Kohlman Lake Aquatic Plant Management Plan

Prepared for
Ramsey-Washington Metro Watershed District

January 2008

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Executive Summary

A macrophyte management plan has been developed for Kohlman Lake using macrophyte survey data collected between 2001 and 2006. The plan will be used in support of ongoing and planned activities designed to improve Kohlman Lake water quality.

Kohlman Lake has a moderately diverse aquatic community; however, two invasive aquatic species, *Myriophyllum spicatum* (Eurasian watermilfoil) and *Potamogeton crispus* (Curlyleaf pondweed) currently tend to dominate overall density and were present in all years. Curlyleaf pondweed has increased in both coverage and density during the survey period, creating an additional management concern due to its contribution of phosphorus to internal loading. Both species can undermine efforts to improve water quality by enhancing the sediment to water column transfer of phosphorus. Heavy growth of these macrophytes will also reduce the effectiveness of alum treatment by limiting settling and distribution of the alum floc to the sediment. Management of these species in and of itself will not allow Kohlman Lake to reach designated water quality goals. However, controlling these species will help improve water quality in Kohlman Lake by limiting current and potential growth as water clarity in the lake increases as a result of planned restoration measures. The following are the intended results for the Kohlman Lake Aquatic Plant Management Plan (APMPP):

- Control of invasive species Eurasian watermilfoil and Curlyleaf pondweed to create conditions necessary for effective alum application and to ensure these species do not proliferate after treatment.

- Control of Curlyleaf pondweed to provide additional water quality benefits by limiting the mid-season contribution of phosphorus this aquatic plant provides Kohlman Lake.

A broad spectrum of currently available options was considered for management of the macrophyte community in Kohlman Lake including: physical (dredging feasibility study completed), mechanical, biological and chemical methods. Chemical treatment with herbicides was chosen as the most effective means to reduce both Curlyleaf pondweed and Eurasian watermilfoil in Kohlman Lake. This decision was based upon the unique characteristics of Kohlman Lake, cost, and the applicability of treatment to address the specific water quality goals for the lake. A combination of Endothall and liquid 2,4-D or Triclopyr will be used to limit the growth of the target species. The costs to manage both Eurasian watermilfoil and Curlyleaf pondweed are listed below. These costs are considered conservative.

Intensive Treatment	Year	Cost	
	1 2 3 4		$45,000 $45,000 $34,000 $23,000
Total (1-4)			$147,000
Maintenance Treatment		Cost	
	Per year		$7,000

It is expected that it will take approximately four years of intensive treatment, followed by subsequent maintenance years of spot treatment, to exhaust the Curlyleaf pondweed seed bank and prevent takeover of the macrophyte community by both species. Initially, the entire lake area will need treatment and post-treatment survey results will dictate follow-up treatment requirements. If alum is decided upon to control internal phosphorus loading, alum will be applied in the fall/spring following the year herbicide treatment has reduced invasive species growth to a level that will not interfere with alum application.

Treatment effectiveness will be monitored in two ways: (1) **Herbicide dose--**In-lake levels of herbicide will be monitored at specified intervals immediately after treatment to assure that the required concentration is maintained, and (2) **Macrophyte surveys**--Macrophyte surveys will be used to assess Curlyleaf pondweed and Eurasian watermilfoil growth after treatment. Future treatments will be optimized using post-treatment survey data.

1.0 Introduction

The Strategic Lake Management Plan for the Phalen Chain of Lakes (draft; Barr, 2004) concluded that a reduction in internal phosphorus loading in Kohlman Lake is necessary in order to significantly reduce in-lake summer phosphorus concentrations in the water column and increase water quality in the lake. The purpose of this study was to develop a macrophyte management plan to help attain this water quality goal for Kohlman Lake through the reduction of invasive macrophyte species that contribute to internal phosphorus loading.

Kohlman Lake, located in the Phalen Chain of Lakes (St. Paul, MN) is a shallow, polymictic lake and the entire area is considered littoral by definition (less than 15 feet in water depth). Detailed macrophyte surveys conducted since 2001 show that macrophytes cover nearly the entire lake at depths less than approximately 9.5 feet. Dense populations of Curlyleaf pondweed (early season) and Eurasian watermilfoil (season long) have been detected and can negatively impact water quality in Kohlman Lake. Curlyleaf pondweed senesces in late June to early July, supplying the lake water with additional phosphorus that is available for uptake and growth by algae. Dense growth of Eurasian watermilfoil can stabilize the water column and limit oxygen transfer to the bottom waters via mixing. Dense macrophyte growth may also limit the effectiveness of restoration efforts designed to limit phosphorus release from the sediment in Kohlman Lake sediment (i.e., alum treatment).

This report evaluates past macrophyte survey data to determine an effective strategy to manage macrophyte growth and improve water quality in Kohlman Lake. There are two main parts of this report:

- An evaluation of existing macrophyte data for Kohlman Lake
- A management plan designed to limit invasive species growth that adversely effects water quality in Kohlman Lake

A broad spectrum of options was considered for management of the Kohlman Lake macrophyte community. A comparison of costs, benefits, and applicability were used to determine the most effective course of action. The treatment recommendations outlined in this report should be considered with the following studies so that a holistic lake management approach is attained for the ultimate benefit of lake water quality in Kohlman Lake:

- Internal Phosphorus Load Study for Kohlman and Keller Lakes
- Phalen Chain of Lakes Untreated Tributary Drainage Area Study
- Phalen Chain of Lakes Carp Population Study
- Phalen Chain of Lakes Wetland Enhancement Study
- Ramsey Washington Metro Watershed District Phosphorus Sources Assessment Study

2.0 Overview of Macrophyte Growth in Lakes

2.1 Aquatic Plant Growth in Lakes

Aquatic plants (macrophytes) grow in the portion of the lake known as the littoral zone. The littoral zone covers the area of lake bottom extending from the shoreline to the maximum depth of the mixed layer. This zone often coincides with the maximum depth of plant growth, generally a depth of about 15 feet. It is the transition zone between the shoreline and the open water portion of a lake. These shallow areas of the lake are generally characterized by abundant light, nutrient rich sediment and diverse plant and animal life. A healthy and productive littoral zone is important for the overall health of a lake.

The width of the littoral zone varies within a lake and between lakes. The slope of the lake bottom as it moves away from the shoreline determines how rapidly the littoral zone dissipates into the open water region. Where the slope of the bottom is gentle, the littoral zone is wide and in shallow lakes, may encompass a large portion of the lake. Where the lake bottom is steep, the littoral zone is narrow and may extend only a few feet into the lake.

Water clarity is also a factor governing plant growth in lakes. When light penetration is limited, the depth to which plants may grow is greatly reduced. Lakes with very high water clarity may have plentiful vegetation, covering the full extent of the littoral zone.

Other physical factors also influence the distribution of aquatic vegetation. Regions of a lake affected by strong wind and wave action may have limited plant growth, while protected and calm areas allow plants to thrive. Sediment type may restrict or encourage plant growth. Finer sediments allow plants to root well and hold onto nutrients while a rocky, gravely substrate impedes plant rooting and growth. In areas where a stream or river enters a lake, plant growth can be variable. Nutrients carried by the stream may enrich the sediments and promote plant growth; or, suspended sediments may cloud the water and inhibit growth.

2.2 Value of Aquatic Plants in Lakes

Aquatic plant growth is an integral part of lake ecosystems and provides many benefits to fish, wildlife, and lake users.

- ***Fish habitat*** **–** Aquatic plants are an essential resource for fish throughout their life cycle. Plant beds provide the necessary spawning conditions for many species of fish and protected habitat for juvenile fish and smaller adult species. Aquatic plants are a major food source for fish species such as sunfish, and provide habitat to other fish foods such as aquatic insects, insect larvae and crustaceans. The density and structure of aquatic plant beds affects the hunting success of predatory fish, too many plants prevent predator movement in the bed and too few plants limit the amount of prey available. Optimal density of the plant bed varies for different predator species.

- ***Wildlife habitat* –** Waterfowl feed and nest in the vegetated regions of a lake. The variety of plants and insects found in aquatic vegetation beds feed waterfowl throughout their lives and migratory stages. Plant roots, shoots and seeds are consumed by different species and life stages. Plant beds also act as shelter and building material for nesting. Nearshore plants are import food for shoreland animals such as moose and deer and provide habitat and food for aquatic mammals such as otter, beaver and muskrat.

- ***Shoreline and sediment stabilization* –** Emergent and floating plants help to blunt wave action towards the shoreline. This provides a stable environment for nest sites and juvenile species. Rooted vegetation helps to prevent shoreline erosion and to stabilize bottom sediments.

- ***Water Quality* –** Aquatic plants help to maintain and improve water quality in several ways. They absorb nutrients from the water and sediment that would otherwise be used by nuisance algae. Certain plants, such as rushes, can filter and break down pollutants. Plant beds also trap sediment from upland runoff and prevent it from affecting the rest of the lake, prevent the resuspension of near shore sediments, and as a result hold excess nutrients and pollutants in the near-shore zone.

- ***Economic Value* –** Aquatic plants are an essential and natural component of lakes, and as such they contribute to the overall health and value of a lake. Sport hunting and fishing industries, as well as lake recreation and tourism, have become large revenue generators and can be important economic resources for local communities.

- ***Aesthetics* –** The natural beauty of aquatic plants contributes to the overall aesthetics of a lake and serves to attract waterfowl and wildlife, also important to lake aesthetics. The aesthetic quality of a lake has even been shown to affect the economic value of lakeshore property.

2.3 Types of Aquatic Plants

Aquatic plants are grouped into four major categories based on plant structure and growth type.

- **Emergent** plants have rigid stems that allow the plants to stand erect above the water surface and are rooted to the lake bottom. Emergent plants grow in the shallowest zone along the shore and typically extend out to depths around a few feet, though some species are found deeper. Emergent plants can withstand fluctuating water levels and can utilize different reproductive strategies during variable conditions. Common emergent plants include cattails, rushes, reed canary grass, arrowhead, and blue flag iris.

- **Floating-leaf** plants have leaves that float on the water's surface and are rooted in the lake bottom. They often grow in protected areas where wave action is minimal. Floating-leaved plants typically grow at intermediate depths in the zone between the nearshore emergent beds and the deeper submersed plants. They generally reproduce by spreading from rhizomes, but can also reproduce from seeds. Water lilies and water shield are commonly found floating-leaved plants.

- **Submersed** plants have leaves and stems that grow completely underwater and are rooted to the lake bottom. Some species have flowers and seeds that extend above the water on short stems and a few species have floating leaves in addition to submersed. Submersed plants grow from the nearshore area, sometimes below floating-leaved plants, to the deepest extent of the littoral zone. Some species grow near the lake bottom, while others grow up to the lake surface and can form mats at the surface. Submersed plants utilize a variety of methods for reproduction or expansion. Plants may spread though rhizomes, produce winter buds or turions, or overwinter as a whole plant. Sexual reproduction is utilized by a few species but is not common. Common submersed plants include milfoil, coontail, and pondweeds.

- **Free-floating plants** float at the water's surface with leaves and stems but are not rooted to the lake bottom. Some species do possess roots-like structures, however they are short and do not anchor the plant to the lake bottom or other surface. Free-floating plants are small and often become clumped together into mats. They can be found in any part of a lake as they are easily moved by wind or currents. When present in large enough quantities, free-floating plants may form mats dense enough to shade out submersed vegetation growing below. Common free-floating plants include duckweeds and watermeal.

- **Algae** have no true roots, stems or leaves and range in size from small, one-celled organisms to large, multi-celled plant-like organisms, such as *Chara*. Algae are found throughout the water column and some species may collect at the lake surface to form mats. *Chara* is frequently found growing in the littoral area of lakes.

2.4 The Role of Aquatic Plant Management

There are several conditions whereby an aquatic plant community may become disturbed and nuisance conditions develop. Both excessive and reduced plant abundance may constitute a "disturbed condition". Causes of nuisance conditions in aquatic plant communities include exotic species invasion, excess nutrient loading and monoculture development. Problems may also result from disruptions to the system from sedimentation, pollution, vegetation removal, and changes in water clarity, causing a decline in the plant community.

Once nuisance conditions have been established, they can become self-reinforcing. For example, Curlyleaf pondweed can establish itself in a lake. Once the Curlyleaf population has reached a critical size, it can begin to crowd out other plant species and become dominant by creating a turbid, algal dominated state in which other native plants can not survive. Once a disturbed condition is established, it is unlikely that a lake will switch back to an ecologically balanced condition. Hence, appropriate, well-planned management is needed to restore the aquatic plant community to a beneficial state, for both overall lake health and recreational use.

3.0 Aquatic Plant Survey Methods

Whole lake aquatic plant surveys have been conducted in Kohlman Lake since 2001 to assess current conditions and monitor ongoing trends. Surveys were completed by either the DNR (2001-2004) or District staff (2006). A complete data set is not available for the 2005 growing season and therefore that year is excluded from the main analysis. The sampling locations and sample methodology were similar between years but there were variations. From 2001 through June 2003, sampling consisted of determining presence or absence with no indication of plant density. Beginning in August 2003, density was recorded as a number between 1 and 4, based on fraction or percentage rake coverage or, in the case of free floating species, percentage of a one-meter square area covered (Table 1).

Table 1 MNDNR density ranking for rooted and free-floating aquatic plants

Rank	Rooted	Free-Floating
1	≤ 1/3 of the rake head	1% - 25%
2	1/3 < Plants filling ≤ 2/3 of the rake head	25% - 50%
3	Plants filling 2/3 of the rake head	51% - 75%
4	Plants over the top of the rake	76% - 100%

Reporting in 2006 was similar except that plant density was represented on a 1 to 5 scale (Table 2).

Table 2 Density ranking for rooted and free floating aquatic plants used in 2006 (RWMWD). Percentage is based on rake coverage

Rank	Rooted	Free-Floating
1	1% - 9%	1% - 9%
2	10% - 29%	10% - 29%
3	30% - 54%	30% - 54%
4	55% - 69%	55% - 69%
5	69% - 100%	69% - 100%

The following is a general overview of the MNDNR sampling methodology (current as of April 2006) used for surveys where control of invasive species (i.e., Curlyleaf pondweed) is the management goal.

- Preferably, two yearly surveys are conducted; one in June before Curlyleaf pondweed senescence and one in August to assess Eurasian water milfoil and macrophyte growth during peak vegetation growth

- The point intercept method is used which requires a grid of sample points covering the lake (the MNDNR can provide this). A minimum of 125 sample points are required with the distance between points no more than 300 feet.

- All plant species observed in a one-meter square area are collected (using a double headed garden rake with a 25 foot line) and recorded at each point, along with water column depth (either by sonar or depth stick). Voucher specimens should be collected and pressed. At least one interval past the point of maximum macrophyte growth depth must be sampled.

- Abundance estimate representation (Figure 1): 1 = ≤ 1/3 of the rake head, 2 = 1/3 < Plants filling ≤ 2/3 of the rake head, 3 = Plants filling 2/3 of the rake head, 4 = Plants over the top of the rake.

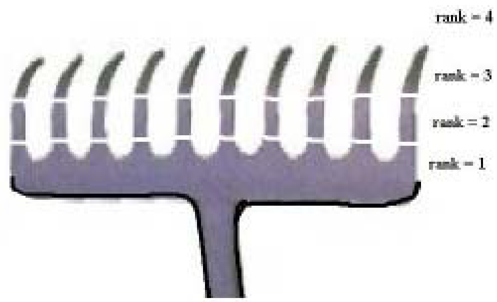
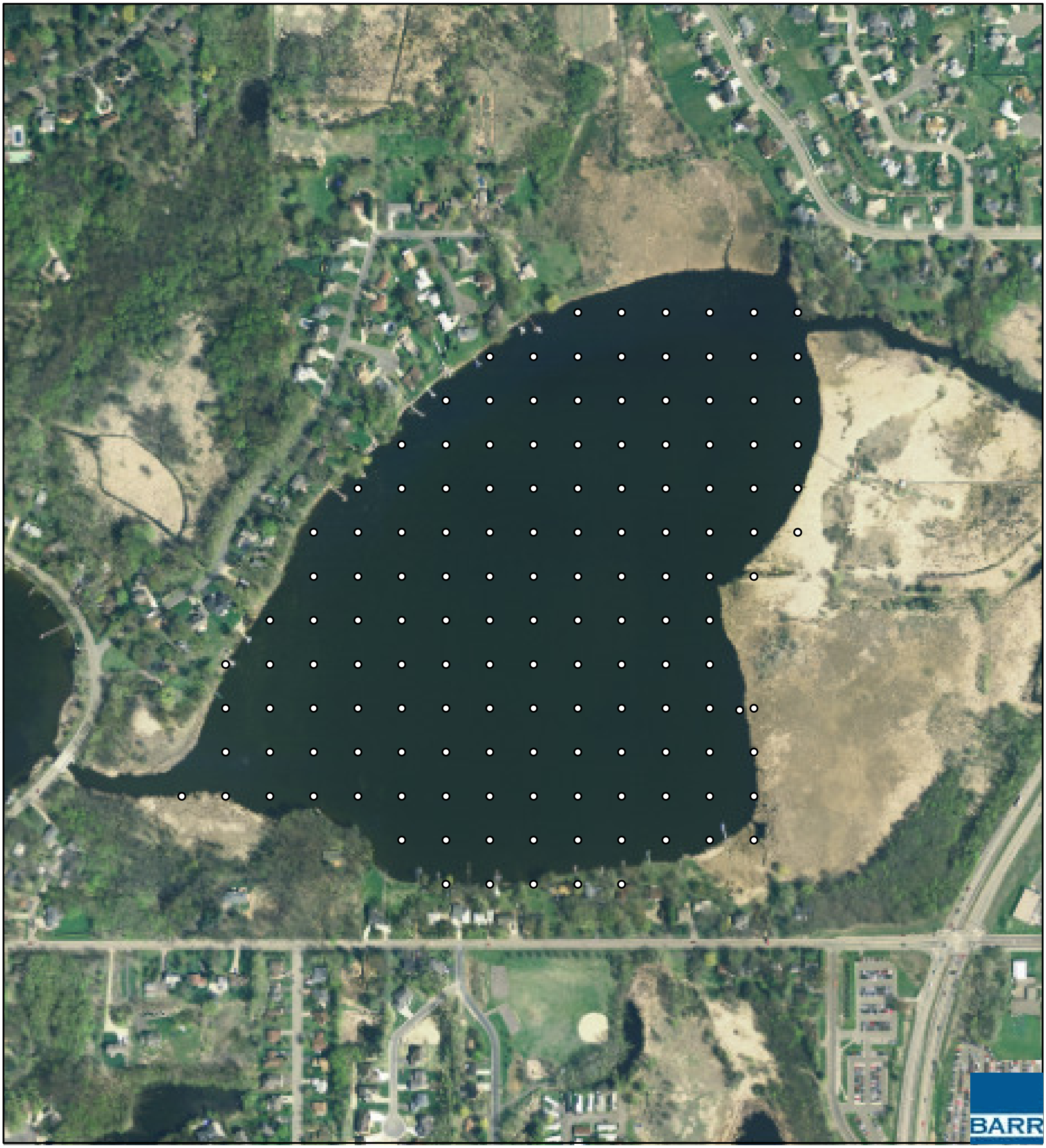


Figure 1 Rake based abundance estimates (MNDNR)

Macrophyte sampling in Kohlman Lake was conducted as follows

- An average of 138 points was surveyed yearly since 2001 (excluding 2005).
- The same sampling points (verified by GPS) were used for all surveys conducted between 2001 and 2004 by the MNDNR (Figure 2). Different points were used during the 2006 sampling season (Figure 3). Due to the number and proximity of the 2001 through 2004 points and the 2006 points, results are expected to be comparable.
- Sediment type was determined at each sample location.
- Collection of samples, identification of species, and determination of density ratings for each species occurred at all sampling points. Density ratings were given in accordance with Tables 1 and 2.



MNDNR Sample Points

Meters
100 0 100 200

Figure 2
MNDNR Sampling Points 2001-2004
Kohlman Lake
Ramsey-Washington
Metro Watershed District

Meters

100 0 100 200

RWMWD Sampling Locations

Figure 3
RWMWD Sampling Locations 2006
Kohlman Lake
Ramsey-Washington
Metro Watershed District

4.1 Aquatic Plant Survey Results

4.1.1 General Conditions

Of the average 138 sampling sites in Kohlman Lake, 22 were open water with no species detected and maximum rooted plant depth averaged 9.4 feet (Table 3). Results of the aquatic plant surveys conducted on Kohlman Lake between 2001 and 2006 indicate a somewhat mixed assemblage of species including submersed (SAV), floating, free-floating (FAV) and emergent vegetation (EAV). The highest number of total macrophyte species detected was 16 in August of 2001 but no significant trends or changes were detected within the population as a whole between sampling periods. However, the two sampling periods with the lowest number of macrophytes detected (nine species) occurred in the most recent two years of sampling, 2004 (June) and 2006 (September). There were generally few sites with all three types of macrophytes (SAV, FAV and EAV) present but approximately one third of the sites contained both FAV and SAV.

Table 3 Lake-wide seasonal and total averages for Kohlman Lake plant surveys 2001 to 2006

June	Sites sampled	Open water sites	Maximum rooted depth (ft)	Total Species	Submergent species[1]	Floating species	Free-floating species	Emergent species	Sites with SAV, FAV and EAV (%)[2]	Sites with SAV and FAV (%)[3]
2001	137	29	10	15	8	2	2	3	0.0	12.4
2002	140	19	9.8	16	9	2	2	2	3.0	29.3
2003	139	19	7.9	16	7	2	3	3	0.8	36.7
2004	139	17	10.3	10	6	2	1	0	0.0	27.3
2005										
2006	141	11	10	12	5	2	3	0	0.0	44.0
Average	139.2	19.0	9.6	13.8	7.0	2.0	2.2	1.6	0.8	29.9
August										
2001	136	33	8	17	10	2	3	1	1.6	25.7
2002	140	24	10.1	15	8	2	2	3	2.3	40.7
2003	134	16	9.4	15	9	2	2	2	1.5	46.3
2004	138	27	9.3	15	8	2	4	0	0.0	43.5
2005										
2006 [4]	138	27	8.9	10	5	1	3	0	0.0	49.3
Average	137.2	25.4	9.1	14.4	8.0	1.8	2.8	1.2	1.1	41.1
Total Average	138.2	22.2	9.4	14.1	7.5	1.9	2.5	1.4	0.9	35.5

1 Includes invasive species (*M. spicatum* and *P. crispus*)
2 Does not include invasive species
3 Does not include invasive species
4 Late summer samples collected September 8

Of the three main types, submersed macrophytes dominated the plant community in all years and, since monitoring began, appear to have increased in coverage during the early part of the growing season (June). Table 4 summarizes the fraction (as a percent) of sample sites with SAV, FAV (includes both floating rooted and free-floating species) and EAV from surveys conducted on Kohlman Lake during 2001 to 2006.

Table 4 Percentage of stations sampled (above maximum plant depth) in Kohlman Lake where either submerged, emergent and/or floating plants were present

	Submergent		Emergent		Floating	
	June	August	June	August	June	August
2001	84.9	81.7	1.6	1.6	15.1	27.8
2002	85.9	87.2	3.0	2.3	30.4	42.9
2003	94.5	90.1	1.6	1.5	40.2	47.3
2004	89.7	81.5	0.0	0.0	27.9	27.9
2006 [1]	90.6	85.4	0.0	3.1	27.9	42.3

1 Late season 2006 sampling conducted September 8

4.1.2 Aquatic Plant Types

A total of 24 known macrophyte species have been detected in Kohlman Lake since surveying began in 2001. 13 of these species are submerged, 2 floating rooted, 5 free-floating and 4 are emergent (Table 5). Species collected that were not identifiable were also included in the total.

Table 5 Macrophyte species detected in Kohlman Lake plant surveys 2001-2006

	Submergent Species												
June	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*Uknown Potamogeton*	*P. zosteriformis*	*Nitella*	*Chara*	*Z. palustris*	*Z. dubia*
2001	X	X	X	X	X	X			X			X	
2002	X	X	X	X	X	X			X		X	X	
2003	X	X	X	X	X	X			X				
2004	X	X		X	X	X			X				
2005													
2006	X	X	X		X				X				

	Submergent Species												
August	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*Uknown Potamogeton*	*P. zosteriformis*	*Nitella*	*Chara*	*Z. palustris*	*Z. dubia*
2001	X	X	X	X	X	X	X		X	X	X		
2002	X	X	X	X	X	X	X		X				
2003	X	X	X	X	X	X	X		X				X
2004	X	X	X	X	X	X	X		X				
2005													
2006	X				X	X		X	X				

	Floating Rooted and Free Floating Species							Emergent Species			
June	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*	Other	*Typha*	*P. arundinacea*	*Uknown Grass*	*Eleocharis sp*
2001	X	X	X			X		X		X	X
2002	X	X	X	X				X	X		
2003	X	X	X	X		X		X	X		X
2004	X	X	X								
2005											
2006	X	X	X	X		X	X				

	Floating Rooted and Free Floating Species							Emergent Species			
August	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*	Other	*Typha*	*P. arundinacea*	*Uknown Grass*	*Eleocharis sp*
2001	X	X	X	X		X		X			
2002	X	X	X			X		X	X		X
2003	X	X	X			X		X			X
2004	X	X	X	X	X	X					
2005											
2006	X		X	X		X					

4.1.3 Frequently Occurring Species

Although there is a somewhat diverse assemblage of macrophytes in Kohlman Lake, a few submersed species tend to dominate the community. Community composition varied from year to year, but generally the following species occurred more frequently during 2001 to 2006 (on average) compared to the rest of the population in Kohlman Lake.

- *Ceratophyllum demersum* (coontail) was found at 81 percent of sample locations
- *Myriophyllum spicatum* (Eurasian watermilfoil) was found at 58 percent of sample locations
- *Potamogeton crispus* (Curlyleaf pondweed) was found at 31 percent of sample locations (June only)

A comparison of frequency of occurrence of macrophyte species in Kohlman Lake shows minimal changes from year to year. The most frequently detected species listed above (i.e., coontail, Eurasian watermilfoil, and Curlyleaf pondweed) occurred in all years. Curlyleaf pondweed coverage changed the most over this time frame, increasing from only 2 percent in June 2001 to more than 70 percent in June 2006 (Figure 4). However, in all the late season surveys, Curlyleaf pondweed had died back, averaging just over 2 percent coverage across the lake. This is typical for Curlyleaf pondweed as it senesces in late June to early July.

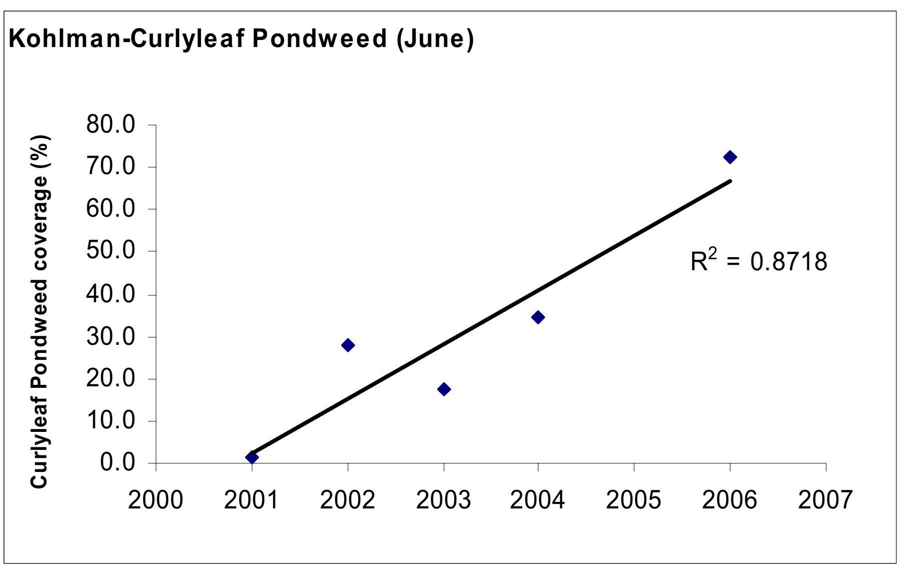


Figure 4 Curlyleaf pondweed site coverage in Kohlman Lake, 2001 to 2006

Eurasian watermilfoil was detected every year but seemed to decline somewhat in 2003 and 2004. In late 2006, however, coverage returned to 61 percent of the sites sampled. Coontail has remained at a consistently high coverage throughout 2001 to 2006, never dropping below 70 percent coverage of sites sampled in Kohlman Lake.

Of the remaining submerged, floating and emergent species found in Kohlman Lake, *Nymphaea tuberos*a (29% occurrence), *Potamogeton zosteriformas* (23% occurrence) and *Lemna minor* (21% occurrence) were detected during each sampling period and were generally consistent between sampling events, with the exception of *Potamogeton zosteriformas,* which increased by approximately 20 percent between 2004 and 2006.

4.1.4 Density of Individual Species

Density data were not recorded during the June 2001 through June 2003 MNDNR surveys. Aquatic plant densities ranged from 0 to 4 in the MNDNR surveys from August 2003 through August 2004 and density in 2006 ranged from 0 to 5 (Table 6). Tables 1 and 2 indicate rake or area coverage and how they relate to the above ranking systems.

Because density data collection began in August 2003, yearly comparisons are somewhat limited. However, a number of conclusions can be drawn:

- Curlyleaf pondweed (*Potamogeton crispus*) density nearly doubled from June 2004 to June 2006. This combined with a doubling in frequency of occurrence during the same time frame, shows that Curlyleaf pondweed coverage and density have increased substantially across the lake.

- White water lily (*Nymphaea tuberosa*) also increased in density in 2006 during both the June and August surveys.

- Yellow water lily (*Nuphar advena*) density increased in June 2006 but was not detected during August of the same year.

- Coontail (*Ceratopyllum demersum*) averaged the highest density (2.4) across all sampling periods.

Again, however, because the ranking scales changed between 2004 and 2006, the above comparisons between these years are not precise.

Table 6 Average macrophyte density in Kohlman Lake. Plants species with no available density data were not included. Density was ranked 0 to 4 in 2003 to 2004 and 0 to 5 in 2006

	June		August		
Submerged	**2004**	**2006**	**2003**	**2004**	**2006 [1]**
Myriophyllum spicatum	1.5	1.8	1.1	1.0	2.1
Potamogeton crispus	1.3	2.4	1.0	1.0	
Potamogeton pectinatus		2.5	1.0	2.5	
Potamogeton pusillus	1.0		1.0	1.5	
Ceratophyllum demersum	2.0	2.6	2.6	2.0	2.6
Elodea canadensis	1.0		1.0		1.0
Najas flexilis			1.0	1.1	
Potamogeton zosteriformis	1.1	1.6	1.1		1.6
Zosterella dubia			1.0	1.8	
Floating					
Nymphaea tuberosa	1.1	2.8	1.1	1.0	3.4
Nuphar advena	1.5	3.8	1.3	1.0	
Lemna minor	1.0	1.2	1.0	1.0	1.5
Spirodela polyrhiza		1.2		1.0	1.0
Wolffia columbiana		1.0	1.0		1.7
Emergent					
Eleocharis spp.			1.0	2.0	
Phalaris arundinacea					
Typha			1.0		

Note: Average density is based on sites that contained the specified plant

1 Late summer samples collected September 8

Although densities generally averaged less than half of the maximum density ranking, there were species that reached maximum density (on at least one occasion) in Kohlman Lake indicating heavy growth of certain species (Table 7). The number of species reaching maximum density increased from 1 to 6 during the 2003 and 2006 sampling periods, respectively.

Table 7 Macrophyte species with maximum density rankings between 2003 and 2006

	June		August		
Submerged	2004	2006	2003	2004	2006 [1]
Myriophyllum spicatum	Max			Max	Max
Potamogeton crispus	Max	Max			
Potamogeton pectinatus		Max			
Potamogeton pusillus					
Ceratophyllum demersum	Max	Max	Max	Max	Max
Elodea canadensis					
Najas flexilis					
Potamogeton zosteriformis				Max	Max
Zosterella dubia					
Floating					
Nymphaea tuberosa		Max			Max
Nuphar advena		Max			
Lemna minor					Max
Spirodela polyrhiza					
Wolffia columbiana					Max
Emergent					
Eleocharis spp.					
Phalaris arundinacea					
Typha					

1 Late summer samples collected September 8

4.1.5 Total Aquatic Plant Density (Cumulative Total of All Species)

Average macrophyte density in Kohlman Lake increased slightly from 1.2 to 1.4 (not statistically significant) between August 2003 and August 2004. Again, because of ranking system changes, some caution is advised when making comparisons with pre-2006 data and 2006 data.

4.1.6 Macrophyte Diversity and Relative Frequency

Past lake surveys have shown that the plant community consists of a moderately diverse assemblage but tends to be dominated by just a few species (see Tables 5 and 6). To determine the diversity of this assemblage, an aquatic plant diversity calculation was completed for Kohlman Lake using a modification of Simpson's Index (1949):

$$1-\sum\left(\frac{rf}{100}\right)^2 \qquad (1)$$

Equation 1. Modified Simpson Index equation for Macrophyte Diversity.

Where:

- rf = the relative frequency of each species.

Frequencies were calculated as the number of sampling points where a species occurred divided by the total number of sampling points at depths less than or equal to the maximum depth of plant growth. Frequencies were normalized to 100 percent to describe community structure (*rf*). Frequencies and relative frequencies are presented in Appendix A.

Table 8 shows the results for macrophyte diversity in Kohlman Lake. Macrophyte diversity is moderate in Kohlman Lake, ranging from 0.74 in June 2001 to 0.84 in both August 2001 and August 2004. No obvious trends were detected in macrophyte diversity in Kohlman Lake over the past six years and the average diversity for this time frame was 0.81.

Table 8 Macrophyte diversity in Kohlman Lake based on a modified Simpson Index (1949)

Year	Macrophyte Diversity	
	June	August
2001	0.74	0.84
2002	0.81	0.82
2003	0.83	0.79
2004	0.77	0.84
2005		
2006 [1]	0.83	0.80
Ave	0.80	0.82

1 Late season samples collected September 8

Table 9 provides data for macrophyte density from other lakes in Wisconsin and Minnesota for general comparison purposes. Kohlman Lake falls into the bottom third of this data set. However, these lakes are not necessarily directly comparable to Kohlman Lake because of differences in bathymetry, size, etc.

Table 9 Diversities of some Wisconsin and Minnesota (MN) plant communities (from Nichols 1997 and Barr 2001-2006)—samples collected by WDNR unless otherwise indicated.

