in/day)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
1
2
3
4
5
6
7
8
9
Jan 2003
Feb 2003
Mar 2003
Apr 2003
May 2003
Jun 2003
Jul 2003
Aug 2003
Sep 2003
Oct 2003
Nov 2003
Dec 2003


Modeled (Reach 509)
Observed (Station 002)
Precipitation
Total Phosphorus (mg/l)
Precipitation (in/day)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
0
1
2
3
4
5
6
7
8
9
Jan 2004
Feb 2004
Mar 2004
Apr 2004
May 2004
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Aug 2004
Sep 2004
Oct 2004
Nov 2004
Dec 2004

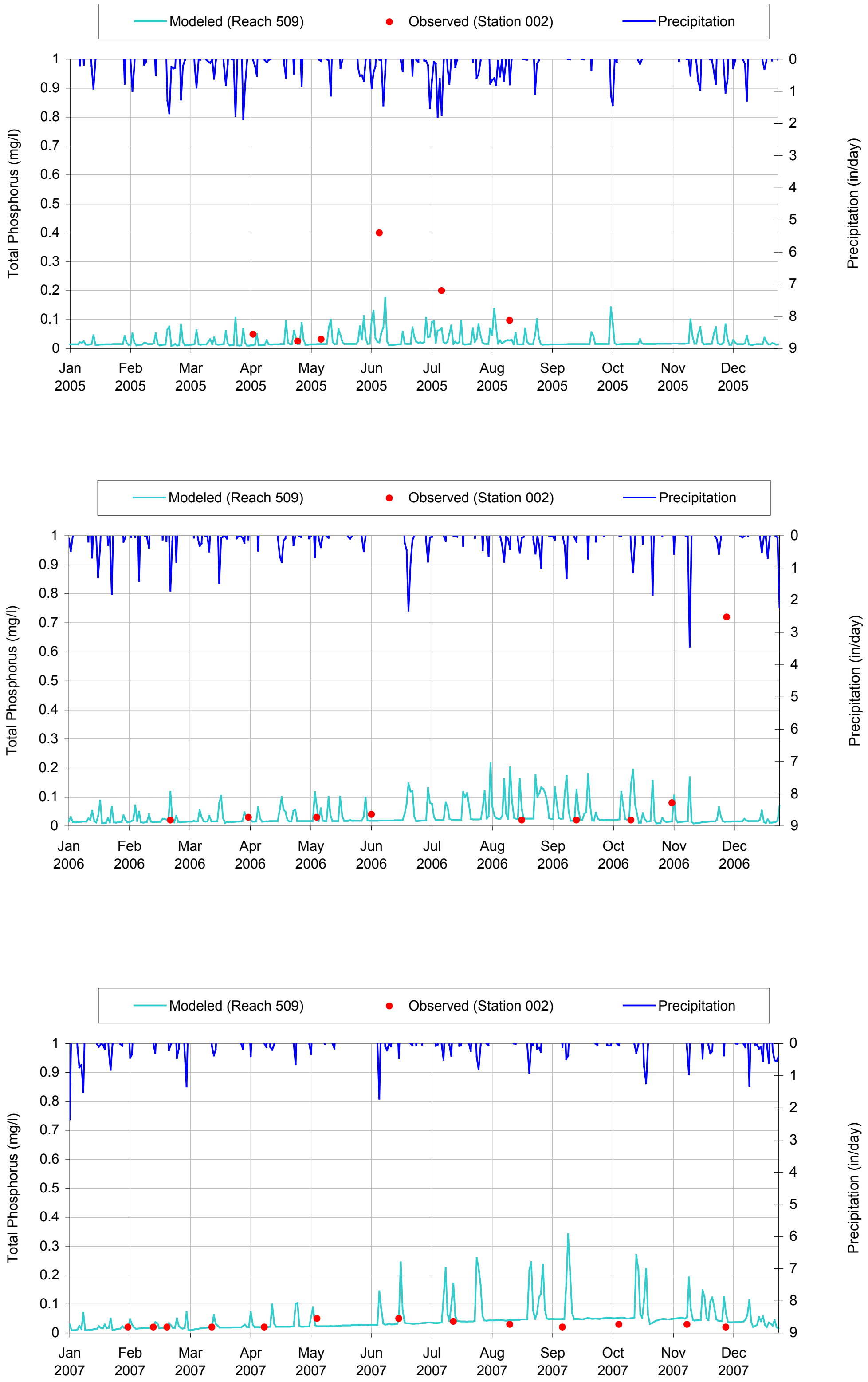


Figure 16. Total Phosphorus Calibration at USGS 02392000 Etowah River near Canton, GA from the LSPC Watershed Model for 2001-2007

4.2 Hydrodynamic Modeling (EFDC)

Bottom elevations and shoreline boundaries define the EFDC model grid. The grid for Lake Allatoona covers the entire lake and includes the Etowah River up to the USGS station 02392000 (Etowah River near Canton, GA). The estimated bottom elevation of each grid cell was defined based on available data from U.S Corps of Engineers – Mobile District, and taking into account the total pool area and volume of the reservoir. Once the bottom elevation was determined for each cell, the stage-area and stage-capacity of Lake Allatoona were compared.

A maximum of 10 uniformly distributed (equal height) vertical layers were defined along the deepest region of the main channel of the lake. This number of layers was found to have a good resolution of the temperature stratification of the lake along the deepest part of the main channel.

EFDC requires boundary conditions to simulate circulation and transportation. These conditions include the water elevations at the downstream boundary, watershed inflows, and meteorological data. The lake levels recorded at the Lake Allatoona dam define the water surface elevation at the downstream boundary along with the measured flows released from Allatoona Dam. The measured flows at the USGS Station 02392000 (Etowah River at Canton) were the upstream boundary and the results of the LSPC model were used as tributary flow inputs to the hydrodynamic model, Environmental Fluid Dynamics Code (EFDC). Figure 17 shows the Lake Allatoona grid and the location of the upstream boundary and tributary flow inputs. The model also considered the point sources that flow directly into the lake.

The meteorological data used included barometric pressure, air temperature, relative humidity, dew point, rainfall evaporations, wind speed, solar radiation, and cloud cover. These data came from the National Climatic Data Center (NCDC) surface airways stations in Rome, Georgia.

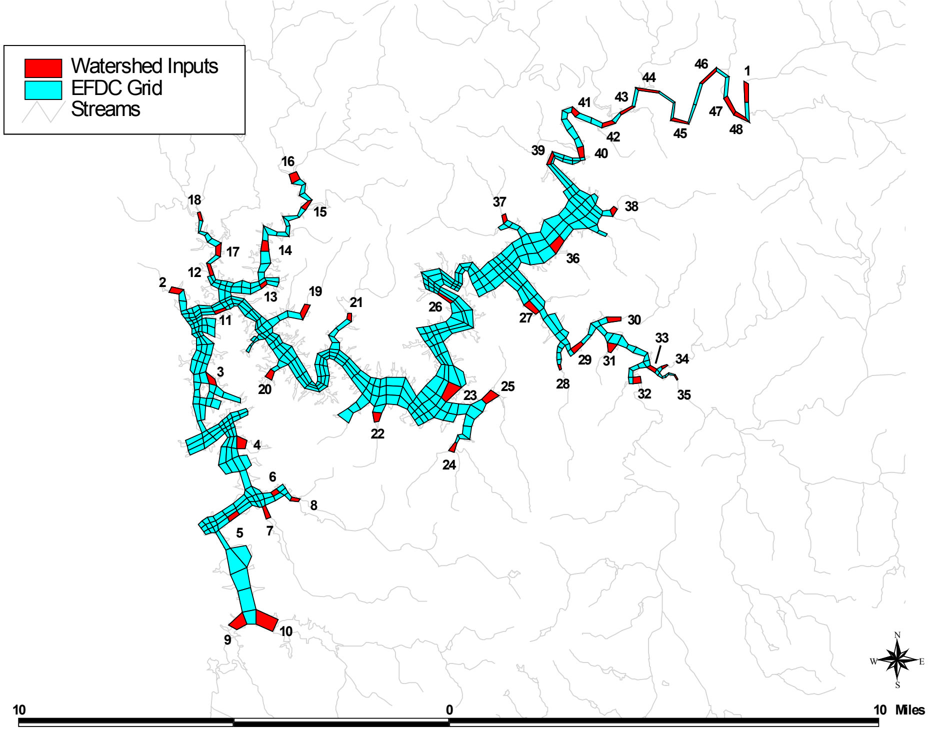


Figure 17. Model Grid for Lake Allatoona, Showing the Location of the Upstream Boundary and Tributary Flow Inputs

4.3 Water Quality Modeling (WASP)

The Water Quality Analysis Simulation Program Version 7.2 (WASP) is a dynamic compartment-modeling program for aquatic systems, including both the water column and the underlying benthos. The program models the time varying processes of advection, dispersion, point and diffuse mass loading, and boundary exchange. WASP is a flexible model, allowing the modeler to structure one, two, and three-dimensional models. Water quality processes are represented in special kinetic subroutines from which the user can choose. These include TOXI, which models toxicants, and EUTRO, which models conventional water quality parameters including algae.

WASP EUTRO calculates the interaction of eight water quality constituents based on interspecies kinetics and user-defined rates, as a function of water temperature (see Figure 18).

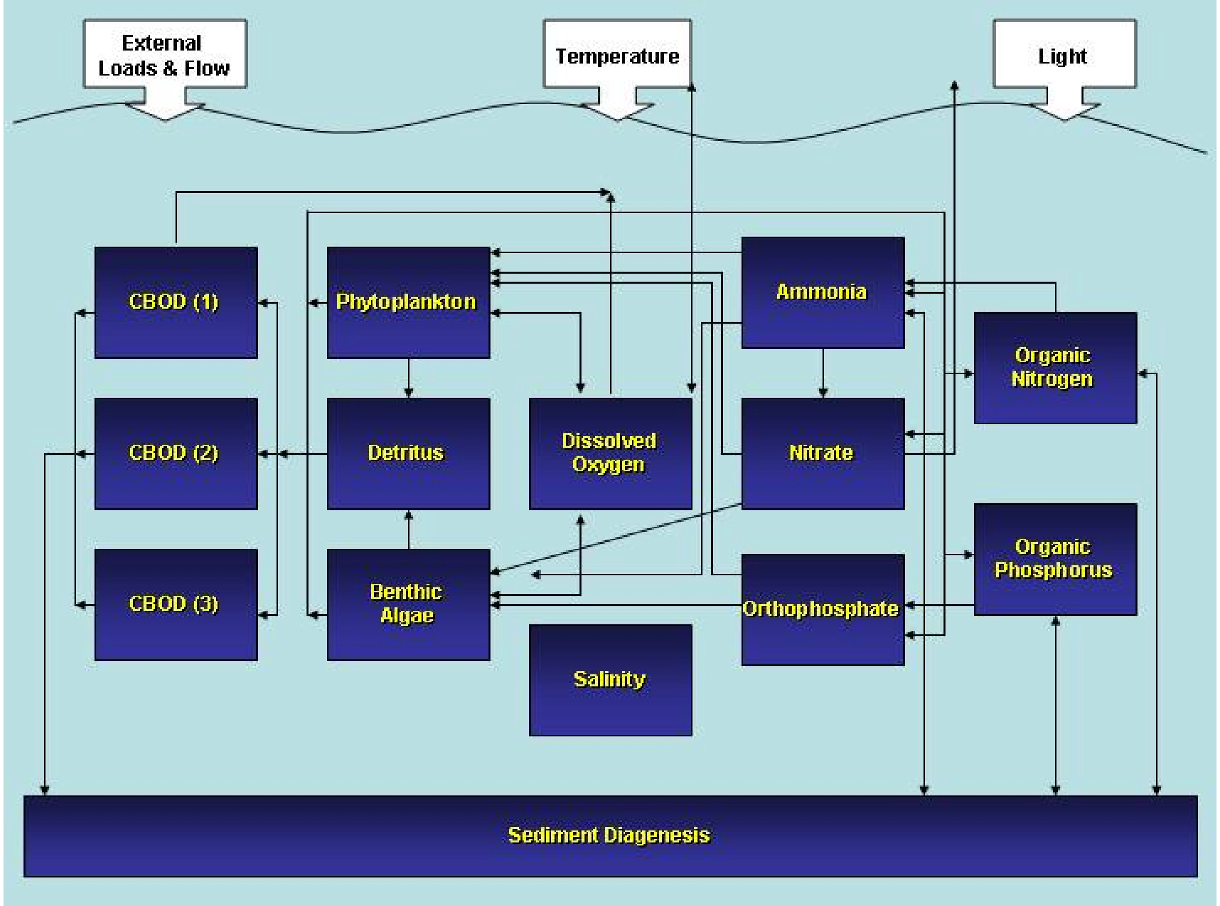


Figure 18. Schematic of Principal Kinetic Interactions for the Nutrient Cycling and Dissolved Oxygen that were Simulated in WASP

The eight state-variables are:

- Organic nitrogen
- Ammonia
- Nitrate-Nitrite
- Organic phosphorus

- Orthophosphate
- Chlorophyll *a*
- Dissolved oxygen
- Biochemical oxygen demand

WASP includes sediment oxygen demand (SOD) and reaeration. The eutrophication module was used in the Lake Allatoona modeling scenarios to simulate the full nutrient dynamics and algal growth in the embayment.

The EFDC transport simulation record, or "hydro-file," was used as the input for the WASP dynamic water quality simulation. The flows and transport parameters calculated within EFDC drive the WASP water quality model and were applied to the same grid used in EFDC.

Inflow constituent concentrations of BOD, total nitrogen, and total phosphorus were determined from the calibrated LSPC model. LSPC predicts total nitrogen and phosphorus loads for each modeled watershed, which included nutrient loads washed off land surfaces during storm events, and loads from point source discharges. WASP, however, requires a fractionation of the nutrients into their constituents. Total phosphorus was fractioned into ortho-phosphate and organic phosphorus. Total nitrogen included organic nitrogen, ammonia, and nitrate-nitrite.

There are eight point sources that were included in the EFDC hydrodynamic and WASP models (Table 23). Daily flow data were input for the Canton WPCP, Cherokee County Water and Sewer, and Cobb County Northwest WWTP, from January 2001 through December 2007. The remaining point source inputs were input at their design flow for the entire simulation.

Table 23. Point Sources Included in the Lake Allatoona Model

Permit Number	Facility Name	Permitted Flow (MGD)
GA0022616	Allatoona Campground	0.02
GA0025674	Canton WPCP	1.89
GA0027456	USA FORSCOM Rec Area	Report
GA0029891	Red Top Mountain State Park	0.003
GA0046451	Cherokee County Water and Sewer Rose Creek	6.0
GA0046761	Cobb County Northwest WWTP	12
GA0047465	USA COE McKinney Camp Ground	0.007
GA0047074	USA COE Old Construction Site Ground	0.003

Daily BOD_5, NH_3 , Total P, and DO concentrations were obtained from 2001 - 2007 OMRs for NPDES permitted facilities that discharge 1.0 MGD or greater . These data were input into the calibration model. Table 24 is a summary of the actual discharges from these facilities for calendar years 2001 through 2007.

Table 24. Summary of the Major Lake NPDES Dischargers 2001-2007

Facility Name	NPDES Permit No.	Receiving Stream	Average Discharge					
			Average Monthly Flow (MGD)	BOD_5 (mg/L)	Total P (mg/L)	PO_4 (mg/L)	NO_2 /NO_3 (mg/L)	NH_3 (mg/L)
City of Canton WPCP	GA0025674	Etowah River/ Lake Allatoona	1.77	12.10	2.79	--	--	1.71
Cherokee County Rose Creek	GA0046451	Lake Allatoona	3.50	3.62	0.17	--	--	0.32
Cobb County Northwest WPCP	GA0046761	Lake Allatoona	6.19	2.04	0.11	0.06	--	0.14

There are two water withdrawals located in Lake Allatoona that were represented in the lake model (Table 25). Monthly average water withdrawal data were obtained from the GAEPD, and are presented in Table 26.

Table 25. Water Withdrawals Included in the Lake Allatoona Model

Withdrawal	Permit Number	Permitted Withdrawal	
		Daily Limit (MGD)	Monthly Average (MGD)
City of Cartersville	008-1491-06	21.42	18.00
Cobb County – Marietta Water Authority	008-1491-05	86.00	78.00

Table 26. Summary of the Monthly Lake Withdrawals

Month	City of Cartersville	Cobb County – Marietta Water Authority
Jan	12.239	39.448
Feb	12.121	39.476
Mar	12.214	41.974
Apr	12.636	46.154
May	13.668	51.862
Jun	14.140	53.745
Jul	13.964	51.859
Aug	14.555	55.539
Sep	14.224	52.018
Oct	13.292	47.311
Nov	12.317	42.286
Dec	11.767	39.135
Annual Avgs	13.086	46.734

Nutrient Fluxes

A relationship was developed between the reductions in a watershed load versus the reduction in the nutrient fluxes. To develop this relationship, two models were used. The first was the LSPC model and the second model was a sediment digenesis model developed by Quantitative Environmental Analysis, LLC (QEA) and Mississippi State University's Engineering Department.

To establish a baseline condition, the LSPC model was run without any changes. The monthly average LSPC output was calculated and input into the sediment digenesis model. The sediment digenesis model was setup for both the Allatoona Creek and Etowah River arms of the lake. Other inputs into the sediment digenesis model included volume, average surface area, average depth, and numerous rates and constants. The volume, surface area, and depth were determined from the hydrodynamic model established for Lake Allatoona. The rates and constants were default values developed by QEA and Mississippi State University, and did not change for any of the model runs. Once all of the inputs were loaded into the sediment digenesis model, the model was run, at steady-state conditions, for both the Allatoona Creek and Etowah River arms, and baseline conditions were established for 2001 through 2007.

The LSPC model was then run for a variety of watershed reduction runs. The first set of runs reduced the urban load by 25, 50, 75, and 95%, while keeping the agriculture load constant. The second set of runs reduced the agriculture load by 25, 50, 75, and 95% while keeping the urban load constant. After the LSPC model runs were completed, the outputs were then input into the sediment digenesis model and the model was run for each watershed load reduction for 2001 through 2007.

The results from the sediment digenesis model were processed by averaging the predicted nutrient fluxes from for each of the years, 2001-2007, to develop a single value. Each landuse (urban and agriculture) and reduction scenario (25, 50, 75, and 95%) run was processed separately. The predicted nutrient fluxes were then compared to the baseline condition, and a percent difference was calculated. This value was assumed to be the percent reduction in the nutrient flux.

During this process, it was noticed that the 2007 results were quite a bit different from the other years. This was most likely due to the extreme drought that was experienced and the minimal watershed loading that occurred. Therefore, 2007 was not used in the analysis.

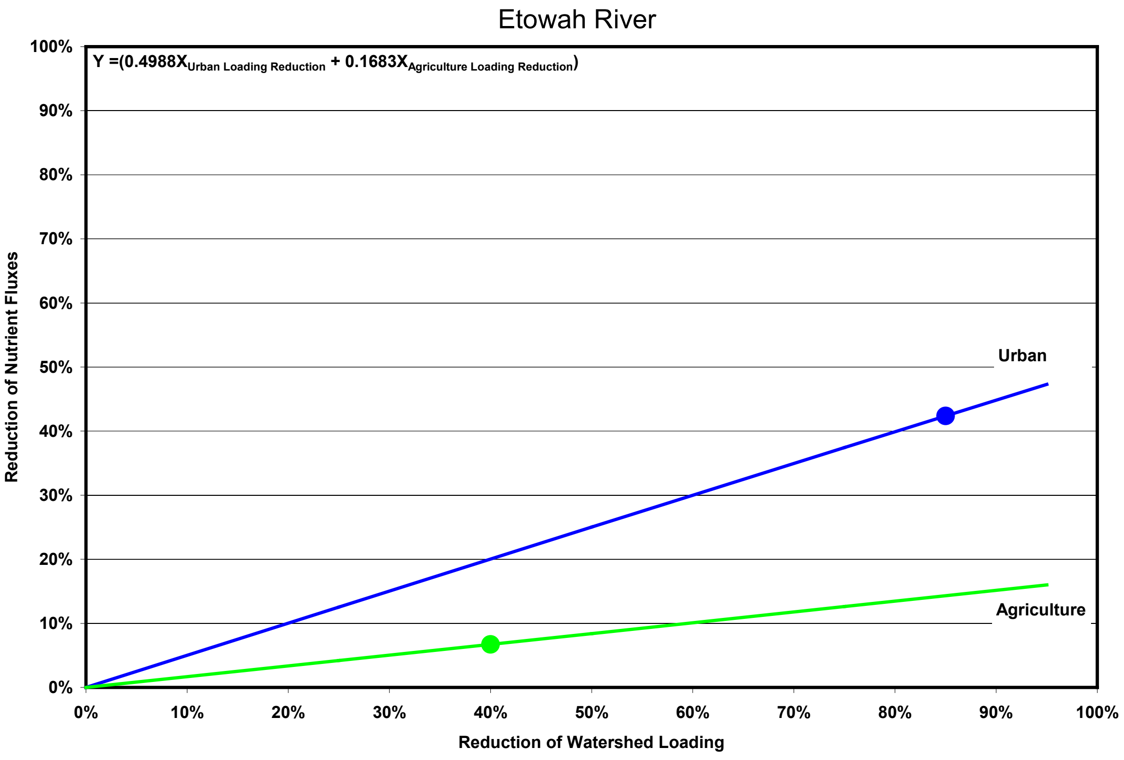
The reductions in watershed load versus the reductions in nutrient flux were plotted (see Figure 19) and the following equations were developed:

Etowah River

$$Y_{\text{Nutrient Flux Reduction}} = [(0.4988X_{\text{Urban Loading Reduction}} + 0.1683X_{\text{Agriculture Loading Reduction}})]$$

Allatoona Creek

$$Y_{\text{Nutrient Flux Reduction}} = [(0.8465X_{\text{Urban Loading Reduction}} + 0.0680X_{\text{Agriculture Loading Reduction}})]$$



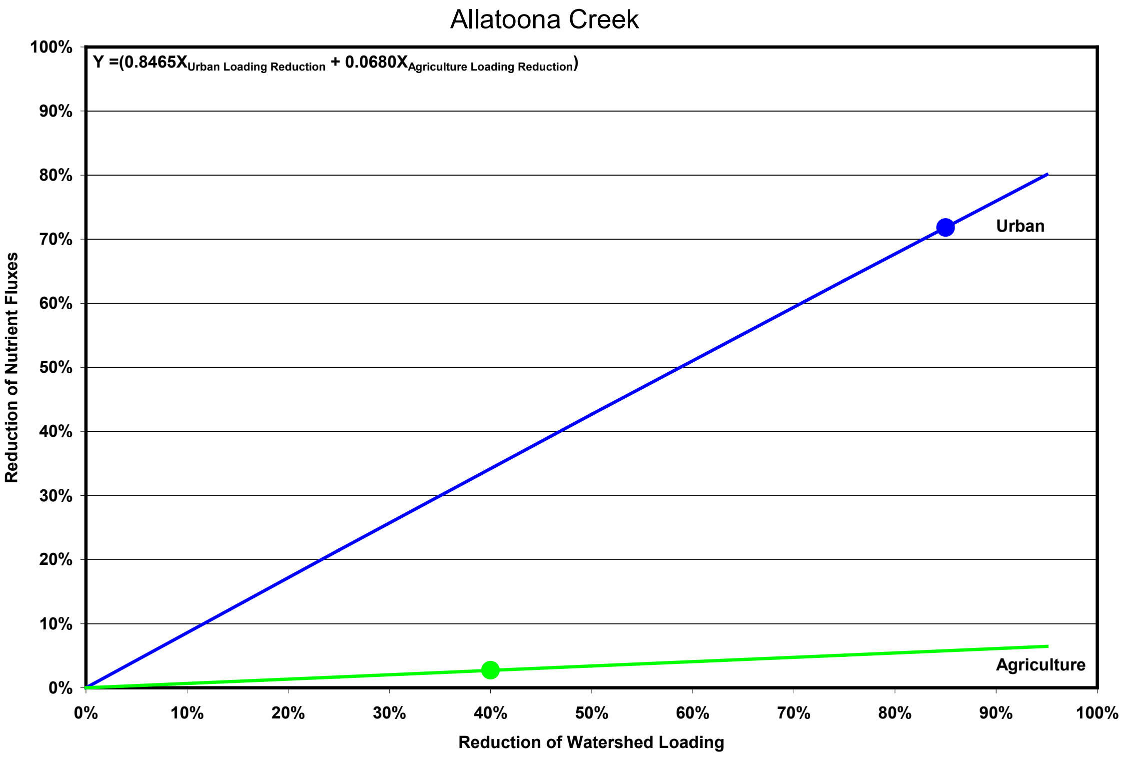


Figure 19. Watershed Load Reductions versus Nutrient Flux Reductions

Modeling Parameters

Table 27 provides the reaction rates and parameters developed during WASP model calibration. These parameters included the reaction rates for BOD, phosphorus, nitrogen, and SOD. The reactions rates used in the calibrated model either came from literature values or field data. SOD rates and benthic nutrient fluxes used in WASP were based on the SOD and nutrient exchange study conducted in the Little River Embayment in June 2001 (US EPA, 2001). Parameters are given by constituent. EPA Region 4 Science and Ecosystem Support Division in Athens, Georgia performed a field survey during June 25-29, 2001. The results of the measurements are presented in the Lake Allatoona Nutrient Exchange and Sediment Oxygen Demand Study, Project #01-0698 (USEPA, 2001). Sediment Oxygen Demand (SOD) and nutrient flux measurements were performed at Station 3, just upstream of Bells Ferry Road. This site is near the GA EPD lake sampling stations where chlorophyll *a* was measured during 2000, 2001, and 2002.

