Report For:

Town of Harvard
Bare Hill Pond Watershed Management Committee
Harvard Massachusetts

Bare Hill Pond In-Lake Water Quality and Plant Survey - 2021

Prepared by:
Aquatic Restoration Consulting, LLC
18 Sunset Drive
Ashburnham, MA 01430

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Introduction

Aquatic Restoration Consulting, LLC (ARC) performed in-lake water quality sampling and aquatic plant surveys within Bare Hill Pond in 2021. The intent of these surveys was to document 2021 summer conditions and compare these data to previous years, identifying any trends.

The Bare Hill Pond Watershed Committee (Committee) has conducted winter water level drawdowns periodically since 2002. Early drawdowns were limited to the depth of the outlet (3.5-foot drawdown) but the installation of a pump system enables the Committee to increase the drawdown depth. Substantial reductions in plant cover and density were observed in association with initial extended water level drawdowns and remained consistent following subsequent drawdowns. A shift in species dominance from tall growing vegetative propagators (spread through fragmentation or by rhizomes) to low growing seed producers was observed. A history of drawdown depth and summary of conditions reported by the Committee is provided in Table 1.

Given that non-native species growth regains community dominance in shallow water following cessation of winter water level drawdown[1] and the potential benefit of improved flushing (removing accumulated phosphorus), the Committee wishes to continue the drawdown program for nuisance aquatic plant management. This report summarizes data collected in 2021 and provides a comparison over several years, with an emphasis on the comparison within the last five years.

[1] see comparison of 2014 data vs data post drawdown in prior reports (https://www.harvard.ma.us/bare-hill-pond-watershed-management/pages/annual-other-reports)

Table 1. History of Bare Hill Pond Winter Drawdowns.

Winter Season	Water Level Reduction and Summary of Following Growing Season Observations
2002-03	1.5 Feet
2003-04	3.5' gravity drawdown
2004-05	3.5' gravity drawdown
2005-06	3.5' gravity drawdown - these first few created evidence of efficacy in drawdown zone and no evidence of substantial issues
2006-07	5' gravity and pump drawdown - some increase in efficacy
2007-08	5' gravity and pump drawdown - good freeze and improvement
2008-09	3.5' gravity drawdown - per request to see if a year off pumping would work - limited efficacy and rebound in plants
2009-10	6' gravity and pump drawdown - planning started for beach excavation and the storm water rain gardens
2010-11	6.5' gravity and pump drawdown - continued incremental efficacy and no harm detected
2011-12	7' gravity and pump drawdown - more efficacy and depth needed for the beach excavation project
2012-13	6' gravity and pump drawdown - backed off to see if efficacy could be maintained
2013-14	No drawdown - year off to see if lower frequency worked - phosphorous stable, some re-emergence in spots
2014-15	5.5' drawdown - heavy snowfall runoff - phosphorous increase and increased observance of invasives by residents in 5 - 8 foot zone but overall reduction in plant volume and at transect sites
2015-16	6.0’ drawdown – very mild winter with an extended warm, dry and sunny growing season following
2016-17	5.75’ drawdown – very mild winter, even warmer than previous year. Wet spring and summer; water level higher than past years
2017-18	6' drawdown; cold long winter with freezing temperatures into April. Period of hot humid weather leading to a pattern of extended wet weather. Water levels remained high throughout the summer.
2018-19	4.5’ drawdown. While 6’ was the goal, it was difficult to achieve the desired drawdown depth due to precipitation. The early portion of the summer was wet and overcast but come July it was warm and dry.
2019-20	6.0’ drawdown. Warm November and March. Very low precipitation/snow cover
2020-21	Attempted 6.0'. Equipment issues prevented holding that depth. Lake was about 3.0' down during a short period of freezing

Influence of Weather

Ideal conditions for a winter water level drawdown to control rooted plants is a consistent cold winter (consecutive days below freezing) with little rain or snow. Snow insulates the ground preventing the hard freeze necessary to kill plant roots. Looking at the historic weather conditions recorded at Fitchburg Airport since 2009 during the Nov 15 through Mar 15 winter season, the winters of 2013-2014 and 2014-2015 had the lowest average minimum temperatures (18.0 and 17.2°F, respectively (Figure 1). The number of days when the low temperature fell below 30°F was 102 during 2013-2014, representing 84% of the days during the period of analysis; similarly, 92 days experienced low temperatures below 30°F in 2014-2015 representing 76% of the time (Figure 2). The next two winters were milder with average lows in mid-20 degrees with fewer days below 30°F. 2017-2018 and 2018-2019 were cold years with 98 and 95 days with low temperatures (81% and 79% of the days) with an average low of 19.5 and 20.2°F, respectively. 2019-2020 had fewer days (83) below 30°F, representing 68% of the winter period and slightly higher average low temperature of 24.4°F. 2020-2021 was a very close match with 2019-2020, with differences in timing of cold weather and precipitation. The number of days below 30°F were 22 in November and December vs 31 last drawdown season. The month with the most cold days was January in 2021. The Fitchburg airport reported over 11 inches of precipitation in November and December in 2020 compared to less than a half inch in these months during 2019 (Figure 3). The inability to sustain a lower water level due to equipment and precipitation made the winter of 2020-2021 a poor drawdown year with limited to no plant control.

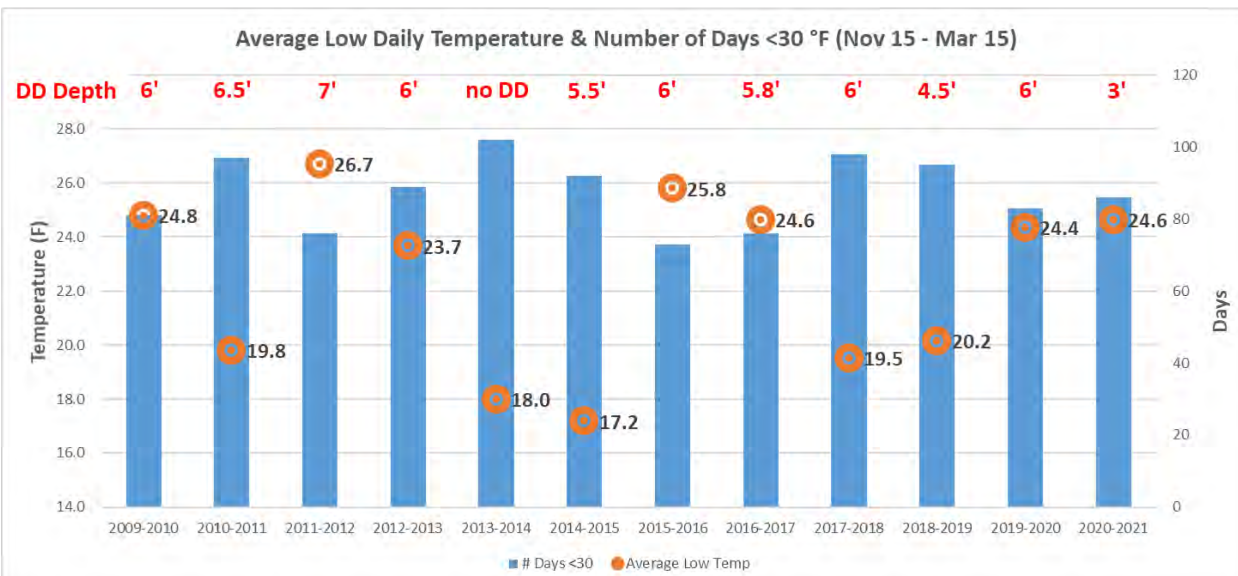


Figure 1. Average Low Air Temperature and Number of Days below 30°F during the Winter Season.

