Pine Lake Protection and Rehabilitation District

Limnological Study of

Pine Lake, Forest County

April 1992 - March 1993

Prepared by :

Northern Lake Service, Inc.

400 North Lake Avenue

Crandon, WI 54520

July 2, 1993

WISCONSIN
DEPT. OF NATURAL RESOURCES
George E. Meyer
Secretary

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

North Central District Headquarters
Box 818
Rhinelander, Wisconsin 54501
TELEPHONE 715-369-8900
TELEFAX 715-369-8932

August 31, 1994

Donald M. Metten
4402 Sixth Avenue
Kenosha, WI 54130

Dear Mr. Metten:

Thank you for sending copies of the Pine Lake planning grant final report. I am in the process of reviewing the report in order to close out your grant with the Department, and so you can receive the final state payment.

To accept the report, I check to see if all of the activities promised to be completed in the grant application were in fact completed and included in the final report. In the case of your final report, it looks complete with the exception of the General Shoreline Survey component of the study. According to your application, this was to include "NLS and lake district personnel to identify areas where septic system or surface run-off problems are likely".

Was the shoreline survey completed? If so, the results of the survey need to be included in the final report. If not, it will need to be addressed in a statement from you or your consultant which I can include as an addendum to the final report. The statement should explain why the survey was not performed as stated in the January 10, 1992 letter to you from Northern Lake Service, Inc.

Another option for you if the survey was not done would be to complete the survey at your convenience and submit a report which would serve as an addendum to the original report.

Please let me know how you would like to proceed. I'd be glad to discuss this by phone also, if you would like to get more information.

Again, thank you for completing the project and sending the reports. I hope you found the project beneficial to Pine Lake and it's residents.

Sincerely,

RDY

Robert D. Young
District Lake Management Coordinator

cc: Carroll Schaal, WR/2

NORTHERN LAKE SERVICE, INC.
Analytical Laboratory and Environmental Services

June 15, 1995

Mr. Robert Young
Wisconsin Department of Natural Resources
Box 818
Rhinelander, WI 54501

Dear Bob,

Enclosed is a copy of the shoreline survey of Pine Lake. I've also sent one to Don Metten to be attached to the report at his end.

If you have any questions or comments on the survey please give me a call.

Sincerely,

R.T. Krueger
Limnologist
Northern Lake Service, Inc.

400 North Lake Avenue • Crandon, WI 54520 • (715) 478-2777 • FAX: (715) 478-3060

Pine Lake Shoreline Survey

Performed 6/9/95 by R.T. Krueger & Mike Macauley

Northern Lake Service, Crandon, WI

(Numbers correspond to numbered points on the lake map.)

(1) First 100 or so yards north from the boat landing is undeveloped with all natural vegetation.

(2) Next is a series of properties with beaches or lawns to the shorelines. These areas are separated by small areas of natural vegetation.

(3) Six small cottages, very low and very close together, most of them are very close to the shore. These have lawns with no buffer zones.

(4) Several large dwellings with greater setbacks and beach shoreline.

(5) Five small dwellings very close to shore with beach shoreline. Some minor erosion problems are evident in this area.

(6) Five dwellings with better set back and moderate buffer zones at the shoreline.

(7) Three dwellings close to the water with lawns to the shore. Also some back development behind them.

(8) Approximately 100 yards of beach and lawn with trailer park approximately 100 ft. from shore.

(9) Three dwellings with lawn and natural vegetation - thick water lily growth could possibly be due to nutrient loading in this area.

(10) Several 100 yards of naturally vegetated, swampy shoreline with extensive macrophyte growth extending far into the lake. This area should be protected as a natural area for wildlife and a

nutrient sink for the inlet.

(11) Steeper shore - some dwellings with buffer zones some without

(12) Several small dwellings close to the shore on a more gradual slope - some with buffer zones some without

(13) Two large dwellings close to shore with natural vegetation between.

(14) Slightly steeper slope; dwellings mostly close to the water but with buffer zones. More large trees were left in this area.

(15) Twenty-five small cottages low to the water and close to shore. Most have open lawns to the shoreline. Residents should be encouraged protect the bulrushes by only using boats in the established paths. This area is broken up by a natural area approximately 200 feet long.

(16) Six dwellings on a much steeper slope with natural vegetation. Very nice aesthetically. One place appears to be a cottage built on top of a boat house.

(17) Twenty to 30 dwellings on a moderate slope, most with natural vegetation in front and between. Some without buffer zones.

(18) Six dwellings with narrow strips of lawn to the shore and approximately 200 feet of natural vegetation between each.

(19) Four dwellings with lawn to the shore. Some apparent erosion problems.

(20) Four dwellings with a bit more natural vegetation - but more should be encouraged.

(21) Huge lawn extending to the shore.

(22) Five dwellings very close to the water and very low.

(23) Approximately 100 yards of natural vegetation.

(24) Ten to 12 dwellings with lawns but many more large trees.

(25) Six dwellings with mostly natural vegetation and good buffer zones where there are lawns.

(26) Several dwellings with boat houses and lawns without buffer zones.

(27) Four dwellings with good set backs and mostly natural vegetation.

(28) Beach

(29) Several dwellings on steep rocky terrain with mostly natural vegetation.