*Sampled by Barr Engineering Company **Sampled by volunteers trained by Barr Engineering

Lake Name	Diversity	Lake Name	Diversity
Amnicon Lake	0.95	Como Lake	0.88
Balsam Lake 2005	0.93*	White Ash Lake, North	0.88**
Church Pine Lake	0.93*	Dowling Lake	0.87
Decorah Lake	0.93	Chute Pond	0.86
Half Moon Lake	0.93	Enterprise Lake	0.86
Spider Chain of Lakes-North Lake	0.93*	Okauchee Lake	0.86
Balsam Lake 1999	0.92*	Pearl Lake	0.86
Beaver Dam Lake (West)	0.92**	Bear Lake	0.85
Muskellunge Lake	0.92	Silver Lake (MN)	0.85**
Round (Wind) Lake	0.92*	Big Butternut Lake	0.84
Spider Chain of Lakes-Fawn Lake	0.92*	Beaver Dam Lake (East)	0.81**
Spider Chain of Lakes--Spider Lake (north)	0.92*	Long Lake T32N	0.81
Apple River Flowage	0.91	Twin Lake, South	0.81
Ashippun Lake	0.91	Helen Lake	0.80
Big Blake Lake (Blake)	0.91*	McCann Lake	0.80
Cedar Lake	0.91	Cary Pond	0.79
Little Elkhart Lake	0.91	Island Lake	0.78
Pine Lake	0.91	Leota Lake	0.78
Post Lake	0.91	Little Arbor Vitae Lake	0.78
Morris Lake (Mt. Morris)	0.91	Mid Lake (Nawaii)	0.78
Sand Lake	0.91*	Half Moon Lake T47N	0.77
White Ash Lake*	0.91**	Clear Lake	0.74
Pike Lake	0.90	Chain Lake	0.74
Mud Hen Lake	0.90	Twin Lake North	0.73
Spider Chain of Lakes--Spider Lake (south)	0.90*	Rib Lake	0.71
Big Round Lake	0.89	Oconomowoc Lake, Upper	0.70
Pigeon Lake	0.89	Silver Lake (Anderson)	0.69
Big Hills Lake (Hills)	0.88	Tichigan Lake	0.69
Spider Chain of Lakes-Clear Lake	0.88*	George Lake	0.58

4.1.7 Floristic Quality

The Kohlman Lake plant community also was assessed using the Wisconsin Floristic Quality Assessment (WFQA). The WFQA is an adaptation of the original floristic quality assessment method developed for the Chicago region (Swink and Wilhelm 1994) The WFQA was used because it is based upon aquatic species that are also found in Minnesota. The basis of the floristic quality assessment is the concept of species conservatism, the degree to which a species can tolerate disturbance and its fidelity to non-degraded conditions. Conservatism is not always equated with rarity. The method uses the aggregate conservatism of all species found on a site as a measure of the site's intactness, an indication of its ecological integrity (Bernthal, 2003).

The method requires the *a priori* assignment of "coefficients of conservatism" to every aquatic plant species in a regional flora, relying on the collective knowledge of a group of experts. The coefficients for aquatic plants were assigned by a group of aquatic ecologists led by Stanley Nichols (Bernthal, 2003).

The method requires an accurate and complete inventory of aquatic plants within a lake. The appropriate coefficient is applied to each species, and an average coefficient of conservatism (Mean C) is calculated for the entire lake. The Floristic Quality Index (FQI) adds a weighted measure of species richness by multiplying the Mean C by the square root of the total number of native species. The equation is as follows:

$$\text{FQI} = \text{Mean C} * \sqrt{N} \qquad (2)$$

Equation 2. Floristic Quality Index.

Where:

- Mean C = $\sum(c_1+c_2+c_3+\ldots c_n)/N$
- N = number of species

Non-native species are assigned a C value of 0. Higher Mean C and FQI numbers indicate higher floristic integrity and a lower level of disturbance impacts to the site (Bernthal, 2003).

Each native aquatic plant species occurring in a regional flora is assigned a coefficient of conservatism (C) representing an estimated probability that a species is likely to occur in a lake relatively unaltered from what is believed to be a pre-settlement condition. The most conservative species require a narrow range of ecological conditions, are intolerant of disturbance, and are unlikely to be found outside non-degraded, remnant natural settings, while the least conservative species can be found in a wide variety of settings, and thrive on disturbance. Coefficients range from 0 (highly tolerant of disturbance, little fidelity to any natural community) to 10 (highly intolerant of disturbance, restricted to pre-settlement remnants). Conceptually this 10-point scale can be subdivided into several ranges.

- 0-3 Taxa found in a wide variety of plant communities and very tolerant of disturbance
- 4-6 Taxa typically associated with a specific plant community, but tolerate moderate disturbance
- 7-8 Taxa found in a narrow range of plant communities, but can tolerate minor disturbance
- 9-10 Taxa restricted to a narrow range of synecological conditions, with low tolerance of disturbance (Bernthal, 2003)

Table 10 shows the coefficient of conservatism for macrophyte species detected in Kohlman Lake.

Table 10 Coefficient of conservation for macrophyte species found in Kohlman Lake

Scientific Name	Common Name	Floristic Quality
Nuphar advena	Yellow water lily	8
Potamogeton pusillus	Small leaf pondweed	7
Nitella	Stonewart	7
Chara	Muskgrass	7
Zannichellia palustris	Horned pondweed	7
Eleocharis sp.	Spike rush	7
Najas flexilis	Slender naid	6
Potamogeton zosteriformis	Flatstem pondweed	6
Zosterlla dubia	Water stargrass	6
Nymphaea tuberosa	White water lily	6
Spirodela polyrhiza	Great duckweed	5
Lemna trisulca	Star duckweed	5
Wolffia columbiana	Watermeal	5
Lemna minor	Lesser duckweed	4
Potamogeton pectinatus	Sago pondweed	3
Ceratophyllum demersum	Coontail	3
Elodea canadensis	Canadian water weed	3
Typha sp.	Cattail	1
Myriophyllum spicatum	Eurasian water milfoil	0
Potamogeton crispus	Curlyleaf pondweed	0

In years 2001 to 2006, the Mean C of Kohlman Lake ranged from 4.0 to 4.44 and the FQI was between 12.7 and 17.8 (Table 11). The overall Mean C of 4.22 indicates the lake's plant community is tolerant of moderate disturbance. The median FQI for Wisconsin Lakes is 22.2 (WDNR, 2005). Kohlman Lake's overall FQI of 15 is less than the data suggests for the median Wisconsin Lake, indicating the aquatic plant community is of poorer quality and more tolerant to disturbance.

Table 11 Mean of coefficient of conservation (mean of C) and floristic quality (FQI) in Kohlman Lake

Year	Floristic Quality		Mean of C	
	June	August	June	August
2001	16.04	17.75	4.29	4.44
2002	16.04	15.77	4.29	4.21
2003	15.50	14.42	4.14	4.00
2004	12.33	16.30	4.11	4.36
2005				
2006 [1]	12.65	13.00	4.00	4.33
Ave	14.51	15.45	4.17	4.27

1 Late summer samples collected September 8

4.1.8 2005 Macrophyte Data

The macrophyte survey conducted by Barr Engineering in 2005 was mostly visual with 6 transects sampled intensively for macrophyte density data. The survey detected substantial growth of Curlyleaf pondweed as well as Eurasian watermilfoil and Coontail in Kohlman Lake (Figure 5). All submersed species detected in the lake are detailed in Table 12.

Table 12 Macrophyte species present in Kohlman Lake in 2005

Species	Common Name	Percent coverage
Ceratophyllum demersum	Coontail	87.0
Potamogeton crispus	Curlyleaf pondweed	69.6
Myriophyllum spicatum	Eurasian watermilfoil	65.2
Potamogeton zostriformus	Flatstem pondweed	39.1
Nymphaea tuberosa	White water Lily	34.8
Potamogeton pectinatus	Sago pondweed	4.3

The 2005 survey, although limited, confirms that Coontail, Eurasian watermilfoil and Curlyleaf pondweed are dominant species in Kohlman Lake.

- No Macrophytes Seen In Water >5' - 6'
- Macrophyte Densities Estimated As Follows: 1 = low; 2 = medium; 3 = high

	Common Name	Scientific Name
Submerged Aquatic Plants: (green)	Curlyleaf pondweed	*Potamogeton crispus*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Sago pondweed	*Potamogeton pectinatus*
	Eurasian watermilfoil	*Myriophyllum spicatum*
	Coontail	*Ceratophyllum demersum*

No Aquatic Vegetation Detected Visually: (blue)

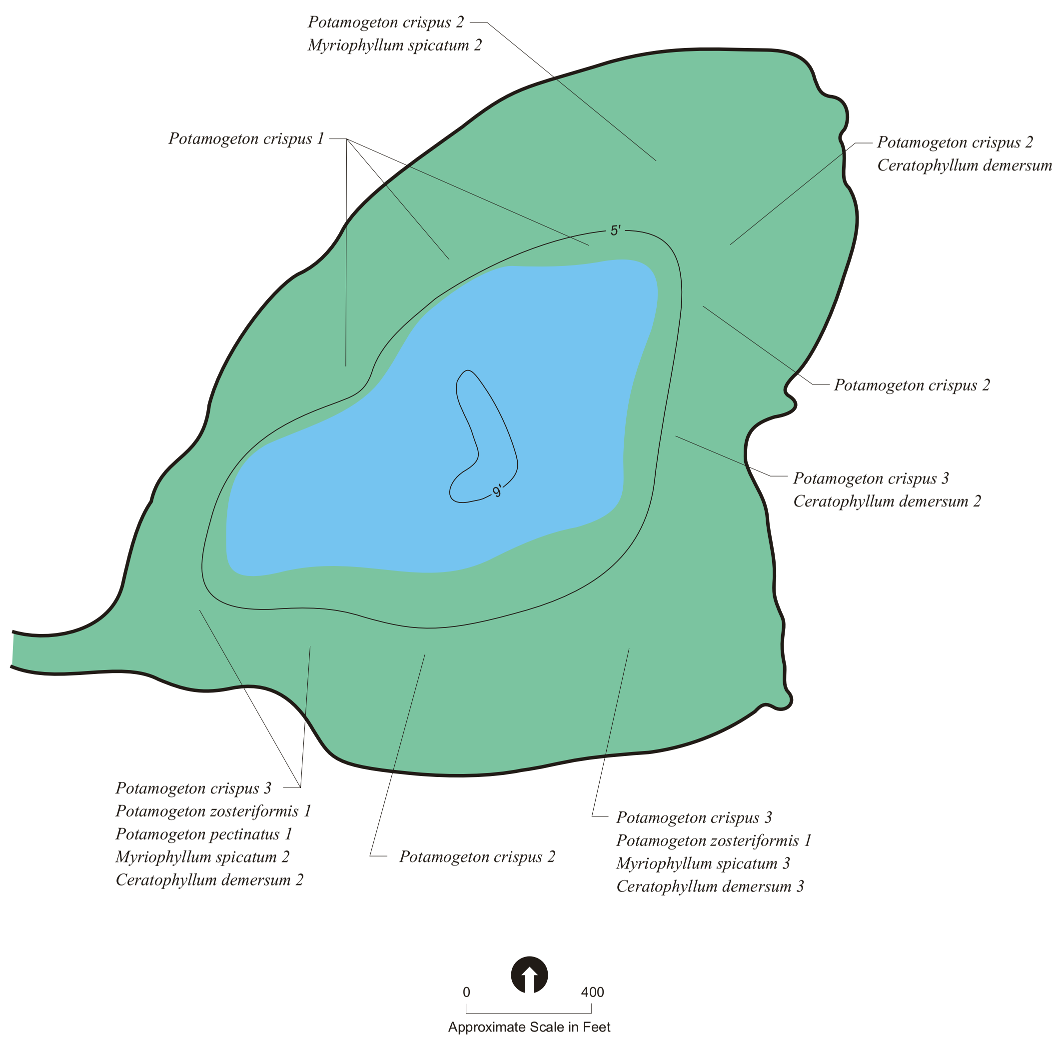


Figure 5

KOHLMAN LAKE
MACROPHYTE SURVEY
JUNE 2005

P:23\62\905\035\Macrophyte Surveys\Kohlman Lake Macrophyte Survey 2005.CDR RLG 10-17-05

4.1.9 Functions and Values of Aquatic Plants

The aquatic plant community (See Appendix A for complete listing of surveys) in Kohlman Lake performs a number of valuable functions. These include:

- Habitat for fish, insects, and small aquatic invertebrates
- Food for waterfowl, fish, and wildlife
- Oxygen production in the water column
- Spawning areas for fish in early spring
- Stabilization of marshy borders of the lake, helping protect shorelines from wave erosion
- Nesting sites for waterfowl and marsh birds

Table 13 gives details on the functions and values the Kohlman Lake plant community and the specific macrophyte species detected in surveys conducted between 2001 and 2006 provides. This table provides additional understanding of the importance of maintaining a balanced aquatic plant community in Kohlman Lake.

Table 13 Functions of individual species found in Kohlman Lake*

Scientific Name (Common Name)	Plant Type	Plant Functions
Ceratophyllum demersum (Coontail)	Submersed	Waterfowl species eat the shoots; it provides cover for young bluegills, perch, largemouth bass, and northern pike; supports insects that fish and ducklings eat.
Chara sp. (Muskgrass)	Submersed	Muskgrass is a favorite food of waterfowl and bass and it is considered valuable fish habitat. Algae and invertebrates found on muskgrass provide additional grazing.
Eleocharis sp. (Spikerush)	Emergent	Spike rush provides food for a variety of waterfowl as well as muskrats. Submersed beds offer habitat and shelter for invertebrates and small fish.
Elodea canadensis (Canadian Waterweed)	Submersed	Provides habitat for many small aquatic animals, which fish and wildlife eat.
Lemna minor (Lesser Duckweed)	Free-Floating	Lesser duckweed is an important food source for ducks and geese, and is also consumed by muskrats, beaver and fish. Large mats of duckweed provide shade for fish and invertebrates.
Lemna trisulca (Star Duckweed)	Free-Floating	Star duckweed is a good food source for waterfowl. Tangled masses of fronds also provide cover for fish and invertebrates.
Myriophyllum spicatum (Eurasian Water Milfoil)	Submersed	Eurasian water milfoil is a limited food source for waterfowl and provides invertebrate habitat, though not ideal.
Najas flexilis (Slender Naiad)	Submersed	Bushy naiad is one of the most important plants for waterfowl. Stems, leaves, and seeds are all consumed by a wide variety of ducks. It is also important to a variety of marsh birds as well as muskrats.
Nitella sp. (Stonewort)	Submersed	Nitella is sometimes grazed by waterfowl. The algae and invertebrates on the surface are attractive to ducks and geese. Nitella also offers foraging opportunities for fish.
Nuphar advena (Yellow Water Lily)	Floating	Leaves provides shade for fish and invertebrates; seeds are eaten by waterfowl; stems, leaves and flowers are eaten by deer; and muskrat, beaver and porcupine eat the rhizomes.
Nymphaea tuberosa (White Water Lily)	Floating	White water lily provides seeds for waterfowl. Rhizomes are eaten by deer, muskrat, beaver, moose and porcupine. The leaves offer shade and shelter for fish.
Phalaris arundinacea (Reed Canary Grass)	Emergent	Beneficial shoreline stabilizer and cover for waterfowl, however it has low food value and flourishes in disturbed sites.
Potamogeton crispus (Curlyleaf Pondweed)	Submersed	Provides some cover for fish; several waterfowl species feed on the seeds; diving ducks often eat the winter buds.
Potamogeton pectinatus (Sago Pondweed)	Submersed	Sago pondweed is an important food for waterfowl, which eat the fruit and tubers. Also serves as habitat for trout and juvenile fish.

Table 13 (continued). Functions of individual species found in Kohlman Lake*

Scientific Name (Common Name)	Plant Type	Plant Functions
Potamogeton zosteriformis (Flat-stem Pondweed)	Submersed	Flat-stem pondweed can be a locally important food source for a variety of geese and ducks. The plant may also be grazed by muskrat, deer, beaver, and moose. Flat-stem pondweed provides a food source and cover for fish and invertebrates.
Typha sp. (Cattail)	Emergent	Cattail provides nesting habitat for birds, food for muskrats and geese and spawning habitat and shelter for fish.
Spirodela polyrhiza (Great Duckweed)	Free-Floating	Great duckweed is a food source for waterfowl, muskrats and some fish. Mats of duckweed create shade for fish and invertebrates.
Wolffia columbiana (Watermeal)	Free-Floating	Watermeal is a food source for waterfowl, muskrats and some fish. Mats of watermeal can create shade for fish and invertebrates.
Zannichellia palustris (Horned Pondweed)	Submersed	Horned pondweed leaves and fruit are a food source for many waterfowl species.
Zosterella dubia (Water Star Grass)	Submersed	Water star grass can be a locally important source of food for geese and ducks. It also offers good cover and foraging opportunities for fish.

*Plant functions are from: Borman, S. et al. 1997. Through the Looking Glass...A Field Guide to Aquatic Plants and Minnesota Department of Natural Resources. 1997. A Guide to Aquatic Plants--Identification and Management.

4.1.10 Percent Similarity of the Macrophyte Community

A comparison of aquatic plant survey data between 2001 and 2006 indicates Kohlman Lake's aquatic plant community varies over time. The percent similarity (C) is a means of comparing data from the two surveys by estimating the degree to which the communities share common components. Percent similarity C is computed as follows:

$$C_{ij} = 1 - \frac{1}{2} \sum_{k=1}^{s} \left| p_{ik} - p_{ij} \right| \qquad (3)$$

Equation 3. Percent similarity for macrophyte communities between seasons.

Where

- C_{ij} = percent similarity between surveys
- $\sum_{k=1}^{s}$ = summing over all species, from species k = 1 to the last species (k = s)
- $|p_{ik}-p_{jk}|$ = absolute value of the relative frequency of species k at sampling period i minus the relative frequency of species k at sampling period j.

Percent similarity was compared between successive years of surveys and the results are presented in Table 14.

Table 14 Percent similarity between macrophyte surveys in Kohlman Lake

Year	Percent Similarity	
	June	August
2001-2002	80	83
2002-2003	79	81
2003-2004	75	88
2004-2006 [1]	71	83
Ave	76	84
2001-2006 [1]	53	79

1 Late season samples collected September 8

Percent similarity was generally lower when comparing June surveys to those conducted later in the season. The late season surveys showed no trend in similarity, however, the June surveys appear to indicate that percent similarity between seasons is decreasing. A reason for the apparent decline in similarity may be the increase in dominance of Curlyleaf pondweed (Figure 4).

Macrophyte communities were also compared between the 2001 and 2006 surveys. Not surprisingly, this comparison was least similar of all the inter-seasonal comparisons. Similarity was lowest (53) when comparing June of 2001 and 2006 and, once again, this could be due to the proliferation of Curlyleaf pondweed in Kohlman Lake during the past six years.

4.3 Macrophyte Species of Concern

4.3.1 Invasive Nuisance Species

Two invasive species, Eurasian watermilfoil and Curlyleaf pondweed, were detected in all years in Kohlman Lake. Aquatic invasive species (AIS) are foreign plants that have been introduced, usually unintentionally, to a region where they did not naturally occur and are undesirable because their natural control mechanisms are not introduced with the species. Consequently, AIS frequently exhibit unchecked growth patterns. However, native plants sometimes successfully compete with AIS, limiting their coverage and preventing increased coverage.

4.3.1.1 *Potamogeton crispus* (Curlyleaf Pondweed)

Curlyleaf pondweed presents two problems of management concern in infested lakes: (1) Because of its earlier growth timing, the plant can gain a strong foothold early in the season, allowing it to dominate the system, choking out other native macrophytes. (2) It can be a substantial source of internal phosphorus to the lake as it senesces in late June to early July. The result is the potential degradation of water quality for the remainder of the growing season.

Curlyleaf pondweed was found in over 70% of all sample sites (2006) in June while it was nearly undetectable in August, being found in just 1.8% of all sites surveyed on average. In addition, a statistically significant increase in Curlyleaf pondweed growth from 2001 to 2006 (June only) has been observed. Sites where Curlyleaf pondweed was detected increased from just 1.5% in the June 2001 sampling event to more than 70% in the June 2006 survey (Figure 6).

Area of Curlyleaf Pondweed

Sample Location

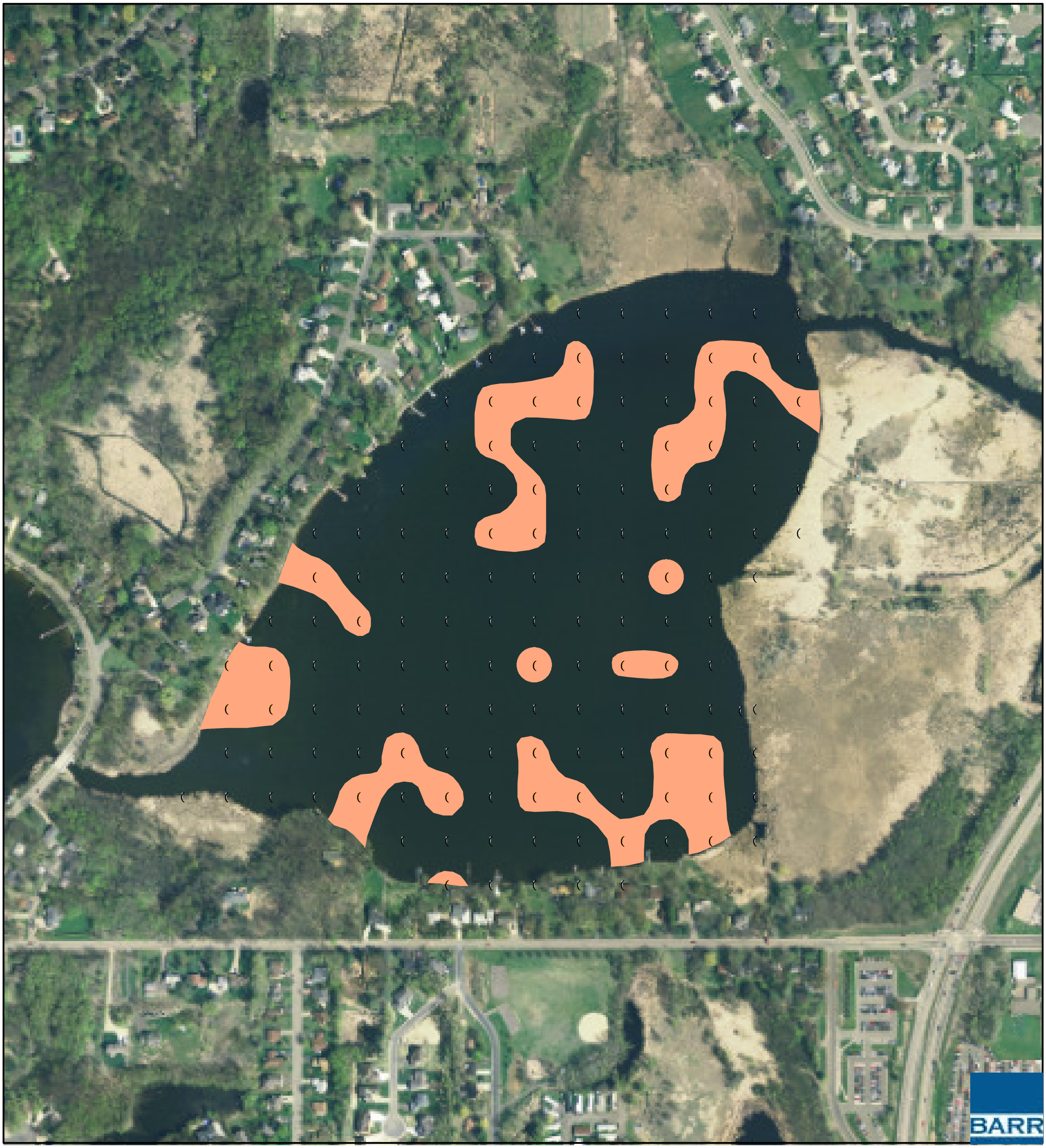
No Curlyleaf Pondweed Present

Curlyleaf Pondweed Present

Meters

100 0 100 200

Figure 6A
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - June 2001
Ramsey-Washington
Metro Watershed District



Area of Curlyleaf Pondweed

Sample Location

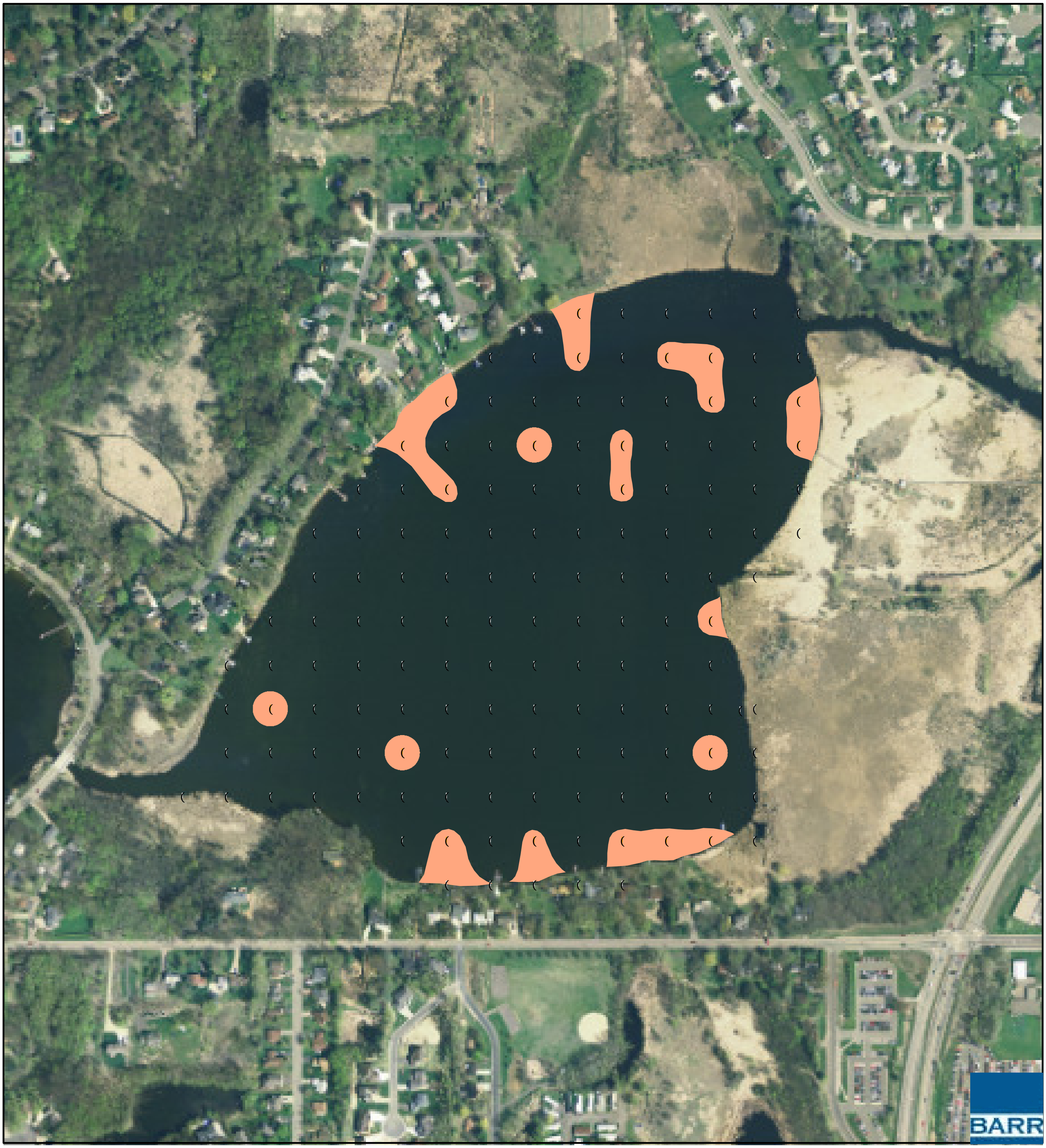
No Curlyleaf Pondweed Present

Curlyleaf Pondweed Present

Meters

100 0 100 200

Figure 6B
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - June 2002
Ramsey-Washington
Metro Watershed District



Barr Footer: Date: 7/13/2006 9:28:19 AM File: I:\Client\Rwmwd\KohlmanLake\Project\2362928BJL\Coontail.mxd User: bal

Area of Curlyleaf Pondweed

Sample Location

No Curlyleaf Pondweed Present

Curlyleaf Pondweed Present

Meters

100 0 100 200

Figure 6C
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - June 2003
Ramsey-Washington
Metro Watershed District

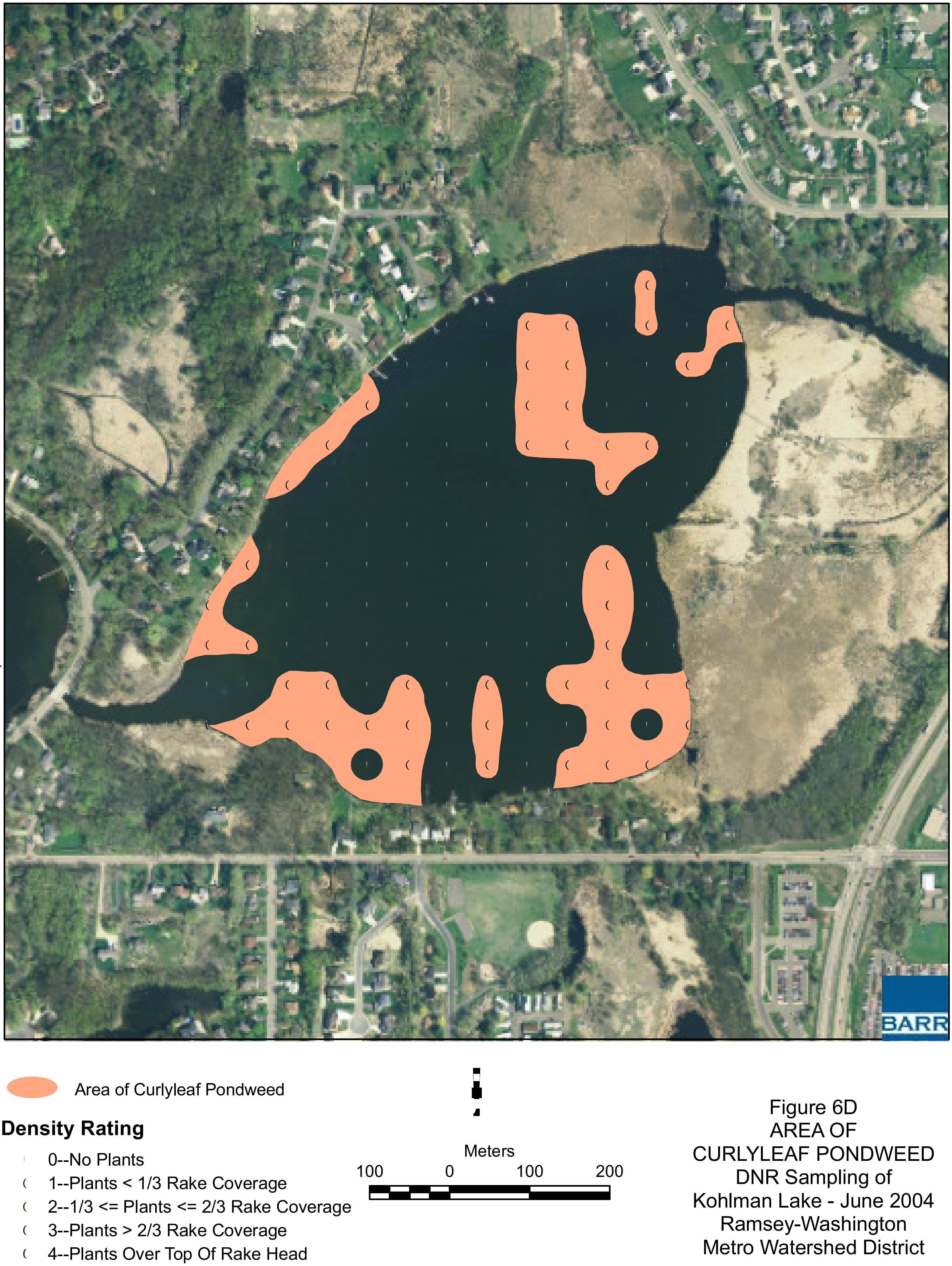
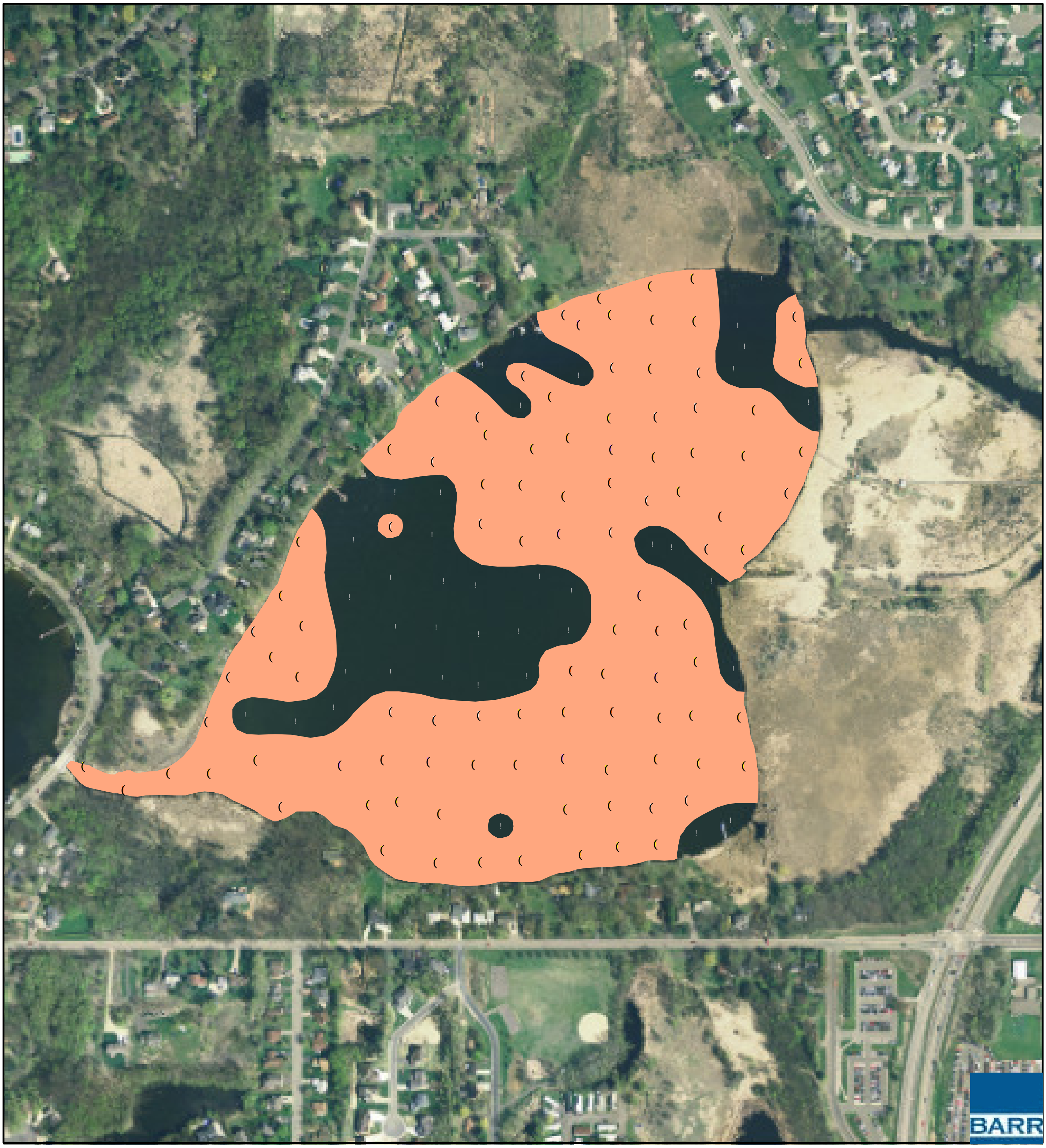