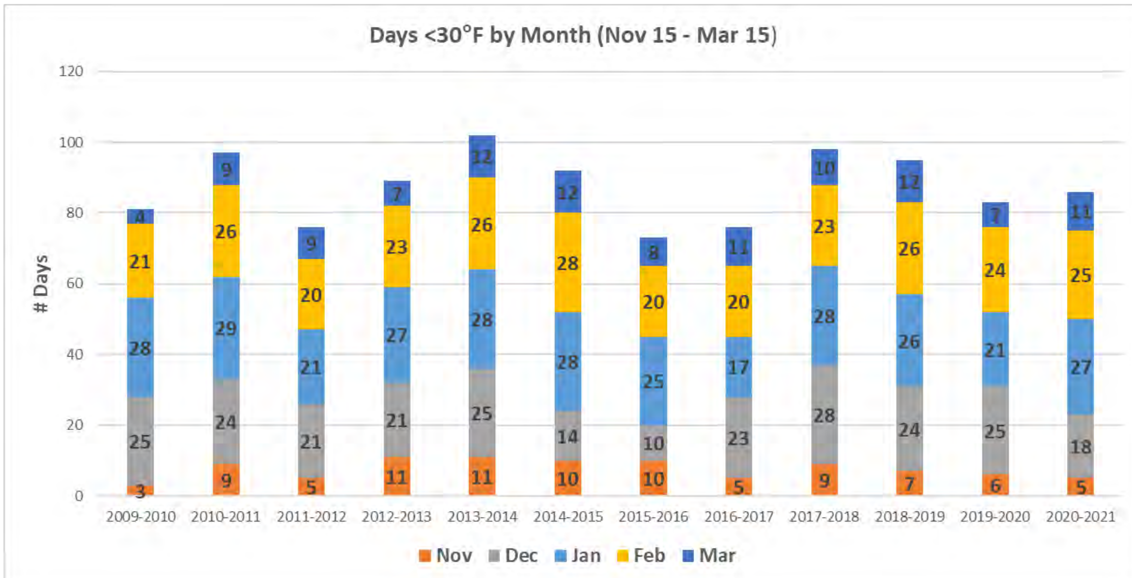


Figure 2. Number of Days with Air Temperatures below 30°F during the Winter Season.

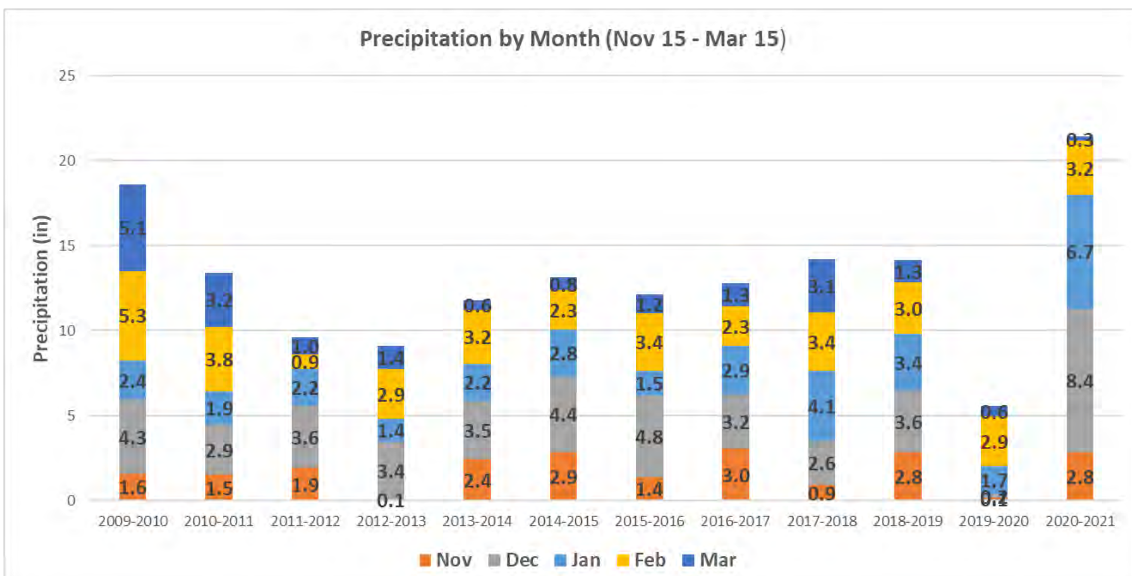


Figure 3. Precipitation during the Winter Season

In-Lake Sampling

In-lake sampling was conducted on May 20, June 29, and July 30 and August 21, 2021. ARC used the same sampling methods as prior surveys for data collection consistency (see prior reports for methodology). In-situ water depth profile measurements of temperature, dissolved oxygen (DO), and specific conductivity were recorded at two locations: shallow basin BHP-1 in the south basin and the deep hole in the north/main basin BHP-2 (Table 2). Figure 4 provides a graphical representation of temperature and DO data for the deep station (BHP-2) in comparison with prior years.

The temperature and DO profiles suggest that the lake began to thermally stratify in May and was moderately stratified by June with temperature changes starting at the five-foot water depth, three feet shallower than 2020. Surface water temperature was the warmest since 2013 during May and June and comparable to 2020 in July. These two years (2020 & 2021) are the warmest on record. DO concentrations are trending in the wrong direction as well. The hypoxic (low oxygen) layer is expanding and resulting in less desirable habitat for aquatic biota. Waters below 10 feet were historically below the 5.0 mg/L threshold considered to support aquatic life, but 2021 data suggest that supportive waters are limited to about 8 feet. This condition also facilitates the release of phosphorus from sediments, resulting in ideal conditions (warm water and plenty of phosphorus) for cyanobacteria blooms. The lake was anoxic (no oxygen) at a depth of 10-feet in 2021 vs 12-14 feet in the past (Table 2, Figure 4). These data suggest that there is substantial oxygen consumption in bottom waters with little to no mixing.

