Cyanobacterial Harmful Algal Bloom (HAB)Freshwater Response

2021 Summary Report

Division of Water Monitoring, Standards and Pesticide Control

Cover Photo- Penbryn Lake, Camden County, 8/27/2021

April 2022

Cyanobacterial Harmful Algal Bloom (HAB) Freshwater Recreational Response

2021 Summary Report

New Jersey Department of Environmental Protection

Water Resource Management

Division of Water Monitoring, Standards and Pesticide Control

Bruce S. Friedman, Director

Bureau of Freshwater and Biological Monitoring

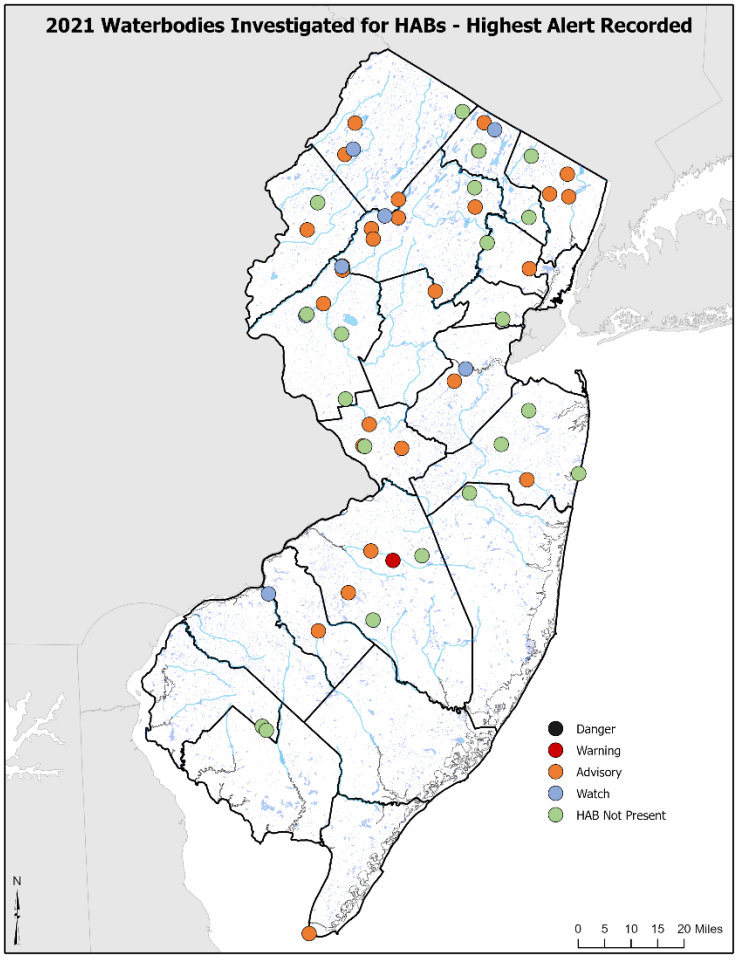
Victor Poretti, Bureau Chief

April 2022

Report prepared by:
Victor Poretti, Bureau Chief
Dean Bryson, Supervisor
Tom Miller, Research Scientist 2
Leah Gibala-Smith Research Scientist 3
Leigh Lager, Geographic Information Systems Specialist
Vincent Mina, Data Management

Executive Summary

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 2021, DEP responded to reports of suspected HABs at 55 waterbodies.* Of these, 35 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.

At each of the 55 waterbodies investigated, multiple sites may have been sampled, depending on localized occurrences in the waterbody, totaling 130 site-specific HAB alerts. The pie chart on the right, Figure 1, illustrates the HAB alert level distribution for all sites at all waterbodies.

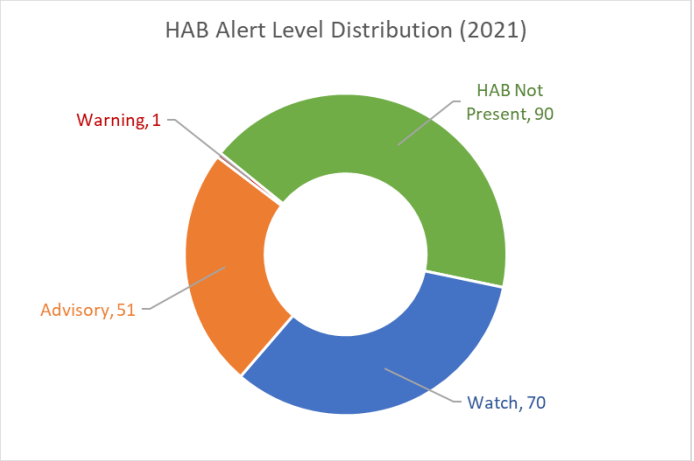


Figure 1

These 55 reports of suspected HABs represent a 44% decrease from 2020.This translated into a significant decrease of waterbodies with confirmed HABs (Watch Alert or above) by 24%. Although a decrease was observed in 2021 compared to 2020, the total confirmed HABs in 2021 exceeded the yearly totals for 2017-2019 (Figure 2).

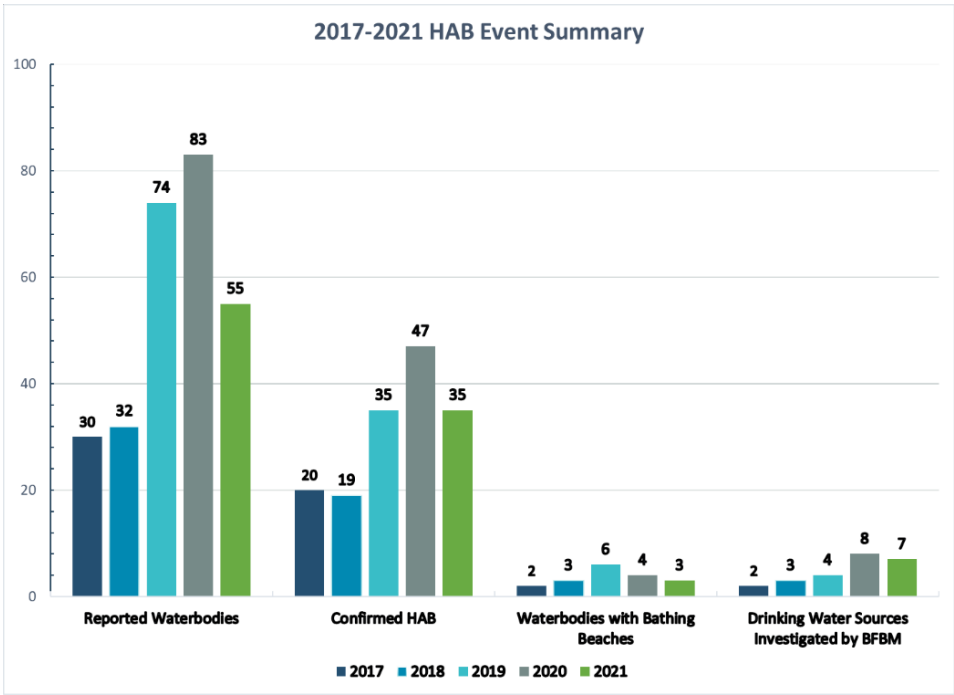


Figure 2

The number of confirmed HABs at drinking water sources decreased from 2020 (Figure 2). In addition, 53% of waterbodies with confirmed HABs in 2021, had a previous confirmed HAB at least once from 2017-2020. Data shows the statewide occurrence of HABs in New Jersey has 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. As of December 2021, there were 12 waterbodies with at least one site with a HAB Alert level of Watch or above. This is a slight decrease from 15 waterbodies in 2020, but still significantly higher than 2019 when only 8 waterbodies had HABs continuing past December.

Though the program began reacting and responding solely to reports of HABs, the program has begun to expand background monitoring, with the expansion of the continuous monitoring buoy network. The continuous monitoring network will provide 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 to develop guidance documents for the prevention and management of HABs and to provide technical advice on proposed 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.

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 strategy 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 2021**.** 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 been 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 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 1) 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.

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 1. HAB Alert Table

A Winter Watch sign (Figure 1) was developed and implemented, 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.

