LAKE & RESERVOIR ASSESSMENTS
FRENCH BROAD RIVER BASIN

Beetree Reservoir

Intensive Survey Branch
Water Sciences Section
Division of Environmental 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 may be determined by the algal density as follows: 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	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 high plant 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 plant 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 plant 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. DEQ 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 French Broad River basin covers 2,842 square miles with 4,113 miles of streams and is the ninth largest river basin in the state. It is located in the Blue Ridge Mountains and includes part or all of Transylvania, Buncombe, Henderson, Madison, Haywood, Yancey, Mitchell and Avery counties. All waters from the basin drain to the Gulf of Mexico *via* the Tennessee, Ohio, and Mississippi Rivers. The French Broad River Basin includes Mount Mitchell (elevation 6,684 feet), the highest mountain east of the Rocky Mountains. Much of the basin lies within the 1.2 million acre Pisgah National Forest or Pisgah Game Lands. The northwest corner of Haywood County is in the Great Smoky Mountains National Park. Over one-half of the basin is forested and the steep slopes limit the area suitable for development and crop production. The basin is composed of three major drainages, the French Broad, Pigeon, and Nolichucky Rivers, that individually flow north into Tennessee.

Six lakes were sampled in this river basin by DWR staff in 2022. One of these, Lake Junaluska, was placed on the 2022 303(d) List of Impaired Waters due to water quality standard violations related to elevated fecal coliform bacteria levels and elevated pH (https://deq.nc.gov/about/divisions/water-resources/water-planning/modeling-assessment/water-quality-data-assessment/integrated-report-files).

On April 2, 2008, a state-wide fish consumption advisory was placed on fish caught in the state which may be high in mercury. These include largemouth bass, blackfish (bowfin), catfish, and jackfish (chain pickerel) See http://www.epi.state.nc.us/epi/fish/current.html for additional information on fish consumption advisories in the state.

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Assessment Methodology

For this report, data from January 1, 2018 through December 31, 2022 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://www.arcgis.com/home/webmap/viewer.html?webmap=9dbc8edafb7743a9b7ef3f6fed5c4db0&extent=-87.8069,29.9342,-71.5801,38.7611.

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 and 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.

Quality Assurance of Field and Laboratory Lakes Data

Data collected in the field via multiparameter water quality meters are uploaded into the Labworks® Database within five days of the sampling date.

Chemistry data from the DWR Water Quality Laboratory are uploaded into Labworks®. If there are data entry mistakes, possible equipment, sampling, and/or analysis errors, these are investigated and corrected, if possible. Chemistry results received from the laboratory that are given a qualification code are entered along with the assigned laboratory code.

Information regarding the WSS Chemistry Laboratory Quality Assurance Program is available on the ISB website: (https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/microbiology-inorganics-branch/methods-pqls-qa).

Weather Overview for Summer 2022

Warm weather began in the state in May following a cool April. The first 90-degree days of the year for most of the state began this month. Raleigh finished May 2022 with six days at or above 90°F. After a dry start, increased rainfall near the end of May resulted in a preliminary average precipitation of 4.08 inches, making the month the 55th-wettest May in the past 128 years. The rainfall gradient in May was from west to east with some of the Mountain areas well above normal for rainfall and many southern Coastal areas experiencing dry conditions. In the Coastal Plains, dry conditions ranged from Abnormally Dry (D0) to Moderate (D1) and Sever Drought (D2).

June started with some much-needed rain on the 2nd and 3rd with more than two inches of rain in the southern Coastal Plains. However, after this promising start, rainfall became greatly reduced across the state despite strong thunderstorms which brough more winds than rain. This month was an historically dry June, particularly in the western Piedmont. Salisbury received 0.22 inches of rain in June, making it the driest June there since 1954. Hickory's total rainfall (1.22 inches) ranked as the 5th-driest June since 1959. Further east, Tarboro received only 0.86 inches of rain, making this June its driest in 130 years.

Coupled with the limited precipitation, the statewide average temperature of 75.2°F made June 2022 the 24th-warmest June in the past 128 years. On June 22nd, Charlotte, Fayetteville, and Laurinburg recorded temperature readings of 101°F while Raleigh recorded a temperature of 100°F. In June, Abnormally Dry conditions (D0) spread across the western part of the state. Drought conditions (D1 and D2) expanded from the eastern region of the state west into the Piedmont. June streamflows were mostly below normal across

the eastern two-thirds of the state and many Coastal Plains streams were below their historical 10th percentile for the month. Most reservoirs in the Piedmont dipped approximately a foot below their seasonal target levels.

