IPS ENVIRONMENTAL AND ANALYTICAL SERVICES
Appleton, Wisconsin

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

REPORT TO:
CHAIN O' LAKES PROPERTY OWNERS ASSOCIATION

December, 1995

TABLE OF CONTENTS

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LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIXES

SUMMARY

The Lower Chain project group consists of Columbia, Ottman, Youngs, Beasley, Bass and Long 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. Lake modeling for some Chain lakes indicated a natural process of phosphorus removal by marl precipitation.

Lower Chain water quality monitoring during Phases I and II indicated in-lake nutrient levels below those expected for the region. The shallower well mixed lakes (Ottman, Bass, Youngs) had relatively higher nutrient readings, but levels were near or slightly above those typical of lake type and regional location. Lower Chain characteristics (relatively large watershed and direct or indirect drainage from all Chain project groups) suggests a relatively high potential for nutrient and sediment input from nonpoint sources. Water quality, except for a slight increase in total nitrogen in a downstream progression, remains similar throughout the Chain and apparently reflects the substantial groundwater input to the system.

Lower Chain recreational use survey results were 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 or commercial 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 beach, and were evenly divided regarding the need for more water accessible restrooms.

Purple loosestrife, an exotic potentially nuisance plant, was present and locally abundant in the Lower Chain.

Water quality protection and water use conflict minimization are priority management objectives for the Lower Chain and all Chain O' Lakes residents. Specific recommendations for the Lower Chain include private well testing for nitrates and/or pesticides, more event sampling (coordinated with flow and rainfall monitoring) and removal or management of the purple loosestrife beds. Other recommendations are applicable to the Lower 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 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 Lower Chain O'Lakes.

DESCRIPTION OF AREA

The Chain O' Lakes is a group of "kettle" lakes in the southwest corner of Waupaca County, Wisconsin (Fig. 1). Kettle lakes were formed when ice was pushed into the soil by retreating glaciers; the depressions subsequently filled with water when the ice blocks melted. The Lower Chain project group consists of Columbia, Ottman, Youngs, Bass, Beasley, and Long in the southwest portion of the Chain.

Predominant shoreline area substrates for the Lower Chain are sandy loam with localized areas of muck and detritus. Localized areas of abundant macrophytes are present on Long and Beasley Lakes, whereas the small shallow lakes (Ottman, Bass and Youngs) have substantial aquatic plant growth.

Generally, groundwater inflow to the Chain O' Lakes is from the northwest. Groundwater input was most visible and documented in Sunset Lake (south and west shores), Otter Lake (northwest shore) and George Lake (north shore) of the Upper Chain O'Lakes.

Lakes within the Lower Chain group are relatively diverse and include the Chain's smallest and shallowest (Youngs, 2 acres, 15 feet, .1% of the total Lower Chain surface area) and one of the largest, deepest (Long Lake, 104 acres, 76 feet, 48%) lakes,

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

along with Columbia (81 acres, 72 feet, 38%), Ottman (13 acres, 15 feet, 6%), Beasley (12 acres, 47 feet, 12.6%), and Bass (3 acres, 8 feet, 1.4%) Lakes (2). Flow within the Lower Chain is from Ottman to Youngs Lake, to Bass, Beasley and then to Long Lake; Beasley Lake also receives inflow from the Little Chain via the outlet from Orlando Lake. Columbia Lake receives inflow from the Upper and Middle Chains through the outlet from Limekiln Lake and from the East Chain through the outlet from Dake Lake before flowing into Long Lake.

Emmon's Creek, which drains over 40% of the Chain O' Lakes watershed, is a permanent inlet to Long Lake. The Crystal River eventually drains Long Lake and the entire Chain O' Lakes system to the Waupaca and Wolf Rivers.

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 Lower Chain has a boat ramp access point off Cleghorn Drive on Columbia Lake (Pers. comm. WDNR).

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 was completed in 1995. Pertinent information from the appraisal as it relates to the Chain O' Lakes is included in the Field Data Discussion section of this report.

Water Quality Monitoring

Water quality samples were taken three feet below surface (designated "S") and three feet above bottom (designated "B") in Columbia, Beasley, and Long Lakes during July and September, 1992, February, May, August and October, 1993, and January, February, May, August and September, 1994 (Table 2, Fig. 2). Bass Lake, Emmon's Creek inlet and Crystal River outlet sites were sampled mid-depth (designated "M") during July and September, 1992, May, February, August and October, 1993, and May, August and September 1994. (Emmon's Creek inlet and Crystal River outlet sites were not sampled February, 1993, due to unsafe ice). Ottman and Youngs Lake were sampled mid-depth during July and September, 1992, and February, 1993; Youngs Lake was also sampled in May, 1993. Parameters measured in the field were Secchi depth, water temperature, pH, dissolved oxygen (DO), and

Table 2. Sample Station Descriptions, Lower Chain, 1992 - 1994.