Table 27. WASP Modeling Parameters

Parameters and Units	Typical Range	Value
Sediment Oxygen Demand, g/m^2-day	1.25 – 3.0	1.25
Temperature Coefficient for SOD 20 ^{o}C, Default=1.0	1.0 - 1.08	1.065
Nitrification Rate at 20 ^{o}C, 1/day	0.025 - 0.2	0.10
Temperature Coefficient for Nitrification Rate 20 ^{o}C, Default=1.0	1.0 - 1.08	1.08
Half-Saturation Constant for Nitrification-Oxygen Limitation, mgO$_2$/L	0.0 – 2.0	1.5
Denitrification Rate at 20 ^{o}C, 1/day	0 - 0.1	0.09
Temperature Coefficient for Denitrification Rate 20 ^{o}C, C, Default=1.0	1.0 - 1.045	1.045
Half-Saturation Constant for Denitrification-Oxygen Limitation, mgO$_2$/L	-	0.01
Mineralization Rate of Dissolved Org N, 1/day	0.02 - 0.2	0.05
Temperature Coefficient for Mineralization Rate of Dissolved Org N	1.02 - 1.08	1.047
Fraction of Dead Phytoplankton N Recycled to Org N, Default=1	0.5 - 1.0	0.5
Mineralization Rate of Dissolved Org P, 1/day	0.02 - 0.22	0.05
Temperature Coefficient for Mineralization Rate of Dissolved Org P	1.02 - 1.08	1.00
Fraction of Dead Phytoplankton P Recycled to Org P, Default=1	0.5 - 1.0	0.5
Saturated Growth Rate of Phytoplankton, 1/day	1.0 - 3.0	1.25
Phytoplankton Growth Temperature Coefficient	-	1.07
Include Algal Self Shading Light Extinction in Steele (0=Yes, 1=No)	-	1
Carbon/Chlorophyll Ratio in Phytoplankton	50 - 100	65/125
Nitrogen Half-Saturation Constant for Phytoplankton Growth	0.01 - 0.2	0.025
Phosphorous Half-Saturation Constant for Phytoplankton Growth	0.0005 - 0.03	0.001
Endogeneous Respiration Rate of Phytoplankton at 20 ^{o}C, 1/day	0.05 - 0.15	0.15
Temperature Coefficient for Respiration 20 ^{o}C, Default=1.0	1.0 - 1.08	1.05
Non-Predatory Phytoplankton Death Rate, 1/day	0.01 - 0.1	0.05
Phosphorous/Carbon Ratio in Phytoplankton	0.015 - 0.025	0.025
Nitrogen/Carbon Ratio in Phytoplankton	0.15 - 0.25	0.30
Half-Saturation Constant for Recycle of N and P Phytoplankton, mg Phyt C/L	-	0.005
Ammonia Fluxes, mg NH$_3$/m^2/day	Field data	0 – 123.4
Ortho P Fluxes, mg Orho-P/m^2/day	Field data	0 – 12.2
Light Option (1 uses input light; 2 uses calculated diel light)	-	2
Phytoplankton Maximum Quantum Yield Constant	-	720
Phytoplankton Optimal Light Saturation	200 - 500	350
Background Light Extinction Multiplier	-	0.50

Parameters and Units	**Typical Range**	**Value**
Detritus & Solids Light Extinction Multiplier	-	0.34
DOC Light Extinction Multiplier	-	0.50
Waterbody Type Used for Wind Driven Reaeration Rate	-	2
Calc Reaeration Option (0=Covar, 1=O'Connor, 2=Owens, 3=Churchill, 4=Tsivoglou)	-	1
Elevation above Sea Level (meters) used for DO Saturation	-	650
Reaeration Option (Sums Wind and Hydraulic Ka)	-	1
Theta -- Reaeration Temperature Correction	-	1.024
Oxygen to Carbon Stoichiometric Ratio	-	2.667
CBOD (1) Deoxygenation Rate at 20C, 1/day	0.05 - 0.7	0.15
Temperature Coefficient for CBOD(1) Deoxygenation Rate 20 ^{o}C, Default=1.0	1.03 - 1.06	1.047
BOD (1) Half Saturation Oxygen Limit (mg O2/L)	-	0.2
CBOD (2) Deoxygenation Rate at 20C, 1/day	0.05 - 0.7	0.04
Temperature Coefficient for CBOD(2) Deoxygenation Rate 20 ^{o}C, Default=1.0	1.03 - 1.06	1.047
BOD (2) Half Saturation Oxygen Limit (mg O2/L)	-	0.2
CBOD (3) Deoxygenation Rate at 20C, 1/day	0.05 - 0.7	0.2
Temperature Coefficient for CBOD(3) Deoxygenation Rate 20 ^{o}C, Default=1.0	1.03 - 1.06	1.047
BOD (3) Half Saturation Oxygen Limit (mg O2/L)	-	0.2
Fraction of Detritus Dissolution to BOD (3)	-	1
Detritus Dissolution Rate (1/day)	-	0.1
Temperature Correction for detritus dissolution	-	1.08

4.4 Model Calibration and Verification

The simulation period for the hydrodynamic model EFDC was from January 1, 2001 through December 31, 2007. The model simulated water surface elevation, flows, and temperature. To help minimize the difference between simulated and measured water surface elevation, the corrective flow feature of EFDC was applied. This feature allows EFDC to calculate, at a given time scale, the amount of flow required to force a match between the calculated and observed water surface elevations. The calculated flow, or “corrective flow,” represents the error in volume associated with the model. This flow can be due to a combination of inaccurate readings of flow inputs or outputs, inaccurate estimates of watershed flow, spatial discrepancies in meteorological data, or unaccounted flow terms. Figure 20 shows the water surface elevation calibration at the Allatoona Dam forebay for the period 2001 through 2007.

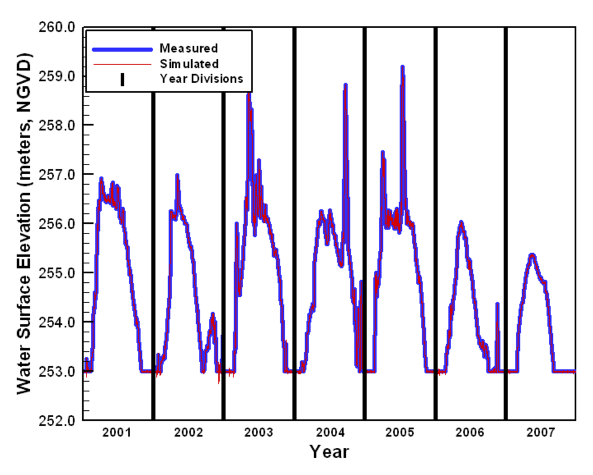


Figure 20. Water Surface Elevation Calibration at the Allatoona Dam Forebay for the Period 2001-2007

Temperature is simulated in EFDC using solar radiation, atmospheric temperature, heat transfer at the water surface, and the temperature of the hydraulic inputs. The Lake Allatoona EFDC model was calibrated to water temperature profile data for 2001 through 2007 measured by GA EPD at five stations throughout the lake. Figure 21 shows the temperature calibration at the Allatoona Dam forebay, during 2005.

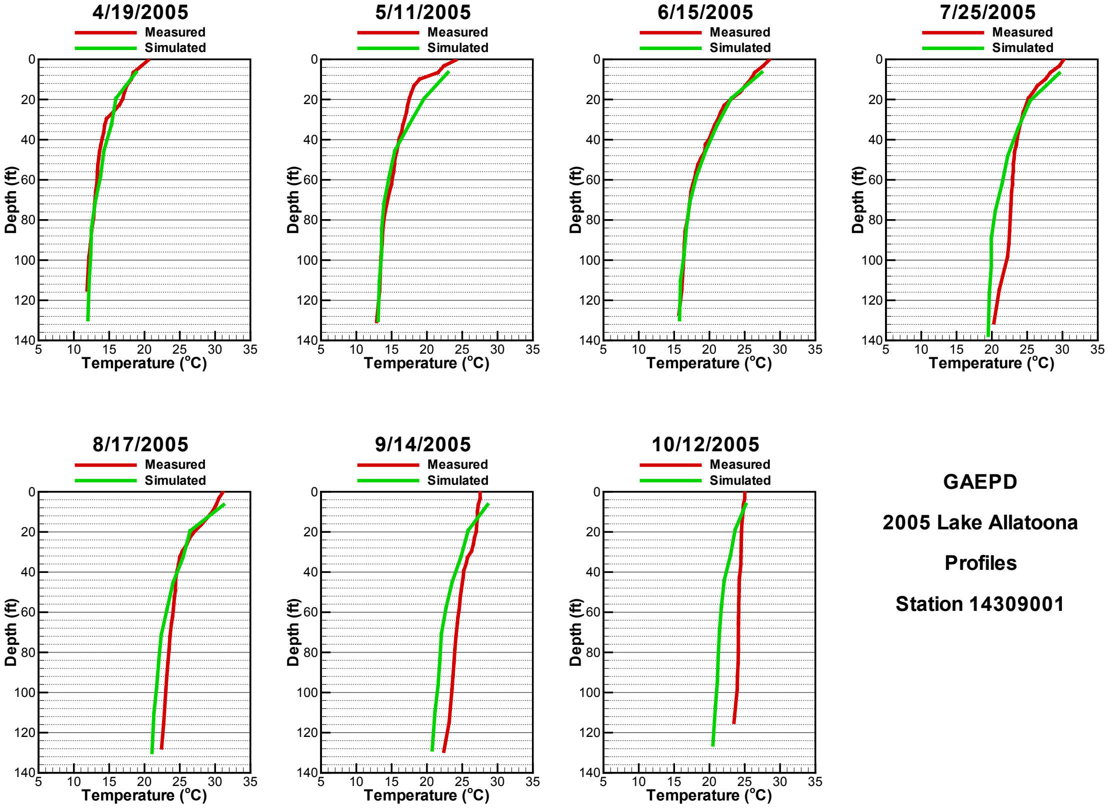
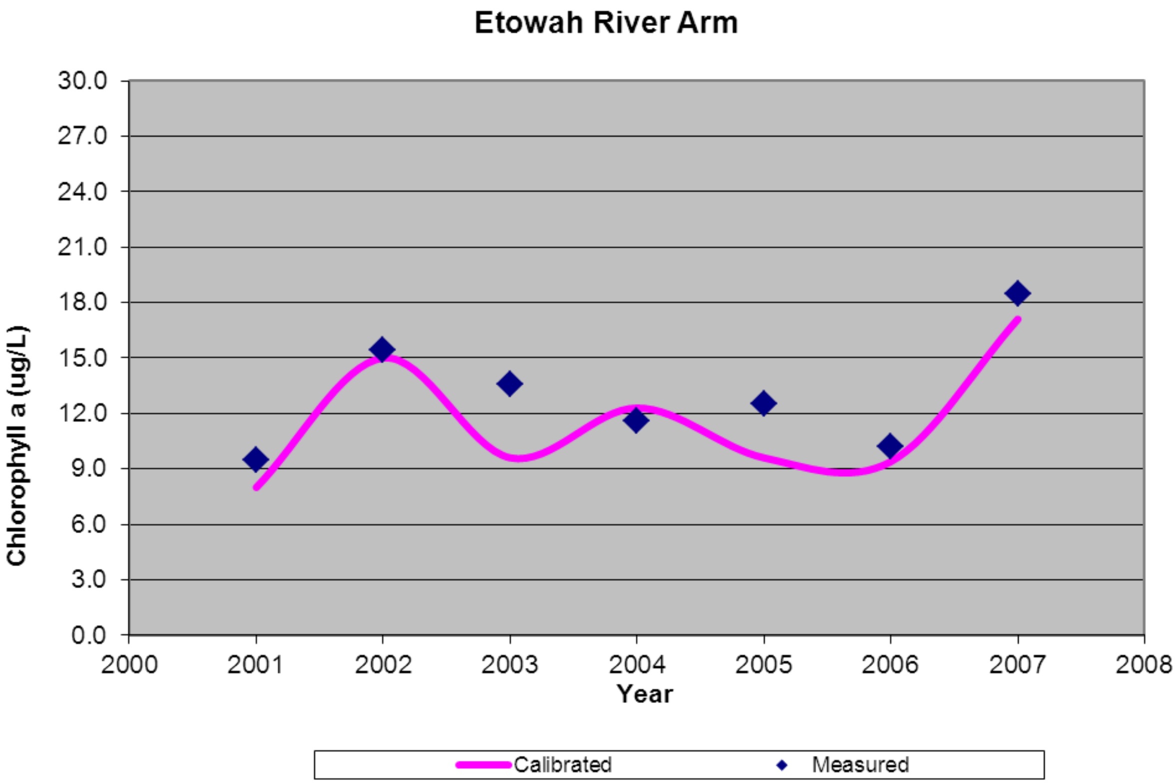
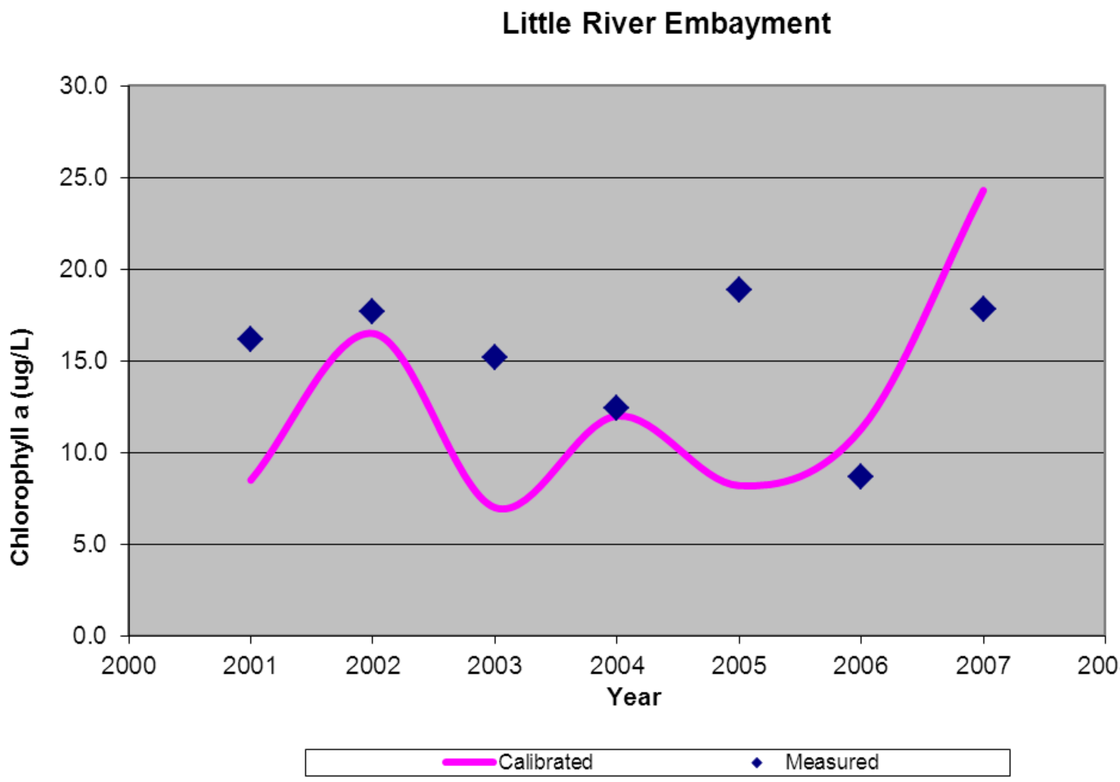


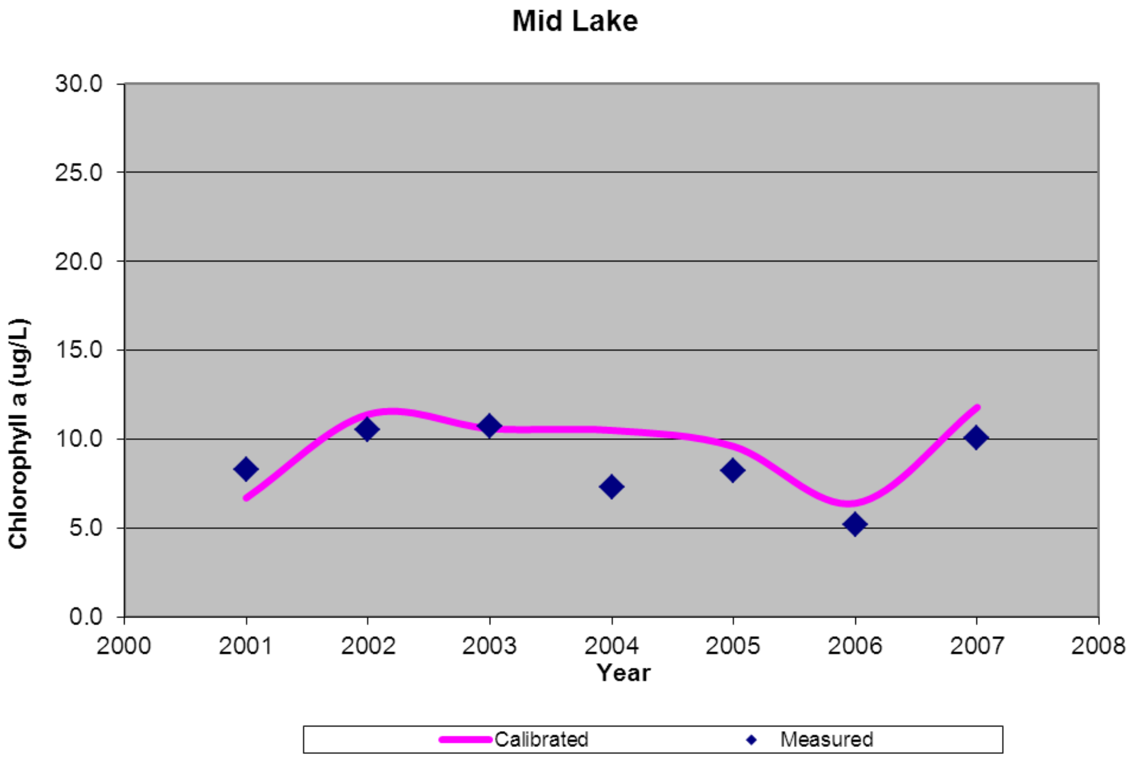
Figure 21. Temperature Calibration at the Allatoona Dam Forebay for 2005

The model calibration period was determined from an examination of the GA EPD 2001-2007 water quality data for the lake. The data examined included chlorophyll *a*, nitrogen components, phosphorus components, dissolved oxygen profiles, and water temperature profiles. The calibration models were run using input data for this period, including boundary conditions and meteorological data.

Measured chlorophyll *a*, ortho-phosphate, total phosphorus, total nitrogen, ammonia, and nitrate/nitrate data for the 2001 through 2007 growing seasons were used as instream targets to calibrate the model. Figure 22 shows the chlorophyll *a* calibration curves for the Etowah River and Allatoona Creek compliance points for 2001-2007.




Little River Embayment
Chlorophyll a (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Calibrated
Measured


Mid Lake
Chlorophyll a (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Calibrated
Measured

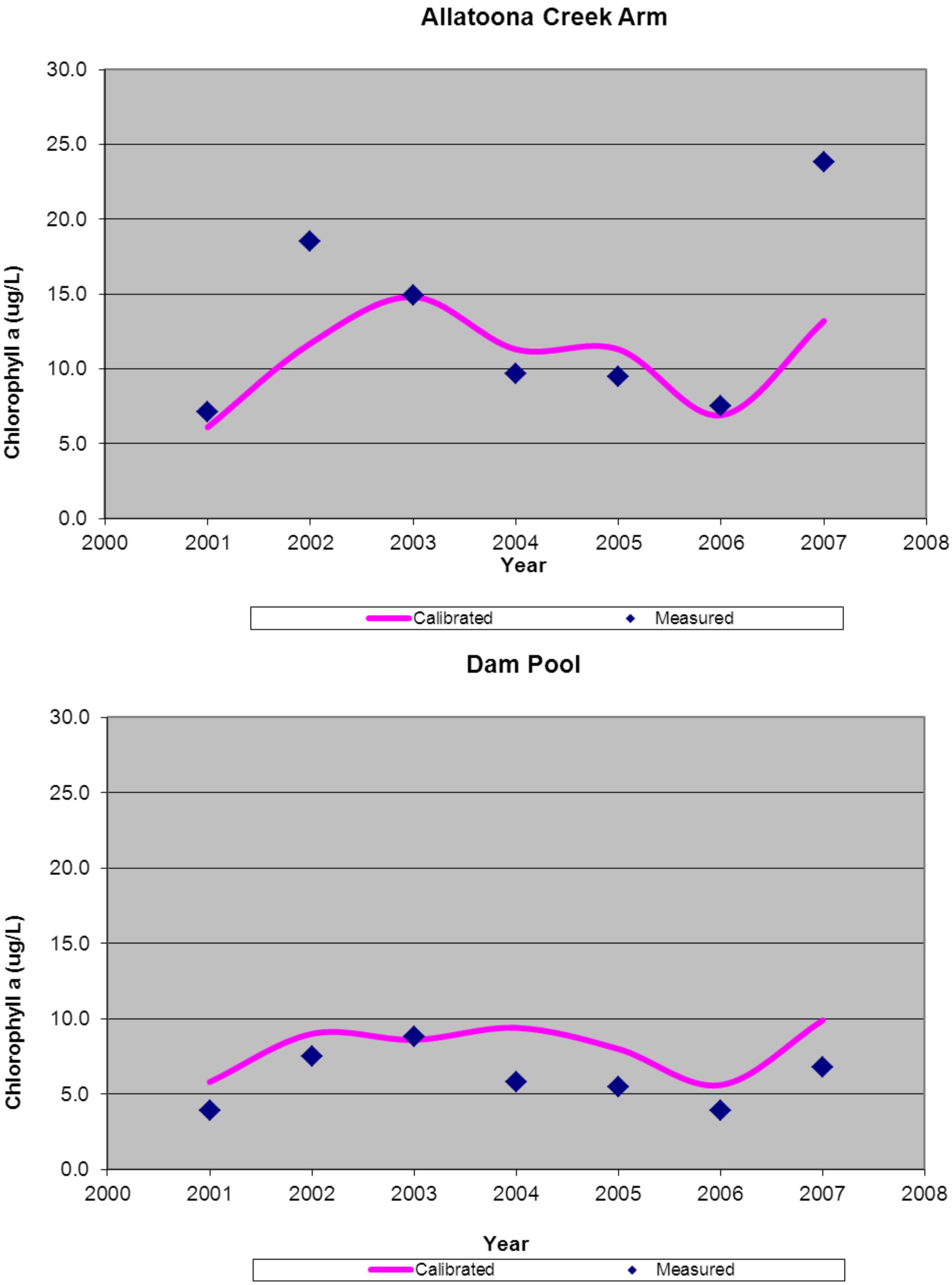


Figure 22. Growing Season Average Chlorophyll *a* Calibration at Etowah River and Allatoona Creek Compliance Points for 2001 – 2007

4.5 Critical Conditions Models

The critical conditions model was used to assess the nutrient loads and chlorophyll *a, and* to determine if a problem exists requiring regulatory intervention. Model critical conditions were developed in accordance with GA EPD standard practices (GA EPD, 1978).

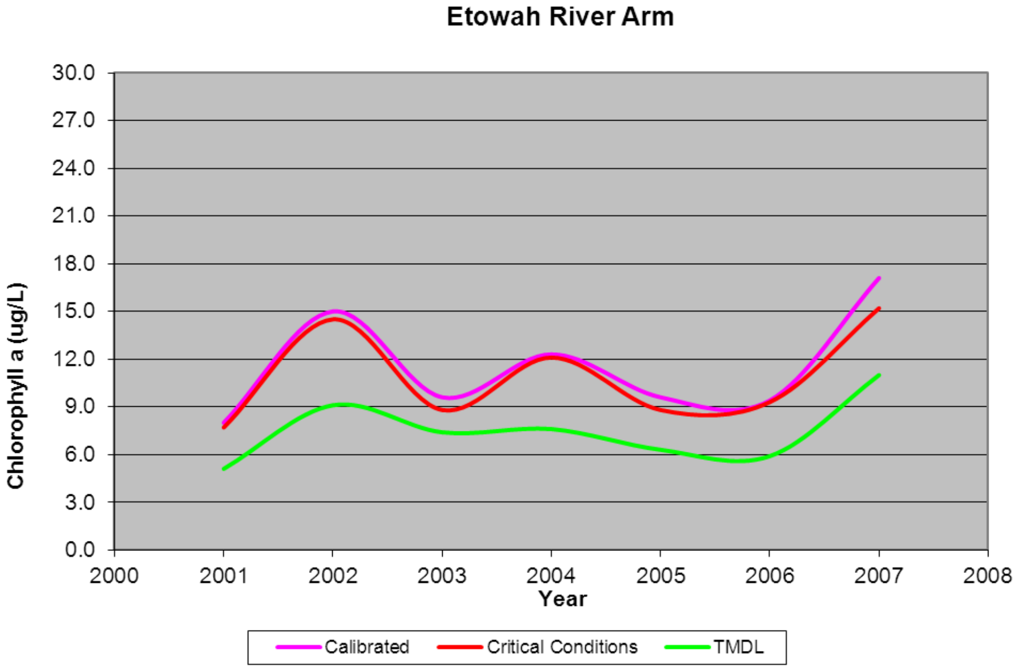
The complex dynamics simulated by the models demonstrated the critical conditions for nutrient uptake and the corresponding algal growth in the embayment. The critical conditions include:

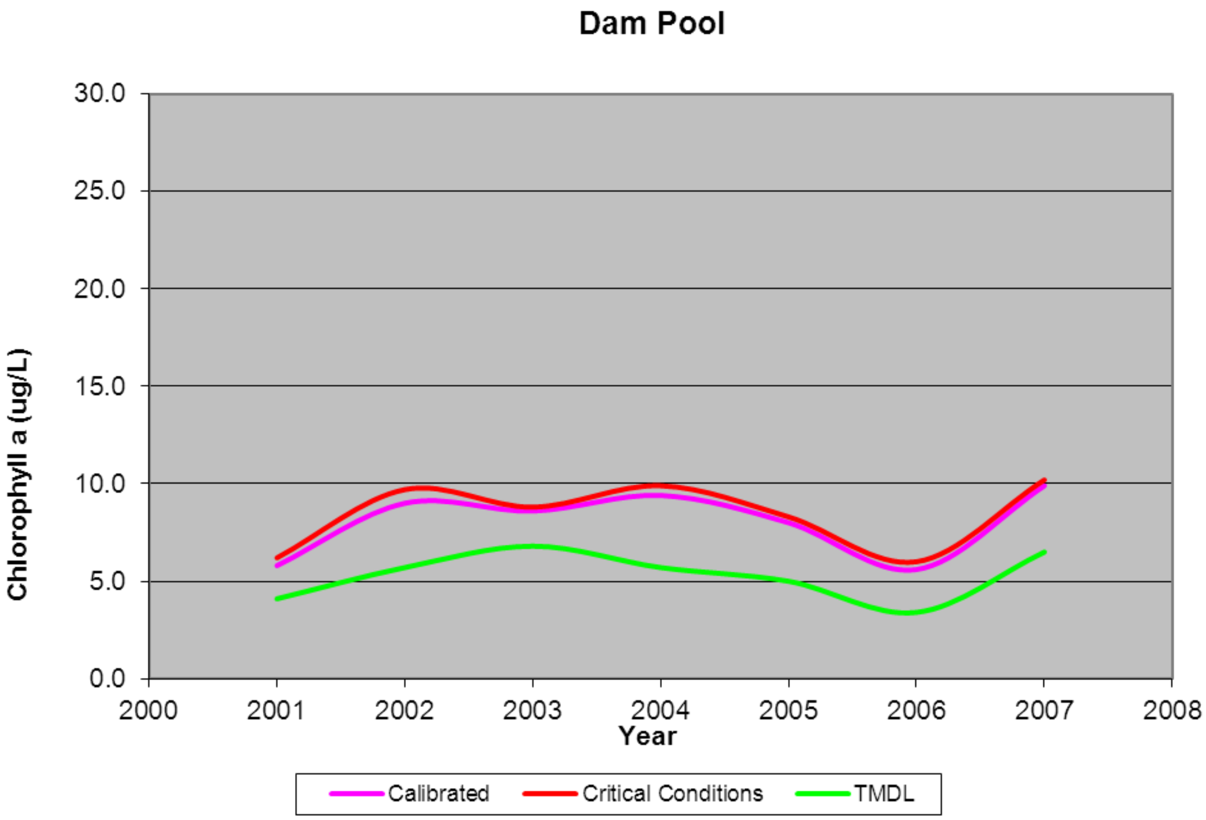
- Meteorological conditions
- Available sunlight
- Watershed flows
- Retention time in embayment
- High water temperatures
- Watershed nutrient loads

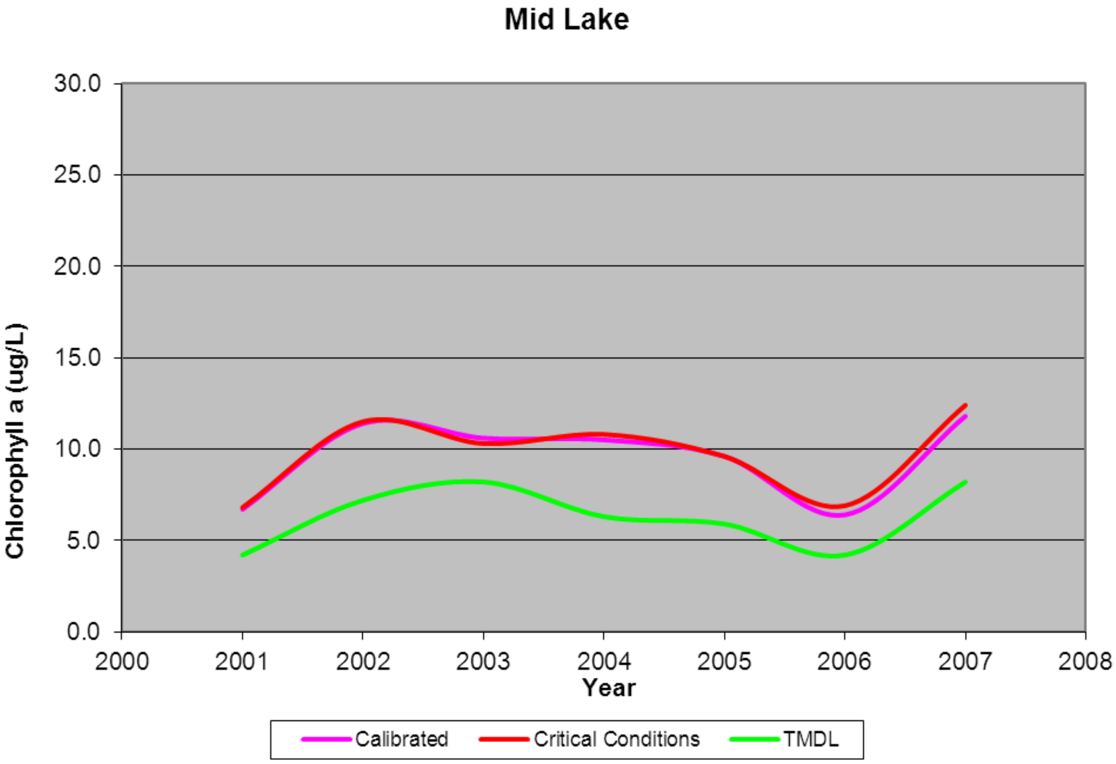
The most critical time period for excess algal growth appears to be the low flow year following a high to normal flow year when excess nutrients have been delivered to the system. During these years, the rainfall is low, sunlight is unlimited, and nutrient fluxes may be high. Small amounts of nutrients during these low-flow sunny periods can cause algae to bloom and measured chlorophyll *a* can exceed the numeric standards.

