Church Pine and Round (Wind) Lakes Macrophyte Surveys and Management Plan

Prepared for
Church Pine, Round, and Big Lake Protection and Rehabilitation District

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Executive Summary

Macrophyte surveys were completed in Church Pine and Round (Wind) Lake during 1997. The surveys evaluated plant coverage, density, and species composition during July. The results indicate macrophyte densities in the lakes' littoral regions were generally at an acceptable level throughout the summer period. Macrophyte densities were considered problematic in a few isolated areas. Consequently, navigation channels are recommended to provide a reasonable access to the lake for residents living adjacent to excessively dense macrophyte (i.e., aquatic weed) beds.

Study results indicate a large number of species were found in Church Pine and Round (Wind) Lakes. The results further indicate the exotic species (i.e., not native to this region) *Potamogeton crispus* (curly-leaf pondweed) was found along much of the east shoreline of Round (Wind) Lake and in two isolated locations along the east shoreline of Church Pine Lake. 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, which eliminate native species. Widespread dense growths of curly-leaf pondweed in neighboring Big Lake are considered objectionable to area residents.

The survey results were used to develop a macrophyte management plan for Church Pine and Round (Wind) Lakes. The six aquatic plant management goals for Church Pine and Round (Wind) lakes are:

- Improve navigation within the lakes through areas containing dense plant beds (two areas within each lake)
- Remove or limit current exotic plants (i.e., curly-leaf pondweed)
- Preserve native species and prevent introduction of additional exotic species
- Preserve and/or improve fish and wildlife habitat
- Protect and/or improve quality of the resources for all to enjoy (i.e., people, fish, wildlife)
- Minimize disturbance of sensitive areas (i.e., fish and wildlife)

The macrophyte management plan includes four parts:

- Harvesting program to create navigation channels, fish cruising lanes, and increased edge in areas with excessive macrophyte growth;

- Treatment program to minimize the exotic, curly-leaf pondweed, to the greatest extent possible;

- Education of lake homeowners;

- Prevent the establishment of other exotic species in the lakes.

Church Pine and Round (Wind) Lakes
Macrophyte Surveys and Management Plan

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1.0 Introduction

The Church Pine and Round (Wind) Lakes, located in the Church Pine, Round (Wind), and Big Lakes chain, in Polk County, Wisconsin are valued by riparian owners, area residents, Polk County, and the WDNR for their fisheries and for recreational-use (see Figures 1 and 2). Concern for the lakes resulted in the formation of a lake association during the 1960s, and the Church Pine, Round, and Big Lake Protection and Rehabilitation District in the 1970s.

The District, with assistance from a consultant, completed a lake and watershed analysis of Church Pine, Round (Wind), and Big Lakes during 1987. The study concluded that macrophyte growth was observed throughout the littoral areas of all three lakes. Species found in the lakes included *Potamogeton crispus*, a problematic exotic species. The study further concluded that Church Pine and Round (Wind) Lakes exhibited good water quality, while Big Lake exhibited objectionable summer algal blooms. Excessive phosphorus loading from North Creek, a tributary to Big Lake, was considered the primary cause of Big Lake's summer algal blooms.

From 1986 through the present, volunteers have collected water transparency data through the WDNR "Self-Help" program. The data, presented in Appendix D, corroborate the 1987 study results. Each summer, Big Lake exhibited a steady decline in water transparency because of algal blooms. Church Pine Lake exhibited good water transparency throughout the period of record, while Round (Wind) Lake exhibited a water transparency midway between that of Church Pine and Big Lakes.

During 1995, representatives from the Church Pine, Round, and Big Lake Protection and Rehabilitation District approached the WDNR to discuss management of the lakes' macrophyte growth. The WDNR recommended that the District complete a macrophyte survey and a macrophyte management plan for each lake.

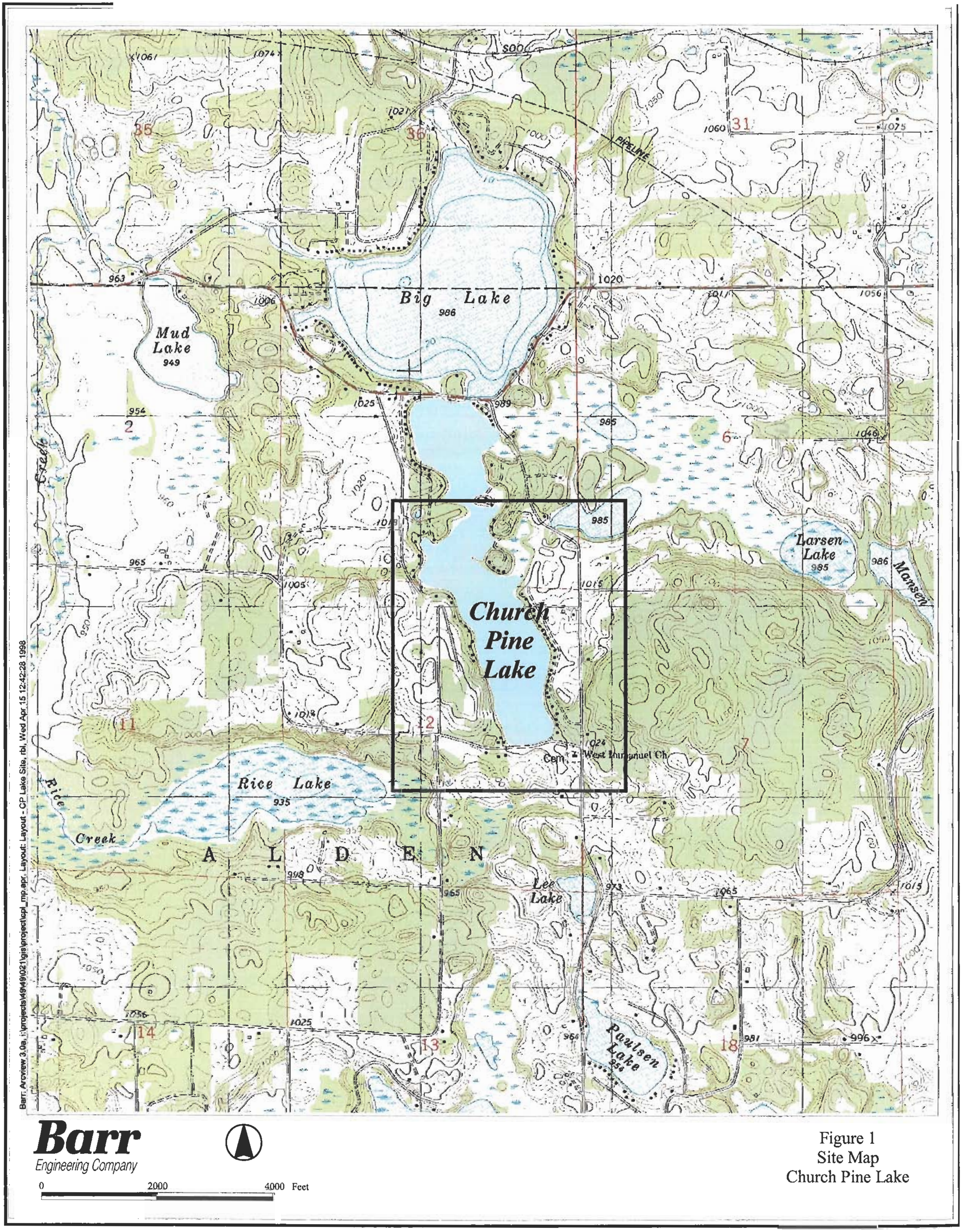


Figure 1
Site Map
Church Pine Lake

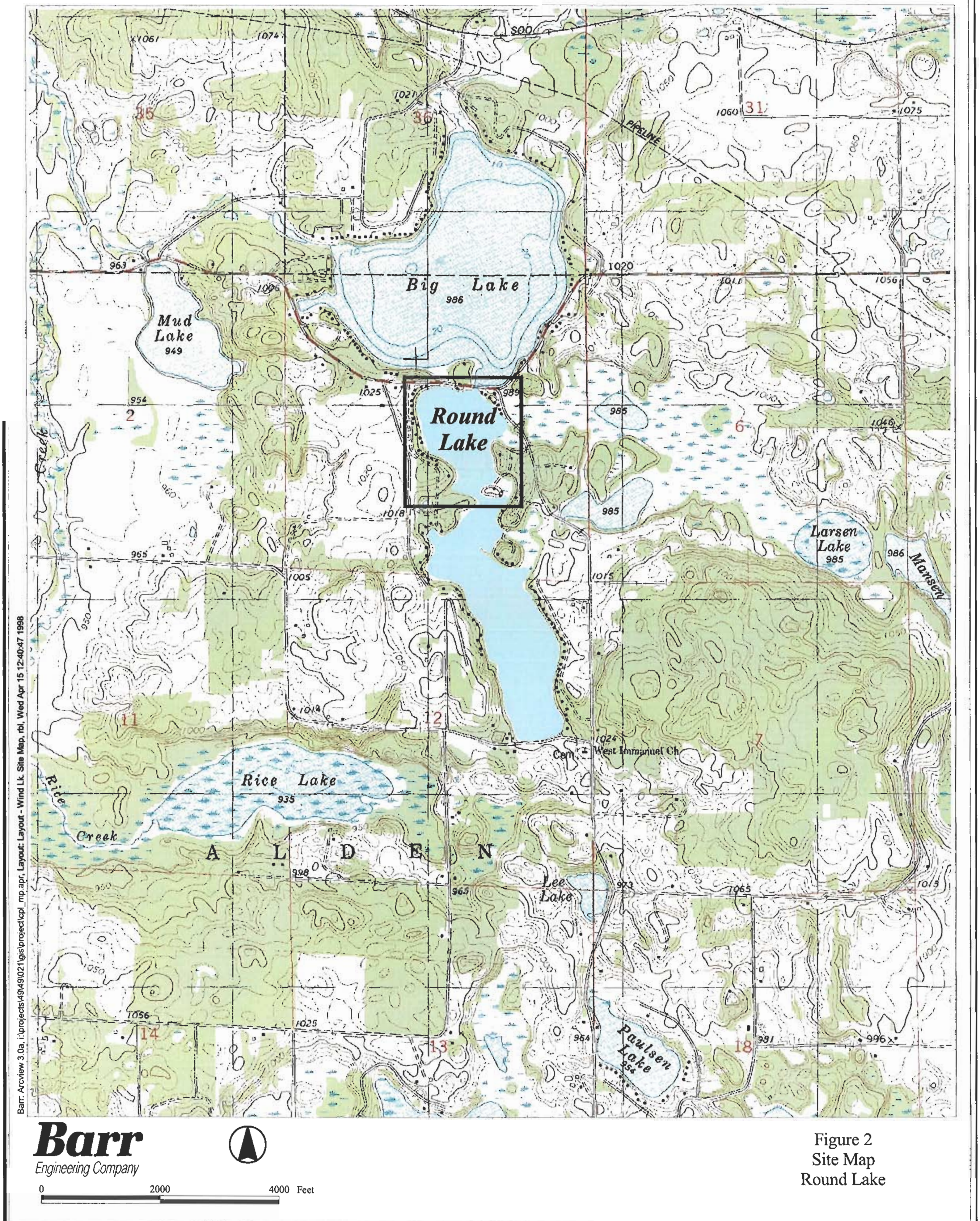


Figure 2
Site Map
Round Lake

Macrophyte surveys of Big Lake were completed during 1996 and a management plan prepared in 1997. Macrophyte surveys of Church Pine and Round (Wind) lakes were completed during 1997. This report presents the macrophyte management plan for Church Pine and Round (Wind) Lakes. The report discusses:

- Overview of macrophyte growth in lakes
- Compilation and assessment of existing information
- The methodology of the 1997 Church Pine and Round (Wind) Lake macrophyte surveys
- Results and Discussion of the 1997 Church Pine and Round (Wind) Lake macrophyte surveys
- Developing a macrophyte management plan
- Macrophyte management plan for Church Pine Lake and Round (Wind) 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 plant-like organisms, 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 in addition to 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 Physical Characteristics (Morphometry)

The Church Pine, Round (Wind) and Big Lakes chain is located in Alden and Garfield Townships of Polk County in northwestern Wisconsin (92^0 32' E. Longitude; 47^0 17' N. Latitude). The general physical characteristics of the lakes are as follows (Lim Tech Consultants 1987):

Parameter	Church Pine Lake	Round (Wind) Lake
Surface area (acres)	91	40
Maximum depth (feet)	45	27
Mean depth (feet)	22.9	14.1
Shoreline length (miles)	2.36	1.07
Volume (acre-feet)	2,082	562

During the mid-1940s, a dam was created at the outlet of Big Lake which raised the water level approximately 2 feet. Prior to the completion of the dam, water flow was probably from Church Pine into Round (Wind) Lake and from Round (Wind) Lake into Big Lake. However, following dam completion, Church Pine and Big Lakes both flow into Round (Wind) Lake.

3.2 Water Quality

Volunteers have collected Secchi disc (i.e., a measure of water transparency) data from Church Pine and Round (Wind) Lakes during most years since 1986. Average summer Secchi disc transparency measurements during the period 1986 through 1995 have ranged from 3.7 meters to 4.6 meters for Church Pine Lake and 2.6 meters to 3.2 meters for Round (Wind) Lake. The long-term average Secchi disc transparency for the 1986 through 1995 period was 4.2 meters for Church Pine Lake and 2.8 meters for Round (Wind) Lake. The data indicate both lakes have been mesotrophic (moderately fertile). The determination was based upon a Trophic State Index (TSI) that relates Secchi disc transparency to water quality and the trophic state of a given lake (Heiskary, 1990).

The 1986 through 1995 data indicate recreational-use impairment did not occur in Church Pine Lake and minimal recreational-use impairment occurred in Round (Wind) Lake. The determination is based upon the results of a survey completed by the Metropolitan Council (Osgood 1989) correlating the perceptions and expectations of people using a lake with its water quality. Survey results revealed the following relationship between a lake's recreational-use impairment and Secchi disc transparencies:

- No impairment occurs at Secchi disc transparencies greater than 4 meters;
- Minimal impairment occurs at Secchi disc transparencies of 2 to 4 meters;
- Moderate impairment occurs at Secchi disc transparencies of 1 to 2 meters;
- Moderate to severe use-impairment occurs at Secchi disc transparencies less than 1 meter (3.3 feet).

