# MORSES POND ANNUAL REPORT: 2020

**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 2020. 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 just the actions of 2020 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 2020. 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 4$^{th}$ 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 4668 gallons of polyaluminum chloride were applied to Morses Pond in 2020, representing 2754 lbs of aluminum, the lowest quantity applied since the initial testing year in 2008 (Table 1). Precipitation during the May-June 2020 period was 4.9 inches and for May-August it was 9.1 inches, both the second lowest values on record after 2016. Having only two storms between turning on the system on May 21st and the end of June, there was no means to distribute aluminum to the lake for most of the key target period. Additionally, the pump serving Bogle Brook did not run during the first storm. Early July rains were treated and would have been in most years, but treatment continued into August in 2020 to manage the phosphorus concentration. Inputs from April and the first 3 weeks of May, along with a certain amount of internal recycling in Morses Pond and hot, dry weather, led to more algae than usual, although the program still met the treatment goals.

**Table 1. Summary of Phosphorus Inactivation Effort, 2008-2020**

| 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 |

## Analysis of Program Results

Water quality is assessed prior to the start of treatment, normally in May, again in early summer, and yet again at least once 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). 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 2020 (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).

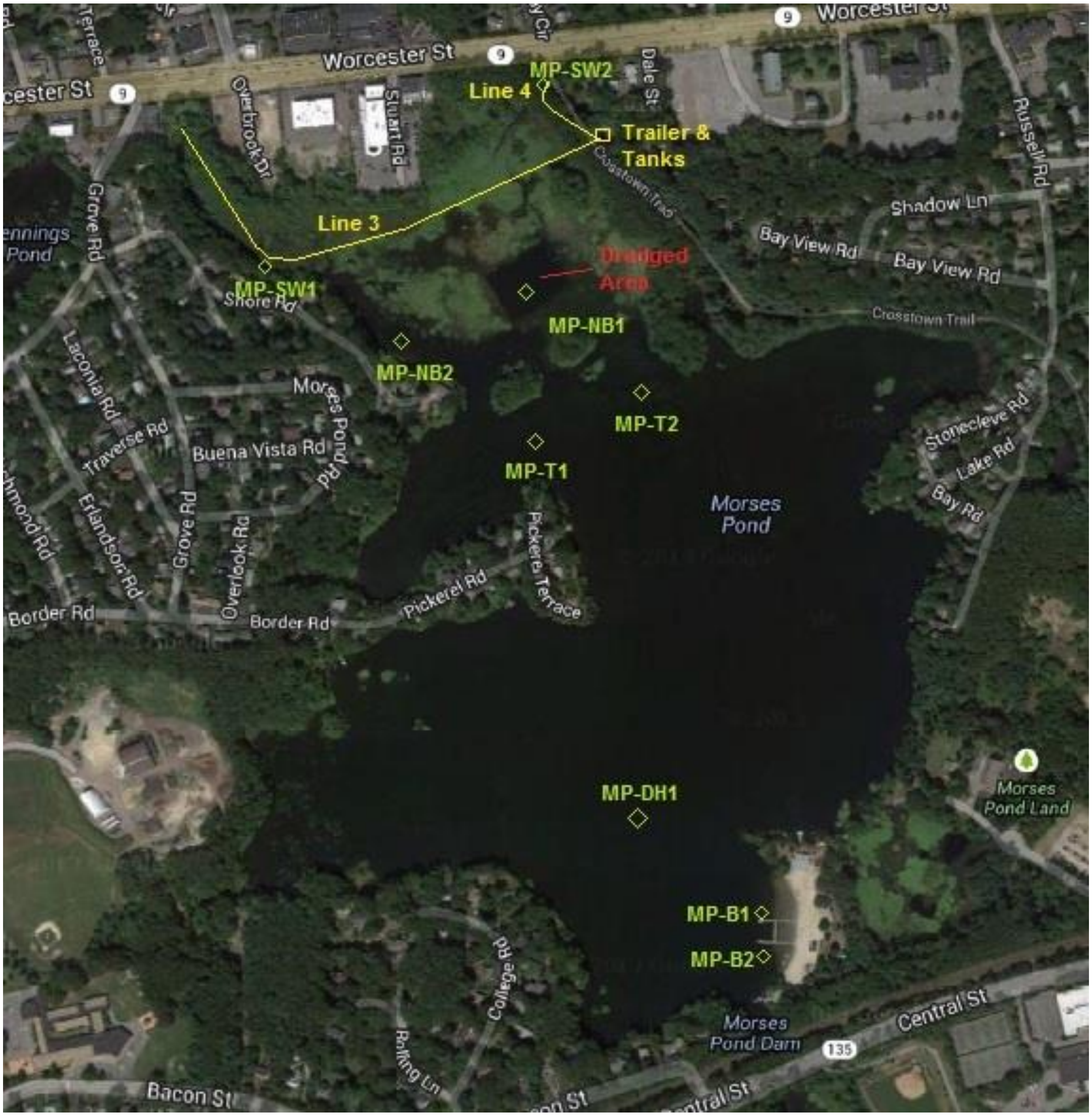
Total phosphorus concentrations were higher in 2019 and 2020 than in recent years. The relatively wet spring and summer seasons combined with lower overall application of aluminum in 2019 and the lower input of aluminum due to an absence of storms in 2020 resulted in higher phosphorus concentrations in the south basin, although the treatment objectives were still met. Phosphorus was maintained at <20 µg/L and did approach the more desirable 10 µg/L at the start of summer. Conditions remained acceptable in the pond into September, but there were higher phosphorus levels in the south basin in late spring and early summer that let algae get a foothold and the very warm weather undoubtedly allowed more algae to grow at the sediment-water interface from which they can rise and enter the water column as the summer progresses. This is a primary means for cyanobacteria blooms to develop, and while no true blooms were observed in 2020, we did have more cyanobacteria that in recent years.

Total Kjeldahl nitrogen values were moderate to high in 2019, ranging from 416 to 660 ug/L in surface waters and reaching a peak of 1960 ug/L in early September in the deepest water. A portion of the pond stratifies and loses oxygen, allowing ammonium to build up through decomposition. This condition also allows the release of phosphorus from deep sediments. The spring treatment period usually limits this increase, but with minimal treatment before summer there was more recycling; deep water phosphorus was 64 ug/L in early September. Nitrate was moderate in early May at 229-341 ug/L but declined to <50 ug/L at most stations by August. Loss of nitrate can be a concern, as low ratios of available N to available P favor cyanobacteria, and a shift toward cyanobacteria was observed in August.

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. 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.

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.

