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WILKE LAKE
LAKE MANAGEMENT STUDY

WILKE LAKE ADVANCEMENT ASSOCIATION
TOWN OF SCHLESWIG
SANITARY DISTRICT #2

February 3, 1995

Prepared For:

Town of Schleswig Sanitary District #2
c/o William Schlegel, Chairman
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Project Number WLS140529

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1.0 EXECUTIVE SUMMARY

On behalf of the Town of Schleswig Sanitary District #2, Northern Environmental Technologies, Incorporated (Northern Environmental) completed a lake management study of Wilke Lake under a Lake Management Planning Grant received during April 1992. Wilke Lake is a 97-acre ground-water seepage lake with a single perennial outlet. The lake, located in southwest Manitowoc County, has a maximum depth of 20 feet, an average depth of nine feet, 1.7 miles of shoreline, about 100 dwellings, and a 467-acre watershed.

During the 1970s, Wilke Lake experienced algae blooms and excessive aquatic plant growth due to high nutrient levels. At that time, Wilke Lake was classed as a eutrophic lake, accelerated by cultural eutrophication. Cultural eutrophication is the human-influenced enrichment of nutrients and sediments in lakes. During 1981, the Sanitary District implemented an aquatic plant management plan because of excessive aquatic plant growth.

During 1992, Northern Environmental began a two-year lake management study. Specific areas of investigation were chemical and physical characteristics of Wilke Lake, the watershed, hydrophytic vegetation, lake sediments, and public opinions. Final work products include detailed baseline-water quality data, an aquatic macrophyte survey, and a lake management plan.

Water quality analysis revealed that Wilke Lake's water quality has improved since the 1970s and can now be classed a mesotrophic lake. Mesotrophic lakes have lower nutrient levels, less biologic productivity, and better water clarity than eutrophic lakes. Severity and frequency of algae blooms have also decreased. The aquatic macrophyte survey revealed that about 75 percent of the vegetation sample points have Eurasian milfoil growth. Eurasian milfoil is an aggressive non-native submergent plant that is a common nuisance plant in shallow Wisconsin lakes. Mechanical harvesting of Eurasian milfoil has decreased internal nutrient cycling and increased the recreational boating opportunities on Wilke Lake.

The lake management plan provides a guideline for maximizing public use without compromising the lake's natural integrity and addresses the physical and cultural concerns of the lake. Highlights of the plan include continuing best management practices, preserving the southwest wetland area, distributing lake educational materials, continuing mechanical harvesting of aquatic plants, experimenting with sediment covers, creating a fish management plan, performing sediment analysis, completing a wetland restoration project, appointing a volunteer lake monitor, and forming lake committees. Implementing management plans will reduce negative cultural impacts on the lake by stabilizing and protecting water quality.

2.0 INTRODUCTION

2.1 Background Information

Wilke Lake is a shallow 97-acre ground-water seepage lake located in southwestern Manitowoc County, Wisconsin. Wilke Lake has a single perennial outlet, a maximum depth of 20 feet, an average depth of nine feet, and 1.7 miles of shoreline with 100 seasonal and year round dwellings (Reference 1). Wilke Lake has a 467 acre, primarily agricultural, watershed (Figure 1). The watershed to lake ratio is 5 to 1. About 90 percent of the shoreline is developed, while the other 10 percent is wetland. One large wetland system, owned by the Wisconsin Department of Natural Resources (WDNR), is located on the north shore of Wilke Lake and a similar wetland is located on the western shore. Presently, as well as in the past, Wilke Lake is experiencing excessive submerged aquatic plant growth. Most plant growth is a non-native plant species, Eurasian milfoil.

2.2 History

Wilke Lake was formed at the end of the last Ice Age, about 10,000 years ago in an area dominated by soils underlain by glacial outwash deposits adjacent to a terminal moraine running from northeast to southwest. A large piece of glacial ice probably was left behind, and when it melted formed Wilke Lake. This type of lake is typically called a "kettle lake".

Today, Wilke Lake suffers from post-settlement human activities. Land use changes from pre-settlement conifer-hardwood forest to agriculture has increased nutrient and sediment loads to Wilke Lake. Wilke Lake is one of the most heavily used lakes in Manitowoc County.

A WDNR report from the early 1960s documented a maximum depth of 22 feet, while the maximum present depth is 20 feet. This yields a post-settlement sedimentation rate of about one foot per 15 years. During the early 1960s, Wilke Lake began managing aquatic plants. From 1960 to 1964, chemicals were periodically applied to control aquatic plants. Unfortunately, no documents regarding the type and rate of application were kept. During the late 1960s, volunteers on the lake used a small weed cutter as a method to control aquatic plants. This method did not actually harvest the cut plants which may have actually stimulated aquatic plant growth. During the 1970s, aquatic plants were not managed, and aquatic plant growth was excessive. Water quality data collected during the 1970s showed shallow secchi disk readings which translate into a high algae content in the water column. A 1972 report titled "A Shoreline and Water Quality Evaluation of Wilke Lake in Manitowoc County" stated that Wilke Lake had " high algae and rooted vegetation growth, high phosphorous and nitrogen levels, and septic system and barnyard runoff problems" (Reference 2). At this time, aquatic plant growth became so dense that late summer boat traffic was severely restricted.

During 1980, the Town of Schleswig Sanitary District #2 (more commonly known as the "Wilke Lake Sanitary District" [WLSD]) was formed with the authority to control and manage aquatic plants. During 1981, the WLSD purchased an aquatic plant harvester, and a larger harvester was purchased to replace the smaller old one during 1993. The WLSD has maintained an aquatic plant management plan since 1981. The plan consists of harvesting and removing aquatic plants each week day for three to four months during the summer. This plan has allowed unrestricted recreational boating use on Wilke Lake without noticeably affecting the fish population. Removing aquatic plants from the lake prevents release of plant tissue nutrients during winter decomposition.

