Development of Farm Pond Management Plan

Report

November 2015

Prepared for:
Board of Selectmen and
Farm Pond Advisory Committee
Town of Sherborn, Massachusetts
19 Washington Street.
Sherborn, MA 01770

Prepared by
Fay, Spofford and Thorndike
400 Crown Colony Drive
Quincy, MA 02169

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Overview of Report

The Farm Pond Management Report ("Management Report") summarizes recent diagnostic field work, watershed evaluation and analysis, review of pond management options, and recommended actions for conserving and protecting the recreational, ecological, and aesthetic features of the Pond. The authors, Fay, Spofford, and Thorndike (FST) of Quincy, MA (formerly doing business as Norfolk Ram Group) assisted by Dr. David Mitchell, CLM, were selected by the Town of Sherborn (the "Town") and the Farm Pond Advisory Committee (FPAC) as the technical consultant for this project in February 2014. This report provides the results from the field work conducted in spring-summer 2014, analytical results and the findings and recommendations based on these analyses.

The report describes the tasks and activities contained in the final scope of work negotiated by the Town with FST. These tasks are organized into four chapters including:

- Chapter 1 - Watershed Assessment: watershed base map, soil conditions, historical and current land use and review of existing water quality data and reports, and preliminary hydrologic model.

- Chapter 2 - Field Work: water quality sampling, bathymetric confirmation, aquatic vegetation mapping, seepage measurements, and shoreline inspection.

- Chapter 3 - Hydrologic and Pollutant Loading models: hydrologic budget, nutrient budget, stormwater contributions, and other sources.

- Chapter 4 – Pond and Watershed Management Options: Evaluation of pond and watershed management and preservation options, solutions matrix with permit requirements and final recommendations.

Additional information including field notes, laboratory analytical reports, water chemistry data, vegetation survey datasheets, etc. are provided in a series of Appendices. A glossary of aquatic terms is included at the end of this report to provide definitions of specialized limnological terms and expressions which may be unfamiliar to the lay public.

1.0 Watershed Mapping and Assessment

Farm Pond (the "Pond") is a natural waterbody situated within the Town of Sherborn in Middlesex County. The Pond is a kettle pond[1] produced by the deposition and subsequent melting of glacial ice remnant produced by retreating glaciers during the last Ice Age. The surface area of the Pond is estimated at 126.3 acres and it drains a watershed area of approximately 409 acres[2] within the larger Charles River basin (MADEP 2013). It has only one minor tributary and a relatively undeveloped watershed. There is an isolated shallow cove or embayment located on the eastern shoreline of the Pond, behind a constructed earth-covered rock berm, which apparently acts as an unregulated outlet. Farm Pond is listed as a Great Pond by the State of Massachusetts (MA EOEEA 2014).

Table 1 provides a summary of the morphometric parameters associated with Farm Pond. The maximum depth is 58 ft with an average depth of just below 20 ft. It has a low shoreline development index (D_L) indicative of its circular shape. Of particular note is the very low watershed to pond area ratio of approximately 3.2 to 1. This low ratio suggests a relatively limited influence of watershed land type on pond water quality.

1.1 Watershed Description and Mapping

The base map of Farm Pond's watershed including current primary land uses is shown in Figure 1. The map was constructed by importing data layers through Massachusetts Geographic Information System (GIS) data viewer (MA DEP 2014).

According to the 13th edition of the Massachusetts Natural Heritage Atlas (October 1, 2008), the land within the Pond watershed along the southwest shoreline (see Figure 1) is within a priority and Estimated Habitat of Rare Species mapped for Easterm Box Turtle (*Terrapene Carolina*). See Letter from MA Division of Fisheries & Wildlife in Appendix K. The Pond itself is not included in this mapping. Any non-exempt work activities within Priority and/or Estimated Habitat require review under the *Massachusetts Endangered Species Act* (MESA, M.G.L. c.131A) and its implementating *Regulations* (321 CMR 10.00)

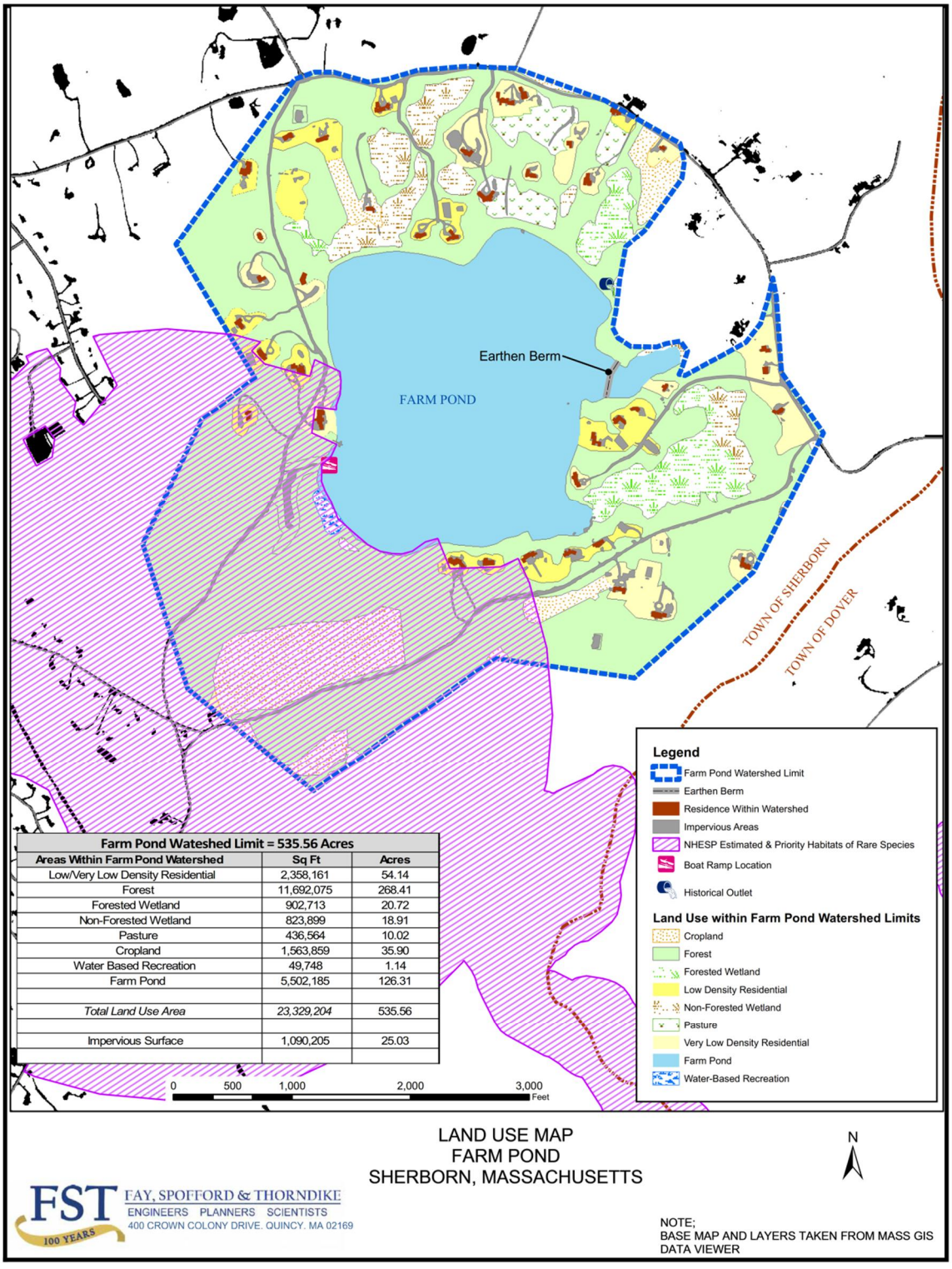
1.1.1 Historical Land Use

Historical pond and watershed use information was condensed from "*Farm Pond, Sherborn, Massachusetts*", Massachusetts Historical Commission (MHC) archives (Form

[1] A kettle hole lake is defined as a waterbody formed in a topographic depression produced by the melting of a stagnant block of ice and the subsequent downward and inward collapse of material (Thorson 2009) For definitions of other aquatic terms see Glossary.

[2] The estimated watershed area is based on GIS mapping with the area around the outlet estimated by best professional judgment.

B datasheet), and information researched by a local resident (FPAC 2011; Johnson 2015; MHC undated). Adoption of the name Farm Pond dates back to identification on the 1831 State Series map. During the 19th century, Farm Pond was used for tourism, fishing and other recreational purposes, as well as commercial ice harvesting (Johnson 2015). In addition, picnic areas were established at two private beaches. Water drawn from the Pond supplied a "modern" cranberry bog located to northeast between Farm Road and Farm Pond but long abandoned (Johnson 2015). The derelict outlet structure located along the northeastern shoreline and the earth-covered rock berm were also reported to be constructed as part of the cranberry cultivation operations.



Farm Pond Wateshed Limit = 535.56 Acres		
Areas Within Farm Pond Watershed	**Sq Ft**	**Acres**
Low/Very Low Density Residential	2,358,161	54.14
Forest	11,692,075	268.41
Forested Wetland	902,713	20.72
Non-Forested Wetland	823,899	18.91
Pasture	436,564	10.02
Cropland	1,563,859	35.90
Water Based Recreation	49,748	1.14
Farm Pond	5,502,185	126.31
Total Land Use Area	*23,329,204*	535.56
Impervious Surface	1,090,205	25.03

Figure 1. Farm Pond watershed map showing current land use

Table 1. Morphometric Characteristics of Farm Pond and its Watershed.

Parameter	Symbol	Value	units
Pond Surface Area	**SA**	126.3	acres
Maximum Length	$\mathbf{L_{max}}$	3,100	ft
Maximum Width	$\mathbf{W_{max}}$	3,000	ft
Mean Width	**W**	1,728	ft
Volume	**V**	1.05E+08	ft^3
Mean Depth	$\mathbf{Z_{avg}}$	19.6	ft
Maximum Depth	$\mathbf{Z_{max}}$	58	ft
Mean to Maximum Depth Ratio	$\mathbf{Z_{avg}:Z_{max}}$	0.34	unitless
Shoreline Length (main basin)	**C**	9,800	ft
Shoreline Development index	$\mathbf{D_L}$	1.19	unitless
Watershed Area	**WA**	409.5	acres
Watershed to Pond Area Ratio	**WA:SA**	3.2:1	unitless

Sources: MA DEQE Farm Pond Fact Sheet (1974); MA DEP (2014)

The derelict outlet structure is located along the northeastern shoreline (GPS references: N 42°14'10.7'; W 71°20'28.8') but the opening at the shoreline is deliberately blocked. The water elevation in the short channel appeared about 2 ft above the water level in the downstream stretch on the date of the inspection (5/29/14). Downstream of the structure, the channel continues eastward into forest towards the old cranberry bog ditches[3] (visible on aerial photographs).

The Commonwealth of Massachusetts obtained the water rights to Farm Pond by legislative action in 1897 so that the Pond could serve as a reservoir for water use at the Medfield Insane Asylum (later called Medfield State Hospital). In 1899 a small brick water intake structure was constructed along the eastern shoreline and a water pipeline running to Farm Road and under the Charles River, was constructed to gravity feed water to the Hospital.

In 1935 an act of the legislation granted the Board of Selectmen of the Town of Sherborn control of Farm Pond with the right to set rules and regulations. Water drawn to the Medfield State Hospital was for boiler use only.

[3] Examination of the aerial photograph used for the preparation of the colored bathymetric map indicated a distinct ditch system downgradient from the Pond that was apparently part of the former cranberry bog.

After the Hospital shut down in 2003, the pipe was capped at the Medfield end. The Sherborn Fire Department subsequently established a dry hydrant on Forest Street to intercept the water drawn from the Pond.

In 2010 an Act of the Legislature deeded Farm Pond to the Town of Sherborn.

Farm Pond is shown on historical USGS maps, including the 1893 Franklin quadrangle map and the 1940 Medfield quadrangle map (USGS 1893; 1940). Both maps clearly show an outlet channel on the northeastern shoreline. The 1893 USGS map lacks the earth covered rock berm that isolates a small eastern embayment. However, in the 1940 version there is an outlet from the eastern embayment which eventually confluences with the original outlet channel (USGS 1940). These features are consistent with the description and chronology of the operation of the former cranberry bog. The most recent USGS map does not show a direct outlet from the Pond (USGS, 1987).

1.1.2 Current Land Use

Current land use was determined through mapping with data layers taken from Massachusetts GIS data viewer (MA DEP 2014). Current land use and approximate acreage (rounded) in the Farm Pond watershed include:

- Forest – 268.4 acres (approximately 66% of watershed);
- Residential (both low and very low residential) – 54.1 acres (13%);
- Wetland (includes both wooded and shrub wetlands) – 39.6 acres (10%);
- Cropland – 35.9 acres (9%);
- Pasture – 10 acres (2%); and
- Recreational (primarily the Sherborn Town Beach) – 1.1 acres (<1%).

The total impervious surface (road, parking lots, driveways, rooftops) found in the watershed was estimated at 25.03 acres or 1.2% of the watershed (MA DEP, 2014). This is significantly less than for the rest of Sherborn, where impervious cover was estimated at 5.15% (EPA, 2010).

The Sherborn zoning map indicates that virtually all of Farm Pond's watershed is zoned "RC" or residential with a 3 acre minimum lot size (Town of Sherborn 2002) (see Appendix B). Based on a watershed windshield survey, there are no apparent active sub-divisions within the watershed nor any signs of impending development. Information regarding the regulations for the public beach is also included in Appendix B.

1.2 Watershed Soils

Soils in the Farm Pond watershed were identified from National Resource Conservation Service (NRCS) data layers available at the Massachusetts Geographic Information System (GIS) data viewer (MA DEP 2014). Watershed soils are depicted on Figure 2, with the legend for the individual soils provided on the following page.

The soils can be generally classified as predominantly Hinckley loamy sand, Merrimack fine sandy loam, and Canton fine sandy loam; All of which are well drained Soils with Hydrologic Soil Rating of "A". Wetlands and low-lying areas are characterized by Swansea and Freetown muck which are poorly drained hydric soils.

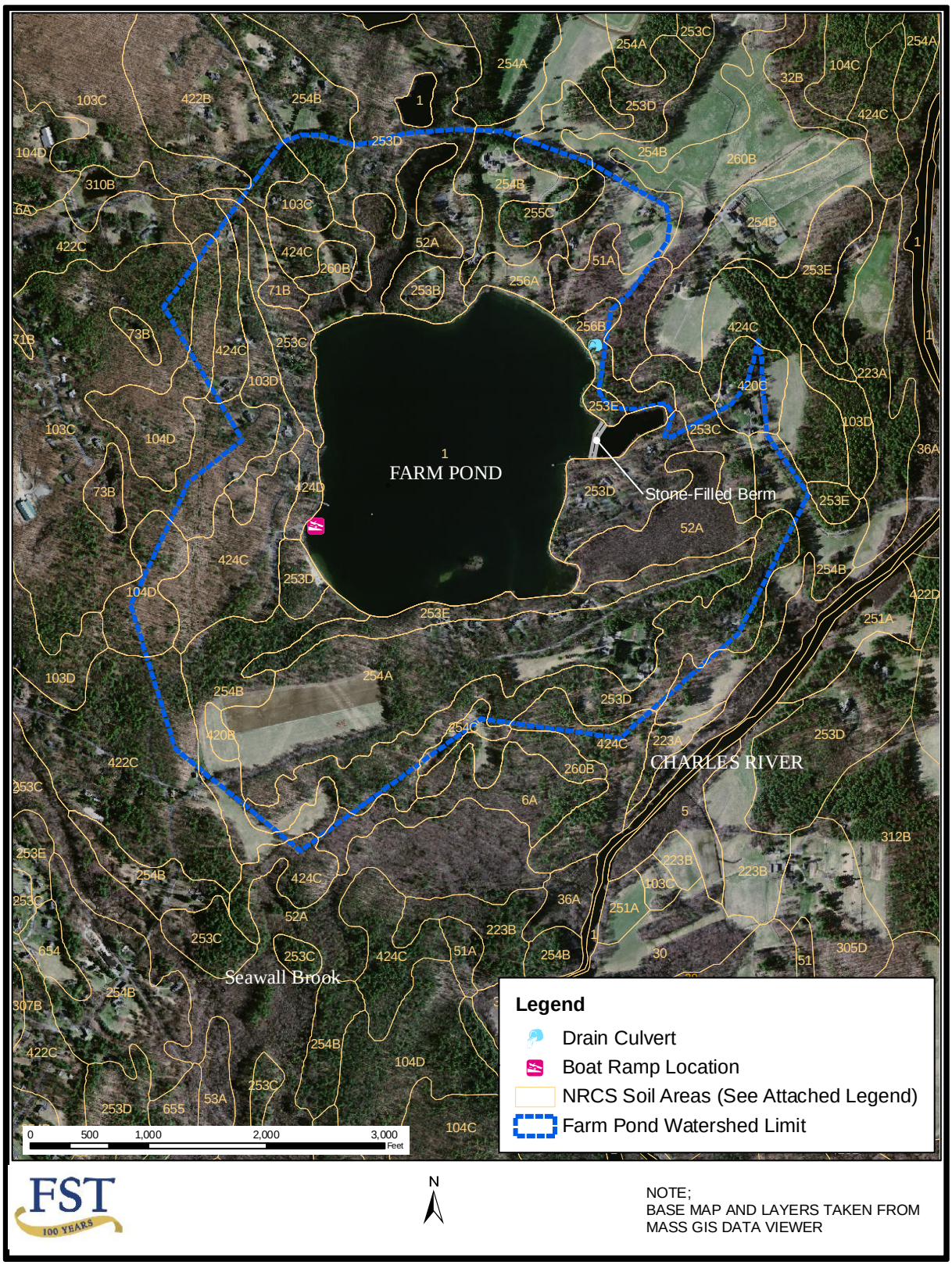


Figure 2. National Resources Conservation Survey soils of Farm Pond Watershed

FARM POND WATERSHED STUDY SOILS DATA	
SOIL TYPE	DESCRIPTION
422B	Canton fine sandy loam, 3 to 8 percent slopes, extremely stony
253D	Hinckley loamy sand, 15 to 25 percent slopes
1	Water
253D	Hinckley loamy sand, 15 to 25 percent slopes
424C	Canton fine sandy loam, 8 to 15 percent slopes, extremely bouldery
254A	Merrimac fine sandy loam, 0 to 3 percent slopes
103C	Charlton-Hollis-Rock outcrop complex, 3 to 15 percent slopes
253E	Hinckley loamy sand, 25 to 35 percent slopes
104D	Hollis-Rock outcrop-Charlton complex, 15 to 25 percent slopes
253D	Hinckley loamy sand, 15 to 25 percent slopes
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony
420C	Canton fine sandy loam, 8 to 20 percent slopes
253D	Hinckley loamy sand, 15 to 25 percent slopes
253C	Hinckley loamy sand, 8 to 15 percent slopes
253E	Hinckley loamy sand, 25 to 35 percent slopes
254B	Merrimac fine sandy loam, 3 to 8 percent slopes
424C	Canton fine sandy loam, 8 to 15 percent slopes, extremely bouldery
254B	Merrimac fine sandy loam, 3 to 8 percent slopes
73B	Whitman fine sandy loam, 0 to 5 percent slopes, extremely stony
103C	Charlton-Hollis-Rock outcrop complex, 3 to 15 percent slopes
254B	Merrimac fine sandy loam, 3 to 8 percent slopes
223A	Scio silt loam, 0 to 3 percent slopes
420B	Canton fine sandy loam, 3 to 8 percent slopes
256A	Deerfield loamy fine sand, 0 to 5 percent slopes
253C	Hinckley loamy sand, 8 to 15 percent slopes
51A	Swansea muck, 0 to 1 percent slopes
253E	Hinckley loamy sand, 25 to 35 percent slopes
253B	Hinckley loamy sand, 3 to 8 percent slopes
1	Water
260B	Sudbury fine sandy loam, 3 to 8 percent slopes
6A	Scarboro mucky fine sandy loam, 0 to 1 percent slopes
253E	Hinckley loamy sand, 25 to 35 percent slopes
103D	Charlton-Hollis- Rock outcrop complex, 15 to 25 percent slopes
253C	Hinckley loamy sand, 8 to 15 percent slopes
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony
424C	Canton fine sandy loam, 8 to 15 percent slopes, extremely bouldery
256B	Deerfield loamy sand, 0 to 5 percent slopes
255C	Windsor loamy sand, 8 to 15 percent slopes
254A	Merrimac fine sandy loam, 0 to 3 percent slopes
424C	Canton fine sandy loam, 8 to 15 percent slopes, extremely bouldery
424D	Canton fine sandy loam, 15 to 25 percent slopes, extremely bouldery
424C	Canton fine sandy loam, 8 to 15 percent slopes, extremely bouldery
254C	Merrimac sandy loam, 8 to 15 percent slopes
253D	Hinckley loamy sand, 15 to 25 percent slopes
254B	Merrimac fine sandy loam, 3 to 8 percent slopes
73B	Whitman fine sandy loam, 0 to 5 percent slopes, extremely stony
52A	Freetown muck, 0 to 1 percent slopes
52A	Freetown muck, 0 to 1 percent slopes
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes
254B	Merrimac fine sandy loam, 3 to 8 percent slopes
104D	Hollis-Rock outcrop-Charlton complex, 15 to 25 percent slopes
103D	Charlton-Hollis- Rock outcrop complex, 15 to 25 percent slopes
254B	Merrimac fine sandy loam, 3 to 8 percent slopes
424C	Canton fine sandy loam, 8 to 15 percent slopes, extremely bouldery
260B	Sudbury fine sandy loam, 3 to 8 percent slopes
5	Saco silt loam, 0 to 3 percent slopes
251A	Haven very fine sandy loam, 0 to 3 percent slopes

1.3 Review of Historical Data and Reports

Collection of water quality data and field observations are used to establish the current conditions of a waterbody. However, it is also important to detect long-term environmental trends, to determine if pond water quality is improving or deteriorating or if there has been a shift in trophic state (see Section 2.2). To conduct this comparison, it is necessary to identify reliable historical data.

Historical water quality data and field observations on Farm Pond were available from three State surveys (MA DEQ 1974; 1983; MA DEP 2013). These survey results include water quality data, temperature and dissolved oxygen (DO) profiles, secchi disk transparency (SDT) depths, observations of phytoplankton and aquatic macrophytes, and shoreline features (see Appendix A).

More recent data is available from the Farm Pond Advisory Committee (FPAC), drawn from that organization's monitoring efforts conducted since the late 1990s (Trainor 2011; 2014). This data includes seasonal measurements of Secchi disk transparency (SDT), total phosphorus (TP), and pH, from 1998 to 2008; temperature and dissolved oxygen (DO) depth profiles from the thermally stratified periods in 2000 and 2001; and an aquatic vegetation map (Boyda 2005). Additional water quality data may be available from FPAC, but it is reportedly in the form of raw field data which have not been transcribed from field sampling forms (Trainor, pers. comm. 2014). FST did not include these data in this analysis.

Additional qualitative information regarding Farm Pond water quality was obtained from Dr. Marianne Moore of Wellesley College (Moore, pers. comm. 2014; 2015). Dr. Moore has taken her college classes to the Pond on multiple occasions and she remarked on the excellent water clarity regularly observed over the years. She also postulated that phytoplankton growth in Farm Pond may be chemically limited by both nitrogen and phosphorus and biotically by grazing by zooplankton that undergo a diurnal migration to avoid fish predation (i.e., rise to feed at night and return to aphotic zone at day).

1.4 Preliminary Hydrologic Budget

A preliminary hydrologic budget was constructed for Farm Pond. The hydrologic inputs (inflows) to Farm Pond are a combination of tributary flow, runoff from the watershed, direct precipitation onto the Pond and any contributions from groundwater seepage. Losses (outflows) from the Pond occur through outlet flow and evaporation. Historically, there were consumptive withdrawals piped to the Medfield State Hospital but this practice has been discontinued.

We were unable to identify any previous attempts at establishing a hydrologic budget for Farm Pond. There are several significant challenges in quantifying inflows and outflows with available data, including:

- **Farm Pond has a very small watershed with no significant tributary inflow**. This means that most runoff will be non-point overland flow which is difficult to estimate.

- **Some small organized inflows may exist but are likely to be intermittent in nature** (e.g., the small channel located at the northwest corner is hydrologically connected to a pond/wetland complex. Inflow or outflow is likely controlled by fluctuations in the local water table such that flow would be highly seasonal).

- **There is no established outlet structure for Farm Pond.** As discussed in the land use section, a former outlet structure along the northeastern shoreline is non-functional and the earth-covered rock berm built across the eastern embayment lacks culverts or an overflow structure. Water leaving Farm Pond does likely so through leakage through the berm and/or overtopping the berm.

Given these challenges and project resources, we used two empirical methods to estimate flows in the Farm Pond system. Seepage into and out of the Pond was not included in these initial calculations but will be considered later in the report based on field work described elsewhere (Section 3.1). Calculations and derivations of the flow ranges discussed below are given in Appendix C.

One estimate of mean flow uses the area of the total watershed (409.3 acres) and applying standard yield coefficients, factors which relate the amount of flow to the unit area. The yield coefficients of Sopper and Lull (1970) suggest a watershed mean flow ranging from 0.64 to 0.96 cfs. Considering the low watershed to Pond area ratio of 3.2:1, this estimate is more approximate since the Pond and watershed are lumped together for the approximate flow and this method is usually used for river systems.

An alternative method uses a combination of watershed runoff and direct inputs (i.e., precipitation and evaporation) to the Pond. Runoff production in New England (in non-urban settings) is typically 40-50% of rainfall (Higgins and Colonell, 1971). We used the geometric mean of the past 25 year record of precipitation for Worcester (or 45.5 inches) and a literature-based evaporative loss of 20 inches per year (NOAA, 1982). Using these values, the amount of runoff from the Farm Pond watershed minus the Pond area (535.6 – 126.3 or 409.3 acres) was calculated and contributions from direct precipitation onto the Pond and evaporative losses included; resulting in annual inflow estimates of 1.12 to 1.24 cfs.

Several factors need to be taken into consideration when evaluating these estimates. Watersheds are characterized by a combination of steep and flat relief (topography), a variety of land uses and a mosaic of soils. The Farm Pond watershed is relatively steep on the western and northern shorelines but is largely forested in land use. Given the steep and close proximity to ledge (bedrock) in much of the western watershed, the higher value (1.34 cfs) is likely to be more representative.

The hydraulic residence time (HRT) is calculated as the Pond's volume divided by annual inflow. For Farm Pond, the HRT was estimated at 2.5 years and its inverse, the flushing rate, was calculated at 0.40 flushes per year. These values indicate that water movement in and out of Farm Pond is very slow and that any pollutant reaching the pond will not be easily flushed out.

2.0 Field Activities

The following field activities were conducted by FST as part of the evaluation of Farm Pond: bathymetric map confirmation, water quality monitoring, aquatic vegetation survey, and groundwater in-seepage measurements. Field notes for the May and August work are provided in Appendix D.

2.1 Bathymetric Map Confirmation

A bathymetric map provides the outline and details of the bottom depth contours of a pond. A detailed bathymetric map of Farm Pond was constructed in 2003 (Seering, A. 2003) following a detailed set of soundings. FST was provided with the GPS database that was the basis for the bathymetric map. Unfortunately, age of the database and lack of supporting software made this information electronically non-accessible so that generation of a new map was not possible. For our assessment, we manually superimposed the existing bathymetric contours on the Pond outline, as practicable (Figure 3)

FST conducted a qualitative confirmation of depth measurements, by comparing points from the field book with the approximated existing contours. Based on this comparison, it was determined that no significant changes to the bathymetric map were required.

2.2 Water Quality Monitoring - 2014

Water quality monitoring of Farm Pond was conducted on May 29 and August 12, 2014 (see Figure 4). The May sampling represents a late spring period when water column nutrient levels are likely to be near their seasonal maximum due to spring runoff from the watershed and potential in-seepage from a high groundwater table. The August sample represents a mid-summer period when the Pond typically experiences high levels of biological activity. The August sample is highly important for diagnostic purposes since it provides evidence of the maximum expression of nutrient-based growth and often represents the most stressful conditions for aquatic life. During late summer, pond surface water temperatures are high, clarity is often at seasonal lows, nuisance algal blooms may occur, and dissolved oxygen may be absent in most deeper zones of the Pond.

Measurements of temperature, dissolved oxygen (DO) pH, and specific conductivity and were taken at pre-selected depth intervals at the deep basin in Farm Pond (FP-1; Figure 3). Measurements were collected using a Yellow Springs Instruments (YSI) 600 XL multi-parametric probe. Total water depth at FP-1 was measured by a hand-held depth meter and location determined by a global positioning system (GPS) unit. Secchi disk transparency (SDT) depth (an estimate of water clarity) was measured.

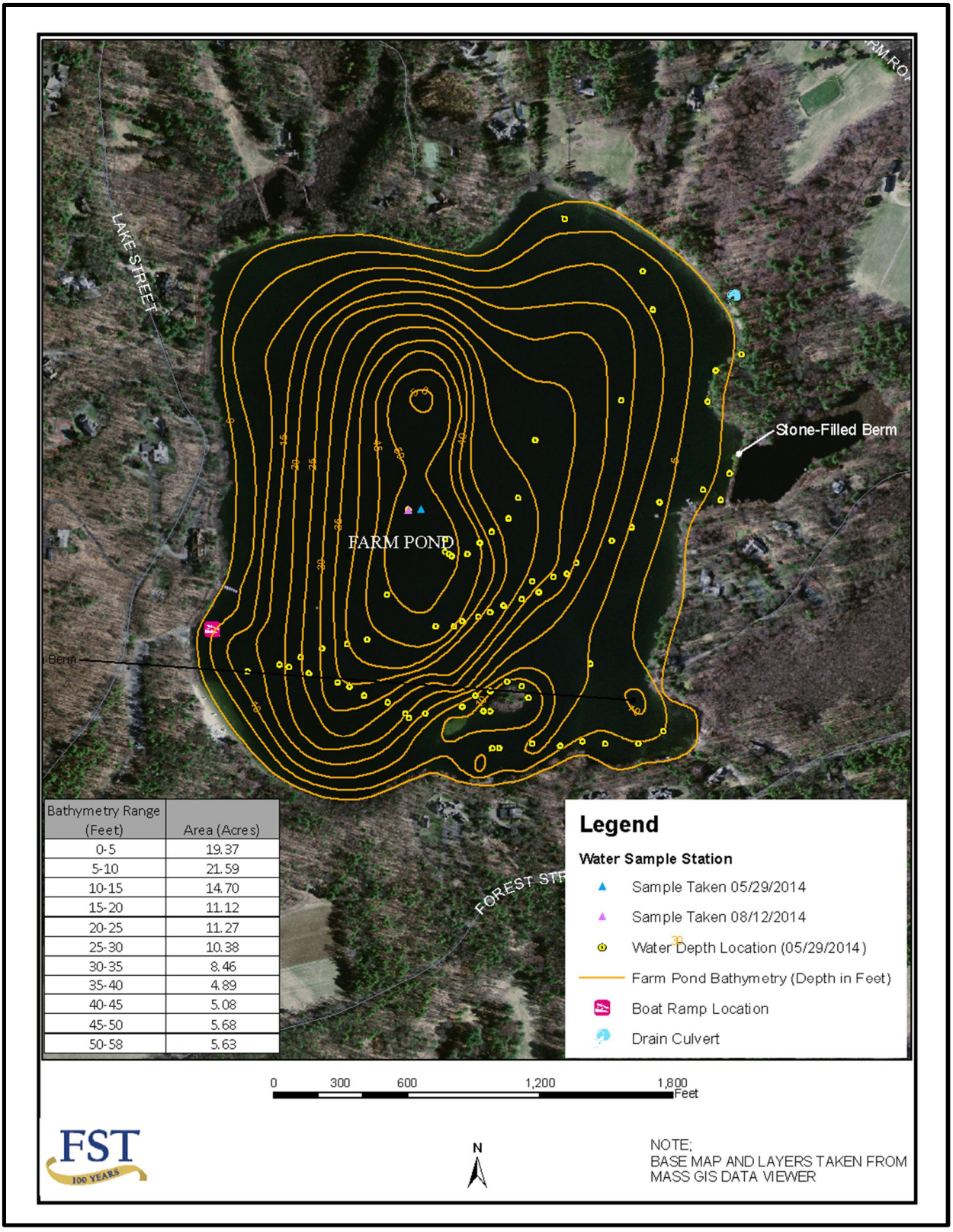


Figure 3. Farm Pond Bathymetric Map

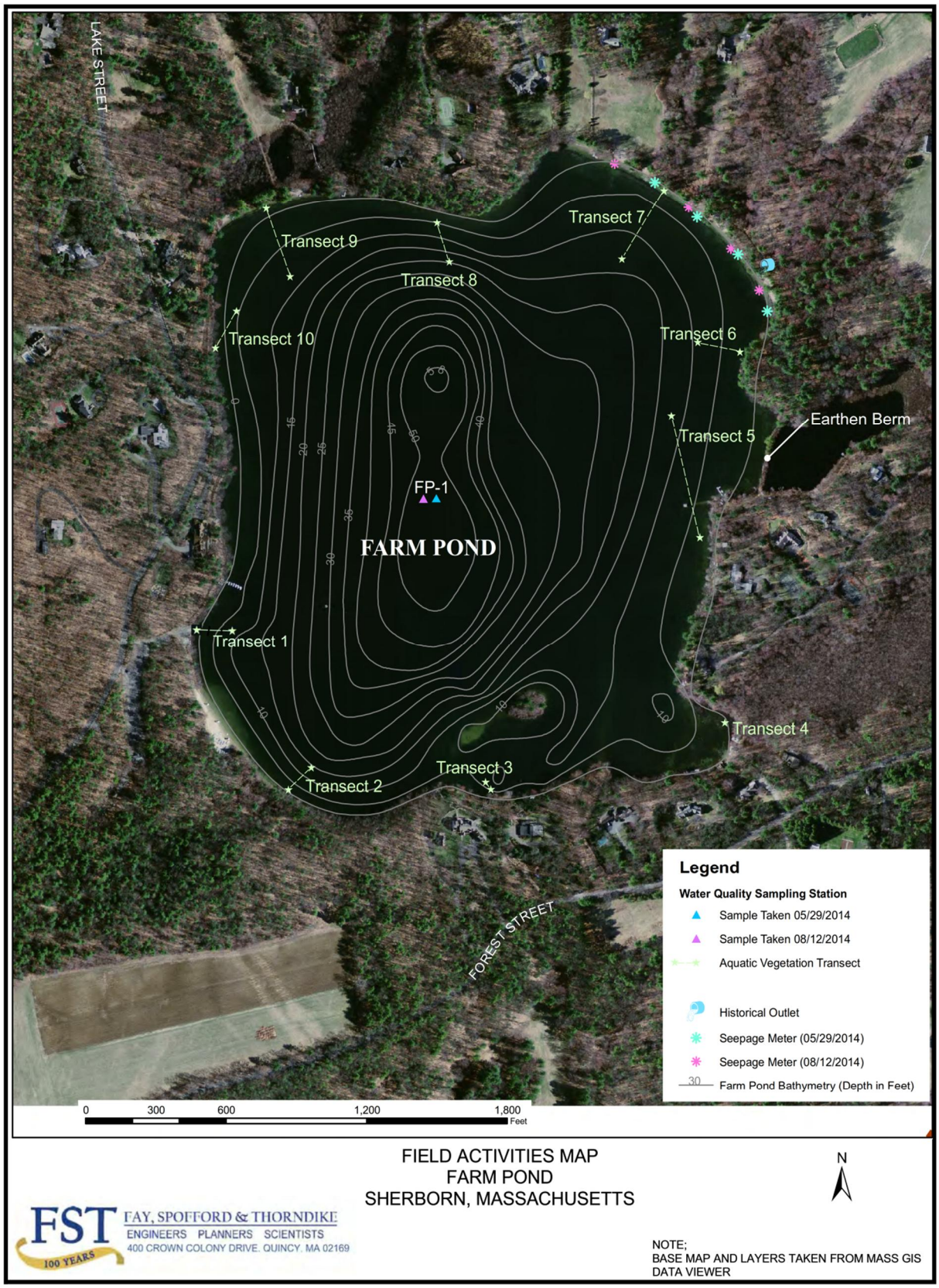


Figure 4. Farm Pond Field Activities Map

The following sections provide an overview of the water chemistry; including that for physiochemical characteristics: temperature, dissolved oxygen and secchi disk transparency (Section 2.2.1); general water chemistry: pH, specific conductivity, alkalinity, hardness and chloride (Section 2.2.2); nutrients (Section 2.2.3); and biological parameters (Section 2.2.4). Laboratory reports of the water quality data for the two samples are provided in Appendix E.

2.2.1 Water Column Physiochemical Characteristics

The temperature and dissolved oxygen depth profiles of Farm Pond during the two survey dates are shown in Figure 5. The profile in late May indicated rapid water temperature change within depths from 15 ft. to 30 ft. The thermocline (defined as the depth of greatest temperature change per unit depth interval) was located at approximately 17.5 ft. This seasonal thermal layering or stratification separates the Pond into three distinct layers: the warm, upper layer (termed the "epilimnion"); the zone of temperature change ("metalimnion"); and the cold, bottom waters ("hypolimnion").

Figure 5a indicates the Pond was thermally stratified during May and that DO concentrations are fairly constant to the bottom. There is a slight oxygen maxima seen within the metalimnion, presumably due to the colder temperature found there, since the amount of DO that can be dissolved in water increases with decreasing temperature. The abundance of DO at the bottom indicates the Pond is at an early stratification stage, not too long after vernal (spring) turnover.

The temperature profile of Farm Pond in mid-August (Figure 5b) exhibits approximately the same thermocline depth as in May but, as expected, there is a greater water temperature difference between the epilimnion and hypolimnion. This is caused by the summer heating of the upper waters while the isolated bottom water temperature is largely unchanged. The major significant difference between the two profiles is the significantly lower bottom DO concentrations observed in August with DO measurements less than 4.0 mg/L below 25 ft.

Comparison of 2014 data with historical State data shows similar patterns of temperature and DO seen in 1974; 1983 and 2005 (Appendix A). The State sampling surveys generally took place later in the summer season and typically demonstrate further depletion of hypolimnetic DO.

The FPAC temperature profiles of 2000 and 2001 exhibit the seasonal progression of thermal stratification in the Pond. The profiles show surface water temperature increasing from spring to a seasonal maximum in late August and then decreasing as the Pond undergoes cooling during the fall. When the pond temperature is uniform throughout the Pond (i.e., isothermal), it undergoes complete mixing throughout the water column (i.e., fall turnover).

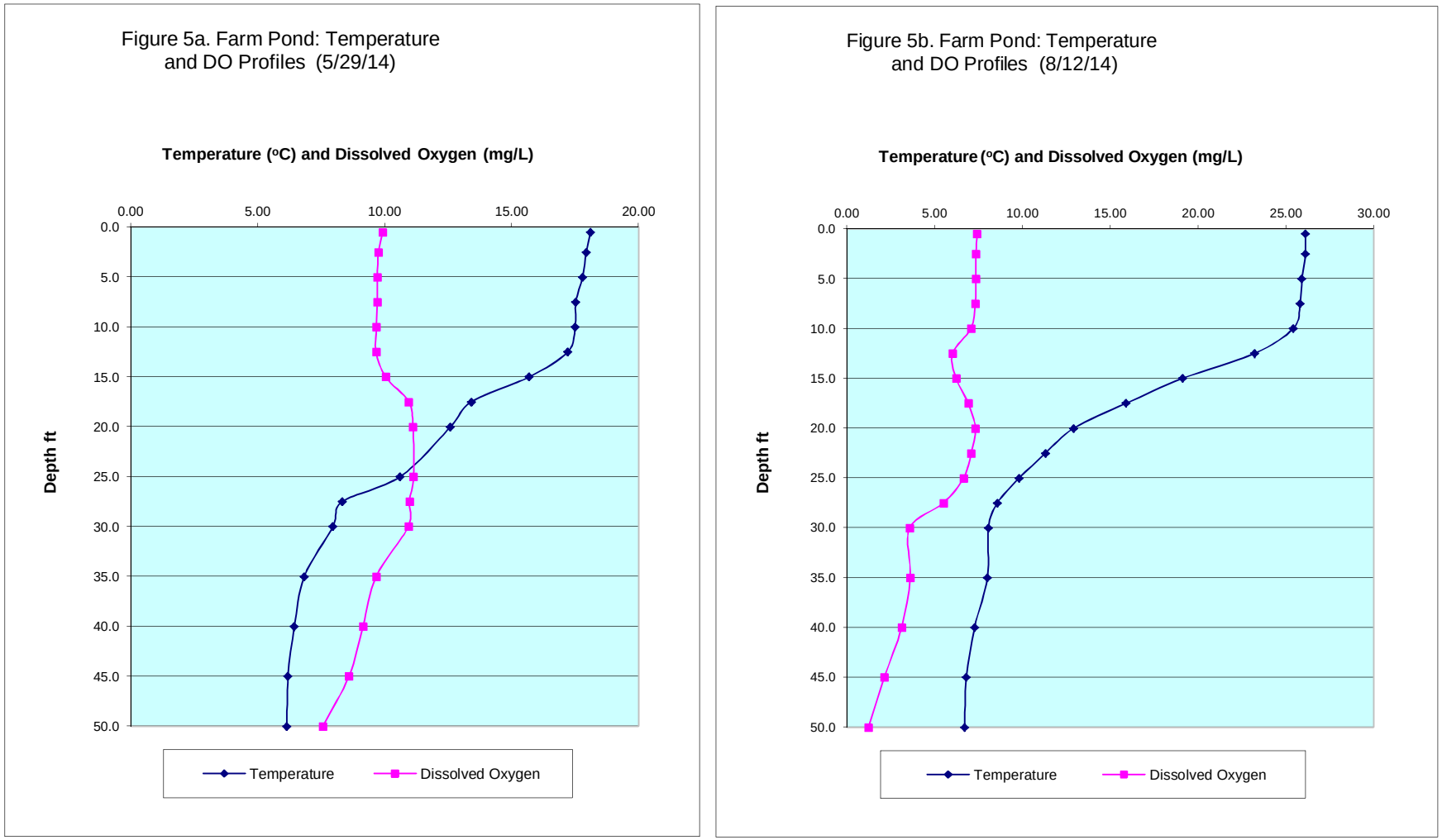


Figure 5. Farm Pond Temperature and DO Depth Profiles: Summer 2014.

Secchi disk transparency (SDT) depth measures the relative penetration of light into pond waters. The greater the SDT depth the further into light can penetrate and provide energy for photosynthesis. This can be particularly important for the depth limits of rooted aquatic plants (macrophytes) on the bottom. High SDT values indicate a lack of particulate matter, both inorganic (silts, clay) and organic (phytoplankton, detritus) in the water column.

As the season progresses, biological activity (phytoplankton) in most ponds begins to increase such that SDT values typically decrease over summer. However, there is no evidence of a seasonal decline in Farm Pond SDT as the value in both May and August was 23.9 ft. (7.3 m) indicative of excellent water clarity. Comparison of 2014 SDT observations to historical State data indicate remarkably consistent water clarity. Measurement in July 1983 was recorded at 26.3 ft. (8 m) and in September 2005 at 24.6 ft. (7.5 m).

The FPAC measures SDT in Farm Pond on a regular basis several times during the year. Table 2 shows the seasonal SDT minima and maxima from 1998 to 2008 (T. Trainor 2014). The greatest SDT clarity measured was 29.5 ft. (9 m) and lowest value was 11.8 ft. (3.6 m). Mean annual maxima over the period was 26.1ft (8 m) and the mean annual minima was 17.2 ft. (5.2 m).

Table 2. Farm Pond Secchi Disk Transparency: 1998-2008.

Year	n	Maximum SDT (ft)	Date	Minimum SDT (ft)	Date
1998	7	30.4	8/7/98	14.1	7/10/98
1999	8	26.2	10/22/99	15.7	7/16/99
2000	7	25.6	10/13/00	15.4	8/20/00
2001	8	24.0	5/27/01	16.4	8/24/01
2002	8	22.0	5/25/02	11.8	4/19/02
2003	8	26.9	10/26/03	18.0	5/25/03
2004	3	24.0	6/13/04	18.9	7/11/04
2005	4	29.5	5/29/05	22.3	8/27/05
2006	1	-	-	22.6	7/14/06
2007	3	25.3	8/12/07	17.1	7/7/07
2008	4	26.9	4/9/08	17.1	7/3/08
Mean annual average (ft):		26.1		17.2	

2.2.2 General Water Quality Characteristics

Water samples were collected at the surface (0.5 ft.) and near bottom (45 ft.) during the May and August surveys (four total) and analyzed for water quality parameters. Analyses were conducted by R.I. Analytical (Warwick, RI) and the lab analytical results are provided in Appendix E. Water quality results are shown in Table 3 and the general trends are described below.

Table 3. Farm Pond Water Quality Characteristics – May and August 2014.

		5/29/14		8/12/2014	
Nutrients	**Unit**	**Surface**	**Deep**	**Surface**	**Deep**
Total Phosphorus	ug/L	<10*	<10*	10	36
Diss. Phosphorus	ug/L	<10*	<10*	<50*	<50*
Ammonia-N	mg/L	0.15	0.21	<0.10*	0.36
Nitrate-N	mg/L	<0.05*	<0.05*	<0.05*	<0.05*
Nitrite-N	mg/L	<0.05*	<0.05*	<0.05*	<0.05*
TKN	mg/L	0.55	0.55	<0.5*	<0.5*
General	Unit	Surface	Deep	Surface	Deep
Alkalinity (as CaCO3)	mg/L	2.0	2.0	2.8	2.8
Hardness	mg/L	7.0	7.0	6.8	7.5
Chloride	mg/L	8.0	7.6	8.1	7.7
Iron	mg/L	<0.1*	<0.1*	<0.05*	0.69
Specific conductance	uS/min	37	26	44	30
pH	SU	8.0	6.7	8.7	6.7
Biological	Unit	Surface	Deep	Surface	Deep
Fecal Bacteria	mg/L	2	<2*	3	<1*
BOD_5	mg/L	<6.0*	<6.0*	<3.0*	<3.0*
Chlorophyll a	ug/L	1.5	NA	2.7	NA

*Method detection limit
NA = not analyzed

General water quality parameters monitored included pH, specific conductivity, alkalinity, hardness, and chloride. The pH in Farm Pond ranged from 8.7 to 6.6 with slightly higher values in the upper depths in August. There was a gradual but significant decline in pH from top to bottom in both May and August. Historical observations from the State indicate more acidic conditions (i.e., pH ranged from 4.2 to 6.1 standard units (SU)) in the Pond during 1974 and 1983 (MA DEQE 1974, 1983). More recent data from the FPAC ranged from 6.2-6.3 SU). A general regional increase in pH levels has been observed in many lakes and ponds in Massachusetts over the last two decades. This may be related to the general decrease in atmospheric pollution seen in the New England due to Clean Air Act provisions and reduction in the number of coal-burning power plants in the Midwest (e.g., http://www.epa.gov/region1/eco/acidrain/).

Specific conductivity is a non-specific water quality parameter related to the total amount of dissolved ions in a water sample. It provides a general indicator of the potential human influence in a freshwater system. In Farm Pond, the specific conductivity generally ranged from 44 to 27 microSiemens per centimeter (uS/cm) with the highest values found in the epilimnion (Appendix E). Comparison to historical State data indicates little change in this parameter over the years. The levels observed are consistent with the assumption that the Pond does not receive high amounts of human-derived (anthropogenic) materials, either by direct precipitation or surface runoff. Waterbodies with high levels of anthropogenic inputs typical show levels greater than 100 uS/cm. In addition, chloride was measured at 7-8 mg/L and indicates that Farm Pond is not highly impacted by road salt inputs occurring through stormwater (e.g., road salt) or groundwater.

Alkalinity (measured as mg/L as $CaCO_3$) is a measure of the relative buffering capacity of the water. In Farm Pond, alkalinity is very low; ranging from 1-2 mg/L as $CaCO_3$. Similarly, the hardness (sum of calcium and magnesium concentrations) is also low at 7 mg/L. These alkalinity and hardness levels are consistent with observations made during the State water quality surveys (MA DEQE 1974, 1983; MA DEP 2013). These characteristics made the Pond more susceptible to the effects of acid deposition in the 1980s-1990s. If alum treatment were proposed for the Pond, particular care would have to be exercised to make sure pH shifts during treatment were kept at acceptable levels. This is usually accomplished by blending alum with sodium aluminate.

Although high bacterial counts may occasionally limit contact recreation, comparison of the Pond 2014 water quality to the Massachusetts Surface Water Quality Standards (314 CMR 4.00) indicates that levels meet Class A water. Class A waters include "*waters designated as a source of public water supply and their tributaries. They are designated as excellent habitat for fish, other aquatic life and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation, even if not allowed. These waters shall have excellent aesthetic value. These waters are protected as Outstanding Resource Waters*". In addition to the water quality standards, the nutrient (nitrogen and phosphorus) concentrations are consistent with low primary productivity and excellent aesthetic value.

2.2.3 Nutrients

Nitrogen and phosphorus concentration are the major nutrient limiting primary productivity in freshwaters. This means that the level of phytoplankton (algal) growth is depending on the level and rate of supply of these critical elements. As described below, the water concentrations of nitrogen and phosphorus are low and are consistent with the low productivity of the Pond.

Nitrogen fractions (NO_3-N, NO_2-N, NH_3-N, and TKN) were analyzed in all water samples. Nitrate (NO_3-N) and nitrite (NO_2-N) concentrations were uniformly below detection limits

(<0.05 mg/L) in all samples. Ammonia (NH_3-N) ranged from non-detection (<0.10 mg/L) to 0.15 mg/L in surface waters and 0.21 to 0.36 mg/L in bottom waters. Total Kjeldahl nitrogen (TKN) was uniform for both top and bottom samples on each day and ranged from 0.55 mg/L in May to below detection (<0.5 mg/L) in August. These concentrations indicate that nitrogen levels are currently very low in Farm Pond. The non-detectable nitrate/nitrite levels suggest little or no impact due to stormwater or septic sources (via groundwater) which are typical watershed sources of nitrate. Historical State data also show low nitrogen levels, suggesting that nitrogen may be a co-limiting growth factor (with phosphorus) for phytoplankton (Moore, pers. comm., 2014). Nitrogen loads to the Pond are discussed further in Section 3.3.

Dissolved and total phosphorus were analyzed in all water samples. The May samples were specifically reanalyzed for phosphorus fractions using a more sensitive detection limit[4]. Even with the more sensitive detection limits, the dissolved phosphorus concentrations in Farm Pond were below detection (< 10 ug/L) (ug/L= parts per billion; note unit change from nitrogen fractions; mg/L)) in all samples. However, due to the very rapid cycling of this nutrient fraction in the food web, low or non-detect concentrations may be found even in more productive ponds, so this finding is not significant in itself.

The total phosphorus surface waters concentrations were below detection ((< 10 ug/L) and 10 ug/L for May and August samples, respectively. The total phosphorus in the bottom waters ranged from 10 to 36 ug/L. Higher levels of TP found in bottom waters may be due to bacterial decay of organic material sinking from the upper waters or regeneration of bound phosphorus from the sediments under anoxic conditions (i.e., little or no oxygen). It is also notable that the total iron, which is non-detectable (<0.050-0.10 mg/L) in both the May samples and August surface sample, is elevated in the deep August sample at 0.686 mg/L. This result is characteristic of low redox conditions releasing iron from the sediments, a process that is tightly coupled with phosphorus regeneration from the sediments. While the observed levels of 2014 deepwater TP are moderate, the State measured deepwater TP at 270 ug/L in September 2005. This suggests that bottom sediments may occasional be a potential source of regenerated phosphorus under late summer (mid-September) conditions.

We compared these results to historical data from the State (MA DEQE 1974; 1983). Both reported higher levels of TP than currently observed with 20 – 30 ug/L in 1974 and 70-130 ug/L 1983. An extremely high value of 2000 ug/L was reported at the "outlet" but there is no indication where this sample was taken. We tend to slightly discount these historical

[4] The May samples were initially measured at a detection limit of 50 ug/L. A second analysis using a more sensitive detection limit (10 ug/L) was conducted to provide more accurate and diagnostic measurements.

values since they seem inconsistent with the level of other parameters (e.g., SDT of 26.3 in 1983) and recognition that MA DEQE detection limits for TP and DP were often set too high (e.g., 100 ug/L).

Far more representative of current conditions are TP data reported for the FPAC for the period 1998-2008 (T. Trainor, 2014). The average TP concentration was 7.9 ug/L with a standard deviation of 2.6 ug/L. These measurements are in good agreement with the concentrations found in the current survey. Phosphorus loads to the Pond are discussed further in Section 3.3.

Another measure of the nutrient levels is by comparison to the U.S. EPA Ambient Water Quality Recommendations that were developed on data from many lakes, ponds and reservoirs for major nutrient ecoregions (i.e., geographical areas) within the United States (Omernik 2000). For each of these ecoregions and nested sub-regions, EPA compiled nutrient and chlorophyll data and derived criteria based on the underlying statistical distribution. Reference conditions were calculated statistically using the 25th percentile (i.e., upper quartile) of the entire nutrient database for each nutrient parameter.

Farm Pond is located within the Northeastern Coastal Zone. For this area, the 25th percentile for total phosphorus is 8 ug/L, total nitrogen is 0.48 mg/L, chl-a is 4.26 ug/L and SDT is 4.9 m (USEPA 2001). Based on the water quality data presented in Table 3 and described elsewhere, the trophic indicators in Farm Pond are at or well below these criteria and would classify it as a reference condition pond.

2.2.4 Biological Parameters

In addition to the water chemistry, samples were analyzed for biologically-related parameters including fecal coliform, five-day biochemical oxygen demand (BOD_5), and chlorophyll *a* pigment.

Fecal coliform was detected in surface samples at 2 and 3 colonies/100 ml; levels which pose no health threat to recreational activities in the Pond. BOD_5 was below detection in all samples taken. This indicates the Pond has a limited build-up of organic material over the summer growing season, presumably due to a lack of in-lake primary production. There may be periods during the year were fecal coliform is elevated along shoreline areas due to the influence of stormwater, recreational activities, or waterfowl, but these factors are unlikely to be influential for the deepwater sections of the Pond.

Chlorophyll a (chl-*a*) is the primary photopigment used for plant photosynthesis and observations from thousands of lakes and ponds indicate there is a high correlation between algae biomass and chl *a* values (e.g., Vollenweider, 1975; Wetzel, 2001). Seasonal chl *a* values in 2014 were very low at 1.5 ug/L (May) and 2.1 ug/L (August) and

are consistent with that observed by the State in 2005 (2.6 ug/L). These low chl *a* values indicate that there was very little algal activity in the water column during 2014.

2.2.5 Trophic State Index (TSI) assessment

Nutrient, chl-*a*, and SDT data can also be used to determine whether Farm Pond is currently supporting all designated water uses, as indicated by its overall trophic status. The concept of trophic status is based on the fact that changes in nutrient levels (measured by TP and TN) cause changes in algal biomass (measured by chl-*a*) which in turn causes changes in pond clarity (measured by SDT). A trophic state index (TSI) is a convenient way to quantify this relationship. This consists of the comparison of ambient values of key indicators (i.e., phosphorus and/or nitrogen fractions, chl-*a*, and SDT) to previously established criteria or thresholds. For these calculations, surface phosphorus values were used and, where values were below detection (e.g., May sample), an assumption of ½ the detection limit was used[5].

For this comparison, we used the Trophic State Index (TSI) developed by Carlson (1977). This method uses a log transformation of SDT values as a measure of algal biomass on a scale from 0 - 100. Each increase of ten units on the scale represents a doubling of algal biomass. Because by chl-*a*) and TP are usually closely correlated to SDT measurements, these parameters can also be assigned trophic state index values (EPA, 2011). Thus, the available trophic state indicators are input into a set of empirical equations:

$$\mathbf{TSI_{sdt}} = 60 - 14.41\ ln\ \text{SDT (m)}$$

$$\mathbf{TSI_{chla}} = 9.81\ ln\ \text{chlorophyll a (ug/L)} + 30.6$$

$$\mathbf{TSI_{tp}} = 14.42\ ln\ \text{TP (ug/L)} + 4.15$$

where: TSI_x is Carlson trophic state index and *ln* is the natural logarithm.

Interpretation of the output of the TSI model is through comparison of the resulting TSI scores to a gradient of scoring ranges that correspond to overall trophic states. These general relationships are described as well as shown pictorially in Appendix E.

Table 4 presents the TSI values calculated for Farm Pond for September 2005 (MA DEP, 2008) and those for May[6] and August 2014. While there is some year-to-year variation in

[5] The use of ½ the method detection limit as an estimate of a non-detected value is commonly used when a non-zero number is required. Thus, there is some uncertainty regarding what the exact value is.

[6] Trophic state refers to the general nutrient concentrations and productivity of a lake or pond. The three common trophic states are oligotrophic ("poorly fertilized'); mesotrophic ("moderately fertilized') and eutrophic ("well fertilized'). For further description of trophic state see Wetzel (2001).

the various parameters, the consensus for these three samples ranged from 30-35. These TSI values place Farm Pond solidly within the oligotrophic[7] pond category (i.e., TSI ranges 30-40). Moreover, comparison between the 2005 and 2014 data indicates that this trophic state has remained constant at this high water quality level over the last 10 years.