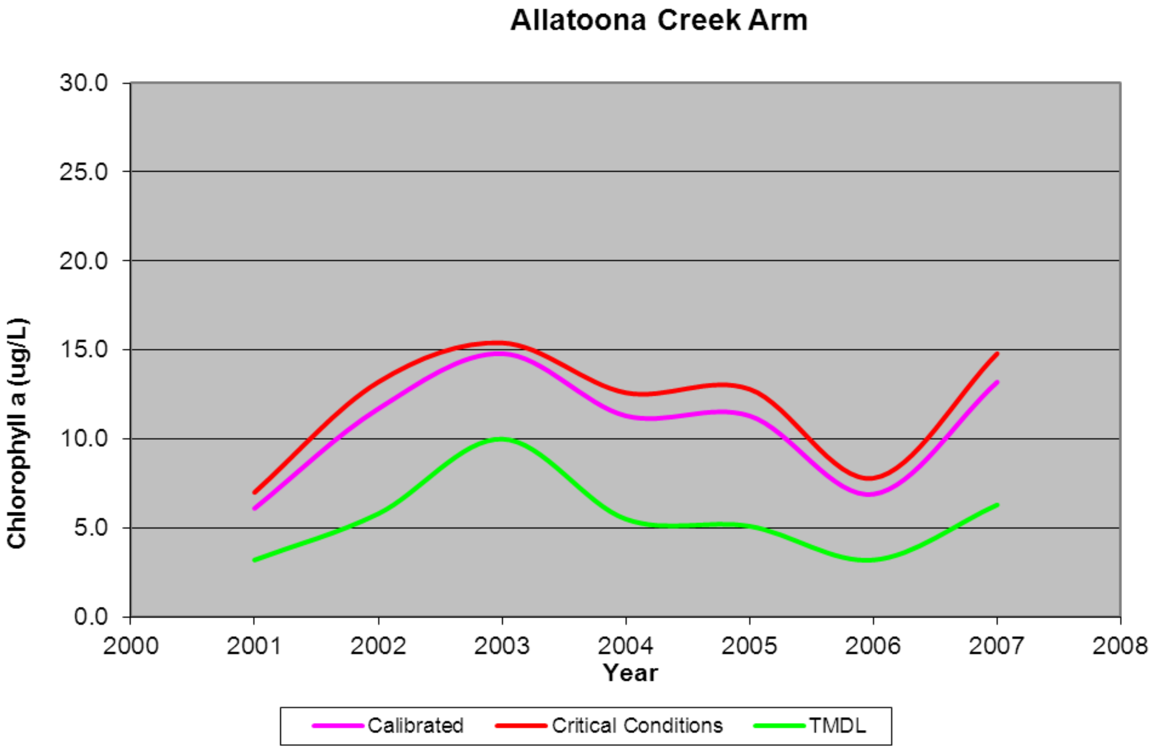
Drought conditions were experienced a couple of times during the period from 2001 through 2007. This simulation period exhibited a wide variety of flow conditions, which included low flows drought conditions in 2001-2002 and 2006-2007, high flows in 2003, and normal flows in 2004-2005.

The critical condition scenario was run with the NPDES point sources at the full permit loads. The permit limits are listed in Table 3. Results of critical conditions runs are plotted in the graphs in Figure 23 along with the existing conditions and TMDL results at the Etowah River and Allatoona Creek compliance points for comparison.




Dam Pool
Chlorophyll a (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Calibrated
Critical Conditions
TMDL


Mid Lake
Chlorophyll a (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Calibrated
Critical Conditions
TMDL



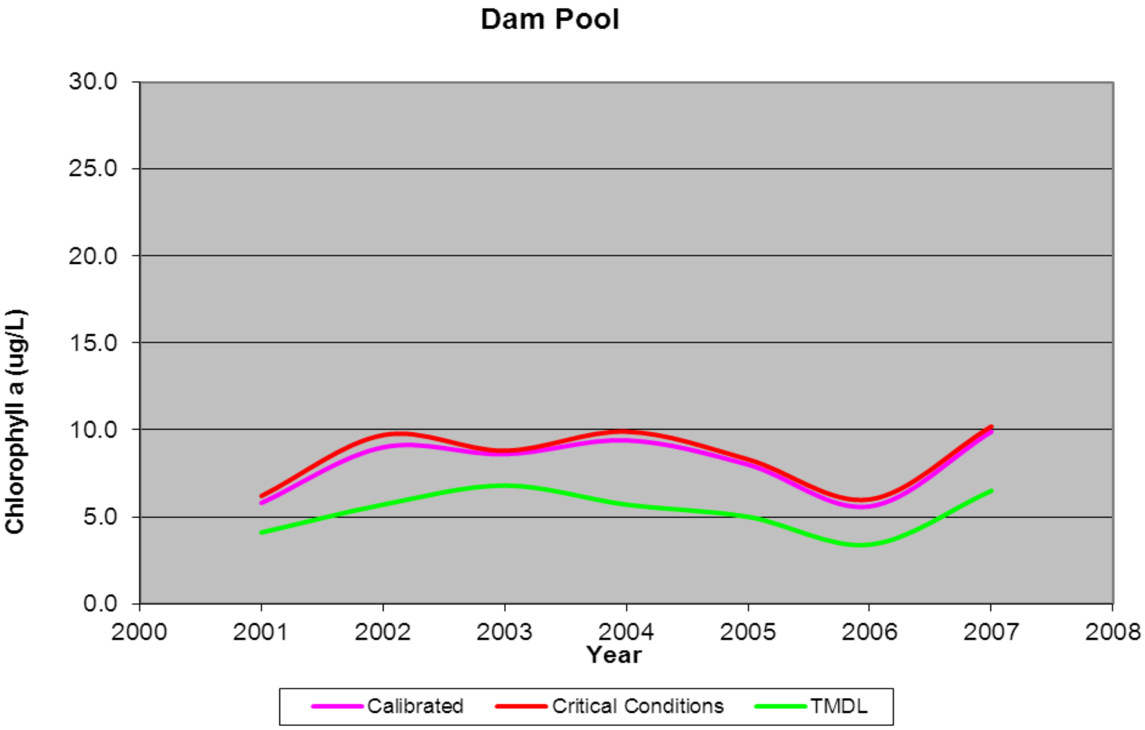


Figure 23. Growing Season Chlorophyll *a* Levels at Existing and Critical Conditions and the TMDL at the Etowah River and Allatoona Creek Compliance Points

5.0 TOTAL MAXIMUM DAILY LOADS

A Total Maximum Daily Load (TMDL) is the amount of a pollutant that can be assimilated by the receiving waterbody without exceeding the applicable water quality standard, which in this case, is the growing season average chlorophyll *a* standards. A TMDL is the sum of the individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources, as well as natural background (40 CFR 130.2) for a given waterbody. The TMDL must also include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the water quality response of the receiving water body. TMDLs can be expressed in terms of either mass per time, toxicity, or other appropriate measures; for nutrients the TMDLs are expressed as lbs/day.

A TMDL is expressed as follows:

$$\text{TMDL} = \Sigma\text{WLAs} + \Sigma\text{LAs} + \text{MOS}$$

The TMDL calculates the WLAs and LAs with margins of safety to meet the lake's water quality standards. The allocations are based on estimates that use the best available data and provide the basis to establish or modify existing controls so that water quality standards can be achieved. In developing a TMDL, it is important to consider whether adequate information is available to identify the sources, fate, and transport of the pollutant to be controlled.

TMDLs may be developed using a phased approach. Under a phased approach, the TMDL includes: 1) WLAs that confirm existing limits and controls or lead to new limits, and 2) LAs that confirm existing controls or include implementing new controls (USEPA, 1991). A phased TMDL requires additional data be collected to determine if load reductions required by the TMDL are leading to the attainment of water quality standards.

The TMDL Implementation Plan establishes a schedule or timetable for the installation and evaluation of point and nonpoint source control measures, data collection, assessment of water quality standard attainment, and if needed, additional modeling. Future monitoring of the listed segment water quality will then be used to evaluate this phase of the TMDL, and if necessary, to reallocate the loads. The nutrient loads calculated for each listed lake segment include the sum of the total loads from all point and nonpoint sources for the segment.

5.1 Waste Load Allocations

The waste load allocation is the portion of the receiving waterbody's loading capacity that is allocated to existing or future point sources. WLAs are provided to the point sources from municipal and industrial wastewater treatment systems with NPDES effluent limits. The maximum allocated phosphorus and nitrogen loads for these wastewater treatment facilities are given in Table 28. Please note that the model showed that the lake is phosphorus limited. Table 28 also includes three proposed facilities. In the future, if there is a new facility or a proposed expansion, then the WLA for the facility would not change but the allowable concentrations would be reduced in proportion to the flow, unless the LA or another WLA can be reduced via pollutant trading.

Table 28. Total Phosphorus WLAs for the Lake Allatoona Watershed Facilities

Facility Name	NPDES Permit No.	Receiving Stream	Total Phosphorus (lbs/yr)	Total Nitrogen (lbs/yr)
Goldkist Poultry Byproducts	GA0000728	Etowah River	3,000	316,585
Eastgate MHP	GA0022292	Owl Creek	470	2,775
Allatoona Campground	GA0022616	Lake Allatoona	300	1,790
Cobb County Noonday Creek WPCP	GA0024988	Noonday Creek	10,960	924,890
City of Canton WPCP	GA0025674	Etowah River	2,875	304,400
Woodstock Rubes Creek WPCP	GA0026263	Rubes Creek	760	83,144
USA FROSCOM Rec Area	GA0027456	Lake Allatoona	910	5,370
Red Top Mountain State Park	GA0029891	Lake Allatoona	45	270
Tate Housing Authority	GA0029955	Long Swamp Creek	150	895
Big Canoe WPCP	GA0030252	East Branch Long Swamp Creek	760	22,375
Jasper WPCP	GA0032204	Polecat Branch	2,435	41,400
Fulton County Little River WPCP	GA0033251	Little River	1,530	71,330
Free Home Elementary School	GA0034185	Buzzard Flapper Creek	15	90
Mountain Brook Center WPCP (R.M. Moore Elementary School)	GA0034959	Moore's Creek	90	535
Cherokee County Fitzgerald Creek	GA0038555	Little River	5,000	348,150
Hampton Reuse Facility (season discharge Nov-Apr)	GA0038903	Settingdown Creek	110	17,810
Cherokee County Rose Creek	GA0046451	Lake Allatoona	6,575	570,770
Cobb County Northwest WPCP	GA0046761	Lake Allatoona	5,845	924,190
USA COE Old Construction Site	GA0047074	Lake Allatoona	45	265
USA COE McKinney Camp Ground	GA0047465	Lake Allatoona	150	895
Tate Elementary School	GA0048518	Mud Hollow Creek	110	650
Manor Water Reuse Facility	Proposed	Chicken Creek	245	14,265
Cherokee County Northeast WPCP	Proposed	Etowah River	3,165	340,940
Etowah Water and Sewer Authority	Proposed	Etowah River	2,435	426,180

Modeling indicates that Lake Allatoona is a phosphorus limited system. In waters where nutrient related impairments are clearly associated with a single nutrient, single nutrient control may be warranted to restore the designated uses. If the key limiting nutrient is controlled, primary production is limited, and this results in the lake meeting its water quality standards. An adaptive management approach will be used to implement the nutrient WLAs in NPDES permits.

Georgia EPD will incorporate the Total Phosphorus WLAs in NPDES permits within eighteen months and permittees may be given compliance schedules. Using the adaptive management approach, the Total Nitrogen WLAs will not be implemented in permits at this time as long as the Lake Allatoona chlorophyll *a* and Total Nitrogen standards are met. However, there is some concern that single nutrient control can enhance export of the uncontrolled nutrient and degrade downstream water quality. It should be noted that EPA states in the Lake Weiss Nutrient TMDL that they "determined that reduction in phosphorus, without concurrent reductions in nitrogen, are expected to result in attainment of the Weiss Lake chlorophyll *a* criteria, Although total nitrogen loads are considered in the modeling analysis, reductions to the existing nitrogen loads are not necessary to address the nutrient impairment within Weiss Lake (EPA 2008)." EPA also looked at potential impacts of nitrogen downstream from Weiss Lake and based on modeling analysis, found that reductions in total phosphorus alone would address the nutrient impairments in the downstream reservoirs (Lake Neeley Henry, Lake Logan Martin, Lay Lake and Lake Mitchell (EPA 2008).Therefore, future monitoring will be conducted to ensure there are no downstream impacts (excess chlorophyll *a* or macrophytes) in the Etowah River, Coosa Rivers, or Lake Weiss. If the Total Nitrogen WLAs need to be incorporated into the NPDES permits in the future, permittees may be given compliance schedules.

State and Federal Rules define storm water discharges covered by NPDES permits as point sources. However, storm water discharges are from diffuse sources and there are multiple storm water outfalls. Storm water sources (point and nonpoint) are different than traditional NPDES permitted sources in four respects: 1) they do not produce a continuous (pollutant loading) discharge; 2) their pollutant loading depends on the intensity, duration, and frequency of rainfall events, over which the permittee has no control; 3) the activities contributing to the pollutant loading may include the various allowable activities of others, and control of these activities is not solely within the discretion of the permittee; and 4) they do not have wastewater treatment plants that control specific pollutants to meet numeric limits.

The intent of storm water NPDES permits is not to treat the water after collection, but to reduce the exposure of storm water to pollutants by implementing various controls. It would be infeasible and prohibitively expensive to control pollutant discharges from each storm water outfall. Therefore, storm water NPDES permits require the establishment of controls or BMPs to reduce the pollutants entering the environment.

The waste load allocations from storm water discharges associated with MS4s (WLAsw) are estimated based on the percentage of urban area in each watershed covered by the MS4 storm water permit. At this time, the portion of each pollutant source that goes directly to a permitted storm sewer and that which goes through non-permitted point sources, or is sheet flow or agricultural runoff, has not been clearly defined. Therefore, it is assumed that approximately 70 percent of storm water runoff from the regulated urban area is collected by the municipal separate storm sewer systems.

This TMDL will use a phased approach. Future phases of TMDL development will attempt to further define the sources of pollutants and the portion that enters the permitted storm sewer systems. As more information is collected and these TMDLs are implemented, it will become clearer which BMPs are needed and how water quality standards can be achieved.

5.2 Load Allocations

The load allocation is the portion of the receiving water's loading capacity that is attributed to existing or future nonpoint sources or to natural background sources. Nonpoint sources are identified in 40 CFR 130.6 as follows:

- Residual waste;
- Land disposal;
- Agricultural and silvicultural;
- Mines;
- Construction;
- Saltwater intrusion; and
- Urban storm water (non-permitted).

As described above, there are two types of load allocations: loads to the stream independent of precipitation, including sources such as failing septic systems, leachate from landfills, animals in the stream, leaking sewer system collection lines, and background loads; and loads associated with nutrient accumulation on land surfaces that is washed off during storm events, including runoff from saturated LAS fields. To determine the LA, the nutrient accumulation loading rates for each landuse and the associated landuse areas were used.

5.3 Seasonal Variation

The Georgia lake chlorophyll *a* criteria are based on the growing season average. The most critical time period for excess algal growth appears to be the low flow year following a high to normal flow year when excess nutrients have been delivered to the system. During this critical time, the rainfall is low, sunlight is unlimited, and nutrient fluxes may be high. Small amounts of nutrients during these low-flow sunny periods can cause algae to bloom and measured chlorophyll *a* can exceed the numeric standards.

A wide variety of flow conditions were exhibited during the simulation period, 2001-2007. This included low flow drought conditions in 2001-2002 and 2006-2007, high flows in 2003, and normal flows in 2004-2005.

The low flow critical conditions incorporated in this TMDL are assumed to represent the most critical design conditions thereby providing year-round protection of water quality. This TMDL is expressed as a total load based on the nutrient accumulation rate for each landuse.

5.4 Margin of Safety

The MOS is a required component of TMDL development. There are two basic methods for incorporating the MOS: 1) implicitly incorporate the MOS using conservative modeling assumptions to develop allocations; or 2) explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

For this TMDL, the MOS was implicitly incorporated by using the following conservative modeling assumptions:

- Critical low flows into the embayment
- Hot summer temperatures
- Critical meteorological conditions
- Long retention times
- Conservative reaction rates

5.5 Total Nutrient Load

The nutrient load that enters the lake each year is dependent on the annual rainfall. The annual Total Phosphorus loads delivered to the major tributary compliance points to meet the TMDL are given in Table 29. This table also included the current critical annual load, as well as the percent reduction need to meet the TMDL.

The TMDL was based on the rate each nutrient accumulates for each landuse. In order to meet the chlorophyll *a* limits in the lake, the urban nutrient accumulation loading rates had to be reduced by 85%, the agricultural nutrient accumulation loading rates, including chicken litter application, had to be reduced by 40%, and the failing septic tanks had to be reduced by 50%. Table 30 presents the total load allocation expressed in lbs/day for the 303(d) listed segments located in Lake Allatoona and includes the current critical loads and corresponding TMDLs, WLAs (WLA and WLA_{sw}), LAs, MOSs, and percent load reductions. The LA and WLA_{sw} is based on each landuse accumulation rate. The WLA is the daily amount that can be discharged and is given for accounting purposes only. The model showed that the lake is phosphorus limited and in waters where nutrient-related impairment is clearly associated with a single nutrient, single nutrient control may be warranted to restore designated uses. The relationship between instream water quality and the potential sources of pollutant loading is an important component of TMDL development, and is the basis for later implementation of corrective measures and BMPs.

Table 29. Annual Total Phosphorus Load Delivered to Lake Allatoona

Station	**Run**	**Annual Total Phosphorus Load (lbs/yr)**						
		2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Etowah River @ GA 5 spur and 140, at the USGS Gage	Critical	216,170	242,482	242,488	227,958	196,164	203,297	158,824
	TMDL	76,175	98,005	92,374	84,367	55,581	66,991	36,982
	Reduction	65%	60%	62%	63%	72%	67%	77%
Little River @ GA 5 (Hwy 754)	Critical	50,655	57,913	61,625	55,944	52,399	50,333	43,145
	TMDL	13,678	18,643	20,076	17,015	14,054	13,919	11,123
	Reduction	73%	68%	67%	70%	73%	72%	74%
Noonday Creek @ North Rope Mill Rd.	Critical	40,494	44,276	47,615	43,515	42,278	39,563	31,640
	TMDL	16,128	17,721	18,515	17,171	16,273	15,977	14,119
	Reduction	60%	60%	61%	61%	62%	60%	55%
Shoal Creek @ GA 108 (Fincher Rd.)	Critical	5,924	11,450	12,589	9,352	6,077	6,552	3,848
	TMDL	4,128	9,085	9,857	7,222	4,104	4,816	2,683
	Reduction	30%	21%	22%	23%	32%	26%	30%

Table 30. Total Daily Nutrient Accumulation Loads, Wasteloads, and Required Load Reductions

Stream Segment		Lake Allatoona – Etowah River Arm		Lake Allatoona – Allatoona Creek Arm		Total Lake Allatoona	
		Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)	Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)	Total Nitrogen (lbs/day)	Total Phosphorus (lbs/day)
Current Load (lbs/day)		62,342	12,718	5465	907	101,715	17,747
TMDL Components	WLA (lbs/day)	4,032	41	23	4	12,109	131
	WLAsw (lbs/day)	422	77	943	154	3,116	510
	LA (lbs/day)	50,852	10,017	2,287	374	67,498	12,890
	MOS (lbs/day)	Implicit	Implicit	Implicit	Implicit	Implicit	Implicit
	TMDL (lbs/day)	55,300	10,136	3,253	532	82,724	13,531
Percent Reduction		14%	20%	40%	41%	19%	24%

6.0 RECOMMENDATIONS

The TMDL process consists of an evaluation of the sub-watersheds for each 303(d) listed stream segment to identify, as best as possible, the sources of the nutrient loads causing the stream to exceed lake standards. The TMDL analysis was performed using the best available data to specify WLAs and LAs that will meet chlorophyll *a* water quality criteria to support the use classification specified for each listed segment.

This TMDL represents part of a long-term process to reduce nutrient loadings to meet water quality standards in Lake Allatoona. Implementation strategies will be reviewed and the TMDLs will be refined as necessary in the next phase (next five-year cycle). The phased approach will support progress toward water quality standard attainment in the future. In accordance with USEPA TMDL guidance, these TMDLs may be revised based on the results of future monitoring and source characterization data efforts. The following recommendations emphasize further source identification and involve the collection of data to support the current allocations and subsequent source reductions.

6.1 Monitoring

Water quality monitoring is conducted at a number of locations across the State each year. The GA EPD has adopted a basin approach to water quality management that divides Georgia's major river basins into five groups. This approach provides for additional sampling work to be focused on one of the five basin groups each year and offers a five-year planning and assessment cycle. The Coosa, Tallapoosa, and Tennessee River Basins will again receive focused monitoring in 2011.

The TMDL Implementation Plan will outline an appropriate water quality monitoring program for the listed streams in the Lake Allatoona watershed. The monitoring program will be developed to help identify the various nutrient sources. The monitoring program may be used to verify the 303(d) stream segment listings. This will be especially valuable for those segments where no data, old data, or spill data resulted in the listing.

6.2 Nutrient Management Practices

Based on the findings of the source assessment, NPDES point source nutrient loads from wastewater treatment facilities do not significantly contribute to the impairment of the listed stream segments. This is because most facilities are required to treat to very high levels. Nutrient loads from NPDES permitted MS4 areas may be significant, but the sources of storm water cannot be easily separated. Sources of nutrients in urban areas include wastes that are attributable to fertilizers, domestic animals, leaks and overflows from sanitary sewer systems, illicit discharges of sanitary waste, leaking septic systems, runoff from improper disposal of waste materials, and leachate from both operational and closed landfills. In agricultural areas, potential sources of nutrients may include CAFOs, animals grazing in pastures, manure application, manure lagoons, and direct access of livestock to streams. Wildlife, especially waterfowl, can also be a significant source of nutrients.

Nutrient management practices are recommended to reduce nutrient source loads to the listed 303(d) stream segments, with the result of achieving the lake chlorophyll *a* standard criteria. These recommended management practices include:

- Compliance with NPDES permit limits and requirements;
- Adoption of NRCS Conservation Practices; and
- Application of Best Management Practices (BMPs) appropriate to agricultural or urban landuses, where applicable.

6.2.1 Point Source Approaches

Point sources are defined as discharges of treated wastewater or storm water into rivers and streams at discrete locations. The NPDES permit program provides a basis for issuing municipal, industrial, and storm water permits, monitoring and compliance with limitations, and appropriate enforcement actions for violations.

In accordance with GA EPD rules and regulations, all discharges from point source facilities are required to be in compliance with the conditions of their NPDES permit at all times. In the future, all municipal and industrial wastewater treatment facilities with the potential for nutrients to be their discharge will only be permitted if there can be an appropriate decrease in the non-point source load or another point source load. This may be allowed under a pollutant-trading program that will allow point to nonpoint source trading and/or nonpoint (agricultural) to nonpoint (urban) source trading. Wastewater treatment facilities may be able to increase their nutrient discharge if there is an appropriate reduction in the non-point source load or another point source load, and this reduction is maintained. In addition, the permits will include routine monitoring and reporting requirements.

6.2.2 Nonpoint Source Approaches

The GA EPD is responsible for administering and enforcing laws to protect the waters of the State. The GA EPD is the lead agency for implementing the State's Nonpoint Source Management Program. Regulatory responsibilities that have a bearing on nonpoint source pollution include establishing water quality standards and use classifications, assessing and reporting water quality conditions, and regulating landuse activities that may affect water quality. Georgia is working with local governments, and agricultural and forestry agencies, such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission, to foster the implementation of BMPs to address nonpoint source pollution. In addition, public education efforts are being targeted to individual stakeholders to provide information regarding the use of BMPs to protect water quality. The following sections describe, in more detail, recommendations to reduce nonpoint source loads of nutrient in Georgia's surface waters.

6.2.2.1 Forested Land

In 1978, GA EPD designated the Georgia Forestry Commission (GFC) to be the lead agency in managing and implementing the silvicultural portion of Georgia's Nonpoint Source Management Program. The GFC is responsible for coordinating water quality issues with regard to forested land in Georgia. The GFC is basically responsible for:

- Developing Best Management Practices (BMPs) for the forestry industry,
- Educating the forestry community on BMPs, and
- Conducting site inspections for compliance with the established BMPs.

