Lake Quinsigamond
2024 Water Quality Report

The City *of* Worcester
Department of Sustainability and Resilience
Lakes and Ponds Program

Summary

The following report is presented by the City of Worcester Department of Sustainability and Resilience (DSR) Lakes and Ponds Program (L&P). It details the program's water quality monitoring results, management activities and outreach efforts at Lake Quinsigamond in 2024. The "State of the Lake" will be rated "Excellent", "Good", "Fair", or "Poor" based on the results' implications for water quality and recreational value. This report will also outline projects and opportunities the City of Worcester's Lakes and Ponds Program (L&P) intends to implement at Indian Lake in 2025.

As an urban waterbody, Lake Quinsigamond is impacted by many of the pressures of the urban environment. Lake Quinsigamond faces challenges including beach closures due to fecal bacteria, high nutrient levels, invasive aquatic plants, and depletion of dissolved oxygen (DO). The lake is managed by the Lake Quinsigamond Commission with support from the City of Worcester, the Town of Shrewsbury, and the Town of Grafton, and efforts continue to support a healthy ecosystem and a wide variety of recreational opportunities. ***In 2024, Lake Quinsigamond Lake received a score of "Good/Fair"***. Continue reading to learn more about this rating and L&P's work at Lake Quinsigamond.

Background

Lake Quinsigamond is a naturally formed, 4-mile-long, 475-acre lake nestled between eastern Worcester and western Shrewsbury, with Grafton to the south. It empties into Flint Pond to the south and later into the Quinsigamond River, ultimately joining the Blackstone River. Lake Quinsigamond and Flint Pond are connected by direct flow through culverts and are generally managed as a single system. The waterbody has a maximum depth of 90 feet, and a water residence time of about 6 months. The Commonwealth of Massachusetts considers Lake Quinsigamond a "Great Pond", meaning that it was larger than 10 acres in its original state and is therefore within the jurisdiction of Chapter 91, a law which protects public rights to access a waterway. There are seven major tributaries that feed the lake from both the Worcester and Shrewsbury side. The lake is crossed by three major roadways, Interstate 290, Route 9, and Route 20.

Lake Quinsigamond is renowned as a major recreational asset for rowing, sailing, swimming, fishing, water skiing, and other motorized and non-motorized boating. The Massachusetts Department of Conservation and Recreation (DCR) manages two parks with bathing beaches on the Worcester side of the lake, and the Town of Shrewsbury manages one boat ramp on the eastern shore and one boat ramp on Flint Pond. Management of the lake is led by the Lake Quinsigamond Commission, a state-level commission consisting of representatives from Worcester, Shrewsbury, and Grafton. The lake is stocked with rainbow and brown trout by MassWildlife in the spring and fall, and northern pike and tiger muskellunge when available. Carp fishing is also gaining popularity at Lake Quinsigamond as a state record mirror carp was recently caught, weighing over 46 pounds. Other popular game fish include largemouth bass, smallmouth bass, chain pickerel, yellow perch, white perch, black crappie, and bullhead catfish.

Lake Quinsigamond is listed on the Massachusetts Impaired Waters 303d List as Category 4a for non-native aquatic plants, *Enterococcus* bacteria, excess algal growth, and low dissolved oxygen. It received a Total Maximum Daily Load (TMDL), or "nutrient budget," in 2002 for phosphorus. At that time, it was suggested that management plans be created to achieve 200 days' supply of oxygen in the hypolimnion (deep, colder layer) during the summer months. The TMDL also identified Flint Pond, the southern section of Lake Quinsigamond, as being impaired for turbidity because it had an average Secchi disk transparency of below 4 feet, which can indicate concerns for both ecological health and human recreational safety. Additionally, the lake hosts at least seven invasive aquatic plants, including Eurasian Milfoil (*Myriophyllum spicatum*), Variable Leaf Milfoil (*Myriophyllum heterophyllum*), Fanwort (*Cabomba caroliniana*), Brittle Naiad (*Najas minor*), Curly Leafed Pondweed (*Potamogeton crispus*), Water Chestnut (*Trapa natans*) and Sacred Lotus (*Nelumbo nucifera*). It also hosts the invasive mollusk *Corbicula fluminea.* The Lakes and Ponds Program began monitoring Lake Quinsigamond as part of its Water Quality Monitoring Program in 2017.

This report details the results of water quality monitoring programs in 2024, as well as the projects L&P intends to implement in 2025. To provide context for the 2024 data, the following paragraph highlights L&P's key findings from 2023.

In 2023, Lake Quinsigamond, received a score of "Good/Fair". As in past seasons, oxygen stress was observed in the deeper areas of the lake. The beach at Regatta Point was closed for a total of 63 days due to fecal bacteria exceedances, and the beach at Lake Park was closed for 25 days. Water clarity continued to decrease from observations in past years, receiving a score of "Fair". As in 2022, cyanobacteria indicators did not suggest that there were any challenges with blooms during the bathing season, but in the fall, L&P again received reports from residents of cyanobacteria-containing scums in the southern portion of the lake. Total phosphorus concentrations on the surface of the lake continued to be low, though samples taken at depth, especially in the southern site, were higher than in previous years.

To view full reports from all previous seasons, please visit WorcesterMA.gov/bluespace or contact greenworcester@worcesterma.gov.

Management Summary

The Lake Quinsigamond Commission (LQC) began implementing an invasive aquatic plant management plan in 2018 to reduce the density of six invasive aquatic plants that were identified by a survey the previous year. Management activities include an annual 3-foot drawdown of the lake, a volunteer effort to remove plants by hand, and chemical treatment with herbicides. Future management efforts may include removal by divers. Management is complicated by the presence of an endangered pondweed (*Potamogeton vaseyi)* that also resides in the lake. As of 2021, Water Chestnut was identified in several regions of the lake, resulting in several community-run Water Chestnut hand-pulling events throughout the summers of 2022, 2023, and 2024.

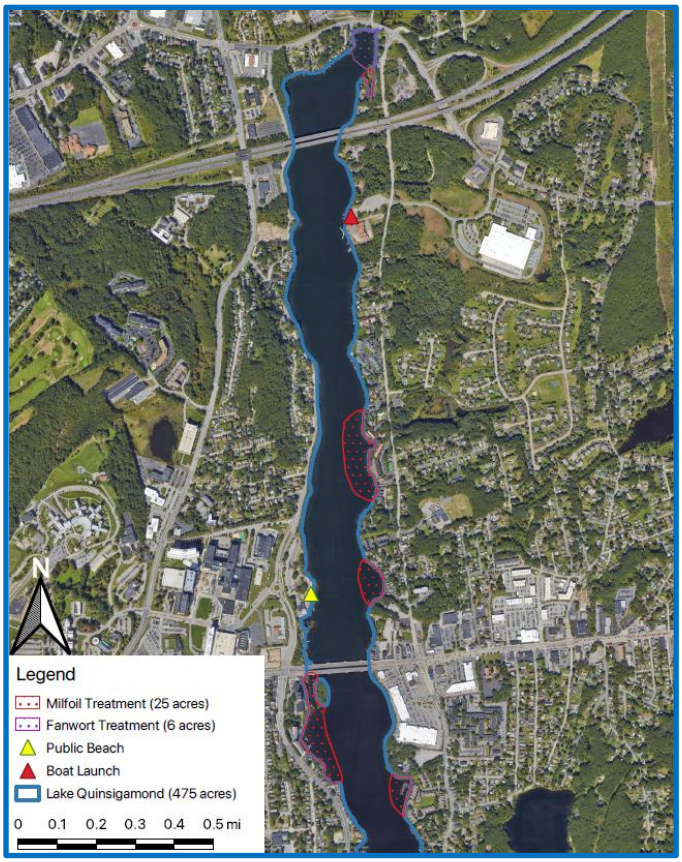


Figure 1 *– Treatment area for herbicide application on 23-Aug 2023.*

In 2024, L&P continued coordinating with LQC to address invasive aquatic plants in Lake Quinsigamond. In 2023, L&P contracted chemical treatment of Eurasian Milfoil, Variable Milfoil, and Fanwort in the Northern section of the Lake (see Figure 1). A post-treatment survey indicated that the treatment was successful, with no observance of target species, though a follow-up survey was recommended for the following spring. In early June 2024, L&P conducted a follow-up survey of the treatment area to determine treatment efficacy and next steps. Native species were primarily observed in the treatment area, though trace regrowth of Eurasian Milfoil was noted in the northernmost section.

Sampling Analysis and Overview

Sampling from multiple locations within a waterbody and its watershed leads to better understanding of the water that enters the lake, how it is transformed within, and the water leaving the lake. To account for these changes over space and time, L&P samples at sites in tributaries, at the surface and bottom of mid-lake sites, and the outlet.

Tributaries, or inlets, are streams that flow into a lake or pond. They collect surface runoff from rain or snowmelt along with some groundwater and carry it through the stream channel to the waterbody. In some cases, tributaries make up a large portion of the water going into the lake, and the quality of the water in these tributaries provides insight into where certain impairments in the lake originate. Outlets

are the major exits for water in the lake. Most L&P water quality parameters are measured at the major natural tributaries and outlets of the lakes.

Lake Quinsigamond was visited twice monthly from May through October and sampled at seven locations: The major aboveground tributaries, Coal Mine Brook and Poor Farm Brook in Worcester and Billings Brook in Shrewsbury; the two deepest parts of the lake (the northern site is about 85-feet deep, and the southern site is about 75-feet deep); and the outlet at the Irish Dam located in the southern part of the lake in Grafton (see Figure 2). At the in-lake locations, probe measurements and water samples were collected 1 foot below the surface of the water ("surface"), and 2 feet above the bottom of the lake ("bottom"). Parameters evaluated on every sampling day included Secchi transparency, temperature, dissolved oxygen (DO), pH, total phosphorus (TP), and total dissolved phosphorus (TDP). Total suspended solids (TSS), ammonia (NH_3), and nitrate (NO_3) were sampled once monthly. Lake profiles were created for temperature, pH, and dissolved oxygen throughout the water column. Altogether, there were 12 sampling events over 22 days as all but two routine sampling events were split between two days.

According to the Northeast Regional Climate Center, the spring of 2024 (Mar - May) had the second highest rainfall total in the period of record (1948 – 2024). Summer of 2024 (Jun – Aug) had below average rainfall, and the fall (Sep – Nov) was the driest in the period of record. The Massachusetts Central Region was classified as Level-3 Critical drought from 1-Oct through 8-Jan 2025, when it was downgraded to a Level-2 Significant Drought. Dry conditions in the summer and fall of 2024 led to reduced flow in tributaries and dry conditions in Poor Farm Brook (See Figure 3). For 21 of the visits there were less than 0.25 inches of rain in the 24 hours prior to sampling.

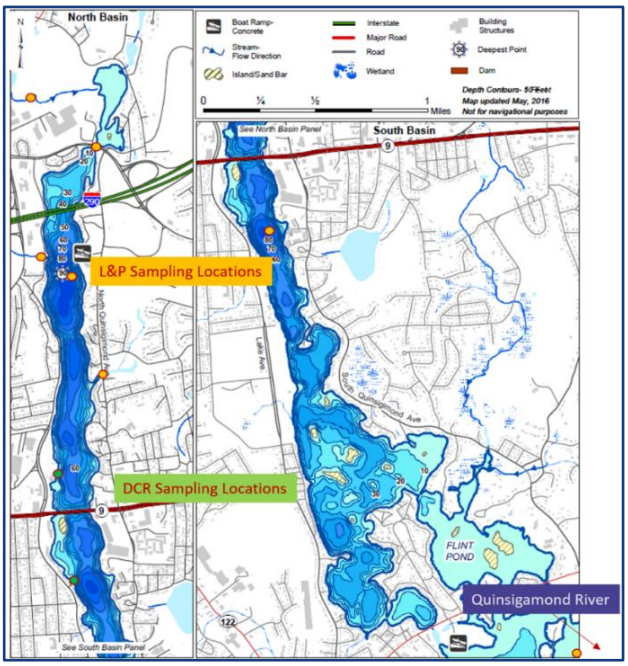


Figure 2 *– Lake Quinsigamond map and approximate sampling locations.*

Figure 3 *– Dry conditions in the summer and fall of 2024 led to dewatering in Poor Farm Brook.*

However, on 9-May there were 0.62 inches of rain in the 24 hours prior to sampling. This day is categorized as "wet weather" and denoted with the symbol  in the figures.