Table 4. Farm Pond TSI Calculations: 2005 & 2014.

Trophic State Calculation Formulas		Sept. 2005 data	TSI scores	May 2014 data	TSI scores	August 2014 data	TSI scores
Secchi Disk:	**TSI(SDT) = 60 - 14.41 ln(SDT)**	7.5	31	7.31	31	7.31	31
	SDT expressed as meters						
Chlorophyll a:	**TSI(CHL) = 9.81 ln(CHL) + 30.6**	2.6	40	1.5	35	2.1	38
	Chlorophyll a expressed as ug/L						
Total Phosphorus:	**TSI(TP) = 14.42 ln(TP) + 4.15**	10	33	5	23	10	33
	TP expressed as ug/L						
	where ln = natural log **Avg. score:**		**35**		**30**		**34**

2.3 Aquatic Vegetation Survey

FST conducted an aquatic vegetation survey on August 12, 2014. The survey transects were placed approximately equidistant around the periphery of the Pond to provide observations from the shallow, near-shore environment (i.e., 1-2 ft. water depth) to deep areas (i.e., 9-12 ft.) in representative areas (Figure 4).

2.3.1 Methods

Observations of submerged species were made at the 10 transects displayed on Figure 4. For each transect, observations were made of the dominant species observed and its presence (sparse, moderate, or dense) as well as the overall density of the areal plant cover of the entire macrophyte community (rated 1-5 with 5 being the highest) and noted on a standardized form. Visual observations were aided by use of an Aqua-Scope viewing scope in shallow water and an Aqua-Vu underwater camera for deeper areas.

A long-handled rake was periodically used to pick up bottom specimens for closer inspection or collection for later identification. Specimens of interest collected were bagged and kept cool for later taxonomic identification using Crowe and Hellquist (1972-1978) and other on-line taxonomic keys, as needed.

[7] Note that 5 ug/L or ½ method detection limit is used for the May 2014 TP value.

GPS locations were noted for the start and end of each transect[8] (Figure 4). Observations were made at representative locations along the depth gradient until the vegetative community did not change and/or light levels were too low to accurately observe. Accordingly, the individual transects were of variable length depending upon the nature and density of aquatic vegetation. Individual transect survey forms are provided in Appendix F.

2.3.2 Results

Overall, the submerged aquatic macrophyte community was judged to be sparse, despite the fact it covers a considerable portion of the Farm Pond bottom in water depths less than 12 ft. The reason for this disparity is that macrophyte species found in Farm Pond are generally very short (e.g., <6-8") in stature. Therefore, the benthic vegetative community does not protrude very high into the water column. Due to this short canopy, it poses no impediment to recreational uses of the Pond. The densest coverage was found in the southeastern cove and consisted of algal mats overlying aquatic moss

At the same time, the small biomass of the macrophytes means it provides little ecological function to the Pond, representing a minor source of carbon (primary production) and providing little habitat cover for benthic macroinvertebrate or young-of-the-year (YOY) juvenile fish or minnows. At about 3-4 ft. of water depth, a band of poorly-decomposed leaf and twig litter was found, which suggests that decomposition of organic materials by bacteria, fungi, and macroinvertebrates is slow in the Pond.

There was low diversity in species composition throughout Farm Pond and about 8 submerged species were noted. The most dominant taxa were pipewort (*Eriocaulon aquaticum*), needle spikerush (*Eleocharis acicularis*), brittlewort (*Nitella* spp.), aquatic moss (*Musci* spp.) and attached algal mats. The most ubiquitous assemblage was that of the macroalgae (*Nitella*) overlain by algal mats resulting in a carpet-like appearance).

Most importantly, there were no observations of aquatic non-indigenous invasive (ANS) species that can enter a pond and quickly overwhelm the natural community as has happened in many other lakes and ponds in the Charles River watershed (e.g., Lake Cochituate, Natick; Morses Pond, Wellesley, and Populatic Pond, Norfolk/Medway). Common invasive species found in these lakes and in stretches of the upper Charles River include curley-leaf pondweed (*Potamogeton cripsus*), Eurasian watermilfoil (*Myriophyllum spicatum*), fanwort (*Cabomba caroliniana*), and water chestnut (*Trapa natans*).

The species assemblage observed was fairly consistent with the species findings of Boyda (2004) with the exception that very little bladderwort (*Utricularia spp.*) was observed.

[8] Note that only one GPS location was recorded for Transect #4.

Utricularia's habitat preference is for acidic, poorly-fertilized waters and rooted in loose organic sediments in low-energy environments. Floating mats of bladderwort have been reported from past years and it is likely that the plant is present in the Pond within some of the back coves.

The sparse macrophyte community is a result of the environmental setting of Farm Pond. Macrophytes have three critical factors for growth: available light, loose, organic substrate for attachment, and a source of nutrients. In Farm Pond, there is excellent water clarity for macrophyte growth, but substrate suitability and ambient nutrient levels are potentially limiting factors for macrophyte growth. Much of the bottom substrate consists of rocky cobble to gravelly sands, with few areas of organic accumulation to allow plant rooting. Most of the near-shore area is virtually devoid of rooted plants due to a combination of poor substrate and heavy wave action. Further, the lack of nutrient uptake from organic sediments and the nutrient poor (oligotrophic) nature of the water column is unfavorable for macrophyte growth.

2.4 Groundwater Seepage Survey

As part of the refinement of the hydrologic budget, a set of groundwater seepage meters (i.e., instruments to detect groundwater seepage in or out of the pond) were deployed. Based on the drainage patterns of the Pond and the availability of a sandy substrate for accurate measurement, these meters were deployed along the northeast corner of the Pond (see Figure 4 for locations). The deployment consisted of five seepage meters in May and six in August. Due to malfunction and equipment loss only four meter readings were obtained in each survey. The amount of groundwater seepage measured is presented in Table 5.

As shown in, Table 5 groundwater seepage was positive in May (1.2 to 25.4 $L/m^2/day$) and neutral or negative in August (-1.1 to 1.0 $L/m^2/day$). This pattern is consistent with local groundwater table discharging to the Pond in spring with a reversal in late summer (i.e., pond recharging groundwater). Two of the seepage meters indicated relatively high groundwater inputs in May along the northeast area. Equipment performance may have been less reliable in May due to wave action on collection bags on high-profile meters subject to surface wave action. Use of a lower-profile seepage meters with more secure bag fitting likely improved the reliability and decreased variance in August readings.

Table 5. Farm Pond Groundwater Meter Seepage Rates.

May Seepage Estimates						
Meter #	**Amount (L)**	**Meter Area (m^2)**	**Influx L / m^2**	**Incubation Period (hr)**	**Incubation Period (dy)**	**Rate (L/m^2/day)**
1	0.05	0.25	0.20	4.08	0.17	1.2
2	0.18	0.25	0.72	4.17	0.17	4.1
3	0.55	0.25	2.20	3.83	0.16	13.8
4	1.045	0.25	4.18	3.95	0.16	25.4
August Seepage Estimates						
Meter #	**Amount (L)**	**Meter Area (m^2)**	**Influx L / m^2**	**Incubation Period (hr)**	**Incubation Period (dy)**	**Rate (L/m^2/day)**
1	0.07	0.25	0.28	7.02	0.29	1.0
3	-0.08	0.25	-0.32	6.95	0.29	-1.1
5	0.02	0.25	0.08	7.02	0.29	0.3
6	-0.08	0.25	-0.32	6.83	0.28	-1.1

Difference in volume is the volume change over area over time. Seepage meters occupy about 0.25 m2, so multiply by 4 for volume per m2. Divide number of hours seepage meter was in place with bag deployed into 24, and multiply that number by volume per m2 to get L/m2/day. Values <5 are low, values >10 are high.

Overall, the rocky nature of the surrounding watershed and lack of sandy substrate for much of the bottom results in the Pond being less conducive to groundwater inputs. Based on these conditions and heavier weight given to the August seepage results, groundwater was judged not to be a significant hydrologic factor in the Pond hydrologic budget (see additional discussion in Section 3.1).

3.0 Hydrologic and Pollutant Loading Models

3.1 Refinement of Hydrologic Model

In Section 1.4, a preliminary hydrologic budget was constructed for Farm Pond. The total input flow is approximately 1.0 cfs. The hydrologic inputs (inflows) to Farm Pond are a combination of runoff from the watershed, direct precipitation onto the Pond and groundwater seepage. Based on the limited amount of seepage measured, the percentage of total input is approximately 52% precipitation; 48% runoff, and <1% seepage. It was not possible to determine the relative importance of outputs (evaporation, outflow) as we did not have an outflow measurement. Therefore, there is some uncertainty regarding the absolute magnitude of the flows in and out of Farm Pond. However, reducing this uncertainty to a finer level would require significantly more effort and time in field work and analysis and increased accuracy is not critical for the data needs of this management plan. Accordingly, this hydrologic budget was judged sufficient to provide the hydrologic assumptions of the pollutant loading model that was used (see Section 3.3).

3.2 Estimate of Stormwater Inputs

Stormwater input refers to runoff generated when precipitation from impervious surfaces or developed areas flow into a collection and conveyance system that discharges it to the Pond at a discrete location (i.e., end of pipe). For Farm Pond, there are four catch basins which drain a limited area on Lake Street (0.75 acre) and which eventually discharges to the Pond. The affected area was identified as 0.02 acre impervious surface (road) and 0.73 ac residential land use.

In 2008, the Town's environmental consultant (FST), installed a best management practice ("BMP") stormwater treatment system including grassed swales, rain gardens and a bioretention soil mixture (Norfolk Ram 2013; see Appendix J for copy of the O&M manual for this BMP). Due to the tiny size of land draining to the catch basin (<0.2% of total watershed), its hydrologic input is satisfactorily modeled using the watershed approach described in 3.1. Nutrient inputs are discussed further in Section 3.3.

3.3 Pollutant Loading Model

With a limited seasonal data set (i.e., two sets of summary water quality samples) and no available inflow and outflow measurements, estimates of pollutant loading from actual data were not feasible. Nitrogen and phosphorus loads to Farm Pond were derived by two separate methods: calculation from empirical models and calculation from a land use-based model calibrated with actual data (Lake Loading Response Model).

Although models are only representations of reality, they can provide insights into the magnitude and range of loading and temper judgments made based on a limited set of actual data. The approaches applied here provide a range of estimates, of nutrient loading and a sense for the potential uncertainty in loading estimates. The empirical formulas and

assumptions made using the land use-based model (i.e., runoff coefficients etc.) are provided in Appendix G. The land use model was calculated based on existing conditions in the watershed as determined by GIS analysis and limited watershed inspection.

The Lake Loading Response Model (LLRM) uses environmental data to develop hydrologic and phosphorus loading budgets for ponds and their tributaries. The LLRM consists of a large Excel spreadsheet that incorporates data about land cover, watershed boundaries, point sources, septic systems, waterfowl, rainfall, and an estimate of internal pond loading, combined with many coefficients and equations from scientific literature on lakes and nutrient cycles, to develop a water and phosphorus loading budgets. The model makes predictions about chl-*a* concentrations and Secchi disk transparency depths. The accuracy of the input parameters has direct bearing on the validity of the final load estimates and trophic predictions.

Water and phosphorus loads (in the form of mass and concentration) are traced from various sources in the watershed, through tributary basins, and into the Pond. Since the model is spreadsheet-based, it uses numbers rather than maps as inputs and outputs. However, it requires detailed information about the type of land uses in the watershed as inputs, which in essence requires mapping as part of the modeling process. AECOM et al. (2011) provides a comprehensive user manual to the model which explains each component of the model in detail.

Watershed Boundaries - The LLRM requires many inputs on a broad range of environmental conditions to calculate water and phosphorus loads for ponds. Watershed and tributary drainage basin boundaries are needed to calculate both the amount of water flowing into the Pond, as well as helping determine what the land uses are that contribute to nutrient loading. The drainage basin boundaries for this model were based on USGS maps, MASS GIS, and best professional judgment regarding watershed boundaries based on assumed outlet location in the northeast corner. Farm Pond has no permanent tributaries of significance so all runoff was assumed to be routed to the Pond basin (i.e., direct runoff). Figure 6. Depicts the Pond's watershed limit.

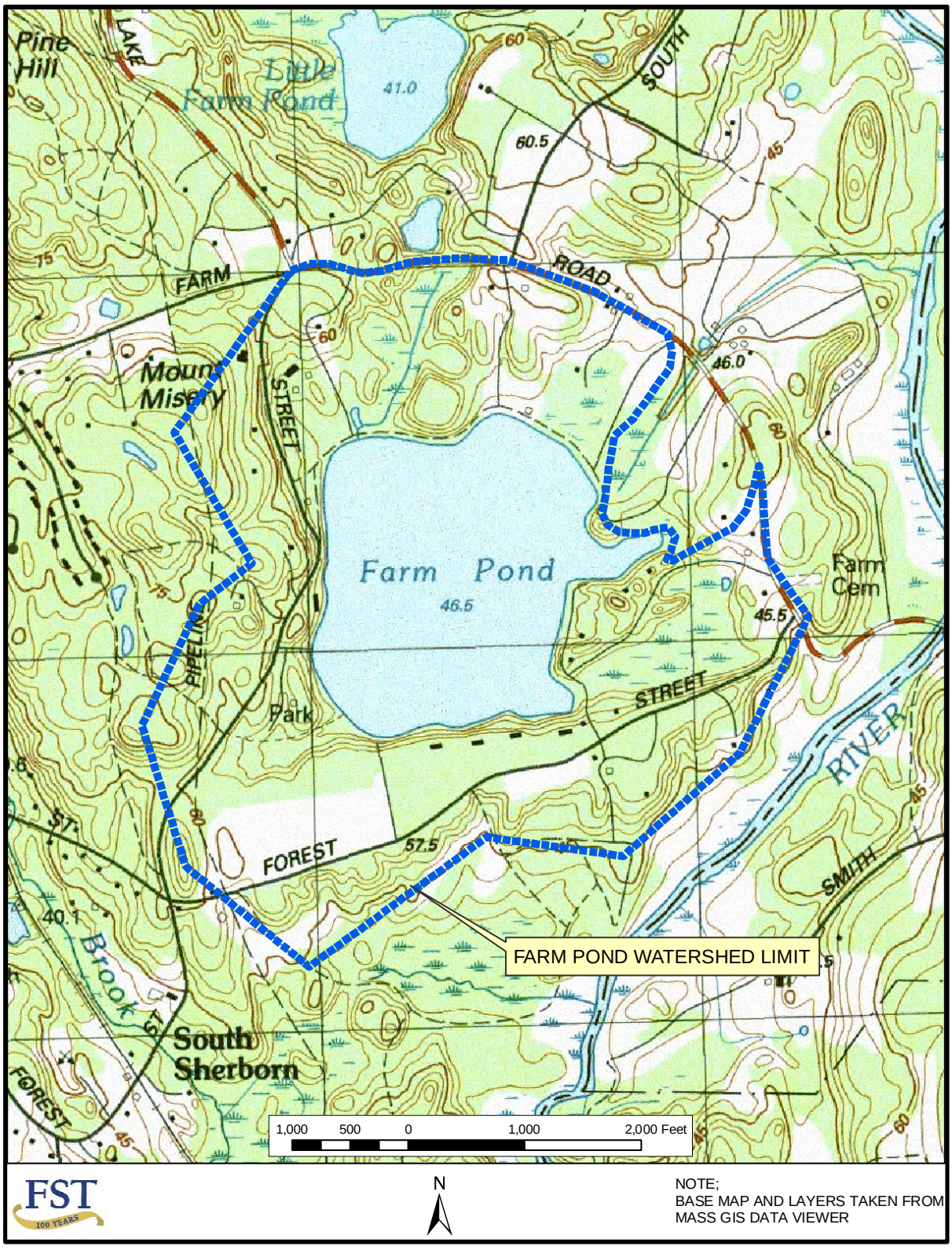


Figure 6. Farm Pond Watershed Limit

Watershed Land Use – current land use is an essential element in determining how much phosphorus is being contributed to the Pond via stormwater runoff. As described in Section 1.1, land use was obtained from importing data layers through the Massachusetts GIS data viewer (MA DEP 2014) while depicts the current land use types throughout the watershed.

Stormwater Inputs - The current nutrient load to the Pond from stormwater was estimated by the U.S. EPA Urban BMP Pollutant Load Reduction Worksheet (see Appendix G). After treatment by the installed BMP, stormwater discharge inputs 2 lbs/yr (0.9 kg) of total nitrogen. The EPA worksheet predicts that no phosphorus will enter the Pond, as it is retained by the rain garden and bioretention filter system.

Septic System Load - septic systems are a source of both water and nutrients to the Pond. Water travels through the system, then continues to move as groundwater, or subsurface flow above the level of groundwater, some of which flows into tributaries or ponds. The ways septic systems prevent phosphorus from reaching surface waters can be varied, complex, and difficult to measure. Generally, the scientific literature shows phosphorus reduction of 20-30% can occur in the septic tank via settling, and between 23-99% in the leach field and immediately surrounding soils (Lombardo 2006). Factors affecting the ability of septic systems to prevent phosphorus from entering surface waters include soil and groundwater pH, redox conditions, and mineral composition.

In some cases, septic systems which had been operating for many decades were found to retain 85% of the phosphorus within the first 30 cm of soil (Harman et al. 1996, and Zanini et al. 1998). Several studies have found that phosphorus migrates through the soil much slower than other dissolved contaminants in wastewater, and that over a distance of between 30 to 300 feet, groundwater phosphorus concentrations were reduced to background levels (Robertson et al. 1998, and Weiskel et al. 1992).

The LLRM used a phosphorus attenuation rate for application to inputs from septic systems. Based on the general literatures rates cited above[9], residences (15) within approximately 100 ft. of the shoreline were conservatively considered to retain 80% of phosphorus, while systems (25) located greater than 100 ft. (or greater) were considered to retain 90%. [Note: the number of residences was tallied using Mass GIS and aerial photography]. This range is also consistent with research showing a range of failure rates from about 10% to 20% (Zanini et al. 1998, USEPA, 2002).

[9] In some cases, septic systems which had been operating for many decades were found to retain 85% of the phosphorus within the first 30 cm of soil (Hartman et al. 1996, and Zanini et al. 1998). Several studies have found that phosphorus migrates through the soil much slower than other dissolved contaminants in wastewater, and that over a distance of between 30 to 300 feet phosphorus was reduced to background levels (Robertson et al. 1998, and Weiskel et al. 1992).

Waterfowl - the number of resident or migratory waterfowl in the watershed are unknown. We estimated 20 resident birds per year on average (assumed half-year residence) based on descriptions of 35+ birds feeding seasonally in local lawns. Waterfowl can be a direct source of nutrients to ponds, however, if they are eating from the pond and their waste returns to the pond the net change may be less than might otherwise be assumed. If in the future, a more precise bird census is available, those numbers can be added to the model easily.

Precipitation - average annual precipitation was determined to be 1.14 m (45.5 in) per year based on long-term precipitation records from MA. Twenty inches of precipitation per year was subtracted from the direct precipitation on the Pond to account for evaporation (NOAA 1982). This adjustment did not reduce the estimate for atmospheric deposition of phosphorus, however, since evaporating water does not transport the nutrient away.

Other Data - many model parameters, such as atmospheric deposition of phosphorus and water yield per unit land area, were considered regional in nature. Additional parameters were set as follows:

- Standard water yield (CFSM) = 1.7, default value within LLRM (this is consistent with the estimated hydrologic budget
- Runoff and baseflow export coefficients (see Appendix G)
- Direct atmospheric deposition phosphorus export coefficient

Nutrient loads for phosphorus and nitrogen inputs to Farm Pond calculated by the LLRM are summarized in Table 6. The total amount of the annual phosphorus load is 32.3 kg/yr and total amount of nitrogen is 724.0 kg/yr. The phosphorus inputs are fairly evenly distributed amongst a number of sources, while the nitrogen inputs are dominated by atmospheric deposition, septic systems and watershed runoff.

Table 6. Summary of LLRM Calculated Nutrient Loads to Farm Pond.

	Phosphorus (kg/year)	**% input**	**Nitrogen (kg/year)**	**% input**
Atmospheric Deposition	10.2	31.6%	332.2	45.9%
Internal recycling from nutrients	3.1	9.6%	7.7	1.1%
Waterfowl	4.0	12.4%	19.0	2.6%
Septic System	7.8	24.1%	152.8	21.1%
Treated Stormwater	0.0	0%	0.9	0.1%
Watershed runoff	7.2	22.3%	211.4	29.2%
Total Loads to Farm Pond	**32.3**	**100%**	**724.0**	**100%**

The hydrologic and nutrient inputs were inserted into a mass balance equation and five well-regarded equations from the eutrophication literature were used to predict in-pond total phosphorus concentrations (terms are defined in Appendix G). The results are presented in Table 7. The mass balance approach simply divides the calculated annual load

by the hydrologic load over the year and does not take into account biological uptake or sediment deposition.

Table 7. Predicted In-Pond TP Concentrations.		**Predicted TP conc. (ppb)**
Model Name	**Equation Formula**	
Mass Balance	TP=L/(Z(F))*1000	**22**
Kirchner-Dillon 1975 (K-D)	TP=L(1-Rp)/(Z(F))*1000	**6**
Vollenweider 1975 (V)	TP=L/(Z(S+F))*1000	**13**
Larsen-Mercier 1976 (L-M)	TP=L(1-Rlm)/(Z(F))*1000	**9**
Jones-Bachmann 1976 (J-B)	TP=0.84(L)/(Z(0.65+F))*1000	**8**
Reckhow General (1977) (R_g)	TP=L/(11.6+1.2(Z(F)))*1000	**4**
	Average of 5 Equations:	**8**
	FPAC Monitoring Mean Value:	**7.9**

The five equations are fairly comparable in components but vary slightly in how they use specifically compute nutrient loads, flushing, and phosphorus retention coefficients. Since we do not know which equation is most representative for Farm Pond, this approach provides a range of values and indicates the uncertainty associated with the predictions.

The predicted in-pond TP concentrations varied from 4 to 13 ppb, with a mean value of 8 ppb. The mean value is consistent with the average TP value of 7.9 ppb reported by FPAC over many years of monitoring. This data provides a reality check for the modeling and indicates that the nutrient budget and its underlying assumptions are reasonable.

The TP predictions from the five equations were then input into predictive equations for chl-*a* and SDT values based on well-established regression of these values on total phosphorus values (Table 8). These equations predict a range of chl-*a* from 1.5 to 4.2 ug/L (ppb) with a consensus value of 2.2 ug/L and peak value of 8.2 ug/L. The measured May and August 2014 chl-*a* concentration in the Pond were 1.5 and 2.7 ug/L, respectively, with an average of 2.1 ug/L. Thus, there is excellent agreement between the predictive equations' consensus value and our observed value.

Table 8. Predicted Chl-*a* and Secchi Disk Transparency Depths.			
MODEL	**Value**	**Mean**	**Measured**
Mean Chlorophyll (ug/L)			
Carlson 1977	1.8		
Dillon and Rigler 1974	1.5		
Jones and Bachmann 1976	1.7		
Oglesby and Schaffner 1978	1.7		
Modified Vollenweider 1982	4.2		
Consensus of five equations		2.2	2.1
Peak Chlorophyll (ug/L)			
Modified Vollenweider (TP) 1982	11.5		
Vollenweider (CHL) 1982	5.9		
Modified Jones, Rast and Lee 1979	7.6	8.3	
Secchi Transparency (ft)			
Oglesby and Schaffner 1978 (Average)	15.1		21.6
Modified Vollenweider 1982 (Maximum)	17.7		26.2

Similarly, SDT depths prediction by the model included an average value of 15.1 ft with a maximum value of 17.7 ft. Based on the FPAC monitoring data, the long-term average SDT depth is 21.6 ft with a maximum of 26.2 ft, while our surveys measured 23.9 ft.

These values indicate that the predictive equations underestimate the actual water clarity. The reason for this discrepancy is not known but it could be postulated that the lack of any major tributaries entering the Pond would eliminate sources of inorganic particles or sediment (i.e., silts and clays) that, in addition to organic biotic materials, could reduce water clarity. Another potential reason for the better than expected clarity is through grazing of phytoplankton by zooplankton. Since the lake is very clear and fish are abundant in the upper waters. it has been hypothesized that the zooplankters undergo a diurnal vertical migration to feed at the surface at night and retreat to deeper, darker waters during the day. Some limited observations support this hypothesis (Moore 2015). Regardless of the actual reason for the under-prediction, Farm Pond is an exceedingly clear body of water.

4.0 Review of Pond and Watershed Management Options

The main objective of the Farm Plan Management Plan study was to collect background watershed characteristics, conduct limited water and sediment quality sampling, investigate seepage and monitor pond thermal structure. The data were used to develop associated analyses of the hydrologic and nutrient budget of the Pond to support evaluation and identification of appropriate pond and watershed management options to protect and conserve Farm Pond's current water quality and recreational uses. The 2014 data and analyses reported in Sections 1 through 3 form the basis for this evaluation.

4.1 Review of Pond Management Options

Pond management options include those methods or actions that are typically conducted to decrease the intensity and frequency of algal blooms, increase water clarity, or reduce macrophyte biomass; all the typical symptoms of eutrophication (i.e., oversupply of nutrients). The state of Massachusetts developed an encyclopedic compilation of physical, chemical, and biological methods to reduce nuisance algal and plant conditions, as well as the method's specific history (including success) of application in Massachusetts waters (Mattson 2004). This material has also been condensed and clarified for use by Conservation Commissions (Wagner 2004).

The first step in identify potential pond management is to identify the problematic condition and what needs to done to correct it. The consensus of diagnostic information available clearly indicates that Farm Pond is an oligotrophic water body with excellent water quality and low levels of nutrient inputs. Both nitrogen and phosphorus are found at low concentrations suggesting that one or even both of these chemicals may be growth limiting for phytoplankton. There is some indication of low levels of internal phosphorus recycling from the sediments during late summer but this is often found near the bottom of ponds, even those of good water, and does not pose a particular concern. Overall, its excellent water quality would classify Farm Pond as a reference (unimpacted) pond in the local ecoregion (USEPA 2001) and it would easily meet Class A water quality standards.

Comparison of the current data to historical State and FPAC data and maps indicate little or no change in water quality over the last 3 decades, with the possible exception of pH which has been readily rising in waters of the Commonwealth. Similarly, macrophyte abundance and biomass was recorded as very sparse during the 1970s and remains so to this day. Our reconnaissance of the macrophyte community also did not identify any aquatic non-indigenous species (ANS) within the Pond.

Overall, these are excellent findings for the citizens of Sherborn, the FPAC, and other local stakeholders. The Pond's excellent water quality and low macrophyte growth support all current uses. There is no evidence of declining water quality or problematic conditions over the span of the sampling data. Given these conditions, there is currently no need for costly pond management options to reduce current algal or macrophyte density, the two

usual concerns with eutrophication (Mattson 2004). However, as part of the scope of work, FTS identified pond management tools associated with the conservation and protection of Pond quality.

The current macrophyte community is composed of a native assemblage adapted to low nutrient levels. As discussed above there are natural limiting factors (substrate, nutrients) which make the possibility of a large macrophyte infestation unlikely. Furthermore, the exclusion of motorized craft and limited boat access in general also greatly reduces the likelihood of anthropogenic introduction of nuisance species. However, given the prevalence of ANS in many ponds in the local Upper Charles River watershed and the possibility of natural introduction (i.e., via waterfowl or wildlife), it is suggested the Farm Pond and the Sherborn Conservation Commission develop a Rapid Response Plan (RRP) to have on hand, if such an introduction occurs. The Town is aware of this threat as evidenced by the guides and booklet posted under "Invasive Species'" section on the SCC website at: http://www.sherbornma.org/Pages/SherbornMA_Conservation /Invasive%20Species.

4.1.1 Elements of a Rapid Response Plan

The RRP is a prepared action plan that ensures that appropriate protocols, trained personnel, equipment, permits, and other resources are ready to go to contain or eradicate newly detected non-indigenous or invasive aquatic plant or animal introductions as they are reported to or discovered by local volunteers or State agency personnel.

The primary goal of a RRP is to initiate eradication efforts or critical interim measures to achieve effective containment while a longer term eradication or suppression strategy is formulated. Inherent in rapid response is the need to use physical techniques or chemical treatments that can aggressively attack an invasive species infestation before it has a chance to proliferate, providing such techniques or treatments are practical and pose little risk to rare or endangered species or human health. This means mobilizing and deploying as quickly as possible to address a newly detected aquatic invasive plant *within the first season of detection, and, preferably, to treat the infestation in less than 30 days.*

To the extent possible, RRP treatment plans which are developed will look beyond the first season of detection to identify a longer term strategy that will best take into account the nature of the species, site conditions, and efficacy of treatment and monitoring methods. It is acknowledged that, in the short run, commonly occurring native communities may be adversely affected, or surface uses may be limited, but these are considered acceptable tradeoffs to avoid spreading harmful ANS to other parts of Farm Pond. In some instances, a RRP assessment may point to the need for longer term surface use restrictions to limit the spread of infestations which prove impossible to eradicate.

RRP Principles

To achieve rapid response, the FPAC, Sherborn Conservation Commission and Selectman's Office would follow the principles below. RRP principles should:

- Reflect sound biology and the specific pond setting;
- Strive for eradication as the primary goal of response deployments;
- Facilitate fast action and interagency decision-making at the lowest level possible;
- Be a priority for staff attention so that water use restrictions may be lifted as soon as possible; minimize infringement on public access, parks, and other facilities;
- Be prepared to shift to a longer term "management" strategy if needed to achieve eradication or, if unsuccessful, shift to suppression;
- Use personnel and resources efficiently; and
- Be flexible, varying the protocol to accomplish steps concurrently or out of order as needed.

An example of a prototype RRP developed by the Massachusetts Department of Conservation and Recreation (ENSR International 2005) for the elimination of fanwort (*Cabomba caroliana*) is provided in Appendix H.

4.1.2 Waterfowl Control

One currently "unmanaged" phosphorus source to Farm Pond is waterfowl. Waterfowl, including ducks, geese, and seabirds, are a valuable natural resource and a source of recreation to the general public, bird watchers, and hunters. However, they are also a source of nutrients, bacteria, and avian diseases.

Of all the waterfowl, Canada geese are particularly opportunistic and can easily become accustomed to urban settings. In New England, resident Canada goose populations have increased dramatically since the 1960's. In urban areas, Canada geese populations have responded explosively to landscape features that provide expanses of short grass for food, lack of natural predators, absence of hunting, and hand feeding by some people.

Although most people find a few geese acceptable, problems develop if local flocks grow and the droppings become excessive (a goose produces a pound of droppings per day). Problems include over-grazed lawns, accumulations of droppings and feathers on play areas and walkways, nutrient loading in ponds, public health concerns at beaches and drinking water supplies, aggressive behavior by nesting birds, and safety hazards near roads.

At this stage, waterfowl impacts on the Pond are not significant, but given that a small amount of phosphorus sponsors a significant amount of algal growth, it is recommended that waterfowl should be tolerated but not encouraged to reside at or near the Pond. This would include discouraging feeding by residents, managing adjacent riparian shoreline areas to reduce access or attractive features (e.g., lawns right at water's edge), and, as needed, more

direct control methods. A compendium of useful geese management techniques is provided by Managing Geese in Urban Environments (Smith et al. 1999).

4.1.3 Pond Stewardship

The current regulations governing recreational use of Farm Pond Reservation (Appendix B) form a policy of strong environmental stewardship that provides an additional layer of protection to the Pond. For example, the probability of macrophyte infestation and to a lesser degree excessive wave action and resuspension of bottom sediment are very much reduced through the prohibition of all boat motors on the Pond and the requirement for washing all boats before launching. In addition, potential nutrient inputs are minimized by preventing soap and detergent use near the Pond (e.g., car maintenance or washing) and avoiding pet or animal wastes. These rules and regulations help sustain and preserve the excellent condition of the Pond.

4.1.4 Designation of Farm Pond as an Outstanding Resource Water

The general classes and water uses of Massachusetts Ponds are described and characterized in 314 CMR 4.00 (i.e., Massachusetts Surface Water Quality Standards). Farm Pond is currently classified as Class B waters with designation as a habitat for fish, other aquatic life, and wildlife, including for their reproduction, migration, growth and other critical functions, and for primary and secondary contact recreation.

The regulations also recognized *outstanding resource waters* (ORWs) which are designated for special protection. ORWs include Class A Public Water Supplies (314 CMR 4.06(1)(d)1.) and their tributaries, certain wetlands as specified in 314 CMR 4.06(2), and other waters as determined by the MA DEP *based on their outstanding socio-economic, recreational, ecological and/or aesthetic values*.

The Clean Water Act requires that state water quality standards protect existing uses by establishing the maximum level of pollutants allowed in state waters. The standards must also protect those waters of a quality that are higher than the standards requirement. The *antidegradation process* helps prevent unnecessary lowering of water quality, and provides a framework to identify those waters that are designated as an "outstanding resource" by the state. Designation as an ORW may provide greater regulatory authority to manage watershed activities to maintain current water quality at its present high level.

Farm Pond could be nominated as an ORW, based on its pristine water quality and exceptional clarity, particularly in the context of numerous degraded lakes in the upper Charles River basin. Its historical status as a drinking water supply and ice supplier attests to the reliability of the water quality. At the same time, the Pond still maintains a vital and unique recreational function in the Town for swimming, fishing and sailing while remaining free of ANS.

Nomination of Farm Pond for status as an ORW is relatively simple and would best be pursued by the Board of Selectmen and/or the FPAC (Szal 2015). This current Farm Pond report provides an updated and comprehensive review of Pond conditions and historical water quality suitable for submittal to MA DEP. It should be noted that the MA DEP has not designated an ORW in many years and the State process is under review (Szal 2015).

4.2 Watershed Management Options

Watershed management covers a number of options and is the most cost-effective means to reduce or eliminate future watershed inputs of contaminants to Farm Pond. Even where in-pond management is applied, watershed management is often necessary and certainly protects the investment made through in-pond techniques. The watershed is the ultimate source of nutrient and sediments to the Pond, and controlling or reducing watershed loads will help protect the Pond for future generations. Primary objectives under the watershed management goal would be preservation of open space, riparian shoreline management, and best practical management of septic systems.

Developed areas are normally the primary target of watershed management. Development of a watershed creates impervious surface that changes the hydrology of the area and tends to increase loading of pollutants to waterways. Pollutants falling from the sky as atmospheric deposition are not incorporated into soils as in forests or meadows, but rather are transported into the aquatic environment. Additional pollutants from human activities in developed areas include solids from exposed soils, nutrients from fertilizers and waste disposal, bacteria from waste disposal and pets, hydrocarbons from automotive and other machine use, and metals from a variety of sources. These are also carried into the aquatic environment and can cause water quality degradation and use impairment.

In the Farm Pond watershed, there is generally mixed land use with a large portion already in forested or protected status. Potential watershed management is particularly targeted at residential land close to the Pond since it is more likely to impact water quality. Reductions in external watershed loading will help preserve long-term water quality. Source reduction controls are methods used to reduce the amount of pollutants generated in the watershed, or to prevent their release to the environment. Techniques for reducing pollutant loads and associated impacts are discussed below.

4.2.1 Land Use Conversion

Land use conversion involves purchasing properties that contribute excessive amounts of pollutants and converting these properties to less deleterious land uses. Preserving undeveloped land in the Farm Pond watershed is highly recommended, with particular emphasis on preserving areas of land that form buffer zones along the Pond. For example, the Town may be able to purchase a residential property and convert the land to open space or simply buy developable property and convert it to a protected status, thus reducing or preventing pollutant generation from this parcel of land. Presently there does not appear to

be any strong need for action within the Farm Pond watershed, but opportunities sometimes arise and should be considered on a case-by-case basis.

4.2.2 Zoning and Land Use Planning

Zoning is a very important component in controlling watershed inputs to aquatic resources where development is not yet extensive. A strong relationship exists between land use type and pollutant generation, with developed lands typically generating greater pollutant loads than non-developed lands. With regard to future phosphorus loadings, an estimate of the potential impact of the hypothetical "build-out" of all buildable lots within a pond's watershed is often developed. However, based on inspection of the parcel lot map and number of residences in the watershed, it appears that very limited future development is likely. The current R-3 (3-acre minimum) zoning within the watershed was judged to be protective of the current water quality (Town of Sherborn 2002).

One alternative approach is for zoning to adopt Surface Water Protection Areas consistent with treatment of Farm Pond as a potential surface water drinking supply. While Farm Pond is currently not a drinking water source, it retains the potential to act as an emergency potable water source. The overall purposes would be to protect and maintain the Pond water as a potential source of public drinking water, to ensure that it is maintained predominantly in its natural, scenic and largely undeveloped condition, and to prevent any land use or change that would materially impair or interfere with its conservation and preservation values as a potential public drinking water supply source.

Under this approach, lands within 400 feet of the upper boundary of the Pond and/or within 200 ft lateral distance from a tributary would be classified as Zone A (MA EOEA/DEP 2000). The remainder of the watershed (out to ½ mile) would be classified as Zone B. Typically, a conservation restriction would be adopted by the Town which provides regulatory authority in Zone A regarding maintenance and updating of septic systems, directs and prioritizes acquisition of open space and/or developable land, and restricts and/or prohibits inconsistent land uses. This might include uses or projects that disturb soils and vegetation (particularly on steep slopes), create large impervious surfaces, excavate sand and gravel deposits, clear-cut forests, store chemical, fertilizers, pesticides, road salting/sanding materials, or other land uses potentially injurious to drinking water. A model Conservation Restriction for drinking water protection is provided in Appendix I (MA EOEA/DEP 2009).

4.2.3 Waste Water Management

A properly functioning on-site waste disposal (septic) system can be an effective means of reducing pollutant loading to an aquatic ecosystem, but does not trap all pollutants and requires inspection and maintenance as do larger public systems. While many pollutants will be removed during passage through 100 ft of suitable soil, the concentration of phosphorus in septic system leachate is much higher than can be tolerated by lakes and ponds, so the greatest possible setback is desired. Title V requirements relate mainly to human health, and

may not be restrictive enough for maintaining Pond health over the longer term, especially in well-drained soils.

Setting a target of 400 ft setback, consistent with a "Zone A" approach, would appear to be very protective of the Pond, although it cannot be definitively stated that a lesser setback is inadequate. Other considerations will undoubtedly play a role in setback determination, and need to be established as a reasonable process for reviewing site-specific plans. Applying the greatest possible setback, to a limit of 400 ft, is desired within the constraints of property boundaries and site features.

For residences that are seasonal, another concern is from conversion to year round residency, a problem at many other Massachusetts lakes and ponds with dense communities around them. This is more difficult to regulate, but highlights the importance of adequate control of wastewater systems.

Maintenance and inspection of on-site waste disposal systems is a recommended management technique for the Farm Pond watershed. Education is the first step in alerting residents to this need. Some effort should be made to educate septic system users of the limitations of those systems, and how users can minimize strain on system capabilities.

4.2.4 Behavioral Modifications

Behavioral modifications involve changing the actions of watershed residents and pond users to improve water quality. Such changes may include conversion to non-phosphate detergents, elimination of garbage grinders, proper inspection and maintenance of septic systems, limits on lawn fertilization, and eliminating illegal dumping. Behavioral modifications can be brought about in two principal ways, through education and/or the implementation of local bylaws and bans. Education is a critical first step and should precede any attempt at regulation.

Education can be accomplished by mailing informative brochures addressing watershed management topics to all residents in the watershed, through the use of video programs on local access television, by placing informative signs in high access areas, or by holding public meetings for watershed residents. Public education relies heavily upon cooperation from residents and other pond users, and is not likely to result in major improvements in water quality by itself. However, some level of improvement has been noted in other studies and the education process sets the stage for community involvement and cooperation.

4.3 Recommendations

The Pond currently enjoys excellent water quality, a healthy but sparse macrophyte community, and sufficient productivity to support an active recreational fishery. Therefore, FST's recommendations for future action are focused on the conservation and preservation

of the present conditions. Based on the review of the current Pond water quality and watershed land use, the following recommendations are made:

- Adopt a Rapid Response Plan for invasive macrophyte species to have in- hand in case of an infestation;
- Institute a seasonal census of the Pond waterfowl with regard to numbers and location, and investigate methods to reduce their impact;
- Nominate Farm Pond for designation as an Outstanding Resource Water by the MA DEP;
- Consider creation of a Surface Water Protection Plan to provide additional regulatory authority to regulate land use practices and development within the proximity of the Pond; and
- Develop (or adopt) educational materials regarding septic system maintenance and behavioral modifications that encourage good environmental stewardship and further reduce impacts to the Pond.

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GENERAL AQUATIC GLOSSARY

Abiotic - Pertaining to any non-biological factor or influence, such as geological or meteorological characteristics.

Acid precipitation - Atmospheric deposition (rain, snow, dryfall) consisting of free or combined acidic ions, especially nitrates, sulfates and oxides of nitrogen and sulfur from industrial and transportation sources.

Algae - Aquatic single-celled, colonial, or multi-celled plants, containing chlorophyll and lacking roots, stems, and leaves.

Alkalinity - A reference to the carbonate and bicarbonate concentration in water. Its relative concentration is indicative of the nature of the rocks within a drainage basin. Lakes in sedimentary carbonate rocks are high in dissolved carbonates (hard-water lakes) whereas lakes in granite or igneous rocks are low in dissolved carbonate (soft-water lakes).

Ammonia Nitrogen - A form of nitrogen present in sewage and is also generated from the decomposition of organic nitrogen. It can also be formed when nitrites and nitrates are reduced. Ammonia is particularly important since it has high oxygen and chemical demands, is toxic to fish in un-ionized form and is an important aquatic plant nutrient because it is readily available.

Anoxic - Without oxygen

Aphotic Zone - Dark zone, below the depth to which light penetrates. Generally equated with the zone in which most photosynthetic algae cannot survive, due to light deficiency.

Aquifer - Any geological formation that contains water, especially one that supplies wells and springs (e.g., sand and gravel aquifer or a bedrock aquifer).

Assimilative Capacity - Ability to incorporate inputs into the system. With regard to lakes, it is the ability to absorb nutrients or other potential pollutants without showing extremely adverse effects.

Attenuation - The process whereby light is reduced as it passes down into the water column due to a combination of absorption and back reflectance. Attenuation is greater in productive lakes.

Background or Reference Value - Value for a parameter that represents the conditions in a system prior to a given influence in space or time.

Bathymetry -.The measurement of depths of water in oceans, seas, or lakes or the information derived from such measurements.

Benthic Deposits - Bottom accumulations which may contain bottom-dwelling organisms and/or contaminants in a lake, harbor, or stream bed.

Benthos - Bottom-dwelling organisms living on, within or attached to the sediment. The phytobenthos includes the aquatic macrophytes and bottom-dwelling algae. The zoobenthos (benthic fauna) includes variety of invertebrate animals, particularly larval forms and molluscs.

Benthic - Living or occupying space at the bottom of a water body, on or in the sediment.

Best Management Practices - (BMP's) State-of-the-art techniques and procedures used in an operation such as farming or waste disposal in order to minimize pollution or waste.

Bioavailable - Able to be taken up by living organisms, usually refers to plant uptake of nutrients.

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Biological Oxygen Demand - The BOD is an indirect measure of the organic content of water. Water high in organic content will consume more oxygen due to the decomposition activity of bacteria in the water than water low in organic content. It is routinely measured for wastewater effluents. Oxygen consumption is proportional to the organic matter in the sample.

Biotic - Pertaining to biological factors or influences, concerning biological activity.

Bloom – An excessively large standing crop of algae, usually visible to the naked eye.

.

CFS - Cubic feet per second, a measure of flow.

Chlorophyll (chl-*a*) - Major light gathering pigment of all photosynthetic organisms imparting the characteristic color of green plants. Its relative measurement in natural waters is indicative of the concentration of algae in the water.

Color - Color is determined by visual comparison of a sample with known concentrations of colored solutions and is expressed in standard units of color. Certain waste discharges may turn water to colors which cannot be defined by this method; in such cases, the color is expressed qualitatively rather than numerically. Color in lake waters is related to solids, including algal cell concentration and dissolved substances.

Concentration - The quantity of a given constituent in a unit of volume or weight of water.

Conductivity - The measure of the total ionic concentration of water. Water with high total dissolved solids (TDS) level would have a high conductance. A conductivity meter tests the flow of electrons through the water which is heightened in the presence of electrolytes.

Decomposition - The metabolic breakdown of organic matter, releasing energy and simple organic and inorganic compounds which may be utilized by the decomposers themselves (e.g., bacteria and fungi).

Deoxygenation - Depletion of oxygen in an area, used often to describe possible hypolimnetic conditions, process leading to anoxia.

Dissolved Oxygen (DO) - Refers to the uncombined oxygen in water which is available to aquatic life. Temperature affects the amount of oxygen which water can contain. Biological activity also controls the oxygen level. DO levels are generally highest during the afternoon and lowest just before sunrise.

Diurnal - Varying over the day, from day to night.

Domestic Wastewater - Water and dissolved or particulate substances after use in any of a variety of household tasks, including sanitary systems and washing operations.

Drainage Basin - A geographical area or region which is so sloped and contoured that surface runoff from streams and other natural watercourses is carried away by a single drainage system by gravity to a common outlet; also commonly referred to as a watershed or drainage area. The definition can also be applied to subsurface flow in groundwater.

Ecosystem - A dynamic association or interaction between communities of living organisms and their physical environment. Boundaries are arbitrary and must be stated or implied.

Epilimnion - Upper layer of a stratified lake and the layer that is mixed by wind and has a higher average temperature than the hypolimnion. Roughly approximates the euphotic zone.

Erosion - The removal of soil from the land surface, typically by runoff water.

Eutrophic - High nutrient, high productivity trophic state generally associated with unbalanced ecological conditions and poor water quality.

Eutrophication - Process by which a body of water ages, most often passing from a low nutrient concentration, low productivity state to a high nutrient concentration, high productivity stage. Eutrophication is a long-term natural process, but it can be greatly accelerated by man's activities. Eutrophication as a result of man's activities is termed cultural eutrophication.

Evapotranspiration - Process by which water is lost to the atmosphere from plants.

Fecal Coliform Bacteria - Bacteria of the coli group that are present in the intestines or feces of warm-blooded animals. They are often used as indicators of the sanitary quality of the water. Their concentrations are expressed as number of colonies per 100 ml of sample.

Food Chain - A linear characterization of energy and chemical flow through organisms such that the biota can be separated into functional units with nutritional interdependence. Can be expanded to a more detailed characterization with multiple linkages, called a food or trophic web.

Groundwater - Water in the soil or underlying strata, subsurface water.

Hardness - A physical-chemical characteristic of water that is commonly recognized by the increased quantity of soap required to produce lather. It is attributable to the presence of alkaline earths (principally calcium and magnesium) and is expressed as equivalent calcium carbonate ($CaCO_3$).

Humus - Humic substances form much of the organic matter of sediments and water. They consist of amorphous brown or black colored organic complexes.

Hydraulic Retention Time (HRT) - Lake water detention period, amount of time that a random water molecule spends in a water body; time that it takes for water to pass from an inlet to an outlet of a water body.

Hydrologic Cycle - The circuit of water movement from the atmosphere to the earth and return to the atmosphere through various stages or processes such as precipitation, interception, runoff, infiltration, percolation, storage, evaporation, and transpiration.

Hypolimnion - Lower layer of a stratified lake. The water layer that is mainly without light, generally equated with the aphotic zone, and has a lower average temperature than the epilimnion.

Impervious - Not permitting penetration or percolation of water.

Intermittent – Discontinuous flow, usually generally referring to the seasonal flow of a stream or swale through a channel drainage path.

Kettle hole lake - A kettle hole lake is a waterbody formed by a topographic depression produced by the melting of a stagnant block of ice and the subsequent downward and inward collapse of deposited material.

Kjeldahl Nitrogen - The total amount of organic nitrogen and ammonia in a sample. It is as determined by the Kjeldahl method, which involves digesting the sample with sulfuric acid, transforming the nitrogen into ammonia, and measuring it.

Leachate - Water and dissolved or particulate substances moving out of a specified area, usually a landfill, by a completely or partially subsurface route.

Leaching - Process whereby nutrients and other substances are removed from matter (usually soil or vegetation) by water. Most often this is a chemical replacement action, prompted by the quality of the water.

Limiting Nutrient - That nutrient of which there is the least quantity, in relation to its importance to plants. The limiting nutrient will be the first essential compound to disappear from a productive system, and will cause cessation of productivity at that time. The chemical form in which the nutrient occurs and the nutritional requirements of the plants involved often determine whether a chemical is limiting or not.

Limnology - The comprehensive study of lakes, encompassing physical, chemical and biological lake conditions.

Littoral Zone - Shallow zone occurring at the land-water interface of aquatic ecosystems. It extends from the shoreline outward to a point where rooted aquatic plants are no longer found due to light limitation.

Loading - Inputs into a receiving water that may exert a detrimental effect on some subsequent use of that water.

Macrofauna - A general term which refers to animals which can be seen with the naked eye or without the aid of a microscope.

Macrophyte - Higher plant, macroscopic plant, plant of higher taxonomic position than algae, usually a vascular plant. Aquatic macrophytes are those macrophytes that live completely or partially in water. May also include algal mats under some definitions.

Mesotrophic - An intermediate trophic state, with variable but moderate nutrient concentrations and productivity.

Metalimnion - The middle layer of a stratified lake, constituting the transition layer between the epilimnion and hypolimnion and containing the thermocline.

MGD - Million gallons per day, a measure of flow.

Micrograms per Liter (ug/1) - A unit expressing the concentration of chemical constituents in solution as mass (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to one milligram per liter.

Nitrate - A form of nitrogen that is important since it is the end product in the aerobic decomposition of nitrogenous matter. Nitrogen in this form is stable and readily available to plants.

Nitrite - A form of nitrogen that is the oxidation product of ammonia. It has a fairly low oxygen demand and is rapidly converted to nitrate. The presence of nitrite-nitrogen usually indicates that active decomposition is taking place (i.e., fresh contamination).

Nitrogen - A macronutrient which occurs in the forms of organic nitrogen, ammonia nitrogen, nitrite nitrogen and nitrate nitrogen. Form of nitrogen is related to a successive decomposition reaction, each dependent on the preceding one, and the progress of decomposition can be determined in terms of the relative amounts of these four forms of nitrogen,

Nitrogen fixation - The process by which certain bacteria and blue green algae make organic nitrogen compounds (initially NH.+) from elemental nitrogen (N2) taken from the atmosphere or dissolved in the water.

Non-point Source - A diffuse source of loading, possibly localized but not distinctly definable in terms of location. Includes runoff from all land types.

Nutrients - Are compounds which act as fertilizers for aquatic organisms. Small amounts are necessary to the ecological balance of a waterbody, but excessive amounts can upset the balance by causing excessive growths of algae and other aquatic plants. Sewage discharged to a waterbody usually contains large amounts of carbon, nitrogen, and phosphorus. The concentration of carbonaceous matter is reflected in the BOD test. Additional tests are run to determine the concentrations of nitrogen and phosphorus. Storm water runoff often contributes substantial nutrient loadings to receiving waters.

Oligotrophic - Low nutrient concentration, low productivity trophic state, often associated with very good water quality, but not necessarily the most desirable stage, since often only minimal aquatic life can be supported.

Organic - Containing a substantial percentage of carbon derived from living organisms; of a living organism.

Outwash - Sand and gravel deposited by meltwater streams in front of glacial ice.

Overturn - The vertical mixing of major layers of water caused by seasonal changes in temperature. In temperate climate zones overturn typically occurs in spring and fall.

Oxygen Deficit - A situation in lakes where respiratory demands for oxygen exceeds its production via photosynthesis or its input from the drainage basin, leading to a decline in oxygen content.

Periphyton - Attached forms of plants and animals, growing on a substrate.

pH - A hydrogen concentration scale from 0 (acidic) to 14 (basic) used to characterize water solutions. Pure water is neutral at pH 7.0.

Phosphorus - A macronutrient which appears in waterbodies in combined forms known as ortho- and poly-phosphates and organic phosphorus. Phosphorus may enter a waterbody in agricultural runoff where fertilizers are used. Storm water runoff from highly urbanized areas, septic system leachate, and lake bottom sediments also contribute phosphorus. A critical plant nutrient which is often targeted for control in eutrophication prevention plans.

Photic Zone - illuminated zone, surface to depth beyond which light no longer penetrates. Generally equated with the zone in which photosynthetic algae can survive and grow, due to adequate light supply.

Photosynthesis - Process by which primary producers make organic molecules (generally glucose) from inorganic ingredients, using light as an energy source. Oxygen is evolved by the process as a byproduct.

Phytoplankton - Algae which are suspended, floating or moving only slightly under their own power in the water column. Often this is the dominant algal form in standing waters.

Plankton - The community of suspended, floating, or weakly swimming organisms that live in the open water of lakes and rivers.

Point Source - A specific source of loading, that is geographically explicit in terms of location. Point sources include effluents or channeled discharges that enter natural waters at a specific point.

Pollution - Undesirable alteration of the physical, chemical or biological properties of water, addition of any substance into water by human activity that adversely affects its quality. Prevalent examples are thermal, heavy metal and nutrient pollution.

Potable – Water usable for drinking purposes, fit for human consumption.

Primary Productivity (Production) - Conversion of inorganic matter to organic matter by photosynthesizing organisms, typically it is the creation of biomass by plants.

Riparian - Of, or related to, or bordering a watercourse.

Runoff - Water and its various dissolved substances or particulates that flow at or near the surface of land in an unchanneled path toward channeled and usually recognized waterways (such as a stream or river).

Secchi Disk Transparency (SDT) - An approximate evaluation of the transparency of water to light. It is the point at which a black and white disk lowered into the water is no longer visible.

Secondary Productivity - The growth and reproduction (creation of biomass) by herbivorous (plant-eating) organisms. The second level of the food web or trophic system.

Sedimentation - The process of settling and deposition of suspended matter carried by water, sewage, or other liquids, by gravity. It is usually accomplished by reducing the velocity of the liquid below the point at which it can transport the suspended material.

Sewage (Wastewater) - The waterborne, human and animal wastes from residences, industrial/commercial establishments or other places, together with such ground or surface water as may be present.

Specific Conductance - Yields a measure of a water sample's capacity to convey an electric current. It is dependent on temperature and the concentration of ionized substances in the water. Distilled water exhibits specific conductance of 0.5 to 2.0 microSiemens per centimeter (uS/cm), while natural waters show values - from 50 to 500 (uS/cm). In typical New England lakes, specific conductance usually ranges from 100-300 (uS/cm). The specific conductance yields a generalized measure of the inorganic dissolved load of the water.

Storm Sewer - A pipe or ditch which carries storm water and surface water, street wash and other wash waters or drainage, but excludes sewage and industrial wastes.

Stratification - Process whereby a lake becomes separated into two relatively distinct layers as the result of temperature and density differences. Further differentiation of the layers usually occurs as the result of chemical and biological processes. In most lakes, seasonal changes in temperature will reverse this process after some time, resulting in the mixing of the two layers.

Stratified Drift - Sand, gravel or other materials deposited by a glacier or its meltwater in a layered manner, according to particle size.

Substrate - The base of material on which an organism lives, such as cobble, gravel, sand, muck, etc.

Surface Water - Refers to lakes, bays, sounds, ponds, reservoirs, springs, rivers, streams, creeks, estuaries, marshes, inlets, canals, oceans and all other natural or artificial, inland or coastal, fresh or salt, public or private waters at ground level.

Suspended Solids - Those which can be removed by passing the water through a filter. The remaining solids are called dissolved solids. Suspended solids loadings are generally high in stream systems which are actively eroding a watershed. Excessive storm water runoff often results in high suspended solids loads to lakes. Many other pollutants such as phosphorus are often associated with suspended solids loadings.

Taxon (Taxa) - Any hierarchical division of a recognized classification system, such as a genus or species.

Thermocline - Boundary level between the epilimnion and hypolimnion of a stratified lake, variable in thickness, and generally approximating the maximum depth of light penetration and mixing by wind.

Till - Unstratified, unsorted sand, gravel, or other material deposited by a glacier or its meltwater.

Trophic Level - The position in the food chain determined by the number of energy transfer steps to that level; 1 = producer; 2 = herbivore; 3, 4, 5 = carnivore.

Trophic State - The stage or condition of an aquatic system, characterized by biological, chemical and physical parameters.

Trophic State Index (TSI) - a convenient way to classify lakes' trophic state through of comparison of ambient values of key indicators (i.e., phosphorus and/or nitrogen fractions, chl-*a*, and SDT) to previously established criteria or thresholds.

Turbidity - The measure of the clarity of a water sample. It is expressed in Nephelometric Turbidity Units which are related to the scattering and absorption of light by the water sample.

Water Quality - A term used to describe the chemical, physical, and biological characteristics of water, usually with respect to its suitability for a particular purpose or use.

Watershed - Drainage basin, the area from which an aquatic system receives water.

Zooplankton - Microscopic animals suspended in the water; protozoa, rotifers, cladocera, copepods and other small invertebrates.

