MORSES POND ANNUAL REPORT: 2021

PREPARED FOR THE TOWN OF WELLESLEY

BY WATER RESOURCE SERVICES, INC.

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This report documents the implementation of the 2005 Comprehensive Morses Pond Management Plan through 2021. 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 2021 within the context of the overall management plan. 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 lake 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 2021. 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. By treating incoming storm water 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 5395 gallons of polyaluminum chloride were applied to Morses Pond in 2021, representing 3183 lbs of aluminum, an increase over 2020 but only 75% of the average annual input since the program began, although it is very close to the average since system automation in 2016 (Table 1). Precipitation during the May-June 2020 period was 7.5 inches and for May-August it was 24.6 inches. While the May-June precipitation total was slightly above average for those months, the May-August total was by far the highest for that period since the P inactivatin system has been in place; it was a very wet summer. There were 12 treatment days in May and June, and early July was functionally one continuous treatment period until the aluminum supply was exhausted by July 6th. Rain continued through much of July, depositing over 10 inches on the pond and its watershed, about three times the normal amount and flushing Morses Pond with untreated runoff.

Table 1. Summary of Phosphorus Inactivation Effort, 2008-2021.

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

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 2021 (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 tends to lead to algal blooms, while values <20 µg/L minimize blooms and values near 10 µg/L lead to highly desirable conditions (Figure 3).

Total phosphorus concentrations in 2021 were among the highest observed since the stormwater treatment system was put in place. Treatment in late May and June was not quite adequate to achieve the target of <20 µg/L. Treatment could have continued further into July with an extra load of aluminum chemical to lower total phosphorus, but so much rain was predicted and did occur that a third load of aluminum was not ordered. July was one of the wettest on record and August provided more than twice the average precipitation for that month. Total phosphorus at the end of August was >30 µg/L, the highest late summer value for the south end of the pond since 2011, before the P inactivation system was revamped for better performance. The amount of rainfall was simply more than the system could handle without a lot more operation than normally conducted in a year. However, we know from experience that the flushing that goes with such high precipitation tends to prevent algae blooms from forming, so it is not considered essential to treat under such prolonged wet conditions.

Total Kjeldahl nitrogen values were moderate to high in 2021, averaging 661 µg/L in the pond and reaching a peak of 1560 µg/L in the deepest water at the end of August. A portion of the pond stratifies and loses oxygen, allowing ammonium to build up through decomposition. Ammonium is not measured directly but is likely the dominant form of nitrogen in the deep water with the elevated TKN value (which also includes ammonium). TKN in first flush samples during a storm were 4130 µg/L for Bogle Brook and 2450 µg/L for Boulder Brook. Nitrate was much lower but not negligible at an average of 218 µg/L in the pond. Nitrate did rise to 1000 µg/L for a post-storm sample in Boulder Brook, suggesting either an illicit storm sewer connection or major lawn fertilizer wash-off. High nitrate (>10 mg/L) can be a health risk, but loss of nitrate can also be a concern, as low ratios of available N to available P favor cyanobacteria.

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. Warmer summers increase water temperature which in turn increases bacterial metabolism and oxygen demand,

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

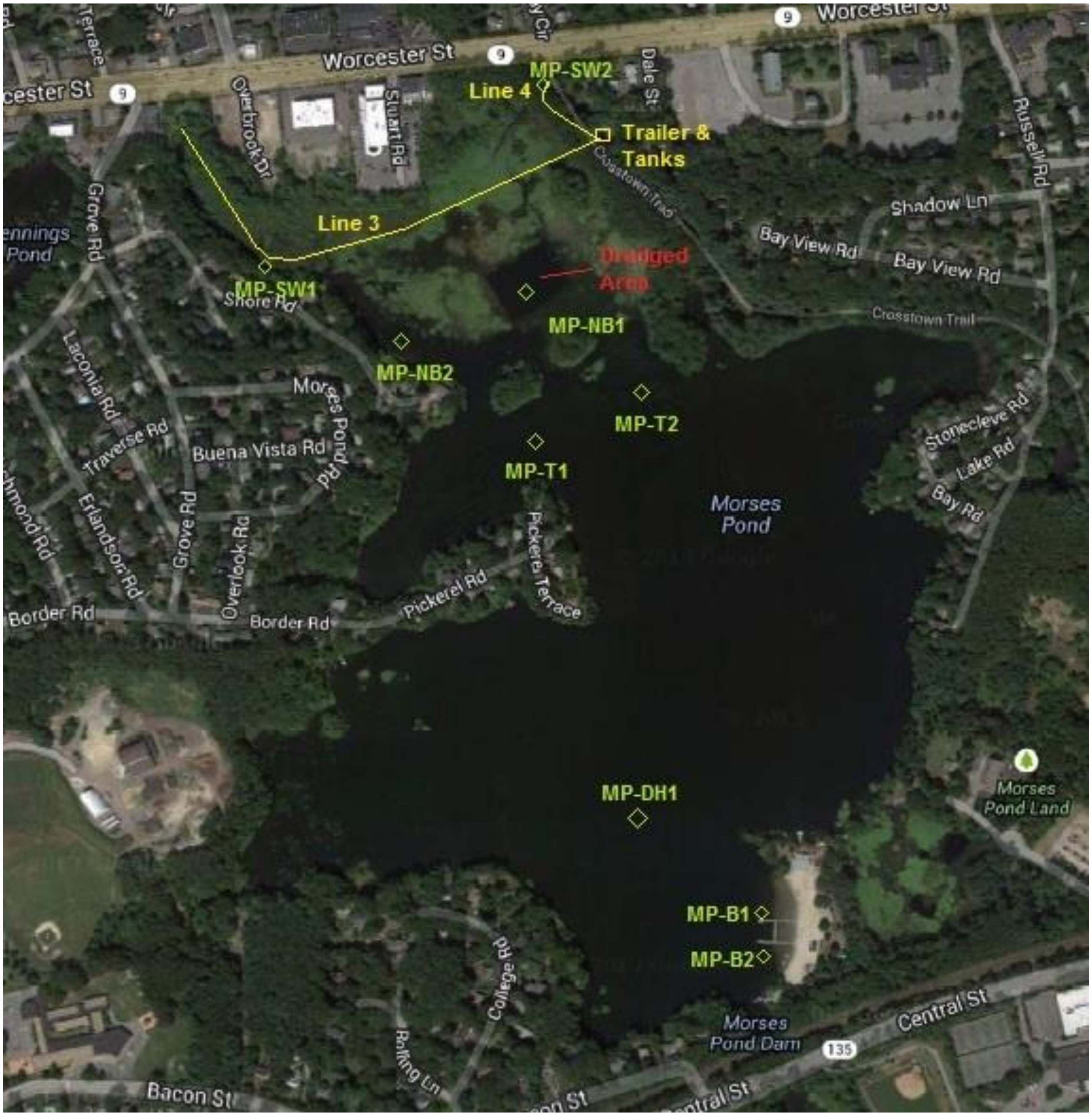


Table 2. Water quality record for Morses Pond in 2021.

