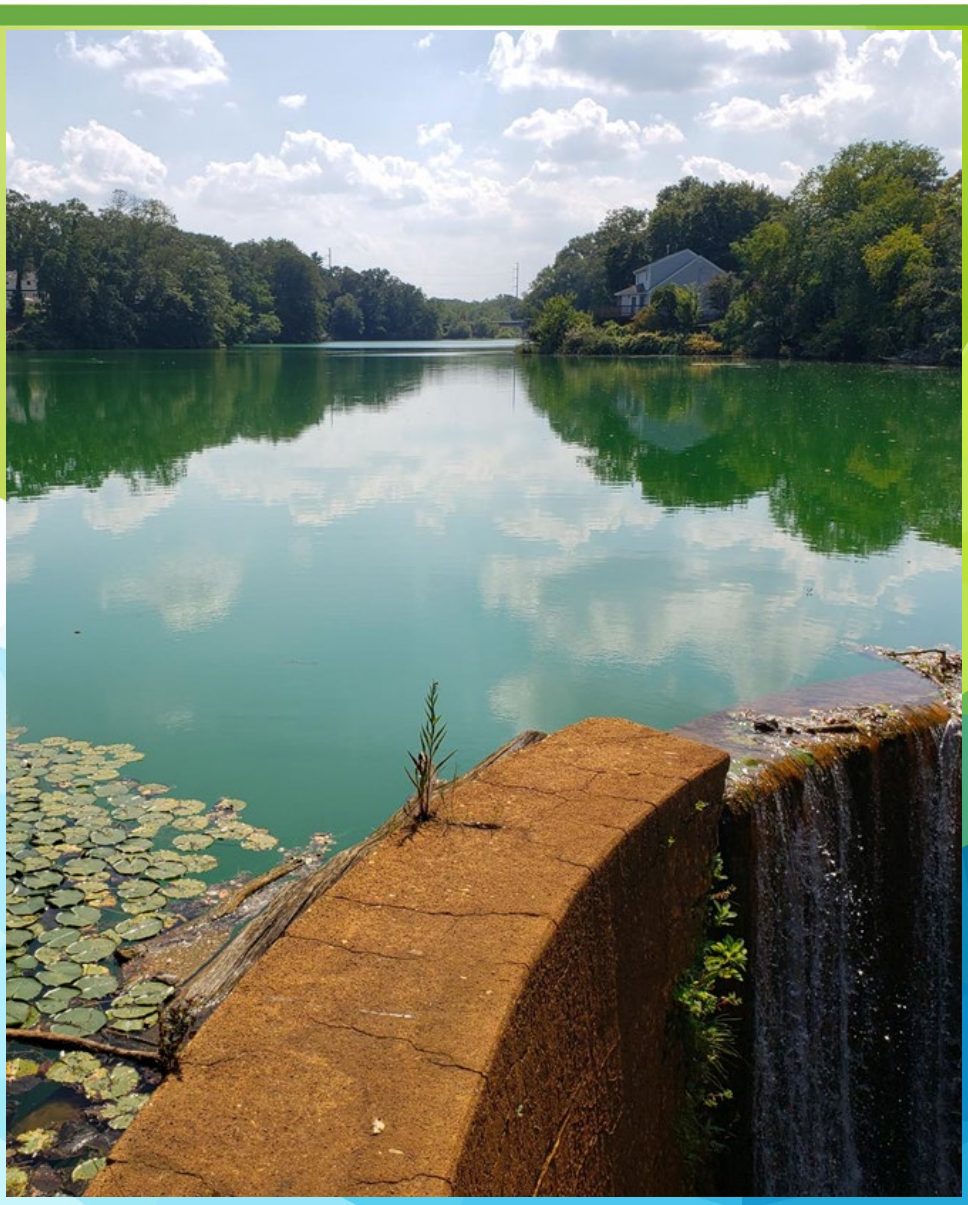
Cyanobacterial Harmful Algal Bloom (HAB) Freshwater Response

2023 Summary Report

Division of Water Monitoring, Standards and Pesticide Control



May 2024

Cyanobacterial Harmful Algal Bloom (HAB) Freshwater Recreational Response

2023 Summary Report

New Jersey Department of Environmental Protection

Water Resource Management

Division of Water Monitoring, Standards and Pesticide Control

Bureau of Freshwater and Biological Monitoring

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Executive Summary

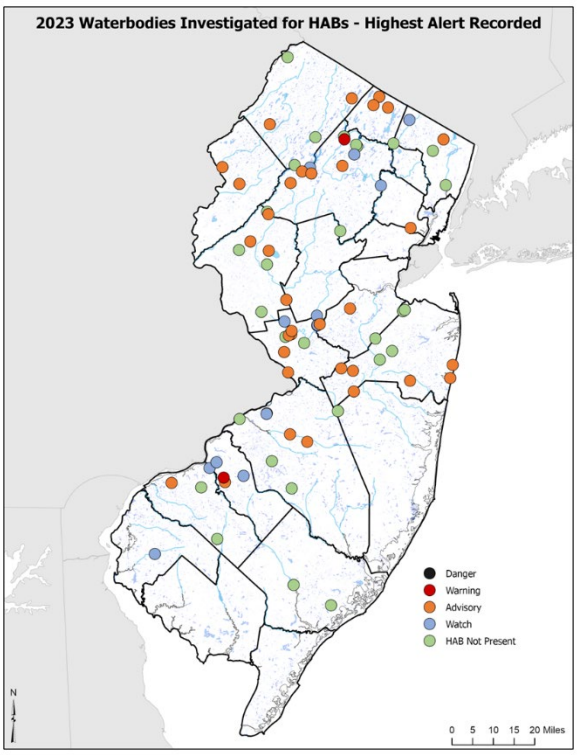


Figure 1. 2023 Waterbodies Investigated for HABS

In 2017, the NJDEP implemented a Cyanobacterial Harmful Algal Bloom (HAB) Freshwater Recreational Response Strategy (Response Strategy). The purpose of the Response Strategy is to provide a unified statewide approach to respond to cyanobacterial HABs in freshwater recreational waters, from public recreational bathing facilities to sources of drinking water, and to protect the public from risks associated with exposure to cyanobacteria and related toxins.

In 2020, a tiered public information and signage system was developed as an enhancement to the HAB Response Strategy. The alert tiers provide clear guidance on advisable recreational activities in waterbodies when a HAB is present. At the same time, the DEP HAB Interactive Map Reporting and Communication System was developed and is used to gather initial information on suspected HABs and to communicate data and alerts to the public.

In 2023, DEP responded to reports of suspected HABs at 88 waterbodies. * Of these, 49 waterbodies had at least one site confirmed by laboratory analysis as having a HAB at or above a Watch Alert tier (>20,000 cells/ml and/ or toxins above thresholds).

*Data in this report reflect investigations of HABs reported to or discovered by DEP during routine monitoring. Other HAB events may have occurred and not reported to DEP.

The first confirmed HAB of the 2023 season was at Greenwood Lake at the end of April (4/28/23). In total, 49 water bodies had confirmed HABs in 2023. Two waterbodies were deemed as Warning alerts (4%), 11 waterbodies were deemed as Watch alerts (22%), and most waterbodies with confirmed HABs were at the Advisory alert tier; 36 water bodies (or 74%) (Figure 2).

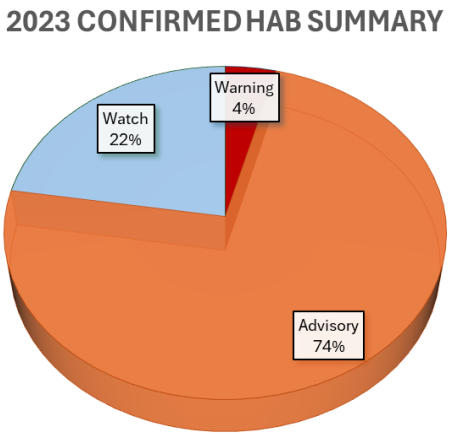
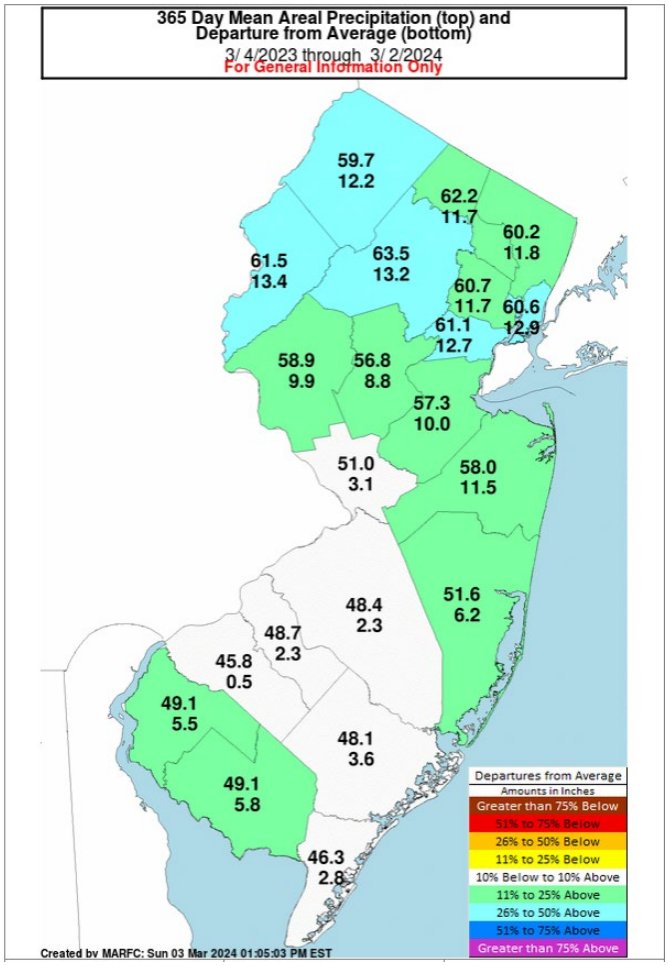


Figure 2. 2023 Confirmed HAB Summary

Figure 3. 365 Day Mean Precipitation and Departure from Average



Rainfall can contribute to the formation of HABs through various mechanisms: nutrient loading, increased turbidity, changes in water chemistry, transport of algal cells, and stratification disruption. Nutrient loading can occur during rain events which may carry phosphorus and nitrogen into water bodies which stimulates the rapid proliferation of HABs. Increased turbidity can reduce the amount of sunlight penetrating the bottom of the waterbody, creating low-light conditions which can encourage the growth of cyanobacteria. During intense storms, algal cells can be transported and washed downstream to other water resources and can exacerbate the bloom intensity or duration. Rainfall events can disrupt thermal stratification by mixing surface and bottom waters causing resuspension of nutrient-rich bottom waters to the surface, further fueling algal growth.

Figure 3 depicts a map separated by county of the last 365 days of average rainfall. The top represents the number of inches of rainfall, while the bottom number indicates the percentage below or above average. Morris, Warren, Sussex, Union, and Hudson counties fell within the range of 26% to 50% above the average rainfall year to date. Within those areas are some of the lakes that continue to have persistent problematic HABS. Several other counties are within the 11% - 25% above average rainfall in 2023.

