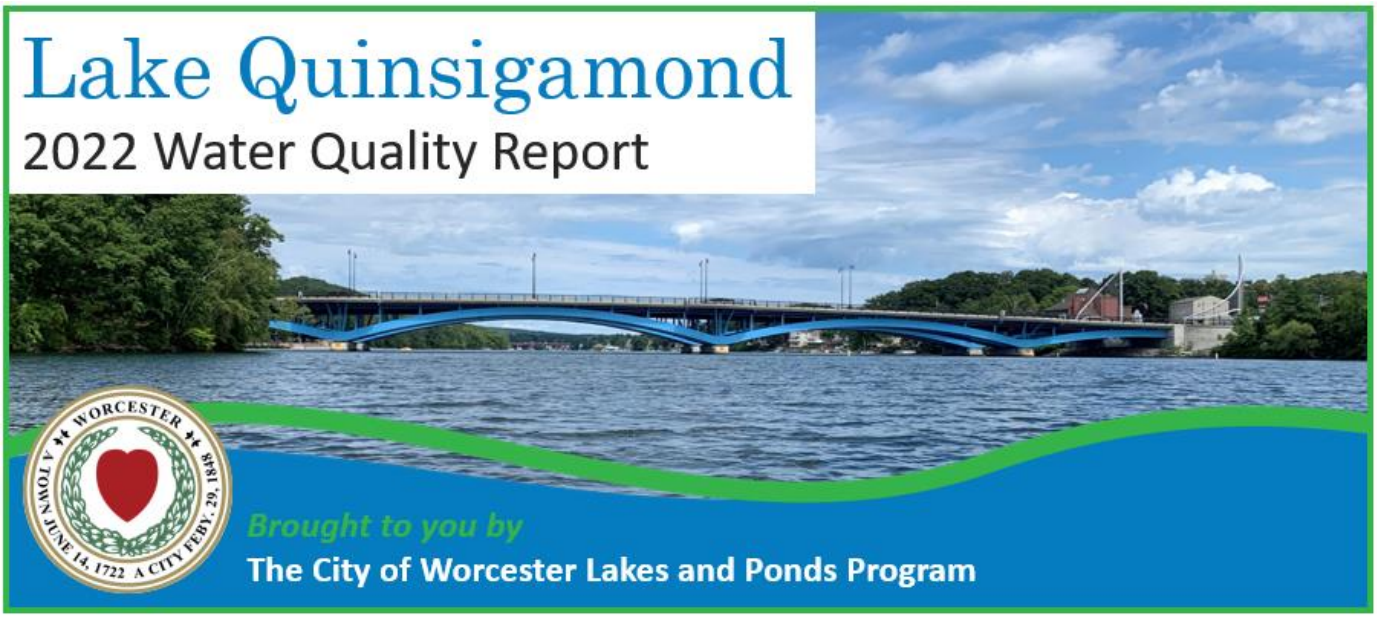


Background

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 generally managed as one system, given the direct flow between them. The waterbody has a maximum depth of 90 feet, and a water residence time of about 6 months The Commonwealth 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 7 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, hosting rowing, sailing, swimming, fishing, water skiing, jet 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 a boat ramp on the eastern shore. Management of the lake is shared by the City of Worcester, the Town of Shrewsbury, the Town of Grafton, and the Lake Quinsigamond Commission. The lake is stocked with rainbow, brown, and brook trout by MassWildlife in the spring and fall. 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, Tiger Muskellunge, Yellow Perch, White Perch, Black Crappie, and Bullhead.

The following report details the results of a collection of water quality monitoring programs in 2022, as well as the exciting projects and opportunities the City of Worcester's Lakes and Ponds Program (L&P) intends on implementing in 2023.

Water Quality Summary

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), a "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 transparency of below 4 feet, which is both an ecological health and human recreational safety concern. Additionally, the lake is host to at least six invasive aquatic plants, including Eurasian Milfoil (*Myriophyllum spicatum*), Variable Leaf Milfoil (*Myriophyllum heterophyllum*), Fanwort (*Cabomba carolinianais*), 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. As of 2021, the overall state of Lake Quinsigamond was considered "Good". Oxygen stress was still a concern in the deeper areas. Beach closures at the state-run beaches continued to be a challenge. However high fecal bacteria indicator concentrations seemed to be isolated to specific shoreline areas and bacteria in the middle of the lake were generally low. Clarity in the lake was lower than usual, and while no cyanobacteria blooms were observed, elevated cyanobacteria cell counts were present around the beach areas in the summer months. Thankfully, these results did not reach levels dangerous to humans or wildlife.

In 2022, Lake Quinsigamond again received a score of "Good". While there was still oxygen stress in the deeper areas of the lake, it was not extraordinary, even with higher water temperatures. The beach at Regatta Point was closed 32 times due to fecal bacteria exceedances, while the beach at Lake Park did not have any closures. Fecal bacteria were not a concern in open water during the sampling season. Water clarity did decrease in 2022 over 2021. Cyanobacteria indicators did not suggest that there were any challenges with blooms during the bathing season, but come fall, cyanobacteria containing scums were identified by residents earlier than usual. 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.

Two events of note in regard to water quality in 2022 include the Lake Ave Sewage Pump Station Overflow, which occurred in early February of 2022, which released 5.75 million gallons of untreated sewage into the lake just south of Route 9, as well as the continued sediment releases through the Route 9 outfall from construction activity off of Belmont Street. These events will be described further later in this report.

Management Summary

Management activities at Lake Quinsigamond include Aquatic Plant Management by the Lake Quinsigamond Commission (LQC) and Nutrient Management by L&P. The Lake Quinsigamond Commission (LQC) began to implement an invasive aquatic plant management plan in 2018 in order 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, as well as chemical treatment with herbicides, though these treatments are complicated by the presence of an endangered pondweed 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 summer of 2022.

In order to address concerns of nutrient and sediment loading, the City of Worcester installed a stormwater treatment device called a best management practice (BMP) near the lake in 2020 (see *Figure 1*). Located on the shore of the lake below the road near Coal Mine Brook, water enters what on the surface looks like a traditional rain garden, but is built on top of an underdrain system and substrates to improve filtration of the stormwater before it enters Coal Mine Brook. An educational sign is posted at the BMP so that hikers on the East-West Trail, which begins at the site, are able to learn more about the system. We hope that this will be another step to address nutrient loading and sedimentation issues from stormwater at this site, and raise awareness about these issues throughout the watershed.

Figure 1 *– A stormwater biofiltration unit near Coal Mine Brook targets sediment and nutrient loading to the Lake.*

Sampling Analysis and Overview

Lake Quinsigamond was visited semimonthly 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 one foot below the surface of the water ("surface"), and two feet abovethe bottom of the lake ("bottom"). Parameters evaluated included: Secchi transparency, temperature, dissolved oxygen (DO), pH, total phosphorus (TP), total dissolved phosphorus (TDP), and *Escherichia coli* (*E. coli*.), total suspended solids (TSS), ammonia (NH_3), and nitrate (NO_3) were sampled monthly, and lake profiles were performed for temperature, pH, and dissolved oxygen. Altogether, there were 12 sampling events over

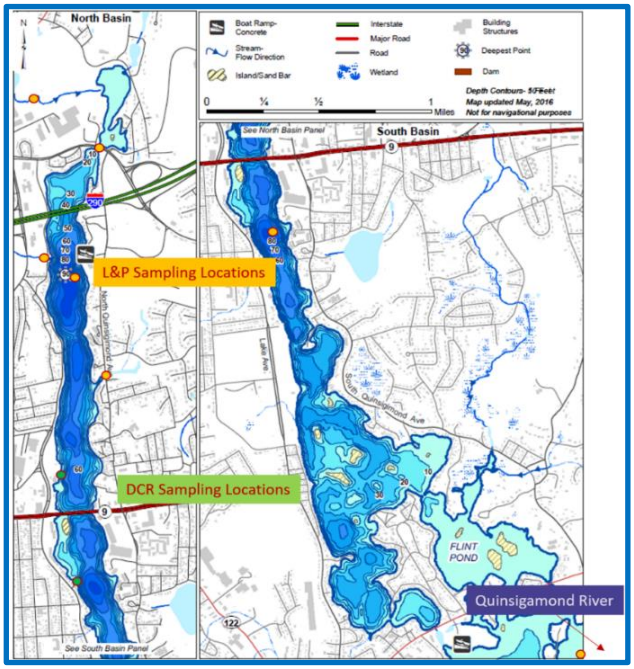


Figure 2 *– Lake Quinsigamond map and approximate sampling locations*

24 days as all routine sampling events were split between two consecutive days. For 20 of the visits there were less than 0.25 inches of rain in the 24 hours prior to sampling. However, on 28-Jun there were 0.40 inches of rain in the 24 hours prior to sampling, on 23-Aug there were 0.58 inches, on 24-Aug there were 0.92 inches, and on 26-Oct there were 0.43 inches. These days are categorized as "wet weather" and denoted with the symbol  .

In addition, the Massachusetts Department of Conservation and Recreation (DCR) tested the two beach areas for *Enterococcus* as an indicator of fecal bacteria on a weekly or twice-weekly basis during the summer months. Volunteers from the Worcester Cyanobacteria Monitoring Collaborative (WCMC) collected samples from the city beach area for phycocyanin and relative cyanobacteria density analysis to assess bloom risk. Samples were taken twice monthly between May and October, on 21-May, 6-Jun, 18-Jun, 5-Jul, 16-Jul, 1-Aug, 12-Sep, 24-Sep, and 3-Oct.