	Date	Depth	Temp	DO	DO	Sp. Cond	pH	Turbidity	CHL	Secchi	Total P	TKN	Nitrate N	Total N	Notes
Station	MM.DD.YY	meters	°C	mg/l	% Sat	µS/cm	Units	NTU	µg/l	meters	ug/L	ug/L	ug/L	ug/L	
Bogle	5/29/2021	0.1									752.0	4130	303	4433	1st flush
Boulder	5/29/2021	0.1									629.0	2450	822	3272	1st flush
Bogle	6/15/2021	0.1									55.3	669	320	989	late-storm
Boulder	6/15/2021	0.1									125.0	722	850	1572	late-storm
MP-NB1	4/23/2021										25.5	576	284	860	
MP-NB2	4/23/2021										25.2	666	273	939	
MP-T1	4/23/2021										20.2	570	269	839	
MP-T2	4/23/2021										25.5	587	275	862	
MP1	4/23/2021	0.7	11.2	12.8	118.0	470	7.7	3.0	6.6	2.1	21.3	587	286	873	
	4/23/2021	2.0	11.1	12.7	117.0	470	7.7	2.9	13.5						
	4/23/2021	4.0	11.1	12.6	116.3	470	7.7	2.9	14.1						
	4/23/2021	4.9	11.1	12.6	115.8	470	7.6	2.6	15.9		23.4	576	284	860	
MP-B	4/23/2021										21.3	541	415	956	
MP-NB1	6/29/2021										25.5	414	81	495	
MP-NB2	6/29/2021										35.1	636	140	776	
MP-T1	6/29/2021										36.1	501	122	623	
MP-T2	6/29/2021										41.4	539	110	649	
MP1	6/29/2021	0.2	27.9	8.6	111.6	544	7.6	2.6	2.9	3.7	23.4	448	138	586	
	6/29/2021	1.0	27.3	8.7	111.5	543	7.7	3.3	3.9						
	6/29/2021	2.0	24.1	8.9	108.1	528	7.7	3.3	4.3						
	6/29/2021	3.0	19.4	6.0	66.0	480	7.7	3.4	21.6						
	6/29/2021	4.0	15.4	1.0	10.5	491	7.5	3.5	8.9						
	6/29/2021	5.0	13.7	1.2	11.9	540	7.3	8.0	6.4						
	6/29/2021	6.0	12.8	0.1	1.1	574	7.0	8.4	2.7		51.0	732	245	977	
MP-B	6/29/2021										25.5	623	151	774	
MP-Bogle	7/13/2021										63.8	950	297	1247	Post-storm
MP-Boulder	7/13/2021										57.4	719	1000	1719	Post-storm
MP-B	7/13/2021										38.3	720	187	907	
MP-T1	7/28/2021										55.3	694	186	880	
MP-T2	7/28/2021										45.7	526	153	679	
MP1	7/28/2021	0.2	24.5	7.7	94.2	417	6.9	1.6	20.5	1.8	47.8	749	118	867	
	7/28/2021	1.0	24.5	7.6	92.2	417	6.8	1.9	22.5						
	7/28/2021	1.5	24.2	5.9	71.8	414	6.6	2.0	11.0						
	7/28/2021	2.0	20.9	0.4	3.9	390	6.6	2.2	8.1						
	7/28/2021	3.0	19.0	0.1	1.1	384	6.5	1.9	6.0						
	7/28/2021	4.0	17.2	0.0	0.0	478	6.5	1.8	2.6						
	7/28/2021	5.0	14.5	0.0	0.0	551	6.5	1.7	2.1						
	7/28/2021	6.0	14.6	0.0	0.0	549	6.5	1.7	2.3		53.1	815	56	871	
	7/28/2021	6.4	13.6	0.0	0.0	570	6.6	1.9	2.1						
MP-B	7/28/2021										45.7	641	93	734	
MP-1	8/31/2021	0.2	25.4	7.6	93.6	390	6.9	1.3	7.7	2.0	38.3	572	101	673	
	8/31/2021	1.0	25.3	7.5	92.2	391	7.0	1.5	8.3						
	8/31/2021	2.0	23.0	1.2	14.6	397	6.8	1.2	3.7						
	8/31/2021	3.1	20.0	0.0	0.0	417	6.7	2.5	16.2						
	8/31/2021	4.0	16.8	0.0	0.1	505	6.6	2.6	2.5						
	8/31/2021	5.0	14.5	0.0	0.0	568	6.6	2.6	2.4						
	8/31/2021	6.0	13.7	0.0	0.0	590	6.6	2.7	2.5		159.0	1560	69	1629	
MP-B	8/31/2021										30.8	584	115	699	

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

leading to lower oxygen concentrations. This is a climate change effect but there is a lot of variation among years. However, in 2021 the added effect of excessive organic inputs from the watershed, especially upstream wetlands, appears responsible for the even lower oxygen at relatively shallow depths. The decomposition of all the added organic matter creates a major oxygen demand and may also add to the nutrient pool within the pond. No fishkills or even stress were observed in the pond, however.

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. Conductivity in 2021 was actually lower than average, probably a function of frequent high flows and flushing. 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 the pH. The pH was lower than usual in July and August of 2021, undoubtedly a function of high flushing, which limits algal photosynthesis and adds more organic material for decomposition and acid release. 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.

Average summer water clarity was lower in 2021 than in any of the last 8 years since the inactivation system was enhanced (Figure 2). Although clarity was still acceptable for contact recreation, the water was murkier than usual and had a distinct brown color much of the summer. High precipitation caused higher flows, more runoff, and more inputs to Morses Pond in July and August of 2021 than any other year in the last two decades. Aside from wash off of urban land, dissolved organic compounds from upstream wetlands were flushed downstream at a greater rate, coloring the water of Morses Pond. Algae concentrations were higher than average for the period of P inactivation station operation, but were not excessive. Low clarity and murky water were mostly a function of non-living particulates and dissolved organic substances in the water of Morses Pond during summer 2021.

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. A total of 3183 lbs of aluminum was applied by early July of 2021, slightly lower than the target, but in July and August there were >17 inches of precipitation compared to the average 6.4 inches, essentially cancelling the effect of pre-July treatment.

The first 12 years of phosphorus inactivation history for Morses Pond has been divided into 3 periods: 2008-2010, 2011-2013, and 2014-2019, both in terms of system function and average summer water clarity data (Figure 2). 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, the 13th year of operation, were not quite as desirable as in recent years, mostly owing to a dry June 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, but the P inactivation system was not really a factor in Morses Pond condition in 2021.

Phosphorus and clarity in 2021 follow the pattern known for Morses Pond (Figure 3) but are more indicative of a year without P inactivation treatment. Functionally, that is an appropriate description for 2021, as any treated water was likely flushed from the pond by the end of July and conditions were controlled by flushing rate more than P concentration.

Figure 2. Average summer water clarity and total phosphorus in Morses Pond, 1994-2021.

