LPL 734 + 735

Solberg Lake Macrophyte Survey and Management Plan

Prepared for
Solberg Lake Association

March 2002

BARR

Acknowledgements

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Executive Summary

Solberg Lake in Price County, Wisconsin, is valued by riparian owners, area residents, Price County, and the Wisconsin Department of Natural Resources (WDNR). Plant growth in Comfort Cove, Disappearing Creek and Squaw Creek currently impairs recreational use of the lake and prevents attainment of the lake's beneficial uses. The Solberg Lake Association initiated a project to complete a macrophyte survey and a macrophyte management plan to identify effective macrophyte management activities that concurrently consider the wishes of residents and the integrity of Solberg Lake (i.e., macrophyte community, fisheries community, waterfowl and wildlife communities, and lakeshore protection).

A macrophyte survey of Solberg Lake was completed during June 18 through June 20, 2001. The survey evaluated plant coverage, density, and species composition. The results indicated the total area of macrophyte (i.e., aquatic plant) coverage in Solberg Lake was approximately 328 acres (i.e., 36 percent of the lake's surface area). The lake noted a 10 percent open area in the lake's littoral zone (the shallow transition zone between dry land and the deeper open area of the lake). Disappearing Creek and Squaw Creek noted open areas of 0 percent and 33 percent, respectively. Macrophyte coverage by type is presented in Figure EX-1. Plant diversity in Solberg Lake was relatively high when compared with 51 Wisconsin lakes (Nichols, 1997). A total of 24 species was found in Solberg Lake. An average of 5 species was found in each sample transect, although, there was considerable variation. The most frequently occurring species in Solberg Lake were *Lobelia dortmanna* (water lobelia) and *Elodea canadensis* (Canada waterweed) occurring at 39 percent and 35 percent of the sample points, respectively. Other species in Solberg Lake occurring in more than 10 percent of sample locations were:

- *Vallisneria americana* (wild celery) occurring at 29 percent of sample points
- *Potamogeton amplifolius* (large-leaf pondweed) occurring at 23 percent of sample points
- *Ceratophyllum demersum* (coontail) occurring at 13 percent of sample points
- *Nymphaea tuberosa* (white waterlily) occurring at 11 percent of sample points

Moderately dense to dense (i.e., plants covered 61 percent or more of the rake head used for sample collection) macrophyte growth was found in very few areas (less than 1 percent of the lake's littoral zone) within Solberg Lake. This density was caused by an individual plant, *Lobelia dortmanna* (water lobelia) in a portion of Disappearing Creek and *Myriophyllum verticullatum* (whorled water milfoil) in Comfort Cove. A sample transect was not located in Comfort Cove. Hence, the 61 to 80 percent estimate of plant growth density in Comfort Cove was based upon observation rather than measurement. Disappearing Creek, the lake's west inlet, noted a plant density range of 1 to 100 percent. The littoral region of Squaw Creek, the lake's north inlet, noted a plant density range of 1 to approximately 60 percent. It was not possible to navigate through the dense growth of floating leaf plants to measure plant density in portions of the stream. Hence, the 60 percent estimate is based on observation rather than measurement. In the majority (81 percent) of the lake's littoral zone, the overall plant growth density was 20 percent or less (i.e., plants covered 20 percent or less of the rake head used for sample collection).

The plant densities recorded during the survey were a key component used to develop a macrophyte management plan for Solberg Lake.

Macrophytes in Solberg Lake consisted entirely of native species (i.e., species historically present in this region), with one exception. A single plant of *Potamogeton crispus* (curly-leaf pondweed) was found at one location and the plant was removed.

The Solberg Lake macrophyte management plan was built on eight principles:

- Define the problem
- Establish goals
- Understand plant ecology
- Identify beneficial uses
- Consider all the techniques
- Specify control intensity
- Develop management plan
- Monitor the results

Solberg Lake's macrophyte problem is excessive plant growth in Comfort Cove and in portions of Disappearing Creek and Squaw Creek. The shallow depths of Disappearing Creek and Squaw Creek exacerbate the navigation problems resulting from heavy plant growth. Dense plant growth in the inlet streams and Comfort Cove causes difficult navigation through these areas. Hence, access to

Solberg Lake is very difficult for campers using Comfort Cove and riparian owners living adjacent to affected portions of the inlet streams.

The Solberg Lake Association established six aquatic plant management goals for Solberg Lake:

1. Improve navigation through Squaw Creek, Disappearing Creek, and Comfort Cove.
2. Improve recreational attributes of the lake
3. Preserve native plant species and prevent introduction/spread of exotic plant species by conducting regular surveillance of the lake and conducting prompt removal activities of all exotic plants found.
4. Preserve and/or improve fish and wildlife habitat
5. Protect and/or improve quality of the resources for all to enjoy (i.e., people, fish, wildlife)
6. Minimize disturbance of sensitive areas (i.e., fish and wildlife)

A feasibility analysis of treatment options was completed to identify a feasible treatment plan to achieve the lake's goals. Four management options were evaluated to determine their feasibility in achieving the lake's goals and the levels of control established for the lake. The options considered were dredging, harvesting, hydroraking, and chemical treatment. Dredging was rejected from further consideration because it is not a financially feasible option. Harvesting was rejected because the shallow depth of the streams and the presence of woody debris and logs prevent the operation of the harvester in the inflowing streams. Hydroraking was rejected because the presence of woody debris and logs prevent the operation of the hydrorake in the inflowing streams. Chemical treatment was considered and recommended. The proposed treatment areas within Disappearing Creek and Squaw Creek are located in areas considered by WDNR to be sensitive habitats for fish and wildlife. Hence, the WDNR has indicated it will carefully evaluate chemical treatment permit applications to determine whether or not harm to fish and wildlife habitat will result from the proposed treatment. Permit approval will be given if no harm to fish and wildlife will result from the treatment. Hence, chemical treatment was recommended for the Solberg Lake Management Plan.

A herbicide treatment plan is recommended to clear navigational channels in Comfort Cove, Disappearing Creek, and Squaw Creek. A trial 3-year treatment program is recommended. Following the 3-year trial program, the Solberg Lake Association will determine whether continued treatment is warranted. Details of the recommended treatment program follow.

Treatment of a 20- to 30-foot wide navigation channel in Comfort Cove and in portions of Disappearing Creek and Squaw Creek will occur monthly during June and July of each year of the

3-year trial period. Areas will be treated with the endothall, (i.e., Aquathol™ or Reward™), a contact herbicide that kills plants by interfering with protein synthesis. The maximum allowed treatment dose will be used to insure treatment effectiveness. Treated areas are estimated to total 2.2 to 2.6 acres and the treatment cost is estimated to be $500 to $600 per acre per treatment event. Hence, treatment costs are estimated to total approximately $2,600 annually.

If budget constraints prevent the treatment of all recommended areas, the following treatment prioritization is recommended:

1. Disappearing Creek
2. Squaw Creek
3. Comfort Cove

The shallow depths of the streams exacerbate navigation problems. Hence, treatment of the streams should have a higher priority than treatment of Comfort Cove.

It is recommended that individual homeowners desiring to apply for permits and fund treatment of navigation channels and recreational areas in front of their property be granted the opportunity. The dense plant growths will likely prevent navigation from the homeowners' docks to the navigation channels created by the Solberg Lake Association in the above program unless a riparian owner funded treatment program is implemented. In addition, riparian owners may be prevented from using the near-shore areas for swimming and other recreational activities unless treatment occurs. The intent of the treatment program should be to treat 20- to 30-foot navigation channels from the homeowners' property to the channel treated by the Solberg Lake Association and to treat a 30- to 40-foot wide area in front of the homeowners' property.

An education program is recommended to help area residents achieve an understanding of:

- The functions and roles of native species/native communities within Solberg Lake
- Exotic species that would pose a threat to the lake if they were introduced

The education program may be completed by the Solberg Lake Association with assistance from the WDNR and/or Solberg County staff.

A long-term evaluation program is recommended to monitor the effectiveness of the lake's macrophyte management plan. A macrophyte survey of the lake is recommended at a frequency of once every 5 years. The methodology used for the 2001 survey of the lake should be used for each survey. Survey results should be compared with the results of previous surveys to determine changes in the macrophyte community. The survey results will indicate the effectiveness of macrophyte management plan implementation and will identify any needed modification of the plan.

Solberg Lake Macrophyte Survey and Management Plan

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1.0 Introduction

Solberg Lake in Solberg County, Wisconsin notes a surface area of 921 acres. The lake is valued by lakeshore property owners, area residents, Solberg County, and the WDNR for its fisheries and for recreational uses (see Figure 1). Its fishery is comprised largely of walleye, although bluegill, muskellunge, rock bass, and black crappie are also present.

Unmanaged aquatic plant growth within the Solberg Lake inlets (Squaw Creek and Disappearing Creek) and Comfort Cove impairs recreational use of the lake. Hence, management is needed to allow attainment of the lake's beneficial uses. The Solberg Lake Association currently finds it difficult to make decisions about the type of macrophyte management that should occur (harvesting, herbicide, or lime slurry treatment), where it should occur, or how often it should occur. Hence, the Solberg Lake Association initiated a project to complete a macrophyte survey and a macrophyte management plan. Information from the macrophyte management plan will be used by the Solberg Lake Association to insure that macrophyte management activities concurrently consider the wishes of residents and the integrity of Solberg Lake (i.e., macrophyte community, fisheries community, waterfowl and wildlife communities, and lakeshore protection).

A macrophyte survey of Solberg Lake was completed during 2001. This report presents the survey results and macrophyte management plan for the lake. The report discusses:

- Overview of macrophyte growth in Solberg Lake
- The methodology of the 2001 Solberg Lake membership and aquatic plant surveys
- Results and discussion of the 2001 Solberg Lake membership and aquatic plant surveys
- Developing a macrophyte management plan
- Macrophyte management plan for Solberg Lake

2.0 Overview of Macrophyte Growth in Lakes

The basis of the following text on macrophyte growth in lakes is Minnesota Department of Natural Resources (MDNR) *A Guide to Aquatic Plants Identification and Management* (1994).

2.1 Location of Aquatic Plant Growth Within Lakes and Impoundments

Within a lake, pond, or impoundment, aquatic plants grow in the area known as the littoral zone—the shallow transition zone between dry land and the open water area of the lake. The littoral zone extends from the shore to a depth of about 15 feet, depending on water clarity. The littoral zone is highly productive. The shallow water, abundant light, and nutrient-rich sediment provide ideal conditions for plant growth. Aquatic plants, in turn, provide food and habitat for many animals such as fish, frogs, birds, muskrats, turtles, insects, and snails. Protecting the littoral zone is important for the health of a lake's fish and other animal populations.

The width of the littoral zone often varies within a lake and among lakes. In places where the slope of the lake bottom is steep, the littoral area may be narrow, extending several feet from the shoreline. In contrast, if the lake is shallow and the bottom slopes gradually, the littoral area may extend hundreds of feet into the lake or may even cover it entirely. Impoundments frequently note extensive littoral areas in the upper portion due to sedimentation and shallow depths. In contrast, the lower portions of impoundments may have little littoral area.

Cloudy or stained water, which limits light penetration, may restrict plant growth. In lakes where water clarity is low all summer, aquatic plants will not grow throughout the littoral zone, but will be restricted to the shallow areas near shore.

Other physical factors also influence the distribution of plants within a lake or pond. For example, aquatic plants generally thrive in shallow, calm water protected from heavy wind, wave, or ice action. However, if the littoral area is exposed to the frequent pounding of waves, plants may be scarce. In a windy location, the bottom may be sand, gravel, or large boulders—none of which provides a good place for plants to take root. 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.

2.1.1 Categories of Aquatic Plants

Aquatic plants are grouped into four major categories:

- Algae have no true roots, stems, or leaves and range in size from tiny, one-celled organisms to large, multi-celled plants, such as *Chara*. Plankton algae, which consist of free-floating microscopic plants, grow throughout both the littoral zone and the well-lit surface waters of an entire lake. Other forms of algae, including *Chara* and some stringy filamentous types (such as *Cladophora*), are common only in the littoral area.
- Submerged plants have stems and leaves that grow entirely underwater, although some may also have floating leaves. Flowers and seeds on short stems that extend above the water may also be present. Submerged plants grow from near shore to the deepest part of the littoral zone and display a wide range of plant shapes. Depending on the species, they may form a low-growing "meadow" near the lake bottom, grow with lots of open space between plant stems, or form dense stands or surface mats.
- Floating-leaf plants are often rooted in the lake bottom, but their leaves and flowers float on the water surface. Water lilies are a well-known example. Floating leaf plants typically grow in protected areas where there is little wave action.
- Emergent plants are rooted in the lake bottom, but their leaves and stems extend out of the water. Cattails, bulrushes, and other emergent plants typically grow in wetlands and along the shore, where the water is less than 4 feet deep.

2.1.2 Value of Aquatic Plants

Aquatic plants are a natural part of most lake communities and provide many benefits to fish, wildlife, and people. In lakes, life depends directly or indirectly, on water plants. They are the primary producers in the aquatic food chain, converting the basic chemical nutrients in the water and soil into plant matter, which becomes food for all other aquatic life. Aquatic plants serve many important functions, including:

- **Provide fish food**—More food for fish is produced in areas of aquatic vegetation than in areas where there are no plants. Insect larvae, snails, and freshwater shrimp thrive in plant beds. Sunfish eat aquatic plants besides aquatic insects and crustaceans.
- **Offer fish shelter**—Plants provide shelter for young fish. Because bass, sunfish, and yellow perch usually nest in areas where vegetation is growing, certain areas of lakes are protected and posted by the DNR as fish spawning areas during spring and early-summer. Northern pike use aquatic plants, too, by spawning in marshy and flooded areas in early-spring.

- **Improve water quality**—Certain water plants, such as rushes, can actually absorb and break down polluting chemicals.
- **Protect shorelines and lake bottoms**—Aquatic plants, especially rushes and cattails, dampen the force of waves and help prevent shoreline erosion. Submerged aquatic plants also weaken wave action and help stabilize bottom sediment.
- **Provide food and shelter for waterfowl**—Many submerged plants produce seeds and tubers (roots), which are eaten by waterfowl. Bulrushes, sago pondweed, and wild rice are especially important duck foods. Submerged plants also provide habitat to many insect species and other invertebrates that are, in turn, important foods for brooding hens and migrating waterfowl.
- **Improve aesthetics**—The visual appeal of a lakeshore often includes aquatic plants, which are a natural, critical part of a lake community. Plants such as water lilies, arrowhead, and pickerelweed have flowers or leaves that many people enjoy.
- **Provide economic value**—As a natural component of lakes, aquatic plants support the economic value of all lake activities. Wisconsin has a huge tourism industry centered on lakes and the recreation they support. Residents and tourists spend large sums of money each year to hunt, fish, camp, and watch wildlife on and around the state's lakes.

3.0 Compilation and Assessment of Existing Information

3.1 1991 Lake Management Report

Results of a 1991 survey of Solberg Lake (see Appendix E) indicated that 11 aquatic plants were found in 15 transects in Solberg Lake. It is important to note that a different sampling methodology was used in the 1991 survey to qualitatively analyze the plant species and that no attempt was made to quantify the individual macrophytes. However, the narrative does indicate that plant growth was sparse. All the plants found in Solberg Lake were in less than 5 feet of water. The percent macrophyte cover of the lake was calculated to be 18 percent (does not include Squaw Creek or Disappearing Creek). The report narrative further states that the aquatic plant community was dominated by *Vallisneria americana* (wild celery), *Potamogeton natans* (floatingleaf pondweed), *Sagittaria sp.* (Arrowhead), and *Potamogeton amplifolius* (Cabbage plants).

Results of a 1991 WDNR survey of Solberg Lake indicate that the lake had a gamefish population composed primarily of walleye, with much smaller populations of panfish and muskellunge. Other fish present include rock bass, black crappie, yellow perch, northern pike, largemouth bass, and smallmouth bass.

The 1991 Lake Management Report recommended seven potential projects to increase the recreational use or to add in the attainment of the lake's beneficial uses (listed below).