Raw data are displayed and explained in this report. No statistical analysis has been performed. Subsequent 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 strives to have a robust data set. L&P therefore uses Quality Assurance/Quality Control checks to ensure that data are representative of local conditions and meet precision and accuracy standards. Review of QAQC check results identifies data that need to be flagged and/or censored before they are shared and can highlight issues that affect data quality. When data failed to meet acceptable criteria for these checks, they were 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.

Fecal Bacteria

Recreational contact with water contaminated by certain fecal bacteria may cause illness. *Enterococcus* are a type of bacteria found in the digestive tract of warm-blooded animals including geese, pets, and humans. While most strains are harmless, some can make you very sick. 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. The DCR collects samples for another fecal bacteria indicator, *Enterococcus* weekly at the public beaches at Lake Park and Regatta Point during the swimming season to ensure that the water is safe for direct contact, closing beaches if the results are above the recreational threshold. L&P collects samples for *E. coli* at the surface of certain in-lake sites during all sampling events to assess *E. coli* conditions in open water. Samples are sent to an external lab for analysis.

Fecal Bacteria at Lake Quinsigamond.

In 2022, DCR tested for *Enterococcus* bacteria at the Lake Park beach 15 times, resulting in no closures (see *Table 1*). Regatta Point was tested 21 times and was closed on four occasions for a total of 32 days (see *Table 2*). Even though closures due to fecal bacteria limited recreation at Lake Quinsigamond, there were fewer closures than in 2021 and many past years. This may have been in part due to fewer rain events washing goose droppings from beaches into the water. As witnessed in the past, even when there are closures near the shore, bacteria do not seem to be present in the middle of the lake. *E. coli* samples collected by L&P at the northern site ranged between 1 and 81 colonies/100 ml with most below 24 colonies/100 ml, or in the range considered "Excellent" (see *Table 3*). This is likely because fecal bacteria are not able to live long outside of a warm-blooded creature. In 2022, L&P rates bacteria at Lake Quinsigamond "Good".

Lake Park	
24-May	11 MPN
31-May	5 MPN
7-Jun	33 MPN
14-Jun	2 MPN
21-Jun	7 MPN
28-Jun	23 MPN
5-Jul	10 MPN
12-Jul	57 MPN
19-Jul	24 MPN
26-Jul	3 MPN
2-Aug	29 MPN
9-Aug	11 MPN
16-Aug	4 MPN
23-Aug	12 MPN
30-Aug	50 MPN

Regatta Point	
24-May	3 MPN
31-May	23 MPN
7-Jun	31 MPN
14-Jun	6 MPN
21-Jun	11 MPN
28-Jun	15 MPN
5-Jul - 7-Jul	411 MPN - 14 MPN
12-Jul - 14-Jul	727 MPN - 365 MPN
19-Jul	86 MPN
26 Jul - 28 Jul	26 MPN - 31 MPN
2-Aug - 4 Aug	20 MPN - 20 MPN
9-Aug	36 MPN
16-Aug	2 MPN
23-Aug - 25-Aug	>2420 - 9 MPN
30-Aug - 1-Sep	345 MPN - 249 MPN

MPN = Most Probable Number

Table 1 (above left) *– Lake Park Beach was sampled 15 times for Enterococcus bacteria in 2022, leading to no closures.*

Table 2 (above right) *– Regatta point beach was sampled 21 times by DCR and was closed for 32 days due to fecal bacteria exceedances. Black text indicates days with no lake closure. Red text indicates days in which fecal bacteria exceedances prompted lake closure. Green text indicates lake re-opening.*

Table 3 (right) *– Results of samples taken in open water for E. coli remained low, not causing concern.*

E. COLI (col/100ml) AT Northern Site	
DATE	RESULT
12-May	1
25-May	3
15-Jun	1
29-Jun	4
13-Jul	3
27-Jul	13
10-Aug	23
24-Aug	81
13-Sep	12
28-Sep	7
12-Oct	4
26-Oct	11

Water Clarity

Water clarity is a measure of the transparency of water. Algae, microscopic organisms, eroded particles, and re-suspended bottom sediments are 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 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 were 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 were taken monthly and submitted to an external lab for analysis.

Water Clarity at Lake Quinsigamond. Water clarity at Lake Quinsigamond is considered generally higher than other area lakes. In 2022, Secchi depth at the northern and southern in-lake sites ranged between 6.75 feet and 17.00 feet, with most results falling between 4 and 10 feet, or in the range considered, "Fair" (see *Figures 3 and 4*). The season's highest recorded Secchi depth for each site was observed on 29-Jun, from which point most readings were in the "Fair" range. Surface TSS results at the northern and southern sites were consistently low, ranging between below the laboratory reporting limit and 3 mg/l, and were within the range considered "Excellent". At the bottom of the Northern Site TSS results were similar, ranging between 2 and 4 mg/l. However, at the bottom of the southern site, there were three higher results, between 10 and 25 mg/l, or in the range considered "Good", toward the end of the sampling season, in the fall. L&P rates water clarity at Lake Quinsigamond at "Good" for 2022.

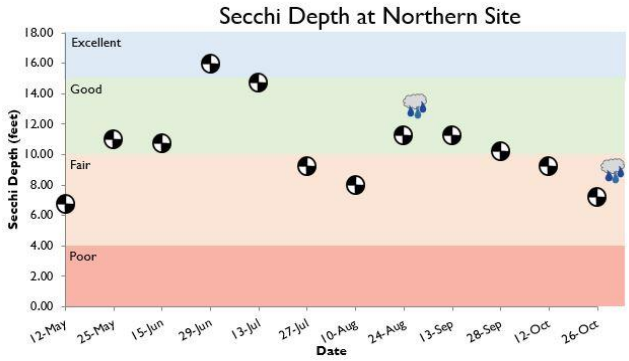


Figure 3 - *Secchi depth ranged from the "Good" to "Fair" categories with depths of 6.75-16 feet.*

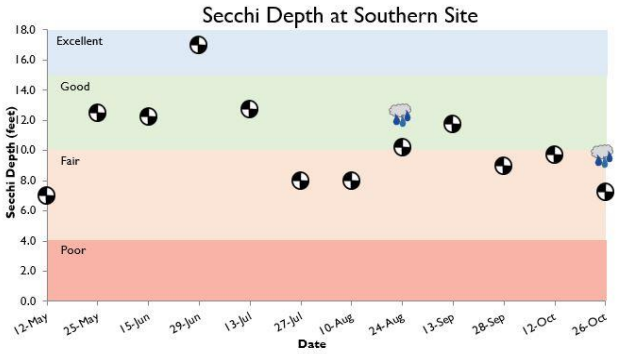


Figure 4 - *Secchi depth was overall "Good" to "Fair" ranging from 7-17 feet.*

Temperature and Stratification

Water temperature is important to both the biological activity and water chemistry in a lake. Many organisms prefer to live in a narrow temperature range, making understanding temperature across the area and depth of a water body essential. Water temperature affects the speed of chemical reactions in addition to how much oxygen can be held in the water. The extent to which water circulates through a lake affects the ability of that water to support aquatic life by mixing oxygen and nutrients up and down 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. While a natural process, stratification can create a physical barrier that prevents the replenishing of oxygen on the bottom layers of the lake, and the rise of sediment 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 are taken 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 13.4°C and 28.3°C, following the expected seasonal distribution (see *Figures 5* and *6)*. Maximum recorded temperature for the season was observed at each site on 10-Aug; 28.3°C at the northern site and 28.1°C at the southern site, right at the edge of what is considered "Poor" for water temperature. Surface water temperature in 2022 was on average about 0.9°C warmer than in 2021. As Lake Quinsigamond experiences stratification during the summer months, temperatures on the bottom of each site were relatively stable, ranging between 2.1°C and 7.0°C, in the range considered "Excellent". However, this data must be observed with caution because difficulties with the long probe cable that allows for deep readings to be taken at these sites, made us unable to collect temperature data on the bottom of the lake after 24-Aug.

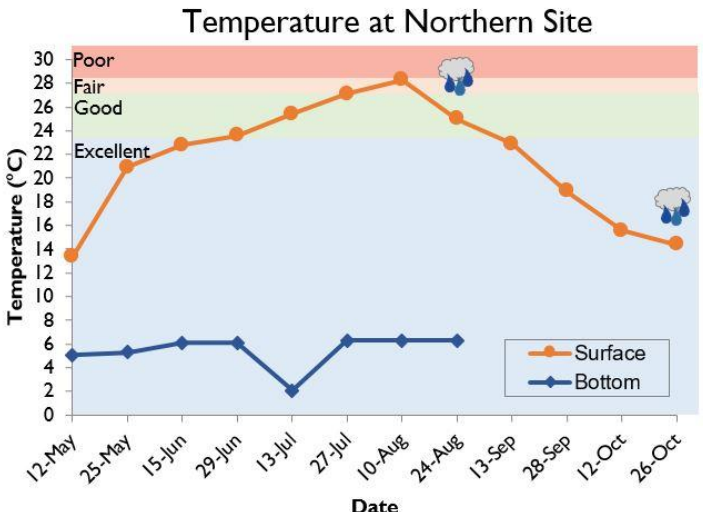


Figure 5 *- Bottom temperature was consistently 6°C or below. Surface temperature steadily increased until early August, reaching 28°C before beginning to decrease.*

