MMA, INC.
CONSULTING ENGINEERS

LAKE PLANNING STUDY

FOR

SOUTH LAKE

VOLUME I OF II

Prepared for:

SPREAD EAGLE CHAIN OF LAKES ASSOCIATION

Florence, WI 54121

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FOR
SOUTH LAKE

EXECUTIVE SUMMARY

South Lake is located in Sections 3 and 4 of Township 39 North, Range 19 East, in the Township of Florence in the northeastern portion of Florence County, Wisconsin. It is the most southeastern lake of the Spread Eagle Chain of Lakes.

The Spread Eagle Chain of Lakes consists of nine lakes totaling approximately 548 acres in size. South Lake is approximately 25 acres in size. The maximum depth of South Lake is approximately 20 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; springs and precipitation supply the remainder.

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 South Lake is "very good" compared to the state averages of Wisconsin lakes.

- Total Phosphorus levels are low (12 ug/l). Unlike other lakes on the Spread Eagle Chain of Lakes, however, the Nitrogen to Phosphorus (N:P) ratios are not high (5:1). N:P ratios > 15:1 would indicate Phosphorus is the limiting nutrient for plant growth. Both Nitrogen and Phosphorus appear to limit plant growth in South Lake.

- 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 (1.8 ug/l), indicating a relatively small amount of algae growth.

- Color, Turbidity and Secchi depths (11 - 20 feet) indicate good water clarity.

- pH levels ranged from 8.4 (January & April) to 8.9 (August). pH levels over 7.0 indicate non-acidic conditions.

Based on the total phosphorus, chlorophyll a and water clarity, South Lake is considered an Oligotrophic Lake (a lake with low nutrient levels). It should be noted however, that like other lakes tested on the Spread Eagle Chain of Lakes, South Lake is on the upper limit of the classification of Oligotrophic, being borderline Mesotrophic.

South Lake has a well-balanced population of desirable aquatic plants. 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.

During the aquatic plant survey conducted on South Lake, eleven different species of aquatic plants were identified. The three most dominant plant species found are

1) Illinois Pondweed
2) Chara
3) Floating-Leaf Pondweed

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

Fish evaluation surveys were conducted on the Spread Eagle Chain of Lakes in 1993, 1994, 1998 and 2005. The results indicate that the Spread Eagle Chain supports a dynamic and diverse fishery. The surveys showed that the Spread Eagle Chain of Lakes is fairly consistent throughout, with minor variations. Natural reproduction of all the major species present was observed.

The Spread Eagle Chain of Lakes supports natural reproduction of a number of pan and game fish species. The fish found during the most recent fish evaluation surveys include Largemouth Bass, Smallmouth Bass, Walleye, Northern Pike, Muskellunge, Bluegill, Rock Bass, Yellow Perch, Black Crappie, White Sucker, Pumpkinseed, Green Sunfish, Black Bullhead.

The concrete bridge located across the channel between East Lake and South Lake was visually inspected during the project. Overall, is in good repair considering its age. Repair of a small section of the underside of bridge needs to be completed to prevent corrosion of exposed structural steel.

An inspection of the dam located at the outlet to South Lake was conducted as part of the Lake Planning Study. A permanent repair needs to be made to the dam to prevent water from seeping around the ends of the dam. Without a permanent repair to the dam, erosion of material around the ends of the dam will continue to occur resulting in lower water levels in the Chain of Lakes during dry periods.

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

- The Spread Eagle Lake Association should continue to monitor the water quality of South Lake. Adverse lake trends can thereby be identified and corrected before irreversible damage to the lake has occurred.

- Educate and involve the of property owners in measures that can maintain and improve water quality on Spread Eagle Chain of Lakes. Maintaining good water quality will help minimize aquatic plant growth and minimize future sedimentation.

- The installation of fish cribs should be continued. Tree drops should be considered to provide much needed near-shore woody cover and bass/panfish spawning sites. Leave any trees and branches that naturally fall into the lake in place. Consider getting involved with fish stocking operations by helping to scatter plant walleye fingerlings by boat throughout the Chain.

- Keep aquatic plants growing near shore and rooted plants on shore to minimize shoreline erosion. 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.

- Repair of a small section of the underside of the concrete bridge located across the channel between East Lake and South Lake needs to be completed to prevent corrosion of the exposed structural steel.

- To permanently eliminate seepage around the ends of the dam, it is recommended to install sheet piling continuously from high ground east of the dam continuously to high ground west of the dam to form an uninterrupted seal in front of the dam.

- Education of lake users should be increased to promote awareness of the imminent threat of exotic species to the Spread Eagle Chain of Lakes.

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1.0. INTRODUCTION

South 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 South 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 South 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 "C."

In January of 2002, 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 South 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 April of 2003.

On April 17, 2003, 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 spring 2003 (ice out), June, July, August, of 2003, and winter 2003-04 (ice on).
- Prepare an assessment of the aquatic plant and fish community.
- Conduct a visual inspection of the bridge crossing the inlet to South Lake
- Evaluate and provide recommendations on inspection, repair, and maintenance of the concrete dam located at the outlet of South Lake.
- Assist the Spread Eagle Chain of Lakes Association with an educational event to be held on South Lake, titled "Canoe Classroom", included later in the report.

- Address the current usage and resulting impact on South 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.
- 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 Upper Green Bay Basin Water Quality Management Plan.
- Conduct a sociological survey consisting of a letter 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 South Lake.
- Consult 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 and submit the report to the WDNR.

1.2. History

As with most of northern Wisconsin and the Upper Peninsula 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 early 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 that started in 1866. Most of the logs that were cut in the late 1800's and early 1900's were floated downriver 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 icehouse 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 icehouse 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 shortly after World War 1.

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

South Lake is located in Sections 3 and 4 of Township 39 North, Range 19 East, in the Township of Florence in the northeastern portion of Florence County, Wisconsin. It is the most southeastern lake of the Spread Eagle Chain of Lakes.

The Spread Eagle Chain of Lakes consists of nine lakes totaling approximately 548 acres in size. South Lake is approximately 25 acres in size. The maximum depth of South Lake is approximately 20 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 many maps incorrectly show an inlet into North Lake that 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.

The outlet to the Spread Eagle Chain of Lakes is located on the south end of South Lake. A small concrete 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 South Lake are predominately loams, sandy loams or loamy sands. The primary soil series around South Lake is the Pence sandy loam, followed by the Sarona - Vilas Complex, Croswell loamy sand and Fordum Loam 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 as a result of the glaciers approximately 12,300 years ago (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).

South Lake bottom soils consist primarily of muck (70%), with lesser amounts of sand, gravel, rubble and boulders (Ref. #3). For complete details on the South Lake bottom soils refer to Figure No. 3 - 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 is one seasonal and one permanent residence on South Lake. There are approximately 330 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 January of 2005. 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. The survey had an excellent return rate: sixty-two percent of the property owners completed and returned the questionnaire. This response indicates that the Spread Eagle Chain of Lakes property owners want to actively participate in the decisions that affect the future of the Spread Eagle Chain of Lakes.

The following indicates the questions asked by the survey followed by the response:

1. Have you ever been to South Lake?

Yes, this year	Yes, within the past 5 years	Yes, but years ago	Never
40.2%	32.4%	20.1%	7.4%

The survey results indicate that 92.6% of Spread Eagle Chain of Lakes property owners have been to South Lake at least once.

2. If you have entered South Lake by water, which kind(s) of watercraft did you use?

Canoe	Kayak	Row Boat	Motorized Fishing Boat	Other
28.8%	12.3%	12.7%	40.3%	5.9%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners used a motorized fishing boat to reach South Lake.

3. What do you perceive to be the main attraction of South Lake?

Fishing	Serenity	Dam	Wildlife	Other
14.4%	67.8%	11.0%	2.7%	4.1%

The survey results indicate that Spread Eagle Chain of Lakes property owners perceive serenity as the main attraction of South Lake.

4. ***The purpose of the South Lake dam is to control the water level of the Chain of Lakes. Are you in favor of having periodic inspections of the dam to identify any need for repairs rather than waiting for the need for potentially major repairs to the surface?***

Yes	No
97.5%	2.5%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners are in favor of periodic inspections of the dam.

5. ***Did you know that Eurasian Milfoil has been found in Florence County lakes (Elwood and Frog Lake)?***

Yes	No
68.0%	32.0%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners were aware that Eurasian Milfoil has been found in Florence County Lakes.

6. ***Did you know that zebra mussels have been found in Florence County (Badwater)?***

Yes	No
55.3%	44.7%

It should be noted that no evidence of zebra mussels in the Badwater area has been documented and the statement that zebra mussels have been found in Florence County can be considered hearsay. The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners have heard that zebra mussels have been found in Florence County.

7. ***Did you know that rusty crayfish have been found in Florence County lakes (Lake Patton)?***

Yes	No
21.7%	78.3%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners were <u>not</u> aware that rusty crayfish have been found in Florence County Lakes.

8. ***Did you know that smelt have been found in Florence County lakes (Keyes Lake and connecting lakes)?***

Yes	No
27.9%	72.1%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners were not aware that smelt have been found in Florence County Lakes.

9. Currently, none of these exotic species have been found in the Chain of Lakes, but can easily transported there. How concerned are you about exotic species getting into the Spread Eagle Chain of Lakes?

Very Concerned	Somewhat Concerned	Not Concerned
83.3%	15.7%	1.0%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners are very concerned about exotic species entering the Chain of Lakes.

10. Would you support efforts to control the above exotic species?

Yes	No
98.5%	1.5%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners would support efforts to help control exotic species from entering the Chain of Lakes.

11. Would you contribute to a Control Exotic Species Fund if needed?

Yes	No
94.3%	5.7%

The survey results indicate that the majority of Spread Eagle Chain of Lakes property owners would contribute to a Control Exotic Species Fund if needed to help control exotic species from entering the Chain of Lakes.

