Plymouth Mill Pond

Sheboygan County, Wisconsin

Comprehensive Management Plan

January 2008

Sponsored by:

Wisconsin Department of Natural Resources
Lake Management Grant Program

PREPARED FOR:

CITY OF PLYMOUTH
PLYMOUTH, WISCONSIN

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Table

LIST OF CHARTS

Chart

LIST OF DIAGRAMS

Diagram

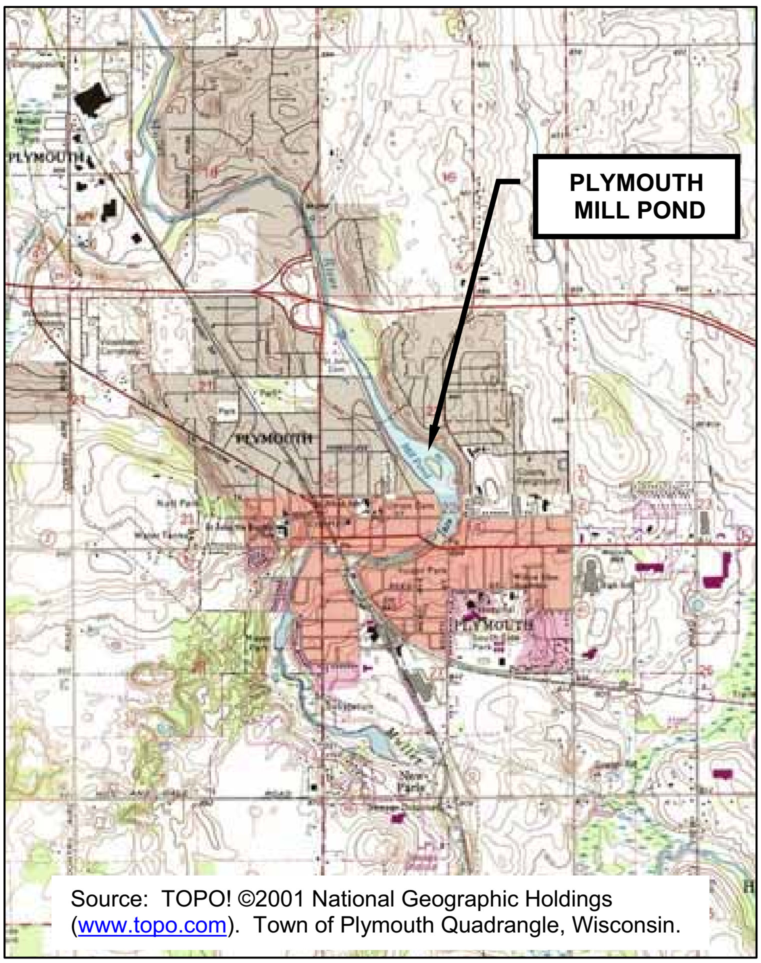
LIST OF APPENDICES

Appendix

INTRODUCTION

The Plymouth Mill Pond is a 41-acre impoundment of the Mullet River located in the City of Plymouth in Section 22, Township 15 North, Range 21 East in Sheboygan County, Wisconsin (Figure 1). The water body is maintained by a dam at the southern end of the pond and it extends north to State Trunk Highway 23 (STH 23). The City of Plymouth owns approximately 2 acres of property at the outlet of the Mill Pond. There is approximately 1,000 feet of shoreline on City school property including a recreational trail along the northwest side of the pond and a pedestrian foot bridge across the northern portion of the pond. The Mill Pond is utilized for boating, fishing, and public ice skating.

The Plymouth Mill Pond has been an amenity to the City and local residents since its conception in the mid-1800s. In recent years, however, degraded water quality has led to algal blooms and aquatic plant growth which have caused odor problems, impeded recreational use of the pond, and negatively impacted the aesthetics of the Mill Pond area. The Plymouth Mill Pond Committee (PMPC), consisting of volunteers, was founded to discuss alternatives for management and attain funding to improve the condition of this water body.



Source: TOPO! ©2001 National Geographic Holdings (www.topo.com). Town of Plymouth Quadrangle, Wisconsin.

Figure 1. Plymouth Mill Pond Location Map

The City of Plymouth and the Mill Pond Committee have applied for and been awarded Lake Planning Grant funds from the Wisconsin Department of Natural Resources (WDNR) to develop their Mill Pond Comprehensive Planning project. The project is split into three stages: Part I - Mill Pond Assessment (completed), Part II – Watershed Modeling/Alternatives Analysis (completed) and Part III – Comprehensive Management Plan. This document represents Part III of the Mill Pond Comprehensive Planning project.

The PMPC realizes that any management options that are recommended must have the support of both the local stakeholders and the regulatory community. Therefore, the PMPC has begun to implement a public involvement strategy. The City of Plymouth conducted a citizen input survey in 2005 to obtain the opinions of the general public, property owners, and local business owners about the current issues and future direction for the Mill Pond. This survey was prepared by the University of Wisconsin Extension-Sheboygan County (UWEX-SC) on behalf of the City of Plymouth. The survey results are presented in Appendix A. The majority of respondents indicated that the water quality of the Mill Pond was fair to poor and 87 percent of the respondents indicated that the Plymouth Mill Pond was important to the community of Plymouth. This project has the support of the local community, and the citizens realize that improvements in the aquatic resource will be a benefit to the environment and will increase use of the Mullet River and the Mill Pond area as recreational resources.

PURPOSE AND GOALS

The goal of Part III of the Plymouth Mill Pond Comprehensive Planning project is to develop a Comprehensive Management Plan for the long-term management of the pond that incorporates information from the Mill Pond Watershed Assessment, Water Quality Assessment, Macrophyte and Sediment Thickness Survey, and Alternatives Analysis. This management plan will guide the PMPC as they move forward with their efforts to improve the ecological, aesthetic, and recreational value of the Mill Pond. The specific objectives of this final phase of the planning process include:

- Development a long-term management plan for the Plymouth Mill Pond that includes water quality objectives, best management practices (BMPs), proposed ordinances, and any additional recommendations. The plan shall include a strategy for implementation, the agency responsible, specifics of what is needed, and a timeframe for completion. It will also determine if any of the recommended BMPs are eligible for a Lake Protection Grant.

- Coordination with the Sheboygan County Land & Water Conservation Department (LWCD) to obtain any information on known erosion control problems, identify critical sites, and develop objectives for land use management in the watershed.

- Coordination with the WDNR-BER to obtain recommended management actions for the protection of any known threatened and endangered resources in the project area.

- Determination the adequacy of existing land use plans, runoff control ordinances, enforcement, and other existing institutional programs relative to the protection of water quality.

- Coordination with the City of Plymouth, Town of Plymouth, Town of Greenbush, Town of Rhine, Town of Forest and Sheboygan County on the expansion of BMPs for development and make suggestions for other relevant land management ordinances.

- Preparation news releases and holding public information meetings to keep the public informed and involved in the planning process.

BACKGROUND

Pond History and Past Management Activities

The original mill dam was constructed in the late 1840s, but was washed out during a flood in 1906. The present dam was constructed in the 1950s. There is speculation that the Mullet River was rerouted when the mill dam was built, but there is no supporting evidence for this. The dam and Mill Pond are shown in roughly their present configuration in both the 1875 and 1889 plat books found in the Plymouth Historical Society Museum. The Mill Pond was drained down in the late 1950s. During this drawdown the river was on the east side of the island.

Partnerships

Implementing a long-term management plan for the Mill Pond will be most successful if the local citizens and the regulatory community work together to evaluate the needs of the pond and determine appropriate management goals. The PMPC has been working with a variety of local organizations to gather background data about the pond and to gather local and regulatory input regarding the project.

The PMPC has partnered with the UWEX-SC on the public outreach components of the project. UWEX-SC prepared the 2005 Citizen Input Survey and has performed some of the preliminary data analysis. A UWEX-SC representative has been involved with Mill Pond Committee meetings and has prepared news releases for the local papers. They are also coordinating and preparing the public information meetings for this project.

The PMPC has also been working with the Sheboygan County Land & Water Conservation Department (LWCD) to obtain existing land use information as well as any information on known erosion control problems. They will partner with the Sheboygan County LWCD on projects as appropriate including detailed soil erosion inventories, barnyard assessments, and the development and implementation of best management practices in the watershed including the identification of key locations for buffer strips.

The City will work closely with the Town of Plymouth and Sheboygan County on the development of best management practices for developments and other construction sites.

Both the Plymouth High School and the Sheboygan Area School District are very interested in participating in the collection of data to support the Mill Pond Assessment program. Both of these school systems have been active in the past with the Testing the Waters program.

The PMPC believes that the information gained through this project belongs to the local stakeholders and the WDNR to increase their database on the Mullet River and the Mill Pond. Therefore, the Committee has been sharing the project results in the following ways.

1. The WDNR has been invited to participate in the public participation process and has been provided with copies of the completed technical memoranda as they have become available. John Masterson, WDNR, is a regular attendee at the Mill Pond Committee meetings.

2. Committee meetings are open to the Public. The Plymouth Review and the Sheboygan Press are often in attendance and provide summary information in the local newspapers.

3. A committee meeting was held to present the findings of the Mill Pond Assessment (Part I). A second committee meeting was held to present the results of the Watershed Modeling/Alternatives Analysis (Part II). A third committee meeting will be held to present the Comprehensive Management Planning (Part III).

4. Copies of the technical memoranda will be available for review at the Plymouth Public Library at 130 Division Avenue in Plymouth ((920) 892-4416). Individuals desiring their own copies will be able to purchase copies for a nominal fee.

5. The water quality data will be submitted to the Plymouth High School Biology Department, when available, for the biology teachers to use with their classes as appropriate. The

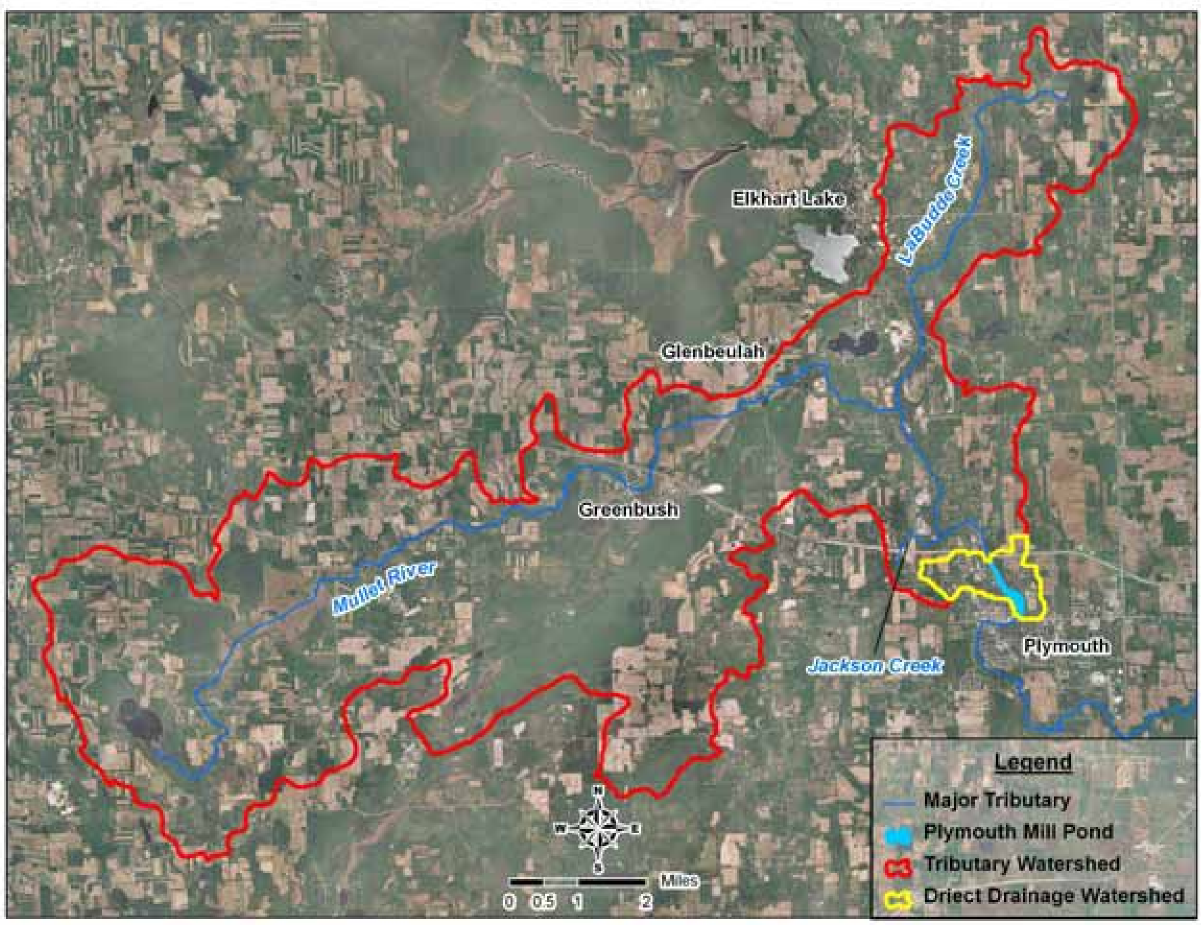
Plymouth High School will also be provided with copies of the completed technical memoranda as they become available.

6. The Mill Pond Committee will continue to look for ways to utilize the public outreach capabilities of the UWEX-SC.

WATERSHED CHARACTERISTICS

Physical Characteristics

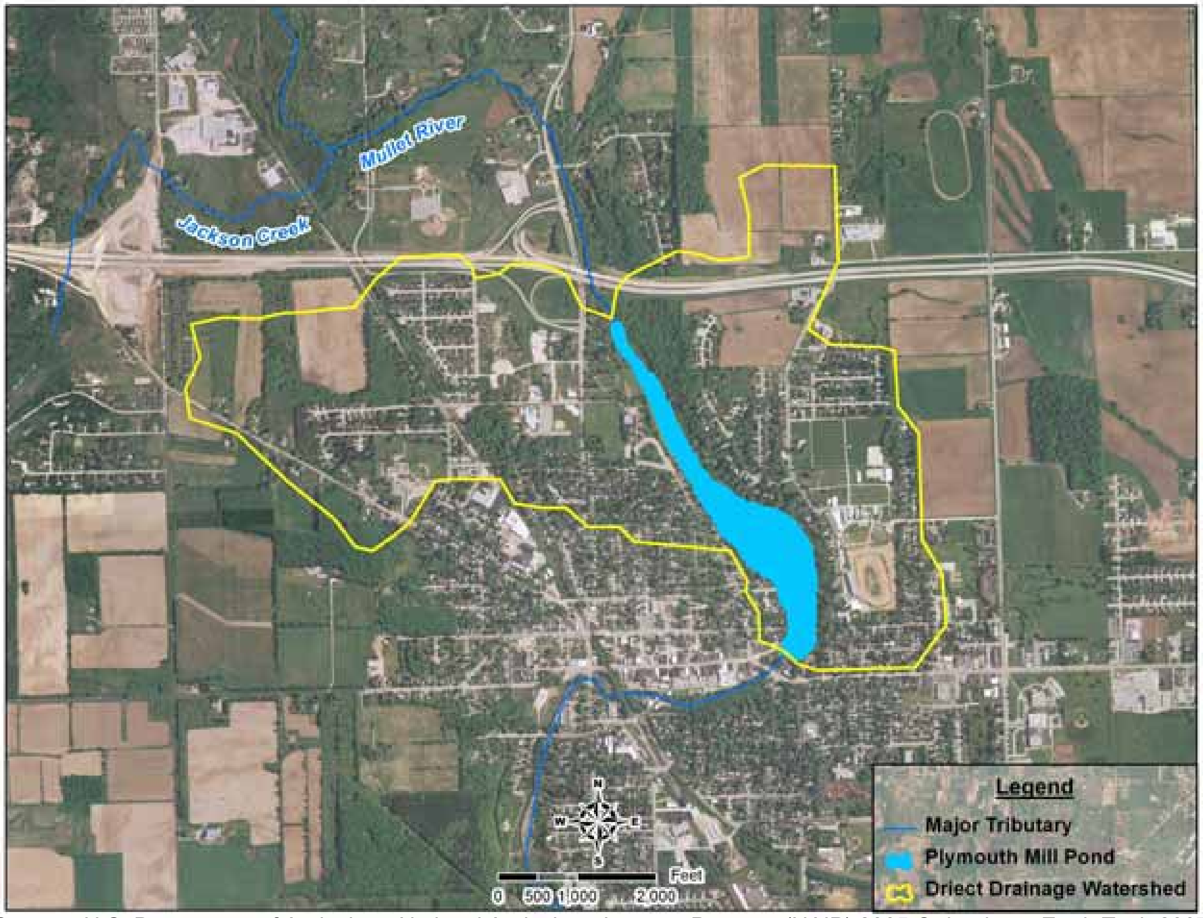
The Mullet River watershed tributary to the Mill Pond drains about 62 square miles in Fond du Lac and Sheboygan counties (Figure 2), and represents the upper two thirds of the Mullet River watershed. The tributary watershed extends from the Mullet Lake area of Fond du Lac County and continues east, gathering drainage from LaBudde Creek to the north near Elkhart Lake and Jackson Creek to the northwest of the City of Plymouth.



Source: U.S. Department of Agriculture National Agriculture Imagery Program (NAIP) 2005 Orthophoto, Earth Tech 2007

Figure 2. Plymouth Mill Pond Tributary and Direct Drainage Watersheds

The direct drainage watershed to the Mill Pond is approximately 1.1 square miles (715 acres) in size (Figure 3) and is located in the City of Plymouth. The direct drainage watershed extends west to County Trunk Highway (CTH) C, north to STH 23, and east to approximately 1,000 feet west of CTH E.



Source: U.S. Department of Agriculture National Agriculture Imagery Program (NAIP) 2005 Orthophoto, Earth Tech 2007

Figure 3. Plymouth Mill Pond Direct Drainage Watershed

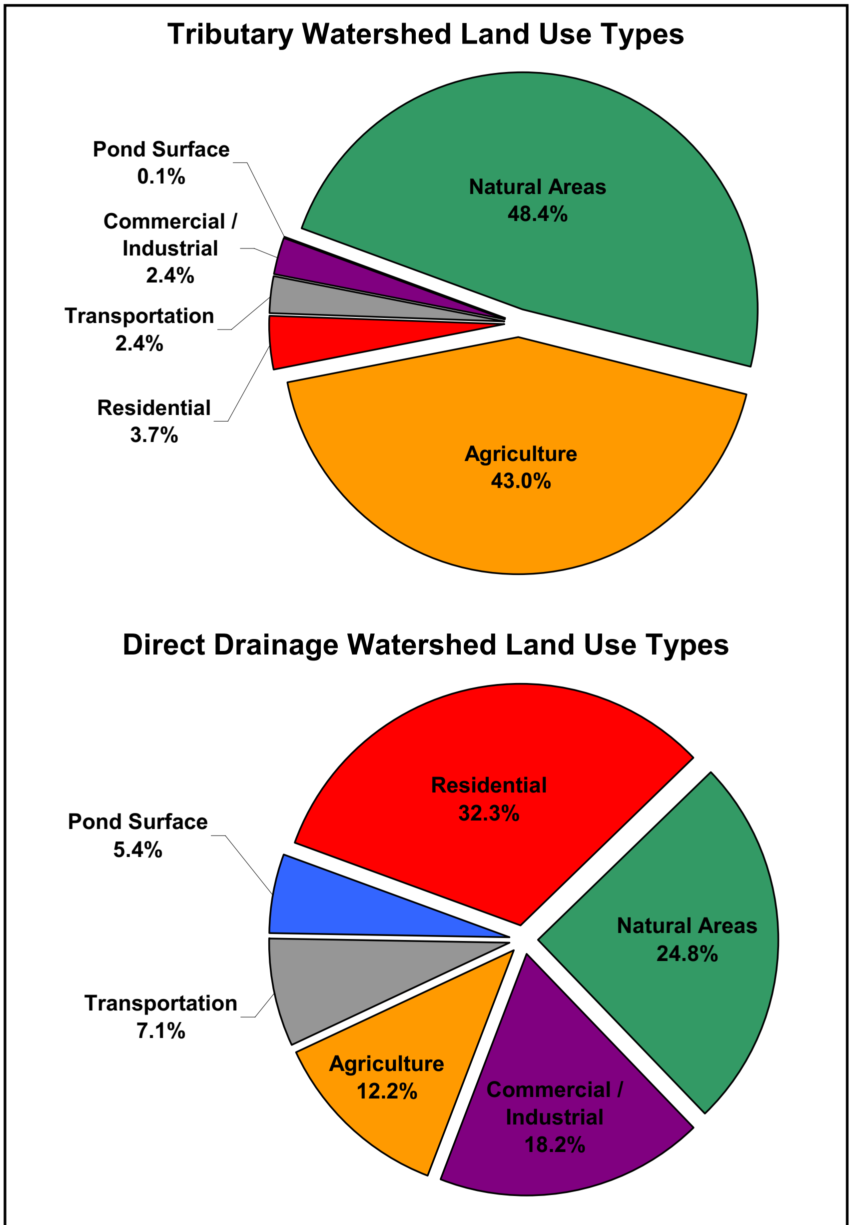
Geology and Soils

The Mill Pond tributary watershed is located in the Southeast Glacial Plains region of Wisconsin. The topography of this region is dominated by rolling till plain intermixed with lakes, outwash plains, and swamps. This landscape was formed by glaciers that covered the area approximately 11,000 years ago. The topography and distribution of soils resulted from glacial action which buried the underlying Niagara dolomite bedrock with unconsolidated deposits ranging from a few feet to several hundred feet in thickness (NRCS, 2007).

The Kettle Moraine, which runs through the middle of the Mill Pond watershed, is a dominant landscape feature in this region. The Kettle Moraine area has relatively steep topography that was created by glacial drift deposits from large masses of glacial ice. Casco and Rodman soils are dominant in the Kettle Moraine. The landscape in the eastern part of the watershed is dominated by drumlins where Hochheim and Theresa soils are dominant. These soils have formed in deposits of loamy material and glacial till. Outwash plains exist in the western part of the watershed. Soils in the western watershed are composed of glacial till that was sorted and deposited as stratified gravel and sand by glacial melt water. Casco and Fox soils have formed in the outwash region and are known to be good sources of sand and gravel (NRCS, 2007).

A majority of the soils in the Mill Pond watershed are part of the Casco-Fox-Rodman association. The soils in this association are well drained to excessively drained soils that have a subsoil of mainly silty clay loam to sandy clay loam or gravelly sandy loam and are underlain by stratified gravel and sand outwash. Soils in this association are suited to growing all common farm crops; however, corn, small grain, and legumes are most commonly planted on these soils. Management concerns for crop cultivation include erosion control, maintaining organic matter content, available water capacity limitations, and fertility limitations. Areas that are not used for crops are used for pasture and wildlife habitat (NRCS, 2007).

Land Use and Land Cover



Source: Bay Lakes Regional Planning Commission 2002.
East Central Wisconsin Regional Planning Commission (Town of Forest 2003).

Chart 1. Plymouth Mill Pond Watershed Land Use Types

The native vegetation of the Mill Pond tributary watershed consisted of a mix of oak forests and maple-basswood forests; however, agricultural and urban land use practices have changed much of the landscape. Only about 10 percent of the native forests remain, and most of the natural communities that remain are associated with large moraines or in areas where the Niagara Escarpment occurs close to the surface (WDNR, 1999).

Current land use within the tributary and direct drainage watersheds was analyzed using a Geographic Information System (GIS) with the most current available land use data as well as aerial photo interpretation from a 2006 color aerial photograph. A summary of current land use within the two watersheds is illustrated in Chart 1.

