Lake Onota Preservation Association

LOPA
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9 May 2025

To: Attached Distribution List

Subject: LOPA Monitoring Program Annual Report for 2023 and 2024

Dear Interested Person,

Attached please find LOPA's latest Monitoring Report. We hope you will find this to be a valuable source of information about Onota Lake, which is located in the Berkshires in Pittsfield, Massachusetts. Monitoring and reporting on Onota Lake are central for LOPA's mission to preserve this beautiful body of water as an environmental and recreational asset for Pittsfield, the Berkshires, Massachusetts, and beyond. Monitoring helps understand how Onota lake functions and provides a scientific basis for lake management and regulation.

The combined 2023 & 2024 report provides data from routine monitoring as well as from investigations of specific threats to the lake's health that occurred during this time period, specifically: (1) the cyanobacteria bloom (north basin, late summer 2023), (2) the discovery of zebra mussel (*Dreissena polymorpha*) DNA in September 2023, and (3) the persistence and (or) spread of invasive vegetation. The collection of routine monitoring data over many years has allowed for comparison of conditions in 2023 with other years to attempt to understand why the cyanobacteria bloom may have occurred that year; this is examined in this report. Past reports can be found at https://onotalake.com/documents.

The routine and special investigation efforts in 2023 and 2024 have benefitted greatly from a committed and capable group of LOPA volunteers, and from the information and insight provided by LOPA's scientific advisory group.

Thank you for your interest in the health of Onota Lake, and for your support and efforts to ensure the integrity of this valuable environmental and recreational asset.

Yours truly,

Karen R. Murray, Ph.D.
LOPA Volunteer Monitoring Program Coordinator

DISTRIBUTION LIST FOR 2023 & 2024 LOPA ANNUAL MONITORING REPORT

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ANNUAL MONITORING PROGRAM REPORT

2023 & 2024

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Monitoring Program Components in 2023 and 2024

Various investigations were conducted on Onota Lake in 2023 and 2024 to provide scientific data regarding biological, physical, and chemical components of the lake's ecosystem (Table 1). Special investigations were conducted to address specific threats to the lake's health, including invasive plants, a cyanobacteria bloom (previously called 'harmful algal bloom), and the detection of DNA from the invasive zebra mussel (*Dreissena polymorpha*). Routine monitoring was also done in 2023 and 2024, extending the data collection that was begun decades ago.

Routine water quality monitoring has been conducted on Onota Lake for more than 25 years, providing information with which to assess current conditions, examine trends over time, consider temporal changes in relation to weather, and evaluate various lake management practices. The analysis and interpretation of these data advance an understanding of how the lake functions and can help uncover factors that could be related to any unusual phenomena and threats that may occur. Other routine monitoring includes an annual seining survey of the nearshore fish assemblage, conducted by the Berkshire Environmental Research Center, under contract to the City of Pittsfield, and with the assistance of LOPA volunteers.

Importantly, some specific threats to the health of the lake warranted additional special investigations in 2023 and 2024. These threats were (1) the occurrence of a small, localized cyanobacteria bloom in late summer and early fall of 2023, (2) the detection of zebra mussel DNA in one of four locations sampled for environmental DNA (eDNA) by the Massachusetts Department of Conservation and Recreation in September 2023, and (3) the resurgence in 2023 and 2024 of Eurasian watermilfoil (*Myriophyllum spicatum*) in portions of the lake after treatment with a systemic herbicide in 2021.

Routine monitoring and special investigations were conducted by Lake Onota Preservation Association (LOPA) volunteers, by consultants under contract to LOPA, and by consultants under contract to the City of Pittsfield. Most of the investigations conducted by consultants were done so with the assistance of LOPA volunteers. Information from other investigations conducted by the State of Massachusetts is also incorporated into this report.

Table 1. Onota Lake investigations conducted during 2023 and 2024 that are addressed in this report. Abbreviations as follows: BERC, Berkshire Environmental Research Center; eDNA, environmental DNA; LAPA-West, Lakes and Pond Association of Western MA; LOPA, Lake Onota Preservation Association; MA DCR, Massachusetts Department of Conservation and Recreation; MA DFW Massachusetts Department of Fish and Wildlife; UNH, University of New Hampshire. Number of sample visits is one unless specified in 'timing' column.

Investigation	Description	Entity	Timing	
			2023	2024
Water quality – routine monitoring **(p. 3)**	Document important limnological characteristics	LOPA volunteers	11x: May – Oct	12x: May – Oct
Cyanobacteria – routine monitoring **(p. 31)**	Identification and quantification to facilitate early detection	Shannon Poulin, under contract to the City of Pittsfield; with LOPA volunteers	7x: June – - Sept	7x: June – Sept
Cyanobacteria – Follow up on bloom of late summer 2023 **(p. 31)**	Identification and quantification	Shannon Poulin, under contract to LAPA-West; with LOPA volunteers	3x: Aug – - Sept	-----
	Sample collection and submission for toxicity testing	City of Pittsfield, with LOPA volunteers	Aug	-----
Fish assemblage surveys (p. 33)	Shoreline seining at 5 long-term monitoring locations selected by MA DFW	BERC under contract to the City of Pittsfield; with LOPA volunteers	Sept	Sept
	Boat electrofishing	MA DFW	June	-----
Macrophyte surveys (p. 34)	Lake-wide plant surveys of photic zones	Solitude Lake Management under contract to the City of Pittsfield; with LOPA volunteers	3x: May, Aug., Sept.	2x: June, Sept
Zebra mussels – routine monitoring **(p. 35)**	eDNA, and visual inspection (including SCUBA diving)	MA DCR	Sept	Sept
Zebra mussels -- Follow up on positive eDNA finding **(p. 35)**	Visual inspection of shoreline, shallows, and infrastructure	MA DCR	Nov	-----
		City of Pittsfield	Nov	-----
	SCUBA diving to visually search for settled adults and juveniles	Biodrawversity Inc. under contract to LOPA; with LOPA volunteers	Dec	May
		Biodrawversity, Inc. under contract to City of Pittsfield; with LOPA volunteers	-----	2x: Aug, Sept
		MA DCR	Sept	2x: Aug
	Targeted and spatially distributed eDNA sampling	UNH, under contract to LOPA; with LOPA volunteers	Dec	-----
		MA DCR	-----	2x: Feb, Sept
		LOPA volunteers and the City of Pittsfield	-----	5x: April, May Jul, Aug

Routine Water Quality Monitoring

Approach:

Routine water quality monitoring of Onota Lake in 2023 and 2024 was focused on documenting patterns across the season (May – October) in nutrient concentrations, transparency (or "clarity"), and depth profiles of temperature, dissolved oxygen, and pH. Sampling was conducted using standard limnological methods, and incorporated recommendations from Kenneth Wagner, Ph.D. (Water Resource Services, Wilbraham, MA). The routine monitoring in 2023 and 2024 extended the record of annual monitoring data that began in 1996. Monitoring reports for prior years are available at https://onotalake.com/documents/.

Sampling was focused on two locations (Figure 1) that have been monitored for more than 20 years: D-2, the deepest location in the north basin (near the southwest end of Thomas Island), and D-6, the deepest location in the south basin (out from the Burbank Park fishing pier). Location coordinates are provided in the headers of Table 2 (D-2) and Table 3 (D-6). The monitoring of both locations is important because Onota Lake has two separate 'basins' that differ greatly in depth, and this difference strongly influences the physical, chemical, and biological characteristics of each basin. As is seen in Figure 1, the maximum depth of the south basin is more than 40 feet greater than that of the north basin. In addition, most of the south basin has depths greater than 30 feet, whereas little of the north basin exceeds 5 feet in depth.

Eleven routine sampling visits were made between May 12 and October 6 in 2023 (Table 2) and 12 visits were made between May 6 and October 4 in 2024 (Table 3). (An additional visit to D-2 was made in 2023 to collect data necessary for cyanobacteria sampling.) These visits covered the entire warm-weather recreational season (henceforth 'season') each year. Sample timing was approximately bi-weekly during most of the season each year.

Depth profiles of temperature, dissolved oxygen, and pH through the season help reveal changes across the season as the lake progresses from spring turnover, through summer stratification, and into the beginning of fall turnover. Because Onota Lake is a typical 'dimictic' lake, the entire water column mixes from top to bottom twice per year - in the spring and in the fall. In summer, dimictic lakes are thermally stratified, with a warmer (lighter) upper layer, or 'epilimnion', a colder (denser) bottom layer, or 'hypolimnion', and an intervening layer ('metalimnion') through which the temperature declines rapidly with increasing depth; this zone of the most rapid decline is called the 'thermocline'. (Dimictic lakes also undergo winter stratification under ice cover.) The timing and duration of summer stratification strongly influences the ecological characteristics and functioning of the lake's two basins and can vary from year to year. Most importantly, a loss of dissolved oxygen over time in the deepest layer affects nutrient cycling, habitat for fish and other animals, and potential growth of cyanobacteria. Relatively warmer spring temperatures and calm conditions can promote earlier stratification, more prolonged isolation of deeper waters from the atmosphere, faster loss of

D.O. near the lake bottom, and greater release of nutrients that can promote the growth of algae and cyanobacteria.

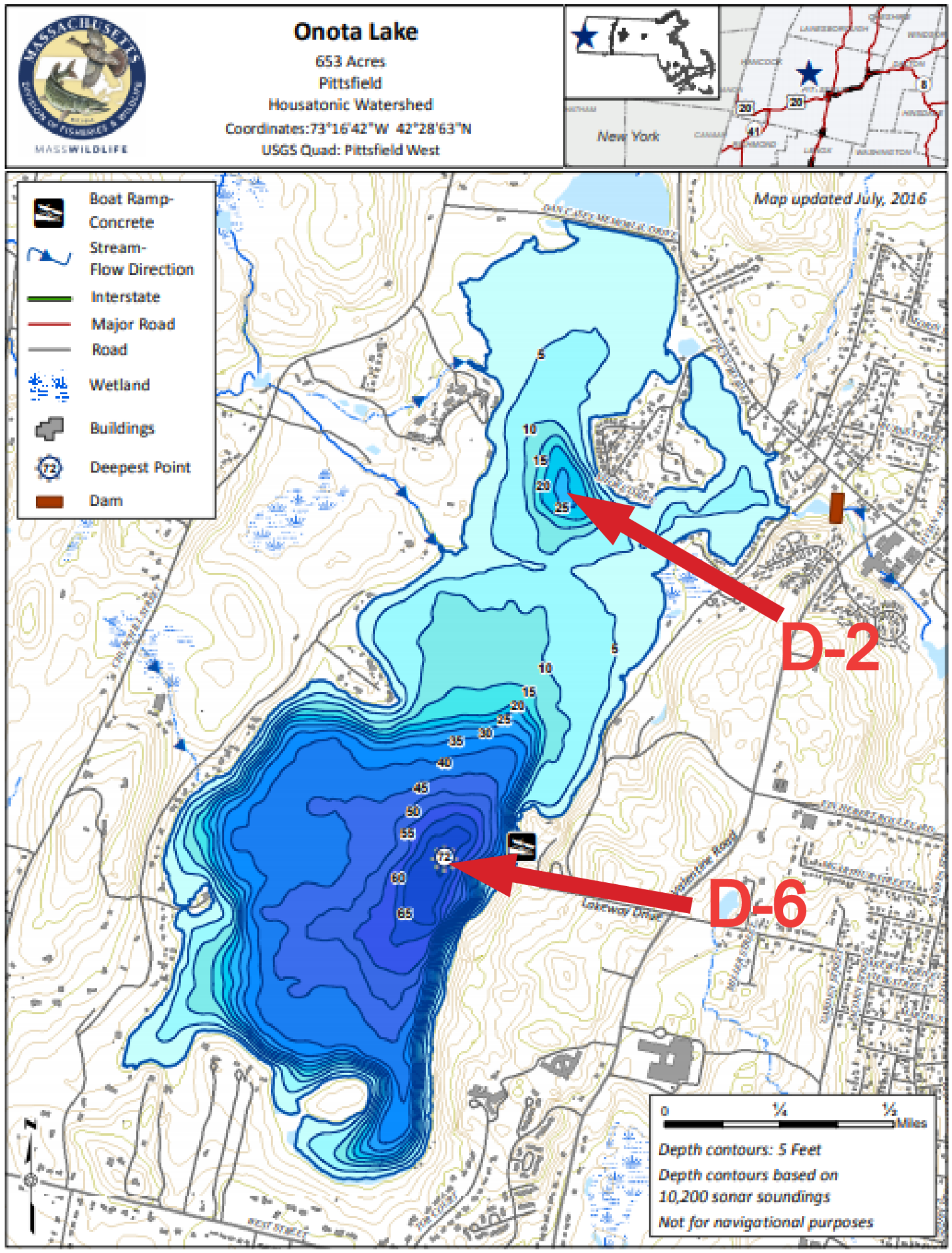

Figure 1. Bathymetric map of Onota Lake, showing the two sites that were sampled routinely in 2023 and 2024: site D-2 in the north basin, and site D-6 in the south basin. Site location coordinates can be found in Tables 2 and 3. Base map is from Massachusetts Division of Fisheries and Wildlife (https://www.mass.gov/files/documents/2018/02/05/Onota_lake.pdf accessed Feb. 18, 2021). Thomas Island can be seen in the upper right portion of the map.

A multiprobe instrument was used to measure temperature, dissolved oxygen, pH, and specific conductance at depths from 1ft to near bottom through the water column. Depth intervals at D-6 were 1 ft, 6 ft, and subsequent 6 ft intervals during most visits (shorter intervals were used at certain depths during some visits). Because site D-2 is shallower, measurements are expected to change more quickly with depth, so 3 ft intervals were typically employed at that site; shorter intervals were sometimes used. The instrument was calibrated for D.O. and pH on each sampling date before arriving at the first site. Because Onota Lake is known to be alkaline, a two-point pH calibration was done using pH standards 7 and 10 (i.e., rather than including pH 4 as a third calibration point, as would be done were the lake more acidic).

The deepest measurements made during routine visits were typically within 2 ft above the lake bottom in 2023 (median 2 ft, range 1 ft – 3 ft at both sites), and all were within 2 ft of the bottom in 2024 (median 1 ft and 2 ft at D-2 and D-6, respectively; range 1-2 ft at both sites). Maximum depth at the sampling location was measured with a weighted line, or with the multiprobe (which uses a transducer to determine depth). Depth calibration of the multiprobe was performed upon arrival at the first site on each sample day.

Transparency is an indicator of amounts of organic (living and non-living) and inorganic particles suspended in the water column, including algae (phytoplankton), bacteria, sediment, decomposing plant and animal material, and other suspended particles. The amount of transparency in a lake can also influence plant and cyanobacteria growth, with greater transparency generally allowing for more growth at lower depths.

Transparency estimation throughout the season can provide a good indication of the aesthetic quality of the water, with high transparency generally more desirable than low transparency. Because transparency is an indicator of algal production, it can be used along with rooted plant growth and nutrient data to broadly characterize the lake's overall primary production status, or 'trophic state'. Lakes with high transparency, low nutrients, and relatively low rooted plant growth are considered 'oligotrophic'. At the opposite end of the trophic state continuum are 'eutrophic' lakes with low transparency, high nutrients, and high rooted plant growth. Lakes intermediate in these characteristics are considered 'mesotrophic'.

Transparency was measured with a Secchi disk -- a simple device that has been in use for more than a century. Measurements were made by lowering the standard black and white Secchi disk until it could no longer be seen and noting this depth, then slowly raising it, and noting the depth at which it reappeared; the Secchi depth was recorded as the mean of the two measurements. The measurements were made from the shady side of the boat, and a view scope was typically used (Tables 2 and 3).

Nutrient analyses were performed on water samples that were collected three times each year: in the early, mid, and late portions of the season. On each date, two water samples were collected from each site: one from the upper part of the water column (approximately 1 foot below the surface) and one from the lower part of the water column (approximately 1.5 feet above the lake bottom). The near-bottom samples were collected with a Van Dorn 'Alpha' horizontal sampler, which allows for collection at a specified depth. The near-surface samples were 'grab samples', collected by hand directly into the sample bottle. All collection gear was rinsed with native water in the field prior to sample collection. Samples were placed in a cooler with ice packs and were either transported to the laboratory on the day of collection or refrigerated overnight and transported to the laboratory the next morning. Samples were analyzed at Microbac Laboratories (Lee, MA) for total Kjeldahl nitrogen, nitrate, and total phosphorus.

Laboratory quality assurance (QA) for nutrient data were provided by the Microbac Laboratories. Field QA sampling for nutrients consisted of an equipment blank (distilled water poured into and then out of the Van Dorn sampler into a collection bottle), and two duplicate samples (one each from the upper and lower waters of site D-2). All laboratory QA results were deemed acceptable. The field blanks were acceptable, and all duplicates were acceptable in 2024. The near-surface duplicate collected in May 2023 was acceptable. However, the deep-water duplicate sample collected on the same date contained much lower concentrations of TKN and TP than did the main sample, indicating that the sampler had likely incorporated some bottom material into the main sample. Because of this, the main sample values of TKN and TP were rejected, and the duplicate sample values were used for that time period. Duplicate sampling was again performed in July 2023 (both surface and deep samples) and all results were acceptable.

Calcium and Alkalinity analyses were performed on some near-surface samples that were collected in 2024. Current information on calcium concentration and alkalinity can be compared with previous values (from 2009) and provide updated understanding of the environmental suitability of Onota Lake for invasive zebra mussel.

Findings:

Secchi disk readings and general site visit information for sites D-2 and D-6 are provided in Tables 2 and 3 (for 2023 and 2024, respectively). Depth profile data for D.O. and temperature are provided in Tables 4 and 5 (for sites D-2 and D-6, respectively). Values of pH from depth profiles at both sites are provided in Table 6, and nutrient data are provided in Table 7.

The maximum depth at both sampling locations varied among site visits, ranging within in both years from 23 ft to 26 ft at site D-2, and from 53 ft to 60 ft at site D-6. Median values of maximum depth were 25 ft and 56 ft for sites D-2 and D-6, respectively within both years. This variation in maximum depths within each site reflects differences in boat location and position among visits, rather than an actual variation in the maximum depth of the lake in each basin.

Table 2. Site visit information and Secchi disk depth from water quality monitoring of Onota Lake in 2023 at sites D-2 (N 42º 28.60'**;** W 073º 16.72') and D-6 (N 42º 27.96'; W 073º 16.90'). '---' denotes 'data not collected'. Wind speed on sample date is estimated. Precipitation and wind speed codes for prior time periods are on a scale from 0 to 5, with 0 indicating 'none' and 5 indicating 'very heavy'. Lake level at dam spillway is inches above dam surface. Abbreviations for Secchi disk notes are as follows: v denotes 'use of view scope', g denotes 'sunglasses worn', and s denotes 'observation made in shade'.

Date & Time in 2023	Air Temp. (°F)	Sky	Wind speed (mph) & direction	Weather 0-24 / 24-48 / 48-72 hours prior		Total depth (feet)	Lake level at dam spillway (inches above)	Secchi disk depth (m) and notes
				Precip. code	Wind speed code			
Site D-2 (north basin)								
5/12 @1020	66	5% clouds	8 W	1/1/1	1/0/0	25	0.25	2.6 v,s
5/24 @1020	66	95% clouds	0	0/1/3	1/2/2	24	0.06	2.9 v,s
6/08 @---	51	Cloudy & smokey	4 WNW	1/2/0	2/2/2	25	-0.14	3.2 v,s
6/20 @0915	64	30% clouds	0-1 SSE	0/1/0	2/2/2	25	-0.12	3.1 v,s
7/11 @0915	68	25% clouds	3-7 WNW	4/2/0	3/2/2	26	0.58	4.0 v,s
7/26 @0915	68	95% clouds	0-3 WSW	2/3/0	2/3/2	26	0.35	3.9 v,s
8/10 @0915	66	90% clouds	0-3 S	0/1/4	3/3/3	25	0.20	3.6 v,s
8/17 @1330	71	100% clouds	4-8 SSE	2/2/3	2/2/4	25	0.36	3.1 v,s
8/24 @1030	66	100% clouds	10-12 SSE	0/0/0	2/3/3	23	0.3	3.3 v,s
9/05 @0915	73	100% clouds, fog	0	0/0/0	2/3/3	25	0.24	4.1 v,s
9/18 @1030	62	heavy clouds, misty	2-4 SE	2/0/0	3/3/3	25	0.31	4.3 v,s
10/6 @0945	62	100% clouds	6-8 SE	0/0/0	2/2/2	24	0.32	4.7 v,s
Site D-6 (south basin)								
5/12 @0940	62	5% clouds	6 W	2/2/2	0/0/0	57	0.26	4.5 v,s
5/24 @0940	59	95% clouds	0	0/1/3	1/2/2	54	0.07	6.0 v,s
6/08 @ 0900	51	100% clouds, smoke, light drizzle	4 WNW	1/2/0	2/2/2	56	-0.14	6.9 v,s
6/20 @ 0845	62	60% clouds	0-2 SE	0/1/0	1/2/2	55	-0.11	6.9 v,s
7/11 @0845	65	30% clouds	6 WNW	3/2/0	2/2/2	53	0.58	7.1 v,s
7/26 @0830	66	100% clouds, dense fog	0-3 WSW	2/3/0	2/3/2	60	0.36	6.0 v,s
8/10 @0845	64	95% clouds	0-3 SSE	0/1/4	3/3/3	56	0.20	5.2 v,s
8/24 @0945	64	90% clouds	2-5 SSE	0/0/0	2/3/3	56	0.31	5.3 v,s
9/05 @0845	71	dense fog	0	0/0/0	2/3/3	55	0.25	6.5 v,s
9/18 @0940	61	rain	2-5 SE	2/0/0	3/3/3	60	0.31	6.3 v,s
10/06 @0930	61	100% clouds	6-8SE	0/0/0	2/2/2	56	0.32	7.5 v,s

Table 3. Site visit information and Secchi disk depth from water quality monitoring of Onota Lake in 2024 at sites D-2 (N 42º 28.60'**;** W 073º 16.72') and D-6 (N 42º 27.96'; W 073º 16.90'). '---' denotes 'data not collected'. Wind speed on sample date is estimated. Precipitation and wind speed codes for prior time periods are on a scale from 0 to 5, with 0 indicating 'none' and 5 indicating 'very heavy'. Lake level at dam spillway is inches above dam surface. Abbreviations for Secchi disk notes are as follows: v denotes 'use of view scope', g denotes 'sunglasses worn', and s denotes 'observation made in shade'.

Date & Time in 2024	Air Temp. (°F)	Sky	Estimated wind speed (mph) & direction	Weather 0-24 / 24-48 / 48-72 hours prior		Total depth (feet)	Lake level at dam spillway (inches)	Secchi disk depth (m) and notes
				Precip. code	Wind speed code			
Site D-2 (north basin)								
5/06 @0915	56	70% clouds	3 WSW	3/0/0	2/2/2	25	---	3.2 v,s
5/21 @1000	72	10% clouds	0	0/0/0	2/2/2	25	---	2.9 v,g,s
6/04 @1030	74	15% clouds	8 SSW	0/0/0	0/0/1	24	---	3.7 s
6/17 @0930	68	5% clouds	0	0/0/0	1/2/2	24	---	3.7 v,g,s
7/01 @0815	59	60% clouds	5-10 NNW	2/0/2	2/2/2	25	---	3.5 v,s
7/15 @0930	77	20% clouds	5-8 WSW	0/0/2	2/2/2	25	---	3.1 v,s
7/30 @0930	74	cloudy	4 S	3/0/0	2/2/2	20	---	3.6 v,s
8/12 @0945	62	30% clouds	6 WNW	4/0/4	3/2/4	25	---	2.9 s
8/26 @0845	63	10% clouds	0	0/2/0	2/2/2	25	2.06	2.9 v,s
9/09 @0900	54	5% clouds	5-8 SW	0/0/0	3/3/3	25	0	3.4 v,s
9/23 @0845	54	90% clouds	1-5 E	2/2/2	0/0/0	25	---	3.3 v,s
10/04 @1015	60	hazy	0	0/0/0	1/1/2	26	---	4.3 v,s
Site D-6 (south basin)								
5/06 @0845	53	dense clouds	2 SW	3/0/0	2/2/2	62	---	5.3 v,s
5/21 @0915	67	10% clouds	0	0/0/0	2/2/2	58	---	7.0 v,g,s
6/04 @0930	70	5% clouds	0	0/0/0	0/0/1	55	---	8.7 v,g,s
6/17 @0845	66	25% clouds	8 SSW	0/0/0	1/2/2	53	---	6.7 s
7/01 @0845	61	75% clouds	5-12 NNW	2/0/2	2/2/2	59	---	4.7 v,s
7/15 @0830	75	10% clouds	3-5 SW	0/0/2	2/2/2	53	---	5.8 v,s
7/30 @0845	71	cloudy	4 S	3/0/0	2/2/2	54	---	4.5 v,s
8/12 @0915	62	15% clouds	6 WNW	4/0/4	3/2/4	56	---	5.2 v,s
8/26 @0810	62	10% clouds	0	0/2/0	2/2/2	59	2.06	4.9 v,s
9/09 @0800	49	clear	1-3 SW	0/0/0	3/3/3	62	0	5.1 v,s
9/23 @0815	52	90% clouds	2-5 E	2/2/2	0/0/0	60	---	5.3 v,s
10/04 @0945	59	dense fog	0	0/0/0	1/1/2	61	---	5.5 v

<u>Temperature profiles and thermal stratification</u>

As in previous years, plots of temperature profiles in 2023 (Figure 2) and 2024 (Figure 3) for sites D-2 and D-6 show both the similarities and the differences between Onota Lake's two basins. Both sites exhibited the very beginning of thermal stratification by the time of the first sampling (on May 12 in 2023, Figures 2A, 2D; on May 6 in 2024, Figures 3A, 3D) with higher temperatures near the surface than near the bottom. Stratification at both sites was complete by early June of each year.

The beginning of thermal stratification was relatively early in both years. This is of particular interest with regard to the cyanobacteria bloom at site D-2 in late summer of 2023, so it is helpful to compare 2023 with other years (there was no bloom in 2024). Temperatures near the surface were warm at both sites on May 12, 2023 (16.7°C and 16.3 °C at D-2 and D-6, respectively), and higher than temperatures in three recent years sampled during May 10-12 at D-2 (11.5°C 12.5°C, and 12.1 °C in 2022, 2021, and 2017, respectively) and D-6 (11.1°C,12.3°C, and 12.3 °C in 2022, 2021, and 2017, respectively). Thermal differences between 1' depth and near-bottom depths at both sites were large on May 12 in 2023 (differences of 8.1°C and 10.6°C for D-2 and D-6, respectively). These differences were much greater than in recent previous years with data for May 10-12 (i.e., 2022, 2021, and 2017); surface to near-bottom temperature differences in those years ranged from 1.3°C to 3.1° C for D-2, and 2.7°C to 6.7°C for D-6. Although it would be interesting to compare these values with 2024 temperatures, a site visit was not made during this time period (May 10-12). Future trends analysis would benefit from more consistent timing of visits among years, to the extent possible. Alternatively, the use of in-situ temperature loggers could be considered.

