Lake Sue Water Quality Report

1991

Prepared By:

Grove Scientific Company
6140 Edgewater Drive
Suite F
Orlando, Florida 32810

Prepared For:

The Lake Sue Improvement Association
Orlando, Florida

05-006.00

October, 1991

GROVE
SCIENTIFIC

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SCIENTIFIC

October 24, 1991

Mr. Jim Rush, President
Lake Sue Improvement Association
2675 Lake Shore Drive
Orlando, Florida 32803

Re: Water Quality Report
Executive Summary

Dear Jim,

Attached is the Lake Sue water quality report requested at the August, 1991 Lake Sue Advisory Board Meeting. This letter is an 'Executive Summary' of its contents. Detailed conclusions and recommendations can be found in sections 5 and 6 respectively.

Lake Sue is a eutrophic lake experiencing seasonal problems with submerged aquatic plants. This is a condition we believe to be a direct result of excess nutrients from stormwater discharge with possible additional input from septic tank seepage and groundwater. The nutrient inputs are directly tied to preexisting urbanization and modification of the upper Howell Branch Drainage Basin. Because Lake Sue is in the middle of the chain of lakes used for stormwater disposal and flood control, nutrients that flow into the lake have been concentrating in the sediments, causing the hydrosoils to act as a nutrient sink for recycling nutrients.

The sources of nutrients impacting Lake Sue include the following:

- o Direct stormwater runoff from the Lake Sue drainage basin.
- o Continuous contribution from upstream lakes, specifically Lake Rowena.
- o Resuspension from the hydrosoil or sediment.
- o Direct runoff from the surrounding properties.

- o Septic tank leachate is most likely an additional source of nutrients impacting Lake Sue, however, there is no empirical data to document and quantify this impact at this time.

- o Atmospheric discharge (precipitation).

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It is currently scientifically and economically impractical to change Lake Sue from a eutrophic or nutrient rich lake to the clear "weed free" lake that the anecdotal historical data indicates once existed. Were a thorough restoration to be performed, without significant and permanent nutrient abatement, the lake would eutrophy once again in a few years. On the positive side, Lake Sue is a biologically healthy lake with better water quality than either of the immediate upstream or downstream lakes. All actions that would prevent further degradation must be encouraged.

Our collective efforts need to be focused on nutrient and stormwater abatement. Specifically, we strongly recommend retrofitting the storm drains around Lake Sue to prevent direct discharge of stormwater in the lake. A total estimated cost of $110,000 to $150,000 to retrofit Beaman Park and four of the drains on Lake Shore Drive was proposed by an associate engineer. These are preliminary costs that may change once a detailed engineering assessment is conducted.

The second important source of nutrients that must be promptly managed is Lake Rowena. A recently published report ranked Lake Rowena as one of the "worst" (most eutrophic) lakes in the City of Orlando. The data generated in our report indicates that Lake Rowena adversely impacts Lake Sue water quality. Stormwater improvements to Lake Rowena, which would necessarily cause nutrient abatement, would result in a net reduction of nutrient load to Lake Sue. Only when significant nutrient abatement is achieved can the complete restoration of Lake Sue be analyzed.

To date, the shoreline revegetation project, with 80% participation of shoreline residents, is a success. In order to maintain the shoreline in a manner that will continue this success, we recommend a lake-wide shoreline maintenance program. This program should include only those areas that have been revegetated and should be implemented on a monthly basis. We propose that only areas with beneficial vegetation and replanted areas be maintained to maximize the project's effectiveness. Orange County has agreed to administer the program and the City of Winter Park has agreed to participate. The project will advertise for competitive bid in December, 1991 to begin in January 1992. The estimated cost ranges from $8,000 to $18,000 per year (excluding areas that have not been revegetated).

Further details are provided in the report. If we can accomplish the stormwater drain retrofits at both Lakes Sue and Rowena, encourage the City of Orlando to reevaluate the Lake Rowena stormwater drainage issues, implement a lake-wide shoreline maintenance program, encourage revegetation of the remaining shoreline properties and continue the water quality monitoring in 1992, this would be an excellent accomplishment.

To achieve these goals, it will require funding support from state and local government as well as continued participation from the Lake Sue Improvement Association. We feel confident that the support is available and this report should be used to solicit the necessary support.

Respectfully,

Grove Scientific Company,

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Purpose

This report has been prepared for the purpose of summarizing the water quality data and the lake management practices implemented by the Lake Sue Improvement Project Team since January, 1988. This document is a follow up to the report titled "Lake Sue Improvement and Management Demonstration Project", published in August 1989. The previous report was prepared primarily as a proposal for obtaining grant money from the Florida Department of Environmental Regulation pollution recovery fund.

Recommendations for the continued management of Lake Sue are detailed herein and summarized in the conclusion and recommendations sections of this report (section 5.0 and 6.0).

Acknowledgements

Since January 1988, the Lake Sue Improvement and Demonstration Project has been a collective effort among private citizens, government and private industry. Not only has it served as a lake management demonstration project, but also as a demonstration of the positive benefits of cooperative effort as opposed to combative litigation. The continued success of this project, and ultimately the preservation of the Howell Branch drainage basin lakes, depends on the continued cooperation of many groups and individuals. The individuals are too numerous to thank individually however, we would like to take this opportunity and acknowledge the following groups:

1. Lake Sue Improvement Association
2. Lake Sue Advisory Board
3. City of Orlando - Stormwater Utility
4. City of Winter Park - Stormwater Utility
5. Florida Department of Environmental Regulation - Central District
6. Florida Department of Natural Resources - Bureau of Aquatic Plant Management.
7. Orange County Environmental Protection Department

In addition, special thanks are extended to Mrs. Barbara Mosely for supplying generous access to the lake via her property for the numerous specialists and workers which lake maintenance requires and to Kevin McCann, City of Orlando, for preparing the water quality summary tables and graphs.

SECTION 1

INTRODUCTION

1.1 BACKGROUND

Since early in the development of the City of Orlando, the lakes of the Howell Branch Drainage Basin have been used for stormwater disposal. The Upper Howell Branch Drainage Basin includes Lakes Dot, Concord, Spring, Adair, Ivanhoe, Highland, Winyah, Estelle, Formosa, Rowena and Sue. All of these lakes are hydraulically connected and the flow of water is towards Lake Sue. Over many decades, nutrients and other contaminants have been accumulating in these lakes. As a result, these lakes have experienced a decline in water quality as evidenced by a decrease in water clarity and an increase in suspended algae and macrophytes. A report prepared in 1983 for the East Central Florida Regional Planning Council titled "Analysis of In-Lake Measures in Demonstration Sub Basins", specifically addresses the deterioration of water quality in the upper Howell Branch lakes.

In response to the observed degradation of Lake Sue, the surrounding residents founded the Lake Sue Improvement Association in 1979 and established a Municipal Services Taxing Unit (MSTU) to generate money (taxes) for the sole purpose of maintaining the lake. Currently the association has 92 members which corresponds to the number of lakeside residents. Sixty-two of the lots are in Orange County and thirty-five are in the City of Winter Park (some residents own multiple lots).

Lake Sue is located in both Orange County and in the City of Winter Park (see Figure 1.1) resulting in multi-jurisdiction with respect to stormwater and lake management. The sixty-two residents in Orange County are taxed according to the MSTU while all Winter Park properties are subject to a stormwater utility fee.

Aquatic plants are managed by Orange County Environmental Protection Department (OCEPD) and the City of Winter Park lakes division through periodic herbicide treatment in Lake Sue. Fundings for these plant management services occur from the taxes mentioned above.

Lake Sue has a total area of 146 acres and a drainage basin of 437 acres. Lake Rowena, which drains into Lake Sue, has a total area of 57 acres but a drainage basin of 844 acres. The Lake Rowena drainage basin includes a significant amount of urbanized area, including the Colonial Plaza Mall. A priority for the entire basin, is to improve the stormwater disposal practice currently in use.

The City of Orlando has recognized this as a serious problem and has implemented a stormwater utility tax to fund desperately needed repairs and retrofits. A document titled "Strategic Techniques for Orlando's Runoff Management Systems Priority Project List" published in 1989 by the City of Orlando summarizes the projects proposed to enhance stormwater quality and improve drainage. The attached maps clearly identify the drainage basin, for both Lakes Sue and Rowena. (See Figures 1.1, 1.2, 1.3, 1.4).

Figure 1.1
Upper Howell Branch Lakes

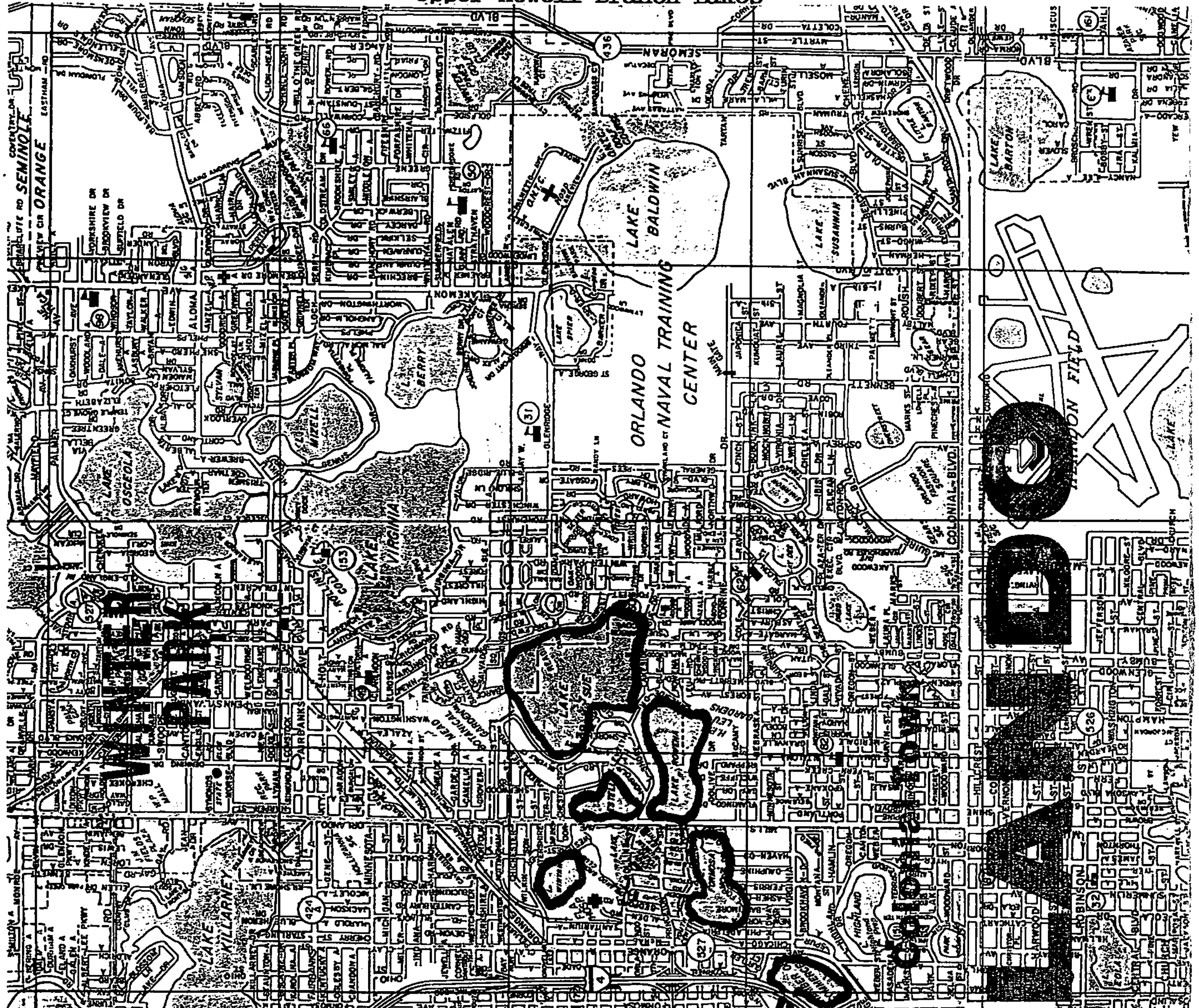


Figure 1.2
Lake Rowena Drainage Basin

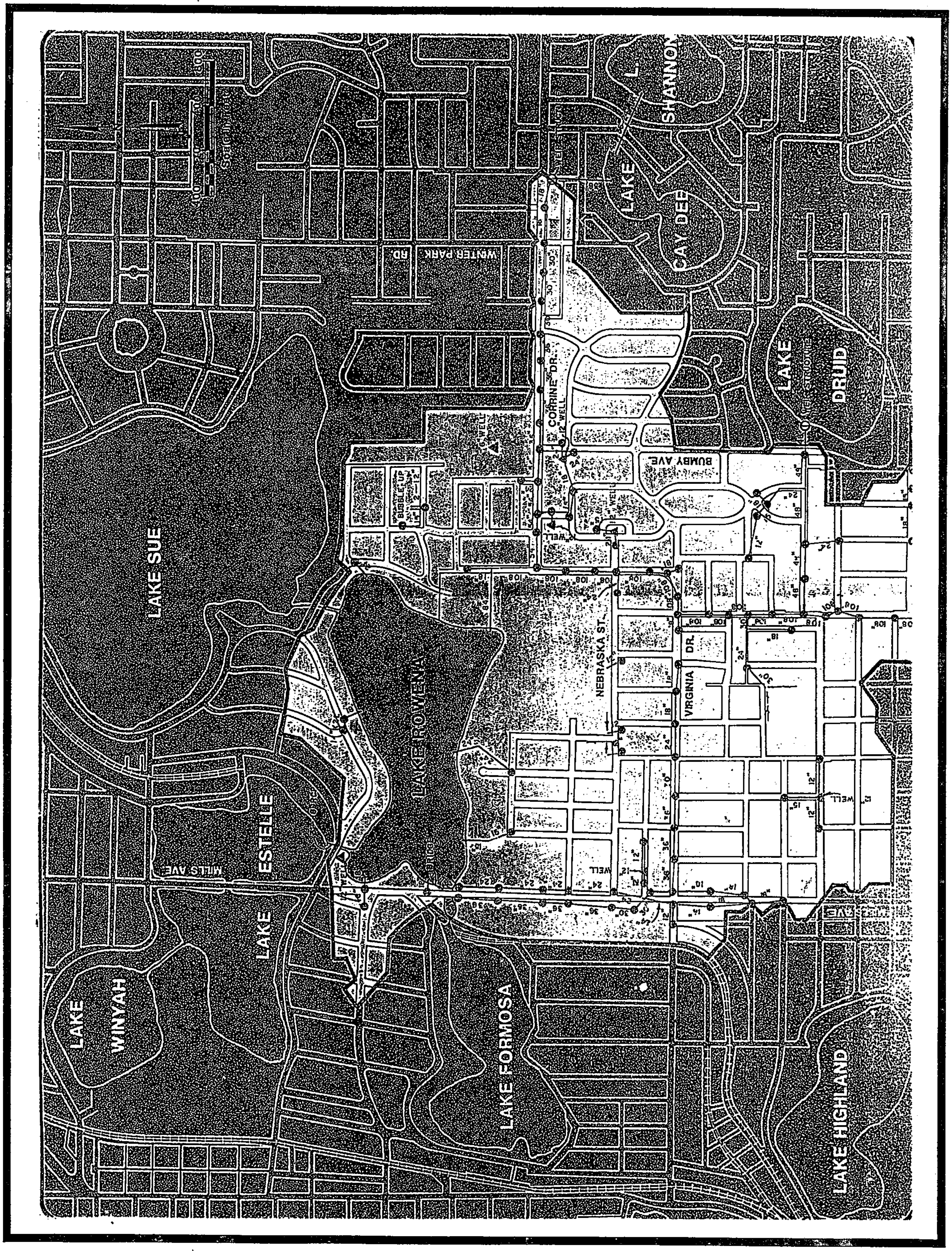


Figure 1.3
Lake Rowena Drainage Basin

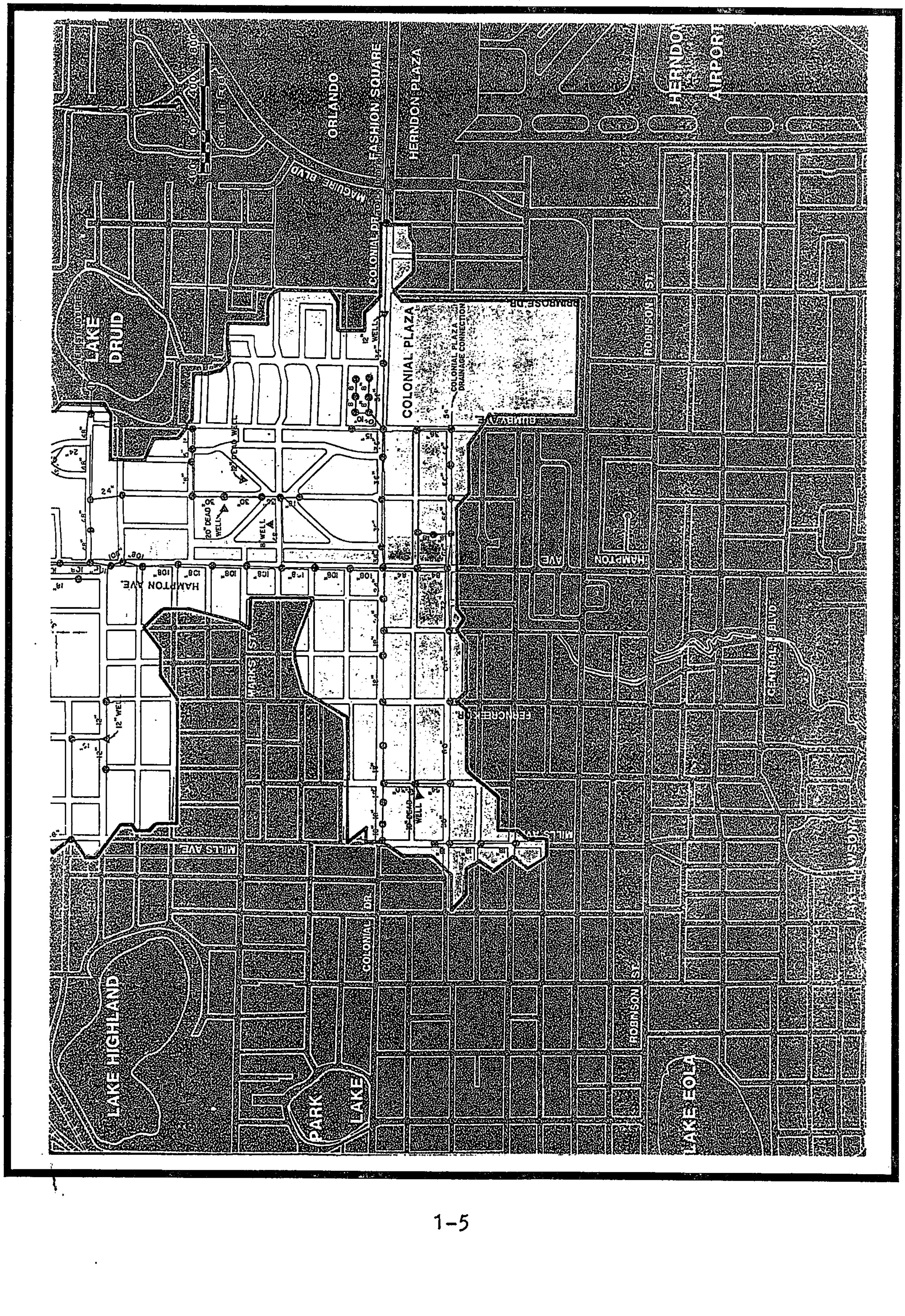
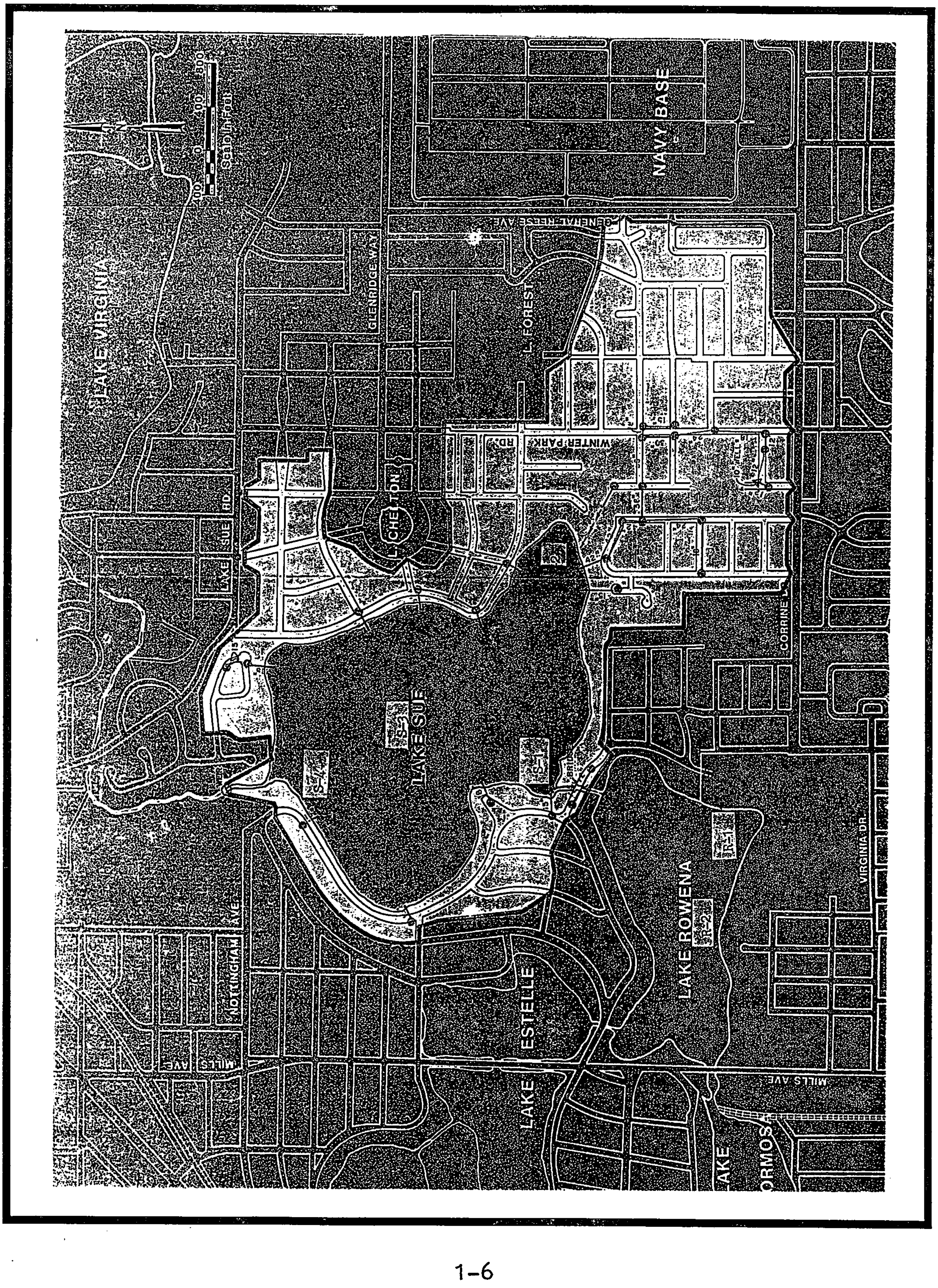


Figure 1.4
Lake Sue Drainage Basin



The ultimate goal of this project is to improve the overall quality of Lake Sue through the use of various lake management techniques. It has been repeatedly stated that this is a long, difficult and costly process. The members of the Lake Sue Improvement Association have stated their desire for long term management as opposed to "quick fixes". Grove Scientific Company has previously outlined the objectives for Lake Sue in the 1989 Lake Sue report referenced in the previous section of this report, they are as follows:

1. Bring the lake into compliance with DNR Aquatic Plant Control rules referenced in chapter 16c-20 of the Florida Administrative Code.
2. Improve recreational use.
3. Improve nutrient abatement.
4. Educate the homeowners.

Each objective will add to the ultimate goal of improving the quality of Lake Sue. The current status of each of these goals is briefly addressed below and in further detail in the following sections.

1.2 COMPLIANCE WITH F.A.C. 16C-20

Approximately eighty percent (80%) of the entire shoreline has been revegetated. Many of the homeowners who did not participate in the 1991 revegetation project are doing so and at their own expense and in accordance with the existing DNR permit. The goal is to have the entire lake in compliance with the DNR Aquatic Plant Control rules listed in chapter 16c-20 of the Florida Administrative Codes by 1994.

1.3 IMPROVE RECREATIONAL USE

Recreational use encompasses several definitions, depending on the individuals' preference, and these uses are not always compatible. Recreational uses in Lake Sue include fishing, boating and swimming. The fisheries are very healthy in Lake Sue with abundant bass and crappie populations. This is due largely to the lake's high productivity and abundant macrophyte population. Too much macrophyte control would adversely affect fish habitat.

This abundance of macrophytes seasonally impedes boat accessibility to water skiing. Since the 1989 herbicide treatment of the Illinois pondweed and hydrilla, boat access has improved, thereby improving this recreational use. The pondweed has however, flowered this summer causing some restrictions on boat accessibility.

As a direct response to the 1989 herbicide treatment, we observed a significant (but temporary) decline in water clarity during 1990 and the spring of 1991. This was a direct response of the algae to the nutrients released by the macrophytes killed by the herbicide treatment. This decrease in water clarity can be considered a decline in the recreational use for swimmers and on a general decline in the esthetics of a lakeview.

1.4 IMPROVE NUTRIENT ABATEMENT

Nutrient abatement is the most important goal and the most difficult to achieve. There have been no improvements in nutrient abatement during the current project. The planned stormwater diversion of Colonial Plaza Mall runoff from Lake Rowena to the Greenwood Lake surface water treatment project has not been implemented due to high cost and public opposition to necessary re-routing of the stormwater along Fern Creek. This subject will be addressed in further detail later in the report.

1.5 EDUCATE THE HOMEOWNERS

Homeowners living around Lake Sue have become both more interested and more educated with respect to lake management. Educational materials have been circulated to all of the residents and there was high attendance at the last meeting of the Lake Sue Improvement Association. An educated, cohesive neighborhood group is Lake Sue's most powerful ally. Education will continue to be an integral part of this ongoing lake management project.

SECTION 2

REVEGETATION AND MACROPHYTE MANAGEMENT

2.1 LITTORAL ZONE REVEGETATION

In 1990, the Florida Department of Environmental Regulation provided $25,000 in grant money from the Pollution Recovery Fund to the Lake Sue Improvement Association to assist in the revegetation of the Lake Sue shoreline. The City of Winter Park donated $10,000 and their herbicide treatment services. Orange County provided bid and contract management services, herbicide treatment services and approximately $9600 to fund the project. The total revegetation capital expenditures for 54 lakefront lots was $44,600.00. The 54 lots represent a 56% participation rate in this project. Other lots were revegetated under private contract.

The project began in January 1991 with shoreline herbicide treatments by the City of Winter Park and Orange County. This was followed by removal of dead vegetation by the aquascape contractor. Planting of native emergent plants was completed by June 1991. Since then, quarterly maintenance of the revegetated areas has been completed by the contractor.

Because of the unusually high rainfall in the central Florida area during the summer of 1991, the lake level has risen to above normal levels. This has resulted in the mortality of certain species of plants used in the revegetation project. The plants are currently being replaced by other species that are more tolerant to fluctuating water levels.

To date, the revegetation of Lake Sue's littoral zone is a success. Exotic and noxious species have been replaced by beneficial native emergent species. A long term maintenance program for the entire shoreline is now required for the continued success of the revegetation project. This maintenance will keep the exotic species from reinvading the shoreline, keep dead plants from building up and maintain a high estethic quality of the shoreline. From a public acceptance standpoint the latter is a very important part of a revegetation project.

An added benefit to the long term maintenance project is to make revegetation more attractive to the remaining few riparian owners who have not yet revegetated. We feel confident that these owners will request revegetation of their lots within the next two years.

2.2 MACROPHYTE MANAGEMENT

Both the City of Winter Park and the Orange County Environmental Protection Department have jurisdiction over the control of submerged aquatic plants. The two agencies share different philosophies in how this should be accomplished. The City of Winter Park applies an aggressive approach to macrophyte management through the use of frequent herbicide treatment. Orange County is much more conservative in their management approach and treats only once or twice a year to control mainly the exotics and to provide boat access.

Though this difference in philosophy has not caused any documented problems in this lake, it does make it more difficult to develop long term management procedures. It is difficult to manage only half a lake; the lake ecology does not recognize city and county boundary lines or any other artificially drawn property boundary.

The long term goals of the Lake Sue Management project include a coordinated macrophyte management procedures between the two local governments. This may be accomplished simply through quarterly communications between Pierre Deschenes, Chief-Lake Division for the City of Winter Park and Keshav Seteram, Supervisor Aquatic Weeds for Orange County.

In August 1991, a survey for submerged macrophytes was conducted by Judith Ludlow, a biologist with the Florida Department of Natural Resources, Bureau of Aquatic Plant Management. Hydrilla continues to populate the lake. In addition to hydrilla, Ceratophyllum (coontail) is becoming a problem in several areas in the lake. Orange County will treat the lake with Sonar®, diquat, or aquathol in December 1991 in an effort to control these submergents. The results of the survey are included in Table 2-1. For those unfamiliar with aquatic plant terminology and ecology, section 4.3 includes a discussion of this topic.

Table 2-1

Estimate of Submerged Plant Species in Lake Sue on July 22, 1991

Species	**Common Name**	**Approximate Acreage**
Potamogeton illinoensis	Illinois pondweed	36
Vallisneria americana	eel-grass	36
Ceratophyllum demersum	coontail	24
Najas quadalupensis	southern naiad	12
Nitella sp.	stonewort	66
Hydrilla sp.	hydrilla	6
Total		**120**
Percentage of lake coverage		**82%**

Source: Florida Department of Natural Resources, Bureau of Aquatic Plant Management

2.3 EFFECT OF MACROPHYTES ON TROPHIC STATE

The presence of a significant macrophyte population may serve to tie up dissolved nutrients in biomass, masking the true trophic state (Canfield and Jones, 1984) and creating the appearance of a healthier lake. This is a possibility for Lake Sue which has over 80% of its area in macrophyte production. Trend analysis has indicated a decrease in trophic state ("cleaner lake") in the last 15 years. It is not known if this is due to a decrease in nutrients entering the lake or to biomass masking. Improved stormwater technology in new development, and the elimination of phosphate detergents in late sixties has helped many surface waters. The Lake Sue basin was developed early in Orlando history so it is unlikely new stormwater management rules have had a measurable effect. The lake is surrounded by homes with septic tank systems. Therefore, reduced phosphate detergents could possibly have benefitted the lake if drainfield leachate is a significant contributor of nutrients; this has not been documented at this time. Since macrophyte production is increasing (most obviously evident in the pondweed bloom of 1988-89), it is possible that the improved trophic state trend is a result of nutrient conversion to macrobiomass. In either case, the value of macrophytes in mitigating excess nutrients cannot be discounted. Trophic state is discussed in more detail in section 4.

2.4 MANAGEMENT ALTERNATIVES

All methods of macrophyte management are a compromise. From an ideal standpoint, physical removal and export is the preferred method. However, the high cost, disposal problems, potential fragmentation spreading and loss of fish and other mobile organisms limit the usefulness of this technique.

Introduction of triploid grass carp is attractive from the standpoint of biomass conversion to fish flesh as opposed to merely killing the plants and allowing them to rot. Problems with this approach are a) lack of thorough understanding of triploid carp stocking rates b) lack of immediate results c) a potential for all the plants (including the newly revegetated littoral zone) to be eliminated. This problem is not as threatening as it once was due to the current use of non-reproductive triploid carp and reduced stocking rates.

Herbicide management continues to be the most effective and controllable method of plant management available. It is the best compromise in every respect. Herbicide treatment has progressed significantly since the days of indiscriminent broadcast application. Current use involves species-targeted, USEPA approved aquatic herbicides and spot application techniques. Problems with herbicide management occur when large amounts of biomass are treated in a short time period or during the high productivity summer months. In these instances, the biomass is not removed but merely settles to the bottom and rots; releasing its nutrients and producing yet another algae biomass explosion.

SECTION 3

STORMWATER AND NUTRIENT ABATEMENT

3.1 CURRENT STATUS

There has been no improvement in either the quantity or quality of the stormwater entering Lake Sue. As a result, we can assume that there has been no reduction in nutrient loading to the lake, either from the upstream lakes or from direct discharge to Lake Sue. Additionally, we have no data on the effects of the septic tanks located around the lake and their overall contribution (or lack of) to nutrient load.

It is fair to assume that much, if not most, of the lake nutrients are bound to the hydrosoils. The submergent and emergent plants also store additional nutrients. Overall, Lake Sue is a nutrient bank. The standing crop of excess microphytes (and an unmeasured portion of the macrophytes) is a direct reflection of the excess dissolved nutrients available. Long term management goals need to emphasize a reduction in the nutrient load caused by external sources. This would include, as a primary factor, the abatement (either removal or treatment) of stormwater. If future data indicates a significant impact from septic tanks surrounding the lake, then this matter will be addressed further. Dredging the bottom muck to remove hydrosoil nutrients is expensive and disruptive to the lake and neighborhood. This is not currently a recommended option.

3.2 STORM DRAINS IN LAKE SUE

There are twelve storm drains entering Lake Sue (see figure 1-1 in section 1.0). As you can see from this map, the drainage basin surrounds Lake Sue and extends eastward toward the Navy base. The largest stormdrain is 42 inches in diameter and is located at

Beamen Park, off Woodlawn Drive and Sue Drive. Beaman park is located in Orange County, and has sufficient land to install a stormwater sediment trap and exfiltration basin.

The feasibility of installing a diversion structure and subsurface exfiltration and sedimentation system to treat the stormwater from this 42-inch pipe was reviewed by Mr. Thaddeus Knowles, P.E. of the engineering firm, T.E. Knowles and Associates. His preliminary review indicates an approximate cost for engineering and construction service of \$50,000 - \$75,000. This cost is based solely on preliminary modeling and estimates of soil permeability and is subject to change once site specific data is made available.

All but one of the five stormdrains on the Winter Park side of the lake have been fitted with a chain link fence and plastic screening to trap trash flowing through storm pipes. Additionally, the areas outside of the fenced areas have been vegetated with beneficial emergent species. This helps camouflage the structure and acts as a sediment trap.