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



# Table 2. Water quality record for Morses Pond in 2020

| Station | Date | Depth | Temp | DO | DO | Sp. Cond | pH | Turbidity | CHL | Secchi | Total P | TKN | Nitrate N |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | MM.DD.YY | meters | °C | mg/l | % Sat | µS/cm | Units | NTU | µg/l | meters | ug/L | ug/L | ug/L |
| | | | | | | | | | | | | | |
| MP-NB1 | 05.21.20 | | | | | | | | | | 13.8 | 426 | 341 |
| MP-NB1 | 06.29.20 | | | | | | | | | | 14 | 416 | <50 |
| MP-NB1 | 07.27.20 | | | | | | | | | | 20.2 | 489 | <50 |
| MP-NB1 | 09.09.20 | 0.2 | 24.0 | 7.6 | 91.6 | 538 | 7.6 | 2.8 | 2.2 | | 11.7 | 585 | <50 |
| | 09.09.20 | 1.0 | 21.6 | 1.2 | 13.3 | 490 | 7.4 | 2.7 | 2.0 | | | | |
| | 09.09.20 | 2.0 | 20.6 | 0.2 | 2.0 | 530 | 7.0 | 3.7 | 5.1 | | | | |
| | 09.09.20 | 3.0 | 18.9 | 0.3 | 3.1 | 527 | 6.9 | 4.3 | 8.6 | | | | |
| | 09.09.20 | 3.9 | 15.8 | 0.2 | 2.3 | 670 | 6.6 | 30.3 | 36.4 | | | | |
| | | | | | | | | | | | | | |
| MP-NB2 | 05.21.20 | | | | | | | | | | 35.1 | 440 | 244 |
| MP-NB2 | 06.29.20 | | | | | | | | | | 21.3 | 533 | 67.8 |
| MP-NB2 | 07.27.20 | | | | | | | | | | 25.5 | 511 | 61.9 |
| MP-NB2 | 09.09.20 | | | | | | | | | | 12.8 | 448 | <50 |
| | | | | | | | | | | | | | |
| MP-T1 | 05.21.20 | | | | | | | | | | 40.4 | 450 | 234 |
| MP-T1 | 06.29.20 | | | | | | | | | | 28.7 | 607 | 90.1 |
| MP-T1 | 07.27.20 | | | | | | | | | | 25.5 | 630 | 55.8 |
| MP-T1 | 09.09.20 | | | | | | | | | | 12.8 | 443 | <50 |
| | | | | | | | | | | | | | |
| MP-T2 | 05.21.20 | | | | | | | | | | 43.6 | 496 | 229 |
| MP-T2 | 06.29.20 | | | | | | | | | | 31.9 | 660 | <50 |
| MP-T2 | 07.27.20 | | | | | | | | | | 23.4 | 504 | <50 |
| MP-T2 | 09.09.20 | | | | | | | | | | 11.7 | 472 | <50 |
| | | | | | | | | | | | | | |
| MP1 | 05.21.20 | 0.6 | 18.3 | 10.5 | 112.8 | 406 | 7.8 | 2.8 | 5.9 | 3.0 | 40.4 | 409.0 | 231.0 |
| | 05.21.20 | 1.0 | 18.1 | 10.5 | 112.3 | 406 | 7.8 | 3.0 | 7.4 | | | | |
| | 05.21.20 | 2.0 | 17.3 | 10.6 | 112.3 | 405 | 7.8 | 3.0 | 3.3 | | | | |
| | 05.21.20 | 3.0 | 13.8 | 10.0 | 98.1 | 402 | 7.7 | 2.9 | 2.2 | | | | |
| | 05.21.20 | 4.0 | 12.8 | 9.3 | 88.7 | 401 | 7.6 | 2.6 | 1.7 | | | | |
| | 05.21.20 | 5.0 | 12.4 | 8.3 | 78.9 | 402 | 7.5 | 2.6 | 1.7 | | | | |
| | 05.21.20 | 6.0 | 11.9 | 4.9 | 45.8 | 405 | 7.4 | 3.1 | 1.7 | | 34.0 | 310.0 | 285.0 |
| | | | | | | | | | | | | | |
| MP1 | 06.29.20 | 0.2 | 25.7 | 7.8 | 97.3 | 458 | 7.6 | 3.8 | 8.9 | 3.4 | 11.7 | 508.0 | 53.3 |
| | 06.29.20 | 1.0 | 25.8 | 7.8 | 97.3 | 457 | 7.6 | 4.2 | 7.8 | | | | |
| | 06.29.20 | 2.0 | 25.7 | 7.8 | 96.5 | 457 | 7.6 | 4.4 | 9.6 | | | | |
| | 06.29.20 | 3.0 | 24.0 | 7.4 | 89.4 | 441 | 7.6 | 4.2 | 6.5 | | | | |
| | 06.29.20 | 4.0 | 18.6 | 5.4 | 59.3 | 418 | 7.5 | 4.1 | 5.3 | | | | |
| | 06.29.20 | 5.0 | 14.7 | 1.5 | 14.8 | 411 | 7.4 | 4.2 | 7.6 | | | | |
| | 06.29.20 | 6.0 | 13.0 | 0.0 | 0.2 | 419 | 7.1 | 6.2 | 3.4 | | | | |
| | 06.29.20 | 6.3 | 12.6 | 0.0 | 0.0 | 422 | 7.0 | 6.7 | 3.4 | | 27.6 | 745.0 | 72.7 |
| | | | | | | | | | | | | | |
| MP1 | 07.27.20 | 0.3 | 29.3 | 9.3 | 123.4 | 533 | 7.6 | 4.5 | 1.6 | 3.2 | 13.8 | 470 | <50 |
| | 07.27.20 | 1.0 | 29.3 | 9.3 | 123.6 | 534 | 7.6 | 4.1 | 2.5 | | | | |
| | 07.27.20 | 2.0 | 28.0 | 9.1 | 117.8 | 534 | 7.6 | 4.3 | 6.3 | | | | |
| | 07.27.20 | 3.0 | 26.4 | 8.7 | 109.5 | 520 | 7.5 | 5.4 | 11.9 | | | | |
| | 07.27.20 | 4.0 | 23.1 | 1.2 | 14.5 | 503 | 7.2 | 7.3 | 7.3 | | | | |
| | 07.27.20 | 5.0 | 16.9 | 0.0 | 0.0 | 478 | 7.1 | 8.7 | 9.0 | | | | |
| | 07.27.20 | 5.0 | 16.6 | 0.2 | 2.5 | 476 | 7.0 | 9.9 | 8.8 | | | | |
| | 07.27.20 | 6.0 | 13.9 | 0.0 | 0.0 | 500 | 6.7 | 21.5 | 11.7 | | 36.1 | 711 | 82 |
| | | | | | | | | | | | | | |
| MP1 | 09.09.20 | 0.3 | 23.9 | 10.3 | 124.1 | 551 | 7.9 | 3.2 | 4.2 | 3.1 | 10.6 | 464 | <50 |
| | 09.09.20 | 1.0 | 23.7 | 10.4 | 124.5 | 549 | 8.2 | 3.3 | 6.0 | | | | |
| | 09.09.20 | 2.0 | 23.6 | 10.3 | 123.5 | 548 | 8.3 | 3.5 | 10.0 | | | | |
| | 09.09.20 | 3.0 | 23.2 | 9.9 | 117.8 | 547 | 8.2 | 3.5 | 13.9 | | | | |
| | 09.09.20 | 4.0 | 22.7 | 6.0 | 70.7 | 542 | 8.0 | 3.8 | 7.9 | | | | |
| | 09.09.20 | 5.0 | 20.7 | 0.2 | 1.8 | 520 | 7.5 | 4.5 | 3.4 | | | | |
| | 09.09.20 | 6.0 | 15.6 | 0.0 | 0.0 | 552 | 7.1 | 16.0 | 3.9 | | 63.8 | 1960 | <50 |
| | 09.09.20 | 6.3 | 15.1 | 0.0 | 0.0 | 569 | 7.1 | 27.9 | 10.2 | | | | |
| | | | | | | | | | | | | | |
| MP-B | 05.21.20 | | | | | | | | | | 36.1 | 397 | 198 |
| MP-B | 06.29.20 | | | | | | | | | | 10.6 | 574 | 54.7 |
| MP-B | 07.27.20 | | | | | | | | | | 13.8 | 465 | <50 |
| MP-B | 09.09.20 | | | | | | | | | | 20.2 | 471 | <50 |

# 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 |
| | 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 |
| **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 |
| **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 |

Salts from road management are a likely source. The pH is slightly elevated near the surface and declines with depth, as decomposition adds acids 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. 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. Alkalinity tends to be moderate at the deep hole location.

