COMPREHENSIVE POND MANAGEMENT PLAN FOR EIGHT PONDS IN WELLESLEY, MASSACHUSETTS

FINAL REPORT [DRAFT]

BY WATER RESOURCE SERVICES, INC.

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1. Introduction

1.1 Project Background and Need

The Town of Wellesley contains many ponds and streams, most linked in some way and ultimately sending water to the Charles River. Ten ponds are considered public. Of these, Morses Pond is the largest and best known, hosting a town beach complex and having adjacent town wells providing water supply. The State Street Pond, off Washington Street in a park, was very recently dredged and was not subject to further study as part of this project. The remaining eight ponds are small but locally important, and were the subject of this management planning process. These include Abbotts, Bezanson, Duck, Farms Station, Icehouse, Longfellow, Reeds and Rockridge Ponds.

Morses Pond has been actively managed for many years, and actions have been directed for over a decade by the Comprehensive Management Plan, finalized in 2005. That plan has greatly enhanced the beneficial uses of Morses Pond and aided the Town in meeting its downstream obligation under the National Pollutant Discharge Elimination System storm water regulations by improving the quality of water discharged downstream. Consideration of how to best manage the other public ponds in Wellesley led to funding for a Wellesley Ponds Comprehensive Management Plan project, the subject of this report.

All of the public ponds in Wellesley receive runoff from watersheds of varying size, most highly developed for residential use. Except for Farms Station Pond, located by a commuter line station and associated parking area, all are in parks or other green spaces, and all have direct public access. Flow through these ponds is highly variable, but all have relatively short detention times during storms. They can all have minimal flow during dry weather. All are subject to issues with rooted aquatic plants or algae that have elicited complaints or negative comments. A comprehensive pond management plan was last approved in 1998, and focused mainly on alternating years of study and dredging for town ponds; six of ten ponds have been at least partially dredged since that plan was developed.

There has been very little assessment of the eight public ponds subject to this evaluation and planning process in the last decade, and in some cases for up to three decades. Some sediment work has been done in conjunction with past dredging, but there are no recent water quality data or biological assessments. Rockridge and Longfellow Ponds are harvested once in most summers, mainly for water chestnut control. Some private fish stocking has occurred in some ponds, but no other management actions are known. Goals for public ponds other than Morses have not been formalized or articulated through any public process, and no current plan is being followed to meet any goals.

The success of the Morses Pond management plan has sparked interest in having other public ponds serve beneficial uses to the maximum degree possible. The Town therefore embarked on an assessment and management planning process to determine the condition of each pond, what uses each might best serve, and the management actions most appropriate to each. Water Resource Services, Inc. (WRS) was contracted to assist the Town in this effort.

1.2 Project Location

This project involves eight public ponds scattered throughout Wellesley (Figure 1). The ponds are focal points within parks, along trail systems, in residential areas and next to community facilities such as Town Hall or the Town Beach. Most but not all have associated parking areas, with some street parking near those without designated parking spaces. All are within a mile of Rt 9, which bisects Wellesley on an east-west axis, but only Abbotts Pond can be seen from Rt 9. They are relatively small, ranging in area from 0.5 to 7.5 acres, but are visual amenities in their respective parks and neighborhoods.

1.3 Uses and Rehabilitation Needs

It was clear from the start of this project that each pond had one or more potential impairments, but without scientific assessment and input from the community, it was not certain how uses matched up with impairments and what should be done in each case. Through field assessment and meetings with town officials and neighborhood residents, general features, uses and desires for each pond were assessed and can be summarized as follows:

Abbotts Pond covers 1.8 acres and is mainly a visual amenity in a neighborhood. It has a narrow strip of public land most of the way around it, but this land is not really park and is uneven and overgrown. Dumping of yard wastes also mars the buffer zone, despite signs forbidding such dumping. It abuts Rt 9, which is just south of the pond. It is used for ice skating by local youth in the winter, but is largely inaccessible due to overgrowth of woody vegetation around the periphery, with fallen trees, vines, dense brush, and wet soils limiting access and even visibility. One home abuts the pond directly. Shallowness limits most uses in spring through fall. The water is usually turbid, and there are few rooted plants in the open water part. Infilling over many years has facilitated establishment of a wooded wetland around most of the pond edge. It serves as a de facto wildlife preserve, given limited human access. One large and two small storm drainage discharges supply water to the pond, causing fluctuations in water level and quality. A former outlet structure indicates some water level control in the past, but there are no flashboards and water level is largely controlled by the elevation of the culvert under Rt 9. Outflow eventually reaches Fuller Brook. There appears to be no strong desire to make this pond more accessible for active use, but enhancing its overall appearance as a visual amenity is desired by the community.

Figure 1. Wellesley public pond locations

Bezanson Pond covers just half an acre in Centennial Park, and is better known as the dog pond. The park is extremely popular with residents for walking their dogs, and many canines choose to swim in this small pond after walking the wooded paths in warmer months. Bezanson Pond was dredged in 2003, and has a sandy periphery. Drainage comes from some peripheral residential area and the Sisters of Charity compound to the northeast, but much of the drainage area is park land. Ground water keeps a small channel from the Sisters of Charity area wet most of the year, and intermittent storm water inputs enter from another usually dry channel network in the park. Bezanson Pond has a concrete outlet structure with flashboards that raise the water level 14 inches. People would like the pond to be a visual amenity and want the water quality to be healthy for dogs. This pond could be a fishing resource, but there does not seem to be any strong interest in active use other than by dogs. One concern from downstream residents is flooding, with a perception that past management of the pond and park has done nothing to abate possible flash flooding in a downstream neighborhood. Eventually water discharged from Bezanson Pond enters the stream system feeding Longfellow Pond.

Duck Pond is located next to Town Hall and is basically a wide channel between the railroad berm and the outlet structure with a backwater pool to the east, connected by small channels around an island. The total pond covers only 0.8 acre. Direct flow to the pool appears minimal, but the main inlet from the north handles a large developed area with high storm water flows, so water backs up into the pool area during storms. The outlet has flashboards that control the water level, with water flowing downstream and culverted under Washington Street and the town library to Fuller Brook. A population of “ornamental” ducks lives at Duck Pond and this pond is largely a visual amenity, with paths and bridges that allow people to stroll around the pond. Duck Pond was dredged in 1986 and 2006, but has newer accumulations of sediment and debris and is usually quite turbid. There appears to be no interest in active recreation on this pond, but a more appealing visual appearance is desired and requires water quality management and occasional clean out of accumulated sediment and debris.

Farms Station Pond is adjacent to the Farms Station of the railroad commuter line in northeastern Wellesley and covers one acre. It receives drainage from a large, mostly urbanized watershed, but has the larger Wights Pond just upstream to provide some purifying detention. A parking area for the rail station is adjacent to the pond and drains to it. Water overflows to a mostly closed drainage system that discharges to the Charles River. This pond tends to be green with algae or small floating plants, but has very few plants rooted in the sediment. It is mainly a visual amenity, although it offers ready access for recreation. Water quality management is perceived as the primary need.

Icehouse Pond is adjacent and openly connected to Morses Pond, covering 5 acres between the beach complex and the water supply facility. Water quality is largely managed incidentally as a function of Morses Pond management, and should be acceptable for all uses. However, rooted plants grow densely in this pond, including invasive species, and there is no access for the harvesters used on Morses Pond for weed control. Icehouse Pond was historically used for ice production, but is now mainly a visual amenity and wildlife sanctuary; swans annually nest there. Access is very limited; much of the periphery is fenced and shoreline area is steep with dense vegetation including poison ivy. There have been complaints about appearance and odors, although it is not clear that the odor comes from the pond. It does tend to accumulate trash blown in from the surrounding area. Some management of plants may be desirable, but it is not certain that any management is needed if the primary use is as a haven for wildlife.

Longfellow Pond is the largest of the ponds addressed by this planning effort, covering 7.5 acres and having a designated parking area and non-motorized boat launch. It is an impoundment of Rosemary Brook, which flows to the Charles River. An outlet structure at its northern end has flashboards that raise the water level about 21 inches. A path circumnavigates the pond in a wooded buffer. Gas lines traverse the pond, an unusual situation that may affect management options. The pond tends to develop a dense plant community every summer, including native and invasive species and dense filamentous green algae mats. Mechanical harvesting is conducted in July of most years. Longfellow Pond has a very large watershed with four upstream impoundments, extending out of Wellesley and into Needham, plus multiple direct entry storm drains from nearby residential areas. Aside from desiring visual appeal, users would like to be able to canoe and fish on this pond, activities that are greatly impaired by dense plant growths. Both water quality and rooted plant control are needed.

Reeds Pond is a 1.9 acre impoundment of Bogle Brook, located about 1000 feet north of Rt 9 and the inlet to Morses Pond. It has a long concrete dam with a cutout area that passes normal flows and a subsurface pipe that allows the water level to be lowered. Reeds Pond receives water from a very large and mostly residential watershed, although runoff from almost two thirds of the drainage area passes through Nonesuch Pond before reaching Reeds Pond. The pond was dredged in 1998 and has a forebay for settling some of the incoming sediment from the large watershed that is cleaned out periodically, but Reeds Pond experiences high flows during storms and does accumulate sediment and debris. There is a small park at the outlet (south) end of the pond and most of the shoreline is in public ownership, but parking and easy access are limited. Homes occupy a ridge to the west and north. Some fishing occurs from shore, but casting is difficult and lines are often seen hanging from branches. Canoes and kayaks could be launched from the outlet area and one location on the east side, but vehicles have to park on Woodside Road. The pond is more of a visual amenity, and users desire control of plants when growths become too dense. Water quality management may be needed, but detention time is short and algae blooms do not tend to accumulate.

Rockridge Pond covers 2.3 acres in a residential neighborhood with public land and a trail around most of it. It has a concrete dam with one 10.5-inch flashboard and a subsurface pipe that can lower the water level by 3 feet over the elevation at the top of the flashboard. Drainage is from a substantial and mostly residential area via storm water drains and channels. Most of the pond was dredged in 2003, but there are extensive summer growths of rooted plants and algae mats. Some private bass stocking has occurred, but no fish survey or management plan exists for this pond. Fishing is popular, but dense peripheral terrestrial vegetation interferes and many trees have fishing line hanging from them. There is a cleared access area on the northeast side and car-top boats can be carried in and launched, but dense aquatic vegetation limits use much of the summer, despite mechanical harvesting in July of most years. Users desire a more aesthetically pleasing appearance and easier fishing, both largely a function of plant and algae control.

1.4 Presentation of Report

This report describes the methodology used to evaluate the eight subject ponds and provides background data on each pond and its watershed from field investigations in 2016. Most data are reported by parameter for all ponds together, including physical, chemical and biological features, after which there are descriptive sections for each pond where the data are used to characterize key conditions and provide management recommendations. There are many tables and graphs, and the casual reader may not want to wade through all the scientific characterization; the data and related information are provided to document conditions and support conclusions relating to management needs, but may be referred to in an encyclopedic fashion as needed by the reader. Key features and recommendations are covered pond by pond, so if one has an interest in any specific pond, it will be easy to get a summary for it.

2. Study Approach and Methods

2.1 Watershed Assessment

The watershed was evaluated through field observation and maps. Nearly all of the potential contributory area for each pond was driven or walked to assess inclusion in its watershed and to identify possible sources of contaminants, with a focus on phosphorus and nitrogen. Google Earth mapping was used to support this effort, with further delineation and maps generated using ARC GIS. Town GIS maps of storm water drainage systems were helpful and were ground truthed to the extent possible. Maps of the contributory area for each pond were produced with subdivisions as appropriate to indicate specific storm drain entry points, storm water piping pattern, and the path of open water tributaries.

2.2 Water Quality

Various water quality sampling was conducted between April and August 2016. Storm water was collected at each pond inlet and storm water drain (see appendix for listing and locations). Passive storm water samplers were used to collect the 1st flush of storm water if WRS personnel were not present during the rain event. Pond outlets were sampled once in April. Icehouse Pond does not have a traditional outlet; at normal pond levels it is connected to Morses Pond, which is more regularly sampled, but the water level was too low in April for the two waterbodies to be connected. Therefore a specific outlet sample for Icehouse was not collected. In-lake water samples were collected near the surface at the deepest point of each pond in June and August. A bottom water sample was collected with a Van Dorn bottle at Farms Station in August because the pond was thermally stratified and anoxic at the bottom.

Field values were generated for temperature, dissolved oxygen, pH, conductivity and turbidity using a Hach Hydrolab DS5 multi-probe sonde calibrated prior to field use. Alkalinity was assessed with a field titration kit from Hach. Samples for lab analysis of total and dissolved phosphorus, nitrate + nitrite nitrogen, ammonium nitrogen, and total Kjeldahl nitrogen (TKN) were analyzed by Microbac Laboratories Inc. in Dayville, CT. Secchi transparency was measured with a Secchi disk and view tube from a boat in each pond. Phytoplankton and zooplankton samples were collected as part of water quality sampling but are addressed in their own section.

2.3 Bathymetry and Sediment Depth Distribution Assessment

Water and sediment depth were assessed by the following procedure in each pond:

a. For each pond, a grid was used to make survey point locations. These GPS locations were chosen with the goal to evenly distribute points over the waterbody.
b. Additional GPS points were recorded in the field as warranted by local conditions to get representative depths and allow more accurate mapping of contours.

c. Metal rods were marked off in 1.0 ft increments and used to measure water and sediment depth. Rods could be attached end to end where greater length was needed.
d. To measure water depth, the rod was inserted into the water column until it hit bottom; this sometimes involves multiple measurements and some finesse where the bottom is especially soft, but most of the Wellesley Ponds were easy to measure. Sediment depth was measured by forcing the rod into the sediment until it hit hard substrate or could not be forced further.
e. At each point water and sediment depths were recorded in feet on a field data sheet.
f. Bathymetry and sediment depth distribution maps were generated using ARC GIS with interpolation between points.

2.4 Sediment Quality Assessment

Sediment samples were collected at the deepest point of each pond in June, 2016. An Ekman dredge was used to collect surficial bottom sediments. Two samples were collected from Duck Pond, one at the deepest location in the pool and the other in front of the outlet structure. Additionally, two samples were collected from Longfellow Pond, one in the south basin and another in the north basin. All samples were delivered to Northeast Laboratories, Inc. in Berlin, CT for sediment analysis, which includes testing for % organic, % total solids, iron bound phosphorus and total phosphorus. This analysis is geared toward assessing internal loading of phosphorus; further testing would be needed to support a dredging feasibility assessment.

2.5 Plankton Analysis

Phytoplankton were collected as grab samples slightly under the water surface. Zooplankton were collected by horizontal tows of an 80 µm mesh net until 380 liters of water were filtered (30 m of tow with a 13 cm diameter net). Plankton samples were preserved with glutaraldehyde in the field (0.5% for phytoplankton, 2% for zooplankton) and concentrated in the lab by sequential settling prior to quantitative assessment under phase contrast microscopy.

2.6 Plant Assessment

Aquatic plant surveys were conducted in June and August 2016. Survey objectives were to determine aquatic plant species presence, relative abundance, and general distribution within each pond. A jonboat was used to access the ponds. An underwater camera, Marcum model 826, was used to visually observe submerged plants when not obvious from the surface. A telescoping rod with a garden “claw” mounted at the end was used to collect plants to physically confirm plant species observed. While in the field, plant locations and abundance were drawn on a map, aided by GPS as warranted.

2.7 Water Quality Modeling

The Lake Loading Response Model (LLRM) was applied to evaluate loading of nitrogen and phosphorus from the watershed, atmosphere, ground water and internal sources to each pond. LLRM is a spreadsheet model that allows actual data to be used to set variable values and provide reality checks on calculated values at key points in the modeling process. The most recently available land use data and the 2016 water quality data from WRS sampling were applied. Loading coefficients and attenuation factors were adjusted until the predicted stream input and in-lake values were close to actual values. Once the model was considered to represent current conditions for each pond, changes in loading were evaluated to determine the potential impact from possible management actions. The expected background load was estimated, assuming all land was in a natural state. The expected conditions from maximum possible best management practice application were also estimated using LLRM.

3. All Ponds Investigative Results

Here we present the investigative results that are common to all ponds and most conveniently displayed and discussed as a whole. More pond-specific details are presented in the following sections, one for each pond.

3.1 Morphology

Wellesley public ponds are generally small, shallow ponds ranging in surface area from 0.5 (Bezanson) to 7.5 ac (Longfellow) (Table 1). The average water depth ranged from 0.9 to 3.8 ft. The ponds ranged in maximum depth from 2.7 (Abbotts) to 9.0 ft (Farms Station).

Table 1. Morphological Information for all ponds

Pond	Pond Area	Water Volume	Average Water Depth	Sediment Volume	Average Sediment Depth
unit	ac	ac-ft	ft	ac-ft	ft
Abbotts	1.8	2.7	1.5	6.3	3.5
Bezanson	0.5	1.3	2.7	0.3	0.5
Duck	0.8	0.8	0.9	0.8	0.9
Farms Station	1.0	3.8	3.8	3.1	3.1
Icehouse	5.0	16.8	3.4	26.2	5.2
Longfellow	7.5	19.2	2.6	13.5	1.8
Reeds	1.9	4.6	2.4	1.8	0.9
Rockridge	2.3	5.5	2.4	2.0	0.9

3.2 Watershed Assessment

Overall, the watersheds (or drainage areas) of the Wellesley public ponds are predominantly developed as residential areas with some commercial uses and open space (Table 2). Additionally, the ponds are small in comparison to the large drainage areas from which water flows into the ponds. Therefore, in-lake water quality is highly dependent upon storm water inputs that are typically greater when precipitation lands on impervious surfaces (for example, roads and roofs), and will carry more pollutants and nutrients into the ponds. When land use designations are broken down into categories, land designated as being in “excavation” use is a small portion of the pond watersheds. In this case, excavation is a combination of mining and transitional land use categories, which according to ARC GIS include open urban area, in the process of being developed from one land use to another, sand and gravel pits, mines and quarries. In most cases in Wellesley, excavation land use is equivalent to disturbed urban land, possibly in the process of redevelopment or other construction.

Table 2. Watershed features for all ponds

Pond Watershed	Developed	Agricultural	Forest	Wetland	Meadow	Excavation	Total Watershed Area (ac)	Pond Area (ac)	Watershed to Pond Area Ratio
Abbotts	81.3%	0.0%	17.2%	1.5%	0.0%	0.0%	55.6	1.8	30.9
Bezanson	38.7%	2.4%	41.5%	0.2%	17.2%	0.0%	44.8	0.5	89.5
Duck Pond	79.2%	0.0%	20.7%	0.2%	0.0%	0.0%	480.8	0.8	601.1
Farms Station	54.1%	0.1%	40.4%	4.8%	0.2%	0.3%	416.8	1.0	416.8
Icehouse Direct	11.8%	0.0%	86.1%	0.0%	0.0%	2.1%	4.4	5.0	0.9
Total Icehouse	66.0%	1.0%	22.0%	9.0%	0.0%	2.0%	5300.0	5.0	1060.0
Longfellow	71.4%	0.7%	18.2%	8.9%	0.8%	0.1%	2033.9	7.5	271.2
Reeds	32.9%	1.5%	51.9%	12.2%	0.0%	1.5%	2709.2	1.9	1456.6
Rockridge	79.5%	0.0%	20.2%	0.3%	0.0%	0.0%	96.4	2.3	41.9

3.3 Incoming Water Quality

Dry and Wet Weather Inputs

Dry and wet weather data (Figures 2-7) and first flush storm water values (Figures 8-11) embody a large sampling effort from spring and summer of 2016. In April, during dry weather but high baseflow conditions with snowmelt, all inlets were sampled and tested for total phosphorus (TP), nitrate + nitrite nitrogen, and total Kjeldahl nitrogen (TKN). Except for the Duck Pond inlet, which flows regularly, this was the only data captured for inlets during dry conditions, as there was minimal background flow after early June during what was a very dry summer. Dry weather minimum values are displayed as 0 in graphics where inlets were not flowing and the average and maximum are the same where only one other value was obtained. For storm drains that were only captured once during wet conditions, minimum, maximum and average values are equal. Wet weather samples were tested for the above parameters and also for ammonium N, dissolved phosphorus (DP), temperature, dissolved oxygen (DO), pH, turbidity and specific conductivity. Temperature, dissolved oxygen and pH were all within reasonable ranges in 1st flush storm water and are not of concern for these ponds.

Turbidity

Turbidity is a measure of the amount of particulate matter in water based on light scattering by particles. Turbidity levels ranged from 0.01 (Longfellow Inlet) to 54.9 NTU (Duck Inlet) (Figure 8). Acceptable turbidity levels are between 3 and 10 NTU for storm water, yet it is not unusual for urban runoff to be as high as 50 or even 100 NTU. As water flows over impervious surfaces (roads, driveways, roofs) particulate matter is picked up and carried to water ways, increasing turbidity. Overall, turbidity levels were highly variable and mostly >10 NTU.

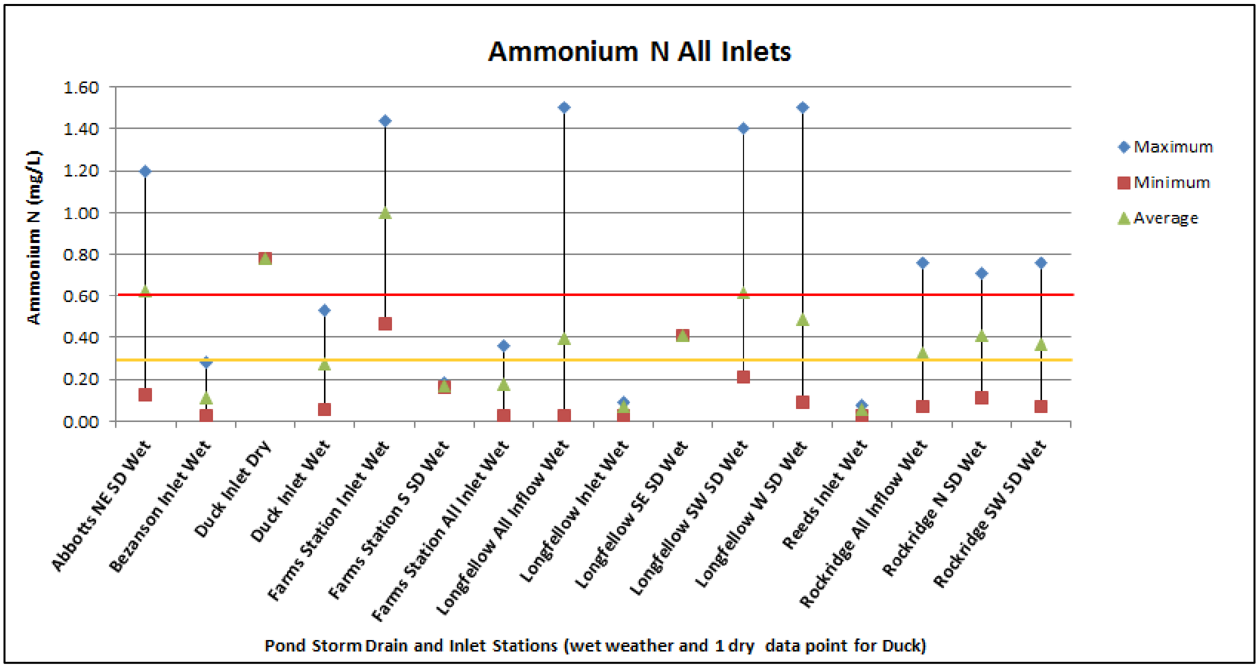

Figure 2. Ammonium N entering all ponds during wet and dry weather

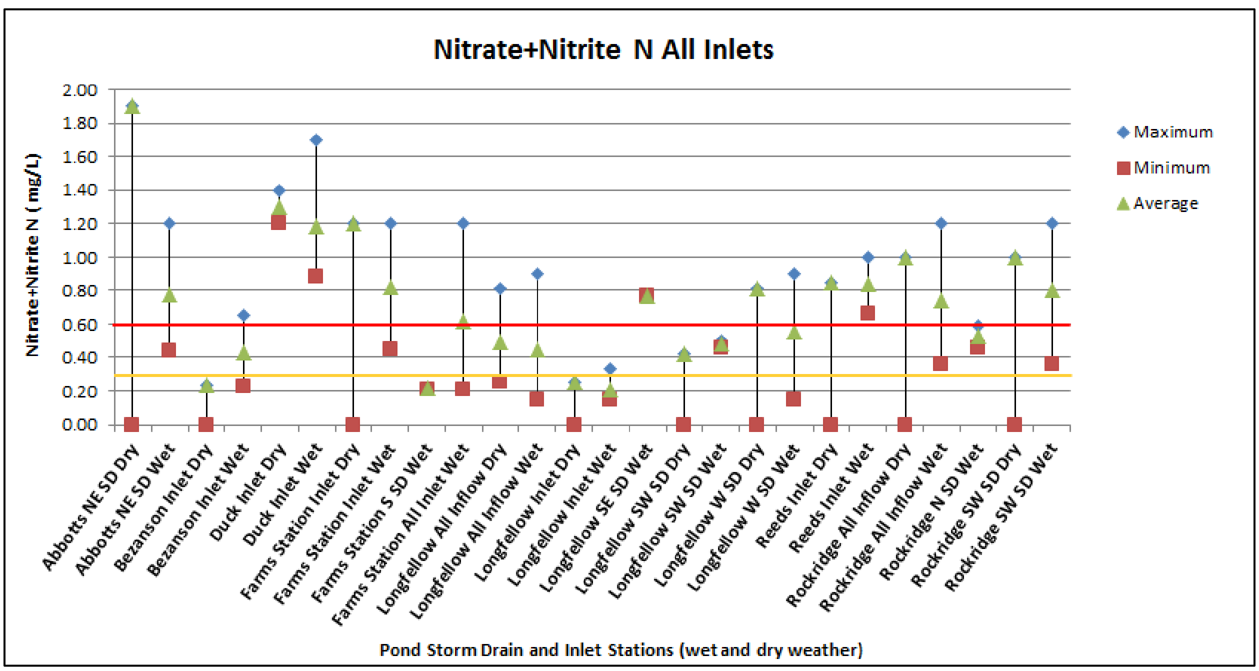

Figure 3. Nitrate+nitrite N entering all ponds during wet and dry weather

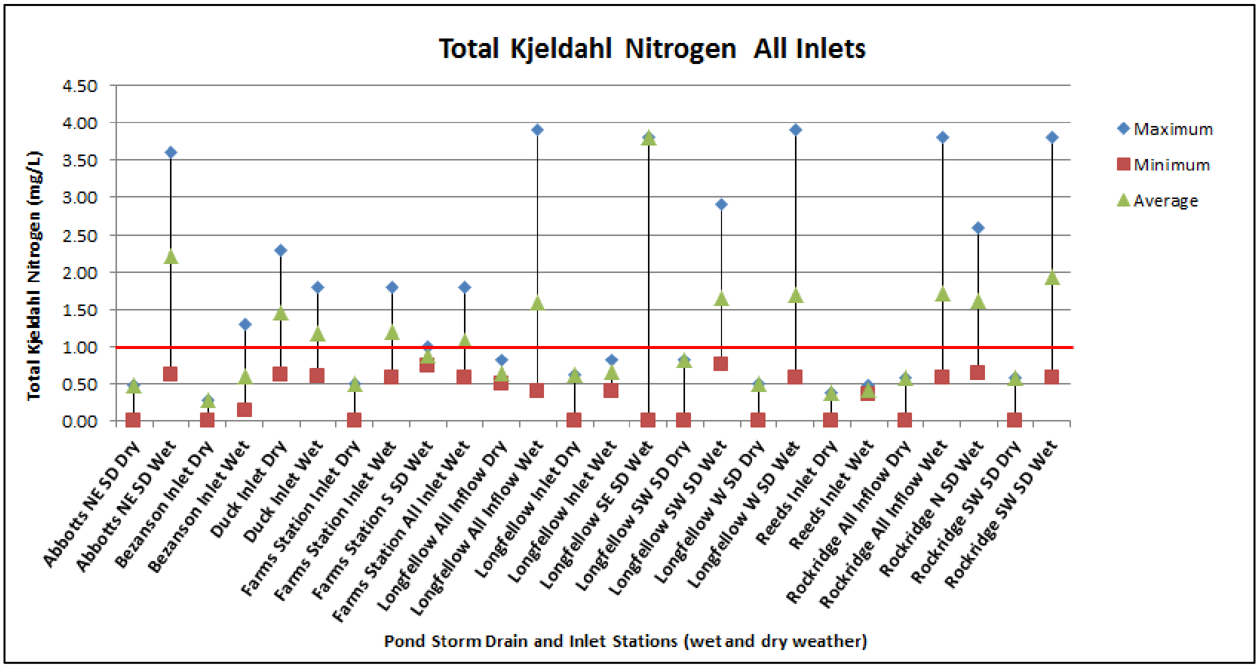

Figure 4. Total Kjeldahl N entering all ponds during wet and dry weather

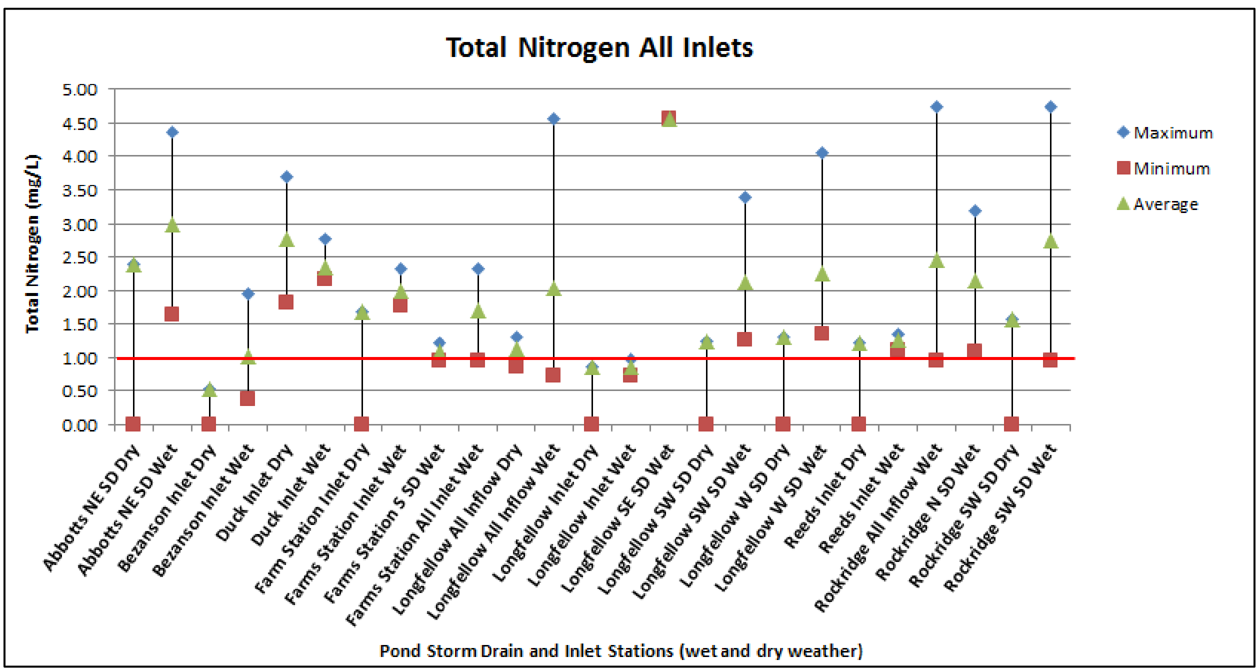

Figure 5. Total N entering all ponds during wet and dry weather

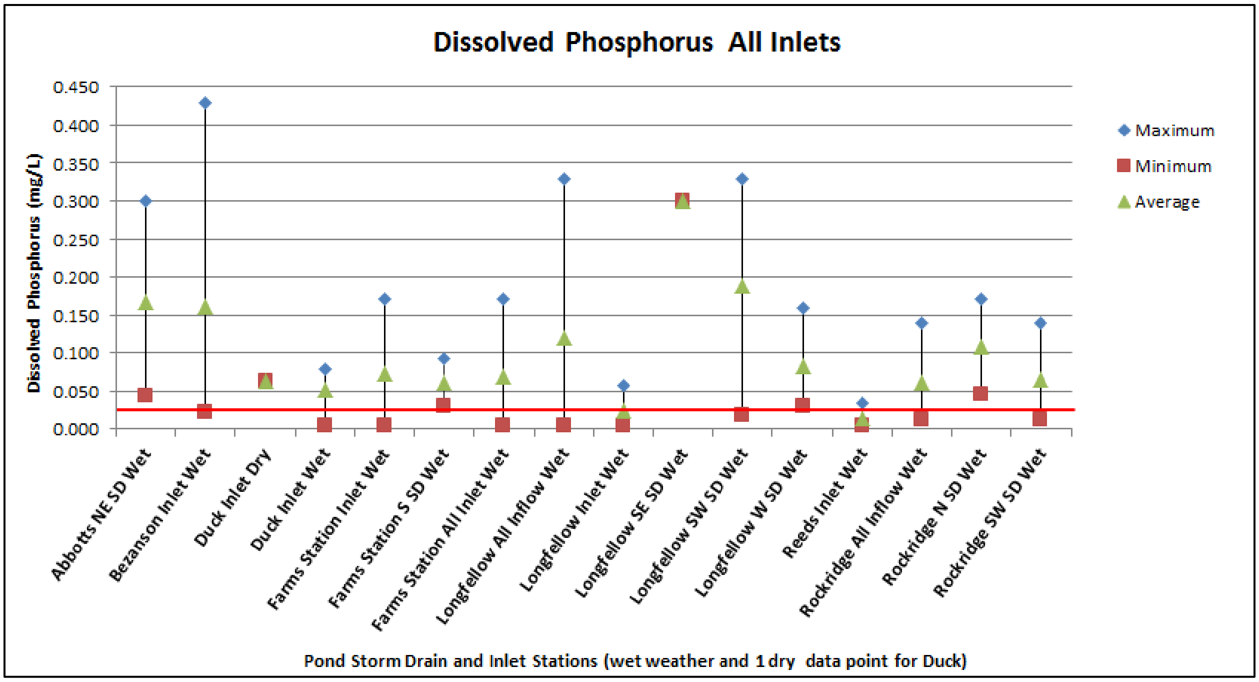

Figure 6. Dissolved phosphorus entering all ponds during wet and dry weather

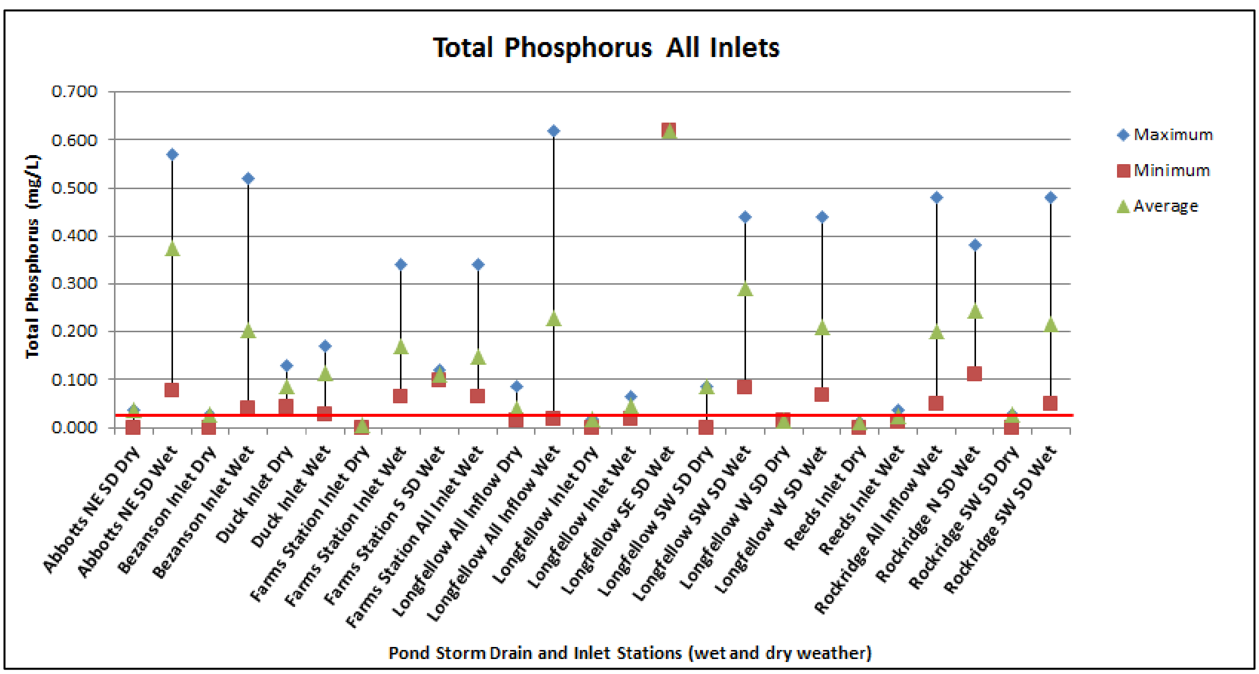

Figure 7. Total phosphorus entering all ponds during wet and dry weather

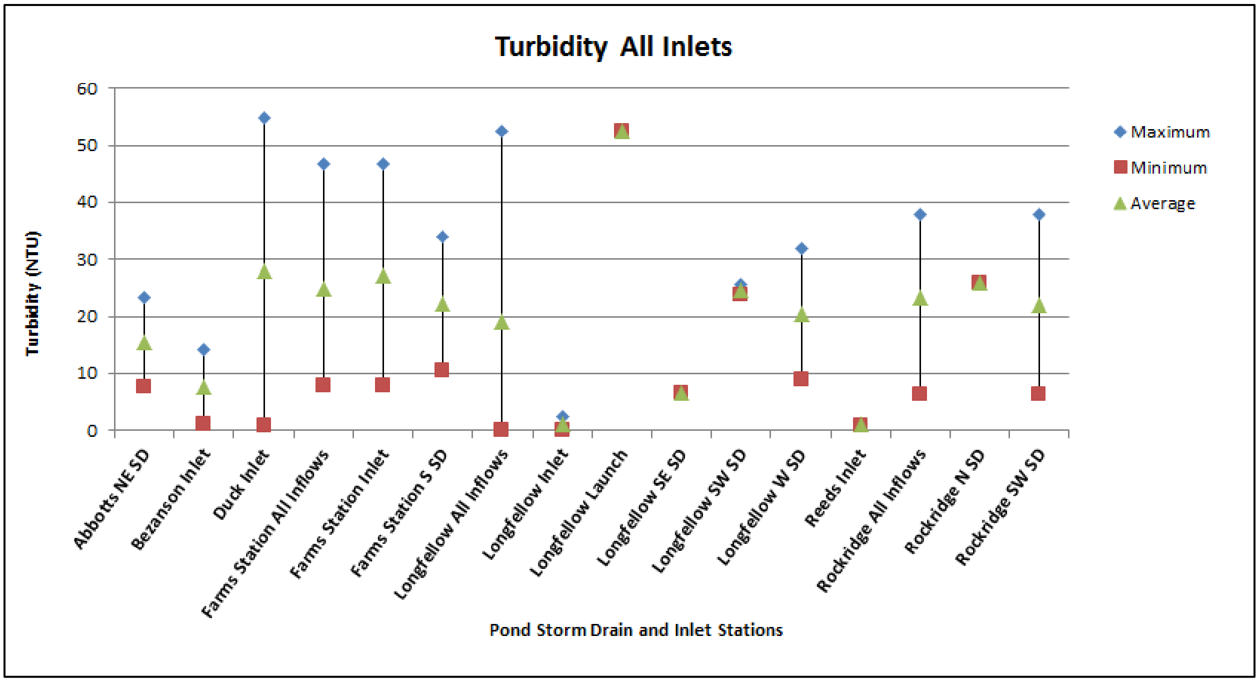

Figure 8. Turbidity in 1st flush storm water entering all ponds

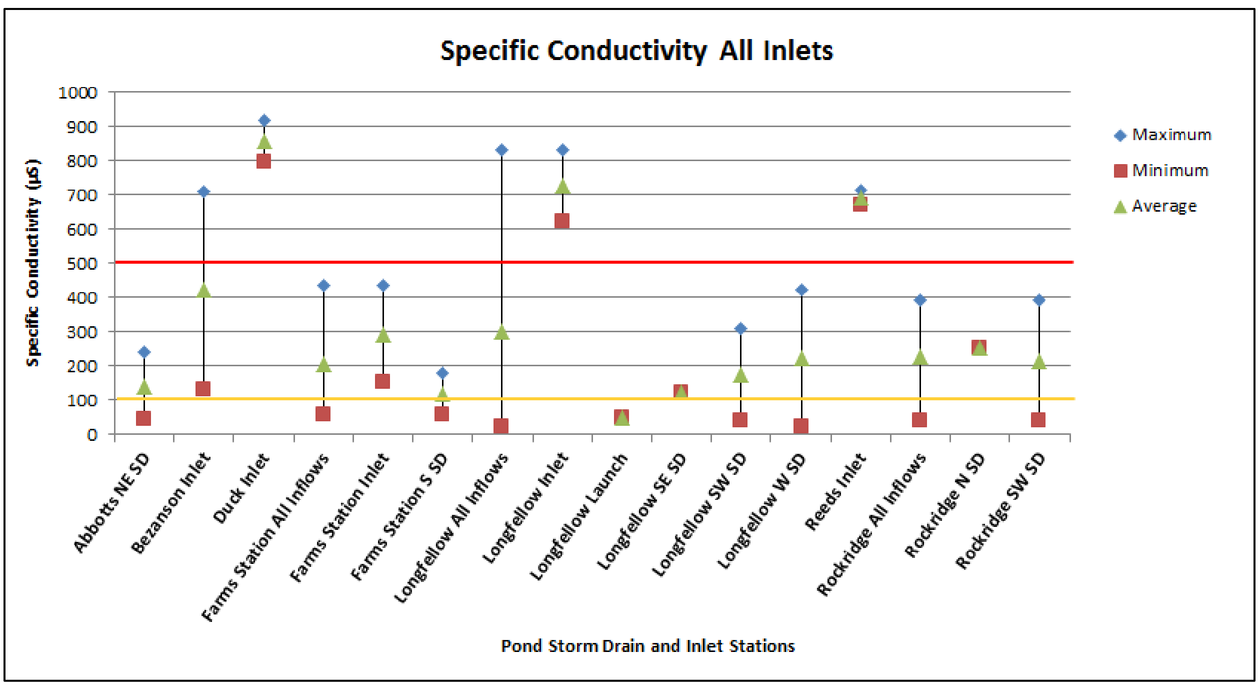

Figure 9. Specific conductivity in 1st flush storm water entering all ponds

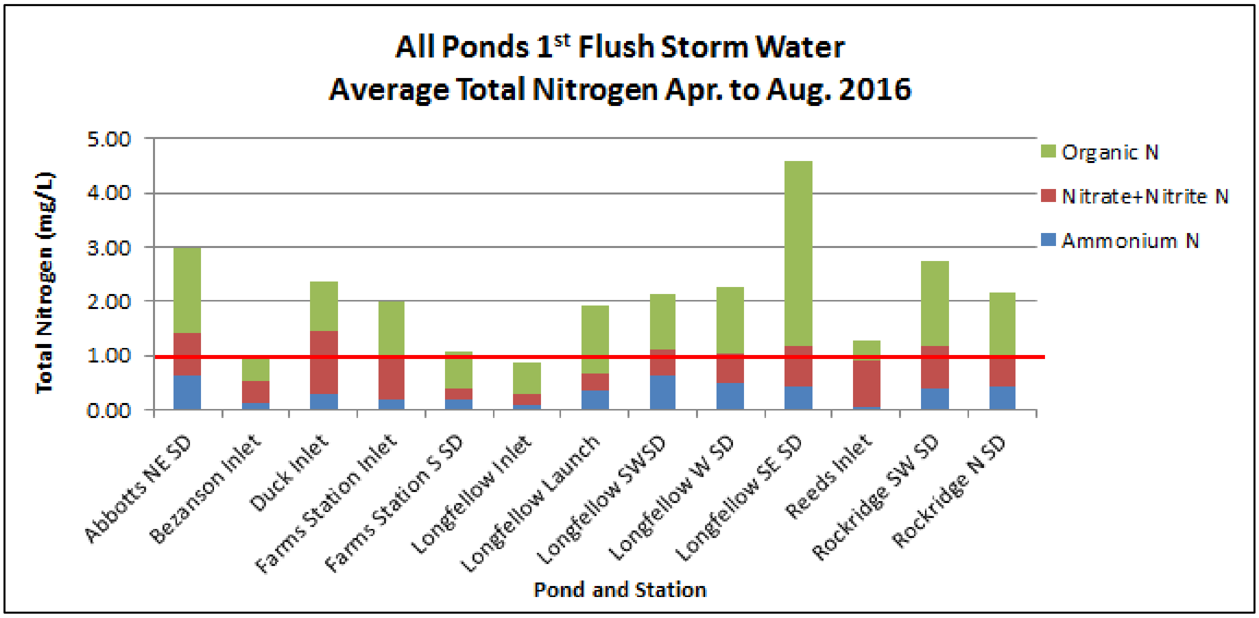

Figure 10. Average total N in 1st flush storm water entering all ponds

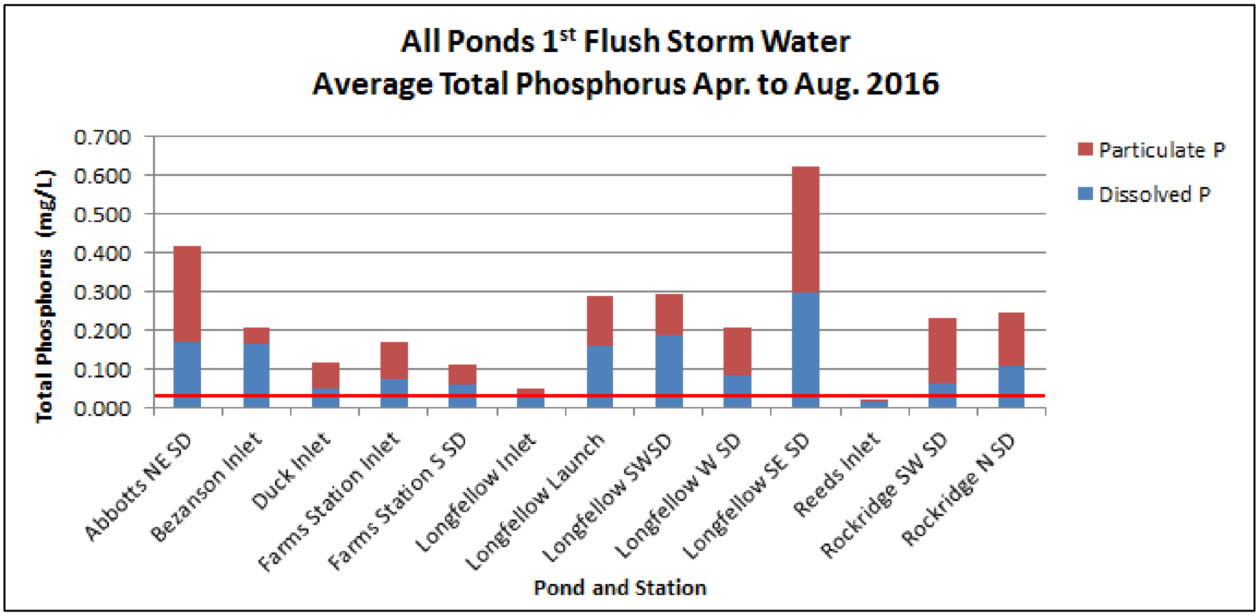

Figure 11. Average total phosphorus in 1st flush storm water entering all ponds

Specific Conductivity

Conductivity is a measure of the overall ion concentration in the water, which imparts electrical conductance that can be measured, and an indirect measure of total dissolved solids (e.g., ions such as chloride, sodium, magnesium, nitrate, sulfate and phosphate). 1st flush storm water had highly variable results for specific conductivity levels, ranging between 23 µS (Longfellow W SD) and 917 µS (Duck inlet) (Figure 9). Values <100 µS are considered low and >500 µS are considered high. High values may be a product of road salt use within the watershed.

Ammonium N

Wet weather ammonium N values ranged from 0.03 mg/L (Bezanson) and 1.50 mg/L (Longfellow W SD) (Figure 2). Storm water values <0.3 mg/L are desirable and concentrations >0.6 mg/L are problematic. At times, each inlet has values of concern. Ponds with upstream detention have low average ammonium N inputs. Under dry conditions, the Duck Pond inlet had a high ammonium N value (0.78 mg/L), indicating that even under dry conditions there is a substantial source of ammonium N. Often a point source like a misconnected or leading sewer pipe is responsible, providing high concentrations during period of low flow, but getting diluted when it rains and runoff volumes are high. Fertilizer application is a possible source, but most ammonium N would be converted to nitrate N by the time it moved through soil and got into the storm water drainage system.

Nitrate+Nitrite N

Inlets were sampled for nitrate+nitrite N under dry and wet conditions (Figure 3). Dry weather nitrate+nitrite N values ranged from 0.24 mg/L (Bezanson) to 1.90 mg/L (Abbotts) and wet weather values ranged from 0.15 mg/L (Longfellow inlet and W SD) to 1.70 mg/L (Duck inlet). Much like ammonium N, values <0.3 mg/L are preferred but storm water inputs >0.6 mg/L are problematic. Most average values were at least slightly elevated over desirable concentrations.

Although there are limited data, a comparison of dry and wet values offers insight into watershed nutrient loading dynamics. Abbotts Pond has a higher input under dry conditions indicating a watershed source of nitrate+nitrite N not dependent on runoff to reach the pond. This could be linked to an illegal discharge, a sewer leak, or a high ground water burden of nitrate from agriculture, septic systems or fertilizer use over years. Considering the watershed land use, fertilizers are most likely the contributing source. Abbotts Pond under wet conditions has lower nitrate+nitrite N indicating storm water is diluting groundwater buildup. The Duck Pond inlet has similar values under dry and wet conditions, indicating the inlet is a continuous source of nitrate+nitrite N due to the highly developed watershed.

Total Kjeldahl Nitrogen

Under wet conditions, all pond inlets total kjeldahl nitrogen (TKN) values ranged from 0.01 mg/L (Bezanson inlet) to 3.90 mg/L (Longfellow W SD) (Figure 4). Dry condition TKN values ranged from 0.28 mg/L (Bezanson inlet) to 2.30 mg/L (Duck inlet). Most values were below the acceptable 1.00 mg/L threshold in dry conditions. TKN is a combination of ammonium N and particulate organic nitrogen. In cases where dry conditions have higher values than wet conditions, ammonium N would be influencing the values because organic particulates do not move in dry weather. Duck inlet had higher values under dry conditions, and is always flowing, receiving water from an urbanized, large watershed with an apparent ammonium N source.

