

LAKE & RESERVOIR ASSESSMENTS PASQUOTANK RIVER BASIN



Lake Phelps

Intensive Survey Unit
Environmental Sciences Section
Division of Water Quality
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GLOSSARY

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| 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 a is an algal pigment that is used as an approximate measure of algal biomass. The concentration of chlorophyll a 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 dissolved 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. |

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|-------------------------------------|--|
| 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 <i>a</i> 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 Pasquotank River Basin consists of 3,697 square miles of flat lands and vast open waters of the northeastern portion of the state. The Pasquotank River is freshwater upstream of Elizabeth City and becomes brackish and tidally influenced downstream. The Alligator River near Lake Phelps is a large blackwater river that is designated as an Outstanding Resource Water. The Alligator National Wildlife Refuge extends along the entire eastern shore of the Alligator River. Lake Phelps is owned by the NC State Parks and is also designated as an Outstanding Resource Water. The lake shore of Lake Phelps consist of wooded swampland transitioning to agricultural land.

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. 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 Pasquotank River Basin (<http://www.epi.state.nc.us/epi/fish/current.html>).

Following the description of the assessment methodology used for the Pasquotank 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.

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.

LAKE & RESERVOIR ASSESSMENTS

HUC 03010205

Lake Phelps



| Ambient Lakes Program Name | Lake Phelps | | |
|----------------------------|--------------|---------|---------|
| Trophic Status (NC TSI) | Oligotrophic | | |
| Mean Depth (meters) | 2.0 | | |
| Volume ($10^6 m^3$) | 98.7 | | |
| Watershed Area (mi^2) | n/a | | |
| Classification | B Sw ORW | | |
| Station | PAS012B | PAS012C | PAS012D |
| Number of Times Sampled | 5 | 5 | 5 |

Lake Phelps, the second largest natural lake in North Carolina, is located in the eastern part of the state in Washington and Tyrrell Counties. It lies on a vast peninsula between Albemarle Sound on the north and the Pamlico River on the south. This peninsula contains numerous low-lying swampy areas underlain by thick organic muck and relatively well-drained areas with fertile mineral and organic soils. Much of the region has been cleared of vegetation, drained, and put into large scale agricultural use. Lake Phelps is recharged by natural precipitation with a small fraction coming from underground aquifers. There is no known overland flow into the lake as it occupies the highest elevation in the area. Lake Phelps has an average retention time of 1161 days, and, because of its shallow depth and wind mixing, the water column does not stratify. Lake Phelps is a Carolina Bay Lake. These lakes are characteristically shallow, oval in shape with a northwest to southeast orientation and have low pH waters that are usually tea-colored from tannins leached from underlying peat beds.

Lake Phelps is owned by the State of North Carolina and is associated with Pettigrew State Park and is used for recreational activities such as fishing and boating. Lake Phelps is unique in that it is inhabited by *Myriophyllum tenellum*, a species of milfoil not previously found south of New Jersey. The N.C. Wildlife Resources Commission has conducted several studies of fish populations in Lake Phelps. The lake currently supports a high quality fishery of largemouth bass, yellow perch, and sunfishes.

Historically, Lake Phelps has been used as a water source for fighting local peat fires. On June 1, 2008, a wildfire started in the Evans Road area on the southeast side of the lake and quickly spread through the Pocosin Lakes National Wildlife Refuge. The fire burned over 40,000 acres for several months before it was finally suppressed. Three canals were dug into Lake Phelps on the southeast side to allow use of

the lake water for fire suppression activities. Approximately two billion gallons of water were pumped from Lake Phelps, New Lake and the Alligator River during the course of the fire. The three canals were filled after the fire was under control.

Lake Phelps was monitored five times in 2009 by ISU field staff to determine if fire suppression activities conducted in the summer of 2008 and atmospheric deposition from smoke in the area had adverse affect on water quality in the lake. In May 2009, the depth of the lake was down by two feet due to water withdrawn to fight the peat fire. By June, the lake level had returned to normal.

