Winslow Homer, The Blue *Boat*, 1892

Lake Management Plan for the Pipe Lakes, Polk County, Wisconsin

July 2004

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with contributions from Wisconsin Department of Natural Resources and the Pipe Lakes Protection and Rehabilitation District

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Lake Management Plan for the
Pipe Lakes, Polk County Wisconsin

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Members of the Pipe Lake Protection and Rehabilitation District and many others contributed in various ways to the work effort on the projects that formed the basis for this Management Plan. They include:

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SUMMARY

The Pipe Lakes consist of North Pipe Lake and Pipe Lake and are located in Polk County, Wisconsin. North Pipe Lake is 66 acres in size, has an average depth of 17 feet and a maximum depth of 37 feet. Pipe Lake is 296 acres in size, has an average depth of 27 feet and a maximum depth of 68 feet.

Goals

The goals of this project were:

* to characterize existing lake conditions.
* to develop a lake management plan that protects, maintains, and enhances Pipe Lakes' water quality.

Lake and Watershed Conditions

Geology and Soils

The Pipe Lakes are glacial lakes formed during the last retreat of the Superior glacial lobe starting about 16,000 years ago. The soils deposited by the glacier are primarily sands and loamy sands.

Watershed Characteristics

The watershed area for North Pipe (including the lake) is 1,168 acres and the watershed for Pipe Lake is approximately 2,475 acres (includes both lakes). Land use is primarily forest comprising 53% of the overall watershed, with agriculture accounting for about 9 percent of the total watershed area (Polk County, 2003).

Stream Quality

The water quality of the tributary streams is good. Phosphorus concentrations have been measured and generally range from 50 to 150 ppb but some readings have been over 300 ppb. Stream phosphorus concentrations are generally low and this helps maintain good water quality in the lakes. It is common for streams in this part of the state to have phosphorus concentrations of around 150 ppb or higher. If both Pipe Lakes tributary streams had phosphorus concentrations at these levels, the lakes would have more algae than they presently do.

Lake Dissolved Oxygen and Temperature

Both Pipe Lakes thermally stratify during the summer. This means that wind action will mix the upper lake water only during the summer. Oxygen concentrations will fall in the bottom water and become depleted in the bottom of the lake.

Lake Clarity

Lake water clarity in Pipe Lake is excellent with a summer average around 14 feet. North Pipe Lake has lower clarity, with a summer average of 6.5 feet. North Pipe has less clarity for several reasons and include: larger watershed to lake surface ratio than Pipe Lake. North Pipe has received more phosphorus per unit surface area compared to Pipe Lake. Also North Pipe is shallower than Pipe Lake. The smaller volume makes it more sensitive to phosphorus

inputs and resulting algae growth. Lastly, North Pipe has a higher color content that derives from wetlands and peat soils in the watershed.

Lake Nutrients

Phosphorus concentrations in the Pipe Lakes are low when compared to other lakes in the North Central Hardwood Forest ecoregion. A growing season phosphorus average for 2003 for North Pipe is 35 ppb and for Pipe is 10 ppb. A predicted phosphorus concentration using ecoregion stream values is higher.

Lake Algae

The Pipe Lakes have algae species that are common to lakes in this part of the state.

Lake Aquatic Plants

There are fair stands of emergent vegetation in shallow water near the shoreline which is beneficial as a filter for nutrients and as fish and wildlife habitat. However, submerged aquatic vegetation coverage in the lakes is low. Aquatic plant diversity is fair with 13 submerged or floatingleaf plant species identified in North Pipe Lake. Pipe Lake has a lower diversity with 10 submerged or floatingleaf plant species.

Lake and Watershed Assessment

- Lake water quality results are above average compared to other lakes in the ecoregion.
- The water quality of the tributary streams is good and does not appear to be the primary source of algae blooms, rather it appears that in-lake components (lake sediments)are a source of phosphorus contributing to algae blooms in North Pipe Lake. However, algae blooms are not considered excessive, based on what could be expected for the size of a watershed that drains to North Pipe Lake.
- Pipe Lake has better than predicted water clarity. It is suspected that the in-lake biology probably plays a key role.

Recommended Lake Management Projects

1. Watershed projects - agricultural

Basic Program: Contact the Polk County Land and Water Resources Department and review and discuss existing acres of agricultural land and existing farming practices. Prepare a written summary along with maps and photos.

Advanced Program: The Land and Water Resources Department could assist the Lake District in implementing best management practices on critical lands areas.

2. Watershed projects - forests and wetlands

Basic Program: Maintain a photolog of typical forest and wetland areas to serve as a benchmark for future reference. Sample open water wetlands for total phosphorus once or twice a summer. Conduct sampling every couple of years.

3. Watershed projects - streams

Basic Program: Continue to monitor watershed streams and analyze samples for total phosphorus and total suspended solids (TSS). If a seasonal average exceeds 150 ppb of phosphorus (as a flow-weighted mean), stream watershed work should be considered. If phosphorus levels become elevated, determine if TSS is the source of the high phosphorus. It may be that stream channel restoration should be considered.

Advanced Program: Based on the stream inventory conducted by lake resident volunteers, there are stretches where tributary streambanks are eroding. The Lake District should contract with the County Resources Department or a consulting engineer to use biostabilization techniques to stabilize eroding streambanks.

4. On-site system maintenance

Basic Program: On-site wastewater treatment systems operate satisfactorily when they are properly installed and maintained. Several activities can be implemented to assist in proper operation of the system. These activities include workshops, septic tank pumping campaigns, and ordinance implementation. However, much of the education needs can be conveyed through newsletters and the Lake District's web site.

Advanced Program: There is little evidence of failing onsite systems based on shoreland setback distances and the septic leachate survey. However there are soil limitations in the shoreland area. As an advanced educational tool, contract with the County to randomly select 10% of the systems around the lake and conduct an onsite inspection. Publish the results in a newsletter.

5. Shoreland protection and enhancement (landscaping projects)

Basic Program: Pipe Lake has stretches of natural shoreline conditions but vegetative buffers and natural conditions are lacking along some of the developed parcels. The challenge is to protect the existing natural conditions and to enhance shorelands that lack native vegetative buffers. A volunteer lakescaping program should be implemented. Initially work with the UW Extension or a Planning Grant consultant to set up a Pipe Lakes Shoreland model describing how to design, install, and maintain a natural shoreland. Publish it on the web and in the lake's newsletter.

Advanced Program: Solicit two to four volunteer lake residents to install a shoreland restoration demonstration site on their property.

6. Aquatic plant projects

Basic Program: Aquatic plants are important in Pipe Lakes for fish habitat and for helping sustain good water quality. Although there is good aquatic plant diversity with 13 species identified in North Pipe, an early summer survey conducted every year or every other year, depending on volunteer availability would determine if the exotic aquatic plant species, called curlyleaf pondweed, was present in Pipe Lakes.

Advanced Program: Sample sediments up to 30 sites around North Pipe and Pipe and analyze for parameters that are indicators for potential nuisance growth of two exotic plants: curlyleaf pondweed and Eurasian watermilfoil. Neither of these exotic species is currently found in Pipe Lakes but if they should invade, knowing their potential for nuisance growth (where plants grow to the lake surface and "top out" creating a recreational hinderance) would be a helpful management tool.

7. Fish management options

Basic Program: Pipe Lakes has a balanced fish community based on WDNR records. Sensitive walleye and panfish spawning habitat should be recognized and published, but no new boating restrictions appear necessary at this time.

Advanced Program: Improving fish habitat such as downing small trees so they fall into the lake would promote smallmouth bass spawning habitat and is a potential project area in the future. Otherwise working with the WDNR on long term habitat protection is recommended.

8. In-lake clarity improvement projects

Basic Program: Good housekeeping practices conducted in the shoreland area will reduce excessive amounts of nutrients running off into Pipe Lakes. Ongoing information inserted into newsletters on fertilizer use and buffer strip maintenance will minimize excessive nutrient inputs into Pipe Lake. Also, a zooplankton and algae monitoring program should be conducted on both North Pipe and Pipe Lakes through the growing season.

Advanced Program: Consider an alum sediment treatment for North Pipe if phosphorus concentrations increase and remain at 15% above the current established baseline for three consecutive years. If water quality in North Pipe declines, it could have adverse water quality impacts on Pipe Lake.

9. Ongoing education program

Basic Program: Results from lake questionnaires indicate lake residents rely heavily on getting lake information from the lake association newsletters. The Lake District's newsletter should be an ongoing instrument to provide lake protection information. Abundant material is available from the WDNR on the internet and from a variety of books, including the book "Lake and Pond Management Guidebook" written by Steve McComas. This material can be inserted into newsletters.

Advanced Program: A variety of educational opportunities are available that go beyond newsletter articles. Lake fairs and demonstration projects could be useful for advancing lake information. A good time for special events is in conjunction with the annual meeting.

10. Watershed and lake monitoring program

Basic Program: Ongoing lake testing should include: Secchi disk, total phosphorus, and chlorophyll a for both lakes. Testing once per month from May through September is adequate to characterize lake conditions. Sampling twice per month would be better. An aquatic plant survey should be conducted every three to four years. The level of effort for a monitoring program depends on the availability of volunteers and funding levels.

Advanced Program: Winter dissolved oxygen levels and phosphorus samples could be collected on alternate years. Because of the possibility of a future North Pipe alum treatment, bottom water samples analyzed for total phosphorus could be collected from Pipe and North Pipe Lakes on a monthly basis from May through September.

1. Introduction and Project Setting

The Pipe Lakes, which consist of Pipe Lake and North Pipe Lake are located in Polk County, Wisconsin (Figure 1). The Pipe Lakes characteristics are shown in Table 1.

The objectives of this study were to characterize existing lake conditions and to make recommendations to protect and improve the lake environment where feasible.

Table 1. Lake statistics (source: Polk County 2003).

	North Pipe Lake	Pipe Lake
Size (acres)	66	296
Mean depth (ft)	17	27
Maximum depth (ft)	37	68

Figure 1. The Pipe Lakes are located in Polk County, Wisconsin.

2. Glaciers and Soils

The Pipe Lakes were formed approximately 16,000 years ago during the last glacial retreat of the Superior Lobe (Figure 2). The soils deposited by the Superior Lobe glacier were primarily sands and loamy-sands. Beneath these soils, at depths of about 50-350 feet, is Precambrian bedrock that is over one billion years old. The bedrock is referred to as the North American shield.

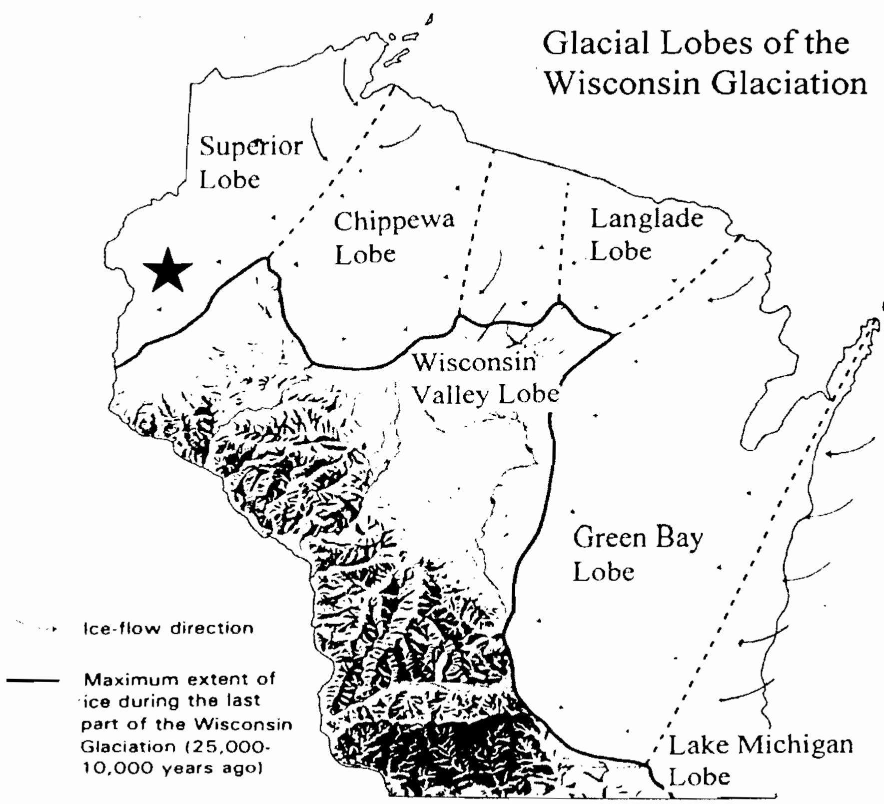


Figure 2. Glacial lobes of the Wisconsin glaciation. The Pipe Lakes are located in the Superior lobe.

Soils in an area are a reflection of the parent material. In this case, material left behind as a result of the retreat of the Superior glacier represent forested silty and loamy soils (Figure 3). The soils have moderate fertility.

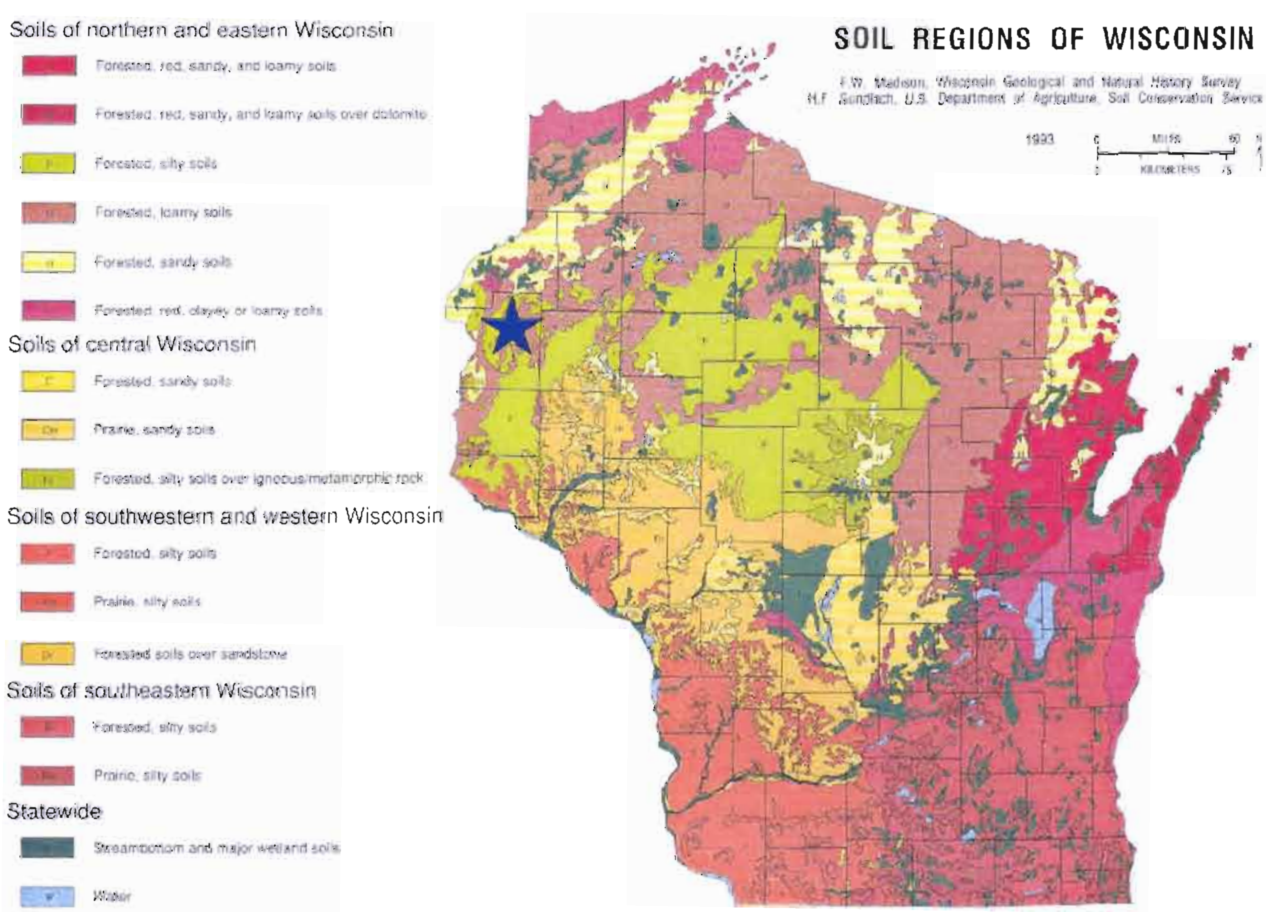


Figure 3. The Pipe Lakes are located within a soils group characterized as forested silty soils.

3. Watershed Features

3.1. Drainage Area and Land Use of the Pipe Lakes

For this study, the Polk County Land and Water Resources Department prepared a watershed map and determined the land use breakdown for the watershed.

Drainage area to Pipe Lakes is 2,475 acres (based on Polk County estimates from a 2003 report) and the delineation is shown in Figure 4 with subwatershed delineations shown in Figure 5.

Land use within the watershed is shown on a map in Figure 5 and is listed in Table 2. Forested land is the dominant land use.

Table 2. General land use in the Pipe Lakes watershed (from Polk County 2003).

	North Pipe Lake (66 ac)		Pipe Lake (296 ac)	
	Acres	Percent	Acres	Percent
Agricultural	75	6.4	228	9.2
Residential	87	8.4	321	13
Forested	806	69	1,320	53
Wetland	110	9.4	235	9.5
Lakes and open water	76	6.5	371	15
Total Watershed Area (includes the lakes)	1,168	99.7	2,475	99.7

The watershed to lake ratio of the North Pipe Lake is 18 to 1 and for Pipe Lake it is 8 to 1. North Pipe Lake experiences midsummer algae blooms but has a fair fishery. Pipe Lake has above average water clarity. To ensure good water quality for years to come conservation measures in the watershed and on the lakeshore of the Pipe Lakes should be considered.

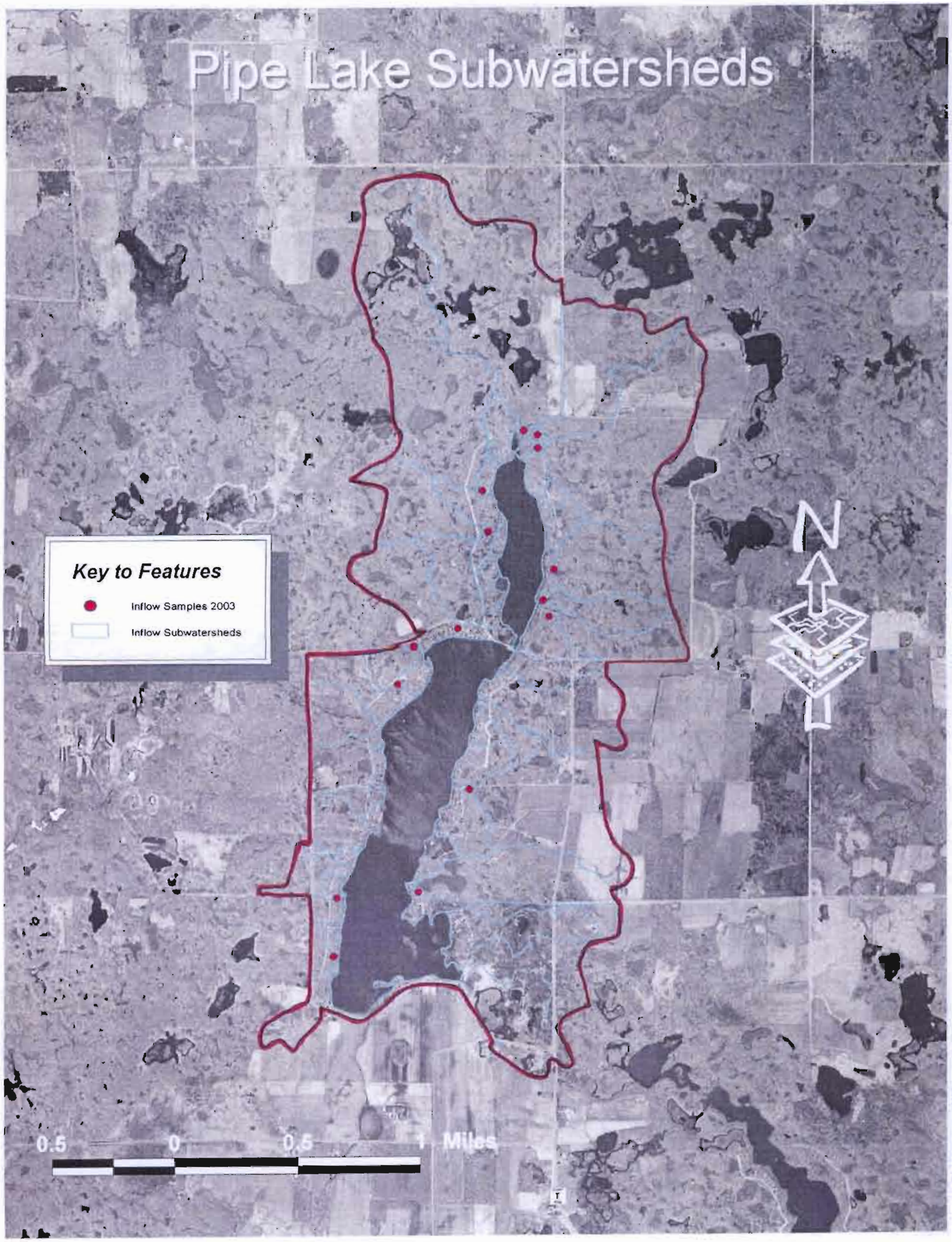


Figure 4. Pipe Lake watershed is outlined in red (source: Polk County).

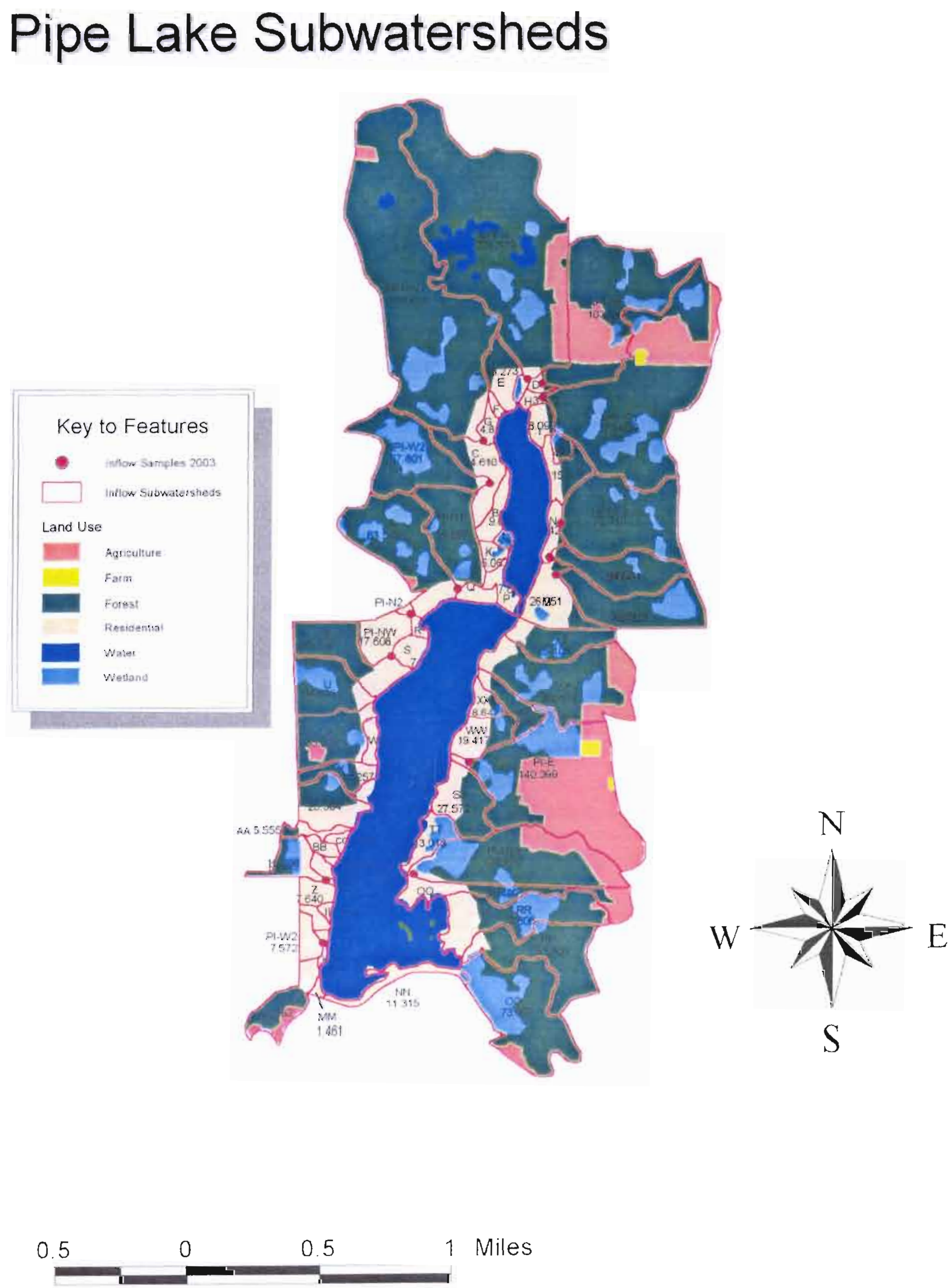


Figure 5. Subwatersheds and land use for the Pipe Lakes (source: Polk County).

Table 3. Acres for each subwatershed (subwatersheds are shown in Figure 5).