Figure 6D
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - June 2004
Ramsey-Washington
Metro Watershed District



Barr Footer: Date: 7/12/2006 6:01:30 PM File: I:\Client\Rwmwd\KohlmanLake\Project\2362928BJL\Watermilfoil.mxd User: bal

Area of Curlyleaf Pondweed

Density Rating (% of Rake Head)

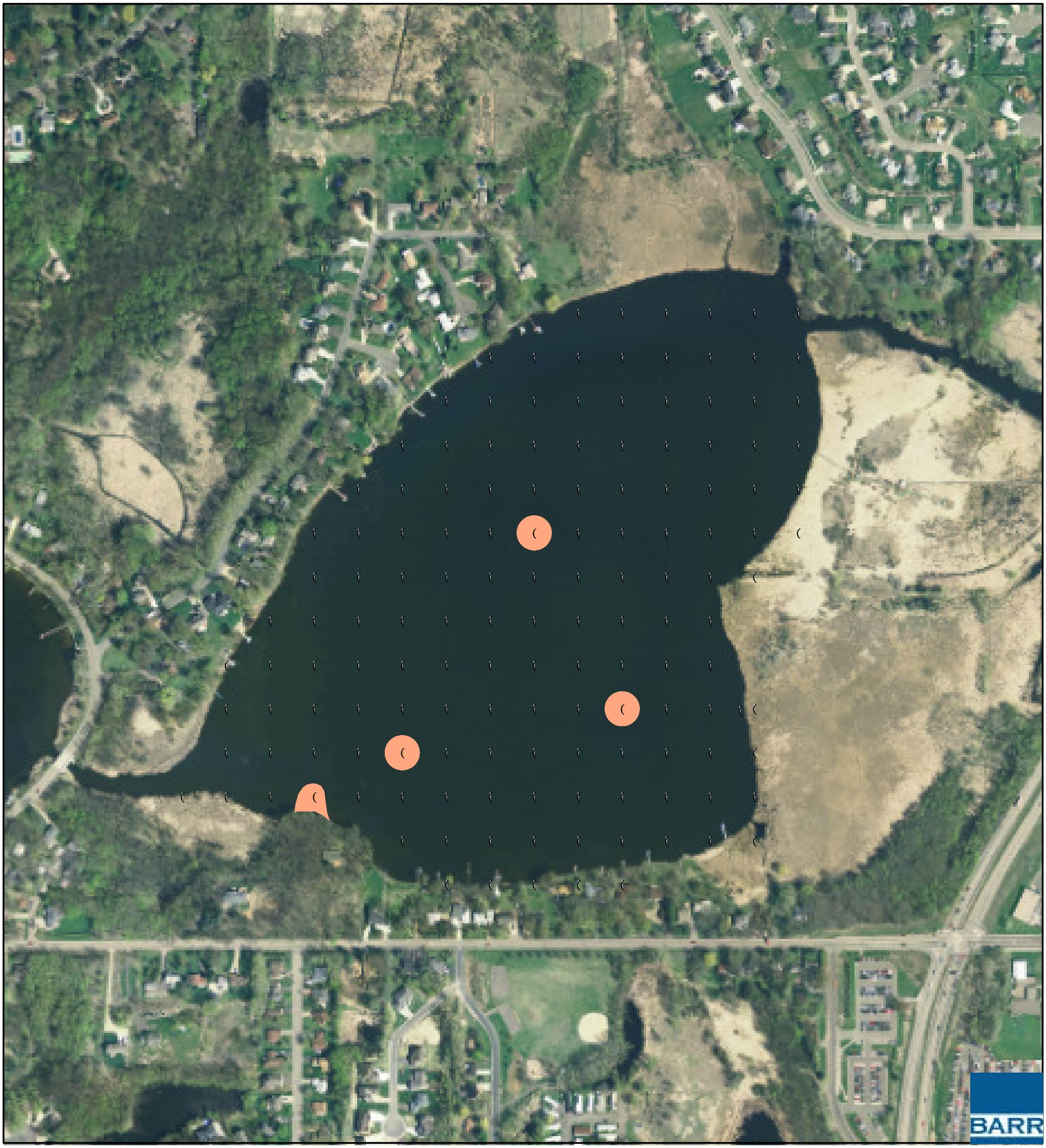
- 0 - 0%
- 1 - 1% to 9%
- 2 - 10% to 29%
- 3 - 30% to 54%
- 4 - 55% to 69%
- 5 - 70% to 100%

Meters

100 0 100 200

Figure 6E
AREA OF
CURLYLEAF PONDWEED
RWMWD Sampling of
Kohlman Lake - June 13, 2006
Ramsey-Washington
Metro Watershed District

Figure 6F
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - August 2001
Ramsey-Washington
Metro Watershed District



Area of Curlyleaf Pondweed

Sample Location

No Curlyleaf Pondweed Present

Curlyleaf Pondweed Present

Meters

100 0 100 200

Figure 6G
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - August 2002
Ramsey-Washington
Metro Watershed District

Area of Curlyleaf Pondweed

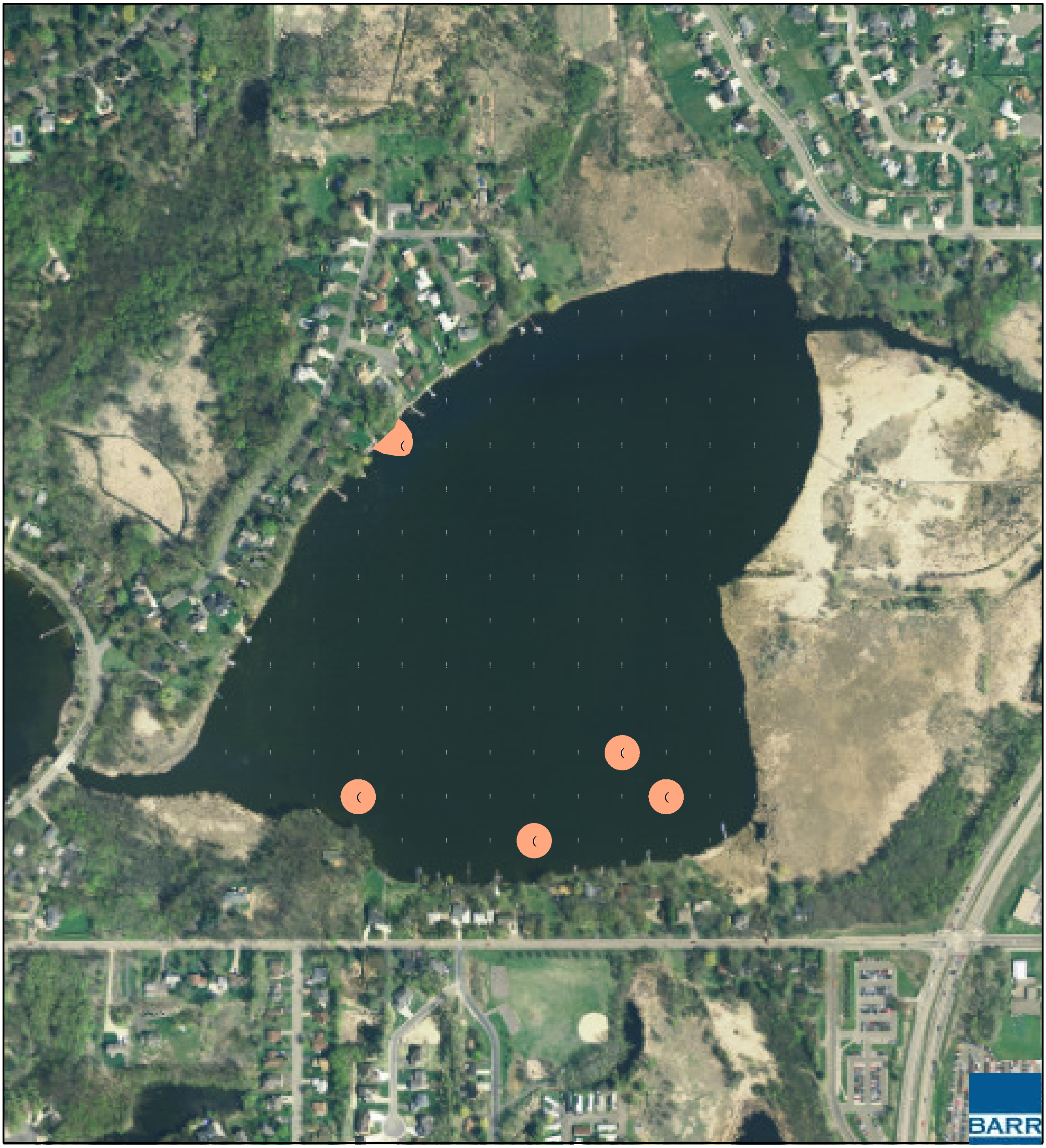
Density Rating

- 0--No Plants
- 1--Plants < 1/3 Rake Coverage
- 2--1/3 <= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 6H
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - August 2003
Ramsey-Washington
Metro Watershed District



Area of Curlyleaf Pondweed

Density Rating

- 0--No Plants
- 1--Plants > 1/3 Rake Coverage
- 2--1/3 <= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 6I
AREA OF
CURLYLEAF PONDWEED
DNR Sampling of
Kohlman Lake - August 2004
Ramsey-Washington
Metro Watershed District

Area of Curlyleaf Pondweed

Density Rating (% of Rake Head)

- 0 - 0%
- 1 - 1% to 9%
- 2 - 10% to 29%
- 3 - 30% to 54%
- 4 - 55% to 69%
- 5 - 70% to 100%

Meters

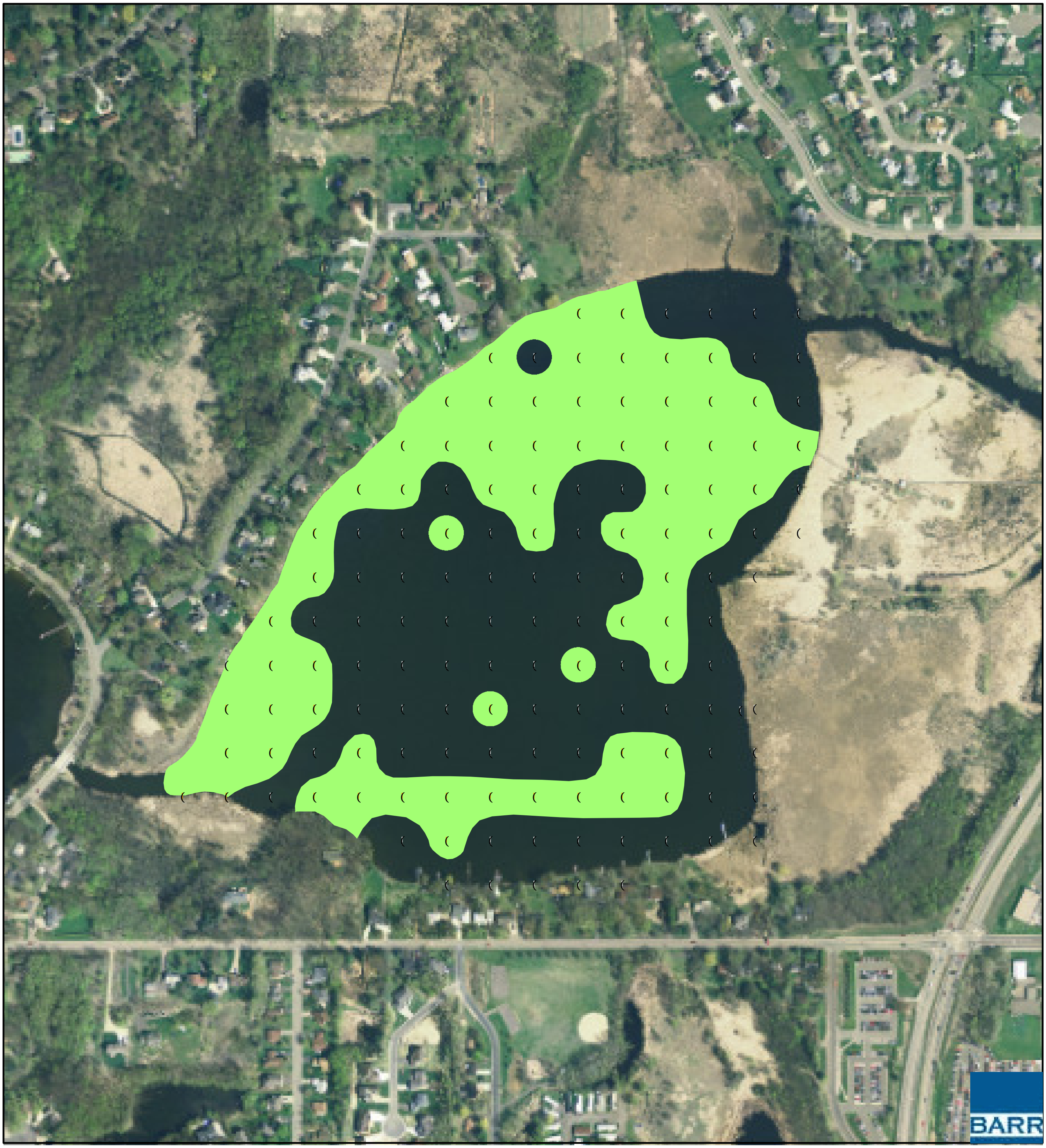
100 0 100 200

Figure 6J
AREA OF
CURLYLEAF PONDWEED
RWMWD Sampling of
Kohlman Lake
September 8, 2006
Ramsey-Washington
Metro Watershed District

4.3.1.2 *Myriophyllum spicatum* (Eurasian Watermilfoil)

Eurasian watermilfoil is an invasive macrophyte that is well adapted to flourish in eutrophic environments. Growth patterns allow it to out-compete many native species in North America, allowing it to dominate in aquatic systems and limit aquatic plant diversity. In some cases, native species have rebounded in abundance and diversity a decade or more after Eurasian watermilfoil introduction but this is not always the case.

Eurasian watermilfoil presence was confirmed in 2000 and currently both coverage and density are moderate to high in Kohlman Lake. Site coverage of Eurasian watermilfoil ranged between 34% and 60% in all sampling events and site coverage was slightly higher in August compared to June. The increase in coverage could be due to a decline in Curlyleaf pondweed in the latter months of the growing season. No overall trends were found in the data from plant surveys between 2001 and 2006 as Eurasian watermilfoil has maintained a consistent presence in the lake. Figure 7 shows both spatial variation and density of Eurasian watermilfoil in Kohlman Lake over the past six years.



Area of Eurasian Watermilfoil

Sample Location

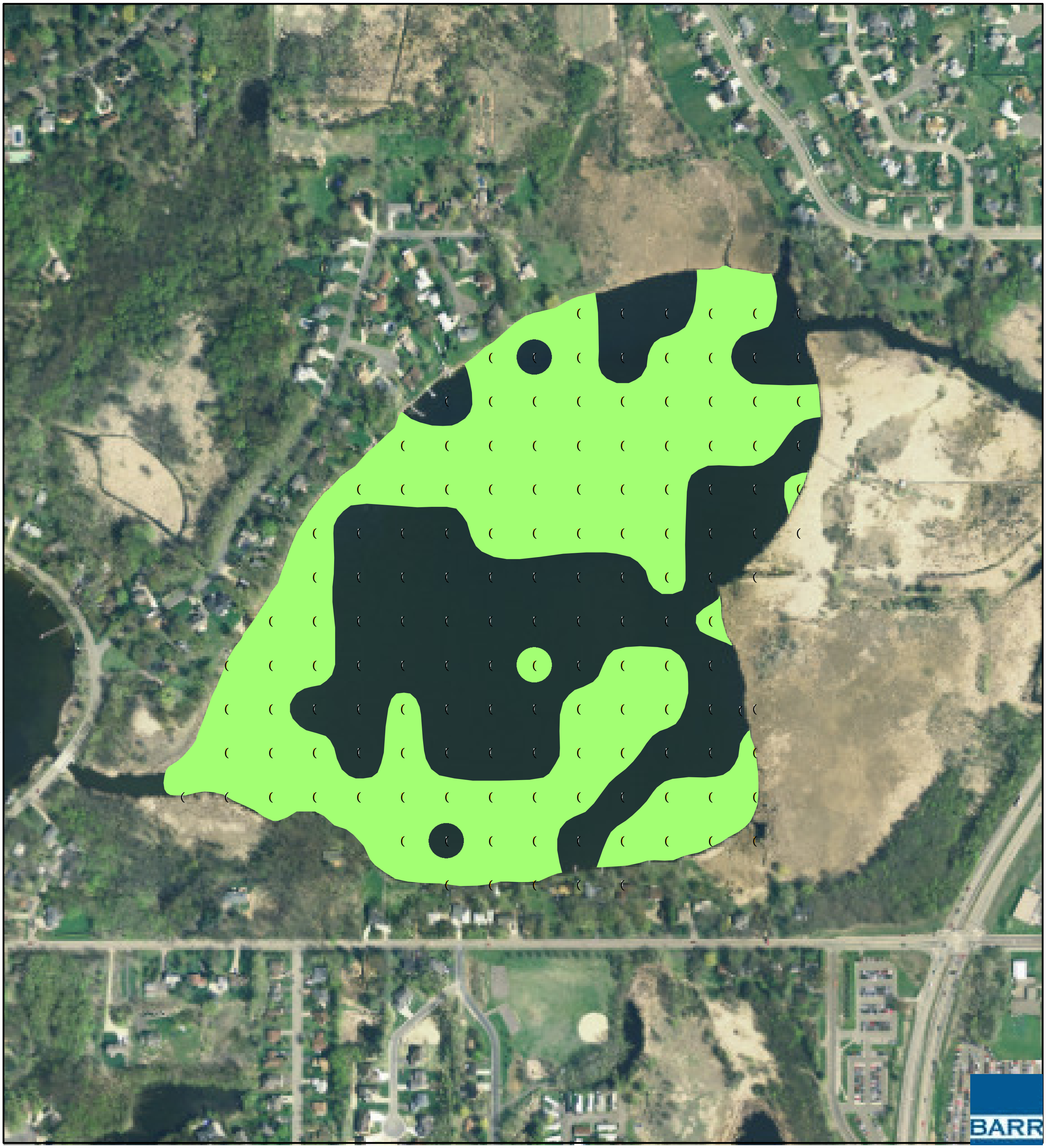
No Eurasian Watermilfoil Present

Eurasian Watermilfoil Present

Meters

100 0 100 200

Figure 7A
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - June 2001
Ramsey-Washington
Metro Watershed District



Area of Eurasian Watermilfoil

Sample Location

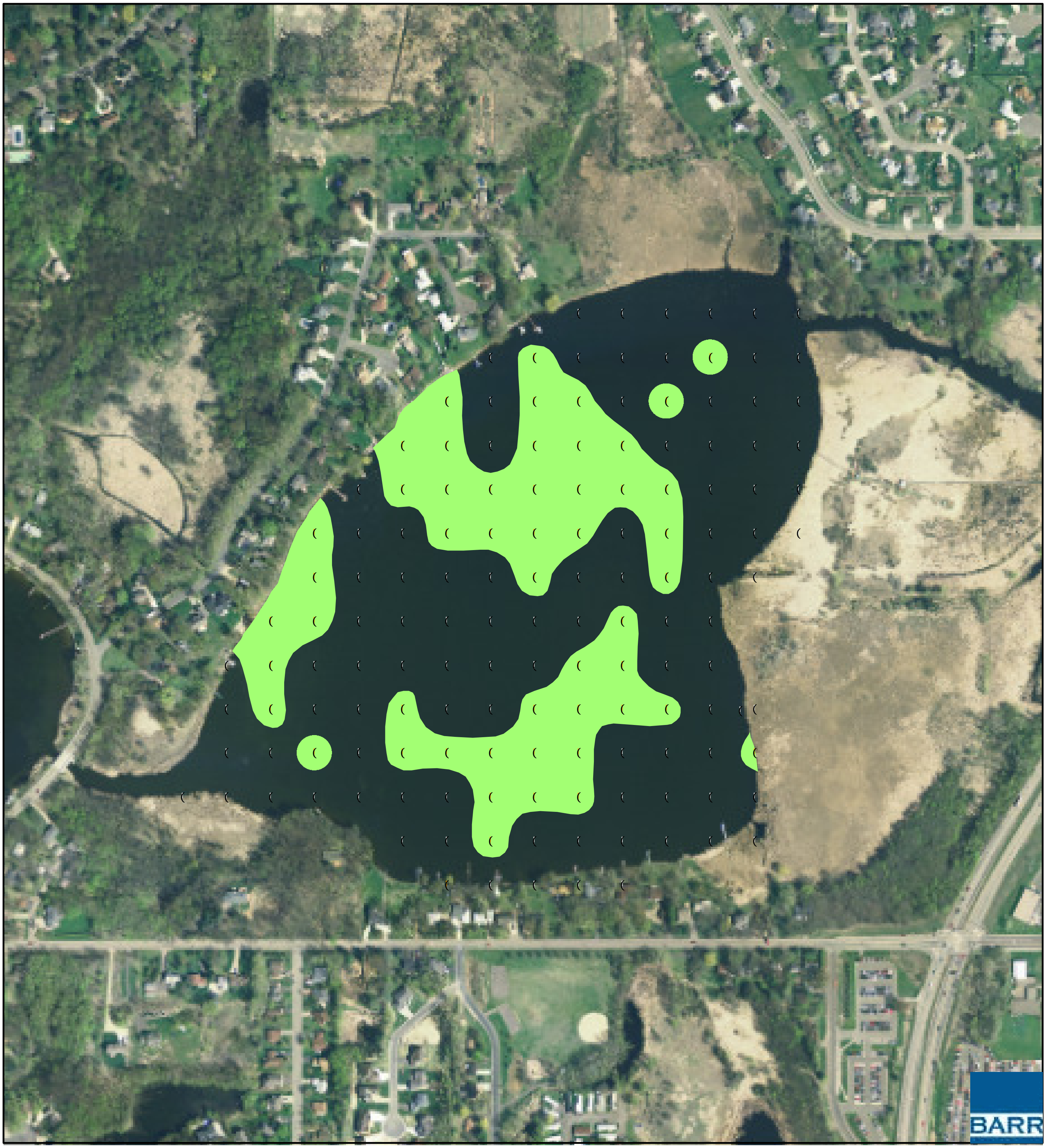
No Eurasian Watermilfoil Present

Eurasian Watermilfoil Present

Meters

100 0 100 200

Figure 7B
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - June 2002
Ramsey-Washington
Metro Watershed District



Area of Eurasian Watermilfoil

Sample Location

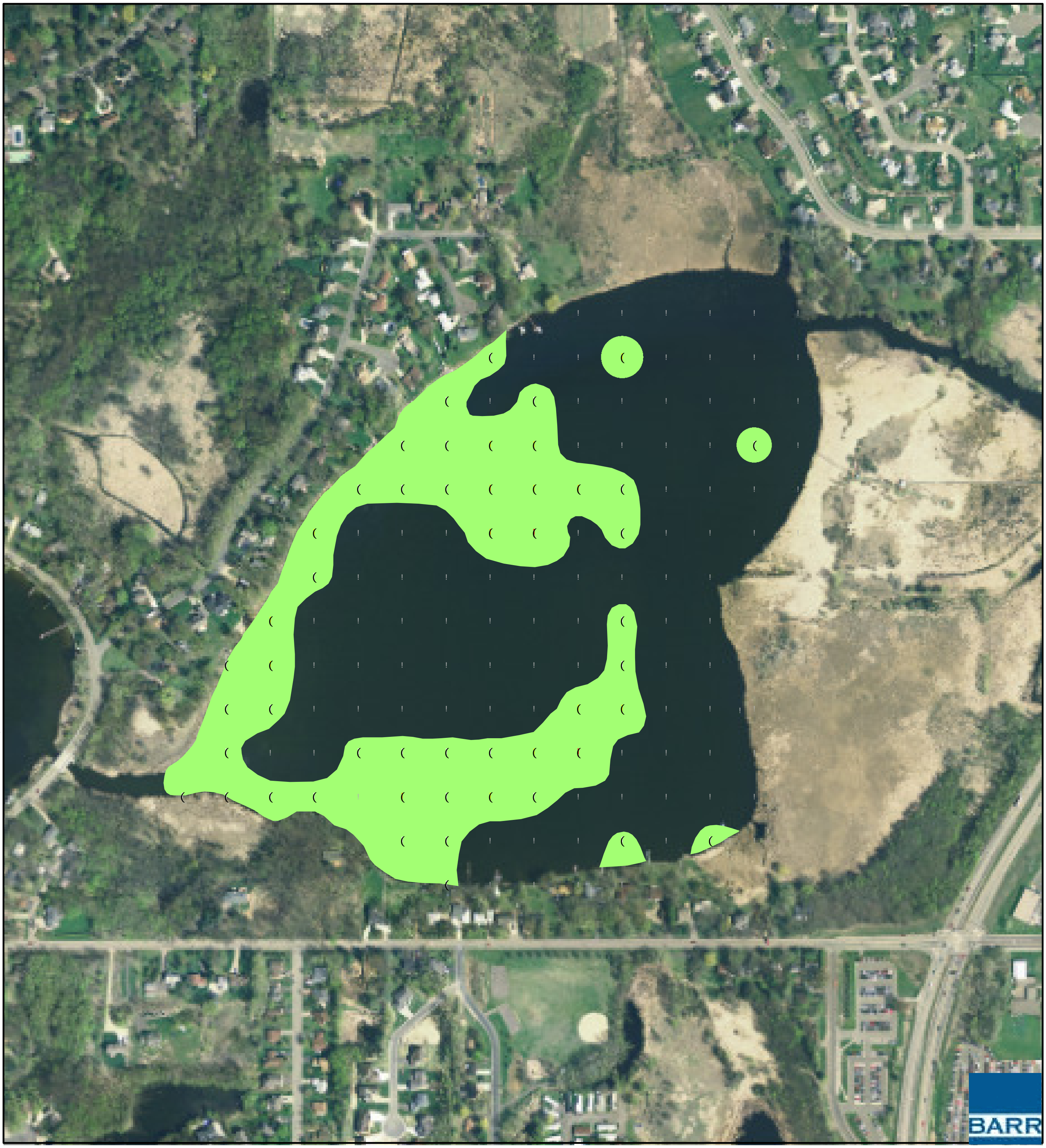
No Eurasian Watermilfoil Present

Eurasian Watermilfoil Present

Meters

100 0 100 200

Figure 7C
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - June 2003
Ramsey-Washington
Metro Watershed District



Area of Eurasian Watermilfoil

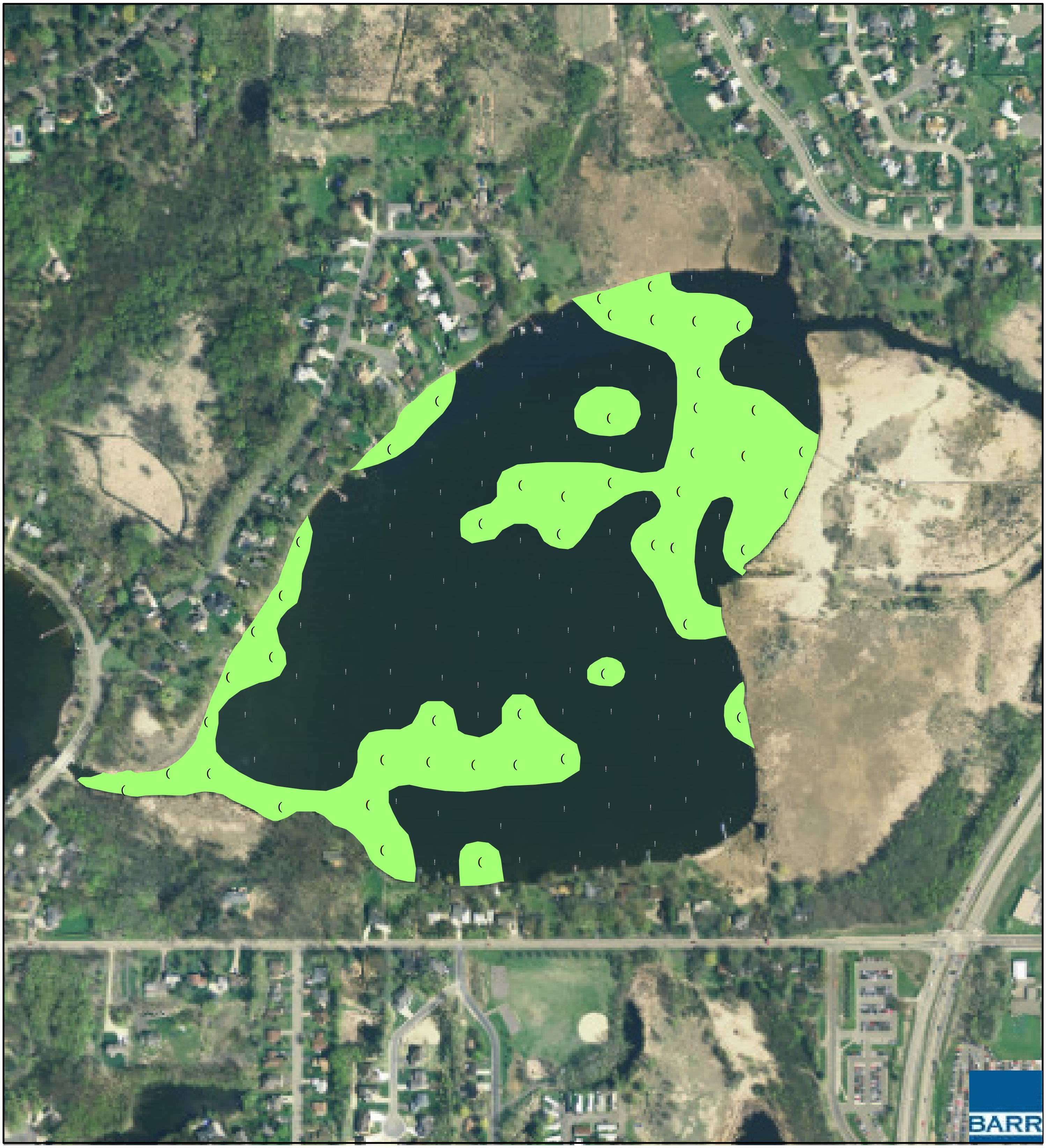
Density Rating

- 0--No Plants
- 1--Plants < 1/3 Rake Coverage
- 2--1/3 <= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 7D
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - June 2004
Ramsey-Washington
Metro Watershed District



Area of Eurasian Watermilfoil

Density Rating (% of Rake Head)

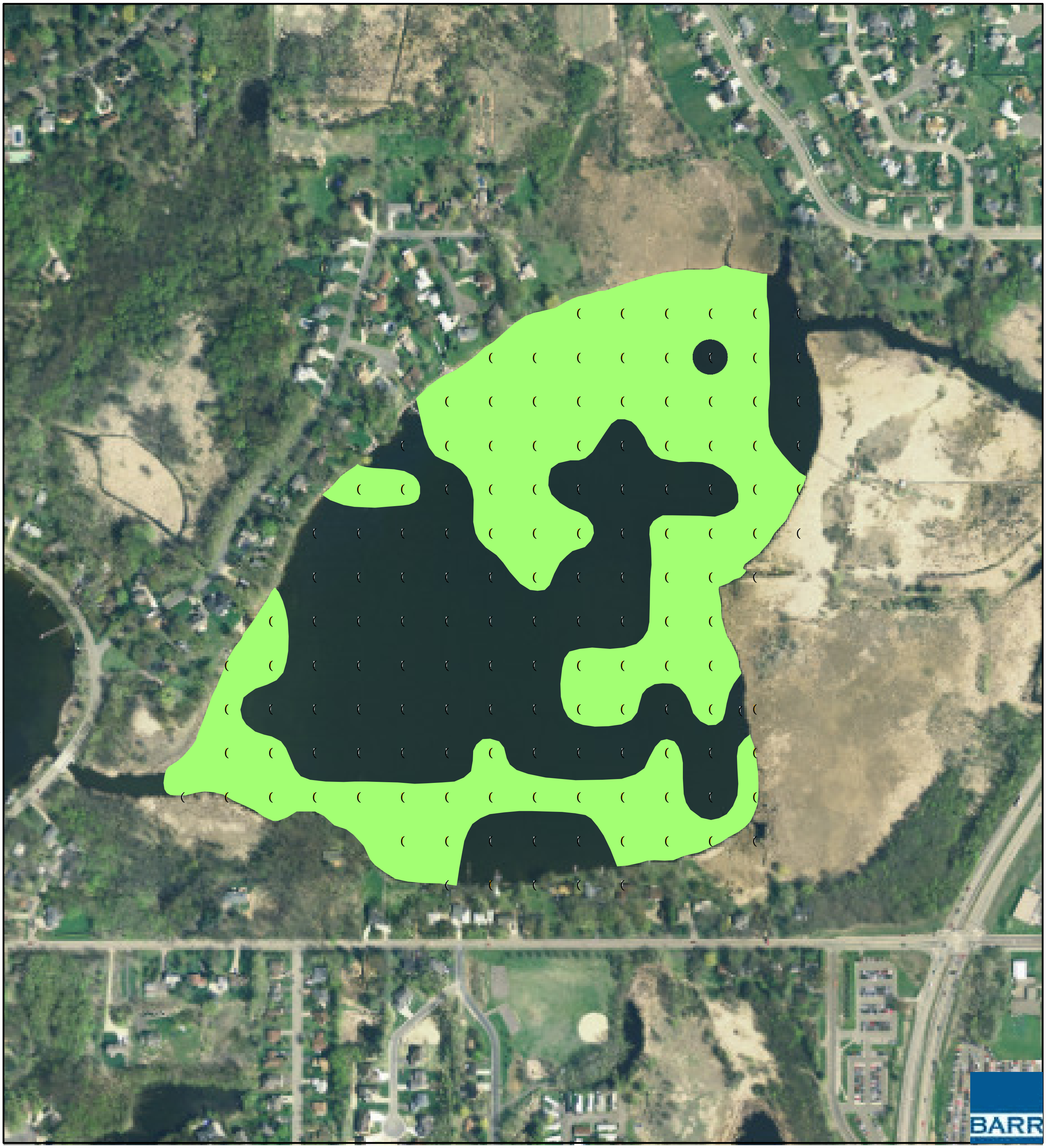
- 0 - 0%
- 1 - 1% to 9%
- 2 - 10% to 29%
- 3 - 30% to 54%
- 4 - 55% to 69%
- 5 - 70% to 100%

Meters

100 0 100 200

Figure 7E
AREA OF
EURASIAN WATERMILFOIL
RWMWD Sampling of
Kohlman Lake - June 13, 2006
Ramsey-Washington
Metro Watershed District

