2020 AQUATIC PLANT MANAGEMENT REPORT
Hop Brook Ponds – Grist Mill, Carding Mill, Stearns Mill
Sudbury, Massachusetts

Report Prepared for: Hop Brook Pond Association c/o Jeff Winston
Sudbury Conservation Commission c/o Lori Capone

December 2020

In accordance with the existing aquatic plant management contract between SŌLitude Lake Management and the Hop Brook Pond Association, the following document serves to provide this year's treatment and survey results for Grist Mill, Carding Mill, and Stearns Mill as well as management recommendations for the next season.

All management activities were consistent with the Orders of Conditions issued by the Town the License to Apply Chemicals issued by the MA DEP – Office of Watershed Management.

Program Summary

TASK	DATE COMPLETED
Pre-Management Vegetation Survey	June 10, 2020
Received approved MassDEP Permit	June 22, 2020
Initial Water Chestnut Treatment – Grist Mill, Stearns Mill	July 14, 2020
Initial Water Chestnut Treatment – Carding Mill	July 21, 2020
Second Water Chestnut Treatment – Grist Mill, Carding Mill, Stearns Mill	August 5, 2020
Post-Management Survey	August 21, 2020

Pre-Treatment Survey

On June 10th, a SŌLitude biologist performed an early season inspection to confirm the growth of water chestnut (*Trapa natans*) throughout the project sites of Grist Mill, Carding Mill, and Stearns Mill Ponds. A canoe or motored jon-boat was used to navigate around the littoral zone of these three ponds.

Stearns Mill Pond displayed dense growth of water chestnut that covered approximately 70% of the surface, followed by curly-leaf pondweed present below the water chestnut at roughly 40% cover, and coontail was present in dense patches. Small patches of yellow waterlily were observed scattered close along the shoreline. Small and greater duckweed covered the surface throughout the navigable area. Navigating through the pond was difficult due to thick growth of submersed vegetation reaching the surface.

Grist Mill Pond also displayed thick growth of water chestnut. Additional species included curly-leaf pondweed, small & greater duckweed, common waterweed, ribbon-leaf pondweed, and coontail. Water chestnut was observed throughout the ponded area at about 80% cover. Curly-leaf pondweed was present beneath the water chestnut primarily on the eastern half of the pond.

Carding Mill Pond displayed roughly 60% cover of water chestnut and roughly 80% cover of curly-leaf pondweed. Other species included common waterweed, white and yellow waterlily, small and greater duckweed, and leafy pondweed. Submersed vegetation was present in moderate densities but was easier to navigate through than in both Stearns and Grist Mill Pond.

Throughout the three ponds, it was evident that water chestnut growth was still relatively immature and small rosettes could still be seen below the surface making their way up the water column (Figures 1-3). Water chestnut and curly-leaf pondweed were the primary dominant aquatic vegetation species present in each waterbody. **No Eurasian watermilfoil was observed in the three ponds.**

Table 2: Submersed aquatic vegetation observed during the June survey

Common Name	Scientific Name	Stearns Mill	Grist Mill	Carding Mill
Coontail	*Ceratophyllum demersum*	X	X	
Common Waterweed	*Elodea canadensis*		X	X
Curly-leaf Pondweed	*Potamogeton crispus*	X	X	X
Greater Duckweed	*Spirodela polyrhiza*	X	X	X
Leafy Pondweed	*Potamogeton foliosus*			X
Ribbon-leaf Pondweed	*Potamogeton epihydrus*		X	
Small Duckweed	*Lemna minor*	X	X	X
Thin-leaf Pondweed	*Potamogeton pusillus*			X
Water Chestnut	*Trapa natans*	X	X	X
White Waterlily	*Nymphaea odorata*			X
Yellow Waterlily	*Nuphar variegata*	X		X

*Red indicates invasive species

2020 Management Summary

Herbicide Applications

Due to logistical challenges with launching the airboat into Grist Mill Pond, the initial treatment at Grist Mill and Stearns Mill took place on July 14 and Carding Mill's on July 21. As Grist and Stearns do not have true boat launch/ramp sites, a crane service was used to mobilize and demobilize the airboat from those two ponds.