The seven stormdrains on the Orange County side of Lake Sue have not been screened. At least two pipes discharge directly into the canal between Lake Sue and Lake Rowena. Since the Orange County side of the lake, along Lake Shore Drive, has some vacant properties, these areas may possibly be retrofitted with sediment traps and exfiltration basins. There is a need to evaluate property availability and access in these areas to determine if stormwater treatment is possible.

Appendix A presents preliminary engineering calculations provided by T.E. Knowles and Associates. This analysis indicates a cost estimate of approximately \$15,000 to retrofit drains 1 through 4 (see figure 3-1) with a sediment trap and exfiltration system.

3.2.1 Description of storm drains

We conducted a survey of these storm drains on October 11, 1991. A brief description of their condition is presented below. The drains have been arbitrarily numbered 1 through 12 starting on Lake Shore Drive near the outlet canal (drain #1) and going counterclockwise around Lake Sue towards the Winter Park side (see Figure 3-1).

Drain 1 - Located the street drain but could not locate the outlet in the lake. The area is heavily vegetated with no stormwater control.

Drain 2 - Outlet to lake covered with primrose willow and cattails. The PVC pipe is in good condition. The drain was observed flowing. No stormwater control.

Drain 3 - Outlet to lake in area heavily vegetated. Concrete pipe is broken with no stormwater control. No flow observed.

Drain 4 - Outlet pipe is concrete and broken in several places. Some vegetation around outlet, no flow and no stormwater control.

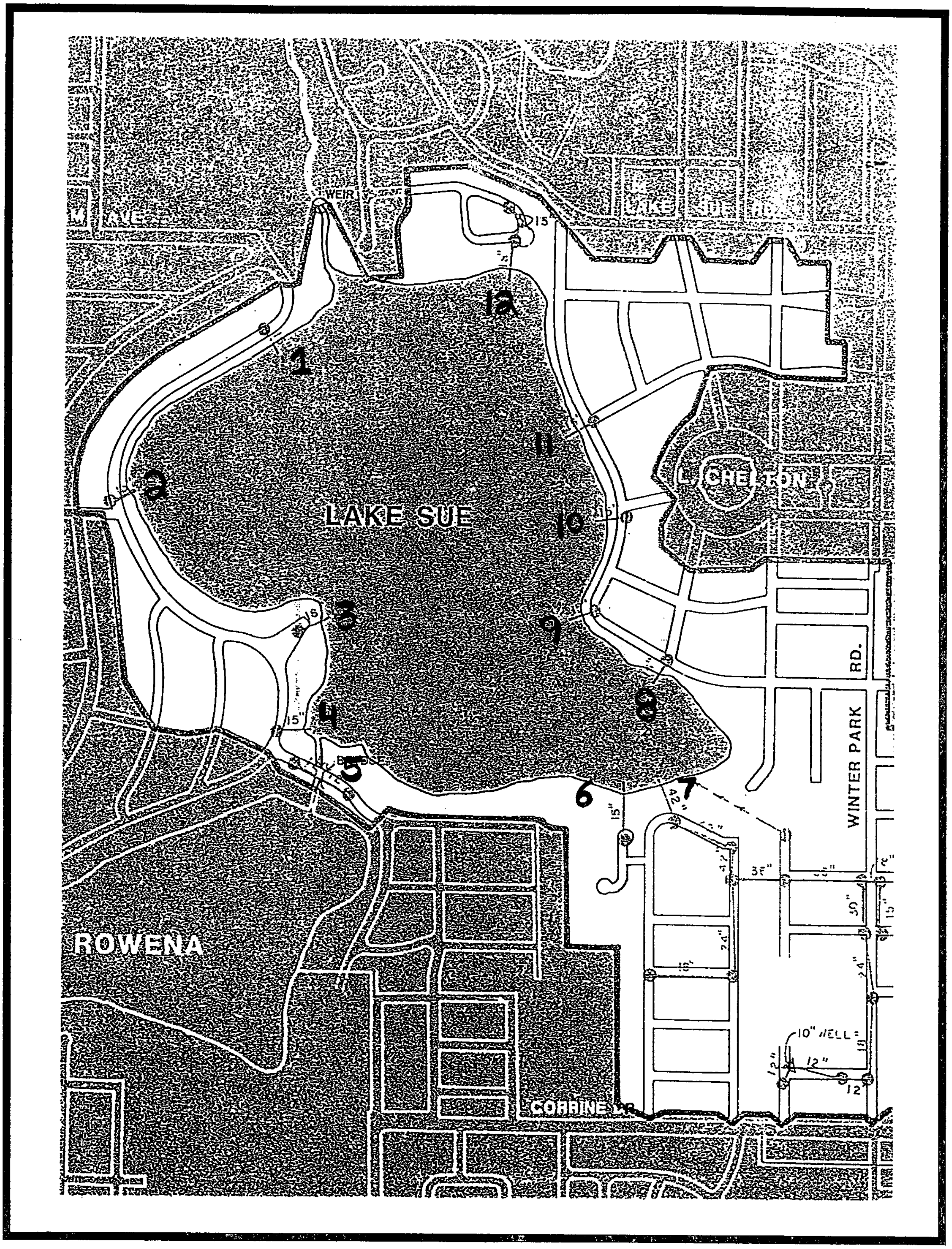
Drain 5 - Entire bridge area in poor condition. No flow and no stormwater control.

Drain 6 - Could not locate.

Drain 7 - Beaman Park - Largest storm drain into Lake Sue with largest drainage basin. No stormwater control. Some flow observed during inspection.

Drain 8 - (Winter Park) - Screen and fence trap in good condition; no flow.

Figure 3.1
Storm drain locations in Lake Sue



Drain 9 - No trap around this pipe. Concrete pipe surrounded by cattails; no flow.

Drain 10- Screen and fence trap in good condition; no flow.

Drain 11- Black PVC pipe in good condition, surrounded by screen and fence trap at end of boat ramp; no flow.

Drain 12- Could not locate.

3.3 NUTRIENT LOADING

The Lake Sue project is moving from a subjective "something must be done" approach to a more quantitative level of description. The water quality monitoring has provided some useful data to begin quantifying nutrient load. Much more quantification of data remains to be done.

In the broadest sense, nutrients come from four main sources; groundwater percolation, upstream rivers and lakes, stormwater and the hydrosoil (which represents the accumulation of nutrients from the first three sources not currently dissolved, tied up in biomass, or exported out of the system).

Based on the average nutrient concentration obtained from the water quality monitoring, and the measured wet season flow, the nutrient load from Lake Rowena to Lake Sue can be calculated with a comfortable level of accuracy as follows:

Lake Rowena Average Nutrient Concentration and Wet Season Flow:

Total Nitrogen = 0.95 mg/l mean values
Total Phosphorus = 0.050 mg/l mean values
Highwater flow = 1.86 MGD
= $(1.86\times10^{6}$ gal/day$)(1$ ft$^{3}/7.48$ gal$)$ = 248,645.8 ft^{3}/day

Lake Rowena Nitrogen Input:

$(0.95$ mg/l$)(6.24\times10^{-5})$ = 5.93×10^{-5} lbs ft^{3}
$(5.93\times10^{-5}$ lbs/ft$^{3})(248{,}645.8$ ft^{3}/day$)$ = 14.7 lbs/day

Lake Rowena Phosphorus Input:

$(0.050$ mg/l$)(6.24\times10^{-5})$ = 3.12×10^{-6} lbs ft^{3}
$(3.12\times10^{-6}$ lbs/ft$^{3})(248{,}645.8$ ft^{3}/day$)$ = 0.78 lbs/day

Direct stormwater inputs to Lake Sue are much more difficult (and expensive) to measure. Because of the difficulties and expenses of stormwater monitoring, engineers and scientists use a variety of factors and models to estimate stormwater impact. The factors and models are often controversial because they are generally a compromise of many variables. However, without "real world" data on the system studied, accepted modeling techniques are the only choice available.

The following estimate of stormwater input to Lake Sue is designed only to initiate discussion and should not be considered indicative of actual condition without further verification.

According to Wanielista (1978), the phosphorus load from an urban stormwater discharge is approximately 1.1 pounds per curb mile and 2.294 pounds per curb mile for nitrogen. The Lake Sue drainage basin contains approximately 14 curb miles of streets. A typical storm can potentially discharge the following nutrient loads:

Phosphorus
(1.1 lbs/curbmile-day)(14 curb miles) =15.4 lbs of phosphorus
Nitrogen
(2.294 lbs/curbmile-day)(14 curb miles) = 32.1 lbs of nitrogen

The calculated input of nutrients is obviously variable throughout the year but does demonstrate an approximate nutrient impact per storm. Most important to consider when reviewing this estimate is that afternoon thunderstorms can be an almost daily occurrence in a typical Central Florida wet season. The wet season corresponds roughly with the hurricane season or from June through October.

Other sources of nutrients such as in-lake recycling from the hydrosoils (which may possibly be the most significant source of nutrients), direct runoff from the surrounding properties, septic tank drainfield leachate, atmospheric contributions and direct discharge of groundwater are considerably more difficult to estimate. It is evident from the lack of data in these areas of nutrient balance that further study is necessary for a clear understanding of all nutrient sources affecting Lake Sue.

The need for more data does not imply that no actions should be taken at this time. Even these conservative estimates indicate, at a minimum, several tons of nitrogen and hundreds of pounds of phosphorus input per year. The abatement and reduction of the known inputs should be promptly addressed without waiting for further study of additional inputs.

SECTION 4

LAKE SUE WATER QUALITY STUDY

4.1 PROGRAM SUMMARY

Since January 1988, a cooperative sampling effort has been undertaken on a quarterly basis on both Lakes Sue and Rowena. The purpose is to characterize these lakes' water quality and biological health. The City of Orlando and Grove Scientific Company collected quarterly samples from several sites in each lake. Orange County Environmental Protection Department also collected one mid-lake sample from Sue and Rowena on a quarterly basis.

In addition to these water samples, Grove Scientific Company and OCEPD collected sediment samples for benthic macroinvertebrate analysis.

4.2 CHEMICAL CHARACTERISTICS

Several "classic" parameters are routinely employed by limnologists as basic descriptors of lake dynamics. No single test can be performed that will yield a simple answer on a lake's health except for only the most grossly contaminated sites. Also, because lakes undergo temporal dynamics, only a study of many years data can identify lake problems when the pollution is not of a gross nature; indeed some lakes that would be considered undesirable for recreational or aesthetic purposes may be completely "natural". A hot spring, generally high in undissolved solids, low in oxygen, full of sulfurous gasses and devoid of biological organisms, may still be in its pristine natural state.

Usually it is the biological aspects of the system that first warn us about a lake's health problems. It then becomes a detective game of backtracking to the presumed pristine state in order to solve the riddle of what went wrong. It is in this back tracking and sluething that chemical analysis comes into play. The data employed in much of this summary and analysis are included in appendices B-E. For discussions of other City of Orlando lakes the referenced material is the 1990 Lake Water Quality Report prepared by the City of Orlando Stormwater Utility Bureau.

4.2.1 pH

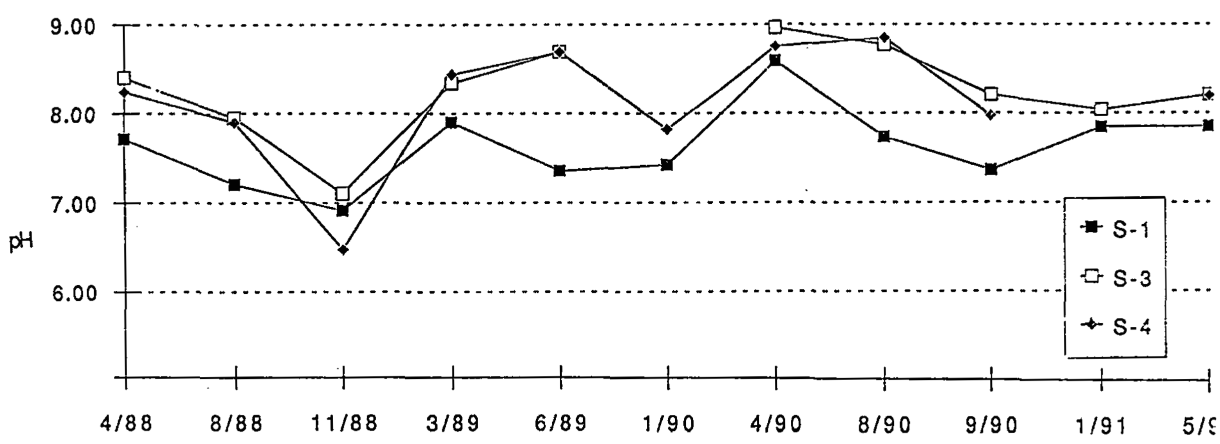
Measurement of pH is one of the most important and frequently used tests in water chemistry, and is used in alkalinity and carbon dioxide measurements and many other acid-base equilibria. At a given temperature the intensity of the acidic or basic character of a solution is indicated by its pH or hydrogen ion activity. Alkalinity and acidity are the acid- and base-neutralizing capacities of a water and usually are expressed as milligrams $CaCO_3$ per liter. Buffer capacity is the amount of strong acid or base, usually expressed in moles per liter, needed to change the pH value of one liter of sample by one unit.

The pH value of water is a measure of acidity or alkalinity. Surface waters can vary considerably into the acid or a alkaline range from natural causes. The majority of Orlando lakes are alkaline with about 90% expressing pH values greater than 7.0. The range of pH for Orlando lakes is from around 6.0 to almost 10.0 with a median value of 7.8. Lakes with high pH values tended to be eutrophic. This is to be expected due to the high rates of photosynthesis observed during algae blooms. The reduction of carbon dioxide, and production of free oxygen (which combines with the hydrogen in water to form hydroxides) have an effect on increasing pH. Unlike the addition of chemical acids or bases, the increase in pH associated with algal activity is transient and does not cause a permanent detrimental effect.

The minimum recorded pH for Lake Sue in this data set was 6.30 on August of 1987, the maximum was 9.10 in March of 1989. The majority of the recorded values lies between the mid sevens and eights. These pH's are consistent with the low alkalinity and occasionally high productivity levels of this lake. Figure 4.1 presents pH values during the period of 1988 to 1991. Appendix E contains the full size figures used throughout this report.

Figure 4.1

pH values at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



4.2.2 Alkalinity

The alkalinity of a lake refers to the quantity of compounds which shift the pH to the alkaline side of the pH range. The higher the alkalinity, the more resistance exists for pH shifts to the acidic range. Because the alkalinity of many surface waters is primarily a function of carbonate, bicarbonate, and hydroxide concentration, it is often taken as a measurement of the concentration of these constituents. Generally, lakes with alkalinities below 40 mg/l are considered softwater lakes. Softwater lakes have reduced concentrations of bicarbonates, carbonates, hydroxides, and decreased resistance to sudden pH changes. The majority of Orlando's lakes can be considered hardwater lakes with over 70% having alkalinity values over 40 mg/l. Orlando's lakes are not typical of Florida lakes in general, with respect to alkalinity. A study of 165 Florida lakes found that over 75% had alkalinity values below 40 mg/l (Canfield and Hoyer 1981). The range of alkalinity values for Orlando lakes is from 3 mg/l to 152 mg/l with a median value of 51 mg/l. The range of alkalinity for Lake Sue during 1990 was from 49 mg/l to 66 mg/l. The alkalinity range for Lake Rowena in 1990 was from 47 mg/l to 64 mg/l. For the whole data set; a low of 45 mg/l was observed in November of 1988 and a high of 78 mg/l in September of 1973. Hardwater lakes are desirable in the respect that acidification from atmospheric depositions ("acid rain") is less likely to occur than in softwater lakes. Alkalinity can have effects on factors such as the types of plants that will prosper in a lake and on the toxicity of pollutants such as heavy metals. In general, higher alkalinities have a positive effect on reducing toxicity due to dissolved metals. Figures 4.2 and 4.3 demonstrates the alkalinity concentration of Lakes Sue and Rowena during the period of 1988 to 1991.

Figure 4.2

Total alkalinity concentrations (mg/l) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.

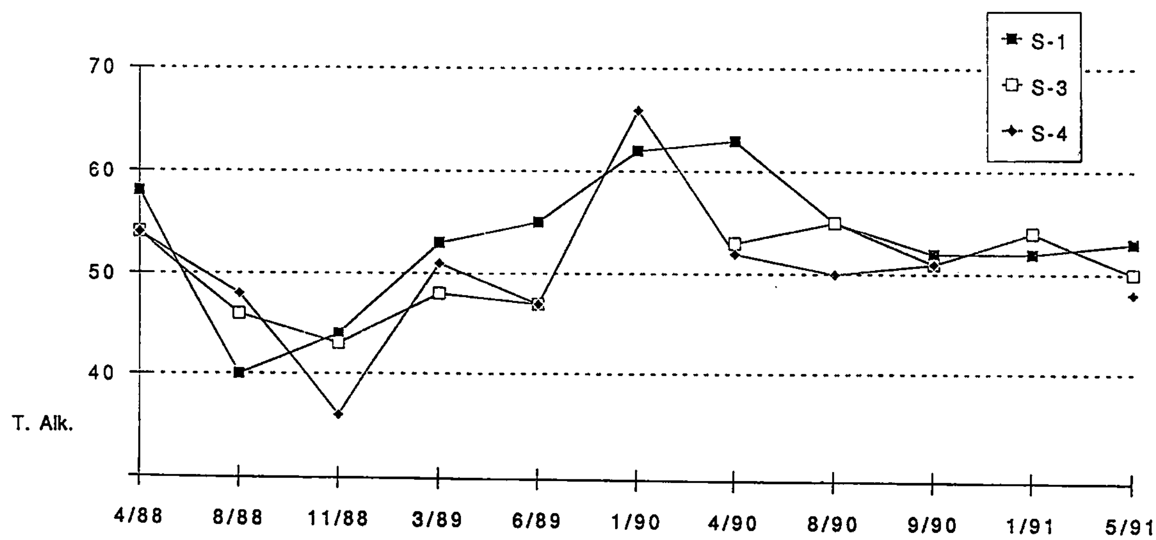
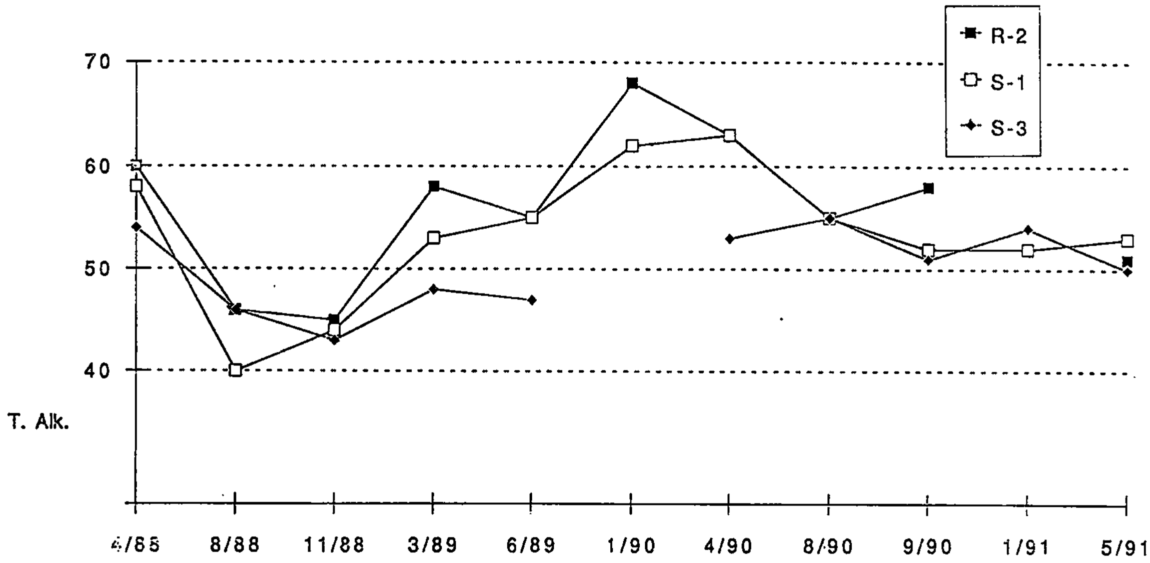


Figure 4.3

Total alkalinity (mg/l) in Lake Rowena (station 2) and Lake Sue (station 1 and 3) from 4/88 to 5/91.



4.2.3 Nutrients

The two most important nutrients in a surface water system are nitrogen and phosphorus. Nitrogen is required for the peptides that form the enzymes upon which all cells rely to catalyze the chemical reactions of life, the protein of organic matter and the nucleic acids that contain the code of life for every cell. Phosphorus is the ultimate chemical fuel for all organic life. Both of these chemicals are constantly recycled in the biosphere. The lack of either nutrient is generally the limiting factor in aquatic productivity. An excess of these nutrients leads directly to excessive productivity. In aquatic systems this excess productivity is generally in the form of an exploding population of primary producers (plants). Because microscopic forms can respond the fastest, the end result is usually an explosion of aquatic microphytes (the familiar "algae bloom").

The ratio of total nitrogen to total phosphorus can be used to determine the limiting nutrient in a lake. The limiting nutrient is the nutrient in low concentration with respect to the other nutrients. For example, if algae needs one (1) part phosphorus to ten (10) parts nitrogen to build tissue, and there is an excess of nitrogen then, the addition of more nitrogen will not increase growth. In this case, phosphorus is the limiting nutrient and efforts to decrease productivity should involve phosphorus removal. Determination of the limiting nutrient is generally done by assuming that lakes with nitrogen to phosphorus ratios greater than 30 are phosphorus limited and lakes with nitrogen to phosphorus ratios less than 10 are nitrogen limited, lakes with ratios between 10 and 30 are balanced. Based on this criteria, during 1990, the majority (66.3%) of City of Orlando lakes were balanced. Reductions in either phosphorus or nitrogen should reduce productivity in balanced lakes. Phosphorus limited lakes comprise 20.1% of the lakes sampled whereas 13.6% were nitrogen limited.

Historically, Lake Sue and Lake Rowena have varied among the three conditions (nitrogen limited, balanced, phosphorus limited). This is expected for balanced lakes since they are often pulled one way or the other depending on seasonal or external factors. Limiting either nitrogen, or phosphorus or both would be an effective method of decreasing excess productivity for these lakes. Table 4-1 summarizes some of the available mid-lake nutrient data on a nutrient balance basis. Both Lake Sue and Lake Rowena are balanced on average, however, they do demonstrate a significant skewing towards phosphorus limited. Therefore, phosphorus removal is a slightly higher priority than nitrogen removal. One should keep in mind that a balanced condition does not mean excessive nutrients are not present. They may very well be present in excessive quantities; balanced merely means one nutrient is not limiting over the other.

TABLE 4-1

Nutrient Balance

(TN/TP)

Date	Lake Sue	Date	Lake Rowena
11-11-74	51 Phosphorus Limited	9-24-73	105 Phosphorus Limited
3-17-81	23 balanced	8-05-74	27 balanced
6-16-81	41 Phosphorus Limited	10-01-74	52 Phosphorus Limited
12-21-81	22 balanced	5-19-75	32 Phosphorus Limited
3-02-82	39 Phosphorus Limited	11-15-77	48 Phosphorus Limited
6-01-82	16 balanced	6-29-83	28 balanced
11-23-82	31 Phosphorus Limited	2-01-88	8 Nitrogen Limited
2-01-88	43 Phosphorus Limited	4-20-88	23 balanced
4-20-88	50 Phosphorus Limited	8-04-88	17 balanced
8-04-88	16 balanced	8-15-88	7 Nitrogen Limited
8-15-88	7 Nitrogen Limited	10-18-88	10 Nitrogen Limited
10-18-88	11 balanced	2-01-89	8 Nitrogen Limited
2-01-89	6 Nitrogen Limited	3-15-89	15 balanced
3-15-89	21 balanced	7-31-89	18 balanced
7-31-89	29 balanced	10-30-89	19 balanced
10-30-89	49 Phosphorus Limited	1-30-90	14 balanced
1-30-90	14 balanced	4-24-90	32 Phosphorus Limited
4-24-90	36 Phosphorus Limited	8-02-90	22 Phosphorus Limited
8-02-90	26 balanced	9-24-90	32 Phosphorus Limited
9-24-90	15 balanced	1-22-91	12 balanced
8-22-91	25 balanced	4-17-91	12 balanced
4-17-91	25 balanced		
Average	27 balanced	Average	26 balanced

TN/TP > 30 = Phosphorus limited

TN/TP <10 = Nitrogen Limited

4.2.3.1 Total Nitrogen and Total Kjeldahl Nitrogen

In waters and wastewaters the forms of nitrogen of greatest interest are, in order of decreasing oxidation state, nitrate, nitrite, ammonia, and organic nitrogen. All of these forms of nitrogen, as well as nitrogen gas (N_2), are biochemically interconvertible and are components of the nitrogen cycle. Analytically, organic nitrogen and ammonia can be determined together and have been referred to as "Kjeldahl nitrogen", a term that reflects the technique used in the determination. Organic nitrogen includes such natural materials as proteins and peptides, nucleic acids and urea, and numerous synthetic organic materials. Typical organic nitrogen concentrations vary from a few hundred micrograms per liter in some lakes to more than 20 mg/l in raw sewage.

During the City of Orlando's 1990 study of 78 Orlando Lakes, total nitrogen values ranged from an absolute minimum value of 0.10 mg/l to an absolute maximum of 3.44 mg/l with a median values of 0.87 mg/l. The critical value at which nitrogen is deemed to be possibly problematical is 1.00 mg/l (Brezonik 1984). Using this criteria, 38.5% of the City lakes have average nitrogen levels which can cause water quality problems. The City of Orlando published an average 1990 total nitrogen value of 1.14 mg/l for Lake Rowena (Lake Sue was not part of the city study). The average total nitrogen for the period 1974 to 1991 (county data) for Lake Sue was 0.94 mg/l. Both county and city midlake data for Lake Sue indicated an overall reduction in nitrogen. When comparing city and county data, site S-3 city data should be used, (this site corresponds to the midlake sampling utilized by the county). Total nitrogen at selected sites is presented in figure 4.4. Figure 4.5 demonstrates the results of trend analysis of the nitrogen data.

Figure 4.4

Total nitrogen concentrations (mg/l) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.

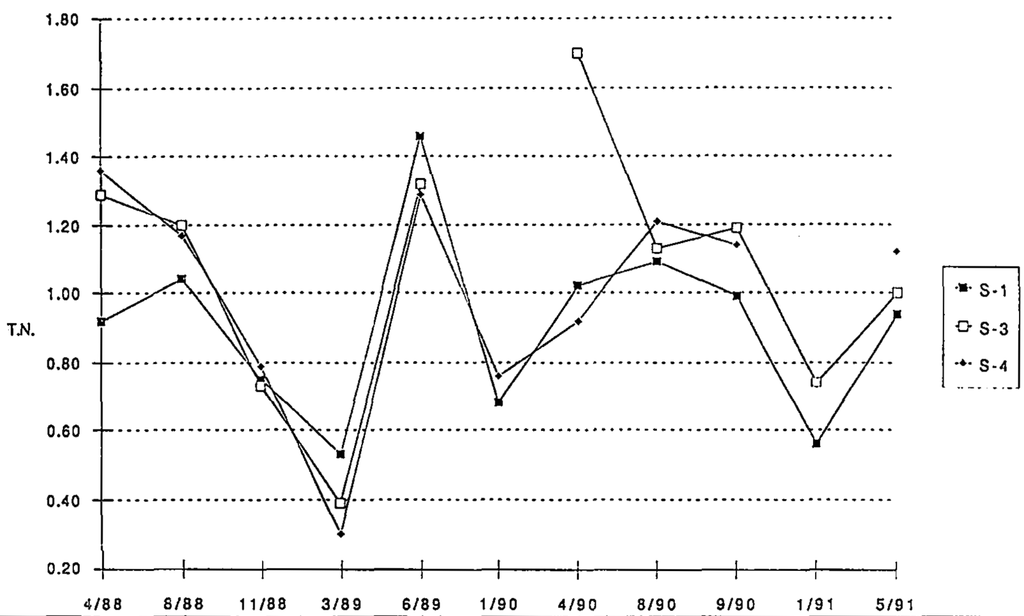
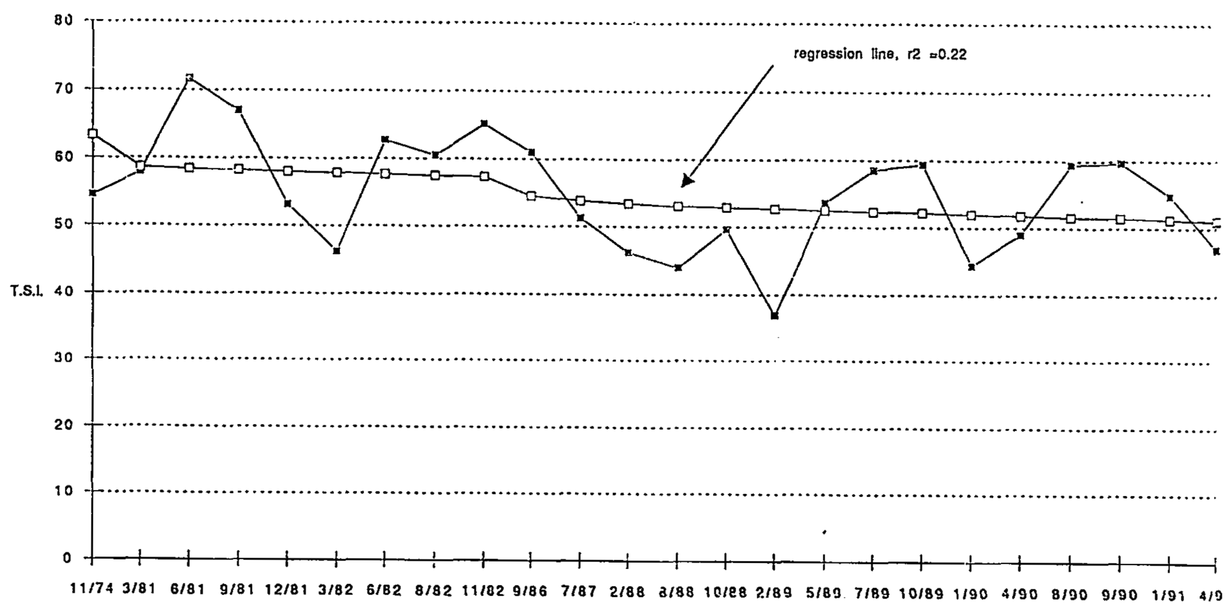


Figure 4.5

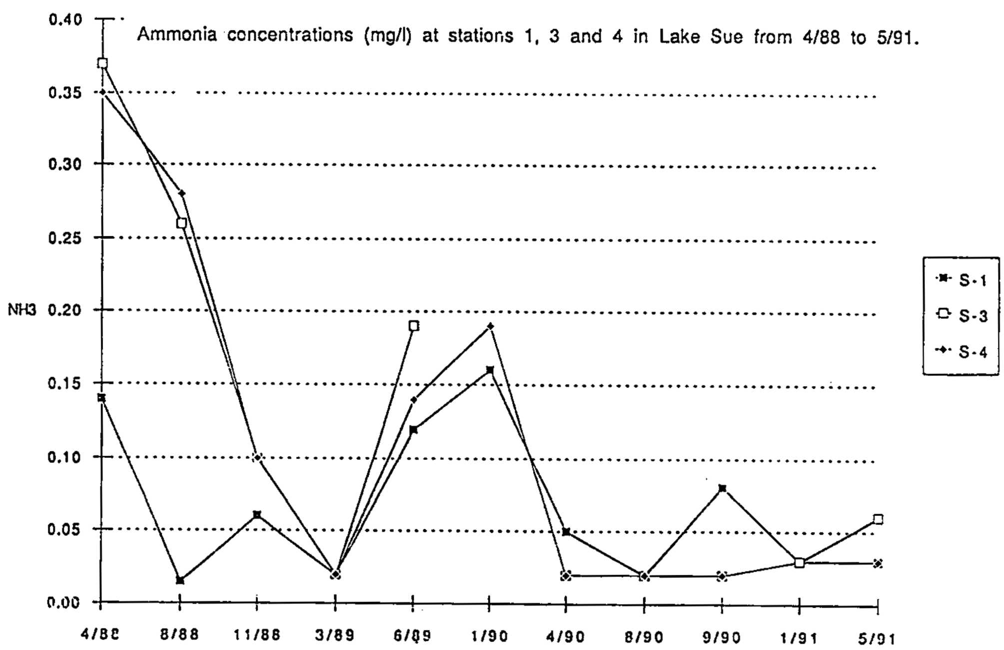
Regression line for trophic state index values (Fl.) in Lake Sue from 11/74 to 4/91. Data collected by Orange County.



4.2.3.2 Ammonia

Ammonia is a nitrogen compound which can be directly utilized by algae and larger aquatic plants. Common sources for ammonia are fertilizer run-off, animal wastes and septic tanks. Ammonia levels in Orlando lakes are generally low with 35.8% of the 78 lakes studied by the City in 1990, having average levels below the detection limit of 0.02 mg/l. The maximum and minimum value for ammonia in Orlando lakes was 0.63 mg/l and <0.03 mg/l, respectively. The general trend for this constituent in both Lake Rowena and Lake Sue has been downward. This should be viewed as a positive improvement. Current levels are only slightly higher than the detection limits. Ammonia levels at selected sites are presented in figure 4.6.

Figure 4.6



4.2.3.3 Nitrates and Nitrites

Nitrates and nitrites are inorganic forms of nitrogen which can be utilized by algae, but to a lesser degree than ammonia. During the 1990 City of Orlando study, nitrate values were generally low with 45% of the lakes having values below the detection limit of 0.02 mg/l. Nitrite values were very low with 95% of the lakes containing levels below the detection limit of 0.02 mg/l. The ranges for nitrates and nitrites in Orlando lakes were <0.01 mg/l to 0.58 mg/l and <0.01 mg/l to 0.09 mg/l, respectively. The median value for nitrate and nitrite was <0.02 mg/l. Lakes Sue and Rowena are therefore, typical of area lakes for these parameters.