3.3 Watershed Characteristics

The general characteristics of the separate watersheds of the lakes are as follows (Lim Tech Consultants 1987):

Parameter	**Church Pine Lake**	**Round (Wind) Lake**
Watershed area (acres)	370	116
Watershed area: surface area ratio	4.1	2.9
Land use:		
Wooded (%)	89	84
Untilled field or pasture (%)	9	14
Tilled field (%)	Not a significant land use	Not a significant land use
Wetlands (%)	2	3
Mixed old field-wooded	Not a significant land use	Not a significant land use

3.4 Hydrologic Budget

No surface flows enter Church Pine Lake other than runoff from the lake's direct watershed. Round (Wind) Lake receives flow from Church Pine Lake, from Big Lake, and from its direct watershed. During 1987, a small flow was observed from Big Lake into Round (Wind) Lake during monthly sample events during March through September. During the same period, no flow was observed between Church Pine Lake and Round (Wind) Lake during most sample days.

The estimated water budget for Church Pine Lake and Round (Wind) Lake is (Lim Tech Consultants 1987):

Calculated Water Budget		
Source	**Church Pine Lake**	**Round (Wind) Lake**
Inputs:		
Precipitation	223.5 acre-ft./yr.	98.3 acre-ft./yr.
Direct Watershed Runoff	40.5 acre-ft./yr.	27.4 acre-ft./yr.
Surface Inflow -- Big Lake	--	64.0 acre-ft./yr.
Groundwater Seepage	NS*	NS*
Total Inputs	264 acre-ft./yr.	189.7 acre-ft./yr.
Outputs:		
Direct Evaporation	213.8 acre-ft./yr.	93.9 acre-ft./yr.
Surface Outlet	20.3 acre-ft./yr.	--
Ground Water	NS*	NS*
Total Outputs	234.1 acre-ft.	93.9 acre-ft.
Hydrological Retention Time	7.8 years	2.9 years

*NS = Not a Significant Source.

3.5 Phosphorus Loading

During 1987, annual phosphorus loads to Church Pine Lake and Round (Wind) Lake were estimated. Sources of phosphorus included surface water runoff (direct watershed and surface inflow) and atmospheric loadings (i.e., both wet and dry deposition). Loading from groundwater was not considered a significant input. The estimated annual phosphorus budget is (Lim Tech Consultants 1987):

Estimated Annual Phosphorus Budget				
Source	**Church Pine Lake**		**Round (Wind) Lake**	
	kg./yr.	**Percent**	**kg./yr.**	**Percent**
Direct Watershed	2.1	21	1.0	10
Surface Inflows (Big Lake)	--	--	5.4	55
Atmospheric	7.8	79	3.4	35
Groundwater	NS*	NS*	NS*	NS*
Total	9.9	100	9.8	100

*NS = Not a Significant Source.

3.6 Shoreline Development

Shoreline development characteristics for the lakes are as follows (Lim Tech Consultants 1987):

Parameter	**Church Pine Lake**	**Round (Wind) Lake**
Number of Residences	62	32
Residences per mile of shoreline	26	30
% steeply sloped	62	9
% moderately sloped	21	56
% developed shoreline (i.e., groomed lawns within three feet of shore)	23	21

3.7 Macrophytes

Macrophyte surveys completed during 1987 indicated the following species were found in Church Pine Lake, Round (Wind) Lake, and Big Lake:

Common Name	**Scientific Name**
Watershield, Water Target	*Brasenia schreberi*
Marsh Marigold	*Caltha palustris*
Sedges	*Carex spp.*

Common Name	Scientific Name
Muskgrasses, Stoneworts, Charas	*Chara sp.*
Coontail, Hornwort	*Ceratophyllum demersum*
Burhead	*Echinodorus sp.*
Northern Milfoil	*Myriophyllum sibericum (formerly exalbascens)*
Bushy Pondweed, Slender Naiad	*Najas flexilis*
Bushy Pondweed	*Najas marina*
Water Lily	*Nuphar sp.*
Water Lily	*Nymphaea sp.*
Reed Canary Grass	*Phalaris sp.*
Cane Grass	*Phragmites sp.*
Large-Leaf Pondweed, Bass Weed, Musky Weed	*Potamogeton amplifolius*
Curly-Leaf Pondweed	*Potamogeton crispus*
Pondweed	*Potamogeton filiformis*
Floating-Leaf Pondweed	*Potamogeton natans*
Sago Pondweed	*Potamogeton pectinatus*
Fern Pondweed, Robbins Pondweed	*Potamogeton robbinsii*
Arrowhead	*Sagittaria spp.*
Bulrush	*Scirpus spp.*
Common Bur-Reed	*Sparganium spp.*
Broad-Leaved Cattail	*Typha latifolia*
Water Celery, Eel-Grass, Tape-Grass	*Vallisneria americana*

Survey results indicated the predominant submerged aquatic plant in Round (Wind) Lake during May and June was *Potamogeton crispus* (Curly-leaf pondweed). Curly-leaf pondweed diminished by July and was replaced by species such as *Vallisneria americana, Potamogeton amplifolius, and Ceratophyllum demersum*. Floating-leaf plants occurred in high numbers in the shallow waters around much of Round (Wind) Lake and in the shallow, northern regions of Church Pine Lake (Lim Tech Consultants 1987).

3.8 Membership Survey Results

During 1987, a survey of area residents was completed to determine opinions concerning water quality, lake-use, and the individual weed management strategies used by area residents. A total of 64 questionnaires were returned (i.e., about 35 percent of the lake population). Of the questionnaires returned, 37 percent were from Church Pine Lake residents, 16 percent from Round (Wind) Lake residents, and 47 percent from Big Lake residents. About 58 percent of the responses were from seasonal residents and 42 percent from permanent residents.

A mean ranking of the various lake problems reported by the residents was calculated for each lake individually. Severity of a particular problem was ranked from 1 to 5, 1 being the value for a particular situation ranked worst by all respondents and 5 being the value given if no respondents reported that situation as being a problem. The mean ranking and standard deviation (in parenthesis) for each lake is (Lim Tech Consultants 1987):

Parameter	**Church Pine Lake**	**Round (Wind) Lake**	**Big Lake**
Weeds	2.52 (1.40)	1.60 (0.70)	2.14 (1.48)
Algae	4.53 (1.23)	3.70 (0.95)	2.97 (1.27)
Water Level	4.17 (1.27)	3.30 (1.57	3.93 (1.44)
Boat Traffic	2.13 (1.62)	2.30 (1.06)	2.93 (1.39)
Fishing Quality	3.71 (1.40)	3.30 (1.57)	3.90 (1.32)
Odors	4.83 (0.48)	4.60 (0.70)	4.21 (1.32)

4.0 Methods

4.1 Aquatic Plant Surveys

Aquatic plant (macrophyte) surveys of Church Pine and Round (Wind) lakes were completed during July 21 through 23 of 1997. The July survey was completed by Barr Engineering Co. with assistance from volunteers.

The methodology used was based upon Jessen and Lound (1962). The surveys were completed according to methods 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 enables the plant specialist an opportunity to determine the presence, frequency, and density of different plant species. The following outlines the methodology followed in the study.

- Transects were chosen at approximately 500-foot intervals of shoreline. The locations of the 17 transects selected for the study of Church Pine Lake are shown on Figure 3. The locations of the 9 transects selected for the study of Round (Wind) Lake are shown on Figure 4. Transects extended from shore to the maximum depth of plant growth.

- Compass readings were taken at each transect location for future reference.

- Transects were broken down into the following depth categories:
  0 to 1.5 feet
  1.5 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 6-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.

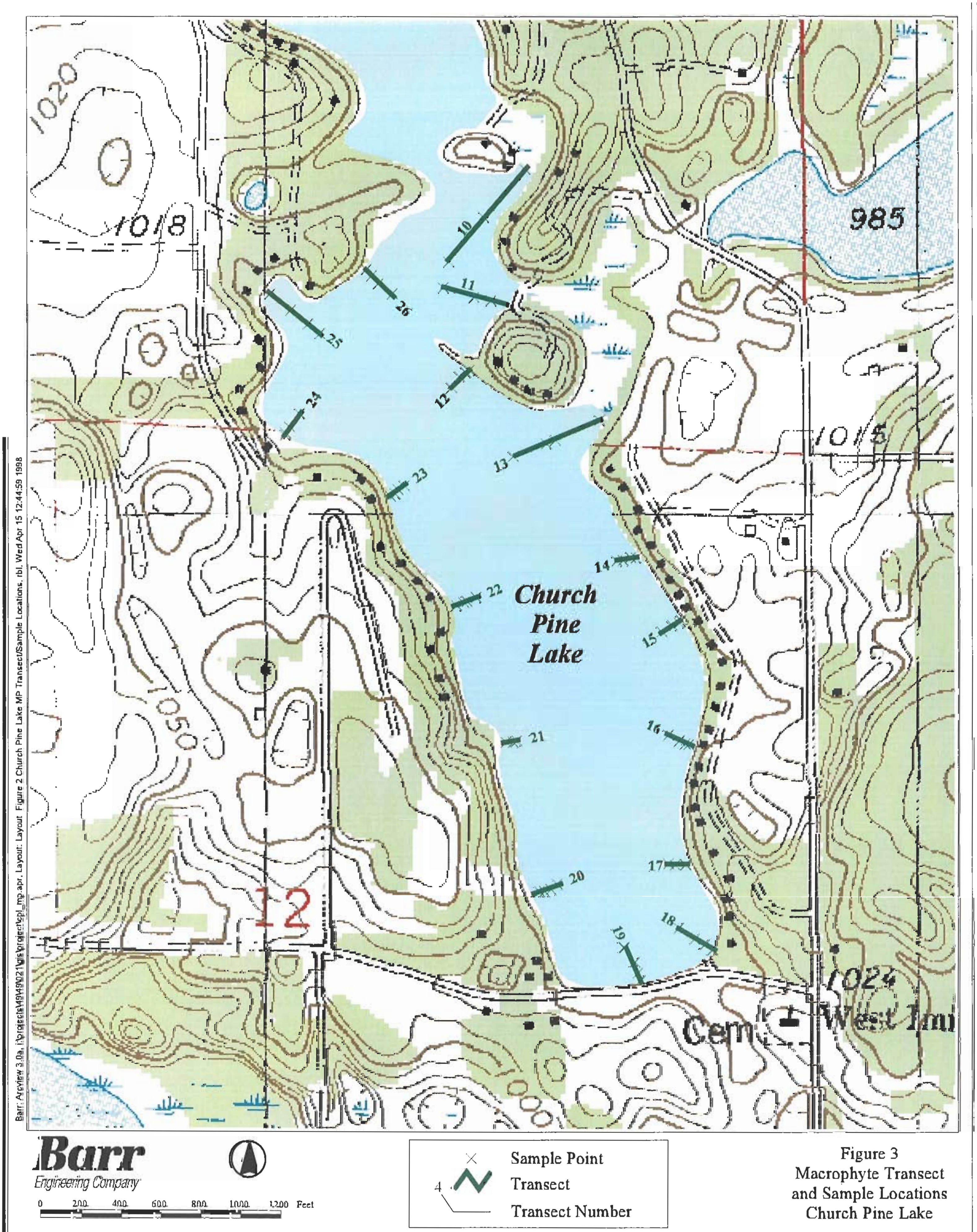


Figure 3
Macrophyte Transect
and Sample Locations
Church Pine Lake

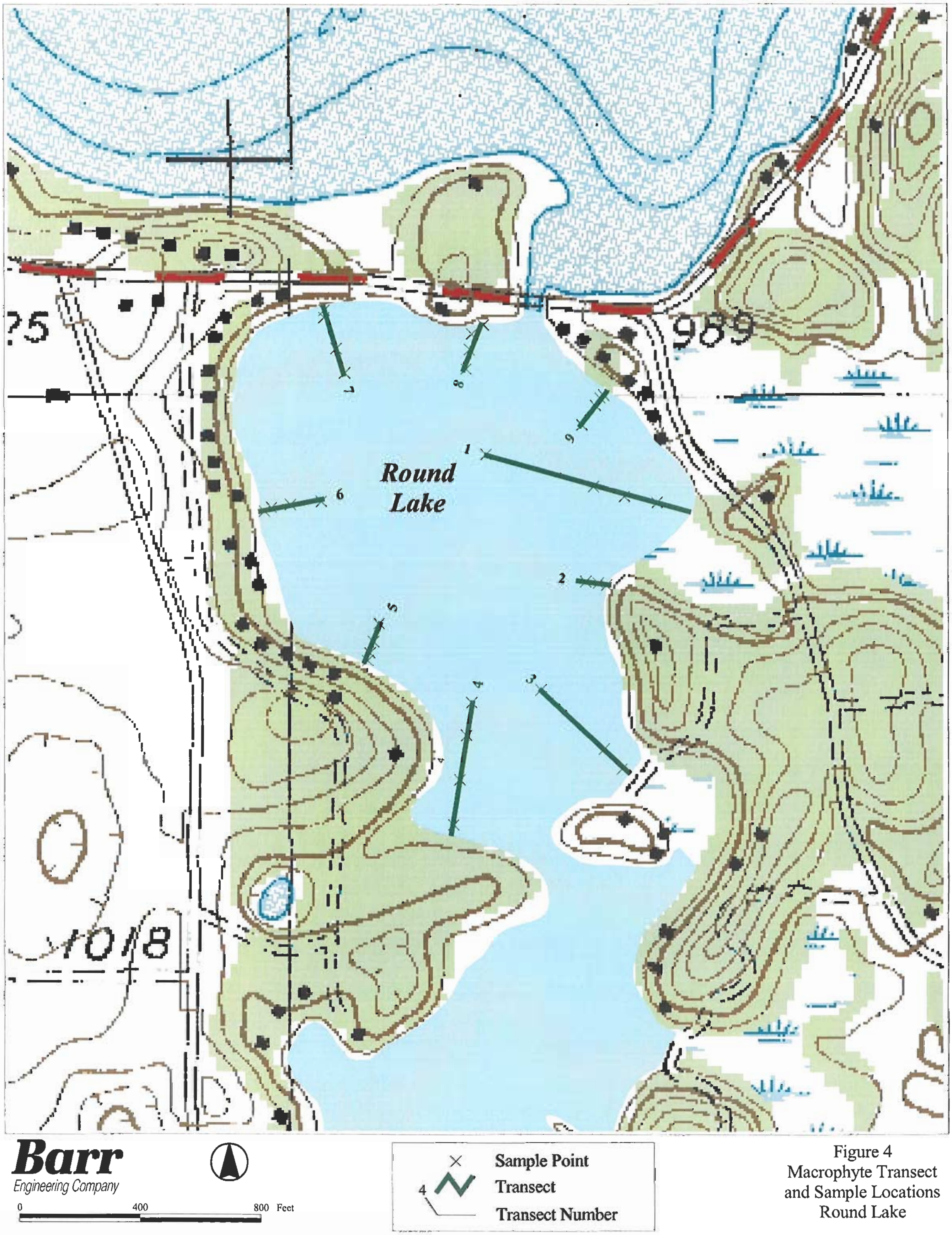


Figure 4
Macrophyte Transect
and Sample Locations
Round Lake

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

Rake Coverage (% of Rake Head) Covered by a 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 for future reference.