Grist Mill's initial treatment had dense water chestnut growth covering almost all open water within the pond area, with the exception of a small area in the southwestern end of the pond. Water level in the pond at the time of treatment was approximately full pool. At the time of the follow up application at Grist, the water level within the pond was significantly lower – partially due to control by Wayside Inn as well as the severe drought conditions for the season. Water chestnut growth was significantly reduced by the time of the follow up application. However, many of the previously treated and then dead plants were still floating and primarily

congregated along the shoreline near the Wayside Inn Road trails on the northeastern end of the pond. The remainder of the pond had significantly more open water conditions than during the initial application and water chestnut growth was primarily in scattered patches from where the boat lanes during the initial application were – which was anticipated. For both treatments, the pond was accessed along the trail off Wayside Inn Road.

Stearns Mill's initial treatment also had very dense water chestnut growth present throughout the entire pond except the southwestern corner along Dutton Road where it was more scattered. The narrow western portion of Stearns was progressively shallower the further west the airboat travelled. The low water levels, lack of water flow and dense chestnut growth in that area caused the impacted and dead water chestnut plants to get "stuck" and remain on the surface after treatment longer than anticipated. However, at the time of the follow up treatment, the remaining water chestnut throughout the entire pond was the boat lanes from the first application. There was a noticeable increase in duckweed present within the area of Stearns closest to the dam along Dutton Road during the second application. For both treatments, the pond was accessed via the parking area along Dutton Road and the dam.

Carding Mill's initial treatment had dense water chestnut growth as well but was more scattered in large patches in comparison to Grist and Stearns as there was more open water throughout the entire pond. The northeast quadrant of the pond had the densest and least scattered growth during the first treatment. Water levels remained relatively stable between the first and follow up treatments. At the time of the follow up treatment, there was a significant odor immediately noticeable upon arrival to the boat launch. Once on the water, it was observed that a reasonable number of sunfish were dead and floating throughout the northeastern quadrant of Carding Mill, although scattered amongst the dense duckweed also within the area. Based on discussions with Jeff Winston and Lori Capone, it is understood that Carding typically suffers from the lowest dissolved oxygen of the three ponds. Although the initial application was conducted only two weeks prior, it is not believed that the fish kill was associated with the treatment as Carding had the least amount of water chestnut relative to the waterbody size at the time of either treatment. There was also a notable increase in duckweed cover during the second application. The access road leading to the boat ramp near the dam was used to access the pond.

All ponds, for both applications, were treated using Clearcast (imazamox) herbicide coupled with an aquatic surfactant to ensure the Clearcast was appropriately staying on the water chestnut plants for maximum efficacy. All applications were conducted using a handheld spray nozzle from the side of the airboat to ensure selective, targeted foliar application to the plants. The airboat travelled in a parallel pattern throughout the waterbodies (where feasible based on the waterbody shape) to maximize the areas of water chestnut to be targeted and minimize the lanes created where the boat was travelling. Each waterbody's application took approximately 1-3 hours, based on size and water chestnut distribution.

Post-Treatment Survey

On August 21st, a SŌLitude biologist performed an early season inspection to confirm the growth of water chestnut (*Trapa natans*) throughout the project sites of Grist Mill, Carding Mill, and Stearns Mill Ponds. A canoe or motored jon-boat was used to navigate around the littoral zone of these three ponds.

Stearns Mill Pond was found with four aquatic species present during the post-management survey, including coontail, water chestnut, small duckweed, and watermeal. Water chestnut was present at trace to moderate patches throughout the pond. Most growth was found on the edges of the pond.

Grist Mill Pond had similar species present to the early-season survey, including water chestnut, watermeal, duckweed, and common waterweed. Water chestnut was present in trace patches throughout the ponded area. A few patches displayed some smaller rosettes that is likely due to late-season growth.