REGULAR MONITORING

Lake	Site Number	Depth
Columbia (Deepest Point)	1201	72 feet
Long (Deepest Point)	1202	76 feet
Emmon's Creek (Inlet)	1203	03 feet
Crystal River (Outlet)	1204	03 feet
Beasley (Deepest Point)	1205	47 feet
Bass (Deepest Point)	1206	08 feet
Youngs (Deepest Point)	1207	15 feet
Ottman (Deepest Point)	1208	15 feet

Event Site	Description
12E1	Emmon's Creek at junction with Rural Road

conductivity (see the Phase I document for specific equipment and methods information). Water samples were also taken by IPS or members of the CLPOA, with IPS instruction, at Site 12E1 on April 5, May 3 and 12, July 6 and August 1, 1994.

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.

_Figure 2. Sample Station Locations, Lower 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
Lower 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 (outflowing versus inflowing) of 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 indicated generally similar water quality among the Lower Chain lakes and trends similar to those observed during Phase I. Long and Bass Lakes exhibited somewhat higher nutrients

than the other Lower Chain lakes and all nutrient data reflected seasonal influences of stratification/mixing and surface or groundwater inflows (Tables 5-12, Figs. 4 and 5).

Surface or mid-depth total nitrogen (for continuously sampled lakes) ranged from 0.728 mg/l (Columbia) to 2.46 mg/l (Bass) with an average of 1.39 mg/l for all Lower Chain Lakes. Relatively high average total nitrogen levels were observed in Emmon's Creek - Inlet with a range of 1.86 mg/l to 2.67 mg/l and an average of 2.25 mg/l; the Crystal River outlet total nitrogen ranged from 1.32 mg/l to 1.73 mg/l with an average of 1.49 mg/l. Relatively high total nitrogen or phosphorus levels were observed during Winter (after fall overturn and when groundwater influence was probably greatest) or during Spring (un- or weakly stratified and possibly influenced by surface water inflows).

Substantially higher values for total phosphorus and other nutrient parameters were observed near bottom at Columbia, Beasley, and Long Lakes, and suggested nutrient release from sediments under anoxic or near-anoxic conditions during summer stratification at these relatively deep points.

Phosphorus levels for the Lower Chain were generally 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

Table 5. Water Quality Parameters, Station 1201, Columbia Lake, Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/14/92	09/22/92	02/02/93	05/19/93	08/16/93	10/04/93	01/25/94	05/02/94	08/02/94	09/21/94
Secchi (feet)		11.4	9.9	NR[2]	10.3	9.1	10.6	NR	9.5	10.5	9.0
Cloud Cover (percent)		70	0	10	90	40	50	0	40	0	100
Temperature (degrees Celsius)	S	20.77	16.90	2.56	15.70	24.30	12.37	2.03	10.21	24.06	21.70
	B	4.76	5.32	3.69	4.74	4.95	5.17	3.03	4.99	5.65	6.14
pH (surface units)	S	8.27	8.42	7.22	NR	8.11	NR	6.88	NR	8.10	NR
	B	6.42	7.11	6.73	NR	5.68	NR	6.54	NR	0.36	NR
D.O. (mg/l)	S	8.82	9.15	9.00	9.89	8.74	9.63	11.10	11.57	8.66	8.50
	B	0.10	0.63	1.63	0.16	0.10	0.98	6.67	0.50	0.36	0.67
Conductivity (umhos/cm)	S	309	287	333	320	287	315	346	328	320	284
	B	371	380	346	353	365	397	362	353	386	359
Laboratory pH (surface units)	S	NR	NR	NR	8.48	NR	NR	NR	8.31	NR	NR
	B	NR	NR	NR	7.75	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	151	NR	NR	NR	163	NR	NR
	B	NR	NR	NR	173	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	214	NR	NR	NR	220	NR	NR
	B	NR	NR	NR	246	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.4	0.5	0.9	0.5	0.4	0.5	0.9	0.6	0.40[3]	0.41[3]
	B	2.9	3.9	1.7	2.0	0.5	3.0	1.0	1.2	2.64[3]	NR
Ammonia Nitrogen (mg/l)	S	0.040	0.049	0.448	0.104	0.019	0.070	0.422	0.166	0.025	0.048
	B	2.07	2.90	0.919	1.24	0.048	2.47	0.583	0.703	1.88	NR
NO_2 + NO_3 Nit. (mg/l)	S	0.452	0.280	0.661	0.703	0.363	0.407	0.473	1.01	0.414	0.318
	B	ND[4]	ND	0.204	0.009	0.357	ND	0.533	0.619	0.022	NR
Total Nitrogen (mg/l)	S	0.852	0.780	1.561	1.203	0.763	0.907	1.373	1.61	0.814	0.728
	B	2.9	3.9	1.904	2.009	0.857	3.0	1.533	1.819	2.662	NR
Total Phosphorus (mg/l)	S	0.006	0.005	0.008	ND	0.008	0.005	0.019	0.009	0.007	0.0060[4]
	B	0.073	0.114	0.062	0.09	0.011	0.035	0.018	0.027	0.039	NR
Dissolved Phos. (mg/l)	S	0.002	0.001	0.003	ND	ND	ND	0.002	NR	ND	ND
	B	0.020	0.042	0.006	ND	ND	0.003	0.001	NR	ND	NR
Nit./Phos Ratio	S	142.0	156.0	195.1	--	95.4	181.4	72.3	178.9	116.3	121.3
	B	39.7	34.2	30.7	22.3	79.9	85.7	85.2	67.37	68.2	NR
Chlorophyll a (ug/l)	S	4	4.29	NR	2.78	4.32	3.66	NR	4.33	4.11	3.10

