Solberg Lake, Price County, Wisconsin
Lake Management Report

April 1993

Submitted to:

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Solberg Lake
Lake and Watershed Characterization: 1977-1991

--Contents--

1. INTRODUCTION AND PROJECT SETTLING

Solberg Lake is a reservoir located in Price County, Wisconsin (Figure 1). Solberg Lake was formed by damming the Squaw River. The Wisconsin Department of Natural Resources (or Department of Conservation) has been working on Solberg Lake since the 1950's conducting fish surveys and stocking gamefish and panfish.

The goals of Solberg Lake project were to understand factors influencing Solberg Lake water quality and to design projects that would improve lake conditions. In 1991, Blue Water Science (St. Paul, Minnesota) sampled Solberg in June, July and August and conducted an aquatic plant survey in August to characterize existing conditions in the lake. We used existing WDNR fishery records to evaluate the fish community.

This is the technical report. We have also prepared 150 copies of an 4-page non-technical report that is geared for members of the Lake Association. We also pressed and mounted samples of typical plants found in Solberg Lake. The mounted plants were given to the Lake Association.

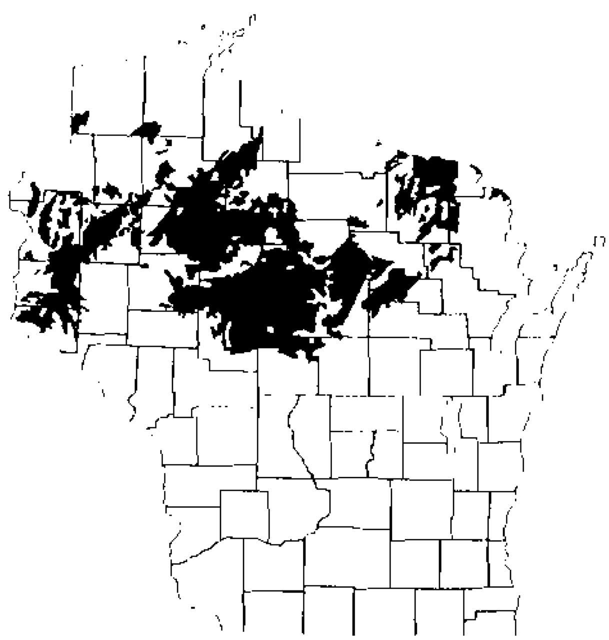
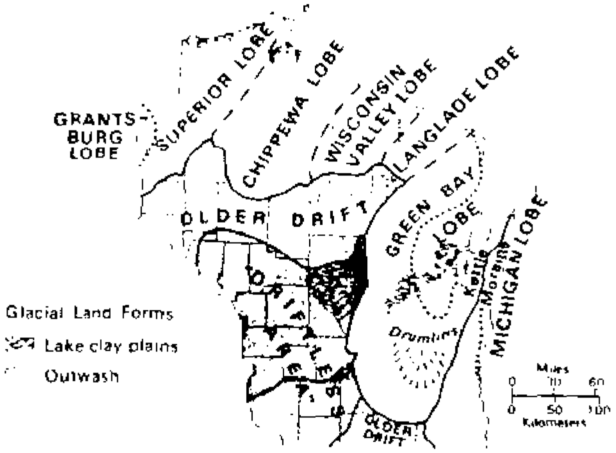


Figure 1. Solberg Lake (a flowage) is in Price C.

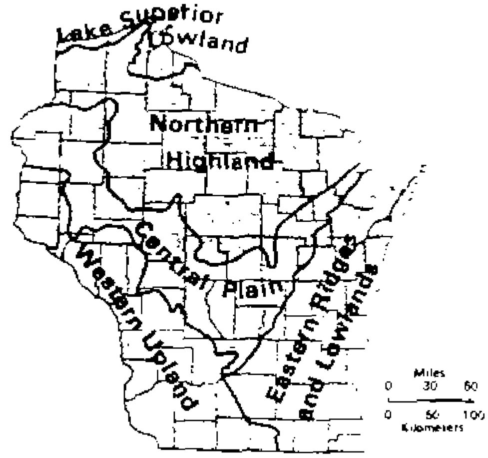
2. GEOLOGIC SETTING

Currently Solberg Lake is a reservoir on the Squaw River in Price County. Solberg Lake lies very close to the continental divide of North America (Figure 2, Map 9). Solberg Lake drains to the Flambeau River which feeds into the Chippewa River which eventually feeds into the Mississippi River. From a glacial setting, Solberg Lake is located in the Chippewa Lobe (Figure 2, Map 6) which covered Price County about 16,000 years ago. Solberg Lake lies in the Northern Highland geographic provence (Figure 2, Map 8). Most of the land area today is a combination of forests and wetlands (Figure 2, Map 11).



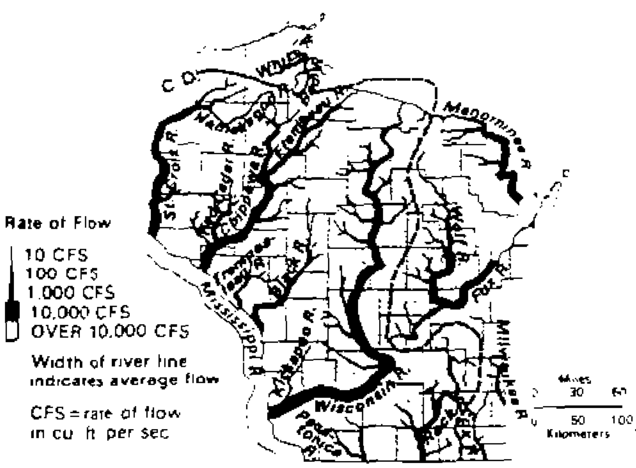
Map 6. GLACIAL GEOLOGY

The last major advance of the ice sheet over Wisconsin was about 16,000 years ago. It covered all but the "driftless" and "older drift" areas. A later ice advanced about 11,000 years ago (dotted boundaries), burying a forest in Manitowoc County. Many land forms were created by the glacial ice and meltwaters: Moraines (solid lines), elongated hills called drumlins, outwash, and lake clay plains. Many peat bogs and lakes occupy glacial pits called kettles.



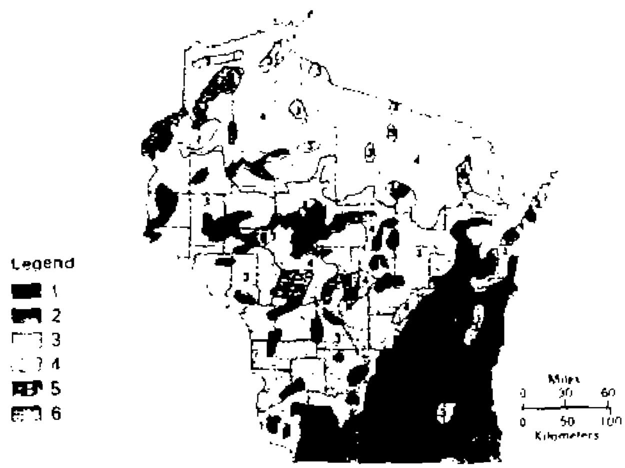
Map 8. GEOGRAPHIC PROVINCES (after Martin, 1932)

The Lake Superior Lowland is an old glacial lake bottom sitting in a much older depression in the bedrock surface. The Northern Highland is a glacial-drift-covered Precambrian "dome," a southern extension of the "Canadian Shield" of igneous and metamorphic rocks. The Central Plain is on an arc of Cambrian sandstones. The drift-covered Eastern Ridges and Lowlands are crossed by dolomite escarpments. The Western Upland is dissected by numerous tributaries to the Mississippi and Wisconsin Rivers.



Map 9. PRINCIPAL RIVERS AND THEIR AVERAGE FLOW

Thirty percent of the state drains to the St. Lawrence River basin, and the remaining 70 percent to the Mississippi River basin. The dashed line represents the continental divide (C.D.) between these two major basins. Peak flows are in March, April and June. The Wisconsin River drains 21 percent of the area of the state; the Chippewa-Flambeau system drains 17 percent; the Fox-Wolf system in northeastern Wisconsin drains 12 percent of the state.



Map 11. AGRICULTURAL AND FORESTRY LAND USE

The map shows land use in terms of proportions of land devoted to agriculture and forestry. Highly productive farm land (1), with less than 15 percent of woodland, is in southern counties. Productive farm land (2), with the same extent of woodland, is prominent in the east, but is also widely scattered. Agricultural land with 15 to 50 percent in woodland (3), occupies about half of the area of the state. Forest lands, not sandy (4), are prominent in the north. Jack pine (5), and scrub oak (6) sandy lands are concentrated in the central plain and northern counties.

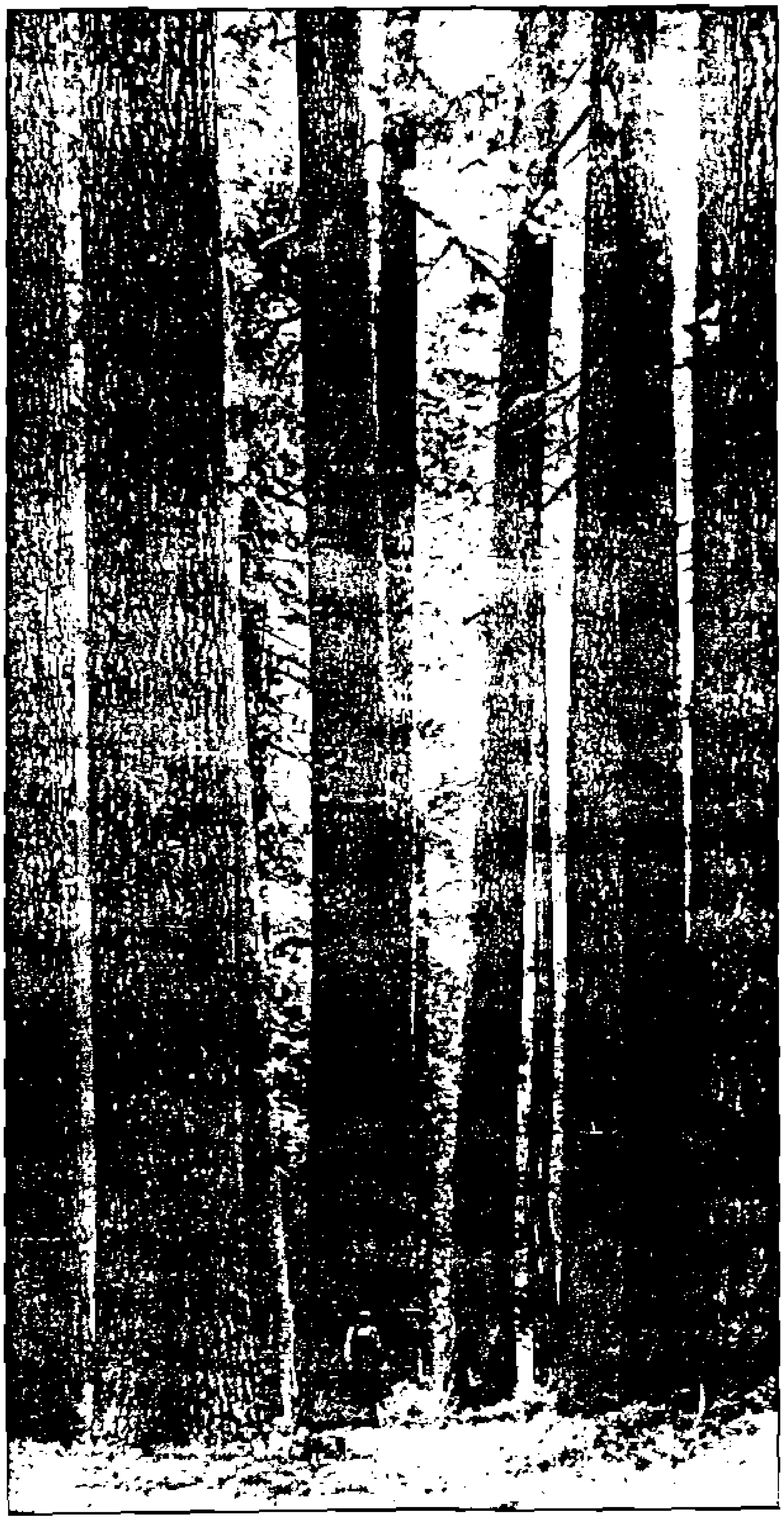
Figure 2. Geology, geography, and land use of Solberg Lake setting.