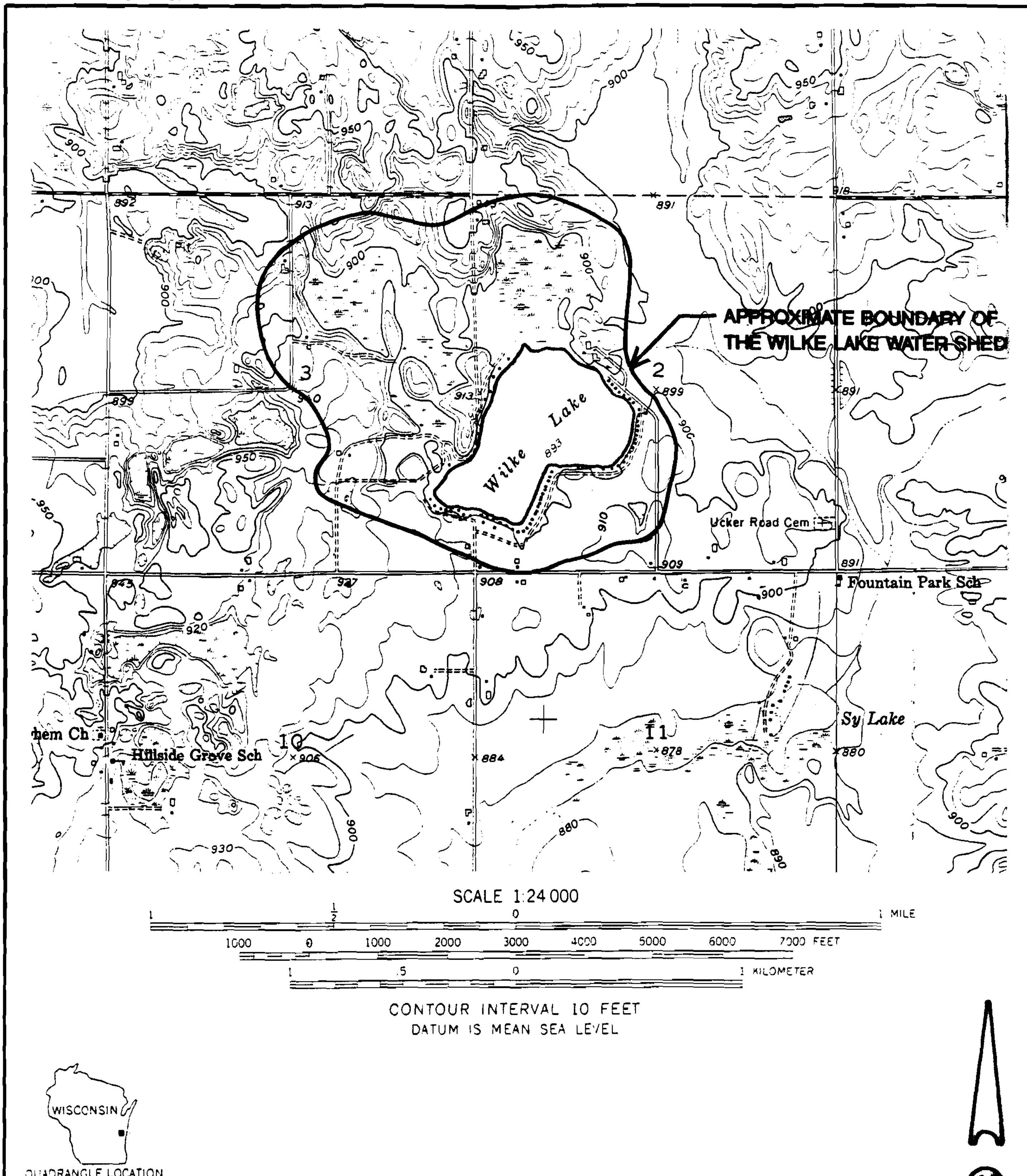
2.3 Workplan

During April 1992, the WLSD received a Lake Management Planning Grant from the WDNR. The grant was to be used to evaluate Wilke Lake's trophic state and Wilke Lake's watershed. An aquatic macrophyte survey was required to receive funding to purchase a new mechanical aquatic plant harvester.

Northern Environmental Technologies, Incorporated (Northern Environmental) cooperated with the WLSD to prepare the desired plan and was later contracted to complete the study. The objectives of the project are listed below.

- Evaluate physical and chemical characteristics of Wilke Lake
- Identify non-point source pollution in the Wilke Lake watershed
- Examine vegetation of Wilke Lake
- Evaluate sedimentation in Wilke Lake
- Conduct a public survey
- Produce a Lake Management Plan

This report summarizes the methods used to conduct the study, presents the results, discusses significance of the results, and provides a Lake Management Plan.



BASE MAP SOURCE: USGS SCHOOL HILL, WISCONSIN 7.5 MINUTE QUADRANGLE

REV.	PROJECT: WLS140529	DATE: 02/08/95	WILKE LAKE MANITOWOC, WISCONSIN
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▲ Northern Environmental Hydrologists • Engineers • Geologists			WILKE LAKE WATERSHED BOUNDARY

FIGURE 1

3.0 METHODS OF INVESTIGATION

A variety of methods were used to evaluate aquatic vegetation, water quality, and watershed characteristics. These methods are briefly discussed below, and are described in more detail in Appendix A.

3.1 Chemical and Physical Analyses

Northern Environmental personnel collected eleven water quality samples over a two-year period. Water samples were taken from the deepest portion of Wilke Lake, half way between the surface and the bottom. This site was selected so water samples could be taken while collecting physical data which requires evaluation of the entire water column at the deepest point of the lake. Chemical tests were performed to determine levels of nutrients, alkalinity, and algae. Dissolved oxygen content, temperature, conductivity, and transparency were measured to classify Wilke Lake's trophic state. All chemical tests were performed by the State Laboratory of Hygiene in Madison, with the exception of the February 1992 sample which was analyzed by National Environmental Testing, Incorporated.

3.2 Watershed Analysis

Wilke Lake's watershed was examined using topographic maps, the Sheboygan River Priority Project (SRPP), Soil Conservation Service soil surveys, meteorologic and hydrologic data, and computer modeling. Data was first examined and then field verified. A watershed survey was conducted to determine point source pollution, identifiable discharges and non-point source pollution, and agricultural runoff into Wilke Lake. A septic survey was also completed by the WLSD pertaining to sanitary sewage disposal systems and potable water sources of Wilke lake property owners.

3.3 Vegetation Surveys

Vegetation surveys were conducted to identify and evaluate the plant species present in Wilke Lake, the wetlands downstream of Wilke Lake, and the ground-water discharge wetland owned by the WDNR. The Wilke Lake vegetation survey was completed during the summer of 1992 while the wetland vegetation surveys were conducted during the Fall of 1994. Vegetation surveys are used to assess the quality and function of the lake system and the surrounding wetland systems. All species were identified to both genus and species level whenever possible.

3.4 Sediment Survey

During February 1992, the thickness of the soft sediments in Wilke Lake were measured. Samples were taken using a grid method and a sediment probe. Sediment surveys provide insight into a lake's past and future.

3.5 Public Opinion Survey

A public opinion survey was distributed to all Wilke Lake Advancement Association (WLAA) members to enumerate pertinent lake issues. Important issues expressed by WLAA members will be incorporated into the Lake Management Plan. Surveys were distributed and returned, and results compiled. Areas of specific concern were also examined in the field.

3.6 Lake Management Plan

A Lake Management Plan was created by comparing data and test results with public opinion. The result is a document which provides a guideline for managing Wilke Lake that will maximize public use without compromising the lake's natural integrity. Recommendations in the plan can be implemented to stabilize and protect water quality in Wilke Lake.

4.0 RESULTS

4.1 Chemical Characteristics

Chemical characteristics can be grouped into three categories: nutrients, alkalinity and pH, and chlorides. Results are found in Table 1. Nutrients include phosphorus and nitrogen, both of which are vital to microphyte (algae) and macrophyte (milfoil) plant growth. Chlorophyll a is also included with nutrients because it is a measure of algae content which is directly related to nutrient levels.