Figure 4. NJ Monthly Temperature Departures (source: Rutgers)

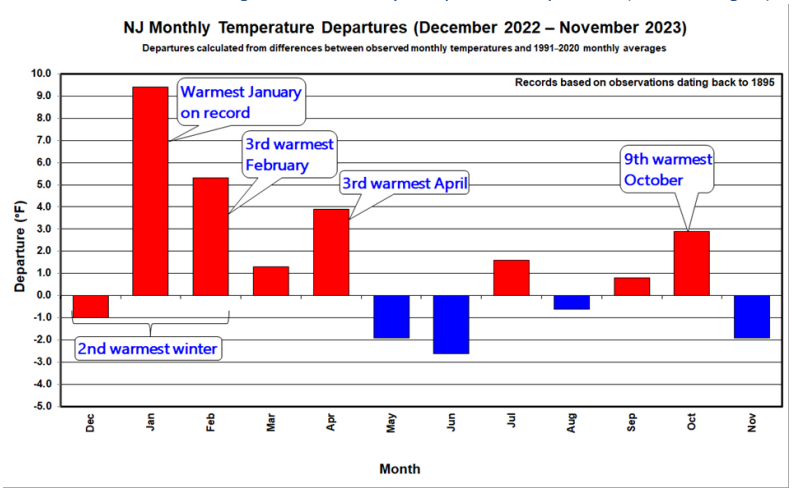


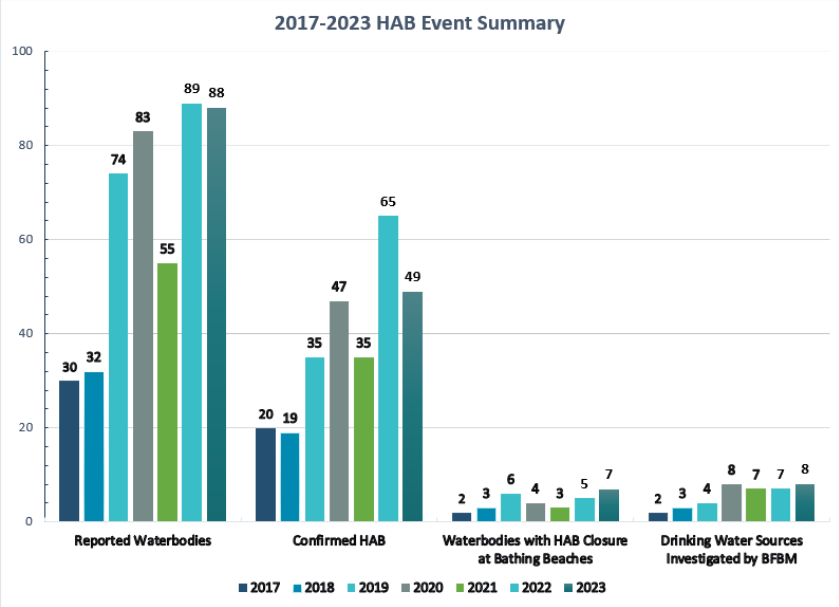
Figure 4 displays a general summary of temperature conditions in 2023. Which shows the warmest month of January on record and the second warmest winter on record from December 2022 into 2023, leading into the growing season. Overall, temperatures in 2023 showed departures higher than the recorded average.

From 2018 to 2019, there was an 74% increase in reported waterbodies of HABs and an increase of 59% in confirmed HABs (Table 1). From 2019 to 2020 there was an increase of 11% in reporting of HABs as well as a 29% increase of confirmed HABs. From 2020 to 2021, both confirmed and reporting HABs decreased significantly (<41%). From a reporting aspect, this may have been caused by the aftereffects of the pandemic (i.e. people returning to work, etc.). From 2021 to 2022, reports increased by 47% and confirmed HABs increased by 60%. Confirmed HABs decreased by 28% in 2023 in comparison to the 2022 season. Displayed in Figure 5 is the percent change of increases and decreases of suspected vs confirmed HABs from year to year.

Year Comparisons	Reported Waterbodies	Confirmed HABS
2017 vs. 2018	-65%	-5%
2018 vs. 2019	+74%	+59%
2019 vs. 2020	+11%	+29%
2020 vs. 2021	-40%	-29%
2021 vs. 2022	+47%	+60%
2022 vs. 2023	-1%	-28%

Table 1. Harmful Algal Bloom Percent Occurrence

Figure 5. 2017-2023 HAB Event Summary

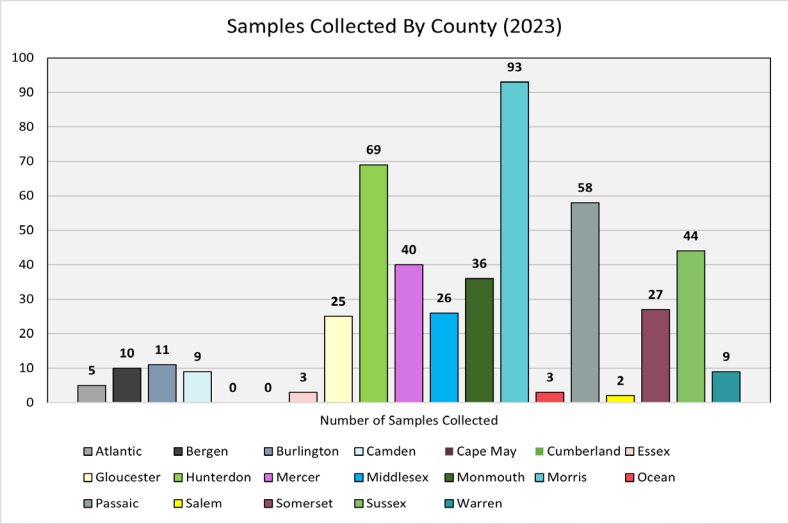


These 88 reports of suspected HABs represent a 1% decrease from 2022, and a 46% increase from 2020 which at the time had the highest occurrence of suspected HAB reports (Figure 5). This translated into a significant increase of waterbodies with confirmed HABs (Watch, Alert or above) by 59% since the program began in 2017. The number of confirmed HABs at drinking water sources increased by 1 in comparison to 2022, while the number of waterbodies with beach closures increased to 7. *Note that the Data shows the statewide occurrence of HABs in New Jersey have increased, and are recurring in many waterbodies since 2017, when the DEP initiated monitoring per the Response Strategy. Further evidence of continued HAB activity is the persistence of blooms into the winter months.

*Information of investigation at sources of drinking water are not to be used to interpret the safety of finished drinking water. The Department and the United State Environmental Protection Agency have established guidance levels and Health Advisory levels with respect to cyanotoxin detections in finished treated drinking water. The DWSG has a guidance document on when to issue public notification based on these levels.

The top 5 counties that samples were collected at were Morris, Hunterdon, Passaic, Sussex, and 5th is Mercer County (Figure 6). Cumberland and Cape May counties did not have any samples collected this year. Note that some of these counties contain larger lakes such as Lake Hopatcong, Greenwood Lake, etc. Therefore, more reports may occur at various locations throughout the lake resulting in more samples collected to cover those different areas. Note that in Figure 6, if a county is not listed on the graph, means there were no samples (0) were collected.

Figure 6. Samples Collected by County (2023)



Lake	Alert	Date
Weequahic Lake	Advisory	11/1/23
Cozy Lake	Advisory	11/8/23
Manasquan Reservoir	Watch	12/5/23
Sunset Lake (Asbury Park)	Advisory	12/12/23
Greenwood Lake	Advisory	12/5/23
Silver Lake Belmar	Watch	12/12/23
Pemberton Lake	Watch	12/20/23

Table 2. Persistent HABs

As of the end of 2023, there were 7 waterbodies with at least one site persisting with a HAB Alert level of Watch or above, i.e. the HAB had not dissipated (Table 2). Four waterbodies had a HAB Alert of advisory and the remaining three had a HAB Alert of Watch. This is a decrease from 19 waterbodies in 2022.

Though the program began by reacting and responding solely to reports of HABs, the program has since implemented background monitoring, with the expansion of the continuous monitoring buoy network, Continuous Data Monitoring Program (rutgers.edu). The continuous monitoring network provides valuable data at waterbodies where HABs have reoccurred. In addition to informing immediate HAB response actions, continuous data will be used by DEP to research water quality factors that may predict or contribute to HAB formation.

The Division of Water Monitoring, Standards and Pesticide Control (DWMSPC) and the New Jersey Sea Grant Consortium (NJSGC) has recruited an Expert Team of lakes management and cyanobacterial HAB experts which developed the HAB Lake Management Guidance, HAB

Guidance, for the prevention and management of HABs and to provide technical advice on prevention and mitigation technologies.

Learn more about the HAB expert team.

Introduction

In 2017, the NJDEP implemented a Cyanobacterial Harmful Algal Bloom (HAB) Freshwater Response Strategy (Response Strategy). The purpose of the Response Strategy is to provide a unified statewide approach to respond to suspected cyanobacterial HABs from freshwater recreational waters to sources of drinking water, and to protect the public from risks associated with exposure to cyanobacteria and related toxins. Although the primary focus of the Response Strategy is the protection of human health, it provides some information and recommendations regarding exposure and prevention of potential impacts to domestic animals (pets), livestock, and wildlife, as well.

The scope of the Response Strategy is for freshwater lakes, ponds, rivers and streams with potential public access, recreational use, public recreational bathing facilities as defined in N.J.A.C. 8:26, and sources of drinking water. These waterbodies may be owned or operated by state, county, municipal, federal, or private entities. As such, coordination of the investigation and response activities will vary depending on ownership and use.

It should be noted that while this Response Strategy is used to address sources of drinking water, it does not address the response for cyanotoxin detections in finished treated drinking water. The detection of cyanotoxins in finished treated drinking water is handled by the Division of Water Supply & Geoscience (DWSG) who has established guidance to best prevent, mitigate, and treat HABs/cyanotoxin as well as developing an emergency protocol for responding to and handling HAB/cyanotoxin events that affect a drinking water source/finished treated drinking water. However, the two Divisions work closely together along with the impacted water supplier during all stages of the incident to provide details and keep all relevant staff updated on the incident. Additional parties included in the coordination include but are not limited to, the Division of Water Enforcement, and other State agencies such as the New Jersey Department of Health, Board of Public Utilities, New Jersey Water Supply Authority, and New Jersey Department of Community Affairs, if appropriate.

Because the easiest way to deal with HABs/cyanotoxins is preventing them from happening, the DWSG also focuses on working with water systems to be better prepared for HAB/cyanotoxin events including creating and maintaining adequate Cyanotoxin Management Plans as well as convening a Drinking Water HAB Task Force to develop strategies and guidance. The DWSG's HAB website contains resources, tools, guidance, templates, and other useful information for water purveyors.

Since 2017, NJDEP has continued to enhance all aspects of its approaches including monitoring, testing, and communication/notification.

This report focuses on the response and monitoring performed in 2022**.** Data in this report reflect investigations of HABs reported to or discovered by DEP during routine monitoring. Other HAB events may have occurred but were not reported to DEP. For more information on other enhancements developed and implemented such as a data downloads, real-time telemetry buoys, and training videos, visit the DEP HAB Website.

Alert Tiers and Communication

In 2020, a tiered public information and signage system was developed as an enhancement to the HAB Strategy. The Alert tiers (Table 3) provide clear guidance on advisable recreational activities in impacted waterbodies, depending on levels of cyanobacteria and/or cyanotoxins present. Color-coded signs provide the public with current conditions and recommendations on which recreational activities are advisable and those that are not. The index makes it clear to the public that, in some instances, boating and related activities may still be suitable when lower levels of harmful algal blooms are detected.

While exposure to cyanobacterial cells that are not producing toxins can result in allergenic-like, flu-like and irritative effects, more serious health effects can result from exposure to cyanotoxins. Blooms may begin producing toxins at any time during an active HAB.

In developing the Alert tiers in 2020, DEP conducted an evaluation of NJ-specific HAB data to determine if there was a level of cyanobacterial cell density that is associated with an appreciable likelihood that a bloom will produce toxins at levels above the NJ toxin thresholds.