- Sediment type was determined at each sampling point.

- Maximum rooting depths were observed at all transects.

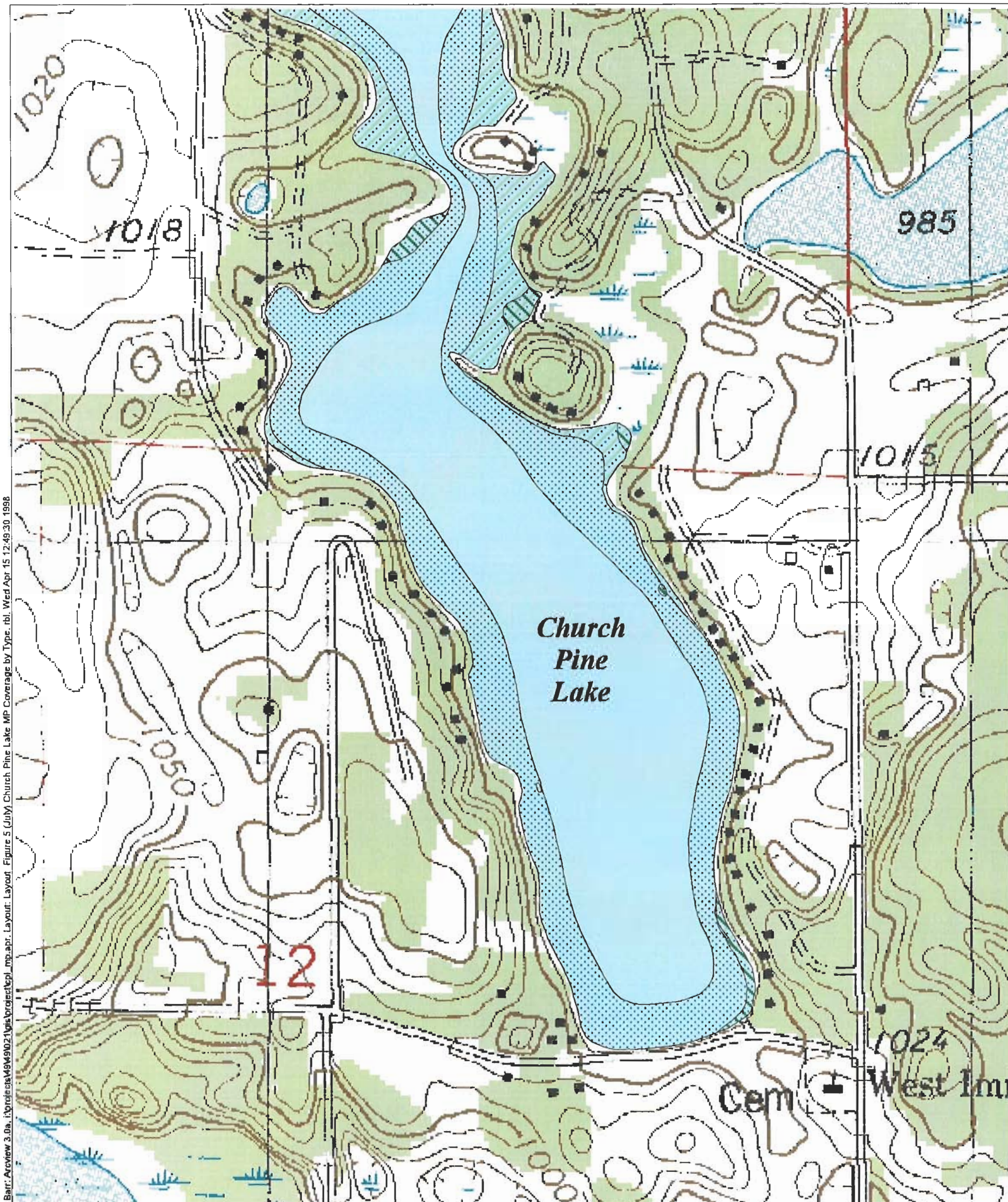
5.0 Results and Discussion

Church Pine and Round (Wind) lakes contain 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 Figures 5 and 6 and Appendices A and B):

- Submersed plants were found in all sample transects of Church Pine Lake and Round (Wind) Lake.
- Floating-leaf plants were found in all of Round (Wind) Lake and almost half of the Church Pine Lake sample transects.
- Emergent plants were found in relatively few (i.e., slightly more than 10 percent) sample transects in both lakes.
- The alga *Chara* was not sited in Round (Wind) Lake and was sited in 39 percent of the sample transects in Church Pine Lake.

The large number of species noted in Church Pine and Round (Wind) lakes during 1997 (i.e., 25 and 20 species from Church Pine and Round (Wind), respectively) is indicative of a stable and healthy macrophyte community. Further evidence of a diverse plant community was indicated by the large number of species found in each transect. The average number of species occurring in each transect from Church Pine Lake and Round (Wind) Lake was 14. The large number of 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 have little impact upon the diverse community;
- affords protection from invasion by exotic species (i.e., exotic species generally invade areas lacking vegetation);



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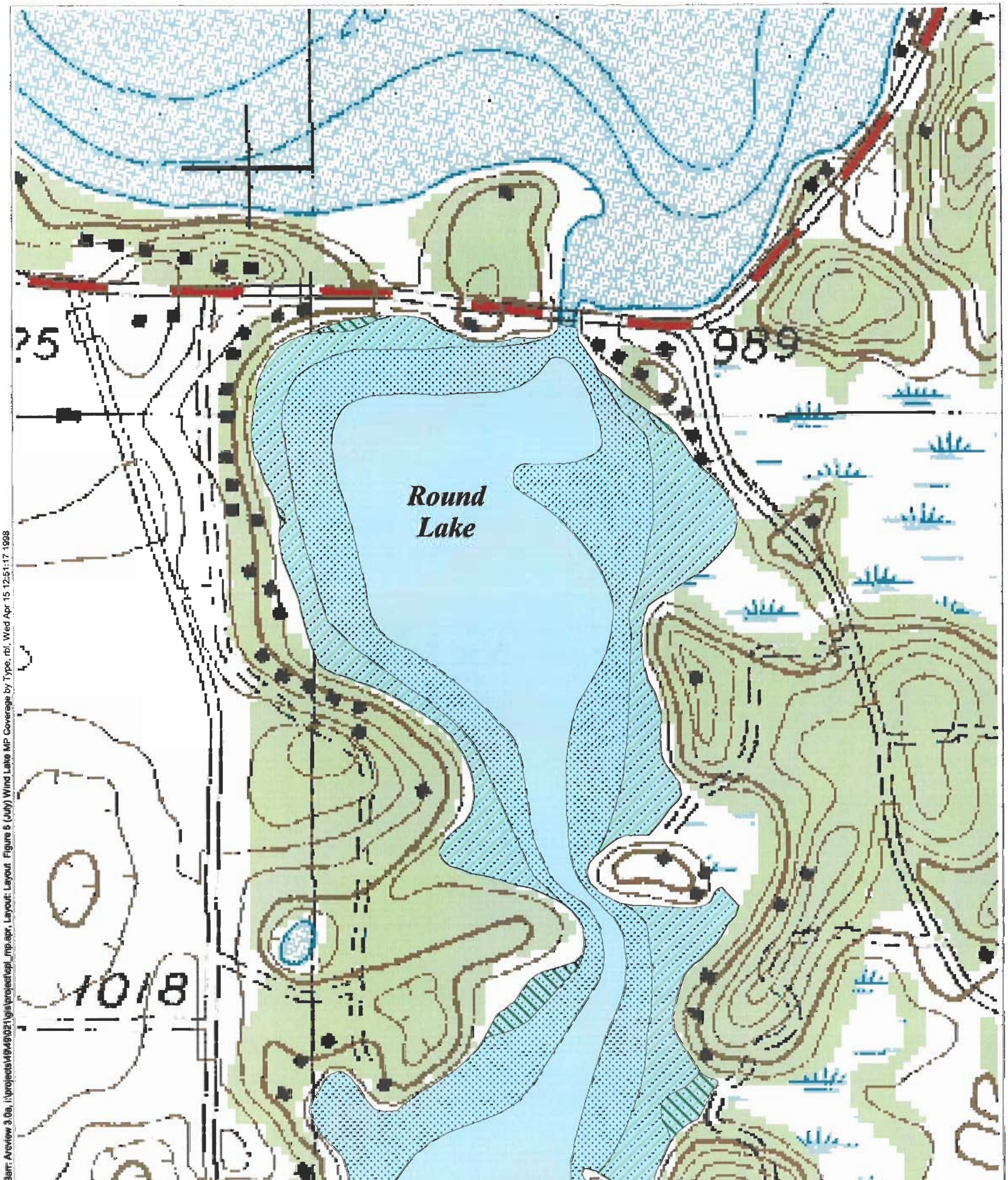
0 200 400 600 800 1000 1200 Feet

Macrophyte Type
- Emergent
- Floating-leaf
- Submerged

Figure 5
Macrophyte Coverage by Type (July)
Church Pine Lake



Barr: Arcview 3.0a, I:\projects\49\49\021\gis\projects\epl_mp.apr, Layout: Layout Figure 5 (July) Wind Lake MP Coverage by Type, rbl, Wed Apr 15 12:51:17 1998

Barr
Engineering Company

0 400 800 Feet

Macrophyte Type
- Emergent
- Floating-leaf
- Submerged

Figure 6
Macrophyte Coverage by Type (July)
Round Lake

A few species were abundant in both lakes during 1997, but diversity characterized the macrophyte community. The four predominant species in Church Pine Lake were *Najas flexilis* (Bushy Pondweed), *Vallisneria americana* (Wild Celery), *Potamogeton gramineus* (Variable Pondweed) and *Potamogeton robbinsii* (Robbin's Pondweed). Each species occurred in 62 percent to 82 percent of the sample locations (See Figure 7). The four predominant species in Round (Wind) Lake were *Ceratophyllum demersum* (Coontail), *Elodea canadensis* (Canada Waterweed), *Potamogeton robbinsii* (Robbin's Pondweed), and *Potamogeton zosteriformis* (Flat-stemmed Pondweed). Each species occurred in 60 percent to 95 percent of the sample locations (See Figure 8). Other abundant species in Church Pine Lake included:

- *Ceratophyllum demersum* (Coontail) in 38 percent of sample locations;
- Chara spp. (Muskgrass) in 39 percent of sample locations;
- *Elodea canadensis* (Canada Waterweed) in 36 percent of sample locations;
- *Myriophyllum sibericum (formerly exalbescens)* (Northern Water milfoil) in 39 percent of sample locations;
- Potamogeton strictifolius (Floating-leaf Pondweed) in 39 percent of sample locations;
- *Potamogeton zosteriformis* (Flat-stemmed Pondweed) in 36 percent of sample locations; and
- *Zosterella dubia* (Water Star Grass) in 36 percent of sample locations.

Other abundant species in Round Lake (Wind) included:

- *Myriophyllum sibericum (formerly exalbascens)* (Northern Water Milfoil) in 45 percent of sample locations;
- Nuphar microphyllum (Little Yellow Water Lily) in 34 percent of sample locations;
- *Nymphaea tuberosa* (White Water Lily) in 34 percent of sample locations; and
- *Vallisneria americana* (Wild Celery) in 47 percent of sample locations.

Macrophyte diversity was calculated for Church Pine and Round (Wind) lakes using a modification of Simpson's Index (1949):

$$1-\sum (rf/100)^2$$

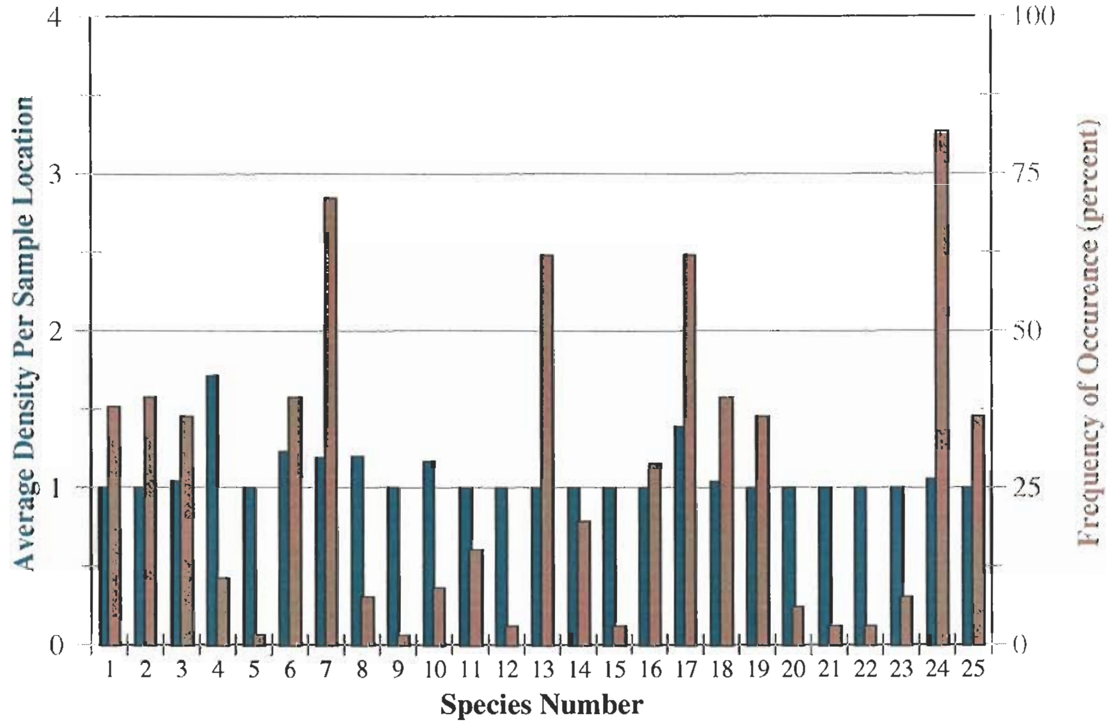
Where:

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% to describe community structure (i.e., rf). Frequencies are shown in Figures 7 and 8. Relative frequencies are presented in Appendix C.