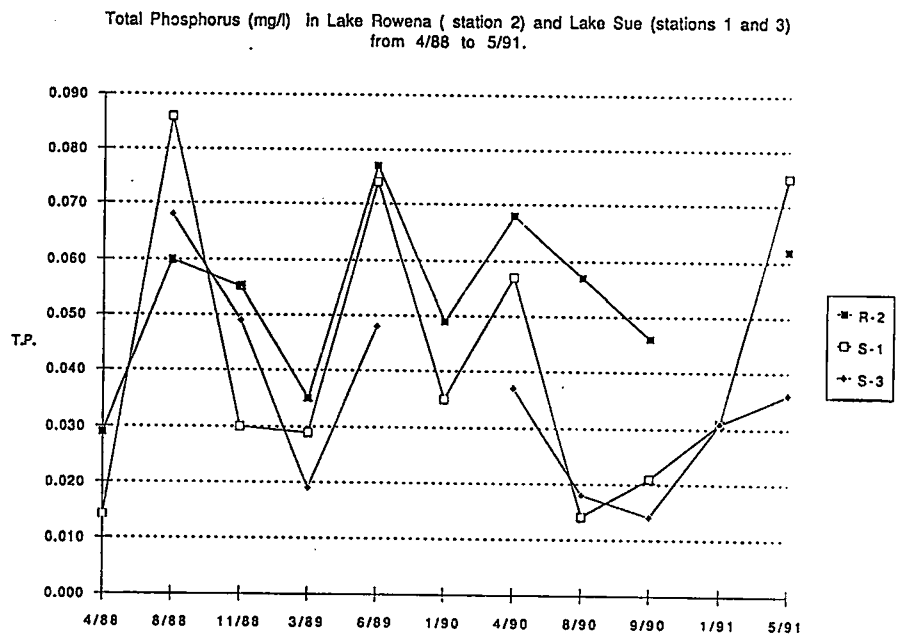
4.2.3.4 Phosphorus

Phosphorus occurs in natural wastes and wastewaters almost solely as phosphates. These are classified as orthophosphates, condensed phosphates (pyro-, meta-, and other polyphosphates), and organically bound phosphates. They occur in solution, in particles or detritus, or in the bodies of aquatic organisms. Phosphates also occur in bottom sediments and in biological sludges, both as precipitated inorganic forms and incorporated into organic compounds.

Orthophosphate is generally assumed to be the most dissolved and available form of phosphate available to aquatic macro- and microphytes (plants). Filtering through a 0.45 micron filter and analyzing the filtrate is the most commonly used method of separating orthophosphate from total phosphorus. The critical level for phosphorus (the point at which a lake is considered to have trophic related problems) is 0.05 mg/l(Brezonik, 1984). Total phosphorus at Lake Sue occasionally exceeds this level. Lake Rowena, exceeds the level frequently, and is generally higher than Lake Sue at all times, making Rowena a phosphorus source for Lake Sue. This relationship is demonstrated in figure 4.7.

Orthophosphorus at both lakes tends to be low (less than 0.0005 mg/l). Oddly, the more eutrophic a lake is, the less of this important nutrient it appears to have. This is due to the high rate of productivity depleting the primary nutrient (orthophosphate) and tying it up as biomass (high in total phosphate), or sediment (high in dead biomass).

Figure 4.7



4.3 PHYSICAL CHARACTERISTICS

The physical characteristics most commonly used to describe a lake include its' size, depth, drainage area, temperature, dissolved oxygen, specific conductance, light penetration, and solids content.

Size, depth and drainage area have been previously discussed. An important aspect of the physical measurements discussed in this section is that many of them are best measured in-situ (that is to say; where and when they occur). It is almost impossible to separate an aliquot for some of these physical measurements and take it to a lab without changing the sample. The best example of an in-situ measurement is temperature. In-situ measurements rarely identify problems other than gross abnormalities in a lake (e.g. poor oxygen or no light penetration). However, taken frequently over a long period of time, they present a picture of a lakes seasonal transitions. Like a doctor listening to a heartbeat or performing reflex test, sometimes an abnormality is immediately obvious but, more often than not, additional testing is required.

4.3.1 Temperature Stratification

Size, depth, and latitude are the primary factors which determine if a lake will develop thermal stratification. Stratification can have a significant impact on nutrient and dissolved oxygen levels. Thermal stratification is the process whereby a lake develops a layer of cooler water which underlies a surface layer of warmer water. The lower layer is termed the hypolimnion, the upper layer is the epilimion and the transitional layer which acts as a barrier between the two is the metalimnion. The metalimnion, which is also called a thermocline, is usually identified by a temperature change of >1°C per meter (Wetzel, 1983).

Because of density differences brought about by temperature differences, the hypolimnion will become anoxic with time which results in increased phosphorus release from the bottom sediments. Water quality problems occur when stratification occurs in lakes and nutrient rich anoxic waters of the hypolimnion mix throughout the lake; algae blooms and fish kills can occur. This is a very common phenomenon in northern temperate lakes which tend to develop stable stratification that persist throughout the summer and mix once in the fall. Stable stratification occurs much less frequently in Florida's semi-tropical lakes because most are shallow enough to be mixed by wind and the temperature differences between seasons are relatively small.

Using the criteria of the presence of a metalimnion, identified by a temperature difference of 1°C per meter, about 41% of Orlando's lakes exhibit thermal stratification. The majority of the lakes that exhibit thermal stratification appear to be polymitic, which means the lake continually stratifies and destratifies throughout the year. Lakes with weak stratifications tend to mix with a minimum amount of disturbance such as a moderate wind produced by a thunderstorm. Lakes Sue and Rowena are deep enough to exhibit occasional weak stratification in the deeper areas and can be considered polymitic lakes.

4.3.2 Dissolved Oxygen

If not for the processes of life, dissolved oxygen would be simply calculated based on temperature, dissolved salts, and atmospheric pressure. Due to photosynthesis by plants and respiration by both plants and animals, dissolved oxygen is one of the more dynamic aspects of lake ecology. The presence of plants and light at the upper layer sometimes cause a net increase over natural saturation levels while the reverse is true in darkness and the presence of decomposing bacteria. The most obvious aspect of oxygen is that it allows the presence of a fishery and it's related organisms (fish food). Less obvious is its' ability to suppress the release of nutrients from the hydrosoil by allowing them to oxidize to less soluble or consumable forms.

Grove Scientific Company has previously prepared dissolved oxygen profiles for the deeper sections of Lakes Sue and Rowena. As expected from the high trophic state index calculated for these lakes, the hypolimnion is anoxic or nearly so in summer when thermal stratifications are at a maximum. In general, epilimnion dissolved oxygen levels for these lakes are well over the 4 mg/l typically considered the minimum necessary to sustain a fishery. Very high surface oxygen levels (greater than saturation or >8 mg/l in the summer) are indicative of excessive primary production (algae blooms). In Florida's rich, semi-tropical environment, this is a common natural phenomenon in the summer. The danger in an algae bloom comes when sunlight levels decline and the population crashes, resulting in a decomposing bacteria bloom that depletes the available oxygen for other organisms. Lake Sue and Rowena do occasionally supersaturate but, fish kills are extremely rare.

4.3.3 Specific Conductivity

Conductivity is a measure of the ability of water to carry an electric current. It is considered the net effect of all ionizable substance in water. The higher the salt content, the easier a current will flow and the greater the conductivity. High values can be natural or caused by land use activity or contaminated discharge. Low values can be caused by temporary slugs of low conductivity stormwater. Low conductivities are generally associated with low dissolved solids and vice versa.

Conductivity for Lakes Sue and Rowena are typical of many Florida surface waters. Typical surface conductivities for these two lake are around 200 umhos/cm. By contrast, City of Orlando tap water is approximately 270 umhos/cm, Lake Poinsette in Brevard County is approximately 700 umhos/cm and the St. John's River at Lake Harney is approximately 1300 umhos/cm. Excessive salts and the resulting high conductivity are not a problem in this lake system.

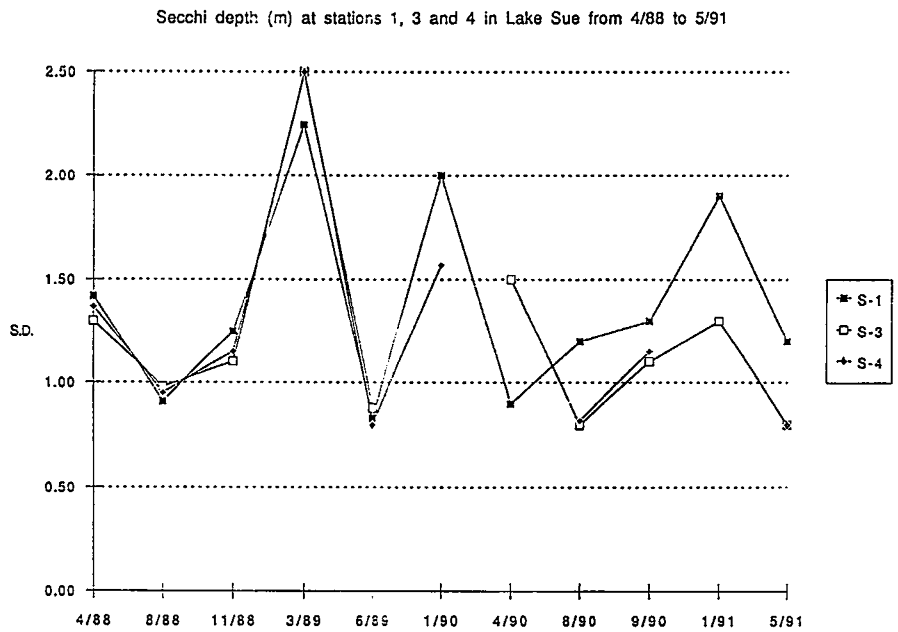
4.3.4 **Transparency**

Transparency is one of the most difficult water quality measurements to interpret. Transparency is a function of several things: dissolved and suspended solids, algae, biomass (measured as chlorophyll a), bacterial biomass, sediment composition, surrounding upland composition (reflected as run-off), wind action and, to a limited degree, color. Transparency determines the depth to which photosynthesis can occur.

4.3.4.1 Secchi depth

The standard measurement of transparency currently used is the Secchi disk depth. For limnological work, a black and white 10 inch diameter disk is lowered until it just disappears from view, raised until it reappears and the depths are averaged. The greater the depth (usually given in meters), the clearer the water. Despite the many variables present (the visual acuity of the observer, the smoothness of the water surface, the presence of interfering color, etc.), Secchi measurements are precise enough to be a tremendous improvement over subjective terms like; "clear", "cloudy", "very cloudy" and so on. The disadvantage with using Secchi measurements is that a single measurement is of little use. If the lake was windblown, if there was an algae bloom in progress, or if other transparency reducing events had recently occurred, one might incorrectly read the data to indicate a turbid system. One of the best uses of Secchi depth is the tracking of seasonal trends. Many waters exhibit seasonal variations in clarity due to increased photosynthetic activity and rainfall in the warm, wet summer followed reduced stormwater runoff and algal population crashes in the cool, dry winter. Lakes Sue and Rowena exhibit such seasonal variations as exhibited in Figure 4.8. This seasonal cycling in clarity is also observable from the chlorophyll-a data. The level of chlorophyll-a has much to do with lake clarity. This component is discussed further in the section on biological characteristics.

Figure 4.8

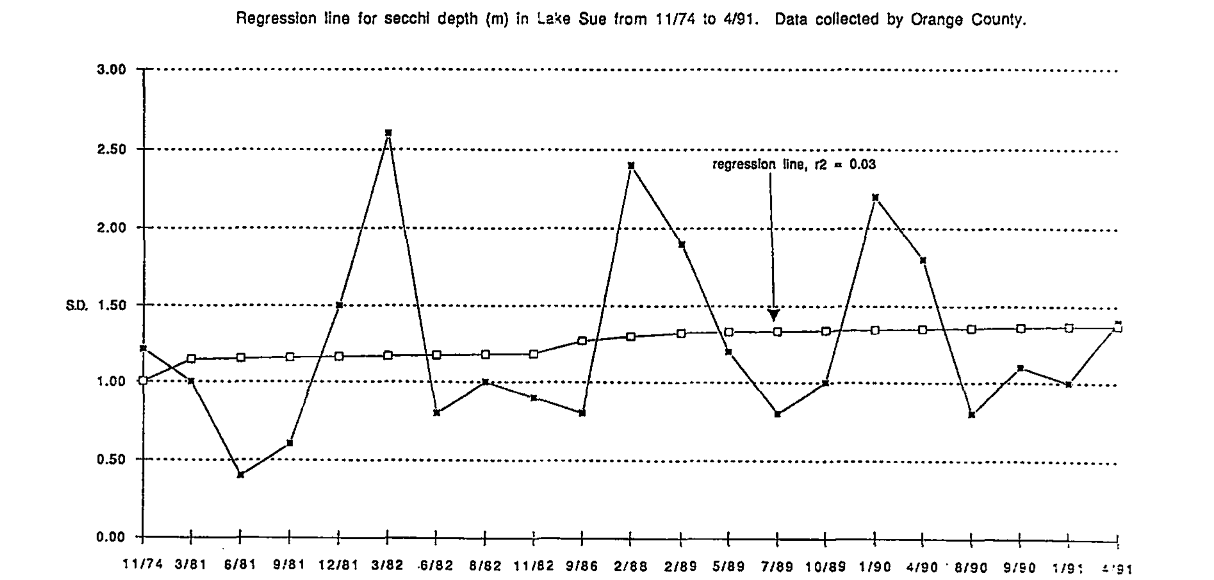


Over a period of many years and many measurements, transparency trends are detectable by Secchi depth measurement. Lakes Sue and Rowena, when observed over the last 17 years, (Figure 4.9) appear to be relatively stable with respect to water clarity trends. The coefficient of determination (r^2) for this trend is well below the level typically considered statistically significant (0.20).

4.3.4.2 Dissolved and Suspended Solids

The solids present in a lake, dissolved or suspended, can have a significant effect on color and transparency. Dissolved solids is a measure of the amount of organic and inorganic material in solution. These materials are mainly bicarbonates, chlorides,

Figure 4.9



sulfates, magnesium and sodium with concentrations generally being less than 200 mg/l in Central Florida lakes (Swilhart et al 1984). Orlando lakes are typical of Central Florida lakes with 91.3% having values below 200 mg/l. The range for dissolved solids during the City's 1990 study was 30 mg/l to 240 mg/l with a median value of 127 mg/l. Dissolved solids contribute to color, hardness, alkalinity, and turbidity. Suspended solids, in particular, contribute to turbidity. Florida is blessed with relatively clear (if highly colored) water. High solids are more typical of large river systems such as the Mississippi and the Thames. Stormwaters and wind stirred sediments are the main cause of high solids not associated with an algal bloom.

Total suspended solids and volatile suspended solids are measure of the solid material suspended in water. Therefore, these factors contribute directly to turbidity. Volatile suspended solids are taken to represent the organic fraction of total suspended solids. The suspended solids in the majority of area lakes are organic in nature with 76.9% of the lakes having greater than 50% of the measured total suspended solids in the volatile fraction. The higher values were found in lakes with high planktonic algae densities. This indicates that much of the suspended solids materials is composed of algal cells. The Environmental Protection Agency classifies surface water with total suspended solid concentrations below 80 as indicative of good water quality. Orlando's lakes are well below this value with the range being from <0.4 mg/l to 32 mg/l and an median value of 5.0 mg/l.

Water clarity problems associated with our city lakes have more to do with organic richness and wind stirred sediments than with visible pollutants or muddy inputs. Suspended solids are important indicators of water quality because high levels entering a lake have the potential to cause sedimentation and/or water quality problems. Pollutants such as heavy metals and phosphorus tend to bind to the solids and are carried into lakes via stormwater runoff or from illegal discharges. These fine particulates then settle to the sediments where they may accumulate and form a sink for future cycling of the pollutants.

4.3.5 Water Budget

Lake Sue is part of the Howell Branch chain of lakes. The Upper Howell Branch begins at Lake Dot in downtown Orlando and ends with Lake Sue at Winter Park. From Lake Sue, the Upper Howell Branch enters Lake Virginia and the remaining Howell Branch lakes which are located in Winter Park. Considering Lake Sue's downstream position from the more polluted upper Howell Branch lakes, it is remarkable the lake has managed to maintain the relatively good health it enjoys. It follows that improvements to upstream lakes are necessary to help Lake Sue maintain its relatively good health.

Natural direct inputs to Lake Sue include natural groundwater springs and an opening to Lake Rowena. Lake Sue drains naturally to Lake Virginia.

During winter and summer of 1991, Grove Scientific performed stream flow measurements at Lake Sue's inlet and outlet (see Appendix F). Measured on a typical wet season day, at least 72 hours after the last significant rain, Lake Sue received 1.86 million gallons a day from Lake Rowena and exported 2.18 million gallons a day to Lake Virginia. Measured on a typical dry season day, Lake Sue exported 0.61 million gallons a day to Lake Virginia, imports from Lake Rowena had dropped to below measurable levels. Because more water leaves Lake Sue than enters from Rowena in both wet and dry seasons, it can be easily deduced that the lake receives significant additional inputs from stormwater drainage, and natural groundwater flow.

4.4 BIOLOGICAL CHARACTERISTICS

The biological characteristics of a lake are what interests humans the most. Without a biology, a lake is merely a cistern, defined by its shape, clarity, and depth. A man-made swimming pool is an example of a lake without biology. The biology of a clean lake is what makes possible a fishery, an attractive landscape and habitat for birds, mammals and other terrestrial creatures. The biology of polluted lakes is what makes the water green and murky, the bottom smelly and slimy and the aquatic plants grow rampant.

Despite the importance of the biology, and because of its complexity, it is the least understood aspect of lake ecology. One way to classify a lake's ecology is to examine its diversity. To do this, the number of different species in a selected sampling of do this, the number of different species in a selected sampling of known area is determined. This sampling is then compared with standardized criteria for diversity in order to determine the ecological health of the study system. Generally, a healthy ecosystem will exhibit high diversity. This applies to the plant population as well as to animals. Unhealthy systems tend to have high populations of a small number of species, healthy systems the opposite.

4.4.1 Vegetation

Lake vegetation can easily be divided into three groups: emergent macrophytes, submergent macrophytes and phytoplankton. Increasing the diversity of plants is the first step in increasing the diversity of animals. Plants provide both habitat and food for animals. Therefore, the plants set the stage for the animals. Many animals require specific plants for food; if the food is not available, all attempts to introduce the animal will fail.

4.3.1.1 Emergent Macrophytes

These are the plants that are familiar to most people as the shoreline plants. In their natural state, Florida lakes enjoy a tremendous diversity and richness in shoreline vegetation. Part of the problem with urban lakes is that developers, wishing to market scenic waterfront views, commonly removed much of the shoreline vegetation from natural lakes prior to construction (or created artificial lakes with bare shores). Since over 70% of Floridians moved here from out of state, few realized how rich and diverse Floridas' semi-tropical lakes naturally were. These newcomers therefore looked upon natures attempts to revegetate as an invasion of "obnoxious weeds". The problem has been further compounded by native opportunists such as Typha (cattail) and by introduced exotics that quickly established themselves and took over entire lakes (hydrilla). The net result of either total removal or opportunistic invasion is a net decrease in plant diversity. Decreased plant diversity trickles down through all the genera and eventually is expressed as decreased animal diversity.

Emergent macrophytes are relatively easy to manage by the use of herbicides and classic landscaping and gardening techniques. Constant vigilance is necessary or exotics will again take over.

As a result of recent revegetation efforts, Lake Sue currently enjoys a wide diversity of natural plants, and, thanks to lake management, a relatively low level of problem exotics. The impetus behind Grove Scientific Company's strong support of littoral zone revegetation is to reintroduce diversity and produce a shoreline thick enough with beneficial native species to crowd out undesirable exotics. In the past, lake management efforts employed inexpensive, aggressive and unselective herbicide management. The end results were often a plant-free, green lake.

4.4.1.2 Submergent Vegetation

The submergents are plants whose entire life process can occur completely submerged. Examples are vascular plants (rooted and flower producing) such as Vallisineria (eel grass) and Potamogeton (pondweed) as well as algae such as Cerotophyllum (coontail) and Nitella (stonewort). Hydrilla is an exotic submergent that can reproduce in overwhelming numbers (reducing diversity and limiting recreational use).

Lake Sue is well covered in submergent vegetation. Some submergents such as pondweed can be beneficial. Rooted submergents are important in consolidating the hydrosoil, recycling nutrients and as fishery habitat. Lake Sue is peculiar in having an enormous mass of pondweed along the middle western shore. While residents have complained that it restricts waterskiing, Grove Scientific Company and O.C.E.P.D. firmly believe the pondweed has a beneficial nutrient filter effect on Lake Sue, and that this is highly responsible for the good water quality this lake enjoys when compared to its sister lakes. The benefits of pondweed also include the biomass of epiphytic phytoplankton and zooplankton, plus habitat and food for fish and larger animals. Decreased lake clarity and poorer fishery have followed attempts to remove large amounts of plant biomass by herbicide treatment. Nutrients will always be converted by biology to biomass. The plan is to favor desirable macrobiomass (higher plants, fish, birds, mammals, ect.) which people can enjoy over undesirable microbiomass (algae, bacteria, nematodes and vermiforms) which result in foul water and reduced fishery.

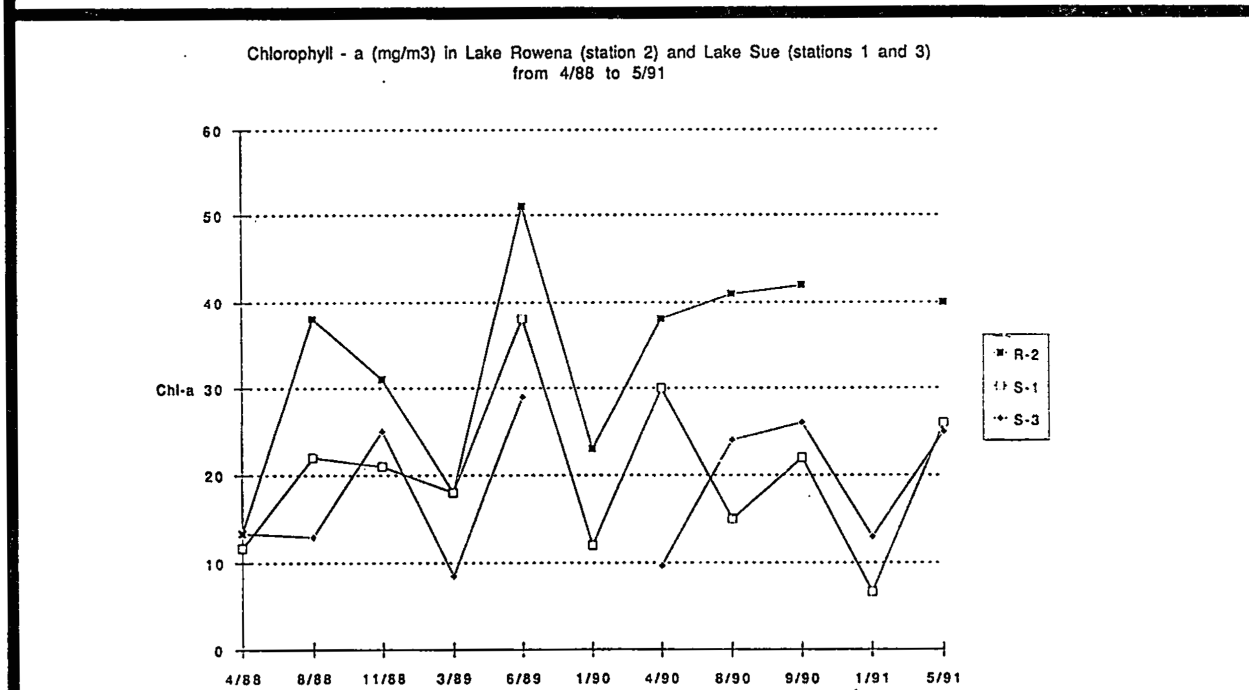
Whether or not Lake Sue has a submergent weed problem is not readily answerable. Currently, it can be said that while the Lake has a good population of desirable submergents (Valliseneria, Potamogeton), the extensive acreage of unrooted algaes (Nitella and Ceratophyllum) indicate a problem with enrichment. These forms can absorb nutrients directly from the water column and can therefore out compete rooted forms in dark silty bottoms. Only constant management prevents Hydrilla from undesirable excessive growth. Where possible, desirable native rooted forms, such as Valliseneria, should be encouraged.

4.4.1.3 Phytoplankton

Phytoplankton are the tiny single and multicelled plants most familiar for their ability to turn the water green in great numbers. The green is a result of the pigment chlorophyll-a, present in all plants. By measuring the amount of chlorophyll-a, the density of planktonic algae can be easily estimated without the need to speciate and enumerate the individuals cells. High chlorophyll-a values indicate high planktonic algae densities and decreased lake clarity. Algae blooms are probably the most common cause of water quality problems in City lakes. Algae have the potential to change the color of water, create odors, deplete oxygen, and create overall undesirable appearances in a water body. The chlorophyll-a values in Lake Sue were variable, values ranged from 6.4 mg/m^3 to 51 mg/m^3. The Florida Department of Environmental Regulation defines lakes with values over 20 mg/m^3 as problem lakes. Using this criteria Lake Sue, along with 40.7% of Orlando lakes, has algae associated problems.

The seasonal cycle of summer bloom and winter die-off is plainly visible in figure 4.10. It can easily be observed that lake Rowena is consistently higher in chlorophyll a, demonstrating values that are consistently over the 20 mg/m^3 criteria for excessive chlorophyll-a. Lake Sue demonstrates summer problems with chlorophyll-a.

Figure 4.10



4.4.2 Benthic macroinvertebrates

Benthic macroinvertebrates are those mainly sessile bottom dwelling organisms retained by a U.S. standard #30 mesh screen. Benthic organisms are useful in determining system health because they are dependant on the quality of their immediate habitat to a greater extent than more mobile organisms that can temporarily flee adverse conditions. By collecting multiple bottom samples of identical size, identifying the organisms, and studying the distribution of species a quantitative statement of diversity may be calculated (the Shannon-Weaver Diversity Index). In addition, some species are indicative of either polluted or clean condition. If these are found, they are considered further evidence to support or dispute the calculated diversity index.

Benthic macroinvertebrate samples from Lake Sue and Rowena are collected semiannually by the OCEPD. The samples are analyzed by OCEPD staff biologists and species identification is verified as needed by James Hulbert, F.D.E.R. Central District. Due to budgetary and staffing constraints, the 1990-1991 data has not been analyzed. Samples were collected, picked and preserved and are awaiting identification and calculation. The O.C.E.P.D. has re-staffed this department but no date has been scheduled for this work. The OCEPD has mentioned it will make the collection available to a responsible group who can undertake the work.

In this report, the 1988 and partial 1989 data is re-submitted. Table 4-11 presents the calculated Shannon-Weaver Diversity Index for Lakes Rowena and Sue during this time period.

The Diversity Indices calculated for both lakes are representative of stressed systems. Several Class II species were found in both lakes, Class II species are generally considered "clean water" organisms. This indicates the lakes can potentially support more sensitive organisms. These Class II species were found in the sandy substrates, the rest of the stations were high organic mucks with decaying plant matter. The data set is too small to generate further conclusions.

Table 4-2

Shannon Weaver Diversity Index

Date	Lake Rowena		Lake Sue			
	R-1	R-2	S-1	S-2	S-3	S-4
4-20-88	0.879	2.307	0.847	1.842	0.859	1.339
8-4-88	0.169	0.579	0.734	1.566	1.413	2.961
3-20-89	1.853	0.854	0.927	1.253	1.591	eliminated

Diversity Index Ranges
0-1 indicates a grossly polluted system
1-3 indicates a moderate level of pollution in system
>3 indicates a clean water system

4.4.3 Plankton

The plankton are those organisms that spend at least a portion of their life span drifting at the will of the currents. These individuals may be pure drifters, active swimmers or capable of buoyancy compensation, but they remain incapable of migrating upstream. Fish larvae and eggs may be considered plankton as may microscopic algae, bacteria, jellyfish, and arthropod larvae. Plankton therefore are usually subdivided according to size instead of by taxonomic group.

The O.C.E.P.D. collects limited plankton data but has not performed statistical or other analysis of the data. An informal grab sample study of inlet and outlet streams at Lake Sue by Grove Scientific in September 1991 determined that Lake Sue contained about thirteen genera compared to about five genera from Lake Rowena. The organisms from Lake Rowena were Anabaena (a blue-green algae of polluted systems) two vermiforms (vermi = wormlike), flagellates and Selenastrum capricornutum (a green algae utilized as food by many filter feeders). The organisms from Lake Sue included all of the above plus several penatte and centrate diatoms, rotifers, and various green and blue-green algae. While more study is required, Lake Sue clearly exhibited greater diversity and higher quality organisms than Lake Rowena. Because planktonic diversity studies are indicative of aquatic health in much of the same way as benthic studies, further formal study of the plankton would help provide a more complete picture of biological health. However, since planktonic studies are of minor regulatory importance, they are rarely funded or pursued.

4.4.4 Nekton

The nekton comprises those large and mobile forms able to move freely throughout the water column. For most limnological purposes, the nekton is synonymous with the fishery. In Florida, limnological fisheries studies are usually the domain of the Florida Freshwater Fish and Game Commission (FFGC). The FFGC usually maintains only limited data on urban lakes, particularly if access to the public is limited. The FFGC oversees the introduction of all exotics such as grass carp, the stocking of lakes for gamefish and the removal of nuisance species such as alligators.

In the area of fisheries, Lake Sue appears to excel when compared to all the other Howell branch lakes. While no formal study has been undertaken, Grove Scientific Company and other members of the Lake Sue project team have performed limited sampling and can confirm a high quality fishery for Largemouth Bass (Micropterus salmoides) and Black Crappie (Pomoxis nigromaculatus). Catfish are present, but do not appear to be a serious pest. Other fish observations include eels, Nile perch, a very few grass carp from a previous stocking, and Longnose Gar. Gambusia and Notropis species are also abundant. The apparent excellent fishery at Lake Sue has much to due with the extensive habitat provided by the heavy macrophyte growth.

SECTION 5

CONCLUSIONS

5.0 CONCLUSIONS

1) Lake Sue has achieved over 80% compliance with F.A.C. 16C-20. Approximately 56% of the lakeshore residents participated in the 1991 revegetation project. An additional percentage have revegetated at their own expense. The lake now enjoys good plant diversity and a healthy fishery.

2) Recreational use for waterskiing is seasonally affected by excessive pondweed and hydrilla growth. This is currently controlled by responsible herbicide management.

3) There has been no improvement in nutrient or stormwater abatement. In recent years, the City of Winter Park has installed screens on all but one of the Winter Park drains; this should be considered a positive first step in nutrient abatement.

   The diversion of Colonial Plaza Mall stormwater from Lake Rowena to the Greenwood Lake surface water treatment project was proposed by the City of Orlando but was successfully opposed in public hearings by the Ferncreek residents. Ferncreek routing was necessary to convey the stormwater to Greenwood Lake. The treatment or diversion of stormwater from this area is vital to restoring Lake Rowena (and thereby Lake Sue).

4) Homeowners in the Lake Sue Improvement Association have been educated and are motivated to improve lake management since the initiation of the Lake Sue Demonstration Project.

5) The littoral zone revegetation and management project has been an overall success in its first year.

6) Lake Sue is a eutrophic system. It experiences fluctuation in water quality and clarity. Were it not for the tremendous macrophyte population, its ability to assimilate nutrients would be severely impaired and the Lake would be continuously eutrophic. Indeed, it is only the apparent excellent biological health that is maintaining the lake in its current observed state. Other than seasonally restricted boat access, the lake is suitable for recreational, agricultural and water supply purposes.

The lake is a part of a major urban stormwater conveyance system. It is unrealistic to expect it to return to a pristine oligotrophic lake anytime in the near future. Significant improvements to return the lake to pristine conditions (nutrient abatement followed by hydrosoil removal) are currently too expensive to undertake with the available budgets. Historically, data from 1974 to present indicate no net reduction in water clarity or trophic state, indeed slight improvement can be inferred. This is a good indication that efforts to improve the lake have an excellent likelihood of long term success. It is imperative that budgetary constraints not be used to limit required improvements.

As part of an urban stormwater conveyance system, active and continual management is necessary in order to prevent further degradation. While the lake will not be returning to its pristine condition anytime soon, it is none the less a beautiful and valuable lake, worthy of the highest levels of protection available. Its protection and management will aid in the management and restoration of the downstream lakes.

SECTION 6

RECOMMENDATIONS

6.0 RECOMMENDATIONS

1) Institute a lake-wide littoral zone management program to maintain all of the revegetated shorelines.

2) Implement a schedule of quarterly communication between the City of Winter Park and Orange County for coordinated herbicide management. Informal communications already occur, the recommendation is for the institution of regularly scheduled communications. Quarterly is recommended.

3) Retrofit county stormdrains at Beaman Park, install a diversion structure and subsurface exfiltration and sedimentation system to treat this the largest stormwater pipe to Lake Sue. Retrofit the four county stormdrains referenced in Section 3.2 with individual exfiltration systems.

   A new bridge is scheduled for construction over the Lake Sue/Rowena canal in early 1992. This will be an excellent opportunity to retrofit a stormwater treatment system in this location. Strong efforts should be applied to the county to accomplish this.

4) The City of Orlando must continue efforts to achieve stormwater abatement at Lake Rowena, particularly at the Leu Gardens stormdrain. The City must not only re-evaluate the stormwater diversion project from the Colonial Plaza Mall, but also study and implement alternative stormwater management activities.

5) Information on lake management efforts will continue to be transmitted to the Lake Sue Improvement Association members on a periodic basis.

6) Every effort to maintain the biological health and significant macrophyte biomass should be applied. Hydrilla and coontail in the lake must be responsibly managed. Sophisticated herbicide treatment continues to be the best plant management technique. The only recommendation in its use is continued restraint from removing large biomass areas at a single event. Mechanical harvesting remains cost prohibitive as well as posing a weed fragmentation spreading problem.

7) The addition of triploid carp at a low stocking rate is worthy of reevaluation at this time. Florida Freshwater Fish and Game Commission should be consulted on this matter.

8) For nutrient abatement to have the best chance of success, additional research is necessary to quantify and evaluate the nutrient budget for the lake. A better understanding of the lake nutrient budget will help prioritize specific areas requiring nutrient abatement. Grove Scientific Company will evaluate methodologies for nutrient load quantification for possible submittal in future management proposals.

9) Include the entire Lake Sue drainage basin in the MSTU tax for lake maintenance.

