West Monponsett Pond

Halifax/Hanson, Massachusetts
2018 Year-End Alum Treatment Report

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Appendices

I. INTRODUCTION

Monponsett Pond located in the towns of Halifax and Hanson, Massachusetts, is a significant ecological, historical, and recreational resource as well as an important supplementary water supply component for the nearby City of Brockton. The 528-acre pond is bisected by Route 58, which splits the water body into two basins - East and West - directly connected by a small culvert in the Southern portion of the pond. Both basins are highly developed with residential homes and receive inputs from a suburban watershed of approximately six square miles.

As a whole, Monponsett Pond has been heavily impacted by the use of its waters and watershed, and both basins have been listed as Category 5 "Impaired" waterbodies on the Massachusetts Integrated List of Waters (303(d) list). The East Basin was listed for nuisance aquatic plants and mercury in fish. A TMDL was approved by the EPA for mercury, thus removing the basin from the list of impaired waters. The Western basin appears on the 2014 303(d) list as a category 5 water body for nutrients, noxious aquatic plants, transparency, and exotic species. The West Basin was included in the mercury TMDL and a draft TMDL for phosphorus was released in November of 2016.

Both basins, especially the West Basin, have been subject to extensive nuisance algae blooms (specifically cyanobacteria – blue-green algae) for many years. During recent summers, these blooms prompted the frequent closure of the Western basin to swimming and boating. Algae testing has been carried out both by the Massachusetts Department of Public Health (MA DPH) and Massachusetts Department of Environmental Protection (MA DEP) throughout the summer months. MA DPH also conducted analysis of water quality, including total phosphorus. These results show a definite correlation between concentration of total phosphorus and total algal cell count in the Western basin throughout the summer. Previous testing and the TMDL have determined that internal loading of phosphorus is prominent in the West Basin, along with watershed loading.

Despite these water quality challenges, the Western basin has been identified as an area of priority habitat by the Massachusetts Division of Fisheries and Wildlife (DF&W) Natural Heritage and Endangered Species Program (NHESP). Three state-listed species of special concern have been confirmed in West Monponsett Pond: Tidewater Mucket (*Leptodea ochracea*), Eastern Pondmussel (*Ligumia nasuta*), and Umber Shadowdragon (*Neurocordulia obsoleta*).

Internal Phosphorus Management

Understanding the correlation between phosphorus levels and growth of potentially harmful cyanobacteria, the Town of Halifax, in cooperation with MA DEP, has investigated and implemented phosphorus management activities in West Monponsett Pond**.**

Various parties have been addressing watershed phosphorus loading including efforts by nearby cranberry bogs. Work focusing on internal phosphorous inactivation began in 2013, under Lycott Environmental, in accordance with the NHESP letter (09-27490) dated June 6, 2012, and the submitted Habitat Management Plan. In that year, a volumetric dose of 3.0 ppm Al was applied in one treatment for a total areal (sediment) dose of 7.1 g/m2. No treatment occurred in 2014, and in 2015 the dose and method were changed to a total of 2.1 ppm Al over three treatments (0.7 ppm each), resulting in an additional sediment dose of 4.9 g/m2 Al. The 2016 season saw one application of 1.4 ppm Al, depositing 3.2 g/m2 Al on the pond bottom. Prior to 2017, a total of 15.2 g/m2 of aluminum have been applied to the bottom of the Western basin.

Following award of a Section 319 Grant to the Town of Halifax and revision of the Habitat Management Plan with NHESP, 17.0 g/m2 (~8 ppm Al) was applied to the West Basin in June of 2017. Despite this significant dose, the pond was still closed for a portion of the 2017 season due to high cyanobacteria counts along the shoreline

even though algae counts and phosphorous levels overall showed a significant improvement. For 2018, the plan was to apply an additional 10 g/m2 to the West Basin. Past treatments have sequentially reduced phosphorus levels in the West Basin and it was estimated that the proposed treatment will continue progress towards meeting WQ goals. With the proposed treatment in 2018, the total sediment dose applied to West Monponsett Pond is now 42.2 g/m2.

Based on experience in similar lakes and the assessment of sediment phosphorus release, a sediment dose of up to 50 g/m^2 is likely to be needed in order to sufficiently reduce internal phosphorus recycling for an extended period of time. The ongoing sediment release, in addition to annual watershed loading, has resulted in reduced efficacy of the past treatments in controlling nuisance bloom conditions, but phosphorus levels and overall conditions have been improving with each sequential dose applied to the pond.

II. PERMITTING

U.S. Environmental Protection Agency National Pollution Discharge Elimination System Permit

Lycott Environmental filed an electronic Notice of Intent (eNOI) under the U.S. Environmental Protection Agency Pesticide General Permit (PGP) for the application of pesticides to the Monponsett Ponds on behalf of the Town of Halifax on May 9, 2012. This application was signed and submitted by the Town of Halifax on May 19, 2013, which then received an active status ten days following its submission. The NOI remains valid through 2018 and will be extended as necessary.

Massachusetts Endangered Species Act Project Review

A 'REVISED Habitat Management Plan for Phosphorus Inactivation in the Western Basin of Monponsett Pond' was submitted to the Massachusetts Division of Fisheries and Wildlife (DF&W) Natural Heritage and Endangered Species Review Program (NHESP) on March 27, 2017. The NHESP provided approval correspondence on May 4, 2017. This revised plan covered work up through the 2018 treatment.

Order of Conditions

The Orders of Conditions (Halifax & Hanson) have been automatically extended by the Permit Extension Act and are therefore valid for an additional four years from the original date of expiration or until June 2019. Revised alum treatment plans were presented to both Commissions in the spring of 2017. Requests for Extensions will need to be made with the Commission to allow work to continue past June 2019.

