

# **2022 Cyanobacteria Monitoring Report for Town of Chatham, Massachusetts**

**December 21, 2022**

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## **2022 Cyanobacteria Monitoring Report for Goose Pond, Lovers Lake, Schoolhouse Pond, Stillwater Pond, and White Pond, Chatham, Massachusetts**

Prepared for the Town of Chatham and the Friends of Chatham Waterways  
By the Association to Preserve Cape Cod

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### **1. SUMMARY**

In 2022, the Association to Preserve Cape Cod (APCC) continued cyanobacteria monitoring in Chatham for the Town of Chatham and the Friends of Chatham Waterways (FCW), following similar monitoring from 2018 through 2021. From June through November, APCC conducted biweekly sampling at six sampling locations (see Appendix 4 for sampling locations). APCC conducted 98 sampling events and collected a total of 98 samples and analyzed samples for cyanobacteria composition and phycocyanin, a cyanobacteria pigment that provides a measure of cyanobacteria biomass.

APCC utilizes a three-level risk characterization system known as “Risk Categories” to describe the results of cyanobacteria monitoring in terms of low, moderate, and high potential risks to human health and pets exposed to harmful cyanobacteria blooms (HCBs). The three Risk Categories are: “Acceptable” (low risk), “Potential for Concern” (moderate risk for humans and pets), and “Use Restriction Warranted” (high risk for humans and pets). In 2022, APCC incorporated complementary microcystin testing from the Barnstable County Department of Health and the Environment Water Quality Lab. Samples characterized by APCC as at risk for an exceedance of the Massachusetts Department of Public Health (MDPH) guidelines for microcystin in recreational waters of 8 parts per billion (ppb) were sent to the County Water Quality Lab for confirmatory testing. The lab then communicated confirmation of microcystin risks in terms of the state limit to APCC and the town health department.

During the 2022 monitoring season, cyanobacteria levels in Lovers Lake, Goose Pond, Stillwater Pond, and White Pond reached APCC’s “Potential for Concern” Risk Category. Goose Pond and Stillwater Pond reached the higher “Use Restriction Warranted” Risk Category. The Town of Chatham Health Department followed up on APCC’s recommendations for responding to the “Use Restriction Warranted” Risk Category by issuing a municipal recreational advisory posting at each pond. APCC sent three water samples collectively from Lovers Lake and White Pond to the County Water Quality Lab for microcystin analysis. Fortunately, none of the samples sent to the county lab exceeded state guidelines. APCC shared all monitoring results with the Town of Chatham, FCW, and the public throughout the season via emailed updates, e-newsletters, frequent updates to our online map at <https://apcc.org/our-work/science/community->

[science/cyanobacteria/](#), and written reports, including this report. This document should be printed in color, as some sections are color-coded.

## 2. BACKGROUND

APCC's Cyanobacteria Monitoring Program partners with officials at the town, county, state, and federal levels as well as local pond associations and residents to conduct cyanobacteria monitoring in Cape Cod ponds. Each season, water samples are collected and processed weekly and shared with local officials and the general public through reports, emails, and an interactive map of monitoring results provided on our website (<https://apcc.org/cyano>). Our goals are to raise public awareness of the health and ecological risks posed by HCBs, to help inform proper responses to cyanobacteria blooms to protect public health, to monitor priority ponds across the Cape, and to motivate public action to address the causes of HCBs by improving water quality.

Cyanobacteria are an ancient group of photosynthetic microorganisms common in freshwater systems on Cape Cod, in the U.S., and worldwide. Under the right conditions, they can multiply rapidly and form harmful cyanobacteria blooms. According to the Centers for Disease Control and Prevention, certain common cyanobacteria genera can produce toxins known as cyanotoxins that can be harmful to humans ([CDC](#)). HCBs have increased worldwide, including in the U.S., due in part to nutrient enrichment and rising water temperatures due to climate change. As the occurrence of HCBs increases, the need for increased cyanobacteria monitoring and awareness has also increased. Additional resources on cyanobacteria are provided in Appendix 1.

Cape Cod ponds are commonly used for swimming, boating, paddle boarding, and fishing. Due to the increasing prevalence of HCBs and the resulting increased threat of public exposure to cyanobacteria and their toxins, MDPH provides guidelines for municipal officials to post and remove advisories at ponds based on established thresholds for cyanobacteria risks ([MDPH](#)). Frequent cyanobacteria monitoring of ponds provides data for resource managers to track cyanobacteria trends in their ponds throughout the season, apply relevant public health criteria, and proactively post and remove recreational advisories. Cyanobacteria monitoring data also provide information on pond health and water quality and help to address data gaps caused by lack of conventional pond water quality monitoring data.

## 3. METHODS

### Overview

APCC's Cyanobacteria Monitoring Program provides scientifically sound data on cyanobacteria community composition, biomass, and estimated toxin concentrations. Our program uses and follows the EPA's Quality Assurance Project Plan (QAPP) for cyanobacteria monitoring, developed by EPA for the Cyanobacteria Monitoring Collaborative or CMC ([CMC QAPP](#)). The CMC QAPP was developed by EPA Region 1 scientists, including Hillary Snook and others, with the goal of encouraging and facilitating widespread monitoring of cyanobacteria. The QAPP is based on methods created by EPA scientists and other cyanobacteria specialists,

including Dr. James Haney at the University of New Hampshire Center for Freshwater Biology and Nancy Leland of Lim-Tex, Inc. The method involves taking concentrated samples of “Bloom Forming Colonies” (BFCs) of cyanobacteria through a 3-meter student plankton net tow and unconcentrated samples of “Whole Lake Water” (WLW) through a 1-meter integrated tube. Samples are then examined for cyanobacteria composition using microscopy.

Cyanobacteria composition is important to document because toxicity varies according to cyanobacteria genus. Samples are also analyzed for phycocyanin concentrations using fluorometry. Phycocyanin is an algal pigment produced by cyanobacteria, different and distinct from chlorophyll, which is produced by algae and plants. Phycocyanin concentrations provide a measure of cyanobacteria biovolume and abundance. The combination of information on composition (obtained through microscopy) and information on cyanobacteria pigment concentrations enables an estimation of risk posed by cyanobacteria at the time of monitoring.

