IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE I
LAKE MANAGEMENT PLAN
EAST CHAIN O' LAKES
WAUPACA COUNTY, WISCONSIN

REPORT TO:
CHAIN O' LAKES PROPERTY OWNERS ASSOCIATION

August, 1993

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GLOSSARY OF TERMS (1, 2, 3)

Anoxic	Water that has extremely low or no dissolved oxygen.
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 permanently inflowing and outflowing streams.
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.
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.
Marl	White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) in hard water lakes. The marl may contain snail and clam shells which are also $CaCO_3$. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in normally low algal populations and good water clarity.
Mesotrophic	A lake of intermediate productivity and clarity.

GLOSSARY OF TERMS
(Continued)

Morphometry Pertaining to the shape, depth or structure of a lake.

N/P Ratio Total nitrogen divided by the total phosphorus found in a water sample. A value greater than 15 indicates phosphorus to be limiting primary production.

Oligotrophic Typically, a lake of low plant productivity and high transparency.

Physicochemical Pertaining to physical and/or chemical characteristics.

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.

Spring Lake Lakes typically having no inlet but possessing an outlet; the primary source of water is groundwater inflow.

Stratification 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

The Chain O' Lakes (Chain) is a recreationally popular group of lakes located in Waupaca County, Wisconsin. Generally, the lakes are spring fed, relatively deep and clear. For plan development, the Chain was divided into Upper, Middle, Lower, East and Little Chain subgroups. Specific Phase I objectives were to establish a water quality monitoring strategy to assess current status and track trends, to improve public awareness and participation, and to initiate assessment of recreational use opinions and options.

The East Chain [redacted] is the second smallest group by lake surface area, and drains the smallest watershed of all the Chain project groups. Water quality for the East Chain lakes was good to excellent, generally similar to that of other Chain project groups and indicative of **oligotrophic**[1] to **mesotrophic** status. Surface nutrient levels were similar between Dake and Miner Lakes and near or below expected levels overall.

The East Chain Lakes have relatively more extensive **littoral** zones as shallow shelf areas are located in the bays of the lakes. **Macrophyte** growth, however, appears to benefit the resource through provision of fish and forage habitat, shoreline stabilization and nutrient uptake. Potentially nuisance species are present in some areas but habitat, overall, does not appear conducive to development of nuisance abundance levels.

Water quality monitoring, recreational use management and prevention of exotic plant or animal introductions are recommended to protect the excellent quality of this resource.

* Water quality trend monitoring should be continued on a similar schedule to supplement the small amount of historic data available. Volunteers should be solicited to take **Secchi depth** readings on Dake and Miner Lakes.

* Because of the small watershed for the East Chain, riparian land owner education and diligence with respect to runoff control, and yard waste and fertilizer management, is especially important. Riparian zones can be the last "buffer strip" between the watershed and the lake and land management should be encouraged to maximize aesthetics and minimize sediment and nutrient input to the lakes.

* Macrophyte management, if considered necessary or desireable, should be limited to localized manual efforts in near shore areas to improve access or aesthetics.

* Recreational use survey results (presently being tabulated) should be analyzed, with appropriate correlations, to assess perceptions and attitudes and develop practical options for future management and minimization of use conflicts.

* Measures to prevent or reduce the potential for invasion of exotic species (e.g., Eurasian milfoil and purple loosestrife which are present and spreading in Waupaca County) should be identified and implemented.

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

INTRODUCTION

The Chain O' Lakes (Chain) is a group of 22 interconnected lakes located in the southwest corner of Waupaca County near the City of Waupaca and the Villages of Rural and King. Most lakes in the Chain are deep, clear, and spring-fed; the Chain, associated wetlands and undeveloped shoreline areas have been designated as environmentally sensitive areas (4).

The Chain O' Lakes Property Owners Association (CLPOA) was formed in the 1960's to provide leadership and coordination of lake preservation and educational activities pertinent to the Chain. The CLPOA has an Executive Committee of 13 elected officers and about 600 members overall.

The CLPOA, in 1990, decided to pursue the development of a long range management plan for the Chain under the Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant Program. The CLPOA officers selected IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin as its consultant to develop the plans. Grant applications, one each for five project groups of the Chain (Table 1), were prepared and submitted in January, 1991. The East chain application incorporated required or CLPOA recommended program components including:

- assessment of current water quality in the East chain and implementation of a monitoring strategy to track trends,
- enhancement of lake property owner awareness of lake problems and establishment of a base of support for lake management efforts,
- location, identification and quantification of aquatic plants on Dake and Miner Lakes,
- development of options for recreational use management.

The East Chain grant application was approved in April, 1991.

Table 1. Lake Management Planning Project Groups, Chain O' Lakes, Waupaca County, WI.

Upper Chain	Middle Chain	Lower Chain
Otter Lake	Nessling Lake	Ottman Lake
Taylor Lake	McCrossen Lake	Bass Lake
George Lake	Round Lake	Youngs Lake
Sunset Lake	Limekiln Lake	Beasley Lake
Rainbow Lake		Long Lake
		Columbia Lake

East Chain	Little Chain
Dake Lake	Orlando Lake
Miner Lake	Knight Lake
	Manomin Lake
	Pope Lake
	Marl Lake

DESCRIPTION OF AREA

The Chain O' Lakes is a group of "kettle" lakes located in the southwest corner of Waupaca County, WI (Figure 1). Kettle lakes are typically formed when large ice blocks are pushed into the soil by a retreating glacier; the depression subsequently fills with water when the ice blocks melt. The East Chain consists of two lakes in the south-central portion of the Chain.

The general topography of Waupaca County is related to glacial activity; the Chain is located in moranic hills left after the retreat of the Cary Glacier (5). Topography adjacent to the lakes is moderately to steeply sloping. The major soil type near the East Chain is well drained Rosholt sandy loam on 12-20 percent slopes (6). Erosion potential is moderate for Rosholt soils and permeability is moderately rapid.

Predominant littoral substrates are sand and **marl**; scattered reaches of rubble and muck are present (Personal communication WDNR). Macrophytes (aquatic plants) are present and locally abundant, primarily in bays, in Dake and Miner Lakes. Two exotic nuisance plant species, Eurasian milfoil (Myriophyllum spicatum) and purple loosestrife (Lythrum salicaria), are established in Waupaca County and are capable of spreading to the Chain O' Lakes system.

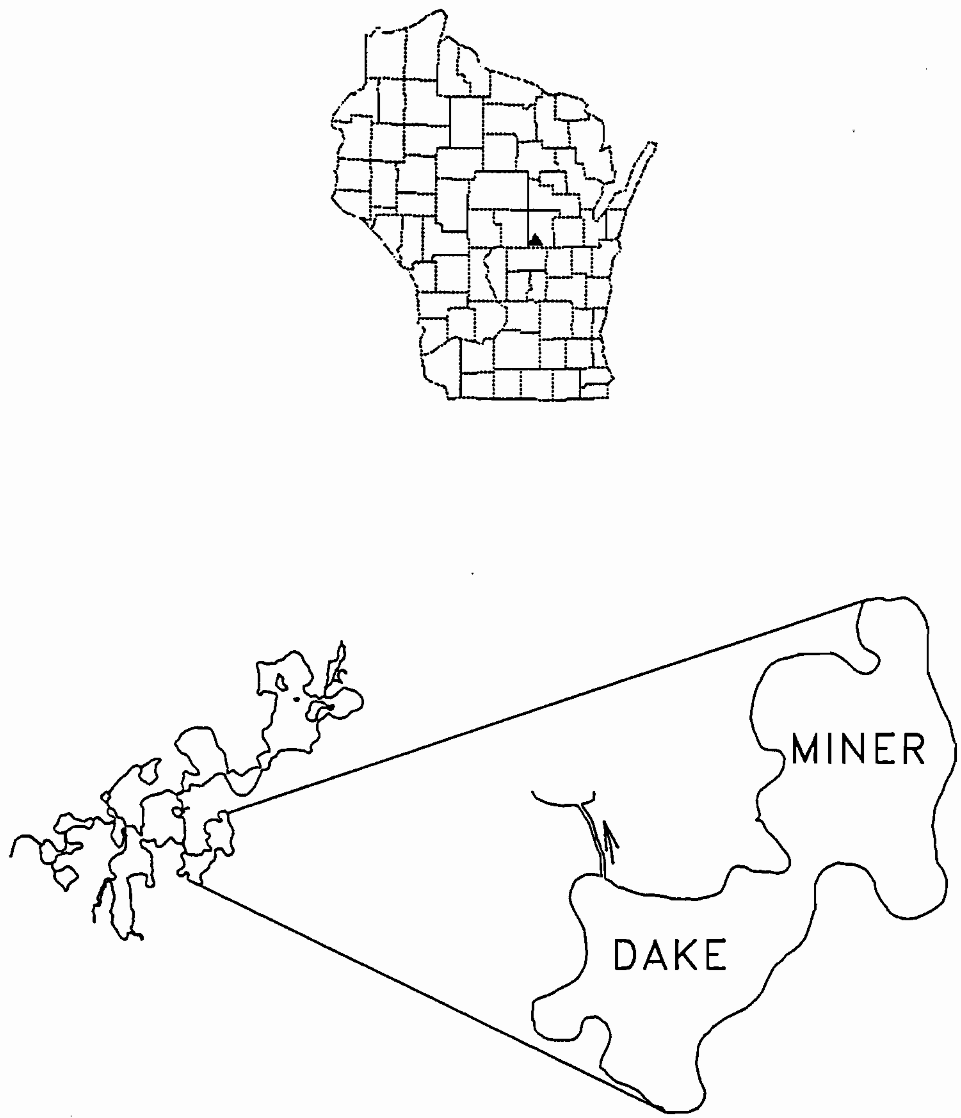


Figure 1. Location Map, Chain O' Lakes, Waupaca County, WI.

The Chain watershed, about 20,000 acres, is predominantly forested with open/agricultural areas. Native trees include maple, ash, oak, and pine, and dairy farming is the chief agricultural activity in the watershed (Pers. comm. WDNR).

Sanitary sewerage collection and treatment is provided for all Chain residences through the Chain O' Lakes Sanitary Lake District but no direct discharge to the Chain occurs from the treatment facility.

Miner Lake is listed as a **spring lake** and Dake as a **drainage lake**, and the lakes have very similar basin **morphometry** (Table 2). Miner Lake is slightly larger (35 acres) than Dake Lake (32 acres) and has twice the maximum depth. Lake volume is 732 and 317 acre-feet for Miner and Dake Lakes, respectively. The lake

Table 2. Physical Characteristics of the East Chain Lakes, Waupaca County, WI.

Lake Name	MINER	DAKE
Location		
Township(s)	21,22N	21N
Range	11E	11E
Section(s)	3,4	4
Lake Type	Spring	Drainage
Area (acres)	35	32
Max. Depth (ft)	52	26
Av. Depth (ft)	24	10
Volume (acre-feet)	732	317
Shoreline (miles)	1.2	1.2
Fetch (miles)	0.39	0.36
Fetch Orientation	N-S	SW-NE
Width (miles)	0.25	0.31
Lake Shore Soils		
Major Type	Rosholt[1]	Rosholt[1]
% Slope	12-20	12-20

[1] = Rosholt sandy loam

basins are relatively small (**fetch** = 0.36 miles, Dake; 0.39 miles, Miner) and deep (maximum depth 26 feet, Dake; 52 feet, Miner). Thermal **stratification** develops during Summer and restricts mixing to spring and fall overturns. Both lakes developed thermoclines at similar depths (18 to 21 feet), but Miner Lake has a much larger **hypolimnion.**

The Chain supports warmwater and coldwater fisheries (Table 3). At least some trout from the Chain are known to migrate into Emmon's Creek to spawn; splake and rainbow trout were stocked in the past by the WDNR to supplement the cold water fishery. Hybrid muskellunge were stocked in the Chain from 1979 to 1986. No stocking presently occurs in the Chain (Pers. comm. WDNR). A WDNR consumption advisory (for mercury) currently exists for largemouth bass taken from Columbia Lake. Fish from Rainbow Lake have also been tested for mercury but no advisory was issued (7).

Public boat ramps are available at about ten locations on the Chain. Most of the connecting channels on the Chain are navigable for powerboats and all but one (Ottman - Youngs) are navigable with a canoe. The East Chain has a boat ramp access point off the east shore of Dake Lake (Pers. comm. WDNR).

Because of intensive recreational use during Summer, the Towns of Dayton and Farmington and the CLPOA adopted ordinances to

Table 3. Chain O' Lakes Fish Species.

COMMON NAME	SCIENTIFIC NAME
Warmwater Game Fish	
Muskellunge	Esox masquinongy
Hybrid muskellunge (muskellunge X northern pike)	
Northern pike	Esox lucius
Walleye	Stizostedion vitreum
Largemouth bass	Micropterus salmoides
Smallmouth bass	Micropterus dolomieui
Lake sturgeon	Acipenser fulvescens
Coldwater Game Fish	
Brown trout	Salmo trutta
Rainbow trout	Salmo gairdneri
Hybrid splake (lake trout X brook trout)	
Cisco	Coregonus artedii
Warmwater Panfish	
Bluegill	Lepomis macrochirus
Black crappie	Pomoxis nigromaculatus
Green sunfish	Lepomis cyanellus
Pumpkinseed	Lepomis gibbosus
Rock bass	Ambloplites rupestris
Warmouth	Lepomis gulosus
Yellow perch	Perca flavescens
Black bullhead	Ictalurus melas
Brown bullhead	Ictalurus nebulosus
Yellow bullhead	Ictalurus natalis
Rough Fish	
Bowfin	Amia calva
White sucker	Catostomus commersoni
Hog sucker	Hypentelium nigricans
Bigmouth buffalo	Ictiobus cyprinellus
Shorthead redhorse	Moxostoma macrolepidotum
Burbot	Lota lota
Forage Fish	
Brook silverside	Labidesthes sicculus
Western mudminnow	Umbra limi
Golden shiner	Notemigonus crysoleucas
Bluntnose	Pimephales notatus
Central stoneroller	Campostoma anomalum
Northern common shiner	Notropis cornutus
Northern creek chub	Semotilus atromaculatus
Blackside darter	Percina maculata
Slimy muddler	Cottus cognatus
Central johnny darter	Etheostoma nigrum

regulate boat traffic on the Chain. Except for the largest lakes (Columbia, Long, Rainbow and Round), all lakes on the Chain have a "no wake" speed limit (Pers. comm. CLPOA). Water skiing on these lakes is limited to 10:00 a.m. - 2:30 p.m. on weekends and Holidays, 10:00 a.m. - 4:00 p.m. on Monday and Friday, and 10:00 a.m. - 7:00 p.m. on Tuesday through Thursday.