Appendices

Appendix A. Historical Reports and Prior Information

TABLE

FARM POND

WATER QUALITY DATA (mg/1)

July 2, 1974

DEPTH(FT)	TEMP.(°F)	D.O.	pH	TOTAL ALKALINITY	NH_3-N	NO_3-N	TOTAL PHOSPHORUS	TOTAL HARDNESS	SILICA	CONDUCTIVITY MICROMHOS/CM
STATION #1 - CENTER HOLE										
Surface	70.3	8.6	5.0	2	0.03	0.0	0.03	7.0	0.5	43
5	69.8	8.3	--	--	--	--	--	--	--	--
10	68.9	8.7	--	--	--	--	--	--	--	--
15	68.9	7.8	--	--	--	--	--	--	--	--
20	68.9	8.2	--	--	--	--	--	--	--	--
25	68.0	8.0	--	--	--	--	--	--	--	--
30	68.0	8.7	--	--	--	--	--	--	--	--
35	62.6	8.4	--	--	--	--	--	--	--	--
40	57.2	7.4	5.2	2	0.02	0.0	0.02	8.0	1.0	44
45	53.2	8.8	--	--	--	--	--	--	--	--
50	50.9	6.7	--	--	--	--	--	--	--	--
54.5	50.9	4.5	5.4	3	0.02	0.0	0.04	8.0	1.5	45
STATION #2 - OUTLET										
Surface	69.0	1.4	4.6	1	0.68	0.0	2.0	13	5.0	64

DIVISION OF WATER POLLUTION CONTROL
LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS (mg. per liter)

JUL 24 1974
LAKE STUDY

Collector: Johnson - Anderson

Source A Sherborn, Farm Pond Sta. #1, Center Hole, surface
Source B " " " " " " " 40'
Source C " " " " " " " 54.5'
Source D " " " " #2, Outlet, surface
Source E Fall River, Suckerr Brook Rt. 24 & 81
Source F " " " " Above Bleacherly Ponds

	A	B	C	D	E	F
Sample No.	R59522	R59523	R59524	R59525	R59526	R59527
Date of Collection	7/2/74	7/2	7/2	7/2	7/2	7/2
Time of Collection					11:40	11:45
Date Received	7/3/74	7/3	7/3	7/3	7/3	7/3
COD						
BOD						
pH	5.0	5.2	5.4	4.6	6.5	6.9
Alkalinity, Total	2	2	3	1	17	24
Suspended Solids						
Total Solids						
Hardness	7.0	8.0	8.0	13		
Silica	0.5	1.0	1.5	5.0		
Spec. Cond.	43	44	45	64		
Total Kjeldahl - N					1.1	1.1
Ammonia - N	0.03	0.02	0.02	0.68	0.64	0.30
Nitrite-N					0.000	0.056
Nitrate - N	0.0	0.0	0.0	0.0	0.7	1.2
Total P	0.03	0.02	0.04	2.0	0.23	0.16
Total Coliform						
Fecal Coliform						
Iron					1.8	1.5
Manganese					0.12	0.10
Zinc					0.00	0.00
Chromium					0.00	0.00
Nickel					0.00	0.00
Cadmium					0.00	0.00
Copper					0.00	0.00

Send to Westboro

TABLE

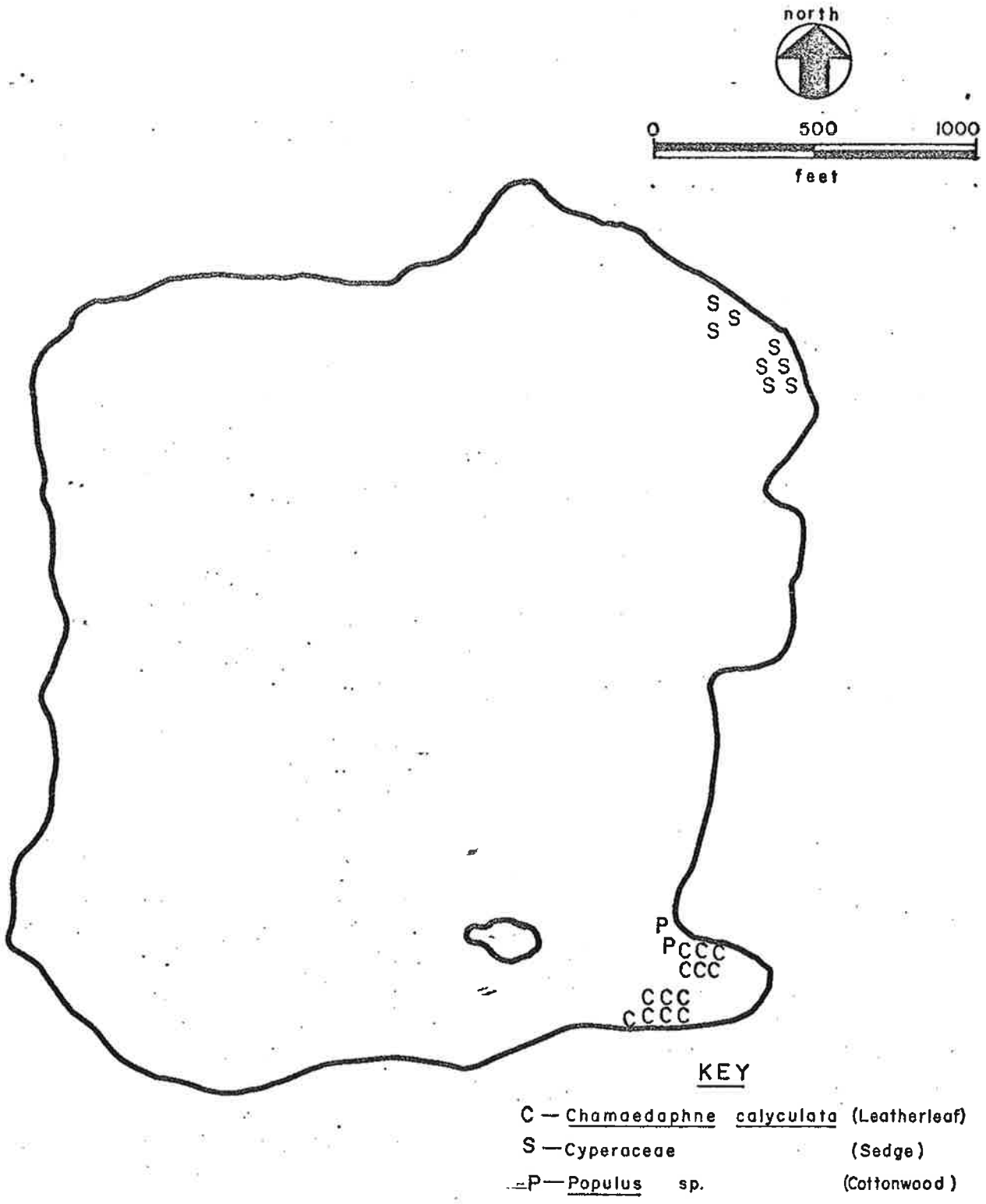
FARM POND

MORPHOMETRIC DATA

Maximum Length	3,100 Feet
Maximum Effective Length	3,100 Feet
Maximum Width	3,000 Feet
Maximum Effective Width	3,000 Feet
Maximum Depth	58 Feet
Mean Depth	19.6 Feet
Mean Width	1,728 Feet
Area	123 Acres
Volume	2,406 Acre Feet
Shoreline (Main Basin)	9,800 Feet
Development of Shoreline	1.19
Development of Volume	1.01
Mean to Maximum Depth Ratio	0.34
Drainage Area	0.45 Square Miles

FARM POND (123 Acres)

Sherborn



AQUATIC VEGETATION 7/2/74

Figure

FIGURE

ARM POND

SHERBORN

AQUATIC VEGETATION

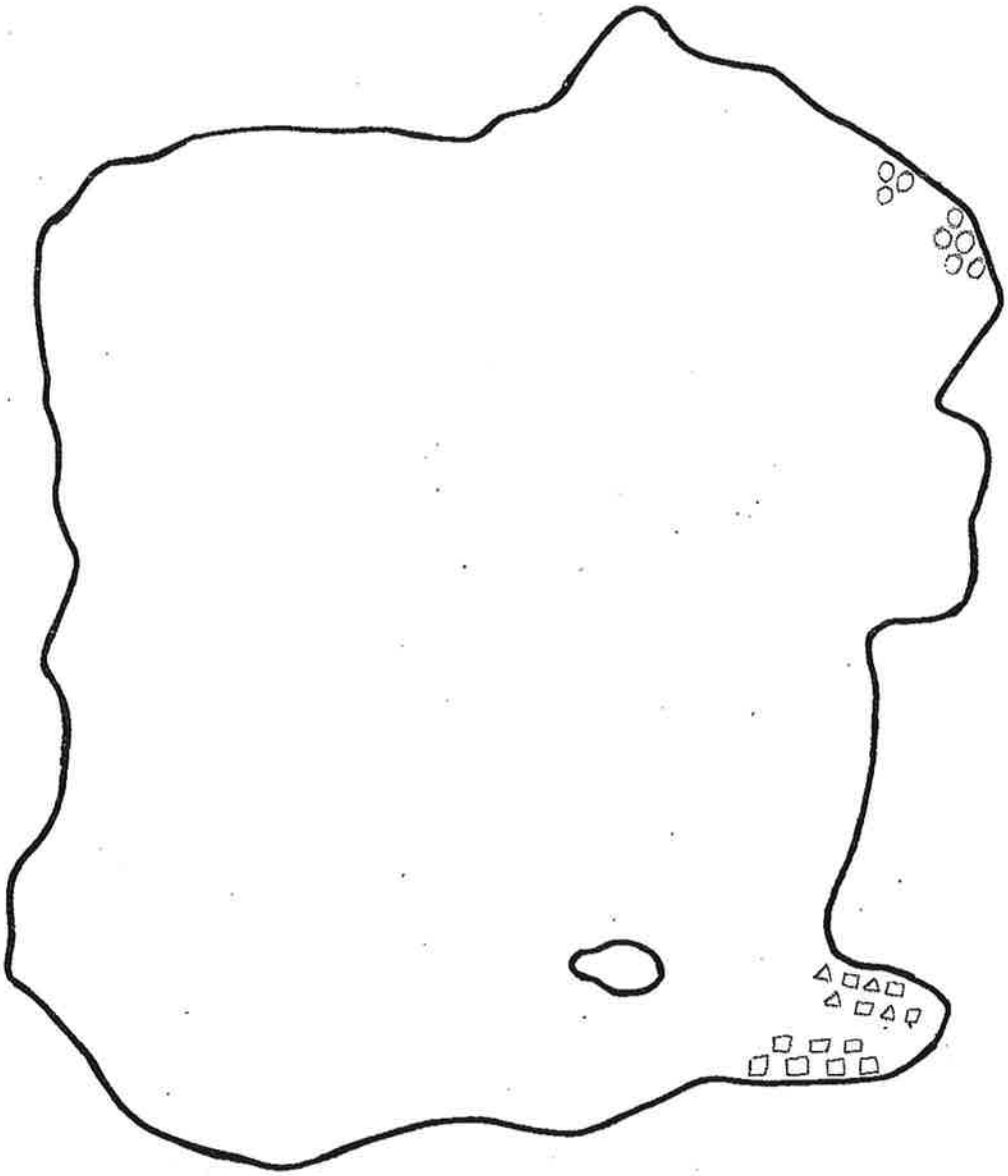
7/2/74

123 ACRES

N

500 1000

FEET



PLANT KEY

□ Chamaedaphne calyculata (LEATHERLEAF)

○ Cyperaceae (SEDGE)

△ Populus sp. (COTTONWOOD)

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL QUALITY ENGINEERING

DIVISION OF WATER POLLUTION CONTROL

TECHNICAL SERVICES BRANCH

LAKE SURVEY DATA SHEET

TYPE OF SURVEY: Chapter 628 Baseline Water Quality

LAKE/POND/IMP. Farm Pond

LOCATION Sherborn

DRAINAGE BASIN

DATE 7/21/83

COLLECTORS Ackerman / White

SECCHI DISK:

WEATHER:

Time 11:00 AM

Air Temperature 70°C

Transparency 7.0 m

Wind light from West

Water Surface Lake ripples

Cloud Cover 5% cloudy

Water Color light blue

SAMPLING STATIONS

DEPTH (M)	WATER TEMP. (°C)	pH	DISSOLVED OXYGEN	SPEC. COND.	METAL SAMPLES	CHEMICAL SAMPLES	BIOLOGICAL SAMPLES	OTHER
0	27.1°C	4.2	8.2	37		✓	TF col,	
1	27.0°C	4.1	8.0	37			Algae + chlor a,	
2	26.8	4.2	7.8	36				
3	26.7	4.2	7.7	36				
4	26.6	4.2	7.6	36				
5	26.5	4.2	7.6	36				
6	25.8	4.2	7.6	35				
7	22.3	4.7	10.3	33		✓		
8	16.6	5.2	11.5	32				
9	13.4	5.9	11.1	30				
10	12.0	6.3	9.8	29				
11	11.0	6.5	7.8	29				
12	10.6	6.5	6.1	29				
13	10.2	6.5	3.2	29				
14	9.9	6.1	2.3	26		✓		
15	9.6	6.1	1.6	27				

1 station

REMARKS:

FLOW SHEETS ATTACHED: Station(s)

✓ HYDROLAB: ph, temperature, dissolved oxygen, specific conductivity

✓ LES: ~~ph~~, alkalinity, hardness, ~~specific conductivity~~, chloride, TKN, NO_3, NH_3, TP, ~~TS SS~~ total coliform, fecal coliform

preserved

LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS
(mg. per liter)

LAKES WQS

Collector: Ackerman

SOURCE A Sherborn Farm Pond, #1(0m)
SOURCE B " " " #1(0m)
SOURCE C " " " #1(8m)
SOURCE D " " " #1(8m)
SOURCE E " " " #1(17m)
SOURCE F " " " #1(17m)

	A	B	C	D	E	F
SAMPLE NO.	R95216	R95217	R95218	R95219	R95220	R95221
DATE OF COLLECTION	7/21/83	--->	--->	--->	--->	--->
TIME OF COLLECTION						
DATE RECEIVED	7/22/83	--->	--->	--->	--->	--->
COD						
BOD						
pH						
ALKALINITY, TOTAL	2			2	2	
SUSPENDED SOLIDS	5.5			3.5	6.0	
TOTAL SOLIDS	22			40	20	
HARDNESS	26			26	26	
TOTAL KIELDAHL - N		0.31	0.28			0.31
AMMONIA - N		0.06	0.14			0.06
NITRATE - N		0.1	0.3			0.1
TOTAL P		0.13	0.11			0.07
TOTAL COLIFORM						
FECAL COLIFORM						
CHLORIDE	3			3	6	

LAWRENCE EXPERIMENT STATION
WASTE WATER ANALYSIS
(mg. per liter)

LAKES WQS

Collector: Ackerman
Botiuk/White

SOURCE A Farm Pond Sherborn, Sta #1
SOURCE B South End Pond, Sta #1
SOURCE C " " " Sta #3
SOURCE D " " " Sta #2 Inlet
SOURCE E
SOURCE F

	A	B	C	D	E	F
SAMPLE NO.	R95212	R95213	R95214	R95215		
DATE OF COLLECTION	7/21/83 →					
TIME OF COLLECTION						
DATE RECEIVED	7/22/83 →					
COD						
BOD						
pH						
ALKALINITY, TOTAL						
SUSPENDED SOLIDS						
TOTAL SOLIDS						
TOTAL KIELDAHL - N						
AMMONIA - N						
NITRATE - N						
TOTAL P						
TOTAL COLIFORM	10	5	40	80		
FECAL COLIFORM	<5	<5	<5	30		
CHLORIDE						

RMC	INV	4 STRIPS	7-22-83	142

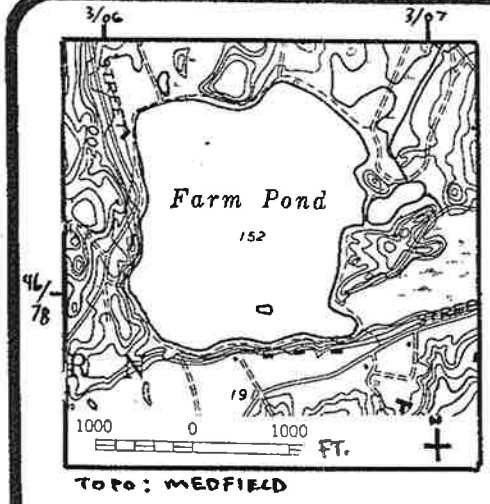
Class	Type	Organism	Count	Tally	Cells/ml	
Bacillariophyceae (Diatoms)	Centric					
	Pennate					
Cyanophyceae (Blue-Greens)	Coccoid	ANACYSTIS CYANEA	1/1	3	41.7	41.
	Filamentous					
Chlorophyceae (Greens)	Coccoid					
	Desmids					
	Filamentous					
	Flagellates					
Xanthophyceae (Yellow-Browns)						
Euglenophyceae (Euglenoids)						
Chrysophyceae (Golden-Browns)						
Cryptophyceae (Cryptomonads)						
Dinophyceae (Dinoflagellates)						
Chrysophyceae (Chrysophytes)						

Chlorophyll a/in mg/m^3

Tot. live algae (c/ml) 13.9 SR =

41.7

STAFF Primer DMD Preserved D/b Quality Control



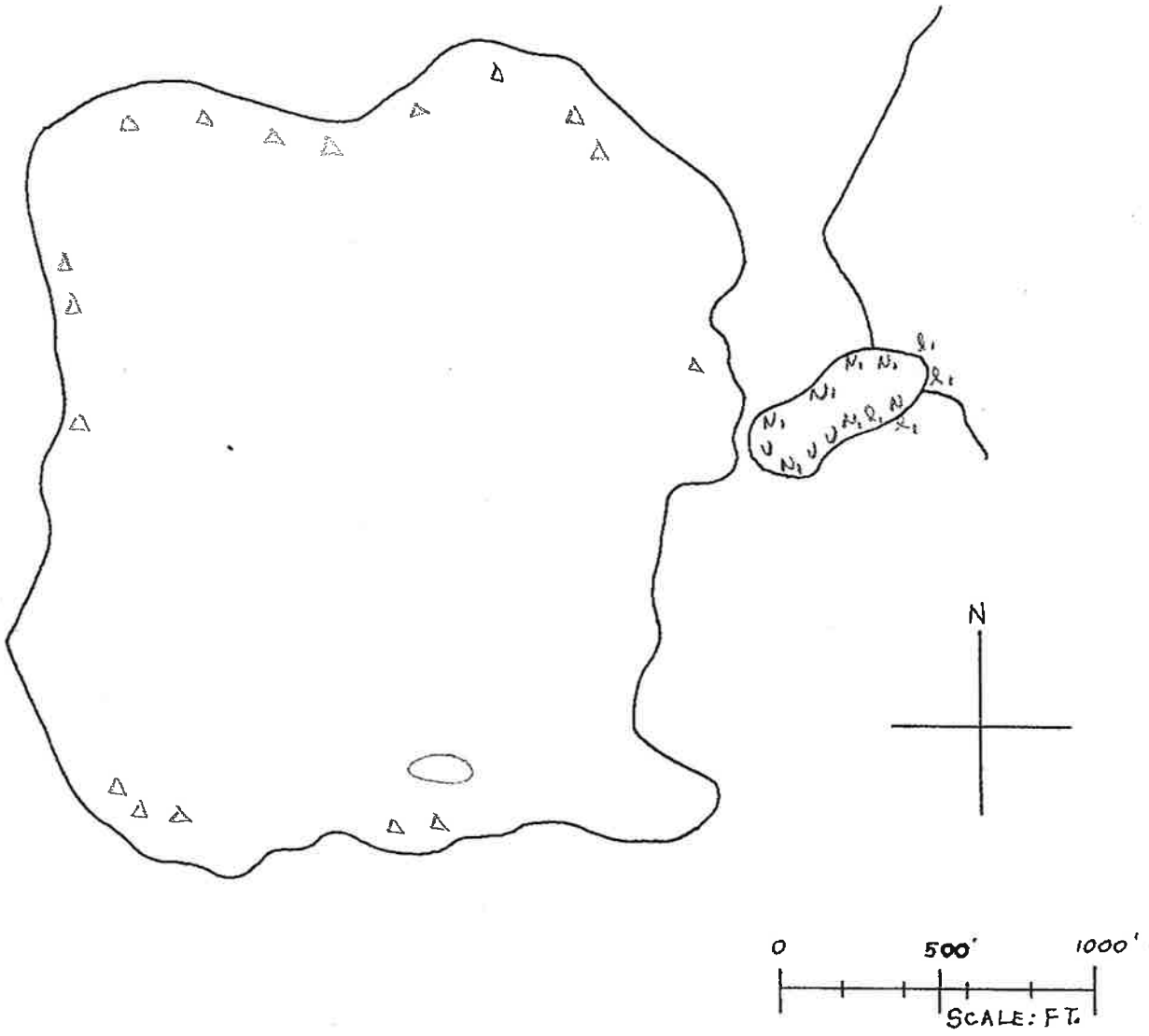
TOPO: MEDFIELD

N_1 = Nymphaea sp.

U = Utricularia sp.

ℓ_1 = Dicodon verticillatus

△ = Algae



DEQE·DWPC·Technical Services Bronch

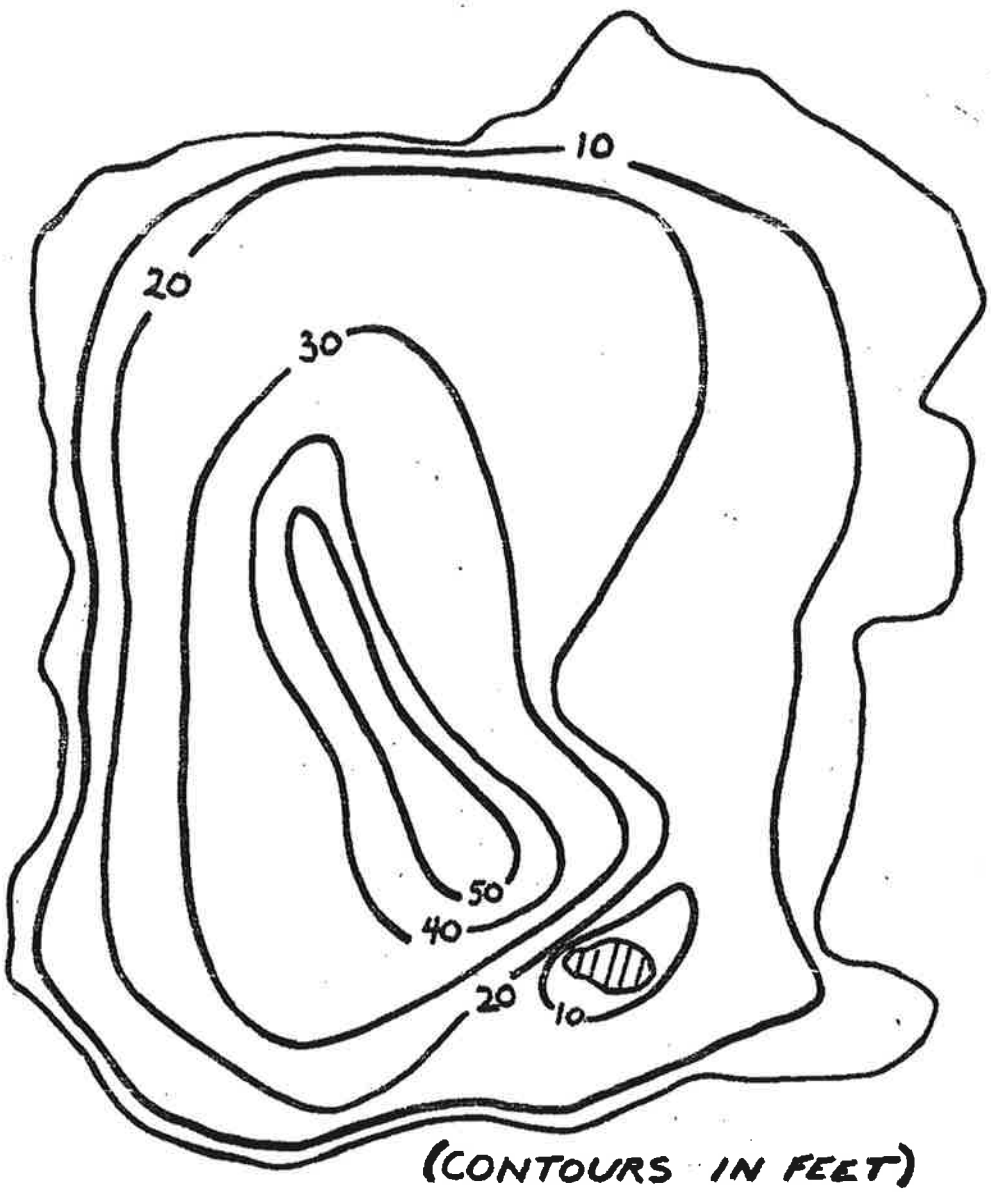
Aquatic Distribution Map
7-21-83

FARM POND / SHERBORN — TOPO: MEDFIELD

FARM POND
SHERBORN

BATHYMETRIC MAP
123 ACRES

0 500 1000
FEET



(CONTOURS IN FEET)

Technical Memorandum

Lake Water Quality Survey 2005
DWM WATER QUALITY MONITORING DATA

July 2013

Massachusetts Department of Environmental Protection
Division of Watershed Management
DWM Control Number CN 224.5

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY AND ENVIRONMENTAL AFFAIRS
Richard K. Sullivan Jr., Secretary
MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION
Kenneth L. Kimmell, Commissioner
BUREAU OF RESOURCE PROTECTION
Bethany Card, Assistant Commissioner
DIVISION OF WATERSHED MANAGEMENT

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Appendices

The deep nutrient criteria lakes listed in Table 1 below, will be sampled once during late summer stratification. Sampling of these deep lakes is targeted at the deep hole or mid-lake station at the critical time period of late summer stratification (Mid-July through mid-September). Note Russell Pond was incorrectly targeted as a deep lake but sampled nevertheless.

Table 1. Nutrient Criteria Deep Lakes Sampled.

unique_ id	Palis	WBNAME	TOWN	Depth Ft	Area Ha
W1289	21043	Goose Pond	Lee	45	97.2
W1290	21078	Onota Lake	Pittsfield	64	246.7
W1291	21105	Stockbridge Bowl;	Stockbridge	53	157
W1292	32054	Norwich Pd	Huntington	48	47.8
W1293	32076	Windsor Pond	Windsor	52	17.7
W1294	35053	Packard Pond	Orange	43	18.4
W1083	36084	Lake Lorraine	Springfield	36	11.4
W1221	41001	Alum Pond	Sturbridge	45	79.2
W1295	42064	Webster L;	Webster	41	476
W1085	51125	Lake Quinsigamond	Shrewsbury	84	285
W1087	71019	Horn Pond	Woburn	40	40
W1296	71043	Upper Mystic Lake	Winchester	82	64
W1297	72039	Farm Pond	Sherborn	50	45.4
W0973	72052	Jamaica Pond	Boston	53	23.4
W0603	81046	Fort Pond	Lancaster	48	30
W1298	81085	Mirror Lake	Harvard	58	10.8
W1299	81132	Spectacle Pd	Lancaster	58	22.8
W1300 *	82061	Hopkinton Res	Hopkinton	53	66.5
W1301	82112	Waushakum Pd	Framingham	53	31.7
W1302	82118	White Pond	Concord	56	15
W1090	82125	Lake Cochituate Mid	Natick	51	51.5
W1303	84036	Baddacook Pd	Groton	48	29.8
W0608	91001	Baldpate Pd	Boxford	41	22.1
W1304	93071	Sluice Pond	Lynn	63	15.8
W1305	94133	Russell Pond	Kingston	10	4.2
W1306	96004	Ashumet Pond	Mashpee	65	79.6
W1307	96091	Flax Pond	Brewster	72	18.4
W1308	96194	Mashpee Pd	Mashpee	84	152
W1309	96279	Scargo Lake	Dennis	48	21.2
W1310	96307	Spectacle Pond	Sandwich	43	33.7

* Indian Brook/Hopkinton Reservoir is an impoundment (also SARIS # 8248400 for Indian Brook)

Palis	Name	DATE	Odor	Clarity	Algal density	Scum	Objectional Deposits	Secchi (m)	Secchi Viewfinder	Secchi on Bottom	Maximum Depth (m)
21078	Onota Lake	8/23/2005	None	Clear	Sparse	No	Yes	4.4	Yes	No	19.7
21105	Stockbridge Bowl;	8/24/2005	None	NR	None	No	No	-8	**	**	-8
32054	Norwich Pd	9/6/2005	None	Slightly Turbid	Sparse	No	No	5.4	Yes	No	14.6
32076	Windsor Pond	8/23/2005	None	Slightly Turbid	Sparse	No	No	3	**	**	15.8
35053	Packard Pond	8/17/2005	None	Clear	None	No	No	2.4	Yes	No	12.8
42064	Webster L;	9/7/2005	None	Clear	Sparse	No	No	6.8	Yes	No	13.5
71043	Upper Mystic Lake	8/10/2005	None	Slightly Turbid	None	No	No	2.4	Yes	No	24
72039	Farm Pond	9/13/2005	None	Clear	None	No	No	7.7	Yes	No	17.7
81085	Mirror Lake	8/3/2005	None	Clear	None	No	No	8.3	Yes	No	20
81132	Spectacle Pd	8/3/2005	None	Clear	Sparse	No	No	5.5	Yes	No	15.9

Palis	Name	DATE	LakePlantCover	Duckweed	Trapa	Cabomba	P_crispus	Egeria	Nymphoides_pelt (yellow)	Lythrum	Najas_minor	Phragmites	Milfoil	M_spicatum	M_heterophyllum	M_aquaticum	Other
21078	Onota Lake	8/23/2005	Sparse	no									X	X			
21105	Stockbridge Bowl;	8/24/2005	None	NR													
32054	Norwich Pd	9/6/2005	Sparse	no													
32076	Windsor Pond	8/23/2005	Sparse	no													
35053	Packard Pond	8/17/2005	None	no													
42064	Webster L;	9/7/2005	Sparse	no		X				X			X				
71043	Upper Mystic Lake	8/10/2005	Sparse	no													
72039	Farm Pond	9/13/2005	Sparse	no													
81085	Mirror Lake	8/3/2005	Sparse	no													
81132	Spectacle Pd	8/3/2005	Sparse	no													

KEY:

1 = New record low for day
2 = < 10th percentile
3 = 10th – 24th percentile
4 = 25th – 74th percentile
5 = 75th – 89th percentile
6 = ≥ 90th percentile
7 = New record high for day

Water Quality Data

All MassDEP DWM water quality data are managed and maintained in the Water Quality Data Access Database (WQD). Tables 5 and 6 below provide the 2006 Farmington River Watershed water quality data. The procedures used to accept, accept with qualification or censor data are based on the DWM Standard Operating Procedures (SOP) for data validation and usability (MassDEP 2012a), and are in addition to separate quality assurance activities and laboratory validation steps undertaken by WES. Definitions for the data qualifiers are provided in Appendix 1. Relative sample depth codes are follows: s=surface; md=mid-depth and nb=near bottom.

PALIS	Water Body	Unique ID	Date	Time	Sample Depth (meters)	Relative Sample Depth	Analyte	Units	Result	Data Qualifiers
71043	Upper Mystic Lake	W1296	8/10/2005	11:40	**	integrated	chlorophyll a	mg/m3	8.2	--
72039	Farm Pond	W1297	9/13/2005	11:05	0.5	s	Apparent color	PCU	<15	--
72039	Farm Pond	W1297	9/13/2005	11:05	0.5	s	Total Phosphorus	mg/L	0.010	--
72039	Farm Pond	W1297	9/13/2005	11:05	0.5	s	True Color	PCU	**	--
72039	Farm Pond	W1297	9/13/2005	11:01	16.7	nb	Total Phosphorus	mg/L	0.29	--
72039	Farm Pond	W1297	9/13/2005	10:50	0-6.5	integrated	chlorophyll a	mg/m3	2.6	h
72052	Jamaica Pond	W0973	9/13/2005	13:40	0.5	s	Apparent color	PCU	20	--
72052	Jamaica Pond	W0973	9/13/2005	13:40	0.5	s	Total Phosphorus	mg/L	0.013	--
72052	Jamaica Pond	W0973	9/13/2005	13:40	0.5	s	True Color	PCU	<15	--
72052	Jamaica Pond	W0973	9/13/2005	13:42	0.5	s	Apparent color	PCU	18	--
72052	Jamaica Pond	W0973	9/13/2005	13:42	0.5	s	Total Phosphorus	mg/L	0.010	--
72052	Jamaica Pond	W0973	9/13/2005	13:42	0.5	s	True Color	PCU	<15	--
72052	Jamaica Pond	W0973	9/13/2005	14:00	13.0	nb	Total Phosphorus	mg/L	0.76	--
72052	Jamaica Pond	W0986	9/13/2005	14:40	--	--	Total Phosphorus	mg/L	0.021	--
72052	Jamaica Pond	W0973	9/13/2005	13:48	0-6.5	integrated	chlorophyll a	mg/m3	7.9	h
72052	Jamaica Pond	W0973	9/13/2005	13:50	0-6.5	integrated	chlorophyll a	mg/m3	7.9	h
81046	Fort Pond	W0603	8/2/2005	14:05	0.5	s	Apparent color	PCU	20	--
81046	Fort Pond	W0603	8/2/2005	14:05	0.5	s	Total Phosphorus	mg/L	0.006	--
81046	Fort Pond	W0603	8/2/2005	14:05	0.5	s	True Color	PCU	18	--
81046	Fort Pond	W0603	8/2/2005	14:05	0.5	s	Apparent color	PCU	26	--
81046	Fort Pond	W0603	8/2/2005	14:05	0.5	s	Total Phosphorus	mg/L	0.006	--
81046	Fort Pond	W0603	8/2/2005	14:05	0.5	s	True Color	PCU	24	--
81046	Fort Pond	W0603	8/2/2005	15:30	13.0	nb	Total Phosphorus	mg/L	0.76	--

PALIS	Name	Unique ID	Date	Time	Sample Depth (m)	Temp(C)	Temp Qualifer	pH (SU)	pH Qual	SpCond (uS/cm)	SpCond Qual	TDS (mg/l)	TDS Qual	DO (mg/l)	DO Qual	DOsat (%)	DOsat Qual
71019	Horn Pond	W1087	8/23/05	10:43	6.5	10.1	--	6.5	i	868	--	555	--	<0.2	i	<2	i
71019	Horn Pond	W1087	8/23/05	10:49	9.0	6.2	--	6.4	i	1270	--	812	--	<0.2	i	<2	i
71019	Horn Pond	W1087	8/23/05	10:57	12.1	4.7	--	6.5	i	1860	--	1190	--	<0.2	i	<2	i
71043	Upper Mystic Lake	W1296	8/10/05	10:03	0.5	26.3	--	8.8	--	702	--	450	--	9.4	--	118	--
71043	Upper Mystic Lake	W1296	8/10/05	10:11	1.5	26.3	--	8.8	--	702	--	450	--	9.4	--	119	--
71043	Upper Mystic Lake	W1296	8/10/05	10:19	2.5	26.3	--	8.8	--	702	--	450	--	9.3	--	118	--
71043	Upper Mystic Lake	W1296	8/10/05	10:28	3.5	22.3	u	7.5	--	686	--	439	--	9.0	u	105	u
71043	Upper Mystic Lake	W1296	8/10/05	10:35	4.0	17.9	u	7.1	--	736	--	471	--	7.9	--	85	--
71043	Upper Mystic Lake	W1296	8/10/05	10:43	4.5	14.4	--	6.8	--	773	--	495	--	5.0	--	50	--
71043	Upper Mystic Lake	????6	8/10/05	10:51	5.0	12.9	u	6.7	--	781	--	500	--	4.5	u	43	u
71043	Upper Mystic Lake	W1296	8/10/05	10:58	5.5	10.9	--	6.6	--	807	--	516	??	2.3	--	21	--
71043	Upper Mystic Lake	W1296	8/10/05	11:08	7.5	6.5	--	6.3	--	1230	--	787	--	<0.2	--	<2	--
71043	Upper Mystic Lake	1296	8/10/05	11:14	12.0	3.3	--	6.4	--	1420	--	909	--	<0.2	--	<2	--
71043	Upper Mystic Lake	W1296	8/10/05	11:20	18.0	3.7	--	6.6	鈥15	1580	--	1010	--	<0.2	--	<2	--
71043	Upper Mystic Lake	W1296	8/10/05	11:26	23.0	3.8	--	6.9	--	1610	--	1030	--	<0.2	--	<2	--
72039	Farm Pond	W1297	9/13/05	9:54	0.6	23.9	--	6.2	--	40	--	25	--	7.4	i	89	i
72039	Farm Pond	W1297	9/13/05	10:03	2.5	23.8	--	6.2	--	39	--	25	--	##	u,i	##	u,i
72039	Farm Pond	W1297	9/13/05	10:10	3.5	23.8	--	6.2	--	39	--	25	--	6.4	u,i	76	u,i
72039	Farm Pond	W1297	9/13/05	10:16	4.6	23.5	--	6.1	--	39	--	25	--	6.7	i	79	i
72039	Farm Pond	W1297	9/13/05	10:23	6.5	22.6	--	5.9	--	39	--	25	--	6.5	i	76	i
72039	Farm Pond	W1297	9/13/05	10:29	7.5	17.6	--	5.8	--	36	--	23	--	7.3	u,i	77	u,i
72039	Farm Pond	W1297	9/13/05	10:34	8.5	14.8	--	5.6	--	37	--	24	--	6.0	i	60	i

PALIS	Name	Unique ID	Date	Time	Sample Depth (m)	Temp(C)	Temp Qualifer	pH (SU)	pH Qual	SpCond (uS/cm)	SpCond Qual	TDS (mg/l)	TDS Qual	DO (mg/l)	DO Qual	DOsat (%)	DOsat Qual
72039	Farm Pond	W1297	9/13/05	10:41	9.6	12.1	--	5.5	--	37	--	24	--	6.6	i	62	i
72039	Farm Pond	W1297	9/13/05	10:49	11.5	9.1	--	5.2	--	37	--	24	--	5.2	i	45	i
72039	Farm Pond	W1297	9/13/05	10:54	13.5	8.1	--	5.3	--	39	--	25	--	1.2	i	10	i
72039	Farm Pond	W1297	9/13/05	11:00	16.7	7.7	--	6.0	--	55	--	35	--	<0.2	i	<2	i
72052	Jamaica Pond	W0973	9/13/05	13:28	0.6	23.9	--	8.6	--	458	--	293	--	8.9	i	107	i
72052	Jamaica Pond	W0973	9/13/05	13:35	2.6	23.5	--	8.8	--	459	--	294	--	9.1	u,i	109	u,i
72052	Jamaica Pond	W0973	9/13/05	13:43	3.5	23.2	--	8.8	--	459	--	294	--	9.2	i	109	i
72052	Jamaica Pond	W0973	9/13/05	13:49	4.6	22.9	--	8.7	--	458	--	293	--	9.1	i	107	i
72052	Jamaica Pond	W0973	9/13/05	13:55	5.5	18.7	u	9.9	c	468	--	299	--	17.7	u,i	193	u,i
72052	Jamaica Pond	W0973	9/13/05	13:59	6.5	12.7	--	9.6	c	473	--	303	--	17.6	u,i	168	u,i
72052	Jamaica Pond	W0973	9/13/05	14:07	7.5	8.9	--	7.2	--	495	--	317	--	9.3	u,i	81	u,i
72052	Jamaica Pond	W0973	9/13/05	14:13	8.5	7.1	--	6.6	--	517	--	331	--	3.1	i	26	i
72052	Jamaica Pond	W0973	9/13/05	14:18	9.5	6.0	--	6.4	--	535	--	342	--	0.3	i	2	i
72052	Jamaica Pond	W0973	9/13/05	14:23	13.0	4.2	--	6.1	--	708	--	453	--	<0.2	i	<2	i
81046	Fort Pond	W0603	8/2/05	14:15	0.5	26.5	--	7.2	--	404	--	258	--	7.4	--	94	--
81046	Fort Pond	W0603	8/2/05	14:22	1.5	25.7	--	7.2	--	404	--	259	--	7.4	--	93	--
81046	Fort Pond	W0603	8/2/05	14:27	2.5	25.2	--	7.1	--	403	--	258	--	7.3	--	90	--
81046	Fort Pond	W0603	8/2/05	14:32	3.6	19.7	--	6.6	--	384	--	246	--	7.5	--	84	--
81046	Fort Pond	W0603	8/2/05	14:39	4.0	14.4	u	6.4	--	385	--	247	--	5.6	--	56	--
81046	Fort Pond	W0603	8/2/05	14:49	4.5	12.2	--	6.3	--	388	--	248	--	4.6	--	44	--
81046	Fort Pond	W0603	8/2/05	14:53	5.0	11.0	--	6.3	--	392	--	251	--	3.9	--	36	--
81046	Fort Pond	W0603	8/2/05	14:59	5.6	9.4	--	6.3	--	400	--	256	--	3.2	--	29	--
81046	Fort Pond	W0603	8/2/05	15:06	6.6	7.4	--	6.2	--	418	--	268	--	1.8	u	15	u
81046	Fort Pond	W0603	8/2/05	15:11	7.6	6.1	--	6.2	--	460	--	294	--	<0.2	--	<2	--
81046	Fort Pond	W0603	8/2/05	15:15	10.1	5.2	--	6.4	--	630	--	404	--	<0.2	--	<2	--
81046	Fort Pond	W0603	8/2/05	15:23	13.4	5.0	--	6.5	--	797	--	510	--	<0.2	--	<2	--

Table 6. Trout Space (<20C and >=6 mg DO) for deep Lakes.

Palis	Name	Date	Trout Space (m)
21043	Goose Pond	8/24/05	1.8
21078	Onota Lake	8/23/05	2.1
21105	Stockbridge Bowl	8/24/05	2.7
32054	Norwich Pond	9/6/05	0
32076	Windsor Pond	8/23/05	0
35053	Packard Pond	8/17/05	0
36084	Lake Lorraine	9/6/05	1.4
41001	Alum Pond	9/7/05	0.7
42064	Webster Lake	9/7/05	0
51125	Lake Quinsigamond	8/16/05	0
71019	Horn Pond	8/23/05	0
71043	Upper Mystic Lake	8/10/05	0.6
72039	Farm Pond	9/13/05	3.3
72052	Jamaica Pond	9/13/05	2.8
81046	Fort Pond	8/2/05	0.4
81085	Mirror Lake	8/3/05	5.1
81132	Spectacle Pond	8/3/05	4.8
82061	Hopkinton Reservoir	8/23/05	0
82112	Waushacum Pond	8/17/05	0
82118	White Pond	9/13/05	3.0
82125	Lake Cochituate	9/13/05	0
84036	Baddacook Pond	8/2/05	0
91001	Baldpate Pond	8/10/05	1.9
93071	Sluice Pond	8/10/05	0.5
94133	Russell Pond	8/30/05	Too shallow
96004	Ashumet Pond	8/31/05	0
96091	Flax Pond	9/1/05	4.9
96194	Mashpee Pond	8/31/05	0
96279	Scargo Lake	9/1/05	0.3
96307	Spectacle Pond	8/30/05	1.4

APPENDIX 1: 2005 DATA SYMBOLS AND QUALIFIERS

Excerpted from: Water Quality Data Validation Report for Year 2006 Project Data (CN 300.0)

The following data qualifiers or symbols are used in the MADEP/DWM WQD database for qualified and censored water quality and multi-probe data. Decisions regarding censoring vs. qualification for specific, problematic data are made based on a thorough review of all pertinent information related to the data.

General Symbols (applicable to all types):

" ## " = Censored data (i.e., data that has been discarded for some reason).

" ** " = Missing data (i.e., data that should have been reported).

" -- " = No data (i.e., data not taken/not required)

" ^^ " = No data due to no water

Multi-probe-specific Qualifiers:

" i " = inaccurate readings from Multi-probe likely; may be due to significant pre-survey calibration problems, post-survey checks outside typical acceptance ranges for the low ionic and deionized water checks, lack of calibration of the depth sensor prior to use, or to checks against laboratory analyses. Where documentation on unit pre-calibration is lacking, but SOPs at the time of sampling dictated pre-calibration prior to use, then data are considered potentially inaccurate.

" m " = method not followed; one or more protocols contained in the DWM Multi-probe SOP not followed, i.e., operator error (e.g., less than 3 readings per station (rivers) or per depth (lakes), or instrument failure not allowing method to be implemented.

" s " = field sheet recorded data were used to accept data, not data electronically recorded in the Multi-probe surveyor unit, due to operator error or equipment failure.

" u " = unstable readings, due to lack of sufficient equilibration time prior to final readings, non-representative location, highly-variable water quality conditions, etc. See Section 4.1 for acceptance criteria.

" c " = greater than calibration standard used for pre-calibration, or outside the acceptable range about the calibration standard. Typically used for conductivity (>718, 1,413, 2,760, 6,668 or 12,900 uS/cm) or turbidity (>10, 20 or 40 NTU). It can also be used for TDS and Salinity calculations based on qualified ("c") conductivity data, or that the calculation was not possible due to censored conductivity data (TDS and Salinity are calculated values and entirely based on conductivity reading). See Section 4.1 for acceptance criteria.

" r " = data not representative of actual field conditions.

" t " = tidal conditions

Sample-Specific Qualifiers:

" a " = accuracy as estimated at WES Lab via matrix spikes, PT sample recoveries, internal check standards and lab-fortified blanks did not meet project data quality objectives identified for program or in QAPP.

" b " = blank Contamination in lab reagent blanks and/or field blank samples (indicating possible bias high and false positives).

" d " = precision of field duplicates (as RPD) did not meet project data quality objectives identified for program or in QAPP. Batched samples may also be affected.

" e " = not theoretically possible. Specifically, used for bacteria data where colonies per unit volume for e-coli bacteria > fecal coliform bacteria, for lake Secchi and station depth data where a specific Secchi depth is greater than the reported station depth, and for other incongruous or conflicting results.

" f " = frequency of quality control duplicates did not meet data quality objectives identified for program or in QAPP.

" h " = holding time violation (usually indicating possible bias low)

" j " = 'estimated' value; used for lab-related issues where certain lab QC criteria are not met and re-testing is not possible (as identified by the WES lab only). Also used to report sample data where the sample concentration is less than the 'reporting' limit or RDL and greater than the method detection limit or MDL (mdl< x <rdl). Also used to note where values have been reported at levels less than the mdl.

" m " = method SOP not followed, only partially implemented or not implemented at all, due to complications with sample matrix (e.g., sediment in sample, floc formation), lab error (e.g., cross-contamination between samples), additional steps taken by the lab to deal with matrix complications, lost/unanalyzed samples, and missing data.

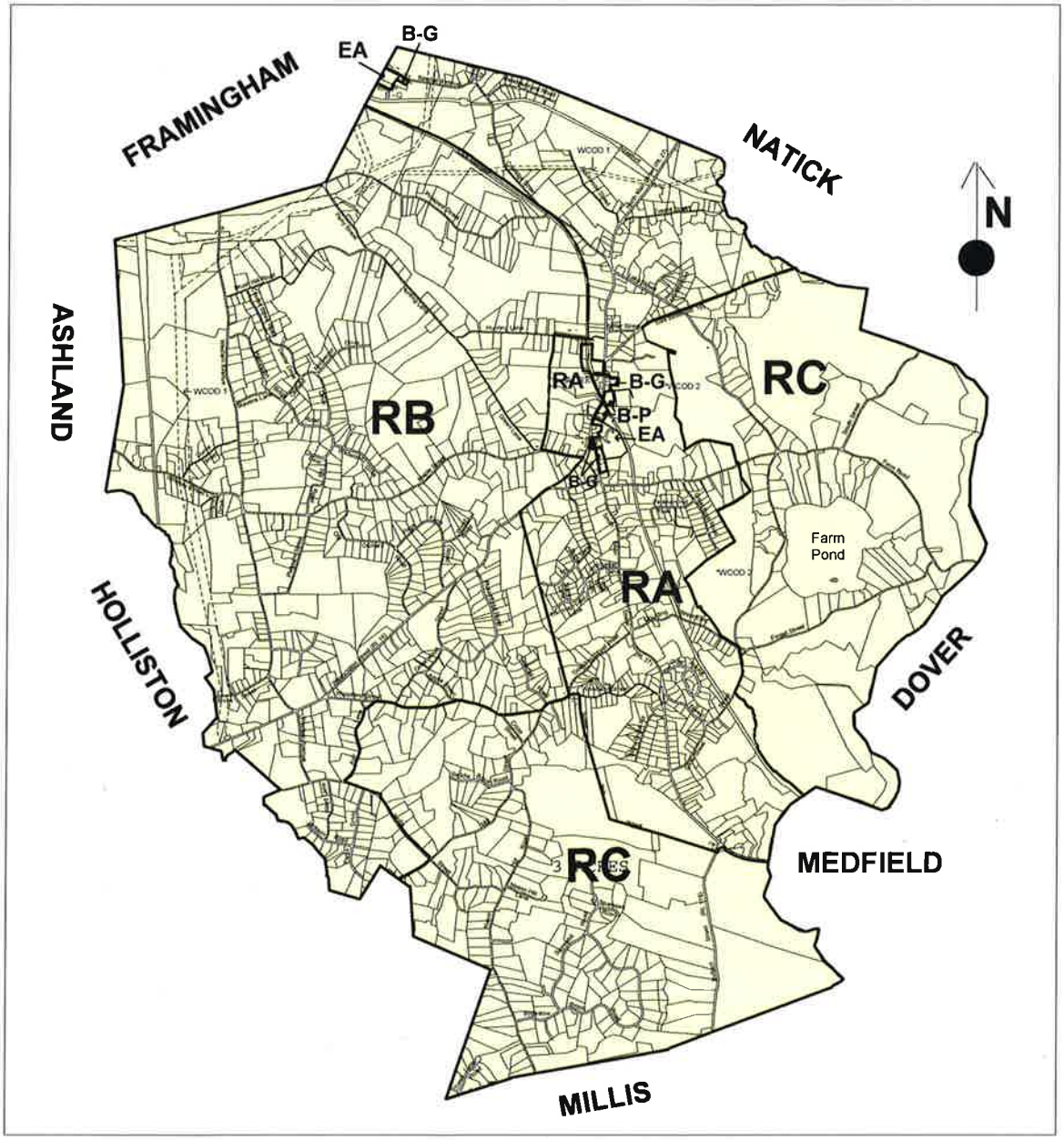
" p " = samples not preserved per SOP or analytical method requirements.

" r " = samples collected may not be representative of actual field conditions, including the possibility of "outlier" data and flow-limited conditions (e.g., pooled).

" t " = tidal conditions

Appendix B. Town of Sherborn Information

SHERBORN ZONING MAP



ZONING DISTRICTS KEY

RA = RESIDENCE A (1-Acre Min. Lot Size (MLS)) RB = RESIDENCE B (2-Acre MLS) RC = RESIDENCE C (3-Acre MLS)
EA = ELDERLY AND AFFORDABLE M = MULTI-DWELLING (Elderly only) B-G = BUSINESS GENERAL
B-P = BUSINESS PROFESSIONAL WCOD = WIRELESS COMMUNICATIONS OVERLAY DISTRICT WCOD #1 is NSTAR easement and fee WCOD #2 is area above 70 meters of marked lots *

(1) 260' west of RR right-of-way
(2) Stone wall, 160' east of Green Lane
(3) Brook & culvert under Washington Street
(4) Junction of Goulding St East and Woodland St
(5) Stone wall, 267' east of junction of Goulding St East and Woodland Streets
(6) Stone wall, 236' south of Route 27 centerline

SHERBORN PLANNING BOARD
APRIL 17, 2002

Based on 1991 Zoning Map prepared by GLM Engineering Consultants, Inc. of Holliston, and a digitized parcel map prepared by Harvard Design and Mapping, Inc. of Cambridge. Parcel lines are for illustrative purposes only and may not be up to date.

This Zoning Map incorporates changes approved at Town Meeting since 1991. It is not official unless adopted by Annual Town Meeting on April 23, 2002.

TOWN OF SHERBORN

FARM POND RESERVATION RULES & REGULATIONS

Farm Pond Reservation is a community resource maintained by the Town of Sherborn for responsible use and enjoyment by the public. Rules are established to help protect the environment and ensure that all can safely enjoy their time at the pond.

Reservation rules are in force at all times all year long.
Violators may be fined $200 and/or be prohibited from use of the Reservation.

- No dogs or horses are permitted anywhere on the reservation.
- No food or beverages permitted except water.
- No smoking; no fires; no littering.
- No motors of any kind on pond.
- All boats must be washed at bath house before launching.
- Town of Sherborn Boat Permit Required
- Children under 12 must be accompanied by an adult.
- Swimming in designated areas only.
- No swimming under docks or perimeter lines or hanging on ropes.
- Artificial flotation devices are not permitted in water.
- Diving permitted in designated areas only.
- Balls and frisbees may be used only at discretion of lifeguards.
- Babies and toddlers must wear swim diapers.
- Use of radios or audio devices with headphones only.
- Low sand chairs only.
- No bike riding on the beach.
- No running on docks.
- No personal belongings on docks.
- No introduction of foreign substances into pond including soap, detergents, gas or oil.
- No fishing from beach when swimmers are present.

Appendix C. Hydrologic calculations

Exhibit C.1 Hydrologic Budget Calculations for Farm Pond

1. Unit Watershed Area Method

	acres	sq. mi.	sq. feet
Watershed Area:	228	0.3563	9.93E+06

Use yield coefficients (Sopper and Lull, 1970)

Low yield:	1.0 /sq. mi.	0.36	cfs or	1.12E+07 ft^3/yr
High yield:	1.5 /sq. mi.	0.53	cfs or	6.91E+05 ft^3/yr

2. Runoff Estimate Method

	acres	sq. mi.	sq. feet
Watershed Area:	228	0.3563	9.93E+06
Lake Surface Area:	123	0.1922	5.36E+06

Assumes fixed portion of precipitation (40-50%) is runoff from watershed to lake. Uses geometric mean of longterm (25 yr) ppt record for Worcester of 3.79 ft ppt/yr. Add direct precipitation to pond and subtract evaporative loss.

High runoff range =	1.88E+07 ft^3/yr
Low runoff range =	1.51E+07 ft^3/yr

Runoff estimates are for MA from Higgins and Colonell (1970).