APCC also utilizes the CyanoCasting method developed by Nancy Leland ([Leland, 2018](#)), which builds on the methods described in the QAPP by including metrics that allow for the forecasting of potential imminent cyanobacteria blooms and estimates of cyanotoxin (i.e., microcystin) concentrations. The forecasting ability of this method provides valuable advance warnings of potential HCBs to inform proactive responses, such as increased sampling frequency or precautionary advisories of ponds to warn the public of the potential for cyanobacteria blooms. The ability to anticipate potential HCBs and estimate their microcystin concentrations based on frequent monitoring is a unique and valuable feature of APCC’s program and stands in contrast to reactive responses involving measurement of cyanobacteria concentrations after a bloom has occurred ([Leland et al. 2018](#), [Leland et al 2019](#)).

This year, as a complement to APCC’s established monitoring program, the Barnstable County Department of Health and the Environment (BCDHE) Water Quality Lab expanded its cyanobacteria toxin testing capabilities to provide local officials with precise toxin measurements from ponds pre-screened by APCC as potentially containing cyanobacteria toxin levels of concern. The screening process was as follows: At each cyanobacteria sampling event, APCC collected separate water samples for toxin analysis if needed. APCC then analyzed cyanobacteria as described above and used the results to screen each pond. If samples had cyanobacteria results (i.e., risk categories) that indicated a possibility of an exceedance of state microcystin guidelines, APCC sent the separate water samples to the BCDHE Water Quality Lab to conduct confirmatory toxin testing of microcystin, one type of cyanobacteria toxin. Toxin test results were then used to determine whether an advisory was warranted. If so, APCC provided a recommendation to the local health official to post an advisory. Local health officials are responsible for deciding whether to post advisories or not. To assist with decision-making, APCC conducted follow-up monitoring that included information on when cyanobacteria levels decreased to the point where an advisory, if posted, could be lifted.



## Sampling Locations

This season, at least 12 samples were collected at each location on a biweekly basis between June and November. Samples were collected for the Town of Chatham and FCW at the locations shown in Figure 1.

**Figure 1. Sampling Locations for Chatham ponds in 2022.**



## **Water Sampling**

Water samples were collected by FCW citizen scientists on a biweekly schedule, between June and November. At each sampling event, three samples were collected from shore, one using a 1-meter tube called the Whole Lake Water sample, a second using a 50-micron (um) mesh student plankton net called the Bloom Forming Colonies sample, and a third grab sample taken in a glass bottle with a PTFE-lined lid called the toxin sample. When cyanobacteria bloom material was found, a sample of the bloom material was taken for additional analysis. Between June 7, 2022, and November 8, 2022, APCC conducted 12 biweekly sampling events at each location for a total of 72 sampling events. Throughout the season, extra off week samples were taken if there was a concern that a cyanobacteria acceleration in growth could occur between the scheduled biweekly sampling events. This season, there were a total of 16 extra samples taken from Chatham ponds. The types of samples collected are described below.

### Whole Lake Water (WLW) Sample

The sample taken from the 1-meter tube is called the Whole Lake Water (WLW) sample. This is an unconcentrated water sample containing cyanobacteria from the full extent of the 1-meter sampling depth from the surface to just above the bottom near shore. This sample is processed by APCC staff to obtain data on cyanobacteria size fractions in the water column. This process is further explained in the “Lab Analysis” section. This sample is not used to forecast future bloom accumulations, as it contains cyanobacteria currently in the water column near shore.

### Bloom Forming Colonies (BFC) Sample

The second sample, which is taken using a student plankton net, is called the Bloom Forming Colonies (BFC) sample. This is a concentrated sample taken by towing the student plankton net across a 3-meter cast near the surface. This sample contains larger cyanobacteria colonies, which tend to form visible blooms and scums. Fundamentally, this sample is analogous to a natural cyanobacteria accumulation that may occur on a pond if the wind condensed cyanobacteria over a distance of 3 meters into a potentially harmful accumulation near shore. Nearshore accumulations of cyanobacteria are considered to pose a higher risk because this is where children and pets typically interact with the pond.

The concentrations of cyanobacteria in BFC samples can fluctuate dramatically and sudden or continuous increases of cyanobacteria concentrations in BFC samples can foreshadow cyanobacteria bloom formations in the near future. Understanding the toxin concentrations of this sample can also provide information on the likelihood of a future microcystin exceedance. This concept is discussed in more detail below.

### Toxin Sample

The third sample is a simple grab sample using a 125 milliliter (mL) amber glass bottle with a PTFE-lined cap. This sample is called the toxin sample. When APCC’s metrics using cyanobacteria composition and concentration indicate a likelihood that microcystin



concentrations may exceed 8 parts per billion (ppb), APCC delivered this sample to the Barnstable County Water Quality Lab for analysis of microcystin.

### Cyanobacteria Scum Sample

The fourth sample, taken only when needed, is called the scum sample and may contain cyanobacteria bloom material. Although visual evidence alone of potential cyanobacteria bloom material can be compelling, microscope and fluorometry analysis of the material can confirm whether the material is indeed a cyanobacteria bloom rather than an accumulation of other algae, diatoms, etc. Microscope analysis of the bloom material also provides information on the genus of cyanobacteria making up the bloom, giving an understanding of the types of toxins that may be present.

### **Field Observations**

Field observations were documented at each sampling event by completion of a field data sheet with information on weather, visual appearance of pond surface, water temperature, etc. Photographs were taken of the pond's shoreline at each sampling event, providing documentation of pond appearance and visible conditions and evidence of bloom accumulations.

### **Lab Analysis**

#### Sample processing

On the same day as sample collection, APCC processed and analyzed samples following our protocol. Triplicate 5 milliliter (mL) samples were taken of each of the 3 to 4 sample types: the WLW sample, the < 50 micron ( $\mu\text{m}$ ) sample, the BFC sample, and the scum sample when possible cyanobacteria bloom material was discovered. The < 50  $\mu\text{m}$  sample was isolated by filtering the WLW sample through a 50 micron ( $\mu\text{m}$ ) filter, which resulted in a sample containing only the relatively small colonies of cyanobacteria. Smaller cyanobacteria, known as pico-cyanobacteria, are also believed to produce cyanotoxins at concerning levels. APCC has been contributing to Nancy Leland's research on these communities and we hope to apply these findings to inform our program in future seasons. The WLW and scum samples were processed without further action. The BFC sample was further separated through the use of Zapprs (see EPA QAPP, [CMC QAPP](#)).

#### Microscopy

Using a microscope, APCC staff and interns counted colonies of cyanobacteria from a 1 mL sample from the BFC sample up to 100 colonies per mL. The information was used to estimate dominance of different cyanobacteria genera. If one genus was found to be the "dominant genus" (defined as 70% of the cyanobacteria community on the slide), then APCC targeted the toxins produced by that genus of cyanobacteria as the toxins of concern for that pond at that time. If a scum sample was taken, APCC also analyzed it under the microscope to inspect genus composition and to confirm whether the scum was indeed composed of cyanobacteria.

