

LAKE & RESERVOIR ASSESSMENTS NEUSE RIVER BASIN



Wiggins Mill Reservoir

Intensive Survey Unit
Environmental Sciences Section
Division of Water Quality
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GLOSSARY

Algae	Small aquatic plants that occur as single cells, colonies, or filaments. May also be referred to as phytoplankton, although phytoplankton are a subset of algae.
Algal biovolume	The volume of all living algae in a unit area at a given point in time. To determine biovolume, individual cells in a known amount of sample are counted. Cells are measured to obtain their cell volume, which is used in calculating biovolume.
Algal density	The density of algae based on the number of units (single cells, filaments and/or colonies) present in a milliliter of water. The severity of an algae bloom is determined by the algal density as follows: Mild bloom = 10,000 to 20,000 units/ml Moderate bloom = 20,000 to 30,000 units/ml Severe bloom = 30,000 to 100,000 units/ml Extreme bloom = Greater than 100,000 units/ml
Algal Growth Potential Test (AGPT)	A test to determine the nutrient that is the most limiting to the growth of algae in a body of water. The sample water is split such that one sub-sample is given additional nitrogen, another is given phosphorus, a third may be given a combination of nitrogen and phosphorus, and one sub-sample is not treated and acts as the control. A specific species of algae is added to each sub-sample and is allowed to grow for a given period of time. The dry weights of algae in each sub-sample and the control are then measured to determine the rate of productivity in each treatment. The treatment (nitrogen or phosphorus) with the greatest algal productivity is said to be the limiting nutrient of the sample source. If the control sample has an algal dry weight greater than 5 mg/L, the source water is considered to be unlimited for either nitrogen or phosphorus.
Centric diatom	Diatoms are photosynthetic algae that have a siliceous skeleton (frustule) and are found in almost every aquatic environment including fresh and marine waters, soils, in fact almost anywhere moist. Centric diatoms are circular in shape and are often found in the water column.
Chlorophyll a	Chlorophyll <i>a</i> is an algal pigment that is used as an approximate measure of algal biomass. The concentration of chlorophyll <i>a</i> is used in the calculation of the NCTSI, and the value listed is a lake-wide average from all sampling locations.
Clinograde	In productive lakes where oxygen levels drop to zero in the lower waters near the bottom, the graphed changes in oxygen concentration from the surface to the lake bottom produces a curve known as clinograde curve.
Cocoid	Round or spherical shaped cell.
Conductivity	This is a measure of the ability of water to conduct an electrical current. This measure increases as water becomes more mineralized.
Dissolved oxygen	The range of surface concentrations found at the sampling locations.
Dissolved oxygen saturation	The capacity of water to absorb oxygen gas. Often expressed as a percentage, the amount of oxygen that can dissolve into water will change depending on a number of parameters, the most important being temperature. Dissolved oxygen saturation is inversely proportion to temperature, that is, as temperature increases, water's capacity for oxygen will decrease, and vice versa.
Eutrophic	Describes a lake with elevated biological productivity and low water transparency.
Eutrophication	The process of physical, chemical, and biological changes in a lake associated with the presence of one or more of the following: excessive nutrients, organic matter, silt enrichment and sedimentation.

Limiting nutrient	The plant nutrient present in lowest concentration relative to need limits growth such that addition of the limiting nutrient will stimulate additional growth. In north temperate lakes, phosphorus (P) is commonly the limiting nutrient for algal growth.
Manganese	A naturally occurring metal commonly found in soils and organic matter. As a trace nutrient, manganese is essential to all forms of biological life. Manganese in lakes is released from bottom sediments and enters the water column when the oxygen concentration in the water near the lake bottom is extremely low or absent. Manganese in lake water may cause taste and odor problems in drinking water and require additional treatment of the raw water at water treatment facilities to alleviate this problem.
Mesotrophic	Describes a lake with moderate biological productivity and water transparency.
NCTSI	North Carolina Trophic State Index was specifically developed for North Carolina lakes as part of the state's original Clean Lakes Classification Survey (NRCD 1982). Values for total organic nitrogen, total phosphorus, chlorophyll a and Secchi depth are used to calculate a numeric score representing the lake's degree of biological productivity.
Oligotrophic	Describes a lake with low biological productivity and high water transparency.
pH	The range of surface pH readings found at the sampling locations. This value is used to express the relative acidity or alkalinity of water.
Photic zone	The portion of the water column in which there is sufficient light for algal growth. DWQ considers 2 times the Secchi depth as depicting the photic zone.
Secchi depth	This is a measure of water transparency expressed in meters. This parameter is used in the calculation of the NCTSI value for the lake. The depth listed is an average value from all sampling locations in the lake.
Temperature	The range of surface temperatures found at the sampling locations.
Total Kjeldahl nitrogen	The sum of organic nitrogen and ammonia in a water body. High measurements of TKN typically results from sewage and manure discharges in water bodies.
Total organic Nitrogen (TON)	Total Organic Nitrogen (TON) can represent a major reservoir of nitrogen in aquatic systems during summer months. Similar to phosphorus, this concentration can be related to lake productivity and is used in the calculation of the NCTSI. The concentration listed is a lake-wide average from all sampling stations and is calculated by subtracting Ammonia concentrations from TKN concentrations.
Total phosphorus (TP)	Total phosphorus (TP) includes all forms of phosphorus that occur in water. This nutrient is essential for the growth of aquatic plants and is often the nutrient that limits the growth of phytoplankton. It is used to calculate the NCTSI. The concentration listed is a lake-wide average from all sampling stations.
Trophic state	This is a relative description of the biological productivity of a lake based on the calculated NCTSI value. Trophic states may range from extremely productive (Hypereutrophic) to very low productivity (Oligotrophic).
Turbidity	A measure of the ability of light to pass through a volume of water. Turbidity may be influenced by suspended sediment and/or algae in the water.
Watershed	A drainage area in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Overview

The Neuse River basin is the third largest basin in North Carolina and is one of only three basins that are located entirely within the state. The Neuse River Basin covers 6,192 square miles and spans 19 counties. The Neuse River originates northwest of the City of Durham in Person and Orange counties and the headwaters start in the Southern Outer Piedmont and the Carolina Slate Belt ecoregions. The uppermost 22 miles of the river's main stem is impounded behind Falls of the Neuse Reservoir dam just northeast of the city of Raleigh. Downstream of the dam, the river continues its course for approximately 185 miles southeasterly past the cities of Raleigh, Smithfield, Goldsboro, and Kinston after which it reaches the tidal waters near Street's Ferry just upstream of New Bern. Downstream of Street's Ferry, the Neuse River significantly broadens and changes into a tidal estuary that empties into the Pamlico Sound. Overall, most of the land use in the Neuse River Basin is agriculture or forest with the only major area of protected forest associated with the Croatan National Forest located in the lower reaches of the basin in Jones and Craven counties. However, there are several areas of rapidly expanding urban land use particularly associated with the cities of Durham, Raleigh, Clayton, Goldsboro, Kinston, and New Bern.

Mercury has been identified as a widespread contaminant in fish from all North Carolina coastal river basins. In the Chowan River basin, elevated mercury levels have been measured in long-lived piscivores such as largemouth bass and bowfin (blackfish). Research indicates that atmospheric mercury deposition is a significant source for the observed mercury levels. A fish consumption advisory has been placed on largemouth bass, black crappie, catfish, chain pickerel, warmouth, Yellow perch and bowfin (or blackfish) caught east of I-85 and black crappie caught south and east of I-95 for mercury contamination was issued by the NC Department of Health and Human Services, Division of Public Health. This advisory includes lakes that support these fish in Neuse River Basin (<http://www.epi.state.nc.us/epi/fish/current.html>). In 2008, catfish, carp and largemouth bass from Crabtree Lake in Wake County were placed on a fish consumption advisory for the presence of polychlorinated biphenyls (PCBs).

Following the description of the assessment methodology used for the Neuse River Basin, there are individual summaries for each of the lakes and a two-paged matrix that distills the information used to make the lakes use support assessments. For additional information on a particular lake (including sampling data), please go to <http://www.esb.enr.state.nc.us/>.

Assessment Methodology

For this report, data from January 1, 2006 through September 30, 2010 were reviewed. All lakes were sampled during the summer from May through September of 2009. Data were assessed for excursions of the state's class C water quality standards for chlorophyll *a*, pH, dissolved oxygen, water temperature, turbidity, and surface metals. Other parameters discussed in this report include Secchi depth and percent dissolved oxygen saturation. Secchi depth provides a measure of water clarity and is used in calculating the trophic or nutrient enriched status of a lake. Percent dissolved oxygen saturation gives information on the amount of dissolved oxygen in the water column and may be increased by photosynthesis or depressed by oxygen-consuming decomposition.

For algae collection and assessment, water samples are collected from the photic zone, preserved in the field and taken concurrently with chemical and physical parameters. Samples were quantitatively analyzed to determine assemblage structure, density (units/ml) and biovolume (m^3/mm^3).

For the purpose of reporting, algal blooms were determined by the measurement of unit density (units/ml). Unit density is a quantitative measurement of the number of filaments, colonies or single celled taxa in a waterbody. Blooms are considered mild if they are between 10,000 and 20,000 units/ml.

Moderate blooms are those between 20,000 and 30,000 units/ml. Severe blooms are between 30,000 and 100,000 units/ml. Extreme blooms are those 100,000 units/ml or greater.

An algal group is considered dominant when it comprises 40% or more of the total unit density or total biovolume. A genus is considered dominant when it comprises 30% or more of the total unit density or total biovolume.

Additional data considered as part of the use support assessment include historic DWQ water quality data, documented algal blooms and/or fish kills, problematic aquatic macrophytes, or listing on the EPA's 303(d) List of Impaired Waters.

For a more complete discussion of lake ecology and assessment, please go to <http://www.esb.enr.state.nc.us/>. The 1990 North Carolina Lake Assessment Report (downloadable from this website) contains a detailed chapter on ecological concepts that clarifies how the parameters discussed in this review relate to water quality and reservoir health.

Weather Overview for Summer 2010

The weather in North Carolina in May, 2010 was warm and wet, especially in the central portion of the state. Most locations in the state experienced above normal temperatures with a few sites subjected to maximum average temperatures near record levels. In general, precipitation in May was heaviest across the piedmont and northern coastal plains regions. Radar-based rainfall estimates indicated many parts of central NC received in excess of six inches in May while gauges indicated that many areas in the mountains and coastal regions had below normal rainfall. Statewide, May ranked as the 11th warmest and 33rd wettest since 1985. The piedmont region of the state in May ranked as the 15th wettest in the past 116 years (NC State Climate Office, June 7, 2010). Table 1 shows the preliminary temperature and rainfall departures from normal for the Neuse River Basin regions of the state from the NC State Climate Office.