12. Lake on which you reside:

Lake	# of Returned Questionnaires	Approximate # of Property Owners per Lake	Response
Bass	50	80	63%
East	12	18	67%
Lily	4	5	80%
Long	26	33	79%
Middle	21	47	45%
North	22	33	67%
Railroad	30	53	57%
South	2	2	100%
West	27	58	47%
Unknown	9		
All Lakes	**203**	**330**	**62%**

The survey results indicate that sixty-two percent of the questionnaires sent out to Spread Eagle Chain of Lakes property owners were returned.

13. Please indicate the top three concerns about the Spread Eagle Chain of Lakes.

Water Quality	Exotic Species	Aquatic Plants	Noise	Water Safety	Fishing	Boat Landing	Other	Water Levels	Wood, Debris	Shoreline Structures	Protect Waterfowl
26.3%	22.0%	8.7%	8.1%	7.7%	6.3%	6.2%	5.1%	4.3%	2.2%	1.8%	1.3%

The survey results indicate that the top three concerns of Spread Eagle Chain of Lakes Property Owners are: Water Quality, Exotic Species, and Aquatic Plants.

14. How would you take care of your #1 concern?

Response	No Response
80.9%	19.1%

The survey results indicated that a majority of the Spread Eagle Chain of Lakes property owners had a comment on how to take care of their number one concern. Copies of the returned questionnaires with written responses can be viewed by contacting the Spread Eagle Lake Association.

15. As part of our on-going grant program, we have available water testing equipment. Carl Sundberg has agreed to be responsible for that equipment and to test and teach others to test water quality. Please indicate your interest in working with Carl in this endeavor.

Percent	# of People
31.5%	56

The survey results indicated that 56 people, or almost one-third of the Spread Eagle Chain of Lakes property owners responding to the question, would be willing to work with Carl Sundberg with water quality testing.

***16.* Grants have better enabled us to involve lake residents in issues such as water safety and environmental concerns by providing educational materials, Skier Down Flags, and this year's Canoe Classroom. Please suggest other ways by which we can increase lake community involvement in matters such as water safety and education.**

Response	No Response
33.3%	66.7%

The survey results indicated that one-third of the Spread Eagle Chain of Lakes property owners had a comment on how to increase community involvement.

***17.* Would you support the grant committee applying for an implementation grant to install a boat wash station at the North Lake Boat Landing?**

Yes	No
88.5%	11.5%

The survey results indicate that the majority of property owners would support the grant committee applying for an implementation grant to install a boat wash station at the North Lake Boat Landing.

***18.* Additional concerns/suggestions?**

Response	No Response
29.4%	70.6%

The survey results indicated that almost one-third of the property owners responding had additional comments or concerns. Copies of the returned questionnaires with written responses can be found as an addendum to this report in Volume II.

2.2. Water Quality

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

Water quality samples were taken five times on South Lake during the 2003 – 2004 sample collection period. They were ice out (April 2003), and June 2003, July 2003, August 2003 and ice on (January 2004). The location of water quality sampling on South Lake is indicated in Appendix "A," Figure No. 5. The following table shows the analytical parameters for each water sampling event:

Water Sampling Parameter	Month Tested
Total Phosphorus	January, April, June, July, August
Dissolved Phosphorus	January, April, June, July, August
TKN	April
Nitrate/Nitrite	April
Ammonia Nitrogen	April
Color, Turbidity, Sulfate, Chlorides, Alkalinity	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, alkalinity, 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 August sampling event. A high fecal coliform count is usually an indication of raw sewage entering the lake. A mid-summer test was conducted because of the high use of on-site systems by lake residents and visitors at this time of year.

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 51601 water analyzer. The probe, located at the end of a 100-foot cable, was lowered into the water to

a specified depth. Readings for DO and temperature were recorded at the prescribed elevation.

The pH (measure of acidity) of surface water in the lake was measured in January, April, June, July and August with an ICM® Model 51601 water analyzer. 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 South Lake. For complete details of the laboratory results refer to Appendix "D."

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 South 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 South Lake during the 2003 – 2004 sampling period. The concentrations are presented in micrograms per liter (ug/l) or parts per billion.

Total and Dissolved Phosphorus Concentrations - South Lake

Month	Sample	Total Phosphorus (ug/l)	Dissolved Phosphorus (ug/l)
January	Top	16	< 2
January	Bottom	14	< 2
April	Top	10	< 2
April	Bottom	10	< 2
June	Top	10	< 2
June	Bottom	15	< 2
July	Top	12	< 2
July	Bottom	13	< 2
August	Top	9	2
August	Bottom	13	2

*Top samples were obtained within one meter of the surface.
*Bottom samples were obtained within one meter of the bottom.

Dissolved Phosphorus concentrations should be less then 10 ug/l during spring turnover (April) to prevent summer algae blooms. The results of sampling on South Lake indicate concentrations of Dissolved Phosphorus to be less than the laboratory detectable level of 2 ug/l. This means that only 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 South Lake Summer of 2003. (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)	South Lake Ave. Total Phosphorus (ug/l)
Very Poor	> 150				
Poor	55-150		65		
Fair	32-55				
Good	16-32	31		25	
Very Good	2-16				12
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 South Lake conducted during spring turnover. The concentrations are presented in milligrams per liter (mg/l) or parts per million.

Results of Testing for Nitrogen - South Lake, April 2003

Sample	Ammonia Nitrogen (mg/l)	Nitrate/Nitrite (mg/l)	TKN (mg/l)	Total Nitrogen (mg/l)
Top	0.019	0.036	< 0.14	0.055

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). South Lake falls in the very low range.

The Total Nitrogen to Total Phosphorus ratio (N:P ratio) for South Lake was found to average 5:1 for the year. N:P ratios greater than 15:1 generally indicate Phosphorus is the limiting nutrient for aquatic plant growth. Unlike other lakes in the Chain, it does not appear from the data that Phosphorus is the sole limiting nutrient for aquatic plant growth. Both Nitrogen and Phosphorus appear to limit plant growth in South Lake.

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 South Lake are provided in the following table:

Chlorophyll a - South Lake, 2003

Month	Chlorophyll a (ug/l)
April	1.13
June	1.55
July	2.77
August	1.65

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 South 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 (greater than 200 colonies per 100 ml sample) 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 August had a count of less than 10 colonies per 100 ml sample.

This indicates 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. South 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 South Lake.

Water Color (Ref. #8) - South Lake, April 2003

Range	Color	South Lake Top Sample (SU)
0-40 units	Low	<5
40-100 units	Medium	
>100 units	High	

The results indicate the color of South Lake is low; this indicates good water clarity.

2.2.2.6. Turbidity

The turbidity of a lake is a measure of the amount of organic and inorganic matter 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 South Lake samples. For our purposes, JTU's and NTU's can be assumed to be the same. The April, 2003, sample indicated a value of 2.6 NTU.

The results for South 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 sources of pollution.

For example, 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	Top Sample (mg/l)
Calcium	24.2
Chloride	5.9
Hardness	104
Iron	< 0.1
Magnesium	10.5
Manganese	9
Potassium	1
Sodium	2.7
Sulfate	< 4.5

The results of testing for metals and salts in South Lake provide a baseline for future readings. They 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 2003.

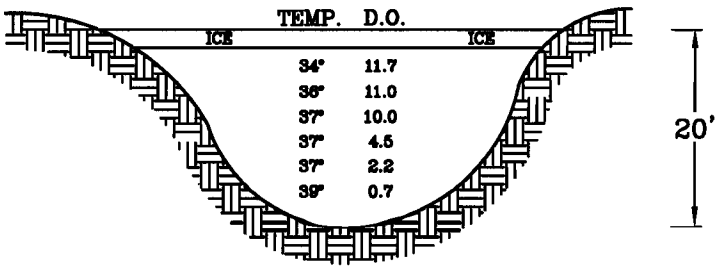
Secchi Depths Measured for South Lake

Month	Secchi Depth (ft.)
April	20.7
June	17.4
July	11.5
August	13.0

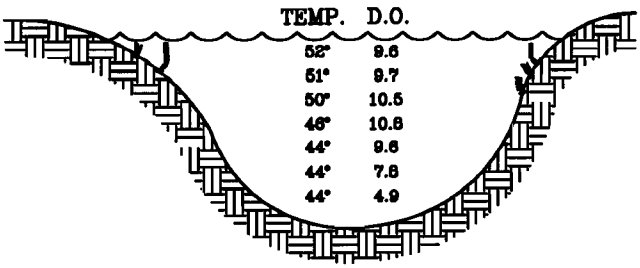
The Secchi depth measured in South Lake in comparison to the water clarity index, indicates South Lake has good to very good water clarity.

2.2.4. Lake Temperature/Dissolved Oxygen

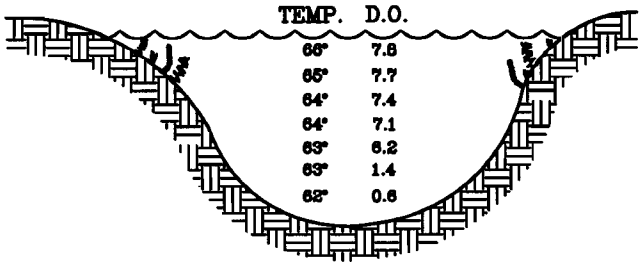
Wave action, mixing of the lake and photosynthesis all add dissolved oxygen (DO) to lake water. Plant and animal respiration and decomposition will decrease the DO supply in a lake. The amount of DO present is also dependent upon water temperature. The lower the temperature of the water, the greater 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 lake's DO level at any time of the year. The following figures provide the temperature and DO levels for South Lake measured during 2003 and January 2004.