Average summer water clarity was slightly lower in 2020 than in any of the last 7 years since the inactivation system was enhanced, but clarity was still acceptable for contact recreation. The lower amount of aluminum delivered and the minimal input during late spring was the main factor here. Clarity was 3 m when the system was turned on, increased to 3.4 m at the end of June after only two treatment events, then declined slightly and gradually through the summer to a low of 3.1 m in early September. Experimentation with the timing and amount of aluminum added appears to now be sufficient to set a lower limit of about 3500 lbs per May-June application period or about 400 lbs per inch of precipitation. A total of 2754 lbs of aluminum was applied in 2020, very little of it in May-June. Compared to the 400 lbs per inch of precipitation guideline, just a little over 300 lbs per inch of precipitation was applied.

The 12-year phosphorus inactivation history can be functionally 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). While treatment in 2008 started late and was largely experimental, results for total phosphorus for 2008 were <20 μg/L. Similar results were achieved in 2009 and 2010; throughout these three years average summer phosphorus was 10-25 μg/L and average summer water clarity was about 3 m (10 ft). Equipment worked well and the operations team was effective in responding to storms.

Total phosphorus was somewhat elevated in 2011-2013, with summer averages of 22-45 μg/L. 2011 and 2013 were the rainy periods and equipment problems became more frequent. Timely repairs kept the treatments going, but they were not as efficient and apparently not as effective as in the previous three years. Detention capacity of the north basin was limited by shallow depth resulting from years of sediment deposition; dredging was planned for fall 2012 but not completed until 2013, and June 2013 set records for precipitation and flows. Water clarity averaged slightly more than 2 m (about 7 ft), not appreciably better than pre-treatment years, although it should be kept in mind that clarity would have been lower in the pre-treatment period if not for copper treatments.

After system modification in 2014 and 2016, clarity reached new highs (Figures 2 and 3). Outstanding conditions in 2014-2016 were a product of dry weather, effective treatment, and improved detention in the north basin following dredging. Phosphorus was low and water clarity was the highest it has been since implementation of the comprehensive plan (and indeed going back almost 30 years). No serious problems were encountered in application, chemical costs were not elevated, and labor costs were reduced by the automated application system in 2016. Wetter conditions in 2017 through 2019 and experimentation with lowering the amount of aluminum applied led to slightly higher phosphorus concentrations in those summers. Desirable conditions were achieved, but not quite at the levels observed in 2014-2016.

2020 stands out as an odd weather year (among other major oddities!), with little precipitation in May and June and therefore no impetus to run the inactivation system, which is triggered by precipitation and intended to treat runoff. While it can be manually overridden to run during dry weather, phosphorus concentrations tend to be lower then and the aluminum will react with other elements, so there is proportionally less benefit to running it during dry weather and no "reserve" of active aluminum is built up in the water column. Phosphorus concentrations prior to the start of 2020 treatment were elevated,

**Figure 2. Average summer water clarity and total phosphorus in Morses Pond, 1994-2020.**

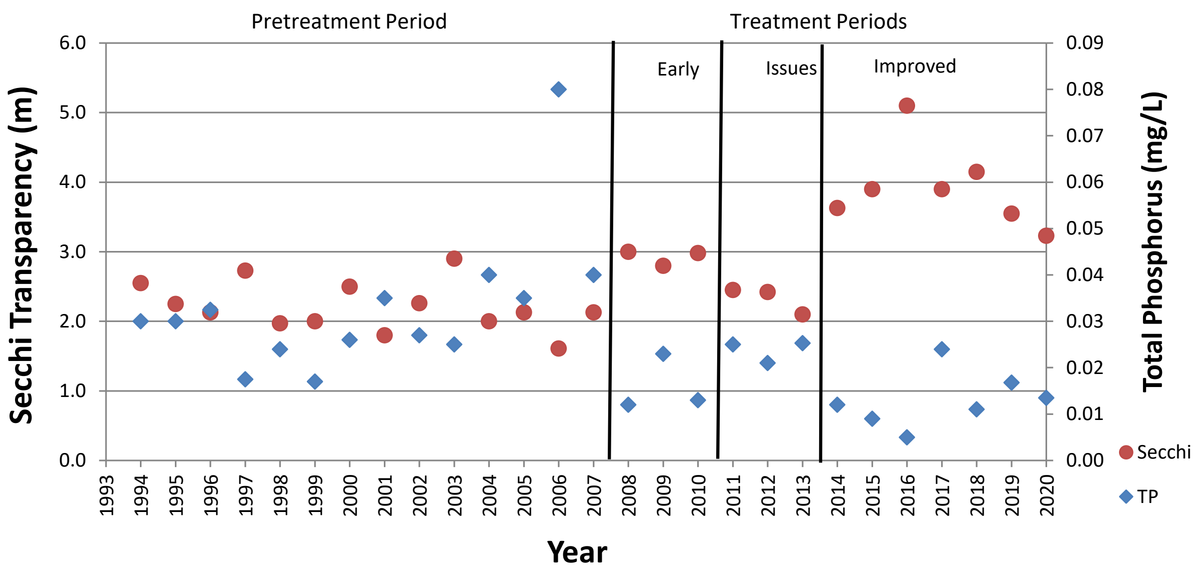
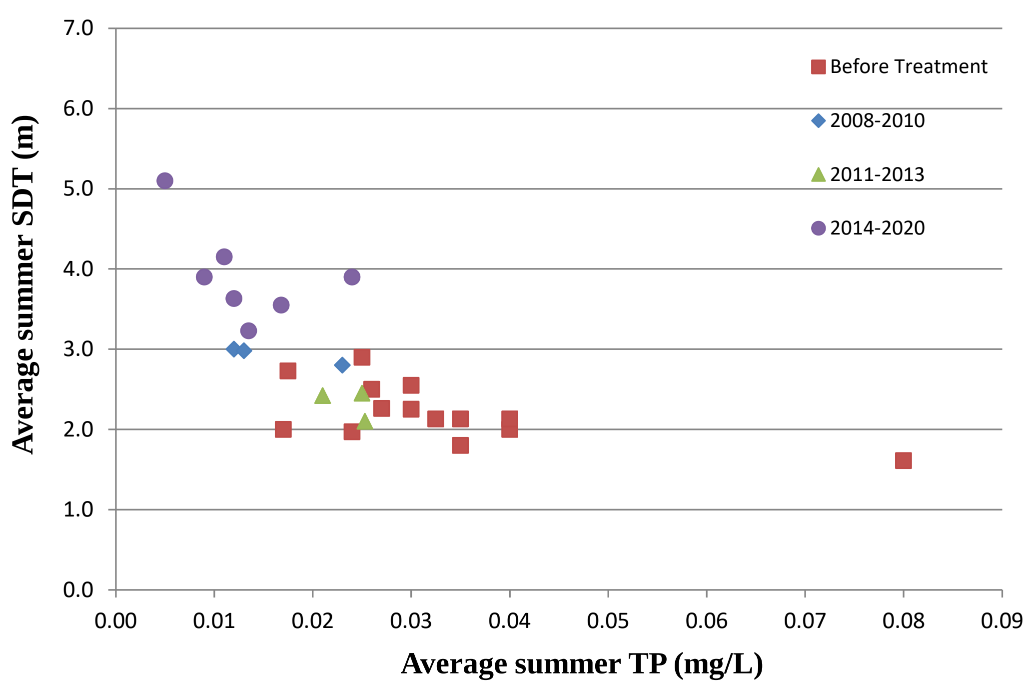



**Figure 3. Relationship between summer water clarity and total phosphorus in Morses Pond.**



so algae could grow, and extension of the treatment process through most of the summer amounted to a maintenance effort rather than a pre-emptive action.

