LPL-39?

MONITORING RESULTS FOR RICE CREEK, OTTER CREEK, AND RICE LAKE

1996 - 1998

Craig Roesler
Department of Natural Resources
Northern Region

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INTRODUCTION

Rice Creek begins about 1/2 mile upstream of Rice Lake (figure 1). After exiting Rice Lake, the creek flows an additional 2 miles before entering Balsam Lake. Otter Creek is a tributary, which joins Rice Creek about half way between Rice Lake and Balsam Lake.

Monitoring of water quality, streamflow, and lake levels was conducted for Rice Creek, Otter Creek, and Rice Lake during 1996 through 1998. Most of the monitoring conducted from October, 1996 to May, 1998 was sponsored by the Balsam Lake Protection and Rehabilitation District with assistance from a DNR Lake Management Planning Grant. The monitoring was done by Matt Rosendahl, a student at Balsam Lake High School. Matt received training from DNR staff. Additional monitoring, which was done by DNR staff is also included in this report.

A previous study (Rose 1993) found that Rice Creek is the largest source of phosphorus loading to Balsam Lake. A previous study of Rice Lake (Engels and Nichols 1994) found that the lake was hypereutrophic with summer Secchi depths averaging about 1 foot. These previous studies were based on data collected in 1988-1990.

More recent monitoring of Rice Lake in the summer of 1996 showed the lake was making dramatic improvements in water quality (Roesler 1996). Also, the previous phosphorus loading estimates for Rice Creek were made during two drought years.

There are a number of efforts currently underway to reduce phosphorus loading to Balsam Lake. The current study was done to provide a more up to date assessment of Rice Creek and Rice Lake. This will assist in selecting and pursuing the most effective phosphorus reduction strategies for Balsam Lake. It will also allow an evaluation of the effectiveness of strategies which are implemented.

MONITORING METHODS

Streams

Three stream sites were monitored - one each on Rice Creek (RC-2) and Otter Creek (OC-3) above their confluence, and one on Rice Creek below their confluence (RC-4)(figure 2).

Samples were collected on 41 dates at the stream sites between October, 1996 and May 1998. Samples were tested for total phosphorus and suspended solids concentrations by the Wisconsin