Figure 7

1997 Church Pine Lake

Average Density and Frequency



Species Number	Species Name	Common Name	Average Density	Frequency of Occurrence (%)
1	*Ceratophyllum demersum*	Coontail/Hornwort	1.0	37.9
2	*Chara spp.*	Muskgrass	1.0	39.4
3	*Elodea canadensis*	Canada Waterweed	1.0	36.4
4	*Eriocaulon spp.*	Pipewort	1.7	10.6
5	*Lemna trisulca*	Star Duckweed	1.0	1.5
6	*Myriophyllum exalbescens*	Northern Watermilfoil	1.2	39.4
7	*Najas flexilis*	Bushy Pondweed	1.2	71.2
8	*Nuphar microphyllum*	Little Yellow Water Lily	1.2	7.6
9	*Nuphar variegatum*	Yellow Water Lily	1.0	1.5
10	*Nymphaea tuberosa*	White Water Lily	1.2	9.1
11	*Potamogeton amplifolis*	Large-leaf Pondweed	1.0	15.2
12	*Potamogeton crispus*	Curly-leaf Pondweed	1.0	3.0
13	*Potamogeton gramineus*	Variable Pondweed	1.0	62.1
14	*Potamogeton illinoensis*	Illinois Pondweed	1.0	19.7
15	*Potamogeton natans*	Floating-leaf Pondweed	1.0	3.0
16	*Potamogeton richardsonii*	Clasping-leaf Pondweed	1.0	28.8
17	*Potamogeton robbinsii*	Robbin's Pondweed	1.4	62.1
18	*Potamogeton strictifolius*	Floating-leaf Pondweed	1.0	39.4
19	*Potamogeton zosteriformis*	Flat-stemmed Pondweed	1.0	36.4
20	*Sagittaria spp.*	Arrowhead	1.0	6.1
21	*Sparganium eurycarpum*	Giant Bur-reed	1.0	3.0
22	*Unidentified Algae*	Unidentified Algae	1.0	3.0
23	*Utricularia spp.*	Bladderwort	1.0	7.6
24	*Vallisneria americana*	Wild Celery	1.1	81.8
25	*Zosterella dubia*	Water Star Grass	1.0	36.4

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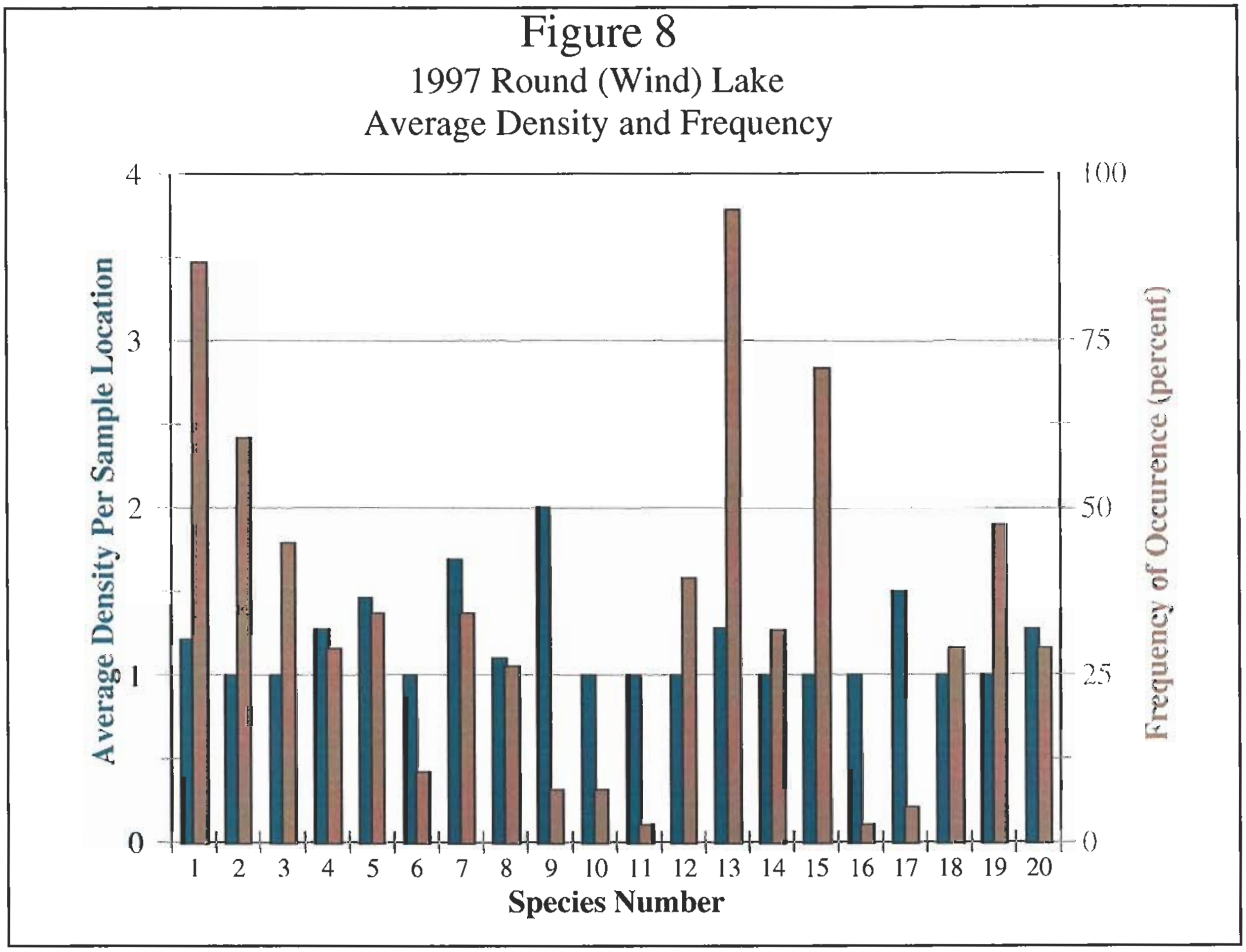


Species Number	Species Name	Common Name	Average Density	Frequency of Occurrence (%)
1	*Ceratophyllum demersum*	Coontail/Hornwort	1.2	86.8
2	*Elodea canadensis*	Canada Waterweed	1.0	60.5
3	*Myriophyllum exalbescens*	Northern Watermilfoil	1.0	44.7
4	*Najas flexilis*	Bushy Pondweed	1.3	28.9
5	*Nuphar microphyllum*	Little Yellow Water Lily	1.5	34.2
6	*Nuphar variegatum*	Yellow Water Lily	1.0	10.5
7	*Nymphaea tuberosa*	White Water Lily	1.7	34.2
8	*Potamogeton amplifolis*	Large-leaf Pondweed	1.1	26.3
9	*Potamogeton crispus*	Curly-leaf Pondweed	2.0	7.9
10	*Potamogeton natans*	Floating-leaf Pondweed	1.0	7.9
11	*Potamogeton pectinatus*	Sago Pondweed	1.0	2.6
12	*Potamogeton richardsonii*	Clasping-leaf Pondweed	1.0	39.5
13	*Potamogeton robbinsii*	Robbin's Pondweed	1.3	94.7
14	*Potamogeton strictifolius*	Floating-leaf Pondweed	1.0	31.6
15	*Potamogeton zosteriformis*	Flat-stemmed Pondweed	1.0	71.1
16	*Sagittaria spp.*	Arrowhead	1.0	2.6
17	*Sparganium eurycarpum*	Giant Bur-reed	1.5	5.3
18	*Utricularia spp.*	Bladderwort	1.0	28.9
19	*Vallisneria americana*	Wild Celery	1.0	47.4
20	*Zosterella dubia*	Water Star Grass	1.3	28.9

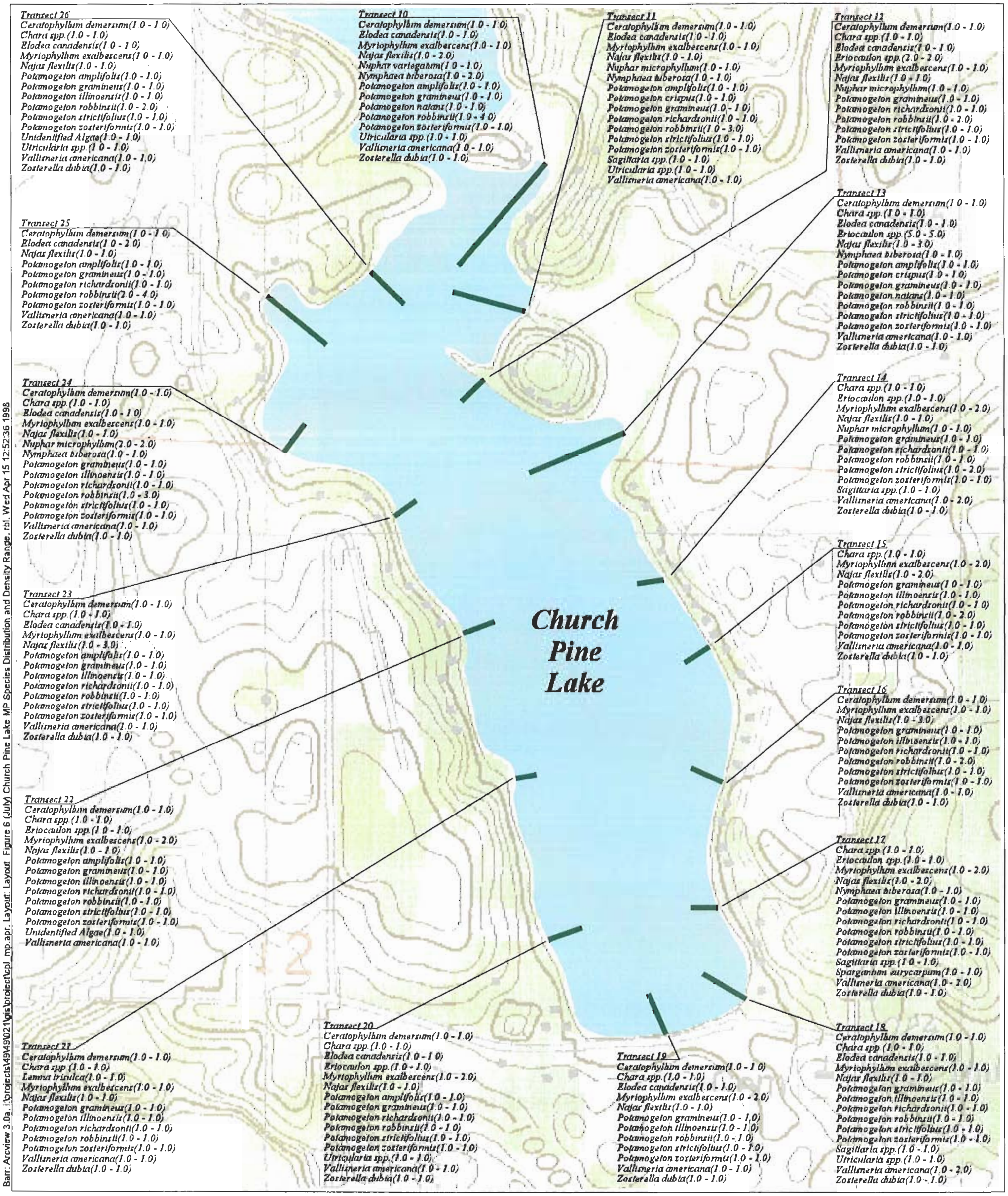
The data indicate the lakes' plant communities are highly diverse. On a scale of 0 to 1, with 0 indicating no plant diversity and 1 indicating the highest plant diversity, Church Pine and Round (Wind) lakes noted diversities of 0.93 and 0.92, respectively during 1997. The diversities are near the high end of the range of diversities noted for 46 Wisconsin lakes sampled by the Wisconsin Department of Natural Resources, Office of Inland Lake Renewal (See Table 1).

The cumulative effect of the large number of species in the lakes 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 points containing no vegetation divided by the total number of sampling points 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 point where plant growth was found. The maximum depth of plant growth in Church Pine Lake was generally 20 feet. The maximum depth of plant growth in Round (Wind) Lake generally ranged from 15 to 20 feet. Church Pine and Round (Wind) lakes noted a 0 percent open area. Consequently the cumulative effect of the large number of species was the growth of plants throughout the littoral area of the lakes.

Although individual species in Church Pine and Round (Wind) Lakes generally occurred in a relatively low density, the concurrent growth of a large number of species at each sample location resulted in an overall plant growth of moderate density. The average density of individual species per sample location in Church Pine Lake ranged from 1 to 1.7 and in Round (Wind) Lake ranged from 1 to 2 (i.e., on a scale of 0 to 5, as discussed in the methods section, 0 indicated the lowest density and 5 indicated the highest density). However the concurrent occurrence of approximately 14 individual species per sample transect resulted in an overall plant growth of moderate density (see Figures 9 and 10). A few isolated locations, however, noted a high macrophyte (i.e., aquatic plant) density. Locations with a high macrophyte density posed navigation problems to area residents.

