MARION MILLPOND
COMPREHENSIVE LAKE MANAGEMENT PLAN
MAXIM PROJECT NO. 1155340093

Prepared for:

City of Marion
217 Main Street
P.O. Box 127
Marion, Wisconsin 54950

Prepared By:

Maxim Technologies
555 South 72nd Avenue
Wausau, Wisconsin 54401

OCTOBER 2005
REVISED NOVEMBER 2005

EXECUTIVE SUMMARY

Maxim Technologies was retained by the City of Marion (City) to develop a comprehensive lake management plant for the Marion Millpond (Pond). The City received a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (DNR) which provided funding up to $10,000.00 for this project with in-kind services and matching funds of 25% provided by the City.

The comprehensive lake management plan includes results of two aquatic plant surveys, water quality sampling, fisheries data review, community survey and preliminary watershed evaluation. Additional activities included the publication of two newsletters to all residents of the City. The management plan includes aquatic plant management recommendations, water quality sampling recommendations and the establishment of several volunteer groups including implementing the Clean Boats, Clean Water program, Self-Help monitoring and the formation of a lake association.

Aquatic Plant Management

Two aquatic plant surveys were conducted during June and July 2005. Thirteen different species of aquatic plants were found in the Pond. The most common aquatic plant in the Pond is coontail, *Ceratophyllum demersum*. Two species of aquatic invasive species, Eurasian water milfoil (EWM), *Myriophyllum spicatum* and Curly-leaf pondweed (CLP), *Potamogeton crispus*, were found. Changes were observed between the June and July plant surveys, specifically the occurrence of CLP. Mechanical harvesting affects the density of aquatic plants in the Pond. Management recommendations include herbicide application utilizing selective herbicides, limited mechanical harvesting and water level manipulation in the form of a winter drawdown.

Water Quality

A water quality sampling program was implemented to determine a baseline trophic state index (TSI) for the Pond. All samples were taken following the DNR's protocol for Baseline Lakes Monitoring. Samples were taken in April, June, August and October of 2005. The Pond can be described as a eutrophic lake based on its high nutrient levels, fair to good secchi disc readings and high chlorophyll *a* levels. Dissolved oxygen levels in July and August were low, less than five parts per million (ppm) at a depth of greater than three feet in July and six feet in August. Management recommendations include the establishment of a volunteer lake monitoring group following the DNR Self-Help Lakes Monitoring program.

Fisheries Data

DNR fisheries data from the early 1970s, 1990 and 2004/2005 indicated a viable self-sustaining fisheries consisting of warm water species such as northern pike, largemouth bass, and panfish. Management recommendations will be provided by Al Niebur, DNR fisheries biologist, upon completion of a detailed final report based on an analysis of fish age and growth. Preliminary results indicate an extremely abundant bluegill population. Predator species were found to be in low densities, likely a contributing factor in the abundant bluegill population.

Community Survey

A survey was send to all residents of the City in early July 2005 to obtain perspectives and opinions on the condition of the Pond and appropriate management options. A total of 525 surveys were mailed and approximately 39% or 204 responses were received. The results included the following information.

- 91% of the respondents do not live on the lake.
- Fishing and enjoying scenic beauty are the common uses of the Pond.
- 61% of the responses stated the overall condition of the Pond has drastically declined in the last ten years.
- 54% of the responses stated aquatic plants are the most significant problem on the Pond.
- Responses indicated that the fiscal and operational management of the Pond is the responsibility of the City and the DNR.
- Approximately 50% of respondents describe their level of knowledge as limited with regard to the following lake-related subjects; aquatic invasive species, aquatic plants, fisheries management, shoreline management, and watershed impacts.
- The following methods of shoreline protection/restoration and water quality protection are suitable for the Pond:
    - 69% of the respondents indicated an annual lake fair or other educational meeting
    - 67% of the respondents indicated the formation of a voluntary lake association
    - 67% of the respondents indicated the establishment of a voluntary water quality monitoring group
    - 59% of the respondents indicated limited use of phosphate-based fertilizer
    - 55% of the respondents indicated the establishment of a boat launch monitoring program
    - 50% of the respondents indicated restrictive shoreline zoning requirements
- Responses indicated the following methods of aquatic plant management are appropriate for the Pond:
    - 60% of the respondents indicated mechanical methods (weed harvester)
    - 58% of the respondents indicated chemical methods (aquatic herbicides)

Watershed Evaluation

A preliminary watershed evaluation was conducted to determine the dominant land uses within the Pigeon River watershed that drains to the Pond. The land uses were evaluated to determine potential negative impacts to the Pond. The land uses were predominantly agriculture and forested land. Management recommendations include:

- Conduct water quality sampling on tributary streams and the Pigeon River downstream of the Pond;
- Conduct runoff sampling on the immediate adjacent shoreline areas;
- Conduct soil sampling on the immediate adjacent shoreline areas; and
- Work with Waupaca County Land Conservation Department and Natural Resource Conservation Service (NRCS) to implement conservation efforts in the Pigeon River Watershed.

Implementation Plan

Aquatic Plant Management Plan

- Implement an early season aquatic herbicide treatment to target EWM and CLP;
- Continue mechanical harvesting to maintain navigation lanes and recreational areas; and,
- Implement a winter drawdown.

Water Quality

- Implement the DNR Self-Help Volunteer Lake Monitoring Program.

Fisheries Data

- Interested citizens and the City remain in communication with DNR fisheries biologist to continually evaluate the fishery and implement management recommendations.

Educational Activities

- Establish Boat Launch Monitoring Group;
- Formation of a Voluntary Lake Association; and
- Establish a Voluntary Water Quality Monitoring Group.

Watershed

- Interested citizens and/or the City pursue lake management planning grant and partner with Waupaca County to conduct a more intense watershed evaluation to identify the nutrient sources to the Pond including the immediate adjacent shoreline properties.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF CHARTS

LIST OF TABLES

LIST OF APPENDICES

TERMINOLOGY AND DEFINITIONS

1.0 INTRODUCTION

Maxim Technologies (Maxim) was retained by the City of Marion (City), through a Wisconsin DNR lake planning grant, to develop a comprehensive lake management plan for the Marion Millpond (Pond).

The objectives of the study were to:

1) conduct two aquatic plant surveys to compare/contrast early growing season and late growing season conditions;
2) conduct water quality sampling to establish a baseline trophic state index (TSI);
3) summarize existing fisheries data;
4) conduct a community survey to gather option and perspectives;
5) conduct a watershed evaluation to identify sources of non-point runoff; and,
6) conduct information and educational activities to educate the Pond community.

2.0 SITE LOCATION, DESCRIPTION AND PROJECT PURPOSE

The Pond is located in the City of Marion, Waupaca and Shawano Counties, Wisconsin. The Pond is a shallow water impoundment of the North Branch of the Pigeon River. The total acreage is approximately 108 acres, with an average depth of six feet. The Pond is located within the Pigeon River watershed and is a portion of the Wolf River Basin. The Pigeon River watershed is approximately 74,444 acres and encompasses 116 square miles. The dominant land use within the watershed is agriculture and one of the dominant habitat features is wetlands. The North Branch of the Pigeon River begins in the Township of Fairbanks, Section 24, T26N, R12E. A series of intermittent and perennial streams flows into the North Branch prior to entering the Pond, including four unnamed Class I trout water streams.

The surrounding land use immediately adjacent to the Pond includes two public parks, (Lion's Point and Wallace Park), residential homes, a golf course and the City. Two public boat launches are located on the Pond, one near the dam at Lion's Park and second landing located in Wallace Park, near the west end of the lake. A swimming beach and playground are also located at Lion's Point.

The City is a small community with a population of approximately 1,300 people. The community has a strong relationship with the Pond, holding annual events such as an ice fishing derby every February. The Pond is a central gathering point for all community residents.

EXISTING AND HISTORIC CONDITIONS

The Pond is a 108 acre impoundment of the North Branch of the Pigeon River. A dam is located at the east end of the pond, underneath Hwy 110 (Main Street). The dam was rebuilt in 1995. The fishery is above average, (based on the current fisheries data), dominated by panfish such as bluegills and predator fish such as northern pike. Aquatic plants are found in relatively high densities throughout the Pond.

During the late 1960s and early 1970s the State of Wisconsin implemented a lake renewal project on the Pond. The Pond was drawn down beginning in 1968 to allow for a series of lake rehabilitation techniques including dam modification, stump and log removal, sediment manipulation, application of various bottom treatments (plastic sheeting, sand blankets, etc.), fish restocking, grading and riprapping shoreland areas, and enhancing recreational facilities. Activities in the drainage basin included simple remedial measures for reducing runoff from three large farms in the watershed. The restoration was completed in 1971 and the conclusion was fairly intensive management procedures would be necessary to maintain the Pond's recreational usability due to its overfertile waters. (Born, et. al, 1973). A copy of this report can be obtained at the Marion Public Library.

Large-scale management efforts were not conducted on the Pond from the early 1970s until the late 1990s when aquatic plants were severely restricting the recreational use of the Pond. A mechanical harvester was purchased in 2001. Native and non-native aquatic plants were harvested to maintain navigation channels and recreational use. Per Wisconsin Administrative Code NR 109, a permit to conduct mechanical harvesting was issued in 2002 and expired December 2004. In order for a multiple year permit to be issued, the City must develop an aquatic plant management plan.