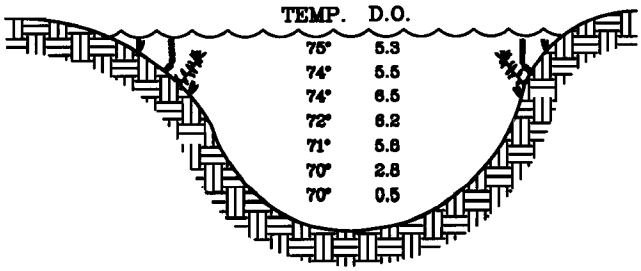
JANUARY



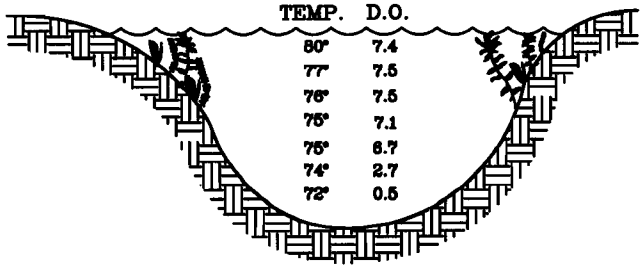
APRIL



JUNE



JULY



AUGUST

TEMPERATURE (°F)
DISSOLVED OXYGEN (mg/l)
ONE METER INTERVALS SHOWN

TEMPERATURE/DISSOLVED OXYGEN PROFILES – SOUTH LAKE

The temperatures and DO levels were measured in South Lake at the sample location in January, April, June, July and August. During January, the temperature at the ice/water interface was the coldest recorded at 34° F and the DO level was the highest at 11.7 mg/l. The DO level dropped to 0.7 mg/l near the bottom due to the decomposition of plant and animal material and the reduced photosynthesis during the winter.

During April, 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 was 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 does not appear to take place in South 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. Since South Lake is not much deeper than 20 feet at its deepest point, this does not have a chance to occur.

2.2.5. Water Quality Assessment

2.2.5.1. Comparative Assessment

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

- Total Phosphorus levels are low (12 ug/l). Unlike other lakes on the Spread Eagle Chain of Lakes, however, the Nitrogen to Phosphorus (N:P) ratios are not high (5:1). N:P ratios > 15:1 would indicate Phosphorus is the limiting nutrient for plant growth. Both Nitrogen and Phosphorus appear to limit plant growth in South Lake.

- 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 (1.8 ug/l), indicating a relatively small amount of algae growth.

- Color, Turbidity and Secchi depths (11 - 20 feet) indicate good water clarity.

- pH levels ranged from 8.4 (January & April) to 8.9 (August). pH levels over 7.0 indicate non-acidic conditions.

2.2.5.2. Trophic State Index

The use of trophic status of a lake is increasingly used as a measure of a lake's overall health. The term "trophic status" refers to the level of productivity in a lake. Lakes undergo a natural aging process called eutrophication, whereby a lake progresses from oligotrophic to eutrophic. Eutrophication is the process by which lakes are enriched with nutrients, increasing the production of rooted aquatic plants and algae. The extent to which the 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). When nutrients enter a lake, they fertilize the lake and encourage algae and plants to grow. As plants, and the animals that feed on the plants, die and decompose, they accumulate on the lake bottom as organic sediments. After thousands of years of natural eutrophication, lakes may evolve to swamps or marshes.

Nutrients from stormwater runoff, urban development, agriculture, lawn and garden fertilizers, and failing septic systems entering a lake can accelerate the natural eutrophication process. Eutrophic changes that would typically take centuries may occur within one person's lifetime.

Lakes can be divided into four categories based upon their trophic state: oligotrophic, mesotrophic, eutropic and hypereutrophic.

A means to examine the overall health or productivity of a lake was developed by R.E. Carlson. Carlson developed a trophic state index (TSI) as means to examine the relationship between Total Phosphorus, Chlorophyll a and Secchi disk readings and its trophic status. The TSI number range and its corresponding description are listed in the following table:

Trophic State Index Values (Ref. #8) - South Lake

Trophic State Index (TSI)	Chlorophyll a (ug/L)	South Lake Chl a (ug/L)	Secchi Depth (m)	South Lake Secchi Depth (m)	Total Phos. (ug/L)	South Lake Total Phos. (ug/L)	Trophic State Attributes
< 30	<0.95		>8		<6		**Classical Oligotrophy:** Clear water, oxygen throughout the year in the hypolimnion.
30-40	0.95-2.6	**1.8**	8-4	**5**	6-12	**12**	Hypolimnion of shallower lakes may become anoxic.
40-50	2.6-7.3		4-2		12-24		**Mesotrophy:** Water moderately clear; increasing probability of hypolimnetic anoxia during summer.
50-60	7.3-20		2-1		24-48		**Eutrophy:** Anoxic hypolimnia, macrophyte problems possible.
60-70	20-56		0.5-1		48-96		Blue-green algae dominate, algal scums and macrophyte problems
70-80	56-155		0.25-0.5		96-192		**Hypereutrophy:** (light limited productivity). Dense algae and macrphytes.
80-90	>155		<0.25		192-384		Algal scums, few macrophytes.

Based on the total phosphorus, chlorophyll a and water clarity, South Lake is considered an Oligotrophic Lake (a lake with low nutrient levels). It should be noted however, that like other lakes tested on the Spread Eagle Chain of Lakes, South Lake is on the upper limit of the classification of Oligotrophic, being borderline Mesotrophic.

2.3. Aquatic Plant Survey Information

2.3.1. Methods of Testing

The aquatic plant (macrophyte) survey was conducted by boat in September of 2003. Aquatic plants were pulled up with a garden rake in the shallow areas of South Lake. In the deeper areas of South 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. 4, included in Appendix "A," provides the aquatic plant survey locations of South Lake. Table No. 1, included in Appendix "E," provides a listing of the aquatic plants and their respective locations. Table No. 2, included in Appendix "E," provides the location of aquatic plants with individual plant abundance. Table No. 3, included in Appendix "E," provides the relative plant abundance by area.

2.3.3. Results of the Aquatic Plant Survey

During the aquatic plant survey conducted on South Lake, eleven different species of aquatic plants were identified. The three most dominant plant species found are

1) Illinois Pondweed
2) Chara
3) Floating-Leaf Pondweed

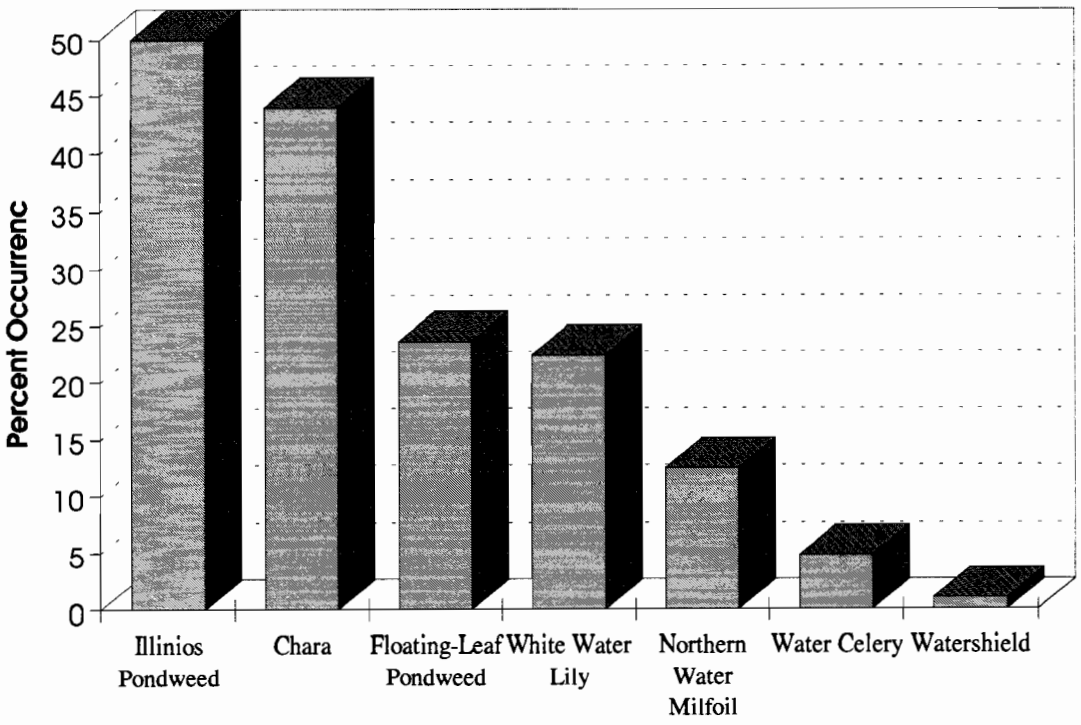
The three most dominant plant species identified are discussed in detail below. For complete details on aquatic plants refer to "Guide to Wisconsin Aquatic Plants" (Ref. #11), provided in Appendix "F."

The most prominent aquatic plant found on South Lake is Illinois pondweed. Illinois pondweed was found to inhabit approximately 50 percent of South 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 & 12).

The second most prominent aquatic plant found at South Lake is Chara. Chara was found to inhabit approximately 44 percent of South 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 that provide food for fish and waterfowl (Ref. #11). See Appendix "F" - Guide to Wisconsin Aquatic Plants for a pictorial representation of Chara.

Floating-Leaf Pondweed was found to inhabit approximately 24 percent of South Lake. Floating-Leaf Pondweed provides good cover for fish, such as panfish, largemouth bass, muskellunge and northern pike. Floating-Leaf Pondweed also supports insects valuable as food for fish and ducklings (Ref. #11).

All the aquatic plants identified in South Lake inhabiting greater than 1% of the area are provided in the following figure:



Occurrence of Aquatic Plants on South Lake

Plant Identification and Percent Occurrence on South Lake

TAXA Common Name	TAXA (Scientific Name)	% OCCURRENCE
Illinois Pondweed	(Potamogeton illoensis)	50%
Chara	(Characeae spp.)	44%
Floating-Leaf Pondweed	(Potamogeton natans)	24%
White Water Lily	(Nymphaea odorata)	22%
Northern Water Milfoil	(Myriophyllum sibiricum)	12%
Water Celery	(Vallisneria americana)	5%
Watershield	(Braseria schreberi)	1.0%
Cattail	(Typha latifolia)	0.9%
Common Waterweed	(Elodea canadensis)	0.8%
Bulrush	(Scirpus validus)	0.5%
Yellow Water Lily	(Nuphar variegatum)	0.4%

The relative density of aquatic plants in South Lake was rated from 0 to 5 (rare to very abundant). The term "very abundant" refers to a relative quantity of aquatic plants that will inhibit motorized boat travel through these areas because of propeller clogging. South Lake has approximately 1 percent of its area inhabited with a "very abundant" amount of aquatic plants, and approximately 3 percent of its area inhabited with an "abundant" (relative density of 4) amount of aquatic plants in the months of July through September. Approximately 38 percent of South 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 South Lake.

