BUREAU OF WATER

South Carolina Department of Health and Environmental Control

2022 South Carolina Cyanotoxin Distribution Project

Technical Report No. 003-2024

S.C. Department of Health and Environmental Control

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May 2024

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SCDHEC – Bureau of Water, Aquatic Science Programs

Table of Contents

List of Figures

List of Tables

List of Appendices

Executive Summary

Harmful algal blooms (HABs) are an increasing concern in the United States and are generally caused by excessive growth of cyanobacteria, or blue-green algae. Cyanobacteria blooms can degrade water quality through increased water column turbidity that reduces light availability for ecologically important vegetation. Die-offs of these blooms can reduce oxygen levels that can lead to fish kills. Some cyanobacteria species produce toxins (cyanotoxins) that are harmful to humans, livestock, and wildlife. In high enough concentrations, cyanotoxins can also cause nuisance taste and odor issues in drinking water and increase the cost of water treatment.

In 2018, the South Carolina Department of Health and Environmental Control (SCDHEC) initiated the HABs Monitoring Program to investigate the effects that cyanotoxins have on human health and the environment within the State. This assessment report covers the cyanotoxin work completed in 2022. In 2022, SCDHEC aimed to:

- Continue collecting baseline data for cyanotoxin distribution in State reservoirs and estuaries,
- Monitor drinking water intakes with a history of HABs and/or taste and odor issues,
- Issue recreational advisories for waterbodies that exceed SCDHEC's state standards, and
- Identify potential correlative relationships between cyanotoxin concentrations and other physicochemical water quality parameters.

In 2022, samples were collected and analyzed for microcystins from 94 monthly-monitored sites across South Carolina reservoirs, estuaries, and influent streams. Microcystin samples were collected from May 1 to October 31. Five (5) of the 94 stations were sampled starting in April due to a special nutrient study on Lake Murray. The monthly-monitored sites were coordinated with routine sampling conducted by SCDHEC regional field staff, which allowed data comparison to other parameters collected contemporaneously. In addition to monthly monitoring of lake and estuarine sites, samples were collected from an additional five (5) lakes at seven (7) drinking water intakes with past algal issues, including taste and odor complaints. Twelve (12) samples from eleven (11) water bodies in response to the occurrence of possible HAB conditions (event-driven samples) were also collected from March through October.

Monthly-monitoring concentrations were less than 1 microgram per liter (µg/L) for microcystins). Concentrations greater than the analytical detection level (≥ 0.100 µg/L for ADDA ELISA method or ≥ 0.016 µg/L for SAES ELISA method) were observed in 81% of samples analyzed for microcystins. Toxin concentrations in all monthly-monitoring samples were less than SCDHEC's recreational standard of 8 µg/L for microcystins.

Microcystins were also detected at all seven (7) drinking water intakes. The drinking water intakes at Lake Rabon (Laurens Commission of Public Works CPW), Lake Whelchel (Gaffney Board of Public Works (BPW)), and Lake Murray (City of West Columbia) had at least one (1) sample that exceeded USEPA 10-day drinking water health advisory value of 0.3 µg/L for microcystins;

There was one (1) recreational advisory issued in 2022 at Lake Wylie for toxin concentrations greater than SCDHEC's state recreational standard. The advisory was removed once the microcystin concentrations were below 8 ug/L and the bloom had dissipated. Recreational watches were also issued in 2022 at Goose Creek Reservoir, Broad River Canal, and Lake Wylie. Recreational watches are issued when a potential toxin producing bloom is identified on a waterbody but producing microcystin or cylindrospermopsin concentrations were less than SCDHEC's state standards, or the identified algal species could potentially be producing algal toxins, such as anatoxin and saxitoxin, that are not in SCDHEC's state standards.

Correlation analyses were conducted for monthly-monitoring microcystin concentration data for Lake Greenwood, Lake Hartwell, Lake Murray, and Lake Wateree. No strong relationships were determined for microcystin concentrations and water quality parameters including dissolved oxygen, pH, temperature, total phosphorous, nitrogen: phosphorus ratio, and chlorophyll *a* for any of the lakes.

This assessment builds on the 2018, 2019, 2020, and 2021 studies and broadens the baseline understanding of cyanotoxin distributions across the State. Future goals of the HABs Monitoring Program include evaluating additional toxins, such as anatoxin and saxitoxin, and expanding sampling to large rivers and streams. This will further enhance the State's growing understanding of cyanotoxin distributions.

Introduction and Background

Harmful algal blooms (HABs) are an increasing concern in U.S. waters. These blooms occur when algae grow excessively in response to elevated nutrient concentrations, typically from non-point source runoff due to a variety of land-uses. In high enough densities, blue-green algae, or cyanobacteria, can impact aquatic life and human health by degrading water quality and producing cyanotoxins. There is growing recognition of the need for increased monitoring of cyanotoxin concentrations in waterbodies and in the water treatment process (Jetto, Grover, & Krantxberg, 2015). The U.S. Environmental Protection Agency (USEPA) has provided health advisory criteria (U.S. Environmental Protection Agency, 2019) and recreational advisory criteria (U.S. Environmental Protection Agency, 2015b,c) for two (2) cyanotoxins (microcystins and cylindrospermopsin). Exposure to high levels of microcystins can lead to liver, reproductive, developmental, kidney, and gastrointestinal effects (U.S. Environmental Protection Agency, 2019). Exposure to high levels of cylindrospermopsin can affect the liver, kidneys, and potential deformation of red blood cells (U.S. Environmental Protection Agency, 2019).

The South Carolina Department of Health and Environmental Control (SCDHEC) has maintained a robust surface water monitoring network since the 1950s. With the advancement of cyanotoxin analytical methods, SCDHEC established the HABs Monitoring Program in 2018 to monitor cyanotoxins statewide. A primary objective of the HABs Monitoring Program is to establish a baseline and context for interpretation of cyanotoxin concentrations in South Carolina's waters, which was accomplished with the adoption of the USEPA's recreational advisory criteria (Table 1) in SCDHEC's State standards in 2020.

Table 1: SCDHEC recreational water quality and swimming advisory criteria for microcystins and cylindrospermopsin. Recreational water activities include swimming, rowing, fishing, boating, etc.

SCDHEC Recreational Water Quality Advisory Criteria		
Microcystin Concentration (µg/L) [a, b]	**Cylindrospermopsin Concentration (µg/L) [a, b]**	**Duration**
8	15	Recreational advisories will remain in place until two (2) consecutive samples report back as less than the advisory criteria

a. SCDHEC Regulation 61-68
b. µg/L = micrograms per liter (parts per billion)

Purpose of Assessment

The purpose of the 2022 assessment was to examine cyanotoxin distributions in South Carolina reservoirs and estuaries and to determine potential risks for recreational and aquatic life uses for waterbodies of the State. Cyanotoxin concentrations were also compared to USEPA drinking water health advisories (Table 2) to identify potential hazards to drinking water facilities. The data were used to identify reservoirs of potential concern and will guide future assessment activities. In 2022, monitoring activities primarily focused on analyzing microcystin toxins based on results from the previous four (4) years. Species having the potential to produce cylindrospermopsin were identified at two (2) waterbodies in 2022 as a result of sampling algal blooms due to complaints.

Table 2: USEPA 10-day health advisory values for microcystins and cylindrospermopsin in drinking water.

Cyanotoxin	USEPA 10-day Drinking Water Health Advisory [a, b]	
	Bottle Fed Infants and pre-school children (µg/L)	**School age children and adults (µg/L)**
Microcystins	0.3	1.6
Cylindrospermopsin	0.7	3.0

a. U.S. Environmental Protection Agency, 2015b, c
b. µg/L = micrograms per liter (parts per billion)

Methods

SCDHEC Bureau of Water (BOW) Aquatic Science Programs (ASP) collected cyanotoxin samples from March 2022 to December 2022 for microcystins. Three (3) types of sampling were conducted as part of the 2020 study: monthly-monitoring at waterbodies throughout the State, sampling at drinking water intakes with a history of algal issues (drinking water lake source monitoring), and sampling in response to complaints (event-driven). The event-driven sampling included visually observed algal blooms and a fish kill in response to citizen and stakeholder complaints. A total of 20 freshwater bodies and 38 estuaries and influent streams were regularly sampled during the monthly-monitoring component, seven (7) drinking water lake intakes were monitored, and twelve (12) samples were collected at eleven (11) different water bodies due to event-driven responses.

Monthly-Monitoring

Ninety-four (94) sites were sampled monthly from May 2022 to October 2022 (Table 3 and Figure 1). These sites were selected from the 2022 list of Ambient Water Quality Monitoring Program sites (SCDHEC, 2022a). The 2022 Ambient Water Quality Monitoring Program collected monthly samples from a total of 244 Base Sites for water quality parameters including temperature, chlorophyll *a*, nutrients, metals, etc. providing an opportunity to compare cyanotoxin results to other water quality parameters. Five (5) of the 94 sites were sampled from April 2022 to October 2022 due to a special nutrient study being conducted on Lake Murray, which were sampled according to SCDHEC BOW technical report No. 003-2023 (SCDHEC, 2023b).

A total of 576 samples were analyzed for microcystins. Sample collection, field analysis, handling, preservation, and Chain of Custody (COC) followed SCDHEC Determination of Total Microcystins and Cylindrospermopsin in Ambient Water Standard Operating Procedure (SOP) (Appendix 1). The field manager oversaw the transportation of the samples and the COCs to the SCDHEC ASP laboratory. Samples were frozen at –20^{o}C for a holding time not to exceed two (2) weeks.

Samples were analyzed for microcystins using the Enzyme Linked Immunosorbent Assay (ELISA) technique described in SCDHEC Determination of Total Microcystins and Cylindrospermopsin in Ambient Water SOP (Appendix 1). The analysis is based on USEPA method 546 (U.S. Environmental Protection Agency, 2015a) with guidance from the assay provider, Abraxis. Microcytsins/Nodularins ADDA ELISA and SAES ELISA plates were used for this analysis, with detection limits of 0.100 ug/L and 0.016 ug/L, respectively.

Table 3: Sampling site locations for monthly-monitoring.