Barr Footer: Date: 8/18/2006 5:07:41 PM File: I:\Client\Rwmwd\KohlmanLake\Project\2362928BJL\DNR_Watermilfoil_06-01.mxd User: bal



Area of Eurasian Watermilfoil

Sample Location

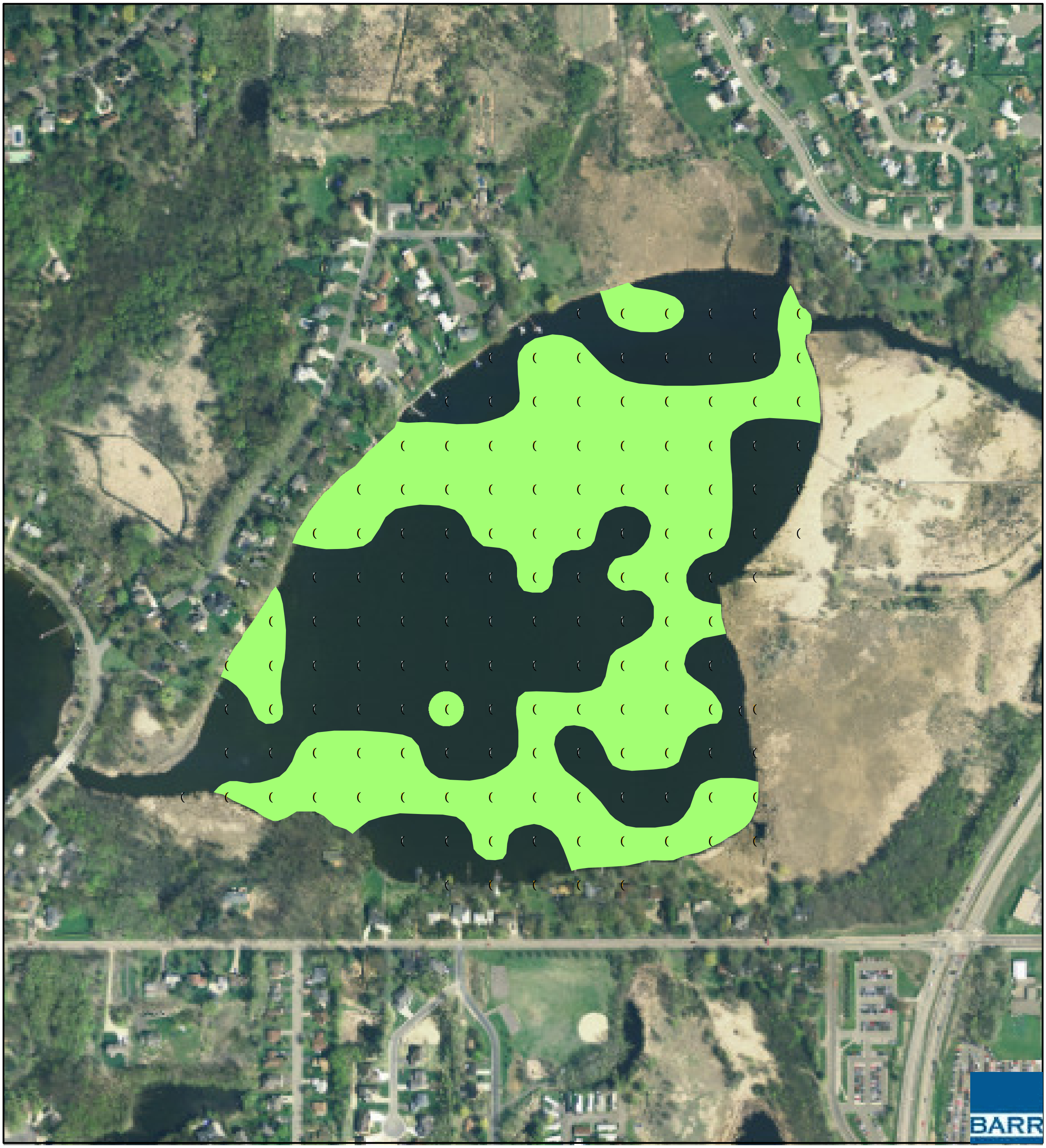
No Eurasian Watermilfoil Present

Eurasian Watermilfoil Present

Meters

100 0 100 200

Figure 7F
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - August 2001
Ramsey-Washington
Metro Watershed District



Barr Footer: Date: 8/18/2006 5:07:41 PM File: I:\Client\Rwmwd\KohlmanLake\Project\2362928BJL\DNR_Watermilfoil_06-01.mxd User: bal

Area of Eurasian Watermilfoil

Sample Location

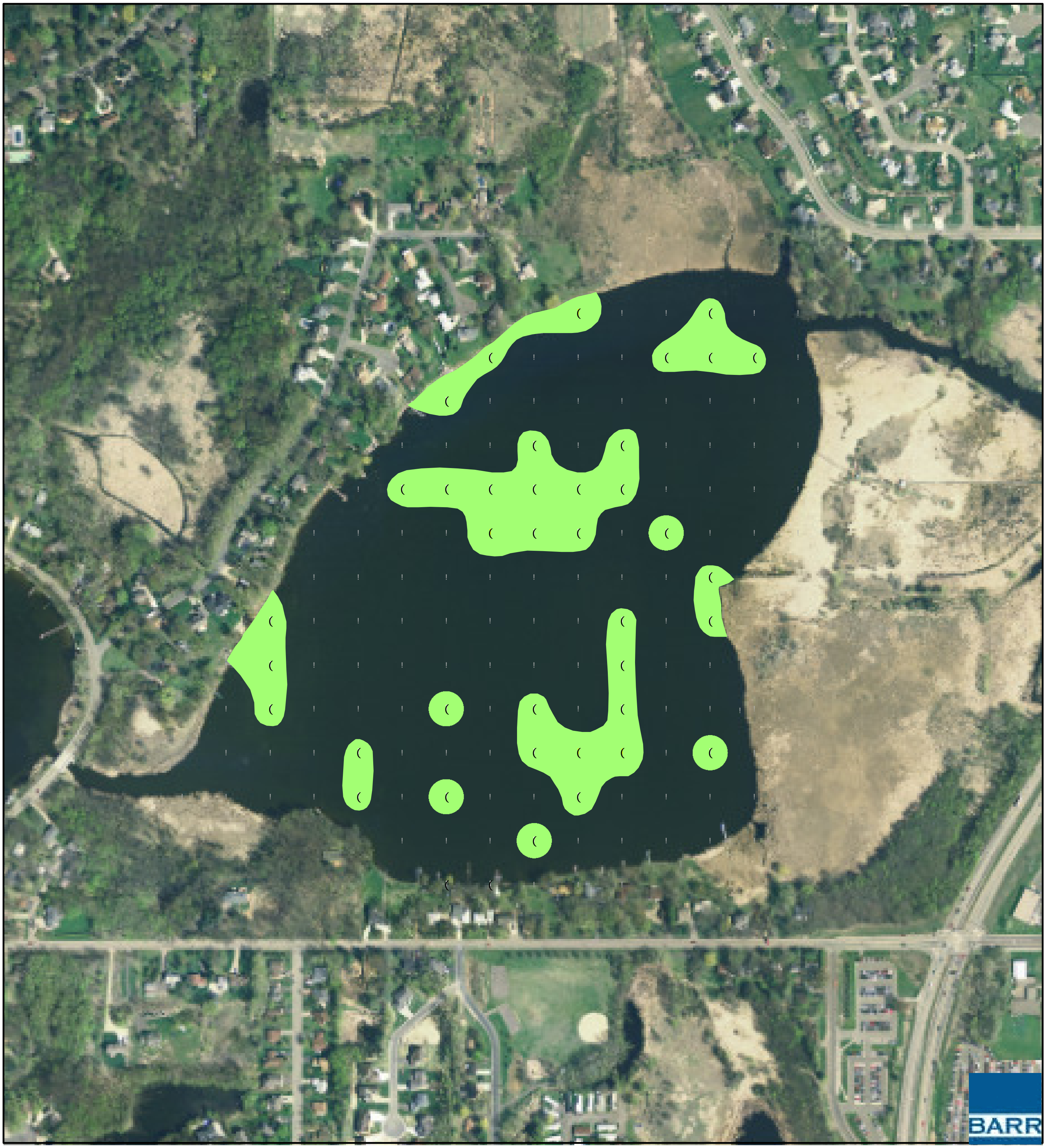
No Eurasian Watermilfoil Present

Eurasian Watermilfoil Present

Meters

100 0 100 200

Figure 7G
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - August 2002
Ramsey-Washington
Metro Watershed District



Area of Eurasian Watermilfoil

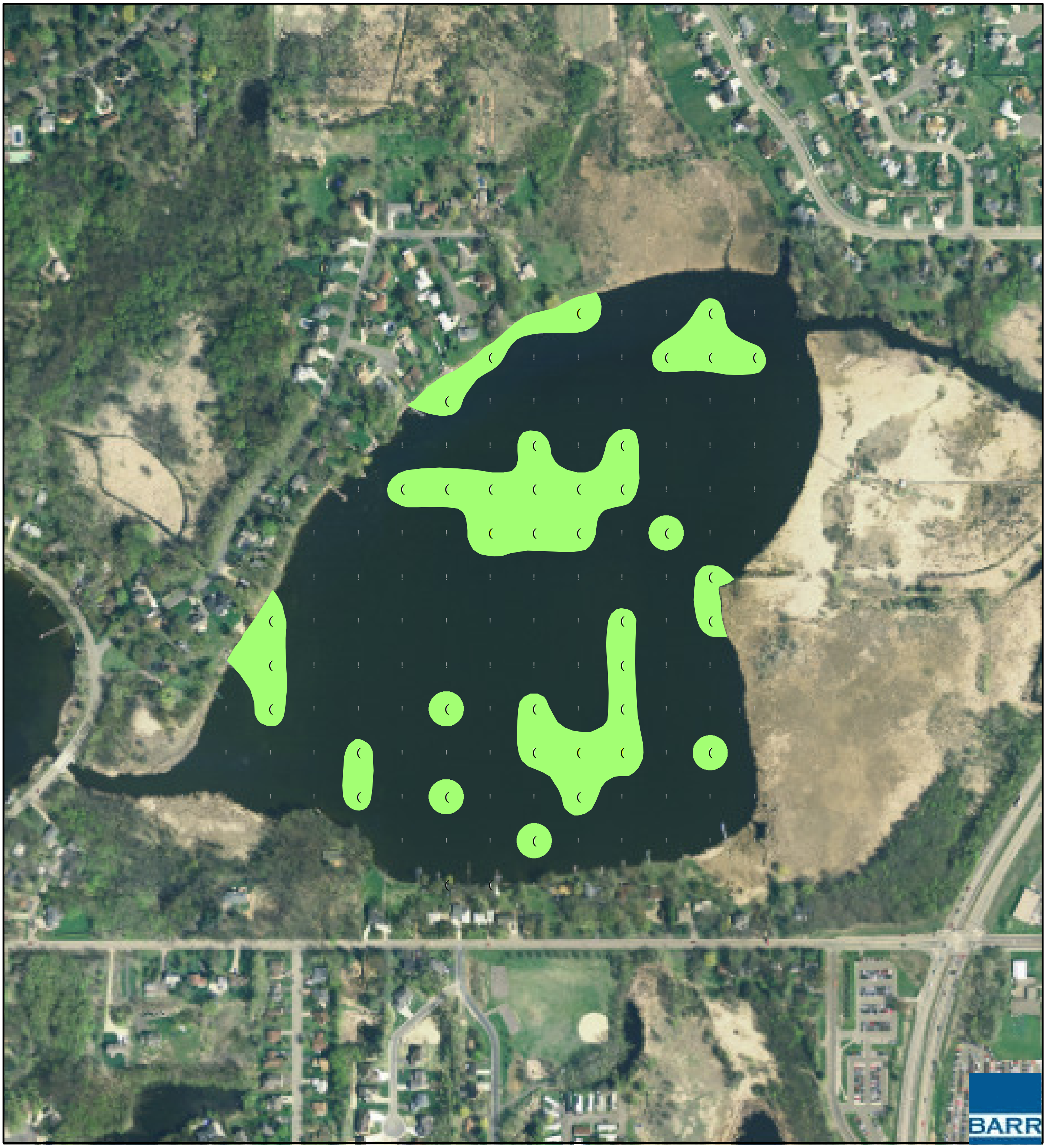
Density Rating

- 0--No Plants
- 1--Plants > 1/3 Rake Coverage
- 2--1/3 <= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 7H
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - August 2003
Ramsey-Washington
Metro Watershed District



Area of Eurasian Watermilfoil

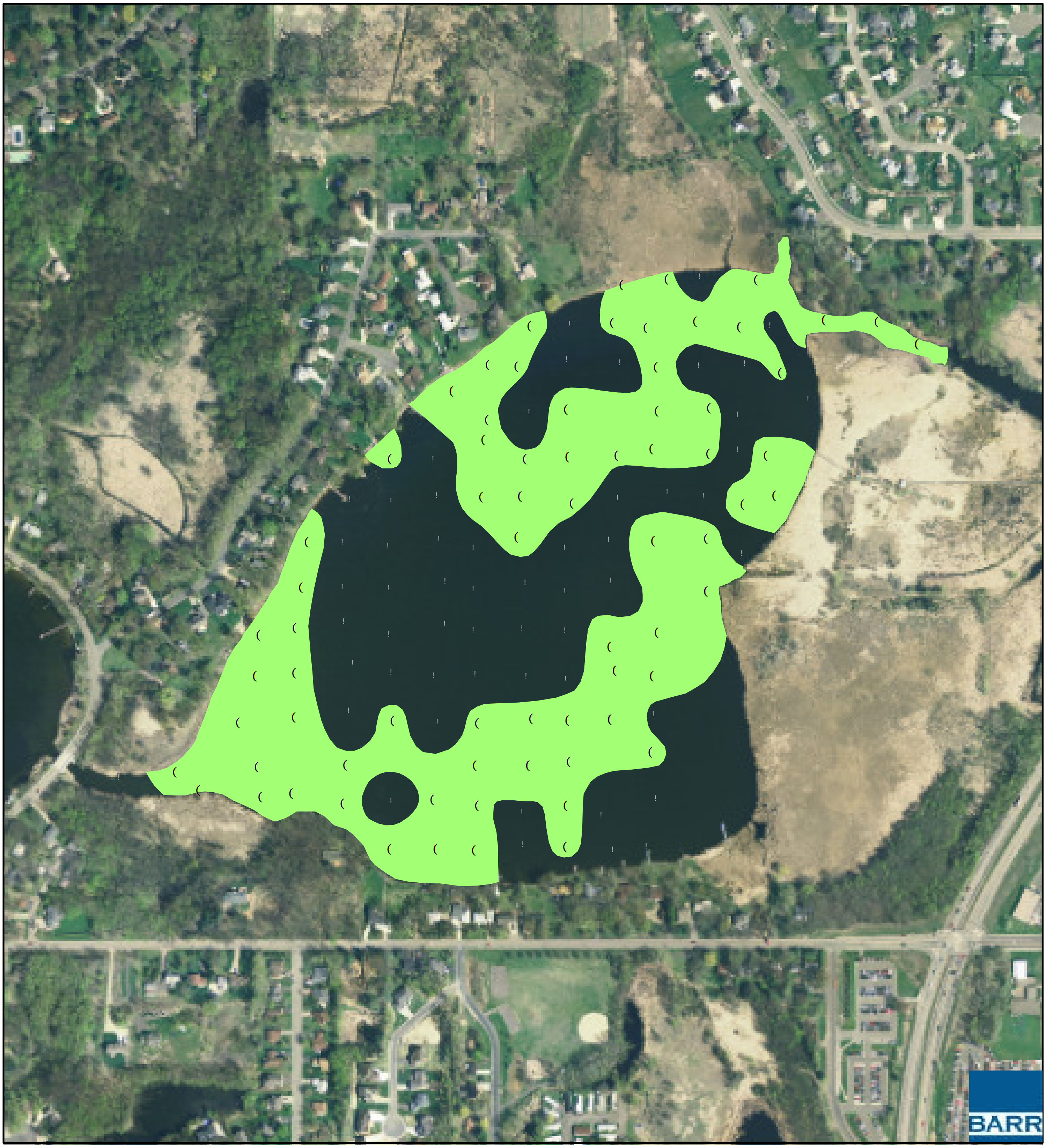
Density Rating

- 0--No Plants
- 1--Plants > 1/3 Rake Coverage
- 2--1/3 <= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 7H
AREA OF
EURASIAN WATERMILFOIL
DNR Sampling of
Kohlman Lake - August 2003
Ramsey-Washington
Metro Watershed District



Area of Eurasian Watermilfoil

Density Rating (% of Rake Head)

- 0 - 0%
- 1 - 1% to 9%
- 2 - 10% to 29%
- 3 - 30% to 54%
- 4 - 55% to 69%
- 5 - 70% to 100%

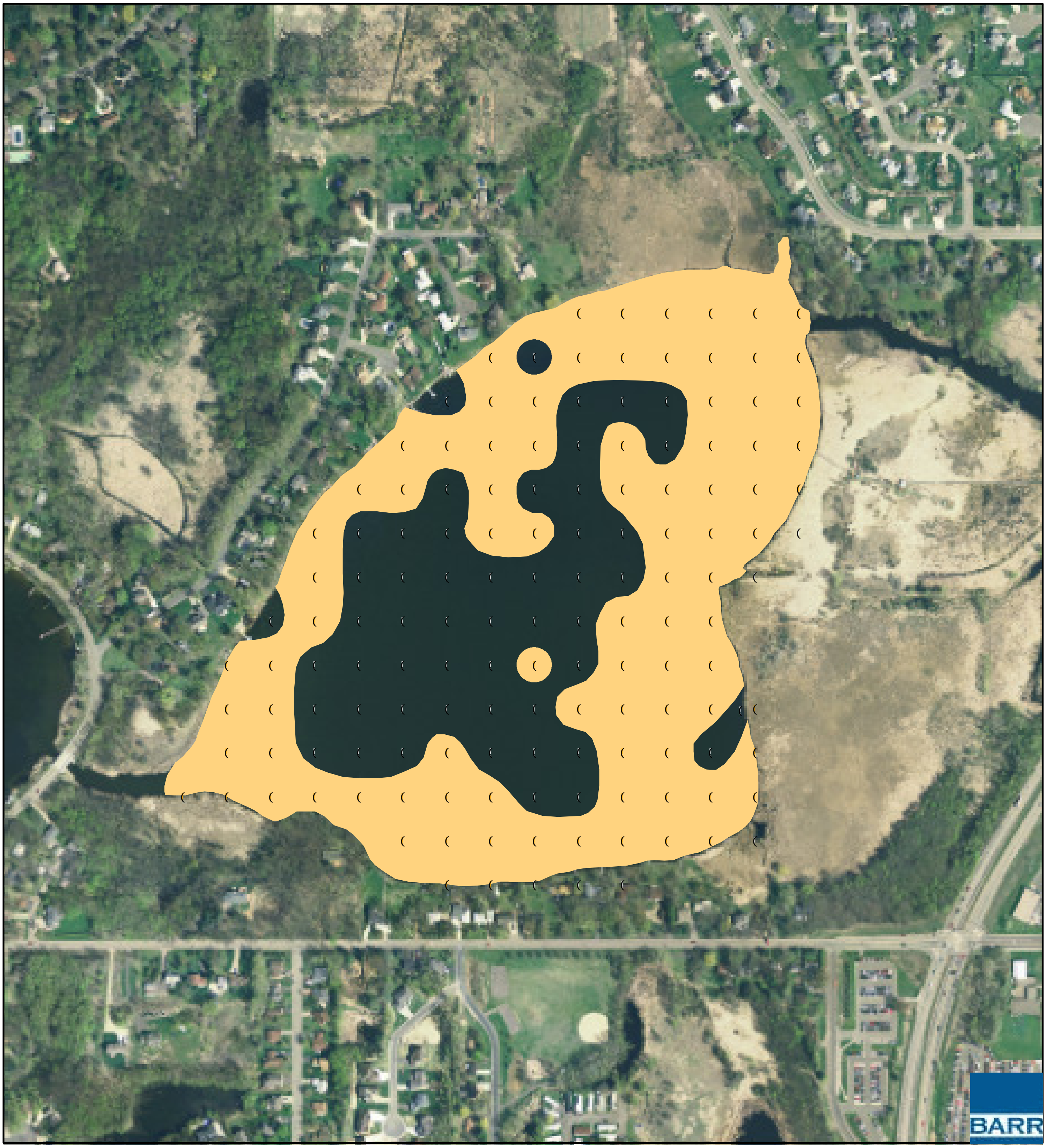
Meters

100 0 100 200

Figure 7J
AREA OF
EURASIAN WATERMILFOIL
RWMWD Sampling of
Kohlman Lake
September 8, 2006
Ramsey-Washington
Metro Watershed District

4.3.2 Nuisance Species – *Ceratopyllum demersum* (Coontail)

Although not invasive, macrophyte species such as Coontail can dominate a system, reducing diversity and function of the aquatic plant community. Coontail had the highest coverage and density of all macrophyte species during all sampling periods in Kohlman Lake from 2001 to 2006 (Figure 8). Coontail growth can, however, be of benefit to aquatic systems because the macrophyte is a sink for phosphorus during the summer months as it flourishes throughout the growing season.



Barr Footer: Date: 10/9/2006 3:38:40 PM File: I:\Client\Rwmwd\KohlmanLake\Project\2362928BJL\DNR_Coontail_06-01.mxd User: bal

Area of Coontail

Sample Location

No Coontail Present

Coontail Present

Meters

100 0 100 200

Figure 8A
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - June 2001
Ramsey-Washington
Metro Watershed District

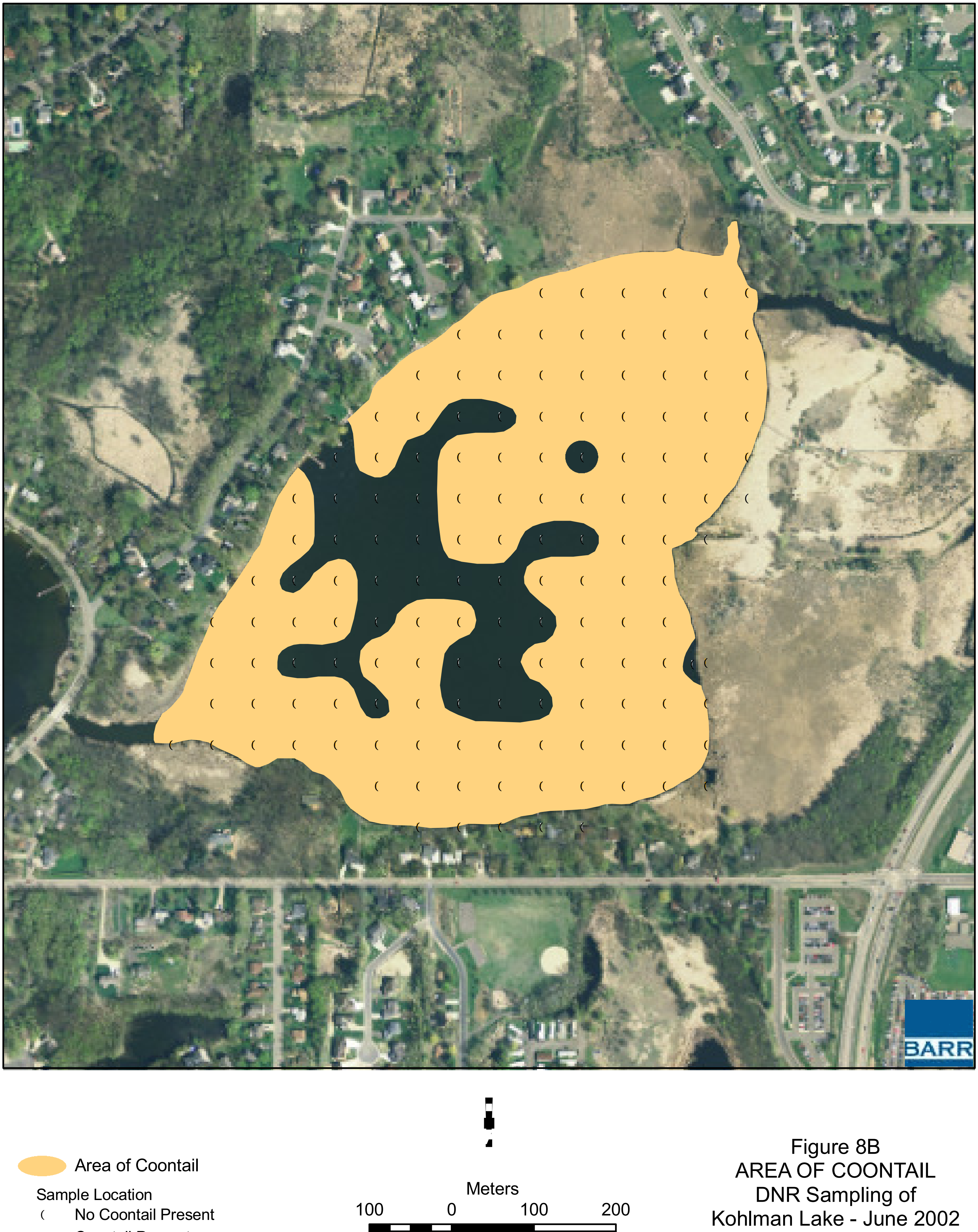
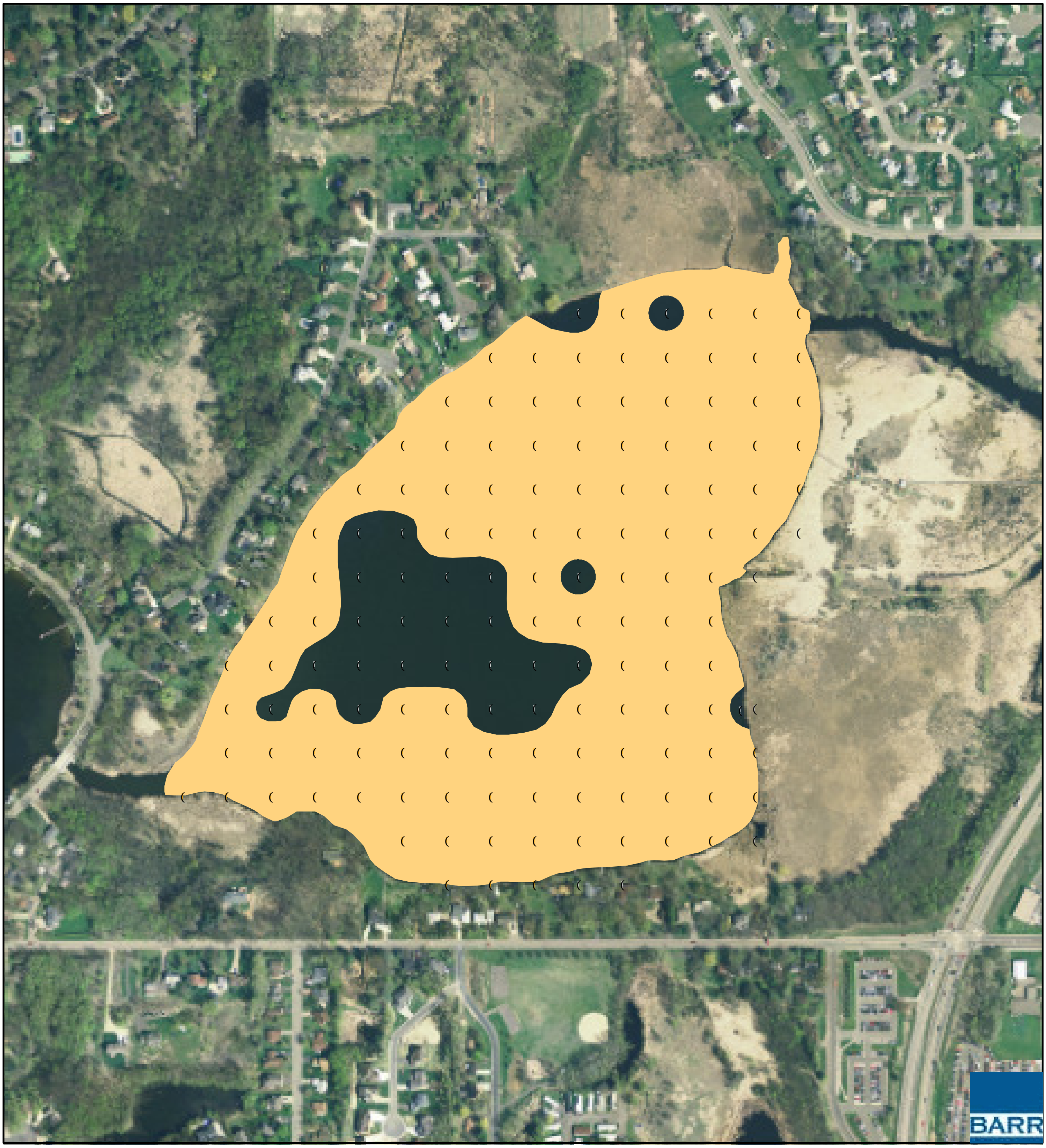


Figure 8B
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - June 2002
Ramsey-Washington
Metro Watershed District



Area of Coontail

Sample Location

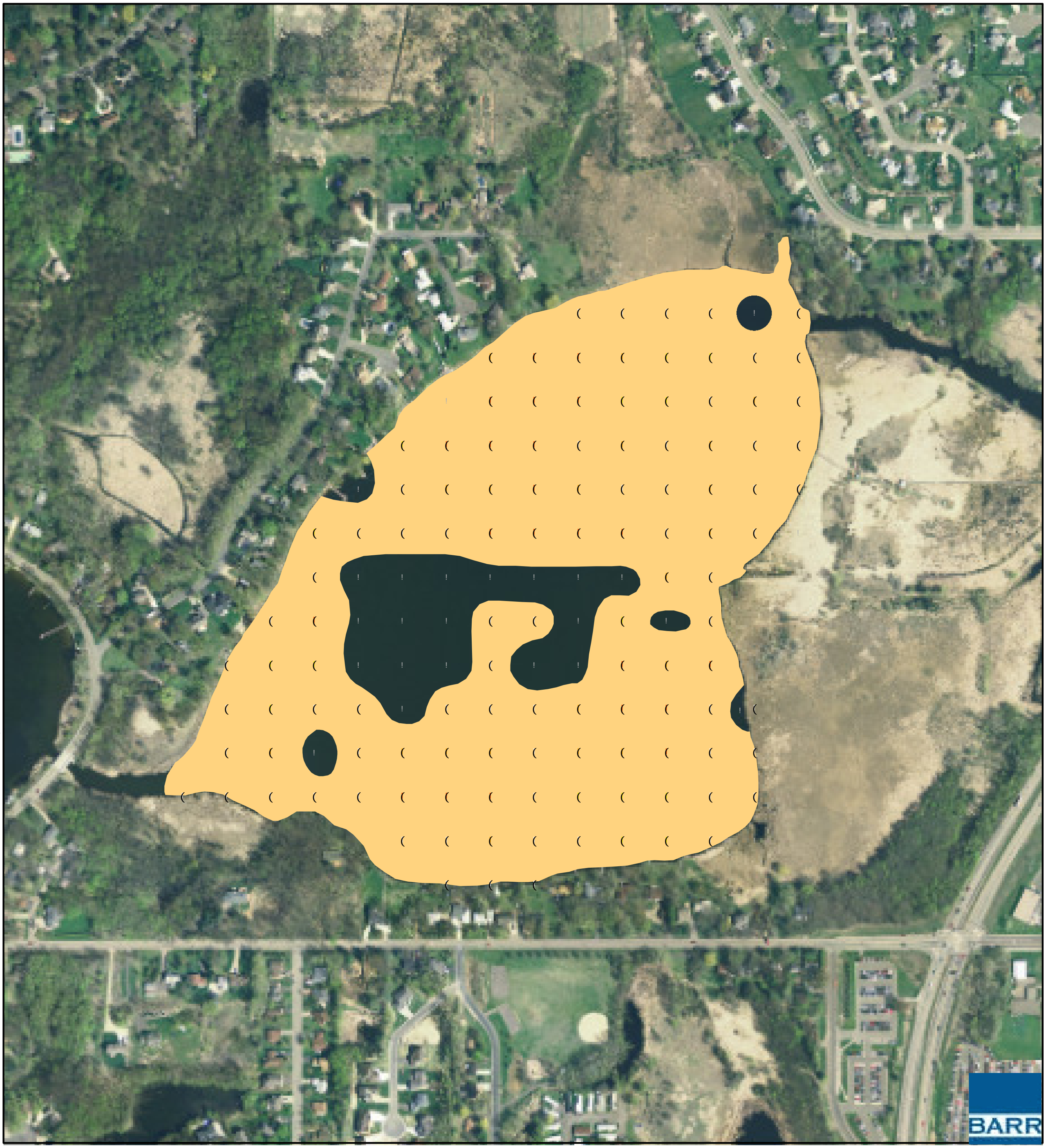
No Coontail Present

Coontail Present

Meters

100 0 100 200

Figure 8C
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - June 2003
Ramsey-Washington
Metro Watershed District



Area of Coontail

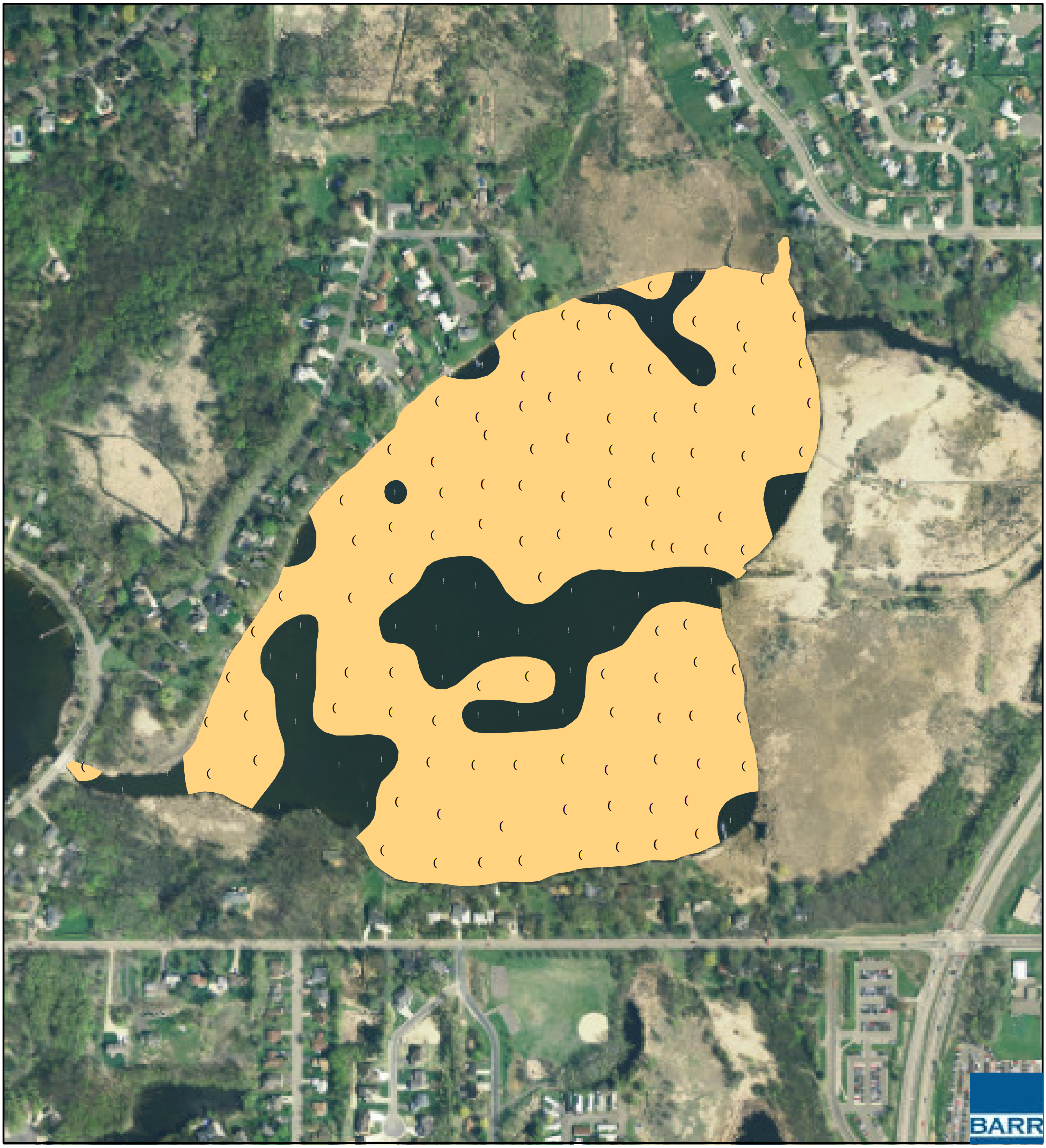
Density Rating

- 0--No Plants
- 1--Plants < 1/3 Rake Coverage
- 2--1/3<= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 8D
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - June 2004
Ramsey-Washington
Metro Watershed District



