Bare Hill Pond Watershed Management Committee
Town of Harvard
Harvard, MA 01451

August 25, 2016

Conservation Commission
Town of Harvard
Town Hall
Harvard, MA 01451

Re: <u>2015-16 Drawdown Report and Fall 2016 Drawdown Plans</u>

Dear Commissioners:

On behalf of the Bare Hill Pond Watershed Management Committee, we are pleased to submit our 2016 annual report. Included with this report is our professional monitoring report from Wendy Gendron as well as our own observational data. We have invited Wendy Gendron, our wetlands biologist consultant to join us at the meeting on September 1, 2016. Exhibit C is Ms. Gendron's Report. In includes additional wetlands and pond monitoring data that she recommended and we discussed at the meeting last year.

In summary, our data indicates that following the draw down last winter, phosphorous levels improved somewhat this year. Last year, in some locations and at certain times, there were levels that exceed the endangerment level of 30 ug/l (0.030 mg/l). We paid close attention to the Pond and its surrounding wetlands this year due to the warmer than usual winter, there was a freeze in January for about 3 weeks, and the limited snow fall. We also paid close attention due to the drought this Spring and Summer. The refill of the Pond, despite the absence of snowmelt (See Exhibit A) was relatively normal until the last 6-12 inches. The normal average height of Pond is 22" below the top surface of the Dam. The refill started at the beginning of February and during February level rose about 20" mostly from the water table due to limited snow melt. Last year at that time there was still deep snow cover on the Pond and ice. By the end of March it rose another 20" or about two feet from the tope surface of the Dam with little or no rain or melt. In April it rose about 7" with little rain or run off, and in May the Pond reached its high of 26" from the top surface of the dam or 4" below average normal height and probably about 1 foot below normal spring height at that time. During June there was very limited rainfall and the Pond slowly dropped to 34" below the top surface of the dam as inflowing water from the water table springs was feeding the downstream wetlands. It remained at this level through July and until now. During July and August Bowers Brook was not flowing into the Pond so this data suggests that Pond stabilized at the water table height. This is consistent with prior years of limited rainfall. In years where there was limited rain, the Pond was typically about 28" (last year in Sept. it was at 29") from the top of the Dam by September until there were fall rains or a draw down. This year it is about 6" lower.

Other observations were that water clarity was significantly improved this year with visibility up to 11 feet. Algal growth and particulates were down. See Wendy Gendron's report.

This may be due to the lack of rainfall and storm water runoff feeding the Pond this year. This suggests that storm water runoff from shorlines may have had less of an impact on water clarity this year. At the same time, greater water clarity, when coupled with lower water depth, allows more sunlight to reach the plants and there were areas of significant growth of invasive species in deeper locations than normal as noted in the Gendron report.

With regard to phosphorous, a completely undeveloped watershed is normally 5-10 ug/l and it would be difficult to get much lower than 20 ug/l given the level of development in our watershed and the pre-existing bound phosphorous in the Pond bottom. The 1998 TDML measured the level at 44 ug/l and our target for the DEP/EPA grant was 30 ug/l.

Ms. Gendron conducted the expanded monitoring survey as requested. She added specified sites to the in lake survey to capture areas that were reported as concerns by residents that had not been captured in prior years. She also added adjacent wetland monitoring as requested and discussed at last year's meeting to monitor the health of the wetlands, and conducted the phosphorous readings in May, June and July. She conducts the plant survey in August so that we have current comparison data at a comparable time at the prescribed transect locations used in the prior plant surveys. The data runs back as far as 2002, and the transects were established by ENSR and used by DEP/EPA to measure our goals in the grant. A copy of the transect map is included in the Gendron report. The 2016 water quality results are compared to those results to results dating from 2004, 2005, 2007, 2009, 2010, 2011, 2013, 2014, 2015 and the TDML reading from 1998.

In the Gendron report, she finds that there is more invasive species growth this year perhaps due to the increased sunlight and to the limited efficacy of the warm weather draw down. She also notes the increased water clarity, and the improvement in phosphorous levels. She notes however that with the levels of dissolved oxygen in the deeper water zones, there is still risk of phosphorous release from the sediments meaning we need to continue to control the phosphorous levels to avoid eutrophic conditions.

In addition to the professional monitoring, we continue our volunteer monitoring program of frogs, fish, mussels and invertebrates, and downstream wetlands. Tom Gormley reports that the frog counts did not indicate a change in populations but were unsual due to the warm weather in February causing frogs to emerge at different times and earlier than normal. He also worked this year to capture historical data before he finished his term on the committee. Tom has taken advantage of Next Door Harvard which has increased participate of volunteers and facilitated counts. Tom will assist in a transition to new count leadership for next year. See report in Exhibit B.

Fishing derbies reported excellent fishing as do periodic unsolicited comments from fishermen. We held a mussel count at the 5 foot stage to see if they are impacted and there were many mussels as well as juveniles indicating their health. Here are a few photos taken in November:


Rick Dickson continues to monitor invasive water chestnut plants finding small numbers which he and others pull. Due to his success over the past several years, he did not seek volunteer help for a weed pull. The water chestnuts continue to be under control as the density of plants is low as reflected in how difficult it is to find them throughout the Pond. He asks us all to be vigilant for any remaining water chestnut plants and to pull them when we see them.

Draw Down Plan

Based on the increased growth of invasive species, and the need to control phosphorous, as well as the limited impact of the draw down last winter on invasive species due to warm weather, we propose to do a draw down for this Fall to restore the invasive growth levels and to keep the invasive species from continuing to repopulate the 5-8' zone. A 6 foot draw down would replicate what was conducted last year and has shown to be sufficient in prior years when there is sufficient cold. We believe the refill this year and the maintenance of the level in the Pond demonstrates that it is acceptable to conduct a draw down this winter. It is important that we keep the phosphorous under control and not allow significant expansion of the invasive species.

Our draw down plan would be the same as last year. We received outstanding support from DPW last winter operating the pump for the first time and assisting with maintenance. This allowed for better timing of pumping, reduced power costs, and the ability to successfully defer pumping until late October. Assuming that there is not significant rainfall in September, the current level of the Pond is now at the target level for mid-October so we would not remove boards until it was needed to achieve a target, or run the pump until removal of boards was insufficient to achieve a target. Depth target is the maximum drawdown as of that date

Date	Depth Target (Measured from the top surface of the dam) 2014	2012	2016 and 2015 Drawdown Depth	2016 and 2015 Actual Depth**
9/24	22”	22”	22”	0”
10/1	22”	34”	22”	0”
10/15	34”	46”	36”	14”
10/24	46”	52”	48”	26”
10/28	52”	58”	56”	34”
Nov 30 or freeze*	5.5’ on pipe	6’ on pipe	6’ on pipe	6’ on pipe

*(measured on pipe marker)
**(amount of water drawn down)

Pumping would begin only when needed to maintain the rate during October but be necessary after reaching approximately 3 feet. The rate would not exceed 2 inches per day per the Order of Conditions. We think this approach will preserve Pond levels in September and October for recreational use (including the rowing season) and still achieve the beneficial draw down effects. If we are unable to achieve the 6.0 foot draw down by November 30, 2015 or a freeze occurs, we will stop and discuss it with the Commission if we have an alternative recommendation.

As in prior years, we would initiate the refill of the Pond on or before February 1, 2016 following notice to the Commission and the abutters. Because snowmelt timing is variable, it is important to timely refilling of the Pond, our experience indicates that deferring the refill beyond February 1 is unwise to ensure the habitat is restored for amphibians, fish and reptiles. This past year suggests this was wise as the Pond rose 20” in February because the freeze ended.

We appreciate the time the Commission has taken, and the effort made to understand, and help manage the project. We look forward to the meeting on September 3.

Sincerely,

Bruce A. Leicher
Chair, Bare Hill Pond Watershed Management Committee

Cc: Conservation Commission Members
Bare Hill Pond Watershed Management Committee Members
Board of Selectmen

Exhibit A

Pond Draw Down and Refill Data   Fall 2015 – Spring 2016

Note: 22” is average normal height of Pond (average range 16”- 28” from top surface of Dam); feet is draw down actual depth from pipe markers

Date	Pond Level	Wetlands Level	Notes
9/19	29”	70”	Pre-draw down limited rain in August
9/25	31”	74”	First boards pulled – limited rain
10/3	29”	68”	
10/7	32”	60”	
10/13	37”	58”	
10/17	40”	60”	Pump on
10/24	50”	53”	Turn pump off
10/31	58”	58”	Pump off
11/3	-	-	Pump restarted
11/7	64”	54”	Slow pump to 48hz
11/14	4 ¾ ft (78”)	57”	
11/19	6 ft (94”)	-	
11/21	6 ft		
12/5	6 ft	69”	
2/4	6 ft		Start refill
2/13	5 ¾		Some snow melt – still cold
2/20	5 ½ ft	78”	
2/27	3 ¾ ft	66”	
3/5	62” (3 ¼ ft)	61”	
3/12	58” (3 ft)	56”	
3/19	52”	59”	
3/26	49”	68”	
4/2	43”	68”	
4/9	36”	62”	
4/16	33”	57”	
4/23”	31”	52”	
4/30	30”	62”	
5/7	27”	60”	
5/28”	26”	60”	
7/30	35”	-	
8/14	34”	68”	

Frog Monitoring Report Exhibit B

Spring 2016 Frog Counting Report
Bare Hill Pond Watershed Management Committee – Tom Gormley
August 2, 2016

The Pond Committee held two frog counts this spring, fewer and more limited in coverage and participation than recent years due to a combination of weather and scheduling challenges. Although we had fewer data points, we believe there were no signs of a decreasing frog population. We have also completed work to capture all of our historical and recent count data in an Excel sheet for multi-year analysis, which may be helpful in the future.
The winter and spring weather this year was obviously very unusual, with warm spring temps coming in February, and then a hard freeze and continuing cold during March which has had a devastating impact on local peach and other fruit crops. It's very possible that this flummoxed our frog population as well, as many frogs including peepers and green frogs were heard calling in the woods and vernal pools as early as mid to late February, far earlier than the standard timing of our first count. By later March and early April, temps had dropped and we heard fewer of these calls on walks around the neighborhood.

First Count
Our first official count was held on March 31 by Tom and Jenny Gormley. Note that this was 2-3 weeks earlier than the first counts in mid-April during the prior 3 years, so we anticipated we might get different results, especially given the weather. Other volunteers from recent years weren't available that evening but we chose to go ahead and take advantage of a warmer night. We visited three locations which are typically the busiest with frogs in the early season – Bowers Rd, behind the tennis courts, and Pond Rd. Strong, consistent choruses of peepers were heard at all locations. Although we heard no other frogs besides the peepers on this count, it seems reasonable to conclude this could be due to the earlier timing of this count, and the weather changes from February to March.

Second Count
Scheduling and weather were again a challenge for the second count on May 19th. Only Tom went out in a light sprinkling rain. At the first location, Bowers Rd, I heard a chorus of peepers and a smaller number of pickerel and green frogs. Unfortunately the sprinkle turned quickly to a downpour, making further counting impractical due to the sound of the rain. Hearing pickerel and green frogs in the middle of spring is very typical compared with recent years, so that was encouraging. No further counts were held this spring.

Electronic Data File
With the help of COA worker Don Soja, we've captured annual frog count data from 2008 forward, with a few data points also from 2003. Some committee members believe there may exist other data entry forms from prior years, but we've been unable to locate them. The data need some formatting in order to make them useful for year to year trending and comparisons. Another committee member or perhaps a student could take this on as a new project.