Dissolved oxygen concentrations at the surface ranged from 7.6 mg/L to 8.0 mg/L and surface water temperatures were less than the state water quality standard of 32 °C during the summer of 2009 (Appendix A). Due to the shallowness of the lake and the large surface area or fetch, the water column was well mixed and dissolved oxygen values at the bottom of the lake was similar to that at the surface. The pH values in this lake are naturally low due to the underlying and surrounding peat beds. In 2009, theses values ranged from 5.2 s.u. to 7.7 s.u. Secchi depths were frequently down to the lake bottom and ranged from 0.7m to 1.8m. The lowest Secchi depths observed during each sampling trip were at the sampling site located at the southeastern end of the lake (PAS012D) where wind and wave action suspended peat particles into the water column. Secchi depths at this site ranged from 0.7m to 1.5m.

Chlorophyll *a* values ranged from 1.7 µg/L to 7.5 µg/L. Nutrient concentration patterns in 2009 were similar to those previously observed in this Lake and do not indicate an increase in nutrient loading (Appendix A). Concentrations of total suspended solids (range = 14.0 to 15.0 mg/L) were greatest in May and may have been associated with the low level of the lake and the suspension of peat particles into the water column from rainfall that occurred the day before the lake was sampled. Values for total suspended solids from June to September were generally less than the laboratory detection levels. Turbidity values in Lake Phelps ranged from 1.6 to 11.0 NTU, and were well below the state water quality standard of 25 NTU for lakes.

A low-level mercury sample collected at PAS012D in May had a value of 1.71 ng/L. This value did not exceed the state water quality standard of 12.00 ng/L.

The water in Lake Phelps is clearer than that of typical Carolina Bay Lakes, which allows for more accurate Secchi depth measurements and calculation of NC Trophic State Index Score (NCTSI). In 2009, Lake Phelps was determined to have moderate biological productivity (mesotrophic) in May and June and very low biological productivity (oligotrophic) in July through September. The decreased Secchi depths associated with suspension of peat particles in the water column along with the moderate levels of total organic nitrogen (which may have been associated with the suspended peat material in the water column) contributed to a higher NCTSI score in May and June. Calculated NCTSI scores from previous monitoring efforts by DWQ field staff have indicated similar shifts between oligotrophic and mesotrophic conditions in Lake Phelps.

**Appendix A – Pasquotank River Basin Lakes Data
October 1, 2006 through September 31, 2010**

| SURFACE PHYSICAL DATA | | | | | | | | |
|-----------------------|--------------------|---------------------|------------|---------------------|------------|-------------------|---------------------------|----------------------|
| Lake | Date m/d/yr | Sampling Station | DO mg/L | Water Temp. C | pH s.u. | Cond. µmhos/cm | Depth Secchi meters | DO Percent SAT |
| PHELPS LAKE | September 24, 2009 | PAS012B | 8.0 | 26.1 | 5.0 | 135 | 1.3 | 98.8% |
| | September 24, 2009 | PAS012C | 7.9 | 25.9 | 5.0 | 139 | 1.6 | 97.2% |
| | September 24, 2009 | PAS012D | 7.5 | 26.4 | 5.1 | 140 | 0.9 | 93.1% |
| | August 25, 2009 | PAS012B | 7.6 | 28.6 | 5.0 | 144 | 1.6 | 98.2% |
| | August 25, 2009 | PAS012C | 7.5 | 28.3 | 5.0 | 144 | 1.8 | 96.4% |
| | August 25, 2009 | PAS012D | 7.4 | 28.3 | 4.9 | 145 | 1.5 | 95.1% |
| | July 20, 2009 | PAS012B | 7.6 | 26.8 | 4.7 | 144 | 1.4 | 95.1% |
| | July 20, 2009 | PAS012C | 7.6 | 26.5 | 4.9 | 144 | 1.3 | 94.6% |
| | July 20, 2009 | PAS012D | 7.8 | 27.0 | 5.2 | 141 | 1.4 | 97.9% |
| | June 25, 2009 | PAS012B | 7.8 | 27.0 | 4.8 | 157 | 1.4 | 97.9% |
| | June 25, 2009 | PAS012C | 7.9 | 27.2 | 4.9 | 155 | 0.9 | 99.5% |
| | June 25, 2009 | PAS012D | 8.3 | 27.0 | 4.9 | 155 | 0.7 | 104.2% |
| | May 27, 2009 | PAS012B | 7.9 | 24.6 | 5.0 | 163 | 0.8 | 94.9% |
| | May 27, 2009 | PAS012C | 7.9 | 24.3 | 5.0 | 160 | 0.9 | 94.4% |
| | May 27, 2009 | PAS012D | 7.7 | 24.6 | 5.0 | 162 | 0.8 | 92.5% |