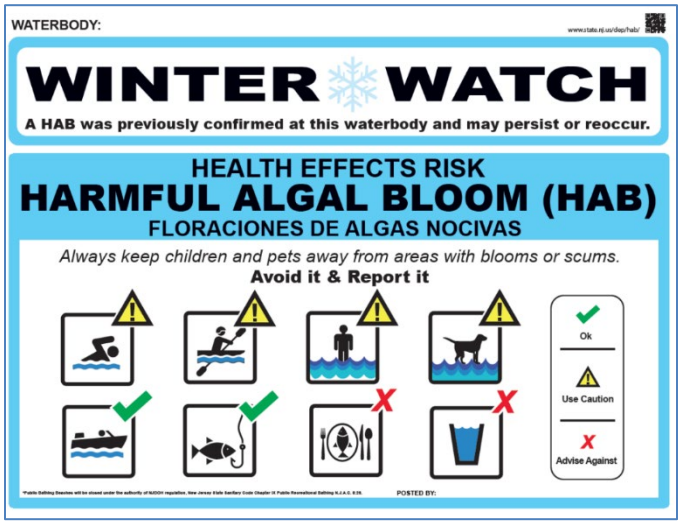


Figure 1. Winter Watch Sign

The DEP HAB Interactive Map Reporting and Communication System (Figure 2) 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.

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)

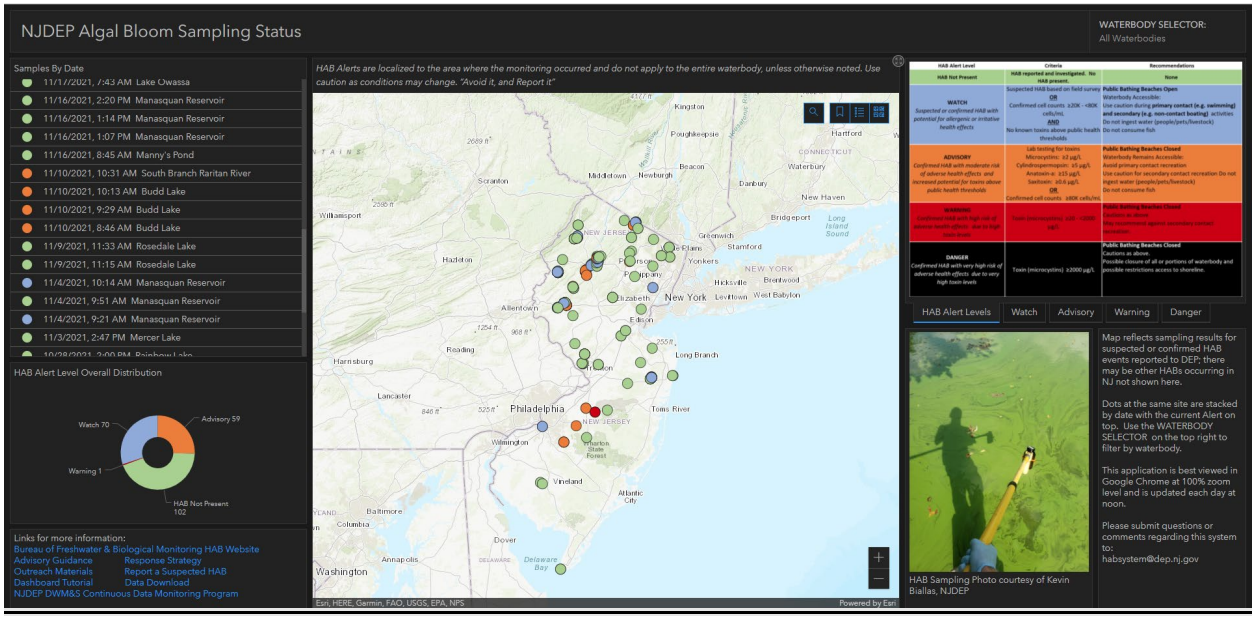


Figure 2. HAB Interactive Map

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 2.

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

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*

Table 2. Response and Monitoring Priorities

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 3. Field Fluorometer For Measuring Phycocyanin

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 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.

Figure 4. Continuous multi-parameter meter.

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 4), but units can also be used for discreet measurements by samplers.

The DWMSPC has developed correlations between phycocyanin measurements and cell concentration. All New Jersey-specific data available from 2017-2019, 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 5 & Table 3).

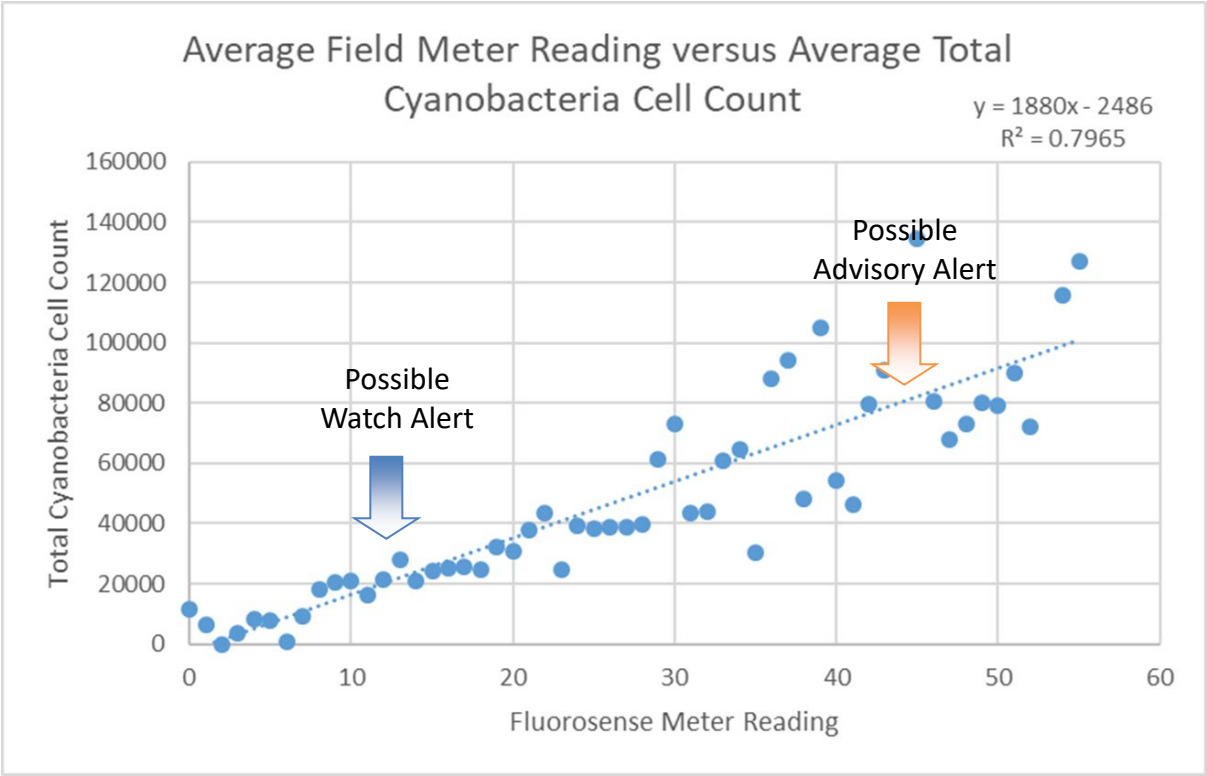


Figure 5. Phycocyanin and cell count correlation for FluoroSense field meter

Estimated individual cell counts cells/ml	Continuous & Discreet Meter µg/L	Estimated FluoroSense RFU	Estimated Lab Fluorometer RFU
20000	1.15	12	33
40000	1.87	23	45.9
80000	3.29	44	71.5
100000	4.00	55	84.3

Table 3. 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 6), 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.

Currently, EPA Standardized Analytical Method for Determining Total Microcystins by the use of 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 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.