Massachusetts Department of Environmental Protection License to Apply Chemicals

SLM prepared and filed for the required License to Apply Chemicals permit from MA DEP Office of Watershed Management; the approved license was issued on May 14, 2018 (#18282).

Image 1: Treatment Vessel

III. 2018 TREATMENT PROGRAM CHRONOLOGY

The tasks performed as part of the 2018 treatment program are outlined below.

- Received approved MA DEP License to Apply Chemicals 5/14/2018
- Alum treatment 5/15 – 5/18/2018

IV. TREATMENT LOGISTICS

Alum applications were administered throughout four (4) days: May 15th through May 18th. The applications were conducted with a specially equipped treatment vessel (**Image 1**). The treatment vessel was equipped with

2 translucent polyethylene tanks, in addition to a fathometer, speedometer, in-line pressure gauges and flowmeters to measure and ensure appropriate chemical delivery. Two separate pumping systems were used to apply aluminum sulfate and sodium aluminate to areas greater than 4' in depth in the West Basin of Monponsett Pond, an area totaling 235 acres. The 235-acre treatment area was divided into three pre-determined treatment zones (**Image 2**) with similar depth characteristics in order to ensure accurate dosing and a more uniform application of the alum and sodium aluminate. An areal dose of 10 g/m^2 was applied to each treatment area. Over the course of the four-day treatment, a total of 19,000 gallons of aluminum sulfate and 9,500 gallons of sodium aluminate were applied to West Monponsett Pond. A map of the treatment vessel tracks from the entire treatment event is provided in **Image 3**.

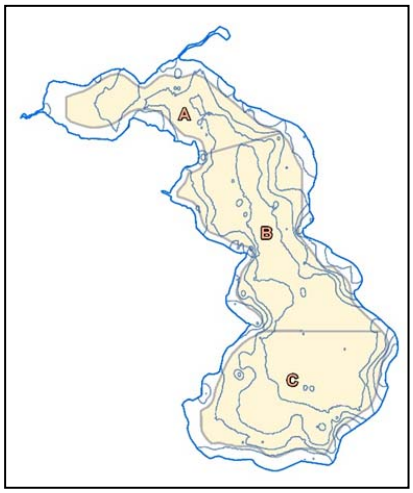


Image 2: Treatment Zones of the Western Basin of Monponsett Pond

Image 3: 2018 Alum Treatment tracks

V. MONITORING PROGRAM

The following table outlines the major components of the monitoring program and their respective goals, as approved in the habitat management plan ('**Appendix A**'). Mussel monitoring was conducted following treatment in 2017 and, based on the revised Habitat Management Plan, no further mussel monitoring is required until one year after alum treatments have ceased.

Table 1. Monitoring program design

Monitoring component	Timing in relation to treatment	Location(s)	Goals
Water Quality	Before, during and after application	Established location within each treatment zone	Evaluate short and long-term effects on water quality
	Monthly		Monitor summer long water quality and algae conditions

a. WATER QUALITY MONITORING

The water quality monitoring was comprised of sample collection for laboratory analysis and basic *in-situ* testing. Water quality samples were collected at predetermined locations within each treatment area immediately before the May treatment event, as well as once a month for four months after the treatment. Each sample was analyzed for: water clarity, pH, turbidity, alkalinity, total phosphorus, and dissolved phosphorus ('**Appendix B, Table 1**'). The *in-situ* treatment testing was performed at the same predetermined

locations before, during and after each treatment day. The testing included temp/dissolved oxygen, water clarity, pH, and alkalinity ('**Appendix B, Table 2**').

Total Phosphorus Monitoring

A total phosphorus measurement was collected monthly from May through October (**Figure 1**). The May sample was collected prior to the treatment. Total phosphorus levels decreased overall following the treatment event, but spiked in August before decreasing again in October. The results show a reduction in total phosphorus of over 50% (Avg. 23 ppb May – <10 ppb at all stations in October) during the course of the season. All samples in October were below the detection limit of 10 ppb.

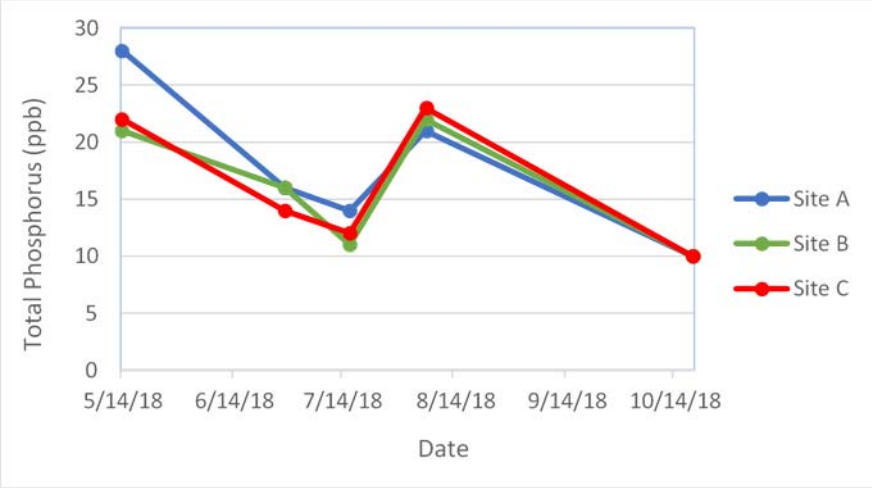


Figure 1: Comparison of total phosphorous (ppb) from May to October

Dissolved Phosphorus Monitoring

A dissolved phosphorus measurement was also collected at each station starting before the treatment, through October (**Figure 2**). Dissolved phosphorus levels were varied from 10-17 ppb prior to treatment, were below detection in June, spiked in July and August at varied station before coming in below detection limits in October. Overall, the results show a significant reduction in dissolved phosphorus during the course of the season.