The two dominant land uses in the tributary watershed are natural areas (48.4%) and agriculture (43.0%). The high percentage of natural area reflects the significant forested areas in the Kettle Moraine and the large wetland complexes that are associated with the Mullet River headwaters. The majority of urban land use is located in the City of Plymouth.

The two dominant land uses in the direct drainage watershed are residential (32.3%) and natural areas (24.8%); however, there is also a significant percent (18.2%) of commercial and industrial land use. The direct drainage watershed is dominated by developed land, in contrast to the tributary watershed, which is dominated by undeveloped land.

POND CHARACTERISTICS

Physical Attributes

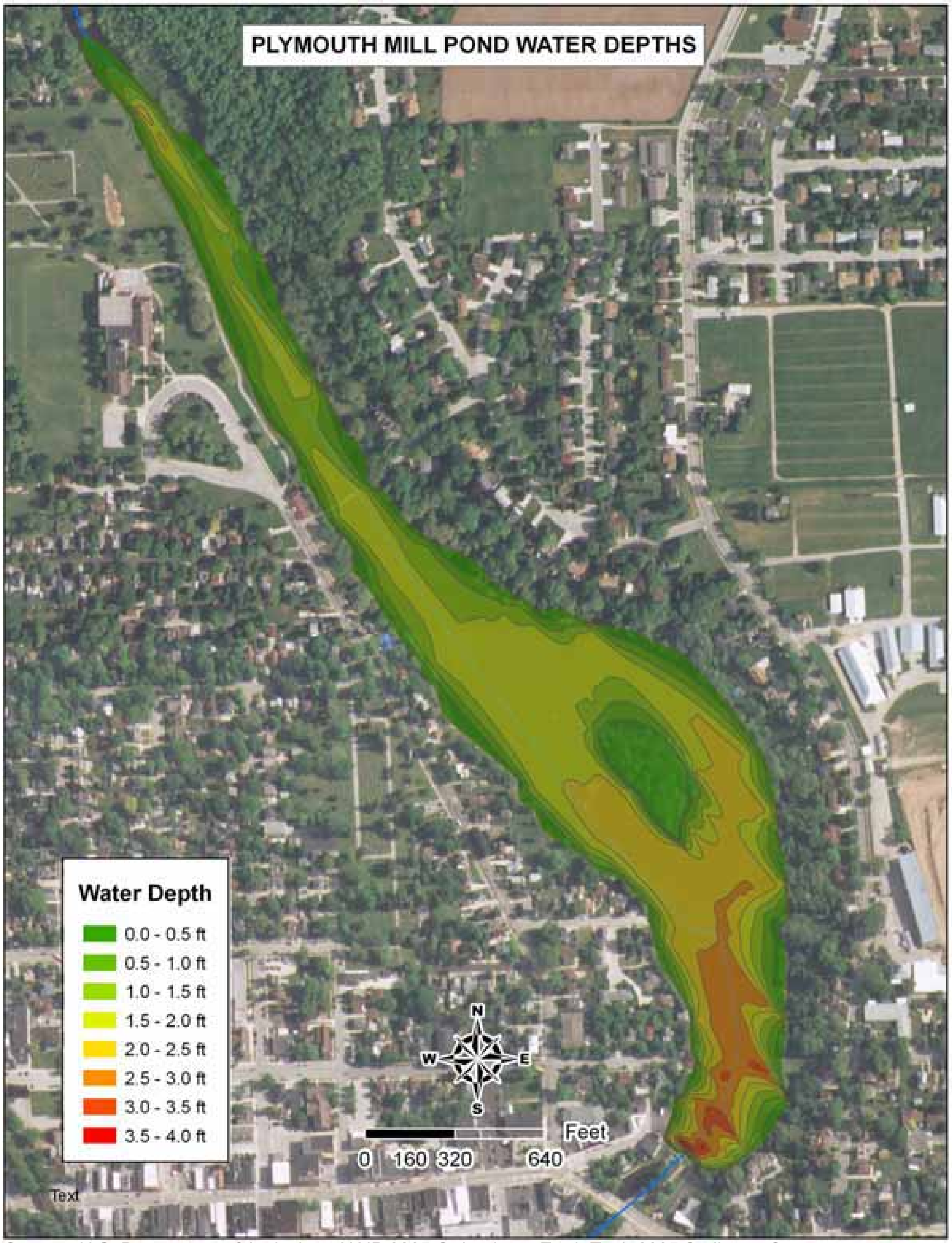
The Mill Pond is a 41-acre impoundment of the Mullet River that is located in the City of Plymouth. The Mill Pond has approximately 2 miles of shoreline that is dominated by residential land use. There is public access to the pond from several city streets and a recreational trail. The average water elevation of the pond ranges between 831.40 and 831.45 feet and the water depth ranges between 1 and 4.3 feet, with an average water depth of 1.8 feet. The volume of the pond basin is approximately 88,390 cubic yards and the flushing rate is approximately 400 times per year (residence time of 0.9 days).

The impoundment has a soft mud bottom and there is generally very little rooted aquatic vegetation. According to WDNR (WDNR, 1999), the Mill Pond supports a population of northern pike, largemouth bass, carp, and a variety of panfish. The Mill Pond attracts a variety of waterfowl and mammals, and multiple pair of Canada geese nest on the pond each year. Large algal blooms and a growing carp population have become management concerns for the Mill Pond.

Bathymetry and Sediment Analysis

A bathymetric survey was conducted at the Mill Pond on September 30 and October 17, 2005. The depth to the top of soft sediment and the depth to hard bottom were measured at 197 points along 6 transects in order to determine the volume of soft sediment that has accumulated in the Mill Pond. Figure 4 shows water depths across the Mill Pond, and Figure 5 shows a 3-dimensional graphic that illustrates the volume of soft sediment in the impoundment. The total volume of accumulated soft sediment in the mill pond is approximately 180,000 cubic yards. The greatest accumulation of sediment occurs between the south end of the island and the dam where the sediment is between 6 and 7 feet thick. A memorandum containing the complete methodology and results of this sampling can be found in Appendix D.

A sediment quality assessment was conducted for the Mill Pond by WDNR on June 29, 1999. Samples were collected at two sample sites in the soft sediment that has accumulated behind the dam. The first site was 49 feet upstream from the dam and consisted of two cores. The top half from each core was composited for a single sample and the bottom of each core was composited for a second sample. This data provided the ability to look at sediment quality that represents different time periods. The sediment that is buried to the greatest depth represents deposition that would have settled at an earlier date. A third sample was collected 328 feet upstream in the mid-channel of the pond. Two cores were collected and composited to make a single sample. Analytical results are shown in Table 1. The pesticides (Aldrin, Alpha BHC, C-chlordane, Chlordane Alpha, Chlordane Gamma, Dieldrin, Endrin, Gamma BHC, Heptachlor, Nonachlor cis) were all less than the level of detection (Galarneau and Masterson, 2001).



Source: U.S. Department of Agriculture NAIP 2005 Orthophoto, Earth Tech 2005 Sediment Contours

Figure 4. Plymouth Mill Pond Water Depths

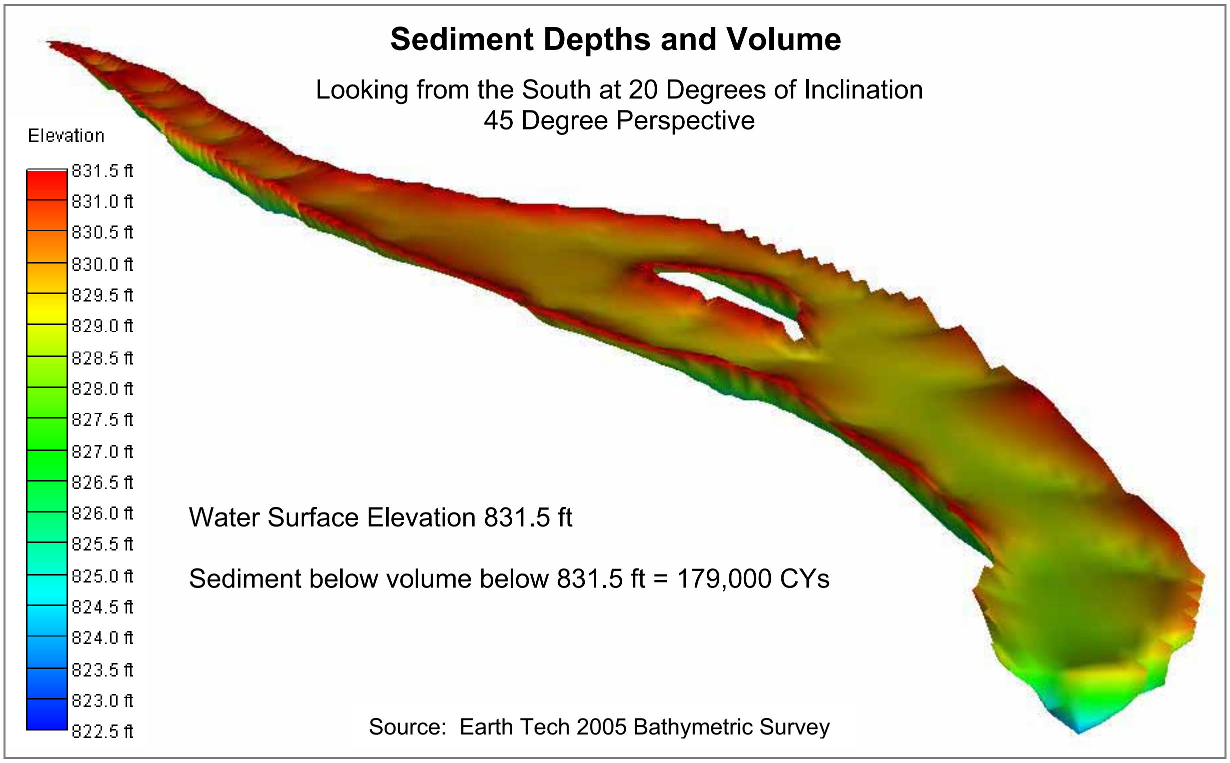


Figure 5. Plymouth Mill Pond Sediment Depths and Volume

Table 1 - Sediment Quality Assessment for the Mill Pond. Collected June 18, 1999

Parameter	49 ft upstream Top of core	49 ft upstream Bottom of core	328 ft upstream
METALS	mg/kg (ppm)	mg/kg (ppm)	mg/kg (ppm)
Arsenic	ND	ND	ND
Cadmium	0.8	0.8	1
Chromium (total)	25	27	25
Copper	30	25	26
Lead	39	23	25
Mercury	0.1	0.099	0.1
Nickel	12	14	13
Zinc	100	81	170
PAHs (total)	0.775	0.717	18.55
PCBs (total)	<0.05	<0.05	<0.05
pp-DDE	0.01	ND	ND
pp-DDD	0.02	ND	0.01
Ammonia-N	58.3	112	39.6
Phosphorus (total)	622	615	523
TOC (Total Organic Carbon)	68,800	59,900	70,400

The top-of-core sample from the sample site located 49 feet upstream had levels below the Threshold Effect Concentration (TEC) for PCBs, pesticides, and all metals except lead. The lead concentration was slightly over the TEC value of 36 ppm. The bottom-of-core sample from the same site had levels below the TEC for PCBs, pesticides, and all the metals tested. There were no significant differences in concentrations between the top-of-core and bottom-of-core samples, which indicates that contaminant inputs from the surrounding watershed have not changed significantly over time. The sample taken 328 feet upstream had concentrations above the TEC value for Cadmium, Zinc, and PAHs (WDNR 2003).

Ammonia concentrations for two of the three samples in the Mill Pond exceed 50mg/L, the lower limit for contaminated soils, which suggests that benthic and epibethic communities may be at risk for toxicity. Though ammonia is readily released from sediments, it's toxicity in water is directly proportional to pH and temperature (EPA/USACE 1998). Most dissolved ammonia is utilized in phytoplankton and macrophyte production.

Phosphorus is also readily released from the sediment and causes surface water euthophication (NRCS 1994). Phosphorus concentrations in the Mill Pond range from 523 to 622 mg/kg. It is predicted that there is a net loss of phosphorus to the sediment of 374 pounds per year due to settling.

Sediment samples from the Plymouth Mill Pond were collected and analyzed by WDNR again in 2004. Results of this sampling were not available for review.

Water Quality

Historic

There is one set of water quality data for one sample location in the Mill Pond that was collected in 1979 by an unknown party. This water sample was collected in the deepest part of the pond located just north of the island. The results of the 1979 sample revealed a secchi depth of 49 inches, a phosphorus level of 38 ug/L, and a chlorophyll-*a* level of 6.85 ug/L (WDNR-SWIMS 1979) These parameters illustrate that over 20 years ago, the Plymouth Mill Pond was a relatively clear, yet productive body of water.

There is also existing water quality data for the segment of the Mullet River that lies within the Mill Pond watershed. The Mullet River downstream of STH 67 is classified as a Warm Water Sport Fish Community stream. Based on 1994 testing by the WDNR, water quality in this segment of the Mullet River was fair to good. Water chemistry and macroinvertebrate samples collected during 1994 indicated that point source dischargers, stormwater runoff, and cropland runoff within the watershed resulted in increased nutrients, sedimentation, and bacteria to the stream (Galarneau and Masterson, 2001). A set of water quality data has also been collected by Plymouth High School Students who have monitored nine biotic and abiotic parameters on the Mullet River 3 to 4 times per year for over 15 years as part of the "Testing the Waters" program. This data may be available to the City of Plymouth for future monitoring.

Figure 6. Plymouth Mill Pond Water Quality Sampling Locations

Current Conditions

Earth Tech collected water samples in the Mill Pond and on the Mullet River during the spring and fall of 2006. Water samples were collected during four sampling events (June, July, August, and October) at two locations in the Mill pond, as well as one location upstream of the Mill Pond and one downstream of the Mill Pond on the Mullet River (Figure 6).

Table 2 presents the water quality sample results for the four stations for each of the four sample events. Temperature, dissolved oxygen, pH and conductivity values were within the normal range for inland lakes and impoundments.

Secchi disc readings could only be measured at Station 3, because the secchi disc was visible all the way down to the substrate at Stations 1, 2, and 4. Chart 2 shows the measurements for secchi disk readings at Station 3 through the sampling period. The water was less clear in July and August, which is typical for lakes in Wisconsin. In late summer, more algae and plankton are suspended in the water column because the nutrient levels are higher at this time during the year.

Chart 3 shows the trend for total phosphorus through the sampling period. Total phosphorus levels peaked in July at all stations and were higher at Stations 2, 3, and 4 than at Station 1. Trends for chlorophyll-a, which is a measure of plant productivity, are shown in Chart 4. Chlorophyll-a levels were lowest at all stations in June, but increased considerably at all but Station 1 as the summer progressed. The additional input of phosphorus is a likely cause of the increase in chlorophyll-a.

Total phosphorus and chlorophyll-a levels were considerably higher at Stations 2, 3, and 4 than at Station 1, the upstream station. This result indicates that a considerable amount of phosphorus is entering Mill Pond from the areas directly adjacent to pond within the direct drainage watershed).

Table 2 - Water Quality Sampling Results for the Mill Pond

Station	Date	Parameters						
		Temp (C)	pH	DO (mg/L)	Cond. (µmhos/cm)	Secchi (m) *	Total P (µg/L)	Chl a (µg/L)
Upstream (Station 1)	6/26/06	18.8	8.5	12.3	696	NA	64	3.89
	7/25/06	20.6	8.3	9.5	681	NA	86	4.32
	8/23/06	16.8	7.8	8.7	719	NA	61	2.54
	10/12/06	6.9	6.9	8.3	705	NA	44	1.44
Pedestrian Bridge (Station 2)	6/26/06	20.2	8.4	8.5	704	NA	78	5.74
	7/25/06	22.6	7.3	6.6	717	NA	123	6.45
	8/23/06	18.6	7.6	5.6	731	NA	98	14.6
	10/12/06	7.1	6.8	8.3	697	NA	49	27
Deep spot Mill Pond (Station 3)	6/26/06	20.3	8.1	6.5	683	1.07	94	10.9
	7/25/06	25	7.5	5.9	743	0.52	141	124
	8/23/06	22.7	7.2	4.6	766	0.61	93	32.2
	10/12/06	6.9	6.8	8.1	657	0.91	50	28.5
Downstream (Station 4)	6/26/06	20.2	8.1	7.2	682	NA	88	8.58
	7/25/06	25.9	8.3	7.9	698	NA	127	57.2
	8/23/06	22.6	7.5	6.5	737	NA	120	42.5
	10/12/06	6.5	6.8	8.1	658	NA	53	60.3

Notes:
* Secchi disc visibility reached the sediment at Stations 1, 2, and 4.

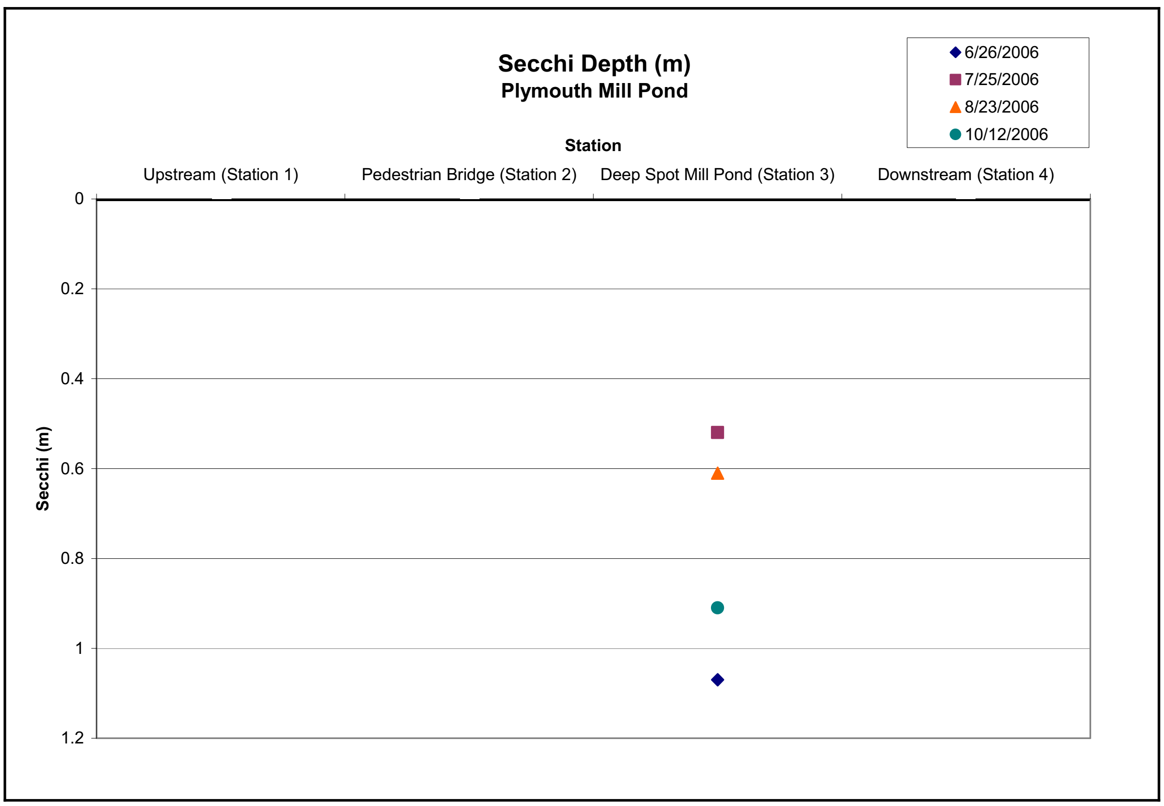


Chart 2. Secchi Depths in the Plymouth Mill Pond

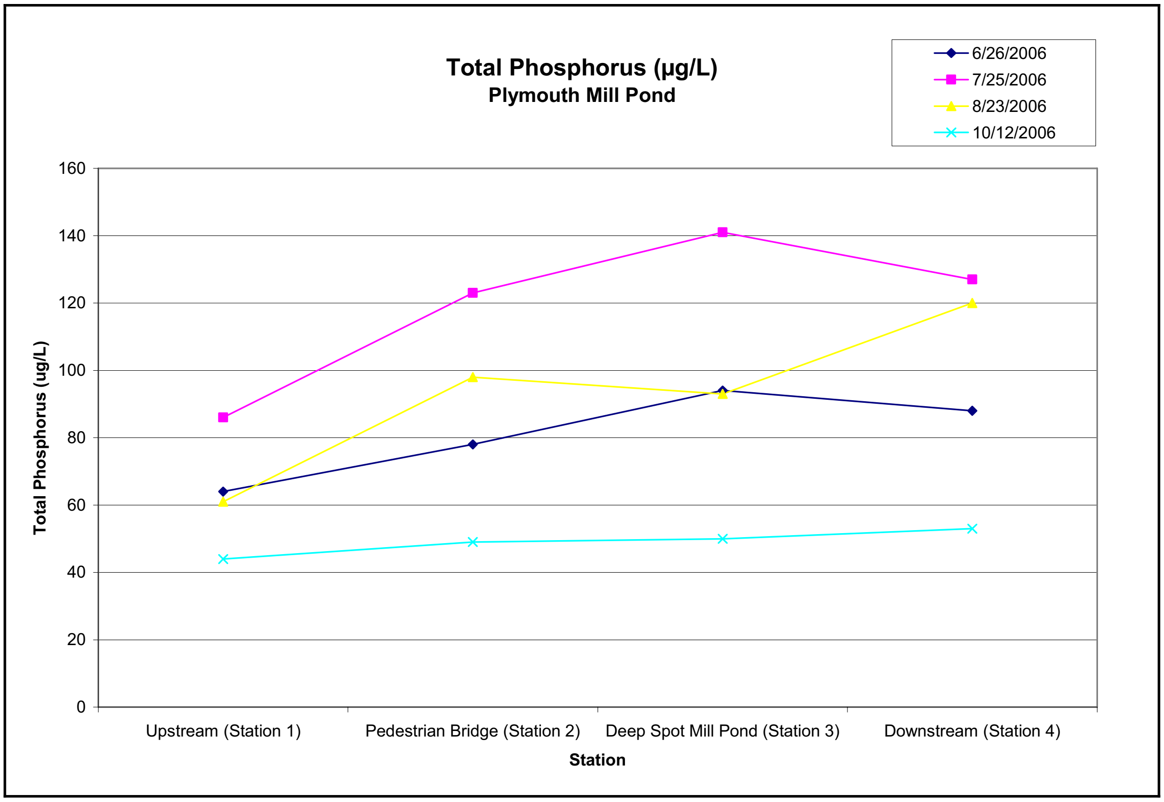


Chart 3. Total Phosphorus Levels in the Plymouth Mill Pond

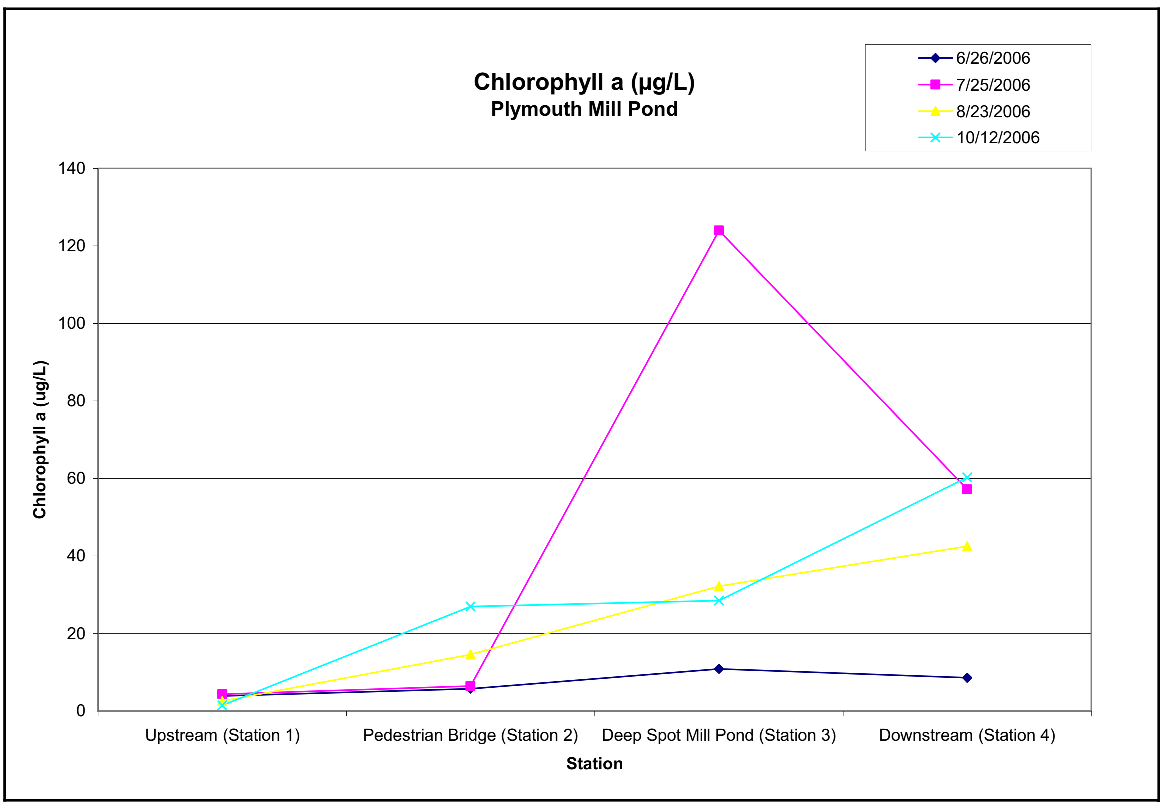
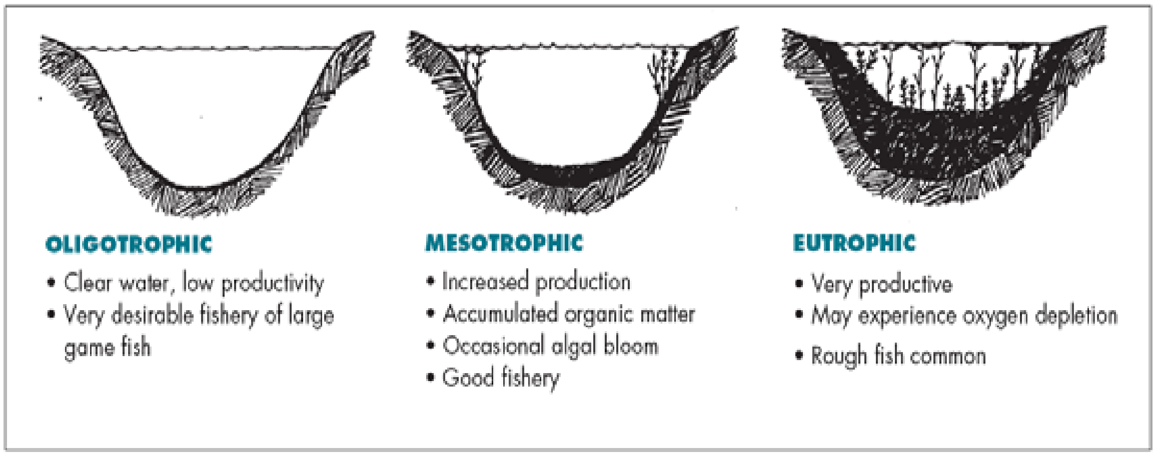