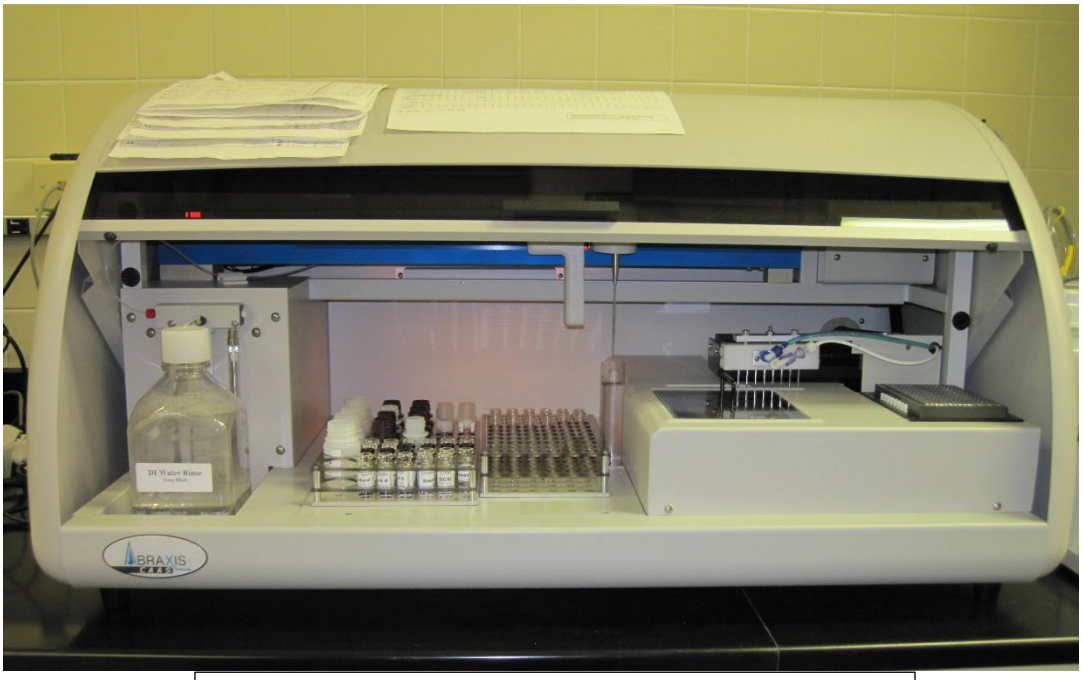


Figure 6. Cyanotoxin Automated Analyzer System (CAAS)

2021 Results and Discussion

Waterbody Summary

In 2021, BFBM responded to suspected HAB reports at 55 waterbodies. Of these, 35 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 was 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 55 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 are for the immediate area where the HAB occurred, and the rest of the waterbody can be used for recreation with normal appropriate precautions. When Alerts are posted, it is noted that there may be other HABs occurring which have been reported and confirmed. As always, recreators are advised to avoid anything that looks like a HAB and to report it to the DEP ("Avoid It and Report It"). Figure 7 shows a map of the waterbodies investigated in 2021 with the highest alert level recorded for that waterbody for the season.

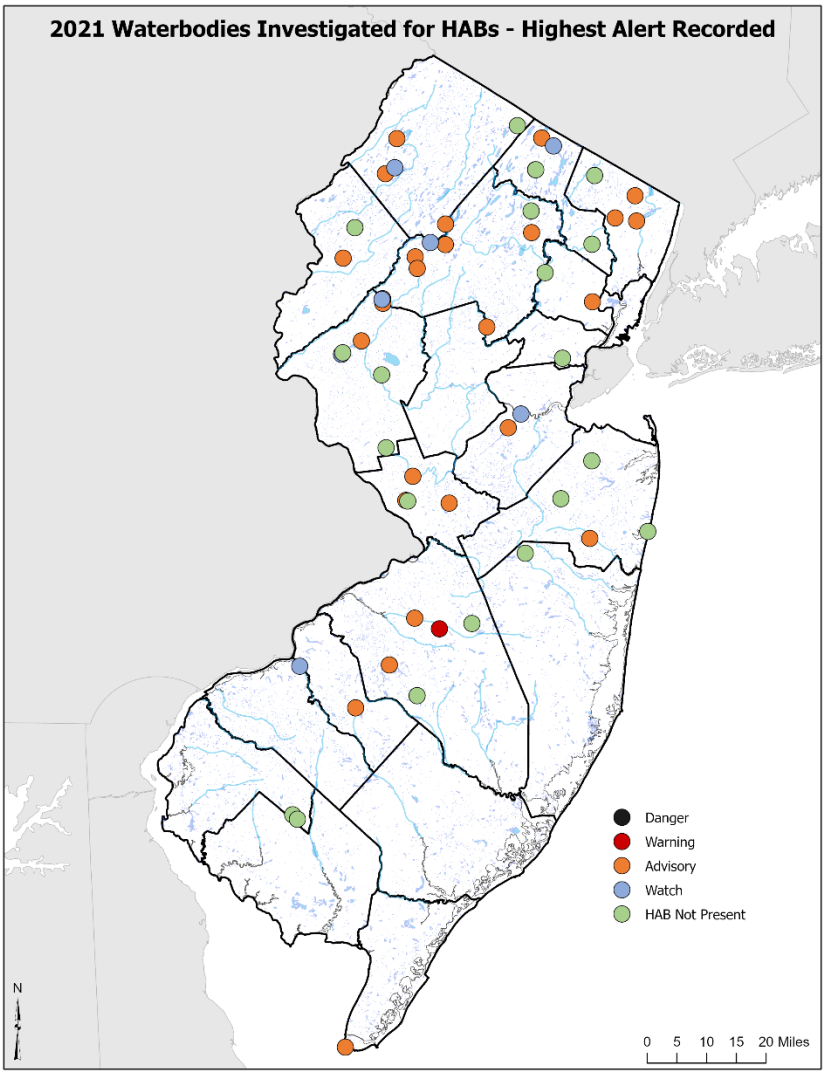


Figure 7. Map of 2021 Waterbodies Investigated

Table 4 lists these waterbodies by county and municipality.

Waterbody Name	Municipality	County	Alert Tier
Darlington Lake	Mahwah Township	Bergen	HAB Not Present
Glen Rock Pond	Glen Rock Borough	Bergen	Advisory
Van Saun Mill Brook	Oradell Borough	Bergen	Advisory
Woodcliff Reservoir	Hillsdale Borough	Bergen	Advisory
Indian Mills Lake	Shamong Township	Burlington	HAB Not Present
Mirror Lake	Pemberton Township	Burlington	HAB Not Present
Pemberton Lake	Pemberton Township	Burlington	**Warning**
Smithville Lake	Eastampton Township	Burlington	Advisory
Timber Lake	Medford Township	Burlington	Advisory
Bellmawr Lake	Bellmawr Borough	Camden	Watch
Penbryn Lake	Winslow Township	Camden	Advisory
Lake Lily	Cape May Point Borough	Cape May	Advisory
Branch Brook Park Lake	Newark City	Essex	Advisory
Passaic River - 01379580	Roseland Borough	Essex	HAB Not Present
Amwell Lake	East Amwell Township	Hunterdon	HAB Not Present
Arb Pond	Clinton Township	Hunterdon	HAB Not Present
Canoe Pond	Lebanon Township	Hunterdon	Watch
Driveway Pond	Lebanon Township	Hunterdon	Advisory
Little Pond	Lebanon Township	Hunterdon	Advisory
Manny's Pond	Union Township	Hunterdon	Watch
Spruce Run Reservoir	Union Township	Hunterdon	Advisory
Tunnel Pond	Union Township	Hunterdon	HAB Not Present
Lake Ceva	Ewing Township	Mercer	Advisory
Lake Sylva	Ewing Township	Mercer	HAB Not Present
Mercer Lake	West Windsor Township	Mercer	Advisory
Rosedale Lake	Hopewell Township	Mercer	Advisory