1. Aquatic plant control by lake water level control.
2. Aquascaping in some near-shore areas (bulrushes, etc.)
3. Landscaping for wildlife
4. Dredging in shallow inflow areas will not harm nor help the lake.
5. Fish stocking should be coordinated with WDNR.
6. Fish habitat improvements may help—rock reefs, smallmouth habitat: work with WDNR.
7. Start a UW-Stevens Point monitoring program and include tributary monitoring.

4.0 Methods

4.1 Membership Survey

Members of the Solberg Lake Association were surveyed during 2001 to determine lake uses, lake use impairment, and opinions regarding macrophyte management options. A total of 257 surveys were mailed. The survey is presented in Appendix A.

4.2 Aquatic Plant Survey

An aquatic plant (macrophyte) survey of Solberg Lake was completed during June 18 through June 20, 2001. Barr Engineering Co. completed the survey with assistance from volunteers.

The methodology followed in the aquatic plant survey was first used in 1962 by Carl Molter, an aquatic plant specialist with the Wisconsin of Department of Natural Resources. The survey methods are outlined in *Wisconsin's Department of Natural Resources Long-Term Trend Lake Monitoring Methods*, (Bureau of Water Resources Management, July 1987) as modified by Deppe and Lathrop (1992). This methodology, referred to as the rake coverage (RC) technique, enables the plant specialist to determine the presence, frequency, and density of different plant species. The following outlines the methodology followed in the study.

- 33 transects were selected for the survey (See Figure 2). Transects extended from shore to the maximum depth of plant growth.
- Transects were broken down into the following approximate depth categories:

  0 to 2.5 feet
  2.5 to 5.0 feet
  5 to 10 feet (or to the maximum rooting depth)

- Four rake samples were taken at each depth zone to determine the presence and abundance of species. The sample point at each depth zone consisted of a 12-foot-diameter circle divided into four quadrants. A tethered garden rake with an extended handle (16 feet) was used to collect a sample from each quadrant.

- Collection of samples, identification of species, and determination of density ratings for each species occurred at all sampling points. The RC technique was used to assign density ratings (Deppe and Lathrop 1992) in accordance with the following criteria:

Rake Coverage (% of Rake Head) Covered by Species	Density Rating
81-100	5
61-80	4
41-60	3
21-40	2
1-20	1
0	0

- A Global Positioning System (GPS) unit was used in the field to note latitude and longitude readings of each sampling point and the maximum rooting depth for future reference.
- Sediment type was determined at each sampling point.
- Maximum rooting depths were observed for the each transect that had a maximum rooting depth.

5.0 Results and Discussion

5.1 Membership Survey Results

Members of the Solberg Lake Association were surveyed to determine their:

- Understanding of the functions and values of aquatic plants
- Uses of the lake
- Perceived impairment of lake uses by aquatic plants
- Aquatic plant management preferences

A total of 257 surveys were mailed and 124 responses were received (i.e., 48 percent return rate). Survey results are presented in Figures 3 through 5 and are summarized in Appendix A. The survey results indicated:

- Most respondents (i.e., 83 percent) recognized that aquatic plants have value.
- Respondents indicated aquatic plants have a high to medium level of importance for fish shelter and spawning, invertebrate habitat, fish food, food and shelter for waterfowl, and shoreline protection.
- Respondents indicated aquatic plants have a low level of importance for aesthetics.
- Respondents indicated the primary use of Solberg Lake is fishing (94 percent). Other major uses include viewing (77 percent), swimming (58 percent), canoeing or paddle boating (56 percent), and power boating (32 percent).
- Respondents indicated the primary use impairment caused by aquatic plants is fishing (40 percent). Other use impairments include swimming (32 percent), canoeing or paddle boating (19 percent), and viewing (17 percent). It is important to note that 36 percent of the respondents indicated that the current levels of aquatic plant growth impaired none of their uses.
- A total of 51 percent of respondents indicated they have removed or attempted to remove aquatic plants around their dock or along their shoreline.
- A total of 55 percent of respondents indicated that the use of chemicals (herbicides) would be "okay," 38 percent said that it was "not okay" to use chemicals to manage aquatic plants, and 7 percent either weren't sure or didn't answer the question.
- A total of 74 percent of respondents indicated that the use of a mechanical harvester would be "okay," 21 percent said that it was "not okay" to use a mechanical harvester to manage aquatic plants, and 5 percent didn't answer the question.

- A total of 48 percent of respondents answered yes, the Lake Association should own and operate a weed harvester, 43 percent of respondents answered no, and 9 percent either weren't sure or didn't answer the question.

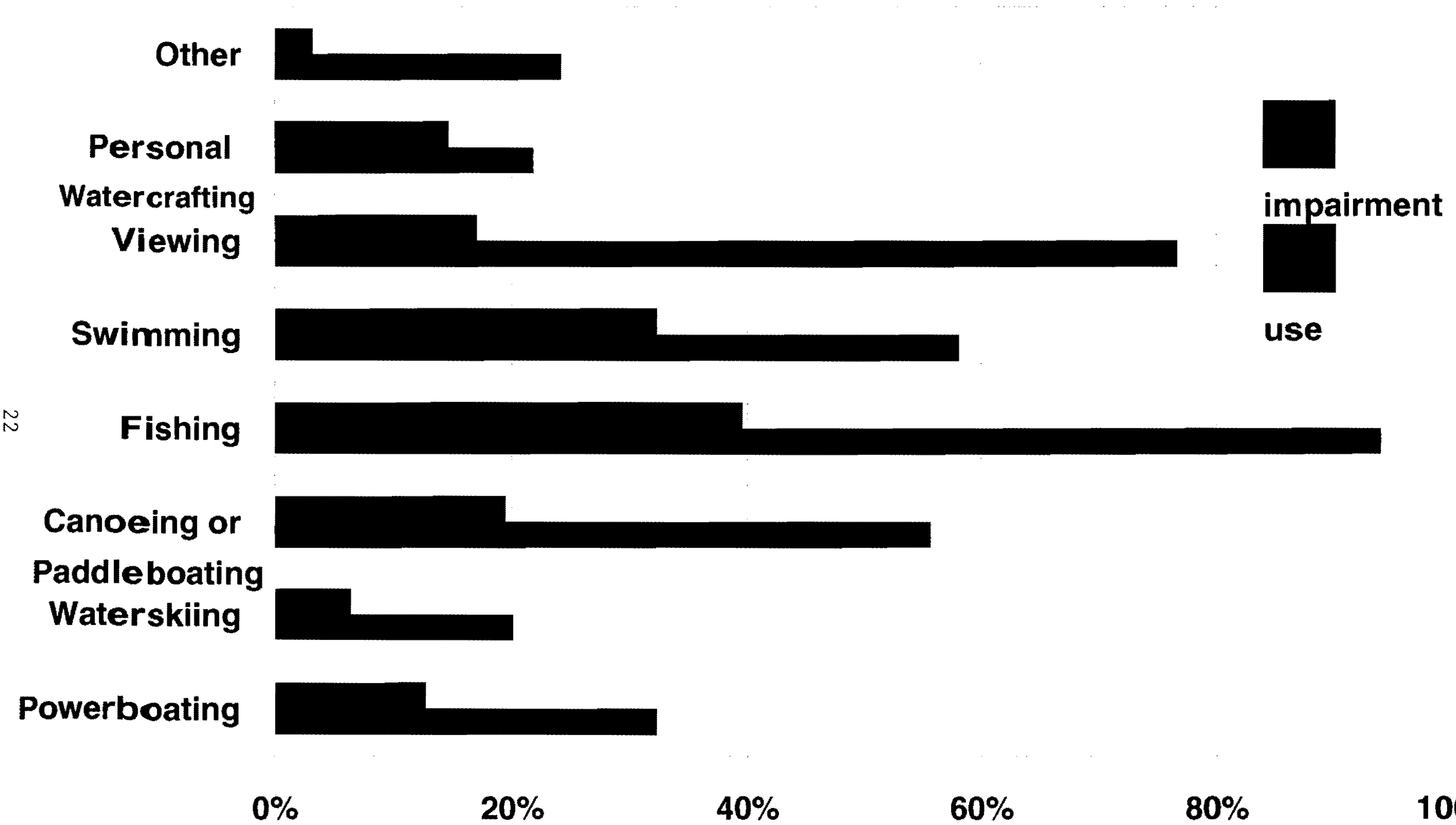


Figure 3. Recreation Use and Impairment Percent of Total Responses

Figure 4. Aquatic Plant Functions
Rated Level of Importance

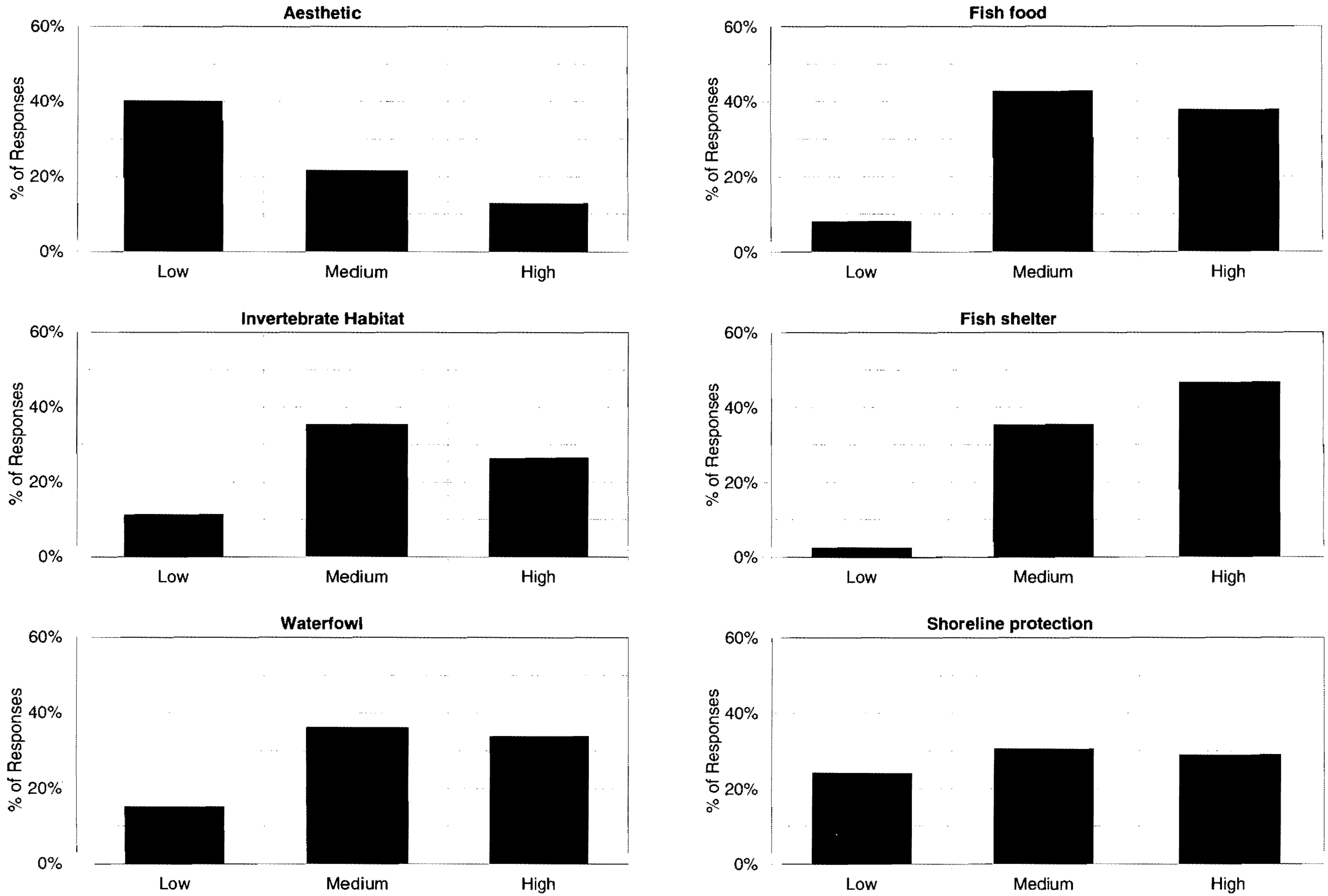
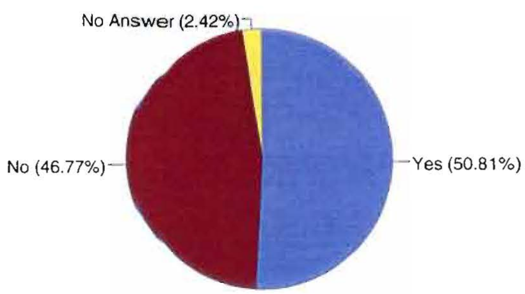
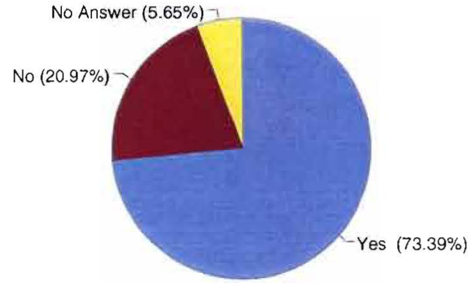


Figure 5
Responses for Managing Aquatic Plants

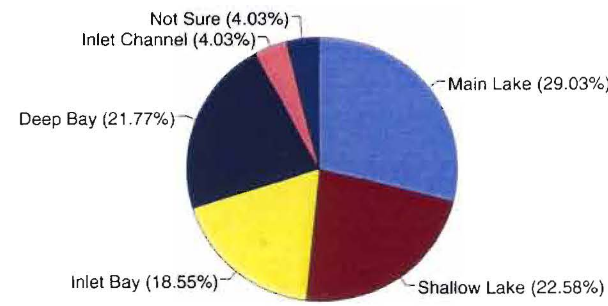
Removed aquatic plants along property?



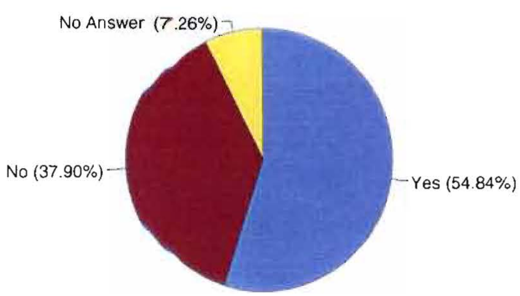
Use of mechanical harvesting?



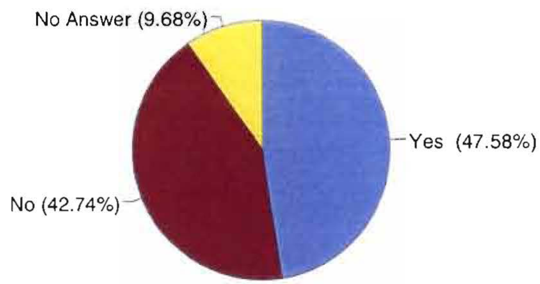
Where do you live?



Apply chemicals?



Own/operate mechanical harvester?



5.2 Macrophyte Survey Results

5.2.1 Macrophyte Types

Results of the 2001 Solberg Lake survey indicate the lake contained a diverse assemblage of macrophyte (aquatic plant) species representing the four macrophyte types—submersed plants, floating-leaf plants, emergent plants, and the alga *Chara*. Of the four types, submersed plants dominated the macrophyte community. Survey results indicated (See Figure 6 and Appendix B):

- Submersed plants were found in 94 percent of sample transects
- Floating-leaf plants were found in 41 percent of sample transects
- Emergent plants were found in 35 percent of sample transects
- The alga *Chara* was sited in 9 percent of sample transects.

5.2.2 Number of Species

The large number of species noted in Solberg Lake during 2001 is indicative of a stable and healthy macrophyte community. Specifically, a total of 24 species were found. Further evidence of a diverse plant community was indicated by the number of species found in each transect. The average number of species occurring in each transect was 5 (i.e., 4.6), although there was considerable variation. Solberg Lake noted from 1 to 12 species per transect and an average of 4.4. Disappearing Creek noted from 5 to 8 species per transect and an average of 6. Squaw Creek noted from 0 to 8 species per transect and an average of 5.