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[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 1202, Long Lake,

Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE									
		07/14/92	09/22/92	02/02/93	05/19/93	08/16/93	10/04/93	01/25/94	05/02/94	08/02/94	09/21/94
Secchi (feet)		23.9	12.1	NR[2]	14.8	14.2	15.2	NR	15.5	10.6	15.0
Cloud Cover (percent)		70	0	10	90	60	50	0	40	0	100
Temperature (degrees Celsius)	S	19.54	15.89	2.12	14.72	21.97	11.43	0.19	10.19	22.67	20.40
	B	5.66	6.36	3.88	5.13	5.66	6.12	3.51	5.50	6.72	7.41
pH (surface units)	S	8.23	8.08	7.24	NR	7.75	NR	7.10	NR	8.14	NR
	B	6.63	7.01	6.72	NR	5.88	NR	6.73	NR	6.17	NR
D.O. (mg/l)	S	8.95	9.08	9.02	9.62	8.42	9.10	10.50	11.61	9.77	9.04
	B	0.10	0.34	0.49	3.16	0.10	0.24	7.34	5.02	0.12	0.57
Conductivity (umhos/cm)	S	310	296	337	321	305	339	345	315	318	291
	B	338	334	357	339	325	345	353	333	351	323
Laboratory pH (surface units)	S	NR	NR	NR	8.39	NR	NR	NR	8.30	NR	NR
	B	NR	NR	NR	7.72	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	161	NR	NR	NR	168	NR	NR
	B	NR	NR	NR	174	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	216	NR	NR	NR	210	NR	NR
	B	NR	NR	NR	232	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.3	0.4	0.6	0.3	0.4	0.3	0.5	0.3	0.44[3]	0.38[3]
	B	0.9	0.7	0.9	0.5	0.4	0.6	0.4	0.5	0.45[3]	NR
Ammonia Nitrogen (mg/l)	S	0.042	0.043	0.303	0.074	0.030	0.030	0.162	0.041	0.01	0.036
	B	0.547	0.406	0.609	0.272	0.238	0.372	0.119	0.225	0.056	NR
NO_2 + NO_3 Nit. (mg/l)	S	1.10	0.955	1.06	1.17	0.967	1.27	1.42	1.32	0.921	0.868
	B	0.801	0.612	0.667	1.12	0.900	0.638	1.44	1.23	1.4	NR
Total Nitrogen (mg/l)	S	1.40	1.355	1.66	1.47	1.367	1.57	1.92	1.32	1.361	1.248
	B	1.701	1.312	1.567	1.62	1.300	1.238	1.84	1.73	1.85	NR
Total Phosphorus (mg/l)	S	0.005	0.009	0.011	ND[4]	0.009	0.014	0.013	0.008	0.012	0.009
	B	0.238	0.112	0.046	0.02	0.086	0.140	0.008	0.013	0.016	NR
Dissolved Phos. (mg/l)	S	0.003	0.003	0.003	ND	0.002	ND	0.002	NR	ND	ND
	B	0.136	0.082	0.031	0.007	0.054	0.086	0.007	NR	ND	NR
Nit./Phos Ratio	S	280.0	150.2	150.9	--	151.9	112.1	147.7	165.0	113.4	138.7
	B	7.1	11.7	34.1	81.0	15.1	8.8	230.0	133.1	115.6	NR
Chlorophyll a (ug/l)	S	1	5.07	NR	0.899	2.58	6.32	NR	3.97	0.06	1.50

