TAMBLING LAKE
PLANNING GRANT REPORT

PHASE 1

INVENTORY

&

RECOMMENDATIONS

Completed by

TAMBLING LAKE ASSOCIATION, INC.
AND
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In Cooperation With
WISCONSIN DEPARTMENT OF NATURAL RESOURCES
LAKE PLANNING GRANT PROGRAM

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INTRODUCTION

Tambling Lake is a 174 acre lake with a small outflow to Tamblin Creek and the Eagle River Chain in southeastern Vilas County, Wisconsin. It's maximum depth is 14' with an average depth of 7 feet. The shallow water shoreline area is primarily sand with the entire deep water bottom area covered with muck. Tambling Lake has relatively soft water with a very light brown water color.

The watershed is mainly forested with second growth northern hardwoods but some of the shoreline has shrub-conifer bog areas. The direct drainage area is approximately 330 acres as steep to moderately steep sandy hills dominate the surrounding landscape. There are currently 73 landowners with shoreline property. Dwellings are found on almost every property. Public access is from Rangeline Road which borders the lake on the southwest corner where Tamblin Creek exists the lake.

The shallowness and muck bottom areas of the lake have affected the use and management of the lake. Tambling Lake has an abundance of aquatic vegetation. It has had several periodic fish kills in the past.

Tambling Lake Association, Inc. with it's consultant, Rand Atkinson of Aquatic Resources, has now inventoried the resource history of Tambling Lake, described the current conditions of the lake community, and recognized problems that lake managers must face. The results of these planning grant activities are described in this report.

ACKNOWLEDGEMENTS

A special thanks to TIM MARISCH whose leadership has organized the lake association and ventured into the lake planning process for the lake community. He has hosted board meetings and lake community gatherings, helped gather current information on the lake with the consultant, and provided easier access to the lake during the grant study.

A thanks also must go out to JERRY & JUDY BEHNKE who have also taken a leadership role in the formation of the district as well as have taken responsibilities of communication with other lake community members on the progress of the grant activities through newsletters and mailings. They have also hosted board meetings and provided easier access to the lake for grant activities. Thank you also for sharing the secchi disc duties during the grant period with KEN LYNCH and GEORGE KALT. These added observations were able to be the consultant's "eyes" between data gathering visits.

Another special thanks must go to long term lake community member BOB REIMER for his help in many ways. His memory for changes in the lake, assistance in the lake profiling, and advice and help on gathering community information were all important in completing this project.

A thank you to all Tambling Lake Association members who contributed time, money, input, and knowledge to this project. Also, thanks to the Wisconsin Department of Natural Resource personnel that reviewed this project and excepted it for grant funding.

LAND RESOURCES OF TAMBLING LAKE

Geology and Watershed Characteristics

Tambling Lake is a 174 acre spring lake with an outfall on the southwest shoreline to Tamblin Creek. Tamblin Creek flows approximately 1/2 mile through wooded upland and a sedge meadow before entering Voyageur Lake of the Eagle River Chain. The creek drops approximately 9' in the first 1/4 mile of stream. Wet soils border much of the Tambling Lake shoreline on the west, north, and northeast before rising steeply to the upland. Some of these wet shoreline areas have been filled in. The land rises steeply on the south shoreline.

Two major drainage ways enter Tambling Lake. The first drainage way extends from Carpenter Lake to the northeast and has been intercepted by Carpenter Lake Road and other road development. A second drainage way enters the lake through a forested tamarack bog that joins the lake on the western shoreline. This drainage way is intercepted by Tambling Lane.

Tambling Lake is in the Deerskin River sub basin of the Wisconsin River basin. The lake was formed when glacial melt water carried debris from the Wisconsin Valley Lobe of the Late Wisconsin glacier. Drumlin hills and ridges were formed northeast of Tambling Lake when the glacier ice deposited till in the Long Lake, Kentuck & North Twin Lake areas. Till is non-sorted, non stratified, sediment deposited directly by glacial ice. These drumlins lay in the northeast- southwest directions with their elevations decreasing in the same direction. Long and narrow drainage ways formed between these drumlins when braided glacier rivers carried sediments of sand and gravel southwest to the Tambling Lake area. This stratified sand and gravel, called out wash, buried a glacial ice sheet that existed where the Tambling Lake area is today. After hundreds of years the underlying ice melted, collapsing and dropping the sand and gravel to the land elevations we find today. Soils developed over this glacial out wash since the final glacial retreat 10,000 years ago.

Bedrock below Tambling Lake is at 1550 feet above sea level. With the highest hills around the lake near the 1650 foot contour there would be approximately 100 feet of sediment below the highest shoreline ridge. With the water level elevation of Tambling Lake at 1625 and a maximum depth of 15 feet there would about 60 feet sediment below the lake at it's deepest spot. Ground elevation of the landscape and water surface elevations of the lakes quickly rise as you travel in a northeast direction from Tambling Lake. Carpenter Lake's water elevation is at 1641 or 16 feet above Tambling Lake's and ridges just east of Carpenter are 50 feet higher than the hill's adjacent to Tambling. Bedrock elevations also rise; therefore, the regional ground water movement in the area follows the general surface waters of the Deerskin River from it's origin near Long Lake to the out wash plain surrounding Eagle River just east and northeast of Tambling Lake.

Tambling Lake's watershed is approximately 329.5 acres, which does not included the lake surface area of 174 acres. 77% of the watershed is wooded with second growth hardwoods and a forested tamarack bog. Light residential development consists of approximately 75 dwellings. This residential development and public roads that service them makeup approximately 23 % of the watershed area. See FIGURE 1.

Soils and Land Use

The soils that developed over the glacial out wash described above determined the vegetation of the upland and the conditions found in the lake today. The soils of the sub watershed, or the immediate shoreline area, are peat or muck where water stands or slowly seeps into the lake. Sand with a layer of leaf litter cover the steep sloping hillsides. The only loam soil on the immediate shoreline is the W-SW shoreline area north of the outlet stream. As you move away from the lake the soils change to loamy sand and sandy loam . See TABLE 1 & 2 and FIGURES 2.

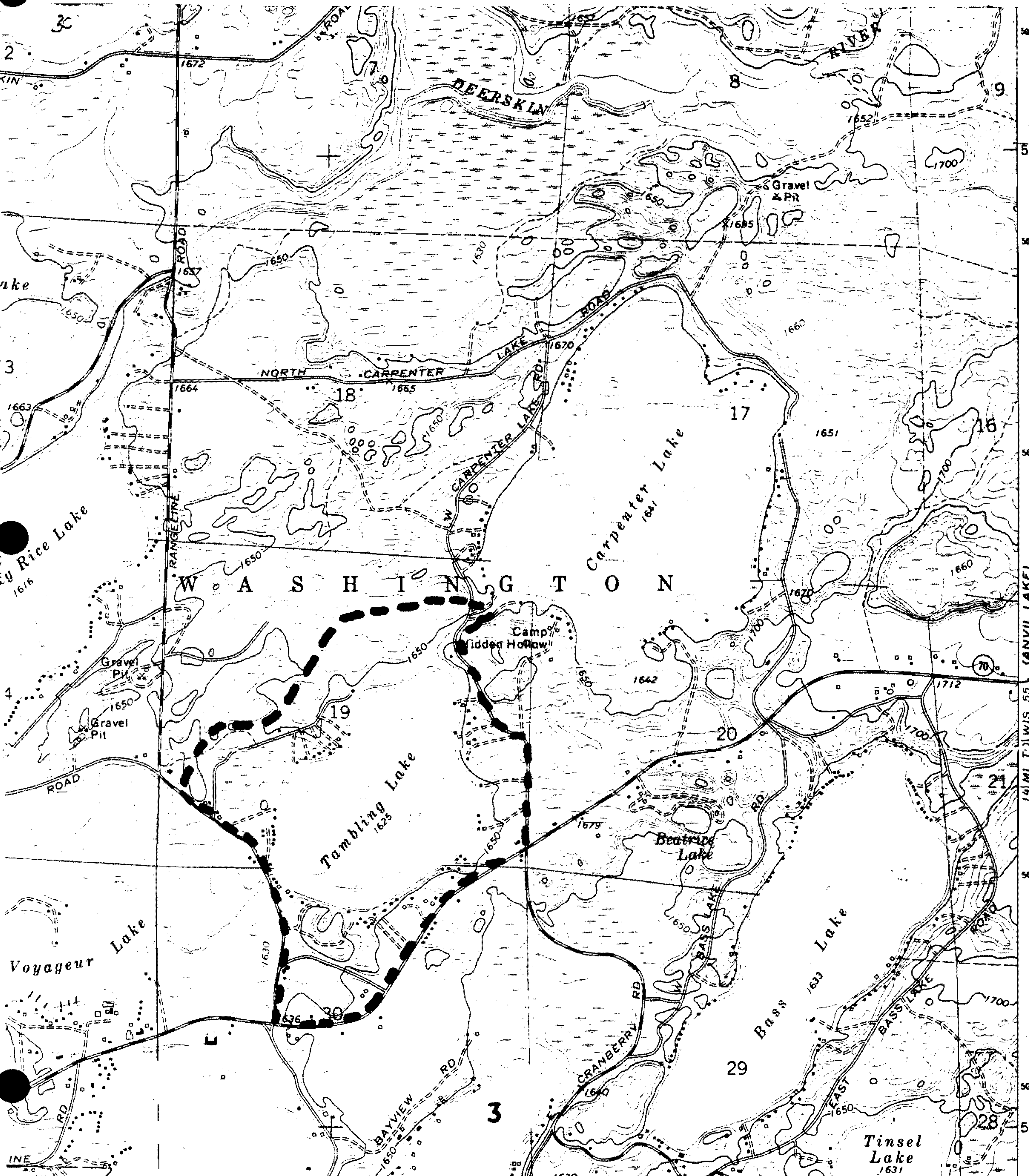
Much of the soft sediment bottom material of Tambling Lake probably developed during the glacial retreat period. At that time the area where Tambling Lake is today was probably a bog that developed over stream sediment material covering glacier ice. Over several hundreds of years the buried ice melted, collapsing the glacial sediment and bog with it. Peat then continued to develop in poorly drained, mineral deficient, and oxygen poor areas adjacent to the lake.

At the same time the glacial stream out wash sediment on the uplands also collapsed as the ice melted creating the hummock terrain we find today. On these higher landscapes accumulations of raw mineral deposits were developing . These minerals easily eroded or were leached through the sandy soils with gravel substrata from the steep slopes into Tambling Lake. In the areas receiving more minerals and water flow, muck was more likely to develop than peat.

Sheltered, excessively drained, slopes and bottom valleys are likely to be moister and cooler than the exposed hills around them. In the small lake basin, like the one Tambling Lake is located in, frost pockets occur where at night cool air sinks down slope producing subfreezing temperatures while the uplands nearby remain above freezing. Bog soils and their associated bog and wetland plant communities do well under these conditions.

The soils of the sub watershed or immediate shoreline areas are described in TABLE 1 and identified on the map in FIGURE 2. The dominant soil of the shoreline is Rubicon Sand. This soils is found in the N, NW, S, and SW shoreline areas from flat areas (RoB) to steep slopes of 35%(RoD). These soils are coarse and underlain by layers of gravel that causes them to drain excessively. Little filtration occurs due to rapid percolation and therefore, water holding capacity is also low. This soil can readily absorb septic tank effluent but does not adequately filter it which leads to pollution of the ground water. These soils are especially suited for pine and aspen trees that are tolerant of these soil conditions.

FIGURE 1. Boundaries of the Tambling Lake Watershed



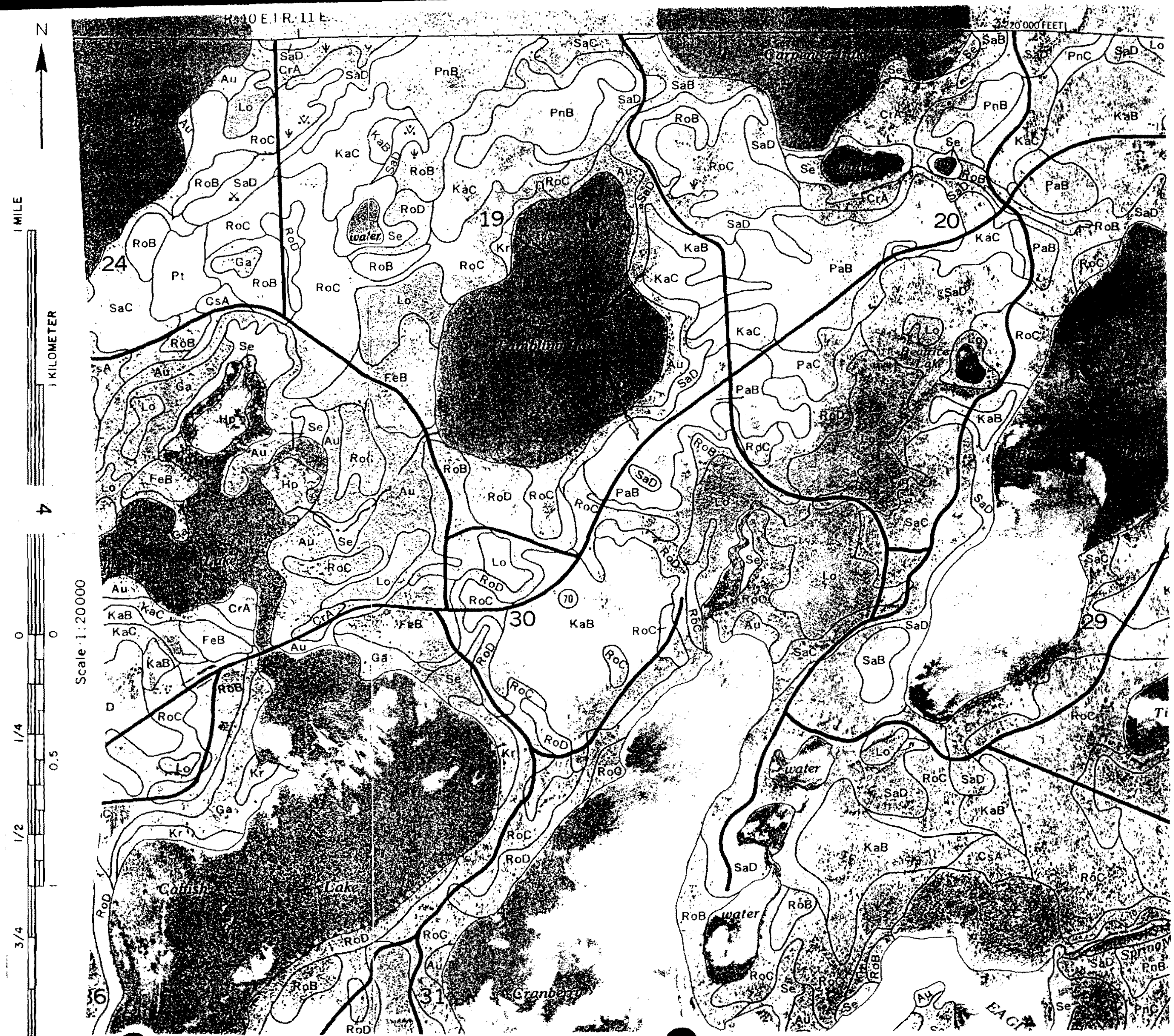


FIGURE 2. Soils of the Tambling Lake Watershed

Sayner-Rubicon Complex (SaD) is found on the very steep slopes of the Tambling shoreline from the northeast to the southeast. This soil has the same characteristics as the Rubicon Sand soil above except in places loamy sand has developed in the surface layer. Ground water pollution can easily occur on these soils. Because of it's presence on very steep slopes erosion from road building or dwelling construction can be a severe problem.

The Fence-Alcona Complex soils (FeB) are found along the west shoreline north of the outlet area. Those soils were created when the water level of Tambling Lake was much higher. This soil material was laid down in still water when it was a much larger glacial lake and then exposed when the water level was lowered or the elevation of the land raised. Permeability of these soils is moderately slow to moderately rapid depending on the stratification. Because of the silt content the available water capacity can be high at times. Depending on the wetness of the site and water table septic systems may or may not work. It is also this shoreline area of the lake that has problems of ice pushup mounds in the spring when the soil is saturated. These stratified soils are low strength soils that when wet can be easily moved or pushed up by the ice by an east wind at ice out. It would also be very susceptible to wave erosion once disturbed. The sediment collection and fill in the outlet area that has raised the lake elevation slightly is saturating this soil causing this problem.

There are three wet soil areas on the immediate shoreline of Tambling Lake. The Augres Sand soil (Au) can be found in the low flat area extending from the NE to SE shoreline except for a east NE sand point that divides this shoreline. Both inlet and outlet areas also have this soil type beneath the accumulated organic matter. Kinross Mucky Sand soil (Kr) can be found in a low flat, poorly drained area on the west shore of the north bay. This soil has 4" of black muck over layers of mottled sand caused by ponding of water. Native wetland vegetation does well on this soil. The third wet soil is the Loxley- Dawson Peat (Lo) soils of the west shoreline tamarack areas. This bog area is a drainage way from the very permeable soils in the watershed above. In all of the wet areas described above trees do not establish very deep root systems and are easily wind thrown. These soils are also of low strength and can be pushed up by ice or eroded by wave action.

Soils of the watershed higher on the landscape are described in TABLE 2 and can be located in FIGURE 2. These soils include the Karlin Loamy Fine Sand (KaC & KaB), the Padus Fine Sandy Loam (PaB), the Pence Sandy Loam (PnB) and the Sayner- Rubicon Complex (SaB). These soils are developed on flats and convex slopes that are nearly level or gently sloped. These soils are excessively to well drained as sand and gravel are found in the substratum. Their relatively flat surfaces and porous characteristics allow decomposed organic matter and chemically weathered minerals to percolate through the surface soil and enter ground water and eventually the waters of Tambling Lake. Most of these areas are wooded with scattered homes and seasonal cottages connected by town roads and private drives.

TAMBLING LAKE
PROPERTY OWNER'S SURVEY & RESULTS

Introduction

A property owner's survey was presented at the Tambling Lake Association, Inc. annual meeting on June 8, 1996 to assess current lake use and gather opinions on the lakes problems and possible solutions to them. The survey can be found in in Appendix I.

The survey was presented and discussed at the meeting and all property owners received a survey by mail. Out of 73 surveys distributed 34 or 46% responded to the survey.