METHODS

FIELD PROGRAM

Water sampling was conducted May 29, August 6, and September 4, 1991 and January 30 and May 6, 1992 at the deepest point of each East Chain lake (Table 4, Figure 2). Both sites (1301, Dake Lake; 1302, Miner Lake) were sampled three feet below the surface (designated "S") and three feet above bottom (designated "B").

Physicochemical parameters measured in the field were Secchi depth, water temperature, pH, dissolved oxygen (DO), and conductivity. Field measurements were taken using a standard Secchi disk and a Hydrolab Surveyor II multiparameter meter; the Hydrolab was calibrated prior to and subsequent to daily use.

Samples were taken for laboratory analyses with a Kemmerer water bottle. Samples were labelled, preserved if necessary, and packed on ice in the field; samples were delivered by overnight carrier to the laboratory. All laboratory analyses were conducted at the State Laboratory of Hygiene (Madison, WI) using WDNR or APHA (8) methods. Spring parameters determined by the laboratory included laboratory pH, total alkalinity, total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and dissolved phosphorus, total solids, and

Table 4. Sample Station Descriptions, East Chain, Chain O' Lakes, 1991 - 1992.

WATER QUALITY

Lake	Site	Latitude (North) / Longitude (West)	Depth
Dake (Deepest Pt.)	1301	44° 19' 28" / 89° 10' 05"	52.0 ft.
Miner (Deepest Pt.)	1302	44° 19' 37" / 89° 09' 59"	26.0 ft.

MACROPHYTE TRANSECTS

Transect	Latitude/Longitude Origin		Transect Length(m)	Bearing (Degrees)	Depth Range[1]	Interval End (m)
Dake Lake						
A	44° 19' 23"	89° 10' 04"	290	340	1/2/3	5/145/290
B	44° 19' 17"	89° 10' 07"	365	19	1/2/3	6/ 35/365
C	44° 19' 21"	89° 10' 19"	350	58	1/2/3	3/ 90/350
D	44° 19' 31"	89° 10' 18"	90	123	1/2/3	8/ 15/ 90
E	44° 19' 33"	89° 10' 00"	55	225	1/2/3	6/ 45/ 55
Miner Lake						
A	44° 19' 47"	89° 09' 59"	10	164	1/2/3	2/ 6/ 10
B	44° 19' 42"	89° 10' 04"	10	120	1/2/3	2/ 6/ 10
C	44° 19' 36"	89° 10' 02"	23	49	1/2/3	2/ 15/ 23
D	44° 19' 30"	89° 09' 51"	75	318	1/2/3	9/ 60/ 75
E	44° 19' 41"	89° 09' 50"	18	244	1/2/3	9/ 14/ 18
F	44° 19' 46"	89° 09' 57"	11	31	1/2/3	5/ 6/ 11

[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)

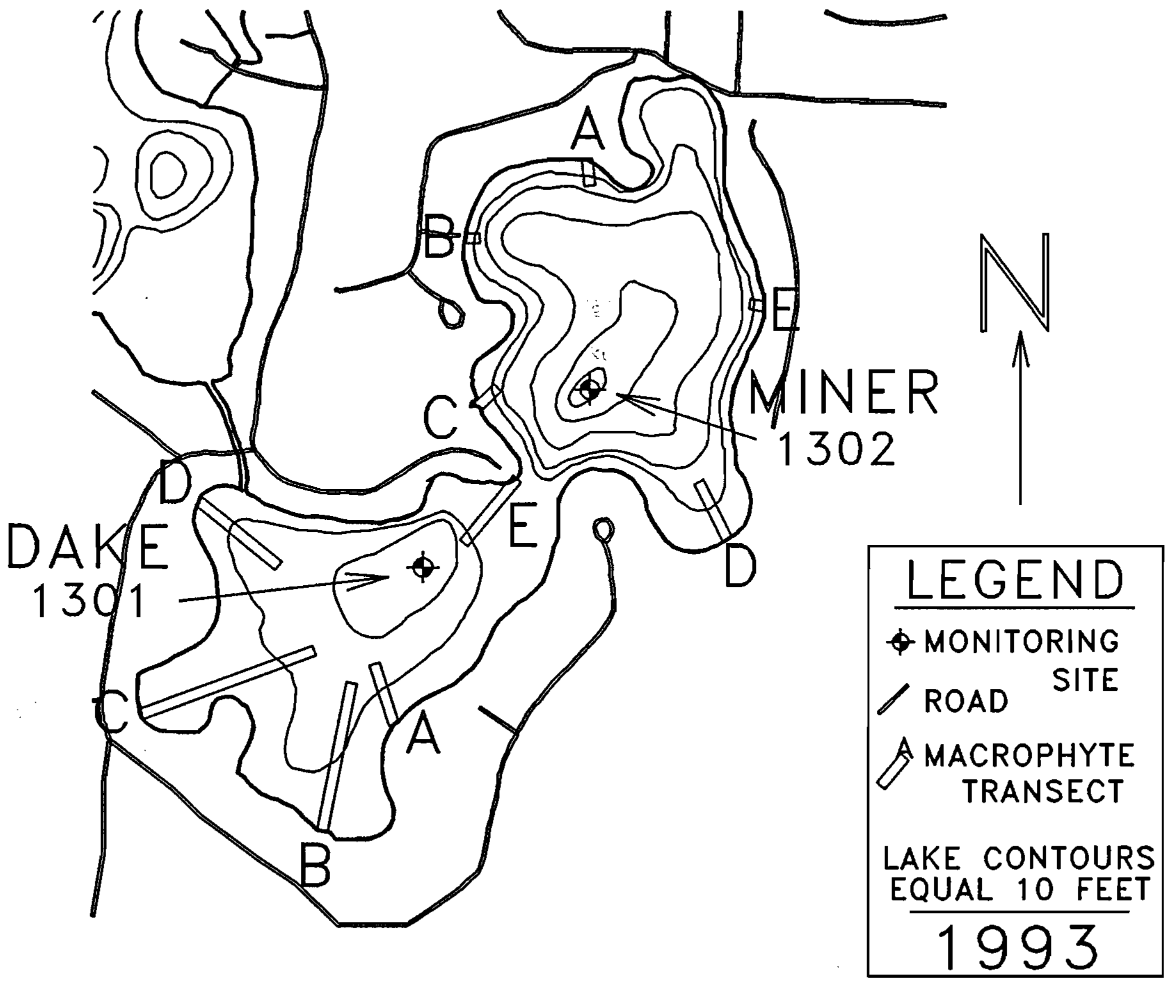


Figure 2. Sample Station Locations, East Chain, Chain O' Lakes, Waupaca County, WI.

chlorophyll a. Summer and late summer laboratory analyses included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus, dissolved phosphorus, and chlorophyll a. Winter water quality parameters included total Kjeldahl nitrogen, ammonia nitrogen, nitrate/nitrite nitrogen, total phosphorus and dissolved phosphorus.

Macrophyte surveys were conducted on Dake and Miner Lakes on May 29 and September 5, 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). Transect endpoints were established on and off shore for use as reference from one sampling period to the next. Points were determined using a Loran Voyager Sportnav latitude/longitude locator and recorded with bearing and distance of the transect (line of collection) for future surveys. Five transects (on Dake) and six transects (Miner) were chosen to provide information from various habitats and areas of interest.

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. Aquatic plant 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

Water Quality Information

Additional lake information was retrieved from the WDNR Surface Water Inventory (5) and the Wisconsin Lake Bulletin Board System.

Land Use Information

Details of zoning and specific land uses were obtained from the UW-Extension, Waupaca County zoning maps, United States Soil Conservation Service soil maps (6), aerial photographs, and United States Geological Survey quadrangle maps. This information, when considered questionable or out-dated, was confirmed by field reconnaissance.

Ordinance information was taken from Waupaca County Zoning Ordinance, Soil Erosion Control and Animal Wastewater Pollution Control Plans acquired from the Land Conservation Department.

Public Involvement Program

Public involvement activities coordinated with the lake management planning process are summarized in Appendix I.

Recreational Use Survey

A survey was distributed to CLPOA for subsequent distribution to members. The survey form was designed to assess current types and levels of use and opinions regarding them. The survey was furnished to CLPOA in June and returned August, 1992; tabulation and analysis are plan development Phase II activities.

FIELD DATA DISCUSSION

The East Chain is comprised of two natural lakes. Flow in the East Chain is from Dake to Miner Lake. There is an navigable outlet channel connecting Miner Lake to Columbia Lake (Lower Chain); the Crystal River (originating from Long Lake in the Lower Chain) serves as the outlet for the entire Chain O' Lakes.

The Chain O' Lakes watershed consists of wooded/wooded residential, open/agricultural and open/residential areas; the East Chain watershed is about 330 acres and primarily wooded residential (not shown) near the lakes (Figure 3). There is no permanent overland inflow to the East Chain.

The East Chain has a watershed to lake ratio of 5:1 which means that five times more land than lake surface area drains to the lakes. This value is less than the 8:1 ratio for seepage lakes (lakes without inlets) in Wisconsin (10) and indicates a low potential for effects of overland inflow and nonpoint source nutrient and sediment inputs to the system.

Monitoring in 1991-1992 (Tables 5 and 6), indicated similar water quality in the East Chain lakes. Surface total nitrogen, which is highly variable among lakes and best considered on a trend or relative basis, ranged from less than 0.407 to 0.855 mg/l with an

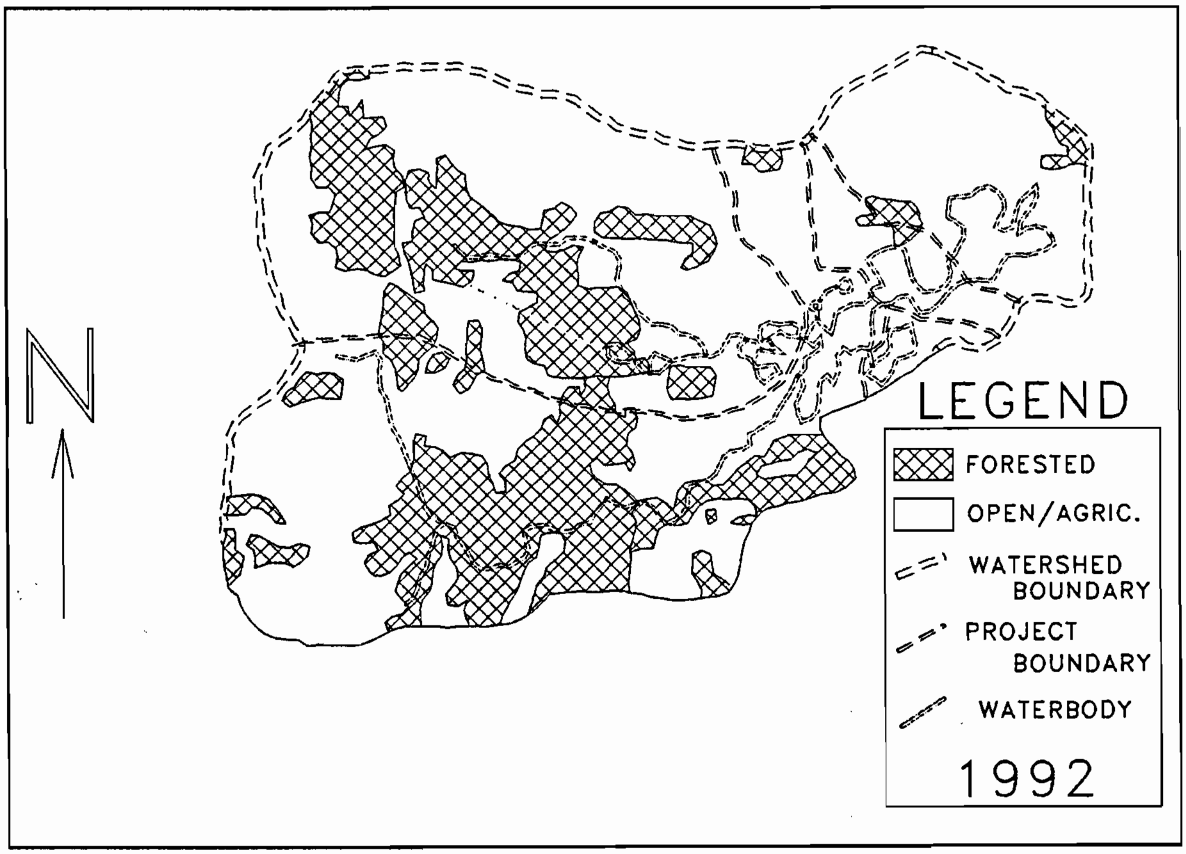


Figure 3. Land Uses in the Chain O' Lakes Watershed, Waupaca and Portage Counties, WI.

Table 5. Water Quality Parameters, Station 1301, Dake Lake, Waupaca County, WI.