Chart 4. Chlorophyll a Levels in the Plymouth Mill Pond

Carlson's Trophic State Index (TSI) is one means available to examine the relationship between total phosphorus, chlorophyll-*a*, and secchi disk readings in a lake, and its overall productivity. TSI. The term "trophic state" refers to the level of productivity in a lake. Productivity refers to the amount of nutrients, plant, and fish biomass. Productivity and trophic state of lakes are typically classified into three categories: oligotrophic, mesotrophic and eutrophic, and are described and illustrated in Diagram A below.

Diagram 1. Trophic States of Lakes



Source: Shaw, Mechenich and Klessig, 2004.

The WDNR has modified Carlson's equations to form a Wisconsin Trophic State Index (WSTI) to better suit lakes in Wisconsin. Individual WTSI values for this study were calculated from the following WTSI equations:

$$\text{Secchi: } WSTI_{SD} = 60 - (14.4 \ln SD),$$

$$\text{Total P: } WSTI_{P} = 28.2 + (7.73 \ln TP), \text{ and}$$

$$\text{Chlorophyll a: } WSTI_{CHL} = 34.8 + (7.56 \ln CHL),$$

where SD = secchi depth in meters, TP = total phosphorus in parts per billion (ppb), and CHL = chlorophyll-*a* in ppb.

Chart 5 presents the trends for WTSI through the sampling period. According to WDNR, the WTSI values for the four stations were typical for eutrophic lakes, except for the chlorophyll-*a* at Station 1, which was typical for a mesotrophic lake. Based on these measurements, the Mill Pond should be considered a eutrophic system, meaning that it is very nutrient rich and contains abundant organic matter. The relationship among the chlorophyll-*a* and total phosphorus WTSI's in 2006 suggests that there is a high volume of algal biomass within the downstream end of the pond, with some limiting factor in the upstream end of the pond, such as the current of the river or nitrogen levels in the water.

Baseline water quality results suggest that the Mill Pond is a eutrophic system. Phosphorus entering the Mill Pond from both the watershed of the Mullet River and from the adjacent landscape is likely to promote the high density of macrophytes in the pond and the algal blooms that occur in the summer. Limiting the phosphorus entering the pond should positively affect the aquatic health and aesthetics of Mill Pond. A memorandum containing the complete methodology and results of the baseline water quality assessment can be found in Appendix C.

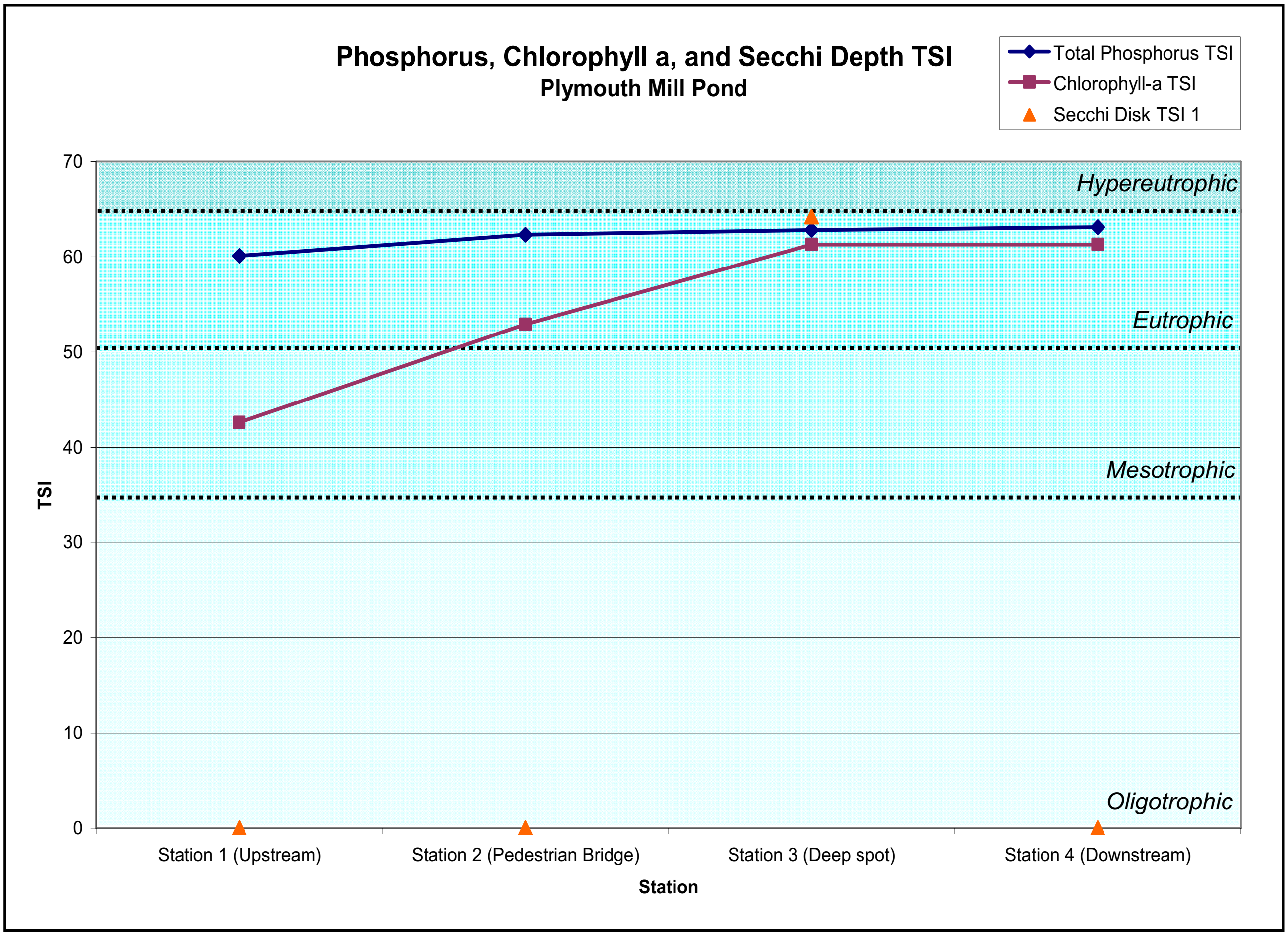
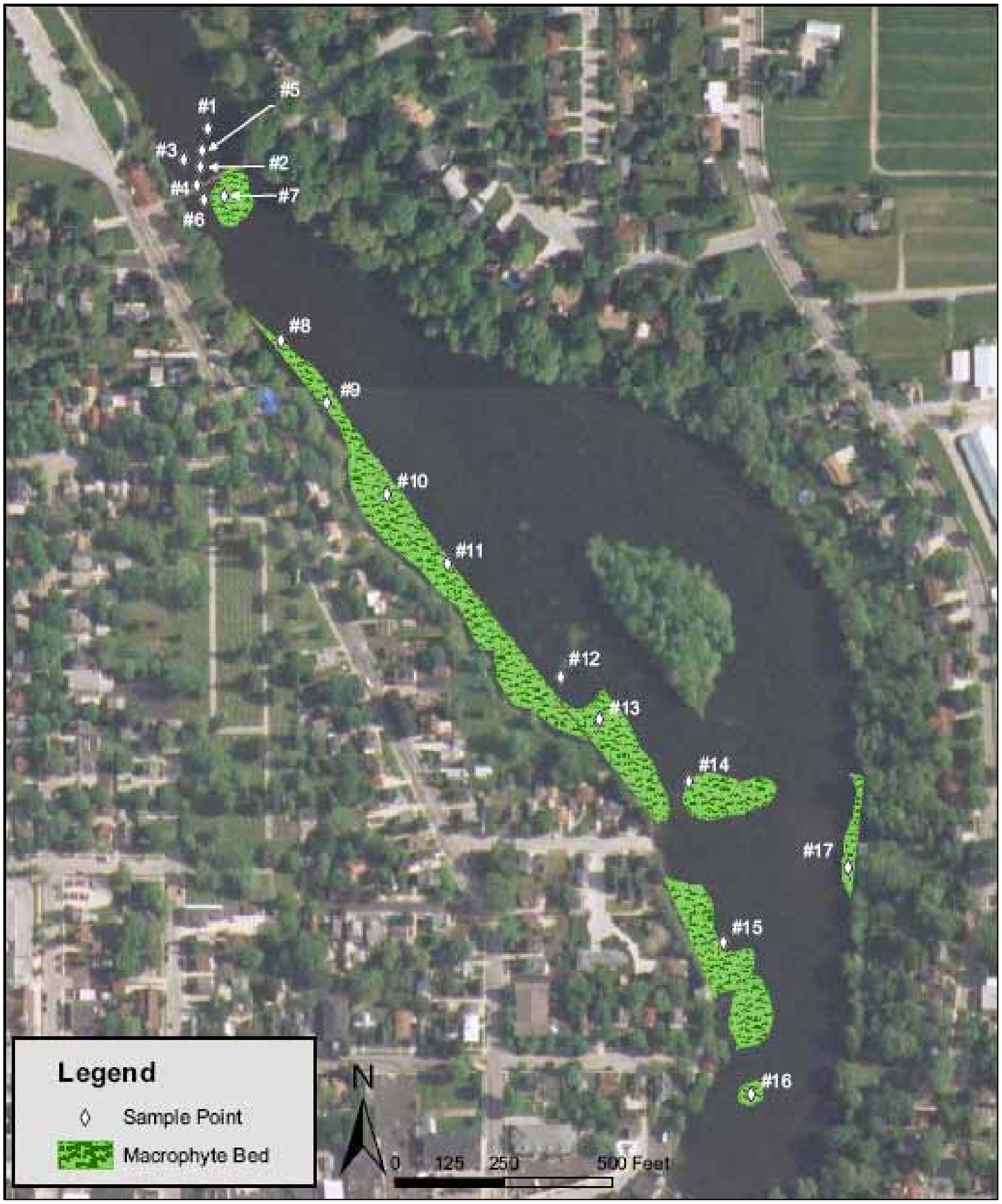


Chart 5. Phosphorus, Chlorophyll-a and Secchi Depth TSI for Mill Pond as compared to TSI Ranges for Trophic States of Lakes (Carlson and Simpson, 1996).

Aquatic Vegetation

The macrophyte community was characterized at 17 locations within Mill Pond (Figure 6) on July 24 and 25, 2006. The sampling locations were chosen based on presence of visible macrophytes during the sampling dates.

The overall abundance of macrophytes was low at the time of the sampling. Approximately 10 percent of the pond was covered with macrophyte beds. The dominant species were sago pondweed (*Potamogeton pectinatus*) and curly-leaved pondweed (*P. crispus*) which were observed at most locations. Coontail (*Ceratophyllum demersum*) and duckweed (*Lemna minor*) accounted for the remaining species. Six macrophyte beds were identified and delineated as shown on Figure 7. The percent coverage of macrophytes within the beds ranged from 0 to 25 percent. No exotic species were observed during the macrophyte survey. A memorandum containing the complete methodology and results of this sampling can be found in Appendix D.



Source: U.S. Department of Agriculture NAIP 2005 Orthophoto, Earth Tech 2006 Macrophyte Survey

Figure 7. Plymouth Mill Pond Macrophyte Populations

WATER QUALITY CONCERNS

In recent years, there have been reports of large algal blooms and excessive macrophyte growth in the Mill Pond that has resulted in diminished aesthetic and recreational value for users. These conditions are likely a result of the excess nutrients (nitrogen and phosphorus) that are available in the pond.

In more than 80 percent of Wisconsin's lakes, phosphorus is the key nutrient affecting the amount of algae and macrophyte growth. Impoundments, which have an average total phosphorus concentration of approximately 65 µg/L (poor water quality index), tend to have higher phosphorus concentrations than other types of lakes. A total phosphorus concentration below 30 µg/L should be maintained to prevent nuisance algal blooms (Shaw, Mechenich and Klessig, 2004).

Data from the baseline water quality sampling indicated that the water coming into the Mill Pond has an average total phosphorus of 63.75 µg/L and the water in the pond has an average total phosphorus of 90.75 µg/L. This data shows us that the water coming into the Mill Pond from the Mullet River is considered to have a poor water quality index due to phosphorus loading from the Mullet River watershed. It also reveals that the direct drainage watershed is contributing additional phosphorus to the Mill Pond system. This phosphorus can originate from a variety of sources such as human and animal waste, soils erosion and sedimentation, and runoff from lawns and agricultural fields. Limiting the amount of nutrients entering surface waters from these sources will be they key to reducing the excess algae and macrophyte production in the Mill Pond.

John Masterson, of the WDNR Plymouth Service Center, was interviewed on the subject of potential impacts to surface water quality in the watershed. According to WDNR records, there are no point sources of pollution, such as wastewater discharges, to the Mullet River upstream of the Mill Pond, and there are no significant areas of non-point source pollution, such as large barnyards or badly eroded farm fields, in the watershed.

A field review of land use and potential nutrient sources in the Mill Pond watershed was conducted in 2006. Results from this field investigation revealed that general agricultural practices in the watershed appeared to be following good management practices from a water quality perspective. A few BMPs, such as low-till/no-till, maintenance of crop residues, vegetated filter strips, and field buffers, could be implemented to help reduce soil erosion during times when the fields are bare. In addition to large agricultural areas, substantial parts of the watershed are woodland, wetlands, or grassland. These natural areas are beneficial from a water quality aspect. The County Fairgrounds was the one area identified during the field review as a possible direct source of pollution and nutrients to the Mill Pond. Upon further investigation, it was found that several treatment practices were implemented within the Fairgrounds in 2004. The County coordinated with WDNR to install a sediment trap under the grandstand, a french drain in the infield and the west side of the racetrack, and sanitary sewer connections for the wash drains by the barn area. These practices provide a reasonable level of treatment for the stormwater runoff from the Fairgrounds and no further improvements were recommended by WDNR. A memorandum containing the complete watershed analysis can be found in Appendix B.

ALTERNATIVES ANALYSIS

Management Options

It was necessary to evaluate the feasibility and cost-benefit of potential water quality management options in order to help the PMPC make appropriate decisions regarding future Mill Pond management. Six management options that would potentially improve the Mill Pond water quality were selected and evaluated in this alternatives analysis. The analysis evaluated the no action alternative in addition to options of removing the dam, dredging the pond sediments, removing aquatic vegetation, drawing down the pond water level, and improving shoreline and urban stormwater management. A memorandum containing the complete Alternatives Analysis can be found in Appendix E.

Of the six alternatives considered, removal of the dam was disregarded because neither the City nor the Mill Pond Committee is interested in permanently draining Mill Pond.

Dredging the pond sediments is an option that would reduce available nutrients in the pond by removing the phosphorus that is bound to the pond sediments. There is currently a high content of phosphorus in the pond sediments that has the potential to dissolve into the water under low oxygen conditions. Removing this phosphorus source may help improve the pond water quality. While dredging the pond may eventually be necessary to restore water depth, this method is not likely to keep the Mill Pond free from excess algae because there will still be nutrients entering the pond system from other sources. This alternative is the most costly, with total costs potentially reaching $7 million. Dredging activities also have the potential to cause negative environmental impacts to the area surrounding Mill Pond.

Removal of the aquatic vegetation is another short term remedy for the Mill Pond. Removing the vegetation would be a temporary solution because the seeds located in the sediments and the surplus nutrients in the pond would allow vegetation to easily re-establish. For vegetation removal to be an effective remedy it would have to be done three or more times a year at a cost of up to $125,000 per removal.

Pond drawdown is an option that may bind some of the excess nutrients to the sediment as the sediments dry and compact. A drawdown may reduce the nutrients available to algae, but it will still be available to rooted macrophytes. The effects of a drawdown would be temporary because the sediments will loosen as they are re-saturated and the nutrients have the potential to re-dissolve into the water. This alternative is relatively cost effective and may provide some temporary benefits, but it should be used in conjunction with another alternative that would work to remove the source of nutrients in the pond system.

Shoreline management and urban stormwater management is an option that would help reduce the amount of sediment and nutrients entering the pond. This alternative has the greatest potential for providing long-term water quality improvements to the Mill Pond because it will help reduce the source of the problem. The County Extension Office and the local WDNR staff could hold public educational meetings, hosted by the City, to inform the public and the City employees on how to better protect the watershed of the Mill Creek from nutrient runoff and erosion.

No action is another possible alternative. This alternative would not provide any temporary or long-term improvements to the Mill Pond. The aquatic vegetation in the Mill Pond has not been as problematic in the past few growing seasons, so the Mill Pond Committee and the City may decide to monitor the Mill Pond over the next few seasons before they decide if further management of the Mill Pond system is necessary.

Summary

Below is an alternatives matrix summarizing some of the important aspects of each alternative. Short-term and long-term effectiveness relates to how well the alternative would reduce aquatic plant and algae growth. Implementability relates to how easily the alternative could physically be implemented.

Alternatives Analysis Matrix

Alternative	Short-Term Effectiveness	Long-Term Effectiveness	Implementability	Public Acceptability	Cost
Dam Removal	High	high	high	low	$80,000
Dredging	High	medium	medium	high	$7,000,000
Aquatic Vegetation Removal	Medium	medium	medium	medium	$125,000/yr
Pond Drawdown	Medium	medium	high	medium	$500
Shoreline and Stormwater Management	Medium	medium	medium	medium	unknown
No Action	Low	low	high	medium	$0

Though dredging has the potential to provide some short-term benefits to the Mill Pond, the high cost and secondary impacts of the dredging activities do not make it a feasible option at this time. However, due to the large sediment loading rate of the pond, dredging may need to be considered in the future in order to restore depth to the pond. Aquatic vegetation removal is also not a feasible option at this time because of the high cost and lack of long-term effectiveness. The alternatives analysis showed that the best means to improve the Mill Pond were to institute a process, with the assistance off the County Extension and the local WDNR offices, to educate the City employees and the public on how to better manage the nutrients and sediments entering the pond through the tributary and direct drainage watersheds of the Mill Pond. This process should be done in conjunction with a drawdown of the pond over the winter months, which would compact the sediments in the pond to increase water depth in the pond and potentially bind some of the nutrients in the compacted sediment. This solution would be the least costly, with the exception of no action, and can be implemented relatively quickly.

MANAGEMENT OBJECTIVES

Management objectives for the Plymouth Mill Pond are split into two separate sections based on location within the watershed and dominant land use. The first set of objectives applies to properties within the Mill Pond's direct drainage watershed, which is located within Plymouth city limits. Most of the land in this watershed is developed and the land use is primarily residential and commercial. The second set of objectives applies to properties within the Mill Pond's tributary watershed that are outside of the Plymouth city limits. The land in this watershed is mostly undeveloped, and agricultural land use is the primary source of nutrients. Refer back to Chart 1 for land use details.

<u>City of Plymouth</u>

- Reduce available nutrient levels by way of a water level drawdown.
- Reduce phosphorus inputs through education and ordinances.
- Prevent exotic species introductions through education.
- Continue monitoring lake water quality and exotic species occurrence.
- Promote conservation through recreational activities and restoration of public open space.
- Ensure that septic systems located adjacent to the pond are operating correctly.

<u>Townships within the Tributary Watershed Outside of the City of Plymouth</u>

- Reduce soil erosion and sedimentation through installation of stream buffers and implementation of agricultural BMPs.

- Reduce nutrient loading through education and ordinances.
- Promote land conservation throughout the watershed.
- Protect any known threatened and endangered resources known to exist within the watershed through coordination with WDNR.

IMPLEMENTATION PLAN

MANAGEMENT OBJECTIVES INSIDE THE CITY OF PLYMOUTH

Management Action: Draw down Mill Pond water levels to the baseline flow of the Mullet River.
Timeframe: Winter 2008-2009
Facilitator: City of Plymouth, Mill Pond Committee
Description: Drawing down the water level in the Mill Pond will allow suspended solids and soft sediment to settle and compact while locking nutrients into the compacted sediments. The settled sediments will increase water depth and provide a stable base for aquatic plant establishment. Aquatic plants will assist in the uptake of excess nutrients in the water. It is recommended that a water level drawdown be repeated every 2 years to ensure long-term effectiveness (NHDES, 2001).

Action Steps:

1. Release public announcement.
2. Remove the weir from the dam for a few months in order to allow a repeated freeze/dry cycle, which will allow for sediment compaction.
3. Clear large debris.
4. Restore water levels.