Eurasian water milfoil (EWM) was first reported in the Pond in 2000. To date, EWM has rapidly expanded within the lake and now is the dominant plant species. The plant growth is abundant and efforts to manage EWM and other aquatic plants in 2004 resulted in approximately 820,000 pounds of plant removal by a mechanical harvester and 40 man-hours per week, for ten weeks.

The local community is increasingly becoming concerned with the overall condition of the Pond. Community members have expressed concerns over runoff from the surrounding watershed and the potential negative impacts, as well as a perception of declining water quality. Concerns regarding the fishery of the Pond have been expressed, including an overabundance of small panfish and fewer large predator fish, such as northern pike. EWM has become a major concern due to its expansive growth and dominance of the aquatic plant community within the Pond. Community members have expressed concerns of EWM negatively impacting the fishery, reducing native plant species, decreasing recreational use, declining property values and a reduction in water quality. The City wishes to educate community members about general lake issues such as aquatic plants and water quality in order to make management decisions that the local community understands and supports. In order to assist with lake management activities and address the community concerns, the City pursued and was awarded a lake management planning grant from the Wisconsin DNR in February of 2005.

3.0 METHODS

3.1 AQUATIC PLANT SURVEYS

Two aquatic plant surveys were conducted during the growing season of 2005. The first survey was completed in early June and the second survey was done in late July. The purpose of conducting two surveys was to identify early season species such as EWM and Curly Leaf Pondweed (CLP), as well as species that flourish later in the growing season. The plant survey followed the methodology set forth in Aquatic Plant Management in Wisconsin, Recommended Baseline Monitoring of Aquatic Macrophytes, (Wisconsin DNR, April 2005). The sampling protocol incorporated the point-intercept method. The sampling resolution was 20 meters for a total of 93 samples points in June (Figure 1a) and 105 sample points in July (Figure 1b). An abundance rating of 0-3 was given for each plant species identified at each sample point (Appendix A). Sediment samples were taken at each data point to determine the substrate. The shoreline was characterized and sensitive areas were identified and mapped (Figure 2). These sensitive areas do not meet the definition as explained in Terminology and Definitions because the determination was not conducted by DNR staff. Water depths were recorded at each sample point and are depicted in Figure 3. All plant species were vouchered and sent to the University of Wisconsin-Stevens Point herbarium for species identification and verification. A plant collection was given to the City for reference and educational purposes. City staff assisted in the plant surveys by providing a boat and volunteer labor. Rates for the donated equipment were established based on the Waupaca County Highway Department equipment rates. Rates for volunteer labor were established per Wisconsin Administrative Code NR 190.

A floristic quality index (FQI) was established by multiplying the square root of the number of species present (N) by the mean of the floristic value of each species, C. Each aquatic plant in Wisconsin has been assigned a C value based on the plant quality. For example, a common aquatic plant in Wisconsin, common waterweed *(Elodea canadensis)* has a C value of three while a less common aquatic plant, grass-leaved arrowhead *(Sagittaria graminea)* has C value of nine. The Simpson Diversity Index is a measure of species richness. A high value of D (diversity index) suggests a stable and undisturbed site and a low D value could suggest pollution, invasive species occurrence and agricultural influence. The index is calculated as follows; $D = N (N - 1) / n(n - 1)$.

3.2 WATER QUALITY SAMPLING

Water quality sampling was conducted following DNR Baseline Lakes protocol four times during the growing season. Samples were collected in April, July, August and October 2005. Additional water quality data was obtained from DNR data from a sample taken in September 2004. Observations included secchi disk readings, temperature/dissolved oxygen profiles, conductivity, dissolved and total phosphorus, Kjeldahl nitrogen, nitrate-plus nitrite-N, ammonia, and chlorophyll *a*. The State Lab of Hygiene was utilized to process all samples. Based on the results of the water quality sampling, a trophic state index (TSI) was established for the Pond, from which to compare future water quality results. The TSI is discussed in Section 4.2.

3.3 FISHERIES

Existing DNR data regarding the Pond fishery was reviewed and analyzed. Past surveys were summarized. DNR fisheries staff conducted mini-fyke netting and electrofishing in 2004 and spring netting during early 2005. Data from the latest fisheries surveys is included in Section 4.3.

3.4 COMMUNITY SURVEY

A community survey was developed in an attempt to identify priorities, goals, and obtain opinions and perspectives related to lake management issues and alternatives. The survey was sent to all (525) households within the City. A copy is provided in Appendix B. Results are presented in Section 4.4.

3.5 WATERSHED EVALUATION

A preliminary watershed evaluation was conducted summarizing existing data regarding the Pigeon River watershed and the immediate adjacent land uses of the Pond. Land use maps were generated and potential negative impacts resulting from the identified land uses were identified. The results are presented in Section 4.5.

3.6 INFORMATION AND EDUCATION ACTIVITIES

Two newsletters were developed detailing the activities of the comprehensive lake management plan. The newsletters were sent to all households (525) within the City. The first newsletter was sent in June of 2005. A second newsletter was developed upon project completion, detailing the aquatic plant survey and community survey results. This newsletter was sent in October of 2005. Examples are included in Appendix C. A lake fair/public meeting occurred in October to discuss the results of the study, community survey and the recommended management alternatives.

4.0 RESULTS

4.1 AQUATIC PLANT SURVEY

General Lake Survey

The general lake survey consisted of visual observations of the aquatic plant community of the Pond. Aquatic plants observed in the Pond in June and/or July included spatterdock *(Nuphar variegate)*, softstem bulrush *(Scirpus validus)*, broad-leaved cattail *(Typha latifolia)*, muskgrass *(Chara spp.)*, common waterweed *(Elodea canadensis)*, curly-leaf pondweed *(Potamogeton crispus)*, floating-leaf pondweed *(Potamogeton natans)*, clasping-leaf pondweed *(Potamogeton richardsonii)*, flat-stem pondweed *(Potamogeton zosteriformis)*, coontail *(Ceratophyllum demersum)*, small duckweed *(Lemna minor)*, stiff water crowfoot *(Ranunculus aquatilis)*, northern water milfoil *(Myriophyllum sibiricum)*, and Eurasian water milfoil *(Myriophyllum spicatum)*. All plant species were photographed and are included in Appendix D. Table 1 lists the plant species in abundance order.

TABLE1
AQUATIC PLANTS ABUNDANCE RANKING

COMMON NAME	SCIENTIFIC NAME	ABUNDANCE RANKING JUNE	ABUNDANCE RANKING JULY	ABUNDANCE RANKING JUNE & JULY
Coontail	*Ceratophyllum demersum*	1	1	1
Eurasian water milfoil	*Myriophyllum spicatum*	2	2	2
Curly-leaf pondweed	*Potamogeton crispus*	3	-	3*
Floating-leaf pondweed	*Potamogeton natans*	10	3	4
Small duckweed	*Lemna minor*	4	4	5
Muskgrass	*Chara spp.*	7	3	6
Northern water milfoil	*Myriophyllum sibiricum*	5	6	7
Spatterdock	*Nuphar variegate*	6	5	8
Common waterweed	*Elodea Canadensis*	10	6	9
Stiff water crowfoot	*Ranunculus aquatilis*	7	-	10*
Flat-stem pondweed	*Potamogeton zosteriformis*	8	7	11*
White-stem pondweed	*Potamogeton praelongus*	9	-	12*
Clasping-leaf pondweed	*Potamogeton richardsonii*	11	-	13*

***Aquatic plant only observed during the June plant survey**

Emergent and Floating Leaf Plants

Emergent and floating leaf plant beds were identified and mapped to depict their present location and size. General observations included the presence of emergent plants and floating leaf plants which dominated the entire upper west end of the Pond, near the south shore west of Wallace Park and the north shoreline, north of Wallace Park as depicted on Figure 4. With the exception of the upper end of the Pond, emergent and floating leaf plant communities are small in size, less than 1/10 of an acre. The upper end of the Pond is dominated by emergent plants such as broad-leaved cattail and floating leaf plants such as spatterdock. Photographs are included in Appendix E. These plant communities are highly variable and their size should be considered a result of the conditions of the growing season.

Aquatic Plant Survey

Submergent plants were observed throughout the Pond. Figures 5a and 5b depict the extent of submergent plant coverage and a depiction of plant density differences of Pond. The average number of species per sample site was 2.5 in June and 1.8 in July, indicating a less diverse plant community in July. This is a result of the dominance of the two most common plants, EWM and coontail.

Coontail is the most common aquatic plant in the Pond. Coontail was found at 49% of the sample points in June and 33% of the sample points in July. Coontail is a native submergent aquatic plant that has long, trailing stems that lack true roots. The leaves are stiff and are arranged in whorls around the stem. The leaves are forked once or twice with teeth along the margins of the leaf. It is most often confused with EWM (Appendix D, Photo 4.) Coontail mainly reproduces by fragmentation due to a lack of routine seed production. Coontail has a tolerance for cool water and low light conditions, allowing it to overwinter as an evergreen plant. The presence of coontail during the winter months provides habitat for other aquatic life such as insects. Waterfowl will feed on coontail and the bushy stems provide shelter and foraging for several species of fish. Coontail can grow to nuisance levels but it is valuable in the plant community for the reasons listed above. High densities of coontail can help reduce the occurrence and density of aquatic invasive species such as EWM and CLP.