Site	Regional Lab	Description	Latitude	Longitude
B-327	Midlands	Monticello Lake	34.3297	-81.3026
B-339	Greenville	Lake Bowen	35.1128	-82.0455
B-345	Midlands	Parr Reservoir	34.2621	-81.3354
B-354	Lancaster	Lake Whelchel	35.1063	-81.6333
CL-041	Greenville	J. Strom Thurmond	33.6699	-82.2076
CL-069	Midlands	Langley Pond	33.5223	-81.8432
CL-089	Midlands	Lake Wateree	34.3368	-80.7049
CSTL-107	Beaufort	Coosawhatchie River	32.5883	-80.9238
CW-016F	Lancaster	Fishing Creek Reservoir	34.6777	-80.8772
CW-033	Midlands	Cedar Creek Reservoir	34.5426	-80.8777
CW-057	Lancaster	Fishing Creek Reservoir	34.6053	-80.8910
CW-174	Midlands	Cedar Creek Reservoir	34.5581	-80.8917
CW-197	Lancaster	Lake Wylie	35.1376	-81.0594
CW-201	Lancaster	Lake Wylie	35.0281	-81.0477
CW-207B	Midlands	Lake Wateree	34.4039	-80.7827
CW-208	Midlands	Lake Wateree	34.4219	-80.8674
CW-230	Lancaster	Lake Wylie	35.0225	-81.0087
CW-231	Midlands	Lake Wateree	34.5365	-80.8749
LCR-02	Midlands	Lake Wateree	34.4858	-80.8998
LCR-04	Midlands	Fishing Creek Reservoir	34.6204	-80.8862
MD-001	Beaufort	Beaufort River	32.4456	-80.6632
MD-004	Beaufort	Beaufort River	32.3653	-80.6779
MD-043	Charleston	Cooper River	32.9629	-79.9212
MD-045	Charleston	Cooper River	32.8453	-79.9335
MD-049	Charleston	Ashley River	32.8758	-80.0815
MD-052	Charleston	Ashley River	32.7966	-79.9719
MD-069	Charleston	Intracoastal Waterway	32.7728	-79.8422
MD-077	Florence	Sampit River	33.3574	-79.2940
MD-115	Charleston	Wando River	32.9228	-79.9273
MD-116	Beaufort	Broad River	32.3848	-80.7838
MD-117	Beaufort	Chechessee	32.3741	-80.8361
MD-118	Beaufort	New River	32.2360	-81.0129
MD-120	Beaufort	Dawho River	32.6366	-80.3418
MD-125	Florence	Intracoastal Waterway	33.8534	-78.6539
MD-130	Charleston	Folly River	32.6596	-79.9433
MD-142	Florence	Waccamaw River	33.4083	-79.2171
MD-173	Beaufort	May River	32.2104	-80.8423
MD-174	Beaufort	Broad Creek	32.1804	-80.7740
MD-176	Beaufort	Colleton River	32.3323	-80.8774
MD-202	Charleston	Stono River	32.7857	-80.1075
MD-206	Charleston	Stono River	32.6744	-80.0046
MD-209	Charleston	Bohicket Creek	32.6223	-80.1643
MD-248	Charleston	Cooper River	32.8905	-79.9627

Site	Regional Lab	Description	Latitude	Longitude
MD-252	Beaufort	Combahee River	32.5643	-80.5570
MD-253	Beaufort	Ashepoo River	32.5330	-80.4484
MD-256	Beaufort	Unnamed Creek	32.3399	-80.5078
MD-257	Beaufort	Ramshorn Creek	32.1288	-80.8890
MD-258	Beaufort	Ramshorn Creek	32.1110	-80.8986
MD-259	Beaufort	Wright River	32.0943	-80.9489
MD-260	Beaufort	S. Edisto River	32.5673	-80.3901
MD-261	Charleston	Yonges Island Creek	32.6947	-80.2229
MD-262	Charleston	N. Edisto River	32.6059	-80.2293
MD-264	Charleston	Wando River	32.8584	-79.8959
MD-266	Charleston	Casino Creek	33.0751	-79.3941
MD-267	Charleston	Five Fathom Creek	33.0366	-79.4769
MD-269	Charleston	Sewee Bay	32.9367	-79.6550
MD-271	Charleston	Hamlin Sound	32.8269	-79.7746
MD-273	Charleston	Kiawah River	32.6080	-80.1274
MD-275	Florence	Pee Dee River	33.4222	-79.2246
MD-277	Florence	Parsonnage Creek	33.5529	-79.0339
MD-278	Florence	Winyah Bay	33.2735	-79.0340
MD-281	Beaufort	Parrot Creek	32.4953	-80.5553
MD-282	Beaufort	Morgan River	32.4438	-80.6069
PD-325	Florence	Black River	33.4138	-79.2504
PD-327	Lancaster	Lake Robinson	34.4675	-80.1698
RL-19154	ASP	Lake Murray	34.0695	-81.6186
S-022	Greenville	Lake Greenwood	34.3278	-82.0849
S-024	Greenville	Lake Greenwood	34.3079	-82.1101
S-131	Greenville	Lake Greenwood	34.2791	-82.0587
S-211	Midlands	Lake Murray	34.0984	-81.4765
S-213	Midlands	Lake Murray	34.1251	-81.4337
S-222	ASP	Lake Murray	34.0802	-81.5625
S-279	ASP	Lake Murray	34.0763	-81.4724
S-308	Midlands	Lake Greenwood	34.3467	-82.1088
S-309	ASP	Lake Murray	34.1315	-81.6048
S-310	Midlands	Lake Murray	34.1151	-81.5999
S-311	Greenville	Boyd Mill Pond	34.4547	-82.2019
S-326	ASP	Lake Murray	34.0682	-81.5869
ST-005	Florence	Santee River	33.2091	-79.3839
SV-098	Greenville	Lake Russell	34.0704	-82.6429
SV-200	Greenville	Lake Hartwell	34.6117	-83.2262
SV-236	Greenville	Lake Hartwell	34.5954	-82.9078
SV-268	Greenville	Lake Hartwell	34.5972	-82.8218
SV-321	Greenville	Broadway Lake	34.4499	-82.5867
SV-331	Greenville	Lake Secession	34.3319	-82.5758
SV-335	Greenville	Lake Jocassee	35.0320	-82.9151
SV-336	Greenville	Lake Jocassee	34.9959	-82.9793
SV-338	Greenville	Lake Keowee	34.8269	-82.8977

Site	Regional Lab	Description	Latitude	Longitude
SV-339	Greenville	Lake Hartwell	34.5112	-82.8098
SV-340	Greenville	Lake Hartwell	34.4032	-82.8391
SV-357	Greenville	Lake Russell	34.1920	-82.6309
SV-361	Greenville	Lake Keowee	34.7339	-82.9183
SV-363	Greenville	Lake Hartwell	34.4800	-82.9454
SV-374	Greenville	Lake Hartwell	34.5721	-82.8299

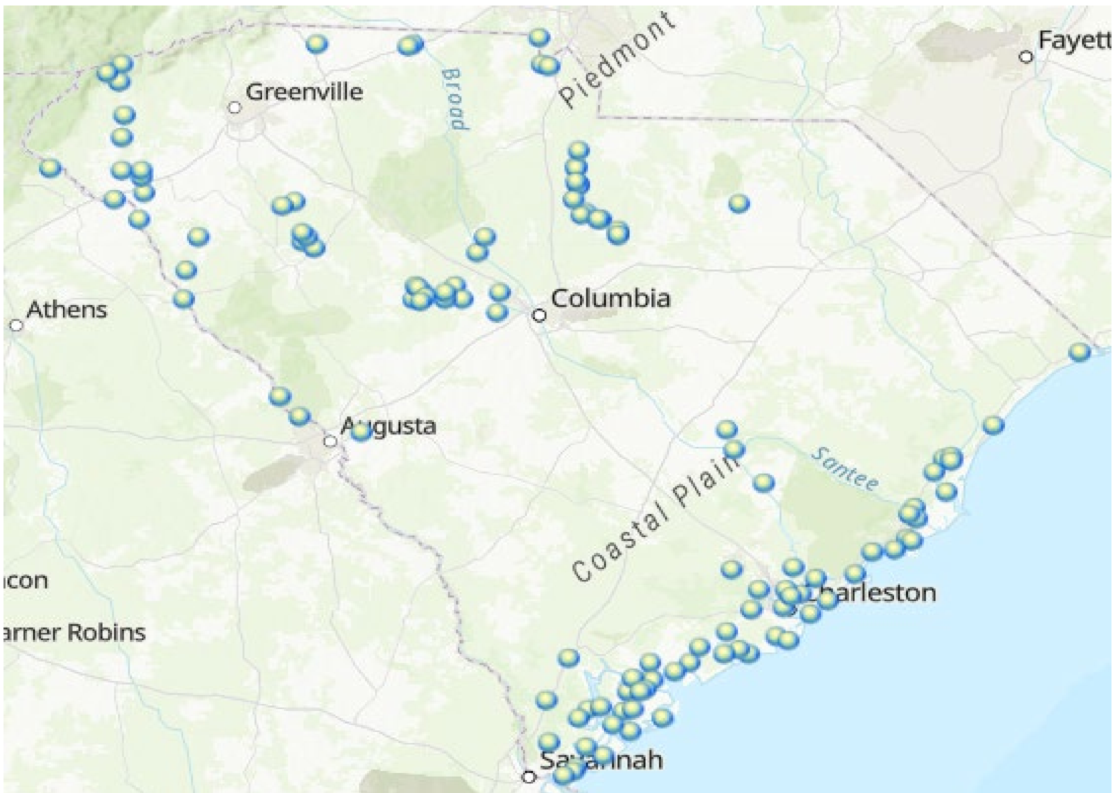

Figure 1: 2022 monthly-monitoring sampling site locations.

Drinking Water Lake Source Monitoring

Five (5) lakes were sampled monthly from May through October 2022 in proximity to intakes for seven (7) different drinking water facilities (Table 4). The lakes and drinking water intake sampling sites were selected based on previous algal issues and taste and odor complaints. A total of 39 samples were collected from the drinking water lakes and analyzed for microcystins, chlorophyll *a*, nutrients, and turbidity. Most samples were collected near the drinking water facility intakes; however, additional samples were collected at other parts of the lakes if algal blooms were observed.

Drinking water sample collection, field analysis, handling, preservation, and laboratory analysis followed the same procedures as described above in the Monthly-Monitoring section.

Table 4: Sampling site locations for five (5) lakes that were monitored at their respective drinking water source intakes.

Lake	Drinking Water Facility	Latitude	Longitude
Lake Wylie	City of Rock Hill	35.0168	-81.0100
Lake Wateree	Lugoff Elgin Water Authority	34.3328	-80.7067
	City of Camden	34.3569	-80.7038
Lake Murray	City of Columbia	34.0215	-81.2326
	City of West Columbia	34.0978	-81.2313
Lake Rabon	Laurens Commissions of Public Works	34.4785	-82.1398
Lake Whelchel	Gaffney Board of Public Works	35.1079	-81.6222

Event-Driven Samples

Eleven (11) waterbodies were sampled in response to complaints reporting algal blooms, fish kills, and/or taste and odor issues during the 2022 sampling season. Sample locations are described in Table 6 below. Toxin samples and/or phytoplankton tow nets were collected after a complaint was received. Samples were observed under the microscope for algal identification at the SCDHEC ASP laboratory and analyzed for microcystins and/or cylindrospermopsin if the species identified was a potential toxin producing species.

Sample collection, field analysis, handling, and preservation followed the same procedures as described above in the Monthly-Monitoring section. Samples identified with cyanobacteria were analyzed via the same procedures as described above in the Monthly-Monitoring section.