2.4. Fish Species Information

The Spread Eagle Chain of Lakes has been shown to support the natural reproduction of a number of pan and game fish species. Electrofishing surveys were conducted by the WDNR on the Spread Eagle Chain of Lakes in September of 1993, September of 1994, and October 1998. Fyke net surveys were also conducted in April 1998 and June 2005.

The next WDNR fish survey of the Spread Eagle Chain of Lakes is scheduled for 2008. The surveys showed that the Spread Eagle Chain of Lakes is fairly consistent throughout, with minor variations (Ref. #19).

The most recent fyke net survey conducted in 2005 revealed a diverse sport fish community, consisting of seven panfish and five game fish species. Bluegill was the most frequently encountered panfish species, followed by rock bass, black crappie and others. Among the game fish, northern pike was the most numerous, followed by walleye and others. Although bluegills were the most common panfish sampled, their relative abundance was not high when compared to other area lakes. Growth rates for panfish were variable, depending on species (Ref. #23).
The following table indicates the size variations of the major species captured during the most recent fyke net survey conducted in 2005:

2005 WDNR Fyke Net Survey – Spread Eagle Chain of Lakes

Species Common Name	Species Scientific Name	Catch	Minimum Size (in.)	Maximum Size (in.)
Black Bullhead	*Ictalurus melas*	1	13.2	13.2
Black Crappie	*Pomoxis nigromaculatus*	30	4.0	11.4
Bluegill	*Lepomis macrochirus*	740	3.0	9.4
Green Sunfish	*Lepomis cyanellus*	11	4.0	5.9
Largemouth Bass	*Micropterus salmoides*	3	6.5	13.9
Muskellunge	*Esox masquinongy*	3	13.5	22.4
Northern Pike	*Esox lucius*	20	14.5	34.4
Pumpkin Seed	*Lepomis gibbosus*	3	5.0	6.9
Rock Bass	*Ambloplites rupestris*	96	3.5	8.9
Smallmouth Bass	*Micropterus dolomieui*	6	5.0	16.9
Walleye	*Sander vitreus*	8	11.0	25.4
Yellow Perch	*Perca flavescens*	1	8.2	8.2

The Chain appears to have a self-sustaining panfish fishery capable of producing quality sizes. Significant angler harvest of larger bluegills is indicated by the truncated size structure of the sampled population (Ref. #23).

The results of fish evaluation surveys conducted by the WDNR in 1993, 1994, 1998, and 2005 are included in Appendix "H."

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

There are no fish cribs in South Lake as can be found in other lakes on the Chain. However, there are possibly a dozen fish boxes. The CCC or Wisconsin Conservation Department may have installed these fish boxes in the 1930's in an effort to help bass spawn and help protect their eggs from being eaten by turtles. The boxes are raised off the bottom and are approximately 3' by 4' in size and are made of 4" logs. They are found in 3' to 5' of water from 50' to 150' from shore. Rocks were placed in the bottom for the nest. When the bass are using them in May or June, the silt is cleaned off and the rocks are visible. These boxes can also be found in East Lake and the east end of Long Lake on the Chain (Ref. #20).

Walleye stocking quotas from 1998 to 2005 were set at 50 small fingerlings (about 1.5"-2") per acre or about 27,000. The new standard DNR stocking rate for small fingerlings, beginning in 2006, will be 35 per acre. The next planned stocking of DNR small fingerlings for the Chain in 2007 will be at 35/acre, or about 19,000 (Ref. #24).

Walleye fingerlings from the Florence Co-op Pond, operated by the Florence County Forestry and Parks Department, were stocked in the Chain in 2001, 2003, and 2004 to supplement the DNR stockings. Numbers stocked ranged from 300 to 4600 fish, from 2.5' to 6" long (Ref. #24).

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. 6 - 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. 7, 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 "H" 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 inlet to West Lake was tested two times in June of 1996 for Phosphorus content. Total Phosphorus content was also low (11.5 ug/l), confirming the watershed is supplying a low amount of phosphorus to the Spread Eagle Chain of Lakes. The testing was completed as part of the Lake Planning Study for West Lake.

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. Lake Usage Impact

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

2.6.1. Fishing

Fishing on South Lake does not appear to have caused significant ecological impact on the lake. While there is no scientific data to substantiate this, the South Lake fishery appears to be in excellent condition with no appreciable reduction in the fish population due to over-fishing.

2.6.2. Motorized Boating

The use of motorized boats on South Lake appears to have had no appreciable impact on the lake. Access to South Lake has, for the most part, restricted the volume and size of the boats entering the lake and therefore, has reduced their potential negative effects on the lake.

The use of motorized boats in other portions of the Chain of Lakes has shifted sediment in the lakes. The sediment shift due to boat traffic is generally only in the shallow areas of the lakes. Plants growing in the bays 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. #15).

Boat traffic also increases shoreline erosion. Shoreline on other lakes of the Chain that do 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. Shoreline erosion due to boat traffic is not present on South Lake.

2.6.3. Shoreline Development

There is very little shoreline development on South Lake and therefore it has had minimal environmental effect on the lake.

Shoreline development on the remainder of the Chain has reduced the area 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. 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 2.6.2 - 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 South Lake is not significant. Water quality data did not indicate excessive levels of nutrients entering the water from septic systems.

2.7. Bridge Inspection

The purpose of this section is to evaluate the condition of the concrete bridge located across the channel between East Lake and South Lake of the Spread Eagle Chain of Lakes.

2.7.1. Bridge History

Very little information is available regarding the history of the bridge across the channel between East Lake and South Lake. Based upon early photos, it appears that two bridges were constructed across the channel between East Lake and South Lake.

The first bridge was a wooden bridge constructed by E.F. Brown in the 1900's. A photo in Putnam Robbins book, *The Eagle Spreads its Wings – 1988*, shows the wooden bridge prior to the construction of the concrete bridge. The Stoddard Dayton car shown on the bridge appears to match the touring cars manufactured by that company circa 1908 to 1913.

A circa 1920 photo supplied by Mr. Ray Burgess shows the newer concrete bridge in the background. It would appear that the wooden bridge was replaced by E.F. Brown in the 1910's by the concrete bridge that is still in use today. The bridge has been repaired several times over the years, but remains essentially the same as it was in circa 1920.

2.7.2. Bridge Evaluation

It should be noted that the bridge was not evaluated for structural integrity or loading capacity. Evaluation of the structural integrity or loading capacity of the bridge is beyond the scope of this project.

The physical condition of the bridge was evaluated based upon a visual inspection conducted on June 11, 2003. The inspection revealed a section of the bridge that needs repair, but the overall condition of the bridge is good, considering its age.

Exposed areas of the original and 1979 repair to concrete portions of the bridge abutments show surface mortar loss and minor cracking consistent with its age.

Longitudinal cracks located midway along the north and south sides of the bridge are present but are not in excess of 1/8" in width.

Two major longitudinal cracks in excess of 1/8" are present midway of the underside of the bridge. The cracks run nearly parallel approximately 2" to 3" apart, almost full length of the bridge. One section approximately 2" x 6" has broken out exposing the structural steel approximately 2" above. Photographic documentation of the bridge inspection can be found in Appendix "B".

2.8. Dam Evaluation

The purpose of this section is to evaluate the condition of the concrete dam located at the outlet of South Lake. The location of the dam on South Lake is shown on Figure No. 5, located in Appendix "A"

2.8.1. Dam History

On June 15, 1948, the Spread Eagle, Lake Elwood Taxpayers Association filed a petition with the Public Service Commission (PSC) requesting a determination of the normal lake level of the Spread Eagle Chain of Lakes.

A hearing with the PSC was held on July 28, 1948. The findings of the PSC were as follows:

1. The normal elevation of the Spread Eagle Chain of Lakes is 50 ½" below the top of the east end of the upstream wheel guard on the bridge between East Lake and South Lake.
2. It will be necessary to construct a dam on the outlet stream to maintain this normal level.

On August 27, 1948, the following was ordered by the PSC:

1. Normal elevation shall be fixed as noted in the findings.
2. Plans for a dam shall be submitted to the PSC for approval.

On March 12, 1951, plans for the dam were received by the PSC.

On November 1, 1955, a letter was submitted to the PSC by Attorney Walter DallaGrana indicating that the dam construction project would not begin until spring or early summer of 1956.

On May 21, 1956, a quitclaim deed was filed with the Florence County Register of Deeds giving the Town of Florence a 15-foot by 60-foot parcel of property at the outlet to South Lake for the purpose of constructing a dam. An easement allowing access by the Town of Florence for repair and maintenance was also conveyed in the deed.

In the minutes of the May 1956 meeting of the Town of Florence Board of Supervisors, it was noted that Walter DallaGrana had received the quitclaim deed for the dam property parcel. Construction could proceed with the dam in June. Members of the Spread Eagle, Lake Elwood Taxpayers Association were in attendance at the meeting.

It is assumed that construction of the dam occurred in 1956 based on the information above.

On August 5, 1990, an application and plan were submitted to the Wisconsin Department of Natural Resources (WDNR) by the Spread Eagle Chain O' Lakes Association. The plan was to make repairs to stop leakage around the ends of the dam. This was to be done by using bagged cement/sand.

On July 17, 1991, the WDNR approved a revised plan for repair that used bagged cement/sand to stop leakage around the ends of the dam.

It is assumed that repairs to the dam were made in 1991.

In 2001, the grant committee of the Spread Eagle Chain O' Lakes Association included a request for inspection and recommendations for repair and maintenance of the dam in the Lake Planning Study for South Lake.

2.8.2. Dam Inspection

A site visit and dam evaluation was conducted on August 2, 2001 and June 11, 2003. Conditions were consistent between the two site visits. The concrete portion of the dam appeared to be in good physical condition. Water levels were high enough to be running over the dam approximately 1-inch.

Water was running around the east side of the dam at a rate of approximately 40 to 50 gallons per minute. The dam had been repaired on the east end by putting plastic down and placing rock on top to keep the water from going around the end of the dam. This repair is beginning to fail.