ACRES	WATERSHED
238.628	NPI-W1
103.747	NPI-NE
173.009	NPI-E3
57.601	NPI-W2
75.313	NPI-E2
34.564	NPI-E1
46.271	NPI-E0
39.697	PI-N1
1.344	PI-N2
17.608	PI-NW
15.266	PI-W1
7.572	PI-W2
88.470	PI-GUL
140.399	PI-E
63.542	A
9.096	B
24.610	C
2.704	NPI-N
229.329	NPI-N
2.827	D
16.273	E
2.154	F
4.811	G
3.572	H
8.099	I
4.601	J
5.063	K
2.359	L
26.251	M
6.942	N
15.677	O
7.877	P
5.591	Q
2.394	R
7.341	S
35.719	T
34.605	U
35.012	V
5.294	W
12.257	X
25.504	Y
7.640	Z
5.555	AA
4.152	BB
2.742	CC
3.550	DD
0.862	EE
0.460	FF
0.016	GG

ACRES	WATERSHED
3.715	HH
1.684	II
1.430	JJ
1.142	KK
22.182	LL
1.461	MM
11.315	NN
73.027	OO
53.600	PP
31.499	QQ
52.806	RR
27.572	SS
13.013	TT
25.108	UU
15.523	VV
19.417	WW
8.647	XX
81.809	ZZ

3.2. Source of Water and Nutrients to the Pipe Lakes

Overview: Source of water to Pipe Lakes is from a combination of rainfall, surface runoff, and groundwater. Rainfall is a significant contributor, and averages about 30 inches annually. The amount of water flowing into and out of the Pipe Lakes is estimated to be about 2 cubic feet per second. Flows were estimated based on runoff amounts listed for Polk County in the Wisconsin Spreadsheet Lake Model (Table 4) and supplemented by stream data monitoring by Pipe Lake volunteers. The amount of groundwater inflow is still a partial mystery, but it appears that groundwater inflow is minor.

Table 4. Average annual water flow into the Pipe Lakes.

	North Pipe Lake	Pipe Lake
Drainage area (acre)(does not include lake)	1,102	2,179
Average yearly runoff for Polk County (feet)(from WILMS model)	0.66	0.66
Estimated total water inflow (acre-feet)	727	1,438

The estimated amount of water coming into Pipe Lake annually (1,438 acre-feet) would be enough water to fill a 1,400 foot deep swimming pool the size of a football field. It would also be enough drinking water to supply a town of 21,000 for a year.

Although this is a lot of water coming into Pipe Lakes, the volume of Pipe Lake is 7,992 acre-feet (296 acres in surface area and averaging 27 feet deep). If Pipe Lake completely dried up, it would take 5 years to fill.

Rainfall: Rainfall is a significant source of water to the Pipe Lakes. Rainfall measurements and lake levels have been taken over the last few years by Pipe Lake volunteers and results are shown in Figure 6. Although lake levels fall over the course of the summer, due primarily to evaporation and infiltration, rainfall does influence lake levels, in the form of direct impacts as well as watershed runoff.

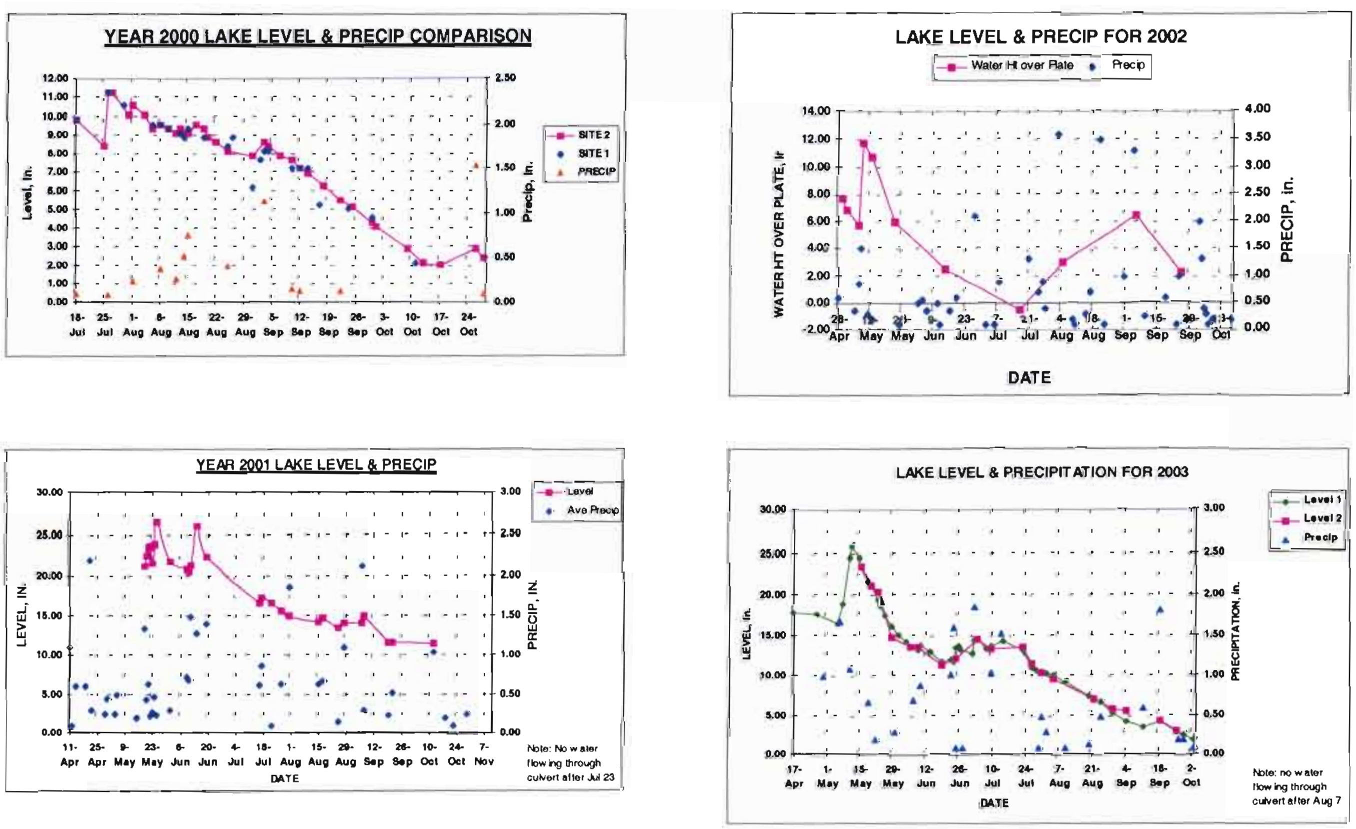


Figure 6. Lake levels and precipitation for the Pipe Lakes.

Stream Flows and Nutrient Concentrations: An ambitious stream sampling program was conducted by Lake District volunteers in 2003. Sample site locations are shown in Figure 7 and results of phosphorus and flow monitoring are shown in Table 5. A summary of phosphorus loading calculated as a daily load is shown in Figure 8.

Sample locations

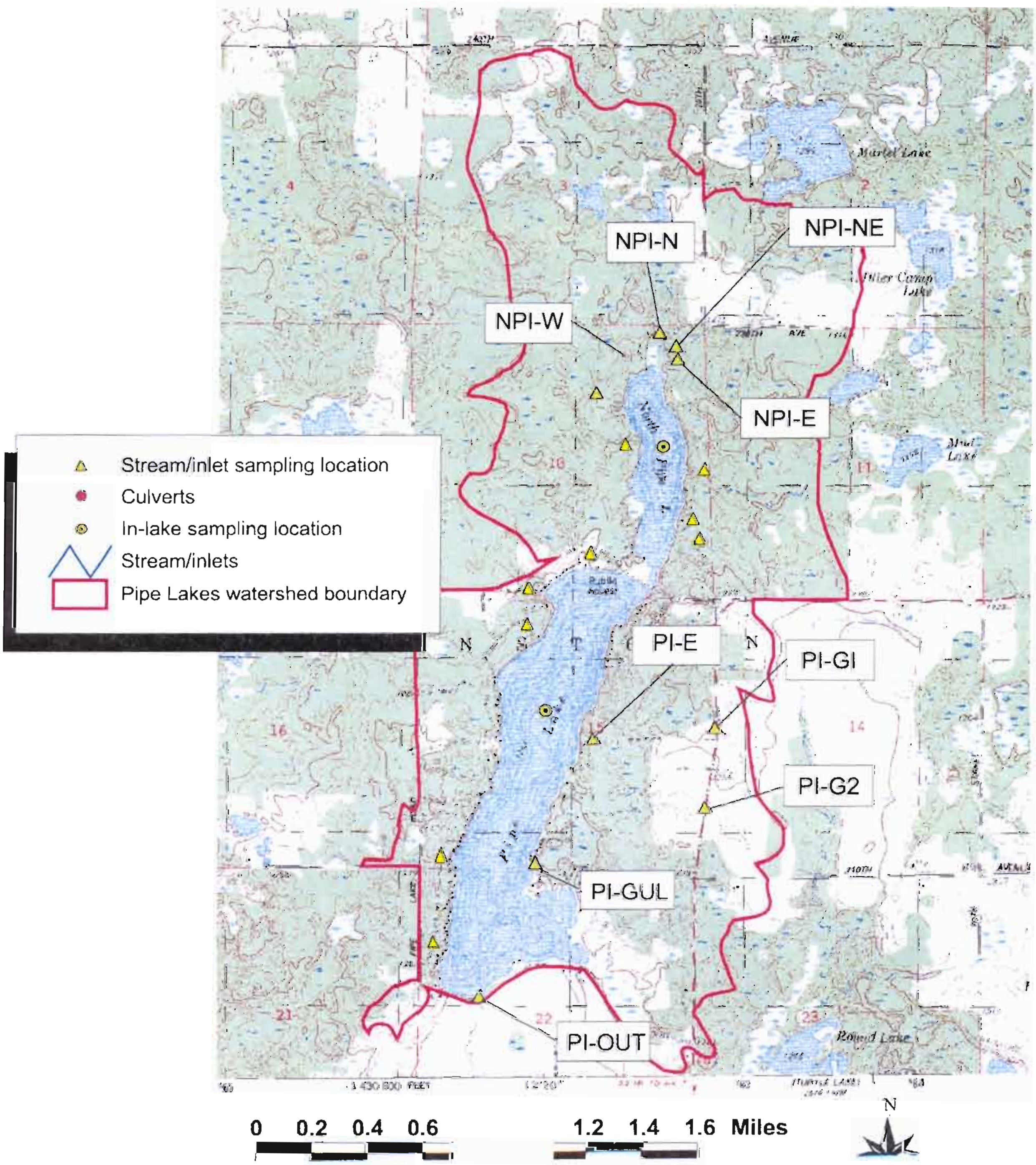


Figure 7. Stream sample locations sampled for the 2000-2001 planning grant study. Streams sampled in 2003 are shown in Table 5.

Streams were sampled for total phosphorus on five dates in 2003 and results are shown in Table 5. Phosphorus concentrations in April and May were moderate and generally higher in June and July. However, the estimated flows were generally low and the resulting calculated total daily phosphorus load was low to moderate.

Table 5. Measured stream phosphorus concentrations, estimated flow, and estimated daily loading for the storm event sample date.

	April 17, 2003			May 6, 2003			May 9, 2003			June 25, 2003			July 4, 2003		
	TP (ppb)	runoff (cfs)	kg/ day	TP (ppb)	runoff (cfs)	kg/ day	TP (ppb)	runoff (cfs)	kg/ day	TP (ppb)	runoff (cfs)	kg/ day	TP (ppb)	runoff (cfs)	kg/ day
NPI-W1	97	1.15	0.27	88	0.92	0.20	90	4.18	0.92	158	1.63	0.63	122	0.8	0.24
NPI-W2	88	0.73	0.16	71	0.63	0.11	105	2.32	0.60	122	0.93	0.28	69	0.32	0.05
NPI-E0								0.78			0.13			0.07	
NPI-E1	77	0.2	0.04	88	0.25	0.05	95	1.48	0.34	183	0.3	0.13	146	0.05	0.02
NPI-E2	79			79	1.3	0.25	96	4.22	0.99	150	1.23	0.45	140	0.47	0.16
NPI-E3	103	0.87	0.22	98	0.93	0.22	150	4.17	1.53	185	1.15	0.52	197	0.48	0.23
NPI-NE	138	1.07	0.36	121	0.57	0.17	158	2.48	0.96	299	1.32	0.97	185	0.38	0.17
NPI-N	60	0.65	0.10	60	0.42	0.06	62	3.18	0.48	93	0.25	0.06	125	0.78	0.24
Total Daily Load			1.15			1.06			5.82			3.04			1.11
NPO	98	8.92	2.14	36	10.03	0.88	47	--	--	32	--	--	36	--	--
PI-N1	87	0.98	0.21	67	0.68	0.11	65	1.15	0.18	129	0.4	0.13	121	0.47	0.14
PI-N2	48	0.1	0.01	46	0.13	0.01	67	0.8	0.13	122	0.12	0.04	88	0.03	0.01
PI-NW	101	0.43	0.11	82	0.32	0.06	83	1.07	0.22	140	0.33	0.11	171	0.23	0.10
PI-W1	99	0.35	0.08	67	0.22	0.04	90	0.78	0.17	123	0.38	0.11	138	0.1	0.03
PI-W2		0.07													
PI-GUL	73	2.47	0.44	90	0.82	0.18	77	4.38	0.83	317	0.55	0.43	351	0.85	0.73
PI-E	129	0.05	0.02	135	0.03	0.01	118	0.08	0.02	195	0.05	0.02	180	0.02	0.01
Total Daily Load			3.01			1.29			1.55			0.84			1.02
PO (outflow)		5.38			5.12			8.87			2.28			3.67	

A summary of estimated daily phosphorus loads from stream sampling results are shown in Figure 8. Sample sites NPI-E3 and NPI-NE had some of the highest loads in the North Pipe watershed and NPO and PI-GUL had the highest loads into Pipe Lake. NPO is the flow from North Pipe into Pipe Lake.

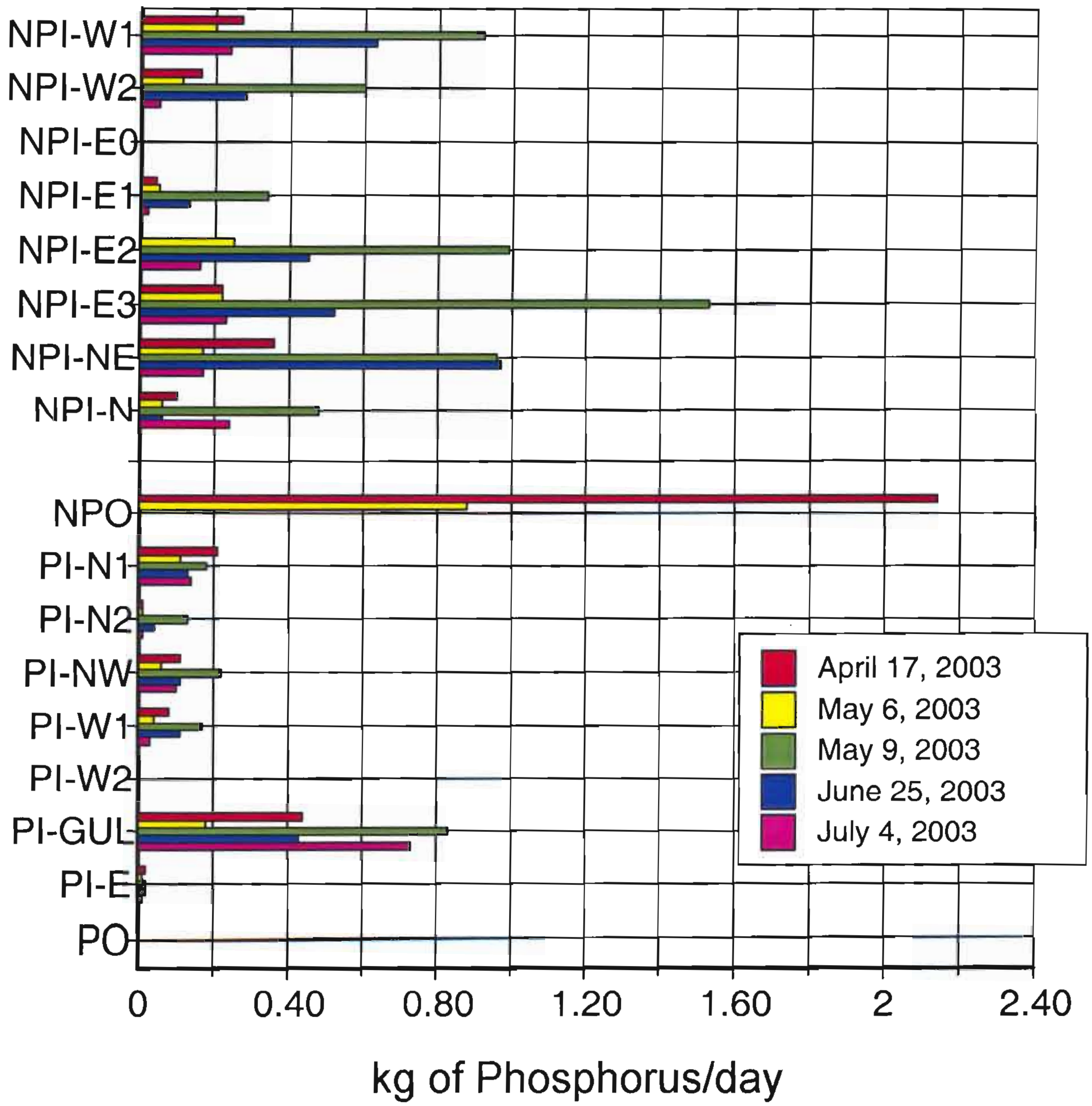


Figure 8. Daily stream loads.

Larry Bresina, left, and Dick Hollar, right, view a stream channel flowing into Pipe Lake in 2003. Not only were 14 stream channels monitored, but a stream channel inventory was also conducted by volunteers.

Groundwater: Groundwater is abundant in the Pipe Lakes watershed, but there doesn't appear to be major groundwater movement into the Pipe Lakes. Rather, the groundwater in the unconfined aquifer (shallow groundwater) is probably intercepted by the wetlands and much of it is further infiltrated or evaporated. The next section discusses groundwater further.

3.3. Groundwater and On-site Wastewater Treatment Systems

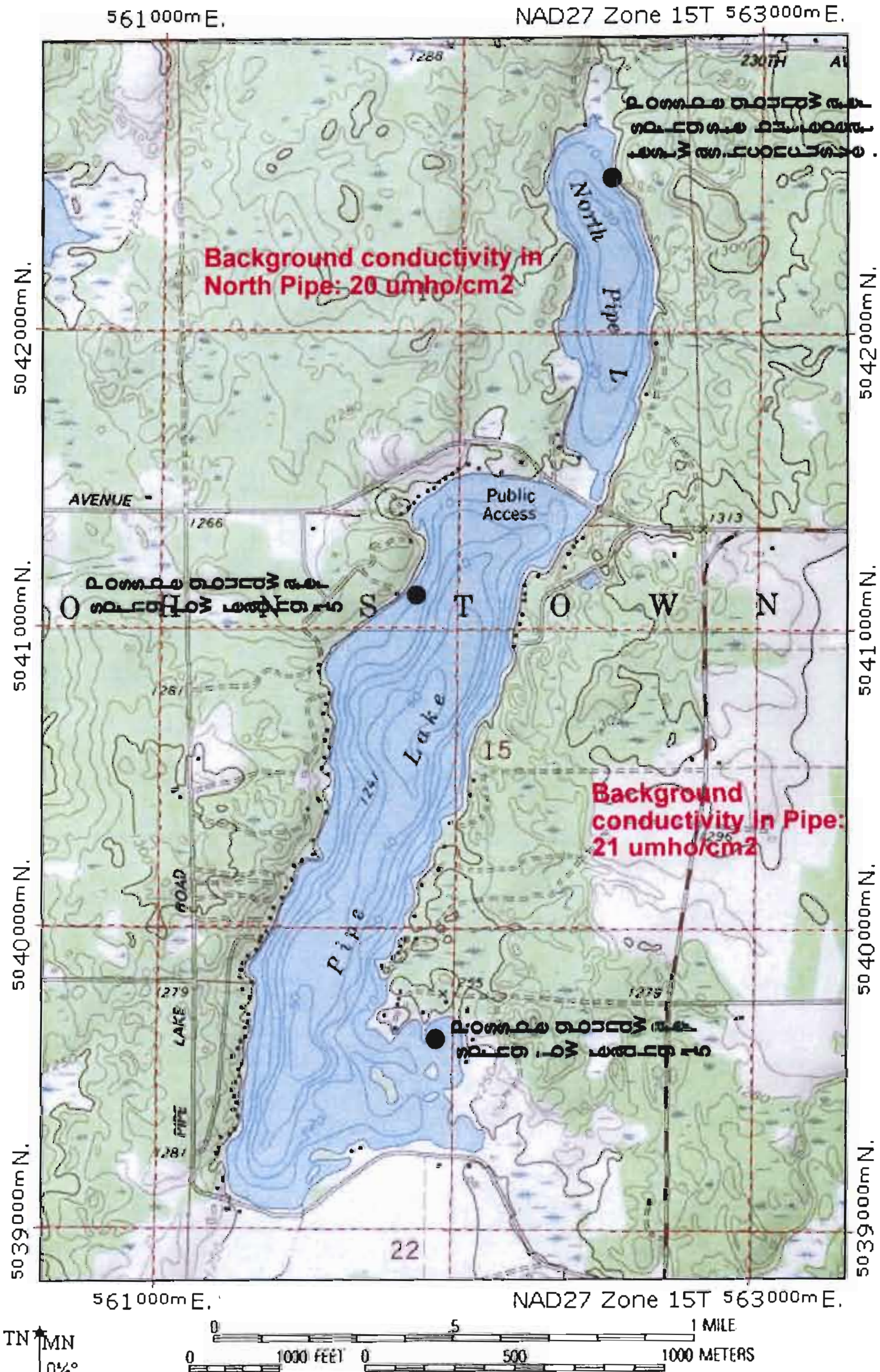
Groundwater inflow was evaluated indirectly by measuring lake water conductivity in the shallow nearshore area. The objective was to see if there was any change in conductivity. An increase or decrease in conductivity could indicate the inflow of groundwater. The groundwater could be coming from natural flows or from septic tank drainfields.

Specific conductance or conductivity is a measure of dissolved salts in the water. The unit of measurement is microSiemans/cm^2 or micro umhos/cm^2, both are used. The saltier the water the higher the conductivity. For example, oceans have higher conductivity than fresh water because oceans have high levels of dissolved salts.

For the conductivity survey on the Pipe Lakes we used a YSI (Yellow Springs Instruments) probe attached to the end of an eight-foot pole (Figure 9). The survey used three people. One person held the probe under the surface of the water, the second person recorded the reading off of a conductivity meter, and the third person maneuvered the boat around the perimeter of the Pipe Lakes.

Results of the conductivity survey are shown in Figure 10. The background or base conductivity was low at 20 umhos/cm. No readings above background levels were observed. The lack of elevated conductivity readings could indicate that there are low levels, if any, of septic tank effluent inputs. Three locations were observed to have conductivity readings below the lake background readings. This suggests that Pipe Lakes may be receiving groundwater inflows in several areas (Figure 10). It is not surprising that springs are found in Pipe Lakes. This was an active glacial area is the past and often leads to subsurface groundwater inflows. However, it appears the amount of groundwater inflow to the Pipe Lakes is minor.

Figure 9. [top] Pipe Lake volunteers assisted with the shoreline conductivity survey. [bottom] A rocky point like this on Pipe Lake sometimes serves as a conduit for groundwater inflows. However, groundwater inflow was not detected here. In fact, it appears that groundwater inflow is minor in the Pipe Lakes.



Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Figure 10. Pipe Lakes conductivity survey results, 2003.

Onsite Systems Status: Onsite systems appear to be in mostly good condition based on the conductivity survey results where no septic system inflows were detected (although that doesn't mean there weren't any), the type of surrounding soils which are good for drainfield conditions, and the setback of the cabins and homes.

A conventional onsite system is shown in Figure 11. With proper maintenance (such as employing a proper pumping schedule) onsite systems are an excellent wastewater treatment option. The challenge is to maintain systems in good working condition.

Sewage bacteria break up some solids in tank. Heavy solids sink to bottom as sludge. Grease & light particles float to top as scum. Liquid flows from tank through closed pipe and distribution box to perforated pipes in trenches; flows through surrounding crushed rocks or gravel and soil to ground water (underground water). Bacteria & oxygen in soil help purify liquid. Tank sludge & scum are pumped out periodically. Most common onsite system.

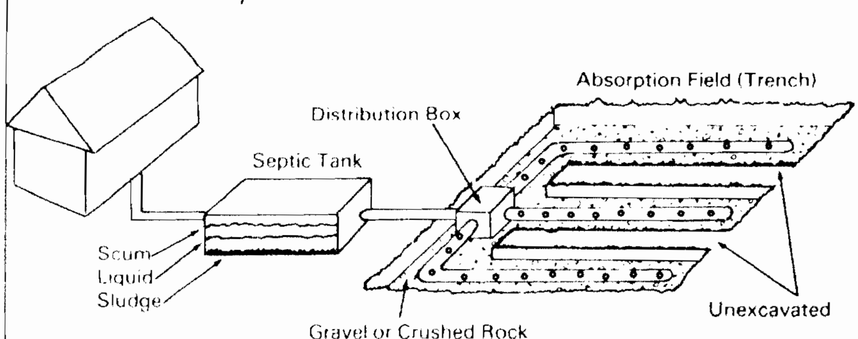


Figure 11. Typical onsite wastewater treatment system found in the Pipe Lakes watershed.

3.4. Shoreland Inventory

The shoreland area encompasses three components: the upland fringe, the shoreline, and shallow water area by the shore. A photographic inventory of the Pipe Lakes shoreline was conducted in August, 2003. The objectives of the survey were to characterize existing shoreland conditions which will serve as a benchmark for future comparisons.

For each photograph we looked at the shoreline and the upland condition. Our criteria for natural conditions were the presence of 50% native vegetation in the understory (ground cover) and at least 50% natural vegetation along the shoreline in a strip at least 15 feet deep. Although the county shoreline ordinance for new development is a 35-foot deep buffer, a 15-foot deep buffer is the minimum needed to achieve some degree of runoff water quality treatment. We evaluated shorelines and uplands at the 75% natural level as well (Figure 12 illustrates the methodology).

A summary of the inventory results is shown in Table 6. Based on our subjective criteria about 64% of the parcels in the Pipe Lake shoreland and 99% of the parcels in North Pipe Lake shoreland area meet the natural ranking criteria for shorelines and upland areas. This is above average for other lakes found in a category referred to as "country lakes". Country lakes are defined as lakes found about 1 to 2 hours driving time from a major metropolitan area such as Minneapolis/St. Paul or Milwaukee. In the next 10 years proactive volunteer native landscaping could improve the natural aspects of a number of parcels.

Table 6. Summary of shoreline buffer and upland conditions in the shoreland area of Pipe Lakes. Approximately 297 parcels were examined.