Direct Precipitation to the Lake =	2.03E+07 ft^3/yr
Evaporation from the Lake	-8.95E+06 ft^3/yr

High runoff total =	0.96	cfs or	3.02E+07 ft^3/yr
Low runoff total =	0.84	cfs or	2.64E+07 ft^3/yr

3. Flushing Rate

Pond Volume = 2406 ac-ft. 1.05E+08 ft^3

Hydraulic Residence Time = (Volume/inflow)

High runoff total =	3.47 yr
Low runoff total =	3.97 yr

Flushing Rate = (inflow/Volume)

High runoff total =	0.29 flushes/yr.
Low runoff total =	0.25 flushes/yr.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Tot	ppt totals
1977	2.76	2.46	5.75	3.69	2.20	4.00	3.84	2.73	6.54	6.33	3.69	4.99	48.98	48.98
1978	9.90	2.08	3.22	2.24	3.69	1.57	3.57	5.00	1.02	3.85	2.07	3.56	41.77	41.77
1979	11.16	2.64	3.71	4.49	4.14	0.79	5.74	7.39	3.80	4.36	3.58	1.89	53.69	53.69
1980	0.95	0.73	6.86	4.77	2.23	4.55	3.59	1.95	1.82	6.16	4.58	1.06	39.25	39.25
1981	0.93	8.37	0.74	3.85	4.48	2.45	7.90	1.03	4.66	5.49	3.13	5.94	48.97	48.97
1982	5.00	3.22	3.67	4.30	2.96	12.17	3.61	3.36	2.69	2.67	4.32	1.70	49.67	49.67
1983	4.85	4.67	7.84	8.59	5.97	2.56	1.32	6.26	1.38	5.77	8.75	6.37	64.33	64.33
1984	2.44	5.78	5.47	4.23	9.94	2.85	5.69	1.17	1.68	3.99	2.71	2.84	48.79	48.79
1985	1.16	2.72	2.89	1.26	5.46	5.24	6.35	3.74	3.77	3.12	6.41	1.93	44.05	44.05
1986	5.56	3.14	2.93	1.59	3.14	7.21	4.83	3.20	0.69	2.72	5.63	7.25	47.89	47.89
1987	5.52	0.25	6.57	8.79	1.55	4.55	0.74	4.61	6.37	4.18	2.77	1.85	47.75	47.75
1988	2.71	2.78	3.46	3.45	4.47	1.25	6.27	2.19	2.70	3.66	7.91	1.42	42.27	42.27
1989	1.18	2.47	2.66	4.25	6.17	5.27	5.67	5.65	4.71	8.21	4.00	0.74	50.98	50.98
1990	3.75	3.88	1.52	4.78	7.65	1.74	2.44	6.84	1.73	10.19	2.41	5.46	52.39	52.39
1991	2.98	2.08	4.92	5.04	4.16	3.06	2.78	8.01	6.40	3.44	5.47	2.89	51.23	51.23
1992	3.01	2.51	4.15	2.59	2.54	4.68	5.25	4.83	3.58	2.36	4.94	4.61	45.05	45.05
1993	2.56	2.38	5.46	4.00	1.79	2.36	3.34	1.90	8.85	3.88	4.85	5.11	46.48	46.48
1994	4.78	1.86	5.38	2.73	5.87	2.48	3.09	7.64	4.84	1.24	4.54	4.81	49.26	49.26
1995	3.71	2.86	1.85	2.19	2.39	1.51	4.33	2.02	3.15	8.64	4.61	1.30	38.56	38.56
1996	6.70	2.83	2.37	6.70	3.33	2.90	6.50	4.03	5.99	5.91	3.00	6.84	57.10	57.10
1997	3.26	1.65	4.39	2.76	2.72	1.61	2.98	3.02	1.44	2.11	5.50	2.32	33.76	33.76
1998	4.59	3.17	5.82	3.30	5.89	9.68	1.76	2.38	1.69	4.93	2.28	1.46	46.95	46.95
1999	6.01	3.38	4.09	0.92	2.77	0.32	4.14	1.87	8.81	3.57	3.38	2.55	41.81	41.81
2000	3.11	2.59	3.82	6.85	3.51	5.84	4.04	2.09	3.01	2.05	3.61	3.62	44.14	44.14
2001	1.64	2.40	6.53	0.75	2.26	6.27	1.91	2.31	3.42	0.70	1.36	2.77	32.32	32.32
2002	2.36	1.43	3.20	3.67	5.55	4.83	2.65	2.94	3.97			30.60		30.60
											Geometric mean:			45.47 or 3.79 ft ppt/yr
											Arithmetic mean:			47.92 or 3.99 ft ppt/yr

*Data from NOAA's "Miscellaneous Climate Records and Averages for Boston"; located at: http://www.erh.noaa.gov/box/AveragesTotals.shtml

Appendix D. Water Quality Data

Farm Pond, Sherbon, MA
Water Quality Data

Station and Sample ID								Field Observations					
Year	Station Field ID	Sample ID Number	Type Sample (S,M,D)	Waterbody Sample	Sample	Sample (ft)	Time (military)	Temp (C)	DO (mg/L)	%DO	Sp. Cond. (uS)	SDT (ft)	pH (SU)
1974	FP-1	R59522	S	Lake	07/02/74	0.5	am	21.3	8.6		43	NA	5.0
1974	FP-1	R59523	M	Lake	07/02/74	40.0		14.0	7.4		44		5.2
1974	FP-1	R59524	D	Lake	07/02/74	54.5		10.5	4.5		45		5.4
1974	FP-1	R59525	S	Outlet	07/02/74	0.5		20.6	1.4		64		4.6
1983	FP-1	R95216/17	S	Lake	07/21/83	0.5	11:00	27.1	8.2		37	26.3	4.2
1983	FP-1	R95218/19	M	Lake	07/21/83	26.3		18.6	11.5		32		5.2
1983	FP-1	R95220/21	D	Lake	07/21/83	55.8		9.8	1.6		27		6.1
2005	FP-1	W1297	S	Lake	09/13/05	2.0	9:54	23.9	7.4	89	40	24.6	6.2
2005	FP-1	W1297	M	Lake	09/13/05	8.2	10:03	23.8			39		6.2
2005	FP-1	W1297	M	Lake	09/13/05	11.5	10:10	23.8	6.4	76	39		6.2
2005	FP-1	W1297	M	Lake	09/13/05	15.1	10:16	23.5	6.7	79	39		6.1
2005	FP-1	W1297	M	Lake	09/13/05	21.3	10:23	22.6	6.5	76	39		5.9
2005	FP-1	W1297	M	Lake	09/13/05	24.6	10:29	17.6	7.3	77	36		5.8
2005	FP-1	W1297	M	Lake	09/13/05	27.9	10:34	14.8	6.0	60	37		5.6
2005	FP-1	W1297	M	Lake	09/13/05	31.5	10:41	12.1	6.6	62	37		5.5
2005	FP-1	W1297	M	Lake	09/13/05	37.7	10:49	9.1	5.2	45	37		5.2
2005	FP-1	W1297	M	Lake	09/13/05	44.3	10:54	8.1	1.2	10.0	39		5.3
2005	FP-1	W1297	D	Lake	09/13/05	54.8	11:00	7.7	0.1	1.0	55		6.0
2014	FP-1	FP-1S	S	Lake	05/29/14	0.5	13:05	18.1	9.9	105	37	24.0	8.0
2014	FP-1		M	Lake	05/29/14	2.5	13:07	17.9	9.8	103	37		7.8
2014	FP-1		M	Lake	05/29/14	5.0	13:09	17.8	9.7	102	36		7.7
2014	FP-1		M	Lake	05/29/14	7.5	13:11	17.5	9.7	102	36		7.6
2014	FP-1		M	Lake	05/29/14	10.0	13:13	17.5	9.7	101	36		7.5
2014	FP-1		M	Lake	05/29/14	12.5	13:15	17.2	9.7	100	36		7.4
2014	FP-1		M	Lake	05/29/14	15.0	13:17	15.7	10.0	101	34		7.4
2014	FP-1		M	Lake	05/29/14	17.5	13:19	13.4	10.9	105	32		7.4
2014	FP-1		M	Lake	05/29/14	20.0	13:21	12.6	11.1	104	31		7.3
2014	FP-1		M	Lake	05/29/14	25.0	13:23	10.6	11.1	99	30		7.3

Farm Pond, Sherbon, MA
Water Quality Data

Station and Sample ID			Nutrients					Water Quality			
Year	Station Field ID	Sample ID Number	Tot. Phos (ug/L)	Dis. Phos (ug/L)	NH3 (mg/L)	TKN (mg/L)	NO3 (mg/L)	Alk. (mg/L)	Hardness (mg/L)	Chloride (mg/L)	Iron (mg/L)
1974	FP-1	R59522	30		0.03		0	2	7.0		
1974	FP-1	R59523	30		0.02		0	2	1.0		
1974	FP-1	R59524	20		0.04		0	3	1.5		
1974	FP-1	R59525	2000		0.68		0	1	5.0		
1983	FP-1	R95216/17	130		0.06	0.31	0.1	2	26.0	3	
1983	FP-1	R95218/19	110		0.14	0.28	0.3	2	26.0	3	
1983	FP-1	R95220/21	70		0.06	0.31	0.1	2	26.0	6	
2005	FP-1	W1297	10								
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297									
2005	FP-1	W1297	290								
2014	FP-1	FP-1S	5	5	0.15	0.55	0.025	2	7.0	8	0.05
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										

Farm Pond, Sherbon, MA
Water Quality Data

Station and Sample ID			Biological		
Year	Station Field ID	Sample ID Number	Fecal Coliform (#/100 ml)	BOD 5 (mg/L)	Chl a (ug/L)
1974	FP-1	R59522			
1974	FP-1	R59523			
1974	FP-1	R59524			
1974	FP-1	R59525			
1983	FP-1	R95216/17	2.5		
1983	FP-1	R95218/19			
1983	FP-1	R95220/21			
2005	FP-1	W1297			2.6
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2005	FP-1	W1297			
2014	FP-1	FP-1S	2	3	1.5
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				

Farm Pond, Sherbon, MA
Water Quality Data

Station and Sample ID								Field Observations					
Year	Station Field ID	Sample ID Number	Type Sample (S,M,D)	Waterbody Sample	Sample	Sample (ft)	Time (military)	Temp (C)	DO (mg/L)	%DO	Sp. Cond. (uS)	SDT (ft)	pH (SU)
2014	FP-1		M	Lake	05/29/14	27.5	13:25	8.3			28		7.1
2014	FP-1		M	Lake	05/29/14	30.0	13:27	8.0	10.9	91	28		7.1
2014	FP-1		M	Lake	05/29/14	35.0	13:29	6.8	9.7	79	27		6.9
2014	FP-1		M	Lake	05/29/14	40.0	13:31	6.4	9.1	74	27		6.8
2014	FP-1	FP-1D	M	Lake	05/29/14	45.0	13:35	6.2	8.6	69.0	26		6.7
2014	FP-1		D	Lake	05/29/14	50.0	11:36	6.2	7.6	60.0	27		6.6
2014	FP-1	FP-1S	S	Lake	08/12/14	0.5	12:15	26.10	7.40	91	44.0	24.0	8.7
2014	FP-1		M	Lake	08/12/14	2.5	12:07	26.10	7.34	91	44.0		8.5
2014	FP-1		M	Lake	08/12/14	5.0	12:09	25.90	7.33	90	44.0		8.3
2014	FP-1		M	Lake	08/12/14	7.5	12:11	25.80	7.31	90	43.0		8.2
2014	FP-1		M	Lake	08/12/14	10.0	12:13	25.40	7.05	85	43.0		8.1
2014	FP-1		M	Lake	08/12/14	12.5	12:15	23.20	6.01	68	41.0		7.8
2014	FP-1		M	Lake	08/12/14	15.0	12:17	19.10	6.21	67	37.0		7.6
2014	FP-1		M	Lake	08/12/14	17.5	12:19	15.90	6.90	71	34.0		7.5
2014	FP-1		M	Lake	08/12/14	20.0	12:21	12.90	7.31	69	32.0		7.4
2014	FP-1		M	Lake	08/12/14	22.5	12:23	11.30	7.07	65	31.0		7.2
2014	FP-1		M	Lake	08/12/14	25.0	12:25	9.80	6.64	61	30.0		7.1
2014	FP-1		M	Lake	08/12/14	27.5	12:27	8.56	5.49	44	29.0		6.9
2014	FP-1		M	Lake	08/12/14	30.0	12:29	8.05	3.57	27	29.0		6.9
2014	FP-1		M	Lake	08/12/14	35.0	12:31	8.00	3.60	24	29.0		6.6
2014	FP-1		M	Lake	08/12/14	40.0	12:33	7.26	3.11	24	29.0		6.8
2014	FP-1	FP-1D	M	Lake	08/12/14	45.0	12:35	6.80	2.13	16	30.0		6.7
2014	FP-1		D	Lake	08/12/14	50.0	12:37	6.70	1.23	10	34.0		6.6

Farm Pond, Sherbon, MA
Water Quality Data

Station and Sample ID			Nutrients					Water Quality			
Year	Station Field ID	Sample ID Number	Tot. Phos (ug/L)	Dis. Phos (ug/L)	NH3 (mg/L)	TKN (mg/L)	NO3 (mg/L)	Alk. (mg/L)	Hardness (mg/L)	Chloride (mg/L)	Iron (mg/L)
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1	FP-1D	10	5	0.21	0.55	0.025	2	7.0	7.6	0.05
2014	FP-1										
2014	FP-1	FP-1S	10	2.5	0.05	0.25	0.025	2.8	6.8	8.1	0.025
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1										
2014	FP-1	FP-1D	36	2.5	0.36	0.25	0.025	2.8	7.5	7.7	0.686
2014	FP-1										

Farm Pond, Sherbon, MA
Water Quality Data

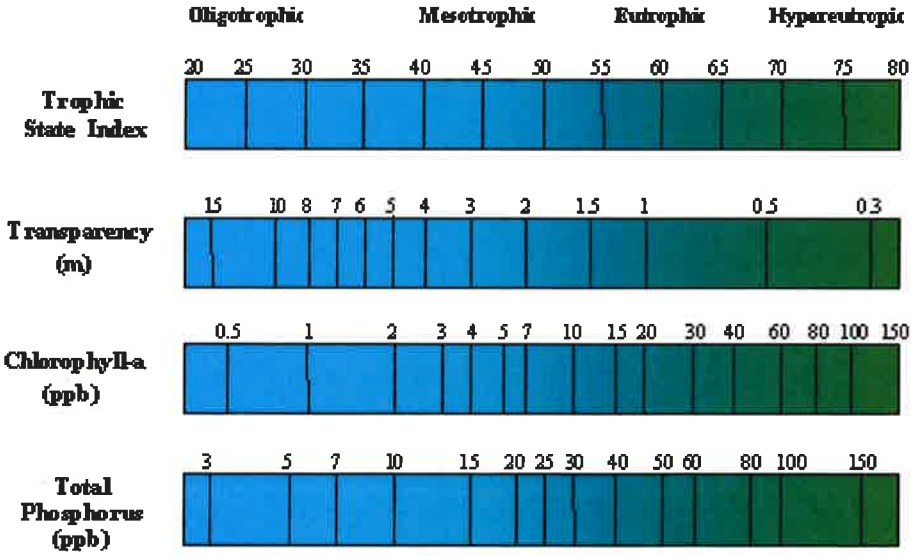
Station and Sample ID			Biological		
Year	Station Field ID	Sample ID Number	Fecal Coliform (#/100 ml)	BOD 5 (mg/L)	Chl a (ug/L)
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1	FP-1D	1	2	
2014	FP-1				
2014	FP-1	FP-1S	3	1.5	2.1
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1				
2014	FP-1	FP-1D	1	1.5	
2014	FP-1				

Trophic State Calculation Formulas		Sept. 2005 data	TSI scores	May 2014 data	TSI scores	August 2014 data	TSI scores
Secchi Disk:	**TSI(SDT) = 60 - 14.41 ln(SDT)**	7.5	31	7.31	31	7.31	31
	SDT expressed as meters						
Chlorophyll a:	**TSI(CHL) = 9.81 ln(CHL) + 30.6**	2.6	40	1.5	35	2.1	38
	Chlorophyll a expressed as ug/L						
Total Phosphorus:	**TSI(TP) = 14.42 ln(TP) + 4.15**	10	33	5	23	10	33
	TP expressed as ug/L						
	where ln = natural log **Avg. score:**		**35**		**30**		**34**

Table 1. TROPHIC STATUS INDEX & WATER QUALITY (Carlson 1977)

TSI score	Description of lake conditions and eutrophic indicators
< 30	Oligotrophic; clear water; high DO throughout the year in the entire hypolimnion
30-40	Oligotrophic; clear water; possible periods of limited hypolimnetic anoxia (DO =0)
40-50	Moderately clear water; increasing chance of hypolimnetic anoxia in summer; fully supportive of all swimmable/aesthetic uses
50-60	Mildly eutrophic; decreased transparency; anoxic hypolimnion; macrophyte problems; warm-water fisheries only; supportive of all swimmable/aesthetic uses but "threatened"
60-70	Blue-green algae dominance; scums possible; extensive macrophyte problems
70-80	Heavy algal blooms possible throughout summer; dense macrophyte beds; hypereutrophic
> 80	Algal scums; summer fish kills; few macrophytes due to algal shading; rough fish dominance

Figure 1. TSI Scoring Graphical presentation



CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike
Attn: Mr. Wayne Perry
One Roberts Road
Plymouth, MA 02360

Date Received: 5/29/14
Date Reported: 6/12/14
P.O. #:
Work Order #: 1405-11558

DESCRIPTION: PROJECT #NS-009 FARM POND SURFACE WATER QUALITY

Subject sample(s) has/have been analyzed by our Warwick, R.I. laboratory with the attached results.

Reference: All parameters were analyzed by U.S. EPA and Massachusetts Contingency Plan (MCP) approved methodologies where applicable. The specific methodologies are listed in the methods column of the Certificate of Analysis.

Data qualifiers (if present) are explained in full at the end of a given sample's analytical results.

Certification #: RI LAI0033, MA M-RI015, CT PH-0508, ME RI00015
NH 2537, NY 11726

This Certificate represents all data associated with the referenced work order and is paginated for completeness. The complete Certificate includes one attachment; the original Chain of Custody.

If you have any questions regarding this work, or if we may be of further assistance, please contact our customer service department.

Approved by:

Data Reporting

enc: Chain of Custody

Customer Name : Fay, Spofford & Thorndike

Work Order #: 1405-11558

MassDEP Analytical Protocol Certification Form

Laboratory Name: R.I. Analytical Laboratories Work Order #: 1405-11558

Project / Location: PROJECT #NS-009 FARM POND SURFACE WATER QUALITY RTN :

This Form provides certifications for the following data set: list Laboratory Sample ID Number(s):

1405-11558-001 through 1405-11558-002

Matrices: ☒ Groundwater/Surface Water ☐ Soil / Sediment ☐ Drinking Water ☐ Air ☐ Other

CAM Protocol (check all that apply below):

8260 VOC CAM II A ☐	7470/7471 Hg CAM III B ☐	MassDEP VPH CAM IV A ☐	8081 Pesticides CAM V B ☐	7196 Hex Cr CAM VI B ☐	MassDEP APH CAM IX A ☐
8270 SVOC CAM II B ☐	7010 Metals CAM III C ☐	MassDEP EPH CAM IV B ☐	8151 Herbicides CAM V C ☐	8330 Explosives CAM VIII A ☐	TO-15 VOC CAM IX B ☐
6010 Metals CAM III A ☒	6020 Metals CAM III D ☐	8082 PCB CAM V A ☐	9014 Total Cyanide /PAC CAM VI A ☐	6860 Perchlorate CAM VIII B ☐	

Affirmative responses to Questions A through F are required for "Presumptive Certainty" status

A	Were all samples received in a condition consistent with those described on the Chain-of Custody, properly preserved (including temperature) in the field or laboratory, and prepared/analyzed within method holding times?	☒ Yes ☐ No
B	Were the analytical methods(s) and all associated QC requirements specified in the selected CAM protocol(s) followed?	☒ Yes ☐ No
C	Were all required corrective actions and analytical response actions specified in the selected CAM protocol(s) implemented for all identified performance standard non-conformances?	☒ Yes ☐ No
D	Does the laboratory report comply with all the reporting requirements specified in CAM VII A, "Quality Assurance and Quality Control Guidelines for the Aquisition and Reporting of Analytical Data"?	☒ Yes ☐ No
E	a. VPH, EPH, and APH Methods only: Was each method conducted without significant modification(s) ? (Refer to the individual method(s) for a list of significant modifications). b. APH and TO-15 Methods only: Was the complete analyte list reported for each method?	☐ Yes ☐ No ☐ Yes ☐ No
F	Were all applicable CAM protocol QC and performance standard non-conformances identified and evaluated in a laboratory narrative (including all "No" responses to Questions A through E)?	☒ Yes ☐ No

Responses to Questions G,H and I below are required for "Presumptive Certainty" status

G	Were the reporting limits at or below all CAM reporting limits specified in the selected CAM protocol(s)?	☒ Yes ☐ No [1]

***Data User Note:** Data that achieve "Presumptive Certainty" status may not necessarily meet the data usability and representativeness requirements described in 310 CMR 40. 1056 (2)(k) and WSC-07-350.*

H	Were **all** QC performance standards specified in the CAM protocol(s) achieved?	☒ Yes ☐ No [1]
I	Were results reported for the complete analyte list specified in the selected CAM protocol(s)?	☐ Yes ☒ No [1]

[1] *All negative responses must be addressed in an attached laboratory narrative.*

I, the undersigned, attest under the pains and penalties of perjury that, based upon my personal inquiry of those responsible for obtaining the information, the material contained in this analytical report is, to the best of my knowledge and belief, is accurate and complete.

Signature:  Position: QA/QC Director

Printed Name: Eric H. Jensen Date: 6-17-14

Case Narrative

Date: 6/12/2014

Fay, Spofford & Thorndike
Attn: Mr. Wayne Perry

One Roberts Road
Plymouth, MA 02360

Project: PROJECT #NS-009 FARM POND SURFACE WATER QUALITY

Work Order #: 1405-11558

The following exceptions were noted for this Work Order:

Chlorophyll A was analyzed at our subcontracted laboratory, Aquatec Biological Services, Inc.

The methods requested for Fecal Coliform, BOD 5, Alkalinity (as CaCO3), Chloride, Dissolved Phosphorous (as P), Nitrite (as N), Nitrate (as N), Total Phosphorous (as P), Ammonia (as N), TKN (as N), and Chlorophyll A are not listed in the table of contents for compendium of MCP analytical methods. Therefore, there is no guideline for presumptive certainty.

Total Metals by 6010

Question I - Per the client's request, only a subset of the MCP analyte list for SW-846 Method 6010 Total Metals is reported.

There were no additional exceptions or analytical issues to discuss concerning the testing requirements for the project.

R.I. Analytical Laboratories, Inc.
CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike

Date Received: 5/29/14

Work Order #: 1405-11558

PROJECT #NS-009 FARM POND SURFACE WATER QUALITY

Sample # 001
SAMPLE DESCRIPTION: FP-1S
SAMPLE TYPE: GRAB **SAMPLE DATE/TIME:** 5/29/2014 @ 12:30

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE ANALYZED		ANALYST
Fecal Coliform (MF)	2	2	cfu/100mls	SM9222D 19 ed	5/29/14	17:11	KCL
BOD 5	<6.0	6.0	mg/l	SM 5210B	5/29/14	22:16	KL
Alkalinity (as CaCO3)	2.0	1.0	mg/l	SM 2320B	5/29/14	16:35	PTT
Chloride	8.0	5.0	mg/l	EPA 300.0	5/30/14	4:43	TAH
Dissolved Phosphorus (as P)	<0.05	0.05	mg/l	SM-4500-P-B,E	6/2/14	8:00	EC
Nitrite (as N)	<0.05	0.05	mg/l	EPA 300.0	5/30/14	4:43	TAH
Nitrate (as N)	<0.05	0.05	mg/l	EPA 300.0	5/30/14	4:43	TAH
Total Phosphorus (as P)	<0.05	0.05	mg/l	SM-4500-P-B, E	6/2/14	8:00	EC
Ammonia (as N)	0.15	0.10	mg/l	SM4500-NH3 B,H	6/3/14	14:16	WWW
TKN (as N)	0.55	0.50	mg/l	SM 4500 NORG D	6/6/14	14:33	JAH
Chlorophyll A	See Attached		mg/m^3	SM 10200-H	6/9/14	0:00	*AQ
Total Metals							
Calcium	1.9	0.05	mg/l	SW-846 6010C	6/2/14	9:53	JRW
Iron	<0.100	0.100	mg/l	SW-846 6010C	6/2/14	9:53	JRW
Magnesium	0.56	0.05	mg/l	SW-846 6010C	6/2/14	9:53	JRW
Hardness as CaCO3	7.0	0.33	mg/l	SW-846 6010C	6/2/14	9:53	JRW
ICP Digestion				SW-846 3010A	5/30/14	23:42	OMC

R.I. Analytical Laboratories, Inc.
CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike

Date Received: 5/29/14

Work Order #: 1405-11558

PROJECT #NS-009 FARM POND SURFACE WATER QUALITY

Sample # 002
SAMPLE DESCRIPTION: FP-1D
SAMPLE TYPE: GRAB **SAMPLE DATE/TIME:** 5/29/2014 @ 12:40

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE ANALYZED		ANALYST
Fecal Coliform (MF)	<2	2	cfu/100mls	SM9222D 19 ed	5/29/14	17:11	KCL
BOD 5	<6.0	6.0	mg/l	SM 5210B	5/29/14	22:18	KL
Alkalinity (as CaCO3)	2.0	1.0	mg/l	SM 2320B	5/29/14	16:35	PTT
Chloride	7.6	5.0	mg/l	EPA 300.0	5/30/14	4:55	TAH
Dissolved Phosphorus (as P)	<0.05	0.05	mg/l	SM-4500-P-B,E	6/2/14	8:00	EC
Nitrite (as N)	<0.05	0.05	mg/l	EPA 300.0	5/30/14	4:55	TAH
Nitrate (as N)	<0.05	0.05	mg/l	EPA 300.0	5/30/14	4:55	TAH
Total Phosphorus (as P)	<0.05	0.05	mg/l	SM-4500-P-B, E	6/2/14	8:00	EC
Ammonia (as N)	0.21	0.10	mg/l	SM4500-NH3 B,H	6/3/14	16:54	JAH
TKN (as N)	0.55	0.5	mg/l	SM 4500 NORG D	6/9/14	15:25	WWW
Chlorophyll A	See Attached		mg/m^3	SM 10200-H	6/9/14	0:00	*AQ
Total Metals							
Calcium	1.9	0.05	mg/l	SW-846 6010C	6/2/14	9:59	JRW
Iron	<0.100	0.100	mg/l	SW-846 6010C	6/2/14	9:59	JRW
Magnesium	0.56	0.05	mg/l	SW-846 6010C	6/2/14	9:59	JRW
Hardness as CaCO3	7.0	0.33	mg/l	SW-846 6010C	6/2/14	9:59	JRW
ICP Digestion				SW-846 3010A	5/30/14	23:42	OMC

* Chlorophyll-a samples analyzed by Aquatec Biological Sciences, Inc

QA/QC Report

Client: Fay, Spofford & Thorndike
WO #: 1405-11558
Date: 6/12/2014

-Method Blanks Results-

Parameter	Units	Results	Date Analyzed
Nitrite (as N)	mg/l	<0.05	5/29/2014
Nitrate (as N)	mg/l	<0.05	5/29/2014
Chloride	mg/l	<5.0	5/29/2014
Alkalinity (as CaCO3)	mg/l	<1.0	5/29/2014
BOD 5	mg/l	<2.0	5/29/2014
Total Phosphorus (as P)	mg/l	<0.05	6/2/2014
TKN (as N)	mg/l	<0.50	6/6/2014
Ammonia (as N)	mg/l	<0.10	6/3/2014
Metals			
Iron	mg/l	<0.100	6/2/2014
Calcium	mg/l	<0.05	6/2/2014
Magnesium	mg/l	<0.05	6/2/2014

-LCS/LCS Duplicate Data Results-

Parameter	CRM Acceptance Limits	Spike Conc	LCS Conc	LCS % Rec	LCS Dup Conc	LCS DUP % Rec	% RPD	Date Analyzed
Alkalinity (as CaCO3)		50.0	50	100	50	100	0	5/29/2014
BOD 5		198	180	91				5/29/2014
Nitrite (as N)		1.0	1.04	104	1.05	105	1	5/30/2014
Nitrate (as N)		1.00	0.983	98	0.990	99	1	5/30/2014
Chloride		10.0	10.2	102	10.2	102	0	5/30/2014
Total Phosphorus (as P)		1.30	1.1	85				6/2/2014
Ammonia (as N)		4.00	3.5	88				6/3/2014
Ammonia (as N)		4.00	4.0	100				6/3/2014
TKN (as N)		5.00	4.3	86				6/6/2014
Metals								
Iron		10.0	10.3	103	10.5	105	2	6/2/2014
Calcium		10.0	10	100	10	100	0	6/2/2014
Magnesium		10.0	10	100	10	100	0	6/2/2014

Aquatec Biological Sciences, Inc.
273 Commerce Street
Williston, VT 05495
Tel: (802) 860 - 1638 Fax: (802) 658 - 3189

SDG: 13943
Project: 14023

Chlorophyll *a* Analytical Report

Project Name:

R. I. Analytical Laboratories, Inc.
41 Illinois Avenue

Warwick, RI 02888

Tel: (800) 937-2580
Fax: (401) 738-1970

E-Mail: kphelan@rianalytical.com

Standard analyses were performed in accordance with Methods for Analysis of Water and Wastes, EPA-600/4/79-020, Test Methods for Evaluating Solid Waste, SW-846, or Standard Methods for the Examination of Water and Wastewater.

Laboratory Sample Number / Client Sample Identification

Method Number : Description	Result (ug/L)
045485 / FS-1S 1405-11558-001 : 5/29/2014 @ 12:30:00 PM	
10200H3-C Chlorophyll a - Corrected; Analyzed: 6/9/2014 4:00:00 PM	1.5
10200H3-U Chlorophyll a - Uncorrected; Analyzed: 6/9/2014 4:00:00 PM	2.1

Notes: Came Pre-filtered using sample volume 1000 ml. P.O. 29902.

Submitted By: Philip Wilson

Thursday, June 12, 2014

CHAIN OF CUSTODY RECORD

R.I. Analytical Laboratories, Inc.

41 Illinois Avenue
Warwick, RI 02888-3007
Tel: 800-937-2580
Fax: 401-738-1970

131 Coolidge St, Suite 105
Hudson, MA 01749-1331
Tel: 800-937-2580
Fax: 978-568-0078

Date Collected	Time Collected	Lab ID	Sample Identification	Grab or Composite	# of Containers & Type [C]	Preservation Code [P]	Matrix Code [M]		Chlorophyll-a - 10200H3	Sample volume = 1000 ml														
5/29/2014	12:30	1405-11558-001	FS-1S	G	1	O	SW		X	X														

Send Report and Invoice to:		Subcontractor Information:	
Company Name:	R.I. Analytical Laboratories, Inc.	Company Name:	Aquatec Biological Sciences, Inc.
Address:	41 Illinois Avenue	Address:	273 Commerce Sreet
City/State/Zip:	Warwick, RI 02888	City/State/Zip:	Williston, VT 05495-7153
Contact Person:	Kristen Phelan	Contact Person:	Jennifer Garrison
Email:	kphelan@rianalytical.com, datareporting@rianalytical.com	Email:	
Telephone:	800-937-2580 ext 116	Telephone:	802-860-1638

Relinquished By	Date	Time	Received by	Date	Time
	6/2/14	1600			

Turn Around Time	
X	Normal
	Rush _____ (Days)

Project Comments

Sample was filtered and the filter put in the freezer on 5/30/14.

If MCL is exceeded, Please notify; Sharon Baker (800-937-2580 x104) or Eric Jensen (401-497-9593) also Alan Ford (401-562-1332/cell #617-893-0253)

PO # : 29902

Temperature Upon Receipt °C

Date Shipped:	6/2/2014
X	UPS
X	Overnight
X	Shipped on Ice
WO #:	1405-11558

Containers: P=Poly, G=Glass, AG=Amber Glass, V=Vial, St=Sterile Preservatives: A=Ascorbic Acid, NH4=NH_4Cl, H=HCl, M=MeOH, N=HNO_3, NP=None, S=H_2SO_4, SB=$NaHSO_4$, SH=NaOH, T=$Na_2S_2O_3$, Z=ZnOAc

Matrix Codes: GW=Groundwater, SW=Surface Water, WW=Wastewater, DW=Drinking Water, S=Soil, SL=Sludge, A=Air, B=Bulk/Solid, O= Filter

CHAIN OF CUSTODY RECORD

R.I. Analytical Laboratories, Inc.

41 Illinois Avenue
Warwick, RI 02888-3007
Tel: 800-937-2580
Fax: 401-738-1970

131 Coolidge St, Suite 105
Hudson, MA 01749-1331
Tel: 800-937-2580
Fax: 978-568-0078

Date Collected	Time Collected	Field Sample Identification	Grab or Composite	# of Containers & Type [C]	Preservation Code [P]	Matrix Code [M]	Alkalinity	Chloride	Hardness	350 Dissolved Phosphorus	Nitrate-N	Nitrite-N	Iron	Total Phosphorus	Ammonia-N	TKN	Fecal Coliform	Chlorophyll-a
5/29/14	1230	FP-1S	G	1P	NP	SW	X											
		FP-1S1	G	1P	NP	SW												
		FP-1S																
		FP-1S	G	1P	N	SW							X					
		FP-1S	G	1P	S													
5/29/14	1230	FP-1S	G	1P	N	SW									X			
5/29/14	1230	FP-1S	G	2AG	N	SW										X	X	

Client Information			
Company Name:	Fay, Spofford, & Thorndike		
Address:	One Roberts Road		
City / State / Zip:	Plymouth MA 02360		
Telephone:	508-747-7900	Fax:	508-747-3658
Contact Person:	Eric Sullivan		

Project Information			
Project Name:	Farm Pond Surface water Quality		
P.O. Number:		Project Number:	~~FS-009~~ N3-009 (*)
Report To:	Wayne Perry	Phone:	508-747-7900 Fax: 508-747-3658
Sampled by:	ES + WP	Email report to these addresses:	
Quote No:			

Relinquished By	Date	Time	Received By	Date	Time
[signature]	5/29/14	2:14	[signature]	5/29/14	2:14
[signature]	5/29/14	1652	[signature]	5/29/14	1652
[signature]	5/29/14	1830	[signature]	5-29-14	1445
[signature]	5-29-14	1945			

Turn Around Time

X	Normal	X	EMAIL Report
	5 Business days		
	Rush _____ (business days)		

Project Comments

Circle if applicable: (GW-1), GW-2, GW-3, S-1, S-2, S-3

MCP Data Enhancement QC Package? (Yes), No

(*) change made per EricSullivan 5/30/14 NP

Temp. Upon Receipt 12 °C

Lab Use Only

✓	Sample Pick Up Only
	RIAL sampled; attach field hours
✓	Shipped on ice
Workorder No:	14E5-11552

Containers: P=Poly, G=Glass, AG=Amber Glass, V=Vial, St=Sterile Preservatives: A=Ascorbic Acid, NH4=[illegible] M=MeOH, N=HNO_3, NP=None, S=H_2SO_4, SB=$NaHSO_4$, SH=NaOH, T=$Na_2S_2O_3$, Z=ZnOAc

Matrix Codes: GW=Groundwater, SW=Surface Water, WW=Wastewater, DW=Drinking Water, S=Soil, SL=[illegible]r, B=Bulk/Solid, O=_____

CHAIN OF CUSTODY RECORD

R.I. Analytical Laboratories, Inc.

41 Illinois Avenue
Warwick, RI 02888-3007
Tel: 800-937-2580
Fax: 401-738-1970

131 Coolidge St, Suite 105
Hudson, MA 01749-1331
Tel: 800-937-2580
Fax: 978-568-0078

04-16-14

Date Collected	Time Collected	Field Sample Identification	Grab or Composite	# of Containers & Type C	Preservation Code P	Matrix Code M	Alkalinity	Chloride, Hardness, BOD	Nitrate-N Nitrite-N	Iron	Total Phosphorus	Ammonia-N	Fecal Coliform	Chlorophyll-a (*)	Dissolved Phosphorus	
5/29/14	12 pm	FP-DUP ID	G	1P	NP	SW	X	X								
		FP-1D	G	1P	NP	SW		X	X					X		
		FP-1D	G	1P	NP	SW							X	X		NP 5/30/14 per Eric Sullivan
		FP-1D	G	1P	N	SW				X						
		FP-1D	G	1P	S	SW					X	X				
		FP-1D	G	2AG	NP	SW								X		
		FP-1D	G	1st	NP	SW							X			

Client Information			
Company Name:	Fay, Spofford, & Thorndike		
Address:	One Roberts Road		
City / State / Zip:	Plymouth MA 02360		
Telephone:	508-747-7900	Fax:	508-747-3658
Contact Person:	Eric Sullivan		

Project Information			
Project Name:	Farm Pond Surface Water Quality		
P.O. Number:		Project Number:	
Report To:		Phone: 508-747-7900	Fax: 508-747-3658
Sampled by:		Email report to these addresses:	
Quote No:			

Relinquished By	Date	Time	Received By	Date	Time
	5/29/14	2:14		5/29/14	2:14
	5/29/14	16:00		5/29/14	16:30
	5/29/14	5:30		5/29/14	17:30
	5-29-14	18:00			

Turn Around Time			
X	Normal	X	EMAIL Report
	5 Business days		
	Rush _____ (business days)		

Project Comments

Circle if applicable: (GW-1) GW-2, GW-3, S-1, S-2, S-3

MCP Data Enhancement QC Package? (Yes) No

(*) do not analyze chlorophyll-a on this sample per Eric Sullivan 5/30/14. NP

Temp. Upon Receipt 12 °C

Lab Use Only	
✓	Sample Pick Up Only
	RIAL sampled; attach field hours
✓	Shipped on ice
Workorder No:	14C5 1155

Containers: P=Poly, G=Glass, AG=Amber Glass, V=Vial, St=Sterile Preservatives: A=Ascorbic Acid, NH4=NH_4Cl, H=HCl, M=MeOH, N=HNO_3, NP=None, S=H_2SO_4, SB=$NaHSO_4$, SH=NaOH, T=$Na_2S_2O_3$, Z=ZnOAc

Matrix Codes: GW=Groundwater, SW=Surface Water, WW=Wastewater, DW=Drinking Water, S=Soil, SL=Sludge, A=Air, B=Bulk/Solid, O=_____

CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike
Attn: Mr. Eric Sullivan
One Roberts Road
Plymouth, MA 02360

Date Received: 6/17/2014
Date Reported: 6/24/2014
P.O. #:
Work Order #: 1406-13136

DESCRIPTION: PROJECT # NS-009 FARM POND SURFACE WATER QUALITY

Subject sample(s) has/have been analyzed by our Warwick, R.I. laboratory with the attached results.

Reference: All parameters were analyzed by U.S. EPA approved methodologies.
The specific methodologies are listed in the methods column of the Certificate of Analysis.

Data qualifiers (if present) are explained in full at the end of a given sample's analytical results.
The Certificate of Analysis shall not be reproduced except in full, without written approval of R.I. Analytical.
Results relate only to samples submitted to the laboratory for analysis.
Test results are not blank corrected.

Certification #: RI LAI0033, MA M-RI015, CT PH-0508, ME RI00015
NH 2537, NY 11726

If you have any questions regarding this work, or if we may be of further assistance, please contact our customer service department.

Approved by:

Sharon Baker
MIS / Data Reporting

enc: Chain of Custody

R.I. Analytical Laboratories, Inc.

CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike
Date Received: 6/17/2014
Work Order #: 1406-13136

Sample # 001
SAMPLE DESCRIPTION: FP-1S (1405-11558-001)
SAMPLE TYPE: GRAB **SAMPLE DATE/TIME:** 5/29/2014 @ 12:30

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Total Phosphorus (as P)	<0.01	0.01	mg/l	SM-4500-P-B, E	6/23/2014 14:45	EC
Dissolved Phosphorus (as P)	<0.01	0.01	mg/l	SM-4500-P-B,E	6/23/2014 14:45	EC

Sample # 002
SAMPLE DESCRIPTION: FP-1D (1405-11558-002)
SAMPLE TYPE: GRAB **SAMPLE DATE/TIME:** 5/29/2014 @ 12:40

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
Total Phosphorus (as P)	0.01	0.01	mg/l	SM-4500-P-B, E	6/23/2014 14:45	EC
Dissolved Phosphorus (as P)	<0.01	0.01	mg/l	SM-4500-P-B,E	6/23/2014 14:45	EC

R.I. ANALYTICAL
Specialists in Environmental Services

CHAIN OF CUSTODY RECORD

41 Illinois Avenue
Warwick, RI 02888-3007
800-937-2580 • Fax: 401-738-1970

131 Coolidge St., Suite 105
Hudson, MA 01749-1331
800-937-2580 • Fax: 978-568-0078

Date Collected	Time Collected	Field Sample Identification	Grab or Composite	# of Containers & Type [C]	Preservation Code [P]	Matrix Code [M]	TPHCS PL 0.01	DISS PHOS PL 0.01
5-29-14	1230	FP-1S (1405-11558-001)	G	3P	SU	GW	X	X
5-29-14	1240	FP-1D (1405-11558-002)	G	3P	SU	GW	X	X

Client Information

Company Name:	FST
Address:	One Roberts Road
City / State / Zip:	Plymouth MA 02360
Telephone:	Fax:
Contact Person:	Eric Sullivan

Project Information

Project Name:	Farm Pond Surface Water Quality
P.O. Number:	Project Number: MS-001
Report To:	Phone: Fax
Sampled By:	Email report to these addresses:
Quote No:	

Relinquished By Signatures	Date	Time	Received By Signatures	Date	Time
Per phone conversation w/ Eric Sullivan	6-17-14	1520	[signature]	6-17-14	1520

Turn Around Time

- [ ] Normal [x] EMAIL Report
- [x] 5 Business days. Possible surcharge
- [ ] Rush – Date Due: ___/___/___

Project Comments

Circle if applicable: GW-1, GW-2, GW-3, S-1, S-2, S-3 MCP Data Enhancement QC Package? Yes No

relog WO# 1405-11558-001 & -002

Temp. Upon Receipt °C

Lab Use Only

- [ ] Sample Pick-Up Only
- [ ] RIAL sampled: attach field hours
- [ ] Shipped on ice

Workorder No: 1406-13136

Containers: P=Poly, G=Glass, AG=Amber Glass, V=Vial, St=Sterile Preservatives: A=Ascorbic Acid, NH4=NH_4Cl, H=HCl, M=MeOH, N=HNO_3, NP=None, S=H_2SO_4, SB=$NaHSO_4$, SH=NaOH, T=$Na_2S_2O_3$, Z=ZnOAc

Matrix Codes: GW=Groundwater, SW=Surface Water, WW=Wastewater, DW=Drinking Water, S=Soil, SL=Sludge, A=Air, B=Bulk/Solid, WP=Wipe, O=_____

R.I. ANALYTICAL
Specialists in Environmental Services

CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike
Attn: Mr. Wayne Perry
400 Crown Colony Plaza
Suite 200
Quincy, MA 02169-0982

Date Received: 8/12/14
Date Reported: 9/3/14
P.O. #:
Work Order #: 1408-17890

DESCRIPTION: PROJECT# NS-009 FARM POND SURFACE WATER QUALITY

Subject sample(s) has/have been analyzed by our Warwick, R.I. laboratory with the attached results.

Reference: All parameters were analyzed by U.S. EPA and Massachusetts Contingency Plan (MCP) approved methodologies where applicable. The specific methodologies are listed in the methods column of the Certificate of Analysis.

Data qualifiers (if present) are explained in full at the end of a given sample's analytical results.

Certification #: RI LAI00033, MA M-RI015, CT PH-0508, ME RI00015
NH 2537, NY 11726

This Certificate represents all data associated with the referenced work order and is paginated for completeness. The complete Certificate includes one attachment; the original Chain of Custody.

If you have any questions regarding this work, or if we may be of further assistance, please contact our customer service department.

Approved by:

Melissa A. Manera

Data Reporting

enc: Chain of Custody

Customer Name : Fay, Spofford & Thorndike

Work Order #: 1408-17890

MassDEP Analytical Protocol Certification Form

Laboratory Name: R.I. Analytical Laboratories Work Order #: 1408-17890

Project / Location: PROJECT# NS-009 FARM POND SURFACE WATER QUALITY RTN

This Form provides certifications for the following data set: list Laboratory Sample ID Number(s):

1408-17890-001 through 1408-17890-002

Matrices: ☒ Groundwater/Surface Water ☐ Soil / Sediment ☐ Drinking Water ☐ Air ☐ Other

CAM Protocol (check all that apply below):

8260 VOC CAM II A ☐	7470/7471 Hg CAM III B ☐	MassDEP VPH CAM IV A ☐	8081 Pesticides CAM V B ☐	7196 Hex Cr CAM VI B ☐	MassDEP APH CAM IX A ☐
8270 SVOC CAM II B ☐	7010 Metals CAM III C ☐	MassDEP EPH CAM IV B ☐	8151 Herbicides CAM V C ☐	8330 Explosives CAM VIII A ☐	TO-15 VOC CAM IX B ☐
6010 Metals CAM III A ☒	6020 Metals CAM III D ☐	8082 PCB CAM V A ☐	9014 Total Cyanide /PAC CAM VI A ☐	6860 Perchlorate CAM VIII B ☐	

Affirmative responses to Questions A through F are required for "Presumptive Certainty" status

A	Were all samples received in a condition consistent with those described on the Chain-of Custody, properly preserved (including temperature) in the field or laboratory, and prepared/analyzed within method holding times?	☒ Yes ☐ No
B	Were the analytical methods(s) and all associated QC requirements specified in the selected CAM protocol(s) followed?	☒ Yes ☐ No
C	Were all required corrective actions and analytical response actions specified in the selected CAM protocol(s) implemented for all identified performance standard non-conformances?	☒ Yes ☐ No
D	Does the laboratory report comply with all the reporting requirements specified in CAM VII A, "Quality Assurance and Quality Control Guidelines for the Aquisition and Reporting of Analytical Data"?	☒ Yes ☐ No
E	a. VPH, EPH, and APH Methods only: Was each method conducted without significant modification(s) ? (Refer to the individual method(s) for a list of significant modifications). b. APH and TO-15 Methods only: Was the complete analyte list reported for each method?	☐ Yes ☐ No ☐ Yes ☐ No
F	Were all applicable CAM protocol QC and performance standard non-conformances identified and evaluated in a laboratory narrative (including all "No" responses to Questions A through E)?	☒ Yes ☐ No

Responses to Questions G,H and I below are required for "Presumptive Certainty" status

G	Were the reporting limits at or below all CAM reporting limits specified in the selected CAM protocol(s)?	☒ Yes ☐ No [1]

***Data User Note:** Data that achieve "Presumptive Certainty" status may not necessarily meet the data usability and representativeness requirements described in 310 CMR 40. 1056 (2)(k) and WSC-07-350.*

H	Were all QC performance standards specified in the CAM protocol(s) achieved?	☒ Yes ☐ No [1]
I	Were results reported for the complete analyte list specified in the selected CAM protocol(s)?	☐ Yes ☒ No [1]

[1] *All negative responses must be addressed in an attached laboratory narrative.*

I, the undersigned, attest under the pains and penalties of perjury that, based upon my personal inquiry of those responsible for obtaining the information, the material contained in this analytical report is, to the best of my knowledge and belief, is accurate and complete.

Signature: [signature] Position: Laboratory Director

Printed Name: Eric H. Jensen Date: 9-3-14

Case Narrative

Date: 9/3/2014

Fay, Spofford & Thorndike
Attn: Mr. Wayne Perry

400 Crown Colony Plaza
Suite 200
Quincy, MA 02169-0982

Project: PROJECT# NS-009 FARM POND SURFACE WATER QUALITY

Work Order #: 1408-17890

The following exceptions were noted for this Work Order:

The methods requested for Fecal Coliform (MF), BOD 5, Chlorophyll A, Nitrite (as N), Nitrate (as N), TKN (as N), Ammonia (as N), Total Phosphorus (as P), Dissolved Phosphorus (as P), Chloride, and Alkalinity (as CaCO3) are not listed in the table of contents for compendium of MCP analytical methods. Therefore, there is no guideline for presumptive certainty.

Chorophyll A were analyzed at our subcontracted laboratory, Aquatec Biological Services, Inc.

Total Metals by 6010

Question 1 - Per the client's request, only a subset of the MCP analyte list for SW-846 Method 6010 Total Metals is reported.

There were no additional exceptions or analytical issues to discuss concerning the testing requirements for the project.

R.I. Analytical Laboratories, Inc.
CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike

Date Received: 8/12/14

Work Order #: 1408-17890

PROJECT# NS-009 FARM POND SURFACE WATER QUALITY

Sample # 001
SAMPLE DESCRIPTION: FP-1S
SAMPLE TYPE: GRAB **SAMPLE DATE/TIME:** 8/12/2014 @ 11:35

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE ANALYZED		ANALYST
Fecal Coliform (MF)	3	1	cfu/100mls	SM9222D 19 ed	8/12/14	17:53	KCL
BOD 5	<3.0	3.0	mg/l	SM 5210B	8/12/14	20:10	KL
Chlorophyll A	See Attached		mg/m^3	SM 10200-H	8/12/14	0:00	*AQ
Nitrite (as N)	<0.05	0.05	mg/l	EPA 300.0	8/13/14	4:32	TAH
Nitrate (as N)	<0.05	0.05	mg/l	EPA 300.0	8/13/14	4:32	TAH
TKN (as N)	<0.50	0.50	mg/l	SM 4500 NORG D	8/19/14	22:20	WWW
Ammonia (as N)	<0.10	0.10	mg/l	SM4500-NH3 B,H	8/19/14	10:57	STH
Total Phosphorus (as P)	0.010	0.010	mg/l	SM-4500-P-B, E	8/20/14	13:40	ML
Dissolved Phosphorus (as P)	<0.05	0.05	mg/l	SM-4500-P-B,E	8/20/14	13:40	ML
Chloride	8.1	2.5	mg/l	EPA 300.0	8/13/14	4:32	TAH
Alkalinity (as CaCO3)	2.8	1.0	mg/l	SM 2320B	8/12/14	15:30	PTT
Total Metals							
Calcium	1.82	0.500	mg/l	SW-846 6010C	8/14/14	11:17	JRW
Iron	<0.050	0.050	mg/l	SW-846 6010C	8/14/14	11:17	JRW
Magnesium	0.556	0.500	mg/l	SW-846 6010C	8/14/14	11:17	JRW
Hardness as CaCO3	6.83	0.33	mg/l	SW-846 6010C	8/14/14	11:17	JRW
ICP Digestion				SW-846 3010A	8/13/14	22:48	OMC

*AQ - Chlorophyll analyzed by Aquatec Biological Services, Inc.

R.I. Analytical Laboratories, Inc.
CERTIFICATE OF ANALYSIS

Fay, Spofford & Thorndike

Date Received: 8/12/14

Work Order #: 1408-17890

PROJECT# NS-009 FARM POND SURFACE WATER QUALITY

Sample # 002
SAMPLE DESCRIPTION: FP-1D
SAMPLE TYPE: GRAB **SAMPLE DATE/TIME:** 8/12/2014 @ 11:50

PARAMETER	SAMPLE RESULTS	DET. LIMIT	UNITS	METHOD	DATE ANALYZED		ANALYST
Fecal Coliform (MF)	<1	1	cfu/100mls	SM9222D 19 ed	8/12/14	17:53	KCL
BOD 5	<3.0	3.0	mg/l	SM 5210B	8/12/14	20:14	KL
Nitrite (as N)	<0.05	0.05	mg/l	EPA 300.0	8/13/14	4:44	TAH
Nitrate (as N)	<0.05	0.05	mg/l	EPA 300.0	8/13/14	4:44	TAH
TKN (as N)	<0.50	0.50	mg/l	SM 4500 NORG D	8/19/14	22:20	WWW
Ammonia (as N)	0.36	0.10	mg/l	SM4500-NH3 B,H	8/19/14	10:57	STH
Total Phosphorus (as P)	0.036	0.01	mg/l	SM-4500-P-B, E	8/20/14	13:40	ML
Dissolved Phosphorus (as P)	<0.05	0.05	mg/l	SM-4500-P-B,E	8/20/14	13:40	ML
Chloride	7.7	2.5	mg/l	EPA 300.0	8/13/14	4:44	TAH
Alkalinity (as CaCO3)	2.8	1.0	mg/l	SM 2320B	8/12/14	15:30	PTT
Total Metals							
Calcium	2.04	0.500	mg/l	SW-846 6010C	8/14/14	11:48	JRW
Iron	0.686	0.050	mg/l	SW-846 6010C	8/14/14	11:48	JRW
Magnesium	0.575	0.500	mg/l	SW-846 6010C	8/14/14	11:48	JRW
Hardness as CaCO3	7.46	0.33	mg/l	SW-846 6010C	8/14/14	11:48	JRW
ICP Digestion				SW-846 3010A	8/13/14	22:48	OMC

QA/QC Report

Client: Fay, Spofford & Thorndike
WO #: 1408-17890
Date: 9/3/2014

-Method Blanks Results-

Parameter	Units	Results	Date Analyzed
Nitrite (as N)	mg/l	<0.05	8/12/2014
Nitrate (as N)	mg/l	<0.05	8/12/2014
Chloride	mg/l	<2.5	8/12/2014
BOD 5	mg/l	<2.0	8/12/2014
Alkalinity (as CaCO3)	mg/l	<1.0	8/12/2014
Total Phosphorus (as P)	mg/l	<0.05	8/20/2014
TKN (as N)	mg/l	<0.50	8/19/2014
Ammonia (as N)	mg/l	<0.10	8/19/2014
Metals			
Calcium	mg/l	<0.500	8/14/2014
Iron	mg/l	<0.050	8/14/2014
Magnesium	mg/l	<0.500	8/14/2014

-LCS/LCS Duplicate Data Results-

Parameter	CRM Acceptance Limits	Spike Conc	LCS Conc	LCS % Rec	LCS Dup Conc	LCS DUP % Rec	% RPD	Date Analyzed
BOD 5		198	198.3	100			0	8/12/2014
Alkalinity (as CaCO3)		50.0	49	98			0	8/12/2014
Nitrite (as N)		1.0	1.09	109			0	8/13/2014
Nitrate (as N)		1.00	0.984	98			0	8/13/2014
Chloride		10.0	9.98	101			0	8/13/2014
Nitrite (as N)		1.0	1.09	109			0	8/13/2014
Nitrate (as N)		1.00	0.984	98			0	8/13/2014
Chloride		10.0	10.1	101			0	8/13/2014
Metals								
Calcium		10.0	10.4	104	10.3	103	1	8/14/2014
Iron		10.0	10.1	101	10.1	101	0	8/14/2014
Magnesium		10.0	10.5	105	10.6	106	1	8/14/2014
Total Phosphorus (as P)		1.30	1.3	100			0	8/20/2014
Ammonia (as N)		4.00	3.2	80			0	8/19/2014
TKN (as N)		5.00	4.3	86			0	8/19/2014

Aquatec Biological Sciences, Inc.
273 Commerce Street
Williston, VT 05495
Tel: (802) 860 - 1638 Fax: (802) 658 - 3189

SDG: 13997
Project: 14023

Chlorophyll *a* Analytical Report

Project Name: Chlorophyll a

R. I. Analytical Laboratories, Inc.
41 Illinois Avenue

Warwick, RI 02888

Tel: (800) 937-2580
Fax: (401) 738-1970

E-Mail: kphelan@rianalytical.com

Standard analyses were performed in accordance with Methods for Analysis of Water and Wastes, EPA-600/4/79-020, Test Methods for Evaluating Solid Waste, SW-846, or Standard Methods for the Examination of Water and Wastewater.

Laboratory Sample Number / Client Sample Identification

Method Number : Description	Result (ug/L)
045723 / FP-1S : 8/12/2014 @ 11:35:00 AM	
10200H3-C Chlorophyll a - Corrected; Analyzed: 8/28/2014 9:25:00 AM	2.1
10200H3-U Chlorophyll a - Uncorrected; Analyzed: 8/28/2014 9:25:00 AM	2.7

Notes: R.I. Analytical Laboratories P.O. Number 30196. Lab ID (in-part, written on sample's wrapping): 17890-1.