LSUE34/LAKE/0923910500900

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Appendix A
Preliminary Engineering Calculations for Storm Drain Retrofitting on Lake Sue

T.E. KNOWLES & ASSOCIATES
CONSULTING ENGINEERS & PLANNERS
13 WEST PINE STREET
ORLANDO, FL. 32801

LETTER OF TRANSMITTAL

DATE 10/11/91. JOB NO. PROP #

ATTENTION BRUNO FERRARO

RE: LAKE SUE DRAINAGE

TO GROVE SCIENTIFIC
6140 EDGEWATER DR.
STE. F., ORL, (32810)

WE ARE SENDING YOU ☐ Attached ☐ Under separate cover via ______ the following items:

☐ Shop drawings ☐ Prints ☑ Plans ☐ Samples ☐ Specifications

☐ Copy of letter ☐ Change order ☐ COMPUTER RUNS & CALCULATIONS

COPIES	DATE	NO.	DESCRIPTION
2		1	1" = 150 MAP OF BEEKMAN PARK @ LAKE SUE
1		1	SMADA RUNOFF COMPUTER RUN
1		3	MODRET RUN ROUTING H_2O INTO GROUND.

THESE ARE TRANSMITTED as checked below:

☐ For approval ☐ Approved as submitted ☐ Resubmit ____ copies for approval

☑ For your use ☐ Approved as noted ☐ Submit ____ copies for distribution

☐ As requested ☐ Returned for corrections ☐ Return ____ corrected prints

☐ For review and comment ☐ ______

☐ FOR BIDS DUE ______ 19____ ☐ PRINTS RETURNED AFTER LOAN TO US

REMARKS THIS DATA IS PRELIMINARY BUT VERY USEFUL. USE IT AS YOU WISH. THE ESTIMATES ARE AS FOLLOWS ->
EST. DRAINAGE COSTS (POLLUTION ABATEMENT).
BEEKMAN PARK - $50,000
LAKESHORE DRIVE - 15,000
TOTAL $65,000

THANKS FOR THE OPPORTUNITY

Ted

FAX COVER LETTER

T.E. KNOWLES & ASSOCIATES
CONSULTING ENGINEERS & PLANNERS
13 WEST PINE STREET
ORLANDO, FL. 32801

TO Bruno Ferraro FROM T.E. Knowles & Associate

Company Grove Scientific FAX NO. 290-9038

Location Orlando, Fl.

H-S OFFICE [] Atlanta [] Chattanooga [] Corporate [] Raleigh

* *

Date Submitted 10/11/91 Date Sent 10/11/91

Time Submitted ____ Time Sent 5:10 PM

Account Number ____ Operator TWS

* *

Message This narrative and calculations are supported by our computer runs on runoff and infiltration submitted to you under separate cover (by mail).

* *

OPERATOR INSTRUCTIONS Number of Pages to Follow 3

[] Return document by office mail [] Mail document

[] Send document to file [] File telecopy

[] Return document immediately [] Copy document and send to

[] Destroy document after sending ____

* *

IF NOT RECEIVED IN ITS ENTIRETY OR DOCUMENT IS ILLEGIBLE, PLEASE CALL 407/839-1717

Lake Sue Drainage

10/11/91

(Discharge through 42" pipe under Beeman Park)

Preliminary calculations and computer generations have revealed that the total volume of the first half inch of runoff from the basin is approximately 50,900 ft.^{3} The total drainage basin is approximately 28.1 acres. This volume of stormwater can be captured and infiltrated in a retention pond of only 5,776 ft.^{3} This retention pond may be much smaller due to the relatively high permeability of the surrounding soils. A computer generated "Modret" calculation shows that the volume of ½ inch of runoff will be easily infiltrated within 72 hours. In Lieu of of a retention pond, another option includes placing 4 foot diameter perforated infiltrator pipes underground, with 4 feet of spacing between the pipes which lay parallel to one another. Six pipes could be laid, each 43.50 feet in length. Between the pipes would be a clean, fine builder's sand with a permeability greater than 5 ft./hr.. At each end of the parallel pipes, headers would connect them. A manhole would be placed in each header to allow entry and cleanout of the pipes when necessary.

10/11/91

However, a second underground perforated pipe design would more likely be used if the underground pipes were chosen for drainage. In this alternative, the pipes would be laid parallel to each other once again. However, they would abut one another in this scenario. For four foot diameter pipes with nine feet between the water table and pipe bottoms, a total length of 38.0 ft. of pipe would be needed. Thus, 10 pipes laid parallel to one another would be required with 40 ft. of headers on both ends of the pipes.

T.E. KNOWLES P.E., AICP
18 WEST PINE STREET
ORLANDO, FLORIDA 32801
(407) 839-1717

Lake Sue Drainage Calculations: 10/11/91

Pond volume required with 9 feet between groundwater table and pond bottom:

$(38' \times 38' \times 4') = 5776\ ft.^3$

Pipe length required with 44 foot headers, Alt. 1:

pipe area $= \pi(2\,ft.)^2 = 12.57\ ft.^2$

header volume $= (12.57\ ft.^2)(2)(44\ ft.) = 1105.8\ ft.^3$

Sand pore volume $= (\underset{\text{porosity}}{0.4})(4\ ft.)^2(\underset{\text{\# sand spaces}}{5})(\underset{\text{pipe length}}{X}) = (32\ ft.^2)(X\ ft.)$

pipe volume $= (12.57\ ft.^2)(\underset{\text{\# pipes}}{6})(X) = (75.4\ ft.^2)(X\ ft.)$

$\therefore\ X = \dfrac{(5776 - 1106)\ ft.^3}{(32 + 75.4)\ ft.^2} = 43.50\ ft.$

Pipe length required with 40 foot headers, Alt. 2:

header volume $= (12.57\ ft.^2)(40\ ft.)(\underset{\text{\# headers}}{2}) = 1005.3\ ft.^3$

pipe volume $= (12.57\ ft.^2)(\underset{\text{\# pipes}}{10})(X\ ft.) = (125.7\ ft.^2)(X\ ft.)$

$\therefore\ X = \dfrac{(5776 - 1005)\ ft.^3}{125.7\ ft.^2} = 38.0\ ft.$

UNSATURATED INFILTRATION ANALYSIS
USING 'MODRET ' PROGRAM

Written By Nicolas E. Andreyev,P.E.
(March, 1989)

SUMMARY OF INPUT PARAMETERS
==========================

POND NAME / NUMBER : Sue

AVERAGE POND BOTTOM LENGTH ===================) 22.000 ft

AVERAGE POND BOTTOM WIDTH ===================) 22.000 ft

AVERAGE SEPARATION BETWEEN BOTTOM & HGWT =====) 9.000 ft most desirable option

VERTICAL HYDRAULIC CONDUCTIVITY ==============) 120.000 ft/d

FACTOR OF SAFETY FOR Kvu ====================) 1.000

AVERAGE EFFECTIVE STORAGE COEFFICIENT ========) 0.200

RESULTS OF UNSATURATED INFILTRATION
==================================

INFILTRATION VOLUME, Vu = 0.02000 ac-ft

MINIMUM TIME TO INFILTRATE Vu, Tsat = 0.36 hrs

SATURATED INFILTRATION ANALYSIS
USING 'MODRET ' PROGRAM

Written By Nicolas E. Andreyev,P.E.
(March, 1989)

SUMMARY OF INPUT PARAMETERS
==========================

POND NAME / NUMBER : Sue

AVERAGE WETTED POND LENGTH ======================) 38.000 ft

AVERAGE WETTED POND WIDTH =======================) 38.000 ft

AVERAGE ELEVATION OF BOTTOM OF AQUIFER ==========) 45.000 ft

AVERAGE ELEVATION OF DESIGN GROUNDWATER TABLE ===) 73.000 ft

AVERAGE ELEVATION OF POND BOTTOM ================) 82.000 ft

ELEVATION OF DESIGN OVERFLOW FROM POND ==========) 86.000 ft

AVERAGE HORIZONTAL HYDRAULIC CONDUCTIVITY ========) 240.000 ft/d

AVERAGE EFFECTIVE STORAGE COEFF. OF SOIL ========) 0.200

AVERAGE STORAGE COEFFICIENT OF POND AREA ========) 1.000

STRESS PERIOD No.	TIME INCREMENT (HOURS)	RECHARGE TO POND AREA (ft/day)	RECHARGE OUTSIDE POND AREA (ft/day)
1.00000	0.25008	135.40044	0.00000
2.00000	0.49992	270.93423	0.00000
3.00000	0.49992	270.93423	0.00000
4.00000	0.49992	270.93423	0.00000
5.00000	0.49992	270.93423	0.00000
6.00000	0.49992	270.93423	0.00000
7.00000	0.49992	270.93423	0.00000
8.00000	24.00000	0.00000	0.00000
9.00000	48.00000	0.00000	0.00000

SUMMARY OF 'MODRET' RESULTS

POND NAME / No.: Sue

STRESS PERIOD	CUMMULATIVE TIME (hrs.)	WATER ELEVATION (feet)	INFILTRATION RATE (cfs)	WEIR OVERFLOW (cubic ft.)
0	0.000	73.000	0.000	0.000
1	0.600	80.720	2.202	0.000
2	1.104	81.680	3.727	0.000
3	1.608	82.740	3.648	0.000
4	2.112	83.690	3.735	0.000
5	2.616	84.520	3.831	0.000
6	3.120	85.230	3.926	0.000
7	3.624	85.850	3.998	0.000
8	27.624	75.120	0.179	0.000
9	75.624	73.570	0.013	0.000

UNSATURATED INFILTRATION ANALYSIS
USING 'MODRET ' PROGRAM

Written By Nicolas E. Andreyev,P.E.
(March, 1989)

SUMMARY OF INPUT PARAMETERS
==========================

POND NAME / NUMBER : Sue

AVERAGE POND BOTTOM LENGTH ===================) 38.000 ft

AVERAGE POND BOTTOM WIDTH ====================) 38.000 ft

AVERAGE SEPARATION BETWEEN BOTTOM & HGWT =====) 6.000 ft

VERTICAL HYDRAULIC CONDUCTIVITY ==============) 120.000 ft/d

FACTOR OF SAFETY FOR Kvu =====================) 1.000

AVERAGE EFFECTIVE STORAGE COEFFICIENT ========) 0.200

RESULTS OF UNSATURATED INFILTRATION
==================================

INFILTRATION VOLUME, Vu = 0.03978 ac-ft

MINIMUM TIME TO INFILTRATE Vu, Tsat = 0.24 hrs

SATURATED INFILTRATION ANALYSIS
USING 'MODRET ' PROGRAM

Written By Nicolas E. Andreyev,P.E.
(March, 1989)

SUMMARY OF INPUT PARAMETERS
==========================

POND NAME / NUMBER : Sue

AVERAGE WETTED POND LENGTH =====================) 54.000 ft

AVERAGE WETTED POND WIDTH ======================) 54.000 ft

AVERAGE ELEVATION OF BOTTOM OF AQUIFER ==========) 45.000 ft

AVERAGE ELEVATION OF DESIGN GROUNDWATER TABLE ===) 73.000 ft

AVERAGE ELEVATION OF POND BOTTOM ================) 79.000 ft

ELEVATION OF DESIGN OVERFLOW FROM POND ==========) 83.000 ft

AVERAGE HORIZONTAL HYDRAULIC CONDUCTIVITY =======) 240.000 ft/d

AVERAGE EFFECTIVE STORAGE COEFF. OF SOIL ========) 0.200

AVERAGE STORAGE COEFFICIENT OF POND AREA ========) 1.000

STRESS PERIOD No.	TIME INCREMENT (HOURS)	RECHARGE TO POND AREA (ft/day)	RECHARGE OUTSIDE POND AREA (ft/day)
1.00000	0.25104	66.79375	0.00000
2.00000	0.49992	134.16632	0.00000
3.00000	0.49992	134.16632	0.00000
4.00000	0.49992	134.16632	0.00000
5.00000	0.49992	134.16632	0.00000
6.00000	0.49992	134.16632	0.00000
7.00000	0.49992	134.16632	0.00000
8.00000	24.00000	0.00000	0.00000
9.00000	48.00000	0.00000	0.00000

SUMMARY OF 'MODRET' RESULTS

POND NAME / No.: Sue

STRESS PERIOD	CUMMULATIVE TIME (hrs.)	WATER ELEVATION (feet)	INFILTRATION RATE (cfs)	WEIR OVERFLOW (cubic ft.)
0	0.000	73.000	0.000	0.000
1	0.480	78.660	2.756	0.000
2	0.984	79.430	3.254	0.000
3	1.488	80.240	3.190	0.000
4	1.992	81.020	3.238	0.000
5	2.496	81.730	3.350	0.000
6	3.000	82.370	3.463	0.000
7	3.504	82.950	3.559	0.000
8	27.504	75.150	0.263	0.000
9	75.504	73.590	0.026	0.000

UNSATURATED INFILTRATION ANALYSIS
USING 'MODRET ' PROGRAM

Written By Nicolas E. Andreyev,P.E.
(March, 1989)

SUMMARY OF INPUT PARAMETERS
===========================

POND NAME / NUMBER : Sue

AVERAGE POND BOTTOM LENGTH ===================) 57.000 ft

AVERAGE POND BOTTOM WIDTH ====================) 57.000 ft

AVERAGE SEPARATION BETWEEN BOTTOM & HGWT =====) 3.000 ft

VERTICAL HYDRAULIC CONDUCTIVITY ==============) 120.000 ft/d

FACTOR OF SAFETY FOR Kvu =====================) 1.000

AVERAGE EFFECTIVE STORAGE COEFFICIENT ========) 0.200

RESULTS OF UNSATURATED INFILTRATION
===================================

INFILTRATION VOLUME, Vu = 0.04475 ac-ft

MINIMUM TIME TO INFILTRATE Vu, Tsat = 0.12 hrs

SATURATED INFILTRATION ANALYSIS
USING 'MODRET ' PROGRAM

Written By Nicolas E. Andreyev,P.E.
(March, 1989)

SUMMARY OF INPUT PARAMETERS
===========================

POND NAME / NUMBER : Sue

AVERAGE WETTED POND LENGTH ======================) 73.000 ft

AVERAGE WETTED POND WIDTH =======================) 73.000 ft

AVERAGE ELEVATION OF BOTTOM OF AQUIFER ==========) 45.000 ft

AVERAGE ELEVATION OF DESIGN GROUNDWATER TABLE ===) 73.000 ft

AVERAGE ELEVATION OF POND BOTTOM ================) 76.000 ft

ELEVATION OF DESIGN OVERFLOW FROM POND ==========) 80.000 ft

AVERAGE HORIZONTAL HYDRAULIC CONDUCTIVITY =======) 240.000 ft/d

AVERAGE EFFECTIVE STORAGE COEFF. OF SOIL ========) 0.200

AVERAGE STORAGE COEFFICIENT OF POND AREA ========) 1.000

STRESS PERIOD No.	TIME INCREMENT (HOURS)	RECHARGE TO POND AREA (ft/day)	RECHARGE OUTSIDE POND AREA (ft/day)
1.00000	0.25104	36.54918	0.00000
2.00000	0.49992	73.41509	0.00000
3.00000	0.49992	73.41509	0.00000
4.00000	0.49992	73.41509	0.00000
5.00000	0.49992	73.41509	0.00000
6.00000	0.49992	73.41509	0.00000
7.00000	0.49992	73.41509	0.00000
8.00000	24.00000	0.00000	0.00000
9.00000	48.00000	0.00000	0.00000

SUMMARY OF 'MODRET' RESULTS

POND NAME / No.: Sue

STRESS PERIOD	CUMMULATIVE TIME (hrs.)	WATER ELEVATION (feet)	INFILTRATION RATE (cfs)	WEIR OVERFLOW (cubic ft.)
0	0.000	73.000	0.000	0.000
1	0.360	76.080	2.747	0.000
2	0.864	76.870	2.171	0.000
3	1.368	77.600	2.347	0.000
4	1.872	78.290	2.465	0.000
5	2.376	78.920	2.641	0.000
6	2.880	79.500	2.788	0.000
7	3.384	80.000	2.955	123.690
8	27.384	74.920	0.313	0.000
9	75.384	73.580	0.041	0.000

```
*************************************************************
*                                                           *
*     SMADA  -  STORMWATER MANAGEMENT AND DESIGN AID        *
*                                                           *
*                                                           *
*************************************************************
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=============
PROJECT TITLE : Lake Sue Drainage
=============

===========
DATE & TIME : 10-09-1991   14:20:28
===========

```
************************************************************
***************  R A I N F A L L   D A T A ***************
************************************************************
```

B:25yr24hr :

TIME (MIN)	RAINFALL (INCHES)
15	.017
30	.026
45	.026
60	.026
75	.026
90	.026
105	.026
120	.026
135	.026
150	.026
165	.026
180	.026
195	.026
210	.026
225	.026
240	.026
255	.034
270	.034
285	.034
300	.034
315	.034
330	.034
345	.034
360	.034
375	.043
390	.043
405	.043
420	.043
435	.043
450	.043
465	.043
480	.043
495	.052
510	.06
525	.06
540	.06
555	.069
570	.069

585	.077
600	.077
615	.086
630	.103
645	.129
660	.155
675	.181
690	.224
705	.894
720	2.37
735	.378
750	.24
765	.198
780	.155
795	.129
810	.112
825	.095
840	.086
855	.077
870	.069
885	.06
900	.06
915	.06
930	.052
945	.052
960	.052
975	.052
990	.052
1005	.043
1020	.043
1035	.043
1050	.043
1065	.043
1080	.034
1095	.034
1110	.034
1125	.034
1140	.034
1155	.034
1170	.034
1185	.034
1200	.026
1215	.026
1230	.026
1245	.026
1260	.026
1275	.026
1290	.026
1305	.026
1320	.026
1335	0
1350	.026
1365	.026
1380	.026
1395	.026
1410	.026
1425	.026
1440	.017