Results

Question 1 asked" How long have you owned property on Tambling Lake?."
The answers ranged from 3 months to 54 years.
The largest group of respondents were those who have lived on the lake less than 5 years. The breakdown was a follows:

Length of Time with Property Respondents	# Respondents	%
0-5 years	12	35%
6-10 years	6	18%
11-15 years	0	0%
16-20 years	5	14%
21-25 years	0	0%
26-30 years	3	9 %
31-35 years	1	3%
36-40 years	1	3%
41-45 years	4	12%
46-50 years	1	3%
50-54 years	1	3%
	--------	-------
	34	100%

In Question 2 owners were asked to check one of several options that describe their property and dwelling type - their responses were as follows:

Dwelling or Property Use Description Respondents	**# Respondents**	**%**
Year-round Home	13	38%
Three-season Home	6	18%
Summer Cottage	6	18%
Winterized Cottage	6	18%
Vacant Lot	3	9%
Other	0	

	34	

Question 3 & 4 related to lake property use. These questions gave several options on how often they used their property and how many people used the facility during that period. The options for time of property was used were # of weekends/ year and # weekdays/ year. The second question asked on an average how many people use the property during the time indicated in the previous question.

The results were interpreted and broken down into categories to describe weekend vs. weekday use.

Year-Round Home Use (13)

Weekends/Year (# People)	**Weekdays/Year (# People)**
52 (7)	255 (7)
52 (2-3)	260 (2-3)
52 (2)	260 (2)
48 (2)	345 (2)
12 (4)	20 (4)
12 (2)	60 (2)
10 (2-3)	40 (2-3)(S,S,F)
8 (5)	20 (3)
? (10)	? (?)
? (2-8)	260 (2)
26 (2)	15 (2)
	? (2-8)
	130 (2)
----------	-----------
Ave. 30 (3.2)	Ave. 151 (2.8)

Three-Season Homes (7)

Weekends/Year (# People)	Weekdays/Year (# People)
26 (2-3)	120 (2)
24 (2)	120 (2)
10 (2)	20 (2)
6 (4)	30 (4)
4 (4)	20 (4)
12 (2-4)	30 (2)
10 (4-5)	50 (4-5)
Ave. 13 (3.1)	Ave. 56 (2.9)

Winterized Cottages (4)

Weekends/Year (# People)	Weekdays/Year (# People)
26 (5)	84 (3)
6 (5)	20 (5)
15 (2)	20 (2)
4 (2)	2 (2)
Ave. 12.75 (3.5)	Ave. 31.5 (3)

Summer Cottages (6)

Weekends/Year (# People)	Weekdays/Year (# People)
16 (2)	80 (2)
12 (3)	30 (3)
9 (4)	45 (3)
6 (4-7)	30 (4-7)
7 (4)	-
? (2-8)	? (2-8)
Ave. 10 (3.7)	Ave. 37 (2.7)

The 34 respondents in total spend 465 weekends with 89 people using the lake and lake property during these weekends. This would average 14 weekends/year with an average of 2.6 people using the dwellings during this period. If these figures are expanded to 73 property owners lake use would total 998 weekends/year with 191 people using the lake during these weekends.

The same 34 respondents in a total spend 1889 week days with 68.5 people using the lake property during this time. This would average to 70 week days / year with an average of 2.5 people using the lake property during these week days. Again, if these figures were expanded to the 73 property owners they would use their lake facility a total of 4056 weekdays/ year with 147 people on the lake during that time.

Question 5 related to lake use and recreational value of their Tambling Lake property. Respondents were asked to number their priorities 1 to 8 (1 being highest value, 8 being lowest value) on a list of brief recreational descriptions. The response was as follows:

Description	**#1**	**#2**	**#3**		**#4**	**#5**	**#6**	**#7**	**#8**
Swimming	0	7	6	-	5	14	0	0	0
Pleasure Boating	0	5	4	-	8	5	0	0	0
Fishing	6	13	5	-	4	2	0	0	0
Duck Hunting	0	0	0	-	0	0	6	2	4
Wildlife Viewing	0	10	11	-	6	0	0	1	0
Scenic Beauty & Tranquility	19	8	0	-	3	1	0	0	0
Water Skiing	0	1	0	-	0	5	6	6	8
Jet Skiing	0	0	0	-	0	0	3	3	3
Other	1*						1**		

* Family Meeting Place   ** Tubing

Scenic Beauty & Tranquility and Fishing were the the highest priorities of the respondents with the former receiving 27 and latter 19 1st and 2nd place votes. Wildlife viewing, with 21 second and third place votes, was also very important to lake residents. Duck hunting, water skiing, and jet skiing received low priority scoring. Jet skiing also received many negative comments.

Question 6 of the property owner survey related to waste water disposal systems in regard to type, age, and maintenance. The results are as follows:

Type	# Respondents	
Septic Tank & Drain field	25	
Septic Tank w/ Lift to Drain field	4	
Holding Tank	1	
Mound System	1	
None	3*	
No Answer	1	
Age		
0-10 years	13	
11-15 years	1	
16-20 years	3	
21-25 years	2	
26-30 years	1	
31+ years	3**	
Unknown or No Reply	10	**1 to be replace in 1996
Maintenance		
Pumping Yearly	4	
Pumped Biannually	1	
Pumping Periodically or as Needed	9	
Pumping Every 3 years	6	
Very Little	3	
None	4	
No Answer	5	

* Two with vacant land

Overall, the sanitary systems on the lake are being replaced as new owners purchase the property or if dwelling use increased. Maintenance standards were reflective of dwelling use with those who used their facility more also had the system pumped more often.

Question 7 related to understanding well water and ground water table elevations around the Tambling Lake through the lake community providing available information regarding their wells. Thirty three lake property owners responded to this question. Only one was able to provide the static head - the water elevation in well before pumping began. Twenty-two property owners responding had sand points and eight had drilled wells. The results are as follows:

Property Access Road Location	**Sand Point Depth**	**Drilled Depth**
Tambling Lane	35',48',?,?	-
W. Carpenter Lake Rd.	10-14',18',25',25', 40',?,?	?,?,80'
STH 70 East	15',50-80',67'	70-80',72'
Rangeline Rd.	25',27',10-12',?,40',32',?	72',90'

Question 8 asked Tambling Lake community owners " What do you feel is the major problem facing Tambling Lake at this time?" The results and comments are as follows:

Problem	**# of Responses**
Too many Weeds(Aquatic Plants)	14
Muck or Shallow Depth,	13
Winter kill or Fish Kill, Low Oxygen	12
Poor Quality or Erratic Fish Population	5
Excessive Boat Speed, Jet Skis Tight Turns	2
Over Development & Increased Lake Use	1
Silt in Outlet	1
Deterioration of Old Piers, Boats, & Shacks	1
Gas Vapor Lamps & Night Light Pollution	1
Parties & Loud Music	1

Question 9 asked the following, "The depth and fertility of Tambling Lake cause many problems for the recreational use of the lake; What priorities would you give to solve, prevent, or keep these problems from worsening?"

Possible Solutions	**#1**	**#2**	**#3**	**#4**	**#5**	**#6**
Water Level & Flow Management	6	6	4	8	3	2
Machine Harvest of Aquatic Plants	1	5	8	4	5	1
Chemical Treatment of Aquatic Plants	1	6	4	3	7	4
Dredging/Removal of Lake Bed Material	14	7	6	3	1	2
Long-Term Shoreline Stabilization, Restoration, & Protection	8	4	5	5	5	3
<u>Others</u>						
Dredge Outlet	1					
Open Natural Springs		1				
Dredge Deep Trench Down Middle			1			
Install Aeration System						1

WATER RESOURCES OF TAMBLING LAKE
WATER QUALITY

Introduction

Assessment of the water quality of Tambling Lake was made using compiled data from water chemistry sampling & physical limnetic studies in 1995 and 1996. This information was combined with existing natural history data and other physical and biological data collected as part of this grant to assess the resources of Tambling Lake. Past water quality data was limited to an early inventory and dissolved oxygen sampling. An ecological assessment approach was used in understanding, interpreting, and communicating the present information collected as part of this grant.

Procedure

Water quality information of Tambling Lake was collected from June 28, 1995 to May 14, 1996. Water chemistry sampling followed the DNR Ambient Lake Monitoring Protocol as close as possible. Self-help secchi disc information was added to this information. All lake sampling occurred near the deepest part of the lake in the north central area of the lake in about 12 feet of water See FIGURE 3.

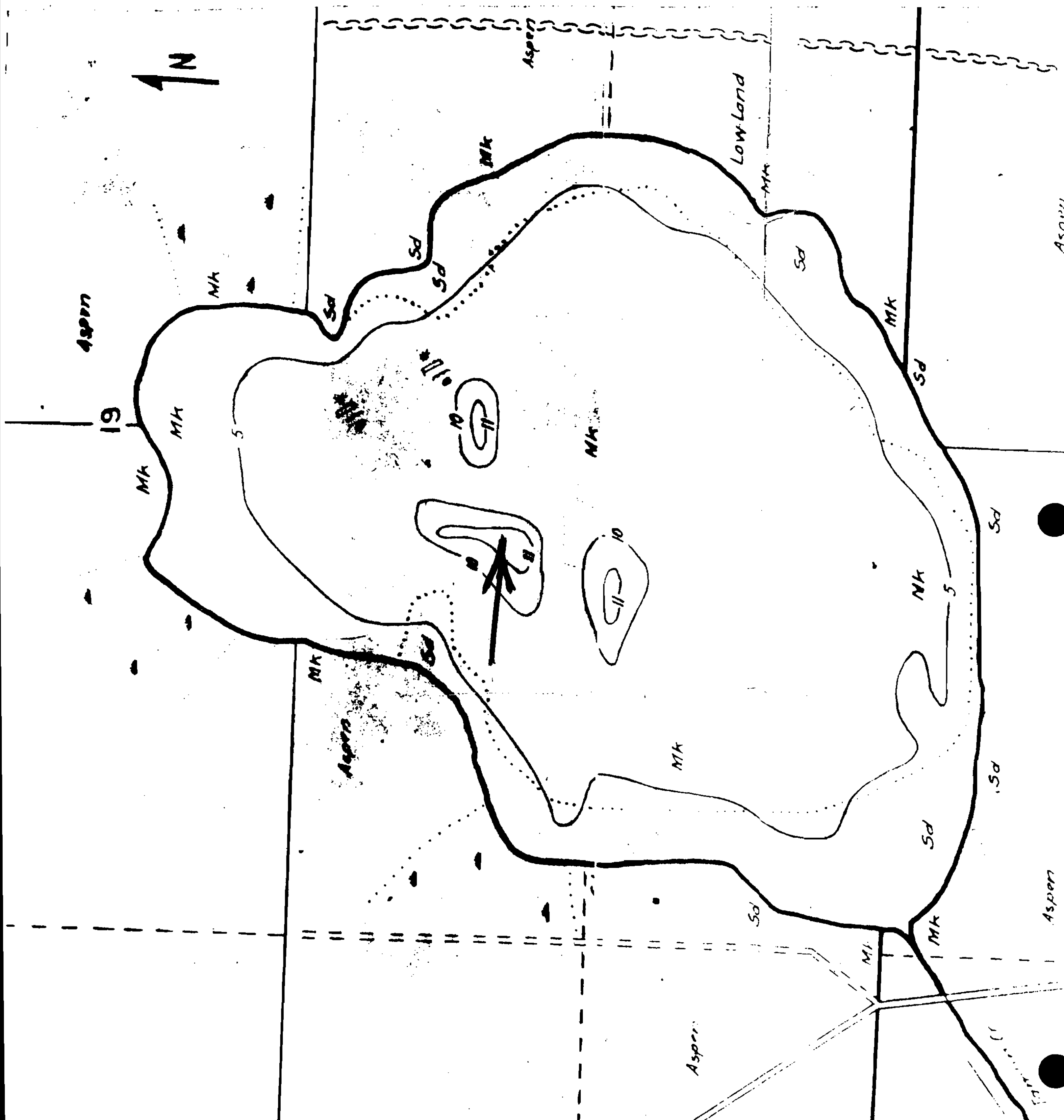
Secchi disc readings, oxygen temperature profiles, and water chemistries were all included in the water quality assessment. Under the ice oxygen profiling was added in February to assess the winter fish kill conditions that occurred in the winter of 1995-96. An additional oxygen- temperature sampling of the lake was completed on March 19, 1996 by the DNR's water resource specialist from Eagle River.

Results

Tambling Lake is a 174 acre spring- fed lake with a maximum depth of 14 feet. The entire deep water areas is covered with muck with the shoreline area estimated to contain 55% sand, 44% muck, and 1% gravel. The accumulation of the bottom organic matter and an abundance of aquatic plant growth on this substrate has a considerable impact on the water quality of Tambling Lake.

Water chemistry results from June 1995 to May 1996 can be found in TABLE 3. Oxygen- temperature profiles and field observations that accompanied the water chemistry samplings can be found in FIGURES 4 to 8. The March oxygen-temperature profiles documenting the severe conditions under the ice can be found in TABLE 4.

FIGURE 3. Location of Water Quality Sampling of Tambling Lake.



Water Chemistry

The chemical elements described in the water analysis of Tambling Lake provided informational pieces to put Tambling's ecological puzzle together. The May 15, 1996 water chemistry was taken two days after ice out when temperature and oxygen were constant from top to bottom. Nutrient's released from winter decaying of plant and animal matter under the ice are now mixed into in the water column. Spring's wind and wave action are mixing these nutrient's with the dissolved minerals that had entered the lake from the surrounding soils. The water has taken on a milky yellow hue with these dissolved elements as the cold water has yet to warm before biological activity of the growing season absorbs these nutrients and minerals into new plant and animal matter. See Table 3.

The minerals sampled on that date include **calcium, magnesium, sodium, potassium, iron, manganese, silica, phosphorus, chlorine, sulfur**. These elements are usually present in water as ions or in complex organic or inorganic compounds. These minerals enter Tambling Lake as water percolates through the soil or runs off the adjacent land from the watershed. The out wash sandy soils of the immediate watershed are mostly made of quartzite or other insoluble minerals that provide very little minerals to Tambling Lake. Tambling Lake receives most of it's minerals through spring seepage from the drained soils northeast of Tambling Lake and contact with bedrock in the aquifer. These dissolved minerals move by the force of gravity to low lying areas where the ground water discharges to rivers, lakes, and springs. Tambling Lake is one of these spring aquifer discharge areas.

Many of these minerals enter the ground water aquifer at the water table where many mix with carbon dioxide to form carbonic compounds. **Calcium** and **magnesium** are two main minerals that react with carbon dioxide in ground and surface water to create these carbonic compounds. These minerals and others that become part of lake's carbonate system affect basic biological activity, the lake's acid buffering capacity, and regulate the solubility of many toxic chemicals.

Calcium along with **magnesium** as dissolved compounds are the principle sources of **alkalinity** and **hardness** in the water. Just after ice out **calcium** and **magnesium** concentrations were 6.2 and 3.7 mg/l , respectively, which supports an **alkalinity** of 27 mg/l and a **hardness** of 25 mg/l (expressed as CaC02). Since **alkalinity** slightly exceeded **hardness**, some **potassium** and **sodium** carbonate compounds were also formed freeing **calcium** and **magnesium** ions. The **alkalinity** of 27 mg/l puts Tambling Lake in the "nonsensitive" range when the sensitivity to acid rain is considered.

The mineral concentration is also associated with waters ability to conduct electricity or the **conductivity** of the water. The **conductivity** of Tambling Lake ranged from 56 under the ice to 60 umhos/cm during the growing season. These **conductivity** values are only about two times the **hardness** value indicating the water is receiving very little human-induced contaminants.

TABLE 3. Water Chemistry of Tambling Lake, 1995-96.

Date	Temp	Dis. Oxygen	O2 Sat.	ChlorA	Secchi	pH-lab
	(oF)	(mg/l)	(%)	(ug/l)	(feet)	(su)
6/28/95	77	8	98	2.05floc	10	7.75
7/25/95	76	11.3	137	0.01phyto	10.5	8.38phyto
8/30/95	72.5	10.1	117	2.18	12	7.95phy &zoo
11/8/95	32	13.4	92	0.53	8.0 B	7.74
4/11/96	32(underice)	0	0			6.7
5/15/96	43.7(B+2')	9.6	78	8.27	5 *	7.48
					*Milky w/ylw hue	
Date	Alkalinity	Ammonia-N	NO3+NO2-N	TK Nitrogen	T.Phosphorus	D.Phosphorus
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
6/28/95	28			0.5	0.023	ND< 0.002
7/25/95	27			0.4	Phyt &Macro	0.004
8/30/95	27			0.4		ND<0.002
11/8/95	24	ND <0.027	ND <0.01	0.01	0.01	ND <0.002
4/11/96	36?				0.028	
5/15/96	27	0.091	0.064	0.037	0.022	ND <0.002
5/15/95						
					Foam	
Date	Hardness	Calcium	Chloride	Sulfate	Conductivity	Color,True
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(umhos/cm)	(su)
6/28/95					60	
7/25/95					60L (75.3 F)	
8/30/95					60L (51.2 F)	
11/8/95		5.7	1.2	3	56	5
4/11/96						
5/15/96	25	6.2	1.5	6	59	55
Date	Iron	Magnesium	Manganese	Potassium	D. Silica	Sodium
	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)
6/28/95						
7/25/95						
8/30/95						
11/8/95	0.12	2.4	0.0015	ND < 0.3		1.7
4/11/96						
5/15/96	*2.5	2.3	0.3	0.6	4.89***	1.8**
	*highw/P				***Quartz-SiO2	**Algae blooms
					Diatoms	
Date	T. Solids	T.Dis. Solids	T.Voltl.Solids	Susp. Solids	V.Susp.Solids	Turbidity
	(mg/l)		(mg/l)	(mg/l)	(mg/l)	(ntu)
6/28/95						
7/25/95						
8/30/95						
11/8/95	40	-	18	ND < 4.88	ND < 4.88	0.5
4/11/96						
5/15/96	50	52	14	ND <4.88	-	6.7
			PAGE18			

Acidity levels fluctuated from a **pH** of 6.7 under the ice (during a zero oxygen period) to a **pH** of 8.38 - during a period of supersaturation of oxygen. These wide ranging pH conditions, or acid level conditions, are due to the chemical reactions that occur in water that release or take up Hydrogen ions (H+). The zero oxygen conditions under the ice releases hydrogen sulfide (H2S) and methane gas (CH3) that react with the low buffered water to release Hydrogen ions and lower the **pH**. Both of these released compounds are toxic to fish and other organisms. The high **pH** corresponded to high supersaturated levels of dissolved oxygen from photosynthesis of aquatic plants that used up all the available carbon dioxide(C02). Carbon dioxide in combination with lake water forms carbonic acid that normally lowers **pH**, but with the tremendous amount of plant growth on sunny summer days the CO2 is used up and the **pH** rises sharply. These wide fluctuations in **pH**, oxygen, and associated water chemistry changes can stress aquatic organisms (e.g. fish, aquatic insects, leeches, zooplankton) and limit there growth, survival, and increase their susceptibility to parasites and disease.