HAB ALERT LEVEL	CRITERIA	RECOMMENDATIONS
NONE	HAB report investigated and no HAB found	NONE
WATCH *Suspected or confirmed HAB with potential for allergenic and irritative health effects*	Suspected HAB based on visual assessment or screening test OR Lab confirmed cell counts between 20k – 40k cells/mL AND No known toxins above public health thresholds	Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) Waterbody Accessible: Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ALERT *Confirmed HAB that requires greater observation due to increasing potential for toxin production* *PUBLIC BATHING BEACHES INCREASE MONITORING*	Lab confirmed cell counts between 40k – 80k cells/mL AND No known toxins above public health threshold	WATCH remains in effect. Public Bathing Beaches Open (dependent upon local health authority evaluation and assessment) and should observe and report changing bloom conditions Waterbody Accessible: Use caution during primary contact (e.g. swimming) and secondary (e.g. non-contact boating) recreational activities Do not ingest water (people/pets/livestock) Do not consume fish
ADVISORY *Confirmed HAB with moderate risk of adverse health effects and increased potential for toxins above public health thresholds*	Lab testing for toxins exceeds public health thresholds OR Lab confirmed cell counts above 80K cells/mL OR Field measurement evidence indicating HAB present and above guidance thresholds (e.g. phycocyanin readings)	Public Bathing Beaches Closed Waterbody Remains Accessible: Avoid primary contact recreation (e.g. swimming) Use caution for secondary contact recreation (e.g. boating without water contact) Do not ingest water (people/pets/livestock) Do not consume fish
WARNING *Confirmed HAB with high risk of adverse health effects due to high toxin levels*	Toxin (microcystin) 20 - 2000 µg/l AND/OR Additional evidence, including, expanding bloom, increasing toxin levels (i.e. duration, spatial extent or negative human or animal health impacts) indicates that additional recommendations are warranted	Public Bathing Beaches Closed Waterbody Remains Accessible: Avoid primary contact recreation (e.g. swimming) May recommend against secondary contact recreation (e.g. boating without water contact) with additional evidence Do not ingest water (people/pets/livestock) Do not consume fish
DANGER *Confirmed HAB with very high risk of adverse health effects due to very high toxin levels*	Toxin (microcystin) > 2000 µg/l AND/OR Additional evidence, including, expanding bloom, increasing toxin levels (i.e. duration, spatial extent or negative human or animal health impacts) indicates that additional recommendations are warranted	Closure of Public Bathing Beaches Possible closure of all or portions of waterbody and possible restrictions access to shoreline. Avoid primary contact recreation (e.g. swimming) May recommend against secondary contact recreation with additional evidence Do not ingest water (people/pets/livestock) Do not consume fish

Table 3. HAB Alert Tiers

The HAB data were evaluated by analyzing the percentage of samples exceeding the NJ advisory guidance level for microcystins (the most common group of cyanotoxins) of 2 µg/L for various ranges of cyanobacteria cell counts. Cell count ranges were used to allow for enough samples for statistical analysis within each range. Each year this evaluation is performed using additional data collected from the previous season. When including 2023 results, the data continues to show a increase in the likelihood of toxin levels above the NJ guidelines when cell counts exceeded 80,000 cells/ml. (Figure 7)

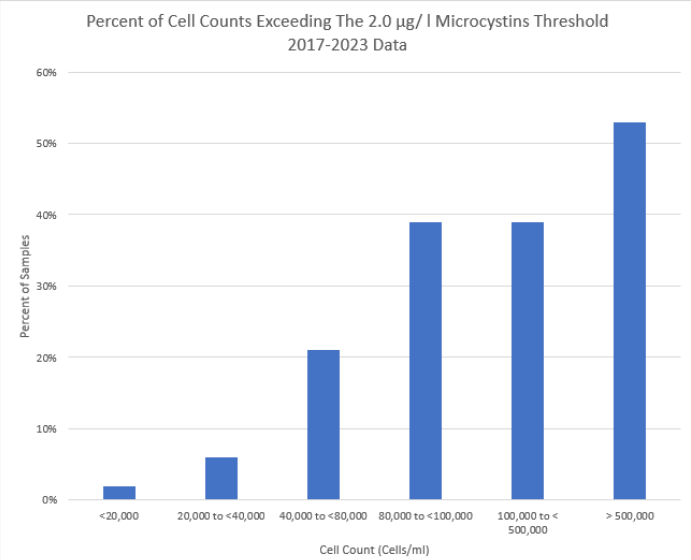


Figure 7. Percent of Cell Counts >2.0ug/L (2017 to 2023 Data)

A Winter Watch sign (Figure 8) was developed and implemented in 2021, to be used during the winter season. As shown by laboratory data, HABs may persist at some waterbodies or recur at other waterbodies. Day-to-day conditions may change and not reflect past Alert postings. The Winter Watch sign is intended to be used at these waterbodies where HABs have a likelihood of recurring during the winter. Because signs posted during the recreational season may not reflect current conditions, or the public may disregard signs they perceive as "old", this new sign provides a fresh perspective during the off season to alert users to be cautious.

The DEP HAB Interactive Map Reporting and Communication System (Figure 8) was developed in 2020 and is used to gather initial information such as: location coordinates, photos, known recreational activities, and extent of the waterbody affected. This information is used to inform DEP to initiate appropriate response actions. After DEP completes the investigation of the suspected HAB, results and any recommendations for public alerts are communicated through the HAB System.

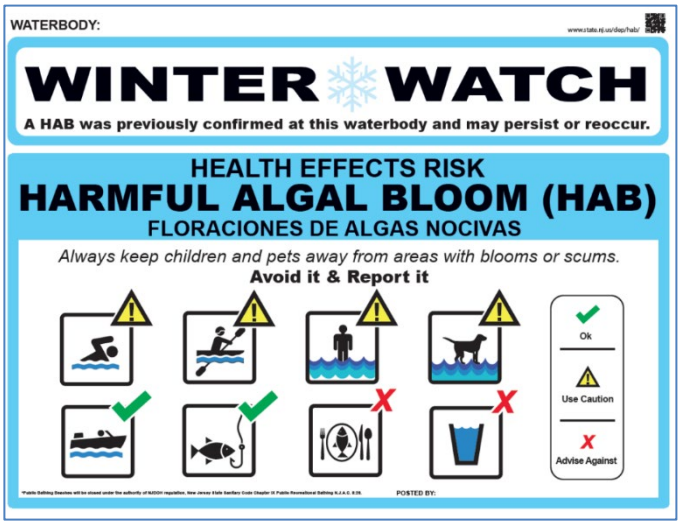


Figure 8. Winter Watch Sign

All Alert information and HAB data are accessible by clicking each point on the interactive map. The map reflects sampling results for suspected or confirmed HAB events reported to DEP.

In 2021, a new feature was added to the system that enables users to download all available data to date. Data downloads can be accessed here: NJDEP Harmful Algal Bloom (HAB) Data Retrieval (arcgis.com)

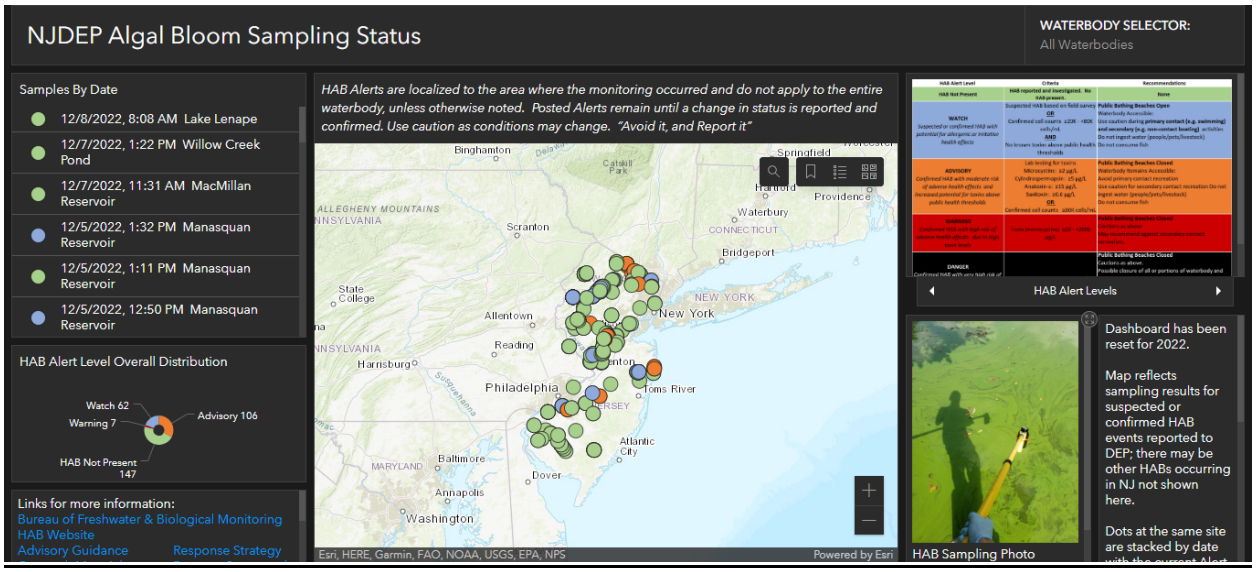


Figure 9. HAB Interactive Map.

Cyanobacterial Harmful Algal Bloom (HAB) Freshwater Recreational Response Procedures

Response

Response of suspected HABs is initiated in multiple ways both internally at DEP and outside. If trained DEP staff observe a suspected HAB while collecting water quality samples as part of the routine Ambient Lakes Monitoring Network, Rivers and Streams routine monitoring networks, or other programs, a field survey, including sample collection (if necessary) is immediately conducted. Also, aircraft flight surveillance * and continuous monitoring buoy data are utilized by BFBM and DWMSPC designated staff to determine if a site survey and sampling is needed. Staff are deployed to areas of the waterbody, as shown by fight data or at buoy locations, where a HAB is suspected above NJ Guidance Thresholds for cell concentration.

Upon receipt of suspected HAB report from within DEP or the public, the BFBM HAB coordinator or designee assesses the information provided in the suspected HAB report, deploys staff, and/or coordinates with partners as necessary. The BFBM HAB coordinator also notifies the responsible agency designated for the waterbody, such as a State Park, Wildlife Management Area (WMA), or local health department. If the responsible agency has trained HAB sampling staff and proper sampling equipment and supplies, they may be requested to perform response activities.

Every effort is made to respond to reported suspected HABs as soon as possible, usually within one business day. In the event resources are limited, the monitoring will be prioritized based on risk to public health. Priority approaches are listed in Table 4.

*Flights are performed weekly weather permitting and described in Supporting Programs section.

Table 4. Response and Monitoring Priorities

1. Prioritization Response Approach for Lakes, Ponds, Reservoirs, Rivers & Streams including Delaware and Raritan Canal

a. Drinking Water Sources

Initial Response	Sampling Frequency	Duration/Season	Final Response
Confirm ASAP	*per Division of Water Supply & Geoscience direction*	*Year Round*	*Continue monitoring at predetermined frequency until clear or per Division of Water Supply & Geoscience direction*

b. **Public Recreational Beaches (PRB)** (in-season, out-of-season skip to *c. Other Recreational Use*) and Secondary Contact Recreational Waters

Initial Response	Sampling Frequency	Duration/Season	Final Response
Confirm ASAP	*Alert tier for bathing beaches only (see table 1) coordinate with partners on additional monitoring. Confirmed HAB Beach Closing – Sample when notified by partners that visual observations or phyco measurement indicates a change of HAB status.*	*May through September*	*After September 30 sample when notified HAB has visually subsided.*

c. **Other Recreational Use** - boating, fishing, public bathing beach (out of season), hunting, domestic animal use, wildlife

Initial Response	Sampling Frequency	Duration/Season	Final Response
Confirm ASAP	*Sample when notified by partners that visual observations or phyco measurement indicates a change of HAB status.*	*Recreational Season or Year Round if necessary*	*December. If HAB is still present or likely to reoccur, a "Winter Watch" alert is posted*

2. Approach for Private Lakes wholly on private property, Ditches, Canals, Stormwater Basins

Initial Response	Sampling Frequency	Duration/Season	Final Response
Assess if there is public access (e.g. fishing or pet access in a private community). Contact owner. Sample on case-by-case basis.	*As needed*	*As needed*	*When clear*

Field Survey

A field survey is performed to gather information following reports of suspected HABs. BFBM staff or partners record site coordinates, observations, take photos, and phycocyanin measurements. BFBM then determines if sampling is warranted. All survey and subsequent sampling information is recorded and submitted using the NJDEP HAB Interactive Map Reporting and Communication System.

Figure 10. Field Fluorometer

Phycocyanin is a pigment unique to cyanobacteria, therefore the presence of a high concentration of phycocyanin is an indicator of a cyanobacteria bloom. Handheld field fluorometers (Figure 10) measure the presence and relative concentration of phycocyanin and are used to qualitatively demonstrate whether cyanobacteria, if present, are in bloom densities. Phycocyanin measurements are used to approximate cell concentration and cannot predict toxin production, toxin levels, identify taxa present, nor quantify cell density directly. However, these measurements can be used as a screening tool for suspected HABs and to monitor the status of confirmed HABs.

