LAKE & RESERVOIR ASSESSMENTS
NEW RIVER BASIN

ASU Lake

Intensive Survey Unit
Environmental Sciences Section
Division of Water Resources
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TABLE OF CONTENTS

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 may be determined by the algal density as follows:

Mild bloom = 10,000 to 20,000 units/ml

Mild 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) found in almost every aquatic environment including fresh and marine waters, as well as moist soils. 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 from the surface to the lake bottom produces a curve known as clinograde curve.

Coccoid 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. The concentrations listed are the range of values observed in surface readings from the sampling locations.

Dissolved oxygen A measurement of oxygen 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 high biological productivity and low water transparency.

Eutrophication	The process of physical, chemical, and biological changes associated with nutrient, organic matter, and silt enrichment and sedimentation of a lake.
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 northern 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). It takes the nutrients present along with chlorophyll *a* and Secchi depth to calculate a lake's 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. DWR 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 New River is part of the oldest river system in North America and flows through rugged terrain containing metamorphic rocks that are 1.1 billion years old. The basin is located within the Blue Ridge Province of the Appalachian Mountains in the northwest corner of the state in Watauga, Ashe and Alleghany counties. It is the state's fourth smallest river basin, encompassing a 765 square-mile watershed drained by approximately 825 miles of streams. The New River originates at the confluence of the North Fork New River and South Fork New River in northeastern Ashe County, flowing northeast into Virginia before eventually flowing into the Kanawha River. One lake (Appalachian State University Lake) was sampled in this river basin by DWR staff in 2013.

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

Assessment Methodology

For this report, data from January 1, 2009 through December 31, 2013 were reviewed. Lake monitoring and sample collection activities performed by DWR field staff are in accordance with the Intensive Survey Unit Standard Operating Procedures Manual (http://portal.ncdenr.org/c/document_library/get_file?uuid=522a90a4-b593-426f-8c11-21a35569dfd8&groupId=38364) An interactive map of the state showing the locations of lake sites sampled by DWR may be found at http://portal.ncdenr.org/web/wq/ambient-lakes-map.

All lakes were sampled during the growing season from May through September. 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 DWR 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://portal.ncdenr.org/web/wq/ess/isu. The 1992 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.

Quality Assurance of Field and Laboratory Lakes Data

Data collected in the field via single or multiparameter water quality meters are entered into the Ambient Lakes Database within 24 hours of the sampling date. These data are then reviewed for accuracy and completeness within a week of entry. Data that have not been reviewed are given a 'P' code for 'Provisional' (data has been entered but not been verified for accuracy and/or completeness). Data that have been verified are given an 'A' code for 'Accepted'.

Chemistry data from the DWR Water Quality Laboratory are entered into the Lakes Database within 48 hours of receipt from the lab. As with the field data, laboratory results are coded 'P' until the entered data is verified for entry accuracy and completeness, after which, the code is changed to 'A'. Generally, laboratory data entered into the Lakes Database are verified within a week following the initial entry.

Data, either laboratory or field, which appear to be out of range for the lake sampled are double checked against field sheets or the laboratory results form by the Lakes Data Administrator for possible data entry error. If there are data entry mistakes, possible equipment, sampling, and/or analysis errors, these are investigated and corrected if possible. If the possible source of an error cannot be determined, the data remains in the database. If an error is determined, the data value is removed from the appropriate database parameter field and placed in the 'Notes' field along with a comment regarding the error. Chemistry results received from the laboratory that have been given an qualification code are also entered into the 'Notes' field along with the assigned laboratory code. Laboratory qualification coded data or data which may be in error due to sampling, handling, and/or equipment problems are only entered into the 'Notes' field and never in the data field(s) in the Ambient Lakes Database.

Additional information regarding the Quality Assurance Program is covered in the Ambient Lake Monitoring Program Quality Assurance Plan. Version 1.1 (July 2012) of this document is available on the ISU website (http://portal.ncdenr.org/web/wq/ess/isu).