The FQI for Pond is 19.5 in June and 14.8 in July or an average FQI of 17.1. According to the Recommended Baseline Monitoring of Aquatic Macrophytes, the median FQI for lakes within the State of Wisconsin is 22.2. The higher an FQI value, the greater the diversity of the native plant community is. The lower FQI value in July is another indicator of a less diverse plant community. The FQI value of an aquatic plant community is valuable to assess changes in the diversity and quality of the plant community over time. The specific statistics are included in Appendix F.

The Simpson Diversity Index for Pond was 0.80 in June and 0.68 in July. The Simpson Diversity Index is an estimator of community heterogeneity. The closer the Simpson Diversity Index is to one, the more diverse the community.

Aquatic Invasive Species

Two species of aquatic invasive species were observed in the Pond. EWM was found at 68 out of 93 sites in June, (64.72 acres), and 62 out of 105 sites in July (113 acres). CLP was found at 37 out of 93 sample sites (26 acres) in June and zero sample sites in July. Figures 6a and 6b depict the location of CLP and EWM in June and July, respectively. These species rank two and three, respectively, out of 13 species present in abundance ranking. Figures 7a, 7b, 7c indicate the densities of EWM and CLP in June and July.

EWM is an exotic plant originating from Europe and Asia. EWM has long, limp stems that branch repeatedly at the water's surface. The leaves are finely divided like a feather with thread-like leaflets in pairs of 14-20. The leaf divisions resemble the bones of a fish. EWM does not produce winter buds but does reproduce by fragmentation. EWM leaflets can form adventitious roots and root. EWM can form dense mats on the surface of the water inhibiting navigation and water movement. Management efforts in Wisconsin have included mechanical harvesting, chemical treatment and biological controls. Seven other native species of milfoil exist in Wisconsin and EWM can easily be confused with these native species.

CLP is an exotic plant species originating from Europe. CLP has slightly flattened stems with oblong leaves with wavy edges and finely serrated leaf margins (Appendix D, Photo 6). It is most commonly confused with clasping-leaf pondweed (Appendix D, Photo 14). CLP produces vegetative buds called turions that look like small, brown pine cones on shortened branches along the stem. CLP is a unique plant because of its growth pattern. It grows under the ice, thus becoming the first plant present during the spring and early summer months. CLP dies in mid-July, while other plants are reaching their peak growth. This die-off was observed in the Pond as CLP was not found during the July survey but was the third most common plant observed in June. The decaying CLP releases its nutrients into the water column where nutrients such as phosphorus become available for other aquatic plants and/or algae. The turions of CLP lie dormant until the water cools in autumn and falls below 75°F. After the water reaches this temperature, the turions germinate to produce winter foliage. It is these turions that pose a major challenge in controlling CLP through mechanical or chemical means.

Sediment

The dominant sediment type observed in Pond was muck. Muck is defined as an organic soil or material, usually a non-compacted soil.

4.2 WATER QUALITY SAMPLING

Trophic State Index (TSI) values are determined by characterizing some common water quality characteristics such as:

- Secchi disc readings;
- Total phosphorus concentrations; and,
- Chlorophyll *a* concentrations.

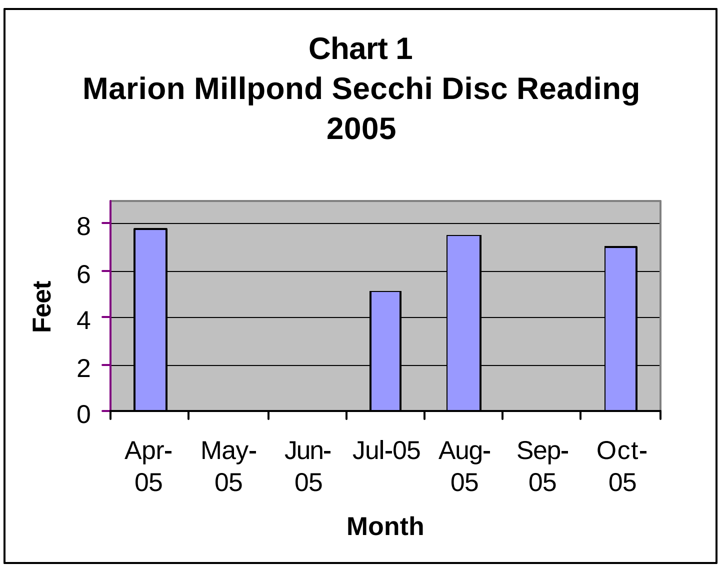
Table 2 shows these three measurements associated with trophic states. Note: low levels of phosphorus are associated with low levels of algae (chlorophyll *a*), which are associated with high secchi disc readings (Shaw, et. al, 2004).

TABLE 2
TROPHIC CLASSIFICATION OF WISCONSIN LAKES
(adapted from Lillie and Mason, 1983)

Trophic class	Total phosphorus (µg/l)	Chlorophyll *a* (µg/l)	Secchi Disc (feet)
Oligotrophic	3	2	12
	10	5	8
Mesotrophic	18	8	6
	27	10	6
Eutrophic	30	11	5
	50	15	4

Water Clarity (Secchi disc readings)

A lake's overall water quality can be measured based on water clarity. Water clarity is measured utilizing a secchi disc. Secchi discs are an eight inch diameter weighted disc painted black and white. The disc is lowered over the side of the boat until it disappears and it is raised until just visible. The average of the two depths is the secchi disc reading. The greater the secchi disc depth, the clearer the water; which is an indicator of better water quality. The average secchi disc reading for the Pond in 2005 was 6.85 feet. Based on this, the Pond can be considered a mesotrophic lake. However, total phosphorus and chlorophyll *a* indicated a eutrophic lake. The secchi disc readings for the Pond in are included in Chart 1.

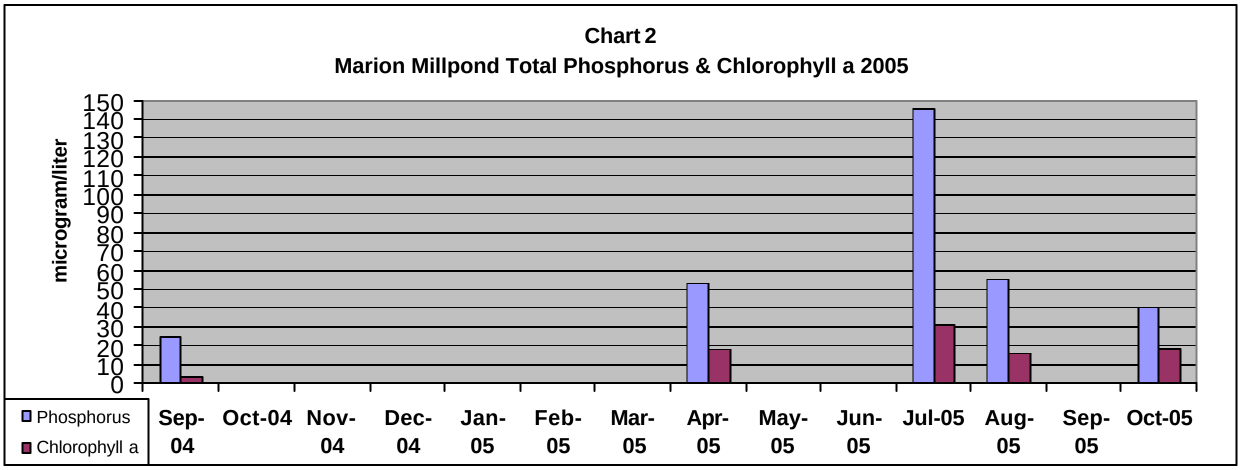


Total phosphorus

Phosphorus in lakes promotes excessive aquatic plant and algae growth. Total phosphorus is measured to determine the amount of nutrients that may be available for aquatic plant or algal growth. Total phosphorus data is available from one sample date in 2004 and four in 2005. The average total phosphorus for the Pond is 64 µg/l. Based on total phosphorus; the Pond can be considered a eutrophic lake. The average for total phosphorus in Wisconsin impoundments is approximately 65 µg/l (Lillie & Mason, 1983). The total phosphorus results for the Pond in are included in Chart 2.

Chlorophyll *a*

Chlorophyll is a pigment found in all green plants that absorbs sunlight that is used as the plant's energy source. Chlorophyll is measured in lakes because it is found in algae and can be used to estimate how much floating algae there is in the lake. High levels of chlorophyll indicate high levels of algae in the lake. The average amount of chlorophyll found in the Pond is 17.4 µg/l. Based on chlorophyll *a*; the Pond can be considered a eutrophic lake (Lillie & Mason, 1983). The chlorophyll *a* results for the Pond in are included in Chart 2.



