IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE I
LAKE MANAGEMENT PLAN
SHAWANO LAKE
SHAWANO COUNTY, WISCONSIN

REPORT TO:
SHAWANO LAKE PROPERTY OWNERS ASSOCIATION

January, 1993

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GLOSSARY OF TERMS (1, 2, 3)

Best Management Practices (BMP's)	Land use practices to control the interactive processes of erosion, runoff and nutrient or pesticide inflows.
Chlorophyll a	Green pigment present in all green plant life and needed in photosynthesis. The amount present in lake water is related to the amount of algae and is therefore used as an indicator of water quality.
Drainage Lake	Generally referred to as natural lakes having permanent inflowing and outflowing streams.
Edge	A biologically diverse area located at the interface of differing habitat types.
Eutrophic	From Greek for "well nourished", describes a lake of high photosynthetic activity and low transparency.
Eutrophication	The process of lake aging or enrichment with nutrients, generally with associated increases in algae or weeds. The extent to which this process has progressed is described by trophic status terms, e.g., oligotrophic, mesotrophic, or eutrophic.
Fetch	The longest distance over which the wind can sweep unobstructed.
Hypolimnion	Lower, cooler layer of a lake during summertime thermal stratification.
Immediately Adjacent Watershed	Here defined as the drainage area immediately around a lake, i.e. within 1,000 feet of shore and any inlet(s).
Littoral	The shallow area of a lake from the shore to the depth where light no longer penetrates to the bottom.
Macrophyte	Commonly referred to as lake "weeds", actually aquatic vascular plants that grow either floating, emergent or submergent in a body of water.

GLOSSARY OF TERMS
(Continued)

Mesotrophic	A lake of intermediate photosynthetic activity and transparency.
N/P Ratio	Total nitrogen divided by the total phosphorus found in a water sample. A value greater than 15 indicates that phosphorus is limiting for primary production.
Physicochemical	Pertaining to physical and/or chemical characteristics.
Residence Time	Commonly called the hydraulic residence time. The amount of time required to completely replace the lake's current volume of water with an equal volume of "new" water.
Secchi Depth	A measure of optical water clarity as determined by lowering a weighted Secchi disk (20 cm in diameter) into the water body to a point where it is no longer visible.
Stratify	Layering of water caused by differences in water density. Thermal stratification is typical of most deep lakes during the Summer. Chemical stratification can also occur.

SUMMARY

Shawano Lake is a large, recreationally popular lake in northeast Shawano County, Wisconsin. The lake drains a relatively small watershed (compared to lake area) which is comprised of predominantly open and agricultural lands.

Water quality readings indicated **mesotrophic**[1] to **eutrophic** conditions for all parameters measured (on the Trophic State Index). There appears to be a slight trend from higher, more variable nutrient readings in the past to more consistent, slightly lower levels presently. The lake is well-mixed throughout the year and nutrient levels are at or near those expected for lakes in the region and other Wisconsin lakes. High productivity appears related as much to basin morphometry (extensive shallow areas) and good water clarity as to moderate in-lake nutrient levels. Monitoring indicated relatively higher nutrient inflow during or after significant rain events.

Macrophyte populations appeared to positively affect the resource (as a whole) through shoreline stabilization, nutrient uptake and fish food and habitat production, but some areas support nuisance levels of macrophytes. The SLPOA currently operates a mechanical harvester (and has implemented a macrophyte management plan) to manage specific areas and help keep portions of the lake area recreationally usable. Most abundant plants include pondweeds (Potamogeton spp.), naiads (Najas spp.) and water celery (Vallisneria americana) and are generally of a desirable nature. Water milfoil (Myriophyllum spp.) is also common and may include Eurasian Milfoil, an exotic, potentially nuisance species.

Recommendations for future management of Shawano Lake are designed to maintain and enhance water quality and improve/enhance recreational access:

- Water quality monitoring (regular, event and Self-Help **Secchi depth**) should be continued to track trends.
- Riparian land management should be emphasized for the extensive and highly developed Shawano Lake shoreline. **Best Management Practices (BMP's)** should be further solicited throughout the watershed,
- Macrophyte harvest according to a flexible schedule should be continued to target reduction of nuisance species and their spread and to create **edge** and access. Emphasis should also be given to identification and effective management or removal of macrophytes particularly prone to spread by fragmentation.
- The SLPOA should consider distribution of a survey to solicit attitudes and priorities of Shawano Lake users. The survey can help to focus management priorities.
- Steps should be taken to prevent spread of exotic species to (and potentially from) Shawano Lake.

[1] Text terms in bold print defined in glossary (pp. vi-vii)

INTRODUCTION

Shawano Lake is located in the Towns of Washington and Wescott in northeast Shawano County, Wisconsin. It is the largest lake in the county and receives heavy recreational use. Currently, fishing pressure is estimated to be in excess of 450,000 hours per year (mostly ice fishing) and recreational boating to be over 500,000 hours per year (Personal communication WDNR).

The Shawano Lake Property Owners Association (SLPOA) was formed in 1981 to organize and direct the preservation of this resource. The Association is governed by an elected, 9 person, Board of Directors. Directors are elected annually by the approximately 450 member Association.

The SLPOA, in October 1990, decided to pursue development of a long range management plan under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program. The SLPOA Directors selected IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin as its consultant to develop the plan. A grant application to initiate development of the plan, incorporating required or recommended program components and the following objectives, was prepared, submitted, and approved in April, 1991:

- acquire historic and current data, to assess the present status of the resource,
- establish a monitoring strategy designed to track long-term lake water quality trends,
- locate, identify and quantify aquatic macrophyte concentrations, and
- increase the awareness of the lake property owners and establish a base of support for lake management efforts.

DESCRIPTION OF AREA

Shawano Lake (T27N, R16E, Sections 10, 13-16, 21-28; T27N, R17E, Sections 17-20) is a **drainage lake** (possessing permanent inlets and an outlet). The City of Shawano and Village of Cecil are located on the west and east ends of the lake, respectively (Figure 1). A dam owned by the Shawano Paper Mill Division of Little Rapids Corporation and operated for hydropower generation controls water levels of the Wolf River and Shawano Lake.

The general topography of Shawano County is related to glacial activity. Shawano Lake is located in the bed of what was Glacial Lake Oshkosh or Nicolet during the Wisconsin stage of glaciation which ended about 10,000 - 15,000 years ago (4). Topography in the **immediately adjacent watershed** is level to gently sloping. Major soil types adjacent to Shawano Lake are poorly drained Cormant mucky loamy fine sands on 0 - 2% slopes, Markay and very poorly drained Cathro mucks on 0 - 2% slopes, and Wainola fine sand on 0 - 3% slopes. Soil permeability is generally rapid on these soils (5). The overall watershed (approximately 65 sq. miles) consists mainly of open/agricultural areas.

Shawano Lake has a surface area of 6,100 acres, an average depth of about 9 feet, a maximum depth of 39.5 feet and a lake volume of 54,900 acre-feet (6). The **fetch** is 5.9 miles and lies in an

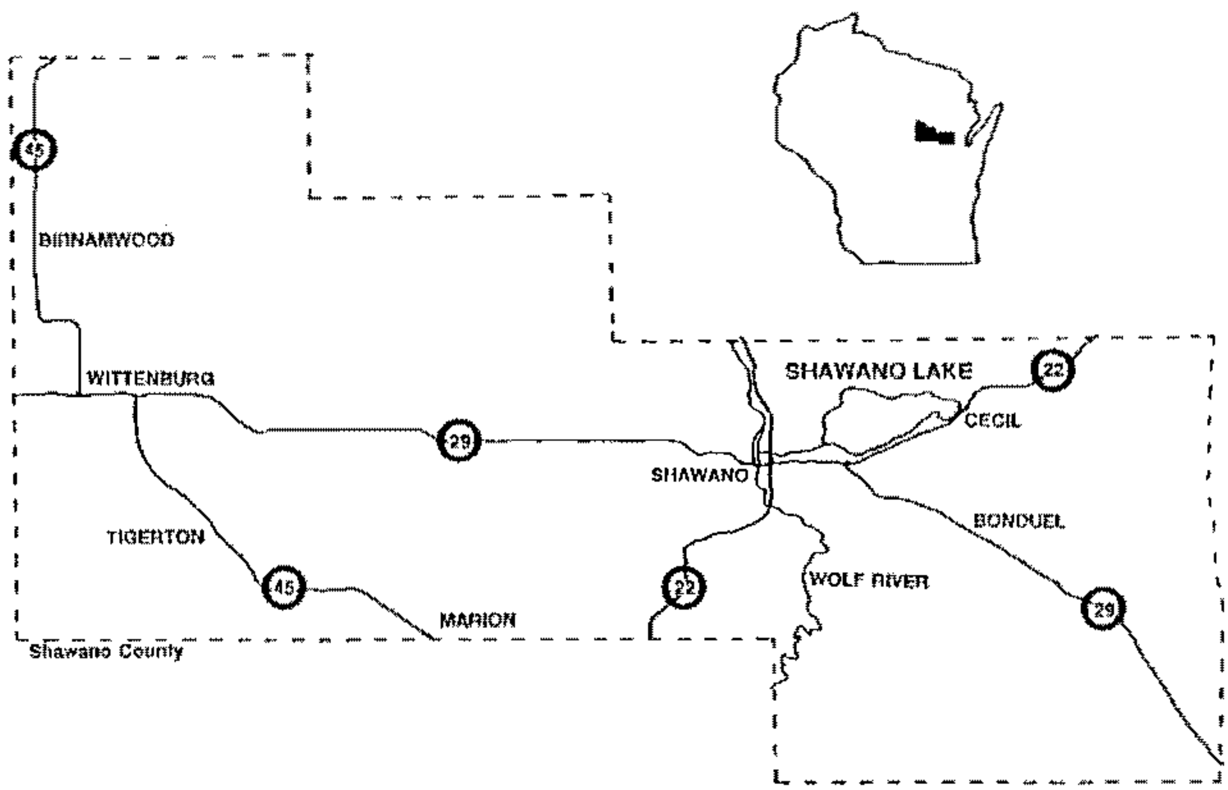

Figure 1. Location Map, Shawano Lake, Shawano County, WI.

east-west orientation and the width is 3.0 miles in a north-south orientation; shoreline length is over 18 miles. The **residence time** for Shawano Lake is estimated to be 1.5 years (Pers. comm. WDNR).