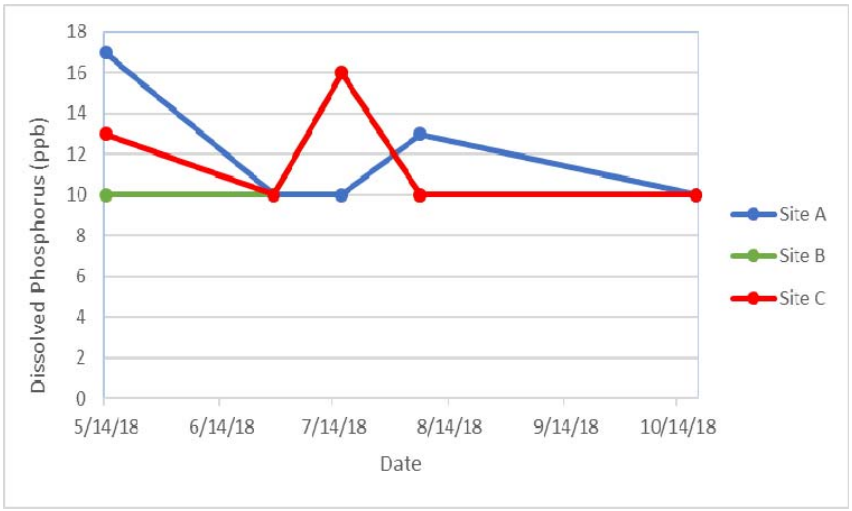


Figure 2: Comparison of dissolved phosphorus (ppb) from May to October

Dissolved Oxygen Monitoring

A dissolved oxygen measurement was collected once a month from May to October (**Figure 3**). A slight increase in dissolved oxygen was observed following the May treatment event; however, levels later decreased, before increasing again at the final measurement. The dissolved oxygen measurements revealed that levels remained within a suitable range (> 5 mg/L) for wildlife populations throughout the duration of the program and were not substantially impacted by the buffered alum treatments.

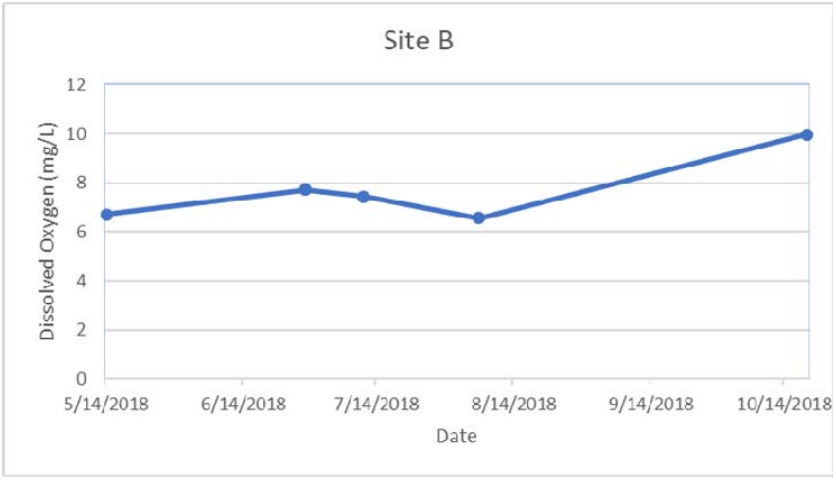


Figure 3: Average dissolved oxygen (mg/L) sampling results of Site B from May to October.

Water Clarity Monitoring (via Secchi Disk)

Water clarity was measured before, during and after each day of the May treatment event (Appendix A - Table 2), and subsequently once per month until October (**Figure 4**). Throughout the four days of the treatment event, the Secchi depth stayed relatively stable between 7 and 8 feet. Clarity improved in July, before decreasing in August. The reduction in water clarity (Secchi depth) in August correlates with an increase in algal cell density.

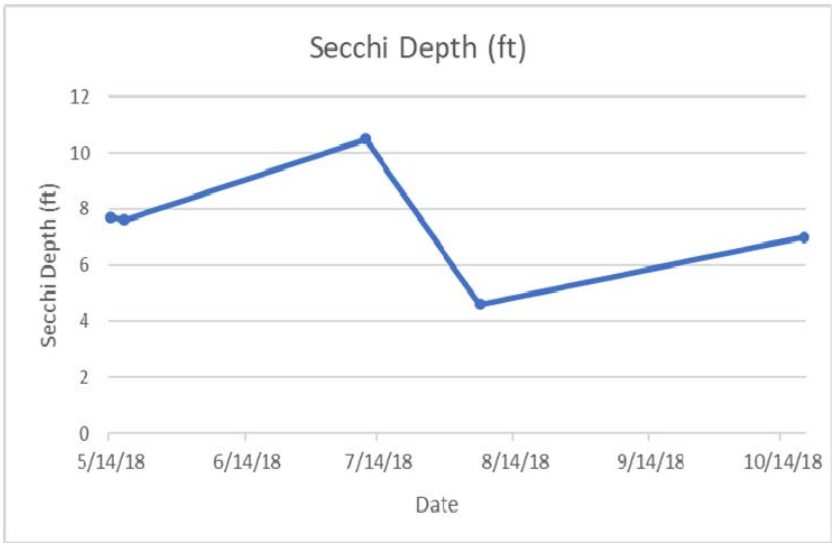


Figure 4: Average Secchi Disk depth (ft.) results of all three treatment zones throughout May treatment event and the following 5 months.

pH Monitoring

A pH measurement was collected before, during and after each day of the May treatment (Appendix A - Table 2) event as well as monthly through October. (**Figure 5**). Overall, the results show relatively constant pH levels between 6.5 and 7 SU, with minimal fluctuation throughout the treatment event.