The Massachusetts Department of Conservation and Recreation (DCR) tested the two state park beaches for *Enterococcus* as an indicator of fecal bacteria on a weekly or twice-weekly basis during the swimming season. Volunteers from the Worcester Cyanobacteria Monitoring Collaborative (WCMC) collected samples for phycocyanin and relative cyanobacteria density analysis to assess bloom risk. Volunteers visited Lake Park beach at Lake Quinsigamond and the Oak Island boat ramp at Flint Pond. WCMC samples were taken eight times at the Lake Park beach (18-May, 3-Jun, 29-Jun, 8-Jul, 27-Jul, 5-Aug, 24-Aug, and 3-Sep) and seven times at the Oak Island boat launch (4-May, 18-May, 29-Jun, 27-Jul, 24-Aug, 28-Sep, and 26-Oct).

Raw data are displayed and explained in this report. No statistical analysis has been performed. Results below the laboratory reporting limit, the smallest amount of a substance that a lab can reliably detect and report in a sample, are expressed with the less-than symbol (<) before the reporting limit. For example, a result with a reporting limit of 1.0 mg/L is shown as <1.0 mg/L. Ratings of "Excellent", "Good", "Fair", and "Poor" for reported values are based on the Massachusetts Department of Environmental Protection's SMART Monitoring Watershed Report Card Criteria.

Quality Assurance/Quality Control

The Lakes and Ponds Program uses Quality Assurance/Quality Control (QAQC) checks to ensure data are representative of local conditions and meet precision and accuracy standards. QAQC check results identify data that must be flagged and/or censored before being shared and QAQC checks can highlight issues that affect data quality. When data fail to meet acceptable criteria for these checks, they are either flagged as being slightly less robust or censored entirely. Flagged data points are marked with a red flag and censored data are not included in this report. For more information on L&P's data quality, please contact greenworcester@worcesterma.gov.

Monitoring Parameters and 2024 Results

Fecal Bacteria

Recreational contact with water contaminated by certain fecal bacteria may cause illness. *Escherichia coli* (*E. coli*) and *Enterococcus* are types of bacteria found in the digestive tract of warm-blooded animals including geese, pets, and humans. While most strains are harmless, some can cause illness. These bacteria enter the water in many ways, including direct contact with animal waste, runoff from the shoreline and impervious surfaces like paved roadways during rainstorms, leaking septic tanks, and illicit sewer connections that empty sewage to the stormwater system. The Commonwealth of Massachusetts has strict regulations for bathing beaches, and the Massachusetts Department of Conservation and Recreation (DCR) collects samples for fecal bacteria weekly at public beaches during the swimming season to ensure that the water is safe for direct contact, closing beaches if the results are above the recreational threshold. Samples are sent to an external lab for analysis. As in-lake *E. coli* results never indicated concern, L&P ceased collecting them in 2023, although beach testing by DCR continues. The Lake

Quinsigamond Watershed Association (LQWA) also conducts fecal bacteria monitoring. Between 2019 and 2023, LQWA collected samples in tributaries, outfalls, and in-lake sites, with support from the Lake Quinsigamond Commission, the Lakes and Ponds Program, and a grant from the Massachusetts Department of Environmental Protection. In 2024, LQWA collected samples for analysis of human DNA biomarkers to determine whether the fecal bacteria in the samples originated from humans or other animals. Results are anticipated in early 2025. More information is available on the LQWA website: www.lqwa.org.

Lake Park Enterococcus CFU/100mL	
21-May	61
28-May	15
4-Jun	6
11-Jun - 13-Jun	602 - 3
18-Jun	8
25-Jun	3
2-Jul	2
9-Jul	6
16-Jul	38
23-Jul	32
30-Jul - 1-Aug	65 - 326*
6-Aug	112*
13-Aug - 15-Aug	31* - 7*
20-Aug	28*
22-Aug	4
27-Aug	3

Regatta Point Enterococcus CFU/100mL	
21-May	35
28-May	104
4-Jun	47
11-Jun	4
18-Jun	10
25-Jun	147
2-Jul	9
9-Jul	158
16 - Jul - 18-Jul	42* - 18*
23-Jul - 25-Jul	38* - 11*
30-Jul	34
6-Aug	84
13-Aug	228*
20-Aug	16*
22-Aug	17*
27-Aug	7

Tables 1 and 2 – *Lake Park Beach (above left) was sampled 19 times by DCR for Enterococcus bacteria in 2024 and was closed for a total of 24 days due to fecal bacteria exceedances. Regatta Point Beach (above right) was sampled 18 times by DCR and was closed for a total of 50 days due to fecal bacteria exceedances. Green text indicates days with no beach closure. Red text indicates days in which fecal bacteria exceedances prompted beach closure. Beaches were closed due to an exceeded single day maximum for Enterococcus (61 CFU/100mL) or an exceeded geometric mean (33). Exceedances due to geographic mean are noted with an asterisk (*)*

Fecal Bacteria at Lake Quinsigamond. In 2024, DCR tested for *Enterococcus* bacteria at the Lake Park beach 19 times, resulting in closures on three occasions for a total of 24 days (see Table 1). Regatta Point was tested 18 times and was closed on two occasions for a total of 50 days (see Table 2). Figures containing all single-day and geomean results can be found in Appendix A. Closures due to fecal bacteria limited recreation at Lake Quinsigamond, with similar number of closures to 2023. Because fecal bacteria tend to be localized and short-lived, it is important to note that beach sampling results represent only the water conditions around the sampling site. Conditions in open water and at different points along the shoreline are likely to vary. Given beach closures significantly affecting recreation at Lake Quinsigamond, L&P rates bacteria at Lake Quinsigamond as "Fair".

Water Clarity

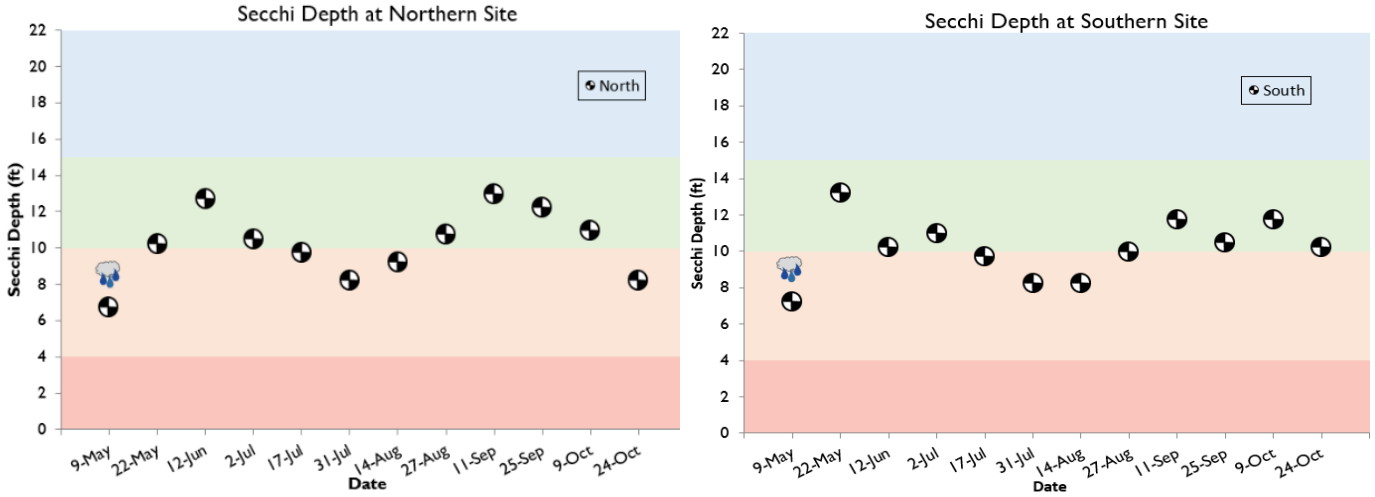
Water clarity is a measure of the transparency of water. Cyanobacteria and other microorganisms, eroded particles, and re-suspended bottom sediments are some factors that interfere with light penetration and reduce water transparency. Clear water allows sunlight to penetrate the depths of a waterbody, supporting growth of aquatic plants, which provide food, shelter, and oxygen to aquatic organisms. Clear water is also pleasant to the eye and may be safer for recreational contact. Turbid water, or water filled with particles, absorbs more heat from sunlight. This reduces the water's capacity to hold oxygen, creating favorable conditions for algal and cyanobacteria blooms, which further reduce clarity. Water clarity can be measured with a Secchi disk or by quantifying Total Suspended Solids (TSS). A Secchi disk is a weighted black and white disk on a calibrated line that is lowered into the water until it is no longer visible. Secchi

readings are collected on each lake visit by L&P. TSS is a measure of the dry weight of suspended particles in a given amount of water. TSS samples are taken once monthly and submitted to a lab for analysis.

Water Clarity at Lake Quinsigamond. Secchi depth in the Northern and Southern in-lake sites ranged between 6.75 ft and 13.25 ft, with most results falling between 10 and 15 ft, or in the range considered "Good" (see Figures 4 and 5). The season's lowest readings for both sites were observed on the first monitoring session, 9-May. Secchi depth readings taken between 17-Jul and 14-Aug were consistently in the range considered "Fair". Aside from these instances and one other reading in the Northern site on 24-Oct, all other readings were considered "Good". In 2024 Secchi depth was generally higher at both sites than in 2023, indicating better water clarity.

Surface TSS results at the Northern and Southern Sites were consistently low, ranging between 1.4 mg/L and 2.7 mg/L, and were within the range considered "Excellent". At the bottom of the Northern and Southern Sites, results were similarly considered "Excellent", ranging between 2.0 and 7.9 mg/L.

At Coal Mine Brook, Poor Farm Brook, and the Irish Dam, TSS results were consistently below 10 mg/L, or in the range considered "Excellent". TSS results at Billings Brook were generally higher with some results in the range considered "Good" and "Fair".



Figures 4 and 5 - *Secchi depth in the Northern and Southern in-lake sites ranged between 6.75 ft and 13.25 ft, with most results falling between 10 and 15 ft, or in the range considered "Good".*

As most Secchi depth readings were considered "Good" and all but one TSS result was considered "Excellent", clarity at Lake Quinsigamond was considered "Good".