Advisories

In 2022, recreational advisories were issued when one (1) or more sample exceeded SCDHEC's state standards for microcystins and/or cylindrospermopsin toxins (Table 1). If a recreational advisory is issued on a waterbody with a drinking water intake, drinking water providers were contacted and recommended to have the finished drinking water tested for toxins. Recreational advisories remained in place until two (2) consecutive cyanotoxin results were below the recreational state standard and the bloom had dissipated. The public was notified about recreational advisories that were issued or lifted via press releases and postings on the SCDHEC HABs webpage: https://scdhec.gov/environment/your-water-coast/harmful-algal-blooms.

Recreational watches were also issued when a potential toxin producing bloom was identified on a waterbody but toxins for microcystin or cylindrospermopsin were less than SCDHEC's state standards, or the identified algal specie could potentially be producing algal toxins, such as anatoxin and saxitoxin, that are not in SCDHEC's state standards. Recreational watches were monitored monthly and were removed once the bloom has dissipated.

Recreational advisories and watches were posted on the Harmful Algal Bloom Monitoring GIS Application: https://gis.dhec.sc.gov/hab_viewer.

Quality Assurance/ Quality Control

In total, 566 of the 576 samples analyzed for microcystins in 2022 passed quality control requirements. Quality Control Requirements can be found in section 10.5 of SCDHEC's Determination of Total Microcystins and Cylindrospermopsin in Ambient Water SOP (Appendix 1). SCDHEC also participated in the Abraxis Cyanotoxins Proficiency Testing Program for recreational water as a check on the accuracy of ASP's routine sample analysis. Performance was evaluated by calculating a z-score metric based on the analysis results of four (4) surface water standards fortified with purified Microcystin-LR, Microcystin-RR, Microcystin-YR, and/or nodularins (toxins produced by *Nodularia sp.*, a cyanobacterium). The z-score metric is as follows:

$$z = \frac{(x - X)}{\sigma}$$

Where:

z= the z score (Standard score)

x= the reported value of analyte

X= the assigned value, the best estimate of the *true* concentration

σ= the estimate of variation (proficiency standard deviation)

The following interpretations for z-scores in proficiency testing schemes are recommended:

Results Obtained	Rating
$z \leq 2$	Satisfactory
$2 < z < 3$	Questionable
$z \geq 3$	Unsatisfactory

The results for SCDHEC's proficiency testing for each of the four (4) samples are listed in the table below.

Sample Number	Result (µg/L) [a]	Z-Score	Evaluation
1	1.15	-0.38	Satisfactory
2	11.3	0.26	Satisfactory
3	14.4	0.10	Satisfactory

a. µg/L = micrograms per liter (parts per billion)

Statistical Analyses

Pearson correlation coefficients were calculated to determine if there were linear relationships between concentrations of microcystins and pH, dissolved oxygen (mg/L), temperature (°C), total phosphorous (mg/L), N:P ratio, and chlorophyll *a* (µg/L) in water bodies that met sample size requirements defined below. Only detectable data (toxin concentration values greater than or equal to the method detection limit) were used for analyses. Microcystin concentration data were considered detectable when result(s) were ≥ 0.016 ug/L for SAES ELISA plates and ≥0.100 ug/L for ADDA ELISA plates.

Fifty-eight water (58) bodies across the State were sampled as part of the 2022 monthly-monitoring program. Due to different hydrologic characteristics among the water bodies, lakes were analyzed individually. Water bodies with a minimum sample size requirement (three (3) detectable samples per month) over the course of six (6) months include Lake Greenwood, Lake Hartwell, Lake Murray, and Lake Wateree.

Pearson correlation matrix output values range from -1 to 1, where values closer to -1 indicate a strong inverse relationship and values closer to 1 indicate a strong positive relationship. Matrix values that are closer to zero indicates no linear relationship. All data analyses were made using Microsoft Excel.

Results

Monthly-Monitoring

From April 2022 through October 2022, a total of 576 samples were collected for microcystins. Of the 566 samples meeting QA/QC guidelines for microcystins, 81% had concentrations greater than or equal to the method detection limit. The maximum microcystin concentration was 0.362 ug/L at station B-354 on Lake Whelchel in October 2022. All monthly-monitoring microcystin concentrations were less than 1 µg/L, which were less than the SCDHEC recreational advisory level of 8 µg/L.

A total of 38 estuarine sites were sampled at 46 different sites during the 2022 monitoring season. Thirty-seven (37) of the 38 estuarine sites had more than one (1) sample with detectable amounts of microcystins (Figure 2). Cooper River had the highest average microcystin concentration (mean ($\bar{x}$)=0.076 µg/L, standard error (SE)=0.009); South Edisto River had the lowest average microcystin concentration ($\bar{x}$=0.020 µg/L, SE=0.001). Refer to Appendix 2 to see the microcystin concentrations of individual sites analyzed each month, organized based on estuary location.

All 20 freshwater lakes had more than one (1) sample with detectable amounts of microcystins (Figure 3). Lake Whelchel had the highest average microcystin concentration ($\bar{x}$=0.340 µg/L, SE=0.014); Lake Jocassee had the lowest average microcystin concentration ($\bar{x}$=0.020 µg/L, SE=0.001). Refer to Appendix 2 to see the microcystin concentrations of individual sites analyzed each month, organized based on lake location.

Microcystins did not strongly correlate with dissolved oxygen, pH, temperature, total phosphorous, N:P ratio, or chlorophyll *a* in Lake Greenwood, Lake Hartwell, Lake Murray, and Lake Wateree with coefficients ranging from -0.21 to 0.29 (Table 5).

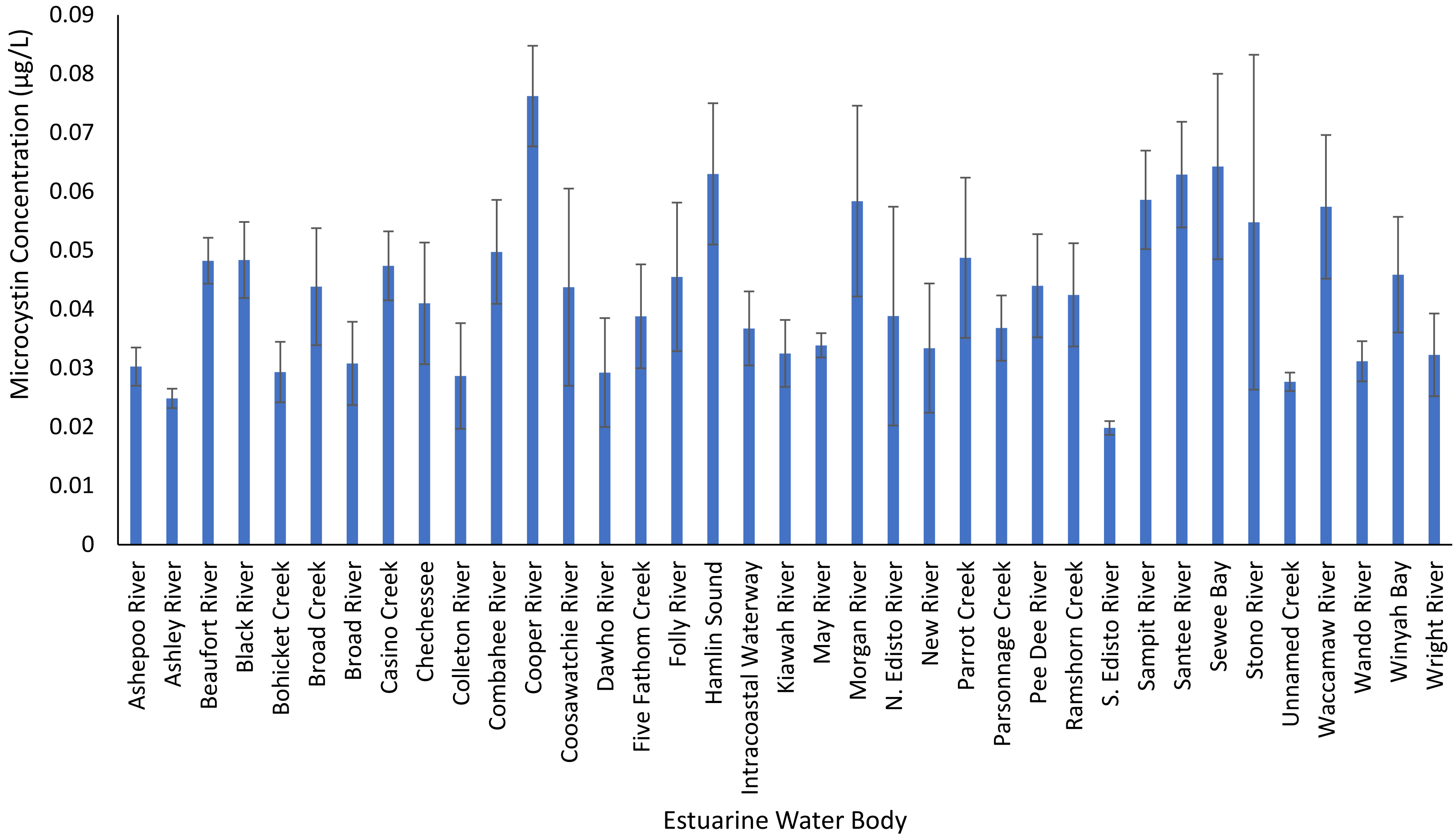

Figure 2: Average detectable microcystin concentrations (µg/L) per estuarine site sampled in 2022. There were 37 estuaries and influent streams that had more than one (1) sample with quantifiable concentrations. The error bars represent +/- one (1) standard error.