3. HISTORY OF SOLBERG LAKE AREA

Solberg Lake is located in Price County and lies just west to a region pock-marked with lakes in Oneida and Vilas Counties. About one hundred years ago the area and the watershed of Solberg Lake was dominated by pine forests (Figure 3). Some of the original pines the first loggers saw were 400 years old. Most of the pine forest was cut in the late 1800's (Figure 4). Today we are looking at second and third growth forest for the most part. Wetlands have been an important part of the landscape for centuries, and not much has been done to them in this part of the state. Today much of Solberg Lake and its watershed is still relatively undeveloped except for tier one development around part of the shoreline. Otherwise much of the watershed is a combination of forested land (second and third growth) and wetlands.

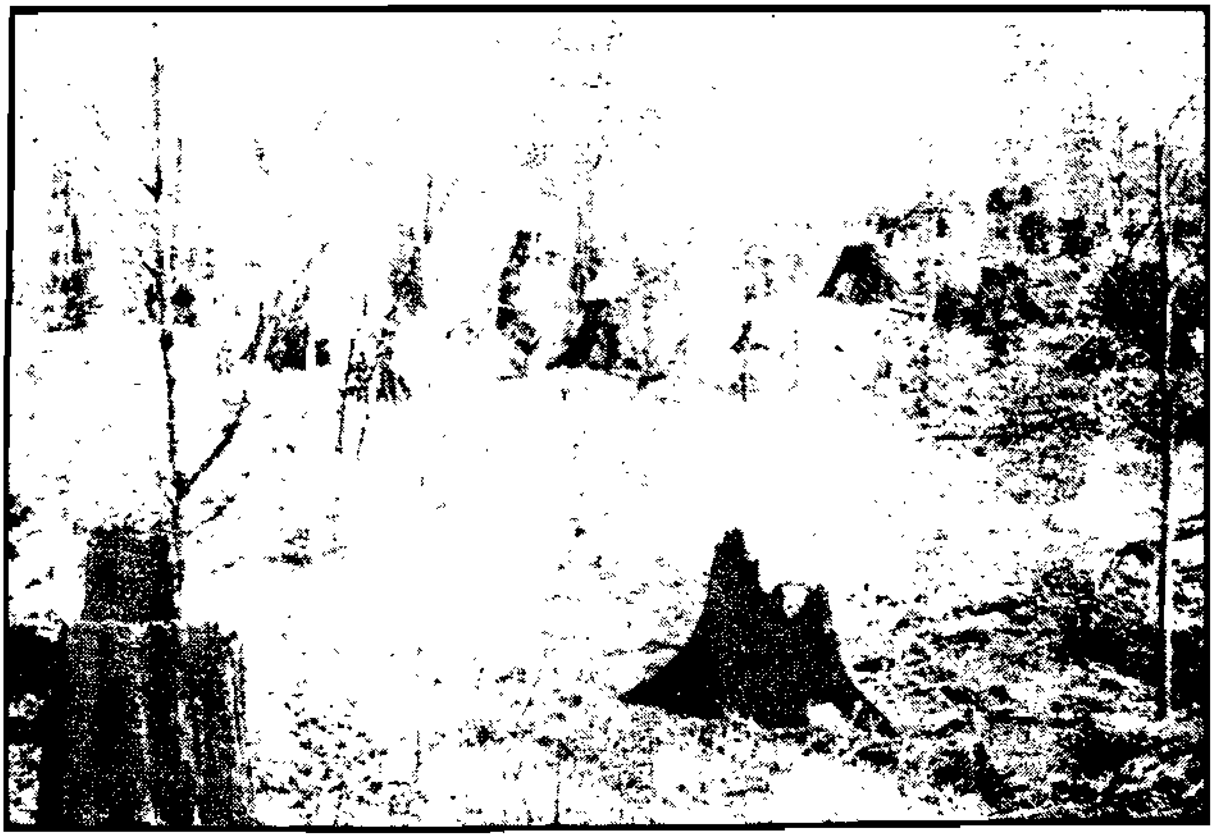
The fish community in these northern Wisconsin lakes prior to settlement and prior to the onslaught of resorters was very different then found today (Figure 5). Game fish species were dominated by large members and they probably exerted important control over prey species such as sunfish, minnows, and other slender body fish.

Today, most of the big lunkers are gone due to a combination of factors that includes fishing pressure and pollution. However, through good fishery management and habitat protection, fisheries can still be very good.



"The crowns of great white pine and Norways lifted themselves high above the ground and became intertwined to cast a shade like the dusk of a tunnel. Starved for sunlight, the branches below them had given up trying to live, and as the trees swayed in the wind, they jostled each other until they became loosened and fell to the ground, leaving the trunks straight and clear."—Isabel Ebert

Figure 3. Example of what the virgin pine forests looked like prior to logging. (Source: Minocqua-Woodruff Centennial Edition, 1988)



Vast acres of logged over, burned over land characterized the lakeland area when E.M. Griffith came to the state.
--Department of Natural Resources photo.

Figure 4. Landscape changed drastically after logging. (Source: Minocqua-Woodruff Centennial Edition, 1988).

102-pound muskie

The Loch Ness monster of the North

Fishermen are known for their whoppers. After reading the following article which appeared in the May 2, 1902, issue of "The Minocqua Times," we know how fishermen got their reputations for being long on stories and short on the truth.

As to the validity of the story, Supt. Nevin and E.D. Kennedy took that secret to their grave. The late Jim Kennedy, son of E.D. Kennedy, told "The Lakeland Times" in 1974 that perhaps the story was true, although he added, "the whiskey flowed quite freely in those days."

A lithograph and copy announcing the 1902 catch follows. We hope you enjoy the rest of these fish tales gleaned from the pages of "The Minocqua Times" and "The Lakeland Times."

7

Supt. Nevin of the State Fish Hatchery Commissioners, who has been taking muskallonge spawn at the Tomahawk and Minocqua lakes the past month, informs us that E.D. Kennedy and himself captured the two largest muskallonge ever taken in these waters.

The largest one was caught in Minocqua lake and weighed 102 pounds, the other being taken in Tomahawk lake and weighed 80 pounds.

After the spawn was taken from these monsters, they were turned back into their native waters, where they await the sportsman to try and land them.

Mr. Nevin has taken muskallonge spawn at this place for the past four years, and says that in seining this season, they have caught more small muskallonge than ever before, which goes to show that they are increasing.

He also informs us that they have about 25,000,000 pike fry ready for distribution and 2,000,000 muskallonge fry, which will be planted in the lakes of Vilas, Oneida and Forest counties. The State Fish Hatchery Commissioners are expected here Saturday to look over the hatchery at this place and to lay out improvements to be done.

Figure 5. Prior to heavy fishing pressure, gamefish communities had their share of big ones. Also it is evident that stocking was underway in the early 1900s. (Source: Minocqua-Woodruff Centennial Edition, 1988)

4. WATERSHED CHARACTERISTICS

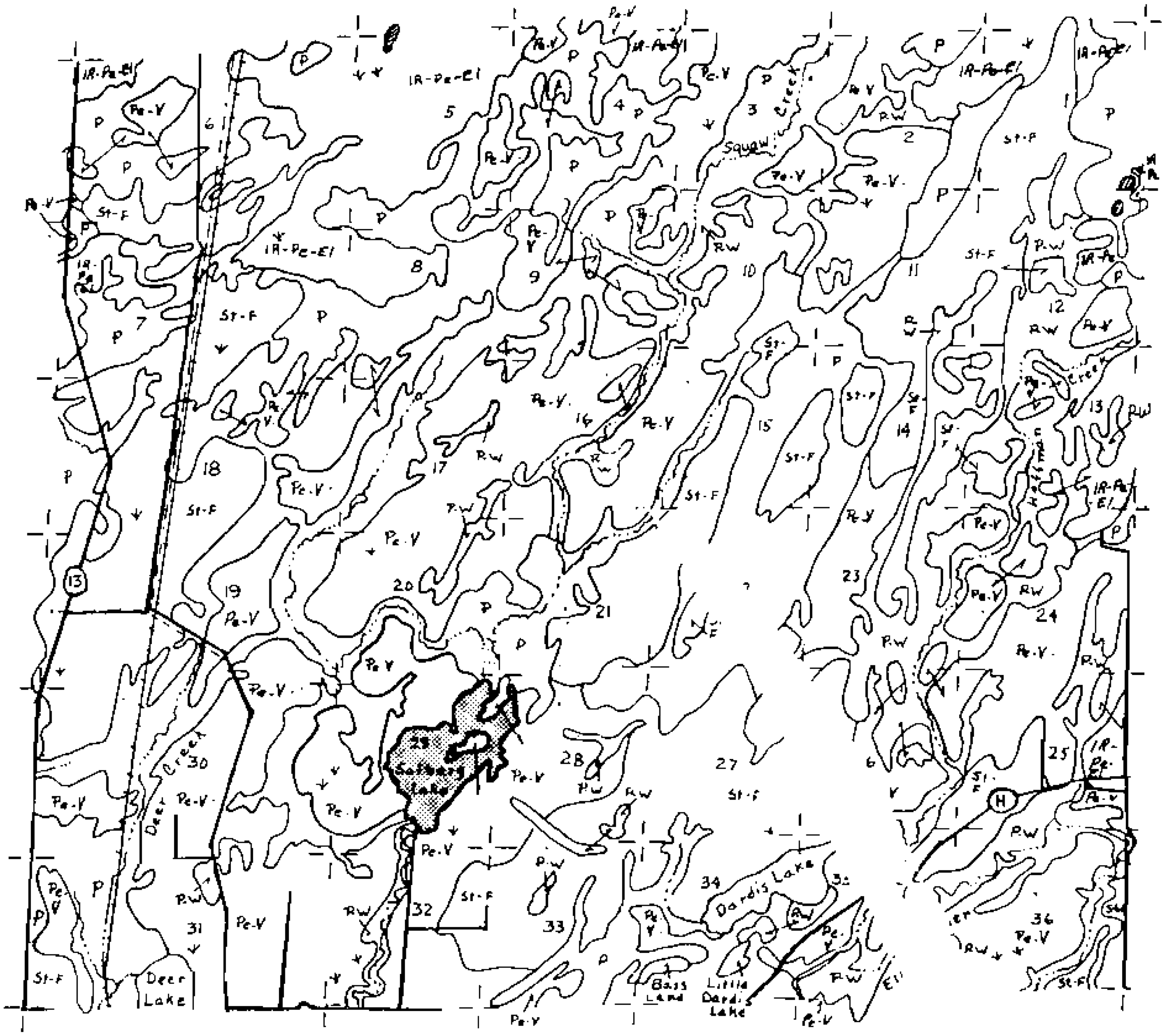
The Solberg Lake watershed encompasses approximately 17,438 acres. Of that 17,438 acres, forest lands account for 9,808 acres, followed by wetlands, 7,180 acres and then 450 acres of residential land (Table 1). Residential land use is composed of tier one cabins that are predominately seasonal in nature with about 92 seasonal homes and 30 permanent homes.