Table 4. 2021 Waterbodies Investigated/ Highest Recorded Alert

Waterbody Name	Municipality	County	Alert Tier
Farrington Lake	North Brunswick Township	Middlesex	Advisory
Weston Mill Pond	New Brunswick City	Middlesex	Watch
Holmdel Park Pond	Holmdel Township	Monmouth	HAB Not Present
Lake Topanemus	Freehold Township	Monmouth	HAB Not Present
Manasquan Reservoir	Howell Township	Monmouth	Advisory
Sylvan Lake	Avon-by-the-Sea Borough	Monmouth	HAB Not Present
Budd Lake	Mount Olive Township	Morris	Advisory
Butler (Kakeout) Reservoir	Kinnelon Borough	Morris	HAB Not Present
Crooked Brook	Montville Township	Morris	Advisory
Lake Musconetcong	Netcong Borough	Morris	Watch
Lake Rogerene	Mount Arlington Borough	Morris	Advisory
South Branch Raritan River	Mount Olive Township	Morris	Advisory
Stone Tavern Lake	Jackson Township	Ocean	HAB Not Present
Barbour Lake	Woodland Park Borough	Passaic	HAB Not Present
Greenwood Lake	West Milford Township	Passaic	Advisory
Lower Mt Glen Lake	West Milford Township	Passaic	Watch
Monksville Reservoir	West Milford Township	Passaic	Watch
Mt Glen Lake	West Milford Township	Passaic	HAB Not Present
Rainbow Lake	Pittsgrove Township	Salem	HAB Not Present
Thundergust Lake	Pittsgrove Township	Salem	HAB Not Present
Branta Pond	Bernards Township	Somerset	Advisory
Lake Hopatcong	Hopatcong Borough	Sussex	Advisory
Lake Owassa	Frankford Township	Sussex	Advisory
Little Swartswood Lake	Hampton Township	Sussex	Watch
Swartswood Lake	Stillwater Township	Sussex	Advisory
Wawayanda Lake	Vernon Township	Sussex	HAB Not Present
Rahway River	Rahway City	Union	HAB Not Present
Mountain Lake	Liberty Township	Warren	Advisory
Silver Lake	Hope Township	Warren	HAB Not Present

Table 4 continued. 2021 Waterbodies Investigated/ Highest Recorded Alert

Data and Alert Levels for all sites sampled can be found on the DEP HAB Interactive Map Reporting and Communication System.

Figure 8 shows the distribution of all sites and Alert levels in 2021.

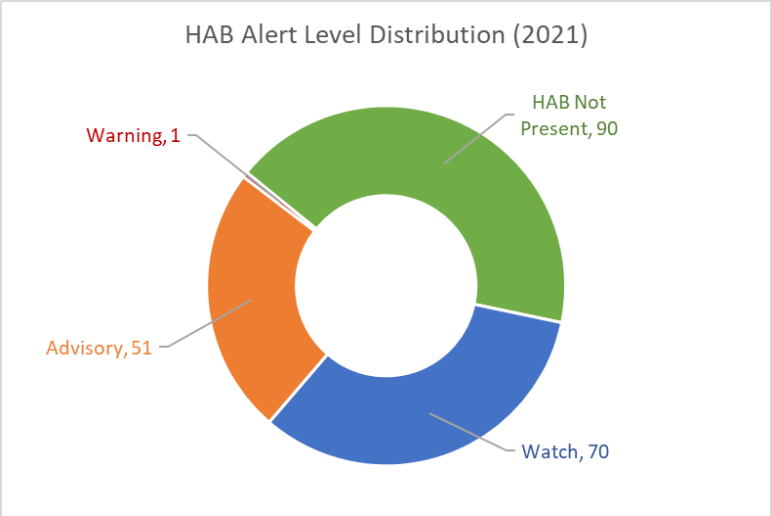


Figure 8. HAB Alert Distribution by Site

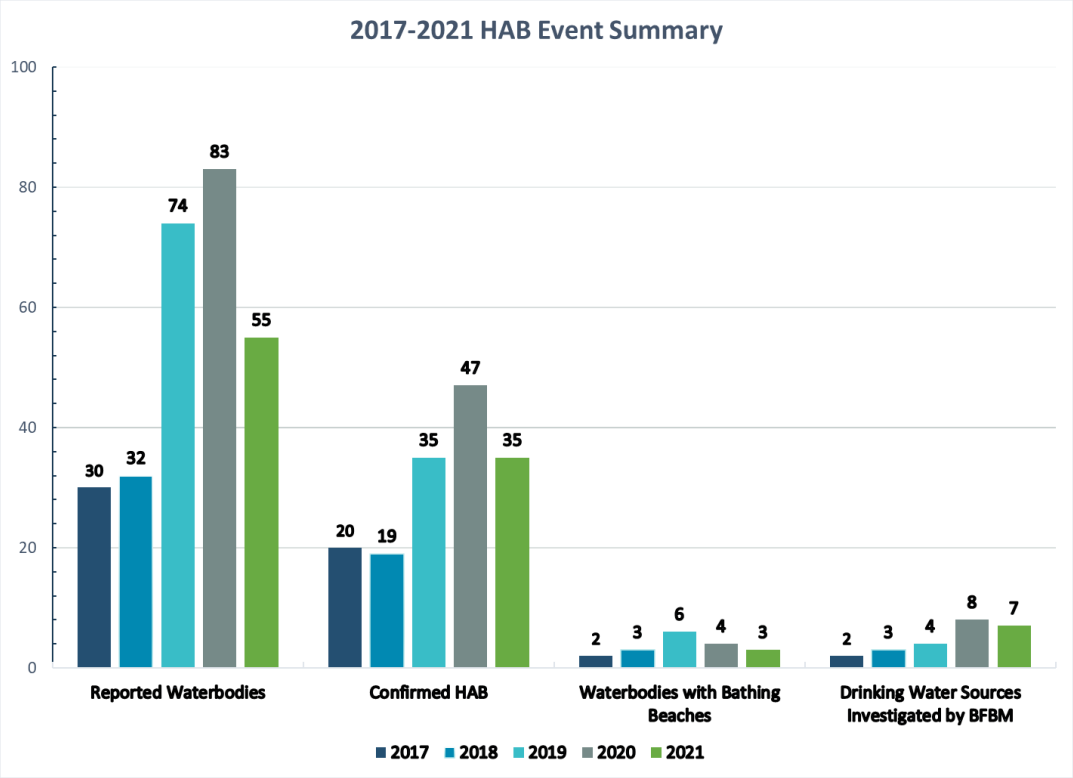


Figure 9. HAB Event Summary by Waterbody

In 2021, there was a decrease in waterbodies with beach closures and HABs at drinking water sources that were also recreational waterbodies (Figure 9).

Public Recreational Bathing Beaches (PRB) and Drinking Water Sources

Beaches:

1. Rogerene Lake
2. Timber Lake
3. Swartswood Girl Scout Camp

Drinking Water Sources at recreational water bodies:

1. Spruce Run Reservoir
2. Manasquan Reservoir
3. Farrington Lake
4. Weston Mills Pond
5. Woodcliff Lake
6. Monksville Reservoir
7. Butler (Kakeout) Reservoir

Recreational Bathing Beach Confirmation

When a HAB was confirmed at Advisory/Beach Closure levels at Public Recreational Bathing Beaches (PRB), 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 were below thresholds for consecutive days, then only one laboratory analysis with cell count and toxin results below thresholds was necessary.

*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. 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 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 2021, laboratory analysis was consistent with the number of reports investigated. There was a slight increase in toxin analysis in 2021 due to the addition of saxitoxin. 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, the overall toxin analysis was reduced as compared to 2017-2019. (Figure 10).