During summer stratification, water can circulate and contact the air throughout the epilimnion (the upper layer), but the greater density of the colder, deeper layers (metalimnion and hypolimnion) isolates them from the atmosphere. Because stratification began earlier in 2023 (as well as in 2024) than other years, the bottom layer at each site was isolated from the atmosphere for longer than in typical years.

The summer stratification pattern in the lake's deep basin (site D-6) exhibited a classic pattern of upper epilimnion, lower hypolimnion, and intervening metalimnion (which contains the thermocline) in both years. The deep layer of cold water (hypolimnion) persisted for the entire summer in both years from about 36' deep to the bottom (Figures 2D-F and 3D-F for 2023 and 2024, respectively). Site D-2 in the north basin also exhibited persistent summer stratification both years (Figure 2A-C) and 3A-C for 2023 and 2024, respectively). However, unlike the deep south basin, the shallow depth of the north basin (maximum about 25 ft) did not allow for the formation of a distinct hypolimnion. Instead, the warmer epilimnion occurred above a layer of rapid change in temperature (the metalimnion), that continued until meeting (or nearly meeting) the lake bottom. This is a typical pattern seen in shallow lakes or in shallow portions of lakes elsewhere in the northern hemisphere.

Thermal stratification started to break up in both basins by mid-September in 2023 (Figures 2C, 2F) and by early September in 2024 (Figures 3C, 3F). With the cooling of the epilimnion, the density difference between layers is reduced and the wind can more easily cause the water column to mix to progressively greater depths until the entire water column is mixed from the surface to the bottom of the lake. This phenomenon of 'fall turnover' was not yet complete at either site as of the last visit of the season (early October) in either year (Figures 2C,F and 3C,F).

Table 4. Water temperature at various depths in Onota Lake during May through October 2023. '---' denotes 'data not collected'.

Depth (ft)	Site visit date											
	5/12	**5/24**	**6/8**	**6/20**	**7/11**	**7/26**	**8/10**	**8/17**	**8/24**	**9/5**	**9/18**	**10/6**
	***Site D-2 Water Temperature* (°C)**											
1	16.7	18.1	17.7	21.3	24.6	24.9	22.8	23.3	22.1	23.8	20.3	19.2
3	---	17.8	17.7	21.0	24.6	24.8	22.8	23.3	22.1	23.8	20.3	19.2
6	16.3	17.7	17.8	20.2	24.5	24.8	22.8	23.3	21.9	23.7	20.4	19.2
9	15.2	16.8	17.8	19.6	24.1	24.8	22.6	23.2	21.8	22.9	20.3	17.9
12	13.2	16.1	17.6	18.3	22.4	23.7	22.5	23.1	21.5	22.1	22.0	16.5
15	11.9	15.1	16.8	16.7	19.0	20.4	22.4	22.3	21.1	21.2	19.8	15.9
16	---	---	---	---	---	---	---	21.2	---	---	---	---
17	---	---	---	---	---	---	---	20.5	---	---	---	---
18	10.7	10.8	12.9	13.9	15.5	17.3	18.6	19.8	19.0	19.6	19.5	15.4
19	---	---	---	---	---	---	---	18.4	---	---	---	---
20	---	---	---	---	---	---	---	16.7	---	---	---	---
21	9.1	9.6	10.2	11.1	12.8	13.8	15.4	16.1	17.2	17.8	18.5	15.2
22	---	---	---	---	---	---	---	15.6	---	---	---	15.1
23	8.6	---	9.7	---	---	---	---	14.9	---	---	---	---
24	---	---	---	9.2	11.1	11.9	13.9	14.0	---	15.3	16.7	---
	***Site D-6 Water Temperature* (°C)**											
1	16.3	17.5	18.3	20.5	24.7	25.2	23.0	---	22.4	23.3	21.4	18.8
6	15.9	16.9	18.3	20.4	24.7	25.2	23.0	---	22.4	23.3	21.4	18.6
12	14.4	16.4	18.3	19.7	24.6	24.8	23.0	---	22.2	22.7	21.4	17.7
18	12.8	15.6	18.1	18.4	20.1	21.5	23.0	---	22.1	22.2	21.4	17.3
24	9.0	9.2	10.9	12.6	15.3	16.0	16.6	---	19.0	18.6	20.1	16.9
30	6.9	7.1	8.0	8.4	10.2	10.5	11.2	---	12.0	12.2	12.5	14.2
33	---	---	---	---	---	---	---	---	10.0	---	---	---
36	6.1	6.4	6.9	7.1	7.9	8.0	8.8	---	8.5	9.5	9.8	9.7
42	5.8	6.0	6.3	6.4	6.9	7.2	7.6	---	7.7	7.9	7.9	8.1
48	5.8	5.9	6.2	6.3	6.6	6.8	7.0	---	7.0	7.0	7.2	7.2
51	---	---	---	---	6.4	---	---	---	---	---	---	---
52	---	5.9	---	---	---	---	---	---		---	---	---
53	---	---	---	6.1	---	---	---	---	---	---	---	---
54	5.8	---	6.4	---	---	6.5	6.8	---	6.6	6.7	6.8	7.0
57	---	---	---	---	---	---	---	---	---	---	6.8	---
58	---	---	---	---	---	6.4	---	---	---	---	---	---

Table 5. Water temperature at various depths in Onota Lake during May through October 2024. '---' denotes 'data not collected'.

Depth (ft)	Site Visit Date											
	5/6	5/21	6/4	6/17	7/1	7/15	7/30	8/12	8/26	9/9	9/23	10/4
						***Site D-2 Water Temperature* (°C)**						
1	15.7	21.1	23.2	22.8	22.9	28.3	24.7	23.7	22.8	19.6	20.2	18.9
3	15.5	20.3	23.0	22.7	22.9	28.2	24.7	23.6	22.8	19.6	20.3	18.9
6	15.2	18.7	22.8	22.7	22.9	28.0	24.7	23.5	22.7	19.6	20.3	18.9
9	15.1	17.7	21.8	22.2	22.9	27.6	24.7	23.4	22.1	19.5	20.2	18.9
12	13.0	16.5	19.7	21.3	22.6	25.6	24.4	23.2	21.4	19.4	20.1	18.8
13	---	---	---	---	22.4	---	---	---	22.8	---	---	---
14	---	---	---	---	21.7	---	---	---	22.8	---	---	---
15	11.3	13.0	15.5	17.1	19.5	20.2	22.6	22.9	22.7	19.2	20.0	18.5
16	---	---	---	---	17.1	---	21.7	22.7	22.1	---	---	---
17	---	---	---	---	15.9	---	20.5	22.5	21.4	---	---	---
18	10.1	11.1	12.9	12.9	14.4	16.5	18.4	21.9	21.0	19.1	19.3	18.2
19	---	10.6	---	12.8	13.1	---	17.5	19.6	20.8	---	---	---
20	---	10.3	---	12.1	12.2	---	---	18.8	20.7	18.8	---	---
21	9.6	10.0	11.1	11.6	22.9	---	---	16.3	20.4	18.7	18.0	17.8
22	---	---	10.5	11.4	---	---	---	---	----	----	---	---
24	---	---	---	---	22.9	13.1	---	14.2	20.1	16.0	16.7	17.1
						***Site D-6 Water Temperature* (°C)**						
1	15.2	19.7	22.4	21.9	23.1	27.8	25.1	23.9	23.0	20.6	20.7	19.2
3	15.2	19.2	22.5	21.9	23.1	27.7	---	23.9	22.9	20.6	20.7	19.2
6	15.1	18.4	22.4	21.9	23.1	27.6	25.1	23.9	22.8	---	20.7	19.2
9	---	---	22.1	---	23.1	27.5	---	---	---	20.6	---	---
12	13.6	17.7	21.5	21.5	23.1	27.2	25.1	23.8	22.4	---	20.7	19.2
15	---	12.7	---	21.3	23.1	25.0	---	---	---	20.6	20.7	---
18	10.4	---	15.7	20.2	21.3	22.7	24.5	23.7	22.0	20.6	20.7	19.2
21	---	---	---	13.3	16.0	19.2	---	---	21.7	20.5	20.6	---
24	8.9	9.8	10.8	12.0	12.5	14.7	16.0	18.3	17.9	20.4	19.2	18.7
27	---	---	---	10.6	10.7	12.0	13.4	15.3	14.2	15.3	16.2	15.6
30	7.7	8.3	9.0	9.1	9.3	10.4	11.3	11.7	12.1	12.8	13.0	13.7
33	---	7.7	---	8.8	9.0	9.5	9.9	10.3	10.5	10.8	11.1	---
36	6.7	7.2	7.5	7.8	8.1	8.5	8.7	9.1	9.5	9.7	9.7	10.2
39	---	6.8	---	7.6	7.8	---	8.2	---	8.5	---	---	---
42	6.3	6.4	6.6	7.3	7.4	7.4	7.6	7.5	---	8.2	8.3	8.4
45	---	---	---	---	7.2	---	---	---	7.6	---	7.8	---
48	6.1	6.2	6.3	6.9	6.9	7.0	7.1	7.1	---	7.5	---	7.5
51	---	---	---	---	6.7	---	---	---	7.1	---	7.4	---
52	---	---	---	6.8		---	7.0	---	---	---	---	---
54	6.1	6.1	6.3	---	6.7	6.8	---	7.0	---	7.1	---	7.3
56	---	6.1	---	---		---	---	---	---	---	---	---
57	---	---	---	---	6.7	6.8	---	---	7.0	---	7.2	---
58	---	---	---	---		---	---	---	---	---	7.2	---
60	6.0	---	---	---		---	---	---	---	7.1	---	7.2

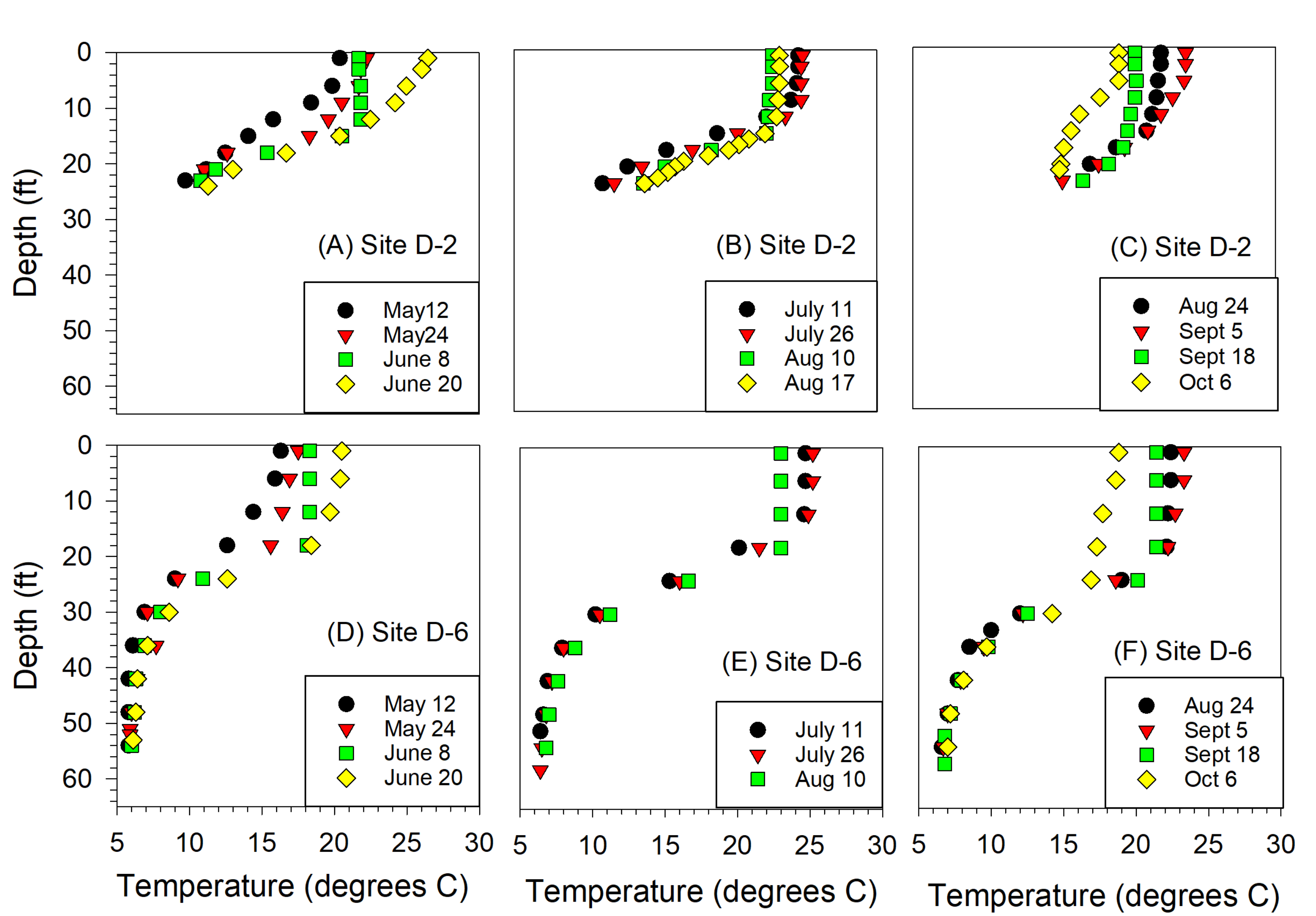

Figure 2. Temperature profiles at sites D-2 (north basin) and D-6 (south) in Onota Lake, in 2023. Each site has three plots to cover the entire season: plots A, B, and C show temperature data for site D-2; plots D, E, and F show temperature data for site D-6. Note that the same depth scale is used for both sites, even though D-2 is much shallower than D-6 (maximum depth at D-2 about 25 ft) Some symbols for Sept 5 (plot F) at greater depths are hidden behind other symbols. All data can be found in Table 4.

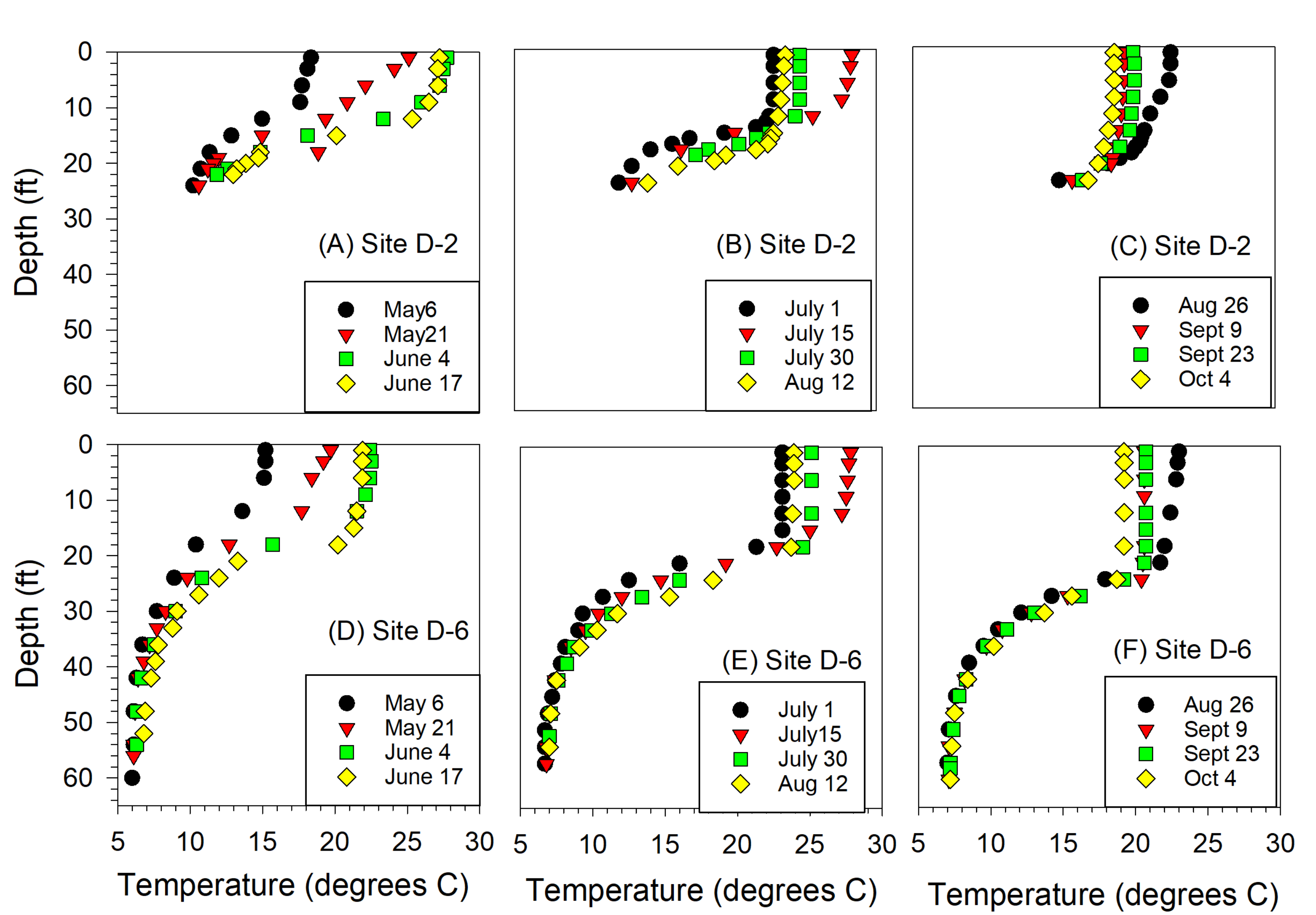

Figure 3. Temperature profiles at sites D-2 (north basin) and D-6 (south) in Onota Lake, in 2024. Each site has three plots to cover the entire season: plots A, B, and C show temperature data for site D-2; plots D, E, and F show temperature data for site D-6. Note that the same depth scale is used for both sites, even though D-2 is much shallower than D-6 (maximum depth at D-2 about 25 ft) Some symbols for July 15 (plot E), Aug 26, and Sept 9 (plot F) at greater depths are hidden behind other symbols. All data can be found in Table 5.

Dissolved oxygen

Sufficient dissolved oxygen (D.O.) is critical to the health of the Onota Lake ecosystem. Requirements vary among the fishes inhabiting Onota Lake, but a minimum D.O. concentration of 5 mg/L is the general 'rule of thumb' associated with a healthy fish assemblage and is the Massachusetts state standard. Concentrations less than 2 mg/L can facilitate the undesirable release of phosphorus, iron, and other substances from the sediment. Importantly, this release of phosphorus can encourage blooms of algae and potentially harmful cyanobacteria. Conversely, very low D.O. (< 2 mg/L) near the bottom in parts of the lake during summer stratification can render those areas unsuitable for invasive Zebra mussels and Asian clams.

As a dimictic lake (having two mixing periods), Onota mixes thoroughly from top to bottom in spring and fall. The contact of the entire water column with the atmosphere delivers D.O. to even the greatest depths. As waters stratify in late spring and continue to warm through the summer, the deeper (colder and thus, denser) waters become isolated from the atmosphere, and D.O. that was present in the beginning of the season gradually becomes depleted. This seasonal progression of D.O. loss near the bottom at both sites can be visualized in profiles of D.O. with depth in 2023 (Figures 3 and 4 for sites D-2 and D-6, respectively) and 2024 (Figures 4 and 5 for sites D-2 and D-6, respectively).

The particularly early onset of stratification in 2023 resulted in earlier-than-usual loss of D.O. near the bottom at both sites. Dissolved oxygen measurements at both sites in 2023 (Tables 4 and 5; Figures 3 and 4) show the loss of D.O. near the bottom as early as the first site visit on May 12.

Because D-2 is relatively shallow, with warmer bottom temperatures (and absence of a cold hypolimnion), the early onset of stratification resulted in little D.O. near the bottom as early as May 12 (Figure 3A) in 2023. Very low D.O. (less than 2 mg/L) subsequently occurred at 18' and deeper for much of the summer and low D.O. conditions reached up to about 12' depth in mid-July (Figure 3B).

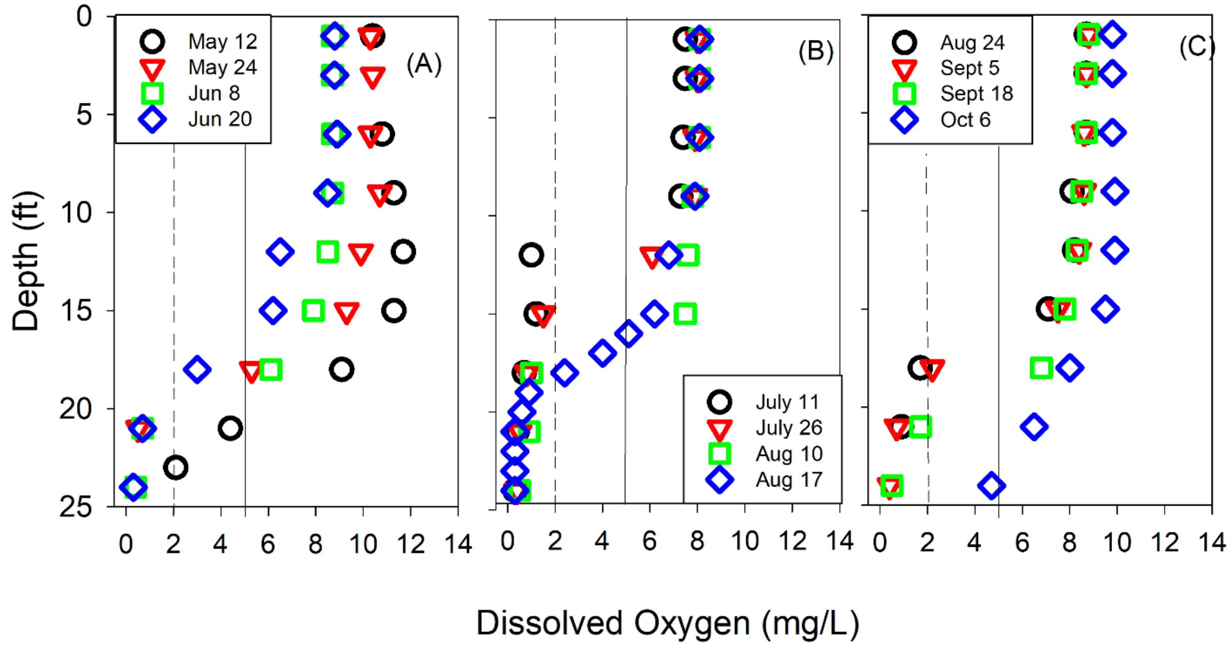

Figure 4. Dissolved oxygen profiles of Onota Lake at site D-2 in 2023. Each plot shows data from 4 site visit dates for the following periods: (A) May 12 – June 20, (B) July 11 – Aug 17, and (C) Aug 24 – Oct 6. The dotted and solid vertical lines in each plot denote 2 mg/L and 5 mg/L D.O., respectively. Data can be found in Table 6.

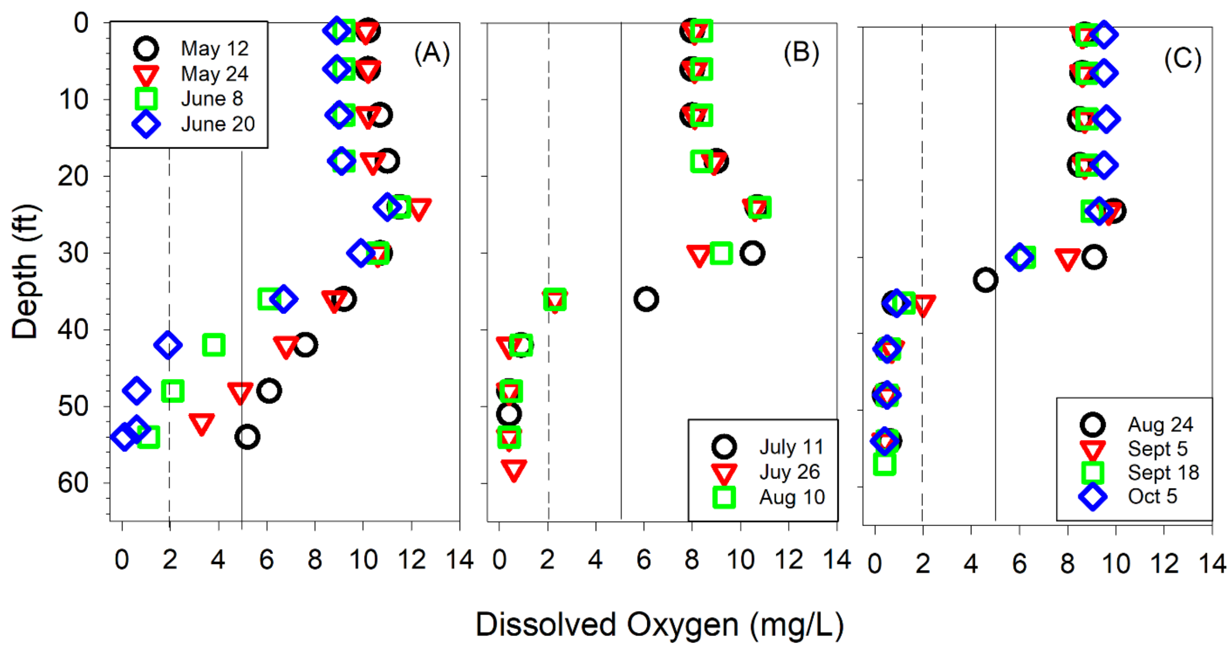

Figure 5. Dissolved oxygen profiles of Onota Lake at site D-6 in 2023. Each plot shows data from 3-4 site visit dates for the following periods: (A) May 12 – June 20, (B) July 11 – Aug 17, and (C) Aug 24 – Oct 6. The dotted and solid vertical lines in each plot denote 2 mg/L and 5 mg/L D.O., respectively. Data can be found in Table 6.

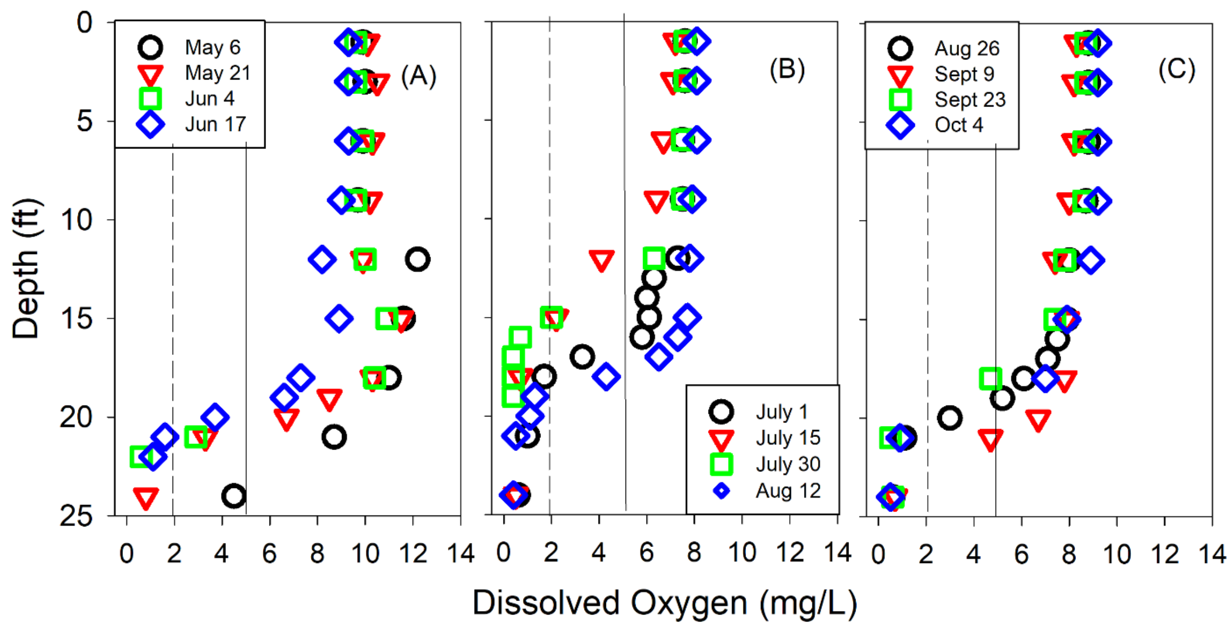

Figure 6. Dissolved oxygen profiles of Onota Lake at site D-2 in 2024. Each plot shows data from 4 site visit dates for the following periods: (A) May 6 – June 17, (B) July 1 – Aug 12, and (C) Aug 26 – Oct 4. The dotted and solid vertical lines in each plot denote 2 mg/L and 5 mg/L D.O., respectively. Data can be found in Table 7.