## Fluorometry to measure phycocyanin pigments

Each triplicate 5 mL sample was frozen and thawed for the purpose of lysing cells to liberate cyanobacteria pigments. Samples were then analyzed for cyanobacteria pigments (phycocyanin) and non-cyanobacteria algal pigments (chlorophyll-a) using a calibrated fluorometer in parts per billion (ppb). APCC uses phycocyanin concentrations in micrograms per liter (ug/L) as an indicator of cyanobacteria biomass rather than cell counts. Understanding cyanobacteria concentrations using fluorometry allows APCC to track cyanobacteria community trends over time. All data was stored on APCC's online server.

## Microcystin Testing by County Water Quality Lab

At each sampling event, APCC collected extra samples for analysis of microcystin if cyanobacteria risk levels were in the "Use Restriction Warranted" category. To ensure that samples for toxin testing were collected on the same date, time, and place as samples for cyanobacteria monitoring, APCC collected GRAB samples for toxin analysis at the same time and location as our samples for cyanobacteria analyses. Samples for toxin analyses were collected and preserved according to MDPH and EPA protocols ([Local Public Health Institute of Massachusetts, Method 546](#)). In the event that APCC's cyanobacteria data indicated the likelihood of a microcystin exceedance, the corresponding GRAB sample(s) were sent to the County Water Quality Lab for toxin analysis. The BCDHE Water Quality Lab then forwarded the toxin testing results and recommendations of a recreational advisory, when warranted, to local officials and APCC. Toxin testing results supplemented APCC's cyanobacteria monitoring data. The simultaneous collection of samples for cyanobacteria and cyanotoxins helped to ensure that cyanotoxin analyses (if warranted) correspond to cyanobacteria monitoring data in terms of time and place. This proactive sampling approach avoids a common pitfall of reactive sampling that can occur when cyanobacteria monitoring data are collected on one date and confirmatory samples are collected several days to a week later when conditions may have changed.

## **Interpretation of Results**

APCC staff interpreted the results within a guidance framework that incorporates the most recent scientific information as well as existing state and federal guidance ([EPA recreational waters, MDPH](#)). Italics indicates text taken directly from state and federal guidance documents and websites.

## Massachusetts Department of Public Health (MDPH) Guidelines for Cyanobacteria

The MDPH cyanobacteria webpage describes guidelines for cyanobacteria in recreational freshwater bodies that are described in italics as follows ("Guidelines for Cyanobacteria at Recreational Freshwater Locations") ([MDPH](#)). Italics indicates text taken directly from state and federal guidance documents and websites.

### *[Issuing a Public Health Advisory]*

*"DPH recommends issuing a public health advisory for HABs at recreational freshwater locations when at least one of the following criteria is met:*

1. *A visible cyanobacteria scum or mat is evident.*
2. *Total cell count of cyanobacteria exceeds 70,000 cells/mL.*
3. *Concentration of the toxin microcystins exceeds 8 µg/L; or*
4. *Concentration of the toxin cylindrospermopsin exceeds 15 µg/L*

*Guideline values are based on US Environmental Protection Agency ([US EPA](#)) and World Health Organization ([WHO 1999](#)) ([WHO 2003](#)) recommendations. When issuing an advisory, signage should be posted at each access point at the waterbody warning against any contact with the water.*

#### *Rescinding a Public Health Advisory*

*Cyanobacteria cells can release cyanotoxins into the water when they die. Therefore, algal toxins may be present when a visible scum or mat is no longer evident. DPH recommends the rescinding of a public health advisory after two successive samples, collected a week apart, demonstrate cell counts or toxin levels below the quantitative guideline values.” ([MDPH](#))*

#### Cyanobacteria Risk Categories

APCC interpreted cyanobacteria data using a system called “Cyanobacteria Risk Categories.” This data interpretation system was created using guidance and feedback from cyanobacteria researchers, Cape Cod health agents, and state guidance. The criteria for the Risk Categories do not include cell counts or cylindrospermopsin (another cyanobacteria toxin), as neither APCC nor the BCDHE Water Quality Lab test for these metrics.

APCC tracked changes in cyanobacteria concentrations between each sampling event. The reason for tracking changes in cyanobacteria concentrations over time is that rapid growth rates, defined here as net daily cyanobacteria growth rates greater than or equal to 0.05, may indicate that a cyanobacteria bloom formation or microcystin exceedance is about to occur. Alternatively, the cyanobacteria concentrations may peak and then decrease before a cyanobacteria bloom or microcystin exceedance occurs. APCC recommended weekly testing of ponds where any APCC sample had a confirmed net daily cyanobacteria growth rate greater than or equal to 0.05. Before August 1, 2022, APCC would also place ponds in the “Potential for Concern” category for one week following a growth rate above 0.05. However, following new guidance from program partners, APCC began to not recommend a change in risk category based on cyanobacteria growth rate data alone starting August 1, 2022.

To assign a Cyanobacteria Risk Category to a pond for a given monitoring period, the most hazardous result among multiple criteria determined the risk category in which the pond was placed. A pond that met even a single criterion in the “**Use Restriction Warranted**” category was placed in that category. Likewise, a pond that met even a single criterion in the “**Potential for Concern**” category, but did not meet any criteria in the “**Use Restriction Warranted**” category, was placed in the “**Potential for Concern**” category. If a pond met no criteria in the “**Use Restriction Warranted**” or the “**Potential for Concern**” categories, that pond was placed in the “**Acceptable**” category. All descriptions and criteria for these categories are summarized in Appendix 2 and discussed below.

## APCC Cyanobacteria Risk Categories

### Acceptable

Definition: No concerning cyanobacteria results at the time and place of sampling. To the best of APCC's knowledge and based on our monitoring results, regular recreational usage of the pond is safe with respect to cyanobacteria and toxins. Map color is blue. Formerly the Low Warning Tier.

Recommended Sampling Frequency: Biweekly. In samples containing low levels of cyanobacteria with high growth rates APCC will recommend weekly sampling.

Recommended Action: None.

### Potential for Concern

Definition: Monitoring results or the presence of cyanobacteria scum at the time and place of sampling indicate a potential for increased risk for exposure to cyanobacteria toxins approaching but below state standards. Conditions do not yet warrant the posting of a recreational human health advisory according to guidelines from the Massachusetts Department of Public Health (MDPH). While these conditions pose low health risks to adults, risks are higher for children or pets based on lower body mass, particularly if contaminated water is incidentally ingested. Children may inadvertently consume pond water while swimming and pet exposure can result from drinking or ingesting pond water or from grooming after swimming. Map color is yellow. Map color yellow with crosshatching indicates a municipal pet advisory has been issued. Formerly the Moderate Warning Tier<sup>1,2,4</sup>.