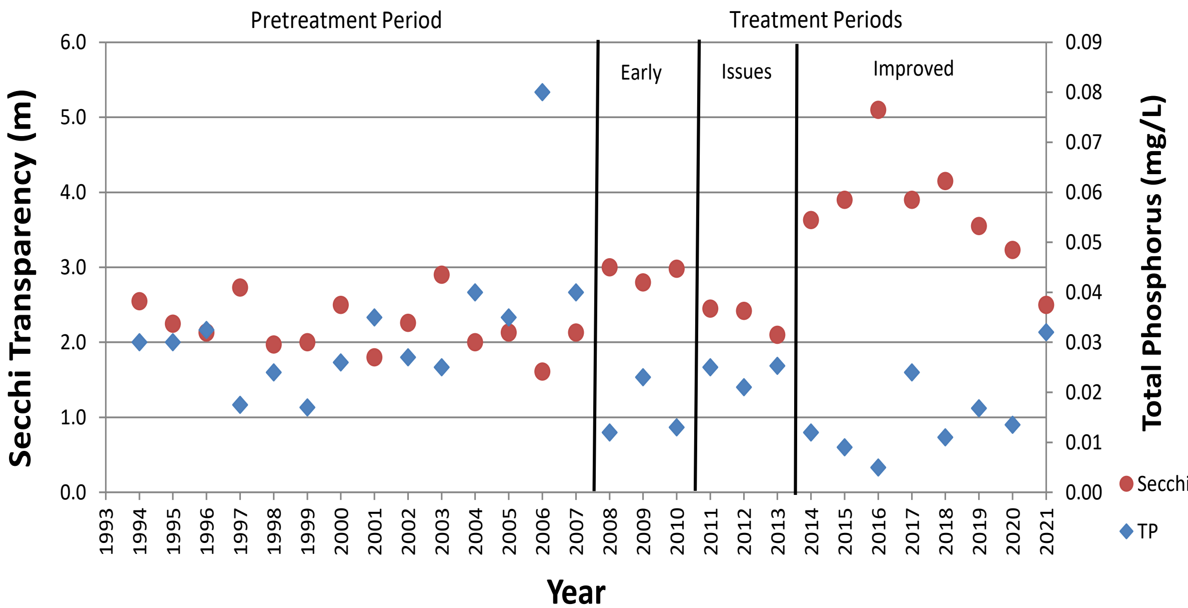
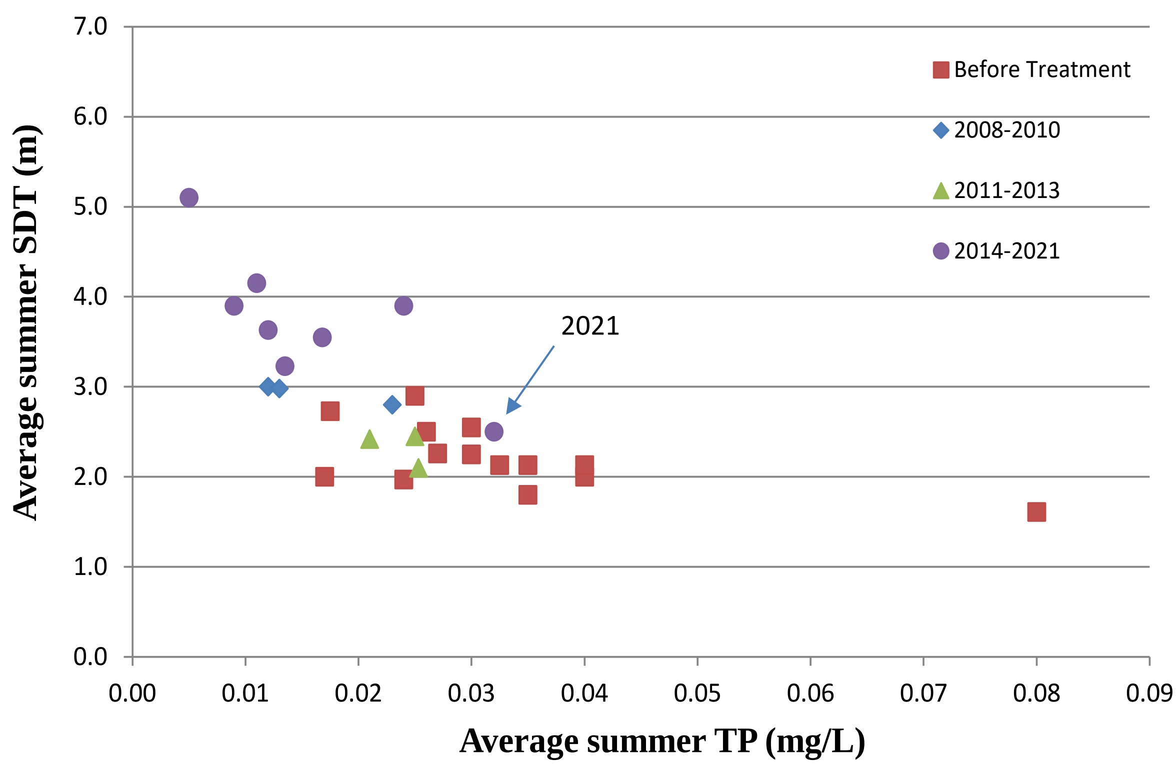


Figure 3. Relationship between summer water clarity and total phosphorus in Morses Pond.



Algal data for 1996-2021 (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. 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. It would seem advisable to plan for more aluminum application in 2022, but the system may not be able to overcome extreme precipitation totals.

Zooplankton have also been sampled, and while not as tightly linked to nutrients, 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 tends to be 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 low 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 2021 were very desirable, with adequate biomass and size distribution to be a valuable link in the food chain.

Figure 4. Summer average algae biomass divided into major algae groups for 1996-2021.

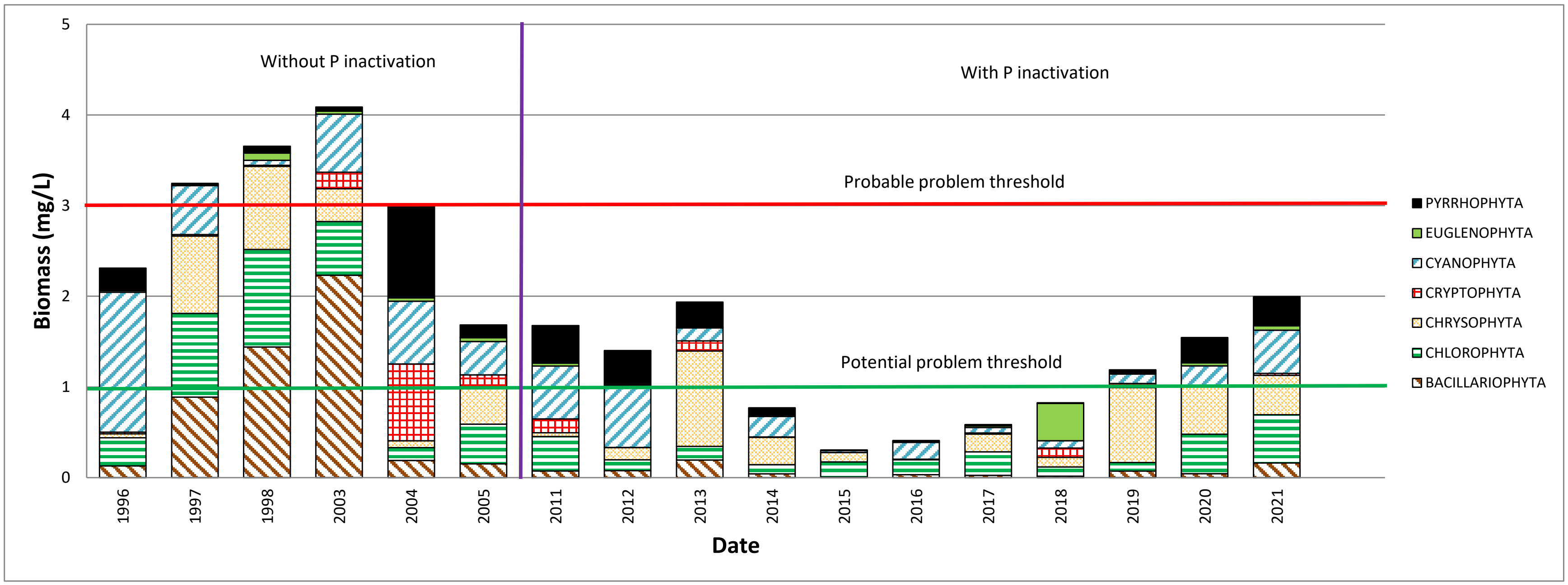


Figure 5. Zooplankton abundance for 1996-2021.