Weather Overview for Summer 2013

May 2013 started off cool but became warmer the second half of the month. Storms during this month tracked to the west and brought substantial rainfall to western NC (Figure 1). The City of Boone, located in the New River Basin, reported their wettest May on record.

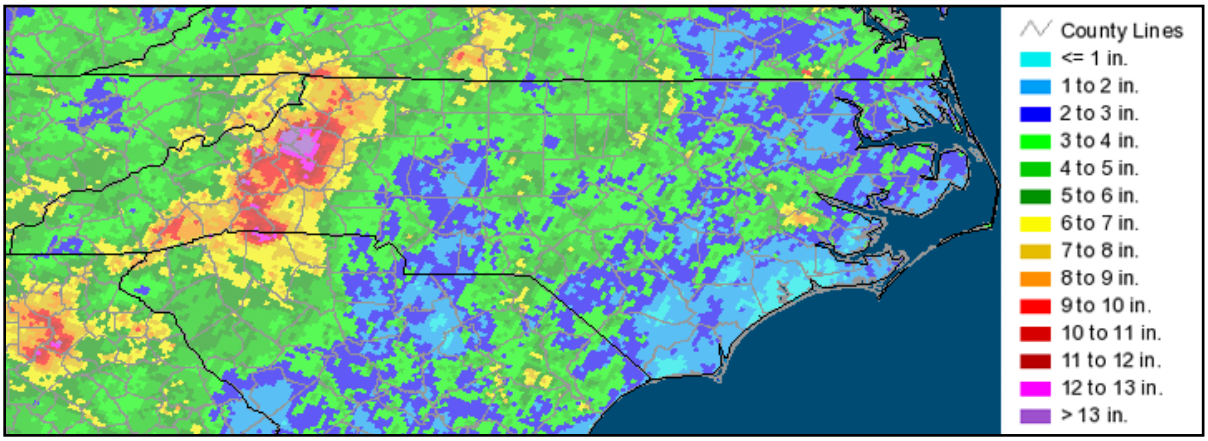

Figure 1. Precipitation for May 2013 based on estimates from NWS Radar. (Data courtesy NNWS/NCEP)

Statewide temperatures in June were closer to the historical mean for the month. Tropical storm Andrea passed through North Carolina on June 7, 2013, and brought rainfall that eliminated the abnormally dry conditions in the eastern part of the state (Figure 2). For the first time since April 2010, no part of NC was experiencing drought conditions.