Recommended Sampling Frequency: Weekly.

Recommended Action:

1. APCC or the town will provide a GRAB sample for toxin analysis to the Barnstable County Water Quality Lab for samples suspected of possibly exceeding the MDPH guidelines for microcystin in recreational waters.
2. The posting of a "Pet Advisory" or similar advisory according to municipal policies and procedures until the pond returns to "Acceptable" status.
3. Sampling should be increased to weekly until all results are once again in the "Acceptable" category.

### **Use Restriction Warranted**

Definition: Monitoring results at the time and place of sampling indicate the pond is unsafe for recreation by humans and pets based on one or more of the following criteria: 1) presence of microcystin at or above state standards (8 ppb microcystin) as described in MDPH guidance, 2) presence of significant cyanobacteria scum layers according to MDPH guidance, 3) a municipal health agent issues a closure for any other reason related to cyanobacteria. Recreational risk to adults is moderate following exposure. Recreational risks are especially high for children and pets following exposure through accidental ingestion of contaminated water. Children may inadvertently consume pond water while swimming and pet exposure can result from ingestion or directly drinking pond water or from grooming after swimming. Due to lower body masses, children and pets are more susceptible to cyanobacteria risks than adults. Map color is red. Map color red with crosshatching indicates a municipal advisory has been issued. Formerly the High Warning Tier<sup>3</sup>.

Recommended Sampling Frequency: Weekly.

### Recommended Action:

1. APCC or the town will provide a GRAB sample for toxin analysis to the Barnstable County Water Quality Lab for samples suspected of possibly exceeding the MDPH guidelines for microcystin in recreational waters.
2. The town should post a recreational advisory or similar advisory according to municipal policies and procedures and otherwise notify the public to avoid contact and exposure until the pond meets criteria to be reopened or the advisory is lifted by the local health agent.
3. Sampling should be conducted weekly until there are two consecutive weeks when results include no significant cyanobacteria scum and toxin testing of samples contain a microcystin concentration below 8 ppb.

### **Recommendations for posting Use Restrictions and Advisories**

Use restrictions and advisories are issued at the discretion of the municipal health agents. As of this date, there is no common set of guidelines in use by health agents across the Cape that provides consistency in posting criteria. As a result, members of the public are advised to contact the health agent in their town (see the contact list provided on APCC's website) to determine the official status of the pond in which they are interested. While ponds exceeding MDPH standards as discussed above were marked in red on APCC's map, this coloration does not always mean that a use restriction was issued by the town. APCC updates our list of restricted ponds as we are informed by the respective towns, but APCC does not speak for the towns unless otherwise and explicitly noted on our posting map.

APCC's recommendations for removing a recreational use advisory mirrors the reopening guidance from MDPH. For a microcystin toxin exceedance or cyanobacteria scum, APCC will recommend lifting a recreational use advisory or closure after two consecutive tests a week apart show microcystin concentrations less than 8 parts per billion (ppb) and little to no presence of cyanobacteria bloom material, depending on the basis for the original restriction. Health agents are solely responsible for the issuance and removal of recreational use advisories or closures related to water clarity, such as clarity less than 4 feet.

### **Reporting**

#### Biweekly reports

APCC provided biweekly reports to report results to local municipal officials and pond associations. Depending on results, reports included recommendations concerning appropriate advisory posting or removal for the public to minimize or avoid risks due to cyanobacteria exposure. During periods of possible harmful cyanobacteria bloom formation requiring weekly sampling, additional reports and updates were sent to officials and pond associations as well. Pond associations play a key role in raising public awareness of cyanobacteria risks and alerting pond residents of cyanobacteria monitoring results throughout the season.

### Interactive map

An interactive map is hosted on APCC's website where recent monitoring results were posted throughout the season. Updates were submitted on an automated basis at 7 p.m. on the same day as reports of results were emailed to town officials. In some cases, automated map updates were postponed a day if a town official requested additional time to review results before they would be posted. The interactive map is located at: <https://apcc.org/cyano>.

### Email alerts

APCC provided an email registry signup on our website for an e-blast system designed to update interested residents about recent harmful cyanobacteria bloom discoveries. Residents could sign up for these Cyanobacteria Alerts throughout the season. The link for the Cyanobacteria Alert e-blast signup is located here <https://apcc.org/our-work/science/community-science/cyanobacteria/cyanobacteria-alert/>.

## **4. RESULTS**

Cyanobacteria monitoring results, Risk Categories, and risk communication are described in this section. For each pond, a table is provided to describe results and risk category designations for each sampling event. A complete table of results is provided in Attachment 1 containing all data collected for the Town of Chatham and the Friends of Chatham Waterways in 2022. This table is formatted to be printed on an 11"x17" sheet. The full Risk Category criteria are included in Appendix 2. Data interpretation and risk communication to town officials and the public for each sampling event are described in this section as well.

Results for the sampling locations are described below. APCC sampled from six locations (see Appendix 4 for a list of these locations).

### Goose Pond: Goose Pond Conservation Area

During the 2022 monitoring season, Goose Pond experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable," "Potential for Concern," and "Use Restriction Warranted" Risk Categories (Table 1 below).

Goose Pond reached the "Potential for Concern" category on 9/13/22 due to the presence of a thin cyanobacteria scum. The cyanobacteria bloom accumulation did not warrant a recreational advisory and the scum dissipated by the following week. From 9/27/22 to 10/3/22, Goose Pond reached the "Use Restriction Warranted" due to the presence of a lingering large cyanobacteria bloom. A municipal recreational advisory was posted immediately and remained in place until the pond met the criteria for lifting the municipal recreational advisory on 10/11/22. Goose Pond was "Acceptable" for the remainder of the sampling season.