July turned out to be the 18th-warmest July since 1895 with a statewide average temperature of 78.8°F. This month was notable for several stretches of heat beginning just after July 4th. Temperatures in Raleigh reached 102°F on July 6th and 7th, tying the high temperature records in the city for these two dates. Smithfield recorded 104°F on July 6th, becoming the hottest site in the state for July 2022.

Rainfall in July was variable across the state with the wettest site being Newport in the eastern Coastal Plains. This town measured 16.57 inches of rain and making July 2022 its wettest July in 25 years. In the Piedmont, the City of Hickory had its 3rd wettest July with 10.18 inches of rain. In contrast, Elizabeth City in the northern Coastal Plains received 4.8 inches of rain. This was 0.9 inches below its usual rainfall amount, placing it 3.6 inches of rain below normal since the start of the summer. Drought conditions across the state improved in July with Abnormally Dry conditions (D0) in the western parts of the state eliminated but remaining in the in parts of the wester Piedmont and Coastal Plains. A strip of Moderate Drought (D1) was located in the western and northeastern Coastal Plains.

Early August 2022 started out hot and humid with high temperatures reaching the upper 90s on August 9th and 10th. Heat relief arrived on August 12th from a pair of cold fronts that moved in from the northwest and brought much needed rain and cooler, less humid air. August 14th was the first night with temperatures in the 50s in the eastern parts of the state. In the west, both Sparta and Mount Mitchell recorded a night low of 49°F on August 13th. August 2022 ended with temperatures once more in the 90s across the state.

A mixture of both wet and dry conditions occurred in the state in August. Parts of the Piedmont were notably dry. Raleigh saw 0.91 inches of rain for the month, making it the second driest August since 1887. Monroe had 2.33 inches of rain for its 20th driest August in 127 years. Hickory, on the other hand, received 3.45 inches of rain and finished August at 3.3 inches of rainfall above normal. By August 30th, much needed rainfall in the driest parts of the state resulted in the disappearance of areas of Moderate Drought (D1). Abnormally Dry Conditions (D0) remained in the northeastern Coastal Plains and in the southern and eastern Piedmont.

The first rain event for the month of September occurred in the southern Mountains on September 4 – 6, dropping more than six inches of rain in some areas. Following this event, the state continued to remain dry. By September 21st, Elizabeth City had received only 0.17 inches of rainfall for the month and Raleigh had received 0.78 inches of rain. On September 30th, Hurricane Ian broke the dry period in the state. The storm brought 5.92 inches of rain to Hatteras and Elizabeth City received 4.49 inches of rain. Despite the rain contribution from Hurricane Ian, the statewide average precipitation of 3.84 inches ranked this month as the 60th driest September since 1985.

Beetree Reservoir

Ambient Lakes Program Name	Beetree Reservoir
Trophic Status (NC TSI)	Oligotrophic
Mean Depth (meters)	10.0
Volume ($10^6 m^3$)	1.90
Watershed Area (mi^2)	8.0
Classification	WS-I HQW
Stations	FRBBTR1
Number of Times Sampled	5

Beetree Creek was impounded in 1926 to form Beetree Reservoir, a water supply for the City of Asheville. The City of Asheville owns the 20 km^2 watershed which is undeveloped. Beetree Reservoir is designated as a High Quality Water (HQW), Water Supply-I and has a maximum depth of 25 meters. This lake is not used for recreation and public access is restricted.

Beetree Reservoir was monitored by DWR field staff in May through September 2022. Surface dissolved oxygen ranged from 8.0 to 9.3 mg/L and surface water temperatures ranged from18.6°C in May to 25.9°C in September (Appendix A). Surface pH values ranged from 6.7 to 7.2 s.u. and surface conductivity ranged from 18 to 21 µmhos/cm. Secchi depths, a measurement of water clarity, ranged from 3.5 to 4.5 meters.

Both total phosphorus (<0.02 mg/L) and total Kjeldahl nitrogen (<0.30 mg/L) were consistently below the DWR laboratory detection levels. Concentrations of NH_3 ranged from <0.02 to 0.05 mg/L and total organic nitrogen ranged from 0.10 to 0.14 mg/L. Chlorophyll *a* values were low, ranging from 4.3 to 6.4 µg/L. The value for microcystins, toxins that may be present in the blue-green alga *Microcystin sp*., were below the NCDWR laboratory detection level of 0.4 µg/L. An Algal Growth Potential Test was conducted on water samples collected from Beetree Reservoir in August 2022 (Table 1). Results indicated that potential nuisance algal blooms in the lake were limited by the concentrations of phosphorus in the lake.

