

Indian Lake

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 Indian Lake in 2024. The "State of the Lake" will be rated "Excellent", "Good", "Fair", or "Poor" based on the results' implications on 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, Indian Lake is impacted by the urban environment. Indian Lake can face challenges including lake closures due to cyanobacteria and fecal bacteria, high nutrient levels, low water clarity, and invasive aquatic plants. However, management by community groups, and more recently, the City of Worcester Lakes and Ponds Program, has led to water quality that supports a healthy ecosystem and a wide variety of recreational opportunities. ***In 2024, Indian Lake received a score of "Fair"***. Continue reading to learn more about this rating and L&P's work at Indian Lake.

Background

Originally a natural 100-acre lake called North Pond, Indian Lake was dammed and expanded in the 1800s to 220 acres in order to supply water to the Blackstone Canal until its closure in 1848. More recently, the construction of I-190 reduced the lake's area to its current size of 190 acres. The Commonwealth considers Indian Lake a "Great Pond", as it was larger than 10 acres in its original state and is therefore within the jurisdiction of Chapter 91, a law protecting public rights to access a waterway. Much of the shoreline of the lake is zoned as residential and privately owned, although there are three city parks allowing public access to the water (See Figure 1). I-190 borders the lake on its northeastern shore. Indian Lake's main

tributary is Ararat Brook, which enters from the north. The lake empties over a spillway into a culvert on the eastern side of the lake, which eventually flows south into Salisbury Pond. Sears Island is residentially populated and is connected by a causeway to the mainland. To the south is a small pond called Little Indian Lake, which is connected to the main lake by a small culvert under Grove Street. Indian Lake has a maximum depth of about 17 feet, with the deepest point in the northeastern portion.



Figure 1 – View of Indian Lake beach from the water.

Indian Lake is popular for recreation, with two City-maintained beaches, Indian Lake Beach at Clason Road and Shore Park, as well as a City-maintained boat ramp at Morgan Park. The lake supports swimming, fishing, motorized and non-motorized boating, and water skiing. Indian Lake is home to a variety of sport fish including largemouth bass, smallmouth bass, white perch, yellow perch, black crappies, bluegills, pumpkinseeds, carp, and northern pike.

As an urban lake, Indian Lake is impacted by the pressures of the city. It is listed on the Massachusetts Impaired Waters 303d List as Category 4a for low dissolved oxygen and non-native plants. It received a Total Maximum Daily Load (TMDL), or a nutrient budget, for phosphorus in 2002. Cyanobacteria have historically been a challenge at the lake, sometimes forming bloom conditions that restrict recreation. However, management by community groups and the Lakes and Ponds Program has led to fewer and shorter lake closures in recent years.

This report details the results of water quality monitoring programs in 2024, as well as the exciting projects and opportunities the City of Worcester’s Lakes and Ponds Program (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, water quality at Indian Lake was rated as “Good”. Despite high rainfall totals, L&P’s management plans were effective at keeping the lake open and safe for recreation. There were no lake closures due to cyanobacteria, and only one beach closure due to fecal bacteria exceedances. Secchi disk clarity was slightly higher than the expected range for Indian Lake, though still low enough to be rated as “Fair”. Despite some oxygen reduction at the bottom during summer months, the top 9 ft of the water column always had suitable oxygen for aquatic life. Although most surface phosphorous results were in ranges considered “Excellent”, L&P rated nutrients in 2023 at Indian Lake as “Good” because active management was required to reduce nutrient concentration and therefore cyanobacteria bloom risk. There were no sightings of invasive Eurasian Milfoil in 2023, though a treatment was done to manage the growth of the plant Thinleaf Pondweed.

To view full reports from all previous seasons, please visit WorcesterMA.gov/bluespace.

Management Summary

Indian Lake has had management plans for cyanobacteria and invasive aquatic plants since the inception of the Lakes and Ponds Program. Given a combination of factors that lead to elevated cyanobacteria growth, preventative lake treatments of aluminum sulfate, or “alum”, and copper sulfate have been required to avoid cyanobacteria blooms and keep the lake safe for recreation.

In 2023, L&P began the use of a novel nutrient management strategy, a dosing station at the lake’s main inlet (see Figure 2). Ararat Brook is the main tributary to Indian Lake and has many storm drain outfalls that carry stormwater containing phosphorus into Indian Lake. The dosing station applies polyaluminum chloride (similar to alum) to the mouth of the brook in small doses when it rains, immobilizing phosphorous before it enters the lake. This method aims to reduce the average lake phosphorus concentration while decreasing the total amount of chemical used.



Figure 2 – In 2023, an “Alum Dosing Station” became operational at the lake’s main inlet, Ararat Brook. The station applies small doses of polyaluminum chloride to the mouth of the brook when it rains, immobilizing phosphorous before it enters the lake.

In 2024, delayed procurement of polyaluminum chloride prevented treatment of spring rainstorms. As the spring of 2024 had above average precipitation, it is likely that a large amount of nutrient-containing sediment was added at this time. When the dosing station became operational in mid-July it applied polyaluminum chloride during rain events and continued operation until early December. However, rainfall totals were far below seasonal averages between mid-July and late-November, greatly reducing dosing opportunities. Cyanobacteria populations jumped from trace amounts on 18-July to 170,000 cells/mL on 31-July, prompting the City of Worcester to issue a health advisory and close lake access. Unfortunately, L&P was not able to contract an algaecide treatment, as treatments past the advisory threshold risk the release of cyanotoxins into the water column. The lake was re-opened on 20-Sep after two consecutive tests showed results below the advisory threshold. Cyanobacteria results remained low for the rest of the season, not requiring further management.