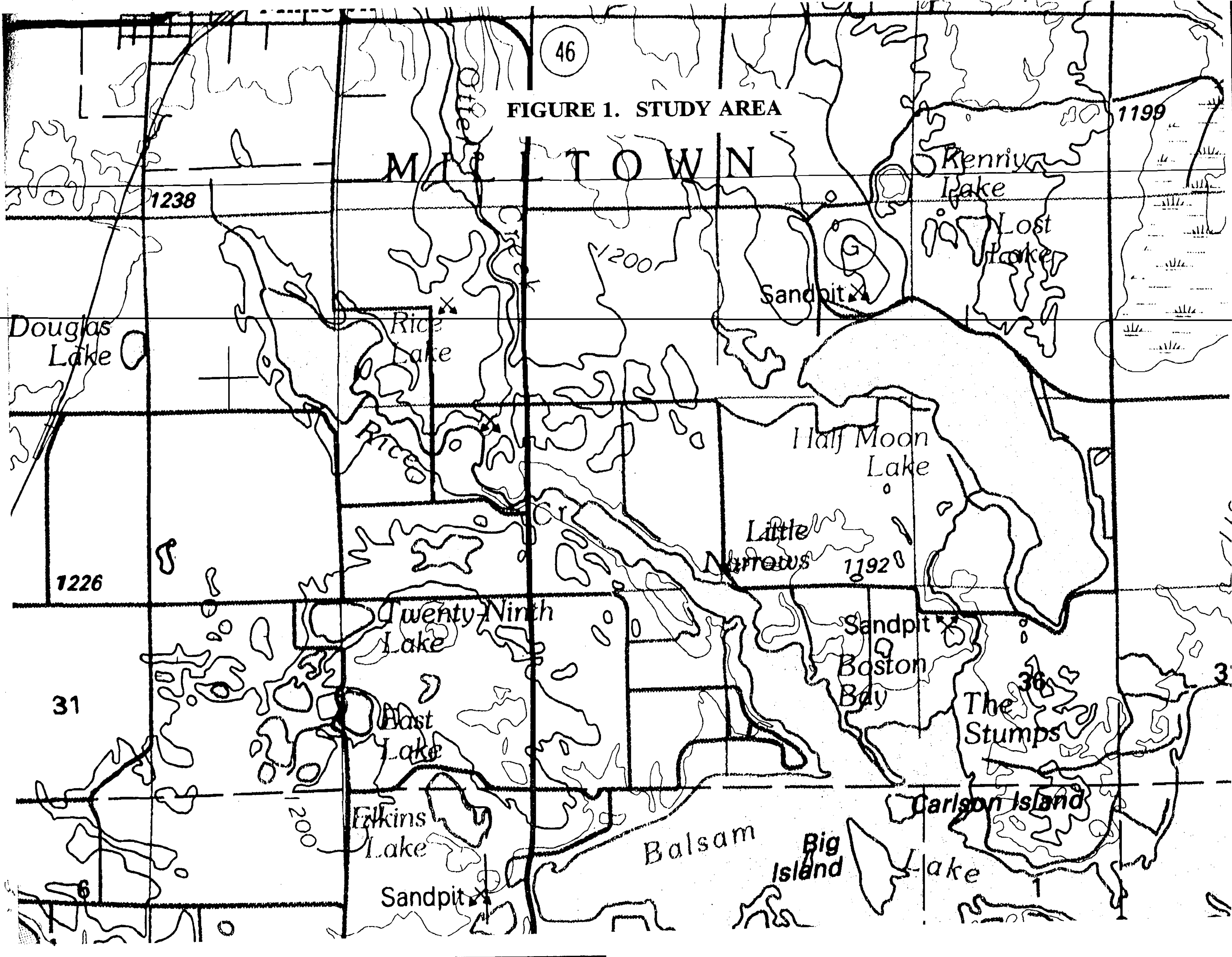


FIGURE 1. STUDY AREA
46
MILLTOWN
1238
1199
Kenniy Lake
Lost Lake
1200
Sandpit
Douglas Lake
Rice Lake
Rice
Half Moon Lake
Little Narrows
1192
1226
Twenty-Ninth Lake
Sandpit
Boston Bay
36
The Stumps
31
Bass Lake
Carlson Island
Elkins Lake
1200
Balsam
Big Island
Lake
6
Sandpit
1

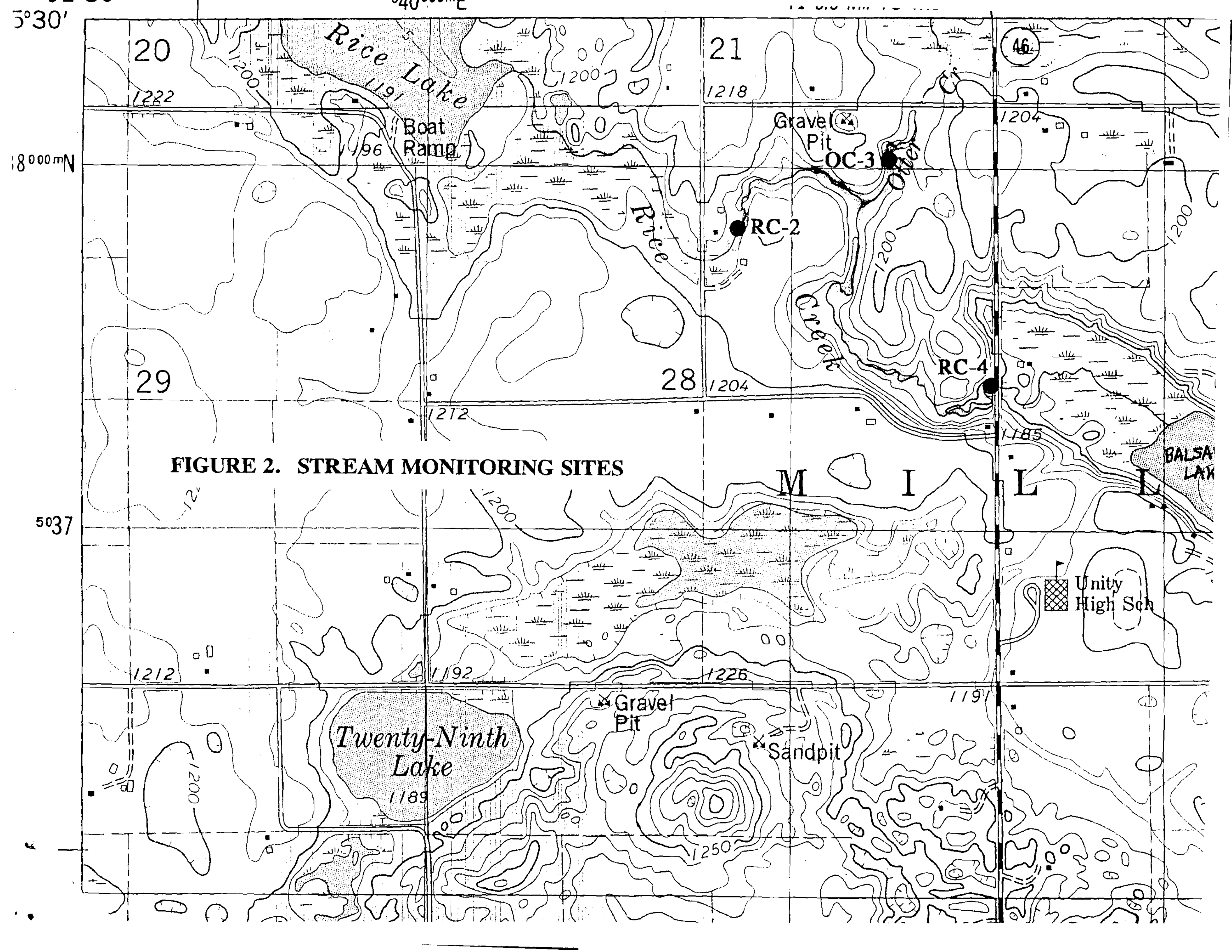


FIGURE 2. STREAM MONITORING SITES

State Laboratory of Hygiene. Samples were collected on an irregular schedule, with emphasis given to collection during high flow periods. Field tests for dissolved oxygen, temperature, and occasionally pH, were also done.