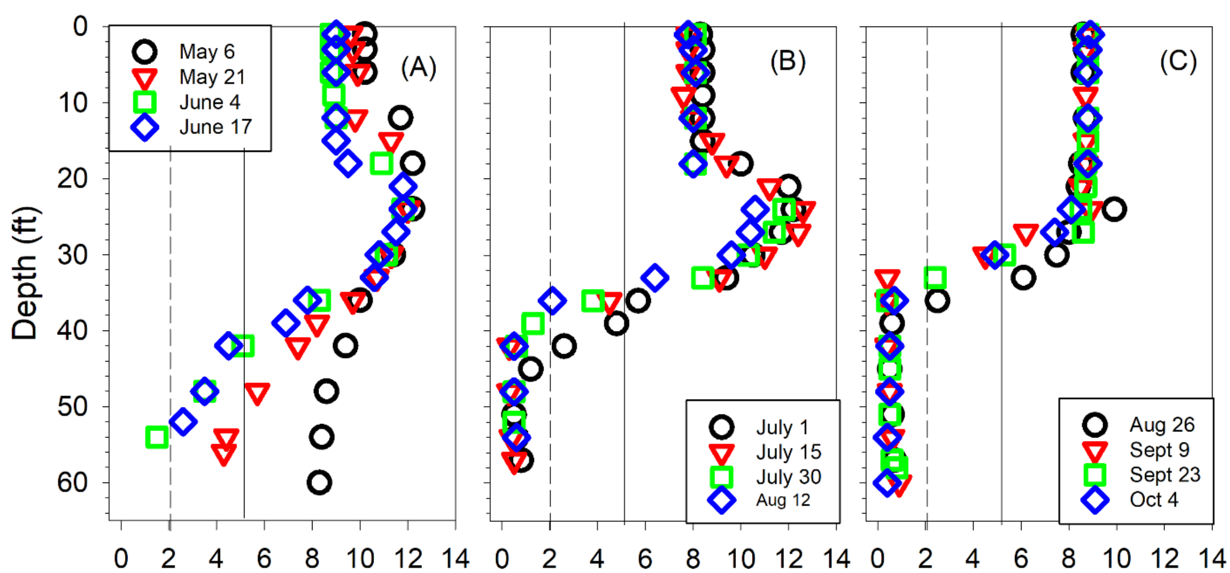

Figure 7. Dissolved oxygen profiles of Onota Lake at site D-6 in 2024. Each plot shows data from 4 site visit dates for the following periods: (A) May 6 – June 17, (B) July 1 – Aug 12, and (C) Aug 26 – Oct 4. The dotted and solid vertical lines in each plot denote 2 mg/L and 5 mg/L D.O., respectively. Data can be found in Table 7.

Table 6. Dissolved oxygen concentration with depth in Onota Lake during May through October, 2023. '---' denotes 'data not collected' ; mg/L - milligrams per liter. Grey shading indicates less than 5 mg/L, generally the minimum for a healthy fish assemblage. Dark grey shading indicates less than 2 mg/L; concentrations lower than 2 mg/L can promote the release of phosphorus from the sediments.

Depth (ft)	Site Visit Date											
	5/12	5/24	6/8	6/20	7/11	7/26	8/10	8/17	8/24	95	9/18	10/6
	Site D-2 Dissolved Oxygen (mg/L)											
1	10.4	10.3	8.7	8.8	7.5	8.0	8.1	8.1	8.7	8.8	8.8	9.8
3	---	10.4	8.7	8.8	7.5	8.0	8.1	8.1	8.7	8.7	8.7	9.8
6	10.8	10.3	8.7	8.9	7.4	7.9	8.1	8.1	8.7	8.6	8.7	9.8
9	11.3	10.7	8.7	8.5	7.3	7.9	7.8	7.9	8.1	8.6	8.5	9.9
12	11.7	9.9	8.5	6.5	1.0	6.1	7.6	6.8	8.2	8.4	8.3	9.9
15	11.3	9.3	7.9	6.2	1.2	1.5	7.5	6.2	7.1	7.5	7.8	9.5
16	---	---	---	---	---	---	---	5.1	---	---	---	---
17	---	---	---	---	---	---	---	4.0	---	---	---	---
18	9.1	5.3	6.1	3.0	0.7	0.8	1.0	2.4	1.7	2.2	6.8	8.0
19	---	---	---	---	---	---	---	0.9	---	---	---	---
20	---	---	---	---	---	---	---	0.6	---	---	---	---
21	4.4	0.5	0.7	0.7	0.4	0.5	0.9	0.3	0.9	0.7	1.7	6.5
22	---	---	---	---	---	---	---	0.3	---	---	---	4.7
23	2.1	---	0.4	---	---	---	---	0.3	---	---	---	---
24	---	---	---	0.3	0.3	0.4	0.5	0.3	---	0.4	0.5	---
	Site D-6 Dissolved Oxygen (mg/L)											
1	10.2	10.1	9.2	8.9	8.0	8.1	8.4	---	8.7	8.6	8.8	9.5
6	10.2	10.2	9.2	8.9	8.0	8.1	8.4	---	8.6	8.6	8.8	9.5
12	10.7	10.2	9.2	9.0	8.0	8.1	8.4	---	8.5	8.7	8.8	9.6
18	11.0	10.4	9.2	9.1	9.0	8.9	8.4	---	8.5	8.7	8.8	9.5
24	11.5	12.3	11.5	11.0	10.7	10.6	10.8	---	9.9	9.7	9.0	9.3
30	10.7	10.6	10.6	9.9	10.5	8.3	9.2	---	9.1	8.0	6.2	6.0
33	---	---	---	---	---	---	---	---	4.6	---	---	---
36	9.2	8.8	6.1	6.7	6.1	2.3	2.3	---	0.8	2.0	1.2	0.9
42	7.6	6.8	3.8	1.9	0.9	0.4	0.9	---	0.5	0.7	0.6	0.5
48	6.1	4.9	2.1	0.6	0.4	0.4	0.5	---	0.4	0.5	0.5	0.5
51	---	---	---	---	0.4	---	---	---	---	---	---	---
52	---	3.3	---	---	---	---	---	---	---	---	---	---
53	---	---	---	0.6	---	---	---	---	---	---	---	---
54	5.2	---	1.1	---	---	0.4	0.4	---	0.6	0.4	0.5	0.4
57	---	---	---	---	---	---	---	---	---	---	0.4	---
58	---	---	---	---	---	0.6	---	---	---	---	---	---

Table 7. Dissolved oxygen concentrations with depth in Onota Lake during May through October, 2024. '---', data not collected; mg/L - milligrams per liter. See Table 6 heading for explanation of shading.

Depth (ft)	Site Visit Date											
	5/6	5/21	6/4	6/17	7/1	7/15	7/30	8/12	8/26	9/9	9/23	10/4
Site D-2 Dissolved Oxygen (mg/L)												
1	9.9	10.1	9.6	9.3	7.6	7.2	7.6	8.1	8.8	8.3	8.7	9.2
3	10.0	10.5	9.6	9.3	7.6	7.1	7.6	8.1	8.8	8.2	8.7	9.2
6	9.9	10.3	9.9	9.3	7.5	6.7	7.5	8.1	8.8	8.2	8.6	9.2
9	9.7	10.2	9.6	9.0	7.5	6.4	7.5	7.9	8.7	8.0	8.6	9.2
12	12.2	9.9	10.0	8.2	7.3	4.1	6.3	7.8	8.0	7.4	7.8	8.9
13	---	---	---	---	6.3	---	---	---	---	---	---	---
14	---	---	---	---	6.0	---	---	---	---	---	---	---
15	11.6	11.5	10.7	8.9	6.1	2.2	2.0	7.7	7.9	7.9	7.4	7.9
16	---	---	---	---	5.8	---	0.7	7.3	7.5	---	---	---
17	---	---	---	---	3.3	---	0.4	6.5	7.1	---	---	---
18	11.0	10.3	10.4	7.3	1.7	0.7	0.4	4.3	6.1	7.8	4.7	7.0
19	---	8.5	---	6.6	---	---	0.4	1.3	5.2	---	---	---
20	---	6.7	---	3.7	---	---	---	1.1	3.0	6.7	---	---
21	8.7	3.3	2.9	1.6	1.0	---	---	0.5	1.1	4.7	0.5	0.9
22	---	---	---	1.1	---	---	---	---	---	---	---	---
24	4.5	0.8	0.6	---	0.6	0.5	---	0.4	0.6	0.7	0.6	0.5
Site D-6 Dissolved Oxygen (mg/L)												
1	10.2	9.6	8.8	9.0	8.3	7.8	8.1	7.8	8.6	8.8	8.8	8.9
3	10.2	9.7	8.8	9.0	8.4	7.8	---	8.0	8.7	8.7	8.8	8.8
6	10.2	9.9	8.8	9.0	8.4	7.8	8.1	8.1	8.6	8.7	8.8	8.8
9	---	---	8.9	---	8.4	7.6	---	---	---	---	---	---
12	11.7	9.8	9.0	9.0	8.4	8.0	8.1	8.0	8.7	8.7	8.8	8.8
15	---	11.3	---	9.0	8.4	8.8	---	---	---	---	8.8	---
18	12.2	---	10.9	9.5	10.0	9.4	8.1	8.0	8.5	8.7	8.7	8.8
21	---	---	---	11.8	12.0	11.2	---	---	8.4	8.5	8.7	---
24	12.2	12.0	11.8	11.8	12.2	12.6	11.8	10.6	9.9	8.9	8.5	8.1
27	---		---	11.5	11.7	12.4	11.4	10.4	8.0	6.2	8.6	7.4
30	11.4	11.3	11.1	10.8	10.5	11.0	10.3	9.6	7.5	4.5	5.3	4.9
33	---	10.7	---	10.6	9.4	9.1	8.4	6.4	6.1	0.4	2.4	---
36	10.0	9.7	8.3	7.8	5.7	4.5	3.8	2.1	2.5	0.4	0.4	0.7
39	---	8.2	---	6.9	4.8	---	1.3	---	0.6	---	---	---
42	9.4	7.4	5.1	4.5	2.6	0.3	0.6	0.5	0.5	0.4	0.5	0.5
45	---	---	---	---	1.2	---	---	---	---	---	0.5	---
48	8.6	5.7	3.5	3.5	0.5	0.3	0.5	0.5	---	0.5	---	0.5
51	---	---	---		0.5	---	---	---	0.6	---	0.5	---
52	---	---	---	2.6	---	---	0.5	---	---	---	---	---
54	8.4	4.4	1.5	---	0.6	0.4	---	0.6	---	0.6	---	0.4
56	---	4.3	---	---	---	---	---	---	---	---	---	---
57	---	---	---	---	0.8	0.5	---	---	0.7	---	0.6	---
58	---	---	---	---	---	---	---	---	---	---	0.8	---
60	8.3	---	---	---	---	---	---	---	---	0.9	---	0.4

Extended periods of low D.O. can promote the release of phosphorus from the bottom sediments, and this phosphorus can contribute to cyanobacteria blooms. Because the deep hole (site D-2) in the north basin is relatively shallow (maximum depth about 25 ft), light can penetrate to near the bottom. This is not the case in the much deeper south basin. This means that the extended period of low D.O. in the north basin could have contributed to the Cyanobacteria bloom of 2023. A comparison of near-bottom D.O. for site D-2 among years (those having available data for four time periods in May and June) shows quite strong variation among years in timing of D.O. depletion (that is, < 2 mg/L), with D.O. dropping to low levels very early in some years, and others having D.O. > 2 mg/L at least until late May (Figure 5). The lower D.O. near the bottom as of May 12 in 2023 corresponds with the relatively early stratification in 2023 (Figure 2A) which resulted in a relatively long period of isolation of bottom waters from the atmosphere.

The relatively long period of low D.O. in 2023 at in the north basin deep hole (site D-2), from which the Cyanobacteria bloom emanated in late July, can be seen by comparing the temporal pattern of D.O. at depth with 2020, 2022, and 2024 (three recent years with ample data across the season, Figure 6). Biweekly concentrations show the very low D.O. at 12 ft depth in early July 2023 (Figure 6A), and the replenishment of D.O. at that depth (likely by wind mixing) by late July. The plot also shows the lower D.O. across most of the season at 18 ft depth (Figure 6B); this depth is near the top of the metalimnion, where Cyanobacteria often reside. Finally, the long period of unusually low D.O. near the bottom, beginning early and persisted through mid to late September 2023, can be seen in Figure 6B.

Despite the extended period of low DO in deeper waters of D-2, the upper waters of D-2 had sufficient D.O. for a healthy fish assemblage throughout most of the 2023 season. D.O. of at least 5 mg/L occurred most of the season at D-2 from near the surface to about 15 or 16’ depth (except for the extremely low D.O. below about 12’ for a period in July; Table 4, Figure 3) . Ample D.O. (at least 5 mg/L) occurred for the entire season at D-6 from surface to about 30’ depth (Table 5, Figure 4). The pattern at D-2 was similar in 2024, with D.O. ≥ 5 mg/L to about ## deep for the entire season (Table ##, Figure ##). Ample D.O. to about 30’ throughout the season was also seen at D-6 in 2024 (Table ##, Figure ##).

Trout and other sensitive fishes require a combination of ample D.O. and sufficiently cold water. This well-oxygenated and cold layer is called the ‘oxythermal’ zone. The oxythermal zone varies among species and life stages having different D.O. and thermal tolerances, and it is influenced by geographic region, lake productivity, morphology, and other factors. Thus, the oxythermal zone cannot be precisely determined for Onota Lake. However, a ‘rule of thumb’ of 5 mg/L D.O. and temperatures of 19° C (66° F) or colder (considered desirable for trout) can be used to compare yearly changes in the vertical extent of ‘trout water’/ ‘oxythermal zone’ in Onota Lake’s deep south basin (D-6). (Note: the north basin is too shallow to have a persistent oxythermal zone and is more suitable for a warm-water fish assemblage.) Data from site D-6 (Tables 4-7) show a persistent oxythermal zone about 6 feet thick, from about 24 to 30 feet or so (keeping in mind the 6’ sampling intervals most visits) for most of the season each year. This layer tends to be thicker early in the season and became thinner with the warming of the upper waters and continued D.O. loss from the deeper waters during the summer stratification period. Examination of previous years’ data (Documents and Reports • LOPA - Lake Onota Preservation Association (onotalake.com)) indicates little year to year variation in the vertical location and depth of this persistent oxythermal zone in deep part of the lake’s south basin.

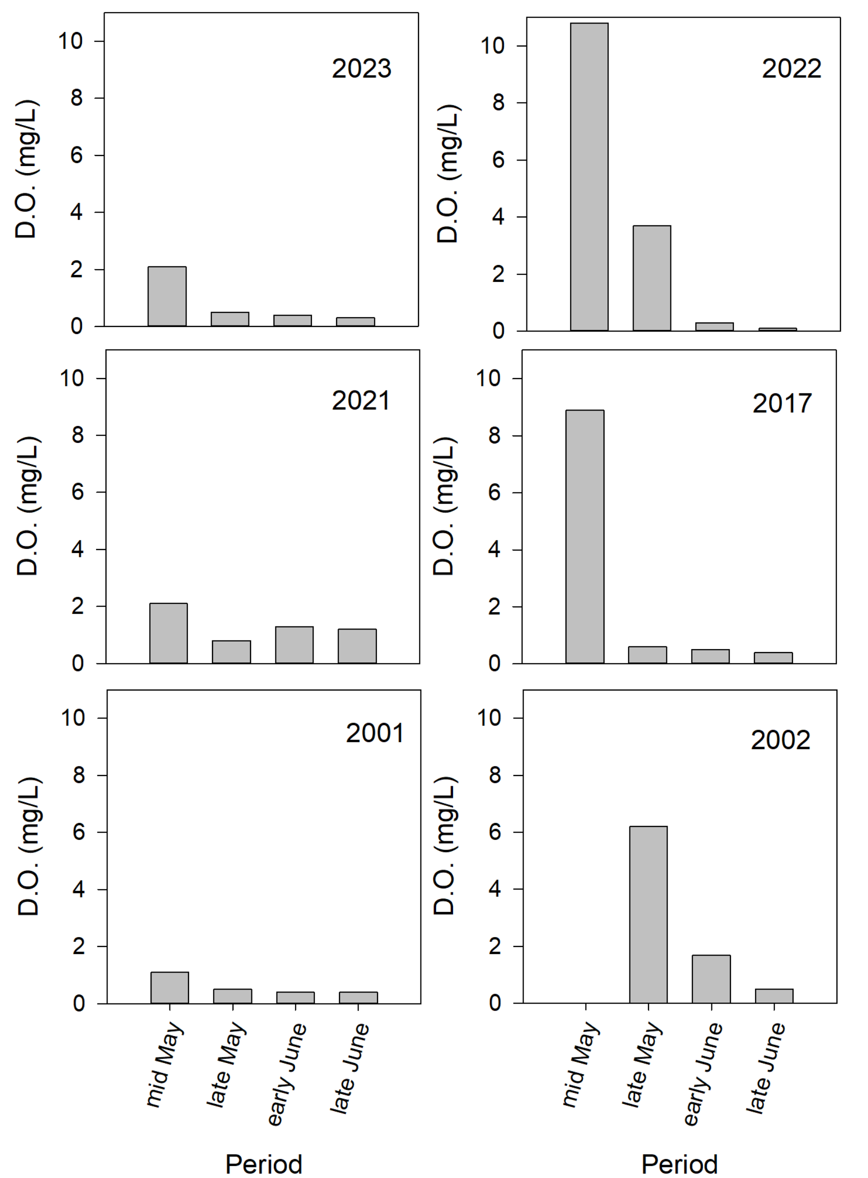

Figure 8. Near-bottom dissolved oxygen (D.O.) at site D-2 in Onota Lake during May and June of selected years from 2001 – 2023. Only prior years having data for at least three of the four time periods are included. mid to late May are included. The early June value for 2021 was recorded as ‘< 2.6’; half of that value was used for the plot.

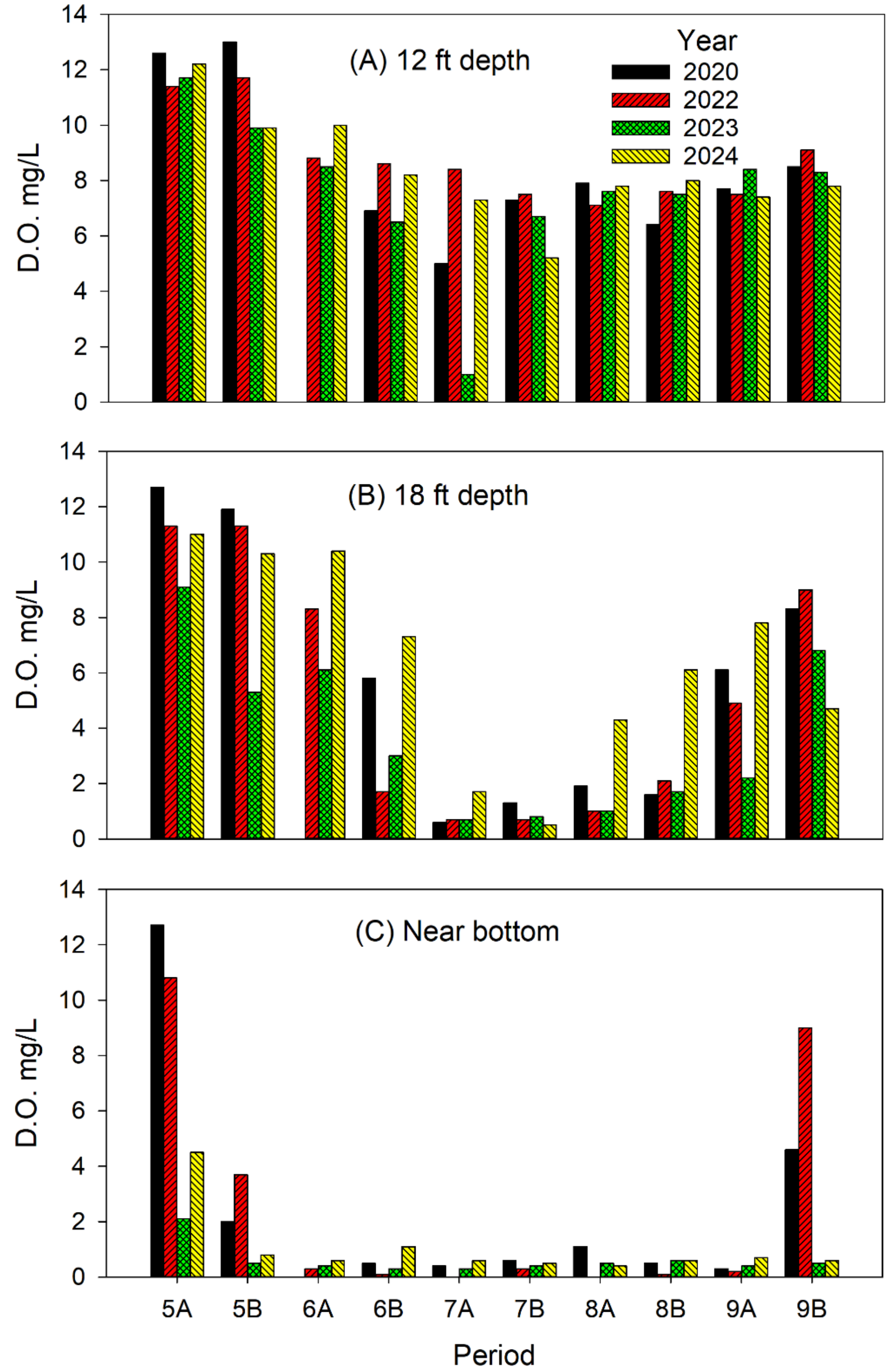

Figure 9. Concentrations of dissolved oxygen (D.O.) at site D-2 in Onota Lake from May through September in 2020, 2022, 2023, and 2024 Plots show measurements from three depths: (A) 12 ft below surface, (B) 18 ft below surface, and (C) near the bottom (generally 2 ft above the bottom). Time periods are as follows: 5A – May 1-15; 5B – May 16-31; 6A – June 1-15; 6B – June 16-30; 7A – July 1-15; 7B – July 16-31; 8A – August 1-15; 8B – August 16-31; 9A – September 1-15; 9B – September 16-30. Most bar values represent a single measurement for that period; means were used when > 1 site visit was made in a single period. (Note: data were not plotted for 2021 because instrument problems did not allow for precise measurement on some dates that year.)

An interesting pattern of highest D.O. at depths of about 18 or 24 feet to 30 feet occurred at site D-6 in throughout most of the 2023 and 2024 seasons, from the first site visit until at least early September (Figures 4 and 6). This 'meta limnetic oxygen maximum' has been noted in previous years. Two factors likely combine to produce the persistent meta limnetic oxygen maximum at site D-6: (1) production of D.O. during photosynthesis by phytoplankton because of sufficient light in the metalimnion (unlike in deeper water where it is too dark), and (2) the ability of colder water in the metalimnion to hold more D.O. than can the overlying warmer water. Meta limnetic oxygen maxima occur in many lakes and can indicate depth zones that are beneficial to fish because of the combination of abundant basal food resources (phytoplankton that are consumed by zooplankton) and the relatively cold temperatures. The position of the meta limnetic oxygen maxima generally coincides with the oxythermal zone at D-6, indicating desirable food, temperatures, and D.O. for cold-water fishes at these depths.

Calcium, alkalinity, and specific conductance

Calcium and alkalinity was analyzed in near-surface samples collected once in 2024, and specific conductance was measured during vertical temperature, pH, and D.O. profiling in both 2023 and 2024. Results can be found in Table 8. Calcium and alkalinity values were similar to those determined in 2009 (MADCR 2009). Specific conductance was similar for the two sites and two years. In general, the highest specific conductance occurred near the bottom, and the lowest values occurred in the epilimnion and earlier in the season.

Table 8. Alkalinity, calcium concentration, and specific conductance statistics for sites D-2 and D-6 in Onota Lake during 2023 and 2024. Abbreviations as follows: ---, data not collected; min, minimum; max, maximum; n, number of samples.

Site	Year	Specific conductance (micro-mhos/cm) May – Oct.				Calcium (mg/L)		Alkalinity (mg/L	
		median	min	max	n	July	Sept.	July	Sept.
D-2	2023	193	163	271	84	---	---	---	---
	2024	202	185	309	125	21.3	21.1	80.0	75.0
D-6	2023	206	188	255	113	---	---	---	---
	2024	197	189	246	177	20.0	20.9	75.0	75.0

pH

The pH pattern at both sites through the season in 2023 (Table 8) and 2024 (Table 9) show the slightly alkaline character of Onota Lake. Alkaline lakes are typical of the Berkshires due primarily to the area's underlying calcium-rich geology. The preferred pH range for fish and other aquatic biota in Massachusetts is 6-8 (but values up to 9 are not usually problematic). Median (typical) pH at D-2 was 7.9 in 2023 and 7.9 in 2024. Median pH at D-6 was 7.7 in 2023 and 8.0 in 2024. The median pH in the upper 12' of water was 8.1 at both sites in 2023, and 8.2

at both sites in 2024. The only occurrences of pH less than neutral (< 7.0) during the summer occurred in the deep waters (hypolimnion) of D-6 in October 2023. In general, pH declined with depth at both sites. This is expected because of acids generated by decomposition, and the absence of photosynthesis in deeper waters (the latter which consumes CO^2 in the upper layer that has sufficient light penetration).

Table 9. Measurements of pH at various depths at sites D-2 and D-6 in Onota Lake during 2023. '---' denotes 'data not collected'.