(30) Six to 10 dwellings approximately 10 feet above the water, mostly with lawns extending to the shore.

(31) Six dwellings with some natural vegetation but buffer strips should be wider.

(32) Five dwellings with lawns to the water and many outbuildings. Also many large trees left in the yards.

(33) Seven dwellings very low to the water and close to the shore, mostly with open lawns to the shore.

(34) Outlet and then approximately 200 yards of swampy natural shoreline.

(35) Three large dwellings with lawns to the shore and a few trees.

(36) Many dwellings mostly with yards and some trees. This area is split in half by about 100 yards of natural vegetation.

(37) Six dwellings about 75 feet apart and close to the water on a relatively steep slope, but with good buffer zones at the shoreline.

(38) Seven dwellings (two mobile homes) low to the water with

yards to the shore and very few trees.

(39) Several dwelling with a mixture of natural vegetation, buffer strips and yards.

(40) Approximately 100 yards of natural, undeveloped shoreline.

(41) Five dwellings very close together - some with buffer zones, some without.

(42) Five dwellings on a steep slope but set back farther and with mostly natural vegetation.

(43) Large dwelling very close to the water with a large patio which probably contributes a lot of runoff to the lake.

(44) Natural shoreline

(45) Four or five dwellings with decent setbacks and mostly natural vegetation.

Recommendations: All residents should be encouraged to maintain a strip of natural vegetation or buffer zone along the shoreline. This strip slows runoff, absorbs nutrients, helps control erosion and improves aesthetics.

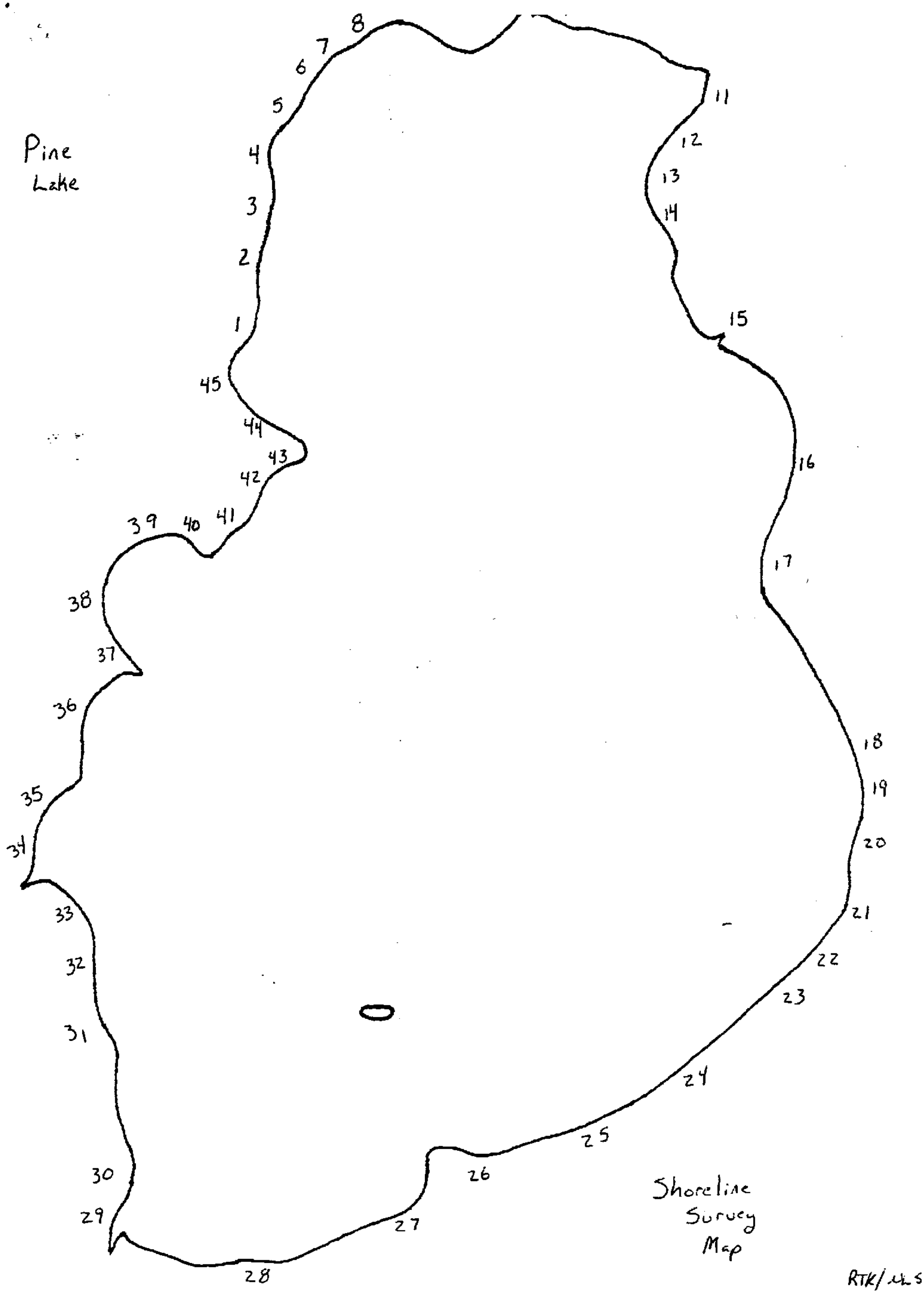
Terracing and other landscaping should be used on steeper slopes to control erosion. Special attention should be given to construction sites to slow erosion.