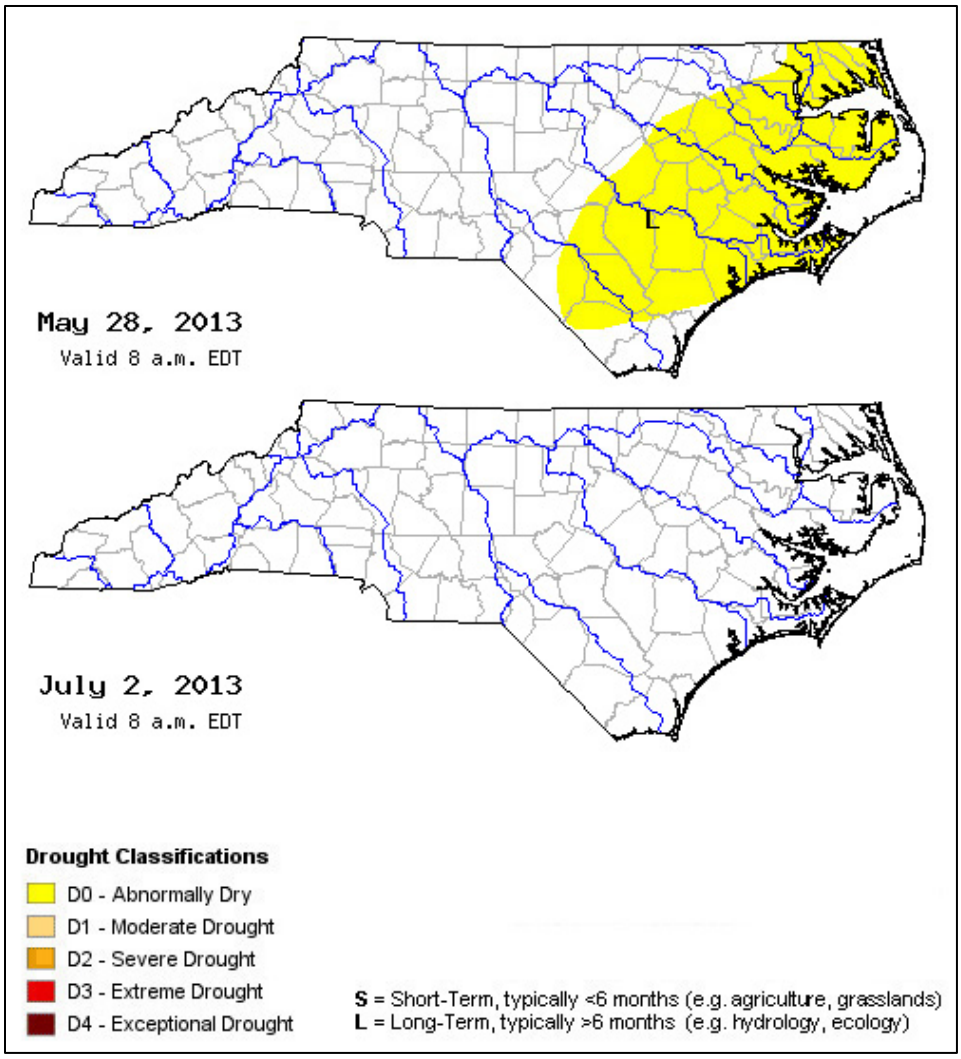

Figure 2. US Drought Monitor Maps for North Carolina showing changes in abnormally dry conditions from the end of May to early July (Image courtesy NCDENR Water Resources).

The wet pattern continued through June, bringing several storms that brought substantial rainfall across the state (Figure 3). June 2013 was ranked as the second wettest June on record since 1895. Most areas of the New River Basin received between 105% to 200% of normal rainfall for the month of June.

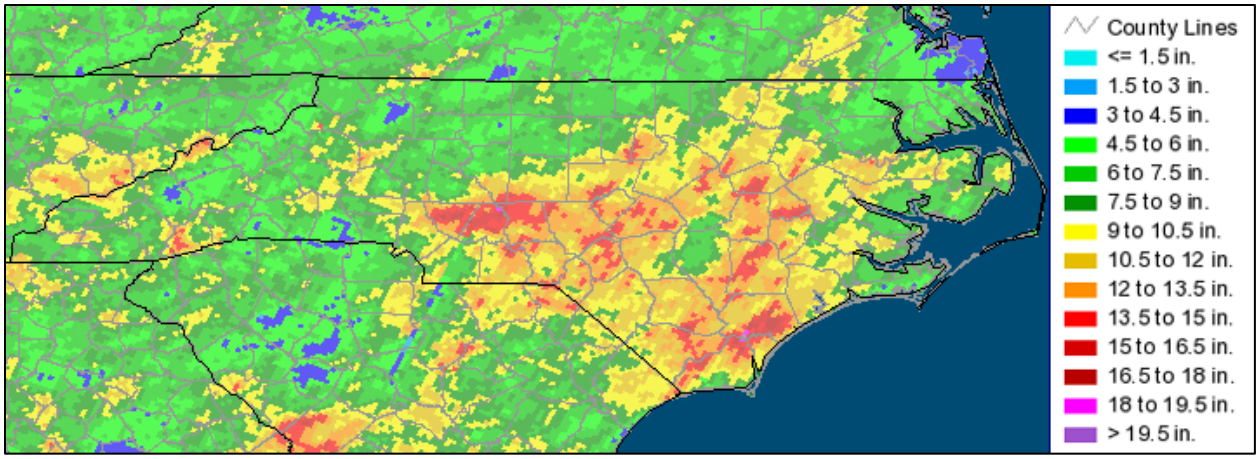

Figure 3. Precipitation for June 2013 based on estimates from NWS Radar. (Data courtesy NNWS/NCEP)