Algal data for 1996-2020 illustrate processes in Morses Pond over the summer (Figure 4). 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 has been below the 1 mg/L threshold indicative of low biomass since the system adjustments of 2014 and cyanobacteria have represented only a small amount of biomass each year. 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 September of 2018 and 2019 some cyanobacteria of the problem genus Aphanizomenon were present, but no surface blooms developed.

In 2020 cyanobacteria were present as early as June and peaked in late August and early September but were still not a dominant component of the phytoplankton assemblage. Alert beach staff and residents noted small accumulations of cyanobacteria on several occasions, usually along shore but never in the swim area, and additional investigation by WRS revealed these to be species known to grow at the sediment-water interface then develop gas pockets in cells that make them buoyant. Once at the surface, the wind can concentrate them along shore. Concentrations in open water and the swim area were not high enough to constitute a human or ecological health threat, but there were more cyanobacteria and more algae in general than in any summer since 2013 and 2014 respectively. Better treatment in the May-June period is needed to minimize summer issues but is partly dependent on an uncontrollable weather pattern.

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 ug/L are low and values higher than 100 ug/L are high 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, filters 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 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. There is no indication of any aluminum toxicity to zooplankton; the treatment protocols minimize this probability. Zooplankton features in 2020 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 1996-2020.**

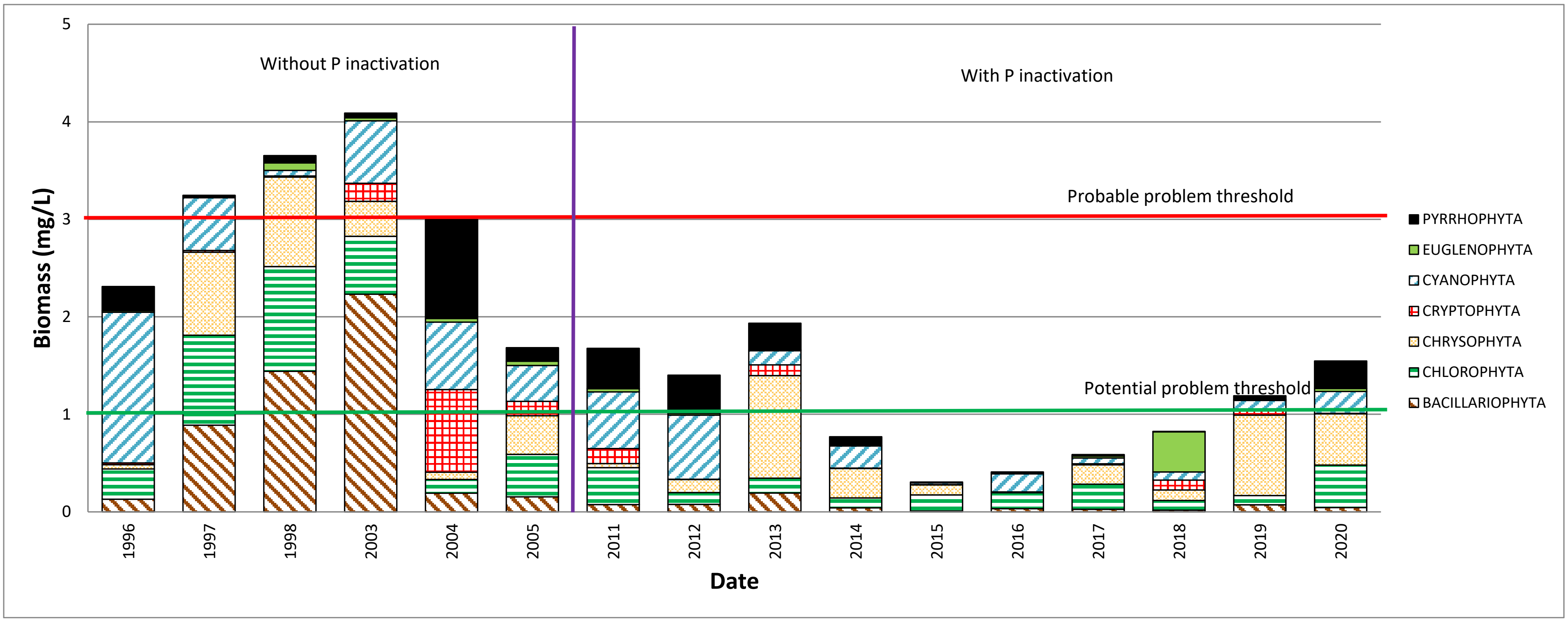


Figure 5. Zooplankton abundance for 1996-2020.