Concentrations of both soluble phosphorus and total phosphorus were determined. Average soluble phosphorus concentrations measured 0.003 milligrams per liter (mg/l). This average is well below the recommended soluble phosphorus level of 0.01 mg/l to prevent algae blooms. Total phosphorus results averaged 0.015 mg/l. Total phosphorus levels of 0.02 mg/l are considered average for natural lakes. Lakes with total phosphorus levels below 0.02 mg/l will generally not have nuisance algae blooms (Reference 3). Lakes with total phosphorus levels between 0.01 to 0.03 mg/l are considered to have good water quality.

Nitrogen levels were measured for ammonia-nitrogen, nitrate and nitrite, kjeldahl nitrogen, and total nitrogen. Ammonia-nitrogen concentrations averaged 0.053 mg/l. Nitrate and nitrite concentrations averaged 0.023 mg/l. Both ammonia and nitrate and nitrite nitrogen series are inorganic forms of nitrogen. If inorganic nitrogen levels are below 0.3 mg/l summer algae blooms are not likely. Kjeldahl nitrogen is an organic form of nitrogen and is used to quantify total nitrogen. Total nitrogen is calculated by adding nitrate and nitrite to kjeldahl nitrogen. Average concentrations of total nitrogen in Wilke Lake are 0.748 mg/l. Average concentrations for southeastern Wisconsin lakes are 1.43 mg/l (Reference 4).

Wilke Lake's total nitrogen to total phosphorus ratio is about 50:1. When the ratio is greater than 15:1, algae growth in the lake is considered phosphorus limited. When the ratio is below 10:1, nitrogen is the limiting nutrient for algae growth, values between 10:1 and 15:1 are considered transitional.

Chlorophyll a is a green pigment used by plants during photosynthesis. Concentrations of chlorophyll a are generally an indicator of the amount of algae in lake water. High levels correspond to summer and fall algae blooms. Winter algae blooms can also occur if solar input is sufficient through clear ice without snow cover. However, normal chlorophyll a levels for winter are low. Average chlorophyll a concentrations in Wilke Lake are 5.19 micrograms per liter (µg/l). Values of 10 µg/l or higher are associated with algae blooms. chlorophyll a readings between 5 and 10 µg/l indicate good water quality (Reference 3).

Alkalinity is one measure of the carbonate system in a lake. Alkalinity is represented by carbonate ($CO_3^{=}$) and bicarbonate (HCO_3^-). These compounds bond with calcium and/or magnesium. Alkalinity is usually measured by the amount of $CaCO_3$ (calcite) in the water. A high alkalinity reading translates into high hardness levels. Hardness relates to presence of soluble minerals in the lake. Northern Environmental water sample data indicates Wilke Lake has a alkalinity level of 176 mg/l. This means Wilke Lake is a hardwater lake. Hardwater lakes are less susceptible to acid rain and more biologically productive than soft water lakes.

Table 1 1992 - 1994 Water Quality Data, Wilke Lake, Manitowoc County, Wisconsin

	02/22/92	05/12/92	07/29/92	08/27/92	09/30/92	01/25/93	05/25/93	07/14/93	07/26/93	08/30/93	01/10/94	Minimum	Maximum	Mean
Depth of Sample (ft)	8.0	10.0	10.0	10.0	10.0	9.0	10.0	8.5	9.0	9.0	9.0			
Alkalinity (as $CaCO_3$) (mg/l)	190	185	152	150	149	185	177	174	177	184	216	149	216	176
Chloride (mg/l)	9.1	9.0	-	9.0	9.0	9.0	8.0	7.0	8.0	8.3	12.2	7.0	12.2	8.86
Chlorophyll a (µg/l)	-	7.00	-	5.04	4.48	2.91	6.26	5.83	7.30	5.58	3.79	2.91	7.3	5.19
Conductivity (umho's/cm)[2,4]	1126	368	313	304	306	391	359	351	354	365	435	304	435	355
Nitrogen-Ammonia (mg/l)[4]	-	0.015	ND	0.005	0.012	0.318	0.044	0.007	0.012	0.008	-	<0.005	0.318	0.053
Nitrogen-Nitrate & Nitrite (mg/l)	<0.2	0.016	ND	ND	ND	0.027	0.009	ND	ND	ND	0.041	<0.007	0.041	0.023
Nitrogen - Kjeldahl (mg/l)[4]	1.7	0.60	0.80	0.80	0.80	0.90	0.70	0.60	0.70	0.70	0.70	0.60	0.90	0.73
Total Nitrogen (mg/l)	-	0.616	-	-	-	0.927	0.709	-	-	-	0.741	0.616	.0927	0.748
Phosphorus - Total (mg/l)[4]	<0.5	0.009	-	0.018	0.015	0.008	0.021	0.016	0.016	0.016	0.015	0.008	0.021	0.015
Phosphorus - Soluable (mg/l)	<0.1	ND	0.002	-	0.005	0.006	0.004	0.003	ND	ND	-	0.002	0.006	0.004
pH (units)	8.11	8.72	8.95	7.21	9.13	8.04	8.47	8.51	8.59	8.65	8.29	7.21	9.13	8.1
Secchi disk (meters)[3]	-	2.0	1.2	1.8	2.3	-	2.4	2.3	3.3	3.1	-	1.2	3.3	2.3

NOTE:

- * = Sample analysis performed by National Environmental Testing, Inc.
- \- = No data available
- ND = Not detected, below respective laboratory detection limit
- 2 = Measured at 25.0°C
- 3 = An average of two measurements
- 4 = Average does not include 02/22/92 concentrations

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January 3, 1995

pH is an exponential index of hydrogen ion concentration used to measure acidity and is also related to the carbonate system. pH is represented on a logarithmic scale from 1 to 14, 7 being neutral. Readings above seven have less hydrogen ions and are basic (alkaline), readings below seven have less hydrogen ions and are considered acidic. Wilke Lake has an average pH reading of 8.4, classifying it as an alkaline or hardwater lake. Most lakes have a pH between six and nine (Reference 5).

The presence of high chloride levels usually indicated human pollutants like road salt, fertilizers, septic systems, and animal wastes. Chloride concentrations of 50 to 100 mg/l are usually associated with septic effluent (Reference 3). The world chloride average for lakes and streams is 7.8 mg/l (Reference 5). The geographic distribution of natural chloride from limestone deposits for Wisconsin indicates Manitowoc County averages about 10 mg/l of chloride in surface waters (Reference 3). Wilke Lake has an average chloride concentration of 8.86 mg/l. The chloride concentrations in Wilke Lake do not reveal human influences and can be considered normal.

4.2 Physical Characteristics

Physical characteristics include dissolved oxygen content, temperature, specific conductance, and transparency. Physical characteristics were measured and analyzed to determine the trophic state of Wilke Lake.