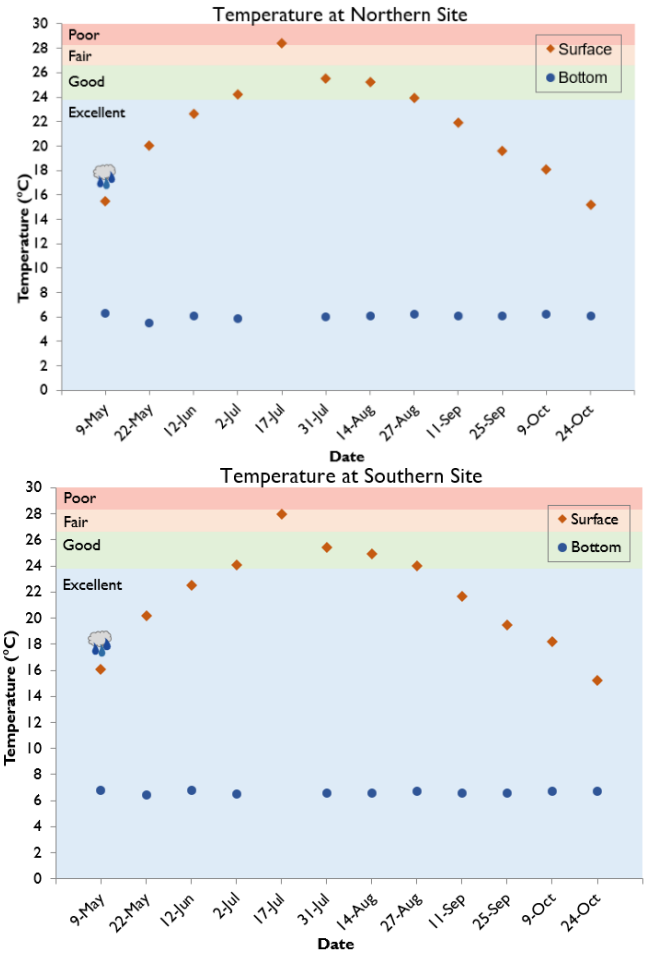
Temperature and Stratification

Water temperature impacts both the biology and chemistry of aquatic ecosystems. Because many organisms prefer to live in a narrow temperature range, understanding temperature across the area and depth of a water body is essential. Temperature also impacts the speed of chemical reactions and the ability of water to hold oxygen. Warmer water can hold less dissolved oxygen than colder water. Temperature dynamics in lakes can also impact the level of mixing occurring in the waterbody, affecting

the distribution of oxygen, nutrients, and organic matter throughout the water column. Because the density of water changes with temperature, variations in temperature can cause cold water to settle in a layer on the bottom while warm water stays on top, resulting in stratification. The area of the water column where the temperature changes rapidly between the warm surface water and the cold bottom water is called the thermocline. While stratification is a natural process, the thermocline can become a barrier that prevents the replenishing of oxygen at the bottom layers of the lake and the rise of sediment and nutrients to the top. Lake Quinsigamond is home to cold water fish species, including trout stocked by MassWildlife in the spring and fall. These fish are sensitive to several factors related to stratification, such as elevated temperatures and low dissolved oxygen (DO). To understand whether stratification is occurring, lake profiles were created by measuring temperature and DO at 5-foot increments throughout the water column.

Temperature and Stratification at Lake Quinsigamond. Surface temperature at the Northern and Southern Sites ranged between 15.2°C and 28.4°C, following the previously observed seasonal distribution (see Figures 6 and 7). Maximum recorded temperature for the season was observed at both sites on 17-Jul. As Lake Quinsigamond experiences stratification during the summer months, temperatures on the bottom of each site were low and stable, ranging between 5.5°C and 6.8°C.

To determine the extent of warming throughout the water column, depth profiles were taken at each site (see Appendix B). During the season's first readings in May, the temperature difference was relatively small between the surface and bottom of the lake, only 9.7°C. As the surface of the water warmed in June, the water below the surface also began to warm and float on the denser, colder



Figures 6 and 7 *- Bottom temperature was consistently low and stable at both sites due to thermal stratification. Surface temperature steadily increased, reaching its peak in mid-July. before beginning to decrease.*

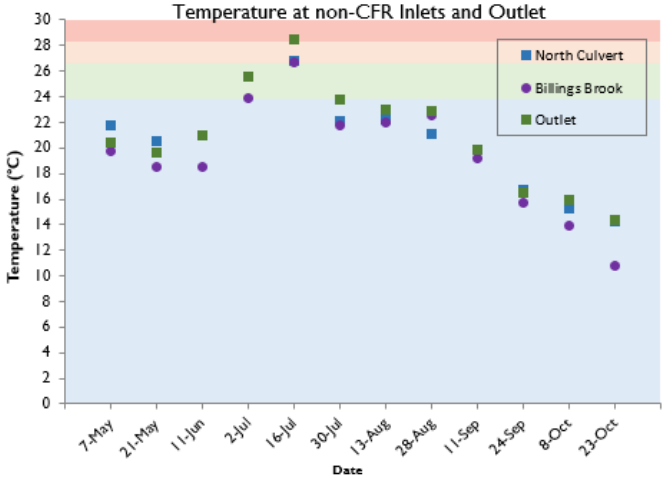


Figure 8 – *Temperature at the non-CFR inlets and the outlet were mostly in the range considered "Excellent" though readings were observed in the "Good", "Fair", and "Poor" categories in July. Temperature at the outlet was usually highest of the three sites.*

water below, creating a thermocline and preventing the mixing of oxygen to the water at the bottom. On 18-Jul, the temperature difference between the surface and bottom layers was greatest, reaching 22.9°C, indicating pronounced thermal stratification. As temperature increased at the surface to levels that are considered stressful to fish, stratification caused the colder water below to become increasingly devoid of oxygen. This pattern continued through mid-September. From late September through late October, the surface temperature dropped, however, a distinct thermocline was present during the last sampling session, indicating that the distinct layers of the water column had not yet begun to thoroughly mix.

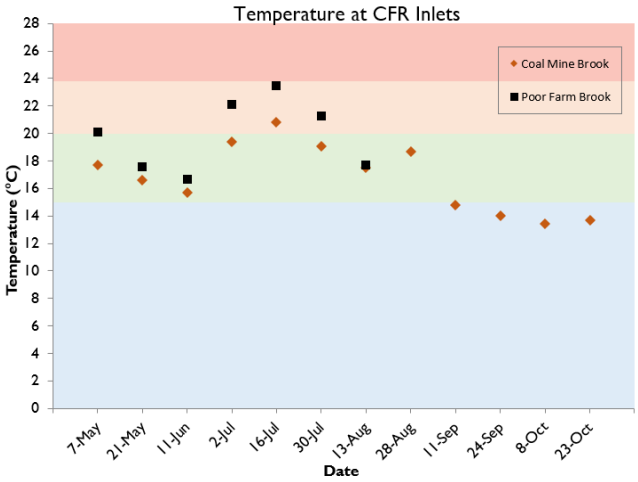


Figure 9 – *According to the stricter standards for cold-water fish resources (CFR), water temperature at Coal Mine Brook was mostly in the range considered "Good" and Poor Farm Brook was mostly in the range considered "Fair" until it stopped flowing in mid-August.*

Temperatures at the lake's northern culverted inlet, Billings Brook, and the lake outlet were generally lower than at in-lake surface sites, ranging from 10.9°C to 26.1°C (see Figure 8). One temperature reading at the outlet on 16-Jul (28.5°C) exceeded the 2024 in-lake maximum. Coal Mine Brook and Poor Farm Brook are both designated as Coldwater Fish Resources (CFR) and were usually cooler than the other tributaries, ranging between 13.4°C and 23.5°C (see Figure 9). Poor Farm Brook was always warmer than Coal Mine Brook and was dry from 28-Aug through the end of the season. According to the stricter standards for CFRs, water temperature at Coal Mine Brook was mostly in the range considered, "Good" and Poor Farm Brook was mostly in the range considered "Fair". While most surface temperatures recorded by L&P fell within the "Excellent" category, higher temperatures recorded at in-lake sites and CFR inlets fell within ranges challenging to cold water fish. L&P rates temperature at Lake Quinsigamond in 2024 as "Good" due to this interaction.

Dissolved Oxygen

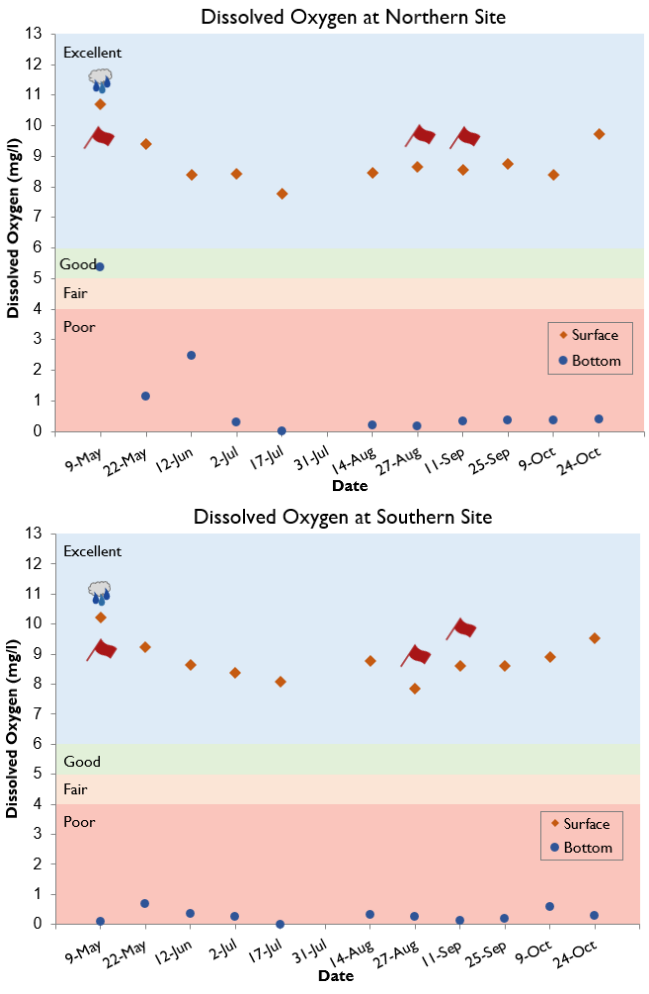
Oxygen dissolved in water is essential to aquatic life just as it is to life on land. Dissolved Oxygen (DO) is a highly variable parameter that is controlled by many factors, including temperature, pressure, aeration, diffusion, rate of photosynthesis, rate of respiration and more. When water temperature rises, water can hold less dissolved oxygen, potentially stressing aquatic organisms. When DO falls below 4 mg/L in warm water systems, or 8 mg/L in CFRs, conditions can be unsuitable for some aquatic life. Thermal stratification, which is layering in the water column based on temperature, can also create a barrier to waterbody mixing, creating areas with depleted DO in some deeper portions of waterbodies. Increased algal growth followed by excessive decomposition of organic material can also lead to low oxygen conditions, and potentially causing fish kills. DO was measured using a galvanic DO sensor on a handheld probe at the water's surface, and two feet from the bottom at the in-lake locations. To form a more complete picture of how DO changes through the water column, depth profiles were created by

measuring DO at 5-ft increments throughout the water column and plotting with temperature (see Appendix B)

Dissolved Oxygen at Lake Quinsigamond. Surface DO at the in-lake sites ranged between 7.79 and 10.67 mg/L, consistently within the range considered "Excellent" (see Figures 10 and 11). On the bottom, DO ranged between 0.09 and 5.37 mg/L with the only reading above 4 mg/L on 9-May.

At the beginning of the season, depth profile results indicated DO above 4 mg/L at depths 70 feet and shallower (see Appendix B). In mid-June, DO at the bottom of the lake began to decrease, and the depth of this decrease became shallower as the season went on while the surface of the water continued to have sufficient oxygen for fish and wildlife. From 31-Jul through the end of monitoring, the oxycline was between 25 and 30 ft deep. The oxycline is a zone in the water column where oxygen concentration changes rapidly with depth, and below which DO can be too low to support aquatic life.