Caring Mill Pond had five species present during the August survey. Species included water chestnut, duckweed, watermeal, ribbon-leaf pondweed, and common waterweed. Similar to Stearns and Grist Mill, water chestnut was scattered in trace to sparse patches throughout the pond. A few large patches remained and were observed in the very northern end of the pond and a few small rosettes determined that late-season growth had occurred.

Curly-leaf pondweed was not present at any of the three ponds due to its lifecycle. Eurasian watermilfoil was not observed during the August survey.

Water Quality

During the pre- and post-management surveys, water quality samples were collected in all three ponds. Sample bottles were hand-scooped in depth of one foot, placed on ice, and brought immediately to Alpha Analytical Laboratories in Westborough, MA. Ten parameters were collected in each pond, including alkalinity, ammonia, total and dissolved phosphorus, E. Coli, nitrate/nitrogen, pH, total Kjedahl nitrogen, true and apparent color, and turbidity.

Table 3: Water quality sample results during June and August 2020

Parameter	Units	Detection Limit	Stearns		Grist		Carding	
			06/10	08/21	06/10	08/21	06/10	08/21
Alkalinity	Mg	2.00	52.2	83.4	60.9	67.2	62.1	91.2
Ammonia	Mg/L	0.075	0.127	ND	0.209	0.480	0.122	ND
Dissolved Phosphorus	Mg/L	0.010	0.041	0.065	0.026	0.107	0.034	0.057
E. Coli	MPN/100mL	1.0	21.57	14.64	6.26	6.32	10.57	8.52
Nitrate	Mg/L	0.100	1.26	ND	12.0	2.97	3.22	ND
pH	pH units	-	7.6	8.0	7.4	7.1	9.6	9.3
Total Kjedahl Nitrogen	Mg/L	0.300	0.761	1.47	ND	1.23	0.841	1.73
Total Phosphorus	Mg/L	0.010	0.073	0.221	0.130	0.173	0.048	0.340
True/Apparent Color	A.P.C.U.	10/25	50/160	34/76	24/32	25/33	40/85	38/92
Turbidity	NTU	0.20	2.8	8.2	0.95	2.5	2.6	9.7

*ND = Not-detected

Alkalinity (high)

Alkalinity is the measure of the water's capacity to neutralize acids. A higher alkalinity can buffer the water against rapid pH changes, which in turn prevents undue stress on aquatic biota due to fluctuating pH levels. The alkalinity of a lake is primarily a function of the watersheds soil and

rock composition. Limestone, dolomite and calcite are all a source of alkalinity. High levels of precipitation in a short amount of time can decrease the waters alkalinity. A typical freshwater lake has an alkalinity of 20-200 mg/L. ***All three Hop Brook Ponds are above 50 mg/L and are considered resistant to changes in pH.***

Nitrogen (extremely elevated)

Ammonia is a measure of two constituents, NH_3 and NH_4^+, and is a transitional product in the breakdown of organic nitrogen (from plants, waste, etc.) into nitrate. It is typically short-lived in the pond environment except under conditions of low dissolved oxygen. Waterbodies that have a high pH and temperature are susceptible to high ammonia concentration; the higher the pH, the more ammonia will be present within the water column. External sources of ammonia include: fertilizers, wastewater effluent discharge, animal waste, and runoff from agricultural lands. High levels of ammonia are toxic to the aquatic environment, notably fish, and typically indicate a eutrophic pond. Levels higher than 0.100 mg/L can be problematic for aquatic biota, however available dissolved oxygen, pH, and temperature are key factors in 'toxic' levels. ***Sampling results in June in all three ponds were above 0.100 mg/L. Grist Mill displayed elevated levels in August.***

Nitrate is a form of nitrogen found in the water column. Nitrate is usually the most prevalent form of inorganic nitrogen in the water and results from such things as natural aerobic bacterial activity, fertilizer use, and air-water exchange. It is also the form that is most readily available for plant and algae growth. Levels of Nitrate (as N) are ideal at <0.30 mg/L. A maximum of 10 mg/L (ppm) is set for EPA drinking water standards. *All three sampling locations were non-detect (below) at <0.30 mg/L.* ***Sampling results in June at all three ponds were extremely elevated. Sampling results in August at Grist Mill was the only pond that displayed elevated levels of Nitrates.***