<u>Professional Monitoring Report   (attached)</u>   Exhibit C

Repot For:

Town of Harvard
Bare Hill Pond Watershed Management Committee
Harvard Massachusetts

Bare Hill Pond In-Lake Water Quality, Plant Survey and Wetland Plot Monitoring 2016

Prepared by:
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18 Sunset Drive
Ashburnham, MA 01430

August 2016

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Introduction

Aquatic Restoration Consulting, LLC (ARC) performed in-lake water quality sampling, aquatic plant survey and wetland plot monitoring of Bare Hill Pond in 2016. The intent of these surveys was to document water quality and plant presence and abundance. These data were compared to previous surveys.

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 has enabled the Committee to increase the 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 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.

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

The Committee, in consultation with ARC and the Town of Harvard Conservation Commission, decided not to perform a drawdown over the winter of 2013–2014. The purpose of the hiatus was to determine if taking a year off would result in discernible changes to the plant community or water quality. While the 2014 survey showed no substantial evidence in the observation points to suggest a drastic increase in plant growth, fanwort (*Cabomba caroliniana*) regained dominance in a portion of the drawdown zone. Observations outside the surveyed points by ARC and lake users made note of a general increase in plant growth. Watershield (*Brasenia schreberi*) was more prevalent in many areas outside the measurement points. Measurable changes in phosphorus concentrations were not observed in 2014.

Given the observed increase in plant abundance and concerns by residents that plant density will continue to increase in absence of a drawdown, the Conservation Commission permitted a 5.5 foot winter water level drawdown in 2014–2015 and a six foot drawdown in 2015-2016. This report summarizes data collected in 2016 and provides a comparison to data over several years, with emphasis on the comparison within the last four years.

In-Lake Sampling

Dry weather in-lake sampling was conducted on May 24, June 13, and July 14, 2016. 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), pH and specific conductivity were recorded at two locations: shallow basin BHP-1 in the south basin and the deep hole in the north basin BHP-2. These data are presented in Table 2. Figure 1 provides a graphical representation of temperature and DO data for the deep station (BHP-2) in comparison with prior years.

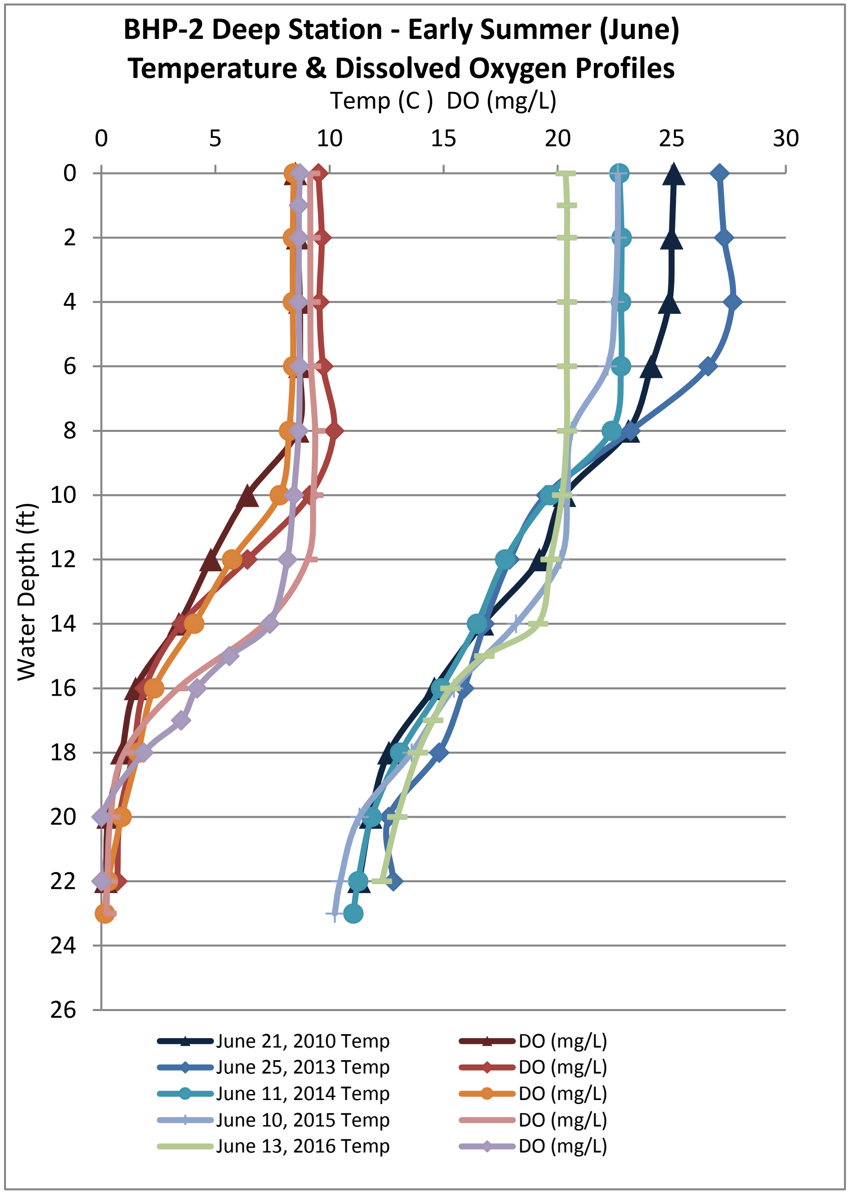
The temperature and DO profiles suggest that the lake began to thermally stratify in May and was weakly stratified by July. Concentrations of DO in May were consistent throughout the water column until a depth of eight feet and showed a slow decline with increased depth. DO dropped substantially after 12 feet in June and July. Concentrations were below the desirable level for fish [5 - 6 milligrams-per-liter (mg/L)] at and below 14-16 feet. These data are consistent over the last several years (Figure 1).

Oxygen depletion starts above the thermocline. Much of the cold water fish refuge area is undesirable given the lack of oxygen. These data suggest that the lake has a substantial oxygen demand and is susceptible to iron-bound phosphorus release from the sediment. Phosphorus can accumulate in the hypolimnion under these conditions. Once the hypolimnetic phosphorus is mixed in the photic zone, algal blooms are more likely to occur.

Generally, surface pH levels are neutral to slightly basic and become more acidic with water depth. The southern basin had a higher basic condition in June 2016 (pH ranging from 8.7 to 9.24 SU) when compared to May and July. Increased photosynthetic activity could have caused a temporary increase in pH; when plants and algae use carbon dioxide from the water column during photosynthesis, this reduces water acidity. Specific conductivity in 2016 increased gradually with time and was above the desirable range (<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 2. Bare Hill Pond Water Depth Profiles 2016

BHP-1														
24-May-16					13-Jun-16					14-Jul-16				
Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)
0	19.56	9.38	7.26	229	0	20.38	10.18	8.70	234	0	26.18	8.46	7.49	246
1	19.54	9.39	7.36	229	1	20.40	10.21	9.05	234	1	26.02	8.54	7.56	246
2	19.53	9.41	7.38	229	2	20.42	10.24	9.08	234	2	25.37	8.74	7.69	245
3	19.54	9.42	7.39	229	3	20.43	10.26	9.10	234	3	25.05	8.75	7.76	245
4	19.57	9.44	7.41	229	4	20.47	10.06	9.24	234	4	25.04	8.69	7.82	246
BHP-2														
Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)	Depth (ft)	Temp (C)	DO (mg/L)	pH (SU)	Spec. Cond (us/cm)
0	18.75	9.28	7.24	229	0	20.34	8.70	7.18	234	0	26.13	8.36	7.65	245
2	18.85	9.19	7.25	229	2	20.41	8.66	7.30	233	2	26.14	8.33	7.63	246
4	18.85	9.21	7.26	229	4	20.40	8.65	7.33	233	4	26.12	8.31	7.63	246
6	18.83	9.19	7.27	229	6	20.40	8.69	7.34	232	6	25.96	8.27	7.62	246
8	17.41	8.9	7.17	227	8	20.40	8.65	7.35	233	8	25.91	8.27	7.61	246
10	16.21	8.64	7.07	226	10	20.20	8.43	7.31	233	10	25.89	8.27	7.61	246
12	15.47	8.29	6.97	226	12	19.69	8.15	7.20	232	12	25.85	8.23	7.60	246
14	14.71	7.35	6.85	225	14	19.14	7.38	7.02	230	14	22.99	5.43	6.94	244
16	14.14	6.52	6.73	224	16	15.30	4.20	6.58	226	16	20.35	0.79	6.53	235
18	13.25	5.4	6.63	224	18	13.88	1.86	6.49	228	18	17.53	0.32	6.43	230
20	12.52	3.14	6.53	226	20	12.97	0.00	6.48	232	20	15.2	0	6.45	232
22	12.14	1.4	6.50	229	22	12.30	0.00	6.40	251	22	13.67	0	6.79	264