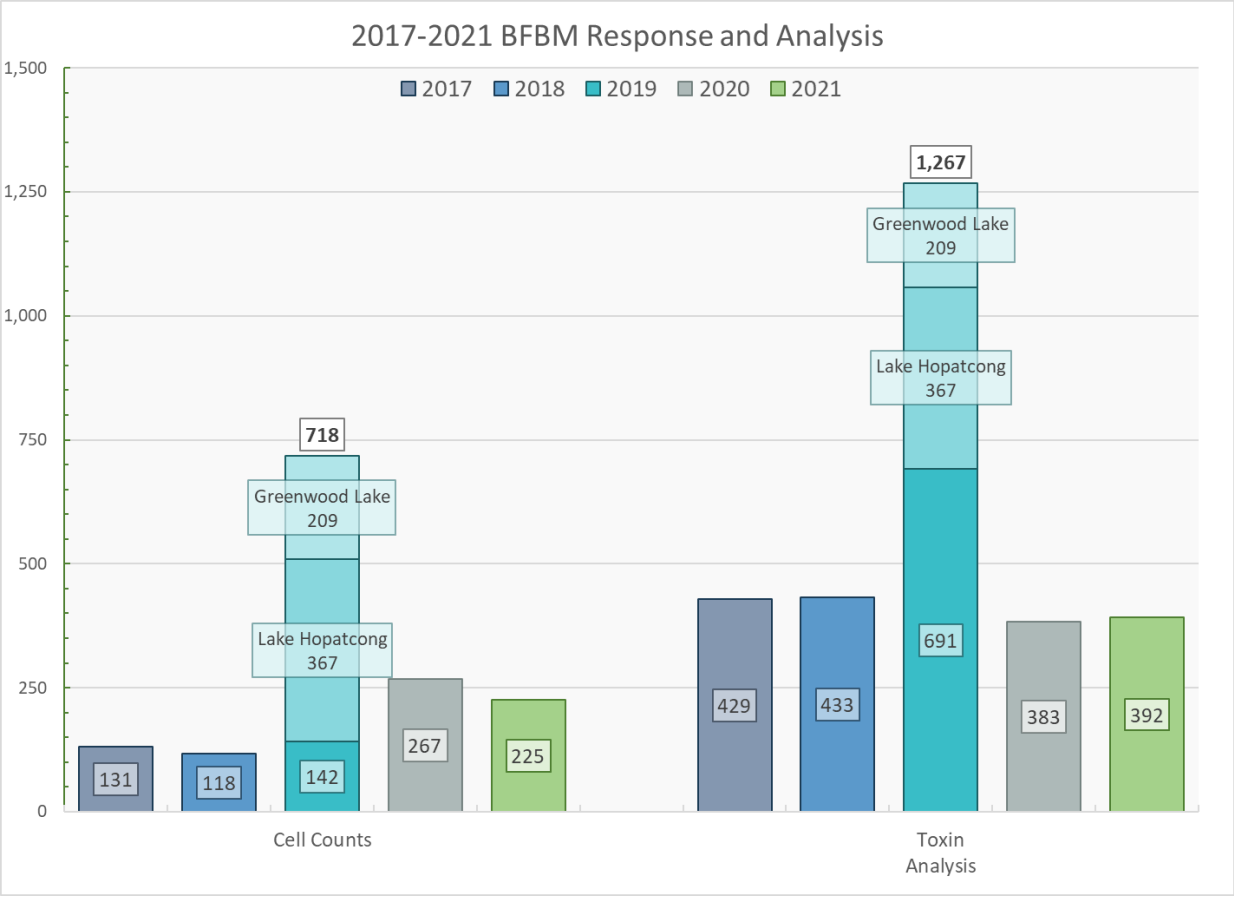


Figure 10. Summary Laboratory Analysis

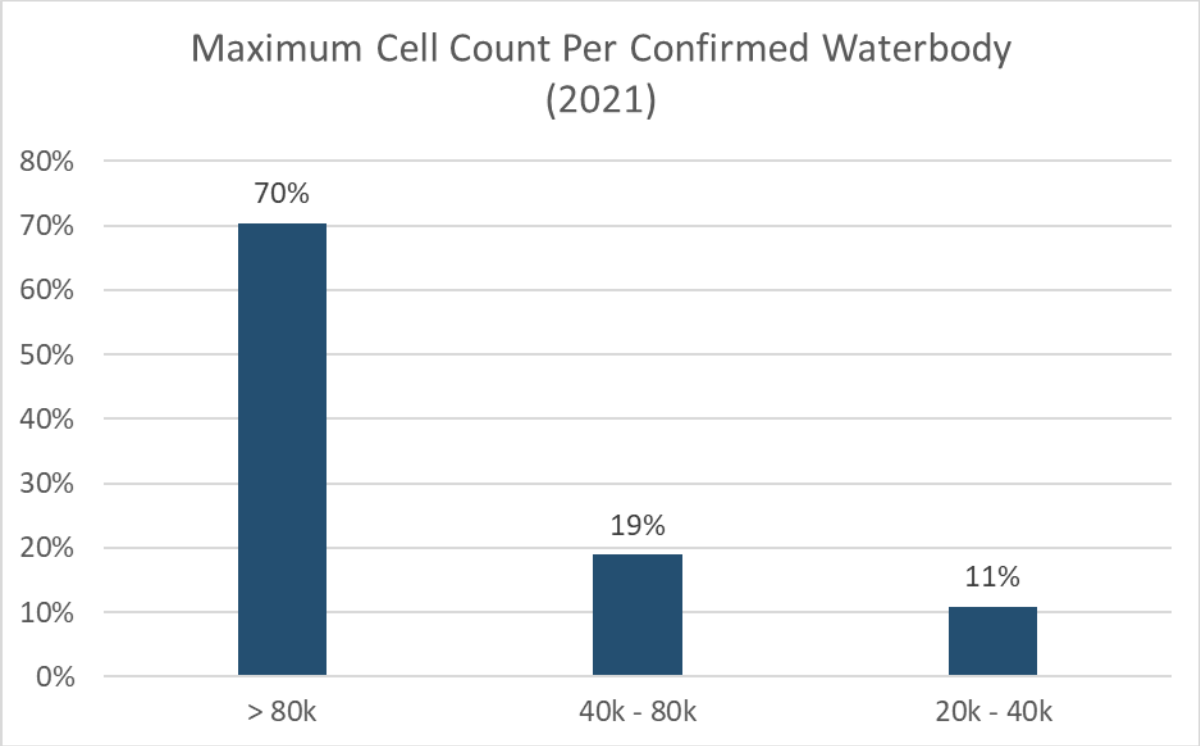


Figure 11. Maximum Cell Count by Waterbody

Figure 11 summarizes the maximum cell count density at any given waterbody investigated during the 2021 season. The majority (70%) 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. 30% of waterbodies with confirmed HABs had a peak alert in the Watch category between 20,000 and 80,000 cells/ ml. 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 concentration, 94,560,000 cells/ml, was at Penbryn Lake, Camden County, while Pemberton Lake, Burlington County recorded the highest microcystins toxin result (Figure 12) of 109.7 µg/L.

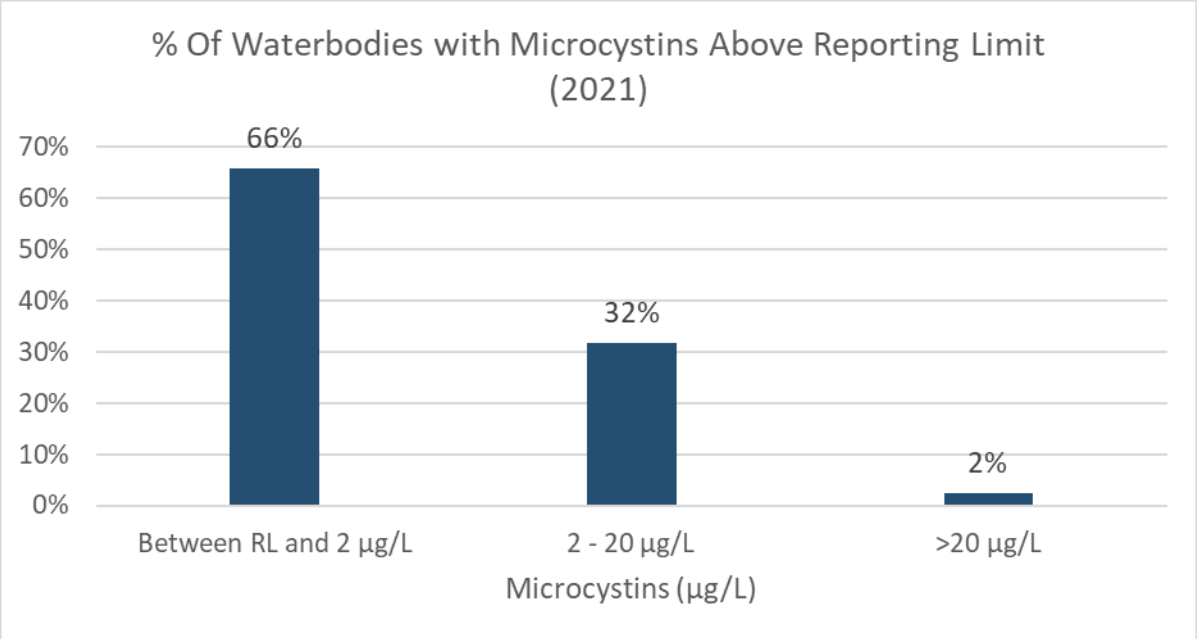


Figure 12. Maximum Toxin Level by Waterbody

The majority of peak microcystins concentration at waterbodies with confirmed HABs, 66%, were between the analysis Reporting Level (RL) of 0.15 µg/L and the Advisory Alert threshold of 2.0 µg/L. 32% were in the Advisory Alert category and only 2% (one waterbody) in the Warning Alert category. There were no results above recreational thresholds for cylindrospermopsin, anatoxin-a, or saxitoxin.