Table 1. Algal Growth Potential Test Results for Beetree Reservoir, August 16, 2022.

Station	Maximum Standing Crop, Dry Weight (mg/L)			Limiting Nutrient
	Control	C+N	C+P	
FRBBTR1	0.09	0.06	1.50	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, Beetree Reservoir exhibited low biological productivity (oligotrophic conditions) in 2022. This reservoir has been consistently oligotrophic since DWR monitoring of this lake began in 1990.

Burnett Reservoir

Ambient Lakes Program Name	Burnett Reservoir	
Trophic Status (NC TSI)	Oligotrophic	
Mean Depth (meters)	12.0	
Volume ($10^6 m^3$)	22.00	
Watershed Area (mi^2)	2.0	
Classification	WS-I HQW	
Stations	FRBBUR2	FRBBUR4
Number of Times Sampled	5	5

Burnett Reservoir (also known as North Fork Reservoir) was built in 1954 to provide drinking water for the City of Asheville. Maximum depth in this reservoir is approximately 121 feet (37 meters) and average depth is 39 feet (12 meters). Burnett Reservoir has a shoreline length of five miles. The undisturbed 15,000-acre watershed is drained by the North Fork Swannanoa River, Sugar Fork and several unnamed tributaries. Burnett Reservoir is classified as a Water Supply-I (WS-I) and as a High Quality Water (HQW).

DWR field staff monitored Burnett Reservoir in May through September 2022. Surface dissolved oxygen ranged from 9.6 mg/L in May to 7.9 mg/L in August (Appendix A). Surface water temperatures in Burnett Reservoir ranged from 17.2°C to 27.1°C and surface pH values ranged from 6.1 to 7.2 s.u. The surface conductivity in this reservoir was very consistent, ranging from 13 to 14 µmhos/cm. Secchi depths ranged from 3.0 in August to 8.5 in May.

Both total phosphorus and total Kjeldahl nitrogen concentrations in Burnett Reservoir were below the DWR laboratory detection levels of <0.02 mg/L and <0.30 mg/L, respectively. The NH3 concentrations ranged from <0.02 to 0.01 mg/L and total organic nitrogen was consistently 0.14 mg/L. Chlorophyll a values were low, ranging from 1.5 to 7.5 µg/L. An Algal Growth Potential Test was conducted on water samples collected from Burnett Reservoir in August 2022 (Table 2). Results indicated that potential nuisance algal blooms in the lake were limited by the concentrations of phosphorus in the lake sites sampled near the dam (FRBBUR4).

Table 2. Algal Growth Potential Test Results for Burnett Reservoir, August 16, 2022.

Station	Maximum Standing Crop, Dry Weight (mg/L)			Limiting Nutrient
	Control	C+N	C+P	
FRBBUR4	0.05	0.04	0.13	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, this reservoir was determined to have low biological productivity (oligotrophic conditions) in 2022. Historically, this has been the trophic state of this lake since DWR monitoring began in 1990.

Lake Julian

Ambient Lakes Program Name	Lake Julian		
Trophic Status (NC TSI)	Oligotrophic		
Mean Depth (meters)	20.0		
Volume ($10^6 m^3$)	2.60		
Watershed Area (mi^2)	5.0		
Classification	C		
Stations	FRBLJ2	FRBLJ4	FRBLJ6
Number of Times Sampled	5	5	5

Lake Julian is an impoundment of Powell's Creek, a tributary of the French Broad River. Constructed in 1963, this lake was created as a source of once-through condenser cooling water for the Asheville Steam Electric Plant. Lake Julian's watershed is primarily residential and urban. Lake Julian Park is a county recreational facility operated by Buncombe County Parks and Recreation Services near Skyland, NC. Recreational boating (electric motors, only) and fishing are allowed on the lake. Sport fish caught in Lake Julian include catfish, largemouth bass and tilapia.

DWR staff monitored this reservoir in May through September 2022. Surface dissolved oxygen in this reservoir ranged from 7.2 to 9.4 mg/L and surface water temperatures ranged from 19.3°C to 26.8°C (Appendix A). Surface pH ranged from 5.6 to 7.5 s.u. The low ph value, which was observed in May, was lower than the state water quality standard of 6.0 s.u. Surface conductivity ranged from 97 to 102 µmhos/cm. Secchi depths in Lake Julian ranged from 3.0 to 7.8 meters.

