MMA, INC.
CONSULTING ENGINEERS

LAKE PLANNING STUDY

FOR

NORTH LAKE

Prepared for:

SPREAD EAGLE CHAIN OF LAKES ASSOCIATION

Florence, WI 54121

MAY 1996

Prepared by:

MMA, INC.
CIVIL AND ENVIRONMENTAL ENGINEERS
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2304 BEL-AIRE COURT P.O. BOX 11507
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June 17, 1996

Darlin Verley
1540 Arapaho Ave.
Grafton, WI 53024

Re: Lake Planning Study for North Lake,
Spread Eagle Chain of Lakes

Dear Mrs. Verley:

We are pleased to enclose for your use, two bound copies of the completed Lake Planning Study for North Lake prepared for the Spread Eagle Chain of Lakes Association.

The Lake Planning Study was performed in general accordance with the Professional Services Agreement dated November 9, 1994.

One copy of the Lake Planning Study was sent to Mr. Tim Rasman, Limnologist, WDNR - Green Bay for the Department's use as specified in the Professional Services Agreement.

One copy each of the Lake Planning Study was placed for reference at the Florence County Library, the Florence Natural Resource and Interpretive Center, and the Florence Town Hall. In addition, a 3.5" diskette of the report was sent to Jim Venny, WDNR - Madison.

If you should have any questions regarding the contents of this report, please feel free to contact us at your convenience.

Thank you for the opportunity to work with you on this project.

Very truly yours,

MMA, INC.

John M. Maas, P.E.
Project Manager

JMM/sf

Enclosures

LAKE PLANNING STUDY
FOR
NORTH LAKE

EXECUTIVE SUMMARY

North Lake is located in Sections 28, 29, 32 and 33 of Township 40 North, Range 19 East in the Township of Florence in the northeastern portion of Florence County, Wisconsin. It is the most northern lake of the Spread Eagle Chain of Lakes.

North Lake is approximately 77 acres in size. The Spread Eagle Chain of Lakes consists of nine lakes totaling approximately 548 acres in size. The maximum depth of North Lake is approximately 43 feet (Ref. #3).

The watershed area of the Spread Eagle chain of Lakes consists of approximately 3,200 acres located primarily to the northwest of the Spread Eagle Chain of Lakes. Runoff from the watershed of Montgomery Lake flows down Montgomery Creek to West Lake. The watershed consists predominantly of forest and wetlands with a scattering of residential development. The inlet to West lake supplies much of the water coming into the Spread Eagle Chain of Lakes with springs and precipitation supplying the remainder. There is no direct inlet supplying water to North Lake.

The outlet to the Spread Eagle Chain of Lakes is located on the south end of South lake. A small concrete compensation dam controls the lake level. Once water flows over the dam, it continues south and east as the Spread Eagle Outlet flowing to the Menominee River.

Overall water quality of North Lake is "very good" compared to the state averages of Wisconsin lakes.

- Total Phosphorus levels are low (8 ug/l) and Nitrogen to Phosphorus (N:P) ratios are high (35:1) indicating Phosphorus is the limiting nutrient for plant growth. (N:P ratios > 15:1 indicate Phosphorus limits plant growth).

- Samples were taken during spring turnover for total kjeldahl nitrogen, nitrate/nitrite, ammonia nitrogen, salts and metals. Results were all in the low to average range.

- Chlorophyll a results are low (1.9 ug/l), indicating a relatively small amount of algae growth.

- Color, Turbidity and Secchi depth (15 - 23 feet) indicate very good water clarity.

- pH levels ranged from 6.5 (February) to 7.7 (June). pH levels over 7.0 indicate non-acidic conditions.

Based on the total phosphorus, chlorophyll a and water clarity, North Lake is considered a Oligotrophic Lake (a lake with low nutrient levels).

North Lake has a good population of desirable aquatic plants overall. There are enough plants to provide cover, food and spawning locations for fish and yet the lake is not clogged with plants that would make boat travel and other recreation activities difficult.

During the aquatic plant survey conducted in late July on North Lake, eighteen different species of aquatic plants were identified. The three most dominant plant species found are Chara at fifty percent occurrence on the lake, Illinois Pondweed at twenty-seven percent occurrence, and Yellow Pond Lily at twenty percent occurrence on North Lake.

No exotic (foreign) species of aquatic plants were found in the aquatic plant survey of the lake.

North Lake supports natural reproduction of a number of pan and game fish species. An electrofishing survey was conducted on the Spread Eagle Chain of Lakes in September of 1994. The results indicate that the Spread Eagle Chain supports a dynamic and diverse fishery.

The fish found in North Lake include Largemouth Bass, Smallmouth Bass, Walleye, Northern, Bluegill, Rockbass, Yellow Perch and Black Crappie.

The following fish species use North Lake as a spawning location: Northern, Bass, Walleye, Bluegill and Crappie.

The Spread Eagle Lake Association should continue to monitor the water quality of North Lake. The Spread Eagle Chain of Lakes Association should join the Wisconsin Self-help Monitoring Program sponsored by the WDNR. Adverse lake trends can thereby be identified and corrected before irreversible damage to the lake has occurred.

A sign should be installed at the public landing to inform the public of the threat of exotic plants, local laws, and the responsibilities of lake users.

It is recommended to replace the existing narrow concrete planking and supporting material at public landing with crushed stone and wider concrete planking.

The level of fish stocking in the Spread Eagle Chain of Lakes should be maintained, but not increased. The addition of fish cribs should be continued. The cribs provide habitat for fish to thrive.

It is not recommended that the Spread Eagle Lake Association pursue the creation of a channel between Dunn's Point and Robbins Island. It is unlikely that any significant amount of sediment will be moved from the bay south of Robbins Island by the creation of a channel or series of culverts.

Measures should be taken to protect the shoreline from erosion due to boat traffic. Keep aquatic plants growing near shore and rooted plants on shore to minimize shoreline erosion. In areas of shoreline erosion, obtain a permit to install rock rip-rap near the shoreline.

Educate and involve the of property owners in measures that can maintain and improve water quality on North Lake. Maintaining good water quality will help minimize aquatic plant growth and minimize future sedimentation.

LAKE PLANNING STUDY
FOR
NORTH LAKE

Prepared for

THE SPREAD EAGLE LAKE ASSOCIATION
Florence, Wisconsin

DISTRIBUTION LIST

No. of Copies	Sent To
2	Darlin Verley Spread Eagle Lake Association 1540 Arapaho Avenue Grafton, WI 53024
1	Tim Rasman Wisconsin Department of Natural Resources Lake Michigan District Headquarters 1125 North Military Avenue P.O. Box 10448 Green Bay, WI 54307-0448
1	Florence County Library 400 Olive Avenue Florence, WI 54121
1	Town of Florence Florence Town Hall 749 Central Avenue Florence, WI 54121
1	Florence Natural Resource & Interpretive Center Intersection Hwy. 70/101 & US-2/141 H.C. 1 Box 83 Florence, WI 54121

LAKE PLANNING STUDY
FOR
NORTH LAKE

Prepared for

THE SPREAD EAGLE LAKE ASSOCIATION
Florence, Wisconsin

May 1996

I hereby certify that this Report has been prepared under my direct supervision and that I am a Registered Professional Engineer licensed in the State of Wisconsin.

_____

John M. Maas, P.E.
Wis. P.E. No. E-22243

_____

Date

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- **WDNR Electrofishing Survey Results**
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References

(Ref. #1) Putnam Robbins. July 22, 1995 conversation and letter to MMA, Inc. dated January 8, 1996. Mr. Robbins, born in 1902, has spent part of every summer at the Spread Eagle Chain of Lakes. Author of *THE EAGLE SPREADS ITS WINGS.*

(Ref. #2) Putnam Robbins. 1988. *THE EAGLE SPREADS ITS WINGS.*

(Ref. #3) Wisconsin Department of Natural Resources. 1971. *Surface Water Resources of Florence County, Wisconsin.*

(Ref. #4) United States Department of Agriculture, Soil Conservation Service. 1992. *Soil Survey of Florence County, Wisconsin,* Unpublished preliminary information.

(Ref. #5) Lee Clayton - Wisconsin Geological and Natural History Survey. 1986. *Pleistocene Geology of Florence County, Wisconsin.* Information Circular 51.

(Ref. #6) Franz Ruttner. 1972. *FUNDAMENTALS OF LIMNOLOGY.* pp. 56 - 104.

(Ref. #7) Tim Rasman, Limnologist - Wisconsin Department of Natural Resources. February 1996.

(Ref. #8) Klessig, Mechenich, Shaw - University of Wisconsin Extension. 1993. *Understanding Lake Data.* Publication G3582. I-06-93-3M-275-S.

(Ref. #9) Lillie and Mason - Wisconsin Department of Natural Resources. 1983. *Limnological Characteristics of Wisconsin Lakes.*

(Ref. #10) Arlo W. Fast. Reviews in Fisheries Science. 1994. *Winterkill Prevention in Lakes and Ponds with Artificial Aeration.* 2(1): 23-77 (1994).

(Ref. #11) Wisconsin Department of Natural Resources. 1992. *Guide to Wisconsin Aquatic Plants.* PUBL-WR-173-92.

(Ref. #12) Norman C. Fassett. 1966. *A MANUAL OF AQUATIC PLANTS.*

(Ref. #13) Russ Heiser - Wisconsin Department of Natural Resources. September 8, 1994. *Electro-fishing Survey of Spread Eagle Chain of Lakes, Florence County, Wisconsin*. Unpublished.

(Ref. #14) Fred Fox. August 15, 1995 conversation. Fred Fox is a lifetime resident and avid fisherman of the Spread Eagle Chain of Lakes.

(Ref. #15) David Majewski - Florence County Forestry and Parks Department. January 30, 1996.

(Ref. #16) Peter R. Weiler - University of Wisconsin, Madison. July 1978. *Littoral - Pelagic Water Exchange in Lake Wingra, Wisconsin, as Determined by a Circulation Model.*

(Ref. #17) Carper, G.L. and R.W. Bachman. 1984. *Wind Resuspension of Sediments in Prairie Lake.*

(Ref. #18) Yousef, Y.A., W.M. McLellon, R.H. Fagan, H.H. Zebuth and C.R. Larrabee. 1978. *Mixing Effects Due to Boating Activities in Shallow Lakes.* Draft Rep. to OWRT, U.S. Dep. Inter. Tech. Rep. ESEI No. 78-10, Washington, D.C.

(Ref. #19) United States Department of Agriculture, Soil Conservation Service. 1987. *Soil Survey of Marinette County, Wisconsin.*

(Ref. #20) United States Department of Agriculture, Soil Conservation Service. 1988. *Soil Survey of Oconto County, Wisconsin.*

Note: The references are noted in the report by insertion of (Ref. #00) at the end of each passage pertaining to the particular reference used.