Total Kjeldahl Nitrogen is a measure of the nitrogen contained in organic compounds, such as proteins and amino acids; the summation of ammonia and organic and reduced nitrogen. It is created from biological growth and decomposition. A concentration of 1.0 mg/l or below is considered desirable. ***Sampling results at all three ponds in August were above 1.0 mg/L which is considered elevated.***

Phosphorus (extremely elevated)

Dissolved phosphorus remains in the water column, while particulate phosphorus settles to the lake bottom or is attached to suspended particles. Dissolved phosphorus is biologically available, used in aquatic processes such as plant and algae growth. Measures any type of phosphorus dissolved in the water column. Generally, dissolved phosphorus over 20 parts per billion (ppb; or 0.02 mg/l) is the threshold at which algal growth can become problematic. ***During both the June and August sampling events, all results were found at elevated levels.***

Total Phosphorus measures all forms of phosphorus in the water column (particulate, dissolved, phosphate). Generally, a total phosphorus concentration over 30 parts per billion (ppb, or 0.03 mg/L) is the threshold at which algae blooms or excessive plant growth can be stimulated. Aquatic systems <12 ppb are considered nutrient poor and oligotrophic; 12-24 ppb contain a moderate amount of nutrients and mesotrophic; 25-96 ppb are nutrient rich and eutrophic; >96 ppb contain excessive nutrients and hypereutrophic. ***During both the June and August sampling***

events, all results were found at undesirable levels. More specifically, during the August sampling event, results at Stearns, Grist, and Carding Mill were extremely elevated.

E. Coli (low)

***E. coli* (*Eschericia coli*)** are the type of fecal coliform associated with fecal material, and some strains cause illness. *E. coli* analysis is used to determine the probability of fecal contamination; it is present in the digestive tract of humans and animals, and therefore is a reliable indicator of fecal inputs. Per EPA regulation, no *E. coli* should be present in drinking water resources. In recreational surface waters (beaches), the EPA set criteria at <126 colonies per 100mL. *All sampling locations counted at <10 colonies, far below the concerning threshold.*

pH (neutral/slightly elevated)

pH is a measurement of basic (alkalinity) or acidity of the waterbody. The pH scale ranges from 0 (acidic) to 14 (basic) with 7 being neutral. Natural pH values of most freshwater systems range between 6 and 8. Extreme pH values (less than 5.5 and greater than 9) have detrimental effects on organism physiology and can result in the direct loss of sensitive species. Diurnal fluctuations in pH are common in freshwater ponds and lakes. The extent to which the pH fluctuates depends on how well the freshwater system is buffered.

Color

Apparent Color The color of the unfiltered pond water, caused by suspended and dissolved matter. This value can change drastically depending on weather conditions: increase with storm events, decrease with drought. There are four approximate categories for Color: 0-25 is clear, 25-40 is light tea-color, 40-80 is tea color, >80 is dark tea color.

True Color The color of filtered pond water, free of particulates; represents only dissolved organic matter (DOM) in the water. True color defines the water color by removing turbidity through filteration. This value can be subtracted from the Apparent Color to determine the quality of water inputs.

Color within the Hop Brook Ponds is considered "light tea colored" to "dark tea colored". Grist Mill displayed the lightest tea colored between the two sampling events, but Stearns and Carding Mill displayed tea to dark tea colored water which determines high organic material.