As the **pH** fluctuates the solubility of other minerals changes. At spring ice out water chemistry sampling when **pH** was the lowest of the season elevated levels of **iron**, **silica**, **sulfate** and **sodium** were found. **Manganese** and **potassium** levels were also up at ice out. By November and ice up- when the pH was high and aquatic productivity low,again, **potassium**, **manganese**, **sulfate** and **iron** concentrations had dropped dramatically. The increased **silica** and **sodium** was associated with the mixing and early diatom (phytoplankton) bloom that was just beginning.

Total **iron** and **manganese** in Tambling Lake on May 15,1996, two days after ice out , was 2.5 and 0.3 mg/l, respectively. In most natural waters concentrations of **iron** are usually in the range of 0.027 to 0.2 mg/l. Concentrations of **manganese** in surface waters are usually less than those of **iron**. This extremely high **iron** level two days after ice out was after the severe winter of 1995-96 when no oxygen was found in the sediment and throughout most of the water column in Tambling Lake. Under these anaerobic (w/o oxygen) conditions high concentrations of reduced **iron** and **manganese** are released from the sediment.

Certain nitrogen compounds can be toxic to both fish and fish food organisms if they do not break down in an oxygen rich environment. Decomposing organic matter- release **ammonia** that quickly converts to **nitrite**, and then to **nitrate** if oxygen is present and temperatures and **pH** adequate. Under the low oxygen/ temperatures that Tambling Lake has during the winter, **ammonia-N** builds up beneath the ice and further stresses fish and other organisms. At ice out **ammonia-N** levels were detected at levels greater than the nitrite-nitrate-N even after spring mixing.

Low oxygen also affects **phosphorus** levels. **Phosphorus** is the most important nutrient limiting the amount of plant growth in a lake. **Phosphorus** is not highly soluble in water and precipitates with **iron** to the lake sediments when oxygen is present. But when Tambling Lake looses oxygen in winter or the sediments are without oxygen throughout the year, **phosphorus** and **iron** become soluble again and are released to the water column and to aquatic plants. Heavy phosphate foaming was observed on the down wind shoreline at the ice out sampling indicating a recent release of phosphorus from plant matter being broken up by spring wind and wave action. **Total phosphorus** levels were high from April under the ice to June while **dissolved phosphorus** levels were below detectable levels. Decomposing plant matter was responsible for these elevated **total phosphorus** levels during these periods.

Inorganic matter dominated the **total solids.** The **total volatile solids** or the estimated dissolved and particulate organic matter in the water sample was 14 mg/l at spring mixing and 18 mg/l at fall mixing. The **total dissolved solids** or the dissolved organic and inorganic matter at spring mixing was 52 mg/l. Dissolved and particulate organic matter represented by the **total volatile dissolved solids** was calculated as 38 mg/l. The long winter under the ice and snow without light penetration and the decay of plant material again contributed to the solid load to the lake at spring mixing.

Tambling Lake's water chemistry, especially the mineral components, is closely associated with the ground water that enters the lake. For a comparison a local well sampled east of Tambling Lake (from direction of ground water flow) was compared to Tambling Lake's water chemistry at ice out below. The chemistries are nearly the same except where the affects of biological activity has influenced the nutrient levels and the minerals most effected by this activity.

Tambling Lake Water Chemistry vs Local Well Water Chemistry.

	S.Conductance	pH	Temperature	Hardness	Calcium	Magnesium
Well 8143*	75	7	46.4 oF	29	6.7	2.9
Tambling L.**	59	6.7	43.7 oF	25	6.2	2.3

	Potassium	Sodium	Alkalinity	Sulfate	Chloride	Silica
Well 8143	0.3	1.9	28	7	0.3	17
Tambling L.	0.6	1.8	27	6	1.5	4.89

	NO2+NO3-N	Ammonia-N	TKN	Phosphorus	Iron	Manganese
Well 8143	< 0.10	<0.010	< 0.10	0.01	0.11	0.022
Tambling L.	0.064	0.091	0.037	< 0.002	2.5	0.3

Well 8143* in Town of Washington East of Tambling Lake(USGS Study 1989, Water Resources of Vilas County,Wisconsin, By G.L. Patterson)

Tambling L.** Water Chemistry Sample on 5/15/96- 2 days after ice out

Oxygen-Temperature & Physical Profiling

Oxygen- temperature profiling and secchi water clarity reading corresponding to water chemistry sampling began in June of 1995 and continued to May 1996. An additional 11 volunteer secchi disc samplings were conducted in 1996.

June 28. 1995

Results and observations for this late June sampling can be found in FIGURE 4. A rain shower prior to the midday sampling cooled the surface temperature to 72 oF. Water temperatures in the water column below the surface to an 8 foot depth fluctuated between 76 and 77 oF. Below 8 feet the temperature was 76 oF.

Dissolved oxygen and saturation levels were near saturation from the surface to 10 feet. From 10 feet to the 12 foot bottom oxygen saturations dropped from 8 mg/l (96% saturation) to 4 mg/l (48 % saturation). This rapid change in oxygen corresponded to the secchi depth.

A light floc was observed in the water column and became heavier at the secchi depth. Plankton in the water column was light. No submerged aquatic plants were observed in the deep water areas during this sampling. Water celery was the only submergent aquatic plant observed and it was limited to the shallow, sandy, shoreline areas. Heavily- rooted floating and emergent plants common to a bog lake were observed. The plants species observed during this sampling.are listed in FIGURE 4.

July 25. 1995

Results and observations from the July sampling can be found in FIGURE 5. On this sunny day water temperatures ranged from 77 oF at the surface to 72 oF on the bottom. From 6 to 9 feet a constant 74 oF was recorded.

Small phytoplankton could be observed throughout the water column but were not at densities to reduce water clarity as secchi depth extended to 10.5 feet. This light algae bloom apparently had continued since before July 14 as volunteer secchi sampling noted "green specs suspended in the water" with "green scum" wind rowed on the shoreline. Aquatic plants now covered the entire bottom. On July 14, in water 6-8 feet, some aquatic plants were already growing nearly to the surface.

This abundant attached plant growth combined with the algae suspended in the water column created midday supersaturated oxygen levels from the surface to 9 foot depth. Saturated dissolved oxygen levels were found from 9 to 11 feet amid heavy plant growth. Dissolved oxygen at the soft sediment bottom was the same as in June- 4 mg/l, but the water temperature was 4 oF cooler than during the June sampling.

An ice pushup area was observed on the southeast shoreline in the outlet area and further sediment filling appeared to have raised the lake water level. The volume of spring seepage and water quality could be affected by this increased water level.

Figure 4. Tambling Lake Oxygen/ Temperature Profiling on June 28, 1995

TAMBLING LAKE-VILAS COUNTY-deep spot

JUN 28,1995	TEMP oF	OXYGEN mg/l	OXYGEN % SAT
0'	72	7.9	91
1'	76	7.7	93
2'	77	8	98
3'	76	7.8	94
4'	77	8	98
5'	77	7.9	96
6'	76	8	96
7'	77	7.9	96
8'	77	8.1	99
9'	76	8.1	98
10'	76	8	96
11'	76	6.4	77
12'B	76	4	48
TAMBLING LAKE OUTLET			
	74	6.7	78

OTHER DATA:

SECCHI DEPTH: 10 FEET
-PHYTO & ZOOPLANKTON PRESERVED
WEATHER: RAIN SHOWER PRIOR
100% CLOUD COVER, LIGHT TO MOD. BREEZES

FIELD NOTES:
-LIGHT FLOC SUSPENDED IN WATER

AQUATIC PLANTS PRESENT:

WHITE WATER LILY	DUCK POTATO
YELLOW WATER LILY	ARROWHEAD
MARSH CINQUIFOIL	PICKEREL WEED
BLUE FLAG IRIS	WATERSHEILD
WATER CELERY	

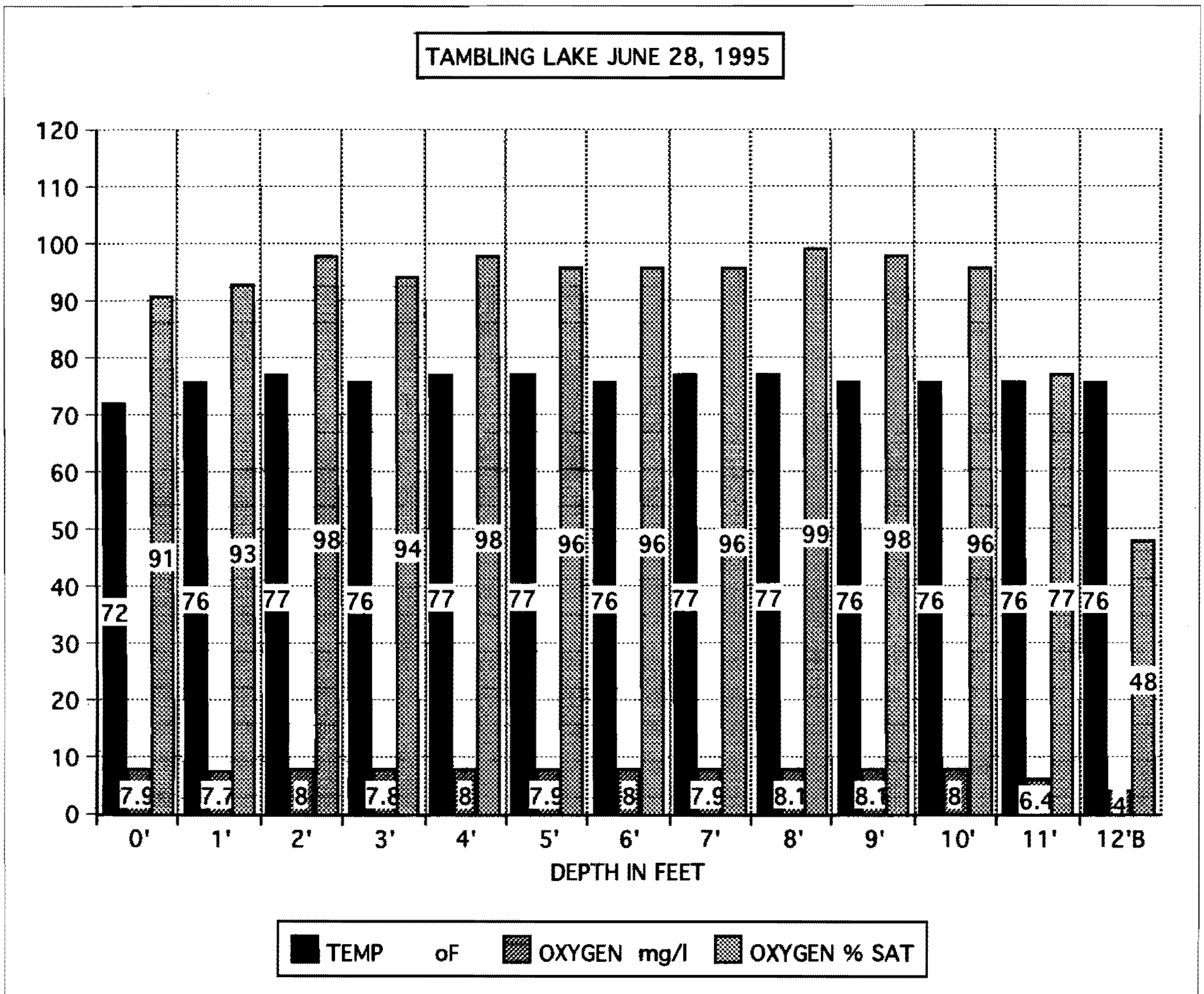


Figure 5. Tambling Lake Oxygen/ Temperature Profiling on July 25, 1995.

TAMBLING LAKE-VILAS COUNTY -deep spot

JULY 25,1995	TEMP oC	OXYGEN mg/l	OXYGEN %SAT
0'	77	11	134
1'	77	11.3	138
2'	76	11.4	137
3'	76	11.3	136
4'	75	11.4	136
5'	75	11.3	135
6'	74	11.4	134
7'	74	11.6	136
8'	74	11.6	136
9'	74	9.5	112
10'	73	8.5	99
11'	72	7.5	98
12'B	72	4	46

CONDUCTIVITY: 75.3 AT 25oC

TAMBLING LAKE OUTLET

	TEMP oC	OXYGEN mg/l	OXYGEN %SAT
	78	8.1	99

CONDUCTIVITY: 74.6 AT 25oC

Weather: 70% Sunny, Wind NW,breezy to 5 mph

OTHER DATA:

SECCHI DEPTH: 10.5 FEET

-SM. PHYTO PLANKTON IN FULL H2O COLUMN

FIELD NOTES:

- WATER CLOUDY ON NORTH SHORE

-CLEAR ON WEST SHRE

AQUATIC PLANTS:

-H2O CELERY	-ARROWHEAD	-SM.LVED PWD
-Y.WATER LILY	-PICKERELWEED	-FERNDPWD
-CHARA	-ELODEA	-WATERSHEILD
-SOFT STEM RUSHES		-STAR GRASS
-MARSH MARIGOLD		-BULLRUSH
-W. H20 LILY ALOND NW BOG		-STONE WORT

-ICE PUSHUP MOUND BY OUTLET

-OUTLET CLOGGED BY P.WEED & B.RUSHES

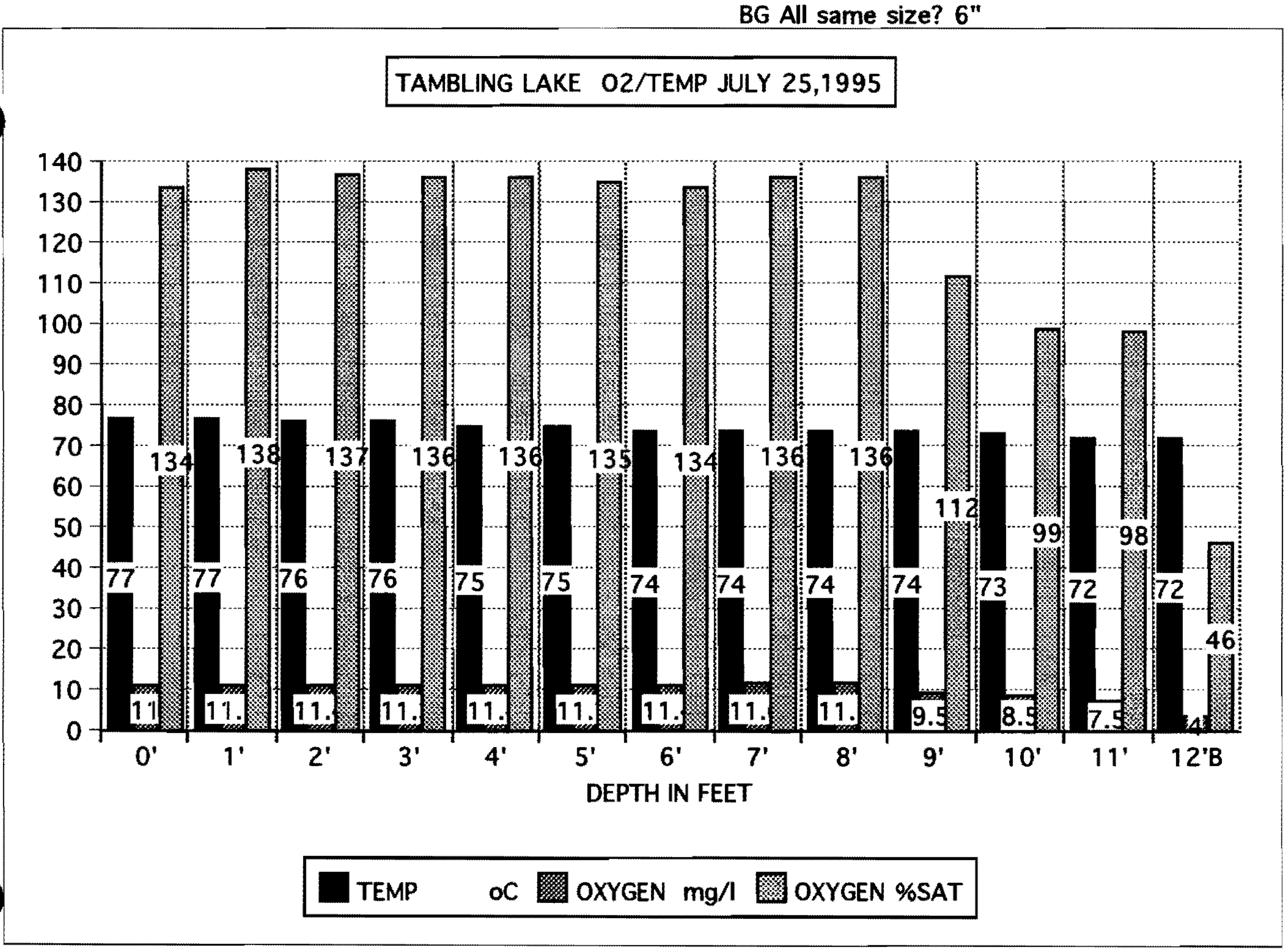
-DEAD TREE STUMPS IN WATER

-RAISED H2O LEVELS,NUTRIENTS LEACH,BOG

FISH OBSERVATIONS:

LMB 14", 8",YOY NP 25" YP 8"

BG All same size? 6"



August 30, 1995

By late August water temperatures were already cooling despite a hot and sunny day with S-SW winds. See FIGURE 6. Water temperature dropped from 73.5 oF at the surface to 70 oF at the bottom. Water temperatures from the 6' depth to the bottom at 12 feet dropped only 1/2 degree from 70.5 to 70.0 OF.

As in July phytoplankton algae were found throughout the water column but not at densities that affected water clarity. The secchi disc visibility was at the bottom in 12 feet of water. Aquatic plants extended to an 8 to 9 foot depth. Again the abundant plant growth created midday supersaturation of oxygen from the surface to the bottom.

Water celery was found attached to the boat anchor when lifted. It is in this deep area where the muck layer is the thinnest with sand and gravel beneath. These are the preferred conditions for water celery growth.