Table 2. Bare Hill Pond Water Depth Profiles 2021.

BHP-1																							
May 20, 2021						June 29, 2021						July 30, 2021						August 21, 2021					
Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)
0	21.72	8.67	6.87	205	0.0	0	29.32	8.13	7.29	157	0.0	0	25.5	8.55	7.10	168	0.0	0	27.59	10.65	8.79	132	22.0
1	21.72	8.71	6.87	204	0.0	1	28.33	8.16	7.53	157	0.0	1	25.57	8.7	7.28	168	0.0	1	27.41	10.69	8.86	132	24.9
2	21.73	8.68	6.86	204	0.0	2	28.01	8.25	7.42	157	0.0	2	25.55	8.67	7.27	167	0.0	2	26.55	11.04	8.97	132	28.4
3	21.74	8.68	6.86	204	0.0	3	27.53	8.79	7.60	157	0.0	3	23.45	6.85	6.74	168	2.4	3	26.24	10.83	8.93	131	29.5
4	21.72	8.62	6.86	204	0.0	4	26.98	9.21	7.86	156	0.0	4	23.55	5.41	6.50	168	0.0	4	25.79	7.85	7.92	127	23.3
5	21.7	8.68	6.87	204	22.3													5	24.73	1.77	7.37	123.5	33.6
BHP-2																							
Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Turbidity (NTU)
0	22.96	8.84	7.05	207	0.0	0	29.46	8.11	7.44	157	0.0	0	24.91	8.55	7.30	168	11.5	0	29.64	10.49	8.94	132	34.0
2	22.75	8.88	7.01	206	0.0	2	29.43	8.09	7.38	157	0.0	2	24.84	8.43	7.23	169	1.6	2	27.2	11.52	9.18	133	24.5
4	22.59	8.89	7.02	206	0.0	4	28.53	8.04	7.26	157	0.0	4	24.8	8.26	7.09	169	1.9	4	26.29	10.92	9.03	132	19.2
6	21.01	8.82	6.94	205	0.0	6	26.10	7.85	7.05	157	0.0	6	23.93	6.65	6.82	169	2.2	6	25.95	8.50	7.02	130	8.9
8	18.01	8.31	6.74	202	0.0	8	25.02	7.12	6.78	155	0.0	8	23.49	5.08	6.65	169	2.7	8	24.95	3.98	6.29	129	0.0
10	16.36	8.06	6.66	201	0.0	10	22.85	4.49	6.40	156	0.0	10	20.84	0.00	6.55	174	4.5	10	23.64	0.07	6.30	128	0.0
12	15.29	6.03	6.48	201	0.0	12	19.63	0.52	6.20	153	0.0	12	19.56	0.00	6.62	188	4.4	12	21.91	0.07	6.51	138	0.7
14	14.96	5.21	6.4	200	0.0	14	17.01	0.00	6.21	152	0.0	14	18.3	0.00	6.73	191	2.0	14	20.39	0.07	6.68	148	1.1
16	14.27	3.93	6.33	201	0.0	16	15.14	0.00	6.31	157	0.0	16	15.86	0.00	6.87	202	0.2	16	18.25	0.08	6.77	155	0.7
18	13.78	3.37	6.27	202	0.7	18	14.16	0.00	6.46	157	0.0	18	14.14	0.00	6.99	210	2.1	18	16.24	0.07	6.83	158	2.4
20	12.98	2.37	6.26	204	2.4	21.5	12.50	0.00	6.87	183	0.0	20	13.35	0.00	7.14	223	3.8	20	14.33	0.00	7.08	170	11.3
21.4	12.52	1.57	6.25	208	3.4							22	12.99	0.00	7.18	232	4.8	22	13.34	0.00	7.10	187	14.9