The west end of the dam was also repaired in past years. It appears that bags of Redicrete were placed from the west end of the dam westward approximately 15' and wrapped in a rubber type material. The sunlight is beginning to rot the rubber in places. Water is still making its way under and around the repair at a rate of approximately 40 to 50 gallons per minute. West of the dam is primarily mucky wetland. A good portion of the water going around the west end of the dam is traveling through the wetland. Photographic documentation of the dam can be seen in Appendix "B".

2.8.3. Dam Recommendations

The dam must be repaired permanently to keep frequent and persistent leakage from lowering the water level of the Spread Eagle Chain of Lakes. MMA, INC. recommends installing ½" thick hot-rolled sheet piles to solve the problem.

Sheet pile can be installed full length across the front of the existing dam, approximately 75 feet, from solid ground east of the dam to solid ground on the west side of the dam. The sheet piles would be installed at a height level with the top of the dam for the length of the existing dam. Outside of the dam, the height of the sheet piles would be raised by three inches to solid ground. This design would allow water to flow at the same elevation as the existing dam is permitted, while creating a solid wall outside the dam preventing water from circumventing the dam.

The cost to install 75 feet of sheet pile in front of the existing dam is estimated as follows:

Material	$5,625.00
Labor	$11,250.00
Engineering, Permitting & Inspection	$2,500.00
TOTAL	$19,375.00

The Town of Florence currently owns the 15-foot by 60-foot parcel on which the dam is located. The recommendation calls for 75 feet of sheet piling to be installed. This means that either a property purchase or an easement must be obtained from the adjacent property owner to make the recommended repairs. Ms. Marian Lies and Mr. John Englund, adjacent property owners, both indicated that they would be amenable to discuss an easement with the Town of Florence. A cost estimate for the proposed easement would only be speculative and therefore is not included in this report.

2.9. Educational Events

The purpose of this section is to describe educational events that were conducted as part of the WDNR Lake Management Planning Grant Program.

2.9.1. Canoe Classroom

A "Canoe Classroom" was held on South Lake of the Spread Eagle Chain of Lakes on Saturday, August 7, 2004 beginning at 10:30 A.M. The Canoe Classroom event was presented as part of the WDNR Lake Management Planning Grant Program to provide a fun way to educate lake residents about water quality, water safety, fish, aquatic plants, and exotic species.

Lake residents and interested individuals arrived at South Lake by canoe, kayak, and by car. The presentation was held at the shoreline of Arthur and Marian Lies.

Darlin Verley, Chairperson of the Spread Eagle Lake Association Grant Committee, gave a welcome to all and presented the schedule of events for the day.

Boy Scout Troop Leader, Mark Lies gave a presentation on canoe and kayak safety. Mr. Lies presented information on how and what to pack for canoe trips, showed paddling techniques, and gave safety tips.

Steven Friberg, P.E., Environmental Engineer for the Spread Eagle Chain of Lakes Association, presented information on exotic species that have been found in nearby lakes. Mr. Friberg demonstrated the use of water testing meters and equipment used in lake studies and how the results of lake testing correlate to lake health.

Local fish expert and Vice President of the Spread Eagle Chain of Lakes Association, Carl Sundberg gave fishing tips and hosted the fishing, canoe and kayak races.

Ken Sovey, President of the Spread Eagle Chain of Lakes Association, presented prizes for the fishing, canoe and kayak races. Mr. Sovey thanked everyone for coming to the event and the Lies for hosting the event.

Photos of the Canoe Classroom event can be seen in Appendix "B".

3.0. CONCLUSIONS

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

3.1. Property Ownership Survey

Based on the results of the survey, the following were indicated:

- The Spread Eagle Chain of Lakes Association should consider periodic inspections of the South Lake Dam.
- The Spread Eagle Chain of Lakes property owners would support efforts to control exotic species.
- The Grant Committee should apply for an implementation grant to install a boat wash station at the North Lake Boat Landing.
- The top three concerns of Spread Eagle Chain of Lakes property owners are: Water Quality, Exotic Species, and Aquatic Plants.

3.2. Water Quality

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

- Total Phosphorus levels are low (12 ug/l). Unlike other lakes on the Spread Eagle Chain of Lakes, however, the Nitrogen to Phosphorus (N:P) ratios are not high (5:1). N:P ratios > 15:1 would indicate Phosphorus is the limiting nutrient for plant growth. Both Nitrogen and Phosphorus appear to limit plant growth in South Lake.
- 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 (1.8 ug/l), indicating a relatively small amount of algae growth.
- Color, Turbidity and Secchi depths (11 - 20 feet) indicate good water clarity.
- pH levels ranged from 8.4 (January & April) to 8.9 (August). pH levels over 7.0 indicate non-acidic conditions.

Based on the total phosphorus, chlorophyll a and water clarity, South Lake is considered an Oligotrophic Lake (a lake with low nutrient levels). It should be noted however, that

like other lakes tested on the Spread Eagle Chain of Lakes, South Lake is on the upper limit of the classification of Oligotrophic, being borderline Mesotrophic.

3.3. Aquatic Plant Survey

During the aquatic plant survey conducted on South Lake, eleven different species of aquatic plants were identified. The three most dominant plant species found are

1) Illinois Pondweed
2) Chara
3) Floating-Leaf Pondweed

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

South Lake has a well-balanced population of desirable aquatic plants. 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

Fish evaluation surveys were conducted on the Spread Eagle Chain of Lakes in 1993, 1994, 1998 and 2005. The results indicate that the Spread Eagle Chain supports a dynamic and diverse fishery. The surveys showed that the Spread Eagle Chain of Lakes is fairly consistent throughout, with minor variations.

The Spread Eagle Chain of Lakes supports natural reproduction of a number of pan and game fish species. The most common game fish encountered in the most recent survey on the Spread Eagle Chain of Lakes was Northern Pike and the most common pan fish was Bluegill. The fish species found during the most recent fish evaluation surveys include

- Largemouth Bass
- Smallmouth Bass
- Walleye
- Northern Pike
- Muskellunge
- Bluegill
- Rock Bass
- Yellow Perch
- Black Crappie
- White Sucker
- Pumpkinseed
- Green Sunfish

- Black Bullhead

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. Lake Usage Impact

It does not appear that there have been significant impacts on the ecosystem of South Lake due to lake usage.

3.7. Bridge

Overall, the concrete bridge located across the channel between East Lake and South Lake is in good repair considering its age. Repair of a small section of the underside of bridge needs to be completed to prevent corrosion of exposed structural steel.

3.8. Dam

A permanent repair needs to be made to the dam to prevent water from seeping around the ends of the dam. Without a permanent repair to the dam, erosion of material around the ends of the dam will continue to occur resulting in lower water levels in the Chain of Lakes during dry periods.

4.0. RECOMMENDATIONS

The following section contains recommendations on water quality, aquatic plant management, fish management, watershed practices, lake usage.

4.1. Water Quality Recommendations

The water quality of South 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 that 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 South Lake. Adverse lake trends can be identified and corrected before irreversible damage to the lake has occurred.

4.2. Aquatic Plant Management Recommendations

South Lake has a well-balanced 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. Large-scale removal of native aquatic plants will only provide areas for exotic plants to move in if they are once introduced.

4.3. Fish Management Recommendations

The Spread Eagle Chain of Lakes supports a diverse fishery. It has been shown to support the natural reproduction of a number of pan and game fish species.

The installation of fish cribs on the Spread Eagle Chain of Lakes should be continued. The cribs provide benefit to anglers and a deeper water habitat for fish. In addition to fish cribs, tree drops should be considered since they would provide much needed, near-shore woody cover and bass/panfish spawning sites. Tree drops can be installed with a free DNR permit.

Lake residents are strongly encouraged to leave any trees and branches that naturally fall into the lake in place.

Lake residents are strongly encouraged to maintain and restore natural shoreline vegetation to the greatest extent possible, to prevent excessive runoff and erosion. Healthy fish populations depend on healthy shorelines and good water quality.

Currently, walleye fingerlings for the Chain are stocked at the only public landing on North Lake, because it can accommodate a large hatchery truck. Better survival could be encouraged by scatter planting throughout the Chain with boats operated by local lake residents.

If the Spread Eagle Lake Association has any questions on stocking fish or fish management, Robert Young of the WDNR - Woodruff office is able to assist them in making fish management decisions.

4.4. Watershed Recommendations

The water quality of South 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. 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. 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 shoreline protection, contact Jayne Wade, Water Regulation and Zoning Specialist at the WDNR Woodruff Office.

4.6. Bridge Recommendations

Repair of a small section of the underside of the concrete bridge located across the channel between East Lake and South Lake needs to be completed to prevent corrosion of the exposed structural steel.

4.7. Dam Recommendations

To permanently eliminate seepage around the ends of the dam, it is recommended to install sheet piling continuously from high ground east of the dam continuously to high

ground west of the dam to form an uninterrupted seal in front of the dam. The sheet piling should be installed three inches higher than the dam outside of the dam, and at the level of the dam immediately in front of the dam.

The acquisition of an easement or the purchase of additional property will need to be completed to install the sheet piling outside the existing 60-foot width of property owned by the Town of Florence.

A permit to complete the proposed work within a waterway is also required through the Wisconsin Department of Natural Resources.

4.8. Exotic Species Recommendations

Education of lake users should be increased to promote awareness of the imminent threat of exotic species to the Spread Eagle Chain of Lakes. Grants for signs and other educational materials should be pursued whenever available to make sure that all lake users are aware that measures can be taken to reduce the chance for the spread of exotic species to the Spread Eagle Chain of Lakes.

The Spread Eagle Chain O' Lakes Association should acquire information regarding the installation of a boat wash station at the North Lake Boat Landing. The Association should access the benefits versus the negative aspects of installing a boat wash station at the Landing. If the Association decides that a boat wash station is in the best interest of the lake community, discussion with the Town of Florence should commence regarding the installation of the boat wash station on the Town owned property. If the Town Board of Supervisors is amenable to the installation of a boat wash station, a grant to cover a portion of the cost of installation should be pursued.