Submitted By: Tuesday, September 02, 2014

Appendix E. Field Survey Notes

Farm Pond Initial Field Inspection: May 2014

Field Objectives:

- Install seepage meters and record potential seepage over day
- Do spot check of existing bathymetric map (20-30 points) and identify general sediment types
- Collect water quality samples from surface and near bottom at deep hole and measure temperature-DO profile of water column, take SDT depth,
- Inspect shoreline, existing SW devices, and outlet structure (photodocument)
- Watershed reconnaissance (to check downgradient areas to east)

General Equipment Need*s:

- Boat/motor/oars/PFDs/anchor w/line
- 4-6 seepage meters with collection devices (see UF document for construction & details)
- Chest waders and wet suit
- Calibrated cylinder and funnel
- Hand-held GPS unit
- GIS-based lake map
- Depth meter
- Sediment probe (i.e., 6-ft calibrated rod)
- Camera
- YSI Series 6-type meter for temp/DO/%DO/Sp.cond/pH and 50 ft cable (it is useful to mark off distance on cable with electrical tape at 5' intervals before mobilizing)
- alpha water bottle for deep sample
- Water quality sample bottles (need to arrange with lab for drop/off)
- Coolers and ice
- Secchi disk & viewer
- Field notebook
- Personal items – water, food, sun protection, etc

*Dave will supply items highlighted in yellow

For Town/FPAC, we need:

- GIS data from recent bathymetric map
- Signage on public beach, town hall and local access cable regarding field work
- Notification of public safety (in case they get calls)
- Recent vegetation map (not necessary for May trip)

Wayne Perry
Dave Mitchell
Eric Sullivan

Farm Pond 5/29/04

Weather clear, calm 50-60s [illegible]ty

observations

SDT = 7.3M
Total depth = 54.8

Outlet - about 13:00

0.5 ft wide, flowing actively
1-1.5 cfs visually estimated, could be due to wave action pushing against berm
Pond behind berm 8-9 acres
Water lilies, pollen

Berm - rock berm with earthen fill, few trees mostly shrubs
no ~~original~~ man-made outlet
some seepage occurring at two points
generally sound
looks to be 2.5 ft - 2 ft head between berm and pond behind

Shoreline - very vegetated with trees and shrubs
no clear indication of water level fluctations

Lake Column Profiles

Depth	T°(C)	DO mg/l	% sat	Sp Cond	pH
0.5	18.1	9.92	105.1	37	7.97
2.5	17.94	9.75	102.6	37	7.79
5.0	17.8	9.71	101.9	36	7.67
7.5	17.53	9.71	101.6	36	7.57
10.0	17.5	9.67	101.0	36	7.47
12.5	17.21	9.66	100.3	36	7.43
15.0	15.7	10.04	101.4	34	7.36
17.5	13.41	10.94	105	32	7.37
20	12.55	11.11	104.3	31	7.34
25	10.61	11.13	98.9	30	7.25
30	7.96	10.93	90.5	28	7.11
35	6.83	9.66	78.5	27	6.94
40	6.44	9.14	74.2	27	6.83
45	6.19	8.59	69.0	26	6.71
50	6.15	7.56	60.0	27	6.56
27.5	8.33	9.70	82.3	28	7.05

Deep Sample taken at 45 feet

20 Farm Pond 5/29/14

	Depth	GPS N	GPS W	Notes
1	12.5	42 13 59.1	71° 20 56"	
2	20.7	42 13 54.4	71° 20 56.1"	
3	25.9	42 13 54.7	71° 20' 54.8"	
4	28.9	42° 13' 55.1	71° 20' 53.3"	
5	38.2	42° 13' 55.3	71° 20' 52.0"	
6	41.3	42° 13' 55.5	71° 20' 50.8"	
7	42.6	42° 13' 58.5	71 20' 49.6"	
8	40.6	42° 14' 01.3"	71° 20' 48.3	
9	41.8	42° 13' 56.1"	71° 20. 46.7	
10	46.2	42° 13' 56.1"	71° 20 45.4	
11	50.1	42° 13 56.3"	71° 20' 45.1	
12	51.7	42° 13' 56.5"	71° 20' 44.1	
13	52.3	42° 13' 56.7"	71° 20' 43.4	
14	45.1	42° 13' 57.0"	71° 20 42.6"	
15	32.1	42° 13 57.3"	71 20 41.5"	
16	14.2	42° 13 57.6"	71° 20 40.5"	
17	20.7	42° 13 58.1"	71° 20 40.9"	
18	21.9	42° 13 58.3"	71° 20 38.6"	
19	21.5	42° 13 58.4	71° 20 38.3"	
20	21.1	42 13 58.9	71° 20 38.2"	

Reference Point – middle of boat ramp

2X GPS = N: 42° 13.561 N: 071. 21. 01.4
42 13.56 071. 21. 013

Farm Pond 5/29/14 21

	Depth	GPS N	GPS W	Notes
21	21.2	42° 13.2[illegible]4	71° 20 37.4"	
22	18.7	42° 13' 52.9	71' 20 36.1"	
23	13.5	42 14 00.5	71° 20' 34.5"	
24	10.7	42° 14' 01.6	71° 20' 33.2"	∠ off buck
25	8.9	42° 14' 02.2"	71° 20 30.6"	∠ off duck Structure Point
26	5.8	42° 14' 01.7'	71° 20' 29.4"	
27		42° 14' 02.9"	71° 20' 28.8"	* outlet in between pine tree + maple
28	7	42° 14' 06.1"	71' 20 30.3"	rocky cobbley
29	5.6	42° 14' 07.5"	71' 20 29.8"	
30	5.3	42° 14' 08.2"	71° 20' 29.2	
31		42° 14' .017	71.20.289	seepage #1 sat 10:20 # 2 deep
32	1.8	42° 14. 113	71.20.304	seepage #3 shell 10:30 = 4 deep
33	2.3	42° 14. 138	71.20.[illegible]	seepage #5 10:40
34	2.4	42. 14 172	71.20.351	seepage #6 11:05

	in		
1,2	11:40	15:45/15:50	1 = 2050 +50
3,4	12:05	15:58/16:02	#3 hard "recycled" bag
6	12:15		2 = 2180 +180
			3 = 2550 +550
No #5 – lack of pipe		no read due to	4 = 3045 +1045
			6 = no reading bag loose

22

Photolog

Phone pix of "outlet" at berm

seepage meters

placement	distance from shore
1	13'
2	26'
3	8 10'
4	16'

23

Station	Depth	GPS N	GPS W	Note
35	23.0	42.14.062	71.20355	
36	24.0	42.140M	71.20.40.7	
37	26.0	42 14 01.8	71° 20' 41.7"	
38	27.4	42° 14' 00.9"	71° 20' 42.3"	
39	30.3	42° 14' 00.3"	71° 20' 43.3"	
40	34.4	42° 13' 59.8"	71° 20' 44.0"	
41	39.9	42° 13 59.3"	71° 20. 44.8"	
42	52.6	42° 13 59.2"	71° 20. 45.7"	
43	56.8	42° 13 59.3'	71° 20' 45.9"	
44	57.5	42° 13' 51.4"	71° 20' 46.1"	
45	24.4	42° 13' 54.3"	71° 20' 55.5"	
46	26.4	42° 13' 54.0"	71° 20' 54.3"	
47	29.8	42° 13' 53.6"	71° 20' 52.6"	
48	29.6	42° 13' 53.4"	71° 20' 51.7"	
49	30.5	42° 13 53.0"	71° 20 51.0"	
50	29.7	42° 13' 52.7"	71° 20 49.6"	
51	25.1	42° 13' 52.0"	71° 20' 49.3"	
52	14.1	42° 13' 52.2"	71° 20' 49.3"	
53	10.0	42° 13 52.2"	71° 20 49.5	
54	7.8	42° 13' 52.5"	71 20' 45.1"	
55	8.3	42 13 53.0"	71 20 44.3"	
56	7.1	42 13 53.2"	71 20' 42.4"	
57	5.2	42 13 53.6"	71 20' 42.4"	
58	4.4	42 13' 53.4"	71 20' 41.5"	

GPS notes

Station	depth	N	W
59	2.7	42°13' 53.0"	71° 20 42.3"
60	8.1	42° 13' 52.3"	71° 20 42.8"
61	3.5	42° 13' 52.3"	71° 20 '43.4"
62	17.3	42° 13' 50.6"	71° 20' 43.3"
63	~~11.8~~	Disregard	NO GPS
64	17.5	42° 13' 50.6	71° 20' 42.9"
65	17.2	42° 13' 50.7	71° 20' 40.9"
66	15.5	42° 13' 50.7"	71° 20' 39.2"
67	5.0	42 13' 50.9"	71° 20' 37.9"
68	7.1	42° 13' 50.8"	71° 20 36.5"
69	6.2	42° 13 50.8"	71° 20 34.5"
70	4.7	42° 13 51.4"	71° 20' 33.0"
71	9.6	42° 14' 10.2"	71° 20' 33.6"
72	8.8	42° 14 11.9"	71° 20' 34.2"
73	7.2	42° 14 14.3"	71° 20' 38.9"

Farm Pond Second Field Monitoring: August 2014

Field Objectives:

- Install seepage meters and record potential seepage over day
- Collect water quality samples from surface and near bottom at deep hole and measure temperature-DO profile of water column, take SDT depth,
- Conduct aquatic vegetation survey

General Equipment* Needs:

- Boat/motor/oars/PFDs/anchor w/line
- 6 seepage meters with collection devices
- Chest waders and wet suit
- Calibrated cylinder and funnel
- Hand-held GPS unit
- GIS-based lake map with Aquatic vegetation transects transcribed and GPS points identified
- Depth meter
- Camera
- YSI Series 6-type meter for temp/DO/%DO/Sp.cond/pH and 50 ft cable (it is useful to mark off distance on cable with electrical tape at 5' intervals before mobilizing)
- alpha water bottle for deep sample
- Water quality sample bottles (need to arrange with lab for drop/off)
- Coolers and ice for water quality samples
- Secchi disk & underwater viewer
- Field notebook
- Aquatic vegetation survey sheets
- Lake rake
- Underwater camera with visor
- Cooler and ziplock bags for plant voucher specimens
- Personal items – water, food, sun protection, etc

*Dave will supply items highlighted in yellow

For Town/FPAC, we need:

- Notification of public safety or swim beach lifeguards (in case they get calls)
- Reminder to resident on NE shoreline that we are coming

GPS

Station	depth	N	W	Notes
59	2.7	42°13' 53.0"	71° 20 42.3"	
60	8.1	42°13' 52.3"	71° 20 42.8"	
61	3.5	42° 13' 52.2"	71° 20 '43.4"	
62	17.3	42° 13' 50.6"	71° 20' 43.3"	
63	~~11.8~~	Disregard	NO GPS	
64	17.5	42° 13' 50.6	71° 20' 42.9"	
65	17.2	42° 13' 50.8	71° 20 · 42.9"	
66	15.5	42° 13	50.7" 71° 20' 39.2"	
67	5.0	42 13'	50.9" 71° 20' 37.9"	
68	7.1	42° 13'	50.8" 71° 20 36.5"	
69	6.2	42° 13	60.8" 71° 20 34.5"	
70	4.7	42° 13	51.4" 71° 20' 33.0"	
71	9.6	42° 14'	10.2" 71° 20' 53.6"	
72	8.8	42° 14	11.1" 71° 20 ' 34.2"	
73	7.2	42° 14	14.3" 71° 20' 32.4"	

Farm Pond August 12, 2014

Wayne Peery
Erica Sullivan
Dave Mitchell

Weather am clear, calm 60-70
12:15 pm cloudy, calm 70-80

Depth	T°(C)	DO ppt	% sat	Sp. Cond	pH
0.5	26.1	7.4	90.8	44	8.72
2.5	26.1	7.34	90.7	44	8.50
5.0	25.9	7.33	90.1	44	8.32
7.5	25.8	7.31	89.8	43	8.22
10.0	25.4	7.05	85.0	43	8.11
12.5	23.2	6.01	68.4	41	7.84
15.0	19.1	6.21	67.0	37	7.63
17.5	15.9	6.9	70.6	34	7.80
20.0	12.9	7.31	69.4	32	7.35
~~22.5~~	11.3	7.07	64.5	31	7.22
~~25~~	9.8	6.64	60.8	30	7.12
~~35~~ 27.5	8.56	5.19	44.4	29	6.93
~~40~~ 30	8.05	3.57	26.9	29	6.89
~~37.5~~ ~~45~~ 35	7.91			28	6.59
~~50~~ 40	7.26	3.11	24.4	29	6.75
48	6.80	2.13	16.2	30	6.67
50	6.70	1.23	10.1	34	6.60

Deep Sample taken at ~~45~~ ft

Total depth = ~~52~~ ft

SDT depth = 7.3 m

30 (thud)	9.48	~~4.42~~	43	29	6.63
35 (thud)	8.0	3.60	24.1	29	6.47

30	9.16	3.05	29.0	29	6.59
27.5	10.2	4.22	45.2	30	6.68

Farm Pond Water Color Profile

Position N: 42 14 00.0
W: 71 20 46.1

Total depth (ft) = 52.8 ft
SDT depth (m) = 7.3 M

Seepage Meters

#	Start	Amount	Finish	Amount	Δ
1	0900	250	1501	320	+70
2	0810	250	—	—	—
3	0815	250	1512	170	-80
4	0820	250	—	~~170~~	~~-80~~
5	8830	250	1531	270	+20
6	0835	250	1525	170	-80

Dock/Boat Launch Reference GPS

N: 42° 13.55.96'
W 71° 21.102

Seepage Meter GPS position

#1	N	42	14	15
	W	71	20	37.4
#2	N			
	W			
~~#3~~	N	42	14	13.2
	W	71	20	33.2
~~#4~~	N			
	W			
#5	N	42	14	11.6
	W	71	20	30.8
#6	N	42	14'	09.8"
	W	71	20'	29.2"

Drainage culvert

N 42° 14' 10.7"
W 71° 20' 28.8"

Appendix F. Aquatic Vegetation Survey

Table 1. List of Common Macrophyte Species: Common and Scientific Names.		
Abbreviation	**Scientific Name**	**Common Name**
Algae	*Not specified*	Algal mat
Moss	*Musci spp.*	Aquatic moss
Bsch	*Brasenia schreberi*	Watershield
Ccar	*Cabomba caroliniana*	Fanwort
Calli	*Callitriche sp.*	Water starwort
Cdem	*Ceratophyllum demersum*	Coontail
Chara	*Chara spp.*	Muskgrass
Dver	*Decodon verticillatus*	Swamp loosestrife
Eaci	*Eleocharis acicularis*	Needle rush
Eaqa	*Eriocaulon aquaticum*	Pipewort
Ecan	*Elodea canadensis*	Waterweed
Emin	*Elatine minima*	Waterwort
Ghet	*Gratiola heterosepia*	Hedge hyssop
Iso	*Isoetes spp.*	Quillwort
Lmin	*Lemna minor*	Duckweed
Lsal	*Lythrum salicaria*	Purple loosestrife
Mhet	*Myriophyllum heterophyllum*	Variable watermilfoil
Mspic	*Myriophyllum spicatum*	Eurasian watermilfoil
Nflex	*Najas flexilis*	Common naiad
Nvar	*Nuphar variegatum*	Yellow water lily
Nit	*Nitella spp.*	Nitella or Brittlewort
Nodo	*Nymphaea odorata*	White water lily
Poly	*Polygonum amphibium*	Water smartweed
Pcord	*Pontederia cordata*	Pickerelweed
Pamp	*Potamogeton amplifolius*	Broadleaf pondweed
Prob	*Potamogeton epihydrus*	Leafy pondweed
Ppul	*Potamogeton robbinsii*	Robbins pondweed
Ranu	*Ranunculus spp.*	Water crowfoot
Sgram	*Sagittaria gramineus*	Submerged arrowhead
Salix	*Salix sp.*	Willow
Spol	*Spirodela polyrhiza*	Big duckweed
Tlat	*Typha latifolia*	Cattail
Tnat	*Trapa natans*	Water chestnut
Ugem	*Utricularia purpurea*	Large Purple Bladderwort
Uspp	*Utricularia spp.*	Bladderwort
Wcol	*Wolffia columbiana*	Watermeal

Methods

The point-intercept methodology is intended to document the spatial distribution and percent cover of aquatic plants at 10 transects located approximately 1000 ft apart on the shoreline. At each point, FTS recorded the following:

- The GPS waypoint.
- Water depth using a metal graduated rod or a mechanical depth finder.
- Plant cover ratings using a standardized system.
- Relative abundance of plant species.

For each plant species, staff recorded whether the species was present at trace (one or two sprigs), sparse (a handful of the plant), moderate (a few handfuls of the plant), or dense (many handfuls of the plant) levels at each site. Plant cover represents the total surface area covered in plants (2 dimensions). For cover, areas with no plants were assigned a "0," areas with approximately 1-25% cover were assigned a "1," a "2" for 26-50%, a "3" for 51-75%, a "4" for 76-99%, and a "5" for 100% cover.

Lake Name: Farm Pond Transect(s): 1-2 Survey Date: 8/12/14

Farm Pond Aquatic Vegetation Assessment Survey Sheet

Transect # 1										Transect # 2									
Transect GPS start:	N									Transect GPS start:	N	42°13'49.4"							
	W										W	71°20'56.0"							
Transect GPS finish	N									Transect GPS finish	N	42°13'50.3							
	W										W	71°20'54.7"							
		Aquatic Vegetation Assessment Site Number										Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.			NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		1	2	3	4	5	6	7	8			9	10	11	12	13	14	15	16
Water Depth (ft)		0.5	5	10						Water Depth (ft)		2	5	10					
Areal Plant Cover		1	1	2						Areal Plant Cover		0	2	2					
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.			NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	1	2	3	4	5	6	7	8	**Plant Name**	**Code**	11	12	13	14	15	16	17	18
Algal mat	Algae									Algal mat	Algae			M					
Aquatic moss	Moss									Aquatic moss	Moss								
Watershield	Bsch									Watershield	Bsch								
Fanwort	Ccar									Fanwort	Ccar								
Water starwort	Calli									Water starwort	Calli								
Coontail	Cdem									Coontail	Cdem								
Muskgrass	Chara									Muskgrass	Chara								
Swamp loosestrife	Dver									Swamp loosestrife	Dver								
Needle spikerush	Eaci									Needle rush	Eaci								
Pipewort	Eaqa	S	S							Pipewort	Eaqa		M	S					
Waterweed	Ecan									Waterweed	Ecan								
Waterwort	Emin									Waterwort	Emin								
Hedge hyssop	Ghet									Hedge hyssop	Ghet								
Quillwort	Iso									Quillwort	Iso								
Duckweed	Lmin									Duckweed	Lmin								
Purple loosestrife	Lsal									Purple loosestrife	Lsal								
Variable watermilfo	Mhet									Variable watermilfo	Mhet								
Eurasian watermilfo	Mspic									Eurasian watermilfo	Mspic								
Common naiad	Nflex									Common naiad	Nflex								
Yellow water lily	Nvar									Yellow water lily	Nvar								
Nitella spp.	Nit		S	S						Nitella spp.	Nit		S	M					
White water lily	Nodo									White water lily	Nodo								
Water smartweed	Poly									Water smartweed	Poly								
Pickerelweed	Pcord									Pickerelweed	Pcord								
Broadleaf pondweed	Pamp									Broadleaf pondweed	Pamp								
Leafy pondweed	Prob									Leafy pondweed	Prob								
Robbins pondweed	Ppul									Robbins pondweed	Ppul								
Water crowfoot	Ranu									Water crowfoot	Ranu								
Submerged arrowhe	Sgram									Submerged arrowhe	Sgram								
Willow	Salix									Willow	Salix								
Big duckweed	Spol									Big duckweed	Spol								
Cattail	Tlat									Cattail	Tlat								
Water chestnut	Tnat									Water chestnut	Tnat								
Purple Bladderwort	Ugem									Purple Bladderwort	Ugem								
Bladderwort	Uspp			S						Bladderwort	Uspp								
Watermeal	Wcol									Watermeal	Wcol								
Species #1	Sp.#1									Species #1	Sp.#1								
Species #2	Sp.#2									Species #2	Sp.#2								
Species #3	Sp.#3									Species #3	Sp.#3								
Species #4	Sp.#4									Species #4	Sp.#4								
Species #5	Sp.#5									Species #5	Sp.#5								

Lake Name: Farm Pond Transect(s): 3 and 4 Survey Date: 08/12/14

Farm Pond Aquatic Vegetation Assessment Survey Sheet

Transect # 3		
Transect GPS start:	N	42°13'49.4"
	W	71°20'44.5"
Transect GPS finish	N	42°13'49.7"
	W	71°20'44.8"

Transect # 4		
Transect GPS start:	N	42°13'52.1"
	W	71°20'31.2"
Transect GPS finish	N	
	W	

		Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		17	18	19	20	21	22	23	24
Water Depth (ft)		2.5	7	10					
Areal Plant Cover		0	2	0					
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	17	18	19	20	21	22	23	24
Algal mat	Algae								
Aquatic moss	Moss								
Watershield	Bsch								
Fanwort	Ccar								
Water starwort	Calli								
Coontail	Cdem								
Muskgrass	Chara								
Swamp loosestrife	Dver								
Needle spikerush	Eaci								
Pipewort	Eaqa								
Waterweed	Ecan								
Waterwort	Emin								
Hedge hyssop	Ghet								
Quillwort	Iso								
Duckweed	Lmin								
Purple loosestrife	Lsal								
Variable watermilfo	Mhet								
Eurasian watermilfo	Mspic								
Common naiad	Nflex								
Yellow water lily	Nvar								
Nitella spp.	Nit		M						
White water lily	Nodo								
Water smartweed	Poly								
Pickerelweed	Pcord								
Broadleaf pondweed	Pamp								
Leafy pondweed	Prob								
Robbins pondweed	Ppul								
Water crowfoot	Ranu								
Submerged arrowhe	Sgram								
Willow	Salix								
Big duckweed	Spol								
Cattail	Tlat								
Water chestnut	Tnat								
Purple Bladderwort	Ugem								
Bladderwort	Uspp								
Watermeal	Wcol								
Species #1	Sp.#1								
Species #2	Sp.#2								
Species #3	Sp.#3								
Species #4	Sp.#4								
Species #5	Sp.#5								

		Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		25	26	27	28	29	30	31	32
Water Depth (ft)		1	4	7					
Areal Plant Cover		5	5	4					
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	25	26	27	28	29	30	31	32
Algal mat	Algae	M	D	S					
Aquatic moss	Moss	D							
Watershield	Bsch								
Fanwort	Ccar								
Water starwort	Calli								
Coontail	Cdem								
Muskgrass	Chara								
Swamp loosestrife	Dver								
Needle spikerush	Eaci	M		M					
Pipewort	Eaqa		M	M					
Waterweed	Ecan								
Waterwort	Emin								
Hedge hyssop	Ghet								
Quillwort	Iso								
Duckweed	Lmin								
Purple loosestrife	Lsal								
Variable watermilfo	Mhet								
Eurasian watermilfo	Mspic								
Common naiad	Nflex								
Yellow water lily	Nvar								
Nitella spp.	Nit	T	M	M					
White water lily	Nodo								
Water smartweed	Poly								
Pickerelweed	Pcord								
Broadleaf pondweed	Pamp								
Leafy pondweed	Prob								
Robbins pondweed	Ppul								
Water crowfoot	Ranu								
Submerged arrowhe	Sgram								
Willow	Salix								
Big duckweed	Spol								
Cattail	Tlat								
Water chestnut	Tnat								
Purple Bladderwort	Ugem								
Bladderwort	Uspp								
Watermeal	Wcol								
Species #1	Sp.#1								
Species #2	Sp.#2								
Species #3	Sp.#3								
Species #4	Sp.#4								
Species #5	Sp.#5								

Lake Name: Farm Pond Transect(s): 5 6 Survey Date: 08/12/14

Farm Pond Aquatic Vegetation Assessment Survey Sheet

Transect # 5		
Transect GPS start:	N	42°13'59.7"
	W	71°20'32.6"
Transect GPS finish:	N	42°14'04.7"
	W	71°20'34.2"

		Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		33	34	35	36	37	38	39	40
Water Depth (ft)		3	6	9					
Areal Plant Cover		1	1	1					
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	33	34	35	36	37	38	39	40
Algal mat	Algae	S		S					
Aquatic moss	Moss								
Watershield	Bsch								
Fanwort	Ccar								
Water starwort	Calli								
Coontail	Cdem								
Muskgrass	Chara								
Swamp loosestrife	Dver								
Needle spikerush	Eaci	T	S	S					
Pipewort	Eaqa								
Waterweed	Ecan								
Waterwort	Emin								
Hedge hyssop	Ghet								
Quillwort	Iso								
Duckweed	Lmin								
Purple loosestrife	Lsal								
Variable watermilfoil	Mhet								
Eurasian watermilfoil	Mspic								
Common naiad	Nflex								
Yellow water lily	Nvar								
Nitella spp.	Nit								
White water lily	Nodo								
Water smartweed	Poly								
Pickerelweed	Pcord								
Broadleaf pondweed	Pamp								
Leafy pondweed	Prob								
Robbins pondweed	Ppul								
Water crowfoot	Ranu								
Submerged arrowhead	Sgram								
Willow	Salix								
Big duckweed	Spol								
Cattail	Tlat								
Water chestnut	Tnat								
Purple Bladderwort	Ugem								
Bladderwort	Uspp								
Watermeal	Wcol								
Species #1	Sp.#1								
Species #2	Sp.#2								
Species #3	Sp.#3								
Species #4	Sp.#4								
Species #5	Sp.#5								

Transect # 6		
Transect GPS start:	N	42°14'07.3"
	W	71°20'30.3"
Transect GPS finish:	N	42°14'07.7"
	W	71°20'32.7"

		Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		41	42	43	44	45	46	47	48
Water Depth (ft)		5.5	7.5	10					
Areal Plant Cover		1	1	1					
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	41	42	43	44	45	46	47	48
Algal mat	Algae	M	S	M					
Aquatic moss	Moss	T							
Watershield	Bsch								
Fanwort	Ccar								
Water starwort	Calli								
Coontail	Cdem								
Muskgrass	Chara								
Swamp loosestrife	Dver								
Needle spikerush	Eaci	S	S						
Pipewort	Eaqa	S		M					
Waterweed	Ecan								
Waterwort	Emin								
Hedge hyssop	Ghet								
Quillwort	Iso								
Duckweed	Lmin								
Purple loosestrife	Lsal								
Variable watermilfoil	Mhet								
Eurasian watermilfoil	Mspic								
Common naiad	Nflex								
Yellow water lily	Nvar								
Nitella spp.	Nit								
White water lily	Nodo								
Water smartweed	Poly								
Pickerelweed	Pcord								
Broadleaf pondweed	Pamp								
Leafy pondweed	Prob								
Robbins pondweed	Ppul								
Water crowfoot	Ranu								
Submerged arrowhead	Sgram								
Willow	Salix								
Big duckweed	Spol								
Cattail	Tlat								
Water chestnut	Tnat								
Purple Bladderwort	Ugem								
Bladderwort	Uspp								
Watermeal	Wcol								
Species #1	Sp.#1								
Species #2	Sp.#2								
Species #3	Sp.#3								
Species #4	Sp.#4								
Species #5	Sp.#5								

Lake Name: Farm Pond Transect(s): 7 8 Survey Date: 08/12/14

Farm Pond Aquatic Vegetation Assessment Survey Sheet

Transect # 7										Transect # 8									
Transect GPS start:	N	42°14'13.9"								Transect GPS start:	N	42°14'12.6"							
	W	71°20'34.6"									W	71°20'47.5"							
Transect GPS finish:	N	42°14'11.1"								Transect GPS finish:	N	42°14'11.0"							
	W	71°20'37.0"									W	71°20'46.8"							
		Aquatic Vegetation Assessment Site Number										Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.			NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		49	50	51	52	53	54	55	56			57	58	59	60	61	62	63	64
Water Depth (ft)		0.5	5	7.5	8.5					Water Depth (ft)		0	2.5	7	10				
Areal Plant Cover		0	1	1	1					Areal Plant Cover		0	1	1	2				
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.			NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	49	50	51	52	53	54	55	56	**Plant Name**	**Code**	57	58	59	60	61	62	63	64
Algal mat	Algae	M	M	M						Algal mat	Algae		S		S				
Aquatic moss	Moss									Aquatic moss	Moss								
Watershield	Bsch									Watershield	Bsch								
Fanwort	Ccar									Fanwort	Ccar								
Water starwort	Calli									Water starwort	Calli								
Coontail	Cdem									Coontail	Cdem								
Muskgrass	Chara									Muskgrass	Chara								
Swamp loosestrife	Dver									Swamp loosestrife	Dver								
Needle spikerush	Eaci									Needle spikerush	Eaci		S	S					
Pipewort	Eaqa	M	M	M						Pipewort	Eaqa				M				
Waterweed	Ecan									Waterweed	Ecan								
Waterwort	Emin									Waterwort	Emin								
Hedge hyssop	Ghet									Hedge hyssop	Ghet								
Quillwort	Iso									Quillwort	Iso								
Duckweed	Lmin									Duckweed	Lmin								
Purple loosestrife	Lsal									Purple loosestrife	Lsal								
Variable watermilfoil	Mhet									Variable watermilfoil	Mhet								
Eurasian watermilfoil	Mspic									Eurasian watermilfoil	Mspic								
Common naiad	Nflex									Common naiad	Nflex								
Yellow water lily	Nvar									Yellow water lily	Nvar								
Nitella spp.	Nit									Nitella spp.	Nit								
White water lily	Nodo									White water lily	Nodo								
Water smartweed	Poly									Water smartweed	Poly								
Pickerelweed	Pcord									Pickerelweed	Pcord								
Broadleaf pondweed	Pamp									Broadleaf pondweed	Pamp								
Leafy pondweed	Prob									Leafy pondweed	Prob								
Robbins pondweed	Ppul									Robbins pondweed	Ppul								
Water crowfoot	Ranu									Water crowfoot	Ranu								
Submerged arrowhead	Sgram									Submerged arrowhead	Sgram								
Willow	Salix									Willow	Salix								
Big duckweed	Spol									Big duckweed	Spol								
Cattail	Tlat									Cattail	Tlat								
Water chestnut	Tnat									Water chestnut	Tnat								
Purple Bladderwort	Ugem									Purple Bladderwort	Ugem								
Bladderwort	Uspp									Bladderwort	Uspp								
Watermeal	Wcol									Watermeal	Wcol								
Species #1	Sp.#1									Species #1	Sp.#1								
Species #2	Sp.#2									Species #2	Sp.#2								
Species #3	Sp.#3									Species #3	Sp.#3								
Species #4	Sp.#4									Species #4	Sp.#4								
Species #5	Sp.#5									Species #5	Sp.#5								

Lake Name: Farm Pond Transect(s): 9 10 Survey Date: 08/12/14

Farm Pond Aquatic Vegetation Assessment Survey Sheet

Transect # 9		
Transect GPS start:	N	42°14'13.2"
	W	71°20'57.2"
Transect GPS finish:	N	42°14'10.4"
	W	71°20'55.8"

Transect # 10		
Transect GPS start:	N	42°14'07.5"
	W	71°21'00.1"
Transect GPS finish:	N	42°14'09.0
	W	71°20'58.9"

		Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		65	66	67	68	69	70	71	72
Water Depth (ft)		2	5	7	10				
Areal Plant Cover		1	2	2	2				
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	65	66	67	68	69	70	71	72
Algal mat	Algae	S	M	M	S				
Aquatic moss	Moss				T				
Watershield	Bsch								
Fanwort	Ccar								
Water starwort	Calli								
Coontail	Cdem								
Muskgrass	Chara								
Swamp loosestrife	Dver								
Needle spikerush	Eaci	M	M	M					
Pipewort	Eaqa								
Waterweed	Ecan								
Waterwort	Emin								
Hedge hyssop	Ghet								
Quillwort	Iso								
Duckweed	Lmin								
Purple loosestrife	Lsal								
Variable watermilfoil	Mhet								
Eurasian watermilfoil	Mspic								
Common naiad	Nflex								
Yellow water lily	Nvar								
Nitella spp.	Nit		M	M	M				
White water lily	Nodo								
Water smartweed	Poly								
Pickerelweed	Pcord								
Broadleaf pondweed	Pamp								
Leafy pondweed	Prob								
Robbins pondweed	Ppul								
Water crowfoot	Ranu								
Submerged arrowhead	Sgram								
Willow	Salix								
Big duckweed	Spol								
Cattail	Tlat								
Water chestnut	Tnat								
Purple Bladderwort	Ugem								
Bladderwort	Uspp								
Watermeal	Wcol								
Species #1	Sp.#1								
Species #2	Sp.#2								
Species #3	Sp.#3								
Species #4	Sp.#4								
Species #5	Sp.#5								

		Aquatic Vegetation Assessment Site Number							
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
		73	74	75	76	77	78	79	80
Water Depth (ft)		0.5	2.5	6					
Areal Plant Cover		0	2	3					
		NO.	NO.	NO.	NO.	NO.	NO.	NO.	NO.
Plant Name	**Code**	73	74	75	76	77	78	79	80
Algal mat	Algae		S	S					
Aquatic moss	Moss								
Watershield	Bsch								
Fanwort	Ccar								
Water starwort	Calli								
Coontail	Cdem								
Muskgrass	Chara								
Swamp loosestrife	Dver								
Needle spikerush	Eaci		S	S					
Pipewort	Eaqa								
Waterweed	Ecan								
Waterwort	Emin								
Hedge hyssop	Ghet								
Quillwort	Iso								
Duckweed	Lmin								
Purple loosestrife	Lsal								
Variable watermilfoil	Mhet								
Eurasian watermilfoil	Mspic								
Common naiad	Nflex								
Yellow water lily	Nvar								
Nitella spp.	Nit								
White water lily	Nodo								
Water smartweed	Poly								
Pickerelweed	Pcord								
Broadleaf pondweed	Pamp								
Leafy pondweed	Prob								
Robbins pondweed	Ppul								
Water crowfoot	Ranu								
Submerged arrowhead	Sgram								
Willow	Salix								
Big duckweed	Spol								
Cattail	Tlat								
Water chestnut	Tnat								
Purple Bladderwort	Ugem								
Bladderwort	Uspp								
Watermeal	Wcol								
Species #1	Sp.#1								
Species #2	Sp.#2								
Species #3	Sp.#3								
Species #4	Sp.#4								
Species #5	Sp.#5								

Farm Pond Aquatic Plants

Prepared for: Farm Pond Advisory Committee
Sherborn, MA

By: Danielle Boyda
8/2004

A Survey of Aquatic Plants in Farm Pond

Danielle Boyda
9/27/2004

Purpose:

The purpose of this project was to discover which aquatic plants live in Farm Pond and to ensure that no invasive species are threatening the pond.

Massachusetts Department of Environmental Management Guidelines:

Earlier this summer, Mr. Steve Scrimshaw and I went to a weed-watching seminar held by the Massachusetts Department of Environmental Management, where we identified different types of aquatic plants and learned important defining characteristics for certain plants. While I was there, I asked Michelle Robinson, one of the leaders of the seminar, for suggestions for the best way to collect aquatic plants in Farm Pond for identification. She told me that I should canoe around the pond, stopping frequently around the perimeter to collect samples. She said that she uses two rakes bolted together to scoop samples from the bottom of the lake. She told me that I should put the samples I collect at each site in separate plastic bags.

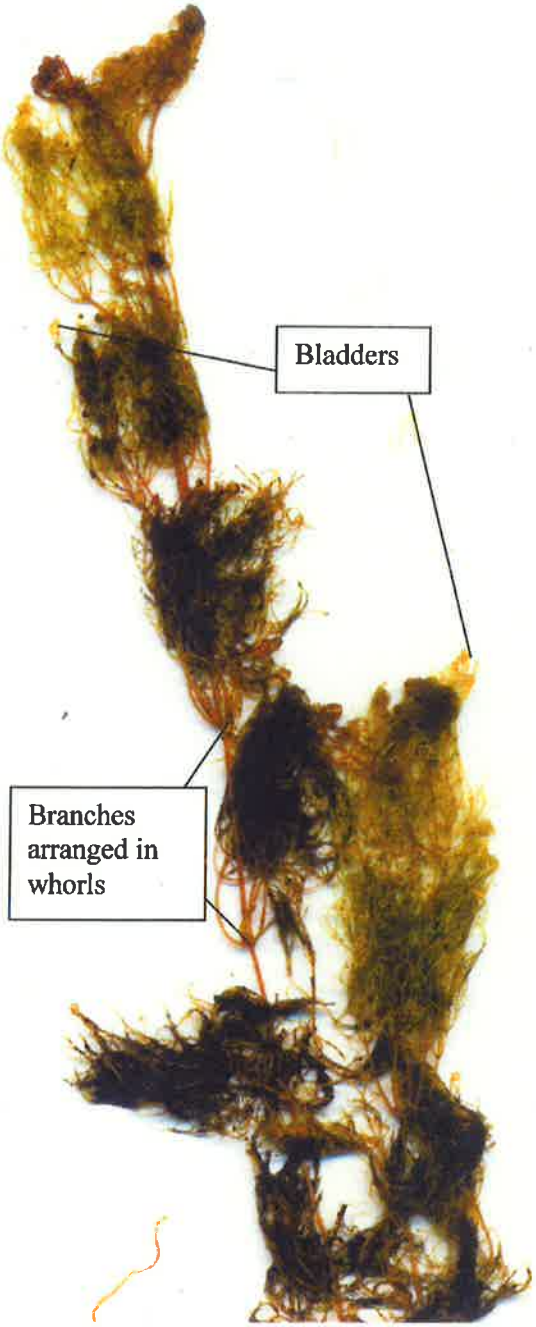
Procedure:

Following her advice, I collected plants from 28 sites, which are marked on a depth map of Farm Pond, included in this report. I later snorkeled around the edge of Farm Pond from the beach to the island so that I could look for plants in shallower water. I identified the samples with a microscope and counted the number of plants of each species at sites. These results have been tabulated in the table contained in this report. I scanned some of the most commonly found plants and included prints of those scans along with brief descriptions in this report.

Observations:

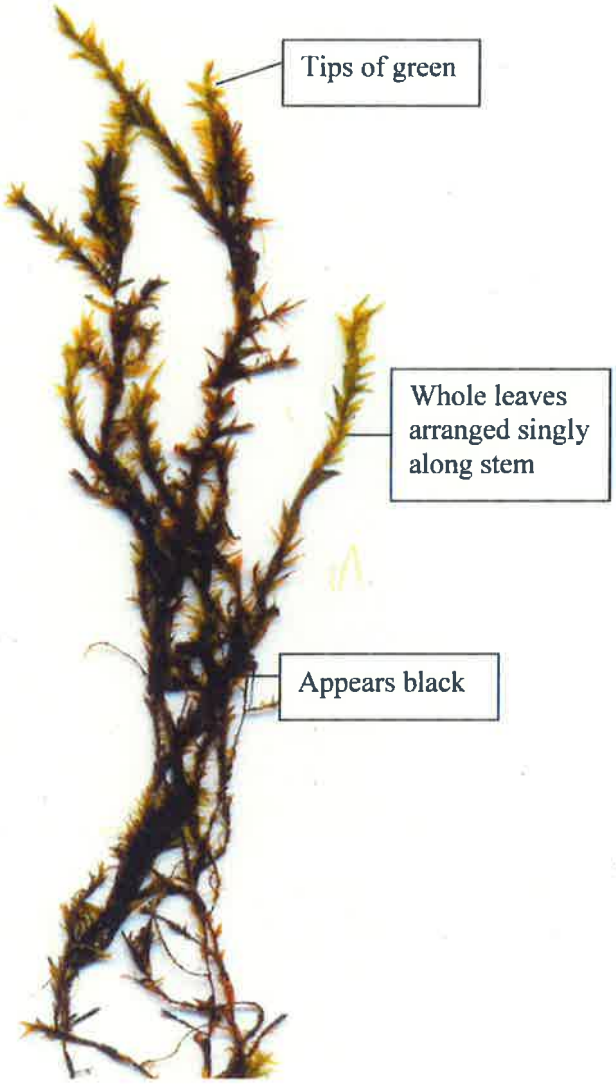
I found that there are no invasive species in Farm Pond, but instead there are only native plants, mostly large purple bladderwort and moss. From the canoe I also noticed needle rush, low water milfoil, northern snailseed pondweed and pipewort. When I snorkeled in shallower water, I noticed a greater variety of plants, most of which were much smaller than the ones I had found in deeper water. I found waterwort, quillwort, and hedge hyssop, in addition to needle rush, northern snailseed pondweed and pipewort.

Large Purple Bladderwort (*Utricularia purpurea*)



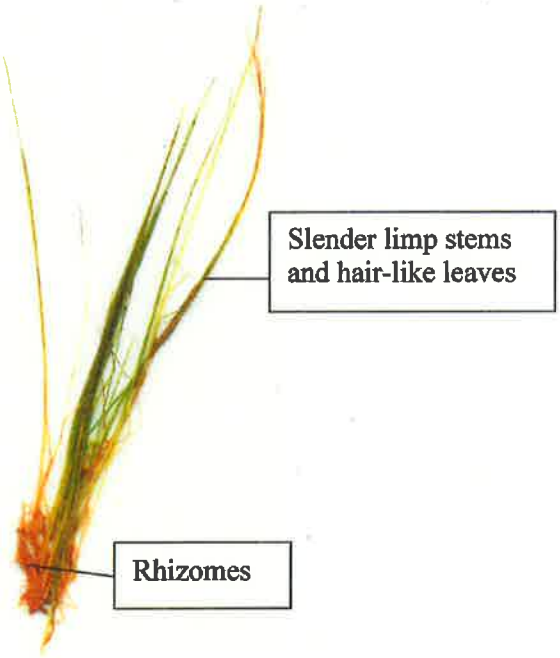
Large purple bladderwort (*Utricularia purpurea*) has clusters of branches arranged in whorls around the stem with bladders at the tips of the branches. It is found in quiet waters with low pH, from shallow water to water several meters deep. (Borman, 1997)

Moss (*Musci*)



Moss (*Musci*) is generally found as a mat on the pond bottom or attached to rocks. The leaves are undissected and are arranged singly along the stem. The plant appears black but may have tips of green.

Needle rush (*Eleocharis acicularis*)



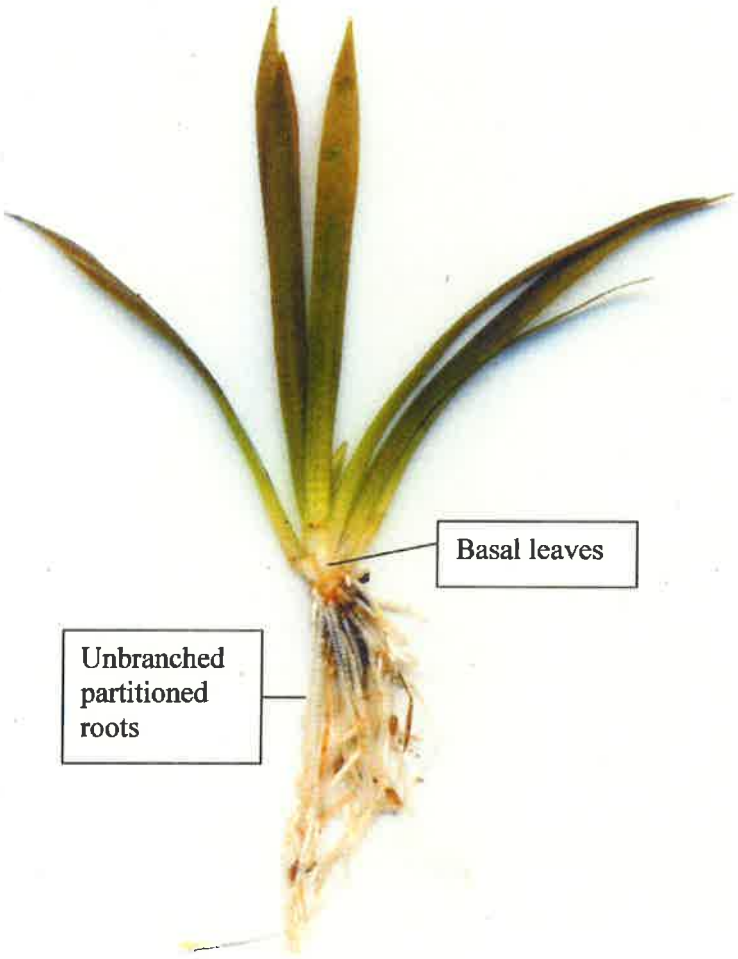
Needle rush (*Eleocharis acicularis*) is a grass-like aquatic plant with slender limp stems and hair-like leaves, with stems developing from a fine rhizome.

Northern Snailseed Pondweed (*Potamogeton spirillus*)

Northern snailseed pondweed (*Potamogeton spirillus*) has spiral fruit and slender stems. The stems have a much branched, compact form. Submersed leaves are linear and usually have a curved appearance. (Janna Hruby and Mara Birkerts)

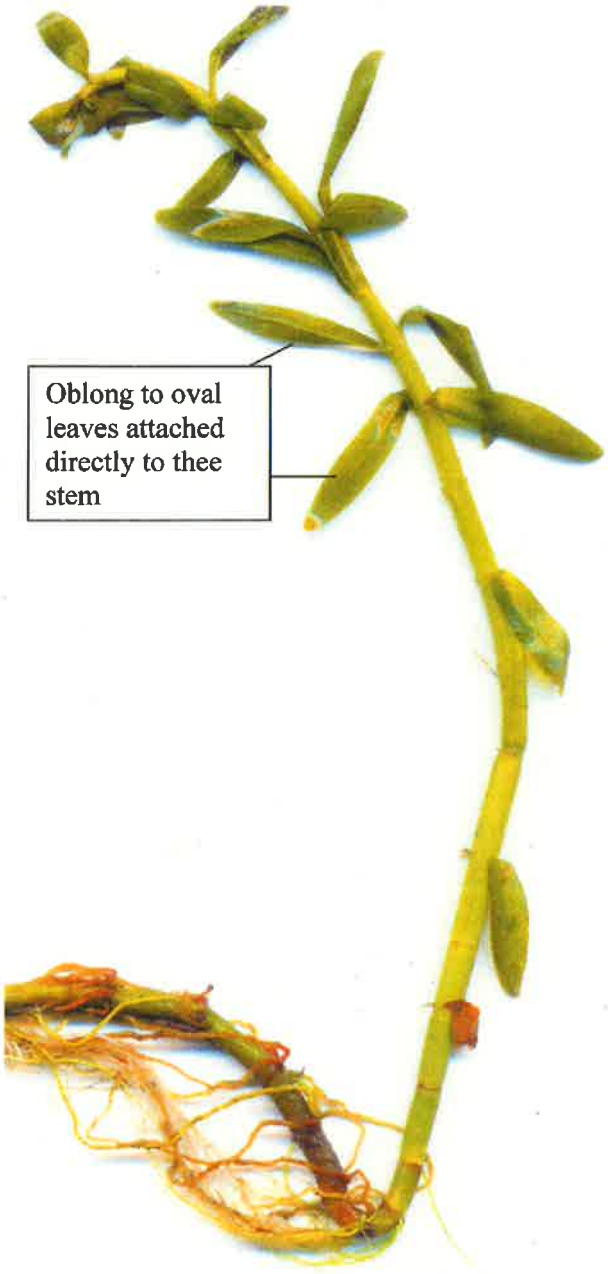
Pipewort (*Eriocaulon aquaticum*)

The distinguishing feature of Pipewort (*Eriocaulon aquaticum)* is the unbranched roots with closely-spaced partitions. The plant has basal leaves that taper from base to tip and is found on sandy shores in shallow water up to 2 meters.



Enlarged picture
Actual size was app. 3.5 inches

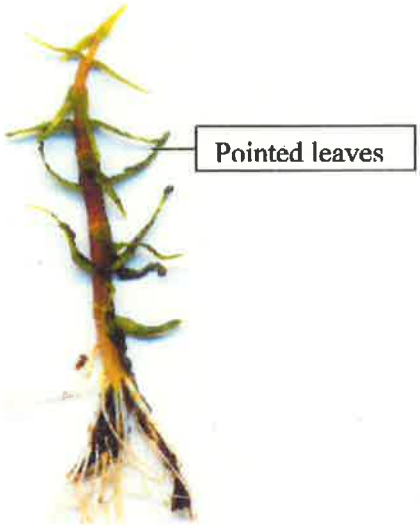
Waterwort (*Elatine minima*)



Enlarged picture
Actual size was app. 1.5 inches

Waterwort (*Elatine minima*) is a dwarf plant, being only a few centimeters, with oblong to oval leaves which are attached directly to the stem. It is found on sandy sites in still or slow-moving water.

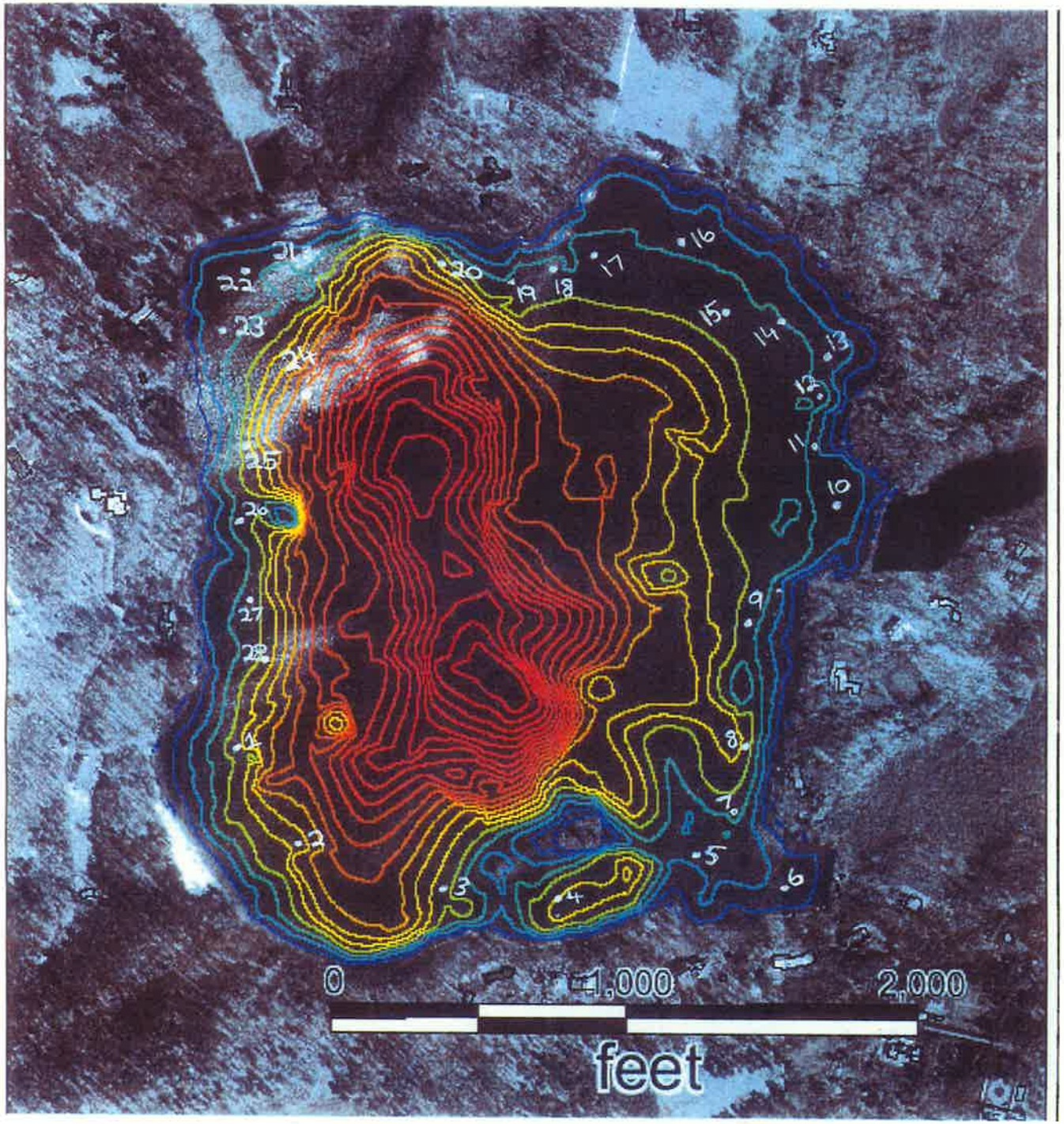
Hedge Hyssop (*Gratiola*)



Hedge hyssop (*Gratiola*) is a small plant with pointed leaves that is found in shallow water of northern lakes.

Quillwort (*Isoetes*)

Quillwort (*Isoetes*) is similar to pipewort except that the roots are not partitioned. The species of quillwort that is found in Farm Pond could be spiny-spored quillwort (*Isoetes echinospora*) because of the pale to medium green leaves 5-15cm long that taper from base to long slender tip. Spiny-spored quillwort is found in soft or sandy sediment in water a few centimeters to several meters deep. (Borman, 1997)



Water Depth In Feet

- -60.0000..-57.0000
- -57.0000..-54.0000
- -54.0000..-51.0000
- -51.0000..-48.0000
- -48.0000..-45.0000
- -45.0000..-42.0000
- -42.0000..-39.0000
- -39.0000..-36.0000
- -36.0000..-33.0000
- -33.0000..-30.0000
- -30.0000..-27.0000
- -27.0000..-24.0000
- -24.0000..-21.0000
- -21.0000..-18.0000
- -18.0000..-15.0000
- -15.0000..-12.0000
- -12.0000..-9.0000
- -9.0000..-6.0000
- -6.0000..-3.0000
- -3.0000..0.0000

Distribution of Plant Species at Farm Pond

(Table 1)

	Number of plants in sample	Purple Bladderwort		Moss (in strands)		Needle rush		Low Water Milfoil		Northern Snailseed Pondweed		Quillwort	
Site #1	47	85%	40/47	13%	6/47	2%	1/47	0%	0/47	0%	0/47	0%	0/47
Site #2	51	82%	42/51	14%	7/51	0%	0/51	4%	2/51	0%	0/51	0%	0/51
Site #3	18	61%	16/18	17%	3/18	0%	0/18	22%	4/18	0%	0/18	0%	0/18
Site #4	102	43%	45/102	38%	39/102	0%	0/102	19%	19/102	0%	0/102	0%	0/102
Site #5	49	25%	12/49	61%	30/49	9%	4/49	6%	3/49	0%	0/49	0%	0/49
Site #6		0%		98%		2%		0%		0%		0%	
Site #7	26	50%	13/26	48%	11/26	8%	2/26	0%	0/26	0%	0/26	0%	0/26
Site #8	25	80%	20/25	20%	5/25	0%	0/25	0%	0/25	0%	0/25	0%	0/25
Site #9	26	46%	12/26	46%	12/26	8%	2/26	0%	0/26	0%	0/26	0%	0/26
Site #10	91	11%	10/91	58%	53/91	13%	12/91	18%	16/91	0%	0/91	0%	0/91
Site #11	33	12%	4/33	88%	29/33	0%	0/33	0%	0/33	0%	0/33	0%	0/33
Site #12	26	90%	23/26	4%	1/26	8%	2/26	0%	0/26	0%	0/26	0%	0/26
Site #13	47	15%	7/47	77%	36/47	2%	1/47	0%	0/47	6%	3/47	0%	0/47
Site #14	54	17%	9/54	3%	2/54	50%	27/54	2%	1/54	17%	9/54	11%	6/54
Site #15	56	41%	23/56	2%	1/56	57%	32/56	0%	0/56	0%	0/56	0%	0/56
Site #16		1%		98%		1%		0%		0%		0%	
Site #17	66	11%	7/66	83%	55/66	0%	0/66	2%	1/66	5%	3/66	0%	0/66
Site #18	54	15%	8/54	72%	39/54	9%	5/54	0%	0/54	2%	1/54	2%	1/54
Site #19	67	76%	51/67	9%	6/67	0%	0/67	15%	10/67	0%	0/67	0%	0/67
Site #20	14	43%	6/14	43%	6/16	7%	1/14	0%	0/14	0%	0/14	7%	7/14
Site #21	74	4%	3/74	0%	0/74	39%	29/74	0%	0/74	0%	0/74	57%	42/74
Site #22	71	14%	10/71	4%	3/71	65%	46/71	14%	10/71	0%	0/71	3%	2/71
Site #23	68	15%	10/68	72%	49/68	13%	9/71	0%	0/68	0%	0/68	0%	0/68
Site #24	63	11%	7/63	89%	56/63	0%	0/63	0%	0/63	0%	0/63	0%	0/63
Site # 25		100%		0%		0%		0%		0%		0%	
Site #26	51	100%	51/51	0%	0/51	0%	0/51	0%	0/51	0%	0/51	0%	0/51
Site #27	35	100%	35/35	0%	0/35	0%	0/35	0%	0/35	0%	0/35	0%	0/35
Site #28	49	49%	24/49	14%	7/49	0%	0/49	31%	15/49	6%	3/49	0%	0/49

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Borman, Susan, et al. Through the Looking Glass. Stevens Point: Wisconsin Lakes Partnership, 1997.

Crow, Garrett E., and C. Barre Hellquist. Aquatic and Wetland Plants of Northeastern North America. Madison: The University of Wisconsin Press, 2000.

Hellquist, Barre C. A Guide to Selected Invasive Non-native Aquatic Species in Massachusetts. Boston: Massachusetts Department of Environmental Management Lakes and Ponds Program, 2001.

Kelly, Wanda. A Guide to Aquatic Plants in Massachusetts. Boston: New England Aquarium, 1999.