Soils in the watershed are dominated by peaty soils Figure 6. The peaty soils have some ability to retain phosphorus that runs off from the watershed, but these peaty soils sometimes give up phosphorus as well. The watershed soils have some limitation for septic tanks systems with most of the problems associated with high groundwater tables.

Table 1. Land use within Solberg Lake Watershed

	Forest	Water	Marsh	Urban-Residential
Percentage	53.5	5	39	2.5
Acres	9,808	915	7,180	450
Hectares	3,969	370	2,906	182

Phosphorus characteristics of watershed soils are shown in Figure 7. The soils have a naturally high level of phosphorus availability.



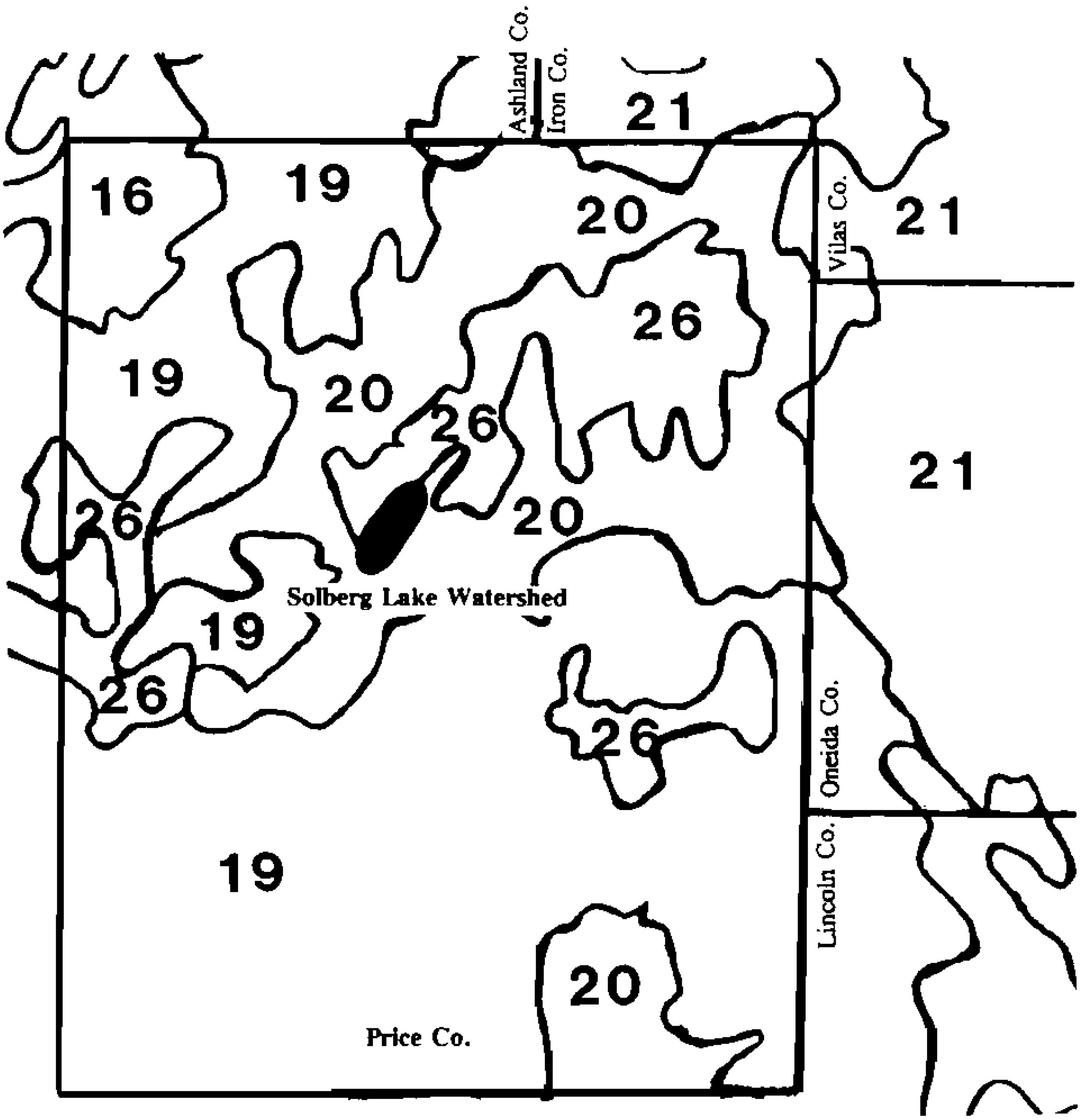
General Soils Map
Sheet 13 of 35

Worcester Township
T38N-RIE

Soil Association	Suitability for Agriculture	Suitability for Forestry	Soil limitations for Sewage Disposal
Peat (P)	Poor	Poor	Severe: Unsuitable, high water table year round
Pence-Vilas (Pe-V)	Poor	Fair	Slight: Gravel substrata suited to dry well installation. These soils are free-draining. Care should be taken to avoid contamination of drinking water source.
Stambaugh-Fifield (St-F)	Good	Good	Slight: Low-lying area have fluctuation water table. Care must be taken to prevent infiltration of silts into drain pipes and filter beds. Free-draining substratum-care should be taken to avoid contamination of drinking water source.

Figure 6. General soils of Solberg Lake area.

Source: General Soil Map Price County, Wisconsin. Prepared by U.S. Soil Conservation Service. June 1966.



Soil Number	Organic matter %				Available phosphorus lbs/A				Available potassium lbs/A				Soil reaction pH				Lime req
	Low	Med	High		Low	Med	High		Low	Med	High		Low	Med	High		
	0-2	2-5	>5		0- 50	51- 100	101- 200+		0- 200	201- 400	400+		4 5- 6.5	6 5- 7.5	7.5+		
	% of soil tests			Av.	% of soil tests			Av.	% of soil tests			Av.	% of soil tests			Av.	Av.
16	3	84	13	3 8	65	20	15	54	67	29	4	176	54	45	1	6 3	2.06
19	3	95	2	3.2	64	26	10	52	70	28	2	163	59	46	1	6 3	2.50
20	68	32	0	1.7	35	18	47	114	63	28	9	149	46	46	8	6 0	1.52
21	33	55	12	2.9	29	8	63	138	76	23	1	170	81	19	0	5 5	1.94
26	0	3	97	56.2	51	23	26	96	59	20	21	200	53	39	8	6.4	0.32

■ Approximately where the watershed is located in Price County. Not to scale.

Source: F.D. Hole. 1977. Photo-mosaic soil map of Wisconsin. Univ. Wisconsin Extension-Madison. A2822-1.

Figure 7. Available phosphorus in the watershed around Solberg Lake. Ratings are "high" for phosphorus.

5. LAKE CHARACTERISTICS

Solberg Lake characteristics are shown in Table 2. Solberg Lake is fairly shallow and has a retention time of about one-half year (6 months).

Lake Water Chemistry

Solberg Lake was sampled in two different locations during June, July, and August, 1991. At each location the following analyses were conducted: nitrogen, phosphorus, temperature, dissolved oxygen, secchi disk, Chlorophyll a, and conductivity. Monitoring results are shown in Table 3. The ratio between nitrogen and phosphorus was 23:1. This ratio indicates that phosphorus is the limiting factor in the lake, and that phosphorus will control the amount of algae in Solberg. As Total Phosphorus increases, over the course of the summer, Chlorophyll a increases, causing the water clarity to decrease and results in the lake being unappealing for recreational users and unappealing for gamefish because they have trouble seeing their forage.

The temperature in the lake was nearly the same from top to bottom, indicating that the lake is well mixed. The dissolved oxygen was even found all to way to the bottom (Figure 8).

In the summer of 1991, the lake had an average secchi disk transparency of 3.6 feet. The greatest reading was 4.3 feet, recorded in July and the lowest was 2.9 feet, recorded in August.

Table 2. Solberg Lake Characteristics

Area (Lake): 915 acres (370 ha)
Mean depth: 8.0 feet (2.4 m)
Maximum depth: 16 feet (4.9 m)
Volume: 6,920.3 acre-feet (854 Ha M)
Littoral area: 15 %
Fetch: 2.35 mile (3.78 km)
Watershed area: 17,438 acres (7,057 ha)
Watershed: Lake
surface ratio 19:1
Estimated average
water residence time 0.5 years

Inlets: 5 Outlets: 1

Land Use (percentage/area):

	Forest	Water	Marsh	Urban-Res.
Percentage	53.5	5	39	2.5
Acres	9,808	915	7,180	450

Development (Homes):	Seasonal	Permanent	Total
	92	30	122

Table 3. Water Chemistry results for Solberg Lake, 1991.

DATE LOCATION		SECCHI DISK FEET	TP ug/l	CHL A ug/l	TKN ug/l	NH3 ug/l	NO3 ug/l	COND umhos
Jun 8, 1991								
Station 1	T	3.5	30	18	800	20	79	30
Station 2	T	4	20	12	600	34	100	30
Station 1	B	-	30	-	-	-	-	-
Station 2	B	-	30	-	-	-	-	-
Jul 30, 1991								
Station 1	T	4	51	25	1000	52	40	34
Station 2	T	4.3	32	17	900	95	32	32
Station 2	B	-	43	-	-	-	-	-
Aug 27, 1991								
Station 1	T	2.9	57	37	900	8	12	35
Station 2	T	3	45	34	900	7	12	35
Station 1	B	-	58	-	-	-	-	-
Station 2	B	-	42	-	-	-	-	-

