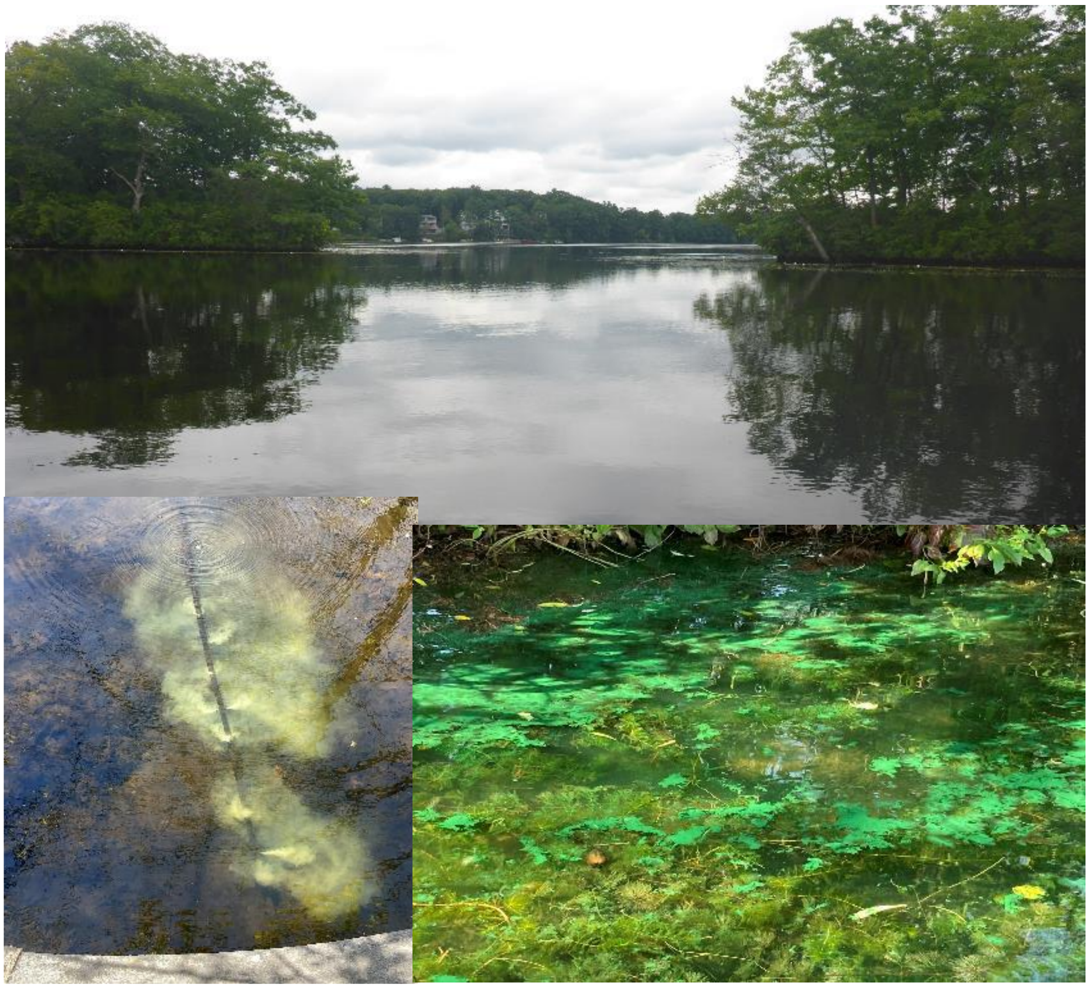
MORSES POND ANNUAL REPORT: 2022



PREPARED FOR THE TOWN OF WELLESLEY

BY WATER RESOURCE SERVICES, INC.

FEBRUARY 2023

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This report documents the implementation of the 2005 Comprehensive Morses Pond Management Plan through 2022 with a focus on the most recent year of activity. Program elements have included: 1) phosphorus inactivation, 2) plant harvesting, 3) low impact development demonstration, 4) education, and 5) dredging. Dredging was completed in 2013 and low impact development demonstration was done earlier than dredging, and these elements have been covered in past reports to the extent that further inclusion is unnecessary. The history of the other elements has also been covered in a cumulative fashion is past reports, most recently December of 2017, so this report has been streamlined to cover mainly the actions of 2022 within the context of the overall management plan and past progress and related data. Additionally, some of the approach applied to Morses Pond was extended to additional, smaller ponds within Wellesley as of 2018 and those efforts are included in this report for completeness.

Phosphorus Inactivation

Operational Background

Phosphorus entering through Bogle Brook and Boulder Brook was determined to be the primary driver of algae blooms in Morses Pond. Dry spring-summer periods fostered fewer blooms than wetter seasons in an analysis of over 20 years of data, although very wet conditions can flush the pond fast enough to also limit blooms. Work in the watershed to limit phosphorus inputs is a slow process and has limits related to urbanization that are very difficult to overcome. Reduction in the phosphorus content of lawn fertilizer is believed to be reducing inputs to the pond, but with so much developed land in the watershed, loading is still excessive. Inactivation of incoming phosphorus is possible, however, and has been used extensively and successfully in Florida to limit the impact of development on lakes there. The comprehensive plan called for a similar effort at Morses Pond.

A phosphorus inactivation system was established at Morses Pond in the spring of 2008. After testing and initial adjustment in 2008, the system has been operated in the late spring and part of summer in 2009 through 2022. The system has been modified over time, with simplification and a different aluminum chemical applied since 2014. The system has been automated since 2016, with control from a smart phone as needed. When a set amount of precipitation has occurred (normally 0.1 inch), the pumps turn on and polyaluminum chloride is fed into the Bogle Brook and Boulder Brook tributaries slightly upstream of the pond at rates of 40 to 80 gallons per hour. The tank serving Bogle Brook holds 2000 gallons, while the tank serving Boulder Brook holds 1000 gallons; Bogle Brook provides roughly twice the flow provided by Boulder Brook and is therefore treated at twice the rate. The system runs for 4 hours in response to a triggering precipitation event, although the duration is adjustable. The system is activated from the week before Memorial Day until about the week after 4th of July, although this is also adjustable as warranted and leftover aluminum is applied during summer when avaialble. By treating incoming stormwater during the late spring period, Morses Pond can achieve a low enough phosphorus concentration to avoid algae blooms for the summer. If there is enough inflow to raise the phosphorus level, this also translates into increased flushing that tends to minimize algae blooms as well.

A total of 5188 gallons of polyaluminum chloride were applied to Morses Pond in 2022, representing 3061 lbs of aluminum, just slightly less than the average since system automation in 2016 (Table 1). However, slightly less than 3000 gallons were applied before the 4th of July, owing to low precipitation in May and June, the rest being applied in July, August, and even September. Precipitation during the May-June 2022 period was 3.7 inches, the lowest since program inception in 2008. Precipitation for May-August was 10.2 inches, third lowest since the inactivation program began. There were 7 treatment days in May and June, one more in early July, and the remaining 8 days scattered over July through September 13, 2022. The lower rainfall meant less phosphorus and other contaminants entering Morses Pond, but also provided less opportunity for treatment. Internal recycling of phosphorus within the pond, while not a major source in most years, was a factor in algae growth during the very hot summer of 2022.

Analysis of Program Results

Water quality is assessed prior to the start of treatment, normally in May, again in early summer, usually in the last week of June, and yet again at least once and more often twice later in the summer in up to three areas: the north basin, the transition zone to the south basin just south of the islands, and near the town beach at the south end of the pond (Figure 1). The sampling near the beach includes the actual swimming area and a point to the NW in the deepest part of the pond. Visual and water quality checks are made on an as needed basis, as part of normal operations or in response to complaints, major storms, or town needs. The water quality record for 2022 (Table 2) incorporates field and laboratory tests at multiple sites. A summary of phosphorus data for key periods since 2008 is provided (Table 3) to put the treatments and results in perspective. It is intended that total phosphorus will decrease through the treatment, such that values in the south basin, assessed in the swimming area near the outlet of the pond, will be lower than in the north basin, with the transition zone exhibiting intermediate values. Based on data collected since the early 1980s, total phosphorus in the south basin in excess of 20 µg/L (0.02 mg/L) tends to lead to algal blooms, while values <20 µg/L minimize blooms and values near 10 µg/L (0.01 mg/L) lead to highly desirable conditions.

Total phosphorus concentrations in 2022 (Table 2) were fairly typical for the project period but much lower than in the very wet 2021. There was less precipitation but most of the phosphorus loading comes with the first flush of stormwater, which is treated at the Bogle and Boulder Brooks inlets, reducing the in-lake concentration. Having more aluminum added in more prolonged storms provides some additional inactivation within the pond, but there were few such storms during the treatment period in 2022. Treatment was extended through summer to use up the aluminum compound in the tanks, but conditions in the pond during summer are largely a function of the starting conditions around the 4th of July. At the end of June the concentration in the southern portion of the pond (deep hole surface and swimming area values) was 0.021 mg/L (Table 3), just over the upper target value, and that concentration declined with summer treatment to 0.015 mg/L, solidly within the target range.

Total Kjeldahl nitrogen values were moderate to high in 2022 (Table 2), ranging from 0.3 to 0.6 mg/L in surface samples from the pond and 0.6 to 2.5 mg/L in the deepest water. A portion of the pond stratifies and loses oxygen, allowing ammonium to build up through decomposition with minimal mixing in that zone. Ammonium is not measured directly but is the dominant form of nitrogen in the deep water with the elevated TKN values.

Table 1. Summary of Phosphorus Inactivation Effort, 2008-2022.

Year	Applied Alum (gal)	Applied Aluminate (gal)	Aluminum Mass (lbs)	# of Treatment Days	May-June Precipitation (in)	May-August Precipitation (in)	Notes
2008	2000	1000	2240	5	6.2	16.7	Testing and adjustment phase, most treatment in July
2009	6002	2900	6595	16	5.9	16.1	Some elevated storm flow untreated
2010	4100	2080	4630	13	6.1	14.5	Additional chemical applied after early July
2011	5000	2475	5569	14	8.0	17.8	Some equipment failures. Additional chemical applied in August in response to bloom
2012	6000	3000	6720	19	6.9	14.4	Equipment problems hampered dosing during treatment
2013	6055	2785	6476	20	13.7	19.1	Very wet June (26.7 cm), unable to treat all storm flows; continued treatment through July
	Polyaluminum chloride						
2014	5985		3531	12	5.5	11.8	No treatment after 1st week of July, first year using polyaluminum chloride
2015	7900		4661	14	6.2	10.5	Leftover chemical used in summer, but little treatment after first week of July
2016	5800		3422	13	4.7	7.3	Only a little over half of the chemical was used by early July, remainder by August 15th
2017	6000		3540	17	8.3	13.9	Two deliveries of chemical were made and all was used by early July
2018	5400		3186	11	4.9	14.1	Two deliveries of chemical were made and all was used by the end of July
2019	5100		3009	14	8.5	17.8	Three deliveries (the 1st was a half load and portions of loads 2 and 3 were used on other ponds) of chemical were made and all was used by the mid-July
2020	4668		2754	9	4.9	9.1	Two deliveries made, parts of both used on other ponds. Limited treatment in June due to dry weather, extended treatment in to August
2021	5395		3183	12	7.5	24.6	Two deliveries made, parts of both used on other ponds. All Al used by early July , while it rained most of July, adding a lot of untreated water to Morses Pond
2022	5188		3061	16	3.7	10.2	Two deliveries made, but only 2500 gal added to Morses Pond before July. Additional treatments in July, Aug, and Sept.

Figure 1. Current system layout and water quality sampling sites in Morses Pond.