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

Table 7. Water Quality Parameters, Station 1203 (Emmon's Creek Inlet), Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE							
		07/14/92	09/22/92	05/19/93	08/16/93	10/04/93	05/02/94	08/02/94	09/21/94
Secchi (feet)		>1.5	>1.0	>3.0	>3.0	>3.0	>3.0	>3.0	NR
Cloud Cover (percent)		70	0	90	50	50	40	0	100
Temperature (degrees Celsius)	M	15.05	10.39	10.25	14.12	10.08	8.77	16.5	14.4
pH (surface units)	M	8.73	8.13	NR[2]	8.79	7.28	NR	7.80	NR
D.O. (mg/l)	M	10.00	9.15	12.79	7.23	9.76	12.57	10.89	9.47
Conductivity (umhos/cm)	M	312	329	346	332	358	332	355	323
Laboratory pH (surface units)	M	NR	NR	8.23	NR	NR	8.27	NR	NR
Total Alkalinity (mg/l)	M	NR	NR	180	NR	NR	178	NR	NR
Total Solids (mg/l)	M	NR	NR	232	NR	NR	226	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	0.5	0.2	ND	0.4	0.5	0.3	0.25[3]	0.36[3]
Ammonia Nitrogen (mg/l)	M	0.020	0.016	0.021	0.026	0.021	0.021	0.026	0.020
NO2 + NO3 Nit. (mg/l)	M	1.41	1.94	1.86	1.94	2.17	2.12	1.98	2.05
Total Nitrogen (mg/l)	M	1.91	2.14	1.86	2.34	2.67	2.42	2.23	2.41
Total Phosphorus (mg/l)	M	0.011	0.007	ND[4]	0.019	0.035	0.009	0.022	0.16
Dissolved Phos. (mg/l)	M	0.005	0.006	0.002	0.002	ND	NR	0.003	ND
Nit./Phos Ratio	M	173.6	305.7	--	123.2	76.3	268.9	101.4	150.6
Chlorophyll a (ug/l)	M	4	1.89	2.42	3.43	4.36	2.20	4.57	2.92

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[1] M = mid-depth; [2] NR = no reading; [3] holding time exceeded by SLOH; [4] ND = not detectable

Table 8. Water Quality Parameters, Station 1204 (Crystal River Outlet), Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE							
		07/15/92	09/22/92	05/19/93	08/16/93	10/04/93	05/02/94	08/02/94	09/21/94
Secchi (feet)		>2.5	>2.0	>3.0	>2.5	>3.0	>3.0	>3.0	>3.0
Cloud Cover (percent)		70	0	90	50	50	40	0	100
Temperature (degrees Celsius)	M	19.26	15.99	14.67	21.94	11.56	10.26	22.5	19.65
pH (surface units)	M	8.22	8.05	NR	7.74	7.40	NR	8.17	NR
D.O. (mg/l)	M	9.35	8.87	9.66	8.50	9.37	12.17	10.07	9.21
Conductivity (umhos/cm)	M	309	295	320	309	341	316	320	300
Laboratory pH (surface units)	M	NR	NR	8.17	NR	NR	8.35	NR	NR
Total Alkalinity (mg/l)	M	NR	NR	159	NR	NR	169	NR	NR
Total Solids (mg/l)	M	NR	NR	212	NR	NR	212	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	0.2	0.4	0.3	0.3	0.2	0.3	0.44[3]	0.32[3]
Ammonia Nitrogen (mg/l)	M	0.034	0.034	0.069	0.019	0.014	0.024	0.011	0.041
NO2 + NO3 Nit. (mg/l)	M	1.12	1.04	1.21	1.09	1.41	1.43	0.974	1.16
Total Nitrogen (mg/l)	M	1.32	1.44	1.51	1.39	1.61	1.73	1.414	1.48
Total Phosphorus (mg/l)	M	0.007	0.008	ND[4]	0.011	0.007	0.009	0.012	0.007
Dissolved Phos. (mg/l)	M	0.002	0.004	ND	ND	ND	NR	0.002	ND
Nit./Phos Ratio	M	188.6	180.0	--	126.4	230.0	192.2	117.8	211.4
Chlorophyll a (ug/l)	M	2	2.27	1.21	3.13	5.43	5.60	8.19	1.64

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[1] M = mid-depth; [2] NR = no reading; [3] holding time exceeded by SLOH; [4] ND = not detectable

Table 9. Water Quality Parameters, Station 1205, Beasley Lake, Chain O' Lakes, July 1992 - September 1994.