	Natural Shoreline Condition		Natural Upland Condition		Undevel. Photo Parcels	Shoreline Structure Present	
	>50%	>75%	>50%	>75%		riprap	wall
PIPE LAKE (no. of parcels = 217)	63% (137)	56% (121)	67% (144)	50% (108)	8% (17)	22% (47)	1% (1)
NORTH PIPE LAKE (no. of parcels = 80)	94% (75)	91% (73)	100% (80)	96% (77)	45% (36)	1% (1)	0% (0)

A comparison of the Pipe Lakes' conditions to other lakes in Minnesota and Wisconsin is shown in Table 7 and in Figure 13.

Figure 12. Both of the pictures are from Pipe Lake. [top] This parcel would rate as having a shoreline with a buffer greater than 50% of the lot width and an understory (ground cover) with greater than 50% natural cover.
[bottom] This parcel would not qualify as having a natural shoreline buffer greater than 50% of the lot width. Also the understory in the upland area is dominated by lawn cover and would be rated as having less than 50% natural cover.

Table 7. Summary of shoreland inventories from Pipe Lakes and 20 other lakes in Minnesota and Wisconsin.

Lake	Eco-region	Date of Survey	Total Number of Parcels (#)	Undevel. Parcels % (#)	Natural Upland Condition > 50% % (#)	Natural Upland Condition >75% % (#)	Natural Shoreline Condition > 50% % (#)	Natural Shoreline Condition >75% % (#)	Parcels with Erosion % (#)	Parcels with Shoreline Revetment % (#)
Pipe Lake/North Pipe Lake Polk Co, WI	CHF	8.03	217 / 80	8 (17) 45 (36)	67 (144) 100 (80)	50 (108) 96 (77)	63 (137) 94 (75)	56 (121) 91 (73)		22 (48) 1 (1)
Big Round Lake Polk co, WI	CHF	8.03	74	14 (10)	27 (20)	24 (18)	39 (29)	34 (25)	1 (1)	14 (10)
Alimagnet Lake Dakota Co, MN	CHF	8.6.03	108	37 (40)	54 (58)	47 (51)	69 (75)	61 (66)	0	16 (17)
Big Bear Lake Burnett Co, WI	LF	9.11.02	87	13 (11)	82 (71)	62 (54)	86 (75)	76 (66)	0	9 (8)
Diamond Lake Kandiyohi Co, MN	CHF	8.13 & 14.02	344	2 (7)	13 (44)	11 (39)	16 (56)	12 (42)	1 (5)	49 (168)
Green Lake Kandiyohi Co, MN	CHF	9.19.01	721	1 (9)	20 (146)	12 (88)	19 (140)	14 (100)	0	62 (446)
Orchard Lake Dakota Co, MN	CHF	9.17.01	109	4 (4)	47 (51)	30 (33)	53 (58)	32 (35)	0	54 (59)
Ravine Lake Washington Co, MN		7.19.01	9	100 (9)	100 (9)	100 (9)	100 (9)	100 (9)	0	0
Rush Lake Chisago Co, MN	CHF	9.16.00	524	11 (58)	48 (253)	28 (147)	51 (267)	38 (201)	1 (3)	18 (92)
West Rush	CHF	9.16.00	332	12 (40)	52 (171)	31 (103)	55 (184)	43 (142)	1 (2)	15 (50)
East Rush	CHF	9.16.00	192	9 (18)	43 (82)	23 (44)	43 (83)	31 (59)	1 (1)	22 (42)
Maple Grove Lake Summary, MN	CHF	9.30 - 10.12.99	644	14 (89)	67 (431)	48 (312)	60 (385)	48 (310)	1 (3)	20 (129)
Cedar Island	CHF	9.30 - 10.12.99	93	5 (5)	62 (58)	35 (33)	55 (51)	39 (36)	0	22 (21)
Eagle	CHF	9.30 - 10.12.99	90	14 (13)	64 (58)	52 (47)	47 (42)	41 (37)	0	35 (32)
Edward	CHF	9.30 - 10.12.99	34	12 (4)	91 (31)	88 (30)	76 (26)	71 (24)	6 (2)	3 (1)
Fish	CHF	9.30 - 10.12.99	170	7 (12)	74 (126)	44 (75)	57 (97)	41 (70)	1 (1)	20 (34)
Pike	CHF	9.30 - 10.12.99	9	56 (5)	100 (9)	100 (9)	100(9)	100 (9)	0	0
Rice	CHF	9.30 - 10.12.99	137	33 (45)	71 (97)	64 (87)	81 (111)	74 (102)	0	19 (25)
Weaver	CHF	9.30 - 10.12.99	111	5 (5)	47 (52)	28 (31)	44 (49)	29 (32)	0	14 (16)
Powers City of Woodbury, MN	CHF		30	90 (27)	90 (27)	90 (27)	97 (29)	97 (29)	0	0
Upper Prior Scott Co, MN	CHF	9.30- 10.12.99	366	10 (37)	51 (187)	36 (132)	35 (128)	31 (113)	4 (15)	46 (168)
Lower Prior Scott Co, MN	CHF	9.24- 30.99	691	10 (66)	36 (249)	24 (166)	22 (152)	17 (117)	5 (35)	54 (373)
Comfort Chisago Co, MN	CHF	10.9- 11.2.98	100	--	62 (62)	--	50 (50)	--	--	12 (12)
Pike Chain Price & Vilas Co, WI			722	380	92 (633)	87 (626)	95 (684)	91 (654)	--	5 (34)
Plum Lake Vilas Co, WI	LF	7.26.01	225	13 (30)	75 (169)	58 (130)	81 (182)	708(158)	--	9(4)
Nancy Lake Washburn Co, WI	LF	9.21.00	217	19 (41)	77 (167)	65 (141)	80 (174)	72 (156)		5 (11)
Big Bearskin Oneida Co, WI	LF	8.10.99	130	--	73 (95)	63 (82)	80 (104)	67 (87)	--	0
Ballard chain Vilas Co, WI	LF	7.23.99	110	--	98 (108)	96 (106)	96 (106)	95 (105)	--	0
Bear Oneida Co, WI	LF	6.8.99	115	6 (7)	93 (107)	78 (90)	84 (97)	77 (89)	1 (1)	8 (9)

* CHF = Central Hardwood Forest Ecoregion
** LF = Lake and Forests Ecoregion

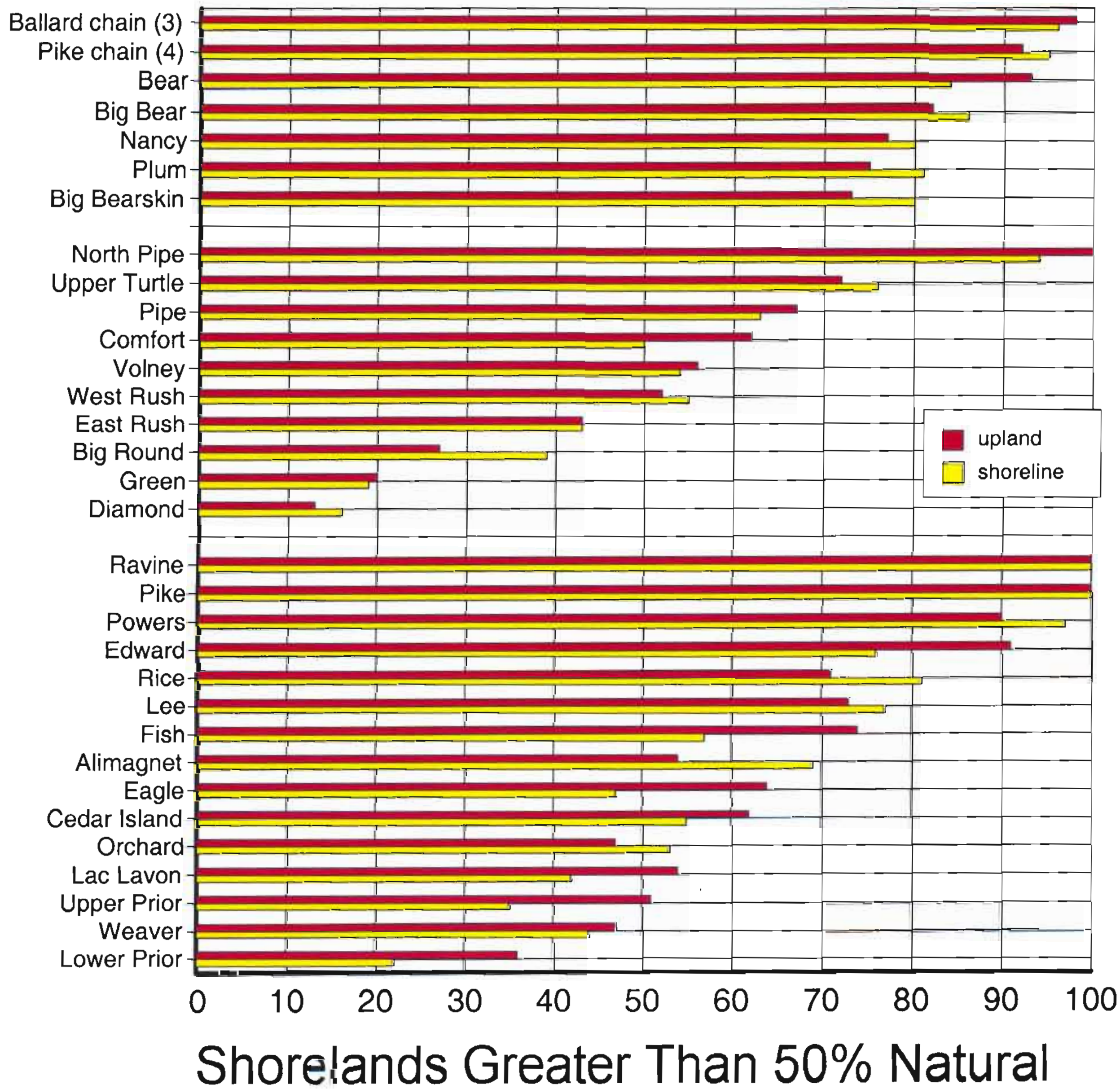


Figure 13. A summary of shoreland inventory results for lakes using an evaluation based on shoreland photographs. For each lake the percentage of shoreline and upland conditions with greater than 50% natural conditions is shown. The first tier of lakes are located in northern Wisconsin which are 4 to 5 hours from a major metropolitan area. The middle tier of lakes are about an hour's drive from the Twin Cities, and are considered to be "country" lakes. The lower tier of lakes are in the Twin City Metropolitan area and are categorized as urban lakes. Several lakes of the "urban" lakes have most of their shoreland owned by the city and there is a high percentage of natural conditions.

The Pipe Lakes are considered to be "country" lakes for this inventory. Natural shoreland conditions for the Pipe Lakes are above average compared to the other country lakes.

3.5. Wildlife Inventory

A wide variety of wildlife are present in the Pipe Lakes area. A summary of wildlife observations in 2003 by lake volunteers is shown in Table 8.

Table 8. Wildlife observations in the Pipe Lakes watershed.

PIPE & NORTH PIPE LAKE WILDLIFE SUMMARY 2003

The following summarizes the wildlife sightings by six and two volunteers on Pipe and North Pipe Lake respectively.

Animals Observed

Animal	Time Frame	Where Sighted
Deer	Anytime	Everywhere
Black Bear	May thru August	Mostly around NP & east on "G"
Gray Squirrel	Spring thru fall	Everywhere
Red Squirrel	Spring thru fall	North Pipe
Black Squirrel	Summer	S end of Pipe
Beaver	Spring thru fall	North Pipe
Muskrat	Spring thru fall	Mainly NP; 1 seen in pond by Pipe & 1 seen at SE end of Pipe
Skunk	Summer	S end of Pipe
Raccoon	Summer & fall	Everywhere
Bats	Spring thru fall	Everywhere

Birds Observed

Bird	Time Frame	Where Sighted
Pileated Woodpecker	May thru Sept	Pipe & North Pipe
Downy Woodpecker	Spring thru fall	Pipe & North Pipe
Goldfinch	Spring thru fall	Everywhere
Red Wing Blackbird	May - July	North end of NP & South end of P
Nuthatch	Spring thru fall	Everywhere
Ruby throated hummingbird	June - Sept	Everywhere
Robin	May - Aug	Pipe & North Pipe
Baltimore Oriole	May - Aug	Pipe & North Pipe
Black Crow	Spring thru fall	Everywhere
Blue Jay	Summer & fall	Pipe & North Pipe
Barn Swallow	May - Aug	Pipe & North Pipe
Tree Swallow	Summer	Pipe
Purple Martin	Summer	Pipe
Junco	May & again in Oct	Pipe & North Pipe
Morning Dove	Summer	Pipe & North Pipe
Yellow Bellied Sapsucker	Summer	Pipe
Cardinal	Summer	S end of Pipe
Black Capped Chickadee	Spring thru fall	Everywhere
Cedar Waxwing	Summer	Pipe
Kingfisher	Aug & Sep	Pipe & North Pipe
Northern Flicker	Summer	Pipe
Rose Breasted Grosbeak	Summer	Pipe & North Pipe
Flycatcher	July	North Pipe
Bald Eagle-saw one catch fish by my place on 8/27	Spring thru fall	Pipe & North Pipe
Red Tailed Hawk	July	North Pipe
Broad Wing Hawk	July	North Pipe
Hoot Owl (heard every night	Summer	North Pipe
Ruffed Grouse	May, Aug, Oct	North Pipe & North end of Pipe
Common Loon	May thru Aug	Pipe & North Pipe

Bird	Time Frame	Where Sighted
Wood Duck	May thru Aug	North Pipe
Small Black & White Duck	April	North Pipe
Mallard Duck	April thru Aug	Pipe & North Pipe
Canadian Geese	Spring and again in fall	Pipe & North Pipe but no nesting geese on lake
Great Blue Heron	Spring thru fall	Pipe & North Pipe
Sand Hill Crane	Aug & Sep	Pipe & fields south
Wild Turkeys	May thru Sep	Around Pipe & North Pipe
2 Peacocks (that is right)	June 7 & Aug	South end of Pipe
Pigeon (banded)	Sep 18,19 & 20	My place-North Pipe
Seagull	Sep & Oct	Pipe Lake

Frogs & Turtles

Snapping Turtle	Summer	North Pipe
Painted Turtle	Summer	North Pipe
Leopard Frog	Summer	Pipe & North Pipe
Frogs (?)	Late spring thru summer	North Pipe

Butterflies

Morning Cloak Butterfly	Not sure	South end of Pipe
Tiger Swallowtail	Not sure	South end of Pipe
Monarch	Not sure	South end of Pipe
Painted Lady Butterfly	Not sure	South end of Pipe
Polyphemus Moth Larva	Not sure	South end of Pipe
Yellow Bear Larva	Not sure	South end of Pipe

3.6. Watershed Synopsis

The watershed area that drains to Pipe Lakes is dominated by forest and wetland acreage. It is in primarily a natural condition. Major features are listed below.

- mostly natural watershed land use.
- streamflow is low.
- some streambank erosion is observed.
- phosphorus concentrations in runoff are low to moderate

Major watershed improvement projects are not needed at this time. However, several project areas will be addressed in the project section.

4. Lake Features

4.1. Lake Map and Lake Statistics

The Pipe Lakes combined are approximately 362 acres in size, with a watershed of 3,738 acres. The average depth of Pipe Lake is 27 feet with a maximum depth of 68 feet and the average depth of North Pipe Lake is 17 feet with a maximum depth of 37 feet (Table 9). A lake contour map is shown in Figure 14.

Table 9. Pipe Lakes Characteristics

	North Pipe Lake	Pipe Lake
Lake area (acres)	66	296
Mean depth (ft):	17	27
Maximum depth (ft):	37	68
Volume (ac-ft):	1,122	7,992
Fetch (longest open water distance)(ft):	4,119	8,482
Shoreline (miles)	1.9	4.5
Watershed area (including lake area):	1,168	2,475
Watershed: Lake surface ratio	18:1	8:1
Littoral area:	31 ac (47%) 0-10 feet deep	135 ac (46%) 0-15 feet deep

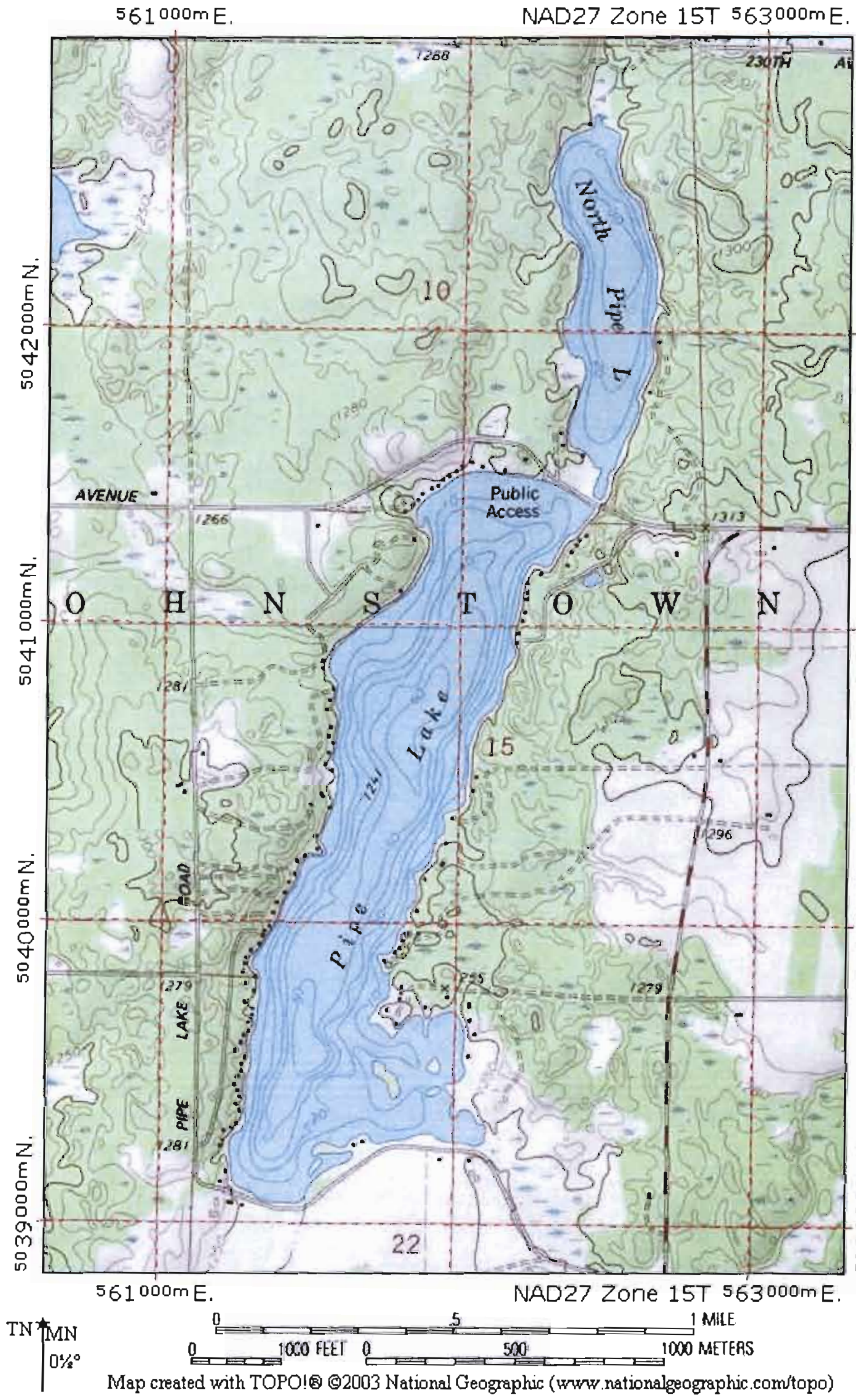


Figure 14. Pipe Lakes Contour Map.

4.2. Dissolved Oxygen and Temperature

Dissolved oxygen and temperature profiles for the Pipe Lakes are shown in Figures 15 through 18.

Profiles were obtained from February through November, 2003 and were collected by Lake District volunteers. By examining the profiles, one can learn a great deal about the condition of a lake and the habitat that is available for aquatic life.

For example the July profiles for both lakes show they were thermally stratified. **Thermally stratified** means that the water column of the lake is segregated into different layers of water based on their temperature. Just as hot air rises because it is less dense than cold air, water near the surface that is warmed by the sun is less dense than the cooler water below it and it "floats" forming a layer called the *epilimnion*, or *mixed layer*. The water in the epilimnion is frequently mixed by the wind, so it is usually the same temperature and is saturated with oxygen.

Below this layer of warm, oxygenated surface water is a region called the *metalimnion*, or *thermocline* where water temperatures decrease precipitously with depth. Water in this layer is isolated from gas exchange with the atmosphere. The oxygen content of this layer usually declines with depth in a manner similar to the decrease in water temperature.

Below the thermocline is the layer of cold, dense water called the *hypolimnion*. This layer is completely cut off from exchange with the atmosphere and light levels are very low. So, once the lake stratifies in the summer, oxygen concentrations in the hypolimnion progressively decline due to the decomposition of plant and animal matter and respiration of benthic (bottom-dwelling) organisms.

The July profiles indicate that the epilimnion extended to a depth of about 12 ft in North Pipe (Figure 15) and to 20 feet in Pipe Lake (Figure 16). Dissolved oxygen was absent below the epilimnion in North Pipe but was present in Pipe Lake.

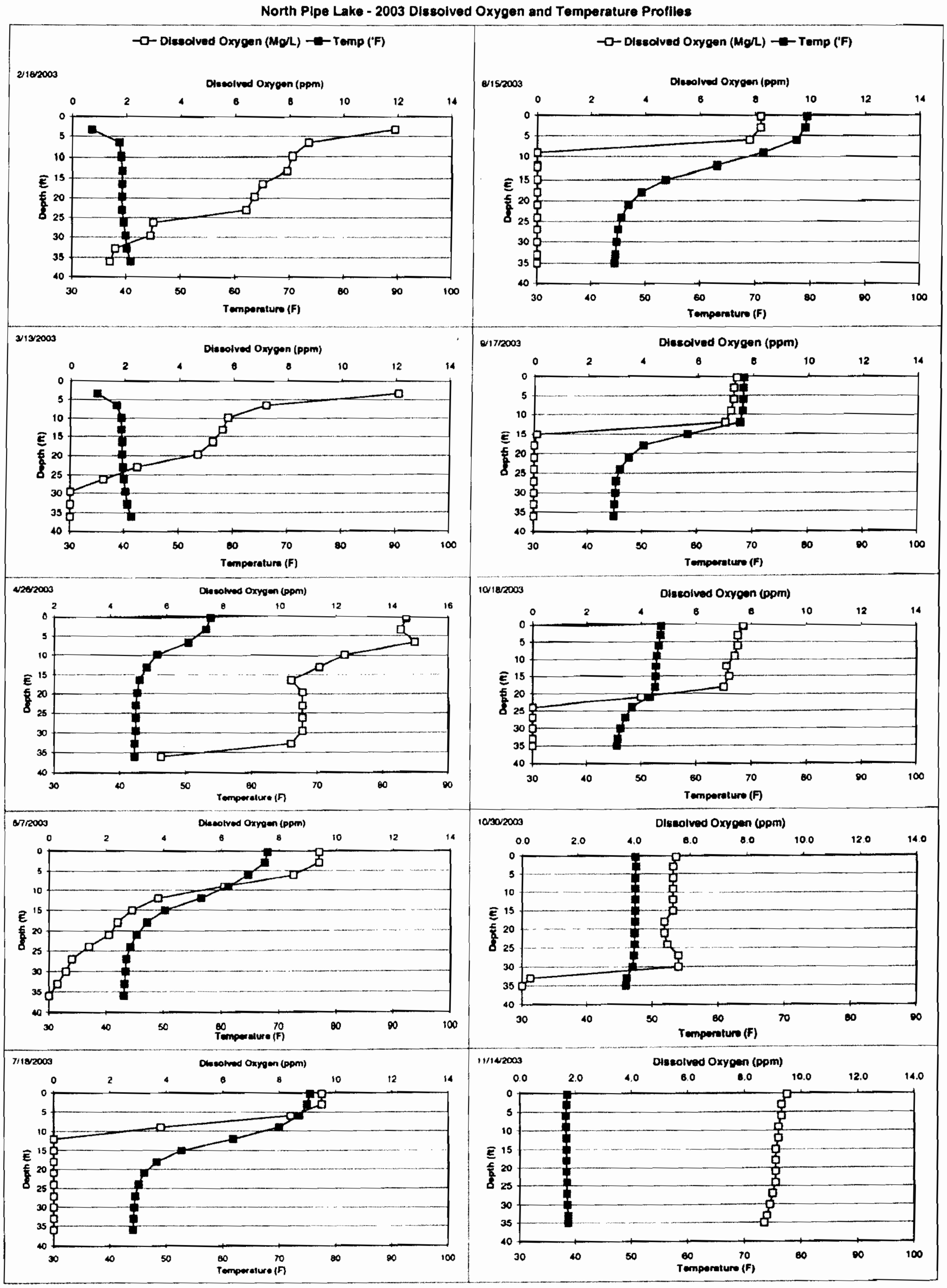


Figure 15. Dissolved oxygen (DO)/temperature profiles for North Pipe Lake for 2003. Dissolved oxygen data are shown with open squares and temperature with filled squares.