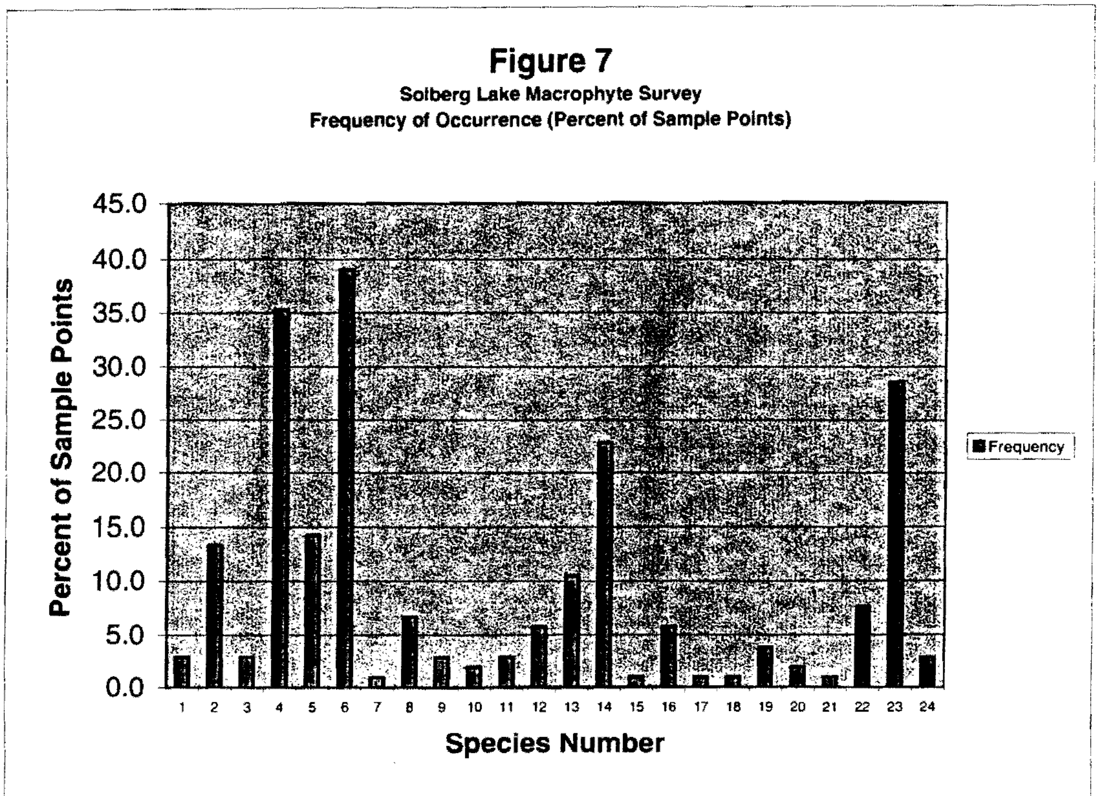
The presence of several species in each transect:

- Provides a diverse habitat for fish and invertebrates (i.e., food for fish) and encourages a more diverse fish and invertebrate community;
- Protects fisheries' habitat from destruction by a disease as a species-specific disease would only impact one species and have little impact upon the diverse community

5.2.3 Abundant Species—Frequently Occurring

The abundance of Solberg Lake macrophyte species was determined by their frequency of occurrence measured as the percentage of sample locations containing each species. A diverse macrophyte community was observed in Solberg Lake and none of its species had a frequency of abundant (i.e., occurring in more than 50 percent of sample locations). However, a few species were common (i.e., occurring in 30 percent to 50 percent of sample locations). The most frequently occurring species in Solberg Lake were *Lobelia dortmanna* (water lobelia) and *Elodea canadensis* (Canada waterweed) occurring at 39 percent and 35 percent of the sample locations, respectively. Other species in Solberg Lake occurring in more than 10 percent of sample locations were (See Figure 7).

- *Vallisneria americana* (wild celery) occurring at 29 percent of sample points
- *Potamogeton amplifolius* (large-leaf pondweed) occurring at 23 percent of sample points
- *Ceratophyllum demersum* (coontail) occurring at 13 percent of sample points
- *Nymphaea tuberosa* (white waterlily) occurring at 11 percent of sample points



Species Number	Scientific Name	Common Name	Frequency (% of samples)
1	*Brasenia schreberi*	*watershield*	2.9
2	*Ceratophyllum demersum*	*coontail*	13.3
3	*Chara spp.*	*muskgrass*	2.9
4	*Elodea canadensis*	*Canada waterweed*	35.2
5	*Eleocharis spp.*	*spikerush*	14.3
6	*Lobelia dortmanna*	*water lobelia*	39.0
7	*Lemna minor*	*lesser duckweed*	1.0
8	*Myriophyllum sibiricum*	*northern watermilfoil*	6.7
9	*Myriophyllum verticillatum*	*whorled watermilfoil*	2.9
10	*Najas flexilis*	*bushy naiad*	1.9
11	*Nuphar advena*	*yellow pondlily*	2.9
12	*Nuphar variegata*	*spatterdock*	5.7
13	*Nymphaea tuberosa*	*white waterlily*	10.5
14	*Potamogeton amplifolius*	*largeleaf pondweed*	22.9
15	*Potamogeton crispus*	*curlyleaf pondweed*	1.0
16	*Potamogeton epihydrus*	*ribbonleaf pondweed*	5.7
17	*Potamogeton illinoensis*	*Illinois pondweed*	1.0
18	*Potamogeton natans*	*floatingleaf pondweed*	1.0
19	*Poa spp.*	*narrow leaf pondweed*	3.8
20	*Potamogeton zosteriformis*	*flatstem pondweed*	1.9
21	*Typha. spp.*	*cattail*	1.0
22	*Utricularia spp.*	*bladderwort*	7.6
23	*Vallisneria americana*	*wild celery*	28.6
24	*Zosterella dubia*	*mud plantian*	2.9

5.2.4 Macrophyte Density

Moderately dense to dense (i.e., plants covered 61 percent or more of the rake head used for sample collection) macrophyte growth was found in very few areas (less than 1 percent of the lake's littoral zone) within Solberg Lake. This density was caused by an individual plant, *Lobelia dortmanna* (water lobelia) in a portion of Disappearing Creek and *Myriophyllum verticullatum* (whorled water milfoil) in Comfort Cove. A sample transect was not located in Comfort Cove. Hence, the 61 to 80 percent estimate of plant growth density in Comfort Cove was based upon observation rather than measurement. Disappearing Creek, the lake's west inlet, noted a plant density range of 1 to 100 percent. The littoral region of Squaw Creek, the lake's north inlet, noted a plant density range of 1 to approximately 60 percent. It was not possible to navigate through the dense growth of floating leaf plants to measure plant density in portions of the stream. Hence, the 60 percent estimate is based on observation rather than measurement. In the majority (81 percent) of the lakes littoral zone, the overall plant growth density was 20 percent or less (i.e., plants covered 20 percent or less of the rake head used for sample collection). Macrophyte density ranges are presented in Figure 8 and species distributions are presented in Figure 9.

5.2.5 Macrophyte Diversity

Macrophyte diversity was calculated for Solberg Lake using a modification of Simpson's Index (1949):

$$1 - \Sigma\,(rf/100)^2$$

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 relativized to 100 percent to describe community structure (i.e., rf). Frequencies are shown in Figure 8. Relative frequencies are presented in Appendix C.

The data indicate an average amount of diversity in the plant community found in Solberg Lake. On a scale of 0 to 1, with 0 indicating no plant diversity and 1 indicating the highest plant diversity, Solberg Lake noted a diversity of 0.84. The diversity measured in Solberg Lake is near the middle range of diversities noted for 51 Wisconsin lakes (See Table 1). Specifically, 29 lakes noted higher diversities, 20 lakes noted lower diversities, and one lake noted the same diversity.

Table 1 Diversities of some Wisconsin Plant Communities (from Nichols 1997 and Barr 2000)
Samples Collected by WDNR Unless Otherwise Indicated

Lake Name	Diversity (Late Summer)	Lake Name	Diversity (Late Summer)
George Lake	0.58	Dowling Lake	0.87
Silver Lake (Anderson)	0.69	Big Hills Lake (Hills)	0.88
Tichigan Lake	0.69	Como Lake	0.88
Oconomowoc Lake, Upper	0.70	White Ash Lake, North***	0.88
Rib Lake	0.71	Big Round Lake	0.89
Twin Lake North	0.73	Pigeon Lake	0.89
Chain Lake	0.74	Mud Hen Lake	0.90
Clear Lake	0.74	Pike Lake	0.90
Half Moon Lake T47N	0.77	Apple River Flowage	0.91
Island Lake	0.78	Ashippun Lake	0.91
Leota Lake	0.78	Big Blake Lake (Blake)	0.91
Little Arbor Vitae Lake	0.78	Cedar Lake	0.91
Mid Lake (Nawaii)	0.78	Little Elkhart Lake	0.91
Cary Pond	0.79	Morris Lake (Mt. Morris)	0.91
Helen Lake	0.80	Pine Lake	0.91
McCann Lake	0.80	Post Lake	0.91
Beaver Dam Lake (East)	0.81	White Ash Lake***	0.91
Long Lake T32N	0.81	Balsam Lake	0.92
Twin Lake, South	0.81	Beaver Dam Lake (West)	0.92
Big Butternut Lake	0.84	Muskellunge Lake	0.92
Solberg Lake[1]	**0.84**	Round (Wind) Lake*	0.92
Bear Lake	0.85	Church Pine Lake	0.93
Chute Pond	0.86	Decorah Lake	0.93
Enterprise Lake	0.86	Half Moon Lake	0.93
Okauchee Lake	0.86	Amnicon Lake	0.95
Pearl Lake	0.86		

* Sampled by Barr Engineering Company
** Sampled by Beaver Dam Lake volunteers trained by Barr Engineering Company
*** Sampled by White Ash Lake volunteers trained by Barr Engineering Company
[1] Sampled in mid-June

5.2.6 Percent Open Area

The cumulative effect of the lake's diverse macrophyte community was assessed from the proportion of open area in the littoral zone (i.e., Percent Open Area). The percent open area was estimated from the number of sampling locations (e.g., Transect 1, Depth Code A is one sample location) containing no vegetation divided by the total number of sampling locations at a depth less than or equal to the maximum depth of plant growth. Maximum depth of plant growth is the water depth at the deepest sampling location where plant growth was found. The maximum depth of plant growth in Solberg Lake was 10.5 feet; the maximum depth of plant growth in Disappearing Creek was 5 feet; there was no maximum depth of plant growth in Squaw Creek (See Appendix D). Solberg Lake noted a 10 percent open area; Disappearing Creek noted a 0 percent open area (One location with no vegetation noted a depth of 5.5 feet, 0.5 feet greater than the maximum rooting depth. Hence the location was not considered for estimation of open space); Squaw Creek noted a 33 percent open area; and the overall open area of the lake and two inflowing streams was 12 percent.

5.2.7 Total Acreage Covered by Macrophytes

The cumulative effect of the large number of species in the lake was further evaluated by estimating the total acreage covered by macrophytes during 2001. The total macrophyte coverage of Solberg Lake was estimated to be 328 acres (i.e., 37 percent of the lake's surface area).

5.2.8 Functions and Values of Macrophytes

The Solberg Lake macrophyte communities (See Figure 9) perform a number of valuable functions. These include (See Table 2):

- Habitat for fish, insects, and small aquatic invertebrates
- Food for waterfowl, fish, and wildlife
- Oxygen producers
- Provide spawning areas for fish in early spring
- Help stabilize marshy borders of the lake; help protect shorelines from wave erosion
- Provide nesting sites for waterfowl and marsh birds

Table 2 Values of Aquatic Plant Species Found in Solberg Lake

Scientific Name (Common Name)	Plant Type	Plant Values
Brasenia Schreberi (Water Shield)	Floating	The seeds, leaves, stems, and buds of watershield are consumed by a wide variety of waterfowl. The floating leaves also offer shade and shelter for fish and invertebrates.
Ceratophyllum demersum (Coontail)	Submersed	Many 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 spp. (Muskgrass)	Submersed	Muskgrass is a favorite waterfowl food. Algae and invertebrates found on muskgrass provide additional grazing. It is also considered valuable fish habitat. Beds of muskgrass offer cover and are excellent producers of food, especially for largemouth bass and smallmouth bass.
Eleocharis spp. (Spike Rush)	Emergent	Spike Rush provides food for a wide variety of waterfowl as well as muskrats. Submersed beds offer habitat and shelter for invertebrates and small fish.
Elodea canadensis (Canada Waterweed)	Submersed	Provides habitat for many small aquatic animals, which fish and wildlife eat.
Lemna minor (Lesser Duckweed)	Floating	Lesser Duckweed is a nutritious food source that can provide up to 90% of the dietary needs for a variety of ducks and geese. It is also consumed by muskrat, beaver, and fish. Rafts of duckweed offer shade and cover for fish and invertebrates. Extensive mats of duckweed can also inhibit mosquito breeding.
Lobelia dortmanna (Water lobelia)	Submersed	Beds of water lobelia can help stabilize sandy, eroding shorelines. It also offers shallow water habitat for invertebrates and young fish.
Myriophyllum sibericum (formerly *exalbescens)* (Northern Milfoil)	Submersed	Provides cover for fish and invertebrates; supports insects and other small animals eaten by fish; waterfowl occasionally eat the fruit and foliage.
Myriophyllum verticillatum. (Whorled Milfoil)	Submersed	Provides cover for fish and invertebrates; supports insects and other small animals eaten by fish; waterfowl occasionally eat the fruit and foliage.
Najas flexilis. (Spiny Naiad, Bushy Pondweed)	Submerged	Bushy Pondweed is one of the most important plants for waterfowl. Stems, leaves and seeds are all consumed by a wide variety of ducks including black duck, bufflehead, canvasback, gadwall, mallard, pintail, redhead, ringnecked duck, scaup, shoveler, blue-winged teal, green-winged teal, wigeon and wood duck. It is also important to a variety of marsh birds as well as muskrats.
Nuphar advena (Yellow Pond Lily)	Floating	Provides seeds for waterfowl including mallard, northern pintail, ring-necked duck, and scaup. Leaves, stems and flowers are grazed by deer. Muskrat, beaver and porcupine eat the rhizomes. The leaves offer shade and shelter for fish as well as habitat for invertebrates.
Nuphar variegata (Spatterdock)	Floating	Yellow water lily anchors the shallow water community and provides food for many residents. It provides seeds for waterfowl including mallard, pintail, ringneck and scaup. The leaves, stems and flowers are grazed by deer. Muskrat, beaver and even porcupine have been reported to eat the rhizomes.