Table 1. Preliminary Temperature and Precipitation Departures from Normal for 2010 (from NC State Climate Reports, June through September).

Month	Neuse River Basin from headwaters to eastern Wake County border		Neuse River Basin east of Wake County border	
	Temperature (F)	Precipitation (in.)	Temperature (F)	Precipitation (in.)
May	+3.5	+1.82 (148%)	+3.8	-0.74 (86%)
June	+4.8	-0.73 (83%)	+5.8	+0.48 (108%)
July	+1.3	+0.36 (110%)	+1.2	-1.36 (77%)
August	+2.5	-0.26 (95%)	+2.2	-1.2 (84%)
September	+3.3	+0.20 (104%)	+2.5	+7.76 (245%)

June 2010 in 2010 was a month of record breaking heat. This month was the warmest June on record for many locations across the state including Raleigh and New Bern. For other monitoring sites, June ranked as one of the top five warmest on record. Statewide, June 2010 ranked as the 2nd warmest June on record since 1985 (the warmest June was recorded in 1952). Precipitation in June was mixed across the state. The southern coastal plains experienced above normal rainfall while other sites had below normal rainfall (northern coastal plains and southwestern mountains). Statewide, June 2010 ranked as the 28th driest June since 1895 (NC State Climate Office, July 6, 2010).

July 2010 in North Carolina was both warm and dry. While not quite as hot as June, temperatures in many locations ranked as one of the top five warmest on record. Some of the locations included Banner Elk, Lincolnton, Murphy, Greensboro, and Raleigh. Along with the heat, drier conditions occurred in July, especially across eastern NC, while central NC fared better. Statewide, temperatures ranked as the 10th warmest since 1985 and the 32nd driest on record (NC State Climate Office, August 9, 2010).

August continued the hot, dry weather across the state. Statewide, NC ranked at the 46th driest and 3rd warmest since 1895. Across the state, daily mean temperatures ranked on the high side and several locations ranked as the 5th warmest August on record. Interestingly, while individual daytime temperatures were not notable for breaking records, nighttime low temperatures were well above average (NC State Climate Office, September 8, 2010).

The first three weeks of September 2010 saw limited rainfall and record-breaking high temperatures. During this period many locations in the state broke records for high temperatures for individual days and the number of warm days. The Raleigh regions was one of these areas. A break in the hot and dry weather occurred the last week of September when heavy rainfall fell across much of central and eastern North Carolina. Most of eastern NC experienced the wettest week on record. Preliminary rainfall amounts in New Bern was 15.47 inches and Wilson saw 11.44 inches.

LAKE & RESERVOIR ASSESSMENTS

HUC 03020201

Lake Michie



Ambient Lakes Program Name	Lake Michie		
<i>Trophic Status (NC TSI)</i>	Eutrophic		
<i>Mean Depth (meters)</i>	8.0		
<i>Volume (10⁶ m³)</i>	15.60		
<i>Watershed Area (mi²)</i>	170.0		
<i>Classification</i>	WS-III; NSW CA		
<i>Stations</i>	NEU0061G	NEU0061J	NEU0061L
<i>Number of Times Sampled</i>	5	5	5

The City of Durham built Lake Michie in 1926 to serve as a water supply. The drainage area of this piedmont reservoir consists of a combination of rural, forested, agricultural and urban land uses. The primary tributary to Lake Michie is the Flat River. In addition to serving as a water supply source, Lake Michie provides public recreation such as fishing and boating.

Lake Michie was sampled five times in 2010 by DWQ field staff. Frequent rainfall occurred within the lake's watershed in May and early June, then became sporadic and localized through June and September. Surface dissolved oxygen in Lake Michie ranged from 5.0 mg/L in August to 9.3 mg/L in June (Appendix A). Water temperatures were greatest in July and ranged from 31.5 °C to 32.4 °C. Thermal stratification was observed at the mid-lake sampling site (NEU0061J) in May at a depth of five meters from the surface. Lake Michie remained stratified through September 20th, which was the last day in 2010 that this lake was monitored by field staff. On this date, hypoxic conditions (<4.0 mg/L dissolved oxygen) were observed at a depth of four meters from the surface at the near-dam (NEU0061L) sampling site (depth to bottom = 11.7 meters).

Surface pH values were within the state water quality standard of not less than 6.0 s.u. and not greater than 9.0 s.u. Secchi depths ranged from 1.1 meter (near the dam in May, July and August) to 0.5 meter. Field staff notes indicated that Lake Michie's water appeared brown in color in June and August following rainfall events within the watershed.

Photic zone total phosphorus ranged from 0.02 mg/L to 0.06 mg/L, with the greatest values observed in June. Nitrogen concentrations were also greater in June as compared with other sampling months (Appendix A). Total suspended solids ranged from less than the DWQ laboratory detection level to 11.0

mg/L and turbidity values ranged from 2.6 to 12 NTUs, which were well within the state water quality standard of 25 NTUs for lakes. Surface metals and total hardness values were also within the applicable state water quality standards.

Water samples were collected at two sampling sites in the lake and shipped to the US Environmental Protection Agency laboratory in Athens, Georgia for an Algal Growth Potential Test (Table 2). Results of this test indicated that algae growth in Lake Michie was limited by phosphorus availability at the mid-lake sampling site (NEU0061J) and limited at the upper end of the lake by nitrogen availability. .

Table 2. Algal Growth Potential Test Results for Lake Michie, July 26, 2010.

Station	Control (mg/L)	C + N (mg/L)	C + P (mg/L)	C + N + P (mg/L)	Limiting Nutrient
NEU0061J	1.02	1.12	1.33	26.14	Phosphorus
NEU0061G	1.43	7.25	1.52		Nitrogen

C+N - Control + 1.0 mg/L Nitrate-N

C+P - Control + 0.05 mg/L Phosphate-P

C+N+P - Control + 1.0 mg/L Nitrate-N + 0.05 mg/L Phosphate-P

Chlorophyll *a* values in Lake Michie ranged from 8.4 $\mu\text{g/L}$ to 37 $\mu\text{g/L}$. The highest chlorophyll *a* value occurred at the upper end of the lake (NEU0061G) in August. Algal blooms were mild during June, moderate during July, and severe during August and September. Algal assemblages were dominated by the filamentous blue-green *Cylindrospermopsis sp.* throughout the summer. The euglenoid *Trachelomonas* was also prevalent during August. Blue-green algae are common indicators of nutrient enrichment and may cause unsightly water discoloration, surface films, flecks, mats, along with taste and odor problems in drinking water. Euglenoids tend to be found in waters rich in organic matter and blooms may discolor water, by forming dense surface films that are often described as “spilled paint”.

Based on the calculated NCTSI scores, Lake Michie was determined to demonstrate elevated biological productivity (eutrophic). Lake Michie was previously determined to be eutrophic in 1988 when it was first monitored by DWQ and in 1995. In 1991, Lake Michie exhibited moderate biological productivity (mesotrophic).

Little River Reservoir



Ambient Lakes Program Name	Little River Reservoir		
Trophic Status (NC TSI)	Eutrophic		
Mean Depth (meters)	7.5		
Volume ($10^6 m^3$)	18.00		
Watershed Area (mi^2)	97.7		
Classification	WS-II; HQW, NSW, CA		
Stations	NEU006S	NEU006T	NEU006U
Number of Times Sampled	5	5	5

Little River Reservoir is an upper piedmont water supply for the City of Durham. Filled in February 1988, the lake has a maximum depth is 49 feet (15 meters). Retention time is approximately 74 days. Mountain Creek, Buffalo Creek, North Fork and South Fork Little River are the tributaries of this reservoir. The drainage area is composed of forests, agriculture, and residences. The lake was previously classified WS-III, but was reclassified to WS-II on request from the City of Durham. An aerator is operated near the lower end of this lake to breakdown lake stratification and improve the quality of the raw drinking water taken from the lake.

In 2010, DWQ field staff sampled Little River Reservoir five times during the summer. Surface dissolved oxygen was lowest in August (range = 5.4 mg/L to 6.4 mg/L) following a heavy (>1.0") localized rainfall event within the lake's watershed (Appendix A). The lowest dissolved oxygen value occurred at the upper end (NEU006S) of Little River Reservoir. The highest surface dissolved oxygen values occurred in early June with values ranging from 9.3 mg/L near the dam (NEU006U) to 10.6 mg/L at the upper end of the lake. Surface water temperatures ranged from a low of 21.9 °C near the dam in May to a high of 32.6 °C at the mid-lake sampling site (NEU006T) in July. This reservoir exhibited strong stratification for dissolved oxygen in June with hypoxic oxygen conditions occurring at a depth of 3.0 to 4.0 meters from the surface at the mid-lake sampling site (depth to bottom = 10.7 meters). This stratification remained present from July through September. Surface pH values were within the state water quality standards of not less than 6.0 s.u. and not greater than 9.0 s.u. Surface conductivity values in the lake ranged from 64 to 78 μ mhos/cm (Appendix A). Lake-wide Secchi depths were lowest in June (range = 0.6 to 0.7 meter) and greatest in May (range = 1.4 to 1.6 meters).

Photic zone nutrient concentrations were greatest in June as compared with the other sampling months (Appendix A). Ammonia and nitrite plus nitrate were generally below DWQ laboratory detection levels from July through September. Water samples were collected at two sampling sites in the lake and shipped to the US Environmental Protection Agency laboratory in Athens, Georgia for an Algal Growth Potential Test (Table 3). Results indicated that algae growth in Little River Reservoir was limited by the availability of nitrogen in July at the upper lake and mid-lake sampling sites.

Table 3. Algal Growth Potential Test Results for Little River Reservoir, July 26, 2010.

Station	Control (mg/L)	C + N (mg/L)	C + P (mg/L)	Limiting Nutrient
NEU006U	0.73	1.38	0.60	Nitrogen
NEU006T	0.89	2.38	0.74	Nitrogen

C+N - Control + 1.0 mg/L Nitrate-N

C+P - Control + 0.05 mg/L Phosphate-P

In response to the increased availability of nutrients in June, chlorophyll a values also increased in June and ranged from 21 $\mu\text{g/L}$ near the dam to 47 $\mu\text{g/L}$ at the mid-lake sampling site (Appendix A). This latter value was greater than the state water quality standard of 40 $\mu\text{g/L}$ for chlorophyll a. Total suspended solids were less than the DWQ laboratory detection levels in 2010 and turbidity values ranged from 2.6 to 12 NTUs, which was less than the state water quality standard of 25 NTUs for lakes.