Patios, driveways, and roofs speed runoff so excessive development near the shore should be discouraged.

Larger trees left in yards can reduce erosion and runoff.

Longer setbacks should be encouraged for new construction.

Septic performance and failure symptoms such as pooling should be carefully monitored, especially in areas very close to lake level.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Shoreline Survey Map
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Introduction

The following is a description of and results from the planning-grant study of Pine Lake performed by Northern Lake Service between April 1992 and March 1993. The purpose of this study was to determine current water quality for comparison to past and future data and provide a basis for recommending improvement/preservation strategies.

Pine Lake is a 1670 acre, seepage lake located in west central Forest County (Sec.22, R12E, T37N). It has a maximum depth of 14 feet, 6.42 miles of shoreline and watershed of 14.0 miles. (From Surface Water Resources of Forest County WDNR- 1977.) The shoreline is quite heavily developed, with approximately 150 dwellings.

Study

This study consisted of five visits to the lake - 3 during open water and 2 during the winter. On the open-water trips, a water sample was collected at approximately the deepest point in the lake using a two-meter PVC sampler. The sample was dispensed into sample bottles with appropriate preservative and iced for transport to the laboratory. A portion of the sample was used for pH and conductivity determination which was done on site. Dissolved oxygen/temperature profiles were also generated and secchi disc visibility measured at the sample site. These activities were done May 5, July 30, November 11,1992. During the July 30 sampling, a general macrophyte survey was performed. For a description of this survey see appendix A.

Samples were analyzed by Northern Lake Service for alkalinity, chloride, chlorophyll α, nitrogen (Kjeldahl, ammonia, and nitrate + nitrite) and phosphorus. These parameters are described on the following pages and all data can be found in appendix B.

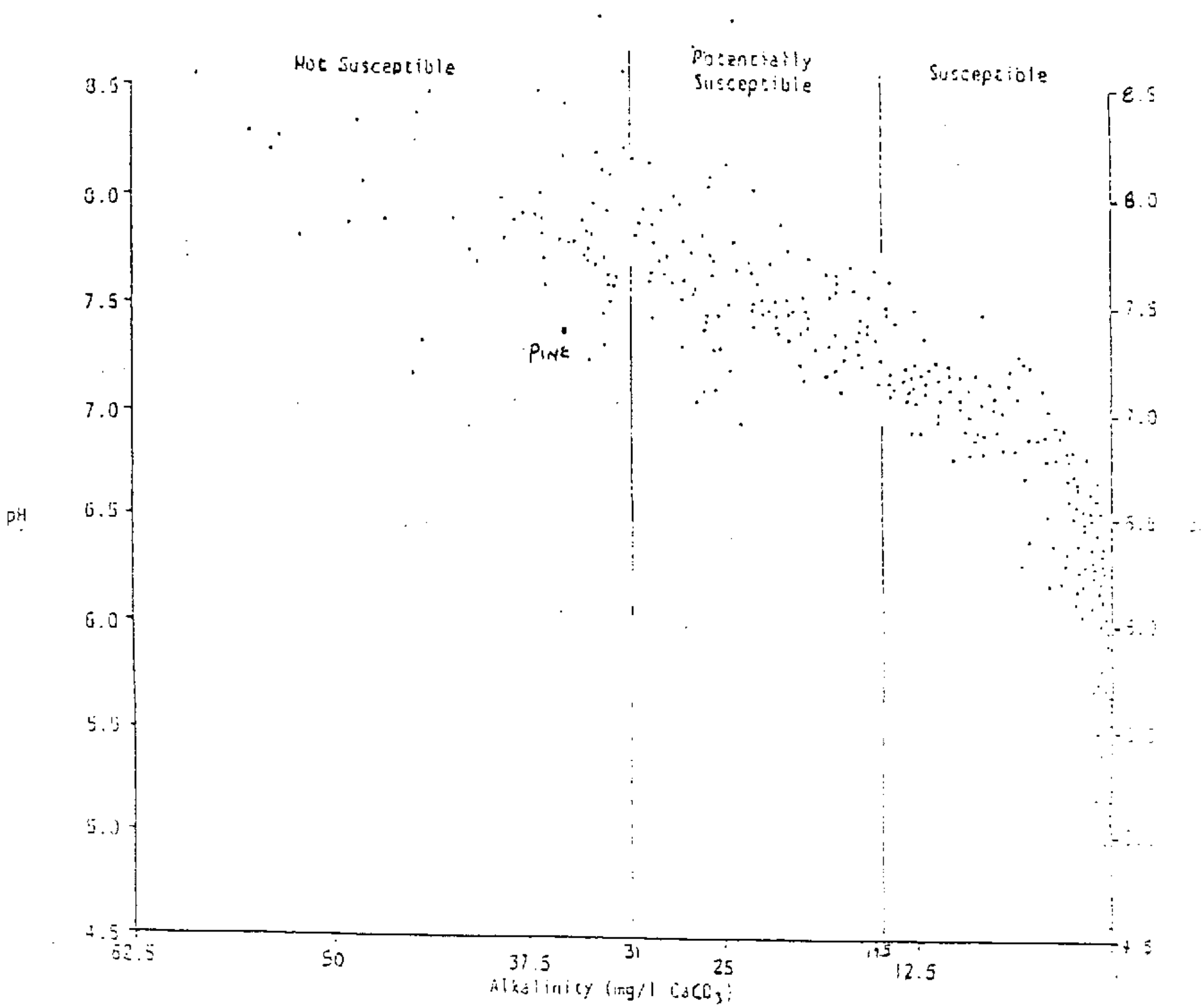
During the winter visits dissolved oxygen/temperature profiles were generated but no samples were collected.