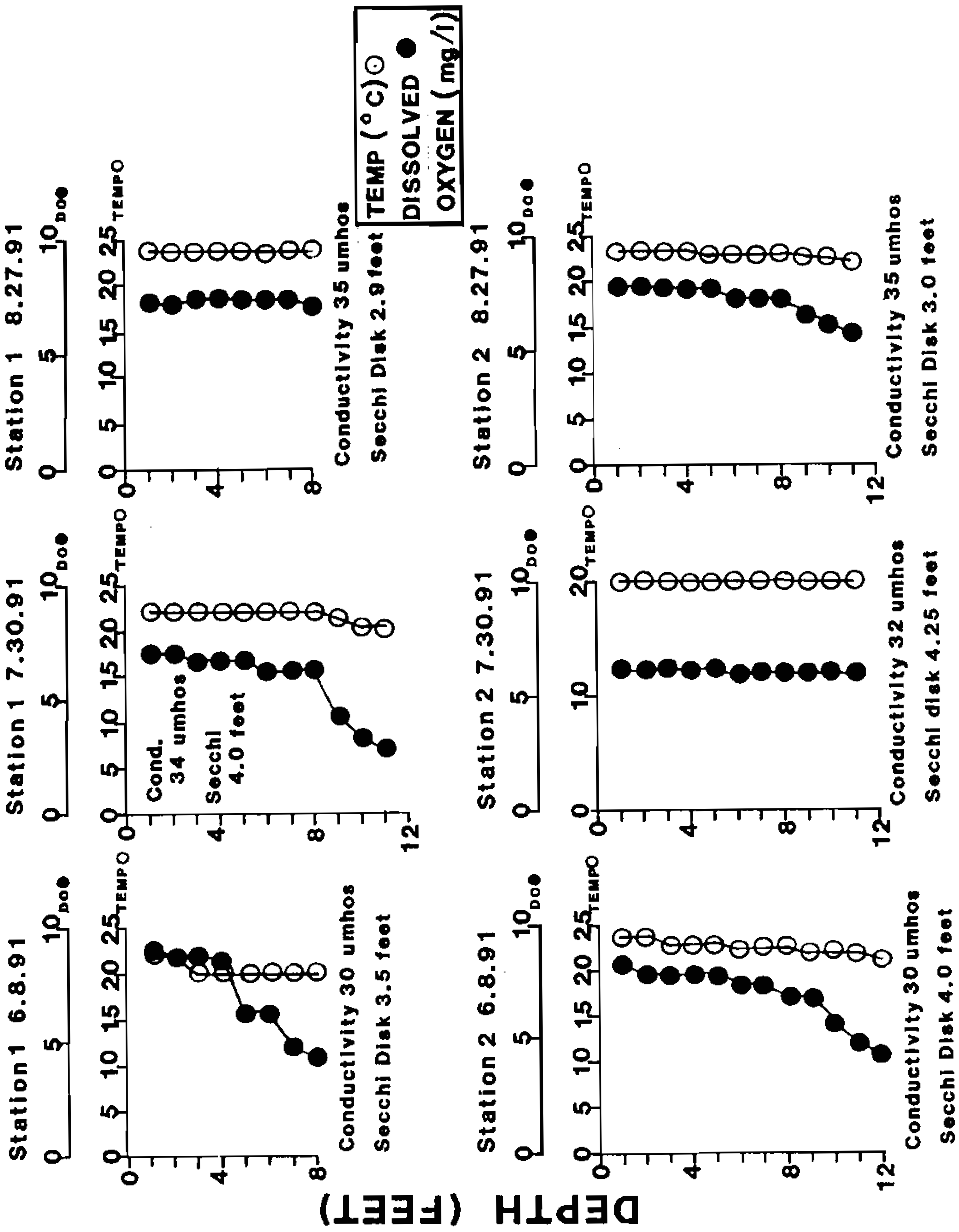


Figure 8. Temperature and oxygen profiles and secchi disc readings for Solberg Lake.

Average summer values for several parameters for Solberg Lake are shown in Table 4. The Trophic State Index indicates Solberg is slightly eutrophic.

Table 4. Summer Data for Solberg Lake, 1991. TSI refers to Trophic State Index.

Parameter	Units	Mean	n	Min	Max
Total phosphorus	ppb	39	6	20	57
Chlorophyll a	ppb	24	6	17	37
Secchi disk	*m*	*1.1*	*6*	*0.88*	*1.3*
Total Kjeldahl N	ppm	0.850	6	0.600	1
Nitrite + Nitrate-N	ppm	0.046	6		
Ammonia-N	ppm	0.036	6	0.007	0.095
pH	SU				
Total Suspended Solids	ppm				
Total Suspended Inorganic Solids	ppm				
Conductivity	umhos/cm	33	6	30	35
TN:TP ratio	23:1				
TSIP (TP)	59				
TSIC (Chl-a)	58				
TSIS (Secchi)	59				
TSI (Mean)	58.6				

Macrophytes

In the summer of 1991 an aquatic plant survey was conducted. Fifteen transects of the lake were completed using a Lowrance X-16 recording sonar (Figure 9, shows the transects) and plant hooks, used to collect species of plants. Some of these plants were brought back to the lab for better identification and to be mounted. The species of plants and depths they were found at are listed in Table 5. The distribution of the plants around the lake is shown in Figure 10.

Table 5. Aquatic vascular plants found in Solberg Lake. All the plants found in Solberg Lake were in less than 5 feet of water.

Species	
Common Name	Scientific Name
Elodea	*Elodea canadensis*
Waterlily	*Nymphaea spp*
Cabbage	*Potamogeton amplifolius*
Coontail	*Ceratophyllum demersum*
Wild celery	*Vallisnersia americana*
Spatterdock	*Nuphar spp*
Floatingleaf	*Potamogeton natans*
Peat	*Sphagnum spp*
Watershield	*Brasenia schreberi*
Naiads	*Najas flexillis*
Arrowhead	*Sagittaris sp.*

Plant growth was sparse in 1991. The color of the water has a direct effect on the depth that some of these species were found and the quantity that was found. Another reason why there might be a limited plant growth would be the substraight the plants have to grow in. Most weeds grow best in slightly mucky/sandy mixture soils, not the hard firm, or rocky sediments that are found around Solberg.

The percent of plant cover was calculated to be 18% of the lake. This percent was determined by using the dot count method of analysis. A common percent of plant coverage which is considered to be good for the lake is around 40% coverage. When plant coverage is less than 40% fertile lakes have a tendency to be dominated by planktonic algae. Currently, Solberg does not have long summer periods of nuisance algae growth. The aquatic plant community of Solberg Lake is dominated by wild celery, floatingleaf pondweed, arrowhead, and cabbage plants.

Examples of sonar tracings for Solberg Lake are shown in Figure 11.

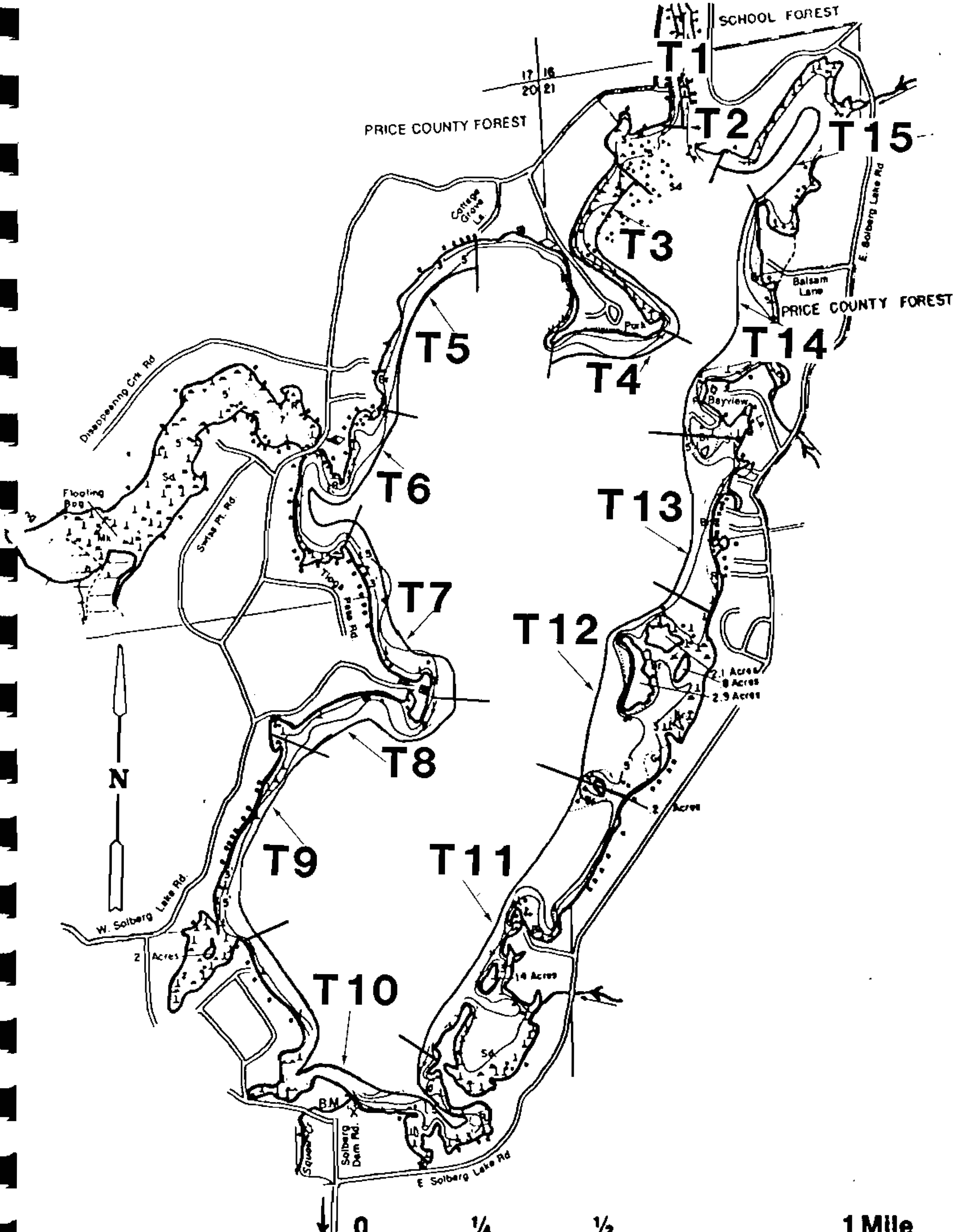


Figure 9. Transects followed in Solberg Lake during the aquatic plant survey conducted in 1991.

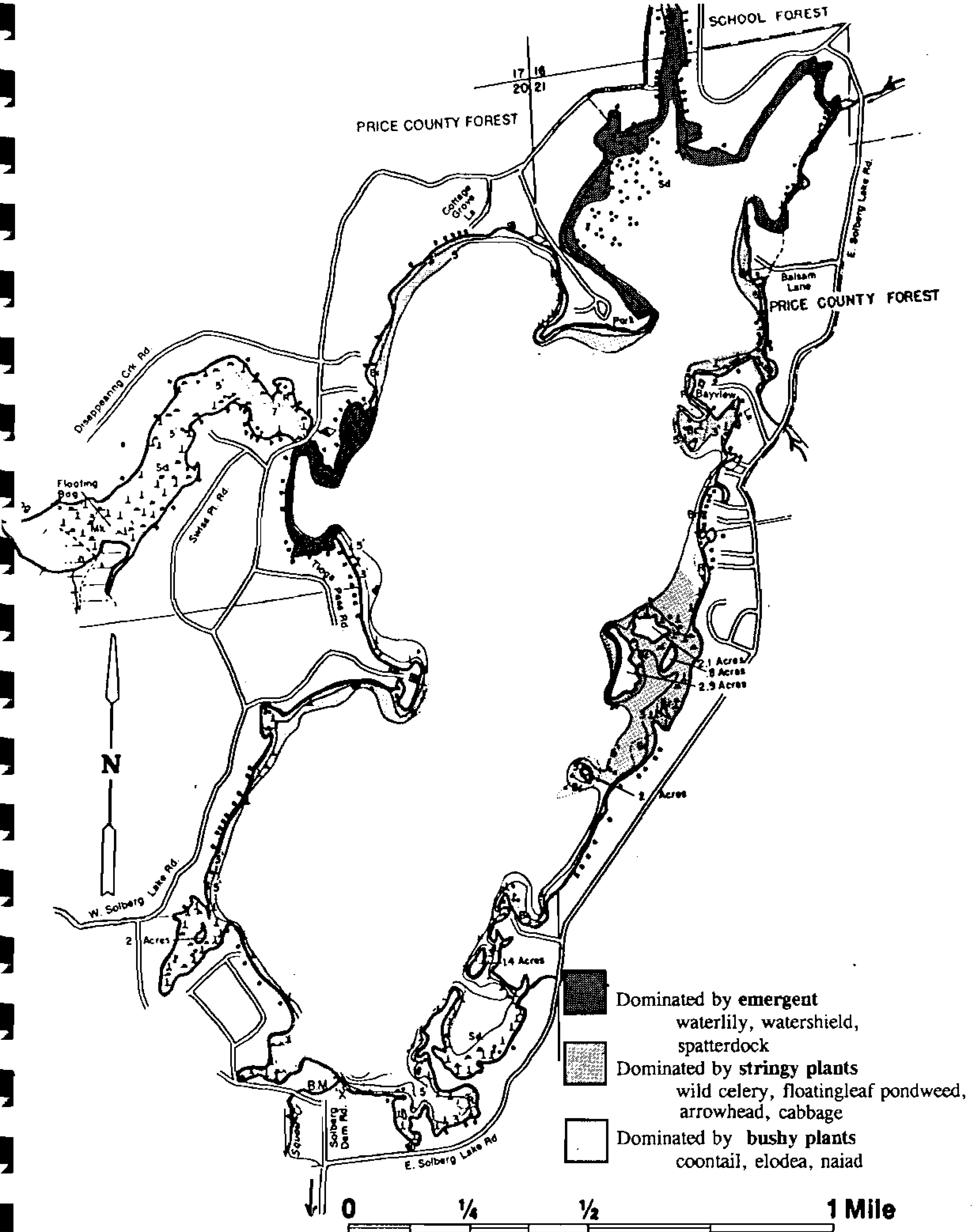


Figure 10. Aquatic plant communities found around Solberg in 1991.