Total phosphorus concentrations ranged from <0.02 to 0.30 mg/L and total Kjeldahl nitrogen ranged from <0.30 to 0.40 mg/L. The concentration of NH_3 in Lake Julian ranged from <0.02 to 0.06 mg/L and total organic nitrogen ranged from 0.09 to 0.39 mg/L. Chlorophyll *a* values in 2022 ranged from 0.5 to 9.3 µg/L and concentrations of the algal toxin, microcystins, were below the DWR laboratory detection level of 0.04 µg/L. An Algal Growth Potential Test was conducted on water samples collected from Lake Julian at the three DWR lake sampling sites in August 2022 (Table 3). Results indicated that potential nuisance algal blooms in the lake were limited by the concentrations of phosphorus in the lake site sampled downstream of the NC 280 bridge (FRBLJ2) and at the site near the dam (FRBLJ6). The sampling site downstream of the Southern railroad bridge near Skyland (FRBLJ4) was co-limited for both nitrogen and phosphorus.

Table 3. Algal Growth Potential Test Results for Lake Julian, August 31, 2022.

Station	Maximum Standing Crop, Dry Weight (mg/L)			Limiting Nutrient
	Control	C+N	C+P	
FRBLJ2	0.18	0.11	0.34	Phosphorus
FRBLJ4	0.09	0.05	0.07	Nitrogen + Phosphorus*
FRBLJ6	0.12	0.06	0.28	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

*Sample reanalyzed for verification of nutrient limitation; data not shown.

In 2022, Lake Julian was determined to have low biological productivity (oligotrophic conditions) based on the monthly calculated NCTSI scores. This reservoir has been oligotrophic since monitoring by DWR began in 1990.

Allen Creek Reservoir

Ambient Lakes Program Name	Allen Creek Reservoir	
Trophic Status (NC TSI)	Oligotrophic	
Mean Depth (meters)	14.0	
Volume ($10^6 m^3$)	3.30	
Watershed Area (mi^2)	13.0	
Classification	WS-I Tr HWQ	
Stations	FRBACR2	FRBACR4
Number of Times Sampled	5	5

Allen Creek Reservoir (also known as Waynesville Reservoir) is a small water supply lake located in the western mountains of North Carolina and owned by the City of Waynesville. The maximum depth is 23 meters. Several tributaries flow into Allen Creek Reservoir, including Steestachee Branch, Bald Creek, Long Branch Creek and Allen Creek.

DWR staff monitored this reservoir in May through September 2022. Surface water dissolved oxygen ranged from 8.5 to 9.0 mg/L and surface water temperatures ranged from 18.1°C to 23.4°C (Appendix A). Surface pH values in this reservoir ranged from 6.8 to 5.5 s.u. with many of the surface reading below the state water quality standard of 6.0 s.u. The acidic nature of local rock, both in and around the reservoir may have an influence on the low pH values observed. Surface conductivities ranged from 14 to 17 µmhos/cm. Secchi depths in Allen Creek Reservoir ranged from 1.9 to 4.3 meters.

Total phosphorus (<0.02 mg/L) and total Kjeldahl nitrogen (<0.30 mg/L) concentrations were below their respective DWR laboratory detection levels. Values for NH_3 ranged from <0.02 to 0.02 mg/L and total organic nitrogen ranged from 0.13 to 0.43 mg/L. Chlorophyll *a* values ranged from 2.2 to 9.1 µg/L and concentrations of the algal toxins, microcystins, were below the DWR laboratory detection level of 0.04 µg/L.

Allen Creek Reservoir was determined to exhibit low biological productivity (oligotrophic conditions) in 2022. Historically, this reservoir has been oligotrophic since DWR staff monitoring began in 1990.

Lake Junaluska

Ambient Lakes Program Name	Lake Junaluska		
Trophic Status (NC TSI)	Mesotrophic		
Mean Depth (meters)	5.5		
Volume ($10^6 m^3$)	4.50		
Watershed Area (mi^2)	63.0		
Classification	B		
Stations	FRB047A	FRB047B	FRB047C
Number of Times Sampled	5	5	5

Lake Junaluska is a 200-acre reservoir located in the mountains of southwestern North Carolina. The lake is privately owned by the United Methodist Church and was built by the Lake Junaluska Assembly as a meeting ground for Southern Methodists in 1913. The lake was formed by impounding a segment of Richland Creek.

DWR monitored this reservoir from May through September 2022. Surface water temperatures ranged from 10.1°C to 26.4°C and surface dissolved oxygen ranged from 9.3 to 10.6 mg/L. Surface pH values ranged from 6.2 to 8.9 s.u. and surface conductivity ranged from 423 to 87 µmhos/cm. Secchi depths in Lake Junaluska ranged from 0.8 to 2.0 meters.