Glossary of Terms

Algae One-celled (phytoplankton) or multicellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphton). Their abundance is measured by the amount of chlorophyll a in an open water sample, and is commonly used to classify the tropic state of a lake (Ref. #8).

Alkalinity A measure of the amount of carbonates, bicarbonates and hydroxide present in water (Ref. #20).

Ammonia Nitrogen A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays. It can be used by most aquatic plants and is therefore an important nutrient (Ref. #8).

Chlorophyll a A green pigment present in all green plant life and required in photosynthesis. The amount found in lake water is related to the amount of algae and is therefore used as an indicator of water quality.

Color Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. The average color value for Wisconsin lakes is 39 units, with color of state lakes ranging from zero to 320 units. Color affects light penetration and therefore the depth at which plants can grow (Ref. #8).

Croswell Loamy Sand Typically, the surface layer is black, very friable, loamy sand about 1 inch thick. The subsurface layer is brown, very friable loamy sand about 2 inches thick. The subsoil is about 27 inches thick. It is dark reddish brown, very friable loamy sand in the upper part; reddish brown, very friable sand in the next part; and yellowish red, mottled, very friable sand in the lower part. The substratum to a depth of about 60 inches is reddish brown and brown , mottled sand (Ref #19).

Epilimnion See "Stratification."

Eutrophic Trophic classification of a lake, indicating very productive and fertile conditions (see Eutrophication).

Eutrophication	The process by which lakes are enriched with nutrients, increasing the production of rooted aquatic plants and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile) (Ref. #8).
Fetch	Distance over water that the wind blows (Ref #17).
Fingerlings	Young fish, 1-4 inches in length.
Friable	Readily crumbled, brittle.
Fry	Newly hatched Fish
Hypolimnion	See "Stratification."
TKN	Total Kjeldahl Nitrogen, ammonium plus organic nitrogen.
Littoral Zone	The shallow area of a lake from the shore to the depth where light no longer penetrates to the bottom.
Loam	Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.
Macrophyte	Aquatic vascular plants that grow either floating, emergent or submergent in a body of water.
Markey Muck	Soils which consist of deep, very poorly drained soils on outwash plains. These soils formed in organic material derived primarily from herbaceous plants and are underlain by sandy material. They are moderately permeable in the upper part and rapidly permeable in the lower part (Ref #20).
Mesotrophic	Trophic classification of a lake, indicating moderately productive conditions (see Eutrophication).
Metalimnion	See "Stratification."
Micromhos	One millionth of a mho. A mho is a unit of conductance reciprocal to the ohm.
Oligotrophic	Trophic classification of a lake, indicating nutrient poor conditions (see Eutrophication).

Pense Sandy Loam — Typically, the surface layer is black sandy loam about 1 inch thick. The subsurface layer is brown sandy loam about 1 inch thick. The subsoil is about 21 inches thick. It is dark brown, friable sandy loam in the upper part; brown, friable sandy loam in the next part; and brown friable loamy sand in the lower part. The substratum to a depth of about 60 inches is strong brown, loose, stratified sand and gravel. In some places the surface layer and subsoil are loamy sand. In other places the stratum is sand (Ref #20).

Permeability — The rate that water travels through soil.

pH — A measure of acidity or alkalinity, numerically equal to 7 for neutral solutions, increasing in acidity as the number decreases from 7 to zero, increasing in alkalinity as the number increases from 7 to 14.

Photosynthesis — The process by which green plants convert carbon dioxide to sugar plus oxygen using sunlight for energy.

Sayner Loamy Sand — Typically, the surface layer is black, very friable loamy sand about 4 inches thick. The subsoil is about 21 inches thick. It is reddish brown, very friable loamy sand in the upper part and strong brown, very friable gravelly sand in the lower part. The substratum to a depth of about 60 inches is strong brown gravelly sand (Ref #19).

Specific Conductivity — A measure of water's ability to conduct electricity. Conductivity is reported in micromhos per centimeter. and is directly related to the total dissolved inorganic chemicals in the water. Values are commonly two times the water hardness unless the water is receiving high concentrations of contaminants introduced by humans (Ref. #8).

Stratification — The layering of water due to differences in density. Water's greatest density occurs at 39°F (4°C). As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface layer (epilimnion), which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion or thermocline.

Thermocline — See "Stratification."

Trophic State See "Eutrophication."

Turnover Overturn of the water mass of a lake from the surface to the bottom under uniform temperature conditions due to the action of wind energy.

SPREAD EAGLE LAKE ASSOCIATION
GRANT COMMITTEE MEMBERS

- Darlin Verley (Chairperson)
- John Lillie
- John Fortier
- Carl Sundberg
- Larry Serratti

SPREAD EAGLE LAKE ASSOCIATION
OFFICERS

Chairperson .....John Lillie

Vice Chairperson .....Marvin Sculati

Secretary.....Connie Landgren

Treasurer .....Dennis Christian

1.0. INTRODUCTION

North Lake is one of nine lakes of the Spread Eagle Chain of Lakes located in northeastern Florence County in northeastern Wisconsin. The Spread Eagle Chain of Lakes is located mid-way between Iron Mountain, Michigan and Florence, Wisconsin, near U.S. Highway 2/141. The location of North Lake is shown on Figure No. 1 - Location Map included in Appendix "A."

This section of the report provides a summary of the work to be performed during the study and some historical and general information pertaining to North Lake and the Spread Eagle Chain of Lakes.

1.1. Purpose

The Spread Eagle Chain of Lakes Association, Inc. was formed in 1988, with the objective **"...to provide a forum in which property owners, as members of the Association, can come together to discuss and act upon matters pertaining to the preservation and upkeep of their properties and of the surrounding area. Major interests include water quality, water safety, property improvement, relations with the Town of Florence, and the use of Spread Eagle waters by the general public."** A copy of the Spread Eagle Chain of Lakes Association bylaws is included in Appendix "B."

In 1994, the Spread Eagle Chain of Lakes Association sought financial assistance from the WDNR Lake Management Planning Grant Program for the purpose of conducting a lake planning study on North Lake of the Spread Eagle Chain of Lakes. The Lake Management Planning Grant Program, authorized under Chapter 144.253, Wisconsin Statutes, provides for assistance to eligible sponsors for the collection and analysis of information needed to protect and restore lakes and their watersheds. Lake Planning Grants provide seventy-five percent of the costs incurred. The Spread Eagle Chain of Lakes Association received notice of grant eligibility in October, 1994.

On November 9, 1994, the Spread Eagle Chain of Lakes Association entered into an agreement with MMA, INC. of Green Bay, Wisconsin to provide the following services in conducting the lake planning study:

- Obtain water quality samples and analyze the samples through the State Laboratory of Hygiene for appropriate parameters five (5) times: during winter 1994-95 (ice on), spring 1995 (ice out), June, July and August, 1995.
- Prepare an assessment of the aquatic plant and fish community.
- Conduct a circulation study.
- Address the public landing to the lake.
- Address the current usage and resulting impact on the lake.
- Estimate sedimentation along the shoreline of North lake.

- Assist the Spread Eagle Chain of Lakes Association, through the education of designated members, with the equipment operation and sampling procedures necessary to continue its efforts of monitoring the quality of the Spread Eagle Chain of Lakes.
- Identify watershed area, delineated environmental sensitive areas (i.e., wetlands and steep slopes), and surface water runoff patterns. Estimate phosphorus loading from the watershed.
- Consider all other lake management activities and other local interest groups in the lake study project.
- Tailor the work undertaken to comply, to the greatest extent possible, with the goals, objectives and recommendations of the basin plan.
- Conduct a sociological survey consisting of a postcard survey of landowners to identify lake management goals and objectives.
- Prepare a news release and attend a public informational meeting to enhance local understanding of the lake's water quality.
- Submit a minimum of two (2) progress reports during the project to the Spread Eagle Lake Association.
- Give recommendations in the areas of water quality, fish management and aquatic plant management.
- Include as part of the final report appropriate physical background information on North Lake.
- Meet with the Lake Study Committee of the Spread Eagle Lake Association near the completion of the project to review material that will be included in the final report. The final report will be written as to be easily understood by the general public.
- Prepare a report summarizing the work to submit to the WDNR.

1.2. History

As with most of northern Wisconsin and the U.P of Michigan, prior to the late 1800's the Florence area was a great virgin forest. The Iron Mountain and Florence areas developed in the late 1800's and earlier 1900's as a result of the logging and mining activities in the area.

Logging activities did not occur in the Florence area until the mid to late 1870's, shortly after the government land sales which started in 1866. Most of the logs that were cut in the late 1800's and early 1900's were floated down river to lumber mills. The Menominee River, located just north and east of the Spread Eagle Chain of Lakes, served as a main vehicle for transporting the logs to the lumber mills. By 1898, most of the large stands of virgin pine in Florence County had been cut by the major logging companies, including the virgin Red and White Pine stands in the Spread Eagle Chain of Lakes area. The last of the remaining small stands of virgin pine were harvested from the Spread Eagle Chain of Lakes in winter of 1907 - 1908 (Ref. #1).

Iron ore was discovered by Hiram D. Fisher in the Florence area in 1873 and in Commonwealth in 1876. The Chicago and Northwestern Railway Company extended rail service to Commonwealth and Florence in 1880 to transport the iron ore mined from the Florence and Commonwealth area. Passenger rail service was provided to Spread Eagle, Commonwealth and Florence in 1881.

Rail service to Spread Eagle opened up the Spread Eagle Chain of Lakes area for recreation and tourism. In 1881, Fred John opened up a resort and an ice house on Bass Island on Bass Lake. It was expanded in 1889 when it was purchased by Emmanuel Chainey to include a popular dance pavilion. In 1894, a resort hotel opened with a saloon and ice house on Eagle Island between Bass Lake and Middle Lake. Each of these resorts had steam powered boats to transport people from the train depot near Railroad Lake to the resorts. Paradise Island on East Lake had a small resort in the 1880's until 1894 (Ref. #2).

In 1882, the first private cottage was built by Mark Dunn on Dunn's Point near the entrance to West Lake. The first major building of cottages on the Spread Eagle Chain of Lakes did not occur until 1904 when the lots on Mosquito Bay of Bass Lake were sold.

Waterfront lots on Spread Eagle Chain of Lakes accessible by roads from the railroad depot sold quickly, while lots which were only accessible by water usually did not sell until the roads were provided. The construction of cottages and homes on North Lake did not occur until Brown's Road was extended around North Lake in circa 1925.

Once roads were built around the Spread Eagle Chain of Lakes making the lots easily accessible, building around the Lakes flourished. Recently, building on vacant lots has given way to the conversion or replacement of summer cottages to year-round homes.