Stream stage (water level) measurements were made on 261 dates, with emphasis given to obtaining more frequent measurements during periods of fluctuating flows. Stages were determined by measuring the distance from the water surface to the upper edge of the road culvert. This avoided the need for the installation of fixed staff gages. Stream stages for unmeasured dates were estimated by interpolating between measured dates.

Streamflows were measured on 26 dates, with an effort made to obtain measurements across the full range of flows occurring. Stage-discharge plots were developed to allow estimation of streamflow based on stage for all dates.

Total phosphorus (TP) and suspended solids (SS) loading rates were determined for the three stream sites. An examination of the TP and SS results showed no significant relationship between streamflow and concentrations. There was a relationship between season and concentrations. Average concentrations for winter (November through March) and spring-summer-fall (April through October) were distinctive and were calculated separately. These average concentrations from each time period were then applied to all dates within those periods. Loads were then calculated by multiplying these average concentrations by the estimated daily streamflows. One exception to this approach was for SS concentrations in Otter Creek, in which case no seasonal distinctions were clear, and so a single average concentration was applied to all dates.

Rice Lake

Rice Lake was monitored at the lake's deepest spot (RL-1)(figure 3). The maximum depth shown in figure 3 is incorrect. The lake's maximum depth is 5 1/2 ft.

The lake was generally sampled monthly during the open water period and less frequently during the period of ice cover. Samples were collected from a depth of 0.5 m. Samples were tested for total phosphorus and chlorophyll a by the Wisconsin State Laboratory of Hygiene. Field tests for Secchi depth, dissolved oxygen, temperature, and pH were also done.

Lake stage was measured periodically. A staff gage was installed at the boat landing near the established benchmark (see figure 3). The benchmark has an assumed elevation of 100.0 ft. The elevation of the staff gage was surveyed each fall and spring to determine any shifting caused by lake ice or other reasons. The staff gage was found to be stable during the open water period.