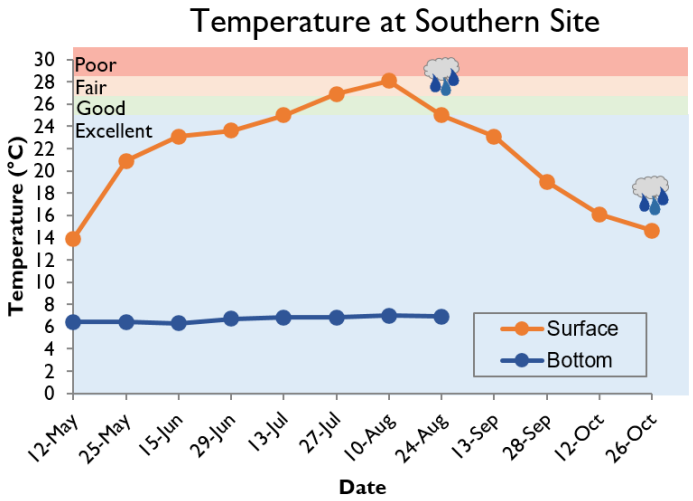


Figure 6 *- Bottom temperature was consistently near 6°C. Surface temperature steadily increased until the early August, reaching 28°C before beginning to decrease.*

To determine the extent of warming throughout the entire water column, depth profiles were taken at each site (see *Appendix*). During the season's first readings in May, the temperature difference was relatively small between the surface and bottom of the lake, only 7.4 °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 water below, creating what is known as a thermocline, and preventing the mixing of oxygen to the water at the bottom. Due to equipment issues temperature readings were only taken down to 65 ft after 15-Jun. 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 September. From early October through late November, the surface temperature dropped and the thermocline became less extreme, leading to greater mixing of the lake's water. While no fish kills were reported at this time, L&P will continue to monitor the temperature and DO dynamics. Given the interaction of water temperature and DO reducing viable habitat for cold water fish, L&P rated Temperature at Lake Quinsigamond in 2022 as "Good".

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 causing stress to aquatic organisms. 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, 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.

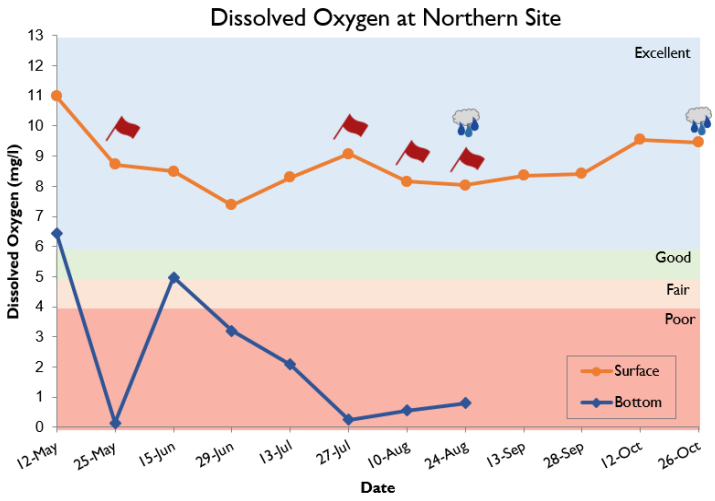


Figure 7 *- DO stayed in the "Excellent" rating category at the surface all season and was generally in the "Poor" category at the bottom of the lake, demonstrating anoxic conditions.*

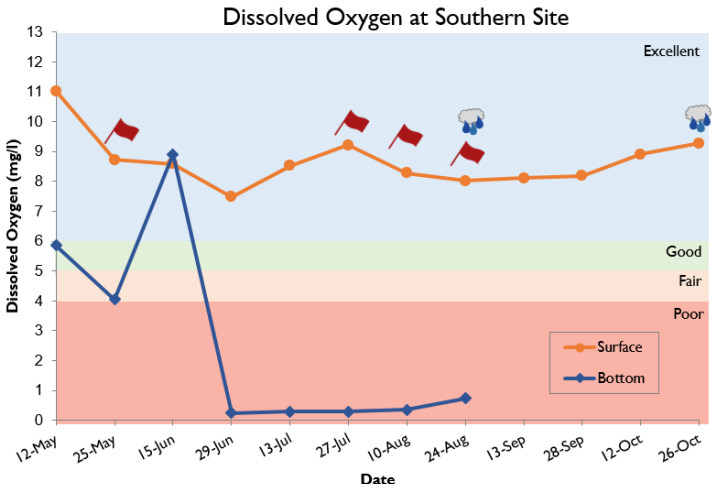


Figure 8 *- DO stayed in the "Excellent" rating category at the surface during all sampling events and was generally in the "Poor" category at the bottom.*

Dissolved Oxygen at Lake Quinsigamond. Surface DO at the in-lake sites ranged between 7.4 and 11.0 mg/l, consistently within the range considered "Excellent" (see *Figures 7* and *8)*. On the bottom DO ranged between 0.0 and 8.9 mg/l with readings above 4 mg/l common early in the season. After 29-Jun , all deep DO readings were below 4 mg/l, or hypoxic, as the lake became stratified. It is notable that difficulties with the long probe cable that allows for deep readings to be taken at these sites, made it unable to collect DO data on the bottom after 24-Aug.

To determine the depth in the water column where oxygen depletion occurs, lake profiles were taken and DO readings were measured at 5-foot intervals and plotted with temperature. At the beginning of the

season, the entire water column was uniformly oxygenated (see *Appendix*). In late June, DO at the bottom of the lake began to decrease, and the depth of this decrease became shallower as the season went on, even as the surface of the water had sufficient oxygen for fish and wildlife. Unfortunately, an equipment failure on 18-Sep made us unable to collect DO readings below 25 feet for the rest of the season. However, as DO dynamics are linked closely to temperature, it can be assumed that DO depletion in the deeper areas of the lake lessened as the thermocline became less extreme, allowing for more mixing throughout the water column. A new probe cable has been purchased for the 2023 season, which will allow for resumed sampling in the deepest areas of the lake.

Temperatures above 20°C and DO below 4 mg/l can put stress on cold water fish such as trout. When faced with these scenarios, fish will swim to an area with lower temperatures or higher DO. During the height of summer, surface water temperatures increase in the top layer of the water, eventually to above 20°C. This also leads to increased thermal stratification, which reduces the oxygen mixing into the lower portions of the lake. Oxygen depletion begins at the bottom of the lake and low oxygen conditions extend into the higher portions of the water column as the summer goes on. This reduces the preferred habitat zone for cold water fish smaller until it no longer exists in a phenomenon known as “the squeeze”, increasing the risk of fish kills.

In 2022 there were two sampling days in which there was no portion of the water column that satisfied both the 4mg/l DO requirement and the 20°C temperature requirement at both sampling sites: on 24-Aug and on 13-Sep. After that point, surface temperatures cooled quickly in the upper portions of the water column and opened up more preferrable habitat close to the water’s surface. Thankfully, even with this theoretically stressful situation, no fish kills were noted on Lake Quinsigamond in 2022. Although drought conditions and high surface water temperatures occurred, there were fewer instances of this situation than in 2021. L&P rated DO as “Fair” in 2022.

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 were 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 7.3 and 8.7 (see *Figures 9* and *10*). pH at the bottom was always lower than the surface. However, a combination of difficulties with the long probe cable and two instances in which data had to be censored only left 5 viable data points out of the planned 12, so it is difficult to draw conclusions from the limited set of data from the bottom of the in-lake sites.

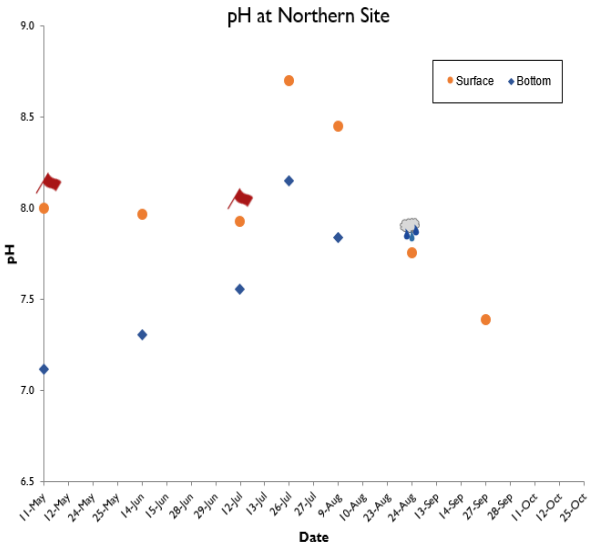


Figure 9 *- Bottom pH ranged from 7.1-8.2. Surface pH ranged from 7.4-8.7.*

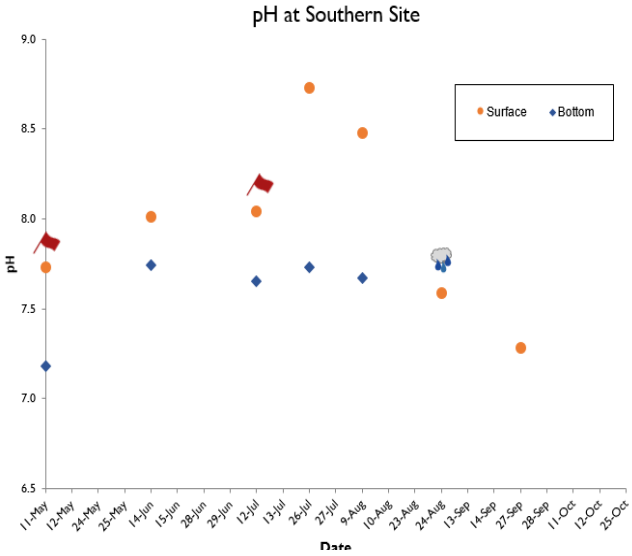


Figure 10 *- Bottom pH ranged from 7.2-7.7. Surface pH ranged from 7.3-8.7.*

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, P 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 collected samples for several compounds and submits them to an external lab for analysis. To measure N, samples were collected for nitrate (NO_3) and ammonia (NH_3) at all sites monthly. As extensive issues were noted with QAQC checks performed by Alpha Analytical Laboratory, the data collected for NH_3 were not considered suitable for inclusion in this report. To measure P, samples were collected for total phosphorus (TP) twice a month at all sites, and total dissolved phosphorus (TDP) twice a month at all bottom sites. TDP was also analyzed to understand how much P is dissolved in the water and available for use by aquatic organisms.