1.3. General Information

North Lake is located in Sections 28, 29, 32 and 33 of Township 40 North, Range 19 East in the Township of Florence in the northeastern portion of Florence County, Wisconsin. It is the most northern lake of the Spread Eagle Chain of Lakes.

North Lake is approximately 77 acres in size. The Spread Eagle Chain of Lakes consists of nine lakes totaling approximately 548 acres in size. The maximum depth of North Lake is approximately 43 feet (Ref. #3). For complete details on the depths of the Spread Eagle Chain of Lakes refer to Figure Nos. 2 & 3 - Lake Survey Maps of the Spread Eagle Chain of Lakes, included in Appendix "A."

It should be noted that Wisconsin Department of Natural Resources (WDNR) publication FM-800-95 Rev - Wisconsin Lakes incorrectly states the size and depth of North Lake at 46 acres and 19 feet, respectively. Likewise, several maps incorrectly show an inlet into North Lake which in fact enters into West Lake. These maps include the WDNR Lake Survey Map shown as Figure No. 2 - Lake Survey Map of the Spread Eagle Chain of

Lakes, included in Appendix "A," Clarkson map No. 3805 - Spread Eagle Chain and the United States Geological Survey (USGS) topographic map - Florence, East.

The inlet to West lake supplies much of the water coming into the Spread Eagle Chain of Lakes; springs and precipitation supply the remainder. There is no direct inlet supplying water to North Lake.

The outlet to the Spread Eagle Chain of Lakes is located on the south end of South lake. A small concrete compensation dam controls the lake level. Once water flows over the dam, it continues south and east as the Spread Eagle Outlet, flowing to the Menominee River.

The soils around North Lake are predominately sandy loams, loamy sands or muck. The primary soil series around North Lake is the Pense sandy loam, followed by the Sayner loamy sand, Markey muck, and Croswell loamy sand (Ref. #4). Descriptions of each of these soil series are located in Glossary of Terms. The sandy soils found around the lake are primarily glacial outwash created after the last stage of glaciation. It appears that the Spread Eagle Chain of Lakes were formed approximately 12,300 years ago from the pitted deposits of glaciers containing ice blocks which eventually melted to form the pits or kettle lakes (Ref. #5).

These soils are typically well drained with permeabilities ranging from rapid to very rapid. On-site septic system drain fields function satisfactorily, but groundwater pollution is a potential problem because of the rapid to very rapid permeability in the lower soils (Ref. #4).

North Lake bottom soils are a mixture of gravel, muck, sand, rubble and boulder. The North Lake bottom soils are dominated by gravel (forty-eight percent) followed by muck (twenty-five percent), sand (twenty percent) with the remaining seven percent rubble and boulder (Ref. #3). For complete details on the North lake bottom soils refer to Figure No. 2 - Lake Survey Map of the Spread Eagle Chain of Lakes in Appendix "A."

The annual average precipitation in the Spread Eagle Chain of Lakes area is 29.8 inches. About 18 inches, or sixty percent, usually falls in May through September (Ref. #3).

Prevailing winds are from the west and northwest from late fall through early spring, and from the southwest the remainder of the year. The average wind speed is six miles per hour (Ref. #3).

Public access to the Spread Eagle Chain of Lakes is gained on the southwest side of North Lake. The public access has adequate parking, a boat ramp, a dock and a latrine.

There are approximately 35 seasonal and permanent residence on North Lake. There are approximately 310 property owners on the entire Spread Eagle Chain of Lakes.

2.0. DISCUSSION OF INFORMATION

The following sections of the report discuss the information generated during the study.

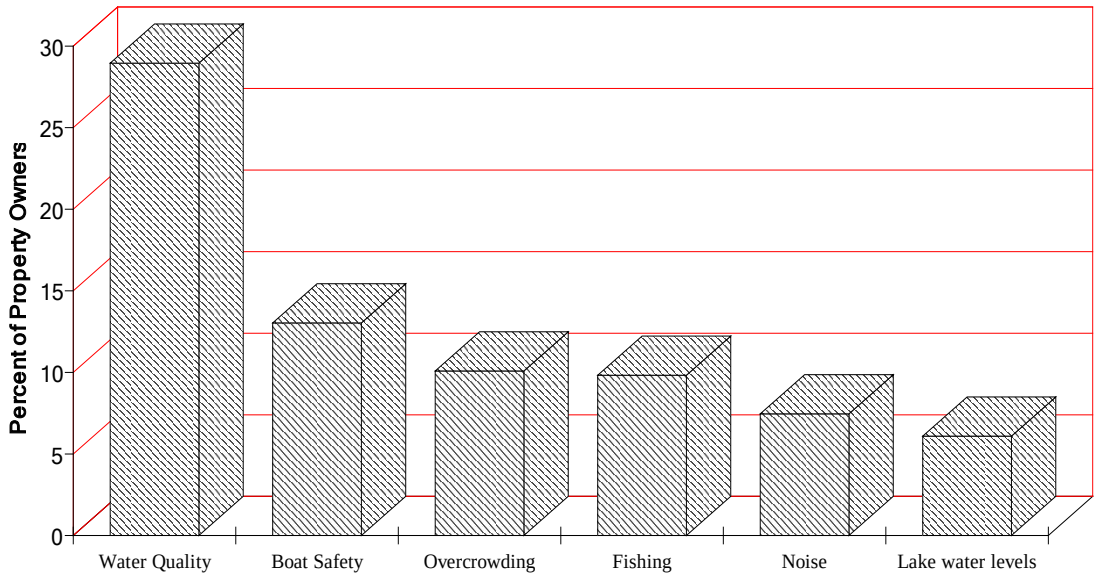
2.1. Property Owner Survey Results

A letter survey was conducted of Spread Eagle Chain of Lakes property owners in June of 1995. The property owners were given an opportunity to express their concerns and offer suggestions regarding the Spread Eagle Chain of Lakes. The Spread Eagle Lake Association will use this information to establish its future goals and objectives. Copies of the returned questionnaires are found in Appendix "D." The survey had an excellent return rate: sixty-seven percent of the property owners completed and returned the questionnaire. This response shows that the Spread Eagle Chain of Lakes property owners want to take an active part in the future of the Spread Eagle Chain of Lakes.

Based on the results of the survey, the top three concerns of the property owners are

1) Water Quality
2) Boat Safety
3) Overcrowding

The following figure graphically shows the results of property owners' concerns:



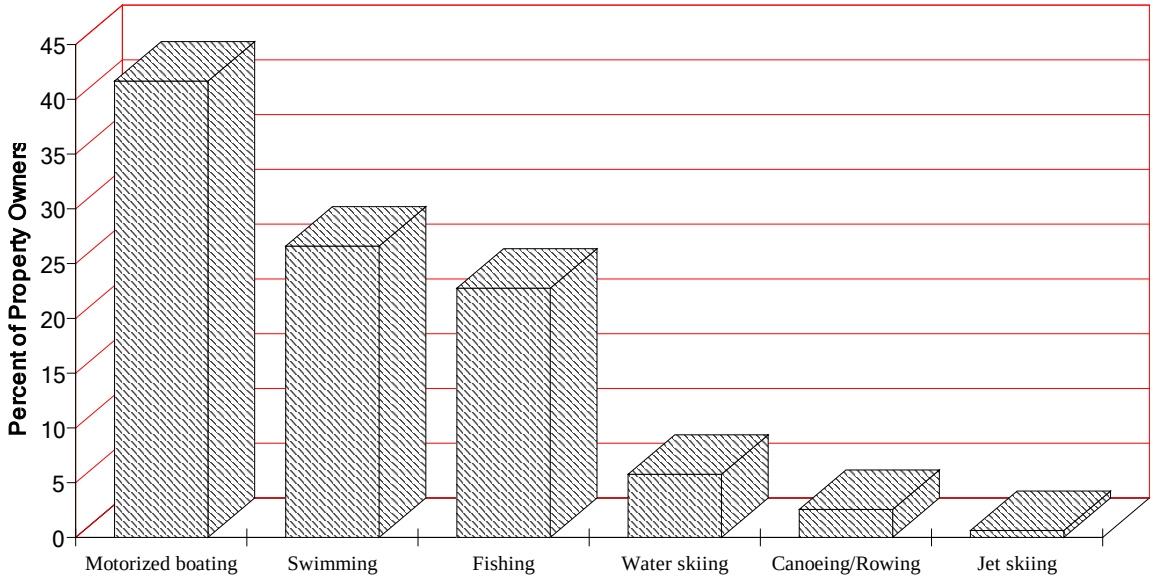
Top Concerns of Spread Eagle Chain of Lakes Property Owners

Twenty-nine percent of the returns indicated water quality as the top concern. Thirteen percent indicated boat safety as the top concern, and ten percent indicating overcrowding as the top concern.

Based on the results of the survey, the top three primary water recreation activities of property owners are

1) Motorized boating
2) Swimming
3) Fishing

The following figure graphically shows the results of property owners' primary water recreation activities:



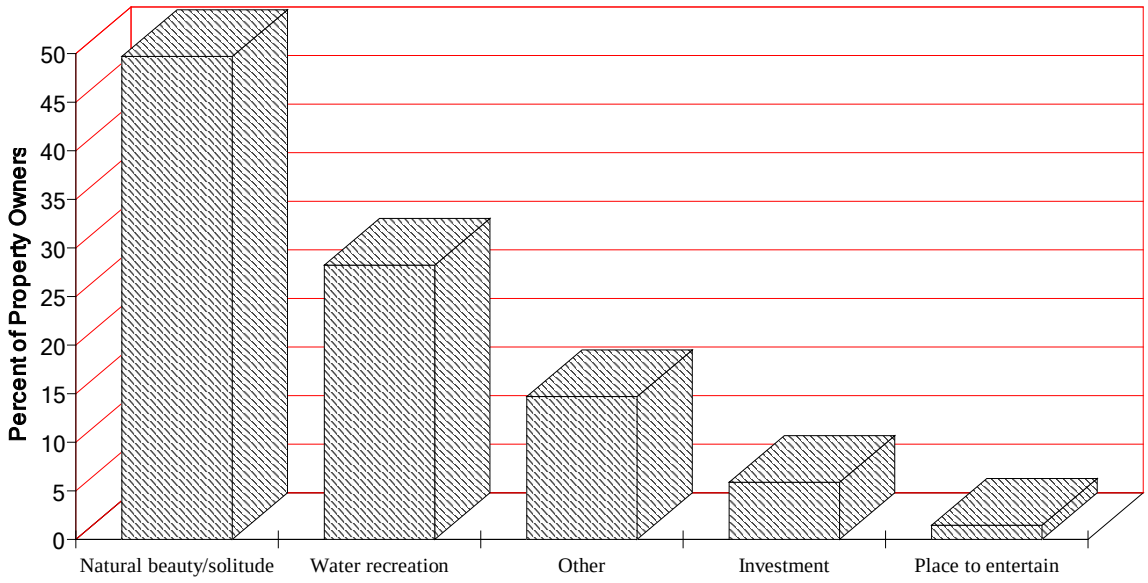
Primary Water Recreation Activities

Motorized boating was indicated as the primary water recreational activity of forty-two percent of the property owners responding to the survey. Swimming was the primary activity of twenty-seven percent, and fishing was the primary activity on the lakes for twenty-three percent of property owners.