Turbidity

An optical measurement quantifying the extent that light is scattered by suspended material within the water column. The more suspended material, the higher the turbidity, and the flow of the water greatly determines the type of suspended load (organic or inorganic) and the particle size within the load. Turbidity is often increased near wetlands or high vegetation, due to decay. Turbidity values in most waterbodies rarely rise above 5 NTU (Nephelometric Turbidity Units). Values greater than 10 NTU indicates high suspended solids, often due to increased runoff, high inflow or construction activity. Suspended solids include soil particles (clay, silt and sand), algae, and plankton. ***The August sample results at both Grist Mill and Carding Mill displayed extremely high results above the desirable threshold of 5 NTU and indicate that high suspended solids existed during the August sample event.***

Dissolved Oxygen and Temperature

Table 4: June and August Dissolved Oxygen and Temperature readings

Depth (Ft.)	Dissolved Oxygen (Mg/L)						Temperature (°C)					
	Stearns		Grist		Carding		Stearns		Grist		Carding	
	6/10	8/21	6/10	8/21	6/10	8/21	6/10	8/21	6/10	8/21	6/10	8/21
SW	4.15	7.65	5.56	4.15	9.88	8.63	19.78	22.54	21.77	24.5	20.22	27.1
1	4.10	7.66	5.11	3.87	8.67	8.68	19.70	21.54	21.76	24.2	20.24	26.9
2	1.48	4.31	4.78	3.53	8.25	6.50	19.25	21.07	21.42	24.0	19.88	26.6