Total phosphorus concentrations ranged from <0.02 to 0.05 mg/L and total Kjeldahl nitrogen ranged from <0.30 to 0.44 mg/L. The values for NH_3 ranged from <0.02 to 0.02 mg/L and total organic nitrogen ranged from 0.13 to 0.43 mg/L. Chlorophyll *a* ranged from 3.7 to 22.0 µg/L and concentrations of the algal toxin, microcystins, were below the DWR laboratory detection level of 0.04 µg/L.

Based on the calculated NCTSI scores in 2022, Lake Junaluska was determined to exhibit moderate biological productivity or mesotrophic conditions in June and July 2022, and elevated biological productivity or eutrophic conditions in August and September 2022. Overall, the trophic state of this reservoir was determined to be moderate or mesotrophic. Historically, the trophic state of this lake has varied between moderately productive (mesotrophic) and eutrophic since monitoring by DWR began in 1981.

Waterville Lake

Ambient Lakes Program Name	Waterville Lake		
Trophic Status (NC TSI)	Eutrophic		
Mean Depth (meters)	23.0		
Volume ($10^6 m^3$)	31.60		
Watershed Area (mi^2)	455.0		
Classification	C		
Stations	FRBWL2	FRBWL4	FRBWL8
Number of Times Sampled	2	2	2

Built in the late 1920's, Waterville Lake (also known as Walters Lake) is an impoundment of the Pigeon River which drains most of Haywood County. This reservoir has a maximum depth of 35 meters. Waterville Lake was constructed to produce hydroelectric power for Asheville and the surrounding area. Access to this lake is restricted to the public.

DWR field staff monitored this reservoir in May and September 2022 (Appendix A). Surface dissolved oxygen in this reservoir ranged from 1.3 to 8.5 mg/L. The low oxygen value, which was observed in Waterville Lake in the Cataloochee Creek arm (FRBWL6) in September was below the state water quality standard of 4.0 mg/L for an instantaneous oxygen reading. Surface water temperatures ranged from 18.5°C to 24.1°C and surface pH ranged from 6.8 to 7.3 s.u. Surface conductivity was high, ranging from 164 to 341 µmhos/cm. Secchi depths ranged from o.9 to 4.0 meters.

Total phosphorus in Waterville Lake ranged from 0.04 to 0.08 mg/L and total Kjeldahl nitrogen ranged from 0.41 to 0.77 mg/L. Values for NH_3 ranged from <0.02 to 0.10 mg/L and total organic nitrogen ranged from 0.39 to 0.76 mg/L. Chlorophyll *a* values ranged from 2.1 to 12.0 µg/L. Microcystin concentrations in this reservoir ranged from <0.4 to 3.5 µg/L, (which was observed in September at site FRBWL4 in Waterville Lake near the mouth of Wilkins Creek). DWR field staff notes described the presence of what appeared to be a "streaky green" surface algal bloom at this site.

In 2022, Waterville Lake was determined to have elevated biological productivity based on the calculated NCTSI scores. Historically, this lake has been predominantly eutrophic since monitoring by DWR field staff began in 1990.

Appendix A - French Broad River Basin Lakes Data
January 1, 2018 Through December 31, 2022