Based on the calculated NCTSI scores for 2010, Little River Reservoir exhibited moderate biological productivity (mesotrophic) conditions in May and elevated biological productivity (eutrophic) conditions in June through September. The trophic state of this reservoir has alternated between mesotrophic or eutrophic since it was first monitored by DWQ in 1988.

Lake Butner



Ambient Lakes Program Name	Lake Butner	
Trophic Status (NC TSI)	Eutrophic	
Mean Depth (meters)	9.0	
Volume (10^6 m^3)	1.40	
Watershed Area (mi^2)	30.1	
Classification	WS-II; HQW, NSW, CA	
Stations	NEU007	NEU007B
Number of Times Sampled	5	5

Lake Butner (also known as R.D. Holt Reservoir) is located on Knap of Reeds Creek in Granville County. The Town of Butner uses this lake as a source of drinking water and for recreational fishing and boating. The maximum depth is 49 feet (15 meters). The watershed is composed of rolling topography characterized by farmland and forests.

Lake Butner was monitored monthly from May through September by DWQ field staff. Surface dissolved oxygen in this reservoir ranged from 6.7 mg/L to 8.4 mg/L and surface water temperatures ranged from

22.2 to 30.8 °C. Surface pH values ranged from 6.7 s.u. to 8.4 s.u., with the lowest pH values observed in August. Surface conductivity values were similar to those previously observed in this reservoir and ranged from 4.8 to 5.3 $\mu\text{mhos/cm}$. Secchi depths in 2010 ranged from 0.7 meter in June following a rainfall event within the lake's watershed to 1.5 meters in July, which was hot and dry.

Total phosphorus ranged from 0.05 mg/L in May to 0.02 mg/L or <0.02 mg/L from July through September (Appendix A). Concentrations in total Kjeldahl nitrogen ranged from 0.35 mg/L to 0.54 mg/L while concentrations of ammonia and nitrite plus nitrate were less than the DWQ laboratory detection level. Total suspended solids were generally at or below DWQ water quality laboratory detection levels and surface metals and hardness were within the applicable state water quality standards.

Chlorophyll *a* values ranged from 8.2 $\mu\text{g/L}$ to 16.0 $\mu\text{g/L}$ in 2010. Despite chlorophyll *a* values below the state water quality standard of 40 $\mu\text{g/L}$, algal blooms were severe during June and moderate during July based on analysis and quantification of phytoplankton samples collected from Lake Butner. Algal assemblages in Lake Butner in 2010 were dominated by the colonial chrysophyte *Dinobryon* during May, the blue-green alga *Chroococcus sp.* and *Aphanizomenon sp.*, and the green alga *Coelastrum sp.* during August to September. The euglenoid *Trachelomonas sp.* was also prevalent during July. Blue-green and euglenoid algae are indicators of nutrient enrichment and may produce taste and odor problems in drinking water.

Notes by field staff indicated that water willow (*Justicia americana*) was present along the lake's shoreline and hydrilla (*Hydrilla verticillata*) was present near the boat ramp and dock.

Overall, Lake Butner was determine to exhibit elevated biological productivity (eutrophic conditions) in 2010. This lake's trophic state has ranged between oligotrophic (very low biological productivity) to eutrophic since it was first monitored by DWQ in 1988.

Lake Rogers



Ambient Lakes Program Name	Lake Rogers
Trophic Status (NC TSI)	Hypereutrophic
Mean Depth (meters)	1.0
Volume ($10^6 m^3$)	0.50
Watershed Area (mi^2)	17.4
Classification	WS-II; HQW, NSW, CA
Stations	NEU017A
Number of Times Sampled	5

Lake Rogers is the water supply reservoir for the Town of Creedmoor. This reservoir was built in 1939 and has a surface area of approximately 210 acres (57 hectares) and a maximum depth of approximately

nine feet (three meters). Tributaries to Lake Rogers include Ledge Creek and Holman Creek. Land in the drainage area consists of forested, residential, agricultural, and wetland areas.

Lake Rogers was sampled five times by DWQ staff in 2010. Surface dissolved oxygen ranged from a low of 4.0 mg/L at the upper end of the lake (NEU017B) in May to 7.6 mg/L at the same location in July (Appendix A). The highest surface water temperature (31.0 °C) was observed in July and surface pH ranged from 6.5 s.u. to 7.9 s.u. Secchi depths in Lake Rogers were consistently less than a meter, suggesting poor water clarity and light penetration into the water column. Field notes from staff monitoring the lake in 2010 indicated that the water had a distinctive brown coloration. Turbidity values at the upper end of the lake were consistently greater than the state water quality standard of 25 NTUs for lakes and reservoirs. In July and September, the turbidity values at both lake sampling sites were greater than the state water quality standard

Total phosphorus concentrations in Lake Rogers ranged from 0.09 mg/L to 0.15 mg/L. Concentrations of total Kjeldahl nitrogen and total organic nitrogen were at levels capable of supporting nuisance algal blooms (Appendix A). Ammonia and nitrite plus nitrate concentrations were less than DWQ laboratory detection levels. In response to the availability of nutrients, chlorophyll *a*, and indicator of algal productivity, ranged from 16 µg/L to 110 µg/L. Lakewide mean chlorophyll *a* values in June (65.5 µg/L), July (90.0 µg/L), August (98.5 µg/L) and September (110.0 µg/L) were greater than the state water quality standard of 40 µg/L. Based on calculated NCTSI scores, Lake Rogers was determined to exhibit extreme biological productivity (hypereutrophic conditions). The trophic state of this lake has ranged from hypereutrophic in 1991 to eutrophic in 1992 and 1995.

In 2005, the City of Creedmoor contacted the US Army Corps of Engineers (ACOE) Wilmington District Office for assistance in reducing the input of nutrients and sediments into Lake Rogers to help reduce water treatment costs. The study area consisted of Lake Rogers and its two tributaries, Ledge and Holman Creeks. Ledge Creek flows into Lake Rogers and continues into Falls of the Neuse Reservoir and Holman Creek flows into Lake Rogers on the eastern side of the lake near SR 1127. The watershed is approximately 17.8 square miles and consists of forest (54%), pasture and grasslands (25%), developed land in the Ledge Creek drainage (12.5%) and Holman Creek (9.9%). (USACOE, 2009). The US Geological Survey (USGS) assisted the ACOE in water quality data collection and characterization of the Lake Rogers watershed (USGS, 2008). Recommendations from the ACOE based on a combination of data collection and the results of the USGS watershed study included implementation of the Neuse River Basin Rules, development of zoning ordinances, sediment trap implementation, a potential Section 206 study, and implementation and enforcement of Best Management Practices (BMP's).

In 2008, The City of Creedmoor implemented a dredging project to improve the water quality of Lake Rogers. This \$1.7 million project was planned to continue through the spring of 2009 (WRAL News, October 22, 2008). When constructed in 1936, the original volume of Lake Rogers was approximately 979 acre-feet (1.58 million cubic yards). By 1998, the volume had decreased to 661 acre-feet (1.06 million cubic yards) due to sedimentation. This degree of sedimentation represented a loss of one-third of the lake's original volume along with an average two foot loss in depth. Approximately 55,000 cubic yards of sediment from 74 acres of lake bed were removed when the dredging project was completed in May, 2009. (http://www.cityofcreedmoor.org/index.asp?Type=B_BASIC&SEC={3369C5DF-E128-4938-A06F-657CCBC607B6}).

Corporation Lake

<i>Ambient Lakes Program Name</i>	Corporation Lake	
<i>Trophic Status (NC TSI)</i>	Eutrophic	
<i>Mean Depth (meters)</i>	1.2	
<i>Volume (10⁶ m³)</i>	0.90	
<i>Watershed Area (mi²)</i>	40.9	
<i>Classification</i>	WS-II; HQW, NSW, CA	
<i>Stations</i>	NEU00C	NEU00C1
<i>Number of Times Sampled</i>	3	3

Corporation Lake is a water supply reservoir located on the Eno River downstream of Lake Orange. This lake was built in 1967 by the Orange-Alamance Water Authority. The surface area is 28 acres (11 hectares) and the maximum depth is approximately eight feet (2.5 meters). McGowan Creek is a tributary of Corporation Lake. The watershed is composed of forested and agricultural areas with a rolling topography.

ISU staff monitored Corporation Lake three times in 2010. Entry could only be made to the lake via a gate located on privately owned land and difficulty obtaining access limited the number of times staff could collect data. Therefore, data were only collected in May, June and July. Surface dissolved oxygen values ranged from 6.4 mg/L to 8.0 mg/L and water temperatures ranged from 18.0 °C in May to 27.1 °C in July (Appendix A). Surface pH ranged from 7.1 s.u. to 7.5 s.u. Secchi depths were greatest in May (range = 1.3 to 1.5 meters) and lowest in July (range = 0.8 to 1.0 meter).

Total phosphorus concentrations in Corporation Lake in 2010 ranged from 0.03 mg/L to 0.06 mg/L (Appendix A). Total Kjeldahl nitrogen ranged from 0.46 mg/L to 0.66 mg/L and total organic nitrogen ranged from 0.31 mg/L to 0.55 mg/L). The greatest turbidity value for Corporation Lake in 2010 was also observed near the dam in June (15 NTUs). Surface metals and total hardness were within applicable state water quality standards.

In June, the chlorophyll *a* near the dam (NEU00C1) was 61 µg/L. This value was greater than the state water quality standard of 40 µg/L for chlorophyll *a*. Algal assemblages in May were dominated by centric diatoms, then by small green algae and euglenoids in June. Diatoms provide a beneficial food source for small crustaceans and fish but may also produce taste and odor problems in drinking water if the number of diatoms become excessive (form blooms). Green algae are also beneficial food sources for aquatic animals such as fish and euglenoids are indicators of nutrient enriched waters. Algal assemblages in Corporation Lake from May through June were below bloom densities (less than 10,000 units/ml).

Based on the calculated NCTSI scores for Corporation Lake, the trophic state in May indicated that the lake exhibited moderate biological productivity (mesotrophic conditions) and elevated biological productivity in June and July (eutrophic conditions). The trophic state of Corporation Lake has ranged between mesotrophic and eutrophic since it was first monitored by DWQ in 1988.

Lake Ben Johnson



<i>Ambient Lakes Program Name</i>	Lake Ben Johnson
<i>Trophic Status (NC TSI)</i>	Mesotrophic
<i>Mean Depth (meters)</i>	1.5
<i>Volume (10⁶ m³)</i>	0.02
<i>Watershed Area (mi²)</i>	64.9
<i>Classification</i>	WS-II; HQW, NSW, CA
<i>Stations</i>	NEU00D
<i>Number of Times Sampled</i>	5

Lake Ben Johnson is a run-of-the- river lake formed by a dam on the Eno River downstream of Corporation Lake. This lake has a maximum depth of approximately seven feet (two meters). The watershed consists of a mix of agricultural, urban, agricultural and forested areas. The City of Hillsborough owns the lake which is also the back-up water supply source for this municipality.