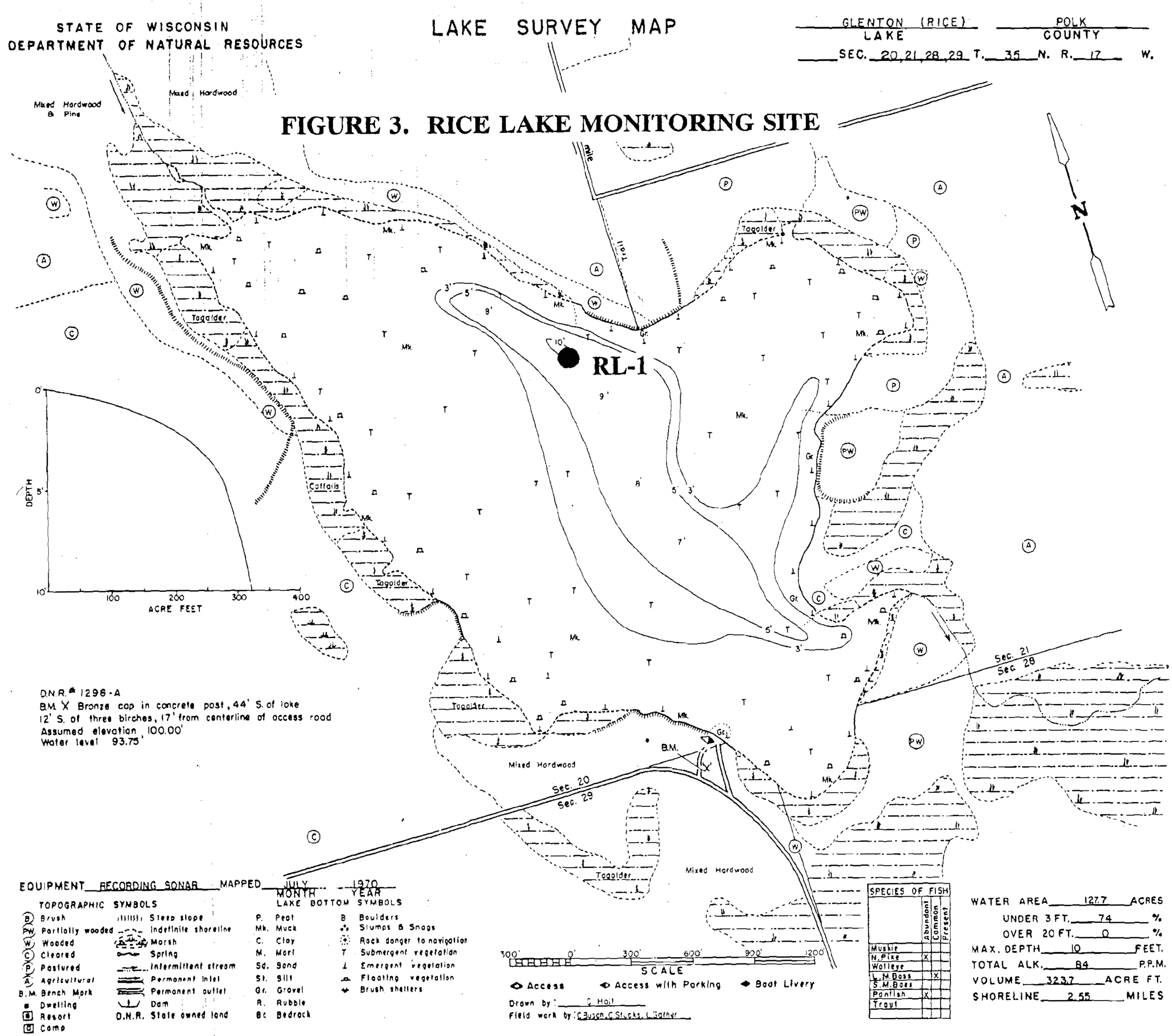


FIGURE 3. RICE LAKE MONITORING SITE

Slight shifting occurred each winter due to lake ice. Stage measurements were corrected to account for these shifts.

RESULTS

Streams

Appendix A provides a complete record of all stream measurements, estimates, and loadings. Average annual TP and SS loadings and concentrations, and streamflows for each stream are listed below:

	Average Annual (10/96 - 5/98)				
Stream Site	TP Load (kg)	SS Load (kg)	TP Conc. (ug/l)	SS Conc. (mg/l)	Flow (cfs)
RC-2	199	44,900	52	11.7	4.29
OC-3	224	12,300	122	6.9	2.05
RC-4	552	76,400	75	10.4	8.22
RC-2 + OC-3	424	57,200	--	--	6.34

(Note: 1 kilogram (kg) = 2.2 pounds; ug/l = micrograms per liter; mg/l = milligrams per liter; cfs = cubic feet per second)

Average annual precipitation during the monitoring period (10/96 - 5/98) was 35.3 inches, as measured at Amery. This is 12% above the long term average of 31.5 inches.

Total Phosphorus (TP)

The TP load from Otter Creek (OC-3, 224 kg) slightly exceeded that from Rice Creek (RC-2, 199 kg). Although the flow in Otter Creek was less than half that of Rice Creek, the TP concentrations in Otter Creek were more than double those in Rice Creek.

The TP load at the downstream Rice Creek site (RC-4), was 552 kg/yr. This is more than the combined loadings from RC-2 and OC-3 (424 kg). Additional TP loading at RC-4 would be provided by groundwater inflow, and runoff from the 168 acre drainage area between RC-4 and the two upstream sites.

Groundwater inflow in this reach is substantial. Streamflow measurements suggest an average groundwater inflow of 1.9 cfs. If groundwater TP concentration is assumed to be 25 ug/l, then an additional 42 kg/yr of TP would be contributed by groundwater.

The 168 acre drainage area contains a mixture of cropland, grassland, woodland, and residential areas. If a TP export rate of 0.4 kg/ha/yr is assumed, then runoff from this area would contribute an additional 27 kg/yr.

Adding these estimates to the combined TP loads of RC-2 and OC-3 gives a total of 493 kg. This is only 11% less than the estimated load at RC-4, which is within the expected range of error of the various estimation processes.

During 1988-1989, TP loading at RC-4 was found to be 251 kg/yr (Rose 1993). This was a drought period, during which flow at this site averaged only 4.1 cfs, which is about half of that measured during the current study. The average TP concentration during 1988-1989 was 69 ug/l, which is comparable, but slightly less than the current average of 75 ug/l.

Also during 1988-1989, TP loading at RC-2 was found to be 138 kg/yr (unpublished data from 1993 Rose study). Flow averaged 2.2 cfs, which is again close to half of that measured during the current study. The average TP concentration during 1988-1989 was 70 ug/l, which is greater than the current average of 52 ug/l. This indicates there has been a TP loading reduction at this site, which agrees with the findings of reduced TP concentrations in Rice Lake (see below).

TP loading from Otter Creek was not measured during 1988-1989. However, since the average TP concentrations at RC-2 are currently less than in 1988-9, and the average TP concentrations at RC-4 are similar to those in 1988-9, it appears that the average TP concentrations in Otter Creek are currently higher than in 1988-9.

Otter Creek flows through a series of large wetlands before entering Rice Creek. These wetlands appear to be very effective at capturing suspended solids. The wetlands probably also capture some phosphorus. However, wetlands vary in their ability to permanently capture phosphorus. Wetlands often capture phosphorus on a temporary basis. Phosphorus attached to particulates can be temporarily captured and then released later as dissolved phosphorus.

Highest TP concentrations in Otter Creek (200-300 ug/l) were found in May through July during periods of stable flow. These high concentrations probably result from phosphorus which has been processed by the wetlands and released as dissolved phosphorus. Samples from Otter Creek were not tested for dissolved phosphorus. However, the low suspended solids concentrations coupled with the high total phosphorus concentrations indicate much of the total phosphorus is present as dissolved phosphorus. Dissolved phosphorus will generally have more of an impact than particulate-bound phosphorus on the growth of algae in Balsam Lake because it is in a form which can immediately be utilized by algae.