Dissolved oxygen is the amount of gaseous oxygen in water. The degree of gaseous solubility is dependent on water temperature, atmospheric pressure, and water salinity. Cold water holds more dissolved oxygen than warm water. Dissolved oxygen is also affected by a lake's biological productivity. Green plants produce oxygen but decomposition and respiration use oxygen. Low levels of dissolved oxygen can cause winter fish kills because winter ice does not allow the air to water oxygen transfer or the photosynthetic oxygen production to balance the loss of oxygen from winter decomposition of organic matter and winter biologic activity. The WDNR water quality standard for warm water lakes is 5 mg/l of dissolved oxygen and 7 mg/l of dissolved oxygen for trout waters. These standards are the minimum amount of oxygen required to maintain a healthy fish population. Sufficient dissolved oxygen levels were recorded to an average depth of 14.4 feet in summer months to support warm water fish. Sufficient dissolved oxygen levels for warm water fish during winter months were observed to an average depth of 12.5 feet. Dissolved oxygen profiles are presented in Table 2.

Temperature profiles for Wilke Lake are presented in Table 3. Water temperature is related to climate, wind patterns, dissolved oxygen content, solubility rates, and chemical reactions. Water temperatures vary with depth. When there is little variation of temperature in the water column, a lake is termed mixed. When temperatures vary from the surface to the bottom, the lake is thermally stratified. Wilke Lake is a dimictic lake that thermally stratifies. Thermal stratification often breaks down in summer, resulting in mixing. A dimictic lake is one that has winter ice and mixes in spring and fall. During summer, thermally stratified lakes have three temperature zone associated with different depths: epilimnion (warm surface layer), metalimnion (transition layer), and hypolimnion (cold bottom layer). Thermal stratification occurs due to differences in water density associated with temperature. During winter, thermal stratification occurs and warmer (39°F) more dense water sinks to the bottom and colder (32 to 38°F) less dense water stays at the surface under a layer of ice (Table 3, profiles 1/25/93 and 1/10/94). Mixing occurs in spring and fall when the ice breaks up and when

Table 2
Dissolved Oxygen Profile

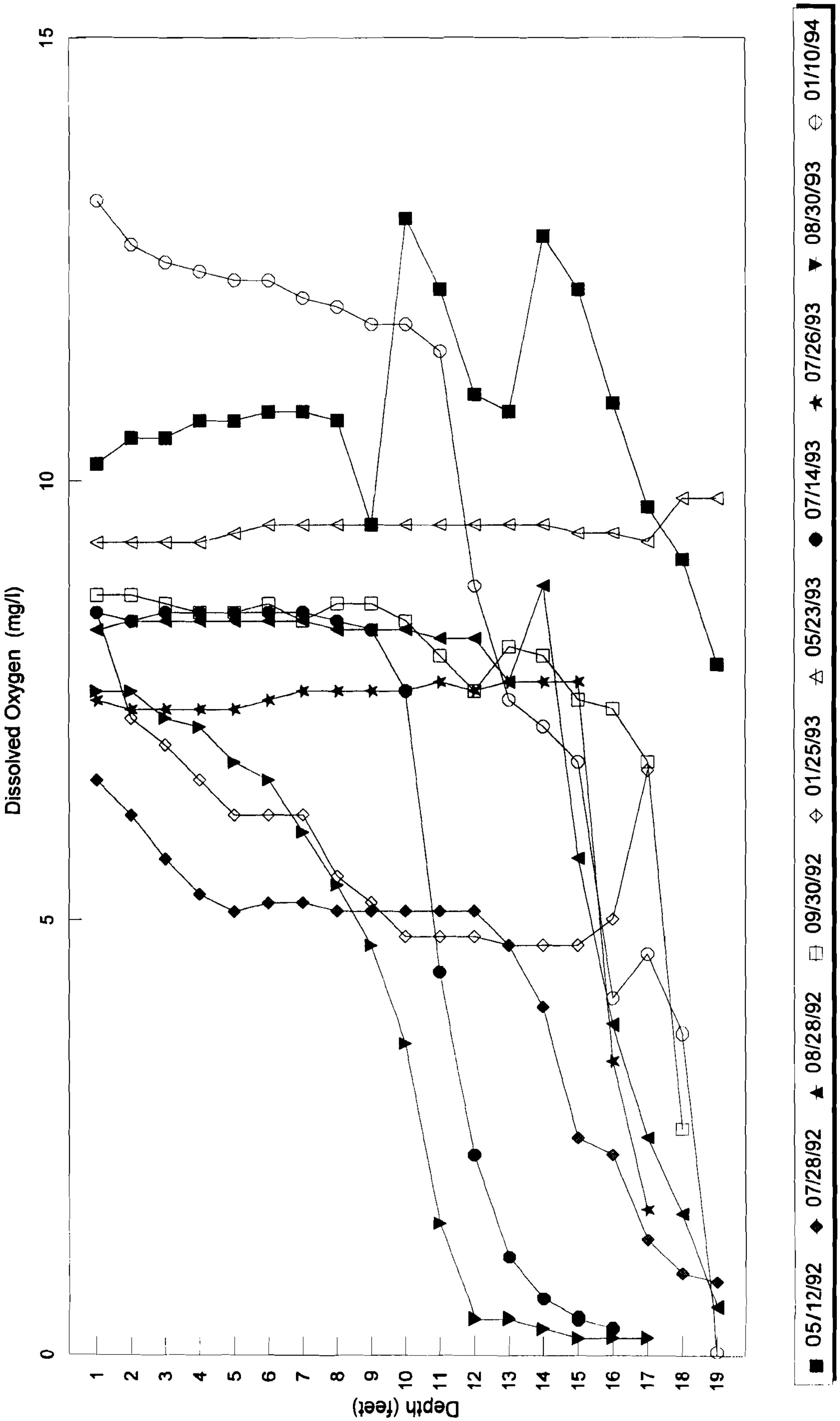
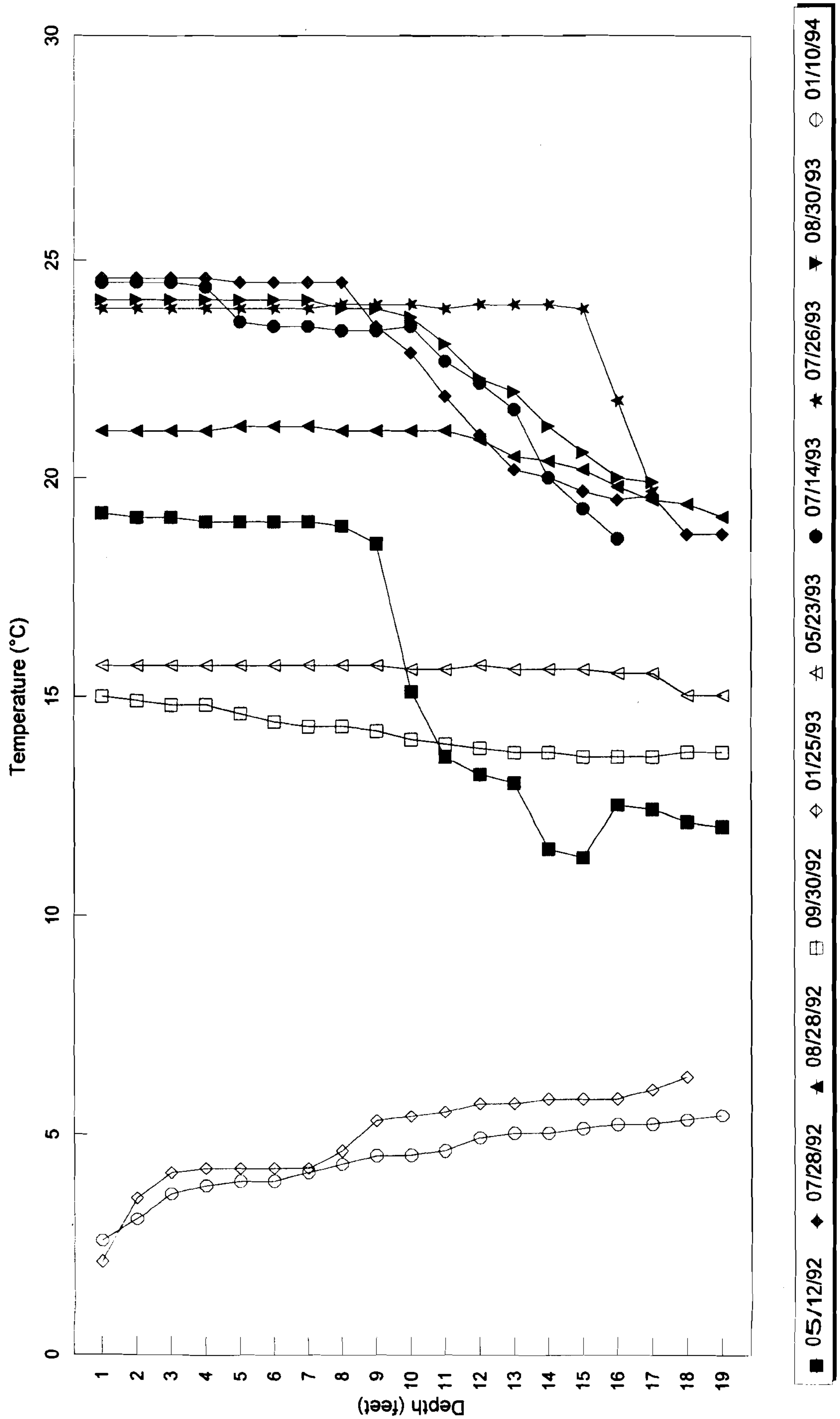