PARAMETER SAMPLE[1] DATE

		07/15/92	09/22/92	02/03/93	05/20/93	08/16/93	10/04/93	02/15/94	05/03/94	08/02/94	09/21/94
Secchi (feet)		16.2	18.7	NR[2]	22.4	15.0	16.3	NR	16.0	12.5	14.0
Cloud Cover (percent)		70	0	10	10	100	50	0	60	0	100
Temperature (degrees Celsius)	S	20.46	16.00	1.60	14.23	22.01	11.63	0.76	11.40	23.37	20.62
	B	5.64	6.18	3.79	5.01	5.49	5.85	3.61	4.68	7.08	NR
pH (surface units)	S	8.46	8.01	7.32	NR	7.76	NR	6.82	7.56	8.22	NR
	B	6.61	6.90	6.82	NR	6.05	NR	6.45	6.50	6.44	NR
D.O. (mg/l)	S	9.77	8.93	8.94	9.76	8.82	11.63	9.79	10.86	10.04	9.72
	B	0.10	0.54	0.33	0.68	0.10	0.49	0.51	0.54	0.37	0.76
Conductivity (umhos/cm)	S	280	292	336	307	294	332	345	306	291	284
	B	371	385	361	388	362	395	357	361	370	356
Laboratory pH (surface units)	S	NR	NR	NR	8.24	NR	NR	NR	8.22	NR	NR
	B	NR	NR	NR	7.79	NR	NR	NR	NR	NR	NR
Total Alkalinity (mg/l)	S	NR	NR	NR	159	NR	NR	NR	163	NR	NR
	B	NR	NR	NR	205	NR	NR	NR	NR	NR	NR
Total Solids (mg/l)	S	NR	NR	NR	196	NR	NR	NR	198	NR	NR
	B	NR	NR	NR	248	NR	NR	NR	NR	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	S	0.4	0.5	0.3	0.4	0.5	0.4	0.4	0.3	0.41[3]	0.43
	B	2.4	0.9	1.1	1.9	0.4	2.2	1.2	1.4	0.92[3]	NR
Ammonia Nitrogen (mg/l)	S	0.036	0.078	0.140	0.078	0.048	0.086	0.152	0.070	0.019	0.025
	B	1.261	0.474	0.808	1.42	0.034	1.64	0.700	1.05	0.468	NR
NO_2 + NO_3 Nit. (mg/l)	S	0.669	0.600	1.53	0.750	0.623	0.733	1.51	0.868	0.459	0.610
	B	ND[4]	0.387	0.412	0.046	0.632	0.007	0.420	0.033	0.207	NR
Total Nitrogen (mg/l)	S	1.069	1.100	1.83	1.150	1.123	1.133	1.91	1.168	0.869	1.04
	B	2.4	1.287	1.512	1.946	1.032	2.207	1.620	1.433	1.127	NR
Total Phosphorus (mg/l)	S	0.008	0.014	0.004	ND	0.012	0.010	0.038	0.010	0.013	0.010
	B	0.244	0.020	0.091	0.20	0.009	0.320	0.059	0.083	0.027	NR
Dissolved Phos. (mg/l)	S	0.002	0.003	0.004	0.003	ND	ND	0.002	NR	ND	ND
	B	0.138	0.005	0.080	0.143	ND	0.25	0.043	NR	NR	NR
Nit./Phos Ratio	S	133.6	78.6	457.5	--	93.6	113.3	50.3	116.8	66.8	104.0
	B	9.8	64.4	16.6	9.7	114.7	6.9	27.5	17.3	41.74	NR
Chlorophyll a (ug/l)	S	3	4.16	NR	0.90	2.65	2.87	NR	2.04	4.09	4.26

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

Table 10. Water Quality Parameters, Station 1206, Bass Lake, Chain O' Lakes, July 1992 - September 1994.