Sixty-two percent of property owners indicated they owned an outboard motorboat; forty-six percent indicated that they owned a canoe, thirty-nine percent a row boat, thirty-two percent a paddle boat, and twenty-eight percent owned a pontoon boat.

Natural beauty/solitude and water recreation were the top two reasons for property owners to purchase property on the Spread Eagle Chain of Lakes.

The following figure graphically shows the results of property owners principal reason for property purchase:



Principal Reason for Purchase of Property

Fifty percent of the property owners indicated that natural beauty/solitude was the principal reason for the purchase of the property. Twenty-eight percent of property owners indicated water recreation as the principal reason for the purchase of property on the Spread Eagle Chain of Lakes. Fifteen percent of the property owners indicated "other" as the principal reason for the purchase of property. "Other" was usually described as "has been in the family for generations."

For complete details of the results of the survey refer to the information included in Appendix "D."

2.2. Water Quality

The purpose of testing a lake's water quality is to document changes in a lake which will help to distinguish between a lake's natural variability and the impacts of human activity. The following information provides a baseline for which future water quality testing of North lake can be measured.

Water quality samples were taken five times on North Lake during 1995. They were ice on (February), ice out (April), and June, July and August. Two samples were also taken on the inlet to West Lake during June for total and dissolved phosphorus. The location of water quality sampling on North Lake is indicated in Appendix "A," Figure No. 4.

The following table shows the analytical parameters for each water sampling event:

Water Sampling Parameter	Month Tested
Total Phosphorus	February, April, June, July, August
Dissolved Phosphorus	February, April, June, July, August
TKN	April
Nitrate/Nitrite	April
Ammonia Nitrogen	April
Color, Turbidity, Sulfate, Chlorides	April
Magnesium, Sodium, Potassium, Calcium	April
Iron, Manganese, Hardness	April
Chlorophyll a	April, June, July, August
Fecal Coliform	July

2.2.1. Methods of Sample Collection and Testing

Water samples were collected for laboratory analysis with a Wildco®, clear acrylic, one-liter, horizontal style water sampler at specified depths and locations. Samples were immediately transferred to appropriate bottles, preserved (if necessary), labeled, packed in ice and sent via overnight express mail to the laboratory. All laboratory analysis was conducted by the Wisconsin State Laboratory of Hygiene in Madison, Wisconsin, using WDNR specified methods.

Sampling and analysis for total phosphorus and dissolved phosphorus were conducted during all sampling events. Phosphorus is normally the limiting factor in aquatic plant growth.

Sampling and analysis for total phosphorus, dissolved phosphorus, total kjeldahl nitrogen, nitrate/nitrite nitrogen, ammonia nitrogen, color, turbidity, sulfate, chlorides, magnesium, sodium, potassium, calcium, iron, manganese and hardness were all conducted during the April sampling event. The April sampling event took place shortly after spring turnover to take advantage of the natural mixing action that occurs at that time. During spring and fall turnover in a lake, nutrients and sediments stored on the bottom are resuspended.

Sampling and analysis for chlorophyll a (a measure of algae growth) were conducted during the April, June, July and August sampling events. These are months when algae growth is expected to be the highest in a lake.

Sampling and analysis for fecal coliform (coliform bacteria found in feces) were conducted during the July sampling event. A high fecal coliform count is usually an indication of raw sewage entering the lake. A mid-summer test was conducted because this is the time of highest use of on-site systems by lake residents and visitors.

In addition to the previously described water sampling, physiochemical parameters were measured in the field. These parameters included Secchi depth, dissolved oxygen (DO), specific conductivity, pH, and water temperature.

The Secchi depth is a measure of water clarity. It is determined using a standard secchi disc. The Secchi disk is a black and white circular plastic plate, 20 centimeters (~8 inches) in diameter. The Secchi disc is lowered over the downwind , shaded side of the boat into the water until it just disappears from sight, then raised again until it is visible. The average depth at which the Secchi disk disappears and reappears is the Secchi depth at that location. Water with greater clarity will have a greater Secchi depth. Secchi depth readings were measured on calm sunny days between 10 A.M. and 2 P.M.

Water temperature and DO readings were obtained with a YSI® Model 50B dissolved oxygen meter. The probe, located at the end of a 60 foot cable, was lowered into the water to a specified depth. Readings for DO and temperature were recorded at the prescribed elevation.

The measurement of specific conductivity (ability to conduct electricity) of lake water was done with a Myron® DC4 digital meter. Samples of water were collected randomly from a boat traveling along the shoreline. The conductivity measurements were recorded at each location. Distilled water has a conductivity of zero micromhos. As minerals and nutrients are added to the water the specific conductivity goes up. A base reading was taken in the middle of the lake at the beginning and end of each test. The readings obtained along the shoreline were compared to the base readings. If the shoreline readings are considerably higher than the base readings, it can be assumed that minerals or nutrients are coming from a source nearby, i.e., leaking septic drain field system, etc.

The pH (measure of acidity) of surface water in the lake was measured in April, June, July and August with an Orion® model 290A pH meter. Readings for pH were taken at the same location as water samples.

2.2.2. Results of Water Quality Analysis

The following sections of the report summarize the water quality sampling and laboratory analysis conducted on North Lake. For complete details of the laboratory results refer to Appendix "E."

Aquatic plants need many elements for growth and survival: Carbon (C), Hydrogen (H), Oxygen (O), Nitrogen (N), Phosphorus (P), Sulfur (S), Calcium (Ca), Magnesium (Mg), Potassium (K), and Iron (Fe). A number of other elements are also necessary, but in extremely small amounts. Only two of these elements are considered major limiting nutrients when it comes to plant growth in lakes: Nitrogen and Phosphorus (Ref. #6).

2.2.2.1. Phosphorus

Phosphorus is a highly variable nutrient in lakes. Its concentration has probably the greatest effect on aquatic plant growth. The concentration of Phosphorus in North Lake was determined as Total Phosphorus and Dissolved Phosphorus.

Dissolved Phosphorus is, as the name implies, dissolved in the water and readily available for aquatic plant uptake. Its concentration generally varies throughout the year.

Total Phosphorus is a better indicator of the amount of Phosphorus ultimately available in a lake for aquatic plant growth. It is the sum of the dissolved Phosphorus and the Phosphorus contained in suspended plant and animal material in the water.

The following table provides the Total and Dissolved Phosphorus concentrations in water samples collected from North Lake during 1995. The concentrations are presented in micrograms per liter (ug/l) or parts per billion.

Total and Dissolved Phosphorus Concentrations - North Lake

Month	Sample	Total Phosphorus (ug/l)	Dissolved Phosphorus (ug/l)
February	Top	13	ND
February	Bottom	ND	ND
April	Top	13	ND
April	Bottom	16	ND
June	Top	ND	ND
June	Bottom	7	ND
July	Top	9	ND
July	Bottom	8	ND
August	Top	7	ND
August	Bottom	57	ND

*ND indicates Dissolved Phosphorus level below the detectable limit of 2 ug/l.
*Top samples were obtained within one meter of the surface.
*Bottom samples were obtained within one meter of the bottom.

It should be noted that the 57 ug/l result for Total Phosphorus obtained from the August bottom sample is higher than normal compared to the rest of the year. During anaerobic (no oxygen) conditions, phosphorus can be driven out of bottom sediment and indicate a temporarily high figure (Ref. #7). This may be a reason for the elevated Total Phosphorus result obtained.

Dissolved Phosphorus concentrations should be less then 10 ug/l during spring turnover (April) to prevent summer algae blooms. The results of sampling on North Lake indicate concentrations to be less than the detectable limit of 2 ug/l. This means that a very small amount of phosphorus is readily available for plant uptake.

The following table provides the average Total Phosphorus concentrations for Wisconsin's natural lakes and impoundments.

Total Phosphorus Concentrations for Wisconsin Lakes and Impoundments Compared to North Lake Summer of 1995. (Adapted from Ref. #8 and Ref. #9)

Water Quality Index	Total Phosphorus (ug/l)	State Ave. Total Phosphorus for all Lakes (ug/l)	State Ave. Total Phosphorus for Impoundments (ug/l)	State Ave. Total Phosphorus for Natural Lakes (ug/l)	North Lake Total Phosphorus (ug/l)
Very Poor	> 150				
Poor	55-150		65		
Fair	32-55				
Good	16-32	31		25	
Very Good	2-16				13
Excellent	<2				

The results of Total Phosphorus concentrations are less than those for other natural lakes and much less than that for all lakes (Ref. #9).

2.2.2.2. Nitrogen

Nitrogen is a relatively stable nutrient in most lakes compared to Phosphorus. Nitrogen is a major natural component in decomposing plant and animal matter. It exists in lakes in several forms including: nitrate (NO_3), nitrite (NO_2), ammonia (NH_4) and organic nitrogen. Total Kjeldahl Nitrogen (TKN) is the combined total of ammonia nitrogen and organic nitrogen. Total Nitrogen is the sum of TKN plus nitrate and nitrite nitrogen. The following table provides the results of Nitrogen testing on North Lake conducted during spring turnover. The concentrations are presented in milligrams per liter (mg/l) or parts per million.

Results of Testing for Nitrogen - North Lake, April 1995

Sample	Ammonia Nitrogen (mg/l)	Nitrate/Nitrite (mg/l)	TKN (mg/l)	Total Nitrogen (mg/l)
Bottom	0.064	0.056	0.016	0.072
Top	ND	0.013	0.400	0.413

Wisconsin lakes have an average Total Nitrogen concentration of 0.86 mg/l, with seventy-one percent of the lakes falling between 0.30 and 1.0 mg/l (Ref #9). North Lake falls in the lower part of the spectrum.

The Total Nitrogen to Total Phosphorus ratio (N:P ratio) for North Lake was found to average 35:1 for the year. N:P ratios greater than 15:1 generally indicate Phosphorus is the limiting nutrient for aquatic plant growth.