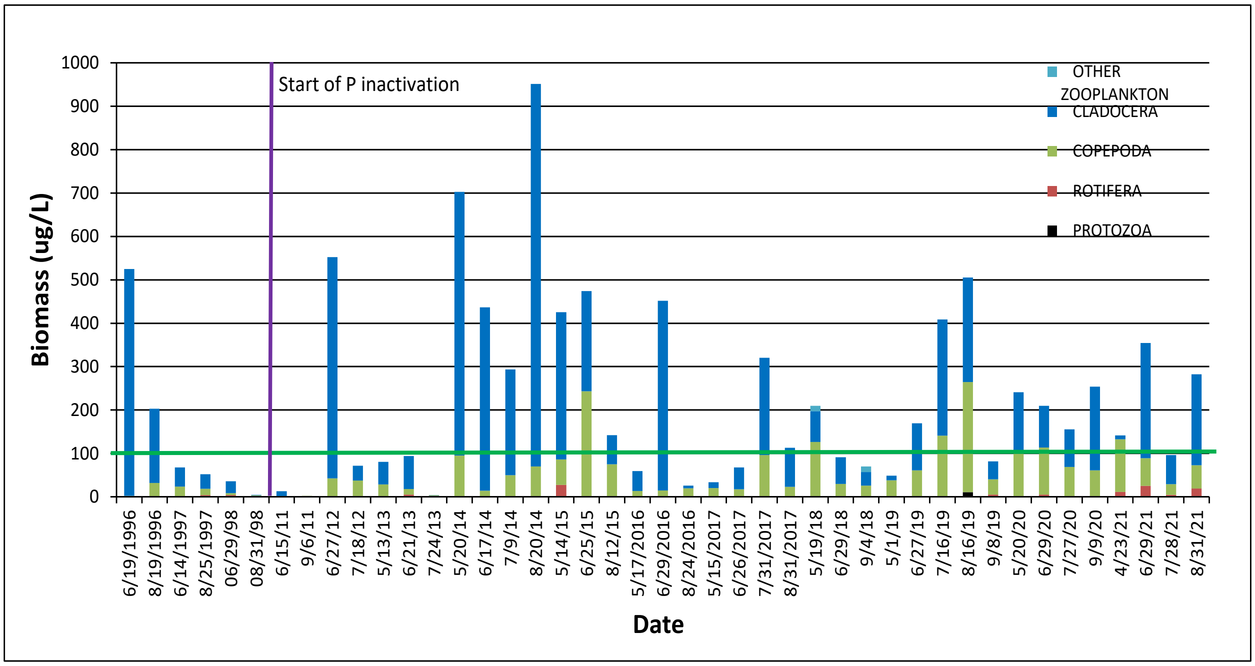
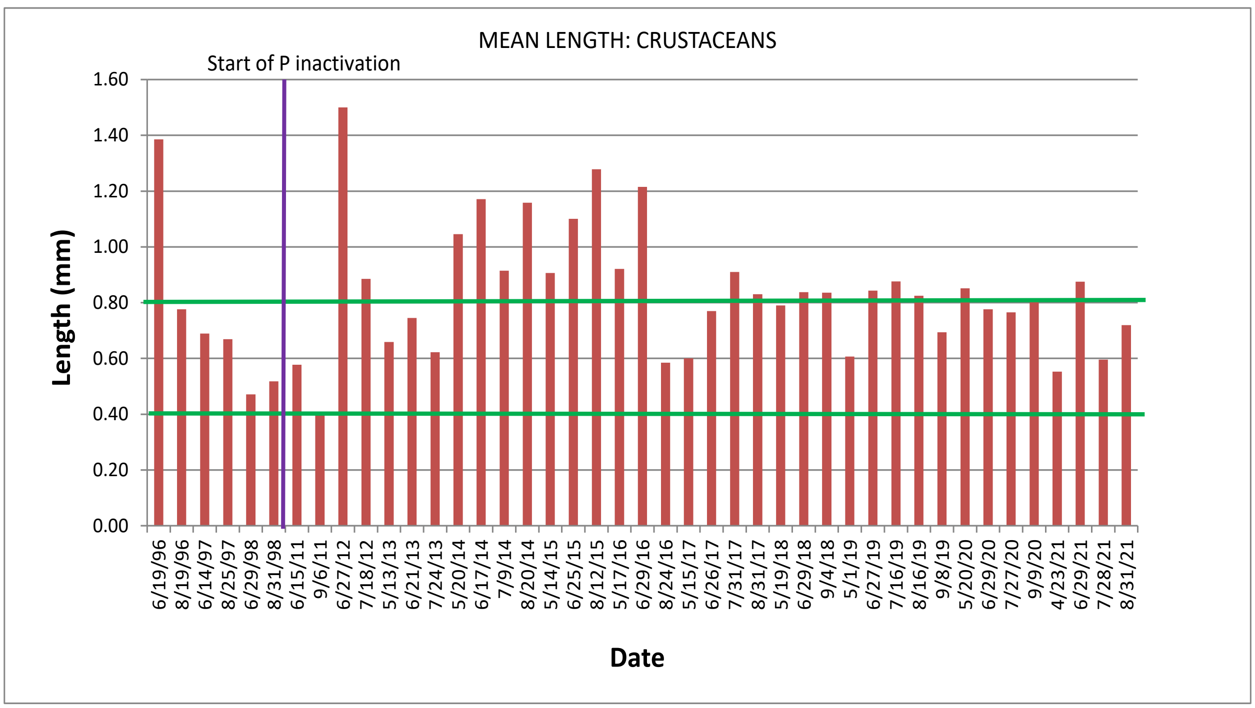


Figure 6. Crustacean zooplankton mean length, 1996-2021.



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.