Management Action: Implement an educational series for local residents in the City of Plymouth to prevent introduction of exotic species, promote the establishment of buffer strips, and reduce phosphorus inputs.
Timeframe: 2008 and thereafter as needed
Facilitator: Mill Pond Committee and local WDNR and UWEX partners
Description: Limiting the amount of nutrients entering a body of water is an effective way to control excessive plant growth and algae blooms. Offer free educational programs that focus on the reduction of phosphorus inputs, the establishment of un-mowed stream buffers and rain gardens for stormwater retention and sediment control, and the prevention of invasive species colonization in and around the Mill Pond. Help residents understand their impacts and encourage local residents to make small changes in their lifestyle to help improve the quality of the Mill Pond.

Action Steps:

1. Select a schedule and location for speaker events and/or workshops.
2. Contact local partners and additional potential speakers to fill the scheduled dates.
3. Publish the schedule of events in local newspapers and media outlets. Organize local mailing.
4. Host events.
5. Seek out additional funding opportunities to further education and outreach.

Management Action: Continue to monitor lake water quality to measure progress.
Timeframe: In Progress
Facilitator: Plymouth High School, WDNR, Mill Pond Committee
Description: Water quality parameters have been established by WDNR and local high school students for sampling points along the Mullet River. Extend sampling points and parameters for further analysis. Baseline water quality data has been provided in this report and are available for comparison in future analyses. Results may be reported to local stakeholders to keep them updated on the status of the water quality of the pond.

Action Steps:

1. Coordinate with local school groups or volunteer organizations and WDNR to establish monitoring protocols and scheduling.
2. Seek additional grant opportunities for citizen monitoring.
3. Provide periodic reports for community extension and education.
4. Report datasets to WDNR for trend analyses.

Management Action: Adopt an ordinance to limit phosphorus applications through reduced lawn fertilizer use in order to prevent excess nutrients from entering the Mill Pond and the Mullet River.
Timeframe: Begin drafting in 2008
Facilitator: City of Plymouth and Mill Pond Committee
Description: Phosphorus levels in the Plymouth Mill Pond range from 40 µg/L to 140 µg/L, which are well above the recommended 30 µg/L for prevention of algal blooms in impoundments (Shaw, Mechenich and Klessig, 2004). Reference the Dane County ordinance (Dane County, 2007), which bans phosphorus inputs via fertilizers where there is no deficiency in nutrient levels, to draft a preliminary ordinance for the City of Plymouth. Utilize education and public awareness channels to build community support.

Action Steps:

1. Research Dane County ordinance (www.countyofdane.com/unified/information/ordinances.aspx).
2. Draft a preliminary ordinance for the City of Plymouth taking into account local requirements and current phosphorus levels.
3. Educate community members about the effects of high phosphorus levels to gain local support. For more information, see *Lake Tides, Volume 31 (3) and Volume 32 (4)*.
4. Finalize the ordinance for the municipality.

Management Action: Consider utilizing alternatives to road salt to improve the water quality of the Mill Pond. Road salt alternatives may include Calcium Magnesium Acetate (CMA) and Potassium Acetate (KA).
Timeframe: Begin planning in 2008.
Facilitator: Mill Pond Committee and City of Plymouth Public Works
Description: The pH levels in the Mill Pond range from 6.8 to 8.5 and are therefore, slightly basic or alkaline. The high alkalinity may be a result of the application of road salts in the urban watershed (*McGinley, 2006*). Research has shown that high concentrations of road salt, or sodium chloride (NaCl), can inhibit plant growth and encourage exotic, salt tolerant species, such as cattails or giant reed grass, to colonize an area and create a monoculture. During snow melt, road salts are released into lakes and streams through runoff and can cause decreased dissolved oxygen levels and increased nutrient loads which lead to eutrohphication (Wegner and Yaggi, 2001).

Action Steps:

1. Research current road salt applications and estimate volumes applied within the Mill Pond direct drainage area.
2. Research alternatives.
3. Weigh the costs and benefits of each alternative.

Management Action: Establish un-mowed vegetated buffer strips along the public shoreline of the Mill Pond.
Timeframe: 2008-2012
Facilitator: Mill Pond Committee, City of Plymouth, WDNR
Description: Establishing un-mowed buffers along the shoreline of the Mill Pond can serve both aesthetic and ecological purposes. Un-mowed shorelines prevent erosion and serve to filter runoff during snowmelt and rain events. Excess nutrients will be absorbed by the vegetation before the water enters the pond. Shoreline restorations in public areas may also open the door for local education opportunities. For more information on Wisconsin Stormwater Regulations, reference *Lake Tides, Volume 31 (4)*.

Action Steps:

1. Designate public space for shoreline restoration or buffer strip.
2. Coordinate with local agencies for stormwater regulations, plant recommendations and erosion control.
3. Install buffers.
4. Consider signage or public events to encourage local Mill Pond stakeholders to follow suit.

Management Action: Ensure that all septic systems adjacent to the Mill Pond are operating correctly.
Timeframe: Regularly
Facilitator: City of Plymouth
Description: Malfunctioning septic systems may release excess nutrients into groundwater sources.

Action Steps:

1. Perform routine checks on septic systems within the Mill Pond watershed, placing high priority on those adjacent to the water body.
2. Take corrective action for any malfunctioning system.

<u>MANAGEMENT OBJECTIVES OUTSIDE THE CITY OF PLYMOUTH</u>

Management Action: Encourage local participation in the Sheboygan County Land and Water Conservation (SCLWC) Stream Buffer Program.
Timeframe: 2008-2012
Facilitator: Mill Pond Committee and SCLWC
Description: The SCLWC is offering a cost sharing option for agricultural stream buffer construction for rural property owners. Three levels of participation are available, each with a one time fee and a 10-year maintenance requirement. More information can be found at http://www.co.sheboygan.wi.us/html/d_lc_bufferstrip.html .

Action Steps:

1. Coordinate with SCLWC to determine when contractors will be available to perform the work in the Mill Pond watershed.
2. Schedule public interest meeting with WDNR and SCLWC to educate local farmers about the program.
3. Facilitate contact lists and initiation of program.

Management Action: Implement an educational series for rural residents to prevent introduction of exotic species, promote native shoreline plantings as buffers, and promote sustainable agricultural practice methods that will reduce excess phosphorus, nitrate, and soil erosion in the watershed.
Timeframe: 2008 and thereafter as needed
Facilitator: Mill Pond Committee, SCLWC, and local WDNR and UWEX partners
Description: The Mullet River Watershed continues to be considered a high priority for selection of nonpoint source management projects and funding (Burzynski, Galarneau and Hackenberg, 2001). Facilitate free educational programs that focus on the reduction of nutrient inputs including synthetic fertilizers, pesticides, and manure, the installation of native plant shoreline buffers, sustainable farming practices, and the prevention and control of invasive species. Help farmers understand their impacts and encourage them to make small changes in their agricultural practice to improve the Mill Pond and the Mullet River.

Action Steps:

1. Select a schedule and location for speaker events and/or workshops.
2. Contact local partners and additional potential speakers to fill the scheduled dates.
3. Publish the schedule of events in local newspapers and media outlets. Organize local mailing.
4. Host events.

Seek out additional funding opportunities to further education and outreach.

Management Action: Coordinate with WDNR in order to protect known threatened and endangered resources within the Mill Pond watershed.
Timeframe: In progress
Facilitator: City of Plymouth, Mill Pond Committee
Description: There are three aquatic endangered resources that are known to occur in the Mullet River Watershed. Projects designed to protect or improve the water quality resource will benefit the protection of these listed resources. Continue to coordinate with DNR to insure that endangered resources are considered during the management implementation process.

Action Steps:

1. Review WDNR's response to the Endangered Resources Review Request once it has been received.
2. Incorporate recommendations provided by WDNR as appropriate.

Additional funding for management implementation may be available through the WDNR Lake Protection Grant Program. Specific tasks that would apply to the management of the Plymouth Mill Pond include lake management plan implementation, development of local regulations and shoreline habitat restoration. For more information regarding WDNR assistance, please refer to http://dnr.wi.gov/org/water/fhp/lakes/lakeprot.htm.

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APPENDIX A

CITIZEN INPUT SURVEY

Mailed	2,411			Business Owners	79
Returned	745			Property Owners	70
Response Rate	30.9%			General Public	596
				Total Received	**745**

CITY OF PLYMOUTH MILL POND FUTURE DIRECTIONS CITIZEN INPUT SURVEY COMPOSITE RESPONSES

The City of Plymouth Mill Pond, located in the central portion of the community, was created 150 years ago when a dam was constructed on the Mullet River. Over the years, the Mill Pond has been used for a variety of purposes. Sedimentation, weeds, and odors have surfaced as current issues facing the Mill Pond.

During the summer of 2005, the Plymouth City Council created a Mill Pond Committee to identify future directions. The committee, in cooperation with the Sheboygan County University of Wisconsin-Extension Office, developed this survey to obtain your opinions about the future of the Mill Pond. Please take a few minutes to complete the questions. ***Your input is important and will be used!*** *The Mill Pond Committee is open to all ideas/opinions and looks forward to receiving yours. (Additional surveys are available for other members of your household by contacting The Plymouth City Clerk/Treasurer, Patricia Huberty, 128 Smith Street, Plymouth, WI 53073, (920) 893-1271, or, if other members of your household wish to use this survey, please have them mark their response with a different color pen/pencil.) Please return survey to location on back by* ***Monday, October 31, 2005.*** *Return postage is provided.*

EXISTING CONDITIONS

1. ***Your perception of the overall water "quality" of the Plymouth Mill Pond is: (check one)***

1.7% Excellent (13) — 11.1% Good (83) — 28.6% Fair (213)
38.1% Poor (284) — 16.9% Don't know (126) — 3.6% No response (26)

2. ***In your opinion, what poses the most critical threats to the Mill Pond's water quality? (check all that apply)***

21.2% Declining water depth due to silt/sediment build-up (486)
10.3% Stormwater pipes that discharge directly into the Mill Pond (236)
8.4% Overland stormwater runoff from areas such as parking lots, roof tops, roadways, and lawns (194)
13.2% Wildlife, especially geese that are attracted to the Mill Pond (304)
13.4% Weeds (307)
7.4% Upstream wastewater treatment facility discharges (170)
10.5% Upstream sanitary and combined sewer overflows (242)
8.7% Upstream agricultural practices (201)
3.8% Upstream construction site erosion (88)
3.1% Other (specify) (71)

3. ***On average during summers, aquatic plant/weed growth in the Mill Pond has been: (check one)***

5.0% Light – very little (37)
18.9% Moderate – just right (141)
28.9% Heavy – weeds limit my use of some of the Mill Pond (215)
9.2% Dense – weeds ruin my ability to enjoy the Mill Pond in any manner (69)
35.2% Don't know (262)
2.8% No response (21)

4. ***Fishing on the Plymouth Mill Pond is: (check one)***

0.4% Excellent (3) — 3.5% Good (26) — 13.8% Fair (103)
28.6% Poor (213) — 51.4% Don't know (383) — 2.3% No response (17)

5. *Which one of the following best describes the type of fish present in the Mill Pond?*

2.8% An equal balance of rough fish and game fish (21)
36.6% More rough fish than game fish (273)
0.7% More game fish than rough fish (5)
54.8% Don't know/don't fish the Mill Pond (408)
5.1% No response (38)

6. *Are geese and gulls that are attracted to the Mill Pond a problem?*

51.4% Yes (383) 28.5% No (212) 15.7% Don't know (117) 4.4% No response (33)

*If yes, what is the problem?*________________

7. *On average during summers, have you experienced any odor from the Mill Pond?*

25.6% Yes (191) 53.9% No (401) 17.4% Don't know (130) 3.1% No response (23)

If yes, which one of the following best describes the magnitude of the odor?

22.0% Faint (51) 47.0% Mild (109) 28.4% Strong (66) 2.6% Overwhelming (6)

Also if yes, what was the extent of the odor?

26.0% Limited to the Mill Pond (57)
63.0% Extended just beyond the shoreline of the Mill Pond (138)
10.0% Extended several blocks from the Mill Pond (22)
1.0% The odor could be detected throughout Plymouth (2)

POND USES

8. *During the past 12 months, which of the following activities have you participated in, on, or around the Plymouth Mill Pond? (check all that apply)*

5.2% Fishing (99)
3.2% Boating (60)
0.9% Snowmobiling (17)
2.5% Picnicking (48)
24.4% Scenic enjoyment (461)
1.8% Other (specify) (35)
16.1% Hiking and/or biking on recreational trails (304)
15.8% Veteran's Memorial Trail use (300)
0.4% Ice fishing (7)
8.3% Ice skating (157)
0.1% Swimming (1)
14.0% Wildlife observation (265)
7.3% Haven't used the Plymouth Mill Pond for any activity during the past 12 months (139)

9. *Currently during the winter months, a portion of the Mill Pond is used as a skating area for the community. How important is this skating area for the community?*

44.7% Very important (333) 33.3% Important (248) 13.9% Somewhat important (104)
4.6% Not important (34) 3.5% No response (26)

10. *Public access to the Plymouth Mill Pond can best be described as:*

25.8% Not enough access (192) 49.8% Adequate access (371) 0.5% Too much access (4)
20.4% Don't know/no opinion (152) 3.5% No response (26)

11. Is there a need to improve the safety around the Mill Pond dam/spillway?

25.4% Yes (189.5) 43.7% No (325.5) 25.9% No opinion (193) 5.0% No response (37)

12. If the island became available to the City of Plymouth, would you support developing the island as a park?

25.1% Yes (187) 30.7% Yes, but not at taxpayers expense (229) 32.5% No (242)
9.0% No opinion (67) 2.7% No response (20)

13. The island within the Mill Pond is currently about three acres. Would you favor enlarging the island?

9.4% Yes (70) 6.3% Enlarge the island, but not with dredged materials from the Mill Pond (47)
64.7% No (482) 16.5% No opinion (123) 3.1% No response (23)

14. If the island was developed as a park, would you support construction of a pedestrian bridge to access it?

21.3% Yes (159) 30.8% Yes, but not at taxpayers expense (230) 37.9% No (282)
6.6% No opinion (49) 3.4% No response (25)

15. If the island was developed as a park and a pedestrian bridge provided access to it, would you use the bridge/island park?

37.2% Yes (277) 26.2% Maybe (195) 27.0% No (201) 8.7% Don't know (65) 0.9% No response (7)

16. Stocking game fish in the Mill Pond is:

14.6% Much needed (109) 26.3% Needed (196) 10.7% Slightly needed (80)
14.9% Not needed (111) 30.4% Don't know (226) 3.1% No response (23)

AESTHETIC VALUES

17. The aesthetic/scenic value of the Plymouth Mill Pond is important to you and your household.

30.5% Strongly agree (227) 40.8% Agree (304) 19.1% Neutral (142)
4.6% Disagree (34) 2.6% Strongly disagree (20) 2.4% No response (18)

18. The aesthetic/scenic value of the Plymouth Mill Pond is important to the community of Plymouth.

37.2% Strongly agree (277) 43.6% Agree (325) 12.2% Neutral (91)
3.1% Disagree (23) 1.5% Strongly disagree (11) 2.4% No response (18)

19. How important overall is the Plymouth Mill Pond to you and your household?

20.5% Very important (153) 27.4% Important (204) 30.5% Somewhat important (227)
15.7% Not important (117) 3.5% No opinion (26) 2.4% No response (18)

20. How important overall is the Plymouth Mill Pond to the community of Plymouth?

31.2% Very important (233) 36.9% Important (275) 18.9% Somewhat important (141)
6.6% Not important (49) 3.8% No opinion (28) 2.6% No response (19)

21. Is the Mill Pond important for tourism?

54.3% Yes (404.5) 26.3% No (195.5) 17.4% Don't know/no opinion (130) 2.0% No response (15)

22. In your opinion, do visitors/tourists to Plymouth view the Mill Pond positively or negatively?

41.5% Positively (309)
9.0% Negatively (67)
45.3% Don't know/no opinion (338)
4.2% No response (31)

23. What improvements would be beneficial to enhance the aesthetic value of the Plymouth Mill Pond?

MANAGEMENT OPTIONS

24. Over the long term, which one of the following management options would you prefer?

37.7% Remove accumulated sediments in the Mill Pond (dredging) (308)
6.7% Use chemicals to control weeds in the Mill Pond (55)
17.8% Use mechanical cutters/harvesters to control weeds in the Mill Pond (145)
11.8% Drawdown/drain water out of the Mill Pond for a period of time to control weeds and allows sediments to compact (96)
10.9% Removal of the dam (eliminate the Mill Pond) (89)
7.5% Do nothing (61)
7.6% Other (specify) (62)

25. To specifically address the weed problem within the Mill Pond, which one of the following management options would you prefer?

34.4% Dredging (256)
9.4% Use chemicals/herbicides (70)
19.5% Use mechanical harvesters/cutters (145)
14.6% Drawdown/drain water out of Mill Pond for a period of time (109)
11.1% Do nothing (83)
9.8% No opinion (73)
1.2% No response (9)

COST/FUNDING

26. Costs associated with the Mill Pond and/or dam should be paid by: (check all that apply)

16.8% All City of Plymouth taxpayers (304)
9.0% Special assessments on Mill Pond property owners (164)
8.7% Business and industry (158)
12.2% Community organizations (222)
23.1% Concerned citizens, donations, and fund raisers (420)
28.9% Grants and other government aid programs, if available (524)
1.3% Other (specify) (23)

27. Are you willing to have tax dollars used for the Mill Pond?

42.1% Yes (314) 45.0% No (335) 7.1% No opinion (53) 5.8% No response (43)

OTHER ISSUES/COMMENTS

28. Please describe any additional issues and/or comments regarding the Plymouth Mill Pond

---

YOUR BACKGROUND/STATISTICAL INFORMATION

29. What is your age?

0.6% Under 18 (5)
0.6% 18 – 24 (5)
2.6% No response (19)
9.3% 25 – 34 (69)
16.0% 35 – 44 (119)
23.2% 45 – 54 (173)
19.9% 55 – 64 (148)
16.1% 65 – 74 (120)
11.7% 75 or older (87)

30. Do you rent or own property in the City of Plymouth?

1.7% Rent (13) 92.6% Own (690) 2.1% Rent and own (15) 3.6% No response (27)

31. Do you consider yourself a seasonal City of Plymouth resident or permanent resident?

1.3% Seasonal (10) 95.6% Permanent (712) 3.1% No response (23)

32. How long have you lived in the City of Plymouth?

9.4% Less than 5 years (70)
10.9% 5 – 10 years (81)
10.7% 50 years or longer (79)
15.7% 11 – 19 years (117)
10.7% 20 – 29 years (80)
15.8% Lifetime resident (118)
13.4% 30 – 39 years (100)
11.3% 40 – 49 years (84)
2.1% No response (16)

33. How many members are in your household?

14.2% 1 (106)
9.1% 5 (68)
42.8% 2 (319)
2.6% more than 5 (19)
11.3% 3 (84)
3.5% No response (26)
16.5% 4 (123)

34. Do you feel the responses you provided in this survey are representative of your household?

91.1% Yes (679) 0.4% No (3) 4.1% Not sure (30) 4.4% No response (33)

35. Do you own property/reside on the Plymouth Mill Pond?

9.4% Yes (70) 86.8% No (647) 3.8% No response (28)

a. If yes, which of the following best describes why you chose property on the Plymouth Mill Pond

38.2% The aesthetics/scenic quality of the Mill Pond (63)
3.0% Cost of property (5)
14.6% For recreation purposes (fishing, swimming, boating, etc.) (24)
3.6% Because of neighbors (6)
7.3% Other (specify) (12)
19.4% Privacy (32)
10.3% For investment purposes (17)
3.0% Family tradition (5)
0.6% Inherited property (1)

b. If yes, please indicate the most important reasons why you own property on the Plymouth Mill Pond

- 6.9% Fishing (12)
- 0.0% Swimming (0)
- 8.7% Boating (15)
- 9.8% Entertaining friends and relatives (17)
- 11.0% Holding property as an investment (19)
- 21.4% Observing wildlife (37)
- 35.8% Enjoying the view, peace and tranquility (62)
- 6.4% Other (specify) (11)

c. If yes, please indicate the most important ways you actually use your property on the Plymouth Mill Pond

- 7.1% Fishing (14)
- 0.0% Swimming (0)
- 11.7% Boating (23)
- 4.1% Other (specify) (8)
- 28.4% Observing wildlife (56)
- 36.0% Enjoying the view, peace and tranquility (71)
- 12.7% Entertaining friends and relatives (25)

36. Do you own a business in the City of Plymouth?

14.0% Yes (104) 78.1% No (582) 7.9% No response (59)

OPTIONAL INFORMATION

Name:______________________________

Address:______________________________

City/Zip:______________________________

THANK YOU!!!

The City of Plymouth Common Council and Mill Pond Committee thank you for your input and cooperation.

Additional surveys for your household are available from The Plymouth City Clerk/Treasurer, Patricia Huberty, 128 Smith Street, Plymouth, WI 53073, (920) 893-1271.

Please mail survey to the location on last page by Monday October 31, 2005. Return postage is provided.

APPENDIX B

PLYMOUTH MILL POND BACKGROUND WATERSHED ASSESSMENT MEMORANDUM

EarthTech
A tyco International Ltd. Company

Memo

1210 Fourier Drive
Suite 100
Madison, WI 53717

P 608.836.9800
F 608.836.9767
www.earthtech.com

Date: May 8, 2007

To: Bill Immich, City of Plymouth Director of Public Works

Copy: Steve Grumann, Earth Tech

From: Bernie Michaud, Earth Tech

Subject: Plymouth Mill Pond Background Watershed Assessment

Introduction

The purpose of this technical memorandum is to summarize background information on the Plymouth Mill Pond and the Mullet River watershed tributary to the mill pond. Also summarized are the findings of a windshield survey of the watershed looking for potential land use impacts to the water quality of the Mullet River and the mill pond. In addition a summary of information for known endangered resources in the project area is provided.

Historical Review

Jim Stahlman, a member of the Plymouth Mill Pond committee provided the following history of the Plymouth Mill Pond. The original dam was constructed in the late 1840s, probably the spring of 1849. There is speculation that the river was rerouted when the dam was built but there is no supporting evidence for this and it is unlikely. The dam and mill pond are shown in roughly their present configuration in both the 1875 and 1889 plat books found in the Plymouth Historical Society Museum. Another dam and mill (Jones Mill) existed upstream on the Mullet River north of the present day Industrial Park in the 1870s and 1880s in the Town of Mankato. This dam was abandoned around 1900. The County Fairgrounds were started in 1897. In 1906 a flood washed out the Plymouth mill dam, which was later reconstructed. The present dam was constructed in the early 1950s. The mill pond was drained down in the late 1950s. During this drawdown the river was on the east side of the island.

Watershed Delineation

The Mullet River watershed tributary to the Plymouth Mill Pond was delineated using a combination of Wisconsin Department of Natural Resources (WDNR) Mullet River watershed GIS information, City of Plymouth storm sewer drainage mapping, and U.S. Geological Survey (USGS) topographic quadrangle maps. The watershed drains about 62 square miles in Fond du Lac and Sheboygan counties as shown in the attached watershed map. The Mullet River originates at Mullet Lake and runs east, gathering drainage from La Budde Creek to the north near Elkhart Lake and Jackson Creek to the northwest of the City of Plymouth.

Land Use

Based on WDNR GIS land use mapping and Earth Tech's windshield survey, the land use in the watershed is primarily agricultural with extensive wooded areas and significant wetland areas buffering the drainage ways of the Mullet River and its tributaries. Extensive areas of wetland also form the headwaters of the Mullet River. The majority of urban land use is in the City of Plymouth.

The Sheboygan County Land & Water Conservation Department (LWCD) was consulted regarding agricultural practices in the project area. The LWCD contact said they do not have information readily available in that regard and referred Earth Tech to WDNR.