Temperature and Dissolved Oxygen

Water temperature greatly affects both the physical and chemical aspects of a lake. Such aspects include decomposition, nutrient recycling, lake stratification, and dissolved oxygen concentrations. Fish will distribute themselves differently in a lake based on the water temperature.

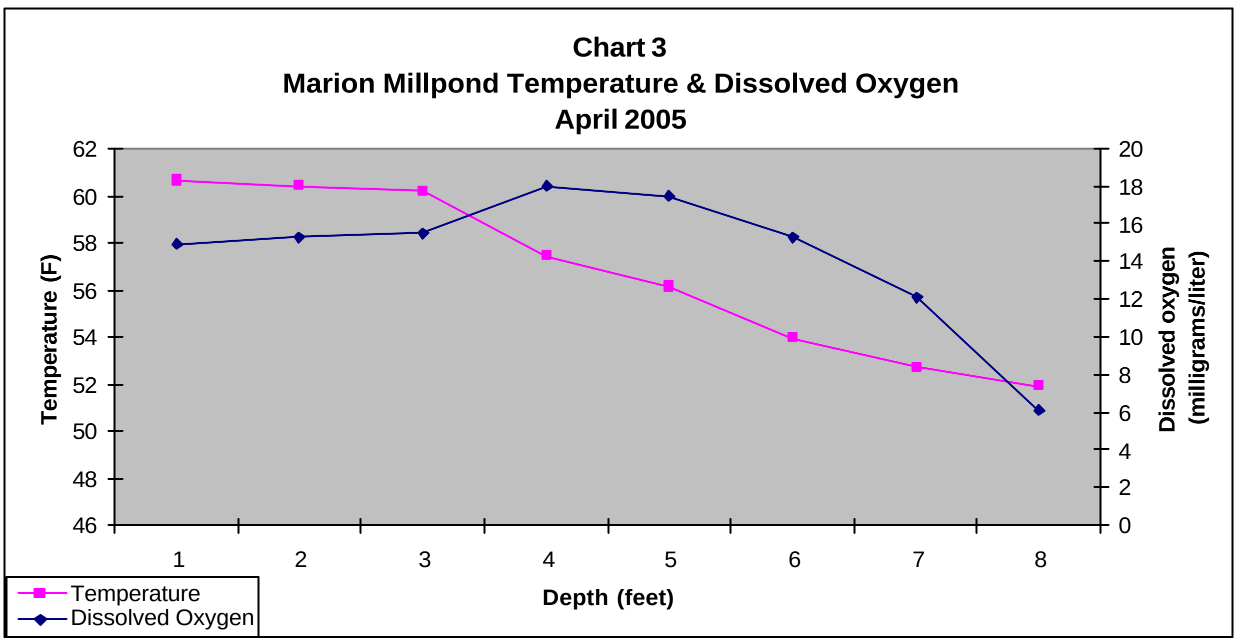
Water temperature is the major factor behind stratification in a lake. Distinct layers are formed in a lake based on the water temperature. The epilimnion, or surface water, is warmer during the summer but the hypolimnion, or bottom water does not get any warmer during the summer. During the fall, deep lakes turn over; meaning the warmer water at the surface cools and the water column is allowed to mix. Shallow lakes and impoundments like the Pond typically do not stratify and will continuously mix from top to bottom. Based on the temperature data recorded during the four sampling events, the Pond does not stratify. Slight temperature differences are found from the surface to bottom but a distinct metalimnion, or layer of water where the temperature changes drastically, was not observed.

Dissolved oxygen (DO) is essential in lakes as all aquatic organisms require DO for survival. The amount of DO that water can hold is dependant on its temperature. The colder water is, the more oxygen it can hold and vice versa. When lakes stratify, the top water and middle layers have the most DO available due to a variety of reasons including active photosynthesis by the aquatic plants and agitation to the surface water by wind. The bottom water, although colder, has very little or no DO available because it does not mix with the upper layer. The steep temperature gradient of the metalimnion prevents any surface water with DO from reaching the bottom waters. (Shaw, et. al , 2004).

As stated earlier, the Pond does not stratify; therefore the differences in DO levels are not extreme from top to bottom. However, in July and August DO levels were dangerously low at a depth of four feet and seven feet, respectively. The levels were below the required oxygen levels for fish listed above. The low DO is likely caused by the high rate of decomposition of aquatic plants such as CLP, and limited mixing of top and bottom water.

Fish species require different levels of dissolved oxygen. The water quality standard for warm water lakes such as the Pond is 5 mg/l. This is the minimum amount of oxygen needed for fish to survive and grow. In July, fish were limited to the top one or two feet of water as the DO level was below 5 mg/l at three feet. In August, fish were limited to the top six feet of water as the DO level was below 5mg/l at seven feet. Temperature and dissolved oxygen profiles are presented in Charts 3-3c.

It is important to note the time of day the DO levels were recorded as this may relate to the low levels. The July and August samples were recorded 10:30 a.m. and 9:00 a.m. respectively. This is important because the aquatic plants in the Pond were likely just beginning to photosynthesis for the day, thus the DO levels were on the rise. Conversely, it could suggest even lower levels of DO during pre-dawn periods. Productive lakes, such as the Pond undergo diurnal fluctuation in the dissolved oxygen levels from daylight to night because during the day the plants are undergoing photosynthesis, a reaction in which oxygen is released. At night, the plants undergo respiration and decomposition.



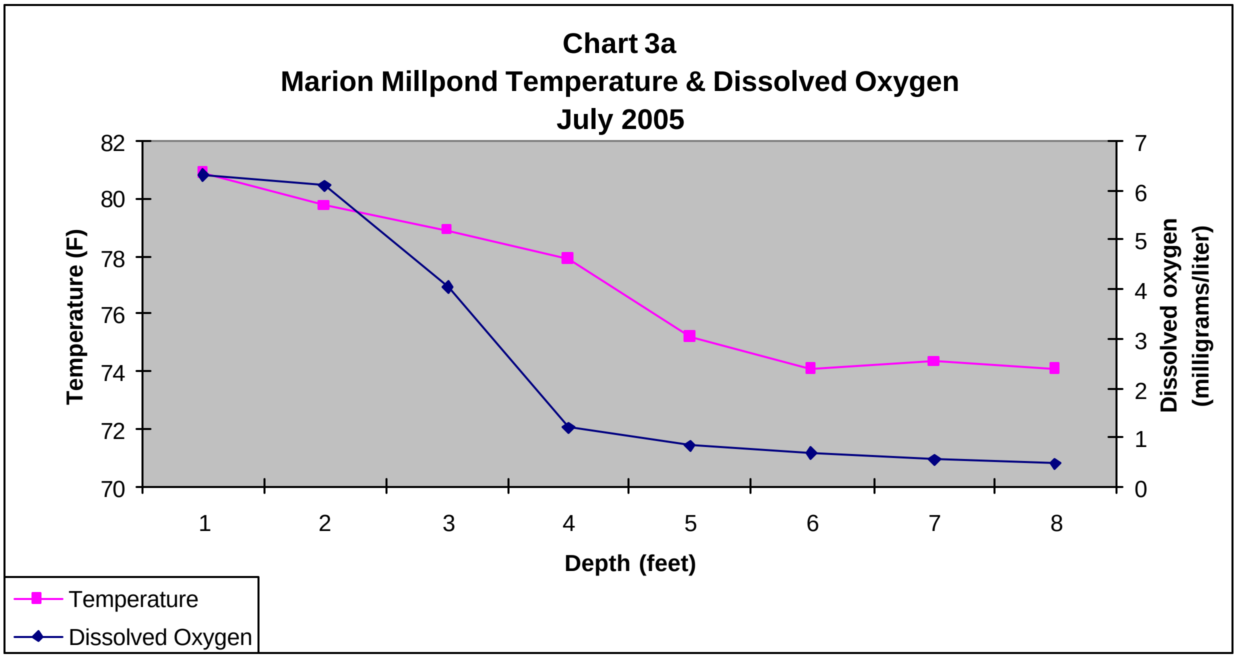


Chart 3a
Marion Millpond Temperature & Dissolved Oxygen
July 2005
Temperature (F)
82
80
78
76
74
72
70
Dissolved oxygen (milligrams/liter)
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
Depth (feet)
Temperature
Dissolved Oxygen