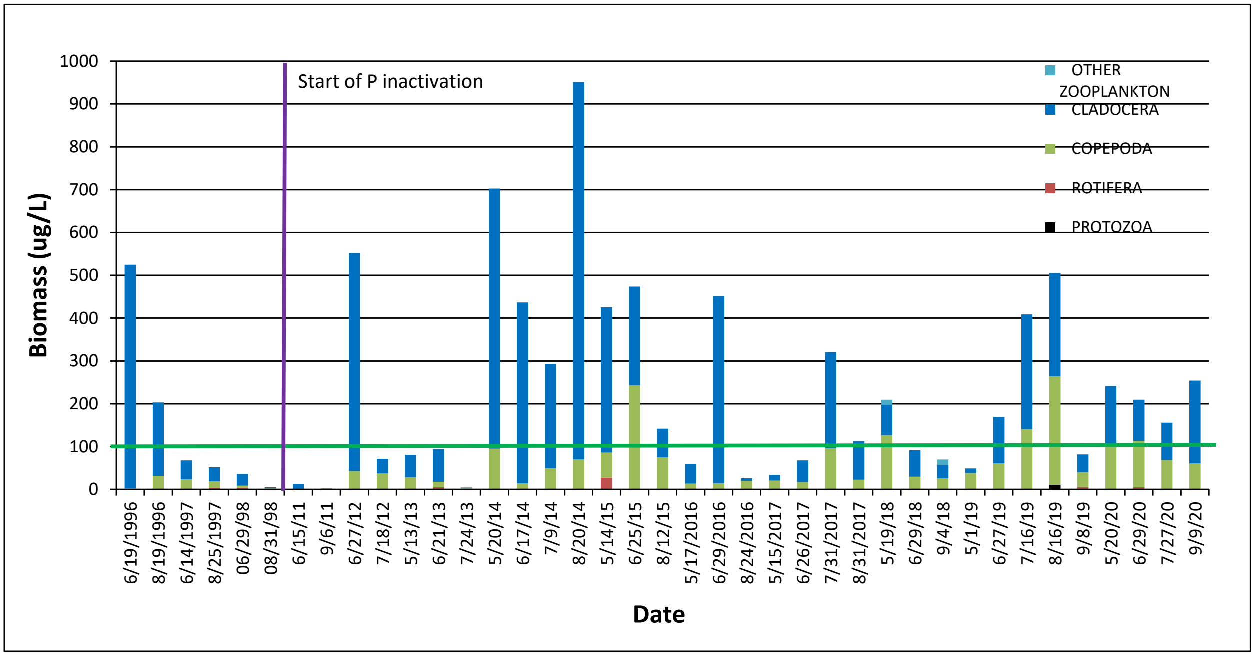
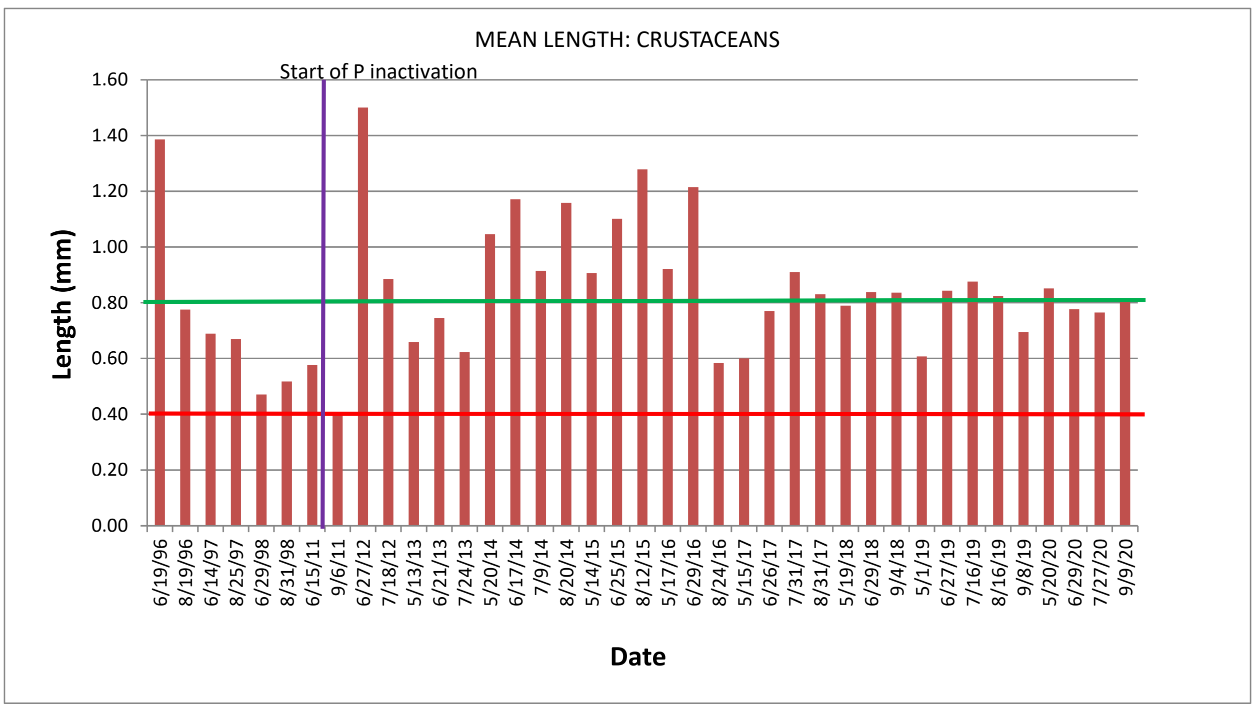



Figure 6. Crustacean zooplankton mean length, 1996-2020.



# 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. 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.

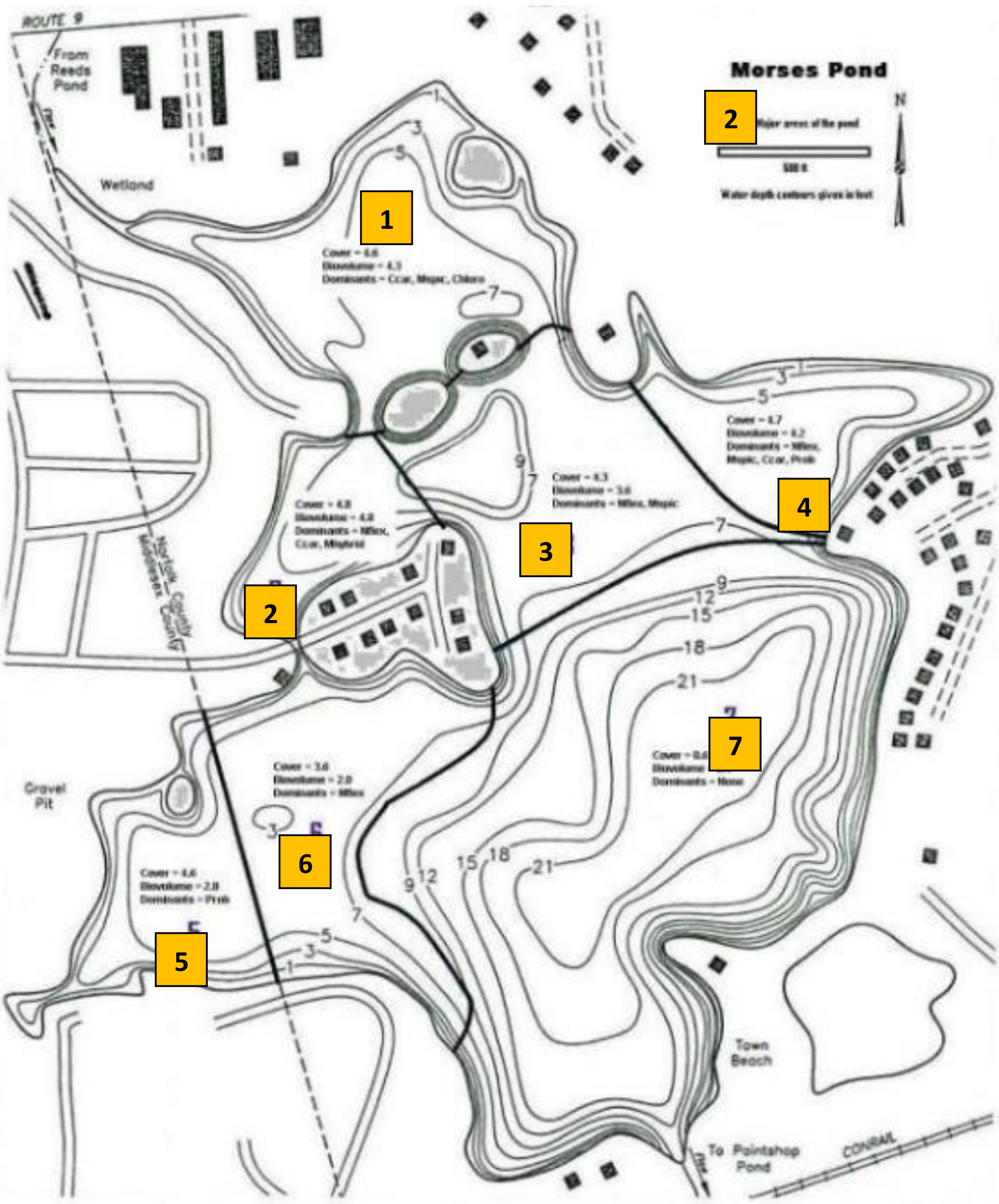
The keys to successful harvesting include:

- 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 30 years, with the oldest one retired a few years ago and the second oldest, and largest, due to be retired in FY22 if it can be replaced. 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 coincidental 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 Zones 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 2020, 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 2020 harvesting occurred on 48 days for a total of 411 hours with 267 hours actually spent cutting. Total loads of aquatic plants harvested have ranged from 54 to 127 per harvesting season, with 2018-2020 all very near the upper end of that range at 126 loads. Total weight of plants harvested, as measured upon entry to the composting facility (so some draining of water, but not a dry weight) has ranged from 224,000 to 808,000 lbs. The 2020 biomass total was estimated at about 195,000 lbs., <60% of the biomass harvested in 2018 and 2019 despite a similar number of cutting hours and loads. One reason that the weight per load was lower in 2020 is that full capacity in the older, larger harvester results in a weight that the aging conveyor cannot push out of the barge. Another is that the larger harvester was not ready for use until mid-June and the smaller harvester holds less biomass per load. As less plant mass was harvested, undesirable conditions were reported for Morses Pond in 2020.