	SURFACE PHYSICAL DATA								PHOTIC ZONE DATA												
Lake	Date	Sampling Station	DO mg/L	Temp Water C	pH s.u.	Cond. µmhos/cm	Secchi Depth 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	Microcystins µg/L	Solids Total mg/L	Total Solids Suspended mg/L	Turbidity NTU	Total Hardness mg/L
BEETREE RESERVOIR	September 6, 2022	FRBBTR1	8.3	25.9	7.2	21	4.5	112.6%	<0.02	<0.30	0.05	0.05	0.20	0.10	0.10	5.6	<0.4	20.0	<2.5	<1.0	5.0
BEETREE RESERVOIR	August 16, 2022	FRBBTR1	8.9	23.1	6.9	20	3.5	114.8%	<0.02	<0.30	<0.02	0.06	0.21	0.14	0.07	6.4	<0.4	27.0	<2.5	1.0	6.6
BEETREE RESERVOIR	July 11, 2022	FRBBTR1	8.0	25.4	7.1	21	4.0	107.4%	<0.02	<0.30	<0.02	0.06	0.21	0.14	0.07	5.3	<0.4	26.0	<2.5	1.1	5.4
BEETREE RESERVOIR	June 6, 2022	FRBBTR1	9.2	19.7	6.7	18	4.0	110.3%	<0.02	<0.30	<0.02	0.09	0.24	0.14	0.10	4.3	<0.4	21.0	<2.5	<1.0	3.6
BEETREE RESERVOIR	May 2, 2022	FRBBTR1	9.3	18.6	6.8	18	4.5	109.3%	<0.02		<0.02	0.05			0.06	4.8	<0.4	21.0		<1.0	3.9
BURNETT RESERVOIR	September 6, 2022	FRBBUR2	8.2	26.6	7.2	14	3.5	111.6%	<0.02	<0.30	0.01	0.01	0.16	0.14	0.02	7.5		22.0	<2.5	<1.0	
BURNETT RESERVOIR	September 6, 2022	FRBBUR4	8.1	27.1	7.1	14	4.5	110.9%	<0.02	<0.30	0.01	0.01	0.16	0.14	0.02	5.5	<0.4	21.0	<2.5	1.1	7.0
BURNETT RESERVOIR	August 16, 2022	FRBBUR2	7.9	25.4	6.1	14	3.0	105.7%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02	5.0		23.0	<2.5	1,2	
BURNETT RESERVOIR	August 16, 2022	FRBBUR4	7.9	25.4	6.8	14	4.0	105.5%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02	3.8	<0.4	16.0	<2.5	<1.0	5.0
BURNETT RESERVOIR	July 11, 2022	FRBBUR2	8.0	26.0	6.3	14	3.6	107.6%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02	4.4		22.0	2.9	1.6	
BURNETT RESERVOIR	July 11, 2022	FRBBUR4	8.1	25.8	6.9	14	5.0	109.1%	<0.02	<0.30	<0.02	0.04	0.19	0.14	0.05	3.6	<0.4	<12.0	<2.5	<1.0	4.2
BURNETT RESERVOIR	June 6, 2022	FRBBUR2	8.8	21.6	6.7	13	6.5	109.2%	<0.02	<0.30	<0.02	0.06	0.21	0.14	0.07	2.4		19.0	<2.5	<1.0	
BURNETT RESERVOIR	June 6, 2022	FRBBUR4	8.6	21.8	7.1	13	6.0	107.3%	<0.02	<0.30	<0.02	0.08	0.23	0.14	0.09	2.1	<0.4	16.0	<2.5	<1.0	4.2
BURNETT RESERVOIR	May 2, 2022	FRBBUR2	9.6	17.7	7.0	13	6.2	110.4%	<0.02		<0.02	0.08			0.09	1.6		<12.0		<1.0	
BURNETT RESERVOIR	May 2, 2022	FRBBUR4	9.5	17.2	6.9	13	8.5	107.6%	<0.02		<0.02	0.10			0.11	1.5	<0.4	<12.0		<1.0	3.9
LAKE JULIAN	September 7, 2022	FRBLJ2	7.2	26.1	7.1	100	3.6	95.4%	<0.02	0.40	<0.02	<0.02	0.41	0.39	0.02	2.5		61.0	<2.5	1.1	
LAKE JULIAN	September 7, 2022	FRBLJ4	7.4	26.4	7.1	99	5.0	99.1%	<0.02	0.36	0.02	0.05	0.41	0.34	0.07	3.1		67.0	<2.5	1.9	
LAKE JULIAN	September 7, 2022	FRBLJ6	7.4	25.9	7.3	99	4.0	98.9%	<0.02	<0.30	0.02	0.03	0.18	0.13	0.05	2.5	<0.4	57.0	<2.5	1.2	28.0