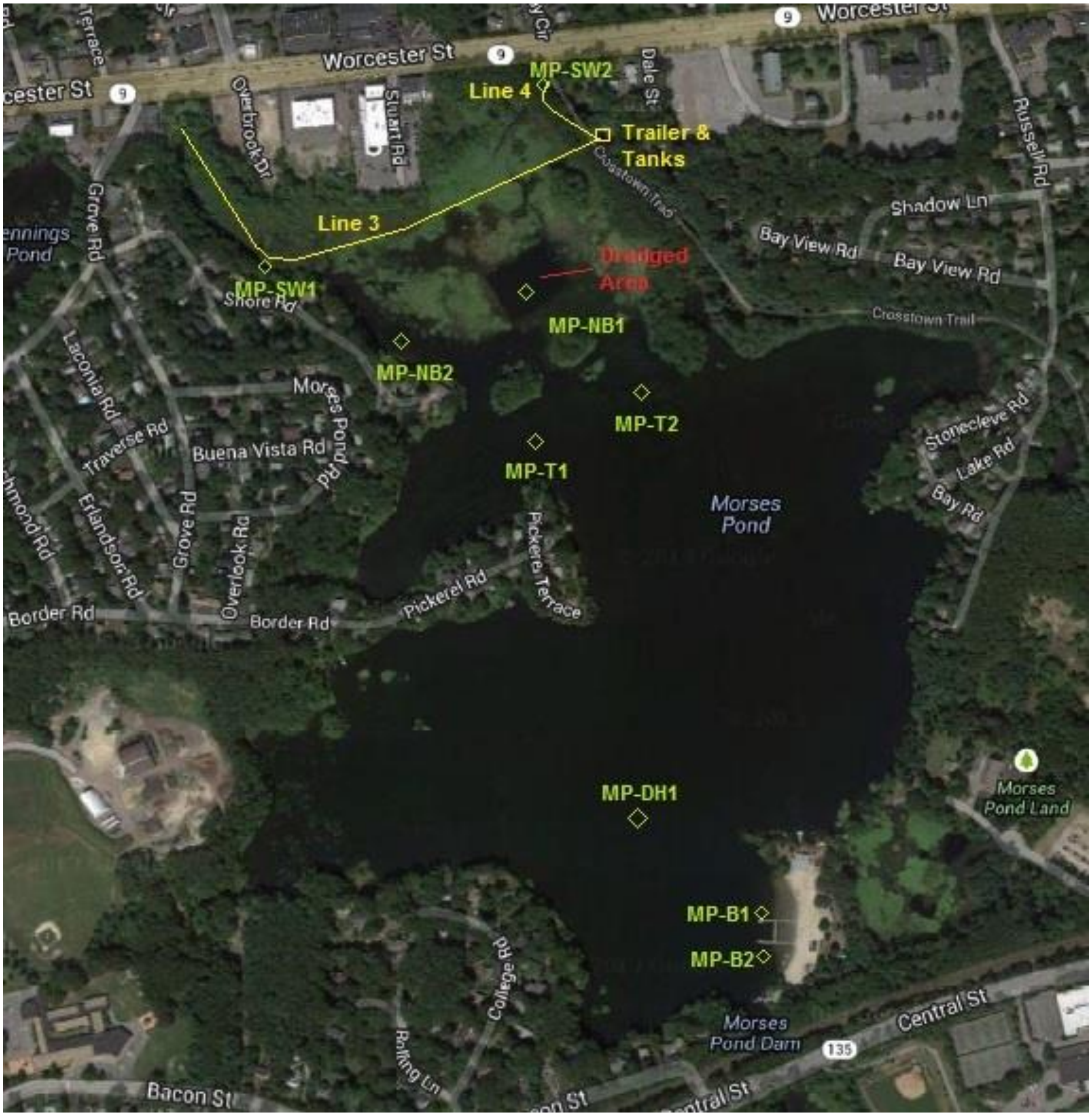


Table 2. Water quality record for Morses Pond in 2022.

	Date	Time	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	CHL	Secchi	Total P	TKN	Nitrate N	Total N
Station	MM.DD.YY	HH:MM:SS	meters	°C	mg/l	% Sat	µS/cm	Units	NTU	µg/l	meters	ug/L	ug/L	ug/L	ug/L
Bogle															
Boulder															
MP-NB1	05.10.22	9:53:54	0.3	14.1	12.3	121.1	430	7.4	3.2	0.0		0.021	0.410	0.387	0.797
	05.10.22	9:54:15	1.0	13.9	12.3	120.6	429	7.5	3.0	0.0					
	05.10.22	9:54:47	2.0	13.3	11.9	115.0	447	7.5	3.0	3.5					
	05.10.22	9:55:23	3.0	11.1	8.6	79.5	459	7.5	3.2	6.4					
	05.10.22	9:55:56	3.4	10.3	4.4	39.6	520	7.4	3.8	5.2					
	05.10.22	9:57:07	3.6	10.0	0.8	6.9	589	7.2	22.3	27.2					
MP-NB2	05.10.22											0.023	0.412	0.374	0.786
MP-T1	05.10.22											0.033	0.431	0.323	0.754
MP-T2	05.10.22											0.021	0.446	0.321	0.767
MP1	05.10.22	10:36:12	0.3	14.1	10.7	105.8	486	7.7	2.4	2.0	3.6	0.019	0.500	0.333	0.833
	05.10.22	10:36:55	1.0	14.0	10.7	105.7	486	7.7	2.7	0.0					
	05.10.22	10:37:25	2.0	14.0	10.7	105.3	487	7.7	2.8	3.8					
	05.10.22	10:37:49	4.0	13.9	10.7	105.3	486	7.7	2.7	4.4					
	05.10.22	10:37:56	4.0	13.9	10.7	105.3	487	7.7	2.7	4.5					
	05.10.22	10:38:11	5.0	13.9	10.8	105.9	487	7.7	2.7	4.7					
	05.10.22	10:39:12	6.0	13.8	10.2	99.7	486	7.7	2.9	4.2		0.045	0.604	0.315	0.919
MP-B	05.10.22											0.016	0.378	0.312	0.690
MP-Bogle	05.31.22											0.043	0.510	0.498	1.008
MP-Boulder	05.31.22											0.066	0.319	1.680	1.999
MP-NB1	06.24.22											0.028	0.408	0.074	0.482
MP-NB2	06.24.22											0.028	0.454	0.025	0.479
MP-T1	06.24.22											0.030	0.455	0.094	0.549
MP-T2	06.24.22											0.032	0.481	0.072	0.553
MP1	06.24.22	11:23:25	0.1	23.3	8.7	103.4	534	7.2	5.5	2.1	3.4	0.019	0.450	0.102	0.552
	06.24.22	11:23:50	1.0	22.5	8.7	101.6	533	7.2	8.9	3.5					
	06.24.22	11:24:24	2.0	22.0	8.3	96.5	532	7.3	6.4	3.7					
	06.24.22	11:24:53	3.0	21.4	7.2	82.6	530	7.3	5.5	5.1					
	06.24.22	11:25:32	4.0	19.7	4.9	54.7	519	7.2	5.1	11.8					
	06.24.22	11:26:09	5.0	15.7	1.2	12.0	496	7.2	6.2	72.3					
	06.24.22	11:26:53	6.0	13.6	0.1	0.5	515	6.9	7.5	3.8		0.034	0.705	0.077	0.782
MP-B	06.24.22											0.022	0.568	0.138	0.706
MP-Bogle															
MP-Boulder															
MP-NB1	08.01.22														
MP-NB2	08.01.22														
MP-T1	08.01.22														
MP-T2	08.01.22														
MP1	08.01.22	10:17:35	0.1	27.4	7.7	99.3	583	7.0		2.9	3.4				
	08.01.22	10:18:06	1.0	27.4	7.8	99.8	582	7.1		3.0					
	08.01.22	10:18:31	2.0	27.3	7.7	98.6	583	7.2		3.3					
	08.01.22	10:18:56	3.0	26.8	6.1	76.9	580	7.2		3.9					
	08.01.22	10:19:36	4.0	23.3	0.8	9.0	542	7.1		11.3					
	08.01.22	10:20:09	5.1	16.5	0.0	0.0	537	7.0		6.2					
	08.01.22	10:20:47	6.0	14.2	0.3	3.0	574	6.8		3.6					
MP-B	08.01.22														
MP-NB1	09.14.22		Equipment malfunction, no field WQ data									0.019	0.461	0.077	0.538
MP-NB2	09.14.22											0.019	0.418	0.110	0.528
MP-T1	09.14.22		Equipment malfunction, no field WQ data									0.016	0.386	0.054	0.440
MP-T2	09.14.22		Equipment malfunction, no field WQ data									0.018	0.307	0.050	0.357
MP-1s	09.14.22		Equipment malfunction, no field WQ data								2.9	0.016	0.434	0.050	0.484
MP-1b	09.14.22		Equipment malfunction, no field WQ data									0.048	2.460	0.050	2.510
MP-B	09.14.22		Equipment malfunction, no field WQ data									0.013	0.463	0.058	0.521

Table 3. Water quality testing results relative to the phosphorus inactivation system

Year	Location	Pre-Application TP (ug/L)	Early Summer TP (ug/L)	Late Summer TP (ug/L)	Observations
2008	North Basin	0.028	0.018	0.013	Mats observed, some cloudiness
	Transition Zone	0.031	0.022	0.014	Some cloudiness, brownish color
	Swimming Area	0.021	0.012	0.012	No blooms reported, first year without copper treatment in some time
2009	North Basin	0.035	0.040	0.063	Cloudy, some green algae mats
	Transition Zone	0.035	0.039	0.045	Cloudy
	Swimming Area	0.015	0.010	0.027	Generally clear, no blooms reported
2010	North Basin	0.026	0.046	0.053	Cloudy, green algae mats evident
	Transition Zone	0.028	0.021	0.032	Brownish color, minimally cloudy
	Swimming Area	0.019	0.015	0.043	Generally clear, no blooms until late August (Dolichospermum)
2011	North Basin	0.053	0.033	0.130	Cloudy, green algae mats evident
	Transition Zone	0.048	0.029	0.095	Slightly brownish
	Swimming Area	0.030	0.029	0.060	August bloom (Dolichospermum), dissipated after just a few days without treatment
2012	North Basin	0.032	0.024	0.048	Very dense plant growth, associated green algae mats
	Transition Zone	0.028	0.037	0.028	Brownish most of summer
	Swimming Area	0.020	0.027	0.024	Had bloom in mid-July (Dolichospermum), treated with copper
2013	North Basin	0.036	0.047	0.030	Water brownish, little visible algae; 1st year with newly dredged area within north basin
	Transition Zone	No Data	0.078	0.032	Generally elevated turbidity, but much of it is not living algae
	Swimming Area	0.024	0.033	0.028	Treatment lowered TP but not to target level; June flushing minimized algae biomass
2014	North Basin	0.030	0.022	0.020	Dense plant growths and green algae mats outside dredged area, water fairly clear
	Transition Zone	0.021	0.020	0.018	Dense plant growths, but water fairly clear
	Swimming Area	0.012	0.013	0.017	Water clear; Secchi to bottom in swimming area, no blooms reported
2015	North Basin	0.012	0.017	0.023	Dense plant growths and green algae mats outside dredged area, water fairly clear
	Transition Zone	0.008	0.015	0.014	Dense plant growths, but water fairly clear
	Swimming Area	0.005	0.005	0.014	Water clear; Secchi to bottom in swimming area, no blooms reported
2016	North Basin	0.012	0.009	0.005	Very dense plant growths after mild winter, but water still clear
	Transition Zone	0.019	0.016	0.005	Dense plant growths but water clear
	Swimming Area	0.014	0.005	0.005	Water clear; Secchi to bottom in swimming area, no blooms reported
2017	North Basin	0.031	0.031	0.013	Dense rooted plants, some algae mats
	Transition Zone	0.027	0.034	0.014	Dense rooted plants, few algae mats
	Swimming Area	0.017	0.018	0.015	Some cloudiness, but no visible algae blooms
2018	North Basin	0.030	0.018	0.016	Dense rooted plants, some algae mats
	Transition Zone	0.031	0.015	0.016	Some cyanobacteria in June, less in August
	Swimming Area	0.017	0.012	0.011	Some cyanobacteria in June, less in August, but water green at 20 ft of depth in early Sept
2019	North Basin	0.025	0.030	0.028	Water turbid with suspended sediment on most visits
	Transition Zone	0.020	0.034	0.022	Water turbid but on obvious cyanobacteria or algae mats
	Swimming Area	0.019	0.015	0.018	No cyanobacteria and few green algae mats observed in May-Aug, some cyanobacteria in
2020	North Basin	0.025	0.018	0.012	Plants very dense but few algal mats
	Transition Zone	0.042	0.030	0.012	Plants dense on most visits, water murky but few visible particles
	Swimming Area	0.038	0.011	0.015	Some cyanobacteria particles early in summer but clarity acceptable at all times
2021	North Basin	0.025	0.030	0.051	Much rain, samples from Bogle and Boulder with TP >0.6 mg/L 1st flush, >0.06 post-storm
	Transition Zone	0.023	0.039	0.051	Plants dominated by fanwort, harvesting effort high but could not keep up with growth
	Swimming Area	0.021	0.025	0.035	Water murky much of summer, but from rain, particulates, and natural color, not high algae
2022	North Basin	0.022	0.028	0.019	Very dry spring and summer, limited Al treatment before July
	Transition Zone	0.027	0.031	0.017	Plants dominated by fanwort, harvesting effort high but could not keep up with growth
	Swimming Area	0.018	0.021	0.015	Algal bloom of Planktothrix in late August into September

Nitrate was much lower but not negligible (Table 2), declining from a high near 0.4 mg/L to close to the detection limit at 0.05 mg/L by late summer. The loss of nitrate favors cyanobacteria, which utilize this nitrogen source less than other algae.

One first flush sample from each of Bogle and Boulder Brooks was collected in 2022 and the only very high value was for nitrate in Boulder Brook (Table 2). This is often indicative of a major input from either wastewater or fertilizer and bears further investigation.

There are usually summer oxygen deficiencies in the deep hole area (MP-1) with depressed or depleted oxygen by early September in many years. In 2019 oxygen was low at 4 m by late June and at 3 m by mid-

July. Conditions were somewhat better in 2020, but oxygen was minimal below 4 m of water depth by late July. In 2021 low oxygen was detected at 4 m in late June and 2 m in late July and August. In 2022 there was minimal oxygen deeper than 4 m by the start of August, but the field meter malfunctioned and data for mid-September are lacking, so we do not know how much worse the oxygen depletion may have become. Warmer summers increase water temperature which in turn increases bacterial metabolism and oxygen demand, leading to lower oxygen concentrations. This is a climate change effect but there is a lot of variation among years. In 2021 the added effect of excessive organic inputs from the watershed, especially upstream wetlands, appears responsible elevated levels of decomposition and the lower than usual oxygen at relatively shallow depths. Conditions in 2022 were more similar to those of 2020 but are still not desirable with regard to oxygen in deeper water.