Depth (ft)	Site Visit Date											
	5/12	5/24	6/8	6/20	7/11	7/26	8/10	8/17	8/24	9/5	9/18	10/6
	Site D-2											
1	---	8.5	8.2	8.2	7.9	8.0	8.0	7.9	8.2	8.3	8.3	8.3
3	---	8.5	8.2	8.2	7.9	7.9	8.0	8.0	8.2	8.2	8.2	8.3
6	---	8.5	8.2	8.2	7.9	7.9	8.0	8.0	8.2	8.2	8.2	8.2
9	---	8.6	8.2	8.1	7.9	7.8	7.9	7.9	8.0	8.2	8.1	8.1
12	---	8.4	8.1	7.6	7.2	7.5	7.8	7.7	7.8	8.1	8.0	8.1
15	---	8.1	7.8	7.5	7.2	7.1	7.8	7.5	7.7	7.9	7.9	8.0
16	---	---	---	---	---	---	---	7.3	---	---	---	---
17	---	---	---	---	---	---	---	7.2	---	---	---	---
18	---	7.4	7.4	7.2	7.1	7.1	7.2	7.2	7.2	7.3	7.7	7.7
19	---	---	---	---	---	---	---	7.1	---	---	---	---
20	---	---	---	---	---	---	---	7.2	---	---	---	---
21	---	7.1	7.2	7.1	7.1	7.1	7.2	7.2	7.2	7.3	7.4	7.4
22	---	---	---	---	---	---	---	7.3	---	---	---	---
23	---	---	7.3	---	---	---	---	7.4	---	---	---	---
24	---	---	---	7.2	7.2	7.4	7.3	7.4	---	7.5	7.4	7.3
	Site D-6											
1	---	8.1	8.1	8.0	7.9	7.9	8.0	---	8.2	8.1	8.3	7.9
6	---	8.2	8.1	8.0	7.9	8.0	8.1	---	8.2	8.2	8.3	7.8
12	---	8.2	8.1	8.0	7.9	7.9	8.1	---	8.2	8.3	8.3	7.8
18	---	8.2	8.2	8.0	7.9	7.9	8.0	---	8.1	8.2	8.3	7.8
24	---	8.0	8.0	7.9	8.0	8.0	8.0	---	8.2	8.0	8.1	7.7
30	---	7.7	7.7	7.6	7.6	7.4	7.5	---	7.7	7.5	7.3	6.9
33	---	---	---	---	---	---	---	---	7.3	---	---	---
36	---	7.4	7.3	7.3	7.3	7.2	7.1	---	7.1	7.1	7.1	6.7
42	---	7.3	7.2	7.1	7.1	7.1	7.0	---	7.1	7.1	7.1	6.8
48	---	7.2	7.1	7.1	7.1	7.2	7.0	---	7.3	7.3	7.3	6.9
51	---	---	---	---	7.3	---	---	---	---	---	---	---
52	---	7.3	---	---	---	---	---	---	---	---	---	---
53	---	---	---	7.2	---	---	---	---	---	---	---	---
54	---	---	7.3	---	---	7.2	7.1	---	7.4	7.4	7.4	7.1
57	---	---	---	---	---	---	---	---	---	---	7.4	---
58	---	---	---	---	---	7.3	---	---	---	--	---	---

Table 10. Measurements of pH at D-2 and D-6 in Onota Lake during 2024. '---' is 'data not collected'.

Depth (ft)	Site Visit Date											
	5/6	5/21	6/4	6/17	7/1	7/15	7/30	8/12	8/26	9/9	9/23	10/4
	Site D-2											
1	8.3	8.5	8.6	8.4	8.0	7.9	7.9	8.1	8.2	8.0	8.3	8.4
3	8.3	8.6	8.6	8.4	8.0	7.9	7.9	8.1	8.2	8.0	8.3	8.4
6	8.3	8.5	8.7	8.4	7.9	7.8	7.9	8.0	8.2	8.0	8.3	8.4
9	8.2	8.5	8.6	8.4	7.9	7.7	7.8	8.0	8.1	8.0	8.3	8.4
12	8.7	8.3	8.4	8.0	7.9	7.5	7.6	8.0	8.0	7.8	8.1	8.4
13	---	---	---	---	7.7	---	---	---	---	---	---	---
14	---	---	---	---	7.6	---	---	---	---	---	---	---
15	8.5	8.4	8.2	7.7	7.3	7.2	7.2	8.0	7.9	8.0	7.9	8.1
16	---	---	---	---	7.2	---	7.1	7.9	7.8	---	---	---
17	---	---	---	---	7.1	---	7.1	7.7	7.7	---	---	---
18	8.1	8.1	8.0	7.4	7.1	7.3	7.0	7.6	7.5	7.9	7.4	7.9
19	---	7.6		7.4	---	---	7.1	7.2	7.4	---	---	---
20	---	7.5		7.3	---	---	---	7.2	7.4	7.6	---	---
21	7.7	7.5	7.4	7.2	7.2	---	---	7.1	7.5	7.5	7.3	7.4
22	---	---	7.3	7.2	---	---	---	---	---	---	---	---
23	---	---	---	---	---	---	---	---	---	---	---	---
24	7.5	7.3	---	---	7.3	7.3		7.3	7.5	7.4	7.3	7.3
	Site D-6											
1	8.4	8.2	8.2	8.1	8.5	8.1	8.1	8.2	8.2	8.1	8.3	8.1
3	8.4	8.3	8.2	8.1	8.5	8.0	---	8.2	8.2	8.3	8.3	8.1
6	8.4	8.3	8.3	8.1	8.4	8.0	8.1	8.1	8.2	---	8.3	8.2
9	---	---	8.2	---	8.4	8.0	---	---	---	8.3	---	---
12	8.6	8.3	8.3	8.1	8.4	8.2	8.1	8.1	8.3	---	8.3	8.3
15	---	8.3	---	8.1	8.4	8.3	---	---	---	8.3	8.3	---
18	8.5	---	8.3	8.1	8.6	8.3	8.1	8.1	8.2	8.3	8.3	8.3
21	---	---	---	8.2	8.6	8.5	---	---	8.1	8.3	8.3	---
24	8.4	8.3	8.3	8.1	8.6	8.6	8.4	8.2	7.7	8.2	7.9	8.3
27	---	---	---	8.0	8.4	8.5	8.1	8.0	7.3	7.5	7.4	7.2
30	7.9	8.0	8.1	7.7	8.0	8.0	7.8	7.9	7.1	7.3	7.1	7.5
33	---	7.8	---	7.7	7.8	7.8	7.6	7.6	7.1	7.2	7.2	---
36	7.6	7.6	7.7	7.5	7.6	7.2	7.4	7.3	7.1	7.3	7.2	7.2
39	---	7.5	---	7.4	7.6	---	7.2	---	7.2	---	---	---
42	7.5	7.4	7.4	7.3	7.4	7.1	7.1	7.3	---	7.4	7.3	7.0
45	---	---	---	---	7.4	---	---	---	7.2	---	7.3	---
48	7.4	7.3	7.4	7.3	7.4	7.1	7.1	7.3	---	7.4	---	7.1
51	---	---	---	---	7.4	---	---	---	7.2	---	7.3	---
52	---	---	---	7.3	---	---	7.2	---	---	---	---	---
53	---	---	---	---	---	---		---	---	---	---	---
54	7.4	7.2	7.3	---	7.5	7.2	---	7.3	7.3	7.4	---	7.2
56	---	7.2	---	---	---	---	---	---	---	---	---	---
57	---	---	---	---	7.6	7.2	---	---	---	---	7.3	---
58	---	---	---	---	---	---	---	---	---	---	7.4	---
60	7.5	---	---	---	---	---	---	---	---	7.4	---	7.2

<u>Transparency</u>

Secchi disk results for 2023 and 2004 are provided in Tables 1 and 2, respectively. As in previous years, site D-2 had much lower transparency than site D-6 throughout the seasons in both years (Figure 7). In general, the Secchi disk results are consistent with trophic state characterization of the north basin (represented by site D-2) as 'mesotrophic to eutrophic', and that of the south basin (represented by site D-6) as 'oligotrophic to mesotrophic'. Secchi depth transparencies at site D-2 ranged from 2.6m to 4.7m in 2023 (Figure 7A) and from 2.9 to 4.3 in 2024 (Figure 7B). Medians were 3.4 in 2023 and 3.2 in 2024; means were 3.6m in 2023 and 3.2m in 2024. Secchi depths at site D-6 ranged from 4.5m to 7.5m in 2023 (figure 7A), and from 4.5 to 8.7 in 2024 (Figure 7B). Medians at D-6 were 6.3m and 5.2m in 2023 and 2024, respectively; means were 6.2m and 5.7m in 2023 and 2024, respectively.

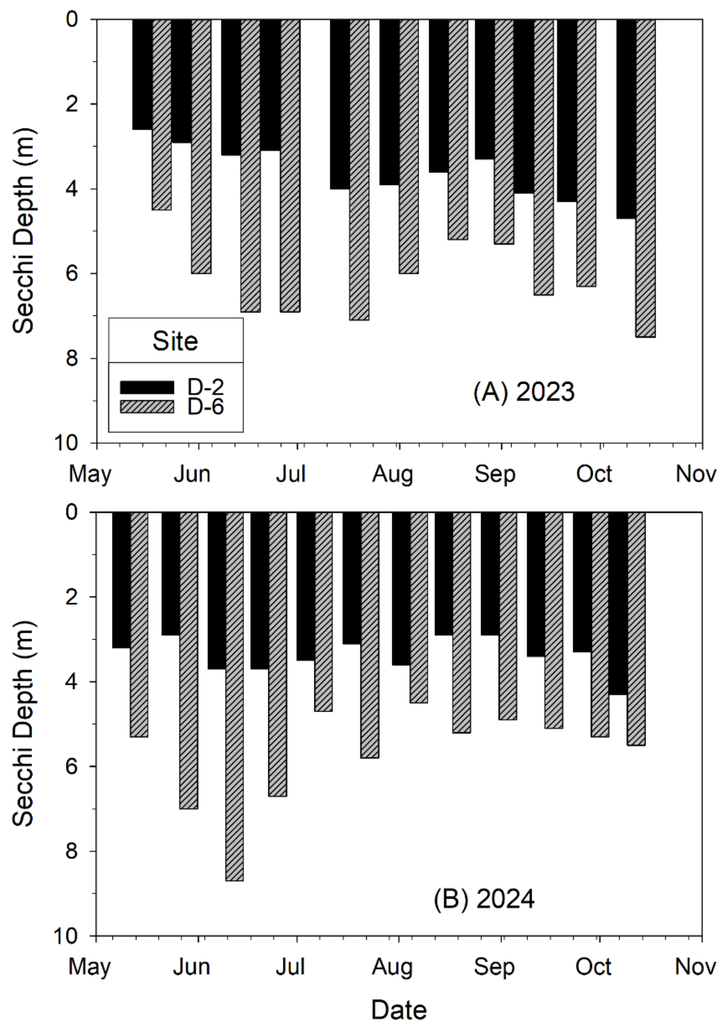

Figure 10. Secchi disk transparency measured in Onota Lake during (A) 2023 and (B) 2024. Measurements were made at two locations: D-2, the deepest part of the north basin, and D-6, the deepest part of the south basin. Site locations are shown on Figure 1; data are provided in Tables 2 and 3 (for 2023 and 2024, respectively.

The lower transparency at site D-2 indicates greater algal biomass and (or) other suspended material in the shallow north basin than in the deeper south basin (represented by D-6). The shallow depth at D-2 allows for sufficient light to penetrate to the bottom for photosynthesis, so that algae can grow throughout the entire water column. In contrast, light sufficient for photosynthesis cannot reach the bottom at D-6, thus limiting the growth of algae to the upper waters. In addition, at D-2, sediment can be resuspended and mixed into the overlying water where it can reduce transparency, but at D-6, the strong thermal gradient from surface to bottom serves to trap the sediment particles in the deep hypolimnion during summer stratification.

Secchi transparency varied across the season at both sites in 2023 and 2024 (Figure 7). Relatively low transparency in May was followed by a period of relatively high transparency, and subsequently by variable transparency. The low transparency in May indicates that this is when concentrations of algae (phytoplankton) and other suspended particulates were greatest. This is expected because spring turnover redistributes nutrients throughout the water column, and the combination of nutrients, warmer temperatures, and ample sunlight spur algal growth (particularly diatoms and golden algae). In addition, spring storms and prior snowmelt would have delivered sediment, nutrients, and other substances to the lake from the surrounding landscape.

A ‘clear-water phase’ typically follows the initial period of low transparency in north temperate lakes such as Onota. This is due to increased feeding activity of large-bodied zooplankton (particularly *Daphnia* spp.) which are voracious consumers of algae when temperatures reach their preferred range. It is typically followed by a reduction in clarity as young of year fish consume more zooplankton and the upper waters warm above the optimal range for *Daphnia* and other zooplankton.

A comparison of transparency among years can be seen in boxplots of Secchi disk values from 2010 through 2024 (Figure 8). Graphically, transparency appears to be greater in recent years (that is, extending to deeper in the water column) than earlier years at both sites. Furthermore, the transparency of site D-2 (Figure 8A) in both 2023 and 2024 was significantly greater than that of four of six prior years with sufficient data ($n \geq 7$) for statistical testing (One way ANOVA, $p < 0.05$, followed by Holm-Sidak all pairwise multiple comparison tests, $p < 0.05$). In contrast, transparency in 2023 at site D-6 (Figure 8B) was significantly higher than only one of the six previous years tested, and there were no statistically significant differences in transparency at D-6 in 2024. (The greater within-year variation at site D-6 could partially explain the lack of statistical significance in pair-wise tests of differences among years at that site.)

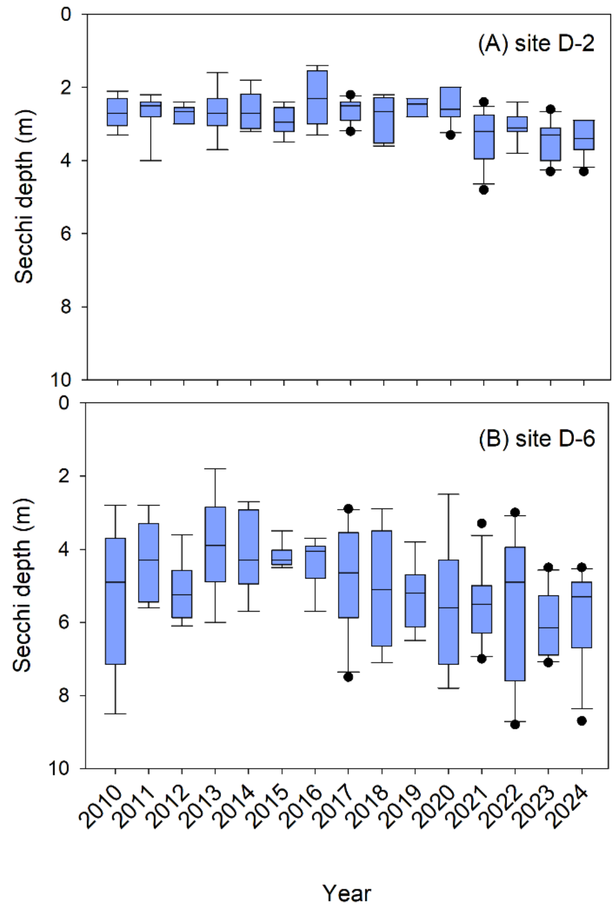

Figure 11. Secchi disk transparency measured in Onota Lake since 2010. Each box represents data collected May through September. Measurements were made at two locations (A) site D-2, the deepest part of the north basin, and (B) site D-6, the deepest part of the south basin. Site locations are shown on Figure 1. The horizontal line within each box represents the median value (50th percentile). The lower and upper bounds of each box represent the 25th and 75th percentiles, respectively. The lower and upper 'whiskers' represent the 10th and 90th percentiles, respectively, and the dots represent outliers. Numbers of samples ranged from 5 to 13 for D-2, and from 5 to 12 for D-6; years with $\geq$ 7 samples (both sites) were 2011, 2013, 2017, 2020, 2021, 2022, 2023, and 2024. Data for past years can be found in annual reports at (Documents and Reports • LOPA - Lake Onota Preservation Association (onotalake.com).

The seasonal pattern of transparency at site D-2 in 2023 (when the late summer Cyanobacteria bloom occurred in the north basin) was graphically compared with other years. Plots of biweekly Secchi disk readings for years with sufficient data (Figure 9) show the greater transparency in 2023 during most site visits beginning in July as compared with the other years (Figures 9B, D, E,F) and greater transparency in May and June site visits in comparison with all years considered except for 2021 (Figure 9C) and 2024 (Figure 9A).

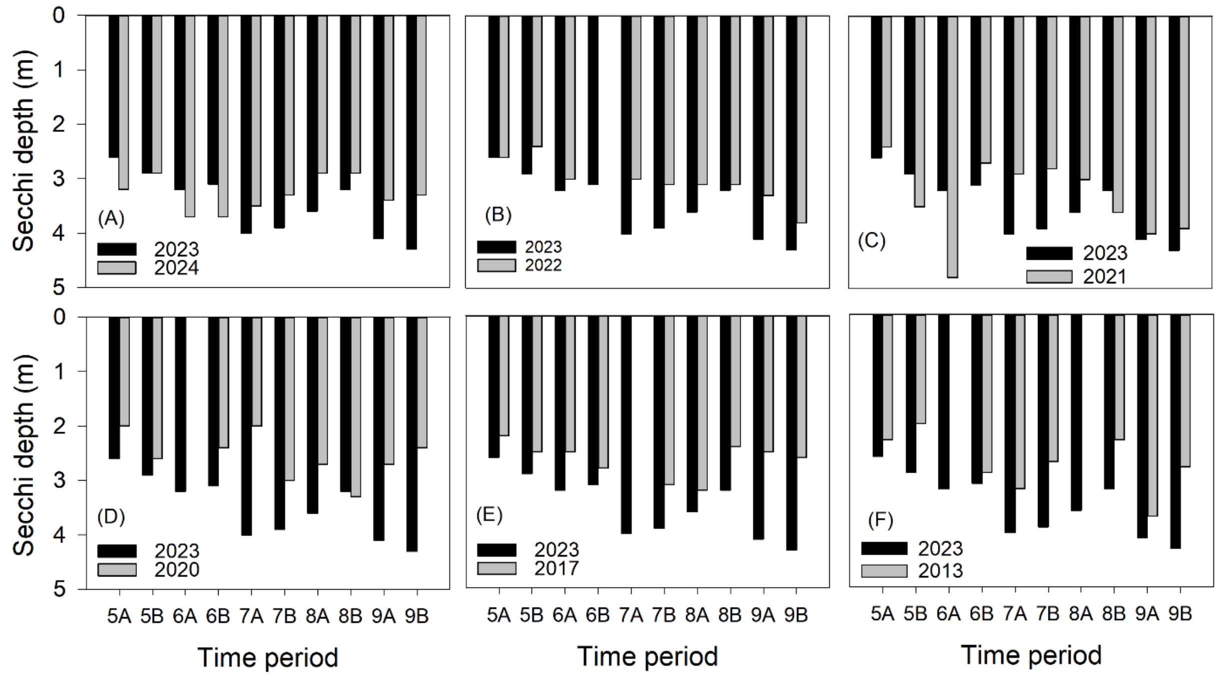

Figure 12. Comparison of Secchi disk transparency across the season at site D-2 (in Onota Lake's north basin) in 2023 (the year of the Cyanobacteria bloom), with (A) 2024, (B) 2022, (C) 2021, (D) 2020, (E) 2017, and (F) 2013. Years represented are those with Secchi data collected in at least 8 time periods from May through September. Time periods are as follows: 5A – May 1-15; 5B – May 16-31; 6A – June 1-15; 6B – June 16-30; 7A – July 1-15; 7B – July 16-31; 8A – August 1-15; 8B – August 16-31; 9A – September 1-15; 9B – September 16-30. Most bar values represent a single measurement for that period; means were used when > 1 measurement (i.e., > 1 site visit) was made in a single period.

Nutrients

Nutrient data for the three sample dates in 2023 and in 2024 are provided in Table 7.

Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium and includes organic nitrogen occurring in algae and other (living and non-living) suspended particulate matter. In general, TKN values are considered low if < 400 ppb, moderate if $\geq$ 400 ppb and < 1,000 ppb, and high if $\geq$ 1,000 ppb. All near-surface samples from 2023 and 2024 had consistently low TKN (less than the detection limit in most samples). All near-bottom samples had moderate or high TKN. These higher near-bottom concentrations are likely due to a combination of nitrogen in settled particles and an accumulation of ammonium nitrogen through decomposition (where low dissolved oxygen prevents its conversion to nitrate).

Nitrate, the dissolved inorganic form of nitrogen, is readily taken up by plants (both algae and macrophytes) and was not detected in any sample (Table 7). This, and the typically low TKN concentrations in the upper water column (where there is ample light for photosynthesis) suggests that nitrogen could limit the growth of some algae in Onota Lake whereby nitrate inputs could promote algal blooms.

Table 6. Nutrient concentration results for water samples collected from Onota Lake in 2023 and 2024. Samples were collected from two sites (D-2 and D-6), and from two depths at each site: shallow (about 1 ft deep) and deep (about 1.5 ft above the lake bottom). Reporting limits are shown in brackets below each analyte name; ppb denotes parts per billion; < denotes 'less than'.

Site	Year	Sample date	Relative depth	Total Keldahl Nitrogen (ppb) [200]	Total Phosphorus (ppb) [10.6]	Nitrate, as Nitrogen (ppb) [50.0]
D-2 (northern basin)	2023	5/24	Shallow (main)	<200	12.8	<50.0
			Shallow (duplicate)	<200	15.9	<50.0
			Deep (main)*	1540*	125*	<50.0
			Deep (duplicate)*	671*	80.8*	<50.0
		7/26	Shallow (main)	<200	<10.6	<50.0
			Shallow (duplicate)	258	<10.6	<50.0
			Deep (main)	1,610	120	<50.0
			Deep (duplicate)	2000	124	<50.0
		9/18	Shallow	<200	<10.6	<50.0
			Deep	937	73.3	<50.0
	2024	5/21	Shallow (main)	<200	<10.6	<50.0
			Shallow (duplicate)	<200	<10.6	<50.0
			Deep (main)	736	27.6	<50.0
			Deep (duplicate)	542	31.9	<50.0
		7/15	Shallow	<200	<10.6	<50.0
			Deep	1080	80.8	<50.0
		9/9	Shallow	218	<10.6	<50.0
			Deep	1840	10.6	<50.0
D-6 (main basin)	2023	5/24	Shallow	217	11.7	<50.0
			Deep	1250	128	<50.0
		7/26	Shallow	<200	<10.6	<50.0
			Deep	1040	38.3	<50.0
		9/18	Shallow	<200	<10.6	<50.0
			Deep	1,410	117	<50.0
	2024	5/21	Shallow	<200	<10.6	<50.0
			Deep	426	10.7	<50.0
		7/15	Shallow	<200	<10.6	<50.0
			Deep	581	61.6	<50.0
		9/9	Shallow	<200	<10.6	<50.0
			Deep	992	136	<50.0

*The much higher concentrations of TKN and TP in the main sample than in the duplicate sample indicate likely inclusion of bottom sediment when collecting the main sample. For this reason, the results from the duplicate sample should be used to represent deep water concentrations on this date.

Phosphorus is the most important nutrient in freshwater lakes because its natural concentrations in freshwaters are typically in limited supply. Thus, any phosphorus additions to lake waters can be readily consumed by algae and rooted plants (macrophytes), potentially resulting in undesirable outcomes such as algal blooms, dense plant growth, and shifts to overall greater biological productivity and lake eutrophication, or ‘aging’. Potentially harmful cyanobacteria (formerly called ‘blue-green algae’) are particularly responsive to phosphorus inputs. Inputs of phosphorus can include runoff from the surrounding landscape (e.g., lawn fertilizers, sediment inputs, animal waste), point discharges, and release from sediments at the lake bottom under conditions of low oxygen (dissolved oxygen < 2 mg/L). Phosphorus in lake waters occurs in organic and inorganic forms that are either suspended as particles or are dissolved in the water. The Onota Lake samples were analyzed for total phosphorus (TP), which includes both particulate and dissolved forms.

Total phosphorus in the upper part of the water column (where there is also enough light for photosynthesis by algae and rooted plants) is represented by the near-surface samples. All samples collected in 2023 and 2024 had TP concentrations that were below the detection limit or very low (well below the 25ppb threshold above which algal blooms occur in many fresh waters). In 2023, near-surface TP concentrations at both sites were low in May samples, and below the detection limit in July and September (Table 7). TP concentration was below the detection limit in every near-surface sample collected in 2024.

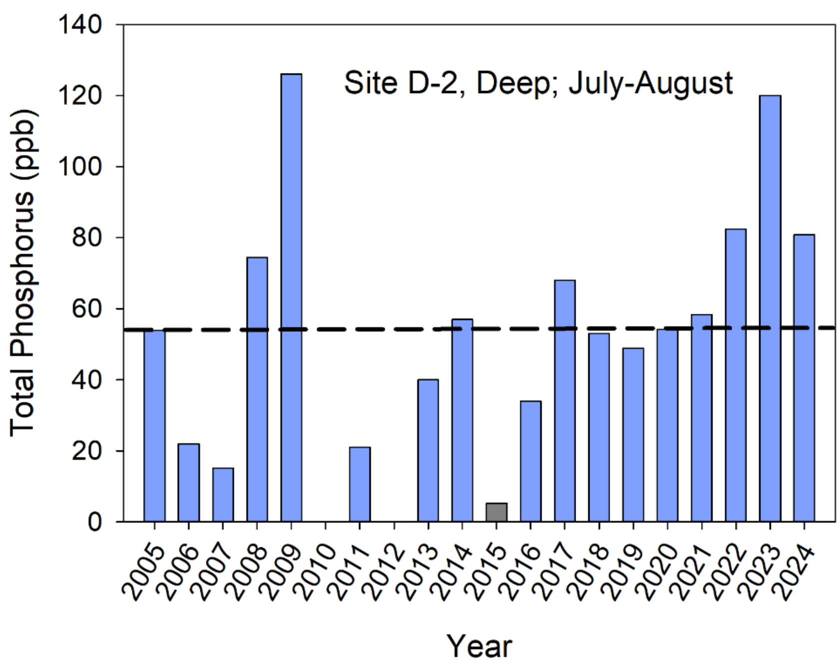

Figure 13. Concentrations of total phosphorus in July-August samples collected from 2005 through 2024 from the deep zone (1.5-2’ above bottom) of site D-2 in Onota Lake’s north basin. The dashed line shows the median value of 54 ppb among all 18 years. The grey bar for 2015 indicates concentration less than the reporting limit of 10.6 ppb. (Note: data were not available for 2010 and 2012.)

Near-bottom TP concentrations at site D-2 in 2023 ranged from 73.3 in September to 124 ppb in 2023. Concentrations were much lower in 2024, ranging from slightly above detection in September to 80.8 ppb in July. TP concentrations in near-bottom samples collected from site D-6 in 2023 ranged from 38.3 ppb in July to 128 ppb in May. TP concentrations near the bottom at D-6 ranged from 10.7 ppb in May to 136 ppb in September.