Table 5 lists the waterbodies with the highest microcystins and cell count concentrations.

Highest Microcystins					
Waterbody name	**Cell Count cells/ml**	**Total Cyanobacteria Genera Present**	**Predominant Taxa**	**Microcystins µg/L**	**Date/ Time**
Pemberton Lake	936,250	4	Microcystis	109.7	12/2/2021, 10:08 AM
Greenwood Lake	86,500	4	Aphanizomenon (Cuspidothrix)	15.74	7/13/2021, 11:00 AM
Van Saun Mill Brook	214,500	1	Microcystis	13.1	8/31/2021, 1:10 PM
Greenwood Lake	33,475	3	Microcystis	12.4	7/13/2021, 11:15 AM
Spruce Run Reservoir	603,750	5	Lyngbya	8.8	8/3/2021, 9:15 AM
Penbryn Lake	4,280,000	2	Woronichinia	8.12	8/27/2021, 9:07 AM
Greenwood Lake	67,000	4	Dolichospermum	5.93	7/27/2021, 7:49 AM
Budd Lake	893,750	3	Microcystis	5.68	11/10/2021, 10:13 AM
Branta Pond	30,000	4	Woronichinia	5.5	7/15/2021, 9:40 AM
Spruce Run Reservoir	450,000	3	Aphanizomenon	5.32	6/1/2021, 9:30 AM
Spruce Run Reservoir	75,750	5	Dolichospermum	5.26	6/29/2021, 12:26 PM
Spruce Run Reservoir	48,875	4	Dolichospermum	5	7/7/2021, 11:11 AM
Spruce Run Reservoir	46,500	5	Dolichospermum	4.79	8/17/2021, 9:10 AM
Lake Rogerene	1,290,000	3	Microcystis	4.54	8/30/2021, 10:32 AM
Rosedale Lake	122,250	4	Pseudanabaena	4.52	10/6/2021, 11:26 AM
Budd Lake	40,250	4	Microcystis	4.06	9/28/2021, 8:45 AM
Mercer Lake	351,250	5	Dolichospermum	3.91	10/7/2021, 12:24 PM
Lake Ceva	322,500	5	Microcystis	3.86	7/12/2021, 8:28 AM
Driveway Pond	5,000	3	Woronichinia	3.39	7/22/2021, 8:36 AM
Swartswood Lake	141,000	4	Dolichospermum	3.11	6/7/2021, 10:23 AM
Swartswood Lake	19,500	4	Lyngbya	2.82	8/3/2021, 9:25 AM
Budd Lake	34,000	3	Microcystis	2.74	11/10/2021, 8:46 AM
South Branch Raritan River	14,000	2	Microcystis	2.45	10/21/2021, 11:50 AM
Budd Lake	263,750	2	Woronichinia	2.17	11/10/2021, 9:29 AM
Budd Lake	49,375	6	Microcystis	2.07	8/10/2021, 12:01 PM
Highest Cell Counts With Low Toxins					
Waterbody name	**Cell Count cells/ml**	**Total Cyanobacteria Genera Present**	**Predominant Taxa**	**Microcystins µg/L**	**Date/ Time**
Penbryn Lake	94,560,000	1	Woronichinia	0.88	12/2/2021, 12:00 PM
Lake Lily	23,650,000	2	Dolichospermum	0.9	8/24/2021, 12:51 PM
Smithville Lake	21,670,000	2	Dolichospermum	0.43	9/8/2021, 9:17 AM
Branta Pond	4,115,000	2	Aphanizomenon	0.15	6/28/2021, 9:42 AM
Glen Rock Pond	3,125,000	1	Woronichinia	1.61	5/24/2021, 7:56 AM
Penbryn Lake	1,321,000	4	Woronichinia	0.17	12/2/2021, 11:43 AM
Timber Lake	1,200,000	1	Planktothrix/Phormidium	0.18	8/4/2021, 11:14 AM

Table 5. Maximum Toxin and Cell Count by Waterbody

During the 2021 season, 88% of multispecies blooms with microcystins (MC) concentrations >2.0 µg/L (25 sites) contained *Microcystis sp.* Although *Microcystis sp*. was present in these samples, data indicates that it was the dominant cyanobacteria taxa in only 10 samples, or less than half. Maximum MC concentration from Pemberton Lake in Dec 2021 exceeded 109 µg/L (highest recorded in 2021) and was associated with a mixed cyanobacteria community dominated by *Microcystis sp.* (717,500 cells/mL). Also observed in this sample were *Aphanocapsa sp*. (32,500 cells/mL), *Cuspidothrix issatchenkoi* (present but below quantification), and an unknown colonial species (186,250 cells/mL). Table 6 show taxa present at all waterbodies with MC concentrations >2.0 µg/L.

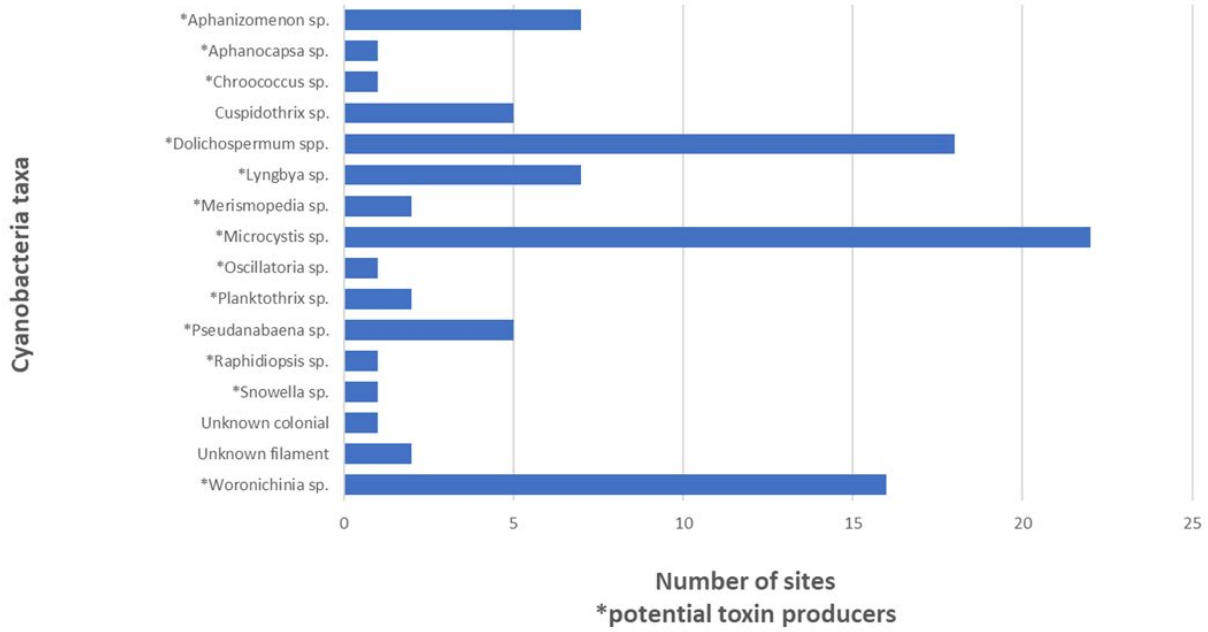
Table 6. Cyanobacterial taxa observed in waterbodies with microcystins (MC) concentrations >2.0 µg/l during 2021 HAB responses in New Jersey+A1:T32