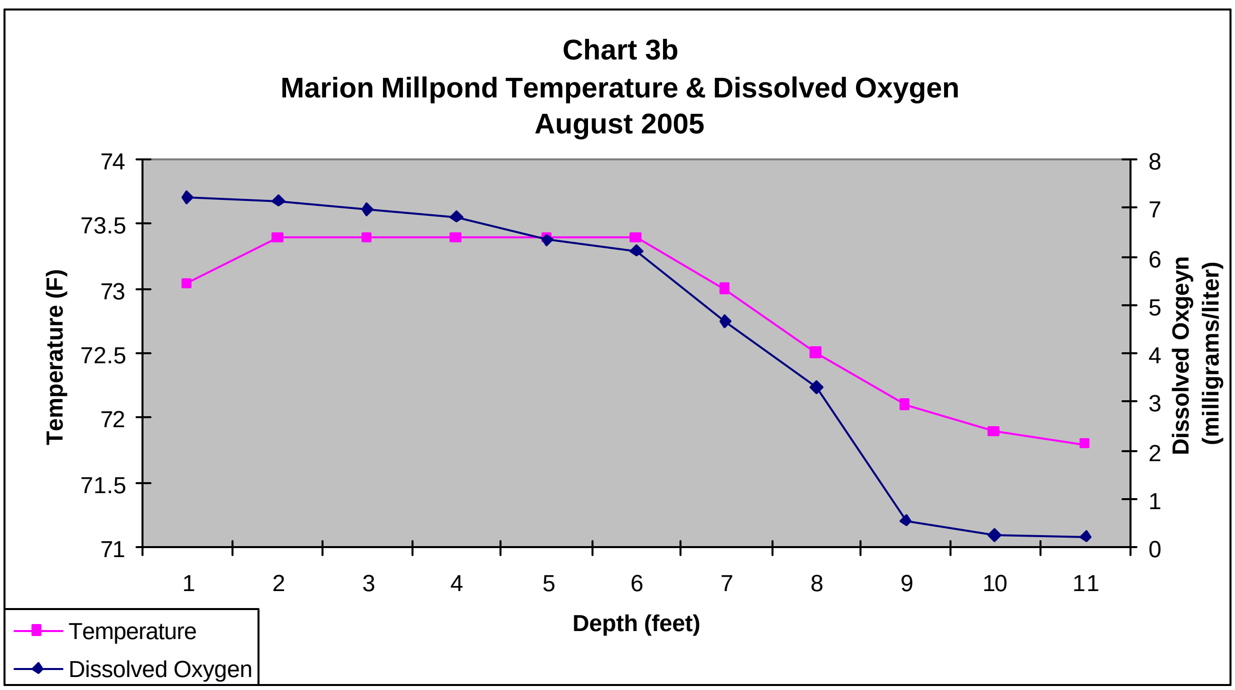
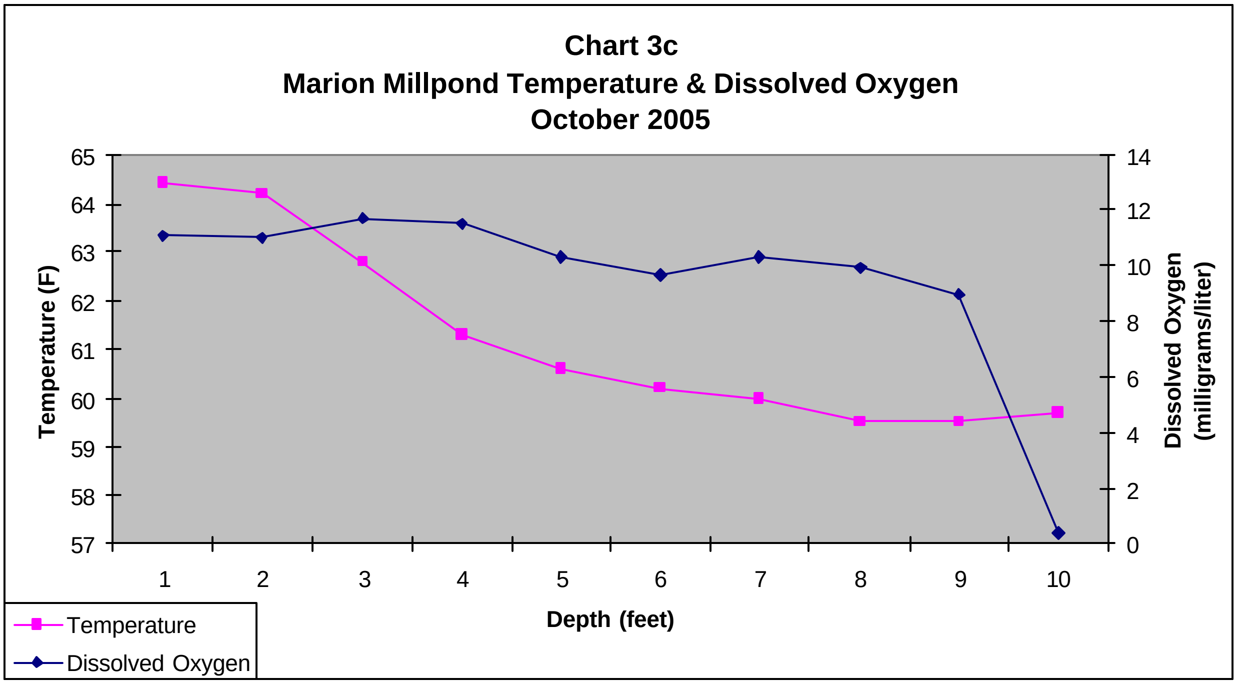


Chart 3b
Marion Millpond Temperature & Dissolved Oxygen
August 2005
Temperature (F)
74
73.5
73
72.5
72
71.5
71
Dissolved Oxgeyn (milligrams/liter)
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
10
11
Depth (feet)
Temperature
Dissolved Oxygen



4.3 FISHERIES RESULTS

Wisconsin DNR fisheries data was reviewed to determine the past and current status of the Pond fishery.

Intense fisheries surveys were conducted during the early 1970's to evaluate the impact of the lake renewal project and subsequent fish restocking program. Fish species found in the Pond during these surveys included northern pike, large mouth bass, walleye, bluegill, yellow perch, black bullhead, pumpkinseed and white sucker. The 1974 fish survey report concluded the fish restocking program was a success. A 1979 fisheries survey concluded the sport fish population is composed of a self sustaining population of northern pike, largemouth bass and assorted panfish. A fyke netting survey was conducted in 1990. However, the fisheries files from the Shawano DNR office did not include a written report from this survey; therefore the author could not include the results.

Recent fisheries surveys have been conducted on the Pond. Mini-fyke netting and electrofishing were conducted during the summer and fall of 2004. Fyke netting was also conducted in spring of 2005, shortly after ice-out.

Largemouth bass was the dominant gamefish sampled in the Pond. Approximately 143 were captured during electrofishing and fyke-netting with length ranges of 3.5 – 22.2 inches. Abundance appeared to be below average; however, size structure appeared to be above average. Northern pike were also present but in lesser numbers. A population of 126 northern pike was estimated from mark and recapture surveys. Northern pike size structure was average with lengths ranges of 15.9 to 31.3 inches. Northern pike spawning took place over a short period of time due to the extremely rapid warm-up of water temperatures during 2005. This may have affected the DNR's ability to capture an adequate sample (Marion Pond Fisheries Survey Summary Report-2005).

Bluegill was the dominant panfish sampled in Marion Pond. A total of 1411 were captured during 6 days of fyke-netting. Population abundance appeared to be above average; however, size structure appeared to be below average. Lengths ranged from 3.9 to 7.6 inches. During the winter of 2005-2006 the DNR will be interpreting age and growth from scale samples which should provide a better assessment of this fishery. Black crappie and yellow perch were found in lesser numbers and exhibited average size. Other panfish species caught during the survey included: pumpkinseed, warmouth, yellow bullhead, black bullhead and brown bullhead. Other forage species included white sucker and golden shiner (Marion Pond Fisheries Survey Summary Report-2005).

4.4 COMMUNITY SURVEY

A total of 526 surveys were sent to all residents of the City in early July 2005. A total of 204 responses were received by Maxim Technologies. A summary of the results are presented below.

- 91% of the respondents do not live on the lake.
- Fishing and enjoying scenic beauty are the common uses of the Pond.
- 61% of the responses stated the overall condition of the Pond has drastically declined in the last ten years.
- 54% of the responses stated aquatic plants are the most significant problem on the Pond.
- Responses indicated that the fiscal and operational management of the Pond is the responsibility of the City and the DNR.
- Approximately 50% of respondents describe their level of knowledge as limited with regard to the following lake-related subjects; aquatic invasive species, aquatic plants, fisheries management, shoreline management, and watershed impacts.
- The following methods of shoreline protection/restoration and water quality protection are suitable for the Pond:
  - 69% of the respondents indicated an annual lake fair or other educational meeting
  - 67% of the respondents indicated the formation of a voluntary lake association
  - 67% of the respondents indicated the establishment of a voluntary water quality monitoring group
  - 59% of the respondents indicated limited use of phosphate-based fertilizer
  - 55% of the respondents indicated the establishment of a boat launch monitoring program
  - 50% of the respondents indicated restrictive shoreline zoning requirements
- Responses indicated the following methods of aquatic plant management are appropriate for the Pond:
  - 60% of the respondents indicated mechanical methods (weed harvester)
  - 58% of the respondents indicated chemical methods (aquatic herbicides)

It is recommended the City consider the results of the survey during the decision-making process with regards to all management activities on the Pond. It is also recommended the City pursue and encourage three educational activities listed as suitable for the Pond community. These activities are the establishment of a boat launch monitoring program, formation of a voluntary lake association and the establishment of a voluntary water quality monitoring group. The options are discussed in detail in Sections 5.2 and 5.4.