```
************************************************************
*********** W A T E R S H E D   A N A L Y S I S ***********
************************************************************
```

WATERSHED DATA FILE NAME = A:Sueshed
SCS CURVE METHOD USED
DRAINAGE AREA (ACRES)= 38.06

TIME OF CONCENTRATION (MINUTES)= 26.7
PERCENT IMPERVIOUS = 14 %
PERCENTAGE OF IMPERV. AR. THAT IS DIRECTLY DRAINED .00
INITIAL ABSTRACTION FOR IMPERV. AREA (INCHES OVER IMPERVIOUS) 0
POTENTIAL ABSTRACTION FOR PERVIOUS AREA (INCHES OVER PERVIOUS) .2
SCS CURVE NUMBER FOR THE PERVIOUS PORTION 49

TABLE: WATERSHED HYDROGRAPH USING SANTA BARBARA ROUTING

TIME INCREMENT	TIME (MINUTES)	RAINFALL DEPTH (INCHES)	INFILTRATION & INIT ABST (INCHES)	RUNOFF DEPTH (INCHES)	INSTANT HYDROGRAPH (CFS)	WATERSHED HYDROGRAPH (CFS)
1	15	0.02	0.015	0.002	0.28	0.06
2	30	0.03	0.022	0.004	0.43	0.19
3	45	0.03	0.022	0.004	0.43	0.29
4	60	0.03	0.022	0.004	0.43	0.35
5	75	0.03	0.022	0.004	0.44	0.39
6	90	0.03	0.022	0.004	0.44	0.41
7	105	0.03	0.022	0.004	0.44	0.42
8	120	0.03	0.022	0.004	0.45	0.43
9	135	0.03	0.022	0.004	0.45	0.44
10	150	0.03	0.022	0.004	0.45	0.44
11	165	0.03	0.022	0.004	0.45	0.45
12	180	0.03	0.022	0.004	0.46	0.45
13	195	0.03	0.022	0.004	0.46	0.46
14	210	0.03	0.022	0.004	0.46	0.46
15	225	0.03	0.022	0.004	0.47	0.46
16	240	0.03	0.022	0.004	0.48	0.47
17	255	0.03	0.028	0.006	0.69	0.52
18	270	0.03	0.028	0.006	0.71	0.60
19	285	0.03	0.028	0.006	0.73	0.65
20	300	0.03	0.027	0.007	0.75	0.69
21	315	0.03	0.027	0.007	0.77	0.72
22	330	0.03	0.027	0.007	0.79	0.75
23	345	0.03	0.027	0.007	0.81	0.77
24	360	0.03	0.027	0.007	0.83	0.79
25	375	0.04	0.034	0.009	1.07	0.86
26	390	0.04	0.033	0.010	1.10	0.96
27	405	0.04	0.033	0.010	1.13	1.03
28	420	0.04	0.033	0.010	1.16	1.08
29	435	0.04	0.032	0.011	1.19	1.12
30	450	0.04	0.032	0.011	1.22	1.16
31	465	0.04	0.032	0.011	1.25	1.19
32	480	0.04	0.032	0.011	1.27	1.22
33	495	0.05	0.038	0.014	1.58	1.31
34	510	0.06	0.043	0.017	1.87	1.49
35	525	0.06	0.043	0.017	1.92	1.67
36	540	0.06	0.043	0.017	1.97	1.79
37	555	0.07	0.048	0.021	2.33	1.95
38	570	0.07	0.048	0.021	2.40	2.13
39	585	0.08	0.053	0.024	2.75	2.32
40	600	0.08	0.052	0.025	2.83	2.53
41	615	0.09	0.057	0.029	3.25	2.75
42	630	0.10	0.068	0.035	4.01	3.14
43	645	0.13	0.083	0.046	5.21	3.78
44	660	0.16	0.097	0.058	6.52	4.70
45	675	0.18	0.111	0.070	7.96	5.81
46	690	0.22	0.132	0.092	10.35	7.28
47	705	0.89	0.485	0.409	46.26	16.50
48	720	2.37	1.022	1.348	152.51	52.85
49	735	0.38	0.135	0.243	27.44	69.14
50	750	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

51	765	0.20	0.067	0.131	14.88	34.52
52	780	0.1[illegible]	0.051	0.104	11.77	25.22
53	795	0.1[illegible]	0.042	0.087	9.87	18.91
54	810	0.11	0.036	0.076	8.63	14.67
55	825	0.09	0.030	0.065	7.36	11.74
56	840	0.09	0.027	0.059	6.70	9.68
57	855	0.08	0.024	0.053	6.02	8.22
58	870	0.07	0.021	0.048	5.42	7.12
59	885	0.06	0.018	0.042	4.72	6.22
60	900	0.06	0.018	0.042	4.74	5.57
61	915	0.06	0.018	0.042	4.75	5.21
62	930	0.05	0.015	0.037	4.13	4.87
63	945	0.05	0.015	0.037	4.14	4.55
64	960	0.05	0.015	0.037	4.15	4.37
65	975	0.05	0.015	0.037	4.16	4.28
66	990	0.05	0.015	0.037	4.17	4.23
67	1005	0.04	0.012	0.031	3.46	4.05
68	1020	0.04	0.012	0.031	3.46	3.79
69	1035	0.04	0.012	0.031	3.47	3.65
70	1050	0.04	0.012	0.031	3.48	3.57
71	1065	0.04	0.012	0.031	3.48	3.53
72	1080	0.03	0.010	0.024	2.76	3.35
73	1095	0.03	0.010	0.024	2.76	3.09
74	1110	0.03	0.010	0.024	2.77	2.95
75	1125	0.03	0.010	0.024	2.77	2.87
76	1140	0.03	0.009	0.025	2.77	2.83
77	1155	0.03	0.009	0.025	2.78	2.81
78	1170	0.03	0.009	0.025	2.78	2.79
79	1185	0.03	0.009	0.025	2.79	2.79
80	1200	0.03	0.007	0.019	2.13	2.65
81	1215	0.03	0.007	0.019	2.14	2.42
82	1230	0.03	0.007	0.019	2.14	2.30
83	1245	0.03	0.007	0.019	2.14	2.23
84	1260	0.03	0.007	0.019	2.14	2.19
85	1275	0.03	0.007	0.019	2.15	2.17
86	1290	0.03	0.007	0.019	2.15	2.16
87	1305	0.03	0.007	0.019	2.15	2.15
88	1320	0.03	0.007	0.019	2.15	2.15
89	1335	0.00	0.000	0.000	0.00	1.68
90	1350	0.03	0.007	0.019	2.15	1.42
91	1365	0.03	0.007	0.019	2.16	1.74
92	1380	0.03	0.007	0.019	2.16	1.92
93	1395	0.03	0.007	0.019	2.16	2.03
94	1410	0.03	0.007	0.019	2.16	2.09
95	1425	0.03	0.007	0.019	2.16	2.12
96	1440	0.02	0.004	0.013	1.42	1.98

ALL UNITS ARE EXPRESSED IN INCHES FOR
TOTAL RAIN= 8.56 TOTAL INFILTRATION & ABSTRACTION= 4.14 TOTAL RUNOFF= 4.42

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Lake Sue Drainage information:

Slope: $\frac{(105-73)\text{ ft.}}{1600\text{ ft.}} \times 100\% = 2.0\%$

Area total: $(1.91\text{ in}^2) \times \frac{640{,}000\text{ ft.}^2}{\text{in.}^2} = 1{,}222{,}400\text{ ft.}^2$

$= 28.06$ acres

Impervious Area: $\left[(110 \times 40)\text{ ft.} \times 40\text{ ft.}\right] = 176{,}000\text{ ft.}^2$

$= 4.04$ acres

Percent Impervious: $\frac{176{,}000}{1{,}222{,}400} \times 100\% = 14.4\%$

Curve number, Pervious areas: 49

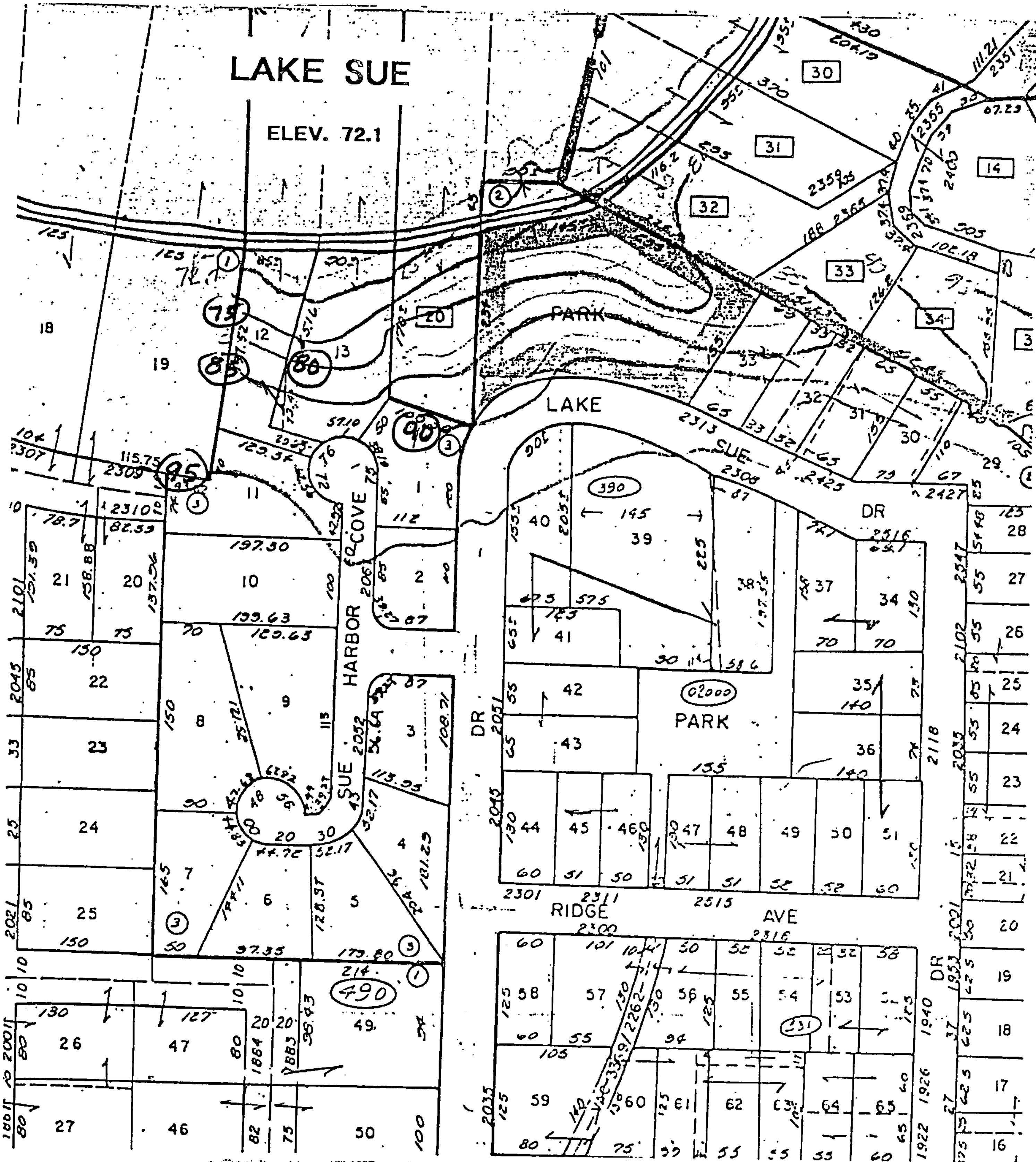
Time of concentration $= \frac{(1600\text{ ft.})}{\frac{1\text{ ft.}}{s}} \times \frac{\text{min}}{60\text{s}} = 26.7\text{ min.}$

First ½" of runoff stored:

$\frac{1}{2}\text{ in.} \times \frac{1\text{ ft.}}{12\text{ in.}} \times 1{,}222{,}400\text{ ft.}^2 = 50{,}930\text{ ft.}^3$

$= 1.169$ acre - ft.

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD



DATE	SEC	TWP	RNG	1/4	SUPPL
9-30-91	18	22	30	SE	D

ASSESSMENT MAP
PREPARED BY
FORD S. HAUSMAN
TAX ASSESSOR
ORANGE COUNTY, FLORIDA

Appendix B

Grove Scientific Company
In-Situ Data
1990 to Date

TECHNICIAN Bruno Ferraro
DATE 10-09-91
PROJECT # 05-009.00
CLIENT NAME Lake Sue Improvement Assoc.
SAMPLED DATE 01-17-90
LOCATION Lake Sue & Lake Rowena

In-Situ Data Summary - Surface Water

Site I.D.#	Time	Depth (m)	Dissolved Oxygen (ppm)	Conductivity umhos/cm	Temperature °C	pH	Secchi Depth (m)	Comments
R-2	0924	0.5 1.0 2.0 3.0 4.0 5.0 T=5.1	10.9 10.4 10.4 10.4 8.1 5.8	158 158 158 158 158 168	13.5 13.3 13.3 13.3 12.9 12.9	6.78		algae bloom
R-1	0941	0.5 1.0 2.0 T=2.3	9.6 9.5 9.5	158 158 158	13.4 13.3 13.3	6.23		
S-1	1002	0.5 1.0 2.0 3.0 4.0 5.0 T=5.5	9.5 9.4 9.5 9.3 6.3 5.4	158 158 158 158 158 155	13.6 13.4 13.3 13.2 11.7 11.6	7.44		
S-4	1016	0.5 1.0 2.0 3.0 4.0 T=4.25	10.8 11.1 11.0 9.3 7.0	158 155 155 153 153	13.4 13.2 13.0 12.7 12.4	8.27		
S-3	1030	0.5 1.0 2.0 3.0 4.0 T=4.1	13.4 13.2 13.1 12.7 12.4	11.4 11.6 11.2 10.4 7.3	153 153 153 152 152	8.34		
S-2	1043	0.5 1.0 2.0 3.0 4.0 T=4.25	13.2 13.0 12.9 12.9 12.2	11.7 11.7 11.7 11.5 8.2	153 153 153 153 153	8.11		

TECHNICIAN Bruno Ferraro
DATE 10-09-91
PROJECT # 05-009.00
CLIENT NAME Lake Sue Improvement Assoc.
SAMPLED DATE 05-09-90
LOCATION Lake Sue & Lake Rowena

In-Situ Data Summary - Surface Water

Site I.D.#	Time	Depth (m)	Dissolved Oxygen (ppm)	Conductivity umhos/cm	Temperature °C	pH	Secchi Depth (m)	Comments
R-2	1035	0.5 1.0 2.0 3.0 4.0 T=4.75	7.8 7.8 7.3 6.2 3.5	NA	21.7 21.6 21.5 21.5 21.3	NA	0.5	Aerators not operating - water very green
R-1	1052	0.5 1.0 T=1.5	7.8 7.4	NA	21.5 21.5	NA	0.5	Aerator working
1-S	1116	0.5 1.0 2.0 3.0 4.0 T=4.5	5.2 5.2 4.2 3.0 0.8	NA	21.4 21.4 21.1 20.7 19.1	NA	1.5	Dead vegetation on bottom
4-S	1136	0.5 1.0 2.0 3.0 T=3.75	9.1 9.2 9.0 8.4 6.2	NA	21.8 21.8 21.7 21.6 21.4	NA	1.25	Healthy standing crop of lilly, pond weed, coon tail, Typha
3-S	1150	0.5 1.0 2.0 3.0 T=4.0	9.5 9.4 9.3 9.2 9.0	NA	21.6 21.7 21.7 21.6 21.5	NA	1.25	
2S	1204	0.5 1.0 2.0 3.0 4.0 T=4.25	8.4 8.4 8.3 8.0 6.9	NA	21.5 21.5 21.4 21.4 21.3	NA	1.0	Water green

TECHNICIAN Revett Mickle
DATE 10-09-91
PROJECT # 05-009.00
CLIENT NAME Lake Sue Improvement Assoc.
SAMPLED DATE 08-01-90
LOCATION Lake Sue & Lake Rowena

In-Situ Data Summary - Surface Water

Site I.D.#	Time	Depth (m)	Dissolved Oxygen (ppm)	Conductivity umhos/cm	Temperature °C	pH	Secchi Depth (m)	Comments
R2	0930	0.5 1.0 2.0 3.0 4.0 T=4.4	8.08 8.26 6.96 4.24 0.56 0.41	0.203 0.203 0.205 0.205 0.208 0.213	30.77 30.71 30.54 30.21 29.73 29.52	8.08 8.11 7.87 7.58 7.10 6.90	0.80	Aerator on, water green
1R	1000	0.5 1.0 2.0 3.0 T=3.70	8.67 8.58 8.32 2.45 1.19	0.202 0.202 0.204 0.204 0.210	30.84 30.70 30.65 30.33 29.87	8.14 8.27 8.23 8.00 7.28	0.90	Clouded up, water green
1S	1030	0.5 1.0 2.0 3.0 4.0 5.0 T=5.6	6.31 6.23 4.60 2.37 0.35 0.31 0.44	0.207 0.207 0.208 0.209 0.223 0.349 0.379	31.03 30.89 30.67 30.29 29.08 25.39 24.71	7.42 7.48 7.34 7.03 6.78 6.09 5.97	1.2	Coontail floating in area, water green, some dead floating vegetation.
4S	1045	0.5 1.0 T=1.7	7.88 8.19 6.94	0.209 0.208 0.210	31.05 30.70 30.42	8.05 8.33 8.21	0.82	Water green
3S	1055	0.5 1.0 2.0 3.0 4.0 T=4.3	7.90 8.14 8.36 3.10 0.84 0.50	0.209 0.209 0.209 0.210 0.236 0.245	31.03 30.92 30.42 29.58 28.39 28.09	8.36 8.41 8.43 7.58 7.08 6.80	0.80	Some floating eel grass, water green

[redacted]ECH[redacted]IAN [redacted]
DATE 10-09-91
PROJECT # 05-009.00
CLIENT NAME Lake Sue Improvement Assoc.
SAMPLED DATE 09-24-90
LOCATION Lake Sue & Lake Rowena

In-Situ Data Summary - Surface Water

Site I.D.#	Time	Depth (m)	Dissolved Oxygen (ppm)	Conductivity umhos/cm	Temperature °C	pH	Secchi Depth (m)	Comments
R-2	0910	0.5 1.0 2.0 3.0 4.0 T=4.5	6.01 6.03 6.04 6.04 6.04 6.04	0.207 0.208 0.208 0.208 0.208 0.208	29.00 29.08 29.10 29.10 29.11 29.11	6.50 6.03 6.04 6.04 6.04 6.04	0.60	Weather sunny and breezy. Ambient temp. 70-75, water green
R-1	0940	0.5 1.0 2.0 3.0 T=3.25	6.76 6.62 6.57 6.64 6.65	0.207 0.208 0.208 0.207 0.207	28.78 28.81 28.78 28.80 28.69	7.00 7.00 7.10 7.15 7.16	0.75	
1-S	1000	0.5 1.0 T=1.25	3.88 4.25 4.37	0.218 0.218 0.218	28.41 28.34 28.15	6.81 6.75 6.74	1.30	Floating eel grass
4-S	1030	0.5 1.0 2.0 3.0 T=4.0	6.41 6.30 6.33 5.62 5.14	0.216 0.216 0.215 0.216 0.217	28.75 28.83 28.70 28.57 28.41	6.85 6.92 7.02 7.04 6.96	1.15	Some pond in the area.
3-S	1100	0.5 1.0 2.0 3.0 T=3.25	7.15 6.93 6.90 6.88 6.88	0.215 0.215 0.215 0.215 0.215	28.93 28.96 28.95 28.94 28.95	7.24 7.32 7.37 7.40 7.40	1.10	