BFBM uses three types of fluorometers: a handheld field meter, laboratory meter, and a YSI data sonde. The YSI data sonde is used for real time continuous monitoring in conjunction with telemetry buoys (Figure 11), but units can also be used for discreet measurements by samplers.

Figure 11. Continuous multi-parameter meter.

The DWMSPC has developed correlations between phycocyanin measurements and cell concentration. All New Jersey-specific data available, where both cell count and phycocyanin samples were analyzed, were used to statistically correlate these parameters. Note that the model of meter has different ranges and requires a separate correlation (Figure 12 & Table 5).

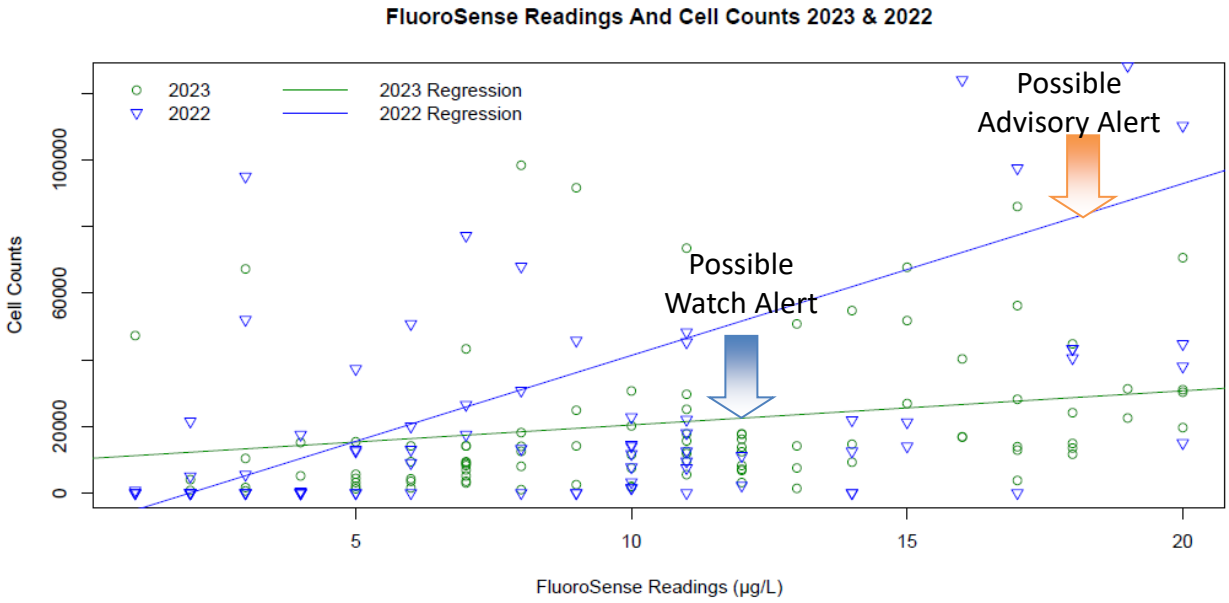


Figure 12. 2023/2022 Comparative Summary of FluoroSense and Cell Counts

FluoroSense meters are used to screen waterbodies for suspected HABs and to monitor the status of a confirmed HAB. An evaluation was conducted comparing the raw data of cell counts from 2017 to 2023 and the intensity of fluorescence emitted by phycocyanin (µg/L) using a FluoroSense meter. Based on the information from the 2023/2022 graph in Figure 12, many of the cell counts (cells/ml) and FluoroSense (µg/L) readings are low and are below the 10,000 cells/ml range. Elevated counts do not occur until a reading of 17 µg/L from the FluoroSense. In comparison to the 2023 data in Figure 12, elevated readings around 8 to 10 µg/L reach that 20k threshold. The average of these two µg/L readings, an approximate result of 13 µg/L.

Estimated individual cell counts cells/ml	Continuous & Discreet Meter µg/L	Estimated FluoroSense (µg/L)	Estimated Lab Fluorometer (ppb)
20000	1.15	13	33.0
40000	1.87	16	45.9
80000	3.29	18	71.5
100000	4.00	>20	84.3

Table 5. Phycocyanin and cell count correlation for all meters used.

Laboratory Analysis

Laboratory analysis is performed when it is confirmed that measurable cyanobacteria are present in a sample.

Toxin analysis is performed at the BFBM laboratory and uses an Enzyme-Linked Immunosorbent Assay (ELISA) method with Eurofins Abraxis brand test kits for cyanotoxin analysis of microcystins, anatoxin-a, cylindrospermopsin, and saxitoxin. Assays are performed using the Cyanotoxin Automated Analyzer System (CAAS) (Figure 13), Eurofins Abraxis brand, PN 475200S or equivalent Microtiter plate reader, capable of reading sample absorbance at 450 nm. Reporting levels for each toxin are adequate to accurately detect and quantify toxins below NJ Health Guidance.

Figure 13. Cyanotoxin Automated Analyzer System (CAAS)

Currently, EPA Standardized Analytical Method for Determining Total Microcystins utilizing the ELISA Method (EPA 546) is the only EPA-approved ELISA method for toxin analysis. Anatoxin-a, cylindrospermopsin, and saxitoxin are also analyzed using the ELISA methods. Procedures specific to these toxins follow the manufacturer's instructions for the kits and instrumentation.

Cyanobacteria cell concentrations are determined in the BFBM laboratory by examining under a compound microscope using direct counts on a Hemocytometer. Standard phytoplankton identification guides are used for taxa identification. Cell counts are reported as cells/ml and all cyanobacteria taxa are identified. The dominant taxa, i.e., most abundant, is noted and posted with the data on the interactive map.

2023 Results and Discussion

Waterbody Summary

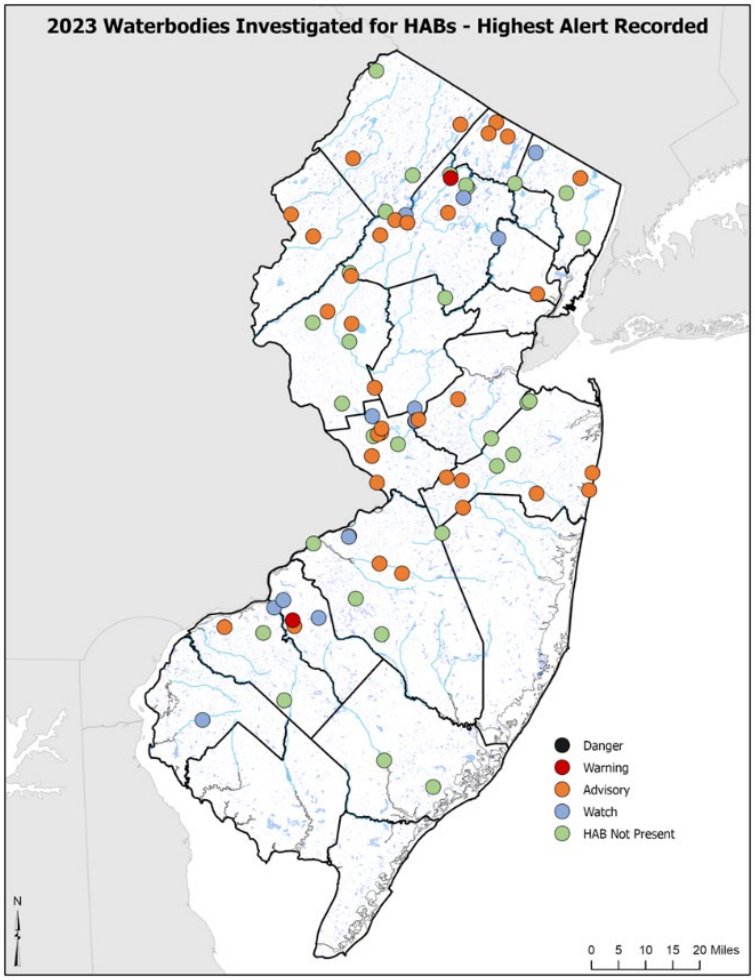


Figure 14. Map of 2023 Waterbodies Investigated.

In 2023, BFBM responded to suspected HAB reports at 88 waterbodies. Of these, 49 waterbodies had at least one site, confirmed by laboratory analysis, as having a HAB at or above a Watch Alert level (>20,000 cells/ml and/or toxins above thresholds). A site was determined as not having a HAB when: field visual observations or phycocyanin measurements indicated no HAB was present and therefore a sample was not collected or; a sample was collected but lab analysis for cell count and toxins were below all thresholds. At each of the 88 waterbodies investigated for a suspected HAB, multiple sites may have been sampled, depending on extent of occurrences in the waterbody. In addition, sites may have been sampled many times over the season due to changing conditions and concerns. The Alert levels intended for the immediate area where the HAB was confirmed through laboratory analysis, and the rest of the waterbody can be used for recreation with normal appropriate precautions. However, even when Alerts are posted, there may be other HABs occurring within that same waterbody or at other waterbodies, which have not yet been reported and confirmed. Therefore, recreators are advised to avoid anything that looks like a HAB and to report it to the DEP ("Avoid It and Report It"). Figure 14 shows a map of the waterbodies investigated in 2023 with the highest alert level recorded for that waterbody for the season.

Table 6. Waterbodies by County and Municipality

Waterbody Name	Highest Advisory Alert	County	Municipality
Bayberry Detention Pond	HAB Not Present	Atlantic	Egg Harbor Township
Lake Lenape	HAB Not Present	Atlantic	Hamilton Township
Indian Lake	HAB Not Present	Bergen	Little Ferry Borough
MacMillan Reservoir	Watch	Bergen	Mahwah Township
Wild Duck Pond	HAB Not Present	Bergen	Ridgewood Village
Woodcliff Lake Reservoir	Advisory	Bergen	Hillsdale Borough
Amico Island Park Pond	HAB Not Present	Burlington	Delran Township
Indian Mills Lake	HAB Not Present	Burlington	Shamong Township
Lower Sylvan Lake	Watch	Burlington	Burlington Township
Pemberton Lake	Advisory	Burlington	Pemberton Township
Smithville Lake	Advisory	Burlington	Eastampton Township
South Branch Rancocas Trib	HAB Not Present	Burlington	Medford Township
Sylvan Lake	HAB Not Present	Burlington	Burlington Township
Bellmawr Lake	Watch	Camden	Bellmawr Borough
Haddon Lake	Watch	Camden	Mount Ephraim Borough
Pine Run	Advisory	Camden	Gloucester Township
Silver Lake	Watch	Camden	Gibbsboro Borough
Timber Creek Pond	Warning	Camden	Gloucester Township
Weequahic Lake	Advisory	Essex	Newark City
Franklinville Lake	HAB Not Present	Gloucester	Franklin Township
Greenwich Lake	Advisory	Gloucester	Greenwich Township
Wynonna Lake	HAB Not Present	Gloucester	Wenonah

Waterbody Name	Highest Advisory Alert	County	Municipality
"North Hill Road Pond"	Advisory	Hunterdon	East Amwell Township
unnamed pond - Teetertown	Advisory	Hunterdon	Lebanon Township
Manny's Pond	HAB Not Present	Hunterdon	Union Township
North Hill Rd Pond	HAB Not Present	Hunterdon	East Amwell Township
County Arboretum Pond	HAB Not Present	Hunterdon	Clinton Township
unnamed pond - Fairgrounds	HAB Not Present	Hunterdon	East Amwell Township
Round Valley Reservoir - Swimming Impoundment	Advisory	Hunterdon	Clinton Township
Spruce Run Reservoir	Advisory	Hunterdon	Union Township
Teetertown Pond	HAB Not Present	Hunterdon	Lebanon Township
Carnegie Lake	Watch	Mercer	Princeton
Ceva Lake	Advisory	Mercer	Ewing Township
Curlis Lake	HAB Not Present	Mercer	Hopewell Township
Finger Dike Swamp	HAB Not Present	Mercer	Lawrence Township
Harry's Brook	HAB Not Present	Mercer	Princeton
Honey Lake	Advisory	Mercer	Hopewell Township
Hopewell Quarry Lake	Watch	Mercer	Hopewell Township
Lamberton Park Pond	Advisory	Mercer	Trenton City
Rosedale Lake	Advisory	Mercer	Hopewell Township
Willow Pond	Advisory	Mercer	Hopewell Township
Farrington Lake	Advisory	Middlesex	East Brunswick Township
Heathcote Brook	Advisory	Middlesex	South Brunswick Township
Machaponix Brook	HAB Not Present	Middlesex	Monroe