Pipe Lake - 2003 Dissolved Oxygen and Temperature Profiles

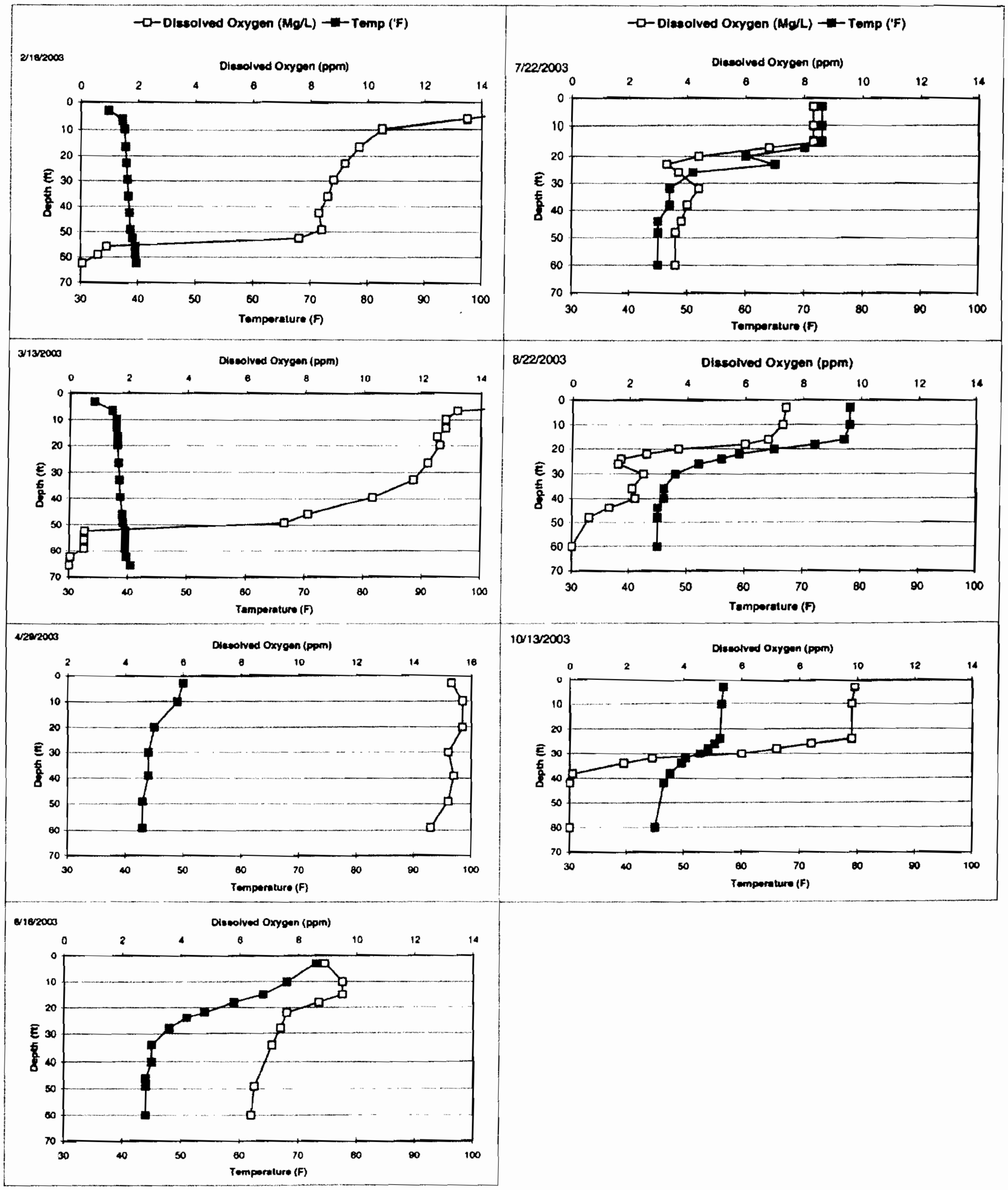
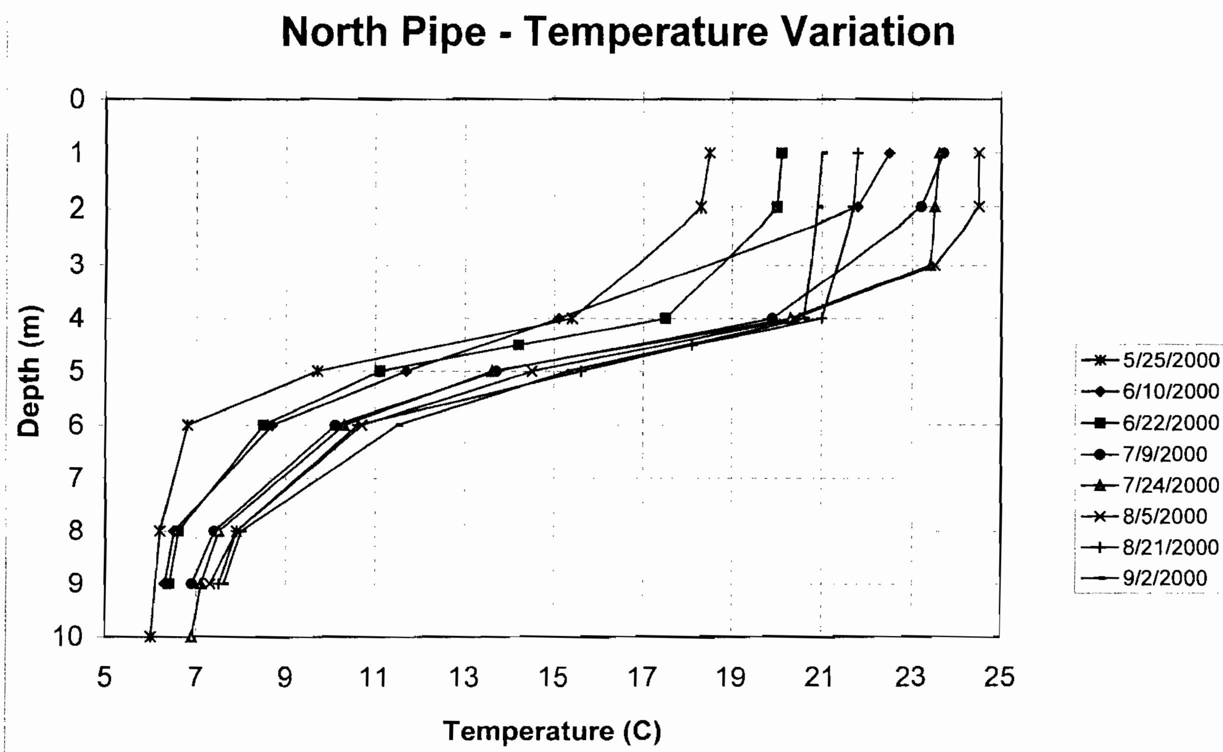


Figure 16. Dissolved oxygen (DO)/temperature profiles for Pipe Lake for 2003. Dissolved oxygen data are shown with open squares and temperature with filled squares.



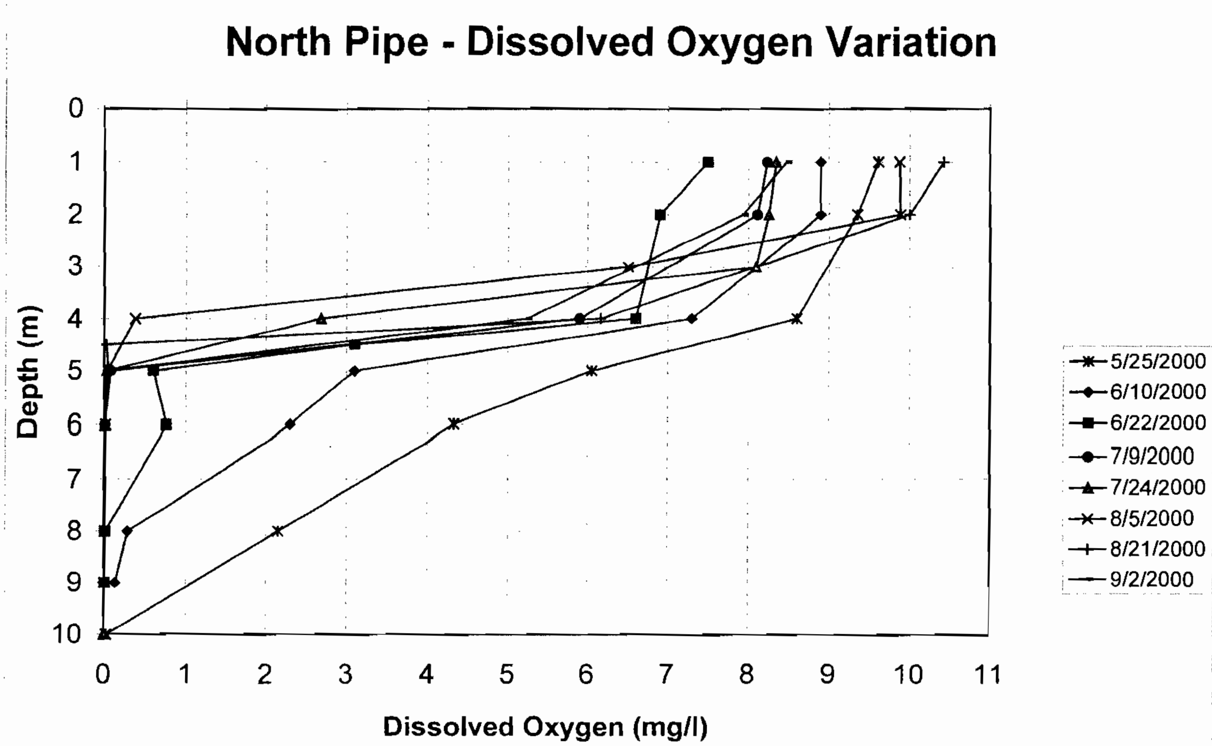
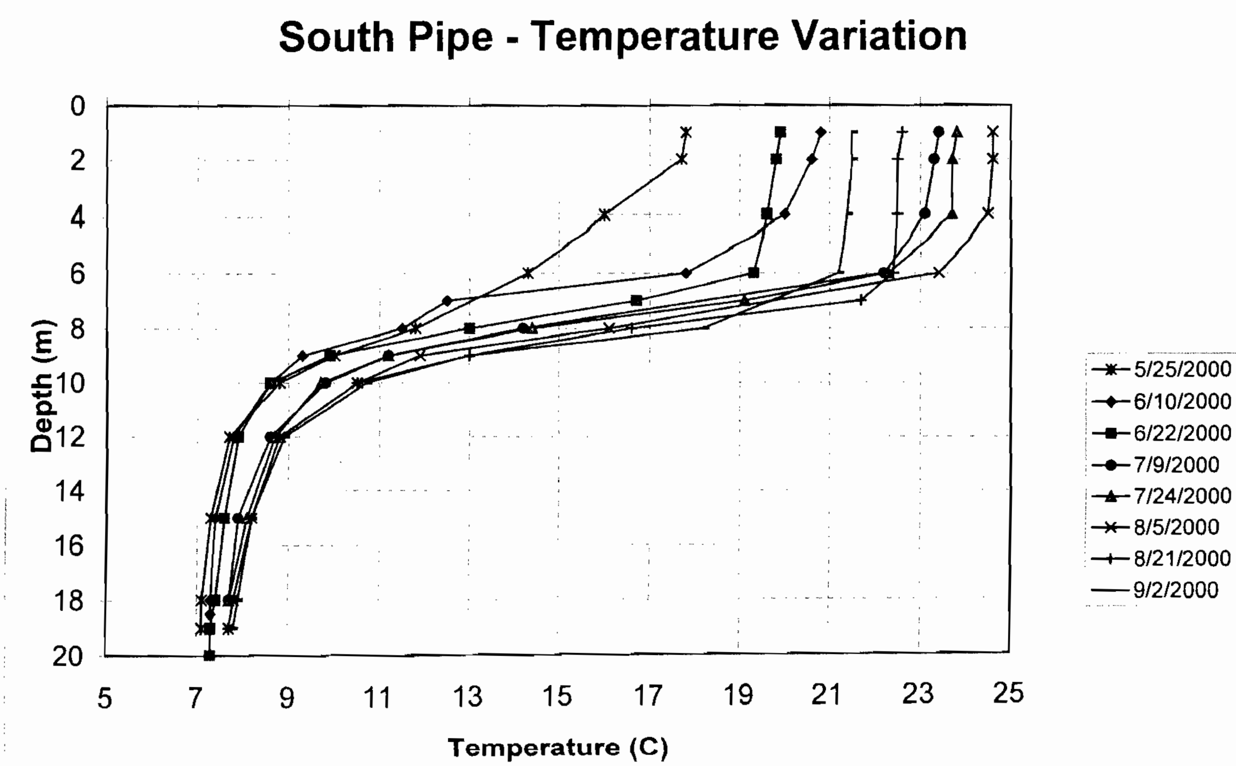


Figure 17. Dissolved oxygen (DO)/temperature profiles for North Pipe Lake for 2000. Dissolved oxygen data are shown in the bottom graph and temperature data are shown in the top graph.



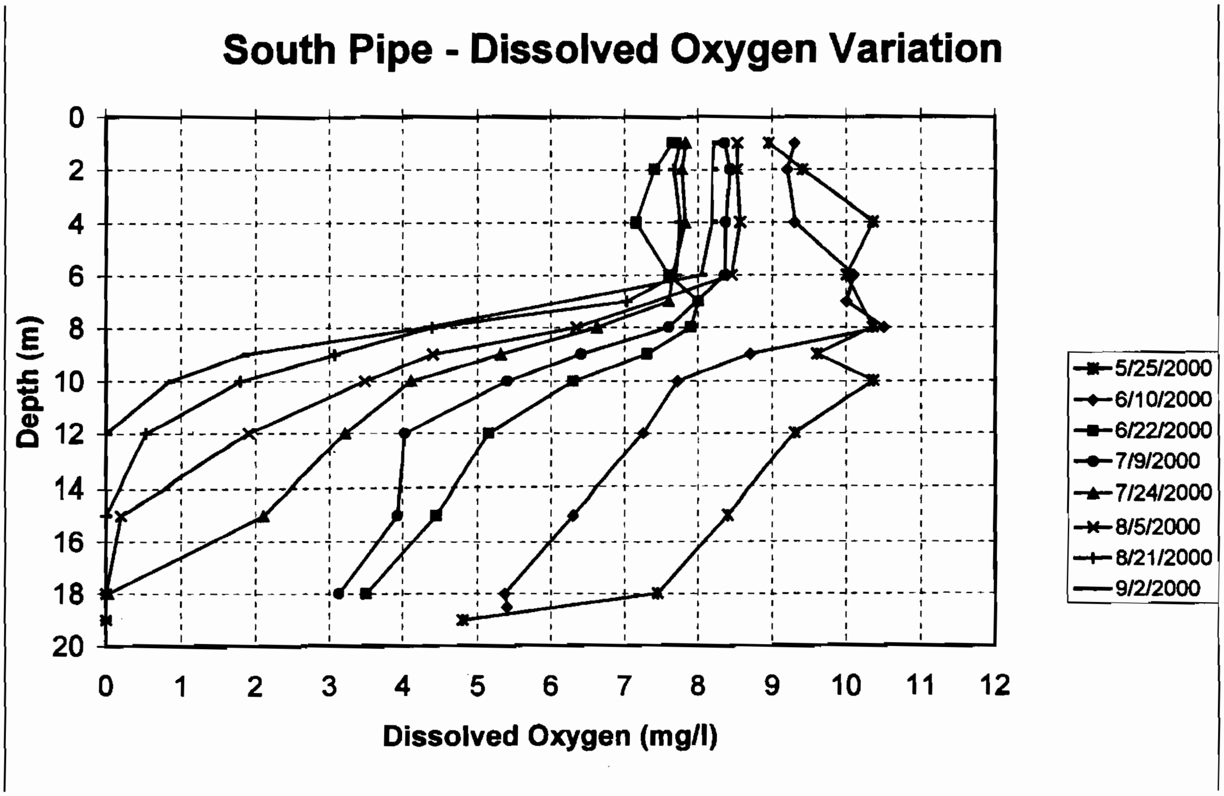


Figure 18. Dissolved oxygen (DO)/temperature profiles for Pipe Lake for 2000. Dissolved oxygen data are shown in the bottom graph and temperature data are shown in the top graph.

4.3. Lake Water Quality Parameters

Summer water quality data from 1998 through 2003 includes Secchi disc, total phosphorus (TP), and chlorophyll a (Chl a) and are summarized in Tables 10-13. Samples were collected at the surface and two feet off the bottom in the deepest area of the Pipe Lakes. Overall, the three water quality indicators (Secchi disc, total phosphorus, and chlorophyll a) indicate North Pipe Lake is in fair shape and Pipe Lake is in excellent shape. Total phosphorus was higher in the bottom water than the top water indicating some phosphorus release from the bottom material (sediments or plants) may be occurring. The bottom phosphorus concentration is typical for lakes that experience dissolved oxygen depletion in the bottom water.

Table 10. Summary of North Pipe Lake summer water quality averages.

Date	SD (m)	SD (ft)	TP Surf (ppb)	TP Botm (ppb)	CHL (Surf) (ppb)
1998					
average	2.18	7.17			
range	2.06-2.36	6.75-7.75			
n	3	3			
1999					
average	2.46	8.07			
range	1.98-2.90	6.50-9.50			
n	8	8			
2000					
average	2.20	7.24	24	227	14.8
range	1.07-3.96	3.50-13.0	22-26	130-292	3-42
n	16	16	5	3	5
2001					
average	1.76	5.78	32*		36*
range	0.91-2.97	3.0-9.75			
n	9	9	1		1
2002					
average	2.48	8.14	28	242	8.6
range	0.99-3.43	3.25-11.25	21-36	138-300	1-17.6
n	14	14	4	3	3
2003					
average		5.86	35	264	35.1
range		3.0-8.25	22-44	111-337	14.3-62.5
n		10	4	4	3
3-yr average (2001-2003)	2.0	6.6	32*	--	26*

* 3-yr average includes only 1 data point for 2001. The 2001 data may not necessarily be representative of the growing season average (collected July 23, 2001).

Table 11. Sampling results for North Pipe for 1998 through 2003

Date	SD (m)	SD (ft)	TP Surf (ppb)	TP Botm (ppb)	CHL (Surf) (ppb)
9/1/1998	2.06	6.75			
9/11/1998	2.13	7.00			
9/22/1998	2.36	7.75			
10/1/1998	2.44	8.00			
10/17/1998	2.13	7.00			
5/9/1999	1.98	6.50			
6/13/1999	2.29	7.50			
6/24/1999	2.90	9.50			
7/6/1999	2.51	8.25			
7/16/1999	2.44	8.00			
7/28/1999	2.67	8.75			
8/24/1999	2.44	8.00			
9/16/1999	2.74	9.00			
10/5/1999	2.44	8.00			
10/12/1999	2.36	7.75			
4/21/2000	2.59	8.50			
5/2/2000	3.96	13.00			
5/25/2000	2.36	7.75			
5/25/2000			22	130	7
6/10/2000	2.51	8.25			
6/22/2000	2.29	7.50			
6/22/2000			25	292	3
6/25/2000	2.97	9.75			
7/9/2000	2.13	7.00			
7/11/2000	2.29	7.50			
7/24/2000	2.29	7.50			
7/24/2000			23		9
7/27/2000	1.98	6.50			
8/5/2000	1.37	4.50			
8/7/2000	1.37	4.50			
8/19/2000			26		42
8/21/2000	1.07	3.50			
9/2/2000	1.22	4.00			
9/13/2000	1.83	6.00			
9/16/2000	1.83	6.00			
9/16/2000			23	259	13
9/29/2000	2.44	8.00			
10/15/2000	2.59	8.50			
2/25/2001			23	249	1.3
4/25/2001	1.22	4.00			
5/10/2001	1.60	5.25			
6/4/2001	1.91	6.25			

Table 11. Concluded.

Date	SD (m)	SD (ft)	TP Surf (ppb)	TP Botm (ppb)	CHL (Surf) (ppb)
6/28/2001	1.91	6.25			
7/12/2001	1.37	4.50			
7/23/2001	0.91	3.00	32		36
8/17/2001	1.22	4.00			
8/31/2001	1.98	6.50			
9/12/2001	2.13	7.00			
9/27/2001	2.97	9.75			
10/1/2001	3.28	10.75			
10/19/2001	2.44	8.00			
5/5/2002	2.59	8.50	36		
5/14/2002	2.13	7.00			
5/17/2002	2.29	7.50			
5/30/2002	2.82	9.25			
6/9/2002	2.51	8.25	25	138	1
6/16/2002	3.05	10.00			
6/28/2002	2.13	7.00			
7/13/2002	0.99	3.25	29	288	17.6
7/27/2002	2.29	7.50			
8/9/2002	2.44	8.00	21	300	7.3
8/26/2002	3.43	11.25			
8/30/2002	3.35	11.00			
9/8/2002	2.82	9.25			
9/22/2002	2.51	8.25			
10/9/2002	2.67	8.75			
10/11/2002			37		8.6
2/17/2003			62	326	
3/13/2003			35	37	
4/26/2003		6.75	72	57	
5/7/2003		7.75			
5/23/2003		6.75			
6/7/2003		6.75	44	111	14.3
6/19/2003		5.75			
7/4/2003		4.00			
7/18/2003		3.25	41	285	62.5
8/1/2003		3.00			
8/15/2003		4.00	32	322	28.4
8/30/2003		4.75			
9/16/2003		8.25			
9/17/2003			22	337	
10/1/2003		8.50			
10/13/2003				270	
10/18/2003		10.00	34		6
11/14/2003			38	40	

w/o internal loading TP 35→26 μg L⁻¹

... "real" internal loading since bottom TP high + surface TP ↑ w/ partial turnover

spring turnover high in 03 ∴ worse Secchi compared w/ 02 ∴ watershed no major problem, not internal loading

monitoring plan: 1) spring turnover TP top 2) top profile mid top 3) fall turnover early-mid Nov top

summer mean TSI — TSI agrees in 02, disagrees in 03 because Chl too high but P + SD OK

Table 12. Summary of Pipe Lake summer water quality averages.

Date	SD (m)	SD ft)	TP Surf (ppb)	TP Botm (ppb)	CHL (Surf) (ppb)
1994					
average	5.18	17.0	10		2.2
range	4.72-5.64	15.50-18.50	8-11		2.1-2.2
n	3	3	2		2
1995					
average	4.57	15.0	9		3.4
range					
n	1	1	1		1
1998					
average	5.36	17.6			
range	5.33-5.41	17.50-17.75			
n	3	3			
1999					
average	5.66	18.6	6		2.0
range	3.89-6.86	12.75-22.50	5-8		1.7-2.4
n	8	8	4		4
2000					
average	5.01	16.4	13	57	3.5
range	3.20-7.62	10.50-25.00	6-38	17-127	1-6
n	18	18	10	3	9
2001					
average	4.27	14.0	12		3.8
range	3.51-5.33	11.50-17.50	5-21		3-5
n	9	9	3		3
2002					
average	5.32	17.4	13		3.9
range	4.11-6.86	13.5-22.5	8-20		2.2-5.5
n	10	10	3		2
2003					
average		13.9	10	95	4.6
range		11.50-17.00	7-14	28-148	2.02-6.6
n		10	4	4	3
3-yr average (2001-2003)	4.6	15.1	12	--	4.0

Table 13. Sampling results for Pipe Lake for 1994-2003.

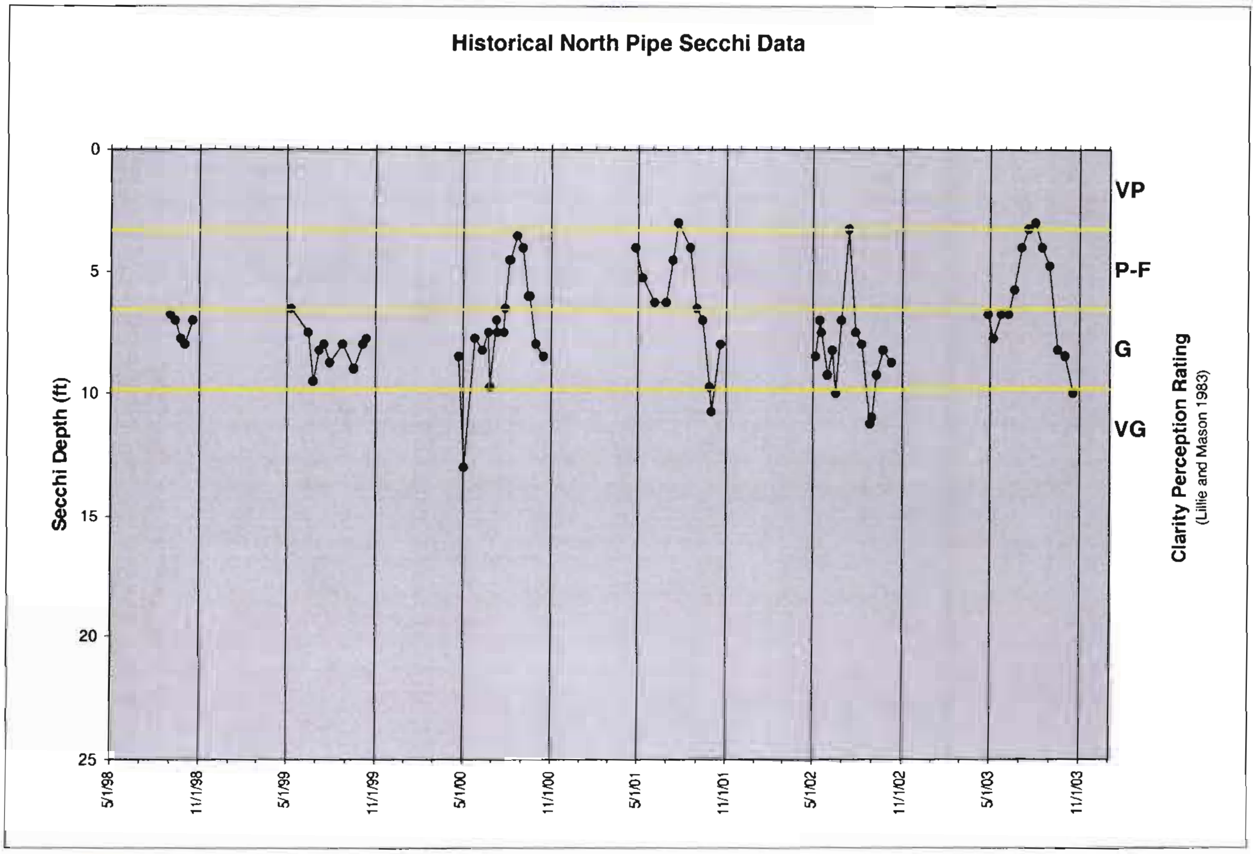
Date	SD (m)	SD (ft)	TP Surf (ppb)	TP Botm (ppb)	CHL (Surf) (ppb)
7/15/1994	4.72	15.50	8		2.2
7/31/1994	5.64	18.50			
8/14/1994	5.18	17.00	11		2.1
10/8/1994	4.27	14.00	11		4.7
6/15/1995	4.57	15.00	9		3.4
9/1/1998	5.33	17.50			1.3
9/11/1998	5.33	17.50			
9/22/1998	5.41	17.75			
10/1/1998	4.57	15.00			
10/17/1998	3.96	13.00	7		4.7
5/9/1999	6.86	22.50	6		
6/13/1999	3.89	12.75	6		2.4
6/24/1999	4.27	14.00			
7/6/1999	4.95	16.25			
7/16/1999	4.42	14.50	5		2
7/28/1999	5.41	17.75			
8/24/1999	5.72	18.75	8		2
9/16/1999	6.71	22.00	8		1.7
10/5/1999	4.42	14.50			
10/12/1999	4.34	14.25	5		2.5
4/21/2000	6.25	20.50	10		
5/2/2000	7.62	25.00			
5/25/2000			9	17	6
5/25/2000	6.25	20.50	6		5
6/10/2000	5.33	17.50			
6/22/2000	4.11	13.50	38		5
6/22/2000			9	27	2
6/25/2000	5.49	18.00			
7/9/2000	3.20	10.50			
7/11/2000	4.42	14.50			
7/24/2000	4.72	15.50	9		1
7/24/2000			32		1.4
7/27/2000	4.11	13.50			
8/5/2000	4.27	14.00			
8/7/2000	4.27	14.00			
8/19/2000	4.42	14.50	7		3.5
8/21/2000	4.42	14.50			
8/22/2000	4.42	14.50	8		
9/2/2000	3.73	12.25			
9/13/2000	5.18	17.00			
9/16/2000			6		4
9/16/2000	4.57	15.00	6	127	4
9/29/2000	5.18	17.00			

Table 13. Concluded.