Survey Findings

pH and Buffering Capacity: pH and total alkalinity or acid neutralizing capacity (ANC) are indications of a lake's susceptibility to the effects of acid rain. pH is the measure of acidity on a logarithmic scale from 1 to 14. A pH factor of 1 is most acidic, 14 most basic and 7 neutral. Alkalinity measures the ability of water to neutralize substances on the upper and lower ends of the pH scale. This process, called buffering, is performed by salts, mainly calcium carbonate salts. The more of these salts present, the higher the alkalinity and the more resistant to pH changes the water is. The pH on Pine Lake ranged from 5.9 to 7.4, indicating near-neutral conditions. Alkalinity was very stable, ranging from 34 mg/l to 38 mg/l, which indicates good buffering potential. According to Surface Water Resources of Forest County (WDNR-1977), the alkalinity of Pine Lake was 37 in 1963, so there has been no depletion of buffering capacity in the last thirty years. Figure 1 shows Pine Lake's position among area lakes in acid susceptibility based on these measurements.

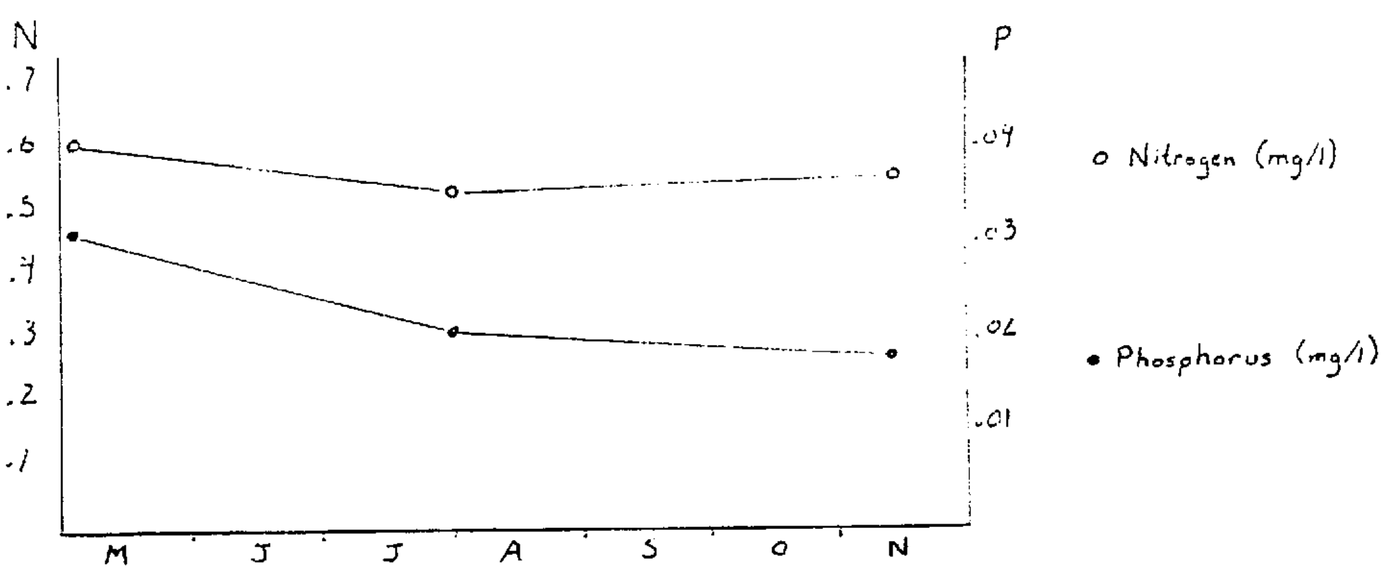
FIGURE 1

ACID RAIN EFFECT SUSCEPTIBILITY
(from Greater Bass Lake Langlade County Feasibility Results;
Management Alternatives. by WDNR Bureau of Water Resources Management - Inland Lake Renewal Section; 1983, p17.)