Daytime temperatures remained either normal or cooler than normal in July while the nightly low temperatures were actually warmer than usual. The excessive moisture and frequent cloud cover blocked sunlight from heating the air during the day, and preventing the loss of heat at night. The wet pattern continued with most of the state receiving above normal rainfall. Statewide average rainfall for July 2013 franked as the third wettest since 1895. The New River Basin received between seven and 20 inches of rain in July

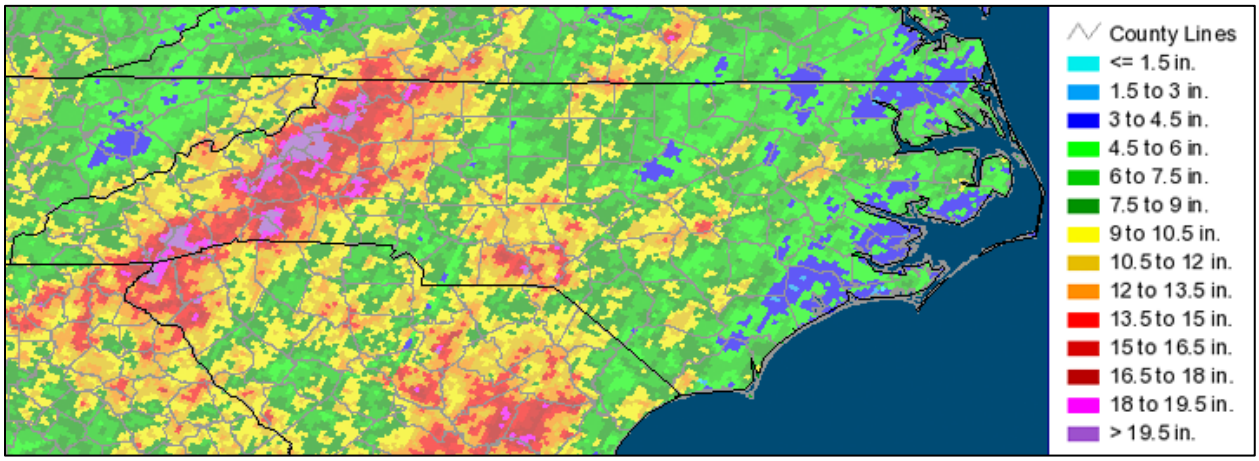

Figure 4. Precipitation for July 2013 based on estimates from NWS Radar. (Data courtesy NNWS/NCEP)

August 2013 continued with the cool, wet conditions of the previous months. Rainfall was more moderate with the statewide average only slightly above normal. The New River Basin experienced approximately 1.5 to 6.0 inches of precipitation in August (Figure 5).