Temperatures above 20°C and DO below 4 mg/L can stress cold water fish such as trout. In these scenarios, fish will swim to an area with lower temperatures or higher DO. In the height of summer, surface water temperatures at Lake Quinsigamond increase in the top layer of the water, to eventually above 20°C. This leads to increased thermal and oxygen stratification. Oxygen depletion begins at the lake bottom and low oxygen conditions extend into higher portions of the water column as the summer goes on. This reduces the preferred habitat zone for cold water fish in a phenomenon known as "the squeeze," increasing the risk of fish kills.

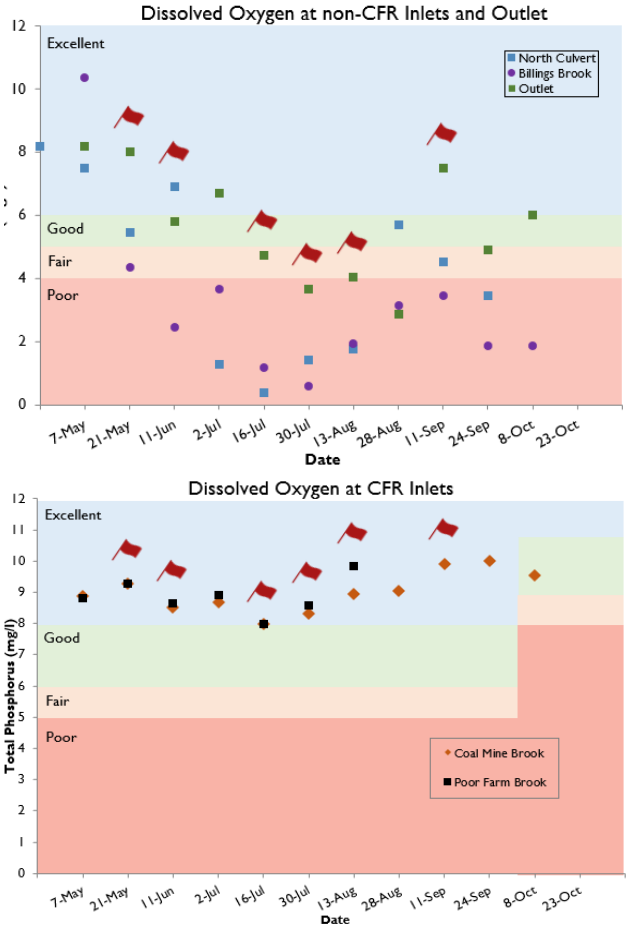


Figures 10 and 11 *- Dissolved oxygen at the Northern and Southern sites stayed in the "Excellent" category at the surface all season and was generally in the "Poor" category at the bottom.*

In 2024 there was one sampling day (11-Sep) in which there was no portion of the water column that satisfied both the 4 mg/L DO requirement and the 20°C CFR temperature requirement at the Northern site. After that point, surface temperatures cooled quickly in the upper portions of the water column and made available more preferrable habitat close to the water's surface. However, between 18-Jul and 11-Sep, there was only a 5-10 ft section of the water column that was habitable for cold-water fish, which likely stressed populations as fish often need to access shallow water to feed.

DO at the lake's northern culverted inlet ranged widely, with 5 of 11 readings below 4 mg/L, or in

the category considered “Poor”. All but two DO readings at Billings Brook were considered “Poor” (see Figure 12). At the outlet, DO was generally in the ranges considered “Excellent” and “Good” near the beginning and end of the sampling season. However, all readings taken between 16-Jul and 28-August were considered “Fair” and “Poor”. DO was above 8 mg/L in the cold-water tributaries, Coal Mine Brook and Poor Farm Brook, on all but one sampling day (see Figure 13). However, Poor Farm Brook was not flowing at the sampling site from 28-Aug through the end of the season. For Coldwater Fish Resources such as Coal Mine Brook and Poor Farm Brook, DO standards are stricter and change seasonally. Given the interaction of water temperature and DO reducing viable habitat for cold water fish, L&P rated DO at Lake Quinsigamond in 2024 as “Fair”.

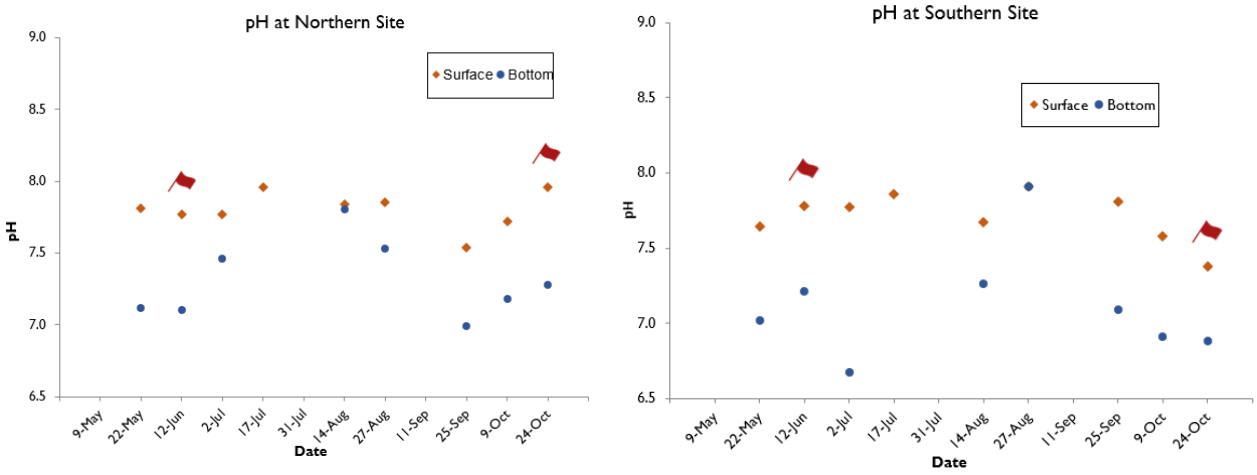


Figures 12 and 13 *- Billings Brook (top) was in the "Poor" category for most of the season. The outlet and North Culvert ranged in category through the season. Poor Farm Brook and Coal Mine Brook (bottom) remained in the "Excellent" category in all but one instance.*

pH

pH is the concentration of hydrogen ions (H+) in a solution. The more H+ ions that are present, the more acidic the solution. On a scale of 0-14 units, 7 is a neutral pH. As pH increases from 7, the solution is more basic, and as pH decreases from 7, it becomes more acidic. In aquatic ecosystems, pH affects most chemical and biological processes including species distribution, growth rate, reproductive success, and nutrient dynamics in lakes. A high pH can promote chemical reactions that release phosphorus from lake sediments. Healthy lakes in our area have a pH between 6.5 and 8.5. pH was measured using an ion-selective electrode (ISE) pH sensor on a handheld monitoring probe. Readings are taken at the water’s surface and two feet from the bottom.

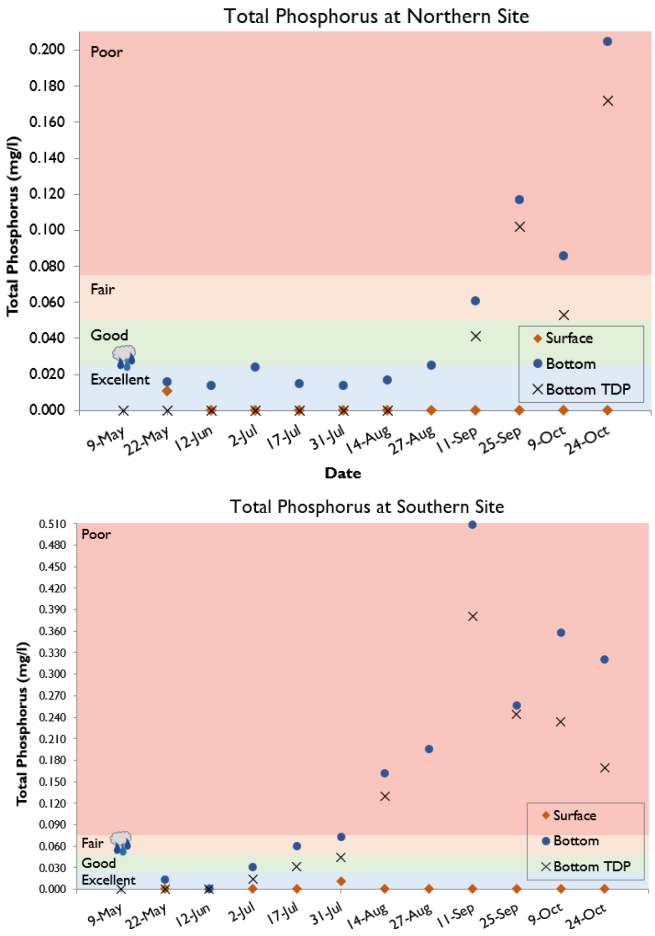
pH at Lake Quinsigamond. Surface pH at the in-lake sites ranged between 7.38 and 7.96 (see Figures 14 and 15). Bottom pH was almost always lower than the surface and ranged between 6.67 and 7.91.



Figures 14 and 15 - *Bottom pH at the Northern and Southern sites ranged from 6.67 – 7.91. Surface pH ranged from 7.38-7.96.*

Nutrients

Nutrients, primarily nitrogen (N) and phosphorus (P), are food sources for aquatic plants and algae. Although plants and algae are the basis of aquatic food chains and necessary for a healthy lake ecosystem, an overabundance of nutrients can lead to issues such as harmful algal blooms and excessive plant growth. Common nutrient inputs to urban lakes and ponds include fertilizers, pet and goose waste, illicit sewer connections to the stormwater system, and runoff that flows over land into the stormwater system. Additionally, under the right conditions, phosphorus can be released from the sediments at the bottom of the lake, becoming more available for uptake by organisms. To examine the nutrients present in program lakes, L&P collects samples for several compounds and submits them to an external lab for analysis. To measure N, samples are collected for nitrate (NO_3) and ammonia (NH_3) at all sites monthly. To measure P, samples are collected for total phosphorus (TP) twice a month at all sites, and total dissolved phosphorus (TDP) twice a month at all bottom sites. TDP is analyzed to understand how much P is dissolved in the water and available for use by aquatic organisms.



Figures 16 and 17 - *Surface total phosphorus at the Northern and Southern sites was consistently considered "Excellent". Bottom total phosphorus increased as the season progressed, with results in the "Excellent", "Good", "Fair", and "Poor" categories. TDP results were consistently lower than bottom TP and followed a similar distribution.*

Nutrients at Lake Quinsigamond. Surface TP at the two in-lake sites was generally very low, consistently below 0.025 mg/L, or in the range considered "Excellent" (see Figures 16 and 17). At the bottom of the in-lake sites, results ranged widely, between below the laboratory reporting limit and 0.509 mg/L. Bottom TP concentrations generally increased over the course of the season. As seen in past seasons, bottom TP was considerably higher at the Southern Site with a maximum recorded value of 0.509 mg/L, compared to the Northern Site with a maximum result of 0.205 mg/L. TDP results from bottom samples ranged between below the laboratory reporting limit and 0.381 mg/L. The Southern Site also exhibited higher TDP concentrations than the Northern Site.

Surface and bottom NO_3 results at both in-lake sites consistently fell below 0.6 mg/L and were in the range considered "Excellent".

Surface NH_3 was below 0.15 mg/L, or in the range considered "Excellent" for all but one reading. Results from bottom sites were consistently greater than 0.50 mg/L, or in the range considered "Poor", and increased as the season progressed. Bottom NH_3 was higher at the Southern Site than the Northern Site in all but one case.