November 8, 1995

A thin layer of ice covered Tambling Lake the night before and ice had to be broken to reach 8' of water for sampling. Water temperature was at 32 oF from top to bottom. See FIGURE 7. Secchi depth extended to the bottom.

Dissolved oxygen saturation was at 92 % from the surface to 4 feet. One foot above the "weed line" the saturation level began increasing; And, at the depth of aquatic plant growth saturation of oxygen was recorded. At the 8' bottom the saturation level fell only slightly. The day was mostly cloudy with an occasional snow squal so a limited amount of photosythesis by the aquatic plants was occurring increasing oxygen levels adjacent. As during the rest of the open water period, the oxygen demand at the muck/ water interface was not great - dropping the oxygen probe into the sediment did not drop the oxygen reading to near zero concentrations.

Figure 6. Tambling Lake Oxygen/ Temperature Profiling on August 30, 1995.

TAMBLING LAKE-VILAS COUNTY-deep spot

AUG 30, 1995	TEMP oC	OXYGEN mg/l	OXYGEN %SAT.	OTHER DATA:
0'	73.5	9.8	114	SECCHI DEPTH : 12 FEET
2'	72.5	10.1	117	PHYTO & ZOOPLANKTON SAMPLED
3'	71.5	10.2	117	-PHYTO PLANKTON IN COLUMN
4'	71.5	10.3	118	
5'	71	10.3	116	FIELD NOTES:
6'	71	10.3	116	AQUATIC PLANTS ABUNDANT:
7'	70.5	10.4	118	-RICHARDSON'S PONDWEED
8'	70.5	10.4	118	-WATER CELERY(ON ANCHOR)
9'	70.5	10.5	119	-ELODEA
10'	70	10.6	119	
11'	70	10.6	119	
12'B	70	10	112	

CONDUCTIVITY: 51.2 AT 24 oC WEATHER: S-SW Wind at 15-20, Sunny, Air temp 80 oF at 2:00

TAMBLING LAKE OUTLET:

	TEMP oC	OXYGEN mg/l	OXYGEN %SAT.
	74.5	10.2	120

CONDUCTIVITY: 51.2 AT 24oC

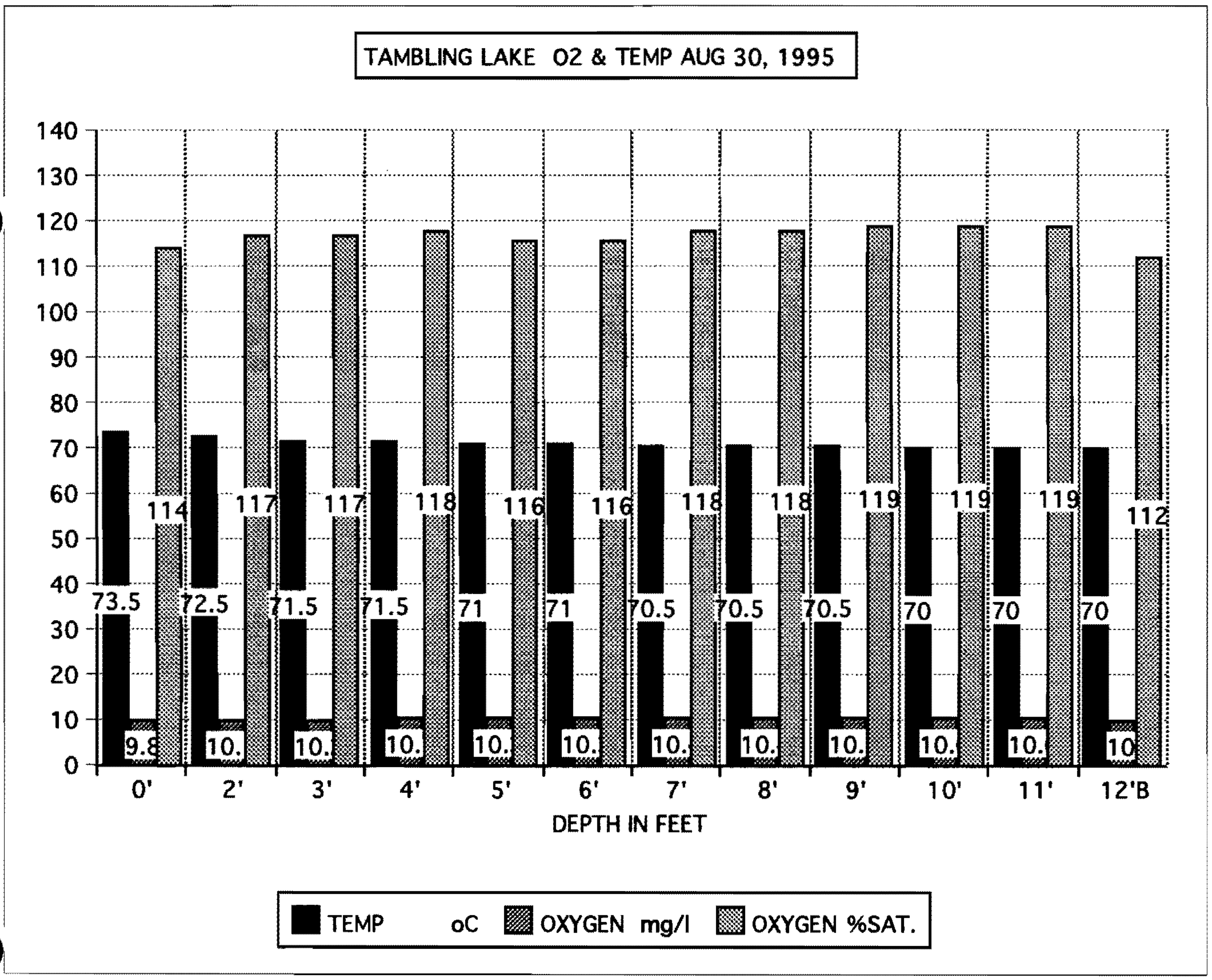
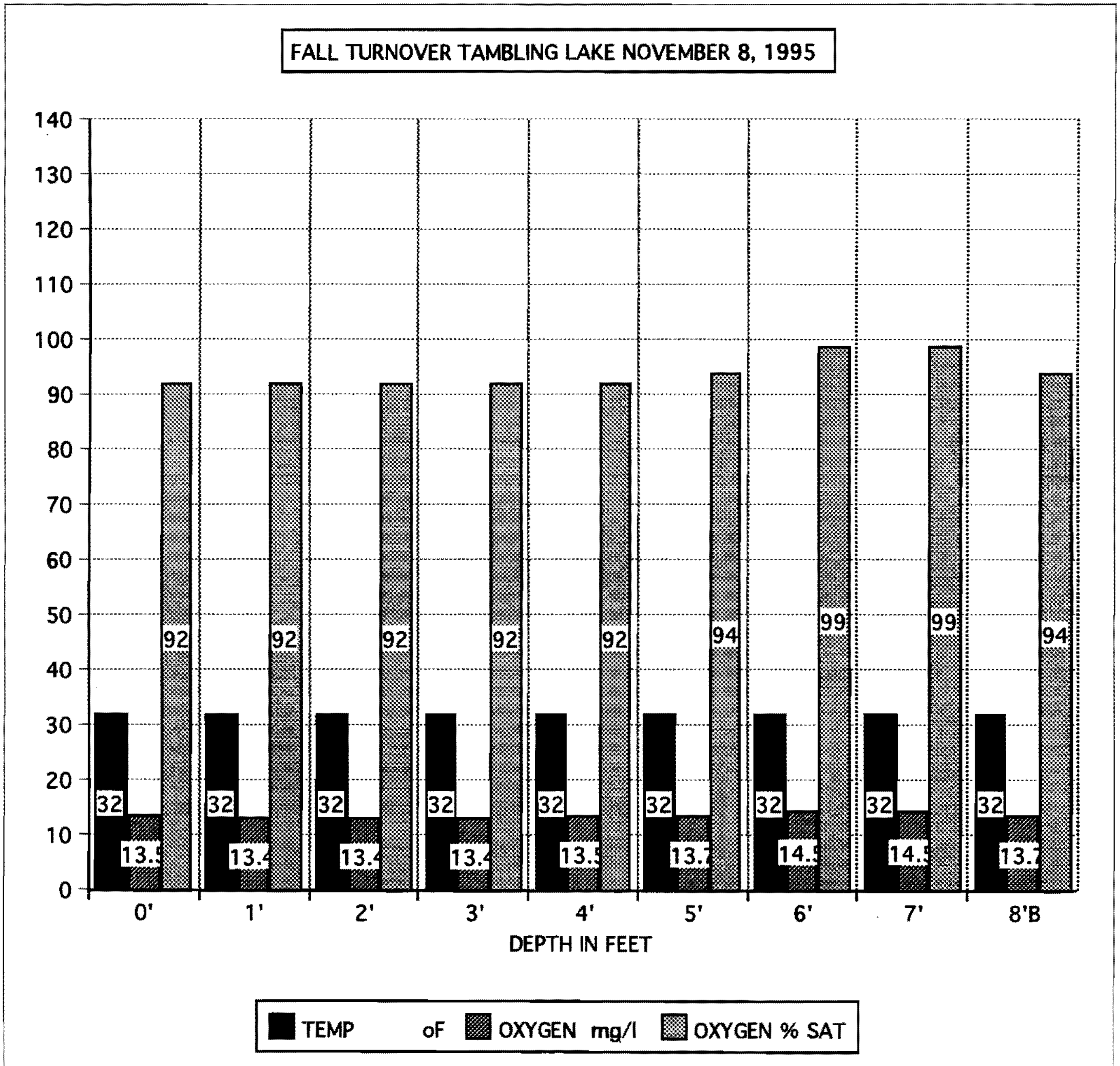


Figure 7. Tambling Lake Oxygen/Temperature Profile on November 8,1995.

TAMBLING LAKE-VILAS COUNTY-deep spot 1/4" Ice

NOV 8,1995	TEMP oF	OXYGEN mg/l	OXYGEN % SAT	OTHER DATA: Snow squal,ice cover in night
0'	32	13.5	92	SECCHI READING:BOTTOM
1'	32	13.4	92	WEED LINE AT 6' DEPTH CORRES. O2 INCR
2'	32	13.4	92	
3'	32	13.4	92	
4'	32	13.5	92	
5'	32	13.7	94	
6'	32	14.5	99	
7'	32	14.5	99	
8'B	32	13.7	94	

CONDUCTIVITY: 51.9 AT 24 0C



February 13, 1996

Tambling Lake has a history of periodic winter kill. With the early fall freeze up and snow cover the winter oxygen/ temperature profile was moved to mid February. The ice was 45" thick with 4" of snow cover at the sampling location. The oxygen conditions that winter follow below in TABLE 4. On the March 19 sampling at sites #2 and #3 the water temperatures near the bottom exceeded 4 oF, which is the temperature that water is the densest. This is an indicator that spring seepage of ground water is occurring at these two deep sites.

TABLE 4. Oxygen/ Temperature Profiles Under the Ice 1996.

TAMBLING LAKE- VILAS COUNTY-deep spot

Feb 13,1996	TEMP oF	OXYGEN mg/l	OXYGEN % SAT	OTHER DATA:
0'				Snow Depth: 4"
1'	32	2.5	17	Ice Depth: 45"
2'	32	2.75	19	
3'	32	0	0	Field Notes: Fish crowded around
4'	32	0	0	Marisch Dock Aerator
5'	34	0	0	
6'	34	0	0	
7'	35.5	0	0	
8'	35.5	0	0	
9'	36	0	0	
10'	36	0	0	
11'	36.5	0	0	
12'	37	0	0	
13'B	38	0	0	
Outlet @ Culvert	32	0.5	3	

TAMBLING LAKE- VILAS COUNTY-by R.C. Boheim- Ice depth 36", Snow Depth 4"
March 19, 1996

Site 1- Adjacent to E Bog

DEPTH(Feet)	TEMP(oC)	O2 (mg/l)
S'	0	ICE
4	2.1	0.05
5	Bottom	

Site 2- Deep Hole Center

DEPTH(Feet)	TEMP (oC)	O2 (mg/l)
S	0	ICE
4	0.4	0.15
5.5	4.2	0
7	4.4	0
8	Bottom	

Site 3- Deep Hole N. Center

DEPTH(Feet)	TEMP (oC)	O2 (mg/l)
S'	0	ICE
4	0.9	0.1
6	4.5	0
8	5	0
10	5	0
12	5.2	0
13.5	-	Bottom

Site 4- North Bay

DEPTH(Feet)	TEMP (oC)	O2(mg/l)
S'	0	ICE
4	1.8	0.1
6	2	0.05
8	3.9	0
10	4	0
11	Bottom	

Site 5- SE Shoreline

DEPTH(Feet)	TEMP (oC)	O2 (mg/l)
S'	0	ICE
4	2.1	0.05
5	Bottom	

May 15, 1996

Spring sampling occurred two days after ice out. Water temperatures were 42 oF from the 1' below the surface to 14'. A warm, 10-15 mph, SW wind and air emperature of 55 oF heated the surface water temperature 1 oF to 43 oF. See FIGURE 8.

Dissolved oxygen concentrations were greatest in the upper two feet and dropped only slightly from 3' to one foot off the bottom at 13'. Oxygen saturation in the upper 2' were from 81-85% and dropped to 78-76% as you sampled deeper. At the bottom oxygen levels dropped to zero.

The results of the depleted oxygen conditions under the ice were now evident. Spring mixing brought bottom water containing dissolved compounds, created under the anaerobic(w/o oxygen) conditions, into the water column. The water had a milky appearance with a yellow hue. Secchi disc clarity, because of this mixing, was limited to 5.0 feet. Phosphorus was being released on the downwind shoreline as heavy phosphate foaming was observed. Other chemical changes during this period are discussed above under the water chemistry section.

Dead fish were observed in areas where water movement and spring seepage held remnant oxygen levels the longest. Dead fish were found in seepage areas along the south and southeast shorelines to include the following: bullheads, large largemouth bass,, a yellow perch, small bluegills, a black crappie, and a single northern. Dead fish were also observed in the east bog area. The outlet area had 10 good size largemouth bass, several dozen black crappies, and a few bluegills or pumpkin seed. Many of these fish appeared to have been trapped under the thicker ice that was found near the shoreline.

Live Elodea, an aquatic plant that does well under the ice with very poor light conditions, was found under the ice in late winter and wind rowed on the southeast shore. This plant may have provided remnant oxygen levels in some other areas of Tambling Lake.

Secchi Disc Monitoring 1995 & 1996.

A volunteer secchi disc program was set up on Tambling Lake during the planning grant data collection period. The results of this monitoring can be found in FIGURE 9. Secchi disc reading between the two years is deceiving. Water was clear to the bottom during both years but during the second year the small area of 12-14' of water was difficult to find as secchi readings were bottom readings in 8 to 9 feet of water.

Figure 8.Tambling Oxygen/Temperature Profile at Spring Mixing May 15, 1996

TAMBLING LAKE-VILAS COUNTY-deep spot

AUG 30, 1995	TEMP oC	OXYGEN mg/l	OXYGEN %SAT.	OTHER DATA:
0'	43	10.5	85	SECCHI DEPTH : 5 feet
2'	42	10.2	81	Weather: 100% Cloud Cover
3'	42	10.2	81	
4'	42	9.8	78	
5'	42	9.8	78	FIELD NOTES:
6'	42	9.7	77	- 2 days after ice out
7'	42	9.6	77	- Water milky w/ a yellow hue
8'	42	9.6	76	
9'	42	9.6	76	
10'	42	9.6	76	
11'	42	9.6	76	
12'	42	9.6	76	
14'B	42	0	0	