The affected area in recent years aside from 2021 is <20% of the pond area and <10% of the pond volume, and no fishkills or even stress have been observed in the pond, but this low oxygen condition is a negative influence on pond ecology. Aside from not supporting aquatic life based on the state standard for oxygen (5 mg/L), low oxygen allows phosphorus to be released from the affected sediment and can foster development of cyanobacteria at the sediment-water interface that later rise to form a bloom. This occurred in each of the last few years, with the 2022 event worse than any in recent years. It was still localized and not a threat to most lake uses, but the trend warrants some consideration.

Conductivity is high in surface waters of Morses Pond and very high in deeper water, indicating large amounts of dissolved solids in the water, although conductivity does not reveal the nature of those solids. Salts from road management are a likely source, but natural inputs from upstream wetlands are also likely substantial. The pH is slightly elevated near the surface and declines with depth, with decomposition adding acids and lowering pH at deeper locations. The pH also tends to increase as water moves through the pond, with photosynthesis by algae and rooted plants removing carbon dioxide and raising pH. Values for pH in 2022 were between 6.9 and 7.7, an acceptable range that indicated no problems. Turbidity is moderate in most of the water column, decreasing with distance from inlets but increasing right at the bottom in the deep hole location; accumulation of very light solids is suggested at the deep hole station and explains most other water quality variation in most years.

Summer water clarity in 2022 was similar to that of past years since the inactivation system was enhanced (Figures 2 and 3), other than 2021, which had the lowest clarity by virtue of high stormwater inputs. Those inputs supported more algal growth but were also a source of non-algal solids and color, both of which reduce clarity. The dry weather in 2022 reduced stormwater inputs and treatment with aluminum further enhanced clarity, but the clarity was not higher than average, given fewer opportunities to treat incoming water and some issues with internal recycling with phosphorus. Clarity in 2021 stands in contrast to all other years of phosphorus inactivation and clarity in 2022 represented a return to the recent norm, which has supported contact recreation and other desirable uses of Morses Pond.

Experimentation with the timing and amount of aluminum has suggested a lower limit of about 3500 lbs per May-June application period or about 400 lbs per inch of precipitation. Only 1756 lbs of aluminum were applied by early July of 2022, but that represented 475 lbs per inch of precipitation, given the very dry conditions. Less benefit was achieved out in the pond, but incoming stormwater was well treated.

Figure 2. Average summer water clarity and total phosphorus in Morses Pond, 1994-2022.

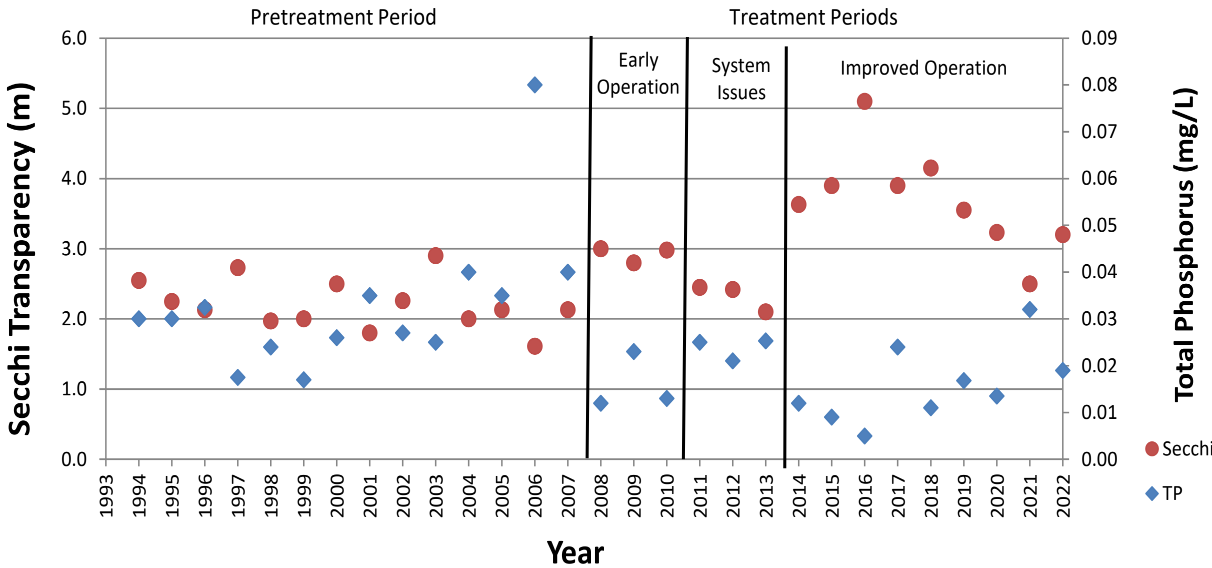
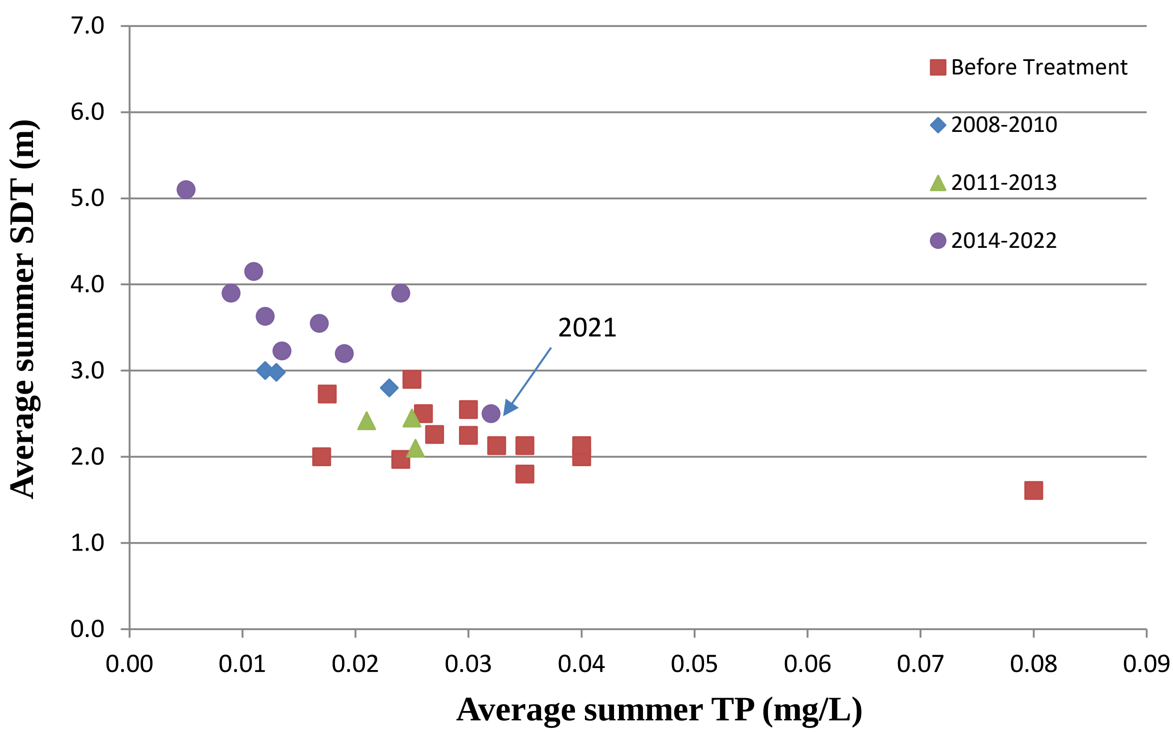


Figure 3. Relationship between summer water clarity and total phosphorus in Morses Pond.



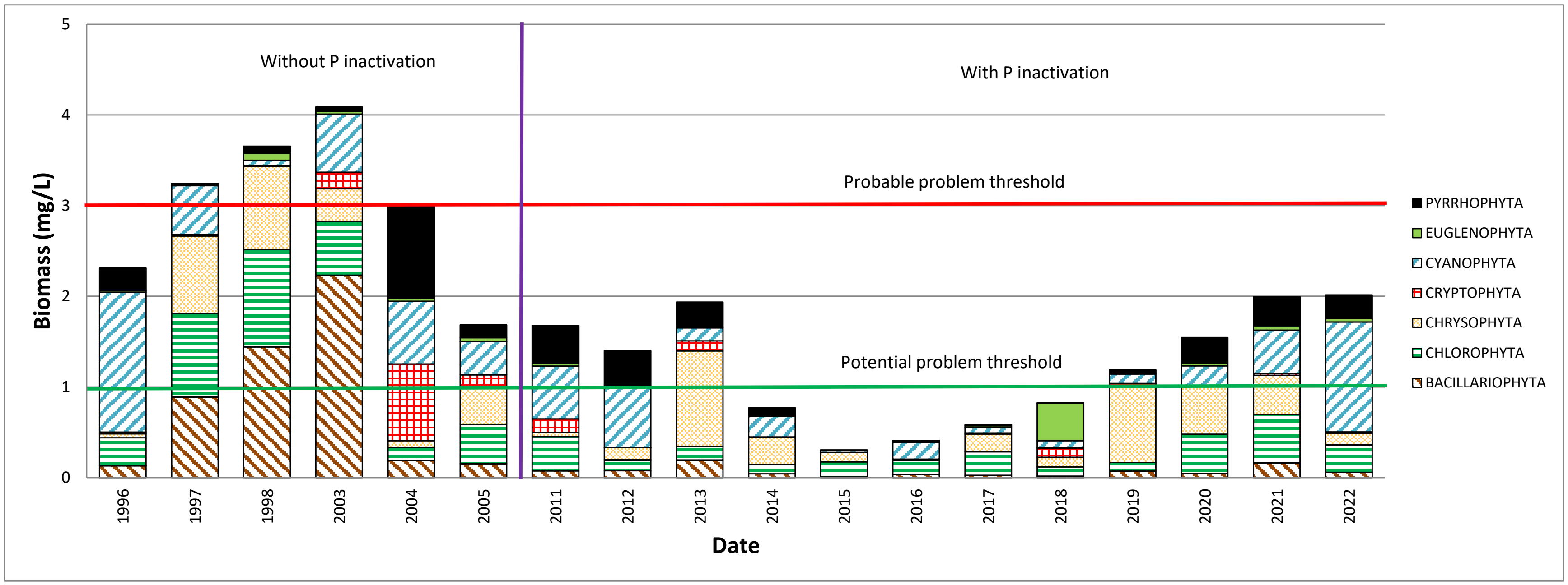
The phosphorus inactivation history for Morses Pond has been divided into 3 periods: 2008-2010, 2011-2013, and 2014-2022, both in terms of system function and average summer water clarity data (Figures 2 and 3). The system worked fairly well for 3 years, had equipment and operational problems for the next 3 years, then was modified and improved, leading to 6 years of low summer phosphorus and superior clarity. Conditions in 2020 and 2022 were not quite as desirable as in recent years, mostly owing to a dry spring that offered limited opportunity to treat incoming stormwater. Conditions in 2021 were even less desirable, given excessive inflows after the treatment period was over. Clarity and algae remained acceptable for contact recreation in all years, but the phosphorus inactivation system has yielded variation in results and has practical limits on its effectiveness.

Algal data for 1996-2022 (Figure 4) indicate that algae biomass and composition can be very variable, depending on combinations of nutrient levels, light, temperature, and flushing. Morses Pond phytoplankton biomass was frequently elevated prior to spring phosphorus inactivation, but since then biomass values have not exceeded the general threshold of 3 mg/L that signals low clarity (note that there is no official threshold for algae, but the red line in Figure 4 is a useful guide). Phytoplankton biomass as an annual spring/summer average was below the 1 mg/L threshold indicative of low biomass after the system adjustments of 2014 until 2019 and cyanobacteria have represented only a small amount of biomass each year until 2022. In 2019 the 1 mg/L threshold was just slightly exceeded, but the average algal biomass increased further in 2020 and 2021. There have been small peaks in biomass at times, but no blooms that would prompt beach closure or other recreational impairment since improved operation of the phosphorus inactivation system in 2014.

In 2018-2021 some cyanobacteria of the problem genus *Aphanizomenon* were present, and have increased each year, but no surface blooms developed, and no beach closure has been needed. The progression of increasing algae since the minimum in 2015 is evident, however, and suggests that the decreasing level of treatment through 2020 needed to be reversed. However, the extremely wet summer of 2021 negated that effort, uncovering the limitation on the P inactivation system. 2022 represented an unusually hot, dry year with less treatment with aluminum prior to summer, and this is reflected in the algae data (Figure 4). The average algal biomass was about the same as for 2021 but more cyanobacteria were present, including *Aphanizomenon*. While still better than the pre-treatment years and with cyanobacteria still well below the abundance threshold at which the MA DPH recommends posting waterbodies with warnings to avoid contact, the inactivation system was not able to deliver the level of control enjoyed in most other years.