Nutrients at Lake Quinsigamond. Surface TP at the two in-lake sampling sites was generally very low, at or below the laboratory reporting limit of 0.010 mg/l (see *Figures 11* and *12*). Bottom TP concentrations increased over the course of the season, with the highest results on the final sampling event, 26-Oct, at 0.408 mg/l at the southern site. Bottom TP was generally higher at the southern site, with an average value of 0.166 mg/l over the course of the season compared to 0.043 mg/l at the northern site. TDP results from bottom samples ranged between below the laboratory reporting limit and 0.205 mg/l. The southern site also exhibited higher TDP concentrations than the northern site. While TP at the surface was generally very healthy, L&P will continue to monitor phosphorus concentrations at the bottom of the lake.

Surface NO_3 results at both in-lake sites consistently fell below 0.6 mg/l and were in the range considered "Excellent". The same was true for the bottom samples except for one result at the northern site that fell in the category considered "Good".

Cyanobacteria

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

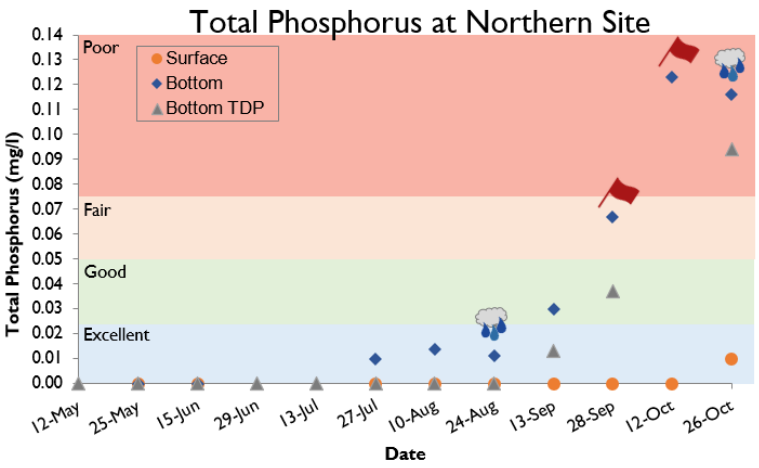


***Figure 11** - TP results at the surface primarily fell in the "Excellent" category. Bottom TP increased in concertation and reached the "Poor" category by the end of the season.*

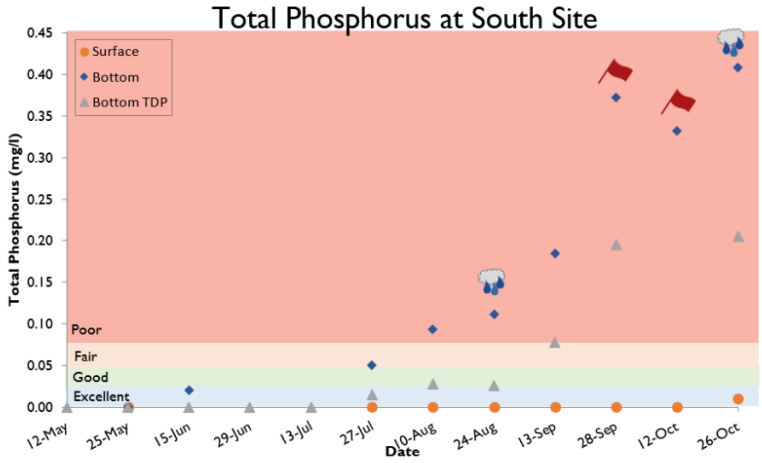


***Figure 12** - TP results at the surface primarily fell in the "Excellent" category. Bottom TP increased in concertation and reached the "Poor" category by the end of the season, with concentrations reaching higher levels than at the northern site.*

To understand the abundance of cyanobacteria and make decisions regarding lake management and safe access, L&P utilized 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 collected water quality samples twice monthly between May and October at 24 waterbodies in and around Worcester, including Bell Pond. Parameters examined included 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 was also able to determine relative density of cyanobacteria genera in samples using a high-powered microscope. Using both phycocyanin and comparative cyanobacteria density the WCMC began to assign 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 near the Regatta Point swimming area, just north of the Route 9 bridge. Over the course of the 2022 season, phycocyanin was detected 4 of the 8 sampling sessions but never exceeded 50 ug/l, the concentration that would indicate bloom conditions (see *Figure 13*). Phycocyanin concentration was generally higher in the second half of the season, with the highest result approaching the level indicative of a bloom during the last sampling session in late October. Cyanobacteria relative density, or the relative abundance of cyanobacteria compared to other organisms, ranged between "low" and "high", with the highest density during the last sampling session. Several genera of cyanobacteria were observed including, *Dolichospermum*, *Microcystis, Woronichinia,* and *Aphanizomenon,* as well as *Microcystis* debris. This led to overall bloom and toxin exposure risk increasing over the course of the season from "almost none" to "low", and finally "elevated" in October.

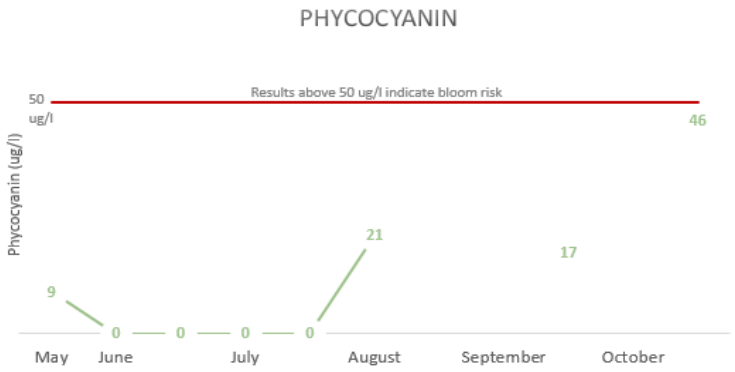


Figure 13 *- Phycocyanin measured in samples collected by the WCMC was low until the end of the season when it reached 46 ug/l.*

Due to Lake Quinsigamond's depth and tendency for thermal stratification and limited mixing until lake turnover, cyanobacteria blooms generally occur until late fall and early winter, when there is limited recreation on the lake. However, in 2022, reports of ephemeral scums throughout the southern portion of the lake were received by L&P earlier than usual, in late-October.

As Lake Quinsigamond is a large and complicated system, and the Lakes and Ponds Program's staffing is limited, tracking these reports 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 2022.

Tributaries

Tributaries 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 can give us hints about where certain impairments in the lake are originating. Outlets are the major exits for water in the lake. Most of the abovementioned water quality parameters were measured at the major natural tributaries and outlets of the lakes in the Worcester Lakes and Ponds Water Quality Monitoring Program.

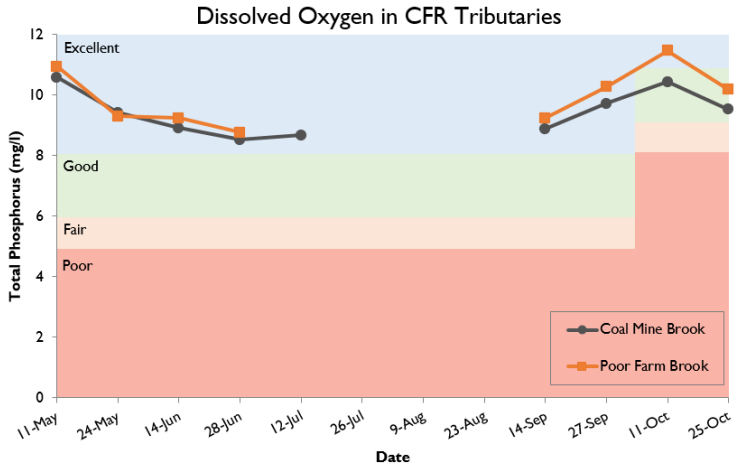


Figure 14 *- DO was above 8 mg/l in CFR streams for the entire season. During the Summer months, this was considered "Excellent".*

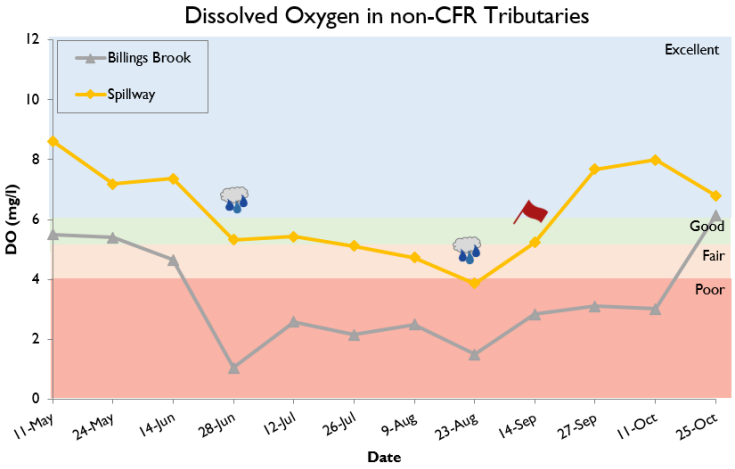


Figure 15 – *DO was in the "Fair" and "Poor" rating category for at the Spillway and Billings Brook for most of the season.*

Tributaries at Lake Quinsigamond. At Lake Quinsigamond, three tributaries were sampled: Poor Farm Brook and Coal Mine Brook in Worcester, and Billings Brook in Shrewsbury. The outlet of the Flint Pond at the Irish Dam in Grafton was also sampled. Coal Mine Brook and Poor Farm Brook are designated Coldwater Fisheries Resource (CFR), which is a special designation given to waterways that support cold water fish species, such as trout. These fish require higher quality water than warm water species.