Lake Ben Johnson was monitored monthly from May through September, 2010. Surface dissolved oxygen was highly variable (Appendix A). In June and August, the dissolved oxygen concentrations were low (4.6 and 4.7 mg/L, respectively) and values in May, July and September ranged from 6.2 to 6.5 mg/L. Lake Ben Johnson was very strongly stratified with hypoxic conditions (<4.0 mg/L) occurring at a depth of two to three meters below the surface (depth to bottom = approximately four meters). Surface water temperatures ranged from 19.9 °C to 28.0 °C and surface pH values ranged from 7.1 s.u. to 7.4 s.u. Surface conductivity values were very consistent and ranged from 80 to 89 μ mhos during the summer. Secchi depths in Lake Ben Johnson ranged from 1.3 meters in May to 0.6 meter in September.

Total phosphorus concentrations ranged from 0.02 mg/L to 0.04 mg/L (Appendix A). Total Kjeldahl nitrogen ranged from 0.31 mg/L to 0.44 mg/L and ammonia concentrations were below the DWQ laboratory detection limit in July through September. Chlorophyll *a* values ranged from 3.2 μ g/L to 8.3 μ g/L. The lake algal assemblage was dominated by centric diatoms in May through June, then by euglenoids from August through September. Total suspended solids were below DWQ laboratory detection levels and turbidity values were low. Surface metals and hardness were within applicable state water quality standards.

Based on the calculated NCTSI scores in 2010, Lake Ben Johnson was determined to exhibit moderate biological productivity (mesotrophic). This lake has ranged between mesotrophic to eutrophic (elevated biological productivity) since it was first monitored by DWQ in 1988.

West Fork Eno River Reservoir



Ambient Lakes Program Name	West Fork Eno River Reservoir			
Trophic Status (NC TSI)	Eutrophic			
Mean Depth (meters)	4.0			
Volume (10 ⁶ m ³)	3.00			
Watershed Area (mi ²)	9.5			
Classification	WS-II; HQW, NSW, CA			
Stations	NEUWFE1	NEUWFE2	NEUWFE3	NEUWFE4
Number of Times Sampled	5	5	5	5

West Fork Eno River Reservoir is maintained by the Town of Hillsborough, which is the largest water system withdrawer. The reservoir was constructed on the West Fork of the Eno River beginning in 1999 and was completed in 2000. The watershed consists of forested and rural areas with agricultural fields, pastureland and residences. West Fork Eno River Reservoir has a maximum depth of 43 feet.

This reservoir was monitored monthly from May through September by DWQ field staff. Surface dissolved oxygen in this reservoir ranged from 5.5 mg/L to 7.6 mg/L, with the lowest dissolved oxygen values observed in August at the upper most sampling sites, NEUWFE1 and NEUWFE2 (Appendix A), Surface water temperatures ranged from of 20.8 °C in May to 31.3 °C in July. Surface pH values ranged from 7.0 s.u. to 7.9 s.u and conductivity values were relatively stable, ranging from 60 µmhos/cm to 67 µmhos/cm. Secchi depths in West Fork Eno River Reservoir were lowest in May (range = 0.5 to 0.7 meter) and greatest in July (range = 2.0 to 2.8 meters). Secchi depths from June through September were greater than one meter, indicating that the clarity of the lake water was good.

Nutrient concentrations in West Fork Eno River Reservoir were greatest in May (Appendix A) followed by June with the exceptions of ammonia and nitrite plus nitrate, which were below DWQ laboratory detection levels. Total organic nitrogen at sampling site NEUWFE2 was 1.18 mg/L in May and total Kjeldahl nitrogen was 1.2 mg/L. Total phosphorus in May ranged from 0.04 mg/L to 0.07 mg/L. Total suspended solids were less than the DWQ laboratory detection levels and turbidity values ranged from 1.8 to 5.5 NTUs. Surface metals and hardness were within applicable state water quality standards.

The greatest chlorophyll *a* values occurred at NEUWFE2 in July (80 µg/L) and again in September (46 µg/L). Both of these values were greater than the state water quality standard of 40 µg/L. Floating clumps of the filamentous blue-green *Oscillatoria* sp. were reported in the mid-section of the lake during July. Analysis of phytoplankton samples collected from this reservoir determined that the algal assemblages were dominated by green and blue-green algae in May, the raphidophyte *Gonyostomum* sp. during June, the euglenoid *Trachelomonas* sp. during August, and the colonial diatom *Aulacoseira* sp. during September. These algae are indicators of nutrient enrichment as was found in West Fork Eno River Reservoir in 2010.

West Fork Eno River was determined to exhibit elevated biological productivity (eutrophic conditions) in 2010 based on calculated NCTSI scores.

Lake Orange



Ambient Lakes Program Name	Lake Orange		
Trophic Status (NC TSI)	Eutrophic		
Mean Depth (meters)	4.0		
Volume ($10^6 m^3$)	0.30		
Watershed Area (mi^2)	10.0		
Classification	WS-II; HQW, NSW, CA		
Stations	NEU00B	NEU00B2	NEU00B4
Number of Times Sampled	5	5	5

Lake Orange is a piedmont water supply reservoir for the City of Hillsborough. Maximum depth is 20 feet (six meters). Major tributaries to Lake Orange include the East and West Fork of the Eno River.

DWQ field staff monitored Lake Orange monthly, from May through September 2010. Surface dissolved oxygen ranged from 7.1 mg/L to 8.1 mg/L (Appendix A). Surface water temperatures were greatest in July, ranging from 31.8 °C to 31.4 °C. Surface pH values ranged from a low of 5.9 s.u. at the upper end of the reservoir (NEU00B) on September 8th to 8.6 s.u. near the dam (NEU00B4) in July. The low pH value in early September was lower than the state water quality standard of 6.0 s.u. Secchi depths ranged from 0.9 to 1.4 meters. The lower Secchi depths were observed at the upper end of the lake and at the mid-lake sampling site on July 26th and September 21st, and only at the upper end of the lake on September 8th.

Photic zone total phosphorus ranged 0.03 mg/L to 0.04 mg/L and total Kjeldahl nitrogen ranged from 0.60 mg/L to 0.79 mg/L (Appendix A). Ammonia and nitrite plus nitrate concentrations were below DWQ laboratory detection levels. Turbidity values ranged from 4.8 to 9.0 NTUs. Values for surface metals and hardness were within applicable state water quality standards.

Chlorophyll a values (range = 23 $\mu g/L$ to 38 $\mu g/L$) were not greater than the state water quality standard of 40 $\mu g/L$. Algal blooms in Lake Orange were mild during June, moderate during July, and mild during August and late September. Assemblages were dominated by the filamentous blue-greens (primarily *Aphanizomenon sp.* and *Planktolyngbya sp.*) throughout the summer. The euglenoid *Trachelomonas sp.* was also prevalent during August. Blue-green algae are common indicators of nutrient enrichment and blooms may cause unsightly water discoloration, surface films, flecks, mats, taste and odor problems in drinking water. Euglenoids tend to be found in waters rich in organic matter and blooms may have produce the appearance of spilled green paint on the lake surface.

In 2010, Lake Orange was determined to exhibit elevated biological productivity (eutrophic conditions) based on the calculated NCTSI scores for May through September. Historically, Lake Orange has been eutrophic since it was first monitored by DWQ in 1988 with the exception of a mesotrophic (moderate biological productivity) score in 1991.

Beaverdam Lake



<i>Ambient Lakes Program Name</i>	Beaverdam Lake
<i>Trophic Status (NC TSI)</i>	Eutrophic
<i>Mean Depth (meters)</i>	
<i>Volume (10⁶ m³)</i>	
<i>Watershed Area (mi²)</i>	52.5
<i>Classification</i>	WS-IV B NSW CA
<i>Stations</i>	NEU019C
<i>Number of Times Sampled</i>	46

Beaverdam Lake is a small impoundment of the Beaverdam Creek arm of Falls of the Neuse Reservoir. The shoreline is forested and the lake is used for recreational fishing, swimming and boating.

This lake was sampled 46 times by ISU field staff during the Neuse River Basin assessment period (October 1, 2006 through September 30, 2010). Surface dissolved oxygen ranged from 5.2 mg/L on July 10, 2006 to 11.9 mg/L on February 21, 2007 (Appendix B). Surface water temperatures ranged from 5.5 °C on January 24, 2007 to 33.3 °C on August 9, 2007. Surface pH values ranged from 5.5 s.u. on November 14, 2006 to 8.3 s.u. on August 9, 2007. Two pH values were lower than the state water quality standard of 6.0 s.u. (4%) during the assessment period

Secchi depths, a measurement of water clarity, ranged from 0.3 to 0.9 meters. These measurements indicated that the water clarity of Beaverdam Lake was limited. Total suspended residue values ranged from 10 and 20 mg/L and may have contributed to the poor water clarity (Appendix B). Staff field notes indicate that the water in Beaverdam Lake appears brown in color.

Total phosphorus concentrations ranged from 0.03 mg/L to 0.08 mg/L (Appendix B). Total Kjeldahl nitrogen ranged from 0.38 mg/L to 1.00 mg/L, and total organic nitrogen concentrations ranged from 0.37 to 0.99 mg/L. Concentrations of ammonia and nitrite plus nitrate were below the DWQ laboratory detection levels with the exception of two nitrite plus nitrate values (0.06 mg/L on July 24, 2006 and 0.03 mg/L on December 12, 2006; Appendix B). Chlorophyll *a* values ranged from 2 µg/L on November 14, 2006 to 120 µg/L on August 22, 2007. Three chlorophyll *a* values were greater than the state water quality standard of 40 µg/L during the assessment period. Creeping water primrose (*Ludwigia grandiflora*) present in Beaverdam Lake was treated with herbicide applications in 2009 and 2010 (NCDWR Aquatic Weed Program, 2009 and 2010).

Based on the calculated NCTSI scores, Beaverdam Lake was found to generally exhibit elevated biological productivity (eutrophic conditions). Excessively productive (hypereutrophic conditions) were present on July 12, 2007, August 22, 2007 and September 2, 2010. In May and August 2010, the swimming area at this lake was closed by Wake County Environmental Services for elevated bacteria levels based on the US Environmental Protection Agency (EPA) water quality standard of acceptable levels of enterococci (less than 61 CFU/100 ml). Levels at Beaverdam Lake in August were 78 CFU/100 ml (Environmental Services News Release, Wake County, NC. August 10, 2010).