Total Nitrogen

Dry weather total nitrogen values ranged from 0.52 mg/L (Bezanson inlet) to 3.70 mg/L (Duck inlet) and wet weather values ranged from 0.37 mg/L (Bezanson inlet) to 4.73 (Rockridge SW SD inlet) (Figure 5). Wet weather values are higher than values in dry conditions, indicating that watershed sources contribute mainly by runoff. Values 1.00 mg/L or higher are of concern and wet weather values were routinely higher. Dry weather flows, however, are lower, at or around 1.00 mg/L in most cases. The lowest first flush storm water total nitrogen concentrations were from lakes with upstream detention or less developed watersheds like that of Bezanson Pond (Figure 10).

Dissolved Phosphorus and Total Phosphorus

Phosphorus is the most important plant and algae nutrient in freshwater, usually limiting productivity. It tends to be in the shortest supply relative to available sources, but when supplied at an adequate level, will lead to algae blooms or mats. Primary sources of phosphorus include natural soils, fertilizers, and wastewater. Phosphorus that winds up in the sediment of ponds can be recycled as well, causing ongoing productivity problems even when watershed sources are controlled.

TP values <0.010 mg/L are preferable and concentrations >0.025 mg/L are associated with excessive productivity and algae blooms. Concentrations >0.050 mg/L are excessive and beyond about 0.100 mg/L P ceases to be limiting. Dry weather TP values ranged from 0.005 mg/L (Farms Station inlet) to 0.170 mg/L (Duck inlet) and wet weather values ranged from 0.020 mg/L (Longfellow inlet) to 0.620 mg/L (Longfellow SE SD) (Figure 7). Most dry weather values are elevated but not of major concern. Corresponding DP values (Figure 6) were lower than TP concentrations but still elevated. Most inlets, either streams or pipes, had very limited flow during dry weather in this study, so the load of P (concentration X flow) will be relatively low during dry weather. The inlet to Duck Pond is always flowing, even during dry conditions, indicating a likely groundwater component in a largely piped drainage system. P transport in groundwater is limited, probably leading to the observed lower dry weather values.

Wet weather inputs for DP are variable and mostly above 0.020 mg/L (Figure 11); the inlets to Longfellow and Reeds Ponds have lower values, undoubtedly related to upstream detention. DP is the bioavailable form of TP, ready for algae and plant uptake, and values >0.010 mg/L are a concern. TP values are much higher, with a substantial particulate component, as is common in first flush storm water. Urban watersheds typically have TP values of 0.300 mg/L or higher. Overall, the inlets are better than average for urban watershed runoff, but concentrations are still high enough to cause algae issues. DP made up about half of the TP on average, but the portion was highly variable. The particulate fraction will settle out and become part of the sediment base, fueling rooted plant growth and algal mats.

3.4 In-Lake Water Quality

Temperature

Temperature is an important feature of ponds, controlling the rate of metabolism and determining what organisms can survive. Temperatures in Wellesley Ponds between June and August ranged from 23 to 28 ^{o}C (Figure 12), which equates to 73 to 82 ^{o}F. Coldwater fish like trout would not survive in those ponds, but a suite of warmwater species will find them quite suitable. The ponds did not get overly hot, despite the warm weather and limited inflow. Most of the ponds were shallow and the temperature was not substantially different top to bottom, although slightly lower bottom temperatures were recorded. Only Farms Station Pond exhibited enough of a thermal gradient to be called stratified.

Dissolved Oxygen

For all Wellesley ponds, average dissolved oxygen at the surface ranged from 5.0 to 11.5 mg/L (Figure 13), all high enough to support desired forms of aquatic life. But aquatic organisms such as fish have to live through the extremes, not just the average. Yet low values were not extreme in most cases. Farms Station Pond was an exception, being thermally stratified during summer and experiencing summer bottom water anoxia (Figure 14) with a maximum depth of only 9 feet. During bottom water anoxia, iron bound phosphorus can be released from sediments, making it bioavailable. Icehouse Pond (Figure 15) also experienced low oxygen at the bottom in August, but was not thermally stratified and oxygen levels were not totally depleted over its 6 foot depth. Despite having a maximum depth of only 5 feet, Longfellow Pond experienced depressed oxygen throughout the water column on the August sampling date. Other ponds with shallower maximum depths exhibited fewer oxygen issues.

Oxygen can be reduced or even depleted by overabundant algae or plants during respiration and high temperature, especially near the bottom where decomposition is most intense and diffusion of oxygen from above is slow. Clearly there is a high oxygen demand in most of the Wellesley ponds, and where mixing and reaeration are limited by temperature, dense plants or algae mats, low oxygen may be encountered. Shallow depth and short flushing time prevent serious oxygen problems in most cases, but in the dry, hot summer of 2016 there were oxygen

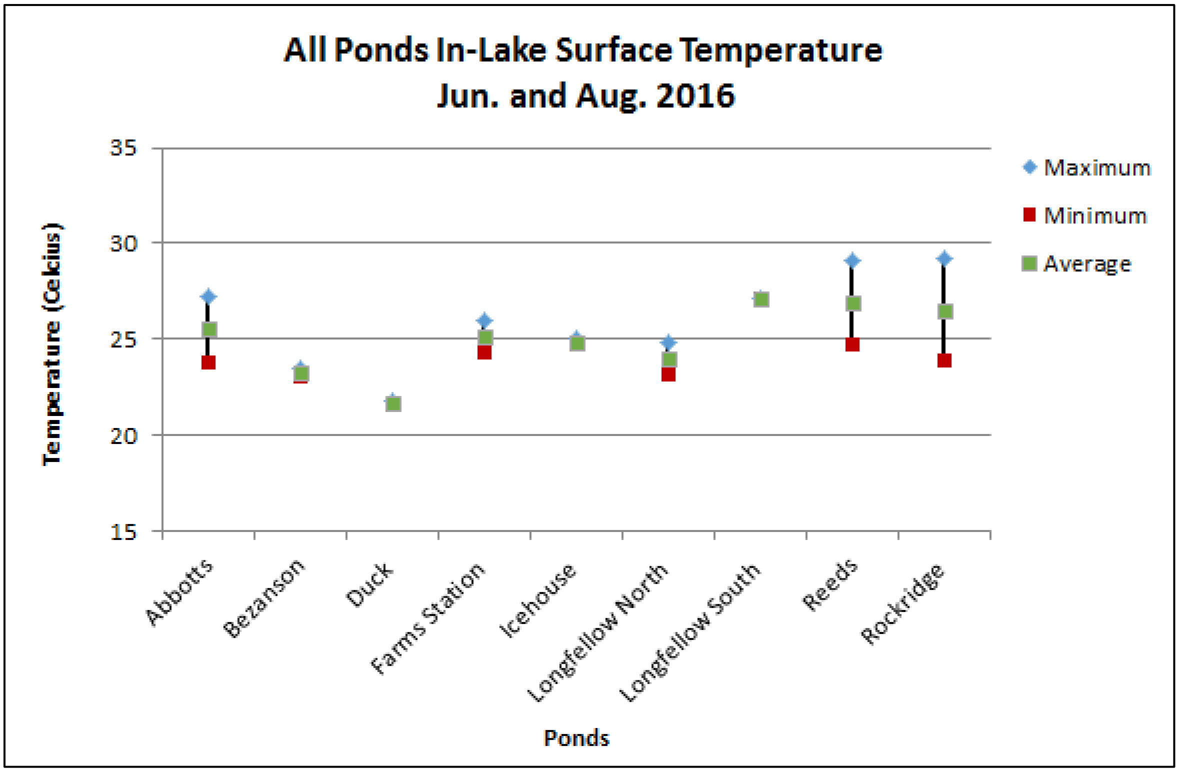

Figure 12. In-lake temperature for all ponds

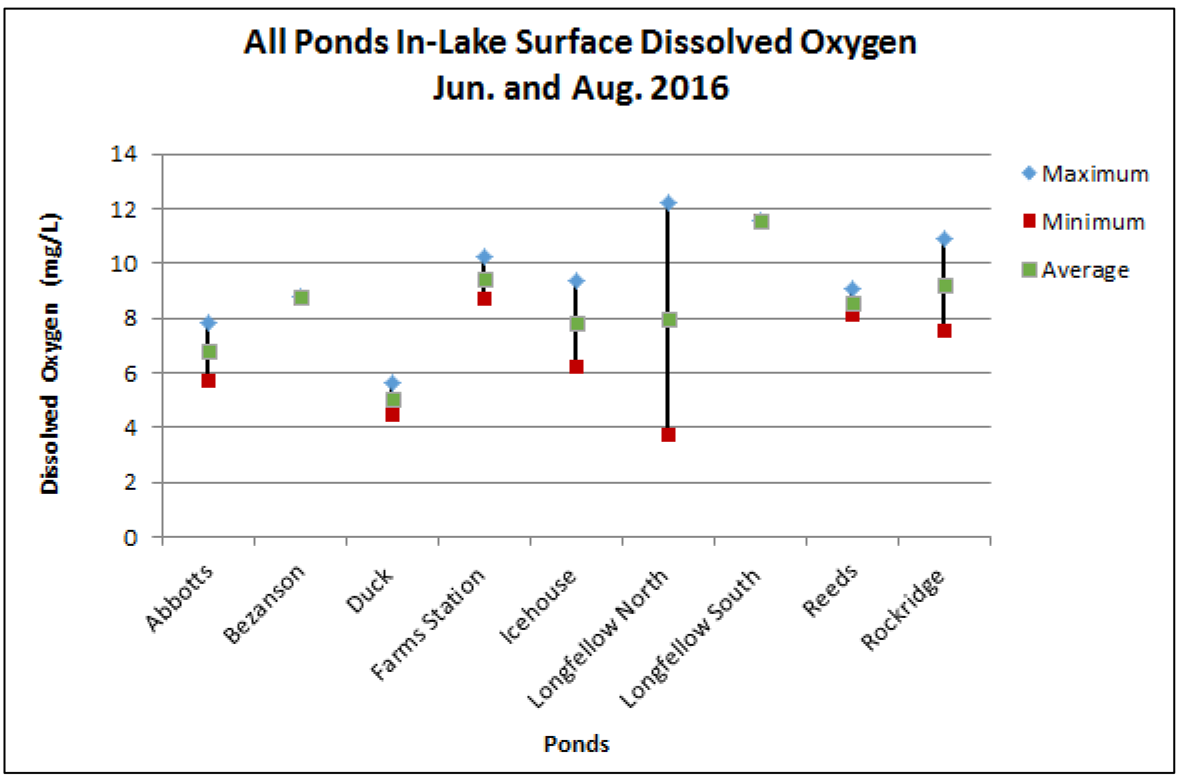

Figure 13. In-lake dissolved oxygen for the surface of all ponds

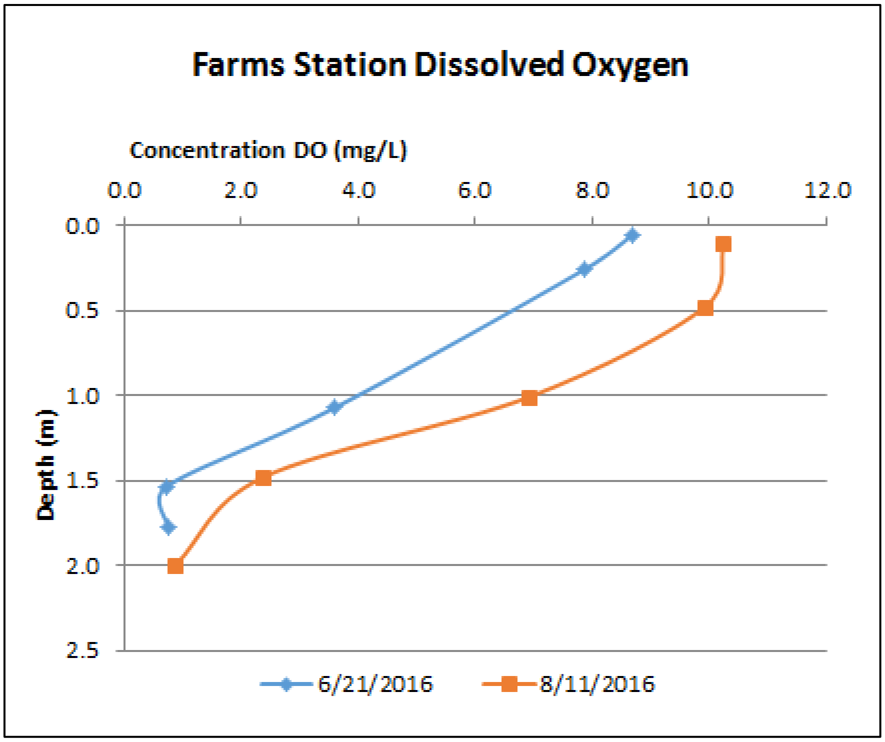

Figure 14. Farms Station oxygen profiles

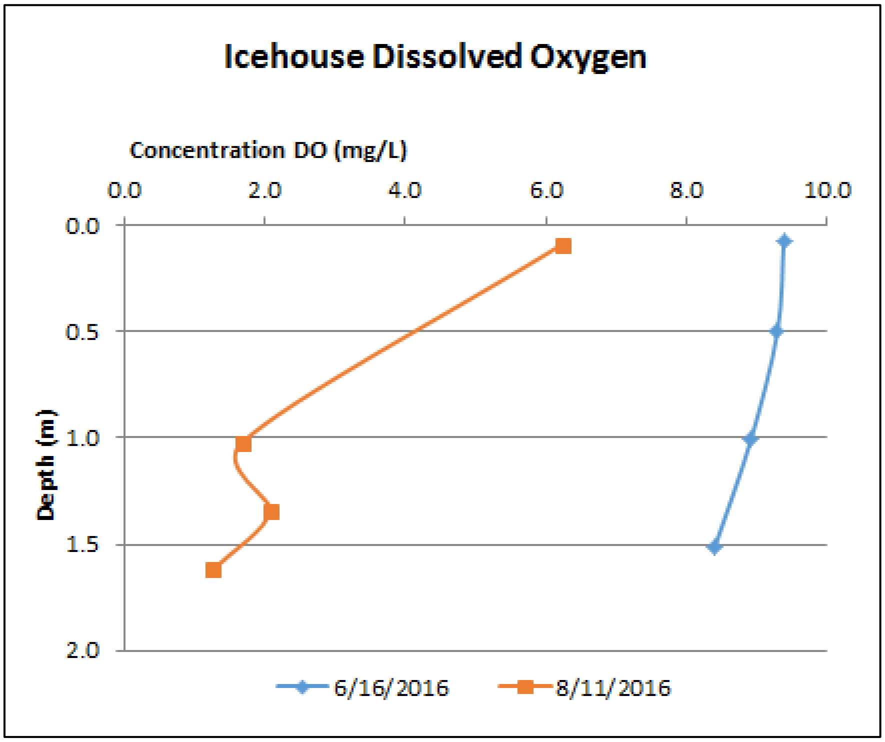

Figure 15. Icehouse oxygen profiles

stresses in some ponds. Problems would not be expected in spring or fall, but there could be oxygen depletion issues under ice in winter if flows are low.

Turbidity

Turbidity provides a measure of water clarity that is not impeded by shallow water depth, as are measurements of Secchi disk transparency when the disk reaches the bottom. Suspended solids may result from tributary inputs, resuspension of bottom sediments, or production of algae in the water column, and these solids increase turbidity, which is a measure of how much light is deflected from a beam passed through a sample of water. Desirable turbidity values are below 3 NTU, and all of the ponds have values above this threshold (Figure 16). Abbotts and Duck Ponds have extremely elevated turbidity, and values in Longfellow Pond are quite high. Abbotts Pond is shallow (1.5 ft) with highly organic sediment volume, allowing wind-induced sediment resuspension; abundant phytoplankton are also a factor. High turbidity in Duck Pond is likely a product of continual flow coming from the large, urban watershed and easily resuspended sediment in this shallow pond. Ponds with upstream detention exhibit lower turbidity values, although all of the ponds had turbidity higher than desirable at some point during sampling.

pH

The pH is a measure of the hydrogen ion concentration of a solution. The pH scale is the inverse of the logarithm of the hydrogen ion concentration, ranging from 1 to 14 standard units (SU). A value of 7 SU is neutral, while values above 7 SU indicate an alkaline solution and values below 7 SU indicate acidic conditions. For optimum species habitat, a pH between 6.0 and 8.0 SU is desired. All of the Wellesley ponds pH values had pH values >7 SU, but only the northern Longfellow Pond basin had any pH value >8.0 SU, at 8.3 SU in August (Figure 17). This value was not extreme and is likely high caused by abundant plants and algae. Dense macrophyte beds or algae mats, as seen in Longfellow Pond, can increase pH by photosynthesis, which removes carbon dioxide. Other ponds may experience slightly elevated pH at times, but no serious pH problems are indicated by the sampling results.

Alkalinity

Alkalinity is a measure of potential pH buffering capacity. Alkalinity in Wellesley ponds ranges from 27 mg/L (Icehouse) to 58 mg/L (Farms Station), all of which indicate moderate buffering capacity (Figure 18). The ponds will be less likely to experience large swings in pH.

Specific Conductivity

Surface waters with conductivity <100 µS are likely to be nutrient poor. Contaminated or fertile lakes, where nutrient-driven phytoplankton blooms are likely to occur, are often characterized by higher conductivity readings (often above 300 µS). However, it is possible to have high conductivity and low fertility when non-nutrient solids concentrations are high or a waterbody

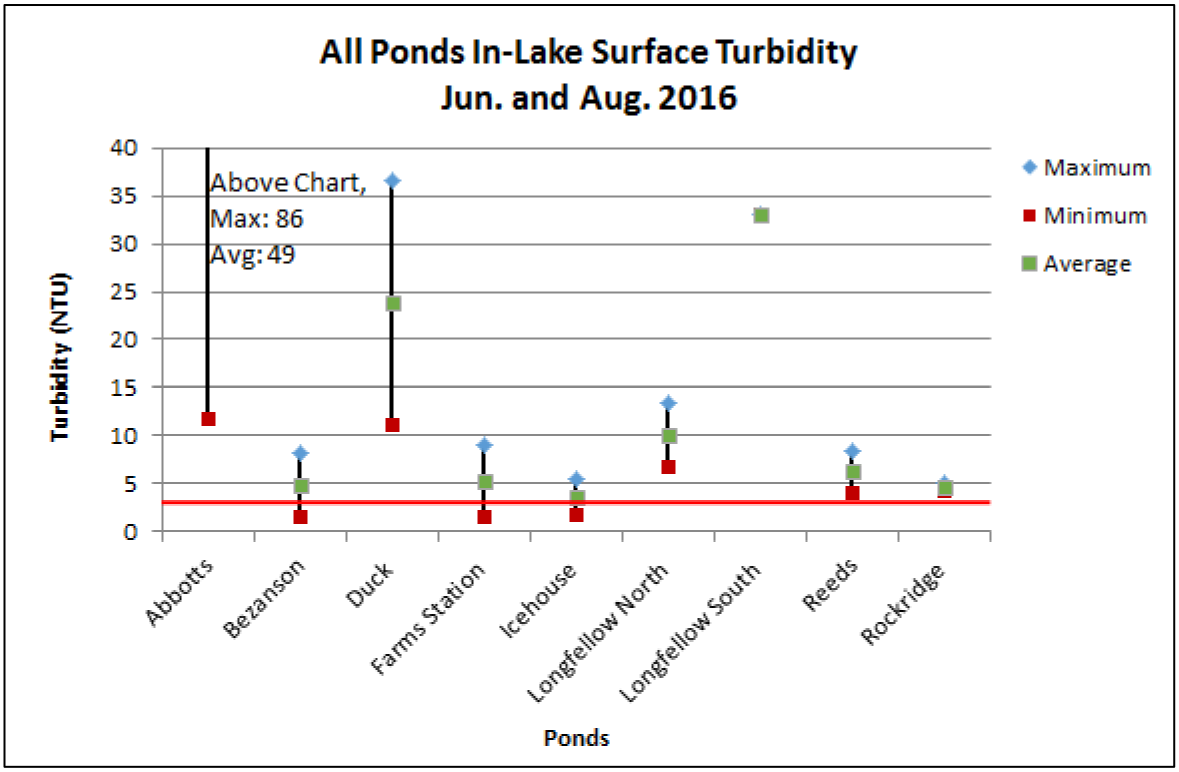

Figure 16. In-lake turbidity for all ponds

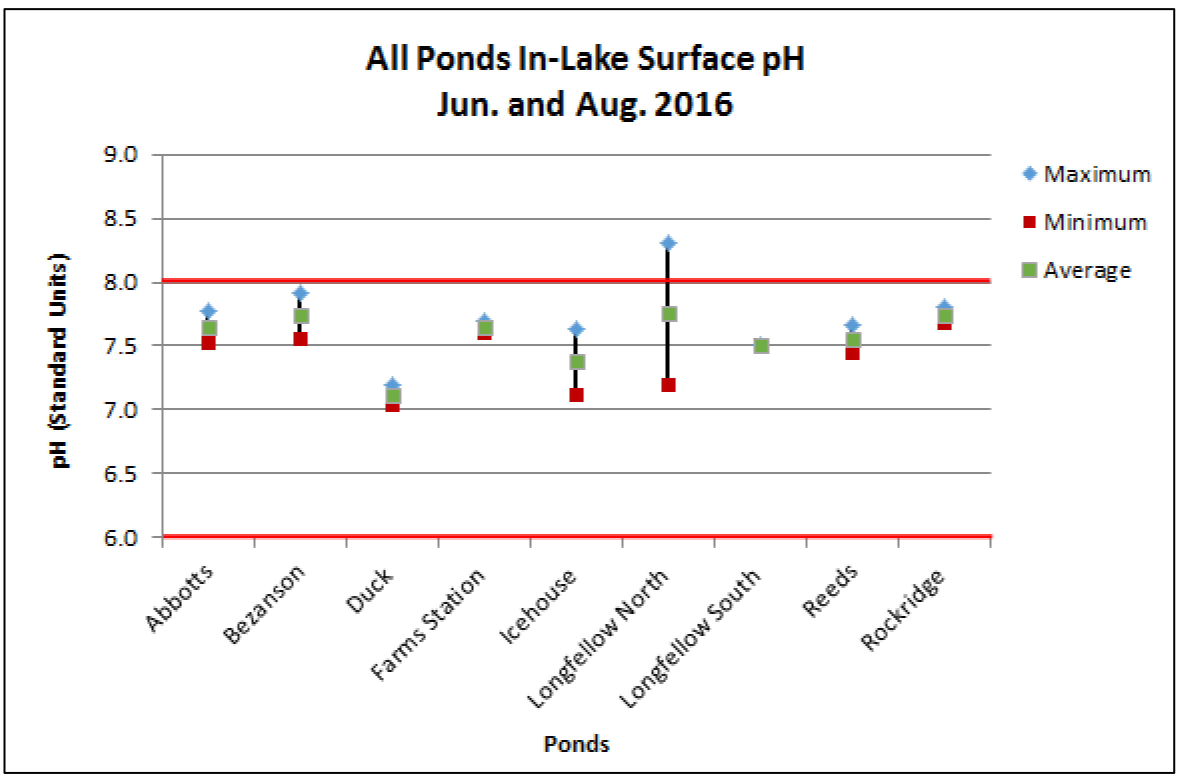

Figure 17. In-lake pH for all ponds

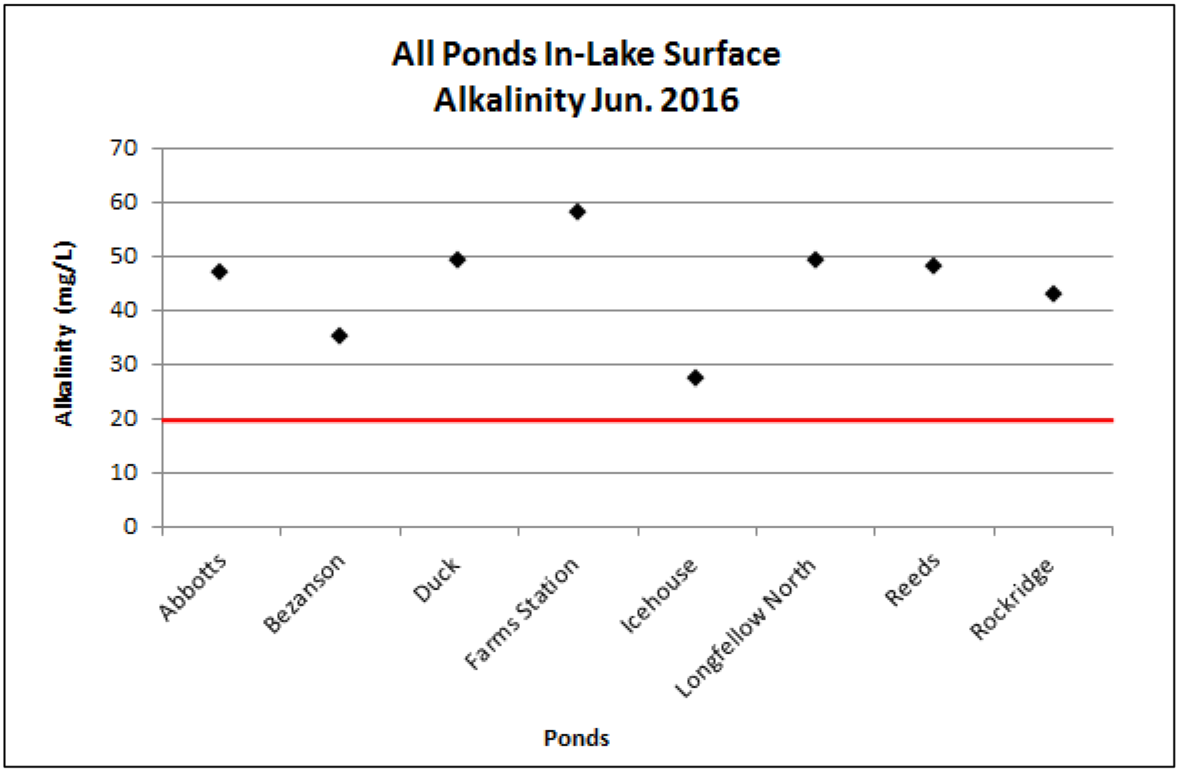

Figure 18. In-lake alkalinity for all ponds

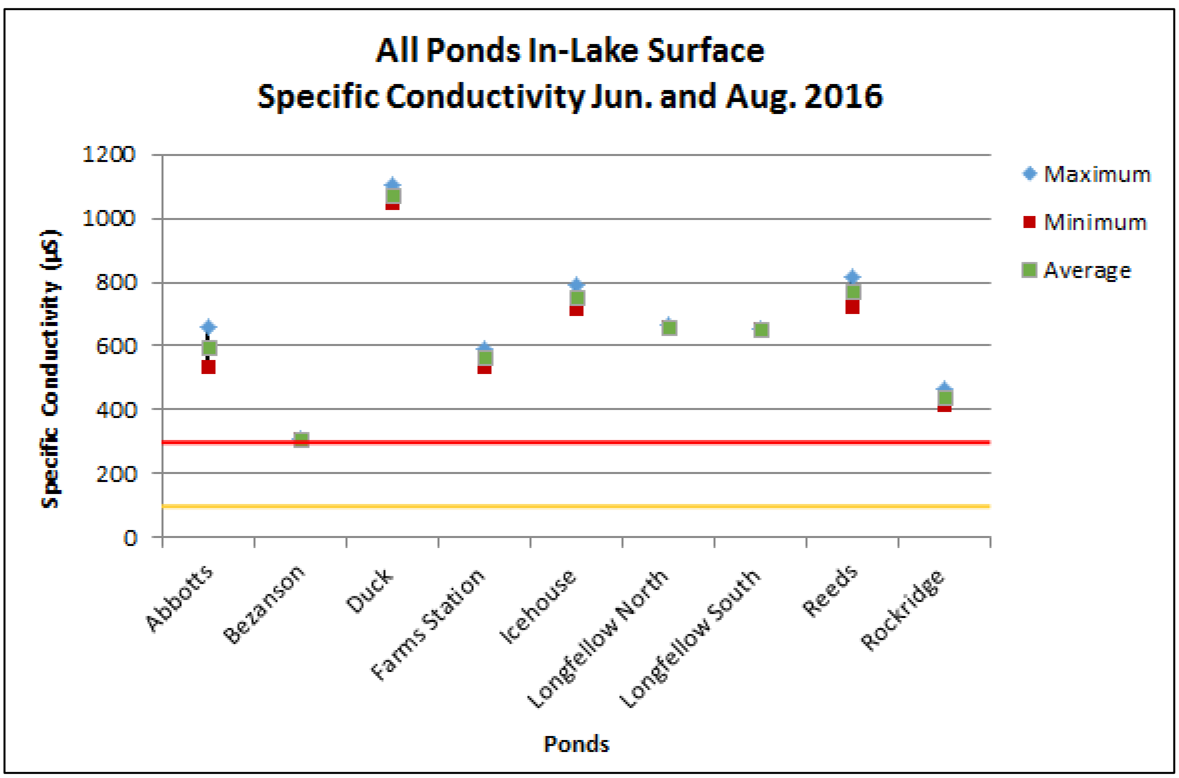

Figure 19. In-lake specific conductivity for all ponds

is impacted by road salt. Conductivity often increases near the bottom of a lake, where decomposition releases dissolved solids into the water column.

Average specific conductivity ranged from 308 µS (Bezanson) to 1076 µS (Duck), which are high average values overall (Figure 19). Duck, Longfellow and Reeds Ponds had the highest conductivity values in their inflows, but inflows to most of the ponds had elevated conductivity and those inputs are reflected in the conductivity of water in the ponds. Most of the ponds have highly urbanized watersheds leading to higher dissolved solids in-lake, particularly from road salt, which can build up in ground water and provide a continuing source of elevated conductivity. The lowest value is from Bezanson Pond, which has the least developed watershed. Having upstream detention is not a major benefit for conductivity control, as many dissolved substances (e.g., sodium and chloride) are not removed by biological processes in upstream ponds.

Secchi Transparency

Secchi disk transparency (SDT) is a measure of water clarity. Secchi depths and maximum water depths are displayed together to demonstrate the relationship of water clarity and depth (Figure 20). Secchi depths were often close to or the same as pond depth, but with such shallow ponds, that does not mean the water was very clear. Among the eight ponds, Abbotts, Duck and Farms Station Ponds were the most impaired, with SDT loosing visibility at about half the water depth. Duck and Abbotts Ponds are very shallow and expected to have a SDT that reaches the bottom, but due to suspended solids and algae this is not the case. Between June and August the SDT in Farms Station and Longfellow decreased noticeably. SDT in other ponds, while low, was more stable.

Nitrogen

Average ammonium nitrogen concentrations in the ponds ranged from 0.08 mg/L (Reeds) to 0.55 mg/L (Duck) (Figure 21). Besides in Duck Pond, ammonium nitrogen values are all low. Average nitrate nitrogen values ranged from 0.03 (Icehouse) to 0.43 mg/L (Reeds). For nitrate nitrogen, Duck and Reeds Ponds have high average values, while the rest of the ponds exhibited low values, below 0.03 mg/L. TKN ranged from 0.40 mg/L (Icehouse) to 1.75 mg/L (Abbotts). Icehouse and Reeds Ponds TKN values were >0.5 mg/L, a desirable level, but the rest of the ponds exhibited higher concentrations. Average organic nitrogen ranged from 0.28 mg/L (Icehouse) to 1.53 mg/L (Abbotts). Average total nitrogen ranged from 0.43 mg/L (Icehouse) to 1.78 mg/L (Abbotts). Organic nitrogen was the dominant form of N in most samples on most dates, indicating either incorporation of N into algae or substantial amounts of non-living organic matter in the water column; both are possible. For total nitrogen, average values are considered to be higher than desirable in all ponds except for Icehouse Pond, and more than half the ponds exhibited values that would be considered clearly undesirable.

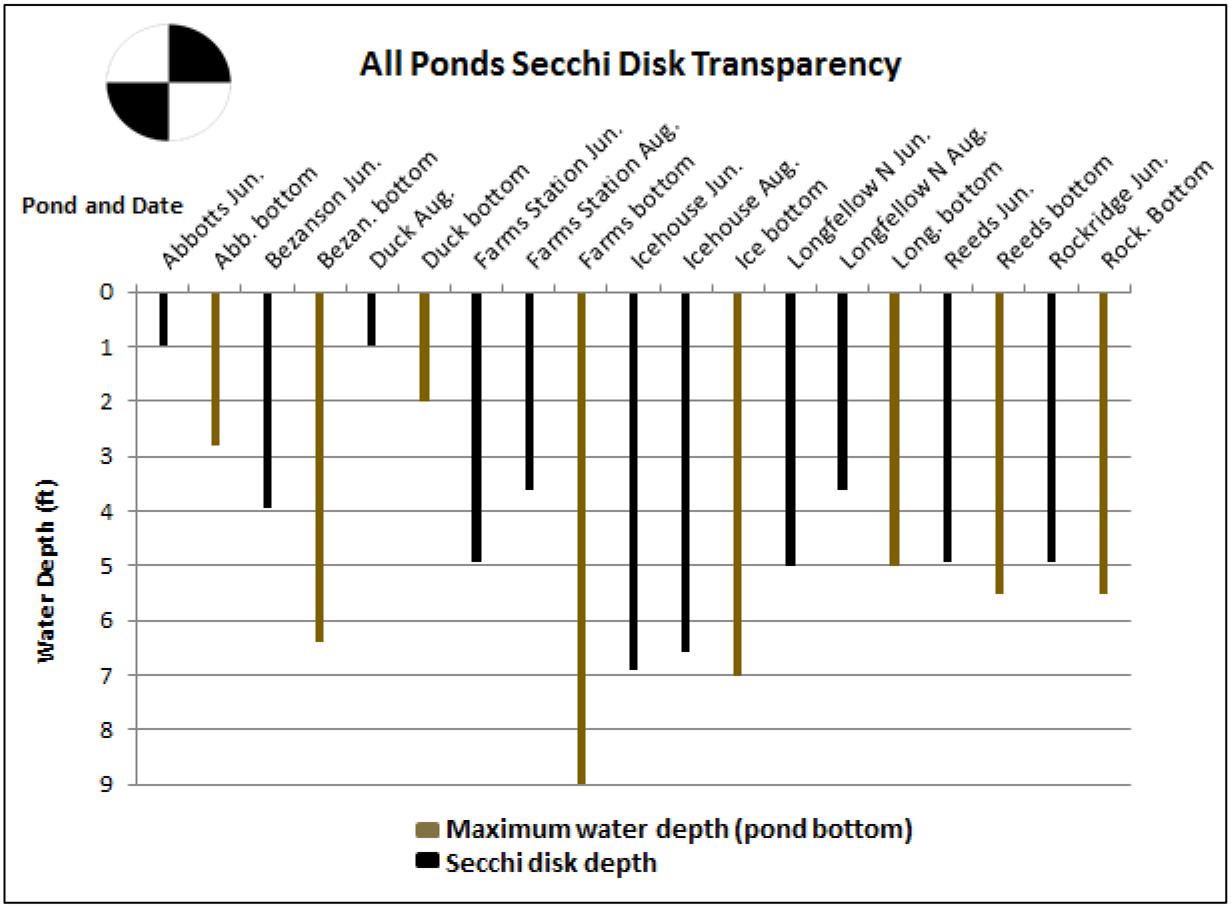

Figure 20. Secchi transparency for all ponds

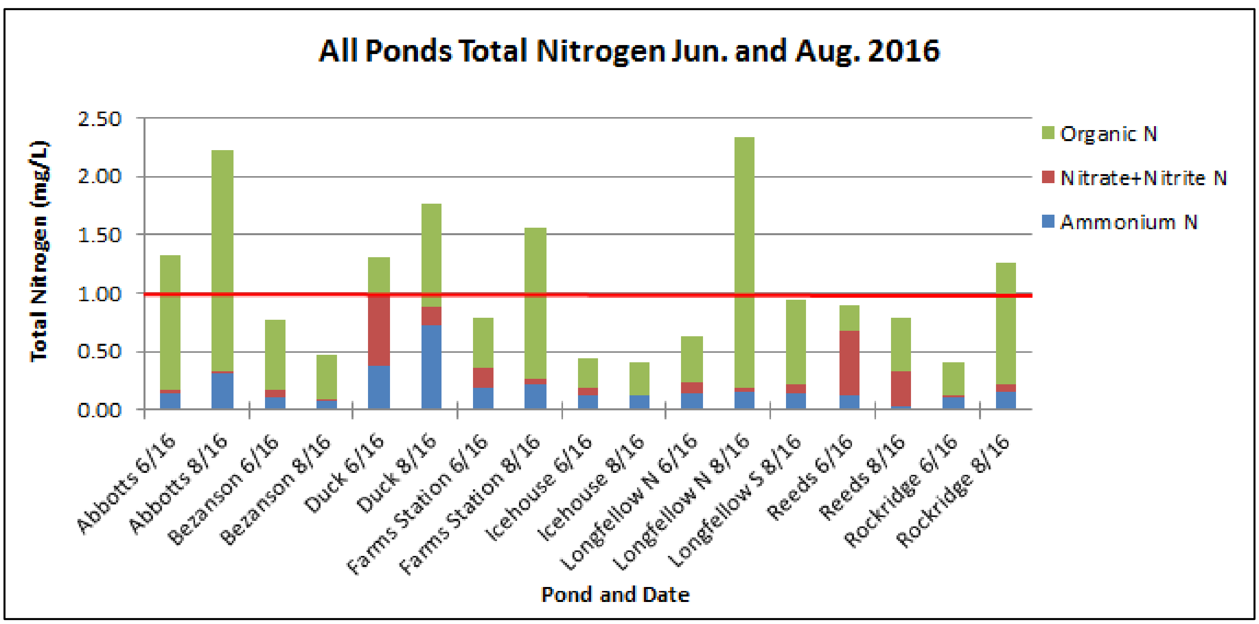

Figure 21. In-lake nitrogen levels for all ponds

Phosphorus

Average total phosphorus values ranged from 0.010 mg/L (Icehouse) to 0.204 mg/L (Longfellow). These are elevated levels, with values <0.010 mg/L considered low and values between 0.010 and 0.025 mg/L considered moderate. Average dissolved phosphorus values ranged from 0.005 mg/L (Icehouse and Duck) to 0.039 mg/L (Abbotts). It was not surprising that Icehouse had the lowest phosphorus level, given that much of its water comes from Morses Pond, which is managed for low phosphorus (Figure 22). Most phosphorus concentrations were elevated but also variable over time. Water quality condition with regard to this important nutrient do not appear stable in most ponds, with Icehouse and Reeds Ponds (both in the same drainage system) as possible exceptions and the exhibiting the lowest concentrations of phosphorus.

Nitrogen:Phosphorus Ratio

Average total phosphorus concentration divided by average total nitrogen concentration provides a rough indication of which of these key nutrients is most likely to limit algae growth. One could look at the ratio of dissolved phosphorus to dissolved nitrogen as well, which shows what is available for uptake at the time of sampling but does not reflect longer term availability. Ratios <10:1 tend to favor cyanobacteria that can fix dissolved nitrogen gas, which other algae cannot do, and cyanobacteria include many forms that cause blooms, taste, odor and even toxicity. Ratios much higher than 10:1 favor other algae, most often green algae in summer.

Ratios for the Wellesley Ponds are mostly >10:1 (Table 3). Abbotts Pond has a TN:TP ratio close to 10:1 and Longfellow Pond has a TN:TP ratio well under 10:1, but neither had much cyanobacteria in 2016. Dissolved N:P ratios were lower than 10:1 in Abbotts, Bezanson and Rockridge Ponds, but again very little cyanobacteria was observed in those ponds in 2016. Overall, it appears that phosphorus is the limiting nutrient for algae in these ponds and the logical target of water quality management.

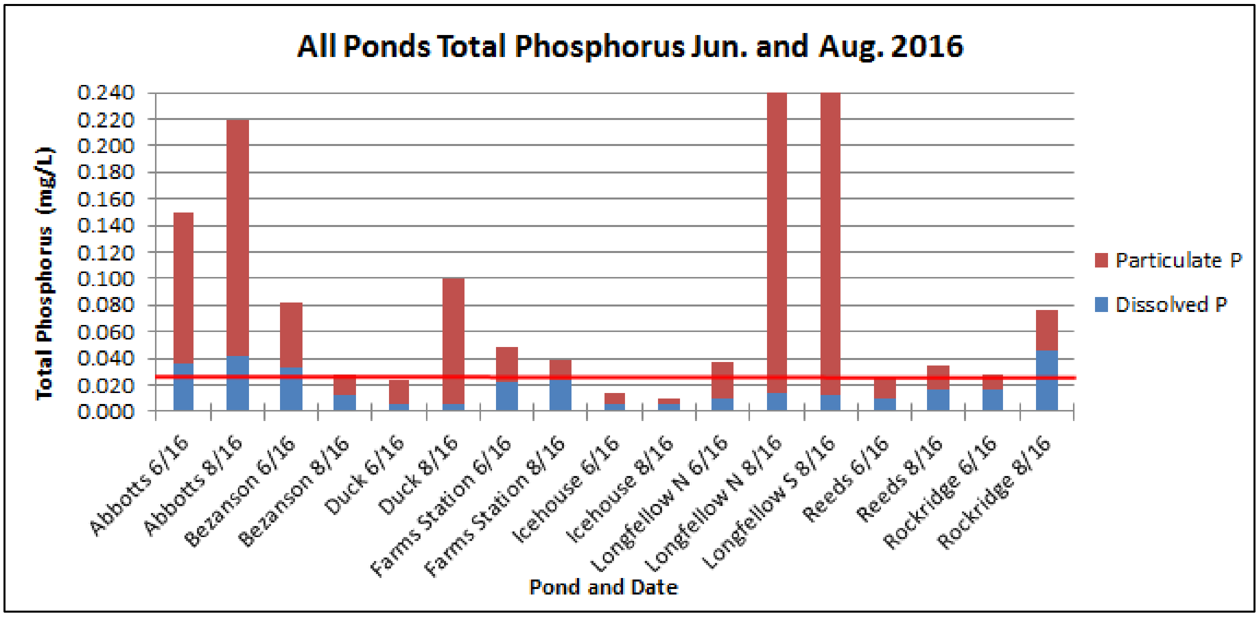

Figure 22. In-lake phosphorus levels for all ponds

Table 3. Ratio of mass of nitrogen to phosphorus for all ponds

Pond	TN/TP	DN/DP
Abbotts	9.6	6.4
Bezanson	11.4	5.8
Duck	25.0	187.0
Farms Station	26.5	13.9
Icehouse	45.1	30.7
Longfellow	7.2	17.5
Reeds	28.0	38.7
Rockridge	16.1	5.6

3.5 Sediment Quality Assessment

The focus of sediment quality assessment for the Wellesley Ponds was on the fertility of the bottom sediment as a source of phosphorus for algae or rooted plants. Key features in that regard include solids content (solids vs water), organic content (organic material vs. inorganic sediment), total phosphorus, and iron-bound phosphorus, which is the portion of total phosphorus most likely to be released from the sediment under low oxygen conditions (Table 4).

Solids content ranged from 14% (Icehouse) to 35% (Bezanson), meaning that 65-86% of the sediment pulled from the ponds was water. This is typical of pond sediments. Organic content of the sediment ranged from 71.4% (Bezanson) to 92.4% (Abbotts), suggesting that all sampled soft sediment was highly organic. There was a gradient, however, with ponds that have been dredged in the past having lower, albeit still elevated, organic content. This suggests that what fills the ponds is mostly a combination of leaves and other organic matter from the watershed and internally produced organic matter, mainly from plants and algae.

Total phosphorus ranged from 354 mg/kg (Icehouse) to 1715 mg/kg (Duck), with all but Icehouse Pond having values >750 mg/kg and four ponds having values >1000 mg/kg. Values >500 mg/kg are considered high, but the availability of that phosphorus cannot be known from total phosphorus concentrations. Iron-bound phosphorus, the dominant available fraction, is considered elevated when >100 mg/kg and is very high when >500 mg/kg. Values for the Wellesley Ponds ranged from 100 mg/kg (Icehouse) to 994 mg/kg (Duck), with values for Abbotts and Farms Station Ponds also >500 mg/kg. There is a lot of available phosphorus in the sediment of these ponds.

Calculating the mass of available phosphorus as the percent solids in the upper 10 cm (4 inches) of sediment times a specific gravity of 1.2 times the iron-bound phosphorus concentration, the amount of phosphorus likely to become available for uptake under low oxygen conditions ranges from 1.7 g/m^2 (Icehouse) to 31 g/m^2 (Duck). Icehouse and Duck Ponds have the extreme values for both total and iron-bound phosphorus, but the other ponds in between do not follow the same pattern; the relation between total and iron-bound phosphorus and the solids and organic content of the sediments of these ponds are variable. Only Icehouse Pond has an available phosphorus mass that would not be considered high.

Because most ponds have elevated masses of available phosphorus in their surficial sediment does not guarantee that the phosphorus will become available; that is a function of oxygen concentrations and direct uptake by algae or rooted plants near the sediment-water interface, which is itself partly dependent on light penetration. Yet the potential for high productivity is substantial in these ponds, even with past dredging of accumulated sediment.

Table 4. Sediment quality for all ponds

	Organic	Solids	Total Phosphorus	Iron Bound Phosphorus	Mass of P to be Treated
Pond	**%**	%	mg/kg dry weight	mg/kg dry weight	g/m2
Abbotts	92.4	16	779	665	12.8
Bezanson	71.4	35	1250	118	5.0
Duck	77.0	27	1715	994	31.6
Farms Station	90.1	18	1540	520	11.2
Icehouse	82.3	14	354	100	1.7
Longfellow	85.3	15	799	487	8.5
Reeds	90.1	16	956	440	8.5
Rockridge	80.8	21	1130	210	5.3

3.6 Plankton Analysis

Algae and small animals (mostly crustaceans) in the water column are an important part of the food web in ponds, but with short detention times it is possible to flush these organisms out of the pond with storm events, creating variation over time. Each pond was sampled twice during this study, just to get an overall impression of the types of algae (phytoplankton) and planktonic animal life (zooplankton) in each pond. Seven divisions of algae were represented in the phytoplankton, with high variability in the amount and types of algae in the phytoplankton of each pond (Figure 23). This variability is further documented by concentrations of chlorophyll-a (Figure 24), a photosynthetic pigment common to all algae.

Abbotts Pond had the greatest amount of phytoplankton, mostly dinoflagellates, which are common in shallow ponds with organic-rich substrates. Longfellow Pond had the next greatest overall algae abundance, with golden algae dominating at the end of spring and a mixed assemblage in mid-summer. Farms Station Pond had the next most abundant algae assemblage, a mix of divisions at the end of spring and mostly small green algae in mid-summer. Other ponds had no more than one of two samples with biomass above the probable problem threshold. Cyanobacteria, the most troublesome algae, were not dominant and abundant in any sample, although some potential problem species were detected and could bloom at times other than when we sampled. Only Abbotts Pond exhibited high chlorophyll-a in both samples, but all ponds except Icehouse and Rockridge Ponds has at least one elevated value.

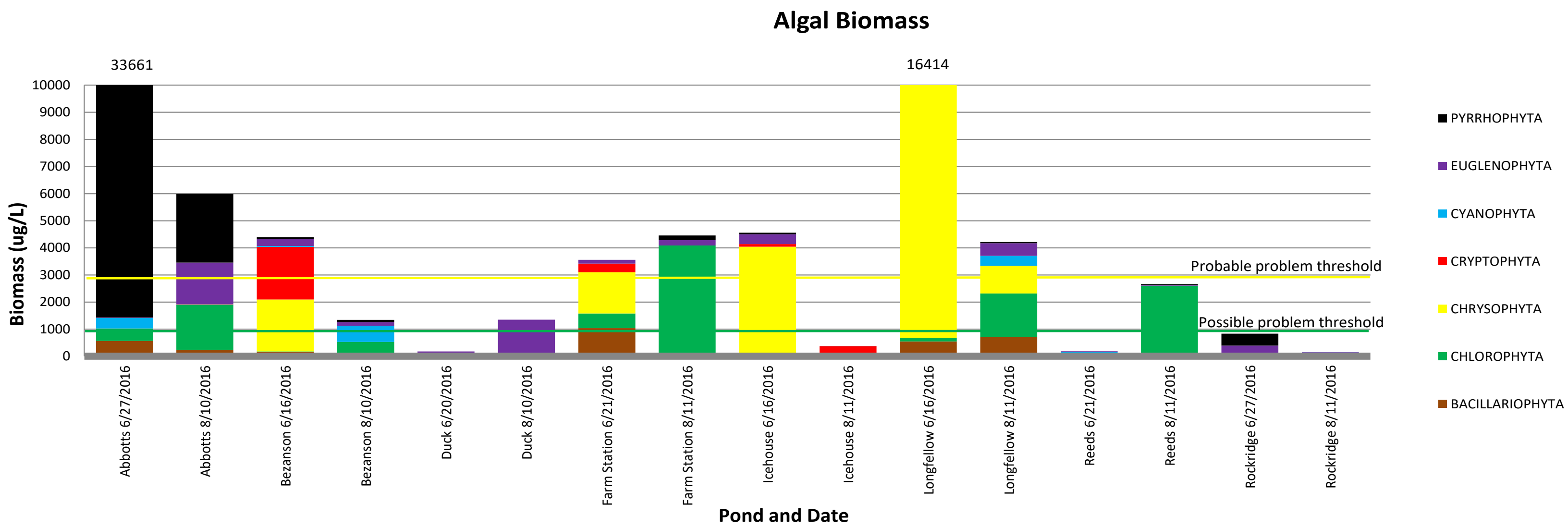

Figure 23. Phytoplankton biomass for all ponds

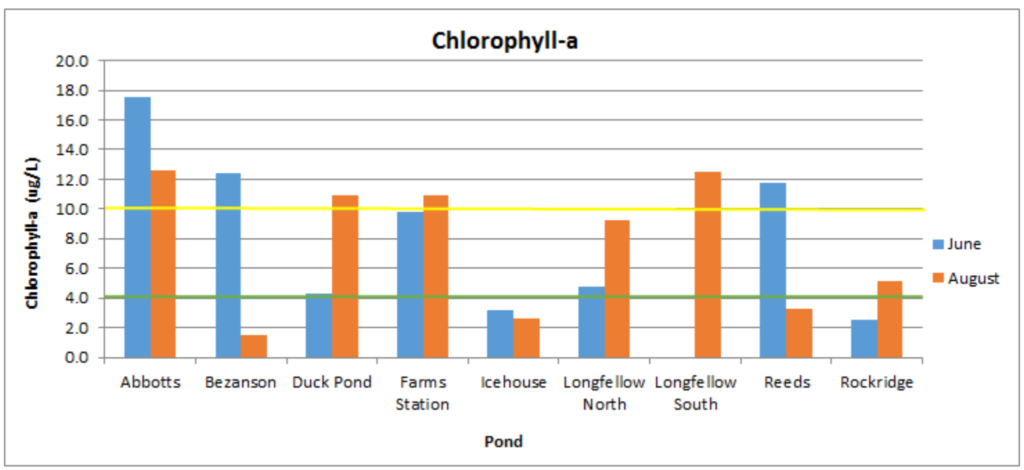

Figure 24. Chlorophyll-a for all ponds

Phytoplankton samples sometimes pick up some mat forming algae, but extensive mats are normally evaluated with the rooted plant community. In the Wellesley Ponds, phytoplankton is the dominant form of algae in only a few cases (Abbotts and Farms Station), while mat forming algae are more common in most. Observed mats included only green algae (Chlorophyta), with *Spirogyra* and *Rhizoclonium* as the most common forms. These can grow quite densely, often in association with rooted plants, and often start on the pond bottom but float to the surface after weeks of growth. Such mats interfere with boating and fishing, often to a greater extent that dense rooted plant assemblages.