5.0. SUMMARY OF RECOMMENDATIONS

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

- The Spread Eagle Lake Association should continue to monitor the water quality of South Lake. Adverse lake trends can thereby be identified and corrected before irreversible damage to the lake has occurred.

- Educate and involve the of property owners in measures that can maintain and improve water quality on Spread Eagle Chain of Lakes. Maintaining good water quality will help minimize aquatic plant growth and minimize future sedimentation.

- The installation of fish cribs should be continued. Tree drops should be considered to provide much needed near-shore woody cover and bass/panfish spawning sites. Leave any trees and branches that naturally fall into the lake in place. Consider getting involved with fish stocking operations by helping to scatter plant walleye fingerlings by boat throughout the Chain.

- Keep aquatic plants growing near shore and rooted plants on shore to minimize shoreline erosion. 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.

- Repair of a small section of the underside of the concrete bridge located across the channel between East Lake and South Lake needs to be completed to prevent corrosion of the exposed structural steel.

- To permanently eliminate seepage around the ends of the dam, it is recommended to install sheet piling continuously from high ground east of the dam continuously to high ground west of the dam to form an uninterrupted seal in front of the dam.

- Education of lake users should be increased to promote awareness of the imminent threat of exotic species to the Spread Eagle Chain of Lakes.

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

This document has been developed and prepared for a specific application, under specific limitations. This document, therefore, may not be used without the prior written approval of the authors, South Lake Grant Committee and MMA, INC.

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.*

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

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(Ref. #18) United States Department of Agriculture, Soil Conservation Service. 1988. *Soil Survey of Oconto County, Wisconsin.*

(Ref. #19) Russ Heiser, Fisheries Biologist - Wisconsin Department of Natural Resources. July 13, 1999. *Fishery Evaluation Survey of Spread Eagle Chain, Florence County, Wisconsin.* Unpublished - Draft.

(Ref. #20) Carl Sundberg. January 27, 2004 correspondence. Carl Sundberg is a resident of West Lake and an avid fisherman of the Spread Eagle Chain of Lakes.

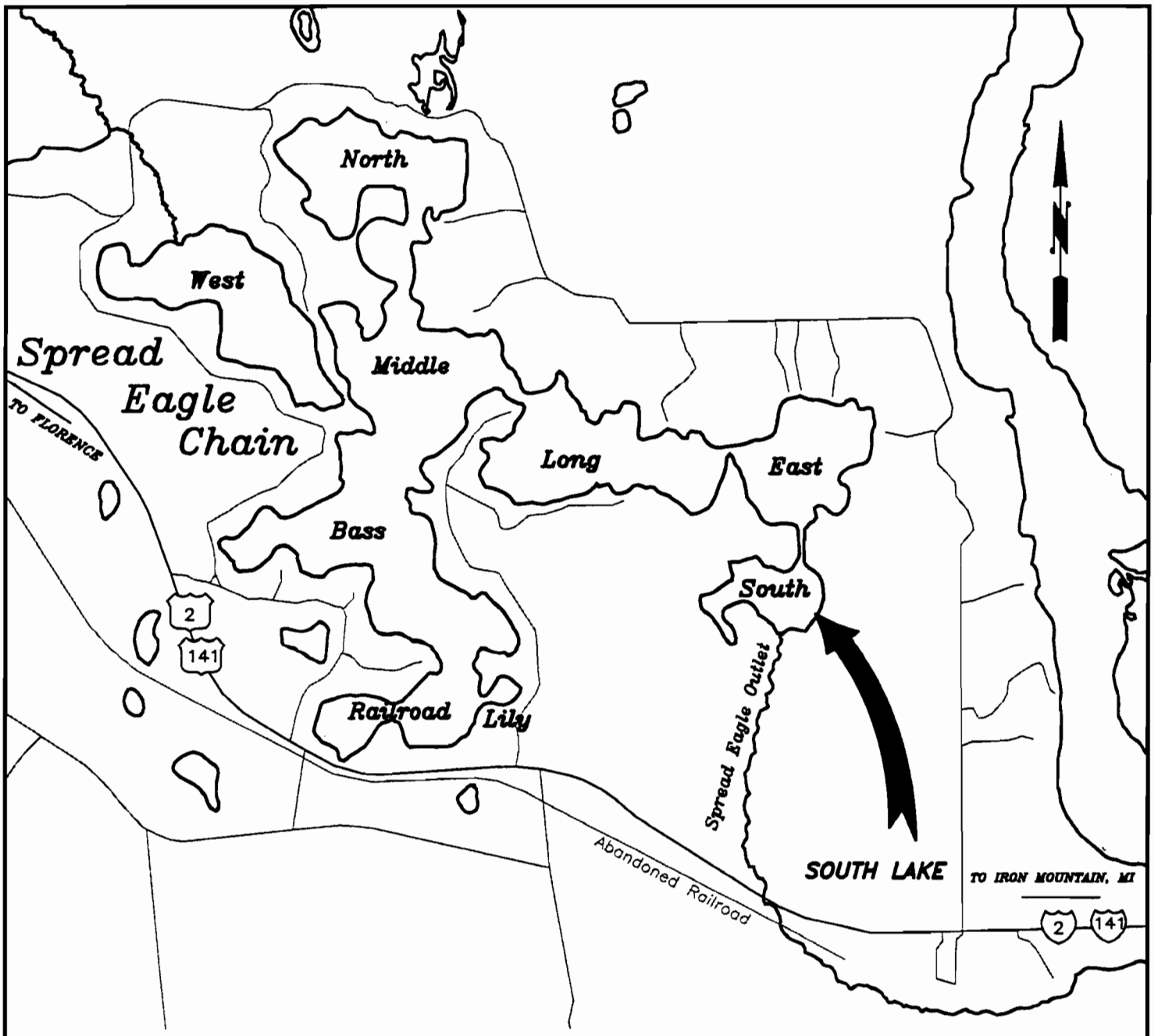
(Ref. #21) Robert Young, Fisheries Biologist - Wisconsin Department of Natural Resources. January 29, 2004. *Detailed Stocking Report Spread Eagle Chain.* Microsoft Excel File.

(Ref. #22) Carlson, R.E. and J. Simpson. 1996. *A Coordinator's Guide to Volunteer Lake Monitoring Methods.* North American Lake Management Society. 96pp.

(Ref. #23) Robert Young, Fisheries Biologist - Wisconsin Department of Natural Resources. January 10, 2006. *Fisheries Survey Report.* Unpublished - Draft. Field work conducted June 13-16, 2005.

(Ref. #24) Robert Young, Fisheries Biologist - Wisconsin Department of Natural Resources. February 16, 2006 Correspondence.

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.



WISCONSIN

SOUTH LAKE
SPREAD EAGLE CHAIN OF LAKES
(FLORENCE COUNTY)

LOCATION MAP
SOUTH LAKE

SCALE: 1"=2000'	APPROVED BY:	DRAWN BY: SMF
DATE: 1/22/04		REVISED:

SPREAD EAGLE LAKE ASSOCIATION
Florence, Wisconsin

MMA, INC. – Florence, WI

FIGURE NUMBER: 1

WISCONSIN CONSERVATION DEPARTMENT

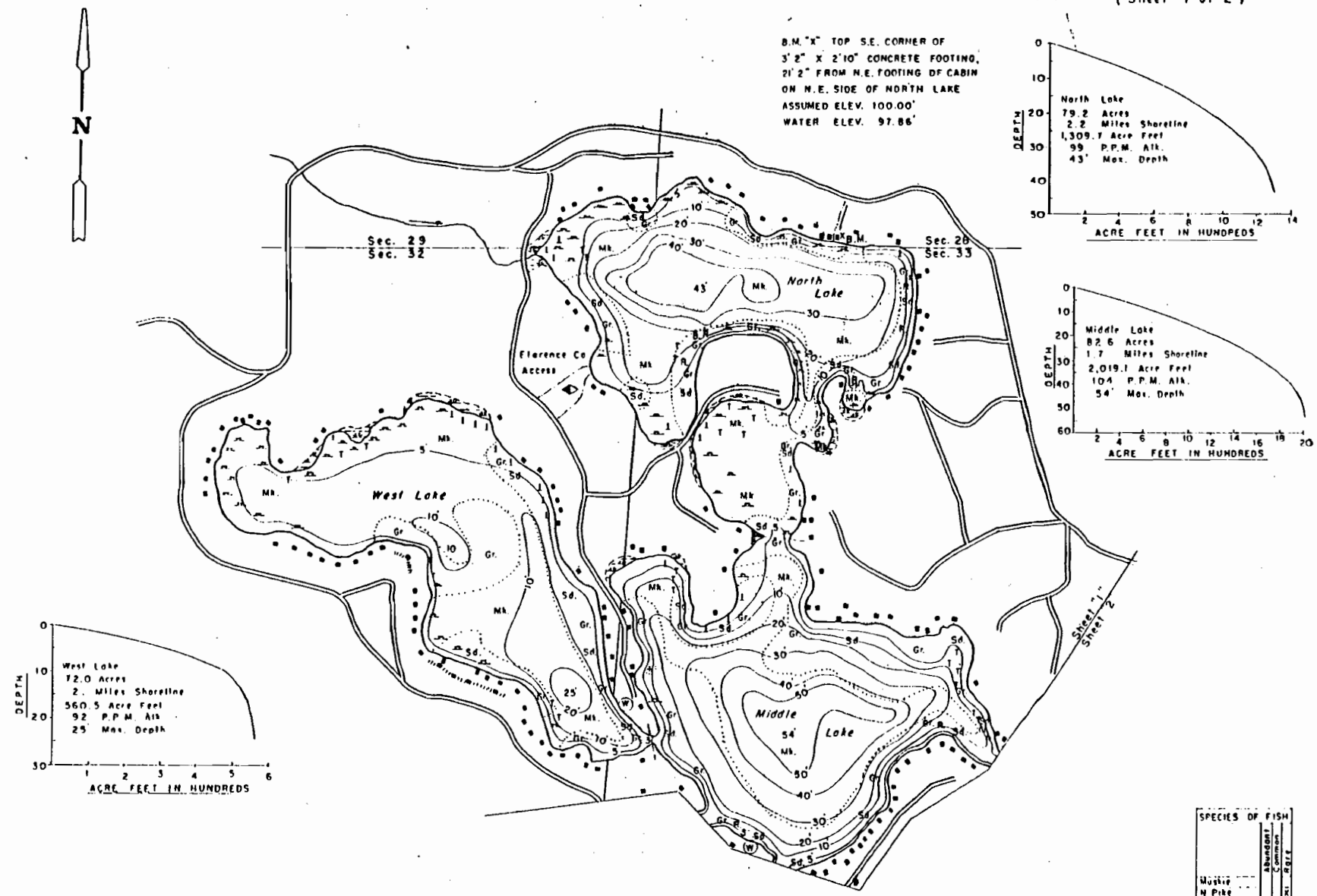
LAKE SURVEY MAP

SPREAD EAGLE CHAIN LAKE — FLORENCE COUNTY

SEC. 32,33,34 3,4,5 T. 39,40 N. R. 19 E.W.M.