The Shawano Lake watershed is 40,000 acres; predominant land use is open/agricultural (44%), forested (42%), and residential (11%) (Pers. comm. Shawano County Soil Conservation Service, SCS) (Figure 2). Private residences and commercial resorts/motels occupy all but three small corridors around the lake (Pers. comm. WDNR). The watershed to lake ratio of about 6.2 to 1 means that 6.2 times more land than lake surface area drains to the lake.

Sanitary sewerage service began in 1974 for nearly all lake residences through the Shawano Lake and Cecil Sanitary Districts (approximately 1825 and 224 residences served, respectively) (Pers. comm. Shawano Lake and Cecil Sanitary Districts). Individual septic systems remain in use at about 100 households (predominantly farm units) in the watershed. Animal waste systems are utilized on approximately 33% of the livestock farms in the watershed (Pers comm. SCS).

The Shawano Lake watershed was designated a priority watershed by the Wisconsin Department of Agriculture, Trade, and Consumer Protection in 1985. About 65% of the livestock farms in critical

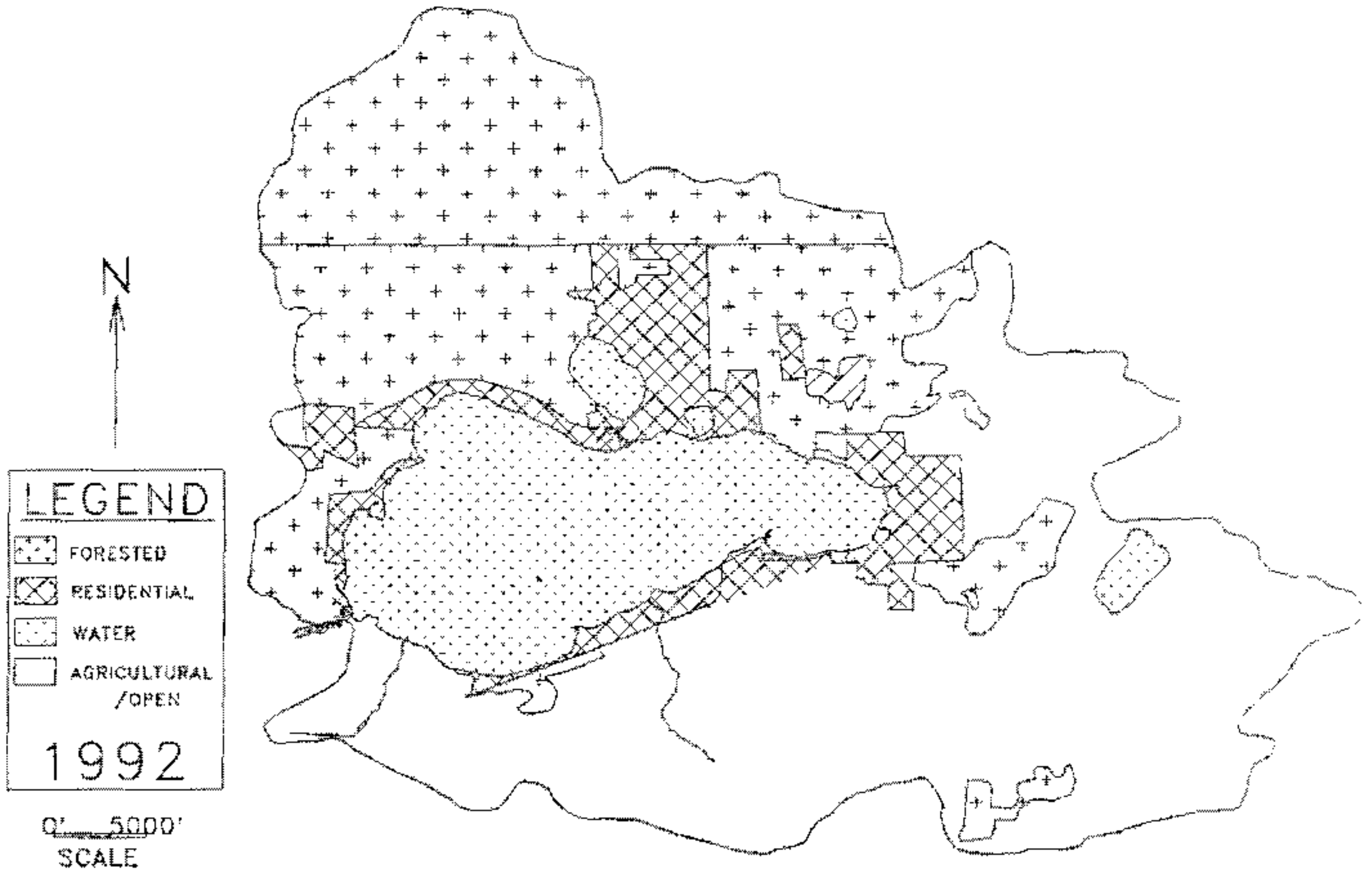

Figure 2. Land Use in the Shawano Lake Watershed, Shawano County, WI.

areas, i.e., within 1000 feet of the lake or tributaries, participated in the program which emphasized feedlot runoff and manure management in the highly agricultural southeast portion of the watershed (Pers. comm. SCS).

Littoral substrates are primarily muck (50%) and sand (50%) with minor areas of rubble located around Schumacher's Island (Pers. comm. WDNR). Much of the littoral zone supports rooted aquatic macrophytes and sometimes at nuisance levels. Historic macrophyte control methods included contracted mechanical harvesters (1985-1991) and chemical application (various years and chemicals). Presently, macrophytes are managed by a mechanical harvester owned by the SLPOA.

Shawano Lake supports a variety of warmwater game, pan, rough, and forage species (Table 1). Fish introductions (Table 2) and historical management have been principally directed toward the northern pike, bass, walleye, and panfish fisheries. A 1988 WDNR fish survey indicated walleye and northern pike populations needed management, while largemouth bass and bluegill populations were healthy (Pers. comm. WDNR). Fish sampling has indicated some mercury contamination; a WDNR fish consumption advisory currently exists for walleye from Shawano Lake (7).

Direct public boat access to Shawano Lake is available at

Table 1. Fish Species Present in Shawano Lake.

COMMON NAME	SCIENTIFIC NAME
Muskellunge	Esox masquinongy
Northern pike	Esox lucius
Yellow perch	Perca flavescens
Walleye	Stizostedion vitreum
Black crappie	Pomoxis nigromaculatus
Bluegill	Lepomis macrochirus
Largemouth bass	Micropterus salmoides
Pumpkinseed	Lepomis gibbosus
Rock bass	Ambloplites rupestris
Smallmouth bass	Micropterus dolomieui
Shorthead redhorse	Moxostoma macrolepidotum
White sucker	Catostomus commersoni
Longnose gar	Lepisosteus osseus
Bowfin	Amica calva
Central mudminnow	Umbra limi
Yellow bullhead	Ictalurus natalis
Black bullhead	Ictalurus melas
Brown bullhead	Ictalurus nebulosus
Bluntnose minnow	Pimephales notatus
Brook silverside	Labidesthes sicculus
Common carp	Cyprinus carpio
Common shiner	Notropis cornutus
Fathead minnow	Pimephales promelas
Golden shiner	Notemigonus crysoleucas
Johnny darter	Etheostoma nigrum
Lake chubsucker	Erimyzon sucetta
Spottail shiner	Notropis hudsonius

Table 2. Recent Fish Introductions, Shawano Lake, Shawano County, WI.

YEAR	SPECIES	SIZE	NUMBER
1965	Walleye	Fry	1,000,000
1966	Walleye	Fry	4,100,000
1967	Walleye	Fry	1,000,000
1968	Walleye	Fry	1,000,000
1968	Walleye	Fingerling	50,000
1969	Walleye	Fry	1,000,000
1970	Walleye	Fry	545,431
1991	Crappie	Fingerling	2,000

approximately ten locations. Indirect boat access via the outlet channel and the Wolf River is also available. Public recreational access is available at 2 county parks, 6 picnic areas, 2 beaches, and 356 acres of public hunting grounds. In addition to public access points, several resorts and campgrounds have private launch sites (Pers. comm. SCS, WDNR).