Of greater concern in 2022 was an eastern shoreline accumulation of the cyanobacterium *Planktothrix*, which grows in deeper water with elevated phosphorus concentrations and rises to form surface scums. Those scums are often blown by the wind into dense shoreline accumulations, as was the case in Morses Pond in mid- to late August of 2022 (cover photo, bottom right). This alga can be toxic and shoreline accumulations have been implicated in dog deaths at other lakes. The shoreline in the affected area was posted with multiple signs for non-contact with warnings to those walking dogs. No toxicity was reported, and the accumulations dissipated within two weeks.

Figure 4. Summer average algae biomass divided into major algae groups for 1996-2022.



Planktothrix was never dominant in the water column and was detected in only one plankton sample, but the accumulations on the east shore north of the beach complex and south of the point dividing harvesting areas 4 and 7 were more abundant than ever before. No such accumulations occurred in 2021, a year of high flushing, but very small accumulations were observed in 2020. No toxicity testing was conducted; potential toxin producers do not have to produce toxins, but the assumption is made that they could when present. Treatment with an algaecide is an option prior to the threshold for abundance of potentially toxic algae (70,000 cells/mL) being exceeded, but by the time shoreline accumulations are observed the concentration is too high to allow treatment that would release any toxins from the cells into the water, as per MA DPH and MA DEP policy. Continued tracking of the algae community is warranted, but reactive management options are limited. Keeping the deep water oxygenated or treating the pond area deeper than about 12 feet directly with aluminum represent proactive steps that could be taken if such accumulations continue.

Zooplankton have also been sampled, and while not as tightly linked to nutrients as algae, provide important information on the link between algae and fish (Figures 5 and 6). Zooplankton biomass varies strongly between and within years. Values <25 µg/L are minimal, and values higher than 100 µg/L are preferred as rough thresholds, with high values desired for both algae grazing and fish food. Morses Pond values span that range and more. Values in later summer are expected to be lower than in late spring or early summer, as fish predation by young-of-the-year fish (those hatching that year) reduces populations of zooplankters. Spring levels will depend on water quality, predation by adult fish, and available algae, which are food for zooplankton. The dominant zooplankton groups are cladocerans and copepods, both groups of micro-crustaceans. *Daphnia*, among the larger cladocerans, filter the water to accumulate algae as food, and can increase water clarity markedly.

Daphnia were present in Morses Pond in all monitored years, a good sign, and abundance was elevated in many samples. The late summer zooplankton population was sometimes sparse but overall the zooplankton community has adequate biomass to support the food web and provide substantial grazing capacity for algae consumption, which helps maintain water clarity. Biomass averages >100 µg/L and the mean crustacean zooplankton length is mostly in the range (0.4 to 0.8 mm) that suggests good balance between gamefish and their prey species. There is no indication of any aluminum toxicity to zooplankton; the treatment protocols minimize this probability.

Zooplankton features in 2022 were very desirable, with adequate biomass and size distribution to be a valuable link in the food chain. The decline in biomass over the summer (Figure 5) was striking but consistent with a strong year-class (loss from feeding by hatching young fish) for planktivorous species like sunfish. Mean length of crustacean zooplankton remained within the desirable range (Figure 6). Zooplankton represent an important consumer of algae in Morses Pond and contribute to clarity even when phosphorus concentrations are higher than desired. However, most zooplankton cannot consume the larger filaments and colonies of bloom-forming cyanobacteria, and it is therefore important to exercise control over phosphorus concentrations to limit threats from that group of algae.

Figure 5. Zooplankton abundance for 1996-2022.

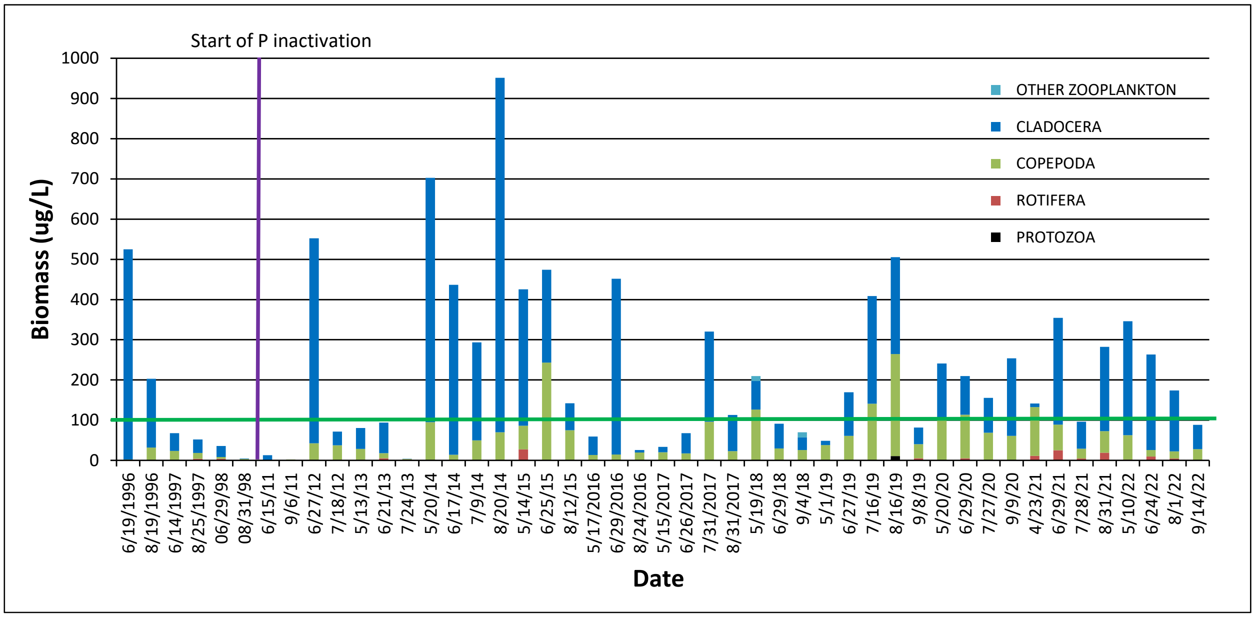
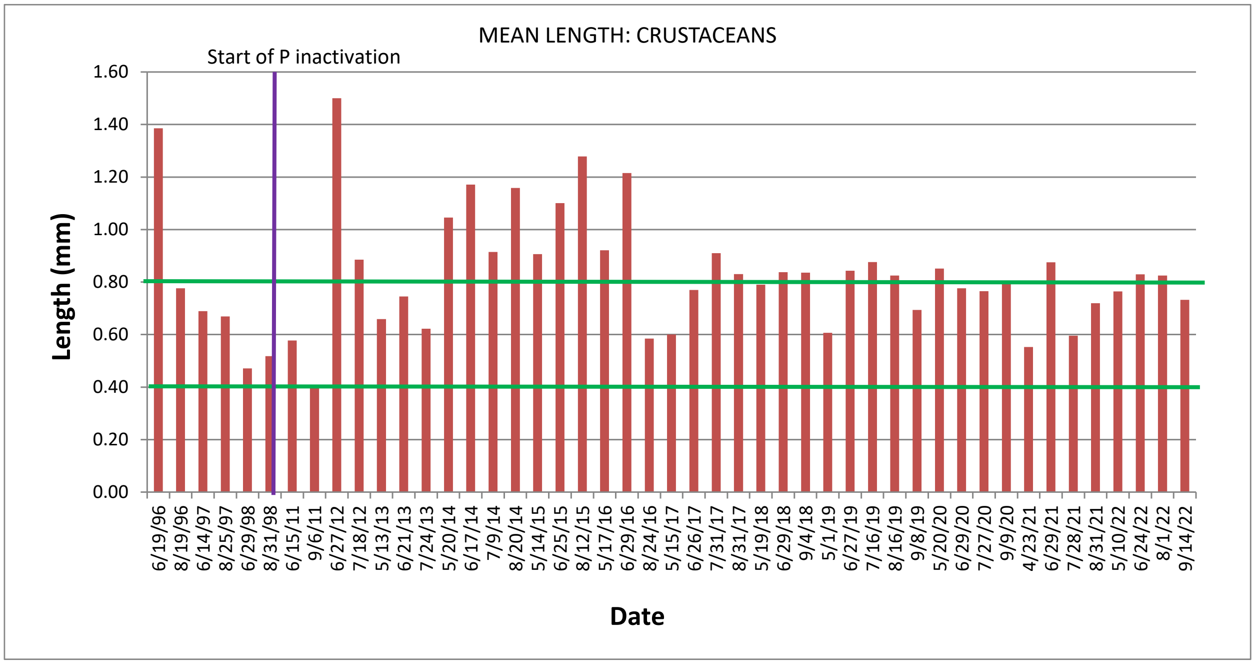


Figure 6. Crustacean zooplankton mean length, 1996-2022.



Mechanical Plant Harvesting

Harvesting Strategy

The Town of Wellesley initiated the enhanced Morses Pond vegetation harvesting program in 2007. The zoned vegetation harvesting strategy originates from the 2005 pilot program and comprehensive management plan written that year. For the pilot program, Morses Pond was divided into seven zones in order to better track the harvesting process. Figure 7 shows these zones and Morses Pond bathymetry. Harvesting protocols have been adjusted through experience to maximize effectiveness and minimize undesirable impacts, such as free fragments that accumulate along shore. The goal is to complete one harvest all targeted areas by the end of June, sometimes using two harvesters, with a cutting order and pattern that limits fragment accumulation, especially at the town swimming beach. This usually involves cutting in area 6 first, with any work around the edge of area 7 second, followed by work in areas 2, 3 and 4 in whatever order appears warranted by conditions. Area 5 is in Natick and is usually not cut, and area 1 is the north basin and is also not cut, except for a channel for residences along the western side. A second cutting occurred from August into October until 2015, when the second cutting was initiated in July and completed by September. In 2021 there was a partial third cutting, extending into October. More frequent plant surveys are now used to inform harvesting priorities, with occasional shifts in which zone is addressed in which order to best meet user needs.

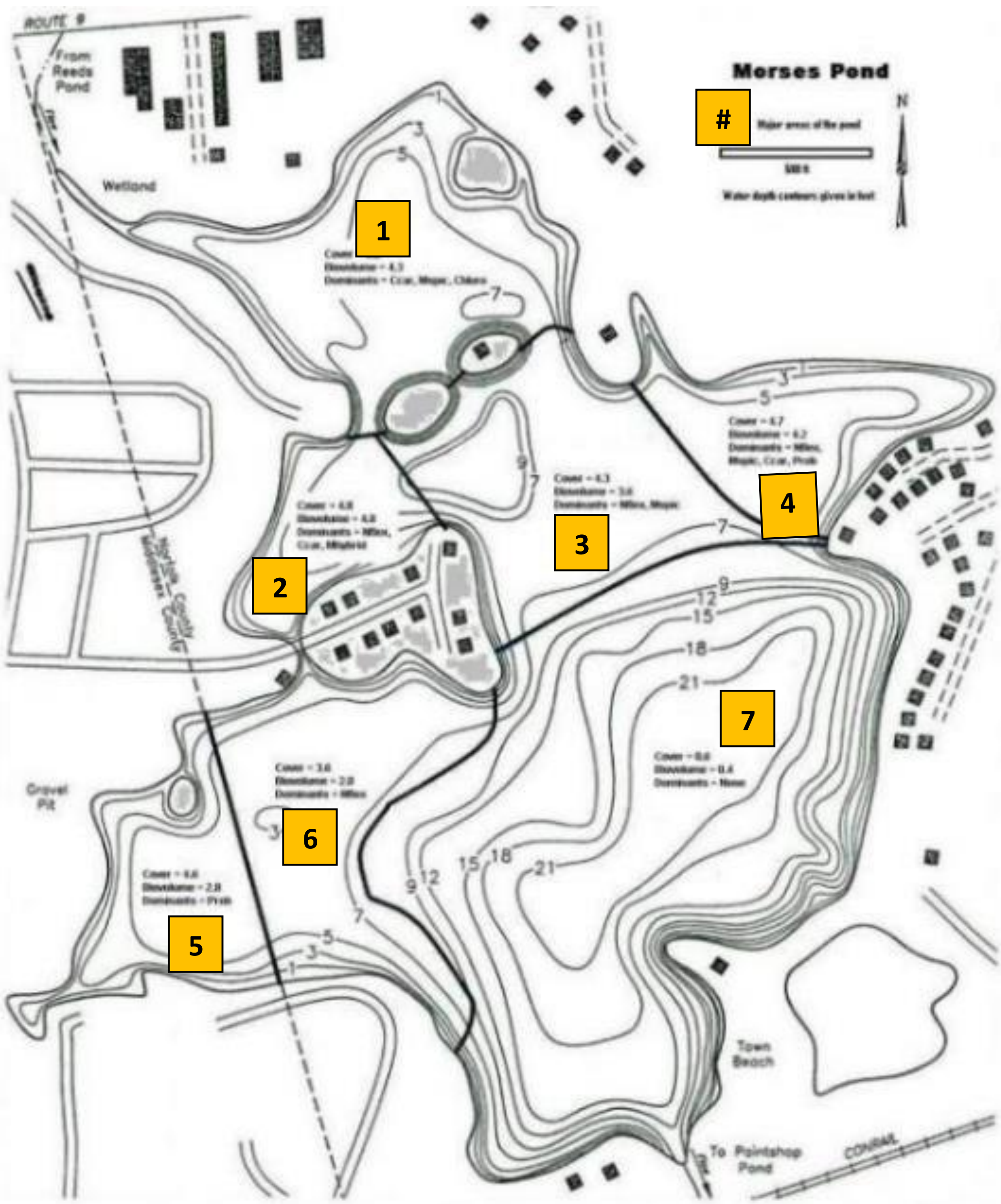
The keys to successful harvesting include:

- Initiating harvesting by the Memorial Day weekend, sooner if plant growths start early in any year.
- Cutting with or against the wind, but not perpendicular to the wind, to aid fragment collection.
- Limiting harvesting on very windy days (a safety concern as well as fragment control measure).
- Using a second, smaller harvester to pick up fragments if many are generated.
- Cutting far enough below the surface to prevent rapid regrowth to the surface, but not so far as to cut desirable low growing species such as Robbins' pondweed.
- Minimizing travel time on the water with a cutting pattern that does not end a run any farther from the offloading point near the outlet than necessary.
- Preventive maintenance in the off season to minimize down time during the harvest season.
- Using trained personnel who know what to cut, where to cut, and how to avoid damage that would necessitate maintenance of the harvester.