In 2022, the central region of Massachusetts experienced drought conditions between May and September. A Level 3 Critical Drought was declared from July through August. Given the reduced rainfall and high temperatures, the tributaries, Coal Mine Brook and Poor Farm Brook did not have enough water to sample for 3 and 4 sampling events respectively. While this phenomenon has occurred in past years, it did not occur in 2021. Although Poor Farm Brook has dried up for long periods in past years, 2022 marked the longest L&P has observed Coal Mine Brook with no flow.

Billings Brook and the lake outlet had a temperature range that was lower than in-lake surface sites and ranged between 10.4°C to 27.3°C throughout the season, generally in the range considered "Excellent". Only in late July did Billings Brook entered the "Fair" category for one sampling event. Coal Mine Brook and Poor Farm Brook, however, were consistently cooler than the other tributaries, ranging between 8.2°C and 19.2°C. Even with the stricter standards for CFR resources, these two streams remained in the "Excellent" and "Good" categories whenever there was water in them.

DO was consistently above 8 mg/l or whenever sampled at Coal Mine Brook and Poor Farm Brook (see *Figure 15*). During the summer months, these readings are considered "Excellent" for a CFR. However, standards are tightened during the fall, and were classified as "Good" for the last two readings of the season. All but three DO readings at Billings Brook were below 4 mg/l, or in the category considered "Poor" (see *Figure 15*). DO was generally in the "Fair" range at the Spillway.

TP at the Spillway and Coal Mine Brook was consistently low, generally always below 0.025 mg/l, or the category considered "Excellent" (see *Figure 16*). TP in Billings Brook was the highest of all tributaries, generally in the categories considered "Fair" and "Poor", even on dry weather days.

TSS at all tributaries except for Billings Brook had results consistently below 10 mg/l, or in the range considered "Excellent". TSS results at Billings Brook, on the other hand, ranged between 6 and 37 mg/l. While generally classified as "Good", these were also the highest results received at Lake Quinsigamond.

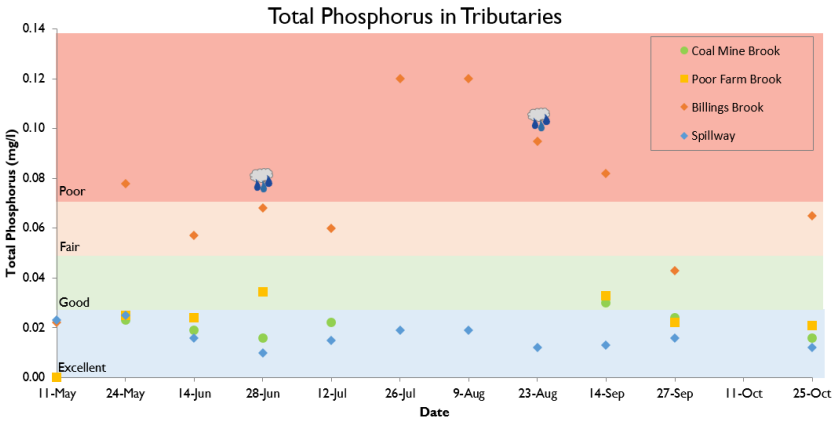


Figure 16 – *TP was generally low in tributaries and at the spillway, apart from Billings Brook, which had "Poor" results even on dry weather days.*

Invasive Aquatic Plants and Animals

Plants and animals are vital parts of any lake ecosystem. Plants provide food, shelter, and oxygen to other aquatic organisms. Their uptake of nutrients reduces the likelihood of algal blooms, and their root systems stabilize sediments. Animals play invaluable roles in food webs and their removal can disrupt the ecology of a system. 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 all available space, disrupting local ecosystems and making recreation more difficult. Invasive organisms can arrive by hitching a ride on boats, pets, or boots to get to a new location. Some are released

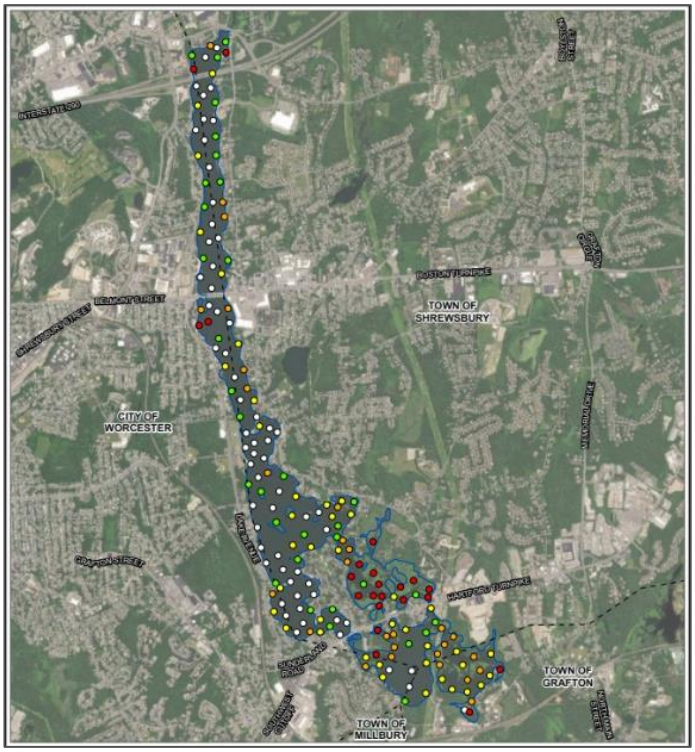


Figure 17 – *Invasive plant cover in Lake Quinsigamond as of late-summer 2022.*

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 and the Lake Quinsigamond Commission (LQC) were used to make management decisions regarding invasive species.

Invasive Aquatic Plants and Animals at Lake Quinsigamond. In 2022, an aquatic plant survey contacted by L&P updated the understanding of distribution and abundance of invasive aquatic plants in Lake Quinsigamond (see *Figure 17*). Invasive aquatic plants identified included 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*). In addition, there were 15 native plant species identified. A rare plant, Vasey's pondweed (*Potamogeton vaseyi*) was not identified in this survey, but was seen in a previous survey earlier in the summer in Old Faith Cove and Half Moon Bay. Most concerning were the Eurasian Milfoil and Fanwort, which were in high density in the southern portion of the lake and Flint Pond. Milfoil was also found along the edges of the lake along the middle and northern portion. Water Chestnut, an aggressive invasive, was also identified recently in the lake, in most abundance in the Round Pond area, but also scattered along the northern edges of the lake. An integrated management plan with cooperation from Shrewsbury, Grafton, and Worcester will be necessary to take on this challenge.

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. *Corbicula fluminea* has a small light brown or green shell and is native to Southeast Asia (see *Figure 18*). 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. They can also clog water intake valves. *Corbicula 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. Over the past few years, residents have found the shells of the *Corbicula fluminea* and have plotted their location in order to better understand the extent of the problem. However, to date, no live specimen has been collected. More information is needed to determine the threat level of the infestation.

Figure 18 *- The invasive mollusk (*Corbicula fluminea*).*

Industrial Contaminants

As a post-industrial urban center, legacy pollutants and emerging contaminants of concern from industrial processes may be present in Worcester's 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. 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. Detected

parameters are shown below. To see a full list of contaminants tested for, contact greenworcester@worcesterma.gov.

Industrial Contaminants in Lake Quinsigamond. All results for VOCs, SVOCs, PCBs, TPH, pesticides, and herbicides were below reporting limits, indicating an extremely low to no concentration. Nine metals were detected including arsenic, barium, calcium, iron, magnesium, manganese, potassium, sodium, and zinc. These metals are naturally occurring in New England soil and were not present in the water in quantities that would negatively affect human health. In several cases, metal results decreased from 2019 testing (see *Table 4).* PFAS is a class of emerging contaminants of concern, however, there are no regulations on PFAS for recreational waterways. There are drinking water regulations for six species of PFAS. The PFAS drinking water limit (also known as an MCL) is a total of 20 ng/l, as a sum of the 6 regulated species. The combined total of regulated PFAS species in Lake Quinsigamond for each day was 13.3 and 16.3 ng/l (see *Table 5*) which is below the drinking water standard and an overall decrease from 2019 results. As drinking water standards are generally much stricter than those of recreational waterways, we can assume that PFAS is not a concern for recreational users of Lake Quinsigamond.