2.2.2.3. Chlorophyll a

Chlorophyll a is a green pigment necessary for photosynthesis. The amount of chlorophyll a found in lake water is used to estimate algae (phytoplankton biomass) in the lake. The concentration of chlorophyll a found in water samples collected in April, June, July and August (algae season) from North Lake are provided in the following table:

Chlorophyll a - North Lake, 1995

Month	Chlorophyll a (ug/l)
April	3.66
June	0.781*
July	0.95*
August	2.26*

* Low Absorbance, result approximate

The average concentration of chlorophyll a in Wisconsin lakes was 14.8 ug/l with sixty-five percent of the lakes having a value of less than 10 ug/l (Ref. #9). The results indicate that North Lake is well below the state average for chlorophyll a.

2.2.2.4. Fecal Coliform

Fecal coliform are coliform bacteria originating from animal feces. A high count from a fecal coliform test usually indicates raw sewage is entering the lake. A mid-summer test was conducted because this is the time of highest use by residents and visitors. The sample taken in July had a count of less than 10 colonies per 100 ml sample.

The results indicate that raw sewage was not detected in the sample obtained.

2.2.2.5. Color

The color of a lake is a measure of the amount of material dissolved in the water. Color is mainly aesthetic, but it can affect light penetration and heat absorbance of lakes. Tannic and humic acids originating from decomposing plant material can give a lake a natural brown color. North Lake was sampled in April for color. The following table provides the water color range from low to high as correlated to standard units (SU) of color, and the results of the samples obtained from North Lake.

Water Color (Ref #8) - North Lake, April 1995

Range	Color	North Lake Top Sample (SU)	North Lake Bottom Sample (SU)
0-40 units	Low	10	10
40-100 units	Medium		
>100 units	High		

The results indicate the color of North Lake is low.

2.2.2.6. Turbidity

The turbidity of a lake is a measure of the amount of material suspended in the water. Levels of turbidity between 0 and 2 Jackson Turbidity Units (JTU) were recorded in forty-four percent of a random data set of Wisconsin lakes according to a 14 year study done by Lillie and Mason. The average Turbidity was listed at 3.1 JTU. Nephelometric Turbidity Units (NTU) are the laboratory units used to measure the turbidity of the North Lake samples. For our purposes, JTU's and NTU's can be assumed to be the same. North Lake April, 1995, sample indicated an average value of 0.75 NTU (0.9 NTU - top, 0.6 NTU - bottom).

The results for North Lake indicate relatively low turbidity.

2.2.2.7. Metals and Salts

The metals and salts found in lake water are primarily related to the types of minerals found in the watershed. The purpose of sampling for these metals and salts is to get a good baseline for future readings to confirm the presence of a pollution source.

The presence of chloride above its naturally occurring level may be an indicator of a pollution source. Sources of chloride may include septic tank effluent, animal waste, potash fertilizer, and drainage from road salt. The presence of sulfate in lake water can be an indicator of acid rain.

The following is a chart indicating the results of spring testing for metals and salts:

Water Sampling Results for Metals and Salts

Parameter	Bottom Sample (mg/l)	Top Sample (mg/l)
Calcium	29	28
Chloride	5.8	4.9
Hardness	120	120
Iron	0.07	0.03
Magnesium	12	12
Manganese	0.190	0.037
Potassium	1.2	1.1
Sodium	2.6	2.6
Sulfate	5	6

The results of testing for metals and salts in North Lake are all in the low to average range compared to other lakes in Wisconsin.

2.2.3. Secchi Depth

Secchi depth is a measure of water clarity. It measures the combination of color and turbidity and takes into account algae growth as well. Secchi depth is generally a good indicator of a lake's overall water quality. The following table provides a general index of water clarity using Secchi depth:

Water Clarity Index

Water Clarity	Secchi Depth (ft.)
Very Poor	3
Poor	5
Fair	7
Good	10
Very Good	20
Excellent	32

The following table provides the actual Secchi depth measured by MMA, Inc. during the summer months of 1995.

Secchi Depths Measured for North Lake

Month	Secchi Depth (ft.)
April	15.0
June	23.0
July	17.2
August	16.4

The Secchi depth measured in North Lake in comparison to the water clarity index, indicates North Lake has very good water clarity.

2.2.4. Lake Temperature/Dissolved Oxygen

Wave action, mixing of the lake and photosynthesis all add dissolved oxygen (DO) to lake water. Plant and animal respiration and decomposition will decrease the DO supply in a lake. The amount of DO present is also dependent upon water temperature. The lower the temperature of the water, the greater the oxygen solubility and vice versa. For example, the maximum solubility of oxygen in water at 32° F is 15 mg/l; at 68° F the maximum solubility of oxygen in water is 9 mg/l (Ref. #8). The maximum density (weight per unit volume) of water is at 39° F. All these factors interplay when you assess a lakes DO level at any time of the year. The following figures provide the temperature and DO levels for North Lake measured during 1995.

Insert Temperature/Dissolved Oxygen Profiles!!!!

The temperatures and DO levels were measured in North Lake at the sample location in February, April, June, July and August. During February, the temperature nearest the surface was the coldest recorded at 33° F and the DO level was the highest at 9.8 mg/l. The lowest DO level is at the bottom of the lake where it dropped to near 0 mg/l due to the decomposition of plant and animal material.

During April, a phenomenon called spring turnover occurred. As the sun warmed the surface water up to 39° F, the 39° F water began to sink to the bottom since the maximum density (weight per unit volume) of water peaks at 39° F. Water that was cooler than 39° F (lighter) began to rise. A great deal of mixing occurred at this time, until the temperature at the top and bottom were the same. During this turnover, some of the decomposed matter and nutrients on the bottom were resuspended. A similar phenomenon occurs in the fall as 39° F water sinks as the surface water is cooled and is replaced by warmer (lighter) water.

During June, July and August, temperatures adjust to the season. The sun maintains the water nearest the surface warm, while the bottom is somewhat cooler. The DO levels remain higher near the surface due to wave action and photosynthesis. Summer stratification appears to take place in North Lake. In most lakes greater than 20 feet, a metalimnion layer exists between the warm surface water layer (epilimnion) and the cooler bottom layer (hypolimnion) and prevents complete mixing. This is what occurs in North Lake as can be seen by the sudden drop in DO after the 20 foot level in July and August.

Temperature and DO levels measured in North Lake in February indicate DO readings greater than 2 throughout the depth. In shallow lakes, oxygen depletion (winterkill) occurs when plant and animal material decay and use up available oxygen. Winterkill of fish can occur when the DO levels fall much below 1 to 2 mg/l (Ref #10). No winterkill can be expected in North Lake due to its depth.

2.2.5. Shoreline Specific Conductivity Survey

The specific conductivity (ability to conduct electricity) of the water was measured along the shoreline of North Lake in late summer. The purpose of the specific conductivity survey is to detect higher than normal amounts of nutrients entering North Lake.

Table No. 1, included in Appendix "F," provides the results of the specific conductivity readings. Figure No. 5 - Specific Conductivity Survey Locations, included in Appendix "A," provides the locations of the conductivity readings.

The specific conductivity readings along the shoreline did not show significant variations above the baseline reading.

2.2.6. Water Quality Assessment

Overall water quality of North Lake is "very good" compared to the state averages of Wisconsin lakes.

- Total Phosphorus levels are low (8 ug/l) and Nitrogen to Phosphorus (N:P) ratios are high (35:1), indicating Phosphorus is the limiting nutrient for plant growth. (N:P ratios > 15:1 indicate Phosphorus limits plant growth).

- Samples were taken during spring turnover for total kjeldahl nitrogen, nitrate/nitrite, ammonia nitrogen, salts and metals. Results were all in the low to average range.

- Chlorophyll a results are low (1.9 ug/l), indicating a relatively small amount of algae growth.

- Color, Turbidity and Secchi depths (15 - 23 feet) indicate very good water clarity.

- pH levels ranged from 6.5 (February) to 7.7 (June). pH levels over 7.0 indicate non-acidic conditions.

The inlet to West Lake was tested two times in June for Phosphorus content. Total Phosphorus content was also low (8 ug/l), indicating the watershed is supplying a low amount of phosphorus to the Spread Eagle Chain of Lakes.

A shoreline specific conductivity survey of North Lake was conducted during July. Specific conductivity indicates the electrical conductivity of the water tested. High amounts of minerals or nutrients would cause increased conductivity of the water and would be indicated by the meter. No abnormal readings were observed.

Based on the total phosphorus, chlorophyll a and water clarity, North Lake is considered a Oligotrophic Lake (a lake with low nutrient levels).

2.3. Aquatic Plant Survey Information

2.3.1. Methods of Testing

The aquatic plant (macrophyte) survey was conducted by boat in late July of 1995. Aquatic plants were pulled up with a garden rake in the shallow areas of North Lake. In the deeper areas of North Lake, a device was lowered to the bottom of the lake and dragged along a transect (straight line across the lake) to retrieve the plants. No plants were found to exist below 16' - 20' depth. All plants were found in the littoral zone (zone of light penetration).

2.3.2. Aquatic Plant Density and Abundance Values

From the aquatic plant samples obtained in July, the individual plant species were identified and the *individual plant species* were given a density value as follows:

- (1) Rare
- (2) Occasional
- (3) Common
- (4) Very Common
- (5) Abundant

By area, the *overall aquatic plant abundance* was given a density value as follows:

- (0) Rare
- (1) Occasional
- (2) Moderate
- (3) Abundant
- (4) High
- (5) Very High

Figure No. 6, included in Appendix "A," provides the aquatic plant survey locations of North Lake. Table No. 2, included in Appendix "F," provides a listing of the aquatic plants and their respective locations. Table No. 3, included in Appendix "F," provides the location of aquatic plants with individual plant abundance. Table No. 4, included in Appendix "F," provides the relative plant abundance by area.

2.3.3. Results of the Aquatic Plant Survey

During the aquatic plant survey conducted in late July on North Lake, eighteen different species of aquatic plants were identified. The three most dominant plant species found are

1) Chara
2) Broad-leaved Pondweed
3) Yellow Water Lily

The three most dominate plant species identified are discussed in detail below. For complete details on aquatic plants refer to "Guide to Wisconsin Aquatic Plants" (Ref. #11), provided in Appendix "G."