Waterbody Name	Highest Advisory Alert	County	Municipality
Assunpink Lake	Advisory	Monmouth	Upper Freehold Township
Lake Lefferts	HAB Not Present	Monmouth	Matawan Borough
Lake Matawan	HAB Not Present	Monmouth	Matawan Borough
Lake Topanemus	HAB Not Present	Monmouth	Freehold Township
Manasquan Reservoir	Advisory	Monmouth	Howell Township
Millhurst Pond	HAB Not Present	Monmouth	Manalapan Township
Rising Sun Lake	Advisory	Monmouth	Millstone Township
Silver Lake	Advisory	Monmouth	Belmar Borough
Sunset Lake	Advisory	Monmouth	Asbury Park City
Budd Lake	Advisory	Morris	Mount Olive Township
Chapin Pond	Watch	Morris	Montville Township
Cozy Lake	Warning	Morris	Jefferson Township
Durham Pond	HAB Not Present	Morris	Rockaway Township
Durham Pond	HAB Not Present	Morris	Rockaway Township
Lake Hopatcong	Watch	Morris	Roxbury Township
Lake Musconetcong	Advisory	Morris	Netcong Borough
Lake Rogerene	Advisory	Morris	Mount Arlington Borough
Moosepac Pond	HAB Not Present	Morris	Jefferson Township
Split Rock Reservoir	Watch	Morris	Rockaway Township
White Meadow Lake	Advisory	Morris	Rockaway Township

Waterbody Name	Highest Advisory Alert	County	Municipality
Oakford Lake	HAB Not Present	Ocean	Plumsted Township
Prospertown Lake	Advisory	Ocean	Jackson Township
Greenwood Lake	Advisory	Passaic	West Milford Township
Monksville Reservoir	Advisory	Passaic	Ringwood Borough
Pinecliff Lake	Advisory	Passaic	West Milford Township
Pompton Lake	HAB Not Present	Passaic	Wayne Township
Alloway Lake	Watch	Salem	Alloway Township
Branta Pond	HAB Not Present	Somerset	Bernards Township
D&R Canal	HAB Not Present	Somerset	Franklin Township
Millstone River	Watch	Somerset	Franklin Township
Beisers Pond	HAB Not Present	Sussex	Sparta Township
Highland Lake	Advisory	Sussex	Vernon Township
Holiday Lake	HAB Not Present	Sussex	Montague Township
Jefferson Lake	HAB Not Present	Sussex	Byram Township
Swartswood Lake	Advisory	Sussex	Stillwater Township
Delaware Lake	Advisory	Warren	Knowlton Township
Mountain Lake	Advisory	Warren	Liberty Township

Note that occurrences of D&R Canal sites were consolidated into one entry in Table 6 as all were “HAB Not Present”. Data and Alert Levels for all sites sampled can be found on the DEP HAB Interactive Map Reporting and Communication System.

Public Recreational Bathing Beaches (PRB) and Drinking Water Sources

2023 Water bodies with beaches and in-season HAB closures:

- Cozy Lake
- White Meadow Lake
- Round Valley – Swimming Impoundment
- Mountain Lake
- Lake Rogerene
- Pinecliff Lake
- Greenwood Lake – beach closures at 3 separate beaches

Recreational Bathing Beach Confirmation

Listed above are the seven waterbodies with beaches and in-season HAB closures in comparison to Figure 6. Of the seven waterbodies, beach closures occurred at 12 individual bathing beaches. When a HAB was confirmed at Advisory/Beach Closure levels at Public Recreational Bathing Beaches (PRB) during the operating season of Memorial Day – Labor Day, the NJ Department of Health, Youth Camps/PRB Project Coordinator was immediately notified. The NJDOH PRB Coordinator then notified the appropriate local authority of the closure Alert and ensured onsite notices were posted. BFBM, or with the assistance of local authorities, monitored the status conditions of the HAB at these PRBs. The Strategy protocol recommends monitoring the HAB status at PRBs until bloom conditions dissipate to below Advisory/ Beach Closure levels, at which time samples are collected for laboratory confirmation analysis. Guidance in the Strategy further states that PRB closures should not be lifted until:

- With no phycocyanin field measurements - two (2) subsequent lab analyses were below cell count and toxin thresholds, or
- If phycocyanin measurements approximated cell counts below beach closing thresholds for consecutive days, then only one laboratory analysis with cell counts and toxin results below thresholds was necessary.

2023 Confirmed HABs at Recreational Waterbodies used as Drinking Water Sources*:

- Spruce Run Reservoir
- Manasquan Reservoir
- Millstone River
- Farrington Lake
- Woodcliff Lake
- Raritan River
- Round Valley

*Drinking Water Source Confirmation**

When a suspected HAB is reported at a possible drinking water source, BFBM immediately notifies the Division of Water Supply & Geoscience (DWSG) to confirm the location and possible

use as a drinking source. If confirmed as a drinking water source, DWSG then informed the appropriate system operators who sampled their raw and finished water per their specific Cyanotoxin Management Plan. **This report summarizes drinking water sources investigated by BFBM that are also open to the public for recreation. Water suppliers may conduct their own investigations which are not reflected in this report.**

*The Advisories addressed in the document are for recreational public bathing beaches or sources of untreated drinking water and are not to be used to interpret the safety of finished drinking water. The Department and the United State Environmental Protection Agency have established guidance levels and Health Advisory levels with respect to cyanotoxin detections in finished treated drinking water. The DWSG has a guidance document on when to issue public notification based on these levels.

Laboratory Cell Count and Toxin Results

In 2023, laboratory analysis was consistent with the high number of reports investigated. There was a significant decrease in toxin analysis in 2023 due to the number of confirmed HABs with microcystins over the 2.0 µg/l. When microcystins are present above 2.0 µg/l, it is protocol to analyze for the other toxins as their likelihood of being present increases. Intensive surveys performed at Lake Hopatcong and Greenwood Lake in 2019 greatly increased the analysis performed that year. The higher numbers in 2017 and 2018 are due to samples collected at routine Ambient Lake Monitoring Network sites to develop toxin analysis capacity. Because routine lake sampling does not target active HABs, results were nearly all non- detect, or very low detection, unless a HAB was occurring at the time of sampling. Beginning in 2020, toxin sampling at Ambient Lake Monitoring Network sites was not performed unless an active HAB was visually observed or measured by field meters. As of 2020, analysis was focused strictly on response sampling. Therefore, toxin analysis in 2017-2019 was biased high compared to the number of sites investigated (Figure 15).

Figure 15. 2017 – 2023 BFBM Response and Analysis Summary.

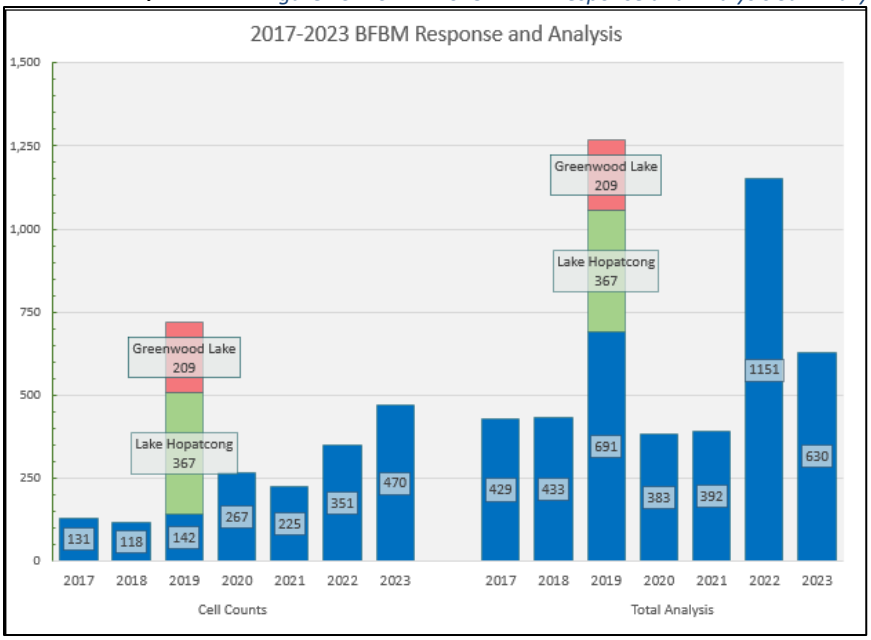


Figure 16 summarizes the maximum cell count density at any given waterbody investigated during the 2023 season. In 2022, the majority (81%) of waterbodies with confirmed HABs had a peak cell count greater than 80,000 cells/ml, placing it in the Advisory Alert or higher category, in comparison to 2023 with cell counts over 80k displayed a decreased to 44%. Most waterbodies with confirmed HABs with results ranging from 40,000 cells/ml to 80,000 cells/ml increased from 2022 (9%) to 28% in 2023 as shown below. An internal action level of 40,000 to 80,000 cells/ml initiates additional monitoring at bathing beaches only. This is to ensure the levels do not exceed the bathing beach closure threshold of 80,000 cells/ml and the proper Alert level is in place to protect bathers.

The highest recorded cell count concentration of 3,000,000 cells/ml, was at Cozy Lake along with the highest recorded toxin result of 1,511 µg/L (Figure 19). In the samples collected in 2023, in Figure 19. are pictures of the most common cyanobacteria taxa that was found. *Aphanizomenon, Dolicospermum, Pseudanabaena,* and *Plankthothrix/Phormidium*.

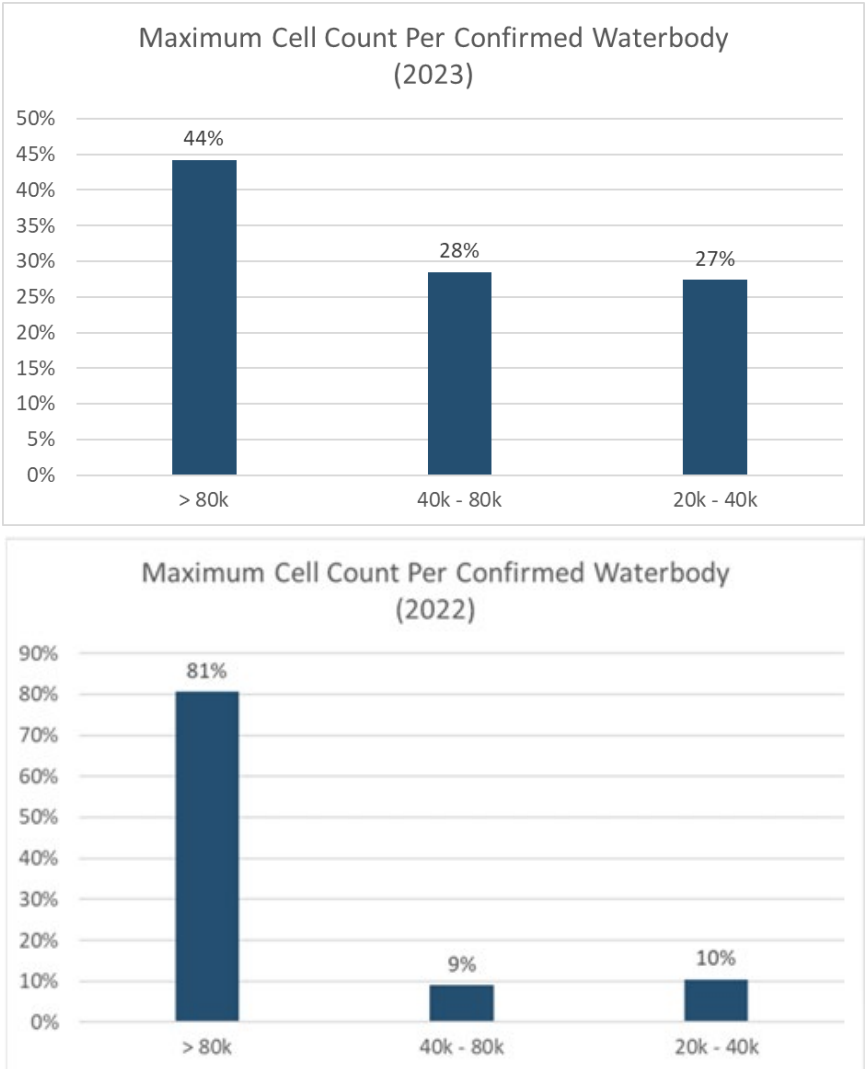
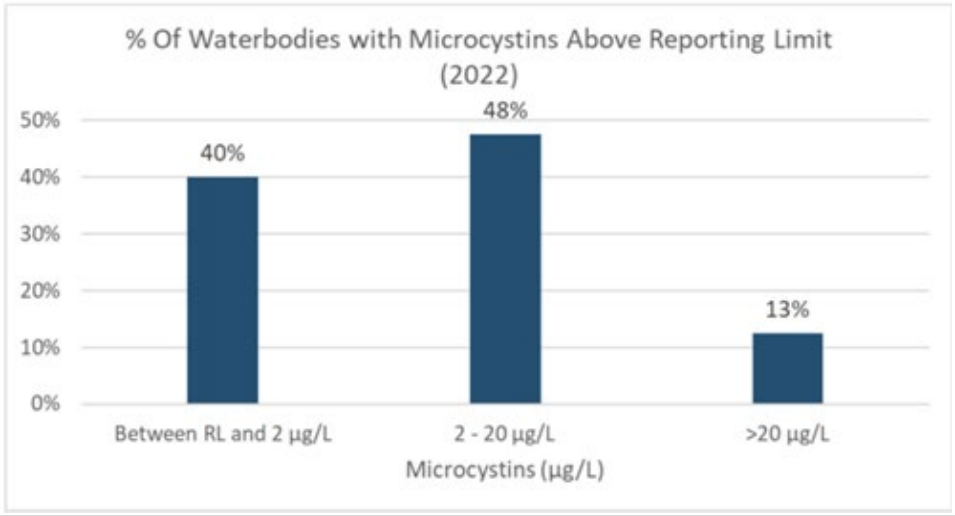