4.5 WATERSHED EVALUATION

The shoreline of the Pond was characterized based on the level of development, plant communities and important aquatic habitat areas such as fish refuges. The shoreline is depicted in Figure 2. The undisturbed shorelines and fish refuges should be protected and considered during any lake management activities.

The North Branch of the Pigeon River flows into the Pond. The land uses are depicted in Figure 8. The dominant land use is agriculture.

In 2001, the Pigeon River watershed was identified as a priority watershed and an Environmental Quality Incentive Program (EQIP) was implemented. Cost-sharing was provided to landowners in Shawano and Waupaca Counties that wished to carry out conservation practices on their land. The EQIP program was implemented to reduce nutrient and sediment runoff to streams and lakes within the watershed, such as the Pond and the Pigeon Lake. To date, conservation practices implemented in the Pigeon River watershed have included the installation of buffer strips along waterways and changes in methodologies from in tilling practices to reduce erosion.

Agriculture is a major source of nutrient and sediment runoff to waterways, including those in the Pigeon River Watershed. Figure 9 depicts the tributaries to the Pond and highlights the areas that may be negatively impacting water quality. These areas were identified by reviewing aerial photography and indicating where the tributaries are adjacent to or pass through agricultural lands.

Another major source of nutrient and sediment runoff to streams and lakes is residential development along the shoreline. Figure 9 depicts the entire shoreline of the Pond and highlights these areas as they may be negatively impacting water quality.

5.0 RECOMMENDATIONS

5.1 AQUATIC PLANT MANAGEMENT PLAN RECOMMENDATIONS

A healthy native plant community is the most effective and cost efficient method of controlling invasive plant species. Aquatic plants are essential in a healthy lake system providing food and protective cover for a variety of animals including waterfowl, shorebirds, fish, furbearers, and invertebrates. Aquatic plants also benefit the physical condition of a lake by reducing shoreline erosion, stabilizing sediments and absorbing nutrients from the water column. Aquatic plants are also a source of scenic beauty. Enjoyment of scenic beauty was listed as one of the most common uses of the Pond.

However, nuisance levels of aquatic plants, both native and invasive can cause several problems for both a lake's ecosystem and users. Dense growth of aquatic plants, particularly plants that reach the water's surface can restrict and even inhibit recreational use of a lake. These dense mats of vegetation can restrict fish movement and interfere with the relationship of predator and prey fish. Also, dense plant growth can cause dramatic shift in daily dissolved oxygen levels. Decaying plants can lead to low dissolved oxygen levels during the winter and after large-scale herbicide treatments. Low dissolved oxygen levels can also lead to fish kills.

An integrated aquatic plant management (APM) plan utilizing several different techniques is recommended for the Pond. The goals of the APM plan are to:

- Protect lake sensitive areas
- Control invasive species (EWM and CLP)
- Maintain and increase current recreational use of the Pond

The objectives of the APM plan are:

- Preserve native aquatic plants
- Manage non-native aquatic plants via chemical and mechanical controls
- Educate community members on the value of native aquatic plants

The recommended techniques to achieve the listed objectives include:

- Aquatic herbicide application
- Water level manipulation
- Limited mechanical harvesting
- Target nutrient sources
- Conduct an annual lake fair/public meeting to discuss the Pond

Other management approaches

Table 3 describes the variety of APM techniques available and their associated advantages and disadvantages. Advantages and disadvantages of each method including, dredging, and benthic (bottom) barriers are discussed in Table 3, (Holdren, et. al, 2001).

TABLE 3
MANAGEMENT OPTIONS FOR CONTROL OF ROOTED AQUATIC PLANTS

OPTION	MODE OF ACTION	ADVANTAGES	DISADVANTAGES
PHYSICAL CONTROLS			
1. Benthic barriers	◆ Mat of variable composition laid on bottom of target area	◆ Prevents plant growth	◆ May cause anoxia at sediment-water interface
	◆ Can cover area for as little as several weeks or permanently	◆ Reduces turbidity from soft sediment	◆ May limit benthic invertebrates
	◆ Maintenance improves effectiveness	◆ Can cover undesirable substrate	◆ May interfere non-selectively with plants in target area
	◆ Most often used in swimming areas and around docks	◆ Can improve fish habitat	◆ May inhibit spawning or feeding by some fish
2. Dredging	◆ Sediment is physically removed by wet or dry excavation, with deposition in a containment area for dewatering/disposal	◆ Achieves plant removal with some flexibility	◆ Temporarily removes benthic invertebrates
	◆ Dredging can be applied on a limited bases, but is most often a major restructuring of a severely impacted system.	◆ Increases water depth	◆ May create turbidity
	◆ Plants and seed beds are removed and re-growth can be limited by light and/or substrate limitation	◆ Can reduce pollutant reserves	◆ May eliminate fish community (complete dry dredging only)
		◆ Can reduce sediment oxygen demand	◆ May cause impacts from containment area discharge
		◆ Can improve spawning habitat for many fish species	◆ May cause impacts from dredged material disposal
		◆ Allows complete renovation of aquatic ecosystem	◆ May interfere with recreation or other uses during dredging
			◆ Usually very expensive
3. Dyes and surface covers	◆ Water-soluble dye is mixed with lake water, thereby limiting light penetration and inhibiting plant growth	◆ Limits light on plant growth without high turbidity or great depth	◆ May not control peripheral or shallow-water rooted plants.
	◆ Dyes remain in solution until washed out of system	◆ May achieve some control of algae as well	◆ May cause thermal stratification in shallow ponds

	◆ Opaque sheet material applied to water surface	◆ May achieve some selectivity for species tolerant of low light	◆ May facilitate anoxia at sediment interface with water
			◆ Covers inhibit gas exchange with atmosphere
4. Mechanical removal	◆ Plants reduced by mechanical means, possibly with disturbance of soils	◆ Highly flexible control	◆ May impact aquatic fauna
	◆ Collected plants may be placed on shore for composting or other disposal	◆ May remove other debris	◆ Non-selectively removes plants in treated area
	◆ Wide range of techniques employed, from manual to highly mechanized	◆ Can balance habitat and recreational needs	◆ May spread undesirable species by fragmentation
	◆ Application once or twice per year usually needed		◆ May generate turbidity
5. Water level control	◆ Lowering or raising the water level to create an inhospitable environment for some or all aquatic plants	◆ Requires only outlet control to affect large area	◆ May create potential issues with water supply
	◆ Disrupts plant life cycle by dessication, freezing, or light limitation	◆ Provides widespread control in increments of water depth	◆ May have potential issues with flooding
		◆ Complements certain other techniques (dredging, flushing)	◆ May impact non-target flora and fauna
6. Herbicides	◆ Liquid or pelletized herbicides applied to target area or to plants directly	◆ Wide range of control is possible	◆ May be toxic to non-target species of plants/animals
	◆ Contact or systemic chemicals kill plants or limit growth	◆ May be able to selectively eliminate species	◆ Possible downstream impacts; may affect non-target areas within pond
	◆ Typically requires application every 1 - 5 years	◆ May achieve some algae control as well	◆ May restrict water use for varying time after treatment
			◆ May increase oxygen demand from decaying vegetation
			◆ May cause recycling of nutrients to allow other growths

7. Biological introductions	◆ Fish, insects, or pathogens that feed on or parasitize plants are added to system to effect control	◆ Provides potentially continuing control with one treatment	◆ Typically involves introduction of non-native species
	◆ The most commonly used organism is the grass carp, but the larvae of several insects have been used more recently, and viruses have been tested	◆ Harnesses biological interactions to produce desired conditions	◆ Effects may not be controllable
		◆ May produce potentially useful fish biomass as an end product	◆ Plant selectivity may not match desired target species
			◆ May adversely affect indigenous species

Aquatic Herbicides

Aquatic herbicides are recommended to reduce the density and occurrence of EWM and CLP. Selective herbicides such as 2,4-D and endothall, when applied during the early growing season have been shown to be effective in reducing the occurrence and density of EWM and CLP.

Selective herbicides can be defined as herbicides that target a particular type or species of plant. For example, 2,4-D, the active ingredient in common herbicides such as Navigate® and Aquacleen® is a systemic, selective herbicide that targets broad-leaved plants such as EWM. Most aquatic plants, such as the pondweeds, are monocots and are not affected by 2,4-D. Endothall, the active ingredient in other common herbicides such as Aquathol® is a contact herbicide that is effective on CLP. Endothall can affect other native pondweeds; therefore it is essential that it be applied in the early growing season when native pondweeds have not yet begun to grow.

The early-growing season is generally described as late spring or early summer prior to the water temperatures reaching 60ºF. Both EWM and CLP are adapted to begin growing in cooler water temperatures than other native plants.

By utilizing a combination of selective herbicides and applying these herbicides during the early growing season, EWM and CLP can be reduced in both occurrence and density. One of the main goals is to reduce the presence of these invasive plants in the early growing season and allow the existing native plant community to establish itself in these disturbed areas.

The specific recommendation for the application of aquatic herbicides for the Pond is as follows:

- Application of granular 2,4-D in areas of EWM (60-113 acres, dependant on the time of application) at a rate of 100 lbs-200 lbs/acre.
- Application of liquid endothall in areas of CLP (20-30 acres) at a rate of 1.5 ppm.
- All applications made during the early season when water temperatures are at or near 60ºF.
- Herbicides should be applied to areas of the lake with the highest density of EWM and CLP only to avoid causing low dissolved oxygen levels if water level manipulation is not implemented.