Zooplankton are planktonic animals that mostly eat algae, and sometimes each other, and are in turn eaten by fish. They are therefore an important link in the food web of a healthy pond. High flushing rates, low food quality, and predation by fish can all depress the zooplankton community. Zooplankton biomass of 50 µg/L is considered moderate, while biomass >100 µg/L is considered high and desirable.

Zooplankton in the Wellesley ponds are highly variable in terms of abundance (Figure 25), although very few samples exceeded the 50 µg/L threshold. Those that did (second sampling of Duck, Farms Station and Rockridge Ponds) were well over the 100 µg/L level. Cladocerans, copepods and rotifers make up most of the zooplankton, with cladocerans and copepods making up most of the biomass, except in Duck Pond in August where the phantom midge (*Chaoborus* sp.) was abundant. Duck Pond in August also had a high concentration of large *Daphnia*, a desirable cladoceran filter feeder. However, the presence of phantom midges and large *Daphnia* at the observed densities suggest that there are few fish in Duck Pond that would eat zooplankton. A substantial amount of the biomass in the second samplings of Farms Station and Rockridge Ponds was also *Daphnia*; there may be few fish in Farms Station Pond, but Rockridge definitely has sunfish and bass populations. Overall, the types of zooplankton present are desirable, but the quantities are low in many cases. Flushing was not a major factor in 2016 during the sampling period, so ponds with less zooplankton are likely influenced by fish predation and food limitations.

The average length of zooplankton also provides indications of ecological interactions with larger individuals consuming proportionally more algae (intake is proportional to the cube of body length) and representing better food for small fish. Too many large zooplankton suggests not enough small fish, will too many small zooplankton suggests an overabundance of small fish that are eating the larger zooplankton. Average length in the Wellesley ponds (Figure 26) is on the small end of the range, suggesting intense fish predation except in Duck Pond, which probably has very few fish. Food resource limitation usually does not depress length that much, and if it did, we would expect more rotifers than we are seeing.

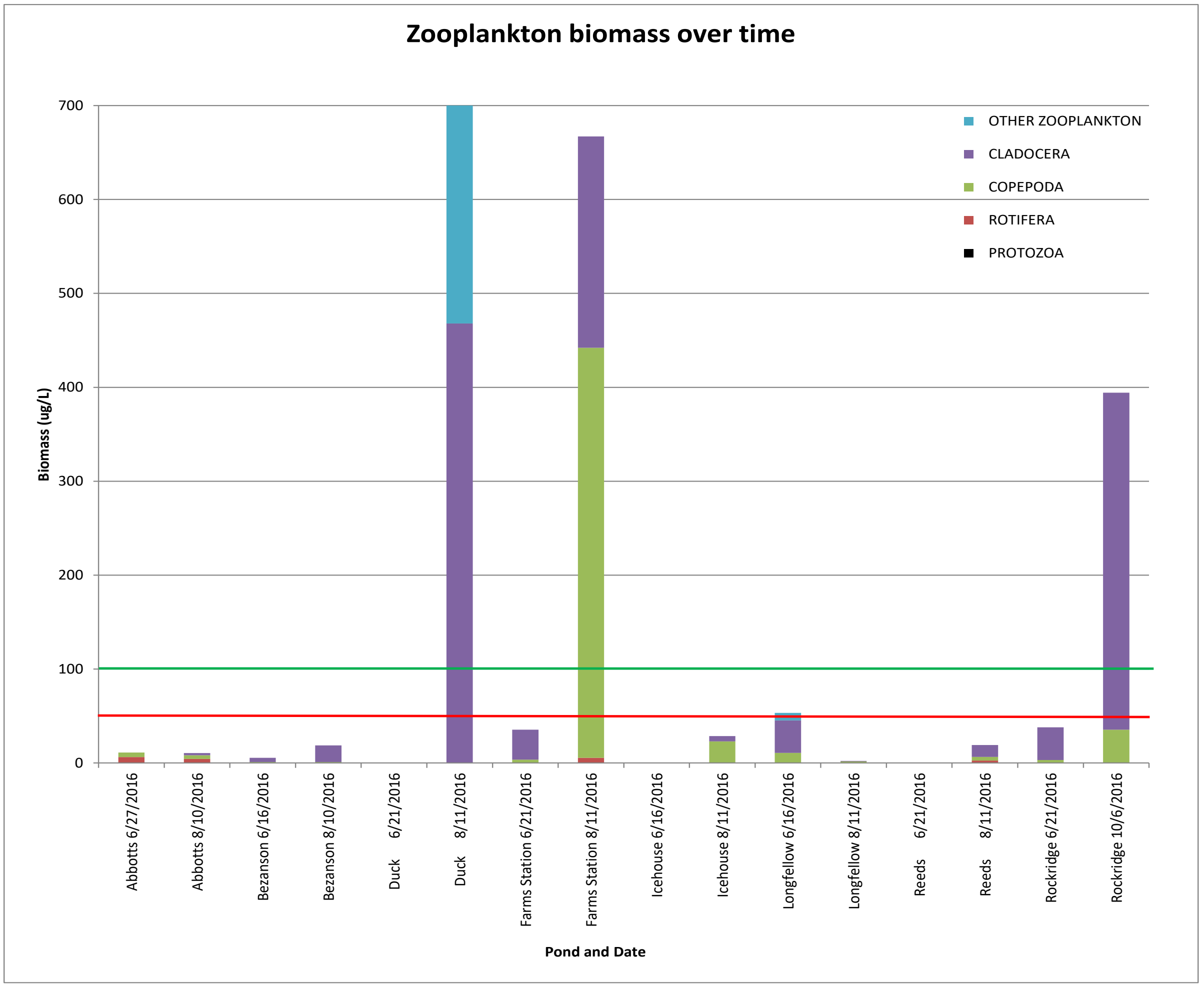

Figure 25. Zooplankton biomass for all ponds

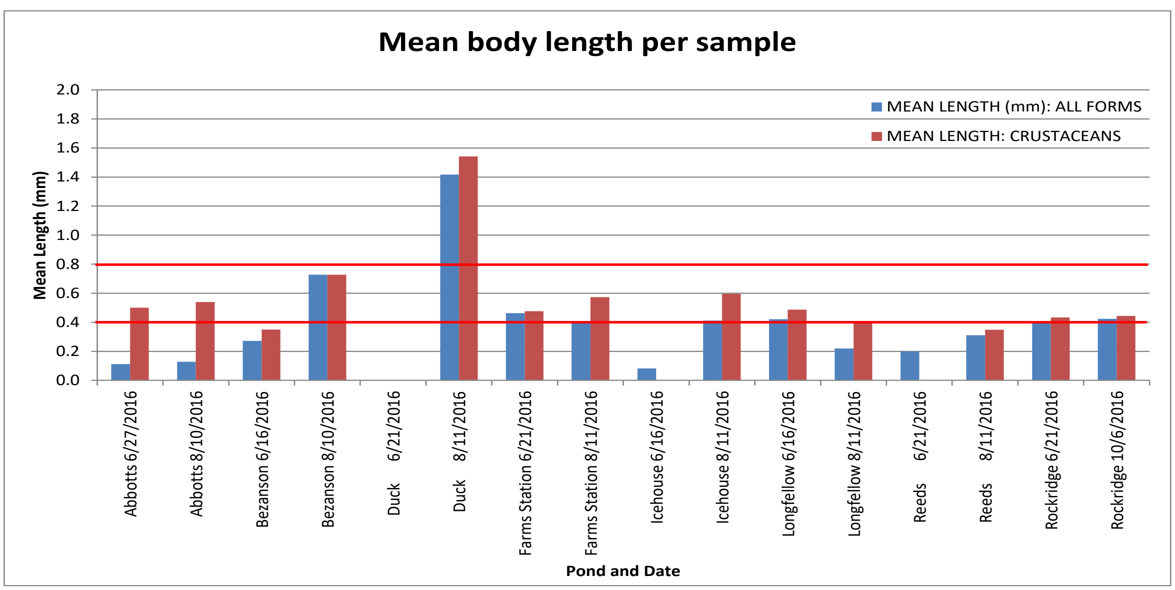

Figure 26. All ponds zooplankton length distribution

3.7 Plant Assessment

A total of 17 aquatic plant species were observed during 2016 surveys (Table 5), plus green algae mats, which are normally assessed for abundance like rooted plants. Collectively, we refer to the vascular plant and algae mat assemblage as “macrophytes”. Icehouse, Longfellow, Reeds and Rockridge Ponds have dense macrophyte assemblages with 6-12 species present plus green algae mats. All of these ponds are shallow and expected to have robust macrophyte communities because light penetrates to the nutrient rich sediment, promoting growth. Algae mats were most prolific in Longfellow and Rockridge Ponds, but rooted plants were dense in those two ponds as well, and each was harvested once in 2016.

Abbotts, Bezanson, Duck and Farms Station Ponds have one to two plant species present, either small floating species or weakly rooted forms. Turbid water reduces light penetration and plant growth in Abbotts, Duck and Farms Station Ponds. Abbotts and Duck Ponds had very little macrophyte growths. Farms Station Pond had a dense surface covering of *Wolffia* in August, but had no plants visible before then. Bezanson Pond had patches of coontail with associated green algae mats creating columns in the water; this pond was dredged in 2003, impacting plant growth for years, but it was not nearly as turbid as Abbotts, Duck or Farms Station Ponds.

One major concern regarding Wellesley ponds plant populations is the invasive species present. Invasive aquatic plants out-compete native species and typically choke out water bodies by growing dense and fast. This process impacts the food web by lowering biodiversity and therefore decreasing available food. Dense plant communities provide safe refuge for small fish and reduce open water hunting habitat for angler preferred species like largemouth bass. Further implications include obstructing recreational boating and unpleasant aesthetics. Economically, these plants become a burden to manage and preventing the spread to more water bodies should be priority in future management.

Of the 17 vascular plant species identified, 5 were invasive forms, meaning they are non-native and likely to cause ecological and economic harm. Those included curly leaf pondweed, water chestnut, fanwort, and two species of water milfoil, Eurasian and variable leaf. Curly leaf pondweed tends to die back in early summer and may be less of a nuisance, while the other invasive plant species can fill most of the water column of the infested ponds. Mechanical harvesting has been performed at Longfellow and Rockridge Ponds mainly for water chestnut control for many years.

Invasive species are found in only 4 of the study ponds, however. Icehouse Pond has both milfoils and fanwort, all known from Morses Pond, and these invasive species are not found in other ponds. Rockridge and Longfellow Ponds both have water chestnut and curly leaf pondweed, with curly leaf pondweed also found in Reeds Pond. Other plants can also grow densely in these ponds, so it is not just invasive species that cause nuisances. Coontail and duckweed are found in 5 ponds, and white water lily is found in 4 ponds; each of these native species can achieve nuisance status.

The loss of aesthetics and recreational opportunity due to dense plant growths is among the biggest problems in the Wellesley ponds. This is not a problem in all ponds, but where excessive plant growths are a problem, it is a serious one.

Table 5. All ponds aquatic plant species presence and dominance (invasive species shaded)

Aquatic Plant Species (Summer 2016)		Wellesley Ponds (X= present, D=dominant)							
Common Name	Scientific Name	Abbotts	Bezan-son	Duck	Farms Station	Icehouse	Long-fellow	Reeds	Rock-ridge
Aquatic smartweed	*Polygonum amphibium*					X			
Bladderwort	*Utricularia* spp.					X			
Coontail	*Ceratophyllum demersum*		D			X	D	X	X
Curly-leaf pondweed	*Potamogeton crispus*						X	X	X
Duckweed	*Lemna minor*	X			X		X	X	X
Eurasian watermilfoil	*Myriophyllum spicatum*					X			
Fanwort	*Cabomba caroliniana*					D			
Flat-stem pondweed	*Potamogeton zosteriformis*					X		X	
Primrose-willow	*Ludwigia* sp.					X	X		X
Stonewort	*Nitella* sp.			X		X			
Variable watermilfoil	*Myriophyllum heterophyllum*					X			
Variable-leaf pondweed	*Potamogeton natans*					X			
Water chestnut	*Trapa natans*						X		X
Watermeal	*Wolffia columbiana*				D		X		
Waterweed	*Elodea canadensis*						X	D	D
White water lily	*Nymphaea odorata*					X	X	X	X
Yellow water lily	*Nuphar variegatum*					X	X		
Total Species (#)		**1**	**1**	**1**	**2**	**12**	**9**	**6**	**7**

4. Abbotts Pond

4.1 Pond Features

Abbotts Pond is located in Wellesley, MA at latitude 42°18'32.0"N and longitude 71°17'11.4"W. It is a small (1.8 ac) boot shaped pond adjacent to Worcester Rd (Rt 9) in a residential area. The shoreline is dense with vegetation except for one clearing for a home at 10 Fox Hill Rd. Besides this home, access to the lake is challenging due to soft sediments and the dense vegetation along the shoreline, although the adjacent land is largely public.

Abbotts Pond is shallow with an average depth of 1.5 ft and a max depth of 2.8 ft. Bathymetry is somewhat irregular, with two deeper depressions at opposite ends of the pond (Figure 27). The pond volume is 2.7 ac-ft when full, but water level can decline substantially as the source of water input is storm water drains.

4.2 Watershed Features

The Abbotts Pond watershed is 55.6 ac, yielding a watershed to pond ratio of 31:1. Most of the watershed (81.3%) is developed as residential area (Figures 28 and 29). The rest is comprised of forested land and wetland. The large watershed to pond area ratio leads to in-lake water quality that is highly dependent upon watershed influences including storm water inputs. Inputs are intermittent with precipitation, but can be substantial in bursts. Inflow is negligible during dry periods.

The main inlet to Abbotts Pond is a storm drainage system entering at the northwest end of the pond, with a large metal pipe near the corner of Chatham Circle and Foxhill Rd. Two smaller storm drainage systems discharge to the pond but are largely inaccessible. An overflow ditch on the southwest side of the pond carries outflow along and eventually under Rt 9. That ditch has a small concrete structure that used to hold flashboards, but no control of water level in Abbotts Pond is currently maintained.

4.3 Designated Uses

There is little recreational use of Abbotts Pond. It is primarily used recreationally during winter for skating when ice is present and access is easier. It is a visual amenity, a natural oasis in a developed area, although turbidity and dense peripheral vegetation detract from aesthetics. Abbotts Pond is providing habitat for wildlife, being somewhat secluded even though it is in a residential area and adjacent to a highway.

Figure 27. Abbotts Pond bathymetry map

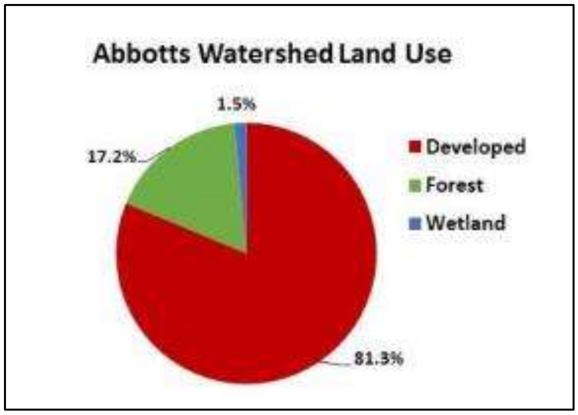

Figure 28. Abbotts Pond watershed land use chart

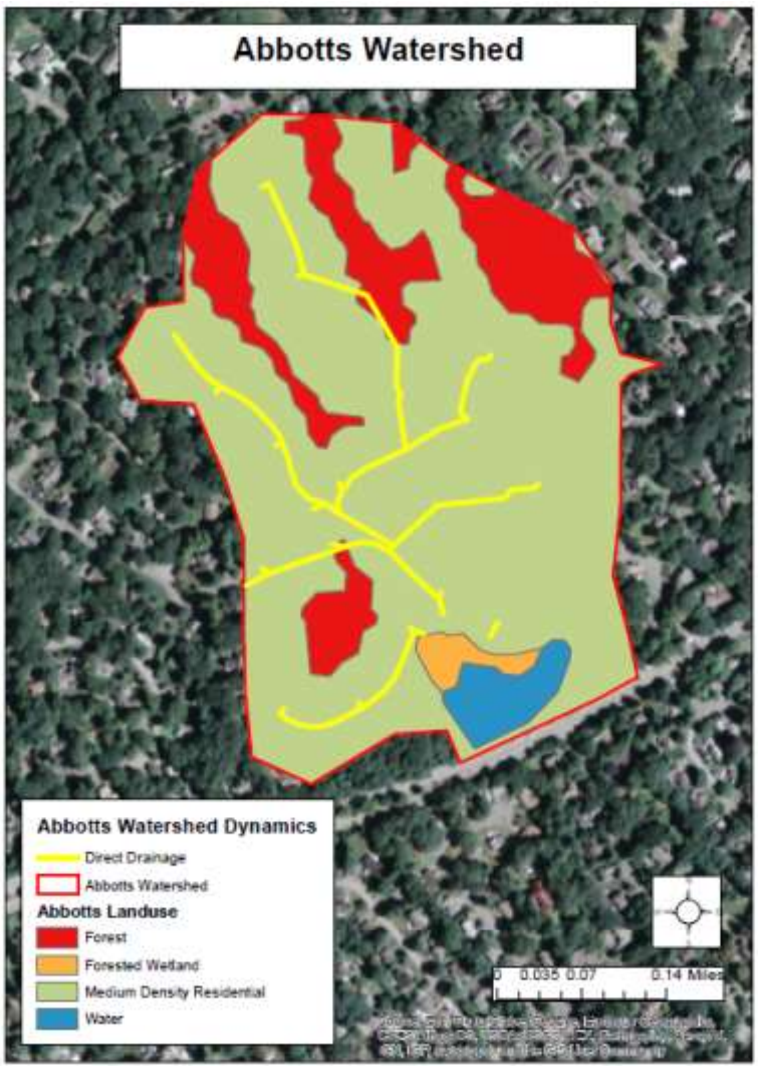

Figure 29. Abbotts Pond watershed land use map

4.4 Additional In-lake Investigative Results

Sediment Assessment

There is more soft sediment in the pond than water; average sediment depth is 3.5 ft with a volume of 6.3 ac-ft, with contours mirroring those of water depth (Figure 30). This soft sediment is highly organic and resuspends easily from the shallow bottom of the pond.

Plant Assessment

In October 2016, one floating aquatic plant species, Duckweed (*Lemna minor*), was found growing in Abbotts Pond. During summer surveys no aquatic plants were observed. Turbid water may be shading out submerged plant growth. Wetland plant species were found growing along the shoreline and brush and vines are very dense in many areas around Abbotts Pond.

General Appearance

Abbotts Pond has a natural look with a highly vegetated shoreline (Figure 31). High turbidity is unappealing, and the number of fallen or leaning trees and dense underbrush limit both views and access. The pond has filled in with sediment and peripheral wetland growths limit recreational use, but the pond may be a wildlife oasis and could be made more attractive and accessible with limited effort.

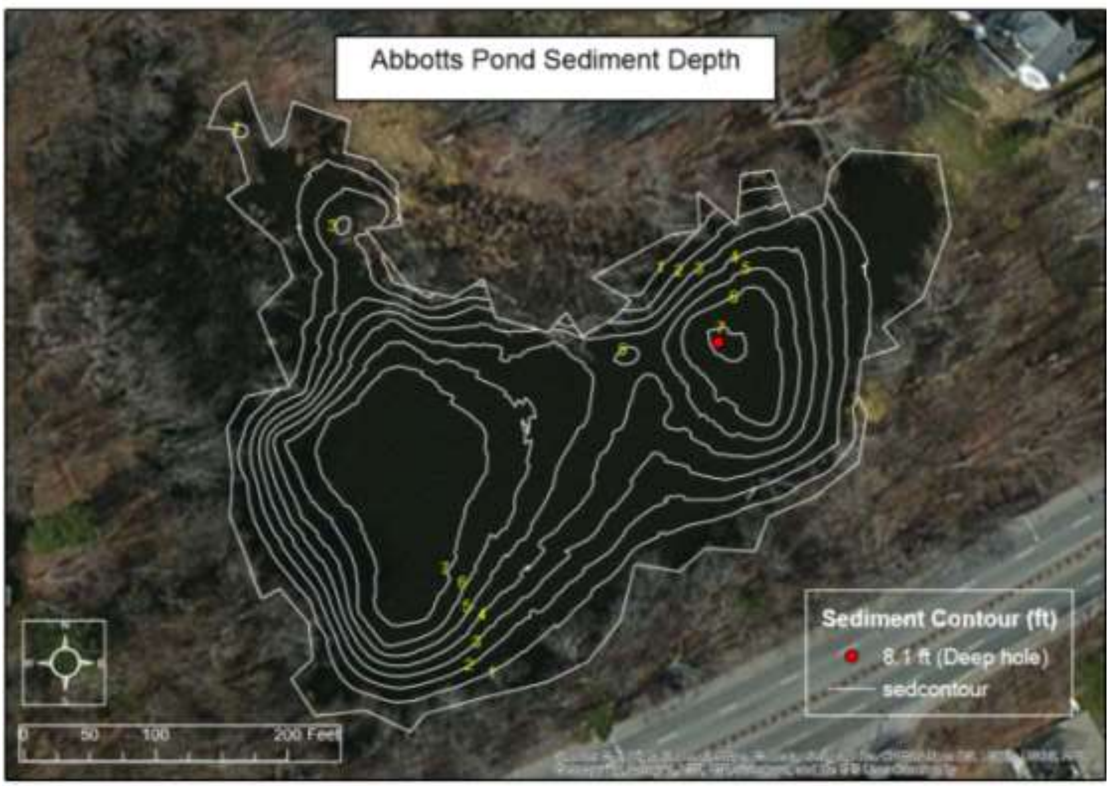

Figure 30. Abbotts Pond sediment distribution map

Figure 31. Abbotts Pond general appearance

4.5 Nutrient Loading

Applying the Lake Loading Response Model to Abbotts Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 6) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

For Abbotts Pond, phosphorus and nitrogen concentrations are very high and the model reasonably predicts that situation. Chlorophyll-a predictions are much higher than actually observed, suggesting that much of the phosphorus may not be available to algae; this is typical of urban runoff. Water clarity is low and is predicted to be low. If all the developed uses of the land in the watershed reverted to forest or wetland, nutrient levels would still be somewhat elevated, mainly due to the large size of the watershed compared to the small area of the pond and its shallow nature. If all feasible best management practices were implemented, nutrient levels would be cut by slightly less than half over current predicted values and conditions would not improve much. Water quality will be an issue in Abbotts Pond almost no matter what is done in the watershed. In-lake maintenance measures would be needed to make substantive improvements.

Table 6. Abbotts Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	142	185	36	80
Nitrogen (ppb)	1522	1780	568	967
Mean Chlorophyll (ug/L)	94.3	8.0	15.8	44.6
Peak Chlorophyll (ug/L)	292.4	12.6	52.3	141.9
Mean Secchi (m)	0.5	0.3	1.5	0.8
Peak Secchi (m)	2.4	0.3	3.6	2.9
Bloom Probability				
Probability of Chl >10 ug/L	100.0%		74.6%	99.7%
Probability of Chl >15 ug/L	100.0%		44.0%	97.3%
Probability of Chl >20 ug/L	99.8%		23.4%	91.2%
Probability of Chl >30 ug/L	97.9%		6.2%	70.6%
Probability of Chl >40 ug/L	92.8%		1.7%	48.7%

4.6 Data Analysis and Interpretation

Abbotts Pond is a natural oasis in a residential area, but suffers from storm water inputs from the developed watershed. It has filled in considerably over many years and continues to receive high loads of solids and nutrients. Reducing those loads will be very difficult, given the nature of the watershed. As it is, Abbotts Pond provides some habitat for small fish, reptiles, amphibians, birds and water-dependent mammals, but the habitat is compromised by highly turbid water, minimal aquatic plants, and very shallow depth. Dense peripheral vegetation and soft wetland soils restrict access by people for recreation, limiting use mainly to winter when ice is present.

There does not appear to be any major public impetus to conduct a major renovation of the pond. Such a renovation would have to include dredging and storm water management, both of which would be very expensive. Only one residence directly abuts the pond, but public access is possible from all other surrounding land if vegetation is cleared and footing improved. The primary value of Abbotts Pond appears to be as a natural area, but its use by humans for aesthetic enjoyment could be enhanced by some landscape management around the periphery.

4.7 Management Recommendations

The primary public feedback for Abbotts Pond was to improve its aesthetics. Removing invasive upland and wetland vegetation and reducing the number of fallen or leaning trees would be desirable and would not compromise habitat to any major degree. Creation of access to the open water by way of a board walk could provide vistas and educational opportunity as well as safe access for winter skating. The water could be treated in late spring or early summer with a low dose of aluminum compounds to reduce turbidity and the improvement might last through the summer in a dry year. Dredging would be needed to prevent further filling of the pond that will eventually lead to it becoming an emergent wetland, but the expense does not appear justified at this time.

5. Bezanson Pond

5.1 Pond Features

Bezanson Pond is a small (0.5 ac) bowl shaped pond located in Centennial Park, located at 135 Oakland St, Wellesley, MA. The pond is at latitude 42°18'25.22"N and longitude 71°15'47.55"W. It is shallow with an average water depth of 2.7 ft, a maximum depth of 6.4 ft and 1.3 ac-ft of water volume (Figure 32). An intermittent stream enters on the north side of the pond and storm water runoff can also enter via a slight linear depression on the east side of the pond. It has a concrete outlet structure with one 14-inch high, 80-inch wide flashboard offering limited water level control.

The pond is accessible from a foot path, part of the Centennial Park trails. Part of its shoreline is wooded while the rest is open, providing access mainly for dogs walked in the park by owners and allowed to cool off in the pond. Bezanson Pond, named for a former Town Engineer, is therefore also known as Dog Pond. Bezanson Pond was dredged in 2003, with the removed sediment spread on upgradient fields within Centennial Park that are now vegetated with grasses and other low growing vegetation, creating meadows.

5.2 Watershed Features

Bezanson Pond's watershed covers 44.8 ac, with a watershed to pond ratio of 90:1. This means that pond water quality is largely dependent upon recent watershed inputs, as flushing can be rapid. This watershed is more forested (41.5%) and meadow (17.2%) than many other drainage areas in Wellesley, but it is also 38.7% developed (Figures 33 and 34). The intermittent stream is largely dependent on ground water and storm water drains on the Sisters of Charity property, an assisted living facility, located at 125 Oakland St, Wellesley Hills, MA. Additional storm water drainage from the watershed is routed in pipes and shallow ditches through woods and meadows and enters on the east side of Bezanson Pond, with some runoff entering diffusely from the west side. Flows can be high and downstream flooding has been reported by neighbors of the park, but the study period in 2016 was very dry.

5.3 Designated Uses

Centennial Park offers multiple walking trails and is a popular destination for people who walk dogs. Bezanson Pond is primarily an aesthetic feature of the park that also serves as a swim area for dogs. With dogs often swimming in and drinking the water it is important to maintain water quality in the pond that will be safe for those pets. Dogs are often sensitive and susceptible to harmful algae blooms (HAB), mainly cyanobacteria (blue-green algae). Bezanson Pond did contain a small amount of potentially harmful cyanobacteria by late summer and blooms should be prevented.

Bezanson Pond is also functioning as a flood control structure for downstream properties. However, with a large watershed to pond area ratio, it is not big enough to provide substantial flood control without active management, such as lowering the water level before anticipated storms. It also provides aquatic habitat and could be used for fishing, but active use by humans is limited.

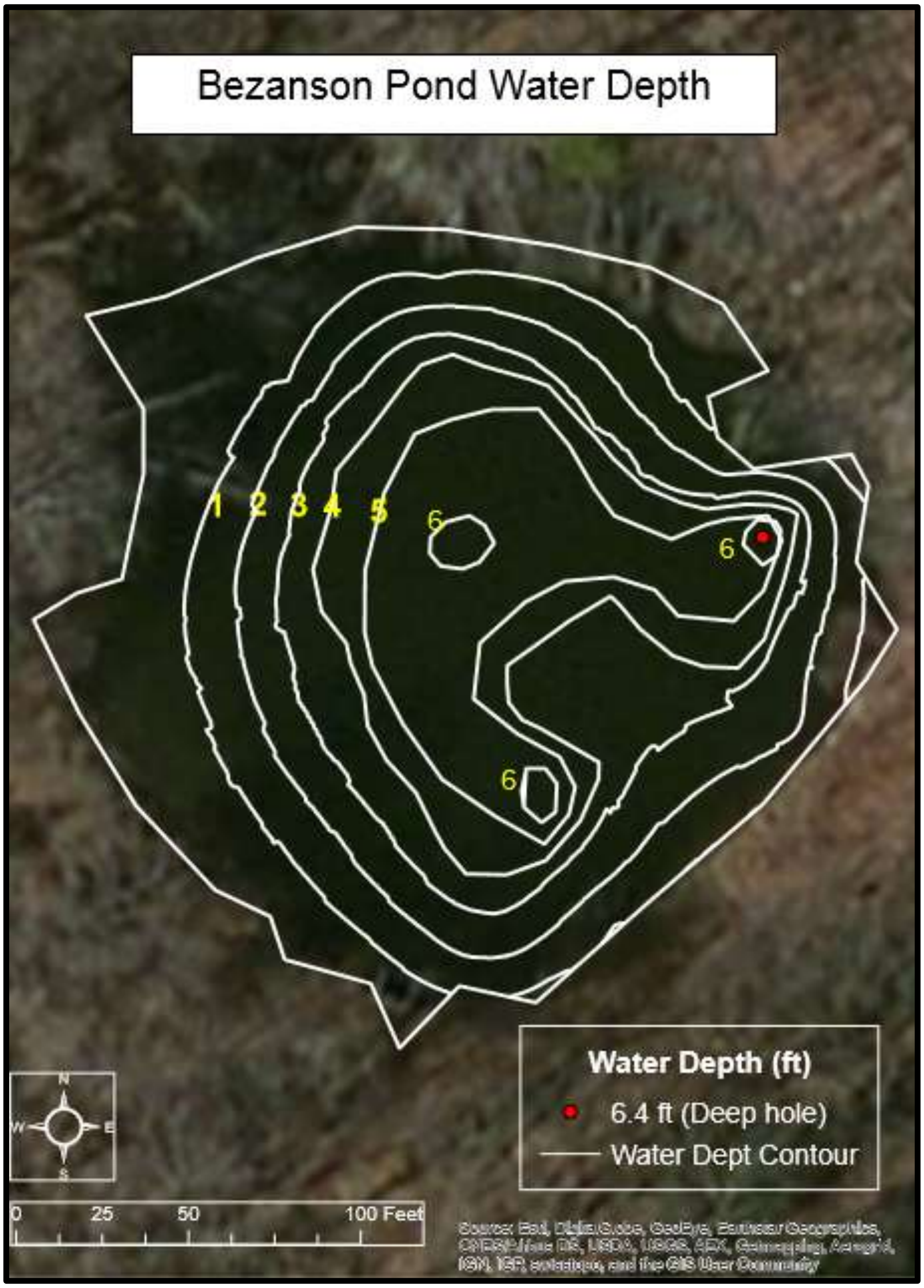

Figure 32. Bezanson Pond bathymetry map

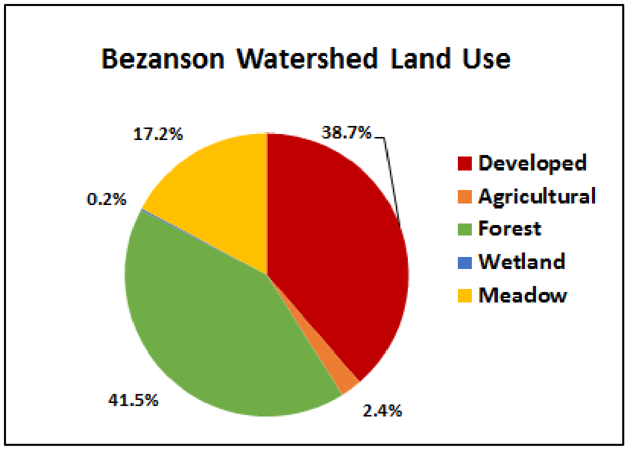

Figure 33. Bezanson Pond watershed land use chart

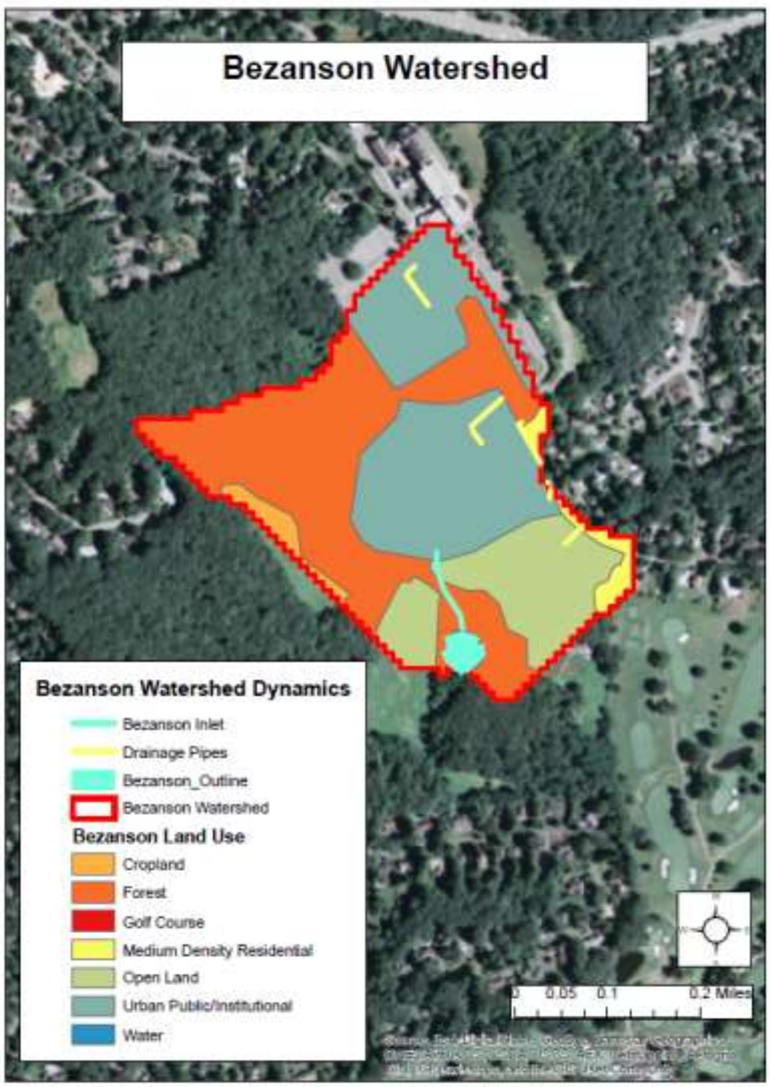

Figure 34. Bezanson Pond watershed land use map

5.4 Additional In-lake Investigative Results

Sediment Assessment

There is very little soft sediment in Bezanson Pond (Figure 35). It was dredged in 2003 and inputs since then appear to have been low. The bottom is mostly sandy with pockets of organic material build-up in deeper water, but the total soft sediment in Bezanson Pond is only about 0.3 ac-ft (0.5 ft over 0.5 ac). Total phosphorus concentration in the surficial bottom sediment is fairly high, but iron-bound phosphorus was the lowest of the assessed Wellesley ponds and was near the low-moderate threshold. The primary rooted plant in Bezanson Pond is coontail, which roots weakly and gets much of its nutrition from the water column, which is unusual among rooted plants but logical in this pond.

Plant Assessment

In the summer of 2016 one vascular plant species, coontail (*Certaophyllum demersum*) was found growing in Bezanson Pond. It was moderately dense along the shorelines and became sparse in deeper water. Filamentous green algae were also abundantly growing along the shorelines and forming columns in the water where growths were extending up from the bottom where growth began.

General Appearance

Bezanson Pond becomes somewhat unsightly during summer with peripheral plant growths and algae mats (Figure 36). It has some woody debris that has fallen into the pond from adjacent woodland; some of this forms valuable habitat, but some has floated free and may become an impediment to outflow or swimming dogs. About half of the shoreline has minimal vegetation, but significant erosion was not observed. Bezanson Pond could be approved as a visual amenity, habitat and dog swimming area, but is attractive most of the year and does pose any major problems for current uses.

5.5 Nutrient Loading

Applying the Lake Loading Response Model to Bezanson Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 7) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

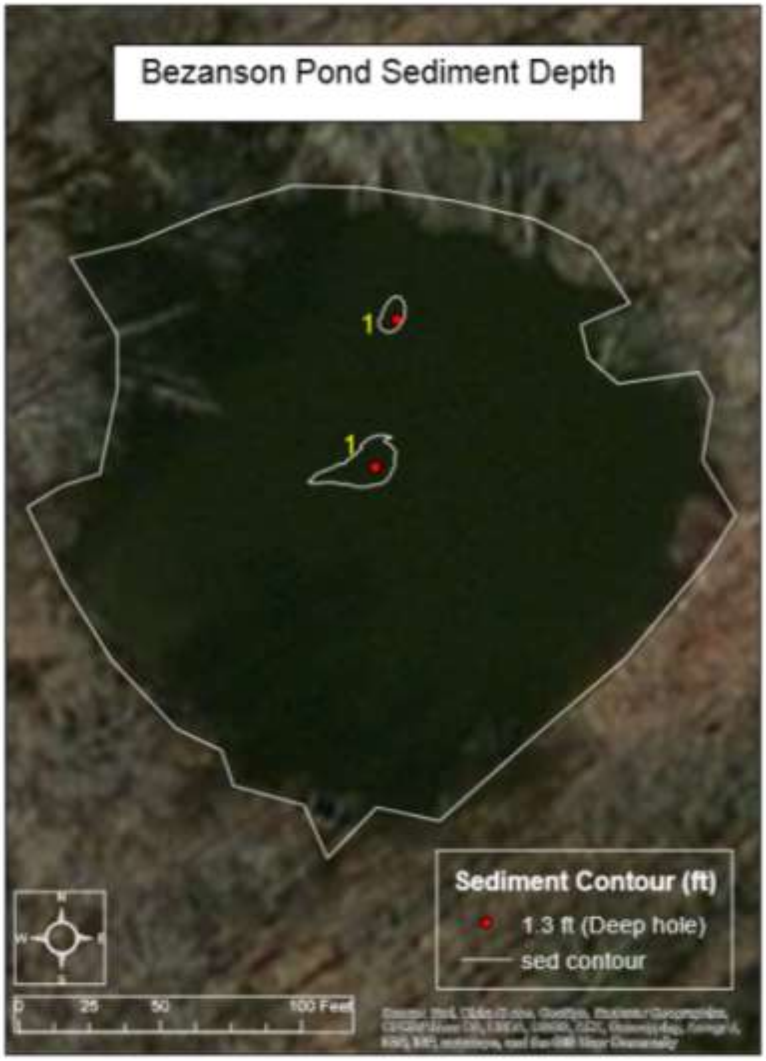

Figure 35. Bezanson Pond sediment distribution map

For Bezanson Pond, phosphorus and nitrogen concentrations are elevated but not extreme and the model reasonably predicts current conditions. Chlorophyll-a predictions are much higher than actually observed, suggesting that much of the phosphorus may not be available to algae; this is typical of urban runoff. Water clarity is low and is predicted to be low. If all the developed uses of the land in the watershed reverted to forest or wetland, nutrient levels would still be somewhat elevated, mainly due to the large size of the watershed compared to the small area of the pond and its shallow nature. If all feasible best management practices were implemented, nutrient levels could be reduced to near the projected background level, but that will still result in algae blooms and low clarity. Some maintenance within the pond may be necessary to achieve and maintain desirable conditions during summer.

Figure 36. Bezanson Pond general appearance

Table 7. Bezanson Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	51	55	32	33
Nitrogen (ppb)	787	620	477	505
Mean Chlorophyll (ug/L)	25.1	11.7	13.5	14.0
Peak Chlorophyll (ug/L)	81.6	17.8	45.1	46.6
Mean Secchi (m)	1.1	1.2	1.6	1.6
Peak Secchi (m)	3.2	1.2	3.7	3.7
Bloom Probability				
Probability of Chl >10 ug/L	94.4%		63.6%	66.2%
Probability of Chl >15 ug/L	78.2%		32.2%	34.7%
Probability of Chl >20 ug/L	58.0%		15.0%	16.6%
Probability of Chl >30 ug/L	27.1%		3.2%	3.8%
Probability of Chl >40 ug/L	11.8%		0.8%	0.9%

5.6 Data Analysis and Interpretation

Bezanson Pond is a small pond in a park setting that is used mainly as a visual amenity and for swimming by dogs. It could be used for fishing (sunfish were observed) and certainly provides aquatic habitat. It also provides some flood control, although the large watershed to pond area ratio limits that function. Bezanson Pond was dredged in 2003 and has not accumulated much soft sediment since, but it does support moderate densities of one species of vascular plant and green algae mats. Nutrient loading is high but not extreme, commensurate with the mixed land uses in the watershed.

Improving water quality through watershed best management practices is possible but expensive, and it is only during summer that pond conditions are less attractive than desired for its uses. While algae blooms were not severe, there were some cyanobacteria present in summer that could represent a health threat if they increased in abundance, especially for dogs that swim in the pond and drink the water. Rooted plants and algae mats are summer features and do affect aesthetics and possibly safety for dogs. So there is a need to improve water quality, but mainly during summer. It would also be appropriate to remove free-floating woody debris to avoid issues at the outlet.

5.7 Management Recommendations

Capturing runoff from the watershed would be possible by creating a detention area in the meadow northeast of the pond, and strategic placement of gabion baskets could inexpensively create such detention. However, this may leave park land wetter than desirable for other uses and the reduction in nutrient loading will be less than 50%. To prevent algae blooms, phosphorus should be reduced to <0.02 mg/L, which is not realistically attainable by watershed measures.

The easiest way to improve water quality in Bezanson Pond is to treat it with a low dose of aluminum near the start of summer and possibly after major storm events that causes major flushing of the pond and are expected to be followed by a multi-week dry period. The aluminum will inactivate phosphorus in the water column and in the sediment, and should limit growth of both algae mats and planktonic algae, including cyanobacteria. A dosing station could be set up, but with only intermittent need, a portable dosing system might be most appropriate. Phosphorus could be reduced to near 0.01 mg/L in the water column, maintaining low algae and high clarity. This will improve both pond appearance and safety for use by dogs. One treatment per summer may be adequate, but it is possible that a second or even third treatment might be needed in some years.

It may be helpful to remove coontail, the only rooted plant in the pond, if it gets too dense. Use of a small harvester would be effective with less than a day of effort. It would also be possible to use a seine or rake with an extended handle from shoreline to pull out coontail, which is weakly rooted. This would also remove associated algae mats, although aluminum treatment may prevent mat formation separately. Herbicides are not used on public property in Wellesley and further dredging appears unnecessary. Benthic barriers could be used to prevent growth in the portion of the pond most used by dogs, but would require at least annual maintenance that could be inconvenient in this setting.

Annual removal of woody debris in the vicinity of the outlet by a backhoe or similar equipment is recommended. This is a simple maintenance measure to avoid clogging or other damage. Woody debris on the opposite side of the pond where the shoreline is wooded should be left in place as habitat for aquatic organisms.

If there is interest in improving fishing in the pond, some bass could be stocked. Currently it appears that there are only sunfish in the pond. Yet Bezanson Pond is not heavily fished and there may be little demand for fishing there.

6. Duck Pond

6.1 Pond Features

Duck Pond is a small (0.8 ac) impoundment created by damming a small stream that has been largely relegated to a storm water drainage system and mostly encased in pipes. It is located at latitude 42°17'53.60"N and longitude 71°17'24.62"W directly adjacent Town Hall and is accessible from the entry road for the Wellesley Town Hall at 525 Washington St. Duck pond is shallow, with an average depth of 0.9 ft and a maximum depth of about 4 ft located in the northeast backwater pool (Figure 37). The pond water volume is 0.8 ac-ft.

The water residence time is low due to flushing by high flows during storm events, but the irregular shape creates a backwater area to the northeast with longer detention time. Even with continual flow, water remains in Duck Pond long enough for solids to settle. A storm drain inlet in the northeastern basin is inactive, so there is no substantial flow through that area except when water backs up from the main channel and around the island during storms.

There is wooden bridge located just downstream of the outlet structure that leads to open area with picnic tables and another bridge from the north onto an island that breaks up the pond into smaller channels. A foot path circumnavigates the pond. The inlet is a large culvert with a partial metal grate located at the northwest end of the pond, passing under the railroad. The outlet is a concrete structure with flashboards.

6.2 Watershed Features

The Duck Pond watershed (481 ac) is extremely large compared to the size of the pond, yielding a watershed to pond area ratio of 601:1. Most of watershed (79.2%) is developed as residential and commercial area, with only about 21% in more natural uses (Figures 38 and 39). While there appears to be baseflow from either an original stream or groundwater drainage to an extensive storm pipe array, most flow into Duck Pond is storm water runoff flowing in an extensive network of pipes in a generally north to south direction.

6.3 Designated Uses

Duck Pond lives up to its name, as it is primarily used by waterfowl that inhabit the immediate area around the pond. Ornamental ducks and geese are the primary waterfowl observed. The waterfowl serve as a community attraction and are fed by the public. People picnic near the pond on nice days and can walk the trails around it. Duck Pond provides some small flood control capacity, but is too small to do more than nominally reduce peak flows and accumulate coarser debris and sediment. It is therefore mainly a visual amenity and habitat oasis in a highly developed area.