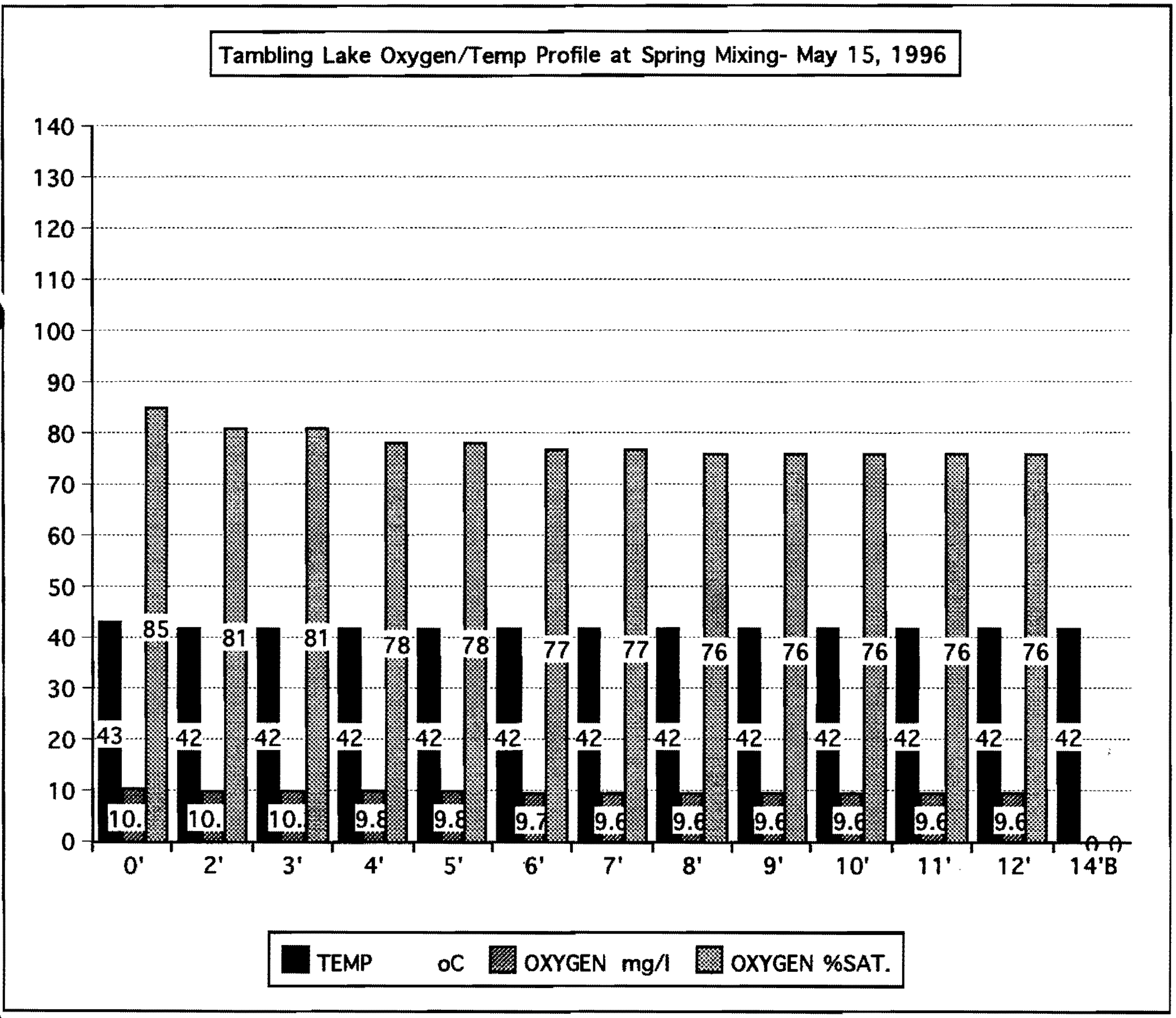
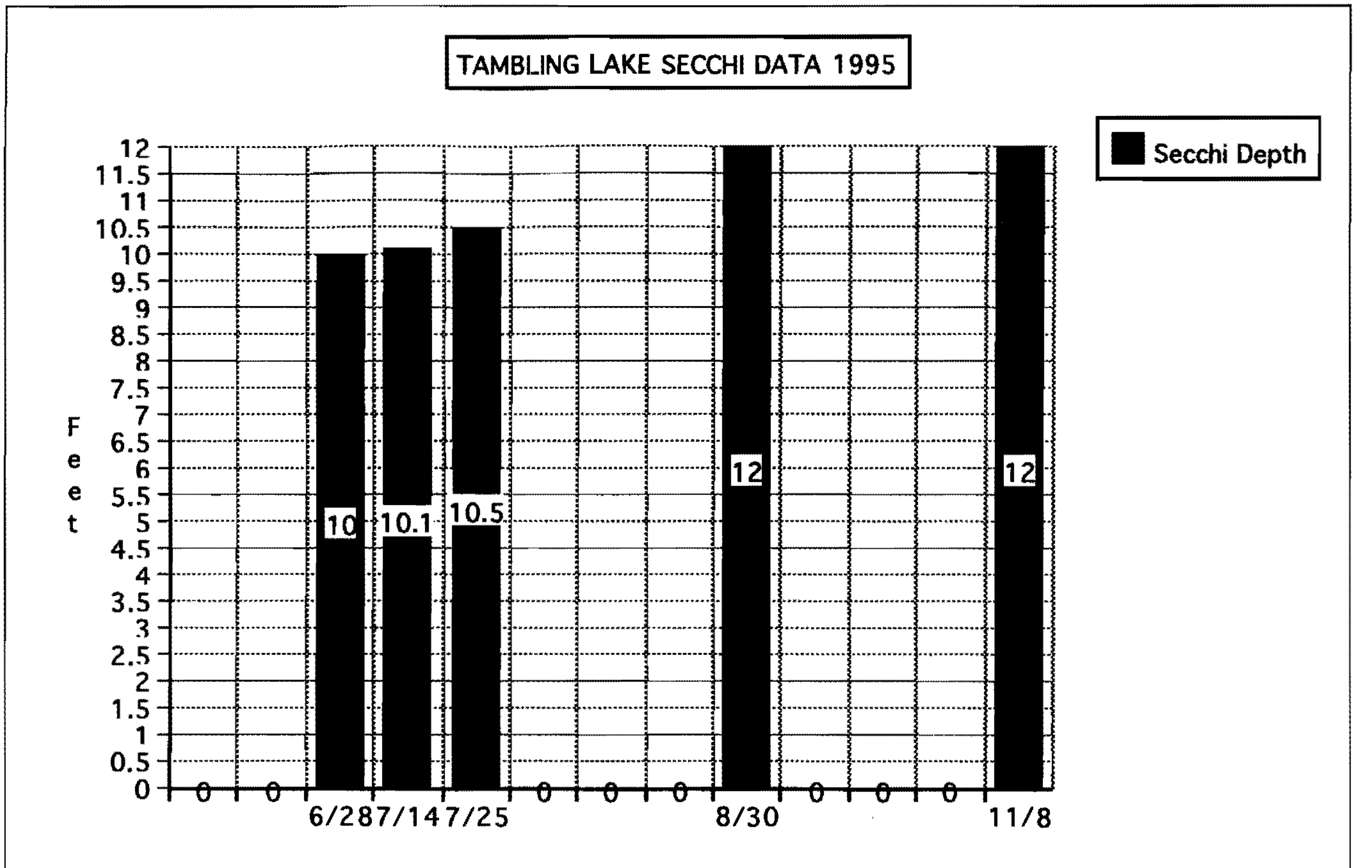
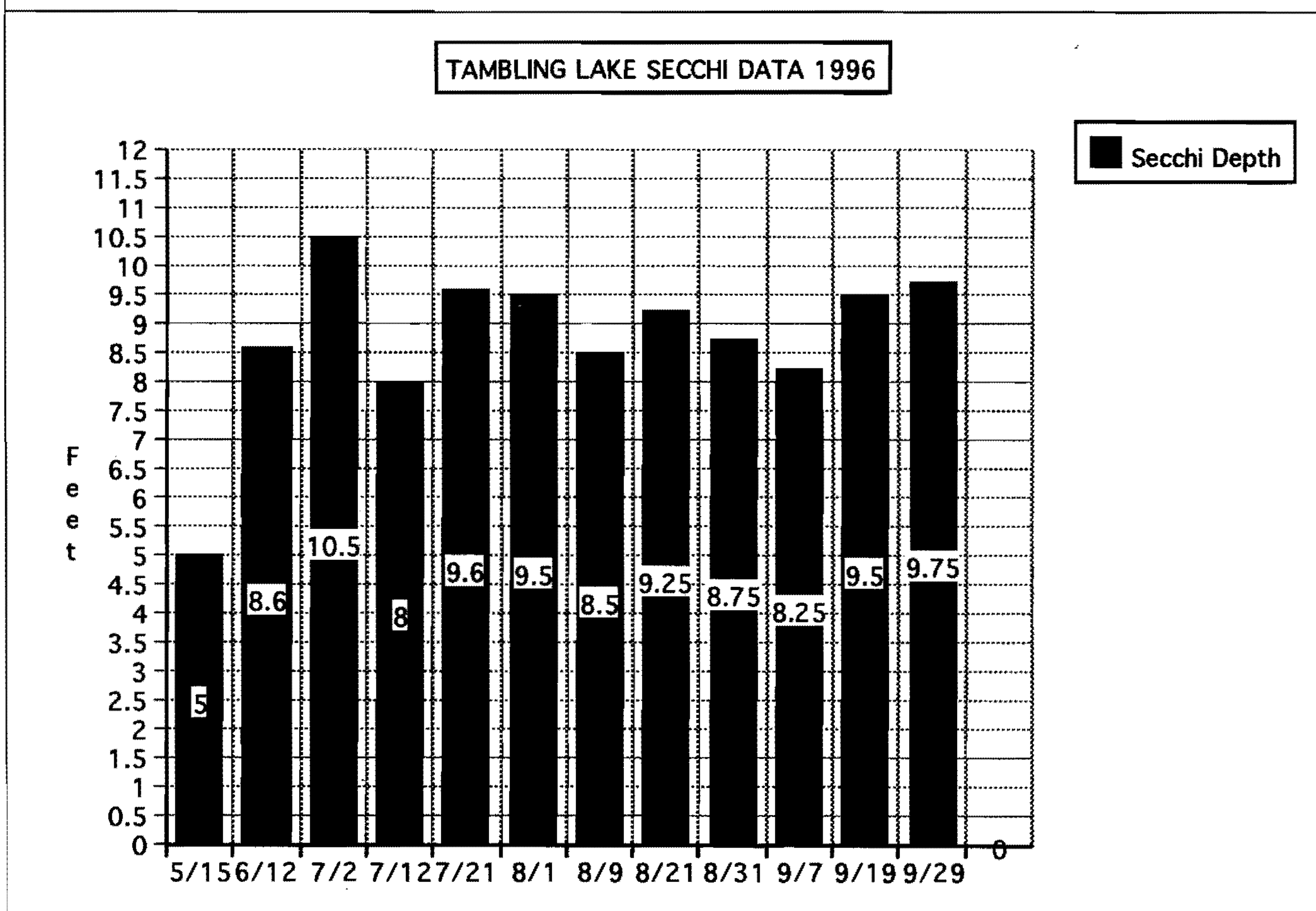


Figure 9. Tambling Lake Secchi Data 1995 & 1996.





AQUATIC PLANTS OF TAMBLING LAKE

Introduction

Most of Tambling Lake's bottom is covered with an organic layer of muck that provides nutrients to the water column and a substrate for submerged plant root production. Most of these deep water areas in depths from 5 to 14 feet have abundant attached aquatic plants (macrophytes) through most of the growing season. Light penetrates the deepest areas of the lake through most of the growing season as indicated by recent secchi disc water clarity observations.

There are several sandy shallow water areas adjacent to shore where deposits of sand and gravel out wash can be found along with aquatic plants that do well on these more firmer, wave swept, shorelines. Many of these plants are submergent, but more are floating or emerge from the water.

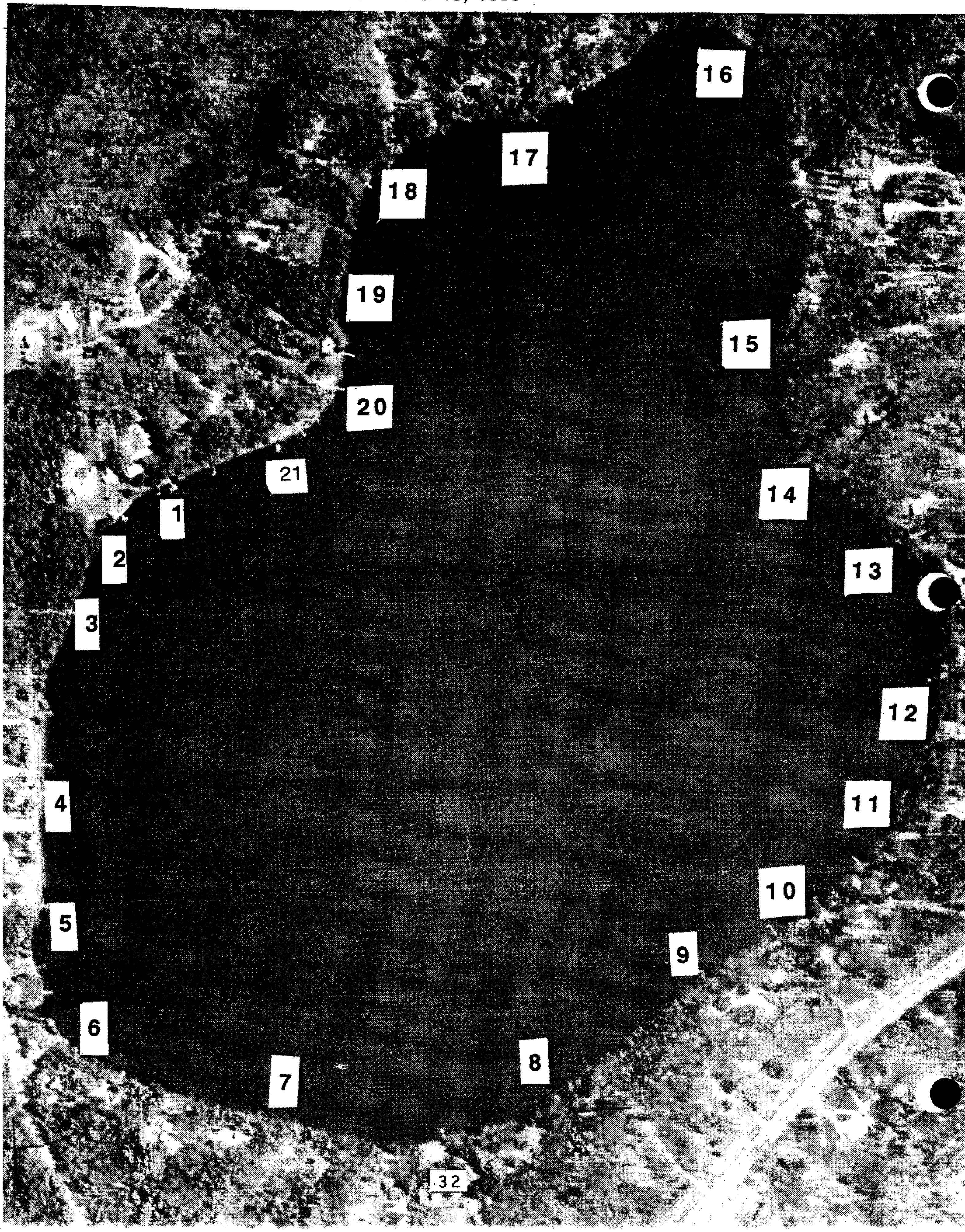
Several wetland communities extend into Tambling Lake from the shoreline. A low flat area can be found extending from the NE to SE shoreline, except for the east NE sand point that separates them. Both inlet and outlet areas have accumulated organic matter for wetland aquatic plant production. A mucky- sandy soil can be found in a low flat, poorly drained area on the west shore of the north bay. This soil has 4" of black muck over layers of mottled sand caused by ponding of water. Native wetland vegetation does well on this soil. The third wetland area is the west shoreline tamarack areas. This bog area is a drainage way from the very permeable soils in the watershed above. In all of the wet areas described above, trees do not establish very deep root systems and are easily wind thrown. Aquatic plants that do well in seepage areas and under acid conditions can be found adjacent to these locations.

Most of these wetland areas above provide all three types of aquatic vegetation: emergent, floating, and submergent. Diversity of habitat accompanies this variety of aquatic plants. Aquatic insects that fish feed upon are abundant among these plants. Structural fish cover is lacking in Tambling so the emergent and floating vegetation of these areas provide most of the physical cover for fish. Plants in these areas also provide food and cover for nesting or resting waterfowl.

Procedure

An aquatic plant survey of Tambling Lake was conducted on August 14 and 15, 1996. The survey used a standard transect sampling method that recognizes plant species, their densities, rooting depth and substrate types. Twenty-one sample transects were made perpendicular to the shoreline extending from the shoreline to the maximum depth. See FIGURE 10. The transects were chosen to represent a variety of habitats from wetlands to steep shoreline extensions and from developed to undeveloped shorelines.

FIGURE 10. TAMBLING LAKE AQUATIC PLANT TRANSECT LOCATIONS ON AUGUST 14 & 15, 1996



Each transect was given a number as indicated in FIGURE 10. The present shoreline owner(s) was noted for each transect beginning point and a compass bearing of transect direction made and recorded. See TABLE 5a & 5b.

A rake was used to sample four quadrants at each of 3 to 4 sampling points that represented increasing depths along a transect. At each sampling point the plants were identified, given an alphabetic letter, and their densities described by a numbering system from 1 to 5. One (1) being sparse and found in only one quadrant to five (5) being dense and appearing in all four quadrants.

The results of this survey were tabulated by abundance and depth. The results were further analyzed to recognize the competition between plants in the plant community. The survey results were also combined with other observations (such as interaction of the plants with substrate,light, and other physical-chemical conditions) made throughout the grant period.

Results & Discussion

Aquatic plants were identified in four depth ranges extending from the shoreline to the deepest areas of the lake. A list of aquatic plants found with an assigned letter and scientific name can be found in TABLE 6a & 6b. Five substrate types were identified in the 0 to 2.5 foot littoral area of the shoreline. Seven substrate types at the 2.6 to 5.0 foot depths. Four sediment descriptions were used in the 5.1 to 9 foot depths. Muck and sand were the only sediment types found at depth of 9.1 to 15 feet .

<u>0 to 2.5 Feet</u>

This littoral zone of the lake is the most sensitive area of the lake ecosystem and the area most effected by human use of the lake. Shoreline develop pressures by shoreline residents can destroy fish and other aquatic animal habitat. In Tambling Lake most of these shallow water areas have a sand substrate. This sand area in most areas of the lake is a base substrate for most of the aquatic plants found in the lake. Natural wave action is important in hydraulically maintaining this substrate for these plants. Excessive wave action by boat activity can destroy or alter these areas and change the plant community.

The most common and abundant aquatic plant in the 0 to 2.5 foot shoreline area was the emergent brown- fruited rush. This plant was most abundant and dense over the shallow water areas of sand. These rush areas are important spawning grounds for rock bass, bluegills, and other sunfish. Those stems that are still standing at the end of winter often catch yellow perch semi- buoyant egg ribbons. These stems suspend them off the bottom and act as a wave-aerated incubation pedestal until the eggs hatch into fry. The fruit is used by some waterfowl, marsh birds, and with it's close proximity to shore is also used by song birds. The bases and roots are sparingly eaten by muskrats.

The second most abundant plant at this depth is the water or wild celery (also called tape grass). This plant produces a whitish-yellow flower supported by a coiled stalk that floats on the surface by late summer. This submergent plant is the most diverse plant found in Tambling Lake. Where sand was mixed with detritus or muck it was just as abundant as the rush above at the 0 to 2.5 foot depth. At the 2.6 to 5.0 foot depth it was most abundant where the sand substrate edge dropped into the muck substrate. This plant provides shade and shelter for bluegill, young perch and bass. It's winter buds and root stock are preferred food for waterfowl where the entire plant attracts marsh and shore birds, and the muskrat.

The small bladderwort was the third most abundant plant in the shallow water areas. This plant was mainly found near bog areas of the shoreline or areas where sand had covered peat bog substrate adjacent. These small aquatic herbs catch small aquatic invertebrates in their tiny bladders and survive the severe winter under the ice as small buds.

The 0 to 2.5 foot depth contained the most diverse plant community in the lake. The submergents included the common waterweed(Elodea), the slender naiad, the fern pondweed. It also included two wide-leaved potamogetons, the variable and leafy pondweeds, and in one place musk grass(Chara). Emergent aquatic plants were also found to include: arum- leaved arrowhead, pickerelweed, spike rush, and in the shallowest water the 3-way sedge. Floating aquatic plants include the yellow water and white water lilies, and watersheild. This variation in aquatic plant type, height, and densities provide cover and shade for a variety of waterfowl and fish over a variety of substrates. Their leaves and stems harbor an abundance of aquatic insects and shelled invertebrates that provide food for both aquatic birds and fish.