Date	SD (m)	SD (ft)	TP Surf (ppb)	TP Botm (ppb)	CHL (Surf) (ppb)
10/15/2000	4.57	15.00	10		2.6
2/25/2001			23	79	1.3
2/25/2001			8		<1
4/25/2001	3.51	11.50	22		
5/10/2001	3.66	12.00			
6/4/2001	3.89	12.75	21		5
6/28/2001	4.80	15.75			
7/12/2001	3.96	13.00			
7/23/2001	3.51	11.50	10		3.4
8/17/2001	4.42	14.50			
8/31/2001	5.18	17.00	[redacted]		3
9/12/2001	5.33	17.50			
9/27/2001	4.27	14.00			
10/1/2001	4.42	14.50	10		4
10/19/2001	4.11	13.50			
4/30/2002	4.57	15.00	14		
5/14/2002	5.11	16.75			
5/29/2002	6.71	22.00			
6/12/2002	6.86	22.50	20		
7/2/2002	4.50	14.75			
7/15/2002	4.57	15.00	11		2.2
7/17/2002	4.57	15.00			
7/29/2002	4.27	14.00			
8/19/2002	4.11	13.50	8		5.5
9/3/2002	5.33	17.50			
9/15/2002	5.11	16.75			
10/8/2002	3.81	12.50	13		8.6
2/17/2003			17	53	
3/13/2003			16	48	
4/24/2003		15.25	19	13	
4/29/2003		15.25			
5/16/2003		9.00			
5/27/2003		16.50			
6/9/2003		16.25			
6/16/2003		15.00	10	28	2.02
6/27/2003		14.25			
7/11/2003		12.00			
7/22/2003		11.75	14	69	6.6
8/15/2003		11.50			
8/19/2003			10	134	5.06
8/22/2003		14.25			
9/16/2003		17.00			
9/17/2003			7	148	
10/1/2003		16.50			
10/13/2003		12.50	13	41	8.26

4.3.1. Secchi Disc Transparency Review

Water clarity is commonly measured with a Secchi disc. Secchi disc results for North Pipe Lake are shown in Figure 19 and for Pipe Lake in Figure 20. Both North Pipe and Pipe show typical seasonal fluctuations with Pipe Lake having the better overall clarity.



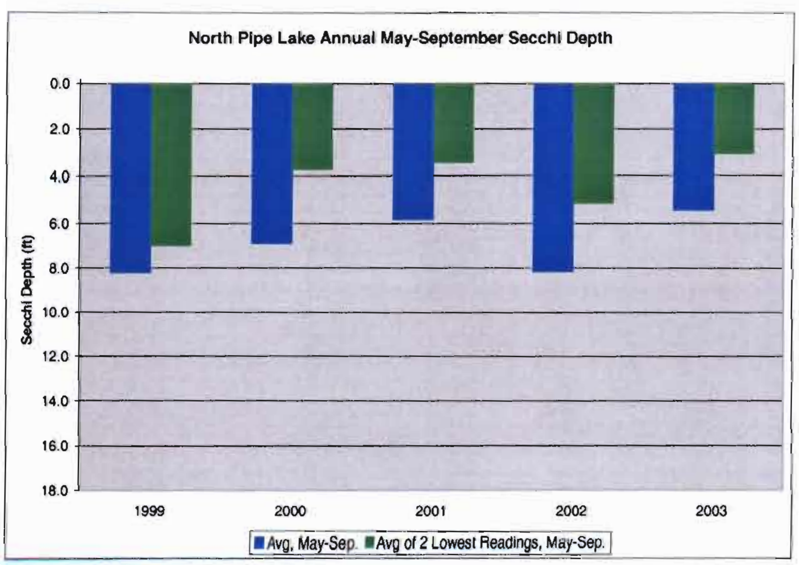
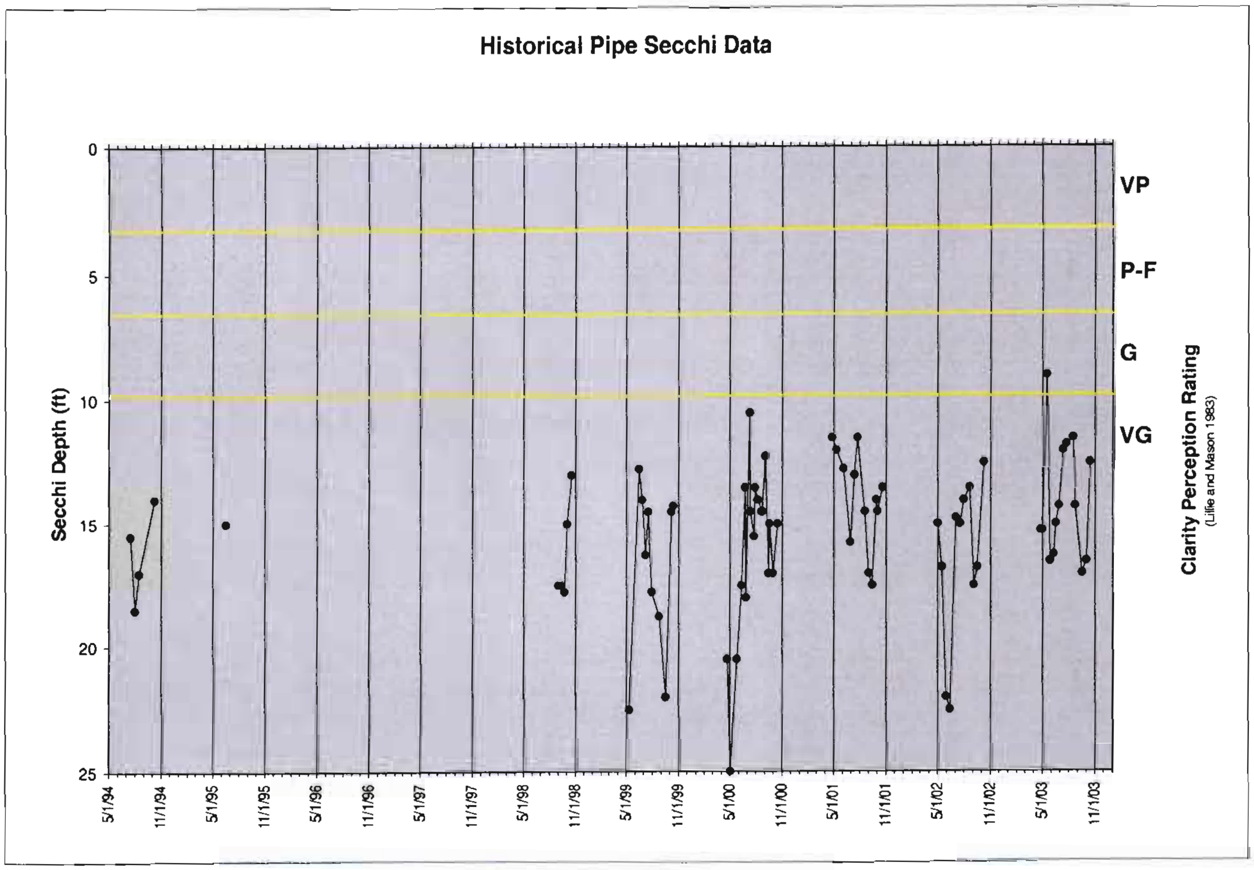


Figure 19. Secchi disc results for North Pipe Lake.



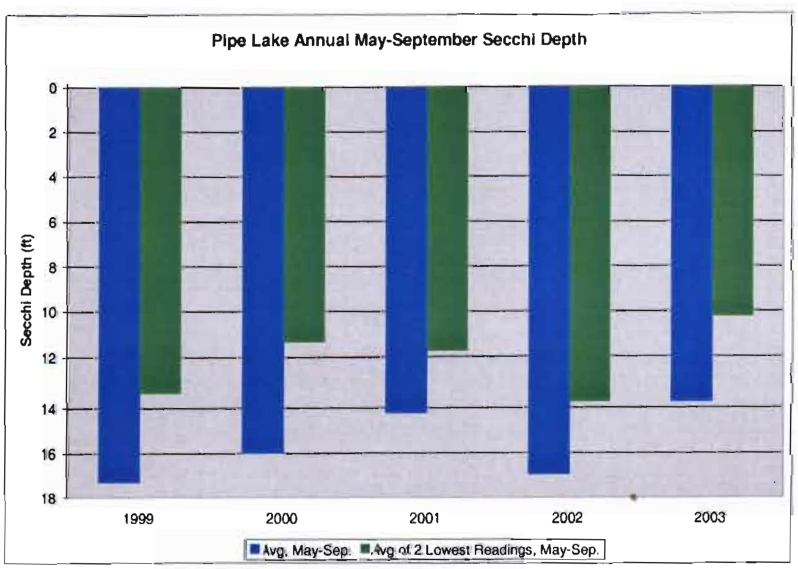
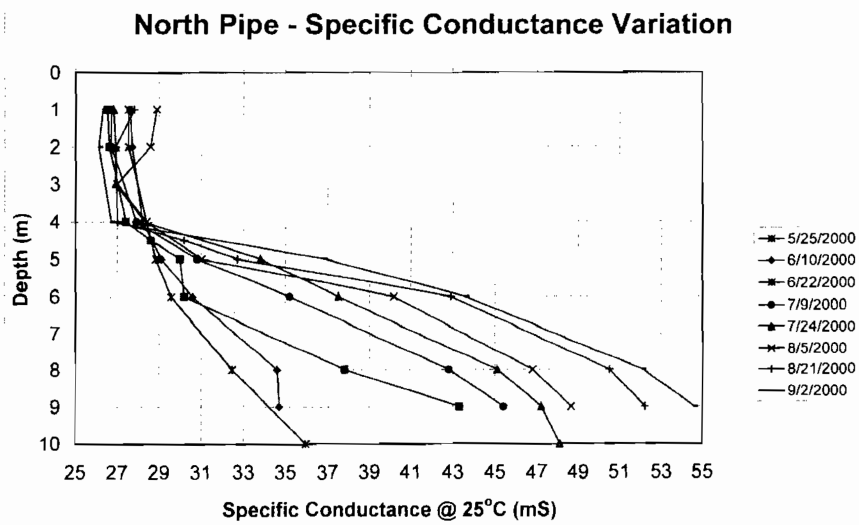


Figure 20. Secchi disc results for Pipe Lake.

4.3.2. Other Lake Water Quality Parameters

In addition to Secchi disc, total phosphorus, and chlorophyll a, several other water quality parameters were collected in 2000. Specific conductance is low in North Pipe and Pipe (Figure 21). It increased in the bottom water which is typical. Additional data are listed in Tables 14 and 15. Two observations stand out. Alkalinity is fairly low for both lakes and this indicates there is not much acid buffering potential. Low alkalinity would make the use of alum more complicated if it is considered in the future. Also, the color of the lake water is different between North Pipe and Pipe. North Pipe has a higher color reading than Pipe Lake. The brownish-reddish color probably originates from wetland discharges to streams which flow into North Pipe. This may also slightly lower the transparency readings in North Pipe.



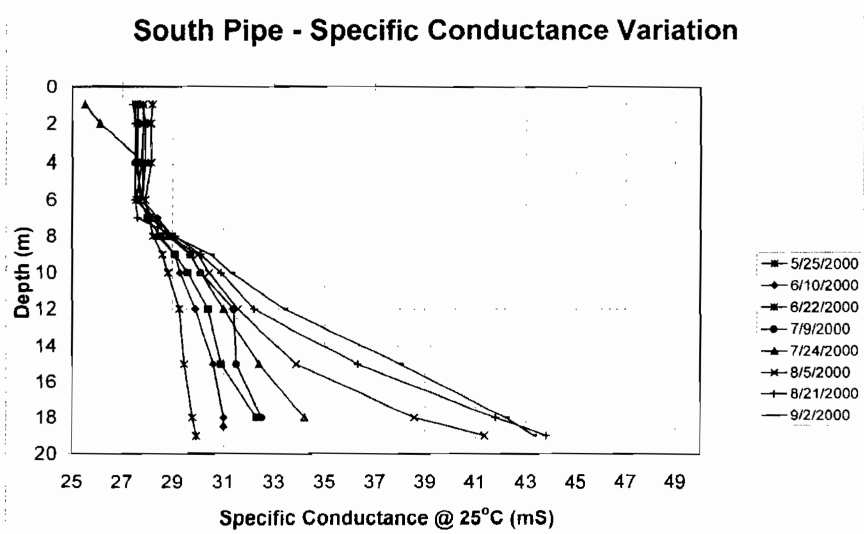


Figure 21. Specific conductance measured for North Pipe and Pipe Lakes in 2000.

Table 14. North Pipe Lake sampling results.

Test	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13
Collection Date	5/25/2000	5/25/2000	6/22/2000	6/22/2000	7/24/2000	7/24/2000	7/24/2000	8/19/2000	9/16/2000	9/16/2000	2/25/2001	2/25/2001	2/25/2001
Labslip Number	IK028005	IK028003	IL000426	IL000424	IL002348	IL002348	IL002346	IL004765	IL007552	IL007554	IL017151	IL017156	IL017151
Field Number	NP-26	NP-15	NP-2B	NP-15	NP-2B	NP-2B	NP-1S	NP-SUR	NP-SUR	NP-BOTT	NP-SU	NP-BT	NP-SU
Calcium (MG/L)	2.8	2.4	-	-	-	-	-	-	-	-	-	-	-
Chloride (MG/L)	1.4	1.2	-	-	-	-	-	-	-	-	-	-	-
Chlorophyll A (Uncorrected) (UG/L)	-	7	-	3	-	-	9	42	13	-	-	-	1.3
Chlorophyll A (Corrected) (UG/L)	-	-	-	-	-	-	-	-	-	-	-	-	1
Pheophytin A (UG/L)	-	-	-	-	-	-	-	-	-	-	-	-	<1
True Color (SU)	55	30	-	-	-	-	-	-	-	-	-	-	-
Conductivity @ 250C (UMHOS/CM)	35	29	37	31	38	38	28	27	29	44	-	40	35
pH (SU)	6.7	7	7.07	7.09	6.23	6.23	6.88	7.84	6.78	6.32	-	6.42	6.59
Alkalinity as CaCO3 (MG/L)	19	18	21	19	14	14	9	9	9	17	-	15	10
Ammonia (MG/L)	-	0.013	-	0.013	-	-	0.013	0.021	0.079	-	-	-	-
Hardness as CaCO3 (MG/L)	11	9.8	-	-	-	-	-	-	-	-	-	-	-
Iron (MG/L)	1.3	0.13	-	-	-	-	-	-	-	-	-	-	-
Magnesium (MG/L)	0.92	0.92	-	-	-	-	-	-	-	-	-	-	-
Manganese (UG/L)	150	12	-	-	-	-	-	-	-	-	-	-	-
Nitrate+Nitrite (MG/L)	-	0.01	-	0.01	-	-	0.01	0.01	0.01	-	-	-	0.344
Total Kjeldahl Nitrogen (MG/L)	-	0.61	-	0.59	-	-	0.72	1.21	0.85	-	0.51	-	0.51
Total Phosphorus (MG/L)	0.13	0.022	0.292	0.025	-	-	0.023	0.026	0.023	0.259	0.023	0.249	0.023
Diss. Reactive Phosphorus (MG/L)	0.063	0.002	-	0.002	0.099	0.099	0.002	0.026	0.002	0.12	0.008	-	0.008
Potassium (MG/L)	1.9	1.8	-	-	-	-	-	-	-	-	-	-	-
Silica (MG/L)	2.02	0.341	-	-	-	-	-	-	-	-	-	-	-
Sodium (MG/L)	0.7	0.9	-	-	-	-	-	-	-	-	-	-	-
Sulfate (MG/L)	4.5	-	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids (MG/L)	34	34	-	-	-	-	-	-	-	-	-	-	-
Turbidity (NTU)	4.9	2.3	-	-	-	-	-	-	-	-	-	-	-
Dissolved Nitrogen (MG/L)	-	-	-	-	-	-	-	-	-	-	-	-	-
Sample Depth (Ft.)	30	3	32	3	-	-	-	-	3	30	-	-	-
Ambient Air Temp. (0C)	65	65	15.56	15.56	67	67	67	-	62	62	-	-	-
Secchi Depth (Ft.)	7.8	7.8	7.5	7.5	7.5	7.5	7.5	3.5	6	6	-	-	-
Cloud Cover (%)	0	0	100	100	50	50	50	-	0	0	-	-	-
Temp. on Receipt (0C)	13	13	14	14	18	18	18	-	10	10	-	-	-

Table 15. Pipe Lake sampling results

Test	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6	Sample 7	Sample 8	Sample 9	Sample 10	Sample 11	Sample 12	Sample 13
Collection Date	5/25/2000	5/25/2000	6/22/2000	6/22/2000	7/24/2000	7/24/2000	7/24/2000	8/19/2000	9/16/2000	9/16/2000	2/25/2001	2/25/2001	2/25/2001
Labslip Number	IK028004	IK028002	IL000427	IL000425	IL002349	IL002349	IL002347	IL004766	IL007551	IL007553	IL017151	IL017154	IL017152
Field Number	SP-46	SP-35	SP-4B	SP-35	SP-4B	SP-4B	SP-3S	P-SUR	P-SUR	P-BOTT	P-SU	P-BT	P-SU
Calcium (MG/L)	2.4	2.3											
Chloride (MG/L)	1.4	1.3											
Chlorophyll A (Uncorrected) (UG/L)	-	6		2			1	3.5	4		1.3		<
Chlorophyll A (Corrected) (UG/L)											1		<
Pheophytin A (UG/L)											<1		1.
True Color (SU)	5	5											
Conductivity @ 250C (UMHOS/CM)	31	29		29	36	36	28	28	29	40	35	36	33
pH (SU)	6.78	7.04		7.04	6.3	6.3	6.83	7.07	7.04	6.4	6.59	6.44	7.03
Alkalinity as CaCO3 (MG/L)	17	17		18	11	11	8	9	8	13	10	11	9
Ammonia (MG/L)	-	0.013		0.013			0.013	0.017	0.024				
Hardness as CaCO3 (MG/L)	9.4	9.2											
Iron (MG/L)	0.05	0.03											
Magnesium (MG/L)	0.86	0.86											
Manganese (UG/L)	13	4											
Nitrate+Nitrite (MG/L)	-	0.01		0.01			0.01	0.01	0.01				0.012
Total Kjeldahl Nitrogen (MG/L)	-	0.37		0.34			0.46	0.35	0.45		0.51		0.37
Total Phosphorus (MG/L)	0.017	0.009	0.027	0.009			0.009	0.007	0.006	0.127	0.023	0.079	0.008
Diss. Reactive Phosphorus (MG/L)	0.002	0.002		0.003	0.047	0.047	0.002	0.002	0.002	0.063	0.008		
Potassium (MG/L)	1.5	1.7											
Silica (MG/L)	0.241	0.064											
Sodium (MG/L)	0.8	0.8											
Sulfate (MG/L)	4.5												
Total Dissolved Solids (MG/L)	26	28											
Turbidity (NTU)	1	2.5											
Dissolved Nitrogen (MG/L)	-												0.033
Sample Depth (Ft.)	60	3	60	3					3	60			
Ambient Air Temp. (0C)	65	65	15.56	15.56	67	67	67		62	62			
Secchi Depth (Ft.)	20.5	20.5	13.5	13.5	15.5	15.5	15.5	14.5	15	15			
Cloud Cover (%)	0	0	100	100	50	50	50		0	0			
Temp. on Receipt (0C)	13	13	14	14	18	18	18		10	10			

4.4. Algae and Zooplankton

Zooplankton are small crustaceans that can feed on algae. An example of a zooplankter from Pipe Lakes is shown in Figure 22. The zooplankton community has typical zooplankton species for lakes in Northern Wisconsin although there was limited sampling in 2003. In the photo below, the image of a copepod is magnified 150 times.

Algae were examined under the microscope as well but not quantified. The algal community was also found to be composed of algal species typical for Northern Wisconsin lakes.

Figure 22. Example of zooplankton species from North Pipe Lake on May 7, 2003.

Zooplankton were sampled in 2003 results are shown in Table 16.

Table 16. Zooplankton counts for Pipe Lakes.

Date	5.7.03 North Pipe	8.24.03 North Pipe	5.7.03 Pipe
Tow depth (ft)	20	15	20
Big Daphnids	3	1	13
Little Daphnids	9	0	2
Ceriodaphnia	0	0	0
Bosmina	0	1	0
Chydorus	0	0	0
Cladoceran (total)	12	2	15
Calonoids	7	1	8
Cyclopoids	10	1	34
Nauplii	4	3	6
Copepods (total)	21	5	48
Rotifers	76	6	31
Total Zooplankton	109	13	94

4.5. Aquatic plant status

Aquatic plants are very important to lakes. They act as nurseries for small fish, refuges for larger fish, and they help to keep the water clear. Currently the Pipe Lakes have a fair diversity of aquatic plants but limited distribution.

Plants were found to be growing out to 8 feet of water depth in both lakes. Rocky nearshore areas and steep drop-offs seem to be the critical limiting factors to aquatic plant distribution.

North Pipe Lake summary statistics are listed in Table 17 and details for individual transects for North Pipe Lake for the plant survey is found in Table 18. Pipe Lake summary statistics are listed in Table 19 and details for individual transects for Pipe Lake for the plant survey is found in Table 20.

Fern pondweed was found at four stations in North Pipe Lake.

Table 17. North Pipe Lake aquatic plant occurrences and densities for the July 1, 2003 survey based on 16 transects and 2 depths, for a total of 32 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-4 feet (n=16)			Depth 5 -8 feet (n=16)			All Stations (n=32)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Bentgrass (*Sparganium sp*)	2	13	0.5	--	--	--	2	6	0.5
Reed #1	1	6	0.5	--	--	--	1	3	0.5
Horsetail (*Equisteum sp*)	1	6	0.5	--	--	--	1	3	0.5
Pickerelweed (*Pontederia cordata*)	2	13	3.5	--	--	--	2	6	3.5
Bulrush (*Scirpus sp*)	6	38	0.6	--	--	--	6	19	0.6
Burreed (*Sparganium sp*)	1	6	0.5	--	--	--	1	3	0.5
Bladderwort (*Utricularia sp*)	1	6	1.0	--	--	--	1	3	1.0
Cabbage (*Potamogeton amplifolius*)	2	13	0.8	2	13	0.8	4	13	0.8
Fern pondweed (*Potamogeton robbinsii*)	1	6	5.0	3	19	2.0	4	13	2.8
Floatingleaf pondweed (*Potamogeton natans*)	1	6	1.0	--	--	--	1	3	1.0
Moss (*Drepanocladus ps*)	--	--	--	1	6	1.0	1	3	1.0
Needle spike rush (*Eleocharis sp*)	3	19	0.7	–	--	--	3	9	0.7
Nitella (*Nitella sp*)	1	6	0.5	--	--	--	1	3	0.5
Rosette	2	13	1.0	1	6	0.5	3	9	0.8
Spatterdock (*Nuphar variegatum*)	2	13	1.3	--	--	--	2	6	1.3
Variable pondweed (*Potamogeton gramineus*)	1	6	0.5	--	--	--	1	3	0.5
Water celery (*Vallisneria americana*)	3	19	0.7	--	--	--	3	9	0.7
Watershield (*Brasenia Schreberi*)	4	25	1.1	3	19	2.0	7	22	1.5
White lily (*Nymphaea sp*)	6	38	1.8	--	--	--	6	19	1.8

Table 18. Transect data for North Pipe Lake for July 1, 2003.

	T1		T2		T3		T4		T5		T6		T7		T8		T9	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Bent grass	0.5				0.5													
Bulrush							0.5				0.5		0.5					
Bladderwort	1																	
Burreed																		
Cabbage	0.5						1			0.5								1
Fern pondweed				1								1						4
Floating pondweed			1															
Horsetail																		
Moss																1		
Needle spike rush					0.5												0.5	
Nitella							0.5											
Pickerelweed			4				3											
Reed #1					0.5													
Rosette										0.5							1	
Spatterdock	2										0.5							
Variable													0.5					
Water celery			1				0.5										0.5	
Watershield		2.5	1	1			2.5	2.5					0.5					
White lily	3										1							
No plants						X								X	X			

	T9.5		T10		T11		T12		T13		T14		T15	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Bent grass														
Bulrush			1						0.5				0.5	
Bladderwort														
Burreed					0.5									
Cabbage														
Fern pondweed	5													
Floating pondweed														
Horsetail			0.5											
Moss														
Needle spike rush									1					
Nitella														
Pickerelweed														
Reed #1														
Rosette									1					
Spatterdock														
Variable														
Water celery														
Watershield			0.5											
White lily	5		0.5		0.5				0.5					
No plants						X	X	X		X	X	X		X

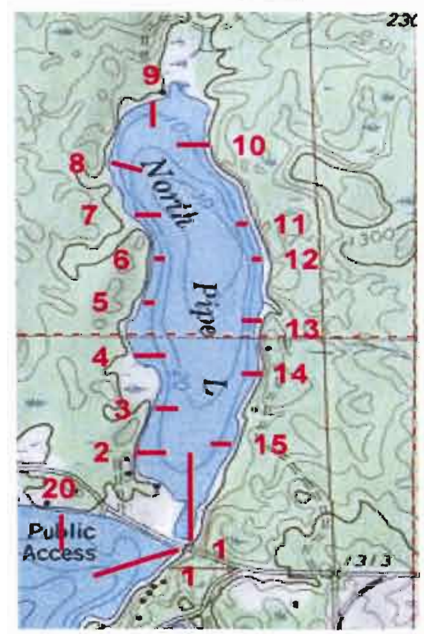


Table 19. Pipe Lake aquatic plant occurrences and densities for the July 1, 2003 survey based on 22 transects and 2 depths, for a total of 44 stations. Density ratings are 1-5 with 1 being low and 5 being most dense.