PARAMETER	SAMPLE[1]	DATE							
		07/14/92	09/22/92	02/03/93	05/19/93	08/16/93	10/04/93	05/03/94	08/02/94	09/02/94

Secchi (feet)		**>5.0**	**>6.0**	**NR[2]**	**>6.0**	**>7.0**	**>8.0**	**>8.0**	**>6.0**	**>6.0**
Cloud Cover (percent)		**70**	**0**	**10**	**90**	**30**	**50**	**60**	**0**	**100**
Temperature (degrees Celsius)	**M**	**19.84**	**14.54**	**1.83**	**14.15**	**20.50**	**11.01**	**10.50**	**22.75**	**20.02**
pH (surface units)	**M**	**8.69**	**7.65**	**7.35**	**NR**	**7.43**	**NR**	**7.47**	**8.38**	**NR**
D.O. (mg/l)	**M**	**11.10**	**7.57**	**8.22**	**8.02**	**8.72**	**11.50**	**11.01**	**11.69**	**9.13**
Conductivity (umhos/cm)	**M**	**245**	**284**	**304**	**304**	**297**	**317**	**287**	**273**	**270**
Laboratory pH (surface units)	**M**	**NR**	**NR**	**NR**	**7.92**	**NR**	**NR**	**NR**	**NR**	**NR**
Total Alkalinity (mg/l)	**M**	**NR**	**NR**	**NR**	**148**	**NR**	**NR**	**NR**	**NR**	**NR**
Total Solids (mg/l)	**M**	**NR**	**NR**	**NR**	**210**	**NR**	**NR**	**NR**	**NR**	**NR**
Tot. Kjeld. Nitrogen (mg/l)	**M**	**0.4**	**0.6**	**0.2**	**0.6**	**0.4**	**0.3**	**0.6**	**0.45[3]**	**0.44[3]**
Ammonia Nitrogen (mg/l)	**M**	**0.040**	**0.097**	**0.053**	**0.122**	**0.057**	**0.057**	**0.108**	**0.027**	**0.059**
NO2 + NO3 Nit. (mg/l)	**M**	**0.767**	**0.957**	**2.26**	**0.948**	**0.969**	**1.08**	**0.942**	**0.474**	**0.700**
Total Nitrogen (mg/l)	**M**	**1.167**	**1.557**	**2.46**	**1.548**	**1.369**	**1.38**	**1.542**	**0.924**	**1.14**
Total Phosphorus (mg/l)	**M**	**0.013**	**0.012**	**0.004**	**0.03**	**0.025**	**0.008**	**0.029**	**0.014**	**0.017**
Dissolved Phos. (mg/l)	**M**	**0.002**	**0.004**	**0.002**	**0.003**	**ND[4]**	**ND**	**NR**	**ND**	**ND**
Nit./Phos Ratio	**M**	**89.8**	**129.8**	**615.0**	**51.6**	**54.8**	**172.5**	**53.17**	**66.0**	**67.06**
Chlorophyll a (ug/l)	**M**	**8**	**4.65**	**NR**	**2.75**	**3.51**	**5.98**	**3.22**	**2.69**	**3.88**

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[1] M = mid-depth; [2] NR = no reading; [3] holding time exceeded by SLOH;
[4] ND = not detectable

Table 11. Water Quality Parameters, Station 1207 Youngs Lake, Chain O' Lakes, July 1992 - May 1993.

PARAMETER	SAMPLE[1]	DATE			
		07/14/92	09/22/92	02/03/93	05/20/93

Secchi (feet)		**>10.0**	**11.0**	**NR[2]**	**10.1**
Cloud Cover (percent)		**70**	**0**	**10**	**10**
Temperature (degrees Celsius)	**M**	**17.73**	**13.58**	**4.13**	**11.73**
pH (surface units)	**M**	**8.11**	**7.47**	**7.00**	**NR**
D.O. (mg/l)	**M**	**10.30**	**4.74**	**0.76**	**9.51**
Conductivity (umhos/cm)	**M**	**297**	**301**	**351**	**298**
Laboratory pH (surface units)	**M**	**NR**	**NR**	**NR**	**7.96**
Total Alkalinity (mg/l)	**M**	**NR**	**NR**	**NR**	**147**
Total Solids (mg/l)	**M**	**NR**	**NR**	**NR**	**206**
Tot. Kjeld. Nitrogen (mg/l)	**M**	**0.4**	**0.8**	**0.8**	**0.4**
Ammonia Nitrogen (mg/l)	**M**	**0.086**	**0.269**	**0.395**	**0.032**
NO2 + NO3 Nit. (mg/l)	**M**	**1.17**	**0.956**	**1.39**	**1.42**
Total Nitrogen (mg/l)	**M**	**1.577**	**1.756**	**2.19**	**1.82**
Total Phosphorus (mg/l)	**M**	**0.006**	**0.017**	**0.019**	**ND[3]**
Dissolved Phos. (mg/l)	**M**	**0.002**	**0.002**	**0.002**	**0.002**
Nit./Phos Ratio	**M**	**262.8**	**103.3**	**115.3**	**--**
Chlorophyll a (ug/l)	**M**	**5**	**3.58**	**NR**	**1.58**

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[1] M = mid-depth; [2] NR = no reading; [3] ND = not detectable;

Table 12. Water Quality Parameters, Station 1208, Ottman Lake, Chain O' Lakes, July 1992 - May 1993.