Table 4 – *Nine metals were detected at Lake Quinsigamond in 2022. These metals are naturally occurring in regional soils and are not present in quantities that could affect human health. "ND" signifies that the compound's concentration was not detected by the lab.*

Parameter	Wet Result	Dry Result	Dry Result	Wet Result	Unit
Metals	**9/23/2022**	**9/29/2022**	**7/22/2019**	**6/13/2019**	
Aluminum, Total	ND	ND	ND	0.0151	mg/l
Arsenic, Total	0.00164	ND	0.00169	0.00144	mg/l
Barium, Total	0.01402	0.0157	0.00777	0.00823	mg/l
Calcium, Total	2.44	2.95	4.26	4.24	mg/l
Copper, Total	ND	ND	ND	0.00358	mg/l
Iron, Total	0.173	0.159	0.155	0.215	mg/l
Magnesium, Total	1.36	1.42	1.58	1.46	mg/l
Manganese, Total	0.1283	0.113	0.08391	0.1588	mg/l
Potassium, Total	1.65	ND	1.74	1.58	mg/l
Sodium, Total	68.0	76.2	83.2	80.8	mg/l
Zinc, Total	0.01437	ND	ND	ND	mg/l

Table 5 – *Several PFAS compounds were detected at Lake Quinsigamond in 2022. The totals of regulated compounds were very low and not of concern for recreational contact. "ND" signifies that the compound's concentration was not detected by the lab. "NT" signified that the compound was not tested for, as the analysis was not yet available.*

Parameter	Wet Result	Dry Result	Dry Result	Wet Result	Unit
Non-Regulated Perfluorinated Alkyl Acids	**8/24/2022**	**7/27/2022**	**6/25/2019**	**10/4/2019**	
Perfluorobutanoic Acid (PFBA)	2.89	2.8	NT	NT	ng/l
Perfluoropentanoic Acid (PFPeA)	4.07	5.65	NT	NT	ng/l
Perfluorobutanesulfonic Acid (PFBS)	3.87	3.52	3.24	2.49	ng/l
Perfluorohexanoic Acid (PFHxA)	3.51	3.82	NT	NT	ng/l
1H,1H,2H,2H-Perfluorooctanesulfonic Acid (6:2FTS)	ND	2.73	NT	NT	ng/l
1H,1H,2H,2H-Perfluorodecanesulfonic Acid (8:2FTS)	ND	8.9	NT	NT	ng/l
N-Ethyl Perfluorooctanesulfonamidoacetic Acid (NEtFOSAA)	2.88	ND	NT	NT	ng/l
Perfluorododecanoic Acid (PFDoA)	ND	2.67	NT	NT	ng/l
Perfluorotetradecanoic Acid (PFTA)	ND	2.45	NT	NT	ng/l
Regulated Perfluorinated Alkyl Acids	**8/24/2022**	**7/27/2022**	**6/25/2019**	**10/4/2019**	
Perfluoroheptanoic Acid (PFHpA)	2.16	2.8	2.04	2.06	ng/l
Perfluorohexanesulfonic Acid (PFHxS)	1.83	1.79	ND	ND	ng/l
Perfluorooctanoic Acid (PFOA)	4.92	5.65	5.51	5.19	ng/l
Perfluorooctanesulfonic Acid (PFOS)	4.39	5.89	3.58	3.79	ng/l
Total	**13.3**	**16.13**	**11.13**	**11.04**	**ng/l**

Litter

Litter, or inappropriately disposed waste, is harmful to the ecological, aesthetic, and recreational value of lakes and ponds. Improperly discarded plastic and Styrofoam products can be mistaken as food by aquatic organisms and can kill them. Mounds of trash and rotting organic material can cause infestation by disease-carrying vermin. Additionally, they look and can smell unpleasant to beachgoers and hikers. Finally, sharp objects like syringes, broken metal, or glass can pose a threat to swimmers and other beach visitors.

Litter at Lake Quinsigamond. Litter is a difficult parameter to measure in a quantitative way, although litter has been determined to be a concern for lake water quality and recreational enjoyment at Lake Quinsigmaond. A study at Lake Park in 2021 found that, of the categories examined, "small items", "tobacco products", and "food packaging and containers" were the most prominent classes of litter present. See *Figure 19* for the relative rankings of the different classes of litter examined. While trash receptacles are left out by DCR, they are often overturned or not used. While litter was not formally qualified in 2022, the Lakes and Ponds Program is attempting to combat this challenge with collaborations with local organizations and an educational campaign, which you can read more about in the following section.

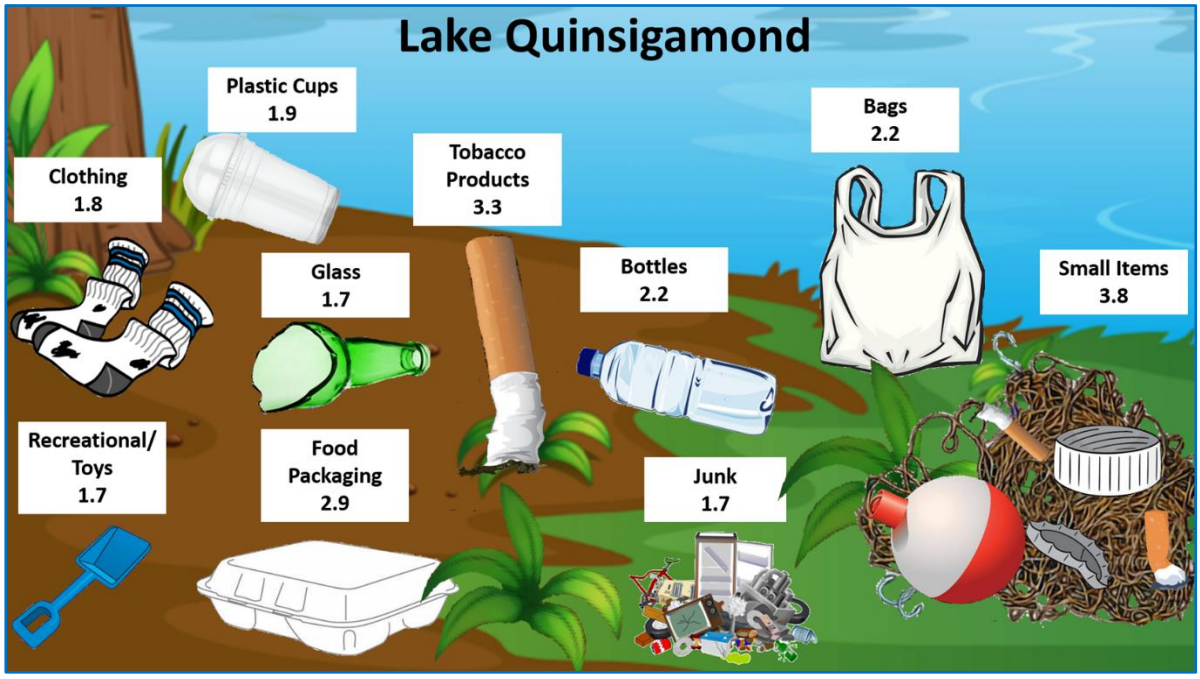


Figure 19 - *The relative abundance of different categories of litter in 2021. A rating of 1 indicates lowest abundance, and 5 is the highest.*

Urban Disturbances at Lake Quinsigamond in 2022

Anthropogenic activity is always changing our lakes, and urban lakes are prone to feel the impacts of human activities more due to the large amount of activity and infrastructure that surround them. When determining the health of a lake, it is important to contextualize water quality in the events that are occurring on shore. While the massive size of Lake Quinsigamond helps to absorb the impact of some small perturbations to water quality, in 2022, there were two events at that were large enough to potentially cause large scale water quality degradation. These events included the Lake Ave Pump Station Sewer Overflow, and the Repeated Sediment Runoff from Belmont Street Construction Activities.

Lake Ave Sewer Pump Station Overflow Event. On Sunday February 6th 2022, one of the pumps at the Worcester Sewer Pump Station on Lake Ave experienced a catastrophic failure, causing the flooding the building and overflow of 5.75 million gallons of untreated sewage over 36 hours into the Lake Quinsigamond (*see Figure 20*). While crews worked around the clock to resolve the issue The City of Worcester Department of Inspectional Services (DIS) released a Recreational Contact Advisory for the portion of the lake south of the Route 9 bridge. For more information on the nature of the failure, a full report can be found on the City of Worcester webpage. L&P quickly created a water quality monitoring plan to monitor threats to the ecosystem and public health risks in the lake. Wastewater contains three elements that may be harmful to humans and lake wildlife: (1) fecal bacteria, (2) organic materials, and (3) other compounds of concern that people send down the drain. A sampling plan was therefore created to evaluate the parameters for E. coli, nutrients (TP, NO_3, NH_3), DO, metals and VOCs. Sampling was

conducted at the lake shoreline behind the pump station and four in-lake locations upstream and downstream of the pump station over the next two months.

Results from this study suggested that water quality had not been significantly adversely affected by the discharge event in the short term. Bacteria concentrations came down quickly after the event ended and did not cause exceedances of the recreational threshold in the middle of the lake. Nutrients associated with organic inputs were not detected in very high concentrations, and oxygen levels appeared to be only slightly affected. No fish kills have been reported. Metals and volatile organic compounds that were tested for were generally not detected, and if they were, not in concerning concentrations.

Figure 20 – *A pump failure at the Lake Ave Sewer Pump station in February flooded the station and released 5.75 million gallons of untreated wastewater into Lake Quinsigamond.*

Results do not suggest that these parameters were not found in more detrimental concentrations during the time of the discharge or in the days immediately following the event. However, by the time sampling occurred, they either were not being observed in concerning quantities, or improved over the following days. In the case of the bacteria, this improvement can be explained by the short lifespan of the organism outside of warm blooded animals. In the case of the organic material, it is expected that dilution of the discharge contributed to the lower concentrations that were observed. In the case of the other compounds, undetectable concentrations in the open water may be due to the low concentration of these compounds in the sewage in the first place.

While acute risks to public health and wildlife appeared to have passed, there were ongoing concerns about the medium- and long-term effects of the event on the lake. L&P began its seasonal Lake Water Quality Monitoring Program on May 11th, in which it continued to collect samples in the southern basin of the lake on a twice monthly basis, as well as make observations in the area immediately around the Pump Station.