	Depth 0-4 feet (n=22)			Depth 5-8 feet (n=22)			All Stations (n=44)		
	Occur	% Occur	Density	Occur	% Occur	Density	Occur	% Occur	Density
Arrowhead (*Sagittaria sp*)	2	9	0.8	--	--	--	2	5	0.8
Bulrush (*Scirpus sp*)	3	14	1.0	--	--	--	3	7	1.0
Cabbage (*Potamogeton amplifolius*)	--	--	--	3	14	1.0	3	7	1.0
Chara (*Chara sp*)	1	5	1.0	1	5	1.0	2	5	1.0
Fern pondweed (*Potamogeton robbinsii*)	--	--	--	5	23	2.1	5	11	2.1
Nitella (*Nitella sp*)	--	--	--	6	27	1.0	6	14	1.0
Needle spike rush (*Eleocharis sp*)	10	45	1.5	14	64	1.1	24	55	1.3
Pickerelweed (*Pontederia cordata*)	2	9	4.0	--	--	--	2	5	4.0
Quillwort (*Isoetes sp*)	2	9	1.0	1	5	0.5	3	7	0.8
Spatterdock (*Nuphar variegatum*)	1	5	0.5	--	--	--	1	2	0.5
Water celery (*Vallisneria americana*)	--	--	--	5	23	0.8	5	11	0.8
Watershield (*Brasenia Schreberi*)	--	--	--	2	9	1.8	2	5	1.8
White lily (*Nymphaea sp*)	2	9	0.5	--	--	--	2	5	0.5
Filamentous algae	--	--	--	4	18	0.8	4	9	0.8

Aquatic plants are sparse along most of the shoreline in Pipe Lake.

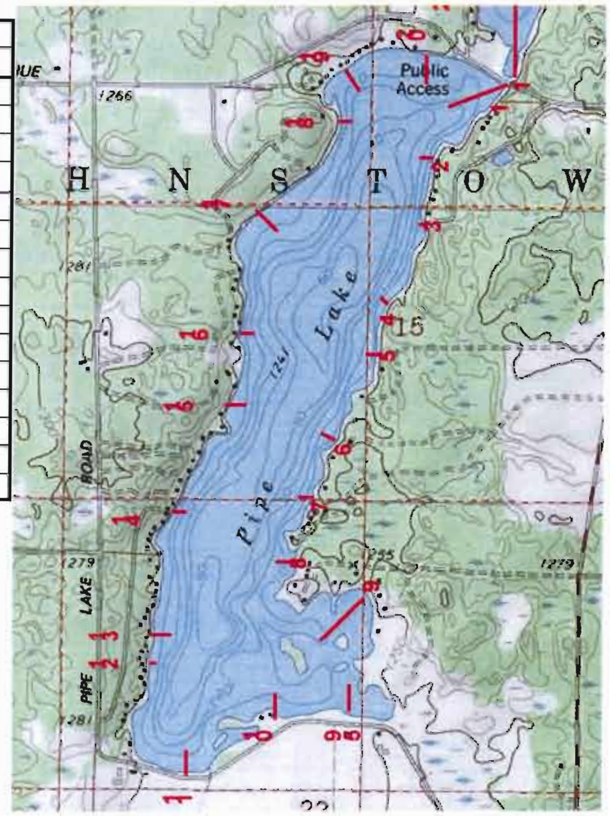
Table 20. Transect data for Pipe Lake for July 1, 2003.

	T1		T1.5		T2		T3		T4		T5		T6		T7		T8	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Arrowhead	1																	
Bulrush	1																	
Cabbage																		
Chara	1																	
Fern pondweed		3																
Nitella		1																
Needle spike rush	2	2			0.5				0.5	0.5			0.5				3	1
Pickerelweed																		
Rosette	1																1	
Spatterdock																		
Water celery		0.5																
Watershield																		
White lily																		
Filamentous algae																		
No plants			X	X		X	X	X			X	X		X				

	T9		T9.5		T10		T11		T12		T13		T14		T15		T16	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Arrowhead																		
Bulrush					1													
Cabbage		1						1								1		
Chara																1		
Fern pondweed		2.5		3.5		0.5										1		
Nitella		0.5				1.5		2										
Needle spike rush	1	0.5		0.5	3	1.5		3						0.5		1		0.5
Pickerelweed	5		3															
Rosette																		
Spatterdock	0.5																	
Water celery						0.5		2										
Watershield		1.5		2														
White lily	0.5														0.5			
Filamentous algae		0.5						1										
No plants							X		X	X	X	X	X					

Table 20. Transect data for Pipe Lake for July 1, 2003 concluded.

	T17		T18		T19		T20	
	0-4	5-8	0-4	5-8	0-4	5-8	0-4	5-8
Arrowhead							0.5	
Bulrush	1							
Cabbage								
Chara								
Fern pondweed								
Nitella						0.5		0.5
Needle spike rush		1.5	0.5	1	3	2	1	0.5
Pickerelweed								
Rosette				0.5				
Spatterdock								
Water celery		0.5		0.5				
Watershield								
White lily								
Filamentous algae						0.5		1
No plants								



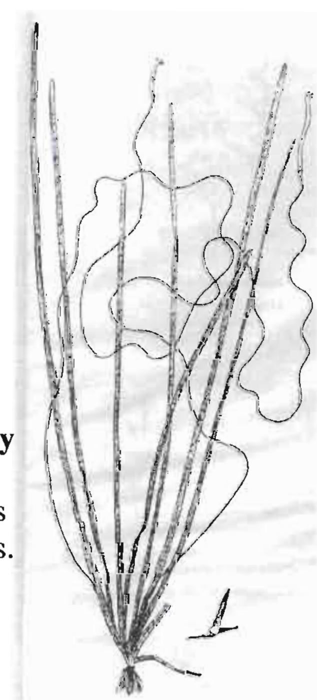
A summary of aquatic plant statistics is shown in Table 21.

Table 21. Aquatic plant survey summary.

	North Pipe	Pipe
Number of submerged and floatingleaf aquatic plant species found	13	10
Most common plant	watershield	needle spikerush
Rarest plant	bladderwort	spatterdock
Maximum depth of plant growth (ft)	8	8

Water celery

Water celery (*Vallisneria americana*) is found in both North Pipe and Pipe Lakes.



4.6. Fishery Status (prepared by WDNR)

A comprehensive fish survey of the Pipe Lakes occurred in 1995 and the following information is from this survey.

Walleye

1. Adult walleye population estimates

Year	Number	Number per Acre
1989	704	2.1
1995	634	1.9

2. Walleye fry or small numbers of fingerlings were stocked for only 7 years from 1933 through 1974. The walleye population has been primarily the product of natural reproduction. Recent walleye stocking is as follows:

Year	Number	Reason
1994	4,182 flg	Mistakenly stocked by St. Croix Tribe
1998	13,567 flg	1995 survey recommended stocking
1999	13,500 flg	Research study
2001	13,500 flg	
2003	30,782 flg	

3. Walleye catch per effort in netting and elecrofishing survey since 1967 indicate moderate fluctuations in walleye abundance. Netting CPE in 1995 (2/net lift) was lower than in 1967 and 1978 surveys (23/net lift) indicating a decrease in walleye abundance.

4. Few large walleye were captured in the 1995 survey. Fifteen percent were 20 inches or larger, the largest was 25.4 inches. Pipe Lakes walleyes have slightly above average growth through age 7, then below average growth.

5. In 1995, 18% of total fishing pressure was directed at walleyes, harvest was estimated at 176 (0.5/acre), and angling exploitation was 35%, with spearing, exploitation increased to 44.6%.

6. Tribal spearing has occurred on Pipe Lake since 1992, with the exception of 1997 and 1998. Walleye spearing totals have ranged from 27 in 1996 to 62 in 1995, with a mean of 52.

Smallmouth Bass

1. In 1995, the adult smallmouth bass population was estimated at 1,201, or 3.5 adults per acre. Catch per effort in past surveys indicates that smallmouth bass have been the most abundant gamefish in Pipe Lakes.
2. In 1995, many of the captured smallmouth (47%) were in the 9.0 to 11.9 inch size range. Eight percent were 14 inches or larger, and the largest was 17.4 inches. Growth of smallmouth bass was below average.
3. In 1995, 33% of the total fishing pressure was directed at smallmouth bass and harvest was estimated at 265 (0.8/acre). The release rate of caught bass was 91%.

Largemouth Bass

1. In 1995, the adult largemouth bass population was estimated at 719, or 2.1 adults per acre. Catch per effort from past surveys indicate that the largemouth bass population has normally been fairly low.
2. In 1995, 20% of the captured bass were 14 inches or larger, and bass up to 20.9 inches were captured. Growth of largemouth bass was slightly below normal.
3. In 1995, 19% of total fishing pressure was directed at largemouth bass, and harvest was estimated at 128 (0.4/acre). The release rate of caught bass was 88%.

Northern Pike

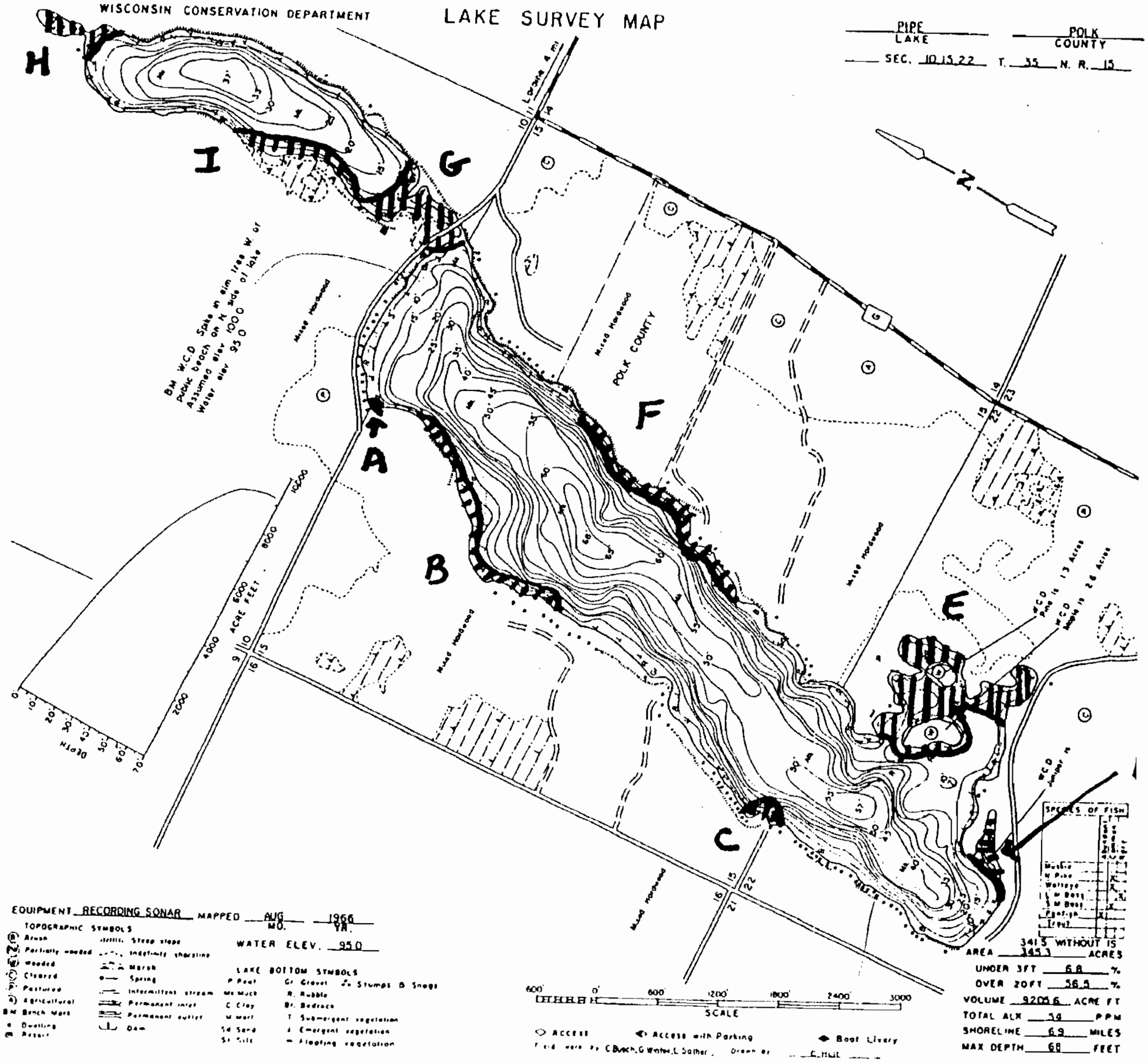
1. In 1995, the adult northern pike population was estimated at 458, or 1.3 adults per acre. Catch per effort from past surveys indicate that the northern pike population has normally been fairly low.
2. In 1995, 21% of the netted northerns were 22.0 inches or larger, and the largest was 27.9 inches. Growth of northern pike was above average.
3. In 1995, 8% of total fishing pressure was directed at northern pike, and harvest was estimated at 74 (0.2/acre).

Panfish

1. Nets were set to sample panfish in 1995. Bluegills were captured in the greatest numbers by a wide margin, while other panfish captured were rock bass, black crappies, yellow bullheads, green sunfish, hybrid sunfish, yellow perch, and black bullheads.
2. In 1995, the size distribution of the bluegill population was good, as 48% of the captured bluegills were 6.0 inches or larger, and 17% were 7.0 inches or larger. The largest bluegill captured was 8.7 inches.
3. In 1995, 22% of total fishing pressure was directed at panfish, mostly for bluegills (14%) and crappies (5%). Bluegills were harvested in the highest numbers (5.5/acre) followed by crappies (1.2/acre).

Management Recommendations

1. Trial stocking of walleye fingerlings at the rate of 50 per acre on alternate years.
2. Current statewide fishing regulations are likely appropriate, although walleye exploitation was high in 1995.
3. Habitat sensitive areas have been identified for Pipe Lake (see map). These include sensitive areas that contain aquatic plant communities which provide important fish and wildlife habitat. Sites A, D, E, G, H, and I. These sites provide spawning habitat for northern pike, bass, and panfish, nursery and feeding areas for fish, and habitat for waterfowl, furbearers, reptiles, and amphibians. Sensitive areas which contain gravel, rock, and rubble substrate for walleye spawning are sites B, C, and F. All these sites should be left in as natural a state as possible, and should not be altered.
4. Fish cribs could provide additional fish habitat. Half logs could enhance smallmouth bass spawning.
5. Additional walleye spawning areas could be developed with the addition of rock substrate.



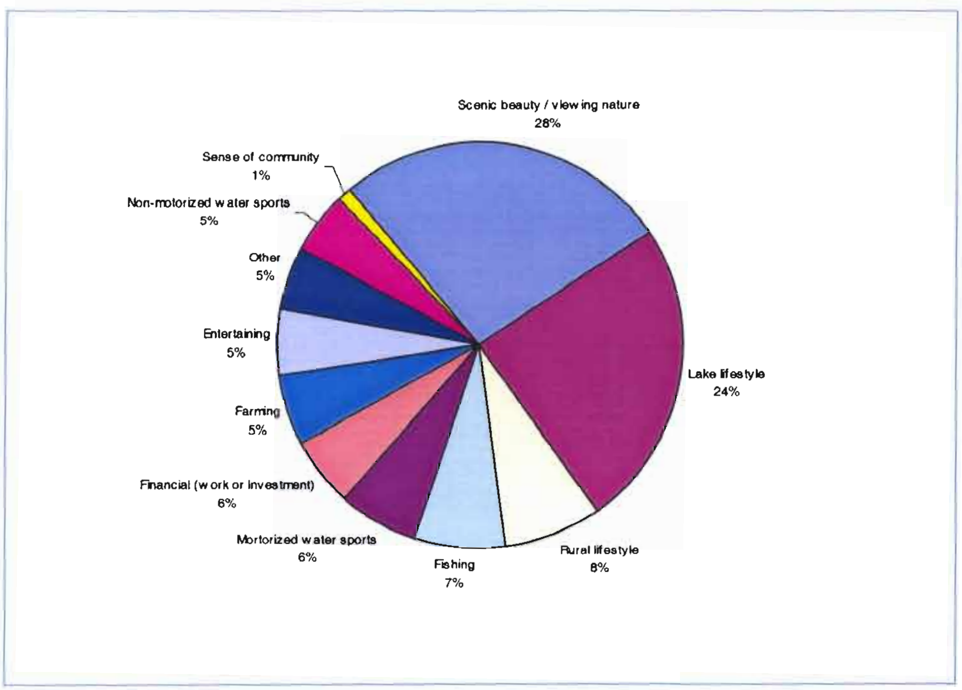
Sensitive areas as related to fish habitat were delineated by the WDNR.

5. Lake and Watershed Assessment

Overview: This section presents several topics that address lake water quality. First there is a summary of lake resident inputs concerning lake conditions. This is followed by a comparison of the Pipe Lakes the ecoregion lakes. Larry Bresina describes the current trophic status of the lakes, and then lake goals are presented. Lastly a water quality improvement strategy is given.

5.1. Lake Questionnaire Results

The Pipe Lakes questionnaire was developed to better understand the concerns, goals, and attitudes of homeowners living around the lake. It was sent out in 2000. Their thoughts and ideas about the use and the quality of your lake are summarized below.



One of the questions asked in the survey was: *"What is the most important reason that you own property on or near Pipe Lake?"*

5.2. Pipe Lakes Status

Ecoregion Comparisons: The water quality of Pipe Lake is excellent and the water quality of North Pipe Lake is fair.

One way to compare the status of Pipe Lakes is to compare them to other lakes in a similar setting or ecoregion. Ecoregions are geographic regions that have similar geology, soils, and land use. The continental United States has been divided into 84 ecoregions, and there are six ecoregions in Wisconsin. A map of Wisconsin ecoregions is shown in Figure 23. The Pipe Lakes are in the North Central Hardwood Forest ecoregion but close to the Northern Lakes and Forests ecoregion (Figure 28). Lakes in this area of the state have some of the best water quality values in the State. A range of ecoregion values for lakes in the two ecoregions along with actual the Pipe Lakes data are shown in Table 22.

Table 22. Summer average quality characteristics for lakes in the Northern Lakes and Forest ecoregion (Minnesota Pollution Control Agency, 1988).

Parameter	Northern Lakes & Forests Ecoregion Values	North Central Hardwood Forest Ecoregion Values	North Pipe Lake (summer average 2001-2003)	Pipe Lake (summer average 2001-2003)
Total phosphorus (μg/l) - top	14 - 27	23 - 50	32	12
Algae [as Chlorophyll (μg/l)]	<10	5 - 22	26	4
Chlorophyll - max (μg/l)	<15	7 - 37	63	7
Secchi disc (ft)	8 - 15	4.9 - 10.5	6.6	15.1
Conductivity (umhos/cm)	50 - 250	300 - 400	20	21

For the broad range of ecoregion values, North Pipe is within ecoregion values for the North Central Hardwood Forest ecoregion for total phosphorus and Secchi disc but is out of range for algae. The water quality of Pipe Lake is better than the ranges given for the North Central Hardwood Forest ecoregion water quality values for total phosphorus and clarity and is within range for algae. Pipe Lake has water quality that is comparable to lakes in the Northern Lakes and Forest Ecoregion.

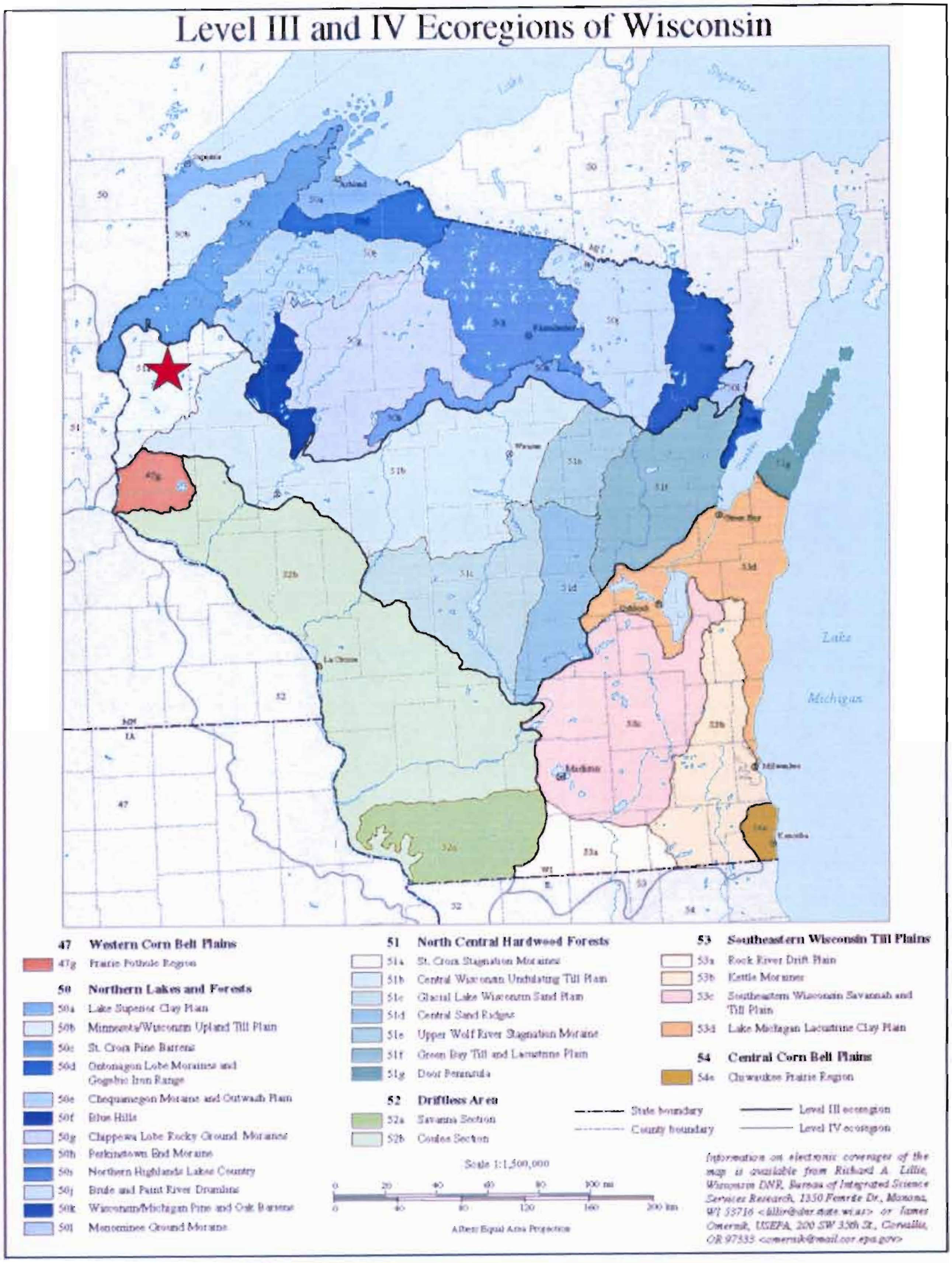


Figure 23. Ecoregion map for Wisconsin. Areas that are labeled with a "50" are within the Northern Lakes and Forest Ecoregion. Areas labeled with a "51" are in the North Central Hardwood Forest Ecoregion. The Pipe Lakes, located in central Polk County are officially in the North Central Hardwood Forest Ecoregion but close to the Northern Lakes and Forest Ecoregion.

Ecoregion Comparisons Based on the Pipe Lakes Watershed Size:
A lake model approach that incorporates the actual watershed size for a lake gives a more refined prediction for what ecoregion lake values should be for a given lake. An ecoregion lake model is a mathematical equation that uses ecoregion stream phosphorus inputs along with lake and watershed characteristics to predict what a lake phosphorus concentration should be. Once a lake phosphorus concentration is determined, then seasonal water clarity and algae concentrations are calculated as well.

Ecoregion lake models for North Pipe and Pipe Lakes were run using North Central Hardwood Forest Ecoregion inputs and the results were compared to observed lake conditions for 2003. Results are shown in Figures 24 and 25. Water quality in the Pipe Lakes is good to excellent.