Since Indian Lake was effectively treated with the systemic herbicide ProcellaCOR in 2021, the invasive aquatic plant Eurasian Milfoil has not regrown or required additional treatment. The absence of Milfoil gave the opportunistic native plant Thinleaf Pondweed a chance to grow rapidly, overtaking the southern portion of the lake. In 2022 and 2023, the Lakes and Ponds Program treated it with the herbicide diquat dibromide (trade name: Reward) to maintain navigability and recreational access. In 2024, growth of Thinleaf Pondweed was not extensive enough to require treatment, with much of its previous distribution replaced by the native plant Elodea which did not impede recreation.

In late September, some patches of the invasive plant *Phragmites australis* were treated with the herbicide glyphosate. The dead patches were later cut to allow for better assessment of regrowth and improved management in the following season.

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 are streams flowing 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 insight into where certain impairments in the lake originate.

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

Indian Lake was sampled twice monthly from late April through October at four locations: the major aboveground tributary, Ararat Brook; the middle of each of the two basins of the lake (the northern site, which is about 17 feet deep and the southern site, which is about 5 feet deep); and the outlet at the spillway, located in the eastern part of the lake (see Figure 3). At the in-lake locations, probe measurements and water samples were collected one foot below the surface of the water (“surface”) and two 2 feet above the bottom of the lake (“bottom”). Parameters evaluated included: Secchi disk depth, temperature, dissolved oxygen (DO), pH, total phosphorus (TP), total dissolved phosphorus (TDP), and *Escherichia coli* (*E. coli*). Samples were also collected for total suspended solids (TSS), ammonia (NH₃), and nitrate (NO₃) once a month. Altogether, there were 12 sampling events.

In 2024, precipitation trends varied widely over course of the year. 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. Two sampling days in 2024 were considered “wet weather” with 24-hour rainfall totals exceeding 0.25 inches. Those



Figure 3 – Aerial view of Indian Lake and approximate sampling locations.

days include 6-Aug (0.26 in), and 20-Aug (0.35 in). Results from wet weather days are denoted with the symbol ☁️ in the figures.

Samples for cyanobacteria cell density were collected by a contractor as needed. Additionally, City of Worcester Department of Inspectional Services tested for *E. coli* as an indicator of harmful pathogens on a weekly basis during the swimming season at Shore Park Beach and Indian Lake Beach.

Raw data are displayed and explained in this report. No statistical analysis has been performed. A laboratory reporting limit is the smallest amount of a substance that a lab can reliably detect and report in a sample. Results below the laboratory reporting limit are expressed with the less-than symbol (<) before the reporting limit. For example, an undetectable 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.

Monitoring Parameters and 2023 Results

Quality Assurance/Quality Control

The Lakes and Ponds Program uses Quality Assurance/Quality Control (QAQC) checks to ensure that data are representative of local conditions and meet precision and accuracy standards. QAQC check results identify data that need to be flagged and/or censored before they are shared and 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 are 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. *Escherichia coli*, or *E. coli* 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 cause illness. These bacteria enter the water in many ways, including through direct contact with animal waste, runoff during rainstorms from the shoreline and impervious surfaces like paved roadways, 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 City of Worcester Department of Inspectional Services collects samples for *E. coli* 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 of 235 *E. coli*/100 mL. In past seasons L&P has collected samples for *E. coli* at the surface of certain in-lake sites to assess *E. coli* conditions in open water. As in-lake *E. coli* results never indicated concern, L&P ceased collecting them in 2023. However, L&P continues to collect *E. coli* samples at Ararat Brook, and beach testing by Inspectional Services continues. Water samples collected by L&P and Inspectional Services are analyzed by separate

labs for *E. coli* using different techniques with different units. Please note that *E. coli*/100 mL and MPN/100 mL are directly comparable.

Fecal Bacteria at Indian Lake In 2024, neither public beach was closed due to fecal bacteria exceedances. Results from beach testing conducted by Inspectional Services ranged between <1 and 206.6 *E. coli*/100mL, with no results exceeding the recreational limit (see Table 2).

E. coli results at Ararat Brook were less consistent and generally higher than those at the beaches, with results ranging from 201.42 to 38,732 MPN/100 mL. Five of 12 results were in the range considered “Fair”, four results were considered “Poor”, and three results were considered “Good”. Two unexpectedly high results were recorded: 38,732 MPN/100mL on 9-Jul and 22,818 MPN/100mL on 6-Aug (see Table 1).

In 2024, L&P rates Indian Lake as "Fair" for fecal bacteria because although *E. coli* generally did not affect recreation at beaches, elevated results at Ararat Brook indicate the need for additional investigation.

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 to 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 sometimes 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 monthly and submitted to a lab for analysis.

| ARARAT BROOK | |
|--------------|-----------------------|
| DATE | RESULT MPN/ 100 mL |
| 30-Apr | 435.17 |
| 14-May | 488.44 |
| 4-Jun | 201.42 |
| 25-Jun | 275.51 |
| 9-Jul | 38,732.00 |
| 23-Jul | 1,299.65 |
| 6-Aug | 22,818.00 |
| 20-Aug | 3,786.00 |
| 4-Sep | 1,203.33 |
| 17-Sep | 461.11 |
| 3-Oct | 410.58 |
| 15-Oct | 210.52 |

Collected by L&P

| | |
|--------------------------|------|
| Excellent | Good |
| Fair | Poor |
| Red Text = Beach Closure | |

| DATE | SHORE PARK BEACH | INDIAN LAKE BEACH |
|--------|---------------------------|---------------------------|
| | RESULT E. coli/ 100 mL | RESULT E. coli/ 100 mL |
| 24-Jun | 206.4 | 46.4 |
| 1-Jul | 20.1 | 25.9 |
| 8-Jul | 16 | 4.1 |
| 15-Jul | 64.4 | 87.8 |
| 22-Jul | 15.8 | 52.9 |
| 29-Jul | 10.8 | 48 |
| 5-Aug | 45.7 | 23.1 |
| 12-Aug | 52 | <1 |
| 19-Aug | 55.4 | 7.3 |

Collected by COW Inspectional Services

Tables 1 & 2 Neither of Indian Lake’s beaches were closed due to fecal bacteria exceedances in 2024. *E. coli* results from Ararat Brook ranged between 201.42 and 38,732 MPN/100mL, with most results in the ranges considered “Fair” and “Poor”.