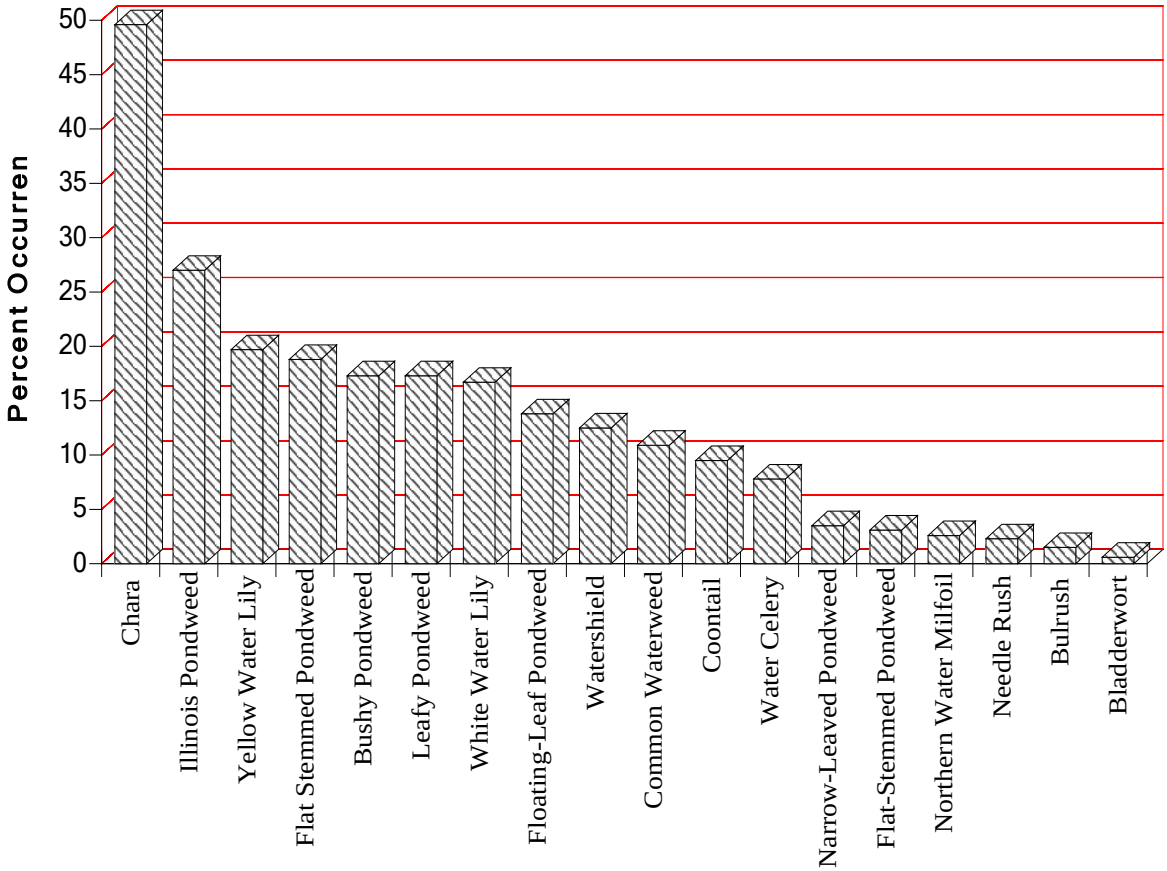
The most prominent aquatic plant found on North Lake is Chara. Chara was found to inhabit approximately fifty percent of North Lake. Even though Chara looks like a plant, it is actually a type of algae. Chara grows entirely below the water surface. It covers a large portion of the lake bottom. Chara has stem-like branches with forked leaves. It has a hollow stem, rough-textured leaves and smells similar to musk when crushed. Chara provides cover for fish and supports insects which provide food for fish and waterfowl

(Ref. #11). See Appendix "G" - Guide to Wisconsin Aquatic Plants for a pictorial representation of Chara.

The second most prominent aquatic plant found at North Lake is Illinois pondweed. Illinois pondweed was found to inhabit approximately twenty-seven percent of North Lake. Illinois pondweed is a broad-leaved aquatic plant that provides an attractive cover for fish, such as panfish, largemouth bass, muskellunge and northern pike. Illinois pondweed also supports insects valuable as food for fish and ducklings (Ref. #11).

Yellow Water Lily was found to inhabit approximately twenty percent of North Lake. Yellow Water Lily provides shade and cover for fish and supports insects valuable as food for fish and waterfowl. Algae also tends to grow under leaves providing food for fish. Waterfowl also eat their seeds. Yellow Water Lily is eaten heavily by muskrats (Ref #12).

All the aquatic plants identified in North Lake are provided in the following figure with the approximate percentage of lake area they inhabited.



Percent Occurrence of Aquatic Plants on North Lake

Plant Identification and Percent Occurrence on North Lake

TAXA Common Name	TAXA (Scientific Name)	% OCCURRENCE
Chara	(Characeae spp.)	50%
Illinois Pondweed	(Potamogeton illoensis)	27%
Yellow Water Lily	(Nuphar variegatum)	20%
Flat Stemmed Pondweed	(Potamogeton zosteriformis)	19%
Bushy Pondweed	(Najas flexilis)	17%
Leafy Pondweed	(Potamogeton robbinsii)	17%
White Water Lily	(Nymphaea odorata)	17%
Floating-Leaf Pondweed	(Potamogeton natans)	14%
Watershield	(Braseria schreberi)	13%
Common Waterweed	(Elodea canadensis)	11%
Coontail	(Ceratophyllum demersum)	10%
Water Celery	(Vallisneria americana)	8%
Narrow-Leaved Pondweed	(Potamogeton pusillus)	4%
Flat-Stemmed Pondweed	(Potamogeton spp.)	3%
Northern Water Milfoil	(Myriophyllum sibiricum)	3%
Needle Rush	(Eleocharis acicularis)	2%
Bulrush	(Scirpus validus)	2%
Bladderwort	(Utricularia vulgaris)	1%

The relative density of aquatic plants in North Lake was rated from 0 to 5 (rare to very abundant). The term "very abundant" refers to a relative quantity of aquatic plants which will inhibit motorized boat travel through these areas because of propeller clogging. North Lake has approximately 1 percent of its area inhabited with a "very abundant" amount of aquatic plants, and approximately 6 percent of its area inhabited with an "abundant" (relative density of 4) amount of aquatic plants in the months of July through September. The areas of North Lake with an ""abundant to very abundant"" amount of aquatic plants are shown in Figure No. 7, included in Appendix "A." Approximately 40

percent of North Lake is classified with an aquatic plant density category of rare (relative density of 0).

No exotic (foreign) plant species were found during the aquatic plant survey of North Lake.

2.4. Fish Species Information

North Lake has been shown to support the natural reproduction of a number of pan and game fish species. An electrofishing survey was conducted on the Spread Eagle Chain of Lakes in September of 1994. The results indicate that the Spread Eagle Chain supports a dynamic and diverse fishery.

Large and smallmouth bass remain the dominant predators with an expanding walleye population. The capture of 22 walleye fingerlings last fall without any walleye planting the year before indicates the natural reproduction of walleye is occurring. Northern Pike are also an important component to the game fishery, but they are not sampled efficiently with electrofishing equipment.

Bluegill dominate the panfish population followed by rockbass, yellow perch, and black crappie. All species supported fish over seven inches with some over ten inches (Ref. #13). The results of electrofishing surveys conducted by the WDNR in 1993 and 1994 are included in Appendix "I."

Available information on the fish species identified during the electrofishing survey is included in Appendix "H." The information includes identification, distribution, habits, habitat, life cycles, fishing hints and environmental concerns for each of these species.

The spawning and nursery locations of fish on North Lake are shown on Figure No. 8, located in Appendix "A" (Ref. #14). The following fish species use North Lake as a spawning location:

- Northern
- Bass
- Walleye
- Bluegill
- Crappie

Locations of fish cribs installed by Spread Eagle Association members and the Florence County Forestry and Parks Department in North Lake during 1994 and 1995 are also shown on Figure No. 8, located in Appendix "A" (Ref. #15).

2.5. Watershed

The watershed area of the Spread Eagle Chain of Lakes consists of approximately 3,200 acres located primarily to the northwest of the Spread Eagle Chain of Lakes. Runoff from the watershed of Montgomery Lake flows down Montgomery Creek to West Lake. The watershed consists predominantly of forest and wetlands with a scattering of residential development. Figure No. 9 - Watershed Area of the Spread Eagle Chain of Lakes, included in Appendix "A," shows the watershed area and surface runoff patterns in the watershed.

Approximately 450 acres of wetland make up part of the Spread Eagle Chain of Lake's watershed area. Wetland locations are shown in Figure No. 10, included in Appendix "A." Much of the wetland area is located to the northwest of the Spread Eagle Chain of Lakes along Montgomery Creek and the tributaries to Montgomery Creek.

The estimated Phosphorus loading of the watershed is approximately 250 lb/year for a dry year, 617 lb/year for a normal year, and 1,580 lb/year for a wet year. These results are based on values obtained using the WDNR Wisconsin Lake Model Spreadsheet (WILMS version 1.01) and the input of watershed data for the Spread Eagle Chain of Lakes Watershed (see Appendix "I" for the printout of the WILMS spreadsheet). The results obtained reflect the low nutrient loading from forested watersheds. If the Spread Eagle Chain of Lakes were located in Dane County, for example, where the watershed contains a higher amount of nutrients and the land is primarily agricultural, the phosphorus loading would be of approximately 522 lb/year for a dry year, 2,140 lb/year for a normal year and 6,350 lb/year for a wet year.

The drainage basin/lake area ratio (DB:LA) of the Spread Eagle Chain of Lakes is approximately 5.8:1. This is based on a watershed (drainage basin) area of 3,200 acres and a lake area of 548 acres. The Spread Eagle Chain of Lakes has a low DB:LA ratio which is generally an indicator of low phosphorus loading.

Figure No.s 2 & 3 - Lake Survey Maps of the Spread Eagle Chain of Lakes, included in Appendix "A," indicate areas of steep slopes around the lakes.

2.6. Public Access

North Lake provides public access to the Spread Eagle Chain of Lakes. The boat landing is located on the southwest side of North Lake. Refer to Figure No. 4, included in Appendix "A" for the location of the boat landing.

The Florence County Forestry and Parks Department manages the boat landing. The boat landing provides parking for approximately 10 to 12 vehicles with trailers. A 12' x 18' concrete plank landing is provided to load and unload boats from trailers. Some problems with the concrete planking have been experienced. Washout from boats

accelerating when loading onto trailers has undermined the support necessary for the planks. Without the necessary gravel base to support the planks, they are subject to breakage when a load is applied. The deepest concrete plank has been removed for this reason.

A 4' x 16' dock is installed as soon as ice is off the water and is removed by October 15th of each year. A permanent outdoor latrine is provided on the northwest corner of the boat landing, and is pumped as needed. A single garbage can is provided and is maintained at least weekly from May to September. The grass is mowed as needed during the summer months.

2.7. Circulation Study

This section looks into the possibility of increasing circulation by opening up a channel between the two bays separated by Robbins Island. The purpose of opening the channel would be to resuspend some of the sediment deposited in the south bay of North Lake and carry it away by water currents for deposition in deeper portions of the Spread Eagle Chain of Lakes. The theoretical and historical aspects of opening circulation will be explored. We will first look at the theoretical aspect of creating a channel between Dunn's Point and Robbins Island.