Shawano Lake provides nesting habitat for migrating waterfowl including mallards, black ducks, blue-wing teal, and wood ducks. A wide variety of the ducks and geese common to the central/Mississippi flyways also rest in the area.

METHODS

FIELD PROGRAM

Shawano Lake water sampling was conducted Spring, Summer, late-Summer and Winter (June 4, July 30, September 9, 1991, and January 27, April 28, and July 7, 1992) at Stations 1501 (west basin), 1502 (deepest point, central basin) and 1503 (east basin) (Table 3, Figure 3). All stations were sampled three feet below the surface (designated "S") and three feet above the bottom (designated "B").

Physicochemical parameters measured in the field included Secchi depth, temperature, dissolved oxygen (DO), pH and conductivity. Measurements were taken using a standard Secchi disk and either a Hydrolab Surveyor II or 4041 multiparameter meter; Hydrolab units were calibrated prior to and subsequent to daily use.

Samples taken for laboratory chemical analyses were collected using a Kemmerer water bottle. Samples were labelled, preserved when necessary, and packed on ice in the field; delivery to the laboratory was made via overnight carrier. All laboratory analyses were conducted at the State Laboratory of Hygiene (Madison, WI) using WDNR or APHA (8) methods. Spring water samples were analyzed for laboratory pH, total alkalinity, total

Table 3. Sampling Station Descriptions, Shawano Lake, 1991 - 1992.

WATER QUALITY

Regular Site	Latitude/Longitude	Depth
1501	44° 48.36' 88° 32.33'	20.0 ft.
1502	44° 48.51' 88° 30.05'	39.0 ft.
1503	44° 48.63' 88° 28.91'	25.0 ft.

Event Site	Location
15E1	Mouth of unnamed inlet near Shady Lane Road; south shore
15E2	Mouth of unnamed inlet near Swan Drive; south shore
15E3	Mouth of Pickerel Creek; in the Village of Cecil; east shore
15E4	Mouth of Duchess Creek; north shore
15E5	Washington Lake outlet; north shore

MACROPHYTE TRANSECTS

Transect	Latitude/Longitude Origin	End	Transect Length(m)	Bearing (Degrees)	Depth Range[1]	Interval End (m)
A	44° 49.12' 88° 30.53'	44° 47.72' 88° 31.63'	850	214	1/2/3	12/37/850
B	44° 48.58' 88° 27.19'	44° 48.68' 88° 27.72'	690	285	1/2/3	15/270/690
C	44° 48.47' 88° 28.60'	44° 48.61' 88° 28.71'	300	333	1/2/3	6/220/300
D	44° 49.11' 88° 28.26'	44° 48.91' 88° 28.33'	390	197	1/2/3	6/240/390
E	44° 47.72' 88° 31.63'	44° 47.94' 88° 31.59'	450	24	1/2/3	6/410/450
F	44° 47.49' 88° 31.07'	44° 47.72' 88° 31.63'	410	295	1/2	2/410
G	44° 48.42' 88° 33.51'	44° 47.72' 88° 31.63'	500	122	1/2/3	15/230/500
H	44° 48.93' 88° 33.01'	44° 47.72' 88° 31.63'	2200	110	1/2/3	8/30/2200

[1] 1 = 0.0 - 0.5m (0.0 - 1.7ft)
2 = 0.5 - 1.5m (1.7 - 5.0ft)
3 = 1.5 - 3.0m (5.0 - 10.0ft)

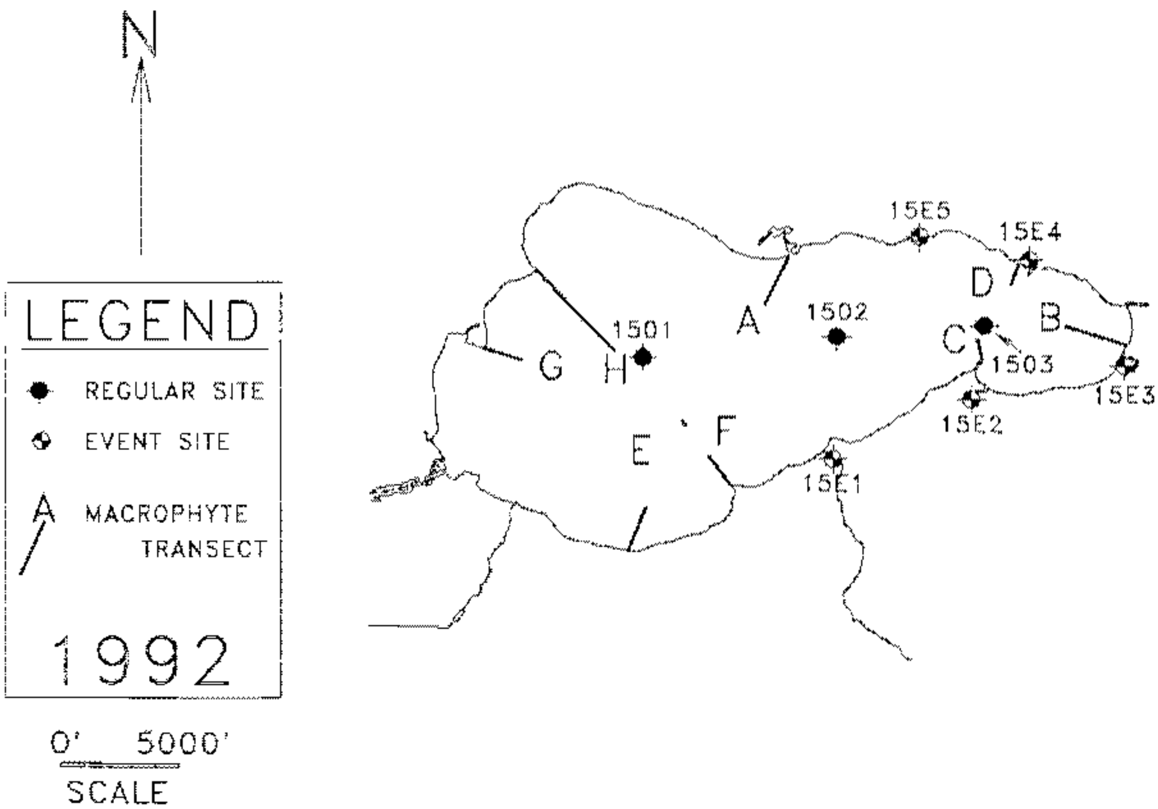

Figure 3. Sampling Stations, Shawano Lake, Shawano County, WI, 1991 - 1992.

Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, dissolved phosphorus, total solids, and **chlorophyll a**. Summer, late Summer and Winter laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, and dissolved phosphorus; chlorophyll a was determined during Spring, Summer and late Summer monitoring periods.

In addition to regular monitoring sites, event monitoring stations (Table 3) were located at five major inlets to characterize water quality of inflows after major runoff events. Event sample laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and dissolved phosphorus.

Macrophyte surveys were conducted July 30 and September 9, 1991 using a method developed by Sorge et al and modified by the WDNR-Lake Michigan District (WDNR-LMD) for use in the Long Term Trend Lake Monitoring Program (9). Eight transects (A-H) were chosen to provide information from various habitats and areas of interest (Figure 3). Transect endpoints were established using a Loran Voyager Sportnav latitude/longitude locator and recorded with bearing and distance of the transect (line of collection) for use in future surveys.

Data were recorded from three depth ranges, i.e., 0 to 0.5 meters (1.7 feet), 0.5 to 1.5 meters (5.0 feet), and 1.5 to 3.0 meters (10.0 feet), as appropriate along each transect. Plants were identified (collected for verification as appropriate), density ratings assigned (see below), and substrate type recorded along a six foot wide path on the transect using a garden rake, snorkel gear or SCUBA where necessary. Macrophyte density ratings, assigned by species, were: 1 = Rare, 2 = Occasional, 3 = Common, 4 = Very Common, and 5 = Abundant. These ratings were treated as numeric data points for the purpose of simple descriptive statistics in the Field Data Discussion section of this report.

OTHER PHYSICOCHEMICAL CHARACTERISTICS

Water Quality Information

Additional lake information was retrieved from the WDNR Surface Water Inventory (10) and the WDNR WI LAKES Electronic Bulletin Board System.

Land Use Information

Details of zoning and specific land uses were obtained from the UW-Extension, Shawano County zoning maps, United States Soil Conservation Service soil maps (5), aerial photographs, and United States Geological Survey quadrangle maps. Information, when considered questionable or outdated was confirmed by field reconnaissance. Ordinance information was taken from Shawano County Zoning Ordinance and the Shawano County Soil Erosion Control and Animal Waste Water Pollution Control Plans. The Shawano County Farmland Preservation Plan also provided ordinance and watershed information.

Public Involvement Program

Various public involvement activities were coordinated with the planning process; these activities are summarized in Appendix I.

FIELD DATA DISCUSSION

Physicochemical characteristics of natural lakes tend toward a state of dynamic equilibrium (i.e., seasonally variable but relatively consistent within that framework over the long-term) defined by basin morphometry and watershed features. Shawano Lake, on an areal basis, has little water over 20 feet deep and apparently does not **stratify** during Summer (Tables 4-6, Appendix II, III). A substantial portion on the water supply for Shawano Lake is overland runoff from an open/agricultural watershed (especially in southeast areas). While effects of nonpoint inflows of sediment and nutrients are potentially greater under these conditions than would be expected in a more forested watershed, the relatively small watershed would tend to reduce the potential for negative effects.