Table 3
Temperature Profile



summer stratification breaks down. Both mixing events are closely related to local weather and solar input warming and cooling the lake water.

Because Wilke Lake has a maximum depth of 20 feet, it can be considered a shallow lake system. Shallow lake systems sometimes mix during summer when wind and wave action are enough to temporarily break down summer thermal stratification. Summer mixing can contribute to algae blooms. Shallow lake systems are generally more productive than deep lake systems. The lower portion of the hypolimnion is often anoxic (void of oxygen). Bottom sediments in an anoxic environment will release phosphorous into the water column. Summer mixing results in increased nutrient availability for algae. A similar occurrence is associated with normal spring and fall mixing.

Specific conductance or conductivity is used to quantify the amount of dissolved inorganic chemicals in a lake. Generally, lakes with high conductivity readings are eutrophic (fertile and productive). Conductivity readings are commonly twice the alkalinity levels (Reference 3). Wilke Lake's average conductivity reading for the two year sample period was 355 μohms/cm. Since 352 μohms/cm is about twice the alkalinity value, 355 μohms/cm can be considered normal and not suspect of receiving large quantities of human contaminants. Septic affluent and fertilizers are common human pollutants which can cause high conductivity readings.

Transparency is a function water color and turbidity and is measured by recording secchi disk depths. A secchi disk is a circular plate painted with alternating quadrants of black and white. Depths are recorded when an observer can no longer see the secchi disk as it is lowered from the surface and when it reappears as it is raised to the surface. The two measurements are averaged to give a reading. The deeper the secchi disk reading, the better the water clarity. High algae content in the water usually accounts for shallow secchi disk readings. The average secchi disk reading for Wilke Lake during the sample period is 7.5 feet (2.3 meters), and indicates good water quality and clarity.

Total phosphorous, chlorophyll a, and secchi disk depths are used to classify a lake's trophic state. A trophic state is an indicator of water quality. Wilke Lake's average total phosphorous level was 0.015 mg/l, average chlorophyll a reading was 5.19 μg/l, and average secchi disk depth was 7.5 feet. These three parameters, along with professional judgement, place Wilke Lake in the mesotrophic class of trophic states (Reference 3). Mesotrophic lakes have occasional algae blooms, medium productivity, sediment/phosphorous cycling, accumulated organic matter, fair to good water quality, and good fisheries.

4.3 Watershed Analysis

The Wilke Lake watershed is approximately 467 acres with a watershed to lake ratio of 5:1 (Figure 1). Approximately 59 percent of the watershed is agricultural cropland. The remaining 41 percent of the watershed is comprised of wetlands (17 percent), grasslands (16 percent), residential/farmstead (7 percent), and developing lands (1 percent).

The watershed was examined as part of the 1990 Sheboygan River Priority Project (SRPP) (Reference 6). The SRPP was started to help improve and protect the water quality of the streams, lakes, wetlands, and ground water within the Sheboygan River watershed and subwatersheds. The project included an inventory of all land uses, the severity of nonpoint pollution sources impacting water quality, and levels of nonpoint source pollution control.

Nonpoint pollution sources of upland sediment, originating from the overland flow of water on fields and soil loss within the Wilke Lake subwatershed, were estimated using the WDNR's Wisconsin Nonpoint model (WIN). Based upon the WIN model, approximately 1,506 tons/year of soil erode annually from the fields within the Wilke Lake watershed. Approximately 45 tons/year of sediment actually reach and enter Wilke Lake.

This means about 97 percent of the eroded soil in the watershed does not reach Wilke Lake. Most of the eroded soil is trapped in grasslands, woodlands, and wetlands. These areas are excellent natural filters. Important sensitive areas in Wilke Lake's watershed include the Cedar-Tamarack swamp adjacent to Wilke Lake and another large swamp/marsh complex on the western shore of Wilke Lake. Both wetland complexes have steep slopes (Reference 7).

Over ninety septic surveys were returned by Wilke Lake residents. A copy of the survey can be found in Appendix B. Results indicate most homeowners have wells on their properties. Also, 63 percent of residents have septic tank systems, 30 percent have a holding tank system, and 7 percent have outdoor privies. The average age of septic systems is 16 years, the average age of holding tanks is 5 years. Many residents voiced concern that the small depressional wetland on the Rabe farm is a source of pollution. Farm and barnyard run-off flow into the wetland and water levels rise in spring until it discharges over the road into Wilke Lake. Problems associated with the Rabe farm wetland were resolved by implementing BMPs funded by the SRPP. Respondents were also concerned with some of the outdoor privies around the lake. However, for the most part, they are only used for emergencies.