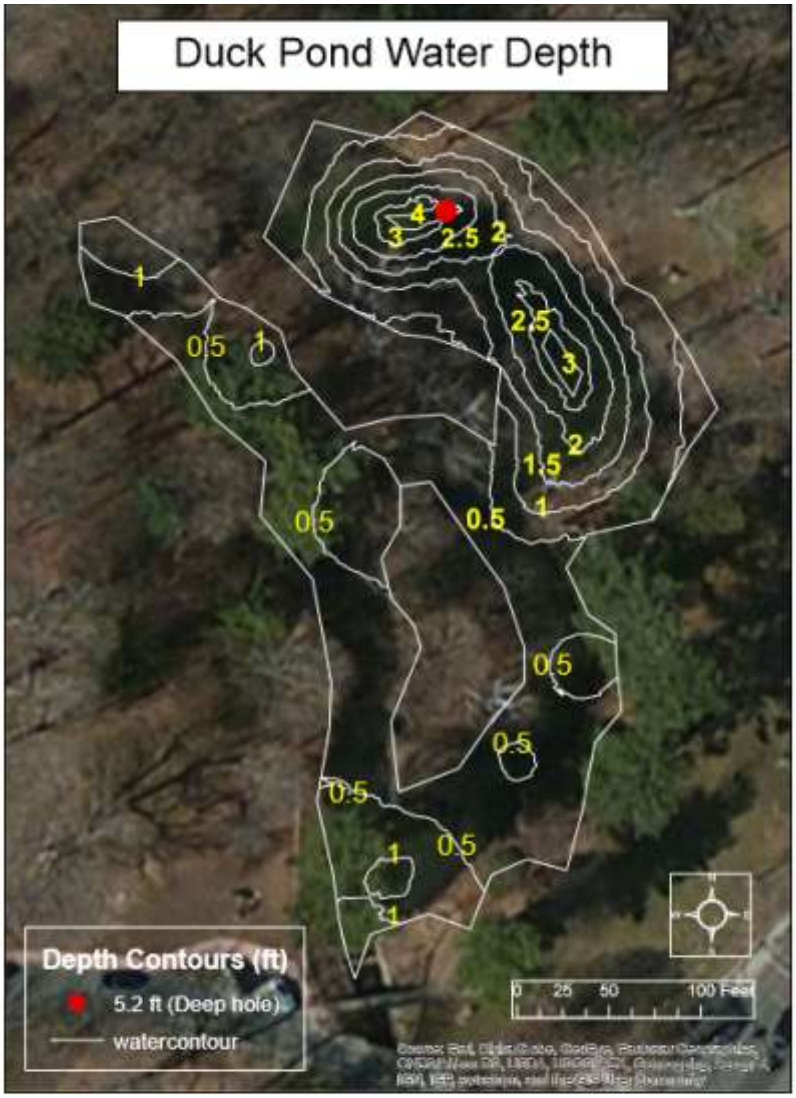

Figure 37. Duck Pond bathymetry map

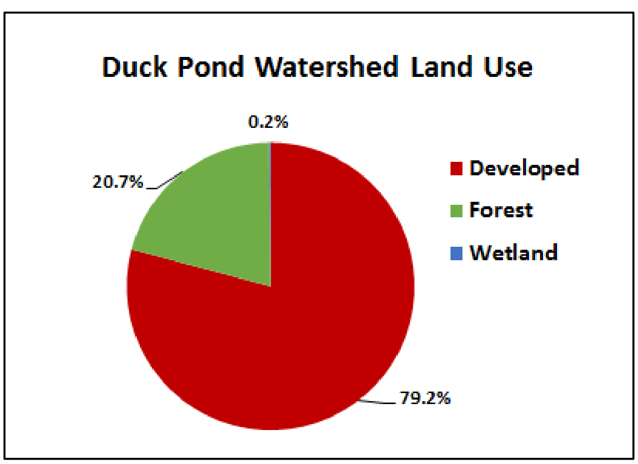

Figure 38. Duck Pond watershed land use chart

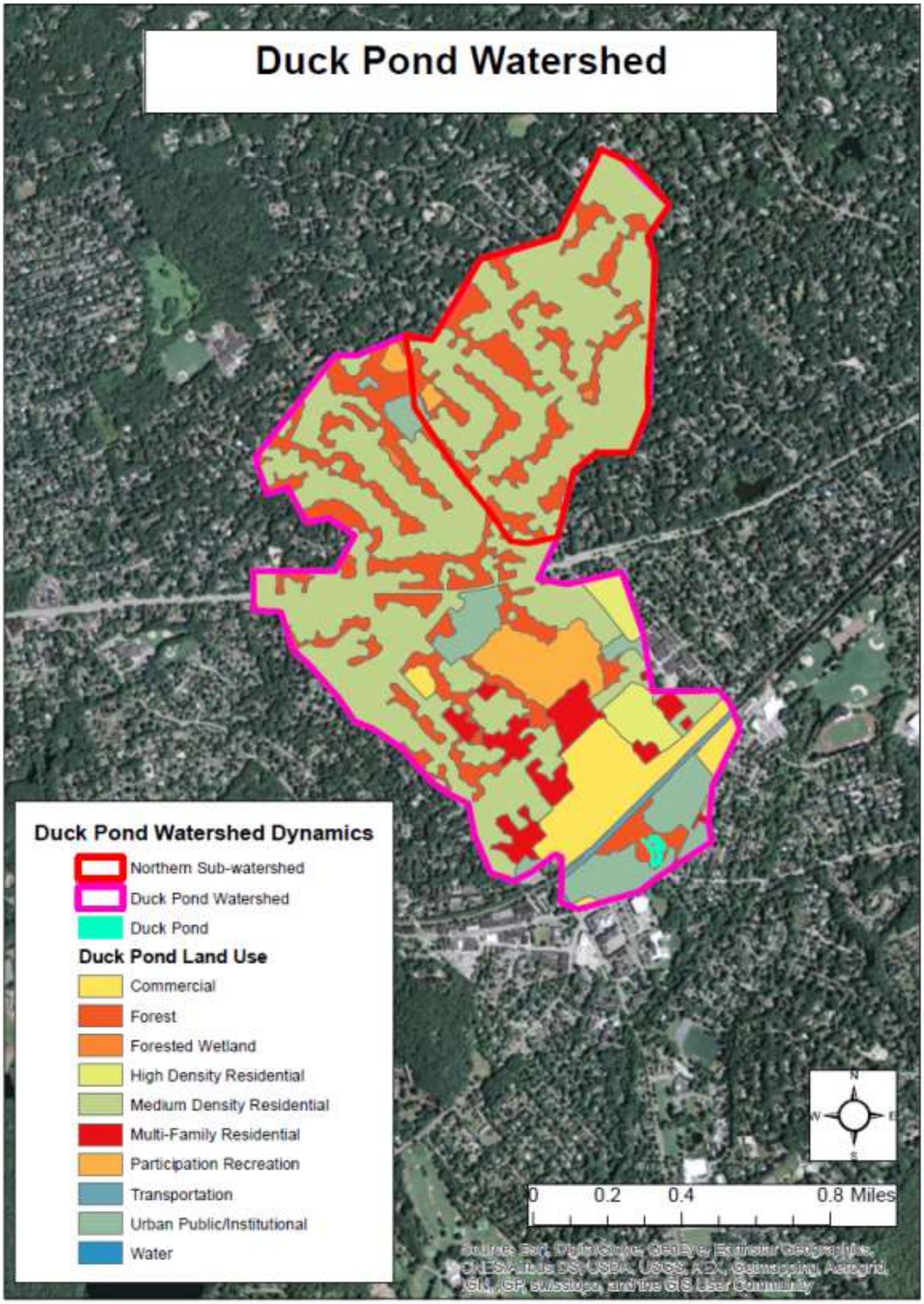

Figure 39. Duck Pond watershed land use map

6.4 Additional In-lake Investigative Results

Sediment Assessment

Duck Pond has a soft sediment depth roughly equal to the water volume of the pond. It was dredged in 1986 and again in 2006, and it would be appropriate to dredge it again anytime the funds are available. With a large urban watershed, it receives road sand, erosion from construction sites, and considerable quantities of leaves. The soft sediment is a heterogeneous mix of fine muck, coarse sand, leaf litter, sticks and other debris, unevenly distributed in the pond (Figure 40). Dredging would double the volume of the pond, but it is not a large system; there are roughly 1300 cubic yards of soft sediment now in Duck Pond.

Plant Assessment

During the summer of 2016 only one plant species, stonewort (*Nitella*), was found growing in Duck Pond. *Nitella* is a macro-alga favored by waterfowl. It is not abundant, possibly due to grazing or shading by turbid water. Planktonic algae are not abundant either, and include mainly euglenoids, a group known to favor organic-rich water. Turbidity is caused mainly by non-living particles, both inorganic and organic. Resuspension of sediment now in the pond is a major source, but new inputs are also significant.

General Appearance

During storm events and for a few days afterward, Duck Pond is highly turbid (Figure 41). Even during dry periods the pond can become turbid with just moderate wind. There is always some water entering Duck Pond, and soft sediment is easily resuspended in the relatively narrow run from inlet to outlet on the west side of the pond. Waterfowl feeding may also stir up sediment. The overall setting for the pond is attractive, but the water itself is usually unappealing, and with a very large and urban watershed, it is unlikely that watershed management can improve water quality in the pond markedly. Maintenance measures in the pond will be essential to any distinct improvement.

6.5 Nutrient Loading

Applying the Lake Loading Response Model to Duck Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 8) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

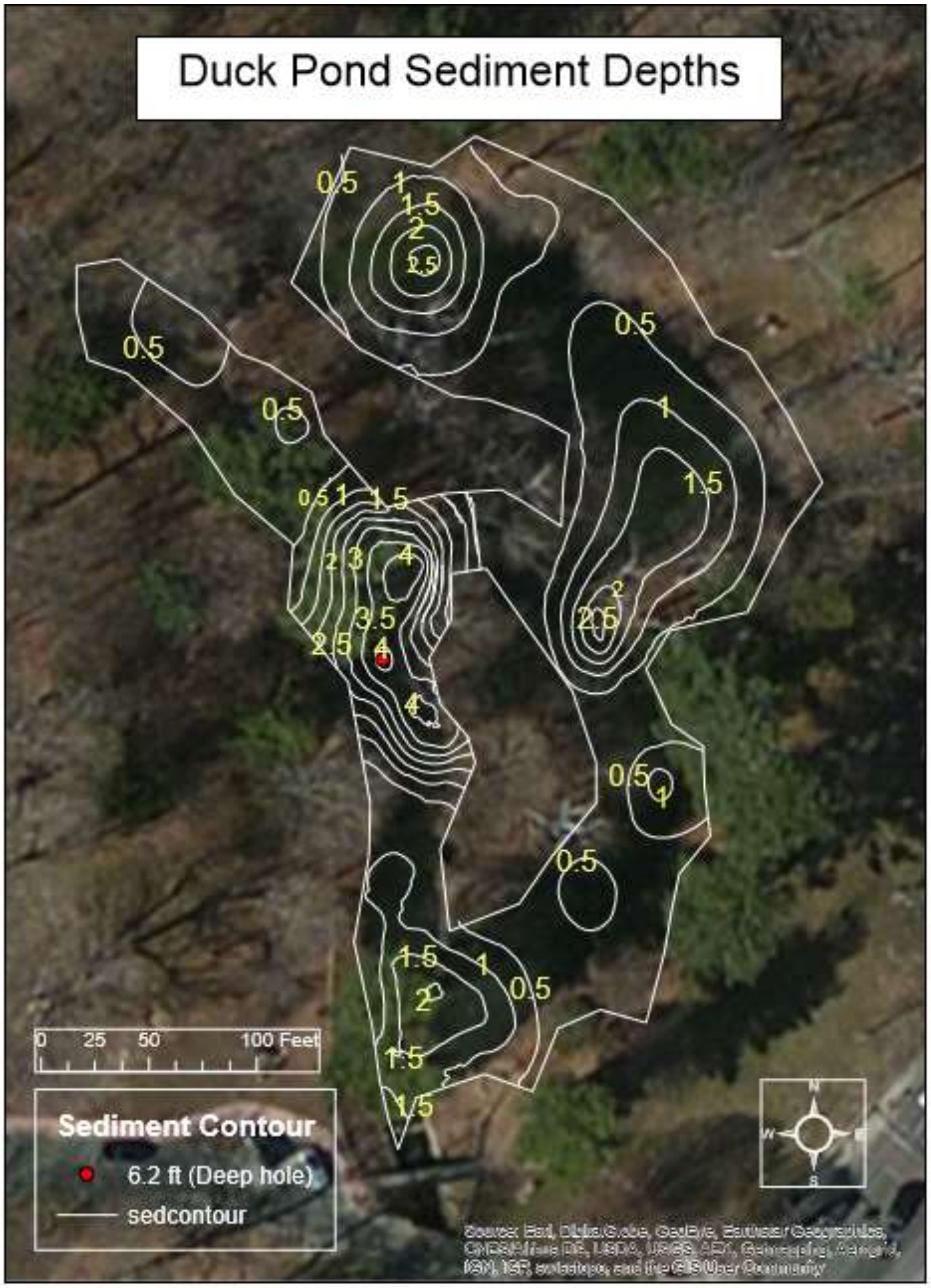

Figure 40. Duck Pond sediment distribution map.

Figure 41. Duck Pond general appearance

For Duck Pond the model slightly overpredicts phosphorus and underpredicts nitrogen, but the values are all very high and the differences do not affect interpretation. Predicted chlorophyll-a is much higher than actual, suggesting that high turbidity causes low light that limits algal productivity. Predicted water clarity is also higher than actual, again suggesting that turbidity from non-living particles affects Duck Pond greatly. Background conditions are much better, but still suggest problems with algae and water clarity. Application of all feasible best management practices will not improve conditions much; the watershed is just too large and too developed to prevent water quality problems in this small pond.

Table 8. Duck Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	128	95	38	82
Nitrogen (ppb)	1736	2000	632	892
Mean Chlorophyll (ug/L)	81.7	23.4	17.1	45.7
Peak Chlorophyll (ug/L)	254.6	41.3	56.6	145.3
Mean Secchi (m)	0.6	0.2	1.4	0.8
Peak Secchi (m)	2.5	0.3	3.5	2.8
Bloom Probability				
Probability of Chl >10 ug/L	100.0%		79.5%	99.7%
Probability of Chl >15 ug/L	99.9%		50.5%	97.6%
Probability of Chl >20 ug/L	99.5%		28.7%	92.0%
Probability of Chl >30 ug/L	96.0%		8.5%	72.3%
Probability of Chl >40 ug/L	88.1%		2.6%	50.6%

6.6 Data Analysis and Interpretation

Duck Pond is a visual amenity and wildlife habitat near Town Hall in Wellesley, but suffers from storm water inputs from a very large urban watershed. It is not feasible to limit inputs to a point where improvement of conditions in the pond would be noticeable without routing most of the incoming storm water around or past the pond. This would negate and flood control function and just pass problems downstream.

There is a minimal rooted plant community and not much algae either, due to high solids loads and related turbidity. There do not appear to be many (or any) fish in Duck Pond. The ornamental waterfowl population is viewed as a positive feature by many people, but may not be well sustained by the pond. The odd shape and flow pattern in Duck Pond leads to variable water and sediment depths, uneven flushing, and poor but variable water quality.

The pond has been dredged twice in the last 30 years and would benefit from sediment removal again, but with such a large and urban watershed this will not greatly improve water quality, just maintain the pond as open water and limit resuspension of sediment for some years. With continual inflow and high loads of many contaminants during storms, Duck Pond will require maintenance activities to show any appreciable improvement in water quality.

6.7 Management Recommendations

Dredging is not usually viewed as maintenance, but qualifies in this case. Duck Pond is a solids retention basin for the drainage system it serves, and with a large contributory area, must be periodically cleaned out to maintain its capacity. If we want the pond to be more aesthetically pleasing and to serve as better habitat, it will be necessary to take additional maintenance actions in the pond. The most logical option is an aluminum dosing station much like that applied to the two main inlets of Morses Pond. Such treatment would enhance settling and clearing in the pond, and might be applied late in storms or even during dry weather flows in this case, clearing the water column after the substantial inputs during storm events. It may be necessary to dose the main inlet and the northeast basin to make conditions more appealing throughout the pond. Treatment may be necessary during or after every storm during spring and summer.

7. Farms Station Pond

7.1 Pond Features

Farms Station Pond, at latitude 42°19'20.97"N and longitude 71°16'18.16"W, is located next to the parking lot for the regional rail station, Wellesley Farms MBTA Commuter Rail Framingham/Worcester Line, 90 Croton St., Wellesley, MA. Farms Station Pond covers 1 ac with a bowl shaped morphometry (Figure 42), with an average depth of 3.8 ac, maximum depth of 9 ft, and 3.8 ac-ft of water volume. Despite being shallow, Farms Station Pond thermally stratifies in the summer, with oxygen depletion (anoxia) occurring in the deeper water layer.

Farms Station Pond receives water from Wights Pond located just upstream across the railroad. The other source of surface water is a storm drain from the MBTA parking lot south of the pond. The outlet is a concrete overflow point on the east side of the pond off Croton St. and flows in a channel for just a short distance before becoming part of an enclosed storm water drainage system.

7.2 Watershed Features

The Farms Station Pond watershed covers 417 ac and has a mix of developed residential (54.1%) and forested (40.4%) land (Figures 43 and 44). Wights Pond and other water features cover 4.8% the total watershed, while other land uses are minor (<1%). While there is more forested land in this watershed than many others evaluated as part of this planning project, the watershed to pond area ratio is still very high at 417:1, predisposing Farms Station Pond to water quality problems.

Water flows generally from west to east in this watershed, draining residential areas into a stream corridor that starts with a small, unnamed pond just west of Cliff Road, passes through the Carisbrooke Reservation and eventually into Wights Pond, a private waterbody not part of this management program development effort. Water overflows Wights Pond into a small stream that crosses under the railroad and enters Farms Station Pond.

7.3 Designated Uses

Farms Station Pond is mainly a visual amenity as part of the MBTA station and the local neighborhood, although it serves an important flood control function as well. It has easy public access and could be used for fishing, but there do not appear to be many fish in this pond. It could be a much better aquatic habitat. Improved appearance is the most commonly expressed goal for Farms Station Pond, as many people use the rail station, and this would be compatible with enhanced aquatic habitat. However, as the water flowing out of Farms Station Pond enters a closed drainage system, the storm water detention capacity of Wights and Farms Station Ponds is important to limiting flood potential in the downstream residential area.

Figure 42. Farms Station Pond bathymetry map

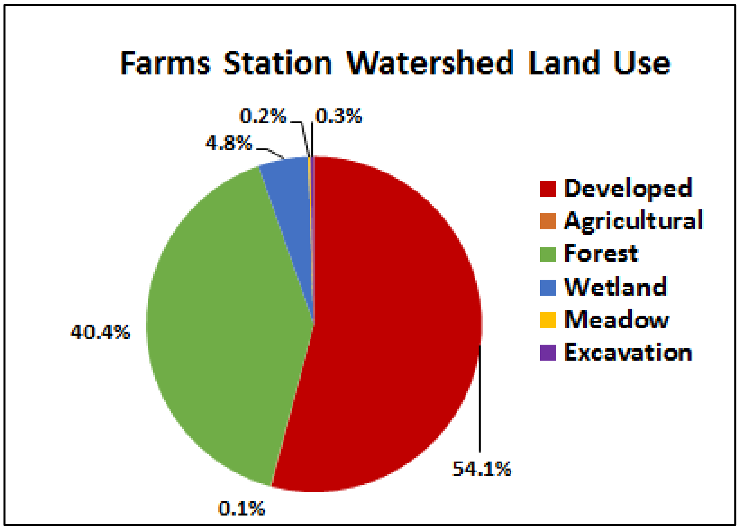

Figure 43. Farms Station Pond watershed land use chart

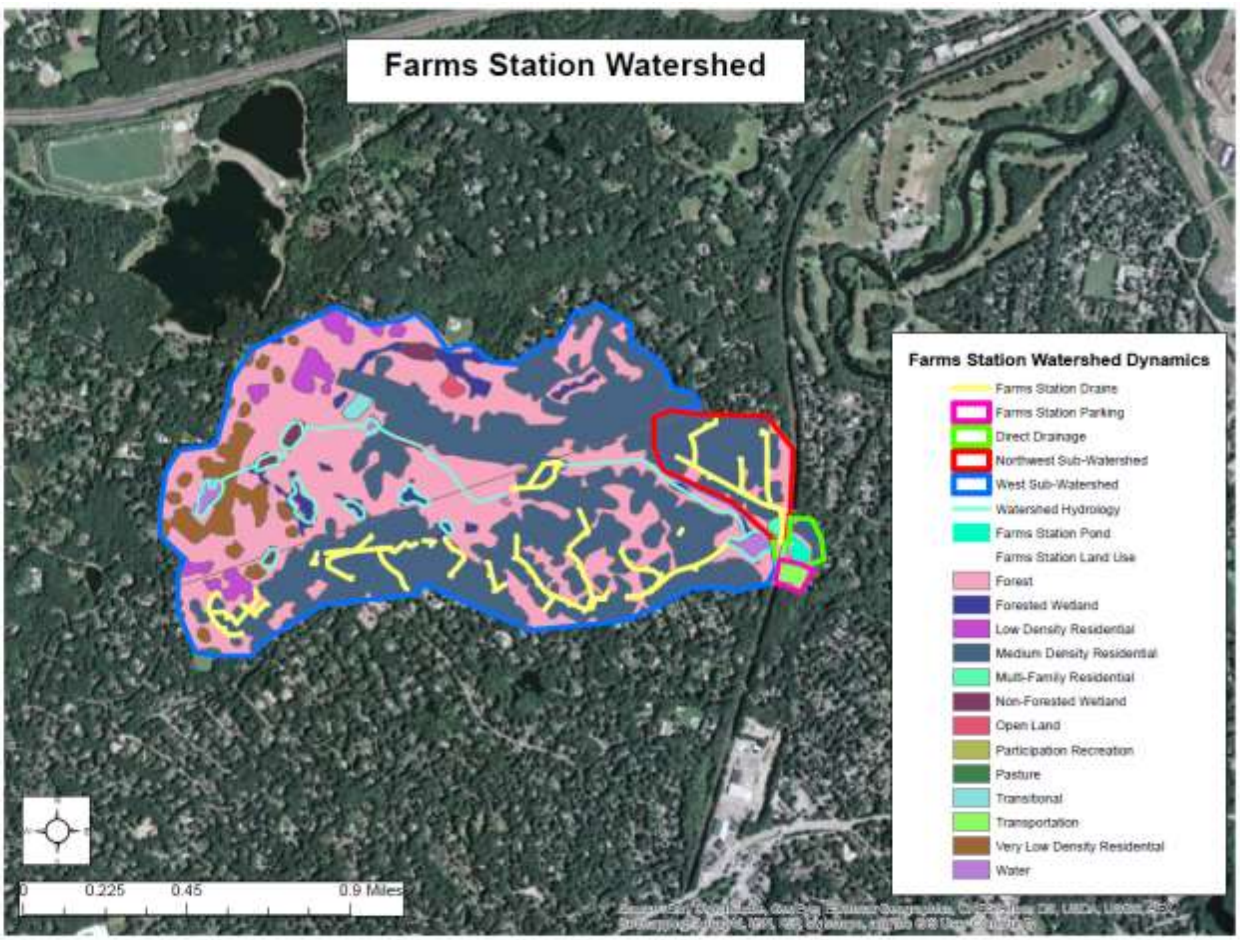

Figure 44. Farms Station Pond land use map

7.4 Additional In-lake Investigative Results

Sediment Assessment

Soft sediment in Farms Station Pond has an average depth of 3.1 ft, equating to 3.1 ac-ft of volume, slightly less than the volume of water held by the pond, but indicative of substantial infilling over many years. The pattern of soft sediment thickness (Figure 45) mirrors the depth contours for water in the pond. Soft sediment is highly organic (90%); with the larger Wights Pond upstream, it is understandable that most of the sediment in Farms Station Pond would be organic matter either suspended in the water leaving Wights Pond or produced in or around Farms Station Pond.

Plant Assessment

Two free floating plant species were found in Farms Station Pond during the 2016 plant surveys. Duckweed (*Lemna minor*) was observed in low abundance during June and July surveys, while watermeal (*Wolffia columbiana*) almost entirely covered the pond surface in October. The water is turbid and dark, shading out submerged plant growth. Relatively steep slopes from shoreline also limit plant growths. Duckweed and watermeal are plants that float on the pond surface, with tiny roots that extend into the water column; these plants are more like algae than other vascular plants with regard to depending on the water column for nutrition.

Green algae dominate the algae community during summer, which creates substantial turbidity when the surface is not covered by floating vascular plants. With Wights Pond upstream, one might expect substantial reduction in available nitrogen entering Farms Station Pond, but the inlet to Farms Station Pond from Wights Pond is high in nitrogen, especially nitrate. Phosphorus levels are also elevated, but phosphorus appears to remain limiting to productivity in Farms Station Pond.

General Appearance

Farms Station Pond ranges from slightly turbid to very scummy to completely covered with tiny floating plants that makes the pond look like a putting green from a golf course (Figure 46). High nitrogen to phosphorus ratios favor green algae over potentially more objectionable cyanobacteria, but excessive green algae and later green floating plants (watermeal) that function like algae give the pond an unappealing appearance. Odors were not extreme during site visits, but decomposition of algae and floating plants causes low oxygen in deeper water and related odors are likely at times. Nutrients to support plant and algae growth appear to come from both upstream and internal recycling, and both may need to be addressed to improve this pond.

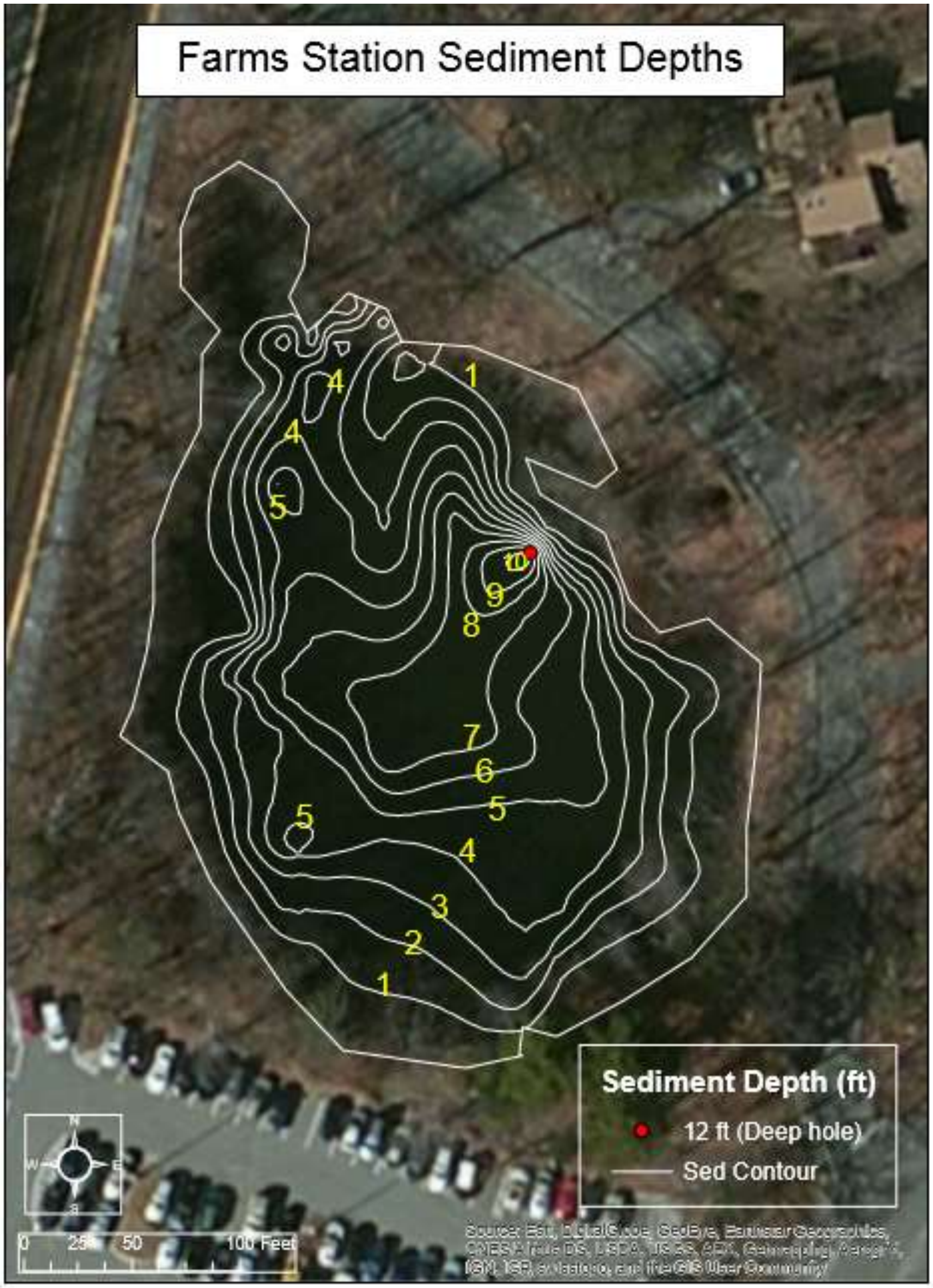

Figure 45. Farms Station Pond sediment distribution map

Figure 46. Farms Station Pond general appearance

7.5 Nutrient Loading

Applying the Lake Loading Response Model to Farms Station Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 9) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

The model predictions are a reasonable match for actual measures of phosphorus and nitrogen (Table 9). Phosphorus is elevated in Farms Station Pond but not extreme; every reduction in loading made should yield improvement. Nitrogen, however, is quite high and includes available forms. This would be expected to lead to dominance by green algae and/or floating vascular plants, which is exactly what we observe in this pond. Predicted chlorophyll-a is considerably higher than the actual values, which may be a function of limited sampling or could reflect light limitation on algae growth; certainly light is limiting at times in this pond. Predicted and actual water clarity measures are similar and low. Water clarity tends to decline rapidly with increasing phosphorus and chlorophyll-a after which the relationship flattens out; hence the relatively close correspondence of actual and predicted average clarity despite overprediction of chlorophyll-a.

In the absence of development in the watershed, background phosphorus concentrations would be expected to average 18 µg/L, which is higher than the 10 µg/L desirable threshold but lower than the 25 µg/L threshold for frequent algae blooms. The size of the watershed is a factor here; even as forest and wetland with upstream detention, more phosphorus will reach Farms Station Pond than desirable. If all feasible best management practices are applied, phosphorus declines only a little. In essence, the current watershed configuration is about as effective as it can be in reducing phosphorus transport. The development is mostly peripheral, with wetlands and small streams along a central corridor and a substantial detention area (Wights Pond) immediately upstream. There are not many more structural techniques that could be applied in this case.

Nitrogen would decline by more than half under background conditions, but with all feasible best management practices implemented the reduction would somewhat less than half. There is more potential to reduce nitrogen in this watershed, but reducing nitrogen without at least a commensurate reduction in phosphorus risks favoring cyanobacteria, which would be very undesirable.

Note also that while Farms Station Pond has high potential for internal phosphorus loading through release from iron bound phosphorus from sediment under low oxygen conditions, the actual mass of phosphorus in the surficial sediment is third lowest among the evaluated ponds and the watershed load greatly overshadows internal sources. While internal loading may need to be addressed as a support for algae and floating plants, especially in early developmental stages as resting stages in the sediment, the incoming phosphorus load is by far the biggest source.

Table 9. Farms Station Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	51	44	18	48
Nitrogen (ppb)	1195	1170	554	677
Mean Chlorophyll (ug/L)	24.8	10.4	6.5	22.9
Peak Chlorophyll (ug/L)	80.6	11.7	22.6	74.7
Mean Secchi (m)	1.1	1.3	2.5	1.2
Peak Secchi (m)	3.2	1.5	4.3	3.3
Bloom Probability				
Probability of Chl >10 ug/L	94.1%		13.4%	92.0%
Probability of Chl >15 ug/L	77.4%		2.7%	72.4%
Probability of Chl >20 ug/L	57.1%		0.6%	50.8%
Probability of Chl >30 ug/L	26.3%		0.0%	21.4%
Probability of Chl >40 ug/L	11.3%		0.0%	8.6%

7.6 Data Analysis and Interpretation

Farms Station Pond has a large watershed that predisposes it to water quality problems. Even with wetlands and ponded areas upstream, the amount of development provides elevated phosphorus and excessive nitrogen, mainly during storm events. Farms Station Pond acts as a small but valuable peak flow attenuator, but as a holding pond it retains enough nutrients to support undesirable quantities of algae and floating plants. Low light, steep bottom slope and greater depth than most Wellesley Ponds restrict plants from growing in the sediment, but surface growths are extensive at times.

Farms Station Pond has lost a little under half its depth over many years and has not been dredged to recover that depth. Extra depth does not appear critical to flood control function, as the outlet structure does not support deep drawdown, but if water clarity is improved, rooted plants could become an issue, and the resting stages of floating plants and algae in that sediment will be an ongoing source of problems.

The nitrogen:phosphorus ratio is high and favors green algae over cyanobacteria. While the pond is overly productive, shifting to cyanobacteria would make things worse, so nothing should be done that lowers the nitrogen:phosphorus ratio. The potential to substantially reduce phosphorus from the watershed is limited, however, suggesting that maintenance measures in the pond will be necessary if conditions are to be improved.

7.7 Management Recommendations

It would be beneficial to dredge Farms Station Pond, but it is not clear that the benefits justify the expense. This pond is already deeper than the other evaluated ponds and the logistics of draining Farms Station Pond are challenging. It may make more sense to inactivate phosphorus, either at the main inlet from Wights Pond during or shortly after storms, or through a low dose treatment of Farms Station Pond when needed. In a dry summer like that of 2016, a single treatment in mid-June might have been sufficient to keep water clarity acceptable for the summer. It may be necessary to coat the bottom of the pond to prevent the watermeal and duckweed resting stages from emerging. The precipitant formed by the common phosphorus inactivators should provide that coating if enough is applied, but it may still take a couple of summers to deplete reserves of those resting stages.

If the water in Farms Station Pond was circulated, low oxygen in the deeper water could be prevented and surface growths of algae or floating plants could be disrupted. This is a physical method with positive water quality benefits, but it does not always reduce overall algae abundance, but rather shifts the types and distribution of those algae. A fountain aerator might be very attractive in this pond and could provide adequate mixing if the intake was set near the bottom of the pond in its deepest area. If additional water could be added during dry periods to increase the flushing rate while pond water was being circulated, that could improve conditions even more, but no ready source of water is available. It would also be possible to combine circulation and phosphorus inactivation, adding a feed line to the circulation system such that a phosphorus inactivator could be injected and mixed with the water. The would be a very effective way to improve appearance of Farms Station Pond and increase deep water oxygen, which will help with both algae control and improve habitat for aquatic organisms.

8. Icehouse Pond

8.1 Pond Features

Icehouse Pond is located at latitude 42°17'48.08"N and longitude 71°18'58.90" and is a small (5.0 ac) bowl shaped pond directly adjacent to Morses Pond in Wellesley MA. Morses Pond is also a Wellesley public pond and provides recreational facilities. People using the town beach pass by Icehouse Pond when walking to and from the beach parking area. Icehouse Pond has an average depth of 3.4 ft and a maximum depth of 6 ft (Figure 47). Icehouse Pond has a water volume of 16.8 ac-ft but the water level and volume fluctuate because of its connection to Morses Pond, which has a managed water level.

Morses Pond flows into Icehouse pond in the spring after the flashboards in the Morses Pond dam are replaced, raising the water level in both ponds by approximately 2.5 ft. At normal pond levels, the two ponds are connected through a small channel with no control structure over which a bridge has been built. During dry conditions, as observed in 2016, the water level can decline and create a separation between Icehouse and Morses Pond. If not created naturally, that separation occurs in late fall when flashboards are removed from the Morses Pond outlet.

8.2 Watershed Features

The direct Icehouse Pond watershed covers only 4.4 ac, smaller than the pond itself, but the complete watershed for Icehouse Pond incorporates that of Morses Pond at 5,300 ac. Land use in the direct watershed draining into Icehouse Pond is 86.1% forested (Figures 48 and 49), vastly different from 66% developed land in the total watershed (Figure 50, see also any Morses Pond annual report). There are no tributary streams feeding this pond, but there are three small storm drains leading to Icehouse Pond, all draining paved access road area. Yet the dominant source of water to Icehouse Pond is Morses Pond, which makes water quality in Icehouse Pond a function of that in Morses Pond. The Morses Pond watershed is highly developed, but water quality is managed by phosphorus inactivation and has been much improved in recent years.

8.3 Designated Uses

Once an actual source of ice, Icehouse Pond now provides wildlife habitat and is a visual amenity, but is not actively used by people. Swans nest in the pond, other waterbirds find food and shelter there, and aquatic invertebrates, fish, reptiles and amphibians reside in Icehouse Pond. There is limited human access to the pond due to fencing, steep slopes and dense vegetation along the shoreline. Several town wells are located nearby, so human use is not encouraged, and there is ample recreational opportunity available on the adjacent Morses Pond and town beach area.

Figure 47. Icehouse Pond bathymetry map

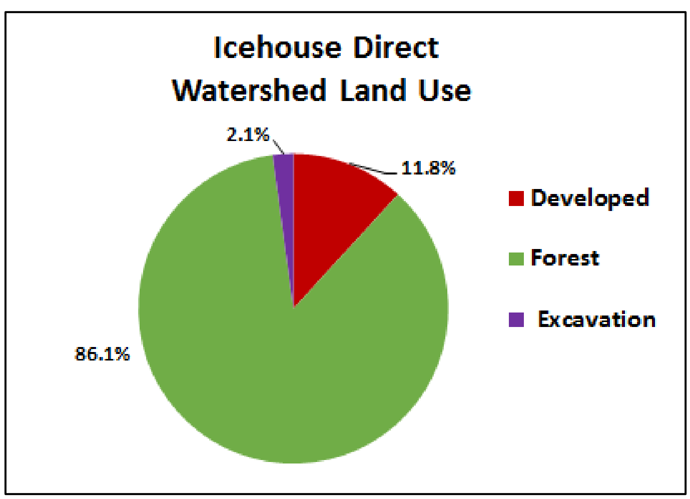

Figure 48. Icehouse Pond direct watershed land use chart

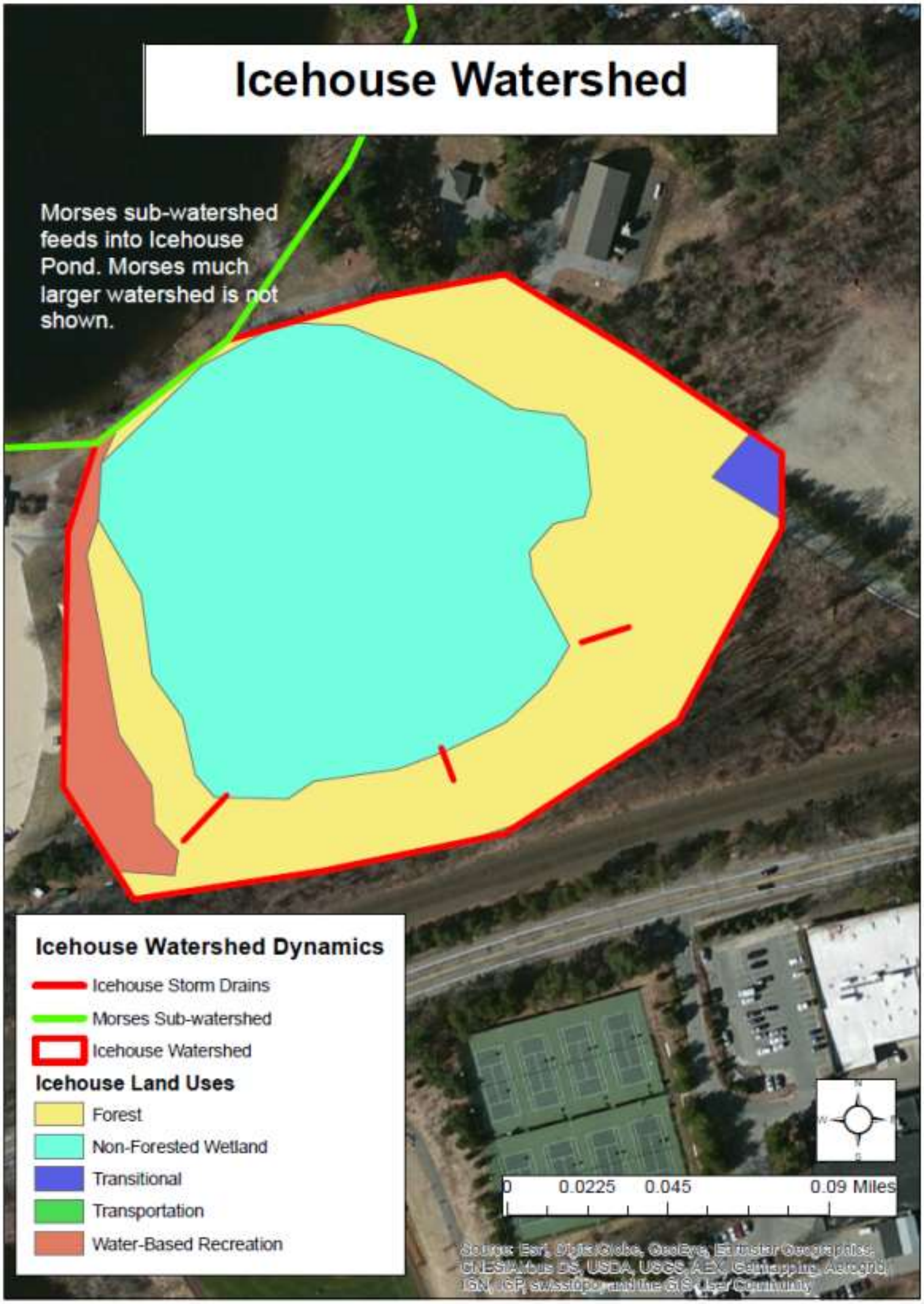

Figure 49. Icehouse Pond direct watershed land use map

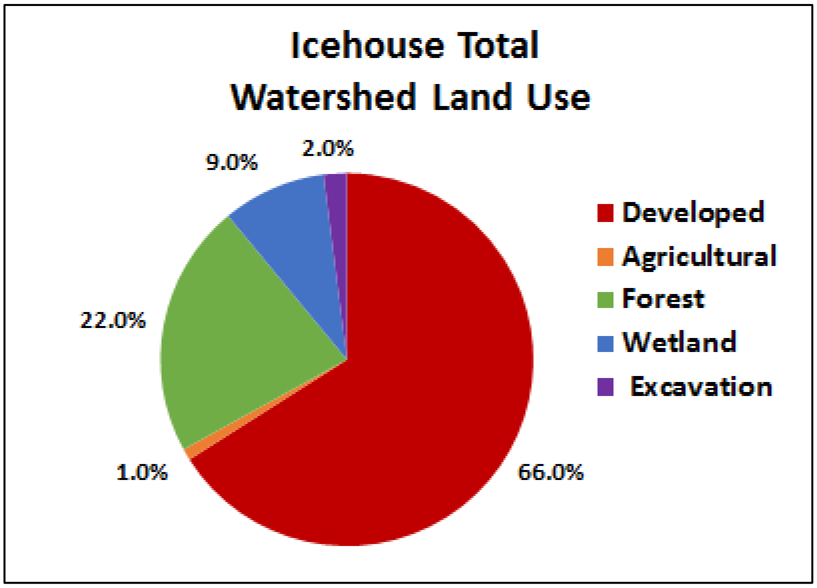

Figure 50. Icehouse Pond total watershed land use chart

8.4 Additional In-lake Investigative Results

Sediment Assessment

Icehouse Pond has a thick layer of soft sediment over all but the very edges of the pond bottom (Figure 51). Average sediment depth is 5.2 ft, with a total estimated volume of 26.2 ac-ft, considerably more than the current water volume of the pond. The material is highly organic and rather watery, typical of very long term accumulations from internal production of rooted plants and algae along with some external inputs of leaves and related debris. There is no evidence of any serious erosion around the pond or heavy solids input from the small storm water drainage systems. The available phosphorus in the Icehouse Pond sediment has the lowest mobile phosphorus content of any pond assessed in this planning effort.

Plant Assessment

During summer 2016 plant surveys Icehouse Pond had 12 plant species present. Invasive fanwort (*Cabomba caroliniana*) was the most abundant plant. Other invasive species observed were two milfoil species, Eurasian watermilfoil, (*Myriophyllum spicatum*) and variable watermilfoil (*Myriophyllum heterophyllum*). Variable water milfoil was dense in locations, often topping out at the surface. All of above plants are also present in Morses Pond at nuisance levels, and the connection between these ponds allows fragment transport. Despite having invasive species, the icehouse plant community was more diverse than other Wellesley ponds. Plant coverage was almost 100% of the pond bottom with about 50% of the water column filled with growing plants during summer. Yellow and white lily pads were observed at moderate

Figure 51. Icehouse Pond sediment distribution map

levels throughout the pond and emergent species create "islands" in the pond. While coverage is dense enough to be unappealing to most people, wildlife habitat value of Icehouse Pond is fairly high.

General Appearance

The density of the plant community in Icehouse Pond and very limited accessibility makes it minimally useful for recreational pursuits, but it does provide aquatic habitat with some value (Figure 53). Value as a visual amenity is partly a function of how people view the pond.

Figure 52. Icehouse Pond general appearance

Birdwatchers and nature enthusiasts may find it appealing, but people interested in swimming, boating or fishing will likely find it unattractive. Icehouse Pond does tend to accumulate trash from the beach complex, blown in by wind with little opportunity for flushing or access for clean ups. Icehouse Pond does have desirable water quality by virtue of its association with Morses Pond, which has been managed for improved quality in recent years. Dense plants represent the primary issue for this pond. There have been a few reports of odors, but the nature and extent of such odors has not been determined.

8.5 Nutrient Loading

Applying the Lake Loading Response Model to Icehouse Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 10) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

Applied to Icehouse Pond, the model suggests low concentrations that match actual values well and a slight overprediction of chlorophyll-a that likely relates to rooted plant interference with algae growth in this pond. Clarity was not quite as high as expected by the model, suggesting turbidity from non-living particles, most likely resuspended organic sediments.

Background conditions as predicted by the model suggest slightly lower phosphorus and nitrogen, slightly lower chlorophyll-a, but much higher water clarity than currently observed. With maximum feasible best management practices implemented, the pond would be only slightly improved over current conditions with regard to nutrients and algae, but would be much clearer according to the model. In essence, nutrient concentrations cannot get much lower than they are now and algae production is not controlling water clarity. The interaction of the water column with thick soft sediment deposits creates turbidity that limits clarity despite low nutrients and algae, and the improvements suggested by management through the model cannot be achieved without addressing accumulated sediment and rooted plants.

Table 10. Icehouse Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	13	11	8	12
Nitrogen (ppb)	366	450	338	334
Mean Chlorophyll (ug/L)	4.4	2.6	2.2	3.8
Peak Chlorophyll (ug/L)	15.8	3.2	8.3	13.8
Mean Secchi (m)	3.1	2.1	4.7	3.4
Peak Secchi (m)	4.7	2.1	5.4	4.9
Bloom Probability				
Probability of Chl >10 ug/L	3.0%		0.0%	1.5%
Probability of Chl >15 ug/L	0.4%		0.0%	0.1%
Probability of Chl >20 ug/L	0.1%		0.0%	0.0%
Probability of Chl >30 ug/L	0.0%		0.0%	0.0%
Probability of Chl >40 ug/L	0.0%		0.0%	0.0%

8.6 Data Analysis and Interpretation

Icehouse Pond has generally desirable water quality but suffers from a thick layer of soft organic sediment that both supports a dense rooted plant assemblage and causes turbidity in the overlying shallow water. The direct drainage area is minimal and impacts from the larger indirect watershed (of Morses Pond) are mitigated by treatments of major inflows to Morses Pond. The primary issues for Icehouse Pond are dense plant growths and slightly elevated turbidity along with lack of accessibility.

Unlike most other ponds assessed in this planning effort, Icehouse Pond is not a product of its watershed as much as it is a reflection of accumulated organic matter in the pond. It is functionally an isolated cover of Morses Pond. Icehouse Pond is transitioning to an emergent wetland, and while there is still substantial water depth in the pond, it is choked with plant growth for much of the summer. Along with a lack of easy access for people, this may benefit some aquatic organisms and many forms of water dependent wildlife, but it creates conditions that some users of the nearby town beach complex on Morses Pond find objectionable.

While the plant community is fairly diverse, it includes invasive species that would best be controlled for both the sake of Icehouse Pond and to minimize the potential for transport to other nearby ponds. However, the invasive species in Icehouse Pond are already in Morses Pond and unlikely to be eradicated there, so the potential for control in Icehouse Pond is limited.

8.7 Management Recommendations

Icehouse Pond does not appear to need any significant watershed management, other than better trash control at the town beach complex nearby. Water quality is generally acceptable and even the noted turbidity is not extreme. There has been no substantial public feedback for this pond that suggests a desire to increase accessibility for human uses of Icehouse Pond; Morses Pond provides adequate access and a wide range of recreational opportunities. The main use of Icehouse Pond is as wildlife habitat. Some might prefer that Icehouse Pond present a more aesthetic vista when walking around it to the town beach, but improving the visual condition of Icehouse Pond may prove difficult and possibly contrary to its current habitat function.

If Icehouse Pond is to be managed as a visual amenity, it would be appropriate to dredge it to limit rooted plant growth and sediment resuspension, but it is not clear that such expense is justified. Maintenance actions might be an option, but are hampered by lack of access; the harvesters used on Morses Pond cannot get under the bridge over the connecting channel and it would require a significant construction project to create a ramp from the nearby access road into Icehouse Pond if a harvester was to be launched there. Herbicides are not an option in this public space by bylaw, and would be questionable on grounds of the nearby town wells anyway. Manual clearing of vegetation would be very temporary and access is a problem for any workforce. Use of benthic barriers might be considered to maintain more open water. Yet unless there is a strong impetus to prevent Icehouse Pond from gradually turning into an emergent wetland, improving Icehouse Pond aesthetics appears to have a fairly low priority.

9. Longfellow Pond

9.1 Pond Features

Longfellow is a 7.5 ac pond located in Wellesley, MA at latitude 42°18'34.95"N and longitude 71°15'13.63"W. It is shallow with an average depth of 2.6 ft and maximum depth of 5.0 ft (Figure 53). The pond water volume is 19.2 ac-ft. The shoreline is entirely wooded and public. Longfellow Pond Trail is a 0.8 mile foot path that wraps around the lake close to the shoreline. There is a parking lot located at the southern end of the pond off Oakland Street with a boat launch. Rosemary Brook enters at the southern end and exits at the north end of this elongated waterbody through a concrete outlet structure with flashboards that raise the water level 21 inches. There are two gas transmission lines that run across the pond in the southern basin; these are below the surface but not buried, with markers along the length of each to warn any boaters of their proximity.

9.2 Watershed Features

Longfellow Pond is small in comparison to the size of its watershed (2034 ac), yielding a watershed to pond area ratio of 271:1. The watershed extends mainly southward from Longfellow Pond into Needham. The Needham Trout Club pond represents the headwaters of Rosemary Brook, which then flows through Rosemary Lake and downstream to Wellesley Reservoir and a second impoundment just upstream of Longfellow Pond. Much of the watershed is developed (71.4%) (Figures 54 and 55) as medium to highly density residential area and there are extensive storm water drainage systems discharging into Rosemary Brook. The large size of the urban watershed will significantly influence in-lake water quality, but Longfellow Pond does have the advantage of three upstream impoundments for detention and some significant wetland areas as well.

The immediate watershed around Longfellow Pond is wooded, but there are residential areas beyond those woods and three storm water drainage systems flow directly into Longfellow Pond. A southwestern drain brings runoff from Standish Circle, a central western drainage system serves the Priscilla Road area, and a southeastern drainage system serves an area on and across Oakland Street and enters at the eastern edge of the parking area.

9.3 Designated Uses

Longfellow Pond is visited regularly by the Wellesley community. The Longfellow Pond trail that wraps around the lake is popular for its aesthetic value and anglers have been noted targeting largemouth bass from shore. Small boats can be launched at the south end of the pond and paddling and fishing in a scenic setting is enjoyed except in summer when plant growths are very dense. Adequate off-street parking facilitates use, and people picnic or just enjoy the view from the south end on nice days. The pond provides substantial fish and wildlife habitat as well.

Figure 53. Longfellow Pond bathymetry map

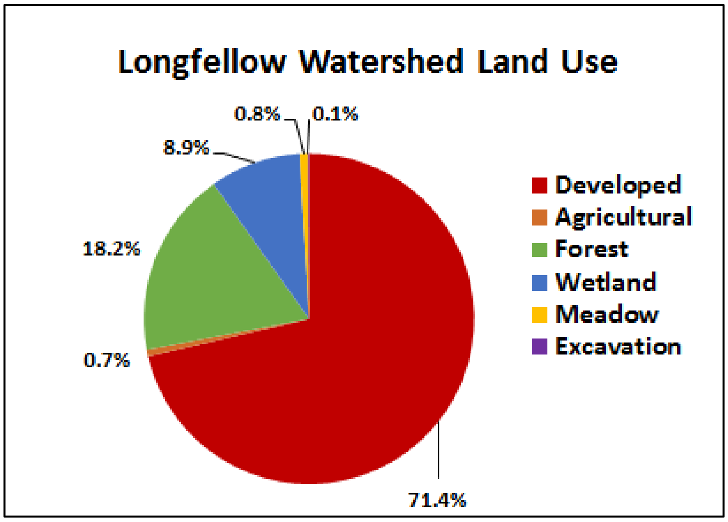

Figure 54. Longfellow Pond watershed land use chart

9.4 Additional In-lake Investigative Results

Sediment Assessment

The total volume of sediment in Longfellow Pond is 13.5 ac-ft, representing an average of 1.8 ft of thickness over the 7.5 ac pond. The sediment thickness is rather uneven however, with deposits of 5 ft thickness in the south basin and 4 ft thickness in the north basin (Figure 56). Other pockets of sediment up to 3 ft thick are found in between, with many areas having only a thin coating. The sediment is highly organic (85%) with elevated total and mobile phosphorus content, although mobile phosphorus is not among the highest values for the studied Wellesley Ponds. With shallow water depth, Longfellow Pond facilitates dense growth of aquatic plants.