PARAMETER	SAMPLE[1]	DATE		
		07/16/92	**09/28/92**	**02/03/93**
Secchi		**9.1**	**7.3**	**NR[2]**

(feet)				
Cloud Cover (percent)		**70**	**0**	**10**
Temperature (degrees Celsius)	**M**	**19.40**	**13.07**	**4.06**
pH (surface units)	**M**	**8.52**	**7.30**	**7.02**
D.O. (mg/l)	**M**	**9.15**	**6.21**	**4.17**
Conductivity (umhos/cm)	**M**	**227**	**323**	**281**
Laboratory pH (surface units)	**M**	**NR**	**NR**	**NR**
Total Alkalinity (mg/l)	**M**	**NR**	**NR**	**NR**
Total Solids (mg/l)	**M**	**NR**	**NR**	**NR**
Tot. Kjeld. Nitrogen (mg/l)	**M**	**0.8**	**3.8**	**1.2**
Ammonia Nitrogen (mg/l)	**M**	**0.050**	**ND[3]**	**0.448**
NO2 + NO3 Nit. (mg/l)	**M**	**0.012**	**ND**	**0.098**
Total Nitrogen (mg/l)	**M**	**0.812**	**3.8**	**1.298**
Total Phosphorus (mg/l)	**M**	**0.011**	**0.30**	**0.014**
Dissolved Phos. (mg/l)	**M**	**0.002**	**0.002**	**0.002**
Nit./Phos Ratio	**M**	**73.8**	**12.7**	**92.7**
Chlorophyll a (ug/l)	**M**	**2.82**	**31.7**	**NR**

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[1] M = mid-depth; [2] NR = no reading; [3] ND = not detectable;

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

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

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).

Nutrient levels at site 12E1 during the single runoff event (July 6, 1994) were not substantially different from those during regular monitoring (all other dates) (Table 13). Average total nitrogen for all dates was 2.19 mg/l; average total phosphorus was 0.027 mg/l.

Emmon's Creek inputs at an average flow of 30.3 cfs (19.6 mgd) were estimated at 1,110 kilograms (2,448 pounds) phosphorus and 46,580 kilograms (102,690 pounds) nitrogen (Fig. 6-8). These inputs far exceeded the TWRPW Project phosphorus input estimate of 1,313 pounds.

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 14); seasonal residents averaged 4.7 months. Respondents indicated a total of 1222 watercraft with an average of 2.9 per household. Pro-rated (to include all landowners)

Table 13. Event Water Quality Parameters, Station 12E1, Emmon's Creek at junction with Rural Road, April 1994 - August 1994.

PARAMETER	SAMPLE[1]	DATE				
		04/5/94	05/03/94	05/12/94	07/06/94[2]	08/01/94
Temperature (degrees Celsius)	M	9.5	NR[3]	11.5	17.5	NR
pH (surface units)	M	7.93	NR	8.28	NR	NR
D.O. (mg/l)	M	9.5	NR	11.2	10.1	NR
Conductivity (umhos/cm)	M	228	NR	366	NR	NR
Tot. Kjeld. Nitrogen (mg/l)	M	1.1	<0.2	<0.2	0.4	0.42[4]
Ammonia Nitrogen (mg/l)	M	0.028	0.019	0.020	0.053	0.011
NO_2 + NO_3 Nit. (mg/l)	M	1.02	2.16	2.15	1.52	2.11
Total Nitrogen (mg/l)	M	2.12	ND[5]	ND	1.92	2.53
Total Phosphorus (mg/l)	M	0.06	0.008	0.011	0.034	0.024
Dissolved Phos. (mg/l)	M	NR	NR	NR	0.007	0.003
Nit./Phos Ratio	M	35.3	--	--	56.47	105.4

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[1] M = mid-depth; [2] actual runoff event sample; [3] NR = no reading; [4] holding time exceeded by SLOH; [5] ND = not detectable

Figure 6. Average Flow Contribution from Overland Sources, Chain O' Lakes, 1994.

Figure 7. Average Nitrogen Contribution from Overland Sources, Chain O' Lakes, 1994.

Figure 8. Average Phosphorus Contribution from Overland Sources, Chain O' Lakes, 1994.

Table 14. Comparison of Recreational Use Parameters for Various User Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Parameter	User Group			
	Lower Chain	Fast Lakes	Slow Lakes	Entire Chain
Average monthly occupancy	7.7	7.5	8.1	7.8
Average number of watercraft (per response)	3.0	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)	0.6	0.6	0.3	0.4
Average number of children less than 12 years old (per respondent household)	0.6	0.5	0.5	0.5
Average respondent age	59.8	59.1	57.7	58.3
Percent of respondents leaving comments	46.0	51.9	44.9	48.0

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.

Lower 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)]. Lower Chain respondents agreed (79% "strongly agree" or "agree" responses) there are too many watercraft [primarily on weekends and holidays (App. I)] and that the number of watercraft cause safety problems (76%) (primary causes identified as non-resident watercraft) and diminish user enjoyment. They agreed there was adequate water safety enforcement on weekdays (84%); fewer agreed for weekends (61%) and holidays (59%) (Table 15). Overall concensus was only somewhat in favor of enactment of more ordinances and limiting boat numbers.

Respondents agreed that there was adequate public boater access to the Chain (94%) and most disagreed ("strongly disagree" or "disagree" responses) with establishment of a park (74%) or beach (64%) on the Chain. Lower Chain respondents, however, were quite evenly split on the need for more public restrooms.