2.6- 5.0 Feet

This depth is less effected by wave action but is second in the variety of aquatic plants. Emergent plants are no longer found and watershield is the only floating plant that was found at that depth. Deep water submergent plants compete with the shallow water submergent at this depth.

By far the most common and abundant plant at this depth was the fern pondweed. It also dominated all waters deeper than this zone. This palm-like fern submergent plant can grow to be 15 feet long and is firmly rooted with a thick stem. Leaves are usually 2 to 8 inches long and are thin and slender. The flower or seed spike may extend above the water surface late in the summer. This tough plant has no value to waterfowl but provides food and shelter for panfish, bass, and northern pike. Walleye pike use this pondweed if they are the dominant vegetation in the lake, especially near drop off areas.

The fern pondweed dominated all the muck substrate areas; but at this depth was competing with the common waterweed (Elodea) and water celery, especially in the sand/muck edge areas. Both water celery and common waterweed were tied as the second most abundant plant species at this depth.

Elodea has branched stems with 3 or 4 oval leaves arranged in whorls. Elodea has a tolerance for the cool water's of Tambling spring seepage as well as a tolerance for low light conditions that allow it to over winter as an entire plant. This was evident when green fragment of this plant were found during the sediment profile through the ice in March. Elodea is most abundant on fine sediments enriched with alkaline organic matter (e.g.Tambling Lake's muck), but can be found over a broad spectrum of sediment types. It also offers valuable shelter and grazing opportunities to fish, although dense stands can lead to fish stunting. It provides food for muskrats and waterfowl as they can eat the plant itself or feed on a wide variety of invertebrates that use the plant as habitat.

5.1 to 9.0 Feet

At this depth muck substrate covers the entire bottom. At this time fern pondweed dominates but in places is facing tough competition with Elodea. Elodea also reproduces predominantly through stem fragmentation, therefore is better suited to spreading and competing with the fern pondweed in the deeper areas of the lake. Water celery and large-leaf pondweed are present but sparse at this depth range.

The greatest variety of submerged aquatic plants at this depth were found over sand substrate in a small area in the northeast of the lake. This area is also one of the best fishing areas in the lake.

9.1 to 15.0 Feet

Muck dominates this depth zone, but one deep water area was found with a sand substrate. Fern pondweed and Elodea were again competing on this muck substrate. On the sand substrate at this depth water celery was more abundant than fern pondweed and Elodea.

Conclusions

The importance of aquatic plants in providing cover and habitat for waterfowl, shorebirds, and fish as well as habitat for food organisms they all feed on has been documented above. Aquatic plant communities are not static. Without noticeable changes by man, they can change over a short period of time as a result of water level and or clarity changes. Dredging, filling, aquatic plant harvesting or chemical treatment are more direct ways man can severely disrupt the aquatic community.

A review of the Department of Natural Resources files found a list of plants and their relative abundance as they existed in Tambling Lake in 1976, twenty one years prior to this survey. This list can be found in TABLE 7. The aquatic plant community has changed considerably since that time. Though some differences in methods and keying- especially among the pondweeds, could account for some variation, other changes are noteworthy.

TABLE 7. Aquatic Plants and their Relative Abundance in Tambling Lake in 1975.

	Common Name	Plant Type	Relative Abundance
1.	Wild Celery	S	A
2.	Yellow Water Lily	F	C
3.	Pink Water Lily	F	C
4.	Burreed	E	C
5.	Bushy Pondweed	S	A
6.	Robbins Pondweed	S	C
7.	Clasping Pondweed	S	P
8.	Flatstem Pondweed	S	P
9.	Large-Leaf Pondweed	S	A
10.	Whitestem Pondweed	S	P
11.	Variable Pondweed	S	P
12.	Leafy Pondweed	S	P
13.	Sago Pondweed	S	P
14.	Pickerelweed	E	C
15.	Arrowhead	E	P
16.	Common Cattail	E	P
17.	Water Lobelia	E	P
18.	Watershield	F	P
19.	Spike rush	E	P
20.	Juncus sp.	E	P

S= Submergent A= Abundant
F= Floating C= Common
E= Emergent P= Present

Among the submergent plants, the fern pondweed now dominants the pondweeds and deep water areas which was not true in 1975 (TABLE 8). Common waterweed (Elodea) not described or absent in 1975 is also now abundant in Tambling Lake. The presence and abundance of most of the wide- leaf pondweeds have either been eliminated or decreased, respectively since 1975.

Loss of a diversity of submergent plants with extensive root systems and replacement by narrow-leaved plants that do not have these root systems can effect several aspects of the lake community. Narrow- leaved plants, with a reduced root system, received much of their nutrients directly from the water. With water warming faster than the spring seepage sediment these narrow-leaved plants can grow quicker in the spring and out compete the rooted, wide leaved plants. Over time they will increase in abundance and hamper navigation. They often grow so thick predator fish are unable to capture panfish forage and stunting can occur, especially in a periodic winter kill situation that Tambling Lake faces.

The shallow water floating and emergent plant community also appears to have changed from 1975 to the present. This appears to be from the increased water levels caused by the pushup mound and silted in outlet. Even a 6" water level over time can effect the make up of shallow water area, mainly because of the physical effects of wave action and moving bottom material with varying amount of nutrients from one area to another.

Absence of burred and cattails, is the most striking change, though the leaf of the burreed and that of the cattail are often confused, neither were identified in the 1996 survey. The burreed was listed as common on 1975 where the cattail was only listed as present. The burreed of the north prefers clean, low- nutrient water and the cattail can grow on almost any moist substrate. A water level increase and/or a change in shoreline hydraulics could cause this change.

The above disappearance of emergent plants corresponds to the appearance of 3-way sedge, arum-leaved arrowhead, and brown-fruited rush. The sedge and rush do well on wet sandy shore areas which would have been enlarged on Tambling with increased water levels from flooding or by erosion. The Arum- leaved Arrowhead prefers cold bog waters or muck shores. It is along the west bog area where this plant was found. Again increased water levels and wave action would increase these conditions in this area.

The changes in the aquatic plants above is from a more diverse to a less diverse community that effects the fish and wildlife community that the lake community finds important. Increased water levels combined with wave action, whether from wind or boat action, is negatively effecting the plant community of Tambling Lake.

Is there other considerations of an attached aquatic plant community now dominated by plants with the ability to remove nutrients directly from the water? Are they competing with the free- floating phytoplankton(algae) for nutrients therefore affecting their densities in Tambling Lake. Phytoplankton is fed on by zooplankton, which in return feeds post larval fish. The success of a year class of any fish can often be attributed to lack of food during this stage in a fish's life.

FISHERIES OF TAMBLING LAKE

Introduction

Little is known about the current fisheries of Tambling Lake. The last survey of the lake was completed nearly 20 years ago in 1975-76. Walleye fingerlings were stocked for three years after this survey and no further stocking has been done until recently after the 1995-96 winter fish kill. Panfish and a few largemouth were transferred from a nearby lake in the spring of 1996. Recent fisheries management efforts before the present fish transfer were to assess winter oxygen conditions under the ice. Low dissolved oxygen levels were common in late winter. The lake residents had been encouraged in the past to install an aeration system to avoid a winter kill.

The purpose of this planning grant study was to gather and analyze all past data on the lake and develop a current inventory of the physical, chemical , and biological conditions. The assessment of the fisheries below meets this intent.

Procedure

The fisheries portion of this grant proposal included reviewing existing fisheries data and ecologically interpreting the relationship between Tambling Lake's current conditions and it's fisheries. A volunteer fish assessment program was introduced and demonstrated at the annual fishery in 1995 and sample age/ growth interpretation presented at the annual spring meeting in 1996.

The fish kill during the winter of 95 & 96 disrupted the fisheries that had developed since the last documented fish kill in 1986. The physical, chemical, and biological conditions that created this fish kill situation were documented in this study.

Results & Discussion

Tambling Lake in the past has supported an excellent fisheries in between periodic winter fish kills. Winter fish kills were documented in 1948, 1965, 1986, and 1996. A probable fish kill occurred during the winter of 1933-34 as the earliest recorded fish stocking occurred in 1934. It appeared to be a fish transfer of several species of fish including northern, walleye, yellow perch, bluegills, white sucker, and minnows. See TABLE 9.

Fish stocking to include sac fry walleye and fingerling walleye, largemouth, muskellunge, and muskellunge/northern hybrid occurred from 1934 until 1976. Stocking stopped at that time until the recent 1996 fish kill when 1200 panfish with a few largemouth were planted into the lake. See TABLE 9.

Fish assessments were made by netting or electroshocking in 1958, 1965, 1967, 1975-76, and in 1986. The 1965 and 1986 electroshocker surveys were winter kill assessments. The first survey in 1958 and comprehensive survey in 1975-76 indicated a healthy and diversified fishery. See TABLE 10 & 11.

TABLE 9. TAMBLING LAKE FISH STOCKING HISTORY

DATE	SPECIES	# PLANTED	SIZE	REMARKS
1934	Northern	?		
	Walleye	?		
	Yellow Perch	?		
	Bluegill	?		
	White Sucker	?		
	Minnows	?		
1934	Walleye	28,814	?	
1935	Walleye	325,880	Fry	
1936	Walleye	356,000.00	Fry	
1939 WPA 2 BRUSH REFUGES,10 SAMPLING TANGLE,SPAWNING BOXES,50 MINNOW SPAWNING BOXES,MAPPED				
1940	Walleye	300,000	Fry	
1941	Walleye	200000	Fry	
1944	Largemouth	375	Fingerlings	
1948 WINTERKILL				
1952	Walleye	2000000	Fry	5/26/52
1953	Walleye	3550	Fingerlings	
1954	Walleye	3400	Fingerlings	
1955	Walleye	3400		
1958 NET SURVEY				
1959	Walleye	10527	Fingerlings	
1960	Walleye	16900	Fingerlings	
1962	Muskie	390	Fingerlings	
1963	TigerMuskie	300	Fingerlings	
1965 WINTERKILL				
1965	Walleye	500000	Fry	
1966	Muskie	100	Fingerlings	
	Largemouth	2000	Fingerlings	
1967	Largemouth	2649	Fingerlings	
1967 ELECTROSHOCKING SURVEY				8/9/67
1968	Muskie	350	Fingerlings	
1969 DREDGING OF NORTH BAY 100 X 100FEET TO3-4.0 FOOT DEPTH = 180,000 FT3				
1970	Walleye	70180	Fingerlings	8/7/70
1971	Walleye	8000	Fingerlings	7/27/71
1976	Walleye	20000	Fingerlings	7/30 & 9/11/76
1977 COMPREHENSIVE SURVEY				
1977	Walleye	10000	Fingerlings	3"
1978	Walleye	8000	Fingerlings	7/11 & 7/26/78
1986 WINTERKILL				
1986 BOOM SHOCKER SURVEY				5/15/86
1996 WINTERKILL				
1996	Largemouth		Adults	
	Bluegill		Adults	
	Pumpkinseed		Adults	

TABLE 10. Fishery Assessment History of Tambling Lake, Vilas Co. Wis

9/3/58 NET SURVEY (4 Days)						
SPECIE	Northern Pike	Muskellunge		Largemouth Bass		Walleye
Number	18			459		16
Size Range	10.5-31.0"			2.0-11.9"		19.8-29.1"
SPECIE	Yellow Perch	Bluegill	Pumpkinseed	Rock Bass		
Number	5	501	437	7		
Size Range	5.3-8.5"	4.0-6.8"	4.3-7.5"	5.0-9.6		
1965 ELECTROSHOCKER WINTERKILL ASSESSMENT						
SPECIE	Northern Pike					
Number	17					
Size Range	11-21"					
SPECIE	Yellow Perch	Golden Shiner	White Sucker	Bullhead		
Number	131	Abundant	Present	300		
Size Range	4-9"					
8/9/67 ELECTOSHOCKING SURVEY						
SPECIE	Northern Pike	Muskellunge		Largemouth Bass		Walleye
Number	Good Population	None		Good Population		None
Size Range	Ave plus growth			Reproduction		
SPECIE	Yellow Perch	Bluegill	Pumpkinseed	Rock Bass	Bullhead	
Number	Good Population	Present	Present		Common	
Size Range	Ave plus growth					
COMPREHENSIVE SURVEY		1975-76				
SPECIE	Northern Pike	Muskellunge		Largemouth Bass		Walleye
Number	57	1		31		180
Size Range	11.5-26.2"	41.0"		3.0-18.5"		8.5-26.0"
Modal Sizes	21.0", 23.0"			9.5"		18.8, 21.8"
Catch/Lift	1.4/			0.7/		4.3/
SPECIE	Yellow Perch	Bluegill	Pumpkinseed	Rock Bass	Black Crappie	Green Sunfish
Number	4351	6	152	45	20	1
Size Range	3.0-7.2"	4.5-9.9"	4.0-6.2"	4.5-9.8"	4.5-10.8"	5.7
Modal Sizes	4.4					
Catch/Lift	103.6"		3.6/	1.1/	0.5/	<0.1/
SPECIE	Golden Shiner	White Sucker	Bluntnose Min.	Mudminnow	Iowa Darter	Bl. Bullhead
Number	4	114	Present	Present	Present	27809
Size Range	3.0-7.2"	6.0-15.4"				4.5-8.4"
Modal Sizes	4.4"	12"				5.7"
Catch/Lift	103.6/	2.7/				662.1/
1986 ELECTROSHOCKER WINTERKILL ASSESSMENT						
SPECIE	Northern Pike	Muskellunge		Largemouth Bass		Walleye
Number	Low Number			Dead- Low #Left		Dead
Size Range						Stopped Stockin[g]
SPECIE	Yellow Perch	Bluegill	Pumpkinseed	Rock Bass	Black Crappie	Green Sunfish
Number	Present	Dead	Present	Dead	Dead	Dead
SPECIE						Bl.Bullhead
Number						Present

The 1958 survey indicated large population of young largemouth with northern pike and walleye also being captured. Bluegill and pumpkin seed were the dominant panfish with a few yellow perch and rock bass also present. The only walleyes captured were from 19.8 to 29.1 inches. Walleye fingerlings were stocked from 1953 to 1955. Two million walleye fry were stocked in 1952. Walleyes before this time had not been stocked since 1941. The walleyes captured in the survey would have been a minimum of 6 years old which would place the smallest fish either from the large fry planting or recruitment. The larger fish captured in this survey must have been recruited from natural reproduction or migrated into the lake from the Eagle River Chain via Tamblin Creek (then called Cat's Paw Creek).

The winter kill electroshocking assessment in the spring of 1965 found only 17 northern pike from 11 to 21" and 131 yellow perch from 4 to 9". These fish species are more tolerant of low dissolved oxygen during winter kill situations. This assessment was followed by stocking of 500,000 walleye fry that year, 100 muskellunge & 2,000 largemouth fingerlings in 1966, and 2,649 more largemouth fingerlings in 1967.

In August of 1967 an electoshocking survey found no muskellunge or walleye but a good population of northern pike and largemouth. Bluegill and pumpkin seed were present but the panfish population was now dominated by yellow perch.

The next survey was a comprehensive survey that occurred in 1976-77. This survey found a good population of predator fish. One 41" muskellunge was captured. The northern pike population was dominated by 21-23" fish and the largemouth bass by 9.5" fish. 180 walleye were captured ranging in length from 8.5 to 26.0" with the largest found in the 18-19" and 21-22" range. This survey also indicated that the yellow perch now dominated the panfish with 4,351 captured from 3.0 to 7.2" range. The dominant size was near 4.4". Pumpkinseed was the second most abundant panfish. Bluegill, rock bass, black crappie, and a green sunfish were also captured. Age growth data from this comprehensive survey can be found in TABLE 12.

From this age growth data several aspects of the healthy fishery at that time can be explored. Walleye fingerlings were stocked in 1970 and 1971 and these fish made up the majority of fish aged (Year classes V &VI). Both older and younger year classes were also found with Age VII & VIII (1968 & 69) year classes also represented in significant numbers. If these other fish year classes were not stocked they either were from natural reproduction or recruitment via the outlet stream to the Eagle River chain. It was reported that in 1973 and 74 walleyes were entering Tambling Lake from Tambling Creek and the Eagle River Chain during the spawning period. There successful reproduction would account for the presence of year classes represented in this survey for those years when no stocking occurred.

TABLE 11. Age and Growth of Gamefish in Tambling Lake from 1975-76 Comprehensive Survey Compared to an Average of NW Wisconsin Fish.

YEAR CLASS	I	II	III	IV	V	VI	VII	VIII	IX
YEAR	75	74	73	72	71	70	69	68	67
WALLEYE		8.5(1)*	12.6(3)	13.3(8)	16.8(41)	18.4(47)	20.6(24)	23.8(10)	22.9(2)
NW WIS. AVE.	5.7	9.5	12.3	14.6	16.6	18.6			
NORTHERN		13.6(5)	18.8(8)	20.9(19)	22.3(17)	23.6(4)	24.8(1)		
NW WIS. AVE.	8.5	13.8	17.4	19.8	22.1	24.1	26.3		
LARGEMOUTH		6.1(11)	9.6(5)	11.7(6)			18.8(1)		
NW WIS. AVE.	3.1	6.3	9.1	12.4	13.1	14.7	16.7		
YELLOW PERCH	2.2(1)	3.7(17)	4.6(19)	5.4(14)	6.1(9)	6.7(1)	9.5(1)		
NW WIS. AVE.	2.7	4.3	5.5	7.1	7.9	9.3			
ROCK BASS		3.2(9)	4.4(13)	6.2(3)	7.9(3)				
NW WIS. AVE.	1.8	3.4	4.7	6.5	7.5	8.7			
BL. CRAPPIE	1.76(6)	3.9(2)		7.9(8)	10.4(1)		10.8(1)		
NW WIS. AVE.	2.4	4.9	6.8	8	9	9.8	9.7		
PUMPKINSEED		2.8(3)	4.0(8)	4.7(6)	5.4(1)	5.4(2)			
NW WIS. AVE.	1.8	2.9	4.5	5	6.1	6.6			
BLUEGILL		2.9(4)	4.8(1)						
NW WIS. AVE.	1.5	3.1	4.3	5.6					

* Length in Inches(# aged)

An investigation of the town records and an interview with town officials finds that the present culvert was replaced in 1985. At the time of setting the new culvert lake property owner's were reported to argue at what elevation the culvert should be placed - one wanting it lower (the second higher) to meet their shoreline requirements for the water level. It was stated that the operator placed it at the same level as the old culvert . Later a board structure was found lodged in the culvert to increase the lake elevation.