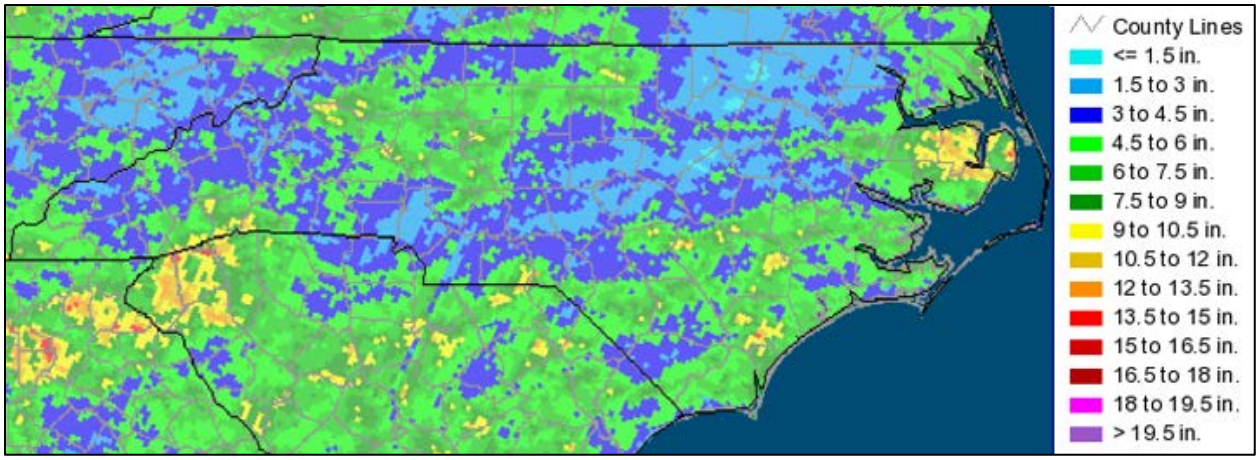

Figure 5. Precipitation for August 2013 based on estimates from NWS Radar. (Data courtesy NNWS/NCEP)

Temperatures in September remained cool while rainfall fell in parts of the state that were the driest in August (Figure 6). Parts of the New River Basin received between one and five inches of rain in September.

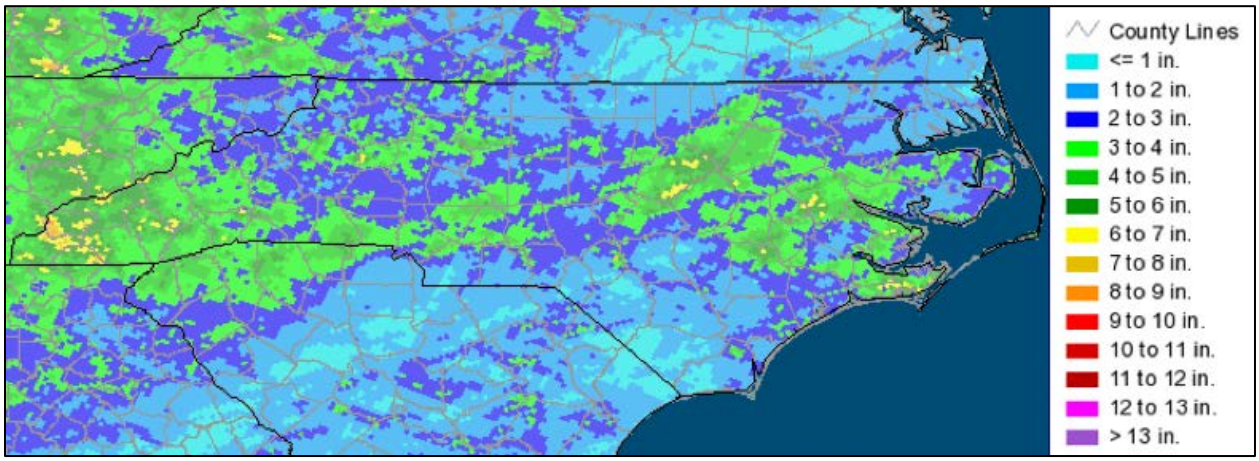

Figure 6. Precipitation for September 2013 based on estimates from NWS Radar. (Data courtesy NNWS/NCEP)

Appalachian State University (ASU) Lake

Ambient Lakes Program Name	ASU Lake
Trophic Status (NC TSI)	Oligotrophic
Mean Depth (meters)	10.0
Volume ($10^6 m^3$)	0.70
Watershed Area (mi^2)	34.0
Classification	WS-II Tr CA
Stations	NEW006E
Number of Times Sampled	5

ASU Lake is a small water supply impoundment located in the mountains of North Carolina. The lake serves as the water supply for Appalachian State University. Construction of the lake and dam began in 1970 and was completed in 1974. The dam is 112 feet high and the receiving stream is Norris Branch. The lake has a maximum depth of 112 feet (34 meters) near the dam. The shoreline of ASU Lake is forested; however the watershed upstream of the lake is a mix of forested land, residential and commercial development.