WDNR Background Information

John Masterson, of the WDNR Plymouth Service Center, was interviewed regarding potential impacts to surface water quality in the watershed. According to WDNR records, there are no point sources of pollution such as wastewater discharges to the Mullet River upstream of the mill pond. There are no significant sources of non-point source pollution, such as barnyards or badly eroded farm fields, in the watershed which stand out.

Curtis Nickels also of the WDNR Plymouth Service Center was interviewed about measures taken at the Sheboygan county Fairgrounds to reduce non-point source pollution. Over the last several years he has worked with the County Fairgrounds to install a sediment trap by the racetrack grandstands, a French drain in the infield, and another on the west side of the racetrack.

Sediment samples from the Plymouth Mill Pond were collected and analyzed by WDNR in 2004. Results of this sampling were not available for Earth Tech review. A review of online USGS water quality data revealed no data collected for the Mullet River.

Watershed Windshield Survey

A windshield survey of the watershed to assess land use practices, as they would impact water quality, was conducted on June 20th, 2006. Eleven different locations were characterized throughout the watershed. These eleven locations are labeled on the attached watershed map. Photographs of the locations are included in Attachment A. The following is a summary of findings for each location.

Site 1) County Fairgrounds

The County Fairgrounds are east of mill pond in the City of Plymouth. The fairgrounds drain directly to mill pond via storm sewers. The fairgrounds have a dirt racetrack for car racing with associated grand stands and barns for livestock. Midget car racing occurs throughout the summer with the County Fair occurring in late summer. This is when the livestock barns are most used, but at the time of the survey fresh horse manure was found near the barns.

The fairgrounds may be a significant source of non-point source pollution to Mill Pond. The dirt track racetrack could generate loadings of mud, oil, grease and gasoline. According to Curtis Nickels of the WDNR, a sediment trap by the racetrack grandstands, a French drain in the infield, and another on the west side of the racetrack has been installed in the past several years in an effort to prevent this non-point source pollution from entering the mill pond. There have been anecdotal observations of the storm sewer outfall going into Mill Pond from the race track area, flowing brown during rain storms. The areas near the barns are paved and are drained by storm sewer inlets. Manure from these areas could easily enter Mill Pond directly from these areas.

Site 2) Bare Field West of CTH OJ

This is a farm field bordering CTH OJ to the west and just north of State HWY 23. This field drains to the Mullet River upstream of the mill pond. At the time of the windshield survey on June 20th, the field was bare with no apparent crop showing. A crop may have been planted and it may not have been apparent at the time.

There was no significant erosion evident from the highway. The field slopes were not severe. It appeared that there was a green space buffer between the field and the river. Overall, as long as the field is vegetated with a crop or other cover, this field is probably not a major source of sediment to the Mullet River.

Site 3) Oat Field by CTH J

This site is an oat field just south of CTH J and west of State HWY 67. The field drains to the Mullet River upstream of Mill Pond. At the time of the survey the oats were well established. Non row crops, such as oats, provide good ground cover and have less potential sediment erosion than row crops, such as corn and soy beans.

Site 4) Corn Field by CTH C

This site is west of CTH C just north of Woodland Road. The field drains to the Mullet River north of the mill pond. At the time of the survey the corn appeared well established and the field well managed.

Site 5) Bare Field West of Racetrack Road

This is a farm field west of Racetrack Road and south of CTH JJ. This field drains to La Budde Creek southeast of Elkhart Lake. At the time of the windshield survey on June 20th, the field was bare with no apparent crop showing. A crop may have been planted and it may not have been apparent at the time.

There was no significant erosion evident from the highway. The field slopes were not severe. It appeared that there was a green space buffer between the field and the river. Overall, as long as the field is vegetated with a crop or other cover, this field is probably not a major source of sediment to La Budde Creek.

Site 6) Corn Field at Southeast Corner of Racetrack Road and CTH JJ

This corn field drains to the corner of this intersection with no apparent outlet. If this field did freely drain it would drain to La Budde Creek. There is an accumulation of eroded sediment at the corner of this field as well as an eroded flow path through the field as shown in the photo. The corn is not growing very well in this field as compared to other corn fields in the watershed, perhaps due to relatively poor soil conditions. If there is free drainage from this field, it could be a source of sediment to La Budde Creek.

Site 7) La Budde Creek Near Golf Course Road

La Budde Creek was observed at a bridge crossing near Golf Course Road southeast of Elkhart Lake and just west of the railroad tracks. The creek water was relatively clear and had aquatic vegetation growing on the bottom. The stream appears to have been straightened, probably due to the construction of the railroad tracks. Despite being straightened, the creek banks are well buffered with dense vegetation. Field observation and map review indicates the most of La Budde Creek is well buffered with green space (woods and wetlands) throughout its course.

Site 8) Glenbeulah Mill Pond

The Glenbeulah Mill Pond is the largest man made impoundment on the Mullet River upstream from the Plymouth Mill Pond. Two smaller impoundments, Otter Pond and the Camp Evelyn Pond, are located within a mile downstream from the Glenbeulah Mill Pond. The Glenbeulah dam is an earthen dam with a concrete gated section located in a Village park.

The Glenbeulah Mill Pond has an accumulation of sediment along the upstream side of the dam. There is also aquatic vegetation growth, however it is not as abundant as that in the Plymouth Mill Pond. There is little development around the shores of the pond, and the Village of Glenbeulah is small compared to the City of Plymouth. The river flowing downstream of the dam is swift flowing and relatively clear but more turbid than La Budde Creek. There are clumps of filamentous algae growing on the shallow rocks below the dam. The Glenbeulah Mill Pond and the other two smaller impoundments downstream act as sediment traps to remove sediment before it reaches the Plymouth Mill Pond.

Site 9) Bare Field North of CTH A

This is a farm field north of CTH A about one mile northeast of the Village of Greenbush. To the north of the field is the Mullet River. At the time of the windshield survey on June 20th, the field was bare with no apparent crop showing. A crop may have been planted and it may not have been apparent at the time.

There was no significant rill erosion evident from the highway. The field slopes were flat. There is a wooded buffer area between the field and the river. Overall, as long as the field is vegetated with a crop or other cover, this field is probably not a major source of sediment to the Mullet River.

Site 10) CTH T and Spring Valley Road

This site consists of farm field to the east and west of Spring Valley Road just north of CTH T about two miles west of the Village of Greenbush. These fields drain north to the Mullet River. The east field is in hay and the west field is in corn as shown in the photos. These fields appeared in good condition and there was a wooded buffer area along the river. These fields were typical of what was seen throughout the watershed.

Site 11) Outlet to Mullet Marsh

This site is the outlet to Mullet Marsh as it crosses CTH G. Mullet Lake and Mullet Marsh form the headwaters of the Mullet River. These two water bodies are surrounded by wetlands and are well buffered from sediments from the surrounding watershed. The flow at this outlet is rather sluggish. The water is clear but stained by tannins. Duckweed is present on the surface.

Watershed Windshield Survey Summary

Overall agricultural practices in the watershed appear to be following good management practices from a water quality perspective. While the survey did find three fields that were bare and possible sources of eroded sediment, it appeared that they were just planted or about ready to be planted. The majority of the farm fields were in good condition and planted in corn, oats, or hay. One eroded corn field was found by Racetrack Road but it appeared to be an enclosed depression without a discharge to La Budde Creek. No large dairy herds or other livestock operations were seen. Substantial parts of the watershed are woodland, wetlands, or grassland that can be beneficial from a water quality aspect.

The one site that perhaps deserves some additional investigation is the County Fairgrounds. Given its proximity to and direct discharge to Mill Pond, non-point source pollution from this site could have a significant impact to the water quality of the pond. Drainage routes from both the racetrack and livestock area, as well as other possible pollutant sources, should be further investigated. If it is found that non-point source pollution from this site is making its way to the mill pond there are a number of practices that could be employed to try and improve the situation. These could include disconnecting the flow paths to the pond, removing the pollutant sources, or treating the runoff before it reaches the pond.

Project Area Endangered Resources

The Endangered Resources Review Request has been submitted to the WDNR Bureau of Endangered Resources. No results were available from WDNR prior to the date of this Technical Memorandum.

ATTACHMENT A

PHOTOGRAPHS

Photo Log – Plymouth Mill Pond Watershed Survey

Site 1 - Dirt Racetrack

Site 1 - Manure near livestock barns

Site 2 - Bare Farm Field West of CTH OJ

Site 3 - Oat Field South of CTH J

Site 4 - Corn Field West of CTH C

Site 5 - Bare Field West of Racetrack Road

Site 6 - Eroded Corn Field at SE Corner of Racetrack Road and Hwy. JJ

Site 7 - La Budde Creek

Site 8 - Glenbeulah Dam

Site 9 - Bare Field north of Hwy A looking toward the Mullet River

Site 10 - Alfalfa Field

Site 10 - Corn Field

Site 11 - Mullet Marsh Outlet

APPENDIX C

MILL POND BASELINE WATER QUALITY ASSESSMENT MEMORANDUM

EarthTech
A tyco International Ltd. Company

Memo

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53083

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May 8, 2007

To: Bill Immich, City of Plymouth

From: Steve Grumann, Earth Tech

Subject: **Mill Pond Baseline Water Quality Assessment Technical Memorandum**

This technical memorandum summarizes the results of the baseline water quality sampling completed by Earth Tech during the summer and fall of 2006, at the Mill Pond located in Plymouth, Wisconsin. Components of the water quality sampling conducted by Earth Tech included field measurements (temperature, pH, dissolved oxygen, conductivity and water transparency) and laboratory analysis (total phosphorus and chlorophyll-*a*).

SAMPLING METHODOLOGY

Water samples were collected by Earth Tech during four sampling events (June, July, August, and October) at two locations in Mill pond and two locations on Mullet River (Figure 1, Attachment A). Sample containers used were shipped in a sealed cooler from the State Hygienic Lab in Madison, WI to the Earth Tech office in Sheboygan, WI. Water samples were collected according to the Wisconsin Department of Natural Resources (WDNR) collection protocols with the following activities.

- Prior to arriving at the site, all field measurement equipment was examined to verify that it was in good operating condition. The sampling equipment was washed with an aqueous cleaner, using elevated temperature and pressure as appropriate. In the field, after each use, the sampling equipment was rinsed well with sample water before readings were taken.

- Sample preservatives and containers were prepared and used as necessary to comply with United States Environmental Protection Agency (USEPA) requirements for the analytes of interest.

- Sample labels were completed at the time of sample collection, noting the site identification, sample location, sample interval (as appropriate), preservative, sample analysis, and sample date.

- For each sample collected, the applicable sampling procedure was recorded in the field notes or on a Sampling Data Sheet. Laboratory chain-of-custody documentation and procedures were followed.

A small water craft was used by two Earth Tech employees to the Sample Stations 2 and 3 to obtain water samples in Mill Pond. While at the stations, sample containers were gently submerged into the water and allowed to fill. Preservation of the appropriate samples was done immediately after collection. Water quality field parameter measurements were taken at each sample station after all water samples were acquired. GPS coordinates of each location were collected and recorded using a hand-held GPS unit (Trimble GeoXT™).

Water samples from Stations 1 and 4 were obtained by an Earth Tech employee who waded into the Mullet River. The employee gently waded from downstream working upstream to minimize disturbance of the sediments. Once in the thalweg of the stream, water samples were collected by submerging the sample containers until full. Preservation of the appropriate samples was done immediately after collection. Water quality field parameter measurements were taken at each sample station after all water samples were acquired. GPS coordinates were collected at each station.

All samples were shipped on ice in a sealed cooler to the State Hygienic Lab for chemical analysis following appropriate chain-of-custody procedures.

RESULTS

Table 1, in Attachment B, presents the water quality sample results for the four Stations for each of the four sample events. Charts 1 through 4 in Attachment C show the trends for temperature, pH, dissolved oxygen, and conductivity, respectively, through the sampling period. Temperature, dissolved oxygen, pH and conductivity values were within the normal range for inland lakes and impoundments.

Secchi disc readings could only be measured at Station 3, because the secchi disc was visible all the way down to the substrate at Stations 1, 2, and 4. Chart 5 shows the measurements for secchi disk readings at Station 3 through the sampling period. The water was less clear in July and August, which is typical for lakes in Wisconsin. In late summer, more algae and plankton are suspended in the water column because the nutrient levels are higher in mid to late summer.

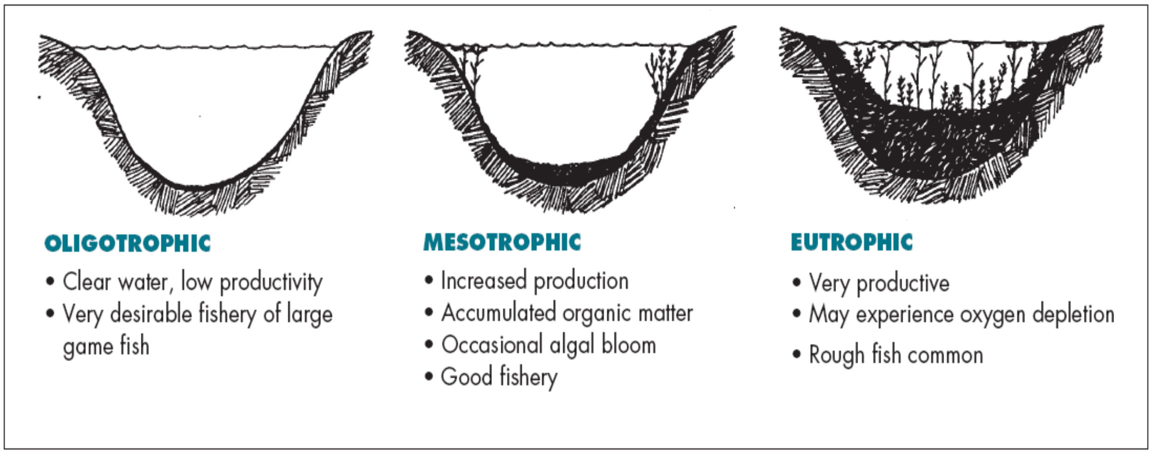
Chart 6 shows the trend for total phosphorus through the sampling period. Total phosphorus levels peaked in July at all stations and were higher at Stations 2, 3, and 4 than Station 1. Total phosphorus and chlorophyll-*a* levels were considerably higher at Stations 2, 3, and 4 than at Station 1, the upstream station. This result indicates that a considerable amount of phosphorus is entering Mill Pond from the area directly adjacent to pond rather than from upstream.

Chart 7 shows the trend for chlorophyll-*a* through the sampling period. Chlorophyll-*a* levels were lowest at all stations in June, but increased considerably at all but Station 1 as the summer progressed. The additional input of phosphorus is a likely cause of the increase in chlorophyll-*a*, a measure of plant productivity.

Trophic status index

Trophic State Index (TSI) is a measurement for characterizing a lake's trophic state. The term "trophic status" refers to the level of productivity in a lake. Productivity refers to the amount of nutrients, plant, and fish biomass. Productivity and trophic state of lakes are typically classified into three categories: oligotrophic, mesotrophic and eutrophic, and are described and illustrated in Diagram A below.

Diagram A. Trophic States of Lakes



Source: University of Wisconsin Extension, Understanding Lake Data

Carlson's Trophic State Index (TSI) is one means available to examine the relationship between total phosphorus, chlorophyll-*a*, and secchi disk readings in a lake, and its overall productivity. The WDNR has modified Carlson's equations to form a Wisconsin Trophic Status Index (WSTI) to better suit lakes in Wisconsin. Individual WTSI values for this study were calculated from the following WTSI equations:

Secchi: $WSTI_{SD} = 60 - (14.4 \ln SD)$,

Total P: $WSTI_{P} = 28.2 + (7.73 \ln TP)$, and

Chlorophyll a: $WSTI_{CHL} = 34.8 + (7.56 \ln CHL)$,

where SD = secchi depth in meters, TP = total phosphorus in parts per billion (ppb), and CHL = chlorophyll-*a* in ppb.

The WTSI results are presented in Table 2 in Attachment B. Chart 8 presents the trends for WTSI through the sampling period. According to WDNR, the WTSI values for the four stations were typical for eutrophic lakes, except for the chlorophyll-*a* at Station 1, which was typical for a mesotrophic lake. Based on these measurements, Mill Pond should be considered a eutrophic system, meaning that it is very nutrient rich, containing abundant organic matter. The relationship among chlorophyll-*a* and total phosphorus WTSI's in 2006 suggests that there is a high volume of algal biomass within the downstream end of the pond, with some limiting factor in the upstream end of the pond, such as the current of the river or nitrogen levels in the water.

CONCLUSIONS

Baseline water quality results suggest that Mill Pond is a eutrophic system, receiving concentrations of phosphorus that is degrading its water quality. Phosphorus entering the Mill

Pond from both the watershed of the Mullet River and from the adjacent landscape are likely to promoting the high density of macrophytes in the pond and the algal blooms the occur in the summer. Limiting the phosphorus entering the pond should positively affect the aquatic health and aesthetics of Mill Pond.

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ATTACHMENT A – FIGURES

FIGURE 1 – WATER QUALITY SAMPLING LOCATIONS

Source: USDA WI Farm Agency NAIP 2005, Earth Tech 2006

Spatial Reference: GCS_North_American_1983

Figure 1 - Water Quality Sampling Locations, 2006

Mill Pond Project
City of Plymouth
Sheboygan County, Wisconsin

December 8, 2006

88673

ATTACHMENT B – TABLES

TABLE 1 – WATER QUALITY RESULTS SUMMARY

TABLE 2 – TROPHIC STATUS INDEX (TSI) RESULTS SUMMARY

Table 1

Water Quality Results Summary
Mill Pond
Plymouth, Wisconsin

Station	Date	Parameters						
		Temp (C)	pH	DO (mg/L)	Cond. (µmhos/cm)	Secchi (m) *	Total P (µg/L)	Chl a (µg/L)
Upstream (Station 1)	6/26/06	18.8	8.5	12.3	696	NA	64	3.89
	7/25/06	20.6	8.3	9.5	681	NA	86	4.32
	8/23/06	16.8	7.8	8.7	719	NA	61	2.54
	10/12/06	6.9	6.9	8.3	705	NA	44	1.44
Pedestrian Bridge (Station 2)	6/26/06	20.2	8.4	8.5	704	NA	78	5.74
	7/25/06	22.6	7.3	6.6	717	NA	123	6.45
	8/23/06	18.6	7.6	5.6	731	NA	98	14.6
	10/12/06	7.1	6.8	8.3	697	NA	49	27
Deep spot Mill Pond (Station 3)	6/26/06	20.3	8.1	6.5	683	1.07	94	10.9
	7/25/06	25	7.5	5.9	743	0.52	141	124
	8/23/06	22.7	7.2	4.6	766	0.61	93	32.2
	10/12/06	6.9	6.8	8.1	657	0.91	50	28.5
Downstream (Station 4)	6/26/06	20.2	8.1	7.2	682	NA	88	8.58
	7/25/06	25.9	8.3	7.9	698	NA	127	57.2
	8/23/06	22.6	7.5	6.5	737	NA	120	42.5
	10/12/06	6.5	6.8	8.1	658	NA	53	60.3

Notes:
* Secchi disc visibility reached the sediment at Stations 1, 2, and 4.

Table 2

Trophic Status Index (TSI) Results Summary
Mill Pond
Plymouth, Wisconsin

Site	Date	Secchi Disk TSI[1]	Total Phosphorus TSI	Chlorophyll- *a* TSI
Station 1 (Upstream)	6/26/06	*NA*	*60.3*	*45.1*
	7/25/06	*NA*	*62.6*	*45.9*
	8/23/06	*NA*	*60.0*	*41.8*
	10/12/06	*NA*	*57.5*	*37.6*
	Average	*NA*	*60.1*	*42.6*
Station 2 (Pedestrian Bridge)	6/26/06	*NA*	*61.9*	*48.0*
	7/25/06	*NA*	*65.4*	*48.9*
	8/23/06	*NA*	*63.6*	*55.1*
	10/12/06	*NA*	*58.3*	*59.7*
	Average	*NA*	*62.3*	*52.9*
Station 3 (Deep spot)	6/26/06	*59.0*	*63.3*	*52.9*
	7/25/06	*69.4*	*66.5*	*71.2*
	8/23/06	*67.1*	*63.2*	*61.0*
	10/12/06	*61.4*	*58.4*	*60.1*
	Average	*64.2*	*62.8*	*61.3*
Station 4 (Downstream)	6/26/06	*NA*	*62.8*	*51.0*
	7/25/06	*NA*	*65.6*	*65.4*
	8/23/06	*NA*	*65.2*	*63.1*
	10/12/06	*NA*	*58.9*	*65.8*
	Average	*NA*	*63.1*	*61.3*

Notes:
[1] = Secchi disk readings not available for Stations 1, 2, and 4 because the disk was visible to the bottom of the pond at these locations.