Phosphorus is often the limiting major nutrient to algal and plant production in lakes. Average surface total phosphorus during 1991-1992 monitoring was similar for the three in-lake monitoring sites [0.022, 0.026, and 0.025 mg/l (parts per million) for sites 1501, 1502, and 1503, respectively]. Overall, surface total phosphorus values ranged from 0.013 to 0.038 mg/l (Tables 4-6, Appendix II, III). Surface total phosphorus levels were at or near levels expected for natural lakes in the central region of Wisconsin (11). Summer surface total phosphorus values

Table 4. Water Qualtiy Parameters, Station 1501, Shawano Lake, Shawano County, WI, 1991 - 1992.

PARAMETER	SAMPLE[1]	06/04/91	07/30/91	09/09/91	01/27/92	04/28/92	07/07/92
Secchi (feet)		7.0	5.0	5.0	NR[2]	5.9	7.9
Cloud Cover (%)		NR	20	95	100	10	80
Temperature (°C)	S	22.25	22.09	21.65	3.2	8.23	19.36
	B	21.78	20.97	21.63	4.77	8.00	18.75
pH (S.U.)	S	8.16	8.75	8.83	8.65	8.11	8.53
	B	8.14	8.69	8.82	7.81	7.86	8.13
D.O. (mg/l)	S	7.89	8.89	8.01	13.70	13.07	9.51
	B	7.93	8.08	7.82	6.99	12.44	8.07
Conductivity (µmhos/cm)	S	287	243	216	256	223	232
	B	292	243	216	274	223	233
Laboratory pH (S.U.)	S	8.3	NR	NR	NR	8.3	NR
	B	8.3	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	119	NR	NR	NR	NR	NR
	B	120	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	158	NR	NR	NR	NR	NR
	B	160	NR	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.7	0.7	0.7	0.8	0.8	0.7
	B	0.7	0.9	0.6	0.7	0.8	0.7
Ammonia Nitrogen (mg/l)	S	<0.013	0.011	0.008	0.047	0.006	0.022
	B	<0.013	0.011	0.006	0.056	0.017	0.020
NO_2 + NO_3 Nitrogen(mg/l)	S	<0.015	ND[3]	ND	0.072	ND	ND
	B	<0.015	ND	ND	0.076	ND	ND
Total Nitrogen (mg/l)	S	<0.715	<0.707	<0.707	0.872	<0.807	<0.707
	B	<0.715	<0.907	<0.607	0.776	<0.807	<0.707
Total Phosphorus (mg/l)	S	0.023	0.027	0.024	0.016	0.030	0.024
	B	0.020	0.023	0.023	0.012	0.026	0.027
Diss. Phosphorus (mg/l)	S	0.005	0.006	ND	0.003	0.002	0.007
	B	0.003	0.006	ND	0.003	0.003	0.004
N/P Ratio	S	<31.1	<26.2	<29.4	54.5	<26.9	<29.4
	B	<35.8	<39.4	<26.4	64.7	<31.0	<26.2
Chlorophyll *a* (µg/l)	S	12	11	13	NR	23	10

[1] S = Near Surface, B = Near Bottom
[2] NR = No Reading;
[3] ND = Not Detectable

Table 5. Water Qualtiy Parameters, Station 1502, Shawano Lake, Shawano County, WI, 1991 - 1992.

PARAMETER	SAMPLE[1]	06/04/91	07/30/91	09/09/91	01/27/92	04/28/92	07/07/92
Secchi (feet)		6.0	5.5	5.0	NR[2]	6.0	8.1
Cloud Cover (%)		NR	20	100	NR	10	80
Temperature (°C)	S	22.07	22.35	21.69	2.96	7.35	19.76
	B	18.42	21.29	20.95	3.95	6.99	18.50
pH (S.U.)	S	8.15	8.80	8.85	7.90	8.57	8.45
	B	8.04	8.60	8.35	7.33	8.35	8.21
D.O. (mg/l)	S	7.30	8.81	8.30	12.95	12.37	9.61
	B	4.30	7.5	3.57	7.43	11.78	8.52
Conductivity (µmhos/cm)	S	283	246	217	241	224	232
	B	299	246	222	278	226	231
Laboratory pH (S.U.)	S	8.3	NR	NR	NR	8.3	NR
	B	8.4	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	119	NR	NR	NR	NR	NR
	B	119	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	168	NR	NR	NR	NR	NR
	B	158	NR	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.7	0.7	0.7	0.8	0.7	0.7
	B	0.6	0.7	0.8	0.6	0.8	NR
Ammonia Nitrogen (mg/l)	S	0.014	0.015	0.005	0.070	0.009	0.019
	B	<0.013	0.035	0.072	0.043	0.009	0.019
NO_3 + NO_2 Nitrogen(mg/l)	S	<0.015	ND[3]	ND	0.075	ND	ND
	B	<0.015	ND	ND	0.191	ND	ND
Total Nitrogen (mg/l)	S	<0.715	<0.707	<0.707	0.875	<0.707	<0.707
	B	<0.615	<0.707	<0.807	0.791	<0.807	--
Total Phosphorus (mg/l)	S	0.033	0.024	0.028	0.029	0.023	0.022
	B	0.021	0.024	0.029	0.012	0.033	0.023
Diss. Phosphorus (mg/l)	S	0.005	0.004	ND	0.002	0.003	0.003
	B	0.005	0.005	ND	0.003	0.002	0.004
N/P Ratio	S	<21.7	<29.4	<25.2	30.2	<30.7	<32.1
	B	<29.3	<29.4	<27.8	65.9	<24.4	--
Chlorophyll *a* (µg/l)	S	11	14	19	NR	21	9

[1] S = Near Surface, B = Near Bottom
[2] NR = No Reading
[3] ND = Not Detectable

Table 6. Water Qualtiy Parameters, Station 1503, Shawano Lake, Shawano County, WI, 1991 - 1992.

PARAMETER	SAMPLE[1]	06/04/91	07/30/91	09/09/91	01/27/92	04/28/92	07/07/92
Secchi (feet)		8.0	5.0	5.0	NR[2]	5.7	6.8
Cloud Cover (%)		NR	20	100	NR	10	80
Temperature (°C)	S	23.64	22.99	21.54	1.32	7.52	20.14
	B	21.40	21.69	20.93	3.84	7.41	18.01
pH (S.U.)	S	8.17	8.70	8.56	7.97	8.10	8.45
	B	8.02	8.62	8.41	7.21	7.87	7.82
D.O. (mg/l)	S	8.03	8.42	8.50	14.93	12.14	9.60
	B	5.24	7.26	4.56	0.92	10.58	6.70
Conductivity (µmhos/cm)	S	285	245	218	231	223	233
	B	304	246	224	465	224	234
Laboratory pH (S.U.)	S	8.4	NR	NR	NR	8.20	NR
	B	8.3	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	119	NR	NR	NR	NR	NR
	B	120	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	164	NR	NR	NR	NR	NR
	B	166	NR	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.6	0.8	0.7	0.7	0.8	0.7
	B	0.7	0.9	0.7	1.0	0.8	0.7
Ammonia Nitrogen (mg/l)	S	<0.015	0.015	0.011	0.022	0.016	0.021
	B	<0.013	0.125	0.044	0.282	0.014	0.018
NO_2 + NO_3 Nitrogen(mg/l)	S	<0.015	ND[3]	ND	0.088	ND	ND
	B	<0.015	ND	ND	0.249	ND	ND
Total Nitrogen (mg/l)	S	<0.615	<0.807	<0.707	0.788	<0.807	<0.707
	B	<0.715	<0.907	<0.707	1.249	<0.807	<0.707
Total Phosphorus (mg/l)	S	0.019	0.030	0.025	0.017	0.038	0.022
	B	0.021	0.042	0.025	0.026	0.033	0.034
Diss. Phosphorus (mg/l)	S	0.003	0.007	ND	0.002	0.002	0.007
	B	0.003	0.005	0.002	0.013	0.002	0.011
N/P Ratio	S	<32.4	<26.9	<28.3	46.4	<21.2	<32.1
	B	<34.0	<21.6	<28.3	48.0	<24.4	<20.8
Chlorophyll _a_ (µg/l)	S	11	16	15	NR	26	7

[1] S = Near Surface, B = Near Bottom
[2] NR = No Reading
[3] ND = Not Detectable

were slightly lower than those typical of the ecoregion in which Shawano Lake is located (12). Similar surface and bottom levels further displayed the well mixed nature of the lake.

Total nitrogen is highly variable among lakes and should only be compared within the same lake and on a relative or trend basis. Surface total nitrogen levels averaged about 0.75 mg/l for each in-lake sample point and were generally similar to those observed near bottom. Nitrogen to phosphorus ratios (**N/P ratio**) greater than 15 indicated phosphorus limited conditions.

Event samples indicated higher (than in-lake) levels of nutrient inflow (Table 7). Total nitrogen ranged from 0.628 to 1.612 mg/l

Table 7. Event Water Quality Parameters, Shawano Lake, 1992.