Water Clarity at Indian Lake. All but one Secchi depth reading was between 4 and 10 ft, or in the range considered “Fair”, though readings were generally higher early and late in the season (see Figure 4). From late June through early September, readings ranged between 3.50 ft and 5.25 ft, indicating decreased water clarity largely due to elevated levels of cyanobacteria in the water column. Unlike in past seasons, Secchi depth was progressively higher from early September through the end of October.

At both in-lake sites, surface TSS results ranged between 1.2 mg/L and 6.8 mg/L, remaining in the range considered “Excellent” during all sampling events. These results were comparable to those in years past. All bottom TSS results from the Northern Site fell below 10 mg/L. As expected, TSS increased as Secchi depth decreased at Indian Lake.

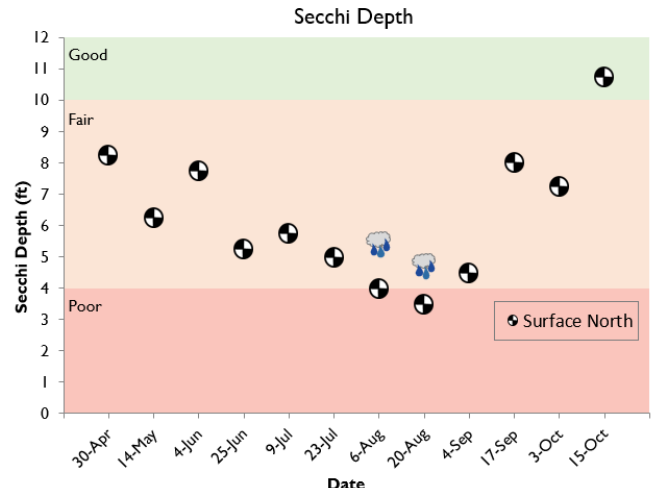


Figure 4 - Secchi depth was considered "Fair" for most of the season with two values in the "Poor" category, and one in the "Good" category. Readings ranged from 3.50-10.75 feet.

TSS results in Ararat Brook and the lake outlet were in a similar range, between <1.0 mg/L to 10 mg/L, except for one result at the outlet of 15.0 mg/L. TSS results from Ararat Brook were generally low, indicating clearer water. Results from the spillway were more similar to the in-lake surface results than those of Ararat Brook. L&P rates water clarity at Indian Lake as “Fair” in 2024.

Temperature

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 experienced throughout the water body, affecting the distribution of oxygen, nutrients, and organic matter. Temperature was measured with a thermometer on a handheld probe at the water’s surface at all sites and at the bottom for in-lake sites. To form a more complete picture of how temperature changes through the water column, depth profiles were created by taking measurements at 1-ft increments through the water column.

Temperature at Indian Lake. Surface temperatures at the Northern and Southern Sites were similar to each other throughout the season, ranging between 11.6 °C and 28.1 °C, following expected seasonal variation (see Figure 5). Surface temperature readings rose at all sites from the beginning of the season through mid-summer, reaching a maximum temperature on 9-Jul before falling for the rest of the season.

Bottom temperature at the Northern Site was consistently lower than the surface, ranging between 12.0°C and 24.3°C.

To determine the extent of warming throughout the entire water column, depth profiles were taken at the Northern Site (see Appendix). During the first three sampling sessions, temperature was relatively consistent throughout the water column. Profiles recorded between 25-Jun and 6-Aug exhibited temperature stratification, with the thermocline between 8 and 13 ft. The maximum temperature difference between the surface and deep water was 6.2° C, indicating relatively mild stratification.

Ararat Brook is the major tributary to Indian Lake. It is a designated Coldwater Fish Resource (CFR), 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. The outlet of Indian Lake is the spillway at its northeastern end. Water temperature in Ararat Brook generally remained in the range suitable for cold water fish, with only one reading above 20°C, the upper avoidance limit for cold water fish. (see Figure 6). Most temperature readings were in the ranges considered “Excellent” and “Good” with one result considered “Fair”. The temperature at the lake outlet was on average 5.9°C higher than in Ararat Brook, demonstrating how much the brook warms while passing through Indian Lake.

L&P rates temperature at Indian Lake as “Good”.

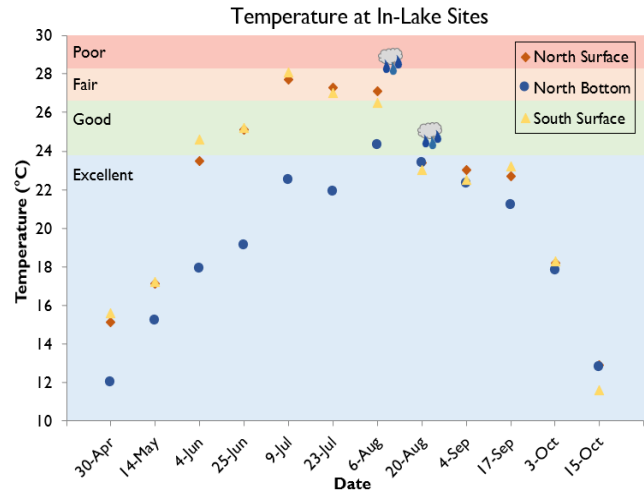


Figure 5 - Surface water temperature remained in the "Excellent" and "Good" categories for most of the 2024 season, with three instances considered "Fair" at the northern surface site and two at the southern surface site. Bottom temperature was considered "Excellent" in all but one instance.