An increasing number of non-cutting hours was observed from 2009 until 2015 (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 in successive years since 2017 and in 2020 it was about the same as back in 2012 and 2013 but was still over one third of all time devoted to the harvesting program.

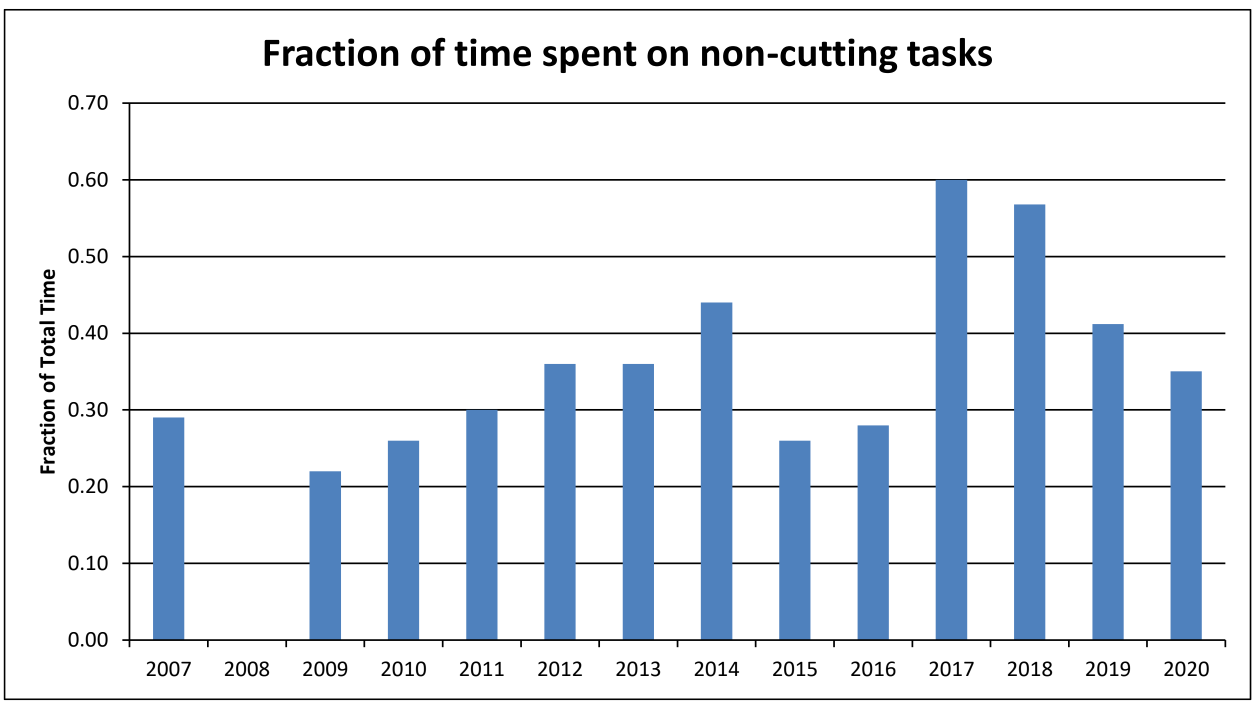
Efficiency is therefore an issue. The need to maximize cutting time conflicts with lower manageable load limits and more frequent trips back to the offloading location next to the outlet at the south end of the pond. Past efforts to establish other offloading points have met with resistance by shorefront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

The pandemic created additional constraints in 2020 and short staffing further limited availability of trained harvesting staff. The larger harvester was not ready to be put in service until mid-June and the smaller harvester had to be used initially. Harvesting occurred on fewer days in 2020 than in 2018 or 2019 but more hours were spent harvesting on those days than in the recent past, resulting a similar number of total cutting hours for the season and an almost identical number of loads hauled, but the loads were smaller and the total plan biomass removed was much less than usual.

**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 |
| For 2009 total hours, assumes 1.5 hr/harvesting day of non-cutting time, based on values for those days with total and cutting hours. | | | | | | | | | | | |
| For 2010 total weight, assumes 202,000 pounds resulting from hydroraking, based on values for days when hydroraking occurred. | | | | | | | | | | | |
| For 2012 and 2013, harvesting includes Area 1, which had very dense plant growths and accounts for additional weight removed. | | | | | | | | | | | |

**Figure 8. Non-cutting hours associated with the harvesting program.**



The other complication in 2020 was the weather, which was warmer earlier than usual and similar to 2016, another problem year for the harvesting program. With plants growing to higher densities earlier, harvesting needed to start earlier or employ both harvesters to catch up in later May, neither of which occurred. As explained previously, once the biomass increases to a high density, cutting becomes less efficient and it is hard to catch up. In 2020 the fanwort, an invasive species that is usually more of a problem in July or later, was already visible from the surface in early June and became very dense over even more of the pond than usual. This occurred in multiple Massachusetts ponds in 2020 and was largely a function of the weather. Despite the best efforts of the available staff and provision of as many hours as in recent years, conditions were much like 2016 when the harvesting program just could not keep up with plant growth that the pond was very weedy, prompting complaints from many residents and users.

## 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 we adjusted this approach to be more responsive to management needs, focusing on a smaller number of points in each designated zone of the pond and surveying 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.

### *2020 Results*

A total of 37 species are known from Morses Pond, with 28 plant species detected 2020 (Table 5), the highest number of species ever, one more than in 2019. Only 3 species were abundant, all invasive species (fanwort and two species of milfoil). Only 3 more species were common, all native species with nuisance potential (coontail and two types of water lilies). Oscillations in species richness are largely a function of less common species being found or not found in any given year and 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 abundant and the other present:

- *Cabomba caroliniana* (Fanwort) – dominant over much of the pond in 2020
- *Myriophyllum spicatum* (Eurasian watermilfoil) – locally dominant in 2020
- *Myriophyllum heterophyllum* (Variable watermilfoil) – locally dominant in 2020
- *Potamogeton crispus* (Curlyleaf pondweed) – present in 2020

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.

**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** |
| *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 |
| *Ceratophyllum demersum* | Coontail | C | C | C | A | 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 |
| *Cyanobacteria* | Blue green algae | | P | | C | P | P | | P | P | P | | | P | |
| *Decodon verticillatus* | Swamp loosestrife | C | P | | P | P | | | | | | | | P | P |
| *Elodea canadensis* | Waterweed | C | C | C | C | C | C | C | C | A | A | A | C | P | P |
| *Lemna Minor* | Duckweed | 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 |
| *Myriophyllum heterophyllum* | Variable watermilfoil | P | C | C | A | A | A | C | C | C | A | A | A | A | A |
| *Myriophyllum spicatum* | Eurasian watermilfoil | A | A | A | A | C | C | A | A | C | A | A | C | C | A |
| *Najas flexilis* | Common naiad | C | C | C | C | 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 |
| *Nuphar variegatum* | Yellow water lily | C | P | P | P | P | P | P | P | P | P | A | C | C | C |
| *Polygonum amphibium* | Smartweed | P | P | P | P | P | P | P | P | P | | P | P | P | P |
| *Pontederia cordata* | Pickerelweed | 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 |
| *Potamogeton crispus* | Crispy pondweed | | C | C | C | P | P | P | C | C | A | A | P | P | P |
| *Potamogeton epihydrus* | Ribbonleaf pondweed | | P | P | P | P | P | P | C | P | | P | P | P | P |
| *Potamogeton perfoliatus* | Claspingleaf pondweed | | | | | P | P | | P | P | | | P | P | P |
| *Potamogeton pulcher* | Spotted pondweed | 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 |
| *Potamogeton spirillus* | Spiral seed pondweed | | | | | 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 |
| *Trapa natans* | Water chestnut | | | | | | | | | | | | | | |
| *Utricularia geminiscapa* | Bladderwort | P | P | | P | | P | P | | P | P | | P | P | P |
| *Utricularia gibba* | Bladderwort | C | | | | 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 |
| | **P=Present, C=Common, A=Abundant** | | | | | | | | | | | | | | |