Plant Assessment

A total of 9 plant species were observed in Longfellow Pond during summer 2016. Coontail (*Certaophyllum demersum*) was the most abundant plant present, but most of the observed plants were abundant in some areas. The plant community changes slightly from north to south in this pond. The southern portion of the lake had dense water chestnut (*Trapa natans*), an invasive species. The northern end plant community was dominated by yellow water lilies on the surface with submerged coontail and waterweed (*Elodea canadensis*) underneath. Watermeal (*Wolffia columbiana*) and filamentous algae growth were initially more abundant in the north, but became dense in the southern portion of the pond as summer progressed. The southern basin was harvested in mid-summer. Water chestnut was specifically targeted, but seeds were already formed and dispersing into the pond at the time of harvesting, so continued dominance is expected in 2017. The plant community achieves a high density during summer, such that boating and fishing are difficult and visual appeal is compromised.

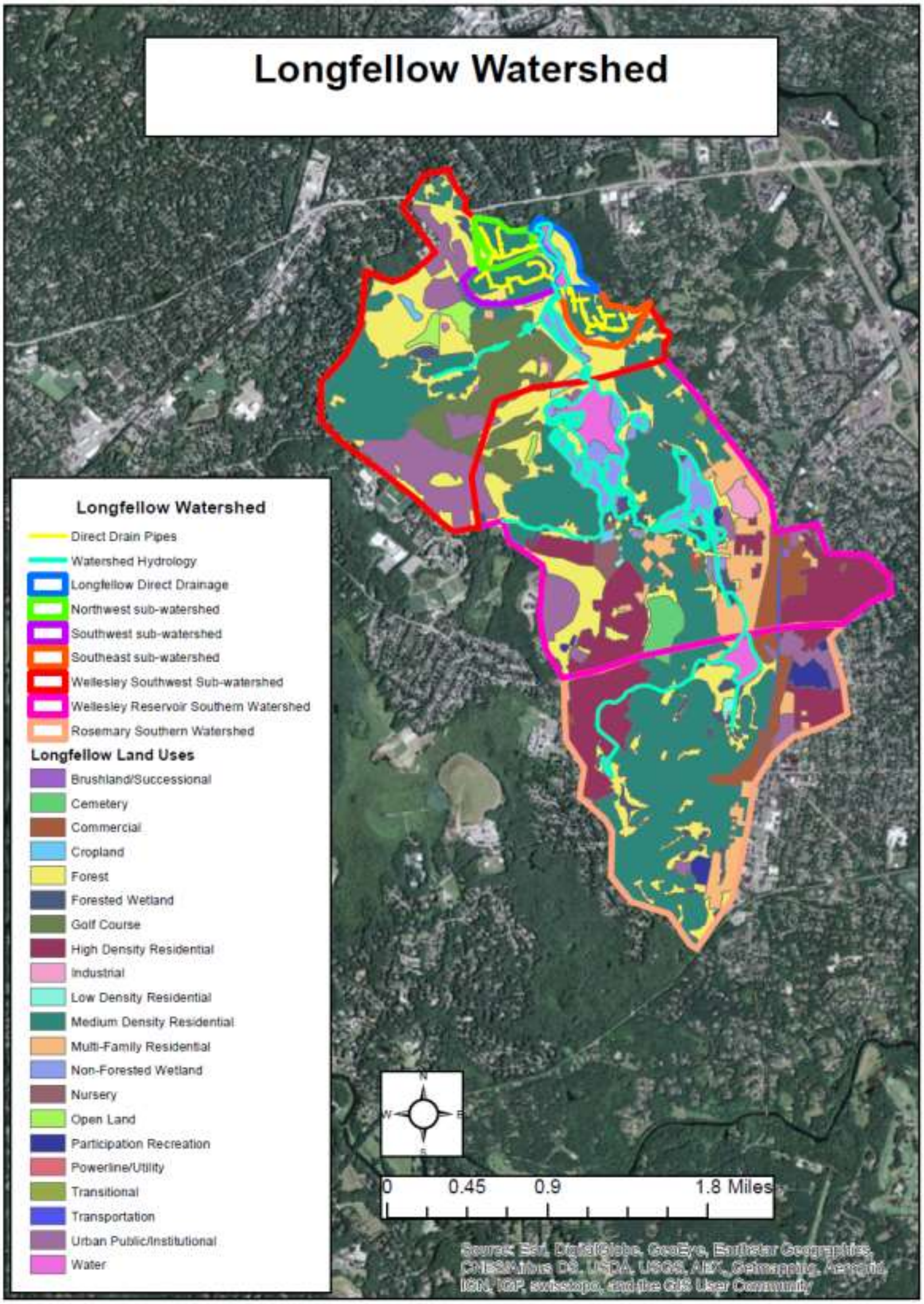

Figure 55. Longfellow Pond watershed land use map

Figure 56. Longfellow Pond sediment distribution map

General Appearance

Longfellow Pond is quite aesthetic for about 8 months of the year, but from June through September the excessive plant growths clog the pond and make it unsightly (Figure 57). Harvesting improves conditions noticeably, but is normally only conducted once per summer, in July or August, and the gas lines restrict how thorough a job can be done. Between surface leaves of water chestnut and water lilies, floating watermeal and duckweed, and filamentous green algae mats, active use of the pond is diminished and visual appeal is lacking. Planktonic algae are sometimes abundant and the water was murky much of the time, but no cyanobacteria blooms were detected. Additionally, geese and ducks tend to congregate at the parking area, leaving feces that detract from the visitation experience.

On the positive side, ample parking, a wooded shoreline, and a walking trail all the way around the pond are very attractive features, and public woodland extends well east of the pond, making Longfellow Pond and its immediate surroundings a potentially very natural and pleasant setting in an urbanized area. Pond management for Longfellow Pond should have a high priority, given great accessibility and use potential.

9.5 Nutrient Loading

Applying the Lake Loading Response Model to Longfellow Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 11) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

Modeling of Longfellow Pond proved difficult; resuspension of bottom sediment and dense aquatic plants confounded measurement of water quality features. Even so, the model predicts elevated levels of phosphorus and nitrogen, algae blooms, and low clarity. Actual measures suggest even more phosphorus, fewer blooms, and slightly clearer water, but none of the conditions, actual or predicted, would be considered desirable. In the absence of any development in the watershed (i.e., background conditions), phosphorus would average about 23 µg/L, a marginally acceptable value, and visibility would extend to the bottom of the pond. With all feasible best management practices applied, the phosphorus level would be about 41 µg/L, which is slightly more than half the predicted current concentration, but would still yield low clarity.

Figure 57. Longfellow Pond general appearance

Longfellow Pond has considerable upstream detention, but the high degree of urbanization and several direct entry storm drains result in elevated nutrient loading and related water quality problems. Rooted plants at the observed density tend to prevent algae blooms in summer, and elevated nitrogen concentrations favor green algae over cyanobacteria, but in the absence of plants algae blooms would be expected. In fact, planktonic algae were abundant in June before plants reached maximum density.

Table 11. Longfellow Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	76	440	23	41
Nitrogen (ppb)	1212	1210	476	481
Mean Chlorophyll (ug/L)	41.3	7.3	9.0	18.8
Peak Chlorophyll (ug/L)	131.9	10.8	30.8	61.8
Mean Secchi (m)	0.8	1.2	2.1	1.3
Peak Secchi (m)	2.9	2.0	4.1	3.5
Bloom Probability				
Probability of Chl >10 ug/L	99.5%		32.4%	84.4%
Probability of Chl >15 ug/L	96.2%		10.2%	57.9%
Probability of Chl >20 ug/L	88.5%		3.3%	35.3%
Probability of Chl >30 ug/L	65.2%		0.4%	11.8%
Probability of Chl >40 ug/L	42.7%		0.1%	3.9%

9.6 Data Analysis and Interpretation

Longfellow Pond is a tremendous asset to the Town of Wellesley, with a natural shoreline, walking trail, adequate parking, and improved boat access. For 8 months of the year it is a fairly scenic location. Yet dense rooted plant growths and algae mats create unsightly conditions during summer and make the pond virtually unusable for boating or fishing. Without dense plants, planktonic algae blooms can be expected, so management is not just a matter of plant control. Nutrient loading is high, despite substantial upstream detention, and internal processes relating to the sediment support elevated productivity and high turbidity even without external inputs.

The plants that cause impairment in Longfellow Pond span the range of ecological types; floating and submerged forms are abundant, but the greatest problems relate to rooted forms with floating leaves, like the invasive water chestnut. Multiple invasive forms are present, but the native coontail is the most abundant plant overall, and is weakly rooted, taking much of its nutrition from the water column. Tiny floating plants and algae mats start as growths on the sediment and rise in the water column, potentially covering the pond. Control by any single technique may prove difficult.

Flows during 2016 were among the lowest known for the area, so external inputs were minimized and problems were still evident. Watershed management is needed, but management within the pond will be necessary to achieve desirable conditions.

9.7 Management Recommendations

The three direct entry storm drains provide nutrient and solids loading to Longfellow Pond that should be reduced, but structural options are limited and more of the total load comes from the inlet and highly diffuse sources upstream. Without changes in land use, reducing nutrient loads from the watershed would require either high maintenance structural systems or very diffuse land management measures applied by property owners. Both approaches are appropriate, but neither is likely to yield the desired level of improvement in a short timeframe and will require a large, ongoing effort to maintain loading control.

In-lake measures have included mainly mechanical harvesting, but not at a level that maintains control over plants. The timing of harvesting has been based mainly on when the harvester and personnel have been available, rather than on targeting plant removal before seeds are produced and on preventing growths from reaching the surface of the pond. More resources, both equipment and manpower, will be needed to run an effective harvesting program, but such a program could be very beneficial and could eventually produce longer term benefits like minimization of water chestnut growths.

Longfellow Pond could be drawn down by 21 inches over the winter, potentially freezing out susceptible vegetation around the periphery, but this would represent a limited number of species over a limited area and would not be sufficient by itself to yield desirable conditions in this pond.

Ideally, Longfellow Pond would be dredged. The quantity of sediment is over 20,000 cubic yards, and removal costs are rarely <\$30/cy, so this is a very expensive proposition (>\$600,000, probably considerably greater based on expected disposal restrictions). Additionally, the presence of gas transmission lines may complicate dredging and increase cost. Yet this would be the best single action that could be taken to improve conditions in Longfellow Pond.

Control over internally available nutrients and turbidity can be achieved with aluminum treatment, much as used in Morses Pond, but with additional options. An inlet dosing station would be appropriate, but may not address sediment resuspension issues farther out in the pond, a problem not faced in Morses Pond due to greater depth there. Low dose treatment in June over most of the pond area could provide improved clarity and strip enough phosphorus to limit planktonic algae and possibly algae mats. Such treatment may be counteracted by mechanical harvesting, which will create substantial turbidity; repeat application of aluminum may be necessary in Longfellow Pond to maintain desired clarity all summer.

Limiting waterfowl use of the parking area and related shoreline would improve the visitor experience in that area. Establishment of a denser buffer zone between the parking area and the pond is recommended, with growths high enough to restrict waterfowl movement but low enough to facilitate views and fishing by people. Creation of anchored, floating islands might encourage waterfowl to spend less time near the parking area. Establishment of additional human access points around the pond is also suggested, to facilitate views and fishing.

10. Reeds Pond

10.1 Pond Features

Reeds Pond is a small (1.9 ac), elongate pond located off of Woodside Rd, Wellesley, MA, at latitude 42°18'28.22"N and longitude 71°19'32.45"W. It is an impoundment of Bogle Brook with an average depth is 2.4 ft and a maximum depth of 5.5 ft (Figure 58). The water volume is 4.6 ac-ft. Reeds Pond has a mostly wooded shoreline with public access mainly along the east side and through a small park at the southern end, but there is no dedicated parking area. The outlet is a 80-foot concrete wall with an approximately 20-foot cut out for normal outflow, but the pond can overflow the entire wall during storm flows. A subsurface pipe allows the pond to be nearly drained under low flow conditions. There is also a small forebay at the pond inlet that traps some incoming sediment and was cleaned out in late 2015 (110 cubic yards removed).

10.2 Watershed Features

The watershed for Reeds Pond covers 2709 ac and is 52% forested and 12% wetland (Figures 59 and 60), but is also 33% developed, mostly as residential area. The watershed is 1426 times the area of the pond, the largest watershed to pond area ratio of all assessed Wellesley ponds. Almost two thirds of the watershed passes through Nonesuch Pond in Weston and Natick, providing substantial detention, but only a small portion of the watershed is within Wellesley, limiting control over watershed activities. A small storm drain delivers runoff from Woodside Road, but Bogle Brook is the dominant water source.

The wooded shoreline is almost all in public ownership, but the west side is densely vegetated and not very accessible. Trees and underbrush are present in other areas but shoreline access is easier. The inlet passes under Woodside Road, coming from a wooded wetland corridor that extends upstream about half a mile. There are numerous small upstream impoundments and wetland areas associated with Bogle Brook and its tributaries, but there is also an extensive storm water drainage system feeding this stream system from developed areas.

10.3 Designated Uses

Reeds Pond is a visual amenity, recreational asset, flood control facility, and upstream detention basin for Morses Pond. Anglers have been observed targeting largemouth bass, mostly from shore, but small watercraft can be launched on this pond. People walk dogs near the pond and some picnic in the park area at the south end of the pond. The outlet is a wide concrete structure with central flashboards and provides limited flood storage; evidence of overflow through the park area by the outlet can be seen after larger storms. Reeds Pond was dredged in 1998, improving its condition and enhancing detention capacity to protect downstream Morses Pond, but it has since accumulated considerable organic sediment.

Figure 58. Reeds Pond bathymetry map

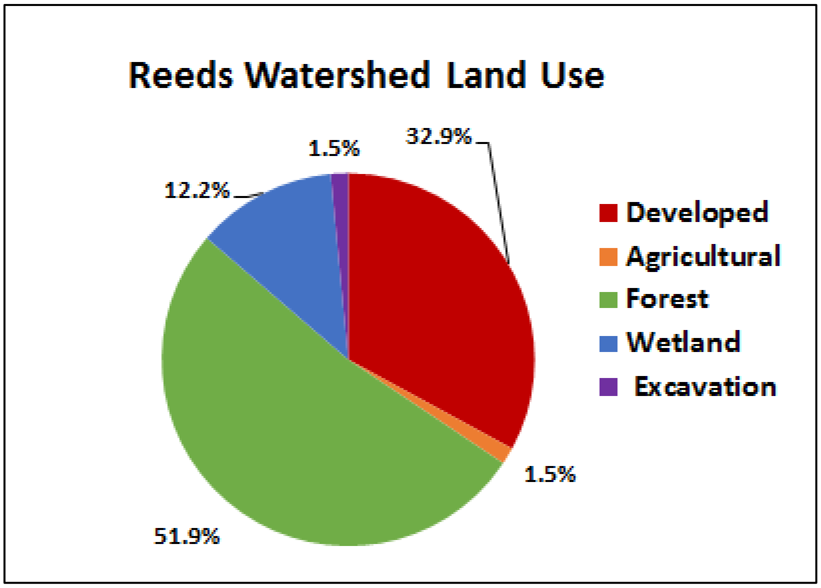

Figure 59. Reeds Pond watershed land use chart

10.4 Additional In-lake Investigative Results

Sediment Assessment

Average sediment depth was 0.9 ft, but the distribution was uneven (Figure 61), especially near the inlet at the north end of the pond. However, this inlet area, an engineered forebay, was cleaned out in December 2017, likely creating the uneven depth profile. Deposits build up to the sides of the pond but a channel is maintained near the center of the pond. Total sediment volume is 1.8 ac-ft, accumulated mostly over the last two decades since dredging, and suggesting that about 28% of the pond has been refilled since it was dredged. Organic content is very high, reflecting mainly inputs of leaves and related vegetation from upstream. Short detention time limits algae accumulation in Reeds Pond, and the organic matter is coarser than would be expected with deposition of algae. Total and iron bound phosphorus concentrations in sediment are elevated, suggesting high growth potential for plants and algae.

Plant Assessment

During summer 2016 plant surveys 6 plant species were observed in Reeds Pond. Of the 6 species, waterweed (*Elodea canadensis*) was the most abundant and was especially dense along the shoreline. One invasive species, curlyleaf pondweed (*Potomogeton crispus*) was observed near the dam. Other plant species were native but less abundant. Shifting distribution of soft sediment with high flows away from shoreline may limit plant growth in Reeds Pond. Floating duckweed was observed, but short detention time in this pond limits its build up; duckweed may be flowing through Reeds Pond from upstream sources.

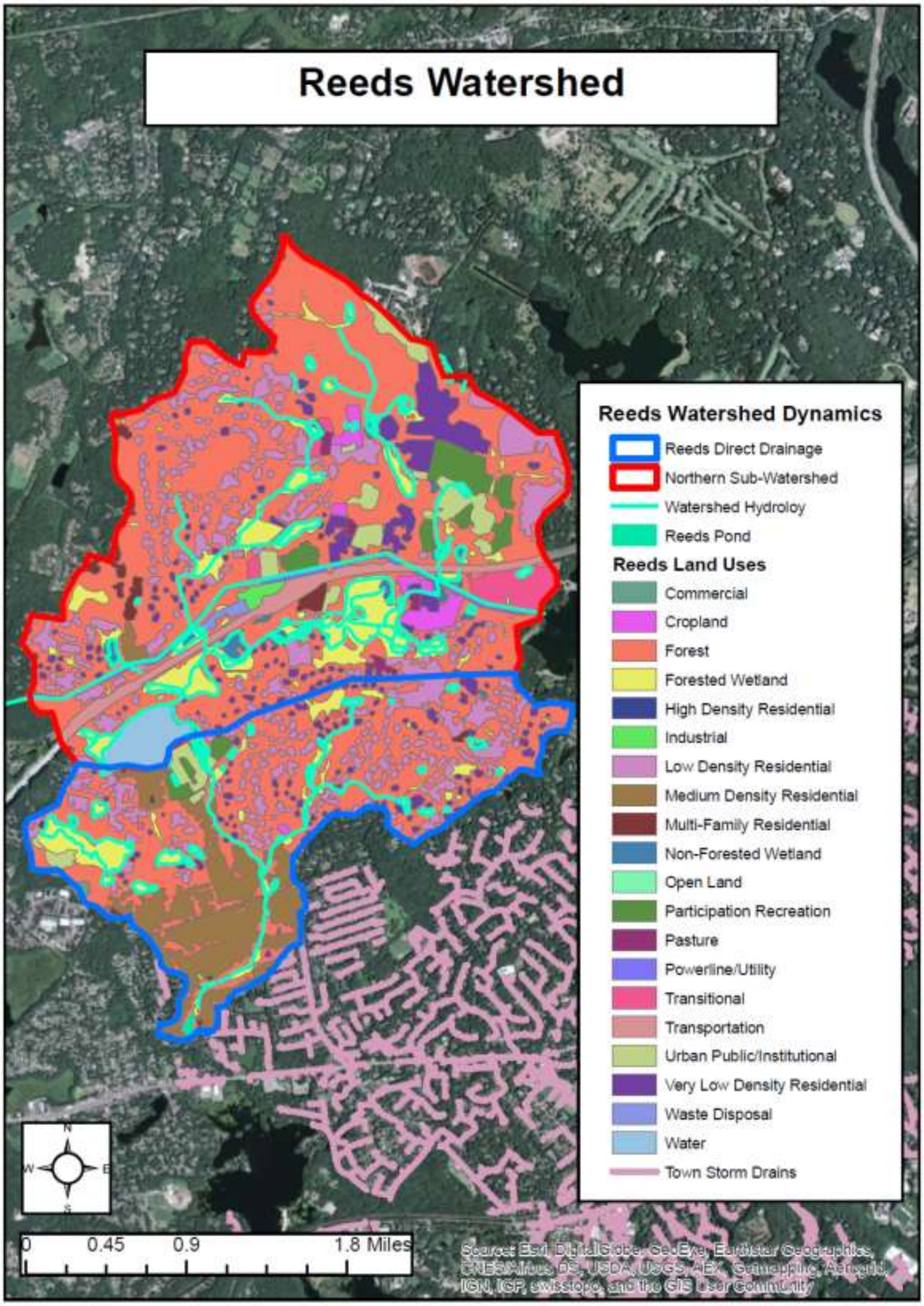

Figure 60. Reeds Pond watershed land use map

Figure 61. Reeds Pond sediment distribution

General Appearance

Reeds Pond maintains general visual appeal throughout the year as a function of short detention time (Figure 62). Algae blooms are not severe and include few scum-forming cyanobacteria. Rooted plant growths are not extreme; sediment and flow features may limit their growth. Water clarity is not high, and the ponds sometimes has a greenish hue from algae or a brownish color from suspended sediment , but the pond reflects its wooded shoreline and provides pleasant vistas for walkers, picnickers and fishermen. Fishing access points are limited and fishing lines can be observed hanging from trees or shoreline brush.

10.5 Nutrient Loading

Applying the Lake Loading Response Model to Reeds Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 12) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

Modeling Reeds Pond is somewhat challenging, as it has a short detention time and in-lake processes have less influence on water quality than in ponds with longer residence times. Data for the pond are limited and from a dry summer, while water quality is likely to be variable and dependent on inflowing water quality. Algae do not typically accumulate, so chlorophyll-a values will be overestimates. Likewise, the pond is shallow, so water clarity measures are limited by having the visibility extend to the bottom of the pond. The predicted current average phosphorus concentration is 66 µg/L, enough to support algae blooms, but high flushing rates keep such blooms from forming most of the time. Average predicted Secchi transparency is lower than the observed 2016 average, but it was a dry summer and the observed value was close to the maximum depth of the pond. Maximum Secchi values cannot be achieved due to shallow depth.

Under background conditions of no development in the watershed, the background phosphorus concentration is predicted at 31 µg/L, which is higher than desirable but very close to the observed average value in a year where watershed influence was at a minimum. Reeds Pond reflects considerable inputs from a very large watershed even under dry conditions. With all feasible best management practices implemented, the predicted phosphorus concentration would be 41 µg/L, still high enough to promote algae blooms. The short detention time in Reeds Pond is critical to it maintaining aesthetic appearance. Water clarity is not high, but allows enough light to reach the shallow pond bottom and promote rooted plant growth.

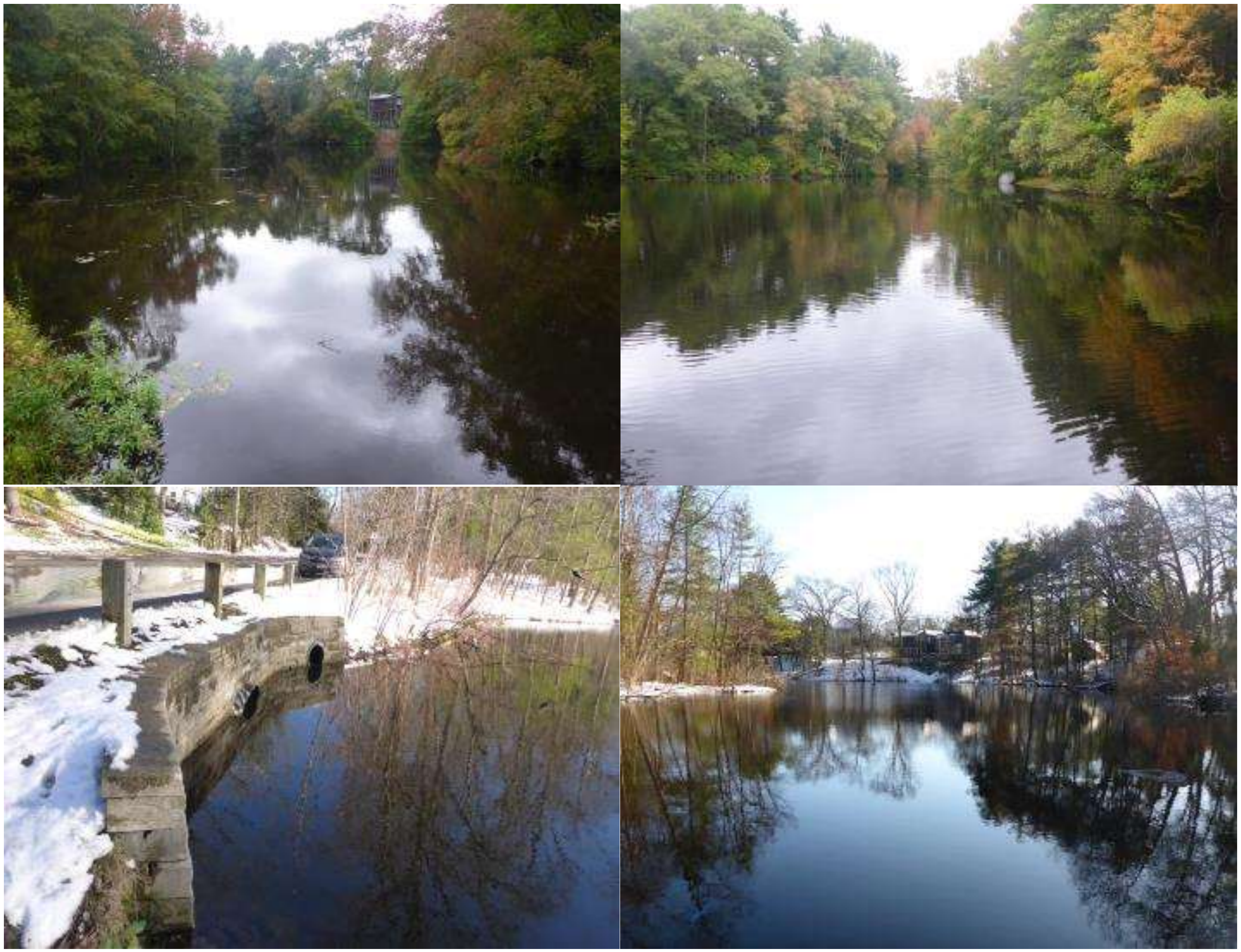

Figure 62. Reeds Pond general appearance

Table 12. Reeds Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	66	30	31	41
Nitrogen (ppb)	876	840	473	553
Mean Chlorophyll (ug/L)	34.6	5.8	12.9	18.9
Peak Chlorophyll (ug/L)	110.0	8.5	43.4	62.2
Mean Secchi (m)	0.9	1.5	1.7	1.3
Peak Secchi (m)	3.0	1.5	3.7	3.4
Bloom Probability				
Probability of Chl >10 ug/L	98.7%		60.5%	84.7%
Probability of Chl >15 ug/L	92.2%		29.3%	58.4%
Probability of Chl >20 ug/L	80.1%		13.1%	35.8%
Probability of Chl >30 ug/L	51.3%		2.7%	12.0%
Probability of Chl >40 ug/L	29.4%		0.6%	4.0%

10.6 Data Analysis and Interpretation

Reeds Pond has very large watershed and despite substantial detention time upstream, extensive wetland areas, and a forebay to trap incoming sediment, the third of the contributing land that is developed provides high loads of nutrients, solids and other contaminants. Observed water quality conditions in 2016 were most similar to predicted conditions in the absence of development in the watershed, a function of low precipitation and minimum loading to the pond. Average nutrient levels are elevated and would be expected to remain elevated even with maximum application of best management practices.

The pond was dredged in 1998 and the forebay was most recently cleaned out in late 2015, but Reeds Pond has lost 28% of its volume since 1998 to incoming sediment, which is mostly organic matter. With a very large watershed to pond area ratio, detention time in the pond is short, even during dry periods, and algae rarely accumulate to bloom levels. Periodic high flows redistribute organic sediment and limit plant density; growths are greatest near shore, out of the path of the highest velocity flows.

Reeds Pond has a wooded shoreline but limited access and parking space. Some fishing does occur, but the pond is mostly a visual amenity for the neighborhood and fills this function most of the time, with limited plant nuisances or algae accumulations. It does supply some peak flow control for downstream, but is very small relative to its watershed and its impact is limited.

Reeds Pond provides upstream detention for Morses Pond, but not enough to protect Morses Pond adequately, and a phosphorus inactivation system is in place at the Bogle Brook inlet to Morses Pond to improve incoming water quality.

10.7 Management Recommendations

Short detention time will keep Reeds Pond in a moderately aesthetic condition nearly all the time; algae and rooted plant accumulations tend not to be extreme. Past dredging restored pond capacity and while ongoing infilling will eventually require dredging again, current sediment deposits are thick in only a few places. Dredging the organic accumulations to either side of the Bogle Brook inlet could be accomplished from Woodside Road with a long reach backhoe and watertight trucks, but no other excavation appears necessary at this time. Certainly the forebay should be cleaned out whenever the need is apparent.

Rooted plant growths are sometimes dense near shore, but are not excessive overall in Reeds Pond at this time. Getting a harvester into the pond to remove plants would be a challenge, but an access point exists off Woodside Road and could be improved to allow harvester launching if the need arises. It would also be possible to draw Reeds Pond down over the winter to freeze peripheral vegetation and allow accumulated sediment in shallow water to slough off into deeper water. This may alleviate some of the denser plant growths.

Algae and resuspended sediment discolor the water at times, and could be addressed with a low dose aluminum treatment if an extended dry period is expected. Yet the entire volume of Reeds Pond is replaced in any substantial storm event, so algae problems tend to be short-lived in this waterbody.

Improve parking represents a challenge in this area, but improved access to the pond could be provided by selective vegetation thinning and trail work.

11. Rockridge Pond

11.1 Pond Features

Rockridge Pond is located off Hundreds Rd. in Wellesley, MA at latitude 42°19'7.04"N, longitude 71°16'57.00"W. It is a small (2.3 ac), U shaped pond with 2.4 ft average depth and a maximum depth of just under 6 ft (Figure 63). Water volume is 5.5 ac-ft. There are two storm drains that flow into Rockridge Pond, a southwest drain off of Cliff Road that represents the main inflow and a north drain accessible from a foot path starting from the parking area. There is an open segment of shoreline on the north east side with a picnic table and small parking area (2 cars). The shoreline is mostly wooded and there is a path that runs about two thirds of the way around the pond, starting at Cliff Road and ending at the outlet. The outlet is a concrete overflow structure with a single 10.5-inch deep, 41-inch wide flashboard from which water flows back into a storm water drainage system. However, there is a subsurface drain controlled by a gate valve that can lower the water in Rockridge Pond by up to 3 feet below the flashboard elevation.

11.2 Watershed Features

The watershed of Rockridge Pond covers 96 acres, yielding a watershed to pond area ratio of 42:1, and the watershed is mostly developed (79.5 %) as residential area (Figures 64 and 65). There is a small pond to the west, which receives storm water runoff from a large portion of the watershed and overflows into a channel that eventually enters the storm water drainage system that enters the Rockridge Pond on its southwest side. Additional storm water drains feed the northern entry pipe, and there is a storm water swale that approaches Rockridge Pond from the west side, although no flow was ever observed reaching the pond.

11.3 Designated Uses

Rockridge Pond functions as a visual amenity, fishing pond and wildlife habitat in a residential neighborhood. It also provides peak flow control and flood mitigation. It was partially dredged in 2003, but dense rooted plant growths and algae mats have continued to develop each summer. Fishing is popular in spring and fall, when plants and algae mats provide less interference, and the pond has populations of bass and sunfish. Fishing from shore is impeded by access limitations, and fishing lines can be seen hanging from tree branches around the pond. Waterfowl are often observed at the pond, including ducks and herons. People sometimes picnic or just enjoy the view from the cleared northeast access point, and people walk dogs on the path along the pond.

Figure 63. Rockridge Pond bathymetry map

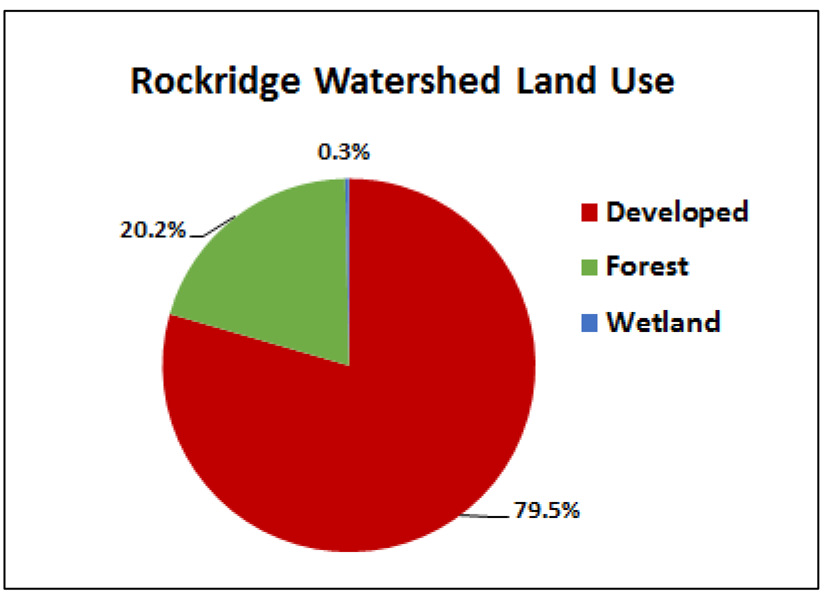

Figure 64. Rockridge Pond watershed land use chart

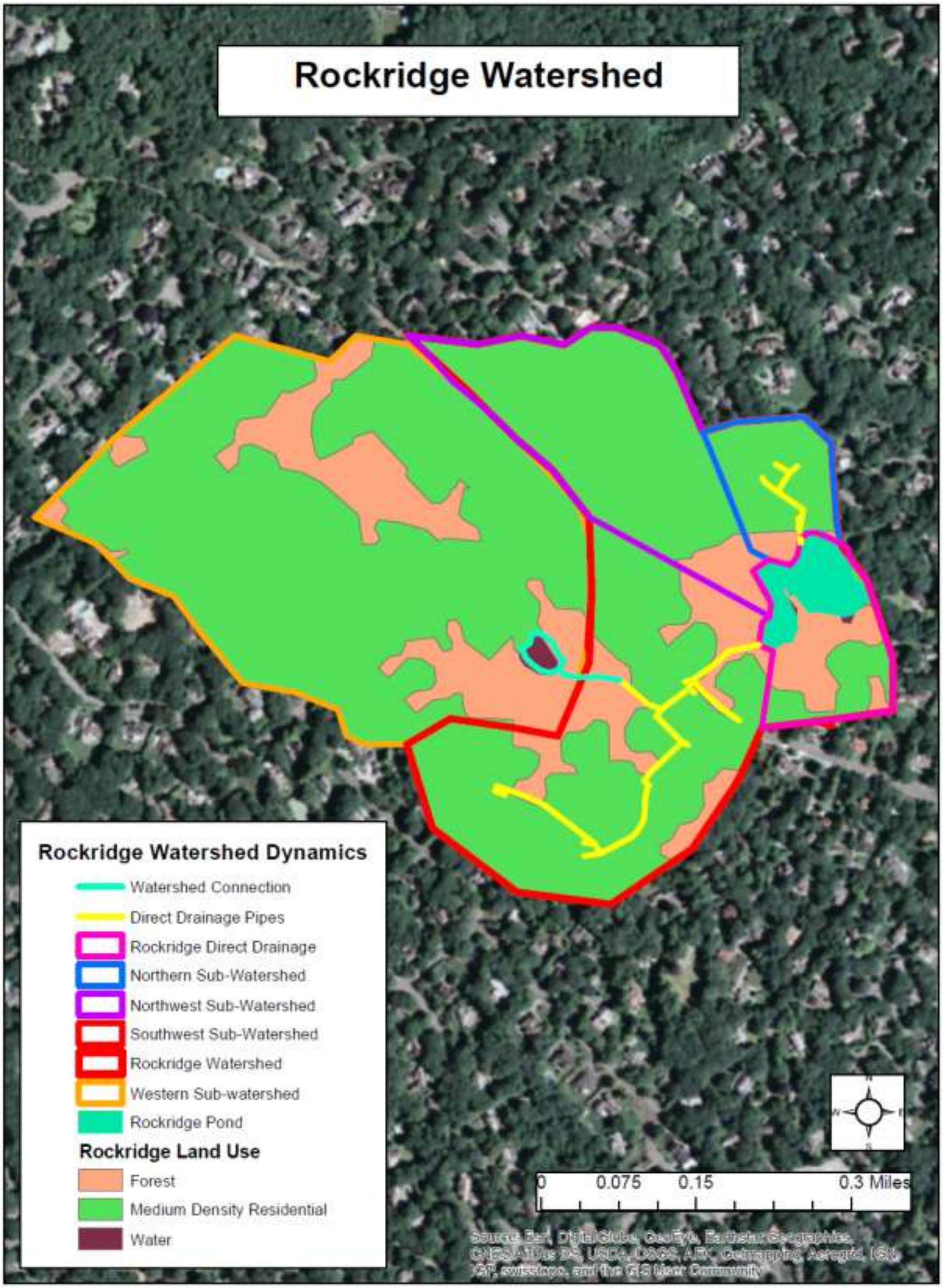

Figure 65. Rockridge Pond watershed land use map

11.4 Additional In-lake Investigative Results

Sediment Assessment

Average soft sediment depth in Rockridge Pond is only 0.9 ft, with the periphery of the pond having been dredged in 2003, but there is a highly organic sediment deposit in the eastern basin with depths up to 4 ft (Figure 66). The pond is therefore sandy at the edge and grades into muck at water depths of about 2 ft, with thicker muck deposits in water greater than 5 ft. Soft sediment volume is currently about 1.8 ac-ft in Rockridge Pond with an organic content of about 81% and elevated total phosphorus concentration but a more moderate iron bound phosphorus content.

Plant Assessment

Aquatic plant surveys in Rockridge Pond in the summer of 2016 revealed 7 aquatic plant species. The cover, or percent of pond area occupied by plants, was almost 100%. The bottom of the southwestern basin was completely covered by plants that were topping out at the surface. Waterweed (*Elodea canadensis*) was the most abundant plant and was dominant in the southwestern basin. Later in summer some form of herbivory or disease caused the waterweed to lose most of its leaves, leaving dense masses of stems in the water. White and yellow water lilies were the next most abundant plants with substantial coverage until the pond was harvested in early August. Two invasive species were observed, water chestnut (*Trapa natans*) and curlyleaf pondweed (*Potamogeton crispus*). Water chestnut has been dominant in some past years, but repeated harvesting of this annual seed-producing plant appears to have reduced its abundance. Green algae mats were also abundant in summer and greatly limit fishing success.

General Appearance

Rockridge Pond is aesthetically pleasing from mid-autumn into late spring, but for summer and a few weeks before and after that season the density of aquatic plants and algae mats is excessive and impairs both visual appeal and active use of the pond (Figure 67). The path around much of the pond offers a natural experience in an urban area, but suitable access to the pond along that trail for fishing is limited. Planktonic algae are not overly abundant and no problem cyanobacteria were detected, but the green algae mats severely limit fishing when present and cause some odor when they decay. Harvesting reduces plant density temporarily, but is only done once per summer and causes substantial turbidity that lasts a few days.

11.5 Nutrient Loading

Applying the Lake Loading Response Model to Rockridge Pond, loads of nitrogen and phosphorus are generated based on land use in the watershed and routed to the lake based on the drainage pattern and any opportunities for attenuation of loading. The predicted in-lake

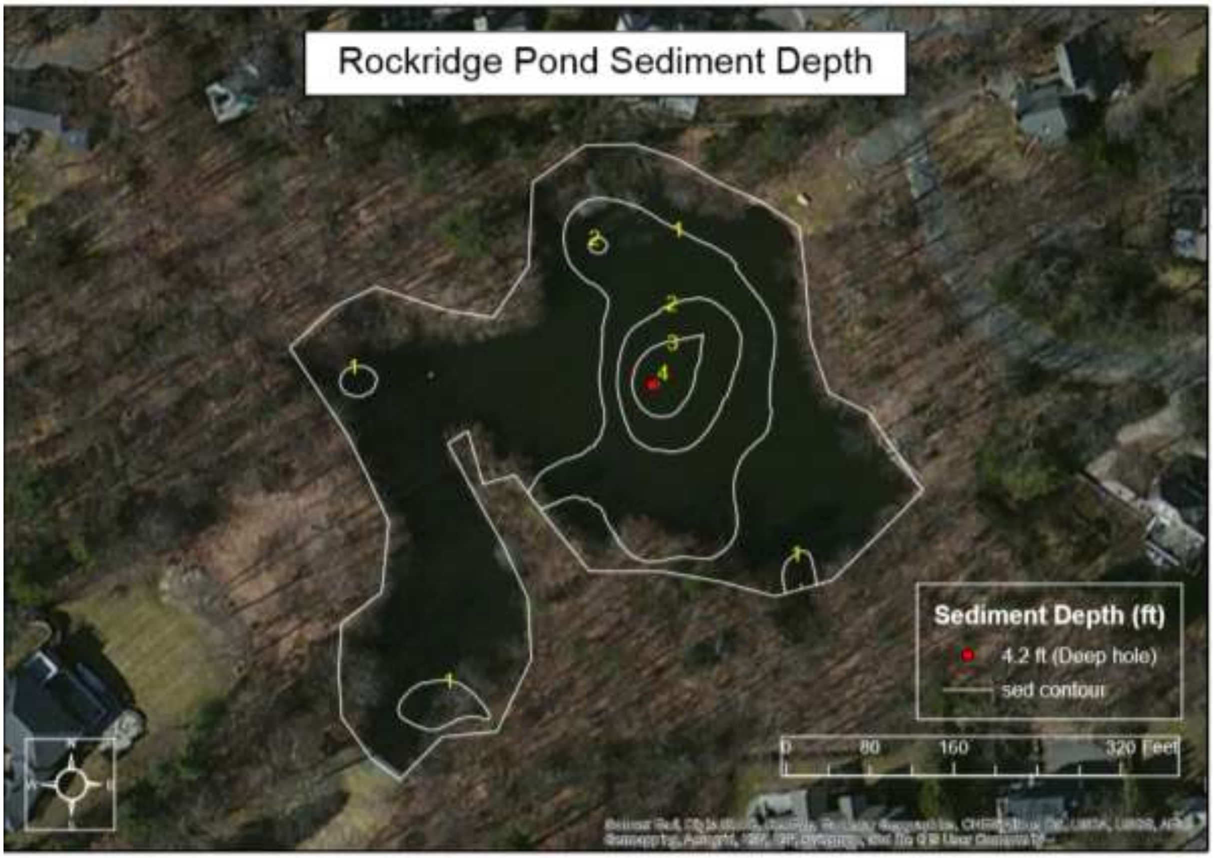

Figure 66. Rockridge Pond sediment distribution map

concentrations of phosphorus, nitrogen and chlorophyll-a (representing algae) plus water clarity as assessed by Secchi disk transparency are compared with actual data (Table 13) to show that the model is properly calibrated. The probability of algae blooms at any chosen level of chlorophyll-a is generated, and all of these features can be estimated for background conditions (undeveloped watershed) and if all feasible best management practices were installed.

For Rockridge Pond, the model predicts a phosphorus concentration somewhat higher than that observed in 2016, but that was a dry year with much lower storm water inputs than usual. Predicted nitrogen was also slightly higher than observed for the same reason. Actual chlorophyll-a was much lower than predicted, partly due to lower nutrient levels but also because rooted plants and algae mats dominate this system and are not included in that measurement. Water clarity was higher than predicted, but visibility is limited by plants and algae mats; actual water clarity is not a good measure of aesthetics in Rockridge Pond.

Changing all developed land into forested land to mimic background conditions, the average phosphorus concentration in Rockridge Pond is predicted at 25 µg/L, at the threshold between

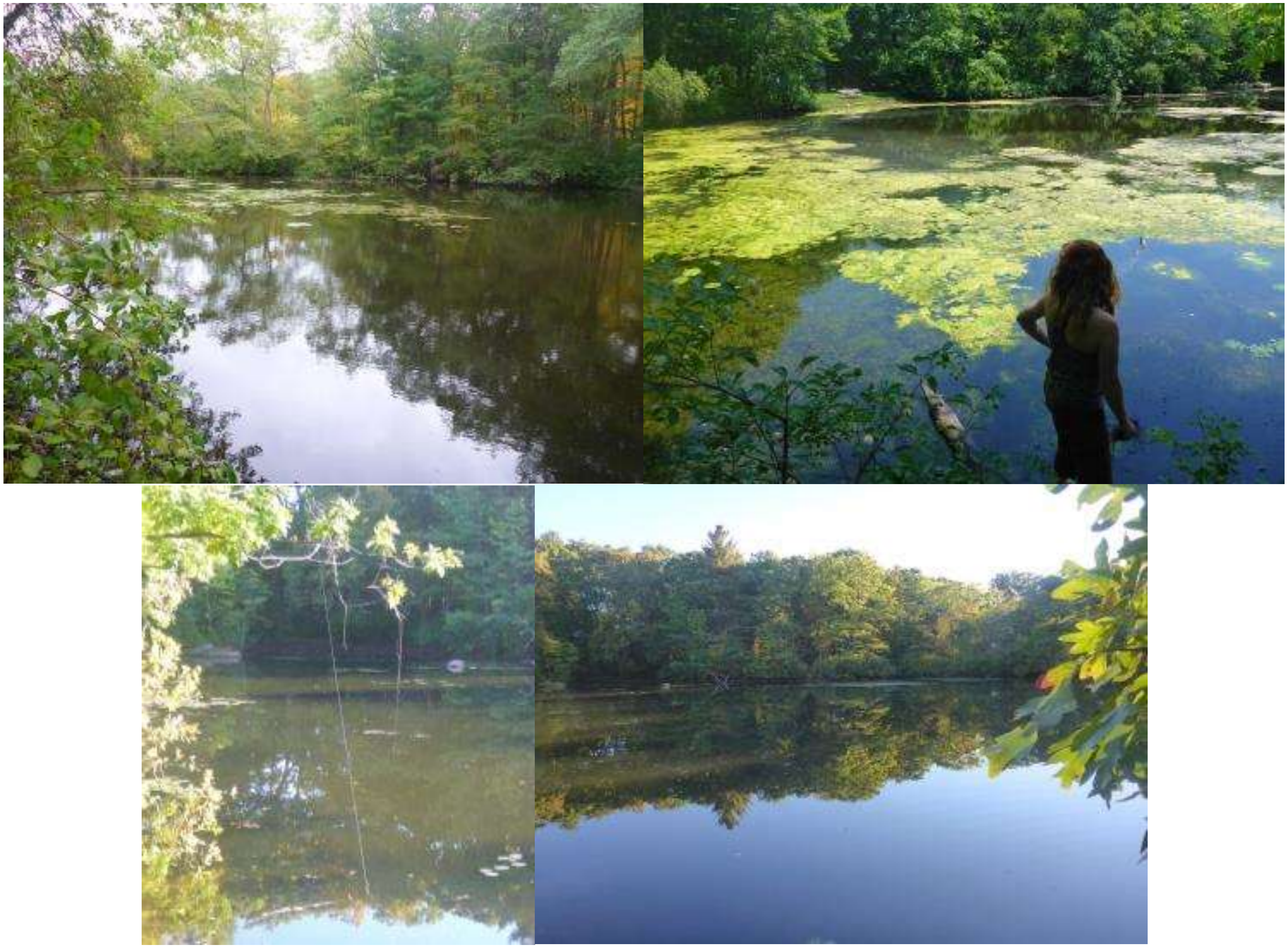

Figure 67. Rockridge Pond general appearance

Table 13. Rockridge Pond Nutrient Loading Analysis

SUMMARY TABLE FOR SCENARIO TESTING	Existing Conditions		Background Conditions	Feasible BMPs
	Calibrated Model Value	Actual Data	Model Value	Model Value
Phosphorus (ppb)	81	52	25	51
Nitrogen (ppb)	1000	840	399	616
Mean Chlorophyll (ug/L)	45.0	2.2	10.0	24.6
Peak Chlorophyll (ug/L)	143.3	2.4	34.1	80.1
Mean Secchi (m)	0.8	1.5	1.9	1.1
Peak Secchi (m)	2.9	1.5	4.0	3.3
Bloom Probability				
Probability of Chl >10 ug/L	99.7%		40.4%	94.0%
Probability of Chl >15 ug/L	97.4%		14.6%	77.0%
Probability of Chl >20 ug/L	91.5%		5.2%	56.5%
Probability of Chl >30 ug/L	71.3%		0.7%	25.9%
Probability of Chl >40 ug/L	49.5%		0.1%	11.1%

moderate and poor conditions. This is largely a function of lesser flushing of Rockridge Pond than most of the other Wellesley ponds evaluated in this effort. The watershed is high developed and most flow enters as storm water, but the watershed is not nearly as large relative to pond area as most other ponds in Wellesley. Water clarity under background conditions would extend to the bottom of the pond in all areas, but this would only promote more rooted plant growths and algae mats.

Implementation of all feasible best management practices would yield a phosphorus concentration much like that observed in 2016, a year with very limited storm water inputs. This makes sense, as most lakes in New England influenced strongly by watershed inputs experienced the best conditions in years in 2016. Nitrogen concentrations would be about 60% of the predicted current average value, and water clarity would be about 1.1 m, enough for light to penetrate to the pond bottom everywhere and continue to facilitate dense rooted plant and algae growths.

11.6 Data Analysis and Interpretation

Rockridge Pond has the potential to be a valuable amenity in a residential neighborhood, but suffers from dense rooted plant growths that include invasive species and green algae mats that can cover a substantial portion of the pond surface during summer. This excessive productivity impairs aesthetic values and limits fishing and any non-motorized boating that might occur. The path around much of the pond provides a natural respite in an urban environment, but direct views of and access to the pond from the trail are limited.

Nutrient loading to Rockridge Pond is elevated as a consequence of storm water runoff from developed land, but is not as extreme as for most other studied Wellesley Ponds. However, the water flow into this pond is lower than for most other ponds in Wellesley, leading to longer detention time in the pond and more time for nutrients to be assimilated by plants and algae. Internal loading of nutrients to the water column was not found to be especially high, but the rooted plants and algae mats can take advantage of nutrients in the sediment. Dredging about 14 years ago limited the thickness of organic, nutrient rich sediments in most areas, but there is still enough of that sediment present to facilitate dense growths of plants and algae mats in Rockridge Pond.