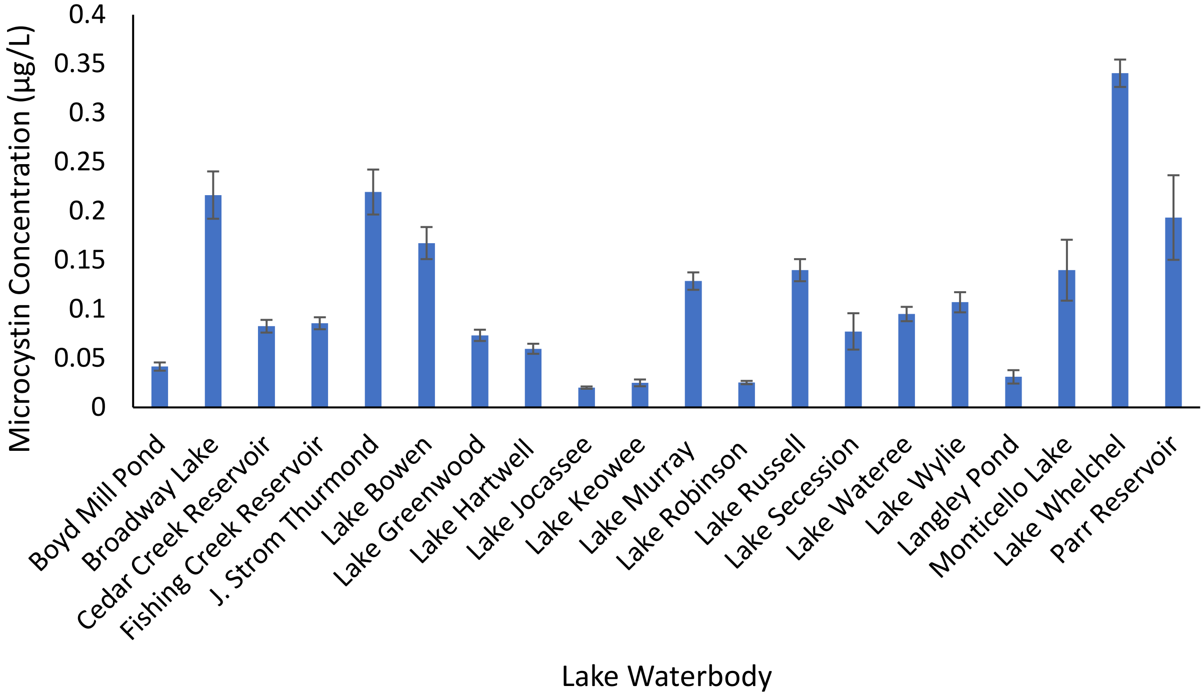

Figure 3: Average detectable microcystin concentrations (µg/L) per freshwater lake in 2022. All 20 lakes sampled had more than one (1) sample with quantifiable concentrations. The error bars represent +/- one (1) standard error.

Table 5: Pearson correlation coefficient results comparing microcystin concentrations (µg/L) in Lake Greenwood, Lake Hartwell, Lake Murray, and Lake Wateree to dissolved oxygen (mg/L), pH, temperature (°C), total phosphorous (mg/L), N:P ratio, and chlorophyll *a* (µg/L).

Water Body	**Microcystin Concentrations Correlation for Respective Water Quality Parameters**					
	Dissolved Oxygen	pH	Temperature	Total Phosphorous	N:P	Chlorophyll *a*
Lake Greenwood	-0.062	0.017	0.095	0.156	-0.140	0.073
Lake Hartwell	-0.156	-0.178	0.068	-0.191	-0.106	0.178
Lake Murray	-0.12	0.18	0.29	-0.21	0.125	-0.21
Lake Wateree	-0.02	0.08	0.01	-0.10	0.015	0.16

Summary of Monthly-Monitoring Findings

- 81% of the 566 samples analyzed for microcystins were detectable (≥ 0.100 µg/L for ADDA ELISA or ≥ 0.016 µg/L for SAES ELISA method).
- All microcystin samples were less than the SCDHEC recreational action level of 8 µg/L.
- There were no strong correlations between microcystin concentrations and dissolved oxygen, pH, temperature, total phosphorous, N:P ratio, and chlorophyll *a* in Lake Greenwood, Lake Hartwell, Lake Murray, or Lake Wateree.

Drinking Water Lake Source Monitoring

From May through October 2022, 39 samples were collected for microcystins at five (5) different lakes for seven (7) different drinking water facilities. Samples collected near the Gaffney BPW drinking water intake at Lake Whelchel had the highest average microcystin concentration ($\bar{x}$=0.278 µg/L, SE=0.058); the City of Camden drinking water intake samples at Lake Wateree had the lowest average microcystin concentration ($\bar{x}$=0.103 µg/L, SE=0.037).) All drinking water samples were below the USEPA 10-day drinking water health advisory of 1.6 µg/L for school age children and adults. All Lake Wateree (City of Camden and Lugoff-Elgin), Lake Wylie (City of Rock Hill), and Lake Murray (City of Columbia) intake samples were below the USEPA 10-day drinking water health advisory values of 0.3 µg/L for bottle fed infants and pre-school aged children (Figure 4). Three (3) samples at the Lake Rabon (Laurens CPW) drinking water intake, two (2) samples at the Lake Whelchel (Gaffney BPW) drinking water intake, and one (1) sample at Lake Murray (City of West Columbia) drinking water intake had microcystin concentrations above 0.3 µg/L. The treatment processes at all drinking water intakes can remove microcystins at these low concentrations.

Fourteen (14) additional drinking water lake samples were collected at algal blooms that occurred on Lake Rabon and Lake Whelchel. All fourteen (14) algal bloom samples collected from Lake Rabon and Lake Whelchel were below 1 µg/L.

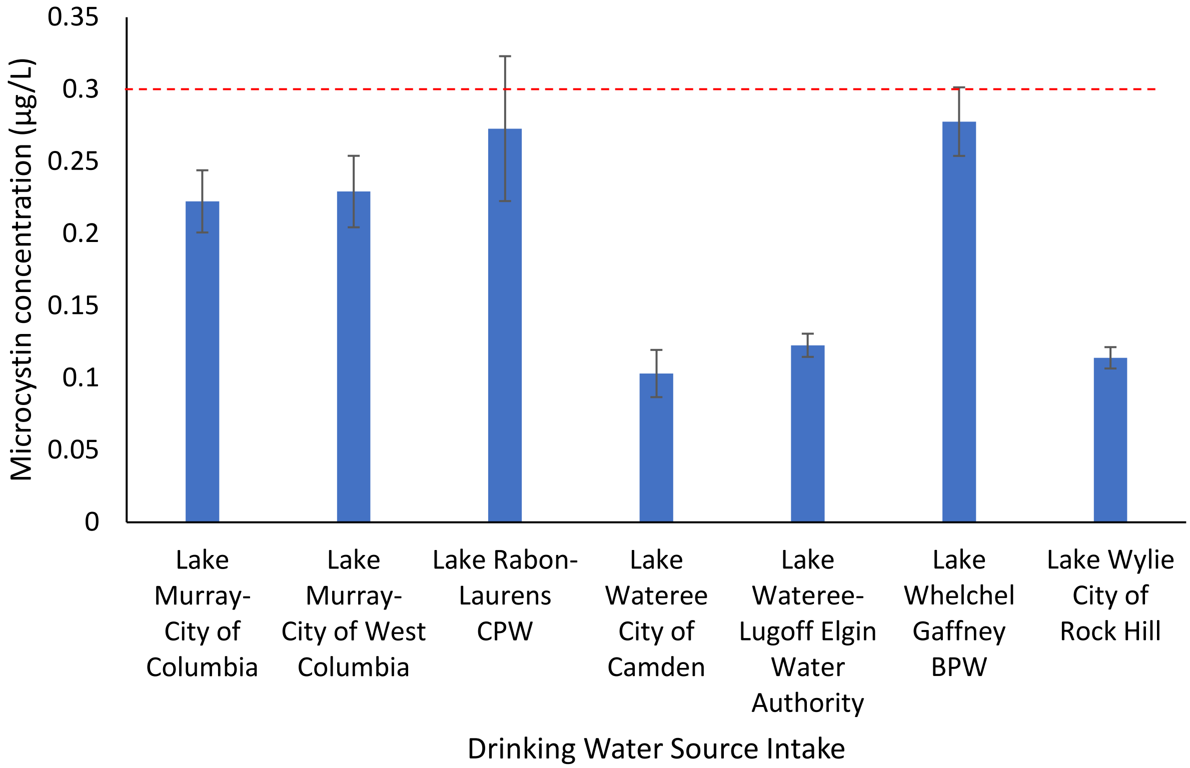

Figure 4: Average detectable microcystin concentrations (µg/L) per drinking water source intake in 2022. There were five (5) lakes sampled for seven (7) different drinking water facilities. The red line indicates the USEPA drinking water 10-day health advisory value of 0.3 for bottle fed infants and pre-school children. The highest average microcystin concentration occurred at Lake Whelchel (0.278 µg/L). The error bars represent +/- one (1) standard error.

Summary of Drinking Water Lake Source Sample Findings

- Microcystins were detected in samples collected near all seven (7) drinking water intakes in 2022 (≥ 0.100 µg/L for ADDA ELISA or ≥ 0.016 µg/L for SAES ELISA method).
- Samples at all seven (7) drinking water intakes were below the USEPA 10-day drinking water health advisory of 1.6 µg/L for school age children and adults.
- Lake Wateree (City of Camden and Lugoff-Elgin), Lake Wylie (City of Rock Hill), and Lake Murray (City of Columbia) samples were below the USEPA 10-day drinking water health advisory values of 0.3 µg/L for bottle fed infants and pre-school aged children.
- Three (3) samples at the Lake Rabon (Laurens Commission of Public Works (CPW)) drinking water intake, two (2) samples at the Lake Whelchel (Gaffney BPW) drinking water intake, and one (1) sample at Lake Murray (City of West Columbia) drinking water intake had microcystin concentrations above 0.3 µg/L.
- The treatment processes at all drinking water intakes can remove microcystins at these low concentrations. Additional samples collected at algal blooms on Lake Rabon and Lake Whelchel were all below 1 µg/L.

Event-Driven Samples

Throughout the 2022 season, the SCDHEC BOW ASP section received twelve (12) complaints on eleven (11) waterbodies. Of the twelve (12) complaint blooms, nine (9) were identified to be cyanobacteria blooms with the potential to produce microcystins. All nine (9) cyanobacteria samples had detectable levels of microcystins (Table 6). The highest concentration of microcystins (8.88 µg/L) was at Lake Wylie, which was greater than SCDHEC's recreational action level. See Advisories and Watches section for more information on the Lake Wylie Advisory issued in 2022.

Two (2) of the twelve (12) complaint blooms had the potential to produce cylindrospermopsin toxins based on the types of species present in the samples (Table 6). However, both samples had cylindrospermopsin levels less than the detection limit (0.040 µg/L).

Table 6: Description and microcystin concentration (µg/L) results from 2022 algal bloom complaints with the associated date of the HAB. Microscopic images of cyanobacteria for four (4) of the designated blooms can be found in Appendix 3.

Sample Location	Sample Description	Collection Date	Microcystins (µg/L) [a]	Cylindrospermopsin (µg/L)
Cobblestone Park, Blythewood	*Microcystis sp., Dolichospermum sp., Aphanizomenon sp., Worchinia sp.*[c]	03/07/2022	0.290	N/A[b]
Easley, SC	Filamentous green algae (non-harmful)	04/01/2022	N/A[b]	N/A[b]
Goose Creek Reservoir	*Aphanizomenon sp.* bloom[c]	04/13/2022	N/A[b]	BDL[d]
Lake Paul Wallace	Bloom of dinoflagellate, *G. instriatum*, with *Microcystis sp.* and *Worchinia*[c]	05/17/2022	0.196	N/A[b]
Broad River Canal	Taste and Odor issues with City of Columbia- *Dolichospermum sp.* bloom	06/01/2022	0.300	BDL[d]
Lake Wateree by station LCR-02	*Phormidium sp.* bloom in response to fish kill	06/29/2022	0.337	N/A[b]
Pioneer Rural Water- Lake Hartwell	Algal Bloom not present in sample	07/11/2022	0.106	N/A[b]
Church Creek	*Scytonema sp.* or *Tolypthrix sp*	07/13/2022	1.88	N/A[b]
Anne Springs Close Greenway	*Planktothrix sp.* bloom[c]	07/25/2022	0.537	N/A[b]
Broad River	Filamentous green algae bloom (non-harmful)	08/31/2022	N/A[b]	N/A[b]
Lake Wylie- Cove between Molokai and Palymyra Dr.	*Microcystis sp.* bloom	10/26/2022	3.37	N/A[b]
Lake Wylie- cove between Nivens Landing Dr. and McHanna Pt.	*Microcystis sp.* bloom	11/01/2022	8.88	N/A[b]

a. µg/L = micrograms per liter (parts per billion)
b. N/A= Not Applicable
c. Microscope image of the associated cyanobacteria can be found in Appendix 3
d. BDL= below detection limit

Summary of Event-Driven Sample Findings

- Nine (9) of the twelve (12) HAB complaint samples detected microcystins (≥ 0.100 µg/L for ADDA ELISA or ≥ 0.016 µg/L for SAES ELISA method).