Table 1 Diversities of some Wisconsin Plant Communities (from Nichols 1997)

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



Barr: Arcview 3.0a, I:\projects\49\49021\gis\project\cpl_mp.apr, Layout: Layout Figure 6 (July) Church Pine Lake MP Species Distribution and Density Range, rbl, Wed Apr 15 12:52:36 1998

Barr Engineering Company

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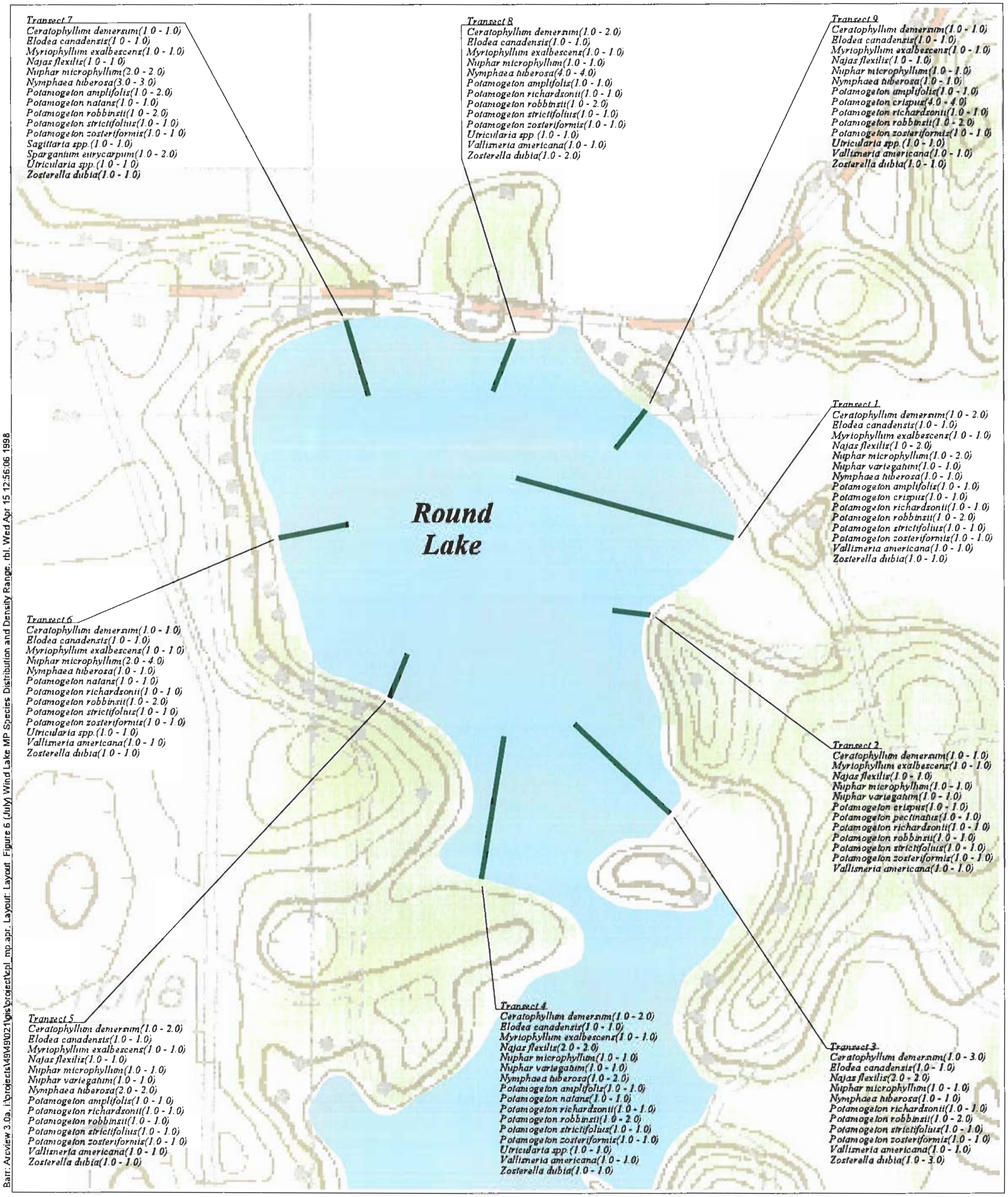
Transect

Figure 9
Macrophyte Species Distribution and Density Range (July)
Church Pine Lake



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Engineering Company

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Transect

Figure 10
Macrophyte Species Distribution
and Density Range (July)
Round Lake

The Church Pine Lake and Round (Wind) Lake macrophyte communities perform a number of valuable functions. These include:

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

Table 2 summarizes the functions performed by several individual species noted in the lakes.

Macrophytes in Church Pine Lake and Round (Wind) Lake consisted primarily of native species (i.e., species historically present in this region). Only one exotic (i.e., not native) species, *Potamogeton crispus* (curly-leaf pondweed), was noted. 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). 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.

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

1. It tends to crowd out native aquatic macrophyte (i.e., lake weed) species.

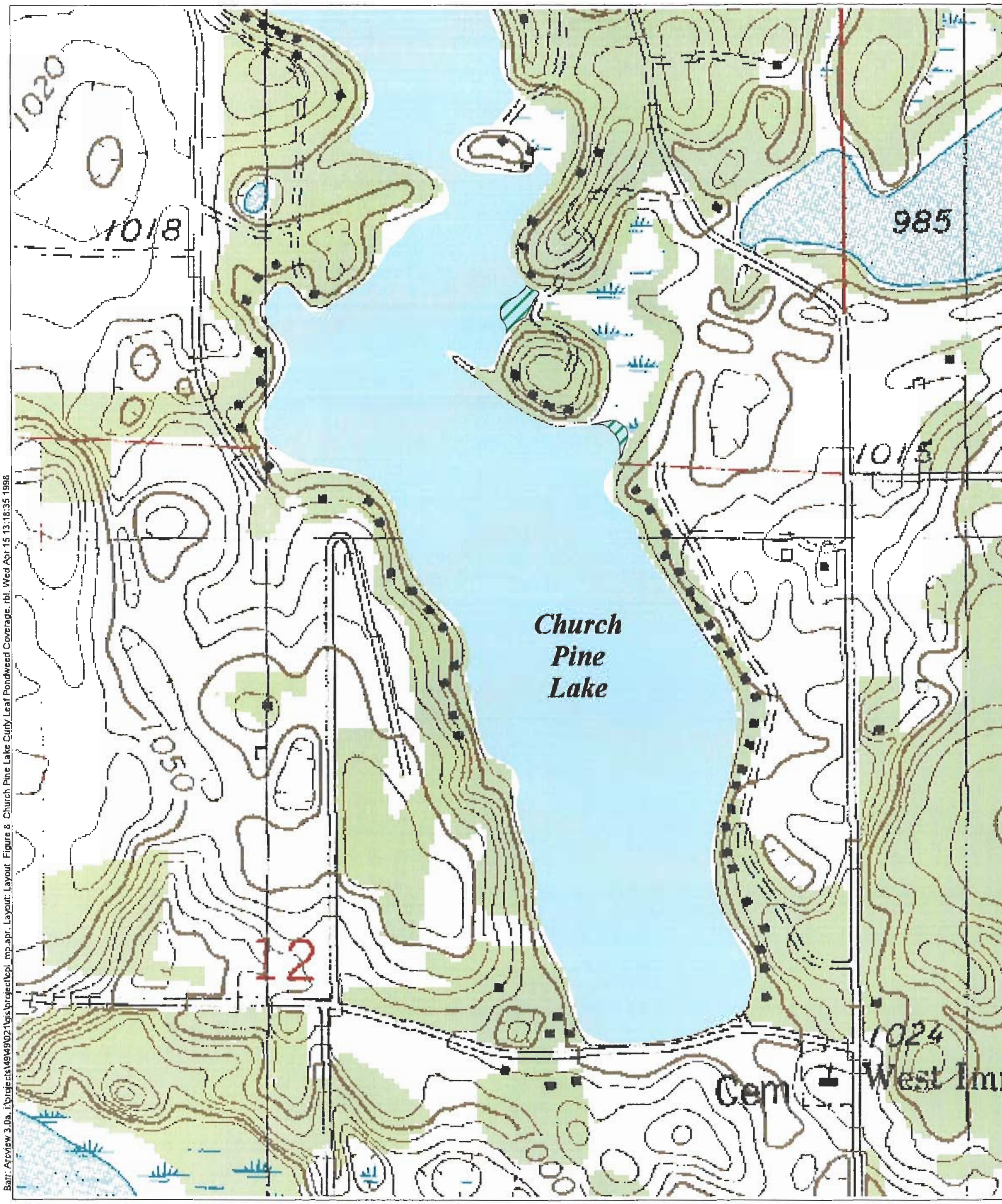
2. Dense colonies of the weed may interfere with recreational activities on the lake.

3. After curly-leaf pondweed dies out in early July, it may sink to the lake bottom and decay, causing oxygen depletion and exacerbating internal release of phosphorus.

Curly-leaf pondweed was found along the eastern shore of Round (Wind) Lake and in two isolated patches along the eastern shore (i.e., in the northern portion) of Church Pine Lake (See Figures 11 and 12). It occurred in low density (i.e., density of 1 on a scale of 0 to 5, with 0 being the lowest density and 5 being the highest density) and occurred concurrently with several native species. Neighboring Big Lake notes a widespread coverage of curly-leaf pondweed. However, it appears that native species are relatively successful in competing with curly-leaf pondweed in Round (Wind) and Church Pine lakes, thus minimizing its impact upon the native plant community.

Table 2 Functions of Aquatic Plant Species Found in Church Pine and Round (Wind) Lakes

Scientific Name (Common Name)	Plant Type	Plant Functions
Elodea canadensis (Canada Waterweed)	Submersed	Provides habitat for many small aquatic animals, which fish and wildlife eat.
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.
Vallisneria americana (Water Celery)	Submersed	Provides shade and shelter for bluegills, young perch, and largemouth bass; choice food of waterfowl, particularly diving ducks; attracts muskrats, marsh birds, and shore birds.
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 zosteriformis (Flat-stemmed Pondweed), *Potamogeton pusillus* (Narrow-leaf Pondweed)	Submersed	Provides some cover for bluegills, perch, northern pike, and muskellunge, though these fish prefer broadleaf pondweeds; good cover for walleye; provide food for waterfowl; support aquatic insects and many small animals that fish and ducklings eat.
Potamogeton Richardsonii (Clasping-leaf Pondweed)	Submerged	Broad-leaf pondweeds provide excellent habitat for panfish, largemouth bass, muskellunge, and northern pike; bluegills nest near these plants and eat insects and other small animals found on the leaves; walleyes use these pondweeds for cover.
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.
Najas flexilis. (Spiny Naiad, bushy pondweed)	Submerged	Entire plants are eaten by waterfowl, especially mallards; provide cover for young largemouth bass and northern pike and small bluegills and perch.
Lemna trisulca (Star Duckweed)	Floating-leaf	Provide food for waterfowl and marsh birds; support insects that fish eat.
Nuphar microphyllum (Little Yellow Water Lily), *Nuphar variegatum* (Yellow Water Lily) and *Nymphaea tuberosa* (White Water Lily)	Floating-leaf	Fruits are eaten by waterfowl and muskrats; the underwater roots contain starch and are edible.
Sagittaria spp. (Arrowhead)	Emergent	Tubers, nutlets and other parts are eaten by waterfowl. Stems, roots and tubers are eaten by muskrats, porcupine and beaver. It also provides shade and shelter for young fish.



Barr: Arcview 3.0a, i:\projects\49\49\021\gis\project\cpl_mp.apr, Layout: Layout Figure 8 Church Pine Lake Curly Leaf Pondweed Coverage, rbl, Wed Apr 15 13:18:35 1998

Barr Engineering Company

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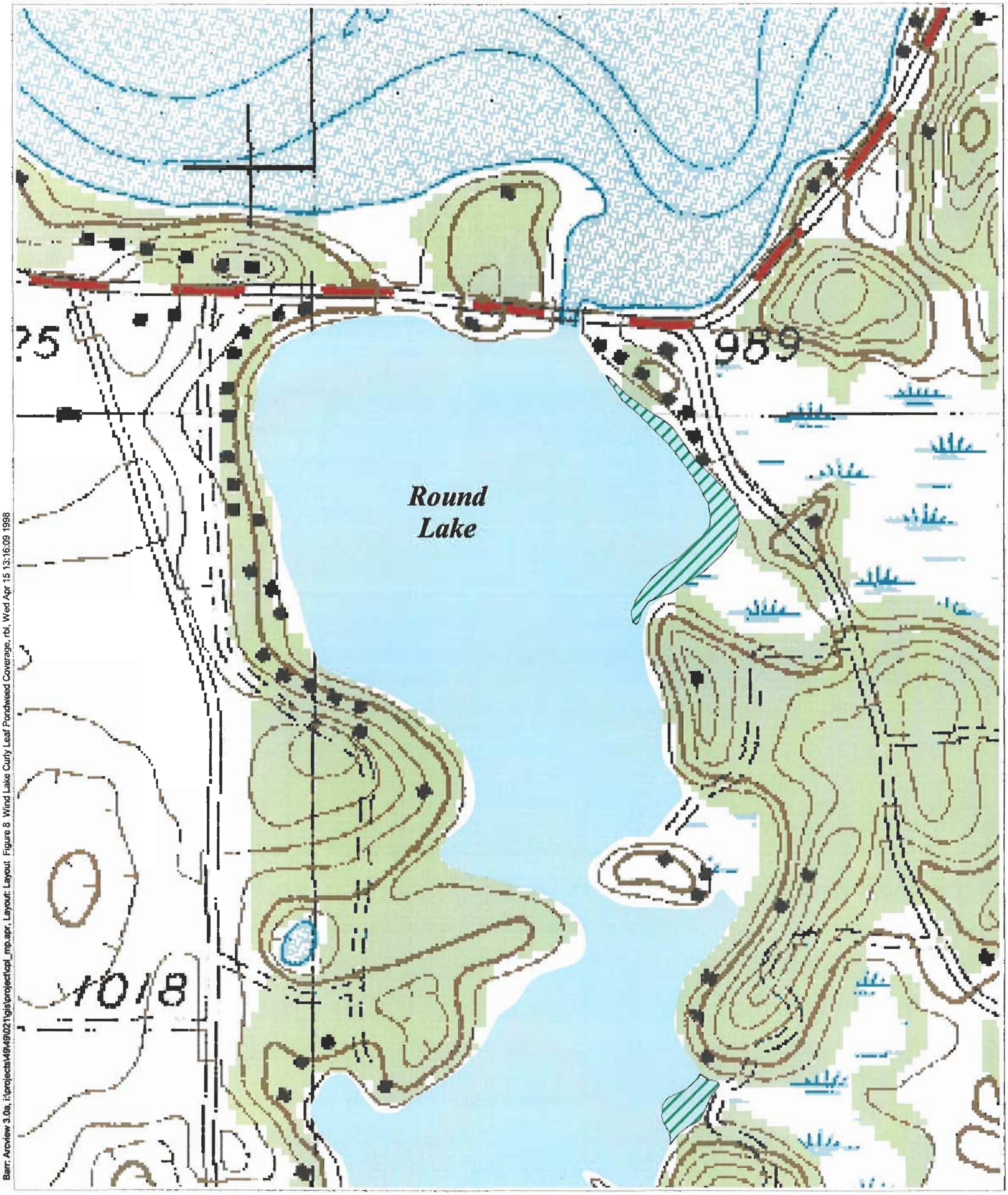
Curly-leaf Pondweed

Figure 11
Curly-Leaf
Pondweed Coverage
Church Pine Lake



Barr: Arcview 3.0a, i:\projects\49\49\021\gis\project\cpl_mp.apr, Layout: Layout Figure 8 Wind Lake Curly Leaf Pondweed Coverage, rbl, Wed Apr 15 13:16:09 1998

Barr
Engineering Company

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Curly-leaf Pondweed

Figure 12
Curly-Leaf
Pondweed Coverage
Round Lake

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 five principles:

- Define the problem
- Establish goals
- Understand plant ecology
- Consider all the techniques
- Monitor the results

These five principles were used to develop a macrophyte management plan for Church Pine Lake and Round (Wind) Lake.