2S	1115	0.5 1.0 2.0 3.0 4.0 T=4.25	6.94 6.84 6.83 6.85 6.80 6.28	0.216 0.216 0.216 0.216 0.216 0.217	29.30 29.29 29.17 29.14 29.12 29.00	7.36 7.34 7.37 7.39 7.39 7.29	1.10	

TECHNICIAN Revett Mickie
DATE 10-09-91
PROJECT # 05-009.00
CLIENT NAME Lake Sue Improvement Assoc.
SAMPLED DATE 02-05-91
LOCATION Lake Sue & Lake Rowena

In-Situ Data Summary - Surface Water

Site I.D.#	Time	Depth (m)	Dissolved Oxygen (ppm)	Conductivity umhos/cm	Temperature °C	pH	Secchi Depth (m)	Comments
2-R	0840	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 T=4.75	8.6 8.7 8.3 8.3 8.5 8.0 8.0 7.6 7.0	180 180 180 180 180 180 180 180 180	18.4 18.4 18.4 18.4 18.4 18.4 18.4 18.4 18.4	6.06	1.25	Weather sunny and warm. No wind, water color green
1-R	0850	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 T=4.5	8.0 7.4 8.3 8.2 8.2 8.2 8.2 8.0	180 180 180 180 180 180 180 180	18.3 18.3 18.3 18.3 18.3 18.3 18.3 18.3	6.06	1.50	
1-S	0915	0.5 1.0 1.5 2.0 2.5 T=2.75	6.5 6.6 7.4 7.5 7.5	190 190 190 190 190	18.3 18.3 18.3 18.3 18.4	5.75	2.75	Lots of hydrilla in the area. Water is real clear, not as green.
4-S	0925	0.5 1.0 1.5 2.0 2.5 3.0 T=3.25	9.7 9.3 9.7 9.8 9.5 9.3	190 190 190 190 190 190	18.3 18.3 18.3 18.3 18.3 18.3	5.84	1.25	Water cloudy and green, lots of pond weed in area.

Site I.D. #	Time	Depth (m)	Dissolved Oxygen (ppm)	Conductivity umhos/cm	Temperature °C	pH	Secchi Depth (m)	Comments
3-S	0935	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 T=4.5	10.0 10.0 10.0 9.6 9.7 9.7 9.5 9.2	190 190 190 180 180 180 180 180	18.4 18.4 18.4 18.3 18.2 18.2 18.2 18.2	5.69	1.50	water green
2S	0950	0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 T=4.5	9.6 9.7 9.4 9.3 9.5 9.8 9.8 9.7	185 190 190 190 190 190 190 190	18.3 18.3 18.2 18.2 18.2 18.2 18.2 18.2	6.56	1.30	

LSUE36.TBL/LAKE/1009910500900

[redacted]
DATE 10-14-91
PROJECT # 05-009.00
CLIENT NAME Lake Sue Improvement Assoc.
SAMPLED DATE 10-10-91
LOCATION Lake Sue & Lake Rowena

In-Situ Data Summary - Surface Water

Site I.D.#	Time	Depth (m)	Dissolved Oxygen (ppm)	Conductivity umhos/cm	Temperature °C	pH	Secchi Depth (m)	Comments
R-1	0930	0.5 1.0 2.0 3.0 4.0 T=4.88	6.23 6.19 6.24 6.11 6.01 5.85	173 173 173 173 173 172	25.66 25.67 25.69 25.67 25.67 25.64	7.10 7.06 7.00 6.47 6.45 6.42	0.80	weather sunny, ambient temp 75°, water green
R-2	0950	0.5 1.0 2.0 3.0 T=3.5	6.47 6.40 5.89 5.86 5.66	173 172 172 173 173	25.54 25.54 25.50 25.49 25.48	7.11 7.08 7.01 6.96 6.92	0.80	
S-1	1015	0.5 1.0 2.0 3.0 4.0 5.0 T=5.7	5.71 5.81 5.89 5.32 4.25 3.57 3.57	174 175 175 176 176 176 177	25.33 25.30 25.17 25.13 25.07 25.01 25.01	7.14 7.10 7.05 7.00 6.93 6.87 6.77	1.0	Water very green
S-3	1030	0.5 1.0 2.0 3.0 T=3.8	7.98 7.93 7.61 7.34 2.10	182 181 182 182 182	25.41 25.40 25.26 25.23 25.23	7.59 7.54 7.52 7.45 7.39	.92	
S-4	1050	0.5 1.0 2.0 T=2.1	7.66 7.13 5.67 5.65	182 183 183 183	25.43 25.33 25.27 25.25	7.53 7.49 7.36 7.30	0.85	Pond weed in area, heavy algae growing around the pond weed.

Appendix C

Water Quality Data
Collected by Orange County

LAKE SUE (ORANGE COUNTY DATA)

SUE		ALK.	pH	T.P.	OP	T.N.	NH3	NO3	NO2	TKN	TSS	VSS	TDS	F.C.	S.D.	Chl-a	TSI
O.C.		mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	100ml	m	mg/m3	(FL.)
11/11/74	74	62	7.50	0.018	0.004	0.91					8.0	3.0	116		1.21	28.1	55
3/17/81	81	66	7.50	0.060		1.40	0.29	0.06			5.0	5.0	152	*20*	1.00	12.9	58
6/16/81	81	41	9.20	0.040		1.62	0.08	0.02			5.0	5.0	135	*20*	0.40	26.8	72
9/22/81	81	55	7.40			1.20	0.12	*0.04*						20	0.60	30.2	67
12/21/81	81			0.054		1.20	0.20	0.08						*20*	1.50	13.2	53
3/2/82	82	60	7.00	0.031		1.20	0.09	*0.04*		1.20				*20*	2.60	10.1	46
6/1/82	82	53	8.50	0.053		0.84	0.08	*0.04*		0.84				44	0.80	33.8	63
8/31/82	82	57	6.30	0.033		1.00	0.25	*0.04*		0.99				*20*	1.00	24.3	60
11/23/82	82	53	6.50	0.045		1.40	0.09	*0.04*		1.40				32	0.90	31.0	65
9/3/86	86	46	7.70	0.056		1.21	0.19	0.04		1.17				*20*	0.80		61
7/29/87	87		8.10	0.033	*0.02*	0.45	*0.04*	*0.01*	*0.020*	0.45						32.0	51
2/1/88	88	45	6.50	0.050		2.17	*0.04*	1.848	0.010	0.32	7.5			>120	2.40	3.9	46
8/15/88	88	48	7.00	0.030	*0.02*	0.22	0.08	0.03	*0.010*	0.19	5.0		95	130		25.4	44
10/18/88	88	53	7.80	0.032	0.001	0.34	0.03	0.018	*0.010*	0.32	5.5		106	2		33.9	50
2/1/89	89		7.30	0.028	*0.01*	0.17	*0.01*	0.011	*0.010*	0.16	1.0			18	1.90	8.9	37
5/23/89	89		9.10		0.002	0.74	*0.03*	*0.01*	*0.010*	0.74	7.0			4	1.20	15.0	54
7/31/89	89			0.029	0.003	0.85	0.03	0.025	*0.010*	0.83	7.0			*2*	0.80	20.7	59
10/30/89	89		7.30	0.024	0.002	1.17	0.02	0.011	*0.010*	1.16	4.5			10	1.00	32.4	59
1/30/90	90	53	7.00	0.040	0.001	0.56	0.14	0.035	*0.01*	0.52	8.0			2	2.20	9.8	44
4/24/90	90	57	8.70	0.030	*0.001*	1.09	0.04	0.019	*0.01*	1.07	*0.4*		109	14	1.80		49
8/2/90	90	49	8.60	0.028	*0.001*	0.80	0.04	0.042		0.76	*1.0*		142	2	0.80	26.7	59
9/24/90	90	51	8.10	0.066	0.005	0.96	0.07	0.01		0.95	6.0		131	*2*	1.10	27.7	60
1/22/91	91	58.8	7.90	0.029	*0.001*	0.72	0.02	*0.01*	*0.010*	0.72	6.0	6.0	131	14	1.00	17.0	55
4/17/91	91	39	8.70	0.016	0.008	0.40	*0.01*	*0.01*	*0.01*	0.40	1.5	1.5	124	2	1.40	14.5	47

LAKE ROWENA (ORANGE COUNTY DATA)

ROWENA	ALK.	pH	T.P.	O.P	T.N.	NH3	NO3	NO2	TKN	TSS	VSS	TDS	F.C.	S.D.	Chl-a
	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	100	m	mg/m3
9/24/73	78	7.9	0.010	0.01	1.05		0.04		1.01	10	8.0	131		1.07	27.7
8/5/74	63	7.9	0.040	0.01	1.06			0.002	1.06	7	7.0	115		0.71	44.7
8/13/74	57	6.5	0.045	<0.001	1.01		0.05	0.002	1.01	0	0.0	114		0.91	40.6
10/1/74	64	7.4	0.019	0.009	1.00		0.03		0.97	10	6.0	113		0.76	38.1
5/19/75	49	8.3	0.038	0.005	1.25		0.02	0.003	1.23	6	6.0	121		0.61	50.9
11/15/77	59		0.025	<0.01	1.20		<0.1		1.20	10	7.0	118			59.1
6/29/83	55	8.8	0.050		1.38		<0.04		1.38						20.5
2/1/88	61	7.3	0.041		0.32	*0.04*	0.027	*0.01*	0.29	1.5		123		1.80	21.1
8/15/88	46	6.9	0.052	0.02	0.36	0.144	0.049	*0.01*	0.31	7.5		105	310		51.6
10/18/88	47	7.0	0.046	0.005	0.47	0.03	0.019	*0.01*	0.45	8		100	2		50.9
2/1/89	46	6.8	0.042	0.001	0.15	*0.01*	0.015	*0.01*	0.14	2.5		103	18	1.30	16.4
5/23/89	48	8.8		0.009	1.21	0.078	0.019	*0.01*	1.19	14		116	54	0.50	62.8
7/31/89			0.048	0.003	0.87	0.025	0.03	*0.01*	0.84	6.5		100	46	0.80	41.9
10/30/89	49	7.0	0.056	0.001	1.06	0.033	0.029	*0.01*	1.03	5.5		121	46	0.50	53.2
1/30/90	47	7.1	0.045	*0.001*	0.64	0.041	0.014	*0.01*	0.63	7.5		126	12	1.30	25.2
4/24/90	61	8.7	0.049	*0.001*	1.56	0.057	0.04	*0.01*	1.51	6.5		115	34	1.00	
8/2/90	61	8.8	0.056	*0.001*	1.24	0.066	*0.01*	*0.01*	1.21	4		138	8	0.80	54.1
9/24/90	64	8.5	0.035	0.007	1.11	0.129	0.024	*0.01*	1.08	16		114	26	0.60	49.4
1/22/91	58	7.7	0.048	*0.001*	0.58	0.01	*0.01*	*0.01*	0.58	6.5	6.5	128	28	1.20	25.9
4/17/91	39	8.8	0.032	0.008	0.38	*0.01*	*0.01*	*0.01*	0.38	4	4.0	108	4	1.40	17

ORANGE COUNTY POLLUTION CONTROL DEPARTMENT

PLANKTON SUMMARY

• [*NOT FOR PUBLICATION*] •

LOCATION Sue

STATION HB 36

SAMPLE NUMBER	DEPTH	CHLOROPHYLL A			CHLOROPHYLL			NON AST CAROT-ENOIDS	CHLOR. A SP-	TOTAL LIVE ALGAE	MIN. NO. SPECIES	CYANOPHYTA		CHLOROPHYTA				CHRYSOPHYTA		OTHER	P.G.I.
		B/A	FUNCT.	N-FUNCT.	A	B	C					COCC.	FIL.	COCC.	FIL.	FLAG.	EUG.	CENT.	PENN.		
20905 1-3090	surf	150.0	7.9	3.2	9.8	1.4	0.2	4.5	2.3	1080	7	360	240	360				60	60		2
21298 4-2490	surf	183.8	0.0	0.0	0.0	0.0	0.0	0.0	1.4												
21759 8-2 90	surf	164.0	25.0	2.3	26.7	2.8	0.0	19.3	1.4												
dup dup	surf	168.9	23.6	0.4	25.2	0.0	0.0	18.0	1.4												
22026 9-2490	surf	166.7	26.6	1.3	27.7	3.9	0.0	13.3	2.1	1380	9	60	1020	120		60	120				~~0~~
	dup	164.9	25.2	2.0	26.5	3.4	6.1	13.4	2.0												
22513 1-2291	surf	155.9	14.7	3.7	17.0	1.3	2.8	8.0	2.1	3600	10	360	600	1560		300			720	60	11
23070 4-1791	surf	173.9	15.2	0.0	14.7	2.1	0.0	12.3	1.2												
23677 7-2391	surf	173.2	14.6	0.0	17.5	0.0	1.5	12.4	1.2	2460	15	720	420	1080		60			120	60	7
dup	surf	160.0	12.2	2.0	13.5	1.3	3.7	12.4	1.1												
field	surf	157.1	12.3	2.8	13.9	1.9	8.9	13.4	1.0												

45-46 (9/79)

ORANGE COUNTY POLLUTION CONTROL DEPARTMENT
Microbiology Summary
[NOT FOR PUBLICATION]

LOCATION Sue

STATION HB36

SAMPLE NUMBER	FECAL INDICATORS 100ml T.C.	F.C.	F.S.	STAPH AURUS 100ml	P.AERUGINOSA 100ml	A.HYDROPHILA 100ml	STD. AEROB PER ml	P.C.35°C ANAER PER ml	H2S PROD. PER ml	ISOL PO4 PER ml	TOTAL FUNGI	OTHER PARAMETERS	REMARKS	REVIEW BY
20905 1-30-90	2E & 20E	2E	<2		<1	40E	8×10^2							
21298 4-24-90	16E	14E	10E		41	>800	1.11×10^3							
21759 8-1-90	16E	2E	4E		8E	<10	1.62×10^3							
dup	14E	2E	4E		2E	<10	1.90×10^3							
22626 9-24-90	20E	<2	<2		>80	38E	326						11:00	
22513 1-22-91	28E	14E	2E		28	730	320						8:44	
23070 4-17-91	56	6E	8E		<1	380	420						0833	
23677 7-23-91	<2	2E	<2		56	>800	70E							
dup	<2	4E	<2		57	710	100E							
field	4E	6E	<2		33	330	90E							

ORANGE COUNTY POLLUTION CONTROL DEPARTMENT
PLANKTON SUMMARY
• [NOT FOR PUBLICATION] •

LOCATION Cheneen STATION HB 34

SAMPLE NUMBER	DEPTH	CHLOROPHYLL A B/A	CHLOROPHYLL A FUNCT.	CHLOROPHYLL A N-FUNCT.	CHLOROPHYLL A	CHLOROPHYLL B	CHLOROPHYLL C	NON AST CAROT-ENOIDS	CHLOR. A SP-	TOTAL LIVE ALGAE	MIN. NO. SPECIES	CYANOPHYTA COCC.	CYANOPHYTA FIL.	CHLOROPHYTA COCC.	CHLOROPHYTA FIL.	CHLOROPHYTA FLAG.	CHLOROPHYTA EUG.	CHRYSOPHYTA CENT.	CHRYSOPHYTA PENN.	OTHER	P.G.I.
18322 9-1588	surf	158.6	46.9	9.1	51.6	14.1	0.0	18.6	2.9	34080	12	540	31440	600		120	540		720	120	10
18716 10-1888	surf	159.8	46.1	7.9	50.9	5.4	13.2	24.3	2.1	159420	8	360	15720	660			120		1080		9
19136 2-189	surf	155.0	14.1	3.8	16.4	1.8	6.7	9.6	1.7	19440	9	180	15726	1080				240	2220		8
19821 5-2389	surf	164.7	58.3	4.8	62.8	0.0	7.4	40.6	1.6	126840	11	480	117960	1086			60		7320		9
20142 7-3189	surf	152.8	35.0	11.4	41.9	4.9	0.0	20.2	2.1	89280	17	600	86520	1200		240	360		240	120	11
dup	surf	157.8	35.6	7.5	40.3	4.3	0.0	20.1	2.0												
field	surf	161.1	33.5	4.9	36.5	3.7	11.1	18.2	2.0												
20548 10-3089	surf	158.4	46.5	9.2	53.2	0.0	8.1	23.0	2.3	18960	18	540	15726	1260		120	60	120	1020	120	12