**Table 1. Summary of cyanobacteria monitoring results for Goose Pond, Chatham, MA.**

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	<i>Dolichospermum</i> spp.	59	-
6/21/2022	Acceptable	<i>Dolichospermum</i> spp.	2	-
7/5/2022	Acceptable	<i>Microcystis</i> spp.	2	-
7/19/2022	Acceptable	<i>Dolichospermum</i> spp.	22	-
8/2/2022	Acceptable	N/A	4	-
8/16/2022	Acceptable	N/A	3	-
8/30/2022	Acceptable	<i>Dolichospermum</i> spp.	5	-
9/13/2022	Potential for Concern	<i>Dolichospermum</i> spp.	17	Small cyanobacteria scum present.
9/22/2022	Acceptable	<i>Dolichospermum</i> spp.	258	-
9/27/2022	Use Restriction Warranted	<i>Dolichospermum</i> spp.	16,420	A large cyanobacteria bloom present.
10/3/2022	Use Restriction Warranted	N/A	16	In this category due to a large cyanobacteria bloom on 9/27/22.
10/11/2022	Acceptable	N/A	3	-
10/25/2022	Acceptable	N/A	2	-
11/8/2022	Acceptable	N/A	6	-

### Lovers Lake North: Residence off Old Comers Road

During the 2022 monitoring season, Lovers Lake North experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable" and "Potential for Concern" Risk Categories (Table 2 below).

Lovers Lake North reached APCC's "Potential for Concern" category from 6/21/22 to 7/5/22 due to net daily cyanobacteria growth rates that exceeded 0.05. At these points, APCC increased sampling to weekly until the growth rate returned below 0.05. Lovers Lake North also experienced elevated net daily cyanobacteria growth rates from 9/8/22 to 10/11/22, prompting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Lovers Lake North remained "Acceptable" on these dates. Fortunately, this elevated growth rate did not result in cyanobacteria bloom formations nor toxin exceedances.

**Table 2. Summary of cyanobacteria monitoring results for Lovers Lake North, Chatham, MA.**

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	N/A	3	-
6/21/2022	Potential for Concern	<i>Anabaena</i> spp.	27	The WLW and BFC net daily cyanobacteria growth rates exceeded or equaled 0.05. Growth rates: 0.05 (WLW), and 0.15 (BFC).
6/29/2022	Potential for Concern	<i>Dolichospermum</i> spp.	86	The BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rate: 0.15 (BFC).
7/5/2022	Potential for Concern	<i>Dolichospermum</i> spp.	717	The <50, WLW, and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.43 (<50), 0.23 (WLW), and 0.35 (BFC).
7/13/2022	Acceptable	<i>Dolichospermum</i> spp.	11	-
7/19/2022	Acceptable	<i>Dolichospermum</i> spp.	5	-
8/2/2022	Acceptable	<i>Dolichospermum</i> spp.	11	-
8/16/2022	Acceptable	<i>Dolichospermum</i> spp.	14	-
8/30/2022	Acceptable	<i>Anabaena</i> spp.	35	-
9/8/2022	Acceptable	<i>Dolichospermum</i> spp.	52	-
9/13/2022	Acceptable	<i>Dolichospermum</i> spp.	209	-
9/22/2022	Acceptable	<i>Gloeocapsa</i> spp.	24	-
9/27/2022	Acceptable	Mixed	155	-
10/3/2022	Acceptable	Mixed	26	-
10/11/2022	Acceptable	<i>Microcystis</i> spp.	39	-
10/17/2022	Acceptable	<i>Microcystis</i> spp.	73	-
10/25/2022	Acceptable	Mixed	13	-
11/8/2022	Acceptable	<i>Microcystis</i> spp.	33	-

## Lovers Lake South: Boat Launch off Lake Shore Drive

During the 2022 monitoring season, Lovers Lake South experienced changes in cyanobacteria levels that at different times placed it in APCC’s “Acceptable” and “Potential for Concern” Risk Categories (Table 2 below).

Following initial “Acceptable” sampling events to begin the season, Lovers Lake South reached APCC’s “Potential for Concern” category on 7/5/22 and 7/13/22 due to net daily cyanobacteria growth rates that exceeded 0.05. At this point, APCC increased sampling to weekly until the growth rate returned below 0.05. Lovers Lake South also reached the “Potential for Concern” category on 8/16/22, 8/24/22, and 9/13/22 due to the presence of small cyanobacteria scums. These accumulations did not warrant municipal recreational advisory postings and each scum dissipated quickly. Lovers Lake South also experienced elevated net daily cyanobacteria growth rates on 10/25/22, prompting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Lovers Lake South remained “Acceptable” on this date. Lovers Lake South was “Acceptable” for the remainder of the sampling season.

During the season, one toxin sample from Lovers Lake South was sent to the County Water Quality Lab for microcystin analysis including samples on 7/5/22. The County Lab reported microcystin results to be non-detectable for the sample.

**Table 3. Summary of cyanobacteria monitoring results for Lovers Lake South, Chatham, MA.**

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	N/A	4	-
6/21/2022	Acceptable	<i>Dolichospermum</i> spp.	5	-
7/5/2022	Potential for Concern	<i>Dolichospermum</i> spp.	212	Cyanobacteria scum present. The <50, WLW, and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.07 (<50), 0.07 (WLW), and 0.27 (BFC) Microcystin result: Non-detect.
7/13/2022	Potential for Concern	<i>Dolichospermum</i> spp.	21	The <50 and WLW net daily cyanobacteria growth rate exceeded or equaled 0.05. Growth rates: 0.05 (<50), and 0.18 (WLW)
7/19/2022	Acceptable	<i>Dolichospermum</i> spp.	7	-
8/2/2022	Acceptable	<i>Dolichospermum</i> spp.	9	-
8/16/2022	Potential for Concern	<i>Dolichospermum</i> spp.	15	Small cyanobacteria scum present.
8/24/2022	Potential for Concern	<i>Dolichospermum</i> spp.	69	Small cyanobacteria scum present.
8/30/2022	Acceptable	<i>Dolichospermum</i> spp.	24	-
9/13/2022	Potential for Concern	<i>Dolichospermum</i> spp.	977	Small cyanobacteria scum present.
9/22/2022	Acceptable	<i>Dolichospermum</i> spp.	53	-
9/27/2022	Acceptable	Mixed	62	-
10/12/2022	Acceptable	<i>Microcystis</i> spp.	21	-
10/25/2022	Acceptable	Mixed	43	-
11/2/2022	Acceptable	Mixed	28	-
11/8/2022	Acceptable	Mixed	64	-

Schoolhouse Pond: Public Beach

During the 2022 monitoring season, Schoolhouse Pond contained no concerning cyanobacteria results at the time and place of each sampling event, keeping the pond in APCC’s “Acceptable” category for the entire season.

Schoolhouse Pond did experience elevated net daily cyanobacteria growth rates from 9/27/22 to 10/17/22 prompting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Schoolhouse Pond remained “Acceptable” on these dates. (Table 4 below).