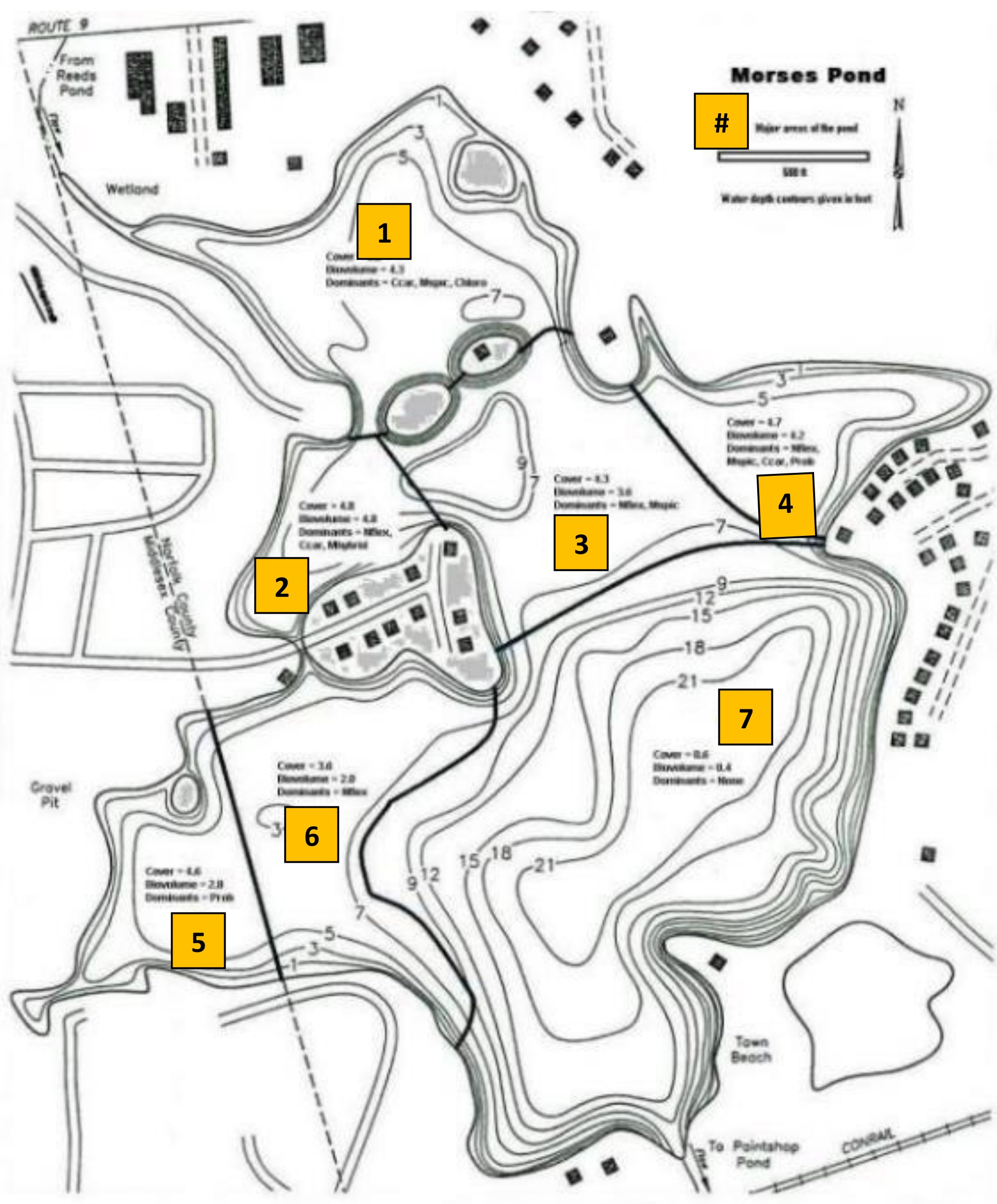
The keys to successful harvesting include:

- 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 2021, 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 2021 harvesting occurred on 57 days for a total of 507.5 hours with 300.5 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. 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 224,000 to 808,000 lbs. The 2021 biomass total was estimated at about 259,000 lbs., more than in 2020 but less than the biomass harvested in 2018 and 2019 despite a greater number of cutting hours and many more loads. The 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 2022, although possibly not by the start of the harvesting season.

An increasing number of non-cutting hours was observed from 2009 until 2015 (Figure 11) 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. 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.

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 2022 should solve much of the problem.

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
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 hours associated with the harvesting program.

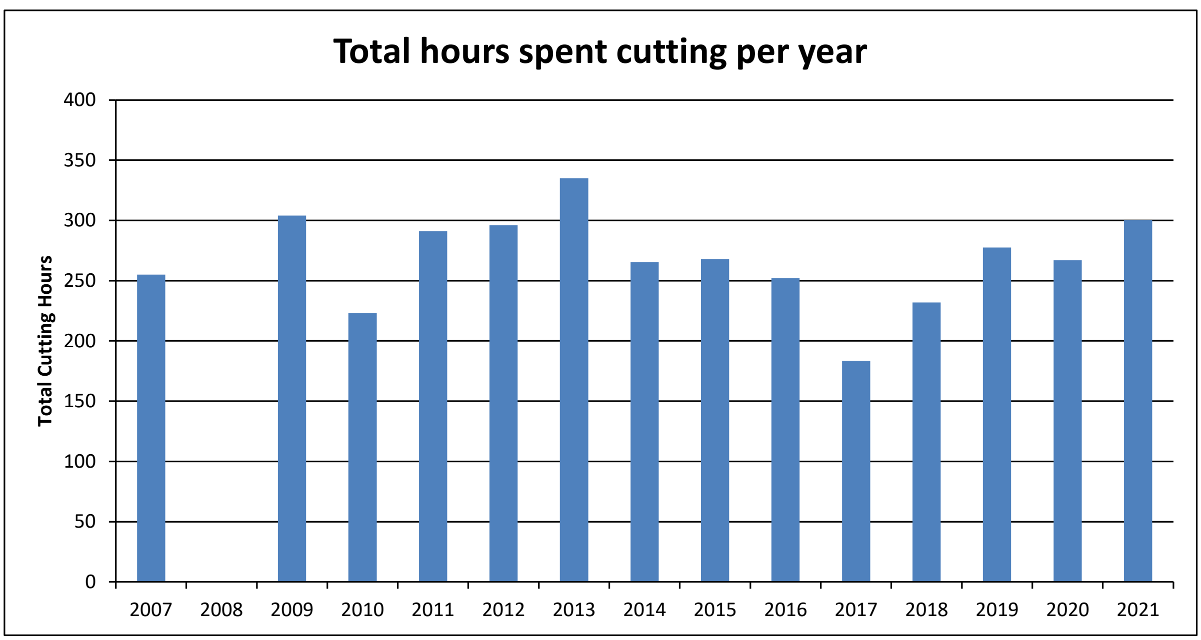


Figure 9. Total mass of plants removed by the harvesting program.

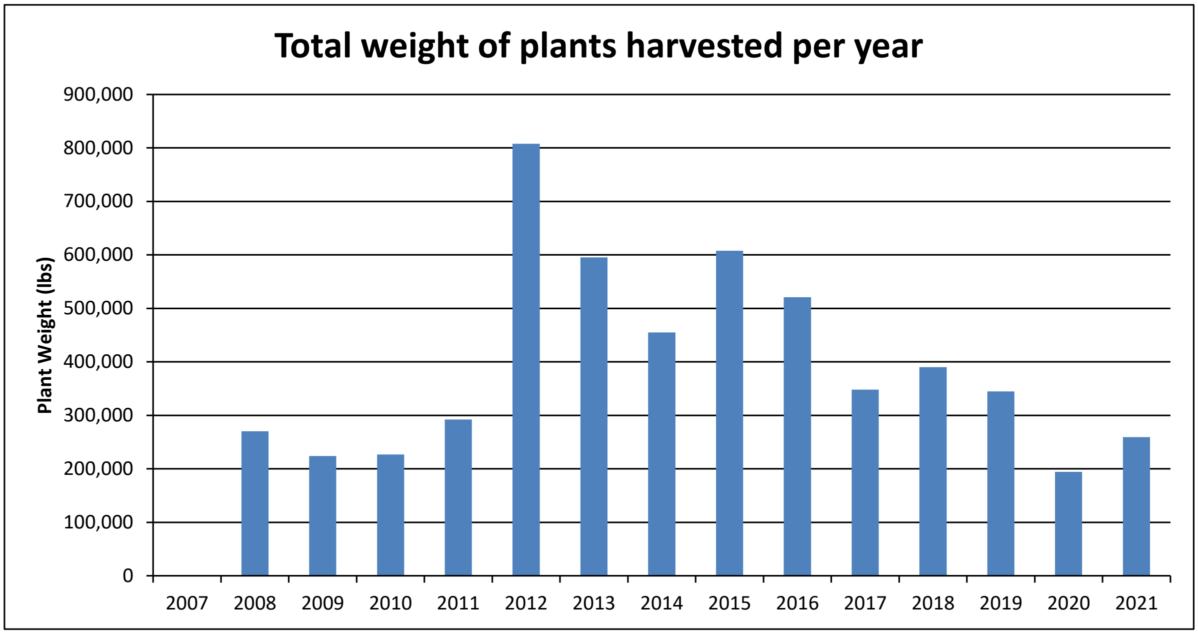


Figure 10. Mass of plants removed per load in the harvesting program.