Scientific Name (Common Name)	Plant Type	Plant Values
		The leaves offer shade and shelter for fish as well as habitat for invertebrates.
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.
Potamogeton amplifolius (Large-leaf Pondweed, Bass Weed, Musky Weed)	Submersed	The broad leaves of *Potamogeton amplifolius* offer shade, shelter and foraging opportunities for fish. Abundant production of large nutlets makes this a valuable waterfowl food.
Potamogeton crispus (Curly-leaf Pondweed)	Submersed	Provides some cover for fish, several waterfowl species feed on the seeds; diving ducks often eat the winter buds.
Potamogeton epihydrus (Ribbon-leaf Pondweed)	Submersed	The fruit produced by ribbon-leaf pondweed can be a locally important food source for a variety of ducks and geese. Mallards gather and graze where the stalks of fruit poke out of the water. Muskrat, deer, beaver and moose may also graze the plants. Leaves and stems can be colonized by invertebrates and offer foraging opportunities for fish.
Potamogeton Illinoensis (Illinois Pondweed)	Submersed	The fruit produced by Illinois pondweed can be a locally important food source for a variety of ducks and geese. The plant may also be grazed by muskrat, deer, beaver, and moose. This pondweed offers excellent shade and cover for fish and good surface area for invertebrates.
Potamogeton natans (Floating-leaf Pondweed)	Submersed	The fruit of Floating-leaf Pondweed is held on the stalk until late in the growing season. This provides valuable grazing opportunities for ducks and geese including scaup and blue-winged teal. Portions of this pondweed may also be consumed by muskrat, beaver, deer, and moose. Floating-leaf pondweed is considered good fish habitat because it provides shade and foraging opportunities.
Potamogeton zosteriformis (Flat-stem Pondweed),	Submersed	Flat-stem pondweed can be a locally important food source for a variety of geese and ducks including redhead and green-winged teal. 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 spp. (Cattail)	Emergent	Cattails provide nesting habitat for many marsh birds ranging from small (red- winged blackbird, marsh wren) to large (least bittern, coot). Shoots and rhizomes are consumed by muskrats and geese. Submersed stalks provide spawning habitat for sunfish and shelter for young fish.
Utricularia spp. (Bladderwort)	Submersed	The trailing stems of bladderwort provide food and cover for fish. Because they are free-floating, they can grow in areas with loosely consolidated sediment. This provides needed fish habitat in areas that are not readily colonized by rooted plants.
Vallisneria americana (Wild Celery)	Submersed	Wild celery is a premiere source of food for waterfowl. All portions of the plant are consumed including foliage, rhizomes, tubers, and fruit. Wild celery beds become a prime destination for thousands of canvasback ducks every fall. Wild celery is also important to marsh birds and shore birds including rail, plover, sand piper, and snipe. Muskrats are also known to graze on it. Beds of wild celery are considered good fish habitat

Scientific Name (Common Name)	Plant Type	Plant Values
		providing shade, shelter, and feeding opportunities.
Zosterella dubia (Water Star Grass)	Submersed	Water star grass can be a locally important source of food for geese and ducks including northern pintail, blue-winged teal and wood duck. It also offers good cover and foraging opportunities for fish.

5.2.9 Exotic Species

Macrophytes in Solberg Lake consisted almost exclusively of native species (i.e., species historically present in this region). In 2001, one exotic (i.e., not native) species occurred in the lake, *Potamogeton crispus* (curly-leaf pondweed). Exotic or non-native species are undesirable because their natural control mechanisms are not introduced with the species. Consequently, exotic species frequently exhibit rapid unchecked growth patterns and may displace native species. Only one plant stem of an exotic species (i.e., curly-leaf pondweed) was found in the entire lake and it was removed. Hence, curly-leaf pondweed is not considered problematic at this time. The location of the curly-leaf pondweed citing in Solberg Lake is noted on Figure 10. Many additional rake casts and a visual search took place in the surrounding area, but no additional curly-leaf pondweed plants were found. Further surveillance and prompt removal of any curly-leaf pondweed plants found in this area are recommended to prevent curly-leaf pondweed growth from becoming problematic.

Because curly-leaf pondweed is problematic in many Wisconsin lakes, a brief discussion of its history and common problems follows. The purpose of the discussion is to provide information for the Solberg Lake Association. It is hoped that the information will help the organization to educate its members to be vigilant in watching for this species and in preventing problems within Solberg Lake.

Curly-leaf pondweed is an exotic perennial, rooted, submersed aquatic vascular plant, which was first noted in Minnesota about 1910 (Moyle and Hotchkiss, 1945). Native to Eurasia, Africa, and Australia, this species has been found in most of the United States since 1950, and is currently found in most parts of the world (Catling and Dobson, 1985).

Curly-leaf pondweed is detrimental to lakes for three reasons:

1. It tends to crowd out native aquatic macrophyte (i.e., aquatic plant) species.
2. Dense colonies of the weed may interfere with recreational activities on the lake.
3. After curly-leaf pondweed dies out in early July, it may sink to the lake bottom and decay. When dense colonies of the weed decay, oxygen depletion and release of phosphorus may occur.

6.0 Developing a Macrophyte Management Plan

A macrophyte management plan is an orderly approach to plant management. It helps define the problem, set priorities, develop management strategies, and evaluate progress. As an educational tool, it can describe the what, how, why, and where of management techniques. As a team effort, a plan can focus community involvement. A successful macrophyte management plan is built on eight principles:

- Define the problem
- Establish goals
- Understand plant ecology
- Identify beneficial use areas
- Consider all the techniques
- Specify control intensity
- Develop management plan
- Monitor the results

These eight principles were used to develop a macrophyte management plan for Solberg Lake.

6.1 Define the Problem

The combined effects of lake morphology and nutrient input from the lake's watershed has resulted in a healthy and diverse macrophyte community in Solberg Lake. However, according to membership survey respondents, aquatic plants have caused problems for recreational users desiring to use personal watercraft, swim, fish, powerboat, canoe/paddle boat, water ski, and view the lake. 2001 macrophyte survey results indicate that excessive plant growths in Comfort Cove and in portions of Disappearing Creek and Squaw Creek have impaired navigation. Therefore, management of macrophyte growth is needed to provide boat passage through Comfort Cove and through portions of Disappearing Creek and Squaw Creek. Such management will support the lake's beneficial uses.

With the exception of Comfort Cove, Disappearing Creek, and Squaw Creek, Solberg Lake notes light to moderate plant growth, which positively impacts the lake's fisheries. Submersed aquatic plants influence both fish distribution and abundance by creating structurally complex habitats (Crowder and Cooper, 1979) that affect predator-prey relationships (Barnett and Schneider, 1974; Moxley and Langford, 1982). Total fish abundance can be substantially higher in areas with aquatic plants than in areas without plants (Laughlin and Werner, 1980; Holland and Huston, 1984). However, foraging success of predators generally declines as plant density increases (Reynolds and Babb, 1978; Savino and Stein, 1982; Durocher, Provine, and Kraai, 1984; Wiley, et al., 1984). Extensive forage cover reduces hunting success of predator species, limiting growth rates and decreasing length/weight condition values. This can lead to an increase in numbers of forage species, which increases competition for food by the foraging species and ultimately leads to an over-crowded condition. Vegetation also serves as cover for macroinvertebrates, and forage species ability to find food may be decreased, intensifying intraspecific and interspecific competition for food. Abundant cover may also allow forage species to harass nesting predators, reducing spawning successes necessary to offset predator mortality rates (Madsen, et al., 1994). Additionally, water quality influenced by dense macrophyte or algae stands often affects fish growth and reproductive success, especially where photosynthesis causes pH shifts above 10. Largemouth bass, for example, become lethargic at high pH, and will not feed or spawn (Buck and Thoits, 1970). The data indicate that maintaining the light to moderate plant density within the majority of the lake would be beneficial to the lakes' fisheries, as would creating cruising lanes through the excessive vegetation in Comfort Cove, Disappearing Creek, and Squaw Creek.

6.2 Establish Goals

The Solberg Lake Association established six aquatic plant management goals for Solberg Lake:

1. Improve navigation through, Squaw Creek, Disappearing Creek, and Comfort Cove
2. Improve recreational attributes of the lake
3. Preserve native plant species and prevent introduction/spread of exotic plant species by conducting regular surveillance of the lake and conducting prompt removal activities of all exotic plants found
4. Preserve and/or improve fish and wildlife habitat
5. Protect and/or improve quality of the resources for all to enjoy (i.e., people, fish, wildlife)
6. Minimize disturbance of sensitive areas (i.e., fish and wildlife)

6.3 Understand Plant Ecology

Macrophyte management alternatives are based upon an understanding of plant ecology. Understanding the biology of aquatic plants and their habitat requirements is necessary to effectively manage plants. Effective management is necessary to maintain the delicate balance of preserving fish and wildlife habitat and concurrently providing reasonable lake-use opportunities to area residents. The following discussion considers aquatic plant ecology and its relationship to macrophyte management alternatives.

The biology of aquatic plants and their habitat requirements are inseparably interrelated. The habitat requirements of plants are divided into two general groups, the living group (biotic) and the nonliving group (abiotic). The following discussion of plant habitat requirements is based upon Nichols (1988).

The biotic group contains the predators, parasites, and other organisms, which depend upon or compete with an organism for their livelihood. These interrelationships form the basis for biological plant management methods.

The abiotic factors form the basis of plant control techniques involving habitat manipulation, and include those physical and chemical attributes which are necessary for plant growth and development: light, bottom type, water, temperature, wind, dissolved gases, and nutrients. Light, water, temperature, dissolved gases, and nutrients relate to the plant's ability to carry out the vital processes of photosynthesis and respiration. Bottom type and wind relate to specific physical locations where a plant can grow. The following discussion will show the relationship between critical habitat requirements and possibilities for management.

Light—Both the quantity and quality of light influence plant growth. Light in the red and blue spectral bands is used for photosynthesis; low and high light intensities inhibit photosynthesis. Management activities that make use of shade and dyes, for example, are based on limiting light intensity or changing the spectral qualities of the light. Deepening the lake through dredging or damming is another method of altering the light available to a plant, as light is naturally attenuated in water and the spectral qualities changed.

Water—In the aquatic environment, water is available in abundance and is, therefore, often overlooked as being critical for aquatic plants. Yet, aquatic plants are adapted to growing in an environment with an abundant water supply and are, therefore, sensitive to water stress.

Macrophytes might be controlled by removing their water supply, resulting in the desiccation of the plant.

Temperature—Plants are generally tolerant of a wide range of temperatures, and temperature fluctuations in the aquatic environment are smaller than in the surrounding aerial environment. Therefore, plant management schemes involving temperature effects depend on artificially exposing aquatic plants to the harsher aerial environment, where not only temperature but desiccation and other factors aid in controlling plant growth.

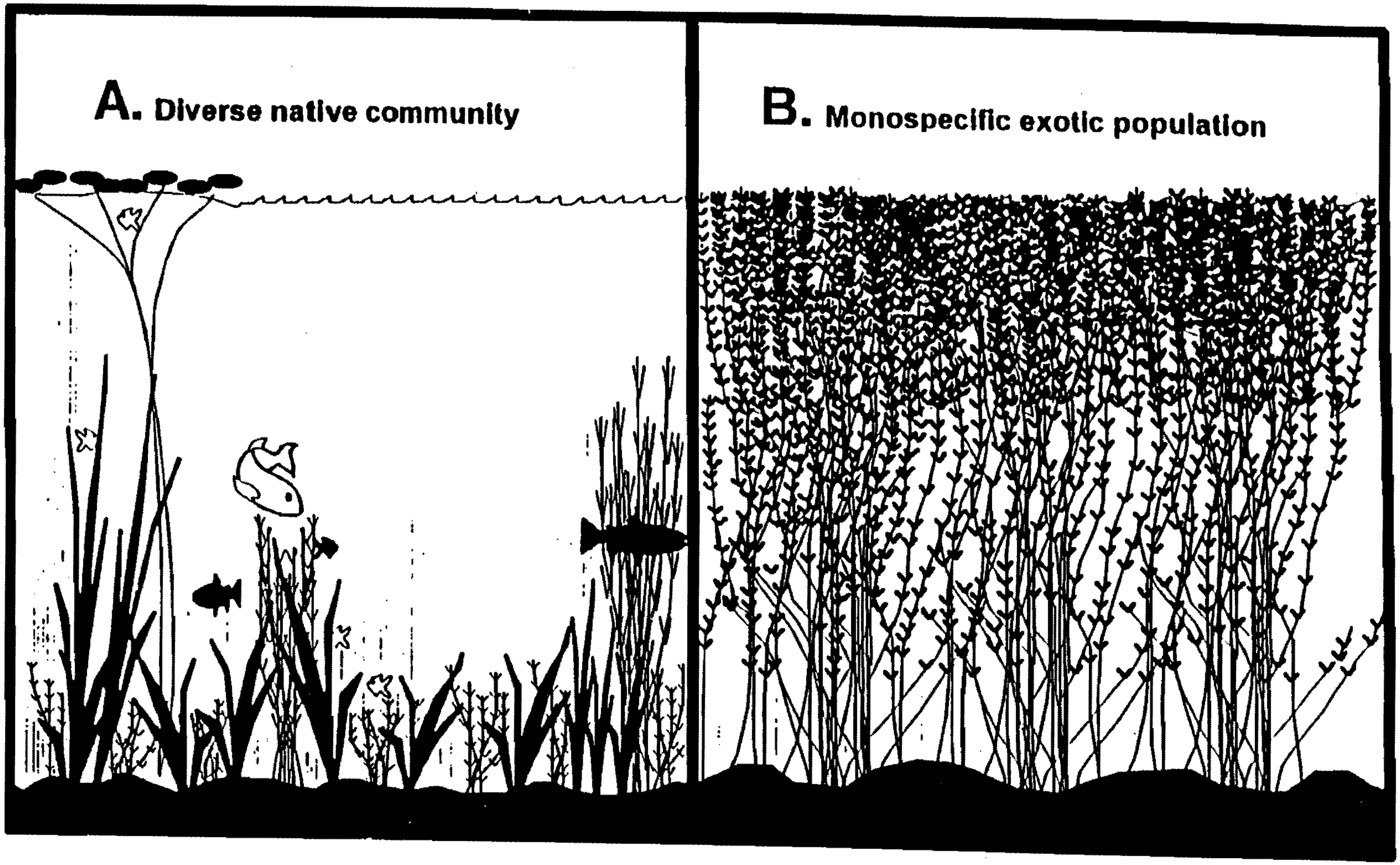
Dissolved Gases—The two gases of primary importance in the aquatic system are carbon dioxide and oxygen, which are used for photosynthesis and respiration, respectively. The availability of carbon in the form of free CO_2 or bicarbonate appears to influence the distribution of some plant species (Hutchinson, 1970). Although oxygen is many times limiting in the aquatic system, most plants are adapted to living in low oxygen conditions. Because the carbon dioxide reaction is so well buffered by an equilibrium with CO_2 in the air and because the plants are tolerant to low oxygen supplies, the success of any scheme to manage plants by altering the dissolved gases in water seems doubtful.

Nutrients—Aquatic plant problems are caused by nutrient enrichment of the sediment. Nitrogen and phosphorus are the two nutrients of prime concern (Vollenweider, 1968; Sawyer, 1947; Stewart and Rohlich, 1967). Gerloff and Krombholz (1966) and Gerloff (1969) point out that the concentration of nutrients in the habitat may not be related to the concentration in the plant, depending on the availability of the nutrient. Plants remove nutrients in excess of their needs and store excess nutrients (i.e., luxury consumption, Gerloff 1969). These excess nutrient supplies could be used at times when the plant undergoes nutrient stress. These factors inherent in the biology of the plant will have to be overcome when developing practical, in-lake methods of nutrient limitation for macrophyte control.

Bottom Type and Wind—Bottom type and wind are physical conditions that may limit plant growth. Some bottom types are rich in nutrients essential for plant growth. Substrates may be altered by removing, covering, or nutrient inactivation. Heavy winds create waves that tear and uproot the plant, and soil types that are too coarse or are not consolidated enough make rooting very difficult.

By manipulating the plant's environment, management tries to induce these limiting conditions and thus restrict the growth of the plants.

The presence of exotic (i.e., not native to this area) plants in a lake system indicates a need for management to protect native communities. Native plant communities are typically dominated by growth forms that concentrate biomass below the surface of the water (See Figure 11A), contain a high diversity of species, and have low to moderate levels of biomass. Exotic plants typically follow an extremely rapid growth pattern. Exotic species generally produce a dense canopy of vegetation at the air: water interface and develop high levels of biomass (See Figure 11B). Such a growth pattern interferes with use of the water resource by recreational-users and may eliminate the beneficial native plant community through shading (Smart, et al., 1996). Management to control the growth of exotic species is necessary to protect the native plant community and provide a reasonable use of the lake to recreational-users. Although Solberg Lake does not currently need an exotic plant management program, continued vigilance to guard against the introduction of exotic plants is needed. In 2001, a single plant of curly-leaf pondweed was found in Solberg Lake and removed. A diligent search for additional plants in the area of the citing yielded no additional plants. Hence, curly-leaf pondweed is not considered problematic. However, the citing indicates a need for surveillance in case additional plants are introduced to the lake in the future.