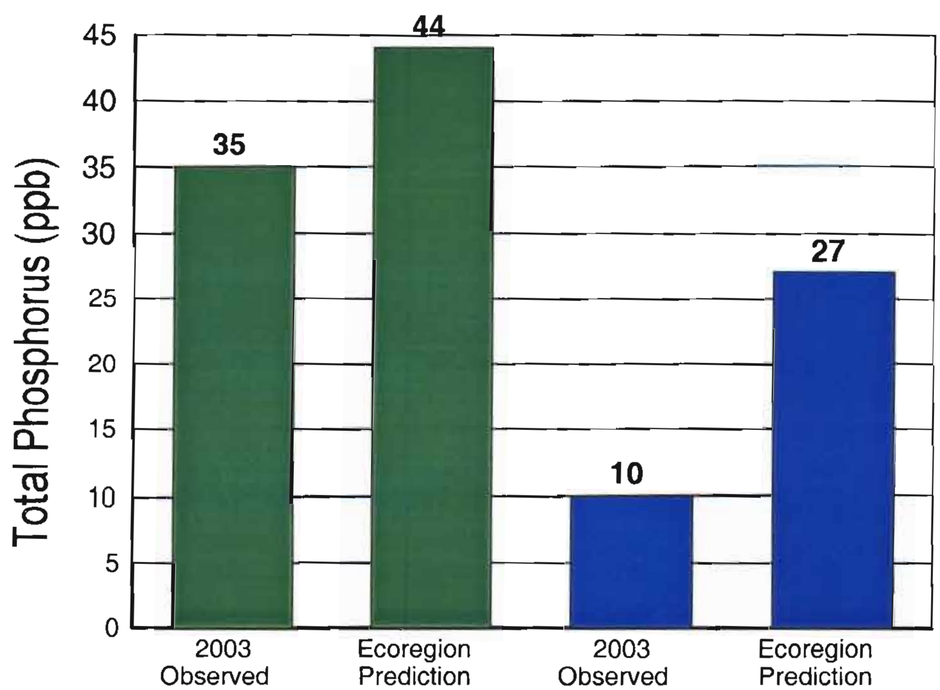
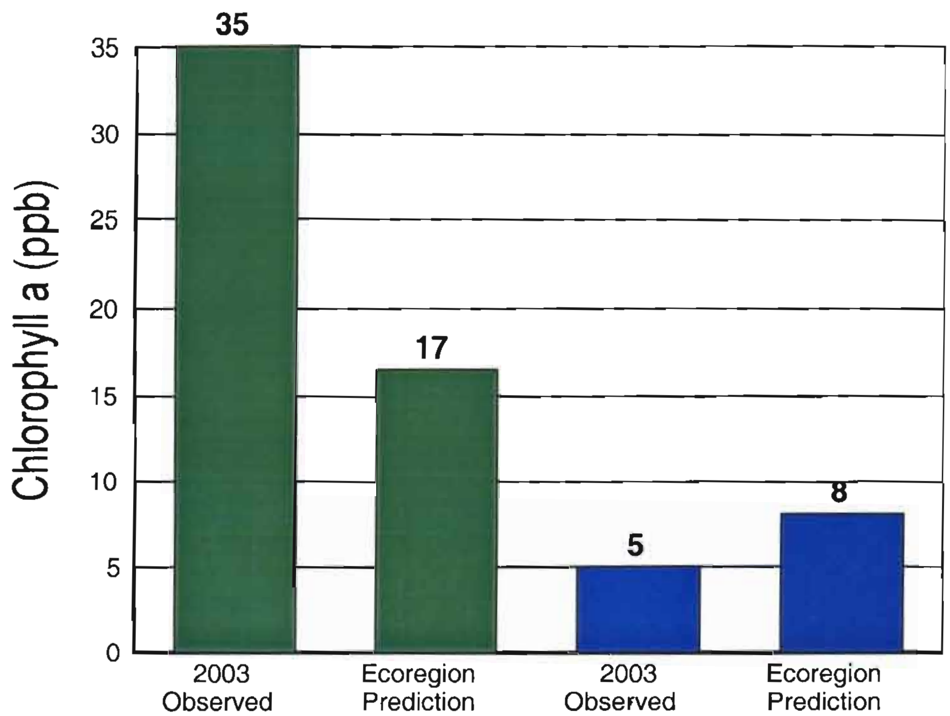


Figure 24. Comparison of total phosphorus conditions for the Pipe Lakes in 2003 to predicted conditions for a lake and watershed with the size of North Pipe and Pipe Lakes situated in the North Central Hardwood Forest ecoregion. Green bars are North Pipe and blue bars are Pipe Lake.



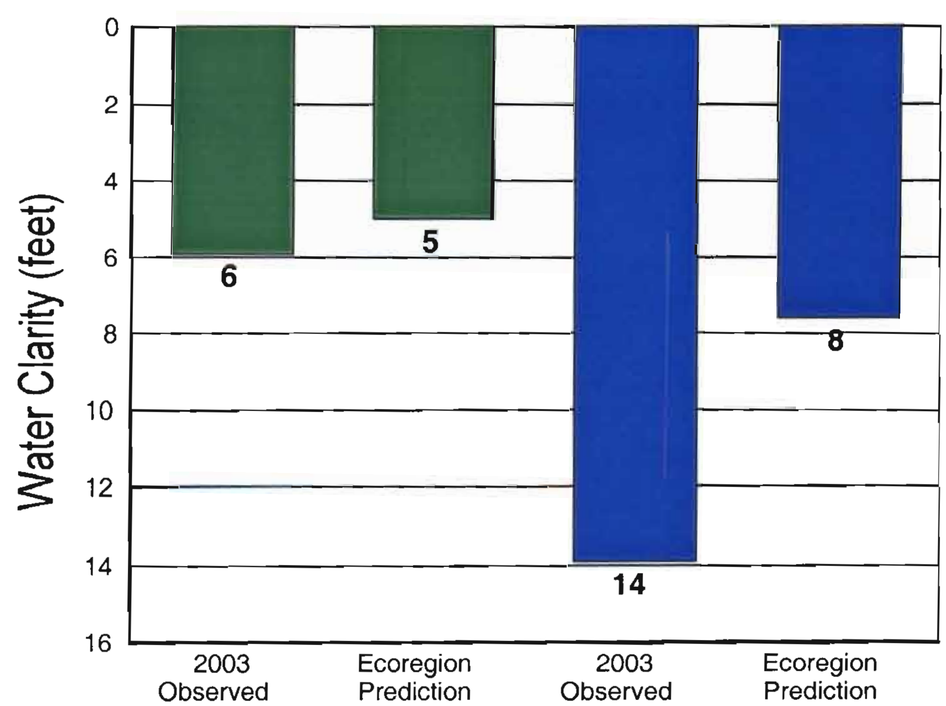


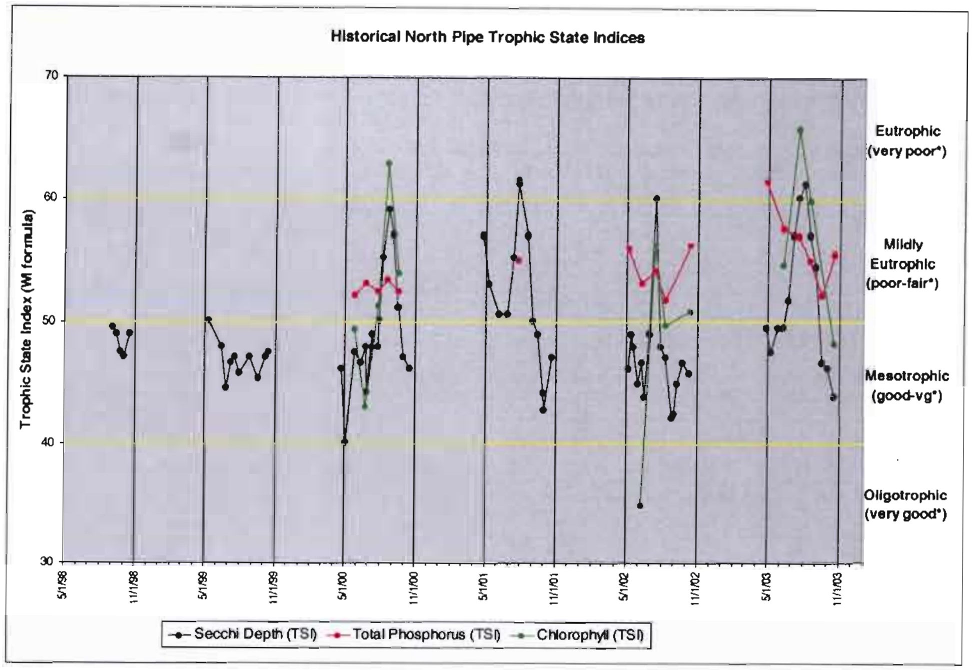
Figure 25. Comparison of chlorophyll a and water clarity conditions for the Pipe Lakes in 2003 to predicted conditions for a lake and watershed with the size of North Pipe and Pipe Lakes situated in the North Central Hardwood Forest ecoregion. Green bars are North Pipe Lake and blue bars are Pipe Lake.

5.3. Trophic State Index for the Pipe Lakes (*prepared by Larry Bresina*)

The Wisconsin DNR uses Carlson's trophic state index to describe the degree of eutrophication or nutrient richness of lakes. This index has a scale from 0 (very clear water) to 100 (very turbid water) and can portray on the same scale the Secchi depth (water clarity), the amount of chlorophyll in the water, or the amount of phosphorus in the water. A trophic state index of 0 corresponds to a Secchi depth of 210 feet. An index of 50 corresponds to a Secchi depth of 6.6 feet. A value of 100 corresponds to a Secchi depth of 2.5 inches. Based on data from many lakes, a relationship among Secchi depth, chlorophyll concentration, and total phosphorus concentration has been developed for Wisconsin lakes. So if the lake being studied is an "average" Wisconsin lake and its trophic state index is 50 based on measuring only the chlorophyll or total phosphorus concentration, the Secchi depth can be accurately predicted to be 6.6 feet (2 meters).

Figure 26 shows historical trophic state indexes or TSI data for Pipe Lake as determined by measuring the Secchi depth, chlorophyll concentration, and the total phosphorus concentration. Note that the chlorophyll and phosphorus TSI values tend to be higher than the Secchi TSI values. These differences are clues that the lake is clearer than would be expected. The Secchi values are mostly in the oligotrophic (low productivity, Secchi depth below 13.1 feet) region while the chlorophyll and phosphorus values are mostly in the mesotrophic (middle productivity, Secchi depth of 6.6-13.1 feet) region.

The trophic state index chart for North Pipe Lake (Figure 26) has chlorophyll and phosphorus values hovering closer to the Secchi values than for Pipe Lake. The phosphorus levels in North Pipe Lake were much higher in the spring of 2003 than previously measured. This high spring level may have contributed to the more severe reduction in clarity during the summer than has been previously measured. The TSI values range from mesotrophic to eutrophic. Mildly eutrophic is between 6.6 and 3.3 feet Secchi depth. Eutrophic is less than 3.3 feet Secchi depth.



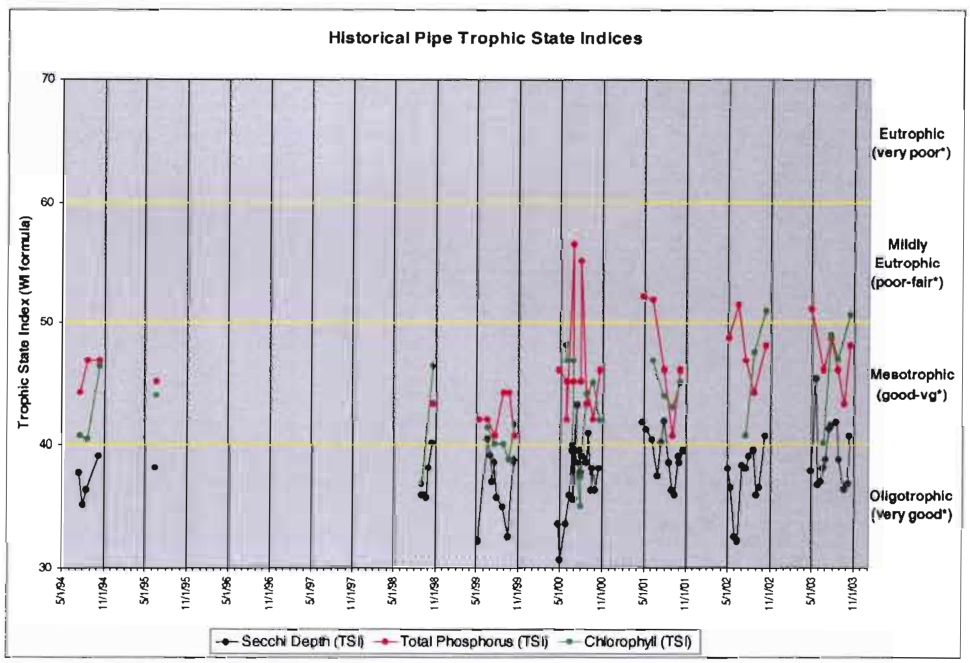


Figure 26. The Trophic State Index (TSI) converts values collected for Secchi disc transparency, total phosphorus, and chlorophyll into a scale from roughly 1 to 100, with 1 being the best water quality. All three water quality parameters are related and a TSI value is often the same for all three parameters. For North Pipe (top graph) the Secchi disc TSI is lower than chlorophyll and phosphorus. For Pipe Lake the Secchi TSI is also better (meaning there is a lower TSI value) than the TSI for chlorophyll and phosphorus. In these cases, water clarity is better than would be expected based on TSI conversions.

5.4. Setting Water Quality Goals for the Pipe Lakes

Although the water quality of Pipe Lake is excellent and the water quality in North Pipe Lake is fair, based on ecoregion models, lake residents have noticed a decline in water clarity over the years.

Indeed, water clarity records indicate both lakes have been more clear in the recent past compared to 2003. A water clarity goal for each lake was proposed by the Water Quality Committee in April 2004. The water clarity goals were:

> **North Pipe Lake: improve clarity by 2 feet for a summer average of 8.6 feet**
> **Pipe Lake: improve clarity by 4 feet for a summer average of 19.1 feet**

Both lakes have come close to these summer average transparencies in the recent past.

To determine the feasibility of these goals, lake models were run to determine what watershed nutrient reductions in the form of lower stream phosphorus concentrations would be needed to meet the goals. Results are shown in Tables 23 and 24.

For North Pipe, the existing phosphorus load is estimated at 58 kg/year (based on using the WDNR LEAP model, and using the known lake phosphorus concentration and back calculating to find the loading that would give that concentration)(Figure 27). Watershed nutrient reductions would need to be reduced by 40% to meet the 8.6 foot clarity goal. This is ambitious, but may be feasible. However, for Pipe Lake, the phosphorus reduction goal will be more difficult to attain. Currently, it is estimated that the phosphorus load to Pipe Lake is 59 kg/yr (also derived from the LEAP model)(Figure 27). The lake model indicates the average stream phosphorus concentration would have to be reduced to 1 ppb. This is not feasible. However, because Pipe Lake has had clarity approaching the 19-foot goal in the past, there must be other factors in place that are contributing to the excellent water clarity in Pipe Lake.

The best guess for an explanation of why Pipe Lake is so clear is probably related to a biological phenomenon, and more specifically to the feeding activities of zooplankton. Zooplankton feed on algae. It's possible that an above average zooplankton population exists in Pipe Lake and may account for better than expected water clarity. More sampling is needed to document zooplankton conditions. To maintain or improve water clarity in Pipe Lake, the emphasis will be on promoting biological approaches in order to meet the clarity goals.

Table 23. Existing conditions and water clarity goals for North Pipe and Pipe Lakes.

	Existing Condition	Goal	Comments
North Pipe			
Secchi disc (ft) (Range of seasonal ave)	6.6 (3 yr ave) (5.9-8.1)	8.6 --	Ambitious goal based on ecoregion reference lakes.
Stream phosphorus concentration (ppb)	87 (estimated)	48 (predicted)	Average stream phosphorus concentration needed to meet goal is 48 ppb. Will be difficult to achieve.
Pipe Lake			
Secchi disc (ft) (Range of seasonal ave)	15.1 (3 yr ave) (13.9 - 18.6)	19.1 --	Ambitious goal based on ecoregion reference lakes.
Stream phosphorus concentration (ppb)	20 (estimated)	1 (predicted)	Average stream phosphorus concentration needed to meet goal is 1 ppb. This is not feasible. However, Secchi disc clarity in 1999 was 18.6 feet. Indicates something is helping reduce phosphorus in the lake. Zooplankton activities are suspected of keeping the lake clearer than would be expected.

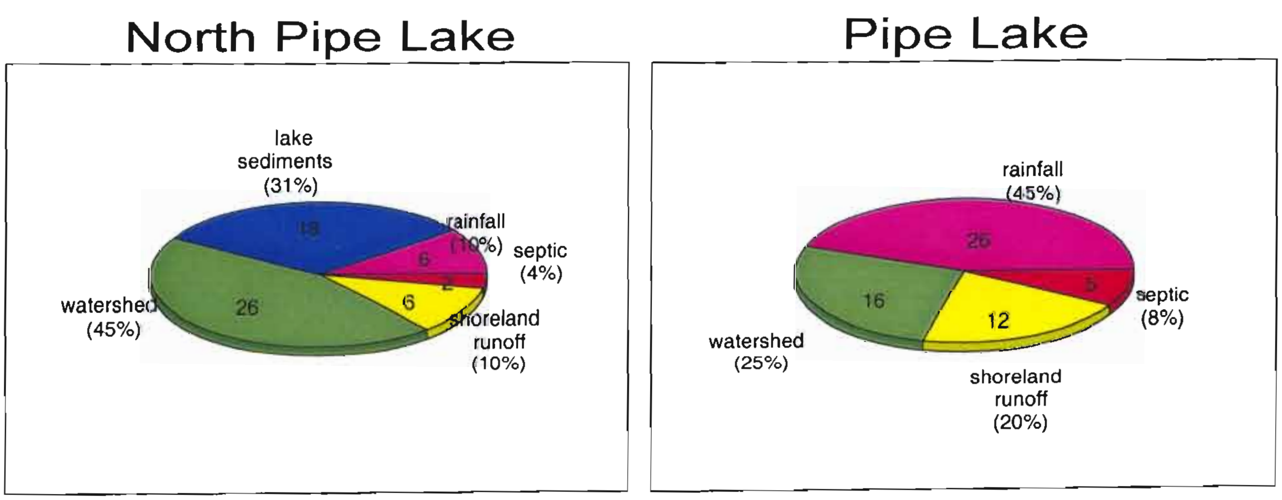


Figure 27. Sources of phosphorus (P) that feed into the Pipe Lakes are shown above. It is estimated that approximately 58 kilograms of phosphorus enter North Pipe Lake annually and 59 kilograms of phosphorus enter Pipe Lake annually.

Several types of modeling approaches were used to generate lake water quality values in Table 24.

Table 24. Lake model predictions for North Pipe and Pipe Lakes. NCHF = North Central Hardwood Forest Ecoregion and NLF = Northern Lakes and Forests Ecoregion.

	Existing Conditions (3 year ave)	Ecoregion Data for NCHF	Ecoregion Data for NLF	Lake Clarity Goals (with other data shown)
North Pipe Lake				
Stream conc (ppb)	87 (stream p conc estimated based on obs. lake p conc)	148 (ecoregion conc used in model)	52 (ecoregion conc used in model)	48 (stream conc needed to meet clarity goal)
Rainfall conc (ppb)	40	40	20	40
TP load (kg)	58	94	57	36
Ave TP inflow conc (ppb)	99	159	54	61
TP (ppb)	32 (observed)	44	25	23
Secchi (ft)	6.6 (observed)	5.0 (predicted from model)	7.9 (predicted from model)	8.6 (clarity goal set by Lake Dist.)
Chl a (ppb)	26 (observed)	17	7	6
Pipe Lake				
Stream conc (ppb)	20 (stream p conc estimated based on obs. lake p conc)	148 (ecoregion conc used in model)	52 (ecoregion conc used in model)	1 (stream conc needed to meet clarity goal)
Rainfall conc (ppb)	40	40	20	40
TP load (kg)	59	206	123	37
Ave TP inflow conc (ppb)	49	172	57	31
TP (ppb)	12 (observed)	27	17	9
Secchi (ft)	15.1 (observed)	7.6 (predicted from model)	11.2 (predicted from model)	19.1 (clarity goal set by Lake Dist.)
Chl a (ppb)	4 (observed)	8	4	2

Calibration values for lake model:
Precip: 0.75 m/yr — Evap: 0.71 m/yr
Runoff: 0.13 m/yr — Atmo. Load: kg/km^2/yr: 30 (NCHF); 15 (NLF)
Rainfall TP: 40 ppb (NCHF); 20 ppb (NLF)

5.5. Water Quality Improvement Strategy

North Pipe can gain potential water quality improvements from watershed projects that address streambank erosion. This may be a way to reduce phosphorus loading and improve clarity. It also appears there is an additional phosphorus source that is impacting North Pipe Lakes and elevating the phosphorus concentration. The phosphorus source is likely the lake sediments. Lake water quality probably will improve only slightly unless the lake sediment phosphorus source is reduced.

There are two good techniques to choose from for reducing phosphorus release from lake sediments: summer aeration or alum. Lakes in Polk County have examples of each technique. Cedar Lake has had aeration for several years and Lake Wapagasset had an alum treatment in 2001. In each case, water quality improvements have been modest. There is no guarantee that either technique will work for sure.

The best candidate technique to reduce sediment phosphorus release in North Pipe Lake is alum, but it would be expensive, costing around $50,000. If the alum treatment was 100% effective in reducing the excessive phosphorus release from lake sediments, lake phosphorus levels would drop slightly in the lake and transparency would increase by about 1.0 feet as a seasonal average. There is no guarantee the effect would last longer than several years. This is a project to consider as a last resort.

The best ways to improve clarity conditions in Pipe Lake are three-fold: improve water quality in North Pipe Lake (which will help Pipe Lake), improve shoreland buffers, and optimize the biological influence of zooplankton in Pipe Lake.

List of Lake Improvement Project Areas for the Pipe Lakes

1. Watershed projects.
2. On-site system maintenance.
3. Landscaping projects.
4. Aquatic plant projects
5. Fish management options.
6. Education program.
7. Watershed and lake monitoring program.

6. Lake Project Ideas for Protecting the Lake Environment (which includes water quality and wildlife)

Project ideas for the Pipe Lakes Lake are geared toward long-term protection of water quality and improving clarity in North Pipe and Pipe Lakes.

A list of recommended projects is shown below and in Table 25:
1. Watershed projects - agricultural.
2. Watershed projects - forests and wetlands.
3. Watershed projects - streams.
4. On-site system maintenance.
5. Shoreland protection and enhancement (Landscaping projects).
6. Aquatic plant projects.
7. Fish management options.
8. In-lake clarity improvement projects.
9. Ongoing education program.
10. Watershed and lake monitoring program.

Table 25. Project list with priority status, roles of various groups, and costs.

	Priority	Groups that Should Be Involved	Costs
1. Watershed projects - agricultural	medium	Polk Co, Lake Dist	volunteer time
2. Watershed projects - forests and wetlands	medium	Lake Dist, Polk Co	volunteer time
3. Watershed projects - streams	high	Lake Dist, Polk Co, Consultant	$10/foot of streambank restored
4. On-site system maintenance	medium	Polk Co, Lake Dist	volunteer time
5. Shoreland protection and enhancement	high	Lake Dist, Polk Co, Consultant	$1,000/lot
6. Aquatic plant projects	high	Lake Dist, Consultant	$4,000
7. Fish management options	medium	Lake Dist, WDNR	volunteer time
8. In-lake clarity improvement projects	high-medium	Lake Dist, Consultant, WDNR	Initial cost is low. However it could be $50,000 if alum is considered
9. Ongoing education program	high	Lake Dist	volunteer time
10. Watershed and lake monitoring program	high	Lake Dist, WDNR	volunteer time and $500+/year

Details for these projects areas are given in the next few pages.

Project 1. Watershed Projects - agricultural

County Soil and Water Conservation Departments recommend that when farmers grow row crops, the following three practices should be considered: conservation tillage, including either no-till or reduced till, grass swales.

Basic Program: Contact the Polk County Land and Water Resources Department and review and discuss existing acres of agricultural land and existing farming practices. Prepare a written summary along with maps and photos.

Advanced Program: Work with the County LWRD to implement a cost share program for installing best management practices on the critical land areas.

Project 2. Watershed Projects - forests and wetlands

Forest and wetlands are significant natural features and should be characterized and protected.

Basic Program: Maintain a photolog of typical forest and wetland areas to serve as a benchmark for future reference. Sample open water wetlands for total phosphorus once or twice a summer. Conduct sampling every couple of years.

Figure 28. [left] Forest setting in North Pipe watershed in subwatershed NP1-E2. [right] Wetland in North Pipe watershed in subwatershed NP1-N.

Project 3. Watershed Projects - streams

Basic Program: Continue to monitor watershed streams and analyze samples for total phosphorus and total suspended solids (TSS). If a seasonal average exceeds 150 ppb of phosphorus (as a flow-weighted mean), stream watershed work should be considered. If phosphorus levels become elevated, determine if TSS is the source of the high phosphorus. It may be that stream channel restoration should be considered.

Advanced Program: Based on the stream inventory conducted by lake resident volunteers, there are stretches where tributary streambanks are eroding. The Lake District should contract with the County Resources Department or a consulting engineer to use biostabilization techniques to stabilize eroding streambanks.

Figure 29. [left] Streambank section in subwatershed NP1-E3. [right] Streambank section in subwatershed NP1-W2.

Project 4. On-site System Maintenance

The septic tank/soil absorption field has been one of the most popular forms of on-site wastewater treatment for years. When soil conditions are proper and the system is well maintained, this is a very good system for wastewater treatment. The on-site system is the dominant type of wastewater treatment found around the Pipe Lakes today.

However, problems can develop if the on-site system has not been designed properly or well-maintained. Around Pipe Lakes there are probably some on-site systems that need maintenance and upgrades. At the same time, it is good practice to ensure that systems that are functioning adequately now will continue to do so in the future.

Basic Program: This project calls for an organized program to be developed that makes homeowners aware of all they can do to maintain their on-site systems.

A description of possible activities associated with the on-site maintenance program are described below:

Workshop: A workshop should be scheduled for the Pipe Lakes Watershed residents to demonstrate the installation of a conforming septic system and the proper care and maintenance of a septic tank and septic system.

Septic Tank Pumping Campaign: Polk County requires that septic tanks associated with a permanent residence pumped 2-3 years in the shoreland area to help reduce phosphorous loading to the septic system drainfield.

Ordinance Implementation: Work to implement and then get enforcement of a county ordinance, where septic systems must be "evaluated" at the time a property is transferred.

Advanced: There is little evidence of failing onsite systems based on shoreland setback distances and the septic leachate survey. However there are soil limitations in the shoreland area. As an advanced education tool, contract with the County to randomly select 10% of the systems around the lake and conduct an onsite inspection. Publish the results in a newsletter.

Project 5. Shoreland Protection and Enhancement - landscaping projects

Controls are in place at the county level to guide new shoreland development. However for existing properties, it is important to either maintain or to improve the natural vegetative buffer. A summary of Wisconsin Shoreland rules and regulations (NR115) is given in Appendix A.

The shoreland area is valuable for promoting a natural lake environment and a natural lake experience for lake users. The shoreland is defined as the upland area about 300 to 1,000 feet back from the shoreline, and out into the lake to about the end of your dock (Figure 30). A shoreland with native vegetation offers more wildlife and water quality benefits than a lawn that extends to the lake's edge. A summary of attributes and functions of native plants in the shoreland area is shown in Table 26.

Figure 30. Cross section of the lake shoreland habitat.

Table 26. Attributes and functions of native plants in the shoreland area (Source: Henderson and others, 1999. Lakescaping for Wildlife and Water Quality. MnDNR).

Important functions of plants in and around lakes
Submergent and emergent plants

- Plants produce leaves and stems (carbohydrates) that fuel an immense food web.
- Aquatic plants produce oxygen through photosynthesis. The oxygen is released into lake water.
- Submerged and emergent plants provide underwater cover for fish, amphibians, birds, insects, and many other organisms.
- Underwater plants provide a surface for algae and bacteria to adhere to. These important microorganisms break down polluting nutrients and chemicals in lake water and are an important source of food for organisms higher in the food chain.
- Emergent plants break the energy of waves with their multitude of flexible stems, lessening the water's impact on bank and thus preventing erosion.
- Plants stabilize bottom sediments, which otherwise can be resuspended by currents and wave action. This reduces turbidity and nutrient cycling in the lake.