Repeated Sediment Runoff from Belmont Street Construction Activities. Starting in October of 2020, during periods of heavy rainfall, residents on Lake Quinsigamond noticed sediment plumes emanating from the stormwater outfall under the Route 9 bridge in Worcester (see Figure 21), creating concern among community members and city officials about water quality. Thanks to commitment by the Worcester Conservation Commission, several active construction sites along Belmont Street & Hospital Drive were identified as major contributors to the sedimentation in the stormwater system. Multiple sites in this area were undergoing construction and had large areas of open soil. These soils are primarily fine sediment, and when large rain events occurred, the sediment was not adequately filtered out by erosion controls, entered the surface drainage system turbid, and emptied into Lake Quinsigamond. Between October of 2020 and April of 2022, this occurred a minimum of six times.

Sediments are concerning to lake water quality because they carry nutrients such as phosphorus, adding to nutrient loading that is already detrimental to water quality, and potentially stimulating the growth of cyanobacteria and invasive aquatic plants. They can also harm fish gill structures and egg masses, and physically shallow a waterbody. Because of these potential detrimental effects, L&P attempted to quantify the impact of the erosion events.

On 25-Mar of 2022, heavy rain led to a visible plume, and L&P was able to collect samples for DO, *E.* coli, TP, and Secchi depth at various locations from the outfall to directly in from the of Marine Corps building to document the extent of the impact.

Secchi depth measurements indicated very low clarity at the outfall and reduced clarity for at least a half mile south of the entry point (see *Figure 22*). Total phosphorus concentrations were high immediately around the outfall (4.66 mg/l), over 100 times what you would expect to find in the lake. As with clarity, the results got less severe with distance from the outfall, but later observations suggested that sediment settling to the bottom of the lake, taking P with it. Thankfully, DO at all sites remained above 6 mg/l suggesting that the nutrients and organic materials were not causing anoxic conditions. *E. coli* results were also low. L&P suspects that these conditions occurred during all sediment releases.

Figure 21 – *During periods of rainfall, residents on Lake Quinsigamond noticed sediment plumes coming from the stormwater Outfall under Rt. 9 in Worcester.*

Figure 22 – *Fine sediments from construction sites off Belmont Street greatly reduced water clarity and contributed nutrients to Lake Quinsigamond.*

Thanks to the combined efforts of the Conservation Commission, Mass DEP, EPA, L&P, and concerned community members, appropriate sediment control measures were enforced on the construction site, and eventually the sites were stabilized. To understand possible long-term effects of this sediment loading, the continuous monitoring buoy that was previously deployed at the southern in-lake site was relocated to the area just south of Ramshorn Island. Additionally, Secchi depth readings were attempted

here during every regular lake monitoring event beginning in May. It should be noted that these readings were generally obscured due to heavy aquatic plant growth.

Ongoing Projects

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 23*). These buoys contain probes that track phycocyanin, chlorophyl, turbidity, and temperature, and remotely upload them to an online database every 30 minutes, 24 hours a day. These data can be viewed in real time L&P and even have alarms if results are above certain preset thresholds. Previously, the buoys were situated at the northern and southern in-lake sampling sites. For the 2022 season, the southern buoy was relocated to in between Ramshorn Island and the Worcester shoreline, south of the Route 9 outfall to better track possible effects from increased disturbances over the past year. The hope is to eventually deploy these devices in more locations to complement other monitoring efforts and make the data available to the public in real time.

Figure 23 *– A continuous monitoring buoy was relocated just south of the Route 9 Outfall to track possible effects from increased disturbances over the past year.*

Water Chestnut Hand Pulling Events

Over 2022, there were reports of newly established patches of Water Chestnut in Lake Quinsigamond. One method of controlling this invasive aquatic plant is to physically remove plants before their seeds are able to spread. The Lake Quinsigamond Watershed Association (LQWA) organized hand pulling events throughout July and August (see *Figure 24*). Volunteers worked from kayaks and small boats to clear patches of Water Chestnut and slow their spread. Although Water Chestnut generally takes 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.

Figure 24 *– Volunteers pulling the invasive Water Chestnut out of Lake Quinsigamond in summer 2022. Source: LQWA Facebook Page.*

Tributary E. coli *Monitoring*

Since 2019, L&P has partnered with the Lake Quinsigamond Watershed Association (LQWA) and the Lake Quinsigamond Commission (LQC) to investigate the abundance and sources of bacteria in the lake. L&P assisted in the development of a sampling plan, and has been supporting sampling costs, while LQWA volunteers recruit, train, and oversee a seasonal intern to collect samples 2-4 times per month for *E. coli* from 8 tributary and 2 in- lake locations. In addition to providing a hands on STEM experience for a young community member, the program has allowed LQWA to further progress its mission and visibility in the community.

In 2022, Samples were collected on 8 days, 20-Jun, 11-Jul, 26-Jul, 9-Aug, 24-Aug, 9-Sep, 23-Sep, and 7-Oct. Results above the recreational threshold of 235 cells/100 ml were commonly seen In 5 of the 10 locations: Belmont St. Outfall, Coal Mine Brook, Billings Brook, O Hara Brook, and Fitzgerald Brook. Similar to the findings of L&P, bacteria was not found in concerning concentrations in the middle of the lake. For a full report on LQWA's findings, see their website at lqwa.org.

Figure 25 *– Volunteers and an intern from LQWA collected samples for* E. coli *from 10 locations in and around Lake Quinsigamond to assess potential inputs to the lake.*

State of the Lake

In 2022, the State of Lake Quinsigamond was "Good". During the summer months, there were no cyanobacteria blooms, and Lake Park Beach did not have any closures due to fecal bacteria exceedances. While Regatta Point beach did experience fecal bacteria related closures, bacteria sampling throughout the lake suggested that bacteria challenges were localized around the shore and were not occurring lake wide. No industrial or emerging contaminants of concern were identified in concentrations that would be harmful to human health. The lake has a high diversity of native aquatic plants, the recent plant survey identified 15 species, which contribute to a healthy ecosystem.

During the warmer months of the season, there were several instances in which a combination of high surface temperatures and DO depletion left little open water with preferable conditions for cold water fish. However there were no fish kills or other observable effects noted. Total phosphorus concentrations were elevated at the bottom of the southern sampling site, which may have contributed to earlier than usual fall cyanobacteria scums. Recent aquatic plant mapping revealed six invasive aquatic plants, as well as the presence of an expanding region of Fanwort, Eurasian Milfoil, and Water Chestnut, which are aggressive and have the potential to reduce recreational opportunities and ecosystem services if not properly managed.

Plan for 2023

Water Quality Monitoring

In 2023, the Lakes and Ponds Program plans to continue to monitor Lake Quinsigamond to track changes in water quality and implement its invasive aquatic plant management plan. Unfortunately, in 2022, equipment failure led to a situation in which DO data was not able to be collected below 25 feet for part of the season. A new probe cable has been purchased for the 2023 season, which should allow for necessary documentation of lake stratification conditions over the course of the season.

Cyanobacteria. In recent years, there has been an increased number of anecdotal reports of cyanobacteria scums in the fall from lake users, when recreation on the lake is reduced. As Lake Quinsigamond is a large waterbody, and many blooms are transient in nature, it can be difficult to confirm every one of these reports. The Lakes and Ponds Program worked with the Department of Public Health (DPH) to develop 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 (see *Figure 26*). 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 staff to visit on a regular basis.

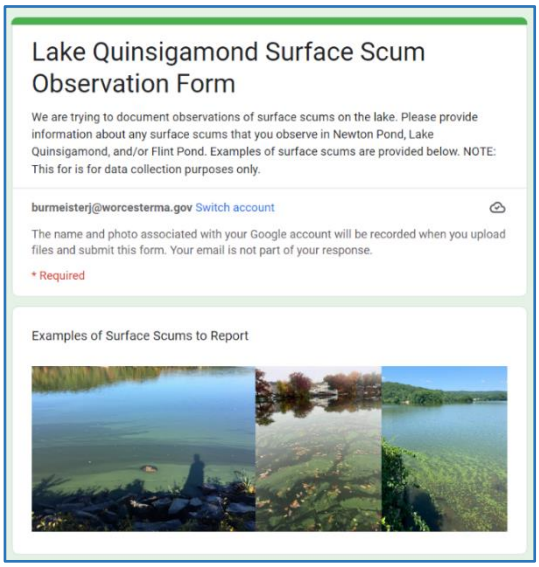


Figure 26 **–** Online Surface Scum Report form which residents can report observations of scums in Lake Quinsigamond.

Lake Management

Invasive Plants. An invasive plant study contracted by L&P quantified and mapped the current distribution of various invasive plants in 2022. Using this newly acquired information, The Lakes and Ponds Program will work with the LQC, LQWA, and the Towns of Shrewsbury and Grafton to develop and implement a sustainable management plan for invasive aquatic plants in Lake Quinsigamond in 2023.