4.4 Vegetation Surveys

The vegetation of Wilke Lake, the Cedar-Tamarack wetland, and the Wilke Lake outlet wetland were surveyed. The results of this survey are listed in Appendix C. Wilke Lake exhibits low species diversity and high productivity (Reference 8). A total of 13 plants were identified, 10 to the species level (References 9, 10, 11). The most abundant genus is Myriophyllum (milfoil). Milfoil was present at 88 percent of the sample points. Milfoil was found growing at a maximum depth of 18 feet, no other plants were observed growing below 11 feet. The growth patterns and population levels suggest that this milfoil is non-native Eurasian milfoil. Eurasian milfoil provides fish cover and supports insects for food, but does not provide much value for wildlife. Chara spp. and Najas flexillis were the second and third most abundant species occurring at 44 percent and 20 percent of the sample points, respectively. These two species are beneficial to wildlife as food, but have little value for fish. In general, the aquatic plant communities of Wilke Lake are fair food sources for wildlife and benefit fish by providing food, cover, and spawning habitat. However, the large monotypic aquatic vegetation bed of Eurasian milfoil destabilizes the food chain. Since the aquatic management plan was established, Milfoil populations have stabilized if not reduced. One result of aquatic plant removal is decreased nutrient cycling from decaying plant materials.

The Cedar-Tamarack swamp vegetation survey revealed one of the major sources of water for the lake. A complete list of plants in the Cedar-Tamarack swamp is found in Appendix C. The large swamp receives water from surface flows, precipitation, and ground water. Several ground-water indicator plant species were observed growing in the wetland. Immediately along the shore, a sedge meadow complex has formed as water from the swamp enters the lake. Growing in the sedge meadow are both Muhlenbergia glomerata (Wild timothy), and Scirpus acutus (Hard-stem bulrush). Wild timothy and Hard-stem bulrush are commonly associated with ground-water discharges (Reference 12). Numerous trails were also observed indicating heavy use by deer. This wetland is important wildlife habitat.

The Wilke Lake outlet wetland is an impacted wetland. The community is dominated by Phalaris arundinacea (Reed canary grass). Reed canary grass is a non-native plant specie that forms monotypic stands in disturbed areas. This decreases diversity and lowers overall habitat quality. The natural flow out of Wilke Lake has been altered and the channel through the fresh (wet) meadow outlet wetland has been straightened. These and other activities probably caused the disturbances which led to Reed canary grass dominance.

No federal or state-designated threatened or endangered species were observed during the vegetation surveys.

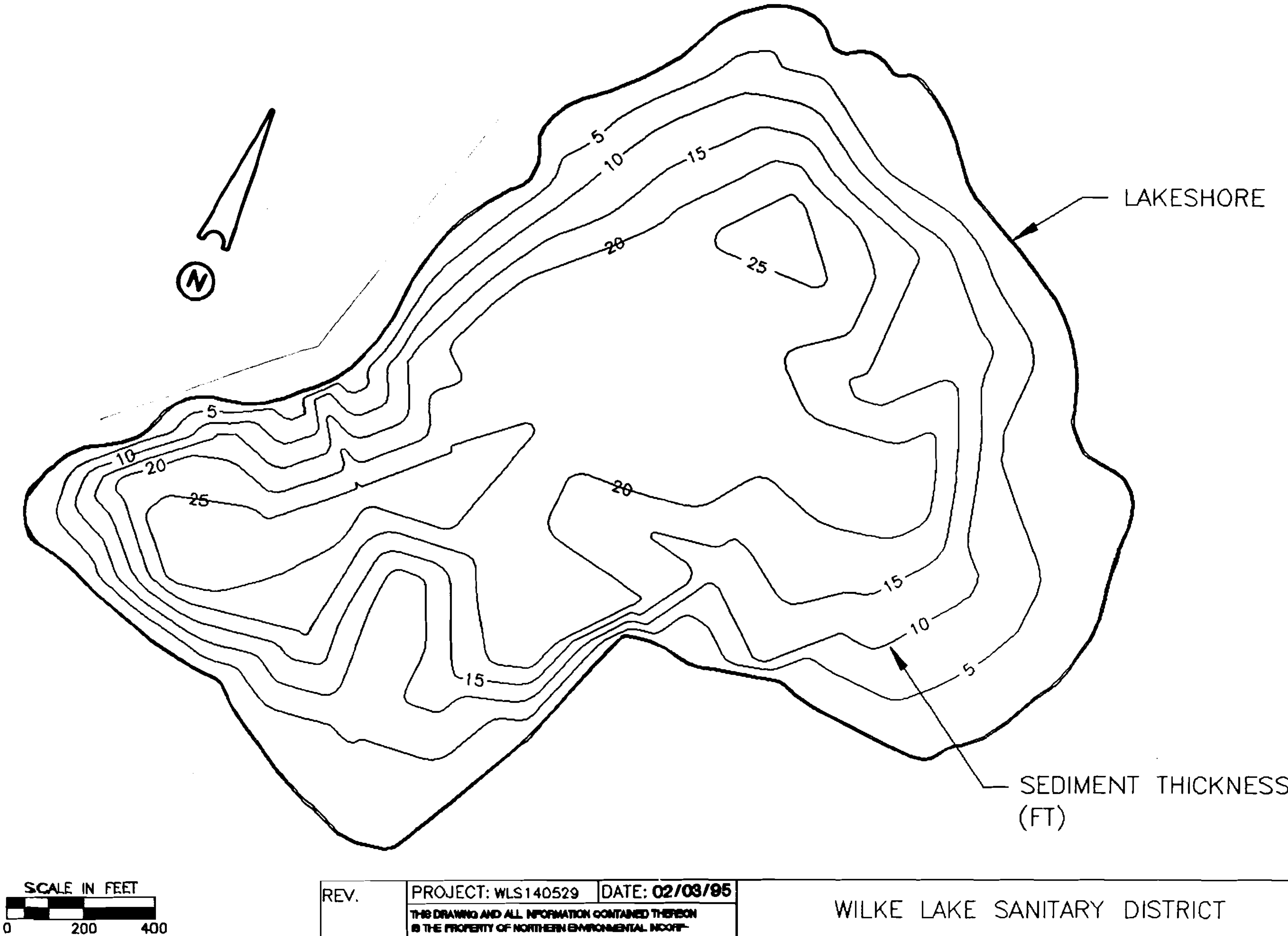
4.5 Sediment Survey

During February 1992, Northern Environmental examined sediment thickness within the lake basin. Sixty sample points were established and data recorded for each. Sediment maps were created with the aid of the Surfer-Version 4 computer model (Figure 2). A maximum thickness of 28 feet of soft sediment was measured, with a mean of 16.6 feet. Approximately 3.2 million cubic yards of soft sediment are estimated to have accumulated in the Wilke Lake basin. The WDNR cancelled the prescribed chemical analysis of sediment cores due to high testing costs.