Fish

The fish study conducted by WDNR on Solberg Lake during the summer of 1991 consisted of 3 hours of electrofishing. The purpose of this survey was to assess year class strength of the young Walleye. The whole shoreline was not tested, due to problems caused by stumps along the shoreline. The species that were found and the quantity that were collected are listed in Table 6.

Table 6. Fish species and quantity found in Solberg Lake in 1991. The electrofishing survey was conducted by Wisconsin Department of Natural Resources.

Species	Number of fish found
Walleye	638
Muskellunge	31
Northern Pike	4
Largemouth Bass	2
Smallmouth Bass	1
Yellow Perch	11
Bluegill	62
Pumpkinseed	5
Black Crappie	20
Rock Bass	30

The last time the Wisconsin Department of Natural Resources (WDNR) stocked any fish in Solberg Lake was 1991. The fish that were stocked by the WDNR were muskellunge. Under the request of the fisheries manager no more fish will be stocked until the WDNR has the opportunity to conduct a full survey in 1994. At that time WDNR will reassess the fish stocked in Solberg Lake and produce a plan that will be beneficial to the lake and the fish community.

Results from earlier fish surveys are shown in Table 7. Fyke nets were the sampling devices and results are not comparable because the 1965 survey was in May and the 1988 survey was in August.

A summary of past stocking records is shown in Table 8. Walleye and Muskies have been the management choices for stocking.

Table 7. Results from past fish surveys

	May 13, 1965 26 Lifts Catch/Lift	Aug 23-26, 1988 20 Lifts Catch/Lift
Muskie	0.6	0.2
Walleye	2.0	1.9
Northern Pike	0.04	0.2
Largemouth Bass	0.4	0.4
Crappie	134.4	14.0
Yellow Perch	1.4	128.8
Pumpkinseed	11.8	7.7
Bluegill	-	24.7
Rock Bass	0.2	7.0
Bullhead	0.5	-
Sucker	0.04	0.1
Red Horse	0.04	-

Table 8. Department of Natural Resources Stocking Records

Date	Species	Number Planted
1952	Muskie	520
1954	Muskie	150
1955	Muskie	5,664
1956	Walleye	8,100
1957	Muskie	4,962
1958	Walleye	8,100
1959	Muskie	1,839
1960	Walleye	8,100
1961	Walleye	80,000
1962	Muskie	1,298
1963	Muskie	1,416
1964	Muskie	1,298
1965	Muskie	1,416
1966	Muskie	1,416
1967	Muskie	590
1968	Muskie	620
1969	Muskie	500
1970	Muskie	800
1971	Bluegill/ Pumpkinseed	7,266
1972	Muskie	600
1973	Muskie	1,000
1974	Muskie	2,293
1975	Muskie	236
1976	Muskie	2,500
1977	Muskie	2,360
1978	Muskie	1,680
1979	Muskie	2,860
1980	Muskie	2,360
1981	Muskie	500
1982	Muskie	750
1983	Muskie	2,360
1984	Muskie	1,200
1985	Muskie	2,220
1986	Muskie	1,720
1987	Muskie	860
1988	Muskie	1,720
1989	Muskie	860
1990	Muskie	860
1991	Muskie	1,720

All fish that were stocked were fingerlings except for the Bluegill/Pumpkinseed which was an adult.

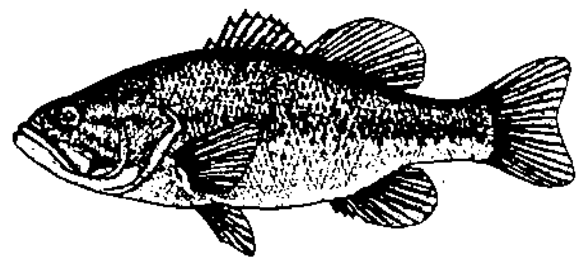
Prey Fish Availability

One way to evaluate fishery data is to determine how much forage is available to the predator fish.

As a way to look at available prey fish we employed techniques used by Lawrence (1958) and Hambright et al (1991), and modified those approaches to get a prey vulnerability index.

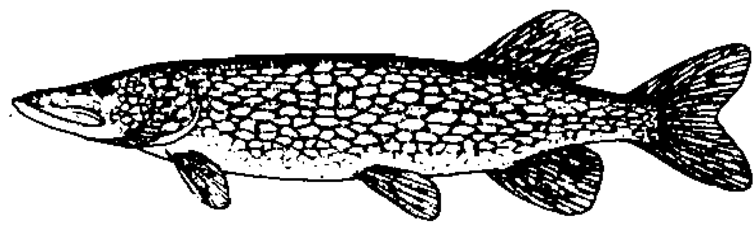
To establish a prey vulnerability index, we need several measurements. One measurement is to determine how large of a prey fish a gamefish can shallow. To do this we have converted gamefish total lengths to mouth widths (also referred to as gape width). Next we have converted prey fish total lengths to body depths. Then we have made the assumption that any prey fish with a body depth less than the mouth width of a gamefish is vulnerable to ingestion.

Literature data have been used to express the total length verses mouth width (gamefish) and total length verses body depth (prey fish). Graphical presentation of predator mouth widths and predator body depths is shown in Figure 12. Equations that describe the total length to mouth width or body depth are shown in Table 9. Charts that display total length verse game fish mouth widths and prey body depths is shown in Table 10.

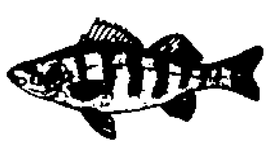


Largemouth Bass, 12.3 inches
3-4 years old, 1 pound

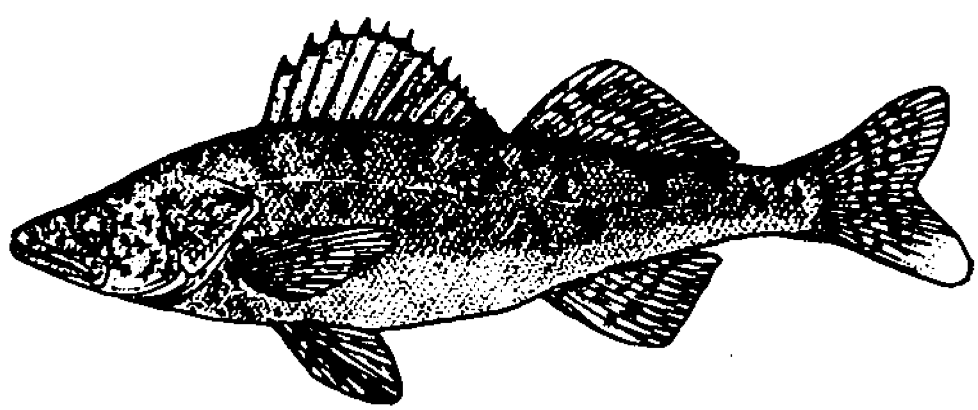
Bluegill sunfish, 4 inches
1-2 years old



Northern Pike, 16.5 inches
6-7 years old, 1.5 pounds



Yellow perch, 5.3 inches
2 years old



Walleye, 21 inches
8 years old, 3 pounds

Figure 12. Relationship (to scale) of predator fish and prey fish in Solberg Lake For gamefish to control stunted sunfish (4 inches), a bass has to be 12.3 inches, a pike, 16.5 inches and a walleye, 21 inches. This is based on the predator mouth width to prey body depth relationship. A 5.3 inch perch is equivalent to a 4 inch bluegill in regard to what can be swallowed by a gamefish.

Table 9. Gape, mouth widths, and body depths as a function of total length for selected prey and gamefish (predator fish).

LARVAL GAMEFISH MOUTH WIDTHS (OR GAPE)

Total length=mm except for yellow perch

Freshwater drum	gape(mm)=0.175L - 0.228	r^2=0.92	n=132	Schael et al 1991
Yellow perch	gape(mm)=0.159L - 0.597	r^2=0.94	n=287	0-24 mm
Black crappie	gape(mm)=0.161L - 0.656	r^2=0.75	n=162	0-30 mm
Yellow perch L=cm	gape(mm)=1.53L - 0.52	r^2=0.98	n=238	Arts & Evens 1987
Largemouth Bass 0-100 mm	mouth width=0.0775L + 1.88			Lawrence 1957

ADULTS GAMEFISH MOUTH WIDTHS

Total length=mm

Walleye	mouth width(mm)=15.43Ln(TL)-61.43	r^2=0.99	derived from Knight et al 1984	
Northern pike	mouth width(mm)=0.087TL - 1.38	r^2=0.98 n=34	Hambright et al 1991	
Largemouth Bass	mouth width(mm)=0.111TL - 1.88	Lawrence	1957	100-199
	mouth width(mm)=0.129TL - 5.16	"	"	200-299
	mouth width(mm)=0.137TL - 7.96	"	"	300-399
	mouth width(mm)=0.196TL - 29.41	"	"	400-499
	mouth width(mm)=0.248TL - 56.36	"	"	500-599

PREY BODY DEPTHS

Total Length(TL)=mm

Bluegill	body depth(mm)=0.418TL - 7.98		
Redear	body depth(mm)=0.346TL - 2.08		
Green	body depth(mm)=0.372TL - 4.36		
Crappie	body depth(mm)=0.3151TL - 5.38	r^2=1.00 n=31	Hambright et al
Gizzard shad	body depth(mm)=0.294TL - 4.59		
Goldfish	body depth(mm)=0.385TL - 8.50		
Golden shiner	body depth(mm)=0.257TL - 4.71		
Largemouth Bass	body depth(mm)=0.237TL - 3.16	(0-299 mm)	
Yellow Perch	body depth(mm)=0.271TL - 1.15	r^2=0.99	Knight et al 1984

Table 10. Gamefish conversion chart.