	STATION				
PARAMETER(units)	15E1	15E2	15E3	15E4	15E5
Date	07/12/92	07/12/92	07/12/92	07/12/92	07/12/92
Total Kjeldahl N(mg/l)	0.9	1.4	0.6	0.7	0.6
Ammonia Nitrogen(mg/l)	0.056	0.116	0.032	0.017	0.039
NO_2+NO_3 Nitrogen(mg/l)	ND[1]	0.212	0.028	ND	0.057
Total Nitrogen(mg/l)	<0.907	1.612	0.628	≤0.707	0.657
Total Phosphorus(mg/l)	0.156	0.143	0.059	0.137	0.026
Diss. Phosphorus (mg/l)	0.066	0.006	0.014	0.030	0.004
N/P Ratio	5.8	11.3	10.6	5.2	25.3

[1] ND = Not Detectable

and averaged 0.902 mg/l (highest value at Station 15E2). Total phosphorus ranged from 0.026 to 0.156 mg/l and averaged 0.104 mg/l (higher values at Stations 15E1, 15E2 and 15E4).

Numerous indices have been developed to assess lake **eutrophication** status based on water quality parameters. The Trophic State Index (TSI) developed by Carlson (13) utilizes Secchi transparency, chlorophyll *a*, and total phosphorus. As with most indices, application is generally most appropriate on a relative and trend monitoring basis. This index does not account for natural, regional variability in phosphorus levels nor in Secchi transparency reduction unrelated to algal growth.

TSI values for historic (Appendix II) and current mid-lake data suggested a **mesotrophic** to early **eutrophic** classification (Figures 4-6). Recent TSI for Secchi transparency and total phosphorus appear less variable than in the past; a slight decline for total phosphorus may also be indicated. TSI's applied to event data would indicate a eutrophic situation.

Macrophytes (Table 8) were found at 44 of 46 sample sites (sample sites = number of depth ranges sampled on both dates) and were relatively diverse taxonomically. Pondweeds (*Potamogeton* spp.), as a group, were most common (35 sites) and abundant; *P. illinoensis* was the most common and abundant pondweed species

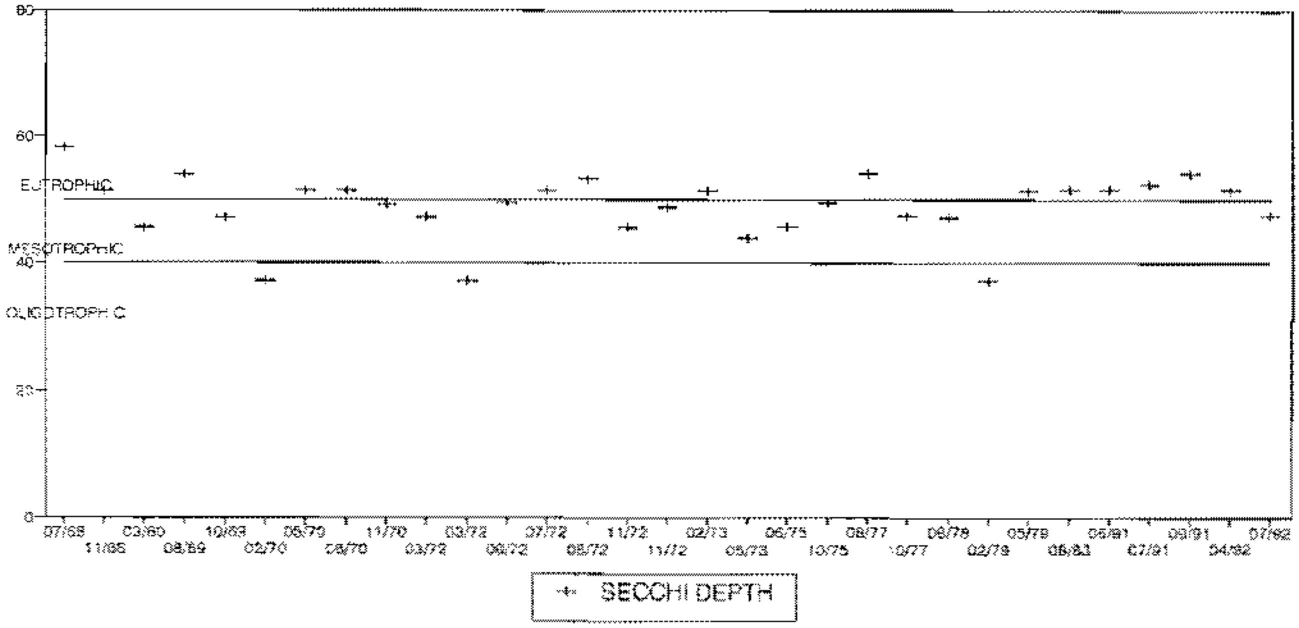

Figure 4. Trophic State Index for Secchi Depth, Shawano Lake

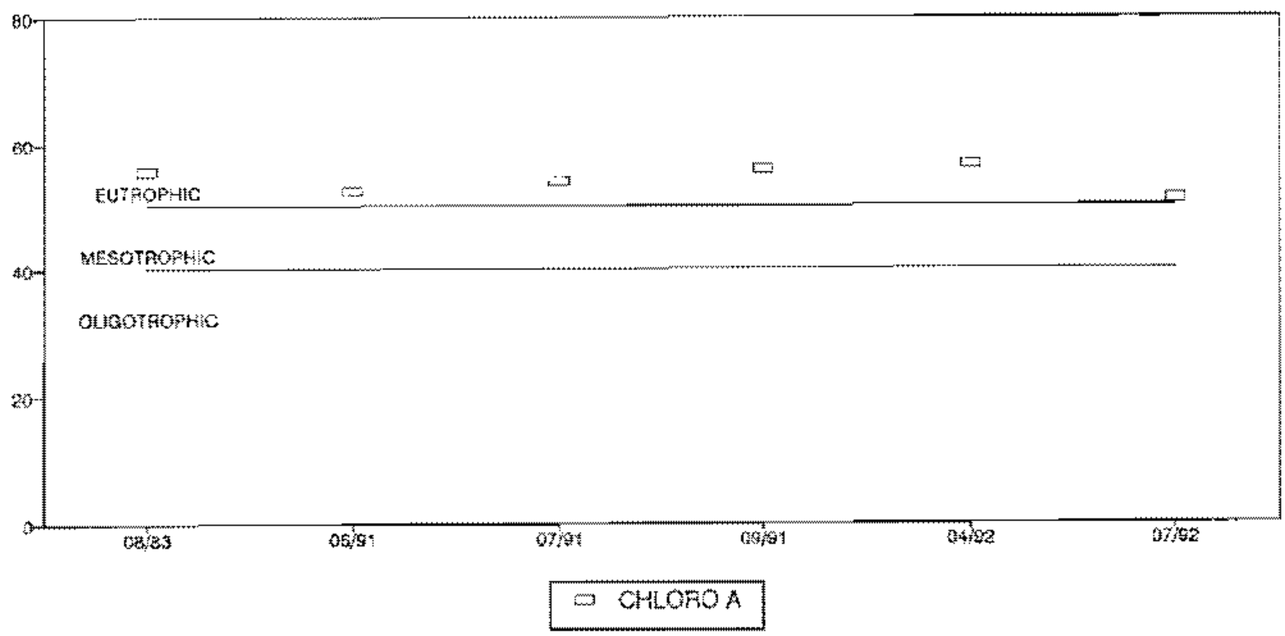

Figure 5. Trophic State Index for Chlorophyll a, Shawano Lake

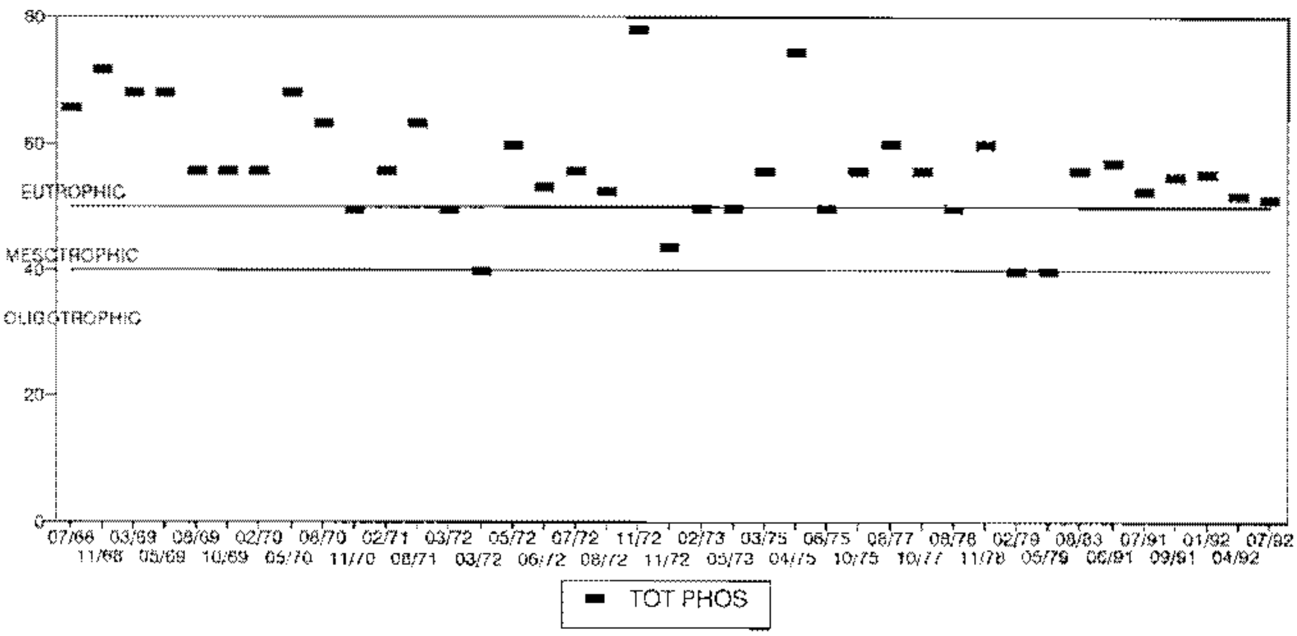

Figure 6. Trophic State Index for Total Phosphorus, Shawano Lake

(Tables 9-11, Appendix IV). Naiads (Najas spp., 33 sites) and water celery (Vallisneria americana, 26 sites) were also widespread and abundant. Plants were often found at nuisance levels and there have been numerous complaints concerning nuisance macrophyte growth in late summer months.