The town has owned harvesters for over 35 years, with the oldest one retired a few years ago and the second oldest, and largest, due to be retired in FY22. In 2019 a new, smaller harvester was put into service and was used instead of the larger, now older harvester on many days, as the larger, older harvester is prone to breakdown at its age. This may have reduced efficiency by virtue of the smaller size of the new harvester but is intended to minimize downtime. Operation of the larger harvester is what the plan was based on, and breakdowns that last for more than a couple of weeks during the harvesting season create conditions from which it can be hard to recover. Harvesting to maintain open water over much of the pond can be a challenging exercise even with properly functioning equipment, given issues with staffing, weather, and simultaneous needs in different parts of the pond. The area that affects the town beach complex has priority when resources are limited.

A decrease in efficiency when plant growth is dense can have a cascading effect that leads to unacceptable conditions over a larger area. The key is to cut before weeds get too dense but not before there is enough biomass to allow substantial collection during a harvesting run (the time between leaving the port area and returning to it). Aquatic plant harvesting is very much like mowing a lawn; if grass is allowed to get too high, cutting becomes difficult in one pass, clogging is an issue, and more frequent unloading of the grass catcher is needed. In the aquatic environment this problem can be magnified, as travel time to dump each load can be substantial. It is therefore important to stay ahead of plant growth when harvesting, maintaining maximum cutting rate and minimizing travel time. Equipment issues that reduce cutting time and allow plants to grow high and dense can prevent achievement of goals.

Figure 7. Plant Management Sectors for Morses Pond.



Harvesting Record

Records provided by the Town of Wellesley document the harvesting effort expended on Morses Pond (Table 4). Although the record is not always complete, records have been kept since 2007. Between late May and late October, from 2007 through 2022, harvesting was conducted on a range of 43 to 76 days. This represents a range of 303 to 537 total hours devoted to some aspect of the harvesting program, and 184 to 335 hours of actual harvesting time. In 2022 harvesting occurred on 44 days for a total of 368.5 hours with 274.5 hours actually spent cutting. Total loads of aquatic plants harvested have ranged from 54 to 184 per harvesting season, a wide range that reflects which harvester is being used and how full the hopper can be before offloading has to occur. Increased number of loads does not necessarily translate into more plants harvested. A total of 168 loads were offloaded in 2022, among the higher values recorded, but the actual weight of plants removed was near the low end of the range. The primary targets are invasive species and bigleaf pondweed but the only selectivity offered is based on depth of cutting; lower growing species are favored.

Total weight of plants harvested, as measured upon entry to the composting facility (so there is some draining of water, but values are still wet weight) has ranged from 156,000 to 808,000 lbs. The 2022 biomass total was the lowest recorded. A few load weights may not have been recorded, but the total mass removed was still likely the least in program history, owing mainly to smaller loads. Weight per load has declined in recent years because at full capacity it is hard to empty the older, larger harvester; the aging conveyor cannot push a full load out of the barge, mainly due to friction and reduced power. Additionally, the larger harvester is out of service for repairs several weeks per harvesting season and the smaller harvester holds less biomass per load. The results are illustrated in Figures 8-10. The larger, older harvester has become the primary limit to program success. A new harvester has been ordered and is expected in 2023, although possibly not by the start of the harvesting season.

An increasing number of non-cutting hours was observed from 2009 through 2014 (Figure 8) and appeared related to increases in time for maintenance and travel. From 2014 through 2017, records were kept for non-cutting hours in categories including transport time on the water, transport time on land, and maintenance. With a renewed emphasis on efficiency, the 2015 record indicates that non-cutting time was roughly cut in half. Non-cutting time increased very slightly in 2016 but was still far less than in 2014. Non-cutting time increased markedly in 2017, as the large harvester was working but not properly, resulting in low efficiency and an eventual breakdown. Note that this harvester experienced considerable downtime in 2016, but time not in use awaiting parts is not counted in the harvesting program. Non-cutting time was reduced steadily from 2017 through 2020 but rose slightly in 2021 to 41% of total hours devoted to the harvesting program. Non-cutting hours were reduced in 2022, down to a level comparable to 2015-2016, and total hours were also similar to 2015-2016 values. Yet the weight per load and total weight of plants removed from Morses Pond was much higher in 2015 and 2016 than in 2022. The current primary factor in non-cutting hours is transport time from the harvesting area to the offloading area with smaller loads. This inefficiency is a function of harvester limitation and mostly not correctable by operators using these harvesters.

Table 4. Harvesting record summary for Morses Pond.

Year	Days of Harvesting per Year	Total Hours per Year	Cutting Hours per Year	Total Hr/Day	Cutting Hr/Day	Total Loads	Total Weight	Weight/ Day	Weight/ Load	Weight/ Total Hr	Weight/ Cutting Hr
	(Days)	(Hr)	(Hr)	(Hr)	(Hr)	(Load)	(Pounds)	(Pounds)	(Pounds)	(Pounds)	(Pounds)
2007	49	359	255	7.3	5.2	109	NA	NA	NA	NA	NA
2008	43	NA	NA	NA	NA	NA	270320	6287	NA	NA	NA
2009	57	390	304	6.8	5.3	78	224060	3931	2891	575	738
2010	44	303	223	6.9	5.1	78	226960	5278	2900	749	1017
2011	54	414	291	7.7	5.4	102	292000	5407	2863	706	1003
2012	70	460	296	6.6	4.2	124.5	807760	11539	6488	1756	2729
2013	76	519.5	335	6.8	4.4	119.5	595277	7833	4981	1146	1777
2014	75	476.5	265.5	6.4	3.5	110	455220	6070	4138	955	1715
2015	57	363	268	6.4	4.7	90	607710	10662	6752	1674	2268
2016	48	350	252	7.3	5.3	85	521000	10854	6129	1489	2067
2017	43	454.5	183.5	10.6	4.3	54	348200	8098	6448	766	1898
2018	66	537	232	8.1	3.5	126.5	390185	5912	3084	727	1682
2019	62	472	277.5	7.6	4.5	126	344708	5560	2736	730	1242
2020	48	411	267	8.6	5.6	125.5	194525	4172	1550	473	729
2021	57	507.5	300.5	8.9	5.3	184	259084	4545	1408	511	862
2022	44	368.5	274.5	8.4	6.2	168	155534	3535	926	422	567

For 2012 and 2013, harvesting includes Area 1 before dredging, which had very dense plant growths and accounts for additional weight removed.

Figure 8. Cutting and non-cutting hours associated with the harvesting program.

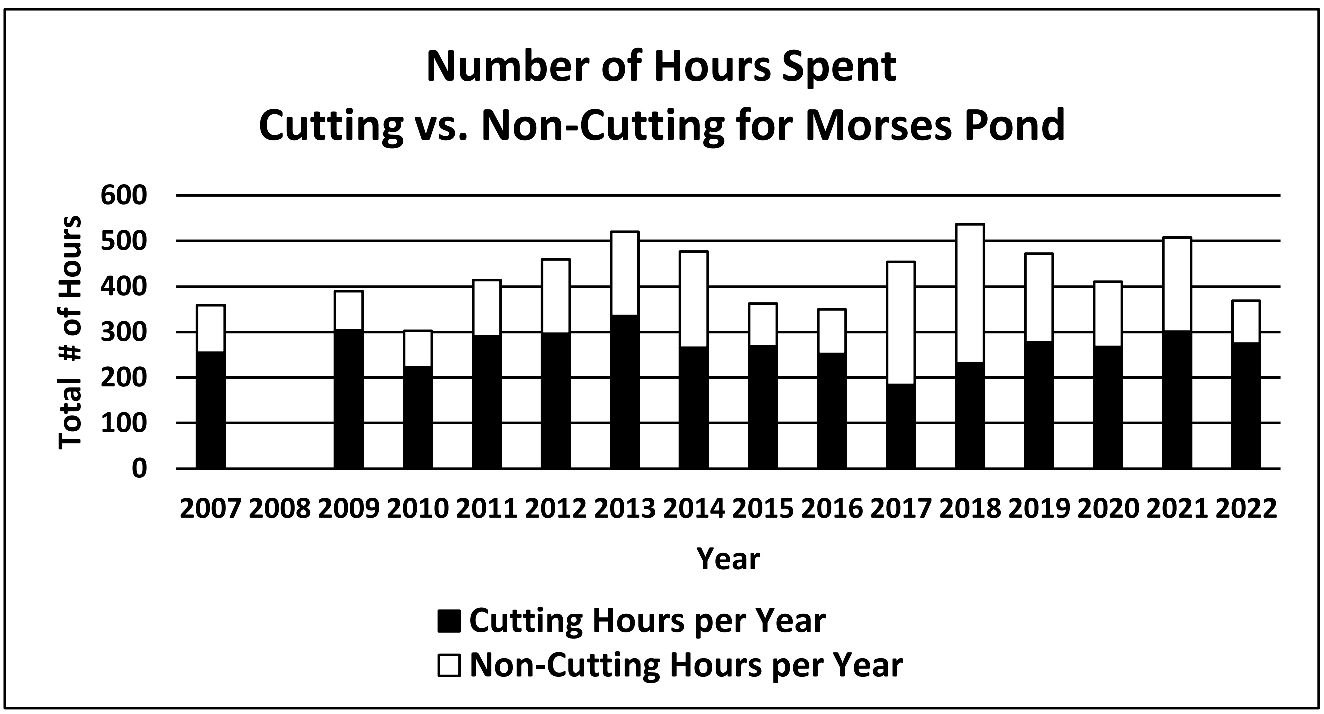


Figure 9. Total mass of plants removed by the harvesting program.