3	0.57		4.02	3.05	6.99	6.07	19.00		20.99	23.6	19.15	23.4
4			2.88	2.89	5.73	2.03			20.87	23.4	18.99	23.1
5			1.74	1.95	4.52				20.66	23.0	18.94	

Table 4 above lists the dissolved oxygen and temperature readings from the June and August surveys. Dissolved oxygen in June at Stearns and Grist were relatively poor. A surface reading of 4.0 mg/L is considerd just below the range to maintain the health of aquatic wildlife; however, Carding Mill displayed a desirable range of oxygen. Carding Mill is the largest and most opened of the three ponds. Carding Mill in both June and August displayed more dispersion of aquatic plants and algae which allows wind and rain events to thoroughly mix the water column and consequently providing oxygen throughout the water column.

Ongoing Management Recommendations

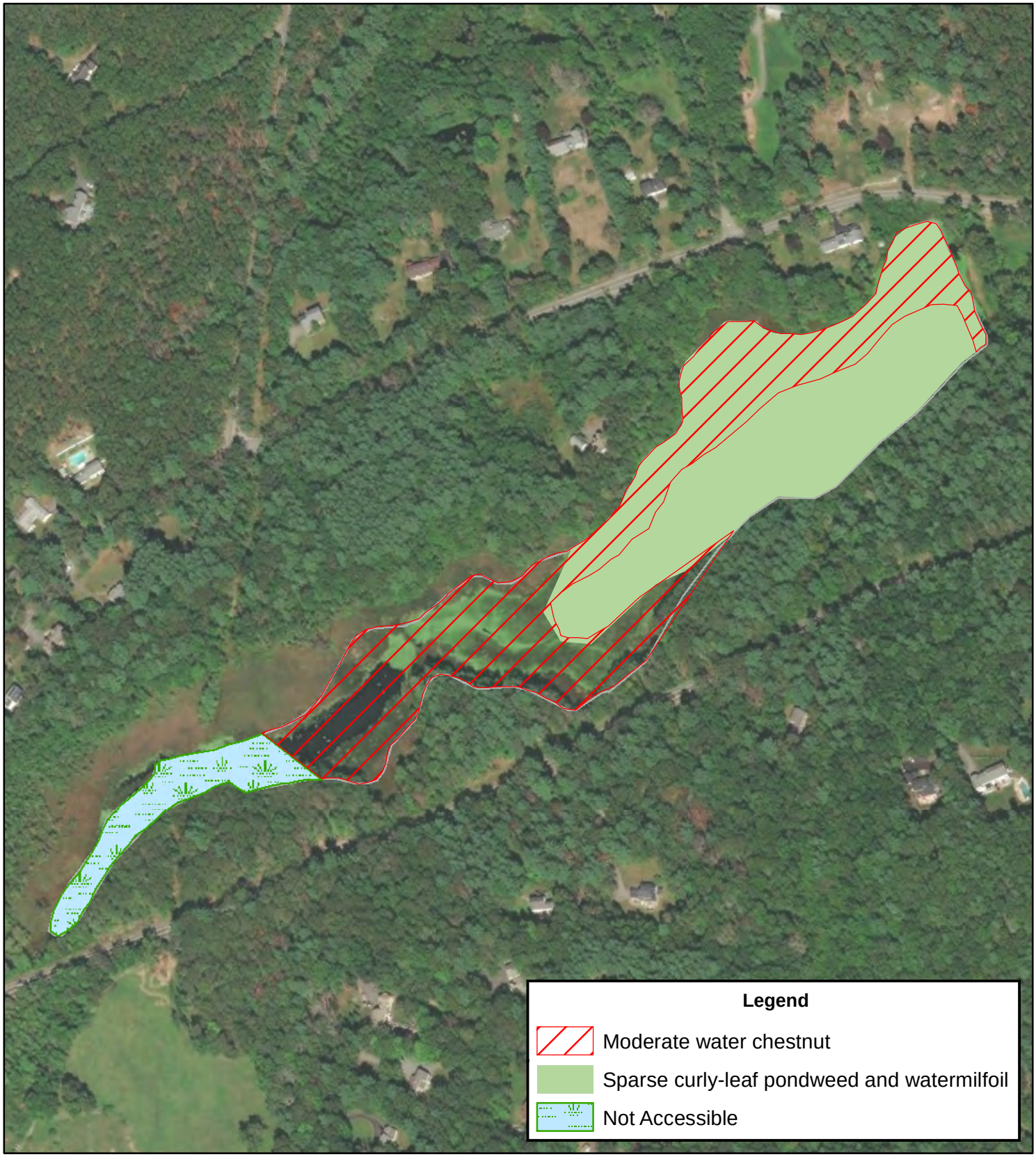
Although excellent control of water chestnut was achieved through this year's program, the ponds' long-established seed bank, nutrients, shallow depths and limited access will continue to present water chestnut control challenges moving forward. Understanding that this was the first year of management, it is also understood and anticipated that herbicide treatments at the Hop Brook Ponds will likely be required for the next few years until water chestnut distributions and densities are decreased to levels where hand-pulling efforts can be effective.