Exotic Species

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

Table 15. Percentage of "Strongly Agree" and "Agree" Responses for Various User Groups, Chain O' Lakes, Waupaca County, Wisconsin.

Opinion	User Group			
	Lower Chain	Fast Lakes	Slow Lakes	Entire Chain
There are too many watercraft on the Chain	79	79	77	77
The current number of watercraft causes safety problems	76	77	75	76
There is adequate water safety enforcement:				
weekdays	84	82	85	84
weekends	61	60	69	65
holidays	59	58	62	60
Additional water use regulations need to be enacted and enforced	59	62	61	61
There should be limits set on the number of watercraft	51	54	54	54
There is adequate public boater access to the Chain	94	92	90	91
There should be more public restrooms on the Chain	47	52	47	50
There should be a public swimming beach on the Chain	36	36	34	35
There should be a public park on the shoreline of the Chain	26	29	29	29

Purple Loosestrife, however, was present and locally abundant in a several areas of the Lower Chain. Major populations are at the north and south shores of Columbia Lake, the east shore of

Beasley Lake and scattered areas along the shores of Long Lake with greatest density at the inlet of Emmon's Creek and the Crystal River Outlet (Fig. 9).

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 and modify entire plant (and thus animal) assemblages.

Figure 9. Purple Loosestrife Growth Areas, Lower Chain, 1994.

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 Lower Chain during Phase II, as during Phase I, indicated good to very good water quality. Surface total phosphorus levels were generally similar to that in the other Chain lakes and generally exhibited weak and variable seasonal trends. Total nitrogen levels tended to be slightly higher, as a whole, than in other Chain groups and seasonal trends indicated higher levels during Winter, when

groundwater
was of greatest influence and lower levels during summer stratification. Most between lake differences observed appeared related to basin depth differences. In-lake surface phosphorus for all lakes continued to be 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; marl precipitation apparently reduces phosphorus levels in at least some Chain lakes.

Flow and nutrient contribution via Emmon's Creek is relatively significant compared with other overland sources to the Chain (Fig. 6-8). Existing estimates of total overland nutrient input to the Chain appear questionable because of the considerable discrepancy between the TWRPW Project and the estimated flow - field measured phosphorus estimate methods.

Recreational Use

Lower 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 evenly split as to limiting the number of

watercraft and only slightly agreeable to additional use regulations. There was relatively low interest in establishment

of a public park or beach on the Chain. Respondents were evenly divided as to the need for more public restrooms on the Chain.

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, has become established in several areas of the Upper, Middle and Lower Chains.

MANAGEMENT RECOMMENDATIONS

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", they should be strongly encouraged to keep abreast of and support the TWRPW Project.

- Residents in the Lower 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 Lower Chain is currently very good but a focused monitoring strategy should be continued. These data could provide a long term trend assessment and detect detrimental influences before effects become widespread or severe.

- Columbia, Long, Beasley, and Bass (deepest point) Lake sites should be considered "indicator lakes" for Lower Chain trend monitoring. Surface only samples during Winter, after ice out and three times during the Summer would minimize collection and laboratory analysis costs.

- More event samples should be collected at Site 12E1; flow determination and rainfall monitoring would enhance the value of this information.

- 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 and 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 on 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 the 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.).

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.

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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APPENDIX I
RECREATIONAL USE SURVEY RESULTS
Lower Chain O' Lakes Management Plan

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APPENDIX II
SUMMARY OF PUBLIC INVOLVEMENT ACTIVITIES
Lower Chain O' Lakes Management Plan

The Chain O' Lakes Property Owners Association (CLPOA) 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 Phase I and Phase II major public involvement efforts.

Planning Advisory Committee

A working group comprised of the CLPOA officers, IPS and WDNR was established at the start of the program. The group provided planning direction and served as main reviewer of the draft plan document.

Brochures

A informational brochure titled "Chain O' Lakes Management Planning Program" was developed and distributed which outlined objectives, elements and ways for CLPOA members to get involved in the planning process.

A Phase I plan summary brochure was also produced. It was made available for CLPOA use and distribution when the plan document was approved by WDNR. The brochure described the main features of plan development, plan recommendations and other pertinent information. Another plan brochure will be produced upon conclusion of Phase II.

Meetings

IPS presented progress reports, provided information about the resource and interpretations of these results periodically and at CLPOA member meetings.

Print Media

After receipt of the grant award, a news release was issued to the Waupaca Post. The release highlighted information about the length and scope of the project and persons to contact for additional information.

A quarterly IPS newsletter entitled "Lake Management News" was developed and distributed to the CLPOA for the officers' use and distribution among the membership. A special "Chain O' Lakes" was also developed to notify the CLPOA of any late developments in the planning program. Information was also prepared for inclusion into the CLPOA newsletter.

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

Prepared for

Chain O' Lakes Property Owners Association

by

December, 1995