These recommendations are based on generally accepted guidelines utilized by the DNR when permitting herbicide applications for invasive species control. Herbicide treatment success can be dependant on a variety of factors including water temperature, wind, application rate, plant growth rate, etc. It is important to keep these factors in mind when determining treatment success.

Other herbicides and their target species are listed in Table 4 (Holdren, et. al, 2001).

All chemical application of herbicides to Waters of the State, such as the Pond, is regulated by the DNR. All chemicals must be registered and labeled by the U.S. Environmental Protection Agency (EPA) and Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP). Chemical application must be applied for on forms provided by the DNR. All requirements of Wisconsin Administrative Code NR 107 must be followed; including the application of the herbicides must be conducted by a certified pesticide applicator. A copy of the administrative code can be found in Appendix H. Large-scale herbicide treatments, such as the one recommended for the Pond, are often associated with a complex application process. It is recommended the City complete the appropriate application forms by January 1 to ensure adequate time for review of the permit application.

Informal aquatic plant surveys should be conducted in the treatment areas to evaluate the treatment success at one, two, and three months after the treatment. These surveys can be conducted by either Maxim Technologies personnel, trained volunteers or City personnel.

The cost of herbicide application can be estimated at approximately $450.00 per acre for granular 2,4-D and $500.00 per acre for liquid endothall. The cost of purchasing 2,4-D is approximately $115.00 per 100 lb. bag. (Verbal communication, Scott Provost, DNR Water Resources Management Specialist)

The City can expect to perform follow-up herbicide applications in subsequent years after the initial application and treatment. **The City cannot expect to eradicate EWM and CLP, only to control it. Therefore, control efforts should be implemented on an annual or bi-annual basis dependant on the aquatic plant community.** The aquatic plant community will require yearly assessment in the form of aquatic plant surveys as discussed earlier.

Water Level Manipulation

Water level manipulation is defined as the raising or lowering of water levels by a control structure such as a dam. The most common type of water level manipulation is a drawdown. Water levels are lowered for a defined period such as the winter by releasing water via a dam. Drawdowns can be effective on impoundments because these waterbodies do not exhibit fluctuating water levels such as natural lakes. Many near-shore plants require water level fluctuation to survive. As discussed earlier and as depicted on Figure 4, the Pond is lacking emergent and floating-leaf plants in the main portion of the Pond. Aquatic plants respond differently to fluctuating water levels and these differences are depicted in Table 5 (Table taken from Holdren, et. al, 2001).

TABLE 4

TABLE 5

Drawdowns can positively impact a lake ecosystem (Holdren, et. al, 2001) in several ways. They are:

- Cost effective way to control aquatic plants;
- Little human effort involved in the method as compared to mechanical harvesting or herbicide application;
- Opportunity to repair shoreline protection such as seawalls and riprap;
- Concentrate game fish and eliminate smaller forage fish;
- Concentrate EWM & CLP to smaller area (acres) to allow for reduced application of aquatic herbicides based on the assumption the areas of the Pond exposed during the winter will only have native aquatic plants.

Drawdowns can have several potential negative impacts (Holdren, et. al, 2001). These impacts may include:

- Loss or reduction of desirable plant species;
- Undesirable spread of drawdown resistant plants such as cattails and rushes (this would be considered a positive for the Pond due to the lack of emergent vegetation);
- Possible fish kills if oxygen levels are too low;
- Changes in fish and invertebrate habitat;
- Mortality to hibernating reptiles and amphibians, dependant on seasonal timing;
- Impacts to connected wetlands;
- Loss of aesthetic appeal during drawdown;
- Potential for more frequent algal blooms because the sources of excessive nutrients have not been addressed and there are fewer vascular plants to use the nutrients, thus it is available for algae;
- Restricted and/or limited recreational use (Consider annual Pond Ice Fishing Event);
- Shoreline structures such as docks and retaining walls may be damaged by freeze/thaw processes;
- Not enough water to refill the Pond.

Figure 10 depicts the areas of the Pond that would be impacted by a drawdown, based on two feet increments.

Mechanical Harvesting

Mechanical harvesting has been conducted in the Pond since 2002. As stated earlier, 820,000 pounds of aquatic plants were removed from the Pond in 2004. In 2005, approximately 780,000 pounds of aquatic plants were removed with an effort of 30 hours/week. Mechanical harvesting has been effective in maintaining navigation lanes and recreational areas for boating and fishing in the Pond. Figure 11 depicts the area of mechanical harvesting, approximately 60 acres. A second benefit of mechanical harvesting has been the removal of biomass, or biological matter (plants) from the lake. The removal of this material may have beneficial side effects of reduced muck in the Pond and less plant decomposition. A reduced rate of decomposition may lead to higher rates of DO; thus limiting the potential for fish kills.

The APM approach for the Pond should incorporate the discussed management options; use of selective herbicides to control EWM and CLP, water level manipulation and limited mechanical harvesting.

Figures 7a, 7b and 7c depict the densities of EWM and CLP in June and July. Herbicide application should be focused on the areas with the highest densities, if the City decides not to conduct a lake-wide herbicide treatment. Water level manipulation will allow a reduction in EWM and CLP in the exposed areas as both plants are susceptible to freeze/thaw conditions. Reproducing stands of EWM and CLP will also be concentrated to a smaller area during the drawdown period. This will allow for a smaller scale herbicide application, thus reducing cost and effort. In order to achieve the maximum results of a winter drawdown, the final pool level should be reached by September 30th and the Pond levels restored near April 30th. After the drawdown period and after the Pond is allowed to refill, limited mechanical harvesting should be implemented to maintain navigation lanes and recreational areas, as well as to reduce plant biomass.

5.2 WATER QUALITY SAMPLING RECOMMENDATIONS

Establishment of a Voluntary Water Quality Monitoring Group

The Self-Help Volunteer Lake Monitoring program is a DNR program that coordinates and funds lake water quality monitoring. Volunteers measure water clarity, using the Secchi Disk method, as an indicator of water quality. This information is then used to determine the lake's trophic state. Volunteers may also collect chemistry, temperature, and dissolved oxygen data, as well as identify and map plants, watch for the first appearance of EWM near boat landings, or alert officials about zebra mussel invasions on Wisconsin lakes.

The DNR provides all equipment to the volunteer. Training of the volunteers is provided by either DNR or University of Wisconsin - Extension staff. The information gathered by the volunteers is used by DNR lake biologists, fisheries experts and water regulation and zoning staff, as well as by UW Extension, lake association and other interested individuals.

5.3 FISHERIES MANAGEMENT RECOMMENDATIONS

Management recommendations will be provided by Al Niebur, DNR fisheries biologist, upon completion of a detailed final report based on an analysis of fish age and growth. Preliminary results indicate an extremely abundant bluegill population. Predator species were found to be in low densities, likely a contributing factor in the abundant bluegill population. A summary of the fish survey is included in Appendix G.

5.4 UTILIZATION OF COMMUNITY SURVEY RESULTS

Establishment of a Boat Launch Monitoring Group

The Clean Boats, Clean Waters program is a volunteer watercraft inspection program to help prevent the spread of aquatic invasive species. Through the Clean Boats, Clean Waters program, volunteers are trained to organize and conduct a boater education program in their community. Volunteers perform boat and trailer checks for invasive species, distribute informational brochures and collect and report any new water body infestations. The program is funded through DNR by an Aquatic Invasive Species (AIS) grant. The AIS grant program allows for 50% cost-share of the boat launch inspection program provided the grantee follows the DNR guidelines of the Clean Boats, Clean Waters program, attends a required training workshop, collects and reports data and is present of boat launch facilities a minimum of 200 hours between May 1 and October 30. All training and handout materials are provided by the State of Wisconsin.

The establishment of a boat launch monitoring group is highly recommended. The volunteer network can consist of interested adults including those who fish the Pond, local youth groups such as Boy Scouts and Girl Scout, 4-H groups and church youth groups. AIS grants can be applied for twice annually with application deadlines of February 1 and August 1.

Formation of a Voluntary Lake Association

Voluntary lake associations are formed under the guidelines of Wisconsin Statute 281.68. Voluntary lake associations have the authority to direct lake management activities in association with the DNR and local municipalities, raise funds for lake management activities, apply for a variety of state grant programs and support educational efforts about lakes in Wisconsin.

The City should research the feasibility of the formation of a voluntary lake association for the Pond. A lake association could assist in the determination and implementation of any lake management activities such as mechanical harvesting, herbicide application and educational activities such as an annual lake fair.

5.5 WATERSHED MANAGEMENT RECOMMENDATIONS

In order to further determine the potential impacts from these areas, more intense water quality sampling should be conducted. The specific locations include T26N, R13, Sections 27, 28, & 34 in Shawano County and T25N, R13E, Sections 4, 5, 6 & 9 in Waupaca County.