11.7 Management Recommendations

No amount of watershed management is expected to prevent problems in Rockridge Pond. While effort to improve storm water runoff quality will enhance the overall quality of the pond and limit the longer term build-up of nutrients in sediment, the sediment in the pond now supports excessive productivity. Dredging reduced the amount of soft sediment around the periphery of the pond, but did not remove all soft sediment and accumulations over the last 14 years are sufficient to allow continued plant and algae nuisances. A more complete dredging would be beneficial, but would be very expensive and it is apparent that even a thin coating of nutrient-rich sediment can support excessive growths in this pond.

An aluminum treatment would inactivate phosphorus in surficial sediment and minimize algae mat production, but this will not prevent rooted plant growths, as these can get nutrients from deeper than the treatment can address. Annual treatment in June should control algae for several months except possibly in a wet summer.

Harvesting plants is a viable strategy and has been applied roughly annually for many years, but harvesting needs to occur earlier and may need to be repeated to maintain desirable conditions. Water chestnut has been reduced in abundance, but could be virtually eliminated with harvesting that removes plants before seeds can be produced and dropped from the plants. It is unlikely that rooted plant growth will be eliminated by harvesting, but there could be shifts to lower growing species and open water could be maintained.

It is possible to draw Rockridge Pond down by about 3 feet over the winter, which would expose the area was dredged and could freeze out some vegetation. However, this would affect pond appearance and may impact non-target biological resources in this pond, and not all problem species are susceptible. Yet the lower water level could cause finer sediments to move into deeper water, making the peripheral substrate more coarse and less hospitable as a plant substrate.

Selective vegetation clearing along the path that runs around much of the pond would improve vistas and facilitate shoreline fishing. Currently briars are an issue in several areas, and some shrubs have grown in thickly in other areas. Low branches on trees could be trimmed to minimize interference with fishing casts.

12. Management Strategy

12.1 Common Problems

The Wellesley ponds face a variety of problems that impair designated uses. Not all are found in every pond, but each problem is found in multiple ponds.

1. Elevated nutrient loading – Phosphorus inputs in excess of 0.025 mg/L (25 µg/L) and nitrogen additions higher than 0.50 mg/L (500 µg/L) are considered elevated and likely to support algae blooms. If those nutrients are incorporated into the sediment, they are likely to support excessive rooted plant growths. Virtually all the ponds have average inputs exceeding these thresholds (Table 14), although Icehouse Pond input values are very close to the thresholds as a function of its connection with Morses Pond, which is managed for low nutrient concentrations.
2. Sediment accumulation – Just a few inches of nutrient rich sediment can support dense growths of rooted aquatic plants or supply phosphorus and nitrogen to the overlying water that will foster growth of algae mats or development of planktonic algae blooms. Even with the dredging program in Wellesley, through which sediment has been removed from Bezanson, Duck, Longfellow, Reeds and Rockridge Ponds within the last 20 years, accumulations are adequate in all ponds to allow nuisance growths.
3. Rooted plants – Bezanson, Icehouse, Longfellow, Reeds and Rockridge Ponds all have excessive growths of plants rooted in sediment. Icehouse, Longfellow and Rockridge Ponds have more serious problems than Bezanson or Reeds Ponds, but growths in each impair uses. Abbotts and Duck Ponds have minimal rooted plants, and Farms Station can be covered by floating watermeal and some duckweed, but those plants are free-floating, not attached to sediment, and are ecologically more similar to algae mats.
4. Algae mats and floating vascular plants – Bezanson, Farms Station, Longfellow and Rockridge Ponds experience dense growths of filamentous algae that form mats or small, floating plants not anchored to the sediment that can cover the pond. Other ponds do not have enough of these mats or free floating plants to represent use impairment.
5. Turbidity induced by planktonic algae or resuspended sediment – All evaluated ponds except for Icehouse Pond have elevated turbidity at times, even during dry weather. Increased turbidity during wet weather is to be expected, but lasting turbidity is a function of either abundant microscopic algae and/or resuspended fine sediment that does not settle quickly.
6. Oxygen stress – All the ponds have highly organic sediment over a substantial portion of the pond bottom, and decay during summer (and possibly under ice in winter, although this was not evaluated) will pull oxygen out of the overlying water. Where the demand is high and resupply of oxygen from the atmosphere to the water column is not rapid, oxygen deficits

can occur and may stress aquatic life, induce odors, and facilitate phosphorus release from sediment. Only Farms Station, Longfellow and Icehouse Ponds exhibited enough oxygen depression to be a concern during sampling visits in 2016, but all of these ponds are threatened to some degree.

7. Access limitations – Abbotts and Icehouse Ponds are largely inaccessible to the public due to shoreline conditions, mainly dense vegetation and unstable footing. Longfellow, Reeds and Rockridge Ponds have access points and peripheral paths, but access could be improved, especially for fishermen. Even where direct access may not need to be increased, views could be enhanced by some selective trimming.
8. Waterfowl nuisances – Duck and Longfellow Ponds have abundant waterfowl that sometimes create nuisances in public access areas. Duck Pond waterfowl are an intended feature of the pond and its surroundings, but at Longfellow Pond the easiest access to shore for geese is the parking area.

Table 14. Phosphorus, Nitrogen and Water Loadings to Wellesley Ponds

	Duck Pond			Longfellow Pond			Farms Station Pond			Rockridge Pond		
DIRECT LOADS TO LAKE	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)
ATMOSPHERIC	0.1	2.1	3935	0.6	19.6	35962	0.1	2.5	4608	0.2	6.0	11040
INTERNAL	0.0	0.1	0	3.0	9.0	0	0.3	0.8	0	0.2	0.6	0
WATERFOWL	4.0	19.0	0	2.0	9.5	0	0.0	0.0	0	1.0	4.8	0
WATERSHED LOAD	101.2	1346.8	748005	353.3	5546.8	4216716	50.6	1173.5	902346	21.0	245.6	212142
TOTAL LOAD TO LAKE	105.3	1368.1	751939	358.9	5584.9	4252678	51.0	1176.8	906954	22.4	257.1	223181
INCOMING CONC (mg/L)	0.140	1.819		0.084	1.313		0.056	1.298		0.101	1.152	

	Icehouse Pond			Bezanson Pond			Reeds Pond			Abbotts Pond		
DIRECT LOADS TO LAKE	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)
ATMOSPHERIC	0.4	13.0	23876	0.0	1.3	2357	0.2	5.0	9125	0.1	4.8	8871
INTERNAL	0.5	1.4	0	0.0	0.0	0	0.1	0.3	0	2.9	7.0	0
WATERFOWL	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
WATERSHED LOAD	0.4	8.3	23085	6.0	85.7	97466	157.3	2005.4	2171145	21.2	224.2	124963
TOTAL LOAD TO LAKE	1.3	22.7	46961	6.0	87.0	99823	157.5	2010.7	2180270	24.3	236.1	133835
INCOMING CONC (mg/L)	0.027	0.483		0.060	0.872		0.072	0.922		0.182	1.764	

12.2 Matching Solutions to Problems

There are multiple theoretical solutions to any pond problem, but not all are really feasible or even applicable to all of the subject ponds. A complete listing of control methods for algae and rooted plants is provided in the Appendix for review, but here we will confine discussion to approaches that make the most sense for the Wellesley ponds.

Elevated Nutrient Loading

The first choice for reduced nutrient loading is always reduction in sources, but with virtually every pond receiving nutrients from a substantially developed watershed much larger than the ponds themselves, this is a major challenge. The modeling for all but Icehouse, Farms Station and Longfellow Ponds suggests that the phosphorus threshold for productivity problems would be exceeded even under background conditions (undeveloped watershed), and only Icehouse Pond can meet that threshold with feasible application of best management practices. This is much the same problem faced by Morses Pond, a problem that has been largely solved with a phosphorus inactivation program in which an aluminum compound is injected into incoming storm water during late spring and occasionally during summer. A similar program for other Wellesley ponds could be developed, but with smaller size, it may be most advantageous to just treat the ponds sometime in June with a repeat later in summer if necessary.

This does not mean that all watershed management action should be abandoned. Wellesley already has ordinances in place to limit runoff and related loading, and the gradual minimization of phosphorus in lawn fertilizers (by manufacturers after enough states have required it) is also expected to reduce urban loading. Maintenance of drainage systems, encouragement of low impact development techniques for new construction or existing residential or commercial properties, and possible additional structural controls are all worthwhile. However, spending very large sums of money to get small reductions in loading will not achieve the goal, and the limitations imposed by urbanized watersheds should be acknowledged. The town's current program of nutrient control under the NPDES program should continue.

Another option in the ponds is dredging, which removes internal reserves that can provide nutrients to the overlying water, but this is an expensive option and one that does not affect the much larger external load calculated for each pond (Table 14). Dredging would help with several other problems, however, and is worthwhile as finances allow.

Sediment Accumulation

Keeping sediment from accumulating is highly desirable, and in developed watersheds the best practice is to keep catch basins clean so that material accumulates in them instead of the pond to which the drainage system leads. There are limits, however, as larger storms flush sediment (both inorganic and organic) through the system and direct leaf fall into ponds cannot be prevented. Ultimately, small ponds with large watersheds must be dredged to restore water depth. The watersheds for all the assessed Wellesley Ponds are large relative to the pond area, and the highly organic nature of sediments in them suggests that the problem is not with trapping inorganic solids from construction or road sanding, but rather the ongoing inputs of organic matter (especially leaves) and internal production of organic matter (algae and plants).

As has been recognized by the Town of Wellesley through past programs, dredging is the only realistic solution to organic sediment build-up. Five of the eight subject ponds have been dredged over the last 20 years, plus the State Street Pond just recently and part of Morses Pond in 2012-2013. While regulations and costs make dredging a challenging practice, it remains essential for restoring pond capacity and also helps with other pond problems, including rooted plants, algae mats and oxygen depression. Additional dredging is appropriate on an as needed basis and when funds are available.

The primary alternative that people read about on the internet is digestion of organic sediments with enzymes or bacterial additives. While this has theoretical appeal and sounds plausible in advertisements, there is no peer reviewed literature indicating any substantive success and the few trials with which we are familiar or have been involved did not reduce organic sediment volume. Instead, while there was indeed enhanced decay and reduced sediment mass, the sediment simply became more watery and actually increased in volume in one recent case very similar to the Wellesley ponds. The estimated cost of complete decay, if achievable, was on the same order as dredging and the timeframe was much longer (5 years or more). This is not yet a practical alternative to dredging.

Rooted Plants

Plant nuisances represent the manifestation of the first two problems above. While most plants take most nutrition from the sediment, some do utilize nutrients from the water column (e.g., coontail, a dominant in some ponds, and floating duckweed and waterweed, although those are considered with algae) and those that do require sediment sources do not need all that much sediment. Rooted plants are part of a healthy pond ecosystem, but when the density gets too high, most pond uses can be impaired. This includes not just human uses, but habitat function as well, as dense rooted plants decrease efficiency by some predatory fish and can cause fluctuations in oxygen, pH and other water quality features that are detrimental. Control of rooted plants in ponds with substantial “soft” sediment is therefore necessary to maximizing pond functions.

Dredging certainly helps limit rooted plant growth, but does not completely prevent it and as observed in the Wellesley ponds, replacement of sediment occurs within years and supports renewed rooted plant growths. Dredging remains an appropriate control technique, but is too expensive to perform on a regular basis.

Grass carp can minimize vegetation in a pond and, where nutrient inputs are already high, can do so with little consequence to water quality. However, grass carp are illegal in Massachusetts, so this option is not available at this time.

Herbicides can reduce vegetation density and can sometimes be used to target invasive species, but are not allowable on public property in Wellesley by town policy, so this option is also not available.

Drawdown, or water level lowering, is usually conducted in late fall and held until late winter and can dry and freeze exposed vegetation. It works on species that overwinter in some vegetative state, but is ineffective on annual, seed producing plants. While the potential exists to lower the water level by removing flashboards or opening valves on subsurface pipes for some of the Wellesley ponds, the magnitude of possible drawdown by removing flashboards is very limited, and not all problem species are susceptible to control by drawdown. Drawdown at Longfellow, Reeds and Rockridge Ponds may be of a magnitude that could improve peripheral plant conditions, but could render those ponds unsightly during the drawdown period and is not likely to be sufficient by itself to achieve the desired level of plant control in those ponds. Drawdown is, however, an inexpensive approach to plant control and could reduce the area targeted by other methods such as harvesting.

Of the common species that become overabundant in Wellesley ponds, Eurasian watermilfoil, variable leaf watermilfoil, fanwort (all invasive species) and coontail can be controlled by drawdown, but all except coontail are found only in Icehouse Pond, which cannot be drawn down more than 2.5 feet as a function of Morses Pond water level control. And even with that annual 2.5 foot drawdown, the three invasive species are still abundant in Icehouse Pond. Water chestnut, duckweed, watermeal and waterweed are typically not controlled by drawdown. Mixed results are expected for white and yellow water lilies, as the heavy root stocks can be deep enough in organic sediment to be protected from drawdown effects. Yet repeated drawdown may make exposed sediments more coarse, limiting plant growth somewhat in the exposed area.

Matching abundant susceptible species to outlet structures that facilitate drawdown, Longfellow, Reeds and Rockridge Ponds are potential candidates for drawdown, but the level of drawdown facilitated by current outlet structures is limited for Reeds (0 inches) and Rockridge (10.5 inches) ponds and subsurface pipes would have to be opened to achieve a meaningful drawdown in those two ponds. Water level control is not currently adequate at Abbotts, Bezanson or Icehouse Ponds and Duck and Farms Station Ponds do not have problems with rooted plants that are attached to sediment. Lowering the water level in November is the standard practice in Massachusetts, with refill by the end of March. Holding a drawdown may be challenging in Longfellow and Reeds Ponds, where the very large watershed can provide higher flows than the outlets can pass. Drawdown may be worth attempting in Longfellow, Reeds and Rockridge Ponds on an experimental basis, but may not be adequate by itself to achieve control over rooted plant communities.

Benthic barriers are sheet materials that can be laid on the bottom of a pond to prevent plants from growing. They can be porous or impermeable and most forms are strong enough to be moved after a time, facilitating control of multiple areas in a single growing season and removal of accumulated sediment from the barrier. While they are slightly negatively buoyant, they are usually weighted down with small sandbags, bricks, or rebar to be sure they stay in place. They can be mounted in frames for easy deployment in small areas or rolled out in a linear swath in overlapping runs to cover larger areas. They are effective for most submerged plants and are often applied to swimming areas (in water deeper than where people wade) or boat launches. Use in areas popular for fishing can be problematic, as hooks will snag the material.

Control of rooted plant nuisances with benthic barriers in all but Duck and Farms Station Ponds could be considered, but may not be the best approach where fishing is a prime use. This suggests that use in Longfellow, Reeds and Rockridge Ponds would be restricted to areas of limited fishing access. Benthic barriers would be visible in the shallow water near shore, and may be considered unaesthetic by some people, but could certainly be tried in selected areas of Bezanson Pond and might be very effective in maintaining open water and more aesthetic views at Icehouse Pond.

Harvesting encompasses a range of techniques and includes manual removal (hand pulling), diver assisted suction harvesting (DASH), mechanical cutting with or without collection of cut plants, and hydroraking (disturbing the bottom and ripping out plants by the roots). DASH is not really applicable in these shallow ponds, and hand pulling will only become applicable when dense growths are thinned, and then only for targeted species like water chestnut, which can be virtually eliminated if pulled before seeds are produced and released. Hydroraking has been employed in Morses Pond in the swimming area and around the periphery where mechanical harvesters cannot work effectively, and would be applicable where plants such as water lilies are dominant. However, hydroraking does not produce lasting results for thinly rooted species like coontail, milfoil species, fanwort, waterweed or pondweeds. Except perhaps in Icehouse, Longfellow and Rockridge Ponds, where water lilies are dense in areas, hydroraking is not a particularly applicable plant control method for these ponds. Other problem species are present in Icehouse, Longfellow and Rockridge Ponds, so hydroraking would not be a complete solution to plant problems in those ponds.

Mechanical harvesting, which has long been practiced at Morses Pond and often annually conducted at Longfellow and Rockridge Ponds, functions similarly to mowing a lawn, cutting aquatic vegetation at water depths up to about 5 ft without greatly disturbing roots. The machine used in Longfellow and Rockridge Ponds through 2016 is an older model (1983), and is unlikely to be fully functional in 2017, but it has cleared vegetation from those ponds in July or early August of most years. Harvesting outside of Morses Pond has been conducted when the harvester and staff were available, limiting harvesting in other Wellesley Ponds.

Abbotts, Duck and Farms Station Ponds do not require rooted plant control at this time, although each could be a candidate for dredging at some point (Table 15). Icehouse Pond has no access for harvesting and cannot be drawn down more than what drawdown of Morses Pond allows (about 2.5 ft), but more open water could be created with benthic barriers. The other four ponds (Bezanson, Longfellow, Reeds and Rockridge) could be addressed with some combination of benthic barriers, drawdown and mechanical harvesting.

Table 15. Summary of Applicable Rooted Plant Control Techniques for Wellesley Ponds

	Wellesley Ponds								
Plant Control Technique	Abbotts	Bezan-son	Duck	Farms Station	Icehouse	Long-fellow	Reeds	Rock-ridge	Notes
Dredging	X	X	X	X	X	X	X	X	Not all ponds need it now
Grass carp									Illegal in MA
Herbicides									Not permitted in Wellesley
Drawdown						X	X	X	Limited outlet capability
Benthic barriers		X			X	X	X	X	Limit use in fishing areas
Harvesting		X				X	X	X	By mechanical means

Algae Mats and Floating Vascular Plants

Problems with loose, floating macrophytes are related more to water quality than sediment, although resting stages of plants and algae do interact with sediment and growth may occur at the sediment-water interface before the plants or algae rise in the water column. Certainly addressing sediment issues (e.g., dredging) would help control nuisance growths of floating plants and algae, but may not be sufficient by itself. Reducing the inflow of nutrients to the ponds would also be helpful in limiting floating plants and algae mats, but as previously described, the size and developed nature of the watersheds involved greatly limits the progress that can be made. Even with no development in the watershed, most of these ponds would be expected to have phosphorus concentrations high enough to support nuisance growths. Both dredging and control of inflowing nutrients remain highly applicable approaches, but cost and effectiveness will be limiting in virtually all Wellesley Ponds. Action within each pond is likely to be necessary to maintain desired conditions. Other means for controlling these growths in the water column include algaecides, phosphorus inactivation, circulation, sonication and flushing.

Flushing could be implemented to shorten detention times, as these ponds are not large, but this would require the use of potable water from hydrants at considerable expense without really reducing loading. Flushing occurs naturally for some ponds (Reeds, Longfellow, Duck, Farms Station) when it rains, as the watersheds are very large relative to pond area. Providing enough water to flush any of these ponds during dry weather represents a challenge and may not be practical. Additionally, adequate flushing may resuspend bottom sediment and cause additional turbidity, impairing the ability of flushing to increase water clarity and overall pond appearance.

Although herbicides are not allowed to be applied on public property in Wellesley, algaecide use has been permitted in Morses Pond on a localized basis to maintain water clarity if algae become overabundant. Since the implementation of phosphorus inactivation at the two main inlets to Morses Pond, only one algaecide treatment has been conducted. Use of algaecides in the Wellesley ponds is possible but much less desirable than controlling phosphorus availability. Effective algaecide use would require weekly algae monitoring, an added cost and complication since rapid turnover of algae analyses is not commonly offered by laboratories offering such services. Also, the regulations governing algaecide use typically limit application to no more than half the target waterbody, leaving a substantial portion of these small ponds untreated. While applicable, algaecides are not a preferred approach for the Wellesley ponds.

Sonication involves placement of sound producing units that emit waves that disrupt algae cell walls. This approach has been described as a "line of sight" technique, whereby the sound waves must have a direct line to the target algae. This means that units must be positioned to cover all target areas and cannot have interference from rooted plant growths. Sonication does not appear to work on floating plants and has enjoyed limited success with algae mats, mostly by preventing growths, not by removing developed mats. Consequently, the potential for this approach to provide acceptable results in the Wellesley ponds is limited, although it remains applicable for some of the ponds.

Circulation involves moving water in a way that disrupts growth by floating plants and algae mats. This can be done by pumping water or moving it with released compressed air. There is a known range of airflow or water movement that works, and these revolve around moving all the target water every 1-5 days. Achieving this rate of circulation is difficult in shallow ponds, as the vertical distance for air bubbles to rise or water to be pumped is very short, decreasing efficiency and increasing the potential to resuspend bottom sediments. Only Farms Station Pond has a physical morphometry suitable for circulation to make a positive difference.

Phosphorus inactivation, practiced at the two main inlets to Morses Pond, has been very successful in reducing the availability of this key nutrient in many systems, including Morses Pond and by connection in Icehouse Pond as well. Aluminum is the most common phosphorus binder applied, and can be used to treat surficial sediment, the water column, or incoming flows. For the small Wellesley ponds, application to the water column seems most appropriate, and would treat surficial sediment as well, although not at the typically higher doses used for that purpose. Application of up to 3 mg/L as aluminum could be conducted in June, after spring flows have subsided, and might keep the ponds free of floating plants and algae mats through summer. Repeat application would be possible as warranted, although such treatment is intended to prevent growths and will not kill them once formed.

Considering the range of applicable techniques for controlling algae mats and floating plants in the Wellesley ponds (Table 16), reducing the inflow of nutrients to the extent possible and dredging the ponds are applicable to all and would provide desirable results, but both are expensive and difficult to implement. The use of water column aluminum treatments to inactivate phosphorus in the water going into summer and provide some level of inactivation of the surficial sediment over time represents a widely applicable and potentially cost effective approach for these ponds.

Table 16. Summary of Applicable Algae Control Techniques for Wellesley Ponds

	Wellesley Ponds								
Algae Control Technique	**Abbotts**	**Bezan-son**	**Duck**	**Farms Station**	**Icehouse**	**Long-fellow**	**Reeds**	**Rock-ridge**	**Notes**
Nutrient inflow control	X	X	X	X	X	X	X	X	Already in use at Icehouse
Dredging	X	X	X	X	X	X	X	X	Will not control inflowing nutrients
Flushing									Sources of water very limited when needed most
Algaecides	X	X	X	X		X	X	X	Not needed in Icehouse, not recommended over P inactivation in other ponds
Sonication		X				X	X	X	Power supply an issue, limited effect on mats or floating plants
Circulation				X					Only Farms Station is deep enough to make this an efficient approach
P inactivation	X	X	X	X	X	X	X	X	Water column treatment appears preferable

Turbidity Induced by Planktonic Algae or Resuspended Sediment

As with floating plants and algae mats, planktonic algae depend mainly on the water column for nutrients. In the Wellesley ponds, modeling overpredicted the quantity of planktonic algae that would be present, suggesting that other factors besides nutrients control planktonic algae. The presence of dense vascular plants, extensive algae mats, and high turbidity in the water that restricts light penetration are likely causes of low planktonic algae in a high nutrient environment. Flushing from storms is also a potential control in some ponds. If vascular plant and algae mat problems are resolved, greater phytoplankton production is expected in many of these ponds and may necessitate action. Only continued resuspension of sediment will limit light and phytoplankton growths, and the associated turbidity is undesirable and a target of control efforts as well.

The list of applicable techniques in Table 16 is appropriate to planktonic algae as well. Dredging would limit internal nutrient reserves and remove resting stages of algae, from which planktonic growths are often initiated. Reducing nutrient inputs from the watershed is also highly applicable. Both dredging and external nutrient controls are expensive however, and there are limitations on the implementation of each, cost for dredging and limits to the effectiveness of best management practices for watershed management. Use of algaecides is applicable but not preferred over phosphorus inactivation for reasons of effectiveness and possible non-target impacts. Sonication is more applicable for planktonic algae than for algae mats, but will not address turbidity from resuspended sediment, and issue for most of the ponds.

Phosphorus inactivation as described for algae mat and floating plant control is equally appropriate for planktonic algae and turbidity control and has been very effective in Morses Pond, by extension to Icehouse Pond, and in other systems in New England. Aside from limiting phosphorus availability and therefore indirectly controlling algae growth, aluminum acts as a coagulant to settle solids and clear the water column. The floc that forms will settle onto the surface of the sediment and congeal it to some degree, limiting resuspension. The dose typically applied for water column control is lower than dose usually applied for inactivation of sediment, but the effect of multiple treatments is additive and improved control of sediment resuspension is expected over time. This will work less well where inflow velocities are high, as may be the case in Duck and Reeds Pond, but both of these flush rapidly and treatment may be needed after larger summer storms to restore clarity.

Oxygen Stress

The highly organic sediment in all the Wellesley ponds creates an oxygen demand that could stress pond ecology, but most of the ponds are so shallow that reaeration from the atmosphere is adequate to prevent low oxygen conditions from developing. Exceptions include Farms Station Pond, which is deeper than the other assessed ponds, and Icehouse and Longfellow Ponds, which develop dense plant communities with high surface coverage that apparently restricts reaeration. There is potential for such limitation in Rockridge Pond as well, but no low oxygen values were observed in that pond in 2016.

Low oxygen can be countered by removing the source of oxygen demand or increasing oxygen input. Dredging of all the ponds is applicable and appropriate, and four of eight have been dredged in the past, removing organic sediments with high oxygen demand. Continuation of that program is advisable, but is expensive and logistically difficult. Reducing plant and algae growths lowers the amount of organic matter added to the sediment and will ultimately lower oxygen demand as well.

Adding oxygen can be accomplished by circulation or removal of plants and algae mats that restrict reaeration. Circulation is only practical for Farms Station Pond, and if the dense covering of watermeal was eliminated oxygen depletion might not occur in deeper portion of this pond. For all ponds experiencing depressed oxygen levels, control of rooted plant biomass would help with natural circulation and movement of oxygen from the atmosphere into the water. So oxygen management is coincident with plant and algae management in all cases.

Access Limitations

Abbotts and Icehouse Ponds have almost no access for people, and that may be an acceptable status if their use is to be confined to wildlife habitat. If access to either is desired, vegetation control and creation of safe footing is needed. In the case of Abbotts Pond, clearing of vines, dense underbrush, and leaning trees would best be accomplished when the ground is frozen. Creation of a short boardwalk from either Chatham Circle or Fox Hill Road through the wooded wetland to open water would offer access and views.

Access to the other six ponds is adequate, but could be enhanced. Existing trails could use some selective trimming for walking, viewing and fishing. Parking at Reeds Pond is limited to nearby Woodside Road, a substantial distance from the outlet park area where canoes and kayaks might be launched, but no easy alternative exists.

Waterfowl Nuisances

Waterfowl at Duck Pond are not viewed as a nuisance, and fencing limits movement of ducks and geese onto the path from the parking area. The primary waterfowl nuisance is at Longfellow Pond, where ducks and geese utilize the parking area to a large extent in summer. Keeping waterfowl out of this area would improve appearance and sanitation. This could be accomplished by fencing, but would be more aesthetically done with low, dense planting along the shore between the parking area and the pond, and by providing alternative areas for waterfowl to congregate off the water. Selective vegetation thinning at a few shoreline points opposite the parking area would help, and a couple of floating islands could be created in the southern basin.

12.3 Plan Development

Further input from neighborhood residents and the user community should be sought, but based on everything learned to this point and the analysis provided so far, a draft management plan for the assessed Wellesley ponds can be formulated. The key inputs needs relate to goals for these ponds, as they can be managed for a range of uses. We have impressions from several meetings to date that have guided this planning effort, but no decisions have been made for ponds with less use (e.g., Abbotts, Icehouse). Adjustment may be necessary if goals as currently understood differ from what the public really wants and the town is prepared to support.

The focus of this plan is on reducing vascular plant and algae nuisances in the Wellesley Ponds. This would logically involve both watershed and in-lake measures, but the nature of the watersheds is such that effort in the watersheds will not yield consistently acceptable conditions in the ponds, by virtue of size and land use. Watershed measures such as street sweeping, catch basin cleaning, reduced phosphate fertilizer use, and minimization of runoff caused by landscape watering are all in place. Continued emphasis on these actions and education of residents about their role in improving runoff water quality is needed, but additional structural measures are viewed as too expensive and not effective enough to warrant inclusion in this plan. Where opportunities arise to better manage storm water, especially were runoff can be reduced by low impact development techniques, full advantage should be taken. But creation of detention areas as large as the existing ponds to better protect those ponds is not rational. Additionally, limited control over private property and even public property outside the border of Wellesley is recognized.

Rooted Vascular Plants

Rooted plant biomass can be reduced by dredging, benthic barriers, drawdown and harvesting. Dredging has been conducted in some ponds already and even those may need to be redredged at some point; removal of accumulated sediment restores the ponds, but is expensive and has environmental impacts that complicate permitting processes. Continuation of the town dredging program is advised, but this is not likely to provide short term relief in many cases.

Benthic barriers are expensive on a unit area basis, but can be effective in small areas. While used most often in swimming areas and at boat launches, benthic barriers would make the most sense to increase open water in Icehouse Pond, where access and direct use are limited and what is desired is a slightly more aesthetic view. Application of about an acre of non-porous benthic barrier could limit rooted plant growth at a cost of approximately $40,000. With limited flow through this pond, maintenance needs should be minimal for non-porous barrier and 5 to 10 years of relief could be expected. Use in other ponds would be limited to areas where the barrier would not be readily visible or interfere with fishing and would not be a mainstay of plant management; some experimentation in Bezanson, Longfellow, Reeds and Rockridge Ponds may be worthwhile. The primary alternative for Icehouse Pond would be to create access for a mechanical harvester and to extend the program conducted in Morses Pond.

Drawdown represents an inexpensive option that could be tried where the outlet supports it and the plant community is susceptible to it (Longfellow, Reeds and Rockridge Ponds), but the depth of drawdown is limited and may not be adequate by itself to prevent summer plant nuisances. Draining these ponds in winter would have ecological impacts that may be unacceptable under the Wetlands Protection Act, but some lowering of Longfellow, Reeds and Rockridge Ponds may warrant experimental use to determine benefits. Outlet modifications to support drawdown will be expensive and the potential benefit is too speculative to warrant that expense for ponds that do not already have an appropriate outlet structure.

Harvesting represents an acceptable maintenance activity in Morses, Longfellow and Rockridge Ponds now, but only Morses Pond gets consistent attention during late spring and summer. At issue is availability of equipment and staff, and with the older, smaller harvester at the end of its lifespan, purchase of a new machine is being planned. If the new harvester is small enough to be more easily transported and used in the Wellesley ponds, Bezanson and Reeds Ponds could be added to Longfellow and Rockridge Ponds as harvested ponds. Access would need to be nominally improved for both Bezanson and Reeds Ponds, but harvesting would be a viable approach in each. Harvesting could also be applied to Icehouse Pond if access was created, larger task for that pond. Harvesting is not needed in Abbotts, Duck, or Farms Station Ponds now. As the smaller harvester is needed to support the Morses Pond program, it is likely to be obtained, and use in other Wellesley ponds would seem advantageous.

One issue for harvesting is timing. Traditionally, Longfellow and Rockridge Ponds have been cut in July or early August, after earlier season work at Morses Pond was completed, and only one period of cutting was provided in each per summer. This is partly a staffing issue, but also relates to the difficulty in transporting a harvester among ponds; specifications for a new harvester should minimize size and maximize transportability and durability. Cutting in June would be preferred, with follow up in August as warranted.

The features of a new harvester have been addressed in a separate document prepared as part of ongoing Morses Pond management planning. The expected cost will be on the order of $150,000, possibly as high as $200,000 with options and accessories. Permitting for harvesting is not complicated and has been done in the past for at least Morses, Longfellow and Rockridge Ponds. The cost of permitting should not exceed about $2000 except for notification of abutters, which could be substantial in some of the neighborhoods.

Control of rooted aquatic plants will reduce the accumulation of organic sediment and associated oxygen demand, two other problems that need to be addressed in most ponds.

Algae and Floating Vascular Plants

Reducing inputs of nutrients to the point where growths of algae and floating aquatic plants are not objectionable is only realistically possible in Icehouse Pond, where this has already been largely accomplished by extension of the Morses Pond phosphorus inactivation program. Other ponds will likely always have elevated nutrient levels with only watershed management, given large, urban watersheds; there are limits to what best management practices can do. Controlling phosphorus concentration in the ponds offers the greatest potential to restrict algae and floating plant nuisances, and has been accomplished elsewhere with aluminum addition.

The easiest way to treat the Wellesley Ponds would be with a portable dosing system (Figure 68). While the details can be adjusted, the intent would be to supply enough aluminum to dose each targeted pond at a concentration of up to 3 mg/L. Using polyaluminum chloride, the same coagulant used at Morses Pond since 2014, the volume of applied solution for each pond (Table 17) ranges from about 11 gallons for Duck Pond to 282 gallons for Longfellow Pond. Other than Longfellow Pond and Icehouse Pond (which does not need to be treated), all ponds to be treated would require <100 gallons of polyaluminum chloride solution.

A small boat would be used to move an injection wand around each pond to be treated, while polyaluminum chloride would be pumped from the trailer through a long hose. Lines in Morses Pond are over 1000 ft long, so distance is only an issue in terms of the amount of hose needed and physically moving it. All but Longfellow Pond would require only a few hundred feet of hose, and several access points might be used to treat Longfellow Pond to limit hose length (most of Longfellow Pond could be reached with 500 ft of hose from two locations, the parking area and the end of Priscilla Road). It would also be possible to treat ponds from their inlets during periods of elevated flow. This could work well with Duck, Longfellow and Reeds Ponds.

Ideally, treatment would occur in June, before plants and algae become dense, but if plant harvesting occurs then, it would be best to wait until that harvesting is complete, as it will generate turbidity that the treatment could address. There is no plan to harvest Abbotts, Duck or Farms Station Ponds, and these could be treated first. Bezanson, which has coontail as its dominant plant and takes most nutrition from the water column, might not need to be harvested if phosphorus inactivation was successful. Icehouse does not require treatment and is unlikely to be harvested unless access is created, so it is mainly Longfellow, Reeds and Rockridge Ponds where aluminum treatment timing needs to be coordinated with any harvesting.

The expected cost of a mobile phosphorus inactivation system is on the order of $70,000. Enough chemical to treat each pond twice between June and August would cost about $4000 and the labor to conduct the treatments would cost about $12,000. A permit under the Wetlands Protection Act would also be needed, along with a License to Apply Chemicals, at a cost of up to $5000, good for 3 years with possible renewal for another 3 years before refiling. The only complication in permitting cost would be notification of the many abutters.

Aluminum treatments should also limit non-algal turbidity, generated mainly through resuspension of organic sediments within the ponds. Treatment may increase the stability of sediments and reduce resuspension by wind, but it may take several water column treatments before such effects are evident. Gradual inactivation of surficial sediment phosphorus is also expected over time, and could be accelerated by higher dose treatments if desired. While the external load was dominant in all ponds, algae mats may be linked to sediment sources.

Figure 68. Schematic of a Portable Aluminum Dosing System

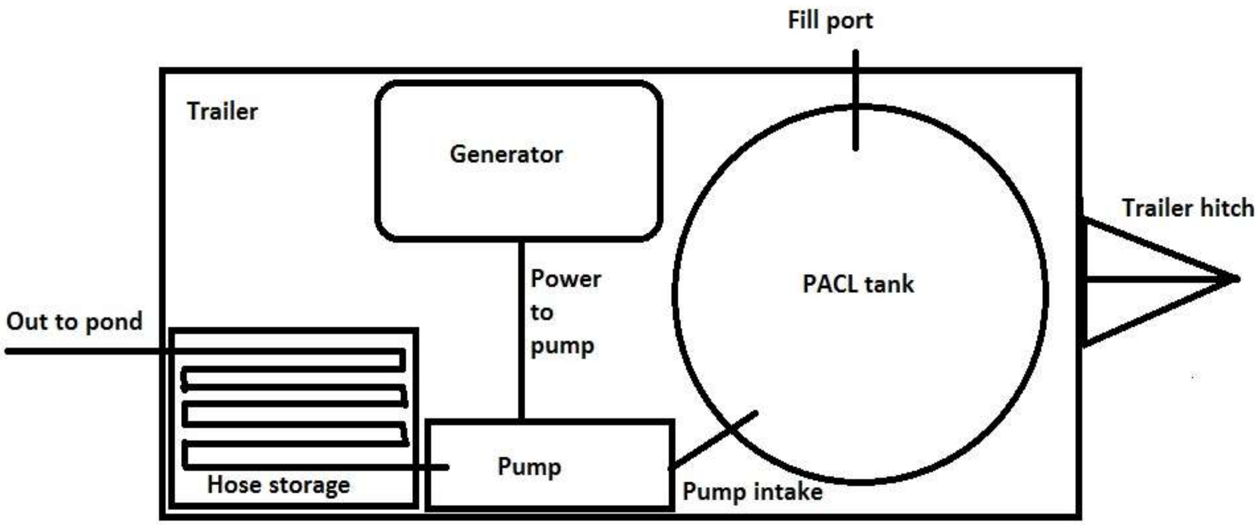

Table 17. Quantity of Polyaluminum Chloride Needed to Treat Ponds

Pond	Pond Area	Water Volume		PACL Mass for 3 mg/L	PACL Vol for 3 mg/L
	Acres	Acre-feet	m3	Kg	Gallons
Abbotts	1.8	2.7	3287	9.9	39.1
Bezanson	0.5	1.3	1647	4.9	19.6
Duck	0.8	0.8	938	2.8	11.1
Farms Station	1.0	3.8	4714	14.1	56.0
Icehouse	5.0	16.8	20669	62.0	245.6
Longfellow	7.5	19.2	23735	71.2	282.0
Reeds	1.9	4.6	5721	17.2	68.0
Rockridge	2.3	5.5	6840	20.5	81.3

Access, Waterfowl and General Appearance Issues

If rooted plant, algae and general turbidity problems were addressed, remaining issues at the ponds would vary by pond and include access for people for various pursuits, waterfowl mainly at Longfellow Pond, and general appearance of the shoreline and pond beyond plants, algae and turbidity.

Access relates to goals, and for some the need is clearer than for others. It is not known if any better access to Abbotts or Icehouse Pond is needed. If so, physical arrangements need to be improved, as neither of these ponds can be conveniently accessed by people now. As wildlife habitats, neither requires more human access. It would be appropriate to do some trimming and clean-up of trees and lower brush at Abbotts Pond, which would best be accomplished when the ground (and pond) was frozen. Massive removal of downed trees or vegetative clearing would not be consistent with provision of wildlife habitat, but improving views around the pond can be accomplished without significant habitat impact.

It seems unlikely that additional human access to Icehouse Pond is needed, as adjacent Morses Pond provides extensive access and a range of recreational opportunities. One can view Icehouse Pond from almost any angle, so the real issue is appearance, with both rooted plants and trash cited as problems. Plant management is addressed separately in this plan. Trash comes mainly from the beach complex, and greater control of waste disposal at that facility is recommended. We also have a report of odor from Icehouse Pond, but have no information on the nature of the odor or if Icehouse Pond was actually the source.

Access to Bezanson, Duck and Farms Station Ponds is adequate for current uses, and even with improvements in plant, algae and turbidity conditions, no additional access improvement appears necessary.

Reeds Pond has a small park area at its southern (outlet) end and access is possible along the eastern shore along a trail, but it would be possible to establish a trail around more of this pond if desired. It is not clear that there is sufficient demand for such a trail, there appears to be one private property that could prevent a complete circuit around Reeds Pond, and the only parking would be on Woodside Road, but there is space on the pond side of that street for a row of cars and minor adjustment would allow safer parking. There is an access point off Woodside Road that may have been used for dredging access in the past and could be improved to serve as a boat launch area and harvester access point.

Longfellow and Rockridge Ponds are perhaps the most used ponds with the greatest range of uses of the assessed Wellesley ponds, and have associated parking and trails. Some improvement of views and shoreline fishing opportunity is desired, and can be accomplished by vegetation trimming along the trails. The use of the parking area at Longfellow Pond by ducks and geese should be discouraged by creating a vegetative barrier to easy transition from water to land, and by making other shoreline areas around the pond more attractive to waterfowl. Creation of a pair of floating islands about 100 feet north of the parking area would provide for both bird safety and enjoyable viewing while limiting sanitation issues in the parking area.

All of the access and appearance issues would likely be addressed by town departments without a quantifiable external cost. Solutions require effort that translates into town expenditures, but there is no major equipment to be purchased or services to be contracted. Some of the access and clean-up work would make good projects for civic groups.

12.4 Plan Summary

While additional input should be sought before finalizing this plan, the key elements can be summarized (Table 18). While all of the ponds could benefit from dredging, this is an expensive action invoked only when necessary. Duck Pond was dredged 11 years ago, but is half full with sediment and debris and should be cleaned out as soon as possible. Longfellow Pond has not been dredged but has lost 41% of its capacity and has serious problems with rooted plants and algae mats that are linked to the accumulated sediment. The gas lines that traverse this pond may complicate or even prevent dredging, and the cost would be more than $600,000, possibly a lot more if the sediment is contaminated with metals and/or hydrocarbons as is often the case in urban ponds. If dredging Duck and Longfellow Ponds can be considered over the next few years, testing of sediment for the complete range of contaminants necessary to apply for permits is recommended in the near future.

Bezanson, Reeds and Rockridge Ponds were all dredged within the last 20 years and while significant soft sediment has accumulated, <30% of capacity has been lost and depths are adequate for designated uses. It should be assumed that these will need to be dredged at some point in the future, but that would be at least a decade away. Abbotts and Icehouse Ponds have more sediment than water at this time, but there is no strong impetus to dredge either. Farms Station Pond is the deepest of the assessed ponds, and while removing the sediment that has reduced its capacity by 45% would be beneficial, adequate depth remains for known or potential uses.

Harvesting for rooted plant control has occurred in Longfellow and Rockridge Ponds previously. An expanded program is recommended, with the addition of Reeds and Bezanson Ponds if needed. More effective harvesting of Longfellow and Rockridge Ponds is a function of acquiring a new harvester, which is planned for FY18 at a cost of about $150,000, and increased staff allocation, yet to be worked out. Expanding harvesting to Reeds Pond requires improvement of a potential launching area, and this pond would probably only need to be harvested once

Table 18. Summary of Management Plan Elements

	Rooted Plants				Algae, Floating Plants, Turbidity		Other	
Pond	Dredging	Harvesting	Drawdown	Benthic Barrier	Watershed Mgmt	P Inactivation	Access Impr.	Waterfowl Control
Abbotts	Need uncertain				Maintain drainage	As needed	Trim vegetation	
Bezanson	20 years?	If needed			Maintain drainage	As needed		
Duck	Soon				Maintain drainage	As needed		
Farms Station	Need uncertain				Maintain drainage	As needed		
Icehouse	Need uncertain	Would need harvester access		1 ac could be strategically covered		Done by connection to Morses Pond	If desired	
Longfellow	If possible	June-Aug	Dec-Feb		Maintain drainage	As needed	Trim vegetation	Buffers/islands
Reeds	10 years? Forebay every few years as needed.	July	Dec-Feb		Maintain drainage	As needed	Create launch, enhance trail	
Rockridge	15 years?	June-Aug	Dec-Feb		Maintain drainage	As needed	Trim vegetation	

(requiring about 2 days of effort) per summer, mostly likely in early July. Harvesting may not be needed at Bezanson Pond if phosphorus controls are implemented, as the dominant plant depends on the water column for nutrition. However, if necessary, it would be possible to put the harvester in Bezanson Pond for less than a day of effort each year, probably in early July.

Drawdown from December through February could be attempted at Longfellow, Reeds and Rockridge Ponds, as outlet structures facilitate water lowering that might alter enough exposed area to reduce plant density the following summer. The winter appearance of those ponds should be discussed with users and neighborhood residents, and drawdown alone is unlikely to provide the level of control desired in these ponds, but may be worth trying at minimal cost.

Benthic barriers could be applied in any pond with a rooted plant problem, but the expense and effort is not worthwhile in light of the other recommendations described above, except at Icehouse Pond. The lack of access for a harvester and lack of water level control limits options in that pond. As this pond is not used for wading or fishing, benthic barriers would not interfere with those uses and could be strategically placed to maintain open water and a more attractive pond. An acre of application at a cost of about $40,000 is suggested if there is a perceived need for plant control in Icehouse Pond.

Watershed management would consist of the programs now in place, whereby drainage systems are maintained through street sweeping, catch basin cleaning, vegetative waste management, and restrictions on watering that might create runoff. No major structural controls are recommended at this time.

The mainstay of additional water quality management would be application of aluminum compounds as performed at Morses Pond, and by extension at Icehouse Pond, with great success. Construction of a portable, trailer mounted, dosing station that could be used to inject polyaluminum chloride into either inlets or the ponds themselves from a small boat is recommended at a cost of up to $70,000. The trailer would contain all equipment and a tank for chemicals, and a hose would run from the trailer to the injection site. The amount of chemical needed is small (11 to 81 gallons each) for all ponds except Longfellow Pond and Icehouse Pond, the latter of which does not need to be treated. Longfellow Pond would require treatment with about 282 gallons, more than all the other ponds combined, but the potential to prevent algae problems and reduce turbidity is high. Two treatments in a summer are envisioned on a trial basis at an operation cost of about $16,000. It is hoped that such a dosing system can be available early enough in FY18 to test it in summer 2017.

Other elements of the plant carry mainly internal costs for the Town of Wellesley, and include trimming vegetation and clearing access points or views at Abbotts, Longfellow, Reeds and

Rockridge Ponds, and altering habitat to limit waterfowl use of the parking area at Longfellow Pond.

The timing of plan implementation is mostly a matter of funding. Acquisition of a new harvester and construction of a portable aluminum dosing station are anticipated in FY18, but may not be available in time to make a large difference in summer 2017 conditions. Drawdown could be permitted and attempted in winter of 2018 if desired. Benthic barrier application to Icehouse Pond has no specific timetable, but would seem to have a lower priority than other plant control techniques. Dredging and watershed management activities are longer term efforts, but sampling of Longfellow and Duck Ponds for regulated contaminants could occur in the near future for planning purposes. Access improvements could occur whenever staff schedules allow or civic groups can be organized to do the work.