The final electroshocking survey occurred in 1986 to assess the winter kill. Northern pike and largemouth bass were found in low numbers. Walleye, largemouth, bluegill, rock bass, black crappie, and green sunfish were found dead at that time. Yellow perch, pumpkin seed, and black bullheads survived the winter kill conditions.

It is probably coincidental that this winter kill occurred the year after the culvert replacement . Yet the walleye spawning runs and walleye presence in the lake that occurred before this time were not witnessed after the culvert replacement. The drought years that followed with the associated low flows, poor walleye reproduction in the chain (documented), and a rip rapped/ plunge pool below the new culvert probably all contributed to the loss of walleye recruitment to Tambling Lake.

What was the fishery like before the 1996 freeze out? The residents reported a healthy population of northern pike and largemouth bass. Fish that were caught, measured, and later aged at a fishery held by lake residents on August 19, 1995 gives us a least a picture of the fishery. These results can be found in TABLE 12.

Two days after the spring of 1996 ice out fish were found dead in the shallow areas of the Tambling Lake. In the outlet area 30-40 black crappies and a few largemouth bass were found dead. They had tried to escape the winter kill conditions under the ice but their escape route to Tamblin Creek was blocked with thick ice and sediment. Several large northern pike were found dead in the southeast shoreline area, but several other smaller ones were observed swimming. Both large and small sunfish were also found dead, but again, two other bluegills were observed swimming. These species and yellow perch were all observed in the lake shortly after ice out but prior to transfer of largemouth and bluegills from a nearby lake by DNR personnel.

TABLE 12. Tambling Lake Fish Sampling 1995 INSERT

Caught during Summer Fisheries on 8-19-95

Species	Age Years	Length Inches	Mean Inches	Length Inches	Mean Length Comparisons Location
LMB	2	6.35	6.35	6.8	Flora L.(Vilas)
LMB	4	12	12	11.2	Flora L.(Vilas)
LMB	5	13.5	13.5	12.4	Flora L.(Vilas)
Northern Pike		2	15.35	15.35	13.7 N. Wisconsin
Bl Crappie	5	7.15		7.8	Seepage L. NW Wisconsin
Bl Crappie	5	7.85		7.8	
Bl Crappie	5	9		7.8	
Bl Crappie	6	8.25	8.625	9.2	Seepage L. NW Wisconsin
Bl Crappie	6	9		9.2	
Rock bass	6	8.65	8.65	7.36	Nebish L. (Vilas)
Rock bass	7	9.65	9.65	7.83	Nebish L. (Vilas)
Bluegill	4	6.5	6.5	4.4	Flora L.(Vilas)
Bluegill	4	6.5			
Bluegill	4	6.5			
Bluegill	4	6.5			
Bluegill	5	6.35	7.0875	5	Flora L.(Vilas)
Bluegill	5	7			
Bluegill	5	7.25			
Bluegill	5	7.75			
Pumpkinseed	4	4.85	4.85	5.12	Flora L.(Vilas)
Pumpkinseed	5	6.35	6.35	6.04	Flora L.(Vilas)
Pumpkinseed	6	6	7.33	6.84	Flora L.(Vilas)
BG/PS Hyb	2	4.5	4.5	2.99	Flora L.(Vilas)
BG/PS Hyb	4	7	7	4.8	Flora L.(Vilas)
BG/PS Hyb	5	7.35	7.35	5.67	Flora L.(Vilas)
Yellow Perch	3	4.85	4.85	5.2	Flora L.(Vilas)
Yellow Perch	3	4.85			
Yellow Perch	4	7.5	7.5	6.3	Flora L.(Vilas)
Yellow Perch	5	7.25	7.25	7.4	Flora L.(Vilas)

ANALYSIS OF SEDIMENT

Introduction

The majority of the deep water areas of Tambling Lake are covered with soft sediment creating a fertile base to grow an abundance of aquatic plants. Excellent water clarity in recent years has allowed light to reach even the deepest bottom areas which permits aquatic plant growth at depths greater than 15 feet.

The sediment profiling accomplished several task. It identified the texture of the soft sediment, the depth to hard bottom sediments below it, and the type of hard sediments beneath. From this information the volume of soft sediment in a particular area of the lake can be calculated to determine the feasibility of sediment removal or dredging.

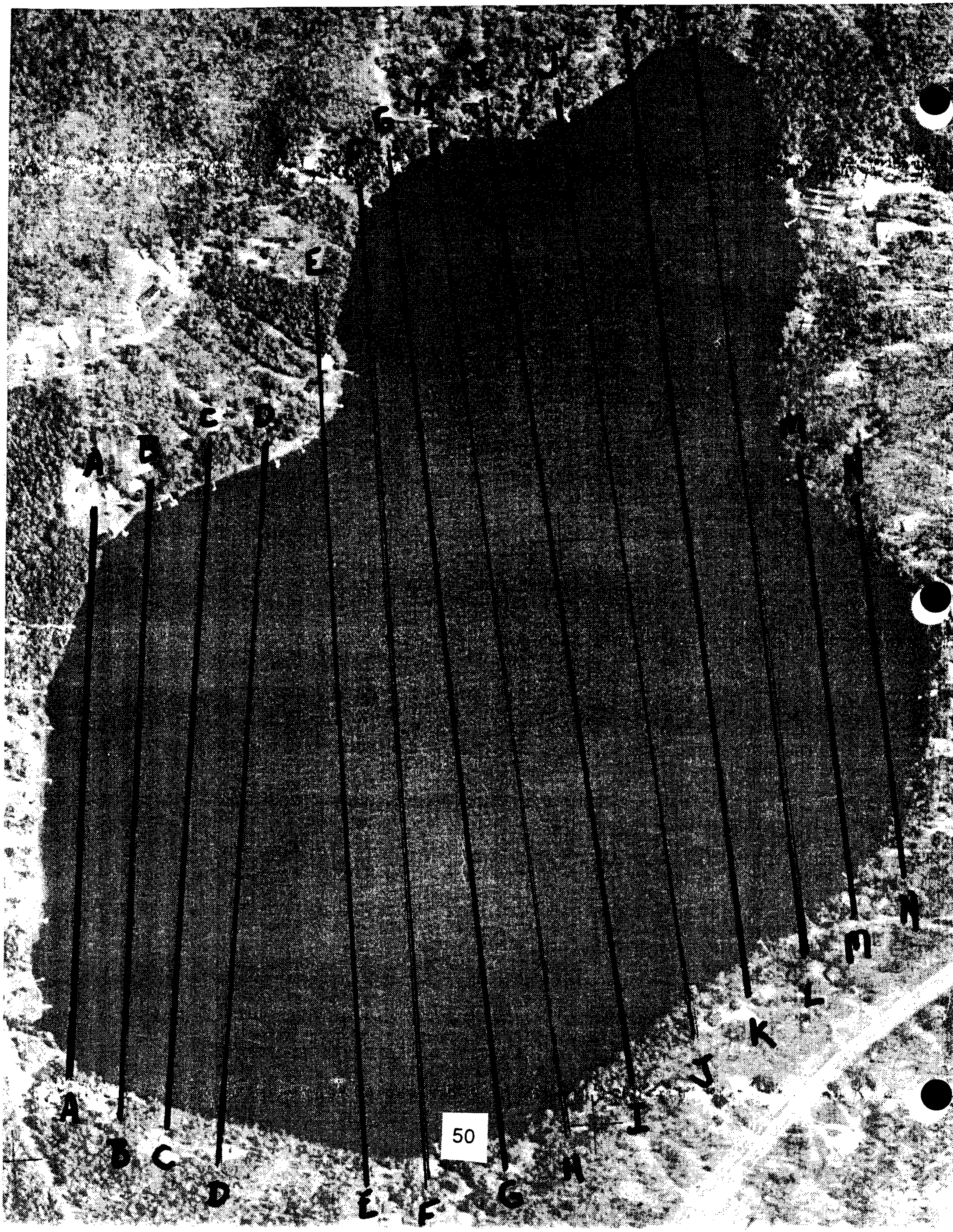
Just as important, it recognized hard bottom sediments beneath the soft sediments. Certain hard bottom sediment areas that are closest to the surface are contact points where water from the adjacent watershed and beyond enters Tambling Lake. Tambling Lake is classified as a spring lake with high fertility. As water travels through these pathways it has greater exposure to minerals in the surface and subsoils, thus increasing it's mineral content. Therefore, this information combined with upland soil information recognizes pathways that nutrients and minerals from the surface and subsurface areas reach the lake. Crossing this data with the plant observations and survey transects has identified associations between hard bottom sediment areas and specific plants. This information also helped us understand where aeration systems can be placed to take advantage of spring flow and natural circulation/ movement of water in Tambling Lake.

Procedure

The soft sediment observations were broken into several categories recognized by texture and resistance of the probe. The categories included muck, oxygenated muck, sandy muck,silty sand, and mucky clay. In many instances hard and soft sediments were stratified, e.g. when sand substrate along a shoreline is pushed by ice or driven by wave action over softer sediment.

Fourteen north-south profile transects were made through the ice from April 9-11, 1996. See FIGURE 11. Water depth to soft sediment was measured at each location with a flat disc. A steel probe mounted on steel pipe extensions was used to measure sediment depths to hard bottom. Sediment types were identified by resistance, sound, and deposits collected on the steel probe. Distance between sampling points along transects B,D,F,H,J, and L was approximate 150 feet. Sampling points on A,C,E,G,I,K,M, and N were at random to confirm direction of hard sediment features below the soft sediment.

FIGURE 11. LOCATION OF TAMBLING LAKE BOTTOM PROFILING TRANSECTS.



Results & Discussion

A hydrographic map of Tambling Lake was made from the depth profiles measured from ice surface to bottom sediments. Water depth at transect sampling points are indicated on this map. One foot interval contour lines (from 5' to 13') were drawn using the sampled depths. See FIGURE 12.

The entire deep water areas of the lake greater than 4 feet were covered with muck. Clear hard sand bottoms can be found in areas closer to the shoreline. The deepest area of the lake had 14' of water. Approximately 20 % of the lake is greater than 10 feet.

Soft sediment depths ranged from less than one foot to over 24 feet (maximum depth for probe). Muck depths at transect sampling points can be found on the map in FIGURE 13. The deepest soft sediment meanders in several "channels" from the northeast corner of the lake to to the outlet area. These deep- now muck filled areas were probably at one time a post glacier waterway that entered the current Tambling Lake basin from Carpenter Lake.

Evidence of this post glacier waterway is further confirmed by materials found beneath the muck at several locations. See FIGURE 14. A large area of rock rubble and gravel were found beneath the muck in the Northeast bay at depths from 7 to 26 feet. This area aligns with the present narrow upland valley that extends from Carpenter Lake to this bay. A second gravel area was found at 27' in the southeast area of the lake. This gravel area was cover with 6 feet of sandy silt. A second area close this point found a thin layer of sand and gravel at 19' over silt and sand. Corresponding upland shoreline soils indicate substratum soil types similar to these original lake bed deposits. Both of these areas probably contribute the majority of spring seepage flows to Tambling Lake and the outlet stream.

Clay deposits were also found under the muck accumulations in many areas of the lake. These deposits ranged from 14 to 24 feet from surface water levels. Often they were found in thin layers with silty sand or sand beneath and muck above. The largest clay deposit areas were found extending from current bog and wetland areas. In the northeast bay a clay bottom substrate was found adjacent to a small cedar swamp on the east shore and another extending from the small wetland on the west side of this bay. The large gravel area mentioned above was found between these clay areas.

Another large area of clay was found in the southeast area of the lake on both sides of the gravel area described earlier. Clay was also found adjacent to the west shoreline adjacent to the peat bog area on the west shoreline. Clay deposits were also found near the outlet area. Clay deposits at all these locations are evidence that at one time wetland and bogs covered much of the area now covered by muck and water and a glacial stream traveled through these wetland.

FIGURE 12. TAMBLING LAKE DEPTH OF WATER BOTTOM PROFILE AND HYDROGRAPHIC MAP.

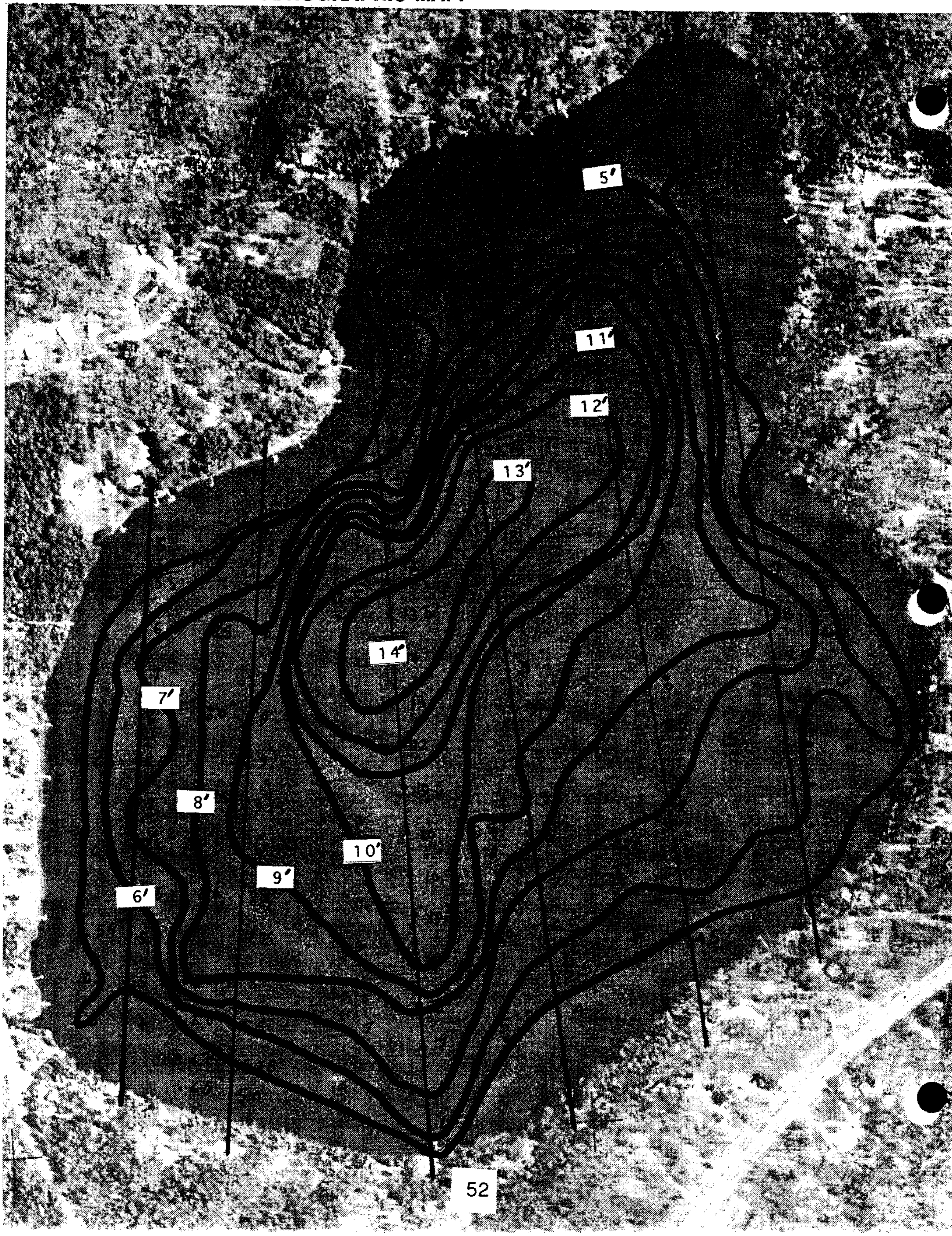
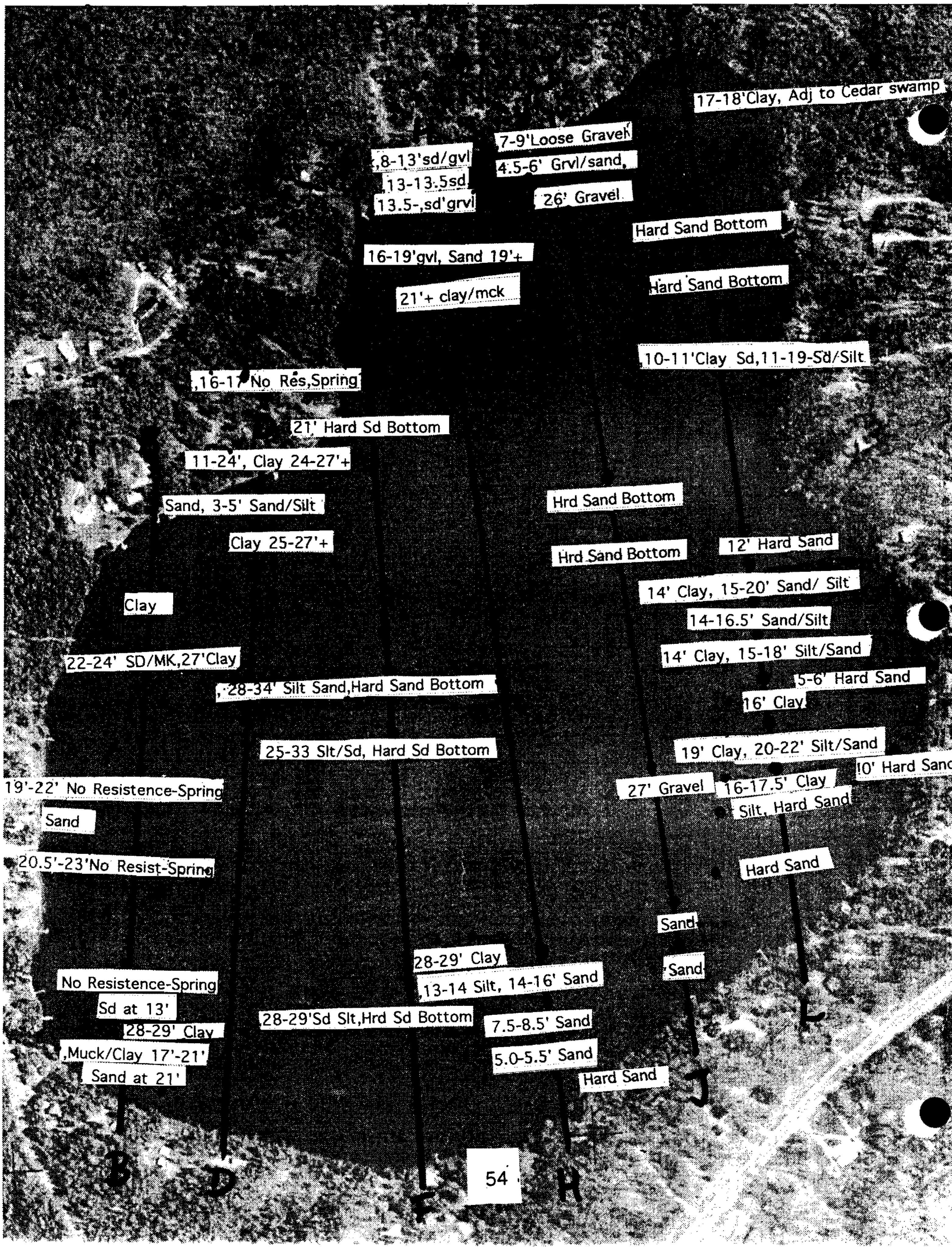


FIGURE 14. MAP OF TAMBLING LAKE HARD BOTTOM SUBSTRATES.