Source: Smart et al., 1996

Figure 11

SUBMERGED AQUATIC PLANT COMMUNITIES

6.4 Identify Beneficial Use Areas

Beneficial uses of a water body must be compatible with its capacity to sustain those uses, both human and natural. A single water body often supports many different beneficial uses. Aquatic plant growth may impair the beneficial uses of a lake and, hence, may create many use conflicts. The management challenge involves identifying the lake's beneficial uses, and realistically managing for these uses.

Solberg Lake is used for a variety of recreational activities. Membership survey respondents indicate the lake is used for fishing, viewing, swimming, canoeing/paddle boating, power boating, personal watercrafting, and waterskiing. According to membership survey respondents, aquatic plants cause impairment of all beneficial uses (i.e., fishing, viewing, swimming, canoeing/paddle boating, power boating, personal watercrafting, waterskiing, and other recreational uses). Solberg Lake Association and District Board Members have identified beneficial use areas within Comfort Cove and portions of Disappearing Creek and Squaw Creek that require management to resolve conflicts created by aquatic plant growth. Figure 12 identifies Comfort Cove, Disappearing Creek, and Squaw Creek as needing navigation channels to support the lake's beneficial uses. The lake's other beneficial uses are also shown on the map. However, public and semi-public swimming beaches, public and semi-private boat landings, and other navigation passageways in the lake do not currently require management. It should be noted that the lake's public swimming beach and boat landings are owned and maintained by Solberg County. Hence, the Solberg Lake Association has no responsibility for the management of boat landings and swimming beach areas. It should also be noted that riparian owners are responsible for the management of beneficial uses of the lake in front of their property (i.e., from the lake's shoreline to the end of the owner's dock, or an equivalent area if no dock is present). Hence, the Solberg Lake Association's responsibility for management of the lake's beneficial use areas is limited to navigational passageways in the lake (i.e., beyond the ends of riparian owners' docks) and the lake's inlets (i.e., beyond the ends of riparian owners' docks in areas immediately upstream from the lake).

In addition to human uses, the lake provides habitat for fish, waterfowl, and other animals. The Wisconsin Department of Natural Resources (WDNR) has identified fish and wildlife sensitive areas in Solberg Lake (See Figure 13). Sensitive areas include habitats that are integral to the lake ecosystem such as nesting sites or fish spawning areas. To protect sensitive areas, plant management within sensitive areas is restricted by the WDNR.

6.5 Consider All Techniques

Following a consideration of all possible management alternatives, feasible options may be identified for Solberg Lake. The following discussion focuses on four types of aquatic plant management techniques currently used for macrophyte control. They include:

1. Physical
2. Mechanical
3. Chemical
4. Biological

Under proposed Wisconsin Administrative Code s. NR 109, a WDNR permit is needed for mechanical plant removal such as harvesting. Manual cutting and raking will be exempted from a permit if the area of plant removal is a single area with a maximum width of no more than 30 feet along the shoreline, provided that any piers, boatlifts, swimrafts, and other recreational and water use devices are located within the 30-foot zone. All cut plants must be removed from the water. Under Wisconsin Administrative Code s. NR 107, a WDNR permit is needed for chemical management of aquatic plants.

6.5.1 Physical

Physical tactics typically used to manage aquatic plants are light manipulation and habitat manipulation. Habitat manipulation includes such techniques as overwinter 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 Solberg Lake is a large lake with 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 was effective in controlling plants down to the depth of drawdown, but had no 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) indicated the benefits of drawdown were temporary, and the same species of plants returned in about their former abundance within a few years (Barr, 1994). For Eurasian watermilfoil, drawdown effects have been variable, partly because of its ability to withstand low temperatures for short periods of time as well as its resiliency and tenacity (Gibbons 1994).

Another commonly-used group of physical control techniques uses 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 from small swimming areas. The barriers are safe and effective, a non-chemical control technique, and use a simple technology. In addition, bottom barriers do not result in significant production of plant fragments (critical for milfoil treatment). Costs vary from approximately $0.30/sq. ft. (Texel™) to $0.35/sq. ft. (Aquascreen™) for materials with an additional $0.2 to $0.50/sq. ft. for installation. Prices for burlap material (available in fabric stores, outlets) average from $0.15 to $0.25/sq. ft. for materials only. Bottom barriers may cause harm to fisheries and invertebrate habitat. Hence, an evaluation of the desired management area is required prior to WDNR permit application to determine whether critical habitat may be harmed by the barrier.

Weed rollers or "Automated Unintended Aquatic Plant Control Devices" are motor-drive rollers (round bars) placed on the lake bottom and 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° 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. The cost is reasonable (approximately $2,000 to $2,500, 1997 cost basis, and the device can be shared by several people) (Osgood, 1997). However, weed rollers cause harm to fisheries and invertebrate habitat. Consequently, use of rollers in Wisconsin lakes is not allowed.

Sediment inactivation has included the application of phosphorus binding substances to sediments (i.e., such as lime slurry). The growth of aquatic plants is inhibited by the reduced availability of phosphorus in sediments (Barr, 2001)

6.5.2 Mechanical

Mechanical control involves macrophyte removal via 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 via small-scale harvesting or hand pulling or hand digging. Hand digging is very useful for aggressive control of sparse or small pockets of Eurasian watermilfoil (Gibbons 1994). The Solberg Lake Association has used hand pulling to clear navigational channels in the lake's inflow streams during the Association's annual fall workday.

Large-scale mechanical control often uses floating, motorized harvesting machines that cut the plants and remove them from the water onto land, where they can be disposed. Harvesting has not proven to be an effective means of sustaining long-term reductions in growth of Eurasian watermilfoil. Regrowth of Eurasian watermilfoil to pre-harvest levels typically occurs within 30 to 60 days, depending on water depth and the depth of cut (Perkins, 1987). In addition, fragments from harvesting may result in additional Eurasian watermilfoil growth and may increase Eurasian watermilfoil coverage within a lake.

Rotovation/cultivation (underwater rototilling) are bottom tillage methods that remove aquatic plant root systems. This results in reduced stem development and seriously impairs the growth of rooted aquatic plants. Derooting methods were developed by British Columbia Ministry of Environment aquatic plant experts as a more effective Eurasian watermilfoil control 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- to 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 to 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 milfoil 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 to 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 species diversity of native plants, of potential benefit to fisheries (Gibbons, 1994). Rototilling is not advised where bottom sediments have excessive nutrient and/or metals concentrations, because of potential release of contaminants into the overlying water. The method does result in 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 costs vary according to treatment scale, density of plants, machinery used and other site constraints. In 1994, contract costs for rotovation in the State of Washington ranged from $1,200-$1,700/acre, depending on treatment size (Gibbons 1994).

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 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 to 97 percent can be achieved by diver dredging (Maxnuk, 1979). Costs range from a minimum of $1,100/day to upwards of $2,000/day (with no dredged material transport).

Hydraulic dredging is the removal of sediment involving the pumping of a mixture of water and sediment to a disposal site located on shore or near the lake. Hydraulic dredging can be less expensive than mechanical dredging (using bulldozers, loaders, etc.) and is often more efficient and safer than Diver dredging.

6.5.3 Chemical

Chemical aquatic vegetation management programs 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 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 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 (Barr, 1997).

6.5.4 Biological

Biological control involves the use of a biological control agent to control macrophyte 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. Weevils have been used experimentally to control Eurasian Watermilfoil (Creed, et al., 1995; Newman, et al., 1995).

Aquatic macrophyte control techniques are summarized in Table 3.

Table 3 Control Techniques for Aquatic Plants: Procedure, Cost, Advantages and Disadvantages (Modified from a Summary Prepared by Vermont DNR in 1998)

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 ac/day @ $1,200/day New machine: $80,000-100,000+	+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 @ $1,500–$2,000/ac	+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/ac Cost of new machine is $100,000+	+Immediate 85% – 95% decrease in stem density +Up to 2 years control +Frequently done in fall when plant fragments not viable	
Hydraulic Dredging	Steel cutter blade dislodges sediment and plants; removed by a suction pump	$2,500/ac and up Cost of new machine is $100,000+	+90% effective at root removal, with plant regrowth probable within 1 year	– Expensive
Diver-operated Suction	Scuba divers use 4" suction hose to selectively remove	Cost is $800–$10,000/ac depending on cost of	+Up to 97% effective at removing plant roots and stems	– Effectiveness varies greatly with type of sediment

Control Technique	Procedure	Cost	Advantages	Disadvantages
Harvesting	plants from lake bottom Plants disposed of on shore	divers, type of sediments, travel time, etc. Cost of new machine $20,000+	+1-2 years of control +Can work in areas with underwater obstruction	- Slow and labor intensive - Expensive - Potentially hazardous because of scuba
Hand pulling	Plants and roots are removed by hand using snorkeling and wading Plants disposed of on shore	Variable, depending on volunteers; divers cost $15-$60/hr	+Most effective on newly established populations 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)	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/ac 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 +Control for up to 2 years possible	- Toxic to fish - Potential risk to human health remains controversial - Plants decompose over 2-3 weeks
Tripclopyr (Garlon 3A)	Liquid systemic herbicide that kills plants by interfering with hormones that regulate normal plant growth	$75/gal or $1200-$1700/ac, depending on water depth, concentration of chemical, etc. Sample collection cost not included	+Effectively removes up to 99% of EWM biomass 4 weeks after treatment +Control may last up to 2 years +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 - Experimental
Fluridone (Sonar)	Systemic herbicide available in liquid and pellet form that	$500-$1500/ac depending on water depth and	+Can be applied near water intakes if concentration is less than 20 ppb	- Long contact time required; may take up to 3 months to work

Control Technique	Procedure	Cost	Advantages	Disadvantages
	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	formulation Sample collection cost not included	+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	- Potential risk to human health remains controversial - Not selective for milfoil - Spot treatments generally not effective
Endothall (Aquathol and Aquathol K)	Granular (Aquathol) and liquid (Aquathol K) kills plants on contact by interfering with protein synthesis Can be applied to surface or subsurface when water temperature is at least 65°F	\$300-\$700/ac depending on treatment area and use of adjuvants Sample collection cost not included	+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
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	\$500-\$950/ac Sample collection cost not included	+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

6.6 Specify Control Intensity

Plant control needs within a lake vary from no control to high control. The appropriate levels of control for various areas within a lake are determined from an evaluation of the lake's uses and plant problems. Three different levels of control are used to address plant problems:

- **No Control**—Plant zones around the lake are identified that should be left alone or protected (e.g., fish and wildlife sensitive areas).
- **Moderate Level of Control**—A moderate level of control is applied to reduce the growth of unwanted aquatic plants in areas identified as requiring management, but not considered essential to achieving the lake's beneficial uses selected by the lake organization's governing board as having the highest lake management priority.
- **High Level of Control**—Certain situations may require aggressive control. Aggressive control may be required to provide navigation lanes for boat passage or to clear vegetation from near shore areas so that swimming and other recreational activities may occur.

To determine the appropriate levels of plant control for Solberg Lake, several pieces of information were evaluated. They include the Beneficial Uses Map (Figure 12), the Macrophyte Species Distribution and Density Range map (Figure 9), and the Fish and Wildlife Sensitive Areas map (Figure 13). Using the above criteria, appropriate levels of control were then determined. Very few areas were identified as needing control. The lake was divided into two control zones: No Control and High Level of Control. Navigation lanes within Comfort Cove, Disappearing Creek, and Squaw Creek were identified as needing a high level of control. The rest of the lake was identified as needing no control. A Control Intensity map of Solberg Lake shows the locations of these control zones (See Figure 14).

6.7 Develop Management Plan

Development of a management plan involves choosing the combination of control efforts that best meet the needs of water body users with the least impact to the environment. The Control Intensity Map is reviewed and an appropriate control method is determined for each control zone. The following considerations are important:

- **The type and extent of plant growth and timing of treatment**—In reviewing control options, it is important to understand both the extent and the life cycle of the problem plant species. If the infested area is small (e.g., 0.25 acres), then large-scale methods would be inappropriate. The same is true for large-scale problems treated with small-scale methods. Understanding the life cycle of plant species in need of control is also important. Some plant species with early-season growth are more susceptible to treatment in the springtime. In other situations, winter or summer treatment may be most effective.
- **Probable duration of control**—The length of plant control should be determined (i.e., a month, a growing season, 1 year, 2 years, or more).
- **Site-specific constraints that might affect use of control method**—The lake should be evaluated to determine control method constraints due to site-specific problems (e.g., Does the site have a lot of submerged logs or bottom debris or water intake pipes that would hamper bottom treatments like rotovation or bottom barrier application?).
- **Capital costs and operation/maintenance costs**—If specialized equipment is to be purchased for the control project, the cost of buying, operating and maintaining it should be determined.
- **Human safety and health concerns**—Human safety and health concerns should be identified for each control option under consideration (e.g., Will the control option restrict use of the water body after treatment by banning water contact or ingestion -- swimming, fishing, drinking or irrigation use? Does the operation of large machinery or equipment occur at peak time of recreational use? Does this control option represent a severe safety hazard or interfere significantly with normal use?).
- **Fisheries, waterfowl or wildlife status and general ecology of water body**—Fisheries and wildlife sensitive areas within the lake should be identified (e.g., Does the aquatic system have important spawning sites?). Control activities that disturb the bottom would be prohibited during periods that are critical to fish and wildlife. The presence of endangered, rare, or sensitive plants or animals utilizing aquatic plant beds could also limit the use of certain control methodologies.
- **Balancing enhancement of beneficial uses with environmental protection**—The final selection of control options involves achieving a balance between beneficial uses of the lake and environmental protection. Consequently, the projected short-term and long-term impacts of control options are evaluated.

- **Possible mitigation techniques and costs, including replacement of untargeted plants that are removed**—Some aquatic plant control techniques pose higher risks of removing non-target plants and organisms, particularly emergent vegetation along the shoreline. Estimates should be made of the types and areas of plant species that may be affected by the control techniques. Lost areas can be mitigated by replanting with plants harvested from local areas. Volunteers can often help with revegetation efforts, if needed.
- **Local, county, state or Federal permit requirements**—Permit requirements for each control option are evaluated to determine what permits are necessary, whether a fee is required, and the expected time it takes to process the permit application(s). All macrophyte management options require a WDNR permit, except manual cutting and raking in areas less than 30 feet along the shoreline.

6.8 Monitor the Results

A monitoring program to evaluate results will provide information to determine whether the management program results in goal achievement. Monitoring will determine changes, both desirable and undesirable, and detect problems before they become unmanageable.

7.0 Macrophyte Management Plan for Solberg Lake

The Solberg Lake Macrophyte Management Plan is based upon achievement of the lake's goals (See Section 6.2) and the levels of control established for the lake (See Section 6.6). Criteria used in the development of the plan are discussed in Section 6.7.

7.1 Feasibility Analysis of Management Options

Four management options were evaluated to determine their feasibility in achieving the lake's goals and the levels of control established for the lake. Affordability was also considered. The four options were:

1. Dredging
2. Harvesting
3. Hydroraking
4. Chemical Treatment

7.1.1 Dredging

Dredging reduces plant growth by increasing the depth and decreasing light availability to plants. The presence of stained waters in the lake's inflow streams suggests that a relatively small increase in stream depth would effectively reduce light availability to plants. Reduced plant growth is expected to result from dredging navigation channels in the lake's inflow streams. In addition, increasing stream depth would decrease the likelihood of contact between boat propellers and vegetation growing along the stream bottom. Current navigation problems are caused by boat propeller contact with plants and bottom sediment. Hence, a dredging feasibility analysis was completed to determine the feasibility of dredging material from the inlets.