ATTACHMENT C – CHARTS

CHART 1 – TEMPERATURE TRENDS
CHART 2 – Ph TRENDS
CHART 3 – DISSOLVED OXYGEN TRENDS
CHART 4 – CONDUCTIVITY TRENDS
CHART 5 – SECCHI DISC READING TRENDS
CHART 6 – TOTAL PHOSPHORUS TRENDS
CHART 7 – CHLOROPHYLL-*a* TRENDS
CHART 8 – WTSI TRENDS

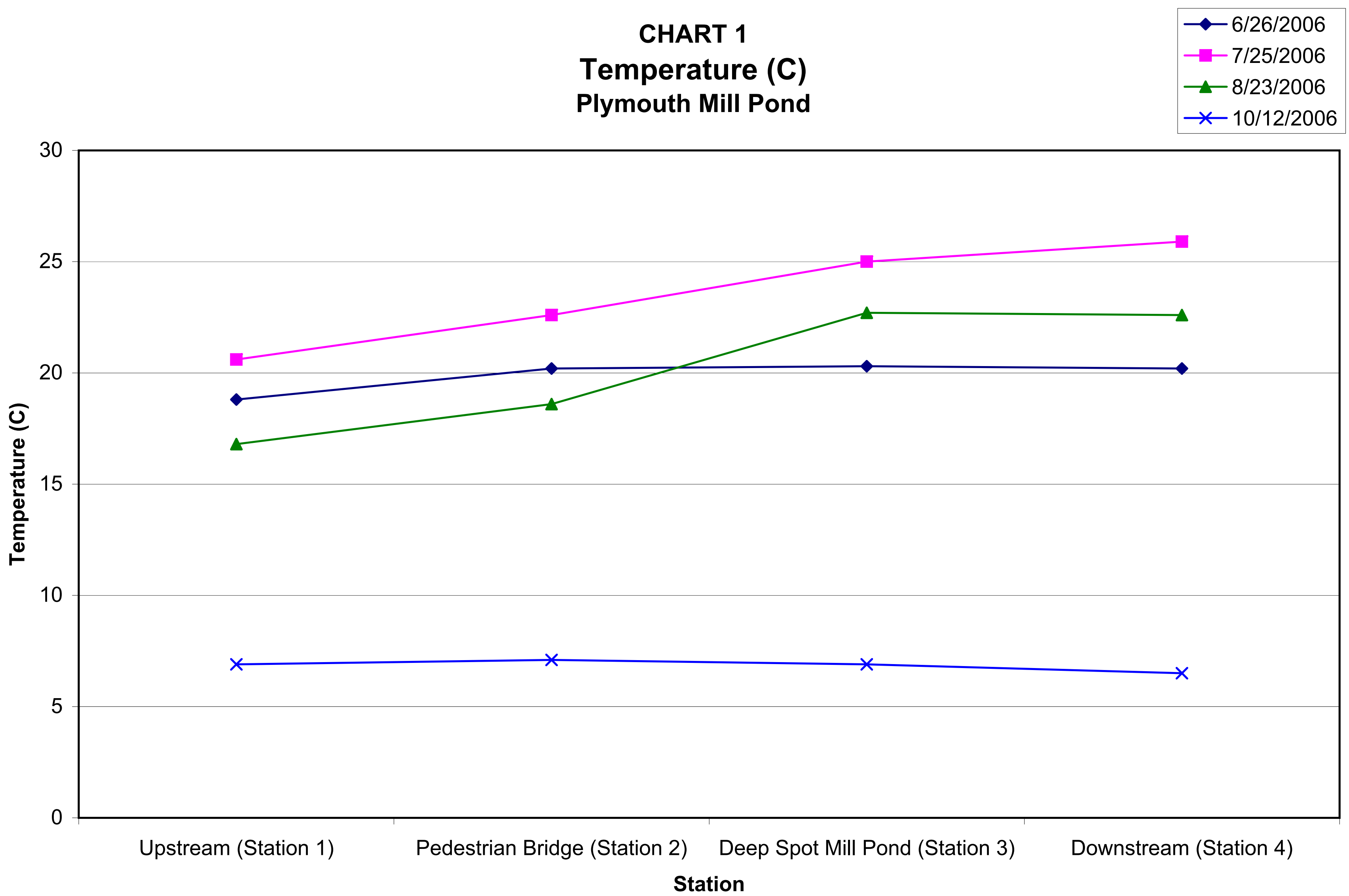
CHART 1
Temperature (C)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
Temperature (C)
30
25
20
15
10
5
0
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

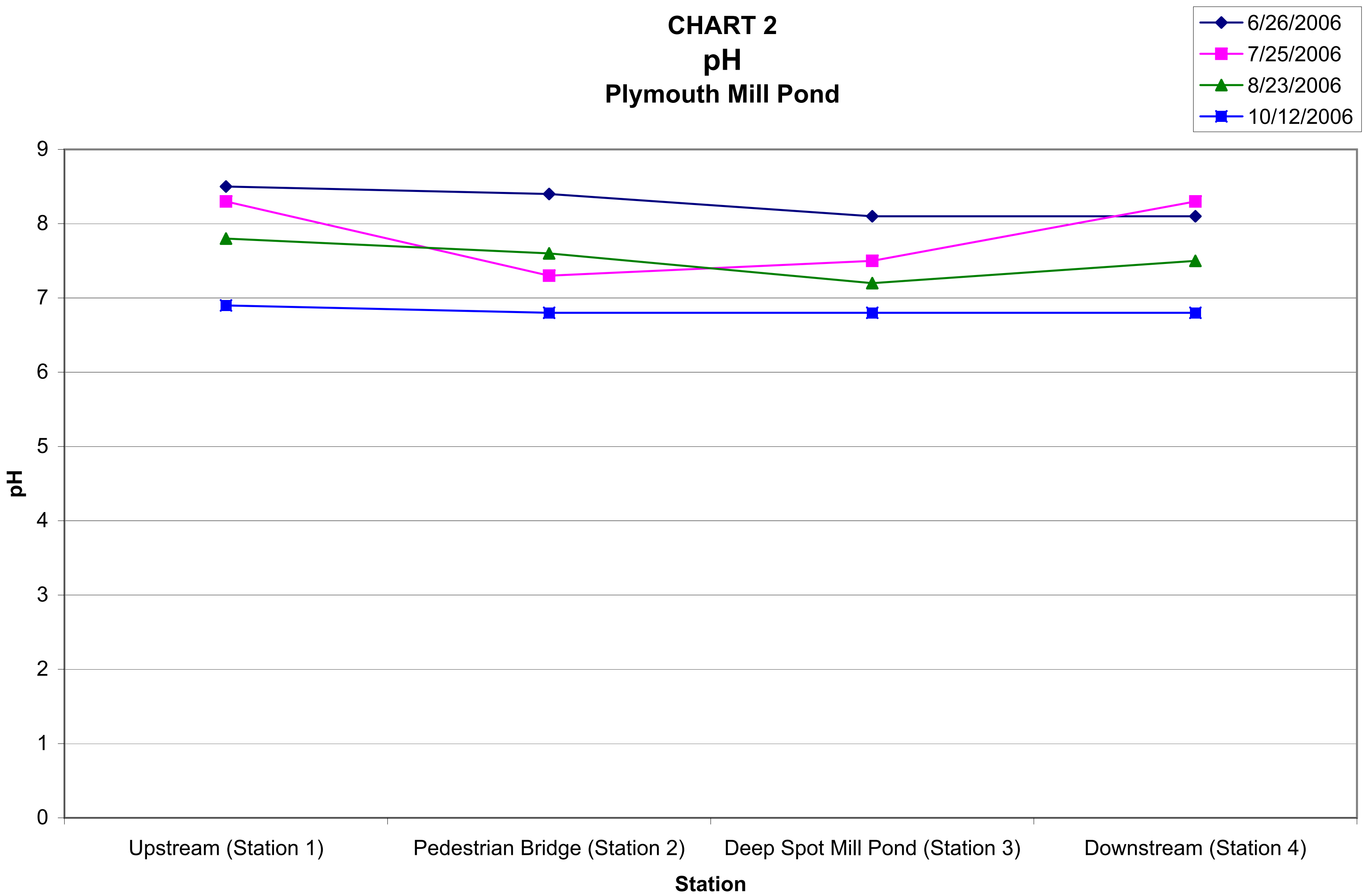
CHART 2
pH
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
9
8
7
6
5
4
3
2
1
0
pH
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

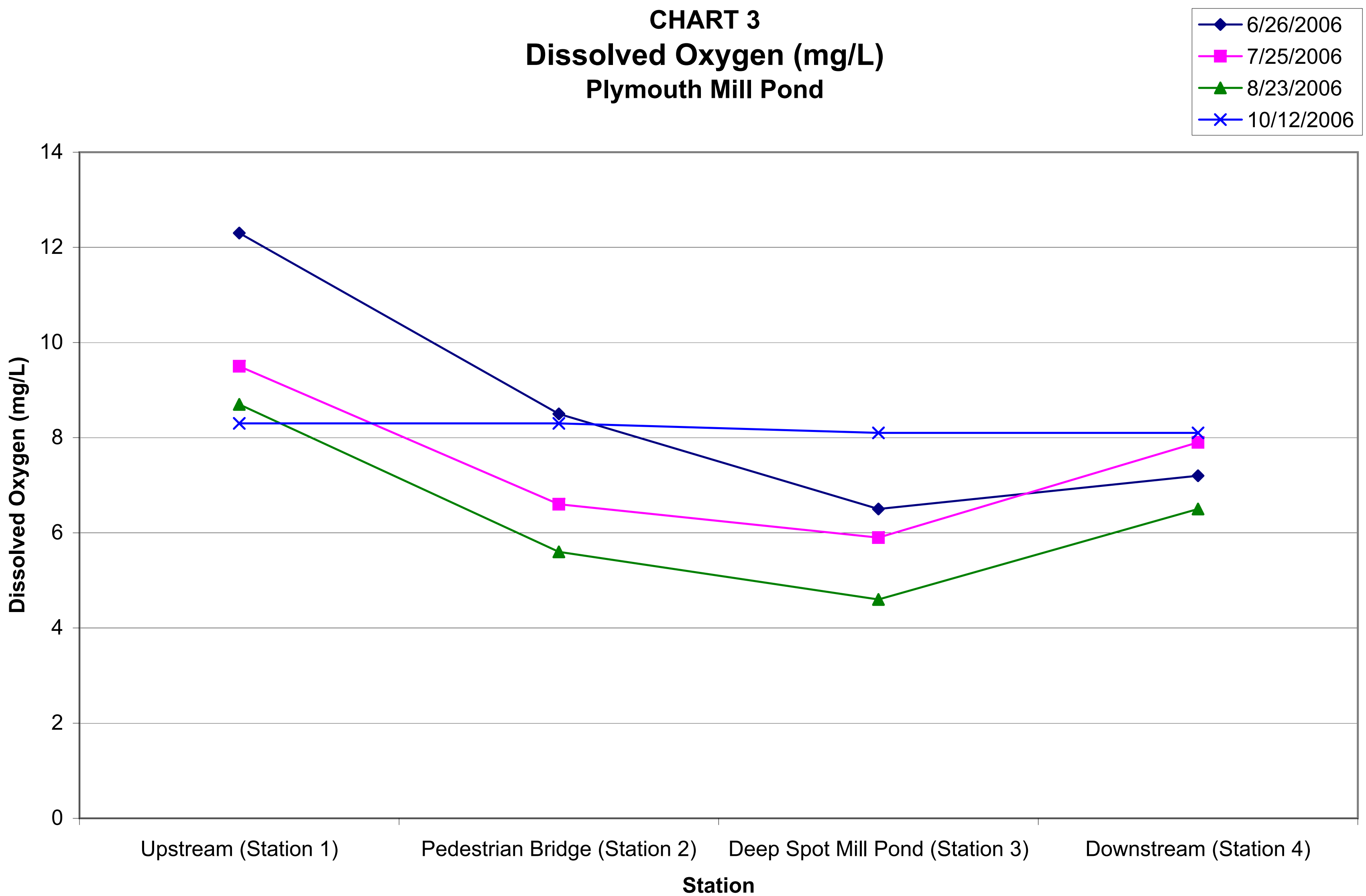

CHART 3
Dissolved Oxygen (mg/L)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
Dissolved Oxygen (mg/L)
0
2
4
6
8
10
12
14
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

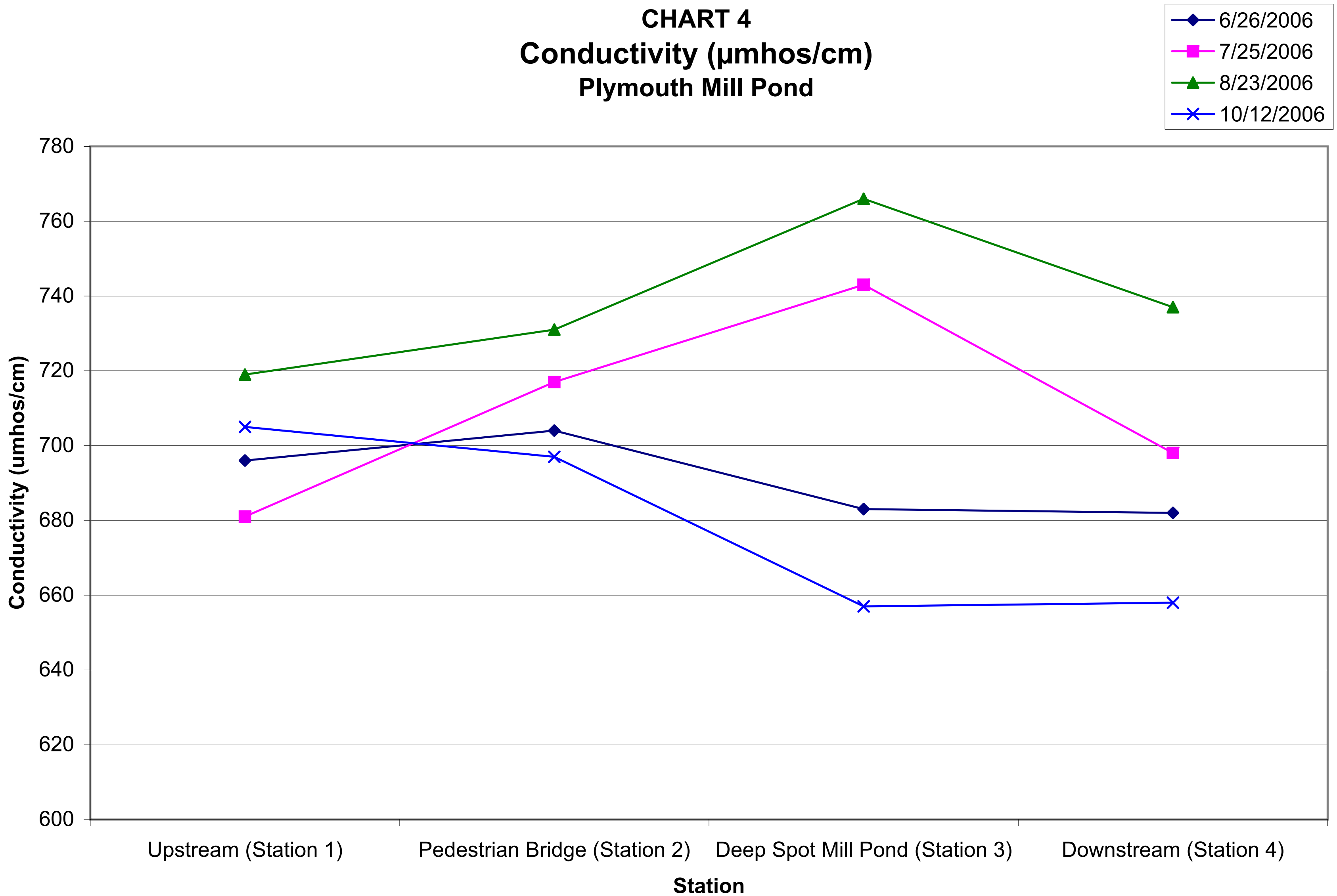
CHART 4
Conductivity (µmhos/cm)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
780
760
740
720
700
680
660
640
620
600
Conductivity (umhos/cm)
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

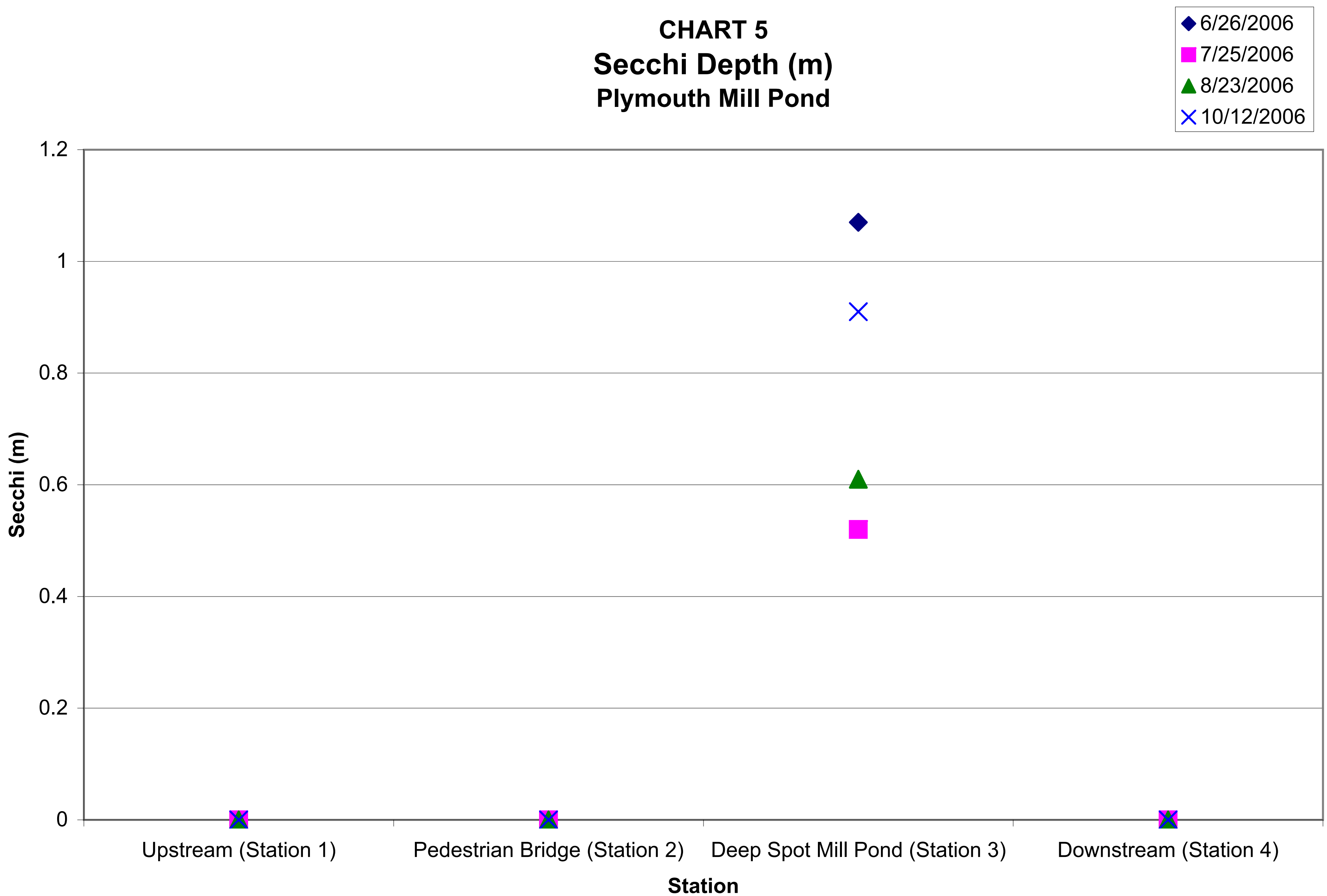
CHART 5
Secchi Depth (m)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
Secchi (m)
1.2
1
0.8
0.6
0.4
0.2
0
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

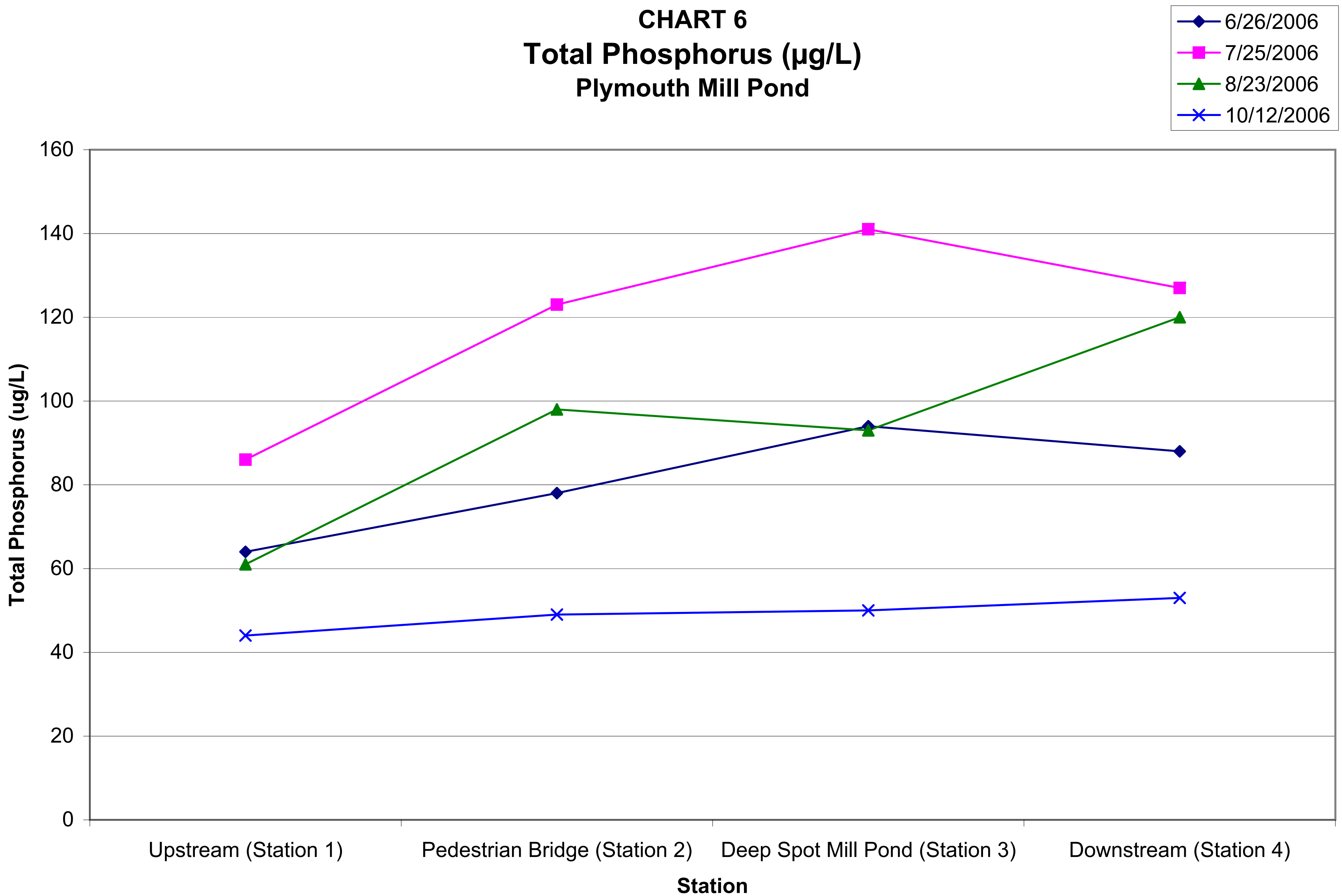
CHART 6
Total Phosphorus (µg/L)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
Total Phosphorus (ug/L)
160
140
120
100
80
60
40
20
0
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

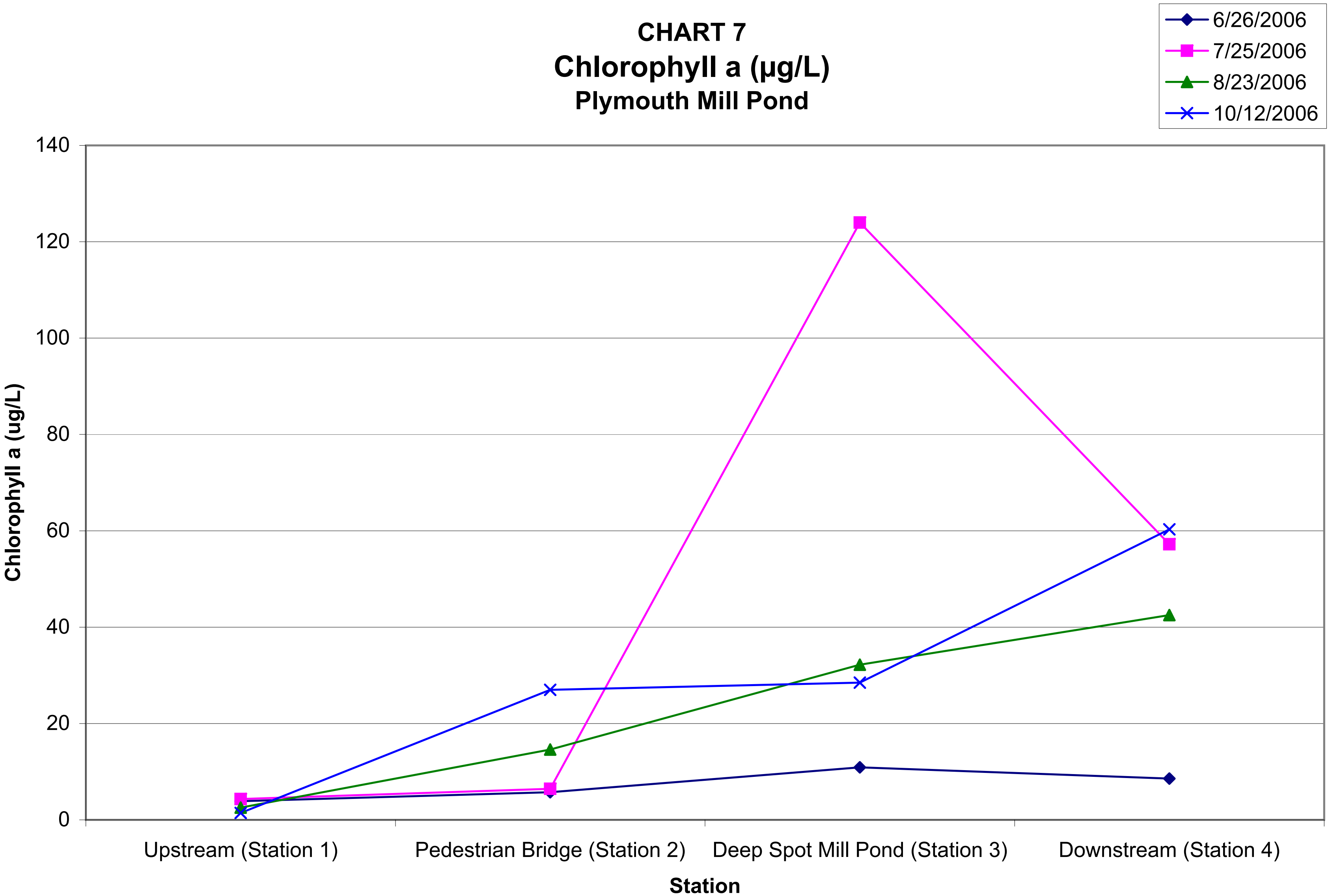
CHART 7
Chlorophyll a (µg/L)
Plymouth Mill Pond
6/26/2006
7/25/2006
8/23/2006
10/12/2006
Chlorophyll a (ug/L)
0
20
40
60
80
100
120
140
Upstream (Station 1)
Pedestrian Bridge (Station 2)
Deep Spot Mill Pond (Station 3)
Downstream (Station 4)
Station