PARAMETER	SAMPLE[1]	05/29/91	08/06/91	09/04/91	01/30/92	05/06/92
Secchi (feet)		22.0	11.0	11.0	NR[2]	10.0
Cloud Cover (%)		20	100	0	100	0
Temperature (°C)	S	24.83	23.35	22.76	3.43	12.87
	B	12.98	17.40	19.65	4.12	7.32
pH (S.U.)	S	8.32	8.95	8.85	NR	8.90
	B	8.12	7.21	7.08	NR	8.50
D.O. (mg/l)	S	8.5	9.35	8.37	9.55	11.06
	B	8.63	0.15	0.13	5.91	10.77
Conductivity (µmhos/cm)	S	267	242	231	277	244
	B	274	324	292	334	244
Laboratory pH (S.U.)	S	8.3	NR	NR	NR	NR
	B	8.1	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	130	NR	NR	NR	NR
	B	132	NR	NR	NR	NR
Total Solids (mg/l)	S	180	NR	NR	NR	NR
	B	178	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.6	0.5	0.5	0.7	0.5
	B	0.6	0.8	0.7	1.1	0.8
Ammonia Nitrogen (mg/l)	S	0.109	0.014	0.018	0.213	0.011
	B	0.106	0.047	0.143	0.597	0.046
NO_2 + NO_3 Nitrogen(mg/l)	S	0.053	<0.007	<0.007	0.046	0.051
	B	0.037	<0.007	<0.007	0.176	0.086
Total Nitrogen (mg/l)	S	0.653	<0.507	<0.507	0.746	0.551
	B	0.637	<0.807	<0.707	1.276	0.886
Total Phosphorus (mg/l)	S	0.011	0.012	0.007	0.007	0.015
	B	0.015	0.026	0.013	0.008	0.039
Diss. Phosphorus (mg/l)	S	ND[3]	0.002	0.002	0.002	ND
	B	ND	0.002	0.003	0.003	ND
N/P Ratio	S	59.4	<42.3	<72.4	106.6	36.7
	B	42.5	<31.0	<54.4	159.5	22.7
Chlorophyll a (µg/l)	S	1[4]	4	4	NR	4

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable; [4] Results Approximate

Table 6. Water Quality Parameters, Station 1302, Miner Lake, Waupaca County, WI.

PARAMETER	SAMPLE[1]	05/29/91	08/06/91	09/04/91	01/30/92	05/06/92
Secchi (feet)		20.0	10.5	13.0	NR[2]	19.0
Cloud Cover (%)		20	100	0	100	0
Temperature (°C)	S	24.21	23.35	23.12	3.59	12.22
	B	5.43	6.57	7.29	4.51	5.23
pH (S.U.)	S	8.33	8.89	8.95	7.42	8.55
	B	7.37	6.49	6.93	6.63	7.30
D.O. (mg/l)	S	8.37	9.24	9.20	8.25	10.71
	B	0.62	0.09	0.27	0.11	0.42
Conductivity (µmhos/cm)	S	264	240	225	257	241
	B	305	312	299	321	269
Laboratory pH (S.U.)	S	8.4	NR	NR	NR	NR
	B	7.4	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	127	NR	NR	NR	NR
	B	151	NR	NR	NR	NR
Total Solids (mg/l)	S	178	NR	NR	NR	NR
	B	200	NR	NR	NR	NR
Total Kjeldahl N (mg/l)	S	0.6	0.4	0.5	0.8	0.5
	B	2.2	2.8	3.6	2.6	1.5
Ammonia Nitrogen (mg/l)	S	0.081	0.014	<0.005	0.250	0.043
	B	1.12	1.99	2.38	1.92	0.762
NO_2 + NO_3 Nitrogen(mg/l)	S	0.059	<0.007	<0.007	0.055	0.051
	B	<0.015	<0.007	<0.007	<0.007	<0.007
Total Nitrogen (mg/l)	S	0.659	<0.407	<0.507	0.855	0.551
	B	<2.215	<2.807	<3.607	<2.607	<1.507
Total Phosphorus (mg/l)	S	0.009	0.010	0.008	0.014	0.008
	B	0.110	0.30	0.31	0.386	0.060
Diss. Phosphorus (mg/l)	S	ND[3]	0.002	0.002	0.008	ND
	B	0.025	0.208	0.26	0.336	0.010
N/P Ratio	S	73.2	<40.7	<63.4	61.1	68.9
	B	<20.1	< 9.4	<11.6	< 6.8	<25.1
Chlorophyll a (µg/l)	S	1[4]	3	3	NR	2[4]

[1] S = Near Surface; B = Near Bottom; [2] NR = No Reading; [3] ND = Not Detectable; [4] Results Approximate

average of 0.650 for Dake Lake and 0.688 mg/l for Miner Lake ("less than" values ignored). Nitrogen values were quite consistent throughout the sampling period.

Phosphorus is often the limiting nutrient to plant and algal production in lakes. Surface total phosphorus levels were similar in Dake and Miner Lakes (range: 0.007 - 0.015 mg/l; both recorded in Dake Lake) with an average of 0.010 mg/l for each lake (Tables 5 and 6). Phosphorus levels for the East Chain were lower than those typical for stratified lakes (0.023 mg/l) and for lakes in the central region in Wisconsin (0.020 mg/l) (10); levels were at or slightly below those typical for the ecoregion in which the Chain is located (0.010-0.014 mg/l) (11) (Figure 4).

Substantially higher values for total phosphorous and other nutrient parameters were observed near bottom in Miner Lake (where depth and hypolimnetic volume are much greater than in Dake Lake) and suggested nutrient release from sediments under **anoxic** or near-anoxic conditions at this relatively deep point. Nitrogen to phosphorus ratios (**N/P ratio**) for surface samples were greater than 15 and indicated the East Chain lakes to be phosphorus limited during the 1991 - 1992 monitoring period.

Miner Lake was completely stratified (e.g., with well defined thermocline and hypolimnion) during summer monitoring; Dake Lake

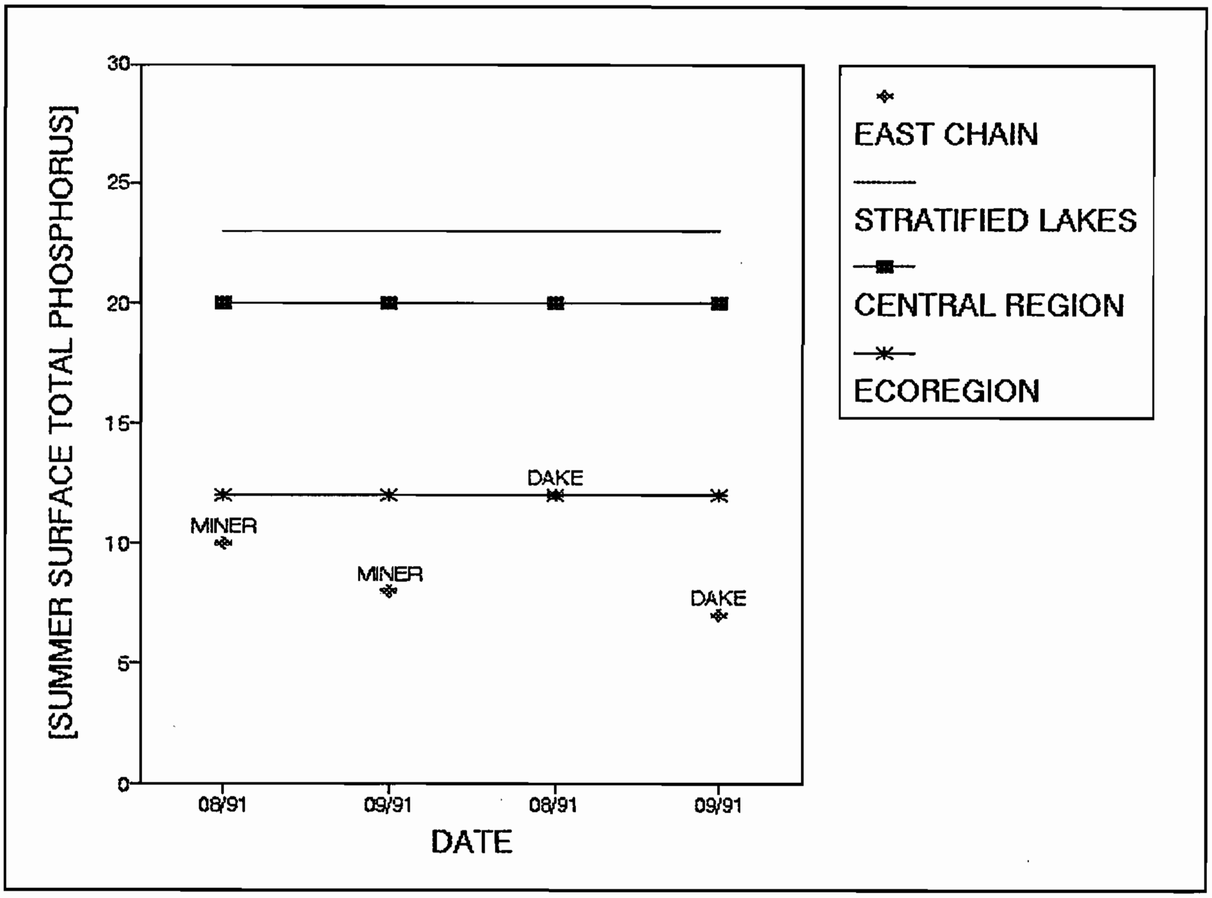


Figure 4. Comparison of Total Phosphorus Levels, East Chain, Chain O' Lakes, 1991.

stratified but only very near the bottom (Table 5, Figure 5, Appendix II). Depth to the thermocline was 18 feet for Miner Lake and 21 for Dake Lake. Hypolimnetic oxygen levels in both lakes during summer stratification were below those generally considered necessary to sustain most aquatic life. Low dissolved oxygen levels occurred near bottom in Miner Lake during all seasons; near bottom dissolved oxygen levels in Dake Lake appeared to remain relatively high except during summer stratification. Winter water column readings indicated typical unstratified conditions with dissolved oxygen levels decreasing with increasing lake depth (Figure 6).

Numerous summarative indices have been developed to indicate lake **eutrophication** status based on water quality parameters. The Trophic State Index (TSI) developed by Carlson (12) 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 particular index does not account for natural, regional variability in total phosphorus levels nor in Secchi transparency reduction unrelated to algal growth (e.g. that associated with color). TSI numbers for the Dake and Miner Lake sites during sampling in 1991 and 1992 (no historic data available) generally indicated oligotrophic to mesotrophic conditions (Figure 7).

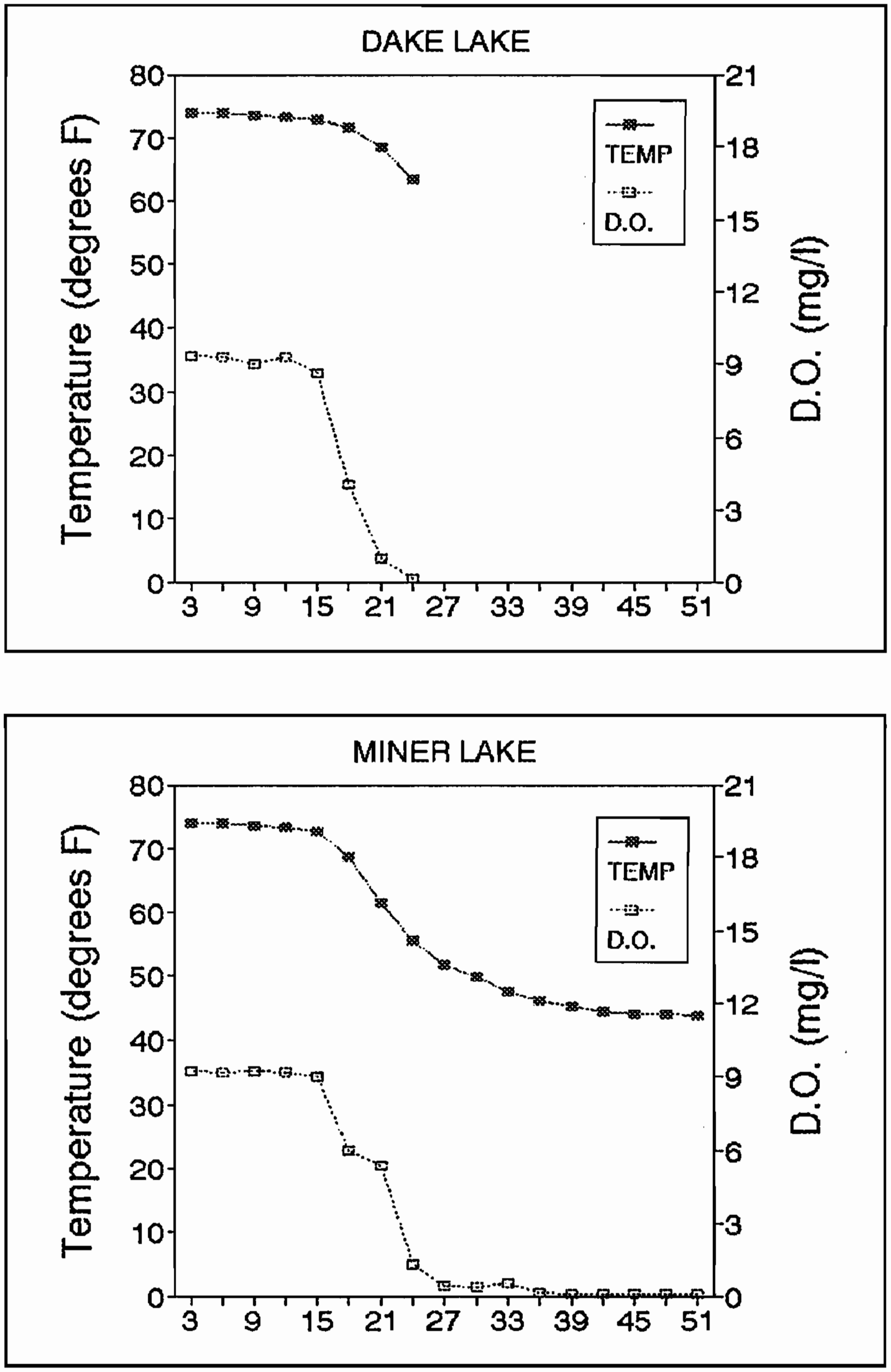
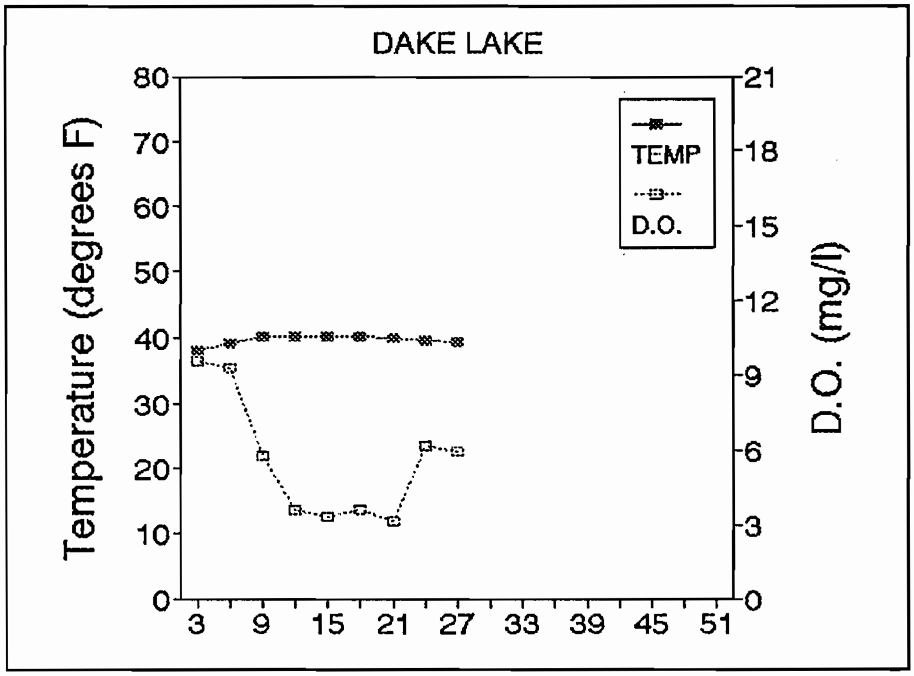