TP results in the tributaries were mostly in the ranges considered "Excellent" and "Good" (see Figure 18). Billings Brook and Coal Mine Brook had more results between 0.025 and 0.050 mg/L, or in the category considered "Good". Billings Brook and Poor Farm Brook had occasional results in the "Fair" category.

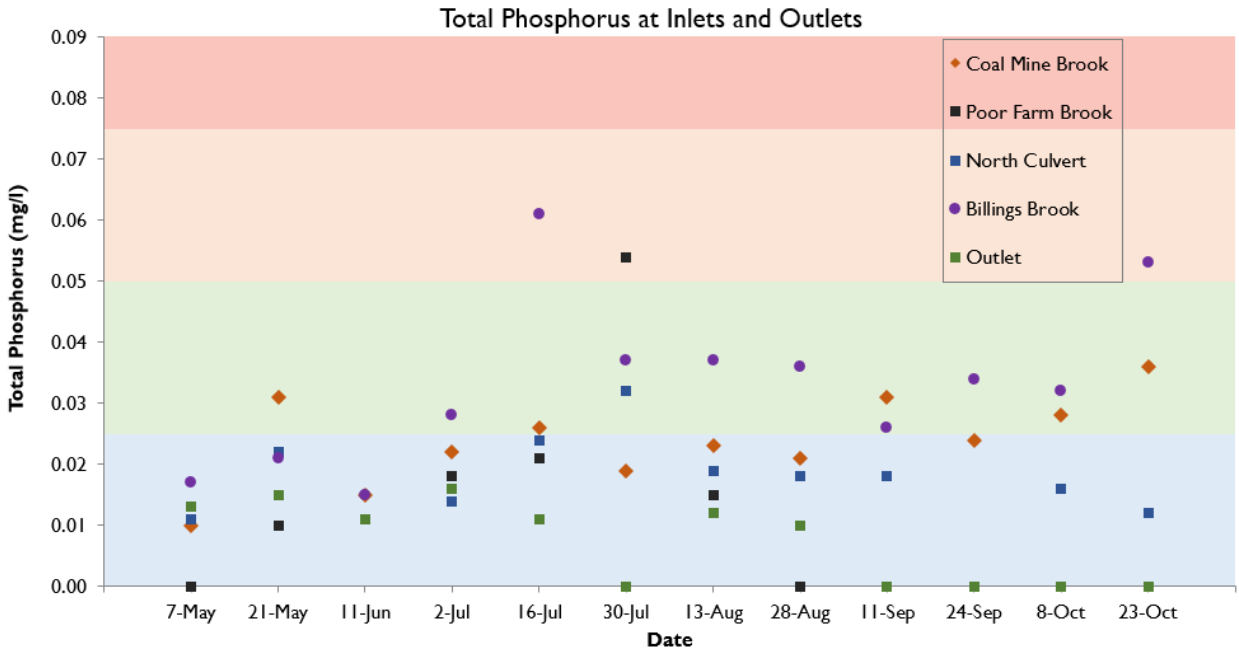


Figure 18 – *TP results in the tributaries were mostly in the ranges considered "Excellent" and "Good". Billings Brook often exhibited the highest results of the tributaries.*

NO_3 in the tributaries was consistently below 0.9 mg/L and in the ranges considered "Excellent" and "Good". Results from Poor Farm Brook and Coal Mine Brook were generally higher than Billings Brook and the spillway, with more results in the "Good" category. NH_3 results in the tributaries were consistently below 0.30 mg/L and in the ranges considered "Excellent" and "Good". Results above 0.15 mg/L or in the

"Good" category were observed once in Poor Farm Brook and twice in Billings Brook. NO_3 was considered "Fair" on one occasion (28-Aug) at Coal Mine Brook.

Cyanobacteria

Cyanobacteria are naturally occurring microorganisms in waterbodies. Using sunlight and nutrients such as N and P, cyanobacteria use photosynthesis to gain energy similarly to plants. While normal at low densities in healthy ecosystems, under the right conditions, some species of cyanobacteria can reproduce quickly and cause potentially harmful blooms. In addition to being unsightly and smelly, cyanobacteria blooms can produce toxins that are harmful to humans and pets. Blooms also have the potential to create low oxygen conditions that can cause fish kills.

To understand the abundance of cyanobacteria and support decisions regarding lake management and safe access, L&P utilizes the data collected by the Worcester Cyanobacteria Monitoring Collaborative (WCMC) to measure cyanobacteria indicators and estimate toxin exposure risk. The WCMC is a group of community science volunteers that collect water quality samples twice monthly between May and October at 24 waterbodies in and around Worcester, including Lake Quinsigamond. Parameters examined include phycocyanin and the relative abundance of cyanobacteria taxa. Like chlorophyll, the pigment phycocyanin is used by cyanobacteria to harness the sun's energy, converting carbon dioxide to sugars for growth and reproduction. Because phycocyanin is unique to cyanobacteria, it can be used as an indicator of cyanobacteria's relative abundance in a waterbody. Cyanobacteria taxa and their comparative abundance helps determine what toxins may be present. The WCMC is also able to determine relative density of cyanobacteria genera in samples using a high-powered microscope. Using both phycocyanin and comparative cyanobacteria density, WCMC results are assigned an overall bloom risk at each participating waterbody. For more information on the WCMC and their results, visit WorcesterMA.gov/WCMC.

Cyanobacteria at Lake Quinsigamond. At Lake Quinsigamond, WCMC samples were taken at the Lake Park swimming area just south of King's Point. Over the course of the 2024 season, at Lake Park, phycocyanin was detected five of the seven sampling sessions it was analyzed but never exceeded 50 µg/L, the concentration that would indicate bloom conditions (see Figure 19). Phycocyanin concentration was highest in late July and early August, with the highest result considered indicative of "elevated" bloom risk. Cyanobacteria relative density, or the relative abundance of cyanobacteria compared to other organisms, ranged between "none" and "high", with the highest density during the two sessions with the highest observed phycocyanin concentrations. Several genera of cyanobacteria were observed including, *Dolichospermum*, *Microcystis, Woronichinia,* and *Aphanocapsa,* and *Gomphosphaeria*. Overall bloom and toxin exposure risk was rated "low" on five of eight sampling sessions, and "elevated" on two sampling sessions, 27-Jul and 5-Aug (see Table 3).

The WCMC also collected samples at the Oak Island boat ramp at Flint Pond. Phycocyanin was detected five of seven sampling sessions, with results below 15 µg/L from early May through late July. The highest reading of 22 µg/L was observed in late August and indicated "elevated" bloom risk. Cyanobacteria relative density ranged between "none" and "high", with the highest ratings from late July through the

end of the season. Overall bloom and toxin exposure risk was rated “low” or “almost none” for the first three sampling sessions, “elevated” for the next three, and low for the final session.

Due to Lake Quinsigamond’s depth and tendency for thermal stratification and limited mixing until lake turnover, cyanobacteria blooms generally do not occur until late fall and early winter, when there is limited recreation on the lake. However, in recent years, reports of ephemeral scums throughout the southern portion of the lake were received by L&P earlier than usual, in late September. L&P staff responded to several reports of scums in fall 2024. Several types of cyanobacteria were identified in the scums, and phycocyanin concentrations were elevated but did not present a concern for public health.

As Lake Quinsigamond is a large and complicated system and the Lakes and Ponds Program’s staffing is limited, tracking reports of scums can be a challenge. It should be noted that WCMC results never indicated high bloom risk at Lake Quinsigamond beach areas during the swimming season and no closures took place. L&P assigned a score of “Good” to Lake Quinsigamond for cyanobacteria in 2024.

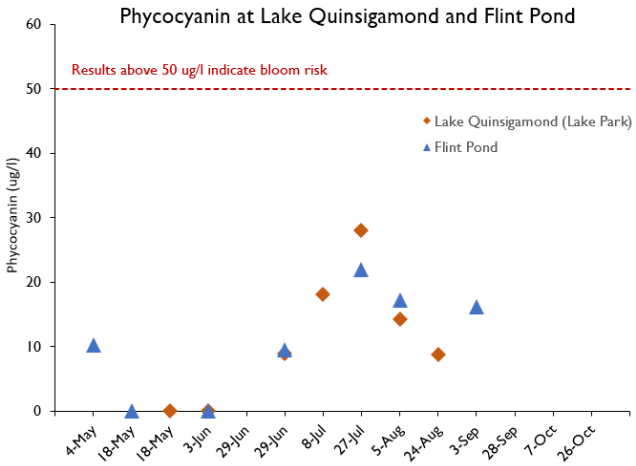


Figure 19 *- Phycocyanin measured in samples collected by the WCMC was consistently below 50 µg/L, the level associated with cyanobacteria bloom risk.*

Overall Bloom Risk at Lake Quinsigamond and Flint Pond

	4-May	18-May	29-Jun	27-Jul	24-Aug	28-Sep	26-Oct
Lake Quinsigamond - Lake Park	Not Taken	Low	Low	Elevated	Low	Not Rated	Not Taken
Flint Pond - Oak Island	Low	Almost None	Low	Elevated	Elevated	Elevated	Low

Table 3 *- Overall cyanobacteria bloom risk ratings derived from data collected by the WCMC ranged between “Almost None” and “Elevated” at Lake Quinsigamond and Flint Pond, with all “Elevated” ratings occurring between 27-Jul and 28-Sep. The above table is a selection of WCMC’s 2024 data. To view all results, visit Worcesterma.gov/WCMC.*

Invasive Aquatic Plants and Animals

An invasive plant or animal is an organism that is not native to the region and outcompetes local flora and fauna. The absence of natural constraints, like predators or environmental limitations, allows invasive plants and animals to reproduce at a rapid rate. When invasive aquatic plants and animals become too numerous or dominant, they can overtake available space, disrupting local ecosystems and making recreation more difficult. Invasive organisms can arrive at new locations by hitching a ride on boats, pets, or boots. Some are released with good intentions as a beautiful addition to a landscape or sport fishing opportunity. Professional surveys and visual inspections from Lakes and Ponds Program staff are used to support management decisions regarding invasive species.

Invasive Aquatic Plants and Animals at Lake Quinsigamond.

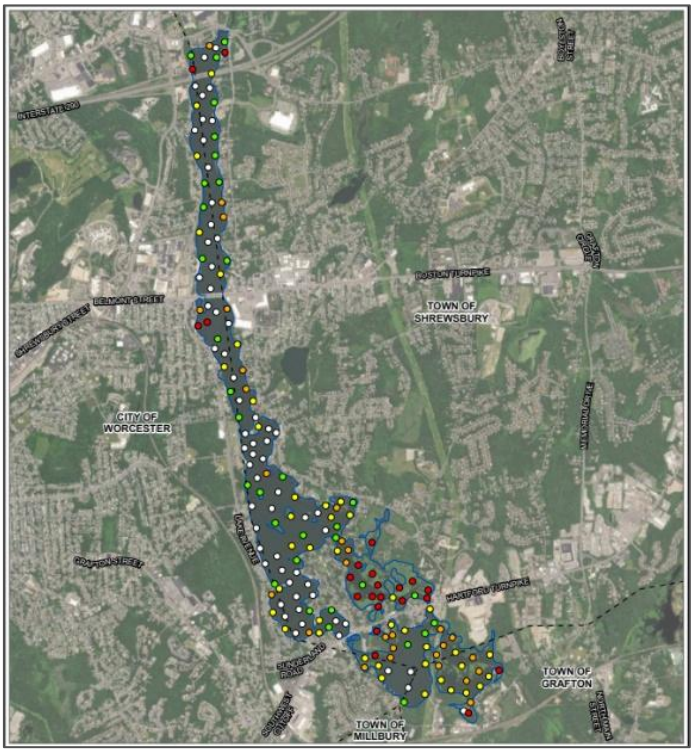


Figure 20 – *Invasive plant cover in Lake Quinsigamond as of late summer 2022.*

Lake Quinsigamond is managed for several invasive aquatic plants and one endangered aquatic plant. Invasive aquatic plants include Eurasian Milfoil (*Myriophyllum spicatum*), Fanwort (*Cabomba caroliniana*), Variable Leaf Milfoil (*Myriophyllum heterophyllum*), Brittle Naiad (*Najas minor*), Curly Leafed Pondweed (*Potamogeton crispus*), and Water Chestnut (*Trapa natans*) (see Figure 20). A 2024 survey by a state-certified botanist confirmed the endangered plant Vasey's Pondweed (*Potamogeton vaseyi*) is present in the Round Pond section of Lake Quinsigamond and may be present in Old Faith Cove or other areas of the lake. The population in Round Pond was often densely intermixed with Fanwort and Brittle Naiad, emphasizing the need for invasive species control. Eurasian Milfoil also grows at high density in the southern portion of the lake and Flint Pond. Dense growth of Water Chestnut is present in the northernmost section of the lake north of Lincoln Street, with additional patches in Round Pond and Flint Pond.