Suspended Solids (SS)

The SS load for Otter Creek (OC-3, 12,300 kg) was much lower than that from Rice Creek (RC-2, 44,900 kg). Lower flows and effectiveness of particulate capture by wetlands are the primary reasons for the lower SS load of Otter Creek. The production of algae and sediment resuspension in Rice Lake probably account for most of the SS load of Rice Creek at RC-2.

The SS load for Rice Creek at RC-4 (76,400 kg) exceeds the sum of the loads from RC-2 and OC-3 (57,200 kg). Runoff from the 168 acre drainage area between the sites could account for an additional 13,600 kg of SS load assuming a SS export rate of 0.2 metric tons per hectare. Adding this estimate to the combined SS loads of RC-2 and OC-3 produces a total SS load of 70,800 kg. This is only 7% less than the estimated SS load at RC-4, which is within the expected range of error of the various estimation processes.

SS loads were not estimated for 1988-1989 in the Rose study, and so there is no basis for comparison.

Rice Lake

Rice Lake monitoring results are listed in table 1. Secchi depth, total phosphorus, chlorophyll a, and water level results are graphically depicted in figures 4 to 7.

Secchi depths (SD) for Rice Lake have been extremely poor in the recent past. From 1988 to 1995, summer SD's averaged 0.9 ft. A dramatic improvement was observed in 1996 when the summer SD averaged 3.2 ft (Roesler 1996). The current study found that the improvement was maintained in 1997, with a summer SD average of 3.0 ft (figure 4). Continued improvement was found in 1998 with a summer SD average of 5.0 ft.

Total phosphorus and chlorophyll a concentrations also reflected this trend. 1997 concentrations were similar to the improved concentrations in 1996. 1998 concentrations were lower than those in 1997 (figure 5 and 6).

Lake water levels in 1997 ranged from 94.17 ft to 94.77 ft (figure 7). Levels rose in the fall that year as a result of beaver activity at the lake outlet. Levels in 1998 ranged from 94.41 to 94.80. Levels in 1988 generally remained higher than those of 1997 as a result of beaver dams.

TABLE 1.

RICE LAKE MONITORING DATA
10/96 - 9/98

TP = total phosphorus (ug/l), CHL = chlorophyll a (ug/l), SD = Secchi depth (ft), D.O. = dissolved oxygen (mg/l), TEMP. = temperature (°C), STAGE = lake surface elevation (ft) relative to benchmark assumed at 100.0'

DATE	TP	CHL	SD	D.O.	TEMP.	pH	STAGE
10/19/96	32	14.5	4.7	10.6	8.0	8.3	
11/11/96							95.11
12/23/96	30			1.8	6.0	6.8	
01/26/96	40			1.6	0.2		
02/25/97	30			0.2	3.5		
03/25/97	49			0.7	3.4		
05/13/97							94.40
05/26/97	67	23.7	2.0*	12.3	16.6	10.6	
06/11/97	39	18.9	2.5*	10.0	24.4	10.3	
06/20/97			3.3				94.19
07/15/97	79	21.7	2.9*	9.9	25.9		94.46
07/16/97			3.0				94.41
07/29/97							94.29
07/30/97	42	22.1	2.45*	9.9	26.1		
07/30/97			2.8				
08/09/97			2.7			8.9	94.17
08/26/97	53	17.5	3.0*	7.2	22.7		94.30
09/15/97	54	18.4	3.2*	8.6	20.2		94.25
09/26/97			5.4			8.0	94.25
10/01/97	35	10.3	3.6*	11.8	15.0		94.40
10/18/97							94.77
01/27/98	69			1.8	1.3		
02/18/98	39			4.0	3.7		
04/21/98	26	4.6	4.2*	14.9	15.0		94.80
05/08/98	43	10.2	5.0	9.4	17.3		94.78
05/20/98	49	7.8	2.25*	8.8	23.9		94.41
06/11/98	54	16.2	4.9	8.5	16.7	8.2	94.66
07/20/98	31	8.4	5.2	8.5	26.8	9.0	94.56
08/13/98	36	10.6	5.0	9.9	26.5	9.2	94.64
09/20/98	32	11.6	5.0	7.9	22.1	9.0	94.68

*These measurements were made by student. Some are believed to be inaccurate.

FIGURE 4.