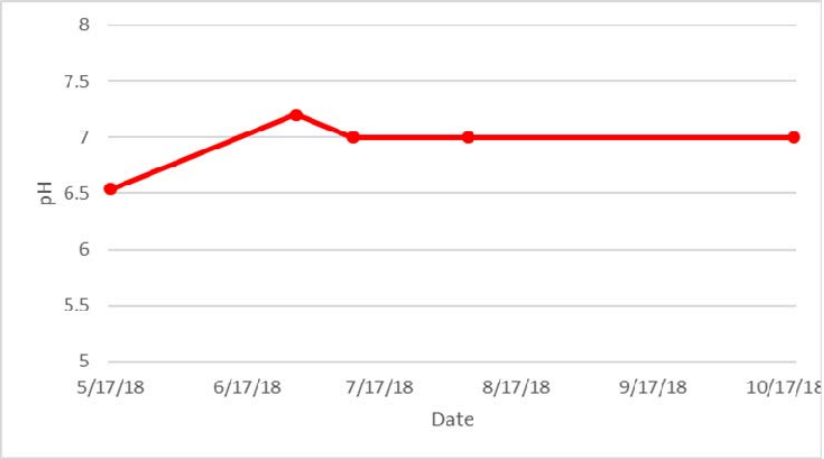


Figure 5: Average pH results of all three treatment zones from May to October.

Total Alkalinity Monitoring

Total alkalinity was measured before, during and after each day of the May treatment event, and subsequently once per month until October (**Figure 6**). The total alkalinity measurements remained between approximately 10 and 12 mg/L throughout the treatment event, with some fluctuation between each day. In the following months the total alkalinity steadily increased, before plateauing.

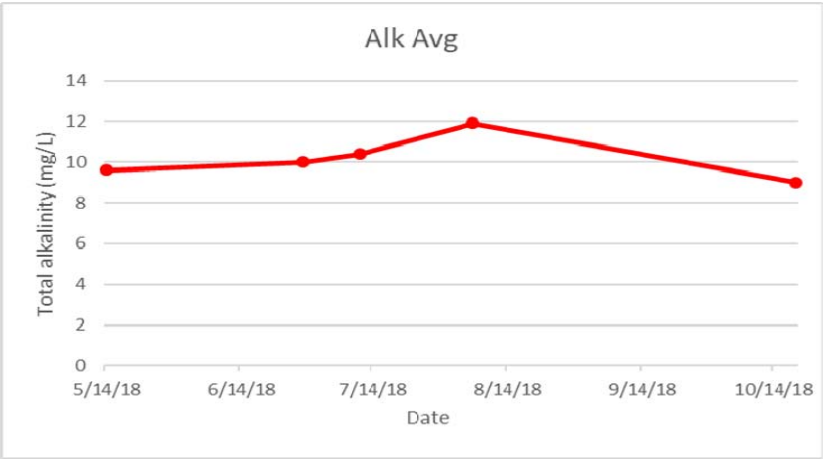


Figure 6: Average total alkalinity (mg/L) results of all three treatment zones from May to October.

b. ALGAE SAMPLING

A single monthly sample (May-October) was collected from Area B within the West Basin for algae species identification and characterization of general species abundance/dominance. Based on the results of these samples the algae assemblage presented a fair amount of variance from month to month. See **Table 1** for a breakdown of the natural count/mL of each phylum of algae observed in the monthly samples.

Table 1:	**Phylum of Algae (Natural Unit Count/mL)**				
Date	**Diatomaceae**	**Rotifera**	**Chlorophyceae**	**Cyanophyceae**	**Protozoa**
5/14/18	41	-	59	-	103
6/28/18	112	-	40	18	370
7/11/18	350	-	-	1,480	1,365
8/6/18	595	-	140	1,845	70
10/19/18	115	-	-	66	-

Overall phytoplankton growth was low in May and June. Cell density increased in July and August, with cyanobacteria comprising the majority of the increase along with Protozoa in July. Overall density remained low. The most abundant and frequently observed blue-green algae were *Chroococcus, Gomphosphaeria and Microcystis.* The blue-green algae cell count fluctuated throughout the 2018 management season, but never exceeded 10,000 cell/ml at anytime. (**Figure 7**).

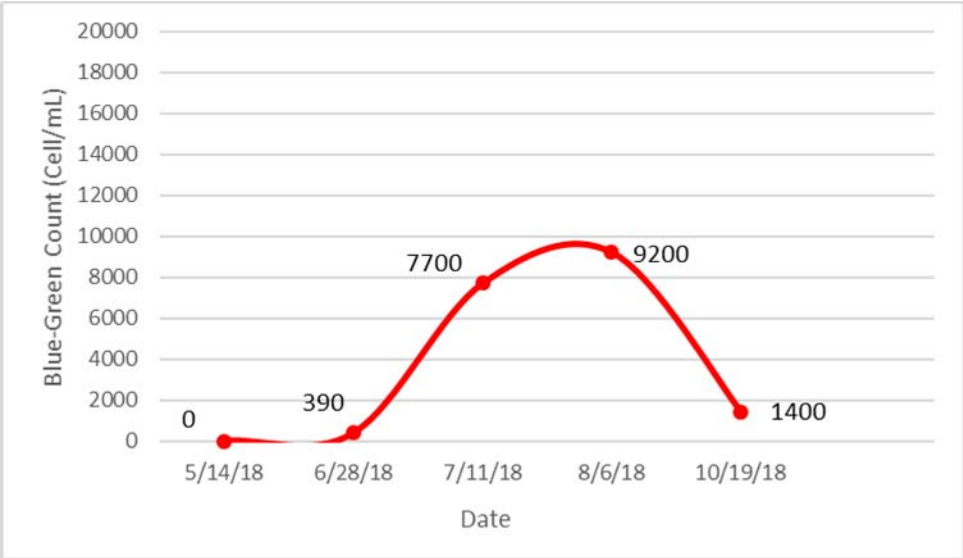


Figure 7: Blue-Green Count/mL from May to October.