LAKE JULIAN	August 17, 2022	FRBLJ2	7.4	26.4	7.0	101	3.5	98.4%	<0.02	<0.30	<0.02	<0.02	0.16	0.14	0.02	3.5		63.0	<2.5	1.2	
LAKE JULIAN	August 17, 2022	FRBLJ4	7.3	26.1	6.9	100	4.0	96.6%	<0.02	<0.30	0.03	0.02	0.17	0.12	0.05	4.0		62.0	<2.5	1.1	
LAKE JULIAN	August 17, 2022	FRBLJ6	7.6	26.0	6.9	102	4.0	100.5%	<0.02	<0.30	0.02	<0.02	0.16	0.13	0.03	3.1	<0.4	62.0	<2.5	<1.0	28.0
LAKE JULIAN	July 12, 2022	FRBLJ2	7.3	26.8	6.9	101	4.5	99.2%	0.03	0.35	0.03	<0.02	0.36	0.32	0.04	2.1		62.0	8.7	5.5	
LAKE JULIAN	July 12, 2022	FRBLJ4	6.9	26.6	7.0	98	4.0	92.2%	<0.02	<0.30	0.02	0.03	0.18	0.13	0.05	2.4		62.0	<2.5	<1.0	
LAKE JULIAN	July 12, 2022	FRBLJ6	7.4	26.7	6.9	101	5.0	100.2 %	<0.02	0.36	0.05	0.05	0.41	0.31	0.10	1.7	<0.04	63.0	<2.5	<1.0	29.0
LAKE JULIAN	June 6, 2022	FRBLJ2	8.7	25.3	7.2	98	5.5	113.9%	<0.02	<0.30	<0.02	0.05	0.20	0.14	0.06	1.3		60.0	<2.5	<1.0	
LAKE JULIAN	June 6, 2022	FRBLJ4	9.1	23.5	7.3	97	6.3	115.4%	<0.02	<0.30	0.06	0.06	0.21	0.09	0.12	9.3		59.0	<2.5	<1.0	
LAKE JULIAN	June 6, 2022	FRBLJ6	8.5	24.9	6.9	97	6.5	110.4%	<0.02	<0.30	<0.02	0.06	0.21	0.14	0.07	2.1	<0.04	61.0	<2.5	<1.0	26.0
LAKE JULIAN	May 2, 2022	FRBLJ2	9.3	19.3	7.5	99	6.0	109.3%	<0.02		<0.02	0.06			0.07	0.5		61.0		1.1	
LAKE JULIAN	May 2, 2022	FRBLJ4	9.4	21.8	7.3	96	7.8	115.9%	<0.02		<0.02	0.06			0.07	1.0		49.0		<1.0	
LAKE JULIAN	May 2, 2022	FRBLJ6	9.3	21.5	7.5	99	7.0	113.2%	<0.02		<0.02	0.06			0.07	1.2	<0.04	62.0		<1.0	26.0
ALLEN CREEK RESERVOIR	September 15, 2022	FRBACR2	8.7	21.2	5.6	17	3.5	109.7%	<0.02	<0.30	<0.02	0.03	0.18	0.14	0.04	9.1		26.0	<2.5	1.3	
ALLEN CREEK RESERVOIR	September 15, 2022	FRBACR4	9.0	20.4	6.2	17	3.0	111.5%	<0.02	<0.30	<0.02	0.03	0.18	0.14	0.04	8.8	<0.4	25.0	<2.5	1.2	7.0
ALLEN CREEK RESERVOIR	August 16, 2022	FRBACR2	8.5	22.6	5.5	17	3.6	110.0%	<0.02	<0.30	<0.02	0.05	0.20	0.14	0.06	4.8		23.0	<2.5	1.2	
ALLEN CREEK RESERVOIR	August 16, 2022	FRBACR4	8.5	22.5	5.6	17	3.9	110.3%	<0.02	<0.30	<0.02	0.05	0.20	0.14	0.06	6.5	<0.4	23.0	<2.5	1.3	5.2
ALLEN CREEK RESERVOIR	July 19, 2022	FRBACR2	8.8	23.0	5.9	16	1.9	114.9%	<0.02	<0.30	<0.02	0.06	0.21	0.14	0.07	7.9		25.0	<2.5	1.7	
ALLEN CREEK RESERVOIR	July 19, 2022	FRBACR4	8.7	23.4	5.6	16	2.7	113.8%	<0.02	<0.30	<0.02	0.06	0.21	0.14	0.07	7.0	<0.4	26.0	<2.5	1.6	6.0
ALLEN CREEK RESERVOIR	June 2, 2022	FRBACR2	8.8	18.2	6.8	14	4.2	105.3%	<0.02	<0.30	<0.02	0.09	0.24	0.14	0.10	2.2		16.0	<2.5	1.7	
ALLEN CREEK RESERVOIR	June 2, 2022	FRBACR4	9.0	18.6	6.6	14	4.0	108.8%	<0.02	<0.30	<0.02	0.09	0.24	0.14	0.10	2.8	<0.4	16.0	<2.5	1.6	3.9
ALLEN CREEK RESERVOIR	May 4, 2022	FRBACR2	9.0	18.1	6.0	15	2.3	106.4%	<0.02		<0.02	0.06			0.07	3.1		29.0	<2.5	3.1	