**Table 4. Summary of cyanobacteria monitoring results for Schoolhouse Pond, Chatham, MA.**

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	<i>Dolichospermum</i> spp.	34	-
6/21/2022	Acceptable	N/A	2	-
7/5/2022	Acceptable	<i>Dolichospermum</i> spp.	9	-
7/19/2022	Acceptable	<i>Dolichospermum</i> spp.	11	-
8/2/2022	Acceptable	N/A	5	-
8/16/2022	Acceptable	<i>Oscillatoria</i> spp.	16	-
8/30/2022	Acceptable	N/A	26	-
9/13/2022	Acceptable	<i>Dolichospermum</i> spp.	24	-
9/27/2022	Acceptable	<i>Dolichospermum</i> spp.	54	-
10/3/2022	Acceptable	<i>Dolichospermum</i> spp.	13	-
10/11/2022	Acceptable	<i>Dolichospermum</i> spp.	34	-
10/17/2022	Acceptable	<i>Dolichospermum</i> spp.	113	-
10/25/2022	Acceptable	<i>Dolichospermum</i> spp.	128	-
11/8/2022	Acceptable	Mixed	43	-



### Stillwater Pond: Neighborhood Boat Launch

During the 2022 monitoring season, Stillwater Pond experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable," "Potential for Concern," and "Use Restriction Warranted" Risk Categories (Table 5 below).

Stillwater Pond reached the "Potential for Concern" category starting on 6/21/22 and from 7/5/2022 to 7/19/22 due to net daily cyanobacteria growth rates above 0.05 during each sampling event. APCC increased sampling to weekly until cyanobacteria concerns decreased. Stillwater Pond also experienced elevated net daily cyanobacteria growth rates from 9/8/22 through 9/22/22, prompting weekly sampling. However, due to a change in communication protocol beginning on August 1st, 2022, Schoolhouse Pond remained "Acceptable" on these dates.

A large cyanobacteria bloom formed at Stillwater Pond on 10/25/22, resulting in a municipal recreational advisory posting by the town Health Department. Due to lingering bloom conditions, the pond did not meet the criteria for the municipal recreational advisory to be lifted by the last sampling date. Fortunately, the Town of Chatham Health Department continued to monitor the pond and lifted the municipal recreational advisory on 11/30/22.

**Table 5. Summary of cyanobacteria monitoring results for Stillwater Pond, Chatham, MA.**

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	<i>Dolichospermum</i> spp.	242	-
6/21/2022	Potential for Concern	<i>Dolichospermum</i> spp.	88	The WLW net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.08 (WLW)
6/29/2022	Acceptable	<i>Dolichospermum</i> spp.	3	-
7/5/2022	Potential for Concern	N/A	11	The <50, WLW, and BFC net daily cyanobacteria growth rates exceeded 0.05. Growth rates: 0.21 (<50), 0.19 (WLW), and 0.19 (BFC).
7/13/2022	Potential for Concern	<i>Dolichospermum</i> spp.	16	The BFC net daily cyanobacteria growth rate equaled 0.05. Growth rate: 0.05 (BFC)
7/19/2022	Potential for Concern	<i>Dolichospermum</i> spp.	29	The BFC net daily cyanobacteria growth rate exceeded 0.05. Growth rate: 0.10 (BFC)
7/27/2022	Acceptable	<i>Dolichospermum</i> spp.	22	-
8/2/2022	Acceptable	<i>Dolichospermum</i> spp.	26	-
8/16/2022	Acceptable	Mixed	20	-
8/30/2022	Acceptable	<i>Dolichospermum</i> spp.	83	-
9/8/2022	Acceptable	<i>Dolichospermum</i> spp.	206	-
9/13/2022	Acceptable	<i>Dolichospermum</i> spp.	390	-
9/22/2022	Acceptable	<i>Anabaena</i> spp.	486	-
9/27/2022	Acceptable	<i>Dolichospermum</i> spp.	116	-
10/11/2022	Acceptable	<i>Anabaena</i> spp.	112	-
10/25/2022	Use Restriction Warranted	<i>Anabaena</i> spp.	124	Municipal recreational advisory posted due to a large cyanobacteria bloom.
11/2/2022	Use Restriction Warranted	<i>Dolichospermum</i> spp.	44	Municipal recreational advisory posted due to a large cyanobacteria bloom.
11/8/2022	Use Restriction Warranted	<i>Anabaena</i> spp.	289	Municipal recreational advisory posted due to a large cyanobacteria bloom on 11/2/22.

### White Pond: Boat Launch

During the 2022 monitoring season, White Pond experienced changes in cyanobacteria levels that at different times placed it in APCC's "Acceptable" and "Potential for Concern" Risk Categories (Table 6 below).

White Pond reached the "Potential for Concern" category on 10/11/22 due to increased future microcystin concerns. The estimated microcystin from the BFC sample on this date included values above 8 ppb, indicating the possibility of a microcystin exceedance in the near future. However, microcystin results from the County Water Quality Lab for this date and for the following week were both well below 8 ppb. White Pond was once again deemed "Acceptable" on 10/17/22.

**Table 6. Summary of cyanobacteria monitoring results for White Pond, Chatham, MA.**

Sampling Date	APCC Current Risk Category	Dominant Genus	Bloom Forming Colonies Phycocyanin (ug/L)	Current Risk Category Notes
6/7/2022	Acceptable	<i>Microcystis</i> spp.	95	-
6/21/2022	Acceptable	<i>Microcystis</i> spp.	35	-
7/5/2022	Acceptable	<i>Microcystis</i> spp.	14	-
7/19/2022	Acceptable	<i>Microcystis</i> spp.	13	-
8/2/2022	Acceptable	Mixed	24	-
8/11/2022	Acceptable	Mixed	75	-
8/16/2022	Acceptable	<i>Microcystis</i> spp.	45	-
8/24/2022	Acceptable	N/A	36	-
8/30/2022	Acceptable	<i>Microcystis</i> spp.	75	-
9/8/2022	Acceptable	Mixed	23	-
9/13/2022	Acceptable	<i>Microcystis</i> spp.	44	-
9/22/2022	Acceptable	<i>Microcystis</i> spp.	40	-
9/27/2022	Acceptable	<i>Microcystis</i> spp.	58	-
10/3/2022	Acceptable	<i>Microcystis</i> spp.	24	-
10/11/2022	Potential for Concern	<i>Microcystis</i> spp.	268	BFC estimated microcystin concentration included values above 8 ppb. Microcystin result: 0.32 ppb.
10/17/2022	Acceptable	<i>Microcystis</i> spp.	194	-
10/25/2022	Acceptable	<i>Microcystis</i> spp.	39	-
11/8/2022	Acceptable	<i>Microcystis</i> spp.	37	-

## 5. CONCLUSIONS

In 2022, six sampling sites were monitored for cyanobacteria in Chatham; two locations on Lovers Lake, Goose Pond, Schoolhouse Pond, Stillwater Pond, and White Pond. Lovers Lake, Goose Pond, Stillwater Pond, and White Pond reached APCC’s “Potential for Concern” Risk Category due to moderate levels of cyanobacteria. Goose Pond and Stillwater Pond reached APCC’s “Use Restriction Warranted” category due to cyanobacteria blooms. The Town of Chatham Health Department followed up by posting municipal recreational advisories at these ponds.