VI. DISCUSSION/CONCLUSION

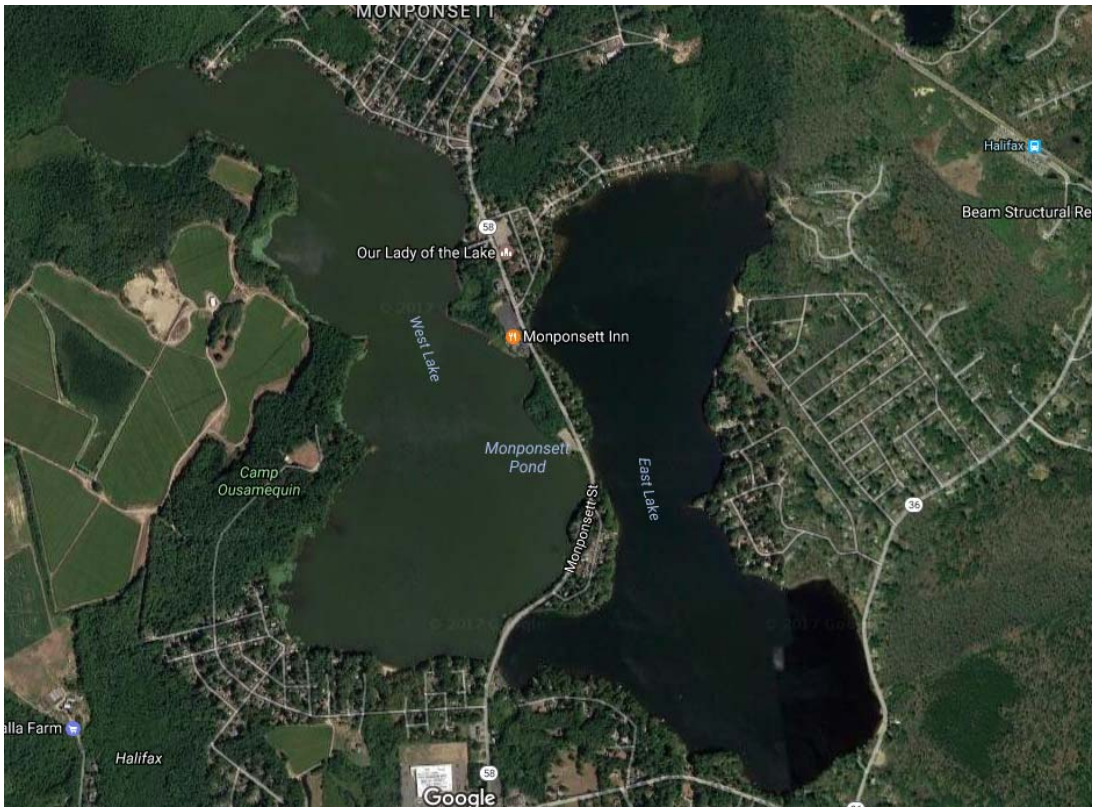
Overall, the 2018 alum treatment at West Monponsett Pond was conducted successfully and with no adverse effects on water quality or non-target organisms. The treatment served to apply an additional 10 g/m^2 of aluminum to the sediment in order to further counteract internal phosphorus loading. Monthly water quality sampling showed overall improvements in phosphorus concentrations, water clarity and algae populations as compared to previous years and the West Basin was not closed to recreation at any point this summer.

We understand that the Town is working with MassDEP to fund another round of alum treatment at the West Basin, and possibly the East Basin in 2019. Another round of treatment in 2019 should bring the applied dose up to the target 50 g/m2 and will hopefully preserve the great conditions seen on the pond in 2018.

Appendix A

REVISED Habitat Management Plan for Phosphorus Inactivation in the Western Basin of Monponsett Pond

REVISED Habitat Management Plan for Phosphorus Inactivation in the Western Basin of Monponsett Pond (2017)



Applicant: Town of Halifax
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Representative: SOLitude Lake Management
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REVISED Habitat Management Plan for Phosphorus Inactivation in the West Basin of Monponsett Pond Halifax/Hanson, Massachusetts 2017

SITE DESCRIPTION & BACKGROUND

Monponsett Pond, located in the towns of Halifax and Hanson, Massachusetts, is a significant ecological, historical, and recreational resource as well as an important supplementary water supply for the nearby City of Brockton. The 528-acre pond is bisected by Route 58, which splits the water body into two basins - East and West - directly connected by a small culvert in the Southern portion of the pond. Both basins are highly developed with residential homes, and receive inputs from a suburban watershed of approximately 6 mi^2.

As a whole, Monponsett Pond has been heavily impacted by the use of its waters and watershed, and both basins have been placed on the Massachusetts Integrated List of Waters (303(d) list). Since 2010, the Eastern basin has been categorized as a 4c water body for presence of exotic species and a Total Maximum Daily Load (TMDL) was published in 2007 for high concentrations of mercury. The Western basin appears on the 2010 303(d) list as a category 5 water body for nutrients, noxious aquatic plants, turbidity, and exotic species. A draft TMDL for phosphorus was released in November of 2016. The presence of two exotic aquatic vegetation species; Fanwort (*Cabomba caroliniana*) and Variable Milfoil (*Myriophyllum heterophyllum*), have been recorded in the Eastern basin, while presence of Fanwort was noted in the Western basin.