Mouth Widths (mm)	Walleye Total (mm)	Walleye Length (inches)	Walleye Weight (pounds)	Largemouth Bass Total (mm)	Largemouth Bass Length (inches)	Largemouth Bass Weight (pounds)	Northern Pike Total (mm)	Northern Pike Length (inches)	Northern Pike Weight (pounds)
0	0	0	0	0	0	0	0	0	0
5				40	1.6	-	73	2.9	-
10	100	3.9	-	107	4.2	-	130	5.1	-
15				152	6	-	188	7.4	-
20	200	7.8	-	197	7.8	-	246	9.7	-
25	275	10.8	-	234	9.2	-	303	12	-
30	375	14.8	1.5	273	10.8	-	360	14.2	-
35	525	20.7	2.8	314	12.3	1	418	16.5	-
40	700	27.6	8	350	13.8	1.9	476	18.7	-
45				387	15.2	2.3	533	21	2
50				405	16	2.7	590	23.2	2.7
55				431	17	3.1	648	25.5	3.6
60				456	18	3.5	705	27.8	4.9
65				482	19	4.5	763	30	5.8
70				510	20.1	5.4	820	32.3	8.2
75				530	20.9	6.3	878	34.6	10.6
80				550	21.7	7.2	935	36.8	13.4

Prey fish conversion chart.

Body Depth (mm)	Bluegill mm (inches)	Pumpkinseed mm (inches)	Crappie mm (inches)	Yellow Perch mm (inches)	Golden shiner mm (inches)	Gizzard shad mm (inches)	Largemouth Bass mm (inches)
0	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	31 (1.2)	31 (1.2)	33 (1.3)	27 (1)	38 (1.5)	33 (1.3)	34 (1.4)
10	43 (1.7)	43 (1.7)	49 (1.9)	41 (1.6)	57 (2.3)	50 (2.0)	56 (2.2)
15	55 (2.2)	55 (2.2)	65 (2.5)	60 (2.3)	77 (3.0)	67 (2.6)	77 (3.0)
20	67 (2.6)	67 (2.6)	81 (3.2)	78 (3.1)	96 (3.8)	84 (3.3)	98 (3.8)
25	79 (3.1)	79 (3.1)	96 (3.8)	96 (3.8)	116 (4.6)	101 (4.0)	119 (4.7)
30	91 (3.6)	91 (3.6)	112 (4.4)	115 (4.5)	135 (5.3)	118 (4.6)	140 (5.5)
35	103 (4.0)	103 (4.0)	128 (5.0)	133 (5.3)	155 (6.1)	135 (5.3)	161 (6.3)
40	115 (4.5)	115 (4.5)	144 (5.7)	152 (6.0)	174 (6.8)	152 (6.0)	182 (7.2)
45	127 (5.0)	127 (5.0)	160 (6.3)	170 (6.7)	193 (7.6)	169 (6.6)	203 (8.0)
50	139 (5.5)	139 (5.5)	176 (6.9)	189 (7.4)	213 (8.4)	186 (7.3)	224 (8.8)
55	151 (5.9)	151 (5.9)	192 (7.5)	207 (8.2)	232 (9.1)	203 (8.0)	245 (9.7)
60	163 (6.4)	163 (6.4)	207 (8.2)	226 (8.9)	252 (9.9)	220 (8.6)	266 (10.5)
65	175 (6.9)	175 (6.9)	223 (9.4)	244 (9.6)	271 (10.7)	237 (9.3)	288 (11.3)
70	187 (7.3)	187 (7.3)	255 (10.0)	263 (10.3)	291 (11.4)	254 (10.0)	309 (12.2)
75	199 (7.8)	199 (7.8)	271 (10.7)	281 (11.1)	310 (12.2)	271 (10.7)	330 (13.0)
80	210 (8.3)	210 (8.3)	287 (11.3)	299 (11.8)	330 (13.0)	289 (11.3)	351 (13.8)
85	222 (8.8)	222 (8.8)	287 (11.3)	318 (12.5)	349 (13.7)	305 (12.0)	372 (14.6)
90	234 (9.2)	234 (9.2)	303 (11.9)	336 (13.2)	369 (14.5)	322 (12.7)	393 (15.5)

Results of gamefish mouth width conversions and preyfish body depth conversions for Solberg Lake 1991 electrofishing survey are shown in Tables 11 and 12.

We looked at total lengths for all preyfish (bluegill, pumpkinseed, crappie, rock bass, yellow perch) and converted total lengths to body depths. We took all gamefish (northern pike, largemouth bass, and walleye) total lengths and converted them to mouth widths. Results are shown in Figures 13 and 14.

To help evaluate these graphs, we have set-up an arbitrary scale called "gamefish coverage". We have assumed a gamefish can ingest a prey that has a body depth less than its mouth width.

In Solberg Lake most of the preyfish community is largely safe from gamefish predation. Predators are too small to eat most of forage in the lake. The area under the prey curve is referred to as gamefish coverage.

The gamefish coverage percentage is only a relative indicator. All it indicates is the relative overlap of gamefish mouth widths with prey body depths. However it does seem to have some value. It will indicate if there is a stunted fish population (low overlap percentage or coverage) and should indicate a well balanced fish community (good gamefish coverage). As more lake surveys are evaluated for gamefish coverage classification schemes will become better defined.

In summary, the idea behind gamefish mouth widths and prey body depths is to develop a technique where a lake manager can take fish survey results, make some graphs and quantify with one number the relative condition of the fish community. As example, a stunted sunfish community is dominated by four inch fish. It takes a 12 inch bass, 16 inch pike, or a 21 inch walleye to eat a stunted sunfish. If the gamefish community does not have enough fish that big, then the stunted sunfish will continue to be numerous.

In Solberg Lake there appears to be too many gamefish and not enough forage. Maybe management efforts should look at developing a better forage base.

Table 11. Number of gamefish at each mouth width

Mouth width (mm)	Walleye	Largemouth Bass	Muskie	Northern Pike	Total Number of Gamefish	Number of gamefish/mile	Percent Gamefish
0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0
15	105	1	1	0	107	20.1	25
20	91	0	4	0	95	18.3	23
25	109	1	13	0	123	23.7	29
30	69	0	0	1	70	13.5	17
35	7	0	7	2	16	3.1	4
40	1	0	1	0	2	0.4	1
45	0	0	3	1	4	0.8	1
50	0	0	0	0	0	0	0
55	0	0	2	0	2	0.4	1
	382	2	31	4	419	80.6	101

Table 12. Number of preyfish at each body depth

Body Depth (mm)	Largemouth Bass	Rock Bass	Bluegill	Pumkinseed	Black Crappie	Yellow Perch	Total Number of Preyfish	Number of Preyfish/mile	Percent Preyfish
0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0
15	0	0	0	0	1	0	1	0.2	1
20	0	1	4	0	0	2	7	1.3	5
25	0	1	4	0	1	0	6	1.2	5
30	1	0	3	0	0	1	5	1.0	4
35	0	2	5	0	1	0	8	1.5	6
40	0	6	7	0	2	0	15	2.9	12
45	0	2	12	0	1	1	16	3.1	12
50	1	0	0	0	2	0	3	0.6	2
55	0	6	8	0	6	4	24	4.6	18
60	0	5	5	2	0	1	13	2.5	10
65	0	3	10	3	0	0	16	3.1	1212
70	0	0	2	0	1	1	4	0.8	3
75	0	1	2	0	2	1	6	1.2	5
80	0	0	0	0	3	0	3	0.6	2
85	0	1	0	0	0	0	1	0.2	1
90	0	1	0	0	0	0	1	0.2	1
95	0	0	0	0	0	0	0	0	0
100	0	1	0	0	0	0	1	0.2	1
	2	30	62	5	20	11	130	25.0	101

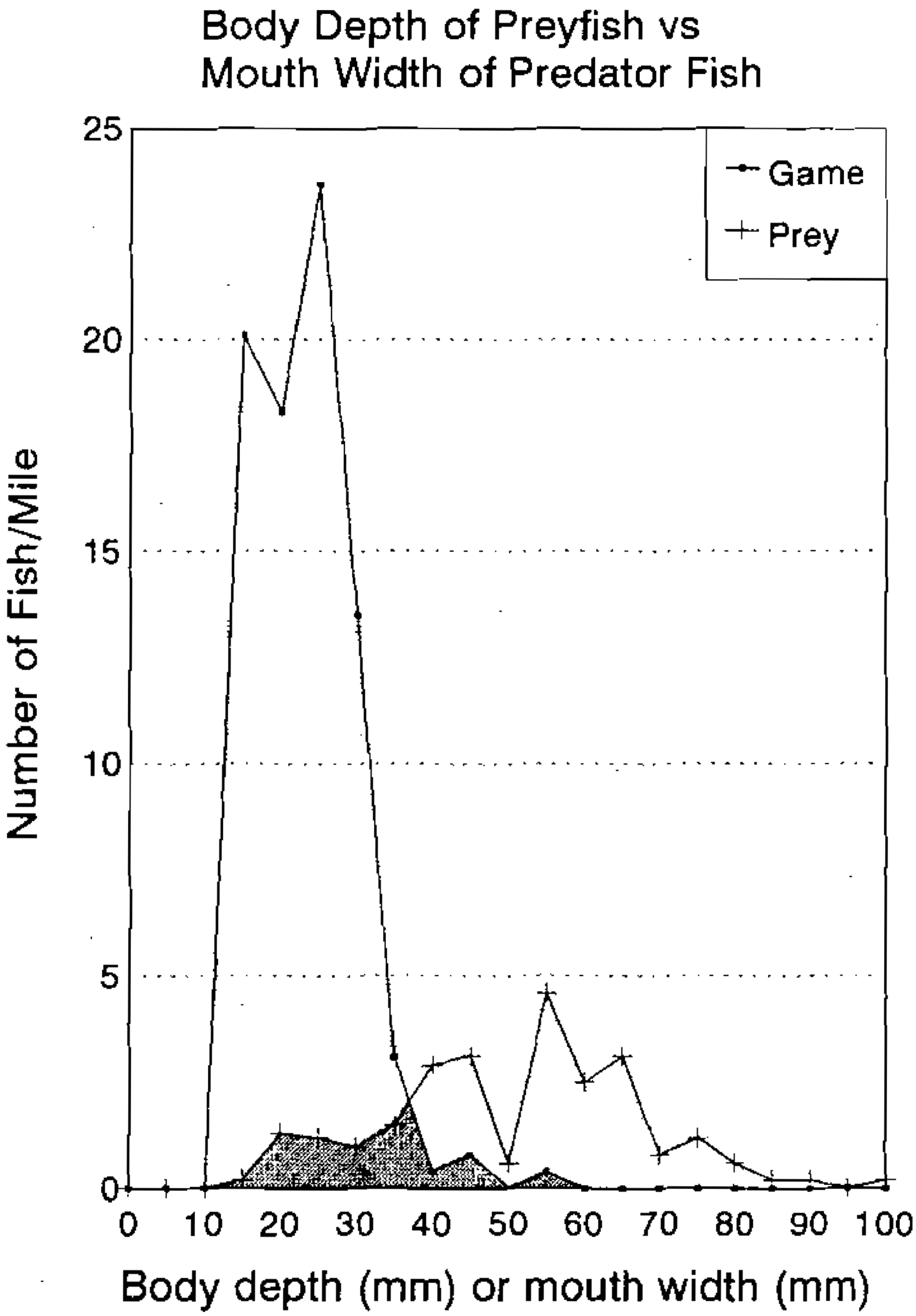


Figure 13. Actual numbers from the 1991 electrofishing survey. There does not appear to be adequate forage for gamefish with mouth widths 30mm or smaller.