Approximately 90 percent of the bottom of Wilke Lake is covered with muck. The remaining 10 percent is covered with sand and gravel. The sand and gravel, along with some glacial boulders, probably constitutes the original lake bottom. The muck is consistent with the mesotrophic classification of Wilke Lake. Mesotrophic lakes have medium to high levels of productivity which produces biomass. This biomass is deposited annually on the lake bottom, and accumulates over time, changing a lake's trophic state. Additional sedimentation is caused by changes in land use over the past 150 years, from native presettlement vegetation to agriculture. The natural succession of the lake is from oligitrophic to eutrophic. However, this natural process can be accelerated through human influences.

4.6 Public Opinion Survey

During 1992, an opinion survey was distributed to the members of the Wilke Lake Advancement Association. A total of 24 surveys were returned, representing about 25 percent of the waterfront owners. The most important findings of the survey are presented below. A sample survey and complete results are found in Appendix D.



REV.	PROJECT: WLS140529	DATE: 02/03/95	WILKE LAKE SANITARY DISTRICT
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▲ Northern Environmental Hydrologists · Engineers · Geologists			

FIGURE 2

- ▲ Areas of Concern
  - Nuisance aquatic vegetation
  - Degraded lake water quality

- ▲ Perceived Water Quality
  - 76 percent considered Wilke Lake clear
  - 50 percent define the water quality as good

- ▲ The Rabe farm at the south end of Wilke Lake was identified as a potential pollution source

- ▲ Actions to be Taken
  - Develop long-term management plan
  - Stock fish
  - Strengthen the WLAA

- ▲ Responsibilities
  - 50 percent of respondents felt the WLSD and/or the WLAA are responsible for lake management
  - 30 percent felt it is the State's responsibility to manage the lake
  - 42 percent felt the WLSD and/or the WLAA are financially responsible for management
  - 30 percent felt the State was financially responsible for management

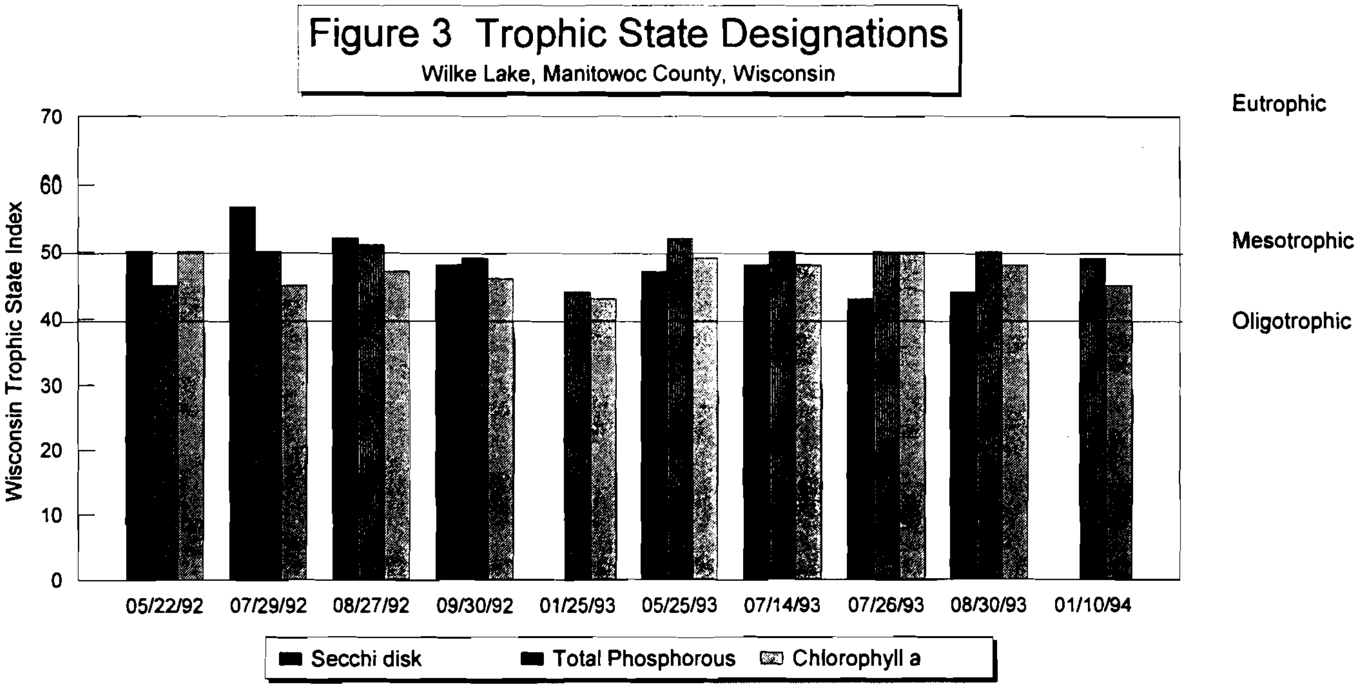
Generally, the members of the WLAA feel their lake has fair to good water quality, an aquatic vegetation problem, and needs a long-term Lake Management Plan to address these and other issues effecting Wilke Lake.

5.0 CONCLUSIONS

Wilke Lake's physical and chemical characteristics indicate that water quality was good during the 1992 to 1994 study. This shows improvement from the water quality data collected during the 1970s. Average values for nutrient concentrations are below levels which would indicate algae blooms. Phosphorous and nitrogen levels support improvements of Wilke Lake's water quality. However, Wilke Lake does experience occasional algae blooms. The location of some of these blooms support the theory that the excess nutrients are coming from drainage systems draining a wetland area between Wilke Lake and Ucker Point Creek Road. Normally, a wetland area would act as a nutrient sink, absorbing and transforming nutrients. When draining a wetland, nutrients are released directly into Wilke Lake. Nutrient sources may include agricultural run off and road run off containing nitrogen, phosphorous, and chlorides. Wetland loss, due to draining, enhances cultural eutrophication. Residential stormwater, agricultural run off, road way run off, increases in impervious land area, septic leachate, sedimentation, and even recreation can contribute to cultural eutrophication.

The amount of nutrients and sediments entering Wilke Lake has increased from cultural influences. A watershed once consisting of mature conifer-hardwood forests is now almost 60 percent cropland. An undeveloped natural pre-settlement shoreline is now 90 percent developed. Sixty percent of homeowners have sanitary sewage systems which drain into septic fields and then into Wilke Lake. These conditions, along with a Eurasian milfoil problem, augment the normally high levels of productivity associated with a shallow dimictic lake that is mesotrophic and located in southeastern Wisconsin. Wilke Lake has total phosphorous levels, secchi disk depths, and chlorophyll a levels which place it in the mesotrophic category of the trophic classification scheme (Figure 3). This trophic state has changed since 1972 when Wilke Lake was classed eutrophic (Reference 1).