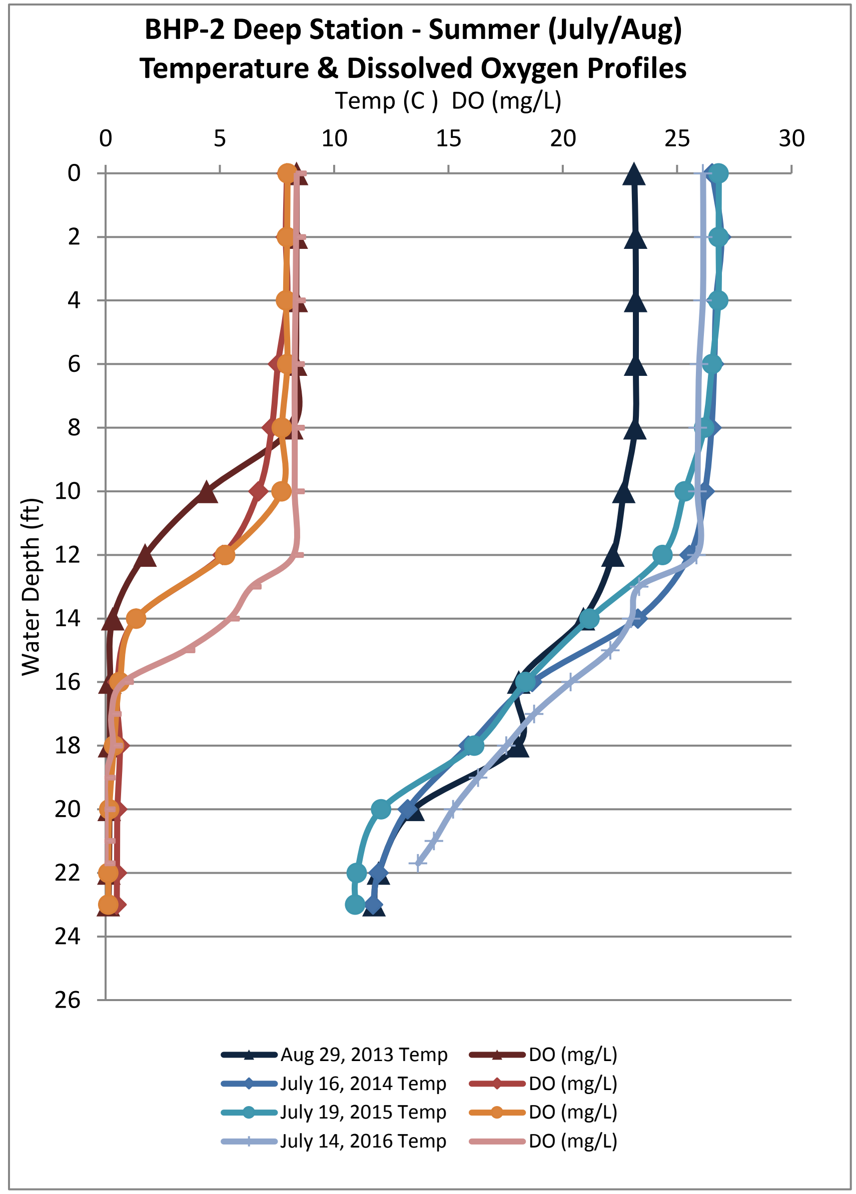


Figure 1. Temperature & Dissolved Oxygen Profiles at BHP-2 for 2010-2016

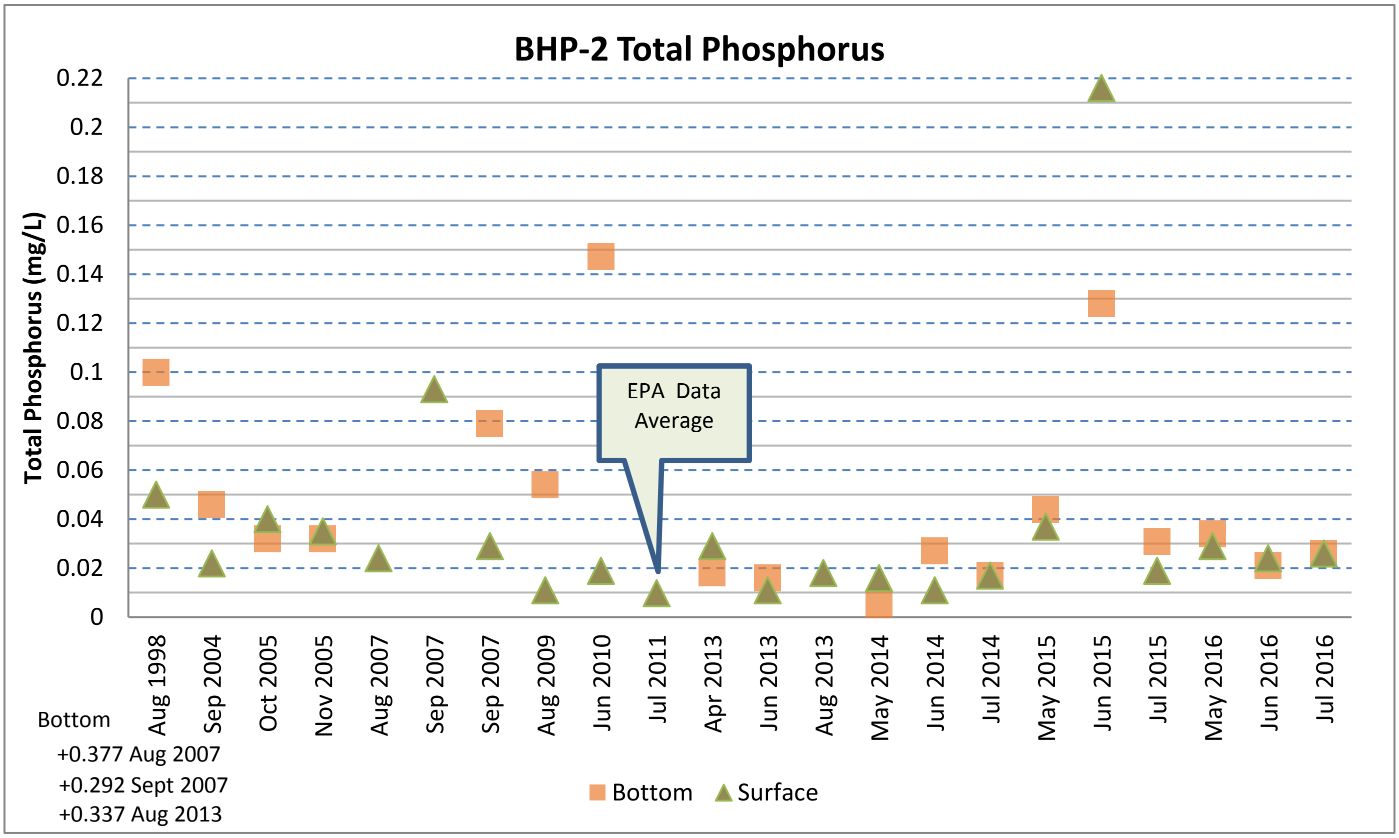
Table 3 provides the results of phosphorus, total suspended solids and water clarity (measured by Secchi disk transparency) during 2016. Comparison with prior years is illustrated graphically in Figure 2. Surface total phosphorus (TP) concentrations in 2016 were more consistent than those measured in 2015 and were generally lower than the previous year but slightly higher than in 2014. The difference between 2014 and 2016 is unlikely statistically significant given the overall variability between years. TP ranged from 0.017 mg/L (low) to 0.034 mg/L, above the threshold where algal blooms are probable. Phosphorus concentrations were highest in May (Figure 2). Dissolved phosphorus values were lower in 2016 than in 2015 and consistent with July 2014 values. Early season 2014 values were lower than 2016. A trend in phosphorus over the summer season was not apparent in 2016 data.

Secchi disk transparency in 2016 ranged from 10.3 to 11.0 feet, with a slight decrease in clarity over time. Clarity was the greatest reported since 2010 (Figure 3). The dry summer, limiting water inflows carrying detritus and other dissolved and particulate matter, may have helped reduce water color and suspended particulates.

Table 3. 2016 Bare Hill Pond In-lake Water Quality Data.

Station	Date	Time	TP (mg/L)	DP (mg/L)	TSS (mg/L)	Secchi (ft)	
2S	5/24/2016	17:50	0.029	0.017	<5	11	
2B	5/24/2016	17:55	0.034	0.017	<5		
1S	5/24/2016	18:15	0.033	0.017	<5	4.8	bottom
2S	6/13/2016	17:30	0.024	0.016	<5	10.5	
2B	6/13/2016	17:35	0.021	0.017	10		
1S	6/13/2016	17:50	0.017	0.016	6	5.0	bottom
2S	7/14/2016	18:00	0.026	<0.02*	5	10.25	
2B	7/14/2016	18:10	0.026	<0.02*	8		
1S	7/14/2016	18:30	0.021	0.023	5	4.0	bottom

TSS = Total Suspended Solids
"Bottom" indicates the Secchi disk reached the pond bottom
* Lab detection limit high



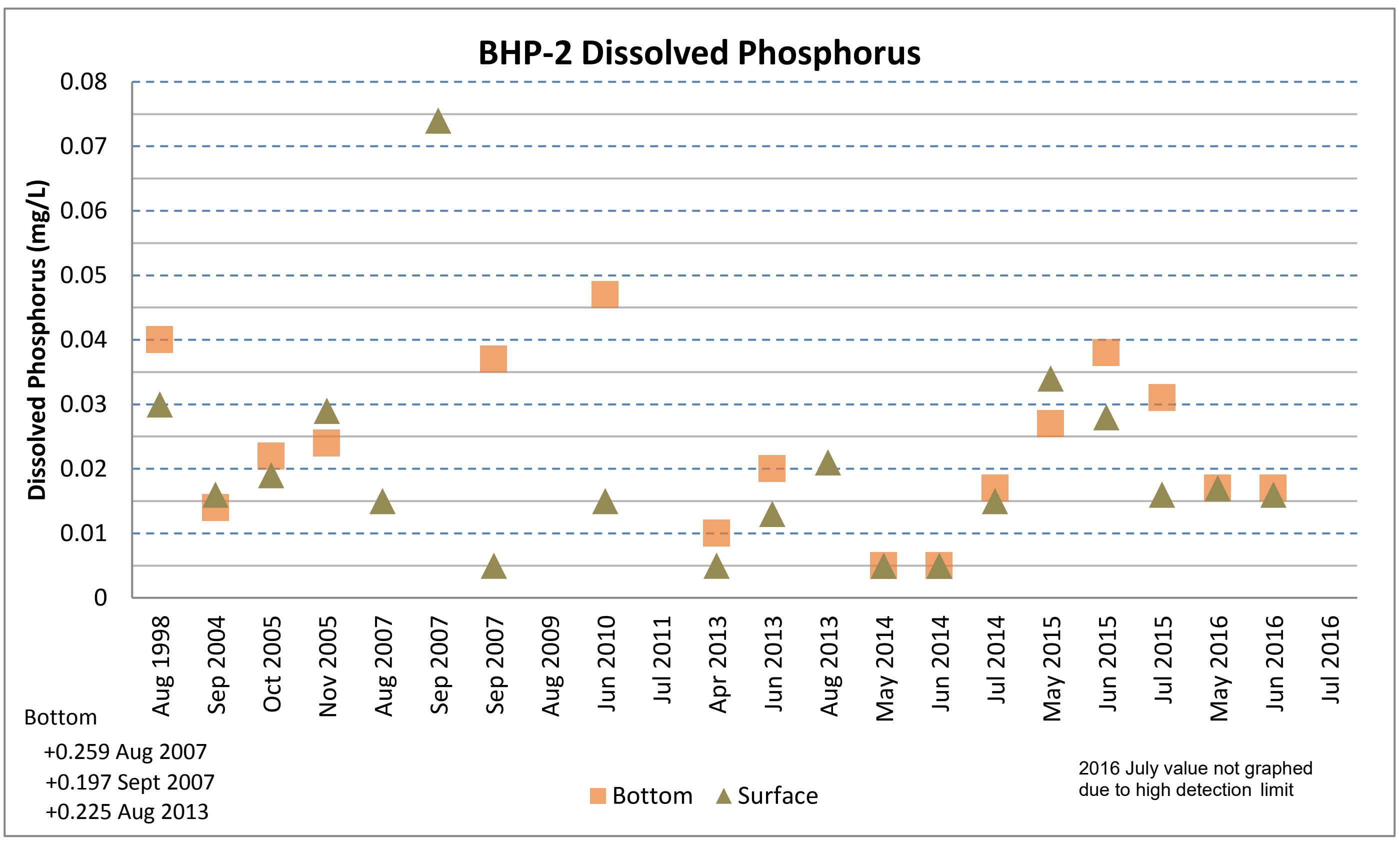


Figure 2. BHP-2 Total and Dissolved Phosphorus Concentrations.