RICE LAKE SECCHI DEPTHS

1997 AND 1998

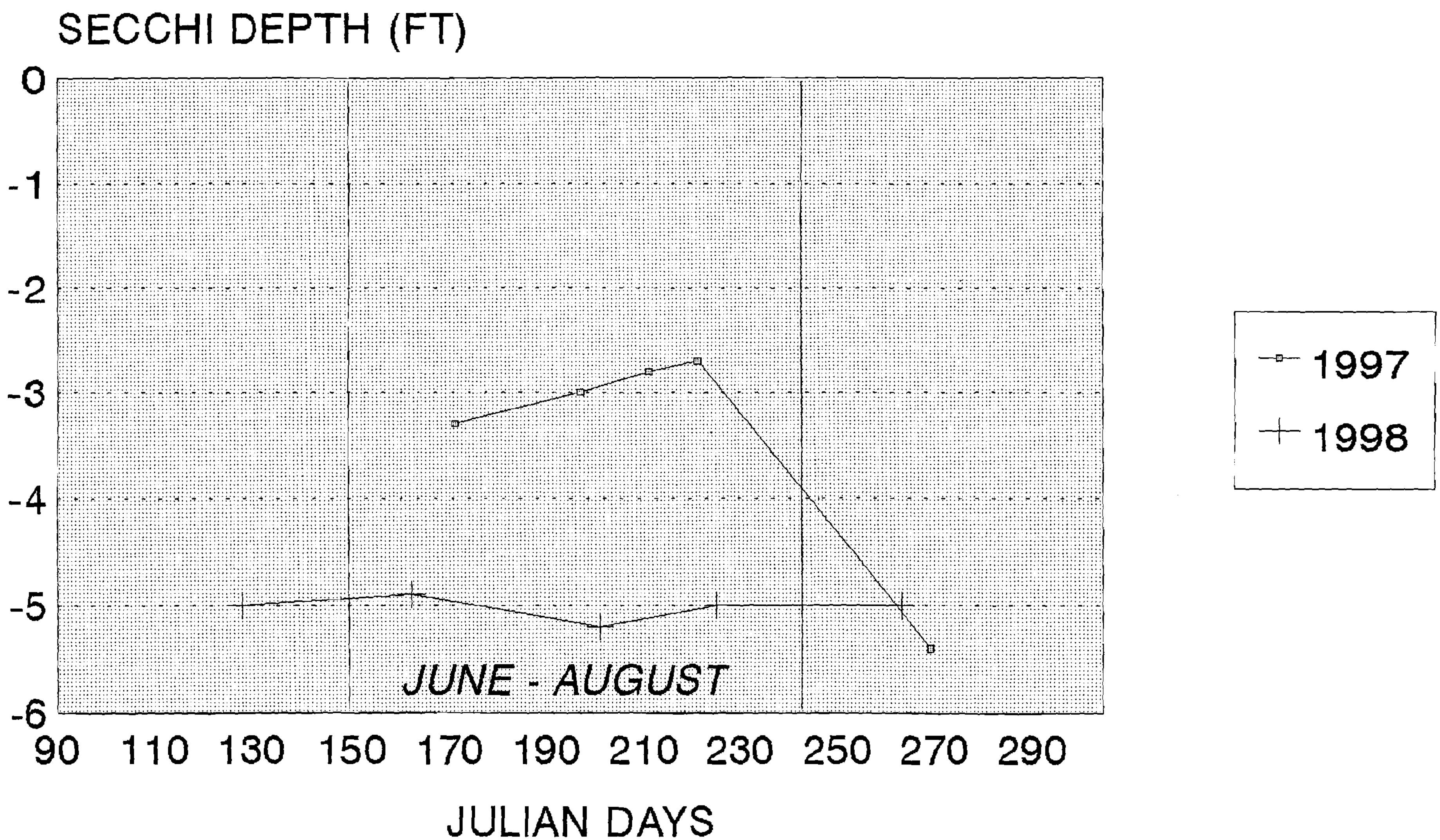


FIGURE 5.