| Lake | Date m/d/yr | Sampling Station | PHOTIC ZONE DATA | | | | | | | | | | Total Solids Suspended mg/L | Turbidity NTU | COMMENTS | Surface Hg µg/L |
|-------------|--------------------|---------------------|------------------|-------------|-------------|-------------|------------|-------------|-------------|--------------|-------------------------|------|--------------------------------------|------------------------|----------|-----------------------|
| | | | TP mg/L | TKN mg/L | NH3 mg/L | NOx mg/L | TN mg/L | TON mg/L | TIN mg/L | Chla µg/L | Solids Total mg/L | | | | | |
| PHELPS LAKE | September 24, 2009 | PAS012B | <0.02 | <0.2 | <0.02 | <0.02 | 0.11 | 0.09 | 0.02 | 1.7 | 90 | <6.2 | 2.1 | | | |
| | September 24, 2009 | PAS012C | <0.02 | <0.2 | <0.02 | <0.02 | 0.11 | 0.09 | 0.02 | 1.9 | 88 | <6.2 | 2.0 | | | |
| | September 24, 2009 | PAS012D | 0.02 | <0.2 | 0.02 | <0.02 | 0.11 | 0.08 | 0.03 | 3.9 | 82 | 7.5 | 5.5 | | | |
| | August 25, 2009 | PAS012B | <0.02 | <0.2 | <0.02 | <0.02 | 0.11 | 0.09 | 0.02 | 3.4 | 88 | <6.2 | 2.4 | | | |
| | August 25, 2009 | PAS012C | <0.02 | <0.2 | <0.02 | <0.02 | 0.11 | 0.09 | 0.02 | 2.6 | 100 | <6.2 | 1.6 | | | |
| | August 25, 2009 | PAS012D | <0.02 | <0.2 | <0.02 | <0.02 | 0.11 | 0.09 | 0.02 | 3.7 | 82 | <6.2 | 3.5 | | | |
| | July 20, 2009 | PAS012B | <0.02 | <0.2 | <0.02 | <0.02 | 0.11 | 0.09 | 0.02 | 3.3 | 91 | <6.2 | 2.3 | | | |
| | July 20, 2009 | PAS012C | <0.02 | <0.2 | <0.02 | <0.02 | 0.11 | 0.09 | 0.02 | 3.7 | 98 | 7.2 | 2.1 | | | |
| | July 20, 2009 | PAS012D | <0.02 | <0.2 | <0.02 | <0.02 | 0.02 | 0.00 | 0.02 | 2.4 | 88 | <6.2 | 2.0 | | | |
| | June 25, 2009 | PAS012B | <0.02 | 0.23 | 0.02 | <0.02 | 0.24 | 0.21 | 0.03 | 2.2 | 92 | <6.2 | 3.4 | | | |
| | June 25, 2009 | PAS012C | <0.02 | 0.26 | 0.02 | <0.02 | 0.27 | 0.24 | 0.03 | 2.6 | 89 | <6.2 | 3.0 | | | |
| | June 25, 2009 | PAS012D | 0.02 | 0.45 | 0.06 | 0.04 | 0.49 | 0.39 | 0.10 | 7.5 | 120 | 12.0 | 8.1 | | | |
| | May 27, 2009 | PAS012B | 0.02 | 0.31 | <0.02 | <0.02 | 0.32 | 0.30 | 0.02 | 5.7 | 110 | 15.0 | 11.0 | | | |
| | May 27, 2009 | PAS012C | 0.02 | 0.31 | 0.02 | <0.02 | 0.32 | 0.29 | 0.03 | 4.9 | 140 | 12.0 | 8.4 | | | |
| | May 27, 2009 | PAS012D | 0.02 | 0.27 | <0.02 | 0.02 | 0.29 | 0.26 | 0.03 | 4.8 | 160 | 14.0 | 7.7 | Hg Field Blank = <1.00 | 1.71 | |