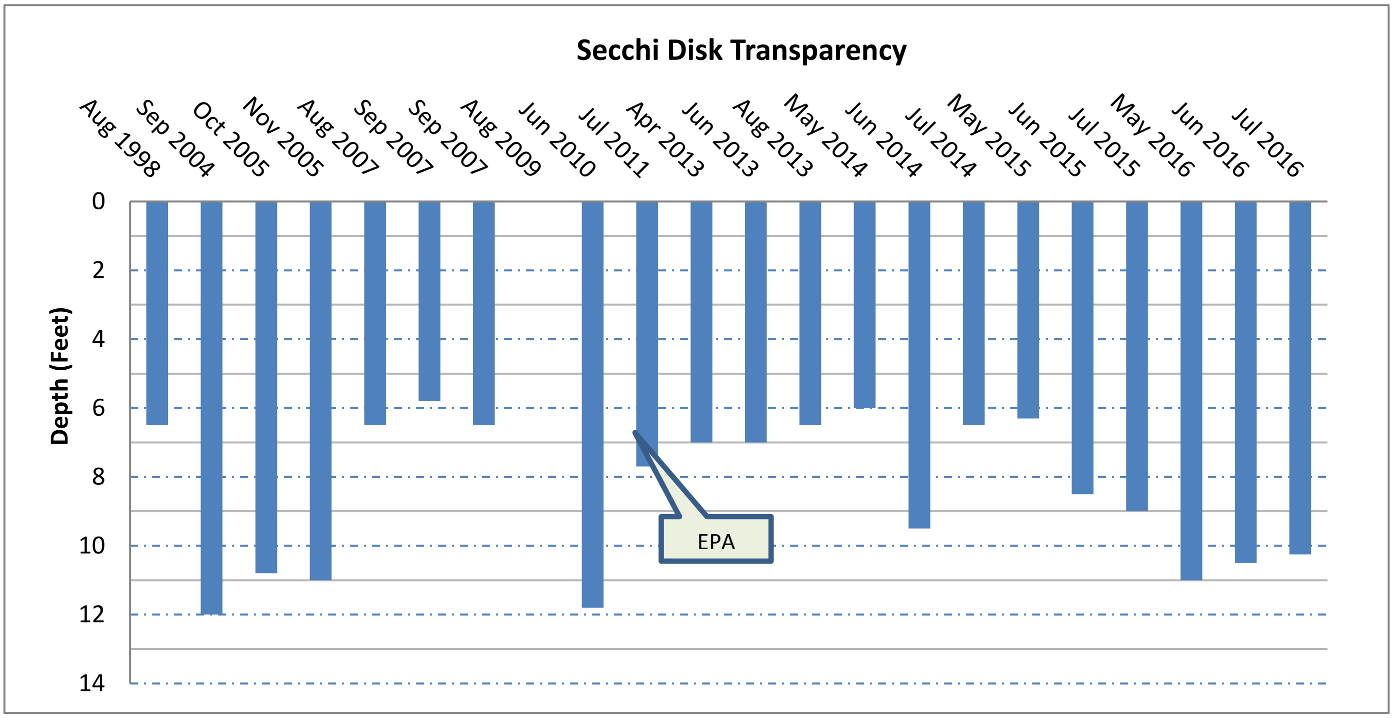


Figure 3. Bare Hill Pond (BHP-2) Secchi Disk Transparency.

In-lake Plant Survey

ARC conducted a plant survey on August 20, 2016. We used the same methods employed during the previous surveys conducted in 1998 through 2015. ARC mapped pond aquatic vegetation along the five transects (A through E) established in 1998. We added an additional eight points this year to obtain data in areas poorly represented. 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. Figures 4 and 5 provide a 2016 transect point summary for plant cover and biovolume.

Table 5 provides a comparison between the last four 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 represent a desired outcome. Numbers shaded red indicate a two category change higher (an increase in plant cover or biovolume over the previous year). 2013 data do not have shaded values as 2013 was the starting point for this comparison. The prior year’s drawdown depth is shown in parentheses next to the year. The Committee did not conduct a drawdown in 2014 and therefore this value is zero.

Generally a shift by two or more ranks (e.g. change from rank 1 to 3) is required before statistical significance is reportable. Plant cover data collected in Transect A (at the southern end of the pond) showed the largest change of all observation locations in 2016. Cover increased in Transect A since 2015 at seven of the eight observation points within the drawdown zone. While 2015 showed a decrease over 2014 (a positive outcome following a 5.5’ drawdown after a hiatus year). 2016 plant cover was generally comparable to 2014, if not slightly higher (A-7 & A-8 had a two rank higher cover in 2016 over 2014). Biovolume was relatively consistent at Transect A with an increase in the drawdown zone at two locations. There was no remarkable change in cover or biovolume in areas outside the drawdown zone for Transect A. Transect B had one point with increased cover and one decreased. All other values were consistent.

The remaining points at Transects C, D and E had mixed results in 2016. Transect C had an increase in cover and biovolume at one point each (both outside the drawdown zone). Transect D resulted in two points with decreased cover and no change in biovolume. No change was observed at Transect E in 2016 over 2015. While mostly only one rank, there is an overall increase in cover and biomass in 2016 over 2014. These data suggest that the mild winter and the extended dry warm growing season may have decreased the efficacy of the drawdown.

Table 4. 2016 Macrophyte Survey Data

				Species (relative abundance %)																				
Point	**Water Depth (ft)**	**Cover**	**Bio-mass**	**Bs**	**Cc**	**Cd**	**Ec**	**FG**	**Iso**	**Mh**	**M. hum**	**Ni.f**	**Nm**	**No**	**Nv**	**Pa**	**Pc**	**P. rob**	**P. spir**	**Pot**	**Sg**	**Spar**	**Usp**	**Va**
A-1	2.5	4	3	25						20		25		25									5	
A-2	2.5	4	2	25								25	5	25									20	
A-3	3.5	5	3	20	5	10				5		20	10	15						10			5	
A-4	3.5	5	3	30				5		5		20	30							5			5	
A-5	3.5	5	2	30								30	20	10	10									
A-6	3.5	4	2	5		10				5		30	5	10	5					10				20
A-7	4.0	4	1									90	10											
A-8	4.3	3	1									100												
A-9	6.0	2	1			45		50		5														
A-10	9.0	2	1					30		70														
A-11	10.5	2	1					100																
A-12	12.0	1	1					90		10														
A-13	5.0	5	2			5				30		10	5											50
B-1	3.0	5	3	5	5		5	5		5	10		5	20					5	5				30
B-2	3.0	5	2	10	5					5	5		5	40	10									20
B-3	3.8	4	1									40	20	20										20
B-4	3.7	2	1									90												10
B-5	3.7	5	1									60		20						10				10
B-6	3.9	5	1									50		20										30
B-7	4.0	5	1									50	10											40
B-8	4.0	5	1	10								25	5	10	10					5				35
B-9	4.0	4	1	30								10		10										50
B-10	3.5	5	2	25	5									20										50
C-1	4.0	5	2		80		5											15						
C-2	7.0	5	3		30					10						60								

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Table 4 (cont). 2016 Macrophyte Survey Data

				Species (relative abundance %)																				
Point	**Water Depth (ft)**	**Cover**	**Bio-mass**	**Bs**	**Cc**	**Cd**	**Ec**	**FG**	**Iso**	**Mh**	**M. hum**	**Ni.f**	**Nm**	**No**	**Nv**	**Pa**	**Pc**	**P. rob**	**P. spir**	**Pot**	**Sg**	**Spar**	**Usp**	**Va**
C-3	8.0	5	3		30					40						10		20						
C-4	10.5	4	2		90					10														
C-5	11.5	1	1			60		40																
C-6	12.0	4	2		100																			
C-7	11.0	4	2		80					20														
C-8	6.7	4	3							50						20				10				20
D-1	2.8	4	2		30									5				30		30	5			
D-2	3.5	4	2		35					10								25		30				
D-3	3.8	2	1		5									45				10		40				
D-4	3.3	5	1	20	10							45								10	5			10
D-5	3.5	4	1	60								40												
D-6	3.8	5	1	50								40								10				
D-7	3.8	5	1	60								40												
D-8	3.3	4	1									10						10		10	50			20
D-9	4.7	5	1									20	60	10										10
D-10	4.7	5	1									10	80											10
D-11	5.0	4	1									40	50											10
D-12	4.5	2	1					20													80			
D-13	8.5	5	2		50					40								10						
E-1	4.5	5	1		5			15				40												40
E-2	4.7	5	1					5				80												15
E-3	5.5	5	2				10	20				10						10		50				
E-4	6.0	5	2		10			20										10		60				
E-5	7.0	5	2		30		10	10		10							30	10						
E-6	8.0	5	3		30			10		40								10		10				

Aquatic Restoration Consulting, LLC

Table 4 (cont). 2016 Macrophyte Survey Data

				Species (relative abundance %)																				
Point	**Water Depth (ft)**	**Cover**	**Bio-mass**	**Bs**	**Cc**	**Cd**	**Ec**	**FG**	**Iso**	**Mh**	**M. hum**	**Ni.f**	**Nm**	**No**	**Nv**	**Pa**	**Pc**	**P. rob**	**P. spir**	**Pot**	**Sg**	**Spar**	**Usp**	**Va**
E-7	8.5	5	2		40					40								20						
E-8	9.3	5	2		70					30														
F-1	3.3	1	1		40													30						30
F-2	7.5	5	2							50						30		20						
G-1	3.5	5	3		60								20					10					10	
G-2	7.5	5	3		10					60						20		10		10				
H-1	3.0	1	1										20											80
H-2	7.5	4	2		10					80						10								
I-1	3.5	1	1										30					60						10
I-2	7.5	4	2		30					70														
Frequency of Occurrence				15	26	5	4	14	0	25	2	27	18	16	4	6	1	17	1	17	4	0	5	23

Genus species (common name)

Bs – *Brasenia schreberi* (watershield)
Cc – *Cabomba caroliniana* (fanwort)
Cd - *Ceratophyllum demersum* (coontail)
Ec - *Elodea canadensis* (waterweed)
FG – filamentous algal mats
Iso - *Isoetes* sp. (quillwort)
Mh – *Myriophyllum heterophyllum* (variable-leaf milfoil)
Ni.f – *Nitella flexilis* (stonewort)
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)
Spar – Sparganium sp. *(bur-reed)*
Usp – *Utricularia* spp. (bladderwort)
Va - *Vallisneria americana* (tape grass)