Both basins have also been subject to extensive nuisance algae blooms (specifically cyanobacteria – blue-green algae) for many years. During recent summers, these blooms prompted the frequent closure of the Western basin to swimming and boating. Algae testing has been carried out both by the Massachusetts Department of Public Health (MA DPH) and Massachusetts Department of Environmental Protection (MA DEP) throughout the summer months. MA DPH also conducted analysis of water quality, including total phosphorus. These results show a definite correlation between concentration of total phosphorus and total cell count in the Western basin throughout the summer.

Despite these water quality challenges, the Western basin has been identified as an area of priority habitat by the Massachusetts Division of Fisheries and Wildlife (DF&W) Natural Heritage and Endangered Species Program (NHESP). Three state-listed species of special concern has been confirmed in West Monponsett Pond: Tidewater Mucket (*Leptodea ochracea*), Eastern Pondmussel (*Ligumia nasuta*), and Umber Shadowdragon (*Neurocordulia obsoleta*).

PROPOSED PHOSPHORUS INACTIVATION PROGRAM

This phosphorous inactivation project began in 2013, under Lycott Environmental, in accordance with the NHESP letter (09-27490) dated June 6, 2012, and the submitted Habitat Management Plan. In that year, a volumetric dose of 3.0 ppm Al was applied in one treatment for a total areal (sediment) dose of 7.1 g/m^2. No treatment occurred in 2014, and in 2015 the dose and method was changed to a total of 2.1 ppm Al over three treatments (0.7 ppm each), resulting in an additional sediment dose of 4.9 g/m^2 Al. The 2016 season saw one application of 1.4 ppm Al, depositing 3.2 g/m^2 Al on the pond bottom. To date a total of 15.2 g/m^2 of aluminum has been applied onto the pond bottom.

Table 1-Historical Dosing Information

Treatment Year	Volumetric Dose	Areal Dose	Notes
2013	3.0 ppm	7.1 g/m^2	Single application
2015	2.1 ppm	4.9 g/m^2	Split over three applications
2013	1.4 ppm	3.2 g/m^2	Single application
Total Areal Dose Applied		**15.2 g/m^2**	

Based on experience in other similar lakes and assessments of the sediment phosphorus release, a sediment dose of up to 50 g/m^2 is likely to be needed in order to sufficiently reduce internal phosphorus recycling. This ongoing sediment release in addition to annual watershed loading has resulted in reduced efficacy of the current treatment plan on controlling nuisance bloom conditions. Based on recent discussion with Mark Mattson (MassDEP) modifications to the management plan are proposed. As a note, based on the recent phosphorus TMDL draft, alum treatment may be conducted in the East Basin of Monponsett Pond at a reduced dose, however no listed species have been identified in that basin.

Aluminum Dose Modification

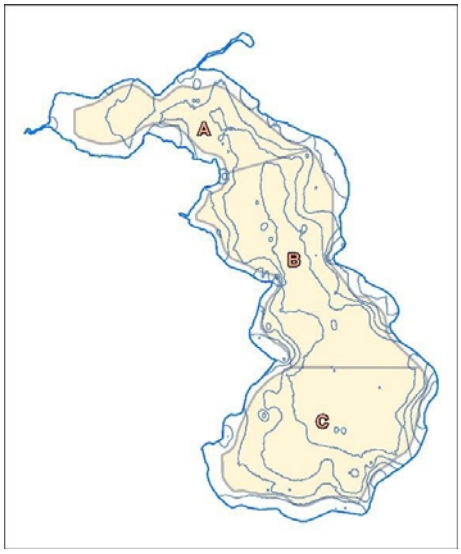
In 2017, the alum treatment plan will involve at least one large scale, early season application of 9.0 g/m^2 (~4 ppm Al) with the hope of inactivating a sufficient amount of available phosphorous in the pond sediments to provide desirably low growth of cyanobacteria. Past treatments have sequentially reduced phosphorus levels in the West Basin and it is estimated that the proposed treatment will meet WQ goals at least for a period of time. Depending on available resources, the dose may be increased up to 17.0 g/m^2 as a single or split-application treatment in 2017. Depending on how dramatically conditions improve in the lake, subsequent applications may not be necessary, however the remaining dose (up to the projected total dose of 50 g/m^2) may be applied in 2018 or plans and grants are also being pursued for an alum micro-floc injection system. The benefit of the injection system is that it will be in place to provide an option for addressing continued watershed phosphorus loading on an on-going basis. A summary of the 2017 treatment results and monitoring data will be supplied to NHESP in the fall, to facilitate their review of any proposed treatments in 2018.

Table 2-Proposed Alum Treatments for West Monponsett Pond

Treatment Year	Areal Dose	Notes
2017	9.0-17 g/m^2	Single or split application – any increase above 9 g/m^2 is pending funding and determination of need.
2018	Up to 17 g/m^2	Single or split application – only applied if needed after assessing results of 2017 treatments and pending funding. Also pending review by NHESP.

Treatment Area

No change to the overall extent of the treatment area is proposed. As with the 2013/2015-2016 treatment program, the aluminum sulfate and sodium aluminate will be applied to areas of the West Basin that are deeper than four (4) feet – a total treatment area of approximately 235 acres. We are proposing to divide the overall treatment area into three zones with relatively uniform depth characteristics (Zone A – 45 acres; Zone B – 98 acres; Zone C – 92 acres). This approach will enable accurate dosing and more uniform application without increasing the risk to rare species.