Appendix G. Nutrient Loading Model

EXPORT MODEL VARIABLES AND INPUT RANGES

VARIABLE	DESCRIPTION	FOR SOUTHERN NE AREA HIGH	MEDIUM	LOW	SOURCE
HYDROLOGIC FACTORS					
Standard Water Yield	Rate of water yield in CFSM by watershed	2.0	1.7	1.5	Sopper and Lull 1970, Higgins and Colonell 1971
Precipitation	Annual rainfall in meters	1.53	1.14	0.81	NOAA Precipitation Records through 2008
Runoff Coefficient	Portion of rainfall converted to overland flow	0.95	0.40	0.10	Dunn and Leopold 1978
Baseflow Coefficient	Portion of rainfall converted to baseflow	0.40	0.20	0.01	Dunn and Leopold 1978

PHOSPHORUS AND NITROGEN EXPORT COEFFICIENTS FOR RUNOFF

		PHOSPHORUS EXPORT (KG/HA/YR)					NITROGEN EXPORT (KG/HA/YR)			
LAND USES		MAXIMUM	MEAN	MEDIAN	MINIMUM	SOURCE	MAXIMUM	MEAN	MEDIAN	MINIMUM
Urban 1 (LDR)	Low density residential (>1 ac lots)	6.23	1.91	1.10	0.19	Omernik 1976, Reckhow et al. 1980, Frink 1991, Sharpley et al. 1992, Line et al. 1998, Clark et al. 2000, Rohm et al. 2002, unpublished AECOM data	38.47	9.97	5.50	1.48
Urban 2 (MDR/Hwy)	Medium density residential (0.3-0.9 ac lots) + highway corridors	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Urban 3 (HDR/Com)	High density residential (<0.3 ac lots) + commercial	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Urban 4 (Ind)	Industrial	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Urban 5 (P/I/R/C)	Park, Institutional, Recreational or Cemetery	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Agric 1 (Cvr Crop)	Agricultural with cover crops (minimal bare soil)	2.90	1.08	0.80	0.10		7.82	5.19	6.08	0.97
Agric 2 (Row Crop)	Agricultural with row crops (some bare soil)	18.60	4.46	2.20	0.26		79.60	16.09	9.00	2.10
Agric 3 (Grazing)	Agricultural pasture with livestock	4.90	1.50	0.80	0.14		30.85	8.65	5.19	1.48
Agric 4 (Feedlot)	Concentrated livestock holding area	795.20	300.70	224.00	21.28		7979.90	3110.70	2923.20	680.50
Forest 1 (Upland)	Land with tree canopy over upland soils and vegetation	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Forest 2 (Wetland)	Land with tree canopy over wetland soils and vegetation	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Open 1 (Wetland/Lake)	Open wetland or lake area (no substantial canopy)	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Open 2 (Meadow)	Open meadow area (no clearly wetland, but no canopy)	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Open 3 (Barren)	Mining or construction areas, largely bare soils	4.90	1.50	0.80	0.14		30.85	8.65	5.19	1.48
Other 1	Define:	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Other 2	Define:	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Other 3	Define:	18.60	4.46	2.20	0.26		79.60	16.09	9.00	2.10

PHOSPHORUS AND NITROGEN EXPORT COEFFICIENTS FOR BASEFLOW

		PHOSPHORUS EXPORT (KG/HA/YR)					NITROGEN EXPORT (KG/HA/YR)			
LAND USES		MAXIMUM	MEAN	MEDIAN	MINIMUM	SOURCE	MAXIMUM	MEAN	MEDIAN	MINIMUM
Urban 1 (LDR)	Low density residential (>1 ac lots)	0.050	0.010	0.010	0.001	Uttormark et al. 1974, Mitchell et al. 1989, Miller et al. 1997, AECOM Unpublished Data, some reliance on runoff references as well	20.00	5.00	5.00	1.00
Urban 2 (MDR/Hwy)	Medium density residential (0.3-0.9 ac lots) + highway corridors	0.050	0.010	0.010	0.001		40.00	10.00	10.00	2.00
Urban 3 (HDR/Com)	High density residential (<0.3 ac lots) + commercial	0.050	0.010	0.010	0.001		80.00	20.00	20.00	4.00
Urban 4 (Ind)	Industrial	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Urban 5 (P/I/R/C)	Park, Institutional, Recreational or Cemetery	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Agric 1 (Cvr Crop)	Agricultural with cover crops (minimal bare soil)	0.050	0.010	0.010	0.001		10.00	2.50	2.50	0.50
Agric 2 (Row Crop)	Agricultural with row crops (some bare soil)	0.050	0.010	0.010	0.001		10.00	2.50	2.50	0.50
Agric 3 (Grazing)	Agricultural pasture with livestock	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Agric 4 (Feedlot)	Concentrated livestock holding area	0.100	0.030	0.030	0.001		100.00	25.00	25.00	5.00
Forest 1 (Upland)	Land with tree canopy over upland soils and vegetation	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Forest 2 (Wetland)	Land with tree canopy over wetland soils and vegetation	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Open 1 (Wetland/Lake)	Open wetland or lake area (no substantial canopy)	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Open 2 (Meadow)	Open meadow area (no clearly wetland, but no canopy)	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Open 3 (Barren)	Mining or construction areas, largely bare soils	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Other 1	Define:	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Other 2	Define:	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Other 3	Define:	0.050	0.010	0.010	0.001		80.00	20.00	20.00	4.00

EXPORT MODEL VARIABLES AND INPUT RANGES

VARIABLE	DESCRIPTION	FOR SOUTHERN NE AREA HIGH	MEDIUM	LOW	SOURCE
HYDROLOGIC FACTORS					
Standard Water Yield	Rate of water yield in CFSM by watershed	2.0	1.7	1.5	Sopper and Lull 1970, Higgins and Colonell 1971
Precipitation	Annual rainfall in meters	1.53	1.14	0.81	NOAA Precipitation Records through 2008
Runoff Coefficient	Portion of rainfall converted to overland flow	0.95	0.40	0.10	Dunn and Leopold 1978
Baseflow Coefficient	Portion of rainfall converted to baseflow	0.40	0.20	0.01	Dunn and Leopold 1978

PHOSPHORUS AND NITROGEN EXPORT COEFFICIENTS FOR RUNOFF

		PHOSPHORUS EXPORT (KG/HA/YR)					NITROGEN EXPORT (KG/HA/YR)			
LAND USES		MAXIMUM	MEAN	MEDIAN	MINIMUM	SOURCE	MAXIMUM	MEAN	MEDIAN	MINIMUM
Urban 1 (LDR)	Low density residential (>1 ac lots)	6.23	1.91	1.10	0.19	Omernik 1976, Reckhow et al. 1980, Frink 1991, Sharpley et al. 1992, Line et al. 1998, Clark et al. 2000, Rohm et al. 2002, unpublished AECOM data	38.47	9.97	5.50	1.48
Urban 2 (MDR/Hwy)	Medium density residential (0.3-0.9 ac lots) + highway corridors	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Urban 3 (HDR/Com)	High density residential (<0.3 ac lots) + commercial	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Urban 4 (Ind)	Industrial	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Urban 5 (P/I/R/C)	Park, Institutional, Recreational or Cemetery	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Agric 1 (Cvr Crop)	Agricultural with cover crops (minimal bare soil)	2.90	1.08	0.80	0.10		7.82	5.19	6.08	0.97
Agric 2 (Row Crop)	Agricultural with row crops (some bare soil)	18.60	4.46	2.20	0.26		79.60	16.09	9.00	2.10
Agric 3 (Grazing)	Agricultural pasture with livestock	4.90	1.50	0.80	0.14		30.85	8.65	5.19	1.48
Agric 4 (Feedlot)	Concentrated livestock holding area	795.20	300.70	224.00	21.28		7979.90	3110.70	2923.20	680.50
Forest 1 (Upland)	Land with tree canopy over upland soils and vegetation	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Forest 2 (Wetland)	Land with tree canopy over wetland soils and vegetation	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Open 1 (Wetland/Lake)	Open wetland or lake area (no substantial canopy)	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Open 2 (Meadow)	Open meadow area (no clearly wetland, but no canopy)	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Open 3 (Barren)	Mining or construction areas, largely bare soils	4.90	1.50	0.80	0.14		30.85	8.65	5.19	1.48
Other 1	Define:	0.83	0.24	0.20	0.02		6.26	2.86	2.46	1.38
Other 2	Define:	6.23	1.91	1.10	0.19		38.47	9.97	5.50	1.48
Other 3	Define:	18.60	4.46	2.20	0.26		79.60	16.09	9.00	2.10

PHOSPHORUS AND NITROGEN EXPORT COEFFICIENTS FOR BASEFLOW

		PHOSPHORUS EXPORT (KG/HA/YR)					NITROGEN EXPORT (KG/HA/YR)			
LAND USES		MAXIMUM	MEAN	MEDIAN	MINIMUM	SOURCE	MAXIMUM	MEAN	MEDIAN	MINIMUM
Urban 1 (LDR)	Low density residential (>1 ac lots)	0.050	0.010	0.010	0.001	Uttormark et al. 1974, Mitchell et al. 1989, Miller et al. 1997, AECOM Unpublished Data, some reliance on runoff references as well	20.00	5.00	5.00	1.00
Urban 2 (MDR/Hwy)	Medium density residential (0.3-0.9 ac lots) + highway corridors	0.050	0.010	0.010	0.001		40.00	10.00	10.00	2.00
Urban 3 (HDR/Com)	High density residential (<0.3 ac lots) + commercial	0.050	0.010	0.010	0.001		80.00	20.00	20.00	4.00
Urban 4 (Ind)	Industrial	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Urban 5 (P/I/R/C)	Park, Institutional, Recreational or Cemetery	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Agric 1 (Cvr Crop)	Agricultural with cover crops (minimal bare soil)	0.050	0.010	0.010	0.001		10.00	2.50	2.50	0.50
Agric 2 (Row Crop)	Agricultural with row crops (some bare soil)	0.050	0.010	0.010	0.001		10.00	2.50	2.50	0.50
Agric 3 (Grazing)	Agricultural pasture with livestock	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Agric 4 (Feedlot)	Concentrated livestock holding area	0.100	0.030	0.030	0.001		100.00	25.00	25.00	5.00
Forest 1 (Upland)	Land with tree canopy over upland soils and vegetation	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Forest 2 (Wetland)	Land with tree canopy over wetland soils and vegetation	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Open 1 (Wetland/Lake)	Open wetland or lake area (no substantial canopy)	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Open 2 (Meadow)	Open meadow area (no clearly wetland, but no canopy)	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Open 3 (Barren)	Mining or construction areas, largely bare soils	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Other 1	Define:	0.010	0.004	0.004	0.001		1.00	0.50	0.50	0.05
Other 2	Define:	0.050	0.010	0.010	0.001		20.00	5.00	5.00	1.00
Other 3	Define:	0.050	0.010	0.010	0.001		80.00	20.00	20.00	4.00

OTHER AREAL SOURCES		PHOSPHORUS EXPORT (KG/HA/YR) MAXIMUM	MEAN	MEDIAN	MINIMUM	SOURCE	NITROGEN EXPORT (KG/HA/YR) MAXIMUM	MEAN	MEDIAN	MINIMUM
Direct Atmospheric Deposition	Wet and dry deposition from aerial sources									
from Forested Area	Deposition originating in largely forested area	0.54	0.27	0.20	0.07	Reckhow et al. 1980, Dillon et al. 1991	11.30	5.96	6.50	0.99
from Agricultural/Rural Area	Deposition originating in largely agricultural area	0.97	0.45	0.30	0.12		38.00	20.98	13.10	10.49
from Urban/Industrial Area	Deposition originating in largely urban area	3.67	1.27	1.00	0.26		24.80	18.51	21.40	7.40
Internal Loading	Release from sediments or macrophytes, oxic or anoxic	10.00	1.00	1.00	0.10	Nurnberg 1984, Nurnberg and LaZerte 2004, unpublished AECOM data	10.00	1.00	1.00	0.10
	(duration of anoxia must be specified)	PHOSPHORUS EXPORT (MG/M2/YR)					NITROGEN EXPORT (MG/M2/YR)			
	For calculation with # of days and areal release	40.00	6.00	2.00	0.10		40.00	12.00	5.00	0.30

NON-AREAL SOURCES		PHOSPHORUS INPUT MAXIMUM	MEAN	MEDIAN	MINIMUM	P SOURCE	NITROGEN INPUT MAXIMUM	MEAN	MEDIAN	MINIMUM
Waterfowl	Direct inputs from birds (kg/bird/yr)	1.86	0.23	0.20	0.06	Brezonik 1973, Uttormark et al. 1974, Gould & Fletcher 1978, Portnoy 1990, Manny et al. 1975, Scherer et al. 1995	5.80	1.00	0.95	0.48
Point Sources	Direct discharge from facility									
	Wastewater - primary treatment (ppm)	6.00	4.00	4.00	1.00	Metcalf & Eddy 1991, DMR data from EPA for many WWTF	70.00	45.00	45.00	20.00
	Wastewater - secondary treatment (ppm)	4.00	2.00	2.00	0.40		10.00	5.00	5.00	1.00
	Wastewater - tertiary treatment (ppm)	1.00	0.50	0.50	0.10		5.00	2.00	2.00	1.00
	Cooling water (ppm)	5.00	1.00	1.00	0.05		1.00	0.05	0.05	0.02

SEPTIC SYSTEM INPUTS		PHOSPHORUS INPUT MAXIMUM	MEAN	MEDIAN	MINIMUM	SOURCE	NITROGEN INPUT MAXIMUM	MEAN	MEDIAN	MINIMUM
Domestic Wastewater Inputs										
	Concentration (ppm)	15.00	8.00	8.00	4.00	Metcalf & Eddy 1991	85.00	40.00	40.00	20.00
	People per dwelling	10.00	2.50	2.50	1.00					
	Cubic meters of water per person per day	0.45	0.25	0.25	0.13					
	Days of occupancy per year	365	180	180	1					
	Attenuation factor (portion that reaches lake)	0.50	0.10	0.10	0.01		0.95	0.80	0.80	0.50

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EXPORT MODEL INPUT AND CALCULATIONS

Cells shaded like this must have values entered or verified
Cells shaded like this are notes to aid processing

COEFFICIENTS

STD. WATER YIELD (CFSM)	1.7
PRECIPITATION (METERS)	1.15

	RUNOFF EXPORT COEFF.			BASEFLOW EXPORT COEFF.		
LAND USE	Precip Coefficient (Fraction)	P Export Coefficient (kg/ha/yr)	N Export Coefficient (kg/ha/yr)	Precip Coefficient (Fraction)	P Export Coefficient (kg/ha/yr)	N Export Coefficient (kg/ha/yr)
Urban 1 (LDR)	0.30	0.65	5.50	0.15	0.010	5.00
Urban 2 (MDR/Hwy)	0.40	0.75	5.50	0.10	0.010	5.00
Urban 3 (HDR/Com)	0.60	0.80	5.50	0.05	0.010	5.00
Urban 4 (Ind)	0.50	0.70	5.50	0.05	0.010	5.00
Urban 5 (P/I/R/C)	0.10	0.80	5.50	0.05	0.010	5.00
Agric 1 (Cvr Crop)	0.15	0.80	6.08	0.30	0.010	2.50
Agric 2 (Row Crop)	0.30	1.00	9.00	0.30	0.010	2.50
Agric 3 (Grazing)	0.30	0.40	5.19	0.30	0.010	5.00
Agric 4 (Feedlot)	0.45	224.00	2923.20	0.30	0.010	25.00
Forest 1 (Upland)	0.10	0.05	2.46	0.40	0.005	1.00
Forest 2 (Wetland)	0.05	0.10	2.86	0.40	0.005	1.00
Open 1 (Wetland/Lake)	0.05	0.10	2.46	0.40	0.005	0.50
Open 2 (Meadow)	0.05	0.10	2.46	0.30	0.005	0.50
Open 3 (Excavation)	0.40	0.80	5.19	0.20	0.005	0.50
Other 1	0.10	0.20	2.46	0.40	0.050	0.50
Other 2	0.35	1.10	5.50	0.25	0.050	5.00
Other 3	0.60	2.20	9.00	0.05	0.050	20.00

NOTE: Precipitation runoff and baseflow coefficients will sum to <1.0

AREAL SOURCES

	Affected Lake Area (ha)	P Export Coefficient (kg/ha/yr)	N Export Coefficient (kg/ha/yr)	P Load (from coeff) (kg/yr)	N Load (from coeff) (kg/yr)	Period of Release (days)	P Rate of Release (mg/m2/day)	N Rate of Release (mg/m2/day)	P Load (from rate) (kg/yr)	N Load (from rate) (kg/yr)
Direct Atmospheric Deposition	51.11	0.20	6.50	10.222	332.215					
Internal Loading	2.5555	1.20	3.00	3.0666	7.6665	60	2.00	5.00	3.0666	7.6665

NON-AREAL SOURCES

	Number of Source Units	Volume (cu.m/yr)	P Load/Unit (kg/unit/yr)	N Load/Unit (kg/unit/yr)	P Conc. (ppm)	N Conc. (ppm)	P Load (kg/yr)	N Load (kg/yr)
Waterfowl	20		0.20	0.95			4	19
Point Sources								
PS-1		0			3.00	12.00	0.0	0.0
PS-2		0			3.00	12.00	0.0	0.0
PS-3		0			3.00	12.00	0.0	0.0

Basin in which Point Source occurs (0=NO 1=YES)

	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10
PS-1	0	0	0	1	0	0	0	0	0	0
PS-2	0	0	0	0	0	0	0	0	0	0
PS-3	0	0	0	0	0	0	0	0	0	0

DIRECT SEPTIC SYSTEM LOAD

Septic System Grouping (by occupancy or location)	Days of Occupancy/ Yr	Distance from Lake (ft)	Number of Dwellings	Number of People per Dwelling	Water per Person per Day (cu.m)	P Conc. (ppm)	N Conc. (ppm)	P Attenuation Factor	N Attenuation Factor	Water Load (cu.m/yr)	P Load (kg/yr)	N Load (kg/yr)
Group 1 Septic Systems	365	<100	15	2.5	0.25	8	20	0.2	0.9	3422	5.5	61.6
Group 2 Septic Systems	365	100 - 300	25	2.5	0.25	8	20	0.05	0.8	5703	2.3	91.3
Group 3 Septic Systems	90	<100	0	2.5	0.25	8	20	0.2	0.9	0	0.0	0.0
Group 4 Septic Systems	90	100 - 300	0	2.5	0.25	8	20	0.1	0.8	0	0.0	0.0
Total Septic System Loading										9125	7.8	152.8

BASIN AREAS

	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
	E. Direct	W. Direct	Upper T1	Lower T1	W. Upper T2	E. Upper T2	Lower T2				
LAND USE	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)	AREA (HA)
Urban 1 (LDR)	20.9	0.0	0	0.0	0.0	0.0	0.0				20.9
Urban 2 (MDR/Hwy)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Urban 3 (HDR/Com)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Urban 4 (Ind)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Urban 5 (P/I/R/C)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Agric 1 (Cvr Crop)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Agric 2 (Row Crop)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Agric 3 (Grazing)	18.8	0.0	0	0.0	0.0	0.0	0.0				18.8
Agric 4 (Feedlot)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Forest 1 (Upland)	109.4	0.0	0	0.0	0.0	0.0	0.0				109.4
Forest 2 (Wetland)	8.5	0.0	0	0.0	0.0	0.0	0.0				8.5
Open 1 (Wetland/Lake)	7.8	0.0	0	0.0	0.0	0.0	0.0				7.8
Open 2 (Meadow)	0.5	0.0	0	0.0	0.0	0.0	0.0				0.5
Open 3 (Excavation)	0.0	0.0	0	0.0	0.0	0.0	0.0				0.0
Other 1											0.0
Other 2											0.0
Other 3											0.0
TOTAL	165.7	0.0	0.0	0.0	0.0	0.0	0.0	0	0		165.7

WATER LOAD GENERATION: RUNOFF

	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
	E. Direct	W. Direct	Upper T1	Lower T1	W. Upper T2	E. Upper T2	Lower T2				
LAND USE	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)	(CU.M/YR)
Urban 1 (LDR)	71933	0	0	0	0	0	0	0	0	0	71933
Urban 2 (MDR/Hwy)	0	0	0	0	0	0	0	0	0	0	0
Urban 3 (HDR/Com)	0	0	0	0	0	0	0	0	0	0	0
Urban 4 (Ind)	0	0	0	0	0	0	0	0	0	0	0
Urban 5 (P/I/R/C)	0	0	0	0	0	0	0	0	0	0	0
Agric 1 (Cvr Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 2 (Row Crop)	0	0	0	0	0	0	0	0	0	0	0
Agric 3 (Grazing)	64688	0	0	0	0	0	0	0	0	0	64688
Agric 4 (Feedlot)	0	0	0	0	0	0	0	0	0	0	0
Forest 1 (Upland)	125810	0	0	0	0	0	0	0	0	0	125810
Forest 2 (Wetland)	4859	0	0	0	0	0	0	0	0	0	4859
Open 1 (Wetland/Lake)	4456	0	0	0	0	0	0	0	0	0	4456
Open 2 (Meadow)	265	0	0	0	0	0	0	0	0	0	265
Open 3 (Excavation)	0	0	0	0	0	0	0	0	0	0	0
Other 1	0	0	0	0	0	0	0	0	0	0	0
Other 2	0	0	0	0	0	0	0	0	0	0	0
Other 3	0	0	0	0	0	0	0	0	0	0	0
TOTAL (CU.M/YR)	272010	0	0	0	0	0	0	0	0	0	272010
TOTAL (CFS)	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30

LOAD GENERATION: RUNOFF P											
	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
	E. Direct	W. Direct	Upper T1	Lower T1	W. Upper T2	E. Upper T2	Lower T2				
LAND USE	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)
Urban 1 (LDR)	13.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.6
Urban 2 (MDR/Hwy)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban 3 (HDR/Com)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban 4 (Ind)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Urban 5 (P/I/R/C)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agric 1 (Cvr Crop)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agric 2 (Row Crop)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agric 3 (Grazing)	7.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5
Agric 4 (Feedlot)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Forest 1 (Upland)	5.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5
Forest 2 (Wetland)	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Open 1 (Wetland/Lake)	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8
Open 2 (Meadow)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Open 3 (Excavation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other 1:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other 2:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Other 3:	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	28.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	28.2
LOAD GENERATION: BASEFLOW P											
	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10	TOTAL
	E. Direct	W. Direct	Upper T1	Lower T1	W. Upper T2	E. Upper T2	Lower T2				
LAND USE	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)
Urban 1 (LDR)	0.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21
Urban 2 (MDR/Hwy)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban 3 (HDR/Com)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban 4 (Ind)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urban 5 (P/I/R/C)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agric 1 (Cvr Crop)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agric 2 (Row Crop)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Agric 3 (Grazing)	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
Agric 4 (Feedlot)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Forest 1 (Upland)	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.55
Forest 2 (Wetland)	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Open 1 (Wetland/Lake)	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04
Open 2 (Meadow)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Open 3 (Excavation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other 1:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other 2:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other 3:	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Point Source #1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Point Source #2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Point Source #3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.03

ROUTING PATTERN

(Basin in left hand column passes through basin in column below if indicated by a 1)

1=YES 0=NO XXX=BLANK	BASIN 1 E. Direct (CU.M/YR)	BASIN 2 W. Direct (CU.M/YR)	BASIN 3 Upper T1 (CU.M/YR)	BASIN 4 Lower T1 (CU.M/YR)	BASIN 5 W. Upper T2 (CU.M/YR)	BASIN 6 E. Upper T2 (CU.M/YR)	BASIN 7 Lower T2 (CU.M/YR)	BASIN 8 (CU.M/YR)	BASIN 9 (CU.M/YR)	BASIN 10 (CU.M/YR)
INDIVIDUAL BASIN	1	1	1	1	1	1	1	1	1	1
BASIN 1 OUTPUT	XXX	0	0	0	0	0	0	0	0	0
BASIN 2 OUTPUT	0	XXX	0	0	0	0	0	0	0	0
BASIN 3 OUTPUT	0	0	XXX	1	0	0	0	0	0	0
BASIN 4 OUTPUT	0	0	0	XXX	0	0	0	0	0	0
BASIN 5 OUTPUT	0	0	0	0	XXX	0	1	0	0	0
BASIN 6 OUTPUT	0	0	0	0	0	XXX	1	0	0	0
BASIN 7 OUTPUT	0	0	0	0	0	0	XXX	0	0	0
BASIN 8 OUTPUT	0	0	0	0	0	0	0	XXX	0	0
BASIN 9 OUTPUT	0	0	0	0	0	0	0	0	XXX	0
BASIN 10 OUTPUT	0	0	0	0	0	0	0	0	0	XXX

CUMULATIVE DRAINAGE AREAS

(Total land area associated with routed water and nutrients)

1=YES 0=NO XXX=BLANK	BASIN 1 E. Direct (CU.M/YR)	BASIN 2 W. Direct (CU.M/YR)	BASIN 3 Upper T1 (CU.M/YR)	BASIN 4 Lower T1 (CU.M/YR)	BASIN 5 W. Upper T2 (CU.M/YR)	BASIN 6 E. Upper T2 (CU.M/YR)	BASIN 7 Lower T2 (CU.M/YR)	BASIN 8 (CU.M/YR)	BASIN 9 (CU.M/YR)	BASIN 10 (CU.M/YR)
INDIVIDUAL BASIN	165.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 1 OUTPUT	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 2 OUTPUT	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 3 OUTPUT	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 4 OUTPUT	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 5 OUTPUT	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0
BASIN 6 OUTPUT	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0
BASIN 7 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0
BASIN 8 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0
BASIN 9 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0
BASIN 10 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX
TOTALS	165.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

WATER ROUTING AND ATTENUATION

SOURCE	BASIN 1 E. Direct (CU.M/YR)	BASIN 2 W. Direct (CU.M/YR)	BASIN 3 Upper T1 (CU.M/YR)	BASIN 4 Lower T1 (CU.M/YR)	BASIN 5 W. Upper T2 (CU.M/YR)	BASIN 6 E. Upper T2 (CU.M/YR)	BASIN 7 Lower T2 (CU.M/YR)	BASIN 8 (CU.M/YR)	BASIN 9 (CU.M/YR)	BASIN 10 (CU.M/YR)
INDIVIDUAL BASIN	952010	0	0	0	0	0	0	0	0	0
BASIN 1 OUTPUT	XXX	0	0	0	0	0	0	0	0	0
BASIN 2 OUTPUT	0	XXX	0	0	0	0	0	0	0	0
BASIN 3 OUTPUT	0	0	XXX	0	0	0	0	0	0	0
BASIN 4 OUTPUT	0	0	0	XXX	0	0	0	0	0	0
BASIN 5 OUTPUT	0	0	0	0	XXX	0	0	0	0	0
BASIN 6 OUTPUT	0	0	0	0	0	XXX	0	0	0	0
BASIN 7 OUTPUT	0	0	0	0	0	0	XXX	0	0	0
BASIN 8 OUTPUT	0	0	0	0	0	0	0	XXX	0	0
BASIN 9 OUTPUT	0	0	0	0	0	0	0	0	XXX	0
BASIN 10 OUTPUT	0	0	0	0	0	0	0	0	0	XXX
CUMULATIVE TOTAL	952010	0	0	0	0	0	0	0	0	0
BASIN ATTENUATION	0.90	0.95	0.95	0.95	0.95	0.95	0.85	1.00	1.00	1.00
OUTPUT VOLUME	856809	0	0	0	0	0	0	0.0	0.0	0.0

LOAD ROUTING AND ATTENUATION: PHOSPHORUS										
	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10
	E. Direct	W. Direct	Upper T1	Lower T1	W. Upper T2	E. Upper T2	Lower T2			
	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)
BASIN 1 INDIVIDUAL	29.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 1 OUTPUT	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 2 OUTPUT	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 3 OUTPUT	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 4 OUTPUT	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 5 OUTPUT	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0
BASIN 6 OUTPUT	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0
BASIN 7 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0
BASIN 8 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0
BASIN 9 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0
BASIN 10 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX
CUMULATIVE TOTAL	29.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN ATTENUATION	0.25	0.90	0.75	0.85	0.80	0.75	0.70	1.00	1.00	1.00
OUTPUT LOAD	7.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

LOAD ROUTING AND ATTENUATION: NITROGEN										
	BASIN 1	BASIN 2	BASIN 3	BASIN 4	BASIN 5	BASIN 6	BASIN 7	BASIN 8	BASIN 9	BASIN 10
	E. Direct	W. Direct	Upper T1	Lower T1	W. Upper T2	E. Upper T2	Lower T2			
	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)	(KG/YR)
BASIN 1 INDIVIDUAL	845.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 1 OUTPUT	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 2 OUTPUT	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 3 OUTPUT	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 4 OUTPUT	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0	0.0
BASIN 5 OUTPUT	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0	0.0
BASIN 6 OUTPUT	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0	0.0
BASIN 7 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0	0.0
BASIN 8 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0	0.0
BASIN 9 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX	0.0
BASIN 10 OUTPUT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	XXX
CUMULATIVE TOTAL	845.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BASIN ATTENUATION	0.25	0.95	0.80	0.90	0.80	0.80	0.75	1.00	1.00	1.00
OUTPUT LOAD	211.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

LOAD SUMMARY			
DIRECT LOADS TO LAKE	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)
ATMOSPHERIC	10.2	332.2	587765
INTERNAL	3.1	7.7	0
WATERFOWL	4.0	19.0	0
SEPTIC SYSTEM	7.8	152.8	9125
WATERSHED LOAD	7.3	211.4	856809
TOTAL LOAD TO LAKE (Watershed + direct loads)	32.3	723.1	1453699
TOTAL INPUT CONC. (MG/L)	0.022	0.497	

THE MODELS

PHOSPHORUS

NAME	FORMULA	PRED. CONC. (ppb)	PERMIS. CONC. (ppb)	CRITICAL CONC. (ppb)
Mass Balance (Maximum Conc.)	TP=L/(Z(F))*1000	22		
Kirchner-Dillon 1975 (K-D)	TP=L(1-Rp)/(Z(F))*1000	6	16	32
Vollenweider 1975 (V)	TP=L/(Z(S+F))*1000	13	34	69
Larsen-Mercier 1976 (L-M)	TP=L(1-Rlm)/(Z(F))*1000	9	24	49
Jones-Bachmann 1976 (J-B)	TP=0.84(L)/(Z(0.65+F))*1000	8	21	43
Reckhow General (1977) (Rg)	TP=L/(11.6+1.2(Z(F)))*1000	4	11	22
Average of Model Values (without mass balance)		8	21	43
Measured Value (mean, median, other)		7.9		

From Vollenweider 1968		
Permissible Load (g/m2/yr)	Lp=10^(0.501503(log(Z(F)))-1.0018)	0.17
Critical Load (g/m2/yr)	Lc=2(Cp)	0.34

PREDICTED CHL AND WATER CLARITY

MODEL	Value	Mean	Measured
Mean Chlorophyll (ug/L)			
Carlson 1977	1.8		
Dillon and Rigler 1974	1.5		
Jones and Bachmann 1976	1.7		
Oglesby and Schaffner 1978	1.7		
Modified Vollenweider 1982	4.2	2.2	2.1
Peak Chlorophyll (ug/L)			
Modified Vollenweider (TP) 1982	11.5		
Vollenweider (CHL) 1982	5.9		
Modified Jones, Rast and Lee 1979	7.6	8.3	
Secchi Transparency (M)			
Oglesby and Schaffner 1978 **(Avg)**	4.6		6.6
Modified Vollenweider 1982 **(Max)**	5.4		8.0

Bloom Probability	
Probability of Chl >10 ug/L **(% of time)**	0.0%
Probability of Chl >15 ug/L **(% of time)**	0.0%
Probability of Chl >20 ug/L **(% of time)**	0.0%
Probability of Chl >30 ug/L **(% of time)**	0.0%
Probability of Chl >40 ug/L **(% of time)**	0.0%

URBAN RUNOFF BMP POLLUTANT LOAD REDUCTION WORKSHEET

Please fill in the gray areas below.

Notes:
The methodology and efficiency values used in this worksheet were developed by the Illinois Environmental Protection Agency.

Please Select a Best Management Practice:

○ Vegetated Filter Strips	○ Sand Filters	◉ Sand Filter/Infiltration Basin
○ Grass Swales	○ WQ Inlets	○ WQ Inlet w/ Sand Filter
○ Infiltration Device	○ Weekly Street Sweeping	○ Oil/Grit Separator
○ Extended Wet Detention	○ Infiltration Basin	○ Wet Pond
○ Wetland Detention	○ Infiltration Trench	
○ Dry Detention	○ Porous Pavement	
○ Settling Basin	○ Concrete Grid Pavement	

Please enter landuse of contributing/drainage area in acres:

	Sewered	Unsewered
Commercial	0	0
Industrial	0	0
Institutional	0	0
Transportation	0.02	0
Multi-Family	0	0
Residential	0.73	0
Agriculture	0	0
Vacant	0	0
Open Space	0	0

Note: Sewered and Unsewered refer to storm sewers.

Estimated Load and Load Reductions

	Load before BMP (lbs/yr)	Load after BMP (lbs/yr)	Load Reduction (lbs/yr)
BOD	17	U	U
COD	120	54	66
TSS	271	54	217
LEAD	0	0	0
COPPER	0	U	U
ZINC	1	0	0
TDS	439	U	U
TN	5	3	2
TKN	3	U	U
DP	0	U	U
TP	1	0	0
CADMIUM	0	U	U

U = Removal Efficiency for the particular BMP and constituent unavailable.

URBAN RUNOFF BMP POLLUTANT LOAD REDUCTION WORKSHEET

Please fill in the gray areas below.

Notes:
The methodology and efficiency values used in this worksheet were developed by the Illinois Environmental Protection Agency.

Please Select a Best Management Practice:

○ Vegetated Filter Strips	○ Sand Filters	◉ Sand Filter/Infiltration Basin
○ Grass Swales	○ WQ Inlets	○ WQ Inlet w/ Sand Filter
○ Infiltration Device	○ Weekly Street Sweeping	○ Oil/Grit Separator
○ Extended Wet Detention	○ Infiltration Basin	○ Wet Pond
○ Wetland Detention	○ Infiltration Trench	
○ Dry Detention	○ Porous Pavement	
○ Settling Basin	○ Concrete Grid Pavement	

Please enter landuse of contributing/drainage area in acres:

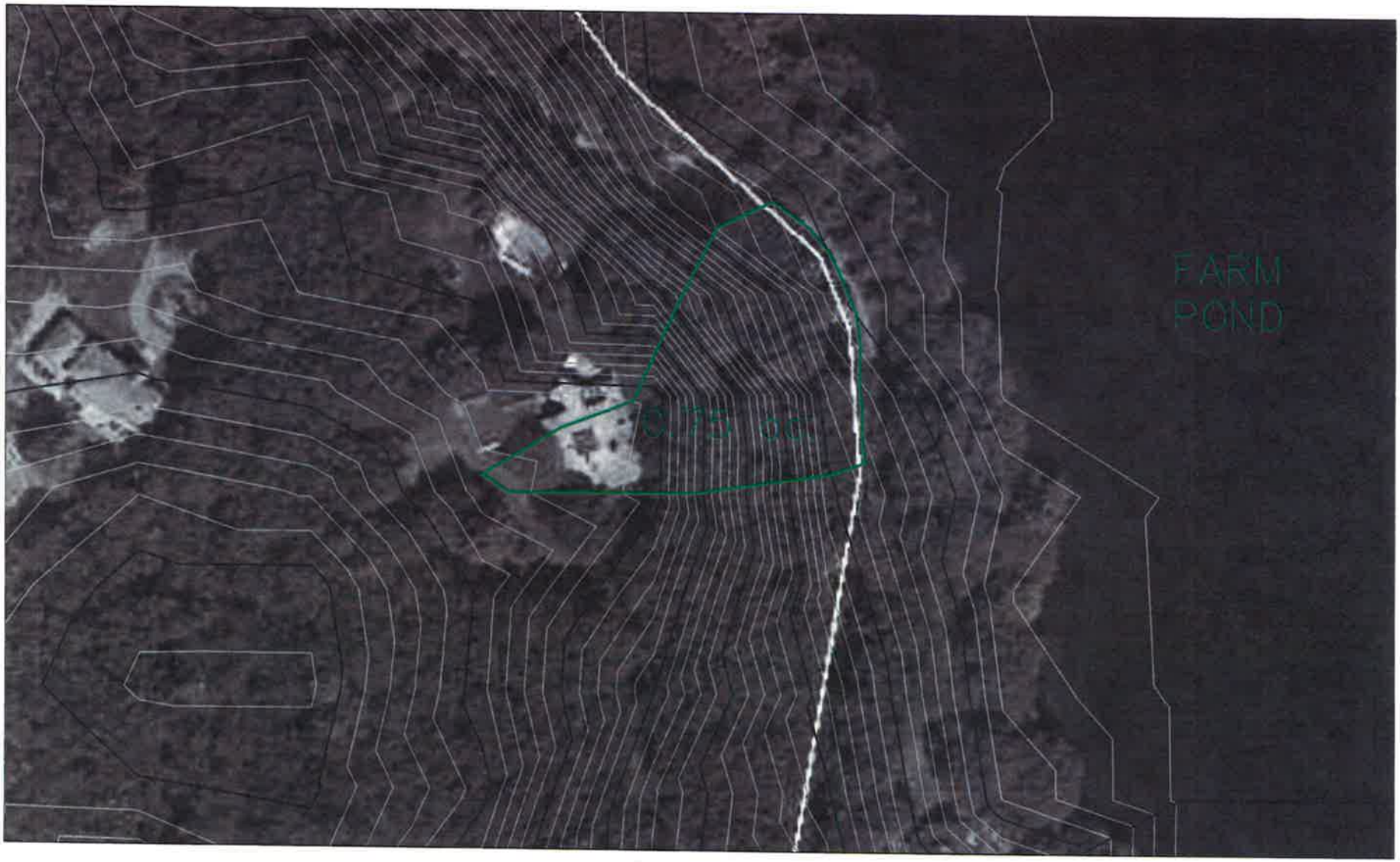
	Sewered	Unsewered
Commercial	0	0
Industrial	0	0
Institutional	0	0
Transportation	0	0.02
Multi-Family	0	0
Residential	0	0.73
Agriculture	0	0
Vacant	0	0
Open Space	0	0

Note: Sewered and Unsewered refer to storm sewers.

Estimated Load and Load Reductions

	Load before BMP (lbs/yr)	Load after BMP (lbs/yr)	Load Reduction (lbs/yr)
BOD	9	U	U
COD	62	28	34
TSS	139	28	111
LEAD	0	0	0
COPPER	0	U	U
ZINC	0	0	0
TDS	230	U	U
TN	2	2	1
TKN	1	U	U
DP	0	U	U
TP	0	0	0
CADMIUM	0	U	U

U = Removal Efficiency for the particular BMP and constituent unavailable.


FARM
POND
0.75 ac.

Appendix H. Pond Management Options

RAPID RESPONSE PLAN FOR FANWORT (*Cabomba caroliniana*) IN MASSACHUSETTS

Prepared for the
Massachusetts Department of
Conservation and Recreation
251 Causeway Street, Suite 700
Boston, MA 02114-2104

dcr

Prepared by
ENSR
2 Technology Park Drive
Westford, MA 01886

ENSR INTERNATIONAL

June 2005

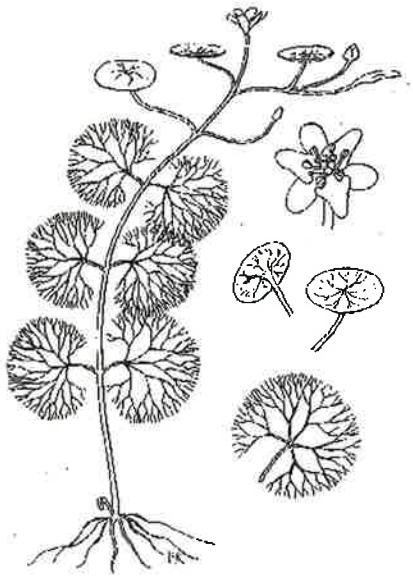
RAPID RESPONSE PLAN FOR FANWORT (*Cabomba caroliniana)* IN MASSACHUSETTS

Species Taxonomy and Identification

Fanwort, *Cabomba caroliniana* is a submerged perennial aquatic plant. Fanwort is fully submerged except for occasional floating leaves when the plant grows to the waters surface. The vertical shoots or stems of fanwort are actually extensions of the fragile, horizontal rhizomes. The stems are branched, can reach a length of 10 meters, and are covered with white or reddish-brown hairs. Submerged leaves are finely divided and arranged around the stem in pairs. The submerged leaves are about 5 centimeters across and fan-shaped. Floating leaves are small, diamond-shaped, and arranged alternately on flowering branches. Flowers are solitary, less than 2 cm across, float on the surface of the water, and are usually white (sometimes yellow or pink). The fruit is a leathery, indehiscent, 3-seeded follicle (Crow and Hellquist 2000).

According to Crow and Hellquist 2000, the following taxonomic characteristics are used to identify Cabomba:

- Submersed leaves opposite, dissected into linear segments; floating leaves small, insconspicuous, oblong to linear-elliptic, peltate, less than 2 cm long, subtending flowers; submersed portions of the plants lacking mucilaginous coating; flowers white to pinkish; stamens 3-6.



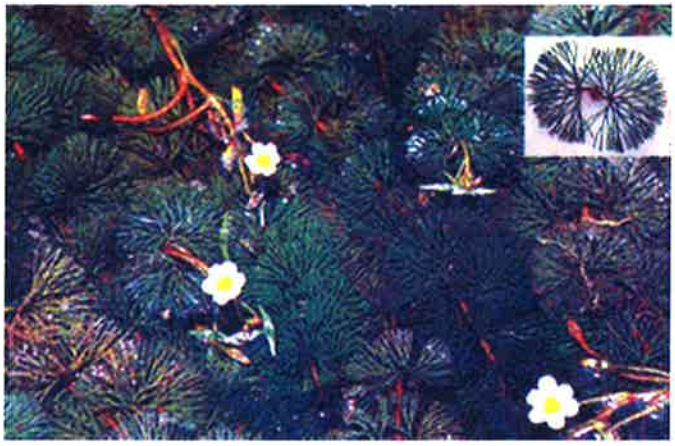


Figure 1. A photograph and diagram of fanwort. The photo was taken from http://www.adkinvasives.com and the diagram was taken from www.fish.washington.edu.

Species Origin and Geography

Fanwort is native to the subtropic-temperate regions of eastern North and South America. Today, it is naturalized in the southeastern United States, and has been introduced throughout the world via the aquarium trade (Orgaard 1991). Within the U.S. it ranges from Florida to Texas in the south, up the east coast to New Hampshire and west to Oklahoma. In the western U.S. it is present in Washington and Oregon (Figure 2). Fanwort is highly capable of transport to new water bodies due to vegetative growth and reproduction. Plant fragments transported to new waterbodies can become rooted and form new shoots. Plant fragments are easily transported to new waterbodies by boats, trailers, fishing gear, wind, animals and currents. In one study, Minnesota authorities found aquatic plants on 23% of all boats inspected (Bratager et al. 1996). In Massachusetts, is it largely a plant of the eastern coastal plain and the granite belt bordering New Hampshire, both areas with acidic waters, and is absent from the more alkaline Berkshire lakes. It often co-occurs and competes with variable watermilfoil (*Myriophyllum heterophyllum*) another invasive plant.

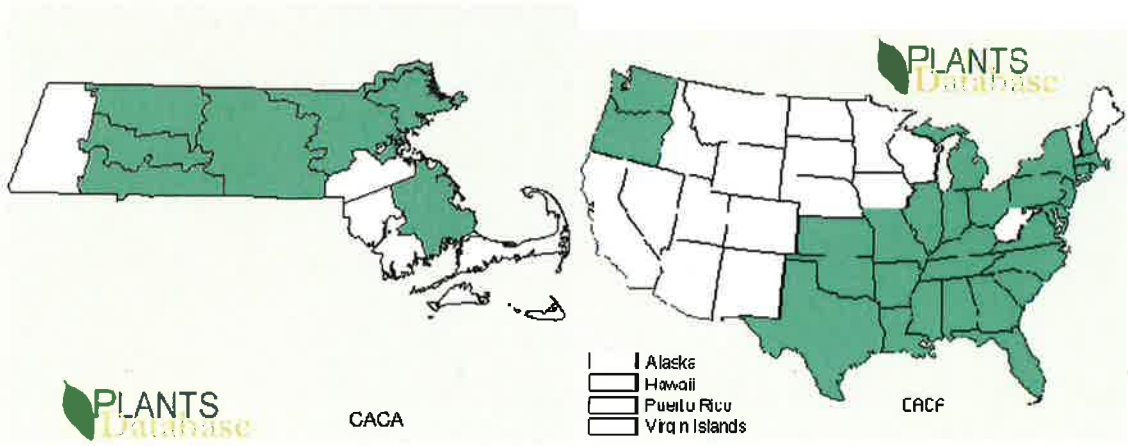


Figure 2. Map indicating the present range of *Cabomba caroliniana* in the United States, and Massachusetts. This map was taken from The USDA Plant Data Base. http://plants.usda.gov/cgi_bin/topics.cgi

Species Ecology

Fanwort grows rooted in the mud of stagnant to slow flowing water, and is found in streams, small rivers, lakes, ponds, reservoirs, sloughs, ditches and canals. Fanwort can grow on a range of substrates, but prefers organic silts, and experiences reduced growth on harder substrates. Fanwort grows well in waters with low pH; the stems begin to defoliate above pH 8. Growth is also hindered in waters with high calcium levels, coincident with high pH in Massachusetts. While fanwort may survive temperatures as low as the freezing point for water, it prefers warm temperatures ranging from 13-27°C. Fanwort is sensitive to drying, and requires permanent water. Typically it grows in less than 10 feet of water, but can grow at depths of up to 30 ft. Fanwort reproduces primarily through plant fragmentation and rhizomes, but it produces flowers and seeds that may have a limited role in dispersal.

Detection of Invasion

As fanwort enters lakes with flow, boats and birds in the vast majority of cases, the logical places to look first are the mouths of tributaries, boat ramps and areas of higher bird concentrations. While mature fanwort growths may reach the surface and form a canopy, new infestations may be less obvious and often require underwater examination for early detection. Although fanwort can grow in water as deep as 30 ft, it typically gets its start in shallow waters (<10 ft deep) and is likely to be visible from a boat with a viewing tube or by snorkeling. Use of an underwater video system (Aqua-Vu or equivalent) can be very helpful in scanning large areas of variable depth, but is more expensive and not usually necessary for detecting early invasion.

Sources may not be obvious, but the pattern of occurrence observed during early detection may provide useful clues. Appearance near boat ramps suggests boats as vectors, while appearance in more remote areas with no direct access or inflows suggests birds as the source. Where growths are detected near the mouth of a tributary, it would be appropriate to check the next upstream waterbody or the stream bed itself if conditions are suitable for rooted plant growth.

There are multiple methods of plant survey, and no truly standardized technique. The object is to be as thorough as time and trained manpower allow, to maximize detection probability. To detect a suspected invasion, or simply to monitor for possible invasion, consider the following steps:

1. Acquire a suitable map of the waterbody, showing shoreline features and reference points, and preferably with water depth contours.
2. Use the taxonomic information supplied here, or supplementary information from taxonomic guides, plant keys, or herbarium sheets to identify fanwort.
3. As fanwort overwinters in a vegetative state, it can be surveyed any time, but is most easily detected and identified in spring as one of the earliest plants to begin growth or in late summer when it may reach the surface.
4. Ideally, space transects around the waterbody, extending from shore to the end of plant growth, with one transect per defined shoreline segment, determining transect location with GPS or readily identified shoreline features. Segments should be of roughly equal length, but this can be based on actual shoreline, straight distance across the water, land use or other features of concern or interest, or encompassed waterbody area. Be sure to cover all boat launch, swimming, inlet, bird congregation, key habitat and intake areas, and any other key access points.
5. Priority can be given to transects of key concern, either based on likely invasion points (access points) or potentially threatened resources (intakes, swimming areas, key habitat) if the number of transects is too great for the manpower and time resources available, but recognize the limitations this will impose on invasion detection.
6. Using a boat with a viewing tube or underwater videocamera, or employing snorkeling or SCUBA gear, examine the plant community along transects between the shore and the maximum depth of plant growth (typically <20 ft, usually <10 ft). Note presence/absence of fanwort and extent of coverage and density where fanwort is encountered. Record observations for 2 ft water depth intervals, with each observation representing either a defined area within the depth range or the

length of the transect between depth intervals (typically 0-2 ft, 2-4 ft, 4-6 ft, and so on). GPS is particularly useful for both transect and point location for future reference.

7. Tabulate all data in a manner that facilitates future comparisons, normally in a spreadsheet or GIS format. Evaluate presence of any fanwort, extent of coverage and density, and pattern of occurrence. Map the distribution of fanwort in the waterbody for visual reference.
8. Repeat the survey at least once every 3 years (about the time for an invasion to have a detectable impact), and preferably every year to allow the earliest possible detection.

Species Confirmation

Unless the invasion is discovered by individuals trained in plant taxonomy, samples should be sent to competent taxonomists for confirmation. In Massachusetts, the Department of Conservation (DCR), the Department of Environmental Protection (DEP), the Massachusetts College of Liberal Arts (North Adams, specifically Dr. Barre Hellquist), and the University of Massachusetts at Amherst (UMASS) have the expertise to assist in plant identification. Many consulting and lake management firms also possess this expertise, but it will be the responsibility of the DCR to determine where specimens should be sent. Therefore, the DCR at 617-626-1411 or 617-626-1395 should be the first point of contact.

Key steps in confirming an invasion include:

1. Collect complete specimens of the suspected fanwort; root systems are less critical for this species, but it is helpful to know that the whole stem has been harvested, and removal of the root crown is necessary for plant control. Place the specimen in a clear container with water for easy viewing (clear 2-L soda bottles without labels work well); keep chilled. Alternatively, specimens can be pressed on a sheet of appropriate (absorbent) paper, covered with wax paper and a stack of books or other suitable weight (an actual herbarium press is useful if available).
2. Contact the DCR representative at 617-626-1411 or 617-626-1395 and inform him/her that a suspected occurrence of fanwort has been detected in the waterbody. The DCR contact will assess past records for the waterbody and will instruct the caller where to send a sample for confirmation, if warranted.
3. As soon as possible, preferably within 2 days, send specimens to the identified DCR representative for confirmation, or to a taxonomic expert as designated by the DCR contact. Note in writing that the enclosed specimen is believed to be fanwort and include the name of the waterbody, the approximate location in the waterbody (a map is helpful) with water depth and any other site-specific observations, the date and time of collection, and the name, address, phone number and email for the collector or sender.
4. The DCR will confirm the identification or provide an alternative identification either directly or indirectly through a recognized taxonomist, and will be responsible for notifying all appropriate agencies, municipalities and citizen groups either potentially affected or responsible for follow-up actions.

Quantifying the Extent of Invasion

Gaining effective control of fanwort depends on detecting all growths, as this species can expand rapidly. The initial discovery may be made during a routine mapping exercise, but mapping approaches suitable for overall plant assemblage characterization (e.g., point intercepts on a grid or transects) may not be appropriate for thorough coverage of recent invasions. Where a growth is detected, it is likely that expansion in the first growing season will be by root crowns, so viewing each discovered growth in concentric circles moving outward from the apparent center will best facilitate mapping of the growth. Detection of additional growths is best accomplished by a thorough visual inspection of the newly infested area, either using tightly spaced transects radiating out from the first discovered growth or focused in the direction of likely current or wind transport.

If the waterbody is large, effort may have to be limited to the most likely locations for invasion. In this regard, examination of any existing plant maps may be helpful. Look for areas of suitable depth (<30 ft, with emphasis on areas 2-10 ft deep) and substrate (moderately organic and silty), known plant and bottom disturbance (marinas, boating lanes, windswept shallows), and plant assemblages of lower density and/or lesser canopy formation.

Evaluation of recent fanwort growths should focus on extent of coverage and degree of dominance. Biovolume or biomass measures are useful but time consuming and are not critical to combating new infestations. Careful stem counts are helpful in assessing the efficacy of possible controls, but are also time consuming. An estimate of stems per unit area and the area covered is more valuable in assessing potential controls for new growths. With regard to dominance, it is important to note other species present, as the presence of protected species and the relative abundance of seed producers vs. vegetative propagators are important to planning management actions. A list of plant species with an approximation of the percent of the community each represents is appropriate.

Assessing the rate of expansion may not be necessary if the invasion is detected early and prompt control actions are implemented. However, where fanwort has been present for more than a single growing season, information on the rate of expansion may be helpful in planning a control strategy and in garnering support for rapid action. Isolated plants are likely to signal the first year of growth, while scattered plants are likely to represent the second year of growth and well established beds will normally be more than two growing seasons old.

Useful steps in quantifying the invasion include:

1. Use the data generated by the transect method in the section on Detection of Invasion to get a first impression of the extent of invasion, preferably in mapped format. Where fanwort is discovered in multiple locations, look for spatial patterns that suggest either transport from the earliest infestation or invasion from multiple sources.
2. If a discovered growth is in a definable cove, examine the entire cove, or at least that portion with a water depth <20 ft.
3. If a discovered growth is associated with a boat ramp, check a suitable area (typically 1-2 acres) associated with that ramp, and check other ramps if present.

4. Where growths occur near a tributary mouth, check area maps for upstream ponds or impoundments on the offending stream and any other tributary and investigate where possible fanwort sources seem most likely.
5. When the new growth appears associated with areas of bird congregation, check all such areas in the waterbody.
6. In all cases, note which areas have established beds vs. scattered plants vs. a single plant or just a few stems.
7. Identify all other plants in association with fanwort growths, to the limit of areas likely to be targeted for control. Follow the protocols for species confirmation where specimens of unknown identity are encountered, paying particular attention to possible protected species or other invasive species.

Species Threat Evaluation

Threats associated with fanwort are the same as those associated with variable watermilfoil (*Myriophyllum heterophyllum*), which occurs in the same habitats and occupies a similar niche. New shoots grow rapidly in the spring and branch repeatedly as they approach the surface of the water. Leaf canopies created by fast growing shoots shade out the germinating seeds or vegetative propagules of understory plants, eventually replacing the native plants and reducing species diversity. Dense and extensive growths of fanwort can affect water quality, including oxygen, pH and organic content. Monospecific stands of fanwort can negatively affect wildlife, and can alter the predator/prey relationship among fish as well as the overall ecology of an aquatic ecosystem. Human uses can be severely impacted by fanwort.

Dense mats of fanwort limit human uses of the waterbody, as dense mats choke channels, clog water intakes, and restrict aquatic activities such as fishing, swimming and boating. Limitations on water uses can negatively impact real estate values (Christie and Varney 2003). The mass of large mats can cause flooding in some waterbodies (www.ecy.wa.gov 2004), and increase sedimentation by trapping detritus (Adams and Prentki 1982).

Oxygen levels can be reduced underneath large fanwort growths due to a decrease in wind mixing, and decaying plants decrease oxygen and increase the nutrient load to the waterbody (Honnell et al. 1992; Engel 1995; www.ecy.wa.gov 2004). High levels of photosynthesis elevate pH and day-night variation causes potentially deleterious pH fluctuations at high fanwort biomass. Decay of large plant masses puts elevated levels of dissolved and suspended organic matter into the water column.

Aquatic macrophytes can provide food, shelter and spawning habitat for a wide variety of fishes (Lillie and Bud 1992). Intermediate densities of aquatic macrophytes, including fanwort, may enhance fish diversity, feeding, growth and reproduction (Dibble et al. 1996). Yet fanwort tends to replace native macrophytes in areas where it is introduced, creating food shortages for fishes (Engel 1995). Dense beds of fanwort can also impede predation, shelter panfishes, and cover spawning areas, leading to potential decreases in sportfish abundance (Engel 1995). Large piscivorous fishes spend more time foraging for prey as density increases, thus reducing growth rates (Savino and Stein 1982). Fanwort beds are believed to decrease fish abundance compared to native vegetation,

and Keast (1983) found that beds of native vegetation supported up to four times as many fish, and up to seven times as many macroinvertebrates as some invasive species. Decreases in macroinvertebrate abundance are expected, based on work on Eurasian milfoil coverage (Cheruvelil et al. 2001). The depletion of oxygen in waterbodies with dense fanwort coverage can also result in fish avoidance, and in extreme cases could cause fish kills (Holland and Huston 1984, Lillie and Bud 1992, Engel 1995).

Potential spread within the waterbody is governed by the physical features of the waterbody (especially water depth and substrate) and the level of activity of potential vectors of spread for fanwort (especially boats, birds, flow and currents). Fanwort grows mostly on organic substrates, sometimes only thinly covering sandy sediment. Rocky to gravelly substrates support much lesser densities of fanwort. The depth range for fanwort is from shore to about 30 ft, but in the vast majority of cases, nuisance growths are observed only to 10 ft of water depth. Boats and birds can actively transport fanwort within a waterbody, but fanwort fragments or dislodged plants also drift with currents.

Potential spread outside the waterbody is mainly a function of surface outflow, birds and human activities. Overflow can carry viable fragments downstream to additional waterbodies. Birds may transport fragments, and may also carry seeds, either externally or in their digestive tract. Seeds are considered to be a limited source of new plants, but even at low viability, this is a potentially important means of invasion. Transport by humans is a known threat, with movement of fragments in or on boats and trailers well documented (Johnstone et al. 1985, Bratager et al. 1996).

All of these factors combine to create a site-specific level of threat. Of primary interest are how great an infestation may become, how readily it may be transmitted to new areas (both inside and outside the infested waterbody), what resources may be impacted to what degree, and what the potential is for eradication or control through rapid response to detection of an invasion. In evaluating the potential threat from a new fanwort infestation in DCR parks on a case by case basis, the DCR staff will consider the following:

1. What portion of the waterbody could be colonized (estimate as the area with water depth <15 ft)?
2. What is the potential for dense bed formation (estimate as the area with fine sediments with high organic content, usually in water <10 ft deep)?
3. What is the potential for rapid (<3 years) spread of fanwort (estimate as the common area from #1 and #2 above and not densely covered by native plants)?
4. What is the potential strength of vectors of internal fanwort spread (boat traffic, flow, currents, open expanses vs. isolated coves)?
5. What is the potential strength of vectors of external fanwort spread (trailered day-use boats, daily or seasonally mobile bird populations, outlets without screening)?
6. What resources and uses are potentially threatened (water supply, swimming, boating, fishing, aesthetics, sensitive or protected populations)?
7. What is the potential for eradication (based on extent and density of coverage, vectors of spread)?

8. What is the potential for confinement (based on extent and density of coverage, physical isolation of area affected, vectors of spread)?

By answering these questions, one can characterize the threat according to the following matrix, which can then govern the response to detection of an invasion:

FACTOR	YES	NO	THREAT EVALUATION	HIGH	MEDIUM	LOW
A large area could be affected			Extent and speed of possible infestation			
Plant density could be high						
Spread could be rapid						
Water supply may be impacted			Nature of possible impacts			
Swimming may be impacted						
Boating may be impacted						
Fishing may be impacted						
Aesthetics may be impacted						
Sensitive species may be impacted						
Protected species may be impacted						
Spread by water flow likely			Ability to spread			
Spread by birds likely						
Spread by boating likely						
Spread by other human activities likely						
Eradication is possible			Potential success of rapid response			
Confinement is possible						

Communication and Education

Once the presence of fanwort has been confirmed, the town(s) in which the waterbody is situated should be notified, usually through the Conservation Commission, which will have a chairperson or an agent who is reachable through Town Hall. It would also be appropriate to notify all relevant stakeholder groups, but these need to be identified and many will not have a central clearinghouse contact for notification. Groups who should be informed about the infestation include any active lake association, shoreline property owners, boaters, anglers, swimmers, birdwatchers, and water suppliers. Notification through individual contacts is desirable but may be inefficient. Posting a notice in the local paper will help publicize the problem, but the notice may not receive widespread attention. Posting the waterbody at access points is perhaps the most effective approach, as it is the actual users that should be informed and warned to avoid spreading fanwort.