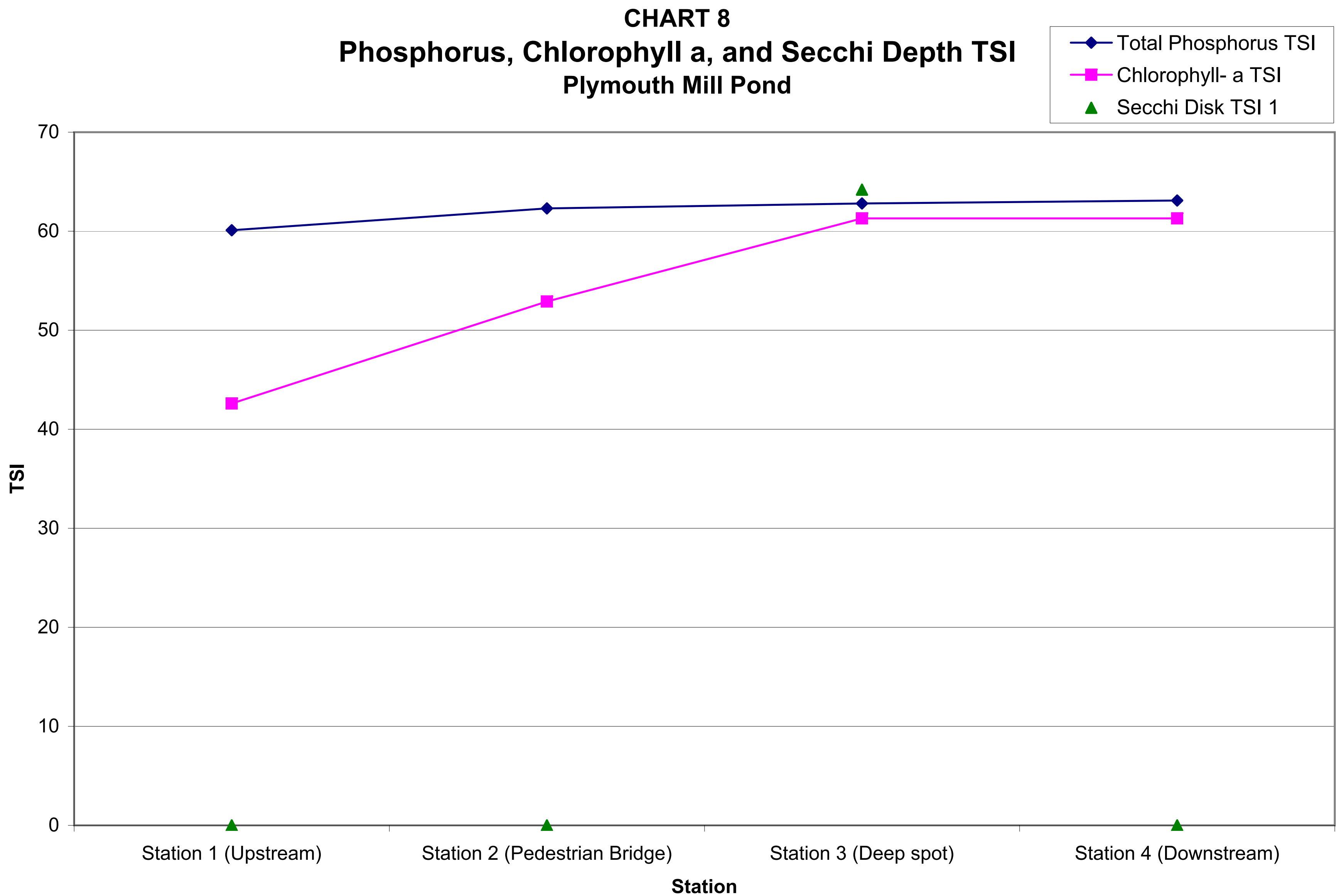
CHART 8
Phosphorus, Chlorophyll a, and Secchi Depth TSI
Plymouth Mill Pond
Total Phosphorus TSI
Chlorophyll- a TSI
Secchi Disk TSI 1
TSI
70
60
50
40
30
20
10
0
Station 1 (Upstream)
Station 2 (Pedestrian Bridge)
Station 3 (Deep spot)
Station 4 (Downstream)
Station

APPENDIX D

MILL POND MACROPHYTE AND SEDIMENT THICKNESS SURVEY MEMORANDUM

EarthTech
A tyco International Ltd. Company

Memo

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May 8, 2007

To: Bill Immich, City of Plymouth

From: Steve Grumann, Earth Tech

Subject: **Mill Pond Macrophyte and Sediment Thickness Survey**

This technical memorandum summarizes the results of the macrophyte (aquatic plant) and sediment thickness survey completed by Earth Tech on July 24th and 25th, 2006 at the Mill Pond located in Plymouth, Wisconsin. Components of the macrophyte survey included field identification of macrophytes in Mill Pond, percent coverage determination of the dominant macrophyte species, field delineation and a GPS-survey of locations of macrophyte beds within Mill Pond. Components of the sediment survey included water depth to sediment, depth to native hardpan, soft sediment thickness, and GPS-surveyed locations of the survey points.

SAMPLING METHODOLOGY

Macrophyte Survey

The macrophyte community was sampled at 17 locations within Mill Pond (Figure 1, Attachment A). The sampling locations were chosen based on presence of visible macrophytes during the sampling dates. Deviations from the proposed sampling plan were made. Instead of sampling a grid throughout Mill Pond for macrophytes, the sampling was confined to locations where macrophytes were visible during the survey.

A canoe was used to paddle around Mill pond, seeking out any areas that had visible macrophytes. When a location was found, macrophytes were physically pulled from the lake and identified to species. The coordinates of each location were recorded using a hand-held GPS unit. Beds of macrophytes that were large enough to delineate were done so by paddling the canoe around the bed while logging GPS positions. Percent coverage of macrophytes was visually estimated to the nearest 5 percent in the beds.

Sediment Depth Methods

Water depth to top of sediment and depth to hardpan were measured at 13 locations through out Mill Pond (locations 5 through 17). The 13 locations were surveyed using a hand-held GPS unit (Figure 1, Attachment B). A secchi disc was used to measure the depth from the top of the water to sediment by slowly lowering the secchi disc until it rested on top of the sediment. The depth from the top of the water to the hardpan was measured by manually pushing a metal sounding pole into the sediment until it could no longer be advanced. The thickness of sediment was calculated by subtracting the depth to sediment from the depth to hardpan.

RESULTS

Macrophyte Sampling

The overall abundance of macrophytes was low during the sample period. Approximately 10 percent of the pond was covered with macrophyte beds. The dominant species were sago pondweed (*Potamogeton pectinatus*) and curly-leaved pondweed (*P. crispus*) which occur at most locations. Coontail (*Ceratophyllum demersum*) and duckweed (*Lemna minor*) accounted for the remaining species. Six macrophyte beds were identified and delineated and are shown on Figure 1 (Attachment A). The percent coverage of the macrophytes within the beds ranged from 0 to 25 percent. The beds were not densely covered, but were the only areas that had sufficient density to consider as a macrophyte bed. Table 1, in Attachment B, summarizes the macrophyte sampling results at each sample location. Photographs of the macrophyte beds are included in Attachment C.

Sediment Depth

Sediment thickness ranged from 0.5 to 5.5 feet. Table 2 in Attachment B summarizes the sediment thickness measurements. As shown in Table 2 and Figure 1, the thicker sediment was observed in the upper reach of Mill Pond. This may result from the water velocity quickly diminishing as it reaches the pond and releasing the entrained sediment from the Mullet River.

RECOMMENDATIONS

In recent years there have been reports of large algal blooms and excessive macrophyte growth in the Mill Pond contributing to low aesthetic and recreational value for users. These conditions are often the result of excess nutrient availability (nitrogen and phosphorus) to aquatic plants. In late July 2006, when field work was completed for this study, algal blooms and the presence of excessive macrophytes were not observed, suggesting that a lack of nutrients may have been limiting the growth.

Possible sources of nutrients that may influence the aquatic vegetation in Mill Pond include upstream agricultural runoff from Mullet River watershed, runoff containing fertilizer from landowners adjacent to the pond, excrement from waterfowl (geese) using the pond, and septic system leakage into the Mullet River and Mill Pond, among others.

Limiting the amount of nutrients entering a water body is an effective way to control excessive plant growth and algae blooms. Landowners adjacent to the lake should use only the recommended amount of fertilizer and apply it only in the fall. Landowners should use a no- or low-phosphorus fertilizer. A strip of un-mown, unfertilized lawn should be established on the shore of the pond to serve as a filter strip to keep fertilizers from entering the pond. Lawn clippings and fallen leaves should be collected so that they do not end up in the pond and create additional nutrient loads when they decompose. In addition, any septic system located near the pond should be checked to make sure it is operating correctly and not draining directly into the pond.

Many geese were observed using the pond near the middle school. A lawn mowed directly down to the water's edge of a pond, void of surrounding shrubs and trees, is ideal goose habitat. Planting a hedge row near the shoreline or leaving an un-mown strip of grass next to the water's edge will deter geese from using the pond. These measures will not keep all geese away from the pond, but should greatly decrease the number of geese using the pond and adjacent lawns.

Preventative measures to limit aquatic macrophytes are the best way to keep aquatic macrophytes from becoming nuisance. However, once they become established at nuisance levels, various management tools can be used to keep them under control. These measures include:

Chemical herbicides: Only those chemicals registered with the U.S. EPA and Wisconsin's Department of Agriculture, Trade, and Consumer Protection (DATCP) may be used in Wisconsin. Table 3 lists the chemicals approved for use in Wisconsin. When using chemicals, it is important to correctly identify the plants and the appropriate chemical for the plant beforehand. Be certain that treatment occurs at the proper time and dosage. In order to apply chemicals in liquid form, the applicator must be licensed with the State of Wisconsin. A permit from the WDNR is also required prior to application.

Manual/Mechanical Harvesting: This includes hand-pulling, raking, or mechanically removing the plants. The WDNR may require an Aquatic Plant Management Plan before it issues a permit for these control methods. Mechanical control requires a permit; while manual control *may* require a permit. The local WDNR Water Management Specialist should be contacted to determine if a permit is necessary.

Physical: This method includes bottom plant barriers (plastic sheets, hay bails) and water level draw-downs. These methods are used only in special circumstances. Because they involve placing structures on the bed of a lake and/or affect lake water level, a Chapter 30 or 31 permit from the WDNR will most likely be needed.

Biological: This method includes herbivores and bacteria. It is illegal to transport or stock carp or crayfish in Wisconsin. Biological control of aquatic plants requires a permit form the WDNR.

Earth Tech recommends that based on the size of Mill Pond and the time and costs associated with dredging and/or manually or mechanically harvesting vegetation, chemical control of nuisance plants would be the best option to control vegetation in Mill Pond. Preventative measures should be initiated to control the growth of aquatic plants and algal blooms, but if large algal blooms and macrophyte beds still occur, treatment of the pond with the appropriate chemicals could provide a short-term solution that would be cost effective and easy to implement.

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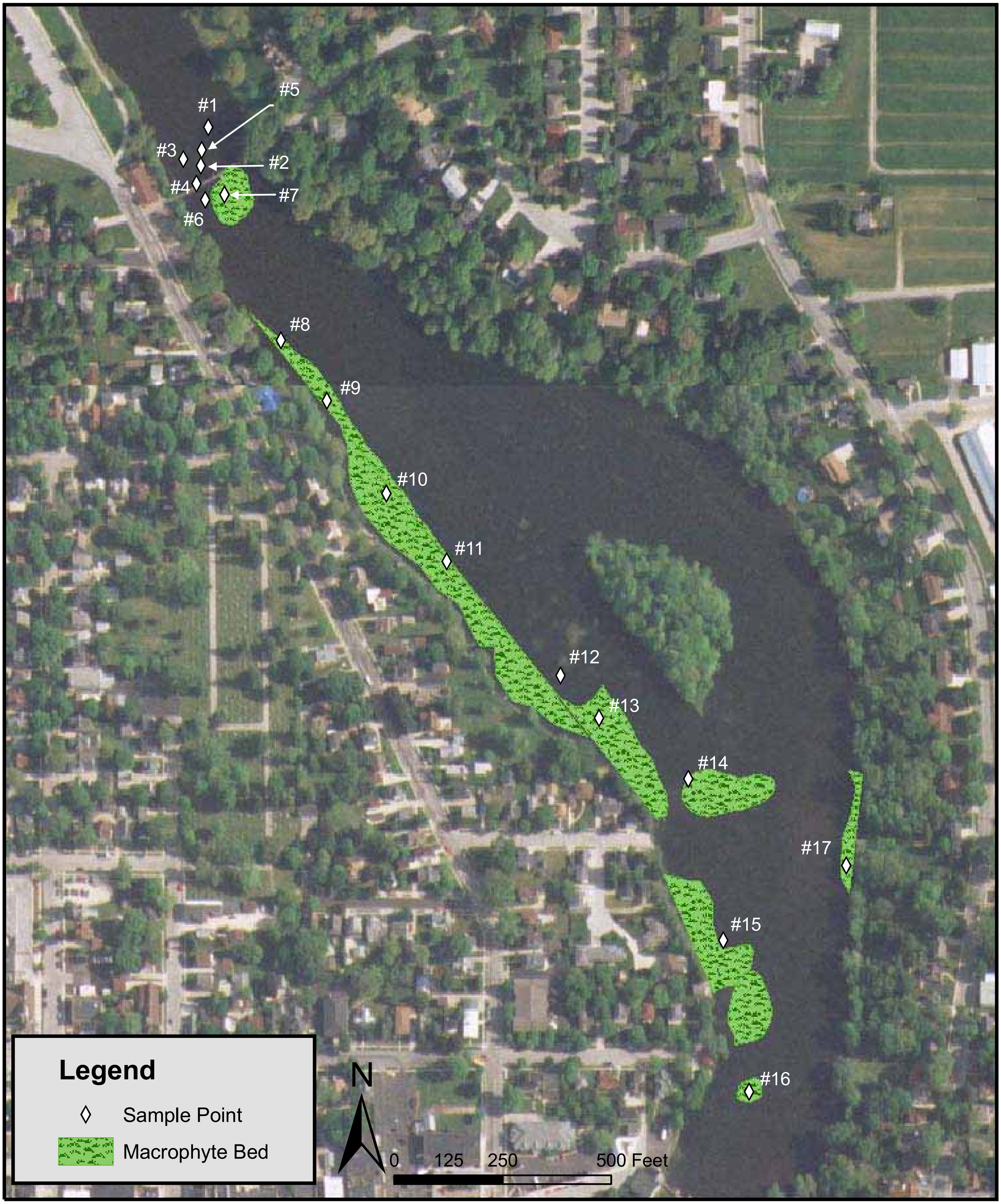
ATTACHMENT A

FIGURES



Source: USDA WI Farm Agency NAIP 2005, Earth Tech 2006

Spatial Reference: GCS_North_American_1983

Figure 1 - Sample Locations and Macrophyte Bed Delineations

Mill Pond Project
City of Plymouth
Sheboygan County, Wisconsin

November 21, 2006

88673

ATTACHMENT B

TABLES

TABLE 1
Mill Pond Macrophyte Survey Results
Plymouth, Wisconsin

Sample Site	Coordinates (WI State Plane)		Species Present	Percent Coverage
	Northing	Easting		
1	645989	645989	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed)	<10
2	2503186	645900	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed)	<10
3	2503146	645913	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed)	<10
4	2503178	645858	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed)	<10
5	2503187	645935	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Ceratophyllum demersum* (coontail) *Lemna minor* (common duckweed)	<10
6	2503200	645821	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Lemna minor* (common duckweed)	<10
7	2503244	645835	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed)	15
8	2503385	645504	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed)	15
9	2503497	645368	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Lemna minor* (common duckweed)	20
10	2503641	645160	*Potamogeton pectinatus* (Sago pondweed)	25
11	2503786	645009	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Lemna minor* (common duckweed)	15
12	2504058	644756	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Lemna minor* (common duckweed) *Ceratophyllum demersum* (coontail)	Not Measured
13	644661	2504150	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Lemna minor* (common duckweed) *Ceratophyllum demersum* (coontail)	25
14	644528	2504360	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Ceratophyllum demersum* (coontail)	15
15	644160	2504455	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Lemna minor* (common duckweed)	10
16	643814	2504526	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Ceratophyllum demersum* (coontail)	20
17	644342	2504732	*Potamogeton pectinatus* (Sago pondweed) *Potamogeton crispus* (curly-leaved pondweed) *Ceratophyllum demersum* (coontail)	20

TABLE 2
Mill Pond Sediment Survey Results
Plymouth, Wisconsin

Sample Site	Coordinates (WI State Plane		Depth to sediment (ft)	Depth to hardpan (ft)	Sediment Thickness (ft)
	Northing	Easting			
5	2503187	645935	1.7	4.8	3.1
6	2503200	645821	1.3	5.9	4.6
7	2503244	645835	1.3	5.8	4.5
8	2503385	645504	1.2	6.7	5.5
9	2503497	645368	1.5	6.3	4.8
10	2503641	645160	1.7	4.4	2.7
11	2503786	645009	1.7	4.0	2.3
12	2504058	644756	1.9	4.5	2.6
13	2504150	644661	1.9	5.0	3.1
14	2504360	644528	2.0	5.3	3.3
15	2504455	644159	2.3	6.9	4.6
16	2504526	643814	2.8	3.3	0.5
17	2504732	644342	1.7	3.3	1.6

TABLE 3

Aquatic Herbicides Approved for Use in Wisconsin[1]
Plymouth, Wisconsin

Chemical (Trade Names)	Management Summary	Management Implications
Copper Compounds (multitude of trade names)	Broad spectrum algaecides used to control both planktonic and filamentous algae. No weekly carryover benefits.	Non-selective and will kill algae within 72 hours. Some algae are resistant. Algae can return within 10 days.
Diquat Dibromide (Reward®, Diquat)	Broad spectrum, contact herbicides that are effective on submersed aquatic plants. No carryover benefits.	Non-selective and will kill plants within 10-14 days. Not effective in turbid waters. Consumption restrictions apply.
Endothal Acid (Aquathol®, Hydrothol®)	Broad spectrum, contact herbicides that are effective on many submersed aquatic plants. No carryover benefits.	Non-selective and will kill plants within 10-14 days. Fish consumption, drinking, and irrigation restrictions apply.
Glyphosate (Rodeo®)	Broad spectrum and systemic (will kill roots). Herbicides used with a surfactant to control emergent and floating plants.	Non-selective and requires the use of a surfactant to ensure uptake by plants. Commonly used for control of purple loosestrife.
2,4-D (Aquakleen, Aquacide, Navigate®, Weedtrine, among others)	Controls only dicotyledons (broad leaf plants such as water lilies, watershield, and water milfoil) with some potential for multiple year control.	Does not control the majority of aquatic plant species found in Wisconsin. Commonly used for control of Eurasian water milfoil. Drinking and irrigation restrictions apply.
Fluridone (Sonar®)	Broad spectrum herbicide that may be dosed selectively for some plants. May have some multiple year control.	Very water soluble and works best when entire pond is treated. Kills plants slowly (20-60 days). Most useful for duckweed control. Irrigation restrictions apply.
Notes: [1]Modified from the WDNR.		

ATTACHMENT C

PHOTOGRAPHS

Mill Pond, looking northeast from southern end of the pond.

Mill Pond, near the pedestrian foot bridge.

Macrophytes near the pedestrian foot bridge.

Duckweed floating near southwest end of Mill Pond.

Macrophytes on west side of Mill Pond.

Macrophyte bed, looking down from pedestrian foot bridge.

APPENDIX E

PLYMOUTH MILL POND ALTERNATIVES ANALYSIS

Alternatives Analysis
Mill Pond
Plymouth, Wisconsin

Prepared for:

City of Plymouth
128 Smith Street
Plymouth, WI 53073

Prepared by:

Earth Tech, Inc.
4135 Technology Parkway
Sheboygan, WI 53083

October 2007

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ATTACHMENTS

1.0 INTRODUCTION AND PURPOSE

The Plymouth Mill Pond has been an amenity to the City and local residents since the mid-1800s. However, in recent years, degraded water quality has lead to algal blooms and aquatic plant growth which have caused odor problems, impeded recreational use of the lake, and negatively impacted the aesthetics of the Mill Pond area. The City of Plymouth and their volunteer Mill Pond Committee have applied for and received grants from the Wisconsin Department of Natural Resources (WDNR) to determine the underlying cause of the degraded conditions and develop a comprehensive plan of action to improve the condition of the Mill Pond.

The Mill Pond is located in the heart of the downtown area of Plymouth in Sheboygan County, Wisconsin in Section 22, Township 15 North, Range 21 East (Figure 1). The Mill Pond is a 41-acre (including the island) lake created by the dam across the Mullet River and extends from the Plymouth dam north to State Trunk Highway (STH) 23. The City of Plymouth owns approximately 2 acres of property at the outlet of Mill Pond. There is approximately 1,000 feet of shoreline on City school property including a recreational trail along the northwest side of the lake and a pedestrian foot bridge across the northern portion of the lake. The Mill Pond is utilized for boating, fishing, and public ice skating. Prior to the recent infestation of aquatic macrophytes, the lake was navigable from the upper end of the lake to the dam. Restoration of the Mill Pond would lead to improved water quality, increased use of the lake as a recreational resource, improved civic pride, and would improve the look of the City to tourists and the local citizenry.

As indicated in the State of the Sheboygan River Basin (WDNR, October 21, 2001), the Mullet River is a high priority for the WDNR and one of the objectives of the WDNR is to work with the City of Plymouth to address safety and water quality issues associated with the Plymouth Mill Pond and its dam. It is anticipated that the WDNR will utilize the information gathered from this project and add it to their dataset for the Sheboygan River Basin and the management plan developed as part of this project will complement WDNR basin planning. There are three aquatic endangered resources that are known to occur in the Mullet River Watershed. Projects designed to protect or improve the water quality resource will benefit the protection of these listed resources.

Although the City, the Mill Pond Committee, and the citizens of Plymouth have some ideas related to long-term management of the lake, there is little data related to the underlying problems related to the current degraded condition and there has been no formal evaluation of potential alternatives. An assessment of the feasibility and cost-benefit of various options is required for the City and the Mill Pond Committee to make sound decisions related to the management of the lake. This report contains an evaluation of the potential long-term management alternatives to solve the problems associated with poor water quality.

2.0 SUMMARY OF ALTERNATIVES

There were six alternatives assessed in this analysis. The alternatives studied during this analysis, with a brief description, follows.

Remove Mill Pond Dam

Removal of the Mill Pond Dam is noted in this report as an alternative, but since this alternative will not meet the goals of the Mill Pond Committee or the City of Plymouth, this alternative was not studied in detail in this analysis.