RICE LAKE TOTAL PHOSPHORUS CONCENTRATIONS

1997 AND 1998

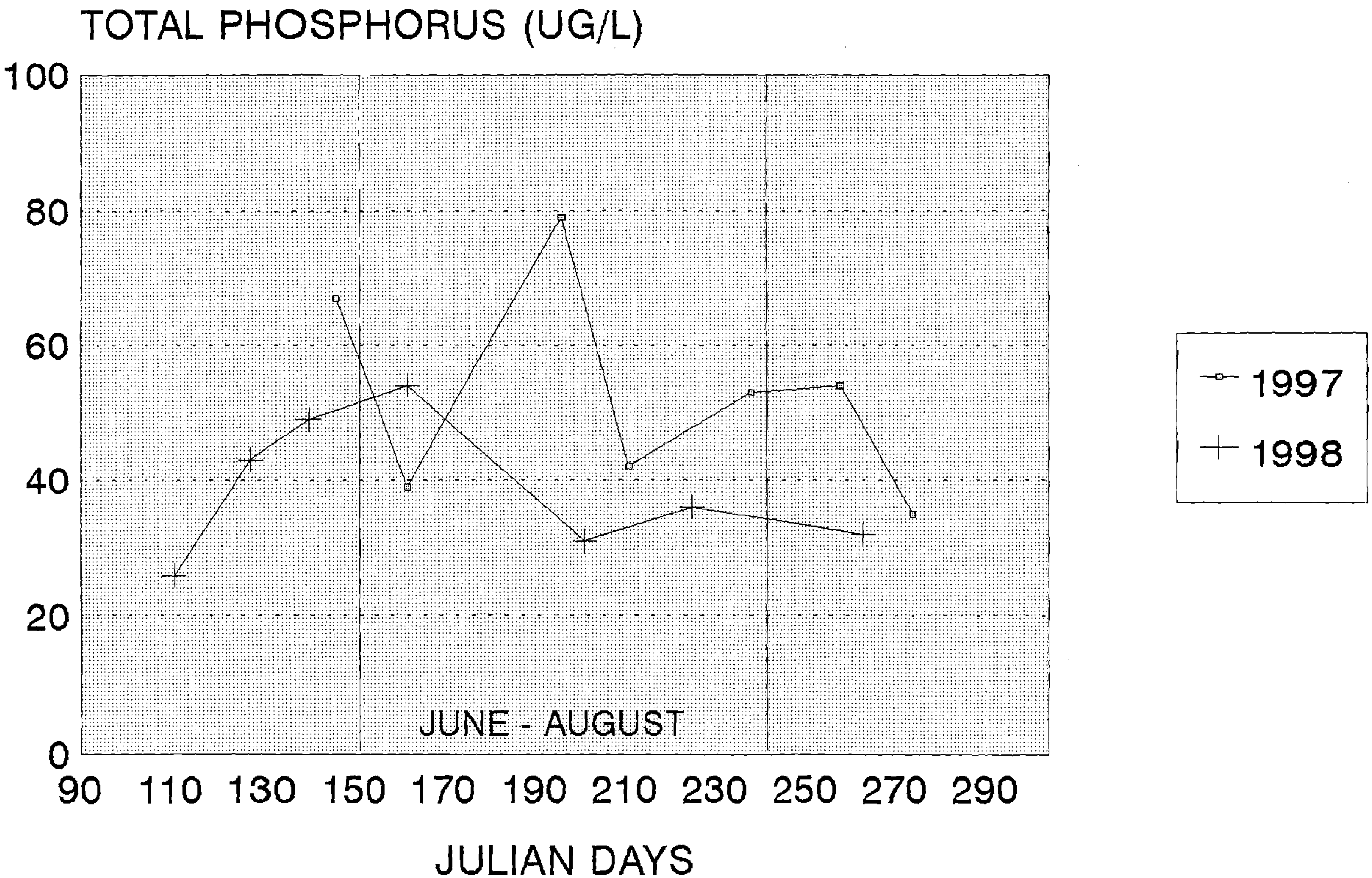


FIGURE 6.