ALLEN CREEK RESERVOIR	May 4, 2022	FRBACR4	9.0	19.2	5.9	15	4.3	108.9%	<0.02		<0.02	0.06			0.07	3.3		27.0	<2.5	3.1	2.0
LAKE JUNALUSKA	September 14, 2022	FRB047A	9.7	23.4	7.9	87	0.8	124.9%	0.03	0.35	<0.02	0.09	0.44	0.34	0.10	14.0		30.0	5.4	5.1	
LAKE JUNALUSKA	September 14, 2022	FRB047B	9.7	23.5	8.2	82	0.9	124.3%	0.02	<0.30	<0.02	0.06	0.21	0.14	0.07	17.0		60.0	3.2	3.6	
LAKE JUNALUSKA	September 14, 2022	FRB047C	9.8	24.0	7.4	81	1.0	126.7%	<0.02	0.40	<0.02	0.05	0.45	0.39	0.06	18.0		64.0	0.6	3.4	
LAKE JUNALUSKA	August 16, 2022	FRB047A	10.4	25.1	8.9	77	1.0	138.1%	0.03	0.44	<0.02	0.05	0.49	0.43	0.06	18.0		56.0	4.6	4.5	
LAKE JUNALUSKA	August 16, 2022	FRB047B	10.4	25.5	8.6	77	1.1	139.4%	0.02	0.41	<0.02	<0.02	0.42	0.40	0.02	22.0	<0.4	54.0	3.6	3.5	
LAKE JUNALUSKA	August 16, 2022	FRB047C	10.6	25.6	8.6	78	1.1	142.4%	0.02	0.37	<0.02	<0.02	0.38	0.36	0.02	19.0		58.0	3.1	2.6	
LAKE JUNALUSKA	July 19, 2022	FRB047A	9.3	26.4	6.4	70	1.4	126.7%	0.02	0.32	0.02	0.27	0.59	0.30	0.29	5.7		68.0	3.6	2.9	
LAKE JUNALUSKA	July 19, 2022	FRB047B	10.4	26.4	8.9	69	2.0	141.4%	0.02	0.30	0.02	0.19	0.34	0.13	0.21	16.0	<0.4	62.0	2.6	3.0	
LAKE JUNALUSKA	July 19, 2022	FRB047C	10.1	10.1	8.2	69	1.8	138.4%	<0.02	0.34	<0.02	0.13	0.47	0.33	0.14	13.0		64.0	2.5	1.9	
LAKE JUNALUSKA	June 1, 2022	FRB047A	10.1	22.6	6.3	47	1.3	127.5%	0.05	0.31	<0.02	0.29	0.60	0.30	0.30	11.0		72.0	12.0	8.4	
LAKE JUNALUSKA	June 1, 2022	FRB047B	10.2	23.5	7.1	44	1.5	131.5%	0.02	<0.30	<0.02	0.23	0.38	0.14	0.24	6.7		47.0	2.9	3.5	
LAKE JUNALUSKA	June 1, 2022	FRB047C	10.3	21.2	7.2	43	1.4	127.4%	0.02	<0.30	<0.02	0.28	0.43	0.14	0.29	8.8	<0.40	37.0	2.5	3.7	
LAKE JUNALUSKA	May 4, 2022	FRB047A	9.6	18.6	6.2	56	1.6	112,3%	0.02		<0.02	0.30			0.31	3.7		53.0	3.2	3.4	
LAKE JUNALUSKA	May 4, 2022	FRB047B	10.2	20.4	7.1	59	1.7	124.4%	<0.02		<0.02	0.22			0.23	11.0		53.0	2.9	2.9	
LAKE JUNALUSKA	May 4, 2022	FRB047C	10.3	20.5	7.3	60	1.8	125.6%	<0.02		<0.02	0.20			0.21	13.0		60.0	<2.5	2.6	
WATERVILLE LAKE	September 7, 2022	FRBWL2	8.2	20.7	7.3	164	0.9	99.3%	0.06	0.41	0.02	0.26	0.67	0.39	0.28	2.8	<0.4	138.0	9.3	10.0	
WATERVILLE LAKE	September 7, 2022	FRBWL4	7.1	24.1	7.0	341	1.1	91.3%	0.08	0.77	<0.02	0.26	1.03	0.76	0.27		3.5	240.0	4.5	3.2	
WATERVILLE LAKE	September 7, 2022	FRBWL6	1.3	22.9	6.8	322	1.6	16.4%	0.06	0.52	<0.02	0.25	0.77	0.51	0.26	12.0	<0.4	120.0	7.5	4.4	
WATERVILLE LAKE	May 3, 2022	FRBWL2	7.8	19.1	7.2	260	1.3	91.7%	0.08		0.10	0.44			0.54	3.3	<0.4	174.0		4.4	
WATERVILLE LAKE	May 3, 2022	FRBWL4	8.3	19.6	7.2	218	3.0	98.4%	0.06		0.10	0.37			0.47	5.3	<0.4	139.0		1.4	
WATERVILLE LAKE	May 3, 2022	FRBWL6	8.5	18.5	7.1	173	4.0	97.5%	0.04		0.07	0.20			0.27	2.1	<0.4	89.0		<1.0	