Pondweeds are probably the most beneficial group of plants with respect to wildlife benefits. Pondweeds have leaves with a relatively large surface area which supports numerous species of aquatic invertebrates (forage fish food), the plants also provide

Table 8. Macrophyte Species Observed, Shawano Lake, 1991 (15).

Taxa	Code
Coontail (*Ceratophyllum demersum*)	CERDE
Muskgrass (*Chara* spp.)	CHASP
Common waterweed (*Elodea canadensis*)	ELOCA
Filamentous algae	FILAL
Small duckweed (*Lemna minor*)	LEMMI
Forked Duckweed (*Lemna trisulca*)	LEMTR
Water milfoil (*Myriophyllum* spp.)	MYRSPE
Bushy pondweed (*Najas* spp.)	NAJSP
Nitella (*Nitella* spp.)	NITSP
Yellow pond lily (*Nuphar* spp.)	NUPSP
White pond lily (*Nymphaea* spp.)	NYMSP
No plants found	NOPLT
Pickerel-weed (*Pontedaria cordata*)	PONCO
Large-leaf pondweed (*Potamogeton amplifolious*)	POTAM
Curly-leaf pondweed (*Potamogeton crispus*)	POTCR
Leafy pondweed (*Potamogeton foliosus*)	POTFO
Illinois pondweed (*Potamogeton illinoensis*)	POTIL
Sago pondweed (*Potamogeton pectinatus*)	POTPE
Small pondweed (*Potamogeton pusillus*)	POTPU
Clasping-leaf pondweed (*Potamogeton richardsonii*)	POTRI
Flat-stem pondweed (*Potamogeton zosteriformis*)	POTZO
Water Crowfoot (*Ranunculus* spp.)	RANSP
Arrowhead (*Sagittaria* spp.)	SAGSP

Table 8. Macrophyte Species Observed (continued), Shawano Lake, 1991.

Taxa	Code
Grassy arrowhead . . . . (*Sagittaria graminea*)	SAGGR
Rush . . . . (*Scirpus* spp.)	SCISP
Broad-leaf cattail . . . . (*Typha latifolia*)	TYPLA
Water celery . . . . (*Vallisneria americana*)	VALAM

cover and spawning habitat and produce roots, shoots, stems, seeds and tubers that are highly desirable waterfowl food (14).

Naiads are typically found completely submerged and usually on mucky substrates in the second and third depth ranges (greater than .5 meters). *Najas* is an annual which reproduces solely by seeds and is most commonly found in non-turbid water with hard substrates (15). It is rated as an excellent source of waterfowl food, but can reach nuisance levels.

Water celery is typically found submerged on relatively harder substrates in turbid water. It is an excellent waterfowl food source and provides fish forage, cover and spawning habitat (15).

Water milfoil (*Myriophyllum* spp.) was also present (21 sites) and moderately abundant in Shawano Lake. Species determination was not verifiable because floral bracts were absent during the

Table 9. Occurrence and Abundance of Macrophytes by Depth, Shawano Lake, July, 1991.

	Depth Ranges					
CODE	1 (N=8)		2 (N=8)		3 (N=7)	
	% of Sites	Σ Abundance (range)	% of Sites	Σ Abundance (range)	% of Sites	Σ Abundance (range)
CERDE	13	2(2)	25	5(2-3)	71	10(1-3)
CHASP	13	2(2)	38	5(1-2)	14	1(1)
ELOCA	38	4(1-2)	25	4(1-3)	14	3(3)
FILAL	88	17(1-3)	38	11(3-4)	14	1(1)
LEMMI	25	5(2-3)	13	1(1)	0	0
LEMTR	13	4(4)	38	8(1-4)	29	2(1)
MYRSPE	25	3(1-2)	38	5(1-2)	71	8(1-2)
NAJSP	50	9(1-4)	88	16(1-4)	100	13(1-4)
NITSP	13	6(1)	13	3(3)	14	3(3)
NUPSP	25	2(1)	13	2(2)	0	0
NYMSP	13	1(1)	0	0	0	0
NOPLT	0	0	0	0	0	0
PONCO	50	10(1-4)	13	4(4)	0	0
POTAM	0	0	0	0	0	0
POTCR	25	4(2)	13	2(2)	29	3(1-2)
POTFO	25	3(1-2)	63	8(1-3)	57	9(1-3)
POTIL	25	4(2)	63	8(1-2)	43	5(1-2)
POTPE	25	4(1-3)	13	1(1)	0	0
POTPU	0	0	13	3(3)	0	0
POTRI	38	5(1-2)	50	9(2-3)	29	2(1)
POTZO	0	0	0	0	0	0
RANSP	0	0	13	1(1)	0	0
SAGSP	13	3(3)	0	0	0	0
SAGGR	13	1(1)	0	0	0	0
SCISP	75	19(1-5)	38	13(4-5)	0	0
TYPLA	13	3(3)	0	0	0	0
VALAM	38	5(1-3)	88	17(1-4)	71	15(2-5)

sample periods. Distinguishing characteristics (red-tinged stems and shoots and more than 12 pairs of leaflets) of Eurasian Milfoil, an exotic plant known to spread rapidly, displace native plants and change plant and animal assemblages, were not apparent, but positive species determination should be attempted.

BASELINE CONCLUSIONS

Shawano Lake is a large, recreationally popular lake in Shawano County, Wisconsin. The lake drains a relatively small, predominantly open/agricultural watershed via five major inlets and has one major outlet tributary to the Wolf River.

- Lake water quality indicated mesotrophic to early eutrophic conditions for all parameters measured on the Trophic State Index; parameters seem to show less variability in recent years and possibly a slight decline in nutrient content. High productivity in the lake is probably related as much to basin morphometry (extensive shallow areas and well mixed relatively clear water) as to moderate nutrient content in the system; event samples generally exhibited higher levels of phosphorus than in-lake samples.
- Macrophyte populations in Shawano Lake are often at nuisance levels and the SLPOA currently operates a harvester to keep densely populated areas of the lake recreationally usable. Most common species include pondweeds, naiads and water celery with a high diversity of aquatic plants. Most abundant plants are of a desirable nature but some species have nuisance growth potential. Several common species are prone to spread by fragmentation, and warrant special attention during harvest or management efforts.

MANAGEMENT ALTERNATIVES DISCUSSION

Shawano Lake is a heavily used recreational resource with fair to good water quality and localized areas of nuisance macrophyte growth. Emphasis should be given to maintenance or enhancement of water quality through minimization of sediment and nutrient inflows, and to enhancement of resource recreational use and aesthetics through macrophyte management.

WATER QUALITY

Because of extensive and highly developed shoreline areas, riparian land use practices can, cumulatively, have a significant influence on Shawano Lake water quality and land owner diligence should be strongly emphasized and encouraged. Common sense approaches are relatively easy and can be very effective in minimizing inputs.

Yard practices can minimize both nutrient and sediment inputs. Lawn fertilizers should be used sparingly, if at all. If used, the land owner should use phosphate-free fertilizers and apply small amounts more often instead of large amounts at one or two times. Composting lawn clippings and leaves away from the lake can reduce nutrient inputs to the lake. If leaves are burned, it should be done in an area where the ash cannot wash directly into the lake (16), or indirectly to the lake via roadside ditches.

Creation of a buffer strip with diverse plants at least 20 feet wide immediately adjacent to the lake can control wave erosion, trap soil eroded from the land above, increase infiltration (to filter nutrients and soil particles), and shade areas of the lake to reduce macrophyte growth (especially on south shores) and provide fish cover. Placement of a low berm in this area can enhance effectiveness of the buffer strip by further retarding runoff during rainfalls. A buffer zone not only protects lake water quality, but creates habitat for wildlife and provides privacy (16).

There are a number of informational sources for land owners with questions regarding land management practices. Some sources are outlined in Appendix V.

MACROPHYTES

Management of macrophyte populations should continue to be a major objective on Shawano Lake where littoral areas are relatively extensive. Macrophytic growth appears to positively affect the resource in some places through forage fish production, shoreline stabilization and negatively in others through reduced access, sediment build-up and decreased aesthetics. The macrophyte management plan approved for the Wisconsin Waterways Commission application (for the cost-share grant for the harvester purchase) should be periodically reviewed to incorporate changes in recreational use and wildlife management. Consideration may also be given to identification and control of macrophyte beds susceptible to spread by fragmentation. Numerous methods of macrophyte control and management are available ranging from radical habitat alteration to more subtle habitat manipulation and are discussed below relative to Shawano Lake applicability.