Area of Coontail

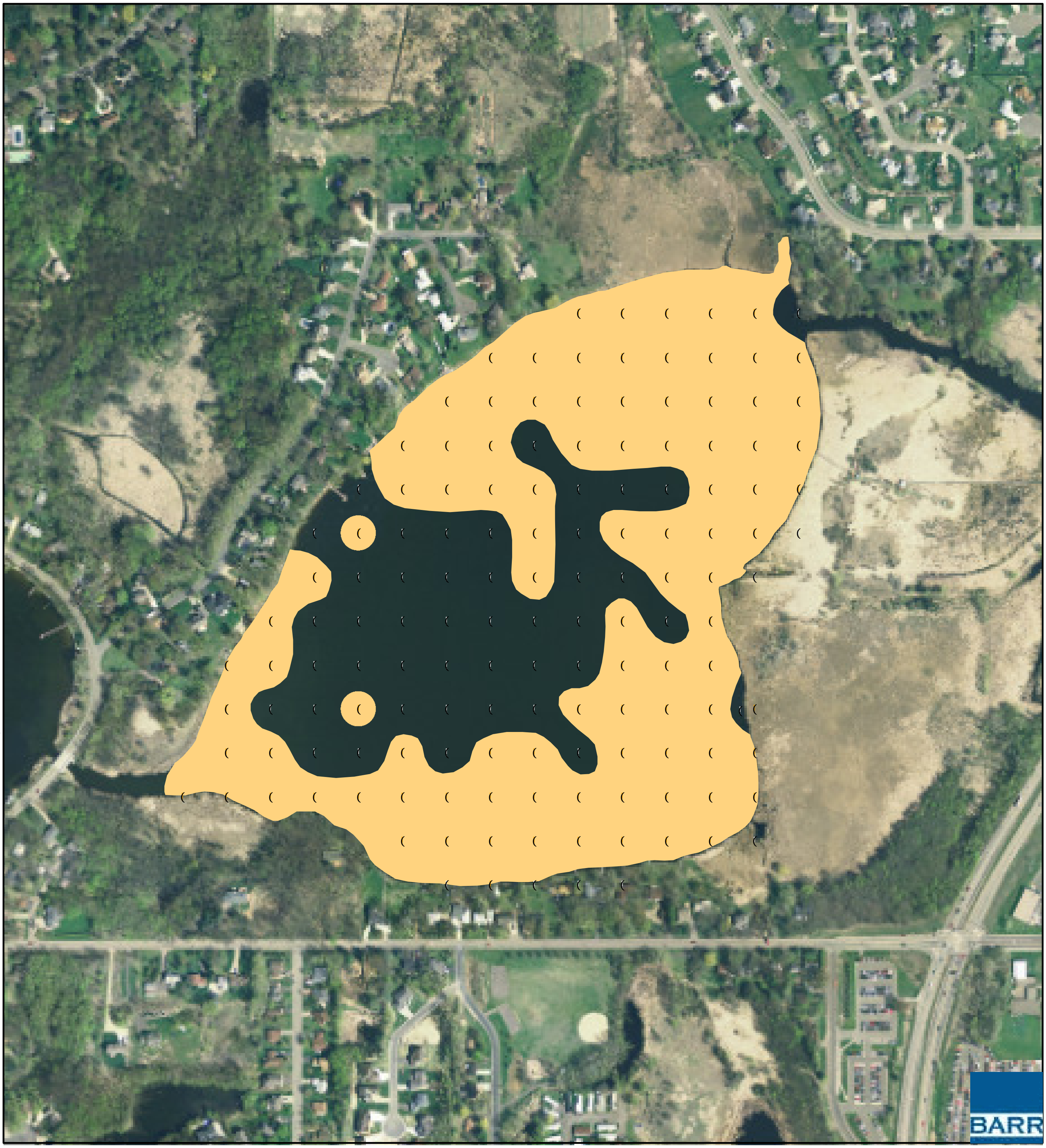
Density Rating (% of Rake Head)

- 0 - 0%
- 1 - 1% to 9%
- 2 - 10% to 29%
- 3 - 30% to 54%
- 4 - 55% to 69%
- 5 - 70% to 100%

Meters

100 0 100 200

Figure 8E
AREA OF COONTAIL
RWMWD Sampling of
Kohlman Lake - June 13, 2006
Ramsey-Washington
Metro Watershed District



Area of Coontail

Sample Location

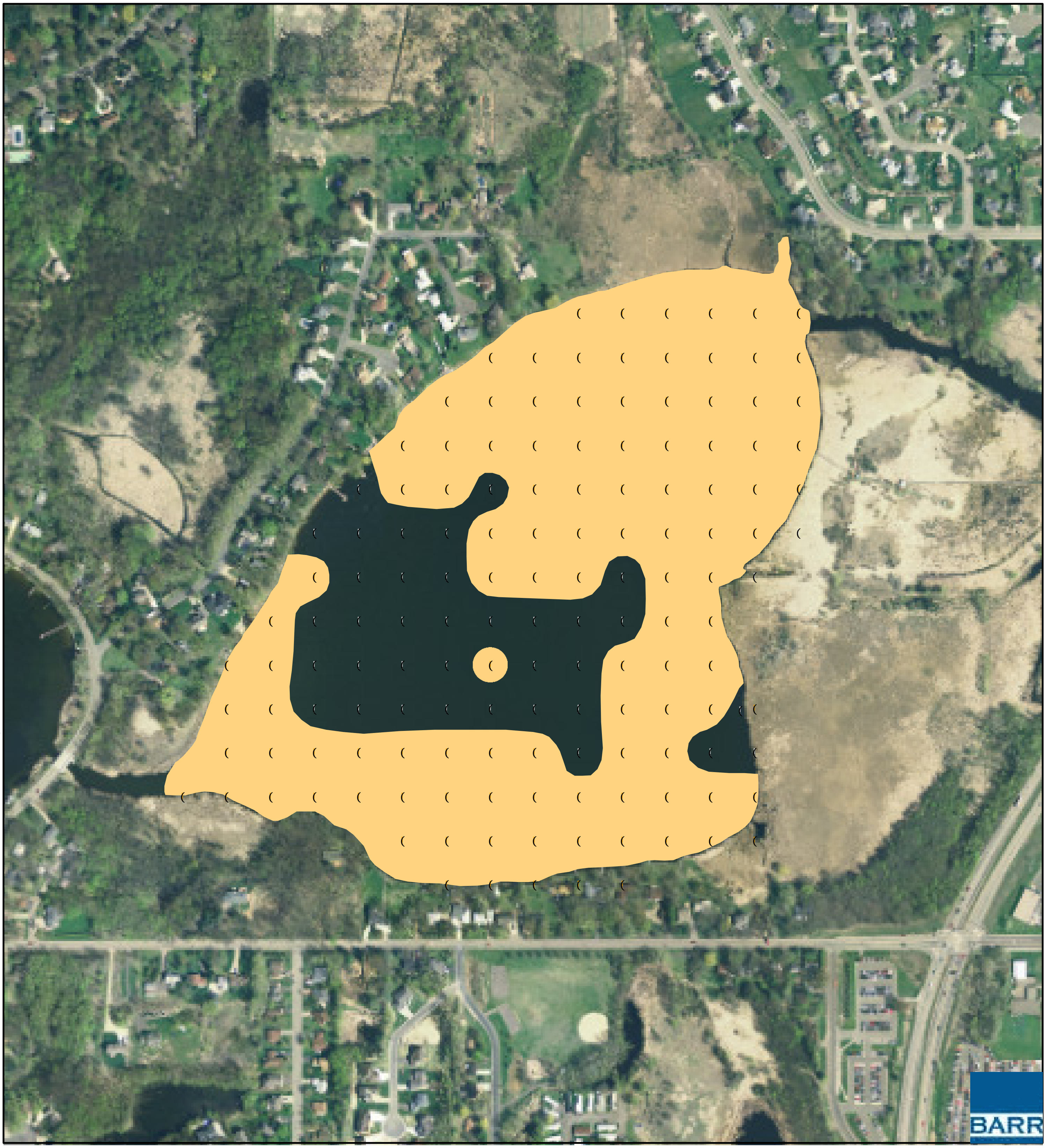
(No Coontail Present

(Coontail Present

Meters

100 0 100 200

Figure 8F
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - August 2001
Ramsey-Washington
Metro Watershed District



Area of Coontail

Sample Location

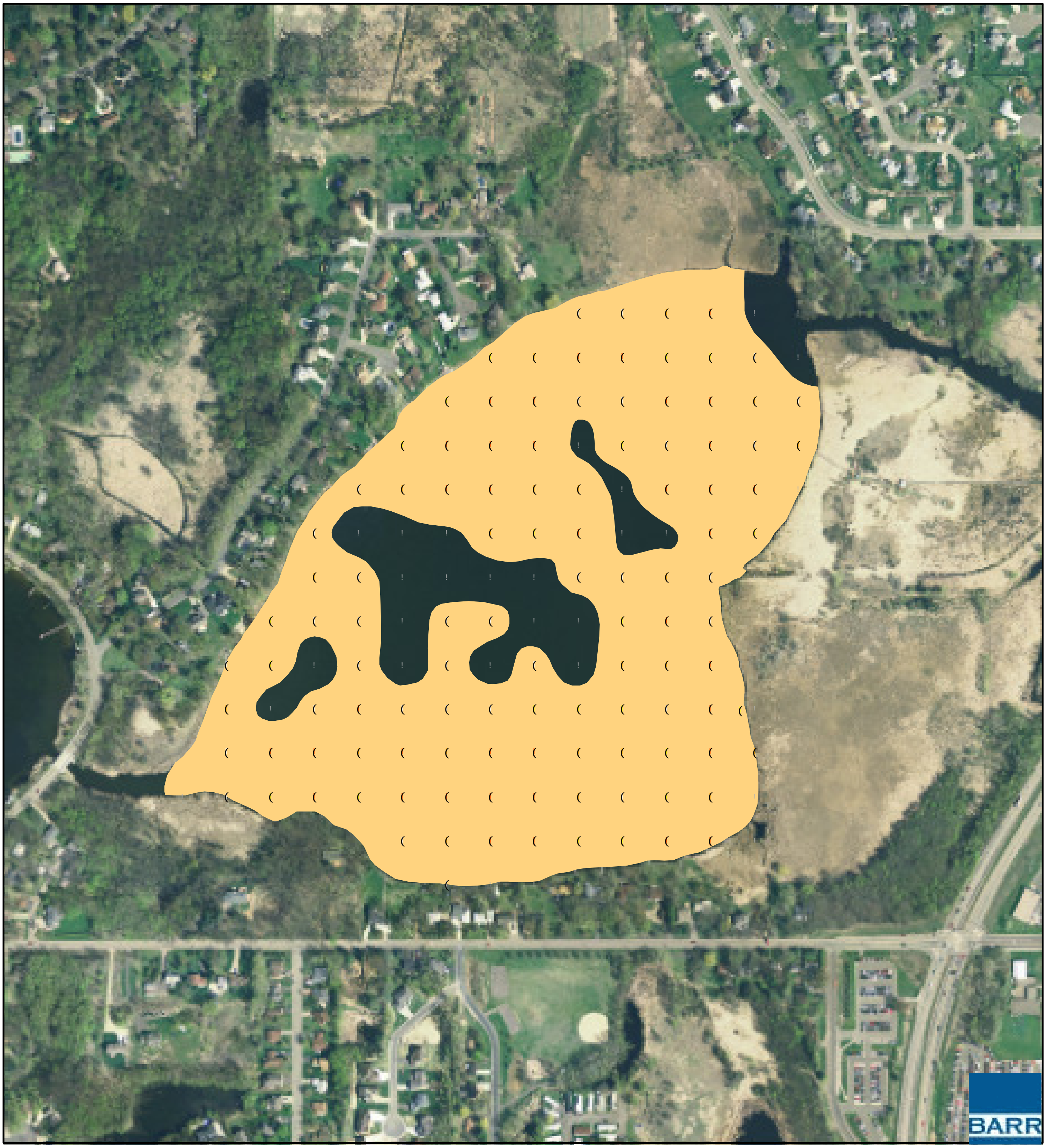
No Coontail Present

Coontail Present

Meters

100 0 100 200

Figure 8G
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - August 2002
Ramsey-Washington
Metro Watershed District



Area of Coontail

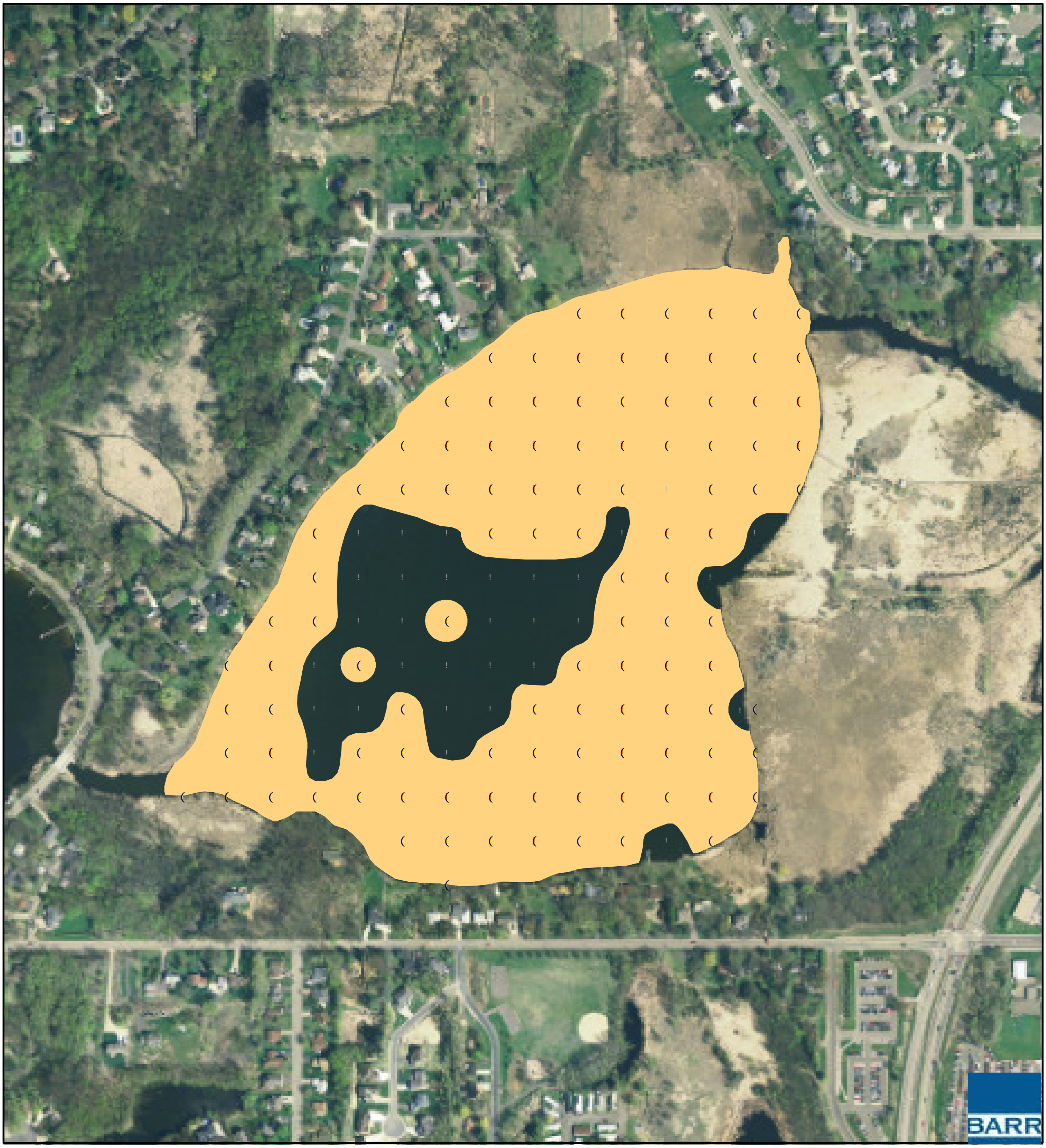
Density Rating

- 0--No Plants
- 1--Plants < 1/3 Rake Coverage
- 2--1/3 <= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 8H
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - August 2003
Ramsey-Washington
Metro Watershed District



Area of Coontail

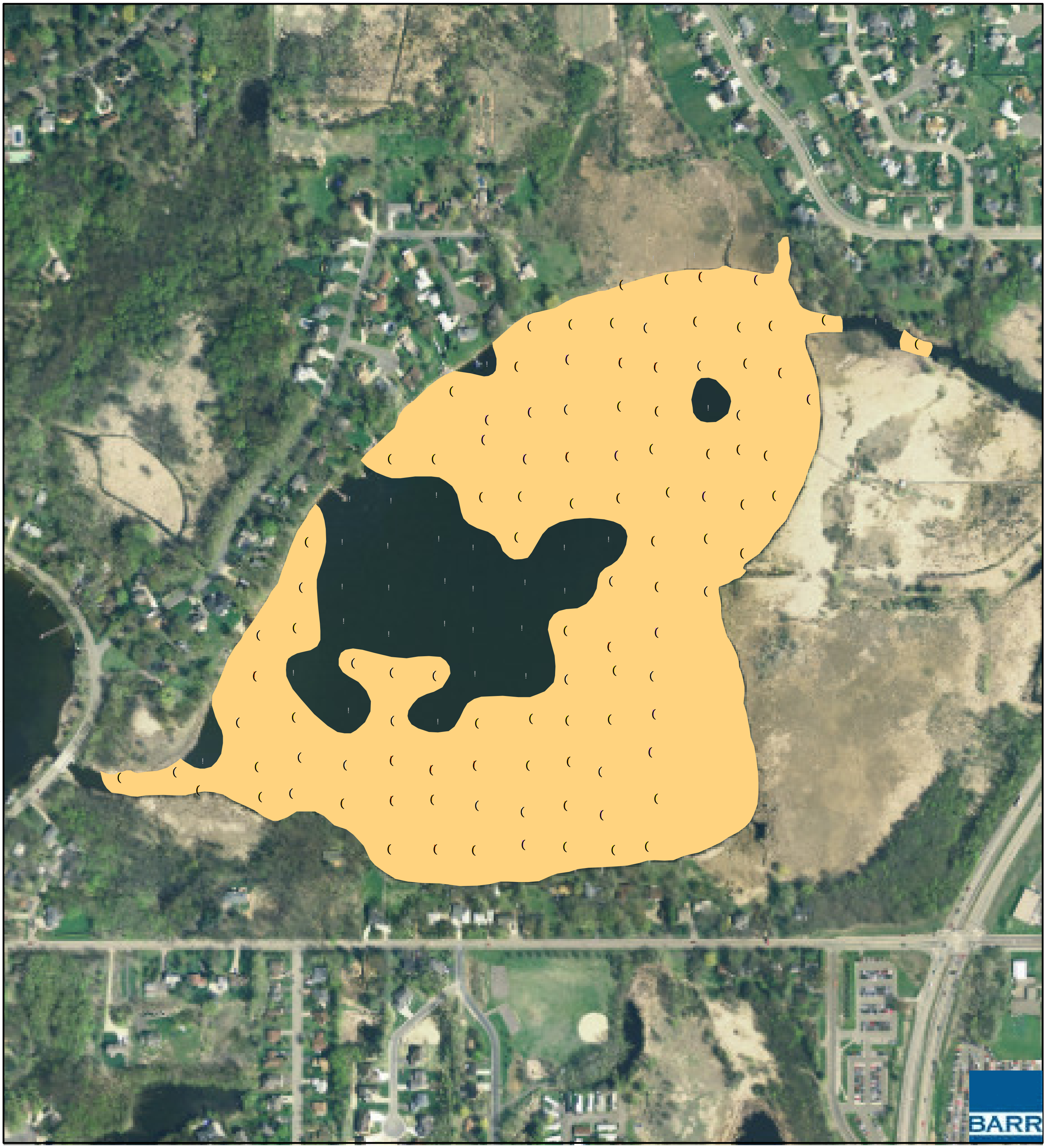
Density Rating

- 0--No Plants
- 1--Plants > 1/3 Rake Coverage
- 2--1/3 <= Plants <= 2/3 Rake Coverage
- 3--Plants > 2/3 Rake Coverage
- 4--Plants Over Top Of Rake Head

Meters

100 0 100 200

Figure 8I
AREA OF COONTAIL
DNR Sampling of
Kohlman Lake - August 2004
Ramsey-Washington
Metro Watershed District



Area of Coontail

Density Rating (% of Rake Head)

- 0 - 0%
- 1 - 1% to 9%
- 2 - 10% to 29%
- 3 - 30% to 54%
- 4 - 55% to 69%
- 5 - 70% to 100%

Meters

100 0 100 200

FIGURE 8 J
AREA OF COONTAIL
RWMWD Sampling of
Kohlman Lake
September 8, 2006
Ramsey-Washington
Metro Watershed District

4.4 Kohlman Lake Water Quality

Water quality has been studied in detail and results can be found in the following recent studies:

- Phalen Chain of Lakes Strategic Lake Management Plan (2004)
- Internal Phosphorus Load Study (2005)
- Untreated Areas Study (2005)
- Total Maximum Daily Load Report (2005)
- Lake User's Survey (2005)
- Kohlman Basin Water Quality Enhancement Study (2006)
- Kohlman Lake Subwatershed Infiltration Study (2006)

Surface water quality, specifically water clarity (Secchi depth), is summarized in this section because it correlates with macrophyte growth.

4.4.1 Internal and External Sources of Phosphorus to Kohlman Lake

Because of the amount of flow that eventually finds its way to Kohlman Lake, external phosphorus reduction strategies are limited by both space and cost. Nonetheless, strategies have been developed to reduce phosphorus loading to the basin. External sources of phosphorus to Kohlman Lake have been investigated in a number of studies detailed in the reports listed above. A number of BMPs have been implemented within the watershed and future improvements have been planned as well.

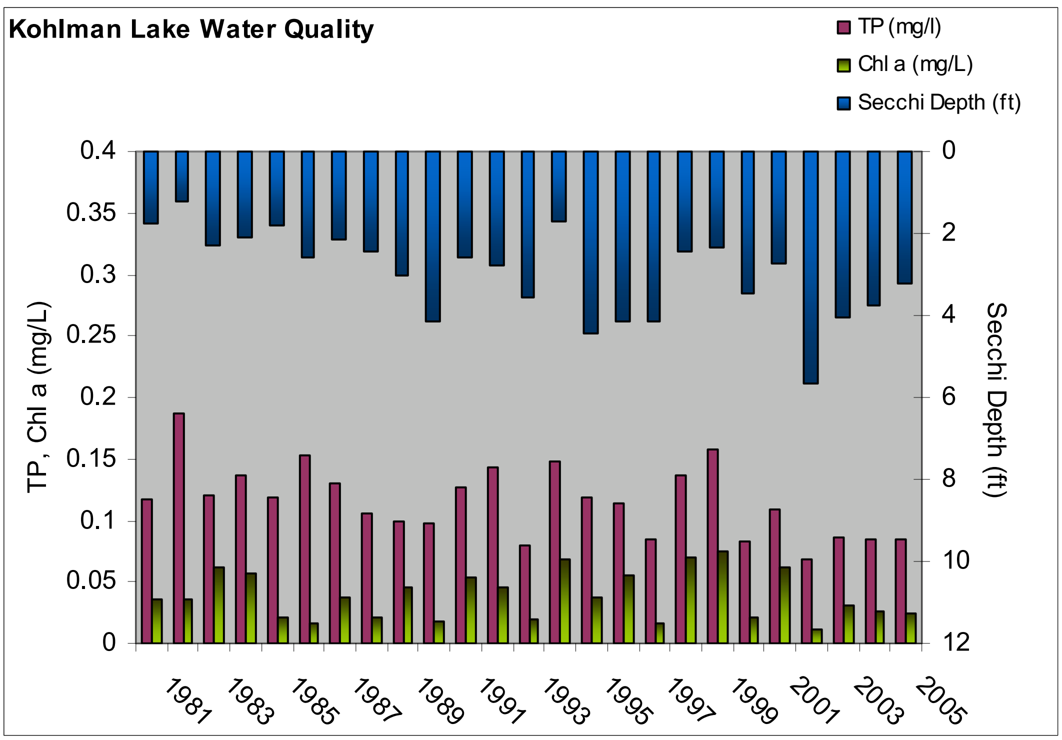
In addition, the Kohlman Basin Water Quality Enhancement Study (draft, Barr 2006) contains a number of innovative technologies to reduce inflow of phosphorus to Kohlman Lake from the basin. A step wise implementation plan has been recommended for these BMP structures beginning with the first phase in 2007. Both the Enhanced Sand Filtration system and the Permeable Limestone Barriers have been constructed as part of the Kohlman Basin Area Enhancement CIP. While the Enhanced Sand Filter will not go online until mid to late 2008 (once the contributing watershed has stabilized), the Permeable Limestone Barriers are operational. Current and future infiltration studies and projects will reduce the amount of runoff from impervious areas, reducing external loading as well.

Internal phosphorus loading is mainly comprised of mobile phosphorus in the sediment that is released into the water column during the summer months. Anoxia (the lack of oxygen) greatly increases this release. In addition, because Kohlman Lake is shallow, it is polymictic, meaning it mixes multiple times during the summer. This allows phosphorus that is released from the sediment to be transported to the surfice water where it can be used for growth by algae.

4.4.2 Current Water Quality

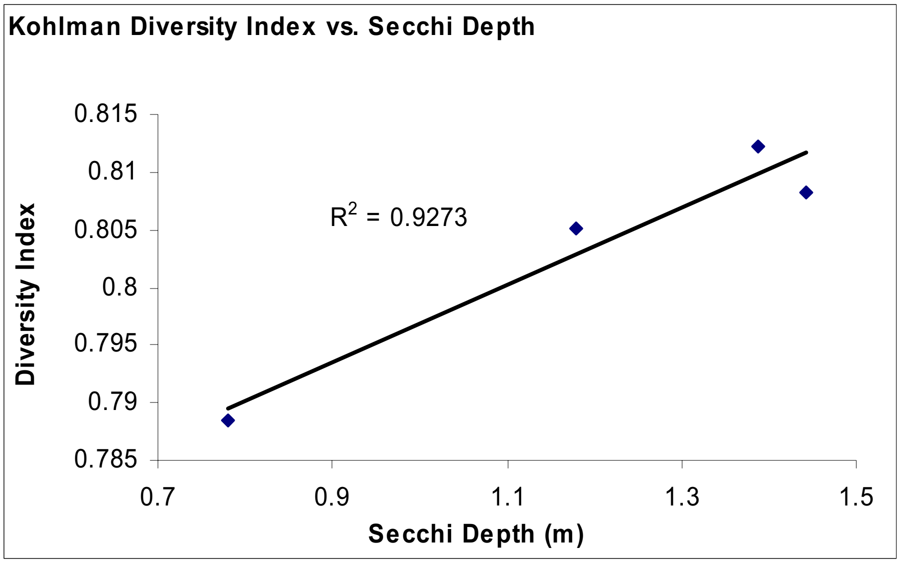
Kohlman Lake is a shallow, polymictic lake that mixes throughout the summer months. Water quality is within the eutrophic range and average growing season Secchi depth, in recent years, has ranged between 0.6 (1999) and 1.4 meters (2002 and 2003). Secchi depth has been as low as 0.4 meters in the early 1980s (Figure 9). Total phosphorus follows the pattern of Secchi depth over the years well, peaking in 1982 (0.187 mg/L) and reaching a minimum of 0.068 mg/L in 2002. Chlorophyll a reached a maximum in 1999 at 0.074 mg/L and was lowest in 2002 dropping to .012 mg/L.

Figure 9 Nutrient related water quality parameters in Kohlman Lake.



It is interesting to note that macrophyte diversity correlates well with Secchi depth in Kohlman Lake. Macrophyte diversity increases as water clarity increases in the lake (Figure 10). This is a sample set within a small range of water clarity levels but nonetheless emphasizes the benefit that water transparency may have on the macrophyte community in the lake

Figure 10 The relationship between water clarity (Secchi depth) and macrophyte diversity in Kohlman Lake



4.4.3 Future Water Quality Goals

The goal is to manage water quality in Kohlman Lake so that it meets the TMDL requirement of 60 µg/L total phosphorus average summer concentration. Short and long term goals of 90 and 70 µg/L, respectively, have also been set by the District. To meet the TMDL requirement, both internal and external sources of phosphorus must be substantially controlled. More importantly and with regard to this report, internal phosphorus loading control is needed to reduce in-lake phosphorus levels and macrophyte management detailed within is necessary to complete this phase of the TMDL work.

5.0 Management Plan

5.1 Problem Definition

The macrophyte community in Kohlman Lake contains two invasive species (Curlyleaf pondweed and Eurasian watermilfoil). The reduction of Curlyleaf pondweed and Eurasian watermilfoil is needed to ensure effective implementation of internal loading reduction measures and prevent additional growth of these invasive species due to increased water clarity after restoration measures are complete.

5.2 Establish Goals and Objectives

5.2.1 General Goals

The main goals for management of macrophytes in Kohlman Lake are to reduce the density of Curlyleaf pondweed and Eurasian watermilfoil in preparation for internal phosphorus loading reduction (alum treatment) and to ensure these species do not proliferate after water clarity increases in the lake. Reduction of Curlyleaf pondweed and Eurasian watermilfoil growth will ensure an effective application of alum can occur and have the added benefit of reducing internal phosphorus loading via plant growth and decay. In addition, reducing growth density of invasive species before internal phosphorus loading reduction occurs will allow native species to compete and improve the health of the macrophyte community.

5.2.2 Long-Term Improvement and Maintenance

It is District policy to manage aquatic plants when necessary to improve water quality. Therefore, monitoring of the macrophyte community will continue and if it is determined that the growth of invasive species have increased such that Kohlman Lake can not meet the designated water quality goal, additional management of macrophytes should occur. This will likely include additional chemical treatment or other methods designed to limit the growth of Curlyleaf pondweed. If macrophyte growth is not limiting the attainment of water quality goals set for Kohlman Lake, no additional maintenance will occur outside of existing programs already in place.

5.3 Management Techniques

Following a consideration of a broad spectrum of possible management alternatives, a feasible management option may be identified for Kohlman Lake. The following discussion focuses on four types of aquatic plant management techniques currently used for aquatic plant control. They include:

- Physical
- Mechanical
- Biological
- Chemical

5.3.1 Physical

Physical methods typically used to manage aquatic plants are light manipulation and habitat manipulation. Habitat manipulation includes techniques such as over winter lake drawdown, dredging, sand blanketing, the use of dyes, and nutrient limitation and inactivation (Barr, 1997).

Although light manipulation has been used in lakes with some success, its greatest utility has been found in managing dense vegetation in streams through streamside shading. Shading by use of different densities of shading cloth has resulted in decreased plant biomass. Natural shade from streamside vegetation has also reduced plant biomass along the stream course (Barr, 1997). Dark colored dyes are sometimes used in small ponds and lakes to reduce aquatic plant growth. The dyes are added to the lake or pond. The resultant change in water color reduces the amount of light reaching the submersed plants, thereby limiting plant growth. Use of dyes is limited to shallow water bodies with no outflow. Because Kohlman Lake has an outflow, dyes cannot be used in the lake for plant management.

Lake level drawdown, particularly over winter, is commonly used to control nuisance aquatic plants in northern North America. Biomass studies before and after drawdown have demonstrated that drawdown is effective in controlling plants down to the depth of drawdown, but has little effect at greater depths. While drawdown is an extremely effective technique for some species, it may actually stimulate the growth of other species. (Madsen and Bloomfield, 1992). A study of Trego Flowage (Washburn County, Wisconsin) showed the benefits of drawdown were temporary, and the same species of plants returned in approximately their former abundance within a few years (Barr, 1994). Drawdown as a plant management technique is only feasible when a dam is present and lowering the water level for a period of time is feasible. Drawdown is not a feasible option for Kohlman Lake.

Another commonly used group of physical control techniques involves benthic barriers, weed rollers, or sediment alteration to inhibit the growth of aquatic plants at the sediment surface. Barrier material is applied over the lake bottom to prevent plants from growing, leaving the water clear of rooted plants. Benthic barriers are generally applied to small areas (Barr, 1997). Negatively buoyant (i.e., sink in water) screens are available in rolls 7 feet wide and 100 feet long. The screens can be laid on the lake bottom in the spring and removed in the fall. These screens can be reused for about 10 years. Burlap has been found to provide up to 2 to 3 years of relief from problematic growth before eventually decomposing (Truelson, 1985 and Truelson, 1989). Bottom barriers would be appropriate for controlling aquatic plant nuisances for small applications such as adjacent to a boat dock or for small swimming areas. The barriers are safe, effective, non-chemical controls that use a simple technology. Bottom barriers do not result in significant production of plant fragments (critical for Eurasian watermilfoil treatment). Bottom barriers may cause harm to fisheries and invertebrate habitat. Consequently, the WDNR should be contacted prior to barrier installation to determine whether a permit is needed. Bottom barriers are not feasible for Kohlman Lake because the area requiring management is larger than this method is designed for.