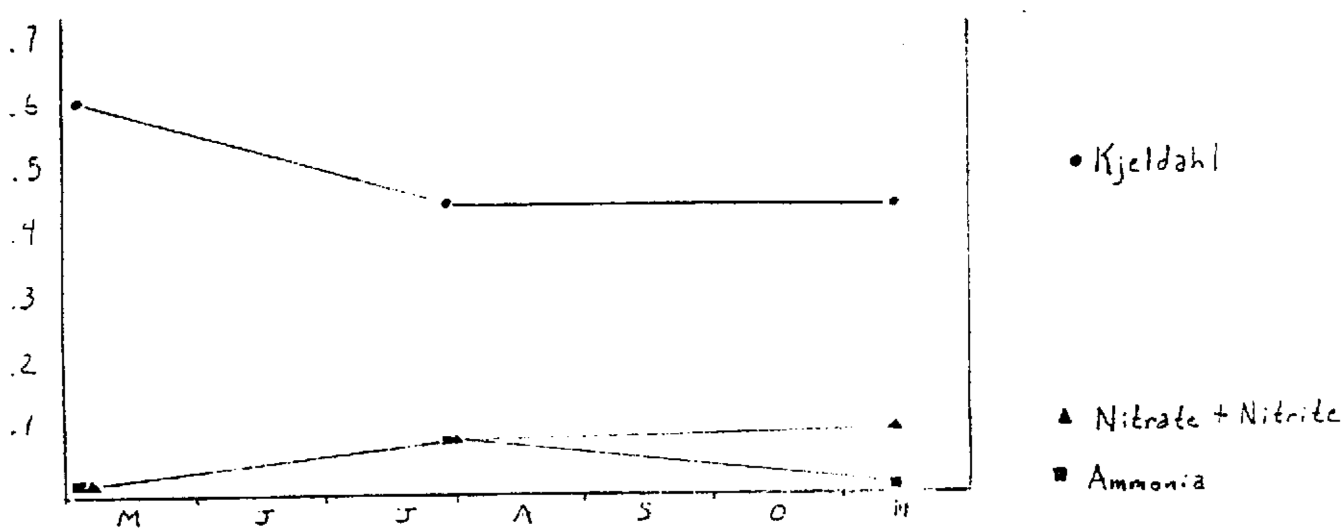
Nutrients: A nutrient is any element, ion or compound necessary for the growth and other life processes of an organism. Most nutrients are required in only trace amounts, but some, the macronutrients, are required in large enough amounts to dictate the productivity of a system. The macronutrients are carbon, nitrogen and phosphorus. Since carbon is so prevalent in a lake its levels do not get low enough to make it a limiting factor. (The limiting factor is the nutrient or energy source that exists in a quantity such that it dictates the extent of growth.) Therefore, nitrogen and phosphorus are considered the most important in terms of potential productivity of a lake.

The ratio of nitrogen to phosphorus remained at about 20:1 during this study. A ratio of 13:1 is generally considered the point above which phosphorus is considered the limiting factor . Graph 1 shows nitrogen and phosphorus levels on Pine Lake during the study. (Note: On this graph nitrogen values are 10 times that of phosphorus.)



High productivity characterized by nuisance weed or algae growth can be expected when total phosphorus levels exceed 15 ug/l. Phosphorus levels in Pine Lake ranged from 18 to 32 ug/l during the study.

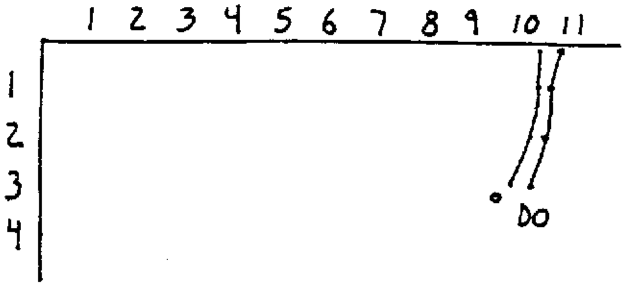
Nitrogen levels ranged from 0.54 mg/l to 0.62 mg/l. These values were consistent with many other lakes in this area. Eighty to 100% of the total nitrogen consisted of organic nitrogen. One component of organic nitrogen is ammonia which can be an indicator of septic contamination. Ammonia levels were only above detection limits on one of the three sampling dates and even then it was not significant enough to indicate a problem. The inorganic portion of total nitrogen is made up of nitrate and nitrite. High levels of these compounds can indicate nutrient contamination from fertilizer or other man-made products. Nitrate + Nitrite levels were quite low, ranging from below detection limits to .11 mg/l. Graph 2 shows the nitrogen component levels during the study.



According to WDNR-1977 total nitrogen levels in 1963 were about .4 mg/l. This is not a significant difference from current levels. (A total phosphorus value is not given for the 1963 sampling.)

<u>Dissolved Oxygen</u> - Dissolved oxygen is critical to the survival of fish. In the spring, when a lake turns over, dissolved oxygen levels will be at or near saturation throughout the water column. Over the course of the summer, levels near the surface will fluctuate slightly with variations in temperature and mixing. In shallow, productive lakes such as Pine, oxygen levels will remain fairly constant throughout the water column during open water periods, but can be depleted very rapidly during the winter when production (by plants) ceases but consumption (by animals) continues. If oxygen levels are depleted enough, fish begin to suffocate causing a phenomenon called "winter kill". Total oxygen depletion also provides a more favorable environment for nutrient recycling from the sediments, meaning more nutrients available for macrophyte or algae growth in the spring.

The following page includes all dissolved oxygen/temperature profiles that were generated during the study. Numbers on the vertical axis are depths in meters. Those on the horizontal axis represent both temperature in °C and dissolved oxygen in mg/l or parts per million. The last three graphs show that oxygen levels were not dramatically depleated during the winter. Dissolved oxygen and temperature data is included in appendix B.