20906 1-3090	surf	150.0	20.5	8.2	25.2	5.4	0.6	9.7	2.6	3360	14	360	540	1200		120	60	240	720	120	9
dup 1-3090	surf	148.5	19.8	8.8	24.9	5.4	1.3	9.7	2.6												
field 1-3090	surf	151.6	20.7	7.4	24.9	5.2	0.0	9.8	2.6												
21299 4-2490	surf	250.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5												
21758 8-190	surf	159.3	38.5	7.0	45.1	0.0	0.0	23.2	2.0												
22025 9-2490	surf	162.2	45.9	5.8	49.4	6.6	14.0	22.4	2.2	31800	7	15720	15720	180		60			120		2
dup	surf																				
field	surf																				
22514 1-2291	surf	153.2	21.2	6.7	25.9	0.0	1.9	10.3	2.5	2640	11	120	240	1740		60			480		6
dup	surf	157.4	21.3	4.7	24.1	3.6	8.7	9.9	2.4												
field	surf	161.7	23.1	3.1	25.8	0.0	1.6	10.7	2.4												
23071 4-1791	surf	170.9	17.1	0.0	17.0	2.1	0.0	10.4	1.6												
dup	surf	163.9	17.7	1.7	18.7	2.8	0.0	11.6	1.6												
field	surf	166.1	16.9	1.0	17.6	2.4	0.0	10.5	1.7			—	LE	—							
23678 7-2391	surf	159.5	13.8	2.4	15.2	2.1	5.2	14.1	1.1	1800	10	480	240	840				120	120		8

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ORANGE COUNTY POLLUTION CONTROL DEPARTMENT
Microbiology Summary
[NOT FOR PUBLICATION]

LOCATION Rowena

STATION H334

SAMPLE NUMBER	FECAL INDICATORS 100ml T.C.	F.C.	F.S.	STAPH AURUS 100ml	P.AERUGINOSA 100ml	A.HYDROPHILA 100ml	STD. AEROB PER ml	P.C.35°C ANAER PER ml	H2S PROD. PER ml	ISOL PO4 PER ml	TOTAL FUNGI	OTHER PARAMETERS	REMARKS	REVIEW BY
18322 8-1588	160E	310	120		>80	>800	1.13×10^3							[illegible]
18716 10-1888	58	2E	20E		10E	150E	3.8×10^2							[illegible]
19136 2-189	26E	18E	8E		2E	190E	4.5×10^2							[illegible]
19921 5-2389	>160	54	142		>80	>800	15							[illegible]
20142 7-3189	164E	46	6E		6E	260	3.7×10^2							[illegible]
dup	170E	42	2E		8E	280	4.4×10^2							[illegible]
field	162E	44	2E		7E	220	4.1×10^2							[illegible]
20548 10-389	>160	46	<2		3E	>800	LE							[illegible]
20906 1-3090	610	12E	4E		3E	1050E	5.7×10^2							[illegible]
dup 1-3090	420	16E	4E		1E	760E	5.0×10^2							[illegible]
field 1-3090	580	10E	4E		2E	920E	5.3×10^2							[illegible]
21299 4-2490	42	34E	208		O.G.	>800	$>3 \times 10^3$							[illegible]
21758 8-190	18E	8E	44E		20E	20E	2.3×10^2							[illegible]
22025 9-2490	50	26	8E		>80	390	330						9:05	[illegible]
dup	38	18E	10E		>80	80	310							
field	56	20E	8E		>80	70	300							[illegible]
22514 1-2291	114	28E	<2		24	650	530						8:25	[illegible]
dup	126	24E	8E		24	610	560							
surf	106	30E	<2		32	590	510							[illegible]
23071 4-1791	28E	4E	4E		7E	680	480						0822	[illegible]
dup	80	8E	6E		7E	360	580							
field	120	4E	6E		4E	240	390							[illegible]
23678 7-2391	24E	6E	<2		18E	150E	330							[illegible]

45-46 (9/79)

Appendix D

Water Quality Data Collected by the City of Orlando and by Lake Sue Project Team

1991 - DNR AQUATIC PLANT SURVEY FORM AND MANAGEMENT REPORT

Water Body Lake Sue County Orange Date 7-22-9

DATE (YYMMDD)	SURV	WATER BODY CODE	SPECIES	CODE	ACREAGE	PROB*
910721	28	21430	Eichhornia crassipes	FE-ECS	0	
			Pistia stratiotes	FE-PSS	0	
			Hydrilla verticillata	SE-HVA	6.0	

COOPERATOR: City of Winter Park & Orange County

*Explain species, acreage and location of problem vegetation and possible solution(s) for achieving control. Include map of water body locating problem vegetation.

Approximate Estimates for remaining Submerged plant species - coverage = ~ 85%

	Acres
Potamogeton illinoensis	36.0
Vallisneria americana	36.0
Ceratophyllum demersum	24.0
Najas quadalupensis	12.0
Nitella sp	6.0
Hydrilla	6.0

PROBLEM RATING
None - 0
Moderate - 1
Severe - 2

Entered ____/____
Initials/Date

DNR AQUATIC PLANT SURVEY FORM AND MANAGEMENT REPORT

Water Body Lake Sue County Orange Date 8-2-90

Species	Code	Acreage	Prob
Alternanthera philoxeroides	EE-APS		
Azolla caroliniana	FE-ACA		
Bacopa caroliniana	EN-BCA		
Bacopa monnieri	EN-BMI		
Bidens spp	EN-BLS		
Brachiaria mutica	EE-BPS	0.1	
Brasenia schreberi	EN-BSI		
Cabomba caroliniana	SN-CCA		
Canna spp	EN-CGS		
Carex spp	EN-CXS		
Cephalanthus occidentalis	EN-COS		
Ceratophyllum demersum	SN-CDM	9.0	
Ceratopteris spp	FE-CST		
Chara spp	SN-CHA		
Cicuta mexicana	EN-CMA		
Cladium jamaicense	EN-CJE		
Colocasia esculenta	EE-CEA	0.1	
Crinum americanum	EN-CAM		
Cyperus alternifolius	EN-CAF	0.1	
Cyperus articulatus	EN-CAT		
Cyperus spp	EN-CSA	0.1	
Decodon verticillatus	EN-DVS		
Echinochloa spp	EN-ECI		
Echinodorus cordifolius	EN-ECS		
Egeria densa	SE-EDA		
Eichhornia crassipes	FE-ECS		
Eleocharis cellulosa	EN-ECA		
Eleocharis interstincta	EN-EIA		
Eleocharis spp	EN-ESP		
Filamentous algae	FN-FAL	28.0	
Fontinalis spp	SN-FSP		
Fuirena scirpoidea	EN-FSC		
Habenaria repens	FN-HRS		
Heteranthera dubia	SN-HDA		
Hydrilla verticillata	SE-HVA	1.0	
Hydrocotyle spp	EN-HYE	0.2	
Hygrophila polysperma	SE-HPA		
Hymenocallis spp	EN-HYM		
Hypericum spp	EN-HYS		
Ipomoea aquatica	EE-IAA		
Juncus effusus	EE-JES		
Juncus repens	EE-JRP		
Juncus roemerianus	EN-JRS		
Juncus spp	EN-JSP		
Leersia hexandra	EN-LHA		
Lemna spp	FN-LEN		
Limnobium spongia	FN-LSA		
Limnophila sessiliflora	EE-LSS		
Ludwigia spp	EN-LAA		
Ludwigia arcuata	SN-LAR		
Ludwigia octovalvis/peruviana	EN-LOP	0.2	
Ludwigia palustris/repens	EN-LPR		
Luziola fluitans	SN-LFS		
Mayaca fluviatilis	SN-MAI		
Micranthemum glomeratum	SN-MMS		
Micranthemum umbrosum	EN-MUM		
Mikania scandens	EN-MSS		
Myriophyllum aquaticum	EE-MAM		
Myriophyllum heterophyllum	SN-MHM		
Myriophyllum laxum/pinnatum	SN-MLM		
Myriophyllum spicatum	SE-MSM		
Najas ancistrocarpa	SE-NAA		

Species	Code	Acreage	Prob
Najas guadalupensis	SN-NGS	1.0	
Najas marina	SN-NMA		
Najas minor	SE-NMR		
Nasturtium officinale	EE-NOE		
Nelumbo lutea	EN-NLA		
Nitella spp	SN-NIT	2.0	
Nuphar luteum	EN-NLM	0.3	
Nymphaea mexicana	EN-NMX		
Nymphaea odorata	EN-NOA		
Nymphoides aquatica	EN-NNA		
Orontium aquaticum	EN-OAA		
Panicum hemitomon	EN-PHN	0.2	
Panicum repens	EE-PRS		
Paspalidium geminatum	EN-PGM	0.7	
Paspalum repens	EN-PRS	0.3	
Peltandra virginica	EN-PVA		
Pennisetum purpureum	EE-PPM		
Phragmites australis	EE-PAS		
Pistia stratiotes	FE-PSS		
Polygonum spp	EN-POL		
Pontederia cordata	EN-PCA	0.1	
Potamogeton crispus	SE-PCS		
Potamogeton diversifolius	SN-PDS		
Potamogeton illinoensis	SN-PIS	11.0	
Potamogeton pectinatus	SE-PPS		
Potamogeton pulcher	SN-PPR		
Potamogeton pusillus	SN-PPS		
Proserpinaca spp	SN-PSP		
Rhynchospora spp	EN-RCA		
Riccia fluitans	FN-RFS		
Ricciocarpus natans	FN-RNS		
Ruppia maritima	SN-RMA		
Sacciolepis striata	EN-SSA		
Sagittaria kurziana	EN-SKA		
Sagittaria lancifolia	EN-SLA		
Sagittaria latifolia	EN-SLT	0.1	
Sagittaria stagnorum	EN-SSM		
Sagittaria subulata/graminea/gracillima	EN-SSG		
Salix spp	EN-SXS	0.1	
Salvinia minima	FE-SRA		
Saururus cernuus	EN-SSC		
Scirpus cubensis	EN-CSS		
Scirpus spp	EN-SSP	0.1	
Sparganium americanum	EN-SAM		
Spartina alterniflora	EN-SAA		
Spartina bakeri	EN-SBI		
Spartina patens	EN-SPS		
Spirodela spp	FN-SPA		
Thalia geniculata	EN-TGA		
Typha spp	EN-TYP	0.5	
Utricularia floridana	SN-UFA		
Utricularia gibba/biflora	SN-UBA		
Utricularia foliosa	SN-UFS		
Utricularia inflata	SN-UIA		
Utricularia purpurea	SN-UPA		
Vallisneria americana	SN-VAA	20.0	
Websteria confervoides	SN-WCS		
Wolffia spp	FN-WSP		
Wolffiella gladiata	FN-WGA		
Zizania aquatica	EN-ZAA		
Zizaniopsis miliacea	EN-ZMA		

1991 - DNR AQUATIC PLANT SURVEY FORM AND MANAGEMENT REPORT

Water Body Lake Sue County Orange Date 7-22-9

DATE (YYMMDD)	SURV	WATER BODY CODE	SPECIES	CODE	ACREAGE	PROB*
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			Pistia stratiotes	FE-PSS	0	
			Hydrilla verticillata	SE-HVA	6.0	

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Entered ________/____
Initials/Date

DNR AQUATIC PLANT SURVEY FORM AND MANAGEMENT REPORT

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Bacopa monnieri	EN-BMI		
Bidens spp.	EN-BLS		
Brachiaria mutica	EE-BPS	0.1	
Brasenia schreberi	EN-BSI		
Cabomba caroliniana	SN-CCA		
Canna spp.	EN-CGS		
Carex spp.	EN-CXS		
Cephalanthus occidentalis	EN-COS		
Ceratophyllum demersum	SN-CDM	9.0	
Ceratopteris spp.	FE-CST		
Chara spp.	SN-CHA		
Cicuta mexicana	EN-CMA		
Cladium jamaicense	EN-CJE		
Colocasia esculenta	EE-CEA	0.1	
Crinum americanum	EN-CAM		
Cyperus alternifolius	EN-CAF	0.1	
Cyperus articulatus	EN-CAT		
Cyperus spp.	EN-CSA	0.1	
Decodon verticillatus	EN-DVS		
Echinochloa spp.	EN-ECI		
Echinodorus cordifolius	EN-ECS		
Egeria densa	SE-EDA		
Eichhornia crassipes	FE-ECS		
Eleocharis cellulosa	EN-ECA		
Eleocharis interstincta	EN-EIA		
Eleocharis spp.	EN-ESP		
Filamentous algae	FN-FAL	28.0	
Fontinalis spp.	SN-FSP		
Fuirena scirpoidea	EN-FSC		
Habenaria repens	FN-HRS		
Heteranthera dubia	SN-HDA		
Hydrilla verticillata	SE-HVA	1.0	
Hydrocotyle spp.	EN-HYE	0.2	
Hygrophila polysperma	SE-HPA		
Hymenocallis spp.	EN-HYM		
Hypericum spp.	EN-HYS		
Ipomoea aquatica	EE-IAA		
Juncus effusus	EE-JES		
Juncus repens	EE-JRP		
Juncus roemerianus	EN-JRS		
Juncus spp.	EN-JSP		
Leersia hexandra	EN-LHA		
Lemna spp.	FN-LEN		
Limnobium spongia	FN-LSA		
Limnophila sessiliflora	EE-LSS		
Ludwigia spp.	EN-LAA		
Ludwigia arcuata	SN-LAR		
Ludwigia octovalvis/peruviana	EN-LOP	0.2	
Ludwigia palustris/repens	EN-LPR		
Luziola fluitans	SN-LFS		
Mayaca fluviatilis	SN-MAI		
Micranthemum glomeratum	SN-MMS		
Micranthemum umbrosum	EN-MUM		
Mikania scandens	EN-MSS		
Myriophyllum aquaticum	EE-MAM		
Myriophyllum heterophyllum	SN-MHM		
Myriophyllum laxum/pinnatum	SN-MLM		
Myriophyllum spicatum	SE-MSM		
Najas ancistrocarpa	SE-NAA		

Species	Code	Acreage	Prob
Najas guadalupensis	SN-NGS	1.0	
Najas marina	SN-NMA		
Najas minor	SE-NMR		
Nasturtium officinale	EE-NOE		
Nelumbo lutea	EN-NLA		
Nitella spp.	SN-NIT	2.0	
Nuphar luteum	EN-NLM	0.3	
Nymphaea mexicana	EN-NMX		
Nymphaea odorata	EN-NOA		
Nymphoides aquatica	EN-NNA		
Orontium aquaticum	EN-OAA		
Panicum hemitomon	EN-PHN	0.2	
Panicum repens	EE-PRS		