6.1 Define the Problem

The combined effects of lake morphology and relatively low nutrient input from the lakes' watersheds have resulted in healthy and diverse macrophyte communities in the lakes. A few dense plant growths were observed, but a moderate growth was generally observed. The dense plant growths cause navigational problems for riparian owners and make it difficult for them to gain access to the lakes. Therefore, navigational channels are needed in the dense plant growth areas to provide lake access to riparian residents.

The moderate plant growth noted in most portions of the lakes provides optimum habitat conditions for the lakes' 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 underscore the importance of preserving the current overall moderate plant density within the lakes to provide optimum conditions for the lakes' fisheries. Density increases within the plant communities would likely result in negative impacts to the lakes' fisheries.

The presence of curly-leaf pondweed in both lakes is of concern because curly-leaf pondweed is an exotic species (i.e., not native to this region) and frequently causes problems by outcompeting native plants and developing objectionable dense growths. Although curly-leaf pondweed is not currently considered a problem, present curly-leaf growth areas may require management to prevent the occurrence of objectionable curly-leaf growth areas.

6.2 Establish Goals

The Church Pine, Round, and Big Lake Protection and Rehabilitation District has established six aquatic plant management goals for Church Pine and Round (Wind) lakes:

- Improve navigation within the lakes through areas containing dense plant beds (i.e., two areas within each lake)
- Remove or limit current exotic plants (i.e., curly-leaf pondweed)
- Preserve native species and prevent introduction of additional exotic species
- Preserve and/or improve fish and wildlife habitat
- Improve quality of resource for all to enjoy (i.e., people, fish, wildlife)
- Minimize disturbance of sensitive areas (i.e., fish and wildlife)

The goals are consistent with Wisconsin Wetland Water Quality Standards stated in Chapter NO 103.03:

"To protect, preserve, restore and enhance the quality of waters in wetlands and other waters of the state influenced by wetlands, the following water quality related functional values or uses of wetlands, within the range of natural variation of the affected wetland, shall be protected: ... (e) Habitat for aquatic organisms in the food web including, but not limited to fish, crustaceans, mollusks, insects, annelids, planktonic organisms and the plants and animals upon which these organisms feed and depend upon for their needs in all life stages; (f) Habitat for resident and transient wildlife species, including mammals, birds, reptiles and amphibians for breeding, resting, nesting, escape cover, travel corridors and food: and (g) Recreational, cultural, educational, scientific and natural aesthetic values and uses."

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 preservation of fish and wildlife habitat and concurrently provide 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.

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.

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.

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.

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.

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.

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

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

Differences in growth patterns between exotic plants (i.e., not native to this area) and native plants indicate a possible need for management of exotic species to protect native communities. Native plant communities are typically dominated by growth forms that concentrate biomass below the surface of the water (See Figure 13A), contain a high diversity of species, and have low to moderate levels of biomass. Exotic plants typically follow a voracious growth pattern. Exotic species generally produce a dense canopy of vegetation at the air:water interface and develop high levels of biomass (See Figure 13B). 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.

The exotic species of concern in Church Pine and Round (Wind) lakes is curly-leaf pondweed. Curly-leaf pondweed has unique life cycle adaptations which give it competitive advantages over many native aquatic plants. Unlike most native plants, curly-leaf pondweed may be in a photosynthetically active state even under thick ice and snow cover (Wehrmeister, 1978). Therefore, it is often the first plant to appear after ice-out. Tenacious growth results in the formation of dense mats by late spring which may crowd out native species and interfere with recreation. (Catling and Dobson, 1985). Curly-leaf usually senesces by early July, but it first forms small reproductive pods called turions (resembles a small pine cone) during late June. These turions disperse by water movement throughout a water body. Turions lay dormant during the summer when native plants are growing, and germinate in the fall when most native vegetation has senesced. Thus curly-leaf pondweed is able to use turions to invade new areas of a water body. The density of curly-leaf pondweed growth in a given year is influenced by winter conditions; winter months with heavy snow cover and thick ice conditions are often followed by less dense plant growth.

Large populations of curly-leaf pondweed can alter the nutrient dynamics of water bodies. As curly-leaf plants senesce in the summer, large amounts of vegetation fall to the lake bottom and decompose. This decomposition can increase internal nutrient loading in a water body, which in turn may cause an increase in algal growth.

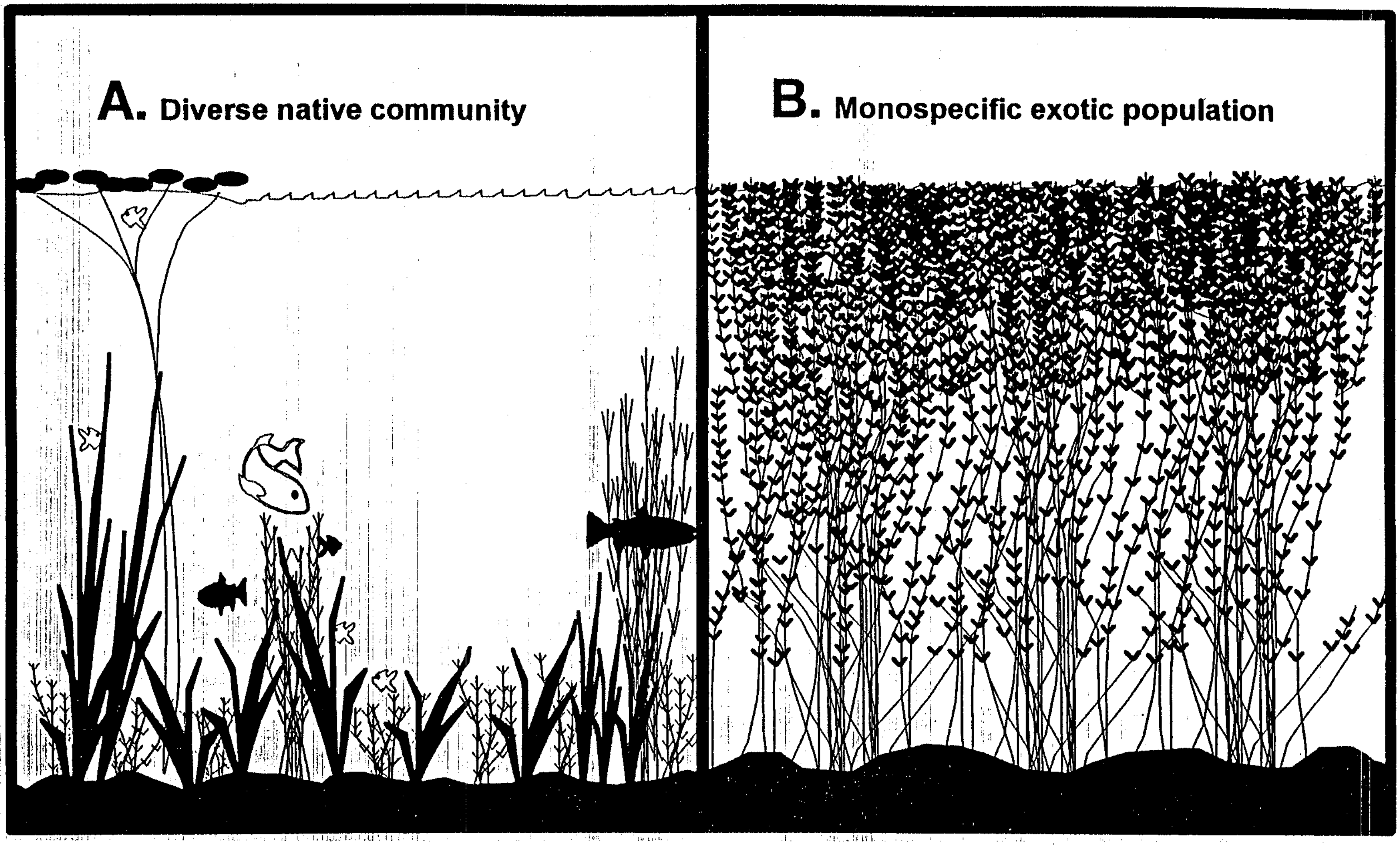


Figure 13
SUBMERSED AQUATIC PLANT COMMUNITIES

Native species appear to compete well with curly-leaf pondweed, restricting its growth within Church Pine and Round (Wind) lakes. However, the continued growth of curly-leaf pondweed throughout Big Lake indicates the continued spread of the plant to Round (Wind) and Church Pine lakes may occur.

6.4 Consider All Techniques

Following a consideration of all possible management alternatives, feasible options may be identified for Church Pine and Round (Wind) lakes. 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

6.4.1 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).

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).

Another commonly-used group of physical control techniques uses benthic barriers or sediment alteration to inhibit the growth of aquatic plants at the sediment surface. Benthic barriers are generally applied to small areas (Barr, 1997).

Sediment inactivation has included the application of phosphorus binding substances to sediments. The growth of aquatic plants is inhibited by the reduced availability of phosphorus in sediments (Barr, 1997)

6.4.2 Mechanical

Mechanical control involves macrophyte removal via harvesting. 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. 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. All plants that are mechanically controlled should be removed from the lake (Barr, 1997)

6.4.3 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. The aquatic plants (sometimes only stems and leaves) die and decompose in the lake. To reduce human exposure to the chemicals, temporary water-use restrictions are imposed in treatment areas whenever herbicides are used. Only herbicides for aquatic use are allowed, and any use of an herbicide requires a WDNR permit (Barr, 1997).

6.4.4 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).

A summary of aquatic macrophyte control techniques available in Wisconsin are summarized in Table 3.

6.5 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.

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

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 up to 3 ac/day @ $300–600/ac New machine: $80,000-100,000+	+Relatively low operational cost	– Can get regrowth within 4 weeks – Removes small fish, turtles, etc.
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 Harvesting	Scuba divers use 4" suction hose to selectively remove plants from lake bottom Plants disposed of on shore	Cost is $800–$10,000/ac depending on cost of divers, type of sediments, travel time, etc. Cost of new machine $20,000+	+Up to 97% effective at removing plant roots and stems +1–2 years of control +Can work in areas with underwater obstruction	– Effectiveness varies greatly with type of sediment – Slow and labor intensive – Expensive – Potentially hazardous because of scuba

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

Control Technique	Procedure	Cost	Advantages	Disadvantages
Handpulling	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

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

Control Technique	Procedure	Cost	Advantages	Disadvantages
Fluridone (Sonar)	Systemic herbicide available in liquid and pellet form that inhibits a susceptible plant's ability to make food Can be applied to surface or subsurface in early spring as soon as plants start to grow	$500-$1500/ac depending on water depth and formulation Sample collection cost not included	+Can be applied near water intakes if concentration is less than 20 ppb +Under favorable conditions susceptible species may decrease 100% after 6-10 weeks +Control lasts 1-2 years depending supplemental hand removal +Because slow-acting, low oxygen generally not a problem	– Long contact time required; may take up to 3 months to work – Potential risk to human health remains controversial – Not selective for milfoil – Spot treatments generally not effective
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	$200-$500/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

7.0 Macrophyte Management Plan for Church Pine Lake and Round (Wind) Lake

The management plan for Church Pine Lake and Round (Wind) Lake is based upon the need to: (1) provide a reasonable access to the lake by users living adjacent to very dense plant growths, (2) control curly-leaf pondweed growth in the lakes, (3) preserve current macrophyte communities (i.e., native species and moderate plant density), and (4) prevent the introduction of additional exotic species to the lake. Details of the management plan follow.