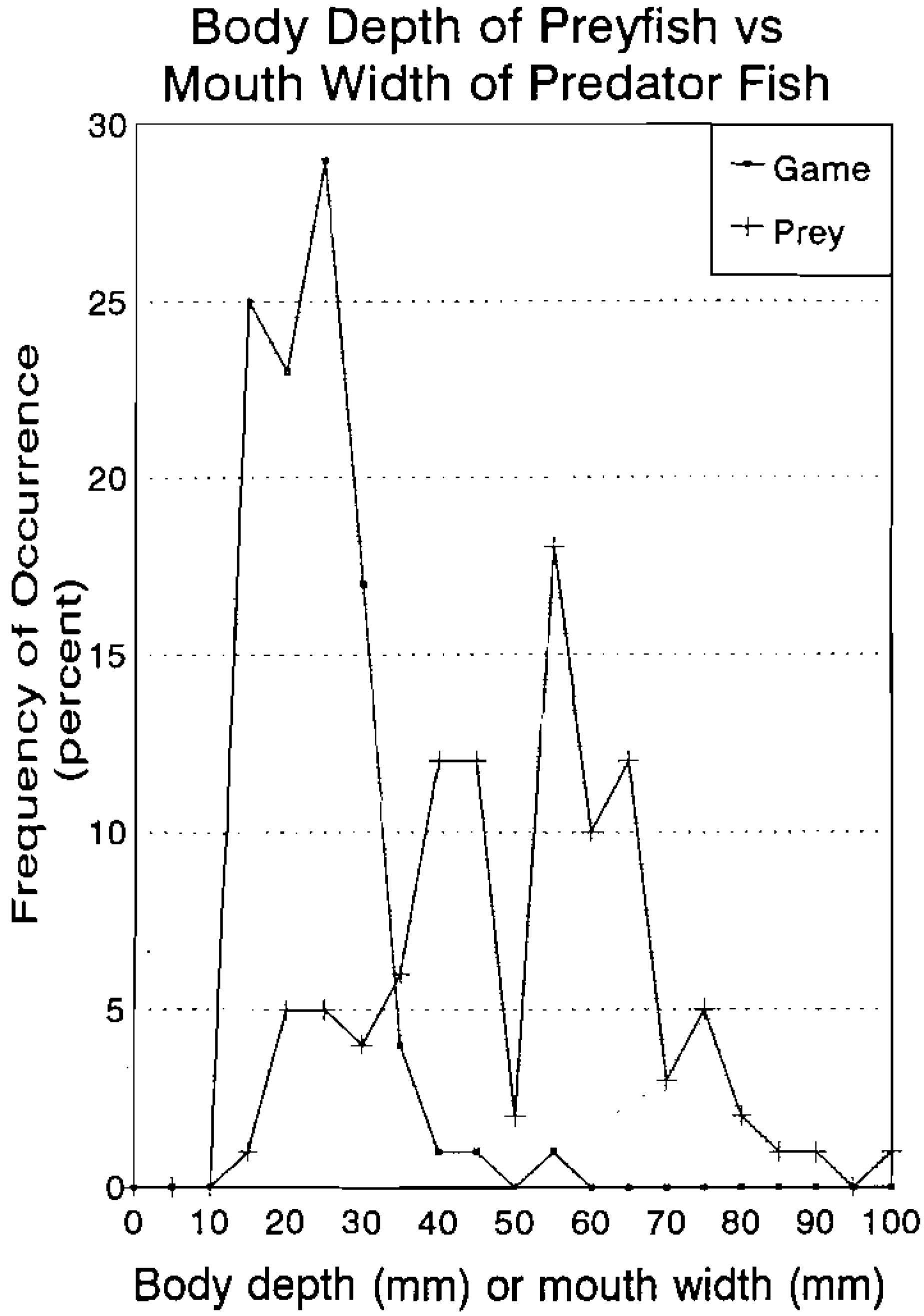


Figure 14. Percent occurrence of gamefish and preyfish at 5mm intervals similar trends are found compared to Figure 13. It appears the forage base is low in numbers.

6. SOLBERG LAKE PHOSPHORUS MODEL

Lake modeling is a tool that aids in predicting what phosphorus concentrations should be in a lake based on the amount of nutrients that comes into a lake on an annual bases. A lake model is used to see how close current conditions are to what we predicted. Also predictions can be made as to what future conditions could be if changes occurred in the watershed.

Two phosphorus models were used to evaluate Solberg Lake. One of the phosphorus models used was the Reckhow and Simpson Model, the other was the Canfield and Bachmann Model. The models are shown in Table 13. Before the models could be run the nutrient budgets, and water budgets had to be determined. By assigning nutrient concentrations with land use delineations and then assuming a certain amount of runoff per year we estimated phosphorus inputs from various land uses. These are referred to as export coefficients and a summary of export coefficients with each land use and the total estimated phosphorus input to Solberg Lake is shown in Table 14. Our nutrient budget calculations indicate that the forest runoff is the major nutrient contributor to Solberg Lake followed by rainfall, wetlands areas, residential land use, and lastly the residential on-site wastewater treatment systems. An unknown variable here is groundwater inputs and we assumed that groundwater inputs were low. The total amount of phosphorus that comes into Solberg Lake in a year is estimated at 850 kg/year.

The values that were calculated for the Canfield-Bachmann phosphorus model are shown in Table 15. For Solberg Lake the Canfield and Bachmann model prediction was 39 parts per billion (ppb) for artificial lakes while the average found for Solberg Lake in the summer of 1991 was 39 ppb.

Table 13. Phosphorus models used for Solberg lake .

Reckhow and Simpson Phosphorus Model (1979)

Predicted phosphorus concentration (mg/l) =

$$\frac{L \text{ (nutrient budget)}}{11.6 + 1.2\, q_s \text{ (water budget)}}$$

where:

$$L\ (g/m^2) = \frac{\text{Mass of phosphorus loading (g)}}{\text{Lake surface area } (m^2)}$$

and:

$$q_s\ (m) = \frac{\text{Volume of water loaded on the lake surface } (m^3)}{\text{Lake surface area } (m^2)}$$

Canfield and Bachmann Phosphorus Model (1981)

$$TP = \frac{L}{z(0.114\,(L/z)^{0.589} + p)}$$

where:

TP (mg/m^3) = concentration of total phosphorus in the lake water

L ($mg/m^2/yr$) = annual phosphorus loading per unit of lake surface area

z (m) = mean depth of the lake

p (yr^{-1}) = hydraulic flushing rate

Table 14. Nutrient input parameters for the Solberg lake phosphorus model.

Land use or nutrient source	Area (ha) volume (m^3) or numbers	Export coefficient (kg/ha/yr)	Estimated phosphorus input (kg/yr)
Forest	3,969 ha	0.1	396.9
Wetland	2,906 ha	0.05	145.3
Urban	182 ha	0.19	34.6
Septic tank systems			
seasonal	92	0.054*	5.0
permanent	30	0.166*	5.0
Rainfall	370 ha	0.4	148
Groundwater	0	0	0

			850.0

* kg/on-site system/yr was derived from the following assumptions and calculations:

seasonal: 60 gallons/day * 2.5 people/cabin = 150 gallons/day/cabin * 3.785 = 567.75 liters * 120 days = 68,130 liters * 0.8 mg/l* = 54,504 mg/year

permanent: 60 gallons/day * 2.5 people/cabin = 150 gallons/day/cabin * 3.785 = 567.75 liters * 365 days = 207,229 liters * 0.8 mg/l* = 165,783 mg/year

** mg/l

Table 15. Total phosphorus (ppb) lake model. Export coefficients are literature values and are derived from EPA Manuals.

PHOSPHORUS LOADING	Export coeff kg/ha/yr	Area ha	Phos input kg/yr
Forest	0.1	3969	397
Wetland	0.1	2906	291
Urban	0.19	182	35
Agriculture	1	0	0
Septic Tank Systems			
Seasonal	0.055	92	5
Permanent	0.166	30	5
Rainfall	0.4	370	148
Groundwater	0.04	0	0
Misc Phos Input			850
	TOTAL MASS ==>		1730

WATER BUDGET			
Avg Runoff, in	12	0.3048	m
Watershed area, ha	7057	7057	ha
Net Precip, rain - evap, inches	0	0	m
Lake surface area, ha	370	370	ha
Net water input rainfall, m^3	0		
Net water input, watershed, m^3	21,509,736		
Total Water, m^3 ==>	21,509,736		

Canfield Bachmann Lake Phosphorus Model

Description	Units	Eq. Symbol	Value
Lake Area	ha	A	370
Mean Depth	m	z	2.4
Lake Volume	m^3	V	8,880,000
Total P mass	kg/yr	M	1,730.12
Total Water	m^3	Q	21,509,736
Total TP load	mg/m^2/yr	L	468
Flushing rate	1/yr	P	2.42
Nat Sed coeff	1/yr	SIGMA_n	1.81
Art Sed Coeff	1/yr	SIGMA_a	2.54
Natural Lake Total Phosphorus, ppb			46
Artificial Lake Total Phosphorus, ppb			39

7. CONCLUSIONS OF THE LAKE AND WATERSHED ANALYSES

Some conclusions of the 1991 lake and watershed analyses are summarized below:

- phosphorus concentrations were between 30 and 50 ppb for the summer of 1991 (Figure 15).

- Using the Carlson Trophic State Index, this makes Solberg Lake eutrophic (Figure 16).

- The plant community in Solberg Lake varies from year to year somewhat dependent on lake water levels.

- The fish community is interesting. Gamefish numbers are high compared to the forage base that is available (according to our methodology used in this report).

- The phosphorus model closely predicted the summer lake phosphorus concentration which was 39 ppb.

- Solberg Lake is approaching a threshold where if it gets much more phosphorus (several hundred pounds per year) nuisance algae blooms could develop.