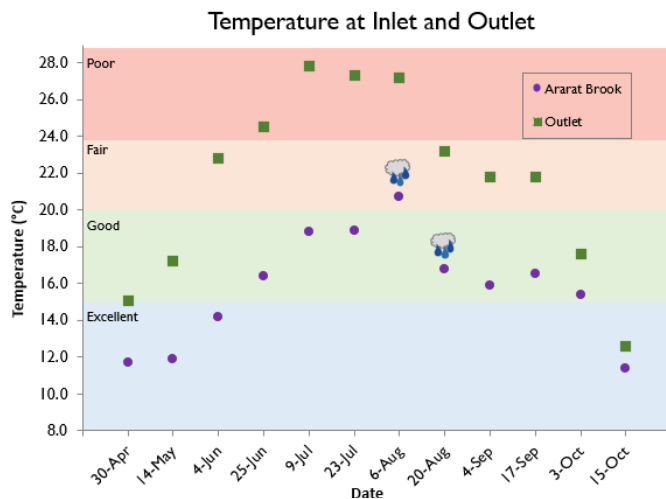


Figure 6 - Water temperature in Ararat Brook remained in the "Excellent" and "Good" categories for a Coldwater Fish Resource (CFR) for most of the 2024 season, with one instance considered "Fair". Temperature at the lake outlet was on average 5.9°C higher than in Ararat Brook, demonstrating how much the brook warms while passing through Indian Lake.

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. Thermal stratification, or 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, or hypoxic 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. To form a more complete picture of how DO changes through the water column, depth profiles were created by taking measurements at 1-ft increments through the water column.

Dissolved Oxygen at Indian Lake. Surface DO in the Northern and Southern sites was high throughout the season, consistently in the range considered "Excellent" (see Figure 7). As seen in past years, bottom DO at the Northern Site was in the "Poor" range for six of 12 readings. All but two bottom readings between 4-Jun and 17-Sep reported DO below 4 mg/L, or in the range considered "Poor".

DO in Ararat Brook ranged between 7.95 and 10.23 mg/L and was mostly in the range considered "Excellent" for a CFR (see Figure 8). At the outlet, DO ranged between 5.20 and 9.39 mg/L.

As observed from depth profile data, the water column was uniformly oxygenated during the first two sampling sessions (see Appendix). At the beginning of June, DO concentration began to drop below 4 mg/L, the lower avoidance limit for fish, in the deepest reaches of the water column. Throughout the season all water above 11 ft was oxygenated. From early June through early August, an oxycline was observed in which water below 11 – 16 ft was hypoxic. By the end of August, the entire water column had

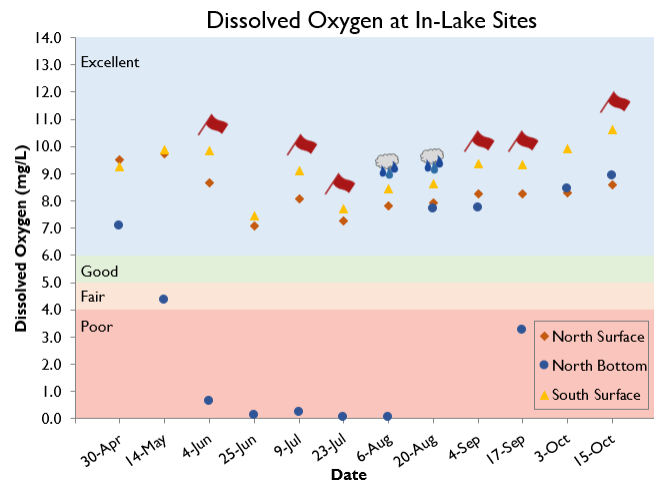


Figure 7 - Dissolved oxygen was considered "Excellent" at the surface throughout the season. Bottom dissolved oxygen readings were in the "Poor" category on six occasions between June and September.

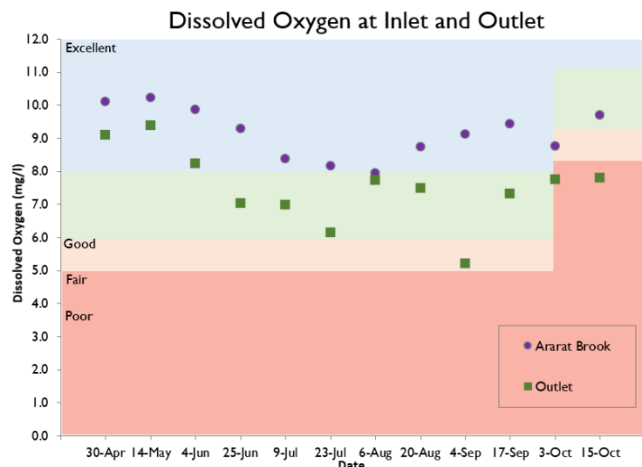


Figure 8 - Dissolved oxygen in Ararat Brook was in the range considered "Excellent" for all but three readings. At the outlet, dissolved oxygen was consistently lower.

DO concentration above 4 mg/L, to the end of the season. Though hypoxic conditions were observed on the bottom of the lake, a large portion of the water remained fully oxygenated, and no fish kills were observed. Despite the presence of an oxycline during summer months, the top 11 ft of the water column always had suitable oxygen for aquatic life. L&P ranks DO at Indian Lake in 2024 as “Good”.