Figure 5. Temperature/DO Profiles, East Chain, Chain O' Lakes, Summer, 1991.



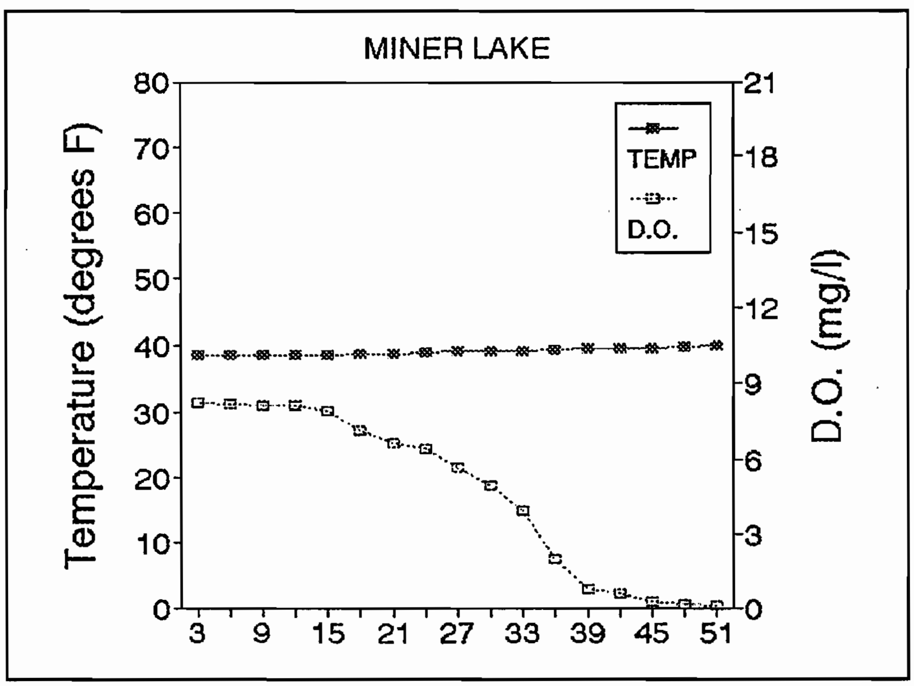


Figure 6. Temperature/DO Profiles, East Chain, Chain O' Lakes, Winter, 1992.

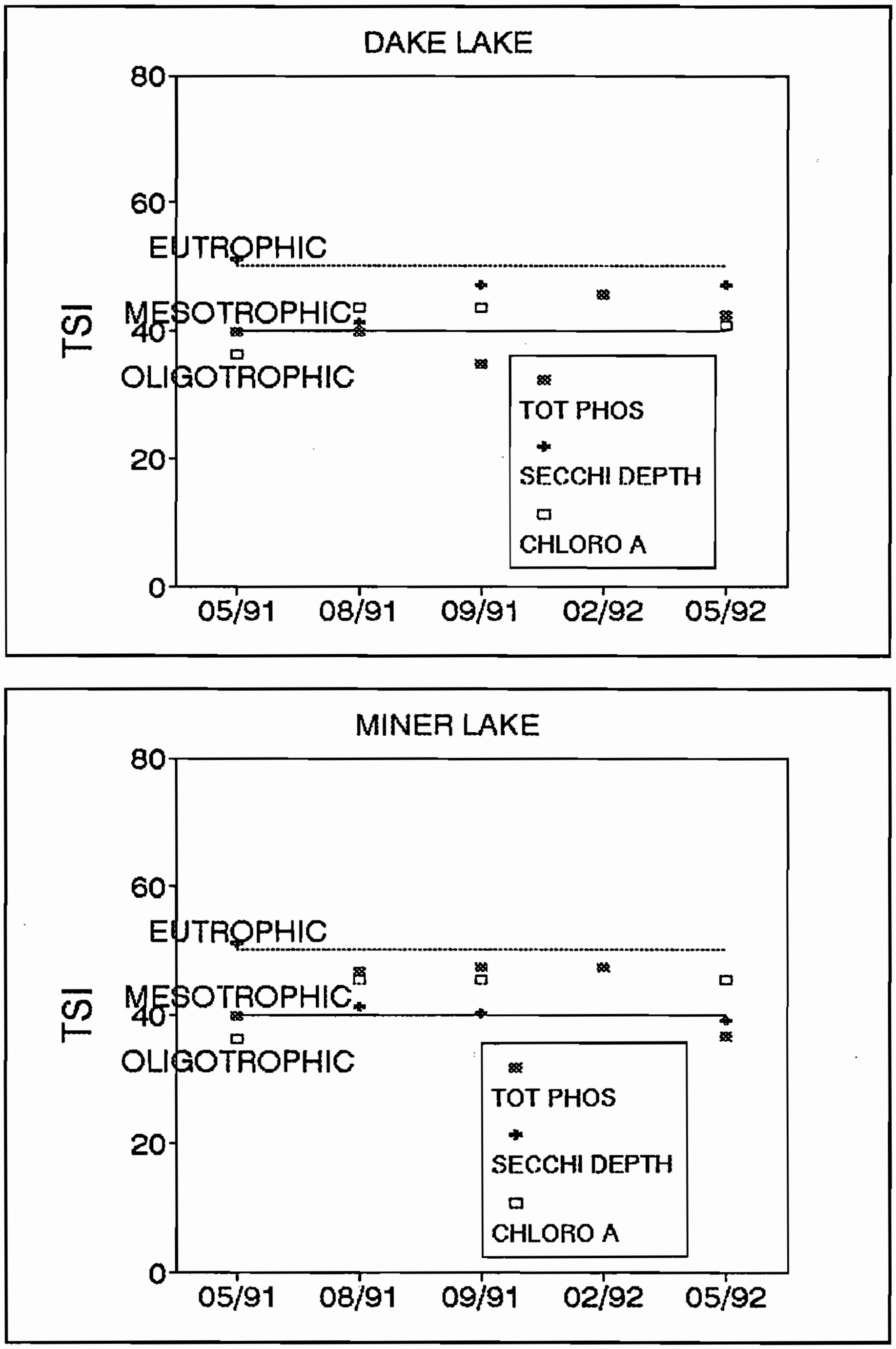


Figure 7. Trophic State Index for Secchi Depth, Total Phosphorus and Chlorophyll a, East Chain, Chain O' Lakes.

Macrophyte surveys (Tables 7-13, Appendix III) indicated somewhat different assemblages in Dake and Miner Lakes. Plants species, most of which are generally considered beneficial, exhibited varying dominance.

Nitella spp. was most abundant in Dake Lake (20 of 30 sites) and fourth-most abundant in Miner Lake (12 of 36 sites). Nitella spp. is typically found in hard water lakes with hard or sandy substrates (13).

Water celery (Vallisneria americana), a common Wisconsin species, was the most abundant species in Miner Lake (32 of 36 sites) but found less frequently in Dake Lake (21 of 30 sites) where it was second-most abundant. Water celery (also known as eel grass), has long tape-like leaves, grows completely submerged and is also typically found on hard substrates; abundance can increase with turbidity. It is rated as excellent waterfowl food and provides fish with forage, cover and spawning habitat but can reach nuisance levels (13). Water celery produces seeds, but spreads mainly from rhizome growth and reproduces mainly by tubers from one year to the next (14).

Pondweeds (Potamogeton spp.), as a group, were common and abundant; P. illinoensis, P. foliosus and P. zosteriformes were the most common pondweed species in both lakes. Pondweeds are

Table 7. Macrophyte Species Observed, Dake and Miner Lakes, 1991 (13).

Taxa	Code
Watershield (Brasenia schreberi)	BRASC
Coontail (Ceratophyllum demersum)	CERDE
Common waterweed (Elodea canadensis)	ELOCA
Filamentous algae	FILAL
Small duckweed (Lemna minor)	LEMMI
Water milfoil (Myriophyllum spp.)	MYRSP
Bushy pondweed (Najas spp.)	NAJSP
Nitella (Nitella spp.)	NITSP
No plants found	NOPLT
Yellow pond lily (Nuphar spp.)	NUPSP
White pond lily (Nymphaea spp.)	NYMSP
Large-leaf pondweed (Potamogeton amplifolious)	POTAM
Pondweed (Potamogeton angustifiolius)	POTAN
Curly-leaf pondweed (Potamogeton crispus)	POTCR
Leafy pondweed (Potamogeton foliosus)	POTFO
Illinois pondweed (Potamogeton illinoensis)	POTIL
Floating-leaf pondweed (Potamogeton natans)	POTNA
Sago pondweed (Potamogeton pectinatus)	POTPE
Clasping-leaf pondweed (Potamogeton richardsonii)	POTRI
Unidentified pondweed (Potamogeton spp.)	POTSP
Flat-stem pondweed (Potamogeton zosteriformis)	POTZO
Rush (Scirpus spp.)	SCISP
Broad-leaf cattail (Typha latifolia)	TYPLA
Water celery (Vallisneria americana)	VALAM

Table 8. Occurrence and Abundance of Macrophytes by Depth, Dake Lake, May, 1991.

CODE	Depth Ranges 1 (N=5) % of Sites	1 (N=5) Σ Abundance (range)	2 (N=5) % of Sites	2 (N=5) Σ Abundance (range)	3 (N=5) % of Sites	3 (N=5) Σ Abundance (range)
NITSP	40	6(3)	80	11(2-3)	100	17(2-4)
NAJSP	100	11(1-5)	80	9(2-3)	40	4(1-3)
POTIL	20	1(1)	40	4(2)	20	2(2)
VALAM	60	10(3-4)	60	8(2-3)	40	4(2)
POTFO	20	1(1)	80	6(1-2)	40	6(3)
POTRI	0	0	80	8(1-3)	60	6(2)
MYRSP	0	0	20	2(2)	100	9(1-3)
NYMSP	60	8(2-4)	40	8(4)	0	0
POTPE	20	2(2)	20	3(3)	20	2(2)
POTNA	20	2(2)	20	3(3)	0	0
POTCR	0	0	40	2(1)	20	2(2)
POTAM	20	3(3)	0	0	0	0
CERDE	20	1(1)	0	0	40	3(1-2)
LEMMI	20	3(3)	0	0	0	0
FILAL	20	3(3)	0	0	20	3(3)
TYPLA	20	1(1)	0	0	0	0
ELOCA	0	0	0	0	20	3(3)
BRASC	0	0	20	1(1)	0	0
NOPLT	0	0	0	0	0	0
POTAN	0	0	0	0	0	0
POTZO	0	0	0	0	0	0

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 cover and spawning habitat and produce roots, shoots, stems, seeds and tubers that are highly desirable waterfowl food (13).

Table 9. Occurrence and Abundance of Macrophytes by Depth, Dake Lake, September, 1991.