DWR field staff sampled ASU Lake monthly from May through September, 2013. Surface dissolved oxygen ranged from 6.0 mg/L in September to 9.3 mg/L in May (Appendix A). Surface water temperature was lowest in May (13.4 °C) and greatest in June (27.7 °C). The thermocline for this reservoir was established by June at a depth of approximately four meters from the surface at the single sampling site near the dam (NEW006E). By September 17th , cooler air temperatures had contributed to a turnover of the lake water and breakdown of the thermocline. Surface pH values were similar to those previously recorded for this reservoir by DWR, and ranged from 7.0 to 8.3 s.u. Secchi depths, an indicator of water clarity, ranged from 2.3 to 3.8 meters.

Total phosphorus in ASU Lake was <0.02 mg/L and total Kjeldahl nitrogen ranged from <0.20 to 0.22 mg/L (Appendix A). Ammonia concentration ranged from <0.02 mg/L to 0.02 mg/L and nitrite plus nitrate ranged from 0.06 to 0.21 mg/L. Chlorophyll *a* values were low and ranged from 1.6 to 8.0 *u*g/L and were similar to concentrations previously observed.

An Algal Growth Potential Test was conducted by the EPA Region 4 Laboratory in Athens, GA on a water sample collected from ASU Lake in July (Table 1). The result of the test indicated that algal growth in this reservoir is limited by the availability of the nutrient, phosphorus.

Table 1. Algal Growth Potential Test (AGPT) Results for ASU Lake.

July 24, 2013

Station	Maximum Standing Crop, Dry Weight (mg/L)			Limiting Nutrient
	Control	C+N	C+P	
NEW006E	0.26	0.28	2.87	Phosphorus

Freshwater AGPT using *Selenastrum capricornutum* as test alga

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

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

Based on the calculated NCTSI scores, ASU Lake was determined to exhibit very low biological productivity or oligotrophic conditions. This lake continues to support its designated use as a water supply source.

Lake	Date	Sampling Station	DO mg/L	Temp Water C	pH s.u.	Cond. µmhos/cm	Depth Secchi meters	Percent SAT	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	Total Solids Suspended mg/L	Turbidity NTU	Total Hardnes mg/L
			SURFACE PHYSICAL DATA						PHOTIC ZONE DATA											
HUC 05050001																				
ASU LAKE	September 17, 2013	NEW006E	6.0	17.4	7.7	62	2.7	62.6%	<0.02	0.23	0.02	0.06	0.29	0.21	0.08	3.8	45	<6.2	1.5	21
	August 15, 2013	NEW006E	7.9	22.4	7.6	48	3.8	91.1%	<0.02	<0.20	<0.02	0.08	0.18	0.09	0.09	1.6	34	<6.2	1.1	16
	July 24, 2013	NEW006E	8.4	23.2	8.3	47	2.6	98.3%	<0.02	0.22	<0.02	0.08	0.3	0.21	0.09	8.0	37	<6.2	2.6	15
	June 20, 2013	NEW006E	7.9	27.7	7.5	54	2.5	100.4%	<0.02	0.22	0.02	0.09	0.31	0.2	0.11	5.9	38	<6.2	3.3	16
	May 14, 2013	NEW006E	9.3	13.4	7.0	53	2.3	89.1%	<0.02	<0.20	<0.02	0.21	0.31	0.09	0.22	2.4	40	<6.2	3.7	15