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 0-14.0 units, 7.0 is a neutral pH. As pH increases from 7.0, the solution is more basic, and as pH decreases from 7.0, 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 Indian Lake.

In 2024, pH at the surface of Indian Lake had a wide range of results. At the Northern site, surface pH ranged between 7.46 and 8.93 with the highest reading taken on 6-Aug (see Figure 9). Surface pH in the Southern site had an even wider range of 7.38 to 9.36. As seen in past years, surface pH readings were often higher at the Southern site than the Northern site. Bottom pH at the Northern site ranged from 6.80 to 8.46. Indian Lake often exhibits the most basic water of any lake in the program. As basic conditions can encourage cyanobacteria growth, L&P will continue to pay close attention to pH readings in Indian Lake.

At Ararat Brook, pH was less variable than at in-lake sites, ranging from 7.35 to 8.06. At the outlet pH more closely resembled in-lake sites, ranging from 7.51 to 8.73.

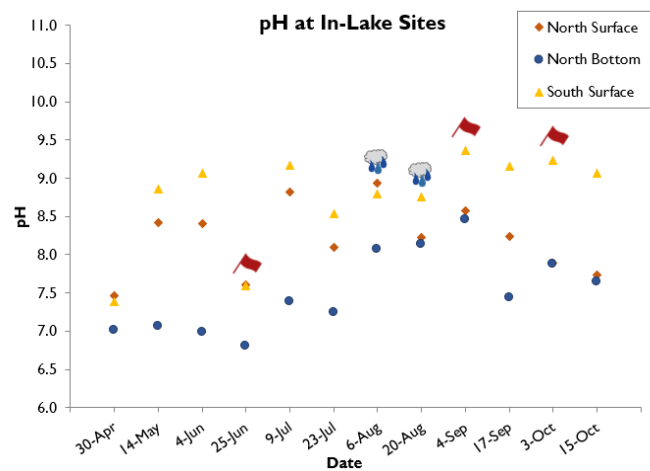


Figure 9 - Surface pH was consistently higher than bottom pH and fluctuated throughout the season.

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 (NO₃) and ammonia (NH₃) 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.

Nutrients at Indian Lake. In 2024, total phosphorous results at the in-lake sites were generally similar to those in 2023. At the Northern Site, surface results ranged from <0.010 to 0.037 mg/L, although all but one result were below 0.025 mg/L, or in the range considered “Excellent” (see Figure 10). At the Northern Site, most bottom TP results ranged from <0.010 to 0.030 mg/L and were therefore considered “Excellent” and “Good”, although there was one outlier result of 0.072 mg/L. All but two samples at this site contained undetectable concentrations of total dissolved phosphorus, with the highest result of 0.051 mg/L considered “Fair”.

In Indian Lake’s primary tributary, Ararat Brook, all but two results fell in the range considered “Excellent” (see Figure 11). The sample with the highest result, 0.166 mg/L, was taken on 6-Aug during a rain event. Results at the lake outlet generally resembled the in-lake and tributary results.

As in past years, NO₃ results were low at all in-lake sites. All but one result was below the reporting limit, and the detected result was below 0.6 mg/L, in the range considered “Excellent”. Results were similar at the lake outlet. As seen in the past, higher NO₃ results were observed at the Ararat Brook inlet, ranging from 0.342 mg/L to 0.787 mg/L. Most of these results were in the range considered “Good,” with two results considered “Excellent”

As in past years, NH₃ results were low at all in-lake surface sites, with all results in the range considered “Excellent”. Results at the Northern bottom site, Ararat Brook inlet, and the outlet were consistently

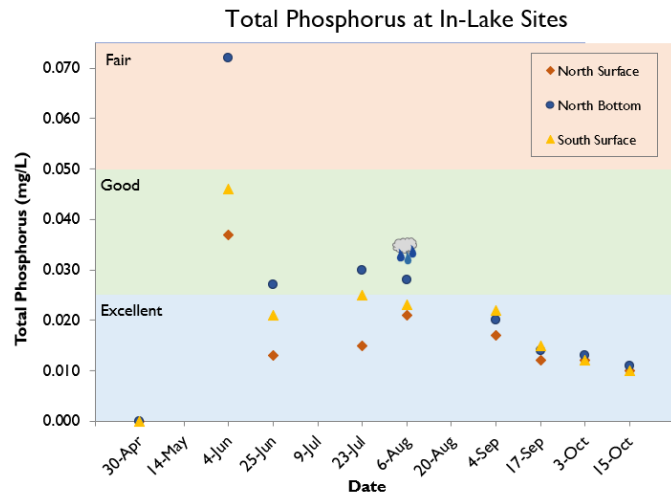


Figure 10 - Total phosphorus at in-lake surface sites was primarily categorized as “Excellent”. The northern bottom site was considered “Excellent” on five occasions, “Good” on three and “Fair” on one.

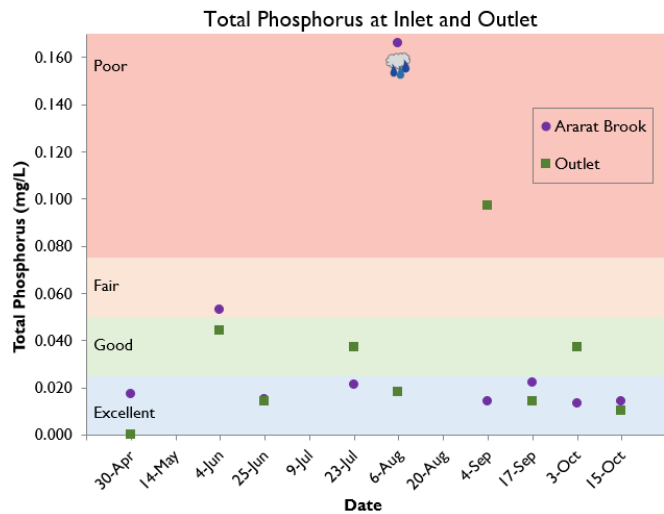


Figure 11 - Total phosphorus results in Ararat Brook were in the “Excellent” category for much of the season, however, it was considered “Fair” on 4-Jun and “Poor” on 6-Aug.

below the reporting limit and in the range considered “Excellent”. L&P rates nutrients in 2024 at Indian Lake as “Good” because active management is required to reduce nutrient concentration and therefore cyanobacteria bloom risk.