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 to high vegetation biovolume in the spring 2020 pre-harvest survey (Figure 9), suggesting rapid spring growth. Biovolume increased to dense levels in unharvested areas over the summer. Conditions were slightly worse in zones 2-4 than in zone 6 in mid-May 2020, much like in 2019. With the beach not opening as usual in 2020 due to the pandemic, more emphasis was placed on zones 2-4 again early in the harvesting program.

Overall biovolume decreased in areas that were harvested but did not achieve the target rating of ≤2 after the first cut was completed in late June. Extra effort by the staff in early July seemed reach the desired condition briefly at that point in time, but biovolume increased faster than it could be harvested and the target of an overall rating of 2 was not observed in the early September survey, after the second cut. Analysis of individual zones suggests that 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 2020 (Figure 10). Visual inspection indicated that invasive plants dominated. Conditions in the harvested zones were much better than in the unharvested areas (#1 and 5) but still unacceptable to many users. Peripheral growths of fanwort were a particular problem in 2020, with dense growths in areas that the harvester just could not reach without risk of damage due to shallow water.

Without adequate harvesting, the plant community of Morses Pond would be too dense in most areas and would be dominated by invasive species, impacting both human uses and habitat for many aquatic organisms and water-dependent wildlife. Harvesting with a larger harvester and support from a smaller harvester can control plant biomass and maintain open water in at least the upper half of the water column, produces very few negative impacts, and supports all designated uses of Morses Pond. Longer term shifts in species dominance have not been observed, so harvesting remains necessary each spring and summer. With more than about a week without harvesting in late spring and summer, for whatever reason, the density of invasive species can become too dense to manage efficiently afterward, especially in a year like 2020. Replacement of the existing, larger harvester is planned for FY22 and should help, but staffing limits and related complications from the pandemic along with weather conducive to early and accelerated plant growth resulted in less than desirable conditions in 2020.

The new, smaller harvester was used successfully in several smaller ponds in Wellesley in July 2020 but spent a lot of time on Morses Pond. It had its first downtime due to equipment malfunction and required repairs that kept it out of action for a couple of weeks late in June. Hopefully this was an isolated occurrence. There were multiple breakdowns with the larger, older harvester but once it was on the water in mid-June after barge leak repair all other repairs were made quickly and downtime was limited.

Figure 9. Biovolume comparison in areas with and without harvesting over time in 2020

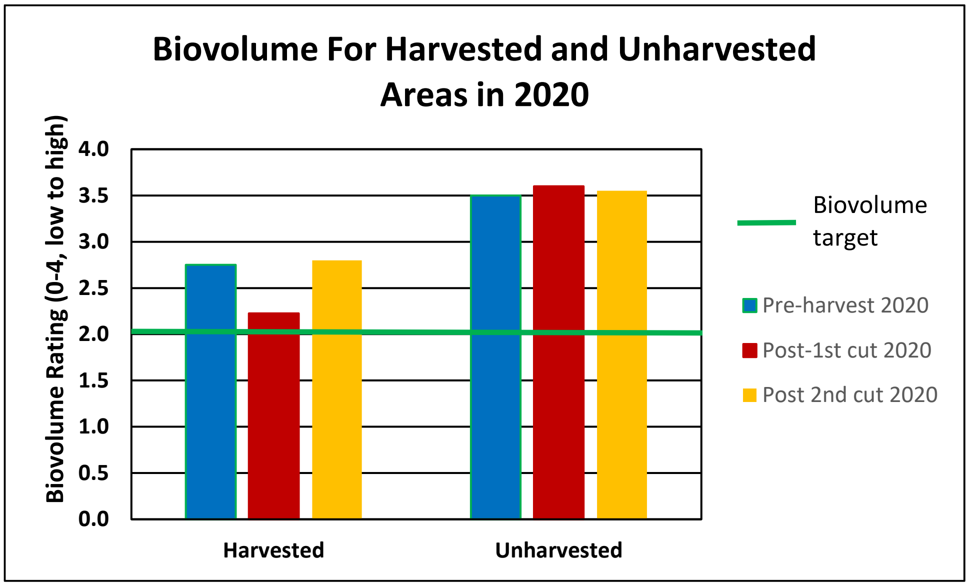
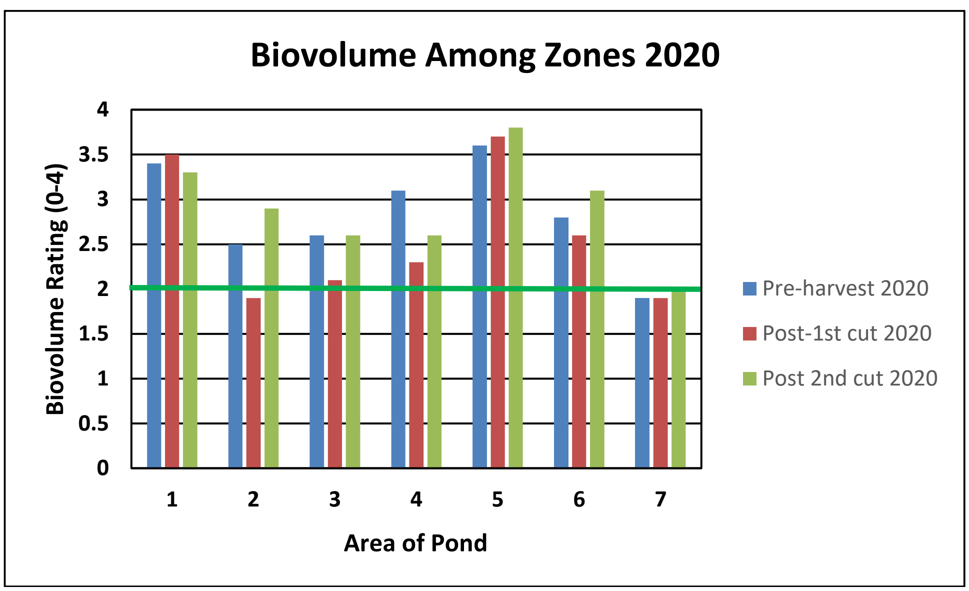



Figure 10. Biovolume comparison over time for each zone in 2020



## Additional Plant Controls

There have been some plant controls additional to mechanical harvesting. Hydroraking has occurred annually if needed in the beach area, prior to setting up the ropes and docks, and shorefront owners have contracted with the hydroraking outfit to do 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 swim area for better safety in 2017 and 2018. In 2017 through 2019 WRS assisted the Recreation Department with the purchase and installation of benthic barriers to restrict plant growths in key areas. This process went very well and eliminated the need for hydroraking in the swim area. Hydroraking is being considered for private shoreline areas through the Friends of Morses Pond for 2021 but no further raking in the public swim area is anticipated.