In 2023, L&P collaborated with LQC to facilitate chemical treatment of 31 acres of Eurasian Milfoil, Variable Milfoil, and Fanwort in the northern section of the lake. A post-treatment survey indicated that the treatment was successful, with no observed target species. In early June 2024, L&P completed a follow up survey of the treated areas and observed a predominance of native species. However, Curly Leafed Pondweed was present, which was not targeted by the 2023 treatment as it grows in abundance earlier in the season than the optimal window to treat invasive Milfoils and Fanwort. Trace regrowth of Eurasian Milfoil was also observed in the northernmost treatment area. In 2024, the Lake Quinsigamond Watershed Association (LQWA) hosted three volunteer Water Chestnut removal events. L&P will continue to collaborate with both LQC and LQWA to inform and implement aquatic plant management in Lake Quinsigamond. In 2025, L&P will contract an updated comprehensive plant survey, pending budget availability.

Figure 21 - *The invasive mollusk (*Corbicula fluminea*).*

Much like invasive plants, invasive animals can severely alter the aesthetics and functioning of a lake. In 2018, an invasive

mollusk, *Corbicula fluminea*, was identified in several areas of the lake. *C. fluminea* has a small light brown or green shell and is native to Southeast Asia (see Figure 21). It is an aggressive invasive that has been known to proliferate to the exclusion of other shellfish, altering the terrain by coating the lake bottom with sharp jagged shells. They are efficient filter feeders that can reduce the food available to juvenile fish. *C. fluminea* can spread from one waterbody to another when they are attached to boats or equipment, but also via the bilge water of boats in their larval stage. To date, no live specimen of *C. fluminea* has been collected. More information is needed to determine the threat level of the infestation.

Industrial Contaminants

Worcester is a post-industrial urban center and legacy pollutants and emerging contaminants of concern from industrial processes are potential threats to recreational waters. These contaminants may cause negative health and environmental effects. Every three years, L&P tests for a range of these compounds on both a wet and dry weather event in our lakes. Because most industrial contaminants are legacy pollutants, contamination levels are not expected to change much year to year. In 2022, L&P tested for 74 volatile organic compounds (VOCs), 72 semi volatile organic compounds (SVOCs), 9 polychlorinated biphenyls (PCBs), petroleum hydrocarbons (TPH), 23 perfluoroalkyl substances (PFAS), 21 pesticides, 10 herbicides, and 22 heavy metals. No results of concern were observed. See the 2022 Lake Quinsigamond Water Quality Report or contact greenworcester@worcesterma.gov. For more information. L&P will conduct sampling for legacy pollutants and emerging contaminants again in 2025, pending budget availability.

State of the Lake

In 2024, Lake Quinsigamond received a score of "Good/Fair." As in past years, the largest impediment to recreation was closure of the two DCR beaches due to fecal bacteria exceedances. The beach at Regatta Point was closed for a total of 50 days, and Lake Park Beach was closed for 24 days, resulting in a rating of "Fair" for fecal bacteria. Multiple invasive aquatic plant species continue to be present in the lake, though management efforts are ongoing. A survey following a 2023 herbicide treatment in the northern portion of the lake indicated a successful reduction of target species, and LQWA hosted three successful volunteer Water Chestnut hand pulling events. Water clarity was generally higher than in 2023 and was rated "Good" overall. Water temperature was rated "Good," though mid-summer stratification created stressful conditions for cold-water fish by reducing suitable habitat. Dissolved oxygen (DO) was rated "Fair" overall due to low oxygen conditions in a large portion of the water column during the summer and fall. Nutrient concentrations were generally low at the surface of the lake, though concentrations of TP and NH_3 rose drastically at the bottom as lake stratification intensified in the summer and fall.

Despite challenges such as fecal bacteria closures, invasive aquatic plants, and stratification-related ecological stress, Lake Quinsigamond continues to support recreational use and maintain ecological health. The City of Worcester's Lakes and Ponds Program (L&P) will continue monitoring and management efforts to protect the lake's water quality and recreational value into the future.

Ongoing Projects and Plan for 2025

Water Quality Monitoring

In 2025, the Lakes and Ponds Program will continue to monitor Lake Quinsigamond to track changes in water quality and support the invasive aquatic plant management plan. Pending budget availability, L&P plans to conduct sampling for industrial contaminants again in 2025. L&P will also work with community and municipal stakeholders to identify potential sources of elevated fecal bacteria and design solutions to improve water quality.

Continuous Monitoring. The Lakes and Ponds Program visits Lake Quinsigamond twice a month to collect water quality data, but because of the size of the lake, it can be a challenge to capture all the changes that are happening during these two visits alone. In 2021, the Lakes and Ponds Program installed solar powered continuous remote monitoring buoys to collect data related to cyanobacteria (see Figure 22). These buoys contain probes that track phycocyanin, chlorophyll, turbidity, and temperature, and remotely upload them to an online database every 30 minutes, 24 hours a day. In 2024, two buoys were deployed in Lake Quinsigamond. The first was placed just south of the Lake Ave. sewer pumping station and the Belmont St. outfalls to better track possible effects from construction-related sediment inputs in 2021 and sanitary sewer overflows in 2021 and 2023. The second buoy was placed near Lake Park to track conditions at the beach. This buoy became detached from its mooring in July and was not redeployed due to needed repairs. In 2025, L&P will redeploy the buoys to track environmental condition and potential cyanobacteria activity.

Cyanobacteria. In recent years, anecdotal reports of suspected cyanobacteria scums in the fall have increased. As Lake Quinsigamond is a large waterbody and many scums are ephemeral, it is not possible to confirm each report. The Lakes and Ponds Program has piloted an online form through which residents can report observations on scum conditions near them, as well as a notification system to alert residents when fall cyanobacteria activity has begun. While scum conditions at Lake Quinsigamond have not typically presented a concern for public health, additional data collection may help improve communication and response time if cyanobacteria scums become more of a risk to recreational users in future years. Empowering residents to track cyanobacteria conditions will improve L&P's reach in knowing how conditions are changing in parts of the lake that are difficult for L&P

Figure 22 *– A continuous monitoring buoy was relocated just south of the Lake Ave. sewer pumping station and the Route 9 outfall to track possible effects from increased disturbances.*

staff to visit on a regular basis. In 2025 L&P will develop additional communication channels for scum reporting and will work to make the form more user friendly. L&P will also improve public communication to educate residents on how to recognize suspected scums and on the importance of avoiding contact in uncertain scum conditions.

Lake Management

Watershed Based Plans. The Lakes and Ponds Program has contracted a consultant to develop watershed-based plans to reduce nonpoint source pollution in the City's three main recreational sub-watersheds. These plans will be based on the EPA's nine-element watershed-based planning framework and make future projects aimed at reducing nonpoint source pollution eligible for state and federal funding. A plan will be created for the Lake Quinsigamond watershed. This project will identify pollutant loads and load reduction targets and provide stakeholders with a roadmap to restoration and protection. The consultant will review existing data, model pollutant load and lake response, set water quality goals, assess potential pollution sources, identify mitigation measures, and develop an implementation strategy for mitigation measures. The plan will include water quality goals for phosphorus, bacteria, and dissolved oxygen, and will focus proposed mitigation measures on phosphorus and bacteria. Proposed mitigation measures may range from conceptual designs for stormwater infrastructure improvements to public education campaigns.

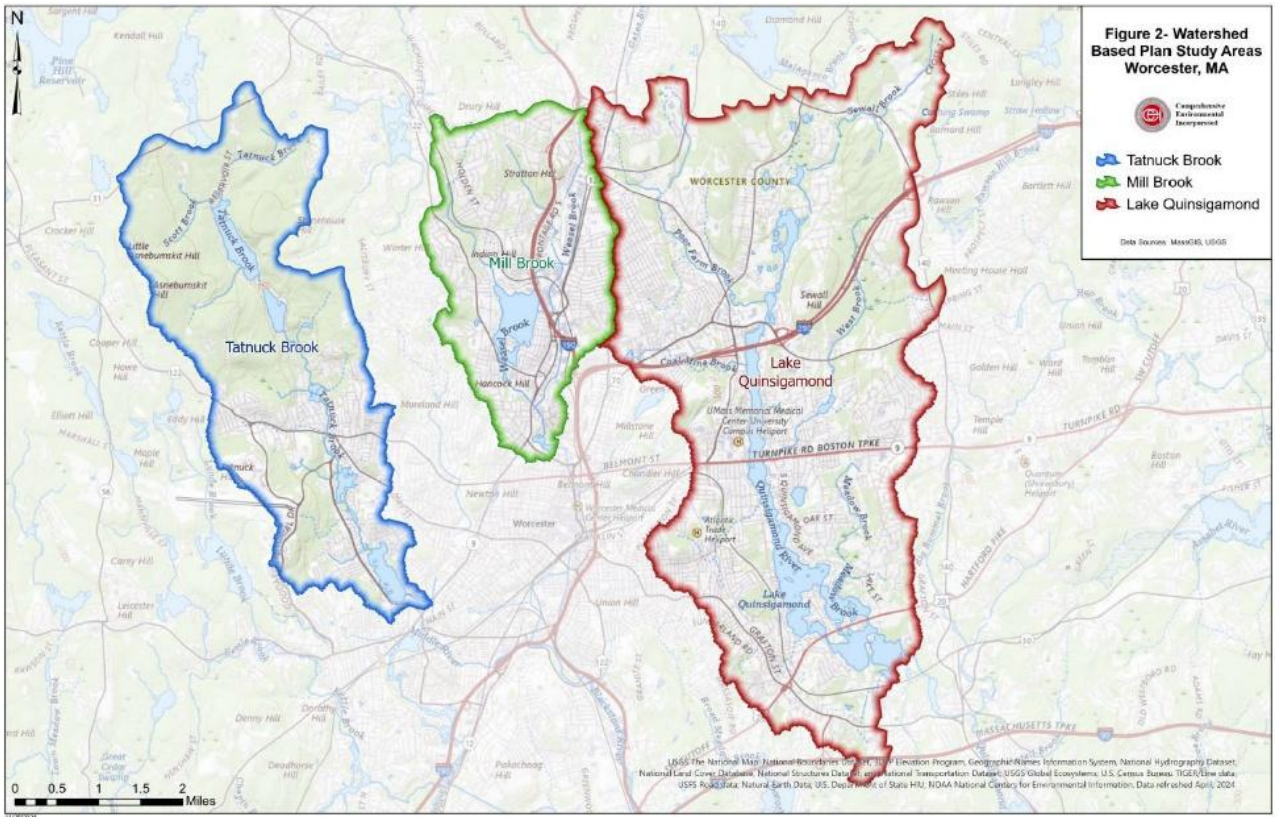


Figure 23 – *The Lakes and Ponds Program has contracted a consultant to develop watershed-based plans to reduce nonpoint source pollution in the City's three main recreational sub-watersheds. This project will identify pollutant loads and load reduction targets and provide stakeholders with a roadmap to restoration and protection. Image credit: Comprehensive Environmental Inc (CEI).*

Stormwater Infrastructure Improvements. In 2024, L&P leveraged funding from the American Rescue Plan Act (ARPA) to contract the installation of two particle separators in stormwater drainage lines discharging into Lake Quinsigamond. Particle separators are units installed in the stormwater system which typically use either chambered systems or swirl concentrators to trap and remove sediment from stormwater. The retained sediment is removed from the separator through periodic maintenance, reducing sediment and nutrient input into waterbodies. The improvements are scheduled for completion in 2025.