The 2023 mid-summer (July) TP concentration near the bottom of site D-2 was compared 2024 and with prior years to evaluate TP as a possible contributing factor to the Cyanobacteria bloom in the north basin of Onota Lake in late summer 2023. (The bloom appeared to have originated from the depths of D-2.) A comparison of July - August TP concentrations in near-bottom samples collected in each of 18 years from 2005 to 2024 (Figure 10) shows that, indeed, the TP concentration in 2023 was higher than all years except for one (2009). The 2023 TP concentration of 124 ppb was more than twice the median (or 'typical') July-August TP concentration of 54 ppb across these 18 years.

Cyanobacteria bloom of 2023, and cyanobacteria monitoring and investigations

Cyanobacteria, often called 'blue-green algae', are photosynthetic bacteria that can produce toxins under certain conditions. Although cyanobacteria are normal components of lake ecology, their monitoring can help assess the potential for a 'Harmful Algal Bloom', which would necessitate beach closing and contact-related warnings to avoid potential exposure to toxins. Massachusetts requires posting a public advisory against water contact when cyanobacterial cell density exceeds 70,000 cells/mL of lake water (https://www.mass.gov/info-details/guidelines-for-cyanobacteria-in-freshwater-recreational-water-bodies accessed March 1, 2021).

The cyanobacteria bloom of 2023: A cyanobacteria bloom was observed in late July of 2023 along the southern shoreline of Thomas Island, near Shore Drive. It was a relatively small and localized bloom that persisted off and on until early September. The LOPA water sampling crew had noted very small particles of this same purplish 'scum' at site D-2 (the north basin's deep hole near Thomas Island) on July 26, moving upward from deeper water to the surface. It appears cyanobacteria residing somewhere in the deep hole's metalimnion (which occurred from about 15 ft to near the bottom in the north basin) moved up to the surface and were blown by the westerly wind into masses that aggregated along the nearby Thomas Island shoreline to the east. Samples of the purplish scum were examined by Shannon Poulin, under contract to LAPA-West (Lake and Pond Association of Western MA), who identified it as *Planktothrix* sp. (likely *P. rubescens*). *Planktothrix* are capable of producing toxins if certain genes are present; these are hepatotoxins (those affecting the liver). The intake of these toxins can cause severe illness and even death. Because of this, exposure to *Planktothrix* is potentially harmful to humans and animals, and particularly to dogs that drink the water or swim in it and then lick their fur, thereby ingesting the toxin. Fortunately, no toxins were detected in the samples that were collected by LOPA volunteers on 8/17, submitted by the City of Pittsfield to

GreenWater Laboratories (Palatka, FL), and analyzed for suites of toxins (specifically anatoxins and microcystins). Over the course of about six weeks (late July until early September), the masses of cyanobacteria were observed to disperse and re-aggregate along the shoreline at various times, depending on wind action. Signage was posted by the city advising against water contact in the vicinity of the bloom and was removed only after repeat observation and water testing showed no or low concentrations of cyanobacteria.

Reasons for the cyanobacteria bloom in 2023 are not entirely clear. It is known that blooms can be promoted by combinations of various environmental factors, including nutrient inputs to a water body and release or nutrients from the lake bottom into the water column, loss of dissolved oxygen, warm temperatures, and periods of calm followed by wind. The long-term data available from LOPA's routine monitoring of Onota Lake provided the ability to compare environmental conditions in 2023 with those of previous years. Results indicate that 2023 was, indeed, atypical in some important ways that could have resulted in the cyanobacteria bloom observed that year. These potentially contributing factors in the north basin include (1) relatively early stratification (Figure 2A, and discussion on page 8), (2) early and persistent depletion of D.O. near the bottom (Figure 4, Figure 8), (3) relatively low D.O. higher in the metalimnion in 2023 than usual with D.O. depletion reaching an unusually shallow depth of 12' in July (Figure 9), (4) greater than usual transparency (Figures 11, 12), and relatively high TP concentrations near the lake bottom in July of 2023 (Figure 13).

Routine cyanobacteria monitoring and special investigations: Despite the occurrence of the bloom in late summer 2023, all of the routine Cyanobacteria monitoring in 2023 showed no indication of a potential issue (Appendix I). Routine monitoring in 2024 also did not show any issues (Appendix II). Onota Lake was monitored for cyanobacteria in the shallower northern basin from late June through early September each year. A total of six sampling visits were made in 2023, including a special visit on 8/25/23 to collect samples in the vicinity of the cyanobacteria bloom. A total of seven visits were made in 2024. This work was done by Shannon Poulin under contract to LAPA-West, and with logistical support from LOPA volunteers. Cyanobacteria monitoring of Onota Lake was coordinated with monitoring of other area lakes as part of the LAPA-West program.

Onota Lake cyanobacteria monitoring in 2023 (Appendix I) and 2024 (Appendix II) included (1) laboratory fluorometric measurement of phycocyanin, a pigment that indicates overall cyanobacteria biomass, (2) identification of cyanobacteria in water samples to the taxonomic level of genus, and (3) cell counts of each genus present. Routine samples were collected from near the surface at the south shore of Thomas Island and in the metalimnion (the layer separating the warmer surface layer from the colder bottom layer) of site D-2. Extra samples to follow up on the cyanobacteria bloom were collected in 2023 at the surface of three locations off of Thomas Island, one at the bloom location and two at locations bracketing the bloom site.

Phycocyanin concentrations, which can be an indicator of cyanobacteria density, were very low (at the detection limit of 0.1 ppb) in every sample both years. Cell densities of cyanobacteria were low in every sample both years, and all were well below the state limit of 70,000 cells/mL above which public advisories are required. Two genera of cyanobacteria were present in 2023 samples, and one in 2024. *Microcystis* sp. was present in low concentrations in every sample both years. *Planktothrix* sp. (likely *P. rubescens*) was detected in only one sample (collected from 17 ft depth) in early September 2023. Notably, *Planktothrix* concentration in this sample was low, and *Planktothrix* was not detected in samples collected at the same date from 18 ft and 19 ft depths.

The routine monitoring in 2023 did not provide warning of the Planktothrix bloom that season, suggesting that an adjustment in methods is needed. This could include collecting water column profiling data (temperature, dissolved oxygen) at shorter depth intervals in order to better ascertain the depth of the thermocline where these cyanobacteria are likely to reside, and (or) the use of a pigment probe during profiling. Although expensive, the pigment probe would allow for in-situ determination of depth at which cyanobacteria concentrations are likely to be highest, and where samples should be collected for identification and cell counts.

Fish surveys

Two types of fish surveys were done in the 2023-2024 periods: seining surveys and a boat electrofishing survey. Both surveys target the near-shore shallow water (that is, 'littoral') fish community. Both types of surveys provide useful 'snapshots' of the littoral fish assemblage where sampled at the time of sampling. Neither seining nor boat electrofishing capture fish in deeper water away from the shoreline, and neither method is designed to collect comprehensive data on species populations or the lake's fish assemblage in general. In both survey methods, specimens are released back into the water near the point of capture after the collection of field data. Results of the seining and electrofishing surveys show that Onota Lake supports a typical warmwater and cool water fish assemblage consisting mainly of species in the sunfish, perch, and minnow families (Centrarchidae, Percidae, and Cyprinidae, respectively).

Seining surveys of the near-shore fish assemblage were conducted in September of each year by Bob Schmidt, Ph.D. and Thomas Coote, Ph.D., of Berkshire Environmental Research Center at Bard College of Simon's Rock (Great Barrington, MA), under contract to the City of Pittsfield, and with assistance from LOPA volunteers. Seining was conducted at the same five stations that had been visited in previous years (starting in 2005), using the same gear and methods. A summary of results is provided here; complete details can be found in Appendices III and IV.

Seven and 13 fish species were collected across all sites in 2023 (Appendix III) and 2024 (Appendix IV); none were protected species. Marked differences between years occurred in the numbers of species and individuals, as well as in species relative abundances; this is associated with habitat differences between years (particularly macrophyte composition and biomass) at the particular seining locations. In 2023, Yellow perch (*Perca flavescens*) was the numerically dominant species, followed by Redbreast sunfish (*Lepomis auritis*) and Bluegill (L. *macrochirus*). Other fishes encountered were Pumpkinseed (*L. gibbosus*), Smallmouth bass (*Micropterus* *dolomieu*), Largemouth bass (*M. salmoides*), and Banded killifish (*Fundulus diaphanous*). In 2024, Bluegill were numerically dominant, followed by Yellow perch, Banded Killifish, Smallmouth Bass, Pumpkinseed, and Largemouth bass. Other species collected in 2024 were Redbreast sunfish, Black crappie (*Pomoxis nigromaculatus*), Rock bass (*Amploplites rupestris*), Brown bullhead (*Ameiurus nebulosus*), Northern pike (*Esox lucius*), and Chain pickerel (*E. niger*), and Common carp (*Cyprinus carpio*). Complete lists and counts can be found in the 2023 and 2024 reports (Appendices III and IV, respectively).

A boat electrofishing survey of nearshore, shallow habitat in selected portions of the lake was conducted by personnel of MA Fish and Wildlife in June of 2023 (Jason Stolarski, Ph.D., MA DFW, personal communication), resulting in collection of 186 individual fish representing 14 species. Bluegill were numerically dominant, followed by Yellow perch and Rock bass. Other species encountered during the boat electrofishing were Redbreast sunfish and Pumpkinseed, Common carp, Brown bullhead, Largemouth and Smallmouth bass, White perch (*Morone americana*), Rainbow trout (*Oncorhynchus mykiss*), White sucker (*Catostomus commersonii*), Bluntnose minnow (*Pimephales notatus*), and Golden shiner (*Notemegonus crysoleucas*).

Macrophyte surveys

The summer of 2023 was the third growing season after treatment of the lake for Eurasian water milfoil with a systemic herbicide due to excessive growth of this invasive macrophyte. This was the application of ProcellaCOR (developed by the company SePRo) to 260 acres of the lake in June of 2021. Follow-up monitoring and surveys showed excellent control in the first year (2021); the 2022 survey showed a very healthy native plant community. However, in August and September of 2022 the north end of the lake (especially around Kelly's Cove) experienced increased milfoil growth, resulting in re-treatment of 14 acres under the company's guarantee. In 2023, surveys (Appendix V) showed that milfoil rebounded steadily, with many areas of moderate to dense growth. The observed increase in milfoil after only 2-3 years post-treatment was unexpected, and thought to be due to insufficient concentration of ProcellaCOR used in the initial treatment.

In 2024, the City contracted Solitude to conduct a milfoil survey in early June (Appendix VI). Additional treatment with ProcellaCOR was done on the basis of that survey. Solitude conducted a second survey in early September (Appendix VI) and identified some 60 acres of milfoil regrowth for which treatment would be appropriate in the spring of 2025. No other aquatic vegetation surveys were conducted in 2024; it was decided to wait until next year in order to better assess the native plant assemblage following the latest ProcellaCOR treatments. Causal inspection suggested that native plant assemblage was still healthy but somewhat subdued, perhaps because of crowding-out from milfoil regrowth.

Other invasive aquatic plants in Onota Lake include curly-leaf pondweed (*Potamogeton crispus*) and European Naiad (*Najas minor*); these continue to be monitored. The invasive water chestnut (*Trapa natans*) continues to be successfully controlled by hand pulling. Common reed

(*Phragmites australis*) is a tall non-native and invasive grass that grows on the shoreline in some areas and replaces native plants. A 2021 survey by Solitude identified Phragmites stands in 13 locations around the lake, prompting a 3-year demonstration removal project beginning the following year, in which a large patch of Phragmites is being treated with herbicides. As the project winds up, a strategy for treating additional locations should be developed. The pink version of the native water lily (*Nymphaea odorata*) has been observed to be invasive and problematic in portions of Kelly's Cove, in the north basin of the lake. It is possible that retreatment of milfoil with a higher concentration of ProcellaCOR will confer some control of the water lilies in this area, while having the expected minimal effect on native plants.

Zebra mussel early detection and rapid response

Onota Lake is highly vulnerable to invasion by Zebra mussels (*Dressiena polymorpha*) because of its location near already-infested waters (including Laurel Lake in nearby Lee, MA), the presence of suitable physical and chemical conditions, and the extensive use of the lake by boaters who trailer their boats to Onota Lake from potential source waterbodies. Once in a waterbody, zebra mussels can spread quickly, causing great harm to the lake's ecological health and recreational enjoyment. Onota Lake is among many water bodies in MA that are routinely monitored for Zebra mussels by MA DCR. This routine monitoring has included visual searches by divers (scuba) as well as the annual collection and analysis of environmental DNA (eDNA) samples.

Unfortunately, zebra mussel DNA was detected in one of the four eDNA samples collected by the MA DCR contractor on September 9, 2023; this was the sample collected near the Burbank Park public boat launch. Once the City and LOPA were made aware of this finding (in late November of 2023), a task force was assembled to follow up on this important finding. The presence of zebra mussel DNA in the lake sample is important because it could have come from living zebra mussels, in the form of metabolic by products (e.g., feces) from settled adults and (or) juveniles, eggs and (or) sperm from adults of reproductive age, or tiny planktonic offspring called 'veligers'. Alternatively, the DNA could have come from dead zebra mussel material that was discharged from a boat entering the lake at the boat launch. Thus, follow up investigations were conducted to determine the likelihood of zebra mussel early colonization in the lake.

Follow up investigations (Table 1) included additional eDNA sampling, conducted by MA DCR contractors, and by LOPA volunteers with support of the City of Pittsfield and LOPA, as well as visual searches. Visual searches were conducted by MA DCR, the City of Pittsfield, and BioDrawversity (the latter with the assistance of LOPA volunteers). None of the 2023 eDNA samples yielded positive findings, but it is important to note that there is a high chance of 'false negatives' when colonies are small and sparsely distributed, and especially during cold weather when metabolism is minimal. Sampling for eDNA was conducted multiple times by LOPA/City in the spring and summer of 2024. These samples were analyzed at the University of New

Hampshire's Collaborative Core Wet Lab (Durham, NH), which provided results within several days of sample collection. A positive sample was collected in July 2024 along the rocky shoreline south of the fishing pier at Burbank Park. Several diving (SCUBA) searches for living specimens were conducted in 2023 and 2024. Several of these were by mussel experts from BioDrawversity, under contract to LOPA and (or) the City of Pittsfield. Thorough searches resulted in the collection of several spent shells (that is, from dead zebra mussels) near the Burbank Park boat launch. Ultimately, after the positive eDNA finding of July 2024, a large zebra mussel was found on the fishing pier. The multiple findings of zebra mussel DNA, the finding of spent shells, and especially the confirmation of a living zebra mussel in Onota Lake provide evidence of a possible early invasion. The need to protect the lake's ecology from irreversible harm warranted treatment of a 1-acre strip of optimal habitat along the shoreline in September 2024 with the copper-based molluscicide EarthTec QZ (discussed in Appendix VII). LOPA and the City are continuing to monitor multiple times per season (with both eDNA and diver searches) to follow up on the Sept 2024 treatment, and to achieve early detection of any further invasion. Early detection, rapid response (including molluscicide and drawdown), as well as boat ramp monitoring and development of a boat wash station are all critical tools to keep Onota Lake (and other regional lakes) free of this extremely harmful invasive species. The diver searches by BioDrawversity are detailed in Appendix VII. Additional information, including a white paper on zebra mussel early detection and rapid response, can be found on the LOPA website.

APPENDICES

LAPA - West

Lakes and Ponds Association of Western Massachusetts
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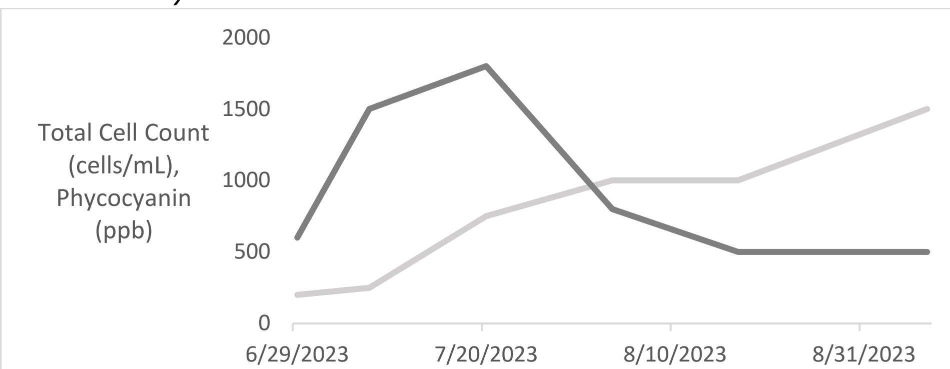
Lake Onota Cyanobacteria Report 2023

Lake Onota was sampled from June to September approximately every two weeks for the summer of 2023 for cyanobacteria. For each sampling time, two samples were taken: one at Bob Race's dock off, Shore Road on Thomas Island, and one from site D2, the deepest area of the Lake's northern basin. The depth from which the D2 sample was collected was determined from temperature and depth profiles collected prior to sample collection and ranged from 17 to 18 feet below surface.

Microcystis was the most common genus of cyanobacteria found on the lake both at the surface and at D2 for most of the summer. The last scheduled sampling though had *Planktothrix* at 17 feet. The phycocyanin levels were consistently 0.1 parts per billion for both the surface and D2 samples (Figure 1).

Two other sampling dates not originally scheduled were on August 12th and August 25th. After a bloom was seen the previous week on August 12th, three samples were taken at various points on Thomas Island, one at 2 Thomas Road, one at 60 Shore Road (where the bloom was seen of Planktothrix), and one at 129 Thomas Island Road. On August 25th, samples were taken at the same exact location. None of these samples contained *Planktothrix* and overall had low cell counts of *Microcystis*.



	6/29/2023	7/7/2023	7/20/2023	8/3/2023	8/17/2023	9/7/2023
Surface	200	250	750	1000	1000	1,500
17 feet	600	1,500	1,800	800	500	500

Surface 17 feet

Figure 1. Total cell count for the six sampling events throughout the summer. *Microcystis* was the most common and *Planktothrix* was present in a small quantity in the last sampling.

The major takeaway from this summer sampling is that the phycocyanin levels continue to be low and the cyanobacteria presence continues to be low, with the exception of the *Planktothrix* blooms that occurred in August. Though the samples that were collected at the surface did not yield any *Planktothrix* present, it wasn't until we took samples above the thermocline that we found them. It is important to keep generating data from year to year on the same lake, therefore providing a basis for comparison.

Compared to previous summers (2019, 2020, and 2021), the phycocyanin levels and genus's present are consistent. Only in 2021 the genus *Aphanizomenon* was present at one sampling event. In 2023, *Planktothrix* was present at 17 feet below the surface, but not in the 18 or 19 foot samples. *Microcystis* was the dominant genus for 2019, 2020, 2021, 2022, and 2023. For previous years data, the information can be found on LOPAs website in the annual monitoring reports.

LAPA - West
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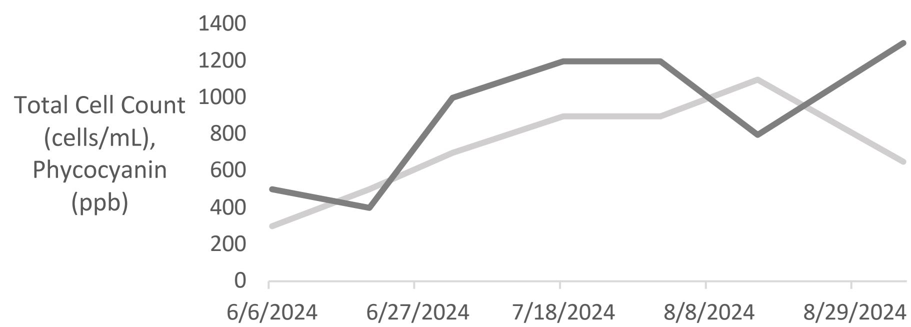
Lake Onota Cyanobacteria Report 2024

Lake Onota was sampled from June to September approximately every two weeks for the summer of 2024 for cyanobacteria. For each sampling time, two samples were taken: one at Bob Race's dock off, Shore Road on Thomas Island, and one from site D2, the deepest area of the Lake's northern basin. The depth from which the D2 sample was collected was determined from temperature and depth profiles collected prior to sample collection and ranged from 17 to 18 feet below surface.

Microcystis was the most common genus of cyanobacteria found on the lake both at the surface and at D2 for most of the summer. The phycocyanin levels were consistently 0.1 parts per billion for both the surface and D2 samples (Figure 1). On August 15th, a sample was taken above and below the thermocline for monitoring for *Planktothrix*.



	6/6/2024	6/20/2024	7/2/2024	7/18/2024	8/1/2024	8/15/2024	9/5/2024
Surface	300	500	700	900	900	1,100	650
17 feet	500	400	1,000	1,200	1,200	800	1,300

Figure 1. Total cell count for the six sampling events throughout the summer. *Microcystis* was the most common genus.

The major takeaway from this summer sampling is that the phycocyanin levels continue to be low and the cyanobacteria presence continues to be low. *Planktothrix* was not seen this year like it was in 2023. It is important to keep generating data from year to year on the same lake, therefore providing a basis for comparison.

Compared to previous summers (2019, 2020, 2021, 2022, and 2023), the phycocyanin levels and genus's present are consistent. Only in 2021 the genus *Aphanizomenon* was present at one sampling event. In 2023, *Planktothrix* was present at 17 feet below the surface, but not in the 18 or 19 foot samples. *Microcystis* was the dominant genus for 2019, 2020, 2021, 2022, 2023 and 2024. For previous years data, the information can be found on LOPAs website in the annual monitoring reports.

BERKSHIRE ENVIRONMENTAL RESEARCH CENTER

Results of Seining Onota Lake, Fall 2023

Robert E. Schmidt
Thomas Coote

Introduction

We have successfully collected fishes in Onota Lake with a seine in twelve of the last sixteen years. This report summarizes our observations in September 2023.

Methods

We visited Onota Lake on September 14, 2023. Fishes were collected with a 100 ft bag seine, a single haul at each of five stations. The seine was 6 ft deep and had a 6 X 6 X 6 ft bag in the center. Mesh was ¼ inch bar. Stations sampled were the same as in previous years: 1-southeast corner of the lake on east side of a concrete dock; 2-beach on southwest shore south of a long wooden dock; 3-west shore south of Parker Brook; 4-along a wooden bulkhead on the northeast shore of Thomas Island; and 5-along Burbank Park beach.

All fish collected were identified and counted. A maximum of 20 individuals of each species at each station were measured (total length). Data were recorded on the survey forms provided by Massachusetts Fish and Game. All fish were returned to the lake.

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Results

Total catch this year was 125 individuals (Table 1). This is a very low total catch and we have taken fewer fishes in only one other year (2014 with 60 fishes). We caught a total of 7 species this year, also on the low end of our observations equal to 2013 with 7 species and greater than 2014 with 5 species. As we have seen in previous years, efforts to successfully control vegetation at these stations affect the total numbers of some fishes collected. Juvenile bluegill specifically congregate around aquatic vegetation. Stations 1, 2, and 5 were usually free of vegetation and had few fishes but this year stations 3 and 4 were also mostly vegetation-free and numbers and diversity of fishes was low at those stations also. Notably, bluegill usually comprised a substantial proportion of the fishes caught whereas this year they were relatively scarce at all stations (Table 1). This is a result of the successful vegetation control.

Table 1. Number of individuals collected at five stations in Onota Lake, September 14, 2023.

	Station						
Species	1	2	3	4	5	Total	%
Bluegill (*Lepomis macrochirus*)	4		5	15		24	19.2
Smallmouth bass (*Micropterus dolomieu*)	3	3			2	8	6.4
Redbreast sunfish (*Lepomis auritus*)	4	7	10	5	2	28	22.4
Largemouth bass (*Micropterus nigrescens*)		2	4	1		7	5.6
Banded killifish (*Fundulus diaphanus*)		1				1	<0.1
Yellow perch (*Perca flavescens*)			28	14		42	33.6
Pumpkinseed (*Lepomis gibbosus*)			2	13		15	12.0
Total number	11	13	49	48	4	125	
Percent of catch	8.8	10.4	39.2	38.4	3.2		

Observations of Conditions by Station

Station 1 (southeast corner)- Bottom was mostly gravel, no vegetation.

Station 2 (west shore beach)- Bottom was sand near shore and silty offshore, one small patch of vegetation.

Station 3 (west shore near Parker Brook)- Bottom was silty with woody debris, relatively few plants.

Station 4 (bulkhead on Thomas Island)- Bottom was moderately deep silt, low density of a variety of submerged aquatic plants.

Station 5 (Burbank Park beach)- Bottom was gravel and sand, no vegetation.

BERKSHIRE ENVIRONMENTAL RESEARCH CENTER

Results of Seining Onota Lake, Fall 2024

Robert E. Schmidt
Thomas Coote

Introduction

We have successfully collected fishes in Onota Lake with a seine in thirteen of the last seventeen years. This report summarizes our observations in September 2024.

Methods

We visited Onota Lake on September 6, 2024. Fishes were collected with a 100 ft bag seine, a single haul at each of five stations. The seine was 6 ft deep and had a 6 X 6 X 6 ft bag in the center. Mesh was ¼ inch bar. Stations sampled were the same as in previous years: 1-southeast corner of the lake on east side of a concrete dock; 2-beach on southwest shore south of a long wooden dock; 3-west shore south of Parker Brook; 4-along a wooden bulkhead on the northeast shore of Thomas Island; and 5-along Burbank Park beach.

All fish collected were identified and counted. A maximum of 20 individuals of each species at each station were measured (total length). Data were recorded on the survey forms provided by Massachusetts Fish and Game. All fish were returned to the lake.

Results

Total catch this year was 637 individuals (Table 1). This is the highest total catch in the 14 years we have sampled Onota Lake. We caught a total of 13 species this year, also the highest number of species (by one). As we have seen in previous years, efforts to successfully control vegetation at these stations affect the total numbers of some fishes collected. Juvenile bluegill specifically congregate around aquatic vegetation. Stations 1, 2, and 5 were free from vegetation and had relatively few fishes. This year stations 3 and 4 were vegetated and numbers and diversity of fishes were higher at those stations. Notably, bluegill comprised 47% of the fishes caught, most of them at station 4 (Table 1).

Table 1. Number of individuals collected at five stations in Onota Lake, September 6, 2024.

	Station						
Species	1	2	3	4	5	Total	%
Bluegill (*Lepomis macrochirus*)			27	275		302	47.4
Smallmouth bass (*Micropterus dolomieu*)	13	11			3	27	4.2
Redbreast sunfish (*Lepomis auritus*)	3	7	5	3		18	2.8
Largemouth bass (*Micropterus nigricans*)		1	8	11	1	21	3.3
Banded killifish (*Fundulus diaphanus*)		6		1	82	89	14.0
Yellow perch (*Perca flavescens*)			63	63		126	19.8
Pumpkinseed (*Lepomis gibbosus*)			7	19		26	4.1
Black crappie (*Pomoxis nigromaculatus*)				19		19	3.0
Rock bass (*Amploplites rupestris*)				3		3	<1.0
Brown bullhead (*Ameiurus nebulosus*)			1			1	<1.0
Northern pike (*Esox lucius*)			1	1		2	<1.0
Chain pickerel (*Esox niger*)			1			1	<1.0
Carp (*Cyprinus carpio*)				2		2	<1.0
Total number	16	25	113	397	86	637	
Percent of catch	2.5	3.9	17.7	62.3	13.5		

Observations of Conditions by Station

Station 1 (southeast corner)- Bottom was mostly gravel, no vegetation.