- Respond to complaints on forestry activities and develop remediation-mitigation plans to bring the sites into compliance with BMPs

The GFC formed a Forestry Nonpoint Source Pollution Technical Task Force to assess the extent of water pollution caused by forestry practices, and to develop recommendations for reducing or eliminating erosion and sedimentation. After a three-year field study, the task force developed a set of BMPs that address all aspects of silviculture, including forest road construction, timber harvesting, site preparation, and forest regeneration. The task force recommended the BMPs be implemented through a voluntary program, exempt from permitting under the Georgia Erosion and Sedimentation Control Act, emphasizing educational and training programs instead. In 1999, the original BMP document was revised to incorporate the 1989 Wetland BMP manual developed by the Georgia Forestry Association. This 1999 Forestry BMP manual was further amended to include Floodplain and Wetland BMPs for riverine and other wetland systems, along with Gully and Ephemeral area BMPs for headwater areas. The current BMP manual, Georgia's Best Management Practices for Forestry, was developed and became effective in May 2009. (GA EPD, 2009).

It is the responsibility of the GFC to educate and inform the forest community (landowners, procurement and land management foresters, consulting foresters, loggers, site prep and tree planting contractors) on the importance of BMPs. The GFC statewide coordinator, four Regional BMP Specialists, and eight district BMP coordinators conduct educational programs across the State. Personnel working in GFC's forestry water quality program receive specialized training in erosion and sediment control, forest road layout and construction, stream habitat assessment, rapid bioassessment (macroinvertebrate) monitoring, wetland delineation, and fluvial geomorphology. The GFC has developed training powerpoint programs, tabletop exhibits, and several online modules available to inform those interested in forestry BMPs across the state. For the benefit of private landowners selling timber, the GFC has developed a Sample Forest Products Sale Agreement, which includes fill in the blank spaces for specific BMP incorporation. Since December 1995, the GFC has been cooperating with the University of Georgia School of Forest Resources, the Georgia Forestry Association, Southeast Wood Producers Association, and American Forest and Paper Association (AFPA) member companies in the ongoing education of loggers and timber buyers through the Sustainable Forestry Initiative (SFI) Master Timber Harvester program. This includes an intensive training session on the BMPs conducted by the GFC.

To determine if educational efforts have been successful and if the BMPs are effective at minimizing erosion and sedimentation, the GFC conducted BMP compliance surveys , the most recent completed in 2011. These BMP surveys are conducted using a rigorous protocol recommended by a Southern Group of State Foresters (SGSF) Task Force. For each survey the GFC takes a statistical sample of forestry operations occurring from two years to within 6 months prior to the survey. The number of samples taken in each county was based on the volume of wood harvested as reported in the State's latest Product Drain Report. Sites are randomly selected and represent each of the three major landowner types (non-industrial private forest, corporate, and publicly owned lands). Results are expressed in terms of percent BMP implementation, which means the percentage of properly implemented BMPs vs. the total number of applicable BMPs. The 2011 survey results show that Georgia's forestry BMP Implementation has reached 95 percent across all landowner types and across all categories of practices.

The GFC also investigates and mediates complaints or concerns involving forestry operations on behalf of the GA EPD and the Army Corps of Engineers (COE) when stream water quality and wetlands are involved, respectively. Complaints from citizens are common, particularly in counties growing in population where landowners are living close to commercial forestry operations. After notifying the forest owner, the GFC District Coordinator conducts a field inspection to determine if BMPs were followed, if the potential for water quality problems exists, and who is the responsible party. If the complaint is valid, GFC will work with the responsible party until the problem is corrected. However, the GFC has no regulatory authority. In situations where the GFC cannot get satisfactory compliance, the case is turned over to GA EPD or COE for enforcement actions under the Georgia Water Quality Control Act or Section 404 of the Federal Clean Water Act.

It is recommended that the GFC continue to encourage BMP implementation, educational training programs, and site compliance surveys. The numbers of individuals trained and site compliance inspections should be recorded each year. In addition, the number of complaints received, the actions taken, and enforcement actions written should be recorded.

6.2.2.2 Agricultural Sources

The GA EPD should coordinate with other agencies that are responsible for agricultural activities in the state to address issues concerning nutrient loadings from agricultural lands. It is recommended that information (e.g., livestock populations by sub-watershed, animal access to streams, manure storage and application practices, etc.) be periodically reviewed so that watershed evaluations can be updated to reflect current conditions.

The following three organizations have primary responsibility for working with farmers to promote soil and water conservation and to protect water quality:

University of Georgia (UGA) - Cooperative Extension Service;
- Georgia Soil and Water Conservation Commission (GSWCC); and
- Natural Resources Conservation Service (NRCS).

UGA has faculty, County Cooperative Extension Agents, and technical specialists who provide services in several key areas relating to agricultural impacts on water quality.

The GA EPD designated the GSWCC as the lead agency for agricultural Nonpoint Source Management in the State. The GSWCC develops nonpoint source management programs and conducts educational activities to promote conservation and protection of land and water devoted to agricultural uses.

The NRCS works with federal, state, and local governments to provide financial and technical assistance to farmers. The NRCS develops standards and specifications for BMPs that are to be used to improve, protect, and/or maintain our state's natural resources. In addition, every five years, the NRCS conducts the National Resources Inventory (NRI). The NRI is a statistically based sample of trends in landuse and natural resource conditions that covers non-federal land in the United States.

The NRCS is also providing technical assistance to the GSWCC and the GA EPD with the Georgia River Basin Planning Program. Planning activities associated with this program will describe conditions of the agricultural natural resource base once every five years. It is recommended that the GSWCC and the NRCS continue to encourage BMP implementation, education efforts, and river basin surveys with regard to river basin planning.

All farmers should develop and implement a Nutrient Management Plan. In addition, a nutrient management assessment, such as EPA's Clean EAST program or similar initiative, should be utilized to ensure that farmers have implemented appropriate nutrient management plans.

All farmers should conduct a Phosphorus Index test on their farm. The Phosphorus Index is a phosphorus assessment tool that determines the ability of phosphorus to move off the land into a waterbody. The Phosphorus Index is based on eight site characteristics including:

- soil erosion
- irrigation erosion
- runoff class
- soil P test
- P fertilizer application rate
- P fertilizer application method
- organic P source application rate
- organic P source application method

If the Phosphorus Index indicates there is a high potential for phosphorus to move from the site, then BMPs should be utilized to reduce the amount of nutrient transported to surface waters from agricultural sources to the maximum extent practicable. In areas where there are elevated nutrient levels in the soil due to historic manure application, BMP's should be utilized which will minimize the movement of nutrients in storm water. These BMPs may include using riparian buffers, reducing the application rate, planting and harvesting crops, determining the appropriate agronomic rate of manure and fertilizer applications using a Nutrient Management Plan and Phosphorus Index tool, changing the time of application, composting the manure, transporting the manure out of the Lake Allatoona watershed to other areas that are nutrient deficit, or incinerating the manure as an alternative fuel source.

6.2.2.3 Urban Sources

Both point and nonpoint sources of nutrients can be significant in the Lake Allatoona watershed urban areas. Urban sources of nutrients can best be addressed using a strategy that involves public participation and intergovernmental coordination to reduce the discharge of nutrients to the maximum extent practicable. Management practices, control techniques, public education, and other appropriate methods and provisions may be employed. In addition to water quality monitoring programs, discussed in Section 6.1, the following activities and programs conducted by cities, counties, and state agencies are recommended:

- Uphold requirements that all new and replacement sanitary sewage systems be designed to minimize discharges into storm sewer systems;

- Further develop and streamline mechanisms for reporting and correcting illicit connections, breaks, and general sanitary sewer system problems;

- Sustained compliance with storm water NPDES permit requirements;

- Work with County Health Departments to encourage proper installation and maintenance of septic tanks; and

- Continue efforts to increase public awareness and education towards the impact of human activities in urban settings on water quality, ranging from the consequences of industrial and municipal discharges to the activities of individuals in residential neighborhoods including appropriate application of fertilizers and the use of green infrastructure to reduce and reuse stormwater.

Nutrients, specifically phosphorus, bind to sediment. The phosphorus load delivered to the lake can be reduced controlling erosion and sedimentation. The Erosion and Sedimentation Act, established in 1975, provides the mechanism for controlling erosion and sedimentation from land-disturbing activities. This Act establishes a permitting process for land-disturbing activities. Many local governments and counties have adapted erosion and sedimentation ordinances and have been given authority to issue and enforce permits for land-disturbing activities. Approximately 113 counties and 237 municipalities in Georgia have been certified as the local issuing authority. In areas where local governments have not been certified as an issuing authority, the GA EPD is responsible for permitting, inspecting, and enforcing the Erosion and Sedimentation Act.

To receive a land-disturbing permit, an applicant must submit an erosion and sedimentation control plan that incorporates specific conservation and engineering BMPs. The *Field Manual for Erosion and Sediment Control in Georgia*, developed by the State Soil and Water Conservation Commission, may be used as a guide to develop erosion and sedimentation control plans (GSWCC, 1997).

Local governments, with oversight by the GA EPD and the Soil and Water Conservation Districts, are primarily responsible for implementing the Georgia Erosion and Sedimentation Act, O.C.G.A. §12-7-1 (amended in 2003). It is recommended that the local and State governments continue to work to implement the provisions of the Georgia Erosion and Sedimentation Act across Georgia.

Once the sediment reaches the lake, there are concerns that the bound nutrients may be released back into the water column. It may be possible to reduce this internal nutrient load by removing sediment from the lake or control the conditions that cause the nutrients to be released from the bottom sediments in the lake.

6.3 Reasonable Assurance

Permitted discharges will be regulated through the NPDES permitting process described in this report. An allocation to a point source discharger does not automatically result in a permit limit or a monitoring requirement. Through its NPDES permitting process, GA EPD will determine whether a new or existing discharger has a reasonable potential of discharging nutrient levels equal to or greater than the total allocated load. The results of this reasonable potential analysis will determine the specific type of requirements in an individual facility's NPDES permit. As part of its analysis, the GA EPD will use its EPA approved 2003 NPDES Reasonable Potential Procedures to determine whether monitoring requirements or effluent limitations are necessary.

Georgia is working with local governments, agricultural and forestry agencies, such as the Natural Resources Conservation Service, the Georgia Soil and Water Conservation Commission, and the Georgia Forestry Commission, to foster the implementation of best management practices to address nonpoint sources. In addition, public education efforts will be targeted to individual stakeholders to provide information regarding the use of best management practices to protect water quality.

6.4 Public Participation

A thirty -day public notice will be provided for this TMDL. During this time, the availability of the TMDL will be public noticed, a copy of the TMDL will be provided on request, and the public is invited to provide comments on the TMDL.

7.0 INITIAL TMDL IMPLEMENTATION PLAN
April 2013

7.1 Initial TMDL Implementation Plan

This plan identifies applicable statewide programs and activities that may be employed to manage point and nonpoint sources of nutrient loads for two segments in the Coosa River Basin. Local watershed planning and management initiatives will be fostered, supported or developed through a variety of mechanisms. Implementation may be addressed by GA EPD initiated Watershed Improvement Projects, Section 319 (h) grant projects, the development of watershed assessment and protection plans, and watershed management initiatives. Any watershed plan that addresses impaired water bodies and / or TMDL implementation will replace this initial plan.

7.2 Impaired Segments

This initial plan is applicable to the following waterbodies that were added to Georgia's 305(b) list of impaired waters in *Water Quality in Georgia* (GA EPD, 2008 – 2009) available on the GA EPD website:

Waterbodies Listed on the 2010 303(d) List for Chlorophyll *a* in the Coosa River Basin

Lake Segment	Location	Category	Segment Area (acres)	Designated Use
Allatoona Lake	Etowah River Arm (Cherokee County)	5	2,785	Recreation / Drinking Water
Allatoona Lake	Allatoona Creek Arm (Cobb and Bartow Counties)	3	3,515	Recreation / Drinking Water

The water use classifications for Lake Allatoona are Drinking Water and Recreation. The criterion violated is listed as chlorophyll a. The potential causes listed are urban runoff and nonpoint source runoff. The specific criteria for chlorophyll *a* in Lake Allatoona, as stated in Georgia's Rules and Regulations for Water Quality Control, Chapter 391-3-6-.03(17)(d) is:

Chlorophyll *a*: For the months of April through October, the average of monthly mid-channel photic zone composite samples shall not exceed the chlorophyll *a* concentrations at the locations listed below:

Upstream from the Allatoona Dam Forebay	10 µg /L
Allatoona Creek upstream from I-75	12 µg /L
Mid Lake downstream from Kellogg Creek	10 µg /L
Little River upstream from Highway 205	15 µg/L
Etowah River upstream from Sweetwater Creek	14 µg /L

7.3 Potential Sources

The EPA Water Analysis Simulation Program (WASP) was used to simulate the fate and transport of nutrients into and out of the embayment and the uptake by phytoplankton, where the growth and death of phytoplankton is measured through the surrogate parameter called chlorophyll *a*.

Phytoplankton contains chlorophyll *a* to carry out photosynthesis. They also need nutrients such as nitrogen and phosphorus to produce food. If nutrient loadings are high, then the number of phytoplankton in a waterbody can increase thereby increasing the amount of measurable chlorophyll *a* in the water. This can lead to water quality impairments due to excessive nutrients from various sources. Source assessments characterize the known and suspected nutrient sources in the watershed. These are generally consist of both point and nonpoint sources.

NPDES permittees discharging treated wastewater are the primary point sources of nutrients. It is recognized that effluent from biological treatment systems that meet their permit limits is not expected to contribute significantly to nutrient loads.

Nonpoint sources of nutrients are diffuse sources that cannot be identified as entering the water body at a single location. These sources generally involve land use activities that contribute nutrients to streams during rainfall runoff events.

Prior to the implementation of this plan, a detailed assessment of the potential sources should be carried out. This will better determine what practices are needed and where they should be focused. Assessment of the potential sources within the watershed will also help when requesting funding assistance for the implementation of this plan. GA EPD is available to provide assistance in completing a watershed survey of the potential sources of impairment through its Non-Point Source Program.

Through water quality modeling, it has been determined that the nutrient loading found in these segments needs to be reduced. This nutrient loading may be due to activities including, but not limited to, fertilizers (residential, commercial), agriculture, impervious surfaces, failing septic tanks, and others. It is believed that if nutrient loads are not reduced, these segments will continue to degrade over time. Remedies exist for addressing excess sediment from both point and non-point sources in streams, and will be discussed in this plan.

7.4 Management Practices and Activities

Compliance with NPDES permits, the Erosion and Sedimentation Control Act, and local ordinances related to stormwater runoff control will contribute to controlling nutrient delivery from regulated activities, and may help to achieve the reductions necessary to meet the TMDL. Using federal, state, and local laws, enforcement actions are available as a remedy for excess sediment coming from regulated sources. These may include illicit discharges, construction, wastewater discharges, and excessive nutrient run-off from other land use activities.

Nutrients produced from non-point sources such as run-off from domestic lawns, agricultural fields, paved surfaces, illicit discharges, failing septic tanks, and others are not regulated and are, therefore, not subject to most enforcement actions. Best Management Practices (BMPs) may be used to help reduce average annual sediment loads and achieve water quality standards, as well as improve the overall aquatic health of the system. Table 1 below lists examples of BMPs that address excess nutrients through buffer protection, filtration, or other methods. This is not an exhaustive list, and additional management measures may be proposed, and will be considered as non-point source controls consistent with this plan.

Examples of BMPs for Use in Controlling Nutrients from Non-Point Sources

Name of BMP	Type (Ag, Forestry, Urban, Other.)
Filter Strips	Agriculture
Reduced Tillage System	Agriculture
Exclusion	Agriculture
Timber Bridges	Forestry
Re-vegetation	Forestry
Sediment Basin	Urban
Porous Pavement	Urban
Wet Detention Pond	Urban
Organic Filter	Urban
Streambank Protection and Restoration	Ag, Forestry, Urban, Other
Stream Buffers	Ag, Forestry, Urban, Other
Additional Ordinances	Ag, Forestry, Urban, Other

Management practices that may be used to help maintain average annual nutrient loads at current levels include:

- Compliance with NPDES (wastewater and/or MS4) permit limits and requirements;
- Implementation of the Georgia Forestry Commission’s BMPs for Forestry;
- Application of Georgia and NRCS agricultural BMPs;
- Adoption of proper fertilization practices;
- Implementation of Conservation Management Plans for agricultural runoff;
- Adherence to DNR River Corridor Protection guidelines;
- Mitigation and prevention of riparian buffer loss due to land disturbing activities;
- Promulgation and enforcement of local natural resource protection ordinances such as land development, stormwater, water protection, protection of environmentally sensitive areas, and others.

Public education efforts target individual stakeholders to provide information regarding the use of BMPs to protect water quality. GA EPD will continue efforts to increase awareness and educate the public about the impact of human activities on water quality.

The GA EPD Watershed Improvement Program should be consulted when selecting appropriate management practices for addressing this TMDL, particularly when determining the best practices for specific watersheds.

7.5 Monitoring

Monitoring of nutrients through field tests may be carried out through GA EPD’s Adopt-A-Stream Program. Additional opportunities for monitoring may be available in the future. If it is determined through stakeholder involvement that either of these types of monitoring should occur, GA EPD will work with those responsible for the monitoring activities, to conduct the necessary training, and take the needed steps to establish a well-organized monitoring program.

7.6 Future Action

This Initial TMDL Implementation Plan includes a general approach to pollutant source identification as well as management practices to address pollutants. In the future, GA EPD will continue to determine and assess the appropriate point and non-point source management measures needed to achieve the TMDLs, and also to protect and restore water quality in impaired water bodies.

For point sources, any wasteload allocations for wastewater treatment plant discharges will be implemented in the form of water-quality based effluent limitations in NPDES permits. Any wasteload allocations for regulated storm water will be implemented in the form of best management practices in the NPDES permits. Contributions of sediment from regulated communities may also be managed using permit requirements such as watershed assessments, watershed protection plans, and long term monitoring. These measures will be directed through current point source management programs.

GA EPD will work to develop Watershed Improvement Projects (WIPs) to address non-point source pollution. This is a process whereby GA EPD and/or Regional Commissions or other agencies or local governments, under a contract with GA EPD, will develop a Watershed Improvement Plan intended to address water quality at the small watershed level (HUC 12). These plans will be developed as resources, needs, and willing partners become available. The development of these plans may be funded through several grant sources including, but not limited to, Clean Water Act Section 319(h), Section 604(b), and/or Section 106 grant funds. These plans are intended for implementation upon completion.

Any Watershed Improvement Plan that specifically addresses water bodies contained within this TMDL, and is accepted by GA EPD, will supersede the Initial TMDL Implementation Plan. Future Watershed Improvement Plans intended to address this TMDL and other water quality concerns, written by GA EPD, and for which GA EPD and/or the GA EPD Contractor are responsible, will contain at minimum the US EPA's 9-Key Elements of Watershed Planning:

1) An identification of the sources or groups of similar sources contributing to nonpoint source pollution to be controlled to implement load allocations or achieve water quality standards. Sources should be identified at the subcategory level with estimates of the extent to which they are present in the watershed (e.g., X numbers of cattle feedlots needing upgrading, Y acres of row crops needing improved sediment control, or Z linear miles of eroded streambank needing remediation);

2) An estimate of the load reductions expected for the management measures;

3) A description of the NPS management measures that will need to be implemented to achieve the load reductions established in the TMDL or to achieve water quality standards;

4) An estimate of the sources of funding needed, and/or authorities that will be relied upon, to implement the plan;

5) An information/education component that will be used to enhance public understanding of and participation in implementing the plan;

6) A schedule for implementing the management measures that is reasonably expeditious;

7) A description of interim, measurable milestones (e.g., amount of load reductions, improvement in biological or habitat parameters) for determining whether management measures or other control actions are being implemented;

8) A set of criteria that can be used to determine whether substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether the plan needs to be revised; and;

9) A monitoring component to evaluate the effectiveness of the implementation efforts, measured against the criteria established under item (8).

The public will be provided an opportunity to participate in the development of Watershed Improvement Plans that address impaired waters and to comment on them before they are finalized.

GA EPD will continue to offer technical and financial assistance, when and where available, to complete Watershed Improvement Plans that address the impaired water bodies listed in this and other TMDL documents. Assistance may include but will not be limited to:

- Assessments of pollutant sources within watersheds;
- Determinations of appropriate management practices to address impairments;
- Identification of potential stakeholders and other partners;
- Developing a plan for outreach to the general public and other groups;
- Assessing the resources needed to implement the plan upon completion; and
- Other needs determined by the lead organization responsible for plan development.

GA EPD will also make this same assistance available, if needed, to proactively address water quality concerns. This assistance may be in the way of financial, technical, or other aid, and may be requested and provided outside of the TMDL process or schedule.

7.7 References

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Appendix A

Lake Allatoona Water Quality Monitoring Data

2000 Though 2007 Monitoring Water Quality Stations

Segment	Location	GAEPD Monitoring Station No.	Monitoring Station Description
Lake Allatoona	Dam Pool	14309001	Upstream from the Dam
Lake Allatoona	Allatoona Creek Arm	14307501	Upstream from I-75
Lake Allatoona	Mid-Lake	14305801	Downstream from Kellogg Creek
Lake Allatoona	Little River Embayment	14304801	Upstream from Highway 205
Lake Allatoona	Etowah River Arm River	14302001	Upstream from Sweetwater Creek

Dam Pool
2000 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/27/00	9.35	0.58	0.32	0.03	0.26	<0.02	<0.04	10.05	16.20
05/31/00	25.61	0.38	0.36	<0.03	<0.02	<0.02	<0.04	9.31	25.33
06/22/00	13.06	0.31	0.29	<0.03	<0.02	<0.02	<0.04	8.25	28.74
07/13/00	7.18	0.28	0.26	<0.03	<0.02	<0.02	<0.04	7.82	29.63
08/23/00	4.45	0.19	0.17	<0.03	<0.02	<0.02	<0.04	7.29	28.26
09/20/00	5.90	0.27	0.23	0.04	0.04	<0.02	<0.04	5.82	25.18
10/17/00	5.64	0.42	0.32	0.14	0.10	<0.02	<0.04	6.15	20.43

Dam Pool
2001 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/26/01	4.49	0.34	<0.1	<0.03	0.24	0.03	<0.04	9.69	18.20
05/16/01	2.79	0.31	<0.1	<0.03	0.21	<0.02	<0.04	8.77	23.22
06/12/01	2.17	0.15	<0.1	<0.03	0.05	<0.02	<0.04	8.70	26.15
07/17/01	5.88	0.20	0.18	<0.03	<0.02	<0.02	<0.04	7.92	29.81
08/15/01	5.27	0.18	0.16	<0.03	<0.02	<0.02	<0.04	7.75	29.19
09/19/01	5.88	0.16	0.14	<0.03	<0.02	<0.02	<0.04	5.78	26.63
10/10/01	<1	0.28	0.22	0.07	0.06	<0.02	<0.04	5.10	22.11

Dam Pool
2002 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/16/02	8.05	0.63	0.27	<0.03	0.36	0.02	<0.04	10.06	20.06
05/15/02	10.53	0.50	0.29	<0.03	0.21	<0.02	<0.04	9.05	22.67
06/19/02	8.05	0.27	0.25	<0.03	0.02	<0.02	<0.04	8.95	27.25
07/17/02	7.43	0.26	0.24	<0.03	0.02	0.020	<0.04	7.98	28.70
08/21/02	3.95	0.19	0.17	<0.03	<0.02	0.03	<0.04	7.35	29.46
09/18/02	6.15	0.35	0.33	<0.03	<0.02	<0.02	<0.04	6.89	26.93
10/08/02	8.08	0.29	0.27	<0.03	0.02	0.02	<0.04	6.88	24.82

Dam Pool
2003 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/15/03	8.98	0.66	0.27	0.04	0.39	<0.02	<0.04	9.53	18.37
05/13/03	6.81	0.48	0.19	<0.03	0.29	<0.02	<0.04	8.65	21.03
06/18/03	13.01	0.25	0.20	<0.03	0.05	0.04	<0.04	8.18	27.07
07/22/03	14.87	0.31	0.29	<0.03	<0.02	<0.02	<0.04	8.44	29.41
08/13/03	8.67	0.51	0.48	<0.03	0.03	<0.02	<0.04	7.89	28.19
09/16/03	6.81	0.28	0.26	<0.03	<0.02	<0.02	<0.04	6.49	26.99
10/15/03	2.79	0.35	0.27	0.10	0.08	<0.02	<0.04	5.44	22.05

Dam Pool
2004 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/04	8.67	0.59	0.16	<0.03	0.43	<0.02	<0.04	9.10	20.15
05/19/04	8.05	0.38	<0.10	<0.03	0.28	<0.02	<0.04	8.26	24.84
06/16/04	2.50	0.27	0.17	<0.03	0.10	<0.02	<0.04	8.43	28.39
07/22/04	3.41	0.31	0.26	0.12	0.05	<0.02	<0.04	7.80	29.44
08/18/04	5.88	0.26	0.24	<0.03	<0.02	<0.02	<0.04	7.15	27.99
09/15/04	8.67	NM	NM	<0.03	<0.02	NM	<0.04	7.29	26.01
10/20/04	3.41	NM	NM	0.11	0.16	NM	<0.04	4.76	21.17

Dam Pool
2005 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/19/05	11.46	0.61	0.25	<0.03	0.36	<0.04	0.03	11.29	19.57
05/11/05	1.00	0.43	0.18	<0.03	0.25	<0.04	<0.02	10.61	22.46
06/15/05	5.57	0.42	0.25	<0.03	0.17	<0.04	<0.02	9.35	27.60
07/20/05	6.18	0.37	0.33	<0.03	0.04	<0.04	<0.02	9.09	29.55
08/17/05	3.10	0.26	0.24	<0.03	<0.02	<0.04	<0.02	8.56	30.54
09/14/05	6.50	0.33	0.31	<0.03	<0.02	<0.04	<0.02	7.02	27.52
10/12/05	4.96	0.38	0.35	0.15	0.03	<0.04	<0.02	4.58	25.00

Dam Pool
2006 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/26/06	2.48	0.63	0.17	<0.03	0.46	<0.02	<0.04	9.25	22.23
05/24/06	5.88	0.54	0.22	<0.03	0.32	<0.02	<0.04	9.04	24.04
06/22/06	6.81	0.27	0.15	0.03	0.12	<0.02	<0.04	9.25	29.22
07/26/06	6.19	0.21	0.19	<0.03	<0.02	0.02	<0.04	8.35	29.95
08/31/06	NM	0.19	0.17	<0.03	<0.02	<0.02	<0.04	7.46	29.43
09/28/06	2.79	0.29	0.21	0.12	0.08	0.04	<0.04	4.74	24.84
10/25/06	2.17	0.57	0.28	0.04	0.29	<0.02	<0.04	5.53	19.64

Dam Pool
2007 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/12/07	3.00	0.76	0.25	<0.03	0.51	0.04	NM	9.45	14.28
05/17/07	7.52	0.58	0.23	<0.03	0.35	<0.02	NM	8.99	23.80
06/12/07	6.30	0.45	0.26	<0.03	0.19	<0.02	NM	7.97	28.18
07/25/07	9.70	<0.22	<0.20	<0.03	<0.02	<0.02	NM	7.90	28.89
08/21/07	7.61	0.25	0.23	<0.03	<0.02	<0.02	NM	7.80	31.08
09/19/07	7.97	<0.22	<0.20	0.03	<0.02	0.03	NM	5.83	27.23
10/23/07	5.27	0.48	0.40	0.17	0.08	<0.02	NM	4.28	22.79