Pleistocene geology studies of this area indicated that this area consists of collapsed stream sediment that hides the original land surface deposited by the glacier. These collapsed areas are described as being "very closely spaced" which hinders their identification by looking at present day surface topography; but this new information on the hard bottom substrates of Tambling Lake clarifies the collapse in this sub basin. A bog developed over a frozen ice mass over several hundreds of years after the retreat of the glacier before a stream and warmer conditions melted the submerged ice mass. This melting collapsed the bog and stream below present day water levels. Over time erosional and biological forces deteriated the submerged bog into much of the muck present today in Tambling Lake. Through time changing water levels in this new lake deposited clay near the outlet areas. More recently plant communities have developed on the surface of the muck and contributed to the earlier deteriated bog materials.

Today these clay areas act as barriers to spring seepage channeling water to gravel areas beneath the lake and through the muck. In many gravel areas the muck immediately above gave little or no resistance compared to the muck nearer the water interface. These areas are areas where spring seepage is the greatest providing minerals and oxygen for decomposition of this muck layer.

RECOMMENDATIONS
FOR THE LONG TERM PROTECTION & MANAGEMENT
OF
TAMBLING LAKE, VILAS COUNTY

The future health of Tambling Lake is dependent on area residents working together to alleviate the problems identified and described in this planning grant inventory. Water level and outlet restoration combined with maintaining adequate oxygen levels throughout the year are the two key components of Tambling Lake management that must be addressed for the future welfare of the lake ecosystem.

There are plenty of nutrients available for fish and aquatic plant growth in Tambling Lake. Providing a suitable oxygenated environment so these nutrients can be utilized by fish, wildlife, and a diversity of aquatic plants is a goal attainable by the lake association. At the same time every effort must be made to keep any new nutrients from entering the lake. Management efforts should also focus on making sure there is adequate habitat for fish and wildlife.

The lake community will be the one who benefits from their own actions. Recreational use benefits include a sustainable fishery and a diverse aquatic plant community for increased wildlife viewing and boating. The monetary value of your lake property is reflected in the quality of your lake.

Tambling Lake management options and recommendations are discussed under the following headings:

A. Winter Aeration System Installation

B. Tamblin Creek Outlet Restoration

D. Watershed Protection Plan

E. Lake Use Plan

F. Future Planning & Funding

WINTER AERATION SYSTEM INSTALLATION

Background

Periodic fish winter kills are problem in Tambling Lake. The resource inventory completed as part of this planning grant was able to assess the conditions of a current fish kill. It also found assessments that document an outstanding fisheries resources between these periodic winter kill situations. Water chemistry evaluation and physical studies from this grant documents the detrimental water chemistry effects that low or no oxygen conditions under the ice have on recirculating nutrients and the aquatic plants and animals present throughout the year. All these facts point to a need for an oxygen circulation system for Tambling Lake under the ice.

New technologies in oxygen transfer and delivery as well as a new understanding of lake circulation makes aeration economical. Lake aeration is a valuable lake restoration technique. The importance of dissolved oxygen to the aquatic community of fish, plankton, and plants and animals living in and on the bottom. is well documented. Aeration is an effective means of improving dissolved oxygen levels. In addition, aeration can lead to improved water quality by eliminating chemicals such as ammonia, hydrogen sulfide, manganese, and ferrous iron which currently build up in Tambling Lake. Although aeration has little direct effect on aquatic plants, it can lead to reduction and channeling of phosphorus, a critical plant nutrient , away from aquatic plants to other living organisms. The prevention of periodic winter kill of fish is the first step in channeling nutrients from bottom sediments to other living organisms, which includes fish and the live organisms they feed on.

The geological features identified in this inventory and the presence of spring seepage and flow towards the outlet suggests that aeration can be effective management tool in Tambling Lake.

Cost and Design

In Tambling Lake with its maximum water depth of 14' diffusers with rotary vane compressor systems are recommended. Two 3/4 hp systems are recommended. The system would consist of 2 compressor systems on shore in a covered box with hoses extended to diffuser assemblies located on the hard bottom gravel areas beneath the muck at 27 feet on Transect J in FIGURE 14. One of these gravel areas is in the north bay of the lake and the second is in the southeast corner. These are major seepage areas beneath the lake and introduction of oxygen should circulate the effects of the added oxygen to beyond the immediate area. The cost of purchasing, operation, and maintenance of the aeration system was presented to the association for FishAmerica Foundation grant aid in 1997.

Operation

Because of the high oxygen demand of the bottom sediments in winter it is recommended that the operation of the aerations systems begin as soon as their is ice forming near the shoreline. This strategy would would use the aeration system to maintain as much oxygen in the lake all the time rather than let the oxygen deplete to low levels beneath the ice and try to restore good oxygen conditions late in winter. Aeration should continue until ice out. The aeration system will even help to free Tambling Lake of this wind- barrier ice even earlier and could help prevent shoreline ice damage.

The system design is conservative in the amount of water attrainment and the size of the ice openings. This will increase safety and reduce the amount of safety fence that would be required.

Management Options

The installation of the aeration systems is costly. The installation of one aeration system would reduce installation, maintenance, and operation cost by nearly half and allow the association to evaluate the adequacy of the one system. Two systems were suggested based on the size and geologic history of the lake.

The lowering of the lake by proper placement of a larger outlet culvert could increase spring flow and help alleviate some winter oxygen depletion. This could also increase the effectiveness of the aeration systems on circulation and improved water quality.

The decision not to install any aeration system would expose the ecosystem to the continuous events described in this evaluation above.

TAMBLIN CREEK OUTLET RESTORATION

Background

At one time game fish, pan fish and minnows moved freely from Voyageur Lake of the Eagle River chain to Tambling Lake via Tamblin Creek. During winter oxygen depletion in 1995-96 fish were drawn to the outlet area but were kept from exiting the lake by several disturbances in that area to include: shoreline fills that effected shallow water lakeshore hydraulics and filled in the channel, periodic ice pushup mounds from easterly winds during spring ice out that blocked the outlet, and a poorly placed, undersized culvert on the town road that collected sediment on the lake(upstream) side and prevented fish and forage fish from entering the lake on the downstream side. At one time walleye used the outlet area to spawn and migrations runs from the Eagle River Chain occurred every spring.

Also, Tamblin Creek to the outlet at Voyageur Lake had become shallow from the widening caused by the falling of woody debris in the second growth hardwood that it passes through. Lake association members have been successful in maintaining a deep central channel by removal of this fallen debris in the fall of 1996 and 1997.

Management Options

The replacement of the outlet culvert with a properly placed 30 foot 48" diameter culvert would help the lake ecosystem in many ways. Below are the effects that restoration of the outlet area could have on Tambling Lake.

FISHERIES RESTORATION benefits would be a direct result of the placement of this culvert and removing the present barrier to fish migration. It would allow the movement of both fish and forage fish to enter and leave the lake. In combination with the aeration system restoration of year round oxygen levels this management practice would increase the production of minnows and other aquatic organisms that game and pan fish feed on. With an unobstructed channel upstream and downstream of the culvert restoration area, and possible increased flows at the outlet, walleye spawning should once again occur in the outlet area. The excellent fisheries that existed in the 1975 could return again.

WATER LEVEL RESTORATION benefits from a properly replaced culvert would probably drop water levels in the lake approximately one foot. This would reduce the hydrostatic head pressure on the spring seepage and could increase the flow and water quality in Tambling Lake. Sandy shoreline areas important for fisheries habitat and recreational uses would probably increase as wave action and shoreline hydraulics would change in these areas. The effects of periodic ice pushup mounds on the west and southeast shorelines should decrease.

AQUATIC PLANT COMMUNITIES could change back to a more diverse community that was present in 1975. The sandy areas would increase thereby increasing emergent vegetation important for fish spawning habitat and food organisms.

WATERSHED PROTECTION PLAN

Background

Direct drainage to Tambling Lake is limited to approximately 330 acres surrounding the lake. The second growth hardwood and bog forest has been disrupted by light residential development and connecting roadways.

Future development of the shoreline and adjacent areas are limited by land zoning restrictions now in place. In the future, further restrictions will be developed to protect the shoreline and open water areas in an effort to protect the lake resources from the recreational pressures of man.

Management Options

The soils surrounding Tambling Lake are suseptable to erosion and are not adequate for wastewater treatment. Management practices should concentrate on addressing these characteristic of the soil.

SHORELINE BUFFER STRIPS should be considered on all the developed lots. The width of this shoreline area is dependent on the steepness of the slope. The steeper the slope the wider the buffer strip should be.

Buffer strips prevent surface water runoff from short grass areas, driveways, walkways, and roadways from entering the lake. It acts as a filter of sediment, salts, and fertilizers that would come from these drainage areas. When planted with flowering plants and native grasses, which have extensive root systems, they can intercept ground water from the upland above. This ground water could contain nutrients from upland wastewater seepage beds.

The esthetic value of the buffer strip is also important. Using a variety of plant species of different heights will not restrict the view from the residence or from the water, only provide a a esthetically pleasing landscape frame. Remember, the most important feature of the lake to the property owner's in the survey was "Scenic Beauty and Tranquility".

Design of these strips can be tailored to your personal needs and wants. An abundance of colors, shapes, and sizes of native vegetation from flowers to shrubs and trees are available for planting. They can be adapted to sunny or shady areas. Walkway approaches can be angled and/or hidden to lessen the affects but still give access to dock or swimming areas. Plants can be selected that attract birds, butterflies, and other wildlife to your shoreline.

MAINTAINING A TREE CANOPY is also very important in the immediate watershed of Tambling Lake and it's bordering wetlands. This practice is particularly important in short grassy area to slow the runoff during heavy rains. The greater the slope the more important a tree canopy is to prevent erosion during storm runoff. Select cutting, wise lot development, and good road building techniques that consider erosion go along way in protecting Tambling Lake.

Mature trees can provide nesting sites for birds including sites for wood duck nesting. Wildlife viewing was high on the property owner's list of lake values. Trees help maintain cool temperatures on the land but also in the lake adjacent to the land. Remember, that aquatic plant growth is temperature dependent .

MAINTAINING SEPTIC SYSTEMS is another key in protecting the Tambling Lake. In the property owner's survey the lake community appears to recognize proper septic maintenance based on use. Septic tanks should be cleaned when settling solid matter fills only 1/3 of the volume of the tank. If not done at this time settling time of solid waste is reduced and solid waste can enter your drain field. Paying close attention to cottage or home use and maintaining a pumping record will help in understanding when to pump.

LAKE USE PLAN

Background

Tambling Lake's water surface area is approximately 174 acres, which puts it at the smaller end of the medium size. Lake surface area is an important determinant of the ability of a lake to support shoreline development and to avoid user conflict.

Tambling Lake's shallow depth, muck, and weeds were indicated as the major problems facing Tambling Lake today. From the recreational aspect management recommendations of the aeration system and restoration of the outlet will lessen the effects of the muck and plants over time. Water clarity is excellent in Tambling Lake which aids in plant growth and creates the perception of that a large area of the lake is shallow. The shoreline of Tambling Lake in most areas drops fairly quickly to deep enough water for navigational purposes.

These management practices should effect the species composition of the aquatic plants over time. A water levels drop of a foot would favor emergent plants over floating and submergent plants in the shallow riparian areas around the lake. Wind and wave action will carry and scour organic matter from the sandy shorelines favoring species such as the soft stem bulrush. This should favor recreational riparian use of these areas and provide more favorable habitat for fish and aquatic organisms.

The removal of the muck substrate is a very environmental sensitive issue and would be very expensive to carry out. With the large amount of muck (soft sediment) covering the bottom (See Figure 13) determining which areas to dredge and the lasting effects of partial dredging would be a lengthy and cumbersome process.

Swimming, pleasure boating, and fishing were all high priorities for lake residents as indicated in the survey. Lake use issues of the future will focus on the conflicts between fishing and pleasure boating and to a lesser extent swimming.

Water skiing and personal water craft (jet skis) need open water areas for operation. Several state laws have been passed to address the safety issues associated with these activities and many more may be passed. It is unlawful to operate a motor boat within 100 feet of any dock, raft pier, or buoyed restricted area on any lake at a speed in excess of "slow no wake". In addition any person operating any type of motor boat that is towing persons engaged in water skiing, aquaplaning, or similar activity may not operate within 100 feet of any occupied anchored boat, any personal water craft, any marked swimming area, or public boat landing. Fishing and swimming areas need to be protected from boat activity for practical and safety reasons.

The above laws have been developed to to place safety first in water related activities. Town ordinances or lake district management laws can be more restrictive than state laws but they cannot be less restrictive.

Management Options

Lake use management should be considered on Tambling lake in the future because of it's relatively small size and the importance placed on water activities that can cause conflict. Any regulation or volunteer effort to eliminate water use conflicts is only good if they are enforced, agreed upon, or understood by all who use the lake.

THE FIRST OPTION is to do nothing. Present state law if adhered to eliminates many conflicts. The fisherman, swimmer, and "no wake boaters" could share the water during the peak season and during high use times under crowded conditions that can occur on weekends.

THE SECOND OPTION is to partition areas of the lake for certain lake use. Partitioning means restricted use of a particular described area of a lake during a particular time of day or time of year. Other partitioning strategies could protect critical habitat areas, e.g. fish spawning areas or waterfowl nesting areas at certain times of the year.

THE THIRD OPTION is to develop time partitioning. For example, fishing from a boat or slow no wake activity could be time slotted from late evening to early morning while other boating activities could be defined to a specific daylight time.

A FOURTH OPTION is to place a horsepower restriction which could limit motor activity to a maximum horsepower or even to electric trolling motors only. This restriction would be used to restrict speed and noise and add to the safety factor.

FUTURE PLANNING AND FUNDING

This planning grant effort has inventoried the resource history of Tambling Lake, described the current conditions of the lake community, and recognized problems that lake managers must face. Solutions to these problems have been described but they need specific plans and money to carry them out.

Lake planning and protection cost -sharing grants are sources of money that can help carry out some of the projects described in this effort. Private companies often tied to sportsmen's interest also can provide money to many projects. In most cases, the landowner's adjacent to the lake must secure at least some of the funds needed towards meeting these management objectives.

Fund raising and association fees are two means of securing funds for smaller projects. Often volunteer efforts are involved in this type of fund raising. Larger projects often lead to the formation of a lake district with taxing authority for specific projects or budget. This option has a legal procedure to follow in it's formation and operation.

APPENDIX 1.TAMBLING LAKE PROPERTY OWNERS SURVEY 1996

NAME: ____________________ CURRENT ADDRESS ____________________

1. HOW LONG HAVE YOU OWNED PROPERTY ON TAMBLING LAKE? _____ years.

2. WOULD YOU CONSIDER YOUR PROPERTY A : a.) Year-round home? _____
   b.) Three seasons home?___ c.)Summer cottage?____d.)Winterized cottage?_____
   e.) Vacant land(acreage)? _______ f.)Business(describe on back) ? ______ .

3. HOW OFTEN DO YOU USE YOUR LAKE DWELLING OR PROPERTY?
   a.) Weekends / year____ b.)Week days/ year____c.) Other (describe on back)_____.

4. ON AN AVERAGE, HOW MANY PEOPLE USE YOUR PROPERTY DURING THE PERIOD(S) CHECKED IN QUESTION #3 ABOVE?
   a.) Weekends______ Weekdays ______Other(use back if necessary) _________.

5. IN DESCRIBING THE USE AND VALUE OF YOUR LAKE PROPERTY **NUMBER 1 THRU 7 BELOW** THE PRIORITY YOU WOULD PLACE ON THE FOLLOWING?
   a.) Swimming ___ b.) Pleasure Boating ___ c.) Fishing ____
   d.) Duck Hunting ___ e.)Wildlife Viewing ___ f.)Scenic Beauty & Tranquility____
   g.) Water Skiing ___ h.) Jet Skiing ____ Other(describe) ______________ ____.

6. WHAT TYPE OF WASTE DISPOSAL SYSTEM DOES YOUR PROPERTY HAVE?____________________________ HOW OLD IS IT? ____ years
   WHAT MAINTENANCE DOES IT REQUIRE? ______________________.

7. WHAT TYPE OF WELL DO YOU HAVE ON YOUR PROPERTY? Drilled? ____
   Driven sand point? ____ Other(describe)?______________ _____. HOW DEEP IS YOUR WELL? ____ feet. IF KNOWN (FROM WELL DRILLER'S REPORT OR WHEN PUMP HAS NOT RUN) WHAT IS OR WAS THE STATIC HEAD? ____ feet?

8. WHAT DO YOU FEEL ARE THE MAJOR PROBLEMS FACING TAMBLING LAKE AT THIS TIME (**PLEASE COMMENT ON BACK**)?

9. THE DEPTH AND FERTILITY OF TAMBLING LAKE CAUSE MANY PROBLEMS FOR THE RECREATIONAL USE OF THE LAKE? WHAT PRIORITIES WOULD YOU GIVE TO SOLVE, PREVENT, OR KEEP THESE PROBLEMS FROM WORSENING. **NUMBER 1 THRU 6 (#1 being your highest,#6 the lowest) YOUR CHOICES**

___Water Level and Flow Management ___ Other (Explain) __________________
___ Machine Harvest of Aquatic Plants ____________________________
___Chemical Treatment of Aquatic Plants ____________________________
___Dredging/ Removal of Lake Bed Material ____________________________
___Long-Term Shoreline Stabilization, Restoration, & Protection

PLEASE RETURN THIS QUESTIONNAIRE WITHIN 10 DAYS TO AQUATIC RESOURCES,INC.,P.O. BOX 2221, WAUSAU, WISCONSIN 54403.