The first element necessary in moving sediment is the resuspension of sediment. To resuspend sediment, the sediment must be moved by the water. This is done either by artificial means (boat wave action or propeller turbulence) or by wind action creating waves. Since the water is very shallow (less than 2') extending into the north side of Robbins Island, boat traffic through the proposed channel would be expected to be minimal. Therefore, we must only consider wave action caused by the wind to resuspend sediment.

Two main elements affect the wave action of water: wind speed and fetch (distance wind travels from shore). Wind speed is decreased by trees on the shore of the water linearly up to a distance of approximately 240 meters (787 feet) from shore (Ref. #16). The wind speed necessary to resuspend sediment under the water can be calculated if we know the fetch and depth to the sediment (Ref. #17). For example, on the south bay of North Lake, the wind speed necessary to resuspend sediment at a depth of 3 feet, at a 300 foot fetch would be 66 miles per hour. Areas closer to shore would require substantially higher windspeeds even when the depth to sediment is lower. It would take a windspeed of approximately 80 miles per hour to resuspend sediment at a depth of 2 feet, at a 200 foot fetch. Boats and currents are normally the only thing to resuspend sediment near shore on the windward side of the lake.

Once sediment is resuspended it must be moved by currents in the water. Currents are generally caused by temperature changes in the lake or flow from a creek or springs toward the outlet of a lake. Current flow in lakes, unlike rivers or creeks, is generally very slow. If we assumed that the entire flow through the outlet from the Spread Eagle

Chain of Lakes is in the range of 2,250 gallons per minute, the retention time (time it takes water to enter a lake until it flows out) of the Spread Eagle Chain of Lakes would be approximately 3 years. This gives you an idea of how slow water flows through a lake. If, however, we would consider that 1/2 the estimated flow of the outlet to the Spread Eagle Chain of Lakes were directed through the channel flowing out of North Lake (far more than actual since there is no inlet to North Lake), the average velocity of the water would be in the range 3.6 inches per minute. If a new channel was constructed, it would further reduce the velocity of the water by an amount equal to the area of the new channel divided by the total area of both channels. Thus, if a new channel was made that was 20 feet wide by 2 feet deep, it would slow flow from 3.6 inches per minute to 3.3 inches per minute. Neither velocity is great enough to carry sediment without it settling out. The addition of a series culverts would have the same effect as a channel and would produce the same result.

The idea of creating a channel between Dunn's Point and Robbins Island is not new. Unknown by many people, Robbins Island was always connected to the mainland as it is now, except for a brief 17 year span from approximately 1908 to 1925. From correspondence and conversation with Mr. Putnam Robbins, it appears that his father, Albert Robbins hired Mr. Tamborini to dig out a channel between Dunn's Point and Robbins Island with the idea of moving some of the sediment out of the bay to the south. Sediment measured at that time was in excess of 13 feet. No bottom could be reached when they tried to measure the depth at that time (Ref #1).

In a letter from Mr. Putnam Robbins to MMA, Inc., Mr. Robbins states, *"Rowboat travelers used the new channel, but launches seldom used it as their launch propellers would be wrapped up with WEEDS. No visible path was formed through the MUCK and WEEDS and the "Talk was we wasted our money."*

When the road was built around the lakes by Andrew Bjorkman it opened up lots to land travel. Until this road was opened, the Brown and Robinson and Browning and Robbins Plat could only be reached by water. The road made it possible to reach Robbins Island by land, so the channel dug by Mr. Tamborini was filled."

2.8. Lake Usage Impact

The purpose of this section is to evaluate the current usage of North Lake and its resulting environmental impact on the lake.

2.8.1. Fishing

Fishing on North Lake has had no significant impact on the lake. The North Lake fishery is in excellent condition with no appreciable reduction in the fish population due to overfishing. The overall size of some game fish may have been reduced by fishing, but a healthy population exists of significant size. No exotic (foreign) fish species have been found to inhabit the lake in any of the electrofishing surveys.

2.8.2. Motorized Boating

The use of motorized boats on North Lake has had some impact on the lake. The use of motorized boats has shifted sediment in the lake. The sediment shift due to boat traffic is generally only in the shallow areas of the lake. For example, the channel from middle lake into North Lake is a major traffic area for boats, this traffic has resuspended sediment in the channel and deposited it further to the west into the bay south of Robbins Island. Plants growing in the bay are generally coated with sediment throughout the summer months. It is unknown how much effect this has on aquatic plant growth or fish reproduction in the bay. Increased sediment concentration in the water does decrease the amount of sunlight available for photosynthesis. When boats resuspend sediment, they also resuspend nutrients normally unavailable for use by aquatic plants. Sediment resuspension by boats is generally limited to water depths 10 to 15 feet below the surface. The greater the horsepower, the larger the particles that can be resuspended as well as the greater the depth affected. The frequency of boat traffic also increases the settling time of sediment (Ref. #18).

Boat traffic also increases shoreline erosion. How much shoreline erosion has taken place on North Lake due to boat traffic is unknown since no baseline points have been established along the shore for that purpose. Shoreline which does not have aquatic plants nearby to help dampen the wave action, or shoreline devoid of rooted vegetation or rip-rap are the most vulnerable to erosion.

Personal watercraft (Jet Skis) have had no greater affect on North Lake than other motorized boat traffic. Personal watercraft are more obvious than conventional boats due to the type of noise they produce and their ability to turn tight circles and operate closer to shore. Their affect on the environment, however, is no different than that of a conventional boat. The operation and subsequent safety concerns of personal watercraft is not within the scope of this report.

2.8.3. Shoreline Development

Shoreline development has reduced some areas once available to wildlife. The areas along the shoreline that once provided a source of food, shelter and breeding for a number of birds and mammals have been reduced. Approximately 17% of the area within 100' of the North Lake shoreline is now without tree cover. Leaving a natural buffer area of trees and shrubs near shore provides wildlife habitat and reduces the chances of soil erosion and the addition of nutrients into the lake.

Associated with shoreline development is increased motorized boat traffic. As noted in Section 2.8.2 - Motorized Boating, boats will resuspend sediment near shore causing the addition of nutrients available to plants in the water, increasing plant growth. Conversely, aquatic plants are also removed by boats in the traffic area. The removal of

plants reduces the dampening effect they have to wave action, making shoreline erosion a greater possibility when boats enter or leave.

With each house built along shore is a septic system. The affect of the septic systems on the North Lake does not appear to be significant. Water quality data in addition to the shoreline conductivity survey do not indicate excessive levels of nutrients entering the water from septic systems.

2.8.4. Public Access

The location of the public access on North Lake has minimal environmental effect on the lake. Sediment shift due to boat traffic can be partially due to boats entering and leaving the boat landing and travelling through North Lake. There were no exotic species of plants found in the aquatic plant survey of the lake. Since North Lake is the only lake with public access, it is most probable that this is the lake where exotic plants would be deposited by boats from affected lakes. The effect of public access was only evaluated for its environmental effect on the lake. The effect of the public access on the residents of North Lake is not within the scope of this report.

2.9. Sedimentation

The sediment found in North Lake is generally located in the bay areas that are protected from wind which allows the sediment to settle. The bottom of North Lake in the deeper sections also contain a great deal of sediment. Because of its inability to support aquatic plants at a depth over 20 feet, only the sediment along shore in the shallow areas will be included in this study.

The sediment has come from over 12,000 years of plant and animal decay. The aquatic plants and animals that have lived in the lake combined with the leaves and trees that fall into the lake have become the sediment we now see.

Each spring and fall as the water temperature equalizes, the lake is said to turn over. Since water is heaviest at 39° F, water both warmer and cooler moves toward the surface. In the process, the movement of water resuspends sediment. The spring and fall are also times of high winds which move the sediment around the lake by circulation. The sediment is finally deposited in the quieter areas of the lake where the water is not moving to keep it suspended.

During the summer months, the wind will resuspend some of the sediment in the shallow areas of the lake for redeposition elsewhere.

Areas which were previously immune to the resuspension of sediment because of their location, are now being mixed up by boat traffic, with the sediment redeposited elsewhere in the lake. For this reason, it may appear that there has been a greater amount of

sedimentation in recent years, when in fact, it is the redistribution of some of the sediment which was deposited over the last 12,000 years.

Figure No. 4, included in Appendix "A," shows sediment depth along the shoreline of North Lake. As can be seen by the map, the areas of greatest sedimentation near the shore are in the protected bays. Most notably are the areas in the bay south of Robbins Island and in the very northwest bay of North Lake. These areas are also areas of high aquatic plant density since the sediment provides nutrients for the plants.

3.0. CONCLUSIONS

The following section contains the conclusions drawn from the information collected during the study of North Lake.

3.1. Property Ownership Survey

Based on the results of the survey, the top three concerns of property owners are

1) Water quality
2) Boat Safety
3) Overcrowding

Natural beauty/solitude and water recreation were the top two reasons for property owners to purchase property on the Spread Eagle Chain of Lakes.

3.2. Water Quality

Overall water quality of North Lake is "very good" compared to the state averages of Wisconsin lakes.

- Total Phosphorus levels are low (8 ug/l) and Nitrogen to Phosphorus (N:P) ratios are high (35:1) indicating Phosphorus is the limiting nutrient for plant growth. (N:P ratios > 15:1 indicate Phosphorus limits plant growth).

- Samples were taken during spring turnover for total kjeldahl nitrogen, nitrate/nitrite, ammonia nitrogen, salts and metals. Results were all in the low to average range.

- Chlorophyll a results are low (1.9 ug/l), indicating a relatively small amount of algae growth.

- Color, Turbidity and Secchi depth (15 - 23 feet) indicate very good water clarity.

- pH levels ranged from 6.5 (February) to 7.7 (June). pH levels over 7.0 indicate non-acidic conditions.

Based on the total phosphorus, chlorophyll a and water clarity, North Lake is considered a Oligotrophic Lake (a lake with low nutrient levels).

3.3. Aquatic Plant Survey

During the aquatic plant survey conducted in late July on North Lake, eighteen different species of aquatic plants were identified. The three most dominant plant species found are

1) Chara
2) Broad-leaved Pondweed
3) Yellow Water Lily

No exotic species of aquatic plants were found in the aquatic plant survey of the lake.

North Lake has a good population of desirable aquatic plants. There is significant plant growth in some of the bay areas where it is necessary to remove aquatic plants for boat access to docks. However, overall there are enough plants to provide cover, food and spawning locations for fish and yet the lake, as a whole, is not clogged with plants that would make boat travel and other recreation activities difficult.

3.4. Fish Species

North Lake supports natural reproduction of a number of pan and game fish species. An electrofishing survey was conducted on the Spread Eagle Chain of Lakes in September of 1994. The results indicate that the Spread Eagle Chain supports a dynamic and diverse fishery.