Falls of the Neuse Reservoir



Ambient Lakes Program Name	Falls of the Neuse Reservoir										
<i>Trophic Status (NC TSI)</i>	Eutrophic										
<i>Mean Depth (meters)</i>	5.0										
<i>Volume (10⁶ m³)</i>	176.60										
<i>Watershed Area (mi²)</i>	769.9										
<i>Classification</i>	WS-IV, B; NSW, CA										
<i>Stations</i>	LC01	LLC01	NEU010	NEU013	NEU013B	NEU0171B	NEU018E	NEU019E	NEU019L	NEU019P	NEU020D
<i>Number of Times Sampled</i>	28	28	23	28	28	28	28	28	28	28	28

Falls of the Neuse Reservoir (Falls Lake) is a large impoundment of the upper Neuse River Basin. This reservoir is used for a variety of purposes including recreation, and as the main water supply reservoir for the City of Raleigh and surrounding towns in Wake County, NC. Falls Lake Dam was constructed in 1981 by the US Army Corps of Engineers (ACOE) and the reservoir began filling in 1983. This reservoir is located on the headwaters of the Neuse River, which is formed by the confluence of the Eno and Flat Rivers in Durham County. Other tributaries include the Little River, and Knap of Reeds, Ellerbe, Ledge, Lick, Little Lick, and Beaverdam Creeks. The watershed of this lake contains a mixture of urban, residential, agricultural and forested areas.

In 2005, the North Carolina General Assembly passed Session Law 2005-190 (also known as Senate Bill 981), which directed the Environmental Management Commission (EMC) to study water supply reservoirs in general and to develop and implement a nutrient management strategy based on a calibrated nutrient response model for certain reservoirs, including Falls Lake. In 2009, Senate Bill 1020 was ratified and signed into law as Session Law 2009-486. This revised the EMC adoption deadline to January 15, 2011 and added certain requirements for water quality improvements in the watershed. A nutrient management strategy was developed and presented to the EMC as draft rules 15A NCAC 2B .0275 through .0282 and .0213(q) in March 2010. Section 5(a) of the draft Goals Rules (15A NCAC 2B .0275) includes provisions for water quality monitoring of Falls Lake and to utilize the data to produce load reduction estimates and to perform periodic use support assessments. Monthly monitoring of Falls Lake began in May 2010 and will continue until 2021 or as required by the nutrient management strategy rules.

A total of 11 sites throughout the reservoir were sampled during each monitoring trip from October 10, 2006 through September 20, 2007. Site NEU010 was dropped from sampling beginning May 6, 2010. Data collected will include physical measurements, nutrients, chlorophyll *a*, and turbidity. These data are used to evaluate progress in attainment of water quality standards and use support in Falls Lake as required by the nutrient management strategy rules. Falls Lake is currently listed on the 2010 303(d) List for excessive turbidity and chlorophyll *a* (http://portal.ncdenr.org/c/document_library/get_file?uuid=8ff0bb29-62c2-4b33-810c-2eee5afa75e9&groupid=38364).

Falls Lake was monitored 28 times from October 10, 2007 to September 2, 2010. A significant drought impacted the Piedmont region of the state in 2007 -2008. During this drought, water levels in Falls Lake dropped significantly. By November 20th, 2007, the reservoir had reached a record low level of 242.62 feet-mean sea level (ft-msl), or 8.88 feet below the full pool level of 151 ft-msl (Figure 1). At this point, approximately 110 days of drinking water remained in the lake. This was supplemented by water from Lake Benson, which increased the water supply 21 days (WRAL News, November 21, 2007).



Figure 1. Falls of the Neuse Reservoir, November 20, 2007 (from WRAL-News, Capitol Broadcasting Company)

Surface water temperatures during the Neuse River Basin assessment period ranged from a low of 4.7 °C on January 30, 2007 to a high of 32.7 °C on August 8, 2007 (Appendix C). The lowest surface dissolved oxygen measurement recorded for the assessment period (4.0 mg/L) was observed at NEU019L (Falls Lake near Channel Marker 6 near Bayleaf) on September 19, 2007. The greatest dissolved oxygen measurement (14.6 mg/L) occurred in May 2007 near the mouth of Ellerbe Creek (ELL10). There were no values for surface dissolved oxygen below the state water quality standard of 4.0 mg/L during the basinwide assessment period. Two surface pH values out of 299 observations were greater than the state water quality standard of 9.0 s.u. for the upper pH limit. These values were 9.1 s.u. at the mouth of Ledge Creek (NEU018E) on July 11, 2007 and a value of 9.2 s.u. at the mouth of Ellerbe Creek (ELL10) on July 26, 2007. Secchi depths in Falls Lake are generally less than one meter with the exception of measurements taken at the lower end of the lake from May through August 2007 (Appendix D). A decrease in turbidity and solids (suspended and total) also occurred in the lower end of the reservoir during this time period. Limited rainfall associated with the drought may have contributed to a decrease in storm runoff and suspended sediments entering the lake.

Between October 11, 2006 and September 2, 2010, total phosphorus ranged from <0.02 mg/L to 0.71 mg/L, total Kjeldahl nitrogen ranged from 0.37 mg/L to 3.40 mg/L and total organic nitrogen ranged from 0.36 mg/L to 3.39 mg/L (Appendix D). Chlorophyll a values exceeded the state water quality standard of 40 µg/L 83 times out of a total of 294 observations (28%). The highest chlorophyll a value recorded was 230 µg/L on August 9, 2007 near the mouth of Ellerbe Creek.

Based on calculated NCTSI scores, Falls Lake was determined to be eutrophic (exhibiting elevated biological productivity) from October 11, 2006 to July 12, 2007. From July 25, 2007 to September 20, 2007, the lake was hypereutrophic (exhibiting extreme biological productivity). The calculated trophic state of Falls Lake returned to eutrophic during the monitoring period in 2010 (May through September).

Big Lake



Ambient Lakes Program Name	Big Lake	
Trophic Status (NC TSI)	Eutrophic	
Mean Depth (meters)	2.0	
Volume (10⁶ m³)	0.05	
Watershed Area (mi²)	7.0	
Classification	B; NSW	
Stations	NEU035G	NEU035H
Number of Times Sampled	5	5

Big Lake is located in Umstead State Park in northwestern Wake County, adjacent to the Raleigh-Durham International Airport. Sycamore Creek is impounded twice within the park, first forming Big Lake and then Sycamore Lake. Land use in Big Lake's watershed is primarily forest and agriculture; and urban development. Big Lake has a maximum depth of 16 feet (five meters) and a mean hydraulic retention time of 25 days.

Monitoring of Big Lake was performed monthly from May through September by DWQ field staff. In May, surface dissolved oxygen ranged from 8.3 mg/L near the dam (NEU035H) to 13.8 mg/L at the upper end of the lake (NEU035G). Surface percent dissolved oxygen saturation at the upper end of Big Lake was 162.5% (Appendix A). Both dissolved oxygen and percent oxygen saturation values were elevated. Notes by the field staff sampling the lake indicated that the lake water had the appearance of "green paint" and the upper end of the lake was silted in. Surface dissolved oxygen at this site was also low from July through September (range = 4.6 mg/L to 4.9 mg/L). Surface pH values were also elevated, ranging from 8.1 s.u. near the dam to 9.7 s.u. at the upper end of the lake. This latter value was greater than the state water quality pH standard of >9.0 s.u.

Secchi depths, and indicator of water clarity, were consistently less than a meter with the exception of the Secchi measurement near the dam in May (1.5 meters). The low Secchi depths suggest that light penetration through the lake water in 2010 was poor.

Total phosphorus ranged from 0.04 mg/L to 0.06 mg/L and total organic nitrogen ranged from 0.61 mg/L to 0.91 mg/L in 2010 (Appendix A). Total suspended solids were greatest at the upper end of the lake from June through September (range = 15 mg/L to 22 mg/L) as compared with values near the dam. Fecal coliform bacteria counts in Big Lake ranged from 1 to 39 colony forming units per 100 ml of lake water. The higher bacteria counts were consistently observed at NEU035G in the upper end of the lake.

Chlorophyll *a* values in Big Lake ranged from 4.8 µg/L to 40 µg/L, with the highest value recorded near the dam in August. A bloom of the blue-green alga *Aphanizomenon sp.* and *Microcystis sp.* were confirmed in May via analysis of water samples collected at NEU035G. Despite the confirmation of the algae bloom, the chlorophyll *a* value was low (4.8 µg/L).

Blue-black balls of algae were observed floating in Big Lake in May and remained present into July. The floating algae balls were mats of the filamentous blue green alga *Oscillatoria sp.* and organic matter. *Oscillatoria sp.* is very common in ponds, lakes and rivers throughout North Carolina. Mats of *Oscillatoria sp.* are dark green to bright blue green in color, slimy, and sometimes reported as “spilled paint”. Mats may collect on submerged vegetation but tend to be more common in the benthos (bottom) where filaments weave together in a mucilaginous matrix incorporating silt and sediments. Thick mats can create an anoxic (no oxygen) layer beneath them while also trapping the oxygen produced by photosynthesis inside the matrix. The combination of gases within and below can cause the mat to break away and float to the surface thereby creating blue, green and black floating clumps or balls.

Hydrilla (*Hydrilla verticillata*) is present in Big Lake. Control of this invasive weed is being managed by the NC Division of Water Resources, Aquatic Weed Program via grass carp stocking of the lake (NCDWR, 2007 and 2008). In 2010, the effectiveness of the grass carp stocking on the growth of hydrilla in the lake was monitored to determine if additional grass carp stocking would be needed (NCDWR, 2010).

Based on the calculated NCTSI scores, Big Lake was determined to exhibit elevated biological productivity (eutrophic conditions) in May through September 2010 on the days it was monitored. Big lake has been consistently eutrophic since it was first monitored by DWQ in 1981.

Reedy Creek Lake



<i>Ambient Lakes Program Name</i>	Reedy Creek Lake
<i>Trophic Status (NC TSI)</i>	Eutrophic
<i>Mean Depth (meters)</i>	2.0
<i>Volume (10⁶ m³)</i>	0.14
<i>Watershed Area (mi²)</i>	4.0
<i>Classification</i>	B; NSW
<i>Stations</i>	NEU035A7
<i>Number of Times Sampled</i>	5

Reedy Creek Lake is located in Umstead State Park, which is adjacent to the Raleigh Durham International Airport. This lake is relatively small with a surface area of 20 acres (eight hectares), a maximum depth of 13 feet (four meters) and a retention time of 11 days. Land use within the watershed is primarily forest and urban. This lake is one of three lakes (Big Lake, Reedy Creek and Sycamore) located within Umstead State Park. Reedy Creek Lake is used primarily for education and recreation.