Weed rollers or 'Automated Unintended Aquatic Plant Control Devices' are motor-drive rollers (round bars) placed on the lake bottom that roll over and uproot plants. The rollers are 25-to-30 feet long and are centered on the end post of a dock. The rollers roll in a circular pattern, normally covering 270^0 or using a 25-foot roller over a full circular area. Weed rollers would be appropriate for controlling aquatic plant nuisances in small areas such as adjacent to a boat dock or for small swimming areas. The rollers are an effective non-chemical control using a simple technology. However, weed rollers cause harm to fisheries and invertebrate habitat. Weed rollers are not feasible for Kohlman Lake because the area requiring management is larger than this method is designed for.

Alteration of lake sediment and water chemistry has included the application of substances (i.e., lime slurry) that affect the carbon composition and the available nitrogen and phosphorus concentrations within the sediment. Growth of aquatic plants may be inhibited by the reduced availability of phosphorus or a change in nitrogen composition in the sediment (Barr, 1997). Lime slurry is an experimental tool currently the subject of a research project by the Eau Galle Aquatic Ecology Laboratory involving Curlyleaf pondweed. Use of lime slurry is not a feasible option for Kohlman Lake because its use is not allowed until ongoing research is complete.

Dredging of Lake Kohlman sediment involves the physical removal of sediment from the lake. Sediment removal can reduce macrophyte coverage and density via removal with the sediment. Another benefit of dredging is the removal of any excess phosphorus in the upper sediment that may be available for release into the water column, contributing to internal loading. A feasibility study completed to determine the costs and benefits of dredging Lake Kohlman sediment indicated this option is not feasible because it is too expensive.

5.3.2 Mechanical

Mechanical control involves aquatic plant removal by harvesting, hand pulling, hand-digging, rotovation/cultivation, or diver-operated suction dredging. Small scale harvesting may involve the use of the hand or hand-operated equipment such as rakes, cutting blades, or motorized trimmers. Individual residents frequently clear swimming areas with small scale harvesting, hand pulling, or hand digging. Small scale harvesting is not a feasible option for Kohlman Lake because the area is too large for management by small-scale methods.

Large-scale mechanical control often uses floating, motorized harvesting machines that cut the plants and remove them from the water and deposit them onto land where they can be disposed. Harvesting has not proven to be an effective means of sustaining long-term reductions for plants such as coontail and Eurasian watermilfoil because they can propagate from fragments generated from mechanical harvesting. Fragments from harvesting may cause coontail or Eurasian watermilfoil to regrow to pre-harvest levels or to spread to new areas and increase coverage of these species within a lake. Hence, harvesting is not a feasible option for Kohlman Lake because fragments from coontail and Eurasian watermilfoil harvesting may increase the coverage of these species within the lake.

Rotovation/cultivation (underwater rototilling) are bottom tillage methods that remove aquatic plant root systems. This results in reduced stem development and seriously impairs growth of rooted aquatic plants. Derooting methods were developed by aquatic plant experts within the British Columbia Ministry of Environment as an alternative to harvesting. Essentially two types of tillage machinery have been developed. Deep water tillage is performed in water depths of 1.5 to 11.5 feet using a barge-mounted rototiller equipped with a 6-10 foot wide rotating head. Cultivation in shallow water depths up to a few meters is accomplished by means of an amphibious tractor or modified WWII "DUCW" vehicle towing a cultivator. Both methods involve tilling the sediment to a depth of 4-6 inches, which dislodges plants including roots. Certain plants like Eurasian watermilfoil have roots that are buoyant and float on the surface where they can be collected.

Treatments are made in an overlapping swath pattern. Bottom tillage is usually performed in the cold "off-season" months of winter and spring to reduce plant growth potential.

Bottom tillage has been used effectively for long-term control of Eurasian watermilfoil where populations are well-established and prevention of stem fragments is not critical. Single treatments using a crisscross pattern have resulted in Eurasian watermilfoil stem density reductions of 80-97 percent in bottom tillage treatments (Gibbons et al., 1987 and Maxnuk, 1979). Depending on plant density, carryover effectiveness of rototilling can persist for up to 2 to 3 years without retreatment. Following treatment, rotovated areas in Washington and British Columbia have shown increases in native plant species diversity, (Gibbons et al., 1994). Rototilling is not advised where bottom sediments have excessive nutrient and/or metals concentrations, because of potential release of nutrients and contaminants into the overlying water. The method results in the production of plant fragments, and is not recommended for use in water bodies with new or sparse Eurasian watermilfoil infestations or where release of fragments is a concern. Bottom tillage is not a feasible option for Kohlman Lake because of the high nutrient concentration of Kohlman Lake sediment that could potentially be transported to the water column during operations.

Diver dredging utilizes a small barge or boat carrying portable dredges with suction heads that are operated by scuba divers to remove individual rooted plants (including roots) from the sediment. Divers physically dislodge plants with sharp tools. The plant/sediment slurry is then suctioned up and carried back to the barge through hoses operated by the diver. On the barge, plant parts are sieved out and retained for later off-site disposal. The water sediment slurry can be discharged back to the water or piped off-site for upland disposal. Diver dredging can be highly effective under appropriate conditions (Gibbons et al., 1994). Efficiency of removal is dependent on sediment conditions, density of aquatic plants and underwater visibility (Cooke et al., 1993). As it is best used for localized infestations of low plant density where fragmentation must be minimized, the technique has great potential for milfoil control. Depending on local conditions, milfoil removal efficiencies of 85-97 percent can be achieved by diver dredging (Maxnuk 1979). Diver dredging is not feasible for Kohlman Lake because it is exclusively used to control Eurasian watermilfoil, and other problematic species (i.e., Curlyleaf pondweed), in addition to Eurasian watermilfoil, are found in Kohlman Lake.

5.3.3 Biological

Biological control involves the use of biological agents to control aquatic plant growth. Biological controls include predation by herbivorous fish, mammals, waterfowl, insects and other invertebrates, diseases caused by microorganisms, and competition from other aquatic plants (Little, 1968). The most widely used biological control agent is herbivorous fish, particularly grass carp. Use of grass carp as a biological control agent is not allowed in Minnesota. In addition, carp species have been shown to increase the transfer of phosphorus (from internal loading) to the surface water in lakes (LaMarra, 1975) unless the sediment has been treated with alum (Steinman, 2004). Weevils have been used experimentally to control Eurasian watermilfoil (not eliminate) with some success (Creed et al., 1995; Newman et al., 1995; Newman, 1999).

5.3.4 Chemical

Aquatic vegetation management programs that use chemical control methods are widespread, being the preferred method of control in many areas. Chemical control involves the use of a herbicide (i.e., a plant-killing chemical) that is applied in liquid, granular, or pellet form. Herbicides are of two types, systemic herbicides and contact herbicides. Systemic herbicides, such as 2,4-D, triclopyr, fluoridone, and glyphosate, are absorbed by and translocated throughout the plant, capable of killing the entire plant (roots and shoots). In contrast, contact herbicides, such as diquat and endothall, kill the plant surface with which it comes in contact, leaving roots alive and capable of regrowth. The aquatic plants (sometimes only stems and leaves) die and decompose in the lake. To reduce human exposure to the chemicals, temporary water-use restrictions are imposed in treatment areas whenever herbicides are used. Only herbicides for aquatic use are allowed, and any use of an herbicide requires a MNDNR permit. Use of the herbicides endothall (Aquathol K) and DMA 4 (liquid 2,4-D) or triclopyr can be used to treat selected macrophytes in Kohlman Lake.

Mechanical, physical, and chemical aquatic plant control techniques and estimated costs are summarized in Table 13. The costs provide a relative cost comparison between the various techniques.

Table 15 Mechanical, physical, and chemical macrophyte control techniques and their associated costs

Control Technique	Procedure	Cost	Advantages	Disadvantages
Mechanical and Physical Removal			**+Immediate plant removal and creation of open water** **+No interference with water supplies or water-use**	**-– Creates plant fragments** **– Usually disturbs sediments, affecting biota and causing short-term turbidity** **– Plant disposal necessary**
Harvesting	Plant stems and leaves cut up to 8 ft below water surface, collected and removed from lake	Cut from 1 to 2 acre/day @ 1500/day New machine: $100,000-120,000	+Relatively low operational cost	– Can get regrowth within 4 weeks – Removes small fish, turtles, etc. – Plant fragments may cause spread of Eurasian watermilfoil
Hydro-raking	Mechanical rake removes plants up to 14 ft below water surface and deposits them on shore	Rake up to 1 ac/day @ $1800-2500 per acre	+Longer lasting control than harvesting because of root removal	– Regrowth by end of growing season
Rotovating	Sediment is "tilled" to a depth of 4"-6" to dislodge plant roots and stems Can work in depths up to 17 ft	Can do up to 2-3 ac/day @$700–$1,200/acre Cost of new machine is $120,000+	+Immediate 85% – 95% decrease in stem density +Up to 2 years control +Frequently done in fall when plant fragments not viable	--Plant fragmnets - -Sediment nutrient disturbance
Hydraulic Dredging	Steel cutter blade dislodges sediment and plants; removed by a suction pump	$3,000/acre and up Cost of new machine is $120,000+	+90% effective at root removal, with plant regrowth probable within 1 year	– Expensive

Table 15 (continued) Mechanical, physical, and chemical macrophyte control techniques and their associated costs

Control Technique	Procedure	Cost	Advantages	Disadvantages
Diver-operated Suction Harvesting	Scuba divers use 4" suction hose to selectively remove plants from lake bottom Plants disposed of on shore	Cost is $1000–$12,000/acre depending on cost of divers, type of sediments, travel time, etc. Cost of new machine $20,000+	+Up to 97% effective at removing plant roots and stems +1–2 years of control +Can work in areas with underwater obstruction	– Effectiveness varies greatly with type of sediment – Slow and labor intensive – Expensive – Potentially hazardous because of scuba
Handpulling	Plants and roots are removed by hand using snorkeling and wading Plants disposed of on shore	Variable, depending on volunteers; divers cost $18-$75/hr	+Most effective on newly established populations of EWM that are scattered in density +Volunteers can keep cost down +Long term control if roots removed	– Too slow and labor intensive to use on large scale – Short-term turbidity makes it difficult to see remaining plants
Chemical Treatment			**+ Doesn't interfere with underwater obstructions**	**– Affects water-use; can be toxic to biota** **– Plants remain in lake and decompose, which can cause oxygen depletion late in the season**
2,4-D (Aquakleen, Aquacide, Navigate)	Systemic herbicide available in liquid and pellet form that kills plants by interfering with cell growth and division Can be applied at surface or subsurface in early spring as soon as plants start to grow, or later in the season	$350–$700/acre depending on plant density and water depth; cost does not include collection or analysis of water samples, which may be required	+Under favorable conditions can see up to 100% decrease +Kills roots and root crowns +Fairly selective for EWM	– Plants decompose over 2-3 weeks

Table 15 (continued) Mechanical, physical, and chemical macrophyte control techniques and their associated costs

Control Technique	Procedure	Cost	Advantages	Disadvantages
Tripclopyr (Garlon 3A)	Liquid systemic herbicide that kills plants by interfering with hormones that regulate normal plant growth	$75/gal or $1200-$1700/acre, depending on water depth, concentration of chemical, etc.	+Effectively removes up to 99% of EWM biomass 4 weeks after treatment +Fast-acting herbicide +Kills roots and root crowns +Fairly selective for EWM	– No domestic-use of water within 1 mile of treated area for 21 days after treatment – No fishing in treated area for 30 days after treatment – Expensive
Fluridone (Sonar)	Systemic herbicide available in liquid and pellet form that inhibits a susceptible plant's ability to make food Can be applied to surface or subsurface in early spring as soon as plants start to grow	$500-$1500/acre depending on water depth and formulation	+Can be applied near water intakes if concentration is less than 20 ppb +Under favorable conditions susceptible species may decrease 100% after 6-10 weeks +Control lasts 1-2 years depending supplemental hand removal +Because slow-acting, low oxygen generally not a problem	– Long contact time required; may take up to 3 months to work – Potential risk to human health remains controversial -– Not selective for milfoil -– Spot treatments generally not effective
Endothal (Aquathol and Aquathol K)	Granular (Aquathol) and liquid (Aquathol K) kills plants on contact by interfering with protein synthesis	$300-$700/acre depending on treatment area and use of adjuvants	+Under favorable conditions can see up to 100% decrease +Fast-acting herbicide	– Regrowth within 30 days – Not selective for milfoil – Does not kill roots; only leaves and stems that it contacts – No swimming for 24 h, no fishing for 3 days
Control Technique	**Procedure**	**Cost**	**Advantages**	**Disadvantages**
Diquat (Reward)	Liquid kills plants on contact by interfering with photosynthesis Can be applied to surface or subsurface when water temperature is at least 65°F	$200-$500/acre	+Fast-acting herbicide +Relatively cheap per acre	– Retreatment within same season may be necessary – Not selective for milfoil – Does not kill roots; only leaves and stems that it contacts – No swimming for 24 h, no drinking for 14 days – Toxic to wildlife

5.4 Management Plan

The Kohlman Lake Aquatic Plant Management Plan (APMPP) outlines management practices required to achieve water quality goals within the lake. Nearly the entire lake area (besides the small deep hole) contains macrophytes and is considered to be littoral (i.e., <15 feet). The initial reduction of Eurasian watermilfoil and Curlyleaf pondweed is necessary to improve settling of alum during treatment to reduce internal phosphorus loading. Management of these species will also ensure that proliferation does not occur after water clarity increases in the lake. This is also applicable if dredging is used in place of alum to reduce internal phosphorus loading. The following APMPP describes practices that are needed to attain and sustain water quality in the lake.

5.4.1 Invasive Species Reduction and Annual Maintenance

The long-term improvement program is comprised of a series of intensive, annual chemical treatments to Kohlman Lake to reduce invasive species and improve water quality in the lake. Endothall, along with liquid 2,4-D or Triclopyr will be used to achieve reductions in both Eurasian watermilfoil and Curlyleaf pondweed.

Triclopyr and liquid 2,4-D perform the same function and have the same result in the treatment of Eurasian watermilfoil. Triclopyr is slightly more expensive than liquid 2,4-D. For this reason, liquid 2,4-D is the preferable choice of chemical whenever it is available. However, a recent interpretation of the label restrictions for liquid 2,4-D by the Minnesota Department of Agriculture prevents the use of liquid 2,4-D in Minnesota until the product is relabeled. At issue is the meaning of the term "active irrigation intake." The intent of the current label restriction is to disallow the use of liquid 2,4-D whenever lake water is withdrawn for irrigation of plants on riparian properties while the concentration of the 2,4-D in the lake is high enough to cause damage or death to any plants receiving irrigation waters. Once the concentration of liquid 2,4-D decreases below a threshold level of 0.1 ppm, irrigation is safe and there is no restriction. Active irrigation intake as used on the current label means an irrigation intake in use while the concentration of liquid 2,4-D in the lake is above the safety threshold level of 0.1 ppm. The Minnesota Department of Agriculture has interpreted the term to mean any irrigation intake that could potentially be used at any time during the ice free season. This broader definition of the term disallows the use of liquid 2,4-D on Minnesota lakes. An update to the labeling of 2,4-D is in progress and is expected to be completed by the spring of 2009. Until the new label clarifies the meaning of active irrigation intake, liquid 2,4-D can not be used in Minnesota unless there are no intakes at the treated water body. Thus, Triclopyr will be used for the treatment of Kohlman Lake in 2008. Liquid 2,4-D will be used for Kohlman Lake treatments occurring after the product label is updated.

The annual maintenance program will prevent nuisance growth and sustain the water quality of Kohlman Lake by treatment of the lake area for both Eurasian watermilfoil and Curlyleaf pondweed. The program is designed to continue limiting the growth of Eurasian watermilfoil and Curlyleaf pondweed after water clarity increases due to decreased phosphorus input and improved water clarity. Program details are as follows:

- Chemically treat Kohlman Lake intensively for approximately three years to reduce Curlyleaf pondweed and Eurasian watermilfoil.
- Inspect the lake through annual surveys specifically monitoring areas of Eurasian watermilfoil and Curlyleaf pondweed growth and spot treat an additional 2-3 years.
- If Eurasian watermilfoil or Curlyleaf pondweed growth is detected after the initial treatment schedule, spot treatments will be conducted.

5.4.2 Treatment Dose Recommendations and Considerations

In order to provide efficient and effective management of Eurasian watermilfoil and Curlyleaf pondweed, treatment must be designed properly. The combined treatment of Endothall and liquid 2,4-D or Triclopyr will target both these plants but the concentration in the water column must be maintained for a specified period for treatment to be as effective as possible. The following doses of each herbicide and duration of treatment are recommended for Kohlman Lake:

- Endothall – 1.0 mg/L for 48 hours
- Liquid 2,4-D or Triclopyr – 0.5 mg/L for 48 hours

Treatment should be conducted during early spring when Curlyleaf pondweed and Eurasian watermilfoil are growing but native species are not and before water temperatures reach 58 to 60 degrees F. In addition, Endothall will kill the roots of the plants first when temperatures are colder (~54 degrees F or less). With these requirements in mind, treatment should be conducted before temperatures reach 58 degrees.

It is possible that large flows into Kohlman Lake (mainly from Kohlman Basin) will result in dilution of the herbicides that are applied to the lake. It will be necessary to monitor flows into Kohlman Lake to determine whether doses need to be adjusted upwards in order to maintain the prescribed herbicide levels for the required contact times. Two options exist to provide adequate dose under higher flow conditions. Granular herbicide near the inlet to Kohlman Lake from Kohlman Basin can be applied to help keep the doses within the proper range. Alternatively, adjusting the liquid doses applied to the entire lake based on the amount of dilution water entering the system can be done as well. This appears to be the better option because the monitoring station at the outlet from Kohlman basin can be used to estimate the additional amount of herbicide needed during the treatment timeframe.

5.4.3 Contingency Plan

Flow entering Kohlman Lake will be used to volume average the amount of herbicide to be applied and calculate additional herbicide needed to maintain proper dose for macrophyte control. The herbicide applicator will be required to adjust the dose based on monitored flow before and during treatment. It is recommended that treatment occur when flow from Kohlman Basin ranges from 0 to 50 cubic feet per second. It is further recommended that treatment dose be adjusted, based upon flow, as follows:

Endothall – Dose of 1.0 to 1.3 ppm depending upon flow from Kohlman Basin

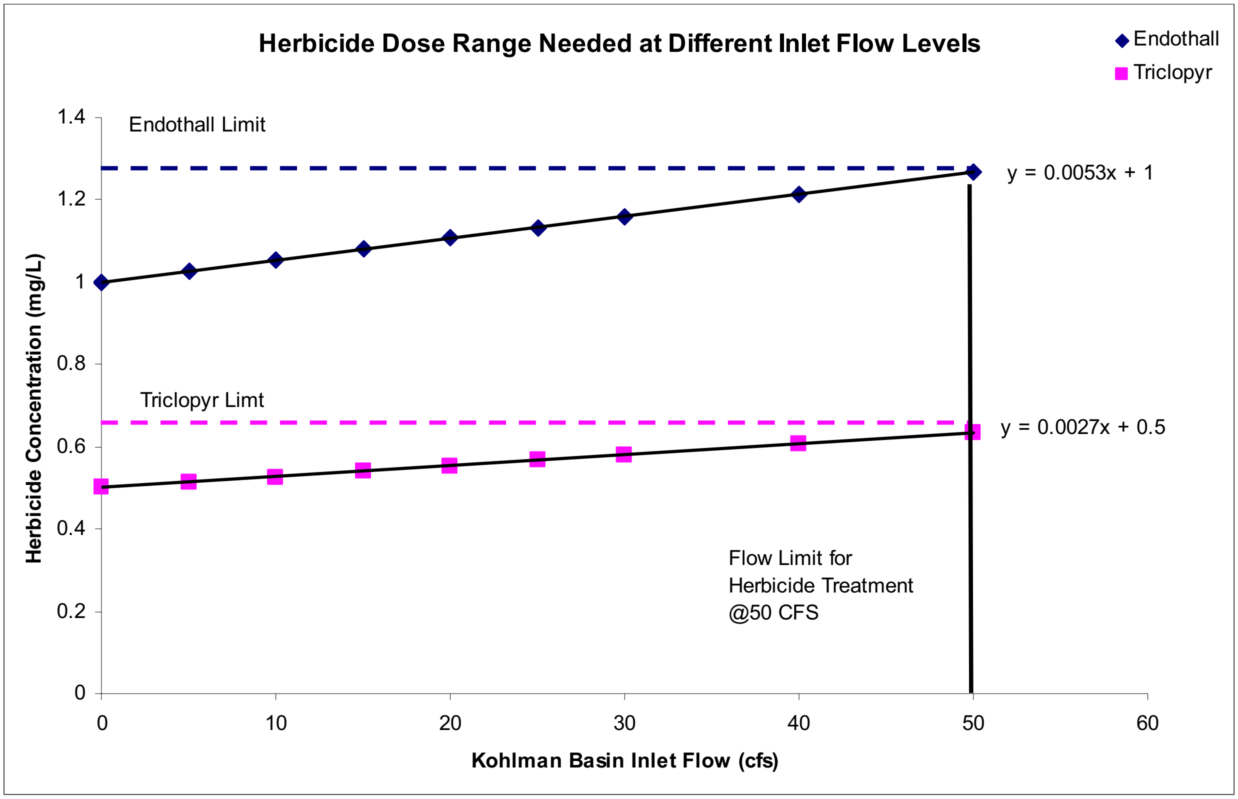
Triclopyr or liquid 2,4-D—Dose of 0.5 to 0.65 ppm depending upon flow from Kohlman Basin.

The dosing rate can be adjusted using the following information (Figure 11) for flow into the lake from Kohlman Basin. Using previous modeling work completed for Kohlman Lake, a total volume of water replaced by inflows can be determined based on the flow coming just from Kohlman Basin at the current monitoring station location.

Additionally, if flow rate coming from Kohlman Basin is too high, stop logs can be added to retain some of the water within Kohlman Basin, thereby reducing overall flow.

If flow into Kohlman Lake is too high in the spring such that application can not occur before water temperature reaches 58 degrees Fahrenheit, herbicide application will be postponed until the following spring.

Figure 11 Herbicide dose range depending upon inflow from Kohlman Basin to Kohlman Lake



5.4.4 Herbicide Use and Restrictions

2,4-D and Triclopyr are selective, systemic herbicides and are biodegradable compounds with residues that are non-persistent in water. Both have a relatively short half-life, 2,4-D averaging 10 days and Triclopyr ranging from less than one day to 7.5 days in water. Both UV light and microorganisms living in the water cause degradation of the herbicides. They convert Triclopyr to carbon dioxide and water and convert 2,4-D to to carbon dioxide, water, and chlorine after application. 2,4-D and Triclopyr selectively kill Eurasian watermilfoil by mimicking the plant hormone auxin, which causes uncontrolled growth and eventually death. Provided sufficient herbicide is conveyed to the plant and root crown, both plant and root crown are destroyed. Other broad leaf species, such as waterlilies, may be affected which is why it is important to apply this herbicide in the early spring when Eurasian watermilfoil is present and most other aquatic plants are not.

Endothall (Aquathol K) is classified as a contact herbicide and works by inactivating plant protein synthesis. Endothall works well when targeting Curlyleaf pondweed, as it is selective for this species.

Other species, such as Naiads may be affected which is why it is important to apply this herbicide in the early spring when Curlyleaf pondweed is present and most other aquatic plants are not.

During and after treatment, a number of restrictions on water use will need to be implemented. There is currently a setback requirement of 1,500 feet with liquid 2,4-D (DMA 4) and irrigation intakes within 1500 feet of the treatment area will need to be shut off until herbicide concentration drops below 0.1 mg/L. No swimming will be allowed for 48 hours and no fishing for 3 days after the end of the treatment period. The RWMWD will require the herbicide applicator, as part of the subcontractor contract, to post advisories at potential public access points and actions will be taken by the District to prevent boat traffic from entering Kohlman Lake during and at least 3 days after treatment.

5.4.5 Treatment Monitoring

Monitoring in Kohlman Lake will be conducted during and after treatment to ensure that proper doses are maintained and eventual breakdown of the herbicide occurs so that concentrations are at levels that allow lake activities to resume. Oxygen levels will be measured in the water following treatment to ascertain that plant degradation does not reduce the lake's oxygen concentrations.

Treatment monitoring will be conducted at one day and 3 days after the herbicide combination is applied to the lake water to determine if proper doses are being maintained. Monitoring will also be conducted at 7, 14, and 21 days after treatment to ensure breakdown of the compounds occurs. If complete breakdown has not occurred by the last sampling period, additional samples will be collected at weekly intervals until this occurs. Samples will be collected at mid-depth of the water column at three sampling location (see Figure 12).

Dissolved oxygen concentrations will be measured at one meter intervals from the surface to the bottom of the lake at each of the three sample locations whenever samples are collected. Plant degradation following treatment is expected to be slow due to the cold water temperatures and no impact on the lake's oxygen concentrations is expected to result from the treatment. The oxygen measurements will provide confirming evidence that the lake's oxygen concentration is not reduced by the treatment.

2006 Aerials Express Photo

Residual Herbicide Monitoring Locations 2008

Meters

100 0 100 200

Figure 12
HERBICIDE RESIDUE MONITORING LOCATIONS 2008
Kohlman Lake
Ramsey-Washington Metro Watershed District

5.5 Risk Assessment

5.5.1 No Treatment Option

The 'no treatment' option for Kohlman Lake consists of not managing the macrophyte community before or after alum treatment. A number of problems may occur if this track is chosen including: (1) inability of the alum floc to properly settle from the water column into the sediment and (2) proliferation of invasive species Curlyleaf pondweed and Eurasian watermilfoil due to expected water clarity increase after alum treatment. Both of these potential problems can reduce the effectiveness of alum treatment either directly (floc settling) or indirectly (increase in macrophyte transfer of phosphorus from the sediment to the water column).

5.5.2 Lower Than Expected Performance

If the herbicide treatment in Kohlman Lake does not perform as expected, it is possible that alum settling will be adversely affected. It is also possible that Curlyleaf pondweed and Eurasian watermilfoil coverage and density will increase if management performance is poor. However, since the herbicides that will be used are selective for these aquatic plants, it is unlikely treatment will be unsuccessful if designed properly. Proper design must address season of application, temperature, water chemistry, desired concentration, and the effect of high volume flows coming from Kohlman Basin (especially in the spring during expected application) will have on treatment.

5.5.3 Expected Performance

Initially, plant coverage and density will decline due to the reduction of invasive species. It is entirely possible (and expected) that native species will replace the invasive aquatic species and overall coverage of aquatic plants may not decrease in the long run. Because water clarity is expected to increase after alum treatment, native species may be able to colonize the entire sediment surface in the lake. Without the nuisance aspects and negative effects on water quality, however, native species colonization will help to create a more natural macrophyte community.

5.5.4 Herbicide Application

The herbicides being applied are approved by the U.S. Environmental Protection Agency for the uses intended in this plan. Chemical management techniques have changed dramatically since the 1960s and 1970s and increased concern changed the review process for chemicals used in water. No product can be labeled for aquatic use if it poses more than a one in a million chance of causing significant damage to the environment, human health, or wildlife resources. In addition, only chemicals with no evidence of biomagnification, bioavailability or persistence in the environment are allowed for use in aquatic systems. The herbicides recommended for use in this management plan, Endothall, 2,4-D, and Triclopyr break down quickly in the environment and pose no long term risks to life in, or around the lake.

5.5.5 High Flow Conditions and Water Temperature

Due to the large watershed that drains to Kohlman Lake, the potential exists for high flows that present risks both before and after application. These risks include: (1) high flow after treatment from a major rainstorm, which conveys herbicide to Gervais before sufficient contact time needed to attain treatment goal potentially causing failure, and (2) water temperature may rise to 58 degrees before flow declines to threshold level needed to maintain proper herbicide dose. If the second condition occurs, the project will be delayed until the following spring.

5.6 Treatment Effectiveness Monitoring Program

An evaluation program is recommended to evaluate the effectiveness of the treatment outlined herein and to comply with the requirements set by the MDNR for herbicide application. The evaluation program consists of the following:

A pretreatment aquatic plant survey will be completed after the water temperature reaches 48 degrees Fahrenheit. The primary purpose of the survey is to determine Curlyleaf pondweed and Eurasian watermilfoil coverage and biomass prior to treatment. The survey will also determine native species present at the time of treatment. A point intercept survey will be used. Sample locations are shown in Figure 3. Sample methods will duplicate methods used for the 2006 aquatic plant survey. Survey data collected during the pretreatment survey will be mapped to determine Eurasian watermilfoil and Curlyleaf pondweed coverage.

During the early spring sampling event, biomass samples will be collected from 35 randomly selected sample locations (Figure 13). Sample locations will be limited to locations containing Eurasian watermilfoil and/or Curlyleaf pondweed. The purpose of limiting sample locations to locations containing Eurasian watermilfoil and/or Curlyleaf pondweed is to insure that the data adequately show treatment effectiveness. Samples will be collected using a rake attached to a pole. At each sample point, the rake will be lowered from the boat perpendicular to the bottom and then raised up to the water surface while slowly being twisted in a clockwise direction. Plant species from each sample will be separated into species and oven-dried to a constant weight

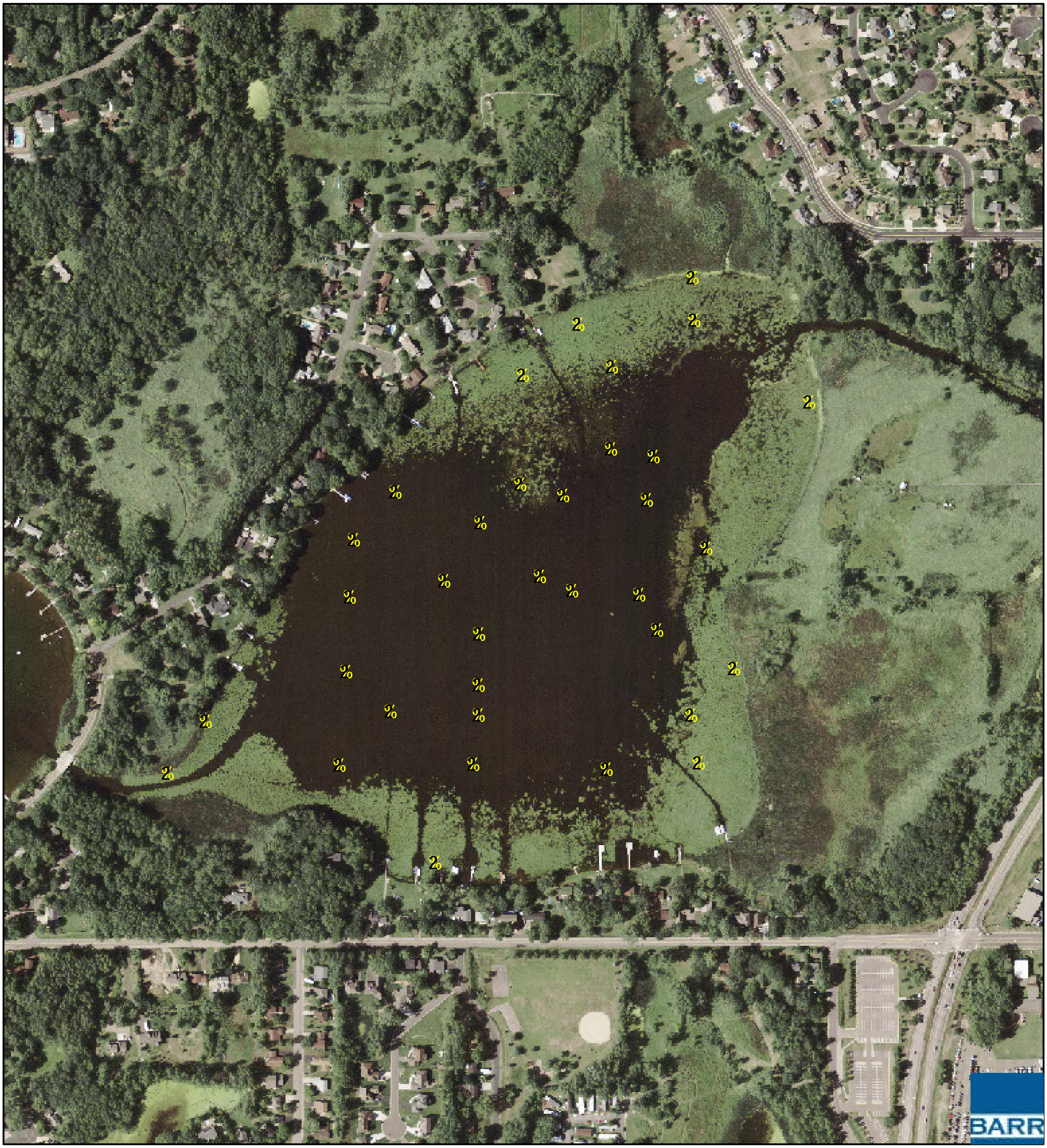
An aquatic plant survey of Kohlman Lake will be completed during June and August. Sample locations and survey methods will duplicate the 2006 Kohlman Lake aquatic plant survey. Additional samples collected in 2008 that were not collected during 2006 are detailed in the following paragraphs.

MDNR requires the collection of herbarium specimens. Hence, a herbarium specimen of each plant species identified in the 2008 June and August survey will be collected, pressed, mounted, labeled, and submitted to the MDNR.

Relative plant abundance will be evaluated by quantifying the amount of plant material collected at each June and August sample point. During each sample event, biomass samples will be collected from 35 randomly selected sample locations (Figure 13). Samples will be collected using a rake attached to a pole. At each sample point, the rake will be lowered from the boat perpendicular to the bottom and then raised up to the water surface while slowly being twisted in a clockwise direction. Plant species from each sample will be separated and oven-dried to a constant weight.

During the fall (October), turion samples will be collected from 35 randomly selected sample locations (Figure 13). Samples will be processed and the number of turions at each sample location will be determined.

The monitoring program will be repeated during each year in which treatment occurs. However, beginning in 2009, a modified point intercept survey will be used for the pre treatment spring monitoring event. Whenever a Curlyleaf pondweed or Eurasian watermilfoil plant is collected, additional samples will be collected in the surrounding area to define the plant growth boundaries. If a pattern of maximum depth is evident, additional samples will be collected along the depth boundary to delineate the maximum depth of Eurasian watermilfoil and Curlyleaf pondweed growth. If Eurasian watermilfoil or Curlyleaf pondweed plants are observed between point intercept points, additional samples will be collected to define the growth areas. Sampling staff will use the guidance provided in this paragraph to determine a system and method that works well to define Eurasian watermilfoil and Curlyleaf pondweed growth areas within Kohlman Lake. Because a whole lake treatment may not be necessary in 2009 and subsequent years for Eurasian watermilfoil, the data will be used to determine areas requiring treatment.