- One (1) of the HAB complaint samples was greater than the SCDHEC state recreational action value of 8 µg/L for microcystins. This sample was at Lake Wylie and had a microcystin concentration of 8.88 µg/L. See Advisories and Watches for more information.
- Two (2) of the twelve (12) HAB complaint samples were analyzed for cylindrospermopsin toxins. Both samples were below the detection limit (≥ 0.040 µg/L).

Advisories and Watches

The recommended USEPA recreational water quality and swimming advisory criteria for microcystins and cylindrospermopsin (Table 1) were adopted as enforceable State water quality standards in 2020. One (1) recreational advisory was issued in 2022 for microcystin concentrations higher than SCDHEC's state standard of 8 µg/L (Table 7). The advisory was lifted once microcystin concentrations were below 8 µg/L and the bloom had dissipated.

The advisory was issued at Lake Wylie on November 1, 2022 following a sample with a microcystin concentration of 8.88 µg/L. The advisory was lifted on December 6, 2022 when the second consecutive sample had a microcystin concentration below 8 µg/L (microcystin concentration was BDL).

Recreational watches were issued in 2022 as a result of algal blooms on Goose Creek Reservoir, Broad River Canal, and Lake Wylie (Appendix 4). The watches did not result in any recreational advisories.

Summary of Advisories and Watches

- A recreational advisory was issued in November 2022 at Lake Wylie for a microcystin concentration exceeding SCDHEC's state standard of 8 µg/L. The advisory was lifted on December 6, 2022.
- Recreational watches were issued in 2022 as a result of algal blooms on Goose Creek Reservoir, Broad River Canal, Lake Wylie. None of the watches resulted in any recreational advisories.

Discussion and Conclusions

A primary goal of the HAB Monitoring Program is to establish cyanotoxin spatial distribution data in South Carolina waterbodies. These 2022 results have (a) contributed to a cyanotoxin concentration baseline for South Carolina waterbodies and (b) provided insight towards cyanotoxin presence/absence expectations. Microcystins were detected in 81% of the samples that passed QA/QC. SCDHEC expanded the HABs Monitoring Program in 2022 by, monitoring seven (7) drinking water intakes at five (5) lakes and increasing the parameter suite to include nutrients and turbidity at each drinking water station.

Overall, the results from the 2022 monthly-monitoring for microcystins in lakes showed toxin concentrations less than 1µg/L, below SCDHEC's recreational standard over 8 µg/L. The low cyanotoxin concentrations observed as part of the monthly-monitoring data suggest that generally recreational activities in South Carolina are not an immediate concern. Maintaining and expanding monthly-monitoring in the future field seasons will help in identifying localized elevated cyanotoxin concentrations in additional environments. A limitation of the monthly-monitoring sampling sites is that they are fixed open-water locations. Cyanobacteria blooms often occur in shallow coves or along shorelines.

The event-driven sampling is a more targeted component of the HAB Program, which provides insight into potential cyanotoxin producing HABs in nearshore environments. Microcystin concentrations in event-driven samples ranged from 0.106 µg/L to 8.88 µg/L. The HAB at Lake Wylie was the only event-driven sample that had a microcystin concentration exceeding the SCDHEC state recreational standard of 8 ug/L. This advisory lasted for approximately one (1) month.

SCDHEC's HAB Monitoring Program collaborated with seven (7) drinking water facilities in 2022 to monitor drinking water intakes at five (5) lakes: Lake Murray, Lake Rabon, Lake Wateree, Lake Whelchel, and Lake Wylie. Microcystins were detected at all drinking water intakes. Lake Rabon, Lake Whelchel, and Lake Murray (City of West Columbia) were the only drinking water intakes that had at least one (1) sample greater than the USEPA 10-day drinking water health advisory value of 0.3 µg/L for bottle fed infants and pre-school aged children. The treatment process at Laurens CPW (Lake Rabon), Gaffney BPW (Lake Whelchel), and City of West Columbia (Lake Murray) can remove microcystins at these low concentrations. As HABs continue to expand and increase in frequency and duration, monitoring drinking water intakes and collaborating with drinking water facilities will continue to be a vital component of the HAB Monitoring Program.

No strong relationships were observed in the monthly-monitoring correlation results comparing microcystin concentrations to dissolved oxygen, pH, temperature, total phosphorus, N:P ratio, and chlorophyll *a* for Lake Greenwood, Lake Hartwell, Lake Murray, and Lake Wateree. The lack of a clear relationship among these monitoring variables suggests that the periodic occurrence of toxin producing cyanobacteria species is more complex than a single variable correlation in the same time and space (Davis, Berry, Boyer, & Gobler, 2009; Paerl & Otten, 2012; Wiltsie, Schnetzer, Green, Vander Borgh, & Fensin, 2018) or is related to environmental variables not routinely measured as part of the ambient monitoring program. Further, these lake-by-lake datasets are small and likely not robust enough for meaningful correlation. More data over the next several years will build on the past four (4) years of data and may provide a clearer understanding of patterns in cyanotoxin production.

In conclusion, the monthly-monitoring cyanotoxin concentrations were lower than the SCDHEC state recreational standards, suggesting recreational activities in South Carolina were not an immediate concern. There was one (1) event-driven sampling event at Lake Wylie where microcystin concentrations exceeded SCDHEC recreational state standards. SCDHEC continued to work with drinking water facilities to monitor seven (7) different drinking water intakes at six (6) lakes for microcystins. Microcystins were present at each drinking water intake, but the drinking water treatment facilities successfully removed the toxin. Even though no strong correlations between microcystin concentrations and other environmental parameters were discerned in this assessment, a larger dataset over several years may provide better insight into relationships among these variables. The HAB Monitoring Program continues to work on educating South Carolina residents on HABs. Future goals of the HABs Monitoring Program include expanding the statewide cyanotoxin study to include other algal toxins, such as saxitoxins and anatoxins, establishing baseline toxin data for large rivers and streams, and conducting a multi-year assessment of the baseline lake cyanotoxin data.

Overall Summary:

- 2022 completed the fifth year of the HAB Monitoring Program. The data gathered in 2018, 2019, 2020, and 2021 will be used to inform future sampling plans and provide insights into lakes that the agency may consider monitoring more frequently.

- The monthly-monitoring sampling suggest no immediate concern for recreation activities due to the low concentrations of microcystins in open water settings.
- A recreational advisory was issued for a cove on Lake Wylie that exceeded the SCDHEC state standard of 8 µg/L. The advisory lasted for the month of November in 2022.
- There were no strong correlations between microcystin concentrations and other parameters measured in Lake Greenwood, Lake Hartwell, Lake Murray, and Lake Wateree. Future analyses would benefit from a larger data set that also includes samples from algal blooms and examines a combination of factors.

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Appendix 1: Standard Operating Procedure for Determination of Total Microcystins and Cylindrospermopsin in Ambient Water

Algal Bloom and Cyanotoxin Field Collection Standard Operating Procedures

Bureau of Water- Aquatic Science Programs

February 23, 2021

Emily Bores, Author, Aquatic Science Programs	02/23/2021 Date
Bryan Rabon, Manager, Aquatic Science Programs	2021-02-23 Date
Jennifer Hughes, Assistant Bureau Chief- BOW	2/24/2021 Date
David Graves, Quality Assurance Manager, EA	2/24/2021 Date

1.0 Background

Algae and cyanobacteria are a large, diverse group of single and multi-celled organisms that can possess characteristics of both plants and animals. Under the right environmental conditions, algae can proliferate and become a nuisance in any body of water. This rapid growth is called an algal bloom and can be associated with foam, scum, or thick layers of algae on the surface of water. Algal blooms can look and smell bad and may cause the water to appear green, red, brown, or blue in color; however, algal blooms cannot always be seen and are not always harmful. Refer to Appendix A for examples of cyanobacteria blooms.

Cyanobacteria can be found at the water surface (scums, mats), at specific depths, or throughout the water column. Cyanobacteria location can also be impacted by weather such as winds, currents, rain, and lake turnover while other species can regulate their buoyancy and move throughout the water column. It is important to note these different variables to understand that cyanobacteria and cyanobacteria blooms may not 'stay' in one place on the waterbody and an absence of an obvious scum or mat does not necessarily indicate the death/decay or absence of a bloom.

Cyanobacteria, or blue-green algae, are a type of species that has the potential to produce toxins. When they contain toxins that affect the health of people, animals, and the environment, they are known as harmful algal blooms (HABs). Cyanobacteria and algal blooms can also cause taste and odor issues in drinking water, decrease water quality, and impact the aesthetic and recreational value of the waterbody. You cannot tell by looking at a bloom whether it is harmful, and additional microscopy and analytical testing will be needed for species identification and toxin quantification.

2.0 Scope and Application

This Standard Operating Procedure (SOP) describes the procedures and safety precautions that should be followed when assessing a HAB and the proper collection and handling techniques. This SOP applies to any DHEC employee that is performing algal bloom sampling in lakes, reservoirs, rivers, streams, estuaries, and if applicable, ponds.

3.0 Health and Safety

Algal blooms may cause exposure to respiratory, dermal, and ingestible toxins. All algal blooms should be treated as potentially harmful until verified otherwise. Samplers should wear gloves (elbow/shoulder length if possible) and waders/boots during sampling. Do not ingest the water or allow it to come in contact with the skin. If water comes into contact with the skin, wash the impacted area immediately. If attempting to avoid spray caused by boats or winds, wearing a mask is recommended. Hands and equipment (boots, waders) should be washed thoroughly with clean tap or distilled water after sampling. It is also important for staff who have sampled HABs to report any symptoms from exposure to cyanotoxins, which can occur immediately to several days after exposure to the toxins. Refer to Table 1 for common cyanobacteria toxins and their associated symptoms.