(Sheet 1 of 2)

B.M. "X" TOP S.E. CORNER OF 3' 2" X 2' 10" CONCRETE FOOTING, 21' 2" FROM N.E. FOOTING OF CABIN ON N.E. SIDE OF NORTH LAKE
ASSUMED ELEV. 100.00'
WATER ELEV. 97.86'



EQUIPMENT RECORDING SONAR MAPPED AUGUST (MO.) 1966 (YR.)

WATER ELEV. 91.89

TOPOGRAPHIC SYMBOLS

- (B) Brush
- (W) Partially wooded
- (W) Wooded
- (C) Cleared
- (P) Pastured
- (A) Agricultural
- BM Bench Mark
- Dwelling
- (R) Resort
- Steep slope
- Indefinite shoreline
- Marsh
- Spring
- Intermittent stream
- Permanent inlet
- Permanent outlet
- Dam

LAKE BOTTOM SYMBOLS

- P. Peat
- Mk. Muck
- C. Clay
- M. Marl
- Sd. Sand
- St. Silt
- Gr. Gravel
- R. Rubble
- Br. Bedrock
- T Submergent vegetation
- E Emergent vegetation
- Floating vegetation
- Stumps & Snags
- Rock danger to navigation

500' 0' 500' 1,000' 1,500' 2,000' 2,500'
SCALE

◇ Access ◆ Access with Parking ◆ Boat Livery

Field work by A. Burchel, P. Michelson Drawn by E. Eaton

SPECIES OF FISH

	Abundant	Common	Rare
Muskie			
N. Pike			
Walleye			
L.M. Bass			
S.M. Bass			
Panfish			
Trout			

552.2 WITH ISLANDS

AREA 548.4 ACRES
UNDER 3FT. 11 %
OVER 20FT. 40 %
VOLUME 10,896 ACRE FT.
TOTAL ALK. 92 - 104 P.P.M.
SHORELINE 14.8 MILES
MAX. DEPTH 75 FEET

Figure No. 2 - Lake Survey Map
Sheet 1 of 2

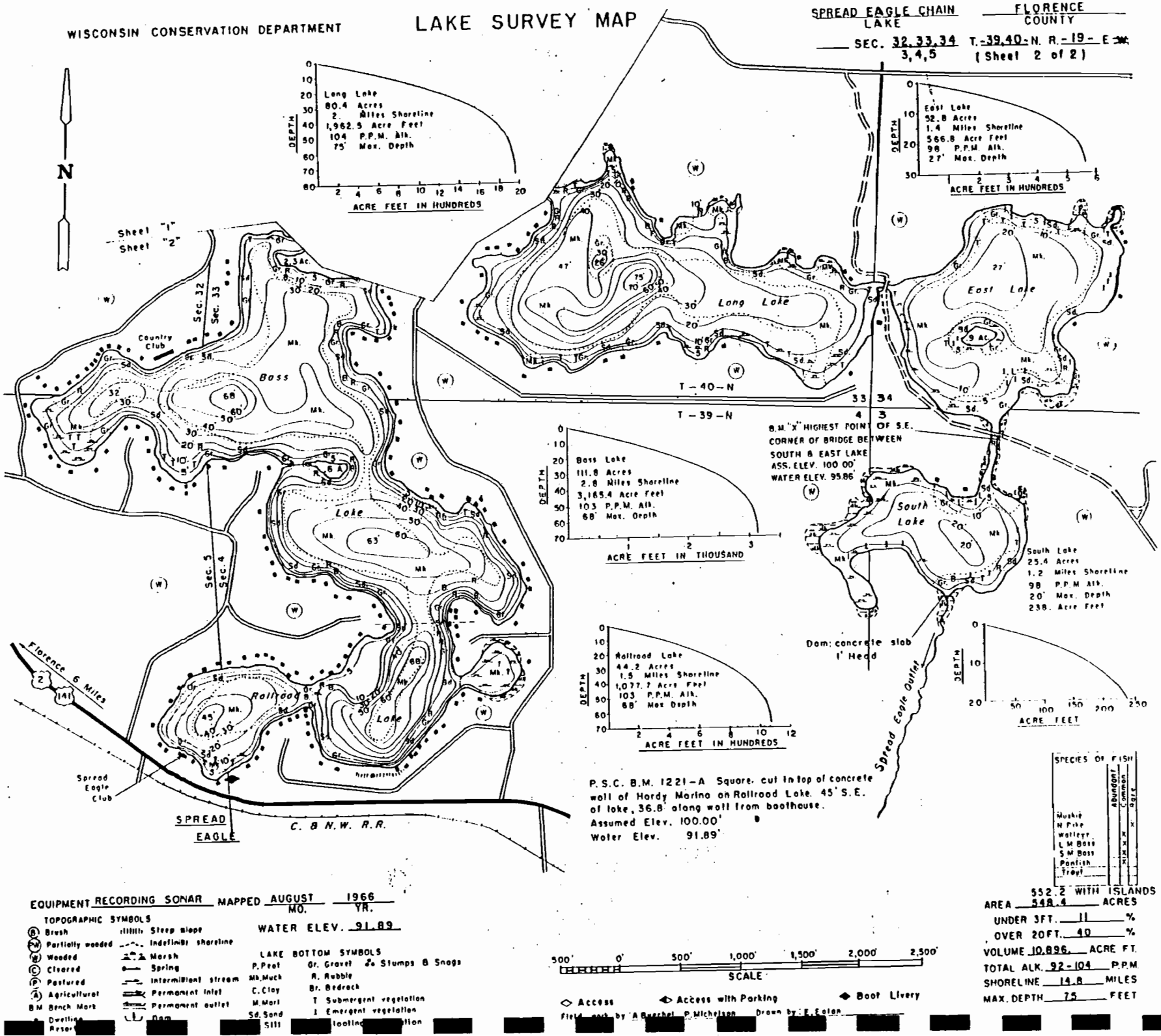
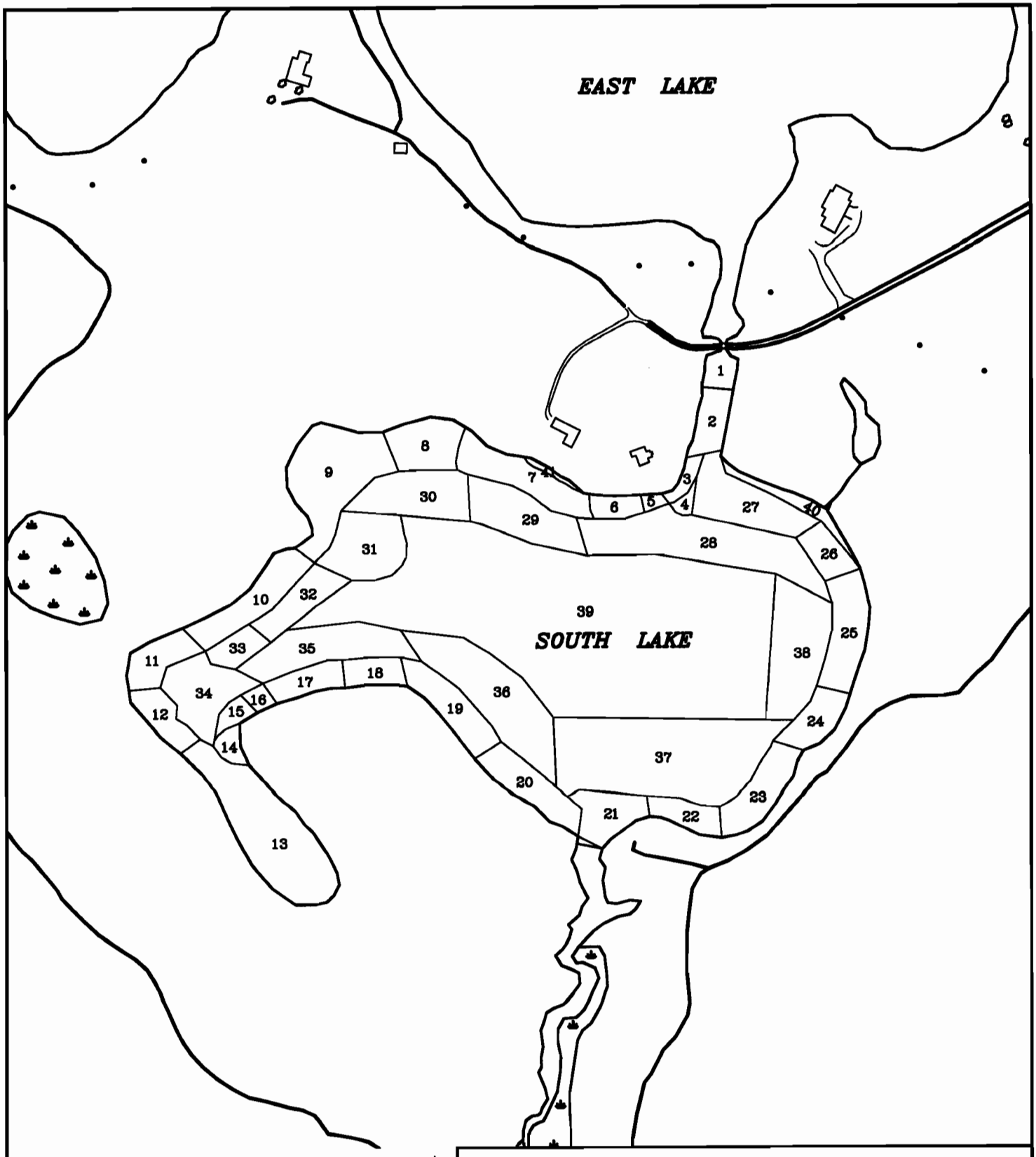


Figure No. 3 - Lake Survey Map
Sheet 2 of 2



NOTE: AQUATIC PLANT TABLES FOUND IN APPENDIX E REFERENCE NUMBERED LOCATIONS SHOWN.