Volunteer Invasive Species Removal. In 2024, the Lake Quinsigamond Watershed Association (LQWA) and a Girl Scout Gold Award candidate organized several hand pulling events to remove Water Chestnut from two portions of the lake (see Figure 24). L&P supported the events and facilitated the loan of City of Worcester Parks Division kayaks. Volunteers worked from kayaks and small boats to clear patches of Water Chestnut and slow its spread in June and July. Two events were held at Gauch Park and one at Sunset Beach. Although Water Chestnut generally requires years of targeted management to fully eradicate, these efforts are invaluable to limiting spread on a season-to-season basis, especially as the infestation at Lake Quinsigamond is in its early stages. In 2025, L&P will continue to support or organize volunteer removal events.

Figure 24 *– Volunteers pulling invasive Water Chestnut in Lake Quinsigamond at an event organized by LQWA and a Girl Scout Gold Award candidate.*

Education and Outreach

Text Message Alert System. In 2023, the Lakes and Ponds Program launched a text message alert system allowing residents to sign up to receive up to date information on lake access to guide upcoming visits. Text messages will alert residents to when a beach is closed for fecal bacteria exceedances, or if a boat ramp is closed because a lake is receiving an invasive aquatic plant treatment. Especially since many lake goers use public transportation to access waterbodies, L&P aims to provide a resource that can help to guide plans before people begin travel. The Lakes and Ponds Program will continue to work with DCR and LQC to establish a flow of information to keep the notifications up to date.

Educational Programming. Since its inception, the Lakes and Ponds Program has partnered with groups such as local schools, Mass Audubon, the EcoTarium, Worcester JCC, and local watershed associations to provide educational programming in which students learn about water quality issues that affect recreation on our waterways and get hands-on experience in environmental monitoring methods.

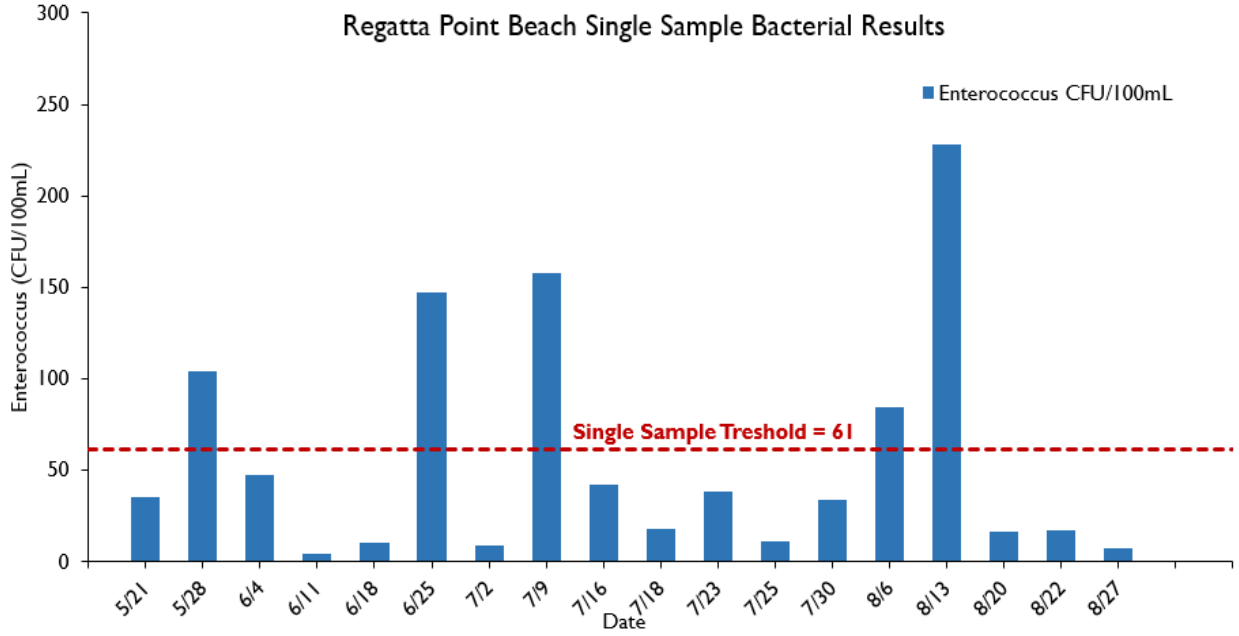
The Lakes and Ponds Program is looking to expand opportunities for educational field trips. If you are affiliated with a school and would like to discuss holding a program together, please email us at greenworcester@worcesterma.gov.

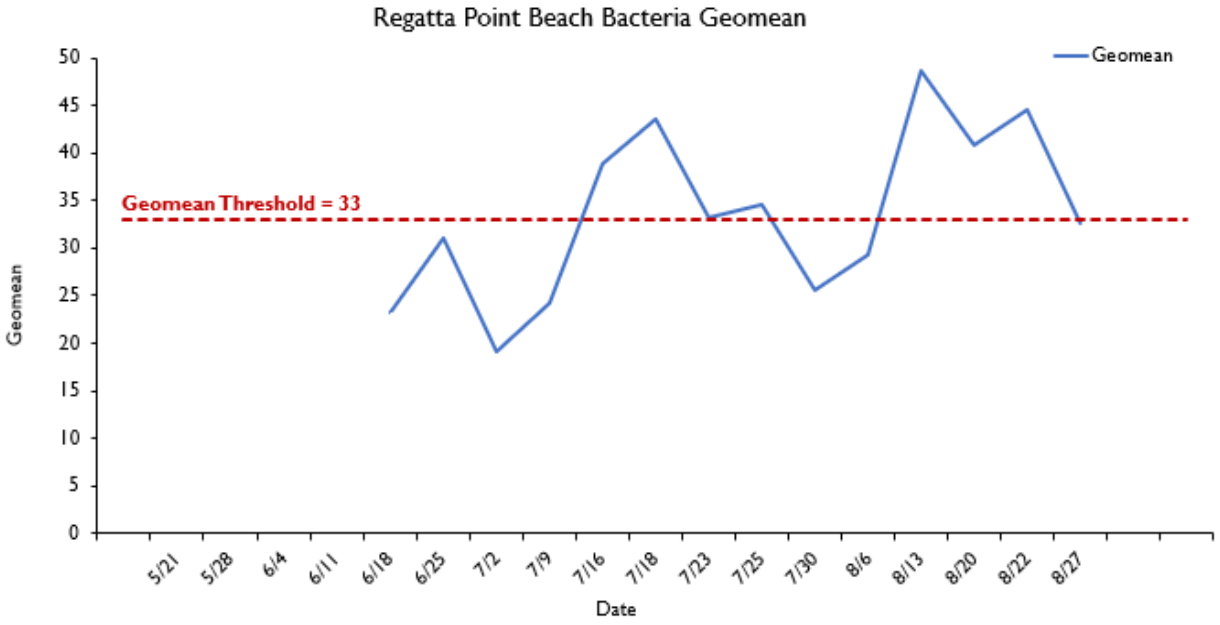
Litter. Inappropriately disposed waste is harmful to the ecological, aesthetic, and recreational value of waterbodies. In 2024, DSR began work on a Zero Waste Master Plan that will provide a comprehensive strategy for understanding and mitigating the impact of waste in our community. Lakes and Ponds Program will collaborate with DSR staff on ways to reduce impact of waste and litter in our lakes and ponds.

To learn more about Lakes and Ponds Program offerings, please see WorcesterMA.gov/bluespace.

Appendix A

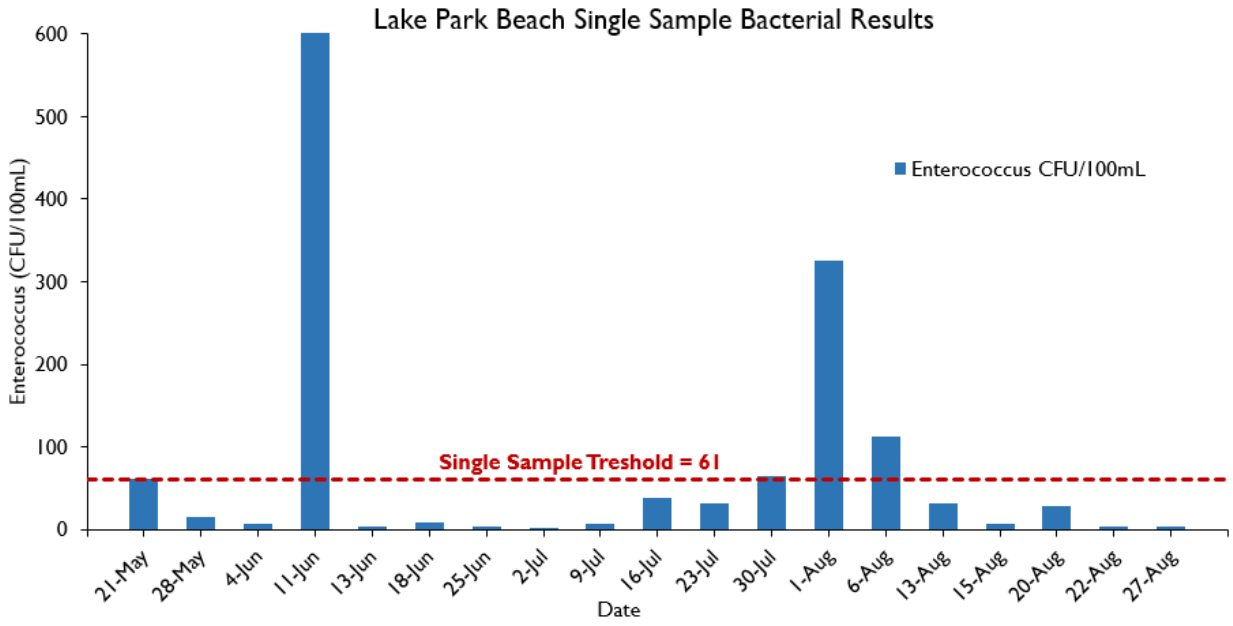
DCR Regatta Point Beach Bacteria Results