Improved water quality can be connected to the harvesting and removing of nutrient rich Eurasian milfoil biomass. Harvesting also improves perceived water quality because aquatic plants are less visible and the aesthetics are increased. However, continued harvesting will only provide short term relief from the aquatic macrophyte problem. More long-term management strategies include dredging, water level drawdown, shading/sediment covers, and biologic controls. Dredging and shading/sediment covers are both expensive management methods, costing between $1,000.00 and $10,000.00 per acre not including dredge disposal costs or cover application costs (Reference 13). Negative impacts of dredging include site disposal problems related to discharging nutrient rich sediment which may contain heavy metals and other toxic compounds. Prior to dredging, chemical analysis of the sediment should be done which can be costly. Chemical composition of sediments can cause increased disposal costs. Even though sediment covers are costly, they have few negative impacts. Sediment covers are natural or synthetic barriers which limit light from reaching sediments and prevent plants from rooting. Temporary damage to benthic invertebrates is unavoidable. Other aquatic management techniques include drawdowns and biologic controls. Water level drawdowns are effective for aquatic plant control, but they are based on exposing large areas of lake bed along the shore. Many residents would be opposed to this based on aesthetics and limits placed on recreation. Drawdowns need to occur during successive freezing and drying periods which cause damage to the plants, and their roots and seeds. Biologic controls using the aggressive grass carp are prohibited in Wisconsin and aquatic insects are restricted to warm weather southern lakes. It can be concluded that drawdowns and biologic controls would not be effective management techniques for Wilke Lake.



Trophic Category Descriptions

Category *	WTSI	Lake Characteristics
Oligotrophic	1-40	Clear water; oxygen rich at all depths, except if close to mesotrophic border; then may have low or no oxygen; cold-water fish likely in deeper lakes.
Mesotrophic	41-50	Moderately clear; increasing probability of low to no oxygen in bottom waters.
Eutrophic	51-70	Decreased water clarity; probably no oxygen in bottom waters during summer, warm-water fisheries only; blue-green algae likely in summer in upper range; plants also excessive.
Hyper-Eutrophic	70-100	Heavy algal blooms throughout the summer; if >80, fish kills likely in summer and rough fish dominate.

WLS140529.figure4
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An experimental sediment cover plan should be implemented. Covers could be applied to areas in the lake where milfoil investigation is heaviest (the center of the lake) or in boat traffic lanes around the lake (around the edges of infested areas). There are no disposal requirements or aesthetic impacts associated with sediment covers. Small areas should be selected for application and monitored for success. Following monitoring, an assessment should be completed to determine the long-term feasibility of this aquatic plant management technique for Wilke Lake. A polypropyl material, trade name Typar, costs about $3,500.00 an acre, has a low application difficulty rating, and is considered effective (Reference 13).

Wetlands serve as open spaces which increase the aesthetics or natural beauty of a lake, many public survey respondents indicated that peace and tranquility are very important to lake front owners. To assure that present levels of wildlife, water quality, and aesthetics are maintained, steps should be taken to preserve the large wetland to the west of Wilke Lake. These wetland sensitive areas act as natural buffers to human activities and impacts. The wetlands around Wilke Lake are the main source of the water in Wilke Lake and filter sediments and nutrients from runoff that enters Wilke Lake.

Achieving stability and improving water quality can be accomplished by implementing the recommended Lake Management Plan. Not all of the recommendations need to be implemented, but all of them will provide benefits for the lake and for the community.

6.0 RECOMMENDATIONS: LAKE MANAGEMENT PLAN

Lake planning should be recommended in a Lake Management Plan (Figure 4). Creating a long-term management plan is also important to Wilke Lake Advancement Association members, as expressed in the public opinion survey. Management recommendations take into account effectiveness, negative impacts, and costs. Effectiveness relates to longevity of the management technique, probability of success, and whether or not the technique addresses the cause of the problem or the effect of the problem. Management techniques are divided into watershed management and in-lake management techniques (Reference 13). Watershed management techniques focus on watershed wide issues such as agricultural and rural point and non-point source pollutants. In-lake management techniques focus on lake physical issues like nuisance aquatic plants, algal blooms, and fisheries; and policy issues like recreational uses and zoning ordinances.

6.1 Watershed Management Techniques

Continuing and increasing use of Best Management Practices (BMP) in the Wilke Lake watershed are the most effective methods for controlling non-point source pollutants. Implementation costs vary greatly between management techniques, however, most are eligible for cost-sharing under WDNR: NR 120. A cost analysis of BMPs can be found in Table 4 (Reference 6).

Preserving the unprotected western wetland area in the Wilke Lake watershed will allow this wetland to continue acting as a buffer for Wilke Lake from human activities. If this wetland is a ground-water discharge wetland, then loss or deterioration of this system may result in changes in the water quality of Wilke Lake. Developing the steep slopes around the wetland would also have negative effects on water quality. Costs to purchase the property in the name of the WLSD would be substantially greater than having the property owner transfer ownership in the form of a preservation easement to the WDNR or the Nature Conservancy. Another option is to zone the land as conservancy so that the land is taxed less and the owner has less incentive to develop the land. Purchasing this wetland would be eligible for 50% project funding up to $100,000.00 under the WDNR Lake Protection Grants. A wetland assessment could be performed to determine the exact size and functional values of the wetland. This assessment would be used to supplement the application for the grant. Because this wetland provides protection of water quality, compliments BMPs in the watershed, and protects the natural ecosystem, this project is a good candidate for a grant. The 1994-95 fiscal budget for this grant program is over $1.3 million (Reference 14).

A WDNR publication titled *Life on the Edge...Owning Waterfront Property* should be distributed to all Wilke Lake home owners. This publication describes in layman terms issues and regulations regarding purchasing and owning waterfront property. It also provides information on improving shoreline habitat and water quality for new and existing homes. At a cost of about $5.00 per publication, all lake home owners could receive a copy for about $500.00.

6.2 In-Lake Management Techniques

Mechanical harvesting of aquatic plants (i.e., Milfoil) should continue. Harvesting reduces the amount of nutrients being recycled in the lake over winter. This management technique provides only a temporary solution to the aquatic plant problem. One goal of continuing this

FIGURE # 4

LAKE MANAGEMENT PLAN

I. WATERSHED MANAGEMENT TECHNIQUES

IMPLEMENT BEST MANAGEMENT PRACTICES

PRESERVE WEST WETLAND AREA

DISTRIBUTE EDUCATIONAL MATERIALS: "LIFE ON THE EDGE" (WDNR PUBLICATION)

II. IN-LAKE MANAGEMENT TECHNIQUES

PHYSICAL:

CONTINUE HARVESTING AQUATIC PLANTS

EXPERIMENTAL SEDIMENT COVERS

CREATE FISH MANAGEMENT PLAN: SURVEY & ASSESSMENT

ANALYZE SEDIMENT

ENHANCE WETLAND: PLUG DRAIN TILES & SELECTIVE PLANTINGS

APPOINT A VOLUNTEER TO MONITOR WILKE LAKE'S PHYSICAL PARAMETERS

IMPROVE SWIM AREAS: PEA GRAVEL BLANKETS (WDNR PERMITS)

CREATE BOAT TRAFFIC LANES WITH BUOYS

POLICY:

FORM RECREATIONAL USE COMMITTEE

FORM EXOTIC SPECIES CONTROL COMMITTEE

CREATE ZONING COMMITTEE