Station 2 (west shore beach)- Bottom was sand near shore and silty offshore, one small patch of vegetation.

Station 3 (west shore near Parker Brook)- Bottom was silty with woody debris, moderate plant density.

Station 4 (bulkhead on Thomas Island)- Bottom was moderately deep silt, moderate density of a variety of submerged aquatic plants.

Station 5 (Burbank Park beach)- Bottom was gravel and sand, no vegetation.

Onota Lake
Pittsfield, MA
Annual Report
2023 Aquatic Management Program

Prepared by: SŌLitude Lake Management
590 Lake Street
Shrewsbury, MA 01545

Prepared for: City of Pittsfield
c/o Jim McGrath
70 Allen Street
Pittsfield, MA 01201
jmcgrath@cityofpittsfield.org

& Lake Onota Preservation Association
c/o Mike Riordan, President
michaelhriordan@icloud.com

Submitted on: December 6, 2023 (REVISED February 7, 2024)

Introduction

After the extensive ProcellaCOR (florpyrauxifen-benzyl) herbicide treatment conducted at Onota Lake in 2021, this year's management focus was on aquatic plant monitoring. As you are well aware however, the lake has experienced significant and unanticipated regrowth of Eurasian milfoil (*Myriophyllum spicatum*) so additional efforts have been taken to work with the SePRO Corporation to determine which areas of regrowth will be covered under the Extended Control Contract (ECC). Based on regrowth in 2022, a partial re-treatment was conducted this summer and additional retreatment will be covered in 2024.

Two detailed aquatic plant surveys (May & August) were conducted in 2023 as well as a third visit (September) conducted with representatives of SePRO. Aside from the ProcellaCOR retreatment, no other herbicide treatments were conducted for submersed plant growth. While there was a significant presence of curlyleaf pondweed (*Potamogeton crispus*) in the spring and early summer, this growth was not managed as such treatment would have also controlled milfoil growth and thus skewed the evaluation of areas that would qualify for retreatment under the ECC. A follow-up treatment of the Phragmites pilot area was also conducted this summer.

In accordance with the existing contract between SŌLitude Lake Management and the City of Pittsfield for Onota Lake, the following document serves to provide this year's survey and treatment results as well as management recommendations for next season.

All work performed at Onota Lake this season was conducted in accordance with the current Order of Conditions (OOC) issued by the Pittsfield Conservation Commission (DEP #263-1012) and the MA DEP – Office of Watershed Management issued License to Apply Chemicals (#WM04-0000754). A chronology of this year's management and brief description of events is as follows:

2023 Program Chronology

● Received MA DEP License to Apply Chemicals	02/26/23
● Early season survey conducted	05/22/23
● Herbicide spot-treatment conducted	06/26/23
● Mid-season survey conducted	08/22/23
● Additional late season survey with SePRO staff	09/19/23
● Common reed Treatment	09/26/23

Survey Methodology

SOLitude's vegetation surveys of Onota Lake are conducted using a littoral meader methodology enhanced with GPS. The littoral zone of the lake is traversed in a zig-zag pattern from shore out to the extent of aquatic plant growth and a combination of visual observations and rake tosses are used to collect data on the aquatic plant assemblage. Points along the survey path are georeferenced using a handheld GPS unit and data is collected at each point which includes the relative abundance of each species present. Relative abundance is noted as either trace, sparse, moderate or dense and takes into account both the areal (bottom) cover of plants as well as their biomass (height in the water column).

Points are collected periodically along the survey path when similar plant assemblages are observed as well as when a notable change in the assemblage is noted, a large patch of one specific species is observed, or when changes in depth/bottom substrate or physical characteristics are seen. Following the survey, point data is imported in ArcMAP GIS software to produce various combinations of maps to display the results.

Early Season Pre-Treatment Survey

Members of the Lake Onota Preservation Association (LOPA) and SŌLitude staff conducted the early season survey together on May 22nd to assess the extent and growth stage of target species within the lake, namely Eurasian watermilfoil and curly-leaf pondweed.

Even though the ProcellaCOR treatment was conducted in 2021, varying densities of Eurasian watermilfoil were observed in Onota Lake during the May survey (see **Figure 1**). There were many areas designated as sparse to moderate abundance, and one area as dense, along the Burbank Park shoreline. Curly-leaf pondweed was also prominent in many areas at varying densities, particularly in the Marina cove and along the northwestern shoreline (also recorded in **Figure 1**). Native plant growth was also documented during this survey. Trace to moderate native plant growth was observed throughout the littoral zone and consisted of waterweed (*Elodea sp.*), large-leaf pondweed (*Potamogeton amplifolius*), Robbins' pondweed

(*Potamogeton robbinsii*), Richardson's pondweed (*Potamogeton richardsonii),* and ribbon-leaf pondweed (*Potamogeton epihydrus*). Native vegetation can be observed in **Figures 2a & 2b**.

Herbicide Treatment

On June 26th, a spot-treatment of selected areas of concern was conducted by SOLitude applicators. These areas were mapped out last season with SePRO and were covered under the ProcellaCOR Extended Control Contact (ECC). Treatment areas can be observed in **Figure 3**.

Mid-season Survey

On August 22nd, SŌLitude Biologists conducted the mid-season survey of the lake to document changes in the plant assemblage from the May survey. Unfortunately, much of the shoreline, particularly the northwest shoreline, exhibited trace to dense watermilfoil regrowth. Even though no treatment of the curly-leaf pondweed was conducted this year, due to its typical growth cycle and senescence around July, only minimal curly-leaf pondweed was observed during this survey. Brittle naiad (*Najas minor*) was the only other non-native species observed during the August survey and it was only observed in one location at sparse density. **Figure 4** displays all invasive species observed during the mid-season survey.

In addition to the native plants documented in the May survey, the Biologists also observed tapegrass (*Vallisneria americana*), muskgrass (*Chara sp.*), clasping leaf pondweed (*Potamogeton perfoliatus*), coontail (*Ceratophyllum demersum),* and only trace observations of common waterweed. **Figures 5a & 5b** show the locations of these native species as observed during the August survey.

Final Vegetation Survey

On September 19th, SŌLitude staff, accompanied by LOPA & City of Pittsfield representatives along with Jon Gosselin from SePRO Corporation, conducted a final survey specifically to evaluate watermilfoil regrowth. This was conducted in order to fulfill the requirements for the ProcellaCOR treatment warranty. As a result of this survey, SePRO had agreed to provide ProcellaCOR product to retreat 47 acres of Onota Lake in 2024 using a dose that is <u>double the original dose</u> used for the 2021 treatment. The map below was provided by SePRO showing the area of retreatment that will be covered under the ECC.

Phragmites Treatment

On September 26th, SOLitude staff conducted the herbicide application to the common reed test location at 120/126 Blythewood Drive. The herbicide AquaNeat (glyphosate) and the approved aquatic surfactant, methylated seed oil (MSO), were applied to the reed foliarly using a backpack sprayer. The initial treatment conducted in 2022 worked extremely well and only scattered groupings of plants were observed and treated this year.

A second area of Phragmites, located on the southern side of the Blythewood culvert (south shore of 122 Blythewood Drive) was inspected this year during the final vegetation survey. This second area of Phragmites has been expanding and is also one of the largest on the lake and should be considered for future treatment. Unlike the treated patch, this second patch has adjacent, native emergent vegetation which may require that a combination of backpack spraying and hand-wicking be employed to be protective of this nearby non-target growth.

Summary and Recommendations

The level of Eurasian milfoil regrowth continued to increase in 2023 and at the same time we continue to see a robust repopulation of native plants throughout the lake. While the amount of regrowth from the 2021 ProcellaCOR treatment is disappointing, retreatment of 14.5 acres was conducted this past summer and retreatment of 47 acres is planned for 2024 at a dose that is double the dose used for the original treatment. The herbicide product for these re-treatments is provided by SePRO under the ECC agreement.

The retreatment conducted this past summer provided excellent control of the milfoil within the treatment area and control was also observed in surrounding areas. The retreatment planned for 2024 is more extensive and combined with continued control in the 2023 treatment areas, should eliminate much but not all of the dense and moderate areas of milfoil growth in the lake. For 2024 and beyond, we recommend the City allocate an annual budget for partial lake maintenance treatment with ProcellaCOR. The extent of the budget will be based on an assumed area of annual treatment to be discussed with the project partners, but for example, we could base the budget on treating up to 50-acres of the lake each year with the specific locations to be determined based on pre-management vegetation surveys.

Curly-leaf pondweed was not affected by the ProcellaCOR herbicide in 2021, so growth is likely to be substantial again in 2024 as it was in 2023. Treatment of the curly-leaf with diquat will likely affect the growth of the recovering native species, although this could be minimized by treating early in the season using the lowest effective dose. Curlyleaf pondweed would need to be treated earlier in the season than milfoil and could be included in the annual maintenance budget.

For common reed management, we recommend a final round of herbicide treatment to control re-growth in the test area, which is already under contract with the City. As mentioned previously, we also recommend initiating treatment of the area of Phragmites along the south shore of the Blythewood culvert.

Of growing concern to residents and users of the lake is the increasing extent and density of waterlilies in the Kelly Cove area of the north end of the lake. We recommend increasing scrutiny and documentation of this growth in future assessments so that potential management evaluations can be made.

Similar to recent historical practice, the management program should include three surveys of the plant distribution in the lake. The first survey should be conducted in mid May mainly to assess the presence of curlyleaf pondweed and milfoil. The timing of the second survey would be variable (late June through early August) depending on the results of the first survey and the timing of management activities. This survey will evaluate any management actions taken earlier in the season and document any additional areas of invasive plant growth, including spiny naiad (*Najas minor*), as well as native plant species. A final plant survey will be conducted in September to document the late season presence of all aquatic plant species in the lake.

SOLitude will plan to hold discussions in the near future with the City and LOPA to review management recommendations and budget for 2024 and subsequent years. We appreciate your collaboration, and look forward to working with you again next season.

FIGURE 1: Pre-Management Survey Density and Distribution of Eurasian Watermilfoil and Curly-leaf Pondweed

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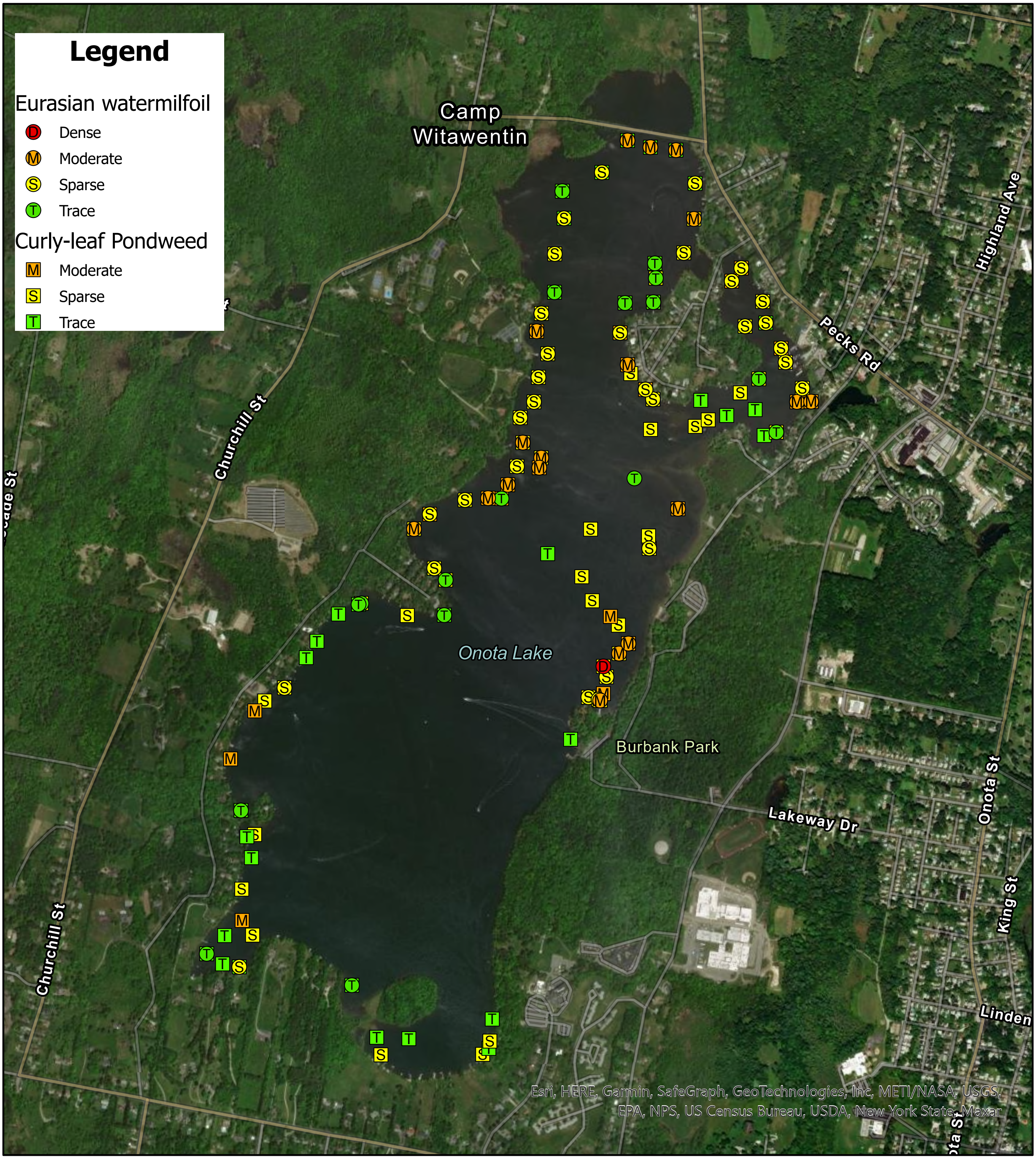
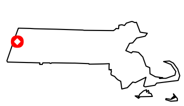


Onota Lake
Pittsfield, MA
Berkshire County



Onota Lake

0 1,375 2,750 Feet

1:18,069

N

Map Date: 6/21/23
Prepared by: DMM
Office: SHREWSBURY, MA

FIGURE 2a: Pre-Management Survey Distribution of Native Vegetation Species (1 of 2)

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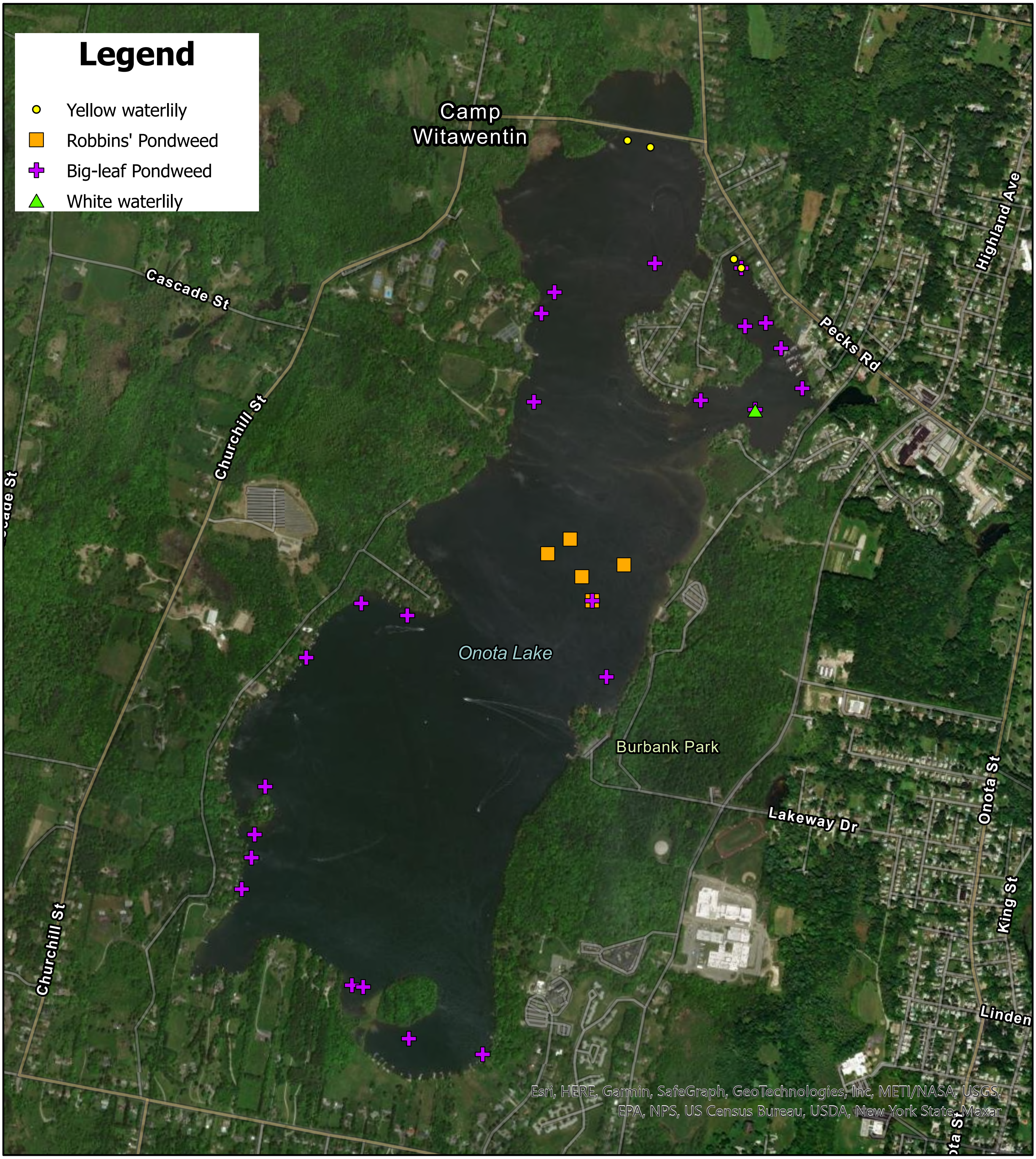

Onota Lake
Pittsfield, MA
Berkshire County

Onota Lake

0 1,375 2,750 Feet

1:18,069

N

Map Date: 6/21/23
Prepared by: DMM
Office: SHREWSBURY, MA

FIGURE 2b: Pre-Management Survey Distribution of Native Vegetation Species (2 of 2)

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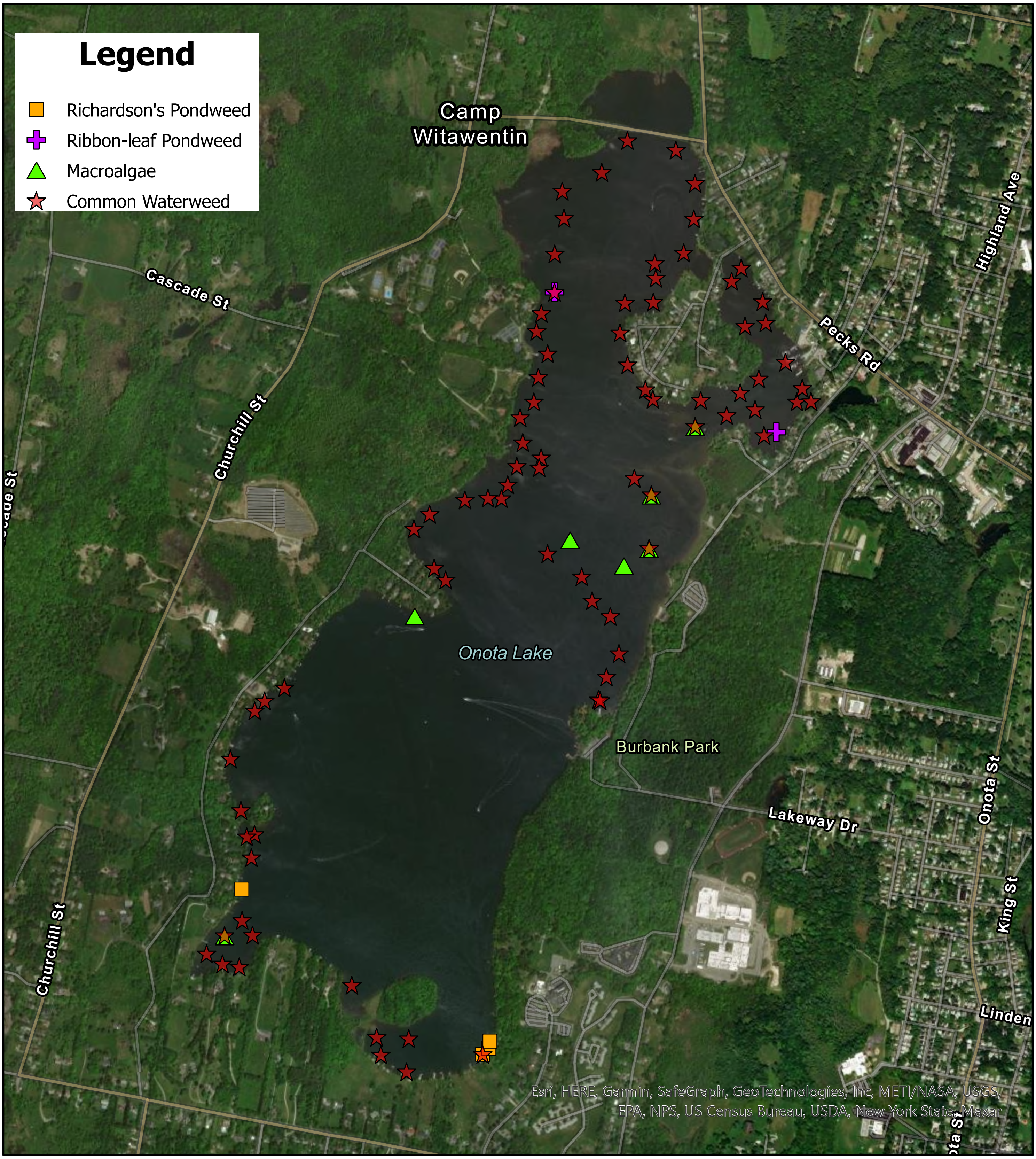

Onota Lake
Pittsfield, MA
Berkshire County

Onota Lake

0 1,375 2,750 Feet

1:18,069

N

Map Date: 6/21/23
Prepared by: DMM
Office: SHREWSBURY, MA

FIGURE 3: ECC Treatment Areas - June 2023 - 14.5 Acres

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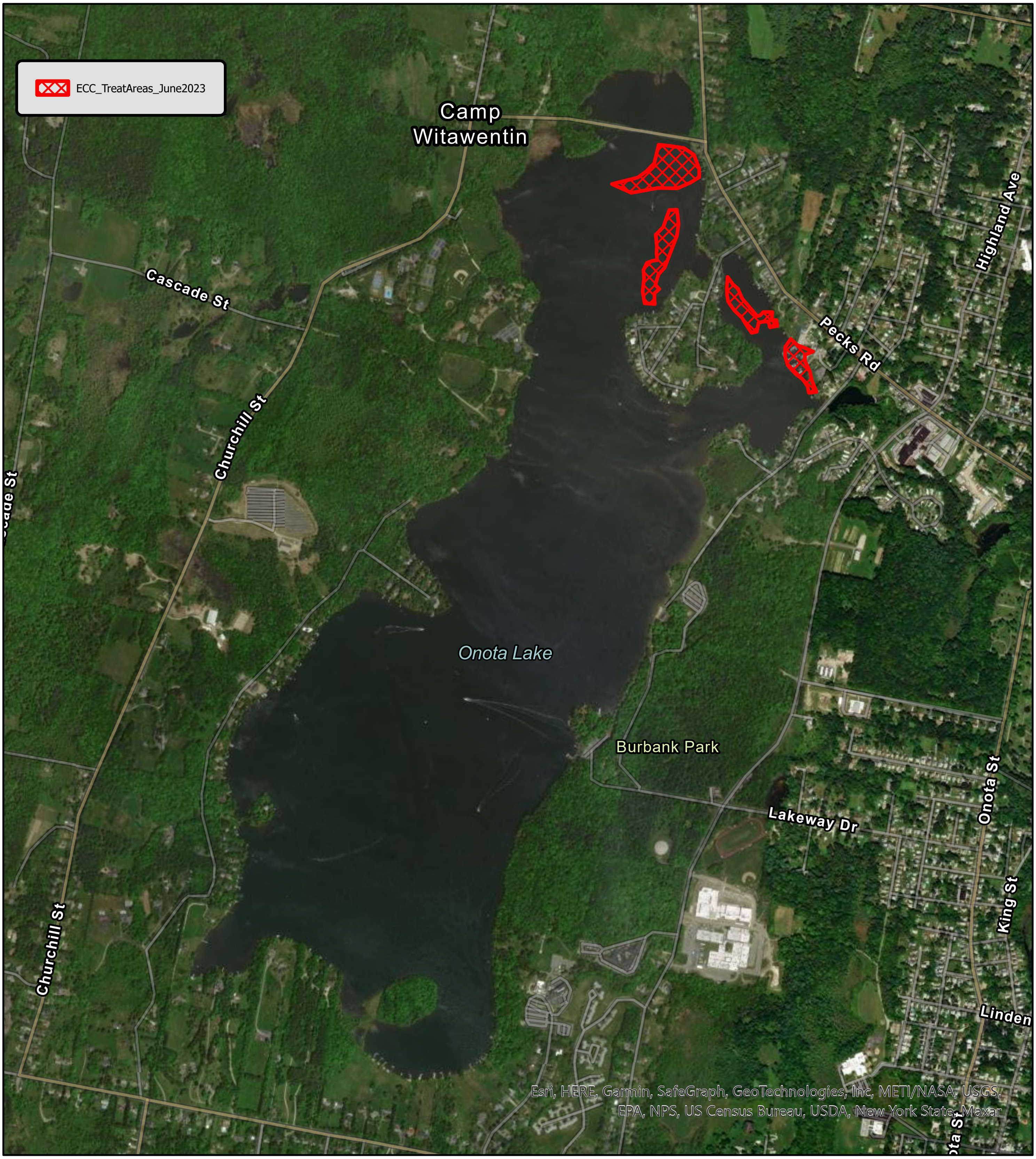