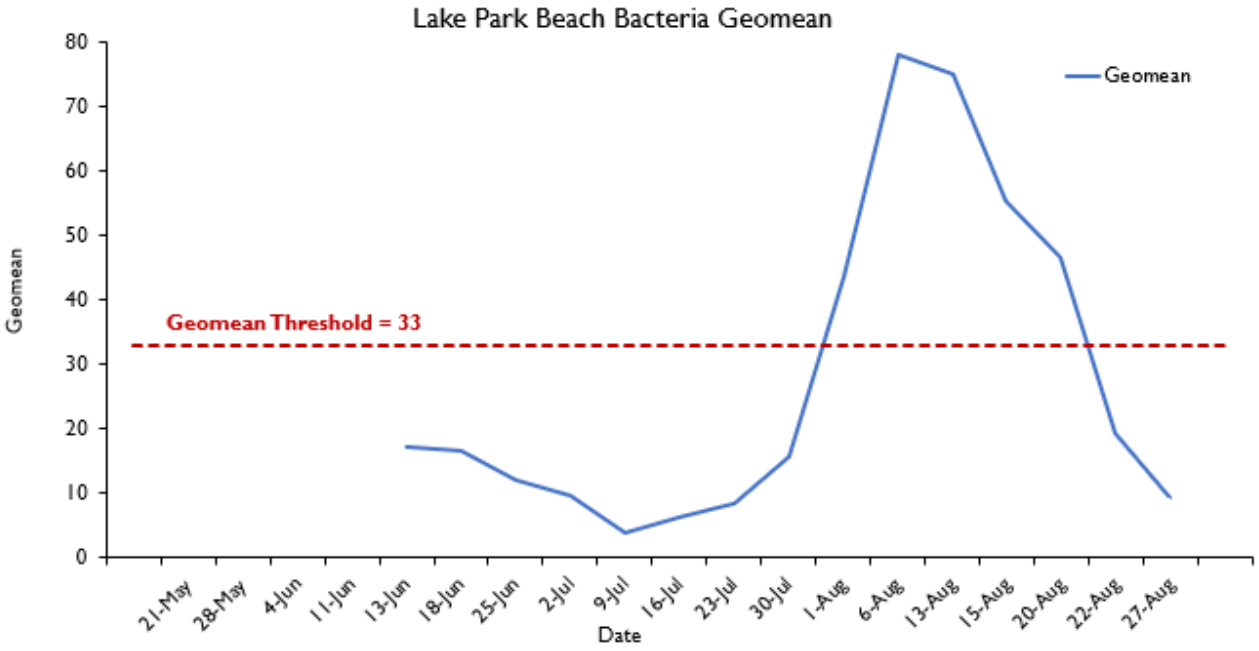




Appendix A

DCR Lake Park Beach Bacteria Results

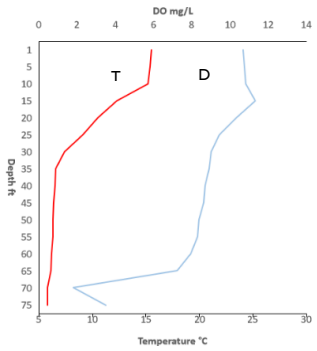




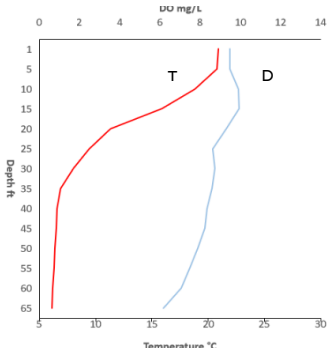
Appendix B

Depth Profiles Southern Site

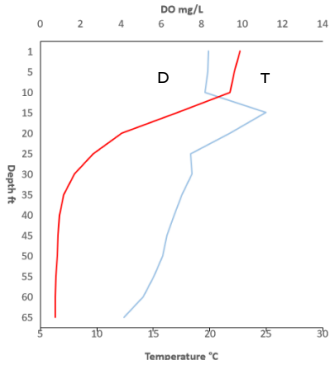
May 9



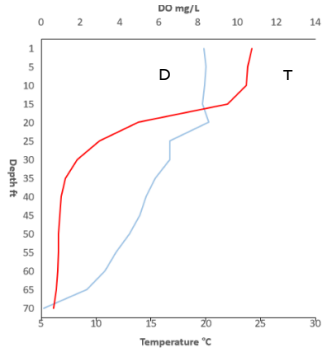
May 22



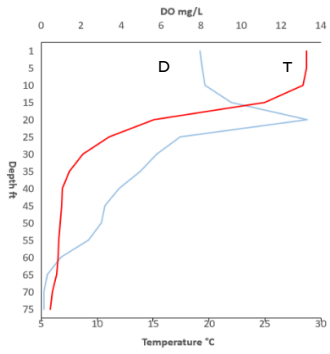
June 12



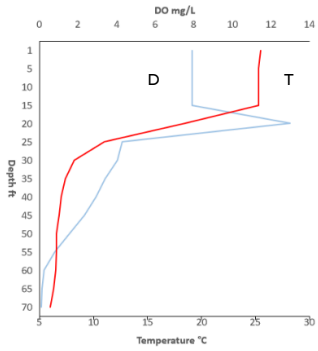
July 2



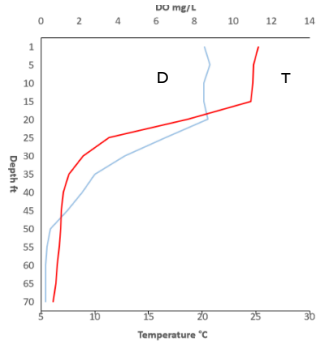
July 18



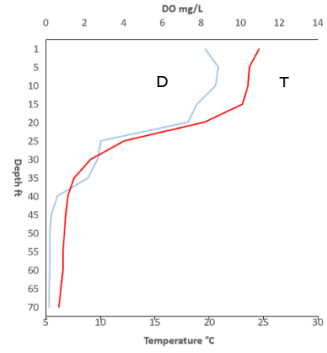
July 31



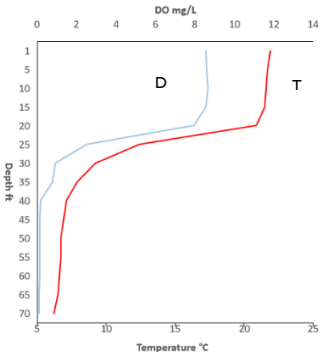
August 14



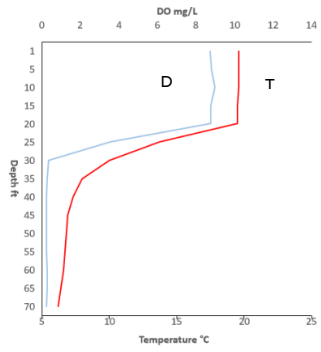
August 27



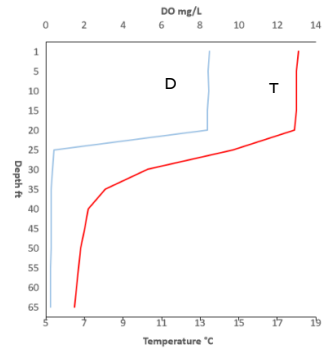
September



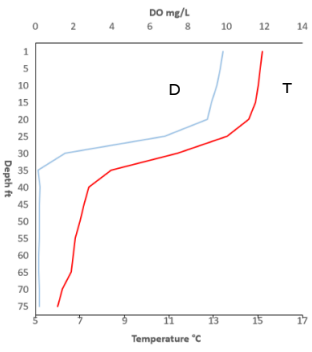
September



October 9



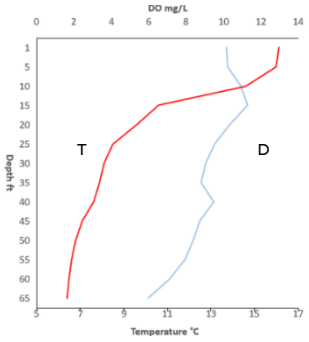
October 24



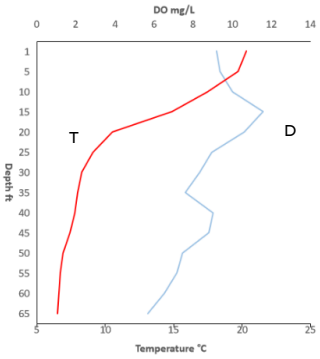
Appendix B

Depth Profiles Northern Site

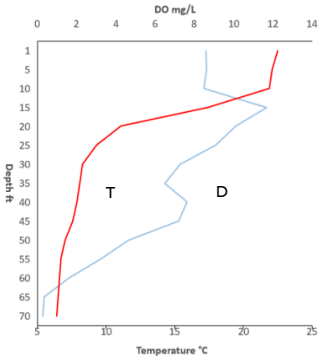
May 9



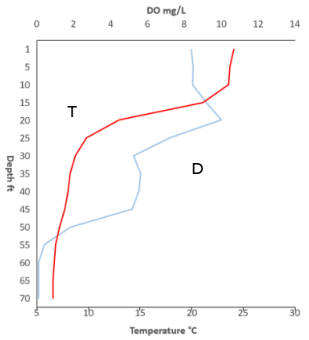
May 22



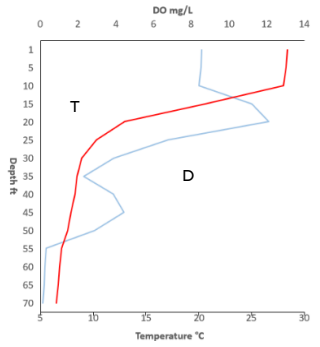
June



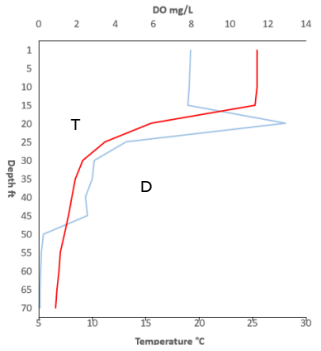
July 2



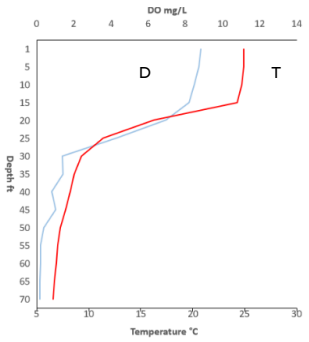
July 18



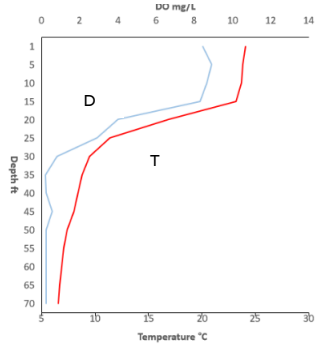
July 31



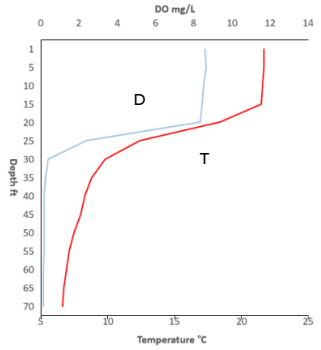
August 14



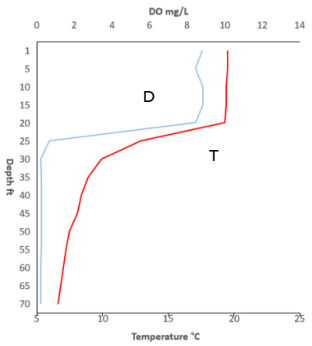
August



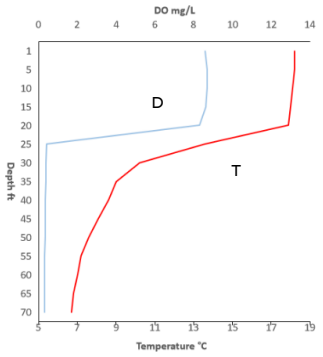
September



September



October 9



October 24