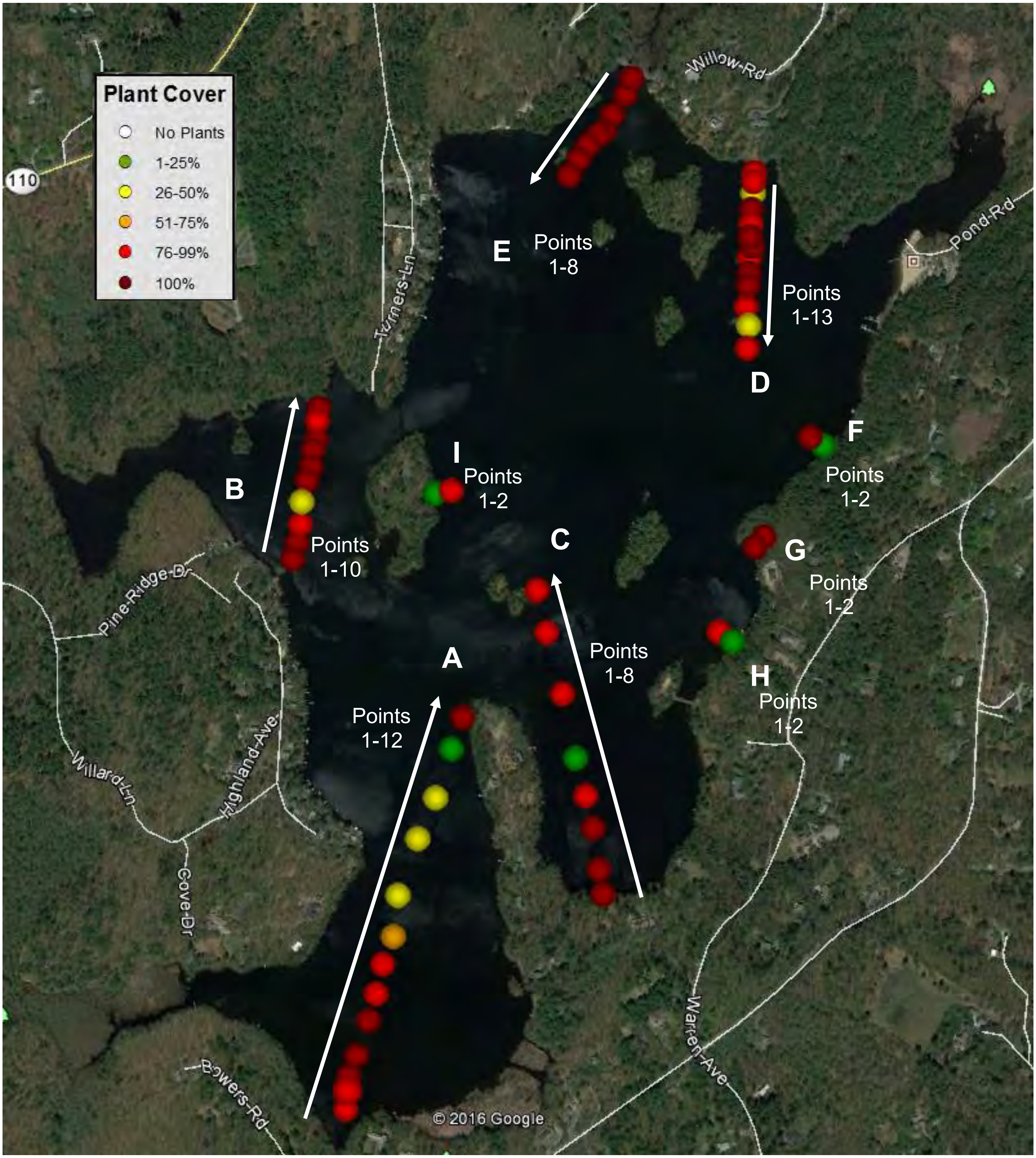

Figure 4. Bare Hill Pond 2016 Plant Cover

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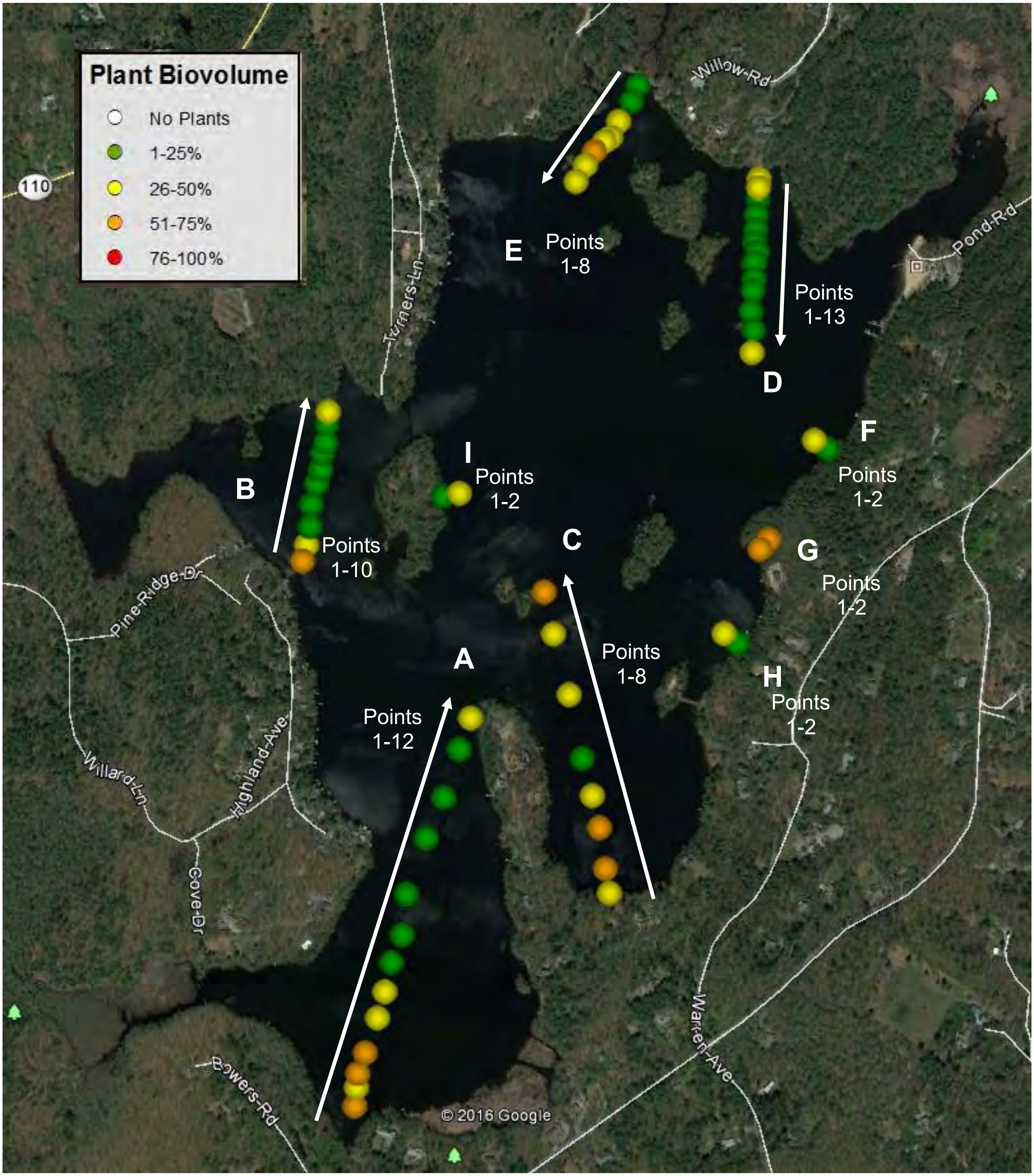

Figure 5. Bare Hill Pond 2016 Plant Biovolume

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Table 5. Bare Hill Pond Cover and Biovolume Relative Change

		COVER								BIOVOLUME							
		2013 (6')		2014 (0')		2015 (5.5')		2016 (6')		2013 (6')		2014 (0')		2015 (5.5')		2016 (6')	
	Point	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT	IN	OUT
Transect A	1	5		5		1		4		2		2		1		3	
	2	5		5		2		4		2		2		1		2	
	3	5		5		3		5		2		1		2		3	
	4	5		5		2		5		2		3		1		3	
	5	3		5		2		5		1		1		1		2	
	6	3		5		1		4		1		1		1		2	
	7	5		2		4		4		2		1		1		1	
	8	2		1			1	3		1		1			1	1	
	9		1		0		2		2		1		0		1		1
	10		0		1		2		2		0		1		1		1
	11		0		0		1		2		0		0		1		1
	12		0		0		0		1		0		0		0		1
	13		0		1		1	5			0		1		1	2	
Transect B	1	2		3		5		5		1		1		2		3	
	2	5		5		5		5		1		2		1		2	
	3	5		5		5		4		1		2		1		1	
	4	5		5		5		2		1		1		1		1	
	5	5		5		5		5		2		2		1		1	
	6	5		5		5		5		1		1		1		1	
	7	5		5		5		5		1		1		2		1	
	8	5		5		3		5		1		1		1		1	
	9	5		4		5		4		2		1		1		1	
	10	5		5		5		5		2		1		2		2	
Transect C	1	2			2		5	5		1			1		2	2	
	2		5		5		5		5		2		2		2		3
	3		4		5		5		5		1		2		3		3
	4		2		1		4		4		1		1		2		2
	5		0		0		1		1		0		0		1		1
	6		1		1		3		4		1		1		2		2
	7		1		1		1		4		1		1		1		2
	8		2		3		4		4		2		1		1		3
Transect D	1	4		5		5		4		1		2		2		2	
	2	5		5		5		4		1		2		2		2	
	3	5		5		5		2		1		2		1		1	
	4	5		5		5		5		1		2		1		1	
	5	5		5		5		4		1		1		1		1	
	6	5		5		5		5		1		1		1		1	
	7	4		5		5		5		1		1		1		1	
	8	5		3		5		4		1		1		1		1	
	9	5		5			5	5		1		1			1	1	
	10	5			3		5	5		1			1		1	1	
	11	5			3		5	4		1			1		1	1	
	12		5		5		5	2			1		2		2	1	
	13		4		4		4		5		2		1		2		2
Transect E	1	5		3		5		5		1		2		1		1	
	2	2		5		5		5		1		1		1		1	
	3		1		5		5	5			1		2		2	2	
	4		4		3		5		5		1		1		2		2
	5		4		4		5		5		2		1		3		2
	6		4		4		5		5		2		1		3		3
	7		4		4		4		5		2		2		2		2
	8		4		4		4		5		2		2		2		2

Increase by 2 or more ranks from prior year

Decrease by 2 or more ranks from prior year

We established eight new plant observation locations. Unfortunately water depth at these locations dropped off rapidly and long term trends comparing within and outside the drawdown zone may not be representative. There is one location, a small cove on the eastern side of the pond (H-1 & H-2) that may prove useful for future data collection.

The general appearance of the pond showed substantially more plant growth topping out at the surface in 2016 than in 2015. This observation is supported by the frequency data and general observations outside the survey points. Watershield, fanwort, milfoil (*Myriophyllum heterophyllum*) and pondweeds (*Potamogeton* spp.) were encountered more frequently at sampling locations in 2016. Figure 6 illustrates the most frequently encountered species data since 2010. Macro algae were abundant again in 2016 (observed at just under 50% of the points). This non-vascular plant is low growing and forms a carpet on the bottom. Plant dominance has shifted from fanwort and milfoil to macro algae and naiads (*Najas spp.*) in past drawdown years. The native plant tape grass (*Vallisneria americana*) was more frequent this year than in years past (10% increase). This plant is an excellent source of food for waterfowl. While these species shifts may not result in a decrease in plant cover, it can reduce plant biovolume if widespread and represent a desired outcome provided plant diversity is maintained or improved.