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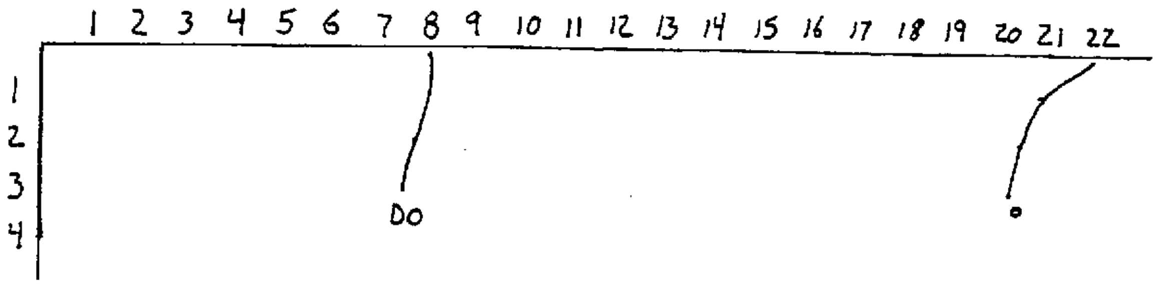

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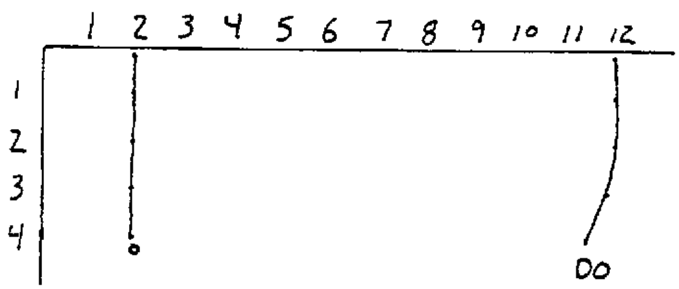

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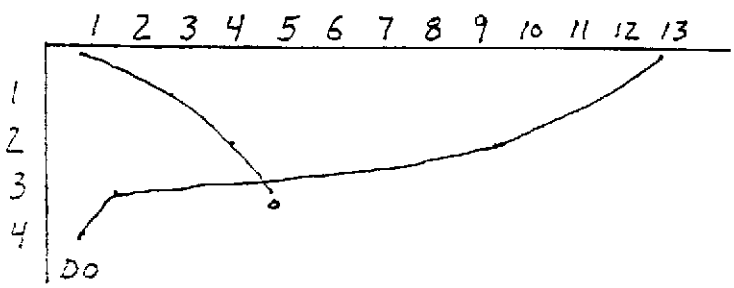

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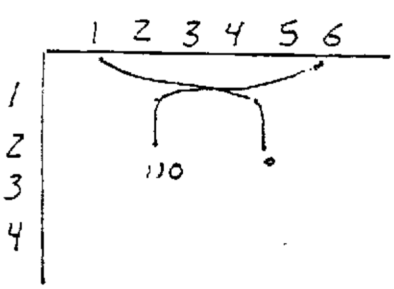
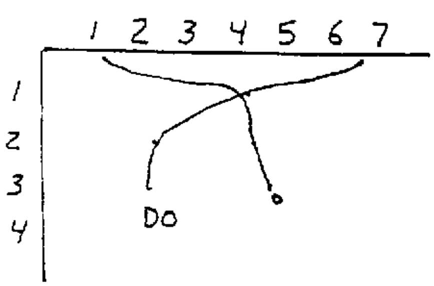


Site A



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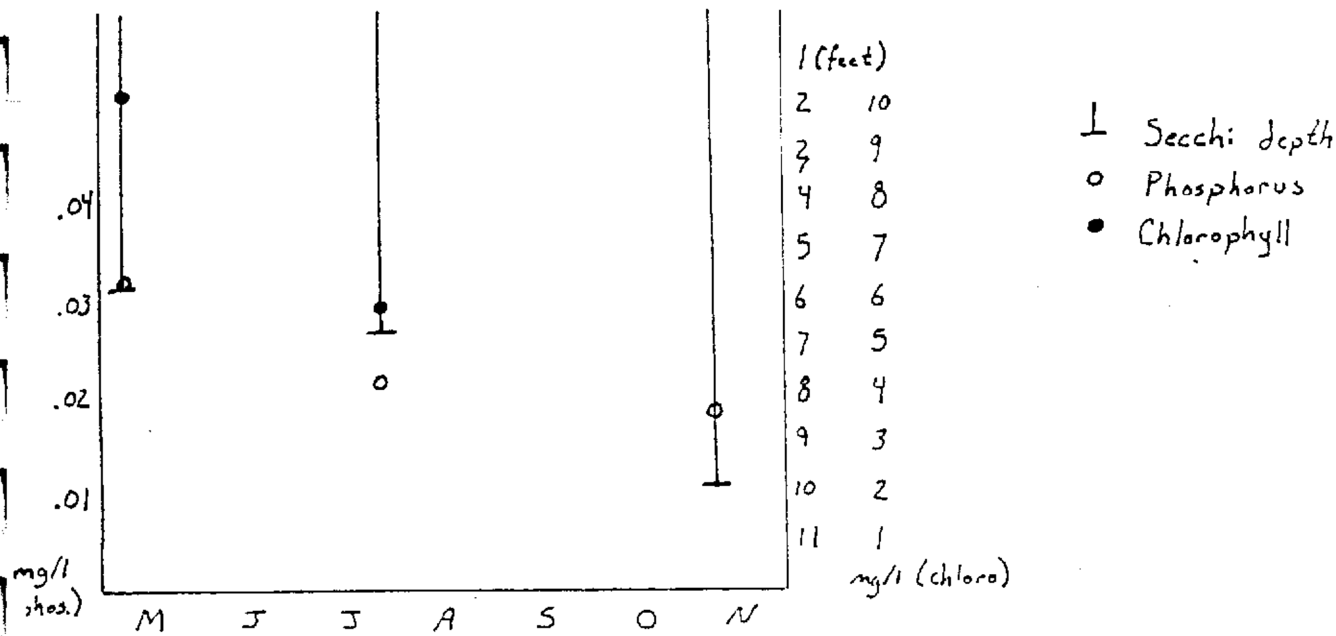
Site B