Sample Date	Waterbody Name	Cell density (cells/mL) of all cyanobacteria taxa observed w/in hemocytometer counting grid	*Aphanizomenon sp.	*Aphanocapsa sp.	*Chroococcus sp.	Cuspidothrix sp.	*Dolichospermum spp.	*Lyngbya sp.	*Merismopedia sp.	*Microcystis sp.	*Oscillatoria sp.	*Planktothrix sp.	*Pseudanabaena sp.	*Raphidiopsis sp.	*Snowella sp.	Unknown filament	Unknown colonial	*Woronichinia sp.	MC (µg/l)
12/02/2021	Pemberton Lake	936,250		+		+				+							+		109.7
07/13/2021	Greenwood Lake	86,500				+	+			+			+						15.74
08/31/2021	Van Saun Mill Brook	214,500								+									13.1
07/13/2021	Greenwood Lake	33,475				+	+			+									12.4
08/03/2021	Spruce Run Reservoir	603,750	+				+	+		+								+	8.8
08/27/2021	Penbryn Lake	4,280,000								+								+	8.12
07/27/2021	Greenwood Lake	67,000					+			+			+			+			5.93
11/10/2021	Budd Lake	893,750	+							+								+	5.68
07/15/2021	Branta Pond	30,000	+				+			+								+	5.5
06/01/2021	Spruce Run Reservoir	450,000	+				+			+									5.32
06/29/2021	Spruce Run Reservoir	75,750					+	+		+					+			+	5.26
07/07/2021	Spruce Run Reservoir	48,875					+	+		+								+	5
08/17/2021	Spruce Run Reservoir	46,500	+				+	+		+								+	4.79
08/30/2021	Lake Rogerene	1,290,000				+	+			+									4.54
10/06/2021	Rosedale Lake	122,250					+		+				+	+					4.52
09/28/2021	Budd Lake	40,250					+	+		+								+	4.06
10/07/2021	Mercer Lake	351,250			+		+		+	+								+	3.91
07/12/2021	Lake Ceva	322,500				+	+			+		+						+	3.86
07/22/2021	Driveway Pond	5,000					+			+								+	3.39
06/07/2021	Swartswood Lake	141,000					+				+		+			+			3.11
08/03/2021	Swartswood Lake	19,500					+	+				+						+	2.82
11/10/2021	Budd Lake	34,000	+							+								+	2.74
10/21/2021	South Branch Raritan River	14,000								+								+	2.45
11/10/2021	Budd Lake	263,750								+								+	2.17
08/10/2021	Budd Lake	49,375	+				+	+		+			+					+	2.07

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

Aphanizomenon sp. (7 sites), *Dolichospermum sp*. (18 sites), *Lyngbya* sp. (7sites), and *Woronichnia sp* (15 sites) were the most frequently observed potentially toxigenic (PTOX) cyanobacteria taxa associated with the *Microcystis sp.* in the majority of multispecies blooms with microcystins above 2.0 µg/L. (Figure 13) These taxa, in addition to the *Microcystis sp.,* are often associated with the production of microcystins.

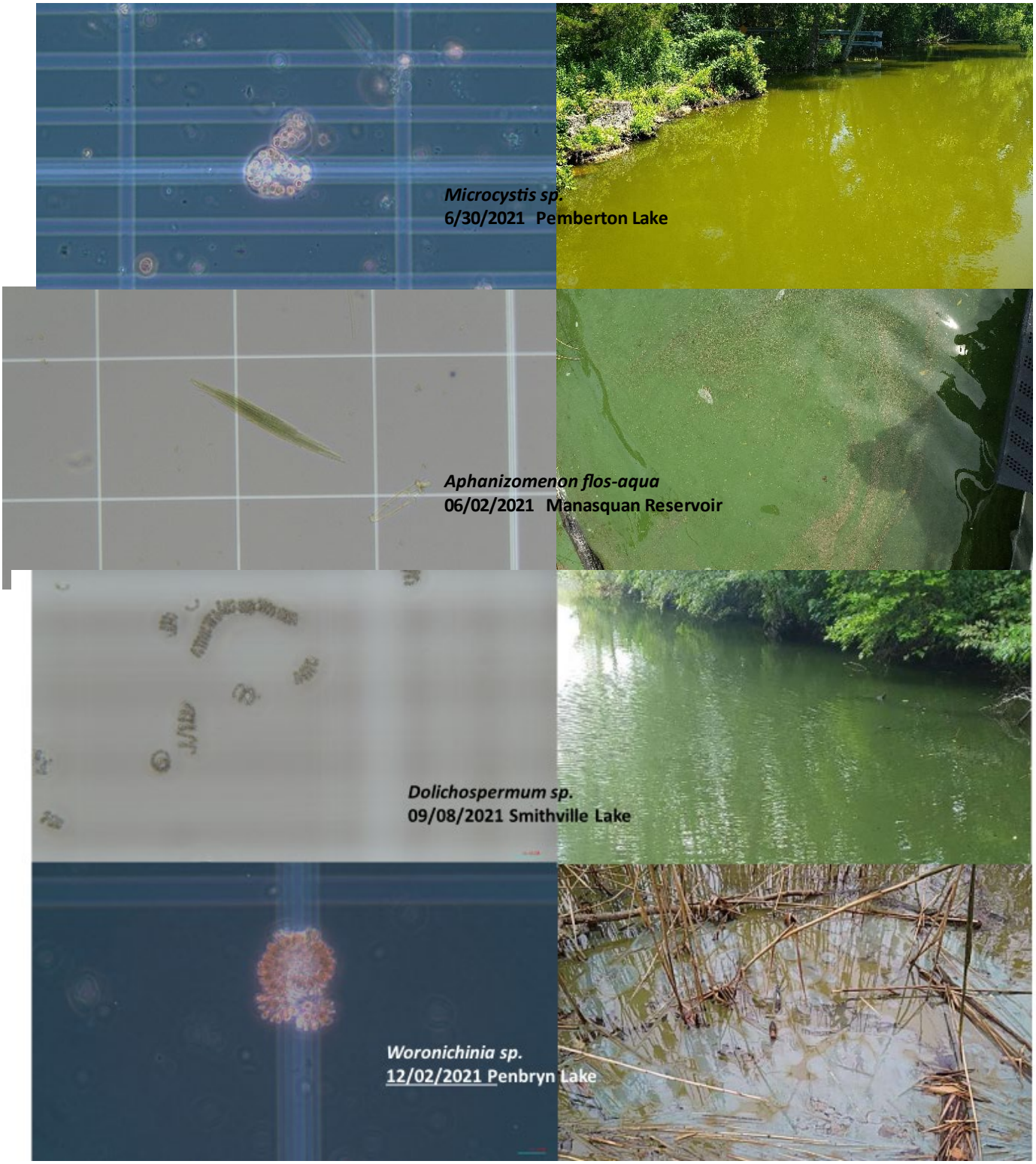
Figure 13. Number of samples with Microcystins >2.0 µg/l in which a specific cyanobacteria taxa occur during 2021



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

- Anatoxin-a (ATX) was detected in 46% of these samples. *Dolichospermum* sp., *Microcystis sp.*, and *Woronichnia sp*. were frequently associated with these blooms. All of these are known anatoxin-a producers.
- Cylindrospermopsin (CYL) was detected in 47% of these samples. *Dolichospermum* sp., *Microcystis sp.,* and *Woronichnia sp*. were associated with more than half of these blooms. Of these, only *Dolichospermum sp*. is a known cylindrospermopsin producer.
- Saxitoxin (STX) was detected in 92% 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 14. Examples of potential toxin producing cyanobacteria observed in samples with microcystins > 2.0 µg/L.



Supporting Programs

As part of HAB response and monitoring, BFBM partners with several DEP and external partners. DEP's Division of Water Enforcement (C&E) 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 perform flight (Figure 15) 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. 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.

Figure 15. Forest Fire Service

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 16 shows examples of the flight data.