Paspalidium geminatum	EN-PGM	0.7	
Paspalum repens	EN-PRS	0.3	
Peltandra virginica	EN-PVA		
Pennisetum purpureum	EE-PPM		
Phragmites australis	EE-PAS		
Pistia stratiotes	FE-PSS		
Polygonum spp.	EN-POL		
Pontederia cordata	EN-PCA	0.1	
Potamogeton crispus	SE-PCS		
Potamogeton diversifolius	SN-PDS		
Potamogeton illinoensis	SN-PIS	11.0	
Potamogeton pectinatus	SE-PPS		
Potamogeton pulcher	SN-PPR		
Potamogeton pusillus	SN-PPS		
Proserpinaca spp.	SN-PSP		
Rhynchospora spp.	EN-RCA		
Riccia fluitans	FN-RFS		
Ricciocarpus natans	FN-RNS		
Ruppia maritima	SN-RMA		
Sacciolepis striata	EN-SSA		
Sagittaria kurziana	EN-SKA		
Sagittaria lancifolia	EN-SLA		
Sagittaria latifolia	EN-SLT	0.1	
Sagittaria stagnorum	EN-SSM		
Sagittaria subulata/graminea/gracillima	EN-SSG		
Salix spp.	EN-SXS	0.1	
Salvinia minima	FE-SRA		
Saururus cernuus	EN-SSC		
Scirpus cubensis	EN-CSS		
Scirpus spp.	EN-SSP	0.1	
Sparganium americanum	EN-SAM		
Spartina alterniflora	EN-SAA		
Spartina bakeri	EN-SBI		
Spartina patens	EN-SPS		
Spirodela spp.	FN-SPA		
Thalia geniculata	EN-TGA		
Typha spp.	EN-TYP	0.5	
Utricularia floridana	SN-UFA		
Utricularia gibba/biflora	SN-UBA		
Utricularia foliosa	SN-UFS		
Utricularia inflata	SN-UIA		
Utricularia purpurea	SN-UPA		
Vallisneria americana	SN-VAA	20.0	
Websteria confervoides	SN-WCS		
Wolffia spp.	FN-WSP		
Wolffiella gladiata	FN-WGA		
Zizania aquatica	EN-ZAA		
Zizaniopsis miliacea	EN-ZMA		

LAKE SUE

SUE		ALK.	pH	T.P.	O.P	T.N.	NH3	NO3	NO2	TKN	TSS	VSS	TDS	F.C.	S.D.	Chl-a	TSI
		mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	100ml	m	mg/m3	(FL.)
4/20/88	S-1	58	7.71	0.014	0.009	0.92	0.14	0.07	0.005	0.85	1.5	0.5	127	20	1.42	11.7	47
4/20/88	S-2	54	8.38	0.024	0.014	1.17	0.06	0.29	0.005	0.88	3.0	1.8	124	70	1.20	14.2	54
4/20/88	S-3	54	8.41		0.018	1.29	0.37	0.22	0.005	1.07	3.5	1.5	125	4	1.30	13.4	56
4/20/88	S-4	54	8.25	0.034	0.018	1.36	0.35	0.26	0.005	1.10	3.0	2.0	114	2	1.37	14.0	55
8/14/88	S-1	40	7.20	0.086	0.005	1.04	0.02	0.05	0.005	1.04	3.0	3.0	105	102	0.91	22.0	62
8/14/88	S-2	46	7.00	0.077	0.006	1.04	0.02	0.05	0.005	1.04	6.0	6.0	111	31	0.93	26.0	62
8/14/88	S-3	46	7.95	0.068	0.005	1.20	0.26	0.05	0.005	1.20	5.5	5.5	108	18	0.98	13.0	58
8/14/88	S-4	48	7.90	0.043	0.006	1.17	0.28	0.05	0.005	1.17	4.5	4.5	109	7	0.95	22.0	59
11/8/88	S-1	44	6.92	0.030	0.005	0.75	0.06	0.05	0.010	0.74	5.0	4.0	87	58	1.25	21.0	54
11/8/88	S-2	44	7.02	0.043	0.005	0.70	0.11	0.05	0.006	0.69	6.0	4.0	92	44	1.15	26.0	57
11/8/88	S-3	43	7.10	0.049	0.005	0.73	0.10	0.05	0.007	0.72	6.0	4.0	101	56	1.10	25.0	57
11/8/88	S-4	36	6.48	0.027	0.005	0.79	0.10	0.05	0.005	0.79	5.0	3.0	109	18	1.15	20.0	54
3/15/89	S-1	53	7.90	0.029	0.005	0.53	0.02	0.05	0.005	0.53	1.5	1.5	103	16	2.25	18.0	46
3/15/89	S-2	50	8.45	0.016	0.005	0.37	0.02	0.05	0.005	0.37	1.5	1.5	105	6	2.75	6.6	36
3/15/89	S-3	48	8.35	0.019	0.005	0.39	0.02	0.05	0.005	0.39	0.5	0.5	101	8	2.50	8.5	39
3/15/89	S-4	51	8.45	0.022	0.005	0.30	0.02	0.05	0.005	0.30	0.5	0.5	103	6	2.50	6.4	37
6/28/89	S-1	55	7.35	0.074	0.005	1.46	0.12	0.05	0.005	1.46	7.0	5.0	103	14	0.83	38.0	66
6/28/89	S-2	52	8.80	0.048	0.005	1.52	0.27	0.05	0.005	1.52	7.0	6.0	105	6	0.71	28.0	68
6/28/89	S-3	47	8.70	0.048	0.005	1.32	0.19	0.05	0.005	1.32	16.0	11.0	103	2	0.88	29.0	62
6/28/89	S-4	47	8.70	0.038	0.005	1.29	0.14	0.05	0.005	1.29	10.0	7.0	109	2	0.80	26.0	64
1/11/90	S-1	62	7.42	0.035	0.005	0.68	0.16	0.02	0.02	0.68	3.0	0.5	131	24	2.00	12.0	47
1/11/90	S-2	62	7.89	0.038	0.005	0.78	0.10	0.02	0.02	0.78	2.5	1.0	136	4	1.25	9.3	51
1/11/90	S-4	66	7.82	0.024	0.005	0.76	0.19	0.02	0.02	0.76	1.2	0.8	132	12	1.57	18.0	52
4/25/90	S-1	63	8.60	0.057	0.007	1.02	0.05	0.02	0.02	1.02	2.5	1.5	111	580	0.90	30.0	62
4/25/90	S-3	53	8.97	0.037	0.007	1.7	0.02	0.02	0.02	1.70	0.5	0.5	110	6	1.50	9.7	53
4/25/90	S-4	52	8.76	0.034	0.007	0.92	0.02	0.02	0.02	0.92	1.5	0.5	107	110		9.1	50
8/1/90	S-1	55	7.73	0.014	0.005	1.09	0.02	0.02	0.02	1.07	2.5	1.0	171	184	1.20	15.0	50
8/1/90	S-3	55	8.78	0.018	0.011	1.13	0.02	0.02	0.02	1.13	2.0	2.0	171	10	0.80	24.0	58
8/1/90	S-4	50	8.86	0.010	0.005	1.21	0.02	0.02	0.02	1.21	4.0	2.5	181	220	0.82	30.0	54
9/24/90	S-1	52	7.36	0.021	0.005	0.99	0.08	0.02	0.02	0.99	4.0	4.0	132		1.30	22.0	54
9/24/90	S-3	51	8.21	0.014	0.005	1.19	0.02	0.02	0.02	1.19	8.0	6.0	136	15	1.10	26.0	
9/24/90	S-4	51	7.97	0.014	0.005	1.14	0.02	0.02	0.02	1.14	7.0	4.0	143	280	1.10	34.0	54
1/23/91	S-1	52	7.84	0.031	0.005	0.56	0.03	0.02	0.02	0.54	0.5	0.5	123	42	1.90	6.7	53
1/23/91	S-3	54	8.04	0.031	0.005	0.74	0.03	0.02	0.02	0.74	0.5	0.5	129	16	1.30	13.0	51
5/9/91	S-1	53	7.85	0.075	0.005	0.94	0.03	0.02	0.02	0.94	3.5	2.0	112	8	1.20	26.0	59
5/9/91	S-3	50	8.21	0.036	0.005	1.00	0.06	0.02	0.02	1.00	6.0	3.0	117	6	0.80	25.0	61
5/9/91	S-4	48	8.20	0.039	0.005	1.12	0.03	0.02	0.02	1.12	5.0	3.0	120	16	0.80	29.0	62

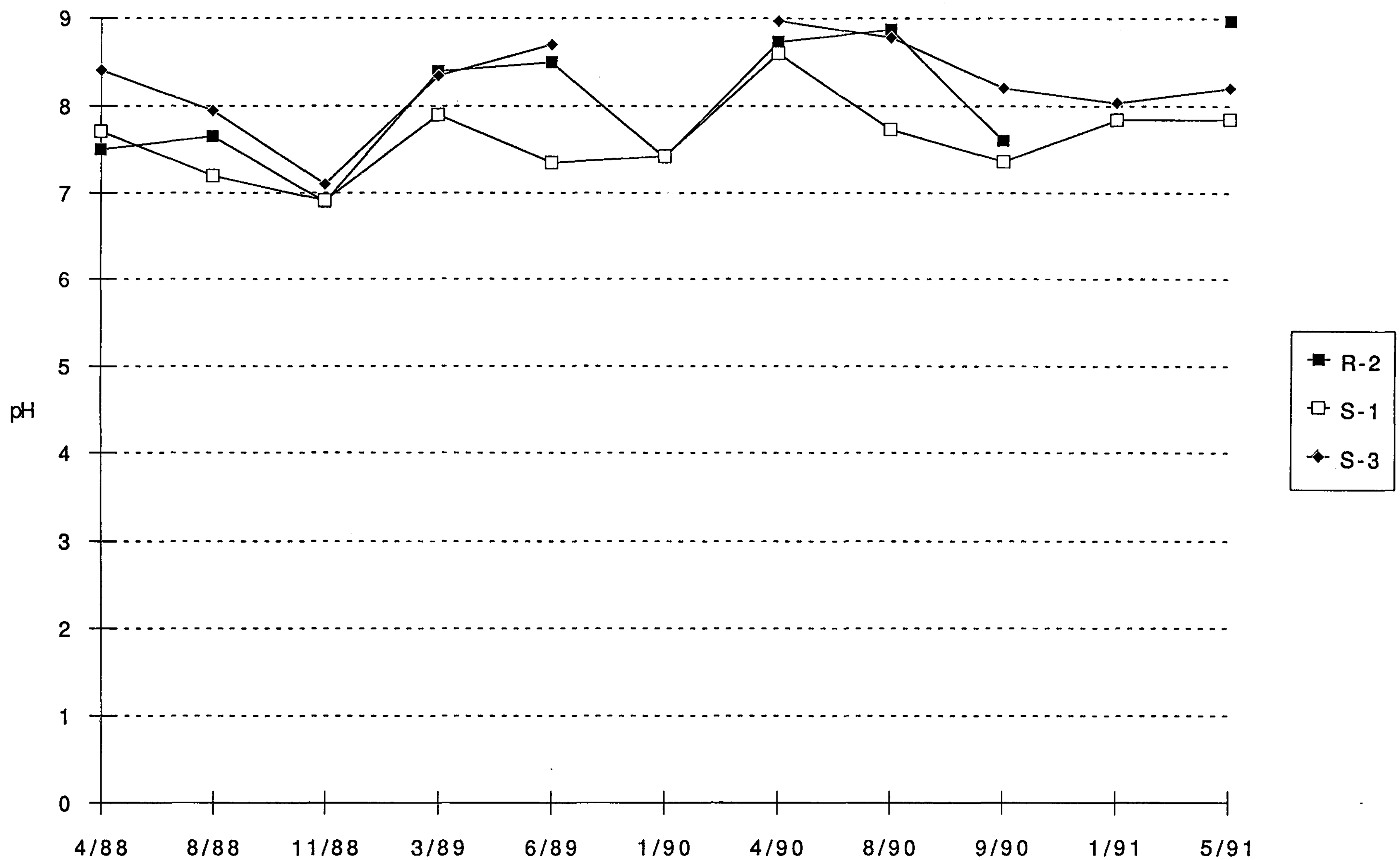
LAKE ROWENA (STATION R-2)

ROWENA (MID)	ALK.	pH	T.P.	O.P	T.N.	NH3	NO3	NO2	TKN	TSS	VSS	TDS	F.C.	S.D.	Chl-a	TSI
2R	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	100ml	m	mg/m3	(FL.)
10/27/87	54.5	8.23	0.063	*0.005*	1.03	0.23	*0.05*	*0.005*	1.03	9.0	7.7	117	13	0.82	42.6	65
4/20/88	60	7.50	0.029	0.018	0.68	0.036	0.08	*0.005*	0.6	2.0	0.5	127	54	1.73	13.4	48
8/4/88	46	7.65	0.060	*0.005*	1.00	0.04	0.056	*0.005*	0.94	4.5	4.5	102	102	0.99	38	62
11/8/88	45	6.90	0.055	*0.005*	0.87	0.06	*0.05*	*0.005*	0.82	3.5	2.5	92	340	1.06	31	60
3/15/89	58	8.40	0.035	*0.005*	0.52	*0.02*	*0.05*	*0.005*	0.52	1.5	1.5	112	*2*	1.25	18	52
6/28/89	55	8.50	0.077	*0.005*	1.52	0.22	*0.05*	*0.005*	1.52	6.0	5.0	101	8	0.76	51	68
1/11/90	68	7.41	0.049	0.005	0.69	0.12	*0.02*	*0.02*	0.69	4.7	0.7	132	18	1.50	23	54
4/25/90	63	8.73	0.068	0.007	0.97	*0.02*	*0.02*	*0.02*	0.97	4.0	1.0	113	6100	0.80	38	65
8/1/90	55	8.87	0.057	*0.005*	1.06	*0.02*	*0.02*	*0.02*	1.06	2.5	2.0	168	450	0.80	41	65
9/24/90	58	7.60	0.046	*0.005*	1.84	*0.02*	*0.02*	*0.02*	1.84	10.0	5.0	134	36	0.60	42	71
5/9/91	51	8.97	0.062	*0.005*	1.07	*0.03*	*0.02*	*0.02*	1.07	4.0	2.0	108	4	0.75	40	65

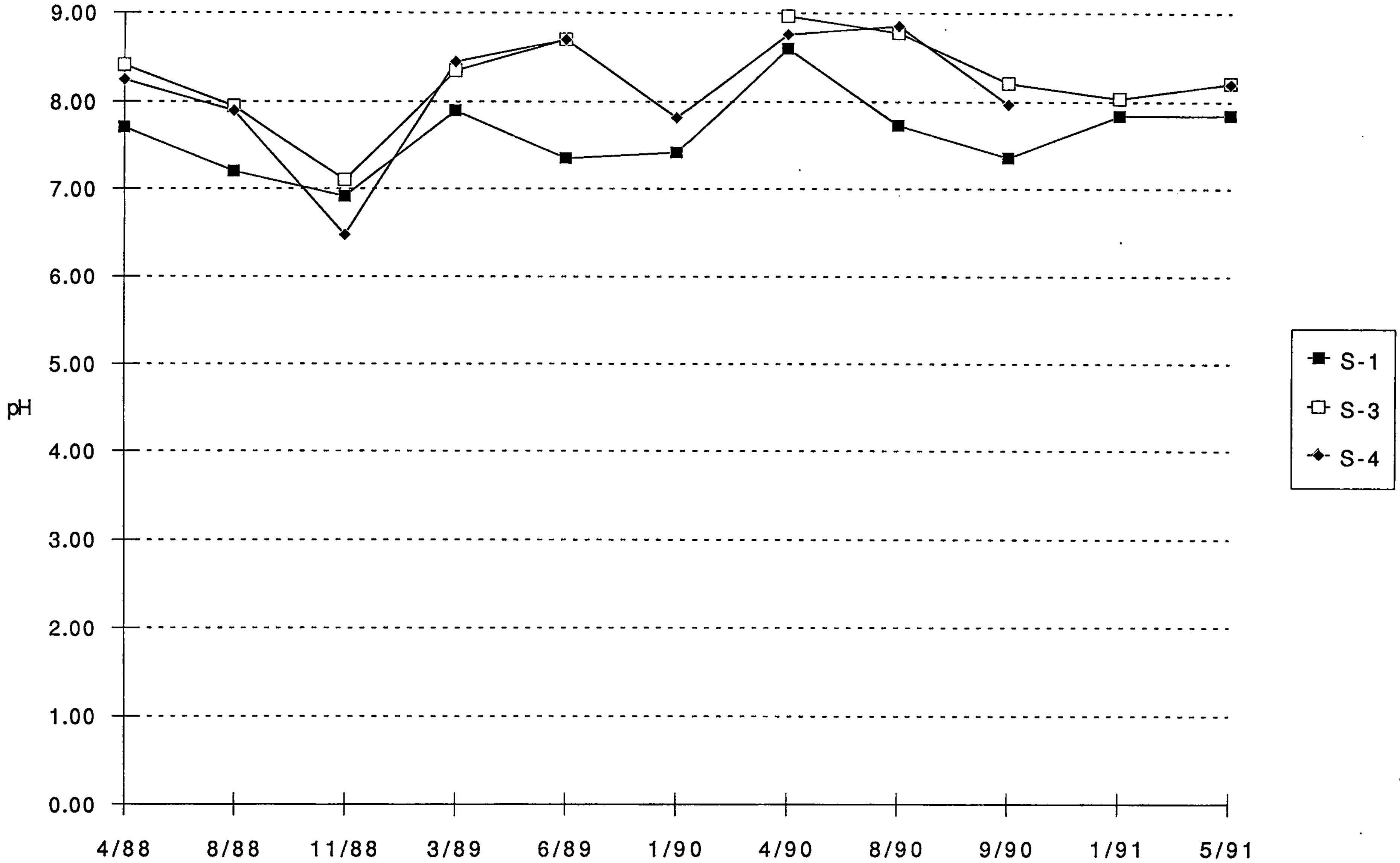
Appendix E

Graphical Data Summaries

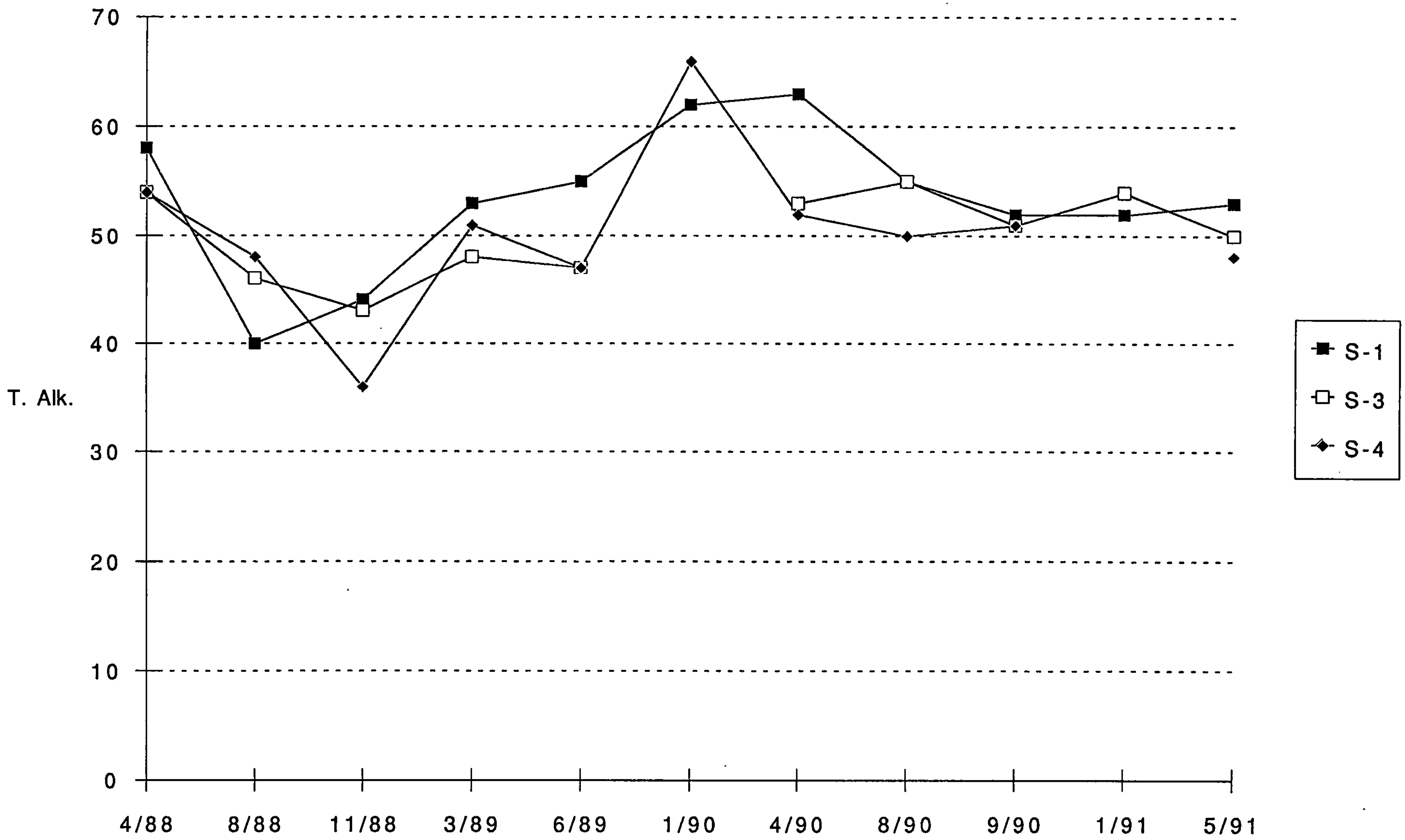
pH values in Lake Rowena (station 2) and Lake Sue (stations 1 and 3) from 4/88 to 5/91



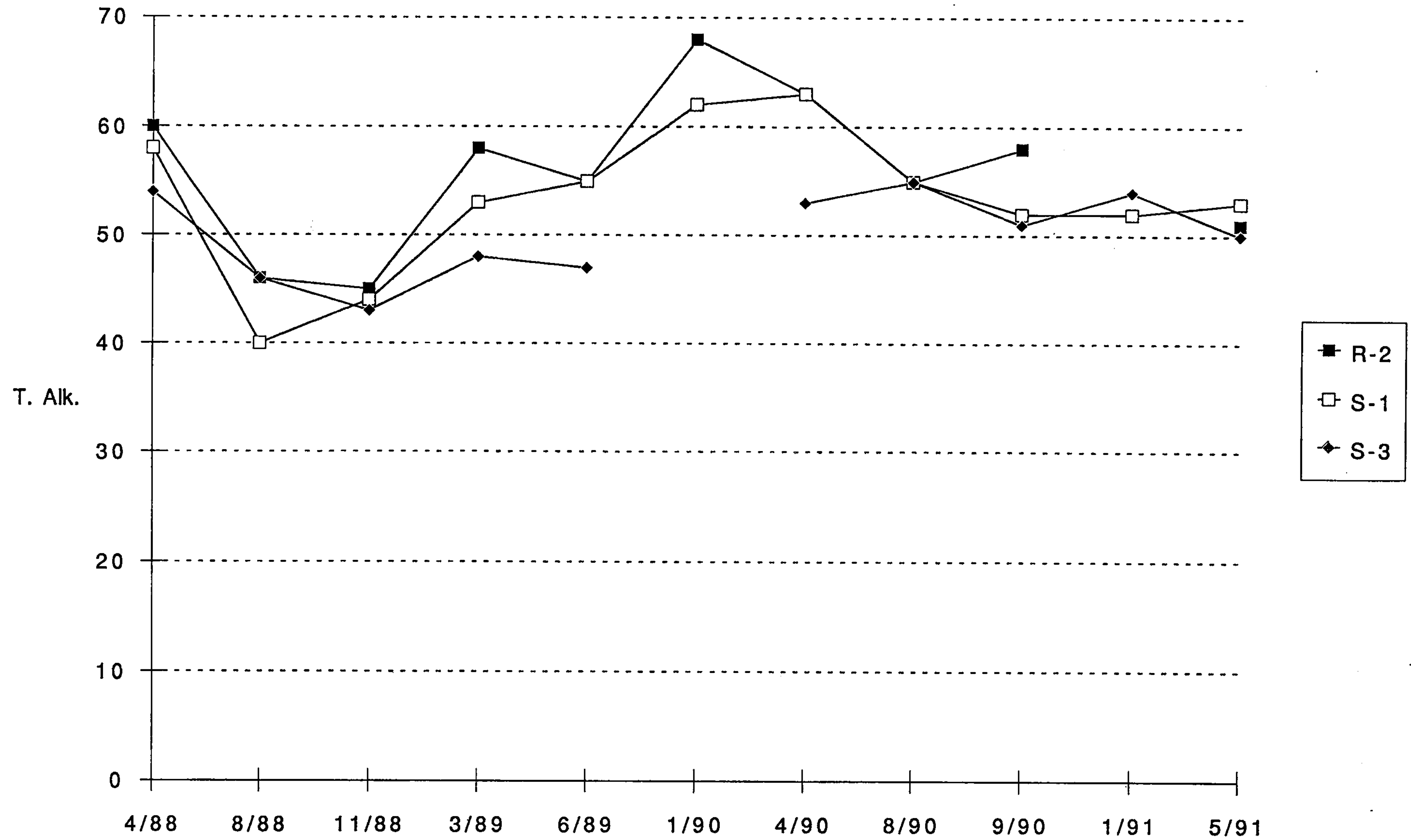
pH values at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



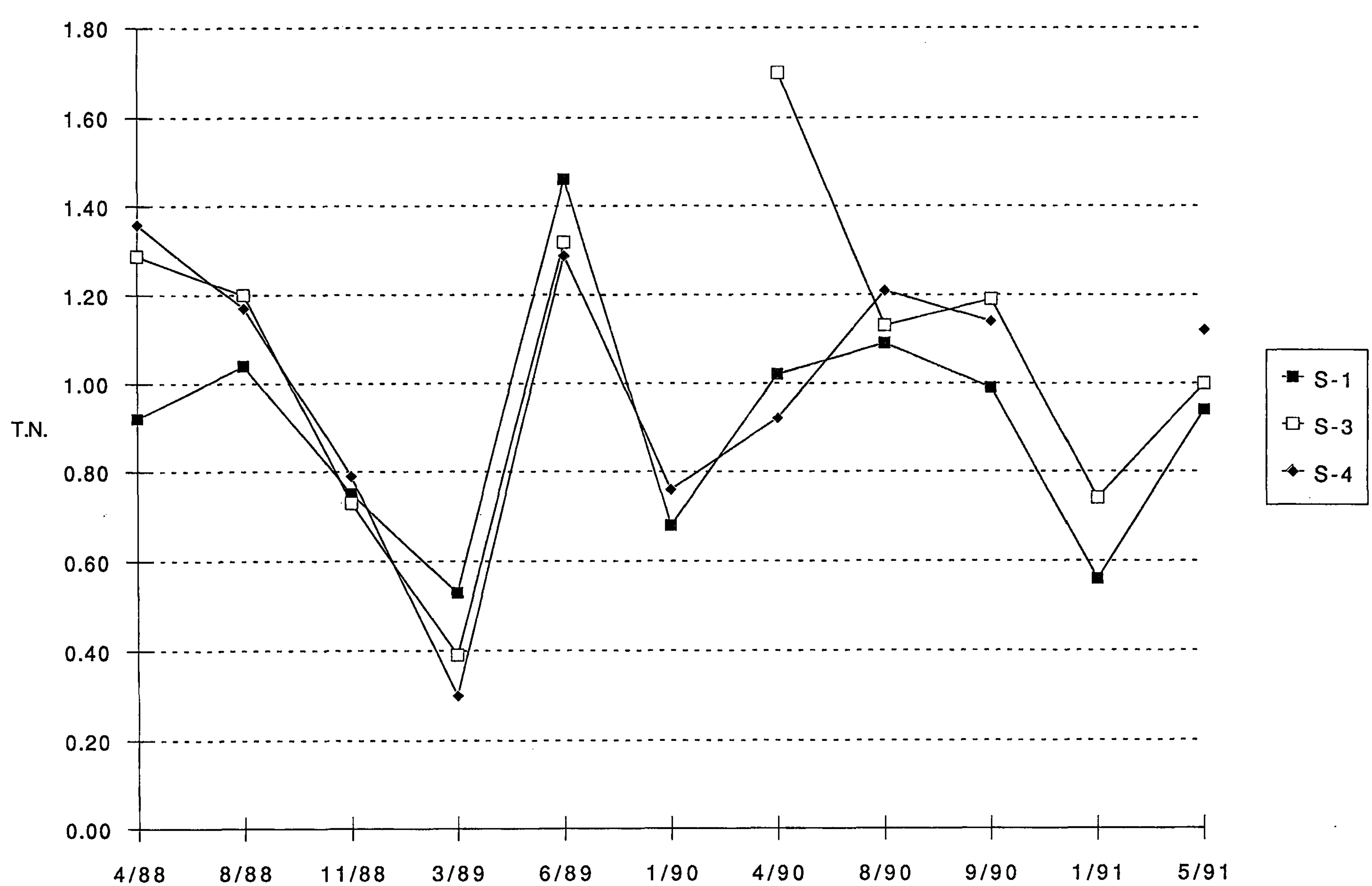
Total alkalinity concentrations (mg/l) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



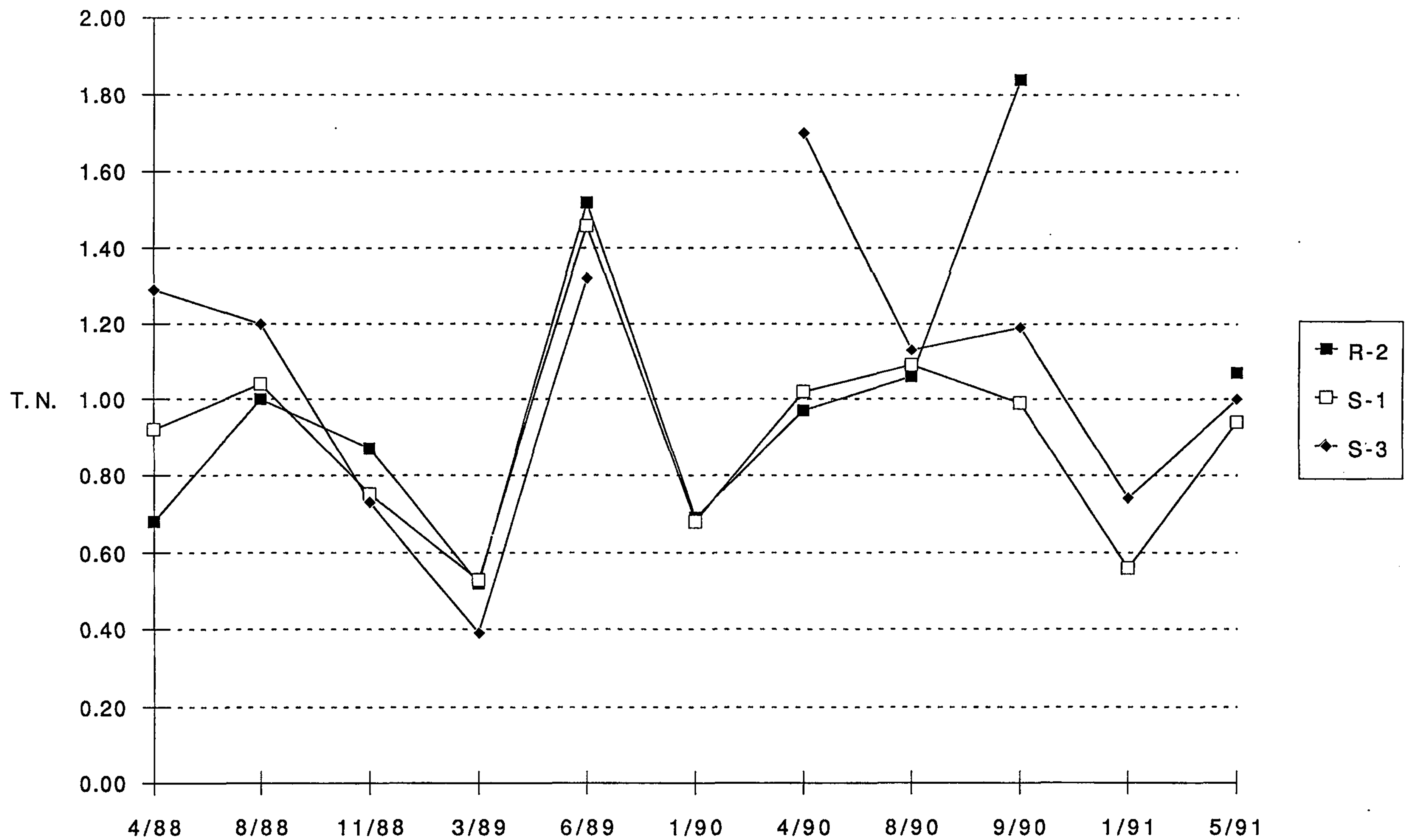
Total alkalinity in Lake Rowena (station 2) and Lake Sue (station 1 and 3) from 4/88 to 5/91.



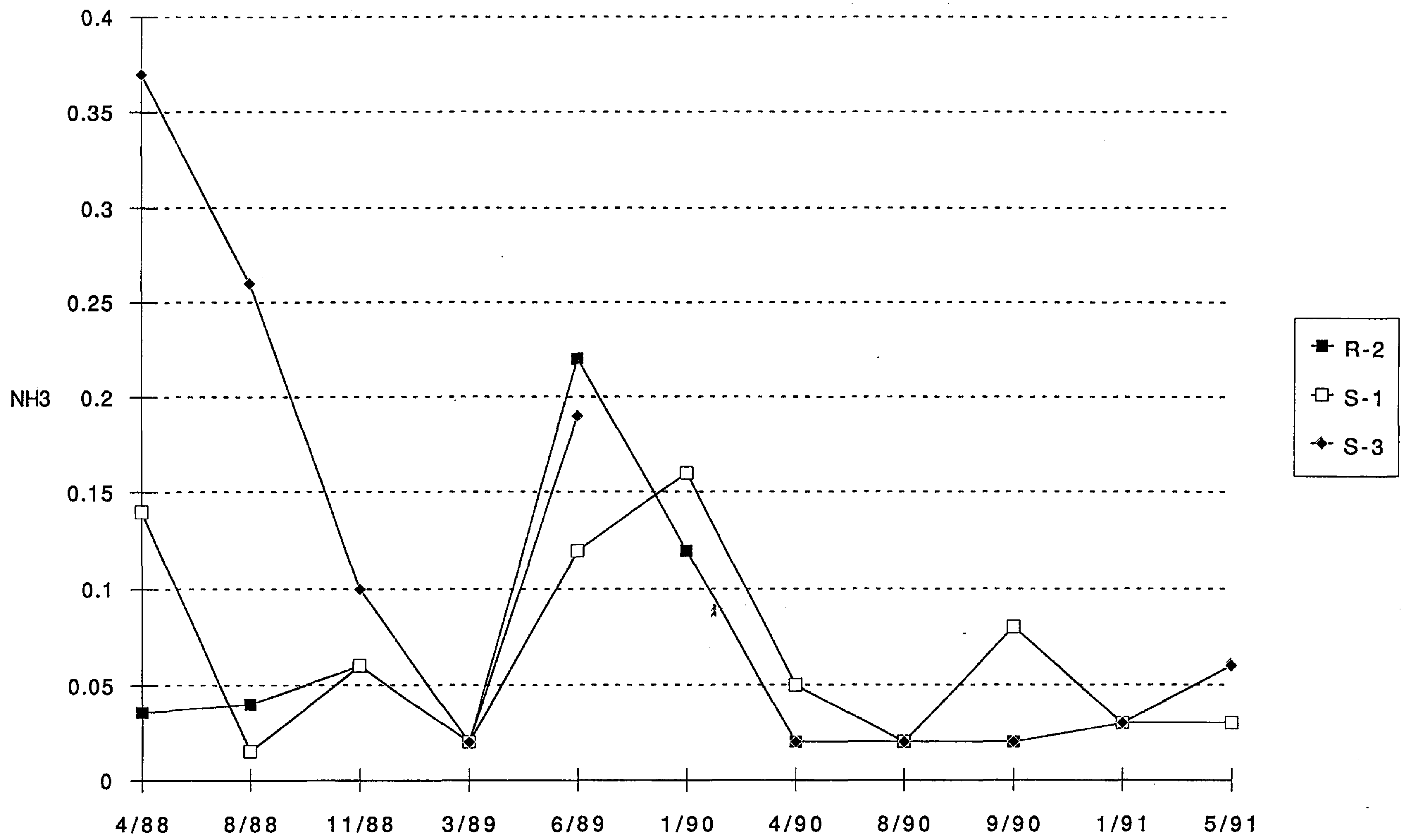
Total nitrogen concentrations (mg/l) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



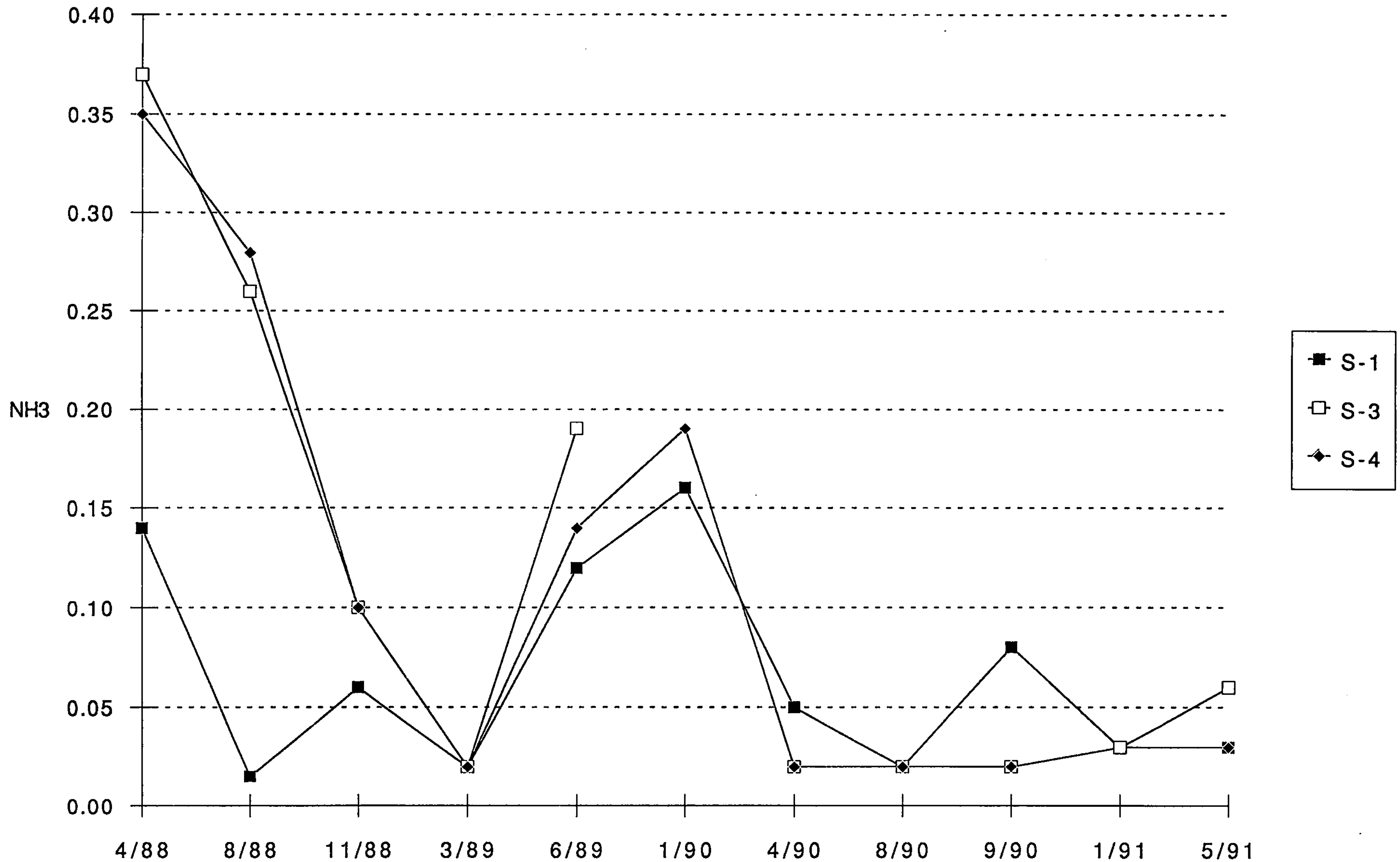
Total nitrogen (mg/l) in Lake Rowena (station 2) and Lake Sue (stations 1 and 3) from 4/88 to 5/91.



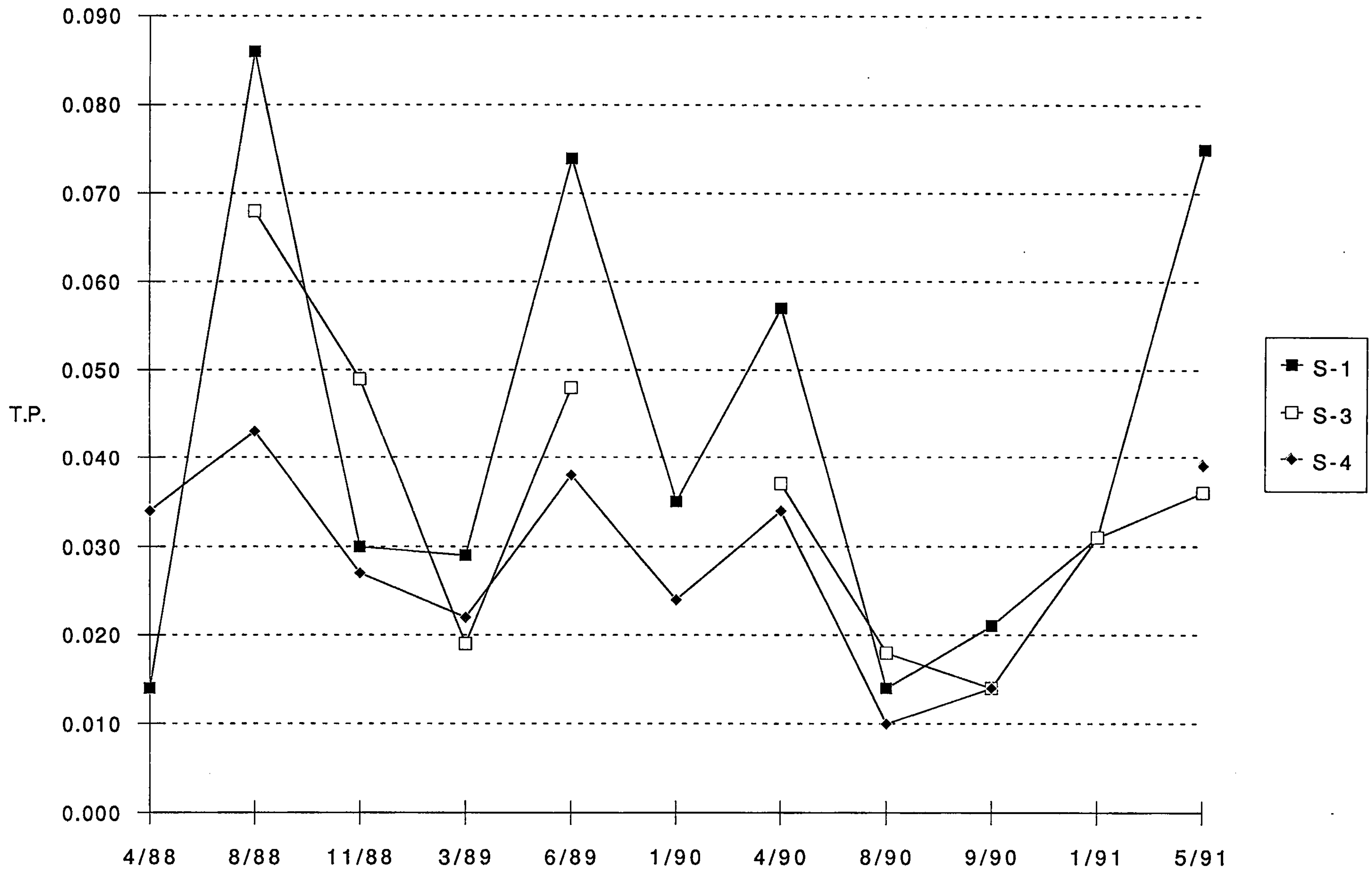
Ammonia (mg/l) in Lake Rowena (station 2) and Lake Sue (station 1 and 3) from 4/88 to 5/91.



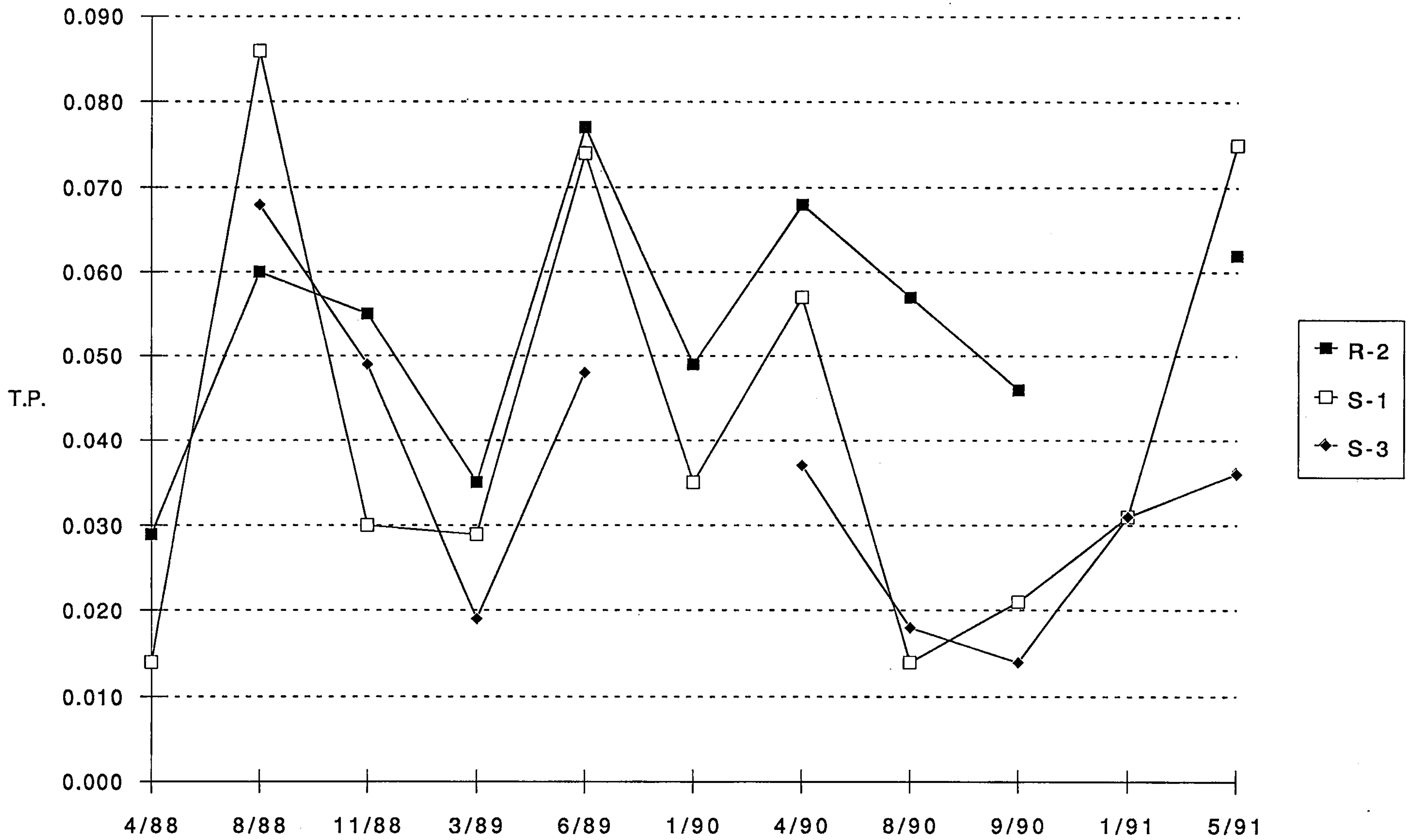
Ammonia concentrations (mg/l) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



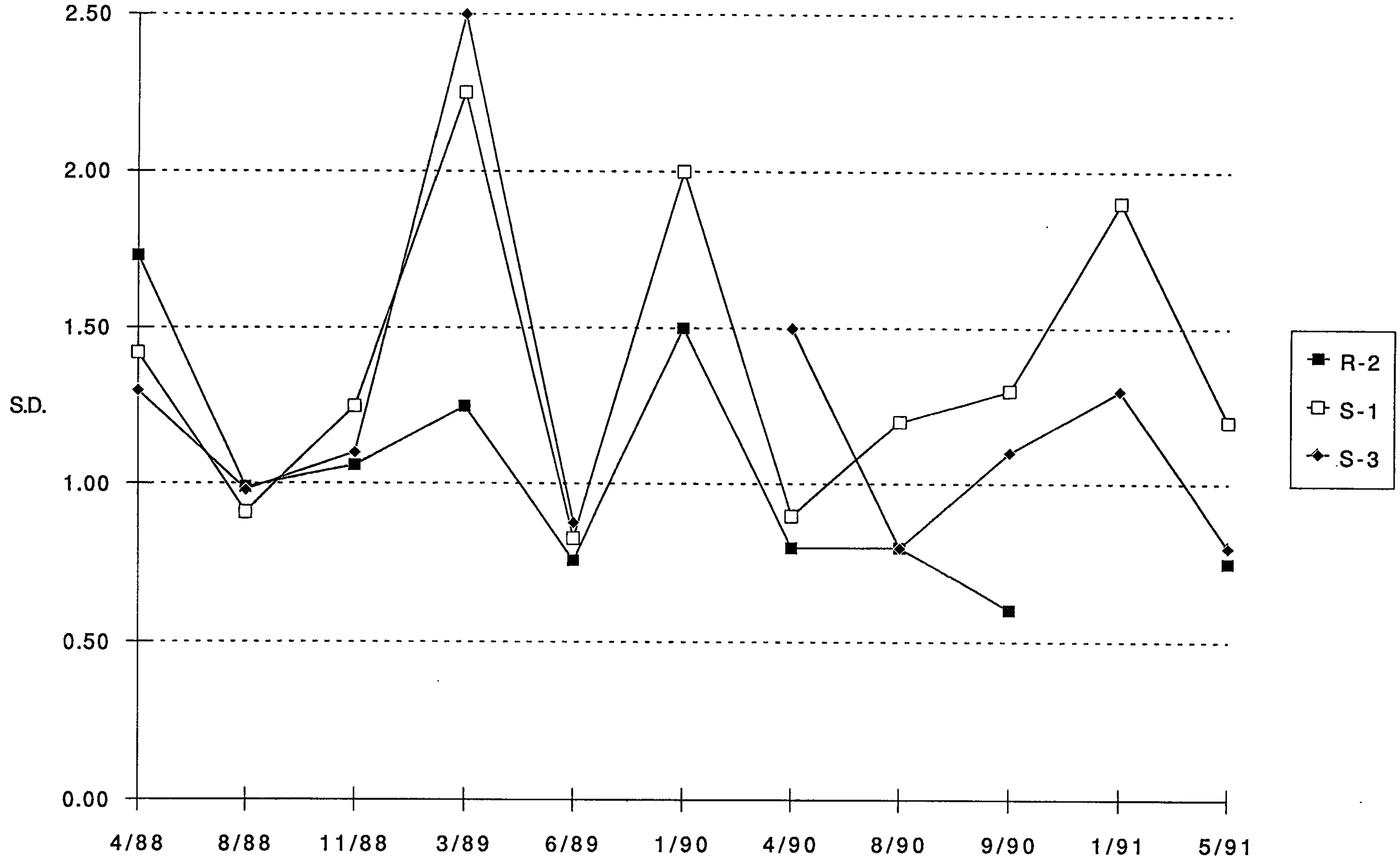
Total phosphorus (mg/l) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



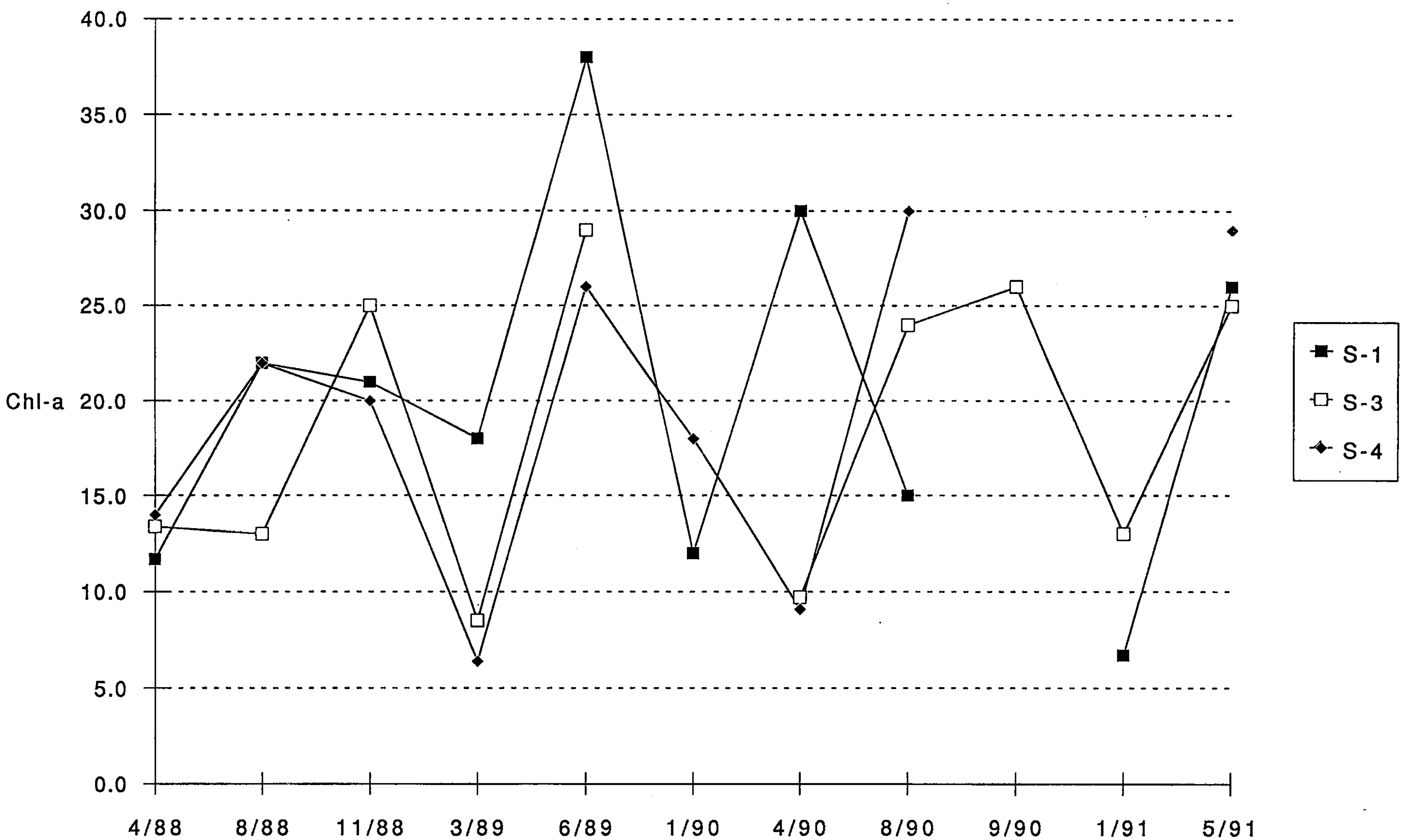
Total Phosphorus (mg/l) in Lake Rowena (station 2) and Lake Sue (stations 1 and 3) from 4/88 to 5/91.



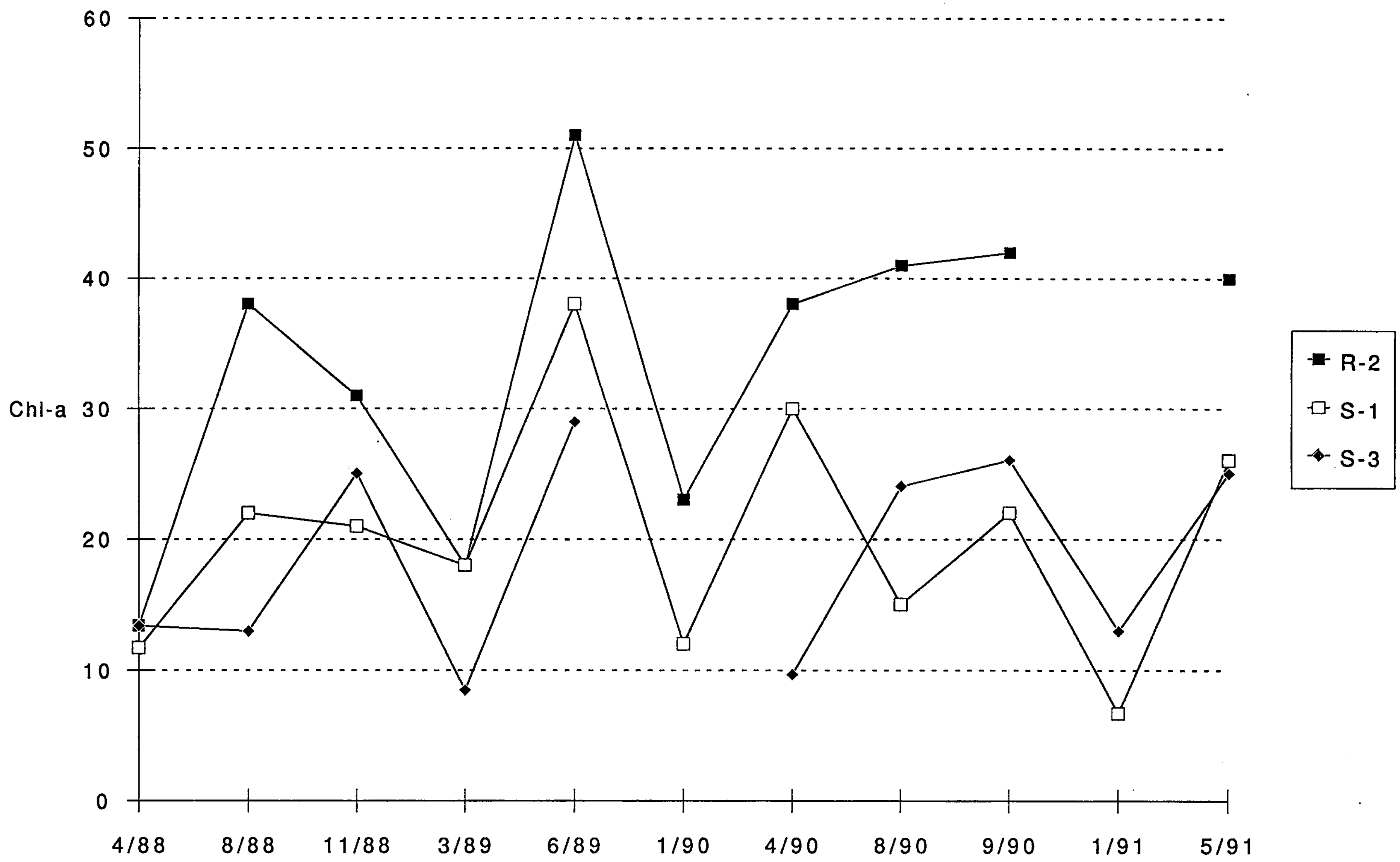
Secchi depth (m) in Lake Rowena (station 2) and Lake Sue (station 1 and 3) from 4/88 to 5/91.



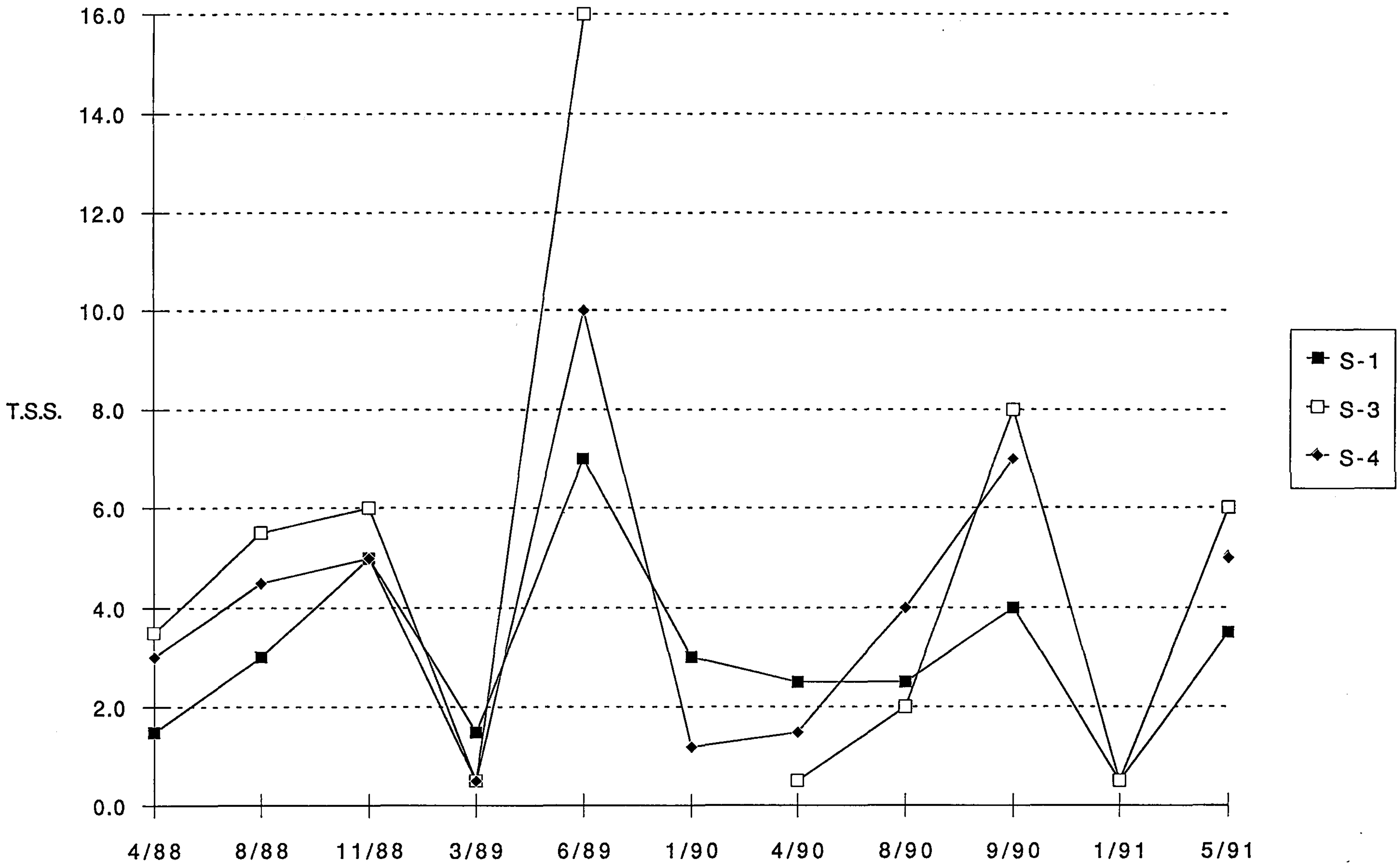
Chlorophyll - a concentrations (mg / m3) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



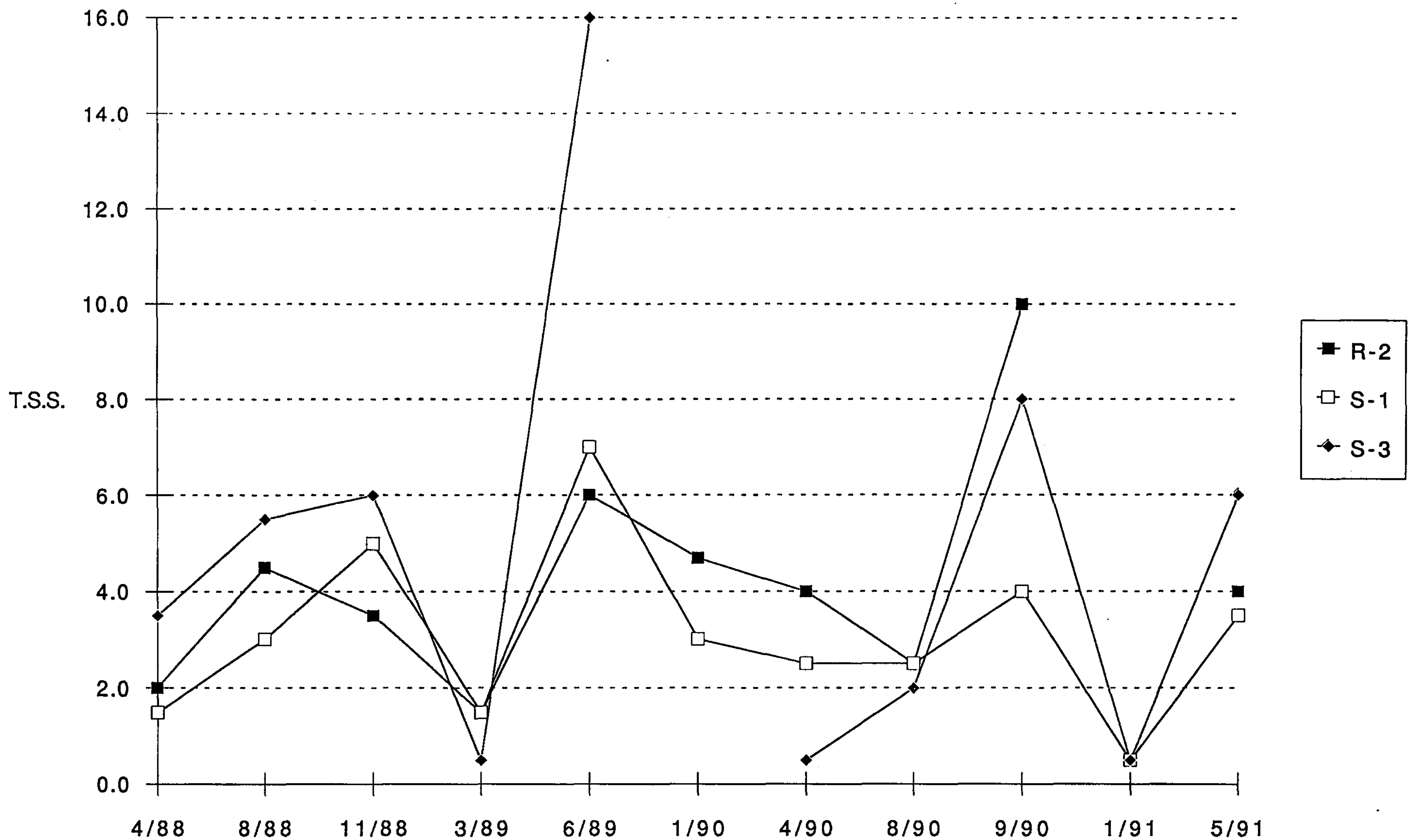
Chlorophyll - a (mg/m3) in Lake Rowena (station 2) and Lake Sue (stations 1 and 3) from 4/88 to 5/91



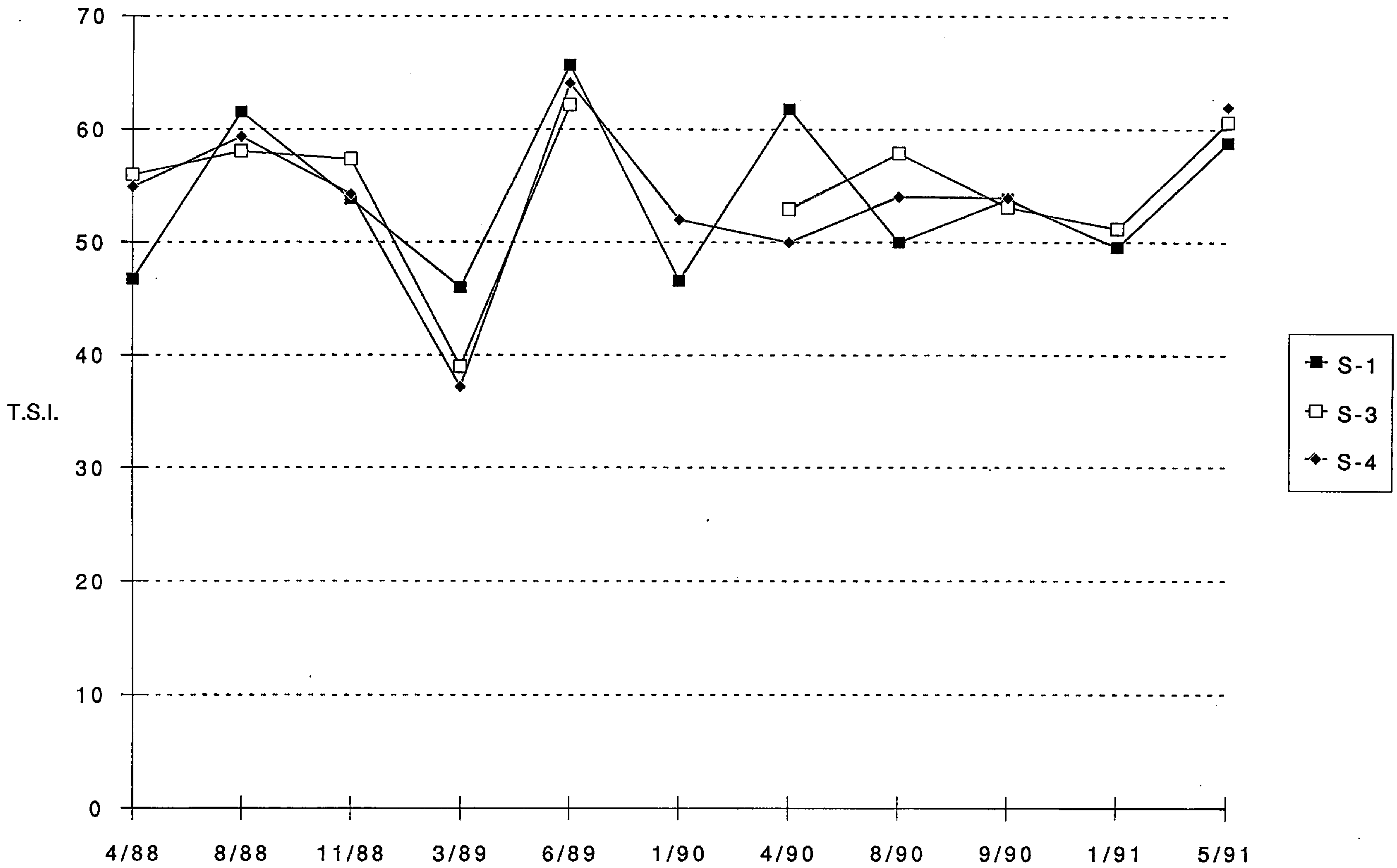
Total suspended solids (mg/l) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



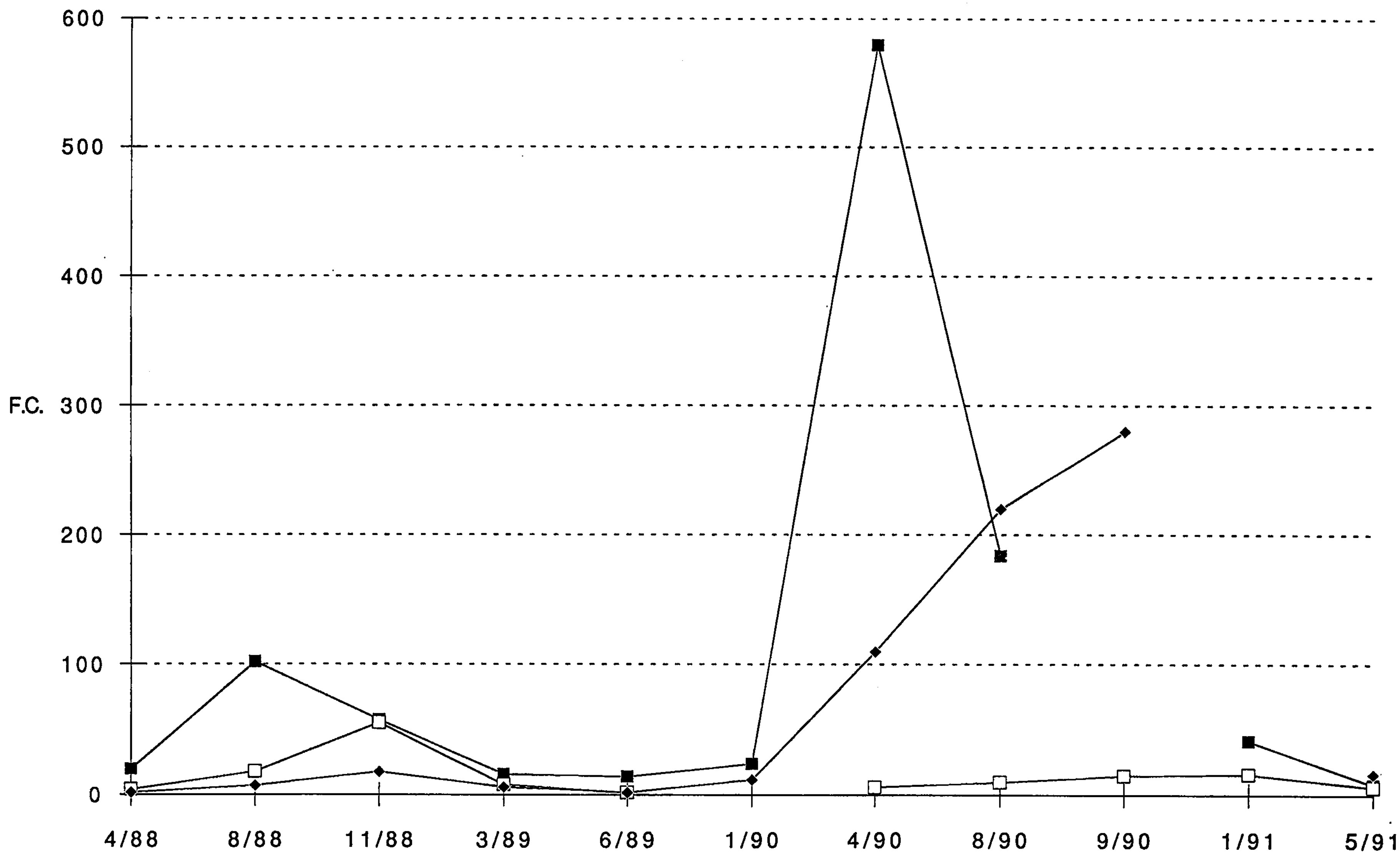
Total suspended solids (mg/l) in Lake Rowena (station 2) and Lake Sue (stations 1 and 3) from 4/88 to 5/91.



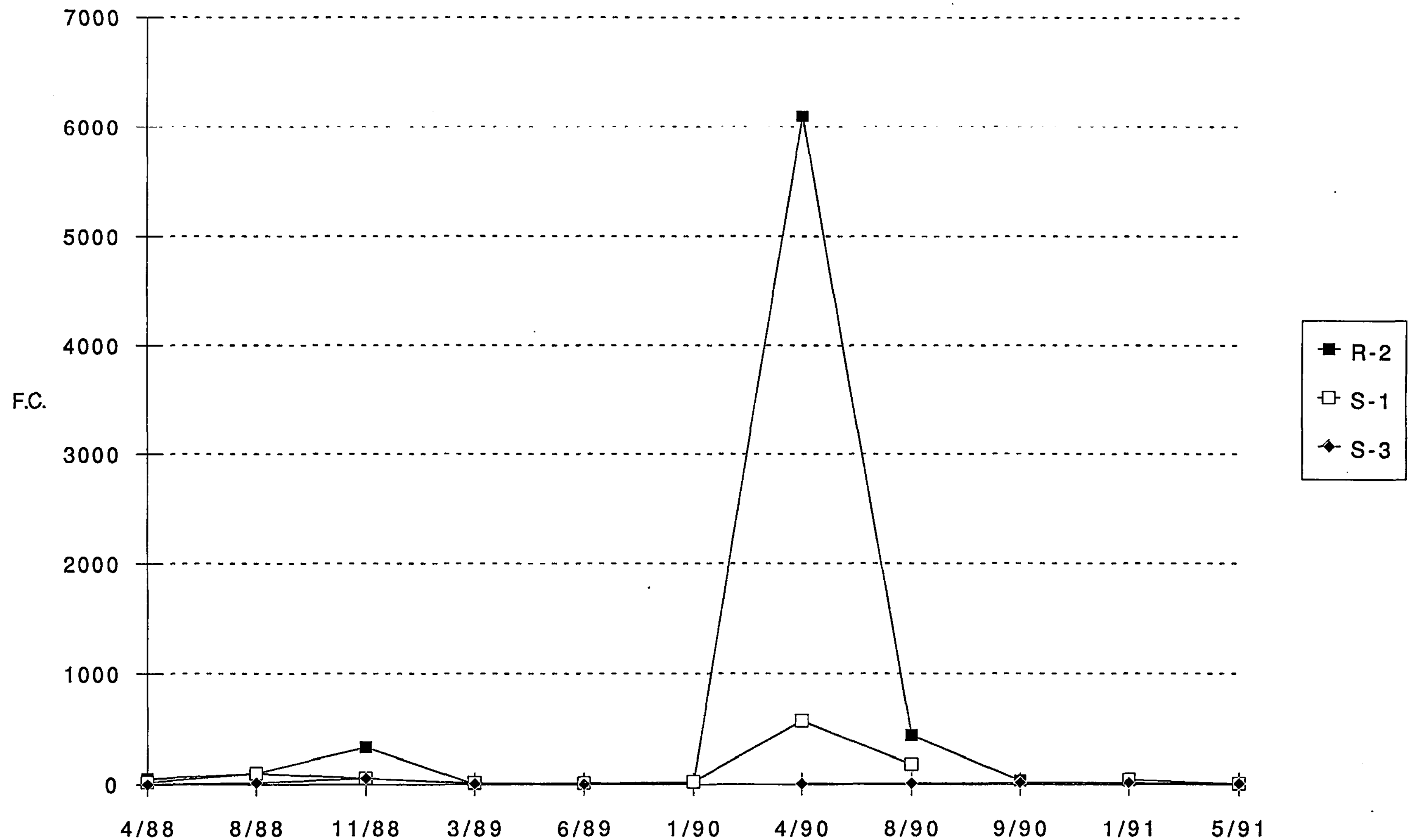
Trophic state index (Fl.) values at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



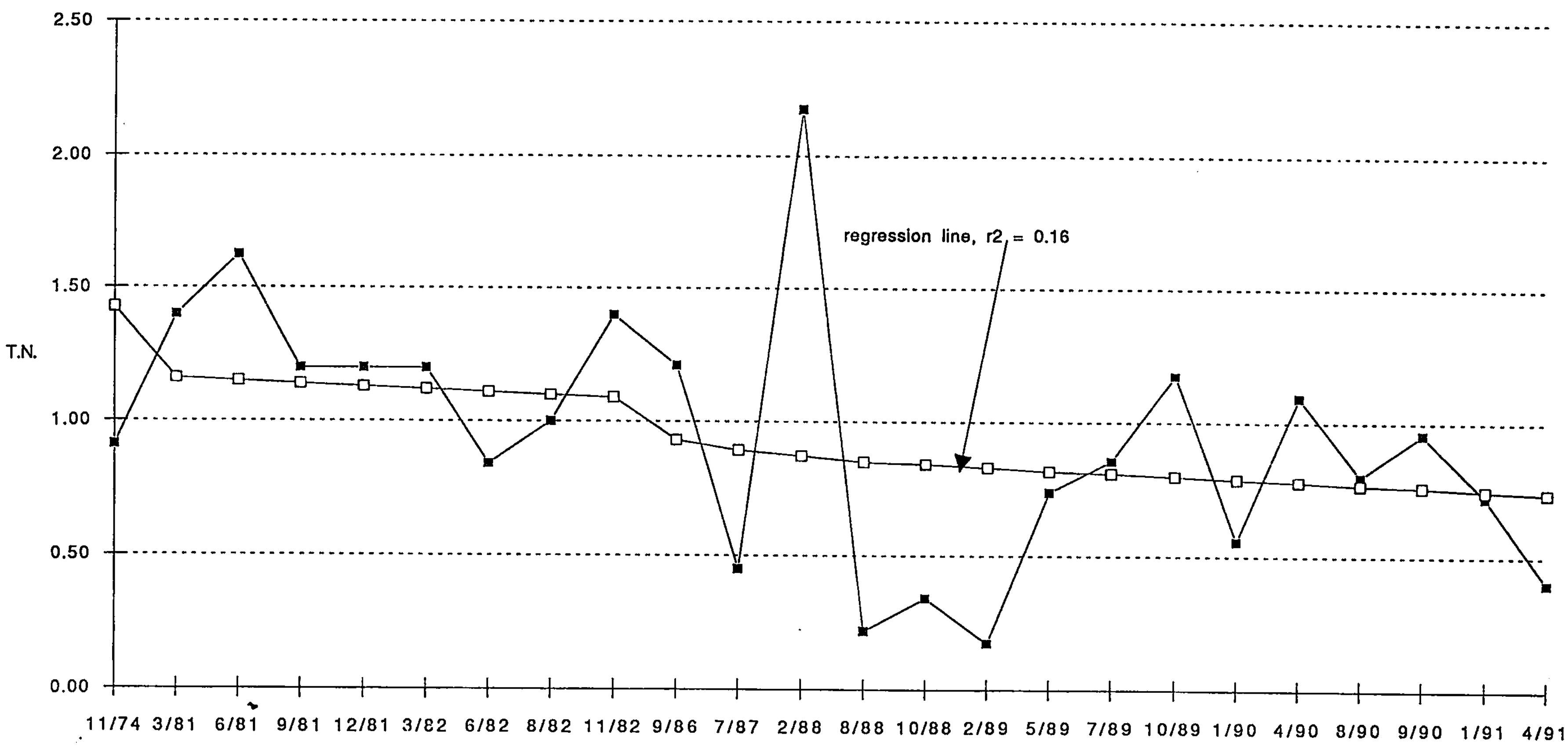
Fecal coliform concentrations (per 100 ml) at stations 1, 3 and 4 in Lake Sue from 4/88 to 5/91.



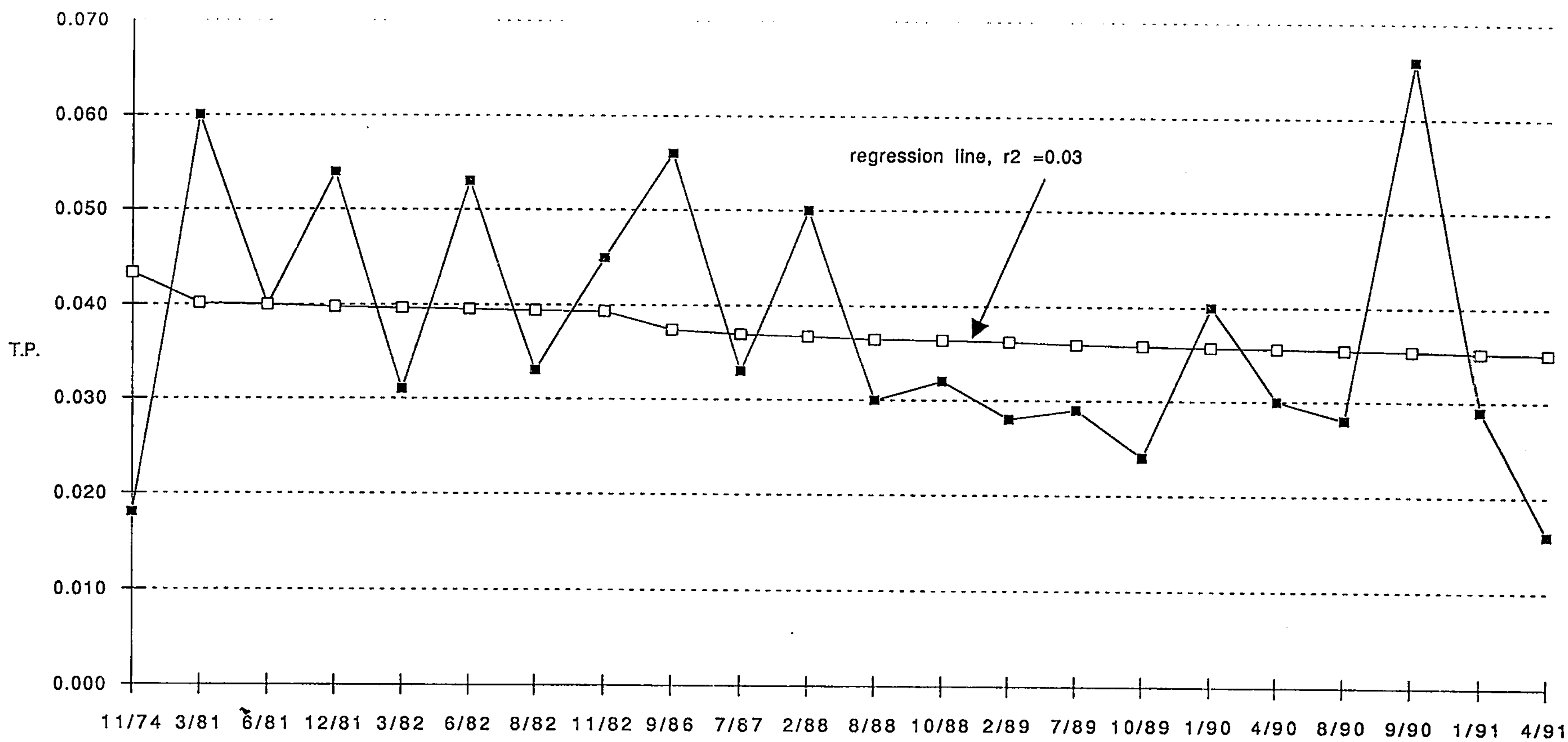
Fecal coliform (per 100 ml) in Lake Rowena (station 2) and Lake Sue (stations 1 and 3) from 4/88 to 5/91.



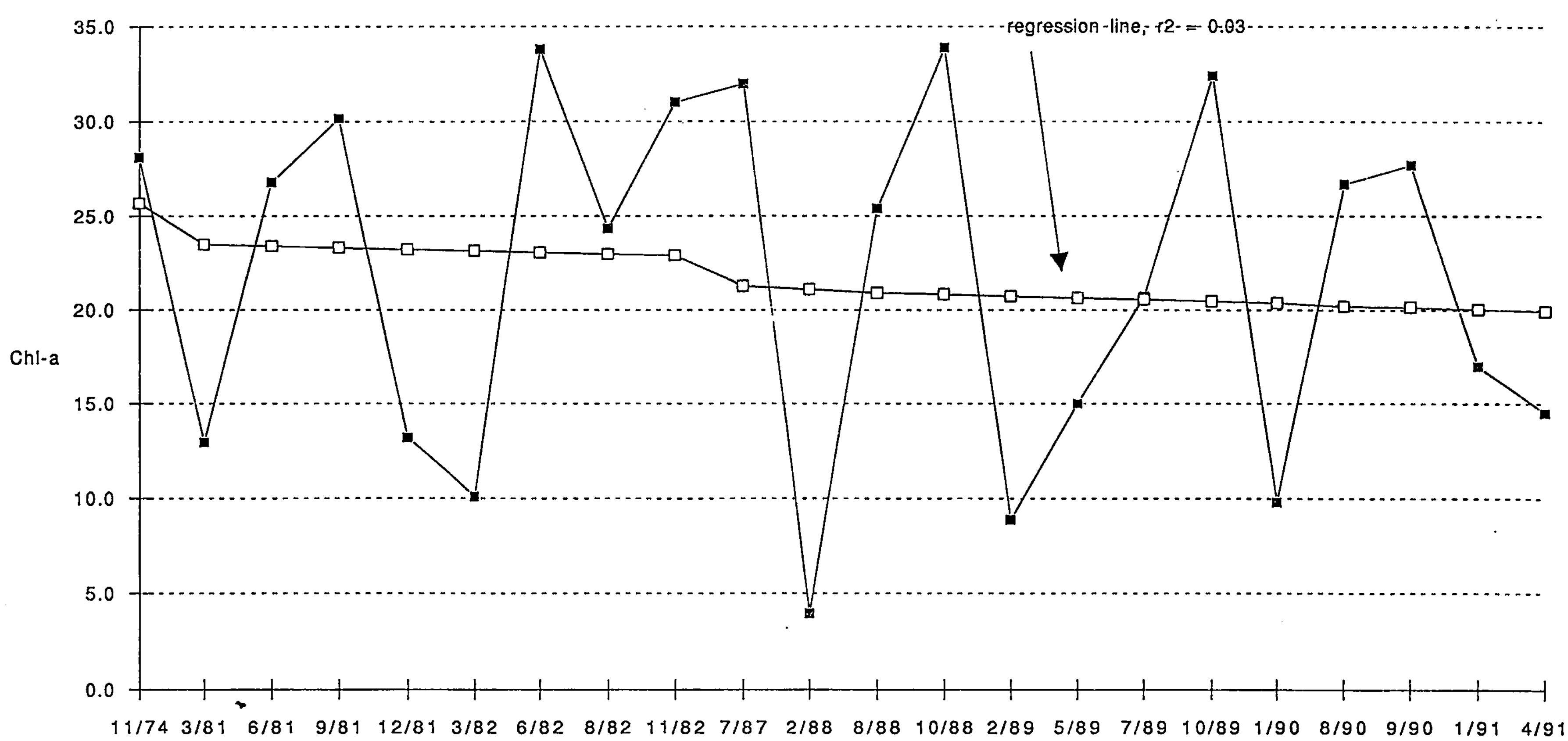
Regression line for total nitrogen (mg/l) in Lake Sue from 11/74 to 4/91. Data collected by Orange County.



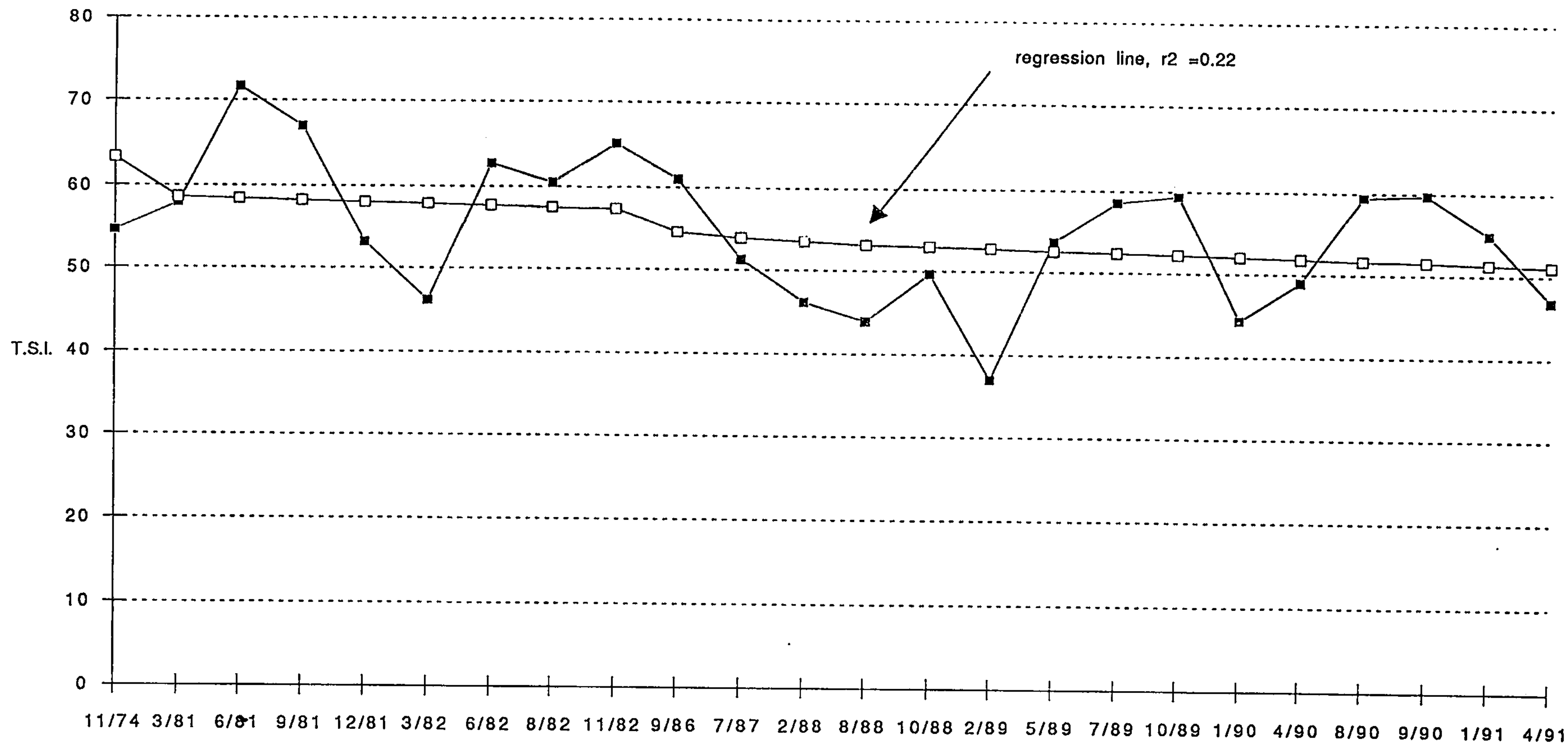
Linear regression line for total phosphorus (mg/l) in Lake Sue from 11/74 to 4/91. Data collected by Orange County.



Regression line for Chlorophyll - a (mg/m3) in Lake Sue from 11/74 to 4/91. Data collected by Orange County.

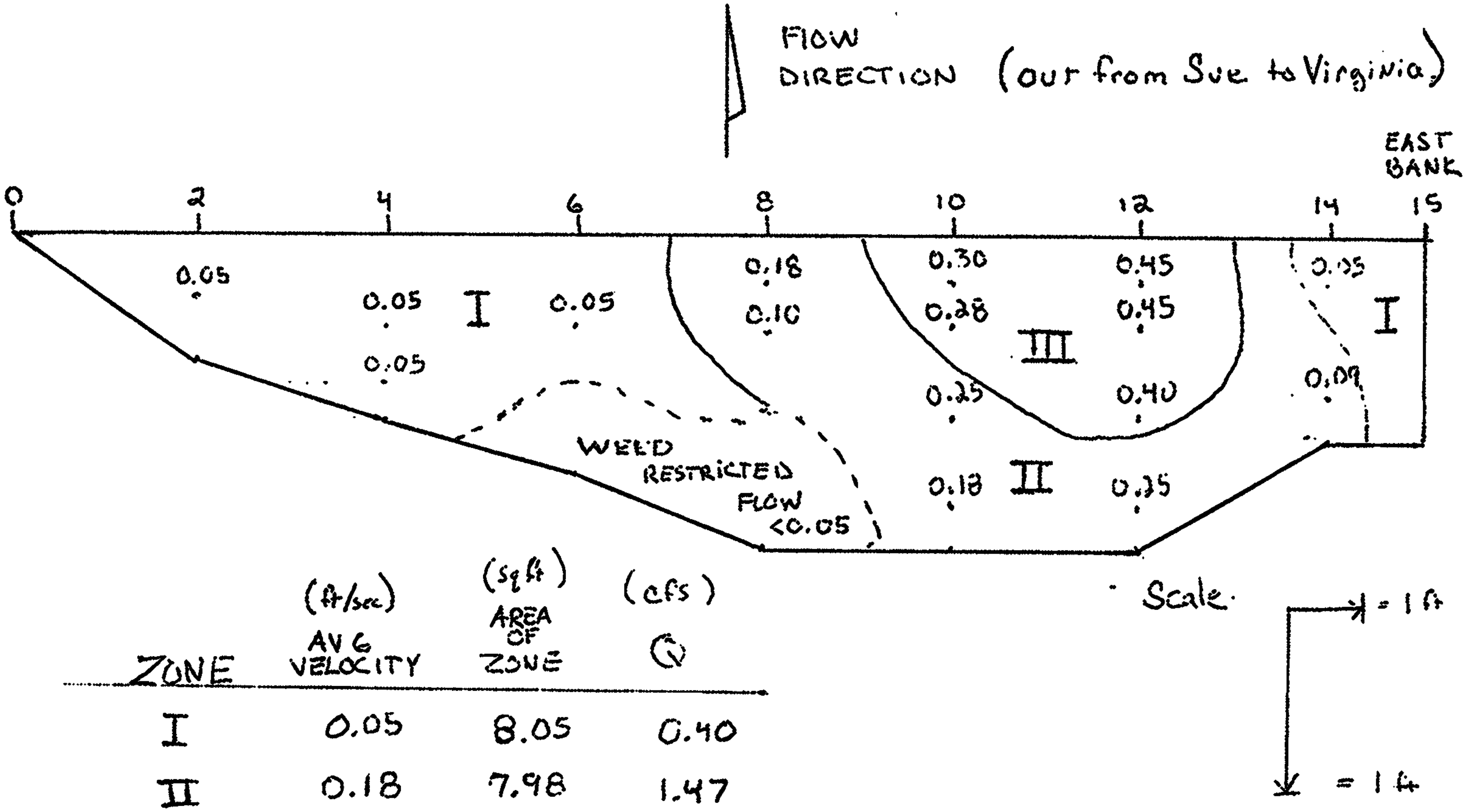


Regression line for trophic state index values (Fl.) in Lake Sue from 11/74 to 4/91. Data collected by Orange County.



Appendix F

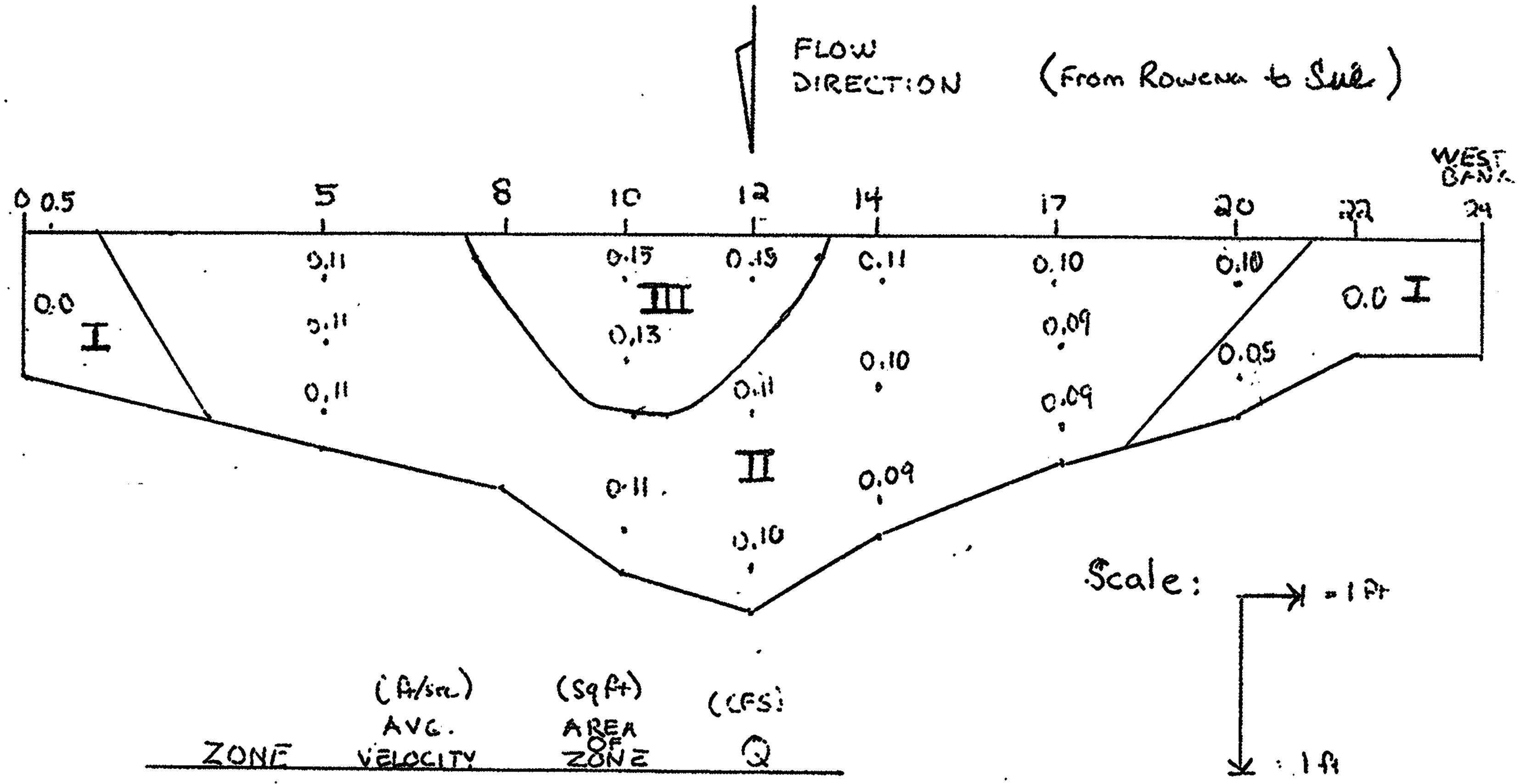
Stream Flow Diagrams



ZONE	(ft/sec) AVG VELOCITY	(sq ft) AREA OF ZONE	(cfs) Q
I	0.05	8.05	0.40
II	0.18	7.98	1.47
III	0.39	3.88	1.51

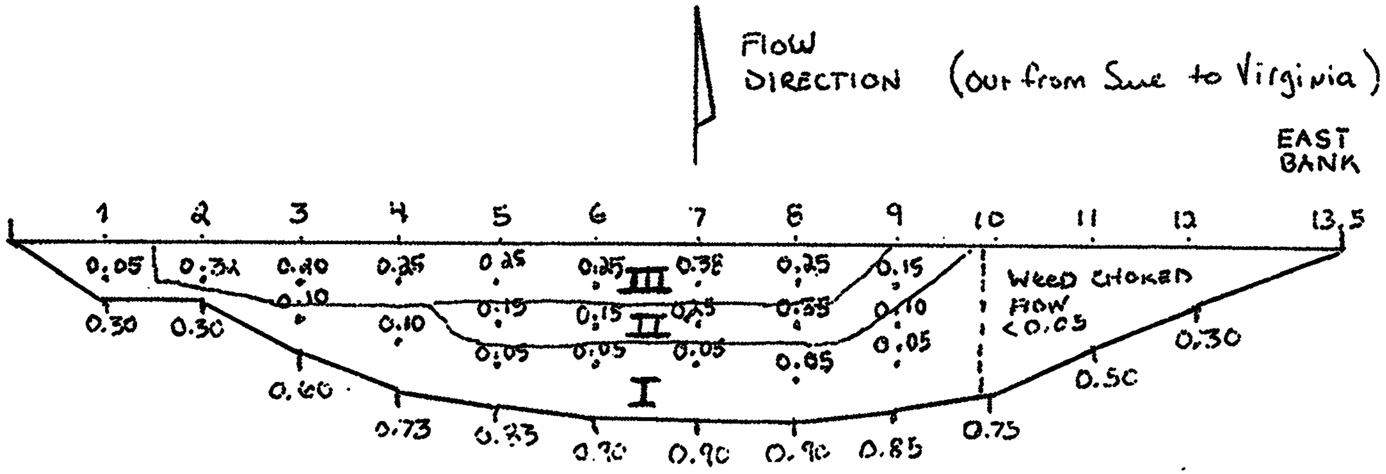
Q total = 3.38 cfs
or 2.18 mgd

September 23, 1991

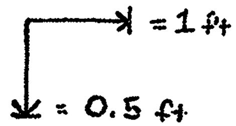


ZONE	(ft/sec) AVG. VELOCITY	(sq ft) AREA OF ZONE	(CFS) Q
I	0.05	4.50	0.23
II	0.10	21.05	2.11
III	0.14	3.80	0.53

Q_{total} = 2.87 cfs
or 1.86 mgd September 23, 1991



Scale:



ZONE	(ft/sec) AVG FLOW VELOCITY	(sq ft) AREA OF ZONE	(cfs) Q
I	0.05	3.34	0.17
II	0.21	1.04	0.22
III	0.27	2.06	0.56

Q_{total} = 0.95 cfs
or 0.61 mgd

January 25, 1991

Note: Inlet from Rowena to Sue flowing to low to measure accurately (< 0.05 ft/sec.)