RICE LAKE CHLOROPHYLL CONCENTRATIONS

1997 AND 1998

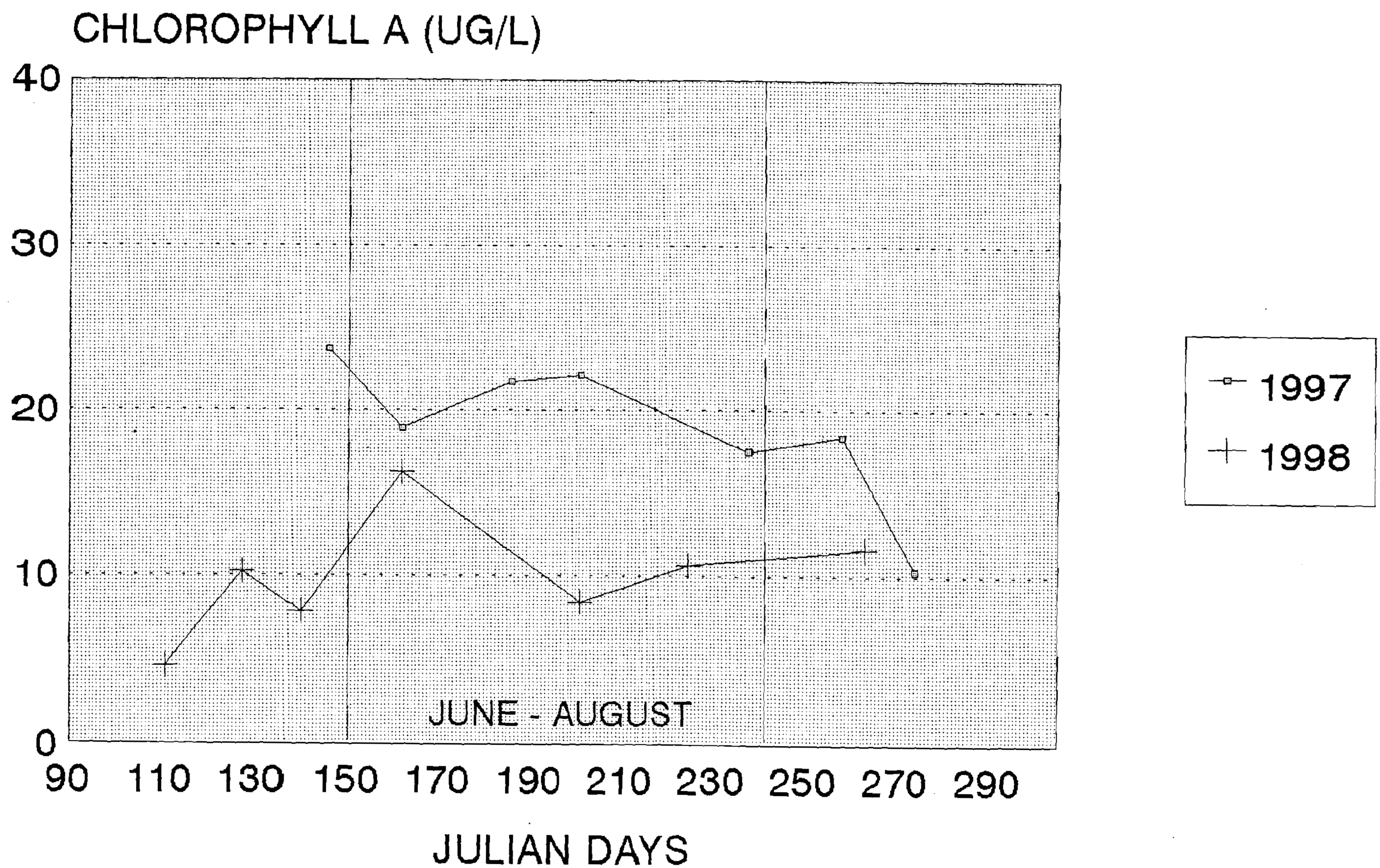
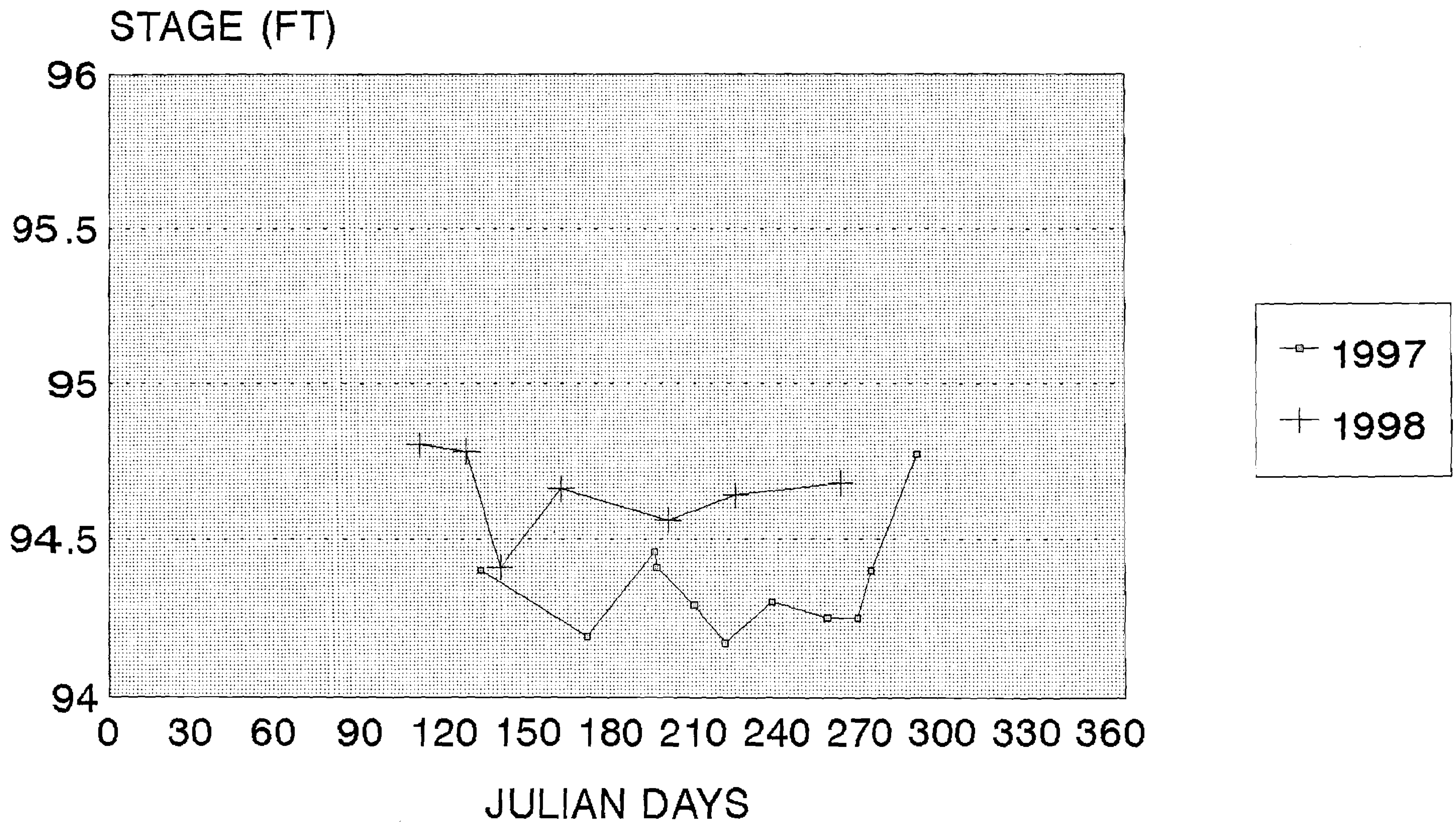


FIGURE 7.

RICE LAKE WATER LEVELS

1997 AND 1998



REFERENCES

1993. Rose, William. Water and Phosphorus Budgets and Trophic State, Balsam Lake, Northwestern Wisconsin, 1987-1989. U.S. Geological Survey. Water Resources Investigations Report 91-4125.

1994. Engels, Sandy and Nichols, Stanley. Restoring Rice Lake at Milltown, Wisconsin. Dept. of Natural Resources. Technical Bulletin No. 186.

1996. Roesler, Craig. Changes in Water Quality of Rice Lake, 1996. Dept. of Natural Resources. Unpublished report.