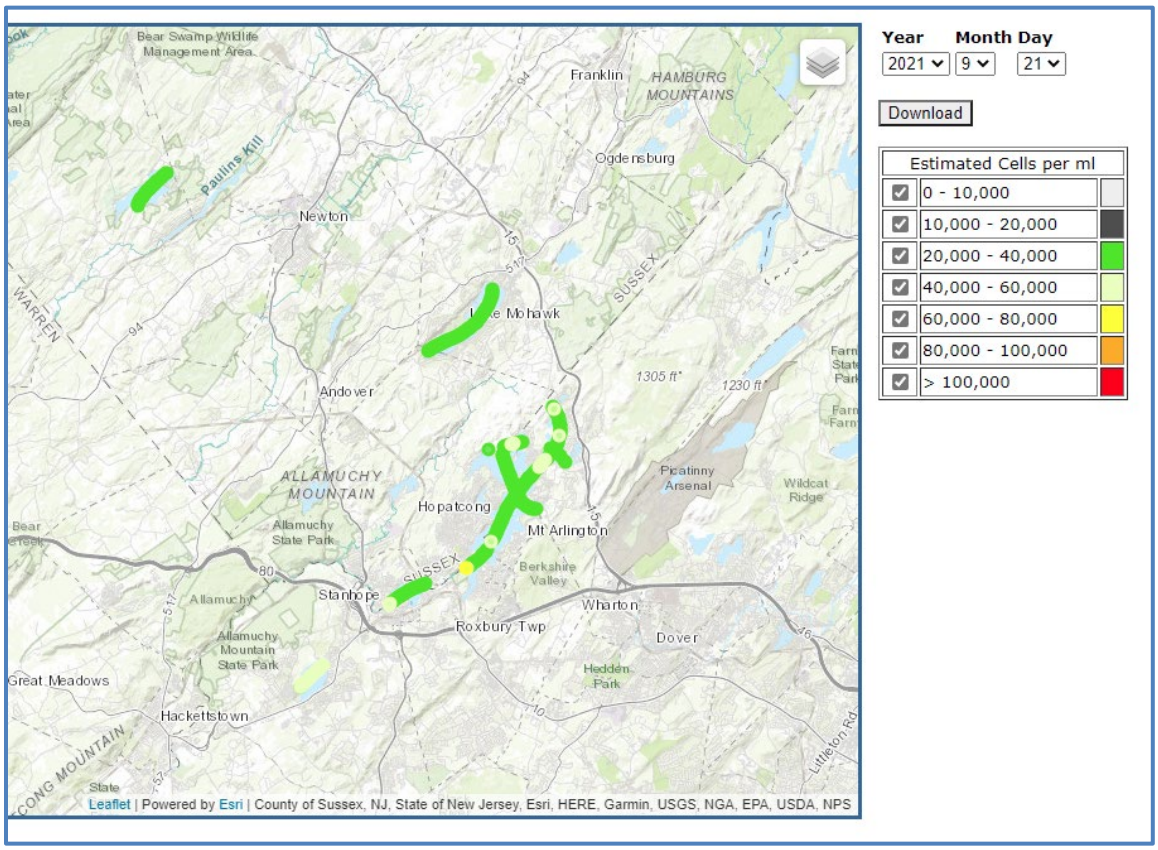


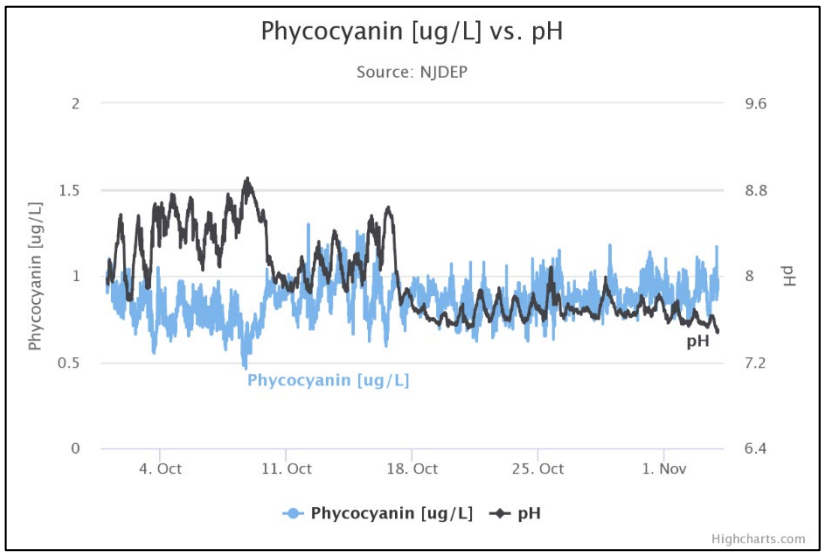
Figure 16. Examples of Fight Data

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 17). Nine (9) 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:

Manasquan Reservoir – 1 meter
Lake Hopatcong – 4 meters (3 Buoys at Lake Hopatcong were damaged and removed during the season)
Spruce Run Reservoir– 1 meter
Swartswood Lake – 2 meters
Budd Lake – 1 meter

Figure 17. 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 NJDEP DWM&S Continuous Data Monitoring Program website. Figure 18 shows an example of a downloadable graph comparing phycocyanin and pH at Spruce Run Reservoir.



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

Figure 18. Example Real-Time Continuous Data Download

The program will continue in 2022 with an additional 3 buoys expected to be deployed.

A field phycocyanin meter loan program was implemented in 2020 and expanded in 2021 from 12 to 35 meters respectively. Meters were loaned to various internal and external partners:

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

These partners played a significant role in screening, status monitoring, and sampling. Partners contributed to approximately 51% of all samples collected for lab analysis as compared to 20% in 2020.

Conclusions

In 2021, there was a 44% decrease in reports of suspected HABs. This translated into a significant decrease in the number of waterbodies with confirmed HABs (Watch Alert or above) by 24%. Although confirmed HABs have decreased since 2020, 2021 data shows the statewide occurrence of HABs in New Jersey has increased, and are recurring in many waterbodies, since 2017 when the DEP initiated monitoring per the Response Strategy. 53% of waterbodies with confirmed HABs in 2021, had confirmed HABs in a previous year since HAB response was initiated in 2017 (Table 7).

Confirmed 2021 Waterbodies from Prior Years					
Waterbody	2017	2018	2019	2020	2021
Branch Brook Park Lake		X	X	X	X
Budd Lake	X	X	X	X	X
Farrington Lake				X	X
Greenwood Lake			X	X	X
Lake Hopatcong		X	X	X	X
Lake Musconetcong			X	X	X
Lake Owassa			X	X	X
Lake Rogerene			X		X
Little Swartswood Lake	X	X			X
Manasquan Reservoir			X	X	X
Manny's Pond	X				X
Monksville Reservoir			X		X
Mountain Lake			X	X	X
Pemberton Lake	X		X	X	X
Penbryn Lake	X				X
Rosedale Lake			X	X	X
Smithville Lake			X		X
Spruce Run Reservoir		X	X	X	X
Swartswood Lake	X	X	X	X	X

Table 7. 2021 Confirmed HAB Waterbodies with Previous HABs

Continued evidence of significant HAB activity is the persistence of blooms into the winter. Sampling and confirmation analysis for 2021 was completed in December and there were 12 waterbodies with at least one site with a HAB Alert level of Watch or above (Table 8). This is a slight decrease from 15 waterbodies in 2020, but still significantly higher than 2019 when only 8 waterbodies had HABs continuing past December. A Winter Watch Alert was recommended for the 2021/2022 winter season at these waterbodies.

2021 HABS Not Dissipated By The End Of The Year (at least 1 site/ Waterbody)

Waterbody name	Alert Tier	County
Smithville Lake	Advisory	Burlington
Pemberton Lake	Warning	Burlington
Penbryn Lake	Advisory	Camden
Bellmawr Lake	Watch	Camden
Branch Brook Park Lake	Watch	Essex
Manasquan Reservoir	Watch	Monmouth
Budd Lake	Advisory	Morris
South Branch Raritan River	Advisory	Morris
Lake Musconetcong	Watch	Morris
Greenwood Lake	Watch	Passaic
Lake Hopatcong	Advisory	Sussex
Mountain Lake	Watch	Warren

Table 8. 2021 HABs Not Dissipated by End of Year

Cell concentrations above recreational guidance thresholds continue to be the main reason for Alert postings. In 2021 only 34% of waterbodies with confirmed HABs had microcystin toxins above the recreational guidance threshold of 2.0 µg/L. These toxin levels are usually associated with multispecies blooms where *Microcysts sp* is present or dominant. Although no other toxins had concentrations above recreational guidance thresholds, some were detected in measurable amounts. 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 will provide 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 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. The team will complete a comprehensive literature review on the prevention and treatment of HABs, review HAB and water quality data, and develop guidance documents for lake management in New Jersey. Guidance documents, anticipated to be available in 2022, will include best management practices (BMPs) for the prevention and management of HABs to be used by NJ lake managers.

The team will also provide technical advice and reviews on proposed mitigation technologies for NJ lakes and review the progress of DEP-funded HAB mitigation grant projects. Additionally, the team will develop a HAB lake management training program for DEP staff and interested stakeholders and conduct a minimum of three one-day training workshops at various locations in the state.