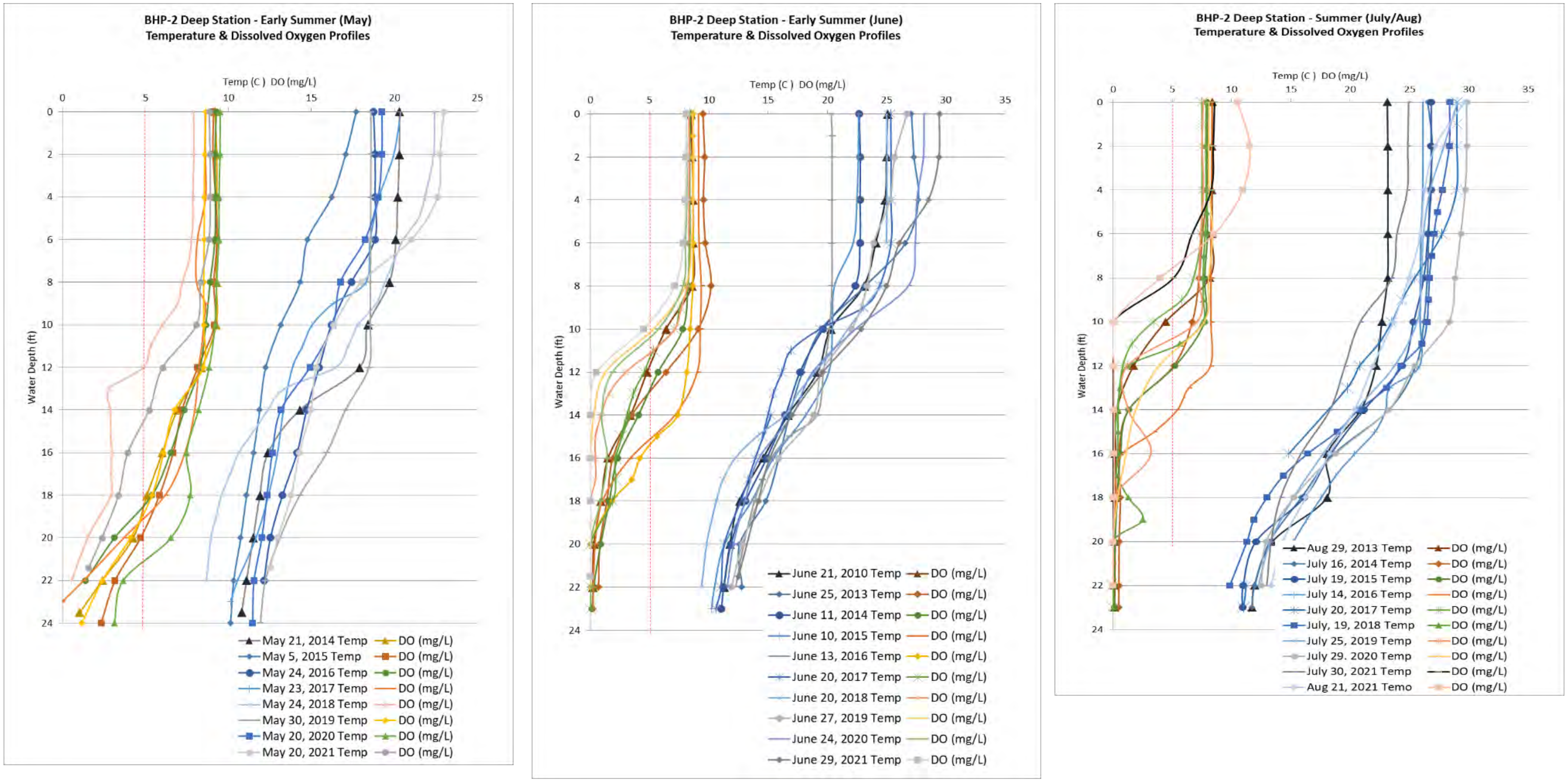


Figure 4. Temperature & Dissolved Oxygen Profiles at BHP-2 for 2010-2021

Specific conductivity in 2021 was similar to prior years and around the upper end of the desirable range threshold (<200 us/cm); values above 200 us/cm can be indicative of elevated dissolved pollutants and high productivity. It is common to have increased conductivity near the water-sediment interface where suspended solids increase conductivity. Surface and mid-depth values were comparable between the two stations.

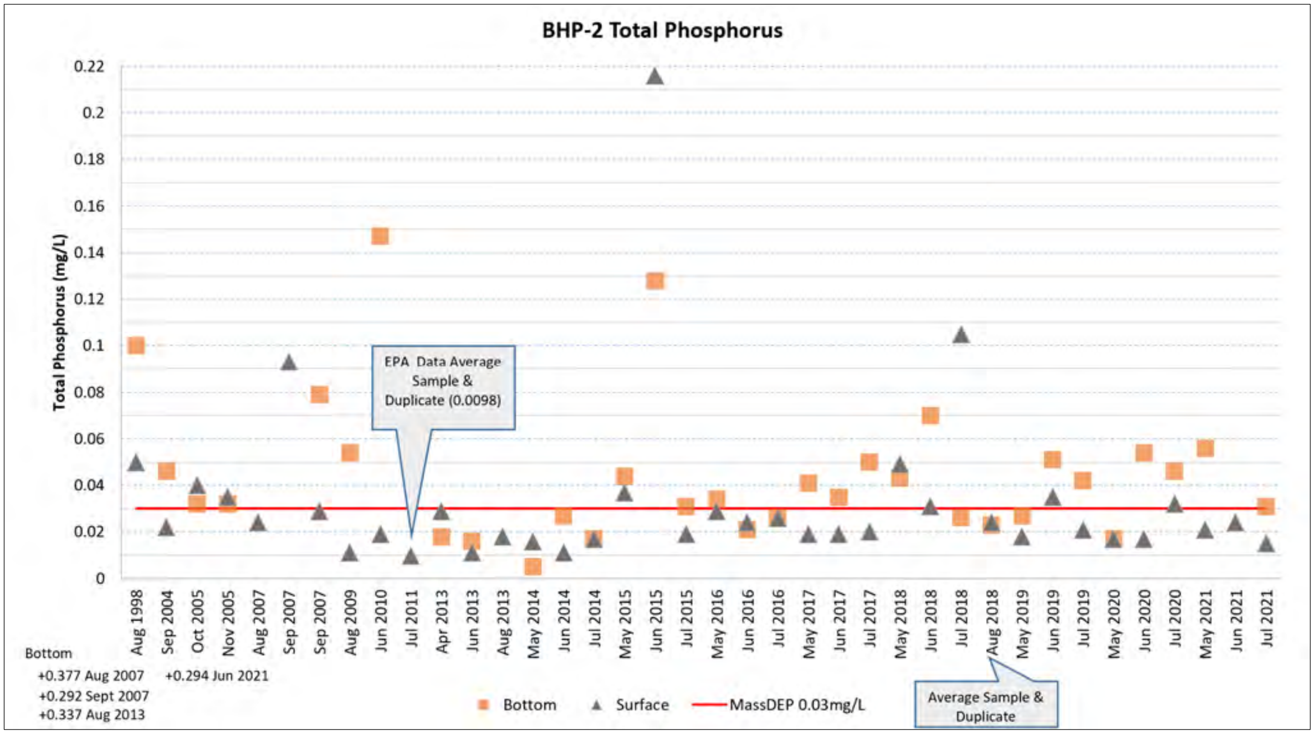
Table 3 provides the results of phosphorus, total suspended solids and water clarity (measured by Secchi disk transparency) during 2021. A comparison of phosphorus concentrations in the main basin (BHP-2) over time is illustrated graphically in Figure 5. Total phosphorus (TP) concentrations were above the Massachusetts Department of Environmental Protection (MassDEP) target concentration of 0.030 mg/L[2] at the surface in May & June at the southern station (BHP-1) and at the bottom during May, June and July in the main basin. TP concentrations above this level increase the probability of algal blooms. Concentrations at the surface in the main basin remained below the MassDEP threshold.

Table 3. 2021 Bare Hill Pond In-lake Water Quality Data.

Station	Date	Time	TP (mg/L)	DP (mg/L)	TSS (mg/L)	Secchi (ft)	
2S	5/20/2021	17:40	0.021	<0.010	<5	12.4	
2B	5/20/2021	17:50	0.056	<0.010	<5		
1S	5/20/2021	18:10	0.057	<0.010	<5	4.7	bottom
2S	6/29/2021	19:40	0.024	0.020	7	12	
2B	6/29/2021	19:45	0.294	0.044	8		
1S	6/29/2021	20:05	0.065	0.016	5	5.0	bottom
2S	7/30/2021	17:00	0.015	0.011	<5	5.3	
2B	7/30/2021	17:05	0.031	0.019	5		
1S	7/30/2021	17:25	0.021	0.018	<5	5.0	bottom
2S	8/21/2021	12:35	NA	NA	NA	3.1	
2B	8/21/2021	12:40	NA	NA	NA		
1S	8/21/2021	11:15	NA	NA	NA	3.0	

TSS = Total Suspended Solids
"Bottom" indicates the Secchi disk reached the pond bottom
SD – Surface quality control duplicate
NA – Awaiting results from laboratory

[2] Bare Hill Pond Bare Hill Pond, Harvard, MA. TMDL Report MA81007-1999-001 July, 1999 Massachusetts Department of Environmental Protection https://www.harvard.ma.us/sites/harvardma/files/uploads/bhp_tmdl.pdf