Dredge Pond

This alternative will involve dredging the existing sediments from the Mill Pond by either mechanical or hydraulic dredging techniques. Dredging the pond would remove the nutrients that are stored in the sediments from the pond system. If mechanical techniques are used, the pond may need to be drained before dredging could begin, depending on the type of dredging used. Hydraulic dredging could be done without draining the pond. Both techniques would require a nearby area to dry the sediments before disposing of them.

Vegetation Removal

This alternative would involve mechanically harvesting the vegetation in the pond. Harvesting the vegetation would remove the material from the pond and remove the nutrients associated with the vegetation breaking down over the winter months from the pond system.

Pond Drawdown

This alternative would involve drawing down the water in the pond. If the pond is drawn down, the sediments would compact and bind some of the nutrients from reentering the system when the water levels are brought back up to the normal elevation.

Shoreline Preservation and Urban Stormwater Management

This alternative involves educating the public and municipal employees on how to employ proper shoreline preservation techniques and fertilizer and sediment management throughout the City.

No Action

This alternative will involve making no changes to the Mill Pond system.

3.0 DISCUSSION OF EACH ALTERNATIVE

Each of the six alternatives are discussed in detail in this section.

3.1 REMOVE MILL POND DAM

As previously stated, removing the Mill Pond Dam is not in the interest of the Mill Pond Committee or the City of Plymouth. Since this alternative would result in the loss of the Mill Pond altogether, no further consideration of this alternative will be made in this Alternatives Analysis. An estimated cost for the removal and restoration of the Mill Pond area is $80,000, based on other dam removals done in the state. There is a WDNR dam removal grant program that would cover half of this cost.

3.2 DREDGE POND

The results of the 2005 bathymetric survey showed that there is approximately 180,000 cubic yards of soft sediment accumulated on the bottom of the Mill Pond. The depth of these sediments range up to 6.8 feet deep with an average depth of 1.8 feet. One management alternative is to remove these sediments by dredging. The sediment analysis conducted for this project estimated that sediment being carried into the Mill Pond by the Mullet River could be accumulating at a rate of 0.3 or 1.2 inches per year over the pond bottom, depending on the calculation method used (see Attachment 1). The table below shows the time it would take to refill areas that are dredged based on these accumulation rates. The time varies considerably depending on the accumulation rate used. The attached sediment analysis indicates that the method used to calculate the 1.2 inches/year accumulation rate is better suited to the Mill Pond than the other method.

Sediment Accumulation Rate	Time to Fill 1.8 Feet of Depth	Time to Fill 6.8 Feet of Depth
0.3 inches/year	72 years	272 years
1.2 inches/year	18 years	68 years

There are two different methods of dredging that can be done at the Mill Pond: mechanical and hydraulic. For the mechanical dredging method, the water in the pond can either be drained or left in place, depending on which method is used. One method involves draining the pond and entering the basin with an excavator. The other method involves floating a barge with an excavator and dredging from the barge. Once the sediment is excavated, the sediment will then be transported by truck to a drying area where the sediment will be allowed to dry prior to finally trucking to a disposal site. The excavation equipment, likely a track hoe or a dragline, will need to be able to deposit the material into a dump truck, which will transport the material to the drying site. In order to do this, either access to the pond edge will need to be gained from multiple points or the dump trucks will need to enter the bed of the Mill Pond. For the trucks to enter the bed of Mill Pond, a gravel road would need to be constructed in the bed of the pond to accommodate the trucks. This gravel bed would be removed after dredging is completed. Since the pond is primarily surrounded by private property and the gravel road in the pond bed would add additional impact to the pond and total cost to the project, mechanical dredging was not considered to be a cost effective option for dredging.

For hydraulic dredging, a barge holding the hydraulic pumps will need to enter the pond. The pumps will remove the sediments from the pond bottom through suction and pump the sediment to either trucks, to transport the material to the drying area, or directly to the drying area if possible. Benefits to this method over the mechanical method are that the pond does not have to be drained for the hydraulic method and that the material can be pumped up to 2 miles to a drying area instead of having to transport it by truck, which will be a large cost savings. Once the material has sufficiently dried, it will need to be deposited at either a landfill or in an area agreed to by the Wisconsin Department of Natural Resources. The cost to dredge the entire 180,000 cubic yards of soft sediment in the Mill Pond by hydraulic methods has been estimated to be between $3.5 and $5.2 million not including disposal costs, which could be as much as $3.2 to $5.4 million if the material needs to be disposed in a landfill.

3.3 AQUATIC VEGETATION REMOVAL

This alternative involves removing the aquatic vegetation by mechanical means, such as raking or cutting. This alternative would remove the existing vegetation in the pond, thereby removing the nutrients tied up in the vegetation. Plants would either be cut with a floating harvester or raked from the pond bottom including the roots and deposited outside of the pond. This alternative may need to be done annually or more often because the plants will continue to grow after they have been cut or raked from the pond. To be an effective alternative, this method would need to be done regularly, as many as three times per year, at a cost of approximately $125,000 per time. Permits from the WDNR would need to be obtained to harvest the plants and a trucking and a disposal site would need to be identified to dispose of the vegetative material at an additional cost. In addition, there are shallow areas of the Mill Pond (the average depth is 1.2 feet) which would not be accessible to a floating harvester. While this alternative would keep parts of the pond free of floating vegetation, aquatic vegetation removal is not an effective long-term solution to controlling the nutrients in the Mill Pond; however it is a temporary solution and would need to be done regularly.

3.4 POND DRAWDOWN

This alternative will involve drawing the water level of the Mill Pond down to baseline flow of the Mullet River. Drawing the water in the pond down will allow the sediments in the pond to settle and compact. This may prevent some of the sediments from becoming resuspended in the water column and perhaps contributing to the nutrients in the water column. The lake modeling analysis done for the project (see Attachment 2) indicates that the sediments are probably not a large source of nutrients to the water column, although they would promote rooted aquatic plants growth. A second benefit of this method is that it would create more water depth in the pond. The average percent solids by weight of the sediment samples collected in the Plymouth Mill Pond on June 18, 1999 was 34 percent. This translates to 21 percent solids by volume if one assumes the dry density of the sediment is 120 pounds/cubic foot. Assuming that the sediments after drawdown achieve 60 percent solids by volume, then the average sediment depth of 1.8 feet would compact by 39 percent to 1.1 feet deep and the maximum sediment depth of 6.8 feet would compact to 4.1 feet deep.

While the cost for this alternative is minimal (approximately $500 for permitting), there will be some impact to the community, because the resource that the Mill Pond supplies to the community will not be available for several months. Although, when water starts to refill the Mill Pond basin, the sediments may re-suspend in the water column, reversing the desired effects of pond drawdown. Since the nutrients in the pond will also be available to rooted vegetation, the long-term effectiveness of this alternative is mostly unknown.

3.5 SHORELINE PRESERVATION AND URBAN STORMWATER MANAGEMENT

This alternative will involve educating the public and the City of Plymouth on better methods to manage the shoreline of the Mill Pond and proper erosion control and stormwater management within the City. The Water Quality assessment completed in 2006 indicated that nutrients and sediments coming into the Mill Pond from the immediate drainage area may have a disproportionate water quality impact to the Mill Pond compared to the drainage area upstream of the pond. Therefore, improvements to the shoreline and the immediate urban drainage area may have the potential to most directly improve the Mill Pond water quality.

The education should stress the importance of establishing an unmowed buffer strip along the shoreline of the pond. Education also needs to include the proper methods and rates of fertilizer application of lawn on private and public property as well as keeping street gutters clear of grass clippings and other organic material. The City and the Mill Pond Committee could consider hosting educational meetings for the public and utilizing the County Extension office or the WDNR for support. The costs to the City and the Mill Pond Committee for this alternative would be minimal.

Urban stormwater management activities that the City can promote includes such activities as: vigorously enforcing construction site erosion control ordinances, street sweeping, catch basin cleaning, and implementing stormwater treatment systems such as detention ponds and sediment traps as required. The cost of these activities could be carried out as part of the normal operating budget of the City as well as costs incidental to new construction.

The Sheboygan County Fairgrounds was assessed for a potential source of stormwater pollution to the Mill Pond. Historically, runoff from the race track and the barn area did flow to the Mill Pond relatively untreated. Several treatment practices were constructed in 2004 with coordination between the County and WDNR. These include a sediment trap under the grandstand, a french drain in the infield and the west side of the racetrack, and sanitary sewer connections for the wash drains by the barn area. These practices provide a reasonable level of treatment for the stormwater runoff from the Fairgrounds and no further improvements are recommended.

3.6 NO ACTION

For this alternative, no action would be taken by the Mill Pond Committee or the City of Plymouth. The Mill Pond would be left as it is with no modifications to the pond or the watershed. There would be no cost for this alternative.

4.0 ANALYSIS OF ALTERNATIVES

Of the six alternatives considered, removal of the dam was disregarded because neither the City nor the Mill Pond Committee is interested in permanently draining Mill Pond.

Dredging the pond sediments is a viable alternative, but according to the results of the sediment modeling completed by Earth Tech in 2007 (Attachment 1), the pond may retain up to 1.2 inches of new sediment per year. While dredging the pond may eventually be necessary to restore water depth, this method is not likely to keep the Mill Pond from becoming infested with algae because there will still be nutrients entering the pond system from other sources. Dredging may limit the extent of rooted aquatic vegetation because these plants cannot grow in depths where sunlight cannot penetrate (the maximum measured water clarity was 1.07 meters) but they would persist in the shallower areas. In addition, this alternative is the most costly, with total costs possibly being as high as $7 million and would cause additional environmental impacts to the area surrounding Mill Pond.

Removal of the aquatic vegetation is another short term remedy for the Mill Pond. Removing the vegetation would only be a temporary solution because there will still be seeds located in the sediments with a surplus of nutrients in the pond. According to the lake eutrophication model completed by Earth Tech in 2007 (Attachment 2), the input of nutrients into the Mill Pond will still occur from runoff from adjacent properties and the watershed. Desirable plants would also be removed with the unwanted species. For vegetation removal to be an effective remedy it would have to be done three or more times a year. At a cost of up to $125,000 per time, this alternative is not cost effective.

Pond drawdown would also not be a good solution by itself. While it may bind some of the nutrients in the sediment, it will not remove the sources of nutrients or keep them from entering the pond. This alternative may be a good solution in conjunction with another alternative that would work to remove the source of nutrients in the pond system. In addition, this alternative would be an inexpensive way to increase water depth in the pond.

Shoreline management and urban stormwater management is the most effective alternative for reducing the nutrient inputs in the Mill Pond. This alternative, in conjunction with drawdown of the pond for a winter season, would reduce the nutrients in the pond system at a reasonable cost to the City and Mill Pond Committee. The County Extension Office and the local WDNR staff could hold public educational meetings, hosted by the City, to inform the public and the City employees on how to better protect the watershed of the Mill Creek from nutrient runoff and erosion.

No action is another possible alternative. While this alternative will not improve the Mill Pond nutrient problem, the last few seasons may have been an aberration from normal conditions in the Mill Pond. The Mill Pond Committee and the City may decide to wait and see what happens in the Mill Pond over the next few seasons and then decide if further management of the Mill Pond system is necessary.

Below is an alternatives matrix summarizing some of the important aspects of each alternative. Short-term and long-term effectiveness relates to how well the alternative would reduce aquatic plant and algae growth. Implementability relates to how easily the alternative could physically be implemented.

Alternatives Analysis Matrix

Alternative	Short-Term Effectiveness	Long-Term Effectiveness	Implementability	Public Acceptability	Cost
Dam Removal	high	high	high	low	$80,000
Dredging	high	medium	medium	high	$7,000,000
Aquatic Vegetation Removal	medium	medium	medium	medium	$125,000/yr
Pond Drawdown	medium	medium	high	medium	$500
Shoreline and Stormwater Management	medium	medium	medium	medium	unknown
No Action	low	low	high	medium	$0

5.0 SUMMARY

Earth Tech completed an alternatives analysis to evaluate six different alternatives to improve the water quality of the Mill Pond in Plymouth, Wisconsin. The alternatives evaluated included removal of the Mill Pond Dam, dredging the pond, pond vegetation removal, drawdown of the pond, shoreline management and urban stormwater management, and no action. The analysis of the alternatives showed that the best means to improve the Mill Pond were to institute a process with the assistance off the County Extension and the local WDNR offices to educate the public and City employees on how to better manage the nutrients and sediments entering the pond in the immediate watershed of the Mill Pond. This process should be done in conjunction with a drawdown of the pond over the winter months to compact the sediments in the pond to increase water depth in the pond and potentially bind some of the nutrients in the compacted sediment. This solution would be the least costly, with the exception of no action, and can be implemented relatively quickly.

ATTACHMENT 1

SEDIMENT LOADING ANALYSIS

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Memo

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10/4/2007

To: Steve Grumann, Earth Tech

Copy: Bernie Michaud, Earth Tech

From: Theran Jacobson, Earth Tech

Subject: Plymouth Mill Pond Sediment Loading Analysis, Project No. 100540

This memorandum summarizes the results of the sediment loading analysis for the tributary area of the mill pond located in Plymouth, WI and the sediment removal efficiency methods evaluated for the mill pond.

Methodology

The average annual inflow to the Plymouth Mill Pond was determined by the evaluation of the Mullet River at the Greenbush, WI gauging station (U.S. Geological Survey (USGS) gauge station #04085746) that recorded flow data for the Mullet River for a five (5) year period from 2001 through 2005.

The unit-area sediment loading values were determined from the Onion River, an adjacent watershed with similar land use. The unit-area loading values from the Onion River were determined from a USGS study (USGS Fact Sheet FS-195-97).

The sediment trapping rate for the Plymouth Mill Pond was calculated using two different empirically derived methods; the Brune's curve and Churchill's curve methods. The methods determine the sediment removal rates for small to large reservoirs using a variety of input parameters. Brune's curve method uses the following input data: reservoir capacity and annual inflow. Churchill's curve method uses the following input data: reservoir capacity and length, and average daily inflow.

Results

The flow data for the Plymouth Mill Pond was calculated from a watershed area ratio from the flows recorded at the Greenbush, WI gauging station. The watershed area for the Mullet River at the Greenbush, WI gauging station is approximately 24.3 square miles (sq. mi.). The watershed area for the Plymouth Mill Pond downstream is approximately 62.2 sq. mi. The recorded flows from the Mullet River at Greenbush, WI were multiplied by the watershed area ratio (62.2 / 24.3 = 2.56) to determine the discharge rate into Mill Pond. The calculated average daily inflow to the Plymouth Mill Pond is approximately 26.7 cubic feet per second (cfs).

The average annual sediment loading to the Plymouth Mill Pond was calculated from a watershed area ratio from the unit-area loading results for the Onion River. The watershed area for the Onion River is approximately 91.8 sq. mi. The average unit-area loading of total suspended solids for the Onion River is approximately 84 tons per sq. mi. (U.S. Dept. of the Interior, FS-195-97) based on two years of monitoring data. The average unit-area loads from the Onion River were multiplied by the watershed area ratio (62.2 / 91.8 = 0.68) to determine the unit-area loads to Mill Pond. The average sediment loading into the Mill Pond is estimated to be 3,540 tons TSS per year (tons-TSS/yr).

The sediment trapping rate of the Plymouth Mill Pond as estimated by the Brune's and Churchill's curve methods is 10% and 63% respectively. These are significantly different results. The following comparison of the two methods was found in a U.S. Bureau of Reclamation document; "As a guideline Brune's curve method should be used for large storage or normal ponded reservoirs and Churchill's curve method should be used for settling basins, small reservoirs, flood retarding structures, semi-dry reservoirs, or reservoirs that are continuously sluiced." (U.S. Dept of the Interior, 2006). This does not appear to provide clear cut guidance for which method to use in this situation. Several factors seem to favor the Churchill's curve method; the Plymouth Mill Pond is a smaller reservoir, the Churchill's method takes into account reservoir length (the mill pond is long and narrow), and it provides a more conservative result (higher trapping rate). At best these methods provide an approximation of what is happening in the mill pond and should be used as a guidance and the results of the two methods could be used as bracketing values.

To translate the amount of sediment trapped by weight to a depth of sediment, the density of the sediment must be known. The average bulk density of the sediment samples collected in the Plymouth Millpond on June 18, 1999 was 0.34 tons per cubic yard. The calculated depth of sediment deposited over the entire surface area of the Plymouth Mill Pond on an average annual basis is then estimated to be 0.3 inches for Brune's method and 1.2 inches for Churchill's method.

Table 1: Sediment Removal Results for Brune's and Churchill's Curve Methods

Method	Sediment Loading (tons TSS / yr)	Average Daily Flow (cfs)	Pond Area (acres)	Reservoir Capacity (acre-feet)	Sediment Removal (%)	Weight Sediment Removed by Pond (tons / yr)	Sediment Deposited (inches/yr)
Brune's	3,540	26.7	39.6	48.1	10	354	0.3
Churchill's	3,540	26.7	39.6	48.1	63	2,230	1.2

References

U.S. Department of the Interior, Bureau of Reclamation, "Erosion and Sedimentation Manual", November 2006.

U.S. Department of the Interior, U.S. Geological Survey, "Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus from Small Watersheds in Wisconsin" Fact Sheet Number: FS-195-97.

ATTACHMENT 2

LAKE MODELING ANALYSIS

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10/4/2007

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From: Bernie Michaud Earth Tech

Subject: Plymouth Mill Pond Lake Modeling, Project No. 100540

This memorandum summarizes the results of the lake water quality modeling of the Plymouth Mill Pond in Plymouth, Wisconsin.

Methodology

The Plymouth Mill Pond was modeled with the lake water quality model **Wisconsin Lake Modeling Suite** (WiLMS). The model estimated phosphorus concentrations in the pond based on physical attributes of the watershed, estimated river flows, and lake morphometry. The watershed area and watershed characteristics were assessed during Part 1 of this project. Additionally, river flow information was interpolated from available United State Geological Survey (USGS) river gaging station information from the nearest appropriate gaging location (see below). The bathymetric mapping created in 2005 was also used in the modeling.

The model was calibrated using the actual pond phosphorus concentrations measured as part of this project. The in-lake phosphorus cycling rate was also assessed using the model.

Hydrologic and Morphometric Data

The average annual inflow to the Plymouth Mill Pond was determined by the evaluation of the Mullet River at the Greenbush, WI gauging station (U.S. Geological Survey (USGS) gauge station #04085746) that recorded flow data for the Mullet River for a five (5) year period from 2001 through 2005. The watershed area for the Plymouth Mill Pond downstream is approximately 62.2 sq. mi. The recorded flows from the Mullet River at Greenbush, WI were multiplied by the watershed area ratio (62.2 / 24.3 = 2.56) to determine the discharge rate into the Plymouth Mill Pond. The calculated average daily inflow to the Plymouth Mill Pond is approximately 26.7 cubic feet per second (cfs) or 5.8 inches of runoff from the watershed.

The Plymouth Mill Pond is approximately 39.6 acres is area with a volume of approximately 48.1 acre-feet. The Mill Pond is shallow with a mean depth of 1.2 feet. The pond volume is small in relation to the inflow so the average pond flushing rate is 400 times per year.

The unit-area sediment loading values were determined from the Onion River, an adjacent watershed with similar land use. The unit-area loading values from the Onion River were determined from a USGS study (USGS Fact Sheet FS-195-97).

Non-point Source Pollution Source Data

Non-point source pollution from stormwater runoff is the largest source of phosphorus to the Plymouth Mill Pond. There are no known point sources of pollution of note. WiLMS estimates non-point phosphorus loading based on land uses in the watershed. The watershed land usage was estimated using USGS mapping and results of the windshield survey conducted in 2006. These results are shown in the table below. WiLMS estimated that the "most likely" loading of phosphorus from non-point source runoff is 19,477 pounds per year.

Land Use	acres	%
Agricultural	25,333	63.6%
Forest	8,768	22.0%
Wetlands	3,710	9.3%
Rural Residential	1,536	3.9%
Medium Density Urban	393	1.0%
High Density Urban	28	0.1%
Pond Surface	40	0.1%
Total	**39,808**	**100%**

The average annual phosphorus loading to the Plymouth Mill Pond was also calculated using the unit-area loading results for Silver Creek near Ripon. The watershed area for Silver Creek is approximately 36.2 sq. mi. The average unit-area loading of total phosphorus for Silver Creek is approximately 283 pounds per sq. mi. (U.S. Dept. of the Interior, FS-195-97) based on nine years of monitoring data. This average unit-area load was multiplied by the Plymouth Mill Pond watershed area (62.2 sq. mi.) to arrive at an estimated average total phosphorus loading of 17,603 pounds per year. This correlates well with the loading calculated by the WiLMS model.

In Pond Phosphorus Prediction

The WiLMS model predicts in lake total phosphorus concentrations using 13 empirical regression equations. Each regression equation is derived from data from many lakes. The model identifies those equations which best fit the lake being modeled. In this analysis it was determined that the "Canfield-Bachmann Artificial Lake Model" and the "Reckhow, 1977 Lakes with qs>50 m/yr Model" best fit the parameter range values for the Plymouth Mill Pond.

These two empirical equations predict the Growing Season Mean (GSM) total phosphorus concentration (the mean for the months June, July, and August). The GSM total phosphorus concentration actually measured in the Plymouth Mill Pond in 2006 was **98 micrograms/liter (ug/l)**. The model predictions are statistically derived and have a level of uncertainty in the results. The initial results are below.

Initial Phosphorus Concentration Predictions

Equation	Low (ug/l)	Most Likely (ug/l)	High (ug/l)
Canfield-Bachmann	124	283	452
Reckhow qs>50m/yr	119	300	522

Model Calibration

The model results above are well above the actual measured total phosphorus concentrations. The WiLMS model has a feature that back calculates what the total phosphorus loading from the watershed should be to arrive at the observed in lake total phosphorus concentration. This back calculation indicated the incoming phosphorus loading would be approximately 6,107 pounds per year. This is 69% less than the loading estimated by the WiLMS non-point source pollution estimator.

The WiLMS non-point source pollution estimator was adjusted to reduce the annual phosphorus loading by 69 %. This may be justified by the fact that the drainage ways and stream banks in the watershed appeared to be well buffered from surrounding land uses by woods, wetlands or other well vegetated areas during the 2006 windshield survey. In addition, the Mullet River at points upstream showed a high degree of clarity. Settling in the upstream Glenbeulah Mill Pond may also reduce the phosphorus load. The calibrated results are below.

Calibrated Phosphorus Concentration Predictions

Equation	Low (ug/l)	Most Likely (ug/l)	High (ug/l)
Canfield-Bachmann	42	100	166
Reckhow qs>50m/yr	37	93	163

Internal Phosphorus Cycling

Bottom sediments were assessed for being a potential source of phosphorus to the pond. WDNR sediment sampling from June 18, 1999 showed phosphorus concentrations in the sediment ranging from 523 to 622 mg/kg. Phosphorus in bottom sediments can be cycled back into the water column under the right conditions. The internal cycling occurs most frequently when the bottom lake water is stratified and anoxic. Phosphorus becomes soluble under anoxic conditions. The Plymouth Mill Pond does not stratify and become anoxic due to its shallow depth (it remains well mixed vertically). The WiLMS model was used to predict the internal phosphorus load from the sediments. It predicted that there is a net loss of phosphorus to the sediment of 374 pound per year due to settling.

Discussion

The WiLMS modeling showed that the loading of phosphorus to the Plymouth Mill Pond from watershed runoff is less than what is typically expected but nonetheless is the central reason why the Mill Pond exhibits eutrophic conditions. This is accentuated by the large amount of flow that is cycled through the Mill Pond.

Bottom sediments may not be releasing phosphorus back into the water column in significant amounts. However it would still be available to promote growth of rooted aquatic plants.

References

U.S. Department of the Interior, U.S. Geological Survey, "Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus from Small Watersheds in Wisconsin" Fact Sheet Number: FS-195-97.

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