It is desirable to post access points with warning signs even before an invasion, displaying a picture or drawing of fanwort and asking waterbody users to be on the lookout for this invasive plant. Users,

particularly boaters, should be asked to inspect their boats and any trailers prior to launching, and to remove any discovered plants with proper disposal in a manner that prevents the plant from reaching the waterbody. A local contact (name and phone number) for notification should be given, typically either a representative of the lake association or the town's Conservation Commission, or both. Users should be advised to mark the location where the plant was observed if at all possible, but not to pull it out unless they can get the whole plant, including the roots. As most users will not be diving or snorkeling, immediate, effective hand harvesting is probably not a realistic expectation.

After an invasion has been discovered, access points should be posted with a warning to users to avoid any action that could spread fanwort. Again, a picture or drawing of fanwort should be provided, and any known locations of the plant should be shown on a map of the waterbody. Users should be asked to notify a local contact if fanwort is found in other areas not shown on the map, and to avoid motorized boating in areas with fanwort. All boats, trailers, fishing equipment, bait buckets or other possible means of transport should be inspected and cleaned prior to leaving the waterbody.

Responsibility for control of fanwort does not rest with any one entity under the laws of the Commonwealth of Massachusetts. Approval for control actions is governed by the Wetlands Protection Act, which always involves the town Conservation Commission and the Commonwealth's DEP. Approval for control actions may also involve the Division of Fisheries and Wildlife and/or the Natural Heritage and Endangered Species Program, both agencies of the Commonwealth, depending upon the resources in the waterbody (particularly if protected species are known from the waterbody). Other agencies and approval programs may apply, depending upon the features of the waterbody (naturally large enough to be a statutory Great Pond), the location of the waterbody (e.g., in an Area of Critical Environmental Concern), or the uses of the waterbody (e.g., as a water supply). However, none of these agencies is charged with controlling invasive species, and there is no legislation in Massachusetts that mandates control of fanwort. The DCR has taken the lead in Massachusetts with regard to encouraging control of invasive species, and supports control efforts as its budget allows. However, outside of the state parks and reservations, control is largely a function of local desire to protect and maintain the resource.

For waterbodies within DCR parks, the following notification procedures are to be followed when a new infestation by fanwort has been confirmed:

1. The DCR contact responsible for confirming the fanwort invasion will notify the DCR Regional Director, Park Supervisor and any regional DCR contact charged with managing water resources. A single letter copied to each party is preferred. The letter should briefly state the problem and outline immediate control steps that are needed, indicating an expected date for a follow up visit by Lakes and Ponds Program staff to begin concerted control measures (see posting procedures below).
2. The DCR contact responsible for fanwort invasion confirmation will also notify the DEP, the DFW and the NHESP in writing; a copy of the letter sent to DCR parties is sufficient. If a contact for an associated citizens' lake or watershed organization is known, notification should be given to that group as well.

3. The Regional Director or a designated park contact for local affairs will notify the town(s) in which the park and waterbody are situated. The appropriate parties within the town(s) to be notified may vary by town, but should include the Conservation Commission and either the Selectmen, Town Manager or Mayor, depending upon local government structure.

For waterbodies within DCR parks, the following posting procedures are to be followed when a new infestation by fanwort has been confirmed:

1. All access points to the waterbody (e.g., boat launches, swimming areas, fishing piers or obvious shoreline fishing points) shall be posted with a photograph or drawing of fanwort and a written notice that this invasive plant has been found in the waterbody.
2. Suggested language is as follows: Warning. Fanwort (*Cabomba caroliniana*) has been found in this waterbody. This invasive plant represents a threat to this waterbody and its users. Caution should be exercised to avoid the spread of this plant. Do not pick or remove this plant if you encounter it, and be sure all equipment brought to this waterbody is clean before leaving.
3. Include a contact name and phone number on all postings.

Quarantine Options

Both natural processes and human activities can spread fanwort, both within an invaded waterbody and to other area lakes. Minimizing the spread of fanwort may require some form of quarantine. Making the waterbody off limits to all users is an extreme action not typically justified for new growths that are likely to be limited in areal coverage. However, keeping people out of infested areas may be a valid option. This may be done by signage, buoys, or an actual sequestration curtain, with cost increasing dramatically in the listed progression.

Where the invasion is occurring at a boat ramp, closure of the ramp may be justified; this will both limit the spread of fanwort and generate public awareness of the problem and a desire to take action against the fanwort. A town may take such an action where the public welfare is deemed to be at stake for a boat ramp owned by the town, but it is not clear that such action is legal for private boat ramps, and towns do not have the authority to close ramps owned by the Commonwealth. Consult with private owners or the Public Access Board of Massachusetts when considering closure of a ramp not owned by the town.

Where the invasion is occurring in a swimming area, closure of that area will have much the same effect and limitations as for boat ramps. If the fanwort growths are localized, it may be possible to partition off the infested area by moving the buoyed ropes that usually delimit swimming areas. If the growths are extensive, it may be appropriate to close the swimming area on the basis of public safety; people can get tangled in dense macrophyte infestations and drown.

The use of sequestering curtains or screens can both restrict access to an infested area and limit the spread of fanwort by vegetative fragmentation. This approach, while often expensive, has been very effective in a number of cases, especially for small areas or coves with a narrow connection to the main body of the waterbody.

Possible expansion routes should be considered and addressed to the extent possible. Sequestration, as noted above, can be highly effective if the infested area is localized and amenable to curtains or screens. Outlets from the waterbody should also be screened to minimize the export of fanwort fragments with outflow. This may be problematic where leaves or other debris are abundant enough to clog such screens, necessitating frequent cleaning. Rotating screens or other automated outflow restrictors are effective but expensive. Drawdown may also limit fanwort escape, if an appropriate subsurface outlet exists and fanwort can be prevented from passing through it. It may be advisable to implement bird controls to limit bird contact with infested areas; scare tactics (e.g., flags or pinwheels on buoys, noisemakers) can be effective for short time periods, which may be all that is necessary for lakes with migratory populations. Greater effort may be needed for lakes with substantial resident bird populations. If boating is allowed, it is advisable to set up a temporary wash station at any ramp; it may be necessary to staff it to maximize use compliance. At the very least, boats and trailers leaving the waterbody should be inspected and cleaned.

Where a fanwort invasion is confirmed in a waterbody in a DCR park, the following quarantine steps will be evaluated and implemented as warranted:

1. Screen the surface outlet of the waterbody to minimize downstream movement of fanwort, maintaining the screen as necessary to facilitate outflow.
2. Lower the water level to prevent surface outflow; a subsurface drain may be used to continue outflow, but fanwort may escape through this exit if not screened, and such screening will require cleaning.
3. Post access points with warnings to avoid the plant and/or certain areas of the waterbody; use marker buoys to identify infested areas.
4. Surround smaller infested areas with sequestration curtain or other enclosing materials that prevent spread and limit access.
5. Curtain off coves or other isolated areas to prevent fanwort spread and limit access.
6. Use scare tactics or other approaches to limit bird use of the waterbody.
7. Set up a washing station and inspection point for boats taken out of the waterbody; require inspection and cleaning where needed.
8. Close any access point (e.g., boat ramp, beach, other points of active contact) in close proximity to fanwort, where the potential for internal or external spread is considered high.
9. Close the waterbody to human use.

Early Eradication Options

Timelines for necessary action with regard to fanwort invasions hinge on stopping the spread of this plant. Root crown expansion occurs throughout the growing season, so the sooner controls are implemented, the smaller the area that must be addressed. Once the growing season is over (about October), plants are largely dormant and many collapse or otherwise be reduced in biovolume until the following spring. Detecting and effectively removing fanwort plants by physical means will therefore be more difficult outside the growing season.

Management options that can be applied to fanwort are covered in The Practical Guide to Lake Management in Massachusetts (Wagner, 2004), a companion guide to the GEIR on Lake

Management, available on-line at http://www.mass.gov/dcr/waterSupply/lakepond/lakepond.htm and supplied to all towns in the Commonwealth by the DCR in 2004. A summary of control approaches with the potential to eradicate fanwort during the early stages of an invasion is provided below.

Hand Harvesting

Mode of action: Plants are removed by divers by hand; removal includes root crowns.

Probability of successful control: Where density is <500 plants per acre over a small number of acres, control can be complete. At higher densities or area of coverage, risk of incomplete harvest or spread by fragment escape increases dramatically.

Potential non-target impacts: Limited; with training, divers recognize fanwort and avoid other plants; risk to non-target plants increases as density of plant community increases. Temporary turbidity increases are expected.

Permitting needs: Can be approved without Order of Conditions under the Wetlands Protection Act through a Negative Determination of Applicability (WPA regulations deemed not to apply, as only the invasive plant is removed).

Monitoring needs: Critical to delineate target area and provide means for divers to stay on course with complete coverage. Monitoring during harvesting to detect and collect fragments is also very important to successful elimination of fanwort.

Range of costs: Often done by volunteers, but estimates from professional operations range from $100 to $500 per acre.

Other considerations: Use of a fragment barrier around all harvesting areas is highly recommended. Effective hand harvesting requires careful planning and is more difficult that it may appear.

Suction Harvesting

Mode of action: Plants can be pulled directly into the suction apparatus, but for best effect this is a suction aided hand harvesting operation, whereby hand harvested plants are fed into the suction tube and filtered out in an above-water chamber. This speeds up the operation and limits fragment dispersal.

Probability of successful control: High potential for eradication at low to moderate densities of fanwort; complete removal probability declines at higher densities.

Potential non-target impacts: May pull in non-target plants and plankton by suction, but effects localized and limited. Turbidity plume at surface from filtering chamber may be substantial.

Permitting needs: Generally requires an Order of Conditions under the Wetlands Protection Act, but may be issued a Negative Determination of Applicability where risk to other species and turbidity are expected to be low.

Monitoring needs: Critical to delineate target area and provide means for divers to stay on course with complete coverage.

Range of costs: $5,000 to $15,000 per acre, depending upon equipment features, contractor mobilization, fanwort density, and total area to be harvested.

Other considerations: Turbidity may be unacceptable where a large area is suction harvested.

Benthic Barriers

Mode of action: Covers target area with a porous or non-porous blanket, limiting light and physically stressing plants.

Probability of successful control: Usually completely eliminates live vegetation from covered area in 30 to 60 days.

Potential non-target impacts: All plants under the barrier will be killed. Some invertebrates are also killed, but many relocate. Fish find the barriers attractive for cover and foraging area, mainly a function of "edge effect" (creation of edges between plants and open water).

Permitting needs: Often approved through a Negative Determination of Applicability (provisions of WPA do not apply) where fanwort is the main plant affected. Otherwise permitted with an Order of Conditions with possible restrictions where other species are at significant risk.

Monitoring needs: Careful delineation of areas to be covered is needed. Condition of plant community, especially root crowns of fanwort, should be assessed prior to removal.

Range of costs: Materials typically cost $0.50 to $1.00 per square foot. With application and maintenance costs, expect $30,000 to $50,000 per acre. However, material can be re-used indefinitely, so costs are greatly reduced for subsequent applications.

Other considerations: To enhance performance, benthic barriers should be carefully anchored and periodically cleaned. To minimize hooks and lures getting caught in benthic barriers, mark location with labeled buoys. Barriers may present a safety hazard in swimming areas.

Water Level Drawdown

Mode of action: Lowered water level exposes plants and substrate to drying and freezing action. Ice damage may also be a factor. Where plants can be dried, frozen, or ripped up by ice action, fanwort can be greatly reduced in abundance or eliminated. With many years of repeated drawdown, exposed substrate tends to be dominated by coarse sediment less hospitable to fanwort invasion.

Probability of successful control: Very high where drying, freezing and/or ice damage occurs. As this is a function of the weather pattern, uncertainty is high; about one out of three years provides effective drawdown conditions in Massachusetts. Where thick organic sediments, spring activity, or other factors limit freezing and drying, success will be lower.

Potential non-target impacts: Other plants that overwinter in vegetative forms are also likely to be harmed. Seed-producing plants may be stimulated. Some invertebrates (especially mollusks), amphibians (most likely frogs), reptiles (particularly wood turtles) and mammals (most probably beaver and muskrat) could be negatively affected. Effects on fish vary, depending upon timing and duration of drawdown and the interaction with feeding and reproduction. Direct water supply and water level in wells may be affected.

Permitting needs: Requires an Order of Conditions under the Wetlands Protection Act, usually entailing a detailed review of the potential for non-target impacts.

Monitoring needs: Can be extensive. Pre- and post-implementation surveys are needed. Aside from effects on the plant community, effects on susceptible fauna may be required. Water supply must be monitored and a contingency plan is needed if supply is impaired. It should be assumed that at least three years of implementation will be needed to conduct a valid assessment of success and non-target impacts.

Range of costs: Where drawdown is facilitated by existing structures, costs are limited to permitting and monitoring, with potential for mitigation costs if impacts are unacceptable.

Other considerations: A very detailed evaluation of potential drawdown impacts is needed before attempting this technique. Issues of downstream flooding, refill time, and impacts on water supply and non-target organisms must be addressed.

Application of Fluridone

Mode of action: This systemic herbicide is absorbed by vegetative tissues and translocated throughout the plant, inhibiting the synthesis of carotenoid pigments. Lack of these auxiliary (protective) photosynthetic pigments causes susceptible plants to die slowly through reduced food production and damage by sunlight. Uptake must be nearly continuous over an extended period (>60 days preferred), necessitating extended exposure time.

Probability of successful control: Where adequate dose (>10 ppb for fanwort) and exposure time (60-120 days) are maintained, fanwort can be eradicated. This has proven difficult to achieve, however, particularly in partial lake treatments. Use of slow release pellet formulations or sequestration of the target area with impervious curtains maximizes exposure time and limits dilution of the dose. Follow up actions, such as hand harvesting, are often necessary, and re-treatment the next year may enhance control. Despite limitations, fluridone is a preferred chemical for fanwort control.

Potential non-target impacts: Susceptibility of other plants to fluridone varies widely, and much of the native community may survive at doses <6 ppb. However, doses <6 ppb are unlikely to control fanwort, and complete control is not typically achieved at <10 ppb. At doses >10 ppb, impact on some non-target plants are expected. Slow die-off of affected plants limits oxygen reduction. No impacts to fauna or humans are expected at applied doses.

Permitting needs: Requires an Order of Conditions under the Wetlands Protection Act and a License to Apply Chemicals from the DEP.

Monitoring needs: Normally the plant community is monitored before and after treatment. The concentration of fluridone is also commonly tracked on a weekly to monthly basis with an Enzyme Limited Immuno-Sorbent Assay (ELISA).

Range of costs: Costs range from $500 to $2,000 per acre, depending upon the form of fluridone applied, any necessary re-treatment to maintain dose, and any sequestration of the target area.

Other considerations: The combination of dose and exposure time is critical to success; the combination of achievable detention time and degree to which non-target plants must be protected will determine the potential for eradication or extended control.

Application of Triclopyr

Mode of action: This systemic herbicide is absorbed by vegetative tissues of dicot plants and translocated throughout the plant, inhibiting synthesis of key enzymes while stimulating growth, resulting in plant death. Uptake is rapid and exposure time can be less than one to three days. Plants sink from the surface within a week and die within three weeks.

Probability of successful control: Where adequate dose (0.75 to 2.5 ppm, usually about 1.5 ppm) and exposure time (6-12 hours up to 3 days) are maintained, impact on fanwort is possible but not consistently obtained in limited trials. As this herbicide was approved in November of 2004

for use in Massachusetts, there is only limited experience under experimental use permits to guide treatment.

Potential non-target impacts: Dicotyledonous plants, including fanwort, are susceptible to triclopyr, while monocotyledonous species, such as naiad and pondweed, are minimally affected at label doses. Impacts to fauna or humans have not been observed at applied doses. No threat to humans has been indicated at label doses.

Permitting needs: Requires an Order of Conditions under the Wetlands Protection Act and a License to Apply Chemicals from the DEP.

Monitoring needs: Normally the plant community is monitored before and after treatment.

Range of costs: Costs are expected to range from $600 to $800 per acre, but there have been too few treatments to date to generalize.

Other considerations: As triclopyr was only registered for use in Massachusetts in 2004, evaluation of its potential is based on experimental use only, and those results are not encouraging. However, lower required exposure times make it an attractive choice with short detention time.

Other Options

Other management options are not listed for one or more of the following reasons:

- impractical on a small scale
- not able to eradicate fanwort
- could cause fanwort to spread
- not approved for use in Massachusetts

Recommended Options for Early Eradication

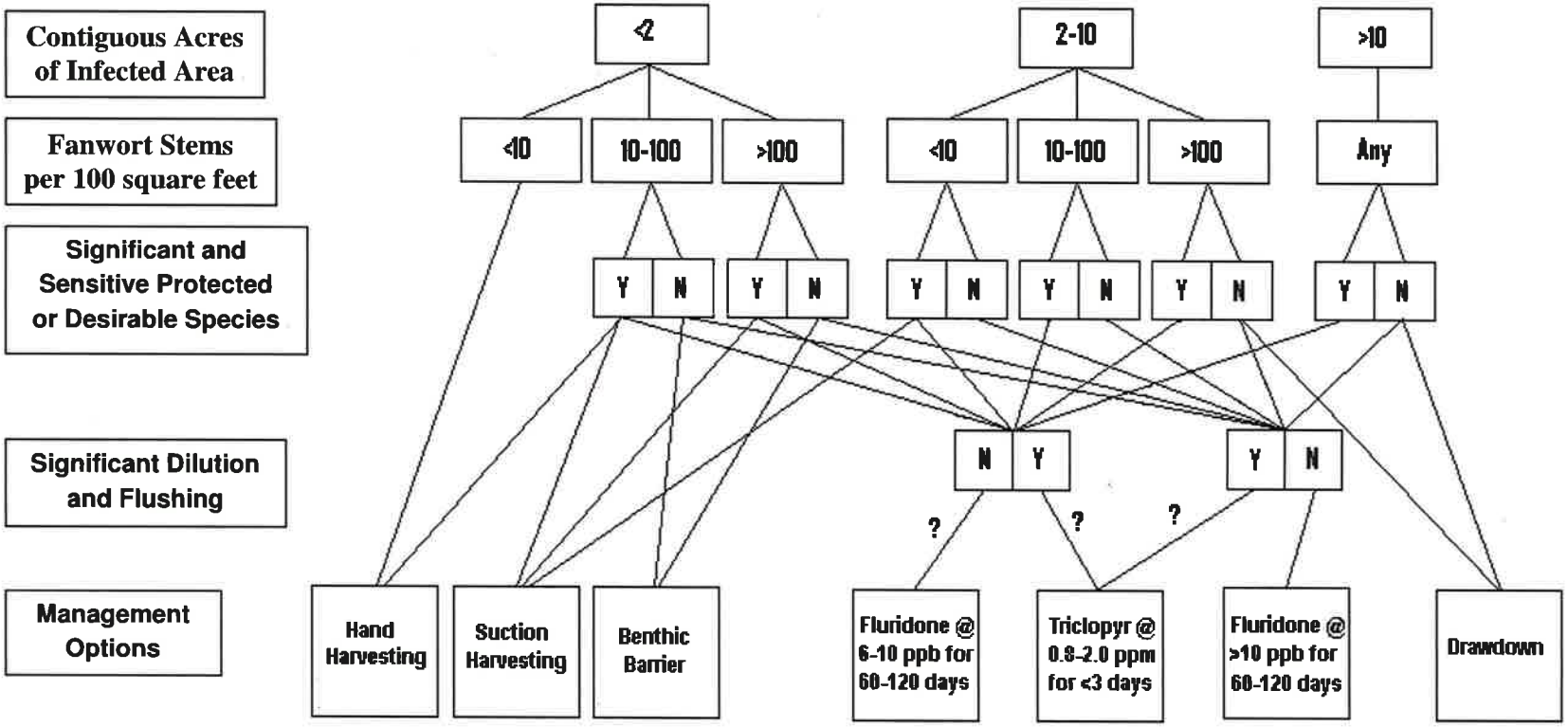
The most commonly recommended early actions are hand harvesting and bottom barriers, each of which has a high potential for success, low cost on a localized basis, and limited permitting needs. Where growths are too dense for effective hand harvesting and too extensive for cost-effective bottom barrier placement, suction harvesting should be considered. Drawdown, where applicable, is perhaps the most widely effective preventive control in cases where repeated invasion is expected or documented, but is not applicable in all cases. Where detention time can be maximized, either on a whole lake basis or with sequestration of a target area, fluridone can eliminate fanwort. On a localized basis, the herbicide triclopyr may have potential for control of fanwort where exposure times are limited and with limited impacts on other native species; more experience is needed to make a more definitive recommendation, however.

A graphic summary of rapid response actions is provided in Figure 3. Most rapid responses will involve sparse growths over a limited area or small, dense beds in a confined area. While the listed techniques may still be applicable after growths have become widespread, addressing them may not qualify as a rapid response, and additional considerations (e.g., impacts to non-target organisms on a lakewide basis) are likely to become more important in the permitting process. It is extremely important to detect an invasion early and act quickly to eliminate the infestation. The selection pathways shown in Figure 3 represent logical choices based on general features of the aquatic system, and are not intended to provide infallible rules or inflexible options. Practitioners should use a careful process of option review based on site specific data when selecting a rapid response.

Deciding Which Technique to Apply

The following decision tree is provided as an aid to evaluating control options. Thresholds for application are given as guidelines, not rigid rules. Individual circumstances may affect the choice of approach and outcome. Follow up monitoring is considered essential, and follow up control after an initial application is considered likely to be necessary.

Figure 3. Decision Tree for the Control of Fanwort (*Cabomba caroliniana*)



Notes: Hand harvesting and suction harvesting must include root system removal. Benthic barrier should remain in place for 30 to 60 days. Fluridone is effective at >10 ppb with >60 days exposure; lesser doses and exposure time may yield some control. Triclopyr approved for use in MA in late 2004; experience is limited in MA. Drawdown use is dependent on many factors, including hydrology and use as a water supply. Moderate to dense growth over an extensive area (>10 acres) may not be appropriate for rapid response consideration.

Control of Established Infestations

This document deals mainly with early invasion and the new infestations that result, but it is important to note that older infestations, where the fanwort has moved throughout the waterbody into all suitable habitats and probably become the dominant plant, can and should be addressed if continued invasion in the region is to be curtailed. The Practical Guide to Lake Management in Massachusetts (Wagner, 2004), a companion guide to the GEIR on Lake Management, provides a review of all available techniques for combating fanwort (*Cabomba caroliniana*) infestations. On a whole lake basis, herbicide treatment is the most cost-effective means for reducing fanwort coverage and density to levels that can be controlled by physical techniques like hand harvesting or bottom barriers. However, only fluridone is applicable at this scale, and effectiveness is highly dependent on both dose and exposure time. Drawdown will reduce fanwort in the drawdown zone, but it is rare that a waterbody can be drawn down enough to eliminate fanwort without unacceptable impacts to non-target species. Techniques suitable for combating new growths are seldom practical or effective on a whole lake scale (e.g., hand harvesting, bottom barriers).

Maintenance techniques that limit the impact of fanwort on waterbody uses, but do not typically result in elimination of fanwort, include mainly mechanical harvesting, hydroraking and rotovation. These physical methods may actually spread fanwort if it is not already everywhere in the waterbody, after which these methods are analogous to mowing a lawn.

Dredging can remove fanwort along with all other plants and any remaining seeds or other propagules associated with the dredged sediment. The cost is extremely high, however, and resulting substrate conditions may still be hospitable to fanwort growth. With much bare area to be colonized, invasive species such as fanwort are likely to become dominant if more desirable species are not actively introduced. Only if dredging results in a water depth too great for effective colonization by fanwort is it likely to be the only method needed to control fanwort in the target area.

Grass carp can eliminate fanwort (and indeed all other submersed plants) when stocked at sufficient density, but are not approved for use in Massachusetts at this time. There are no known invertebrate herbivores that attack fanwort to an extent that might facilitate control.

Prevention of Re-Infestation

Once an invasion has been repulsed through any of the above methods, it should be apparent that the waterbody is susceptible to fanwort. As the cost of prevention is much less than the cost of rehabilitation of an infested waterbody, steps should be taken to reduce the risk of re-introduction of fanwort. As fanwort most often comes from a local source, control activity is encouraged on a watershed, multi-municipal or regional level. Working across political boundaries with limited funding is difficult, but represents the most sweeping opportunity to limit future invasions. Alternatively, and almost essential as a back-up, steps need to be taken at the individual waterbody to reduce the risk of re-introduction. Key steps may include:

- Education through the lake association or town for all users about the threat of fanwort, how to avoid introducing it to the waterbody, how to identify it, and who to contact if it is found. See the other sections in this document for relevant information to be provided.

- Posting of all access points with signs warning of the threat, showing how to identify fanwort, and urging that boats, fishing gear and other recreational equipment be cleaned before and after use in the waterbody. See the section on Communication and Education in this document.
- Provision of wash stations at boat ramps, and/or staffing of ramps with inspectors.
- Drawdown where applicable and permitted to minimize overwintering of introduced fanwort.
- Monitoring of the plant community to detect fanwort, with a focus on boat ramps and inlets.

Summary

1. Fanwort (*Cabomba caroliniana*) is an invasive plant normally identified by fan-shaped submerged leaves arranged around the stem in pairs.
2. Fanwort is native to the subtropic-temperate regions of eastern North and South America. It is most often transported on boats or trailers, by birds, and with water flow.
3. Fanwort can be transported great distances by fragments that can root and grow. It becomes locally abundant by root crown expansion. Seeds are of limited importance in dispersal, but cannot be ignored completely in evaluating routes of new infestations or regrowth from seemingly eradicated populations.
4. Fanwort creates canopies that shade out other plant species. At high density it provides poor habitat for most water-dependent fauna, impairs recreational uses, and can have negative impacts on water supply and flood control.
5. Fanwort is most often detected in the early stages of infestation in water <10 ft deep by visual examination (viewing tube from boat or mask and snorkel). Look first in the vicinity of boat ramps, inlets, and areas of bird congregation. One effective long-term monitoring strategy involves setting up transects representing areas of the lake and searching at discrete depth intervals from shore to the maximum depth of plant growth.
6. When detected, map fanwort coverage with notation of density as beds, scattered plants, or solitary stems. Be thorough with visual coverage of potentially infested areas. Record all other species present and their relative abundance. Confirm identification through the DCR.
7. Educate waterbody users by whatever means practical about the threat and presence of fanwort. Posting of access points is useful in all cases. Signs should show how to identify fanwort, urge that all boats, trailers and other recreational equipment be cleaned before and after use in the waterbody, and provide a contact name and phone number for reporting or correspondence.
8. It is advantageous to quarantine infested areas until removal can be attempted. Closing beaches and boat ramps can be problematic, legally and practically, but can promote greater awareness and support for prompt action. Use of curtains or screens both to keep people out of an infested area and to keep fanwort inside is desirable but expensive.
9. Eradication of fanwort detected early in an invasion can be accomplished with hand harvesting, suction harvesting, benthic barriers, drawdown, or the herbicide fluridone. The herbicide triclopyr may be effective, but was approved for use in Massachusetts in late 2004 and experience is limited. Hand harvesting and benthic barriers are often allowable without an Order of Conditions under the WPA, and can therefore be implemented most rapidly. Each method has benefits and drawbacks, and the specific circumstances will affect which option(s) can be applied.

10. A range of additional options are available to combat later stage invasions. Those not mentioned as eradication options for new infestations have some feature that prevents effective, rapid use, but these techniques may have applicability under special circumstances.
11. Drawdown, where feasible, can act as a deterrent to invasion on an annual basis at a relatively low cost, through direct impact on invading fanwort and by gradually altering the peripheral sediment features to make them less hospitable, but has many possible impacts on aquatic resources and requires a thorough evaluation in each case.
12. Once fanwort has been removed after an invasion event, steps are necessary to prevent re-infestation. Education of waterbody users, with a focus on boating, and ongoing monitoring to detect new fanwort plants are critical components. It should be assumed that fanwort will return, but it is far easier to address new growths than to combat a full infestation.

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Appendix I. Watershed Management Options

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DRINKING WATER PROGRAM

DEVELOPING A LOCAL SURFACE WATER SUPPLY PROTECTION PLAN

Updated May 2000

Contents

INTRODUCTION

This guidance document outlines the minimum components which should be included in a local Surface Water Supply Protection Plan for filtered reservoirs, provides a step-by-step approach to water supply protection planning, and gives examples of local protection options. **The document is intended to provide water suppliers with a low-cost method of developing a plan using existing information and maps, their own water supply expertise and knowledge of watershed conditions, assistance from volunteers, and input from various individuals and groups.**

Assistance may be obtained from the Executive Office of Environmental Affairs (EOEA) watershed teams which are implementing the Watershed Initiative in the twenty-seven river basins in Massachusetts. The Watershed Initiative is a phased, five-year cyclical program to collect and share water resource information, assess the impacts to water resources, and develop and implement activities to protect and improve them. Water Supply staff in the Department's Boston and regional offices participates on the basin teams and can be contacted for assistance.

Developing a plan to improve watershed protection has many benefits, including: increased protection against waterborne diseases; possible filtration/disinfection cost savings; possible avoidance of disinfection by-products; good public relations; and is an integral part of multiple barrier protection.

An approved protection plan is required to obtain disinfection log credit from the Department under the Surface Water Treatment Rule. Suppliers have obtained up to .5 log credit for having an approved plan and more suppliers may want to apply for credit in anticipation of the Enhanced Surface Water Treatment Rule.

It is important to develop a timetable for implementing the actions identified in the plan. A lead person should be assigned to evaluate progress, assess the timetable annually, update the plan's information as needed and revise the entire plan at least every three years. During the watershed component of the sanitary survey, DEP staff will be available to review the status of watershed protection actions with the water supplier and to provide technical assistance.

The Department is also conducting the Source Water Assessment Program (SWAP), a new federal requirement, to determine the susceptibility of public drinking water sources to potential contamination. Assessments will be developed for the 3000 public water supply sources in Massachusetts by 2003. Assessment results, GIS mapping and recommendations for improving local protection will be provided to suppliers, local officials, community groups and the public.

There are four basic steps for the development and implementation of watershed protection actions.

1. **Delineate**
2. **Inventory**
3. **Protect**
4. **Educate**

The following guidance recommends using these four steps to develop a local Surface Water Supply Protection Plan. **The plan's required components are *two maps*** (or one if the Geographic Information Systems (GIS) map recently distributed by the Department to public surface water suppliers is being used as the base map) **and *seven written summaries***. The GIS map which suppliers received contains most of the watershed characteristics, land uses, and protected open space information which is needed to develop a plan. The seven summaries may be written as seven chapters.

The guidance is divided into a column which shows specific information that must be included in a plan and a column which outlines what actions should be taken by the supplier to obtain that information. Some sections, however, may need to be modified for a particular system. For example, for non-municipal systems, the section entitled *Municipal Land Use Improvements* could be modified to discuss communications with a municipality about such improvements.

Public surface water suppliers may call the DEP offices listed on page 18 with questions about this guidance and to request assistance with developing and implementing a local protection plan. Draft plans may be submitted to DEP staff for preliminary review and comment.

After DEP approved the Surface Water Supply Protection Plan for North Andover, Linda Hmurciak, Assistant Superintendent of the Water Treatment Plant, forwarded a copy to the Town Library and asked that it be displayed during National Drinking Water Week in May. She also enclosed a poster to hang in the library and requested that water-related books be featured in the children's section during that week. Linda calls the protection plan, which was written by staff, "another avenue for education of our source" and says that she subsequently received a request to put more than one copy in the library.

STEP 1: DELINEATE

The first step, DELINEATE, involves mapping. In order to assess and prioritize possible threats to a public drinking water source, the following information related to watershed characteristics, land uses and other activities, at minimum, should be assembled on a map. Most of the information shown below can be found on the GIS map which was distributed to public surface water suppliers in January 1997. Updated maps to use in plans can be obtained by calling the Drinking Water Program at (617) 292-5727. Additional information regarding impacts to your source may be obtained from local, state or federal agencies.

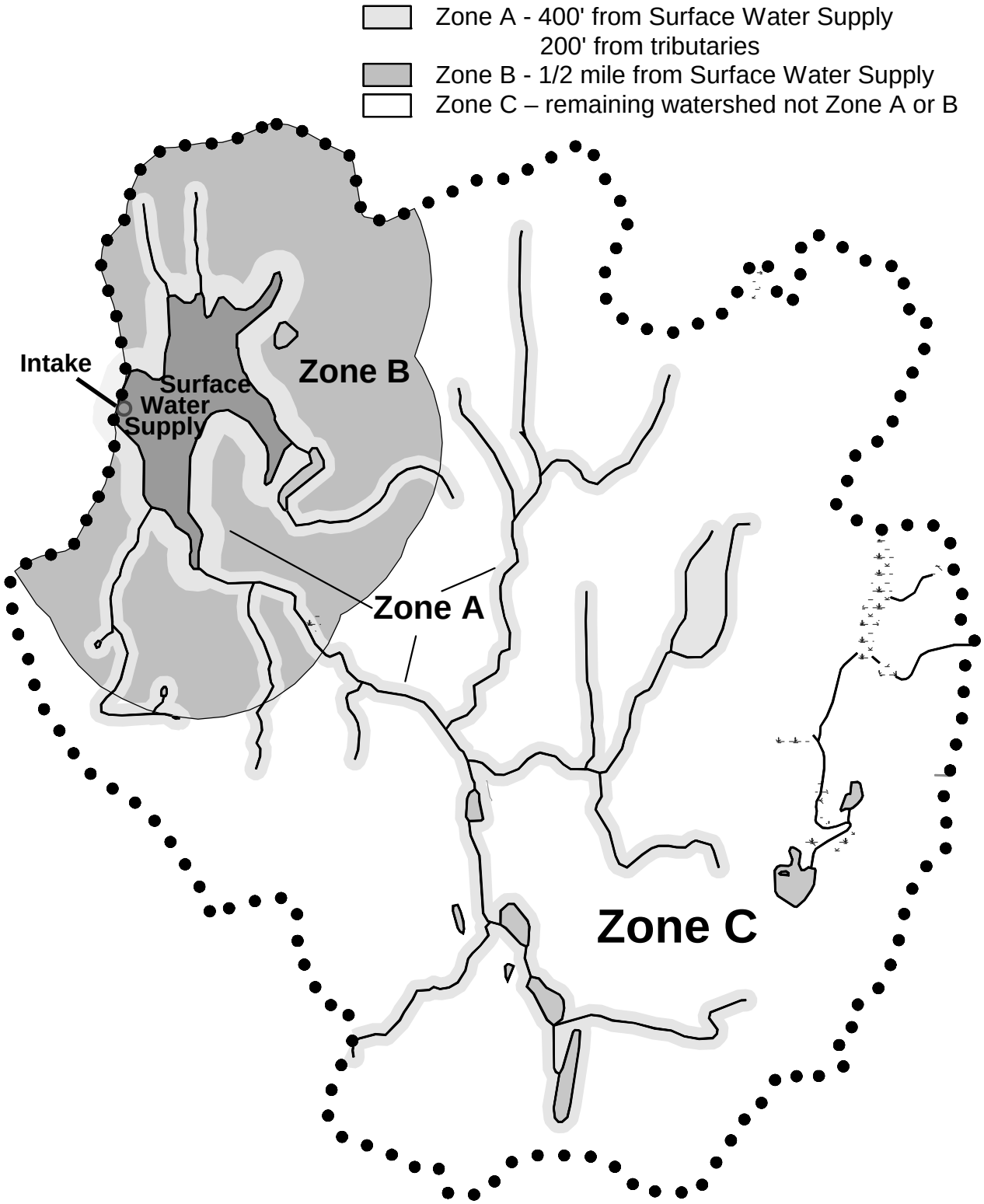
MAP #1 (For base map, may use GIS map provided by DEP)

Watershed Characteristics

The watershed characteristics information required to be submitted on Map #1 helps to show where the areas most vulnerable to contamination are located.

Submit This Information to DEP on Map #1	Action Needed
a. surface drinking water source	confirm location on map
b. surface water supply intake	confirm location on map
c. tributaries	confirm locations on map
d. protection Zones A, B, C for surface sources (see Figure 1)	confirm locations on map
e. drinking water wells	confirm locations on map
f. 100-year floodplain at surface water source	consult FEMA map; delineate on GIS map

Figure 1. **Surface Water Supply Protection Areas**



Land Uses

The following land uses may have negative impacts on drinking water quality and should be prohibited or controlled within Zone A of the surface source. Additional high and medium risk activities should also be controlled within Zones B and C.

Identifying the locations of these activities in the watershed should shape local protection efforts to reduce or eliminate ***existing*** impacts and prevent ***future*** problems.

Submit This Information to DEP on Map #1	Action Needed
g. major existing land uses (high density residential, commercial & industrial areas, private recreation, for example)	confirm locations on map; update map as needed
h. agricultural activities (feedlots, horses, cows, kennels, nurseries, crops, etc.)	confirm locations on map; update as needed
i. permitted solid waste facilities	confirm locations on map; contact DEP Solid Waste for more information; update map as needed
j. state & federal listed hazardous waste sites; other known waste sites within protection zones	confirm locations on map; contact DEP Waste Site Clean-up & local Board of Health for more information; update map as needed
k. permitted wastewater discharges within water supply protection zones	confirm locations on map; contact DEP Water Pollution Control (WPC) & EPA Region I for more information; update map
l. known parking lot, roadway, or other stormwater discharges into surface water supply & tributaries	contact local Highway Dept. & DEP WPC (for permitted stormwater discharges) and delineate on map
m. major roads, railroads, airports within protection zones	confirm locations on map
n. subsurface sewage disposal problem areas which may affect water supply	contact Board of Health, Board of Sewer Comm.; delineate on map

o. areas at water supply where high bacterial readings have been detected in the past	delineate on map
p. other areas of existing or potential impact to water supply: highly erodible soils, steep slope, needed dam repairs, utility rights-of-way using herbicides, sand & gravel excavations, road salt storage areas, planned major projects (airports, expansions of existing land uses, etc.)	delineate on map
q. underground storage tanks (including residential)	contact Board of Health, Fire Dept.; confirm locations on map; update as needed

MAP #2 (For base map: may use GIS map provided by DEP)

The following information, related to *permanently* protected land parcels and local zoning, can be assembled on the GIS map provided in January 1997 by DEP (map shows permanently protected parcels *which are in the GIS database*) or on a separate map. Updated GIS maps to use in plans can be obtained by calling the Drinking Water Program at (617) 292-5727.

Protected Open Space

"Permanent" protection means that the lands will not be sold or developed. Permanently protected parcels may include lands owned by the water supplier, Conservation Commission, nonprofit land trust, some state agencies, or private property upon which activities are restricted for water supply protection through easements, conservation restrictions and other mechanisms.

Mapping permanently protected parcels in the watershed helps to show where additional land acquisition or other types of deed control options are needed. This data, combined with a review of watershed characteristics and historical, present and future land use information, helps to focus land acquisition or other deed control efforts within the areas of the watershed which are the most vulnerable to contamination.

It is important to develop a system for prioritizing properties so that resources can be used to acquire the most vulnerable lands first. Additional criteria used to prioritize parcels for acquisition might include: distance to intake, source, and tributaries; zoning; slope; soil type; extent of bordering vegetated wetlands; wildlife; and proximity to other protected parcels.

Submit This Information to DEP on Map #2	Action Needed
a. protected open space/recreation parcels within watershed	use GIS map provided by DEP or contact MassGIS to obtain a separate open space/recreation map for your watershed; talk with local Assessors and Conservation Commission to confirm information on map; update as needed

Local Zoning

A review of existing local zoning provides a good idea of what types of land uses COULD occur within Zones A, B & C in the future.

Submit This Information to DEP on Map #2	Action Needed
b. current zoning (residential, commercial, business, industrial, farming, other)	refer to town zoning map; transfer information to GIS map or other base map; or submit current zoning map

STEP 2: INVENTORY

The second step to watershed protection, INVENTORY, involves summarizing and prioritizing private and public land uses and activities, which are, or may be, an impact on your surface source.

You may contact the Department's regional offices for information relative to the status of your basin in the five-year cycle and to take advantage of inventories, assessments, and other data which may be available through EOEA river basin teams. The teams collect and share water resource information, assess impacts, and develop and implement activities to protect and improve those resources.

EOEA agencies participating on the teams include the Department of Environmental Protection, Department of Environmental Management, Office of Coastal Zone Management, Department of Fisheries, Wildlife & Environmental Law Enforcement, Office of Technical Assistance, Metropolitan District Commission, and the Department of Food & Agriculture. In addition, teams have invited representation from Mass. Highway Department, Mass. Water Resources Authority, regional planning agencies, conservation districts, and watershed associations.

The Department will be inventorying and mapping potential contaminant sources under the Massachusetts Source Water Assessment Program.

SUMMARY #1

Land Use Impacts

Submit This Information to DEP in Summary #1	Action Needed
a. water supply impacts from EXISTING land uses	review current land uses on Maps #1 & 2; consult with town officials & staff and determine which land uses are impacting--or have the potential to impact--water supply

Existing and future land use activities which may have an impact on surface water sources include: on-site septic systems; public and private recreational activities; municipal uses and facilities; untreated stormwater runoff; public and private forestry practices; uncontained storage of fertilizers, manure, road salt/sand; domestic animals; new construction; sand and gravel excavations; spills along roads and railroads and at commercial and industrial facilities; above ground and underground storage tanks; erosion; unpermitted and unauthorized activities; waste disposal areas; use, storage and disposal of hazardous materials; non-sanitary wastewater.

Submit This Information to DEP in Summary #1	Action Needed
b. potential water supply impacts from FUTURE land uses allowed by current zoning	review land uses on Map #1 and those uses allowed by current zoning on Map #2; consult with town officials and staff and determine what future land uses may impact water supply

Public Access/Recreation Impacts

Submit This Information to DEP in Summary #1	Action Needed
c. existing or potential water supply impacts from public access and recreational activities (trails, other facilities)	summarize use on and near water supply

Examples of impacts from allowing public use of water supplier-owned lands include: erosion, trash, vehicular and pedestrian traffic, parking, unauthorized swimming and other activities, restrooms, and waste from domestic animals.

Wildlife Impacts

Submit This Information to DEP in Summary #1	Action Needed
d. existing impacts or potential water supply impacts from wildlife	review existing local, state, or federal information, or conduct in-house survey of wildlife populations in close contact with surface water supply; summarize

Wild animals, farm animals, and domestic pets can be carriers of waterborne diseases such as Giardia, Cryptosporidium, Salmonella, etc. Animal populations to monitor for include--but are not limited to--gulls, geese and other birds, dogs, horses, beaver, muskrat, and deer.

A wildlife survey need not be an expensive, time-consuming effort. In addition to the first-hand knowledge of the water supplier and staff, information may have already been collected by state and federal wildlife agencies. In addition, interested individuals, professors and students from nearby colleges, members of land trusts, and others can often be recruited to conduct a volunteer inventory.

In-lake Problems

Submit This Information to DEP in Summary #1	Action Needed
e. existing impacts or potential in-lake problems (algae, aquatic vegetation, bacteria)	summarize

Other

Submit This Information to DEP in Summary #1	Action Needed
f. other areas of concern	summarize

SUMMARY #2

Watershed Sampling Plan

Submit This Information to DEP in Summary #2	Action Needed
a. include, at minimum, locations of regular sampling for bacteria & turbidity	review identified impacts and select sampling locations which will give a good indication of the success of watershed protection efforts

STEP 3: Protect

The third step to watershed protection, PROTECT, involves developing actions, and time frames for those actions, to address the land uses and activities which were prioritized for action in the previous section. Unless there is an immediate threat, actions for most protection measures discussed in the plan should be developed on a three-year schedule. The assessments conducted under the Mass. Source Water Assessment Program will include recommendations on how suppliers and others can take action to address impacts to local drinking water sources.

It is important to conduct public outreach throughout the process of developing a local protection plan to disperse information and to obtain input from various groups which have a stake in water supply protection. Outreach efforts are particularly important and useful during the selection and development of protection measures. Outreach should be directed at residents, public officials and staff, community groups, businesses, agricultural entities, and others. Where there are multi-town watersheds, educational efforts should be undertaken regionally. The Department will be conducting outreach to distribute SWAP information to the public and to encourage public involvement in, and support of, local protection measures.

SUMMARY #3

Watershed Control

One option for controlling watershed activities is direct land purchase by the water supplier. It is also possible to acquire control through other means, such as conservation restrictions, easements, purchase of development rights and other written agreements. Under such agreements, the land remains in private ownership and may continue to provide revenue to the owners through activities which are consistent with water supply protection. This type of control should be emphasized within Zone A of the surface water source and within other vulnerable areas, such as where there are, or could be, high impact land uses within Zones B & C.

Submit This Information to DEP in Summary #3	Action Needed
a. prepare 10-year plan for land purchase or control through deed restrictions/easements	review Maps #1 & #2 and target parcels for purchase or deed control for water supply protection; coordinate efforts with local town boards and private land trusts

Water suppliers should have a written management program for each property which is under their control. The program should include regular, logged inspections to look for unauthorized activities, illegal dumping, obstructions to stream flow, deteriorating or missing signs, other maintenance needs, and to check boundaries for encroachment by adjacent landowners.

Municipal Land Use Improvements

Municipal uses within the watershed should be reviewed to ensure that any detrimental activities are identified and corrected. Municipal activities which could have an impact on surface water sources include: road salt/sand use and storage; chemical use and storage; composting and recycling facilities; sites of permanent or one-day household hazardous waste collection events; motor oil collection centers; underground storage tanks; gasoline pumps; vehicle repair operations; public recreation areas; and septic systems.

It is also important to plan for the installation of a municipal sewage collection system where needed, the repair and maintenance of existing water supply distribution lines and the construction of new lines.

Submit This Information to DEP in Summary #3	Action Needed
b. describe plans to eliminate or control municipal activities/ relocate facilities detrimental to water supply; develop schedule for infrastructure improvements	discuss local needs with capital improvement committee and other appropriate town boards to ensure adequate long-term funding of projects

The City of Chicopee, with assistance from the Pioneer Valley Planning Commission and a Clean Water Act s.319 Nonpoint Source Competitive Grant from DEP, has established a Stormwater Management Program and passed a municipal ordinance that instituted a stormwater management fee to be collected from residents The fee is expected to generate $500,000 annually. The Planning Commission created a packet which contains a summary of the project, a step by step guide to developing a local stormwater utility, sample outreach materials and a model stormwater utility ordinance which can be used as a model by others. This project was the first of its kind in Massachusetts.

SUMMARY #4

Public Access/Recreation Control

Submit This Information to DEP in Summary #4	Action Needed
a. develop plan to control	determine what level of

public access on water supply and within adjacent water supplier-owned lands; include provisions for inspections, enforcement, and education	public access is acceptable to protect water supply quality from degradation and vandalism

Measures to control public access/recreation include: replanting eroded areas; rerouting trails away from vulnerable soils, slopes and intake; developing "adoption" program; creating well-defined parking areas; installing and maintaining signs denoting water supply; blocking off vulnerable areas to vehicular and pedestrian traffic; conducting regular inspections; maintaining an inspection log; developing and enforcing rules; and conducting public education. Public access/recreation should be prohibited if appropriate controls, and funds to sustain those controls, are not available.

Wildlife Management

Submit This Information to DEP in Summary #4	Action Needed
b. develop plan to control wildlife contact with surface water supply	determine measures to control wildlife contact with surface water supply

Standard procedures for wildlife management include: regular inspections for wildlife presence near source, especially near intake; appropriate actions, such as use of an air cannon, to deter presence; and regular water quality monitoring to assess wildlife impacts. Nearby landfills and sewage treatment facilities should be contacted to determine whether a gull management program is regularly conducted.

The Metropolitan District Commission (MDC) has Aquatic Wildlife Pathogen Control Zones at Quabbin and Wachusett Reservoirs. Within those designated areas, MDC staff focuses their aggressive gull/waterfowl harassment program. The creation of those zones was based on existing knowledge of pathogens, settling rates, hydrologic modeling and other factors.

The establishment of Aquatic Wildlife Pathogen Control Zones is one component of MDC's Pathogen Prevention Program, which also includes agricultural controls, recreation and access restrictions, sewer construction, on-site wastewater disposal management and extensive vegetated buffer zones.

In-lake Management

Submit This Information to DEP in Summary #4	Action Needed

c. develop procedures for managing in-lake problems (algae, aquatic vegetation, bacteria, etc.), including source sampling for bacteria at least 2 times per year	determine measures to control in-lake problems

Controls for in-lake problems include: conduct regular water quality monitoring and inspections; identify failing septic systems; control public access/recreational uses near surface water source; establish vegetative buffer; eliminate direct stormwater discharges to source and tributaries; and otherwise reduce the quantity of nutrients entering the system from direct/indirect runoff. The Department of Environmental Management's Lakes & Ponds Program may be contacted at (617) 727-3267, or www.state.ma.us/dem, for assistance.

Staffing

Submit This Information to DEP in Summary #4	Action Needed
d. identify primary contact person responsible for implementing local watershed protection measures, system operation and maintenance; develop outline for meeting staffing needs	assess staffing needs

Employ sufficient and qualified staff to perform all system operations, maintenance and repairs, monitoring, inspections, and enforcement, as well as the watershed protection measures outlined in the protection plan. The water supplier shall also have the ability to update the plan at least every three years.

SUMMARY #5

Regulatory Controls

Where other protection measures are not appropriate or effective, the following local regulatory controls are some **options**: re-zoning, zoning and non-zoning bylaws, other non-zoning mechanisms (such as subdivision rules and regulations, which can allow flexibility in development based on land characteristics), Board of Health regulations, Best Management Practices (BMPs) for agriculture, erosion control, and stormwater management. Model bylaws and recommended BMPs can be obtained from DEP and regional planning agencies.

Submit This Information	Action

to DEP in Summary #5	Needed
a. evaluate current water supply protection regulations and analyze what additional local regulatory actions are needed for water supply protection; use a 3 year time-line for actions	review maps #1 & #2 and land use inventory; talk to town officials & staff; identify actions to be taken to address specific water supply needs; contact DEP for technical assistance; include water supply protection component in Town's Master Plan

The Newburyport City Council passed a Water Supply Protection District ordinance to protect Indian Hill and Artichoke reservoirs, as well as the City's ground water sources. The ordinance's prohibitions include the following land uses within Zone A and Zone I: any activity which causes earth movement or disturbance; construction or placement of permanent structures; construction of new roads; storage of animal manure; and horse paths.

The Town of Marlboro passed a Water Supply Protection bylaw which applies to all new construction, reconstruction, expansion of existing buildings, and new or expanded uses. There are criteria for site design, including conditions for impervious areas, hazardous materials, fill, emergency response, monitoring, runoff and infiltration. Clearing, grading, earth moving or construction of any kind within fifty feet of a wetland resource area is prohibited.

SUMMARY #6

Emergency Planning

Submit This Information to DEP in Summary #6	Action Needed
a. status of emergency response plan/procedures	determine if emergency plan addresses water supply protection or needs to be updated to address those issues; conduct a pilot run of emergency system

Information to be assembled into an emergency response plan, or procedures, for water supply protection includes: response team, communication system, equipment, training, and drills. For multi-town watersheds, emergency planning should be coordinated with all towns in the watershed.

Step 4: Educate

The fourth step to watershed protection, EDUCATE, involves assessing the water supply-related educational needs within your watershed and developing programs to address those needs. In multi-town watersheds, each educational program should be focused on the entire watershed. The formation of a multi-town committee can help the water supplier promote and establish a base-line level of protection in each community. The committee can assist with the planning and implementation of water supply-related educational efforts.

EOEA basin teams, which may be contacted through the Department's Boston and regional offices, can also provide assistance with outreach activities.

In addition, the Department will be conducting outreach activities to distribute SWAP information, mapping, and recommendations for local actions.

SUMMARY #7

Education

Submit This Information to DEP in Summary #7	Action Needed
a. develop year-round program of activities targeted at varied audiences	determine what types of educational activities are needed within the community for water supply awareness and which of those activities are able to be conducted by water supplier (consider time, staff, funding)

Educational activities include: Water Department open houses, water fairs; media contact; bill stuffers; work with town officials; schools; community groups; businesses; etc. For multi-town watersheds, efforts should be coordinated with other water suppliers in watershed.

The Pioneer Valley Planning Commission and the Barnes Aquifer Protection Advisory Committee teamed up, using a grant from the Massachusetts Environmental Trust, to hold workshops for small business owners, especially auto body shops, about Best Management Practices that they can implement to improve their business management and protect ground and surface waters. Planning board members and other officials from Easthampton, Holyoke, Southampton, and Westfield were also brought into the project. The Planning Commission noted that "it was a pleasure to work with the business owners" and that the materials developed as part of that grant are available to other communities to use to accomplish similar goals.

Communication/Coordination

Submit This Information to DEP in Summary #7	Action Needed
b. show communication with other towns in watershed; plan coordinated protection efforts	exchange copies of watershed maps and bylaws, Board of Health regulations, etc. related to water supply protection; form inter-municipal agreement and/or committee

Three of the City of Cambridge's reservoirs are located in other communities and Fresh Pond, located in Cambridge, is the City's largest open space. Chip Norton, the Watershed Manager, has a lot of challenges when it comes to protection. The Water Department is particularly good at public outreach. They have a web site which discusses water supply administration, budget, distribution, operation, engineering, water quality information, water facts and brochures and has a description of the awards the Water Department has received for their protection work. They also have a newsletter that is distributed within Cambridge and the other towns in the watersheds and have developed partnerships with area businesses.

Being a water district, rather than a municipal system, can be particularly challenging. At the Cherry Valley & Rochdale Water District, which serves 4200, Superintendent Michael Knox and the Water Commissioners developed a DEP-approved protection plan for Henshaw Pond. The Water District is very pro-active and has developed the ability to work with others to get things done – local officials, state agencies, developers, schools and others.

For example, they put together a Memorandum of Understanding (MOU) with the School Committee regarding the placement of two underground storage tanks at a new high school. The agreement set the terms for the installation and annual testing of monitoring wells as well as protective measures.

The District is currently working with a variety of parties to make stormwater improvements to Route 9.

ASSISTANCE

Public surface water suppliers may call the following DEP offices with questions about this guidance and to request assistance with developing and implementing a local protection plan. In addition, draft plans may be submitted to the Boston office for preliminary review and comments.

In addition, the Drinking Water Program has two new grant programs to plan and implement local source protection projects! Information can be obtained from the Department's web page or by calling (617) 292-5770.

DEP Offices

Boston (617) 292-5500 1-800-337-6245 **TDD** (617) 574-6868
Western Region/Springfield (413) 784-1100
Central Region/Worcester (508) 792-7650
Northeast Region/Wilmington (978) 661-7600
Southeast Region/Lakeville (508) 946-2700

Web Page http://www.state.ma.us/dep

Examples of town bylaws and Drinking Water Program policies, regulations, guidance manuals and fact sheets are available on the Department's web site.

Water suppliers serving fewer than 10,000 persons may also contact Larry Stepenuck of the Rural Community Assistance Program (RCAP) at (978) 297-5300 for help.

*The Drinking Water Program has two new grant programs to fund local protection work. Public water suppliers are eligible to apply for funds from the **Wellhead Protection Grant Program**. Many kinds of projects are eligible for funding, including hiring a local staff person to develop or maintain wellhead protection efforts, removing potential sources of contamination from Zone I and conducting educational programs.*

*Third party organizations, such as watershed groups, volunteer boards and committees, regional planning agencies and consultants are eligible to apply for funds from the **Source Water Protection Grant Program** to provide technical assistance to public water suppliers. Eligible projects include developing a local surface water supply protection plan or protection bylaw, designing stormwater improvements, or managing existing water supplier-owned lands.*

You can visit DEP's web site (Drinking Water Program) or call (617) 292-5770 for more information.

COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE OFFICE OF ENERGY & ENVIRONMENTAL AFFAIRS
DEPARTMENT OF ENVIRONMENTAL PROTECTION
ONE WINTER STREET, BOSTON, MA 02108 617-292-5500

DEVAL L. PATRICK
Governor

TIMOTHY P. MURRAY
Lieutenant Governor

IAN A. BOWLES
Secretary

LAURIE BURT
Commissioner

MODEL ZONE A CONSERVATION RESTRICTION

For Protecting Surface Waters Used as Public Drinking Water Sources
2009

INTRODUCTION

This Model is designed to assist public water suppliers in developing a Conservation Restriction to protect land located near and around surface waters used for public drinking water supplies. This Model focuses on protecting land located in a Zone A but may be modified to protect land in a Zone B and/or Zone C. This Model additionally provides for public recreation, maintenance of vegetation, wildlife habitat and trails, and archeological investigations.

What You Need to Know

- Conservation Restrictions (CR) established pursuant to M.G.L. c.184, s.32 require approval by MassDEP AND the Executive Office of Energy and Environmental Affairs (EOEEA).
- Draft CRs must be reviewed by MassDEP prior to acceptance by the public water supplier (PWS).
- CRs must be placed under the control of the Board of Water Commissioners OR the Board of Selectmen (acting as the Board of Water Commissioners).
- A MassDEP public hearing and Notification is required. MassDEP assists with this process.
- PWS must submit a Permit application [BRP WS-26] for land acquisition. This is available with instructions at http://www.mass.gov/dep/water/approvals/dwsforms.htm#landacq. MassDEP assists with this process.
- EOEEA requires a CR application to be completed. In some cases a Baseline Survey must also be completed. Information and assistance with these requirements are available from the Division of Conservation Services, (617) 626-1138 or http://www.mass.gov/envir/dcs/Restrictions/default.htm
- Modifications to this Model require MassDEP review and approval.