Appendix

Supplemental Information

Sampling Station Locations for Wellesley Ponds

Pond	Station	Designation	Description	Notes
Abbotts Pond	In-Lake	AP-1	Central area, deepest point	Shallow pond overall
	Outlet	AP-Out	Overflow ditch on SW side, accessed through wooded area off Chatham Circle	Used to have concrete and flashboard structure, goes under Rt 9
	NE Storm drain	AP-NESD	Large metal pipe near corner of Chatham Circle and Foxhill Road	
Bezanson	Outlet	BP-Out	Outlet structure on west side, accessed from parking lot via foot trail down hill	Too small to warrant in-lake sample from boat
	Inlet	BP-In	Small stream on NE side of pond, accessed by foot path	Likely intermittent, starts with storm drains on Sisters of Charity property
Duck	Outlet	DP-Out	Overflow off Washington St by access road to town hall	Pond too small and linear to do in-lake sample
	Inlet	DP-In	Large culvert from north with partial metal grate, best accessed by foot along west side of pond, waders helpful	
	NE Storm drain	DP-NESD	Pipe from north in NE lobe of pond, accessed by foot from either side of pond	Not active - no flow in storm of 4/12/16, 7/10/16
Farms Station Pond	In-lake	FSP-1	Central area, deepest point	
	Inlet	FSP-In	Inlet on W side from upstream pond under railroad, accessed from siding	Comes from upstream pond
	Outlet	FSP-Out	Outlet on E side off Croton Street	
	S Storm drain	FSP-SSD	Storm drain on S side off parking lot	
Icehouse	In-lake	IH-1	Deepest point near NW corner	No inlet or storm drains, connects to Morses Pond at normal water level
	Outlet	IH-Out	Overflow to/from Morses Pond, at bridge on foot path going to beach	Flow could go either way depending on water levels, but most likely to come from Morses Pond
Longfellow	In-lake	FP-1	Central area, about half way up linear pond	May not be deepest point
	Inlet	LP-In	Stream from south under Oakland St., W of parking area	Comes from upstream pond
	Outlet	LP-Out	Outlet structure at N end, accessed by foot path off Carver Rd	Stream flows N toward Rt 9
	SW Storm drain	LP-SWSD	Storm drain on W side of southern portion of pond, accessed by foot path W of inlet	Drains Standish Circle area
	W Storm drain	LP-WSD	Storm drain on W side of central portion of pond, accessed from steep slope at end of Priscilla Road	Drains Priscilla Road area
	SE Storm drain	LP-SESD	Storm drain in SE corner of pond, accessed off parking lot	Drains large area across Oakland St.
Reeds Pond	Inlet	RE-In	Inlet off Woodside Road	There is a main culvert and several overlow culverts passing under Woodside; use judgment on which to sample under what conditions
	Outlet	RE-Out	Outlet structure off Cedar Brook Road	Pond probably too small and linear to warrant in-lake sampling
	N Storm drain	RE-NSD	Small drain off Woodside Road by inlet	May not be large enough to warrant sampling; very small compared to inlet
Rockridge Pond	In-lake	RO-1	Central area, deepest point	
	Outlet	RO-Out	Outlet structure off Hundreds Circle	
	SW Storm drain	RO-SWSD	Storm drain off Cliff Road, accessed by footpath	
	N Storm drain	RO-NSD	Pair of small drains accessed by foot path from parking area	Not certain that both drains are active - flow in only E drain, none in W drain, on 4/12/16

Water Quality Data for Wellesley Ponds

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Abbotts	Outlet	Nitrate+Nitrite N (mg/L)	0.09										
Abbotts	Outlet	TKN (mg/L)	0.70										
Abbotts	Outlet	Total Nitrogen (mg/L)	0.79										
Abbotts	Outlet	Total Phosphorus (mg/L)	0.047										
Abbotts	NESD	Temperature (C)		11.4	9.4							22.5	
Abbotts	NESD	Dissolved Oxygen (mg/L)		10.2	10.5							7.8	
Abbotts	NESD	Dissolved Oxygen (% sat)		94.4	93.4							91.3	
Abbotts	NESD	Turbidity (NTU)		7.6	0.6							23.2	
Abbotts	NESD	Spec. Conductivity (uS)		239	363							44	
Abbotts	NESD	pH (standard units)		6.8	7.2							7.0	
Abbotts	NESD	Chlorophyll-a (ug/L by DS5)		2.1	3.9							4.8	
Abbotts	NESD	Ammonium N (mg/L)		0.13	0.06					1.20	1.00	0.15	
Abbotts	NESD	Nitrate+Nitrite N (mg/L)	1.90	1.20	2.80					0.76	0.72	0.44	
Abbotts	NESD	TKN (mg/L)	0.48	0.61	0.32					3.60	3.40	1.20	
Abbotts	NESD	Org N (mg/L)		0.48	0.26					2.40	2.40	1.05	
Abbotts	NESD	Total Nitrogen (mg/L)	2.38	1.81	3.12					4.36	4.12	1.64	
Abbotts	NESD	Total Phosphorus (mg/L)	0.036	0.075	0.022					0.550	0.570	0.300	
Abbotts	NESD	Dissolved Phosphorus (mg/L)		0.043	0.017						0.300	0.160	
Abbotts	NESD	Flow (cfs)		0.3	0.1								
Abbotts	In-Lake	Temperature (C)							27.3			23.8	
Abbotts	In-Lake	Dissolved Oxygen (mg/L)							7.9			5.7	
Abbotts	In-Lake	Dissolved Oxygen (% sat)							100.5			68.6	
Abbotts	In-Lake	Turbidity (NTU)							11.8			86.6	
Abbotts	In-Lake	Spec. Conductivity (uS)							535			660	
Abbotts	In-Lake	pH (standard units)							7.8			7.5	
Abbotts	In-Lake	Alkalinity (mg/L)							47				
Abbotts	In-Lake	Secchi Disc Transparency (ft)							0.3				
Abbotts	In-Lake	Chlorophyll-a (ug/L by DS5)							3.5			12.6	
Abbotts	In-Lake	Chlorophyll-a (ug/L by spec.)							31.6				
Abbotts	In-Lake	Ammonium N (mg/L)							0.14			0.31	
Abbotts	In-Lake	Nitrate+Nitrite N (mg/L)							0.03			0.03	
Abbotts	In-Lake	TKN (mg/L)							1.30			2.20	
Abbotts	In-Lake	Org N (mg/L)							1.16			1.89	
Abbotts	In-Lake	Total Nitrogen (mg/L)							1.33			2.23	
Abbotts	In-Lake	Total Phosphorus (mg/L)							0.150			0.220	
Abbotts	In-Lake	Dissolved Phosphorus (mg/L)							0.036			0.420	

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
***In-lake field values measured at the surface**		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Bezanson	Outlet	Nitrate+Nitrite N (mg/L)	0.03										
Bezanson	Outlet	TKN (mg/L)	0.35										
Bezanson	Outlet	Total Nitrogen (mg/L)	0.38										
Bezanson	Outlet	Total Phosphorus (mg/L)	0.013										
Bezanson	Inlet	Temperature (C)		11.9	10.4							22.6	
Bezanson	Inlet	Dissolved Oxygen (mg/L)		10.2	10.2							8.1	
Bezanson	Inlet	Dissolved Oxygen (% sat)		95.6	92.4							95.2	
Bezanson	Inlet	Turbidity (NTU)		1.0	0.8							14.3	
Bezanson	Inlet	Spec. Conductivity (uS)		712	255							132	
Bezanson	Inlet	pH (standard units)		7.1	7.1							7.8	
Bezanson	Inlet	Chlorophyll-a (ug/L by DS5)		1.7	0.0							4.4	
Bezanson	Inlet	Ammonium N (mg/L)		0.03	0.03	0.03							
Bezanson	Inlet	Nitrate+Nitrite N (mg/L)	0.24	0.40	0.18	0.23							
Bezanson	Inlet	TKN (mg/L)	0.28	0.33	0.14	0.14							
Bezanson	Inlet	Org N (mg/L)		0.31	0.12	0.12							
Bezanson	Inlet	Total Nitrogen (mg/L)	0.52	0.73	0.32	0.37							
Bezanson	Inlet	Total Phosphorus (mg/L)	0.026	0.055	0.017	0.039							
Bezanson	Inlet	Dissolved Phosphorus (mg/L)		0.022	0.021	0.033							
Bezanson	Inlet	Flow (cfs)		0.5	0.1								
Bezanson	In-Lake	Temperature (C)					23.1					23.5	
Bezanson	In-Lake	Dissolved Oxygen (mg/L)					8.8					8.7	
Bezanson	In-Lake	Dissolved Oxygen (% sat)					104.4					103.5	
Bezanson	In-Lake	Turbidity (NTU)					8.1					1.5	
Bezanson	In-Lake	Spec. Conductivity (uS)					308					0	
Bezanson	In-Lake	pH (standard units)					7.6					7.9	
Bezanson	In-Lake	Alkalinity (mg/L)					35						
Bezanson	In-Lake	Secchi Disc Transparency (ft)					1.2						
Bezanson	In-Lake	Chlorophyll-a (ug/L by DS5)					17.8					5.6	
Bezanson	In-Lake	Chlorophyll-a (ug/L by spec.)					8.8						
Bezanson	In-Lake	Ammonium N (mg/L)					0.11					0.07	
Bezanson	In-Lake	Nitrate+Nitrite N (mg/L)					0.05					0.03	
Bezanson	In-Lake	TKN (mg/L)					0.72					0.44	
Bezanson	In-Lake	Org N (mg/L)					0.61					0.37	
Bezanson	In-Lake	Total Nitrogen (mg/L)					0.77					0.47	
Bezanson	In-Lake	Total Phosphorus (mg/L)					0.082					0.027	
Bezanson	In-Lake	Dissolved Phosphorus (mg/L)					0.033					0.012	

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		Date	4/5/16	4/12/16	4/12/16	5/24/16	6/16/16	6/21/16	6/27/16	7/29/16	8/2/16	8/10/16	8/11/16
Duck	Outlet	Temperature (C)						17.6				21.5	
Duck	Outlet	Dissolved Oxygen (mg/L)						3.7				4.5	
Duck	Outlet	Dissolved Oxygen (% sat)						39.3				51.4	
Duck	Outlet	Turbidity (NTU)						57.1				36.5	
Duck	Outlet	Spec. Conductivity (uS)						936				1049	
Duck	Outlet	pH (standard units)						6.9				7.0	
Duck	Outlet	Chlorophyll-a (ug/L by DS5)						5.6				41.3	
Duck	Outlet	Ammonium N (mg/L)						0.86				0.72	
Duck	Outlet	Nitrate+Nitrite N (mg/L)	1.30					0.82				0.16	
Duck	Outlet	TKN (mg/L)	0.56					2.40				1.60	
Duck	Outlet	Org N (mg/L)						1.54				0.88	
Duck	Outlet	Total Nitrogen (mg/L)	1.86					3.22				1.76	
Duck	Outlet	Total Phosphorus (mg/L)	0.032					0.100				0.100	
Duck	Outlet	Dissolved Phosphorus (mg/L)						0.040				0.005	
Duck	Inlet	Temperature (C)		11.8	11.4							19.7	
Duck	Inlet	Dissolved Oxygen (mg/L)		10.0	9.5							6.8	
Duck	Inlet	Dissolved Oxygen (% sat)		93.4	88.0							75.4	
Duck	Inlet	Turbidity (NTU)		54.9	1.6							1.0	
Duck	Inlet	Spec. Conductivity (uS)		798	721							917	
Duck	Inlet	pH (standard units)		6.8	6.6							7.2	
Duck	Inlet	Chlorophyll-a (ug/L by DS5)		1.7	11.2								
Duck	Inlet	Ammonium N (mg/L)		0.06	0.14	0.53		0.78			0.35	0.16	
Duck	Inlet	Nitrate+Nitrite N (mg/L)	1.20	1.20	1.20	0.96		1.40			0.88	1.70	
Duck	Inlet	TKN (mg/L)	0.62	0.99	0.50	1.80		2.30			1.30	0.60	
Duck	Inlet	Org N (mg/L)		0.93	0.36	1.27		1.52			0.95	0.44	
Duck	Inlet	Total Nitrogen (mg/L)	1.82	2.19	1.70	2.76		3.70			2.18	2.30	
Duck	Inlet	Total Phosphorus (mg/L)	0.043	0.100	0.035	0.160		0.130			0.170	0.027	
Duck	Inlet	Dissolved Phosphorus (mg/L)		0.076	0.005	0.078		0.063			0.044	0.005	
Duck	Inlet	Flow (cfs)		3.5	1.0								

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
***In-lake field values measured at the surface**		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Duck	Pool/ In-lake	Temperature (C)						21.8				21.5	
Duck	Pool/ In-lake	Dissolved Oxygen (mg/L)						5.6				4.5	
Duck	Pool/ In-lake	Dissolved Oxygen (% sat)						65.2				51.4	
Duck	Pool/ In-lake	Turbidity (NTU)						11.2				36.5	
Duck	Pool/ In-lake	Spec. Conductivity (uS)						1102				1049	
Duck	Pool/ In-lake	pH (standard units)						7.2				7.0	
Duck	Pool/ In-lake	Alkalinity (mg/L)						49.0					
Duck	Pool/ In-lake	Secchi Disc Transparency (ft)						0.1				0.3	
Duck	Pool/ In-lake	Chlorophyll-a (ug/L by DS5)						5.8				41.3	
Duck	Pool/ In-lake	Chlorophyll-a (ug/L by spec.)						2.8					
Duck	Pool/ In-lake	Ammonium N (mg/L)						0.4				0.72	
Duck	Pool/ In-lake	Nitrate+Nitrite N (mg/L)						0.61				0.16	
Duck	Pool/ In-lake	TKN (mg/L)						0.70				1.60	
Duck	Pool/ In-lake	Org N (mg/L)						0.32				0.88	
Duck	Pool/ In-lake	Total Nitrogen (mg/L)						1.31				1.76	
Duck	Pool/ In-lake	Total Phosphorus (mg/L)						0.023				0.100	
Duck	Pool/ In-lake	Dissolved Phosphorus (mg/L)						0.005				0.005	
Farms Station	Outlet	Nitrate+Nitrite N (mg/L)	1.00										
Farms Station	Outlet	TKN (mg/L)	0.64										
Farms Station	Outlet	Total Nitrogen (mg/L)	1.64										
Farms Station	Outlet	Total Phosphorus (mg/L)	0.022										
Farms Station	Inlet	Temperature (C)		11.1	10.7							23.1	
Farms Station	Inlet	Dissolved Oxygen (mg/L)		10.9	11.0							7.4	
Farms Station	Inlet	Dissolved Oxygen (% sat)		101.1	100.3							87.3	
Farms Station	Inlet	Turbidity (NTU)		7.8	5.2							46.8	
Farms Station	Inlet	Spec. Conductivity (uS)		435	455							154	
Farms Station	Inlet	pH (standard units)		7.2	7.5							6.9	
Farms Station	Inlet	Chlorophyll-a (ug/L by DS5)		5.9	2.6							8.3	
Farms Station	Inlet	Ammonium N (mg/L)		0.10	0.07	0.03					0.36	0.25	
Farms Station	Inlet	Nitrate+Nitrite N (mg/L)	1.20	1.20	1.40	1.10					0.52	0.45	
Farms Station	Inlet	TKN (mg/L)	0.49	0.57	0.43	0.77					1.80	1.60	
Farms Station	Inlet	Org N (mg/L)		0.47	0.36	0.75					1.44	1.35	
Farms Station	Inlet	Total Nitrogen (mg/L)	1.69	1.77	1.83	1.87					2.32	2.05	
Farms Station	Inlet	Total Phosphorus (mg/L)	0.005	0.063	0.019	0.071					0.200	0.340	
Farms Station	Inlet	Dissolved Phosphorus (mg/L)		0.036	0.005	0.005					0.079	0.170	

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Farms Station	SSD	Temperature (C)		13.6								24.4	
Farms Station	SSD	Dissolved Oxygen (mg/L)		10.7								8.0	
Farms Station	SSD	Dissolved Oxygen (% sat)		104.1								96.7	
Farms Station	SSD	Turbidity (NTU)		34.0								10.5	
Farms Station	SSD	Spec. Conductivity (uS)		178								59	
Farms Station	SSD	pH (standard units)		7.5								7.1	
Farms Station	SSD	Chlorophyll-a (ug/L by FL)		2.4								3.6	
Farms Station	SSD	Ammonium N (mg/L)		0.16								0.18	
Farms Station	SSD	Nitrate+Nitrite N (mg/L)		0.22								0.21	
Farms Station	SSD	TKN (mg/L)		0.74								1.00	
Farms Station	SSD	Org N (mg/L)										0.82	
Farms Station	SSD	Total Nitrogen (mg/L)		0.96								1.21	
Farms Station	SSD	Total Phosphorus (mg/L)		0.120								0.099	
Farms Station	SSD	Dissolved Phosphorus (mg/L)		0.092								0.030	
Farms Station	SSD	Flow (cfs)		0.1	<0.01								
Farms Station	In-Lake Surface	Temperature (C)						24.3					26.0
Farms Station	In-Lake Surface	Dissolved Oxygen (mg/L)						8.7					10.2
Farms Station	In-Lake Surface	Dissolved Oxygen (% sat)						105.2					128.1
Farms Station	In-Lake Surface	Turbidity (NTU)						9.1					1.5
Farms Station	In-Lake Surface	Spec. Conductivity (uS)						534					592
Farms Station	In-Lake Surface	pH (standard units)						7.7					7.6
Farms Station	In-Lake Surface	Alkalinity (mg/L)						58.0					
Farms Station	In-Lake Surface	Secchi Disc Transparency (ft)						1.5					1.1
Farms Station	In-Lake Surface	Chlorophyll-a (ug/L by DS5)						11.7					9.1
Farms Station	In-Lake Surface	Chlorophyll-a (ug/L by spec.)						6.0					
Farms Station	In-Lake Surface	Ammonium N (mg/L)						0.18					0.21
Farms Station	In-Lake Surface	Nitrate+Nitrite N (mg/L)						0.18					0.06
Farms Station	In-Lake Surface	TKN (mg/L)						0.60					1.50
Farms Station	In-Lake Surface	Org N (mg/L)						0.42					1.29
Farms Station	In-Lake Surface	Total Nitrogen (mg/L)						0.78					1.56
Farms Station	In-Lake Surface	Total Phosphorus (mg/L)						0.049					0.039
Farms Station	In-Lake Surface	Dissolved Phosphorus (mg/L)						0.022					0.023

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Farms Station	In-Lake Bottom	Temperature (C)						17					21.3
Farms Station	In-Lake Bottom	Dissolved Oxygen (mg/L)						0.1					0.9
Farms Station	In-Lake Bottom	Dissolved Oxygen (% sat)						7.9					10.0
Farms Station	In-Lake Bottom	Turbidity (NTU)						17.6					28.8
Farms Station	In-Lake Bottom	Spec. Conductivity (uS)						713					755
Farms Station	In-Lake Bottom	pH (standard units)						6.4					6.0
Farms Station	In-Lake Bottom	Chlorophyll-a (ug/L by DSS)						9.3					209.4
Farms Station	In-Lake Bottom	Ammonium N (mg/L)											0.21
Farms Station	In-Lake Bottom	Nitrate+Nitrite N (mg/L)											0.06
Farms Station	In-Lake Bottom	TKN (mg/L)											1.50
Farms Station	In-Lake Bottom	Org N (mg/L)											1.29
Farms Station	In-Lake Bottom	Total Nitrogen (mg/L)											1.56
Farms Station	In-Lake Bottom	Total Phosphorus (mg/L)											0.110
Farms Station	In-Lake Bottom	Dissolved Phosphorus (mg/L)											0.025
Ice House	In-Lake	Temperature (C)					24.7						25.1
Ice House	In-Lake	Dissolved Oxygen (mg/L)					9.4						6.2
Ice House	In-Lake	Dissolved Oxygen (% sat)					114.8						76.7
Ice House	In-Lake	Turbidity (NTU)					5.4						1.7
Ice House	In-Lake	Spec. Conductivity (uS)					716						792
Ice House	In-Lake	pH (standard units)					7.6						7.1
Ice House	In-Lake	Alkalinity (mg/L)					27						
Ice House	In-Lake	Secchi Disc Transparency (ft)					2.1						2.0
Ice House	In-Lake	Chlorophyll-a (ug/L by DSS)					3.2						2.0
Ice House	In-Lake	Chlorophyll-a (ug/L by spec.)					1.5						
Ice House	In-Lake	Ammonium N (mg/L)					0.12						0.12
Ice House	In-Lake	Nitrate+Nitrite N (mg/L)	0.03				0.06						0.01
Ice House	In-Lake	TKN (mg/L)	0.48				0.38						0.41
Ice House	In-Lake	Org N (mg/L)					0.26						0.29
Ice House	In-Lake	Total Nitrogen (mg/L)	0.51				0.44						0.42
Ice House	In-Lake	Total Phosphorus (mg/L)	0.014				0.014						0.005
Ice House	In-Lake	Dissolved Phosphorus (mg/L)					0.005						0.005

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Longfellow	Outlet	Nitrate+Nitrite N (mg/L)	0.27										
Longfellow	Outlet	TKN (mg/L)	0.44										
Longfellow	Outlet	Total Nitrogen (mg/L)	0.71										
Longfellow	Outlet	Total Phosphorus (mg/L)	0.015										
Longfellow	Outlet	Dissolved Phosphorus (mg/L)											
Longfellow	Inlet	Temperature (C)		11.5								21.1	
Longfellow	Inlet	Dissolved Oxygen (mg/L)		11.3								6.8	
Longfellow	Inlet	Dissolved Oxygen (% sat)		105.4								77.6	
Longfellow	Inlet	Turbidity (NTU)		0.1								2.4	
Longfellow	Inlet	Spec. Conductivity (uS)		832								622	
Longfellow	Inlet	pH (standard units)		6.9								7.1	
Longfellow	Inlet	Chlorophyll-a (ug/L by DS5)		9.1								7.2	
Longfellow	Inlet	Ammonium N (mg/L)		0.03		0.09						0.09	
Longfellow	Inlet	Nitrate+Nitrite N (mg/L)	0.25	0.33		0.16						0.15	
Longfellow	Inlet	TKN (mg/L)	0.61	0.39		0.82						0.73	
Longfellow	Inlet	Org N (mg/L)		0.37		0.73						0.64	
Longfellow	Inlet	Total Nitrogen (mg/L)	0.86	0.72		0.98						0.88	
Longfellow	Inlet	Total Phosphorus (mg/L)	0.016	0.017		0.065						0.058	
Longfellow	Inlet	Dissolved Phosphorus (mg/L)		0.005		0.011						0.014	
Longfellow	Inlet	Flow (cfs)		5.0	4.5								
Longfellow	SW SD	Temperature (C)		12.2								23.0	
Longfellow	SW SD	Dissolved Oxygen (mg/L)		10.7								8.2	
Longfellow	SW SD	Dissolved Oxygen (% sat)		101.5								97.0	
Longfellow	SW SD	Turbidity (NTU)		25.7								23.7	
Longfellow	SW SD	Spec. Conductivity (uS)		311								41	
Longfellow	SW SD	pH (standard units)		6.8								7.2	
Longfellow	SW SD	Chlorophyll-a (ug/L by DS5)		2.8								6.4	
Longfellow	SW SD	Ammonium N (mg/L)		0.23							1.40	0.21	
Longfellow	SW SD	Nitrate+Nitrite N (mg/L)	0.42	0.50							0.48	0.46	
Longfellow	SW SD	TKN (mg/L)	0.82	0.75							2.90	1.30	
Longfellow	SW SD	Org N (mg/L)		0.52							1.50	1.09	
Longfellow	SW SD	Total Nitrogen (mg/L)	1.24	1.25							3.38	1.76	
Longfellow	SW SD	Total Phosphorus (mg/L)	0.085	0.083							0.440	0.350	
Longfellow	SW SD	Dissolved Phosphorus (mg/L)		0.018							0.330	0.220	
Longfellow	SW SD	Flow (cfs)		0.3									

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Longfellow	W SD	Temperature (C)		11.2	10.2							23.0	
Longfellow	W SD	Dissolved Oxygen (mg/L)		10.6	11.0							8.2	
Longfellow	W SD	Dissolved Oxygen (% sat)		97.6	99.2							97.2	
Longfellow	W SD	Turbidity (NTU)		9.0	1.9							32.0	
Longfellow	W SD	Spec. Conductivity (uS)		423	413							23	
Longfellow	W SD	pH (standard units)		6.8	7.0							7.1	
Longfellow	W SD	Chlorophyll-a (ug/L by DS5)		1.8	0.0							6.4	
Longfellow	W SD	Ammonium N (mg/L)		0.16	0.03	0.09					1.50	0.20	
Longfellow	W SD	Nitrate+Nitrite N (mg/L)	0.81	0.90	1.00	0.79					0.15	0.38	
Longfellow	W SD	TKN (mg/L)	0.49	1.10	0.33	0.57					3.90	1.20	
Longfellow	W SD	Org N (mg/L)		0.94	0.31	0.48					2.40	1.00	
Longfellow	W SD	Total Nitrogen (mg/L)	1.30	2.00	1.33	1.36					4.05	1.58	
Longfellow	W SD	Total Phosphorus (mg/L)	0.014	0.100	0.005	0.067					0.440	0.230	
Longfellow	W SD	Dissolved Phosphorus (mg/L)		0.030	0.014	0.049					0.095	0.160	
Longfellow	W SD	Flow (cfs)		1.0	0.3								
Longfellow	SESD	Temperature (C)										22.4	
Longfellow	SESD	Dissolved Oxygen (mg/L)										7.8	
Longfellow	SESD	Dissolved Oxygen (% sat)										90.8	
Longfellow	SESD	Turbidity (NTU)										6.5	
Longfellow	SESD	Spec. Conductivity (uS)										124	
Longfellow	SESD	pH (standard units)										7.1	
Longfellow	SESD	Chlorophyll-a (ug/L by DS5)										52.0	
Longfellow	SESD	Ammonium N (mg/L)										0.41	
Longfellow	SESD	Nitrate+Nitrite N (mg/L)										0.77	
Longfellow	SESD	TKN (mg/L)										3.80	
Longfellow	SESD	Org N (mg/L)										3.39	
Longfellow	SESD	Total Nitrogen (mg/L)										4.57	
Longfellow	SESD	Total Phosphorus (mg/L)										0.620	
Longfellow	SESD	Dissolved Phosphorus (mg/L)										0.300	

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
***In-lake field values measured at the surface**		Date	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Longfellow	Launch Storm Water	Temperature (C)										25.4	
Longfellow	Launch Storm Water	Dissolved Oxygen (mg/L)										8.3	
Longfellow	Launch Storm Water	Dissolved Oxygen (% sat)										102.3	
Longfellow	Launch Storm Water	Turbidity (NTU)										52.6	
Longfellow	Launch Storm Water	Spec. Conductivity (uS)										48	
Longfellow	Launch Storm Water	pH (standard units)										7.5	
Longfellow	Launch Storm Water	Chlorophyll-a (ug/L by DSS)										4.8	
Longfellow	Launch Storm Water	Ammonium N (mg/L)										0.35	
Longfellow	Launch Storm Water	Nitrate+Nitrite N (mg/L)										0.31	
Longfellow	Launch Storm Water	TKN (mg/L)										1.60	
Longfellow	Launch Storm Water	Org N (mg/L)										1.25	
Longfellow	Launch Storm Water	Total Nitrogen (mg/L)										1.91	
Longfellow	Launch Storm Water	Total Phosphorus (mg/L)										0.290	
Longfellow	Launch Storm Water	Dissolved Phosphorus (mg/L)										0.160	
Longfellow	In-Lake North Surface	Temperature (C)					23.1						24.9
Longfellow	In-Lake North Surface	Dissolved Oxygen (mg/L)					12.2						3.7
Longfellow	In-Lake North Surface	Dissolved Oxygen (% sat)					144.7						45.9
Longfellow	In-Lake North Surface	Turbidity (NTU)					6.8						13.5
Longfellow	In-Lake North Surface	Spec. Conductivity (uS)					667						657
Longfellow	In-Lake North Surface	pH (standard units)					8.3						7.2
Longfellow	In-Lake North Surface	Alkalinity (mg/L)					49						
Longfellow	In-Lake North Surface	Secchi Disc Transparency (ft)					2.0						1.1
Longfellow	In-Lake North Surface	Chlorophyll-a (ug/L by DSS)					5.5						5.9
Longfellow	In-Lake North Surface	Chlorophyll-a (ug/L by spec.)					4.3						
Longfellow	In-Lake North Surface	Ammonium N (mg/L)					0.14						0.16
Longfellow	In-Lake North Surface	Nitrate+Nitrite N (mg/L)					0.09						0.03
Longfellow	In-Lake North Surface	TKN (mg/L)					0.53						2.30
Longfellow	In-Lake North Surface	Org N (mg/L)					0.39						2.14
Longfellow	In-Lake North Surface	Total Nitrogen (mg/L)					0.62						2.33
Longfellow	In-Lake North Surface	Total Phosphorus (mg/L)					0.037						0.370
Longfellow	In-Lake North Surface	Dissolved Phosphorus (mg/L)					0.010						0.014

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Longfellow	In-Lake South Surface	Temperature (C)											27.1
Longfellow	In-Lake South Surface	Dissolved Oxygen (mg/L)											11.6
Longfellow	In-Lake South Surface	Dissolved Oxygen (% sat)											147.7
Longfellow	In-Lake South Surface	Turbidity (NTU)											33.1
Longfellow	In-Lake South Surface	Spec. Conductivity (uS)											650
Longfellow	In-Lake South Surface	pH (standard units)											7.5
Longfellow	In-Lake South Surface	Secchi Disc Transparency (ft)											0.6
Longfellow	In-Lake South Surface	Chlorophyll-a (ug/L by DS5)											10.8
Longfellow	In-Lake South Surface	Ammonium N (mg/L)											0.14
Longfellow	In-Lake South Surface	Nitrate+Nitrite N (mg/L)											0.07
Longfellow	In-Lake South Surface	TKN (mg/L)											0.88
Longfellow	In-Lake South Surface	Org N (mg/L)											0.74
Longfellow	In-Lake South Surface	Total Nitrogen (mg/L)											0.95
Longfellow	In-Lake South Surface	Total Phosphorus (mg/L)											0.670
Longfellow	In-Lake South Surface	Dissolved Phosphorus (mg/L)											0.012
Reeds	Outlet	Nitrate+Nitrite N (mg/L)	0.80										
Reeds	Outlet	TKN (mg/L)	0.54										
Reeds	Outlet	Total Nitrogen (mg/L)	1.34										
Reeds	Outlet	Total Phosphorus (mg/L)	0.010										
Reeds	Inlet	Temperature (C)		11.2	10.5							20.7	
Reeds	Inlet	Dissolved Oxygen (mg/L)		10.8	10.9							7.91	
Reeds	Inlet	Dissolved Oxygen (% sat)		99.6	98.9							89.6	
Reeds	Inlet	Turbidity (NTU)		0.8	4.9							1.2	
Reeds	Inlet	Spec. Conductivity (uS)		714	722							671	
Reeds	Inlet	pH (standard units)		6.8	7.1							6.8	
Reeds	Inlet	Chlorophyll-a (ug/L by DS5)		3.8	0.9							1.4	
Reeds	Inlet	Ammonium N (mg/L)		0.076	0.120	0.025						0.076	
Reeds	Inlet	Nitrate+Nitrite N (mg/L)	0.85	0.87	0.84	0.66						1.00	
Reeds	Inlet	TKN (mg/L)	0.37	0.47	0.38	0.44						0.36	
Reeds	Inlet	Org N (mg/L)		0.39	0.26	0.42						0.28	
Reeds	Inlet	Total Nitrogen (mg/L)	1.22	1.34	1.22	1.10						1.36	
Reeds	Inlet	Total Phosphorus (mg/L)	0.010	0.018	0.005	0.011						0.037	
Reeds	Inlet	Dissolved Phosphorus (mg/L)		0.005	0.015	0.005						0.033	
Reeds	Inlet	Flow (cfs)		13.3	12.0								

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
***In-lake field values measured at the surface**		Date	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Reeds	In-Lake	Temperature (C)						24.7					29.1
Reeds	In-Lake	Dissolved Oxygen (mg/L)						8.1					9.1
Reeds	In-Lake	Dissolved Oxygen (% sat)						99.1					119.9
Reeds	In-Lake	Turbidity (NTU)						4.0					8.5
Reeds	In-Lake	Spec. Conductivity (uS)						818					722
Reeds	In-Lake	pH (standard units)						7.4					7.7
Reeds	In-Lake	Alkalinity (mg/L)						48.0					
Reeds	In-Lake	Secchi Disc Transparency (ft)						1.5					
Reeds	In-Lake	Chlorophyll-a (ug/L by DS5)						8.4					3.3
Reeds	In-Lake	Ammonium N (mg/L)						0.13					0.03
Reeds	In-Lake	Nitrate+Nitrite N (mg/L)						0.54					0.31
Reeds	In-Lake	TKN (mg/L)						0.35					0.48
Reeds	In-Lake	Org N (mg/L)						0.22					0.46
Reeds	In-Lake	Total Nitrogen (mg/L)						0.89					0.79
Reeds	In-Lake	Total Phosphorus (mg/L)						0.025					0.035
Reeds	In-Lake	Dissolved Phosphorus (mg/L)						0.010					0.016
Rockridge	Outlet	Nitrate+Nitrite N (mg/L)	0.47										
Rockridge	Outlet	TKN (mg/L)	0.55										
Rockridge	Outlet	Total Nitrogen (mg/L)	1.02										
Rockridge	Outlet	Total Phosphorus (mg/L)	0.011										
Rockridge	SWSD	Temperature (C)		11.7	10.6							22.8	
Rockridge	SWSD	Dissolved Oxygen (mg/L)		10.9	11.1							7.7	
Rockridge	SWSD	Dissolved Oxygen (% sat)		102.0	101.0							90.4	
Rockridge	SWSD	Turbidity (NTU)		37.8	2.4							39.4	
Rockridge	SWSD	Spec. Conductivity (uS)		392	449							44	
Rockridge	SWSD	pH (standard units)		6.9	7.3							7.1	
Rockridge	SWSD	Chlorophyll-a (ug/L by DS5)		5.1	11.2							6.8	
Rockridge	SWSD	Ammonium N (mg/L)		0.15	0.05	0.07				0.76	0.66	0.22	
Rockridge	SWSD	Nitrate+Nitrite N (mg/L)	1.00	1.10	1.40	0.36				0.93	1.20	0.42	
Rockridge	SWSD	TKN (mg/L)	0.58	1.50	0.33	0.58				3.80	2.40	1.40	
Rockridge	SWSD	Org N (mg/L)		1.35	0.28	0.51				3.04	1.74	1.18	
Rockridge	SWSD	Total Nitrogen (mg/L)	1.58	2.60	1.73	0.94				4.73	3.60	1.82	
Rockridge	SWSD	Total Phosphorus (mg/L)	0.026	0.150	0.020	0.048				0.480	0.160	0.250	
Rockridge	SWSD	Dissolved Phosphorus (mg/L)		0.016	0.005	0.013					0.089	0.140	
Rockridge	SWSD	Flow (cfs)		0.4	0.2								

Pond	Station	Parameters	Dry	1st Flush	Post-Storm	1st Flush	Dry	Dry	Dry	1st Flush	1st Flush	1st Flush and Dry	Dry
In-lake field values measured at the surface		**Date**	**4/5/16**	**4/12/16**	**4/12/16**	**5/24/16**	**6/16/16**	**6/21/16**	**6/27/16**	**7/29/16**	**8/2/16**	**8/10/16**	**8/11/16**
Rockridge	NSD	Temperature (C)		12.6									
Rockridge	NSD	Dissolved Oxygen (mg/L)		10.3									
Rockridge	NSD	Dissolved Oxygen (% sat)		98.5									
Rockridge	NSD	Turbidity (NTU)		25.8									
Rockridge	NSD	Spec. Conductivity (uS)		252									
Rockridge	NSD	pH (standard units)		6.7									
Rockridge	NSD	Chlorophyll-a (ug/L by DS5)		3.2									
Rockridge	NSD	Ammonium N (mg/L)		0.11								0.71	
Rockridge	NSD	Nitrate+Nitrite N (mg/L)		0.46								0.59	
Rockridge	NSD	TKN (mg/L)		0.63								2.60	
Rockridge	NSD	Org N (mg/L)										1.89	
Rockridge	NSD	Total Nitrogen (mg/L)		1.09								3.19	
Rockridge	NSD	Total Phosphorus (mg/L)		0.110								0.380	
Rockridge	NSD	Dissolved Phosphorus (mg/L)		0.045								0.170	
Rockridge	NSD	Flow (cfs)		0.1									
Rockridge	In-Lake	Temperature (C)							23.9			29.2	
Rockridge	In-Lake	Dissolved Oxygen (mg/L)							7.5			10.9	
Rockridge	In-Lake	Dissolved Oxygen (% sat)							90.7			144.3	
Rockridge	In-Lake	Turbidity (NTU)							4.3			5.1	
Rockridge	In-Lake	Spec. Conductivity (uS)							465			418	
Rockridge	In-Lake	pH (standard units)							7.7			7.8	
Rockridge	In-Lake	Alkalinity (mg/L)							43				
Rockridge	In-Lake	Secchi Disc Transparency (ft)							1.5				
Rockridge	In-Lake	Chlorophyll-a (ug/L by DS5)							1.9			2.4	
Rockridge	In-Lake	Chlorophyll-a (ug/L by spec.)							1.9				
Rockridge	In-Lake	Ammonium N (mg/L)							0.10			0.16	
Rockridge	In-Lake	Nitrate+Nitrite N (mg/L)							0.03			0.07	
Rockridge	In-Lake	TKN (mg/L)							0.38			1.20	
Rockridge	In-Lake	Org N (mg/L)							0.28			1.04	
Rockridge	In-Lake	Total Nitrogen (mg/L)							0.41			1.27	
Rockridge	In-Lake	Total Phosphorus (mg/L)							0.028			0.076	
Rockridge	In-Lake	Dissolved Phosphorus (mg/L)							0.017			0.046	

Water Quality Profiles for Wellesley Ponds

Pond	Date	Depth	Temperature	Dissolved Oxygen	Dissolved Oxygen	Turbidity	Spec. Conductivity	pH	Alkalinity mg/L	Secchi	Chlorophyll-a
	M/D/YY	meters	Celcius	mg/L	% sat	NTU	µS	standard units	mg/L	meters	ug/L by DS5
Abbotts	6/27/16	0.1	27.3	7.9	100.5	11.8	535	7.8	47	0.3	3.5
	8/10/16	0.0	23.8	5.7	68.6	86.6	660	7.5			12.6
Bezanson	6/16/16	0.0	23.1	8.8	104.4	8.1	308	7.6	35	1.2	17.8
	6/16/16	0.2	22.7	8.2	97.0	8.2	306	7.4			20.4
	6/16/16	0.5	21.4	6.8	77.4	7.5	308	7.5			15.0
	6/16/16	1.1	19.9	5.1	56.9	9.3	310	7.4			10.4
	8/10/16	0.0	23.5	8.7	103.5	5.6	0	7.9			1.5
Duck	6/21/16	-0.1	21.8	5.6	65.2	11.2	1102	7.2	49		5.8
	8/10/16	0.0	21.5	4.5	51.4	36.5	1049	7.0		0.3	41.3
Farms Station	6/21/16	0.1	24.3	8.7	105.2	9.1	534	7.7	58	1.5	11.7
	6/21/16	0.3	23.1	7.9	93.1	10.8	511	7.6			16.4
	6/21/16	1.1	21.3	3.6	41.3	16.3	523	7.1			126.3
	6/21/16	1.5	18.5	0.7	7.7	17.4	606	6.4			17.3
	6/21/16	1.8	17.0	0.8	7.9	17.6	713	6.4			9.3
	8/11/16	0.1	26.0	10.2	128.1	1.5	592	7.6		1.1	9.1
	8/11/16	0.5	24.8	9.9	121.4	35.3	590	7.5			11.3
	8/11/16	1.0	24.2	6.9	83.7	34.1	592	7.4			12.4
	8/11/16	1.5	23.7	2.4	28.5	38.3	603	7.0			56.7
	8/11/16	2.0	21.3	0.9	10.0	28.8	755	6.0			209.4
Icehouse	6/16/16	0.1	24.7	9.4	114.8	5.4	716	7.6	27	2.1	3.2
	6/16/16	0.5	23.2	9.3	110.6	4.4	712	7.6			5.3
	6/16/16	1.0	22.6	8.9	104.7	4.4	707	7.6			5.5
	6/16/16	1.5	21.7	8.4	97.1	4.4	707	7.5			5.7
	8/11/16	0.1	25.1	6.2	76.7	1.7	792	7.1		2.0	2.0
	8/11/16	1.0	24.2	1.7	20.4	2.5	790	7.0			2.3
	8/11/16	1.3	24.1	2.1	25.2	2.7	794	6.9			2.4
	8/11/16	1.6	24.0	1.3	15.3	6.2	791	6.8			3.7

Pond	Date	Depth	Temperature	Dissolved Oxygen	Dissolved Oxygen	Turbidity	Spec. Conductivity	pH	Alkalinity mg/L	Secchi	Chlorophyll-a
	M/D/YY	meters	Celcius	mg/L	% sat	NTU	µS	standard units	mg/L	meters	ug/L by DS5
Longfellow N	6/16/16	0.3	23.7	11.4	136.8	6.4	668	7.9	49	2.0	4.4
	6/16/16	0.6	22.0	12.0	139.1	7.0	667	8.2			7.1
	6/16/16	0.3	23.1	12.2	144.7	6.8	667	8.3			5.5
	6/16/16	0.2	23.9	12.1	146.0	6.4	671	8.5			4.0
Longfellow N	8/11/16	0.3	24.9	3.7	45.9	13.5	657	7.2		1.1	5.9
	8/11/16	0.5	24.5	2.6	31.4	33.5	654	7.1			7.9
	8/11/16	1.0	24.5	2.0	24.3	106.7	654	7.0			8.2
Longfellow S	8/11/16	0.1	27.1	11.6	147.7	33.1	650	7.5		0.6	10.8
	8/11/16	0.5	24.1	10.4	126.2	42.0	639	7.5			13.3
Reeds	6/21/16	0.0	24.7	8.1	99.1	4.0	818	7.4	48	1.5	8.4
	6/21/16	0.8	20.9	6.6	75.1	17.9	821	7.3			15.2
	8/11/16	-0.1	29.1	9.1	119.9	8.5	722	7.7			3.3
Rockridge	6/27/16	0.0	23.9	7.5	90.7	4.3	465	7.7	43	1.5	1.9
	6/27/16	0.5	23.0	7.2	85.4	4.1	462	7.8			4.0
	6/27/16	0.8	22.8	6.9	81.7	4.6	463	7.8			3.7
	8/11/16	-0.1	29.2	10.9	144.3	2.4	418	7.8			5.1

Phytoplankton Data

TAXON	Abbotts 06/27/16	Abbotts 08/10/16	Bezanson 06/16/16	Bezanson 08/10/16	Duck 06/20/16	Duck 08/10/16	Farm St 06/21/16	Farm St 08/11/16	Icehouse 06/16/16	Icehouse 08/11/16	Longfellow 06/16/16	Longfellow 08/11/16	Reeds 06/21/16	Reeds 08/11/16	Rockridge 06/27/16	Rockridge 08/11/16
	PHYTOPLANKTON DENSITY (CELLS/ML)															
BACILLARIOPHYTA																
Centric Diatoms																
Aulacoseira	441	657	0	0	0	0	1305	100	0	0	686	372	0	0	0	0
Cyclotella	25	438	0	0	0	0	29	0	0	0	0	186	125	29	0	0
Araphid Pennate Diatoms																
Asterionella	0	0	0	0	0	0	3132	0	0	0	0	0	0	0	0	0
Fragilaria/related taxa	0	0	0	0	0	0	0	0	0	0	858	335	0	0	0	0
Synedra	50	0	30	20	0	0	15	0	0	22	14	37	0	0	13	40
Monoraphid Pennate Diatoms																
Achnanthidium/related taxa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cocconeis	0	0	0	0	0	0	0	0	0	11	0	0	0	29	0	13
Biraphid Pennate Diatoms																
Cymbella/related taxa	0	0	0	10	0	0	0	0	0	0	0	0	0	29	0	0
Gomphonema/related taxa	13	0	15	10	0	19	0	0	0	0	0	0	0	15	0	0
Navicula/related taxa	13	0	0	10	0	0	0	0	0	22	29	0	0	0	0	40
Nitzschia	353	0	0	0	0	0	0	0	0	11	72	0	25	0	25	27
CHLOROPHYTA																
Flagellated Chlorophytes																
Coccoid/Colonial Chlorophytes																
Ankistrodesmus	63	15476	30	40	0	0	15	60	27	11	0	0	100	0	0	27
Chlorella	0	0	0	0	0	0	1160	4000	0	0	0	0	0	24090	0	0
Crucigenia	0	0	0	0	0	0	0	160	0	0	0	0	0	0	0	0
Elakatothrix	0	0	0	0	0	0	58	40	0	22	0	0	0	0	0	0
Golenkinia	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0
Kirchneriella	0	0	0	0	0	0	0	0	0	44	0	0	0	0	0	0
Micractinium	0	0	0	0	0	0	29	0	0	0	0	0	0	0	0	0
Oocystis	0	0	0	0	0	0	0	160	106	0	0	0	0	0	0	0
Pediastrum	202	234	0	160	0	0	0	0	0	0	57	1190	0	0	0	0
Scenedesmus	202	234	0	40	0	0	1334	3600	53	44	57	670	75	58	0	106
Schroederia	0	0	0	0	0	0	0	120	0	0	0	0	0	0	0	0
Sphaerocystis	0	0	122	0	0	0	0	240	0	0	0	0	0	0	0	0
Tetraedron	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0
Tetrastrum	0	117	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filamentous Chlorophytes																
Oedogonium	0	0	0	0	0	0	0	0	0	0	0	186	0	0	0	0
Ulothrix	0	0	0	0	0	0	0	0	0	0	0	0	325	0	0	0
Desmids																
Closterium	88	0	0	0	0	0	44	70	0	0	29	37	0	15	0	0
Cosmarium	0	0	0	0	0	0	0	70	0	0	0	0	0	0	0	0
Euastrum	0	0	0	0	0	0	29	0	0	0	0	37	0	0	0	0
Mougeotia/Debarya	0	0	0	20	0	0	0	0	0	0	0	37	0	0	13	0
Staurastrum	25	15	0	0	0	0	0	0	0	0	0	93	0	0	38	0
CHRYSOPHYTA																
Flagellated Classic Chrysophytes																
Dinobryon	0	0	638	0	0	0	508	0	1330	0	5205	335	0	0	13	0
Mallomonas	0	0	0	0	0	0	0	0	0	0	0	19	0	0	0	0
Synura	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0
Non-Motile Classic Chrysophytes																
Haptophytes																

	PHYTOPLANKTON DENSITY (CELLS/ML)															
	Abbotts	Abbotts	Bezanson	Bezanson	Duck	Duck	Farm St	Farm St	Icehouse	Icehouse	Longfellow	Longfellow	Reeds	Reeds	Rockridge	Rockridge
TAXON	**06/27/16**	**08/10/16**	**06/16/16**	**08/10/16**	**06/20/16**	**08/10/16**	**06/21/16**	**08/11/16**	**06/16/16**	**08/11/16**	**06/16/16**	**08/11/16**	**06/21/16**	**08/11/16**	**06/27/16**	**08/11/16**
Tribophytes/Eustigmatophytes																
Ophiocytium	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0
Pseudostaurastrum	13	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Raphidophytes																
CRYPTOPHYTA																
Cryptomonas	0	0	1216	0	0	0	551	0	200	211	29	37	50	0	0	27
CYANOPHYTA																
Unicellular and Colonial Forms																
Filamentous Nitrogen Fixers																
Cuspidothrix	3024	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dolichospermum	0	0	152	3000	0	0	0	0	0	0	0	1860	150	0	0	200
Filamentous Non-Nitrogen Fixers																
Pseudanabaena	0	0	0	0	0	0	0	0	0	333	0	0	0	0	0	0
EUGLENOPHYTA																
Euglena	13	1664	0	0	58	502	0	0	27	0	0	37	0	0	0	0
Phacus	13	0	0	0	15	484	0	0	0	0	0	0	0	0	0	0
Trachelomonas	13	715	182	80	145	930	145	110	27	0	114	446	25	29	113	13
Strombomonas	0	0	15	10	0	0	0	0	0	0	0	0	0	0	0	0
PYRRHOPHYTA																
Ceratium	1852	146	0	0	0	0	0	10	0	0	0	0	0	0	25	0
Peridinium	0	0	30	40	0	0	0	0	27	0	0	19	0	15	0	0
DENSITY (CELLS/ML) SUMMARY																
BACILLARIOPHYTA	**894.6**	**1095**	**45.6**	**50**	**0**	**18.6**	**4480.5**	**100**	**0**	**66.6**	**1658.8**	**930**	**150**	**102.2**	**37.5**	**119.7**
Centric Diatoms	466.2	1095	0	0	0	0	1334	100	0	0	686.4	558	125	29.2	0	0
Araphid Pennate Diatoms	50.4	0	30.4	20	0	0	3146.5	0	0	22.2	872.3	372	0	0	12.5	39.9
Monoraphid Pennate Diatoms	0	0	0	0	0	0	0	0	0	11.1	0	0	0	29.2	0	13.3
Biraphid Pennate Diatoms	378	0	15.2	30	0	18.6	0	0	0	33.3	100.1	0	25	43.8	25	66.5
CHLOROPHYTA	**579.6**	**16074.6**	**152**	**270**	**0**	**0**	**2668**	**8520**	**186.2**	**133.2**	**143**	**2250.6**	**500**	**24163**	**50**	**133**
Flagellated Chlorophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Coccoid/Colonial Chlorophytes	466.2	16060	152	250	0	0	2595.5	8380	186.2	133.2	114.4	1860	175	24148.4	0	133
Filamentous Chlorophytes	0	0	0	0	0	0	0	0	0	0	0	186	325	0	0	0
Desmids	113.4	14.6	0	20	0	0	72.5	140	0	0	28.6	204.6	0	14.6	50	0
CHRYSOPHYTA	**12.6**	**14.6**	**638.4**	**0**	**0**	**0**	**507.5**	**10**	**1330**	**0**	**5205.2**	**353.4**	**0**	**0**	**25**	**0**
Flagellated Classic Chrysophytes	0	0	638.4	0	0	0	507.5	0	1330	0	5205.2	353.4	0	0	25	0
Non-Motile Classic Chrysophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Haptophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tribophytes/Eustigmatophytes	12.6	14.6	0	0	0	0	0	10	0	0	0	0	0	0	0	0
Raphidophytes	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
CRYPTOPHYTA	**0**	**0**	**1216**	**0**	**0**	**0**	**551**	**0**	**199.5**	**210.9**	**28.6**	**37.2**	**50**	**0**	**0**	**26.6**
CYANOPHYTA	**3024**	**0**	**152**	**3000**	**0**	**0**	**0**	**0**	**0**	**333**	**0**	**1860**	**150**	**0**	**0**	**199.5**
Unicellular and Colonial Forms	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Filamentous Nitrogen Fixers	3024	0	152	3000	0	0	0	0	0	0	0	1860	150	0	0	199.5
Filamentous Non-Nitrogen Fixers	0	0	0	0	0	0	0	0	0	333	0	0	0	0	0	0
EUGLENOPHYTA	**37.8**	**2379.8**	**197.6**	**90**	**217.5**	**1915.8**	**145**	**110**	**53.2**	**0**	**114.4**	**483.6**	**25**	**29.2**	**112.5**	**13.3**
PYRRHOPHYTA	**1852.2**	**146**	**30.4**	**40**	**0**	**0**	**0**	**10**	**26.6**	**0**	**0**	**18.6**	**0**	**14.6**	**25**	**0**
TOTAL	**6400.8**	**19710**	**2432**	**3450**	**217.5**	**1934.4**	**8352**	**8750**	**1795.5**	**743.7**	**7150**	**5933.4**	**875**	**24309**	**250**	**492.1**
CELL DIVERSITY	**0.67**	**0.39**	**0.63**	**0.28**	**0.35**	**0.47**	**0.78**	**0.56**	**0.43**	**0.70**	**0.43**	**0.93**	**0.77**	**0.03**	**0.74**	**0.77**
CELL EVENNESS	**0.54**	**0.38**	**0.63**	**0.25**	**0.73**	**0.79**	**0.68**	**0.49**	**0.48**	**0.68**	**0.41**	**0.74**	**0.85**	**0.03**	**0.82**	**0.81**