Allatoona Creek Arm
2000 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/27/00	15.50	0.59	0.51	0.03	0.08	0.02	<0.04	9.91	16.42
05/31/00	8.35	0.39	0.37	<0.03	<0.02	<0.02	<0.04	7.96	25.68
06/22/00	8.65	0.32	0.27	<0.03	0.05	0.02	<0.04	7.80	29.21
07/13/00	8.33	0.37	0.35	<0.03	<0.02	0.02	<0.04	7.36	29.92
08/23/00	9.68	0.33	0.30	<0.03	0.03	0.02	<0.04	6.02	27.40
09/20/00	<1	0.46	0.44	<0.03	<0.02	0.02	<0.04	8.31	24.87
10/17/00	14.60	0.81	0.55	<0.03	0.26	0.02	<0.04	9.62	18.33

Allatoona Creek Arm
2001 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/17/01	2.02	0.62	0.38	<0.03	0.24	0.03	<0.04	8.18	16.43
05/16/01	5.45	0.26	<0.1	<0.03	0.16	<0.02	<0.04	8.34	24.27
06/12/01	7.69	0.28	0.22	<0.03	0.06	0.02	<0.04	8.63	26.52
07/17/01	9.81	0.21	0.19	<0.03	<0.02	<0.02	<0.04	8.85	30.39
08/15/01	7.74	0.32	0.30	<0.03	<0.02	<0.02	<0.04	7.85	29.36
09/19/01	13.42	0.27	0.25	<0.03	<0.02	<0.02	<0.04	7.61	26.13
10/10/01	3.10	0.26	0.24	<0.03	<0.02	0.03	<0.04	8.12	19.61

Allatoona Creek Arm
2002 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/16/02	59.47	0.52	0.40	<0.03	0.12	0.02	<0.04	10.14	21.91
05/15/02	13.94	0.36	0.34	<0.03	0.02	<0.02	<0.04	8.57	23.44
06/19/02	8.36	0.30	0.30	<0.03	<0.02	0.03	<0.04	7.91	27.78
07/17/02	9.60	0.32	0.32	<0.03	<0.02	0.02	<0.04	7.47	29.10
08/21/02	8.05	0.35	0.35	<0.03	<0.02	0.03	<0.04	7.66	29.96
09/18/02	16.27	0.46	0.46	<0.03	<0.02	0.02	<0.04	8.57	26.82
10/08/02	13.82	0.50	0.47	<0.03	0.03	0.03	<0.04	8.11	24.63

Allatoona Creek Arm
2003 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/15/03	7.74	0.61	0.35	0.08	0.26	0.02	<0.04	8.77	19.45
05/13/03	14.87	0.58	0.43	0.08	0.15	0.02	<0.04	8.02	21.71
06/18/03	20.44	0.52	0.50	<0.03	<0.02	0.04	<0.04	7.46	27.17
07/22/03	18.89	0.29	0.27	<0.03	<0.02	<0.02	<0.04	7.69	29.46
08/13/03	14.25	0.43	0.41	<0.03	<0.02	<0.02	<0.04	7.06	28.19
09/16/03	15.80	0.37	0.35	<0.03	<0.02	<0.02	<0.04	6.43	26.82
10/15/03	12.39	0.47	0.45	0.07	<0.02	<0.02	<0.04	6.65	21.28

Allatoona Creek Arm
2004 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/04	5.88	0.35	0.20	<0.03	0.15	<0.02	<0.04	8.57	21.60
05/19/04	12.39	0.29	0.20	<0.03	0.09	<0.02	<0.04	8.53	25.10
06/16/04	2.50	0.27	0.25	<0.03	<0.02	<0.02	<0.04	8.12	28.70
07/22/04	13.94	0.30	0.28	0.04	0.02	<0.02	<0.04	7.97	30.07
08/18/04	4.96	0.33	0.31	<0.03	<0.02	<0.02	<0.04	7.17	28.10
09/15/04	9.92	NM	NM	<0.03	<0.02	NM	<0.04	7.59	25.13
10/20/04	18.43	NM	NM	0.04	<0.02	NM	<0.04	7.87	19.99

Allatoona Creek Arm
2005 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/19/05	11.15	0.42	0.26	<0.03	0.16	<0.02	<0.04	9.84	20.12
05/18/05	10.53	0.56	0.47	<0.03	0.09	<0.02	<0.04	9.40	24.43
06/15/05	6.19	0.51	0.49	<0.03	<0.02	<0.02	0.04	9.03	28.59
07/20/05	10.22	0.40	0.38	<0.03	<0.02	0.06	<0.04	9.32	29.19
08/17/05	10.22	0.37	0.35	<0.03	<0.02	0.02	<0.04	8.62	30.68
09/14/05	7.43	0.46	0.44	<0.03	<0.02	<0.02	<0.04	7.20	27.27
10/12/05	10.53	0.42	0.40	0.08	<0.02	0.03	<0.04	7.79	24.29

Allatoona Creek Arm
2006 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/26/06	3.10	0.35	0.30	<0.03	0.05	<0.02	<0.04	8..53	23.44
05/24/06	8.05	0.29	0.27	<0.03	<0.02	<0.02	<0.04	8.96	25.18
06/22/06	6.50	0.22	0.20	<0.03	<0.02	<0.02	<0.04	8.47	29.55
07/26/06	5.27	0.25	0.23	<0.03	<0.02	0.04	<0.04	7.86	30.09
08/31/06	8.36	0.45	0.43	0.04	<0.02	0.03	<0.04	7.80	29.39
09/28/06	11.77	0.39	0.37	<0.03	<0.02	0.08	<0.04	7.36	24.05
10/25/06	9.60	0.38	0.36	<0.03	<0.02	0.02	<0.04	9.13	16.13

Allatoona Creek Arm
2007 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/12/07	34.00	0.61	0.59	<0.03	<0.02	0.03	NM	9.61	15.10
05/17/07	25.00	0.46	0.44	<0.03	<0.02	<0.02	NM	10.12	24.48
06/12/07	23.02	0.39	0.37	<0.03	<0.02	<0.02	NM	8.54	28.10
07/25/07	27.60	0.24	0.22	<0.03	<0.02	<0.02	NM	8.58	29.11
08/21/07	22.17	0.44	0.42	0.04	<0.02	0.02	NM	7.35	30.89
09/19/07	11.69	0.30	0.28	<0.03	<0.02	0.03	NM	6.97	26.37
10/23/07	23.09	0.63	0.61	<0.03	<0.02	0.05	NM	7.26	21.04

Mid-Lake
2000 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/27/00	6.49	0.66	0.35	0.04	0.31	0.03	<0.04	9.38	16.77
05/31/00	22.27	0.33	0.30	<0.03	0.03	<0.02	<0.04	8.91	25.92
06/22/00	16.03	0.32	0.30	<0.03	<0.02	<0.02	<0.04	8.59	29.06
07/13/00	9.23	0.30	0.28	<0.03	<0.02	<0.02	<0.04	7.74	29.90
08/23/00	7.78	0.31	0.29	<0.03	<0.02	<0.02	<0.04	7.23	28.17
09/20/00	9.08	0.28	0.24	<0.03	0.04	<0.02	<0.04	7.55	24.95
10/17/00	11.16	0.49	0.36	0.10	0.13	<0.02	<0.04	8.32	20.41

Mid-Lake
2001 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/26/01	10.38	0.44	<0.1	<0.03	0.34	<0.02	<0.04	9.75	18.69
05/16/01	8.67	0.25	<0.1	<0.03	0.15	<0.02	<0.04	8.68	23.71
06/12/01	11.30	0.16	<0.1	<0.03	0.06	<0.02	<0.04	8.86	26.20
07/17/01	8.67	0.14	0.12	30.00	<0.02	<0.02	<0.04	8.64	29.78
08/15/01	7.12	0.22	0.20	<0.03	<0.02	<0.02	<0.04	8.42	29.33
09/19/01	10.38	0.19	0.17	<0.03	<0.02	<0.02	<0.04	7.14	26.20
10/10/01	1.55	0.29	0.21	<0.03	0.08	<0.02	<0.04	6.92	21.19

Mid-Lake
2002 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/16/02	9.60	0.67	0.34	0.03	0.33	0.03	<0.04	10.17	18.63
05/15/02	12.39	0.53	0.31	<0.03	0.22	<0.02	<0.04	8.75	22.44
06/19/02	13.01	0.30	0.28	<0.03	0.02	0.02	<0.04	8.60	27.25
07/17/02	10.84	0.27	0.25	<0.03	<0.02	0.02	<0.04	7.96	29.08
08/21/02	6.78	0.20	0.18	<0.03	<0.02	0.02	<0.04	7.54	28.95
09/18/02	10.83	0.36	0.34	<0.03	0.04	0.02	<0.04	7.01	26.77
10/08/02	9.42	0.40	0.32	<0.03	0.08	0.03	<0.04	7.41	24.58

Mid-Lake
2003 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/15/03	4.96	0.59	0.19	0.04	0.40	<0.02	<0.04	9.53	18.20
05/13/03	12.70	0.68	0.43	<0.03	0.25	0.02	<0.04	8.96	21.45
06/18/03	15.80	0.36	0.30	<0.03	0.06	<0.02	<0.04	8.18	27.02
07/22/03	12.08	0.15	0.12	<0.03	0.03	<0.02	<0.04	8.46	29.49
08/13/03	12.39	0.31	0.26	<0.03	0.05	<0.02	<0.04	8.27	28.33
09/16/03	10.84	0.32	0.30	<0.03	0.02	<0.02	<0.04	7.15	26.77
10/15/03	6.19	0.37	0.28	0.06	0.09	<0.02	<0.04	6.98	21.80

Mid-Lake
2004 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/04	6.81	0.51	0.17	<0.03	0.34	<0.02	<0.04	8.98	20.84
05/19/04	6.50	0.44	0.20	<0.03	0.24	<0.02	<0.04	8.21	23.85
06/16/04	7.25	0.33	0.16	<0.03	0.17	<0.02	,0.04	8.31	28.21
07/22/04	4.34	0.27	0.25	<0.03	<0.02	<0.02	<0.04	8.24	29.84
08/18/04	6.19	0.26	0.24	<0.03	<0.02	<0.02	<0.04	7.62	28.27
09/15/04	12.08	NM	NM	<0.03	0.07	NM	<0.04	6.76	25.31
10/20/04	7.74	NM	NM	0.09	0.14	NM	<0.04	6.99	20.88

Mid-Lake
2005 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/19/05	12.39	0.51	0.19	<0.03	0.32	0.03	<0.04	10.46	19.40
05/11/05	9.91	0.51	0.26	<0.03	0.25	<0.02	<0.04	10.13	22.89
06/15/05	5.57	0.63	0.36	0.07	0.27	0.02	0.04	9.03	27.83
07/20/05	7.12	0.31	0.28	<0.03	0.03	0.03	<0.04	9.16	29.92
08/18/05	5.57	0.26	0.23	<0.03	0.03	<0.02	<0.04	8.53	30.69
09/14/05	7.74	0.33	0.31	<0.03	<0.02	<0.02	<0.04	7.72	27.27
10/12/05	9.29	0.41	0.31	0.06	0.10	<0.02	<0.04	8.06	24.71

Mid-Lake
2006 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/26/06	5.57	0.64	0.22	<0.03	0.42	0.03	<0.04	9.23	22.53
05/24/06	4.34	0.52	0.18	<0.03	0.34	<0.02	<0.04	8.98	24.74
06/22/06	4.34	0.33	0.18	<0.03	0.15	<0.02	<0.04	9.21	29.63
07/26/06	4.34	0.19	0.17	<0.03	<0.02	0.03	<0.04	8.08	30.21
08/31/06	6.19	0.25	0.23	<0.03	<0.02	<0.02	<0.04	7.37	29.51
09/28/06	6.50	0.30	0.19	0.04	0.11	0.02	<0.04	7.07	24.74
10/25/06	4.96	0.61	0.38	0.05	0.23	<0.02	<0.04	7.98	18.31

Mid-Lake
2007 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/12/07	3.05	0.63	<0.20	<0.03	0.43	<0.02	NM	8.93	14.85
05/17/07	8.43	0.51	0.21	0.04	0.30	0.03	NM	8.79	23.19
06/12/07	7.72	0.48	0.28	<0.03	0.20	<0.02	NM	8.45	27.56
07/25/07	11.76	<0.22	<0.20	<0.03	<0.02	<0.02	NM	7.83	28.06
08/21/07	9.47	0.23	0.21	<0.03	<0.02	0.02	NM	7.57	31.57
09/19/07	16.24	0.28	0.25	0.03	0.03	<0.02	NM	7.15	26.46
10/23/07	13.99	0.55	0.35	0.08	0.20	<0.02	NM	6.93	22.08

Little River Embayment
2000 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/27/00	25.79	1.10	0.61	0.05	0.49	0.05	<0.04	9.82	16.82
05/31/00	18.93	0.67	0.50	<0.03	0.17	0.04	<0.04	9.22	26.57
06/22/00	29.48	0.71	0.66	<0.03	0.05	0.04	<0.04	10.03	29.99
07/13/00	30.17	0.83	0.77	0.04	0.06	0.04	<0.04	6.66	29.88
08/23/00	43.41	1.28	0.82	0.04	0.46	0.03	<0.04	9.89	27.21
09/20/00	12.58	2.63	0.63	0.07	2.00	0.11	<0.04	7.74	21.99
10/17/00	25.92	2.43	0.63	0.05	1.80	0.06	0.05	10.46	16.93

Little River Embayment
2001 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/17/01	21.34	1.01	0.48	<0.03	0.53	0.02	0.04	8.96	19.11
05/16/01	3.74	0.85	0.18	<0.03	0.67	0.02	<0.04	8.92	23.39
06/12/01	14.45	0.43	0.25	<0.03	0.18	<0.02	<0.04	9.46	26.44
07/17/01	13.01	0.38	0.25	<0.03	0.13	0.03	<0.04	8.92	29.75
08/15/01	21.99	0.56	0.42	<0.03	0.14	0.07	<0.04	9.41	29.44
09/19/01	23.75	0.77	0.45	<0.03	0.32	0.03	<0.04	8.14	24.93
10/10/01	14.87	3.22	0.42	<0.03	2.80	0.04	<0.04	7.97	17.30

Little River Embayment
2002 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/16/02	26.95	1.16	0.40	<0.03	0.76	0.03	<0.04	11.21	19.87
05/15/02	14.25	0.87	0.47	0.07	0.40	0.03	<0.04	7.06	21.85
06/19/02	17.96	0.44	0.44	0.06	NM	0.03	<0.04	9.04	27.24
07/17/02	24.47	0.75	0.51	0.05	0.24	0.06	<0.04	9.30	29.72
08/21/02	20.61	1.26	0.72	0.13	0.54	0.06	<0.04	8.34	29.34
09/18/02	7.33	2.40	1.00	0.27	1.40	0.23	0.11	4.33	22.69
10/08/02	12.30	1.66	0.66	<0.03	1.00	0.09	<0.04	8.36	23.42

Little River Embayment
2003 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/15/03	15.18	1.05	0.30	<0.03	0.75	<0.02	<0.04	10.83	18.03
05/13/03	12.70	0.97	0.61	0.06	0.36	0.06	<0.04	7.30	21.56
06/18/03	12.39	0.95	0.53	0.07	0.42	0.04	0.04	6.05	24.29
07/22/03	15.80	0.49	0.27	<0.03	0.22	<0.02	<0.04	8.31	29.98
08/13/03	12.08	0.71	0.42	<0.03	0.29	0.02	<0.04	8.37	28.34
09/16/03	24.16	0.76	0.55	<0.03	0.21	0.02	<0.04	9.32	26.02
10/15/03	13.94	1.00	0.42	<0.03	0.58	0.02	<0.04	8.29	20.06

Little River Embayment
2004 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/28/04	5.27	1.20	0.37	<0.03	0.83	0.03	<0.04	7.97	21.70
05/19/04	15.18	1.16	0.41	<0.03	0.75	0.04	<0.04	8.41	23.60
06/16/04	5.30	1.07	0.38	0.04	0.69	0.04	<0.04	8.63	28.09
07/22/04	16.11	0.80	0.38	<0.03	0.42	0.04	<0.04	8.69	29.75
08/18/04	17.03	0.87	0.47	0.04	0.40	0.04	<0.04	8.73	28.28
09/15/04	7.12	NM	NM	<0.03	0.36	NM	<0.04	8.38	24.67
10/20/04	20.60	NM	NM	0.05	0.90	NM	<0.04	8.60	17.78

Little River Embayment
2005 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/19/05	30.58	1.53	0.58	0.06	0.95	0.06	<0.04	11.44	19.42
05/11/05	6.81	1.54	0.34	0.06	1.20	0.04	<0.04	10.34	22.61
06/15/05	11.15	1.23	0.55	0.06	0.68	0.04	0.06	9.51	28.04
07/20/05	16.72	0.86	0.58	<0.03	0.28	0.05	<0.04	10.25	29.78
08/17/05	17.34	0.91	0.44	<0.03	0.47	0.04	<0.04	10.15	30.43
09/14/05	31.28	0.85	0.61	<0.03	0.24	<0.02	<0.04	10.14	26.97
10/12/05	18.58	1.44	0.44	<0.03	1.00	0.02	<0.04	9.58	23.69

Little River Embayment
2006 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/26/06	11.77	1.39	0.48	<0.03	0.91	0.05	<0.04	8.95	22.98
05/24/06	9.29	1.44	0.44	<0.03	1.00	<0.02	<0.04	10.02	24.90
06/22/06	13.32	1.58	0.48	0.06	1.10	0.04	>0.04	10.17	29.59
07/26/06	10.53	1.73	0.63	0.04	1.10	0.06	<0.04	8.92	29.93
08/31/06	8.05	2.11	0.91	<0.03	1.20	0.06	0.02	7.16	28.73
09/28/06	6.58	1.84	0.34	<0.03	1.50	0.04	<0.04	8.08	23.03
10/25/06	1.55	3.05	0.45	<0.03	2.60	0.04	<0.04	9.60	10.72

Little River Embayment
2007 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/12/07	8.50	1.65	0.35	<0.03	1.30	0.02	NM	9.73	13.94
05/17/07	15.15	1.60	0.50	0.05	1.10	0.06	NM	8.44	23.82
06/12/07	21.02	1.53	0.54	0.04	0.99	<0.02	NM	7.96	27.97
07/25/07	26.13	1.68	0.70	0.05	0.98	<0.02	NM	8.60	27.55
08/21/07	19.38	2.73	0.83	0.08	1.90	0.06	NM	9.22	31.97
09/19/07	15.54	4.77	0.67	0.10	4.10	0.05	NM	8.66	22.45
10/23/07	18.71	5.90	1.00	0.26	4.90	0.07	NM	7.90	20.70

Etowah River Arm
2000 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/27/00	5.94	0.60	0.36	0.06	0.24	0.04	<0.04	9.06	17.04
05/31/00	14.32	0.35	0.33	<0.03	0.02	0.03	<0.04	9.08	26.00
06/22/00	12.68	0.34	0.32	<0.03	<0.02	0.03	0.04	8.69	29.53
07/13/00	19.90	0.46	0.44	<0.03	<0.02	0.02	1.00	8.76	30.54
08/23/00	18.31	0.44	0.41	0.06	0.03	0.02	<0.04	8.37	27.41
09/20/00	17.69	0.53	0.51	<0.03	0.02	0.03	<0.04	8.76	24.24
10/17/00	14.15	0.56	0.42	0.04	0.14	0.04	<0.04	9.86	18.82

Etowah River Arm
2001 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/17/01	1.73	0.40	0.19	<0.03	0.21	0.03	<0.04	8.21	18.29
05/16/01	4.03	0.26	0.12	<0.03	0.14	<0.02	<0.04	9.06	23.16
06/12/01	16.52	0.12	<0.1	<0.03	<0.02	<0.02	<0.04	9.66	26.47
07/17/01	8.05	0.12	<0.1	<0.03	<0.02	<0.02	<0.04	9.08	29.44
08/15/01	13.32	0.32	0.30	<0.03	<0.02	<0.02	<0.04	8.65	29.07
09/19/01	20.13	0.38	0.36	<0.03	<0.02	0.03	<0.04	8.54	25.09
10/10/01	2.79	0.35	0.26	<0.03	0.09	0.02	<0.04	8.62	17.67

Etowah River Arm
2002 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/16/02	10.84	0.50	0.26	<0.03	0.24	0.02	<0.04	10.55	19.76
05/15/02	11.77	0.57	0.37	<0.03	0.20	0.02	<0.04	8.49	21.79
06/19/02	14.25	0.34	0.30	<0.03	0.04	0.03	<0.04	8.90	26.67
07/17/02	16.72	0.43	0.41	<0.03	<0.02	0.03	<0.04	9.07	28.96
08/21/02	14.52	0.37	0.35	<0.03	<0.02	0.04	<0.04	7.88	29.00
09/18/02	22.43	0.65	0.60	0.06	0.05	0.06	<0.04	6.93	25.90
10/08/02	17.49	0.07	0.47	<0.03	0.07	0.04	<0.04	9.05	24.44

Etowah River Arm
2003 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/15/03	6.19	0.43	0.17	<0.03	0.26	<0.02	<0.04	9.74	17.26
05/13/03	20.75	0.59	0.37	<0.03	0.22	0.04	<0.04	9.36	22.03
06/18/03	13.63	0.42	0.27	<0.03	0.15	<0.02	<0.04	7.74	26.88
07/22/03	10.53	0.32	0.27	<0.03	0.05	<0.02	<0.04	8.47	29.35
08/13/03	17.96	0.35	0.33	<0.03	0.02	<0.02	<0.04	8.70	28.09
09/16/03	17.65	0.69	0.61	<0.03	0.08	<0.02	<0.04	8.65	25.88
10/15/03	8.67	0.45	0.36	<0.03	0.09	<0.02	<0.04	8.34	20.34

Etowah River Arm
2004 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/19/05	9.60	NM	NM	<0.03	0.30	0.04	<0.04	10.49	19.35
05/11/05	7.43	0.43	0.13	<0.03	0.30	0.03	<0.04	10.50	22.59
06/15/05	12.70	0.97	0.64	0.11	0.33	0.05	0.05	9.43	26.53
07/20/05	10.22	0.53	0.47	<0.03	0.08	0.06	<0.04	11.02	29.57
08/17/05	12.70	0.46	0.44	<0.03	<0.02	0.04	<0.04	9.80	30.05
09/14/05	18.58	0.38	0.36	<0.03	<0.02	0.16	<0.04	10.01	26.82
10/12/05	16.42	0.48	0.32	<0.03	0.16	<0.02	<0.04	9.15	23.51

Etowah River Arm
2005 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/19/05	9.60	NM	NM	<0.03	0.30	0.04	<0.04	10.49	19.35
05/11/05	7.43	0.43	0.13	<0.03	0.30	0.03	<0.04	10.50	22.59
06/15/05	12.70	0.97	0.64	0.11	0.33	0.05	0.05	9.43	26.53
07/20/05	10.22	0.53	0.47	<0.03	0.08	0.06	<0.04	11.02	29.57
08/17/05	12.70	0.46	0.44	<0.03	<0.02	0.04	<0.04	9.80	30.05
09/14/05	18.58	0.38	0.36	<0.03	<0.02	0.16	<0.04	10.01	26.82
10/12/05	16.42	0.48	0.32	<0.03	0.16	<0.02	<0.04	9.15	23.51

Etowah River Arm
2006 Water Quality Monitoring Data

Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/26/06	10.84	0.81	0.44	<0.03	0.37	0.03	<0.04	9.04	22.76
05/24/06	10.53	0.58	0.28	<0.03	0.30	0.05	<0.04	9.74	24.63
06/22/06	8.36	0.46	0.42	0.04	0.04	0.04	<0.04	10.06	29.04
07/26/06	17.34	0.50	0.48	<0.03	0.02	0.06	<0.04	8.61	29.60
08/31/06	11.77	0.59	0.54	<0.03	0.05	0.03	<0.04	7.57	29.70
09/28/06	7.43	0.55	0.42	<0.03	0.13	0.09	<0.04	8.13	20.00
10/25/06	5.27	0.68	0.40	0.06	0.28	0.04	<0.04	8.54	14.12

Etowah River Arm
2007 Water Quality Monitoring Data

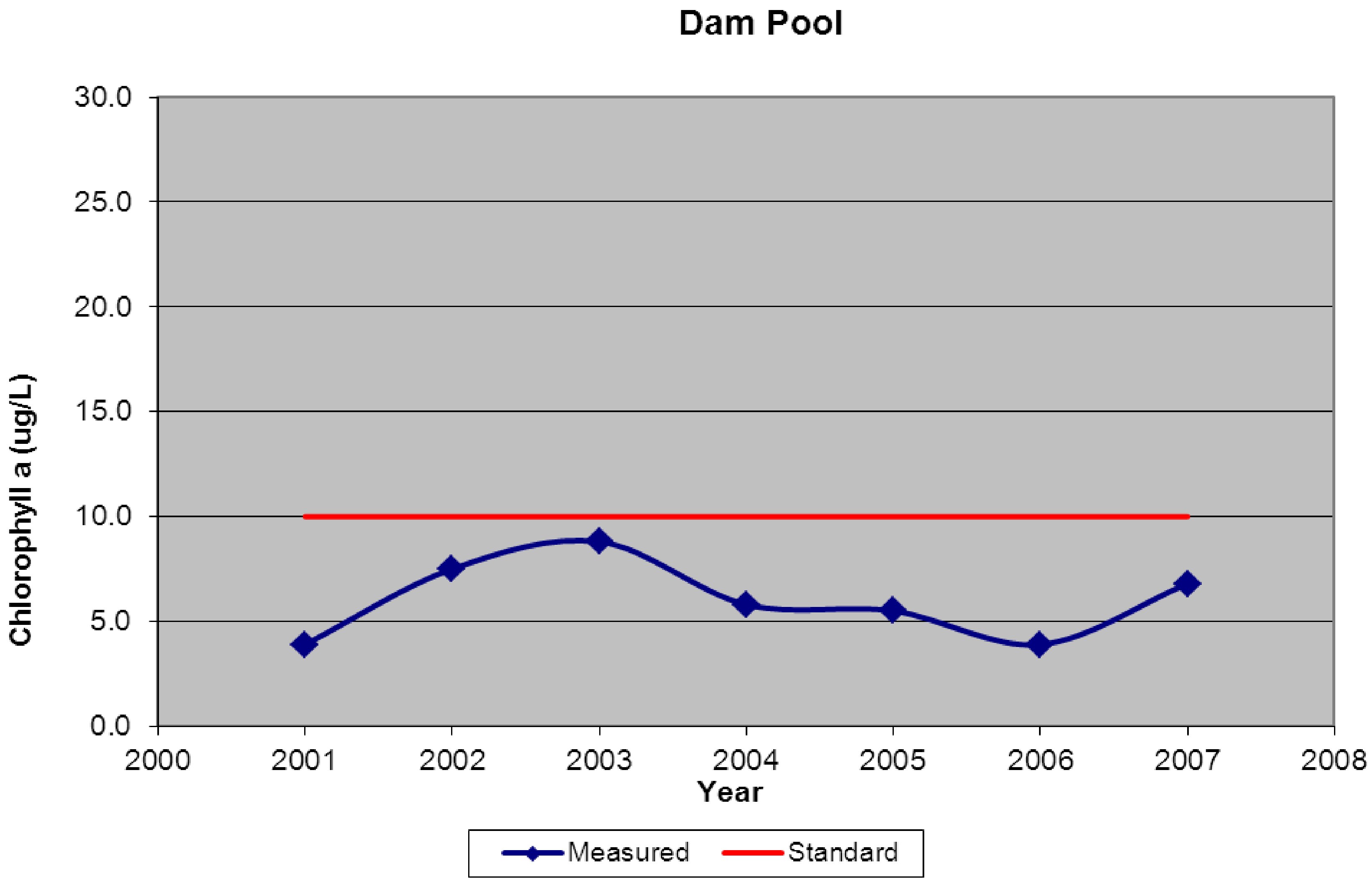
Date	Chlorophyll *a* (mg/L)	Total N (mg/L)	TKN (mg/L)	NH3 (mg/L)	NO2/NO3 (mg/L)	Total P (mg/L)	Ortho P (mg/L)	DO (mg/L)	Water Temp (deg C)
04/12/07	4.80	0.45	<0.20	<0.03	0.25	0.03	NM	9.23	13.74
05/17/07	8.27	0.51	0.28	0.03	0.23	<0.02	NM	8.39	23.60
06/12/07	26.05	0.48	0.38	<0.03	0.10	0.02	NM	8.70	27.52
07/25/07	23.84	0.30	0.28	<0.03	<0.02	0.04	NM	9.21	27.65
08/21/07	17.11	0.30	0.28	<0.03	<0.02	0.03	NM	8.06	31.28
09/19/07	23.84	0.44	0.37	0.04	0.07	0.06	NM	7.84	24.32
10/23/07	25.52	0.70	0.48	<0.03	0.22	0.04	NM	8.03	20.43