Application Methodology

Treatment will be conducted with our specially equipped treatment vessel. The treatment vessel will be equipped with a fathometer and speedometer. The use of the speedometer enables us to prepare calibration table for chemical delivery (gal/min) versus vessel speed (mph) which will insure even distribution of the alum and sodium aluminate. Suitable in-line pressure gauges and flowmeters to measure chemical delivery rates will also be used.

The treatment vessel will be equipped with 2 translucent polyethylene tanks with a combined capacity of up to 1,500 gallons. These tanks are also graduated on the outside, which allows our operators to visually monitor chemical delivery to insure the desired volumetric ratio is met.

Since the two chemicals cannot be tank-mixed prior to application, there are two separate pumping systems for each product including individual spray lines and drop-hoses. The chemical delivery spray boom will be mounted on the stern of the boat where the drop-hoses will emit the chemicals into the propwash of the outboard motor. Dispersing the chemicals into the propwash promotes flash mixing of the two products and ultimately excellent floc formation. Through our extensive prior alum/aluminate treatment experience, we have found that the use of this arrangement and application methodology provides the best results.

The treatment will be guided with an on-board GPS (CASE EX-Guide 250 guidance system). The guidance systems will show the pond and treatment area and treatment sector boundaries. The system logs the path of the treatment vessel. Each load of chemical will be logged and monitored.

The 9 g/m^2 treatment will entail the application of approximately 17,000 gallons of aluminum sulfate and 8,500 gallons of sodium aluminate. The treatment will require 3-4 days to complete.

MONITORING PROGRAM

The table below outlines the components of the monitoring program and the goals of each. Details are provided in the following sections.

Table 1: Monitoring Program Design

Monitoring Component	Timing in relation to treatment	Location(s)	Goal
Water quality	Before, during, and after each application	3 established locations within each treatment zone	Evaluate short and long-term effects on water quality
Monitoring of state-listed species	Upon reaching suitable conditions (phosphorus levels <20 pbb and sustained cyanobacteria counts <50,000 cell/ml), one year following completion of alum treatments and 5-years after completion of alum treatments	5 paired plots	Evaluate short and long-term effects on these species identified by NHESP as potentially susceptible to the treatment

Water Quality Monitoring

The water quality monitoring plan for West Monponsett Pond will include sampling at a single location within each of the three treatment zones. Sampling collection will occur immediately prior to each treatment and several days following each treatment. In addition to the sample collection, basic *in situ* testing will be performed throughout each alum application.

Each pre and post-treatment water quality sample will be analyzed for the following parameters.

- pH
- Alkalinity
- Total Phosphorus
- Dissolved Phosphorus

The *in situ* testing that will be performed during treatment will include the following.

- Secchi depth
- Dissolved oxygen
- pH
- Alkalinity

Monitoring of State-Listed Mussel Species

Long-term Mussel Monitoring Program

Since the submission of the original 'Habitat Management Plan' in May 2012, the pre-treatment and one year following the initial 2013 alum treatment long-term mussel monitoring event have been performed. Minor modifications to the proposed long-term mussel monitoring provided in the original 'Habitat Management Plan' were made by the NHESP-approved biologist performing these surveys. Monitoring was also conducted in 2015, but was abbreviated in extent due to poor and potentially toxic conditions. In order to maintain comparability with past mussel monitoring events, the modified survey methodology (below) will be implemented on 3 occasions, 1) upon reaching suitable conditions (phosphorus levels <20 pbb and sustained cyanobacteria counts <50,000 cells/ml), 2) one year following completion of alum treatments and 3) 5 years after completion of alum treatments. This methodology was provided to the NHESP by Biodrawversity in a report titled, "Monitoring the Effects of Low-Dose Alum Treatment on *Leptodea ochracea*, *L. nasuta*, and *Neurocordulia obsolete* in the Western Basin of Monponsett Pond (Halifax, Massachusetts)" and the relevant excerpt is copied below. Per conversations with the NHESP in 2015, additional revisions to this methodology is indicated below in **bold** text.

> *The basic sampling unit [will be] a 1 x 1 meter ($1m^2$) quadrat bounded by a frame, with two centerlines that [divide] the quadrat into four 0.5 x 0.5 meter sections. The centerlines facilitated more careful searching in the low-visibility environment. Quadrat locations [will be] marked with underwater markers and recorded with GPS to enable the precise area of each to be resurveyed. Five quadrats [will be] established at 10 sites (50 quadrats total); the 10 sites [will be] paired (one shallow, one deep) at five locations in the pond (Figure 1). The quadrats [will be] arranged in a consistent pattern at each site (Figure 2). For each quadrat, biologists [will] first [conduct] a visual and tactile search to count the number of mussels (all species) occurring at or near the surface. The biologists then [will excavate] and [sieve] sediment from within one-fourth ($0.25m^2$) of the quadrat area to find buried mussels. Surface counts and buried counts [will be] recorded for each species, and shell length* ***and shell condition*** *[will be] recorded for L. ochracea and L. nasuta. Once these two steps [are] completed, all mussels [will be] placed back within the confines of the each quadrat. The following habitat information [will be] recorded for each quadrat: water depth, spatial extent of each substrate type, and percent cover of macrophytes. During the two post-treatment surveys, biologists [will] also [count]* ***and note shell condition of*** *freshly dead shells in addition to the steps described above.*

Figure 1 & 2. Mussel and Dragonfly monitoring stations (**Figure 1**) and quadrat arrange (**Figure 2**) derived from Biodrawversity's 2014 report, "Monitoring the Effects of Low-Dose Alum Treatment *Leptodea ochracea*, *Ligumia nasuta*, and *Neurocordulia obsolete* in Monponsett Pond.