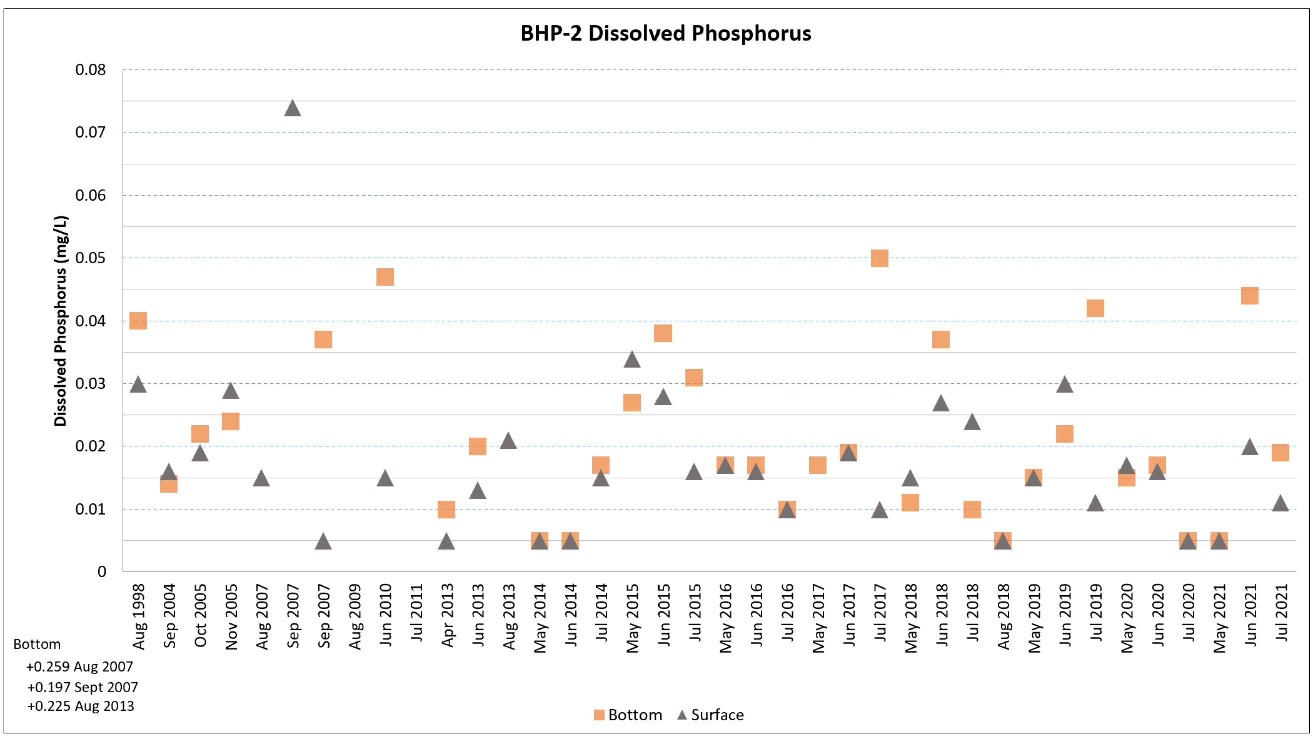


Figure 5. BHP-2 Total and Dissolved Phosphorus Concentrations.

Similar to 2020, we noted that during the filtering of the bottom phosphorus sample in July, the filter appeared green and suggested that there were enough algae present to cause the discoloration of the filter. The BOH sampled the lake on August 3rd and results confirmed presence of algae in concentrations great enough to indicate a bloom. Cyanobacteria concentrations exceeded 20,000 cells/mL. The cyanobacteria community was dominated by *Aphanizomenon flos-aquae*, a known toxin producer and a threat to human health. Conditions continued to decline and the BOH resampled on August 17. These data revealed a total cyanobacteria count of 204,841 cells/mL. *Aphanizomenon* was still dominant, representing 97% of the total cells. The August 2020 bloom was primarily *Dolichospermum* (also known toxin producer) with a smaller amount of *Aphanizomenon.*

Secchi disk transparency in 2021 ranged from 3.0 to 12.4 feet. The lowest value was recorded in August during the bloom and was below the MassDEP State Water Quality Standard for swimming (4 feet; Figure 6). Clarity was greatest in May and declined through the summer.

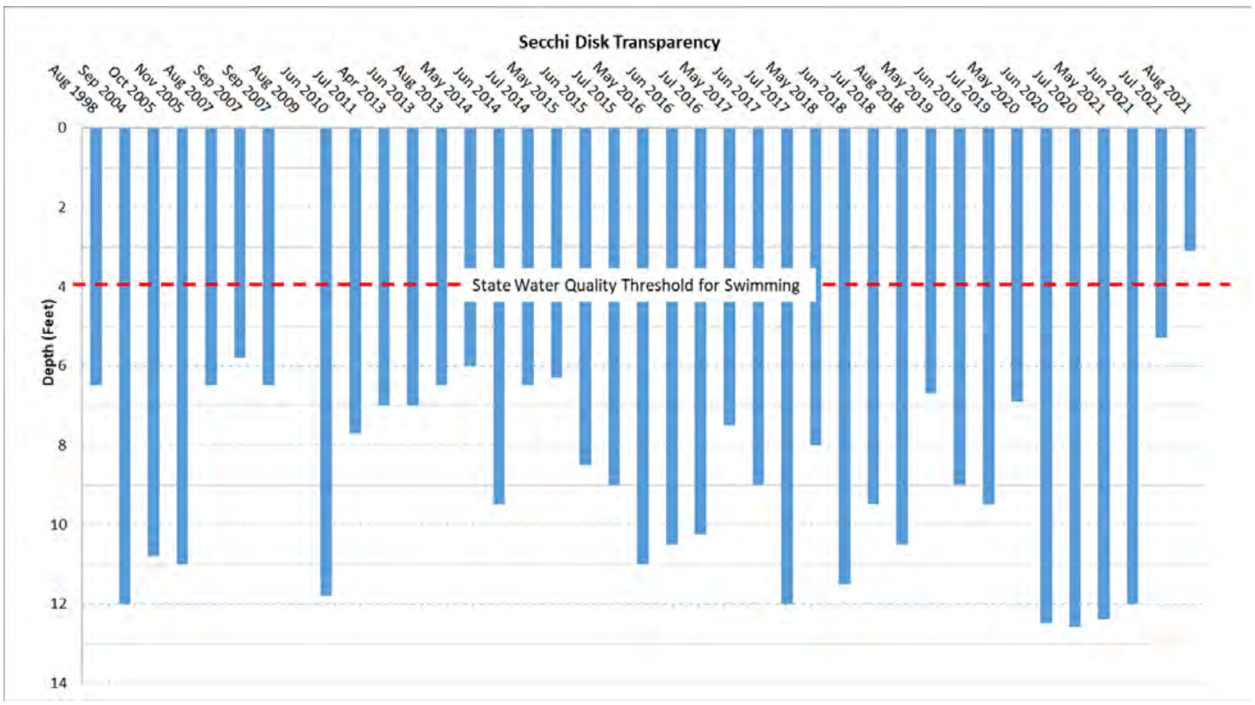


Figure 6. Bare Hill Pond (BHP-2) Secchi Disk Transparency.