The specific plan evaluated was an increase in stream channel depth from approximately 2 to 3 feet to a depth of 5 to 6 feet. The dredging analysis assumed mechanical dredging methodology because it was the most feasible option for the inlet streams. Specifically, the analysis assumed that dredging would involve utilizing a backhoe mounted on a float-in barge to create navigation channels within Squaw Creek and Disappearing Creek. Each navigation channel would be approximately 25 feet wide by 2000-feet long (total area equals 2.30 acres) (See Figure 15). An average of 3 feet of sediment would be removed to obtain an average channel depth of 5 to 6 feet, for a total removal amount of approximately 8,500 cubic yards. Dredging costs would vary greatly depending upon the location of a suitable deposition location and type of substrate removed. Estimated costs from $85,000 to $250,000, assuming the substrate was tested and found to be non-hazardous (no heavy metals or other forms of contamination). Because of financial constraints, dredging is not a feasible option for the Solberg Lake Association. Hence, dredging was rejected from further consideration for the Solberg Lake Management Plan.

7.1.2 Harvesting

Harvesting navigation channels in Squaw Creek, Disappearing Creek, and Comfort Cove was evaluated. A harvestor is unable to operate in the inflowing streams because of their shallow depth (i.e., 2 to 3 feet) and the presence of logs and woody debris within the stream channel. Hence, harvesting was rejected from further consideration for the Solberg Lake Management Plan.

7.1.3 Hydroraking

Hydro-raking involves the use of a mechanical rake to remove plants and their roots. The plant materials are removed from the waters. The use of a hydrorake to create navigation channels within Disappearing Creek, Squaw Creek, and Comfort Cove was considered. The analysis concluded that a hydrorake is able to operate within the shallow streams. However, logs and woody debris within the stream channel prevent the operation of a hydrorake. Hence, the option is not available for Solberg Lake and was rejected from further consideration for the Solberg Lake Management Plan.

7.1.4 Chemical Management

Chemical aquatic vegetation management involves the use of a herbicide to kill plants within treatment areas. The use of a herbicide to create navigation channels within Disappearing Creek, Squaw Creek, and Comfort Cove was considered. The proposed treatment areas within Disappearing Creek and Squaw Creek are located in areas considered by WDNR to be sensitive habitats for fish and wildlife. Hence, the WDNR has indicated it will carefully evaluate chemical treatment permit applications to determine whether or not harm to fish and wildlife habitat will result from the proposed treatment. Permit approval will be given if no harm to fish and wildlife will result from the treatment. Hence, chemical treatment was recommended for the Solberg Lake Management Plan.

7.2 Management Plan

The Solberg Lake Management Plan outlines the treatment program intended to provide warranted plant management for the lake. The Solberg Lake Association will fund treatment of navigation channels within Disappearing Creek, Squaw Creek, and Comfort Cove. Riparian owners may fund the treatment of recreational areas in front of their property and navigation channels from their homes to the navigation channel created by the Solberg Lake Association.

A herbicide treatment plan is recommended to clear navigational channels in Comfort Cove, Disappearing Creek, and Squaw Creek. A trial 3-year herbicide treatment program is recommended.

Following the 3-year trial program, the Solberg Lake Association will determine whether continued treatment is warranted. Details of the recommended treatment program follow.

Treatment of 20-to 30-foot wide navigation channels in Comfort Cove and in portions of Disappearing Creek and Squaw Creek will occur monthly during June and July of each year for a 3-year period. Areas will be treated with endothall, (i.e., Aquathol™ or Reward™), a contact herbicide that kills plants by interfering with protein synthesis. The maximum allowed treatment dose will be used to insure treatment effectiveness. Treated areas are estimated to total 2.2 to 2.6 acres and the treatment cost is estimated to be $500 to $600 per acre per treatment event. Hence, treatment costs are estimated to total $2,600 annually. The recommended chemical treatment areas are shown in Figure 16. The treated lake navigation channels provide benefits to:

- **Home-owners**—The navigation channels will provide easier access to the main lake body for those home- owners who live adjacent to Disappearing Creek, Squaw Creek, and Comfort Cove.
- **The lake's fisheries**—The harvested navigation channels will provide cruising lanes for the Comfort Cove, Disappearing Creek, and Squaw Creek fisheries (e.g., bass). The fish will expend less energy and will more easily capture prey while swimming through the cruising lanes than swimming through untreated dense weed growths. The treated areas are expected to produce increased numbers of invertebrates which will result in an increase in food for the lake's fisheries. The increased number of invertebrates results from an increase in the edge area within the dense plant beds. Studies have shown that larger quantities of invertebrates live at the edge of dense plant beds than in the middle. Consequently, treating channels through dense plant beds will increase the edge area, thus increasing invertebrate numbers (Pellet 1998).

If budget constraints prevent the treatment of all recommended treatment areas, the following treatment prioritization is recommended:

1. Disappearing Creek
2. Squaw Creek
3. Comfort Cove

The shallow water depths of the streams exacerbate navigation problems. Hence, treatment of the streams should have a higher priority than treatment of Comfort Cove.

The trial herbicide plan assumes that repeated treatment will reduce the density of aquatic plants in the treated areas to the extent that annual treatment may no longer be needed. Consequently, an evaluation of the treated areas is recommended following the 3-year trial program to determine whether continued treatment is warranted.

It is recommended that individual homeowners desiring to apply for permits and fund treatment of navigation channels and recreational areas in front of their property be granted the opportunity. Floating leaf plants are particularly problematic in the near shore areas of Disappearing Creek and Squaw Creek. The dense plant growths will likely make navigation difficult from the homeowners' docks to the navigation channels created by the Solberg Lake Association in the above program unless a riparian owner funded treatment program is implemented. In addition, riparian owners may be prevented from using the near-shore areas for swimming and other recreational activities unless treatment occurs. Because of the dense plant growths in the streams, riparian homeowners have obtained WDNR permits and funded a treatment program during 2000 and 2001. Areas treated included a 40-foot wide area in front of each riparian owner's property and a 25- to 30-foot channel in the streams. The chemical LV6 was used to treat the floating leaf plants.

Areas that may be considered for treatment by homeowners in a riparian owner funded program are shown in Figure 16. The intent of the optional riparian owner treatment program is to treat 20- to 30-foot navigation channels from the homeowners' property to the channel treated by the Solberg Lake Association and to treat a 30- to 40-foot wide area in front of the homeowners' property.

7.3 Education of Lake Homeowners

An education program is recommended to help area residents achieve an understanding of:

- The functions and roles of native species/native communities within Solberg Lake.
- The exotic species, especially curly-leaf pondweed, and the threat of exotic species to the native plant community within Solberg Lake if they were introduced.

The education program may be completed by the Solberg Lake Association with assistance from the WDNR and/or Solberg County staff.

7.4 Fall Work Day

The Solberg Lake Association holds an annual fall work day to complete warranted projects with volunteer labor. It is recommended that the Lake Association use the annual fall work day to complete warranted macrophyte management projects such as hand removal of plants in navigation channels or surveillance of critical areas to search for possible exotic plants. If small areas of exotic plants are found, hand removal of the plants should occur promptly.

7.5 Evaluation Program

An evaluation program is recommended to monitor the effectiveness of the macrophyte management plan. It is recommended that a macrophyte survey of the lake be completed once every 5 years. The methodology used for the 2001 survey of the lake should be used for each survey. Survey results should be compared with results of previous surveys to determine changes in the macrophyte community. The survey results will indicate the effectiveness of macrophyte management plan implementation and will identify any needed modifications of the plan.

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Solberg Lake Homeowner Aquatic Plant Survey

1. On what part of the lake is your property situated?
   36 Main Lake   28 Inlet Bay   23 Inlet Channel
   27 Shallow Bay   5 Deep Bay   5 Not sure

2. How do you use the lake. (Select all that apply.)
   40 Power Boating   72 Swimming
   25 Water-skiing   95 Viewing
   69 Canoeing or paddle boating   27 Personal Watercrafting
   116 Fishing   7 Other

3. Which of your uses do you feel are impaired by current levels of aquatic plant growth in Solberg Lake
   16 Power Boating   40 Swimming   45 None of my uses.
   8 Water-skiing   21 Viewing
   24 Canoeing or paddle boating   18 Personal Watercrafting
   49 Fishing   4 Other ________________

4. Please rate the importance of aquatic plants to the following functions in a lake.

Aquatic Plant Functions

Level of Importance for a Healthy Lake	Aesthetics	Fish Food	Invertebrate Habitat	Fish Shelter & Spawning Area	Food & Shelter for Waterfowl	Shoreline Protection & sediment stabilization
Low	50	10	14	3	19	30
Medium	27	53	44	44	45	38
High	16	47	33	58	42	36

5. Do you believe that there is an aquatic plant problem in front of your property?
   70 Yes   50 No

6. Have you removed or attempted to remove aquatic plants around your dock or along your property shoreline?
   63 Yes   58 No

7. What is your feeling to chemical use to remove aquatic plants in your lake?
   68 Okay   47 Not okay   1 Not Sure

8. What is your feeling to mechanical harvesting of aquatic plants in your lake?
   91 Okay   26 Not okay

9. Do you feel your lake association should own and operate a weed harvester?
   59 Yes   53 No   1 Not Sure

10. We welcome your additional comments?

Solberg Lake June 18, 19 and 20, 2001

Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
DC1	A	2.0	Muck	*Total Density @ Station*	N/A	1	1	1	1	1.00	N/A
DC1	A	2.0	Muck	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
DC1	A	2.0	Muck	*Eieocharis spp.*	spikerush	1	0	1	1	0.75	3
DC1	A	2.0	Muck	*Utricularia spp.*	bladderwort	0	0	0	1	0.25	1
DC1	B	4.0	Muck	Total Density @ Station	N/A	2	4	1	3	2.50	N/A
DC1	B	4.0	Muck	*Lobelia dortmanna*	water lobelia	2	4	1	3	2.50	1
DC1	B	4.0	Muck	*Elodea canadensis*	Canada waterweed	0	0	0	1	0.25	1
DC1	AA	2.4	Sand/Muck	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
DC1	AA	2.4	Sand/Muck	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
DC1	AA	2.4	Sand/Muck	*Chara spp.*	muskgrass	0	0	0	1	0.25	1
DC2	A	2.0	Muck	Total Density @ Station	N/A	1	2	1	1	1.25	N/A
DC2	A	2.0	Muck	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
DC2	A	2.0	Muck	*Utricularia spp.*	bladderwort	0	1	1	1	0.75	1
DC2	A	2.0	Muck	*Eleocharis spp.*	spikerush	0	1	0	0	0.25	3
DC2	A	2.0	Muck	*Typha. spp.*	cattail	0	0	1	0	0.25	3
DC2	A	2.0	Muck	*Brasenia schreberi*	watershield	0	0	0	1	0.25	2
DC2	B	3.5	Muck	Total Density @ Station	N/A	5	5	4	4	4.50	N/A
DC2	B	3.5	Muck	*Lobelia dortmanna*	water lobelia	5	5	4	4	4.50	1
DC2	AA	2.4	Muck	Total Density @ Station	N/A	2	2	3	4	2.75	N/A
DC2	AA	2.4	Muck	*Lobelia dortmanna*	water lobelia	1	1	2	4	2.00	0
DC2	AA	2.4	Muck	*Elodea canadensis*	Canada waterweed	1	1	1	0	0.75	1
DC2	AA	2.4	Muck	*Nymphaea tuberosa*	white waterlily	0	1	0	0	0.25	2
DC2	AA	2.4	Muck	*Myriophyllum sibiricum*	northern watermilfoil	0	0	1	0	0.25	1
DC3	A	2.3	Muck/Woody Debris	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
DC3	A	2.3	Muck/Woody	*Nymphaea tuberosa*	white waterlily	1	0	0	0	0.25	2
DC3	A	2.3	Muck/Woody	*Vallisneria americana*	wild celery	0	1	1	1	0.75	1
DC3	A	2.3	Muck/Woody	*Potamogeton amplifolius*	largeleaf pondweed	0	0	0	1	0.25	1
DC3	B	5.5	Muck	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
DC3	BB	3.5	Muck	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
DC3	BB	3.5	Muck	*Potamogeton amplifolius*	largeleaf pondweed	1	0	0	0	0.25	1
DC3	BB	3.5	Muck	*Nymphaea tuberosa*	white waterlily	1	0	0	0	0.25	2
DC3	BB	3.5	Muck	*Elodea canadensis*	Canada waterweed	0	1	1	1	0.75	1
DC3	BB	3.5	Muck	*Brasenia schreberi*	watershield	0	1	0	1	0.50	2
DC3	BB	3.5	Muck	*Chara spp.*	muskgrass	0	0	1	1	0.50	1

[1]Type (plant community): 1=submerged, 2=floating-leaf, 3=emergent

Solberg Lake June 18, 19 and 20, 2001

Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
SC1	A	1.7	Muck/Logs	Total Density @ Station	N/A	2	1	1	1	1.25	N/A
SC1	A	1.7	Muck/Logs	*Potamogeton natans*	floatingleaf pondweed	1	0	0	0	0.25	2
SC1	A	1.7	Muck/Logs	*Potamogeton amplifolius*	largeleaf pondweed	1	0	0	0	0.25	1
SC1	A	1.7	Muck/Logs	*Elodea canadensis*	Canada waterweed	1	1	1	0	0.75	1
SC1	A	1.7	Muck/Logs	*Nuphar advena*	yellow pondlily	1	1	0	1	0.75	2
SC1	A	1.7	Muck/Logs	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
SC1	A	1.7	Muck/Logs	*Utricularia spp.*	bladderwort	1	1	1	0	0.75	1
SC1	A	1.7	Muck/Logs	*Ceratophyllum demersum*	coontail	0	1	1	1	0.75	1
SC1	AA	2.2	Muck	Total Density @ Station	N/A	2	2	2	1	1.75	N/A
SC1	AA	2.2	Muck	*Ceratophyllum demersum*	coontail	2	1	2	1	1.50	1
SC1	AA	2.2	Muck	*Elodea canadensis*	Canada waterweed	1	1	1	1	1.00	1
SC1	AA	2.2	Muck	*Potamogeton amplifolius*	largeleaf pondweed	0	0	0	1	0.25	1
SC1	AAA	2.0	Muck	Total Density @ Station	N/A	1	1	0	1	0.75	N/A
SC1	AAA	2.0	Muck	*Ceratophyllum demersum*	coontail	1	1	0	1	0.75	1
SC1	AAA	2.0	Muck	*Elodea canadensis*	Canada waterweed	1	1	0	0	0.50	1
SC1	AAA	2.0	Muck	*Nuphar advena*	yellow pondlily	0	1	0	0	0.25	2
SC1	AAA	2.0	Muck	*Myriophyllum sibiricum*	northern watermilfoil	0	0	0	1	0.25	1
SC2	A	2.2	Muck/Logs	Total Density @ Station	N/A	2	2	1	1	1.50	N/A
SC2	A	2.2	Muck/Logs	*Ceratophyllum demersum*	coontail	1	1	1	0	0.75	1
SC2	A	2.2	Muck/Logs	*Elodea canadensis*	Canada waterweed	1	1	0	1	0.75	1
SC2	A	2.2	Muck/Logs	*Potamogeton amplifolius*	largeleaf pondweed	0	1	1	0	0.50	1
SC2	A	2.2	Muck/Logs	*Vallisneria americana*	wild celery	0	1	0	1	0.50	1
SC2	A	2.2	Muck/Logs	*Nuphar variegata*	spatterdock	0	0	1	1	0.50	2
SC2	B	2.8	Muck	Total Density @ Station	N/A	1	2	1	2	1.50	N/A
SC2	B	2.8	Muck	*Ceratophyllum demersum*	coontail	1	1	1	1	1.00	1
SC2	B	2.8	Muck	*Potamogeton amplifolius*	largeleaf pondweed	1	1	1	1	1.00	1
SC2	B	2.8	Muck	*Elodea canadensis*	Canada waterweed	1	0	1	1	0.75	1
SC2	B	2.8	Muck	*Vallisneria americana*	wild celery	0	1	0	1	0.50	1
SC2	B	2.8	Muck	*Utricularia spp.*	bladderwort	0	0	0	1	0.25	1
SC2	BB	3.8	Muck	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
SC2	BB	3.8	Muck	*Vallisneria americana*	wild celery	1	1	0	0	0.50	1
SC3	B	3.8	Muck	Total Density @ Station	N/A	0	0	0	0	0.00	N/A