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 hypoxic conditions leading to fish kills.

To understand the abundance of cyanobacteria and make decisions regarding lake management and safe access, L&P contracts samples for cyanobacteria cell counts on a regular basis at Indian Lake to determine bloom risk. When results are above the recreational threshold of 70,000 cells/mL, the waterbody must be closed to recreation until cell counts fall. When possible and necessary, L&P uses preventative lake treatments such as algaecide to stop cyanobacteria growth in the early stages of a bloom before cell counts exceed the recreational threshold.

Cyanobacteria at Indian Lake. Indian Lake has favorable conditions for cyanobacteria growth, including warm water, elevated pH, and steady external nutrient inputs through Ararat Brook. L&P has documented cyanobacteria blooms over the past years and developed a management plan which relied on algaecides and flocculants. In 2023, L&P began using a novel nutrient management strategy, an alum dosing station at the inlet of Indian Lake’s main tributary Ararat Brook. When the alum dosing station became operational in early June 2023, it began adding polyaluminum chloride to the lake during rain events.

Results from weekly testing contracted by L&P in 2024 ranged between trace amounts and 211,000 cells/mL of cyanobacteria (see Figure 12). Cell counts remained far below the advisory threshold of 70,000 cells/mL for much of the spring and early summer. However, results jumped from trace amounts on 18-July to 170,000 cells/mL on 31-July, prompting the City of Worcester to issue a health advisory and close lake access. Unfortunately, L&P was not able to contract an algacide treatment, as treatments past the advisory threshold risk the release of cyanotoxins into the water column. L&P continued weekly testing and results remained above the advisory threshold until 3-September. The lake was re-opened on 20-Sep after two consecutive tests showed results below the advisory threshold, ending 50 days of lake closure. Cyanobacteria results remained low for the rest of the season. As cyanobacteria bloom conditions significantly impacted recreation, leading to 50 days of lake closure, L&P rates cyanobacteria as “Poor” in 2024.

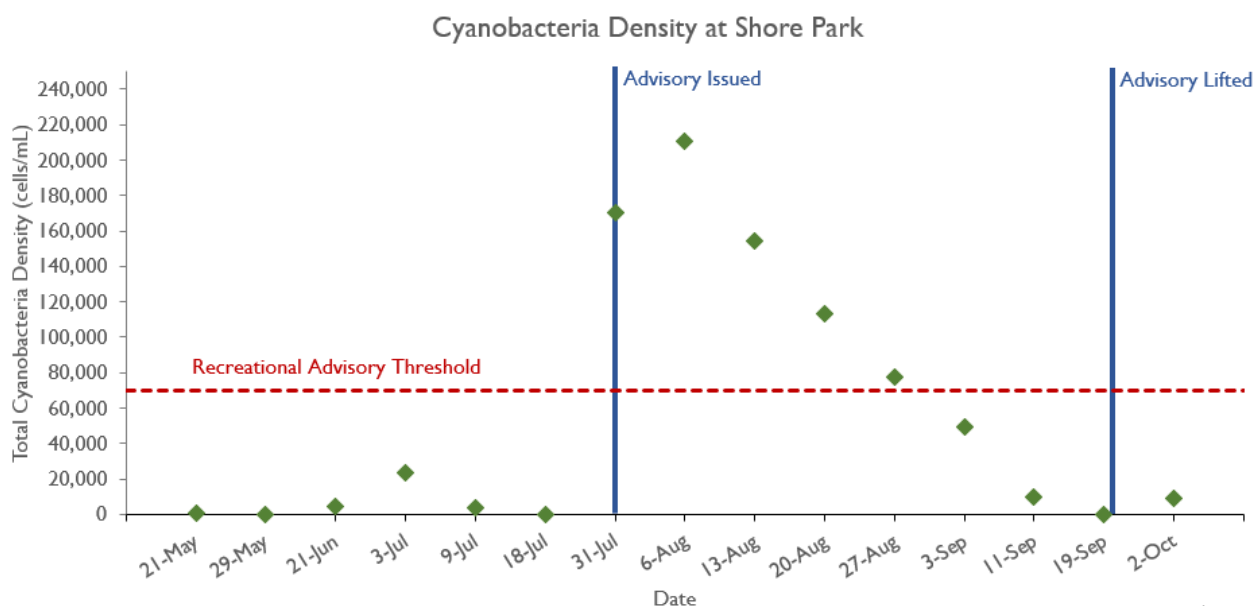


Figure 12 – In 2024, cyanobacteria density was low until it exceeded the recreational advisory threshold of 70,000 cells/mL on 31-Jul, prompting lake closure. Results remained above the threshold until 3-Sep, and the lake was reopened on 20-Sep.

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 as a sport fishing opportunity. Professional surveys and visual inspections from L&P staff are used to make management decisions regarding invasive species.