Figure 16. 2023/2022 Maximum Cell Count per Confirmed Waterbody



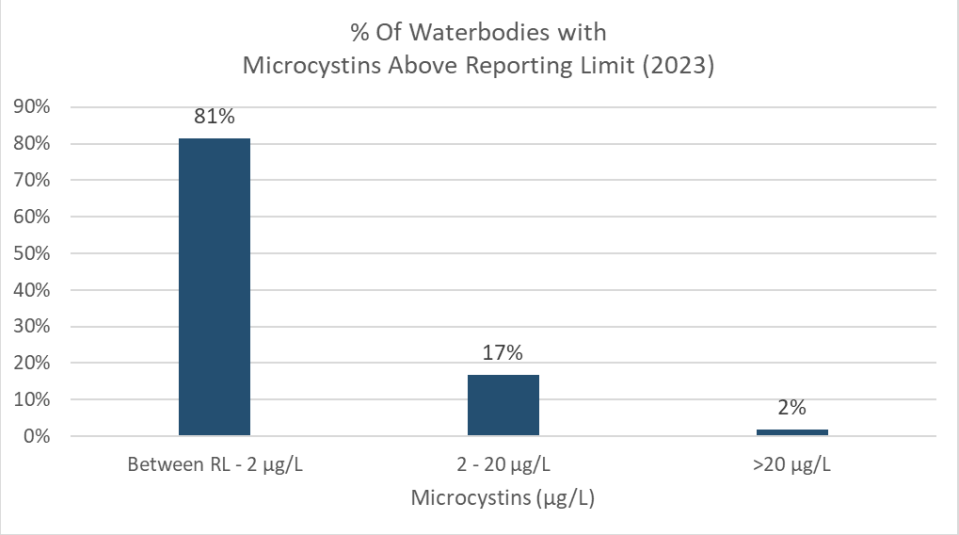


Figure 17. 2023/2022 Microcystin Threshold Per Confirmed Waterbodies

The majority of peak microcystins concentration at waterbodies with confirmed HABS, concentration at waterbodies with confirmed HABS, 81% were between the analysis Reporting Level (RL) of 0.15 µg/L and the Advisory Alert threshold of 2.0 µg/L. 17% were in the Advisory Alert category and 2% in the Warning Alert category. This is a significant decrease in high toxin occurrence in the categories of Advisory and Warning Alerts in comparison to results from 2022 (Figure 17). The highest toxin concentrations occurred between June to early November. The following waterbodies exceeded thresholds for the following toxins: Cozy Lake for microcystins (1,511 µg/L) and saxitoxin (2.60 µg/L), detections of cylindrospermopsin (17.95 µg/L) in Monksville reservoir, and Greenwich Lake with anatoxin (1.21 µg/L). Table 9 lists the waterbodies with the highest microcystins and cell count concentrations.

Table 7. 2023 Cyanobacterial Taxa with MCT >2.0 ug/L

Cyanobacterial taxa observed in waterbodies with highest microcystins (MC) concentrations >2.0 µg/l during 2023 HAB responses in New Jersey

Sample Date	Waterbody Name	Cell density (cells/mL) of all cyanobacteria taxa observed w/in hemocytometer counting grid	*Aphanizomenon sp.	*Aphanocapsa sp.	*Chroococcus sp.	*Coelosphærium	*Dolichospermum spp.	*Lyngbya sp.	*Merismopedia sp.	*Microcystis sp.	*Oscillatoria sp.	*Planktothrix sp.	*Pseudanabaena sp.	*Phormidium	*Raphidiopsis sp.	*Snowella sp.	Unknown colonial	*Woronichinia sp.	MC (µg/l)
10/3/23, 1:03PM	Budd Lake	870,000								+									12.33
7/20/23, 9:55PM	Budd Lake	203,000								+									4.23
10/3/23, 10:29AM	Cozy Lake	14,500					+												12.32
7/17/23, 10:36AM	Cozy Lake	905,000								+									1000.00
7/24/23, 1:30PM	Cozy Lake	46,750								+									22.68
7/24/23, 1:35PM	Cozy Lake	46,375								+									32.05
7/5/23, 10:43AM	Cozy Lake	2,257,500								+									1266.80
8/2/23, 10:51AM	Cozy Lake	3,000,000					+												1511.00
8/29/2023, 12:01PM	Cozy Lake	47,500								+									36.07
9/13/23, 10:41AM	Farrington Lake	49,000					+												2.62
6/28/23, 8:25AM	Greenwich Lake	2,440,000					+												15.65
12/5/23, 10:06AM	Greenwood Lake	16,375	+																2.75
4/28/23, 9:22AM	Greenwood Lake	42,250										+							4.31
5/19/23, 9:13AM	Greenwood Lake	64,500										+							4.85
5/25/23, 8:36AM	Greenwood Lake	69,625	+																2.47
6/13/23, 9:02AM	Greenwood Lake	78,625	+																3.54
6/21/23, 10:05AM	Greenwood Lake	88,750	+																3.20
6/6/23, 10:00AM	Greenwood Lake	67,750	+																2.25
7/12/23, 9:16AM	Greenwood Lake	565,000	+																2.64
7/25/2023, 8:20AM	Greenwood Lake	150,375	+																2.91
8/15/23, 8:55AM	Greenwood Lake	108,025											+						2.55
8/2/23, 8:53AM	Greenwood Lake	119,750	+																3.18
8/29/23, 9:16AM	Greenwood Lake	143,125										+							6.34
9/21/23, 10:10AM	Greenwood Lake	76,375										+							2.99
7/19/23, 10:24AM	Lake Musconetcong	929,250				+													5.13
7/25/23, 2:40PM	Lamberton Park Pond	25,625								+									3.16
9/6/23, 11:23AM	Monksville Reservoir	91,625	+																2.37
8/16/23, 11:10AM	Mountain Lake	67,250										+							2.69
8/16/23, 11:31AM	Mountain Lake	124,125																	2.44
8/8/23, 10:27AM	Pine Run	956,250								+									10.04
10/12/23, 12:52PM	Rising Sun Lake	5,250	x																3.42
9/5/23, 11:41AM	Rosedale Lake	63,750										+		+					3.53
9/5/23, 12:01PM	Rosedale Lake	48,150										+							2.76
6/19/23, 11:38AM	Spruce Run Reservoir	820,000					+												2.65
7/25/23, 9:43AM	Spruce Run Reservoir	874,750																+	7.00
6/15/23, 11:08AM	Swartswood Lake	13,750										+							2.24
7/13/23, 7:37AM	Timber Creek Pond	101,500					+												22.39
11/1/23, 10:44AM	Weequahic Lake	10,500								+									4.99
9/7/23, 10:56AM	Weequahic Lake	119,750								+									7.06
8/15/23, 12:22PM	White Meadow Lake	141,125								+									5.88
8/2/23, 12:26PM	White Meadow Lake	14,875										+		+					2.30
8/9/23, 9:07AM	White Meadow Lake	13,500										+		+					2.35
7/31/23, 9:02AM	Woodcliff Lake Reservoir	151,375																+	3.31

Cyanobacterial recorded as present (+). Green highlight indicates the most dominant taxa in the sample. "*" indicate taxa associated with the potential to produce microcystins.

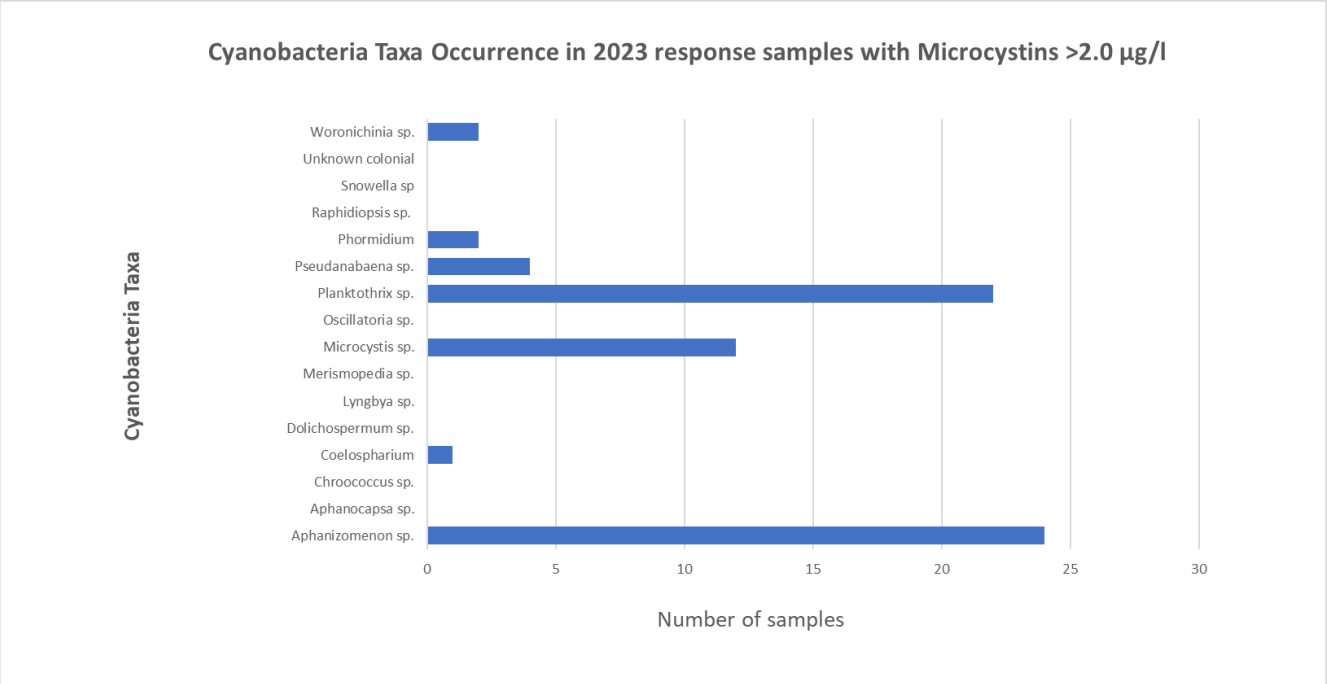


Figure 18. Cyanobacteria Taxa Occurrence in 2023 response samples

All samples were analyzed for microcystins. When micocystins results were above 2.0 µg/L, some samples were analyzed for the three other toxins if a waterbody had a significant recreational health risk and/ or cell concentrations was above 150,000 cells/ml. The toxins and their respective NJ recreational guidance thresholds are: anatoxin-a (15 µg/L), cylindrospermopsin (5 µg/L), and saxitoxin (0.6 µg/L). Anatoxin-a and cylindrospermopsin were detected at or above the lower detection limits of the tests in some samples, but none approached their recreational guidance threshold. Only cylindrospermopsin exceeded the 5 µg/L at two waterbodies. Saxitoxin exceeded the 0.60 µg/L threshold at one waterbody. An internal literature review was performed to determine taxa with the potential to produce each toxin.