For 2021, we recommend conducting the pre-management survey efforts in early to mid-June again (spring weather dependent) to understand the growth stage and potential distribution of water chestnut plants to be targeted for treatment. We will be planning to conduct the initial application at all waterbodies prior to July 1, assuming growth is at an appropriate stage to do so. This year's timing of treatments was great for understanding the true coverage of water chestnut through each waterbody, however, navigation may prove to be easier if treatment is conducted slightly earlier in the year. As was done this season, two applications for each waterbody are anticipated in order to maximize impact to all water chestnut plants. Further, knowing that access at Grist Mill and Stearns Mill was limited to utilizing a crane to mobilize the airboat into the water, we will plan to proceed the same way for future applications, until a small jonboat can be utilized, if feasible. Finally, we recommend continuing with a post-management survey in mid-August to assess the treatments' impacts and strategize for future years' management efforts.

We enjoyed working with the Hop Brook Ponds Association and the Town this year for this project and look forward to working together again in 2021 to continue restoring the Mill Ponds.

Figure 1: Grist Mill Pond Distribution of Invasive Aquatic Vegetation

SOLITUDE
LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Grist Mill Pond
Sudbury, MA

Grist Mill Pond

0 375 750 Feet

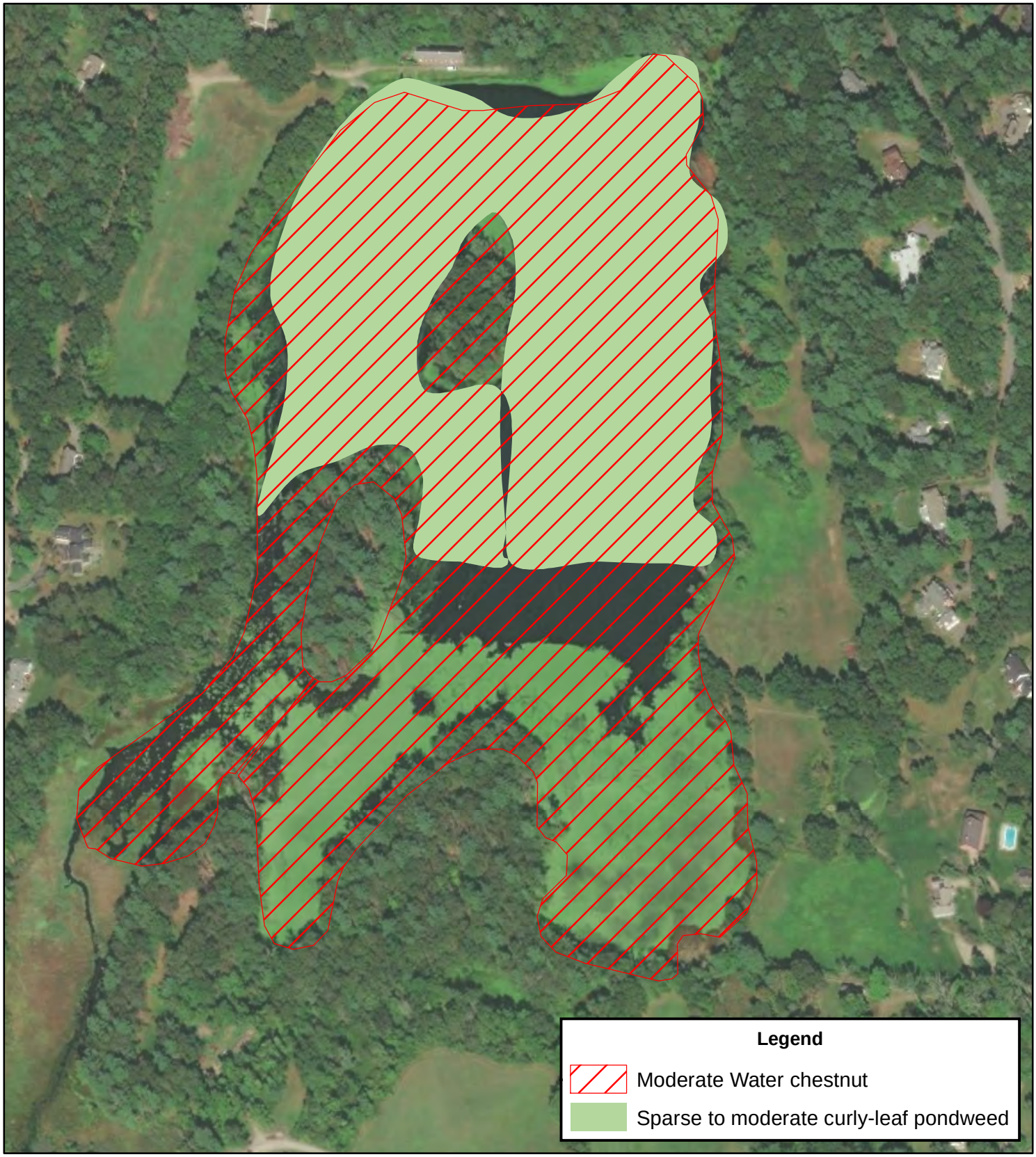
1:4,080

N

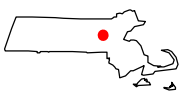
Map Date: 06/25/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 2: Carding Mill Pond Distribution of Invasive Aquatic Vegetation

SOLITUDE LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com



Carding Mill Pond
Sudbury, MA



Carding Mill Pond

0 310 620 Feet

1:3,500

N

Map Date: 06/25/2020
Prepared by: ALM
Office: SHREWSBURY, MA

Figure 3: Stearns Mill Pond Distribution of Invasive Aquatic Vegetation

SOLITUDE LAKE MANAGEMENT
888.480.5253
solitudelakemanagement.com

Stearns Mill Pond
Sudbury, MA

Stearns Mill Pond

0 390 780 Feet

1:4,725

N

Map Date: 06/25/2020
Prepared by: ALM
Office: SHREWSBURY, MA