Dredging is a drastic form of habitat alteration. Dredging could entail massive lake-wide sediment removal (to a depth at which macrophyte growth would be retarded due to reduced sunlight) or spot dredging of limited (high priority) areas. Large scale sediment removal is very costly. Spot dredging, because of lower cost may be a reasonable alternative in some cases. Because of potentially extensive dredge areas, the high potential for wind and motor redistribution of sediment, and resuspension of mercury contaminated sediments, dredging should not be considered for Shawano Lake at this time.

Chemical treatment has been shown to eradicate undesirable species and leave others intact. The WDNR strongly discourages the use of chemicals, however, because of nutrient release, oxygen depletion, sediment accumulation, bioaccumulation and other unknown environmental hazards including invasion potential from nuisance exotics. Chemical effects are nondiscriminate and may harm desireable or beneficial plant populations. Chemical use in the past has not shown lasting effects and should not be considered for Shawano Lake at this time.

Aquatic plant screens have been shown to reduce plant densities in localized areas and may be applicable in near-shore or localized areas here. A fiberglass screen or plastic sheet is placed and anchored on the sediment to prevent plants from growing. This may also make some sediment nutrients unavailable for algal growth. Screens should be removed each fall and cleaned in order to last a number of years.

A newer technique of rototilling sediments to destroy plant roots appears to be effective in controlling plant growth for a relatively longer period than harvesting. The process is about the same cost per hour as a contracted macrophyte harvester (17).
A potential problem is disturbance of the sediments and resuspension of nutrients or toxics.

Installation of floating platforms (black plastic attached to wooden frames) just after ice-out can shade the sediments, restrict plant growth and help to open corridors for swimming or boat navigation. Shading is usually required for three weeks to two months to impact nuisance plant growth (18). A drawback is that the area cannot be used while the platform is in place.

Remaining control methods consist, in one form or another, of macrophyte harvest. It is a commonly used technique which can be applied on a widespread or localized basis. Its efficiency, based on method of cut/harvest, can vary substantially with depth. The SLPOA currently operates a harvester with an approved macrophyte management plan.

Mechanical macrophyte harvest is a popular means for macrophyte management because it is area (and possibly species) selective and actually removes plants (and subsequently nutrients) from the system. Certain precautions and actions should be taken concerning mechanical harvest, however.

Water milfoil, coontail and common waterweed (all potentially nuisance species) are present in Shawano Lake and are known to spread easily by fragmentation. Care must be given to completely remove cut plants to prevent further spread. In addition, many plants produce seeds and harvest efforts may further aid in species spread by way of seed dispersal. By concentrating widespread harvest in the early growing season and later limiting harvest areas, this potential can be reduced.

Harvest can include large areas of removal around popular areas of the lake but should also include cutting access lanes through the larger plant beds. These lanes will increase edge habitat and access for predator fish and recreation. This method of cut has been shown to reduce stunted fish populations and increase diversity. Areas and general timing of harvest should be made available to lake users at major access points to maximize use of these areas and minimize power boat usage outside of harvest areas in the dense growth areas. This indiscriminant power boat usage can lead to masses of "prop cut" plants and also potentially spread nuisance species. Any passages between popular areas should also be located.

Selective SCUBA assisted harvest has also been shown to selectively manage macrophytes. It can be used in deeper areas and to target only desired species (e.g., Eurasian milfoil) or nuisance growth areas. This method is labor intensive, but has proved to effectively reduce nuisance plant levels for up to two years (17). This method can give native or more beneficial species a "head start" and thus reduce abundance of the particular nuisance species targeted.

Raking weeds (using an ordinary garden rake) in the frontage area can be a very effective localized plant control method when done on a regular basis. Such concentration on the problem shallow water areas would reduce efforts expended on other control methods and should be encouraged. Harvested plants should be removed away from the lakeshore area to prevent nutrients from reentering the system.

MANAGEMENT RECOMMENDATIONS

Management recommendations for Shawano Lake include objectives to protect and enhance water quality, to efficiently create access and improve aesthetics of the resource and to obtain information about lake user attitudes and priorities.

Water quality monitoring should be continued in Shawano Lake on a similar schedule to provide data necessary to track trends. Given the similar water chemistry between the three sample points (during this study), a single monitoring site (at the deepest point) may be sufficient. Event monitoring should be continued to assess nutrient levels entering the lake. Further investigation of lands drained to event sites may be warranted. Self-help Secchi monitoring should be implemented.

Riparian land management can have a significant impact on Shawano Lake water quality given the highly developed and extensive shoreline. Practices such as buffer stripping, fertilizer management and runoff control are affordable, common sense approaches that can help to control overland inflow of sediment and nutrients. Best Management Practices (BMP's), summarized in Appendix VI, have been implemented on a number of areas in the highly agricultural southeast area of the watershed and further participation and implementation should be solicited.

Mechanical macrophyte management should be continued on Shawano Lake and follow a flexible schedule to target reduction of nuisance species, create edge and access, and reduce (to the point practical) further spread of nuisance species. Maps locating harvest areas should be made available at major access points to maximize use of these areas and reduce "prop cut" plants. Water milfoil species should be positively determined and SCUBA aided removal (or other species selective method) implemented.

The SLPOA may also consider distribution of a user survey to determine attitudes and priorities of the lake users. A survey can yield valuable information on amount of use, popular areas and general ideas of water quality and association efforts.

The SLPOA, in cooperation with towns, the county and the state, should take an active role in protecting the Shawano Lake resource from invasion by exotic, potentially harmful species. By posting signs at boat landings, providing educational brochures and educating the public about harmful species and their prevention, infiltration of purple loosestrife and Eurasian milfoil and other exotic species may be slowed or even stopped.

IMPLEMENTATION

The success of any lake management plan relates directly to the ability of the association/district to obtain funds and regulatory approval necessary to implement the plan. The SLPOA is a voluntary association that does not have a lake district's specific legal or financial powers (to adopt ordinances or levy taxes or special assessments) to meet plan objectives.

The Shawano Lake watershed is located within the political jurisdictions of the Towns of Washington and Wescott, County of Shawano and the State of Wisconsin. These units have the power to regulate land uses and land use practices. Shawano County ordinances and plans possibly pertinent to the Shawano Lake plan are summarized in Appendix VII.

Potential sources of funding are listed in Appendix VIII.

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APPENDIX I
SUMMARY OF PUBLIC INVOLVEMENT ACTIVITIES
Shawano Lake Management Plan

The Shawano Lake Property Owners Association (SLPOA) initiated steps to develop a comprehensive lake management plan under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program in the Fall of 1990. A public involvement program was immediately initiated as part of the planning process. The following is a summary of major public involvement efforts.

Planning Advisory Committee

A Planning Advisory Committee (PAC) comprised of SLPOA, WDNR, University of Wisconsin-Extension and IPS representatives was established at the start of the program. The PAC provided planning direction and served as main reviewer of the draft plan document.

Brochures

A management plan summary brochure will also be produced. It will be made available for SLPOA use and distribution when the plan document has been approved by WDNR. The brochure will describe the main features of plan development, plan recommendations and other pertinent information.

Meetings

IPS presented progress reports, provided information about the resource and interpretations of these results at several board and association meetings.

Print Media

The area newspaper, "Shawano Evening Leader" published articles about the planning program throughout the course of the program.

An IPS newsletter entitled "Lake Management News" was developed and distributed to the SLPOA for the Board's use and distribution among the membership. A special "Shawano Lake Edition" was also developed to notify the SLPOA of any late developments in the planning program.

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
Water Chemistry: 03/75 - 08/77; Deepest Site
Source: WDNR

	Sample Dates					
PARAMETER	03/18/75	04/29/75	06/25/75	10/28/75	08/16/77	08/16/77
Depth (feet)	6	0	0	0	0	35
Secchi (meters)	NR	NR	2.7	2.1	1.5	-
pH (S.U.)	7.4	7.7	8.3	8.0	7.6	7.6
Conductivity (umhos/cm)	180	194	220	213	245	251
Total Alkalinity (mg/l)	131	76	106	96	82	103
Hardness (mg/l)	152	89	116	109	NR	NR
Calcium (mg/l)	NR	NR	NR	NR	22	26
Magnesium (mg/l)	NR	NR	NR	NR	17	16
Sodium (mg/l)	NR	NR	NR	NR	4	5
Potassium (mg/l)	NR	NR	NR	NR	1.8	3.5
Iron (mg/l)	NR	NR	NR	NR	0.40	0.06
Manganese (mg/l)	NR	NR	NR	NR	<0.03	<0.03
Chloride (mg/l)	NR	NR	NR	NR	5	5
Turbidity (NTU's)	NR	NR	NR	NR	1.7	2.1
Total Organic N (mg/l)	0.51	2.02	0.43	0.49	0.56	0.69
Ammonia Nitrogen (mg/l)	0.09	0.05	0.06	0.08	0.17	0.05
NO_2 + NO_3 Nitrogen(mg/l)	0.28	0.05	<0.01	0.01	0.043	0.031
Total Nitrogen (mg/l)	0.68	2.12	<0.50	0.58	0.76	0.76
Total Phosphorus (mg/l)	0.03	0.11	0.02	0.03	0.04	0.02
Phosphate Phos. (mg/l)	0.009	0.006	0.006	0.002	0.021	0.010
N/P Ratio	29.3	19.3	<25.0	19.3	19.0	36.0
Chlorophyll a (ug/l)	NR	NR	NR	NR	NR	-