[1]Type (plant community): 1=submerged, 2=floating-leaf, 3=emergent

Solberg Lake June 18, 19 and 20, 2001

Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
SC3	BB	4.0	Muck	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
SC3	BBB	4.2	Muck/Twigs	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
1	A	2.1	Sand/Muck	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
1	A	2.1	Sand/Muck	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
1	A	2.1	Sand/Muck	*Ceratophyllum demersum*	coontail	1	0	0	1	0.50	1
1	A	2.1	Sand/Muck	*Potamogeton amplifolius*	largeleaf pondweed	0	1	0	0	0.25	1
1	A	2.1	Sand/Muck	*Nuphar variegata*	spatterdock	0	0	1	0	0.25	2
1	C	6.5	Sand/Logs	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
1	CC	10.0	Sand/Logs	Total Density @ Station	N/A	0	0	0	1	0.25	N/A
1	CC	10.0	Sand/Logs	*Ceratophyllum demersum*	coontail	0	0	0	1	0.25	1
2	A	2.0	Sand/Logs	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
2	A	2.0	Sand/Logs	*Potamogeton zosteriformis*	flatstem pondweed	1	0	0	0	0.25	1
2	A	2.0	Sand/Logs	*Vallisneria americana*	wild celery	1	1	0	0	0.50	1
2	A	2.0	Sand/Logs	*Potamogeton amplifolius*	largeleaf pondweed	1	0	0	0	0.25	1
2	A	2.0	Sand/Logs	*Elodea canadensis*	Canada waterweed	0	1	0	1	0.50	1
2	A	2.0	Sand/Logs	*Najas flexilis*	bushy naiad	0	0	1	0	0.25	1
2	B	3.7	Muck	Total Density @ Station	N/A	1	0	1	0	0.50	N/A
2	B	3.7	Muck	*Vallisneria americana*	wild celery	1	0	0	0	0.25	1
2	B	3.7	Muck	*Nuphar variegata*	spatterdock	0	0	1	0	0.25	2
2	C	6.5	Sand/Logs	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
3	A	2.0	Coarse Sand	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
3	A	2.0	Coarse Sand	*Elodea canadensis*	Canada waterweed	1	0	0	0	0.25	1
3	A	2.0	Coarse Sand	*Zosterella dubia*	mud plantian	0	1	0	0	0.25	1
3	A	2.0	Coarse Sand	*Ceratophyllum demersum*	coontail	0	1	0	0	0.25	1
3	B	3.0	Sand/Wood	Total Density @ Station	N/A	1	0	0	1	0.50	N/A
3	B	3.0	Sand/Wood	*Lobelia dortmanna*	water lobelia	1	0	0	1	0.50	1
3	B	3.0	Sand/Wood	*Ceratophyllum demersum*	coontail	0	0	0	1	0.25	1
3	C	5.0	Sand/Wood	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
3	C	5.0	Sand/Wood	*Elodea canadensis*	Canada waterweed	1	0	0	0	0.25	1
3	C	5.0	Sand/Wood	*Lobelia dortmanna*	water lobelia	1	1	0	0	0.50	1
4	A	2.1	Woody Debris	Total Density @ Station	N/A	1	1	1	0	0.75	N/A
4	A	2.1	Woody Debris	*Lobelia dortmanna*	water lobelia	1	1	1	0	0.75	0
4	B	4.0	Woody Debris	Total Density @ Station	N/A	0	1	1	1	0.75	N/A
4	B	4.0	Woody Debris	*Lobelia dortmanna*	water lobelia	0	1	1	1	0.75	1
5	A	2.5	Woody Debris	Total Density @ Station	N/A	1	1	0	1	0.75	N/A
5	A	2.5	Woody Debris	*Gratiola aurea*	dwarf hyssop	1	1	0	1	0.75	1

[1]Type (plant community): 1=submerged, 2=floating-leaf, 3=emergent

Solberg Lake June 18, 19 and 20, 2001

Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
5	B	3.6	Woody Debris /Coarse Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
5	B	3.6	Woody Debris /Coarse Sand	*Lobelia dortmanna*	water lobelia	1	1	1	1	1.00	1
5	C	5.0	Coarse Sand	Total Density @ Station	N/A	1	0	0	0	0.25	N/A
5	C	5.0	Coarse Sand	*Lobelia dortmanna*	water lobelia	1	0	0	0	0.25	1
6	A	2.3	Sand/Rock	Total Density @ Station	N/A	0	1	0	0	0.25	N/A
6	A	2.3	Sand/Rock	*Potamogeton epihydrus*	ribbonleaf pondweed	0	1	0	0	0.25	1
6	B	4.3	Sand/Rock	Total Density @ Station	N/A	0	0	0	1	0.25	N/A
6	B	4.3	Sand/Rock	*Potamogeton epihydrus*	ribbonleaf pondweed	0	0	0	1	0.25	1
6	C	6.0	Sand/Rock	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
7	A	2.5	Sand	Total Density @ Station	N/A	1	0	0	0	0.25	N/A
7	A	2.5	Sand	*Potamogeton epihydrus*	ribbonleaf pondweed	1	0	0	0	0.25	1
7	B	3.5	Sand	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
7	B	3.5	Sand	*Elodea canadensis*	Canada waterweed	1	0	0	0	0.25	1
7	B	3.5	Sand	*Lobelia dortmanna*	water lobelia	0	1	0	0	0.25	1
7	C	6.0	Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
7	C	6.0	Sand	*Elodea canadensis*	Canada waterweed	1	1	1	1	1.00	1
7	C	6.0	Sand	*Eleocharis spp.*	spikerush	0	0	1	0	0.25	3
8	A	2.0	Rock	Total Density @ Station	N/A	0	0	1	1	0.50	N/A
8	A	2.0	Rock	*Potamogeton epihydrus*	ribbonleaf pondweed	0	0	1	1	0.50	1
8	B	3.7	Sand/Rock	Total Density @ Station	N/A	1	1	2	1	1.25	N/A
8	B	3.7	Sand/Rock	*Lobelia dortmanna*	water lobelia	1	1	2	1	1.25	0
8	C	5.3	Sand/Woody Debris	Total Density @ Station	N/A	1	1	0	4	1.50	N/A
8	C	5.3	Sand/Woody Debris	*Lobelia dortmanna*	water lobelia	1	1	0	4	1.50	1
8	AA	2.3	Coarse Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
8	AA	2.3	Coarse Sand	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
8	AA	2.3	Coarse Sand	*Lobelia dortmanna*	water lobelia	1	0	0	0	0.25	0
8	AAA	2.3	Sand/Rock	Total Density @ Station	N/A	0	1	1	1	0.75	N/A
8	AAA	2.3	Sand/Rock	*Elodea canadensis*	Canada waterweed	0	1	0	0	0.25	1
8	AAA	2.3	Sand/Rock	*Lobelia dortmanna*	water lobelia	0	0	1	1	0.50	0
8	BB	4.4	Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
8	BB	4.4	Sand	*Elodea canadensis*	Canada waterweed	1	0	0	0	0.25	1
8	BB	4.4	Sand	*Lobelia dortmanna*	water lobelia	0	1	1	1	0.75	1
8	BB	4.4	Sand	*Potamogeton amplifolius*	largeleaf pondweed	0	0	0	1	0.25	1

[1]Type (plant community): 1=submerged, 2=floating-leaf, 3=emergent

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Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
8	CC	6.5	Sand	Total Density @ Station	N/A	1	0	1	1	0.75	N/A
8	CC	6.5	Sand	*Lobelia dortmanna*	water lobelia	1	0	1	1	0.75	1
8	CC	6.5	Sand	*Elodea canadensis*	Canada waterweed	1	0	0	0	0.25	1
9	A	2.3	Sand/Rock	Total Density @ Station	N/A	1	0	0	0	0.25	N/A
9	A	2.3	Sand/Rock	*Lobelia dortmanna*	water lobelia	1	0	0	0	0.25	1
9	B	4.0	Sand/Woody Debris	Total Density @ Station	N/A	2	2	2	4	2.50	N/A
9	B	4.0	Sand/Woody Debris	*Gratiola aurea*	dwarf hyssop	2	2	2	4	2.50	1
9	C	5.5	Rock/Sand	Total Density @ Station	N/A	0	0	1	1	0.50	N/A
9	C	5.5	Rock/Sand	*Potamogeton amplifolius*	largeleaf pondweed	0	0	1	1	0.50	1
10	A	1.6	Sand	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
10	B	4.2	Sand	Total Density @ Station	N/A	1	0	1	1	0.75	N/A
10	B	4.2	Sand	*Elodea canadensis*	Canada waterweed	1	0	1	0	0.50	1
10	B	4.2	Sand	*Lobelia dortmanna*	water lobelia	1	0	1	1	0.75	1
10	C	5.8	Sand	Total Density @ Station	N/A	1	1	0	1	0.75	N/A
10	C	5.8	Sand	*Gratiola aurea*	dwarf hyssop	1	1	0	1	0.75	1
11	A	1.6	Sand/Rock	Total Density @ Station	N/A	1	0	1	1	0.75	N/A
11	A	1.6	Sand/Rock	*Lobelia dortmanna*	water lobelia	1	0	0	0	0.25	1
11	A	1.6	Sand/Rock	*Poa spp.*	narrow leaf pondweed	0	0	1	1	0.50	1
11	B	3.6	Sand/Logs	Total Density @ Station	N/A	0	1	0	1	0.50	N/A
11	B	3.6	Sand/Logs	*Elodea canadensis*	Canada waterweed	0	1	0	1	0.50	1
11	B	3.6	Sand/Logs	*Lobelia dortmanna*	water lobelia	0	1	0	1	0.50	1
11	C	6.0	Sand/Logs	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
11	C	6.0	Sand/Logs	*Lobelia dortmanna*	water lobelia	1	1	0	0	0.50	1
11	C	6.0	Sand/Logs	*Elodea canadensis*	Canada waterweed	1	1	0	0	0.50	1
12	A	2.2	Muck	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
12	A	2.2	Muck	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
12	A	2.2	Muck	*Nymphaea tuberosa*	white waterlily	1	0	0	0	0.25	2
12	A	2.2	Muck	*Eleocharis spp.*	spikerush	1	0	0	0	0.25	3
12	A	2.2	Muck	*Potamogeton amplifolius*	largeleaf pondweed	0	0	1	0	0.25	1
12	B	3.7	Muck/Woody Debris	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
12	BB	4.5	Muck	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
12	BB	4.5	Muck	*Elodea canadensis*	Canada waterweed	1	1	0	0	0.50	1
13	A	2.3	Mud/Muck	Total Density @ Station	N/A	0	4	1	1	1.50	N/A
13	A	2.3	Mud/Muck	*Lobelia dortmanna*	water lobelia	0	3	1	1	1.25	1

[1]Type (plant community): 1=submerged, 2=floating-leaf, 3=emergent

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Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
13	A	2.3	Mud/Muck	*Myriophyllum verticillatum*	whorled watermilfoil	0	1	0	0	0.25	1
13	B	4.5	Sand/Mud	Total Density @ Station	N/A	0	0	1	1	0.50	N/A
13	B	4.5	Sand/Mud	*Myriophyllum verticillatum*	whorled watermilfoil	0	0	1	1	0.50	1
13	B	4.5	Sand/Mud	*Elodea canadensis*	Canada waterweed	0	0	0	1	0.25	1
13	C	6.5	Sand	Total Density @ Station	N/A	0	2	0	0	0.50	N/A
13	C	6.5	Sand	*Myriophyllum verticillatum*	whorled watermilfoil	0	2	0	0	0.50	1
13	BB	4.5	Sand	Total Density @ Station	N/A	1	0	0	1	0.50	N/A
13	BB	4.5	Sand	*Lobelia dortmanna*	water lobelia	1	0	0	1	0.50	1
13	BB	4.5	Sand	*Eleocharis spp.*	spikerush	0	0	0	1	0.25	3
13	CC	6.0	Sand	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
14	A	1.5	Mud/Logs	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
14	A	1.5	Mud/Logs	*Myriophyllum sibiricum*	northern watermilfoil	1	0	0	0	0.25	1
14	A	1.5	Mud/Logs	*Vallisneria americana*	wild celery	0	1	1	1	0.75	1
14	A	1.5	Mud/Logs	*Elodea canadensis*	Canada waterweed	0	1	1	0	0.50	1
14	A	1.5	Mud/Logs	*Utricularia spp.*	bladderwort	0	0	1	0	0.25	1
14	B	3.4	Muck	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
14	B	3.4	Muck	*Vallisneria americana*	wild celery	1	1	1	0	0.75	1
14	B	3.4	Muck	*Eleocharis spp.*	spikerush	1	0	1	1	0.75	3
14	C	7.0	Muck	Total Density @ Station	N/A	1	1	1	0	0.75	N/A
14	C	7.0	Muck	*Lobelia dortmanna*	water lobelia	1	1	1	0	0.75	1
14	C	7.0	Muck	*Eleocharis spp.*	spikerush	1	1	0	0	0.50	3
14	C	7.0	Muck	*Vallisneria americana*	wild celery	1	0	0	0	0.25	1
15	A	2.3	Sand	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
15	A	2.3	Sand	*Lobelia dortmanna*	water lobelia	1	0	0	0	0.25	1
15	A	2.3	Sand	*Eleocharis spp.*	spikerush	0	1	0	0	0.25	3
15	B	4.5	Muck	Total Density @ Station	N/A	3	1	2	2	2.00	N/A
15	B	4.5	Muck	*Potamogeton amplifolius*	largeleaf pondweed	1	1	1	1	1.00	1
15	B	4.5	Muck	*Lobelia dortmanna*	water lobelia	2	0	1	1	1.00	1
15	B	4.5	Muck	*Elodea canadensis*	Canada waterweed	1	0	0	1	0.50	1
15	B	4.5	Muck	*Eleocharis spp.*	spikerush	0	1	1	0	0.50	3
15	C	5.7	Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
15	C	5.7	Sand	*Lobelia dortmanna*	water lobelia	1	1	1	1	1.00	1
15	C	5.7	Sand	*Potamogeton amplifolius*	largeleaf pondweed	0	0	1	0	0.25	1
16	A	2.5	Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
16	A	2.5	Sand	*Elodea canadensis*	Canada waterweed	1	1	0	0	0.50	1
16	A	2.5	Sand	*Vallisneria americana*	wild celery	0	0	1	0	0.25	1
16	A	2.5	Sand	*Potamogeton epihydrus*	ribbonleaf pondweed	0	0	1	1	0.50	1