In-lake Plant Survey

ARC conducted a plant survey on August 21, 2021. We used the same methods employed during the previous surveys conducted in 1998 through 2020. ARC mapped pond aquatic vegetation along the five transects (A through E) established in 1998. We also repeated the eight points added in 2016 (F through I). Each transect was divided into a series of observation points and were located using Global Positioning System (GPS). A total of 60 points were assessed during the survey.

The plant survey focused on macroscopic fully submerged (e.g., milfoil), floating-leaved (e.g., pond lily), and/or free-floating plants (e.g., duckweed). At each transect point, we recorded the percent cover of all plants, the percent biovolume (as measured by the amount of the water column filled with plants) using a semi-quantitative (0-5) ranking system. A rank of 0 represented 0% cover/biovolume. A rank of 1 corresponded to 1 - 25% cover/biovolume; 2 = 26 - 50%; 3 = 51 - 75%; 4 = 76 - 99; and 5 = 100%. Species observed in each transect were identified and assigned a percent of composition of all species present. Water depth was also recorded at each transect point. These data are presented in Table 4.

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Table 4. 2021 Macrophyte Survey Data

Point	Water	Cover	Bio-volume	Bs	BG	Cc	Cd	Ec	Eleo	FG	Iso	Macro	Mega	Mh	Mhum	Nf	Nm	No	Nv	Pa	Pc	Poly	Prob	Pspir	Pot	Sg	Spar	Usp	Va
A-1	3.5	2	1				20							10				**50**				20							
A-2	3.9	3	2	**30**			10		5									50						5					
A-3	4.8	4	2	**30**	10		20												30									10	
A-4	5.0	2	2	25		10	**30**		5								10											20	
A-5	4.9	3	2	**50**		30								10														10	
A-6	5.1	3	2			**70**												20										5	5
A-7	5.7	4	1									**100**																	
A-8	6.9	3	1									**100**																	
A-9	8.0	3	1									**90**																	10
A-10	10.6	0	0																										
A-11	12.1	0	0																										
A-12	13.7	0	0																										
A-13	5.5	1	1																							**100**			
B-1	3.6	4	4	10		10											20	15	10									5	**30**
B-2	4.5	4	2														**60**	30											10
B-3	5.0	4	2									**30**					10	10										20	**30**
B-4	4.0	4	2									10					**30**	10										20	**30**
B-5	4.6	4	2			20											10	20										20	**30**
B-6	4.6	4	2									10				10	20	20											**40**
B-7	4.6	4	2									**30**				10	10	10										10	**30**
B-8	5.0	4	2									10		10		10	**30**	10											**30**
B-9	4.6	4	2														**40**	10	10										**40**
B-10	4.6	4	2			10						**30**					**30**												**30**
C-1	6.3	4	1			10						10											**80**						
C-2	9.0	4	2																				**100**						
C-3	9.7	4	2																				**100**						
C-4	11.0	3	3			**100**																							
C-5	13.2	0	0																										
C-6	13.3	0	0																										
C-7	13.0	0	0																										
C-8	8.0	3	1			25																	35						**40**
D-1	4.3	5	4			**100**																							
D-2	4.0	4	4		10	**50**												40											
D-3	4.6	4	4		20	**60**												20											
D-4	4.6	4	3		10							**40**					**40**		5									5	
D-5	4.6	4	3	**30**												10	10		10									**30**	10
D-6	4.6	4	2	40												10												**40**	10
D-7	4.6	4	3	10		10											30												**50**
D-8	5.0	5	1									20					**60**												20
D-9	5.0	5	1														**60**												40

Shaded cell indicates dominant species at observation point

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Table 4 (continued). 2021 Macrophyte Survey Data

Point	Water	Cover	Bio-volume	Bs	BG	Cc	Cd	Ec	Eleo	FG	Iso	Macro	Mega	Mh	Mhum	Nf	Nm	No	Nv	Pa	Pc	Poly	Prob	Pspir	Pot	Sg	Spar	Usp	Va
D-10	5.6	4	1									**30**				**30**	10												**30**
D-11	6.0	4	1			20								10			**50**												20
D-12	6.3	2	1			20																							**80**
D-13	7.3	2	2			90																	10						
E-1	5	2	1																										**100**
E-2	6.1	4	1									**80**																	20
E-3	6.3	4	2			**30**						**30**	10															10	20
E-4	7.2	2	2			**90**								10															
E-5	8	3	2			**60**								10						10			20						
E-6	8.7	4	2			**50**																	**50**						
E-7	9.3	4	2			**50**																	**50**						
E-8	10.3	2	1			**100**																							
F-1	5.6	0	0																										
F-2	8.3	4	2			10								**60**									30						
G-1	3.6	3	2			**50**								10				10					30						
G-2	8.6	4	3			20														**60**			20						
H-1	4.3	1	1																							**100**			
H-2	8.3	2	2			**60**								40															
I-1	4.3	2	1			**90**																	10						
I-2	11.3	1	1			**100**																							
Frequency of Occurrence				8	4	28	4	0	2	0	0	15	1	9	0	6	18	15	5	2	0	1	12	1	0	2	0	13	24
Frequency Dominant				4	0	15	1	0	0	0	0	10	0	1	0	1	9	1	0	1	0	0	5	0	0	1	0	2	14
% Time Dominated when Presen				50%	0%	54%	25%	0%	0%	0%	0%	67%	0%	11%	0%	17%	50%	7%	0%	50%	0%	0%	42%	0%	0%	50%	0%	15%	58%

Bs – *Brasenia schreberi* (watershield)
BG – *Cyanobacteria* (*Bluegreen algae*)
Cc – *Cabomba caroliniana* (fanwort)
Cd - *Ceratophyllum demersum* (coontail)
Ec - Elodea canadensis (waterweed)
FG – filamentous algal mats
Iso - *Isoetes* sp. (quillwort)
Mega - *Megalondonta beckii* (water marigold)
Macro algae: Ni.f – *Nitella flexilis* and/or *Chara* (stonewort)
Mh – *Myriophyllum heterophyllum* (variable-leaf milfoil)
Nf - *Najas flexilis*
Nm - *Najas minor* (brittle waternymph)
No – *Nymphaea odorata* (white-flower waterlily)
Nv – *Nuphar variegata* (yellow-flower waterlily)
Pa - *Potamogeton amplifolius*
Pc - *Potamogeton crispus*
Prob – *Potamogeton robbinsii* (Robbins pondweed)
Pspir - *Potamogeton spirillus* (spiral pondweed)
Pot – *Potamogeton* spp. (pondweeds)
Sg - *Sagittaria graminea* (duck potato)
Spar – Sparganium sp. *(bur-reed)*
Usp – *Utricularia* spp. (bladderwort)
Va - Vallisneria americana (tapegrass)

Shaded cell indicates dominant species at observation point

Table 5 provides a comparison between the last five surveys. The "IN" column in Table 5 represents the sample locations that were susceptible to the prior year's drawdown ("in" the drawdown zone). One would expect to see changes in this column with variation of drawdown depth, provided the weather is ideal (exposed shoreline is subjected to freezing temperatures for a prolonged period without the insulating effect of snow cover). The "OUT" column represents data at sample locations where water depths are greater than the drawdown depth ("out" of the drawdown zone). No change related to the drawdown is expected in these cells. Ranks shaded green represent a change of two or more categories lower than the previous year and, in general, represent a desired outcome. Numbers shaded red indicate a two category change higher (an increase in plant cover or biovolume over the previous year). The prior year's drawdown depth is shown in parentheses next to the year.