Chlorophyll

Chlorophyll α, a pigment found in algae, is used as an indicator of algal growth. It is often closely associated with water clarity and phosphorus levels. Phosphorus is nesessary for algal growth and the more algae, the lower the visibility, thus the relationship. The following graph shows that relationship on Pine Lake.



For complete chlorophyll results see appendix 2.

Macrophytes

Aquatic plant growth occured throughout most of Pine Lake to a depth of 13 feet. Twenty-eight different species were observed during the July 30, 1992 study. Of these, four were floating-leaf plants, three were emergent, and the remaining 21 were submergent species. A separate report on this study, including field sheets, maps and species descriptions, is included as appendix A.

Summary & Recommendations

As a lake ages and nutrients accumulate, it becomes more productive or eutrophic. The rate of this process can be dramatically effected by the activities of man. The situation on Pine Lake is one of naturally high productivity probably moderately increased by man.

Natural factors include the lake's size, shape and surounding geography. Since Pine Lake is large and relatively shallow, the action of the wind is able to keep recycling nutrients for use by plants or algae. Since the littoral zone or the area which receives enough light to support plant growth, extends over the entire bottom of the lake, the potential biomass of the system is limited only by the ammount of available nutrients. Also, the ratio of watershed to surface area is quite high (≈ 5:1). This means that nutrients from an area approximately five times the size of the lake are being washed into the lake. The nutrient load is also increased by the relatively heavy shoreline development.

The following two models use phosphorus, chlorophyll α and Secchi depth to estimate water quality and trophic state (lake age). As the models show Pine Lake is quite eutrophic (productive), but water quality is still in the "good" range.

Trophic Level	Total Phosphorus	Secchi Disc	Chlorophyll
Eutrophic			
	20	2.0	8.5
Mesotrophic			
	10	4.0	2.3
Oligotrophic			

(Carlson, R.E., 1977, A trophic state index for lakes: Limnology and Oceanography, March, v. 22(2), p. 361-369)

Water quality index	Total Phosphorus (mg/l)	Chlorophyll α (ug/l)	Secchi (ft)
Excellent	<0.001	<1	<19.7
very good	.001-.010	1-5	9.8-19.7
good	**.010-.030**	**5-10**	**6.6-9.8**
fair	.030-.050	10-15	4.9-6.6
poor	.050-.150	15-30	3.3-4.9
very poor	>.150	>30	>3.3

(Lillie, R.A., and J.W. Mason, 1983, Limnological characteristics of Wisconsin lakes: Wisconsin Dept. of Natural Resources Technical Bulletin No 138, 1116 p.)

A number of actual and potential problems exist due to this situation. Eutrophic conditions often mean extensive weed growth, which can limit recreational activities and adversely affect aesthetics. Macrophytes also provides cover for small fish which is necessary to an extent, but if it becomes too thick and widespread, larger predators are not able to hunt effectively, and a large population of stunted panfish may result. Shallow lakes with extensive weed growth, like Pine may also suffer winter oxygen depletion severe enough to stress or kill fish. Fortunately it seems that water coming into Pine Lake during the winter brings enough oxygen to keep this from happening.

A number of different management strategies can be considered for Pine Lake. Both chemical treatment and mechanical harvesting are classic responses to problem weed growth. Chemical treatment should be used in conjunction with a specific management plan in order to preserve areas of desirable weed growth. On Pine Lake these areas include the floating-leaf beds, especially the large one near the north shore, beds of native emergents and much of the deeper water broad-leafed pondweeds or "cabbage beds" . Table 1 shows the effectiveness of 5 currently-used herbicides on specific macrophytes. Further information on weed control chemicals can be found in DNR published information sheets--PUBL-WR-135-90 through PUBL-WR-145-90 and How to Identify and Control Water Weeds and Algae 1976 James C. Schmidt. Drawbacks of chemical treatment include the possibility of residual effects on non-target members of the system - especially after long-term use. Also, this method does not remove anything from the system. Nutrients are recycled and available for further weed growth.