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
Water Chemistry: 10/77 - 08/83; Deepest Site
Source: WDNR (Continued)

PARAMETER	Sample Dates			
	10/25/77	10/25/77	08/02/83	08/02/83
Depth (feet)	0	38	0	36
Secchi (meters)	2.4	-	1.6	-
pH (S.U.)	7.9	7.9	8.5	8.5
Conductivity (umhos/cm)	109	109	-	-
Total Alkalinity (mg/l)	107	109	116	116
Hardness (mg/L)	NR	NR	NR	NR
Calcium (mg/l)	22	23	NR	NR
Magnesium (mg/l)	16	15	NR	NR
Sodium (mg/l)	2	3	NR	NR
Potassium (mg/l)	1.3	1.5	NR	NR
Iron (mg/l)	<0.06	<0.06	NR	NR
Manganese (mg/l)	<0.03	0.03	NR	NR
Chloride (mg/l)	6	6	NR	NR
Turbidity (NTU's)	1.8	1.9	NR	NR
Total Organic N (mg/l)	0.43	0.40	≤0.80	≤0.70
Ammonia Nitrogen (mg/l)	0.03	0.05	<0.02	<0.02
NO_2 + NO_3 Nitrogen(mg/l)	<0.090	0.044	<0.02	<0.02
Total Nitrogen (mg/l)	0.54	0.48	<0.82	<0.72
Total Phosphorus (mg/l)	0.03	0.03	0.03	0.02
Phosphate Phos. (mg/l)	<0.004	<0.004	<0.004	<0.004
N/P Ratio	18.0	16.0	<27.3	36.0
Chlorophyll *a* (µg/l)	NR	NR	18	NR

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
Water Chemistry: East Basin, Midlake
Source: EPA Eutrophication Survey

PARAMETER	06/22/72	06/22/72	06/22/72	Sample Dates 08/24/72	08/24/72	08/24/72	08/24/72
Depth (feet)	0	15	25	0	4	15	20
Temperature (°C)	19.2	19.5	16.5	NR[1]	20.8	20.5	20.4
D.O. (mg/l)	6.8	6.3	4.9	NR	7.8	-	6.6
Secchi (feet)	8.0	-	-	5.7	-	-	-
Conductivity (umho)	200	200	205	223	223	223	200
pH (S.U.)	8.20	8.30	7.70	8.30	8.30	8.35	8.10
Total Alkalinity (mg/l)	103	100	101	106	104	102	103
NO_2 + NO_3 Nitrogen (mg/l)	0.050	0.050	0.050	0.060	0.060	0.060	0.060
Ammonia Nitrogen(mg/l)	0.140	0.120	0.190	0.060	0.060	0.070	0.070
Total Phosphorus (mg/l)	0.025	0.021	0.020	0.028	0.032	0.031	0.031
Dissolved Phos. (mg/l)	0.012	0.006	0.006	0.018	0.008	0.008	0.007
Chlorophyll a (ug/l)	10.5[2]	-	-	9.0[2]	-	-	-

[1] NR = No Reading
[2] Value known to be in error

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
Water Chemistry: East Basin, Midlake
Source: EPA Eutrophication Survey (Continued)

	Sample Dates			
PARAMETER	11/08/72	11/08/72	11/08/72	11/08/72
Depth (feet)	0	4	15	24
Temperature (°C)	NR[1]	5.8	5.8	5.8
D.O. (mg/l)	NR	11.4	11.3	11.7
Secchi (feet)	6.0	-	-	-
Conductivity (µmho)	240	230	230	235
pH (S.U.)	7.70	7.70	7.70	7.70
Total Alkalinity (mg/l)	107	108	107	104
NO_2 + NO_3 Nitrogen (mg/l)	0.040	0.040	0.040	0.040
Ammonia Nitrogen(mg/l)	0.060	0.070	0.060	0.050
Total Phosphorus (mg/l)	0.012	0.017	0.016	0.019
Dissolved Phos. (mg/l)	0.006	0.008	0.009	0.007
Chlorophyll a (µg/l)	10.0[2]	-	-	-

[1] NR = No Reading
[2] Value known to be in error

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
Water Chemistry: Lake Center, Midlake
Source: EPA Eutrophication Survey (Continued)

	Sample Dates					
PARAMETER	06/22/72	06/22/72	08/24/72	08/24/72	08/24/72	08/24/72
Depth (feet)	6	10	0	4	10	15
Temperature (°C)	18.9	16.9	NR[1]	20.3	20.3	20.2
D.O. (mg/l)	7.2	9.6	NR	NR	7.2	7.3
Secchi (feet)	7.0	-	5.3	-	-	-
Conductivity (µmho)	205	200	223	222	222	225
pH (S.U.)	8.20	8.20	8.25	8.25	8.20	8.25
Total Alkalinity (mg/l)	101	101	102	110	109	109
$NO_2 + NO_3$ Nitrogen (mg/l)	0.050	0.050	0.070	0.070	0.080	0.070
Ammonia Nitrogen(mg/l)	0.100	0.100	0.090	0.070	0.080	0.070
Total Phosphorus (mg/l)	0.025	0.025	0.024	0.022	0.020	0.018
Dissolved Phos. (mg/l)	0.012	0.006	0.009	0.009	0.008	0.007
Chlorophyll a (µg/l)	38.7[2]	-	11[2]	-	-	-

[1] NR = No Reading
[2] Value known to be in error

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
Water Chemistry: Lake Center, Midlake
Source: EPA Eutrophication Survey (Continued)

PARAMETER	11/08/72	Sample Dates 11/08/72	11/08/72
Depth (feet)	0	4	16
Temperature (°C)	NR[2]	5.6	5.6
D.O. (mg/l)	NR	10.6	11.0
Secchi (feet)	7.2	·	·
Conductivity (µmho)	230	230	235
pH (S.U.)	7.80	7.80	7.80
Total Alkalinity (mg/l)	101	103	103
$NO_2 + NO_3$ Nitrogen (mg/l)	0.050	0.040	0.040
Ammonia Nitrogen(mg/l)	0.050	0.050	0.050
Total Phosphorus (mg/l)	0.013	0.017	0.017
Dissolved Phos. (mg/l)	0.009	0.009	0.008
Chlorophyll *a* (µg/l)	8.7[1]		-

[1] NR = No Reading
[2] Value known to be in error

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
Water Chemistry: West Basin, Midlake
Source: EPA Eutrophication Survey (Continued)

			Sample Dates			
PARAMETER	06/22/72	06/22/72	08/24/72	08/24/72	11/08/72	11/08/72
Depth (feet)	0	6	0	4	0	4
Temperature (°C)	18.0	18.0	NR*	19.6	NR	5.6
D.O. (mg/l)	7.0	6.4	NR	NR	NR	10.5
Secchi (feet)	7.5	-	NR	-	7.0	-
Conductivity (µmho)	210	210	220	220	235	235
pH (S.U.)	8.20	8.10	8.35	8.40	7.70	7.70
Total Alkalinity (mg/l)	103	104	109	108	103	104
NO_2 + NO_3 Nitrogen (mg/l)	0.050	0.050	0.070	0.060	0.050	0.060
Ammonia Nitrogen (mg/l)	0.090	0.050	0.070	0.060	0.060	0.050
Total Phosphorus (mg/l)	0.024	0.026	0.020	0.021	0.014	0.014
Dissolved Phos. (mg/l)	0.010	0.015	0.008	0.008	0.006	0.007
Chlorophyll a	7.7[2]	-	6.6[2]	-	10.0[2]	-

* NR = No Reading
[2] Value known to be in error

APPENDIX II
HISTORIC WATER QUALITY DATA
Shawano Lake, Shawano County, WI
TSI Parameters: 07/68 - 05/79; Deepest Point
Source: WDNR - Bureau of Research

Sample Dates

PARAMETER	07/08/68	11/05/68	03/06/69	05/12/69	08/25/69	10/27/69	02/16/70	05/05/70
Depth (feet)	0	0	0	0	0	0	0	0
Secchi (feet)	3.7	6.0	9.0	-	5.0	8.0	16.0	6.0
Total Phosphorus (mg/l)	0.06	0.09	0.07	0.07	0.03	0.03	0.03	0.07

Sample Dates

PARAMETER	08/18/70	11/04/70	02/11/71	08/24/71	03/07/72	03/20/72	05/11/72	07/31/72
Depth (feet)	0	0	0	0	0	0	0	0
Secchi (feet)	6.0	7.0	-	-	8.0	16.0	-	6.0
Total Phosphorus (mg/l)	0.05	0.02	0.03	0.05	0.02	0.01	0.04	0.03

Sample Dates

PARAMETER	11/07/72	02/20/73	05/14/73	08/07/78	11/08/78	02/26/79	05/16/79
Depth (feet)	0	0	0	0	0	0	0
Secchi (feet)	9.0	6.0	10.0	4.0	-	16.5	6.0
Total Phosphorus (mg/l)	0.16	0.02	0.02	0.02	0.04	0.01	0.01