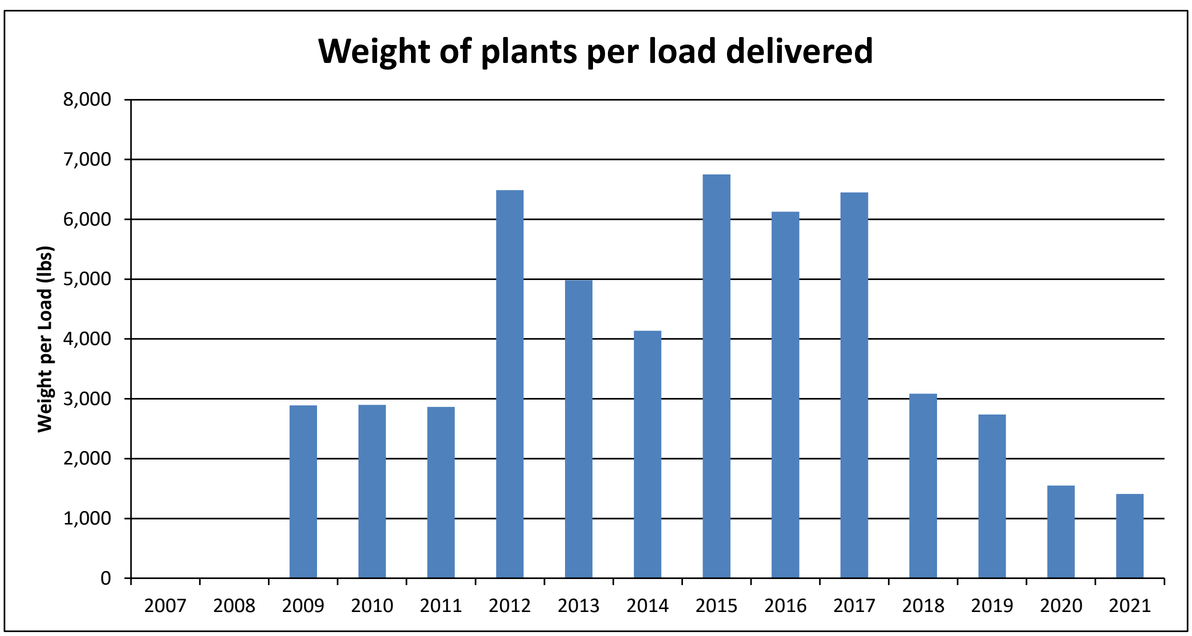
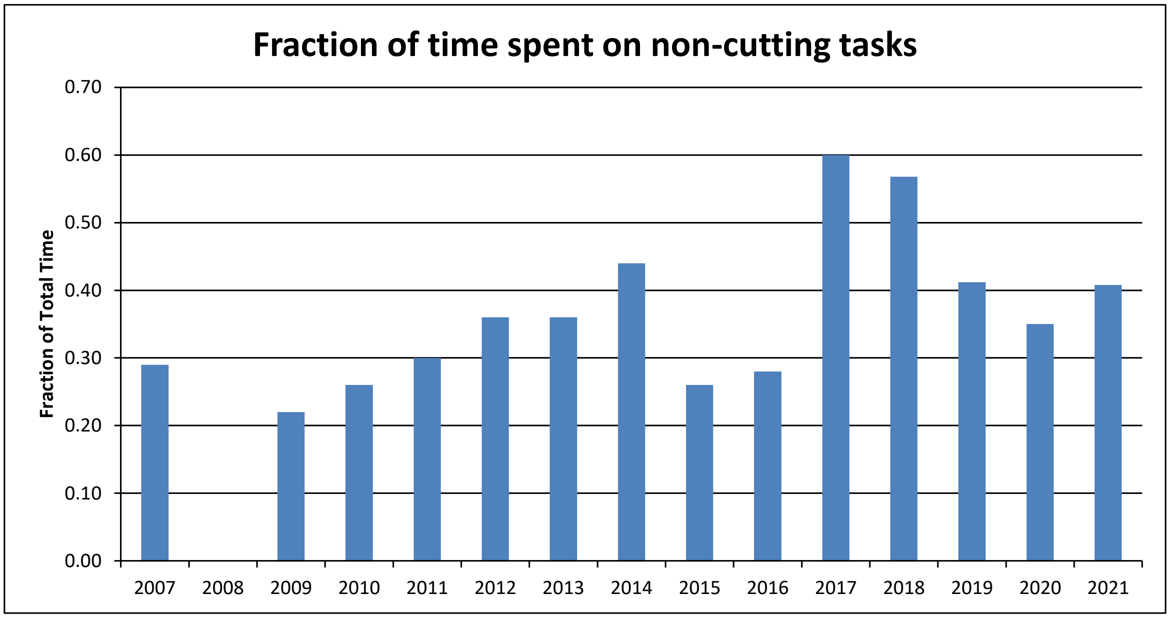


Figure 11. Non-cutting hours associated with the harvesting program.



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.

Harvesting was conducted in sector 2 on 11 days, in sector 3 on 23 days, in sector 4 on 10 days, and in sector 6 on 21 days. Additionally, the western shoreline of sector 1 was cut twice and some work around the periphery of sector 7, including the beach area, was conducted on 3 days. Some days were split between sectors but on some days both harvesters were working in different sectors.

Equipment problems in 2021 included at least two periods of downtime for the larger, older harvester and four breakdowns of the shore conveyor. Repairs were relatively prompt, with needed parts on hand or quickly acquired, but significant time was still lost. The weather was also an issue, with more storms than usual in summer 2021. Both harvesters were operated on several days when manpower was available, and the staff spent long days and extra days to try to keep up. Any failure to meet harvesting goals in 2021 was a matter of equipment limitations, weather, and rapid growth and early dominance by fanwort, not short staffing or lack of effort.

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.

2021 Results

A total of 37 species are known from Morses Pond, with 24 plant species detected in 2021 (Table 5), slightly more than average for this waterbody. Only fanwort was very abundant, all invasive species (fanwort and two species of milfoil). Only with 6 more species common, a mix of invasive (2 milfoils) and native (2 water lilies, bigleaf pondweed, coontail) species with nuisance potential. 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 surveys since 2018 has increased species detection. The dominant suite of species remains the same, with 3 of the 4 invasive submerged aquatic plant species dominating:

- *Cabomba caroliniana* (Fanwort) – dominant over much of the pond in 2021
- *Myriophyllum spicatum* (Eurasian watermilfoil) – common in 2021
- *Myriophyllum heterophyllum* (Variable watermilfoil) – common in 2021
- *Potamogeton crispus* (Curlyleaf pondweed) – present in 2021

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 our 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 three 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 2020 pre-harvest survey (Figure 12), which was conducted fairly early on April 23rd. 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. 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 not met overall after either of the two rounds of harvesting (Figure 12).