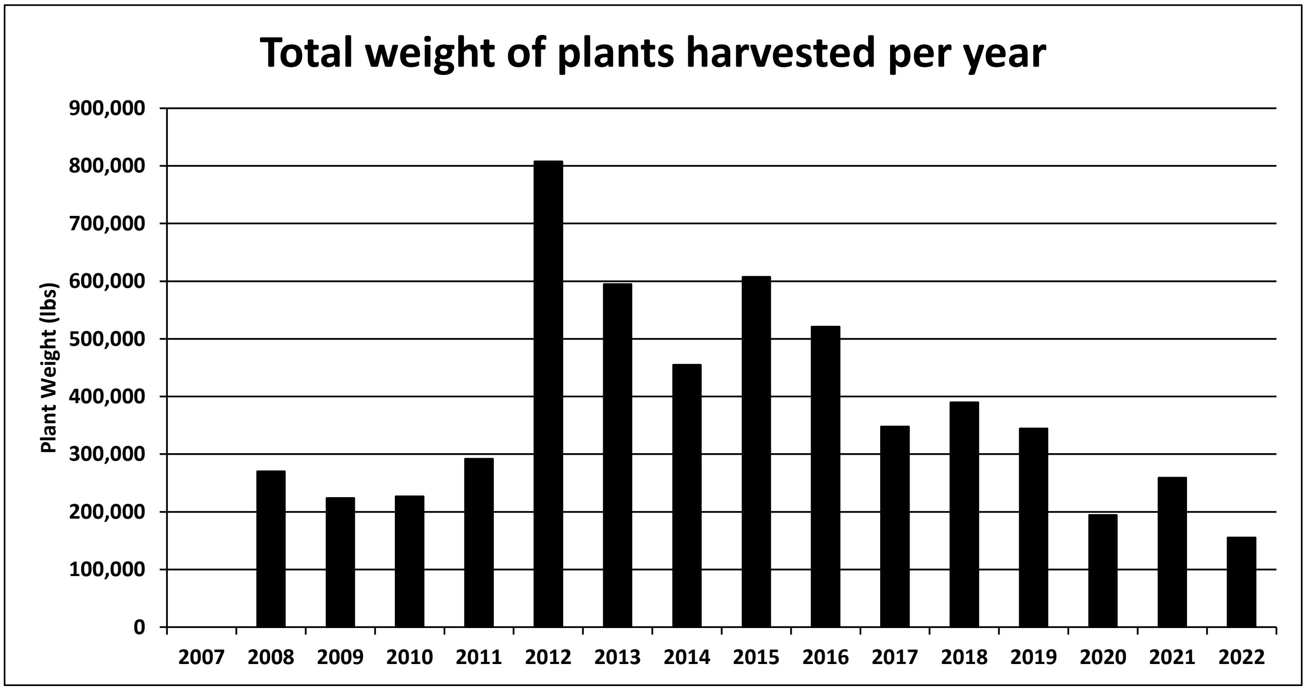
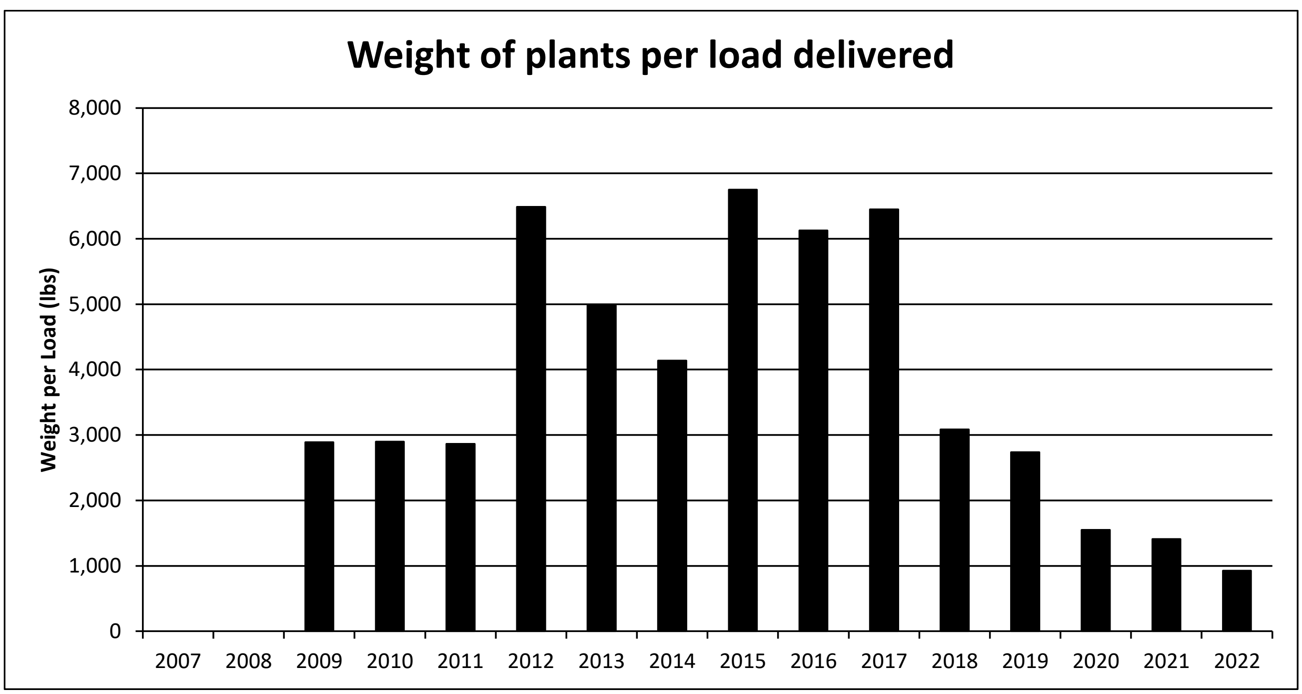


Figure 10. Mass of plants removed per load in the harvesting program.



Efficiency is therefore an issue. The need to maximize cutting time conflicts with lower manageable load limits and more frequent trips back to the offloading location next to the outlet at the south end of the pond. Past efforts to establish other offloading points have met with resistance by shorefront residents and a renewed inquiry along those lines in 2020 raised similar concerns of truck traffic, noise, and odor. The new large harvester expected in 2023 should solve much of the problem.

The other issue for harvesting is an apparent transition in plant dominance. In 2020 fanwort, an invasive species that is usually more of a problem in July or later, was already dense in some areas by late June and became very dense over even more of the pond than usual as summer progressed. The same situation occurred in 2021 and slows the harvesting process somewhat. Fanwort has been observed earlier and at greater dominance in other Massachusetts lakes as well in recent years, possibly a function of weather and climate changes. Despite the best efforts of the available staff, it is difficult to keep up with fanwort growths and some areas required more frequent harvesting that could be provided. Fanwort was again abundant in 2022, but not quite at 2020-2021 levels. Eurasian watermilfoil enjoyed an early season resurgence and curlyleaf pondweed, a typical spring dominant, remained abundant longer than usual into the summer. The plant community is dominated by invasive species that grow rapidly and achieve high densities, necessitating more effort with better equipment than is currently available.

Harvesting was conducted in sector 2 on 18 days, in sector 3 on 18 days, in sector 4 on 12 days, and in sector 6 on 11 days. Additionally, the western shoreline of sector 1 was cut om 3 days. Some days were split between sectors but on some days both harvesters were working in different sectors. Despite greater attention to sectors 2, 3 and 4 in 2022 than in some recent years, plant densities could not be maintained at the desired level. Staffing was limited later in summer when there were pressing needs elsewhere in town, but the equipment limitations appear to be the main factor in continued plant issues.

Plant Surveys

Plant surveys are conducted to support harvesting operations, assessing where the need is greatest and evaluating success. The timing of surveys has varied, sometimes before harvesting, sometimes after, and comparisons have been useful but not always consistent. A point-intercept methodology was applied to document the spatial distribution and percent cover and biovolume of aquatic plants at specific re-locatable sites. At each point the following information is recorded:

- The GPS waypoint.
- Water depth using a metal graduated rod or a mechanical depth finder.
- Plant cover and biovolume ratings using a standardized system.
- Relative abundance of plant species.

For each plant species, staff recorded whether the species was present at trace (one or two sprigs), sparse (a handful of the plant), moderate (a few handfuls of the plant), or dense (many handfuls of the plant) levels at each site. Plant cover represents the total surface area covered in plants (2 dimensions). For cover, areas with no plants were assigned a “0,” areas with approximately 1-25% cover were assigned a “1,” a “2” for 26-50%, a “3” for 51-75%, a “4” for 76-99%, and a “5” for 100% cover. Like plant cover, a quartile scale was used to express plant biovolume, defined as the estimated volume of living plant material filling the water column (3 dimensions). For biovolume, 0= no plants, 1= 1-25%, 2=26-50%, 3=51-75%, 4=76-100%, and 5= 100% of plants filling the water column.

After 2017 this approach was adjusted to be more responsive to management needs, focusing on a smaller number of points in each designated zone of the pond and surveying at least three times, allowing for evaluation of conditions before cutting, after the first cut, and after the second cut. The target condition, based on the assessment methodology above, is to have each targeted harvesting area exhibit an average biovolume of about 2 (25-50% of the water column filled with plants, mainly the bottom quarter to half) but not to restrict the coverage except in key access areas like the public beach, such that sediment is stabilized and habitat is maximized.

2022 Results

A total of 37 species are known from Morses Pond, with 24 plant species detected in 2022 (Table 5), slightly more than average for this waterbody. Only fanwort and Eurasian watermilfoil were very abundant, both invasive species. Only 5 more species were common, the invasive curlyleaf pondweed and 4 native species (2 water lilies, bigleaf pondweed, coontail) with nuisance potential. Variable leaf milfoil, abundant in some years, was present but not abundant in 2022. Oscillations in species richness are largely a function of less common species being found or not found in any given year and the date of the survey. The shift to 3 or even 4 surveys since 2018 has increased species detection. The dominant suite of species remains the same, with 2 of the 4 invasive submerged aquatic plant species dominating in 2022, another common, and the fourth present.

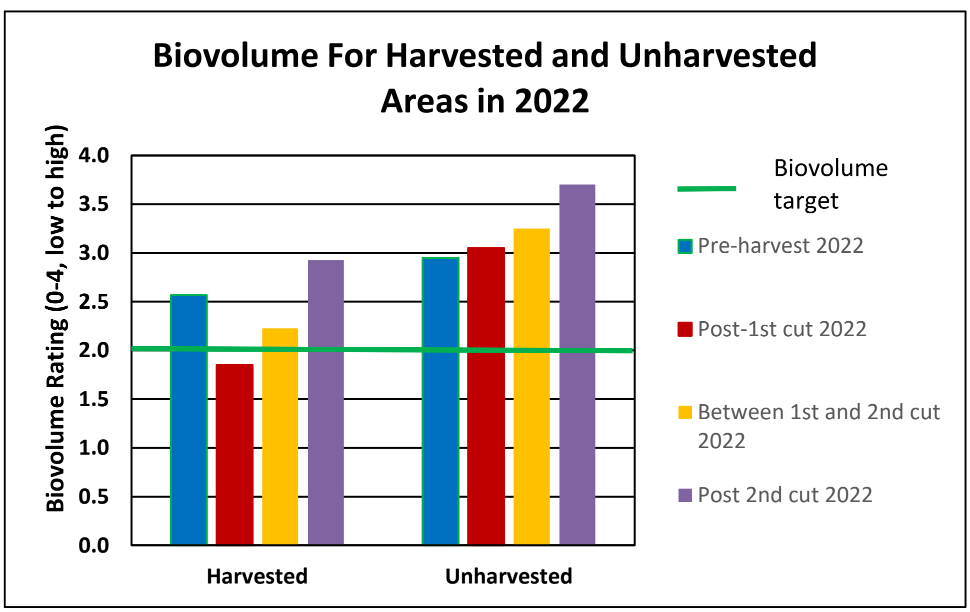
Note that *Trapa natans*, water chestnut, is also known from Morses Pond, but owing to the efforts of volunteer water chestnut pullers, it has never been found in the standard survey. Also note that *Lythrum salicaria* (purple loosestrife) is a peripheral invasive species that can be abundant but rarely picked up by the aquatic surveys.

Biovolume is a function of ice out date, the rate of plant growth, the date of the survey and any harvesting effort. The 3-4 survey per year approach allows tracking of conditions and progress of harvesting in target zones of the pond. Morses Pond exhibited moderate vegetation biovolume in the spring 2022 pre-harvest survey (Figure 11). Note that the pre-harvest plant biovolume for areas that are routinely harvested was lower than that of areas that are not harvested, suggesting some carryover effect from past harvesting, but not a large difference. Biovolume increased to dense levels in unharvested areas over the summer, but also increased in harvested areas. However, biovolume in harvested areas was about 25% lower than for unharvested areas, the difference being the effect of harvesting. Yet the target biovolume rating of 2 (25-50% of water column filled) was met overall only after the first round of harvesting (Figure 11). The overall rating exceeded 2 before the second round of harvesting was in full swing and less staffing resulted in a further increase in biovolume rating through the second round of harvesting.

Table 5. Aquatic plants in Morses Pond.