Data for 2021 were expected to be less desirable than 2020 given the lack of drawdown depth and weather. The survey data indicate cover conditions were slightly lower than 2020 (increase at three locations and decrease at seven locations) but overall cover categories did not change substantially between years with the exception of Transect C at points 6 and 7. These locations had substantial coverage of fanwort in 2020 but no plants were observed at this location this year. This could be due to light limitation experienced last summer and again this year associated with the algal bloom. Biovolume in 2021 was similar to 2020 with five locations experiencing an increase and four locations with a decrease.

This year there was a substantial shift in species composition (Table 6). The most notable changes were increases in the frequency of non-native species, specifically fanwort (10% increase), milfoil (8% increase) and brittle naiad (22% increase). The increase in milfoil was particularly apparent as there were numerous long fragments of the plant scattered throughout the lake. This increase is likely due to the lack of a successful drawdown coupled with significant periods of low light, favoring the growth of aggressive non-native species. Bladderwort increased as well (22% increased frequency of occurrence). While primarily a native species, this plant is often considered a nuisance because of its abundance and growth characteristics. There was a substantial reduction in macroalgae in 2021 (frequency of occurrence reduced by 15%). The combination of macro alga *Nitella* and *Chara* have been successful in occupying the drawdown zone and are considered a beneficial replacement for fanwort and milfoil because they are low growing (creating a carpet like condition) and rarely impede contact recreation. One positive change was the reduction of filamentous green algae; however this type of algae is preferred over bluegreen since they do not produce toxins so perhaps this is not as beneficial as it would be absent the presence of cyanobacteria. Tapegrass (*Vallisneria americana*) was still abundant and frequency of occurrence remained unchanged since 2021. Select plant species frequency data are shown in Figure 7.

Table 5. Bare Hill Pond Cover and Biovolume Relative Change

		2018 (6')		2019 (4.5')		2020 (6.0')		2021 (3.0')		2018 (6')		2019 (4.5')		2020 (6.0')		2021 (3.0')	
	Point	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Transect A	1	2		2		4			2	2		2		4			1
	2	2		3		2			3	2		2		1			2
	3	4		4		4			4	2		2		1			2
	4	4		4		4			2	2		3		1			2
	5	4			4	4			3	2			3	1			2
	6	5			5	4			3	1			2	1			2
	7	5			5	1			4	1			4	1			1
	8		1		2	2			3		1		2	1			1
	9		1		2		1		3		1		1		1		1
	10		1		4		1		0		1		2		1		0
	11		1		1		2		0		1		1		1		0
	12		0		0		0		0		0		0		0		0
	13		4		2	2			1		1		1	1			1
Transect B	1	5		5		4			4	3		3		3			4
	2	5			4	4			4	2			1	2			2
	3	5			5	5			4	1			3	2			2
	4	5			5	5			4	1			3	2			2
	5	5			4	5			4	1			1	2			2
	6	5			5	5			4	1			1	2			2
	7	5			5	5			4	1			1	2			2
	8	5			4	5			4	1			1	2			2
	9	5			5	5			4	1			1	2			2
	10	5			5	5			4	1			1	2			2
Transect C	1		5		4	1			4		2		3	1			1
	2		5		4		4		4		3		2		1		2
	3		5		4		4		4		2		3		2		2
	4		4		4		3		3		2		2		2		3
	5		1		1		1		0		1		1		1		0
	6		4		4		4		0		2		2		2		0
	7		4		4		4		0		2		2		2		0
	8		4		4		4		3		2		3		3		1
Transect D	1	5		3		4			5	1		1		2			4
	2	5			5	4			4	1			3	2			4
	3	5			5	4			4	1			4	2			4
	4	5		5		4			4	1		2		1			3
	5	5		5		4			4	1		3		1			3
	6	5			5	4			4	1			2	2			2
	7	5		5		4			4	1		3		2			3
	8	5			5	4			5	1			2	2			1
	9		5		5	4			5		1		2	1			1
	10		5		5	4			4		1		1	1			1
	11		5		4	4			4		1		1	1			1
	12		5		4		4		2		1		1		2		1
	13		5		4				2		1		2				2
Transect E	1	5			4	5			2	2			1	2			1
	2	5			5	5			4	1			1	2			1
	3		5		5		5		4		1		2		2		2
	4		5		5		4		2		3		2		2		2
	5		5		5		4		3		3		3		2		2
	6		5		5		4		4		2		3		2		2
	7		5		5		4		4		2		3		2		2
	8		5		5		3		2		2		3		2		1
Supplemental	F-1	1			1	1			0	1			1	1			0
	F-2		5		5		5		4		2		2		2		2
	G-1	2			3	4			3	1			2	2			2
	G-2		5		4		4		4		2		3		2		3
	H-1	1		1		1			1	1		1		1			1
	H-2		4		4		4		2		2		2		2		2
	I-1	1			1	1			2	1			1	1			1
	I-2		4		4		4		1		2		1		1		1