	Depth Ranges					
CODE	1 (N=5)		2 (N=5)		3 (N=5)	
	% of Sites	Σ Abundance (range)	% of Sites	Σ Abundance (range)	% of Sites	Σ Abundance (range)
NITSP	40	3(1-2)	80	11(2-3)	60	6(2)
NAJSP	60	4(1-2)	100	9(1-2)	100	14(2-3)
POTIL	20	2(2)	100	11(2-3)	80	8(2)
VALAM	80	7(1-3)	100	13(2-3)	80	11(2-3)
POTFO	20	1(1)	0	0	60	4(1-2)
POTRI	0	0	0	0	0	0
MYRSP	40	2(1)	40	4(1-3)	80	11(2-3)
NYMSP	20	3(3)	40	4(2)	0	0
POTPE	40	4(1-3)	60	6(1-3)	60	6(1-3)
POTNA	0	0	0	0	0	0
POTCR	0	0	0	0	0	0
POTAM	20	1(1)	40	2(1)	0	0
CERDE	0	0	0	0	20	2(2)
LEMMI	20	3(3)	0	0	0	0
FILAL	20	3(3)	0	0	0	0
TYPLA	0	0	0	0	0	0
ELOCA	0	0	0	0	0	0
BRASC	0	0	0	0	0	0
NOPLT	20	0	0	0	0	0
POTAN	0	0	60	6(2)	80	9(2-3)
POTZO	20	2(2)	0	0	60	5(1-2)

Water milfoil (Myriophyllum spp.) was also moderately abundant (14 sites in Dake Lake; 31 sites in Miner Lake) in the East Chain. Species determination was not verifiable because of a lack of floral bracts during the sample periods. Species may include Eurasian Milfoil, an exotic plant known to spread rapidly, displace native plants and change plant and animal assemblages. While the plants did not exhibit the more obvious

Table 10. Occurrence and Abundance of Macrophytes by Depth, Miner Lake, May, 1991.

CODE	Depth Ranges 1 (N=6) % of Sites	Σ Abundance (range)	2 (N=6) % of Sites	Σ Abundance (range)	3 (N=6) % of Sites	Σ Abundance (range)
NOPLT	17	0	0	0	0	0
NAJSP	67	9(1-3)	100	12(1-3)	50	5(1-2)
NITSP	33	5(1-4)	50	7(2-3)	33	3(1-2)
VALAM	50	5(1-2)	100	12(1-3)	100	17(2-3)
POTFO	17	2(2)	33	5(2-3)	17	3(3)
POTIL	0	0	50	6(1-3)	17	1(1)
FILAL	17	1(1)	17	2(2)	33	3(1-2)
MYRSP	50	3(1)	83	10(1)	100	14(2-3)
CERDE	0	0	0	0	83	5(1)
POTRI	33	3(1-2)	67	8(1-3)	67	5(1-2)
TYPLA	17	2(2)	0	0	0	0
NYMSP	33	3(3)	0	0	0	0
POTPE	67	6(1-2)	50	5(1-2)	0	0
POTZO	0	0	17	3(3)	83	10(1-4)
ELOCA	33	2(1)	33	4(1-3)	50	3(1)
NUPSP	17	4(4)	33	5(1-4)	0	0
BRASC	0	0	17	1(1)	0	0
SCISP	0	0	0	0	0	0
POTAM	0	0	0	0	0	0
POTAN	0	0	0	0	0	0

distinguishing characteristics of Eurasian Milfoil, e.g. red-tinged stems and shoots and more than 12 pair of leaflets, positive species determination should still be attempted.

Table 11. Occurrence and Abundance of Macrophytes by Depth, Miner Lake, September, 1991.

CODE	Depth Ranges 1 (N=6) % of Sites	1 (N=6) Σ Abundance (range)	2 (N=6) % of Sites	2 (N=6) Σ Abundance (range)	3 (N=6) % of Sites	3 (N=6) Σ Abundance (range)
NOPLT	0	0	0	0	0	0
NAJSP	17	2(2)	83	10(1-3)	83	10(1-3)
NITSP	17	4(4)	50	8(2-3)	17	3(3)
VALAM	83	13(2-4)	100	18(2-4)	100	18(2-4)
POTFO	17	2(2)	83	10(2)	50	6(2)
POTIL	17	3(3)	67	8(1-3)	0	0
FILAL	0	0	0	0	0	0
MYRSP	83	6(1-2)	100	11(1-2)	100	16(2-3)
CERDE	0	0	17	1(1)	83	7(1-2)
POTRI	0	0	17	1(1)	17	1(1)
TYPLA	0	0	0	0	0	0
NYMSP	33	6(3)	33	6(3)	0	0
POTPE	50	6(2)	50	6(2)	17	1(1)
POTZO	0	0	17	3(3)	67	7(2-3)
ELOCA	0	0	33	5(2-3)	33	3(1-2)
NUPSP	33	5(1-4)	33	5(1-4)	0	0
BRASC	0	0	0	0	0	0
SCISP	17	1(1)	0	0	0	0
POTAM	17	1(1)	33	4(2)	0	0
POTAN	0	0	33	3(1-2)	33	3(1-2)

Table 12. Abundance Distribution and Substrate Relations for Selected Macrophytes, Dake Lake, 1991.

Transect	Substrate	NITSP M	NITSP S	VALAM M	VALAM S	NAJSP M	NAJSP S	POTIL M	POTIL S	MYRSP M	MYRSP S	NYMSP M	NYMSP S
A1	SILT/SAND	3	0	0	0	1	0	1	0	0	0	0	0
A2	SILT/RUBBLE	3	3	2	3	2	2	2	3	0	0	0	0
A3	SILT	4	2	2	2	1	2	2	2	1	0	0	0
B1	MUCK	0	0	4	1	5	1	0	0	0	1	4	0
B2	MUCK	3	3	3	2	3	2	0	2	2	3	4	2
B3	MUCK	2	0	2	0	3	3	0	2	1	2	0	0
C1	SILT	0	0	3	2	1	0	0	0	0	0	2	0
C2	SILT	0	0	3	3	2	1	2	2	0	0	4	2
C3	SILT/MUCK	4	0	0	3	0	3	0	2	3	3	0	0
D1	SAND/MUCK	0	2	3	3	2	2	0	2	0	1	2	3
D2	MUCK	2	3	0	3	2	2	0	2	0	1	0	0
D3	SILT	3	2	0	3	0	3	0	2	2	3	0	0
E1	SAND	3	1	0	1	2	1	0	0	0	0	0	0
E2	SILT/SAND	3	2	0	2	0	2	0	2	0	0	0	0
E3	SILT	4	2	0	3	0	3	0	0	2	3	0	0

Table 13. Abundance Distribution and Substrate Relations for Selected Macrophytes, Miner Lake, 1991.

Transect	Substrate	VALAM M	VALAM S	NAJSP M	NAJSP S	MYRSP M	MYRSP S	NITSP M	NITSP S	POTFO M	POTFO S	POTZO M	POTZO S
A1	SILT/MUCK	0	3	0	0	0	2	0	0	0	2	0	0
A2	SILT/MUCK	2	3	3	3	0	2	2	0	2	2	0	0
A3	SILT/MUCK	3	3	0	3	3	3	2	3	3	0	0	2
B1	SAND/GRAVEL	1	4	3	0	0	1	0	0	2	0	0	0
B2	SILT/MUCK	3	4	2	0	3	2	0	0	0	2	0	0
B3	SILT/MUCK	3	3	2	0	2	3	1	0	0	2	1	0
C1	ROCK/SAND	0	0	0	0	1	1	1	0	0	0	0	0
C2	SAND/GRAVEL	1	2	1	2	1	2	0	0	0	2	0	0
C3	SILT/SAND	3	4	0	2	2	2	0	0	0	2	4	2
D1	SAND	2	2	1	0	1	1	0	0	0	0	0	0
D2	SILT/MUCK	1	3	3	2	3	2	3	3	0	2	0	0
D3	SILT	3	3	2	2	2	3	0	0	0	0	2	0
E1	SAND	0	2	3	0	0	0	0	0	0	0	0	0
E2	SAND/MUCK	2	3	2	2	1	1	0	3	3	2	0	0
E3	SILT	2	2	0	2	3	3	0	0	0	2	3	0
F1	SAND	2	2	2	2	1	1	4	4	0	0	0	0
F2	SAND	3	3	1	1	2	2	2	2	0	0	3	3
F3	SAND	3	3	1	1	2	2	0	0	0	0	0	3

BASELINE CONCLUSIONS

The East Chain consists of two connected lakes that account for only nine percent of the total lake surface area of the Chain O' Lakes and only about two percent of the Chain watershed. The East Chain doesn't receive any permanent surface inflow and drains to the Lower Chain through a channel connecting Dake and Columbia Lakes.

Water quality was found to be good to excellent for all parameters measured and indicated high infiltration of surface runoff, groundwater inflow and, overall, an oligotrophic to mesotrophic classification. Because of the small watershed, the East Chain has a low potential for nonpoint source sediment and nutrient runoff. Nutrient levels were at or below those typical of lake type and regional location. Both lakes stratify during summer and exhibit low dissolved oxygen near bottom. Miner Lake (the deeper of the two) has a much greater hypolimnetic area and exhibits low oxygen and relatively higher nutrient levels near bottom during all seasons. Dake Lake, except during stratification, apparently mixes more completely and exhibits higher near bottom oxygen.

Macrophyte populations appeared to positively affect the resource (as a whole) through shoreline stabilization, nutrient uptake and fish food and habitat production. Most common plants included *Nitella* spp., water celery and pondweeds; macrophytes, overall, did not appear to be present at nuisance levels in either Dake or Miner Lakes.

Recreational use during summer months is excessive and the towns and lake association have taken steps to control boat traffic. A recreational use survey was distributed during Phase I of this project to identify and quantify the uses.

MANAGEMENT RECOMMENDATIONS

Management recommendations for the East Chain are targeted at maintenance of existing good to excellent water quality through continued monitoring, reduction of nutrient inflow to the system (where possible and practical), and assessment of the need for further regulation on the Chain to maximize enjoyment of the resource by all.

Relatively little is known about historic water quality on the East Chain; efforts should be made to continue regular water quality testing. Regular monitoring should be conducted in a similar schedule. Self-Help secchi disk monitoring should be conducted by volunteers on each lake.

Riparian landowners, given the very small direct watershed, can have an especially significant effect on East Chain water quality and can help by implementing lake lot management practices to prevent nutrient and sediment runoff to the lakes. Many of these practices are common sense approaches. Fertilizer and compost management, buffer stripping and runoff control are inexpensive ways to help reduce these inputs and slow lake aging processes.

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, 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 protects lake water quality, creates habitat for wildlife, and provides privacy.

Sources of local assistance for landowners who would like more information on these or other methods of land management are outlined in Appendix IV. Information on pertinent ordinances and plans are presented in Appendix V.

Macrophyte populations in the East Chain are not comprised of potentially nuisance species and are not present at nuisance abundance levels. Macrophytes in the East Chain probably are of substantial benefit to the fishery. Localized and selective macrophyte manipulation may be implemented near shore where considered necessary or desireable to improve access or aesthetics.

Recreational use survey data, when compiled and analyzed should indicate the attitudes and preferences of landowners adjacent to the Chain. These data may help to focus recreation management efforts or identify options (e.g., further regulation) to maximize enjoyment of the Chain O' Lakes resource.

The CLPOA, in cooperation with local townships, Waupaca County and the State of Wisconsin, should take an active role in protection of the Chain resource from invasion by exotic, potentially harmful species. The spread of purple loosestrife or introduction of Eurasian milfoil and other exotic species may be slowed or prevented by posting signs at boat landings, providing brochures or other materials to educate the public about harmful species and their prevention. Efforts must also be made to control known populations of purple loosestrife and Eurasian milfoil.

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IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

PHASE II
EAST CHAIN O' LAKES MANAGEMENT PLAN
WAUPACA COUNTY, WISCONSIN

REPORT TO:
CHAIN O' LAKES PROPERTY OWNERS ASSOCIATION

December, 1995

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SUMMARY

The East Chain project group consists of Miner and Dake Lakes of the Chain O 'Lakes, a group of 22 mostly interconnected relatively small lakes in Waupaca County, Wisconsin. Water quality is good to very good and related to substantial groundwater inflow. Water quality, along with the Chain's proximity to population centers, contribute to highly developed shoreline areas (many permanent residential) and periodic high to excessive non-resident recreational use. An initial resource assessment was made in 1992 (Phase I Chain O 'Lakes Management Plans); this document supplements the 1992 report with Phase II efforts toward development of a comprehensive lake management plan.

The Chain O 'Lakes watershed, primarily agricultural but with significant forested and wetland areas, is a subwatershed of the Tomorrow/Waupaca River basin which has recently been granted Priority Watershed Project Status. Variable, but generally low groundwater nitrate levels were observed in the Chain subwatershed during the appraisal phase of the Priority Watershed Project. Overland flow nutrient and sediment inputs were estimated to be lower than expected, but field estimates for nutrients were substantially higher. Modeling for some Chain lakes indicated a natural process of phosphorus removal by marl precipitation.

East Chain water quality monitoring during Phases I and II indicated in-lake nutrient levels below those expected for the region. Surface total nitrogen levels in Miner and Dake Lakes were relatively lower than in most other Chain O 'Lakes. Differences between the East Chain lakes, except those related to water column stratification in Miner Lake, were small.

East Chain recreational use survey results were generally similar to those of the Chain O 'Lakes overall and various resident user groups. Results indicated periodic excessive use during summer weekends or holidays with perceived safety problems and diminished recreational enjoyment of the resource related primarily to non-resident watercraft. Water safety enforcement was considered adequate at all times, slightly less so during periods of peak use, and no clear concensus was evident regarding the need for additional regulation. Residents agreed there was adequate access, disagreed with the need for a public park or swimming beach, and were slightly in favor of more water accessible public restrooms.

Purple loosestrife, an exotic potentially nuisance plant, was not present in the East Chain, but is established in nearby Chain O 'Lakes project groups.

Water quality protection and water use conflict minimization are priority management objectives for the East Chain and all Chain O 'Lakes residents. Specific recommendations for the East Chain include private well testing for nitrates and pesticides, event sampling where appropriate to assess overland sediment and nutrient inflows, protection/maintenance of existing aquatic plant beds, monitoring for purple loosestife establishment, and use management emphasis on the sport fishery or other more passive recreational uses.