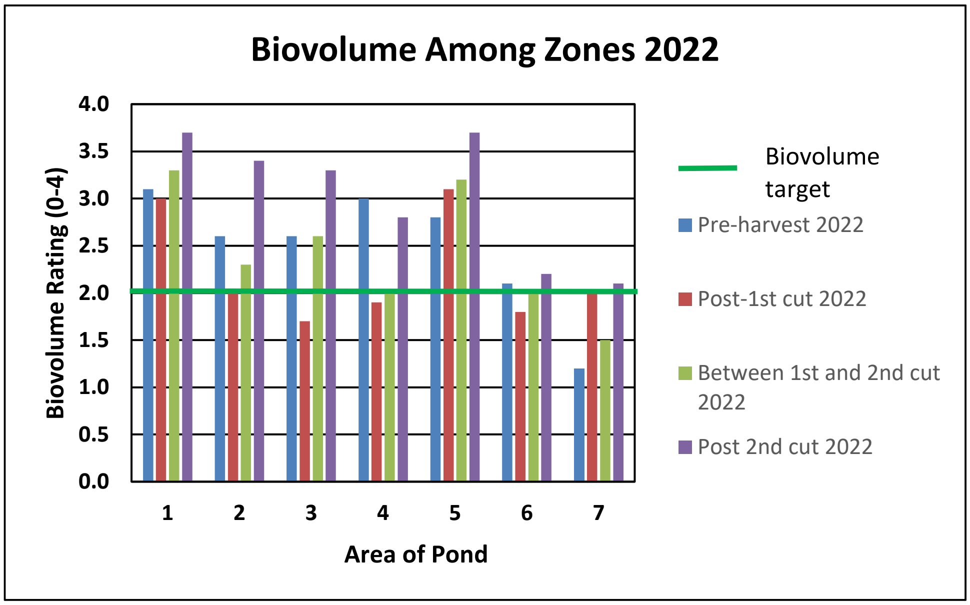
		Plant Rating for Year															
Scientific Name	**Common Name**	**2005**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Brasenia schreberi	Watershield							P	P					P			
Callitriche sp.	Water starwort	P		P													
Cabomba caroliniana	Fanwort	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
Ceratophyllum demersum	Coontail	C	C	C	A	C	C	C	C	C	C	C	C	C	C	C	C
Chlorophyta	Green algae	C	C	C	A		P	C	P	P	A	A	P	P	P	P	P
Cyanobacteria	Blue green algae		P		C	P	P		P	P	P			P			P
Decodon verticillatus	Swamp loosestrife	C	P		P	P								P	P	P	P
Elodea canadensis	Waterweed	C	C	C	C	C	C	C	C	A	A	A	C	P	P	P	P
Lemna Minor	Duckweed	P	P	P	P	P	P	P		P		P	P	P	P	P	P
Lythrum salicaria	Purple loosestrife	P	P	P	P	P	P			P				P	P	P	P
Myriophyllum heterophyllum	Variable watermilfoil	P	C	C	A	A	A	C	C	C	A	A	A	A	A	C	P
Myriophyllum spicatum	Eurasian watermilfoil	A	A	A	A	C	C	A	A	C	A	A	C	C	A	C	A
Najas flexilis	Common naiad	C	C	C	C	P	P	P	P	P	P		P	P	P	P	P
Nymphaea odorata	White water lily	C	C	C	C	C	C	C	P	P	P	P	P	P	C	C	C
Nuphar variegatum	Yellow water lily	C	P	P	P	P	P	P	P	P	P	A	C	C	C	C	C
Polygonum amphibium	Smartweed	P	P	P	P	P	P	P	P	P		P	P	P	P	P	P
Pontederia cordata	Pickerelweed	P		P	P			P		P			P	P	P	P	P
Potamogeton amplifolius	Broadleaf pondweed	C	C	C	C	C	C		C	C	C	C	P	C	C	C	C
Potamogeton crispus	Crispy pondweed		C	C	C	P	P	P	C	C	A	A	P	P	P	P	C
Potamogeton epihydrus	Ribbonleaf pondweed		P	P	P	P	P	P	C	P		P	P	P	P	P	P
Potamogeton perfoliatus	Claspingleaf pondweed					P	P		P	P			P	P	P	P	P
Potamogeton pulcher	Spotted pondweed	P			P	P	P	P	P	P	P		P	P	P	P	
Potamogeton robbinsii	Fern-leaf pondweed	C	C	C	C	P	P	P	C	A	C	A	C	P	P	P	P
Potamogeton spirillus	Spiral seed pondweed					P	P	P	P	P	P			P	P	P	P
Potamogeton zosteriformis	Flatstem pondweed						P	P			P		P	P	P		
Ranunculus sp.	Water crowfoot										P				P		
Salix sp.	Willow				P												
Sagittaria gramineus	Submerged arrowhead	P	P	P		P	P			P			P				P
Sparganium sp.	Burreed														P		
Spirodela polyrhiza	Big duckweed	P				P		P									
Typha latifolia	Cattail			P										P	P	P	P
Trapa natans	Water chestnut																
Utricularia geminiscapa	Bladderwort	P	P		P		P	P		P	P		P	P	P	P	P
Utricularia gibba	Bladderwort	C				P				P			P	P	P	P	
Valisneria americana	Water celery				P	P	P			P		P	P	P	P		
Wolffia columbiana	Watermeal	P			P		P										
	# of Species	23	20	20	24	24	25	20	18	25	18	15	23	27	28	24	24
	P=Present, C=Common, A=Abundant																

Figure 11. Biovolume comparison in areas with and without harvesting over time in 2022.



Considering the individual sectors of Morses Pond, all four harvested sectors (#2, 3, 4 and 6) met the biovolume target after the first cut (Figure 12). All four of the major target zones for harvesting exhibited plant biomass higher than desirable after the second cut was completed in 2021. Only sector 4 was still below the target level as the second cut was getting underway and none of the sectors met the target at the end of the second cutting. Yet the harvested zones were in much better condition that the unharvested sectors (#1 and 5). Sector 7 is mostly deep and not included in this comparison, although part of the area is surveyed and routinely yields acceptable plant biovolume overall. Even then, there are dense areas near the boat launch by the beach facility that cause problems.

Figure 12. Biovolume comparison over time for each sector in 2022.



Additional Plant Controls

Plant controls additional to mechanical harvesting have been applied in Morses Pond. Volunteer hand pullers search for and remove water chestnut each year. Hydroraking had occurred annually if needed in the public swim area, prior to setting up the ropes and docks, until use of benthic barrier in 2017 to limit plant growths. Shorefront owners had contracted to have hydroraking done in sections of shoreline in the same timeframe as the swim area was raked. A modified version of the hydrorake allowed sand to be moved below the water line and regrading of the swim area for better safety occurred in 2017 and 2018. Although the town no longer needs to have hydroraking on an annual basis, residents banded together and sponsored a hydroraking program in spring 2021.

Hand harvesting of water chestnut is practiced each year by a group of volunteers supported by the town. This effort has kept water chestnut in check, with only scattered plants found and removed each year. Preventing this invasive species from getting established in Morses Pond is an important function that a group within the Friends of Morses Pond has fulfilled well.

The benthic barrier chosen for use in the swim area, called Lake Bottom Blanket, has proven effective, durable, and relatively easy to install and remove. Three panels were installed in 2017 in late May and removed in early August. Those same panels, each 10 X 80 feet, were installed in late May of 2018 and left in place through early August 2019, with just inspection and light cleaning in May of 2019. Panels were removed, cleaned, and stored in August 2019. Sediment accumulation and plant growth suggests that the barrier can be installed and left in place for 2 summer seasons before removal is necessary to maintain effectiveness.

The pandemic resulted in suspension of normal beach operations and the benthic barrier was not installed in 2020. The beach was open without facilities, docks or lifeguards and with social distancing among family groups. "Beach rangers" checked people in and patrolled the beach area. The same mode of beach operation was employed in 2021 but the benthic barrier was re-installed with a new configuration and expanded coverage. Six 10 X 80-foot panels were installed, in a 3 X 2 panel arrangement that created a swimming area 240 X 20 feet just beyond the ropes at the top of the slope. These barriers keep a long area weed-free and facilitate "lap swimming". The barriers remained in place until August of 2022 with just a light cleaning in June 2022. The panels were removed, cleaned, and stored in August 2022. Re-installation is planned for late May of 2023 after any dock placement is complete.

Education

Education programs are ongoing in Wellesley, but no new initiatives were implemented by WRS in 2022. The NRC website has useful information on protection of the environment and living a more sustainable lifestyle as a resident of Wellesley. Included is information on:

- Understanding stormwater and its impact on our streams and ponds.
- The impact of phosphorus on ponds.
- The importance of buffer strips and how to establish and maintain them.
- Managing residential stormwater through rain gardens, infiltration trenches, rain barrels and other Low Impact Development (LID) techniques.
- Organic lawn and landscape management.
- Tree maintenance and related town bylaws.
- Recycling needs and options.
- Energy efficiency in the home.

Wellesley also has bylaws relating to lawn watering and other residential activities that affect water quality in streams and lakes. The extent to which residents understand these regulations is uncertain, but the website helps in this regard. The right messages are being sent, but reception and reaction have not been gauged recently. A conservation-oriented day camp was run at Morses Pond before the pandemic and sessions on aspects of the pond were included. No in-person education was conducted in 2020-2022 as a consequence of the pandemic.

MA DEP Study of Morses Pond

The MA DEP chose Morses Pond as one of its study lakes for 2022 under the Watershed Planning Program operating out of the Worcester office. The rationale for choosing Morses Pond has not been given but the additional monitoring is welcome. Water quality that could be assessed by automated field equipment was logged at the deep hole station using a monitoring buoy. Additional sampling was conducted for laboratory water quality. Water depth and plant density were mapped over the pond area, although this was done when plant density was at its highest and the water level was about 1 foot lower than normal, resulting in interference and many erroneous or missing values. Adjustment of the maps may be possible, but the extent of field verification is not clear. Benthic invertebrates were sampled and fish tissue samples were collected for contamination assessment. Data are not yet available but should be sometime in 2023.

If a report is prepared, the information should be considered and incorporated into the 2023 annual summary for Morses Pond as appropriate. As the work was done by the Watershed Planning Program, one might expect some recommendations for management, but the extent of analysis and interpretation remains unknown. A copy of this annual summary should be provided to the Watershed Planning Program of MA DEP for their information.

Management at Other Wellesley Ponds

There has been a desire to expand the success of the Morses Pond program to other waterbodies in Wellesley. This is a challenge, as many are small, shallow and receive considerable stormwater from highly developed watersheds. Not all are easily accessible for larger equipment. There is no economy of scale to be achieved, but it is possible to improve conditions to make these other ponds more favorable habitat, more aesthetically pleasing, and potentially to achieve other use goals, notably fishing. A report on the condition of eight ponds and the potential for improvement was prepared in 2017 based on 2016 field work. The ponds included were Abbotts, Bezanson, Duck, Farms Station, Icehouse, Longfellow, Reeds and Rockridge.

The new small harvester is used on Rockridge and Longfellow Ponds, where the previous small harvester had been used on a roughly annual basis. Harvesting occurred in July of 2020 and appeared to be successful. Only Rockridge Pond was harvested in 2021, for about 3 days with about 4000 pounds of plants removed. With water levels low in 2022, no harvesting was conducted outside Morses Pond.

Prior to 2019, Farms Station Pond had a thick coating of duckweed that could be removed by harvesting, but not efficiently, and alternative treatment appears to have been successful in 2019 through 2022 (see below). The harvester could also be used on Bezanson and Reeds Ponds if needed. Bezanson did not exhibit plant problems in 2019 through 2022, an apparent function of alternative treatment (see below). Plant problems in Reeds Pond are mainly a function of infilling at the inlet end; dredging is needed as harvester access to that area is too limited. Abbotts Pond and Duck Pond are too shallow for harvesting, not very accessible for heavy equipment, and do not really have rooted plant problems. Icehouse Pond is not accessible to the harvester, but access could be created if so desired.

The other aspect of Morses Pond management with transferability was phosphorus inactivation. While creating injection stations at each pond is not cost effective, the potential to treat each with a portable system was recognized. A commercially available tree sprayer unit mounted on a truck was obtained and dedicated to treating five of the Wellesley Ponds: Abbotts, Bezanson, Duck, Farms Station and Rockridge. Longfellow might benefit from treatment but is too large to address without extra effort that does not seem warranted at this time.

Simply spraying polyaluminum chloride onto the pond surface is not as effective or efficient as mixing it with incoming stormwater, but as a low-cost alternative to dosing stations this was deemed a worthwhile experiment. All needed equipment cost <$10,000 and the chemical was obtained from the tanks serving the Morses Pond phosphorus inactivation system. An initial treatment was performed in late June of 2018 in accordance with the projected dose needs from the 2017 report on those ponds, requiring about 207 gallons of polyaluminum chloride spread over 4 ponds (Abbotts Pond was not treated in late June 2018). Phosphorus and algae were assessed prior to and one week following treatment. A second treatment with double the dose of the first treatment was performed in late July of 2018, this time including Abbotts Pond, and water quality and algae were again assessed a week after treatment.

Treatment was repeated on June 10 and July 22 in 2019, with about 417 gallons of polyaluminum chloride spread over 5 ponds in each application (Abbotts @ 80 gal, Bezanson @ 40 gal, Duck @ 22 gal, Farms Station @ 112 gal, and Rockridge @ 163 gal). Phosphorus concentration and general pond condition was assessed before and after each treatment. This process was repeated in 2020 on June 22nd and August 17th of 2020 for the same ponds at the same doses.

In 2021 the rains came before any treatment had been conducted. After initial cessation of rain in early July, a treatment was performed on July 6th. Duck Pond was not treated, as flushing was still high, and Farms Station received a different aluminum polychloride solution, one with a higher aluminum concentration that halved the application volume, as a test from a new supplier. Abbotts, Bezanson, and Rockridge Ponds were treated as in previous years with the same doses. Rain resumed and flushing was too high for the treatment to have made much difference. No further treatment was attempted in 2021.