Invasive Aquatic Plants and Animals at Indian Lake. Historically, Indian Lake has hosted several species of invasive plants, including European Naiad (*Najas minor*), Eurasian Milfoil (*Myriophyllum spicatum*), and

Common Reed (*Phragmites australis*), as well as native plants that can become a nuisance for recreation, such as Thinleaf Pondweed (*Potamogeton pusillus*). A wide array of management techniques have been used at Indian Lake, including lake drawdown, removal of plants by divers, and herbicide application. Since the eradication of Eurasian Milfoil in 2021, management efforts have focused on addressing *Phragmites* and overgrowth of Thinleaf Pondweed. In 2024, areas previously overgrown with Thinleaf Pondweed were dominated by Western Waterweed (*Elodea nuttallii*), a native plant species that grew in abundance but did not impede recreation. No management effort was necessary to control either native species in 2024.

Phragmites is an invasive reed which grows along the water's edge in shallow areas and can crowd out native plants and increase sedimentation. L&P contracted management with the herbicide glyphosate in September. Because many of the *Phragmites* stands are established, eradication will likely take multiple years of consistent management. In November, some of the treated patches were cut to enable assessment of future regrowth. In 2025, L&P plans to manage *Phragmites* through cutting in the summer with a follow up herbicide treatment in the fall if necessary. L&P will also contract an updated plant survey in 2025 to continue to track populations of invasive and nuisance plants.

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. 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 detected. See the [2022 Indian Lake 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

Overall, water quality at Indian Lake was rated as “Fair” in 2024. Cyanobacteria blooms were a significant impediment to recreation and water quality. L&P rated cyanobacteria as “Poor” in 2024 because cyanobacteria bloom conditions necessitated 50 days of lake closure. Although *E. coli* did not cause beach closure in 2024, elevated results at Ararat Brook indicate the need for additional investigation, leading to L&P's rating of “Fair”. Although most surface phosphorous results were in ranges considered "Excellent" and “Good”, rapid growth of cyanobacteria indicates a nutrient load that is problematic for lake health. Surface water and tributary temperature mostly remained in the categories considered “Excellent” and “Good” in 2024, leading to a rating of “Good”. Secchi clarity was mostly in the range considered “Fair”. Despite low oxygen conditions at the lake bottom during summer months, the top 11 ft of the water column always had suitable oxygen for aquatic life leading to a rating of “Good”. As in 2023, there were no sightings of invasive Eurasian Milfoil. L&P continued management of the invasive plant *Phragmites australis* in 2024.

Despite cyanobacteria bloom conditions that necessitated 50 days of lake closure, the lake was recreationally available for the rest of the season and supported key aspects of a healthy ecosystem. L&P will continue and improve monitoring and management efforts to preserve 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 Indian Lake to track changes in water quality and implement its cyanobacteria and invasive aquatic plant management plans. L&P will continue to contract cyanobacteria cell counts to better understand cyanobacteria population dynamics and inform management and public health decisions. Because high and widely fluctuating pH can indicate conditions favorable for cyanobacteria and stressful for other aquatic life, continued monitoring is essential. L&P will continue to pay particular attention to pH in 2025, as high and widely fluctuating pH can indicate conditions that are favorable for cyanobacteria and stressful for other aquatic life. As a lack of large rain events in 2024 limited sampling to better understand Dosing Station efficacy and optimize operations, L&P will contract continued monitoring in 2025. This will guide dosing requirements and ensure that the project is attaining its intended goal of removing phosphorus before it enters the lake. Pending budget availability, in 2025 L&P will also conduct sampling for industrial contaminants and contract a comprehensive plant survey to guide future management.



Figure 13 – A continuous monitoring buoy was deployed to track cyanobacteria indicators in the northern cove of Indian Lake.

Since 2022, the Lakes and Ponds Program has seasonally deployed solar powered continuous monitoring buoys in the northern cove of Indian Lake (see Figure 13). These buoys use probes to track the cyanobacteria indicators phycocyanin and chlorophyll, as well as turbidity and temperature. In 2025, L&P will continue to refine its approach to utilizing the data it collects to aid in determining water quality in the cove and efficacy of the dosing station.

Lake Management

Watershed Based Plans. In late 2024, the Lakes and Ponds Program contracted a consultant to develop watershed-based plans to reduce nonpoint source pollution in the City’s three main sub-watersheds (see Figure 14). These plans will be based on the EPA’s 9-Element watershed-based planning framework and