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**
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
Ceratophyllum demersum	Coontail	C	C	C	A	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
Cyanobacteria	Blue green algae		P		C	P	P		P	P	P			P		
Decodon verticillatus	Swamp loosestrife	C	P		P	P								P	P	P
Elodea canadensis	Waterweed	C	C	C	C	C	C	C	C	A	A	A	C	P	P	P
Lemna Minor	Duckweed	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
Myriophyllum heterophyllum	Variable watermilfoil	P	C	C	A	A	A	C	C	C	A	A	A	A	A	C
Myriophyllum spicatum	Eurasian watermilfoil	A	A	A	A	C	C	A	A	C	A	A	C	C	A	C
Najas flexilis	Common naiad	C	C	C	C	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
Nuphar variegatum	Yellow water lily	C	P	P	P	P	P	P	P	P	P	A	C	C	C	C
Polygonum amphibium	Smartweed	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
Potamogeton amplifolius	Broadleaf pondweed	C	C	C	C	C	C		C	C	C	C	P	C	C	C
Potamogeton crispus	Crispy pondweed		C	C	C	P	P	P	C	C	A	A	P	P	P	P
Potamogeton epihydrus	Ribbonleaf pondweed		P	P	P	P	P	P	C	P		P	P	P	P	P
Potamogeton perfoliatus	Claspingleaf pondweed					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
Potamogeton spirillus	Spiral seed pondweed					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			
Sparganium sp.	Burreed														P	
Spirodela polyrhiza	Big duckweed	P				P		P								
Typha latifolia	Cattail			P										P	P	P
Trapa natans	Water chestnut															
Utricularia geminiscapa	Bladderwort	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
	P=Present, C=Common, A=Abundant															

Considering the individual sectors of Morses Pond, sector 3 met the biovolume target after the first cut and sector 6 was close, but sectors 2 and 4 were well above the target (Figure 13). Yet sector 4 was cut first in 2021 and sector 2 was cut just 2 weeks before the assessment, so this appears to be an issue of regrowth between cuttings. All four of the major target zones for harvesting (#2, 3, 4 and 6) exhibited plant biomass higher than desirable after the second cut was completed in 2021. Yet the harvested zones were in much better condition that the unharvested ones (#1 and 5). Further, sectors 2 and 4 had been in very favorable condition for at least a few weeks after the second cut. Visual inspection indicated that invasive plants dominated, mainly fanwort. Rapid growth by this species coupled with harvester limitations are producing the observed problems.

Figure 12. Biovolume comparison in areas with and without harvesting over time in 2021.

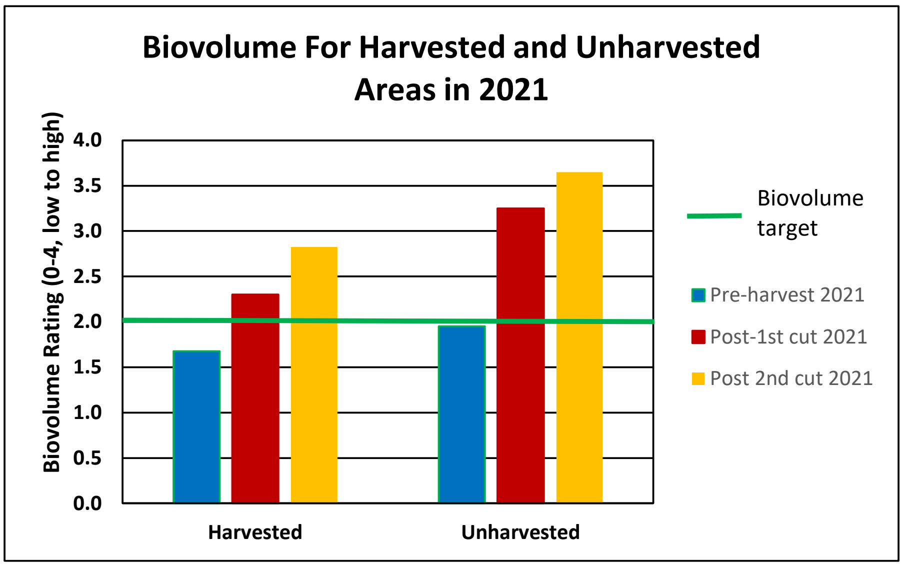
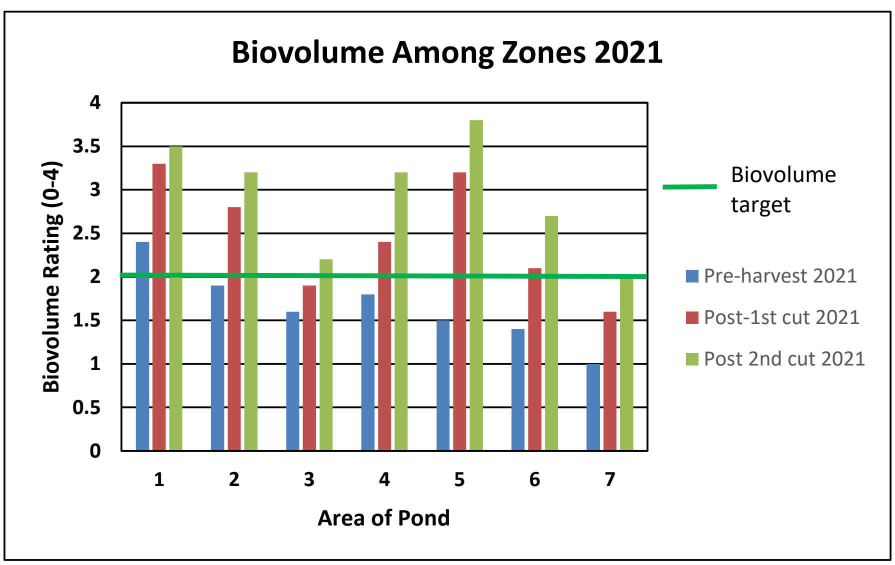


Figure 13. Biovolume comparison over time for each sector in 2021.



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 will remain in place until August of 2022. In-place cleaning is anticipated to be needed in late May 2022.

Hydroraking in 2021 was planned over the winter, covered under the existing permit, and conducted in May 2021. A narrow band of nearshore area was hydroraked off 32 properties, with material placed on a barge that was offloaded at the closest of 6 sites. An estimated 94 cy of material was trucked to the town composting facility. All offloading areas were restored after use. Residents paid for the service, but the town provided planning, permitting and supervision aid. Accolades are due to Mr. Thomas Heller, who managed the project on behalf of participating residents and dealt with all the typical issues of such a project to bring it to successful fruition.

Education

Education programs are ongoing in Wellesley, but no new initiatives were implemented by WRS in 2021. 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 storm water 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 storm water 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 or 2021, however, as a consequence of the pandemic.

Management at Other Wellesley Ponds

There is 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 storm water 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 was used. 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. Farms Station Pond had a coating of duckweed that could be removed by harvesting, but not efficiently, and alternative treatment appears to have been successful in 2019 and 2020 (see below). The harvester could also be used on Bezanson and Reeds Ponds if needed. Bezanson did not exhibit plant problems in 2019 through 2021 and this may be a 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 that can mount 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 storm water, 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 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 in 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.

Abbotts Pond showed limited response to treatment (Figure 14). 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 storm water inputs and more frequent treatment or a greater dose may be necessary if this approach is to succeed.