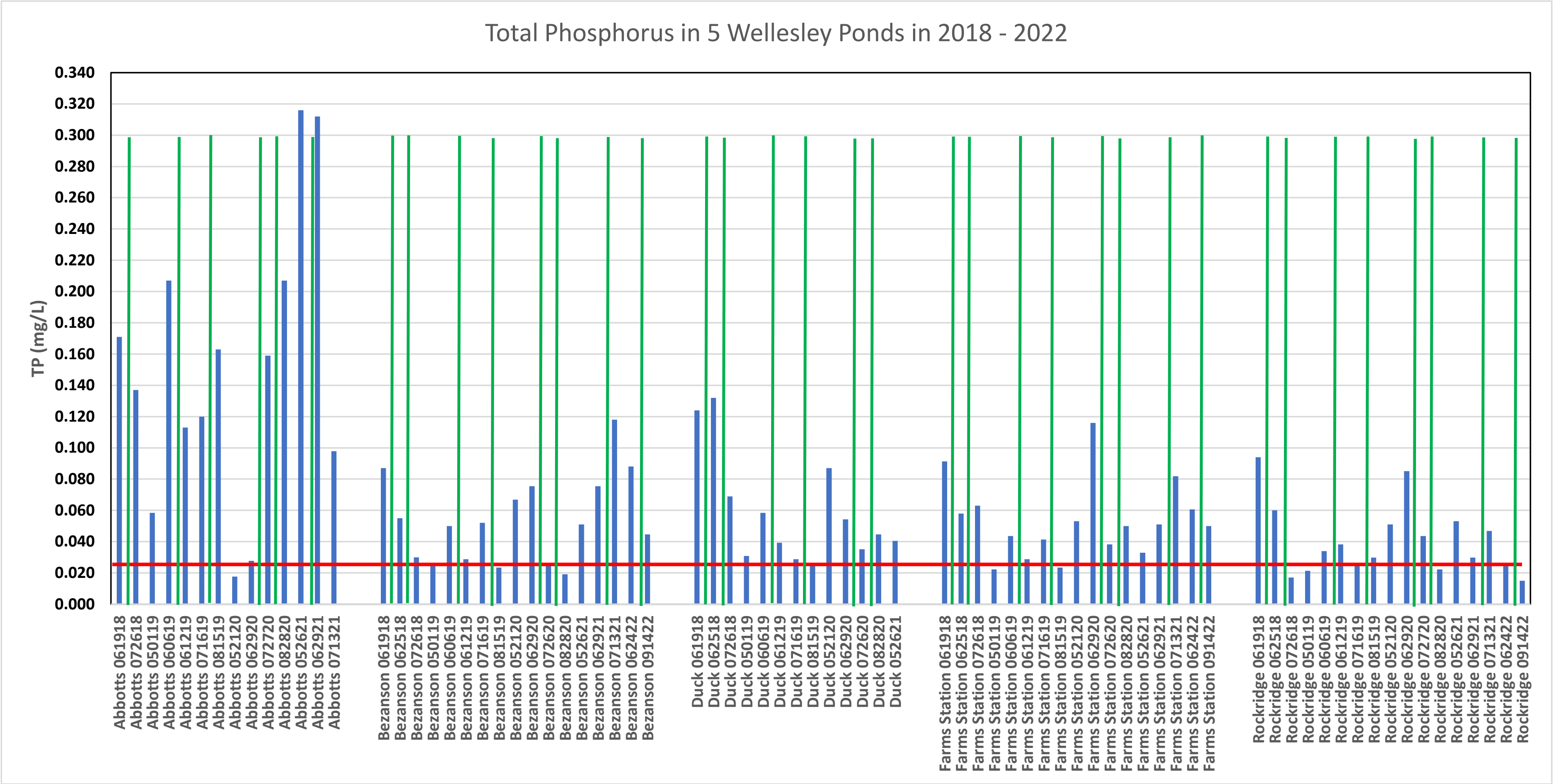
Only one treatment was conducted on Bezanson, Farms Station, and Rockridge Ponds in early July of 2022. Results from Abbotts Pond and Duck Pond were not sufficient to support continued treatment, but the other ponds had responded well to treatment. A second treatment may not have been necessary, given very dry conditions, but staffing limitations prevented such treatment anyway in summer 2022.

Abbotts Pond showed limited response to treatment (Figure 13). Phosphorus did not decline to anywhere near the target level of 20 µg/L in 2018-2021 and the water was murky on all survey dates. Dominant algae included dinoflagellates and green algae in 2018 and green and blue-green algae in 2019 and 2020, with a return to green algae in 2021. Access was limited and coverage may not have been adequate. This is a very shallow pond dominated by stormwater inputs and more frequent treatment or a greater dose may be necessary if this approach is to succeed.

Bezanson Pond exhibited a desirable response to all treatments, showing declines in phosphorus (Figure 13) and algae to near desirable thresholds. No filamentous green algae mats formed in the years with

Figure 13. Phosphorus before and after aluminum treatments of five Wellesley Ponds

Green vertical lines indicate treatment dates, red horizontal line indicates target P concentration



treatment and microscopic algae were mostly desirable forms. Also striking was the decline in the vascular plant coontail (*Ceratophyllum demersum*), which is unusual among rooted plants in that it gets most of its nutrition from the water column instead of the sediment via roots. The treatment appears to have solved both algae and vascular plant problems in this pond (Figure 14), making it far better in its role as a dog swimming pool. Bezanson Pond did not develop algae or macrophyte problems in 2021 but the water was murkier, a likely result of so much storm runoff input, and there was some floating coontail, probably dislodged by high inflows. Conditions were acceptable throughout summer of 2022.

The clarity of Duck Pond improved as a result of treatment; aluminum coagulates and settles suspended solids even if not algae. However, there were few algae in Duck Pond, owing to short residence time, so the increased clarity represents a reduction in suspended non-algal particles. This is desirable but short-lived, as even a small storm can completely change the water in Duck Pond. Also, with increased clarity the thick sediment deposits, within a few inches of the pond surface in many areas, become more visible. Duck Pond needs to be dredged to restore any pond functions.

Farms Station Pond had a problem with duckweed (*Lemna minor*), a floating aquatic plant, and while algae biomass can be high, it was not the main problem for this pond. The treatment had a partial impact on the duckweed in 2018 (Figure 14), but growths were apparent even before the first treatment. Phosphorus concentration decreased in 2018, but not to the degree desired. Treatment was conducted earlier in 2019 and the duckweed cover never formed. Duckweed is another vascular plant that gets its nutrition from the water column, so the treatment addresses duckweed as well as algae. Phosphorus was decreased (Figure 13), although not quite to the desired level, but there were only some peripheral algal mats and the pond looked good through the summer (Figure 14). Treatment in 2020 resulted in conditions similar to or slightly better than in 2019 (Figure 14), but there were some cyanobacteria mats that appeared near the outlet in August. No duckweed or algae problems were evident in 2021 but flushing was high. No duckweed was observed in 2022 but some peripheral growths of filamentous green algae were observed. Overall, conditions in Farms Station Pond have been markedly improved by aluminum addition but continued addition appears necessary to maintain desired features.

Rockridge Pond exhibited desirable decreases in phosphorus (Figure 13), chlorophyll-a and algae biomass in response to treatment in 2018, approaching or achieving the target levels after the second treatment. In 2019 the treatment appeared to provide clear water, but phosphorus concentrations were not far above the desirable threshold even before treatment. There were some filamentous green algae, but not as much as in years prior to treatment, and there were no other problem species of algae detected. However, rooted plant growths were dense in the pond in May and June of 2019 and harvesting should probably have occurred earlier. The rooted plants may have limited algae as much as treatment did.

Phosphorus was higher in 2020 after the first treatment but the second treatment reduced it to the target level and algae were not a problem in 2020. Rooted plants were selectively harvested in July and that activity may have increased phosphorus by bottom disturbance. Treatment with aluminum should follow harvesting to achieve best results, but harvesting is not typically conducted until sometime in July and algae can be a problem in Rockridge Pond before that time. In 2021 there was just the one P inactivation treatment of Rockridge Pond, on July 6th, and harvesting was conducted for 3 days later in July, removing

Figure 14. Photographic documentation of improvement in two Wellesley Ponds

Bezanson Pond August 2016

Bezanson Pond August 2020

Farms Station Pond Sept 2016

Farms Station Pond Aug 2018

Farms Station Pond Aug 2019

Farms Station Pond Aug 2020

about 4000 pounds of vegetation. High inflow caused murky water and there was a visible oil sheen in a few areas on July 13th, but there were no substantial algae problems in 2021, probably a function of flushing. No harvesting occurred in 2022 and just a single aluminum treatment in early July was performed; conditions with respect to algae were generally desirable through summer 2022.

The phosphorus inactivation program for these smaller ponds showed variable results, generally quite positive for Bezanson, Farms Station, and Rockridge Ponds but less impressive for Abbotts and Duck Ponds, which were dropped from the treatment program in 2022. A different approach will be needed for Abbotts and Duck Ponds if improvement is to be gained. Dredging would help, but access to Abbotts Pond and the ratio of cost to potential benefits is questionable, this being more a wildlife area with minimal human use. Dredging Duck Pond, both to restore its detention capacity as a stormwater management feature and to enhance its aesthetic quality in a park setting adjacent to Town Hall, is desirable.

Dredging of Reed and Duck Ponds has been recommended for several years and funds have been allocated for work in the near future. The soft sediment quantity in each pond was evaluated in fall of 2022. Duck Pond contains roughly 3500 cubic yards (cy) of mixed sand and organic sediment. Slightly less than 600 cy are in the eastern backwater area that may not be easily drained for conventional dredging, but almost 3000 cy could be removed by excavation equipment after removing the boards at the outlet and allowing the water level to decline. Duck Pond was last dredged in 1986 but it is not clear that all soft sediment was removed at that time. Reeds Pond contains about 5500 cy of mostly organic sediment, 3200 cy of which are in the upstream half of the pond and have virtually filled the pond in that area. All sediment could be removed by conventional excavation by lowering the pond level through a drain installed for that purpose when the pond was last dredged in 1999. The amount of sediment removed in 1999 is similar to what is now in the pond, although the small forebay at the upstream end of Reeds Pond has been excavated 8 times over the last 23 years with an average of about 100 cy removed each time.

The next logical step in the dredging process for Reed and Duck Ponds is to sample the target sediment in accordance with an approved MA DEP plan to determine the quality of the sediment. That quality will determine any disposal restrictions and will affect the cost of dredging. Once quantity and quality of sediment to be removed have been determined, engineering plans can be developed, and permit applications can be filed. A more detailed memorandum was submitted by WRS to the NRC and follow up work is being pursued.

Needs for 2023

The following activities are recommended for 2022:

1. Orders of Conditions for the harvesting and phosphorus inactivation programs were renewed in spring 2021 and the permits should not need to be extended until 2024. The MA DEP is now enforcing an interpretation of Sec 401 program that calls for a Water Quality Certificate (permit under 401) if more than 100 cy of material are removed from a waterbody. Calculation based on the 2021 vegetation harvest suggests that about 155 cy of vegetation was removed, so a Sec 401 permit might have been necessary. However, processing of an application in 2022 determined that the harvesting in Morses

Pond did not require a 401 permit for reasons that were not fully explained. The DEP is having some difficulty with its internal consistency among programs and relation to the federal statutes (like Sec 401 of the federal Clean Water Act) and we need to remain vigilant on possible needs, but only awareness is needed, not any substantive action in 2023.

2. The phosphorus inactivation program was permitted through the Wetlands Protection Committee in spring of 2021 and will not need renewal until spring of 2024. However, this activity requires an annual permit from the MA DEP. This permit process transitioned to an online process in 2020. Wellesley now has an account that should allow for easy renewal and that renewal was accomplished in November 2021, covering the operation for 2022. Renewal in late 2022 was attempted but the system has been changed and we need to re-apply during winter or early spring 2023. While no complications are currently anticipated, a new application has to be filed with MA DEP through its online portal.
3. The precipitation station associated with the phosphorus inactivation system was moved to the top of the pump enclosure in 2022 in anticipation of building demolition on Dale Street. The phosphorus inactivation system was given extensive maintenance in fall of 2022, given the failure of multiple sensors and one of the pumps, apparent victims of a lightning strike or other electrical issues in mid-summer 2022. One control panel has to be replaced in early spring of 2023 and the non-functioning pump was sent for repair or refurbishment. To date, it has been determined that nothing is wrong with the mechanical aspects of the pump, but the electronics are non-functional and difficult to replace. Work is ongoing, but that pump or a replacement will need to be installed in early spring of 2023. The system should be tested in early May and treatment should commence the week before Memorial Day, as usual.
4. Conduct the water quality monitoring program as in recent years. Acquire data and insights from the MA DEP Watershed Planning Program study of 2022 when available and adjust the monitoring program as appropriate. Pay close attention to the algal community and consider options for further management if peripheral accumulations of cyanobacteria recur or if planktonic concentrations become elevated.
5. The benthic barrier placement in the swim area was given a negative Determination of Applicability by the Wetlands Protection Committee that required no further permitting, but any need for renewal should be addressed through the Wetlands Protection Committee; a negative Determination of Applicability does not necessarily extend indefinitely. The barrier was placed in 2020, left in place through 2021, and removed and cleaned in August 2022. Re-installation is anticipated for May of 2023, after any dock placement is completed. Affirmation of continued negative Determination of Applicability should be sought.
6. While not a perceived need for 2023, any further hydroraking should probably be managed by the Town, given increasing permitting complexity and limited offloading sites with possible use conflicts. The work in 2021 required a lot of coordination effort and it may be best orchestrated by Town staff.
7. Plant monitoring should occur in early May and harvesting should commence as early as needed to stay ahead of rooted plant growths. The new large harvester may not arrive in time to start the 2023 season but is on order. Maintenance on the older harvesters and making the best possible use of them to keep up with plant growths is essential. A focus on efficiency during actual harvesting operations is needed, but the primary limiting factors in recent years have been equipment problems and staffing limitations. Coordination with the harvesting crew is desirable.

8. Bezanson, Farms Station and Rockridge Ponds should be treated with aluminum in mid- to late June and again in late July as needed. It would be desirable to time one treatment of Rockridge Pond to immediately follow any plant harvesting performed in that pond.
9. Plan for dredging Reeds Pond and Duck Pond in 2024 or 2025. Follow up work on sediment quality testing, engineering, and permitting is needed.