Toxins Produced	Type of Toxin	Health Effects in Humans	Onset of Symptoms
Anatoxin- a	Neurotoxins	**Nervous System** Labored breathing, convulsions, numbness,	Minutes to Hours

Saxitoxins		paralysis, and Dog deaths caused by Anatoxin-a	
Microcystins	Hepatotoxin	**Liver** GI symptoms, elevated liver enzymes in blood, death of cells, destruction of blood vessels	Hours to Days
Cylindrospermopsin	Hepatotoxin	**Liver and Kidneys** Symptoms like food poisoning/ possible kidney failure	Hours to Days

Table 1: Cyanobacteria toxins produced and their health effects in humans. Table adapted from presentation by Jen Maucher Fuquay, coordinator of the Phytoplankton Monitoring Network (PMN).

4.0 Equipment and Supplies

___ Protective Equipment: elbow length gloves, safety goggles/glasses, mask, boots, waders

___ PETG or Glass 500mL (clear or amber) sample bottles. The Aquatic Science Programs (ASPs) provide the PETG bottles

___ Paper towels and Plastic bags (to place sample bottle in, if needed)

___ Camera for field pictures

___ GPS

___ Pencils/Pens and Sharpies

___ Algal Bloom Report Form (D-4110)

___ Cooler with ice or ice pack

___ In-situ meter if site parameters (such as D.O., temp) are being taken

5.0 Algal Bloom Site Evaluation and Sampling

5.1 Prior to conducting a field investigation, DHEC staff should obtain as much information about the potential HAB as possible. This includes:

5.1.1. Location of the bloom and type of waterbody. Use Appendix C to determine whether the complaint bloom should be sampled based on waterbody type and/or location. If the bloom is to not be sampled, but rather referred to Clemson Extension or a private lab, refer to Appendix B for resources.

5.1.2. Extent of the bloom on the waterbody, description, photos, etc.

5.1.3. History of the bloom- when did it form, how long has it been on the waterbody, has it gotten bigger/smaller, has there been blooms there in previous years, etc.

5.2. Consult with the ASPs if necessary, to determine whether the bloom should be sampled. See Appendix C for the Flowchart for HAB response sampling. Private Pond/ Stormwater ponds are a case by case situation.

5.3 At the bloom site, identify characteristics of the bloom using the Algal Bloom Report Form (Appendix D). This includes documenting the color and physical nature of the bloom.

5.3.1. Take photos of the bloom both close up and of the spatial extent of the bloom, if possible. Other photos can be taken to capture anything else that is deemed noteworthy.

5.3.2. All observations should be recorded on the Algal Bloom Report Form.

5.3.3. Refer to Appendix E on whether an algal bloom/fish kill should be sampled for in situ measurements.

5.4 A surface grab sample is the most common method of algal bloom collection when the bloom forms a concentrated algal mat or scum on the surface of the water. The purpose of a surface grab sample is to collect a whole water sample from a single point. This sample will capture material accumulated on the surface AND in the water column (i.e. scums, mats, algal material, etc.)

5.4.1. If the impacted area is not easily accessible and access to a boat is not possible, another dip method is acceptable (i.e. bottle on a stick, bottle on a string, bucket) as long as a representative grab sample is still collected.

5.5 To characterize risk of exposure by water contact, samples are collected from sites where the most visible indicators of a bloom are present. This will help determine the maximum concentration of cyanobacteria and potential toxins in that specific area.

5.5.1. Put on gloves and obtain a clean bottle labeled with the site location, date, and time. A 500mL disposable bottle that is PETG or glass is the recommended bottle for sample collection. The use of plastic containers other than PETG is not recommended as some plastic will absorb or bind with the toxins, resulting in inaccurate results.

5.5.2. Remove cap and submerge bottle into the surface of the water, submerging 2-4 inches below the surface, but not so low that water goes into the glove. If possible, attempt to sample in the middle of the bloom. The bottle should contain a mixture of both water and algal sample (scum, mat, clump, etc.) DO NOT collect the sample by only skimming the top of the water.

5.5.3. Try to avoid overfilling the bottle, leaving about 1 inch of headspace; immediately cap the bottle and wipe off the exterior to remove any spilled content from the exterior of the container.

5.5.4. Place the algal bloom samples on ice and ship to the ASPs within 24 to 36 hours. Cyanotoxins are sensitive to high temperatures so immediately store samples from 2-8 C on wet ice.

5.5.5. Coolers can be addressed to: Aquatic Science Programs

2600 Bull Street

Columbia, SC 29201

5.5.6. Please notify personnel at the ASPs when samples are being shipped and/or are in transit. Pictures taken of the bloom can be sent to Emily Bores at WTR_ASP_HAB@dhec.sc.gov

6.0 Laboratory Analytical Methods

Samples will be analyzed via microscopy when received by the lab to determine dominant algal species. If potential toxin-producing algal species are identified, toxin analysis via ELISA (if possible) should be conducted to determine the toxicity of the bloom. Refer to the SOP, Determination of Total Microcystins and Cylindrospermopsin in Ambient Water, for ELISA methodology. Recreational advisories will be issued (if necessary) based on the EPA's recreational values for microcystins and cylindrospermopsins, shown in Table 2. Recreational advisories will be issued by the ASPs and will be listed online and through a media press release. If there are drinking water intakes on the waterbody, drinking water facilities will be notified if quantifiable amount of toxins are found that could affect their finished drinking water (See Table 3 for EPA drinking water health advisory guidelines). Drinking water facilities will be notified via phone and/or email about drinking water concerns by the ASPs. ASPs will coordinate all efforts with the Division of Drinking Water & Recreational Water Protection when a drinking water intake or a permitted natural recreational area is being impacted by a HAB. Additional sampling may be conducted until toxin levels are no longer measurable or they are below the EPA recreational guidelines.

Total Microcystins (ug/L)	Cylindrospermopsin (ug/L)	Duration
8	15	1 in 10-day assessment period across a recreational season

Table 2: EPA recreational Health Advisories

Cyanotoxin	Drinking Water Health Advisory (10-day)	
	Infants and pre-school children	School-age children and Adults
Microcystins	0.3 ug/L	1.6 ug/L
Cylindrospermopsin	0.7 ug/L	3.0 ug/L

Table 3: EPA drinking water health advisories for finished drinking water

7.0 References

Florida DEP. Sampling for Cyanobacteria Blooms. Available at: http://publicfiles.dep.state.fl.us/dear/labs/biology/hab/cyanobacteria_sop.pdf

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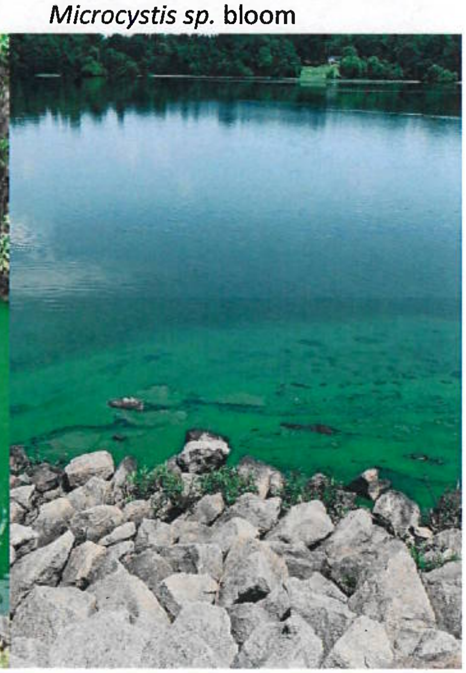
Appendix A: Examples of Cyanobacteria Blooms

Planktothrix sp. Bloom

Microcystis sp. bloom

Aphanizomenon sp. Bloom



Dolichospermum sp. and *Microcystis sp.* bloom

Appendix B: Clemson Extension and Private Lab Resources

Clemson Extension:

Samples can be submitted to Clemson extension for a cost of $20 as of 07/01/2020 where they can ID the algal bloom. They cannot test for toxin production.

The form to fill out to submit a sample is located at:

https://www.clemson.edu/public/regulatory/plant-problem/pdfs/form-weed-id-2018-pdf.pdf

Under suspected ID and/or comments: Can add language about concerns for algal bloom

Fill out Section for "If from a pond": Responses here will be used to inform management resources provided

Fill out "pond" under "location of planting"

Samples can be dropped off at a county Extension office. There is an office in every county. Contact information can be found at:

https://www.clemson.edu/extension/co/index.html

If the extension offices are still closed due to Covid-19, samples can be submitted by shipping to the lab at:

Clemson University Plant and Pest Diagnostic Clinic

511 Westinghouse Rd., Pendleton, SC 29670

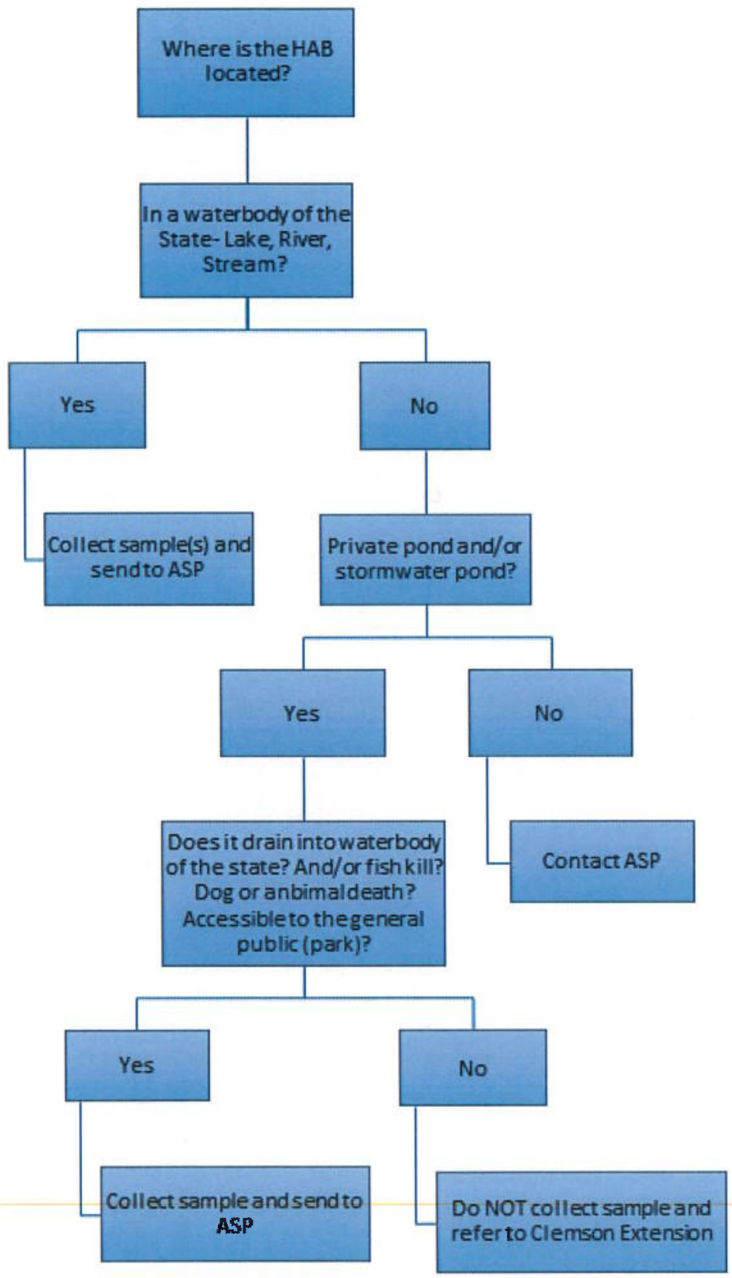
Mail a check along with the sample made out to "Clemson University" and placed in a plastic bag. It would be helpful to have an ice pack shipped with the sample to keep it cool. Ship the sample on a Monday so it can reach the lab by Thursday.