This lake was monitored by DWQ field staff monthly from May through September 2010. Secchi depths were less than a meter with the exception of the measurement in May which was 1.3 meters (Appendix A). Secchi measurements less than a meter generally suggest poor water clarity. Surface dissolved oxygen was elevated and ranged from 8.2 mg/L to 9.9 mg/L. On July 7th, the percent dissolved oxygen saturation value at the surface of the lake was 133.7%. Also on July 7th, the surface ph value was elevated (9.0 s.u.).

Total phosphorus in Reedy Creek Lake ranged from 0.04 mg/L to 0.10 mg/L and total Kjeldahl nitrogen ranged from 0.48 mg/L to 1.00 mg/L (Appendix A). Total organic nitrogen concentrations ranged from 0.47 mg/L to 0.99 mg/L. Ammonia and nitrite plus nitrate concentrations, however, were less than the DWQ water quality laboratory detection levels. In response to the availability of nutrients, chlorophyll *a*, an indicator of algal productivity, ranged from 9.8 µg/L to 120.0 µg/L. The greatest chlorophyll *a* value (120 µg/L) occurred on August 4th.

Hydrilla (*Hydrilla verticillata*) a highly invasive aquatic plant, is present in Reedy Creek Lake. Control of this invasive weed is being managed by the NC Division of Water Resources, Aquatic Weed Program via grass carp stocking of the lake (NCDWR, 2007, 2008 and 2009). In 2010, a barrier was installed into the lake to concentrate the grass carp in a region of the lake where hydrilla remains problematic (NCDWR, 2010).

Reedy Creek Lake was determined to exhibit elevated biological productivity (eutrophic conditions) in May, June, July and September. In August, the NCTSI score for this lake indicated that conditions in the lake were exceptionally productive (hypereutrophic). Reedy Creek Lake was previously determined to be eutrophic in 1995 and mesotrophic (exhibiting moderate biological productivity) in 1991 when it was first monitored by DWQ.

Sycamore Lake



Ambient Lakes Program Name	Sycamore Lake
Trophic Status (NC TSI)	Eutrophic
Mean Depth (meters)	7.0
Volume ($10^6 m^3$)	0.17
Watershed Area (mi^2)	4.2
Classification	B; NSW
Stations	NEU035J
Number of Times Sampled	5

Sycamore Lake is the third of the three lakes monitored in Umstead State Park. Sycamore Lake, with a surface area of 22 acres and is relatively small. The maximum depth of 13 feet (four meters). Land use in the watershed is primarily forest and agriculture. Sycamore is used for recreation and education.

Sycamore Lake was monitored monthly from May through September 2010 by DWQ field staff. Surface dissolved oxygen ranged from 5.6 to 8.4 mg/L with the lowest surface dissolved oxygen reading observed in September (Appendix A). Surface water temperatures ranged from 24.2 °C to 29.3 °C and surface pH values ranged from 7.3 to 8.1 s.u. Secchi depths in Sycamore Lake were less than a meter (0.7 meter) from June through August. In May and September, the Secchi depths were at or slightly greater than one meter.

Total phosphorus concentrations were consistently 0.04 mg/L, total Kjeldahl nitrogen ranged from 0.62 mg/L to 0.90 mg/L and total organic nitrogen concentrations ranged from 0.60 mg/L to 0.89 mg/L (Appendix A). Ammonia and nitrite plus nitrate concentrations were at or less than DWQ laboratory detection levels with the exception of a nitrite plus nitrate value in May (0.06 mg/L). Chlorophyll *a* values for Sycamore Lake ranged from 13 µg/L in May to 38 µg/L in August.

Blue-black algae balls were observed floating in Sycamore Lake during June and July. It is not clear whether the algae in Sycamore Lake originated within the lake or came in from Big Lake upstream. The floating algae balls were composed of the filamentous blue-green alga, *Oscillatoria sp.*, and organic matter.

The invasive aquatic weed Hydrilla (*Hydrilla verticillata*) is present in Sycamore Lake. Control of this invasive weed is being managed by the NC Division of Water Resources, Aquatic Weed Program via grass carp stocking of the lake (NCDWR, 2007 and 2008). In 2010, the effectiveness of the grass carp stocking on the growth of hydrilla in the lake was monitored to determine if additional grass carp stocking would be needed (NCDWR, 2010)

Based on the calculated NCTSI scores, Sycamore Lake was determined to be very productive biologically (eutrophic) in 2010. This lake has been consistently eutrophic since it was first monitored by DWQ in 1991.

Lake Wheeler



<i>Ambient Lakes Program Name</i>	Lake Wheeler	
<i>Trophic Status (NC TSI)</i>	Eutrophic	
<i>Mean Depth (meters)</i>	4.0	
<i>Volume (10⁶ m³)</i>	7.60	
<i>Watershed Area (mi²)</i>	28.2	
<i>Classification</i>	WS-III; NSW	
<i>Stations</i>	NEU055A01	NEU055A02
<i>Number of Times Sampled</i>	5	5

Lake Wheeler is located in southwestern Wake County upstream of Lake Benson on Swift Creek. Approximately half of the watershed is forested, but urban and agricultural areas are also significant. This lake has a maximum depth of 30 feet (nine meters) and an average hydraulic retention time of 72 days. Lake Wheeler provides water for the City of Raleigh via flow to Lake Benson, which is located immediately downstream. This lake is also used extensively for recreational purposes including canoeing and kayaking.

Lake Wheeler was sampled monthly, from May through September, by DWQ field staff. During the summer of 2010, surface dissolved oxygen ranged from 6.4 to 8.2 mg/L and surface water temperature ranged from 21.2 °C to 31.7 °C (Appendix A). Surface pH values ranged from 7.1 s.u. to 9.1 s.u. This latter value, which was observed near the dam (NEU055A02) on July 14th, was greater than the state water quality standard of a pH upper limit of not greater than 9.0 s.u. Surface conductivity values ranged from 8.6 umhos to 103 in May and July 2010. Secchi depths in May were 1.0 to 1.1 meters and to 0.9 and 1.4 meters in June. The lower Secchi depth measurements for these two months were observed at the sampling site in the upper end of the lake (NEU055A01). From July through September, the Secchi depths for Lake Wheeler had dropped to below one meter, suggesting that the water clarity of the lake decreased as the summer progressed.

Total phosphorus ranged from 0.02 mg/L to 0.04 mg/L while total Kjeldahl nitrogen ranged from 0.45 mg/L to 1.00 mg/L and total organic nitrogen ranged from 0.43 mg/L to 0.99 mg/L (Appendix A). Ammonia concentrations ranged from 0.02 to 0.04 mg/L in May then decreased to concentrations less than the DWQ laboratory detection level. The concentration of nitrite plus nitrate in Lake Wheeler was consistently below the DWQ laboratory detection level in the summer of 2010. Chlorophyll a values ranged from 13 to 50 µg/L with the chlorophyll a values at the upper end of the lake in July (50 µg/L) and in August (44 µg/L) greater than the state water quality standard of 40 µg/L.

An analysis of phytoplankton samples from Lake Wheeler in July revealed the presence of an extreme bloom (>30,000 units/ml) which was dominated by the small filamentous blue-green alga, *Planktolyngbya* sp. The blue-green alga, *Cylindrospermopsis* sp., was also present. These alga are associated with taste and odor problems in drinking water, requiring additional treatment steps by the water treatment facility to alleviate the problem.

The turbidity values in Lake Wheeler were less than the state water quality standard of 25 NTUs and surface metals were within applicable state water quality standards. Based on the calculated NCTSI scores, Lake Wheeler was determined to be eutrophic (exhibiting an elevated level of biological productivity) in 2010. Nutrient concentration, chlorophyll a values and low Secchi depth measurements contributed to this finding. The trophic state of Lake Wheeler has varied between mesotrophic (moderate biological productivity) and eutrophic since it was first monitored by DWQ in 1981.

Lake Benson



<i>Ambient Lakes Program Name</i>	Lake Benson	
<i>Trophic Status (NC TSI)</i>	Eutrophic	
<i>Mean Depth (meters)</i>	3.0	
<i>Volume (10⁶ m³)</i>	3.60	
<i>Watershed Area (mi²)</i>	64.9	
<i>Classification</i>	WS-III; NSW	
<i>Stations</i>	NEU055A3	NEU055A4
<i>Number of Times Sampled</i>	5	5

Lake Benson is a man-made impoundment located in southern Wake County. The first impoundment on the site, called Rand's Mill Pond, was built in 1844. In 1927, the City of Raleigh purchased the land and the dam for use as a water supply. The reservoir was expanded in 1953 to bring the total storage watershed area of 65 mi² (168 km²) and a maximum depth of 20 feet (six meters). The primary tributary to the lake is Swift Creek. The topography of the drainage area is characterized by rolling hills with approximately half of the land area forested.

Lake Benson was a water supply source for the City of Raleigh from 1953 to 1987 when it was retired as a water supply source in 1987 with the expansion of the E.M Johnson water treatment facility at Falls of the Neuse Reservoir. With the increasing growth of Raleigh and surrounding areas in Wake County, a new water treatment facility was constructed at Lake Benson. The Dempsey E. Benton Water Treatment Plant was dedicated in May 2010 and has a capacity of producing 20 million gallons of drinking water per day (MGD) with the possibility of a future increase in production of up to 40 MGD. Because Lake Wheeler is located upstream of Lake Benson, water from this lake can be used to supplement the water in Lake Benson if needed.

The lake level in Lake Benson decreased by four feet from normal pool during the summer of 2010 to permit work on the dam. Surface dissolved oxygen in Lake Benson ranged from 6.1 mg/L at the upper end of the lake (NEU055A3) in August to 8.7 mg/L near the lower end of the lake (NEU055A4) in July (Appendix A). Surface water temperatures in Lake Benson were greatest in June (33.6 °C at the lower end of the lake). Surface pH values were within state water quality standards and surface conductivity

ranged from 87 to 102 umhos/cm. Secchi depths were consistently less than a meter, suggesting that the clarity of the water in Lake Benson was greatly reduced.