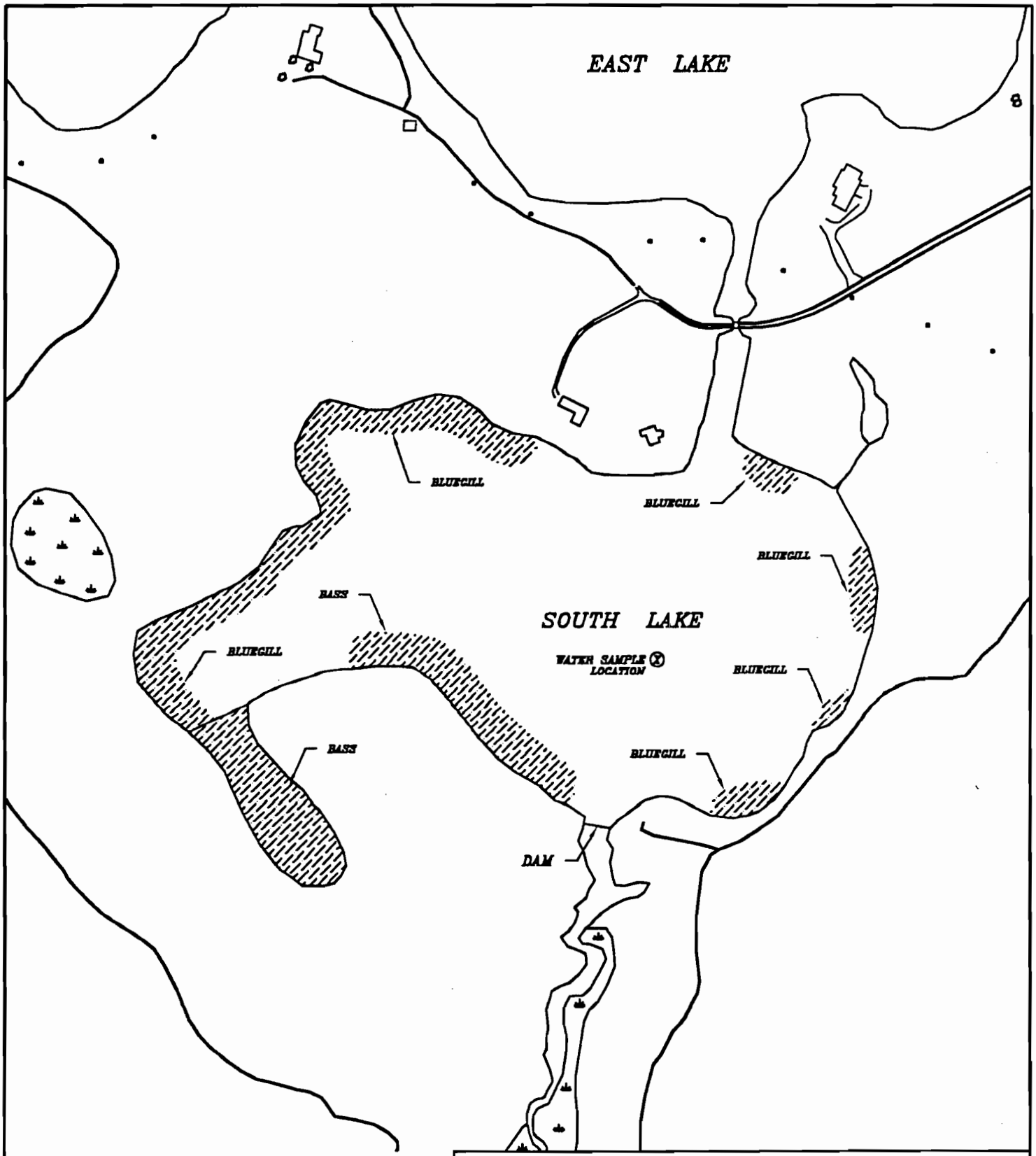
AQUATIC PLANT SURVEY LOCATIONS

SCALE: 1"=300'	APPROVED BY:	DRAWN BY: SMF
DATE: 1/19/04		REVISED:

SPREAD EAGLE CHAIN OF LAKES ASSOCIATION
Florence, Wisconsin

MMA, INC. – Florence, WI

FIGURE NUMBER: 4



SPAWNING & NURSERY LOCATIONS

SCALE: 1"=300'	APPROVED BY:	DRAWN BY: SMF
DATE: 2/19/04		REVISED:

SPREAD EAGLE CHAIN OF LAKES ASSOCIATION
Florence, Wisconsin

MMA, INC. – Florence, WI

FIGURE NUMBER: 5

DIGITAL BASE MAP FILES USED WITH PERMISSION FROM THE FLORENCE UTILITY COMMISSION.

LEGEND

ARROWS INDICATE SURFACE RUNOFF PATTERNS AND WATER FLOW DIRECTION

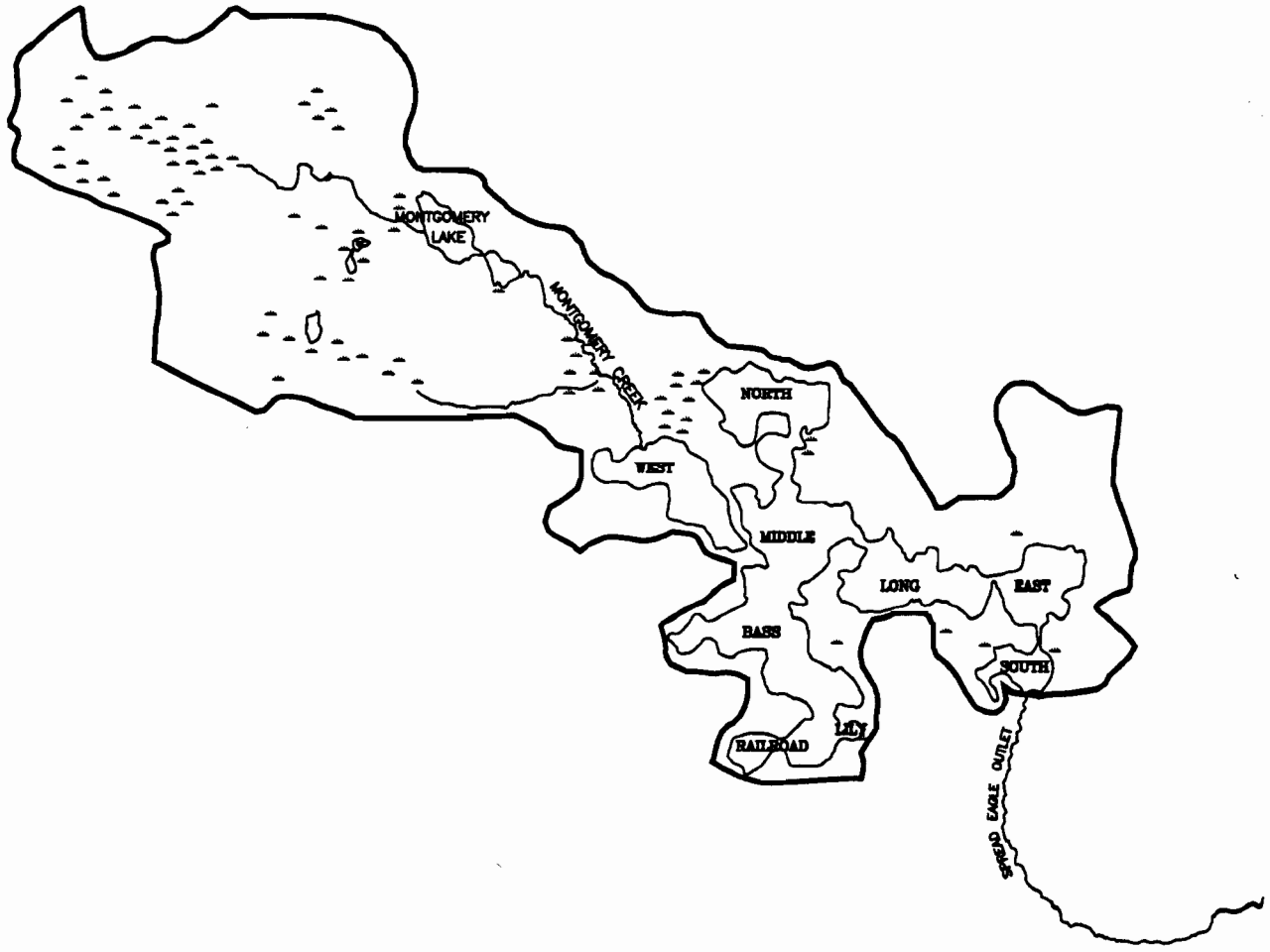
WATERSHED AREA OF THE SPREAD EAGLE CHAIN OF LAKES

SCALE: 1"=4000'	APPROVED BY:	DRAWN BY: SMF
DATE: 4/1/05		REVISED:

SPREAD EAGLE CHAIN OF LAKES ASSOCIATION
Florence, Wisconsin

MMA, INC. – Florence, WI

FIGURE NUMBER: 6



LEGEND

WETLAND AREA

WETLAND AREAS OF THE SPREAD EAGLE CHAIN WATERSHED

SCALE: 1"=4000'	APPROVED BY:	DRAWN BY: SMF
DATE: 4/1/05		REVISED:

SPREAD EAGLE CHAIN OF LAKES ASSOCIATION
Florence, Wisconsin

MMA, INC. - Florence, WI

FIGURE NUMBER: 7