2006 Aerials Express Photo

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Biomass and Turion Sample Locations 2008

Meters

100 0 100 200

Figure 13
BIOMASS AND TURION SAMPLE LOCATIONS 2008
Kohlman Lake
Ramsey-Washington Metro Watershed District

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Appendices

Appendix A

Summary Data

Frequency of Occurrence and Diversity-June

June 2001

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	88	39.2	0.3922	0.1539
Eurasian watermilfoil	68	30.3	0.3031	0.0919
Flatstem pondweed	10	4.5	0.0446	0.0020
Common duckweed	3	1.3	0.0134	0.0002
White waterlily	16	7.1	0.0713	0.0051
Small Pondweed	13	5.8	0.0579	0.0034
Canadian Waterweed	12	5.3	0.0535	0.0029
Sago pondweed	6	2.7	0.0267	0.0007
Columbian watermeal	2	0.9	0.0089	0.0001
Yellow waterlily	2	0.8	0.0079	0.0001
Cattail	1	0.4	0.0045	0.0000
Curlyleaf pondweed	2	0.7	0.0071	0.0001
Needle spike rush	1	0.4	0.0045	0.0000
Horned pondweed	1	0.4	0.0045	0.0000
TOTAL	224	98.0	0.9796	0.2600
	Diversity = 1 - sum of (rf/100)^2		Diversity	0.73995

June 2002

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	82	32.4	0.3241	0.1050
Eurasian watermilfoil	62	24.5	0.2452	0.0601
Curlyleaf pondweed	28	11.1	0.1109	0.0123
White waterlily	26	10.2	0.1022	0.0104
Flatstem pondweed	12	4.7	0.0467	0.0022
Canadian Waterweed	10	4.0	0.0395	0.0016
Common duckweed	10	3.8	0.0380	0.0014
Small Pondweed	6	2.3	0.0234	0.0005
Great duckweed	4	1.8	0.0175	0.0003
Horned pondweed	4	1.5	0.0146	0.0002
Sago pondweed	3	1.2	0.0117	0.0001
Yellow waterlily	2	0.9	0.0088	0.0001
Cattail	2	0.9	0.0088	0.0001
Reed canary grass	1	0.6	0.0058	0.0000
Muskgrass	1	0.3	0.0029	0.0000
TOTAL	254	98.2	0.9825	0.1944
	Diversity = 1 - sum of (rf/100)^2		Diversity	0.80564

June 2003

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	90	33.5	0.3352	0.1124
Eurasian watermilfoil	40	15.0	0.1500	0.0225
Common duckweed	26	9.7	0.0970	0.0094
White waterlily	23	8.5	0.0853	0.0073
Flatstem pondweed	22	8.2	0.0823	0.0068
Curlyleaf pondweed	17	6.5	0.0647	0.0042
Columbian watermeal	16	5.9	0.0588	0.0035
Sago pondweed	11	4.1	0.0412	0.0017
Great duckweed	8	2.9	0.0294	0.0009
Small Pondweed	7	2.6	0.0265	0.0007
Yellow waterlily	3	1.2	0.0118	0.0001
Canadian Waterweed	2	0.9	0.0090	0.0001
Cattail	1	0.3	0.0029	0.0000
Reed canary grass	1	0.3	0.0029	0.0000
Needle spike rush	1	0.3	0.0029	0.0000
TOTAL	268	100.0	1.0000	0.1695
	Diversity = 1 - sum of (rf/100)^2		Diversity	0.83050

June 2004

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	86	38.7	0.3874	0.1501
Eurasian watermilfoil	37	16.6	0.1656	0.0274
Curlyleaf pondweed	35	15.6	0.1556	0.0242
White waterlily	27	12.3	0.1225	0.0150
Small Pondweed	18	8.3	0.0828	0.0069
Flatstem pondweed	14	6.3	0.0629	0.0040
Canadian Waterweed	2	1.0	0.0099	0.0001
Common duckweed	1	0.7	0.0066	0.0000
Yellow waterlily	1	0.7	0.0066	0.0000
TOTAL	222	100.0	1.0000	0.2277
	Diversity = 1 - sum of (rf/100)^2		Diversity	0.77227

June 2006

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	76	24.4	0.2437	0.0594
Curlyleaf pondweed	73	23.2	0.2322	0.0539
Flatstem pondweed	40	12.9	0.1287	0.0166
White waterlily	40	12.6	0.1264	0.0160
Eurasian watermilfoil	35	11.0	0.1103	0.0122
Common duckweed	22	7.1	0.0713	0.0051
Sago pondweed	19	6.0	0.0598	0.0036
Great duckweed	4	1.4	0.0138	0.0002
Yellow waterlily	3	0.9	0.0092	0.0001
Columbian watermeal	1	0.5	0.0046	0.0000
TOTAL	313	100.0	1.0000	0.1670
	Diversity = 1 - sum of (rf/100)^2		Diversity	0.83303

Frequency of Occurrence and Diversity-August

August 2001

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	75	28.1	0.2809	0.0789
Eurasian watermilfoil	62	23.1	0.2306	0.0532
Flatstem pondweed	25	9.2	0.0917	0.0084
Common duckweed	21	7.7	0.0769	0.0059
White waterlily	20	7.4	0.0739	0.0055
Small Pondweed	19	7.1	0.0710	0.0050
Canadian Waterweed	17	6.2	0.0621	0.0039
Sago pondweed	8	3.0	0.0296	0.0009
Columbian watermeal	8	3.0	0.0296	0.0009
Great duckweed	6	2.4	0.0237	0.0006
Yellow waterlily	2	0.7	0.0066	0.0000
Cattail	2	0.7	0.0066	0.0000
Curlyleaf pondweed	2	0.6	0.0059	0.0000
Slender Naid	2	0.6	0.0059	0.0000
Stonewart	1	0.3	0.0030	0.0000
Muskgrass	1	0.2	0.0022	0.0000
TOTAL	268	97.6	0.9765	0.1631
	Diversity = 1 - sum of (rf/100)^2		**Diversity**	**0.83687**

August 2002

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	81	29.8	0.2982	0.0889
Eurasian watermilfoil	62	22.6	0.2264	0.0513
Common duckweed	32	11.6	0.1160	0.0135
White waterlily	29	10.5	0.1049	0.0110
Flatstem pondweed	17	6.1	0.0609	0.0037
Curlyleaf pondweed	3	1.1	0.0110	0.0001
Columbian watermeal	27	9.9	0.0994	0.0099
Sago pondweed	2	0.6	0.0055	0.0000
Small Pondweed	2	0.8	0.0083	0.0001
Yellow waterlily	1	0.3	0.0028	0.0000
Canadian Waterweed	14	5.0	0.0497	0.0025
Cattail	2	0.8	0.0083	0.0001
Reed canary grass	1	0.2	0.0022	0.0000
Needle spike rush	1	0.2	0.0022	0.0000
Slender Naid	1	0.4	0.0042	0.0000
TOTAL	272	99.6	0.9958	0.1810
	Diversity = 1 - sum of (rf/100)^2		**Diversity**	**0.81895**

August 2003

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	85	37.9	0.3788	0.1435
White waterlily	34	14.9	0.1488	0.0221
Eurasian watermilfoil	31	13.5	0.1353	0.0183
Common duckweed	27	12.2	0.1217	0.0148
Flatstem pondweed	25	11.2	0.1116	0.0125
Columbian watermeal	11	4.7	0.0473	0.0022
Canadian Waterweed	3	1.4	0.0135	0.0002
Small Pondweed	3	1.3	0.0125	0.0002
Yellow waterlily	2	1.0	0.0101	0.0001
Slender Naid	2	0.7	0.0068	0.0000
Cattail	2	0.7	0.0068	0.0000
Curlyleaf pondweed	1	0.3	0.0034	0.0000
Sago pondweed	1	0.3	0.0034	0.0000
TOTAL	226	100.0	1.0000	0.2140
	Diversity = 1 - sum of (rf/100)^2		**Diversity**	**0.78603**

August 2004

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	79	30.6	0.3057	0.0935
White waterlily	36	13.7	0.1371	0.0188
Eurasian watermilfoil	33	12.6	0.1257	0.0158
Common duckweed	32	12.3	0.1229	0.0151
Flatstem pondweed	26	10.0	0.1000	0.0100
Great duckweed	17	6.6	0.0657	0.0043
Columbian watermeal	13	4.9	0.0486	0.0024
Canadian Waterweed	10	4.0	0.0400	0.0016
Curlyleaf pondweed	4	1.4	0.0143	0.0002
Sago pondweed	4	1.4	0.0143	0.0002
Small Pondweed	4	1.4	0.0143	0.0002
Yellow waterlily	1	0.6	0.0057	0.0000
Slender Naid	1	0.3	0.0029	0.0000
Star duckweed	1	0.3	0.0029	0.0000
TOTAL	259	100	1.000	0.16211
	Diversity = 1 - sum of (rf/100)^2		**Diversity**	**0.83789**

September 2006

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Coontail	81	29.086	0.291	0.085
Eurasian watermilfoil	61	21.884	0.219	0.048
White waterlily	42	15.235	0.152	0.023
Flatstem pondweed	42	14.958	0.150	0.022
Common duckweed	38	13.850	0.139	0.019
Columbian watermeal	5	1.939	0.019	0.000
Great duckweed	5	1.662	0.017	0.000
Small pondweed	3	1.108	0.011	0.000
Elodea	1	0.277	0.003	0.000
TOTAL	278	100	1.000	0.198
	Diversity = 1 - sum of (rf/100)^2		**Diversity**	**0.80196**

Floristic Quality Index-June

June 2001

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Yellow waterlily	8	1	8
Small Pondweed	7	1	7
Needle spike rush	7	1	7
Horned pondweed	7	1	7
Flatstem pondweed	6	1	6
White waterlily	6	1	6
Columbian watermeal	5	1	5
Common duckweed	4	1	4
Coontail	3	1	3
Canadian Waterweed	3	1	3
Sago pondweed	3	1	3
Cattail	1	1	1
Eurasian watermilfoil	0	1	0
Curlyleaf pondweed	0	1	0
Mean C	4.3		
N	14		
FQI	16.0		

June 2002

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Eurasian watermilfoil	0	1	0
Curlyleaf pondweed	0	1	0
White waterlily	6	1	6
Flatstem pondweed	6	1	6
Canadian Waterweed	3	1	3
Common duckweed	4	1	4
Small Pondweed	7	1	7
Great duckweed	5	1	5
Horned pondweed	7	1	7
Sago pondweed	3	1	3
Yellow waterlily	8	1	8
Cattail	1	1	1
Muskgrass	7	1	7
Mean C	4.3		
N	14		
FQI	16.04		

June 2003

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Eurasian watermilfoil	0	1	0
Common duckweed	4	1	4
White waterlily	6	1	6
Flatstem pondweed	6	1	6
Curlyleaf pondweed	0	1	0
Columbian watermeal	5	1	5
Sago pondweed	3	1	3
Great duckweed	5	1	5
Small Pondweed	7	1	7
Yellow waterlily	8	1	8
Canadian Waterweed	3	1	3
Cattail	1	1	1
Needle spike rush	7	1	7
Mean C	4.1		
N	14		
FQI	15.5		

June 2004

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Eurasian watermilfoil	0	1	0
Curlyleaf pondweed	0	1	0
White waterlily	6	1	6
Small Pondweed	7	1	7
Flatstem pondweed	6	1	6
Canadian Waterweed	3	1	3
Common duckweed	4	1	4
Yellow waterlily	8	1	8
Mean C	4.1		
N	9.0		
FQI	12.3		

June 2006

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Curlyleaf pondweed	0	1	0
Flatstem pondweed	6	1	6
White waterlily	6	1	6
Eurasian watermilfoil	0	1	0
Common duckweed	4	1	4
Sago pondweed	3	1	3
Great duckweed	5	1	5
Yellow waterlily	8	1	8
Columbian watermeal	5	1	5
Mean C	4.0		
N	10.0		
FQI	12.6		

Floristic Quality Index-August

August 2001

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Eurasian watermilfoil	0	1	0
Flatstem pondweed	6	1	6
Common duckweed	4	1	4
White waterlily	6	1	6
Small Pondweed	7	1	7
Canadian Waterweed	3	1	3
Sago pondweed	3	1	3
Columbian watermeal	5	1	5
Great duckweed	5	1	5
Yellow waterlily	8	1	8
Cattail	1	1	1
Curlyleaf pondweed	0	1	0
Slender Naid	6	1	6
Stonewart	7	1	7
Muskgrass	7	1.00	7.000
Mean C	4.4		
N	16		
FQI	17.75		

August 2002

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Eurasian watermilfoil	0	1	0
Common duckweed	4	1	4
White waterlily	6	1	6
Flatstem pondweed	6	1	6
Curlyleaf pondweed	0	1	0
Columbian watermeal	5	1	5
Sago pondweed	3	1	3
Small Pondweed	7	1	7
Yellow waterlily	8	1	8
Canadian Waterweed	3	1	3
Cattail	1	1	1
Needle spike rush	7	1	7
Slender Naid	6	1	6
Mean C	4.2		
N	14		
FQI	15.8		

August 2003

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
White waterlily	6	1	6
Eurasian watermilfoil	0	1	0
Common duckweed	4	1	4
Flatstem pondweed	6	1	6
Columbian watermeal	5	1	5
Canadian Waterweed	3	1	3
Small Pondweed	7	1	7
Yellow waterlily	8	1	8
Slender Naid	6	1	6
Cattail	1	1	1
Curlyleaf pondweed	0	1	0
Sago pondweed	3	1	3
Mean C	4.0		
N	13.0		
FQI	14		

August 2004

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Curlyleaf pondweed	0	1	0
Flatstem pondweed	6	1	6
White waterlily	6	1	6
Eurasian watermilfoil	0	1	0
Common duckweed	4	1	4
Sago pondweed	3	1	3
Great duckweed	5	1	5
Yellow waterlily	8	1	8
Columbian watermeal	5	1	5
Small Pondweed	7	1	7
Canadian Waterweed	3	1	3
Slender Naid	6	1	6
Star duckweed	5	1	5
Mean C	4		
N	14		
FQI	16.30		

September 2006

Species Name	Coefficient of Conservatism	Species Present = 1 Species Absent = 0	Floristic
Coontail	3	1	3
Eurasian watermilfoil	0	1	0
White waterlily	6	1	6
Flatstem pondweed	6	1	6
Common duckweed	4	1	4
Columbian watermeal	5	1	5
Great duckweed	5	1	5
Small pondweed	7	1	7
Elodea	3	1	3
Mean C	4		
N	9		
FQI	13.00		

Percent Similarity-June

June 2001-2002

Common Name	June 2002 Relative Frequency	June 2001 Relative Frequency	$\|p_{ik}-p_{ij}\|$
Coontail	0.324	0.392	0.068187
Eurasian watermilfoil	0.245	0.303	0.057865
White waterlily	0.102	0.071	0.030863
Flatstem pondweed	0.047	0.045	0.002138
Common duckweed	0.038	0.013	0.024581
Columbian watermeal	0.000	0.009	0.008915
Small pondweed	0.023	0.058	0.03459
Canadian Waterweed	0.040	0.053	0.013977
Curlyleaf pondweed	0.111	0.007	0.103863
Sago pondweed	0.012	0.027	0.015066
Yellow waterlily	0.009	0.008	0.000897
Cattail	0.009	0.004	0.004301
Spike rush	0.000	0.004	0.004457
Great duckweed	0.018	0.000	0.017517
Muskgrass	0.003	0.000	0.002919
Horned pondweed	0.015	0.004	0.01014
		sum $p_{ik}-p_{ij}$	**0.39**
		Cij = 1-(0.5)* (sum $\|p_{ik}-p_{ij}\|$)	**0.80**

June 2003-2004

Common Name	June 2004 Relative Frequency	June 2003 Relative Frequency	$\|p_{ik}-p_{ij}\|$
Coontail	0.387	0.335	0.052176
Eurasian watermilfoil	0.166	0.150	0.015586
White waterlily	0.123	0.085	0.037236
Flatstem pondweed	0.063	0.082	0.019426
Common duckweed	0.007	0.097	0.090421
Columbian watermeal	0.000	0.059	0.058814
Small pondweed	0.083	0.026	0.056315
Canadian Waterweed	0.010	0.009	0.000954
Curlyleaf pondweed	0.156	0.065	0.090933
Sago pondweed	0.000	0.041	0.04117
Yellow waterlily	0.007	0.012	0.00514
Cattail	0.000	0.003	0.002941
Spike rush	0.000	0.003	0.002941
Great duckweed	0.000	0.029	0.029407
		sum $p_{ik}-p_{ij}$	**0.50**
		Cij = 1-(0.5)* (sum $\|p_{ik}-p_{ij}\|$)	**0.75**

June 2002-2003

Common Name	June 2002 Relative Frequency	June 2003 Relative Frequency	$\|p_{ik}-p_{ij}\|$
Coontail	0.324	0.335	0.011186
Eurasian watermilfoil	0.245	0.150	0.095255
White waterlily	0.102	0.085	0.016899
Flatstem pondweed	0.047	0.082	0.035629
Common duckweed	0.038	0.097	0.059091
Columbian watermeal	0.000	0.059	0.058814
Small pondweed	0.023	0.026	0.003111
Canadian Waterweed	0.040	0.009	0.030532
Curlyleaf pondweed	0.111	0.065	0.046242
Sago pondweed	0.012	0.041	0.029492
Yellow waterlily	0.009	0.012	0.003005
Cattail	0.009	0.003	0.005818
Spike rush	0.000	0.003	0.002941
Great duckweed	0.018	0.029	0.011891
Muskgrass	0.003	0.000	0.002919
Horned pondweed	0.015	0.000	0.014597
		sum $p_{ik}-p_{ij}$	**0.41**
		Cij = 1-(0.5)* (sum $\|p_{ik}-p_{ij}\|$)	**0.79**

June 2004-2006

Common Name	June 2004 Relative Frequency	June 2006 Relative Frequency	$\|p_{ik}-p_{ij}\|$
Coontail	0.387	0.244	0.143739
Eurasian watermilfoil	0.166	0.110	0.055218
White waterlily	0.123	0.126	0.00392
Flatstem pondweed	0.063	0.129	0.065822
Common duckweed	0.007	0.071	0.064642
Columbian watermeal	0.000	0.005	0.004598
Small pondweed	0.083	0.000	0.082781
Canadian Waterweed	0.010	0.000	0.009934
Curlyleaf pondweed	0.156	0.232	0.076555
Sago pondweed	0	0.060	0.05977
Yellow waterlily	0.007	0.009	0.002573
Great duckweed	0	0.014	0.013793
		sum $p_{ik}-p_{ij}$	**0.58**
		Cij = 1-(0.5)* (sum $\|p_{ik}-p_{ij}\|$)	**0.71**

Percent Similarity-August

August 2001-2002

Common Name	Aug 2002 Relative Frequency	Aug 2001 Relative Frequency	$\|p_{ih}-p_{ij}\|$
Coontail	0.298	0.281	0.0173
Eurasian watermilfoil	0.226	0.231	0.0042
White waterlily	0.105	0.074	0.0310
Flatstem pondweed	0.061	0.092	0.0308
Common duckweed	0.116	0.077	0.0391
Columbian watermeal	0.099	0.030	0.0698
Small pondweed	0.008	0.071	0.0627
Canadian Waterweed	0.050	0.062	0.0124
Curlyleaf pondweed	0.011	0.006	0.0051
Sago pondweed	0.006	0.030	0.0240
Yellow waterlily	0.003	0.007	0.0038
Slender Naid	0.004	0.006	0.0017
Cattail	0.008	0.007	0.0017
Spike rush	0.002	0.000	0.0022
Great duckweed	0.000	0.024	0.0237
Muskgrass	0.000	0.002	0.0022
Stonewart	0.000	0.003	0.0030
		sum $p_{ih}-p_{ij}$	**0.33**
		Cij = 1-(0.5)* (sum $\|p_{ih}-p_{ij}\|$)	**0.83**

August 2003-2004

Common Name	Aug 2004 Relative Frequency	Aug 2003 Relative Frequency	$\|p_{ih}-p_{ij}\|$
Coontail	0.306	0.379	0.0730
Eurasian watermilfoil	0.126	0.135	0.0096
White waterlily	0.137	0.149	0.0117
Flatstem pondweed	0.100	0.112	0.0116
Common duckweed	0.123	0.122	0.0011
Columbian watermeal	0.049	0.047	0.0012
Small pondweed	0.014	0.013	0.0018
Canadian Waterweed	0.040	0.014	0.0265
Curlyleaf pondweed	0.014	0.003	0.0109
Sago pondweed	0.014	0.003	0.0109
Yellow waterlily	0.006	0.010	0.0044
Slender Naid	0.003	0.007	0.0039
Cattail	0.000	0.007	0.0068
Great duckweed	0.066	0.000	0.0657
Star duckweed	0.003	0.000	0.0029
		sum $p_{ih}-p_{ij}$	**0.24**
		Cij = 1-(0.5)* (sum $\|p_{ih}-p_{ij}\|$)	**0.88**

August 2002-2003

Common Name	Aug 2002 Relative Frequency	Aug 2003 Relative Frequency	$\|p_{ih}-p_{ij}\|$
Coontail	0.298	0.379	0.0805
Eurasian watermilfoil	0.226	0.135	0.0912
White waterlily	0.105	0.149	0.0439
Flatstem pondweed	0.061	0.112	0.0507
Common duckweed	0.116	0.122	0.0058
Columbian watermeal	0.099	0.047	0.0521
Small pondweed	0.008	0.013	0.0042
Canadian Waterweed	0.050	0.014	0.0362
Curlyleaf pondweed	0.011	0.003	0.0077
Sago pondweed	0.006	0.003	0.0021
Yellow waterlily	0.003	0.010	0.0074
Slender Naid	0.004	0.007	0.0025
Cattail	0.008	0.007	0.0015
Spike rush	0.002	0	0.0022
		sum $p_{ih}-p_{ij}$	**0.39**
		Cij = 1-(0.5)* (sum $\|p_{ih}-p_{ij}\|$)	**0.81**

August 2004-2006

Common Name	Aug 2004 Relative Frequency	Aug 2006 Relative Frequency	$\|p_{ih}-p_{ij}\|$
Coontail	0.306	0.291	0.014856
Eurasian watermilfoil	0.126	0.219	0.093122
White waterlily	0.137	0.152	0.015212
Flatstem pondweed	0.100	0.150	0.049584
Common duckweed	0.123	0.139	0.015647
Columbian watermeal	0.049	0.019	0.029181
Great duckweed	0.066	0.017	0.049094
Small pondweed	0.014	0.011	0.003205
Canadian Waterweed	0.040	0.003	0.03723
Curlyleaf pondweed	0.014	0.0	0.014286
Sago pondweed	0.014	0.0	0.014286
Yellow waterlily	0.006	0.0	0.005714
Slender Naid	0.003	0.0	0.002857
Star duckweed	0.003	0.0	0.002857
		sum $p_{ih}-p_{ij}$	**0.35**
		Cij = 1-(0.5)* (sum $\|p_{ih}-p_{ij}\|$)	**0.83**

Appendix B

Raw Data

June 2001

Site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*Elocharis sp.*	*P. zosteriformis*	*Z. palustris*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	*Typha*	*Uknown Grass*
		Submerged Auquatic Species									Floating Species		Free-Floating Species		Emergent Species	
48	2					1		1								1
5	2.3					1									1	
1	3	1			1	1	1		1		1					
11	3	1			1	1	1						1	1		
25	3	1				1										
87	3	1				1										
36	3.3			1		1					1					
121	3.3				1	1	1									
2	3.5	1			1	1	1			1	1					
6	3.5				1	1			1		1					
60	3.5	1				1					1					
115	3.7					1						1	1	1		
140	3.7				1	1	1				1					
131	3.8				1	1	1									
114	4					1										
128	4				1						1		1			
130	4					1					1					
133	4				1	1			1		1					
144	4					1	1									
138	4.4					1	1									
3	4.5	1				1										
26	4.5					1			1		1					
120	4.5			1		1										
129	4.5					1					1					
135	4.5	1				1										
134	4.6	1			1	1	1									
4	4.7	1			1	1					1					
75	4.7					1										
143	4.8					1										
89	4.9			1		1			1							
9	5	1				1										
18	5	1				1										
35	5	1				1										
37	5	1				1										
62	5					1										
73	5															
101	5	1		1		1					1					
102	5				1	1										
116	5					1						1				
118	5					1										
127	5			1		1			1							
136	5	1				1										
141	5	1				1	1		1							
142	5					1	1		1							
117	5.1										1					
10	5.2	1									1					
137	5.5					1										
27	5.8	1				1										
100	5.8	1				1										
119	5.8					1										
47	6	1														

		M. spicatum	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*Elocharis sp.*	*P. zosteriformis*	*Z. palustris*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	*Typha*	*Uknown Grass*
49	6				1	1										
59	6	1				1										
85	6	1														
108	6	1				1			1							
111	6	1														
113	6	1				1										
122	6	1				1										
125	6	1				1										
126	6	1				1										
38	6.2	1				1										
124	6.2	1				1										
7	6.5	1				1					1					
123	6.5	1				1										
8	6.7	1				1										
17	7	1				1										
34	7	1				1										
46	7	1				1										
50	7	1				1	1									
63	7	1														
72	7	1				1										
76	7	1														
86	7	1		1		1										
88	7	1	1													
103	7	1				1										
104	7	1				1										
105	7					1										
109	7	1				1										
112	7	1														
107	7.7	1				1										
106	7.8	1				1			1							
12	8		1													
16	8	1				1										
57	8	1				1										
58	8	1				1										
69	8	1				1										
70	8	1														
71	8	1				1										
84	8	1														
90	8	1				1										
91	8	1				1										
97	8					1										
110	8	1				1										
14	8.4	1														
15	8.5					1										
19	8.5	1														
28	8.5															
51	8.5															

		M. spicatum	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*Elocharis sp.*	*P. zosteriformis*	*Z. palustris*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	*Typha*	*Uknown Grass*
56	8.5					1										
92	8.5					1										
96	8.5	1														
98	8.5	1				1										
39	8.9					1										
24	9															
45	9															
64	9															
65	9															
93	9					1										
94	9	1				1										
95	9															
13	9.2	1														
40	9.5															
77	9.5															
79	9.5	1														
44	9.6	1														
29	9.8															
20	10															
52	10	1														
66	10					1										
67	10															
68	10															
78	10					1										
80	10															
81	10															
82	10															
83	10															
53	10.2															
22	10.5															
30	11															
31	11															
32	11															
33	11															
54	11															
55	11															
21	11															
23	11															
43	12															

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		Submerged Auquatic Species									Floating Species		Free-Floating Species		Emergent Species	
Site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*Chara*	*P. zosteriformis*	*Z. palustris*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*Typha*	*P. arundinacea*
199	1	1				1					1		1		1	1
18	2					1					1		1	1	1	
3	2					1	1			1	1		1	1	1	
91	2	1	1			1	1			1	1					
121	2	1				1										
197	2	1			1	1					1		1	1		
204	2					1			1		1					
220	2	1				1			1		1		1	1		1
200Ak	2					1					1					
106	2.5	1				1					1					
198	2.5	1				1					1		1			
188	2.5					1		1								
209	2.7	1			1	1							1			
21	3	1	1			1				1	1					
33	3	1				1	1		1		1					
48	3	1			1	1	1				1					
152	3	1	1			1					1					
167	3	1			1	1	1				1					
54	3	1				1										
221	3			1		1					1					
206	3	1				1										
223	3					1							1	1		
224	3					1			1		1		1	1		
164	3					1										
149	3	1				1					1					
133	3					1										
118	3	1			1	1					1					
187	3	1				1	1				1					
20	3.5	1	1		1	1			1		1		1			
37	3.5	1				1					1					
19	4	1				1	1			1						
63	4	1	1			1										
182	4	1	1			1					1	1				
183	4	1	1			1						1				
168	4	1	1			1	1									
34	4	1				1										
70	4	1														
205	4					1					1					
86	4	1				1					1					
102	4					1					1					
192	4	1	1			1										
207	4	1				1			1				1			
222	4	1	1			1			1		1					
194	4	1				1	1		1	1						
208	4		1			1										
193	4	1	1		1	1	1		1							
179	4					1					1					
163	4					1										
148	4	1	1			1			1							
137	4					1										
122	4	1				1					1					
107	4	1				1										
185	4					1					1					
184	4		1			1					1	1				
92	4					1					1					
186	4					1										

Site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*Chara*	*P. zosteriformis*	*Z. palustris*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*Typha*	*P. arundinacea*
189	4.5					1					1					
190	4.5					1										
191	4.5	1	1			1			1				1			
178	4.5	1				1	1									
170	4.5	1				1										
78	4.5	1				1										
77	5	1				1	1				1					
36	5	1	1			1	1									
130	5	1	1			1										
101	5	1				1										
117	5	1	1			1										
132	5	1	1	1		1										
153	5					1										
169	5		1			1			1							
172	5				1	1										
173	5	1	1	1		1										
131	5.3	1							1							
129	5.5	1	1			1										
177	5.5	1				1			1							
171	5.5	1	1			1										
79	5.6	1	1													
115	5.8	1				1										
174	6	1				1										
176	6	1	1			1							1			
147	6	1	1			1			1							
162	6	1				1			1							
154	6	1				1										
138	6	1	1			1										
155	6	1				1										
53	6	1	1			1					1					
124	6.2		1													
85	6.3	1				1										
94	6.4					1										
114	6.5	1	1			1										
100	6.5	1														
116	6.5	1	1													
123	6.5	1	1			1										
108	6.5	1				1										
140	6.5	1				1										
93	6.5	1	1			1										
157	6.5					1										
52	6.5	1														
158	6.5															
141	6.8															

Site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*Chara*	*P. zosteriformis*	*Z. palustris*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*Typha*	*P. arundinacea*
125	6.9															
35	7	1	1			1										
49	7	1				1										
159	7	1				1										
144	7	1				1										
145	7	1				1										
175	7	1	1	1		1										
161	7	1				1										
146	7	1				1										
139	7	1														
109	7															
156	7	1	1			1										
142	7					1										
51	7.2	1				1	1									
50	7.3															
143	7.3															
160	7.5	1														
64	7.5					1										
95	7.5					1										
126	7.6	1	1													
110	7.7															
65	7.9															
84	8															
69	8															
80	8	1				1										
127	8															
67	8.8		1			1										
128	8.8					1										
99	9															
68	9															
111	9.1					1										
113	9.2					1										
96	9.4					1										
81	9.5															
66	9.8					1										
112	9.9															
97	10.8															
82	11.4															
83	11.6															
98	11.2															

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			Submerged Auquatic Species								Floating Species		Free-Floating Species			Emergent Species	
data sheet order	site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*E. cf acicularis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*W. columbiana*	*Typha*	*P. arundinacea*
121	121	0.5					1										
113	18	1					1			1	1		1	1	1	1	
114	3	1					1				1		1		1		
117	91a	1	1				1										
119	106a	1				1	1										
128	198	1				1	1			1	1						
6	200a	1.3			1						1						
18	19	1.5					1			1							
82	204	1.5			1	1	1			1	1						
65	221	1.6		1			1			1	1		1				
115	77	1.6					1			1	1						
127	199	1.6	1				1				1	1					
38	224	1.7			1		1			1			1	1			
81	220	1.7					1			1	1		1				
37	209	1.8			1		1										
44	21	1.8					1				1		1				
125	182	1.8		1			1				1	1	1		1		
34	164	2					1			1							
35	179	2			1					1							
36	194	2			1		1			1	1		1				
40	208	2.1			1		1			1							
64	222	2.1		1		1	1				1		1				
66	206	2.1					1										
124	167	2.1		1	1	1	1			1	1						
45	28	2.3				1	1				1						
80	205	2.3			1		1			1							
99	187	2.3		1	1		1			1							
126	184	2.3		1			1			1	1	1					
63	207	2.4					1			1	1						
116	92	2.4		1			1				1						
5	186	2.5					1				1		1		1		
8	170	2.5	1				1						1		1		
9	155	2.5	1				1										
41	193	2.5	1	1			1	1									
79	190	2.5					1			1							
100	172	2.6					1						1	1	1		
118	107	2.6	1				1								1		
120	122	2.6		1			1										
137	63	2.6					1			1	1						
138	48	2.6					1										
139	33	2.6					1				1						
130	168	2.7					1				1						
67	191	2.8					1			1							
46	37	2.9	1				1				1		1				
22	79	3	1	1			1										
31	133	3	1				1										
32	148	3		1			1			1			1		1		
33	149	3		1	1												
57	163	3					1				1		1		1		
62	192	3		1			1			1							
98	188	3					1										
136	78	3.1					1			1							1

data sheet order	site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*E. cf acicularis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*W. columbiana*	*Typha*	*P. arundinacea*
55	101	3.4	1				1										
56	102	3.4	1	1			1				1		1				
122	137	3.4					1					1					
28	169	3.5					1										
39	223	3.5			1	1	1			1			1		1		
58	132	3.5	1				1										
129	183	3.5					1				1						
19	34	3.6					1				1		1				
75	130	3.6	1				1						1	1	1		
7	185	3.7			1		1			1							
76	145	3.7	1				1						1				
50	54	3.8	1				1										
52	70	3.8					1										
131	153	3.8					1										
132	138	3.8	1				1										
133	123	3.8	1				1										
72	116	3.9					1						1				
45	36	4	1				1										
59	147	4	1				1						1	1	1		
60	162	4					1						1	1	1		
61	177	4	1				1						1				
68	176	4					1			1			1		1		
83	189	4					1										
27	154	4.1					1										
30	118	4.2				1	1			1	1						
29	117	4.3					1						1				
71	131	4.3	1	1			1	1					1	1	1		
123	152	4.3		1	1	1	1		1								
134	108	4.4	1				1										
17	35	4.5	1	1													
54	86	4.5	1	1			1				1						
69	161	4.5	1	1			1			1							
4	171	4.7					1										
74	115	4.9	1				1										
78	175	4.9	1				1						1	1	1		
87	129	4.9	1				1										
97	173	4.9	1				1						1		1		
26	139	5	1				1										
49	53	5	1				1										
70	146	5	1				1						1		1		
24	109	5.1	1				1										
20	49	5.2	1				1										
25	124	5.2	1				1										
3	156	5.3	1				1										
101	157	5.5	1				1										
135	93	5.5					1										

data sheet order	site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*E. cf acicularis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*W. columbiana*	*Typha*	*P. arundinacea*
10	140	5.6	1				1										
23	94	5.6	1				1										
53	85	5.6	1				1						1				
42	178	6		1			1	1					1	1	1		
73	100	6	1	1			1										
77	160	6	1	1			1										
85	159	6					1										
86	144	6	1				1										
96	158	6					1										
21	64	6.1					1										
47	52	6.1	1				1										
2	141	6.3	1														
11	125	6.3	1														
108	51	6.3															
13	95	6.5					1										
16	50	6.5					1										
88	114	6.5	1				1										
12	110	6.7															
102	142	6.8					1										
51	69	6.9															
14	80	7	1				1										
95	143	7															
1	126	7.1															
94	128	7.1	1				1										
15	65	7.3															
89	99	7.5	1				1										
103	127	7.5					1										
84	174	7.9	1				1						1	1	1		
93	113	7.9															
112	111	8															
109	66	8.1															
48	68	8.3															
107	67	8.3															
90	84	8.5															
110	81	8.6															
111	96	8.8															
104	112	9															
91	83	10.5															
92	98	10.5															
105	97	10.5															
106	82	10.6															