Onota Lake
Pittsfield, MA
Berkshire County

Onota Lake

0 1,375 2,750 Feet

1:18,069

N

Map Date: 6/21/23
Prepared by: DMM
Office: SHREWSBURY, MA

Figure 4: Mid-season Density and Distribution of Invasive Vegetation

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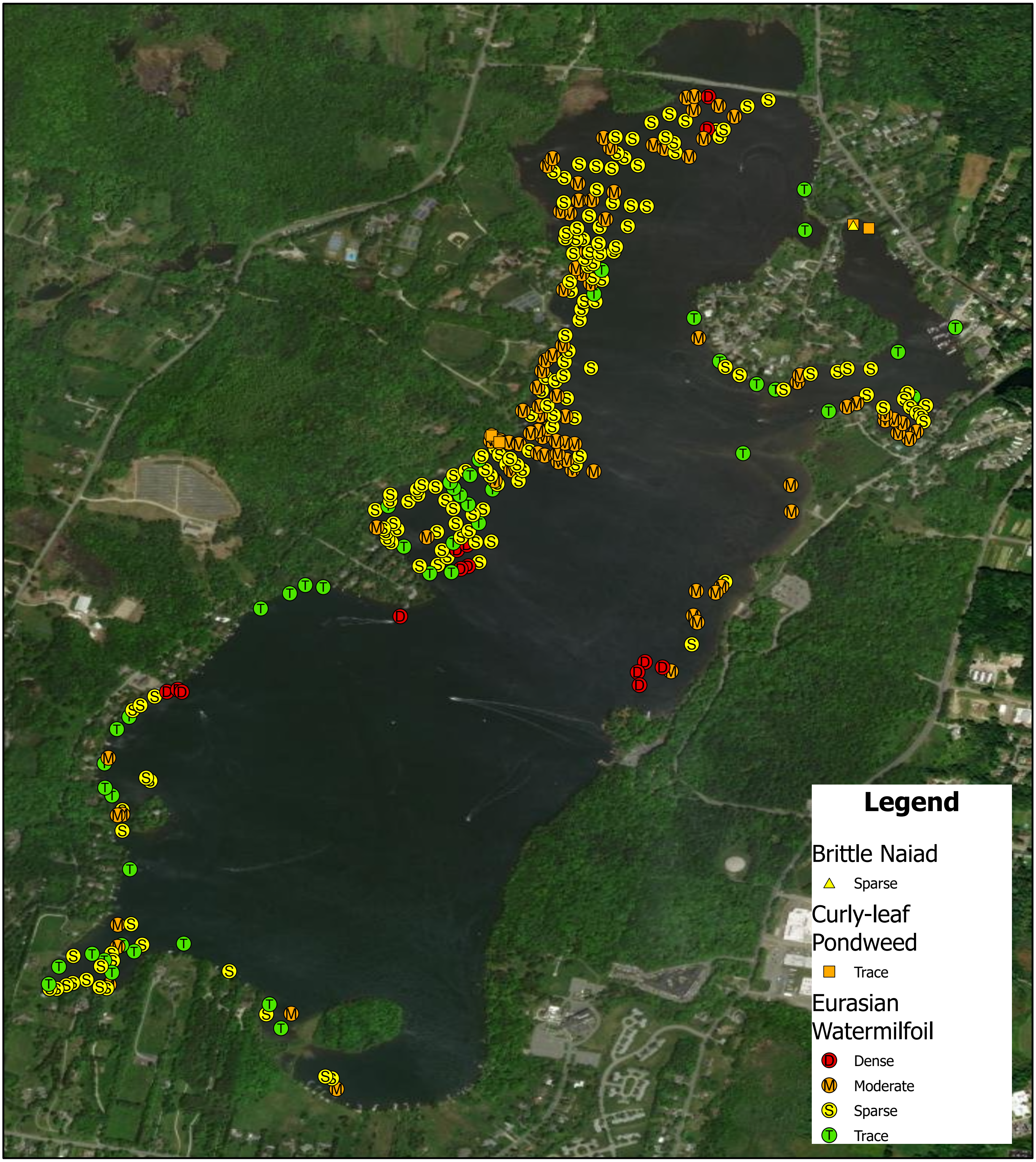

Lake Onota
Pittsfield, MA

N

Lake Onota

0 50 100 200 Feet

1:16,696

Survey Date: 08/22/2023
Map Date: 09/11/2023
Prepared by: KV
Office: SHREWSBURY, MA

FIGURE 5a: Mid-season Distribution of Native Aquatic Vegetation (Map 1 of 3)

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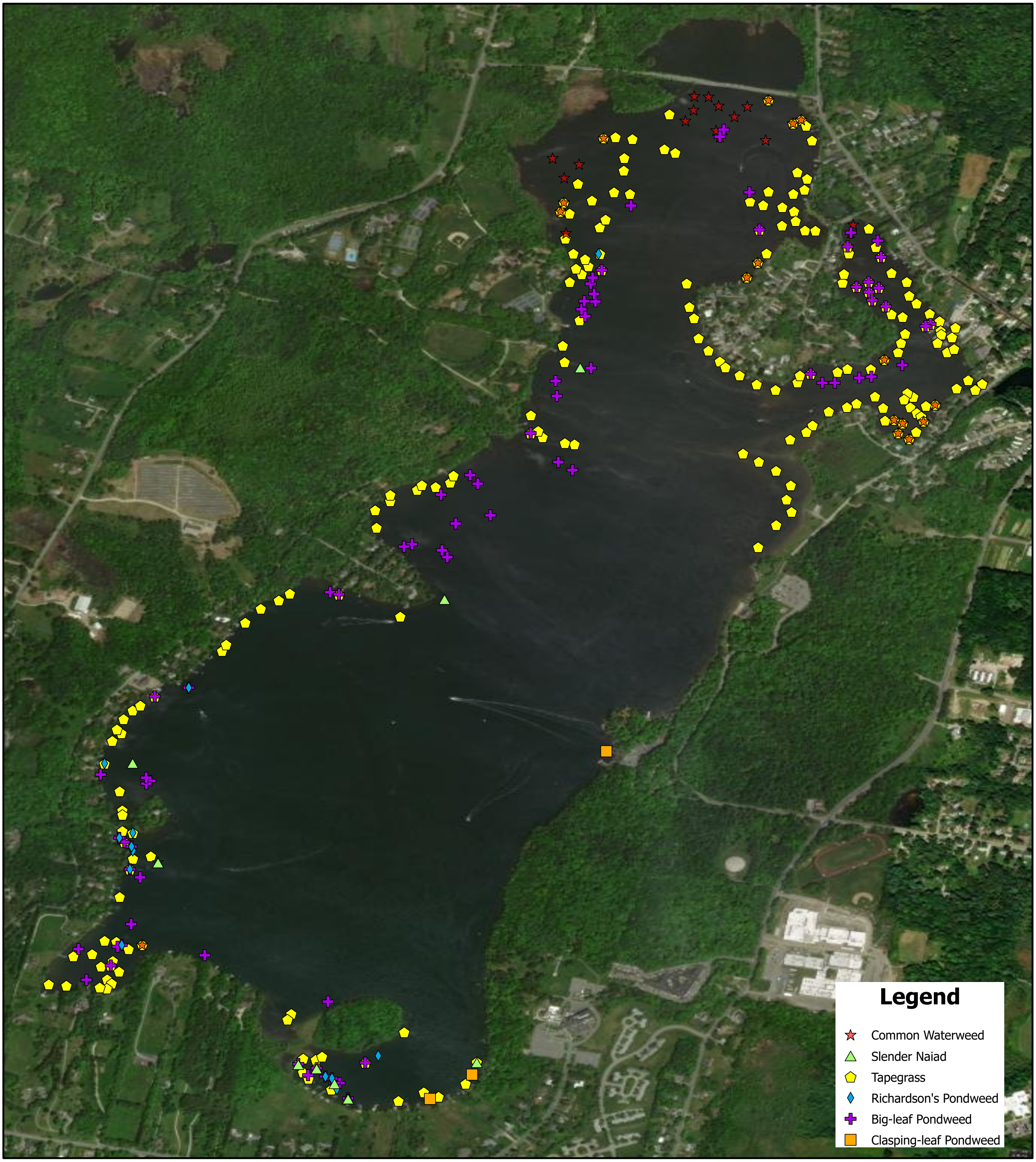

Lake Onota
Pittsfield, MA

N

Lake Onota

1:16,696

0 50 100 200 Feet

Survey Date: 08/22/2023
Map Date: 09/11/2023
Prepared by: KV
Office: SHREWSBURY, MA

FIGURE 5b: Mid-season Distribution of Native Aquatic Vegetation (Map 2 of 3)

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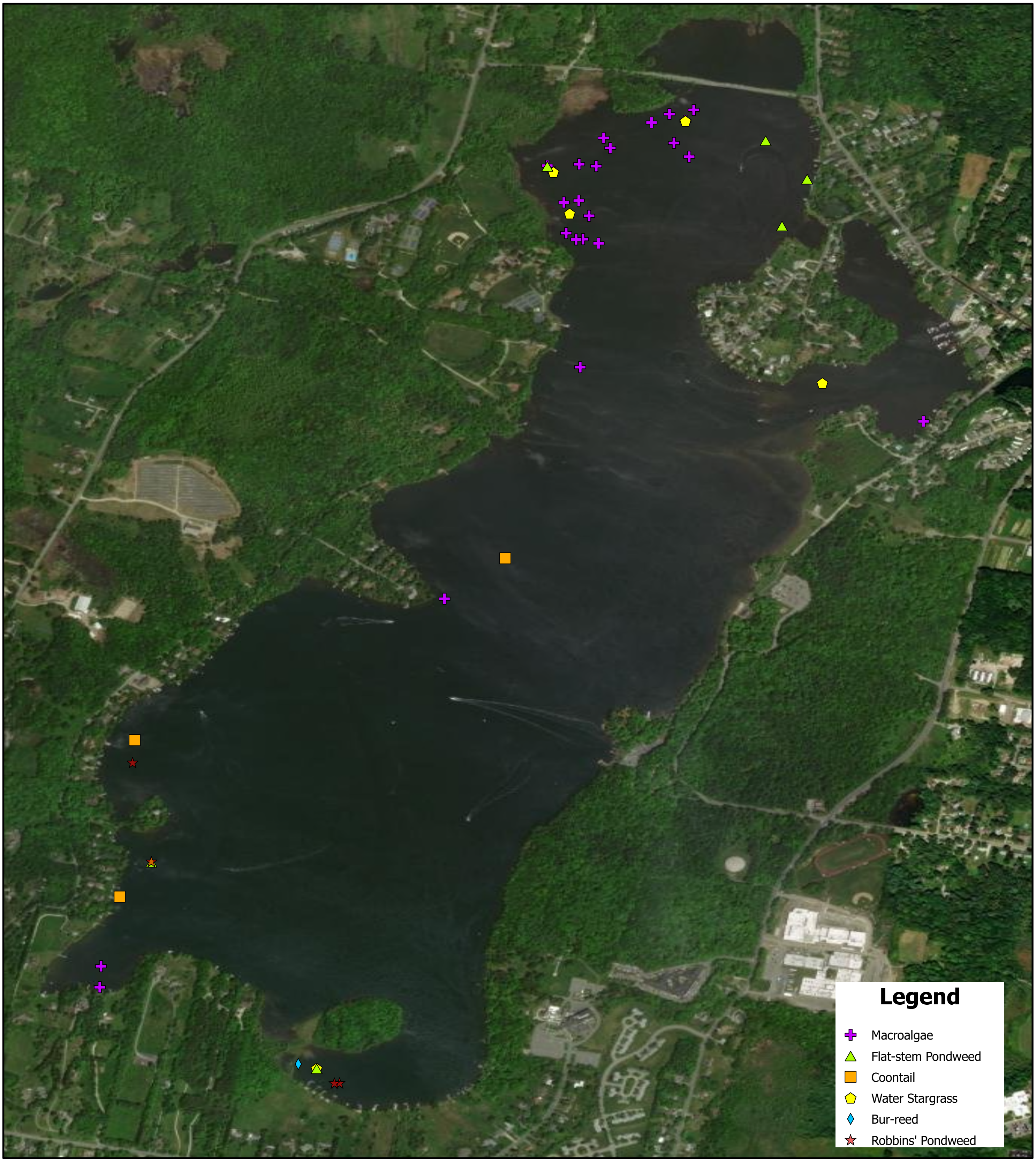

Lake Onota
Pittsfield, MA

N

Lake Onota

0 50 100 200 Feet

1:16,696

Survey Date: 08/22/2023
Map Date: 09/11/2023
Prepared by: KV
Office: SHREWSBURY, MA

FIGURE 5c: Mid-season Distribution of Native Aquatic Vegetation (Map 3 of 3)

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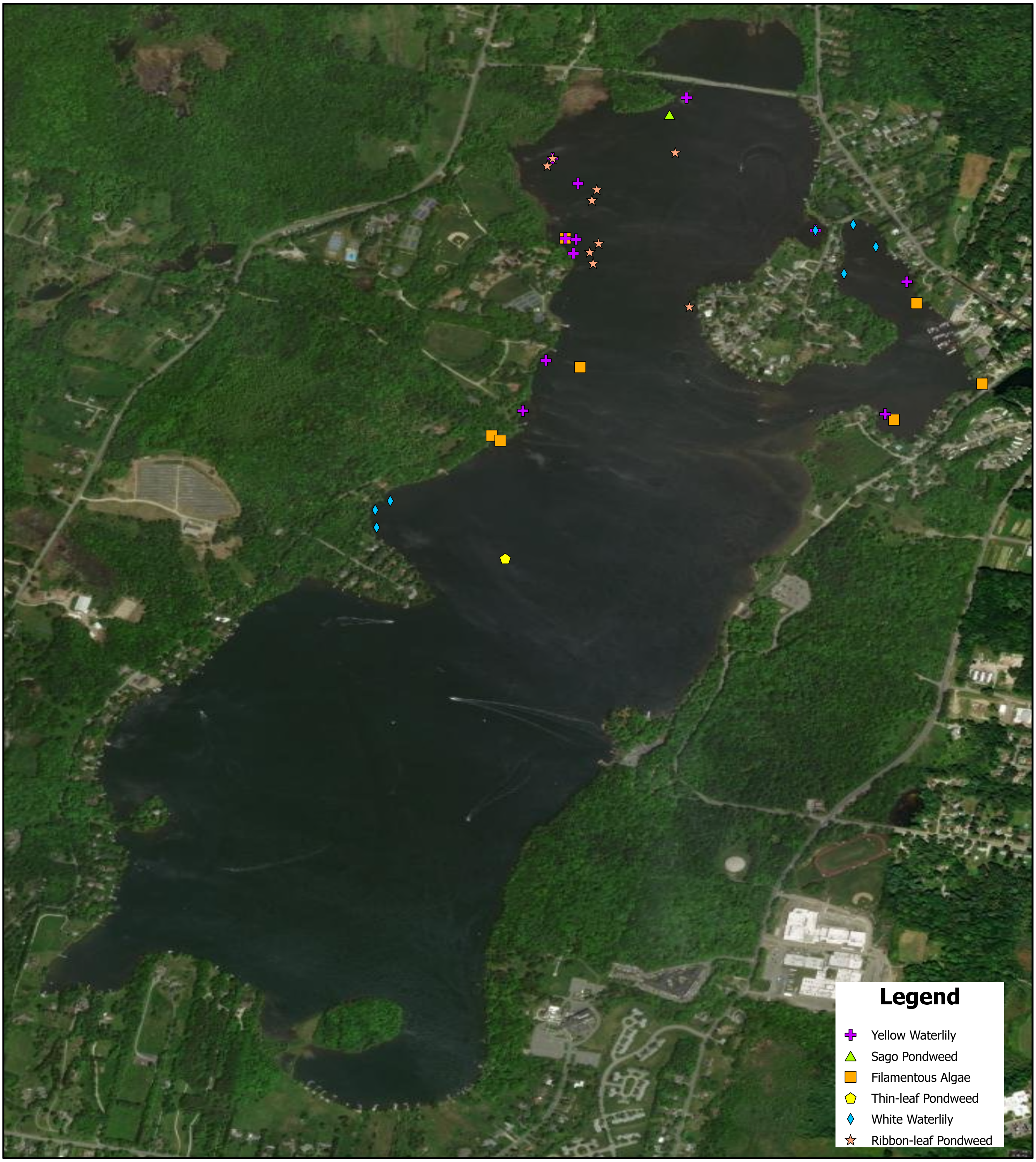

Lake Onota
Pittsfield, MA

N

Lake Onota

0 50 100 200 Feet

1:16,696

Survey Date: 08/22/2023
Map Date: 09/11/2023
Prepared by: KV
Office: SHREWSBURY, MA

Onota Lake
Pittsfield, MA
Annual Report
2024 Aquatic Management Program

Prepared by: SŌLitude Lake Management
590 Lake Street
Shrewsbury, MA 01545

Prepared for: City of Pittsfield
c/o Jim McGrath
70 Allen Street
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jmcgrath@cityofpittsfield.org

&

Lake Onota Preservation Association
c/o Mike Riordan, President
michaelhriordan@icloud.com

Submitted on: December 18, 2024

Introduction

Since 2021, non-native plant management at Onota Lake has focused on monitoring and treatment with florpyrauxifen-benzyl (ProcellaCOR) for control of Eurasian watermilfoil (*Myriopyllum spicatum*). Although the initial treatment with ProcellaCOR did not provide the full longevity of control initially expected, the reduced impact to the lake's native plant populations versus prior use of diquat herbicide was remarkable. In 2023, a follow up treatment was conducted in the north bay which was covered by SePRO as part of its Extended Control Contract. This past summer, a more extensive follow-up treatment, which was partially funded by SePRO and which was conducted with a higher dose, was completed.

Evidence of Zebra mussels (Dreissena polymorpha) was detected via eDNA sampling in the fall of 2023 and again in 2024 including the discovery of one live specimen attached to the fishing pier. In a proactive effort, consistent with rapid response protocol, the City contracted SOLitude to conduct treatment in and around the boat ramp area (1-acre) with Earthtec QZ.

In accordance with the existing contract between SŌLitude Lake Management and the City of Pittsfield for Onota Lake, the following document serves to provide this year's survey and treatment results as well as management recommendations for next season.

All work performed at Onota Lake this season was conducted in accordance with the current Orders of Conditions (OOC) issued by the Pittsfield Conservation Commission (DEP #263-1012 & #263-1225) and the MA DEP – Office of Watershed Management issued Licenses to Apply Chemicals (#WM04-0001651). The EarthTec QZ treatment was conducted under the License to Apply Chemicals (#WM04-0001747). A chronology of this year's management and brief description of events is as follows:

2024 Program Chronology

• Received MA DEP License to Apply Chemicals	06/05/24
• Early season survey conducted	06/07/24
• Herbicide spot-treatment conducted	06/17/24
• Phragmites Treatment	09/05/24
• Late season survey	09/05/24
• Received MA DEP License to Apply Chemicals (EarthTec)	10/04/24
• Initial EarthTec QZ treatment	10/17/24
• Follow-up EarthTec QZ treatment	10/31/24

Early Season Pre-Treatment Survey

An early-season survey was conducted by a SOLitude Aquatic Biologist on June 7th in order to determine the distribution and density of Eurasian milfoil growth within Onota Lake. A throw rake was utilized to collect samples from deeper water that could not be visually observed. . During the survey, trace to dense populations of Eurasian watermilfoil were observed throughout the littoral zone (see **Figure 1**). Based on the extent of growth within the lake, a ProcellaCOR treatment targeting 75.4 acres was scheduled for June 17th.

Herbicide Treatment

On June 17th, a 75.4 acre treatment of Eurasian watermilfoil was conducted by licensed SOLitude applicators. These areas were developed after the preseason survey in conjunction with the City and LOPA. Treatment areas can be observed in **Figure 2**. During this treatment, an airboat equipped with an onboard mixing tank and calibrated pump system was utilized to conduct the treatment. Lake water was brought on board through the pump system to dilute the herbicide mixture. This mixture was then injected subsurface via a weighted, subsurface hose system. The boat operator utilized a GPS unit to guide the treatment within the treatment zones and ensure equal coverage.

Phragmites Treatment

On September 5th, A licensed SOLitude project manager conducted the final stage of a trial Phragmites treatment. This treatment occurred at specific locations along Blythewood Drive. The herbicide AquaNeat (glyphosate) and surfactant MSO (methylated seed oil) were applied to the phragmites in a foliar spray from a backpack sprayer. This treatment targeted any remaining phragmites from the 2023 treatment.

Final Vegetation Survey

On September 5th, A licensed SOLitude project manager conducted a final vegetation survey. The post-season survey was conducted to determine the efficacy of the ProcellaCOR treatment program, and assess any remaining vegetative growth within the lake. During the survey, it was observed that Eurasian watermilfoil was greatly reduced. Milfoil was observed in the Northwestern cove, along the northeastern shoreline, and in the southwestern cove. No milfoil was observed along the western shoreline or the south eastern shoreline. The remaining assemblage of milfoil can be observed in **Figure 3**.

Zebra Mussels Treatment

After extensive discussions, a zebra mussel treatment plan was developed in conjunction with the City, LOPA and Dr. David Hammond from Earth Science Labs. In the beginning of October, a permit was obtained from MA DEP to proceed with an EarthTec QZ treatment. The initial treatment was scheduled for October 17th. A one-acre treatment zone (see **Figure 4**) encompassing the boat launch and surrounding area was traversed by a boat equipped with a calibrated pump system and on-board holding tank. Similarly to the ProcellaCOR treatment, the herbicide was diluted with lake water and injected subsurface directly to the treatment zone. A GPS was utilized to guide the boat operator through the treatment zone.

The follow-up treatment was conducted on October 31st. This treatment was conducted in the same manner as the initial treatment. During all treatments, no negative effects to non-target aquatic wildlife were observed.

Summary and Recommendations

This summer, a ProcellaCOR herbicide treatment was conducted at a higher dose across a majority of the lake where significant milfoil regrowth was present. While the post-treatment survey indicates good control was achieved, monitoring in 2025 will be required to determine if the higher dose provides improved and longer lasting control than previous efforts.

Moving into the 2025 treatment season, we recommend continuing the ProcellaCOR treatment program. To begin the season, a vegetation survey will be conducted in order to assess the distribution and density of this target species, as well as document the native plant assemblage within Onota Lake. Based on the survey results, treatments will be conducted on an as needed basis. We recommend that the City budget for 60 acres of ProcellaCOR treatment, but the need could be less. We also recommend continuing with mid-season and late season surveys to better understand the overall growth pattern of the vegetation within Onota Lake and determine the efficacy of any treatments. Native plants were not surveyed in 2024, but should be included again moving forward.

Since ProcellaCOR is not effective on curly-leaf pondweed, it has not been addressed since 2020. Addressing this species again with diquat may affect the growth of the recovering native species, although this could be minimized by treating early in the season using the lowest effective dose. Curlyleaf pondweed would need to be treated earlier in the season than milfoil and could be included in the annual maintenance budget.

For the zebra mussels, no further treatments are recommended at this time unless on-going monitoring efforts reveal further evidence of their presence in Onota Lake. After three years of treating the Phragmites test plot, good control and very minimal regrowth was observed. We recommend monitoring the test plot for any regrowth this year and consideration for treatment of other areas around the lake.

We thank you for your business during the 2024 season and we look forward to working with you in 2025. If you have any questions regarding the information or recommendations contained within this report, please feel free to contact our office directly.

Figure 1: 2024 Eurasian Watermilfoil Distribution and Density

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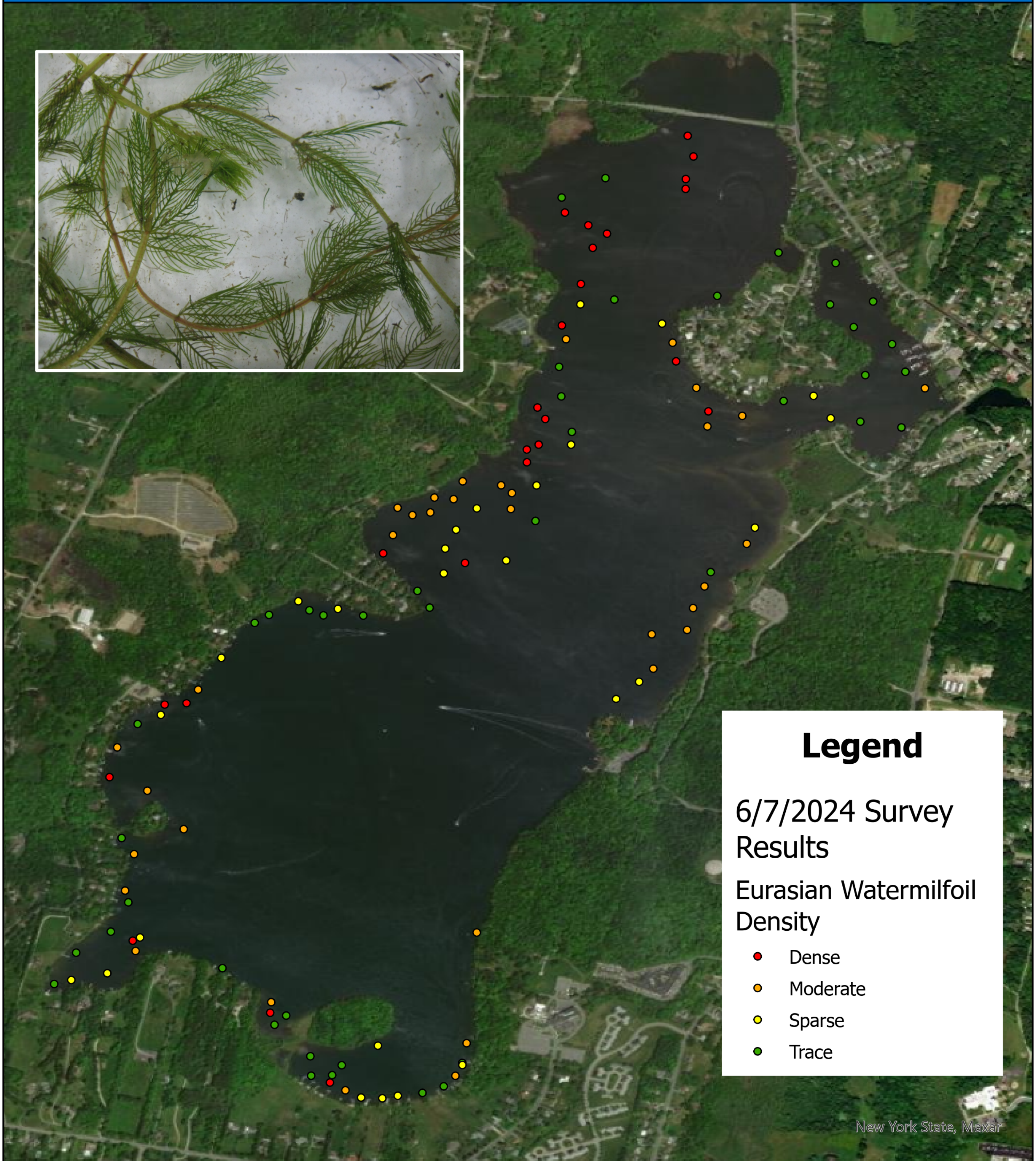