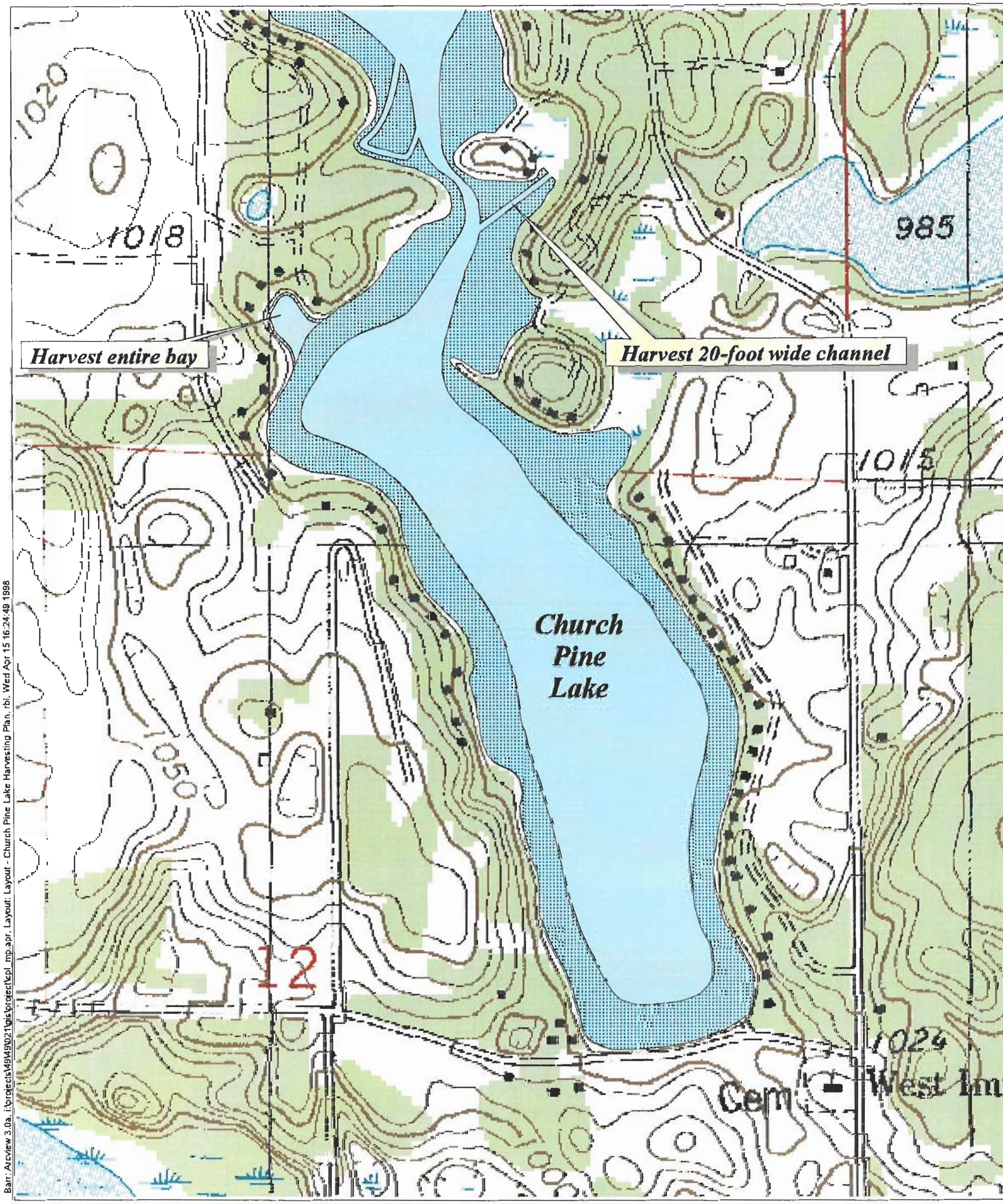
7.1 Harvesting Plan

A harvesting plan was developed for Church Pine Lake and Round (Wind) Lake to provide navigation channels to lake-users living adjacent to very dense plant growths. The harvested navigation channels will concurrently provide benefits to the lakes' fisheries. Benefits include cruising lanes for fish (e.g., bass) and increased invertebrate populations. The increased numbers of invertebrates will result 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 macrophyte beds than in the middle. Consequently, cutting channels through dense plant beds will increase the edge area, thus increasing invertebrate numbers. Increased invertebrate numbers result in increased quantities of food for the fish (Pellet 1998). Cutting channels through plant beds also makes it easier for fish to move through the plant bed and capture their prey (Marshall 1990).

The harvesting plan for Church Pine Lake and Round (Wind) Lake is presented in Figures 14 through 15. The harvested channel width will be restricted to 20 feet through areas designated as fish sensitive areas by the area fisheries manager (See Figures 16 and 17). The restriction will minimize disturbance to the fishery. Channel widths in areas not designated as fish sensitive areas will be based upon navigation needs of riparian residents.

7.2 Curly-leaf Pondweed Control

A treatment plan was developed to minimize curly-leaf pondweed growth in Church Pine Lake and Round (Wind) Lake (See Figures 18 through 19). The treatment program will protect native species and preserve current native communities (i.e., native species and moderate plant density).



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Barr Engineering Company

0 200 400 600 800 1000 1200 Feet

Macrophyte Occurrence

Figure 14
Harvesting Plan
Church Pine Lake

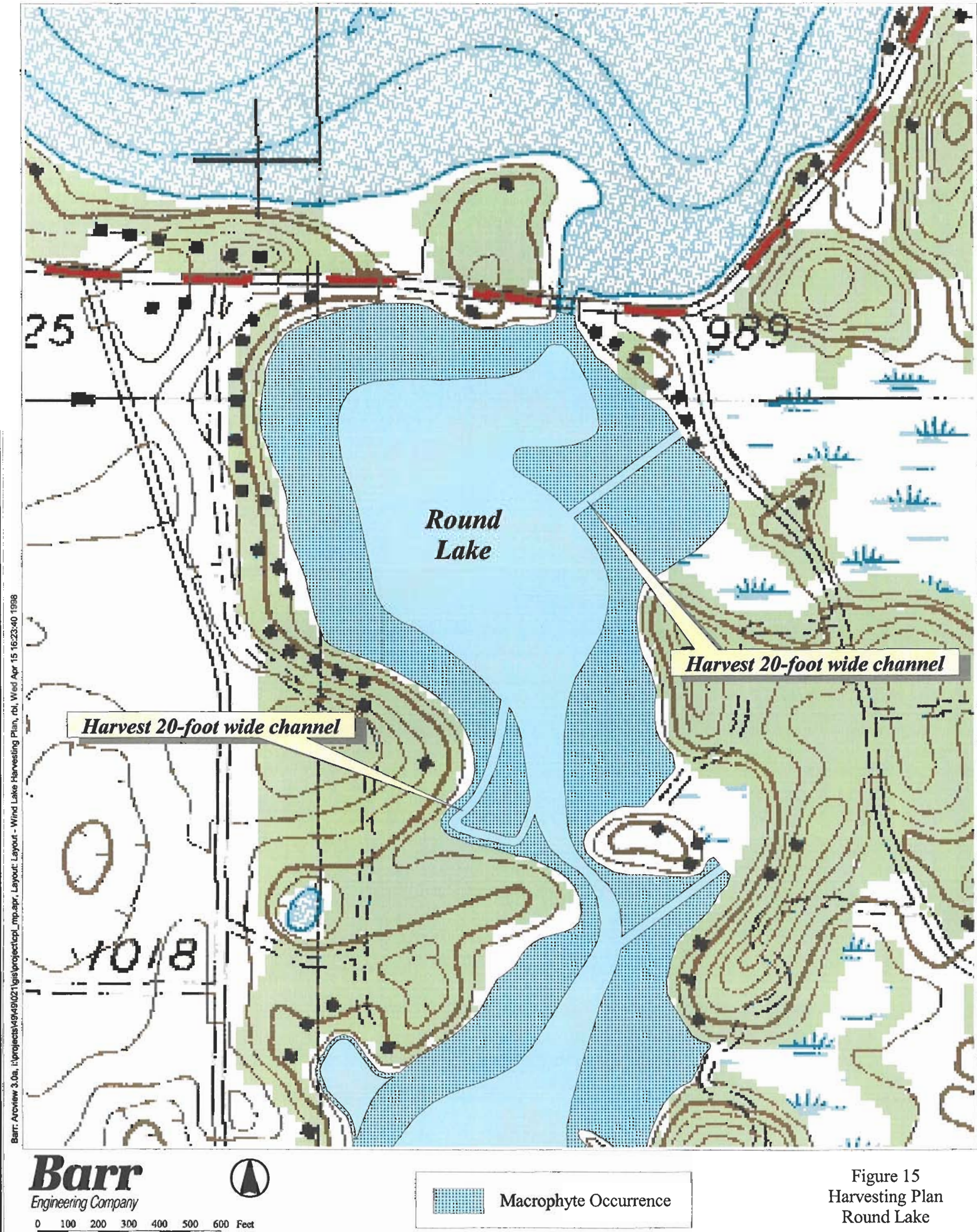
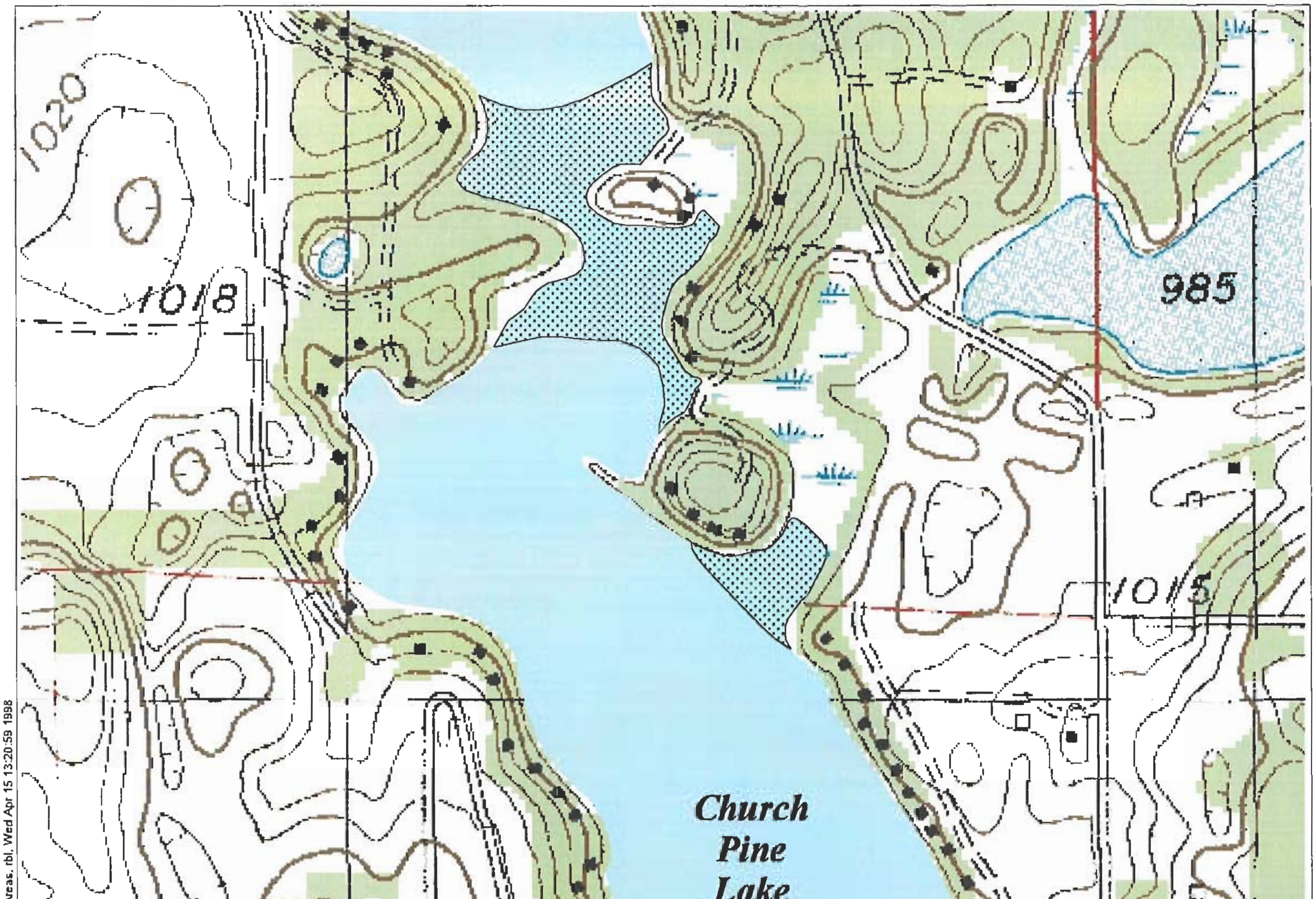


Figure 15
Harvesting Plan
Round Lake



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Sensitive Areas

Figure 16
Sensitive Areas
Church Pine Lake

Barr: Arcview 3.0a, I:\projects\49\49\021\gis\project\cpl_mp.apr, Layout: Layout Figure 10 Church Pine Lake Sensitive Areas, rbl, Wed Apr 15 13:20:59 1998