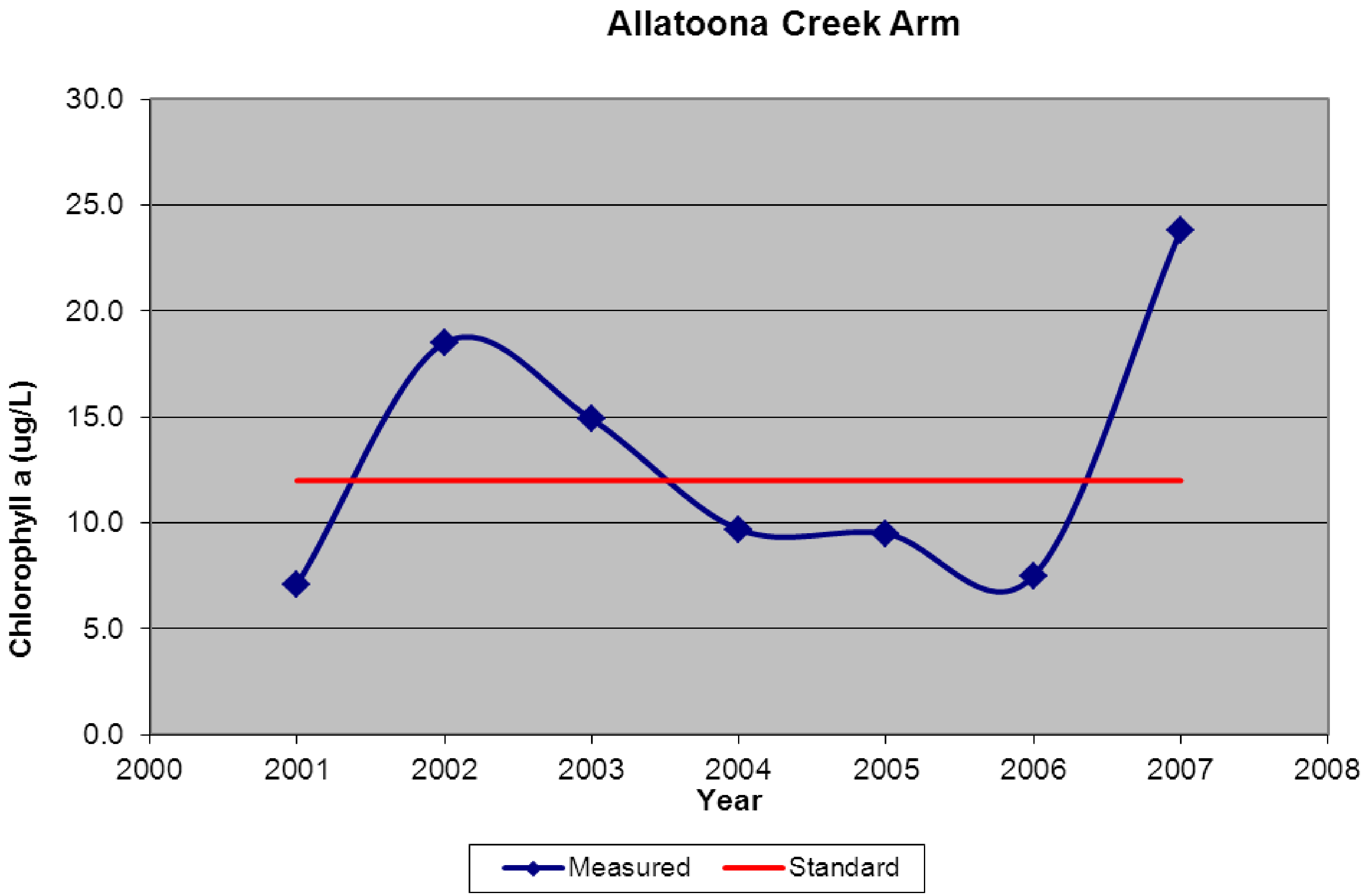
Appendix B

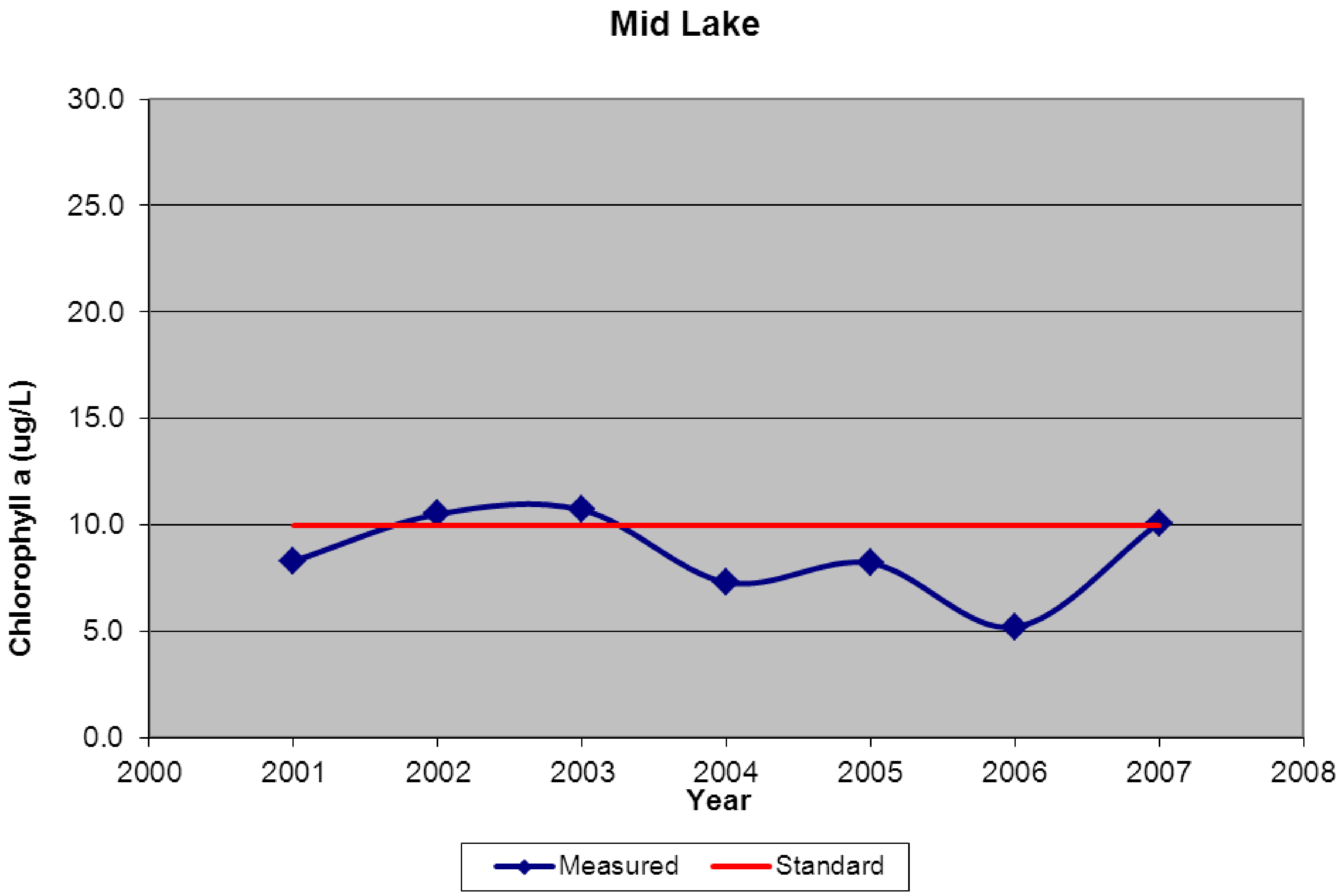
Average Annual Growing Season Chlorophyll *a* Plots

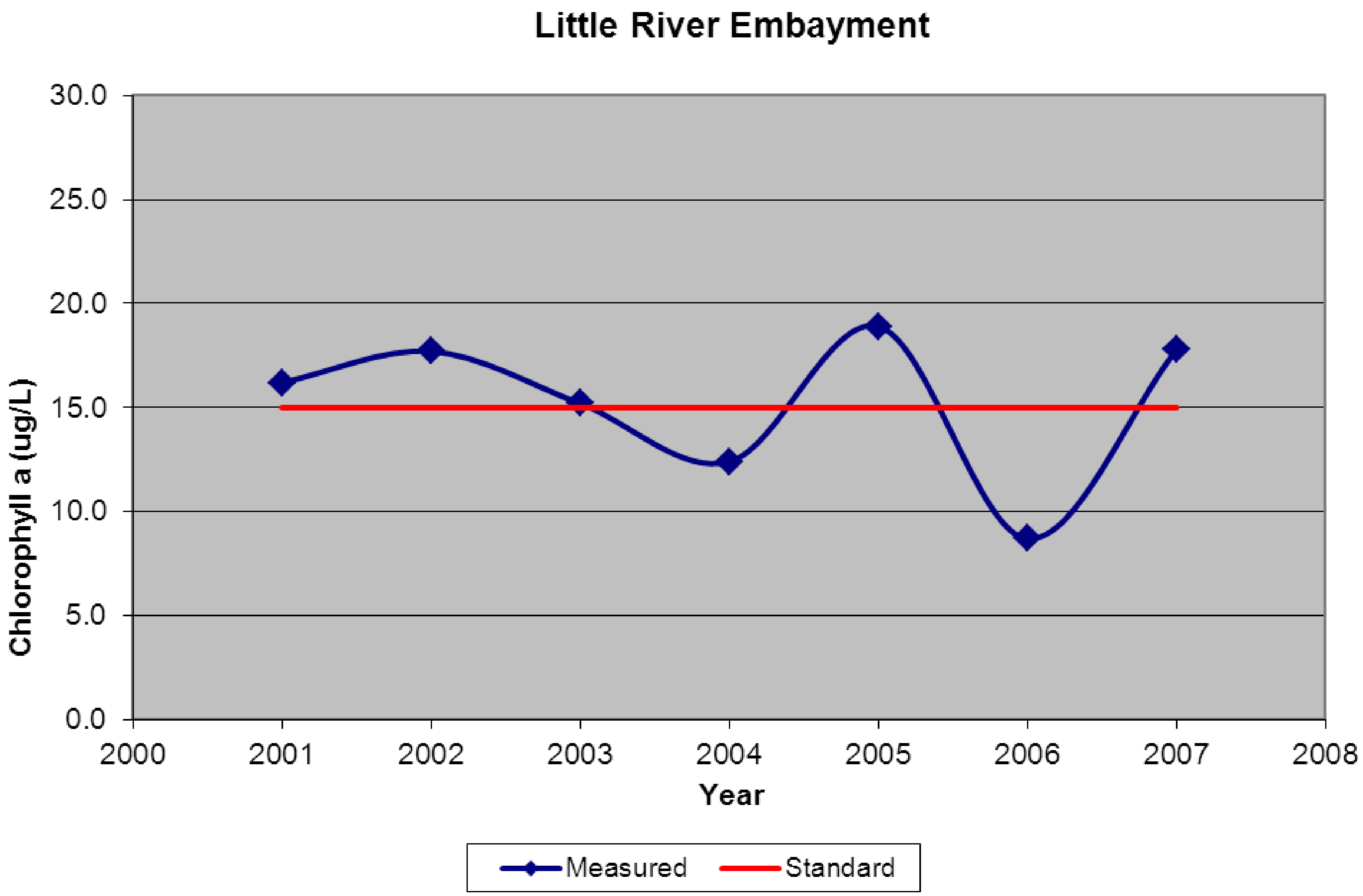
Average Annual Growing Season Chlorophyll *a*

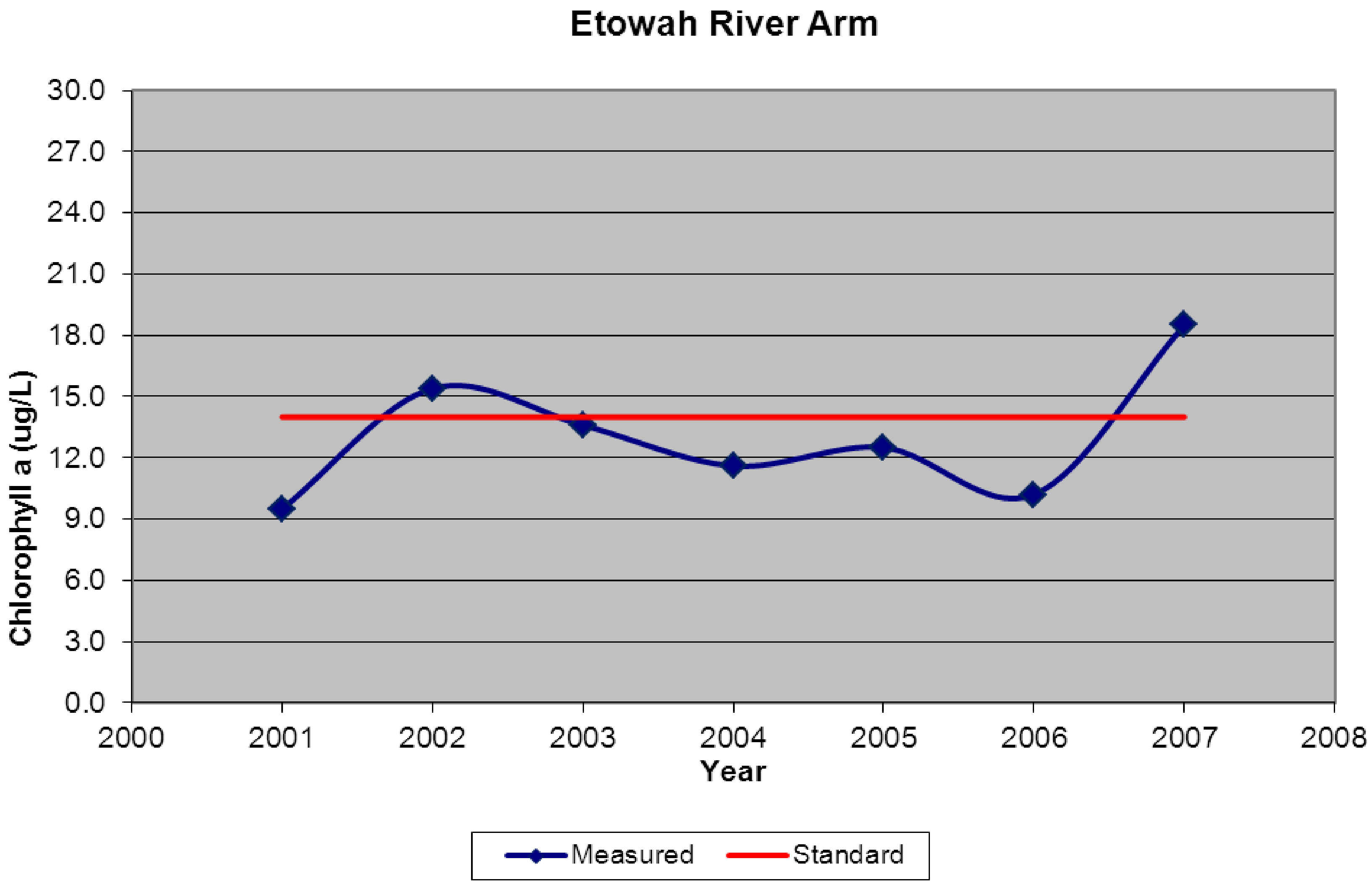
	Standard	2000	2001	2002	2003	2004	2005	2006	2007
US Dam Forebay	10	10.2	3.9	7.5	8.8	5.8	5.5	3.9	6.8
Allatoona Creek Arm	10	9.4	7.1	18.5	14.9	9.7	9.5	7.5	23.8
Midlake DS Kellogg	10	11.7	8.3	10.5	10.7	7.3	8.2	5.2	10.1
Little River US Hwy 205	15	26.6	16.2	17.7	15.2	12.4	18.9	8.7	17.8
Etowah River, upstream Sweetwater Creek	12	14.7	9.5	15.4	13.6	11.6	12.5	10.2	18.5


Dam Pool
Chlorophyll a (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Measured
Standard


Allatoona Creek Arm
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Chlorophyll a (ug/L)
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Measured
Standard


Mid Lake
Chlorophyll a (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Measured
Standard


Little River Embayment
Chlorophyll a (ug/L)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Measured
Standard


Etowah River Arm
Chlorophyll a (ug/L)
30.0
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
2000
2001
2002
2003
2004
2005
2006
2007
2008
Year
Measured
Standard

Appendix C

Description and Results of Lake Allatoona Scenario Runs

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INTRODUCTION

The Lake Allatoona Watershed is located in northern Georgia, northeast of Atlanta (Figure 1-1). The drainage area covers 1,120 square miles and is bounded on its downstream end by Lake Allatoona and upstream end by the Tennessee Valley Divide on the Blue Ridge Mountains near Dahlonega, Georgia. Although most of the watershed is within a 50-mile radius of downtown Atlanta, land cover in the drainage area is predominantly forested. However, there are dense residential and commercial areas in the watershed near Woodstock, Roswell, Marietta, and Canton (Figure 1-2). The area is located within the region of north Georgia that is experiencing rapid development and population growth from the expanding Atlanta Metropolitan Area. It is this growth that is posing a significant threat to the environmental quality and ultimate economic sustainability of the water resources of the area. There will be an ever-increasing need to balance water resources protection while allowing for smart economic development in the local communities.

The State of Georgia recently completed a nutrient TMDL targeting chlorophyll *a* for parts of Lake Allatoona (Draft April 2009). In the process of developing the TMDL for Lake Allatoona, three computer models were developed for Lake Allatoona and its watershed. The models included a watershed model, an in-lake hydrodynamic model, and an in-lake water quality model. The watershed model of Lake Allatoona was developed using the Loading Simulation Program in C++ (LSPC). This model includes all point sources that have a permitted discharge of greater than 0.1 MGD within the watershed. The watershed model simulates the effects of surface runoff on both water quality and flow and was be calibrated to data collected from 2001 through 2007. The results of this model were used as tributary flow inputs to the hydrodynamic model, Environmental Fluid Dynamics Code (EFDC). EFDC was used to simulate the transport of water within the lake as well as flows into and out of Lake Allatoona. The Water Quality Analysis Simulation Program (WASP), version 7 released in April 2005 by EPA Region 4, was used to simulate the fate and transport of nutrients within the lake and the uptake by phytoplankton. The growth and death of phytoplankton is measured through a surrogate parameter called chlorophyll *a*. The WASP model was calibrated to nutrient and chlorophyll *a* concentrations. The EFDC and WASP models include all major point sources of nutrients within the lake. The setup, calibration and validation of these computer models are documented in the following two reports:

- *Watershed Hydrology and Water Quality Modeling Report for Lake Allatoona, Georgia (Tetra Tech 2009)*
- *Hydrodynamic and Water Quality Modeling Report for Lake Allatoona, Georgia (Tetra Tech 2009)*

Once the 3 models were calibrated for Lake Allatoona and its watershed, various scenarios were run and analyzed. The following section describes the scenarios that were run.

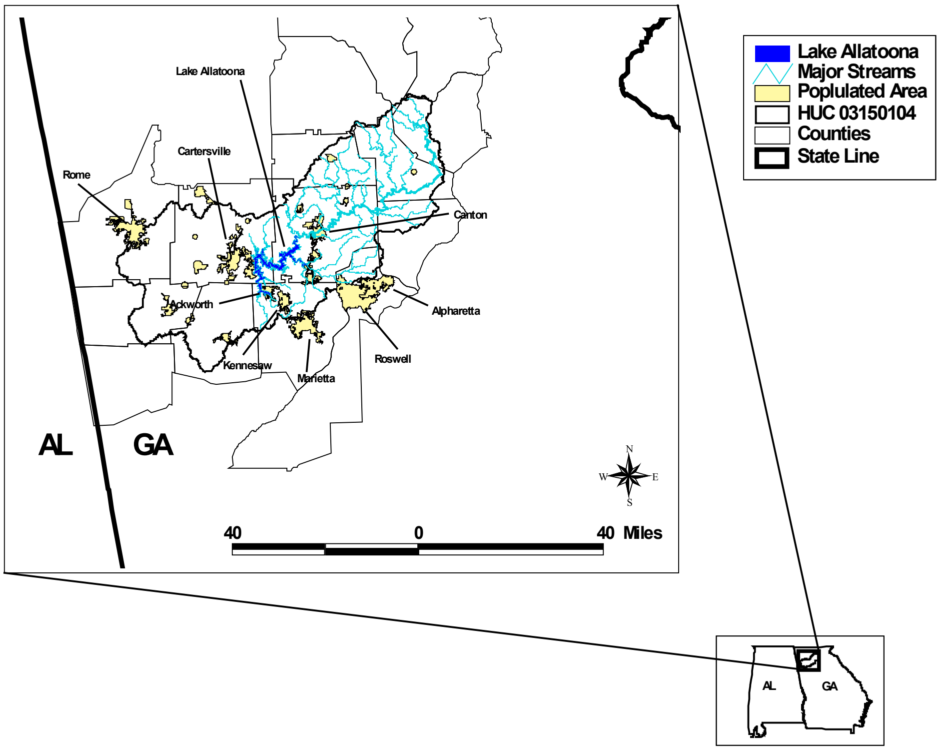

Figure 1-1 Location of Lake Allatoona

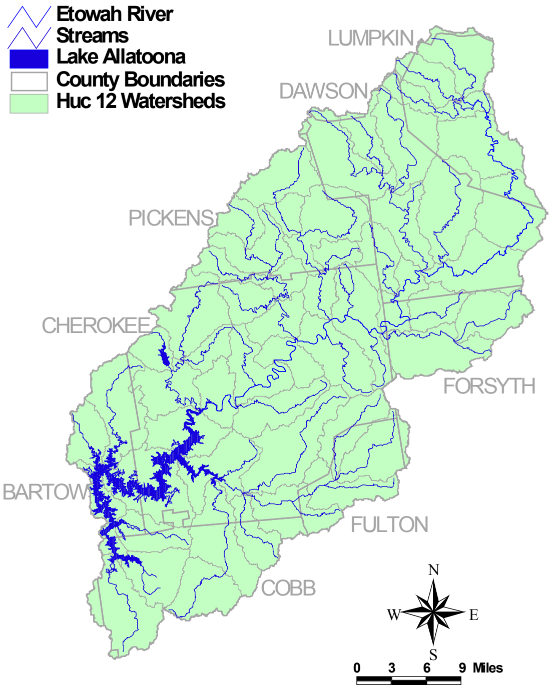

Figure 1-2 Lake Allatoona Watershed

2.0 DESCRIPTION OF SCENARIOS

Seven scenarios were run using the models developed for the Lake Allatoona TMDL. For each scenario, both hydrology and water quality outputs from the LSPC model were examined at 4 tributary locations in the Lake Allatoona Watershed (Figure 2-1 and Table 2-1). The outputs were examined from January 1, 2001 through December 31, 2007. Watershed flows were evaluated based on monthly and annual average flows and percentiles of daily average flows. Watershed water quality was evaluated based on annual and monthly loading, annual and monthly concentrations, and percentiles of daily average concentrations. Watershed flows and water quality were input into the EFDC and WASP models, respectively. The outputs for the EFDC and WASP model were evaluated at five locations (Figure 2-2 and Table 2-2) around Lake Allatoona from 2001 through 2007. Results were evaluated on growing season average (April 1 through October 31). A short description of each scenario is presented below.

2.1 Scenario 1A

Scenario 1A was performed using the calibrated Lake Allatoona Watershed hydrology and water quality model (LSPC), the calibrated Lake Allatoona hydrodynamic model (EFDC), and the calibrated Lake Allatoona water quality model (WASP). The calibrated LSPC model was run using monthly flow data for watershed water withdrawals, as well as daily and/or monthly flow and water quality data from point source discharges. If no data were available for the point source discharges, values were input at the permitted limits, or in some cases values were assumed if no permit limit existed.

2.2 Scenario 1B

Scenario 1B was performed using the calibrated (Scenario 1A) Lake Allatoona Watershed hydrology and water quality model (LSPC), the calibrated Lake Allatoona hydrodynamic model (EFDC), and the calibrated Lake Allatoona water quality model (WASP) as a starting point. Point source discharges and water withdrawals were then input at their current permitted limits.

2.3 Scenario 1C

Scenario 1C was performed by taking Scenario 1B and reducing both the Urban nutrient loading and the Agricultural nutrient loading until all 5 lake water quality stations were in compliance with the chlorophyll *a* water quality standard. This was done by first reducing the urban nutrient loading until the Allatoona Creek station (14307501, see Figure 2-2 and Table 2-2) met its water quality standard for chlorophyll *a*. Once the Allatoona Creek station met the chlorophyll *a* standard, the Agricultural nutrient loading was reduced until the Etowah River station (14302001, see Figure 2-2 and Table 2-2) met its water quality standard for chlorophyll *a*. In the end, an 85% reduction was needed in the urban nutrient loading and a 40% reduction was needed in the Agricultural nutrient loading.

2.4 Scenario 1D

Scenario 1D was an all forested scenario. This scenario was performed using the calibrated (Scenario 1A) Lake Allatoona Watershed hydrology and water quality model (LSPC), the calibrated Lake Allatoona hydrodynamic model (EFDC), and the calibrated Lake Allatoona water quality model (WASP) as a starting point. Point source discharges, water withdrawals, and septic tanks were then removed and all landuse was converted to forest.

2.5 Scenario 1E

Scenario 1E was a Shoal Creek 12,500 lb/yr Total Phosphorus Load scenario. This scenario was performed using the Scenario 1C Lake Allatoona Watershed hydrology and water quality model (LSPC), the Lake Allatoona hydrodynamic model (EFDC), and the Lake Allatoona water quality model (WASP) as a starting point. An addition load (2,643lbs/yr) was added to Shoal Creek so that in 2003 the annual Total Phosphorus load for Shoal Creek was 12,500 lbs/yr.

2.6 Scenario 1F

Scenario 1F was a No Point Source scenario. This scenario was performed using the calibrated (Scenario 1A) Lake Allatoona Watershed hydrology and water quality model (LSPC), the calibrated Lake Allatoona hydrodynamic model (EFDC), and the calibrated Lake Allatoona water quality model (WASP) as a starting point. Point source discharges and water withdrawals were then removed.