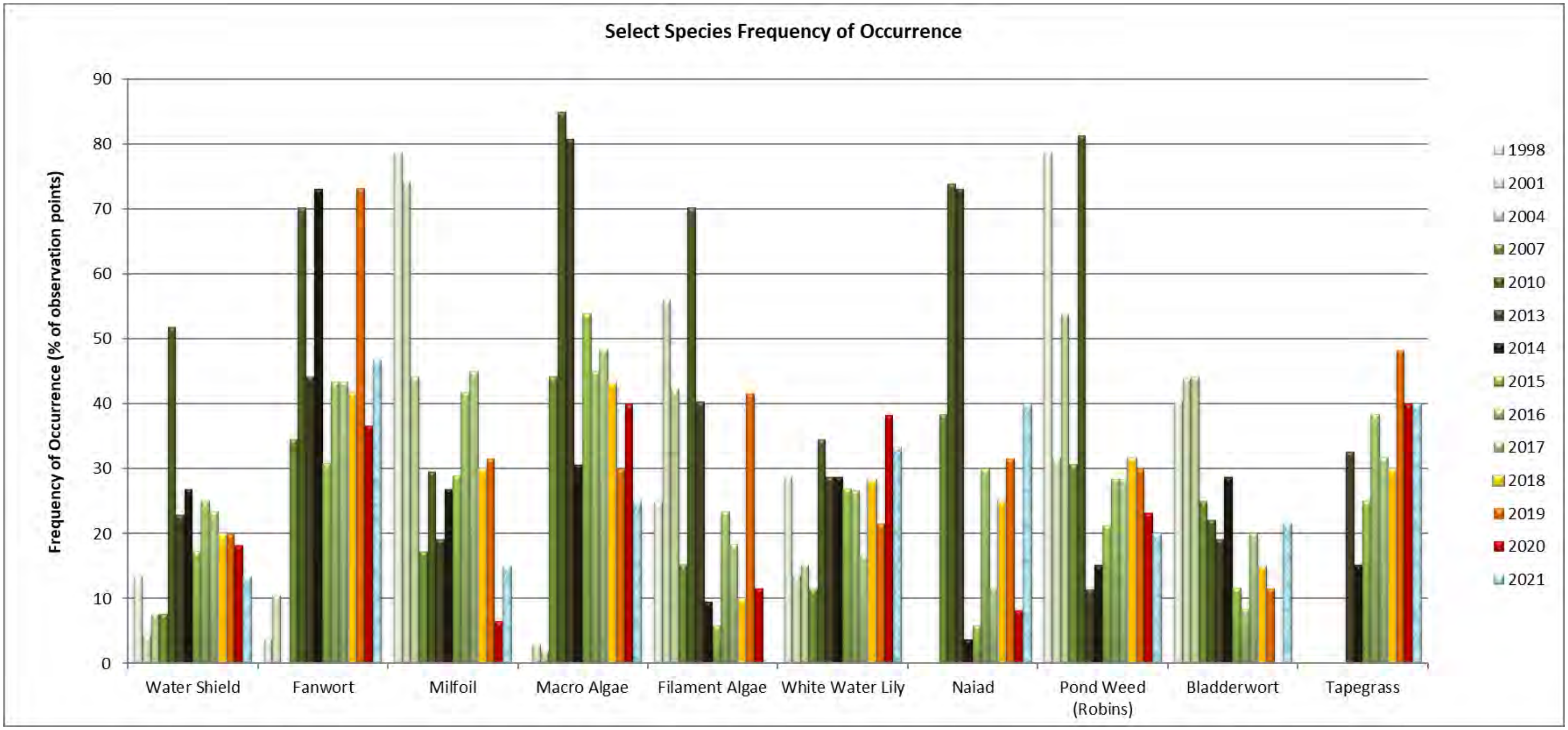
Increase by 2 or more ranks from prior year Decrease by 2 or more ranks from prior year

Table 6. Select Species Frequency of Occurrence (%)

	Water Shield	Fanwort	Milfoil	Macro Algae	Filament Algae	White Water Lily	Naiad	Pond Weed (Robins)	Bladder wort	Tapegrass
1998	13	4	79	0	25	29	0	79	40	0
2001	5	11	74	3	56	14	0	32	44	0
2004	8	0	44	2	42	15	0	54	44	0
2007	8	35	17	44	15	12	38	31	25	0
2010	52	70	30	85	70	35	74	81	22	0
2013	23	44	19	81	40	29	73	12	19	33
2014	27	73	27	31	10	29	4	15	29	15
2015	17	31	29	54	6	27	6	21	12	25
2016	25	43	42	45	23	27	30	28	8	38
2017	23	43	45	48	18	17	12	28	20	32
2018	20	42	30	43	10	28	25	32	15	30
2019	20	73	32	30	42	22	32	30	12	48
2020	18	37	7	40	12	38	8	23	0	40
2021	13	47	15	25	0	33	40	20	22	40
Increase/Decrease from prior year										
	-5	10	8	-15	-12	-5	32	-3	22	0

Naiad includes both native and non-native species occurrence

Figure 7. Bare Hill Pond Select Plant Species Frequency of Occurrence



Conclusion

Surface water total phosphorus concentrations were elevated in the south basin and in bottom waters of the main basin. With the sustained and expanding zone of low to no oxygen in portions of the lake deeper than 10 feet, internal loading remains a concern. The consecutive years of cyanobacteria blooms are a symptom of warmer, low oxygenated, nutrient-rich waters. Secchi disk transparency was high for the lake early this summer but drastically declined in July with the lowest value recorded in recent years, only three feet in August. Not surprisingly, the lack of clarity coincided with a cyanobacteria bloom. The most abundant species during the bloom was *Aphanizomenon flos-aquae*, a known toxin producer.

The aquatic plant coverage was slightly reduced in 2021 but biovolume was consistent with 2020. The decrease in cover is likely the result of light reduction experienced in 2020 and again this year caused by the algae bloom. Despite the reduction in cover, non-native species have increased in abundance. This is likely due to an unsuccessful drawdown. The lake has sustained a desirable coverage of low growing macroalgae and other seed producing plants in the drawdown zone following successful drawdown years. This year, however, the non-native species, fanwort, milfoil and brittle naiad increased.

While we were hopeful that last year's algal bloom was the result of an odd weather year (hot dry summer), a repeat bloom occurred this August during a very wet year. The lake may have reached a tipping point where the warming summers and increased availability of phosphorus from sediments will continue to result in more frequent and severe blooms. The sediment analysis planned for September 2021 will help assess whether internal loading is the potential root cause of the less than desirable conditions we've seen in the last two years.

The pond's plant community is dense and diverse enough to support fish and wildlife, there are shifts in species composition between years, but the drawdown has proven to improve conditions; reduced dense monocultures of fanwort and milfoil in the drawdown zone and encouraging growth of low growing beneficial plants that are less of a nuisance for recreation. The drawdown is likely improving flushing and ridding the lake of accumulated phosphorus from internal recycling over the summer. Conditions may become worse if algae and associated nutrients are not flushed out of the system.

Recommendations

We have reduced the monitoring of wetland plots and iris since data collected thus far have not revealed significant negative impacts associated with the drawdown. We have expanded water quality monitoring and are planning to perform an assessment of the internal phosphorus loading potential this fall. The low dissolved oxygen and more extreme weather conditions are a challenge. The sediment data may reveal some potential management measures that have potential to improve conditions for aquatic life and reduce bloom occurrence. We will evaluate these options once sediment and dissolved oxygen demand is assessed.

Given the success of the drawdown over the years in minimizing non-native fanwort and milfoil density within the drawdown zone and improved flushing, the Committee wishes to implement a 6.5-foot drawdown this coming winter. This will reduce non-native species abundance and provide an added benefit of reduced phosphorus retention. The aquatic macrophyte survey, and other fauna surveys performed by the Committee will continue on an annual basis to assess year to year changes.