Education and Outreach

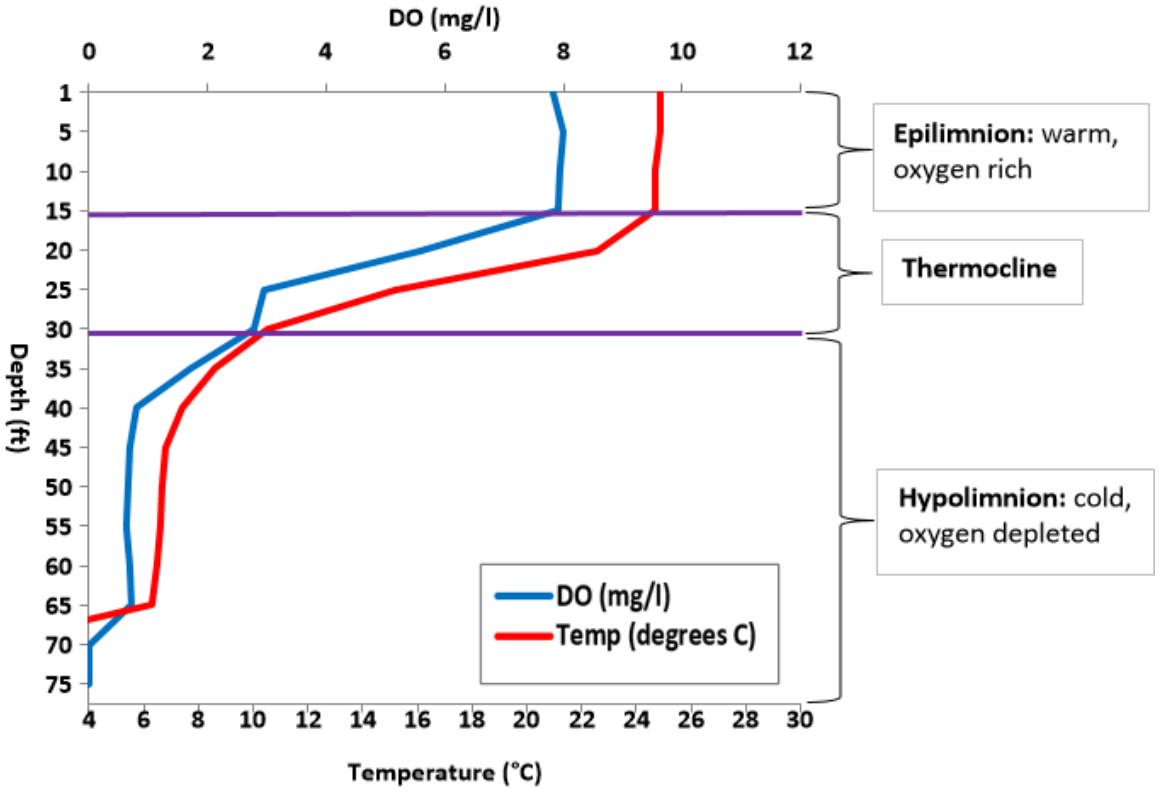
Litter. The Lakes and Ponds Program will work with its partners, including the Department of Public Works & Parks, and Worcester Green Corps, to use our data to create litter reduction strategies. L&P will also help to build pride around Lake Quinsigamond with videos and signage related to its high-quality water, including the re-release of the "Blue Space Minute" Episode on Litter, which debuted in April of 2022.

Text Message Alert System. In 2023, the Lakes and Ponds Program will release a text message alert system and residents can 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

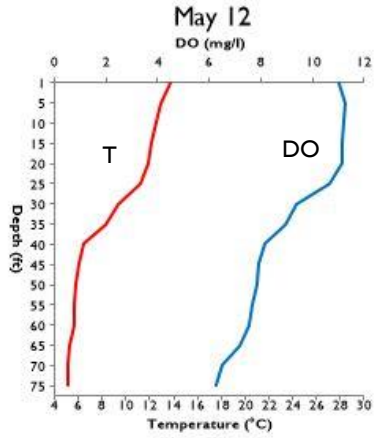
is closed because a lake is receiving an invasive aquatic plant treatment. Especially since many lake goers use public transportation to access waterbodies, L&P aims to provide a resource that can help to guide plans before people begin travel. The Lakes and Ponds Program will work with DCR, Inspectional Services, and the Parks Department to establish a flow of information to keep the system up to date.

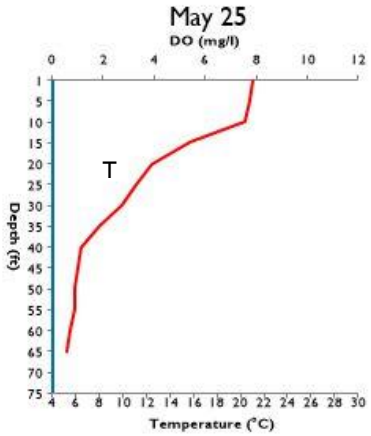
To learn more about Lakes and Ponds Program offerings, please see WorcesterMA.gov/bluespace.

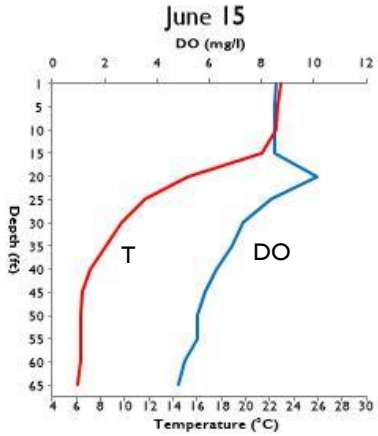
Appendix: Depth Profiles Key

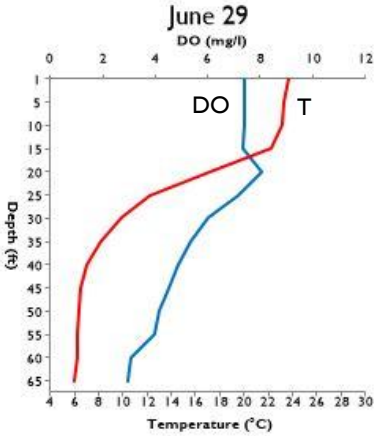


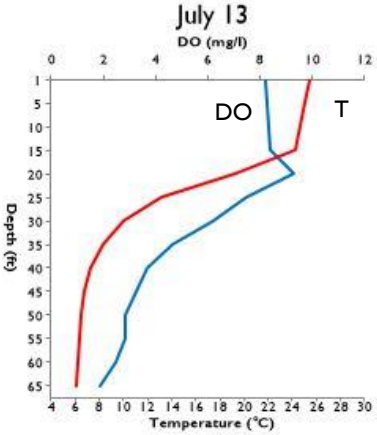
Appendix: Depth Profiles Northern Site

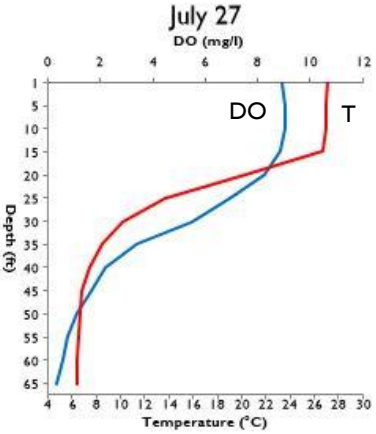


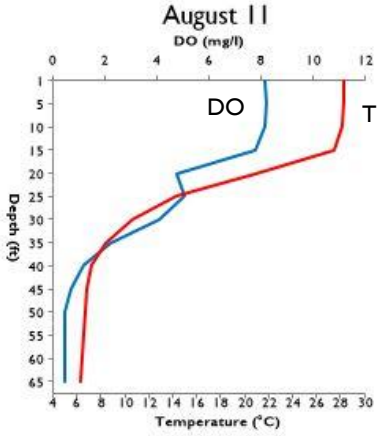


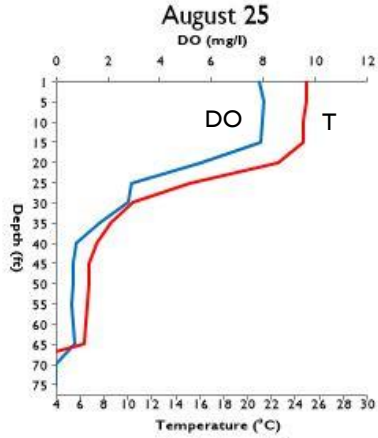


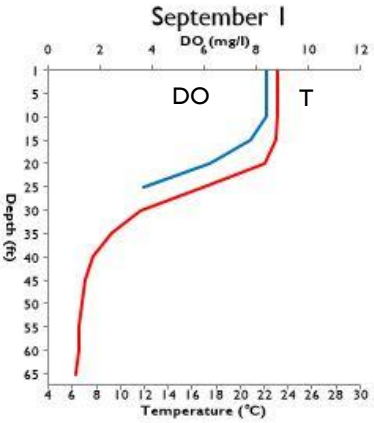


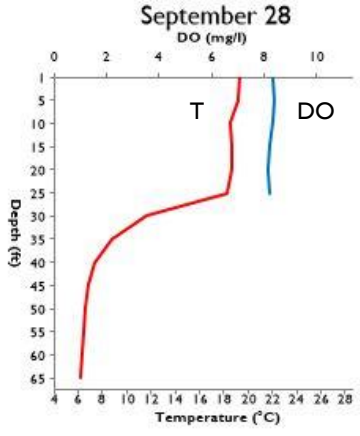


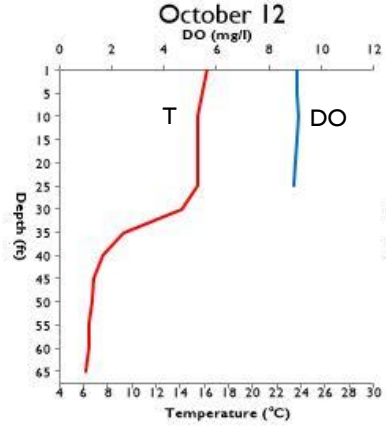


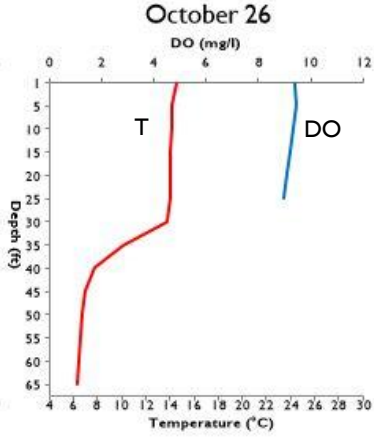












Appendix: Depth Profiles Southern Site