Mechanical harvesting is very effective but also very labor and cost intensive. The size of Pine Lake and the scope of the growth would probably require full-time harvesting during the growing

Table 1. Common aquatic weed species and their responses to herbicides (modified from Pickerel/Crane Lake A Phase 1 Diagnostic & Feasibility Study 1992)

	Diquat	Endothal	2,4-...	Glyphosate (Rodeo)	Fluridone (Sonar)
EMERGENT SPECIES					
Sagittaria spp (arrowhead)	NO	NO	YES		YES
cirpus spp (bulrush)	NO	NO	YES	YES	YES
ypha spp (cattail)	YES	NO	YES	YES	YES
Lythrum salicaria (purple loosestrife)				YES	
LOATING SPECIES					
Brasenia schreberi (watershield)	*NO*	*YES*	*YES*		*NO*
emna minor (duckweed)	YES	NO	YES		YES
uphar spp (cowlily)	NO	YES	YES	YES	YES
Nymphaea spp (water lily)	NO	YES	YES	YES	YES
UBMERGED SPECIES					
eratophyllum demersum (coontail)		YES	YES	YES	YES
Chara spp (stonewort)	NO[2]	NO[2]	NO[2]	NO[2]	
lodea canadensis (elodea)	YES	?	NO		YES
yriophyllum spicatum (milfoil)	YES	YES	YES	NO	YES
Najas flexilis (najad)	YES	YES	NO	NO	YES
ajas guadalupensis (southern najad)	YES	YES	NO		YES
Potamogeton amplifolius (large-leaf pondweed)	*?*	*YES*	*NO*		
. crispus (curly-leaf pondweed)	*YES*	*YES*	*NO*		
P. natans (floating leaf pondweed)	*YES*	*YES*	*YES*		*YES*
. pectinatus (sago pondweed)	*YES*	*YES*	*NO*		*YES*
P. illinoiensis (Illinois pondweed)					*YES*
anunculus spp (buttercup)	*YES*		*YES*		

ES Controlled
O Not controlled
BLANK Information unavailable
? Questionable control
controlled by copper sulfate

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season. A modified harvesting method in which large strips are harvested may be successful on Pine Lake. This is a bit less labor intensive, provides clear boating lanes, and removes some nutrients from the system. It is also beneficial to the fishery by maintaining much cover but also creating long edges where larger predator fish can hunt. Like chemical treatment, mechanical harvesting should follow a management plan to help maintain the system. Both of these methods treat only the symptoms though and last one or part of one season. (The strip harvesting has been shown in some cases to last several seasons.)

Table 2 compares harvesting, chemical treatment and a number of other management tools.

While the water quality of Pine Lake is not threatened by any serious land use problems such as industrial waste or heavy agriculture,it is effected to an extent by man's activities on the lake and in the watershed. Proper "common sense" practices can be as important as high-tech rehabilitation efforts. These are low-tech, low-cost practices by lake residents and users to avoid accelerating the lake aging process. They include the following:

* Maintain naturally vegetated "buffer zones" along the shore,
* Carefully monitor septic system performance,
* Landscape to decrease erosion,
* Divert runoff from construction sites,
* Avoid the use of chemical fertilizers,
* Operate motorized water craft slowly in shallow, heavily sedimented areas.

	Mechanical Harvesting	Aquatic Herbicides	Dredge	Rototill	SCUBA	Bottom Screens	Drawdown	Biological
Effect on Ecosystem	Remove plant material, some small fish	possible residual effects	removes littoral zone, disturbs sediments	disturbs sediments	removes aquatic vegetation	creates clear-cut	downstream water quality effects, possible fishery effects	needs research
Effective Large-scale	yes	yes - but possible residual effects	yes	yes	no - very labor intensive	no	yes	yes
Effective Small-scale	no - difficult to maneuver	yes	yes	no	yes	yes	no	no
Species Selective	no	yes - if applied properly	yes	no	yes	no	no	yes with fungi and insects
Removes Nutrients	yes	no	yes	no	yes	no	no	no
WDNR Acceptibility	high - minimul environmental impact	low - permit required	low - many environmental impacts	medium - prefer harvesting	high - proven effective in southern WI	high - for small areas, permit required	low - physical features of dam prevents drawdown	low - many unknowns
Public Acceptibility	high	medium - more public info needed	medium - many environmental impacts	medium - new technology	high - has been demonstrated to maintain channels up to 2 years	medium - effective but difficult to maintain	medium - depends on many factors, may have to coordinate with utility company	medium - more research and public info needed
Per acre cost	$200 to $600	$75 to $600	$15,000 to $20,000	$1500	varies depending on volunteers	$10,000 to $15,000	nominal	N/A

format taken from "Minnesota Aquatic Plant Control Draft Reconnaissance Report," August 1989

These efforts, while they do not have exhibit the dramatic effects of high tech strategies, provide longer-lasting improvement or preservation of the system.

Finally, we recommend a long-term, self-help monitoring program. A simple program which can be an extremely effective indicator of changes in aging trends is regular Secchi disc readings. As the graph on page 6 showed, this measurement is often on indicator of nutrient levels. It should be done at regular intervals of about 2 weeks and can be used with or without annual nutrient analysis to track water quality for a minimal cost. Information on establishing a self-help monitoring program is available through the Departmant of Natural Resources.

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