[1]Type (plant community): 1=submerged, 2=floating-leaf, 3=emergent

Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
16	A	2.5	Sand	*Potamogeton crispus*	curlyleaf pondweed	0	0	0	1	0.25	1
16	A	2.5	Sand	*Eleocharis spp.*	spikerush	0	0	0	1	0.25	3
16	B	3.9	Muck/Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
16	B	3.9	Muck/Sand	*Potamogeton amplifolius*	largeleaf pondweed	1	0	1	1	0.75	1
16	B	3.9	Muck/Sand	*Vallisneria americana*	wild celery	1	1	1	0	0.75	1
16	B	3.9	Muck/Sand	*Lobelia dortmanna*	water lobelia	0	0	1	1	0.50	1
16	C	7.0	Sand	Total Density @ Station	N/A	1	1	2	1	1.25	N/A
16	C	7.0	Sand	*Lobelia dortmanna*	water lobelia	1	1	1	1	1.00	1
16	C	7.0	Sand	*Potamogeton amplifolius*	largeleaf pondweed	0	0	1	0	0.25	1
16	C	7.0	Sand	*Myriophyllum sibiricum*	northern watermilfoil	0	0	1	0	0.25	1
17	A	2.0	Sand	Total Density @ Station	N/A	1	0	1	0	0.50	N/A
17	A	2.0	Sand	*Potamogeton illinoensis*	Illinois pondweed	1	0	0	0	0.25	1
17	A	2.0	Sand	*Lobelia dortmanna*	water lobelia	0	0	1	0	0.25	1
17	B	3.5	Sand	Total Density @ Station	N/A	1	0	1	0	0.50	N/A
17	B	3.5	Sand	*Elodea canadensis*	Canada waterweed	1	0	0	0	0.25	1
17	B	3.5	Sand	*Lobelia dortmanna*	water lobelia	1	0	0	0	0.25	1
17	B	3.5	Sand	*Poa spp.*	narrow leaf pondweed	0	0	1	0	0.25	1
17	C	5.3	Sand	Total Density @ Station	N/A	0	1	1	1	0.75	N/A
17	C	5.3	Sand	*Myriophyllum sibiricum*	northern watermilfoil	0	1	0	0	0.25	1
17	C	5.3	Sand	*Lobelia dortmanna*	water lobelia	0	1	1	1	0.75	1
17	C	5.3	Sand	*Elodea canadensis*	Canada waterweed	0	1	0	1	0.50	1
17	C	5.3	Sand	*Eleocharis spp.*	spikerush	0	0	1	0	0.25	3
17	CC	6.0	Sand	Total Density @ Station	N/A	0	0	1	1	0.50	N/A
17	CC	6.0	Sand	*Myriophyllum sibiricum*	northern watermilfoil	0	0	1	0	0.25	1
17	CC	6.0	Sand	*Elodea canadensis*	Canada waterweed	0	0	1	1	0.50	1
17	CC	6.0	Sand	*Poa spp.*	narrow leaf pondweed	0	0	0	1	0.25	1
18	A	2.2	Sand/Logs	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
18	A	2.2	Sand/Logs	*Potamogeton epihydrus*	ribbonleaf pondweed	1	0	0	0	0.25	1
18	A	2.2	Sand/Logs	*Lobelia dortmanna*	water lobelia	0	1	1	1	0.75	1
18	A	2.2	Sand/Logs	*Vallisneria americana*	wild celery	0	0	0	1	0.25	1
18	B	4.8	Sand/Logs	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
19	A	1.7	Sand	Total Density @ Station	N/A	0	0	0	1	0.25	N/A
19	A	1.7	Sand	*Vallisneria americana*	wild celery	0	0	0	1	0.25	1
19	A	1.7	Sand	*Nuphar advena*	yellow pondlily	0	0	0	1	0.25	2
19	B	2.6	Sand	Total Density @ Station	N/A	0	0	0	1	0.25	N/A
19	B	2.6	Sand	*Vallisneria americana*	wild celery	0	0	0	1	0.25	1
19	C	5.5	Sand	Total Density @ Station	N/A	0	0	1	1	0.50	N/A

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Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
19	C	5.5	Sand	*Vallisneria americana*	wild celery	0	0	1	0	0.25	1
19	C	5.5	Sand	*Lobelia dortmanna*	water lobelia	0	0	0	1	0.25	1
20	A	1.6	Sand/Rock	Total Density @ Station	N/A	1	1	0	1	0.75	N/A
20	A	1.6	Sand/Rock	*Nymphaea tuberosa*	white waterlily	1	1	0	1	0.75	2
20	B	5.0	Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
20	B	5.0	Sand	*Nymphaea tuberosa*	white waterlily	1	1	1	1	1.00	2
20	C	6.0	Sand	Total Density @ Station	N/A	0	1	0	0	0.25	N/A
20	C	6.0	Sand	*Nymphaea tuberosa*	white waterlily	0	1	0	0	0.25	2
21	A	2.0	Sand/Rock	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
21	A	2.0	Sand/Rock	*Vallisneria americana*	wild celery	1	0	0	1	0.50	1
21	A	2.0	Sand/Rock	*Elodea canadensis*	Canada waterweed	1	0	0	1	0.50	1
21	A	2.0	Sand/Rock	*Nymphaea tuberosa*	white waterlily	0	1	0	0	0.25	2
21	A	2.0	Sand/Rock	*Eleocharis spp.*	spikerush	0	0	1	0	0.25	3
21	B	4.0	Sand/Rock	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
21	B	4.0	Sand/Rock	*Elodea canadensis*	Canada waterweed	1	1	1	0	0.75	1
21	B	4.0	Sand/Rock	*Eleocharis spp.*	spikerush	1	0	0	1	0.50	3
21	B	4.0	Sand/Rock	*Potamogeton amplifolius*	largeleaf pondweed	1	1	1	0	0.75	1
21	B	4.0	Sand/Rock	*Gratiola aurea*	dwarf hyssop	1	0	1	0	0.50	1
21	B	4.0	Sand/Rock	*Utricularia spp.*	bladderwort	0	0	1	0	0.25	1
21	C	5.5	Sand/Rock	Total Density @ Station	N/A	0	1	0	1	0.50	N/A
21	C	5.5	Sand/Rock	*Lobelia dortmanna*	water lobelia	0	1	0	1	0.50	1
21	C	5.5	Sand/Rock	*Elodea canadensis*	Canada waterweed	0	0	0	1	0.25	1
22	A	1.9	Sand	Total Density @ Station	N/A	0	0	0	1	0.25	N/A
22	A	1.9	Sand	*Vallisneria americana*	wild celery	0	0	0	1	0.25	1
22	B	4.0	Sand/Woody Debris	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
22	B	4.0	Sand/Woody Debris	*Elodea canadensis*	Canada waterweed	1	1	0	0	0.50	1
22	B	4.0	Sand/Woody Debris	*Lobelia dortmanna*	water lobelia	0	1	1	1	0.75	1
22	C	6.0	Sand/Woody Debris	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
22	C	6.0	Sand/Woody Debris	*Lobelia dortmanna*	water lobelia	1	1	1	1	1.00	1
23	A	2.5	Sand	Total Density @ Station	N/A	1	0	0	0	0.25	N/A
23	A	2.5	Sand	*Vallisneria americana*	wild celery	1	0	0	0	0.25	1
23	B	3.5	Coarse Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A

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Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
23	B	3.5	Coarse Sand	*Potamogeton amplifolius*	largeleaf pondweed	1	1	1	1	1.00	1
23	B	3.5	Coarse Sand	*Elodea canadensis*	Canada waterweed	1	1	1	1	1.00	1
23	B	3.5	Coarse Sand	*Zosterella dubia*	mud plantian	0	0	0	1	0.25	1
23	C	5.0	Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
23	C	5.0	Sand	*Potamogeton amplifolius*	largeleaf pondweed	1	1	1	1	1.00	1
23	C	5.0	Sand	*Zosterella dubia*	mud plantian	0	0	1	0	0.25	1
24	A	1.7	Sand	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
24	A	1.7	Sand	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
24	A	1.7	Sand	*Elodea canadensis*	Canada waterweed	1	1	1	1	1.00	1
24	A	1.7	Sand	*Chara spp.*	muskgrass	0	1	0	0	0.25	1
24	A	1.7	Sand	*Nuphar variegata*	spatterdock	0	0	1	0	0.25	2
24	A	1.7	Sand	*Ceratophyllum demersum*	coontail	0	0	1	0	0.25	1
24	B	4.8	Sand	Total Density @ Station	N/A	0	1	0	0	0.25	N/A
24	B	4.8	Sand	*Elodea canadensis*	Canada waterweed	0	1	0	0	0.25	1
24	B	4.8	Sand	*Potamogeton amplifolius*	largeleaf pondweed	0	1	0	0	0.25	1
25	A	2.5	Woody Debris	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
25	A	2.5	Woody Debris	*Vallisneria americana*	wild celery	1	0	1	0	0.50	1
25	A	2.5	Woody Debris	*Nuphar variegata*	spatterdock	1	0	0	1	0.50	2
25	A	2.5	Woody Debris	*Najas flexilis*	bushy naiad	0	1	0	0	0.25	1
25	A	2.5	Woody Debris	*Ceratophyllum demersum*	coontail	0	0	1	1	0.50	1
25	A	2.5	Woody Debris	*Potamogeton amplifolius*	largeleaf pondweed	0	0	0	1	0.25	1
25	B	3.8	Woody Debris	Total Density @ Station	N/A	1	2	1	1	1.25	N/A
25	B	3.8	Woody Debris	*Ceratophyllum demersum*	coontail	1	1	1	1	1.00	1
25	B	3.8	Woody Debris	*Elodea canadensis*	Canada waterweed	1	1	1	1	1.00	1
25	B	3.8	Woody Debris	*Vallisneria americana*	wild celery	0	0	0	1	0.25	1
25	BB	3.6	Sand/Woody Debris	Total Density @ Station	N/A	1	1	1	2	1.25	N/A
25	BB	3.6	Sand/Woody Debris	*Potamogeton amplifolius*	largeleaf pondweed	1	1	1	1	1.00	1
25	BB	3.6	Sand/Woody Debris	*Vallisneria americana*	wild celery	1	0	0	0	0.25	1
25	BB	3.6	Sand/Woody Debris	*Potamogeton zosteriformis*	flatstem pondweed	0	0	0	1	0.25	1
25	C	6.3	Logs/Woody Debris	Total Density @ Station	N/A	0	0	1	1	0.50	N/A
25	C	6.3	Logs/Woody Debris	*Potamogeton amplifolius*	largeleaf pondweed	0	0	1	1	0.50	1

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Transect	Depth Code	Depth (ft)	Substrate	Species (Scientific Name)	Species (Common name)	Density Rating	Density Rating	Density Rating	Density Rating	Average Density	Type[1]
26	A	1.9	Muck/Logs	Total Density @ Station	N/A	1	2	1	2	1.50	N/A
26	A	1.9	Muck/Logs	*Vallisneria americana*	wild celery	1	0	0	1	0.50	1
26	A	1.9	Muck/Logs	*Potamogeton amplifolius*	largeleaf pondweed	1	0	0	0	0.25	1
26	A	1.9	Muck/Logs	*Elodea canadensis*	Canada waterweed	1	0	0	1	0.50	1
26	A	1.9	Muck/Logs	*Lemna minor*	lesser duckweed	1	0	1	0	0.50	2
26	A	1.9	Muck/Logs	*Nuphar variegata*	spatterdock	0	1	1	0	0.50	2
26	A	1.9	Muck/Logs	*Nymphaea tuberosa*	white waterlily	0	1	1	0	0.50	2
26	A	1.9	Muck/Logs	*Brasenia schreberi*	watershield	0	1	0	0	0.25	2
26	A	1.9	Muck/Logs	*Myriophyllum sibiricum*	northern watermilfoil	0	1	0	0	0.25	1
26	A	1.9	Muck/Logs	*Ceratophyllum demersum*	coontail	0	1	1	2	1.00	1
26	A	1.9	Muck/Logs	*Utricularia spp.*	bladderwort	0	0	1	0	0.25	1
26	B	2.8	Muck/Logs	Total Density @ Station	N/A	1	2	1	1	1.25	N/A
26	B	2.8	Muck/Logs	*Utricularia spp.*	bladderwort	1	0	0	0	0.25	1
26	B	2.8	Muck/Logs	*Eleocharis spp.*	spikerush	1	1	0	0	0.50	3
26	B	2.8	Muck/Logs	*Elodea canadensis*	Canada waterweed	1	0	1	1	0.75	1
26	B	2.8	Muck/Logs	*Ceratophyllum demersum*	coontail	0	2	0	1	0.75	1
26	C	5.7	Mud/Muck	Total Density @ Station	N/A	1	1	1	1	1.00	N/A
26	C	5.7	Mud/Muck	*Eleocharis spp.*	spikerush	1	1	0	0	0.50	3
26	C	5.7	Mud/Muck	*Lobelia dortmanna*	water lobelia	0	1	1	1	0.75	1
26	C	5.7	Mud/Muck	*Elodea canadensis*	Canada waterweed	0	0	1	0	0.25	1
27	A	1.5	Rocks/ Boulders	Total Density @ Station	N/A	1	1	0	0	0.50	N/A
27	A	1.5	Rocks/ Boulders	*Gratiola aurea*	dwarf hyssop	1	0	0	0	0.25	1
27	A	1.5	Rocks/ Boulders	*Poa spp.*	narrow leaf pondweed	0	1	0	0	0.25	1
27	B	4.7	Sand/Rock	Total Density @ Station	N/A	1	0	1	1	0.75	N/A
27	B	4.7	Sand/Rock	*Lobelia dortmanna*	water lobelia	1	0	1	1	0.75	1
27	C	6.5	Sand	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
28	A	2.5	Muck	Total Density @ Station	N/A	1	1	1	2	1.25	N/A
28	A	2.5	Muck	*Vallisneria americana*	wild celery	1	1	1	1	1.00	1
28	A	2.5	Muck	*Potamogeton amplifolius*	largeleaf pondweed	0	0	1	1	0.50	1
28	A	2.5	Muck	*Nymphaea tuberosa*	white waterlily	0	0	1	0	0.25	2
28	C	5.7	Muck	Total Density @ Station	N/A	0	0	0	0	0.00	N/A
28	B	4.2	Muck	Total Density @ Station	N/A	1	0	0	0	0.25	N/A
28	B	4.2	Muck	*Nymphaea tuberosa*	white waterlily	1	0	0	0	0.25	2
28	B	4.2	Muck	*Elodea canadensis*	Canada waterweed	1	0	0	0	0.25	1

[1]Type (plant community): 1=submerged, 2=floating-leaf, 3=emergent

Table E-1
2001 Solberg Lake Macrophyte Frequency of Occurrence, Relative Frequency, and Diversity

Lake: Solberg

Species Name	Frequency of Occurrence	rf	rf/100	(rf/100)^2
Brasenia schreberi	2.9	1.62	0.016	0.00026
Ceratophyllum demersum	13.3	7.57	0.076	0.00573
Chara spp.	2.9	1.62	0.016	0.00026
Elodea canadensis	35.2	20.00	0.200	0.04000
Eleocharis spp.	14.3	8.11	0.081	0.00657
Lobelia dortmanna	39.0	22.16	0.222	0.04912
Lemna minor	1.0	0.54	0.005	0.00003
Myriophyllum sibiricum	6.7	3.78	0.038	0.00143
Myriophyllum verticillatum	2.9	1.62	0.016	0.00026
Najas flexilis	1.9	1.08	0.011	0.00012
Nuphar advena	2.9	1.62	0.016	0.00026
Nuphar variegata	5.7	3.24	0.032	0.00105
Nymphaea tuberosa	10.5	5.95	0.059	0.00354
Potamogeton amplifolius	22.9	12.97	0.130	0.01683
Potamogeton crispus	1.0	0.54	0.005	0.00003
Potamogeton epihydrus	5.7	3.24	0.032	0.00105
Potamogeton illinoensis	1.0	0.54	0.005	0.00003
Potamogeton natans	1.0	0.54	0.005	0.00003
Poa spp.	3.8	2.16	0.022	0.00047
Potamogeton zosteriformis	1.9	1.08	0.011	0.00012
Typha. spp.	1.0	0.54	0.005	0.00003
Utricularia spp.	7.6	4.32	0.043	0.00187
Vallisneria americana	28.6	16.22	0.162	0.02630
Zosterella dubia	2.9	1.62	0.016	0.00026
TOTAL	176.19	100.00	1.000	0.15565

Diversity = 1 - sum of (rf/100)^2 **Diversity** **0.84435**

Table
2001 Solberg Lake Maximum Rooting Depth

Lake: Solberg Lake

Sample Date:June 18 - 20, 2001

Transect	Maximum Rooting Depth (Feet)
DC1	None
DC2	None
DC3	5.0
SC1	None
SC2	None
SC3	None
1	10.5
2	6.5
3	7.5
4	5.3
5	7.0
6	6.0
7	6.5
8	7.0
9	6.5
10	7.0
11	7.0
12	7.0
13	7.0
14	8.0
15	7.5
16	7.0
17	8.0
18	6.5
19	6.5
20	7.0
21	7.0
22	7.0
23	7.0
24	7.5
25	7.5
26	7.5
27	6.5
28	None
average =	**7.0**