- Anatoxin-a (ATX) was detected in 12.0 % of these samples. *Dolichospermum* sp., *Microcystis sp.*, and *Woronichnia sp*. were associated with some of these blooms. All of these are known anatoxin-a producers.
- Cylindrospermopsin (CYL) was detected in 11.6 % of these samples. *Dolichospermum* sp., *Microcystis sp.,* and *Woronichnia sp*. were associated with some of these blooms. Of these, only *Dolichospermum sp*. is a known cylindrospermopsin producer.
- Saxitoxin (STX) was detected in 13.1 % of these samples. *Aphanizomenon sp.*, *Cuspidothrix sp., Dolichospermum* sp., *Microcystis sp*., and *Woronichnia sp*. are associated with some of these blooms. Other than *Woronichnia sp*., these are all known saxitoxin producers.

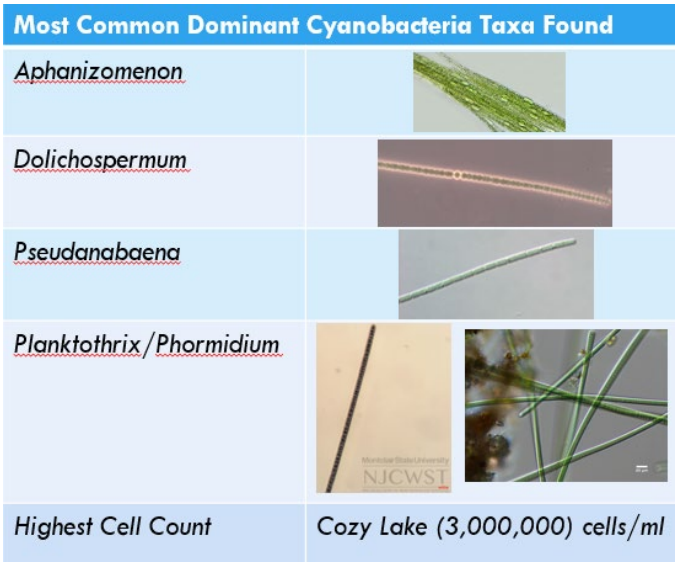


Figure 19. Most Common Dominant Cyanobacteria Found in Samples

Table 8 provides additional information on highest cell count information. Table 11 lists the waterbodies with the highest Microcystin toxin concentrations.

2023 Highest Cell Counts					
Waterbody Name	Cell Count (cells/ml)	Total Cyano Genera	Predominant Taxa	Microcystins	Sample Date
Cozy Lake	3000000	4	Dolichospermum	1511	8/2/2023
Round Valley Reservoir - Swimming Impoundment	2550000	3	Planktothrix/Phormidium	0.31	8/8/2023
Greenwich Lake	2440000	3	Dolichospermum	15.65	6/28/2023
Cozy Lake	2257500	3	Microcystis	1266.8	7/5/2023
Highland Lake	2072500	2	Dolichospermum	1.07	7/5/2023
Sunset Lake	1250000	4	Pseudanabaena	0.09	5/18/2023
Round Valley Reservoir Swimming Impoundment	1045000	5	Woronichinia	0.18	7/17/2023
Pine Run	956250	2	Microcystis	10.04	8/8/2023
Lake Musconetcong	929250	5	Coelosphaerium	5.13	7/19/2023
Cozy Lake	905000	5	Microcystis	1000	7/17/2023
Spruce Run Reservoir	874750	4	Dolichospermum	9.34	7/25/2023
Smithville Lake	872000	3	Cylindrospermopsis	0.12	5/18/2023
Budd Lake	870000	3	Microcystis	12.33	10/3/2023
Spruce Run Reservoir	820000	2	Dolichospermum	2.65	6/19/2023

Table 8. 2023 Highest Cell Counts

Aphanizomenon sp. (23 sites), *Dolichospermum sp*. (7 sites), and *Woronichnia sp* (2 sites) were the most frequently observed potentially toxigenic (PTOX) cyanobacteria taxa associated with the *Microcystis sp.* in most multispecies blooms with microcystins above 2.0 µg/L. (Table 9) These taxa, in addition to the *Microcystis sp.,* are often associated with the production of microcystins.

Table 9. 2023 Highest Microcystin Toxin (Highest to lowest)

2023 Highest Microcystins (Highest to lowest)					
Waterbody Name	**Cell Count (cells/ml)**	**Total Cyano Genera**	**Predominant Taxa**	**Microcystins**	**Sample Date**
Cozy Lake	3000000	4	Dolichospermum	1511	8/2/2023
Cozy Lake	2257500	3	Microcystis	1266.8	7/5/2023
Cozy Lake	905000	5	Microcystis	1000	7/17/2023
Cozy Lake	47500	3	Microcystis	36.07	8/29/2023
Cozy Lake	46375	5	Microcystis	32.05	7/24/2023
Cozy Lake	46750	5	Microcystis	22.68	7/24/2023
Timber Creek Pond	101500	3	Dolichospermum	22.39	7/13/2023
Greenwich Lake	2440000	3	Dolichospermum	15.65	6/28/2023
Budd Lake	870000	3	Microcystis	12.33	10/3/2023
Cozy Lake	14500	3	Dolichospermum	12.32	10/3/2023
Pine Run	956250	2	Microcystis	10.04	8/8/2023
Spruce Run Reservoir	874750	4	Dolichospermum	9.34	7/25/2023
Greenwood Lake	143375	7	Aphanizomenon	8.658	8/29/2023
Weequahic Lake	119750	4	Microcystis	7.06	9/7/2023
Spruce Run Reservoir	702500	3	Woronichinia	7	7/25/2023
Greenwood Lake	143125	6	Planktothrix/Phormidium	6.34	8/29/2023
White Meadow Lake	141125	4	Microcystis	5.88	8/15/2023
Lake Musconetcong	929250	5	Coelosphaerium	5.13	7/19/2023
Weequahic Lake	10500	2	Microcystis	4.99	11/1/2023
Greenwood Lake	36125	3	Aphanizomenon	4.94	5/19/2023
Greenwood Lake	59250	6	Aphanizomenon	4.865	7/25/2023
Greenwood Lake	64500	3	Planktothrix/Phormidium	4.85	5/19/2023
Greenwood Lake	153625	4	Aphanizomenon	4.77	6/21/2023
Greenwood Lake	42750	7	Planktothrix/Phormidium	4.62	9/21/2023
Greenwood Lake	45125	6	Planktothrix/Phormidium	4.574	8/29/2023
Greenwood Lake	43500	5	Planktothrix/Phormidium	4.44	9/21/2023
Greenwood Lake	83750	6	Aphanizomenon	4.36	8/2/2023
Greenwood Lake	42250	3	Planktothrix/Phormidium	4.31	4/28/2023
Budd Lake	203000	4	Microcystis	4.23	7/20/2023
Greenwood Lake	52750	2	Phormidium	3.896	12/5/2023
Greenwood Lake	7625	2	Phormidium	3.884	12/5/2023
Greenwood Lake	107750	4	Pseudanabaena	3.6	6/13/2023
Greenwood Lake	78625	4	Aphanizomenon	3.54	6/13/2023
Rosedale Lake	63750	7	Planktothrix/Phormidium	3.53	9/5/2023

2023 Highest Microcystins (Highest to lowest) (continued)					
Waterbody Name	**Cell Count (cells/ml)**	**Total Cyano Genera**	**Predominant Taxa**	**Microcystins**	**Sample Date**
Greenwood Lake	150000	4	Planktothrix	3.42	6/21/2023
Rising Sun Lake	5250	3	Aphanizomenon	3.42	10/12/2023
Greenwood Lake	150375	8	Aphanizomenon	3.344	7/25/2023
Woodcliff Lake Reservoir	151375	4	Woronichinia	3.31	7/31/2023
Greenwood Lake	136375	4	Pseudanabaena	3.243	6/13/2023
Greenwood Lake	102500	8	Pseudanabaena	3.234	9/21/2023
Greenwood Lake	28125	4	Planktothrix/Phormidium	3.205	6/6/2023
Greenwood Lake	88750	5	Aphanizomenon	3.2	6/21/2023
Greenwood Lake	119750	7	Aphanizomenon	3.18	8/2/2023
Lamberton Park Pond	25625	1	Microcystis	3.156	7/25/2023
Greenwood Lake	70625	5	Planktothrix/Phormidium	3.13	8/2/2023
Greenwood Lake	38375	4	Aphanizomenon	3.083	7/25/2023
Greenwood Lake	35375	6	Planktothrix/Phormidium	3.05	8/29/2023
Greenwood Lake	126500	5	Aphanizomenon	2.99	7/12/2023
Greenwood Lake	76375	5	Planktothrix/Phormidium	2.99	9/21/2023
Greenwood Lake	55750	4	Aphanizomenon	2.98	6/21/2023
Greenwood Lake	61250	4	Planktothrix/Phormidium	2.93	6/13/2023
Greenwood Lake	203125	3	Aphanizomenon	2.91	7/12/2023
Rosedale Lake	48150	6	Planktothrix/Phormidium	2.76	9/5/2023
Greenwood Lake	16375	3	Aphanizomenon	2.754	12/5/2023
Mountain Lake	67250	4	Planktothrix/Phormidium	2.69	8/16/2023
Greenwood Lake	116375	8	Planktothrix/Phormidium	2.67	8/15/2023
Spruce Run Reservoir	820000	2	Dolichospermum	2.65	6/19/2023
Greenwood Lake	565000	4	Aphanizomenon	2.64	7/12/2023
Greenwood Lake	311875	3	Aphanizomenon	2.63	7/12/2023
Farrington Lake	49000	3	Dolichospermum	2.62	9/13/2023
Greenwood Lake	108025	5	Pseudanabaena	2.55	8/15/2023
Greenwood Lake	90875	7	Aphanizomenon	2.5	8/2/2023
Greenwood Lake	61625	3	Aphanizomenon	2.49	5/25/2023
Greenwood Lake	69625	3	Aphanizomenon	2.47	5/25/2023
Mountain Lake	124125	5	Planktothrix/Phormidium	2.44	8/16/2023
Greenwood Lake	105750	6	Planktothrix/Phormidium	2.42	8/15/2023
Monksville Reservoir	91625	null	Aphanizomenon/Cuspidothrix	2.37	9/6/2023
White Meadow Lake	13500	3	Planktothrix/Phormidium	2.35	8/9/2023
White Meadow Lake	14875	4	Planktothrix/Phormidium	2.3	8/2/2023
Greenwood Lake	67750	3	Aphanizomenon	2.252	6/6/2023
Swartswood Lake	13750	1	Planktothrix/Phormidium	2.24	6/15/2023

2023 Highest Microcystins (Highest to lowest) (continued)

Waterbody Name	Cell Count (cells/ml)	Total Cyano Genera	Predominant Taxa	Microcystins	Sample Date
Greenwood Lake	139500	8	Planktothrix/Phormidium	2.21	8/15/2023
Greenwood Lake	107625	6	Aphanizomenon	2.15	8/2/2023
Greenwood Lake	40250	4	Aphanizomenon	2.147	6/6/2023

Supporting Programs

As part of HAB response and monitoring, BFBM partners with several DEP and external partners. DEP's Division of Water Enforcement (DWE) aided in response screening and sampling. The State Park Service is also a significant partner providing assistance with response screening and sampling as well as posting Alerts when needed and monitoring the daily status of Park waterbodies.