Shoreline and upland plants

- Shoreline and upland plants provide food and cover for a variety of birds, amphibians, insects, and mammals above the water.
- The extensive root systems of shoreline plants stabilize lake-bank soils against pounding waves.
- Plants growing on upland slopes that reach down to lake hold soil in place against the eroding forces of water running over the ground, and help to keep lake water clean.
- Upland plants absorb nutrients, like phosphorus and nitrogen, found in fertilizers and animal waste, which in excessive concentrations are lake pollutants.

Basic Program: Improving Upland Native Landscape Conditions: In the glacial lake states, three broad vegetative groups occur: pine forests with a variety of ground cover species including shrubs and sedges: hardwood forests with a variety of understory species, including ferns: and tallgrass prairie with a variety of grasses as well as bur oaks and willow trees. Residences around the Pipe Lakes are in the hardwood forest group.

Reestablishing native conditions in the shoreland area not only improves stormwater runoff quality, it also attracts a variety of wildlife and waterfowl to the shoreland area. Benefits multiply when other neighbors naturalize because the effects are cumulative and significant for water quality and wildlife habitat.

When installing native vegetation close to the shoreline residents are actually installing a buffer. A buffer is a strip of native vegetation wide-enough to produce water quality and wildlife improvements. Much of the natural vegetative buffer has been lost in shoreland areas with development where lawns have been extended right down to the shore.

Lawns are not necessarily bad for a lake. However they can be over fertilized and then runoff carries phosphorus to the lake. Also, lawns function as a low grade open prairie, with poor cover for wildlife and a food supply that is generally poor, except for geese who may find it attractive. Replacing lawn areas with native landscaping projects reduces the need for fertilizer, reduces the time it takes to mow, increases the natural beauty of a shoreland area, and attracts wildlife.

Lawns do not make very good upland buffers. With runoff, short grass blades bend and do not serve as a very effective filter. Tall grass that remains upright with runoff is a better filter. Kentucky bluegrass (which actually is an exotic grass) is shallow-rooted and does not protect soil near shorelines as well as deep-rooted native prairie grasses, shrubs, or other perennials. Grass up to the shoreline offers poor cover, so predators visit other hiding areas more frequently reducing the prey food base and limiting predator populations in the long run. Also with short ground cover, ground temperatures increase in summer, evapotranspiration increases and results in drying conditions, reducing habitat for frogs and shoreline dependent animals.

Buffer Strip Considerations: A functional upland buffer should be at least 15 feet deep. With this you start getting water quality and wildlife habitat benefits. But a 35 foot deep buffer is recommended. In the past, before lakeshore development, buffers ringed the entire lake. For lakeshore residents it is recommended the length of the buffer extend for 75% of the shoreline, although 50% would produce buffer benefits.

A buffer strip can address two problem areas right away. Geese are shy about walking through tall grass because of the threat of predators. There will always be a few who charge right through but it is a deterrent for most of them. Also, muskrats shouldn't be a problem. They may burrow into the bank, but generally not more then 10 feet. With a buffer going back 15 to 25 feet, you won't be mowing over their dens. An occasional den shouldn't produce muskrat densities that limit desirable aquatic vegetation.

Several types of buffers can be installed or propagated that offer nutrient removal as well as wildlife benefits. Examples include:

Tall grass, sedge, flower buffer: Provides nesting cover for mallards, blue-winged teal and Canada geese. Provides above ground nesting

habitat for sedge wrens, common yellow throat and others.
Shrub and brush buffer: Provides nesting habitat for lakeside songbirds such as yellow warblers, common yellowthroat, swamp sparrows, and flycatchers. It also provides significant cover during migration.
Forested buffers: Provides habitat for nesting warblers and yellow-throated vireo, Diamond herons, woodducks, hocked mergansers, and others. Upland birds such as red-winged blackbirds, orioles, and woodpeckers use the forest edge for nesting and feeding habitat.

Even standing dead trees, which are referred to as snags, have a critical role. When they are left standing they serve as perching sites for kingfishers and provide nesting sites for herons, egrets, eagles, and ospreys. In the midwest over 40 bird species and 25 mammal species use snags. To be useful, they should be at least 15 feet tall and 6-inches in diameter.

The initial step for lake residents to get started is to simply make a commitment to try something. Just what the final commitment is evolves as they go through a selection process. The next step in the process is to conduct a site inventory. On a map with lot boundaries, house and buildings, driveway, turf areas, trees, shrubs, and other features are drawn. If there is a chance, the property is checked during a rainstorm. Look for sources of runoff and even flag the routes. Find out where the water from the roof goes, and see if there are temporary ponding and infiltration areas. Are the paths down to the lake eroding? Then the next step is to consider a planting approach.

Native Landscaping for Buffers: Three Approaches: Native landscaping efforts can be put into three categories:

1. Naturalization
2. Accelerated Naturalization
3. Reconstruction

1. Naturalization: With this approach, the resident is going to allow an area to go natural. Whatever is present in the seedbank is what will grow. If they want to install a buffer along the shoreline, let a band of vegetation grow at least 15 feet deep from the shoreline back and preferably 25 feet or deeper. Just by not mowing will do the trick. Residents can check how it looks at the end of the summer. It will take up to three years for flowers and native grasses to grow up and be noticed. Residents can also select other spots on their property to "naturalize".

2. Accelerated Naturalization: After developing a plant list of species from the area, residents may want to mimic some features right away.

They can lay out a planting scheme and plant right into existing vegetation. Several Wisconsin and Minnesota nurseries can supply native plant stock and seeds. The nurseries can also help select plants and offer planting tips. Wildflowers can be interspersed with wild grasses and sedges. Mulch around the new seedlings. With this approach lake residents can accelerate the naturalization process.

3. Reconstruction: To reestablish a native landscape with the resident's input and vision, another option is to reconstruct the site with all new plants. Again plant selection should be based on plants growing in the area. Site preparation is a key factor. Residents will want to eliminate invasive weeds and eliminate turf. This can be done with either herbicides or by laying down newsprint or other types of paper followed by 4 to 6 inches of hardwood mulch. Plantings are made through the mulch. This is the most expensive of the three native landscaping categories. Residents can do the reconstruction all at once, or phase it in over 3 to 5 years. This allows them to budget annually and continue evolving the plan as time goes by.

Also mixing and matching the level-of-effort categories allows planting flexibility. Maybe a homeowner employs naturalization along the sides of the lot and reconstruction for half of the shoreline and accelerated naturalization for the other half. Examples of the three approaches are shown in Figure 3.

A book that covers the shoreland improvements is "Lakescaping for Wildlife and Water Quality" by Carrol Henderson and others and is available from the Minnesota Department of Natural Resources for $21 (651.296.6157).

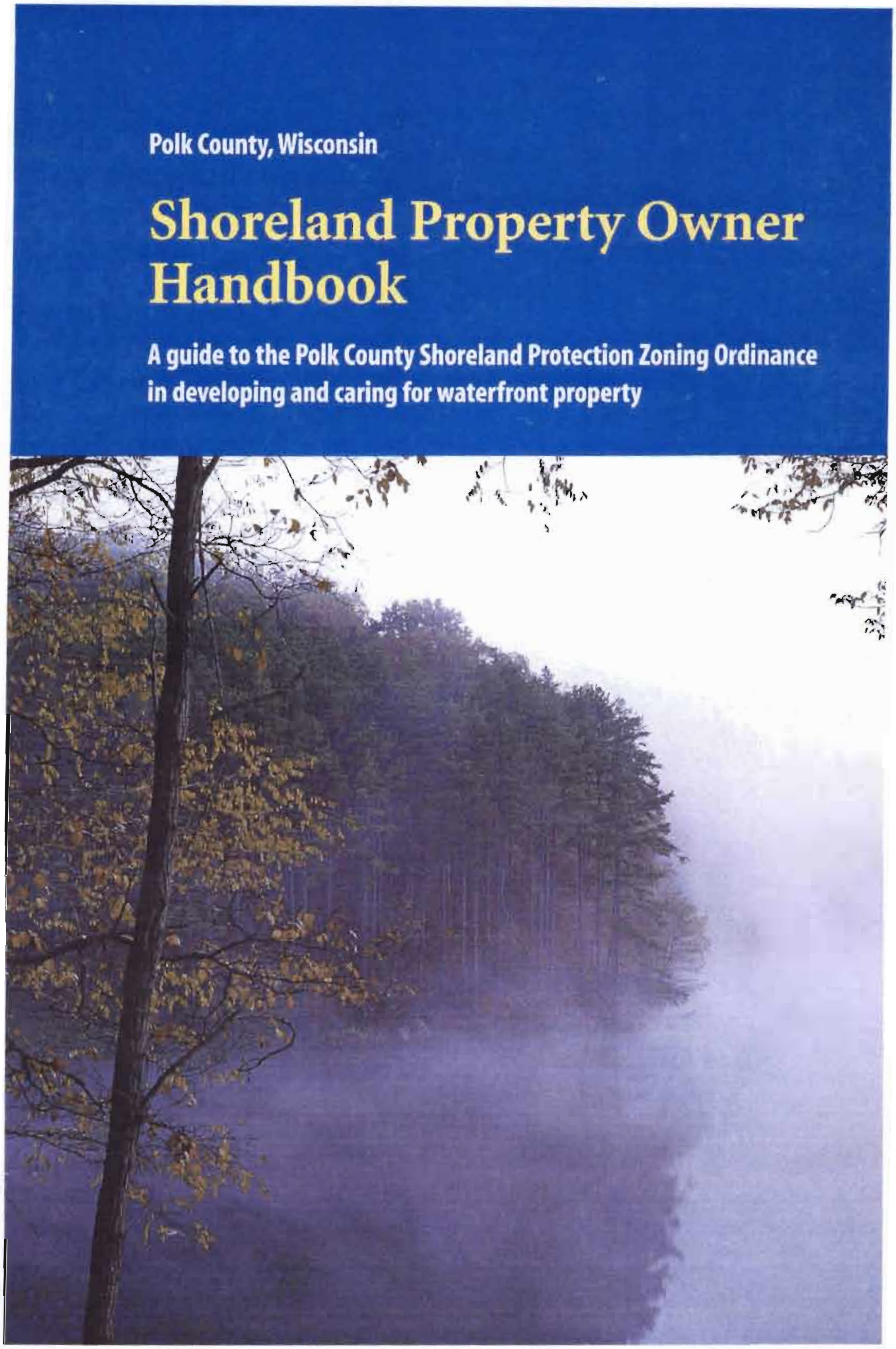
Advanced Program: Solicit two to four volunteer lake residents to install a shoreland restoration demonstration site on their property.

1. Naturalization: The easiest way to implement a natural shoreline setting is to select an area and leave it grow back naturally.

2. Accelerated Naturalization: To accelerate the naturalization, plant shrubs, wild flowers, or grasses into a shoreland area.

3. Restoration: This involves removing existing vegetation through the use of paper mats and/or mulching and planting a variety of native grasses, flowers, and shrubs into the shoreland area.

Examples of three shoreland management options.



A handy reference that should be utilized is the county's Shoreland Property Owner Handbook. Shown here is the cover, but these booklets are available from the Polk County Land and Water Resources Department, Balsam Lake, Wisconsin.

Project 6. Aquatic Plant Projects

A high priority lake protection recommendation is to maintain healthy native aquatic plant communities in the Pipe Lakes. Currently, the Pipe Lakes have a variety of emergent and submergent aquatic plant growth. Aquatic plants are vital for helping sustain clear water conditions and contribute to fish habitat (Figure 31). The challenge is to maintain and/or protect submerged aquatic plants in the Pipe Lakes.

Basic Program: Conduct a lake soil fertility survey by collecting up to 30 lake sediment samples from the Pipe Lakes to determine if soils can support native aquatic plant growth. Sample areas with plants and areas without plants. If soil fertility is similar, then something other than nutrients are inhibiting plant growth.

- Maintaining natural shoreland conditions can promote improved plant distribution because of improved water quality runoff.

- In the south end of Pipe Lakes, some small-scale aquatic plant removal in the form of creating channels to open water could be implemented. However, only the minimum amount of plants should be removed to allow navigation and mechanical means is recommended over chemical approaches. Plants in this end of the lake are important fish habitat. Rules for aquatic plant removal are given in Appendix B.

Advanced Program: Using the same sediments collected in the Basic Program, analyze for parameters that are indicators for potential nuisance growth of two exotic plants: curlyleaf pondweed and Eurasian watermilfoil. Neither of these exotic species is currently found in Pipe Lakes but if they should invade, knowing their potential for nuisance growth would be a helpful management tool.

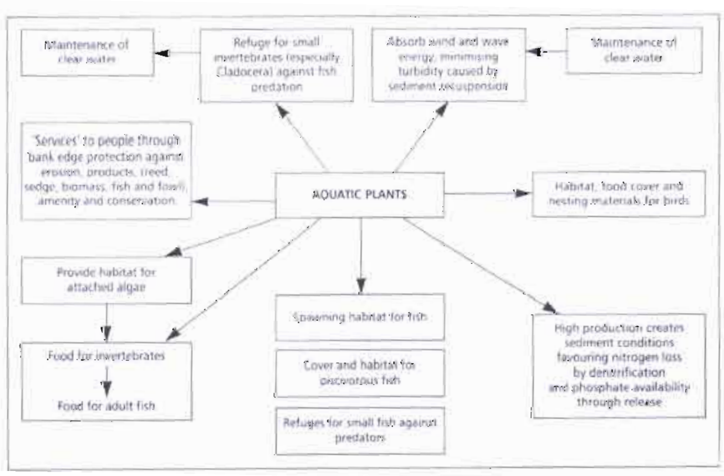


Figure 31. Links between aquatic plants and other organisms, including ourselves (source: Moss and others. 1996. A guide to the restoration of nutrient-enriched shallow lakes. Broads Authority Norwich, England).

Shallow coves and bays in North Pipe (shown above) and in Pipe (bottom photo) have the best aquatic plant growth. Otherwise plant growth is sparse along the sandy rocky shorelines of the Pipe Lakes.

Project 7. Fish Management Options

[Management recommendations are based on WDNR management plans]

Basic Program: Pipe Lakes has a balanced fish community based on WDNR records. Sensitive walleye and panfish spawning habitat should be recognized and published, but no new boating restrictions appear necessary at this time.

Advanced Program: Improving fish habitat such as downing small trees so they fall into the lake would promote smallmouth bass spawning habitat and is a potential project area in the future. Otherwise working with the WDNR on long term habitat protection is recommended.

Project 8. In-lake Clarity Improvement Projects

North Pipe Lake: The basic program involves several components such as:

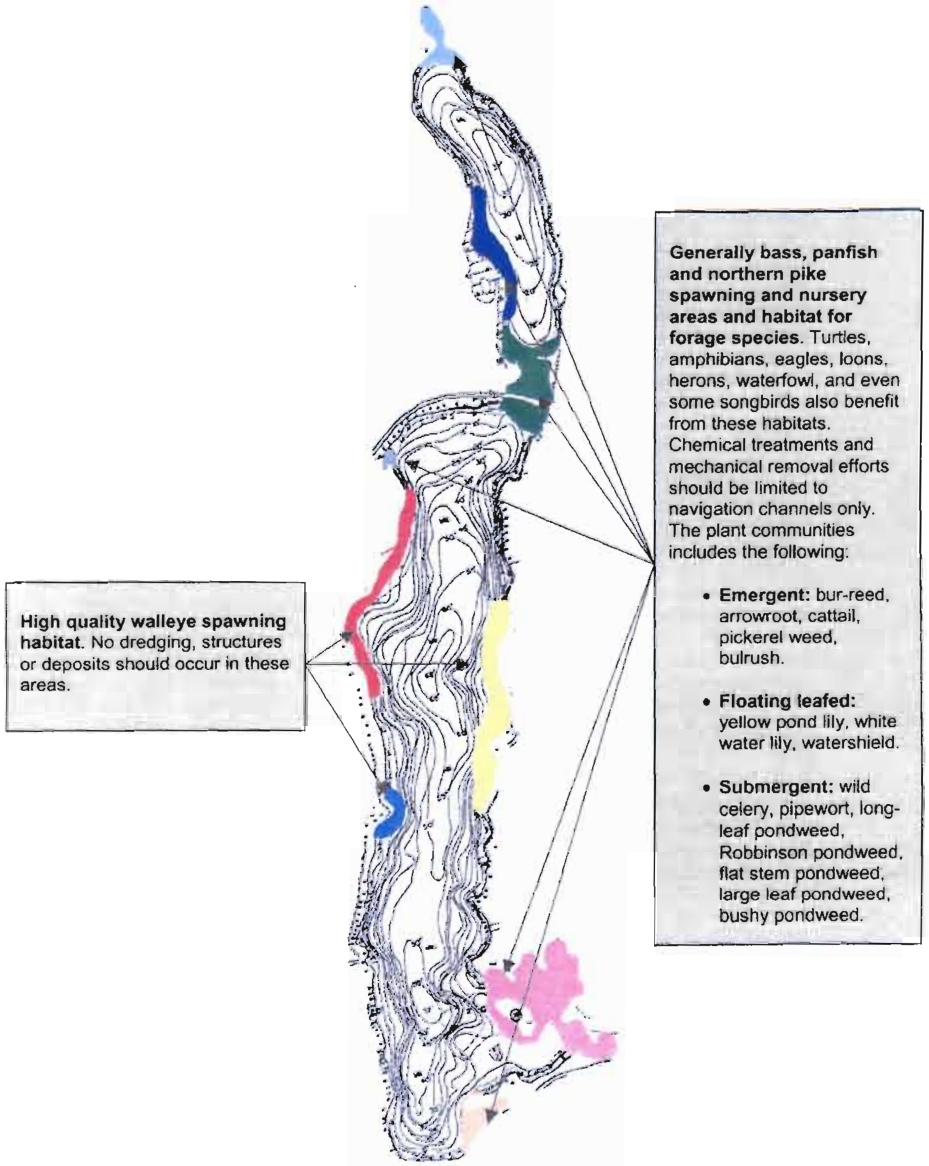
- reduce stream phosphorus input (project 3)
- increase aquatic plant distribution (project 6)
- characterize the zooplankton and algae communities (this project). Lake monitoring should include characterizing zooplankton and algae over the growing season.

An advanced project would be to consider an alum application . . . a future project.

Pipe Lake:

- maintain shoreland buffers
- characterize the zooplankton and algae communities
- protect fish habitat
- reduce lake phosphorus concentration in North Pipe Lake which will help Pipe Lake

[left] Zooplankton feed on algae. It's possible that Pipe Lake maintains a healthy zooplankton population which may influence water clarity.
(right) An alum addition would probably reduce internal loading in North Pipe, but it is expensive.



Protecting fish spawning and fish nursery areas could indirectly aid water clarity in Pipe Lake.

Project 9. Ongoing Education Program

Lake residents get an important amount of lake protection information from the lake newsletter. Each issue should offer tips on lake protection techniques. There is abundant material available. An example of an informational piece is shown below.

Reduce Waste *If not you, who?*

YOUR LAWN AND THE ENVIRONMENT

New phosphorus lawn fertilizer law aims to protect Minnesota lakes and rivers

Minnesota has recently passed a law that restricts the use of lawn fertilizers containing phosphorus, the primary nutrient that turns lakes green with algae.

New Phosphorus Law

Starting January 1, 2004, **fertilizers containing phosphorus cannot be used on lawns in the Twin Cities metro area** (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott and Washington counties). Greater Minnesota is restricted to lawn fertilizers with 3 percent or less phosphate content (with fertilizer, phosphorus is measured as *phosphate*). Look for the middle number on a bag of fertilizer. For the metro area, it should be zero (0) and in Greater Minnesota it should be three (3).

Keep fertilizer off paved surfaces: It's illegal to spread any fertilizer on hard surfaces such as streets, sidewalks, and driveways. Rain can wash the fertilizer into nearby storm drains or road ditches, eventually getting into a lake or river near you. If you accidentally spill or spread fertilizer on a hard surface, clean it up immediately.

Exemptions

Fertilizers containing phosphorus may be used on lawns if a soil test indicates that it is needed or if you are establishing a new lawn.

These restrictions do not apply to fertilizers used for agricultural crops, flower and vegetable gardening, or on golf courses by trained staff.

DO THE GREEN THING: FERTILIZE RESPONSIBLY Many garden centers and hardware stores now carry phosphorus-free lawn fertilizers.

Will phosphorus-free fertilizer keep my lawn healthy?

While phosphorus is necessary to grow healthy lawns, soils in many parts of Minnesota already have an adequate amount. In these instances, adding more phosphorus in fertilizer is not needed and will not benefit your lawn. Healthy lawns can be maintained with phosphorus-free fertilizers.

THE PROBLEM: TOO GREEN

GREEN AND MUCKY Excess algae and weed growth is a major problem in many Minnesota lakes and waterways.

MORE PHOSPHORUS, LESS FISH Too much algae lowers oxygen levels and darkens the water. This can have a devastating effect on fish populations.

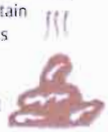
What to look for

On any bag or box of fertilizer, there is a string of three numbers. The middle number indicates phosphorus content and should read "0" in the Twin Cities seven-county metropolitan area, and "3" or less in Greater Minnesota.

What can you do to protect water quality?

Fertilizers, leaves, grass clippings, eroded soil, and animal waste are all sources of phosphorus. When they are swept or washed into the nearest street or storm drain, they end up in your local lake or river. You can do your part to protect water quality by doing the following:

- Follow Minnesota's new phosphorus lawn fertilizer law.
- Keep leaves and lawn clippings out of your gutters, streets, and ditches.
- Clean lawn and garden equipment on the grass, not on hard surfaces. Never wash or blow soil or grass clippings into the street.
- Pick up pet waste promptly. Pet waste can contain harmful bacteria as well as nutrients. Never drop pet waste in the street or ditches.
- Control soil erosion around your house. When left bare, soil is easily washed away with rain, carrying phosphorus with it. Soil erosion can be prevented by keeping soil covered with vegetation or mulch.



SWEEP IT UP Grass clippings and leaves left on streets and sidewalks are a major source of phosphorus.

Find out what you need: Test your soil

A soil test is a good idea, especially if you are concerned that your lawn may need phosphorus.

Instructions on soil testing are available through the University of Minnesota Extension Service's INFO-U by calling 612-624-2200 (metro) or 1-800-525-8636 and requesting message 468.

Soil testing information can also be obtained through the Internet by visiting **www.extension.umn.edu** and searching for "Lawn Soil Testing."

A list of laboratories certified for soil testing by the Minnesota Department of Agriculture can be found at **www.mda.state.mn.us/appd/soilabs.htm.**

Visit **www.reduce.org** for lots of ideas about reducing waste and toxic chemicals in your day-to-day life.

reduce.org

For more information on lawn care

- The **Yard & Garden Line** is the University of Minnesota Extension Service's one-stop telephone link to information about plants and insects in the home landscape. Call 612-624-4771, or (toll free) 1-888-624-4771 in Greater Minnesota.
- University of Minnesota **Extension Service's web site**: www.extension.umn.edu. From the home page click on "Garden" then on "Lawns."
- University of Minnesota Extension Service - **Sustainable Urban Landscape Information Series** (SULIS): www.sustland.umn.edu. From the home page, click on "Maintenance" then on "Lawn care."
- **Minnesota Department of Agriculture**: www.mda.state.mn.us. From the home page, click on "Water & Land," then on "Lawn Care & Water Quality."

To obtain additional copies of this fact sheet

contact Office of Environmental Assistance's **Education Clearinghouse** at 1-800-877-6300, 651-215-0232 or e-mail: clearinghouse@moea.state.mn.us.

AGRICULTURE

Metro WaterShed Partners

Extension

Minnesota Office of Environmental Assistance

Project 10. Watershed & Lake Monitoring Program

Basic and Advanced Programs: A lake and watershed monitoring program is outlined in Table 17. It is designed to be flexible to accommodate the volunteer work force and a fluctuating budget.

Table 17. Pipe Lakes Water Quality Monitoring Program.

Category	Level	Alternative	Labor Needed	Cost/Year
Streams	1	Monitor 2 or 3 streams 3 or 4 times per year.	Moderate	$250
	2	Monitor 5 or 6 streams 5 or 6 times per year.	Moderate	$500
A. Dissolved oxygen	1	Check dissolved oxygen in Pipe Lakes Lake every two weeks in January, February, and March depending on winter conditions. Also check DO in summer.	Moderate	$0
	2	Check dissolved oxygen in Pipe Lakes Lake every one to two weeks in December, January, February, and March, depending on winter conditions and collect phosphorus samples. Also check DO in summer.	Moderate	$0
B. Water clarity	1	Secchi disc taken at spring and fall turnover.	Low	$0
	2	Secchi disc monitoring once per month May - October.	Low-moderate	$0
	3	Secchi disc monitoring twice per month, May - October.	Moderate	$0
C. Water chemistry	1	Spring and fall turnover samples are collected and sent to UW-Stevens Point. Selected parameters for analysis include: TP and chlorophyll.	Low	$200
	2	Spring and fall turnover samples are collected and sent to UW-Steven Point. Standard package of parameters is analyzed.	Low	$600
	3	Sample for phosphorus and chlorophyll once per month from May - September (surface water only).	Low-moderate	$300
	4	Sample for phosphorus and chlorophyll twice per month from May - October.	Moderate	$600
	5	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N once per month (May-October)	Moderate	$960
	6	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N twice per month (May-October).	Moderate	$1,920
D. Special samples or surveys	1	Special samples: suspended solids, BOD, chloride, turbidity, sampling bottom water, and other parameters such as zooplankton, algae, and aquatic plants.	--	$100-$3,000

UW-Stevens Point Lab Analysis Costs:

Total phosphorus	$12.00	Total suspended solids	$8.00
Chlorophyll a	$20.00	Total volatile solids	$8.00
Kjeldahl-N	$12.00	Dissolved solids	$8.00
Nitrate/Nitrite-N	$10.00	Turbidity	$6.00
Ammonia-N	$10.00	BOD	$20.00

For 2004, a recommended program consists of the following categories: Streams 1, A1, B3, and C3. In addition, zooplankton and algae should be monitored monthly from May through September for a year or two. Also, an aquatic plant survey should be conducted every three years.