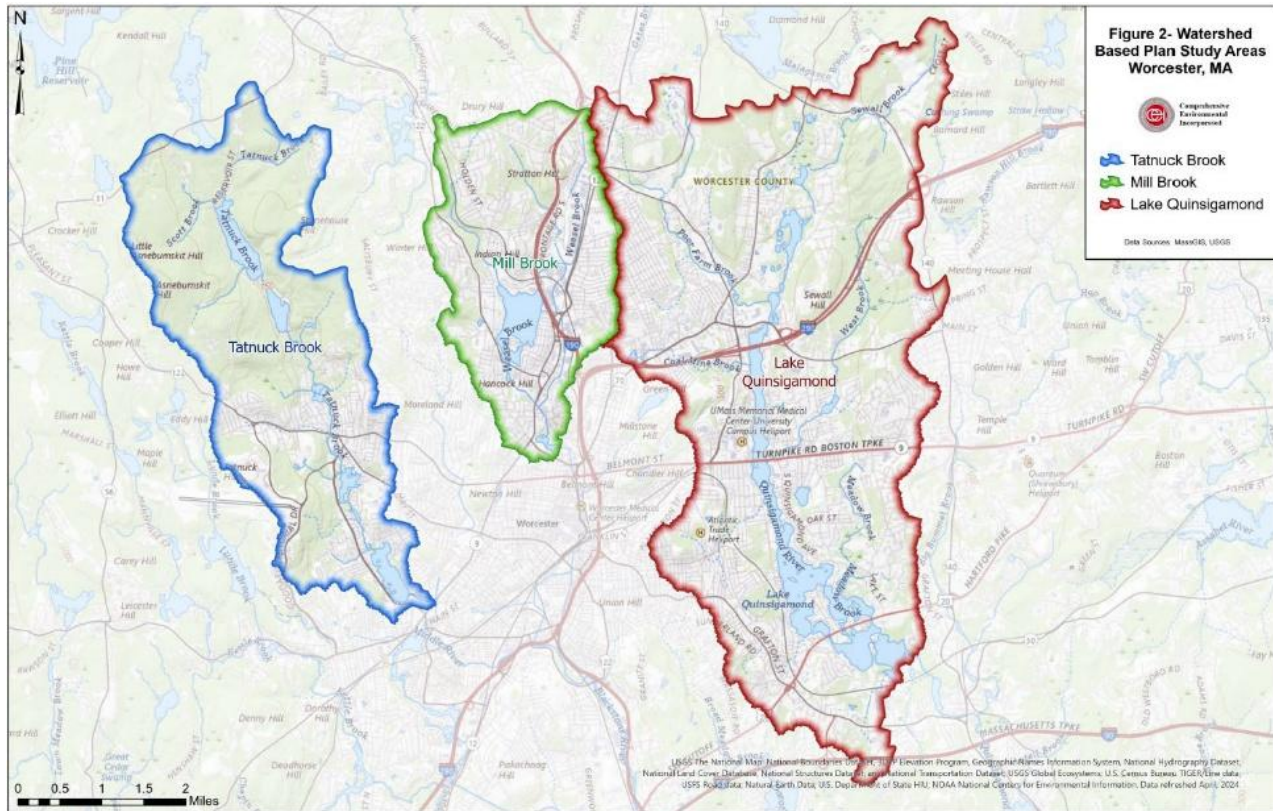


Figure 14 – The Lakes and Ponds Program has contracted a consultant to develop watershed-based plans to reduce nonpoint source pollution in the City’s three main recreational sub-watersheds. This project will identify pollutant loads and load reduction targets and provide stakeholders with a roadmap to restoration and protection. Image credit: Comprehensive Environmental Incorporated (CEI).

make future projects to reduce nonpoint source pollution eligible for state and federal funding. A plan will be created for Mill Brook Watershed, which includes Indian Lake. This project will identify pollutant loads, set 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. The plans are scheduled to be completed in spring 2026.



Figure 15 – The Indian Lake Dosing Station became operational in early June of 2023.

Dosing Station. In 2024, L&P continued to refine operation of the newly constructed dosing station which inactivates phosphorous-containing sediments as they enter Indian Lake (see Figure 15). Though initial observations and monitoring results from 2023 were encouraging, procurement challenges and a lack of rainstorms in the summer of 2024 limited dosing and monitoring opportunities. Contractual procurement challenges have since been resolved, enabling the station to become operational for dosing spring rainstorms. In 2025 L&P will continue to hone operational procedures and monitor performance. It will likely take several years to understand the full potential impacts of this system, however, initial results are encouraging. This project was made possible by advocacy from the Indian Lake Watershed Association (ILWA) and other community partners, and land donations from Bancroft School and the Unitarian Universalist Church.

Boat Decontamination Stations. In 2022, the Lakes and Ponds Program utilized funds from the American Rescue Plan Act (ARPA) to install solar powered boat decontamination stations at Indian Lake to limit the spread of invasive plants that can be unintentionally transmitted as hitchhikers on watercraft (see Figure 16). These stations are free to use and contain instructions on best practices for intercepting invasive aquatic plants before they can take root in our waterbodies. There are blowers and grabbers to remove weeds in hard-to-reach places, brushes to scrub algae off the sides of boats and tools to drain and dry bilge water. To help spread the word on the stations, L&P created a “Blue Space Minute” called [Boat Cleaning Stations](#) that is available on the City of Worcester YouTube channel.

Goose Fencing. In 2021, the Lakes and Ponds Program began implementing a goose fencing pilot project that aimed to reduce the number of beach closures at Indian Lake by humanely keeping geese away from the beach (see Figure 17). Geese usually enter the beach from the water and are uncomfortable when there are barriers between the beach and the water as the water is their escape route from land predators. However, Canada geese are intelligent and quickly learn to ignore or avoid many types of deterrents. L&P has worked with lifeguards at City beaches to pilot different fencing methods since 2021 with varied results due to fence design, lifeguard availability, and



Figure 16 - Solar powered boat decontamination stations were installed at Indian Lake and Coes Reservoir to enable lake goers to decontaminate their watercraft before and after use to avoid transporting invasive plants between lakes.



Figure 17 – New goose fencing materials used in 2024 were more easily implemented by staff but were not as effective at reducing the amount of goose droppings on City beaches.

quick acclimation of geese to the varied approaches. In 2025, L&P will continue to refine the approach to deterring geese from City beaches to reduce the risk of beach closures due to fecal bacteria exceedances.

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 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 lakegoers 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 Inspectional Services and the Parks Department to establish a flow of information to keep the system up to date. To sign up to receive text alerts, visit [worcesterma.gov/bluespace](https://www.worcesterma.gov/bluespace).

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 lakes and ponds. 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. The Lakes and Ponds Program will collaborate with DSR staff on ways to reduce impact of waste and litter in our lakes and ponds. The Indian Lake Watershed Association has been committed to stewardship of the Indian Lake for many years, including Spring and Fall litter cleanup events. To learn more about their efforts and learn how to get involved, visit them at [ilwa.org](https://www.ilwa.org).

To learn more about Lakes and Ponds Program offerings, please see [WorcesterMA.gov/bluespace](https://www.WorcesterMA.gov/bluespace).

Appendix: Depth Profiles