ONATA LAKE
Pittsburg, Massachusetts

Center: 73°16'56"W 42°28'15"N
Scale: 1:17,258

N

ONATA LAKE

0 0.25 0.5 Miles

Survey Date: June 7, 2024
Prepared by: E. Vulgamore
Office: SHREWSBURY, MA

Figure 2a: 2024 Treatment Areas

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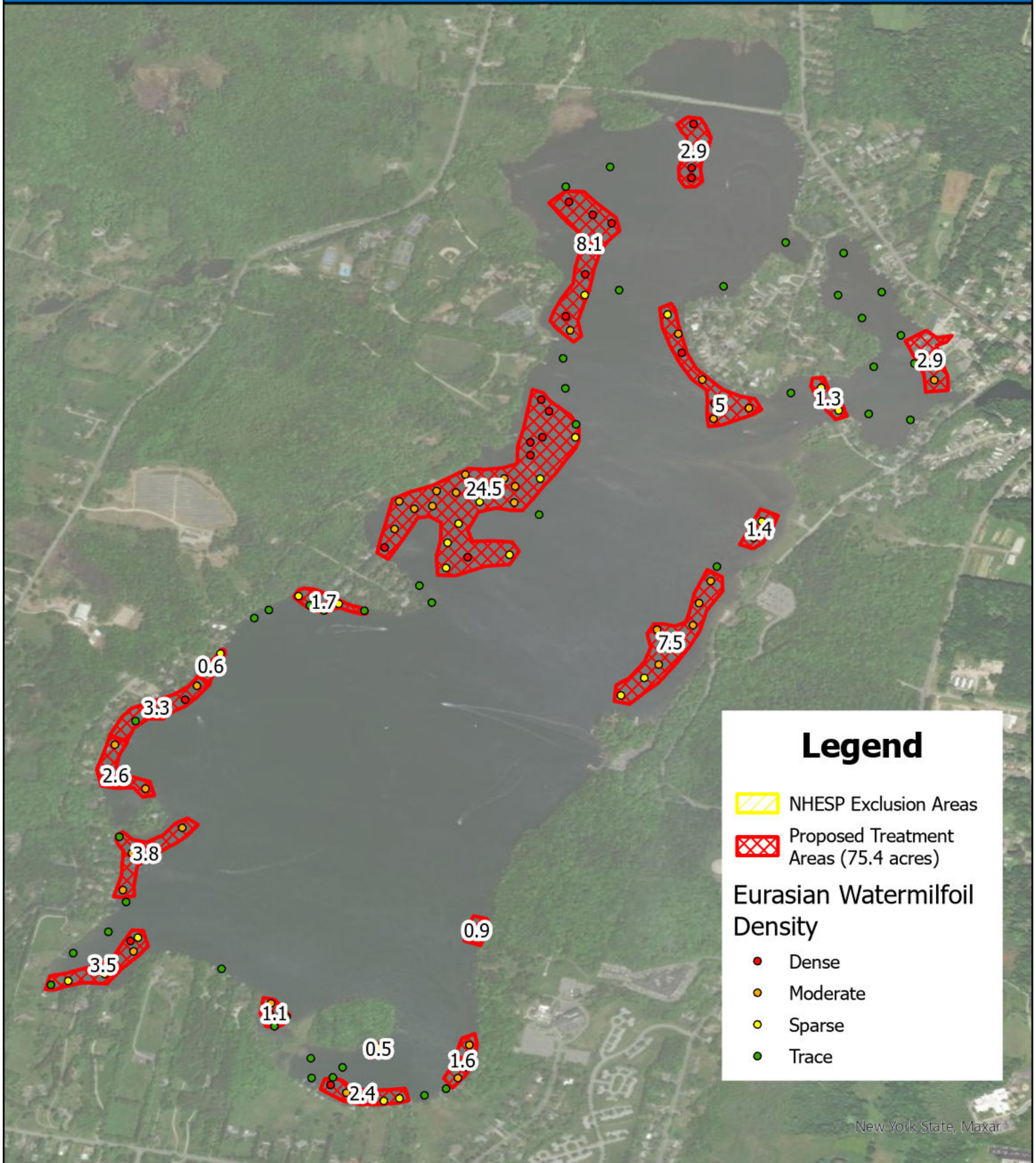

ONOTA LAKE
Pittsfield, Massachusetts

Center: 73°16'56"W 42°28'14"N
Scale: 1:17,000

N

ONOTA LAKE

0 0.24 0.49 Miles

Survey Date: June 14, 2024
Prepared by: DM
Office: SHREWSBURY, MA

Figure2b: June 17th Treatment Tracks

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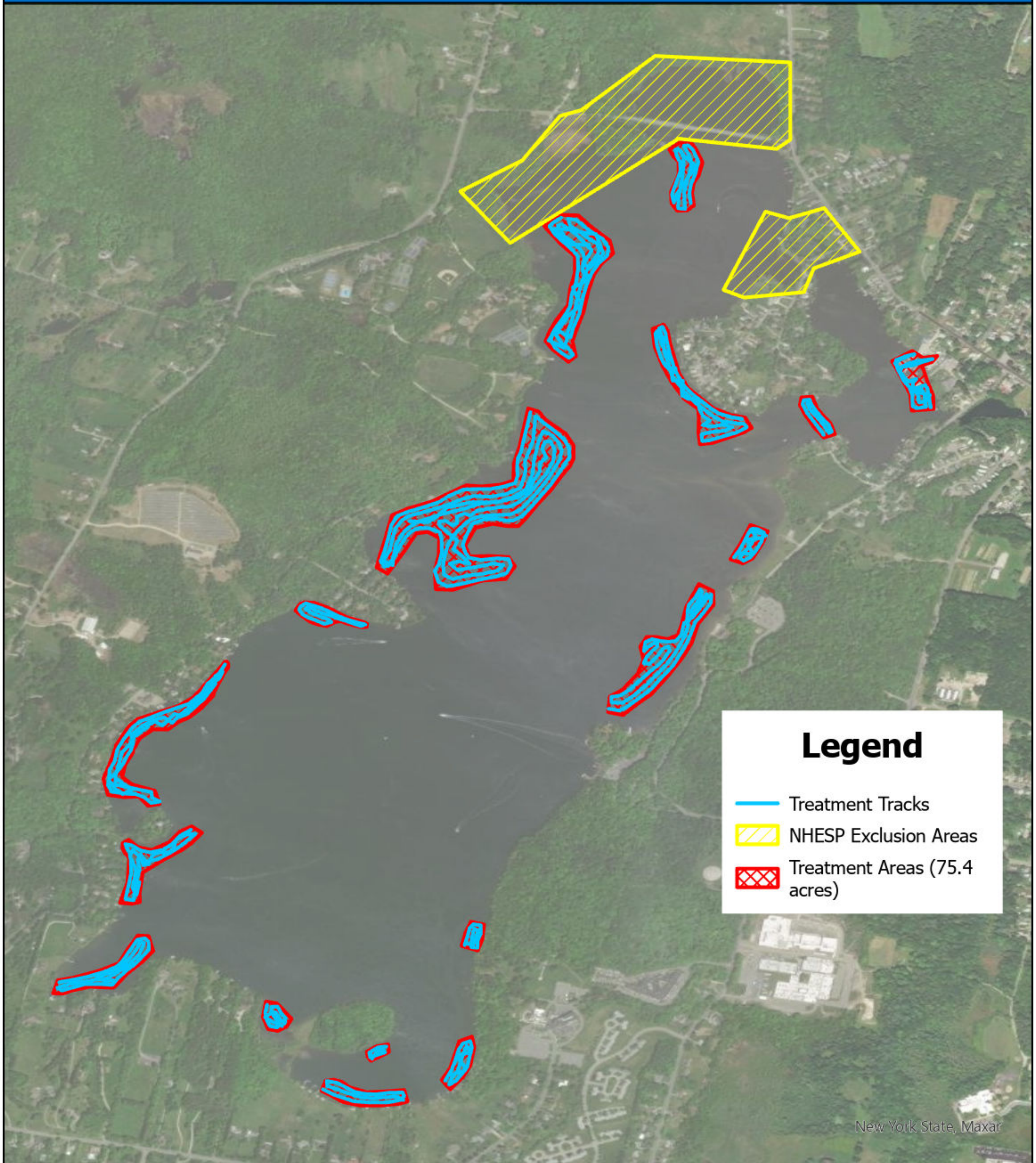

ONOTA LAKE
Pittsfield, Massachusetts

Center: 73°16'56"W 42°28'16"N
Scale: 1:17,431

N

ONOTA LAKE

0 0.25 0.51 Miles

Map Date: September 9, 2024
Prepared by: DM
Office: SHREWSBURY, MA

Figure 3: September 2024 Milfoil Locations

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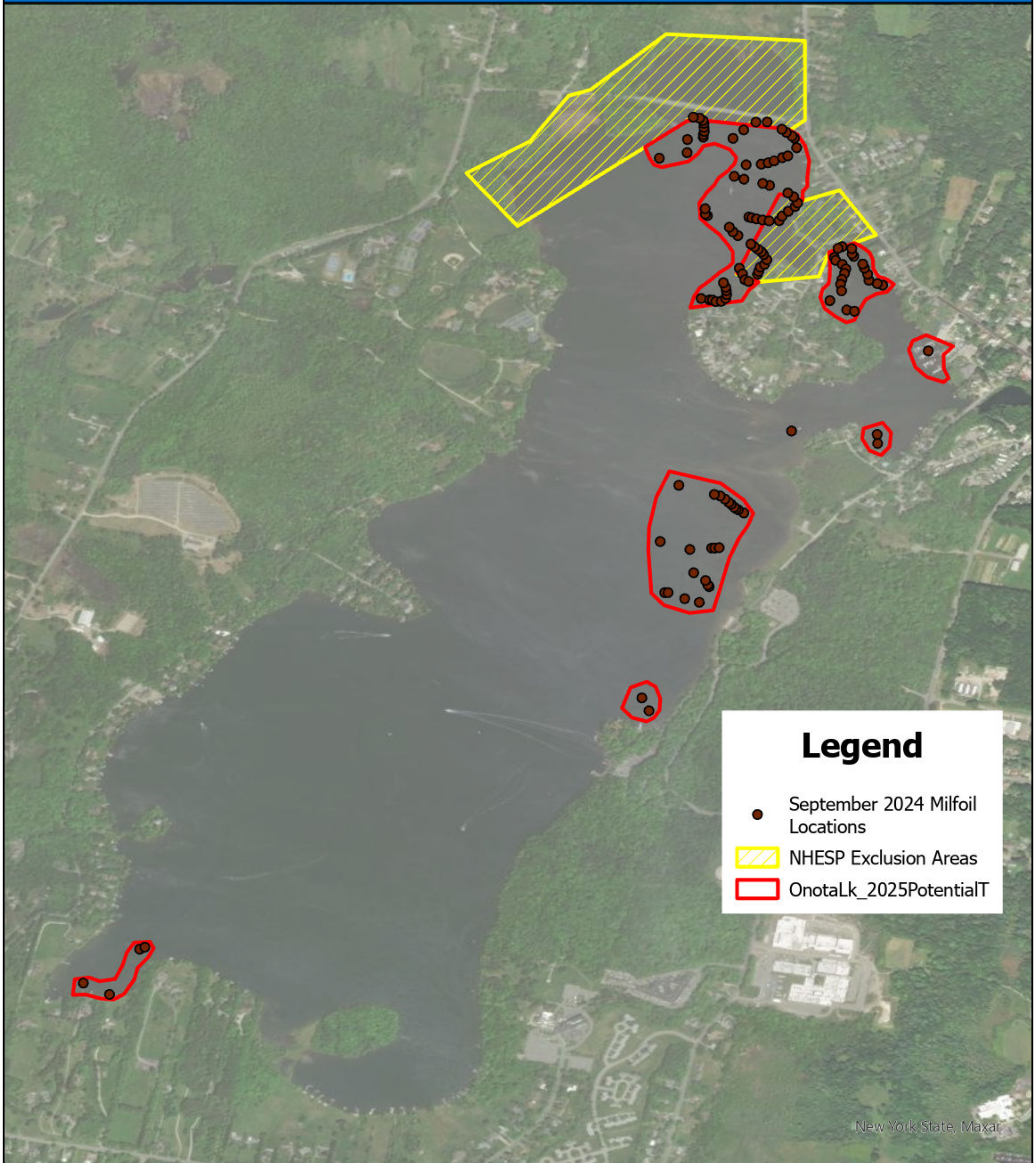

ONOTA LAKE
Pittsfield, Massachusetts

Center: 73°16'57"W 42°28'15"N
Scale: 1:16,988

N

ONOTA LAKE

0 0.24 0.49 Miles

Survey Date: September 5, 2024
Prepared by: DM
Office: SHREWSBURY, MA

Figure 4: Proposed EarthtecQZ Treatment Area (1 acre)

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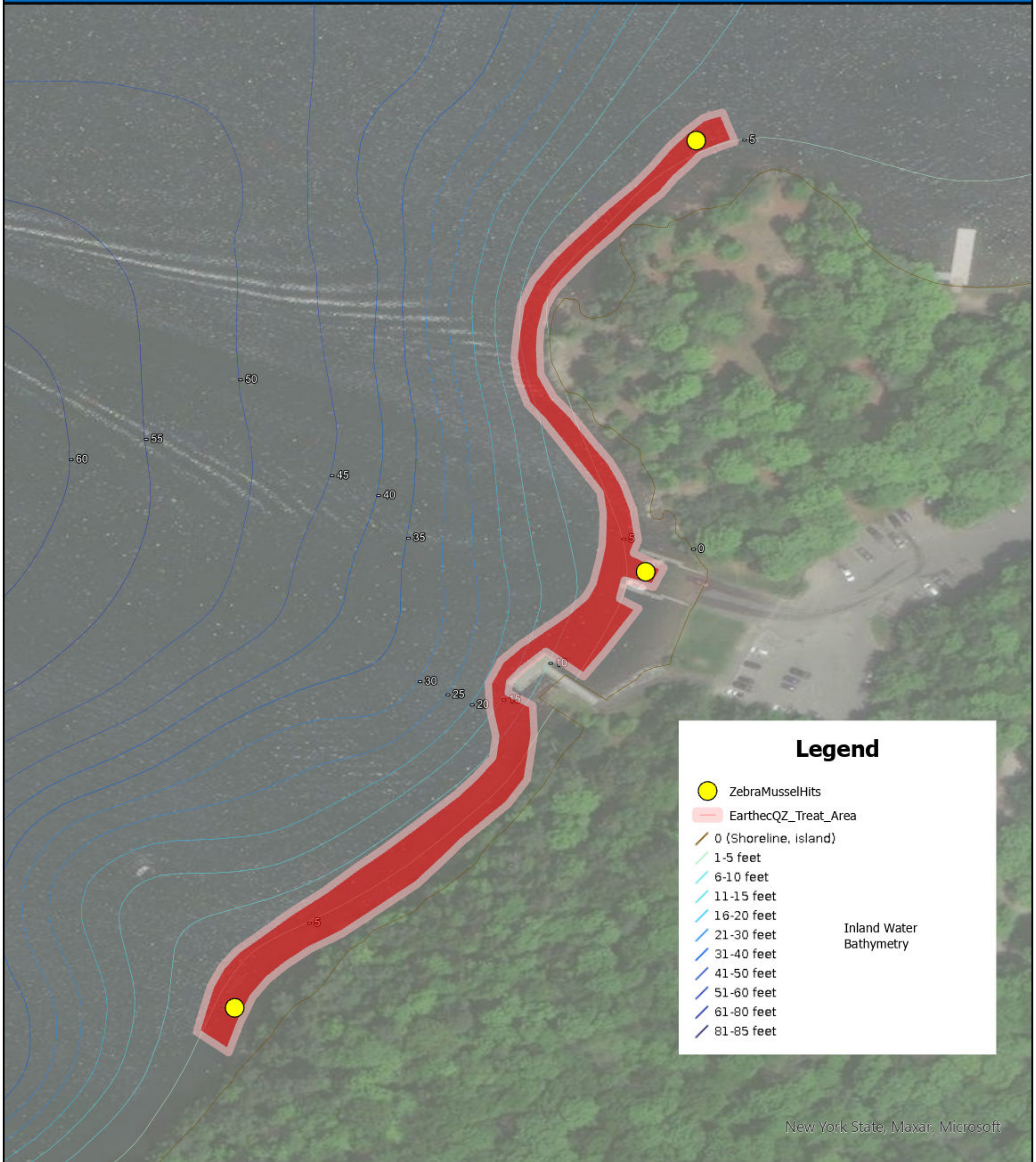


ONOTA LAKE
Pittsfield, Massachusetts

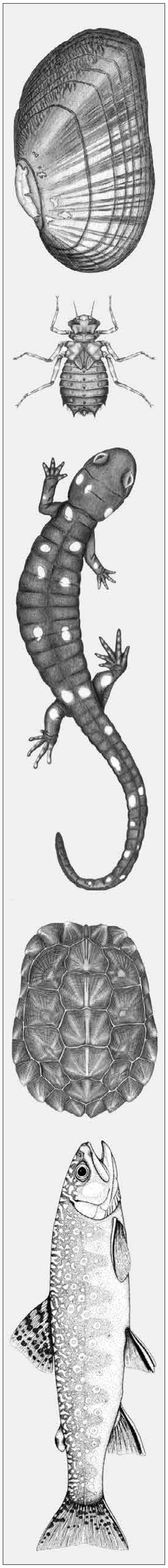
Center: 73°16'49"W 42°27'56"N
Scale: 1:1,879

N

ONOTA LAKE

0 0.03 0.05 Miles

Survey Date: September 26, 2024
Prepared by: DM
Office: SHREWSBURY, MA



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REPORT

Zebra Mussel (*Dreissena polymorpha*) Survey in Lake Onota in Pittsfield, MA

INTRODUCTION

The non-native and invasive zebra mussel (*Dreissena polymorpha*) was detected in Lake Onota using environmental DNA (eDNA) sampling techniques in September 2023. The positive sample was collected along the shoreline near the state boat ramp. On December 4, 2023, Ethan Nedeau of Biodrawversity met with Karen Murray and Dave Reinhart (both board members of Lake Onota Preservation Association [LOPA]) at the public boat ramp to conduct a qualitative survey for juvenile and adult zebra mussels. The lake level had been drawn down during the fall, achieving a 2 ft drawdown by early December. This exposed large amounts of suitable habitat that could be checked on foot. Nearshore shallow areas and deeper offshore areas were also searched using three methods: (1) wading with view buckets out to a maximum depth of 3.0 ft, (2) use of an underwater camera connected to a view screen, primarily lowered off the fishing platform, and (3) SCUBA diving for approximately 70 minutes out to a maximum depth of 18 feet. The SCUBA and view bucket inspections included the rocky shoreline just north of the actual boat launch, as well as the area next to and under the fishing pier to the south of the boat launch. Afterward, Ethan and Karen went to the Lakeway Drive bridge near the lake's outlet to check suitable habitat near the bridge using view buckets, the underwater camera, and checking exposed substrates. In total, approximately 3.0 hours were spent searching for juvenile and adult zebra mussels. Neither live nor dead zebra mussels were detected at either site. Live native mussels and Asian clams (Corbicula fluminea) were observed at both sites. Both sites contained large amounts of suitable habitat for zebra mussels, based primarily on substrate (large amounts of coarse rock and concrete) and water depth.

Lake Onota boat ramp and fishing pier.

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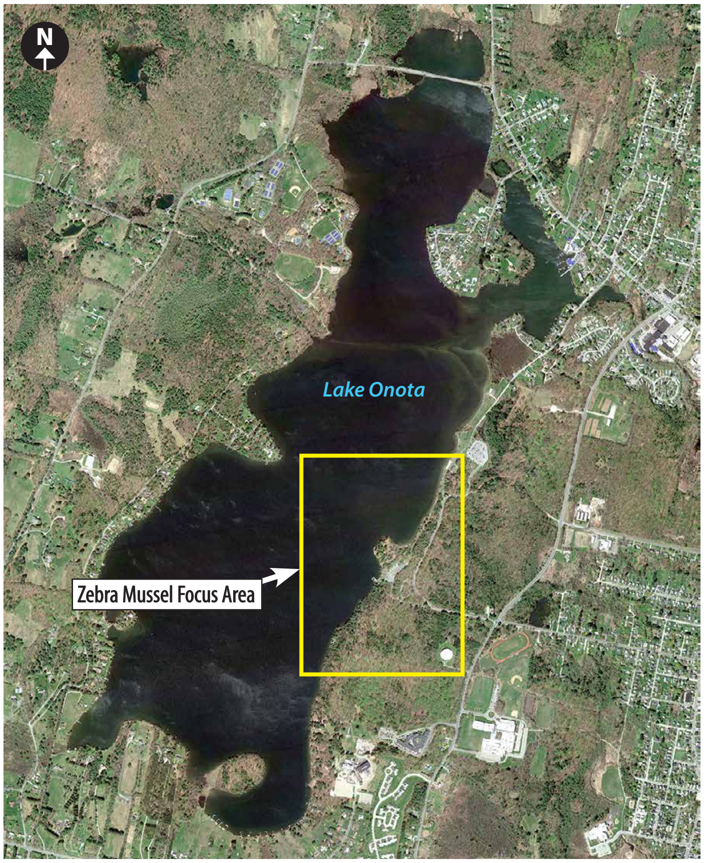

Figure 1. Lake Onota in Pittsfield, MA, showing focus area for zebra mussel searches.

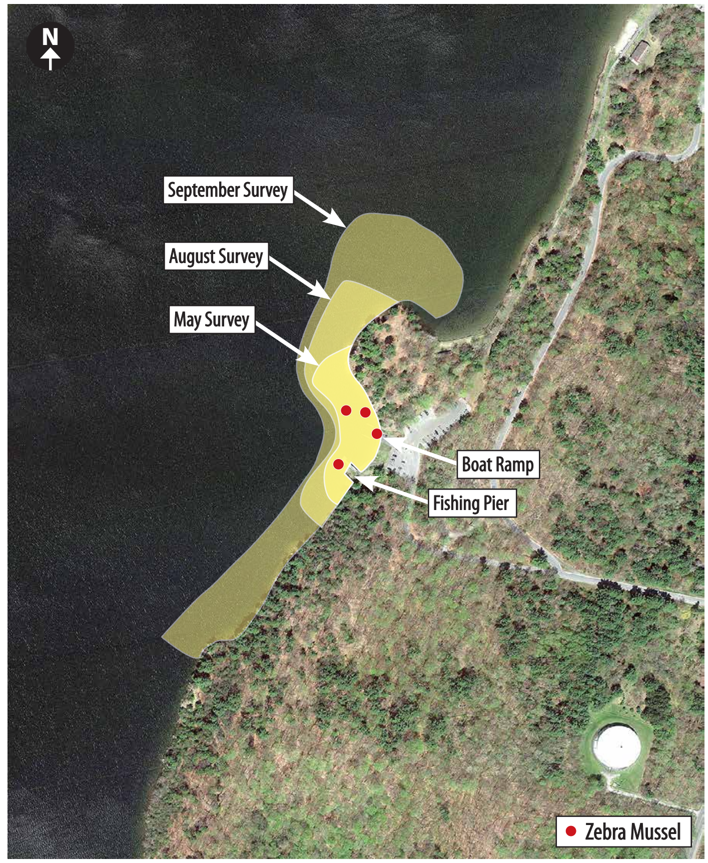

Figure 2. Zebra mussel search areas in May, August, and September (2024) and locations where zebra mussels were detected.

Additional zebra mussel surveys were conducted in 2024 for LOPA and the City of Pittsfield. This report summarizes results of the 2024 surveys completed by Biodrawversity. These included three separate surveys: (1) May 28, 2024, at the request of LOPA; (2) August 21, 2024, for the City of Pittsfield after there was another positive eDNA sample collected in July; and (3) September 10, 2024, for the City of Pittsfield. In addition to Biodrawversity's three surveys, the Massachusetts Department of Conservation and Recreation (DCR) conducted surveys on August 15 and August 21 (the latter conducted jointly with Biodrawversity).

SEARCH AREAS AND METHODS

All the 2024 surveys were centered on the state boat ramp and fishing pier near where eDNA sampling had detected zebra mussels (Figures 1 and 2). The May 2024 survey stayed relatively close to the boat ramp and fishing pier, and the two subsequent surveys ventured farther north and south from the original survey areas (Figure 2), in addition to resurveying areas from the previous surveys. Searches were conducted primarily by snorkeling along the shoreline in water depths of 1.0 to 3.0 ft, and SCUBA diving in offshore areas in water depths of 3.0 to 30.0 ft.

Very small zebra mussel shell detected at the boat ramp in May 2024.

Table 1. Summary of survey results and search efforts for the 2024 zebra mussel surveys in Lake Onota.

Date	Zebra Mussels	Notes on Findings	Shell Lengths (mm)	Search Notes
5/28/24	5 shells	4 shells found on the boat ramp in 2-4 ft of water. 1 shell (the larger one) was found north of the boat ramp in 2 ft of water.	6.0, 7.0. 10.0, 11.0, 29.0	3.0 person-hrs of search time. Max depth 17 ft. Stayed close to ramp and fishing pier. Larger shell found where there had been a positive eDNA hit.
8/21/24	1 shell	1 half shell found at 17 ft depth north and west of the boat ramp. [DCR found one on the fishing pier piling on August 15]	10.0 The live one found by DCR was ~32.0 mm	6.0 person-hrs of search time, not including DCR time. Max depth 29 ft. Expanded the previous survey northward and southward from the ramp and pier area.
9/10/24	0	None detected	-	10.0 person-hrs of search time. Max depth 30 ft. Significantly expanded previous search area southward and northward: ~260m south of the fishing pier to ~240m north of the boat ramp, around the peninsula.

Biologists typically focused on areas of suitable habitat, especially hard artificial (concrete, metal pilings, trash) and natural (cobble, boulder, and bedrock) substrates. These substrate types were very common throughout surveyed areas. Zebra mussels were measured and photographed.

SURVEY RESULTS

Taken together, the surveys by Biodrawversity and DCR from December 2023 to September 2024 detected six shells and one live zebra mussel (Table 1). The six shells ranged in length from 6.0 to 29.0 mm but five were small juveniles between 6.0 and 11.0 mm. The single live zebra mussel was found by DCR on the metal piling of the fishing pier; this was a large adult (~32 mm). All the zebra mussels detected were very close to the boat ramp and fishing pier. None were detected in areas farther to the north or south, despite a very large amount of suitable habitat in both directions.

CONCLUSION

Zebra mussels have now been detected in Lake Onota in 2023 and 2024, first only with eDNA sampling (September 2023) and then with both physical surveys and eDNA sampling in 2024. However, only a small fraction of the eDNA samples collected in Lake Onota have been positive, and the snorkel and SCUBA surveys conducted near those areas

Zebra mussel shells found in May 2024.

Live zebra mussel found by DCR in August 2024.

suggest that zebra mussels may be present but at extremely low densities that are difficult to detect with fairly short-duration qualitative surveys. Detecting and characterizing this newly established population could utilize a combination of eDNA sampling, working with residents on a monitoring/reporting system (e.g., checking docks/floats, mooring lines, boats, and nearshore shallow areas), annual systematic searches of deeper areas by SCUBA diving, and annual searches of shallow areas just after the autumn drawdown.

Lake Onota has suitable water chemistry and physical habitat for zebra mussels (Biodrawversity 2009). If zebra mussels are to become more firmly established in Lake Onota, they will be more prevalent in areas with preferred substrate (natural surfaces such as cobble, boulder, bedrock, and artificial surfaces such as docks, piers, mooring blocks, etc.). Deepest areas of the lake will not sustain large numbers of zebra mussels due to low dissolved oxygen and poor substrate quality. Conversely, shallow habitats (less than about 3 ft deep), even with suitable substrate, will not sustain large numbers of zebra mussels due to susceptibility to freezing of the substrate in the winter months (especially with winter drawdowns).

LITERATURE CITED

Biodrawversity. 2009. Zebra Mussel Phase 1 Assessment: Physical, Chemical, and Biological Evaluation of 20 Lakes and the Housatonic River in Berkshire County, Massachusetts. Report prepared for the Massachusetts Department of Conservation and Recreation, Boston, MA.