Photic zone total phosphorus ranged from 0.04 to 0.09 mg/L and total Kjeldahl nitrogen ranged from 0.69 to 1.20 mg/L (Appendix A). Total organic nitrogen also ranged from 0.68 to 1.19 mg/L. Both ammonia and nitrite plus nitrate were at or below DWQ laboratory detection level. In response to the availability of nutrients, chlorophyll *a* values were frequently greater than the state water quality standard of 40 µg/L. The greatest chlorophyll *a* values occurred in July (71 µg/L and 72 µg/L). The water level in the lake had dropped by three to four feet, increasing the concentration of nutrients in the lake. An analysis of phytoplankton samples taken from Lake Benson on July 14th and 15th indicated the presence of extreme blooms (≥ 100,000 units/ml) of the filamentous blue-green alga *Cylindrospermopsis* sp. Blue-green algae are associated with taste and odor problems in drinking water and additional treatment of raw water sources is frequently required to alleviate this problem.

Hydrilla (*Hydrilla verticillata*) is present in Lake Benson and the application of herbicides was planned for 2010 as a means of controlling this aquatic weed. (NCDWR, 2010). Based on the calculated NCTSI scores, Lake Benson was determined to exhibit elevated biological productivity (eutrophic) in 2010. This lake has been consistently eutrophic since it was first monitored in 1981 by DWQ, with the exception of 1988 when it was found to be moderately productive (mesotrophic).

Lake Crabtree



Ambient Lakes Program Name	Lake Crabtree		
Trophic Status (NC TSI)	Hypereutrophic		
Mean Depth (meters)	2.0		
Volume (10⁶ m³)	0.50		
Watershed Area (mi²)	51.4		
Classification	B; NSW		
Stations	NEUCL1	NEUCL2	NCECL3
Number of Times Sampled	5	5	5

Lake Crabtree was built in 1989 by the Soil Conservation Service as one of 11 lakes constructed for flood control. Wake County owns a park around the lake, which is used for recreational activities such as hiking and canoeing. The maximum depth of the lake is approximately 13 feet (four meters). Several point sources discharge upstream of Lake Crabtree and three tributaries - Crabtree Creek, Hales Branch, and Stirrup Iron Creek - drain portions of Cary, Morrisville, and the Raleigh-Durham International Airport into Crabtree Lake. A fish consumption advisory for carp and catfish taken from Lake Crabtree was issued on May 7, 2004 due to the presence of polychlorinated biphenyls (PCB) contamination (<http://www.epi.state.nc.us/epi/fish/current.html>).

Lake Crabtree was monitored monthly from May through September 2010 by DWQ field staff. Surface dissolved oxygen ranged from 6.7 mg/L to 8.7 mg/L and water temperatures ranged from 21.0 °C to 32.4 °C (Appendix A). Surface pH values were within state water quality standards and ranged from 6.7 to 8.6 s.u. Secchi depths were consistently less than a meter (range = 0.3 to 0.6 meter). These low Secchi depths indicate that light penetration into the lake's water is poor. Turbidity values for Lake Crabtree in 2010 were frequently greater than the state water quality standard of 25 NTUs for lakes and reservoirs. The highest turbidity value (60 NTUs) occurred at NEUCL1 in the Crabtree Creek arm of the lake in June.

Total phosphorus ranged from 0.07 mg/L to 1.10 mg/L, total Kjeldahl nitrogen ranged from 0.78 mg/L to 1.20 mg/L and total organic nitrogen ranged from 0.77 to 1.19 mg/L (Appendix A). Ammonia and nitrite plus nitrate were generally below the DWQ laboratory detection levels. Chlorophyll *a* values were greater than the state water quality standard of 40 µg/L at individual lake sampling sites from June through September. The greatest chlorophyll *a* value, 69 µg/L, occurred at the sampling site near the dam (NEUCL3) in July. Analysis of phytoplankton samples collected from Lake Crabtree in 2010 indicated that algal blooms were mild during June, moderate during July, and severe during August to September. Algal assemblages were dominated by the colonial green *Coelastrum sp.* during spring and by the filamentous blue-green *Cylindrospermopsis sp.* throughout the summer. The euglenoid *Trachelomona sp.* was also prevalent during July. Blue-green algae are common indicators of nutrient enriched water and may form unsightly water discoloration, surface films, flecks, mats as well as producing taste and odor problems in drinking water. Euglenoids are also indicators of nutrient enriched water and blooms may create the appearance of spilled green paint on the surface of a lake.

Based on the calculated NCTSI scores for 2010, Lake Crabtree was determined to exhibit extreme biological productivity (hypereutrophic). The trophic state of Lake Crabtree has alternated between eutrophic to hypereutrophic conditions since it was first monitored by DWQ in 1990.

Lake Crabtree is on the 2010 303(d) List for the fish consumption advisory due to PCB contamination and for turbidity values greater than the state water quality standard (http://portal.ncdenr.org/c/document_library/get_file?uuid=8ff0bb29-62c2-4b33-810c-2eee5afa75e9&groupId=38364).

Bass Lake



Ambient Lakes Program Name	Bass Lake	
Trophic Status (NC TSI)	Eutrophic	
Mean Depth (meters)	3.0	
Volume ($10^6 m^3$)	0.10	
Watershed Area (mi^2)	95.0	
Classification	B; NSW	
Stations	NEU057C	NEU057C1
Number of Times Sampled	5	5

Bass Lake is a public recreation lake located near Holly Springs in Wake County. Although the lake is primarily fed by Basal Creek, there are also two intermittent unnamed tributaries entering the lake. The original impoundment was created when Basal Creek was dammed to create a rice paddy. This effort was unsuccessful and subsequently the dam was raised and a gristmill installed. The current lake has a maximum depth of 11 feet (three and a half meters) and is used for recreational boating (canoeing) and fishing as part of the Bass Lake Park managed by the town of Apex.

Bass Lake was sampled monthly from May through September in 2010 by DWQ field staff. Surface dissolved oxygen ranged from 7.5 mg/L to 9.1 mg/L (Appendix A) and surface water temperatures ranged from 23.6 °C to 34.3 °C. Surface pH values ranged from 6.7 s.u. to 8.7 s.u. Surface conductivity values ranged from 58 to 74 μ mhos/cm. Secchi depths were greatest in September (1.0 meter) and less than a meter from May through August. Notes by field staff indicated that the lake water had a brown coloration in 2010.

Photic zone total phosphorus ranged from 0.05 mg/L to 0.12 mg/L, total Kjeldahl nitrogen ranged from 0.73 mg/L to 1.20 mg/L and total organic nitrogen concentrations ranged from 0.71 mg/L to 1.19 mg/L (Appendix A). Ammonia and nitrite plus nitrate were at or below DWQ laboratory detection levels. On August 12, 2010 a water sample was collected at the sampling site at the upper end of the lake (NEU057C) and shipped to the US Environmental Protection Agency laboratory in Athens, Georgia for an Algal Growth Potential Test. Results of the test determined that algae growth at the sampling site was limited by the availability of nitrogen. Chlorophyll *a* values in Bass Lake ranged from 33 μ g/L to 74 μ g/L and the lake-wide mean chlorophyll *a* values for May through September were greater than the state water quality standard of 40 μ g/L. The greatest individual chlorophyll *a* values (72 μ g/L and 74 μ g/L) occurred on July 15th. Algal blooms were mild during May, severe during June, July and September, and extreme during August. Algal assemblages were dominated by golden-brown algae in May and by filamentous blue-greens June to September. Blue-green algae are associated with lakes experiencing nutrient enrichment.

Bass Lake was determined to exhibit elevated biological productivity (eutrophic conditions) in May, June, August and September 2010, and extremely elevated biological productivity (hypereutrophic conditions) in July. Overall, Bass Lake was eutrophic during the summer of 2010. Both nutrient and chlorophyll *a*

values measured in Bass Lake in 2010 contributed to its trophic state. Bass Lake has been determined to be eutrophic since it was first monitored in 1987 by DWQ.

Lake Johnson



Ambient Lakes Program Name	Lake Johnson	
Trophic Status (NC TSI)	Eutrophic	
Mean Depth (meters)	3.0	
Volume (10⁶ m³)	0.70	
Watershed Area (mi²)	7.1	
Classification	B; NSW	
Stations	NEU042C	NEU0431A
Number of Times Sampled	5	5

Lake Johnson is owned by the City of Raleigh and is located in Wake County. The original use of the lake was as an auxiliary water supply for the City of Raleigh, but the lake is now used solely for recreation. Lake Johnson is essentially subdivided into two basins by a road crossing at mid-lake. The lake has a maximum depth of 20 feet (six meters) and Walnut Creek is the major lake tributary. In recent years, the predominantly forested and agricultural watershed has become increasingly urban.

Surface dissolved oxygen values for Lake Johnson in 2010 were within state water quality standards and ranged from 5.7 mg/L at the upper end of the lake (NEU042C) in June to 9.2 mg/L at the lower end of the lake (NEU0431A) in May (Appendix A). Surface water temperatures ranged from 21.3 °C in May to 31.2 °C in June. Both of these measurements were made at the upper end of the lake. Surface pH values were within state water quality standards (range = 6.9 to 7.8 s.u.) and surface conductivity was found to be greatest in May (127 to 129 µmhos/cm). Secchi depths, and indication of the clarity of the lake water, were greatest at the lower end of the lake (range = 1.1 to 1.7 meters) and lower in the upper end of the lake (range = 0.6 to 0.9 meter).

Photic zone total phosphorus in Lake Johnson ranged 0.02 mg/L to 0.08 (Appendix A) with the greatest concentrations of this nutrient present in the upper end of the lake from June through September. Total Kjeldahl nitrogen (range = 0.43 mg/L to 0.71 mg/L) and total organic nitrogen (0.42 to 0.70 mg/L) also exhibited a similar pattern of greater concentrations in the upper end of Lake Johnson as compared with the lower end. Concentrations of ammonia and nitrite plus nitrate were consistently less than the DWQ laboratory detection levels. Chlorophyll *a* values ranged from 11 µg/L in May to 45 µg/L in September. This latter value was greater than the state water quality standard of 40 µg/L. As with the nutrients in Lake Johnson, the greater chlorophyll *a* values each month were found in the upper end of the lake as compared with the lower end. An analysis of a phytoplankton sample collected from the lake in July uncovered the presence of a moderate algae bloom completely dominated by *Planktolyngbya* sp., a small filamentous blue-green alga.

Based on the calculated NCTSI scores for 2010, Lake Johnson was determined to exhibit elevated biological productivity (eutrophic conditions). Total phosphorus and total organic nitrogen concentrations along with low Secchi depths contributed to this finding. The trophic state of this lake has varied between oligotrophic (very low productivity) and eutrophic since it was first monitored by DWQ in 1981.