Bezanson Pond exhibited a desirable response in the first 3 years, showing declines in phosphorus (Figure 14) and algae to near desirable thresholds. No filamentous green algae mats formed in the years with 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

Figure 14. Phosphorus before and after aluminum treatments of five Wellesley Ponds

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

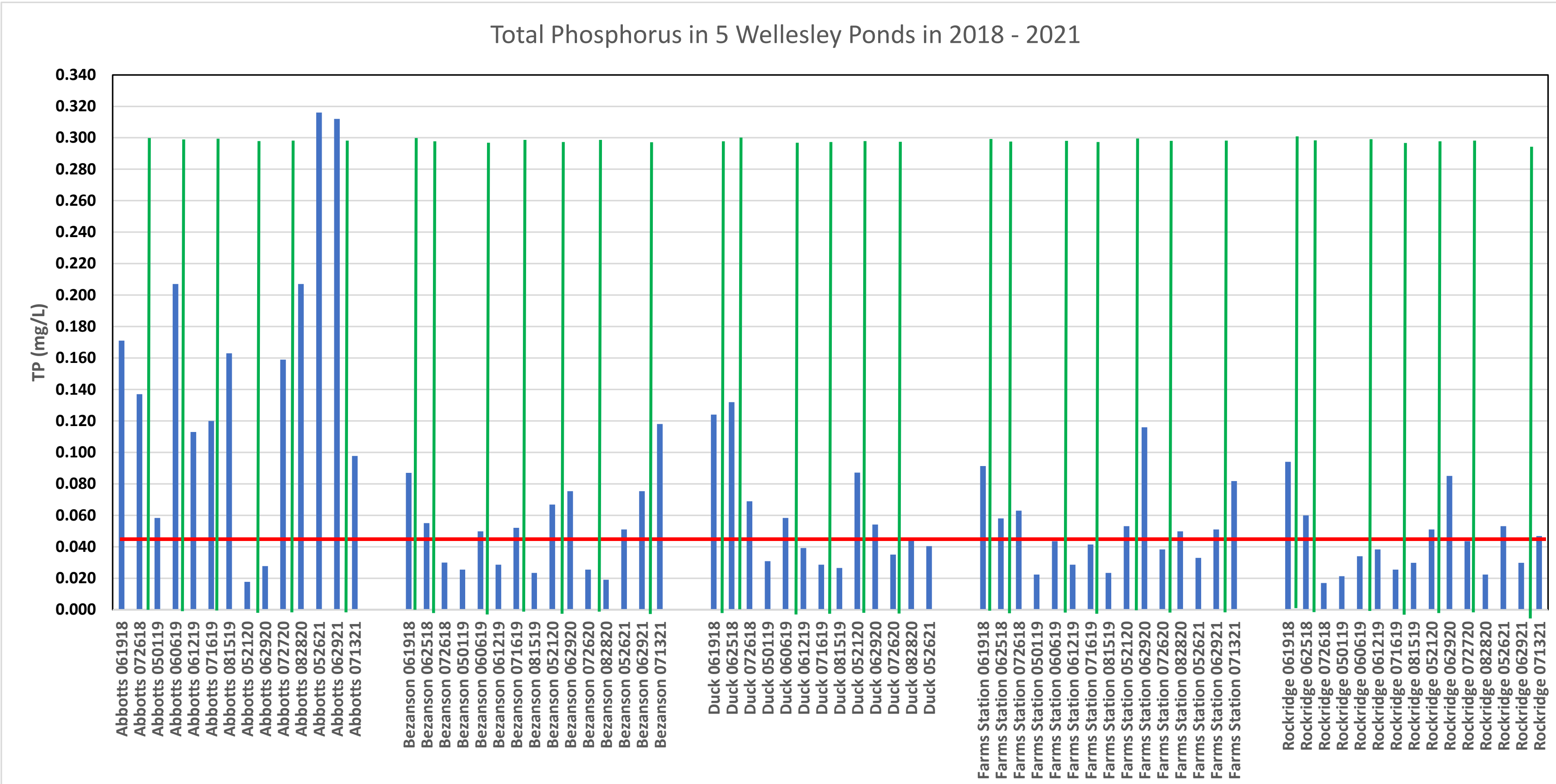


Figure 15. Photographic documentation of improvement in two Wellesley Ponds

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

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 15), 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.

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.

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 15), 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 it as well as algae. Phosphorus was decreased (Figure 14), although not quite to the desired level, but there were only some peripheral algal mats and the pond looked good through the summer (Figure 15). Treatment in 2020 resulted in conditions similar to or slightly better than in 2019 (Figure 15), 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.

Rockridge Pond exhibited desirable decreases in phosphorus (Figure 14), 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 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 overall there were no algae problems in 2021.

The phosphorus inactivation program for these smaller ponds showed promise in 2018 through 2020. Bezanson and Farms Station Ponds exhibited markedly better conditions in 2019 and 2020 than in past years and this may be all that is needed to keep those ponds in a condition appropriate for their intended uses. It would be best if treatment of Rockridge Pond followed harvesting, which should occur earlier in the summer, if possible, but if harvesting has to wait until July the paired treatment approach can be continued. Duck Pond does not require much aluminum, but conditions in this pond would be much enhanced by dredging and clearing the water under current conditions provides only slight benefit for a short period. Treatment of Abbotts Pond will probably necessitate launching a boat and spraying from the pond surface to get adequate coverage, as the results from 2018 through 2021 were not acceptable, and more intensive management may be needed in this shallow, highly eutrophic pond.

Needs for 2022

The following activities are recommended for 2022:

Orders of Conditions for both the harvesting and phosphorus inactivation programs were renewed in spring 2021 and the permits should not need to be extended until 2024. However, 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 appears necessary in 2022.

The phosphorus inactivation program requires an annual permit from the MA DEP in addition to the permit issued by the Wellesley Wetlands Commission, also under Sec 401. This permit process has transitioned to an online process in 2020. Wellesley now has an account that will allow for easy renewal and that renewal was accomplished in November 2021, so the operation should be covered for 2022. Renewal in late 2022 is recommended.

The phosphorus inactivation system should be tested in early May and treatment should commence the week before Memorial Day. The precipitation station should be moved in anticipation of building demolition on Dale Street. Application of more aluminum in the May-June period is needed if at all possible (based on weather) and treatment into July should be planned in the event of wet weather, although the extreme conditions of 2021 do not warrant extended treatment. This operation normally uses two loads of aluminum at 5000-6000 gal in total but may need to increase to 7500-9000 gal, especially if about 800 gal are redirected for P inactivation in the smaller ponds.

The benthic barrier placement in the swim area was given a negative Determination of Applicability by the Wetlands Commission that required no further permitting, but any need for renewal should be addressed through the Wetlands Commission. The barrier was left in place through 2021 and should be inspected and cleaned as needed in late May or early June 2022. This can probably be accomplished by snorkeling with a broom. If the docks are installed in 2022, care should be taken not to damage the benthic barrier panels.

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 2022 season, so this may necessitate early maintenance on the older harvester and making the best possible use of it to keep up with plant growths. A focus on efficiency during actual harvesting operations is needed.

Treat Bezanson, Farms Station and Rockridge Ponds with aluminum in early to mid-June and again in July. Time one treatment of Rockridge Pond to immediately follow any plant harvesting performed in that pond. Abbotts Pond could be treated, but the dose may need to be higher and coverage should be more even than possible with spraying from the shoreline. Duck Pond is probably not worth treating until after it is dredged, but it requires the smallest amount of aluminum of any pond and can be done if it appears to need it.

Plan for dredging the sedimentation basin at the upstream end of Reeds Pond and all of Duck Pond. If funding can be secured, dredging as soon as possible is recommended.