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			Submerged Auquatic Species								Floating Species		Free-Floating Species			
Data sheet order	site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
70	121	0.5					1									
82	224	1				1	1			1						
7	91	1.7	1				1			1						
19	118	2	1				3				1					
34	21	2	1	1			1			1			1			
59	204	2					1				1					
64	200A	2					1				1					
65	199	2		1			1				1					
66	198	2		1			1				2					
67	182	2	1	1			1			1	1	2				
83	223	2		2		1	1				1					
1	3	2.5	1			1	1				1					
2	18	2.5	1	1		1	1				1		1			
57	221	2.5				1	1				1					
58	220	2.5				1	1				1					
60	188	2.5					1	1		1						
61	187	2.5				1	1				1					
68	167	2.5		1		1	2									
84	222	2.5				1	1									
100	207	2.5		1		1	3									
4	48	2.6	1	1			1				1					
3	33	3	1	1		1	1			1	1					
6	77	3	1			1	1			1	1					
18	102	3	1			1				1						
31	106	3					1									
35	37	3	2	1			1				1					
78	164	3				1	1									
79	179	3				1	1			1						
81	209	3				1										
99	208	3					1									
110	205	3					1			1	1					
69	152	3.2	1	1			2				1					
8	92	3.3	1	1			1			1	1					
124	137	3.3				1	1				2					
5	63	3.5		2			1				1					
30	107	3.5					3									
32	19	3.5	1				1									
33	20	3.5	1	1			1			1	2					
44	54	3.5	2	1			2									
45	70	3.5	1	1												
63	185	3.5					1	1		2	1					
75	133	3.5					4				1					
77	149	3.5				1	1				1					
85	122	3.5		1			1				1					
95	148	3.5		1			4				1					
97	178	3.5					2			1						
98	193	3.5		1			2									
108	191	3.5					3									

Data sheet order	site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
109	206	3.5	1			1	1			1						
120	168	3.5		2			2									
121	183	3.5				1	1				1	1				
122	184	3.5		1		1	1			1	2					
125	138	3.6					2									
62	186	3.7					4									
76	132	3.8	1				4				1					
126	139	3.8	4				3									
74	86	4	1	1			2				1					
96	163	4	2	1			3									
111	189	4				1	3				1					
112	190	4		1		1	3			1						
119	169	4		1			4									
115	173	4.3					3									
9	93	4.5	1	3			4									
17	101	4.5	1				4									
20	117	4.5				1	4				1					
38	34	4.5					3				1					
52	78	4.5	3	1			4				1					
53	79	4.5	1				3									
75	85	4.5	1				1									
92	129	4.5	4				4	1								
93	130	4.5	2				4									
101	192	4.5					1									
102	177	4.5					2									
107	176	4.5					1			1						
116	172	4.5		2												
123	153	4.5					2									
117	171	4.7		4			3				1					
29	108	5	2				4									
80	194	5		1		1	1			1						
86	123	5	1	2			1									
103	162	5		2			2									
104	147	5		1			4									
118	170	5		1			4									
138	155	5.1	2				4									
113	175	5.2		1			1									
127	140	5.2	2				3									
132	145	5.2	3	1			3									
139	154	5.2		2			3									
114	174	5.4		1			1									
21	116	5.5	2				4									
22	115	5.5	3				3									

Data sheet order	site	Depth (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
36	36	5.5	2				2									
37	35	5.5	1	1			2									
42	52	5.5					4									
43	53	5.5	1				1				1					
94	131	5.5	2				4									
105	146	5.5		1			1									
137	156	5.5	1				4									
16	100	6	1				3									
23	114	6	3				4									
106	161	6		1			3									
131	144	6.3					4									
133	160	6.3	1	1			1									
39	49	6.5		1												
51	64	6.5	1	1			1									
87	124	6.5	2	1			1									
136	157	6.5	1				2									
134	159	6.8	1				4									
28	109	7	1				3									
46	69	7.2					1									
88	125	7.2					1									
128	141	7.2														
135	158	7.4														
10	94	7.5	1	1			3									
27	110	7.5					1									
40	50	7.5					1									
41	51	7.5					2									
129	142	7.7														
72	84	7.9					1									
130	143	7.9														
91	128	8														
11	95	8.1					1									
50	65	8.2					1									
89	126	8.3														
54	80	8.5														
90	127	8.6					1									
49	66	8.7														
15	99	8.8					1									
26	111	9					1									
47	68	9.1														
12	96	9.8														
24	113	9.8														
48	67	9.8														
55	81	10														
56	82	10														
25	112	10.3					1									
71	83	10.5														
13	97	11.5														
14	98	11.5														

June 2006

				Submerged Macrophyte Species									Floating Species		Free-Floating Species					Algae Species			
ID	Depth (ft)	Substrate	Vegetation height (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*Uknown Pot*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*	Other	Spriogyra	Net Algae	Filamentous	Emergent
1	1.50	Hard	1.50		2	4		1				2											
2	2.00	Hard	2.00	1	4	3									1								
3	1.90	Hard	1.90	1	3	2						1	3										
4	2.20	Hard	2.20	1	3			1				3	3										
5	3.00	Medium	3.00		2			3				1	4										
6	1.70	Hard	1.70	1	1	3							3										
7	2.00	Hard	2.00	3	2	2						3	3										
8	2.00	Medium	2.00	3	2	3		1					3										
9	2.30	Hard	2.30		2	1		2				3	3										
10	2.20	Hard	2.20	2	2	1		4				4	3										
11	1.90	Hard	1.90		2	4		2				1	2			1						3	
12	1.70	Hard	1.70		3			2				2	1									3	
13	2.60	soft	2.60		2			3				1	2		1							4	
14	2.00	Hard	2.00		2	1		4					5										
15	2.60	Medium	2.60			3		3				1	4										
16	2.70	soft	2.70			5						1	2	3									
17	2.50	soft	2.50		2	4		1					1	4									
18	2.00	Medium	2.00	1	3	3		1					1	3	1							2	
19	2.20	Hard	2.20			1		2					3		1							3	
20	1.20	Hard	0.20																		4		
21	2.00	Hard	2.00	1	2	3		1					3		1							2	
22	2.30	Medium	2.30	1	1	4							3		1							2	
23	2.10	Hard	2.10	1	2	2		1					2		2								
24	2.00	Hard	2.00					5				1	3		2							3	
25	2.20	soft	2.20		2	1		2					1		1	1							
26	2.60	soft	2.60		1	1		1				2	2		1	1							
27	1.90	soft	1.90					1				3	3		1	2							
28	2.00	soft	0.00		2	3						1	1									4	
29	2.00	Medium	2.00	2	2	3		2					3		2								
30	2.00	Medium	2.00	2	3							2	3		2	1							
31	1.80	Hard	1.80		1	1		2				2	5		1					1			
32	2.00	Hard	2.00					2					3							1			
33	2.20	Medium	2.20										4		1								
34	2.40	Medium	2.40	1	5			1					4									1	
35	2.50	Hard	2.50	1	2			3				3											
36	3.30	Hard	0.00					2														1	
37	1.70	Hard	0.00	1	2	1																	
38	2.30	Hard	2.30	3	3			1				1	3									1	
39	2.40	Hard	2.40	1	1			3				3	4		2								
40	1.70	Hard	1.70	3	1			1					4		1								
41	1.80	Hard	0.00	1	1	5		1				1	4										
42	4.60	soft	0.00					2														1	
43	4.30	soft	4.30	2	3							1											
44	5.30	soft	5.30		3							1											
45	8.00	soft	3.00					3															
46	7.20	soft	3.00					1															

ID	Depth (ft)	Substrate	Vegetation height (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*Uknown Pot*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*	Other	Spriogyra	Net Algae	Filamentous	Emergent
47	5.00	Medium	0.00																	1			
48	4.50	Medium	3.50		1			4															
49	3.30	Medium	3.30		1			5							1			1				4	
50	3.00	Medium	3.00		1			5					2		1							2	
51	2.10	Medium	2.10		5			2					4		1	1							
52	2.00	Medium	2.00	2	2			1				1	5					1				1	
53	2.00	Hard	2.00	3	3							1	3		1								
54	2.00	soft	2.00	3	2	2		3				2	3									2	
55	1.50	Medium	1.50	1				1				3									2	1	
56	1.40	soft	1.40					2				2			1					1			
57	2.30	Medium	2.30					1				1											
58	2.10	soft	2.10	3	3			2				2	3		1							2	
59	2.20	Hard	2.20	3	2			3				1											
60	2.90	Medium	2.90		4			3				1	2									3	
61	2.00	Hard	2.00		1			1				1	3									3	
62	4.00	Hard	4.00	4				3															
63	4.50	soft	4.50		5																	2	
64	2.30	Hard	2.30	1	2			1				2	2										
65	2.70	Medium	2.70		2			2				2	3		2							3	
66	2.80	soft	2.80		2			4					2									2	
67	2.40	Medium	2.40		2			5						5								3	
68	2.80	soft	2.80		1			5				1	5										
69	3.10	soft	3.10		1			5														5	
70	3.50	Medium	3.50		3			4					1									2	
71	3.20	Medium	3.20		2			5					2									3	
72	2.60	Medium	2.60					5					2									5	
73	2.70	Hard	2.70		3			5				1	2									5	
74	2.80	Hard	2.80		2			3					3									3	
75	6.10	soft	0.00																				
76	4.20	Medium	4.20		5																		
77	3.80	Medium	3.80	3	4																		
78	4.70	soft	4.70	2	5			2															
79	5.10	Medium	5.10	2	3			2				1											
80	5.50	Medium	5.50	1	3			2															
81	5.10	Medium	5.10	1	5			2															
82	4.40	Medium	4.40		2			5				1										2	
83	3.60	Medium	3.60		3			3				1										1	
84	3.50	Medium	3.50		3			4				1											
85	5.10	soft	5.10		4			2													3		
86	6.60	soft	6.60		3															3		1	
87	6.30	soft	6.30	1	2																		
88	7.00	soft	0.00		1																		
89	6.60	soft	6.60	1	1			1															
90	7.40	soft	0.00		1			2															
91	7.10	Medium	0.00					2				1											

August 2001

			Submerged Auquatic Species										Floating Species		Free-Floating Species			Emergent Species
site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*Chara*	*Nitella*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*W. columbiana*	*Typha*
1	1						1						1					1
2	1		1				1	1					1		1			1
5	1	X	1				1						1		1			
48	1	X	1				1						1					
60	1		1	1		1	1						1		1			
118	1	X	1			1	1	1	1	1		1						
26	1.5		1			1	1			1			1		1		1	
98	1.5		1			1	1	1										
134	1.5		1		1		1								1			
139	1.5							1										
112	1.7	X	1			1	1						1	1	1		1	
4	2		1				1			1			1		1			
6	2		1			1	1	1		1			1		1			
11	2		1			1	1	1					1					
72	2		1				1											
85	2	X	1			1	1	1		1					1			
86	2		1			1	1											
99	2		1			1	1						1					
100	2	X	1				1											
111	2	X	1				1	1		1								
115	2	X	1			1	1			1			1					
117	2		1		1	1	1	1		1					1			
124	2		1			1	1			1					1			
126	2		1			1	1								1	1	1	
128	2		1				1	1					1		1	1	1	
129	2		1			1	1	1		1			1		1			
131	2	X	1	1	1	1	1	1		1								
135	2	X	1			1	1	1	1	1			1		1	1		
138	2				1		1	1		1					1			
127	2.2		1				1						1		1	1	1	
10	2.5	X	1				1			1	1		1					
37	2.5	X	1		1	1	1											
47	2.5		1		1		1						1					
73	2.5						1											
121	2.5		1				1											
130	2.5	X	1				1											
136	2.5					1	1	1		1			1		1			
116	2.8		1				1			1								
3	3		1				1											
18	3		1				1											
25	3		1															
35	3						1											
49	3					1	1			1								
69	3	X	1				1											
74	3	X	1				1			1								
87	3	X	1			1	1	1		1								
97	3		1				1											
104	3		1															
114	3	X				1	1						1	1	1	1	1	

site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*Chara*	*Nitella*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*W. columbiana*	*Typha*
120	3						1											
123	3						1	1		1					1			
132	3		1				1			1					1		1	
133	3	X	1			1	1	1		1					1	1	1	
137	3						1	1		1			1		1	1	1	
113	3.1				1	1	1			1			1		1	1	1	
119	3.2	X	1		1		1	1		1					1			
9	3.5		1				1											
61	3.5						1											
71	3.5		1				1											
84	3.5		1				1											
103	3.5	X	1				1	1		1								
105	3.5		1				1			1								
122	3.5	X	1				1			1			1		1			
8	4	X																
27	4		1				1						1					
28	4						1											
59	4		1		1		1											
82	4	X	1				1											
88	4	X					1											
38	4.5		1				1											
50	4.5		1				1											
68	4.5		1				1											
89	4.5	X	1				1											
106	4.5		1				1											
7	5		1				1											
34	5		1				1											
57	5	X	1				1											
58	5		1				1											
62	5		1				1			1								
63	5	X					1											
94	5	X																
96	5		1				1											
101	5		1				1			1								
109	5		1				1			1								
110	5		1				1						1					
15	5.5	X																
16	5.5						1											
70	5.5		1															
81	5.5																	
93	5.5	X					1											
108	5.5		1				1											
95	5.8						1											
13	6	X																

site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*Chara*	*Nitella*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*W. columbiana*	*Typha*
14	6	X																
40	6																	
51	6	X	1				1											
52	6	X																
56	6		1															
75	6																	
78	6	X																
80	6		1															
83	6		1				1											
102	6						1											
107	6																	
92	6.5																	
12	7																	
19	7	X																
20	7	X					1											
39	7																	
44	7	X																
45	7						1											
46	7		1				1											
58	7																	
64	7																	
76	7		1				1											
77	7		1															
79	7																	
90	7		1				1											
91	7						1											
24	7.5						1											
53	7.5	X																
65	7.5				1													
29	8																	
33	8																	
66	8																	
67	8		1				1											
54	9																	
30	9																	
41	9																	
22	9																	
43	10																	
42	10																	
23	10																	
31	11																	
32	11																	
21	11																	

August 2002

			Submerged Auquatic Species								Floating Species		Free-Floating Species		Emergent Species		
site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	*Elocharis sp.*	*Typha*	Reed Canary Grass
136	1		1				1								1		
220	1.2						1			1	1		1	1		1	1
151	1.5		1				1										
197	1.8		1				1				1					1	
222	2.3	X	1				1	1		1	1		1	1			
91	2.5						1				1		1	1			
106	2.5		1				1										
121	2.5		1				1				1		1	1			
3	2.5						1				1		1	1			
187	2.6		1				1				1		1	1			
200A	2.6		1				1				1					1	
223	2.8	X	1				1			1	1						
164	3	X	1				1	1		1	1		1	1			
179	3		1				1	1		1	1		1	1			
188	3	X					1	1	1								
206	3	X					1	1					1	1			
208	3	X					1	1		1	1		1	1			
209	3						1						1				
224	3		1				1	1		1			1	1			
118	3						1				1		1	1			
152	3	X	1				1				1		1	1			
18	3	X	1				1	1			1		1	1			
198	3	X	1				1				1		1	1			
149	3.1					1	1	1									
204	3.2						1	1									
205	3.3						1				1		1				
21	3.3	X	1				1				1		1				
133	3.4	X	1				1			1	1						
33	3.4		1				1				1		1	1			
194	3.5						1	1		1	1		1	1			
186	3.5				1		1				1						
221	3.5						1			1	1		1	1			
182	3.5		1				1			1	1		1	1			
137	3.5		1				1						1	1			
77	3.5						1				1		1	1			
48	3.5		1	1			1			1	1		1	1			
102	3.6						1										
163	3.7						1						1	1			
191	3.7		1			1	1										
19	3.7						1	1									
193	3.8						1	1		1	1						
207	3.8	X	1				1			1	1		1	1			
20	3.8						1				1			1			
122	3.8						1						1	1			
190	3.9		1				1			1		1					
37	3.9		1				1							1			
169	4	X	1				1				1						
178	4						1										
192	4		1				1	1					1	1			

site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	*Elocharis sp.*	*Typha*	Reed Canary Grass
189	4	X	1				1			1	1						
185	4		1				1				1						
117	4						1										
86	4		1				1										
167	4	X	1				1				1		1	1			
107	4		1				1										
92	4						1				1		1	1			
63	4		1				1						1	1			
183	4	X	1				1				1						
54	4.3	X	1														
85	4.4	X	1				1										
115	4.5		1														
170	4.8	X	1				1										
130	4.8		1				1						1				
34	4.8						1				1		1	1			
171	5		1				1			1							
172	5		1				1			1							
173	5		1				1										
176	5		1				1						1	1			
177	5		1				1										
132	5		1				1				1						
36	5		1				1										
78	5		1				1										
93	5	X	1				1				1						
168	5	X					1			1							
116	5.2		1				1										
145	5.5		1				1	1									
146	5.5	X	1				1	1					1				
147	5.5		1			1	1						1				
148	5.5	X	1				1			1			1				
161	5.5		1				1										
154	5.5		1				1						1				
153	5.5	X					1										
155	5.7		1	1			1										
70	5.7		1														
123	5.8	X	1				1			1			1	1			
162	6		1				1			1			1	1			
174	6		1				1										
175	6	X	1				1										
131	6	X	1		1		1	1									
129	6		1	1			1										
101	6		1				1										
64	6		1				1										
108	6	X	1				1						1	1			

site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	*Elocharis sp.*	*Typha*	Reed Canary Grass
138	6		1				1										
156	6.2		1				1										
35	6.3	X	1				1	1									
139	6.4																
160	6.4		1				1										
49	6.5		1				1										
157	6.7																
100	6.7	X	1				1										
79	6.7	X	1	1			1										
51	6.7																
53	6.7						1										
159	6.8	X					1										
69	6.9		1														
158	7		1														
114	7		1				1										
94	7						1										
144	7.1		1				1										
124	7.1	X	1				1										
109	7.3	X					1										
140	7.4	X	1														
141	7.4	X															
125	7.6	X	1														
52	7.6																
110	8.1																
50	8.1																
143	8.2						1										
95	8.2		1														
142	8.3																
128	8.4		1				1										
80	8.4																
65	8.6	x															
126	9																
127	9.2																
111	9.5						1										
84	9.7																
67	9.9																
66	9.9	x															
113	10.1						1										
68	10.1																
96	10.4																
81	10.4																
99	10.5																
112	10.6																
97	11.6																
83	12.3																
82	12.4																
98	12.6																

August 2003

				Submerged Auquatic Species										Floating Species		Free-Floating Species		Emergent
Data sheet order	site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*Elocharis sp.*	*Z. dubia*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	Typha
1	3	0.5											1	1				1
2	18	0.5						1						1		1		1
47	91	0.5		1				1										
5	21	1	X					1						1				
48	106	1		1														
127	0	1.5						2			1			1		1	1	
60	118	1.5	X	1			1	2			1			1		1		
85	149	1.5		2				1						2		1		
118	188	1.5		1			1	1		1								
126	199	1.5						3						1		1	1	
131	207	1.5						3								1	1	
73	137	1.8						2										
4	20	2	X					3			1			1				
10	33	2	X					2						3				
11	48	2						4									1	
26	77	2						1			1			1				
36	102	2	X	1				2			1			1		1		
61	133	2						3			1			1				
98	152	2	X					2			1			1		1		
86	164	2						1			2	1		1				
99	167	2	X					4						2				
111	179	2						3			2							
124	182	2						4						1	1	1	1	
119	187	2		1			1	1		1	1			1		1	1	
112	194	2	X	1				4			1					1		
125	198	2	X				1				1			1				
128	204	2						2			2				1	1		
129	205	2						4						1		1		
130	206	2	X			1		1	1					1				
132	208	2		1				1										
133	221	2						3			1			1		1	1	
134	222	2						1			1			1		1		
25	63	2.2	X	1	1			2			1			1				
46	92	2.4						3			1				2			
3	19	2.5						1									1	
49	107	2.5						4						1		1		
72	122	2.5	X	1				4						1		1		
121	185	2.5						4						1				
120	186	2.5						4			1			1				
115	191	2.5						4			1			1				
6	37	2.7	X	1				2						1				
45	93	2.7	X	1				4						1				
17	54	3						1										
59	117	3						4						1		1		
84	148	3						4			1							
87	163	3						4			1					1		
101	169	3						2										
110	178	3		1				2										

Data sheet order	site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*Elocharis sp.*	*Z. dubia*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	Typha
123	183	3						3										
122	184	3	X	1				4			1			1				
117	189	3						4			1			1		1	1	
116	190	3						4	1		2					1	1	
114	192	3						4			1			1		1	1	
113	193	3		1				2										
44	94	3.1						3			1							
35	86	3.2						2			1			1		1		
9	34	3.5						4			1			1				
18	70	3.5						1										
27	78	3.5						4						1		1		
100	168	3.5	X					2						1				
34	85	3.6		1				3										
82	146	3.8																
37	101	4						4										
71	123	4						4								1		
62	132	4						4								1		
83	147	4						1										
97	153	4						1										
102	170	4	X					1										
103	171	4						3								1		
104	172	4	X					4								1	1	
105	173	4	X					3						1				
106	174	4		1														
108	176	4	X					1			1							
109	177	4						4								1	1	
64	130	4.2	X	1				3			1			1				
8	35	4.5		1														
7	36	4.5		1				2										
50	108	4.5	X					4								1		
58	116	4.5						4						1		1		
65	129	4.5		1				2										
63	131	4.5		1				4								1		
74	138	4.5	X	1				3										
88	162	4.5						1										
107	175	4.5	X					4								1	1	
56	114	4.6		2				3										
16	53	5						3										
24	64	5		1				3										
57	115	5		1				4						1		1		
81	145	5	X	1				3	1		1					1		
95	155	5		1				2						1				
94	156	5		1				3			1					1		
89	161	5	X	1				2	1									

Data sheet order	site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*Elocharis sp.*	*Z. dubia*	*N. tuberosa*	*N. lutea*	*L. minor*	*W. columbiana*	Typha
12	49	5.5						4										
28	79	5.5						4										
51	109	5.5	X					4			1							
75	139	5.5		2				3										
76	140	5.5						2										
96	154	5.5		2				3										
93	157	5.5		1				2										
90	160	5.5		1														
29	80	5.8						1										
43	95	5.9	X	1				1										
52	110	5.9						1										
14	51	6																
15	52	6						1										
38	100	6		1				4						1				
70	124	6	X	1				4										
69	125	6		1				2										
77	141	6																
80	144	6		1				4										
79	143	6.2						1										
68	126	6.4						1										
13	50	6.5						1										
19	69	6.5																
92	158	6.5						1										
91	159	6.5	X															
23	65	6.8						4										
66	128	7																
78	142	7																
53	111	7.1																
67	127	7.5																
21	67	7.6						1										
55	113	7.6																
22	66	7.7						1										
30	81	7.8																
42	96	7.8						1										
39	99	7.8																
20	68	8						1										
33	84	8																
54	112	8						1										
41	97	9.4						1										
32	83	9.7																
31	82	9.8																
40	98	10																

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				Submerged Auquatic Species								Floating Species		Free-Floating Species			
	site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
39	91	0.5		1				1				1					
87	106	0.5		1		1					1	1		1			
98	199	0.5						2				1	2	1	1		1
66	200a	1.0	x					1	1			4		1	1		1
97	198	1.0	x				1	1			1	4		1	1		
138	209	1.1				1		1				2		1	1		
6	21	1.5		1				1				2		1			
18	149	1.5						1	1		1	3		1			
35	48	1.5	x					1			1						
117	187	1.5	x	1				1	3		1	1		1	1		1
137	194	1.7						4			1			1	1		
19	164	1.8		3			1	3	2					1			
136	179	1.8		2				1			1	1		1			
10	70	1.9						1									
1	3	2.0		1				1				1		1			
2	19	2.0		1				1				1					
13	102	2.0	x	1				2	1								
15	118	2.0	x					1			1	3		1			
33	18	2.0		1				3				2		1			
34	33	2.0		1				1				2		1			
38	77	2.0		1				1			1	3					
92	152	2.0				1		1									1
94	167	2.0										2		1	1		1
95	182	2.0						1				4		1			1
121	204	2.0		1			1		2		1	1		1	1		
123	205	2.0	x					1	1		1	2		1	1		1
124	220	2.0		1				1	1		3	1		1	1		
125	206	2.0	x	4				1			1	1		1	1		
139	224	2.0						1			1			1	1		
141	208	2.0						2			1			1			
9	54	2.1						3									
140	223	2.1						3				3		1	1		
11	86	2.3	x		1			2				1					
128	221	2.3						4	1		1			1	1		1
134	177	2.4						3									
3	20	2.5	x					3			1	2		1			
7	37	2.5						2				1					
14	117	2.5						4				3					
16	133	2.5						3			1	2		1			
17	148	2.5						4			1	1					
20	163	2.5	x					4				1		1			1
36	63	2.5			1			2			1	1					
40	92	2.5		1				2			1	2		1			
57	184	2.5						2					2	1	1		
58	183	2.5						4			1	1		1			
59	168	2.5			1			2			1						
65	185	2.5						1	3		1	1		1	1		
67	186	2.5	x			1		4			1	1		1			

	site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
90	137	2.5	x	1		1		1									
126	207	2.5	x					4			1	3			1	1	
135	178	2.5						4							1		
142	193	2.5						4				1		1	1		
5	36	2.6	x	1				4									
127	222	2.6	x					4	1		1	1		1	1		1
118	188	2.8		1					2	2				1			
52	115	2.9	x	3				3									
86	107	3.0	x	3				2						1			1
143	192	3.0						2									
144	191	3.0		1				3			2	1					
22	161	3.1		1				4			1						
27	156	3.1		1				4									
133	176	3.1						3			1						
21	162	3.2	x					2			1						
37	78	3.5		1				3				1					
41	93	3.5		1				4						1	1		1
53	116	3.5						4									1
63	169	3.5						4				2					
64	170	3.5						3									
89	122	3.5		2	1			4				2		1			1
112	123	3.5						4				1		1	1		1
120	189	3.5	x	1				4				3		1			1
129	190	3.5						3	1		1	3		1			
45	124	3.7		1				2									
108	144	3.7		1				2									
55	85	3.8						2									
81	131	3.8	x					4				1					
82	130	3.8		1				4									1
116	172	3.8						1									
4	35	3.9	x	1				1									
8	53	3.9						1									
54	100	3.9	?					4									
12	101	4.0		1				4									
28	155	4.0						4									
60	153	4.0						4									
61	138	4.0						4									
104	132	4.0						4									
132	175	4.0															
62	154	4.1			1			4									
69	34	4.1						4				2		1	1		
26	157	4.2		1				3									
44	139	4.2		1				1			1						
105	147	4.2	x	2				4				1					
130	173	4.2						3									
43	140	4.5		1				3	1								
68	171	4.5						4									
131	174	4.5		2				4									
51	114	4.6		2				2									

	site	Depth (ft)	Biomass	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
72	79	4.6						2			1						
23	160	4.7	x	1				1			1						
25	158	4.8	x					1									
70	49	4.8															
71	64	4.9						1									
42	94	5.0															
83	129	5.0		1				2									
32	52	5.1						1									
46	109	5.1						1									
24	159	5.3															
111	141	5.4	x					1									
106	146	5.5		1				3									
107	145	5.5	x	2				3									
115	125	5.5						2									
85	108	5.6		2				4									
78	50	5.8															
77	51	6.0															
56	69	6.2															
109	143	6.2															
110	142	6.2															
47	110	6.3															
73	80	6.3						1									
84	128	6.3	x														
114	126	6.3															
79	65	6.5															
99	95	6.5	x														
31	67	6.8	x														
113	127	6.8															
50	113	7.1															
80	84	7.2															
29	68	7.3															
76	66	7.3						1									
48	111	7.5															
100	96	7.8															
103	99	7.8															
49	112	8.0															
74	81	8.1															
101	97	9.3						2									
30	83	9.8															
75	82	9.8															
102	98	10.1															

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ID	Depth (ft)	Substrate	Vegetation height (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*Uknown Pot*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
1	1.90	Medium	1.90					2					5					
2	2.60	Medium	2.60	2				1				5	5					
3	2.90	Hard	2.90	5								2						
4	3.60	Hard	3.60	1				1				1	5		1			
5	4.00	Medium	4.00	3				4				1	1		1			
6	3.00	Hard	3.00	1				1					1		1			
7	4.90	soft	4.30	1				2										
8	4.30	Hard	3.30	2				1				1						
9	3.10	Hard	3.10	2				2										
10	6.40	soft	0.00															
11	4.30	Hard	2.20									1						
12	3.20	Hard	3.20	1				2				4	1					
13	5.70	soft	4.70					2										
14	2.80	Hard	2.80	3				2					5					
15	4.00	Medium	4.00	1				5					1					
16	5.10	soft	5.10	2				5										
17	2.30	Hard	2.30	1								1	5					
18	2.80	Hard	2.80	1				3				1	5					
19	2.00	Hard	2.00	2				1					4		1			
20	2.30	Hard	2.30					2				1	5					1
21	2.50	Hard	2.50	1				2				1	5		1	1		
22	1.80	Hard	1.80	1				3	1		2	1	3		2			
23	2.60	Hard	2.60	1				1				2	5		1	1		
24	2.10	Hard	2.10	1				2			3		4		3			
25	0.00		0.00															
26	0.00		0.00															
27	0.00		0.00															
28	2.50	Hard	2.50	2				3				5	1		2	1		
29	1.80	Hard	1.80					4					5		3	1		
30	1.80	Medium	0.00	4				2				1			2			
31	2.10	Hard	2.10	1				5				2	1		3	1		
32	2.20	Hard	2.20					3				1	3		4			
33	2.70	soft	2.70	3				2							2			
34	2.50	Hard	2.50	2											1			
35	2.70	Hard	2.70	3				2				1	3		2			
36	2.90	Hard	0.00	1				4				1			5			
37	0.00		0.00															
38	2.00	Hard	2.00					5				2	2		4			2
39	2.60	Hard	2.60	2				3				1	4		1			1
40	2.20	Hard	2.20	2				2					5		1			
41	2.80	Hard	2.80	2				3				1	4		1			
42	1.90	Hard	1.90					3			1	1	5		1			
43	2.00	Hard	2.00	4				1			1		3		1			
44	3.30	Medium	3.30	1				2				1	5		2			
45	3.50	Medium	3.50					5				1			3			
46	3.10	Hard	3.10	1				3				1	1		2			
47	3.40	Hard	2.80	1								2						
48	3.40	Medium	2.00					1				1						

ID	Depth (ft)	Substrate	Vegetation height (ft)	M. spicatum	P. crispus	P. pectinatus	P. cf. pusillus	C. demersum	E. canadensis	N. flexilis	Uknown Pot	P. zosteriformis	N. tuberosa	N. lutea	L. minor	S. polyrhiza	L. trisulca	W. columbiana
49	3.40	Medium	3.40	2				4				2			1			
50	2.90	Hard	1.90					3				1						
51	2.90	Hard	2.90					1				3	3		1			
52	2.80	Hard	2.80					3				2	4		1	1		
53	5.90	Hard	5.30	2				2										
54	4.10	soft	3.10	2				3				3						
55	4.80	Medium	4.80					2				1			1			5
56	5.10	soft	5.10	3				3										
57	6.70	soft	0.00															
58	6.50	soft	6.00	2				4										
59	5.60	soft	5.60	3				2										
60	5.20	soft	5.20	4				2										
61	5.10	soft	5.10	5				1							1			
62	3.60	Medium	3.60					5					1					
63	2.30	Hard	2.30					2				1	5		1			1
64	2.10		0.00					2				2	1					
65	3.50	Medium	3.50					2					5		1			
66	4.30	soft	4.30	1				5				1						
67	4.50	soft	4.00					5										
68	4.80	Medium	4.80	3				1				3			1			
69	4.80	soft	4.80	2				5				2						
70	5.00	Medium	5.00	5				3							1			
71	7.20	soft	2.00					1										
72	6.10	soft	0.00					3				2						
73	5.60	soft	5.60	1				5				2			1			
74	4.90	soft	4.90	5				2							1			
75	3.30	soft	3.30					4				1	2		1			
76	3.20	Medium	3.20					5					4		1			
77	4.60	soft	4.60	2				1							1			
78	5.20	Medium	5.20	3				4										
79	5.50	Medium	4.00	1				2										
80	7.00	soft	4.00															
81	7.90	soft	4.50															
82	7.40	soft	5.30					2										
83	6.70	soft	5.50					1										
84	5.90	soft	5.00	3				2				1						
85	5.80	Medium	5.80	1				3				2						
86	4.00	soft	4.00	2				3				1	4		1			
87	2.80	Hard	2.80	1				2					5		1			
88	2.80	Hard	2.80					5					3		1			
89	4.70	Medium	4.70					1				1	2					
90	6.00	Medium	6.00	4				2										
91	6.90	Medium	6.00	1				2										
92	7.60	soft	5.60															
93	8.30	soft	5.50															
94	7.90	soft	5.50															
95	5.00	Hard	4.50	2				2				1						
96	4.10	Hard	4.10	4				2							1			
97	4.80	Medium	4.80	1				5					2		1			1

ID	Depth (ft)	Substrate	Vegetation height (ft)	*M. spicatum*	*P. crispus*	*P. pectinatus*	*P. cf. pusillus*	*C. demersum*	*E. canadensis*	*N. flexilis*	*Uknown Pot*	*P. zosteriformis*	*N. tuberosa*	*N. lutea*	*L. minor*	*S. polyrhiza*	*L. trisulca*	*W. columbiana*
98	4.00	Medium	4.00					5					1		1			1
99	5.50	Medium	4.50	2				3										
100	8.00	soft	0.00															
101	10.40	soft	0.00															
102	9.60	soft	0.00															
103	8.50	soft	0.00															
104	6.80	soft	5.50	1				2										
105	5.80	Medium	5.00	2				4										
106	4.00	Hard	4.00	1				1				1	4		1			
107	2.80	Hard	2.80	2				3					4					
108	2.60	Hard	2.60	3				4				1	4		1			
109	3.60	Hard	3.60	1				3				1	4		1			
110	5.50	soft	5.50	5				4				1						
111	7.00	soft	0.00															
112	8.80	soft	0.00					1										
113	10.70	soft	0.00															
114	11.70	soft	0.00															
115	10.80	soft	0.00															
116	6.70	soft	0.00															
117	6.30	soft	0.00															
118	10.60	soft	0.00															
119	11.60	soft	0.00															
120	10.90	soft	0.00															
121	8.80	soft	0.00					1										
122	6.90	Medium	0.00	1				1										
123	5.50	Medium	5.50	5				4										
124	3.20	Hard	3.20					4					4		1			
125	2.30	Hard	2.30	2				3					5					
126	2.40	Hard	2.40	1				3				1	4					
127	5.80	soft	5.00	1				1										
128	7.90	soft	0.00															
129	8.90	soft	0.00					1										
130	8.60	soft	0.00															
131	7.60	soft	0.00															
132	6.90	Medium	0.00	1														
133	6.80	Medium	5.50	2				2										
134	3.30	Medium	3.30	5				1					1					
135	1.60	Hard	1.60	4				1				2	1					
136	2.20	Hard	2.20	1				2					5					
137	2.80	Hard	2.80	1				2				2	5					
138	2.30	Hard	2.30	2				3					4					