In 2022, Goose Pond received a municipal recreational advisory posting from September 21, 2022, to October 11, 2022. Stillwater Pond received a municipal recreational advisory posting from October 25, 2022, through the end of the sampling season. In years past, each of the Chatham ponds in this network has received at least one municipal recreational advisory posting, although the frequency of postings and ponds that required a posting have varied from year to year. For a comparison of interpreted cyanobacteria risks in 2022 compared to previous seasons, see Appendix 3.

In the previous four years of monitoring, APCC’s monitoring data and the presence of cyanobacteria scums was used to estimate cyanobacteria risk. In 2022, the County Water Quality Lab’s capability to conduct microcystin analyses provided the town health department and APCC with direct measurements of toxin, increasing understanding of current toxin risks. In 2022, three toxin samples were sent to the County Water Quality Lab due to concerns of a possible exceedance, but these samples all were reported under the MDPH microcystin threshold of 8 ppb.

APCC’s 2022 cyanobacteria monitoring program collected and analyzed 72 samples and documented field conditions on each of the scheduled 72 sampling dates throughout the season as well as an additional 26 based on higher growth rates or higher warning categories. All results were promptly shared with Friends of Chatham Waterways and the Town of Chatham via biweekly reports and then entered into the APCC Interactive Map following the completion of sample analysis (<https://apcc.org/cyano>).

## 6. RECOMMENDATIONS

Based on the results from the 2022 monitoring season and previous monitoring work, APCC provides the following recommendations:

**Recommendation 1: Continue the sampling season to include early and late season monitoring.**

Many ponds in APCC’s cyanobacteria monitoring program experience their highest cyanobacteria concentrations in the spring and the fall. Additional early and late season monitoring could shed light on potential bloom conditions outside of the typical June to Labor Day monitoring season. Although residents may interact with these ponds less during these times, there are still dangers posed to pets who may consume or swim in these waters while on walks during colder months.

Recommendation 2: Continue yearly cyanobacteria monitoring. Monitoring over multiple years for full seasons would provide greater understanding of the cyanobacteria community in Lovers Lake, Goose Pond, Schoolhouse Pond, Stillwater Pond, and White Pond. More seasons of data will allow us to draw better predictions year after year. Continued monitoring will also allow for the ability to track degradation in the ponds as increased occurrence of harmful cyanobacteria blooms point to larger issues of pond impairment. Monitoring efforts will shed light on the ponds most in need of protection and restoration.

Recommendation 3: Reduce nutrient loading to freshwater ponds. Residents surrounding vulnerable pond ecosystems should reduce potential nutrient pollution flowing from their properties towards the pond. Excess fertilizer use, septic systems around ponds, inadequate stormwater management, and inadequate vegetated buffers are examples of behaviors that exacerbate nutrient loading of ponds.

In addition to managing nutrients, changing climate conditions, including the currently warming atmosphere and altered rainfall patterns, are believed to play a significant role in the increasing frequency and intensity of harmful cyanobacteria blooms ([Paerl et al., 2019](#)). Residents and officials should understand that there may be many factors leading to cyanobacteria issues on Cape Cod. Continued work around cyanobacteria and water quality will lead to increased awareness, a safer public, and hopefully improved health of our freshwater ponds.

For a comprehensive list of actions that residents, municipalities, and state agencies can take to promote pond health, visit APCC's State of the Waters: Cape Cod website ([State of the Waters](#)), specifically, the Action Plan for ponds. For additional information on restoration of impaired ponds, the new Freshwater Initiative program for Cape Cod ponds will provide towns, communities, and organizations with information and resources for pond protection, management, and restoration. This program is led by the Cape Cod Commission with support from APCC. For more information, visit the Cape Cod Commission's Freshwater initiative website at: <https://capecodcommission.org/our-work/cape-cod-freshwater-initiative/>.

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## Appendix 1. Resources on Cyanobacteria

Harmful cyanobacteria blooms in freshwater bodies are the subject of numerous reports published by scientists, state and federal agencies, and organizations, some of which are listed here:

- The World Health Organization recognized the public health consequences of cyanobacteria in water in 1999 ([WHO<sup>1</sup>](#)).
- The Centers for Disease Control (CDC) call cyanotoxins “among the most powerful natural poisons known” ([CDC Fact Sheet on Harmful Algal Blooms](#)). The [CDC's Physician Card on Harmful Algal Blooms \(HABs\)](#) states that swallowing water containing cyanobacteria can damage the central nervous system, liver or kidneys; skin contact can cause allergic dermatitis and conjunctivitis; and inhalation of aerosols containing cyanobacteria or their toxins can cause wheezing, coughing, chest tightness, and shortness of breath.
- New England Interstate Water Pollution Control Commission ([NEIWPC](#)) is an interstate commission that helps the states of the Northeast preserve and advance water quality. NEIWPC's webpage states that “the frequency of HAB occurrence is on the rise and cyanobacteria toxicity has been associated with human health impacts including skin rashes, gastrointestinal and respiratory disease, and liver damage. Effects can be even more pronounced (potentially even fatal) in animals ranging from cattle to dogs. HABs have direct implications to the use of recreational waterbodies for contact recreation, the susceptibility of public water supplies to toxins, and the overall degradation of our aquatic resources.”
- U.S. Environmental Protection Agency (EPA):
  - “Monitoring and Responding to Cyanobacteria and Cyanotoxins in Recreational Waters.” ([EPA recreational waters](#))
  - EPA Office of Ground Water and Drinking Water webpage. Managing Cyanotoxins in Public Drinking Water Systems. ([EPA drinking water](#))
  - EPA webpage on nutrient pollution and HABs. ([EPA and nutrient pollution](#))
- State agencies, including New York ([NY](#)), Rhode Island ([RI](#)), and New Hampshire ([NH](#)) have cyanobacteria monitoring programs and provide guidance concerning public health and environmental risks posed by cyanobacteria.
- Commonwealth of Massachusetts:
  - Cyanobacteria webpage: ([Massachusetts](#))
  - Massachusetts Department of Public Health (MDPH) website on “Guidelines for cyanobacteria in freshwater recreational water bodies.” ([MDPH](#))