Other recommendations are applicable to the East and other Chain project groups and emphasize continued focus and expanded involvement (designated Chain O 'Lakes Property Owners Association individuals or committees) in watershed-wide surface water and groundwater quality issues, use management, and exotic species control. These recommendations, which include trend monitoring for water quality, are designed to identify potential problem areas or conflicts before they become widespread or severe.

INTRODUCTION

The Chain O' Lakes is a group of 22 mostly interconnected lakes in the Towns of Dayton and Farmington, Waupaca County, Wisconsin. The lakes are, in general, relatively small, highly developed, groundwater fed and located in a sandy, mostly level watershed. The lakes are a major tourist attraction for Waupaca County and occasionally receive excessive recreational use.

The Chain O' Lakes Property Owners Association (CLPOA), which serves as the main steward for the resource, was formed in the 1960's and currently has about 800 voting members (1). The CLPOA received its first Wisconsin Department of Natural Resources (WDNR) Lake Management Planning Grant in April, 1991. IPS Environmental & Analytical Services (IPS) of Appleton, Wisconsin was selected as their consultant for management plan development.

The Chain O' Lakes was delineated into five Project Groups (Table 1) for management planning purposes. Phase I efforts included baseline assessment activities (for water quality and aquatic plants) and a public involvement program. Specific physical properties, preliminary methods, and other introductory and technical information for the Chain O' Lakes and the respective Project Groups were presented in the Phase I reports (printed 1993).

Table 1. Lake Management Planning Project Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Upper Chain	Middle Chain	Lower Chain
Otter Lake	Nessling Lake	Ottman Lake
Taylor Lake	McCrossen Lake	Bass Lake
George Lake	Round Lake	Youngs Lake
Sunset Lake	Limekiln Lake	Beasley Lake
Rainbow Lake		Long Lake
		Columbia Lake

East Chain	Little Chain
Dake Lake	Orlando Lake
Miner Lake	Knight Lake
	Manomin Lake
	Pope Lake
	Marl Lake

A Phase II grant was received in August, 1993; Phase II efforts included continuation of the water quality monitoring and public involvement programs, analysis of a recreational use questionnaire (circulated under Phase I) and more intensive assessment of areas of concern in the watershed. This report presents the results of these Phase II lake management planning efforts for the East Chain O' Lakes.

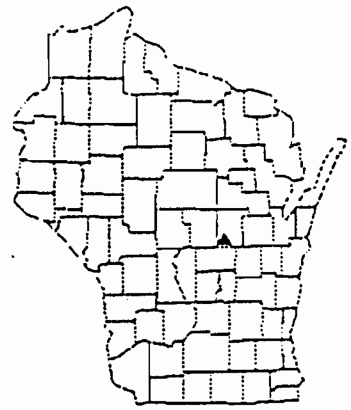
DESCRIPTION OF AREA

The Chain O' Lakes are a group of "kettle" lakes in the southwest corner of Waupaca County, Wisconsin (Fig. 1). Kettle lakes are formed when ice is pushed into the soil by retreating glaciers; the depressions subsequently filled with water when the ice blocks melted. The East Chain consists of Dake and Miner Lakes in the south-central portion of the Chain.

The Chain O' Lakes is largely groundwater fed with inflow generally from the northwest. Surface flow in the East Chain is from Miner to Dake Lake and out through a navigable channel to Columbia Lake of the Lower Chain Project group. The Crystal River drains the Chain O' Lakes to the Waupaca River.

Miner Lake is deeper (52 ft) and only slightly larger (35 acres) than Dake Lake (26 ft, 32 acres). About ten public boat ramps are available on the Chain with most of the connecting channels navigable for powerboats and all but one (Ottman - Youngs) navigable with a canoe. A boat ramp is available on Dake Lake.

Predominant shoreline area substrates for the East Chain are sand and marl with localized areas of muck and detritus. The East Chain lakes, compared to most of the other Chain O' Lakes, have relatively extensive littoral zones with more widespread and locally abundant aquatic plants.



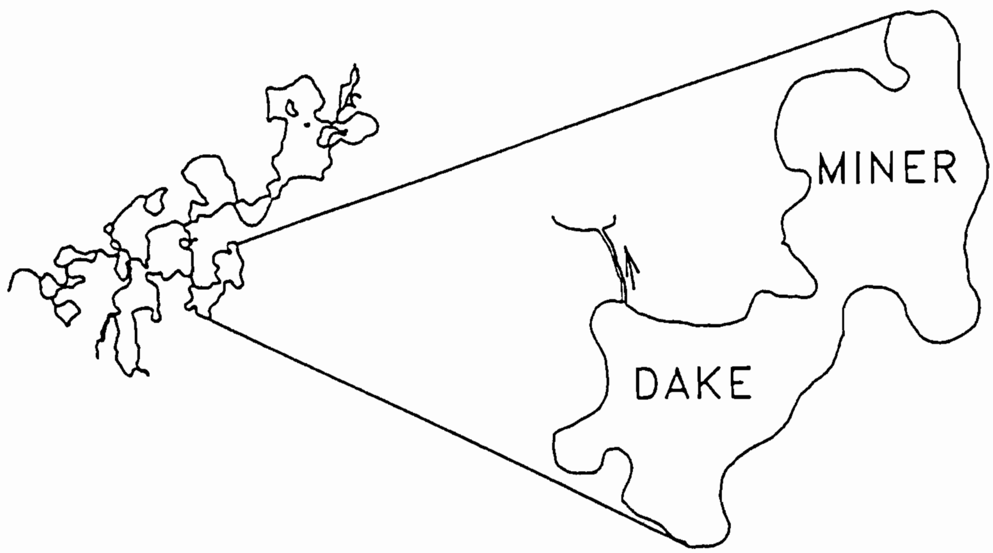


Figure 1. Location Map, Chain O' Lakes, Waupaca County, Wisconsin.

Because of intensive recreational use, the Towns of Dayton and Farmington and the CLPOA adopted ordinances to regulate boat speeds on the Chain. Except for the largest lakes (Columbia, Long, Rainbow and Round), all lakes on the Chain have a "no wake" speed limit. Water skiing on these lakes is limited to 10:00 a.m. - 2:30 p.m. on weekends and Holidays, 10:00 a.m. - 4:00 p.m. on Monday and Friday, and 10:00 a.m. - 7:00 p.m. on Tuesday through Thursday.

METHODS

Watershed Characteristics

Most watershed information was obtained during the appraisal process of the Tomorrow/Waupaca River Priority Watershed (TWRPW) Project. The appraisal began February, 1994 and is scheduled to be completed in 1995. Pertinent information from the appraisal as it relates to the Chain O' Lakes is included in the Results and Discussion section of this report.

Water Quality Monitoring

Water quality samples were taken on July 15 and September 22, 1992; February 3, May 19, August 17 and October 4, 1993; January 24, May 3, August 3 and September 21, 1994. Samples were collected three feet below the surface and three feet above bottom for both lakes (Table 2, Fig. 2). Parameters measured in the field were Secchi depth, water temperature, pH, dissolved oxygen (DO), and conductivity (see the Phase I document for specific equipment and methods information).

Recreational Use

A recreational use survey of the CLPOA membership was conducted to obtain property and lake use, water use opinions and demographics information. About 800 questionnaires were distributed (one per household) by CLPOA neighborhood volunteers to maximize the return rate. A sample survey questionnaire is included in Appendix I.

Table 2. Sample Station Descriptions, East, 1992 - 1994.

REGULAR MONITORING

Lake	Site Number	Depth
Dake (Deepest Point)	1301	26 feet
Miner (Deepest Point)	1302	52 feet

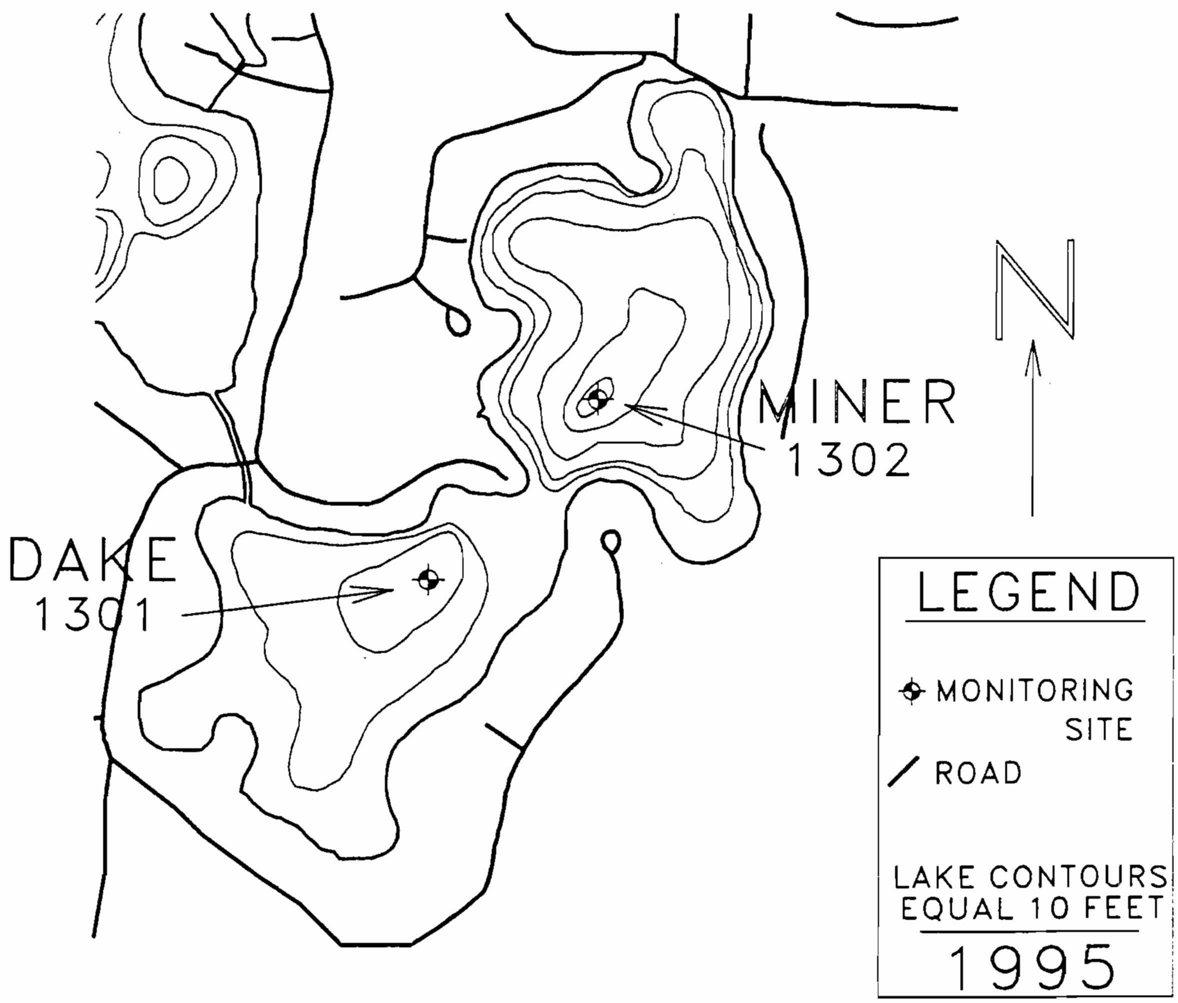


Figure 2. Sample Station Locations, East Chain, 1992 - 1994.

Exotic Species

Visual observations [including a full shoreline cruise and in-lake observations (raking and SCUBA)] were made throughout the Phase I and II grant periods to document the occurrence of exotic species. Target species included Eurasian Water Milfoil (*Myriophyllum spicatum*), Purple Loosestrife (*Lythrum salicaria*) and Zebra Mussels (*Dreissena polymorpha*).

Public Involvement Program

Public involvement activities were coordinated to inform and educate the CLPOA about lake management in general and specifics regarding the Chain O' Lakes resource. Activities included news releases, IPS newsletters, article preparation for CLPOA newsletters, meeting attendance and presentations to the CLPOA and other interested parties. Public involvement activities are summarized in Appendix II.

FIELD DATA DISCUSSION

Watershed Characteristics

The Chain O' Lakes watershed is estimated to be 33,819 acres or 17% of the entire TWRPW (3). Land use for the Chain O' Lakes subwatershed was determined during the 1994 - 1995 inventory to be: non-irrigated agriculture, 16,931 acres (50%); irrigated agriculture, 2,205 acres (7%); forested, 10,921 acres (32%); wetland (including surface water), 1,673 acres (5%); and developed areas, 2,089 acres (6%) (Fig. 3).

There were 220 landowners who had livestock operations in the TWRPW, of which 168 (76%) had more than 20 animal units and 52 (24%) had 20 or fewer animal units. Sixty-two percent of the barnyards were surface drained; 38% were internally drained (4).

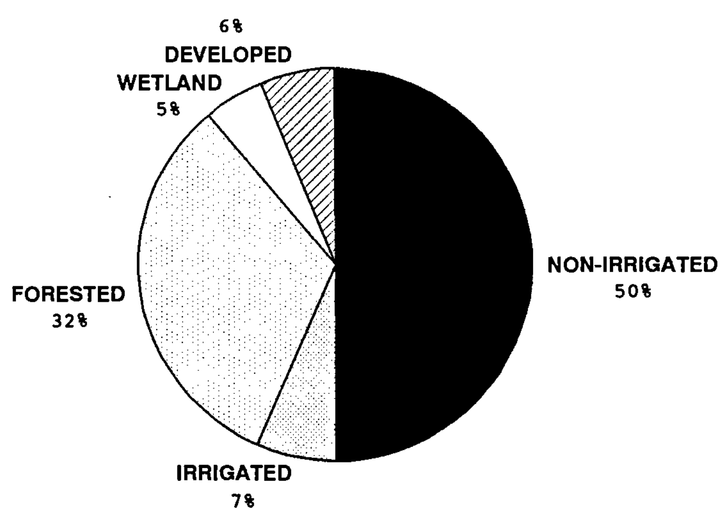


Figure 3. Land Uses in the Chain O' Lakes Subwatershed, 1994.