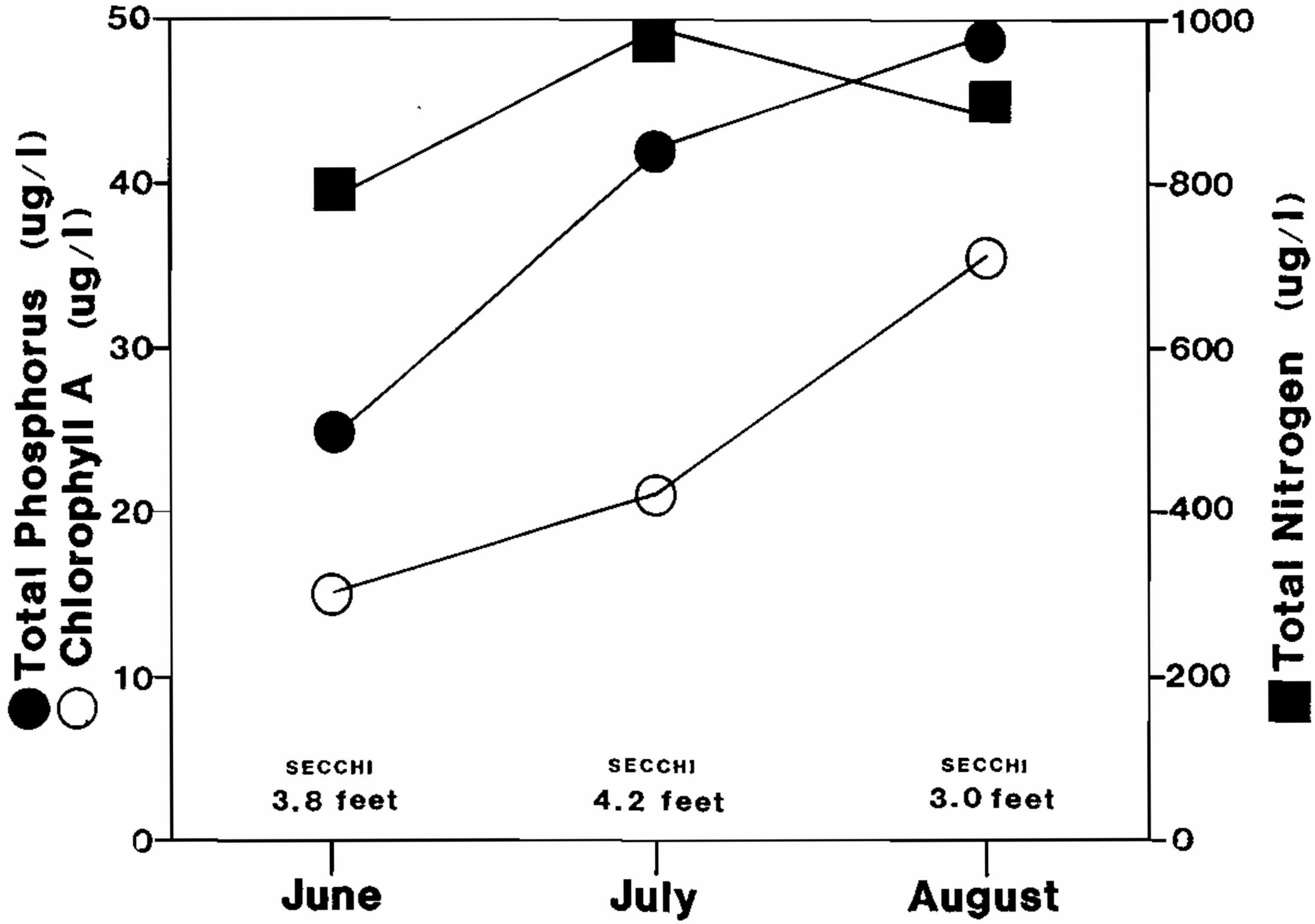
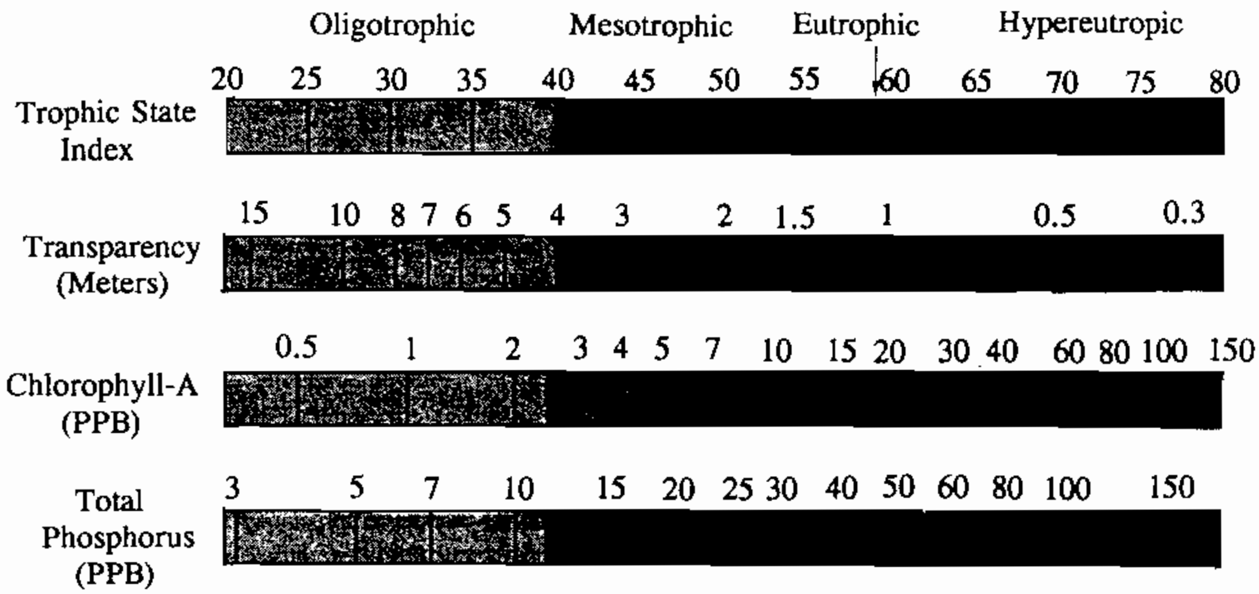


Figure 15. Phosphorus, nitrogen, and chlorophyll through the 1991 summer.



TSI = Trophic State Index

TSI(Chl a) = 36.25 + 15.5 $\log_{10}$ [Chl a]
ppb or ug/l
TSI(TP) = 60 - 33.2 $\log_{10}$ (40.5/TP)
ppb or ug/l
TSI(Secchi) = 60-(SD $\log_{10}$ x 33.2)
meters

Figure 16. Carlson's Trophic State Index. Taken from NALMS (1988). Solberg is rated at 59, the eutrophic area.

8. FUTURE PROJECTS

A summary of recommended projects for Solberg Lake is listed below in Table 16.

Table 16. Summary of recommended projects.

1. Aquatic plant control by lake water level control.
2. Aquascaping in some near-shore areas (bulrushes, etc.).
3. Landscaping for wildlife.
4. Dredging in shallow inflow areas will not harm nor help the lake.
5. Fish stocking should be coordinated with WDNR.
6. Fish habitat improvement may help-rock reefs, smallmouth habitat: work with WDNR.
7. Start a UW-Stevens Point monitoring program and include tributary monitoring.

Details of the projects are described below:

1. Aquatic plant control by lake water level control: Aquatic plants need nutrients and light to grow. The nutrients are available in Solberg's Lake sediments, however, light may not be reaching the lake bottom in some years. Because the Squaw Creek inflow goes through wetlands, it comes into Solberg with a brown stain. The stain inhibits light penetration. Therefore in dry years, the lake level may be down and light reaches areas it doesn't make it to in wet years and higher water levels. This may explain why in 1989 and 1990 (dry years) weeds were more common than in 1991 when lake levels were up. In the future, if lake levels are down, one might expect more weeds compared to wet years. If more plants are desired, the lake level can be lowered by removing boards at the dam. If there are too many weeds in the lake in a dry year, my recommendation would be to wait for a year to see if lake levels come back up and the weeds should go down. This is also the cheapest weed management approach.

2. Aquascaping in near-shore areas: Aquatic plants make good, natural fish habitat. In some cases homeowners may be interested in transplanting aquatic plants to nearshore areas to enhance fish habitat and also serve to control erosion. Appropriate plants for Solberg Lake would be emergents such as hardstem and softstem bulrush, and arrowhead. Burreed is another good emergent to plant. Submerged plants to transplant would include plants already found in Solberg such as elodea, cabbage, water celery, and naiads. Only native plants should be considered.

The Price County Land Conservation Department in Phillips and the WDNR in Spooner has additional information.

3. Landscaping for wildlife: The quest for the "perfect" lakeshore property: does it mean wide open spaces with a green lawn ending in a sandy beach? or does it mean a landscape that has a variety of plants and trees both on the land and in the water? or is it something in between? Also another question that goes hand-in-hand is: how much work do you want to put into a place that has been known as a place to relax?

If your idea of the "perfect" property is the big green lawn, this can mean you are in for a lot of work. Not only do you have to take the time for lawn maintenance, which cuts back on fishing time, you have to take the time to keep an eye out for the animals that like the wide open view. Canadian Geese may stop over for some grazing, and leave some nice reminders. Also you will have to keep an eye open for invading plant species, with a battle between the good and bad plants occurring on an annual basis.

Another option is the natural look that starts on your property and extends right into the lake. The natural look also helps protect the reason why you chose this property in the first place, the lake because it can reduce the amount of nutrients that run into the lake. What is a "natural" look? If you own 100 feet of shoreline it may mean naturalizing about 75 feet of shoreline, and lake bottom and clearing about 25 feet for a swimming beach and/or boat landing. You may want to refer to the original vegetation map for your area (check with the Land Conservation Department for details) and reestablish natural vegetation on your whole property. The original vegetation in the Solberg Lake watershed was the Pine Woods. However Maple, Elm, Oak, and a variety of shrub-like plants are native to the area as well.

When choosing the type of vegetation to use keep in mind what will bring beauty and viewing enjoyment all year round. You may want to talk to other neighbors who have naturalized their property to see what has worked and what has not worked for them. There is no wrong way to customize your property. Just keep in mind some basic ideas:

-study the landscape of your property

-learn the natural shoreline conditions-plants will help stabilize the shoreline

-plant things that will be enjoyable year round

-plant what you enjoy

Why not put out some bird houses, this will add in bringing in different birds and be useful as a form of bug control.

Enjoy your new found wildness!!

4. Dredging in shallow areas: Some inflow areas in Solberg Lake are shallow and this may hinder some boating access from shore to open water. For homeowners affected by these ares, the easiest solution is to get a boat with a shallow draft. If dredging is considered to be necessary, it will neither hurt nor help the lake. Homeowners must have proper permits and disposal areas prepared.

Overall, the sedimentation rate in Solberg appears to be low. Many areas in the lake have a hard bottom indicating low sedimentation rates and also the surrounding land use of forest and wetlands (rather than agriculture) would indicate that sediment inputs should be low. If dredging is done, its benefits should last for some time. Usually, lake associations do not sponsor small-scale dredging unless it benefits the whole lake. Typically homeowners will band together to cover the cost of small-scale dredging.

5. Fish stocking: The soundest fish management approach is to make sure the habitat is in good shape. This means maintaining good water quality. However, some stocking is still done. The WDNR manages Solberg for muskies and walleyes. Only muskies are stocked and walleyes are maintained by natural reproduction. It appears that two species can do well in Solberg. Will any other gamefish do well? I would like to think that maybe smallmouth

bass could get a small foothold without adversely impacting walleyes and muskies.

However, I do not have a good handle on the forage base in Solberg...meaning the suckers, small fish, and minnows. The WDNR is conducting a fish survey in 1994. If possible, maybe their netting could specialize some on forage fish availability (shoreline seining or use of minnow traps). Without proper forage, no new gamefish introduction will be very successful. My recommendation is to use the WDNR 1994 survey results to characterize the fish community and then consider only smallmouth bass as a potential new stocking, if conditions seem favorable.

6. Fish habitat improvement: If the forage fish base is low (the 1994 survey will document if it is) is there a way to increase the forage base which includes suckers, minnows, and yellow perch. Usually stocking will not work, because the forage will be eaten about as fast as they are put in. The key is to improve habitat. For Solberg Lake, one type of habitat improvement may be to increase aquatic plants. This may help the spawning success of yellow perch and weeds will also offer protection and hiding for small fish. Projects 1 and 2 give some ideas on aquatic plant management approaches.

Rock reefs for walleyes and half-log shelters for smallmouth bass are possible structural approaches for improving spawning success. However, at the present time walleyes may be doing well enough that they don't need more spawning area, their need is for more forage.

7. Start a monitoring program: There is ongoing monitoring on Solberg Lake because secchi disc measurements are being taken. However UW-Stevens Point has a reasonable water chemistry program that is appropriate for lake associations. Dr. Byron Shaw at UW-Stevens Point is the contact. Sampling is done in spring and fall, and a sample should be taken at Squaw Creek inlet as well to monitor what is coming into Solberg Lake.