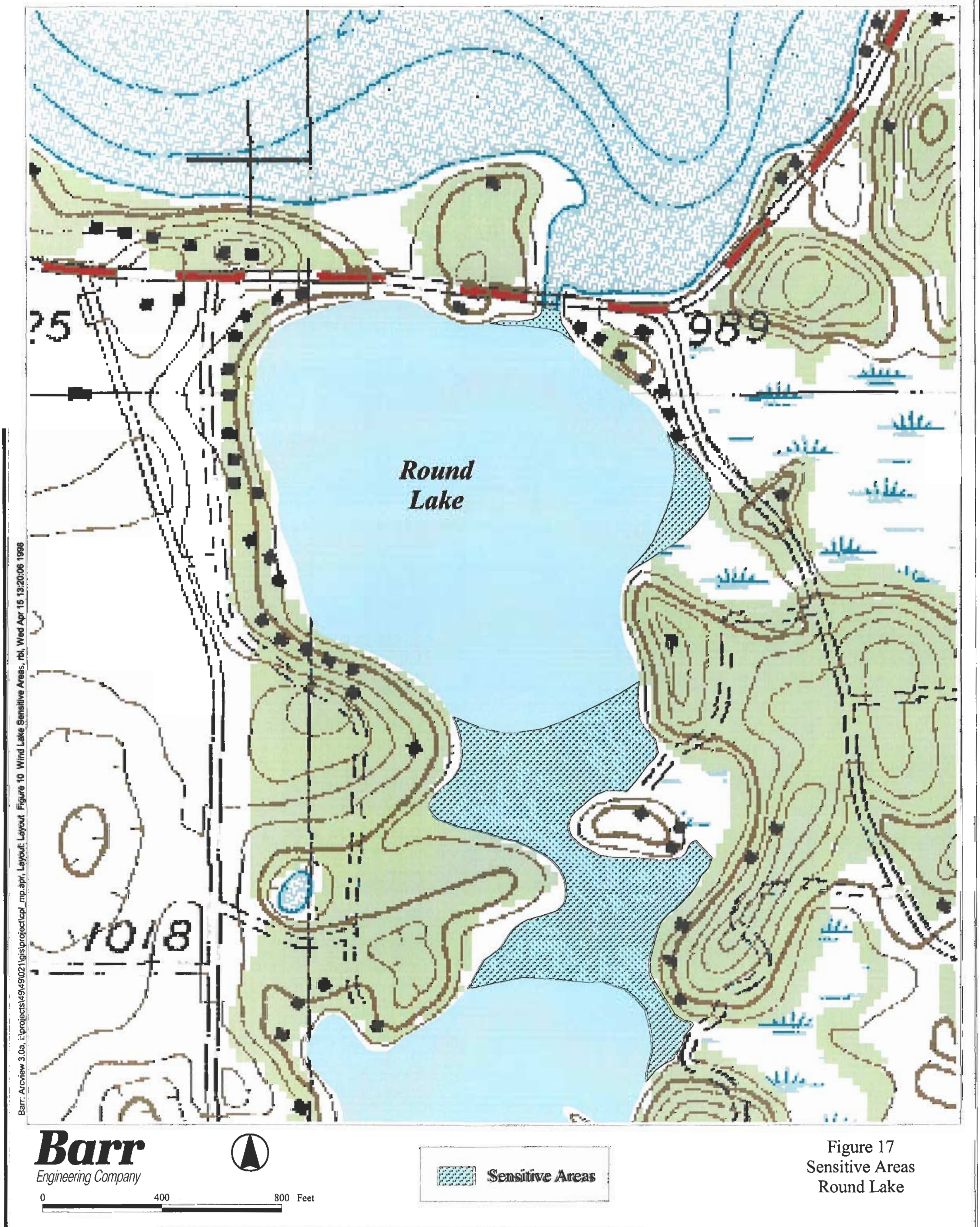
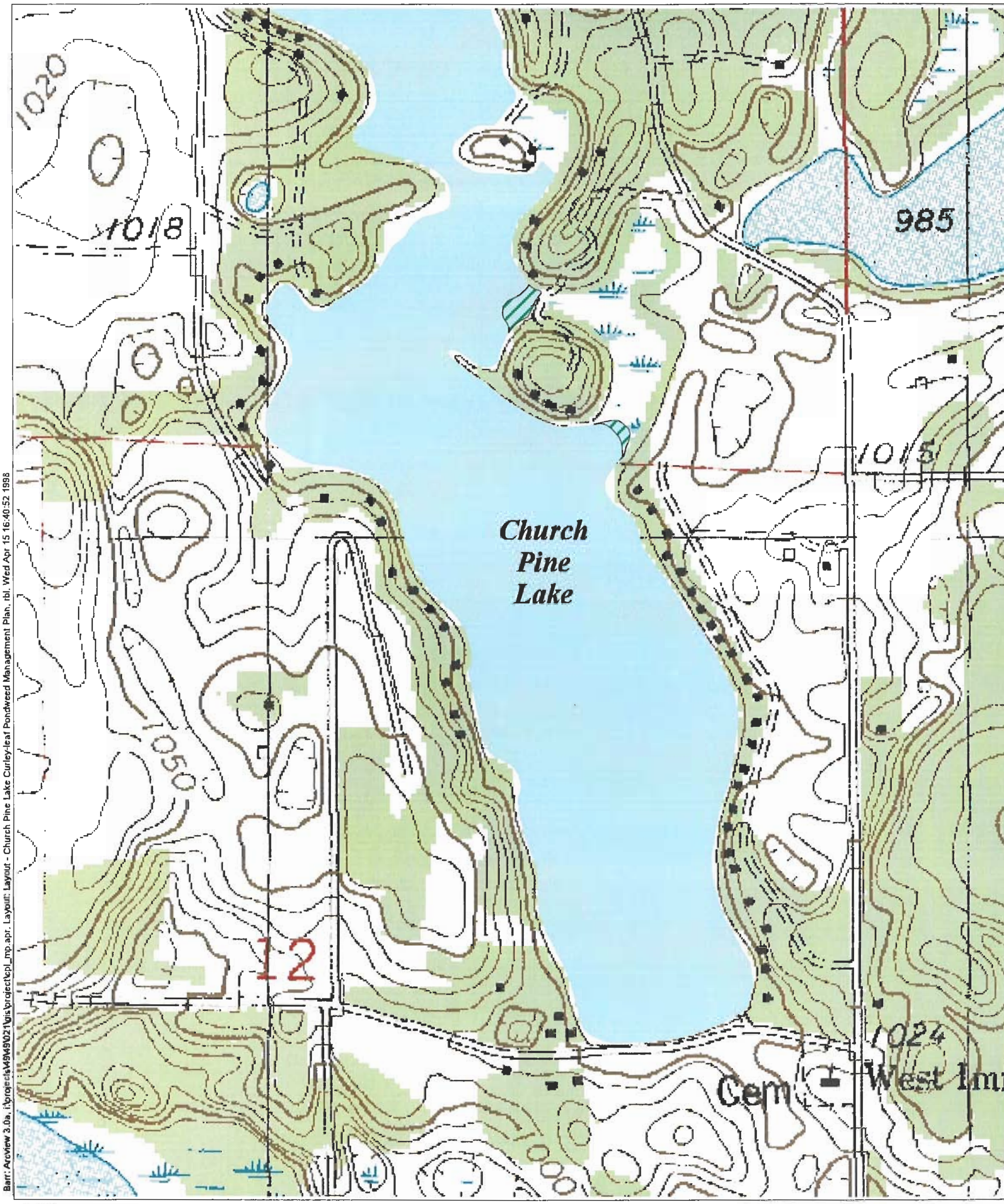


Figure 17
Sensitive Areas
Round Lake



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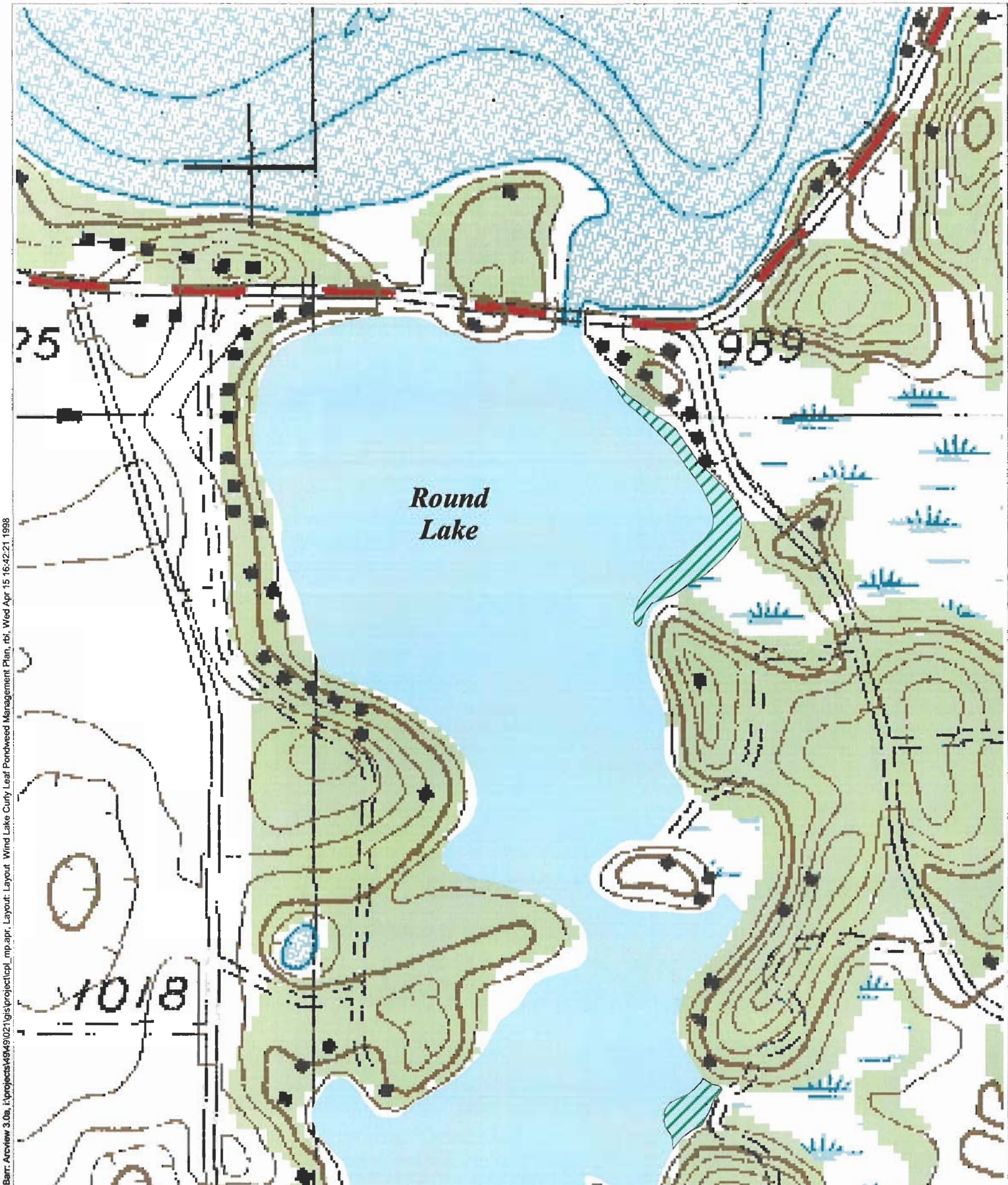
0 200 400 600 800 1000 1200 Feet

Curly-leaf Pondweed Treatment Areas

Figure 18
Curly-Leaf Pondweed Management Plan
Church Pine Lake



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Barr
Engineering Company

0 400 800 Feet

Curly-leaf Pondweed Treatment Areas

Figure 19
Curly-Leaf Pondweed
Management Plan
Round Lake

Treatment will consist of early spring harvesting or early spring herbicide treatment (i.e., Reward, active ingredient = Diquat) of all curly-leaf growth areas (See Figures 11 and 12). A study to determine the effectiveness of early spring harvesting and early spring herbicide treatments to control curly-leaf pondweed is currently in progress in Big Lake. The District may use the Big Lake study results to provide guidance in its decision regarding the most effective treatment method for curly-leaf pondweed control in Church Pine and Round (Wind) lakes. Alternatively, the District may try both treatment methods in Church Pine and Round (Wind) lakes and evaluate the results to determine the most effective control method for the lakes.

7.3 Education of Lake Homeowners

An education program will be completed to help area residents achieve an understanding of:

- The functions and roles of native species/native communities within Church Pine Lake and Round (Wind) Lake.

- The exotic species, curly-leaf pondweed, and its threat to the native plant community within Church Pine Lake and Round (Wind) Lake.

The education program will be completed by the Church Pine, Round, and Big Lake Protection and Rehabilitation District with assistance from the WDNR and the Polk County Land Conservation Department.

7.4 Control Introduction of Exotic Species to the Lake

A plan to control the introduction of exotic species was developed to protect the native species communities within the lakes. The plan involves education of lake-users and constant vigilance by lake residents. The education component involves:

- Posting signs at boat launches reminding lake-users to remove aquatic plants from boat trailers before entering and before leaving the lakes to prevent the introduction of unwanted species.

- Volunteers from the Church Pine, Round, and Big Lake Protection and Rehabilitation District could be present at the boat launches during busy weekends in June through August to inspect boats and trailers, distribute educational flyers, and advise boat owners to always remove vegetation from boats and trailers before entering or leaving the lakes.

- Information concerning exotic species and a reminder to remove plants from boat trailers could be displayed on bulletin boards at the boat launches. The bulletin board could be used to encourage boaters to pick up a free brochure describing exotic species, the potential dangers of exotic species, and the importance of vegetation removal to prevent exotic species introduction. The brochure could be placed in a dispenser located near the boat launch.

- Professionals such as WDNR staff, Polk County staff, or a consultant could hold informational meetings. The meetings could provide information about exotic species, methods of exotic species introduction, problems caused by introduction of exotic species, and prevention of exotic species introduction. Training to identify exotic species such as curly-leaf pondweed and Eurasian watermilfoil could be provided by a professional.

Creation of a Shoreline Weed Attack Team (SWAT) to inspect the littoral areas of the lakes for possible invasion by exotic species is recommended. A combination of planning and teamwork by lake residents will protect the lakes from exotic species invasion. The two most likely points for exotic species introduction are public boat launches and the water inlets to the lakes. The latter would include the channel between Big Lake and Round (Wind) Lake and the channel between Round (Wind) Lake and Church Pine Lake. The lake inlets should be inspected regularly throughout the summer for possible pioneer Eurasian Watermilfoil or curly-leaf pondweed or other exotic vegetation establishing in that area. An inspection schedule could be established for SWAT volunteers to insure that regular inspection occurs.

Lastly, constant vigilance by lake residents and/or SWAT volunteers will be needed to identify changes in curly-leaf pondweed growth within the lake and/or the establishment of Eurasian watermilfoil or other exotic species in the lake. The Church Pine, Round, Big Lake Protection and Rehabilitation District could form SWAT teams to conduct annual surveys of the entire littoral area of each lake. The team could establish an inspection schedule and plan a cookout/social gathering to follow completion of the inspection. Individual exotic plants identified by the survey should be removed by covering with a fine mesh bag[1] and the root crown of the plant should be removed whenever possible. This is likely to require snorkeling equipment. The plants that are dug up should be removed from the lake and disposed of where they have no chance of being

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[1]Nitex - a nylon mesh used for plankton nets can be purchased from aquatic suppliers, such as WILDCO and mesh bags could be sewn from the material. A 300 micron mesh would be adequate for capturing plants, including plant fragments.

washed into the lake. The areas with beds of exotic plants (e.g. curly-leaf pondweed, Eurasian watermilfoil) should be marked clearly on a map and could also be supplemented with markers along the shoreline. A treatment approach for the beds should be identified and a WDNR permit for treatment obtained.

7.5 Evaluation Program

An evaluation program is recommended to monitor the effectiveness of the lake management plan. A macrophyte survey of each lake should be completed once every five years. The methodology used for the 1997 survey of the lakes 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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