NJ Forest Fire Service performs flight (Figure 20) surveillance at several larger Northern NJ lakes of concern. Visual observations are recorded as well as remote sensing of phycocyanin pigment. DWMSPC Bureau of Marine Water Monitoring developed a customized algorithm that can reliably detect and estimate phycocyanin concentrations in freshwaters through wavelength reflectance signatures.

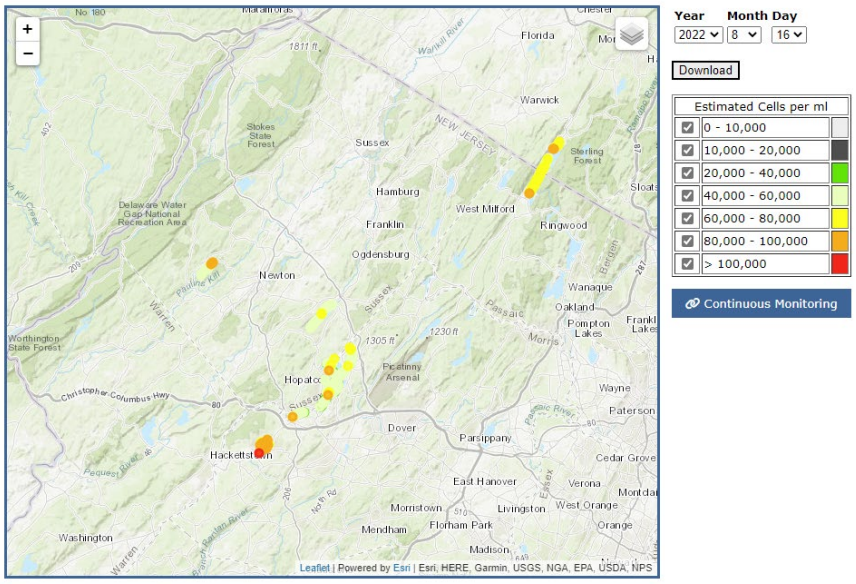
Figure 20. Forest Fire Service

These measurements are not used as a replacement for confirmation analysis, but as a screening and status monitoring tool to detect relative increases and decreases in phycocyanin pigment concentrations. When levels change significantly i.e., indicate a change in Alert status, sampling staff are deployed for confirmation laboratory analysis.

As an enhancement in 2022, flight data was made available to the public at: Algal Bloom Remote Sensing (rutgers.edu) Flights were performed once per week during the recreational season at the following lakes (weather permitting):

Lake Hopatcong, Greenwood Lake, Musconetcong Lake, Budd Lake, Spruce Run Reservoir, Lake Mohawk, Swartswood Lake, and Round Valley Reservoir (non-HAB control lake). Other lakes were added as needed. Figure 20 shows examples of the flight data.

Figure 21. Examples of flight data.



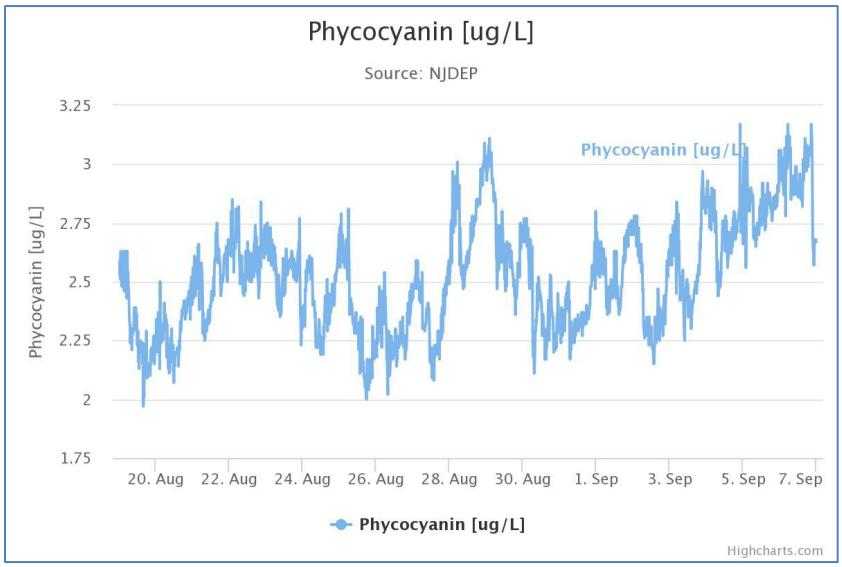
The Bureau of Marine Water Monitoring has also assisted in developing a program using buoys equipped with continuous monitoring meters and real-time telemetry technology (Figure 21). Eleven (11) buoys were deployed at select waterbodies. The sites were chosen due to recreational and/or drinking water significance, repeated HAB occurrence, duration, and previous elevated levels of HABs at these waterbodies. The waterbodies had one or more remote monitoring devices to provide best feasible coverage for HAB status monitoring & response:
Lake Hopatcong – 4 meters
Spruce Run Reservoir– 1 meter
Swartswood Lake – 2 meters
Budd Lake – 1 meter
Greenwood Lake – 1 meter
Greenwich Lake – 1 meter
Manasquan Reservoir – 1 meter

Figure 22. Real-Time Continuous Buoy Program

These meters also measure other water quality parameters such as temperature, dissolved oxygen, and pH. As with phycocyanin measurements previously mentioned, this data is used for screening and status monitoring. Water quality data may be used to assess factors that may contribute to or characterize HAB

production. Data can be downloaded or viewed in real time at the Continuous Data Monitoring Program website. Figure 23 shows an example of a downloadable graph with phycocyanin measurements at Greenwood Lake.

Figure 23. Example Real-Time Continuous Data Download



Cells per ml	Meter
20000	1.15
40000	1.87
80000	3.29
100000	4.00

The program will continue in 2024. Based on data collected in 2022, buoys may be deployed at other waterbodies.

A field phycocyanin meter loan program was implemented in 2020 and expanded in 2022 from 12 to 40 meters respectively. No additional meters were distributed in 2023. These partners played a significant role in screening, status monitoring, and sampling.
Meters were loaned to various internal and external partners:

- 10 -Water systems: AC MUA, North Brunswick WTP, Newton Twp, NJWSA (2), Sussex Borough Water, New Brunswick WA, City of Newark, Butler, NJ American North
- 5 -County/ local HDs: Sussex Co, Monmouth Co, Salem Co, Burlington Co, Hopatcong City Hall
- 2 -County/Local parks: Mercer Co, Hunterdon
- 7 -DEP Parks: North, Central, South, Swartswood, Wawayanda, Spruce Run (2)
- 5 -DEP C&E
- 12 – Commissions and Lake Associations: Greenwood Lake Commission (2), Mountain Lake, Watershed Institute (3), Lake Hopatcong Foundation (2), Lake Owassa, Cranberry Lake, Branta Lake, Lake Hopatcong Commission

Conclusions

In 2023, there was a 1% decrease in reports of suspected HABs from 2022. This translated into a significant decrease in the number of waterbodies with confirmed HABs (Watch Alert or above) by 28% as compared to 2022. Comparing reported waterbody data from 2017 to 2023 shows a statewide increase of 66%. In addition, comparing confirmed harmful algal blooms from 2017 to 2023 shows an increase of 59%. Data shows the statewide occurrence of HABs in New Jersey has increased in many waterbodies, since 2017 when the DEP initiated monitoring per the Response Strategy. In 2023, 33% of waterbodies with confirmed HABs, had confirmed HABs in a previous year since HAB response was initiated in 2017 (Table 10).

Table 10. 2023 Confirmed HAB Waterbodies with Previous HABs

2023 Confirmed HAB Waterbodies with Previous HABS							
Waterbody Name	2017	2018	2019	2020	2021	2022	2023
Alloway Lake				X		X	X
Bellmawr Lake					X	X	
Branta Pond					X	X	
Budd Lake	X	X	X	X	X	X	X
Canoe Pond					X	X	
Ceva Lake	X		X		X	X	
Cozy Lake				X		X	X
Daretown Lake			X	X		X	
Duck Pond		X				X	
Elmer Lake			X			X	
Farrington Lake				X	X	X	
Greenwich Lake				X		X	
Greenwood Lake			X	X	X	X	X
Haledon Reservoir				X		X	
Lake Hopatcong			X	X	X	X	X
Lake Musconetcong			X	X	X	X	
Lake Sylvia	X		X		X	X	
Little Pond					X	X	
Manasquan Reservoir			X	X	X	X	X
Manny's Pond	X	X	X		X	X	
Mountain Lake			X	X	X	X	X
Pemberton Lake	X		X	X	X	X	X
Pompton Lake				X		X	
Pompton River	X					X	
Quarry Pond				X		X	
Ramapo River				X		X	
Rosedale Lake			X	X	X	X	X
Smithville Lake					X	X	X

2023 Confirmed HAB Waterbodies with Previous HABS							
Waterbody Name	2017	2018	2019	2020	2021	2022	2023
Spruce Run Reservoir			X	X	X	X	X
Sunset Lake			X	X		X	
Swartswood Lake	X	X	X	X	X	X	X
Van Saun Mill Brook					X	X	
Woodcliff Lake Reservoir				X	X	X	

Continued evidence of significant HAB activity is the persistence of blooms into the winter. Sampling and confirmation analysis for 2023 was completed in December and there were 7 waterbodies with at least one site with a HAB Alert level of Watch or above (Table 11). This is a decrease from 16 waterbodies in 2022. A Winter Watch Alert was recommended for the 2023/2024 winter season at these waterbodies.

Table 11. 2023 Persistent HABs

Lake	Alert	Date
Weequahic Lake	Advisory	11/1/23
Cozy Lake	Advisory	11/8/23
Manasquan Reservoir	Watch	11/28/23
Sunset Lake (Asbury Park)	Advisory	12/12/23
Greenwood Lake	Advisory	12/5/23
Silver Lake Belmar	Watch	12/12/23
Pemberton Lake	Watch	12/20/23

In previous years, cell concentrations above recreational guidance thresholds were the main reason for Alert postings. Toxin levels are usually associated with multispecies blooms where *Microcysts sp* is present or dominant. Multi-species blooms (especially those containing *Aphanizomenon sp., Cuspidothrix sp., Dolichospermum* sp., *Microcystis sp*., and *Woronichnia sp.*) were present in samples where other toxins were detected by laboratory analysis. Therefore, it is recommended that the complete suite of toxins with recreational guidance thresholds in New Jersey be analyzed when these taxa are present in a sample.

The USEPA states (https://www.epa.gov/cyanoHABs/causes-cyanoHABs): “There is widespread agreement within the scientific community that the incidence of HABs is increasing both in the U.S. and worldwide. This recent increase in the occurrence of HABs has been attributed to increasing anthropogenic activities and their interaction with factors known to contribute to the growth of cyanobacterial blooms. Point sources (which may include discharges from municipal and industrial wastewater treatment plants, concentrated animal feeding operations (CAFOs), Municipal Separate Storm Sewer Systems (MS4s), stormwater associated with industrial activity, and other and non-point sources (which may include diffuse runoff from agricultural fields, roads and stormwater), may be high in nitrogen and phosphorus and can promote or cause excessive fertilization (eutrophication) of both flowing and non-flowing waters.”

The expansion of the continuous buoy network provides valuable data at waterbodies where HABs have reoccurred. In addition to informing immediate HAB response actions, continuous data will be used by DEP to research water quality factors that may predict or contribute to HAB formation.

In 2021, DWMSPC and the New Jersey Sea Grant Consortium (NJSGC) recruited a team of lakes management and cyanobacterial HAB experts to address the second component of the Governor's HAB initiative focusing on enhancing scientific expertise and building the state's capacity for HAB response. The HAB Expert Team's primary objective is to provide guidance to DEP on HAB prevention, mitigation and management for NJ lakes and other waterbodies. As a culmination of their research, literature review, and data analysis, the ET developed the HAB Lake Management Guidance, HAB Guidance, which provides details to lake managers on how to develop a lake-specific action plan. The Guidance includes HAB prevention, mitigation, and management for NJ waterbodies that considers short-term and long-term action plan components. A virtual workshop was held in April 2023, which offered a comprehensive overview on the components of the Guidance. A recording of the Workshop and presentation materials are available on the HAB ET website, Expert Team. The Expert Team will continue to provide guidance on emerging technologies and data analysis.