Groundwater

Nitrate was identified as a contaminant of concern in the Wolf River Basin Plan (5) and was targeted for analyses in the TWRPW Project groundwater appraisal. Relative to other subwatersheds in the TWRPW Project, residential well samples in the Chain O' Lakes subwatershed had the lowest average nitrate levels [2.59 milligrams per liter (mg/l)] (Table 3). Fifty-seven percent of the Chain O' Lakes subwatershed well samples were below 2 mg/l; nitrate levels over 2 mg/l are generally considered indicative of human impact on groundwater. Thirty-two well samples (8.2%) in the Chain O' Lakes subwatershed were over the health standard of 10 mg/l (4).

Table 3. Well Nitrate Data by Subwatershed for the Tomorrow/ Waupaca River Priority Watershed Project, 1995.

Subwatershed	No. of Samples	>2 mg/l	>10 mg/l	>20 mg/l	Average
Upper Tomorrow	258	168	66	20	6.82
Spring Creek	275	154	39	5	4.71
Chain O' Lakes	389	136	30	2	2.59
Crystal River	266	117	22	5	3.27
Waupaca/ Weyauwega	63	15	11	4	5.31
	=====	=====	=====	=====	=======
Total	1,251	590	168	36	4.54
Percent	100%	47%	13%	3%	

Surface water nitrate levels were also assessed during periods of highest groundwater contribution to the Tomorrow/Waupaca River system. Various creek samples taken March 1, 1994 or January 20, 1995 averaged 3.06 and 3.52 mg/l, respectively (Table 4). The highest nitrate levels were observed in Radley and Murray Creeks during January, 1995.

Table 4. Nitrate Levels (mg/l) for Surface Water in the Chain O' Lakes Subwatershed, 1994 - 1995.

	03/01/94	01/20/95
Radley Creek (South Road)	3.51	5.06
Radley Creek (1st Avenue)		7.1
Hartman Creek (Rural Road)	0.94	1.03
Emmon's Creek (Rural Road)	2.48	2.18
Emmon's Creek (3rd Avenue)		1.97
Murray Creek (South Road)	2.77	2.37
Murray Creek (10th Road)		6.0
Tomorrow/Waupaca Average	3.06	3.52

Lakes

A computer model applied by WDNR to the western portion of the Chain O' Lakes indicated that the Chain has a natural ability to remove phosphorus from the water column via marl precipitation. Marl (calcium carbonate) binds with phosphorus and settles to the lake bottom.

Overall, the lakes modeled (Marl, Pope, Manomin, Orlando, Knight, Ottman, Youngs, Bass, Beasley and Long) showed a 36% reduction of (outflowing versus inflowing) phosphorus. Reduction ranged from 8% for Orlando Lake to 90% for Marl Lake (4). Phosphorus levels measured during Phase I and Phase II efforts for these lakes were near or below levels predicted by the model.

Sediment and Nutrient Delivery

Sediment delivery was estimated to be less than expected for the Chain O' Lakes subwatershed; the Chain subwatershed included 7.7% of the cropland draining to streams for the TWRPW but had only 6.0% of the sediment delivery (146 tons per year). With an estimated nine pounds of phosphorus per ton of sediment, phosphorus delivery is 1,313 pounds per year. Sediment was estimated to be entirely from upland sources, as none of the 21.8 miles of streambank were observed to be degraded (4).

Water Quality

Current data for Dake and Miner Lakes indicated, as would be expected given their proximity relative isolation from other Chain Lakes, similar water quality, and trends similar to those observed during Phase I (Tables 5 & 6, Figs. 4 & 5). Differences

Table 5. Water Quality Parameters, Station 1301, Dake Lake, Chain O' Lakes, July 1992 - October 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/15/92	09/22/92	02/03/93	05/19/93	08/17/93	10/04/93	01/24/94	05/03/94	08/03/94	09/21/94
Secchi (feet)		10.7	10.3	NR[2]	>26.0	10.5	7.8	NR	>26.0	11.0	13.0
Cloud Cover (percent)		0	0	10	70	30	20	0	60	80	100
Temperature (degrees Celsius)	S	21.30	16.61	2.91	15.82	24.18	12.39	7.35	11.30	24.39	21.67
	B	15.61	16.68	4.61	9.28	19.54	11.96	5.97	10.00	20.68	20.09
pH (std units)	S	8.77	8.89	7.16	8.00	8.69	NR	7.10	7.60	8.56	NR
	B	7.16	8.82	6.89	7.05	6.84	NR	6.40	7.51	6.97	NR
D.O. (mg/l)	S	9.37	9.06	7.05	9.35	9.84	10.10	8.51	11.06	9.53	9.17
	B	0.13	8.47	0.68	8.18	0.47	9.16	2.41	10.48	0.48	5.74
Conductivity (umhos/cm)	S	230	223	275	247	203	230	272	253	227	211
	B	286	223	300	260	295	231	300	254	300	216
Laboratory pH (surface units)	S	NR	NR	NR	8.23	NR	NR	NR	NR	NR	NR
	B	NR	NR	NR	7.99	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	118	NR	NR	NR	NR	NR	NR
	B	NR	NR	NR	124	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	164	NR	NR	NR	NR	NR	NR
	B	NR	NR	NR	174	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.5	0.5	0.7	0.5	0.5	0.6	0.7	0.6	0.61[3]	0.71[3]
	B	0.8	0.5	0.8	0.6	0.6	0.6	0.9	0.5	0.70[3]	NR
Ammonia Nitrogen (mg/l)	S	0.026	0.017	0.252	0.071	0.013	0.016	0.147	0.071	0.012	0.12
	B	0.216	0.025	0.455	0.179	0.079	0.038	0.412	0.058	0.009	NR
NO_2 + NO_3 Nit. (mg/l)	S	ND[4]	ND	0.031	0.027	ND	ND	0.022	ND	ND	ND
	B	ND	ND	0.015	0.036	ND	ND	0.038	0.051	ND	NR
Total Nitrogen (mg/l)	S	0.5	0.5	0.731	0.527	0.5	0.6	0.722	0.6	0.61	0.71
	B	0.8	0.5	0.815	0.636	0.6	0.6	0.938	0.551	0.70	NR
Total Phosphorus (mg/l)	S	0.009	0.007	0.006	ND	0.010	0.010	0.013	0.009	0.010	0.012
	B	0.021	0.006	0.011	ND	0.012	0.013	0.016	0.013	0.011[4]	NR
Dissolved Phos. (mg/l)	S	0.002	0.002[4]	0.003	ND	ND	0.003	0.001[4]	NR	ND	ND
	B	0.003	0.001[4]	0.002	0.003	ND	ND	0.001[4]	NR	ND	NR
Nit./Phos Ratio	S	55.6	71.4	121.8	–	50.0	60.0	55.5	66.7	61.0	59.2
	B	38.1	83.3	74.1	–	50.0	46.2	58.6	42.4	63.6	NR
Chlorophyll a (ug/l)	S	5	7.66	NR	0.915	3.30	17.6	NR	.726	3.27	6.76

[1] S = surface, B = bottom; [2] NR = no reading; [3] holding time exceeded by SLOH; [4] ND = not detectable

Table 6. Water Quality Parameters, Station 1302, Miner Lake, Chain O' Lakes, July 1992 - October 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/15/92	09/22/92	02/03/93	05/19/93	08/17/93	10/04/93	01/24/94	05/03/94	08/03/94	09/21/94
Secchi (feet)		12.0	12.3	NR[2]	23.2	15.0	10.4	NR	21.0	14.5	11.0
Cloud Cover (percent)		0	0	10	70	30	10	0	60	80	100
Temperature	S	21.16	17.43	2.32	15.44	24.21	13.18	4.65	11.15	24.30	21.82
(degrees Celsius)	B	6.54	7.08	3.88	5.09	6.33	6.62	4.36	5.47	7.30	7.82
pH	S	8.82	8.76	7.12	7.70	8.45	NR	6.93	7.64	8.43	NR
(std units)	B	6.47	6.85	6.78	6.11	5.69	NR	6.18	6.55	5.96	NR
D.O.	S	9.88	9.21	7.02	9.33	9.05	9.13	7.02	11.34	9.41	10.03
(mg/l)	B	0.09	0.56	0.44	0.15	0.09	0.56	0.77	0.89	0.29	0.73
Conductivity	S	233	221	249	246	216	244	249	249	234	208
(umhos/cm)	B	285	298	262	296	290	317	260	268	293	276
Laboratory pH	S	NR	NR	NR	8.19	NR	NR	NR	8.24	NR	NR
(surface units)	B	NR	NR	NR	7.49	NR	NR	NR	NR	NR	NR
Total Alkalinity	S	NR	NR	NR	117	NR	NR	NR	126	NR	NR
(mg/l)	B	NR	NR	NR	145	NR	NR	NR	NR	NR	NR
Total Solids	S	NR	NR	NR	158	NR	NR	NR	160	NR	NR
(mg/l)	B	NR	NR	NR	188	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen	S	0.5	0.5	0.7	0.5	0.4	0.5	0.7	0.5	0.56[3]	0.64[3]
(mg/l)	B	2.3	0.8	1.1	3.0	2.4	3.1	1.2	1.3	0.60[3]	NR
Ammonia Nitrogen	S	0.020	0.012	0.261	0.096	0.010	0.009	0.258	0.048	0.56	0.010
(mg/l)	B	1.173	0.050	0.607	1.02	1.80	2.42	0.647	0.778	0.60	NR
$NO_2 + NO_3$ Nit.	S	ND[4]	ND	0.026	0.028	ND	ND	0.018	ND	ND	ND
(mg/l)	B	ND	ND	0.012	ND	ND	ND	0.010	ND	ND	NR
Total Nitrogen	S	0.5	0.5	0.726	0.528	0.4	0.5	0.718	0.5	0.56	0.64
(mg/l)	B	2.3	0.8	1.112	3.0	2.4	3.1	1.210	1.3	0.60	NR
Total Phosphorus	S	0.006	0.005	0.014	ND	0.007	0.007	0.026	0.009	0.007[4]	0.010
(mg/l)	B	0.181	0.025	0.079	1.08	0.27	0.288	0.121	0.059	0.020	NR
Dissolved Phos.	S	0.003	ND	0.012	ND	ND	ND	0.017	NR	ND	ND
(mg/l)	B	0.093	0.001	0.066	0.033	0.152	0.222	0.088[4]	NR	ND	NR
Nit./Phos Ratio	S	83.3	100.0	51.9	–	57.1	71.4	27.6	55.6	80.0	64.0
	B	12.7	32.0	14.1	2.8	8.9	10.8	10.0	22.0	30.0	NR
Chlorophyll a (ug/l)	S	2	4.52	NR	0.982	2.02	8.65	NR	1.81	2.80	8.24

[1] S = surface, B = bottom; [2] NR = no reading; [3] holding time exceeded by SLOH; [4] ND = not detectable

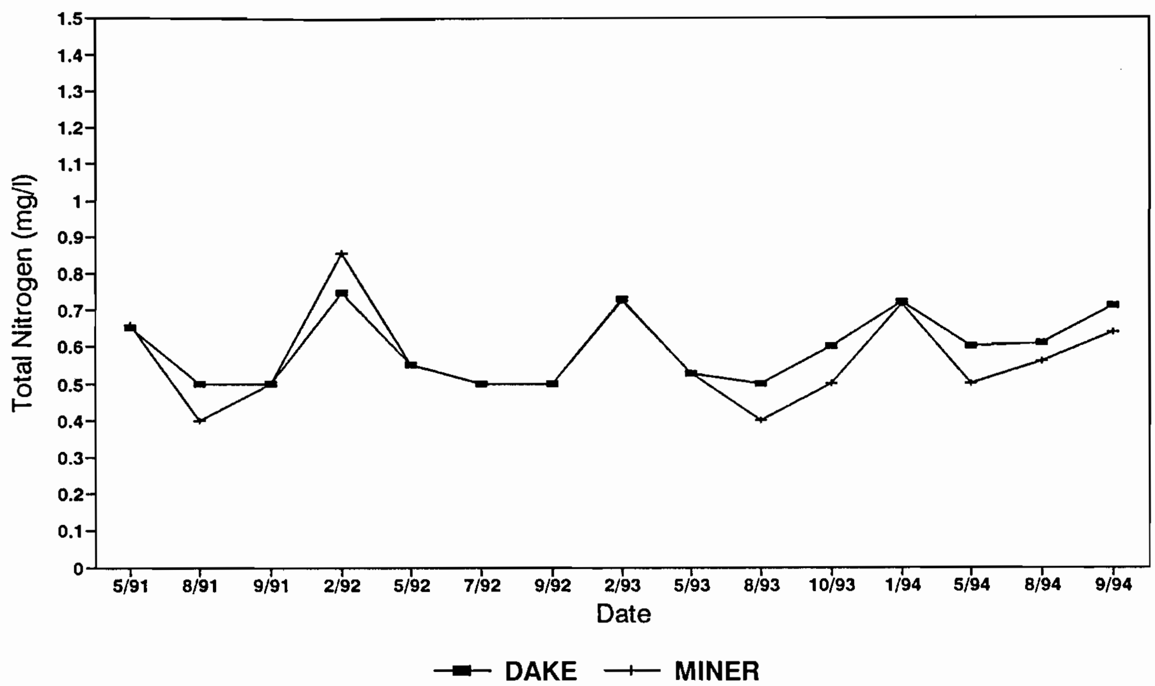


Figure 4. Surface Total Nitrogen Trends for the East Chain, 1991 - 1994.