2.7 Scenario 1G

Scenario 1G was a No Point Source or Septics scenario. This scenario was performed using the calibrated (Scenario 1A) Lake Allatoona Watershed hydrology and water quality model (LSPC), the calibrated Lake Allatoona hydrodynamic model (EFDC), and the calibrated Lake Allatoona water quality model (WASP) as a starting point. Point source discharges, water withdrawals, and septic tanks were then removed.

2.8 Scenario 1H

Scenario 1H was a No Point Source, Septics, or Nutrient Fluxes scenario. This scenario was performed using the Scenario 1F Lake Allatoona Watershed hydrology and water quality model (LSPC), the Lake Allatoona hydrodynamic model (EFDC), and the Lake Allatoona water quality model (WASP) as a starting point. Point source discharges, water withdrawals, septic tanks, and nutrient fluxes in Lake Allatoona were then removed.

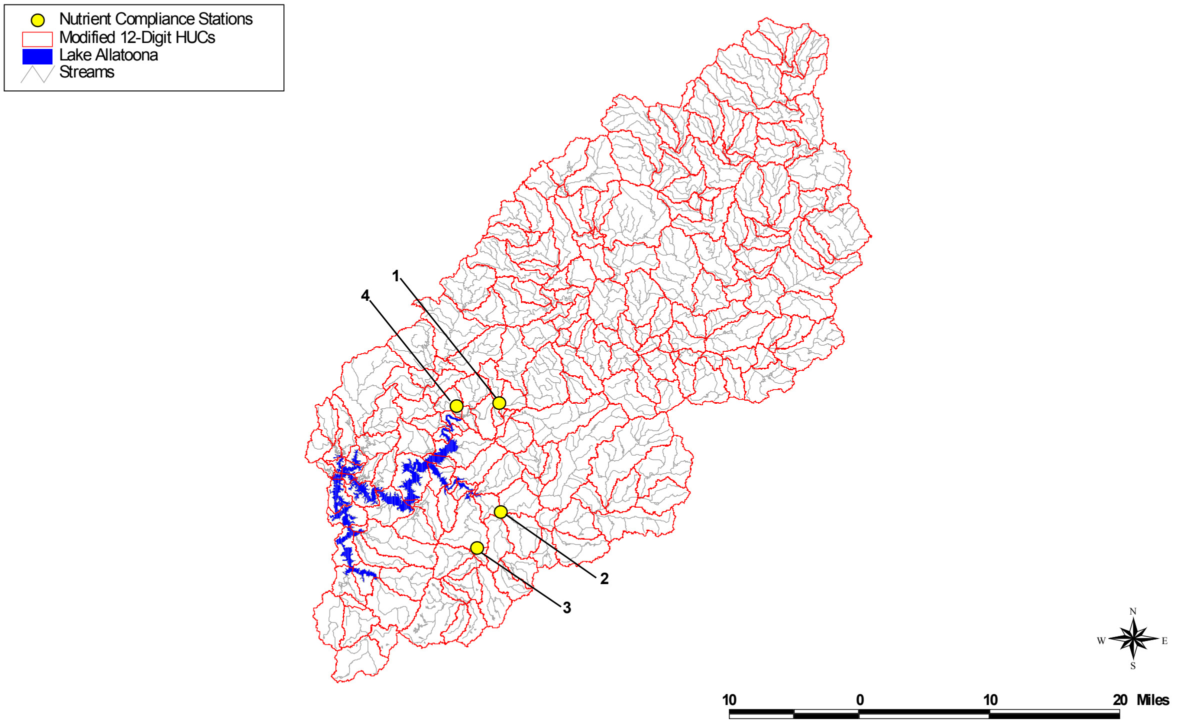

Figure 2-1 Lake Allatoona Watershed Assessment Sites

Table 2-1 Summary of Lake Allatoona Watershed Assessment Sites

Station ID	Station Name	Drainage Area (Acres)	LSPC Subbasin
1	Etowah River at State Highway 5 spur and 140, at the USGS Gage	409,685	509
2	Little River at State Highway 5 (Highway 754)	89,398	347
3	Noonday Creek at North Rope Mill Road	26,238	326
4	Shoal Creek at State Highway 108 (Fincher Road)	43,850	406

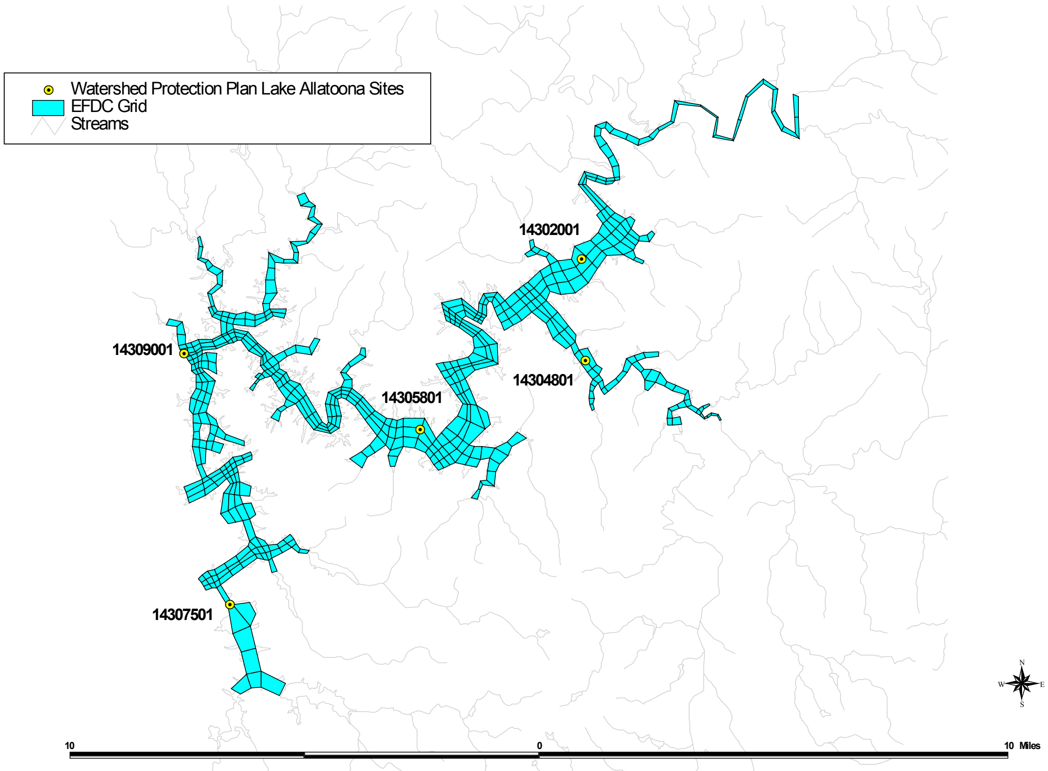

Figure 2-2 Lake Allatoona Assessment Sites

Table 2-2 Summary of Lake Allatoona Assessment Sites

Station Name	Station Number	EFDC Cell		WASP Segment	Layers
		I-Value	J-Value		
Downing Creek @ Hwy 205	14302001	17	63	420	2
Rose Creek @ Towne Lake Pkwy	14304801	23	69	463	2
Lake Allatoona – Kellogg/Owl Embayment	14305801	31	45	266	4
Lake Ackworth Outlet	14307501	58	13	28	2
Lake Allatoona – US from Allatoona Dam	14309001	31	13	12	10

3.0 ANALYSIS OF SCENARIOS

3.1 Total Phosphorus Standard

The TMDL for Lake Allatoona was based on the rate each nutrient accumulates for each landuse type. These values were not comparable to the annual Total Phosphorus load delivered to the major tributary compliance points. The TMDL Scenario 1C shows that after the Urban, Agricultural, and septic tank nutrient loading reductions were applied to the Lake Allatoona Watershed, the nutrient loading at Shoal Creek at GA 108 is still higher than the original Total Phosphorus standard of 9,200 lbs/yr in 2003 (Table 3-1).

Table 3-1 Summary of Annual Total Phosphorus Loads for Scenario 1C (TMDL)

Year	2001	2002	2003	2004	2005	2006	2007	Average
Etowah River @ GA 5 spur and 140, at the USGS Gage	76,175	98,005	92,374	84,367	55,581	66,991	36,982	72,925
Little River @ GA 5 (Hwy 754)	13,678	18,643	20,076	17,015	14,054	13,919	11,123	15,501
Noonday Creek @ North Rope Mill Rd.	16,128	17,721	18,515	17,171	16,273	15,977	14,119	16,558
Shoal Creek @ GA 108 (Fincher Rd.)	4,128	9,085	**9,857**	7,222	4,104	4,816	2,683	5,985

Recognizing that urbanization causes an increase impervious surfaces, which in turn cause an increase in the flow during storm events, these loads were compared to the annual total phosphorus load for the all forested Scenario 1D. The all forested load for Shoal Creek in 2003 was only 18% lower than the TMDL load for Shoal Creek (Table 3-2. This is due to the landuse of the Shoal Creek watershed given in Table 3-3, which is approximately 83% forested. These results indicate that the original annual Total Phosphorus Load Standard for Shoal Creek may be too low and needs to be revised.

Table 3-2 Summary of Annual Total Phosphorus Loads for Scenario 1D (All Forested)

Year	2001	2002	2003	2004	2005	2006	2007	Average
Etowah River @ GA 5 spur and 140, at the USGS Gage	48,121	69,914	59,999	57,130	26,066	42,243	15,830	48,121
Little River @ GA 5 (Hwy 754)	2,982	9,092	9,661	7,030	3,114	4,347	2,084	2,982
Noonday Creek @ North Rope Mill Rd.	2,792	6,390	7,202	4,665	2,406	3,153	1,192	2,792
Shoal Creek @ GA 108 (Fincher Rd.)	2,603	7,465	8,024	5,711	2,605	3,592	1,650	2,603

Table 3-3 Shoal Creek Landuse

Stream/Segment	Landuse Categories - Acres (Percent)													
	Open Water	**Low Intensity Residential**	**High Intensity Residential**	**High Intensity Commercial/Industrial/Transportation**	**Bare Rock/Sand/Clay**	**Quarries/Strip Mines/Gravel Pits**	**Transitional**	**Forest**	**Row Crops**	**Pasture/Hay**	**Other Grasses (Urban/Recreational;e.g.parks/lawns)**	**Woody Wetlands**	**Emergent Herbaceous Wetlands**	**Total**
Shoal Creek	475 (1.1)	14 (0)	0 (0)	0 (0)	0 (0)	12 (0)	273 (0.6)	35,911 (82.9)	78 (0.2)	3,644 (8.4)	2,772 (6.4)	156 (0.4)	0 (0)	43,337 (100)

Based on these results, the annual Total Phosphorus Load for Shoal Creek should be revised to 12,500 lbs per year. This is a 35% increase in the all forested annual Total Phosphorus load to account for the increased load due to urbanization. The model (Scenario 1E) showed that by increased the Shoal Creek annual Total P load to 12,500 lbs/yr had little effect on the lake chlorophyll level at the Etowah River monitoring site as seen in Figure 3-1.

3.2 Chlorophyll *a* Standards

Scenarios 1B, 1D, 1F, 1G, and 1H were run to determine the impact of the fluxes, landuse changes, point sources, and septic tanks on the chlorophyll *a* levels. The chlorophyll *a* due to the fluxes is the results of nutrients entering the lake attached to sediment. Under anoxic conditions, these nutrients are released from the bottom sediments into the water column where they can be used by the algae. Deposition and buildup of sediments in reservoirs is a natural process. Therefore, there will always be nutrient fluxes in lakes. In addition, there will be an increase in chlorophyll *a* levels due to changes in landuse as a result of impervious surfaces. Figures 3.2 through 3.6 indicate that the growing season average of the original chlorophyll *a* criteria for the Etowah River and Allatoona Creek stations may be too low and need to be revised, although the TMDL was developed to meet the original chlorophyll *a* criteria of 10 µg/L for Allatoona Creek and 12 µg/L for the Etowah River.

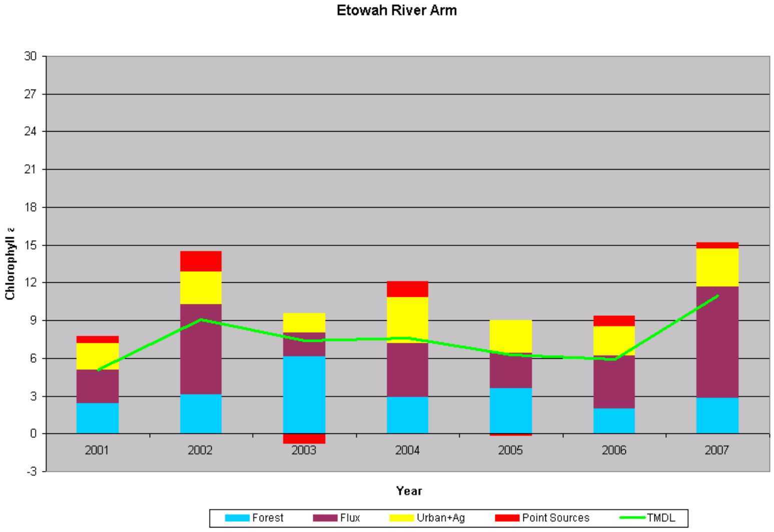

Figure 3-2 Etowah River Arm Chlorophyll *a* Contributions

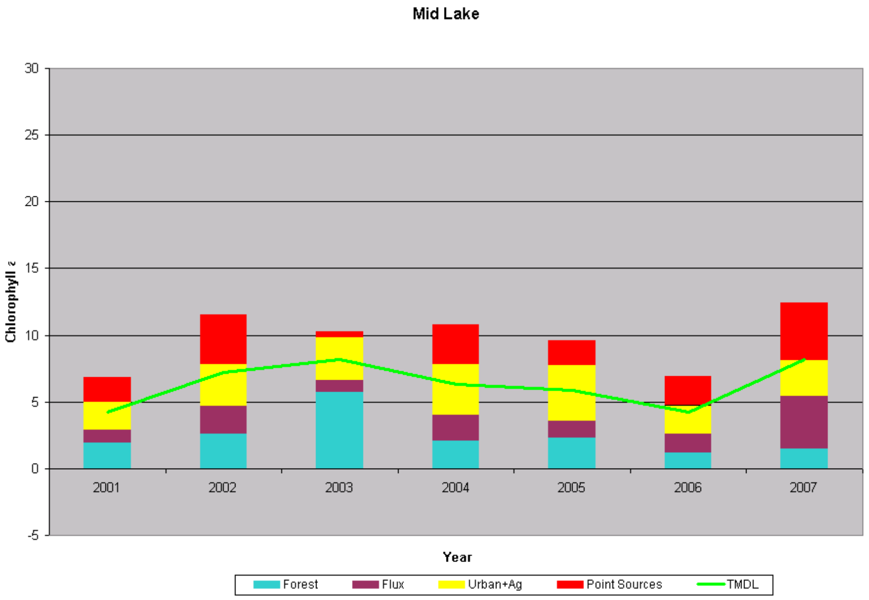

Figure 3-3 Mid Lake Chlorophyll *a* Contributions

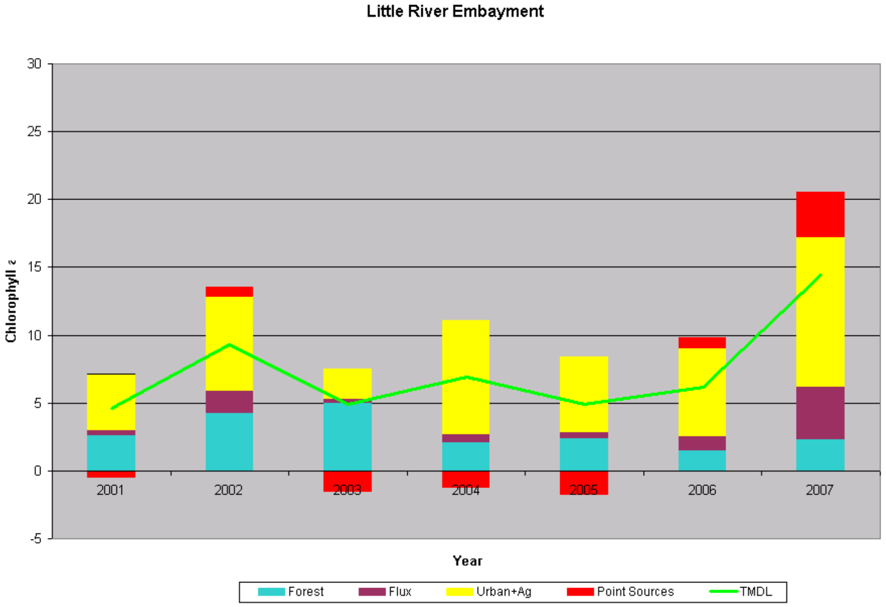

Figure 3-4 Little River Embayment Chlorophyll *a* Contributions

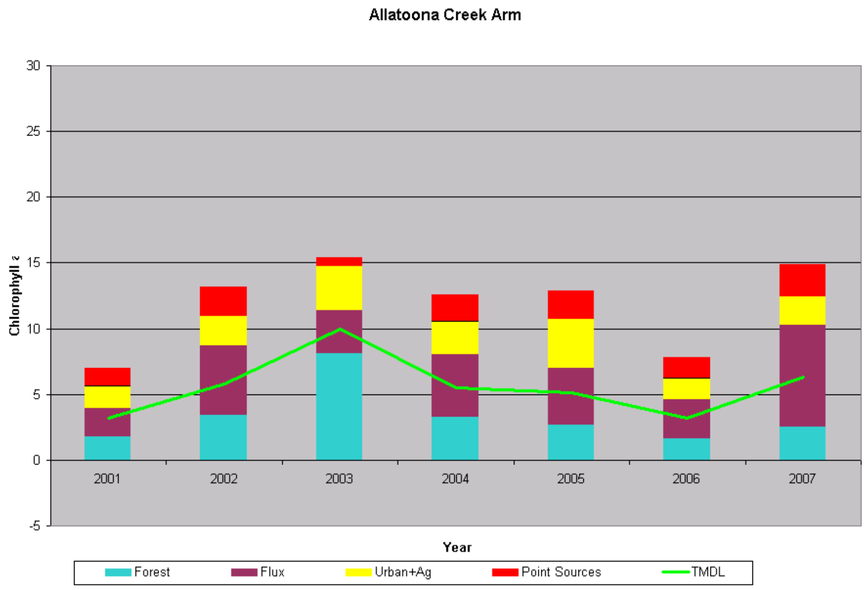

Figure 3-5 Allatoona Creek Arm Chlorophyll *a* Contributions

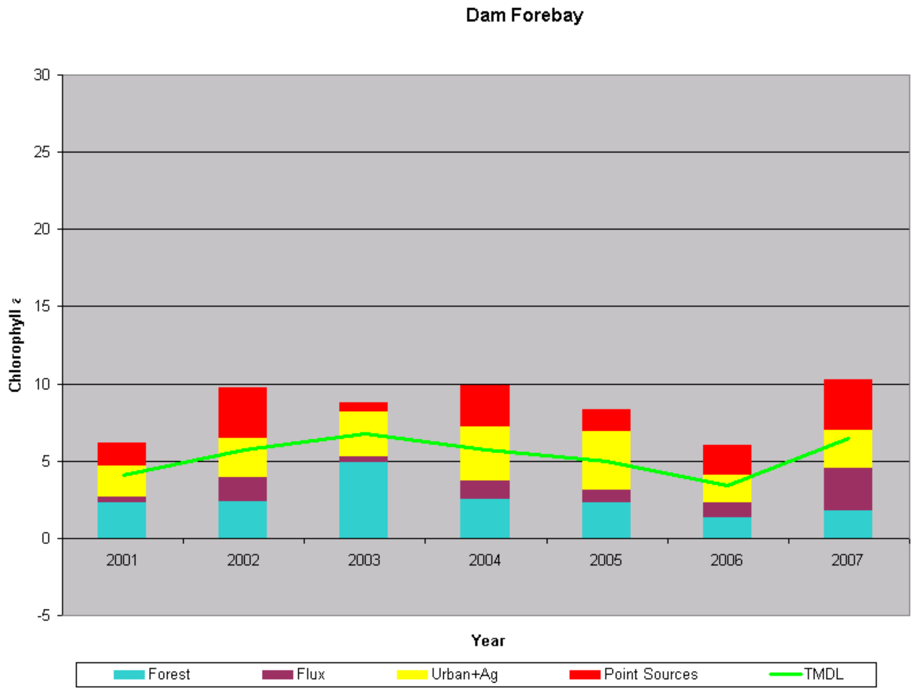

Figure 3-6 Dam Forebay Chlorophyll *a* Contributions

Allowing for an increase in chlorophyll *a* levels due to current and future landuse changes, the chlorophyll *a* criteria for Allatoona Creek upstream from I-75 should be revised to 12 µg/L and the chlorophyll *a* criteria for Etowah River upstream from Sweetwater Creek should be revised to 14 µg/L.

3.3 Total Nitrogen Standard and Nutrient Limitation

The Lake Allatoona modeling indicates that the lake is phosphorus limited. The Calibration Scenario 1A and the TMDL Scenario 1C model runs show that at all five stations in Lake Allatoona, phosphorus is the limiting nutrient. Figures 3-7 through 3-16 present time series of the nitrogen, phosphorus, and light limitation for the most critical year, 2007. Values for the limitation range from 0 to 1, with the lower of the two values (nitrogen and phosphorus) being the limiting nutrient.

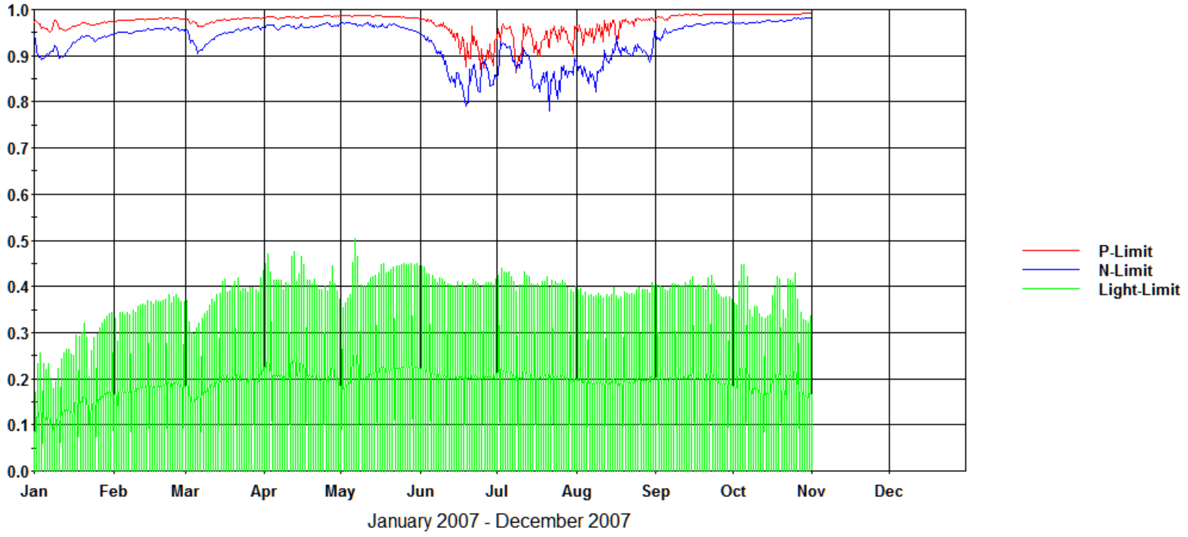

Figure 3-7 **Lake Allatoona Etowah River Station (14302001) Nutrient Limitation for Scenario 1A (Calibration)**

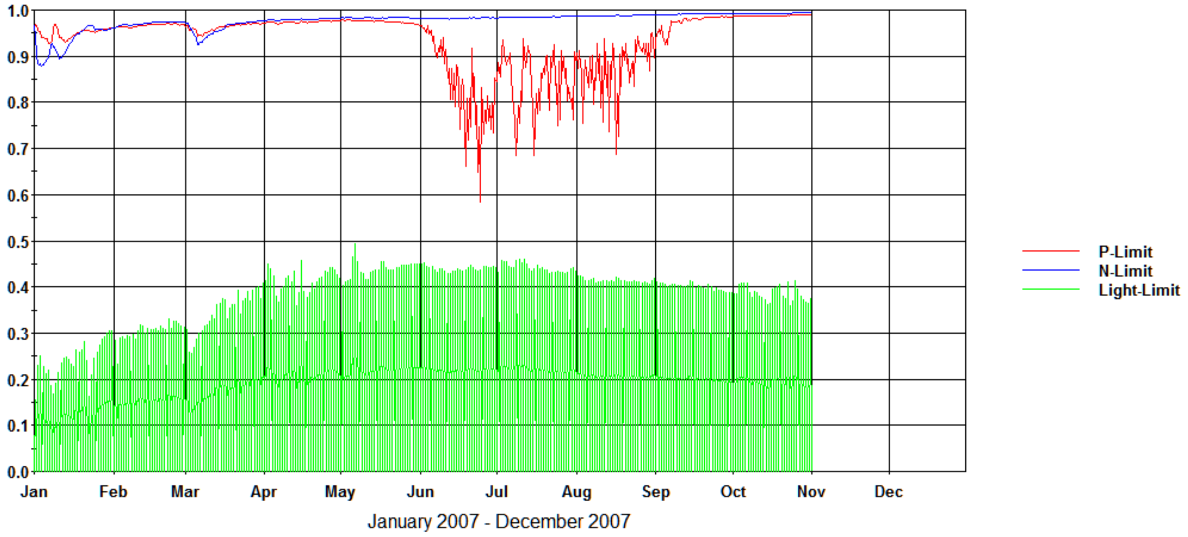

Figure 3-8 **Lake Allatoona Etowah River Station (14302001) Nutrient Limitation for Scenario 1C (TMDL)**

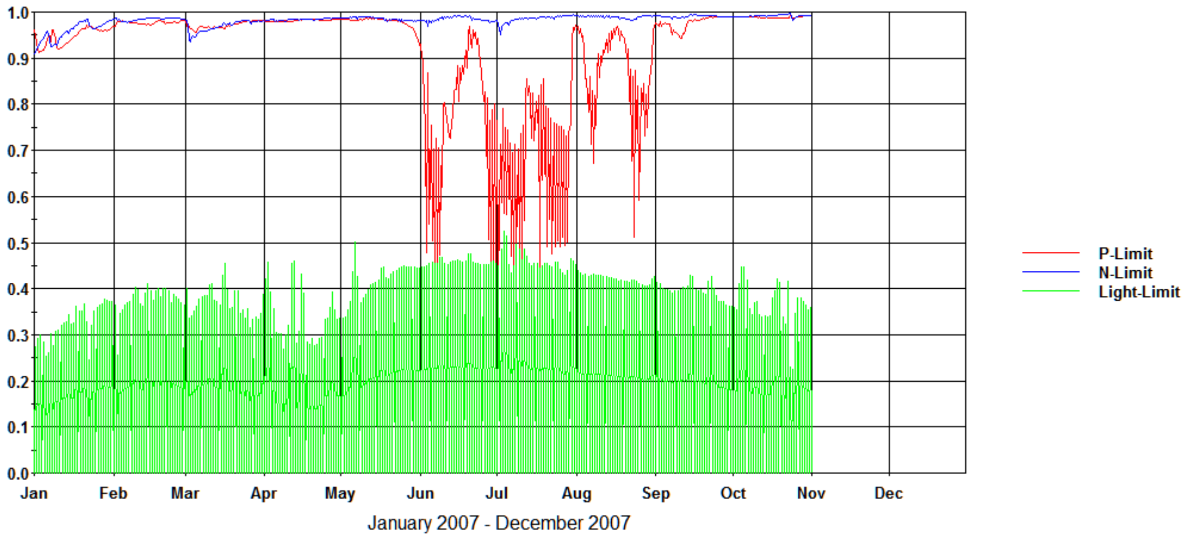

Figure 3-9 Lake Allatoona Little River Station (14304801) Nutrient Limitation for Scenario 1A (Calibration)