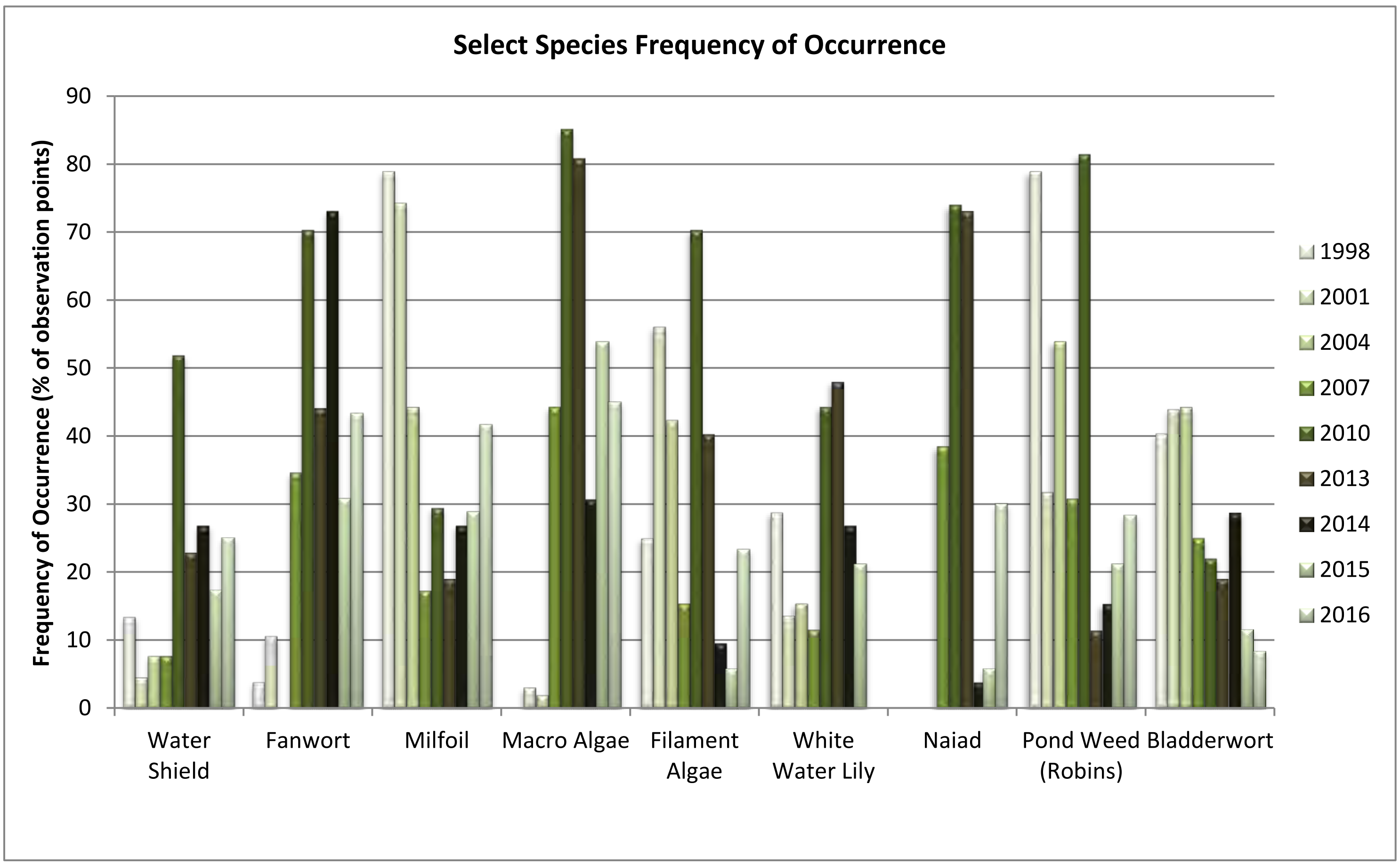


Figure 6. Bare Hill Pond Select Plant Species Frequency of Occurrence

Three plants of the invasive species water chestnut (*Trapa natans*) were observed (and pulled) between points A-2 and A-3 in the southern cove. Also, a boat trailer pulled by a truck with Connecticut license plates was noticed in the parking area covered in plants. The boat ramp monitor was advised of the issue and she discussed the need to clean the trailer with the angler. We also recommended that she mention that it is illegal in the Commonwealth of Massachusetts to transport plants and if caught, the state could impose a hefty fine.

Wetland Plot Monitoring

Wetland plants downstream of the dam and north of the town beach were documented on August 18, 2016. A wetland scientist recorded plants using the same methodology used by ENSR in 2001 (MADEP Handbook: *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act*). Plots 1 and 2 from 2013 were relocated in 2016. Two additional plots were added to the 2016 survey north of the town beach. Attempts were made to relocate the two plots established in 2001 based on direction from descriptions provide in 2001. Plot 4 is believed to be located within the same general location as the plot from 2001, and the 2001 Plot 3 location appeared to be flooded and was therefore relocated further northwest of Plot 4.

In general, vegetation diversity in Plot 1 remained similar to that documented in 2013 with only slight changes in plant species and estimated cover. Plot 2 diversity appeared to have increased somewhat with additional plants noted in the herbaceous layer. However, the top dominate plants, cattail (*Typha latifolia*) and upright sedge (*Carex stricta*), remained the same in both plots from 2013 to 2016. Cattail in both of these plots did not increase in abundance, however, when compared to 2013. Both of these plots contained about a foot of standing water, a positive sign given the extreme drought we are experiencing this summer. The wetland located north of the town beach is also dominated by cattail as observed in Plots 3 and 4 during the 2001 survey. Plot 3 represents a sample of the vegetative community toward the center of the wetland while Plot 4 represents the plants at the wetland margin, adjacent to forested uplands. As mentioned in 2013, cattail can form a dense monoculture that reduces vegetation diversity and wildlife habitat value, and although it dominates in all sample plots, it has not increased since 2013.

Conclusion

2016 data and general observations suggest that milfoil and fanwort density have increased, with milfoil making a resurgence from lower frequencies over the past six years. Thick patches of milfoil were observed when traveling to and from the sample locations. Plants in water depths up to 8-10 feet were observed topping out at the surface. Native pondweeds were also very abundant at and between observation locations.

The New England area is currently experiencing a drought and the pond water level is lower than normal. The pond is also very clear, with Secchi disk transparencies the highest since 2010. These conditions are favorable to rooted plant growth. The photic zone is larger as more light is reaching the bottom. Many lakes in the region are experiencing excessive plant growth this year.

Phosphorus values were less variable this year and more comparable to 2014, although slightly higher. The pond continues to suffer from low dissolved oxygen. This is a concern for fish seeking cold water refuge in the hot summer and the potential to accumulate phosphorus in the hypolimnion.

No significant change was observed in the wetland plots. These data suggest that contiguous wetlands have not been negatively impacted by winter water level manipulation. Cattails have not increased in density and we observed a slight increase in species diversity at one plot. Monitoring of the two new plots will assist in further evaluation of potential impacts to contiguous emergent wetlands.

I do not have any significant concerns with a repeated six foot drawdown this year. Phosphorus values have stabilized over last year and the pond has seen some of the best clarity in recent years, but the plants (specifically milfoil and fanwort) are still problematic. While most of the milfoil is within areas outside the drawdown zone, fanwort was frequently encountered within this zone. With some luck, the weather will cooperate and we will have a hard, prolonged freeze reducing fanwort biomass.

Appendix A – Wetland Plot Vegetation Sheets

2016 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Overcast, 82ºF
Date: August 18, 2016
Plot Size: 30-ft radius, Plot 1
Observers: Julia Stearns
Photographs: Yes (Log Photos 1 and 2)

General Description of the Vegetation Sample Station: Plot 1

Vegetation sample Plot 1 is located in the scrub-shrub wetland community approximately 100 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. The established Plot 1 from 2013 was marked in the field with pink surveyors ribbon and staked with an orange colored rebar and relocated during this survey. As described on the 2013 data form the plot includes a fringe of flood plain forest along its eastern border and a small seasonal stream enters from the east and flows west. The windfall, identified in 2013, is still noticeable along the western portion of the plot. An additional windfall was observed just east of center in the plot. The estimated plant cover in Plot 1 is over 90 percent. The sample plot was photographed during the survey, see Photos 1 and 2 of the attached Photographic Log.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 – 5%; 6-15%; 16—25%; 26-50%; 51-75%; 76-95%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees:	Red Maple (*Acer rubrum*)	3	26-50%
	White Pine (*Pinus strobes*)	2	6-15%
	White Oak (*Quercus alba*)	1	1-5%
Shrubs:	Sweet Pepperbush (*Clethra alnifolia*)	4	26-50%
	Arrowwood (*Viburnum dentatum*)	2	6-15%
	Black Chokeberry (*Aronia melanocarpa*)	3	26-50%
	Multiflora Rose (*Rosa multiflora*)	2	6-15%
	Swamp Rose (Rosa palustris)	1	1-5%
	Speckled Alder (*Alnus incana*)	1	1-5%
	Meadow Sweet (*Spiraea alba*)	1	1-5%
Herbaceous:	Cattail (*Typha latifolia*)	4	16-25%
	Wool-grass (*Scirpus cyperinus*)	2	6-15%
	Purple loosestrife (*Lythrum salicaria*)	2	6-15%
	Royal fern (*Osmunda regalis*)	2	6-15%
	False nettle (*Boehmeria cylindrica*)	2	6-15%
	Upright Sedge (**Carex stricta**)	3	6-15%
	Sensitive fern (*Onoclea sensibilis*)	1	1-5%
	Jewelweed (*Impatiens capensis*)	1	1-5%
	Pickerelweed (*Pontederia cordata*)	1	1-5%

	Water Parsnip (*Sium suave*)	2	1-5%
	Bittersweet Nightshade (*Solanum dulcamara*)	1	1-5%
Vine	Wild Grape (*Vitis* sp.)	3	1-5%

Soil consists of approximately 3-4 inches of black muck over sand and gravel. Soil was saturated with free standing water recorded within 1 inch of the soil surface and areas of 6-12" of standing water.

2013 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Overcast, 75ºF
Date: August 29, 2013
Plot Size: 30-ft radius, Plot 1
Observers: Julia Stearns
Photographs: Yes (Log Photos 1 and 2)

General Description of the Vegetation Sample Station: Plot 1

Vegetation sample Plot 1 is located in the scrub-shrub wetland community approximately 100 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. Efforts were made to relocate the original plot established in 2001, however the plot and wooden stake were not found during the 2013 visit. It is believed the general area of the original Plot 1 was located based on identifiable descriptions and data collected during the 2001 survey. The general location of Plot 1 was located based on identifiable descriptions and data collected during the 2001 survey. The newly established Plot 1 was marked in the field with pink surveyors ribbon and staked with an orange colored rebar. A fringe of flood plain forest occurs along the eastern edge of the sample plot. A small seasonal stream enters the plot from the east and flows west and a windfall is situated along the western portion of the plot. The estimated plant cover in Plot 1 is over 80 percent. The sample plot was photographed during the survey, see Photos 1 and 2 of the attached Photographic Log.

Species List with Estimated Cover and Abundance Rankings for Dominants

Cover Estimates: 1 – 5%; 6-15%; 16—25%; 26-50%; 51-75%; 76-95%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees:	Red Maple (*Acer rubrum*)	3	26-50%
	White Pine (*Pinus strobes*)	2	6-15%
	White Oak (*Quercus alba*)	1	1-5%
Shrubs:	Sweet Pepperbush (*Clethra alnifolia*)	4	26-50%
	Arrowwood (*Viburnum dentatum*)	2	6-15%
	Black Chokeberry (*Aronia melanocarpa*)	3	26-50%
	Multiflora Rose (*Rosa multiflora*)	2	6-15%
	Swamp Rose (***Rosa palustris***)	1	1-5%
Herbaceous:	Cat-tail (*Typha latifolia*)	5	16-25%
	Wool-grass (*Scirpus cyperinus*)	3	16-25%
	Purple loosestrife (*Lythrum salicaria*)	3	6-15%
	Royal fern (*Osmunda regalis*)	2	6-15%
	False nettle (*Boehmeria cylindrica*)	2	6-15%
	Slender-leaved goldenrod (*Solidago tenuifolia*)	2	6-15%
	Sensitive fern (*Onoclea sensibilis*)	3	6-15%
	Jewelweed (*Impatiens capensis*)	3	6-15%
	Upright Sedge (***Carex stricta***)	3	6-15%
	Arrow Arrum (*Peltandra virginica*)	1	1-5%
	Water Parsnip (*Sium suave*)	2	1-5%

Soil consists of approximately 3-4 inches of black muck over sand and gravel. Soil was saturated with free standing water recorded within 1 inch of the soil surface.