LAKE & RESERVOIR ASSESSMENTS

HUC 03020202

Cliffs of the Neuse Lake



<i>Ambient Lakes Program Name</i>	Cliffs of the Neuse Lake
<i>Trophic Status (NC TSI)</i>	Mesotrophic
<i>Mean Depth (meters)</i>	9.0
<i>Volume ($10^6 m^3$)</i>	0.10
<i>Watershed Area (mi^2)</i>	0.4
<i>Classification</i>	B; NSW
<i>Stations</i>	NEU07113A
<i>Number of Times Sampled</i>	5

Cliffs of the Neuse Lake is located in a state-owned park of the same name in Wayne County. The lake has a maximum depth of 194 feet (59 meters). Mill Creek, the only significant tributary, was impounded to form the lake in 1953. The small watershed is completely forested and contained entirely in the park. The lake is used for recreational swimming, boating and education.

This lake was sampled five times in 2010 by DWQ staff. Surface dissolved oxygen ranged from 6.8 mg/L in August to 8.3 mg/L in May and June (Appendix A). Surface water temperatures ranged from 23.5 °C in May to 31.0 °C in July. Surface pH values ranged from 4.2 to 4.4 s.u., which is a natural condition for this lake. The acidic pH level in Cliffs of the Neuse Lake is due to the presence of an aquifer beneath the state park that contains iron sulfite which forms sulfuric acid. Springs are present in the bottom of Cliffs of the Neuse Lake that release this acidic water from the aquifer into the lake. Surface conductivity was lowest in September (75 μ mhos/cm) and greatest in August (88 μ mhos/cm). Secchi depths in Cliffs of the Neuse Lake were greater than one meter (range = 1.4 to 2.4 meters) indicating good light penetration into the lake's water column.

Total phosphorus concentrations were generally below DWQ laboratory detection levels in 2010 (Appendix A). Concentrations of total Kjeldahl nitrogen ranged from 0.26 mg/L to 0.41 mg/L and total organic nitrogen ranged from 0.25 mg/L to 0.40 mg/L. Ammonia was 0.07 mg/L in May and decreased to levels below the DWQ laboratory detection level from June through September. Chlorophyll a values started at 10 μ g/L in May and increased to 31 μ g/L by September.

Cliffs of the Neuse Lake was determined to exhibit elevated biological productivity in May, primarily due to the nutrient concentrations in the lake. From June through August, the calculated NCTSI scores indicated that the lake had become moderately productive (mesotrophic) and by September, the lake's productivity was low (oligotrophic). Overall, Cliffs of the Neuse Lake was determined to be moderately productive during the summer of 2010. Cliffs of the Neuse Lake has previously been found to fluctuate between oligotrophic and mesotrophic conditions since it was first monitored by DWQ in 1981.

LAKE & RESERVOIR ASSESSMENTS

HUC 03020203

Buckhorn Reservoir



Ambient Lakes Program Name	Buckhorn Reservoir	
Trophic Status (NC TSI)	Eutrophic	
Mean Depth (meters)	1.2	
Volume ($10^6 m^3$)	3.80	
Watershed Area (mi^2)	154.8	
Classification	WS-V; NSW	
Stations	NEU084B	NEU084C
Number of Times Sampled	5	5

Buckhorn Reservoir is a shallow impoundment which serves as the water supply for the City of Wilson. Completed in 1976, this reservoir has a maximum depth of eight feet (2.4 meters). The drainage area consists of flat land used for agriculture and forests. Turkey Creek and Moccasin Creek are the primary tributaries to Buckhorn Reservoir.

This lake was monitored monthly from May through September by DWQ field staff in 2010. Surface dissolved oxygen ranged from 5.2 mg/L in July to 8.7 mg/L in September (Appendix A). In July, both of the lake sampling sites exhibited low surface dissolved oxygen, but these values were not less than the state minimum water quality standard of 4.0 mg/L for an instantaneous reading. Surface water temperature in Buckhorn Reservoir ranged from 21.4 °C in May to 32.3 °C in June. Surface pH values were within the state water quality standard of not less than 6.0 and not more than 9.0 s.u. Secchi depths in Buckhorn Reservoir were less than a meter in May, June July and September, and slightly greater than a meter in August. The Secchi depths measurements suggest that light penetration into the lake water column is poor. Despite this, turbidity measurements in 2010 were low and well within the state water quality limit of 25 NTUs for lakes and reservoirs. Surface metals and hardness were within the applicable state water quality standards in 2010.

Photic zone total phosphorus concentrations ranged from 0.02 mg/L to 0.04 mg/L while total organic nitrogen ranged from 0.57 mg/L to 0.82 mg/L and total Kjeldahl nitrogen ranged from 0.58 mg/L to 0.83 mg/L (Appendix A). Ammonia and nitrite plus nitrate values were greatest in May, then dropped to below DWQ laboratory detection levels from June through September. Chlorophyll *a* values ranged from 13 to 25 $\mu g/L$ May and June. In July, the chlorophyll *a* value at the upper end of the lake (NEU084B; 42 $\mu g/L$) was greater than the state water quality standard of 40 $\mu g/L$. In August and September, the chlorophyll *a* values at both lake sampling sites were greater than the state water quality standard with the greatest value (70 $\mu g/L$) occurring at the upstream lake sampling site in September. Algal blooms were mild during June, severe during July to August, and moderate to severe during September. Algal assemblages were dominated by filamentous blue-green algae including *Cylindrospermopsis sp.*,

Aphanizomenon sp., and *Planktolyngbya sp.*, throughout the study. Blue-green algae are common indicators of nutrient enriched water and may form unsightly water discoloration, surface films, flecks, mats as well as producing taste and odor problems in drinking water.

Based on the calculated NCTSI scores, Buckhorn Reservoir was determined to be eutrophic (exhibiting elevated biological productivity). Buckhorn Reservoir has been consistently eutrophic since it was first monitored by DWQ in 1988.

Lake Wilson



Ambient Lakes Program Name	Lake Wilson
Trophic Status (NC TSI)	Hypereutrophic
Mean Depth (meters)	4.9
Volume ($10^6 m^3$)	0.70
Watershed Area (mi^2)	40.2
Classification	WS-III; NSW
Stations	NEU096B4
Number of Times Sampled	5

Lake Wilson is a small reservoir located on Toisnot Swamp, downstream of Silver Lake. The maximum depth of this lake is 8.5 feet (2.6 meters) and the drainage area consists of swamps and areas used agriculture and residential homes.

This reservoir was monitored five times from May through September by DWQ field staff. The Secchi depths in May was 1.0 meter in May and less than a meter from June through September (Appendix A). These low Secchi depths were similar to those previously measured in this lake. Turbidity values in 2010 were below the state water quality standard of 25 NTUs and notes made by field staff indicate that the lake appeared to be brown and perhaps tannin-stained (i.e., tea colored).

Surface dissolved oxygen in Lake Wilson ranged from 3.7 mg/L in July to 8.8 mg/L in September. The surface dissolved oxygen value in July was lower than the state water quality standard of 4.0 mg/L for an instantaneous reading. Surface water temperatures ranged from 21.7 C in May to 31.6 C in August and surface pH values ranged from 6.3 to 8.0 s.u.

Photic zone total phosphorus ranged from 0.07 mg/L to 0.11 mg/L, total Kjeldahl nitrogen ranged from 0.86 mg/L to 1.20 mg/L and total organic nitrogen ranged from 0.85 mg/L to 1.19 mg/L (Appendix A). Nitrite plus nitrate was less than the DWQ laboratory detection level as were the concentrations for ammonia, with the exception of the ammonia concentration for July (0.11 mg/L). In response to the availability of nutrients in Lake Wilson, chlorophyll *a* values in June (48 $\mu g/L$), July (46 $\mu g/L$) and September (47 $\mu g/L$) were greater than the state water quality standard of 40 $\mu g/L$. Surface metals and hardness were within applicable state water quality standards

Lake Wilson was determined to be hypereutrophic (exhibiting extremely high biological productivity) in 2010 based on the calculated NCTSI scores. Lake Wilson was previously determined to be eutrophic (having elevated biological productivity) in 1991 and 1995 when it was previously monitored by DWQ.

Wiggins Mill Reservoir



<i>Ambient Lakes Program Name</i>	Wiggins Mill Reservoir	
<i>Trophic Status (NC TSI)</i>	Eutrophic	
<i>Mean Depth (meters)</i>	0.5	
<i>Volume (10⁶ m³)</i>	0.60	
<i>Watershed Area (mi²)</i>	237.1	
<i>Classification</i>	WS-IV; NSW, CA	
<i>Stations</i>	NEU084D	NEU084F
<i>Number of Times Sampled</i>	5	5

Contentnea Creek was impounded in 1915 to form Wiggins Mill Reservoir. Forty years later, the dam was raised by a foot, increasing the lake to 200 acres (81 hectares) in surface area. The City of Wilson owns Wiggins Mill Reservoir, which uses it as a water supply. Access is restricted to boats with electric motors. Land use in the Contentnea Creek watershed is dominated by agriculture with some forested areas and residential development. The water of Wiggins Mill Reservoir has a distinctive tannin or tea-color which is due to water from Bloomery and Contentnea Creek Swamps flowing into the reservoir.

Wiggins Mill Reservoir was sampled monthly from May through September 2010 by DWQ field staff. Surface dissolved oxygen was lowest in May (5.4 mg/L at both lake sampling sites; Appendix A) and the greatest surface dissolved oxygen values were observed the following month (7.5 and 7.7 mg/L). Surface water temperatures ranged from 22.1°C in May to 31.7°C in July. Surface pH values in this reservoir ranged from 5.9 s.u. near the dam (NEU084F) in June to 7.2 s.u. at the same site in July. The surface pH values for this reservoir are generally low due to the inflow of low pH swamp water and values observed in 2010 were similar to those recorded on previous DWQ monitoring trips. Secchi depths were less than one meter and may have been reduced by the tea-coloration of the lake water.

Total phosphorus concentrations in Wiggins Mill Reservoir ranged from 0.05 mg/L to 0.10 mg/L, total Kjeldahl nitrogen ranged from 0.69 mg/L to 0.83 mg/L and total organic nitrogen ranged from 0.65 mg/L to 0.84 mg/L (Appendix A). Chlorophyll *a* values ranged from 11 µg/L (in May) to 39 µg/L (in July). Total suspended solids (57 mg/L) and turbidity (36 NTUs) values were greatest at the upper end of the reservoir on September 9th. The turbidity value for September was greater than the state water quality standard of 25 NTU for lakes.

Based on the calculated NCTSI scores, Wiggins Mill Reservoir was determined to exhibit an elevated level of biological productivity (eutrophic conditions) in 2010. This reservoir has been found to be consistently eutrophic since it was first monitored by DWQ in 1988.

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