Private Lab Resources:

If a citizen wants to have their pond/lake tested for algal toxins, refer them to the link of possible private labs below, provided by the EPA

https://www.epa.gov/cyanohabs/laboratories-analyze-cyanobacteria-and-cyanotoxins

Appendix C: HAB sampling flow chart



Appendix D: Algal Bloom Report Form (RIMS #D-4110)

Access the most Current Form from RIMS.

ALGAL BLOOM REPORT FORM

This form should be completed and sent with a representative algal sample to the **Aquatic Science Programs**, **2600 Bull Street, Columbia, S. C. 29201**. The fresh sample should be placed on ice or ice packs and should be shipped the same day as collection. Fill the sample bottles provided to the top. If you do not have a provided sample bottle, a glass jar can be used instead. Please call the **Aquatic Science Programs at (803)898-8374** if there are any questions.

Collector's Name____________________ Date________________ Time________________

EA Office__________________________ Phone__________

Waterbody Name_____________________ County__________________

If Pond/Lake - Tributary:

Inflowing____________________ Outflowing__________________

Basin___________________________

REASON FOR SAMPLING (Check):

Fish Kill ☐ Discoloration in Water ☐ Taste/Odor Problem ☐ Scum or mat on surface ☐

Other(Specify)____

____

Description of Bloom:

Include a map or GPS coordinates to indicate the exact location of the water body affected by the algal bloom. Also include qualitative observations of the bloom (i.e., color, floating mats or clumps, % of surface covered by bloom, etc.) in the space below. Please describe the current weather conditions and the weather conditions prior to bloom (if known).

Color				

Floating Mats or Clumps				
% covered by Bloom				
Odor				
Other Details				
Latitude			Longitude	
Map				

Please flip to the reverse side if Physical and/or Chemical data was taken

PHYSICAL MEASURMENTS (If Applicable)

	DO (mg/L)	pH	Temp. (°C)	Conductivity	Salinity
0.3 m					
1.0 m					
2.0 m					
3.0 m					
Bottom					
Bottom Depth (m):					

Complete only if the sample is from a **private** pond or lake:

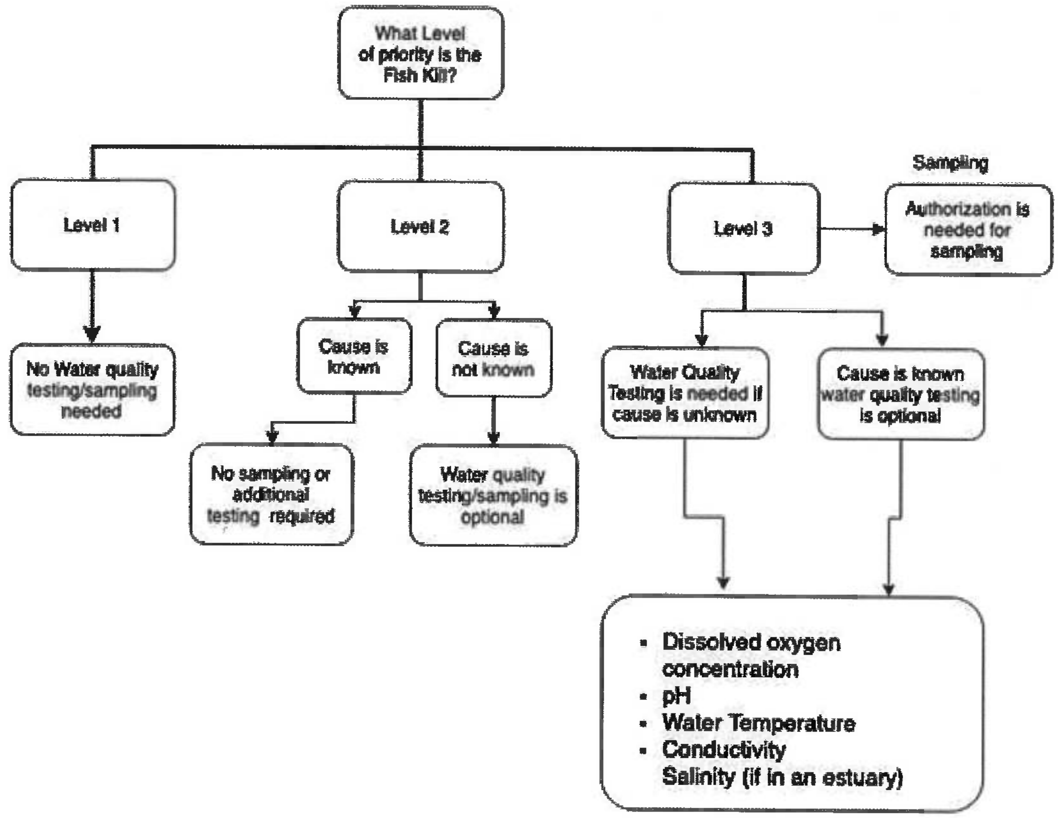
Pond/Lake Owner_______________________________ Age of Pond/Lake____________________

Approximate size (acres) _______________________________

Is Pond/Lake Fertilized? _________________________

Any Additional Comments:

Appendix E: Field Assessment Priorities for Fish Kills



When to respond is based on the following priorities:

Field Assessment:

For calls received after normal business hours, the Environmental Response Section telephone duty officer and the ROSC will confer to share information and to determine the proper Level classification of each notification. The regional office will classify calls received during normal business hours. As a courtesy to the public and agencies SC DHEC works with (i.e. SC DNR, USF&W and Riverkeepers), all fish kill calls are followed up by DHEC. The Field Assessment will help delineate the appropriate response DHEC investigators will take upon determining a level of priority.

- Level 1 A notification/concern raised by the public; the incident is handled as a complaint based on the available information obtained in the initial assessment. Examples would include situations where the event is documented to have occurred in a storm water retention pond; where only a few dead fish are observed in a remote area with no wastewater discharge immediately upstream; or where the initial report is made to the Department several days after the event was observed by the caller and only small numbers of fish are involved. These would be calls where there are reports of dead fish within a body of water not intended to support aquatic life.

- Level 2 A field investigation is needed but can be delayed until the next calendar day when: The person doing the initial assessment is reasonably sure of the cause of the kill and the water body is not waters of the State (i.e. a private pond) or impacting State waters. For safety reasons, notifications of fish kills needing a field investigation received at night can be delayed until daylight.

- Level 3 If the initial assessment will not allow for a Level 1 or 2 classification, then an immediate field investigation is required. This would be a report of a fish kill in public waters (i.e. SC lakes, streams, and rivers).

Appendix 2: Results of 2022 microcystin analyses, which are organized by water body, sites within those water bodies, and the analytical results for each of the sites based on the sampling month.

Water Body	Site	Microcystin Concentration (µg/L) [a]						
		Apr	May	Jun	Jul	Aug	Sep	Oct
Ashepoo River	MD-253	- [b]	0.027	BDL [c]	BDL	BDL	0.0335	BDL
Ashley River	MD-049	-	0.0295	0.0255	-	BDL	0.025	0.0235
	CSTL-102	-	-	-	-	0.0385	0.0285	0.0395
	MD-052	-	0.0275	BDL	0.016	0.027	BDL	BDL
Beaufort River	MD-001	-	0.0385	0.0445	0.0505	0.061	0.0515	0.0245
	MD-004	-	0.0495	0.042	0.0505	0.0655	0.0705	0.0305
Black River	PD-325	-	-	0.0315	0.062	0.0535	0.0465	BDL
Bohicket Creek	MD-209	-	BDL	0.023	0.0255	BDL	0.0395	BDL
Boyd Mill Pond	S-311	-	0.049	-	0.047	0.04	0.0305	BDL
Broad Creek	MD-174	-	0.0605	0.033	0.0195	0.0845	0.039	0.0265
Broad River	MD-116	-	0.017	0.021	0.057	0.033	0.026	BDL
Broadway Lake	SV-321	-	0.1475	0.2985	0.214	-	0.2045	0.217
Casino Creek	MD-266	-	0.0325	BDL	0.0465	0.0495	0.061	BDL
Cedar Creek Reservoir	CW-033	-	-	0.0955	0.0625	0.0955	0.0645	0.075
	CW-174	-	-	0.1075	0.088	0.105	0.089	0.0445
Chechessee	MD-117	-	0.0465	-	0.021	0.0555	BDL	BDL
Colleton River	MD-176	-	0.018	0.0215	BDL	0.0465	BDL	BDL
Combahee River	MD-252	-	0.0635	0.034	0.035	0.0665	BDL	BDL
Cooper River	MD-043	-	0.027	0.093	0.146	0.1195	0.102	0.052
	MD-045	-	0.0205	0.074	0.0445	0.087	0.0975	BDL
	MD-248	-	0.043	0.066	0.0615	0.0845	0.1015	-
Coosawhatchie River	CSTL-107	-	0.0605	0.027	-	-	-	-
Dawho River	MD-120	-	BDL	0.0385	BDL	-	BDL	0.02