2001 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Cloudy, Lt. Wind, 55-60 º F
Date: November 14, 2001
Plot Size: 30-ft. radius, Plot 1
Observers: Don Schall
Photographs: Yes (Figure 1)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in the scrub-shrub wetland community approximately 100 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. A narrow fringe of flood plain forest occurs along the edge of the sample plot. The estimated plant cover in the sample plot is over 60 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	Abundance	Estimated Cover
Trees:	Red Maple (Acer rubrum)	5	16-25%
	White Pine (Pinus strobus)	4	6-15%
	Black Gum (Nyssa sylvatica)	3	6-15%
Saplings:	Red Maple (Acer rubrum)	4	Included in Tree Cover
Shrubs:	Sweet Pepperbush (Clethra alnifolia)	5	51-75%
	HB Blueberry (Vaccinium corymbosum)	4	6-15%
	Arrowwood (Viburnum dentatum)	4	6-15%
	Swamp Azalea (Rhododendron viscosum)	3	6-15%
	Black Chokeberry (Aronia melanocarpa)	3	1-5%
Vines:	Wild Grape (Vitis sp.)	3	1-5%
Herbaceous:			
Wool-grass (Scirpus cyperinus)		4	6-15%
Soft Rush (Juncus effusus)		4	6-15%
Cinnamon Fern (Osmunda cinnamomea)		4	6-15%

Sample plot is subject to spring floods and backwater flooding due to a beaver dam at the culvert under Route 110. Dam material was recently removed from the culvert. Standing deadwood is present in the scrub-shrub wetland due to past flooding. A windfall red maple occurs in the sample plot. Soil consists of approximately 3 inches of black muck over sands and gravel. Soil was saturated with free water recorded 8 inches below the soil surface. Signs of past flooding were evident at the base of standing trees and exposed boulders.

2016 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands

Weather: Overcast, 82ºF
Date: August 18, 2016
Plot Size: 30-ft radius, Plot 2
Observers: Julia Stearns
Photographs: Yes (Photos 3 and 4)

General Description of the Vegetation Sample Station: Plot 2

Vegetation sample Plot 2 is located in the scrub-shrub wetland community approximately 500 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. The orange colored rebar installed during the 2013 survey was relocated during the 2016 survey. A fringe of flood plain forest occurs along the eastern edge of the sample plot. The 2016 estimated plant cover was over 90 percent as was observed in 2013. Although new species were identified and noted during the 2016 survey overall species abundance was very similar to 2013. The sample plot was photographed during the survey and photos are provided in the Photograph Log (photos 3 and 4).

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 – 5%; 6-15%; 16—25%; 26-50%; 51-75%; 76-95%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees:	Red Maple (*Acer rubrum*)	3	16-25%
	White Pine (*Pinus strobes*)	2	6-15%
	Black Oak (*Quercus velutina*)	1	1-5%
Shrubs:	Maleberry (*Lyonia ligustrina*)	3	16-25%
	Black Alder (*Ilex verticillata*)	2	1-5%
	Swamp Rose (**Rosa palustris**)	4	16-25%
	Meadowsweet (*Spiraea latifolia*)	2	6-15%
	Silky dogwoos (*Cornus amomum*)	2	6-15%
	Buttonbush (*Cephalanthus occidentalis*)	1	1-5%
	Glossy Buckthorn (*Frangula alnus*)	1	1-5%
Herbaceous:	Cat-tail (*Typha latifolia*)	5	51-75%
	Upright Sedge (**Carex stricta**)	5	51-75%
	Purple loosestrife (*Lythrum salicaria*)	4	26-50%
	Wool-grass (*Scirpus cyperinus*)	4	16-25%
	Marsh Fern (*Thelypteris palustris*)	3	6-15%
	Sedge (*Carex* sp.)	3	6-15%
	Pickerelweed (*Pontederia cordata*)	2	1-5%
	Water Parsnip (*Sium suave*)	2	1-5%
	Marsh St. Johnswort (*Triadenum virginicum*)	1	1-5%
	Soft-stemmed Bulrush (*Scirpus validus*)	1	1-5%
	Water Hemlock (*Ciduta maculata*)	1	1-5%

	Royal Fern (*Osmunda regalis*)	1	1-5%
	Bittersweet Nightshage (*Solanum dulcamara*)	1	1-5%
	Water Willow (*Decodon verticillatus*)	1	1-5%
	Lurid Sedge (*Carex lurida*)	1	1-5%
	Water Purslane (*Ludwigia palustris*)	2	1-5%
	Bluejoint grass (*Calamagrostis*)	3	1-5%

Soil consists of approximately 8 inches of black muck over sand and gravel. Approximately 12-18" of standing water was observed amongst the vegetation.

2013 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands

Weather: Overcast, 75ºF
Date: August 29, 2013
Plot Size: 30-ft radius, Plot 2
Observers: Julia Stearns
Photographs: Yes (Photos 3 and 4)

General Description of the Vegetation Sample Station: Plot 2

Vegetation sample Plot 2 is located in the scrub-shrub wetland community approximately 500 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. Efforts were made to relocate the original plot established in 2001, however the plot and wooden stake were not found during the 2013 visit. The general location of Plot 2 was located based on identifiable descriptions and data collected during the 2001 survey. Plot 2 was marked in the field with pink surveyors ribbon and staked with an orange colored rebar. A fringe of flood plain forest occurs along the eastern edge of the sample plot. The 2013 estimated plant cover was over 90 percent. The sample plot was photographed during the survey and photos are provided in the Photograph Log (photos 3 and 4).

Species List with Estimated Cover and Abundance Rankings for Dominants

Cover Estimates: 1 – 5%; 6-15%; 16—25%; 26-50%; 51-75%; 76-95%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees:	Red Maple (*Acer rubrum*)	3	16-25%
	White Pine (*Pinus strobes*)	2	6-15%
Shrubs:	Maleberry (*Lyonia ligustrina*)	3	16-25%
	Black Alder (*Ilex verticillata*)	2	1-5%
	Swamp Rose (***Rosa palustris***)	3	16-25%
	Meadowsweet (*Spiraea latifolia*)	3	16-25%
Herbaceous:	Cat-tail (*Typha latifolia*)	5	51-75%
	Upright Sedge (***Carex stricta***)	5	51-75%
	Wool-grass (*Scirpus cyperinus*)	5	26-50%
	Purple loosestrife (*Lythrum salicaria*)	4	26-50%
	Rice cutgrass (*Leersia oryzoides*)	3	6-15%
	Water Purslane (*Ludwigia palustris*)	2	1-5%
	Marsh Fern (*Thelypteris palustris*)	3	6-15%
	Sedge (*Carex* sp.)	3	6-15%
	Arrow Arrum (*Peltandra virginica*)	2	1-5%
	Water Parsnip (*Sium suave*)	2	1-5%

Soil consists of approximately 8 inches of black muck over sand and gravel. Soil was saturated to the soil surface and small areas of surface were observed amongst the vegetation.

2001 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Cloudy, Lt. Wind, 55-60 º F
Date: November 14, 2001
Plot Size: 30-ft. radius, Plot 2
Observers: Don Schall
Photographs: Yes (Figure 2)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in the scrub-shrub wetland community approximately 500 ft. north of the dam at the northern end of the pond. Access to the sample plot is from the service road to the dam off Willow Road. A narrow fringe of flood plain forest occurs along the edge of the sample plot. The estimated plant cover in the sample plot is over 60 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	Abundance	Estimated Cover
Trees:	Red Maple (Acer rubrum)	5	16-25%
	White Pine (Pinus strobus)	4	6-15%
Saplings:	Absent		
Shrubs:	Sweet Pepperbush (Clethra alnifolia)	5	16-25%
	HB Blueberry (Vaccinium corymbosum)	4	16-25%
	Black Alder (Ilex verticillata)	4	6-15%
	Swamp rose (Rosa palustris)	3	1-5%
Vines:	Absent		
Herbaceous:	Wool-gGrass (Scirpus cyperinus)	5	16-25%
	Tussock Sedge (Carex stricta)	5	26-50%
	Sedge (Carex sp.)	3	6-15%
	Purple Loosestrife (Lythrum salicaria)	3	1-5%
	Canada Bluejoint Grass (Calamagrostis canadensis)	4	1-5%
	Burreed (Sparganium sp.)	4	6-15%
	Water Purslane (Ludwigia palustris)	3	1-5%

Sample plot is subject to spring floods and backwater flooding due to a beaver dam at the culvert under Route 110. Standing deadwood is present in the scrub-shrub wetland due to past flooding. Soil consists of approximately 8 inches of black muck over sands and gravel. Soil was saturated with free water recorded 2 inches below the soil surface.

2016 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Overcast, 82ºF
Date: August 18, 2016
Plot Size: 30-ft radius, Plot 3
Observers: Julia Stearns
Photographs: Yes (Log Photos 5 and 6)

General Description of the Vegetation Sample Station: Plot 3

Vegetation sample Plot 3 is a new plot located in the scrub-shrub/emergent wetland community approximately 1000 ft. north of town beach parking lot. Access to the sample plot is from the bike trail along Pond Road and approximately 300 ft. to the northwest. This newly established Plot was marked in the field with pink surveyors ribbon tied to a stand of Speckled Alder at the plot's eastern perimeter; the plot center was located approximately 30 feet west of this survey ribbon. The Plot is also located approximately 100 ft. northwest of Plot 4. A narrow fringe of scrub-shrub wetland occurs to the east of the sample plot. The estimated plant cover in Plot 3 is over 85 percent. The sample plot was photographed during the survey, see Photos 5 and 6 of the attached Photographic Log.

Species List with Estimated Cover and Abundance Rankings for Dominants

Cover Estimates: 1 – 5%; 6-15%; 16—25%; 26-50%; 51-75%; 76-95%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees	Absent		
Shrubs:	Buttonbush (*Cephalanthus occidentalis*)	2	6-15%
	Speckled Alder (*Alnus incana*)	1	6-15%
Herbaceous:	Cat-tail (*Typha latifolia* and *T. angustifolia*)	5	96-100%%
	Upright Sedge (Carex stricta)	3	26-50%
	Smartweed (*Polygonum* sp.)	2	6-1-5%
	Arrow-leaved Tearthumb (*Polygonum sagittatum*)	2	6-15%
	Purple loosestrife (*Lythrum salicaria*)	1	1-5%
	Arrowhead (*Sagittaria* sp.)	1	1-5%
Vine	Wild Grape (*Vitis* sp.)	3	1-5%

Soil consists of approximately 3-4 inches of black muck over sand and gravel. Soil was saturated to the soil surface, areas of deep pooled water.

2016 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. One
Community Type: Scrub-Shrub Wetland
Soil Type: Muck and sands and gravel

Weather: Overcast, 82ºF
Date: August 18, 2016
Plot Size: 30-ft radius, Plot 4
Observers: Julia Stearns
Photographs: Yes (Log Photos 7 and 8)

General Description of the Vegetation Sample Station: Plot 4

Vegetation sample Plot 4 is located in the scrub-shrub/emergent wetland community approximately 900 ft. north of town beach parking lot. Access to the sample plot is from the bike trail along Pond Road and approximately 200 ft. to the northwest. Efforts were made to relocate the original plot established in 2001, however the plot and wooden stake were not found during the 2016 visit. It is believed the general area of the original Plot 4 was located based on identifiable descriptions and data collected during the 2001 survey. The newly established Plot 4 was marked in the field with pink and blue surveyors ribbon tied to a Red Maple sapling in the center of the plot. The trail to the plot was also marked with pink surveyors tape for future relocation and surveys. A narrow fringe of scrub-shrub and forested wetland occurs to the east of the sample plot. The estimated plant cover in Plot 4 is over 80 percent. The sample plot was photographed during the survey, see Photos 7 and 8 of the attached Photographic Log.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 – 5%; 6-15%; 16—25%; 26-50%; 51-75%; 76-95%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	**Abundance**	**Estimated Cover**
Trees:	Red Maple (*Acer rubrum*)	2	16-25%
	White Pine (*Pinus strobes*)	1	1-5%
	Red Oak (*Quercus rubra*)	1	1-5%
	Black Oak (*Quercus velutina*)	1	1-5%
Sapling	Red Maple (*Acer rubrum*)	1	1-5%
Shrubs:	Buttonbush (*Cephalanthus occidentalis*)	2	16-25%
	Speckled Alder (*Alnus incana*)	3	16-25%
	Meadow Sweet (*Spiraea alba*)	1	1-5%
	Buttonbush (*Cephalanthus occidentalis*)	2	16-25%
Herbaceous:	Cat-tail (*Typha latifolia* and *T. angustifolia*)	5	76-95%%
	Purple loosestrife (*Lythrum salicaria*)	4	51-75%
	Marsh St. Johnswort (*Triadenum virginicum*)	3	16-25%
	Water Hemlock (*Ciduta maculate*)	1	1-5%
	Bittersweet Nightshade (*Solanum dulcamara*)	1	1-5%
	Wool-grass (*Scirpus cyperinus*)	1	1-5%
	Arrow Arrum (*Peltandra virginica*)	1	1-5%

	Arrowhead (*Sagittaria* sp.)	1	1-5%
	Upright Sedge (Carex stricta)	3	26-50%
	Smartweed (*Polygonum* sp.)	1	1-5%
	Three-way Sedge (*Dulichium arundinaceum*)	1	1-5%

Soil consists of approximately 3-4 inches of black muck over sand and gravel. Soil was saturated to the soil surface with shallow areas of pooled water.