**Appendix 2. APCC’s Cyanobacteria Risk Categories.**

<b>APCC 2022 Cyanobacteria Risk Categories Revised 7/26/2022</b>				
<b>Criteria</b>		<b>APCC Acceptable</b>	<b>APCC Potential for Concern</b>	<b>APCC Use Restriction Warranted</b>
<b>Microcystin</b>	Potential microcystin calculated by APCC based on measurement of phycocyanin in Bloom Forming Colony samples.	Potential microcystin calculated at low levels that do not warrant additional toxin testing <sup>2,4</sup> .	Potential microcystin is elevated to a point where an exceedance is deemed possible and confirmatory toxin testing warranted <sup>2,4</sup> .	
	Measured microcystin by Barnstable County Water Quality Lab.	Less than 4 ppb microcystin <u>measured</u> in GRAB sample.	Between 4 and 8 ppb microcystin <u>measured</u> in GRAB sample.	Greater than 8 ppb microcystin <u>measured</u> in GRAB sample <sup>3</sup> .
<b>Cyanobacteria Blooms and Scums</b>	Cyanobacteria bloom material reported and confirmed by APCC.	None present at the time and place of sample collection.	A cyanobacteria scum or bloom is present but is deemed to be <u>insignificant</u> by the Massachusetts Department of Public Health and the town’s health agent.	A cyanobacteria scum or bloom is present and is deemed to be <u>significant</u> by the Massachusetts Department of Public Health or the town’s health agent <sup>3</sup> .
<b>Notes</b>	<p>To interpret cyanobacteria data using this table, the most hazardous result determines the category the pond is placed in from right to left. A pond that meets even a single criterion in the “Use Restriction Warranted” column will be placed in that category. Likewise, a pond that meets even a single criterion in the “APCC Potential for Concern” category but does not meet any criteria in the “APCC Use Restriction Warranted” category, will be placed in the “APCC Potential for Concern” category. If a pond meets no criteria in the “APCC Use Restriction Warranted” or the “APCC Potential for Concern” category, that pond is placed in the “APCC Acceptable” category.</p> <p><sup>2</sup>Developed with recommendations from Nancy Leland of Lim-Tex Inc. and affiliated with the University of New Hampshire Center for Freshwater Biology.</p> <p><sup>3</sup>Criteria attributed to MDPH.</p> <p><sup>4</sup>Predictive cyanobacteria metrics that project and estimate risks, rather than reactive cyanobacteria metrics that measure risk after a bloom has occurred.</p>			



**Appendix 3. Goose Pond, Lovers Lake, Schoolhouse Pond, Stillwater Pond, and White Pond 2018-2022 Cyanobacteria Risk Comparison.**

As of 2022 APCC has completed five seasons of cyanobacteria monitoring for the Town of Chatham. The tables below detail APCC’s communication of cyanobacteria risk for Goose, Schoolhouse, Stillwater, and White Pond, and Lovers Lake in each season. Red indicates a “Use Restriction Warranted” or “High Warning Tier” designation, yellow indicates a “Potential for Concern” or “Moderate Warning Tier” designation, and blue indicates an “Acceptable” or “Low Warning Tier” designation. See the 2018, 2019, 2020, and 2021 APCC reports for the Town of Chatham for more information on findings and risk communication in these sampling seasons.

<b>Goose Pond 2018-2022 Cyanobacteria Risk Comparison</b>												
	<b>June</b>		<b>July</b>		<b>August</b>		<b>September</b>		<b>October</b>		<b>November</b>	
<b>Year</b>	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2018	Blue	Blue	Red	Blue	Blue	Blue	Blue	Red	Blue	Blue		
2019	Red	Yellow	Blue	Yellow	Blue	Blue	Blue	Blue				
2020	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Red	Red	
2021	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	
2022	Blue	Blue	Blue	Blue	Blue	Blue	Yellow	Red	Red	Blue	Blue	

<b>Lovers Lake 2018-2022 Cyanobacteria Risk Comparison</b>												
	<b>June</b>		<b>July</b>		<b>August</b>		<b>September</b>		<b>October</b>		<b>November</b>	
<b>Year</b>	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th
2018	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue		
2019	Yellow	Yellow	Blue	Blue	Yellow	Yellow	Blue	Blue				
2020	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Blue	Yellow	Blue		
2021	Blue	Blue	Blue	Blue	Blue	Blue	Red	Red	Blue	Blue	Blue	
2022	Blue	Yellow	Blue	Blue	Yellow	Yellow	Blue	Blue	Blue	Blue	Blue	

<b>Schoolhouse Pond 2018-2022 Cyanobacteria Risk Comparison</b>														
	<b>June</b>		<b>July</b>		<b>August</b>		<b>September</b>		<b>October</b>		<b>November</b>		<b>December</b>	
<b>Year</b>	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st
2018	Blue													
2019	Yellow	Blue				Yellow	Blue							
2020	Blue											Red		
2021	Blue													
2022	Blue													

<b>Stillwater Pond 2018-2022 Cyanobacteria Risk Comparison</b>															
	<b>June</b>		<b>July</b>		<b>August</b>		<b>September</b>		<b>October</b>		<b>November</b>				
<b>Year</b>	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-30th	
2018	Blue														
2019	Yellow	Red	Blue				Yellow	Blue							
2020	Blue		Yellow	Blue											
2021	Blue														
2022	Blue		Yellow				Blue				Red		Blue		

<b>White Pond 2018-2022 Cyanobacteria Risk Comparison</b>																
	<b>June</b>		<b>July</b>		<b>August</b>		<b>September</b>		<b>October</b>		<b>November</b>					
<b>Year</b>	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-31st	1st-15th	16th-30th	1st-15th	16th-30th		
2018	Blue				Red		Blue									
2019	Red						Yellow				Red					
2020	Blue				Yellow		Red				Blue					
2021	Blue		Red				Blue				Red					
2022	Blue								Yellow		Blue					

#### Appendix 4: Sampling Locations:

- **Goose Pond**: Conservation Area off Old Queen Anne Road
- **Lovers Lake**:
  - Residence off Old Comers Road **(Private)**
  - Neighborhood boat launch off Lake Shore Drive. **(Private)**
- **Stillwater**: Boat launch at the end of Stillwater Drive. **(Private)**
- **Schoolhouse**: Public beach off Schoolhouse Pond Road.
- **White Pond**: Boat launch off Wilfred Road.