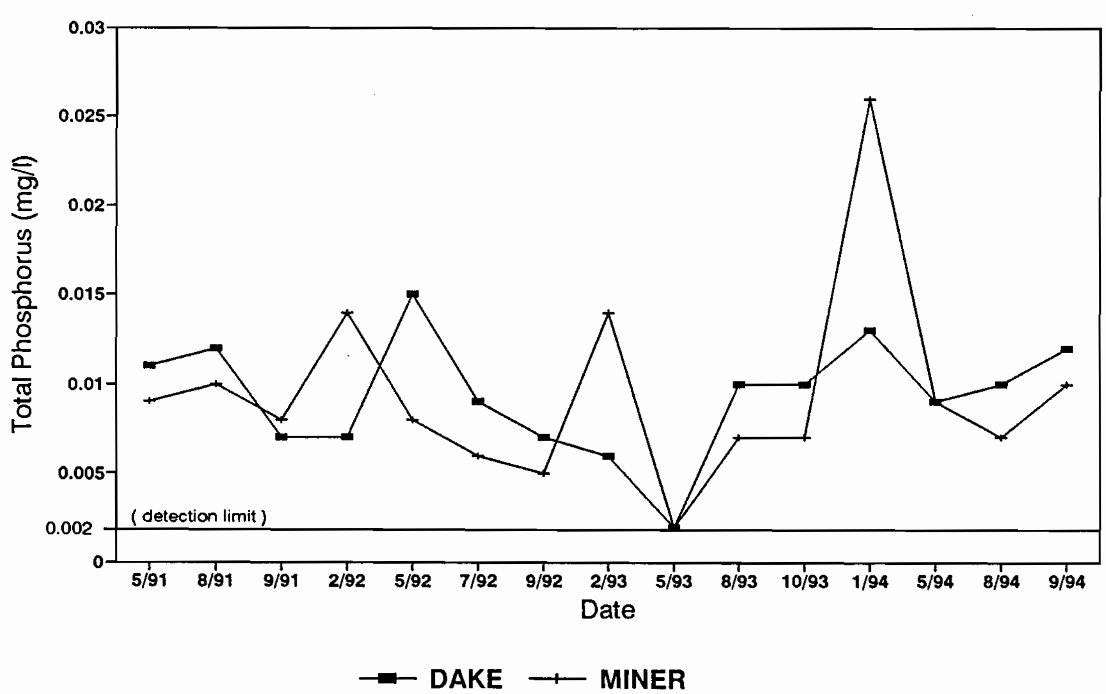


Figure 5. Surface Total Phosphorus Trends for the East Chain, 1991 - 1994.

observed appeared related to basin depth differences and the flow pattern from Miner Lake through Dake Lake.

Average surface total nitrogen levels in Miner (0.557 mg/L) and Dake (0.600 mg/L) Lakes were considerably lower than observed in most other Chain lakes; surface total phosphorus levels (0.010 mg/L in each) were generally similar that in the other Chain Lakes. Seasonal trends were present and appeared to reflect seasonal influences of stratification/mixing and surface or goundwater inflows.

Phosphorus levels for the East Chain were lower than those typical for stratified lakes (0.023 mg/l) and for lakes in the central region in Wisconsin (0.020 mg/l) (6); levels were at or below those typical for the ecoregion in which the Chain is located (0.010 - 0.014 mg/l) (7). NOTE: Some data were indicated to have exceeded the recommended maximum holding time before analysis. A study has shown, however, that the data remain accurate for samples analyzed well after the 28-day holding time (8).

Recreational Use

About 43% of all Chain O' Lakes respondents indicated they were permanent residents. Average occupancy for all respondents was 7.8 months (Table 7); seasonal residents averaged 4.7 months. Respondents indicated a total of 1222 watercraft with an average

Table 7. Comparison of Recreational Use Parameters for Various User Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Parameter	User Group			
	East Chain	Fast Lakes	Slow Lakes	Entire Chain
Average monthly occupancy	8.7	7.5	8.1	7.8
Average number of watercraft (per response)	2.5	3.1	2.7	2.9
Average number of adults (per respondent household)	2.3	2.4	2.4	2.4
Average number of children 12 - 18 years old (per respondent household)	0.3	0.6	0.3	0.4
Average number of children less than 12 years old (per respondent household)	0.3	0.5	0.5	0.5
Average respondent age	57.0	59.1	57.7	58.3
Percent of respondents leaving comments	47.2	51.9	44.9	48.0

of 2.9 per household. Pro-rated (to include all landowners) results would estimate almost 2,300 watercraft on the Chain O' Lakes, or 3.2 boats per acre (not including visitor watercraft). Most common watercraft types (in order) were canoes, pontoon boats, row/paddle boats and boats with less than 25 horsepower motors.

East Chain resident responses did not differ substantially from those of the Chain, as a whole, or from "fast" [wake lake residents (Rainbow, Round, Columbia and Long Lakes)] or "slow" [no wake lake residents (all others)] (Table 8). East Chain respondents agreed (78% "strongly agree" or "agree" responses) there are too many watercraft [primarily on weekends and holidays

Table 8. Percentage of "Strongly Agree" and "Agree" Responses for Various User Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Opinion	User Group			
	East Chain	Fast Lakes	Slow Lakes	Entire Chain
There are too many watercraft on the Chain	78	79	77	77
The current number of watercraft causes safety problems	74	77	75	76
There is adequate water safety enforcement:				
weekdays	86	82	85	84
weekends	66	60	69	65
holidays	63	58	62	60
Additional water use regulations need to be enacted and enforced	56	62	61	61
There should be limits set on the number of watercraft	49	54	54	54
There is adequate public boater access to the Chain	93	92	90	91
There should be more public restrooms on the Chain	44	52	47	50
There should be a public swimming beach on the Chain	31	36	34	35
There should be a public park on the shoreline of the Chain	27	29	29	29

(App. I)] and that the number of watercraft cause safety problems (74%) (primary causes identified as non-resident watercraft) and diminish user enjoyment. They agreed there was adequate water safety enforcement on weekdays (86%); fewer agreed for weekends (66%) and holidays (63%) (Table 13). Overall concensus was only somewhat in favor of enactment of more ordinances and limiting boat numbers, East Chain respondents considered these alternatives slightly less favorable than other user groups.

Respondents agreed that there was adequate public boater access to the Chain (93%) and most disagreed ("strongly disagree" or "disagree" responses) with establishment of a park (73%) or beach (69%) on the Chain. East Chain responses favoring more public restrooms were slightly less than for the other user groups.

Exotic Species

Eurasian Water Milfoil was not observed in the East Chain O' Lakes; aquatic plant surveys (1991) and visual observations (1991 - 1994) indicated only native water milfoil species (mainly *Myriophyllum exalbescens*), present in the East Chain. There were no observations of Zebra Mussels.

Purple Loosestrife was not observed in the East Chain, but it was present and locally abundant in a several areas of other Chain project groups. Purple Loosestrife is an exotic plant with a bright purple flower, originally propagated in the United States by the horticulture industry for flower gardens. It blooms late June to July and produces seeds soon after. The plant is able to outcompete native wetland vegetation, spread quickly and modify entire plant (and thus animal) assemblages.

BASELINE CONCLUSIONS

Watershed Characteristics

TWRPW Program well sample nitrate results, despite some instances of concern (e.g., > 10 mg/l), indicated that the Chain O' Lakes subwatershed had the lowest average nitrate readings for the entire Tomorrow/Waupaca River Watershed. Surface water samples indicated variable nitrate readings for the Chain subwatershed with highest readings in Murray and Radley Creeks.

Sediment/nutrient delivery for the Chain subwatershed of the TWRPW Project appraisal was estimated to be lower than all other subwatersheds. The Chain O' Lakes subwatershed contained almost 8% of the surface drained farmland but was estimated at only 6% of the sediment delivery; no stream degradation was observed for the 21.8 miles of streams in the Chain subwatershed.

Water Quality

Regular water quality monitoring in the East Chain during Phase II, as during Phase I, indicated good to very good water quality with in-lake nutrients for both lakes near or below levels expected for stratified lakes, lakes in the central region of Wisconsin and lakes in the ecoregion in which the Chain is located. Surface total nitrogen levels were considerably lower than observed in most other Chain lakes; surface total phosphorus levels were generally similar that in the other Chain Lakes.

Most between lake differences observed appeared related to basin depth differences and the general flow pattern from the deeper Miner Lake through Dake Lake. Miner Lake exhibited water column stratification during Summer and low dissolved oxygen near bottom on all sample dates; Dake Lake occasionally exhibited low dissolved oxygen near bottom, but surface to bottom temperature and nutrient differences were typically considerably less than in Miner Lake.

Recreational Use

East Chain resident responses to the recreational use survey were in general agreement with those from the Chain as a whole and from "fast" and "slow" lake user groups. Watercraft use on the Chain is high and respondents generally agreed that the current number of watercraft caused safety problems. They also indicated that water safety enforcement was adequate, but fewer agreed during weekend or holiday periods of heavy recreational use. Respondents were somewhat agreeable to, but rather evenly split, regarding additional use regulations or limiting the number of watercraft. There was relatively low interest in establishment of a public park or beach on the chain but respondents were more agreeable (about evenly split) as to the need for more public restrooms on the Chain.

East Chain user group vs other user group responses were probably not significant. The slight differences observed, however, appeared to reflect the locational aspects of Dake and Miner Lakes, i.e., somewhat isolated and off the main thoroughfare provided by the Upper, Middle and Lower Chain Lake groups.

Exotic Species

There were no observations of Zebra Mussels or Eurasian Water Milfoil in the Chain. Purple Loosestrife, which is widely distributed in Wisconsin and Waupaca County, was not observed in the East Chain but has become established in several areas of the Upper, Middle and Lower Chains.

MANAGEMENT RECOMMENDATIONS

The East Chain is smaller and generally weedier than the Upper, Middle and Lower Chain project groups, and is located off the major recreational boat traffic routes. These conditions present somewhat different management options, particularly relative to recreational use. Management objectives in the East Chain, as in all Chain O' Lakes project groups, should include water quality maintenance and protection; the sport fishery and other passive forms of recreational could more easily be emphasized in the East Chain.

Watershed: The Chain O'Lakes is significantly influenced by groundwater and receives some surface water inflow from the watershed. Residents should be made aware of the potential effects of watershed uses on their resource. In addition to a continuous focus on "yard management" and activities on shorelines immediately adjacent, or directly draining, to the lakes, they should be strongly encouraged to keep abreast of and support the TWRPW Project.

- Residents in the Middle Chain watershed should have private wells tested for nitrates and/or pesticide levels.

- Groundwater samples should be collected at various points in the Chain O' Lakes watershed to determine areas of concern.

Water Quality: Water quality in the East Chain is currently very good; total nitrogen levels are generally lower than elsewhere in the Chain O' Lakes. A monitoring strategy should be continued to provide a long term trend assessment and detect detrimental influences before effects become widespread or severe.

- Water quality monitoring should be continued in the East Chain lakes. Surface only samples during Winter, after ice out and three times during the Summer would minimize collection and laboratory analysis costs.

- Sampling during snowmelt or rainfall runoff events could be initiated at any sites identified as providing significant inflow. Assessment of these sites could lead to designation of the drainage area as sensitive and reduce sediment or nutrient loading to the East Chain.

- Groundwater nutrient and flow direction/rates should be collected for the Chain O' Lakes system when feasible.

Recreational Use: Chain O'Lakes resident recreational use survey results suggest that use, during summer weekends and holidays, is at or near saturation levels and that most perceive the problems related to non-resident or commercial watercraft. There does not appear, however, to be a clear concensus that additional regulations are desirable to address the situation. The CLPOA, then, should form a committee, or enlist some outside assistance, to address direct education or prevention measures to attempt minimization of use conflicts; these may include

- Development of maps for distribution which define best potential use zones for different recreational activities (skiing, fishing, canoeing, SCUBA diving/snorkeling, pleasure boating, dining, snowmobiling, etc.),

- Brochures, for visitors at access points, emphasizing "water use ethics" along with information an available restrooms, access points and applicable regulations and ordinances,

- Development of water accessible restrooms and waste disposal facilities for boaters,

- Initiation of a reasonable ramp fee at some/all access points with money collected directed toward access maintenance or lake management/protection activities, and

- Riparian landowners education about pertinent ordinances (dock design/size, boat numbers per pier, building near lakeshores, near-lake improvements, etc.).

The habitat conditions in and the location of the East Chain lakes appear appropriate for designation as a prime fishing area.

Exotic Species: Of the three exotic species of most current concern, only purple loosestrife appears to be established in the Chain O'Lakes.

- Identified purple loosestrife stands should be treated as soon as it is practical to do so; localized growth areas or individual plants should be treated first and more extensive growth areas later. It is best to treat plants before flowering (May to mid June). Plants are treated by cutting the top off and spraying the remainder with a Roundup-surfactant mix; plants in standing water should be treated with a Rodeo-surfactant mix. Chemicals can be applied using hand spray bottles or larger chemical sprayers. Sites should be revisited in subsequent years to treat remnant individuals.

- An exotic species watch group should be organized to monitor or remove exotic species (i.e., Purple Loosestrife, Zebra Mussels and Eurasian Water Milfoil) when encountered. Members should coordinate with the WDNR Exotic Species Program and inform the CLPOA membership and public on the hazards of exotic species as they relate to the Chain O' Lakes.

Aquatic Plants: Aquatic plant populations in Miner and Dake Lakes, as determined in Phase I activities, are not comprised of potentially nuisance species nor are they present at nuisance abundance levels. While fishery assessment was beyond the scope of these planning activities, aquatic plant communities in Miner and Dake Lakes are probably of substantial benefit to the fishery. Aquatic plant management in the East Chain should be limited to localized and selective removal near shore when considered necessary or desirable to improve access or aesthetics.

Public Involvement: Informational and educational programs for the CLPOA membership and public should be continued. Meetings, presentations, newsletters and/or news releases should continue to include information on groundwater and surface water quality, recreational use issues and the spread or control of exotic species.

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