In order to further determine the potential impacts from the shoreline areas, more intense water quality sampling should be conducted. A second method to assess the impacts from the adjacent shoreline is soil sampling. Shoreline property owners can contact the local agricultural cooperative service and have their lawn tested for nutrient levels to determine if they might be over-fertilizing.

The City should work with Waupaca County Land Conservation Department and Natural Resource Conservation Service (NRCS) to implement conservation efforts in the Pigeon River Watershed, specifically the locations identified as potential areas of water quality impacts.

6.0 IMPLEMENTATION PLAN

The following timeline is suggested for implementation of the recommendations.

November 2005

- City of Marion to determine appropriate management options based on results of comprehensive lake management plan.
- Recruit volunteers to act as Clean Boats, Clean Waters Volunteers to monitor public boat launches.

December 2005

- Apply for large-scale herbicide application permits from DNR.
- Apply for Lake Management Planning Grant to conduct detailed watershed evaluation (February 1st deadline).
- Apply for Aquatic Invasive Species Prevention & Control Grants to establish a Clean Boats, Clean Waters program.
- Apply for small-scale lake management planning grant to establish a lake association.
- Determine pesticide applicator (internal staff or external contractor).

January 2006

- Contact DNR Lake Management Coordinator to participate in Self-Help Lakes Monitoring Program.

April 2006

- Begin monitoring water temperatures shortly after ice-out.
- Conduct secchi disc monitoring two times during the month.
- Begin permit application process for Winter 2006/2007 drawdown.

May/June 2006

- Conduct herbicide application when water temperatures reach 60ºF.
- Conduct aquatic plant survey in treatment areas 30 days after application.
- Conduct secchi disc monitoring two times during the months of May & June.

July/August 2006

- Conduct aquatic plant survey in treatment areas 60 days after application.
- Conduct secchi disc monitoring two times during the month.

August/September 2006

- Conduct aquatic plant survey in treatment areas 90 days after application.
- Conduct secchi disc monitoring two times during the months of August & September.
- Begin lowering water levels on the Pond.

October 2006

- Conduct secchi disc monitoring two times during the month.
- Hold public meeting to discuss herbicide treatment and secchi disc results.

April 2007

- Begin raising water levels to capture spring runoff.

May/June 2007

- Conduct herbicide application when water temperatures reach 60ºF.
- Conduct aquatic plant survey in treatment areas 30 days after application.

Remainder 2007

- Evaluate APM implementation strategies and determine future APM management techniques.

MAXIM TECHNOLOGIES

Prepared by:	Reviewed by:
Crystal Olson Environmental Scientist	Walt Vering Project Biologist

CO/WV:bj
S:\ENV\Lake management\Marion Millpond\FinalReport11_28_05.doc

7.0 REFERENCES

Holdren, C., W. Jones, and J. Taggart. 2001. Managing Lakes and Reservoirs. N. Am. Lake Manage. Soc. and Terrence Inst., in coop. with Off. Water Assess. Watershed Prot. Div. U.S. Environ. Prot. Agency, Madison, WI.

Klessig, L., N. Bouwes, and D. Yanggen. 1994. The Lake in Your Community. University of Wisconsin-Extension, Madison, WI.

Borman, S, R. Korth, and J. Temte. 1997. Through the Looking Glass. Environmental Resources Center, University of Wisconsin-Extension, Madison, WI.

Shaw, B., C. Mechenich, and L. Klessig. 2004. Understanding Lake Data. Environmental Resources Center, University of Wisconsin-Extension, Madison, WI.

Born, S., T. Wirth, E. Brick, and J. Peterson. 1973. Restoring the Recreational Potential of Small Impoundments. Technical Bulletin No. 71, Department of Natural Resources, Madison, WI.

TERMINOLOGY AND DEFINITIONS

1) **Emergent aquatic plant community** – an emergent aquatic plant community can be defined as a plant community in which the plants emerge or grow above the surface of the water. Emergent aquatic plants are rooted with the majority of the vegetative portion of the plant above the surface of the water. They provide a variety of benefits including habitat for fish, furbearers, waterfowl, shorebirds and aquatic insects. Beds of emergent plants reduce wave energy caused by wind or motor boats, thus reducing shoreline erosion. Emergent aquatic plants found in the Pond include bulrush and cattail.

2) **Floating-leaf aquatic plant community** – a floating leaf aquatic plant community can be defined as a plant community in which the majority of the vegetative portion of the plant (usually the leaf) lies on the surface of the water. They provide a variety of benefits including habitat for fish, waterfowl, shorebirds and aquatic insects. Beds of floating-leaf plants reduce wave energy caused by wind or motor boats, thus reducing shoreline erosion. A floating-leaf aquatic plant found in the Pond includes spatterdock.

3) **Point-intercept method** – the point-intercept method is a sampling protocol in which the location and number of sample points is determined by establishing a grid pattern for a specific lake based on the size of the lake and complexity of the shoreline. The distance from each sample point is termed the sampling resolution. Each sample point is equal distance from another point. For example, the sampling resolution for the Pond was 60 meters spacing between each sample point.

4) **Relative frequency** – relative frequency can be defined as the frequency of a species divided by the sum of the decimal frequencies of all species. The sum of all frequencies should equal 100 percent. This statistic presents an indication of how the plants occur throughout a lake in relation to each other.

5) **Frequency of occurrence**– frequency of occurrence can be defined as the number of times a species was observed, divided by the total number of sampling points.

6) **Floristic Quality Index (FQI) –** the FQI can be defined as an indicator of a lake quality. This value is helpful in comparing lakes around the state or comparing a single lake's plant community over time.

7) **Simpson Diversity Index** – is an estimator of community heterogeneity. It is based on relative frequency. The closer the Simpson Diversity Index is to one, the more diverse the community.

8) **Heterogeneity** – heterogeneity can be defined for the purpose of this report as a diverse or mixed aquatic plant community

9) **Aquatic invasive species** – aquatic invasive species are defined in NR 198.12(1).“Aquatic invasive species” means non-indigenous water or wetland-dwelling organisms or their hybrids whose introduction into aquatic ecosystems causes or is likely to cause adverse economic, recreational or environmental impacts or harm to human health. Common aquatic invasive plant species include Eurasian water milfoil (EWM) and Curly-leaf pondweed (CLP), both of which occur in the Pond.

10) **Trophic State Index (TSI)** - trophic state index can be defined as an indicator of the lake's eutrophication state. Eutrophication is the process by which lakes are enriched with nutrients, increasing aquatic plants and algae. The TSI value is an indication if the lake is oligotrophic, mesotrophic or eutrophic.

11) **Oligotrophic -** oligotrophic lakes are those lakes with poor nutrients. These lakes typically have good water clarity and low aquatic plant production.

12) **Mesotrophic** - mesotrophic lakes are those lakes that are in the medium range of eutrophication. These lakes have higher nutrients levels, poorer water clarity and more plants than oligotrophic lakes.

13) **Eutrophic** - eutrophic lakes are those lakes that have high nutrient levels, abundant aquatic plants and algae and poor water clarity. **The Pond is considered a eutrophic lake**.

14) **Impoundment –** an impoundment is defined as an artificial waterbody created by a control structure to raise the water levels, usually of a stream or river. The Pond is an impoundment created by the presence of a dam on the North Branch of the Pigeon River.

15) **Class I Trout Water** – Class I trout water is defined as a waterway that is capable of enough natural reproduction to fill up the entire available habitat. No supplemental fish stocking is required.

16) **Watershed –** a watershed can be defined as all of the land and water areas that drain or flow toward a central collector such as a larger stream, river or lake that is at a lower elevation.

17) **Sensitive areas** - sensitive areas are defined in Wisconsin Administrative Code NR 107.05(i)1 as areas of aquatic vegetation identified by the department as offering unique fish and wildlife habitat, including seasonal or lifestage requirements, or offering water quality or erosion control benefits to the body of water.

18) **Secchi disc –** a black and white weighted disc that is lowered into the water column to measure the transparency of the water.

19) **Submergent aquatic plants** - submergent aquatic plants have the majority of their leaves growing beneath the water's surface with the exception of an occasional flower stalk. Common submergent aquatic plants in the Pond are coontail, EWM and CLP.

20) **Epilimnion -** the epilimnion is defined as the uppermost, warmest, well-mixed layer of a lake during summer stratification.

21) **Hypolimnion –** the hypolimnion is the lower, cooler layer of a lake during summer stratification.

22) **Metalimnion** - layer of rapid temperature and density change in thermally stratified lakes; lies between epilimnion and hypolimnion. Resistance to mixing is high in the region.

23) **Respiration -** process by which aquatic organisms convert organic material to energy. It is the reverse reaction of photosynthesis. Respiration consumes oxygen and releases carbon dioxide. It also place as organic matter decays.

24) **Photosynthesis -** process by which green plants convert carbon dioxide dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base, and is an important source of oxygen for many lakes.

25) **Diurnal fluctuation -** a fluctuation of dissolved oxygen levels from high levels during the day and low levels at night. The high levels during the day are caused by high rates of photosynthesis. The low levels during the night are caused by high rates of respiration.

26) **Biomass** - the weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a give time. For the purpose of this report, biomass is the amount of aquatic plants in the Pond.