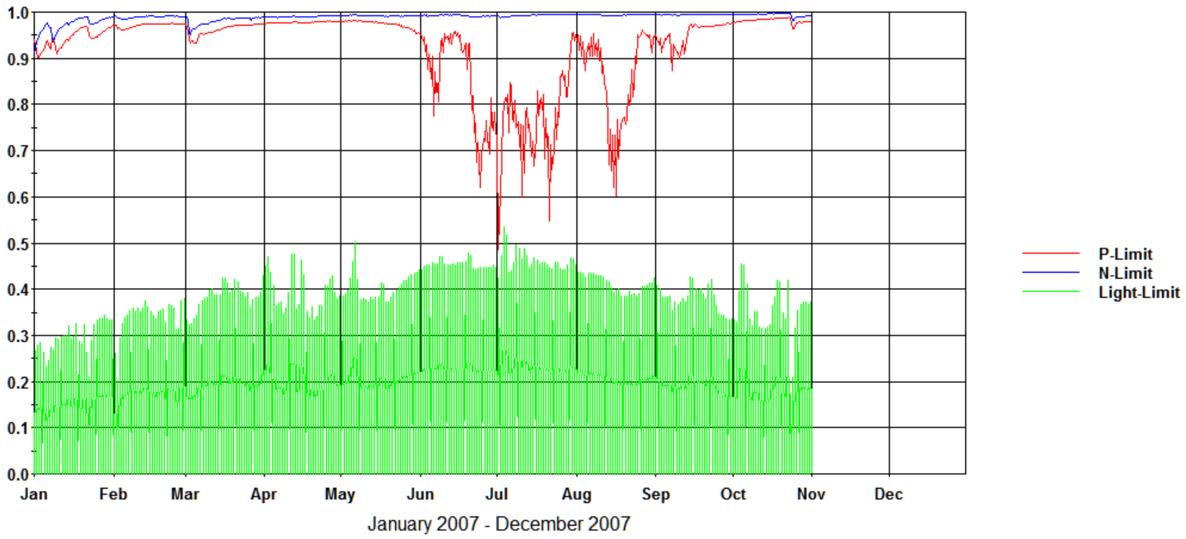

Figure 3-10 Lake Allatoona Little River Station (14304801) Nutrient Limitation for Scenario 1C (TMDL)

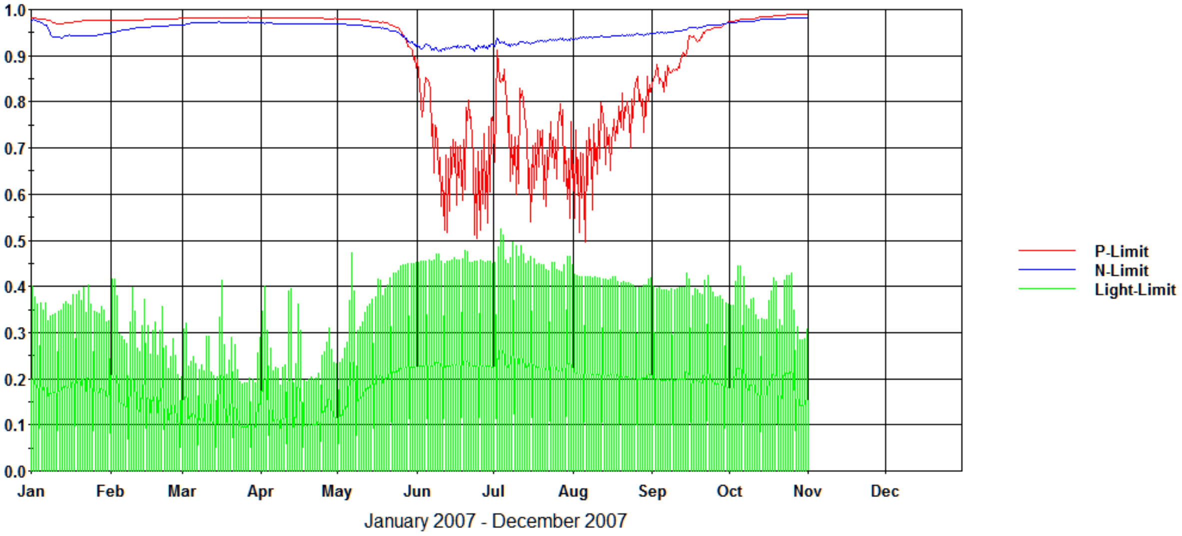

Figure 3-11 **Lake Allatoona Mid-Lake Station (14305801) Nutrient Limitation for Scenario 1A (Calibration)**

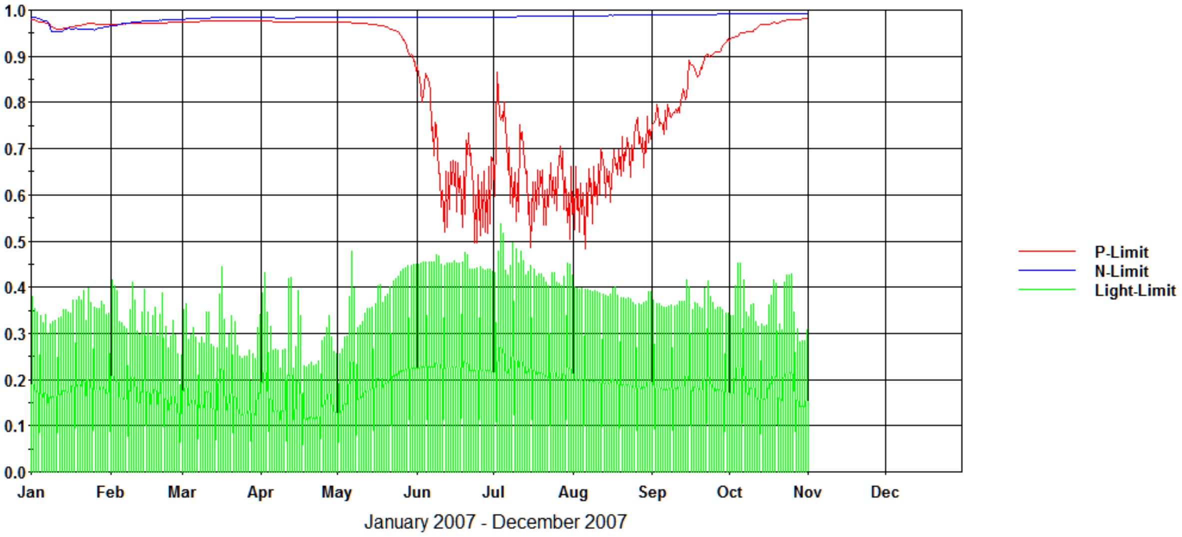

Figure 3-12 **Lake Allatoona Mid-Lake Station (14305801) Nutrient Limitation for Scenario 1C (TMDL)**

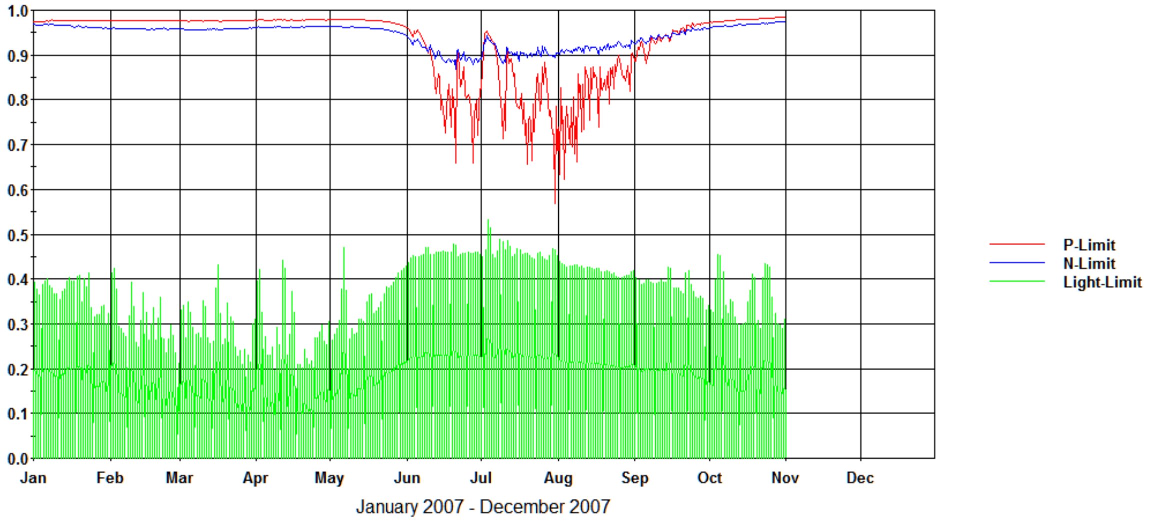

Figure 3-13 Lake Allatoona Dam Forebay Station (14309001) Nutrient Limitation for Scenario 1A (Calibration)

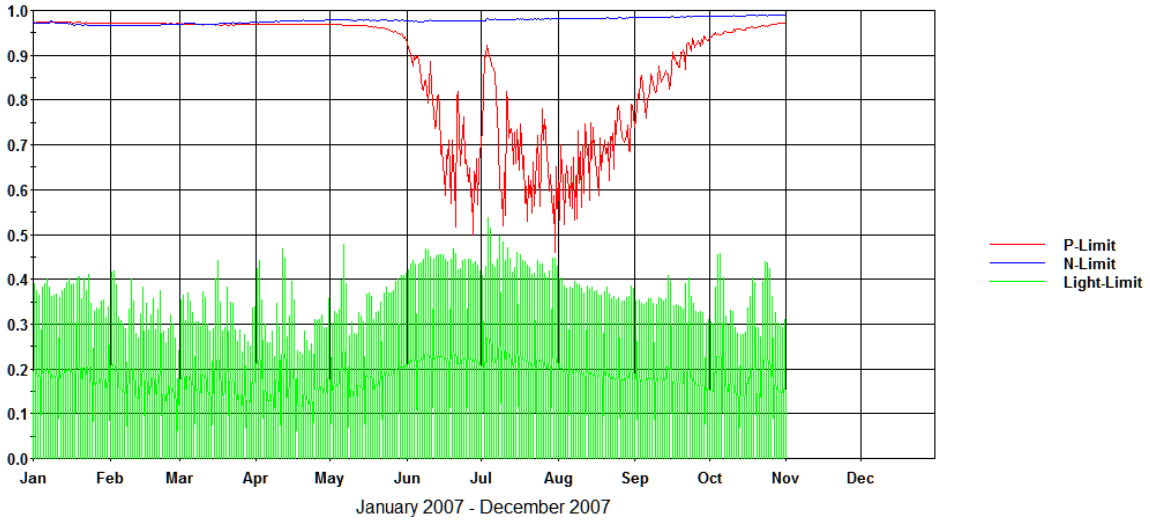

Figure 3-14 Lake Allatoona Dam Forebay Station (14309001) Nutrient Limitation for Scenario 1C (TMDL)

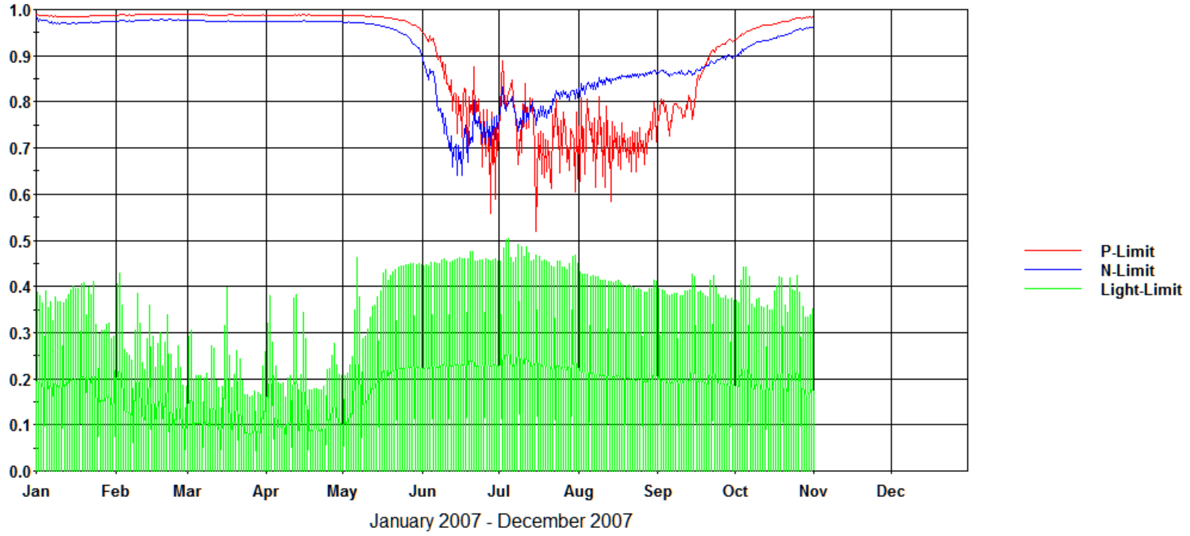

Figure 3-15 Lake Allatoona Allatoona Creek Station (14307501) Nutrient Limitation for Scenario 1A (Calibration)

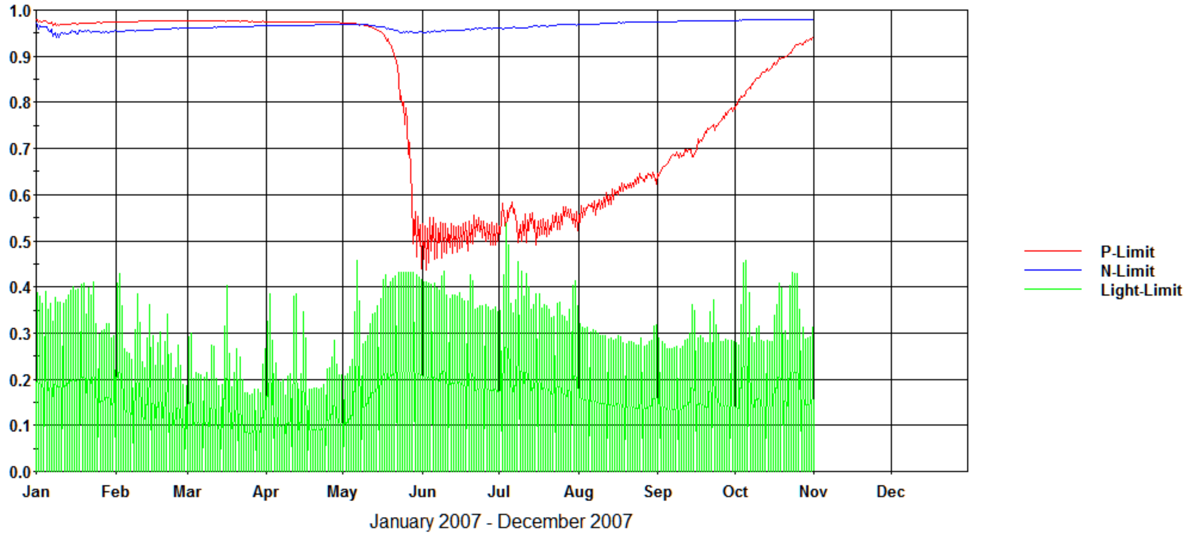

Figure 3-16 Lake Allatoona Allatoona Creek Station (14307501) Nutrient Limitation for Scenario 1C (TMDL)

The chlorophyll Total Nitrogen Limit Lake Allatoona

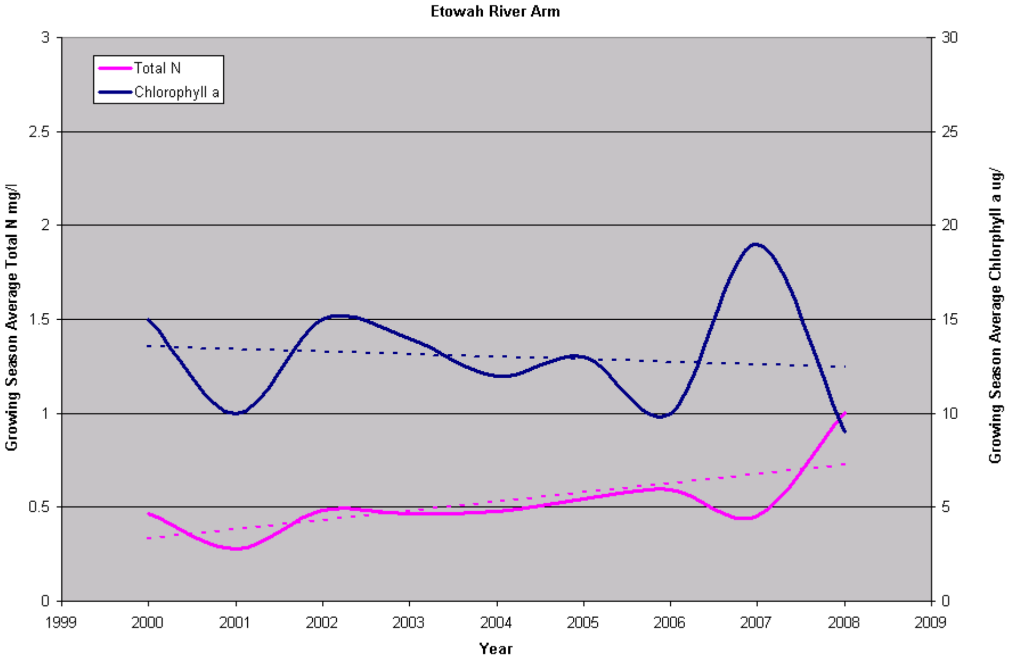

Figure 3-17 **Lake Allatoona Etowah River Arm Growing Season Chlorophyll *a* and Total Nitrogen Levels**

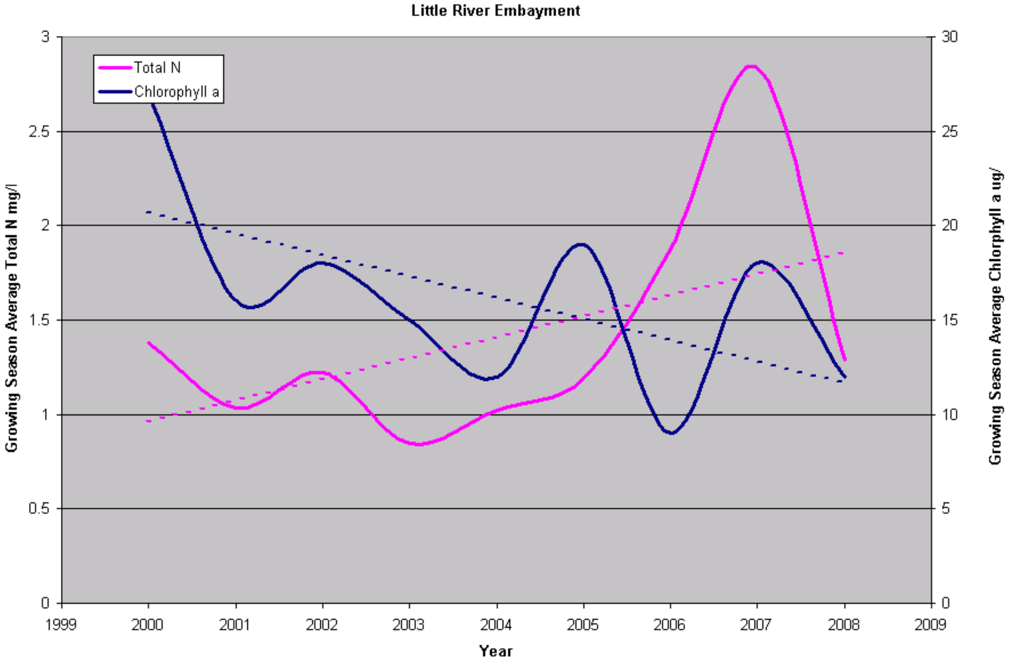

Figure 3-18 **Lake Allatoona Little River Growing Season Chlorophyll *a* and Total Nitrogen Levels**

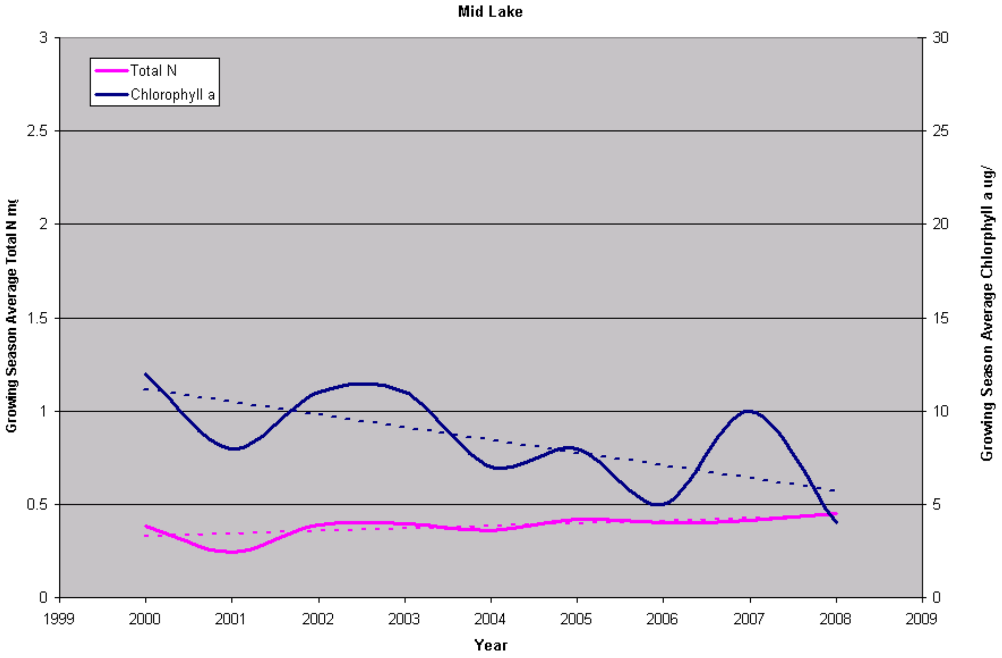

Figure 3-19 Lake Allatoona Mid Lake Growing Season Chlorophyll *a* and Total Nitrogen Levels

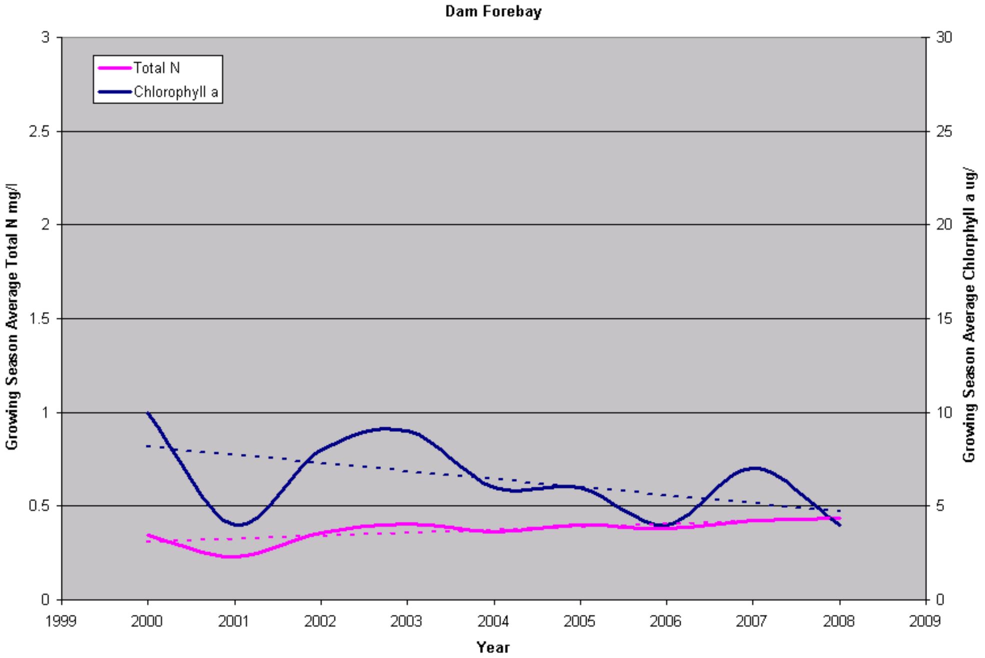

Figure 3-20 Lake Allatoona Dam Forebay Growing Season Chlorophyll *a* and Total Nitrogen Levels

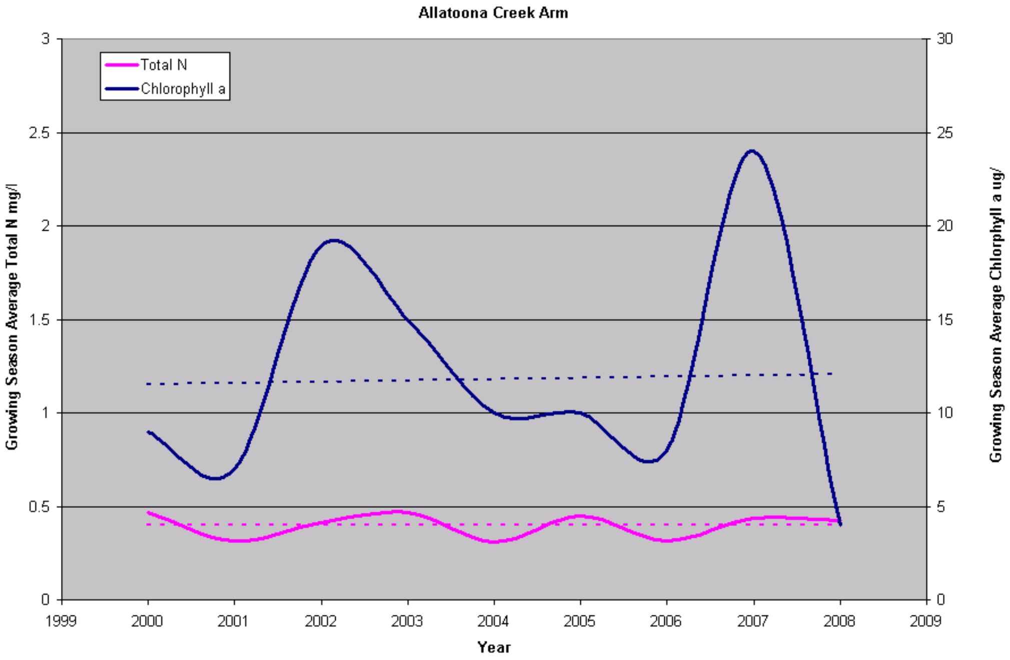

Figure 3-21 Lake Allatoona Allatoona Creek Arm Growing Season Chlorophyll *a* and Total Nitrogen Levels