How to Use this Model

1. **Fill** in underlined blanks with the correct information and remove underline.
2. **Replace** [bracketed words] with the requested information and remove brackets
3. **Choose** the correct choice of [underlined terms/words] and remove underlines and brackets.
4. **Delete** all notes and footnotes.
5. **Do not remove** words in "quotations" or (parenthesized words and phrases).

CONSERVATION RESTRICTION
FOR PUBLIC DRINKING WATER SUPPLY PROTECTION
date of draft

[I/We] _____ , of [Name of Municipality], [Name of County] Massachusetts, being [the sole owner/all of the owners], for my successors and assigns, "Grantor", acting pursuant to Sections 31, 32, and 33 of Chapter 184 of the Massachusetts General Laws, hereby grant to the [Town/City] of [Name of Municipality] by and through its Board of Water Commissioners[1] pursuant to Massachusetts General Laws Chapter 40 Section 41, its permitted successors and assigns, "Grantee", for _____ dollars ($__ .00) and other consideration, in perpetuity and exclusively for public drinking water supply protection, the following Conservation Restriction on a parcel of land, "Premises", located in the [Town/City] of [Name of Municipality], Massachusetts constituting approximately___ acres [2] and more particularly described in Exhibit A and attached Plan of Land[3]. For Grantor's title see [Name of County] Registry of Deeds Book #_____ page #_____.

Grantee acquires this Conservation Restriction subject to the approval of the Department of Environmental Protection pursuant to Massachusetts General Laws Chapter 40 Sections 39B and 41 and subject to the approval of the Secretary of Energy and Environmental Affairs pursuant to Massachusetts General Laws Chapter 184, Section 32.

- *Notes:*
  i. *If there is a mortgage on the Premises, a subordination [4] attached a subordination as an Exhibit.*
  ii. *If there are building envelopes or other structural exclusions, identify them in the above paragraph.*
  iii. *Draft CRs should be dated with page numbers; the final executed copy should not be dated.*
  iv. *If the CR is funded by a state grant or purchased with Community Preservation funds; the grant documents and a certified or attested copy of any municipal meeting votes regarding the purchase and expenditure of funds should be referenced and attached as an exhibit.*
  v. *The M.G.L. referenced in this Model are provided at the end of this document.*

I. PURPOSE

This Conservation Restriction is defined in and authorized by Sections 31 through 33 of Chapter 184 of the Massachusetts General Laws and otherwise by law. The purpose of this Conservation Restriction is to protect and maintain the drinking water quality of the [Name Water Supply] [Source ID#], approved by the Massachusetts Department of Environmental Protection as a source of public drinking water, and to ensure the Premises will be maintained in its current condition, as set forth in the Baseline Survey[5], in perpetuity, predominantly in a natural, scenic and undeveloped condition and to prevent any use or change that would materially impair or interfere with its conservation and preservation values as a public drinking water supply source.

Note: If the land to be acquired under this CR borders land previously acquired by the municipality for public use/Article 97; include the following sentence under the Purpose section: "Permits for the change

[1] Or Board of Selectman acting as the Board of Water Commissioners
[2] State if the CR covers only a portion of the lot/parcel; e.g " 2 acres of a 4 acre lot"
[3] Or other map suitable for recording.
[4] A subordination allows a debt or claim that has priority to take second position behind another debt, particularly a new loan.
[5] Omit if a Baseline Survey is not completed.

in use must be secured from all departments including, but not limited to [Name of Municipal Boards] which is protected under [cite applicable Massachusetts General Law and Code of Massachusetts Regulation] and in accordance with Article 97 of the Amendments to the Massachusetts Constitution and otherwise by law"**.**

II. PROHIBITED ACTS AND USES, EXCEPTIONS THERETO, PERMITTED USES

A. Prohibited Acts and Uses

Subject to the exceptions set forth herein, the Grantor will neither perform nor allow others to perform the following acts and uses that are prohibited on, above, or below the Premises:

1. No building or expansion of buildings. No mobile home, road, sign or other advertising display, swimming pool, tennis court, utility services, poles and equipment, or other permanent or temporary structures shall be constructed, placed or permitted to remain on said Premises below or above the ground.

2. No soil, loam, peat, gravel, sand, rock, landfill, mineral substance, refuse, trash, debris, junk, waste, vehicle parts or bodies, septage or other unsightly or offensive materials shall be placed, stored or dumped therein the Premises, nor any nuisances allowed to be present on the Premises.

3. No soil, loam, peat, gravel, sand, rock, landfill or other mineral substance or natural deposit shall be excavated, or removed from the Premises.

4. No snowmobiles, motorcycles, mopeds, all-terrain vehicles, or other motor vehicles of any kind shall be used, stored, maintained, operated or otherwise allowed on the Premises except for vehicles required for public safety, (i.e., fire, police, ambulance) and individual transportation vehicles (ITV) necessary for the mobility of persons with disabilities [6].

5. No pesticides as defined by the Federal Insecticide, Fungicide and Rodenticide Act of 1947, as amended, shall be mixed or stored on or under the Premises.

6. No fertilizers or animal manure shall be stored or used on the Premises.

7. No animal grazing, stabling, hitching, standing or feeding shall occur on the Premises.

8. No toxic or hazardous substances, material or wastes, shall be transported, used, stored, applied or disposed of in any manner or to any extent on or under nor transported over or through the Premises.

9. No underground or above-ground fuel storage tanks shall be installed, placed or allowed to remain on the Premises.

10. Notwithstanding the foregoing provisions with regard to specific prohibited uses and activities, but in addition thereto, no other use shall be made of the Premises and no activity permitted thereon which, in the opinion of the Grantee, is or may become inconsistent with or threatening to the purpose and intent of this Conservation Restriction as herein before stated.

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[6] An exception for ITVs must be included if the Premises will be open to the public.

B. Permitted Uses, Reserved Rights and Exceptions [7]

The Grantor reserves the right to conduct or permit the following activities and uses on the Premises, but only if such uses and activities do not materially impair the conservation values of the purpose of this restriction for protecting the drinking water quality of the [Name of Water Supply]. Activities under this section shall be in compliance with all federal, state and local laws, rules, regulations, and permits. The inclusion of any reserved right requiring a permit from a public agency does not imply that the Grantee or the Commonwealth takes any position of whether such permit should be issued.

> *Note: The following Permitted activities and uses are examples. These and other uses and activities (such as forestry and low intensive agriculture) may be allowed on a case-by case basis. Considerations include the proximity of the of the use/activity to the drinking water supply and site-specific conditions, such as areas subject to flooding,, steep slopes, erodible soils and other features that may impact drinking water quality. Uses and activities inconsistent with 310 CMR 22.20 will not be allowed.*

1. Passive Public Recreational Activities On shore fishing, hiking, bird-watching, cross-country skiing and other non-motorized outdoor recreational activities that do not materially alter the landscape or degrade drinking water quality and the maintenance and use of trails and roads located within the Premises for passive recreational purposes.

2. Pruning and Invasive Species

(a). Removal of brush by pruning and cutting to prevent, control or remove hazards, disease, insect or fire damage, and/or to preserve the present condition of the Premises.
(b). Removal of non-native or invasive flora and planting of indigenous species.

3. Wildlife Habitat Improvement With the prior written permission of Grantee, measures designed to restore native biotic communities, or to maintain, enhance or restore wildlife, wildlife habitat, or rare or endangered species including selective planting of native trees, shrubs and plant species.

4. Archaeological Investigations The conduct of archaeological activities, including without limitation survey, excavation and artifact retrieval, following submission of an archaeological field investigation plan and its approval in writing by Grantee and the State Archaeologist of the Massachusetts Historical Commission (or appropriate successor official).

5. Trails and Signs

(a). The marking, clearing and maintenance of existing footpaths and trails.
(b). The erection, maintenance and replacement of signs with respect to hunting, trespass, trail access, identity and address of the occupants, sale of the Premises, the Grantee's interest in the Premises, and the protected Conservation values.

[7] Uses to be retained by the Grantor are listed in this section. Retained uses must be consistent with protecting drinking water quality. Section Paragraph B may be omitted if the Grantor is not retaining any rights.

III. NOTICE AND APPROVAL

Whenever notice to or approval by Grantee is required under the provisions of Sections II and III, Grantor shall notify Grantee in writing not less than 60 days prior to the date Grantor intends to undertake the activity in question. The Grantors hereby shall not commence any use or activity that requires prior written approval without having obtained Grantee's approval according to the procedures set forth hereunder:

1. The notice shall describe the nature, scope, design, location, timetable and any other material aspect of the proposed activity in sufficient detail to permit the Grantee to make an informed judgment as to its consistency with the purposes of this Conservation Restriction.

2. Where Grantee's approval is required, Grantee shall grant or withhold approval in writing within 60 days of receipt of Grantor's request. Grantee's approval shall not be unreasonably withheld, but shall only be granted upon a showing that the proposed activity shall not materially impair the purposes of this Conservation Restriction.

3. Failure of Grantee to respond in writing within 60 days shall be deemed to constitute approval by Grantee of the request as submitted, so long as the request sets forth the provisions of this section relating to deemed approval after 60 days in the notice.

4. Any notice, request, consent, or communication required hereunder shall be in writing and either served personally or sent by certified mail, return receipt requested, and postage prepaid.

IV. LEGAL REMEDIES OF THE GRANTEE

A. Legal and Injunctive Relief

The rights hereby granted shall include the right to enforce this Conservation Restriction by appropriate legal proceedings and to obtain injunctive and other equitable relief against any violations, including, without limitation, relief requiring restoration of the Premises to their condition prior to the time of the injury complained of (it being agreed that the Grantee may have no adequate remedy at law). The rights hereby granted shall be in addition to, and not in limitation of, any other rights and remedies available to the Grantee for the enforcement of this Conservation Restriction. The Grantee shall attempt to resolve issues concerning violations through negotiations with the Grantor prior to resorting to legal means. In the event of a dispute over the boundaries of the Conservation Restriction, the Grantor shall pay for a survey and permanent monumentation of the boundaries.

The Grantor covenants and agrees to reimburse the Grantee all reasonable costs and expenses (including reasonable counsel fees) incurred in enforcing this Conservation Restriction or in taking reasonable measures to remedy, abate or correct any violation thereof, provided that a violation of this Conservation Restriction is acknowledged by the Grantor, or determined by a court of competent jurisdiction, to have occurred.

B. Non-Waiver

Enforcement of the terms of this Conservation Restriction shall be at the discretion of Grantee. Any election by the Grantee as to the manner and timing of its right to enforce this Conservation Restriction or otherwise exercise its rights hereunder shall not be deemed or construed to be a waiver of such rights.

C. Disclaimer of Liability

By acceptance of this Conservation Restriction, the Grantee does not undertake any liability or obligation relating to the condition of the Premises pertaining to compliance with and including, but not limited to, hazardous materials, zoning, environmental laws and regulations, or acts which are not caused by the Grantee or anyone acting under the direction of the Grantee.

D. Acts Beyond the Grantor's Control

Nothing contained in this Conservation Restriction shall be construed to entitle the Grantee to bring any actions against the Grantor for any injury to or change in the Premises resulting from causes beyond the Grantor's control, including but not limited to fire, flood, storm and earth movement, or from any prudent action taken by the Grantor under emergency conditions to prevent, abate, or mitigate significant injury to the Premises resulting from such causes. The parties to this Conservation Restriction agree that in the event of damage to the Premises from acts beyond the Grantor's control, that if it is desirable that the Premises be restored, the parties will cooperate in attempting to restore the Premises if feasible**.**

V. ACCESS

The Grantee is hereby granted a permanent easement of access to enter the Premises, or to permit personnel from the Massachusetts Department of Environmental Protection a duly constituted agency organized under the laws of the Commonwealth of Massachusetts, to enter the premises, with reasonable notice to the landowners, for the purpose of inspecting the same to determine compliance with or to enforce this Conservation Restriction, or taking any and all actions with respect to the Premises as may be necessary or appropriate with or without order of court, to remedy or abate any violation.

VI. EXTINGUISHMENT

A. Termination

If circumstances arise in the future such as render the purpose of this Conservation Restriction impossible to accomplish, this Restriction can only be terminated or extinguished, whether in whole or in part, by a court of competent jurisdiction under applicable law. If any change in conditions ever gives rise to extinguishment or other release of the Conservation Restriction under applicable law, then Grantee, on a subsequent sale, exchange, or involuntary conversion of the Premises, shall be entitled to a portion of the proceeds in accordance with paragraph B below, subject, however, to any applicable law which expressly provides for a different disposition of the proceeds. Grantee shall use its share of the proceeds in a manner consistent with the Conservation purpose set forth herein.

B. Proceeds

Grantor and Grantee agree that the grant of this Conservation Restriction gives rise to a real property right, immediately vested in the Grantee, with a fair market value that is at least equal to the proportionate value that this Conservation Restriction, determined at the time of the gift, bears to the value of the unrestricted property at that time. Such proportionate value of the Grantee's property right shall remain constant.[8] *Note: For an explanation of paragraphs A and B above, see Notes at end of document*

[8] For an explanation of paragraphs A and B, see Notes at end of document

C. Grantor/Grantee Cooperation Regarding Public Action

Whenever all or any part of the Premises or any interest therein is taken by public authority under power of eminent domain or other act of public authority, then the Grantor and the Grantee shall cooperate in recovering the full value of all direct and consequential damages resulting from such action. All related expenses incurred by the Grantor and the Grantee shall first be paid out of any recovered proceeds, and the remaining proceeds shall be distributed between the Grantor and Grantee in shares equal to such proportionate value. If a less than fee interest is taken, the proceeds shall be equitably allocated according to the nature of the interest taken. The Grantee shall use its share of the proceeds like a continuing trust in a manner consistent with the Conservation purposes of this grant.

VII. ASSIGNABILITY

A. Running of the Burden

The burdens of this Conservation Restriction shall run with the Premises **in perpetuity**, and shall be enforceable against the Grantor and the successors and assigns of the Grantor holding any interest in the Premises.

B. Execution of Instruments

The Grantee is authorized to record or file any notices or instruments appropriate to assuring the perpetual enforceability of this Conservation Restriction; the Grantor, on behalf of herself and her successors and assigns, appoint the Grantee their attorney-in-fact to execute, acknowledge and deliver any such instruments on her behalf. Without limiting the foregoing, the Grantor and her successors and assigns agree themselves to execute any such instruments upon request.

C. Running of the Benefit

The benefits of this Conservation Restriction shall be in gross and shall not be assignable by the Grantee, except in the following instances: As a condition of any assignment, the Grantee shall require that the purpose of this Conservation Restriction continues to be carried out; and the Assignee, at the time of the assignment, qualifies under Section 170(h) of the Internal Revenue Code of 1986, as amended, and applicable regulations thereunder, and is a donee eligible to receive this Conservation Restriction under Section 32 of Chapter 184 of the General Laws of Massachusetts.

VIII. SUBSEQUENT TRANSFERS

The Grantor agrees to incorporate by reference the terms of this Conservation Restriction in any deed or other legal instrument by which he divests himself of any interest in all or a portion of the Premises, including a leasehold interest and to notify the Grantee within 20 days of such transfer. Failure to do so shall not impair the validity or enforceability of this Conservation Restriction.

The Grantor shall be liable to only for violations occurring during or his or her ownership, or for any transfer, if in violation. Liability for any acts or omissions occurring prior to any transfer and liability for any transfer if in violation of this Conservation Restriction shall survive the transfer. Any new owner shall cooperate in the restoration of the Premises or removal of violations caused by prior owner(s) and may be held responsible for any continuing violations.

IX. ESTOPPEL CERTIFICATES

Upon request by the Grantor, the Grantee shall, within twenty (20) days, execute and deliver to the Grantor any document, including an estoppel certificate, which certifies the Grantor's compliance with any obligation of the Grantor contained in this Conservation Restriction.

X. NON MERGER

The parties intent that any future acquisition of the Premises shall not result in a merger of the Conservation Restriction into the fee. The Grantor agrees that it will not grant, and the Grantee agrees that it will not take title, to any part of the Premises without having first assigned this Conservation Restriction to ensure that merger does not occur. If it is determined that a transfer or assignment of any interest will result in a merger, no deed shall be effective until this Conservation Restriction has been assigned or other action taken to avoid a merger and preserve the terms and enforceability of this Conservation Restriction. It is the intent of the parties that the Premises will be subject to the terms of this Conservation Restriction in perpetuity, notwithstanding any merger.

XI. AMENDMENT

If circumstances arise under which an amendment to or modification of this Conservation Restriction may be appropriate, Grantor and Grantee may jointly amend this Conservation Restriction; provided that no amendment shall be allowed that will affect the qualification of this Conservation Restriction or the status of Grantee under any applicable laws, including Section 170(h) of the Internal Revenue Code of 1986, as amended, or Sections 31, 32 and 33 of Chapter 184 of the General Laws of Massachusetts.

Any amendments to this Conservation Restriction shall occur only in exceptional circumstances. The Holder will consider amendments only to correct an error or oversight, to clarify an ambiguity, and in circumstances where in granting an amendment there is a net gain in Conservation value. All expenses of all parties in considering and/or implementing an amendment shall be borne by the persons or entity seeking the amendment. Any amendment shall be consistent with the purposes of this Conservation Restriction, shall not affect its perpetual duration, shall be approved by MassDEP and the Secretary of EOEEA and if applicable, shall comply with the provisions of Article 97 of the Amendments to the Massachusetts Constitution. Any amendment shall be recorded in the [Name of County] Registry of Deeds.

XI. EFFECTIVE DATE

This Conservation Restriction shall be effective when:

(a). The Grantor and the Grantee have executed it;
(b). The administrative Approvals required by Section 32 of Chapter 184 of the General Laws have been obtained, and;
(c). It has been recorded in the [Name of County] Registry of Deeds.

XII. RECORDATION

The Grantee shall record this instrument in timely fashion in the [Name of County] Registry of Deeds.

XIII. NOTICES

Any notice, demand, request, consent, approval or communication that either party desires or is required to give to the other shall be in writing and either served personally or sent by first class mail, postage pre-paid, addressed as follows: To Grantor: [address] To Grantee: [address] or to such other address as any of the above parties shall designate from time to time by written notice to the other.

XIV. GENERAL PROVISIONS

A. Controlling Law

The interpretation and performance of this Conservation Restriction shall be governed by the laws of the Commonwealth of Massachusetts.

B. Liberal Construction

Any general rule of construction to the contrary notwithstanding, this Conservation Restriction shall be liberally construed in favor of the grant to effect the purpose of this Conservation Restriction and the policy and purposes of Massachusetts General Laws Chapter 184, Sections 31 through 33. If any provision in this instrument is found to be ambiguous, any interpretation consistent with the purpose of this Conservation Restriction that would render the provision valid shall be favored over any interpretation that would render it invalid.

C. Severability

If any provision of this Conservation Restriction or the application thereof to any person or circumstance is found to be invalid, the remainder of the provision of this Conservation Restriction shall not be affected thereby.

D. Entire Agreement

This instrument sets forth the entire agreement of the parties with respect to this Conservation Restriction and supersedes all prior discussions, negotiations, understandings or agreements relating to the Conservation Restriction, all of which are merged herein.

XV. MISCELLANEOUS

A. Pre-existing Public Rights

Approval of this Conservation Restriction pursuant to Massachusetts General Law Chapter 184, Section 32 by any municipal officials and by the Secretary of Energy and Environmental Affairs is not to be construed as representing the existence or non-existence of any pre-existing rights of the public, if any, in and to the Premises, and any such pre-existing rights of the public, if any, are not affected by the granting of this Conservation Restriction.

B. Subordination of Mortgage

The Grantor shall record at the appropriate County Registry of Deeds simultaneously with this Conservation Restriction all documents necessary to subordinate any mortgage, promissory note, loan, equity credit line, refinance assignment of mortgage, lease, financing statement or any other agreement which gives rise to a surety interest affecting the Property.

WITNESS my hand and seal this _____day of , 200_.

_____
Name(s) & signatures of ALL owners

COMMONWEALTH OF MASSACHUSETTS

Suffolk, ss:

On this_____ day of _____, 200_, before me, the undersigned notary public, personally appeared _____and proved to me through satisfactory evidence of identification which was _____to be the person whose name is signed on the proceeding or attached document, and acknowledged to me that he/she signed it voluntarily for its stated purpose.

_____
Notary Public
My Commission Expires:

ACCEPTANCE OF GRANT

The above Conservation Restriction was accepted by [Grantee_] this _____ day of 200_.

By: [Board of Water Commissioners/Select Board]

_____

_____

_____

_____

_____

Its: _____, duly authorized

COMMONWEALTH OF MASSACHUSETTS

_____, ss:

On this _____day of _____ , 200_, before me, the undersigned notary public, personally appeared _____, proved to me through satisfactory evidence of identification which was _____ to be the person whose name is signed on the proceeding or attached document, and acknowledged to me that he signed it voluntarily for its stated purpose.

_____
Notary Public
My Commission Expires:

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APPROVAL OF BOARD OF WATER COMMISSIONERS
(OR ACTING SELECT BOARD)

We, the undersigned, being a majority of the [Board of Water Commissioners/Select Board] of the [Town/City} of [Name of Municipality] Massachusetts, hereby certify that at a meeting duly held on _____, 200_, the Board voted to approve the foregoing Conservation Restriction to the pursuant to Section 32 of Chapter 184 of the General Laws of Massachusetts.

[Board of Water Commissioners/Select Board]

_____

_____

_____

_____

_____

COMMONWEALTH OF MASSACHUSETTS

_____, ss:

On this_____day of _____, 200_, before me, the undersigned notary public, personally appeared _____,and proved to me through satisfactory evidence of identification which was personal knowledge to be the persons whose names are signed on the proceeding or attached document, and acknowledged to me that they signed it voluntarily for its stated purpose as [Board of Water Commissioners/Select Board] for the [Town/City] of [Name of Municipality].

_____
Notary Public
My Commission Expires:

APPROVAL BY COMMISSIONER OF
DEPARTMENT OF ENVIRONMENTAL PROTECTION

The undersigned, Commissioner of the Massachusetts Department of Environmental Protection of the Commonwealth of Massachusetts, hereby certifies that the foregoing Conservation Restriction to the [Town/City/] of [Name of Municipality] has been approved in the public interest pursuant to Massachusetts General Laws, Chapter 40, Sections 15B and 41.

Dated: _____, 200_

_____
Laurie Burt
Commissioner of MassDEP

COMMONWEALTH OF MASSACHUSETTS
Suffolk, ss:

On this_____ day of _____, 200_, before me, the undersigned notary public, personally appeared Laurie Burt and proved to me through satisfactory evidence of identification which was personal knowledge to be the person whose name is signed on the proceeding or attached document, and acknowledged to me that she signed it voluntarily for its stated purpose as Commissioner of MassDEP.

_____
Notary Public
My Commission Expires:

APPROVAL BY SECRETARY OF ENERGY AND ENVIRONMENTAL AFFAIRS
COMMONWEALTH OF MASSACHUSETTS

The undersigned, Secretary of Executive Office of Energy and Environmental Affairs of the Commonwealth of Massachusetts, hereby certifies that the foregoing Conservation Restriction to the [Town/City] of [Name of Municipality] has been approved in the public interest pursuant to Massachusetts General Laws, Chapter 184, Section 32.

Dated: _____, 200_

_____
Ian A. Bowles
Secretary of Environmental Affairs

COMMONWEALTH OF MASSACHUSETTS

Suffolk, ss:

On this_____ day of _____, 200_, before me, the undersigned notary public, personally appeared Ian A. Bowles and proved to me through satisfactory evidence of identification which was personal knowledge to be the person whose name is signed on the proceeding or attached document, and acknowledged to me that he signed it voluntarily for its stated purpose as Secretary of Energy and Environmental Affairs for the Commonwealth of Massachusetts.

_____
Notary Public
My Commission Expires:

Exhibits

Exhibit A. Description of the Premises

Attach an 8 ½ x 11 draft Plan of Land (or municipal Assessors map or other map suitable for recording).

(a). The map must identify:
- The Map # and Lot/Parcel #;
- Existing structures (sheds, driveways etc) and their dimensions;
- The location of proposed activities (haying fields, hiking trails etc); and
- Boundaries of building envelopes and other exclusions.

(b). The following Notes must be on the Plan/Map:
- Label the Premises with the words *"Conservation Restriction*";
- The area of the CR should be identified (i.e. *This CR covers 2 acres of a 6 acre parcel*); and
- *This property is acquired for water supply protection pursuant to Massachusetts General Laws Chapter 40, Sections 39, 41 and 15B and Article 97 of the Amendments to the Massachusetts Constitution. This land is under the control of the Board of Water Commissioners of the [Name of Municipality]. Massachusetts Department of Environmental Protection (MassDEP) approval is required before any portion of this property can be transferred to a different ownership or control or before the property can be changed to a different use.*

Exhibit B. Subordination of Mortgage

If there is a mortgage on the Premises, attach a subordination.

(Sample) Subordination of Mortgage

I/We, ____, Present holder(s) of a mortgage on property located at____ Massachusetts ("Premises") from__to __dated __ and recorded with ____Registry of Deeds in Book___, Page___, hereby approve of, and subordinate the Mortgage and the obligations secured thereby to the Conservation Restriction covering all/a portion of the Premises to be recorded, to the same extent as if the Conservation Restriction had been executed and recorded before the execution and recording of the Mortgage. In Witness Whereof, the said _____ has caused its corporate seal to be hereto affixed and these presents to be signed in its name and behalf by _____ its_____this ___day of ____, 20_.

_____

by: _____, 20_____

Attach acknowledgement certificate/notarization here

Exhibit C. Funding Approval

If the CR is funded by a state grant or Community Preservation funds; the grant documents and a certified or attested copy of any municipal meeting votes regarding the purchase of the land and expenditure of funds should be referenced and attached as an Exhibit.

Exhibit D

If one is required, attach the Baseline Survey

Legal References

MGL c. 40 s. 39B Acquisition of land and water For the purpose of establishing a water supply or water distributing system as authorized by section thirty-nine A, any town, by its board of water commissioners or selectmen authorized to act as such, may take by eminent domain under chapter seventy-nine, or acquire by purchase or otherwise, and hold, the waters, or any portion thereof, of any pond, brook, spring, stream or ground water sources within its limits, not already appropriated for purposes of public water supply, and any water or flowage rights connected therewith; and also for said purpose may take by eminent domain under chapter seventy-nine, or acquire by purchase or otherwise, and hold, all lands, rights of way and other easements necessary for collecting, storing, holding, purifying and treating such water and protecting and preserving the purity thereof and for conveying the same to any part of the town; provided, that no source of water supply and no lands necessary for protecting and preserving the purity of the water shall be taken or used without first obtaining the advice and approval of the department of environmental protection, and that the location and arrangement of all dams, reservoirs, wells……or other works necessary in carrying out the provisions of sections thirty-nine A to thirty-nine E, inclusive, shall be subject to the approval of said department.

MGL c. 40 s. 41 Protection of water supply Towns and water supply and fire districts duly established by law may, with the consent and approval of the department of environmental protection, given after due notice and a hearing, take by eminent domain under chapter seventy-nine, or acquire by purchase or otherwise, and hold, lands, buildings, rights of way and easements within the watershed of any pond, stream, reservoir, well or other water used by them as a source of water supply, which said department may deem necessary to protect and preserve the purity of the water supply. **All lands taken, purchased or otherwise acquired under this section shall be under the control of the board of water commissioners of the town/city or water district acquiring the same**, who shall manage and improve them in such manner as they shall deem for the best interest of the town or district. All damages to be paid by a town or district by reason of any act done under authority hereof may be paid out of the proceeds of the sale of any bonds authorized by law to be issued by such town or district for water supply purposes or from any surplus income of the water works available therefore. A town may also make a contract to contribute to the cost of building, by any other town situated in the watershed of its water supply, a sewer or system of sewers to aid in protecting such water supply from pollution.

M.G.L c.184 s.31 defines a Conservation Restriction as: **"** a right, either in perpetuity or for a specified number of years, whether or not stated in the form of a restriction, easement, covenant or condition, in any deed, will or other instrument executed by or on behalf of the owner of the land or in any order of taking, appropriate to retaining land or water areas predominantly in their natural, scenic or open condition or in agricultural, farming or forest use, to permit public recreational use, or to forbid or limit any or all (a) construction or placing of buildings, roads, signs, billboards or other advertising, utilities or other structures on or above the ground, (b) dumping or placing of soil or other substance or material as landfill, or dumping or placing of trash, waste or unsightly or offensive materials, (c) removal or destruction of trees, shrubs or other vegetation, (d) excavation, dredging or removal of loam, peat, gravel, soil, rock or other mineral substance in such manner as to affect the surface, (e) surface use except for agricultural, farming, forest or outdoor recreational purposes or purposes permitting the land or water area to remain predominantly in its natural condition, (f) activities detrimental to drainage, flood control, water conservation, erosion control or soil conservation, or (g) other acts or uses detrimental to such retention of land or water areas".

MGL c. 184 s 32 Effect, enforcement, acquisition, and release of restrictions No conservation restriction ….as defined in section thirty-one, held by any governmental body or by a charitable corporation or trust whose purposes include conservation of land or water areas or of a particular such area …… shall be unenforceable on account of lack of privity of estate or contract or lack of benefit to particular land or on account of the benefit being assignable or being assigned to any other governmental body or to any charitable corporation or trust with like purposes, or on account of the governmental body the charitable corporation or trust having received the right to enforce the restriction by assignment, provided (a) in case of a restriction held by a city or town or a commission, authority or other instrumentality thereof it is approved by the secretary of environmental affairs if a conservation restriction, and (b) in case of a restriction held by a charitable corporation or trust it is approved by the mayor, or in cities having a city manager the city manager, and the city council of the city, or selectmen or town meeting of the town, in which the land is situated, and the secretary of environmental affairs if a conservation restriction, the commissioner of the metropolitan district commission if a watershed preservation restriction, the commissioner of food and agriculture if

an agricultural preservation restriction, the Massachusetts historical commission if a preservation restriction, or the director of housing and community development if an affordable housing restriction.

Article 97 The people shall have the right to clean air and water, freedom from excessive and unnecessary noise, and the natural scenic, historic, and esthetic qualities of their environment; and the protection of the people in their right to the Conservation, development and utilization of the agricultural, mineral, forest, water, air and other natural resources is hereby declared to be a public purpose. The general court shall have the power to enact legislation necessary or expedient to protect such rights. In the furtherance of the foregoing powers, the general court shall have the power to provide for the taking, upon payment of just compensation therefore, or for the acquisition by purchase or otherwise, of lands and easements or such other interests therein as may be deemed necessary to accomplish these purposes. Land and easements taken or acquired for such purposes shall not be used for other purposes or otherwise disposed of except by laws enacted by a two thirds vote, taken by yeas and nays, of each branch of the general court.

Explanation of Paragraph B in Section V

The purpose of Paragraph B is to ensure that if the Conservation Restriction is released (extinguished), the Grantee is reimbursed accordingly.

The appraised fair market value of the property before the Conservation Restriction (CR) is $(A). The appraised fair market value of the property after the Conservation Restriction is applied is $(B). The value of the Conservation Restriction is $(A - B = C). The proportionate value of the Conservation Restriction in relation to the fair market value of the parcel before the Conservation Restriction is applied is (C/A). Such proportionate value of the Grantee's property right shall remain constant and in the proportion of (C/A) to the Grantee and (B/A) to the Grantor, in the event the CR is extinguished.

The fair market value of a CR is the difference between the fair market value of the property before the Restriction is applied. **EXAMPLE:** If the fair market value of a property prior to a CR is $100,000, and the fair market value is $10,000 after the CR is applied, then the value of the CR is $90,000 (or 9/10ths of the fair market value of the parcel before the CR).

The proportionate value of the CR is assumed to remain constant over time, regardless of whether the fair market value of the property increases or decreases. It is this proportionate value (in this example 9/10ths) to which the Grantee is entitled if the CR is released. To determine the value of a CR years after it was established; the fair market value of the parcel must be determined by an appraisal assuming there was no Restriction. Then the ratio (determined at the time the Restriction was established) is applied to the fair market value. For example; if at the time of extinguishment the property is appraised (without the CR) to have a fair market value of $200,000 (a $100,000 increase), the Grantee would be entitled to 9/10ths of $200,000.

In order to calculate the amount of funds due the grantee in the event the Restriction is released: the amount paid for the CR and the fair market value of the property before the Restriction is applied, should be stated in the CR. If the CR is acquired through a gift or bargain sale, then the proportionate value would be the ratio between the fair market value of the property before establishment of the Restriction and the amount the Grantee actually paid, if anything, for the Restriction.

Appendix J. BMP Operation & Maintenance Plan

Operation & Maintenance Plan for Stormwater Best Management Practices (BMPs) at Farm Pond Recreation Area Sherborn, MA

Prepared for:
Town of Sherborn
19 Washington Street
Sherborn, MA 01770

Prepared by:
Fay, Spofford, & Thorndike
400 Crown Colony Drive
Quincy, MA 02169
www.fstinc.com

Revised August, 2014

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APPENDICES

1.0 Introduction

The Town of Sherborn has been striving to improve the water quality in Farm Pond, initially through a demonstration project, and then through a grant funded project. The Projects goal are to control stormwater runoff and reduce the concentration of non-point source pollutants contained in stormwater runoff that is entering Farm Pond, a Great Pond, 114 acres in size. The Town applied for in 2010 and received a section 319 Non point source pollution reduction grant from the MA DEP and US EPA to implement additional Stormwater BMPS. The areas of improvement for these Projects are within the Town-owned right-of-way on Lake Street.

2.0 Purpose

This Operation & Maintenance Plan (O&M Plan) provides a mechanism for the consistent inspection and maintenance of stormwater drainage structures installed during the course of the Projects. Included in this O&M Plan is a description of the stormwater structure, the location of each structure, an inspection schedule for each stormwater structure, and a standard form to be utilized to document the inspection and maintenance of each stormwater structure.

3.0 Descriptions and Locations of Stormwater BMPs

3.1 Description

There is one proposed catch basin (with seven others existing), one reinforced geogrid cart path, a crushed stone swale, and a subsurface recharge system (with two others existing), four existing raingardens, three sediment forebays and two vegetated water quality swales. For a more detailed description, refer to Plans entitled “Farm Pond Stormwater BMP Improvements, Sherborn, Massachusetts”, prepared by Norfolk Ram Group, LLC. Reduced 11x17 plans are included in Appendix B. Full size (24”x36”) plans are on file at the Town of Sherborn CM & D Department.

3.1.1 RainGardens

RainGardens function as soil and plant-based filtration devices that remove pollutants through a variety of physical, biological, and chemical treatment processes. The

RainGardens used in this Project utilize a bioretention system consisting of a soil bed planted with native vegetation all located above an underdrain layer. Stormwater runoff entering the RainGarden system is filtered first through the hardwood bark mulch layer and then the bioretention soil mixture before being collected and then conveyed downstream by the underdrain system. Runoff storage depths above the planting bed surface are less than 6 inches. Bioretention systems are used to remove a wide range of pollutants, such as suspended solids, nutrients, metals, hydrocarbons, and bacteria from stormwater runoff. They can also reduce peak runoff rates and increase stormwater infiltration when designed as a multi-stage, multi-function facility[1].

3.1.2 Catch Basins

One new pre-cast catch basin is proposed for the Site, The proposed catch basin will be equipped with a deep sump. The existing catch basins were implemented during previous BMP installations, with the most recent ones having deep sumps (the existing catch basins with Lake Street do not have deep sumps)

3.1.3 Water Quality Swales

Water Quality Swales are designed primarily for the prescribed stormwater quality volume and have incorporated specific features to enhance their stormwater pollutant removal effectiveness. Pollutant removal rates are significantly higher for water quality swales than normal drainage channels[2].

3.1.4 Sediment Forebays

Sediment forebays are typically on-line units,designed to slow stormwater runoff velocity and settle out sediment. The design volume of the sediment forebay is sized to hold 0.1-inch/impervious acre to pre-treat the water volume received.

3.1.5 Subsurface Recharge Chambers

There are three sets of subsurface recharge chambers utilizing Cultec Contactor 100 model chambers. These engineered structures are designed to provide runoff storage

[1] New Jersey Stormwater Best Management Practices Manual, February 2004, Chapter 9.1, "Standard for Bioretention Systems".

[2] Massachusetts' Department of Environmental Protection and Office of Coastal Zone Management, "Stormwater Management, Volume II, Stormwater Technical Hand Book, March 1997, Chapter 3D, Water Quality Swales".

and recharge back into the ground. The first set of existing chambers is a series of three chambers installed in the path between the boat ramp and the beach area. The second set of existing chambers consists of two rows of two chambers each located south of the southernmost footpath which extends down to the beach area. The proposed set of chambers shall be installed in the existing dirt access roadway between the boat ramp and the beach area, near the cart path.

3.1.6 Cable Concrete Erosion Control Mats

512 ft.^{2} of articulating concrete block mats were placed at the base of the boat ramp to help capture and recharge runoff prior to it entering into the pond. The mats are permeable with a geotextile fabric attached to the underside of the blocks and the voids are filled with peastone and ¾ in. brownstone to help capture sediment in the runoff.

3.1.7 Crushed Stone Swales

Crushed stone swales are designed primarily for runoff volume and peak flow control. The proposed crushed stone swale adjacent to the reinforced geogrid shall convey runoff towards the catch basin/recharge chambers at the base of the path. Stone check dams have been placed within the swales to reduce runoff velocities further.

3.1.8 Reinforced Geoweb with aggregate infill

Confinement of loose aggregate within Geoweb cells permits their use on steeper slopes than would otherwise be possible. Aggregate-filled Geoweb slope protection can tolerate more intense sheet-flow conditions than unconfined aggregate cover layers. The cell walls prevent channeling that could otherwise develop within the cover layer by limiting localized flow concentrations and increasing hydraulic shear stresses.

3.2 Location

The drainage BMPS are located at the Farm Pond Recreation and at the bend of the roadway in Lake Street. The locations are also shown provided in Appendix B of this Manual.

4.0 Inspection Frequency, Safety, and Schedule

4.1 Inspection Frequency:

A complete and thorough inspection of the system using the inspection and maintenance form provided in Appendix A of this Manual shall be performed once a month during the first six months of operation and then on a semi-annual basis (once in the spring and once during the fall) and after major rain events (approximately 2.0 inches of rain). See Section 5.0 Implementation and Maintenance Procedures for a description of the inspection activities.

4.2 Inspection Safety:

The inspector performing the inspections on the drainage structures must have the proper safety equipment (heavy duty gloves, steel-toed boots, hard hat, and first aid kits, etc.) and training before conducting any inspections. If the drainage structures reveal any safety problems the site activities may need to be modified to reduce or eliminate the safety risk. The following is a list of safety precautions the inspector should be aware of when conducting the drainage structure inspections.

- Never enter a confined space unless you have proper Occupational Health and Safety Administration (OSHA) training. Do not enter any confined space until the atmosphere has been checked and proper safety equipment is worn or erected.
- Avoid entering pipes or conduits without another individual present. If the structural strength of a pipe or conduit is questionable, do not enter the pipe or conduit.
- Check the ventilation in the drainage structures before using any ignitable materials. Some drainage structures may be sealed or have poor ventilation, posing a safety risk to the inspector if the vapor comes in contact with an open flame. Also, be sure to allow the drainage structures to vent for a period of time if a peculiar odor is present.
- Wear gloves if any mechanical parts or structures components are going to be handled. Wearing gloves not only reduces the risk of getting cuts and abrasions, but also reduces the exposure of pollutants to the skin.
- Lift manhole covers or other structural covers (access covers, grates, etc.) carefully. These items can be very heavy and if wet, can be slippery. Also, learn the correct way to lift heavy items to avoid back injury.

- Check the water depth of the system before you take a step in the water. The water may be deeper than you think or there may be steep slopes below the water line.

- Be aware that nails, broken glass, or other sharp debris may be in the storm water system and can cause injury. Wearing the proper safety clothing will reduce the safety risk associated with these objects.

4.3 Maintenance:

All maintenance work must be done in accordance with OSHA regulations. Maintenance personal will have the proper safety equipment (heavy duty gloves, steel-toed boots, hard hat, first aid kits, etc.) and training before performing any maintenance on the drainage structures. The following is a list of safety precautions maintenance personnel should be aware of when they perform maintenance on the drainage structures.

- Operate equipment safely and in accordance with the manufacturer's specifications. Equipment operators must remain aware of site personnel at all times to avoid causing injury to others.

- Contact Dig Safe System Inc. at 1-888-DIG-SAFE seventy-two (72) hours before excavating a site. Underground utility wires and pipes may be present. Cover excavated areas that cannot be filled in at the end of the day. Also, be aware of overhead electrical wires that could come in contact with maintenance equipment.

- Identify where you will dispose removed sediment or wastes prior to cleaning the drainage structures. Use shovels, trowels or a high-suction vacuum to remove wastes. Do not clean sediment or waste with bare hands. The sediment or waste may be hazardous. Place the sediment or waste in an area where it can not be washed into a storm drain or water body.

- Wear gloves if any mechanical parts or structural components are going to be handled. Wearing gloves not only reduces the risk of getting cuts and abrasions, but also reduces the exposure of pollutants to the skin.

5.0 Implementation and Maintenance Procedures

The Town of Sherborn CM & D Department is responsible for inspecting and maintaining the stormwater system components. The following list of inspections and maintenance will be performed on the required schedule. All sediment, debris, and hydrocarbons contaminated

material that are removed during the maintenance of the stormwater system components should be properly handled and disposed.

5.1 Raingardens

The primary maintenance requirement for RainGardens (Bioretention Systems) is that of inspection, and repair or replacement of the RainGarden's individual components. Typically, these activities consist of nothing more than that which is required of any landscaped area. The primary maintenance function is the removal of accumulated sediment and debris. Other potential tasks include the replacement of dead vegetation, soil pH regulation, erosion repair at inflow points, mulch replenishment, unclogging of the underdrain and repair of inflow structures.

5.1.1 Checklist

Table 5-1 **RainGarden Maintenance Schedule**
Soil
• Visually inspect and repair in the Spring and Fall. In the event of erosion, stabilize erosion path with 3/4 –inch crushed stone. • Remove accumulated sediment, debris, and litter • Check the soil pH every other Spring. Apply appropriate product to adjust pH, as required. The recommended soil pH levels should range from be between 5.0 and 6.0 for the raingardens.
Mulch
• Re-mulch any void areas by hand, as needed. • Every Spring, add a fresh mulch layer. • Every 3rd year, remove and replace mulch.
Plants
• Once a month, during the growing season visually inspect vegetation for disease and pest problems. • Every Spring and Fall, remove and replace all dead and diseased

vegetation. • Weed, as needed. • Prune excess growth and dead branches every Spring. • During periods of drought, inspect for signs of stress (unrevied wilting, yellow, spotted or brown leaves, loss of leaves, etc.). Water in the early morning as needed.
Asphalt Inlet
• Every Spring and Fall, inspect asphalt inlet. Remove accumulated sediment, fallen leaves and debris.
General
• Annually, after a heavy rainstorm, inspect RainGardens for signs of ponding and to make sure water dissipates after a period of 4 to 6 hours. • Monthly, inspect and remove accumulated trash and debris from raingarden.
Underdrain Inspection Port
• Visually inspect each underdrain pipe cleanout to observe signs of clogging and/or broken pipe.

5.2 Vegetated Water Quality Swales

The vegetated water quality swales should be inspected for slope integrity, soil moisture, health of vegetation, soil stability, erosion and sedimentation. Regular maintenance tasks include mowing, watering, weeding, pest control and sediment removal.

5.2.1 Checklist

Table 5-2 **Water Quality Swale Maintenance Schedule**
Soil
• Visually inspect and repair in the Spring and Fall. In the event of erosion, stabilize erosion path by reestablishing soil, grass and mulch.

• Check the soil pH every other Spring. Apply appropriate product to adjust pH, as required. The recommended pH levels should range from between 5.0 and 6.0 for the water quality swales. • Every spring and fall, remove accumulated sediments and debris.
Check Dam
• Visually inspect the edges of the check dams for signs of erosion. Repair as needed. • Every spring and fall, visually inspect the surface of the crushed stone check dam for indications of clogging. Remove the clogged crushed stone and replace with and equivalent layer of ¾-inch crushed stone.
Grass
• Once a month, during the growing season , visually inspect vegetation for disease and pest problems. • Every Spring and Fall, remove and replace all dead and diseased vegetation. • Weed, as needed. • Reseed if needed, to maintain effectiveness of vegetation for pollutant and sediment removal. • Mow at least once a year. Never cut shorter than 4-inches. • During periods of drought, inspect for signs of stress (unrevied wilting, yellow, spotted or brown leaves, loss of leaves, etc.). Water in the early morning as needed.
General
• In the event of heavy sediment accumulation, the vegetated water quality swale may need to be reconstructed.

5.3 Catch Basins

Inspections will be performed once during the spring and once during the fall. The catch basins shall be inspected for structure and pipe conditions, gas/ oil trap conditions and sediment/trash accumulation. It is important to remove the sediment that has accumulated during the winter months before the spring precipitation. Sediment shall be removed from the catch basins at least annually. During the inspection, inlet and outlet pipes will be inspected for clogs and cleaned, as needed. The inspector will also look for signs of ponding of water and oil/grease inside of the structures.

5.4 Sediment Forebay

Sediments and associated pollutants are removed only when sediment forebays are actually cleaned out, so regular maintenance is essential. Frequently removing accumulated sediments will make it less likely that sediments will be resuspended. At a minimum, sediment forebays shall be inspected monthly and cleaned out at least four times per year. Stabilize the floor and sidewalls of the sediment forebay before making it operational, otherwise the forebay will discharge excess amounts of suspended sediments.

5.5 Subsurface Recharge Chambers

Inspections will be performed once during the spring and once during the fall. The chambers shall be inspected for structure and pipe conditions and sediment/trash accumulation. It is important to remove the sediment that has accumulated during the winter months before the spring precipitation. Sediment shall be removed from the recharge chambers as necessary to ensure functionality of the chambers.. During the inspection, inlet and pipes will be inspected for clogs and cleaned, as needed. The recharge chambers are equipped with 6" diameter inspection ports that will be brought to grade and kept accessible for ease of inspection.

5.6 Cable Concrete Mats

Inspections will be performed once during the spring and once during the fall. The mats shall be inspected for structural integrity and sediment/trash accumulation. Sediment shall be removed when it has visibly accumulated where it will affect the ability of the BMP to filter runoff. The ¾ in. brownstone should be removed, either by raking it out manually or by using a vactor truck to remove it. The ¾ in. brownstone can then be replaced with clean washed ¾ in. brownstone.

5.7 Crushed Stone Swales

Inspections will be performed once during the late spring and once during the fall. The swale shall be inspected for sediment/trash accumulation. Sediment shall be removed it has visibly accumulated where when it will affect the ability of the BMP to filter runoff. The 1 ¼ in. crushed stone should be removed by raking it out and can be replace with clean washed 1 ¼ in. crushed stone.

5.8 Reinforced Geoweb with aggregate infill

Inspections will be performed once during the late spring and once during the fall. The geoweb path shall be inspected for sediment/trash accumulation and stone washout. Sediment shall be removed when it has visibly accumulated where it will affect the ability of the BMP to filter runoff. The 1 ¼ in. crushed stone should be removed by raking it out and can be replace with clean washed 1 ¼ in. crushed stone.

6.0 Inspections and Record Keeping

An “Inspection and Maintenance Form” shall be filled out each and every time inspectional or maintenance work is performed.

A binder will be kept at the Town Hall, 19 Washington Street, Sherborn, MA that contains all of the completed forms and/or photos and related material. The inspection reports in the binder will be maintained for a minimum of three years, and will include photo documentation of the inspections.

A review of all Operation & Maintenance actions will take place annually to ensure that these Stormwater BMPs are being taken care of in the manner illustrated in this Operation & Maintenance Plan.

APPENDIX A

Inspection Forms

NORFOLK RAM GROUP
ENGINEERING THE ENVIRONMENT

BIORETENTION MAINTENANCE INSPECTION FORM

Facility Number: _____ Date: _____ Time: _____

Weather: _____ Inspector(s): _____

Date of Last Rainfall: _____ Amount: _____ Inches

Street Location: _____ GPS Coordinates: _____

Scoring Breakdown:		
N/A = Not Applicable	**1 = Monitor (potential for future problem exists**	*** Use open space in each section to**
N/I = Not Investigated	**2 = Routine Maintenance Required**	**further explain**
0 = Not a problem	**3 = Immediate Repair Necessary**	**scoring as needed**

1. Outlet							
Broken	N/A	N/I	0	1	2	3	
Clogging	N/A	N/I	0	1	2	3	
Submerged Outlet Pipe	N/A	N/I	0	1	2	3	
2. Bioretention Soil Mix							
Sediment Accumulation > 1"	No	Yes					
Ponding more than 24 hours after rain	No	Yes					
Soil pH							
Sediment Accumulation in soil bed	N/A	N/I	0	1	2	3	
Oil/ chemical accumulation in soil bed	N/A	N/I	0	1	2	3	
Other	N/A	N/I	0	1	2	3	
3. Underdrain							
Broken	N/A	N/I	0	1	2	3	
Clogging	N/A	N/I	0	1	2	3	
4. Plants							
Disease/Pest Problems	N/A	N/I	0	1	2	3	
Weeds	N/A	N/I	0	1	2	3	
Excess growth and/or dead branches	N/A	N/I	0	1	2	3	
5. Asphalt Inlet							
Accumulated Sediment	N/A	N/I	0	1	2	3	
6. Mulch							
Overall Condition	N/A	N/I	0	1	2	3	
7. Erosion							
Soil and/or debris erosion	N/A	N/I	0	1	2	3	

Overall Condition of Facility

Total number of concerns receiving a:

(1) _____ - Need Monitoring
(2) _____ - Routine Repair
(3) _____ - Immediate Repair Needed

Inspector's Summary:

NORFOLK RAM GROUP
ENGINEERING THE ENVIRONMENT

Pictures:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Sketches, If Necessary:

NORFOLK RAM GROUP
ENGINEERING THE ENVIRONMENT

SEDIMENTATION FOREBAY MAINTENANCE INSPECTION FORM

Facility Number: _____ Date: _____ Time: _____

Weather: _____ Inspector(s): _____

Date of Last Rainfall: _____ Amount: _____ Inches

Street Location: _____ GPS Coordinates: _____

Scoring Breakdown:		
N/A = Not Applicable	**1 = Monitor (potential for future problem exists**	*** Use open space in each section to**
N/I = Not Investigated	**2 = Routine Maintenance Required**	**further explain**
0 = Not a problem	**3 = Immediate Repair Necessary**	**scoring as needed**

1. Forebay						
Sediment/ Debris Accumulation	N/A	N/I	0	1	2	3
Weeds	N/A	N/I	0	1	2	3
Other	N/A	N/I	0	1	2	3
2. Erosion						
Soil and/or debris erosion	N/A	N/I	0			
Scour	N/A	N/I	0	1	2	3
Other	N/A	N/I	0	1	2	3
3. Asphalt Inlet						
Accumulated Sediment	N/A	N/I	0	1	2	3

Overall Condition of Facility

Total number of concerns receiving a:

(1) _____ - Need Monitoring
(2) _____ - Routine Repair
(3) _____ - Immediate Repair Needed

Inspector's Summary:

NORFOLK RAM GROUP
ENGINEERING THE ENVIRONMENT

Pictures:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Sketches, If Necessary:

NORFOLK RAM GROUP
ENGINEERING THE ENVIRONMENT

GRASSED SWALE MAINTENANCE INSPECTION FORM

Facility Number: _____ Date: _____ Time: _____

Weather: _____ Inspector(s): _____

Date of Last Rainfall: _____ Amount: _____ Inches

Street Location: _____ GPS Coordinates: _____

Scoring Breakdown:		
N/A = Not Applicable	**1 = Monitor (potential for future problem exists**	*** Use open space in each section to**
N/I = Not Investigated	**2 = Routine Maintenance Required**	**further explain**
0 = Not a problem	**3 = Immediate Repair Necessary**	**scoring as needed**

1. Check dams						
Undermined/eroded	N/A	N/I	0	1	2	3
Debris/trash accumulations	N/A	N/I	0	1	2	3
Sediment accumulation	N/A	N/I	0	1	2	3
2. Grassed Swale						
Disease/Pest Problems	N/A	N/I	0	1	2	3
Sediment/ Debris Accumulation	N/A	N/I	0	1	2	3
Weeds	N/A	N/I	0	1	2	3
Other	N/A	N/I	0	1	2	3
Consistent Mowing- Grass kept at minimum height of 4" or greater	N/A	N/I	0	1	2	3
3. Underdrain						
Broken	N/A	N/I	0	1	2	3
Clogging	N/A	N/I	0	1	2	3
4. Soil						
pH level						
5. Erosion						
Soil and/or debris erosion	N/A	N/I	0	1	2	3

Overall Condition of Facility

Total number of concerns receiving a:

(1) _____ - Need Monitoring
(2) _____ - Routine Repair
(3) _____ - Immediate Repair Needed

Inspector's Summary:

NORFOLK RAM GROUP
ENGINEERING THE ENVIRONMENT

Pictures:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____

Sketches, If Necessary:

Appendix K. Letter from Division of Fisheries & Wildlife

Commonwealth of Massachusetts

Division of Fisheries & Wildlife

MassWildlife

Wayne F. MacCallum, *Director*

December 17, 2014

Mark Manganello
LEC Environmental Consultants, Inc
12 Resnik Road
Suite 1
Plymouth MA 02360

RE: Project Location: Farm Pond
Town: SHERBORN
NHESP Tracking No.: 14-33870

To Whom It May Concern:

Thank you for contacting the Natural Heritage and Endangered Species Program of the MA Division of Fisheries & Wildlife (the "Division") for information regarding state-listed rare species in the vicinity of the above referenced site. Based on the information provided, this project site, or a portion thereof, is located **within** *Priority Habitat 1486* (PH 1486) and *Estimated Habitat 192* (EH 192) as indicated in the *Massachusetts Natural Heritage Atlas* (13th Edition). Our database indicates that the following state-listed rare species have been found in the vicinity of the site:

Scientific name	Common Name	Taxonomic Group	State Status
Terrapene carolina	Eastern Box Turtle	Reptile	Special Concern

The species listed above is protected under the Massachusetts Endangered Species Act (MESA) (M.G.L. c. 131A) and its implementing regulations (321 CMR 10.00). State-listed wildlife are also protected under the state's Wetlands Protection Act (WPA) (M.G.L. c. 131, s. 40) and its implementing regulations (310 CMR 10.00). Fact sheets for most state-listed rare species can be found on our website (www.mass.gov/nhesp).

Please note that projects and activities located within Priority and/or Estimated Habitat **must** be reviewed by the Division for compliance with the state-listed rare species protection provisions of MESA (321 CMR 10.00) and/or the WPA (310 CMR 10.00).

Wetlands Protection Act (WPA)

If the project site is within Estimated Habitat and a Notice of Intent (NOI) is required, then a copy of the NOI must be submitted to the Division so that it is received at the same time as the local conservation commission. If the Division determines that the proposed project will adversely affect the actual Resource Area habitat of state-protected wildlife, then the proposed project may not be permitted (310 CMR 10.37, 10.58(4)(b) & 10.59). In such a case, the project proponent may request a consultation with the Division to discuss potential project design modifications that would avoid adverse effects to rare wildlife habitat.

Division of Fisheries and Wildlife
Field Headquarters, One Rabbit Hill Road, Westborough, MA 01581 (508) 389-6300 Fax (508) 389-7890
An Agency of the Department of Fish and Game

A streamlined joint MESA/WPA review process is available. When filing a Notice of Intent (NOI), the applicant may file concurrently under the MESA on the same NOI form and qualify for a 30-day streamlined joint review. For a copy of the NOI form, please visit the MA Department of Environmental Protection's website: http://www.mass.gov/dep/water/approvals/wpaform3.doc.

MA Endangered Species Act (MESA)

If the proposed project is located within Priority Habitat and is not exempt from review (see 321 CMR 10.14), then project plans, a fee, and other required materials must be sent to Natural Heritage Regulatory Review to determine whether a probable "take" under the MA Endangered Species Act would occur (321 CMR 10.18). Please note that all proposed and anticipated development must be disclosed, as MESA does not allow project segmentation (321 CMR 10.16). For a MESA filing checklist and additional information please see our website: www.mass.gov/nhesp ("Regulatory Review" tab).

We recommend that rare species habitat concerns be addressed during the project design phase prior to submission of a formal MESA filing, as avoidance and minimization of impacts to rare species and their habitats is likely to expedite endangered species regulatory review.

This evaluation is based on the most recent information available in the Natural Heritage database, which is constantly being expanded and updated through ongoing research and inventory. If you have any questions regarding this letter please contact Lauren Glorioso, Endangered Species Review Assistant, at (508) 389-6361.

Sincerely,

Thomas W. French

Thomas W. French, Ph.D.
Assistant Director