	PHYTOPLANKTON BIOMASS (UG/L)															
TAXON	**Abbotts 06/27/16**	**Abbotts 08/10/16**	**Bezanson 06/16/16**	**Bezanson 08/10/16**	**Duck 06/20/16**	**Duck 08/10/16**	**Farm St 06/21/16**	**Farm St 08/11/16**	**Icehouse 06/16/16**	**Icehouse 08/11/16**	**Longfellow 06/16/16**	**Longfellow 08/11/16**	**Reeds 06/21/16**	**Reeds 08/11/16**	**Rockridge 06/27/16**	**Rockridge 08/11/16**
BACILLARIOPHYTA																
Centric Diatoms																
Aulacoseira	132.3	197.1	0.0	0.0	0.0	0.0	391.5	30.0	0.0	0.0	205.9	111.6	0.0	0.0	0.0	0.0
Cyclotella	2.5	43.8	0.0	0.0	0.0	0.0	2.9	0.0	0.0	0.0	0.0	465.0	12.5	73.0	0.0	0.0
Araphid Pennate Diatoms																
Asterionella	0.0	0.0	0.0	0.0	0.0	0.0	626.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fragilaria/related taxa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	257.4	100.4	0.0	0.0	0.0	0.0
Synedra	131.0	0.0	133.8	88.0	0.0	0.0	11.6	0.0	0.0	17.8	11.4	29.8	0.0	0.0	10.0	31.9
Monoraphid Pennate Diatoms																
Achnanthidium/related taxa	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cocconeis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	11.7	0.0	5.3
Biraphid Pennate Diatoms																
Cymbella/related taxa	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	29.2	0.0	0.0
Gomphonema/related taxa	12.6	0.0	15.2	10.0	0.0	18.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	14.6	0.0	0.0
Navicula/related taxa	6.3	0.0	0.0	5.0	0.0	0.0	0.0	0.0	0.0	11.1	14.3	0.0	0.0	0.0	0.0	20.0
Nitzschia	282.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	8.9	57.2	0.0	20.0	0.0	20.0	21.3
CHLOROPHYTA																
Flagellated Chlorophytes																
Coccoid/Colonial Chlorophytes																
Ankistrodesmus	6.3	1547.6	3.0	4.0	0.0	0.0	1.5	6.0	2.7	1.1	0.0	0.0	10.0	0.0	0.0	2.7
Chlorella	0.0	0.0	0.0	0.0	0.0	0.0	116.0	400.0	0.0	0.0	0.0	0.0	0.0	2409.0	0.0	0.0
Crucigenia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Elakatothrix	0.0	0.0	0.0	0.0	0.0	0.0	5.8	4.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0	0.0
Golenkinia	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kirchneriella	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	0.0	0.0	0.0
Micractinium	0.0	0.0	0.0	0.0	0.0	0.0	87.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Oocystis	0.0	0.0	0.0	0.0	0.0	0.0	0.0	64.0	42.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pediastrum	40.3	46.7	0.0	32.0	0.0	0.0	0.0	0.0	0.0	0.0	11.4	238.1	0.0	0.0	0.0	0.0
Scenedesmus	20.2	23.4	0.0	60.0	0.0	0.0	133.4	2880.0	5.3	4.4	5.7	67.0	7.5	5.8	0.0	10.6
Schroederia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sphaerocystis	0.0	0.0	24.3	0.0	0.0	0.0	0.0	48.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tetraedron	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.7	0.0	0.0	0.0	0.0	0.0	0.0
Tetrastrum	0.0	23.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filamentous Chlorophytes																
Oedogonium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1004.4	0.0	0.0	0.0	0.0
Ulothrix	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	65.0	0.0	0.0	0.0
Desmids																
Closterium	352.8	0.0	0.0	0.0	0.0	0.0	174.0	280.0	0.0	0.0	114.4	148.8	0.0	58.4	0.0	0.0
Cosmarium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	56.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Euastrum	0.0	0.0	0.0	0.0	0.0	0.0	29.0	0.0	0.0	0.0	0.0	37.2	0.0	0.0	0.0	0.0
Mougeotia/Debarya	0.0	0.0	0.0	314.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	37.2	0.0	0.0	12.5	0.0
Staurastrum	20.2	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	74.4	0.0	0.0	30.0	0.0
CHRYSOPHYTA																
Flagellated Classic Chrysophytes																
Dinobryon	0.0	0.0	1915.2	0.0	0.0	0.0	1522.5	0.0	3990.0	0.0	15615.6	1004.4	0.0	0.0	37.5	0.0
Mallomonas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.3	0.0	0.0	0.0	0.0
Synura	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0
Non-Motile Classic Chrysophytes																
Haptophytes																

	PHYTOPLANKTON BIOMASS (UG/L)															
	Abbotts	**Abbotts**	**Bezanson**	**Bezanson**	**Duck**	**Duck**	**Farm St**	**Farm St**	**Icehouse**	**Icehouse**	**Longfellow**	**Longfellow**	**Reeds**	**Reeds**	**Rockridge**	**Rockridge**
TAXON	**06/27/16**	**08/10/16**	**06/16/16**	**08/10/16**	**06/20/16**	**08/10/16**	**06/21/16**	**08/11/16**	**06/16/16**	**08/11/16**	**06/16/16**	**08/11/16**	**06/21/16**	**08/11/16**	**06/27/16**	**08/11/16**
Tribophytes/Eustigmatophytes																
Ophiocytium	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pseudostaurastrum	10.1	11.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raphidophytes																
CRYPTOPHYTA																
Cryptomonas	0.0	0.0	1945.6	0.0	0.0	0.0	313.2	0.0	95.8	313.0	5.7	7.4	10.0	0.0	0.0	5.3
CYANOPHYTA																
Unicellular and Colonial Forms																
Filamentous Nitrogen Fixers																
Cuspidothrix	393.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Dolichospermum	0.0	0.0	30.4	600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	372.0	30.0	0.0	0.0	39.9
Filamentous Non-Nitrogen Fixers																
Pseudanabaena	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA																
Euglena	6.3	832.2	0.0	0.0	29.0	251.1	0.0	0.0	339.2	0.0	0.0	18.6	0.0	0.0	0.0	0.0
Phacus	3.8	0.0	0.0	0.0	4.4	145.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Trachelomonas	12.6	715.4	182.4	80.0	145.0	930.0	145.0	196.0	26.6	0.0	114.4	446.4	25.0	29.2	273.8	13.3
Strombomonas	0.0	0.0	80.6	53.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PYRRHOPHYTA																
Ceratium	32228.3	2540.4	0.0	0.0	0.0	0.0	0.0	174.0	0.0	0.0	0.0	0.0	0.0	0.0	435.0	0.0
Peridinium	0.0	0.0	63.8	84.0	0.0	0.0	0.0	0.0	55.9	0.0	0.0	39.1	0.0	30.7	0.0	0.0
DENSITY (CELLS/ML) SUMMARY																
BACILLARIOPHYTA	**567.0**	**240.9**	**149.0**	**113.0**	**0.0**	**18.6**	**1032.4**	**30.0**	**0.0**	**42.2**	**546.3**	**706.8**	**32.5**	**128.5**	**30.0**	**78.5**
Centric Diatoms	134.8	240.9	0.0	0.0	0.0	0.0	394.4	30.0	0.0	0.0	205.9	576.6	12.5	73.0	0.0	0.0
Araphid Pennate Diatoms	131.0	0.0	133.8	88.0	0.0	0.0	638.0	0.0	0.0	17.8	268.8	130.2	0.0	0.0	10.0	31.9
Monoraphid Pennate Diatoms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.4	0.0	0.0	0.0	11.7	0.0	5.3
Biraphid Pennate Diatoms	301.1	0.0	15.2	25.0	0.0	18.6	0.0	0.0	0.0	20.0	71.5	0.0	20.0	43.8	20.0	41.2
CHLOROPHYTA	**439.7**	**1652.7**	**27.4**	**412.0**	**0.0**	**0.0**	**546.7**	**4054.0**	**50.5**	**18.9**	**131.6**	**1607.0**	**82.5**	**2473.2**	**42.5**	**13.3**
Flagellated Chlorophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	66.8	1641.0	27.4	98.0	0.0	0.0	343.7	3718.0	50.5	18.9	17.2	305.0	17.5	2414.8	0.0	13.3
Filamentous Chlorophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1004.4	65.0	0.0	0.0	0.0
Desmids	373.0	11.7	0.0	314.0	0.0	0.0	203.0	336.0	0.0	0.0	114.4	297.6	0.0	58.4	42.5	0.0
CHRYSOPHYTA	**10.1**	**11.7**	**1915.2**	**0.0**	**0.0**	**0.0**	**1522.5**	**3.0**	**3990.0**	**0.0**	**15615.6**	**1013.7**	**0.0**	**0.0**	**47.5**	**0.0**
Flagellated Classic Chrysophytes	0.0	0.0	1915.2	0.0	0.0	0.0	1522.5	0.0	3990.0	0.0	15615.6	1013.7	0.0	0.0	47.5	0.0
Non-Motile Classic Chrysophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	10.1	11.7	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raphidophytes	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	**0.0**	**0.0**	**1945.6**	**0.0**	**0.0**	**0.0**	**313.2**	**0.0**	**95.8**	**313.0**	**5.7**	**7.4**	**10.0**	**0.0**	**0.0**	**5.3**
CYANOPHYTA	**393.1**	**0.0**	**30.4**	**600.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**3.3**	**0.0**	**372.0**	**30.0**	**0.0**	**0.0**	**39.9**
Unicellular and Colonial Forms	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Filamentous Nitrogen Fixers	393.1	0.0	30.4	600.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	372.0	30.0	0.0	0.0	39.9
Filamentous Non-Nitrogen Fixers	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0
EUGLENOPHYTA	**22.7**	**1547.6**	**263.0**	**133.0**	**178.4**	**1326.2**	**145.0**	**196.0**	**365.8**	**0.0**	**114.4**	**465.0**	**25.0**	**29.2**	**273.8**	**13.3**
PYRRHOPHYTA	**32228.3**	**2540.4**	**63.8**	**84.0**	**0.0**	**0.0**	**0.0**	**174.0**	**55.9**	**0.0**	**0.0**	**39.1**	**0.0**	**30.7**	**435.0**	**0.0**
TOTAL	**33660.9**	**5993.3**	**4394.3**	**1342.0**	**178.4**	**1344.8**	**3559.8**	**4457.0**	**4557.9**	**377.4**	**16413.5**	**4211.0**	**180.0**	**2661.6**	**828.8**	**150.3**
BIOMASS DIVERSITY	**0.11**	**0.65**	**0.51**	**0.74**	**0.24**	**0.38**	**0.78**	**0.59**	**0.23**	**0.35**	**0.12**	**0.95**	**0.79**	**0.21**	**0.53**	**0.84**
BIOMASS EVENNESS	**0.09**	**0.62**	**0.51**	**0.66**	**0.50**	**0.63**	**0.68**	**0.51**	**0.26**	**0.34**	**0.12**	**0.76**	**0.88**	**0.22**	**0.59**	**0.88**

Zooplankton Data

	ZOOPLANKTON DENSITY (#/L)															
TAXON	**Abbotts 6/27/16**	**Abbotts 8/10/16**	**Bezanson 6/16/16**	**Bezanson 8/10/16**	**Duck 6/21/16**	**Duck 8/11/16**	**Farms Station 6/21/16**	**Farms Station 8/11/16**	**Icehouse 6/16/16**	**Icehouse 8/11/16**	**Longfellow 6/16/16**	**Longfellow 8/11/16**	**Reeds 6/21/16**	**Reeds 8/11/16**	**Rockridge 6/21/16**	**Rockridge 10/6/16**
PROTOZOA																
Ciliophora	6.3	3.2	0.0	0.0	0.0	0.0	0.0	0.0	2.4	9.4	0.0	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
ROTIFERA																
Asplanchna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0
Brachionus	7.9	3.2	0.8	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
Conochilus	0.0	2.4	0.0	0.0	0.0	0.0	0.0	132.2	3.6	0.0	1.6	0.3	0.0	0.4	1.6	0.0
Filinia	6.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	13.2
Keratella	56.9	44.2	0.0	0.0	0.0	2.1	0.8	0.0	0.5	0.0	2.4	0.9	0.0	0.4	1.2	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	1.6	0.0	0.0
Trichocerca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.0
COPEPODA																
Copepoda-Cyclopoida																
Cyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6	0.3	0.0	1.2	0.0	5.3
Mesocyclops	0.0	0.8	0.0	0.0	0.0	0.0	1.2	108.6	0.0	0.0	1.6	0.0	0.0	0.0	2.3	9.2
Diaptomus	1.6	1.6	0.0	0.0	0.0	0.0	0.0	3.5	0.0	10.1	0.8	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	1.6	0.8	0.4	0.4	0.0	0.0	0.8	14.2	0.0	3.9	1.6	0.3	0.0	0.4	0.0	4.0
CLADOCERA																
Alona	0.0	0.8	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
Bosmina	0.0	0.0	2.7	0.4	0.0	0.0	7.0	33.0	0.0	2.3	2.4	0.3	0.0	10.9	7.8	124.1
Ceriodaphnia	0.0	0.0	0.0	0.0	0.0	0.0	2.0	21.2	0.0	0.8	4.7	0.0	0.0	0.4	8.6	18.5
Chydorus	0.0	0.0	0.0	0.4	0.0	2.1	0.8	3.5	0.0	0.0	4.7	0.3	0.0	0.4	0.4	0.0
Daphnia ambigua	0.0	0.0	0.4	0.0	0.0	3.2	9.8	57.8	0.0	0.4	0.0	0.0	0.0	0.4	0.8	48.8
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	12.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diaphanosoma	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTHER ZOOPLANKTON																
Chaoboridae	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
SUMMARY STATISTICS																
DENSITY																
PROTOZOA	6.3	3.2	0.8	0.0	0.0	0.0	0.0	0.0	2.4	9.4	0.0	0.3	0.0	0.0	0.0	0.0
ROTIFERA	71.1	49.8	0.8	0.0	0.0	4.2	0.8	135.7	4.6	0.0	4.0	1.5	0.3	4.7	2.7	13.2
COPEPODA	3.2	3.2	0.4	0.4	0.0	0.0	2.0	126.3	0.0	14.0	5.5	0.6	0.0	1.6	2.3	18.5
CLADOCERA	0.0	0.8	3.5	1.8	0.0	17.9	19.5	115.6	0.0	4.3	12.6	0.6	0.0	12.1	17.6	191.4
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	80.6	56.9	5.5	2.1	0.0	24.2	22.2	377.6	7.0	27.7	22.9	2.9	0.3	18.3	22.6	223.1

	ZOOPLANKTON BIOMASS (UG/L)															
	Abbotts	**Abbotts**	**Bezanson**	**Bezanson**	**Duck**	**Duck**	**Farms Station**	**Farms Station**	**Icehouse**	**Icehouse**	**Longfellow**	**Longfellow**	**Reeds**	**Reeds**	**Rockridge**	**Rockridge**
TAXON	**6/27/16**	**8/10/16**	**6/16/16**	**8/10/16**	**6/21/16**	**8/11/16**	**6/21/16**	**8/11/16**	**6/16/16**	**8/11/16**	**6/16/16**	**8/11/16**	**6/21/16**	**8/11/16**	**6/21/16**	**10/6/16**
PROTOZOA																
Ciliophora	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ROTIFERA																
Asplanchna	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	0.0	0.0
Brachionus	0.7	0.3	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Conochilus	0.0	0.1	0.0	0.0	0.0	0.0	0.0	5.3	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0
Filinia	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Keratella	5.1	4.0	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.1	0.0
Polyarthra	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0
Trichocerca	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
COPEPODA																
Copepoda-Cyclopoida																
Cyclops	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.9	0.7	0.0	2.9	0.0	12.9
Mesocyclops	0.0	1.0	0.0	0.0	0.0	0.0	1.5	393.6	0.0	0.0	2.0	0.0	0.0	0.0	2.9	11.6
Diaptomus	0.8	0.8	0.0	0.0	0.0	0.0	0.0	5.5	0.0	12.4	0.4	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	4.2	2.1	1.0	1.0	0.0	0.0	2.1	37.5	0.0	10.3	4.2	0.8	0.0	1.0	0.0	10.5
CLADOCERA																
Alona	0.0	2.4	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.4	0.0	0.0	0.0	0.0	0.0
Bosmina	0.0	0.0	2.7	0.4	0.0	0.0	6.9	32.4	0.0	2.3	2.3	0.3	0.0	10.7	7.6	121.6
Ceriodaphnia	0.0	0.0	0.0	0.0	0.0	0.0	8.4	95.6	0.0	2.0	25.4	0.0	0.0	1.0	25.6	48.0
Chydorus	0.0	0.0	0.0	0.4	0.0	2.1	0.8	3.5	0.0	0.0	4.6	0.3	0.0	0.4	0.4	0.0
Daphnia ambigua	0.0	0.0	0.6	0.0	0.0	5.1	15.8	93.7	0.0	0.6	0.0	0.0	0.0	0.6	1.3	189.2
Daphnia pulex	0.0	0.0	0.0	0.0	0.0	460.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Diaphanosoma	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.8	0.0	0.0	0.0	0.0	0.0	0.0
Leptodora	0.0	0.0	0.0	16.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
OTHER ZOOPLANKTON																
Chaoboridae	0.0	0.0	0.0	0.0	0.0	1050.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ostracoda	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.0
SUMMARY STATISTICS	**Abbotts**	**Abbotts**	**Bezanson**	**Bezanson**	**Duck**	**Duck**	**Farms Station**	**Farms Station**	**Icehouse**	**Icehouse**	**Longfellow**	**Longfellow**	**Reeds**	**Reeds**	**Rockridge**	**Rockridge**
BIOMASS	**6/27/16**	**8/10/16**	**6/16/16**	**8/10/16**	**6/21/16**	**8/11/16**	**6/21/16**	**8/11/16**	**6/16/16**	**8/11/16**	**6/16/16**	**8/11/16**	**6/21/16**	**8/11/16**	**6/21/16**	**10/6/16**
PROTOZOA	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0
ROTIFERA	6.1	4.4	0.1	0.0	0.0	0.4	0.1	5.4	0.2	0.0	0.3	0.1	0.0	2.6	0.2	0.5
COPEPODA	4.9	3.8	1.0	1.0	0.0	0.0	3.5	436.6	0.0	22.7	10.4	1.5	0.0	3.9	2.9	34.9
CLADOCERA	0.0	2.4	4.5	17.7	0.0	467.7	31.8	225.1	0.0	5.7	34.7	0.6	0.0	12.7	34.9	358.9
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0	1050.0	0.0	0.0	0.0	0.0	7.9	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	11.2	10.6	5.6	18.7	0.0	1518.1	35.4	667.2	0.3	28.6	53.3	2.2	0.0	19.2	38.0	394.3
MEAN LENGTH (mm): ALL FORMS	0.11	0.13	0.27	0.73		1.42	0.46	0.40	0.08	0.41	0.42	0.22	0.20	0.31	0.39	0.42
MEAN LENGTH: CRUSTACEANS	0.50	0.54	0.35	0.73		1.54	0.48	0.57		0.60	0.49	0.40		0.35	0.43	0.44

Phosphorus, Nitrogen and Water Loads to the Wellesley Ponds

	Duck Pond			Longfellow Pond			Farms Station Pond			Rockridge Pond		
DIRECT LOADS TO LAKE	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)
ATMOSPHERIC	0.1	2.1	3935	0.6	19.6	35962	0.1	2.5	4608	0.2	6.0	11040
INTERNAL	0.0	0.1	0	3.0	9.0	0	0.3	0.8	0	0.2	0.6	0
WATERFOWL	4.0	19.0	0	2.0	9.5	0	0.0	0.0	0	1.0	4.8	0
WATERSHED LOAD	101.2	1346.8	748005	353.3	5546.8	4216716	50.6	1173.5	902346	21.0	245.6	212142
TOTAL LOAD TO LAKE	105.3	1368.1	751939	358.9	5584.9	4252678	51.0	1176.8	906954	22.4	257.1	223181
INCOMING CONC (mg/L)	0.140	1.819		0.084	1.313		0.056	1.298		0.101	1.152	

	Icehouse Pond			Bezanson Pond			Reeds Pond			Abbotts Pond		
DIRECT LOADS TO LAKE	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)	P (KG/YR)	N (KG/YR)	WATER (CU.M/YR)
ATMOSPHERIC	0.4	13.0	23876	0.0	1.3	2357	0.2	5.0	9125	0.1	4.8	8871
INTERNAL	0.5	1.4	0	0.0	0.0	0	0.1	0.3	0	2.9	7.0	0
WATERFOWL	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0	0.0	0.0	0
WATERSHED LOAD	0.4	8.3	23085	6.0	85.7	97466	157.3	2005.4	2171145	21.2	224.2	124963
TOTAL LOAD TO LAKE	1.3	22.7	46961	6.0	87.0	99823	157.5	2010.7	2180270	24.3	236.1	133835
INCOMING CONC (mg/L)	0.027	0.483		0.060	0.872		0.072	0.922		0.182	1.764	

Algae Management Options

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
1) Management for nutrient input reduction	♦ Includes wide range of watershed and lake edge activities intended to eliminate nutrient sources or reduce delivery to lake ♦ Essential component of algal control strategy where internal recycling is not the dominant nutrient source, and desired even where internal recycling is important	♦ Acts against the original source of algal nutrition ♦ Creates sustainable limitation on algal growth ♦ May control delivery of other unwanted pollutants to lake ♦ Facilitates ecosystem management approach which considers more than just algal control	♦ May involve considerable lag time before improvement observed ♦ May not be sufficient to achieve goals without some form of in-lake management ♦ Reduction of overall system fertility may impact fisheries ♦ May cause shift in nutrient ratios which favor less desirable algae
1a) Point source controls	♦ More stringent discharge requirements ♦ May involve diversion ♦ May involve technological or operational adjustments ♦ May involve pollution prevention plans	♦ Often provides major input reduction ♦ Highly efficient approach in most cases ♦ Success easily monitored	♦ May be very expensive in terms of capital and operational costs ♦ May transfer problems to another watershed ♦ Variability in results may be high in some cases
1b) Non-point source controls	♦ Reduction of sources of nutrients ♦ May involve elimination of land uses or activities that release nutrients ♦ May involve alternative product use, as with no phosphate fertilizer	♦ Removes source ♦ Limited ongoing costs	♦ May require purchase of land or activity ♦ May be viewed as limitation of "quality of life" ♦ Usually requires education and gradual implementation

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
1c) Non-point source pollutant trapping	♦ Capture of pollutants between source and lake ♦ May involve drainage system alteration ♦ Often involves wetland treatments (det./infiltration) ♦ May involve storm water collection and treatment as with point sources	♦ Minimizes interference with land uses and activities ♦ Allows diffuse and phased implementation throughout watershed ♦ Highly flexible approach ♦ Tends to address wide range of pollutant loads	♦ Does not address actual sources ♦ May be expensive on necessary scale ♦ May require substantial maintenance
2) Circulation and destratification	♦ Use of water or air to keep water in motion ♦ Intended to prevent or break stratification ♦ Generally driven by mechanical or pneumatic force	♦ Reduces surface build-up of algal scums ♦ May disrupt growth of blue-green algae ♦ Counteraction of anoxia improves habitat for fish/invertebrates ♦ Can eliminate localized problems without obvious impact on whole lake	♦ May spread localized impacts ♦ May lower oxygen levels in shallow water ♦ May promote downstream impacts
3) Dilution and flushing	♦ Addition of water of better quality can dilute nutrients ♦ Addition of water of similar or poorer quality flushes system to minimize algal build-up ♦ May have continuous or periodic additions	♦ Dilution reduces nutrient concentrations without altering load ♦ Flushing minimizes detention; response to pollutants may be reduced	♦ Diverts water from other uses ♦ Flushing may wash desirable zooplankton from lake ♦ Use of poorer quality water increases loads ♦ Possible downstream impacts

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
4) Drawdown	♦ Lowering of water over autumn period allows oxidation, desiccation and compaction of sediments ♦ Duration of exposure and degree of dewatering of exposed areas are important ♦ Algae are affected mainly by reduction in available nutrients.	♦ May reduce available nutrients or nutrient ratios, affecting algal biomass and composition ♦ Opportunity for shoreline clean-up/structure repair ♦ Flood control utility ♦ May provide rooted plant control as well	♦ Possible impacts on non-target resources ♦ Possible impairment of water supply ♦ Alteration of downstream flows and winter water level ♦ May result in greater nutrient availability if flushing inadequate
5) Dredging	♦ Sediment is physically removed by wet or dry excavation, with deposition in a containment area for dewatering ♦ Dredging can be applied on a limited basis, but is most often a major restructuring of a severely impacted system ♦ Nutrient reserves are removed and algal growth can be limited by nutrient availability	♦ Can control algae if internal recycling is main nutrient source ♦ Increases water depth ♦ Can reduce pollutant reserves ♦ Can reduce sediment oxygen demand ♦ Can improve spawning habitat for many fish species ♦ Allows complete renovation of aquatic ecosystem	♦ Temporarily removes benthic invertebrates ♦ May create turbidity ♦ May eliminate fish community (complete dry dredging only) ♦ Possible impacts from containment area discharge ♦ Possible impacts from dredged material disposal ♦ Interference with recreation or other uses during dredging
5a) “Dry” excavation	♦ Lake drained or lowered to maximum extent practical ♦ Target material dried to maximum extent possible ♦ Conventional excavation equipment used to remove sediments	♦ Tends to facilitate a very thorough effort ♦ May allow drying of sediments prior to removal ♦ Allows use of less specialized equipment	♦ Eliminates most aquatic biota unless a portion left undrained ♦ Eliminates lake use during dredging

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
5b) "Wet" excavation	♦ Lake level may be lowered, but sediments not substantially exposed ♦ Draglines, bucket dredges, or long-reach backhoes used to remove sediment	♦ Requires least preparation time or effort, tends to be least cost dredging approach ♦ May allow use of easily acquired equipment ♦ May preserve aquatic biota	♦ Usually creates extreme turbidity ♦ Normally requires intermediate containment area to dry sediments prior to hauling ♦ May disrupt ecological function ♦ Use disruption
5c) Hydraulic removal	♦ Lake level not reduced ♦ Suction or cutterhead dredges create slurry which is hydraulically pumped to containment area ♦ Slurry is dewatered; sediment retained, water discharged	♦ Creates minimal turbidity and impact on biota ♦ Can allow some lake uses during dredging ♦ Allows removal with limited access or shoreline disturbance	♦ Often leaves some sediment behind ♦ Cannot handle coarse or debris-laden materials ♦ Requires sophisticated and more expensive containment area
6) Light-limiting dyes and surface covers	♦ Creates light limitation	♦ Creates light limit on algal growth without high turbidity or great depth ♦ May achieve some control of rooted plants as well	♦ May cause thermal stratification in shallow ponds ♦ May facilitate anoxia at sediment interface with water
6.a) Dyes	♦ Water-soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting algal growth ♦ Dyes remain in solution until washed out of system.	♦ Produces appealing color ♦ Creates illusion of greater depth	♦ May not control surface bloom-forming species ♦ May not control growth of shallow water algal mats ♦ Altered thermal regime
6.b) Surface covers	♦ Opaque sheet material applied to water surface	♦ Minimizes atmospheric and wildlife pollutant inputs	♦ Minimizes atmospheric gas exchange ♦ Limits recreation

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
7) Mechanical removal	♦ Filtering of pumped water for water supply purposes ♦ Collection of floating scums or mats with booms, nets, or other devices ♦ Continuous or multiple applications per year usually needed	♦ Algae and associated nutrients can be removed from system ♦ Surface collection can be applied as needed ♦ May remove floating debris ♦ Collected algae dry to minimal volume	♦ Filtration requires high backwash and sludge handling capability ♦ Labor and/or capital intensive ♦ Variable collection efficiency ♦ Possible impacts on non-target aquatic life
8) Selective withdrawal	♦ Discharge of bottom water which may contain (or be susceptible to) low oxygen and higher nutrient levels ♦ May be pumped or utilize passive head differential	♦ Removes targeted water from lake efficiently ♦ May prevent anoxia and phosphorus build up in bottom water ♦ May remove initial phase of algal blooms which start in deep water ♦ May create coldwater conditions downstream	♦ Possible downstream impacts of poor water quality ♦ May promote mixing of remaining poor quality bottom water with surface waters ♦ May cause unintended drawdown if inflows do not match withdrawal
9) Sonication	♦ Sound waves disrupt algal cells	♦ Supposedly affects only algae (new technique) ♦ Applicable in localized areas	♦ Unknown effects on non-target organisms ♦ May release cellular toxins or other undesirable contents into water column

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
10) Hypolimnetic aeration or oxygenation	♦ Addition of air or oxygen provides oxic conditions ♦ Maintains stratification ♦ Can also withdraw water, oxygenate, then replace	♦ Oxic conditions reduce P availability ♦ Oxygen improves habitat ♦ Oxygen reduces build-up of reduced cpds	♦ May disrupt thermal layers important to fish community ♦ Theoretically promotes supersaturation with gases harmful to fish
11) Algaecides	♦ Liquid or pelletized algaecides applied to target area ♦ Algae killed by direct toxicity or metabolic interference ♦ Typically requires application at least once/yr, often more frequently	♦ Rapid elimination of algae from water column , normally with increased water clarity ♦ May result in net movement of nutrients to bottom of lake	♦ Possible toxicity to non-target species ♦ Restrictions on water use for varying time after treatment ♦ Increased oxygen demand and possible toxicity ♦ Possible recycling of nutrients
11a) Forms of copper	♦ Cellular toxicant, disruption of membrane transport ♦ Applied as wide variety of liquid or granular formulations	♦ Effective and rapid control of many algae species ♦ Approved for use in most water supplies	♦ Possible toxicity to aquatic fauna ♦ Accumulation of copper in system ♦ Resistence by certain green and blue-green nuisance species ♦ Lysing of cells releases nutrients and toxins
11b) Peroxides	♦ Disrupts most cellular functions, tends to attack membranes ♦ Applied as a liquid or solid. ♦ Typically requires application at least once/yr, often more frequently	♦ Rapid action ♦ Oxidizes cell contents, may limit oxygen demand and toxicity	♦ Much more expensive than copper ♦ Limited track record ♦ Possible recycling of nutrients

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
11c) Synthetic organic algaecides	♦ Absorbed or membrane-active chemicals which disrupt metabolism ♦ Causes structural deterioration	♦ Used where copper is ineffective ♦ Limited toxicity to fish at recommended dosages ♦ Rapid action	♦ Non-selective in treated area ♦ Toxic to aquatic fauna (varying degrees by formulation) ♦ Time delays on water use
12) Phosphorus inactivation	♦ Typically salts of aluminum, iron or calcium are added to the lake, as liquid or powder ♦ Phosphorus in the treated water column is complexed and settled to the bottom of the lake ♦ Phosphorus in upper sediment layer is complexed, reducing release from sediment ♦ Permanence of binding varies by binder in relation to redox potential and pH	♦ Can provide rapid, major decrease in phosphorus concentration in water column ♦ Can minimize release of phosphorus from sediment ♦ May remove other nutrients and contaminants as well as phosphorus ♦ Flexible with regard to depth of application and speed of improvement	♦ Possible toxicity to fish and invertebrates, especially by aluminum at low pH ♦ Possible release of phosphorus under anoxia or extreme pH ♦ May cause fluctuations in water chemistry, especially pH, during treatment ♦ Possible resuspension of floc in shallow areas ♦ Adds to bottom sediment, but typically an insignificant amount
13) Sediment oxidation	♦ Addition of oxidants, binders and pH adjustors to oxidize sediment ♦ Binding of phosphorus is enhanced ♦ Denitrification is stimulated	♦ Can reduce phosphorus supply to algae ♦ Can alter N:P ratios in water column ♦ May decrease sediment oxygen demand	♦ Possible impacts on benthic biota ♦ Longevity of effects not well known ♦ Possible source of nitrogen for blue-green algae

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
14) Settling agents	♦ Closely aligned with phosphorus inactivation, but can be used to reduce algae directly too ♦ Lime, alum or polymers applied, usually as a liquid or slurry ♦ Creates a floc with algae and other suspended particles ♦ Floc settles to bottom of lake ♦ Re-application typically necessary at least once/yr	♦ Removes algae and increases water clarity without lysing most cells ♦ Reduces nutrient recycling if floc sufficient ♦ Removes non-algal particles as well as algae ♦ May reduce dissolved phosphorus levels at the same time	♦ Possible impacts on aquatic fauna ♦ Possible fluctuations in water chemistry during treatment ♦ Resuspension of floc possible in shallow, well-mixed waters ♦ Promotes increased sediment accumulation
15) Selective nutrient addition	♦ Ratio of nutrients changed by additions of selected nutrients ♦ Addition of non-limiting nutrients can change composition of algal community ♦ Processes such as settling and grazing can then reduce algal biomass	♦ Can reduce algal levels where control of limiting nutrient not feasible ♦ Can promote non-nuisance forms of algae ♦ Can improve productivity of system without increased standing crop of algae	♦ May result in greater algal abundance through uncertain biological response ♦ May require frequent application to maintain desired ratios ♦ Possible downstream effects
16) Enhanced grazing	♦ Manipulation of biological components of system to achieve grazing control over algae ♦ Typically involves alteration of fish community to promote growth of grazing zooplankton	♦ May increase water clarity by changes in algal biomass or cell size without reduction of nutrient levels ♦ Can convert unwanted algae into fish ♦ Harnesses natural processes	♦ May involve introduction of exotic species ♦ Effects may not be controllable or lasting ♦ May foster shifts in algal composition to even less desirable forms
16.a) Herbivorous fish	♦ Stocking of fish that eat algae	♦ Converts algae directly into potentially harvestable fish ♦ Grazing pressure can be adjusted through stocking rate	♦ Typically requires introduction of non-native species ♦ Difficult to control over long term ♦ Smaller algal forms may be benefited and bloom

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
16.b) Herbivorous zooplankton	♦ Reduction in planktivorous fish to promote grazing pressure by zooplankton ♦ May involve stocking piscivores or removing planktivores ♦ May also involve stocking zooplankton or establishing refugia	♦ Converts algae indirectly into harvestable fish ♦ Zooplankton response to increasing algae can be rapid ♦ May be accomplished without introduction of non-native species ♦ Generally compatible with most fishery management goals	♦ Highly variable response expected; temporal and spatial variability may be high ♦ Requires careful monitoring and management action on 1-5 yr basis ♦ Larger or toxic algal forms may be benefitted and bloom
17) Bottom-feeding fish removal	♦ Removes fish that browse among bottom deposits, releasing nutrients to the water column by physical agitation and excretion	♦ Reduces turbidity and nutrient additions from this source ♦ May restructure fish community in more desirable manner	♦ Targeted fish species are difficult to control ♦ Reduction in fish populations valued by some lake users (human/non-human)
18) Microbial competition	♦ Addition of microbes, often with oxygenation, can tie up nutrients and limit algal growth ♦ Tends to control N more than P	♦ Shifts nutrient use to organisms that do not form scums or impair uses to same extent as algae ♦ Harnesses natural processes ♦ May decrease sediment	♦ Minimal scientific evaluation ♦ N control may still favor cyanobacteria ♦ May need aeration system to get acceptable results
19) Pathogens	♦ Addition of inoculum to initiate attack on algal cells ♦ May involve fungi, bacteria or viruses	♦ May create lakewide "epidemic" and reduction of algal biomass ♦ May provide sustained control through cycles ♦ Can be highly specific to algal group or genera	♦ Largely an experimental approach. May promote resistant forms ♦ May cause high oxygen demand or release of toxins by lysed algal cells ♦ Effects on non-target organisms uncertain

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
20) Competition and allelopathy by plants	♦ Plants may tie up sufficient nutrients to limit algal growth ♦ Plants may create a light limitation on algal growth ♦ Chemical inhibition of algae may occur through substances released by other organisms	♦ Harnesses power of natural biological interactions ♦ May provide responsive and prolonged control	♦ Some algal forms appear resistant ♦ Use of plants may lead to problems with vascular plants ♦ Use of plant material may cause depression of oxygen levels
20a) Plantings for nutrient control	♦ Plant growths of sufficient density may limit algal access to nutrients ♦ Plants can exude allelopathic substances which inhibit algal growth ♦ Portable plant "pods" , floating islands, or other structures can be installed	♦ Productivity and associated habitat value can remain high without algal blooms ♦ Can be managed to limit interference with recreation and provide habitat ♦ Wetland cells in or adjacent to the lake can minimize nutrient inputs	♦ Vascular plants may achieve nuisance densities ♦ Vascular plant senescence may release nutrients and cause algal blooms ♦ The switch from algae to vascular plant domination of a lake may cause unexpected or undesirable changes
20b) Plantings for light control	♦ Plant species with floating leaves can shade out many algal growths at elevated densities	♦ Vascular plants can be more easily harvested than most algae ♦ Many floating species provide waterfowl food	♦ Floating plants can be a recreational nuisance ♦ Low surface mixing and atmospheric contact promote anoxia
20c) Addition of barley straw	♦ Input of barley straw can set off a series of chemical reactions which limit algal growth ♦ Release of allelopathic chemicals can kill algae ♦ Release of humic substances can bind phosphorus	♦ Materials and application are relatively inexpensive ♦ Decline in algal abundance is more gradual than with algaecides, limiting oxygen demand and the release of cell contents	♦ Success appears linked to uncertain and potentially uncontrollable water chemistry factors ♦ Depression of oxygen levels may result ♦ Water chemistry may be altered in other ways unsuitable for non-target organisms

Options for Control of Macrophytes

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
Physical Controls			
1) Benthic barriers	♦ Mat of variable composition laid on bottom of target area, preventing growth ♦ Can cover area for as little as several months or permanently ♦ Maintenance improves effectiveness	♦ Highly flexible control ♦ Reduces turbidity from soft bottoms ♦ Can cover undesirable substrate ♦ Can improve fish habitat by creating edge effects	♦ May cause anoxia at sediment-water interface ♦ May limit benthic invertebrates ♦ Non-selective interference with plants in target area ♦ May inhibit spawning/feeding by some fish species
1.a) Porous or loose-weave synthetic materials	♦ Laid on bottom and usually anchored by weights or stakes ♦ Removed and cleaned or flipped and repositioned at least once per year for maximum effect	♦ Allows some escape of gases which may build up underneath ♦ Panels may be flipped in place or removed for relatively easy cleaning or repositioning	♦ Allows some growth through pores ♦ Gas may still build up underneath in some cases, lifting barrier from bottom
1.b) Non-porous or sheet synthetic materials	♦ Laid on bottom and anchored by many stakes, anchors or weights, or by layer of sand ♦ Not typically removed, but may be cleaned periodically	♦ Prevents all plant growth until buried by sediment ♦ Minimizes interaction of sediment and water column	♦ Gas build up may cause barrier to float upwards ♦ Strong anchoring makes removal difficult and can hinder maintenance
1.c) Sediments of a desirable composition	♦ Sediments may be added on top of existing sediments or plants. ♦ Use of sand or clay can limit plant growths and alter sediment-water interactions. ♦ Sediments can be applied from the surface or suction dredged from below muck layer	♦ Plant biomass and propagules buried ♦ Sediment can be made less hospitable ♦ Nutrient release from sediments may be reduced ♦ Surface sediment can be made more appealing to humans ♦ Reverse layering requires no addition or removal of sediment	♦ Lake depth may decline ♦ Sediments may mix with underlayment ♦ Addition of sediment may cause initial turbidity ♦ New sediment may contain nutrients or other contaminants ♦ Generally too expensive for large scale application

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
2) Dredging	♦ Sediment is physically removed by wet or dry excavation, with deposition in a containment area ♦ Dredging can be applied on a limited basis, but is most often a major restructuring of a severely impacted system ♦ Plants and seed beds are removed and re-growth can be limited by light and/or substrate limitation	♦ Plant removal with some flexibility ♦ Increases water depth ♦ Can reduce pollutant reserves ♦ Can reduce sediment oxygen demand ♦ Can improve spawning habitat for many fish species ♦ Allows complete renovation of aquatic ecosystem	♦ Temporarily removes benthic invertebrates ♦ May create turbidity ♦ May eliminate fish community (complete dry dredging only) ♦ Possible impacts from containment area discharge ♦ Possible impacts from dredged material disposal ♦ Interference with uses during dredging ♦ Usually very expensive
2.a) “Dry” excavation	♦ Lake drained or lowered to maximum extent practical ♦ Target material dried to maximum extent possible ♦ Conventional excavation equipment used to remove sediments	♦ Tends to facilitate a very thorough effort ♦ May allow drying of sediments prior to removal ♦ Allows use of less specialized equipment	♦ Eliminates most aquatic biota unless a portion left undrained ♦ Eliminates lake use during dredging
2.b) “Wet” excavation	♦ Lake level may be lowered, but sediments not substantially dewatered ♦ Draglines, bucket dredges, or long-reach backhoes used to remove sediment	♦ Tends to require less preparation and be less costly than dry dredging ♦ May allow use of easily acquired equipment ♦ May preserve most aquatic biota	♦ Usually creates extreme turbidity ♦ Sediment deposition in surrounding area ♦ Normally requires containment area to dry sediments prior to hauling ♦ Severe disruption of ecological function ♦ Lake uses impaired during dredging

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
2.c) Hydraulic (or pneumatic) removal	♦ Lake level not reduced ♦ Suction or cutterhead dredges create slurry which is hydraulically pumped to containment area ♦ Slurry is dewatered; sediment retained, water discharged	♦ Creates minimal turbidity and limits impact on biota ♦ Can allow some lake uses during dredging ♦ Allows removal with limited access or shoreline disturbance	♦ Often leaves some sediment behind ♦ Cannot handle extremely coarse or debris-laden materials ♦ Requires advanced and more expensive containment area ♦ Requires overflow discharge from containment area
3) Dyes and surface covers	♦ Water-soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting plant growth ♦ Dyes remain in solution until washed out of system. ♦ Opaque sheet material applied to water surface	♦ Light limit on plant growth without high turbidity or great depth ♦ May achieve some control of algae as well ♦ May achieve some selectivity for species tolerant of low light	♦ May not control peripheral or shallow water rooted plants ♦ May cause thermal stratification in shallow ponds ♦ May facilitate anoxia at sediment interface with water ♦ Covers inhibit gas exchange with atmosphere
4) Mechanical removal ("harvesting")	♦ Plants reduced by mechanical means, possibly with disturbance of soils ♦ Collected plants may be placed on shore for composting or other disposal ♦ Wide range of techniques employed, from manual to highly mechanized ♦ Application once or twice per year usually needed	♦ Highly flexible control ♦ May remove other debris ♦ Can balance habitat and recreational needs	♦ Possible impacts on aquatic fauna ♦ Non-selective removal of plants in treated area ♦ Possible spread of undesirable species by fragmentation ♦ Possible generation of turbidity

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
4.a) Hand pulling	♦ Plants uprooted by hand (“weeding”) and preferably removed	♦ Highly selective technique	♦ Labor intensive ♦ Difficult to perform in dense stands
4.b) Cutting (without collection)	♦ Plants cut in place above roots without being harvested	♦ Generally efficient and less expensive than complete harvesting	♦ Leaves root systems and part of plant for re-growth ♦ Leaves cut vegetation to decay or to re-root ♦ Not selective within applied area
4.c) Harvesting (with collection)	♦ Plants cut at depth of 2-10 feet and collected for removal from lake	♦ Allows plant removal on greater scale	♦ Limited depth of operation ♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ More expensive than cutting
4.d) Rototilling	♦ Plants, root systems, and surrounding sediment disturbed with mechanical blades	♦ Can thoroughly disrupt entire plant	♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ Creates substantial turbidity ♦ More expensive than harvesting

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
4.e) Hydroraking	♦ Plants, root systems and surrounding sediment and debris disturbed with mechanical rake, part of material usually collected and removed from lake	♦ Can thoroughly disrupt entire plant ♦ Also allows removal of stumps or other obstructions	♦ Usually leaves fragments which may re-root and spread infestation ♦ May impact lake fauna ♦ Not selective within applied area ♦ Creates substantial turbidity ♦ More expensive than harvesting
5) Water level control	♦ Lowering or raising the water level to lower suitability for aquatic plants ♦ Disrupts plant life cycle by drying/ freezing, or light limitation	♦ Requires only outlet control to affect large area ♦ Provides widespread control in increments of water depth ♦ Complements dredging and flushing	♦ Potential issues with water supply ♦ Potential issues with flooding ♦ Potential impacts to non-target flora and fauna
5.a) Drawdown	♦ Lowering of water over winter period allows desiccation, freezing, and physical disruption of plants, roots and seed beds ♦ Timing and duration of exposure and degree of dewatering are critical aspects ♦ Variable species tolerance to drawdown	♦ Control with some flexibility ♦ Opportunity for shoreline clean-up/structure repair ♦ Flood control utility ♦ Impacts vegetative propagation species with limited impact to seed producing populations	♦ Possible impacts on emergent wetlands ♦ Possible effects on overwintering reptiles and amphibians ♦ Reduction in potential supply ♦ Alteration of downstream flows ♦ Possible overwinter water level variation ♦ May result in greater nutrient availability for algae

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
5.b) Flooding	♦ Higher water level in the spring can inhibit seed germination and plant growth ♦ Higher flows which are normally associated with elevated water levels can flush seed and plant fragments from system	♦ Where water is available, this can be an inexpensive technique ♦ Plant growth need not be eliminated, merely retarded or delayed ♦ Timing of water level control can selectively favor certain desirable species	♦ Water for raising the level may not be available ♦ Potential peripheral flooding ♦ Possible downstream impacts ♦ Many species may not be affected, and some may be benefitted ♦ Algal nuisances may increase where nutrients are available
Chemical controls			
6) Herbicides	♦ Liquid or pelletized herbicides applied to target area or to plants directly ♦ Contact or systemic poisons kill plants or limit growth ♦ Typically requires application every 1-5 yrs	♦ Wide range of control is possible ♦ May be able to selectively eliminate species ♦ May achieve some algae control as well	♦ Possible toxicity to non-target species ♦ Possible downstream impacts ♦ Restrictions of water use for varying time after treatment ♦ Increased oxygen demand from decaying vegetation ♦ Possible recycling of nutrients to allow other growths
6.a) Forms of copper	♦ Contact herbicide ♦ Cellular toxicant, suspected membrane transport disruption ♦ Applied as wide variety of liquid or granular formulations	♦ Moderately effective control of some submersed plant species ♦ More often an algal control agent	♦ Toxic to aquatic fauna as a function of concentration, formulation, and water chemistry ♦ Ineffective at colder temperatures ♦ Copper ion accumulates in sediments

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
6.b) Forms of endothall (7-oxabicyclo [2.2.1] heptane-2,3-dicarboxylic acid)	♦ Contact herbicide with limited translocation potential ♦ Membrane-active chemical which inhibits protein synthesis ♦ Causes structural deterioration ♦ Applied as liquid or granules	♦ Moderate control of some emersed plant species, moderately to highly effective control of floating and submersed species ♦ Limited toxicity to fish at recommended dosages ♦ Rapid action	♦ Non-selective in treated area ♦ Toxic to aquatic fauna (varying degrees by formulation) ♦ Time delays on use for water supply, agriculture and recreation ♦ Safety hazards for applicators
6.c) Forms of diquat (6,7-dihydropyrido [1,2-2',1'-c] pyrazinediium dibromide)	♦ Contact herbicide ♦ Absorbed by foliage but not roots ♦ Strong oxidant; disrupts most cellular functions ♦ Applied as a liquid, sometimes in conjunction with copper	♦ Moderate control of some emersed plant species, moderately to highly effective control of floating or submersed species ♦ Limited toxicity to fish at recommended dosages ♦ Rapid action	♦ Non-selective in treated area ♦ Toxic to zooplankton at recommended dosage ♦ Inactivated by suspended particles; ineffective in muddy waters ♦ Time delays on use for water supply, agriculture and recreation
6.d) Forms of glyphosate (N-[phosphonomethyl glycine)	♦ Contact herbicide ♦ Absorbed through foliage, disrupts enzyme formation and function in uncertain manner ♦ Applied as liquid spray	♦ Moderately to highly effective control of emersed and floating plant species ♦ Can be used selectively, based on application to individual plants ♦ Rapid action ♦ Low toxicity to aquatic fauna at recommended dosages ♦ No time delays for use of treated water	♦ Non-selective in treated area ♦ Inactivation by suspended particles; ineffective in muddy waters ♦ Not for use within 0.5 miles of potable water intakes ♦ Highly corrosive; storage precautions necessary

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
6.e) Forms of 2,4-D (2,4-dichlorophenoxyl acetic acid)	♦ Systemic herbicide ♦ Readily absorbed and translocated throughout plant ♦ Inhibits cell division in new tissue, stimulates growth in older tissue, resulting in gradual cell disruption ♦ Applied as liquid or granules, frequently as part of more complex formulations, preferably during early growth phase of plants	♦ Moderately to highly effective control of a variety of emersed, floating and submersed plants ♦ Can achieve some selectivity through application timing and concentration ♦ Fairly fast action	♦ Variable toxicity to aquatic fauna, depending upon formulation and ambient water chemistry ♦ Time delays for use of treated water for agriculture and recreation ♦ Not for use in water supplies
6.f) Forms of fluridone (1-methyl-3-phenyl-5-[-3-{trifluoromethyl} phenyl]-4[IH]-pyridinone)	♦ Systemic herbicide ♦ Inhibits carotenoid pigment synthesis and impacts photosynthesis ♦ Best applied as liquid or granules during early growth phase of plants	♦ Can be used selectively, based on concentration ♦ Gradual deterioration of affected plants limits impact on oxygen level (BOD) ♦ Effective against several difficult-to-control species ♦ Low toxicity to fauna	♦ Impacts on non-target plant species possible at higher doses ♦ Extremely soluble and mixable; difficult to perform partial lake treatments ♦ Requires extended contact time
6.g Amine salt of triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid)	♦ Systemic herbicide ♦ Readily absorbed by foliage, translocated throughout plant ♦ Disrupts enzyme systems specific to plants ♦ Applied as liquid spray or subsurface injected liquid	♦ Effectively controls many floating and submersed plant species ♦ Selectively effective against dicot plant species, including many nuisance species ♦ Effective against several difficult-to-control species ♦ Low toxicity to fauna ♦ Fast action	♦ Impacts on non-target plant species possible at higher doses ♦ Current time delay of 30 days on consumption of fish from treated areas ♦ Necessary restrictions on use of treated water for supply or recreation not yet certain

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
Biological Controls			
7) Biological introductions	♦ Fish, insects or pathogens which feed on or parasitize plants are added to system to affect control	♦ Provides potentially continuing control with one treatment ♦ Harnesses biological interactions to produce desired conditions ♦ May produce potentially useful fish biomass as an end product	♦ Typically involves introduction of non-native species ♦ Effects may not be controllable ♦ Plant selectivity may not match desired target species ♦ May adversely affect indigenous species
7.a) Herbivorous fish	♦ Grass carp most commonly used, but the larvae of several insects have been used and viruses are being tested ♦ Sterile juveniles stocked at density which allows control over multiple years ♦ Growth of individuals offsets losses or may increase herbivorous pressure	♦ May greatly reduce plant biomass in single season ♦ May provide multiple years of control from single stocking ♦ Sterility intended to prevent population perpetuation and allow later adjustments	♦ May eliminate all plant biomass, or impact non-target species ♦ Funnels energy into algae ♦ Alters habitat ♦ May escape upstream or downstream
7.b) Herbivorous insects	♦ Larvae or adults stocked at density intended to allow control with limited growth ♦ Intended to selectively control target species ♦ Milfoil weevil is best known, but still experimental	♦ Involves species native to region, or even targeted lake ♦ Expected to have no negative effect on non-target species ♦ May facilitate longer term control with limited management	♦ Incomplete control likely; oscillating cycle of control and re-growth expected ♦ Predation by fish may complicate control ♦ Other lake management actions may interfere

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
7.c) Fungal/bacterial/ viral pathogens	♦ Inoculum used to seed lake or target plant patch ♦ Growth of pathogen population expected to achieve control over target species	♦ May be highly species specific ♦ May provide substantial control after minimal inoculation effort	♦ Effectiveness and longevity of control not well known ♦ Infection ecology suggests incomplete control likely
7.d) Selective plantings	♦ Establishment of plant assemblage resistant to undesirable species ♦ Plants introduced as seeds, cuttings or whole plants	♦ Can restore native assemblage ♦ Can encourage assemblage most suitable to lake uses ♦ Supplements targeted species removal effort	♦ Largely experimental ♦ May not prevent nuisance species from returning ♦ Introduced species may become nuisances