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 before removal 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. However, 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. It is hoped that normal operation can resume in 2021.

Hand harvesting of water chestnut is practiced each spring 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.

## Education

Education programs are ongoing in Wellesley, but no new initiatives were implemented by WRS in 2019. 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 has also been run at Morses Pond in recent years and sessions on aspects of the pond have been included. No in-person education was conducted in 2020, 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. 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 or 2020 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 that seemed transferable 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 22$^{nd}$ and August 17$^{th}$ of 2020 for the same ponds at the same doses.

Abbotts Pond showed limited response to treatment (Figure 11). Phosphorus did not decline to anywhere near the target level of 20 µg/L in 2018-2020 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. 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 all 3 years, showing declines in phosphorus (Figure 11) 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 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 12), making it far better in its role as a dog swimming pool.

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 12), 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 11), although not quite to the desired level, but there were only some peripheral algal mats and the pond looked good through the summer (Figure 12). Treatment in 2020 resulted in conditions similar to or slightly better than in 2019 (Figure 12), but there were some cyanobacteria mats that appeared near the outlet in August.

Rockridge Pond exhibited desirable decreases in phosphorus (Figure 12), chlorophyll-a and algae biomass in response to treatment in 2018, approaching or achieving the target levels after the second treatment.

**Figure 11. Phosphorus before and after aluminum treatments of five Wellesley Ponds**

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

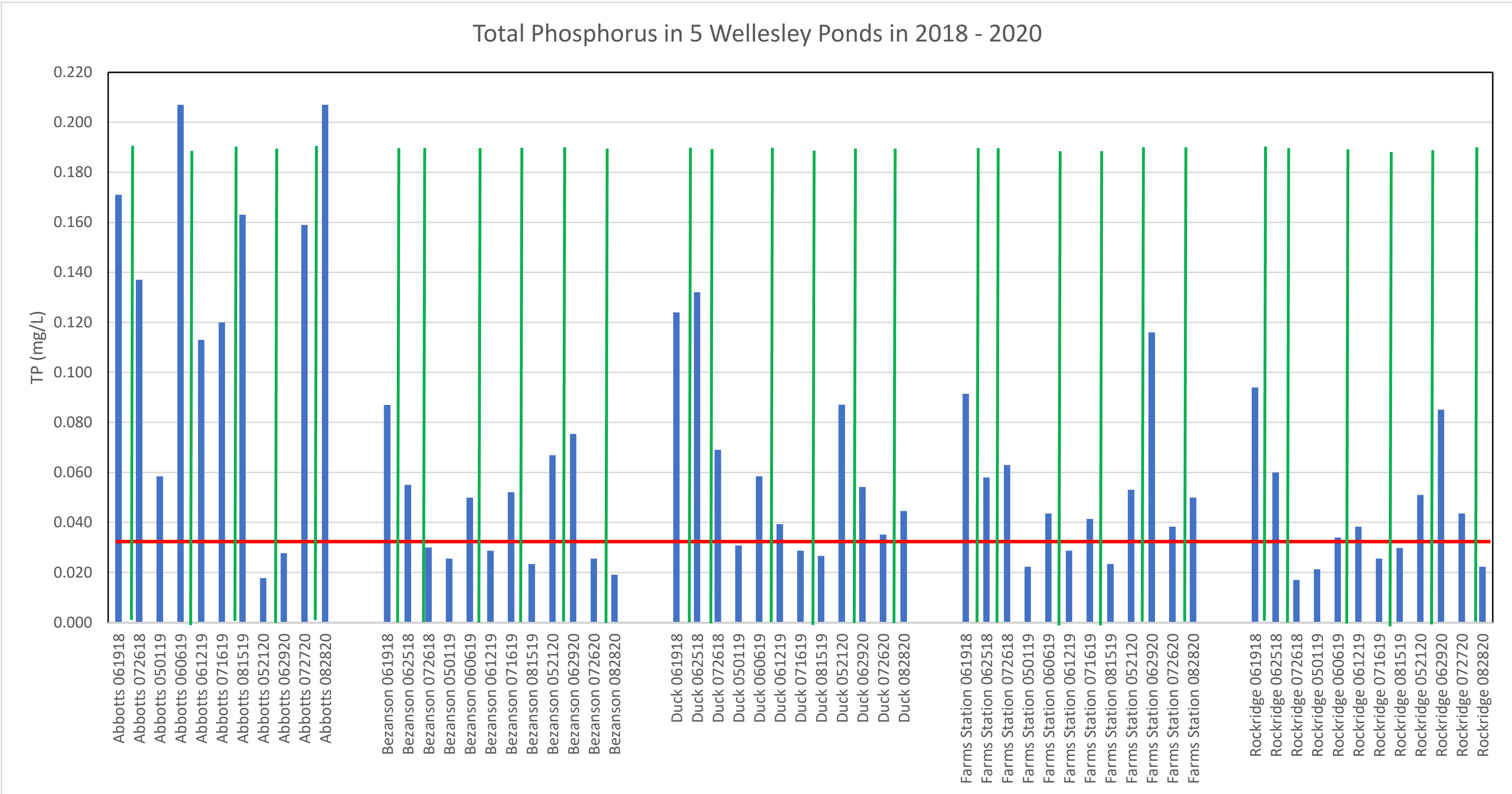


**Figure 12. Photographic documentation of improvement in two Wellesley Ponds**

**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**

In 2019 the treatment appeared to provide clear water, but phosphorus concentrations were not far above the desirable threshold even before treatment. There was some filamentous green algae, but not as much as in years prior to treatment, and there were no other problems 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.

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 use at 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 2020 were not acceptable.

## Needs for 2021

The following activities are recommended for 2021:

Orders of Conditions for both the harvesting and phosphorus inactivation programs will expire in spring 2021 and renewal is needed to conduct those programs in late spring and summer of 2021. The phosphorus inactivation program also requires an annual permit from the MA DEP that has transitioned to an online process in 2020. WRS opened an account in 2020 to meet tight timelines prior to the start of the treatment season, but the 2021 permit should be set up under a Wellesley account that will allow for easier renewal in the future. The benthic barrier placement in the swim area was given a negative Determination of Applicability that required no further permitting, but any need for renewal should be addressed through the Wetlands Commission.

The phosphorus inactivation system should be tested in early May and treatment should commence the week before Memorial Day. No change from recent operation is recommended, but application of more aluminum in the May-June period is needed if at all possible (based on weather).

Plant monitoring should occur in early May and harvesting should commence as early as needed to stay ahead of rooted plant growths. This may necessitate maintenance on the harvesters earlier than has been practiced in recent years, but that process is limited by maintenance space and staffing; late season snow removal and other priority activities have sometimes prevented more timely maintenance of the harvesters in the spring. A focus on efficiency during actual harvesting operations is needed.

A new, larger harvester should be ordered as early in FY22 as possible, assuming funding for that purchase remains in the budget. That harvester would not be available for use in 2021 but getting it early enough to do some training and be ready for use at the start of the 2022 harvesting season would be desirable.

Poll shorefront homeowners about the desire to have hydroraking performed in spring of 2021 and if there is sufficient interest, acquire permits and make arrangements with a vendor for the needed services.

Install the benthic barrier in the town swim area in late May. Consider using the additional panels purchased previously but not yet installed. This would double the bottom coverage and may be needed in light of observed plant conditions in 2020.

Treat Bezanson, Farms Station and Rockridge Ponds with aluminum in early to mid-June and again in July. Time the 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.