The fish found in North Lake include

- Largemouth Bass
- Smallmouth Bass
- Walleye
- Northern
- Bluegill
- Rockbass
- Yellow Perch
- Black Crappie

The following fish species use North Lake as a spawning location:

- Northern
- Bass
- Walleye
- Bluegill
- Crappie

3.5. Watershed

The watershed area of the Spread Eagle chain of Lakes consists of approximately 3,200 acres located primarily to the northwest of the Spread Eagle Chain of Lakes. Runoff from the watershed of Montgomery Lake flows down Montgomery Creek to West Lake. The watershed is predominantly forest and wetland with a scattering of residential development.

Since the watershed is predominantly forest and wetland, its runoff is low in nutrients.

3.6. Public Access

North Lake provides public access to the Spread Eagle Chain of Lakes. The boat landing is located on the southwest side of North Lake. It is managed by the Florence County Forestry and Parks Department.

Public access to North Lake is adequate to accommodate local residents and visitors. Some improvements are recommended to the landing as are noted in Section 4.5 - Public Access Recommendations.

3.7. Circulation Study

Based on theoretical calculations and past efforts, creating a channel or series of culverts between Dunn's Point and Robbins Island would not significantly change the amount of sediment located in the bay south of Robbins Island.

3.8. Lake Usage Impact

There have been no significant impacts on the ecosystem of North Lake due to lake usage. Sediment shifts due to boat traffic and decreased wildlife habitat due to shoreline development are the main impacts related to the usage of North Lake.

3.9. Sedimentation Impact

The sediment has come from over 12,000 years of plant and animal decay. Some of the sediment is resuspended by spring and fall turn over as well as wind and wave action and is redeposited in quieter portions of the lake. In more recent times, high horsepower motorized boats have made major changes in where the sediment is deposited. Areas which were previously immune to the resuspension of sediment because of there location in relation to the wind, are now being mixed up with the sediment being deposited elsewhere.

4.0. RECOMMENDATIONS

The following section contains recommendations on water quality, aquatic plant management, fish management, watershed practices, public access, circulation, lake usage, and sedimentation.

4.1. Water Quality Recommendations

Since the water quality of North Lake is very good as compared to other Wisconsin Lakes, continued sound ecological practices by residents are necessary to maintain or improve water quality. Education and involvement of property owners should be promoted.

Mailers can be sent to property owners informing them of sound ecological practices which include the following:

- Have your septic system checked by a qualified individual.
- Have your septic tank pumped every three years.
- Keep an undisturbed buffer zone of natural trees and plants between the lake and your dwelling.
- Avoid using chemical fertilizers, if you choose to have a lawn.
- Don't dump leaves or grass clippings in the lake.

It is important that Spread Eagle Association continues to monitor the water quality of North Lake. The Spread Eagle Lake Association should join the Wisconsin Self-help Monitoring Program sponsored by the WDNR. As part of the program, lake data is collected by volunteer members of the Spread Eagle Chain of Lakes Association. Data is provided to the WDNR to help identify lake trends. Adverse lake trends can be identified and corrected before irreversible damage to the lake has occurred.

4.2. Aquatic Plant Management Recommendations

North Lake has a good quantity of aquatic plants necessary for a healthy ecosystem. Aquatic plants which hinder boat access to docks can be removed by small scale cutting or pulling. Large scale removal of aquatic plants or the use of chemicals to kill aquatic plants is not recommended. Removal of native aquatic plants will only provide areas for exotic plants to move in if they are once introduced.

Steps should be taken to inform the public of the threat of exotic plants and what can be done to slow their introduction to unaffected lakes. Mike Kroenke of the University of Wisconsin Extension, located at the Florence Natural Resource and Interpretive Center, is willing to prepare applications for matching funds through the Wisconsin Department of Natural Resources for lake associations interested in providing signs at public landings to

inform the public of exotic plants. Informing the public of the threat of exotic plants is strongly recommended.

4.3. Fish Management Recommendations

Currently, the Spread Eagle Chain of Lakes has an excellent fishery. Walleye are being lightly stocked in the Spread Eagle Chain of Lakes with the addition of approximately 2,000 fingerlings every couple of years. It is not recommended at this time to increase fish stocking. If walleye stocking were increased dramatically, they would be in competition with bass and thereby reduce there numbers. Only walleye and northern would be left if this would occur. This may be good for the avid fisherman, but for kids and the average fisherman it would not, since bass are fish everyone can have fun catching.

The addition of fish cribs should be continued. The cribs provide habitat for fish to thrive.

If the Spread Eagle Lake Association has any questions on stocking fish, Russ Heiser of the WDNR - Peshtigo office is able to assist the Spread Eagle Lake Association with any fish management decisions.

4.4. Watershed Recommendations

Since the water quality of North Lake is very good, continued sound ecological practices of residents within the watershed are necessary to maintain or improve water quality. Education and involvement of property owners should be promoted as is recommended in Section 4.1 - Water Quality Recommendations.

4.5. Public Access Recommendations

It is recommended that the current concrete planking used to support trailers backing into the water be replaced. The base material under the planking should be removed and replaced with a 6" pad of crushed 1½" stone. Wider 4' x 6" x 12' long concrete planks should be installed to replace the existing narrow planking. The wider planking would have fewer spaces between planks resulting in less chance of washout and subsequent breakage.

As noted in Section 4.2 - Aquatic Plant Management Recommendations, it is recommended that the Spread Eagle Lake Association pursue the process of acquiring a sign at the Public Landing to inform the users of the landing of the threat of exotic plants to the Spread Eagle Chain of Lakes. The sign would also serve to educate the users of the public access site of the general laws and responsibilities associated with the lake usage. As with public access sites on any lake, a certain amount of disruption exists simply due to the increase in traffic near the landing. Local residents near the landing tolerate

excessive noise, litter and general intrusion on the serenity they hoped to obtain by living near a lake. It is hoped that by making visitors aware of the sacrifices that are made by local residents, a mutual respect can by developed; a respect which evolves from recognizing the desires of visitors and residents alike, and the responsibilities that are inherent.

4.6. Circulation Study Recommendations

It is not recommended that the Spread Eagle Lake Association pursue the creation of a channel or series of culverts between Dunn's Point and Robbins Island. It is unlikely that any significant amount of sediment will be moved from the bay south of Robbins Island by the creation of a channel.

4.7. Lake Usage Recommendations

Since the use of boats on the lakes is not going to decrease in the foreseeable future, it is best to protect the shoreline as much as possible. Keep aquatic plants growing near shore and rooted plants on shore to minimize shoreline erosion. In areas where shoreline erosion develops, it is recommended that the owners secure a permit to install rock rip-rap near the shoreline. Leave a natural buffer area of trees and shrubs near shore to provide a wildlife habitat as well as to reduce the chances of soil erosion and filter nutrients that could enter the lake.

To obtain information about a permit to install rip-rap or other shoreline protection, contact Robert Rosenberger, Water Regulation and Zoning Specialist at the WDNR - Wausaukee Office.

4.8. Sedimentation Recommendations

There is very little that can be done to stop the continued addition of sediment to a lake. The continual decay of plants and animals in addition to surface water runoff will continue to add to this process. However, by reducing the amount of nutrients added to a lake, plant life can be minimized and thereby decrease the amount of sediment added. Following the recommendations listed in Section 4.1 - Water Quality Recommendations will help.

The redistribution of sediment due to boat traffic is difficult to control. This is especially true on North lake where a channel provides access to the lake from the remainder of the Chain of Lakes. Short of implementing no-wake zones, sediment from boat traffic will continue to be redistributed.

One way to eliminate the sediment already in place is removal. This is typically done by small floating dredges. However, it has been shown over the years that dredging is only a

temporary remedy. Sediment from decaying plants and animals will again fill in dredged areas. Aquatic plant harvesting, in addition to the initial dredging of affected areas may help slow the addition of sedimentation. After the summer growing season, aquatic plants are harvested and placed on land to decompose. This reduces the sediment buildup and nutrient deposition from decomposing aquatic plants, thereby slowing aquatic plant growth. Dissolved oxygen uptake by decomposing aquatic plants in winter months will also be reduced.

There are drawbacks, however. Changing these areas of sedimentation may affect the spawning and nursery locations for some fish. As can be seen in Figure No.s 4 & 8, located in Appendix "A," the areas of greatest sedimentation are also good areas for the spawning of bass, bluegill and northern. The removal of sediment and aquatic plant harvesting should be weighed carefully against the effect it may have on the fish community.

5.0. SUMMARY OF RECOMMENDATIONS

The following is a summary of recommendations provided to improve the ecosystem of North Lake:

- Educate and involve property owners in measures that can maintain and improve water quality on North Lake. Mailers or newsletters can be sent to property owners informing them of sound ecological practices. Maintaining good water quality will help minimize aquatic plant growth and minimize future sedimentation.

- The Spread Eagle Lake Association should continue to monitor the water quality of North Lake. The Spread Eagle Chain of Lakes Association should join the Wisconsin Self-help Monitoring Program sponsored by the WDNR. As part of the program, lake data is collected by volunteer members of the Spread Eagle Chain of Lakes Association. Data is provided to the WDNR to help identify lake trends. Adverse lake trends can be identified and corrected before irreversible damage to the lake has occurred.

- Install a sign at the public landing to inform the public of the threat of exotic plants, local laws, and the responsibilities of lake users.

- Replace existing concrete planking and supporting material at public landing with crushed stone and wider planking.

- Maintain the level of fish stocking in the Spread Eagle Chain of Lakes. The addition of fish cribs should be continued. The cribs provide habitat for fish to thrive.

- It is not recommended that the Spread Eagle Lake Association pursue the creation of a channel between Dunn's Point and Robbins Island. It is unlikely that any significant amount of sediment will be moved from the bay south of Robbins Island by the creation of a channel.

- Take measures to protect the shoreline from erosion due to boat traffic. Keep aquatic plants growing near shore and rooted plants on shore to minimize shoreline erosion. In areas of shoreline erosion, obtain a permit to install rock rip-rap near the shoreline.

- Carefully weigh the pros and cons of dredging and/or plant harvesting. Be certain to consider all the alternatives and the resulting ecological effects.

6.0. REPORT LIMITATIONS

This document was developed and prepared as a limited investigation and evaluation subject to the constraints of cost and time. This document is not intended to represent a total, complete, exhaustive or extensive investigation and evaluation.

The report was performed with the degree of care and levels of skill and experience ordinarily used, under like, or similar circumstances, by Professional Consultants practicing in this general locality and similar areas. No other warranty or guarantee, expressed, or implied, is made with respect to the findings, conclusions and professional advice and opinion included in this document.

The report contained in this document is based upon an observation of site conditions, information provided by the WDNR and investigation of historical and public records.

7.0. USE OF DOCUMENT BY OTHERS

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