2001 FIELD REPORT: VEGETATION SAMPLING SHEET

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. Two
Community Type: Emergent Wetland
Soil Type: Muck over sands and gravel

Weather: Cloudy, Lt. Wind, 55-60 º F
Date: November 14, 2001
Plot Size: 30-ft. radius, Plot 3
Observers: Don Schall
Photographs: Yes (Figure 3)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in emergent wetland community approximately 400 ft. north of the town beach parking lot. Access to the sample plot is from the bike trail along Pond Road. A narrow fringe of scrub-shrub wetland occurs along the upper edge of the pond at the sample plot. The estimated plant cover in the sample plot is over 75 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	Abundance	Estimated Cover
Trees:	Absent		
Saplings:	Absent		
Shrubs:	Sweet Pepperbush (*Clethra alnifolia*)	4	6-15%
	HB Blueberry (*Vaccinium corymbosum*)	4	6-15%
	Swamp Azalea (*Rhododendron viscosum*)	3	1-5%
	Gray Birch (*Betula populifolia*)	3	1-5%
Vines:	Absent		
Herbaceous:			
Cat-tail (*Typha latifolia* and *T. angustifolia*)		5	76-95%
Sedge (*Carex* sp.)		3	6-15%
Purple Loosestrife (*Lythrum salicaria*)		3	1-5%
Blueflag (*Iris versicolor*)		3	1-5%
Water Purslane (*Ludwigia palustris*)		3	1-5%
Royal Fern (*Osmunda regalis*)		3	1-5%

Sample plot is subject to extended periods of exposure due to water drawdown in the fall. Water level is managed to control nuisance aquatic vegetation in Bare Hill Pond. A narrow fringe of scrub-shrub wetland exists along the upper edge of the sample plot. Soil consists of over 16 inches of black muck over sands and gravel. Soil was saturated to the soil surface.

2001 Field Report: Vegetation Sampling Sheet

Site Name: Bare Hill Pond
Location: Harvard, Massachusetts
Transect No. Two
Community Type: Emergent Wetland
Soil Type: Muck over sands and gravel

Weather: Cloudy, Lt. Wind, 55-60 º F
Date: November 14, 2001
Plot Size: 30-ft. radius, Plot 4
Observers: Don Schall
Photographs: Yes (Figure 4)

General Description of the Vegetation Sample Station:

Vegetation sample plot is located in emergent wetland community approximately 900 ft. north of the town beach parking lot. Access to the sample plot is from the bike trail along Pond Road. A narrow fringe of scrub-shrub wetland occurs to the east of the sample plot. The estimated plant cover in the sample plot is over 75 percent. The sample plot was photographed during the survey performed on November 14, 2001.

Species List with Estimated Cover and Abundance Rankings for Dominants
Cover Estimates: 1 - 5%; 6-15%; 16-25%; 25-50%' 51-75%; 76-95%; and 96-100%
Frequency of Occurrence Scale: 5 = Abundant; 4 = Frequent; 3 = Occasional; 2 = Infrequent; and 1 = Rare

	Species Name	Abundance	Estimated Cover
Trees:	Absent		
Saplings:	Absent		
Shrubs:	Absent		
Vines:	Absent		
Herbaceous:			
Cat-tail (*Typha latifolia* and *T. angustifolia*)		5	26-50%
Canada Bluejoint Grass (*Calamagrostis canadensis*)		5	26-50%
Purple Loosestrife (*Lythrum salicaria*)		5	16-25%
Wool-grass (*Scirpus cyperinus*)		4	6-15%

Sample plot is subject to extended periods of exposure due to water drawdown in the fall. Water level is managed to control nuisance aquatic vegetation in Bare Hill Pond. A narrow fringe of scrub-shrub wetland exists just to the east of the sample plot. Soil consists of over 16 inches of black muck over sands and gravel. Soil was saturated to the soil surface.

100 Foot Photos Exhibit D

Location
Ten 100' Segment Sites

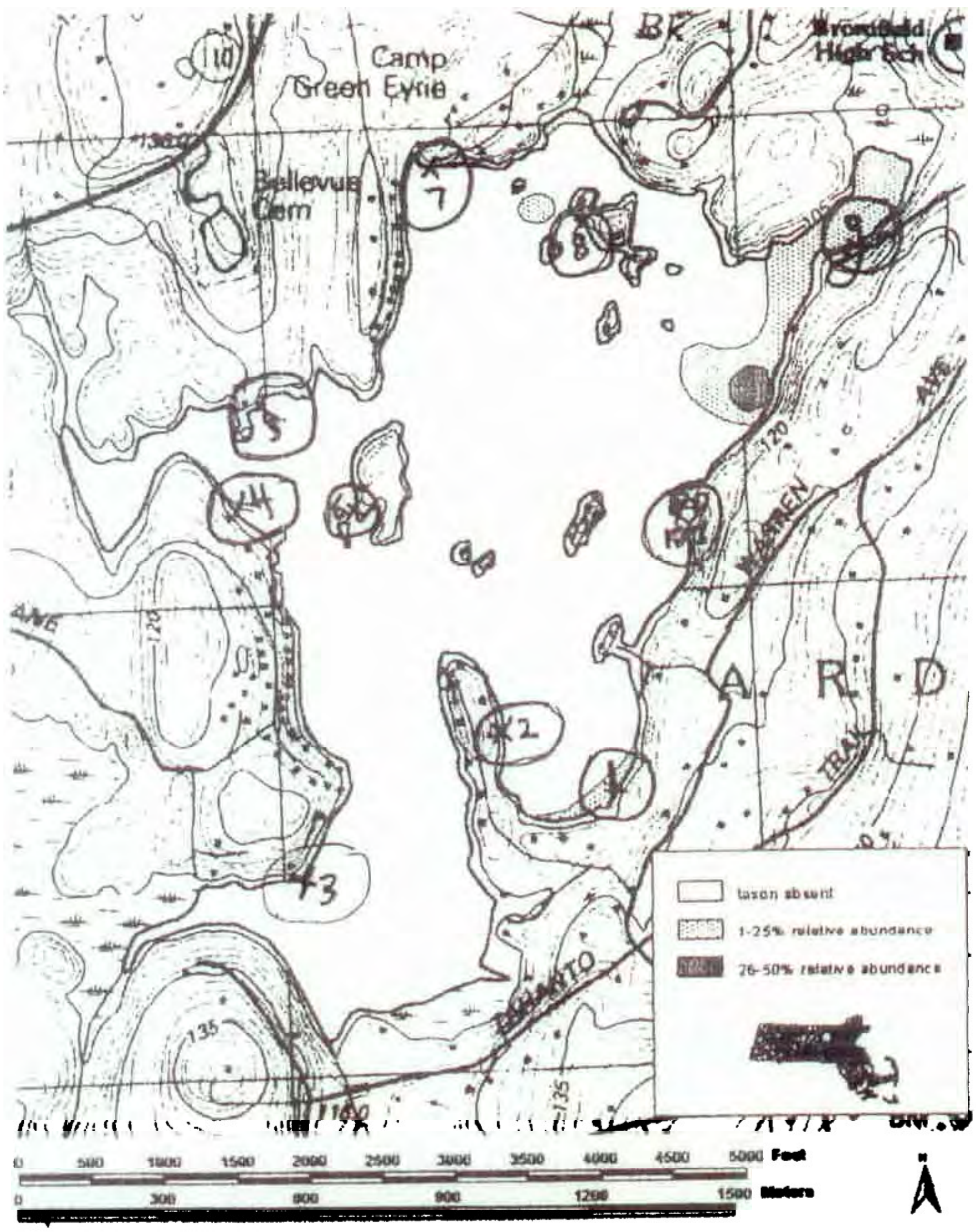
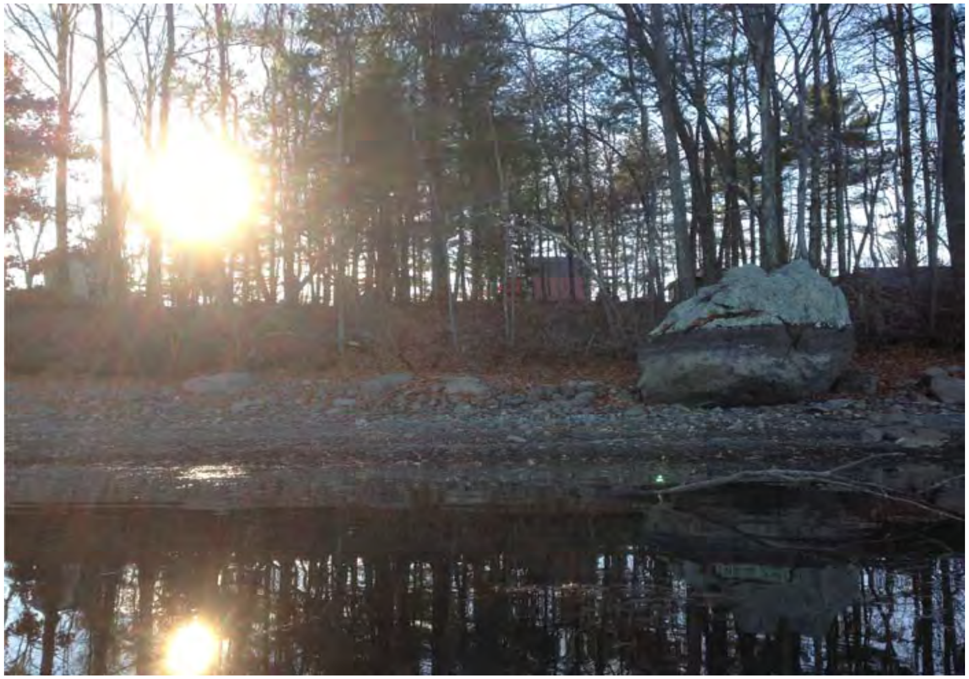


Figure 5. Distribution and relative abundance of fanwort (*Cabomba caroliniana*) in Bare Hill Pond in October 2001, from data in Appendix A.

Site 2

Site 2 North Side Penninsula



Site 2

Site 2

Site 3

Site 4,5,

Site 2

Site 3

Site 6

Site 7

Site 5

Looking West into Outer Clapps Brook

Site 8

Site 10

Site 7

Site 8

Site 10

Site 9 Behind Beach

Site 10

Storm Water basin at Beach

Site 10 behind beach

Site 1

Site 10

Site 1