Figure 1. Locations of mussel monitoring sites (Sites 1-5, including shallow and deep plots at each site) and dragonfly survey sites (E-1, E-2, and W-1 to W-7) in West and East Monponsett Pond in Halifax, MA.

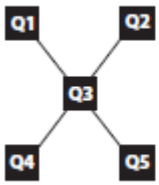


Figure 2. Spatial array of 5 1.0 m^2 quadrats (Q) at each site. Bricks were left on the lake bottom at Q1, Q2, Q4, and Q5; these were connected by strings and the intersection of the two strings marked the location of Q3. These were easily installed in 2013 and found again in 2014.

Monitoring of State-Listed Dragonfly Species

Long-term Dragonfly Monitoring Program

As stated above, since the submission of the original 'Habitat Management Plan' in May 2012, the pre- treatment and one year following the initial 2013 alum treatment long-term dragon-fly monitoring event have been performed. Minor modifications to the proposed long-term mussel monitoring were made by the NHESP-approved biologist performing these surveys. In order to maintain comparability with past events, the modified survey methodology will be implemented on 3 occasions, 1) upon reaching suitable conditions (phosphorus levels <20 pbb and sustained cyanobacteria counts <50,000 cells/ml), 2) one year following completion of alum treatments and 3) 5 years after completion of alum treatments.. This methodology was provided to the NHESP in a report titled, "Monitoring the Effects of Low-Dose Alum Treatment on *Leptodea ochracea*, *L. nasuta*, and *Neurocordulia obsolete* in the Western Basin of Monponsett Pond (Halifax, Massachusetts)" and the relevant excerpt is copied below. No additional revisions were requested during previous conversations with the NHESP.

> *Dragonfly surveys, focusing on N. obsoleta … [is scheduled to be completed in 2018]. Survey timing… [will]… accommodate weather conditions during the emergence period to ensure that surveys [are] conducted under the best possible conditions. Qualitative surveys of larvae, exuviae, and tenerals [will be conducted] using a combination of aquatic D-net sweeps in or near aquatic vegetation and other submerged structure,*

snorkeling in shallow water to hand-pick larvae, and walking along the shoreline to look for exuviae and tenerals on the lakeshore (especially rocks, bridge abutments, and trees). The causeway between the West and East basins [will be] surveyed most intensively, but several other locations in West and East Monponsett Pond [will] also [be] assessed and surveyed (Figure 1[see above]). Specimens [will be] collected, preserved in alcohol, and identified under a dissecting microscope.

Monitoring of Fish and Wildlife Response to Treatment

As in previous years, *in situ* in-water and shoreline monitoring will investigate any potential mortality of fish and other wildlife as a consequence of the buffered alum treatment. During the buffered alum treatment, *in situ* in-water and shoreline monitoring for fish and/or other wildlife mortalities will be conducted by the treatment/monitoring team. *In situ* in-water and shoreline monitoring will proceed as follows:

- **Treatment team**

    - Licensed applicator and assistant(s) will actively monitor the immediate treatment area for fish and/or wildlife mortality during application

- **Treatment/Monitoring Team**

    - Inspections of the treatment areas will be conducted in conjunction with *in situ* water testing

    - Twice daily (before and after daily treatment) visual inspection of pond's perimeter for fish and/or wildlife mortality will be performed.

Any deceased fish and/or wildlife encountered during *in situ* in-water monitoring will be documented. Documentation will include: written observations regarding the counts (by species), time observed, and photographs of each specimen. All information pertaining to a fish and/or wildlife kill event will be immediately provided to the Division of Fisheries and Wildlife—Southeast (DFW-SE).

REPORTING

During any year that treatment and/or monitoring is performed, the NHESP will be provided with a year-end report. The report will include documentation of any alum treatments performed (i.e., treatment dates and amounts of products applied) and associated monitoring (i.e., pre, in situ, and post-treatment water quality monitoring, and *in situ* monitoring of fish and wildlife in all years, as well as mussel monitoring. The year-end report will also discuss the treatment program's on-going efficacy any conclusion regarding effects of the treatment program to the state-listed species and their habitat.

Appendix B

Treatment Monitoring Program at the West Basin of Monponsett Pond Raw Data (Table 1-2)

Table 1. Monthly water quality sampling results

Date	Site ID	TP (ppb)	DP (ppb)	TAlk (mg/L)	Turbidity (NTU)	DO (mg/L)	Avg. Secchi (ft.)
5/14/18	A	28	17	x	x	x	7.7
	B	21	10	9.6	x	6.72	
	C	22	13	x	x	x	
6/28/18	A	16	10	x	0.95	x	X
	B	16	10	10	1.1	7.72	
	C	14	10	x	0.80	x	
7/11/18	A	14	10	x	1.3	x	10.5
	B	11	16	10.4	0.82	7.44	
	C	12	16	x	0.70	x	
8/6/18	A	21	13	x	2.8	x	4.6
	B	22	10	11.9	2.8	6.56	
	C	23	10	x	2.9	x	
10/19/19	A	10	10	x	0.95	x	7
	B	10	10	9	1.3	9.96	
	C	10	10	x	1.3	x	

x – No data collected

Table 2. *In-situ* water quality sampling results

Date	Site ID	pH (surface)	Avg. Alk (mg/L)	Avg. Secchi (ft)
5/14/18	A	6.67	x	7.0
	B	6.81		
	C	6.72		
5/15/18	A	7.0	x	6.76
	B	6.80		
	C	6.72		
5/17/18	A	6.85	x	7.3
	B	7.04		
	C	6.87		
5/18/18	A	6.85	x	7.3
	B	6.71		
	C	6.69		
	B			
	C			