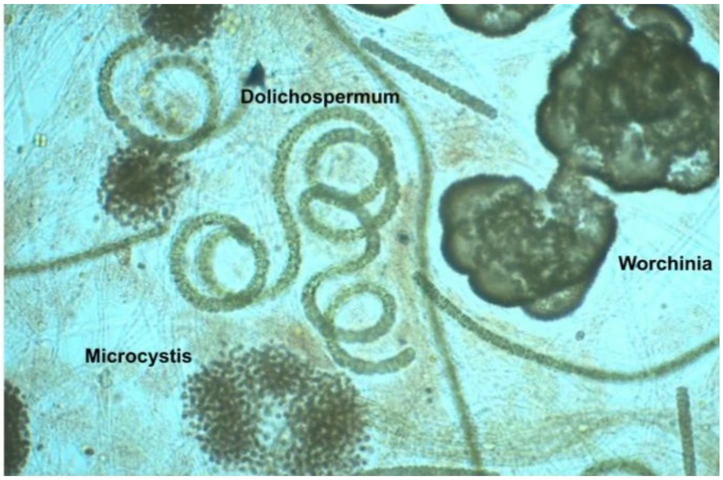
Water Body	Site	Microcystin Concentration (μg/L) [a]						
		Apr	May	Jun	Jul	Aug	Sep	Oct
Fishing Creek Reservoir	CW-016F	-	-	0.0675	0.124	0.071	0.1145	0.1105
	CW-057	-	-	0.079	0.1005	0.073	0.0525	0.0975
	LCR-04	-	-	0.088	0.08	-	0.0955	0.0465
Five Fathom Creek	MD-267	-	0.0245	0.0235	0.042	0.0715	0.0325	BDL
Folly River	MD-130	-	0.055	0.0205	BDL	0.061	BDL	-
Great Swamp	MD-129	-	BDL	BDL	BDL	0.0315	0.0295	0.049
Hamlin Sound	MD-271	-	0.051	BDL	BDL	0.075	-	BDL
Intracoastal Waterway	MD-069	-	0.036	0.0255	0.0185	0.0645	-	BDL
	MD-125	-	BDL	0.019	0.0595	0.027	BDL	0.044
J. Strom Thurmond	CL-041	-	0.147	0.1985	0.215	0.211	0.226	0.319
Kiawah River	MD-273	-	0.0385	0.043	BDL	0.0315	0.017	-
Lake Bowen	B-339	-	0.103	0.191	0.144	0.176	0.1715	0.219
Lake Greenwood	S-022	-	0.082	0.057	0.0395	0.0505	0.107	0.0905
	S-024	-	0.021	0.085	-	0.094	0.0625	0.1125
	S-131	-	0.0545	0.072	0.067	0.081	0.097	0.0675
	S-308	-	0.067	0.0525	0.14	0.0715	-	0.044
Lake Hartwell	SV-200	-	0.027	BDL	BDL	BDL	BDL	0.016
	SV-236	-	0.025	0.0375	0.0925	0.069	0.075	0.1225
	SV-268	-	BDL	0.0255	BDL	BDL	BDL	0.0265
	SV-339	-	0.0415	0.0585	0.0605	0.016	0.0555	0.0765
	SV-340	-	0.05	0.103	0.0435	BDL	0.0345	0.1085
	SV-363	-	0.068	0.0565	0.0895	0.058	0.057	0.089
	SV-374	-	0.039	0.06	0.0655	BDL	-	0.105
Lake Jocassee	CL-019	-	BDL	BDL	BDL	BDL	BDL	BDL
	SV-335	-	0.022	-	BDL	BDL	BDL	BDL
	SV-336	-	BDL	BDL	BDL	0.018	BDL	0.0205
Lake Keowee	SV-338	-	BDL	BDL	BDL	0.029	BDL	0.019
	SV-361	-	BDL	0.0225	BDL	0.018	BDL	0.0365
Lake Murray	RL-19154	0.034	0.2635	0.296	0.1575	0.0685	0.06	0.093

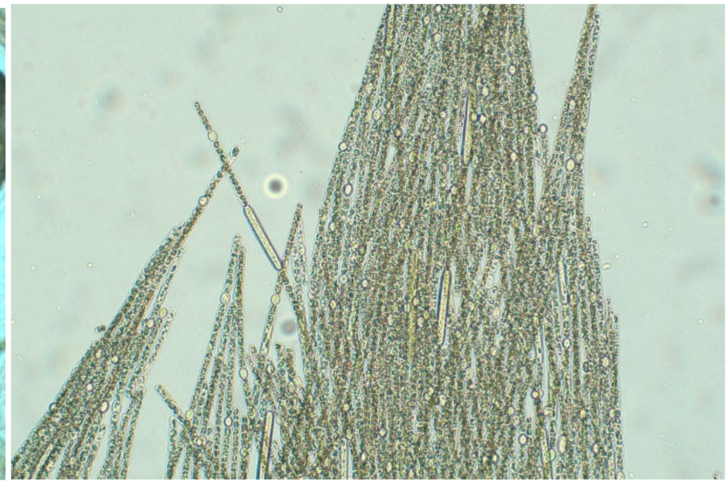
Water Body	Site	Microcystin Concentration (µg/L) [a]						
		Apr	May	Jun	Jul	Aug	Sep	Oct
	S-211	-	0.171	0.204	0.1675	0.1875	0.236	0.1455
	S-213	-	0.21	0.2395	0.2175	0.2415	0.1395	-
	S-222	0.046	0.081	0.1515	0.1055	0.1015	0.055	0.0955
	S-279	0.0495	-	-	-	0.125	-	0.1305
	S-309	0.021	0.088	0.0945	0.133	0.0305	0.0955	0.0755
	S-310	-	0.0355	0.1085	0.09	0.0855	0.0965	0.0405
	S-326	0.149	0.3435	0.2975	0.1825	0.162	0.078	0.11
Lake Robinson	PD-327	-	-	0.0265	0.0275	BDL	0.022	BDL
Lake Russell	SV-098	-	0.1515	0.1375	0.127	-	0.093	0.125
	SV-357	-	0.2275	0.14	0.151	-	0.111	0.13455
Lake Secession	SV-331	-	0.025	0.1245	0.1135	0.0915	0.0925	0.0175
Lake Wateree	CL-089	-	0.1235	0.11	0.11	0.064	0.109	0.22955
	CW-207B	-	0.111	0.069	0.1235	0.07	0.0765	-
	CW-208	-	0.057	0.067	0.0835	0.0945	0.086	0.0955
	CW-231	-	-	0.1135	0.159	0.0975	0.0725	0.1525
	LCR-02	-	0.0585	0.089	0.0575	0.0555	0.071	0.058
Lake Wylie	CW-197	-	-	0.066	0.0915	-	0.086	0.1695
	CW-201	-	-	0.13	0.094	0.0315	0.1035	0.1285
	CW-230	-	-	0.1105	0.1185	BDL	0.163	0.1005
Langley Pond	CL-069	-	0.0495	0.0165	0.029	0.0295	BDL	-
May River	MD-173	-	0.0325	BDL	0.032	0.031	0.04	BDL
Monticello Lake	B-327	-	0.1285	0.2816	0.1575	0.1005	0.065	0.1055
Morgan River	MD-282	-	0.0345	0.04	BDL	0.1055	0.0535	BDL
N. Edisto River	MD-262	-	BDL	BDL	0.0195	BDL	0.076	0.021
New River	MD-118	-	BDL	0.033	0.0185	0.076	0.019	0.0205
Parr Reservoir	B-345	-	0.05	0.0966	0.0495	0.064	0.097	0.06855
Lake Whelchel	B-354	-	-	0.3365	0.2875	0.358	0.3585	0.3615
Parrot Creek	MD-281		0.029	0.0375	0.0395	0.089	BDL	BDL
Parsonnage Creek	MD-277	-	BDL	0.0485	0.032	0.0485	0.019	0.036

Water Body	Site	Microcystin Concentration (µg/L) [a]						
		Apr	May	Jun	Jul	Aug	Sep	Oct
Pee Dee River	MD-275	-	-	0.051	0.074	0.031	0.024	0.04
Ramshorn Creek	MD-257	-	0.0435	0.029	0.0415	0.0955	0.016	BDL
	MD-258	-	0.049	0.022	0.0165	0.069	BDL	BDL
S. Edisto River	MD-260	-	BDL	0.018	0.0195	-	BDL	0.0225
Sampit River	MD-077	-	0.0715	0.06	0.08	0.072	0.0405	0.0275
Santee River	ST-005	-	-	0.0505	0.0445	0.077	0.0795	-
Sewee Bay	MD-269	-	0.0485	BDL	BDL	0.08	-	BDL
Stono River	MD-202	-	0.0465	0.022	0.224	BDL	BDL	BDL
	MD-206	-	0.0315	BDL	0.0195	0.018	0.022	-
Unnamed Creek	MD-256	-	0.0235	0.0245	0.031	0.0335	0.027	0.0265
Waccamaw River	MD-142	-	-	0.0895	0.083	0.031	0.049	0.0345
Wando River	MD-115	-	0.0455	0.0225	0.02215	0.03	0.0435	BDL
	MD-264	-	0.0305	BDL	0.018	0.042	0.027	BDL
Winyah Bay	MD-278	-	0.028	-	0.0575	0.0675	0.0305	BDL
Wright River	MD-259	-	0.0285	BDL	0.02	0.0525	0.028	BDL
Yonges Island Creek	MD-261	-	BDL	BDL	BDL	BDL	0.047	BDL

a. µg/L = micrograms per liter (parts per billion)
b. No data available
c. BDL= below detection limit

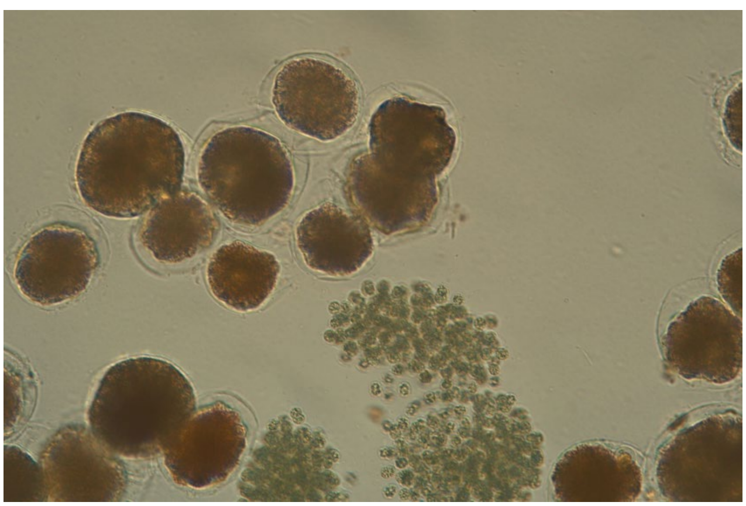
Appendix 3: Microscopic images of cyanobacteria from the 2022 HAB complaint sites.





Microcystis sp, Dolichospermum sp, and *Worchinia sp,* bloom at Cobblestone Park 03/07/2022

Aphanizomenon sp. bloom on Goose Creek Reservoir 04/12/2022



Bloom of dinoflagellate, *G. instriatum*, with *Microcystis sp.* at Lake Paul Wallace 05/17/2022

*Planktonthrix sp.*bloom at Anne Spring Greenway 07/25/2022

Appendix 4: Recreational Watches issued on Goose Creek Reservoir and Lake Wylie. Samples were collected monthly at the waterbody until the bloom was no longer present.

Lake Name	Location	HAB description	Associated algal toxins	Watch Issued	Watch Lifted
Goose Creek Reservoir	Entire lake	*Aphanizomenon sp.*	Cylindrospermopsin, Anatoxin, Saxitoxin	04/13/2022	07/01/2022
Broad River Canal	Below the pedestrian bridge by the floating pier	*Dolichospermum sp.* bloom	Microcystins, Cylindrospermopsin, Anatoxin, Saxitoxin	06/01/2022	07/01/2022
Lake Wylie	Cove between Molokai Dr. and Palmyra Dr	*Microcystis sp.*	Microcystins	10/25/2022	12/06/2022