Deer Lake Planning Grant Report
Polk County, Wisconsin

Prepared for
Deer Lake Improvement Association

In Cooperation with
Polk County Land Conservation Department
Wisconsin Department of Natural Resources

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DEER LAKE PLANNING GRANT REPORT

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DEER LAKE PLANNING GRANT REPORT

1.0 EXECUTIVE SUMMARY

The study described by this report was initiated by the Deer Lake Improvement Association for the purpose of providing information to water resource managers and citizens regarding the management of Deer Lake. The study resulted in determining that Deer lake is a mesotrophic to slightly eutrophic lake, which experiences degraded water quality in the fall due to internal loads of phosphorus.

Hydrologic budgets constructed from study data indicate that the lake is strongly influenced by groundwater inflows, especially during dry periods. The lake is at a trophic level where it is very sensitive to even slight increases in nutrient loads. The sources of nutrients which represent the greatest potential for degrading Deer Lake's water quality are the Lake's urban and agricultural watersheds. Water quality monitoring conducted on the stormwater and snowmelt runoff indicates that some tributaries are experiencing degraded water quality, likely due to agricultural sources.

Management recommendations include increased education of lake shore property owners, participation in the Priority Watershed Project and additional lake planning grant studies to assist the Priority Watershed Management Team. These efforts should focus on identifying means to retain/detain stormwater on Deer Lake's watershed and minimizing increases in nutrient loads associated with the projected increase of permanent residents on Deer Lake.

2.0 INTRODUCTION

Deer Lake is located in Polk County, in western Wisconsin. The lake is located in the Balsam Branch of the Apple River Watershed system. The watershed is ultimately tributary to the St. Croix River.

Deer Lake is an important local recreational resource, popular for fishing and boating. The likely reason for the lake's popularity is its relatively good water quality. Water quality data from the Wisconsin Self Help Lake Monitoring

Program, which is collected by volunteers of the Deer Lake Improvement Association, has shown that the lake is mesotrophic to slightly eutrophic in nature. Lakes within this classification typically exhibit relatively good water quality, however, they can be very susceptible to even minor increases in pollutant loads.

The Deer Lake Improvement Association recognized the importance of the maintaining Deer Lake's water quality and preventing its degradation. Therefore, the Association initiated an application to the Wisconsin Lake Planning Grant Program to receive a $10,000 grant. The grant money was to be used to conduct a study of the lake and its watershed.

The objectives of the Deer Lake Planning Grant Study were as follows:

1. Provide a means to educate the public about lake water quality management.

2. Provide a guide to resource managers in their continuing efforts to protect the quality of Deer Lake.

3. Collect detailed information about Deer Lake and its tributary watershed.

4. Use the information to develop management strategies for future protection/restoration actions.

2.1 Lake and Watershed Description

The physical morphometry of Deer Lake is outlined in Table 1 and is shown on Figure 1. The lake consists of two basins; the larger East basin has a maximum depth of 45 feet, the West basin has a maximum depth of approximately 26 feet.

Deer Lake has five main watersheds; the areas are presented in Table 2. Watersheds 4 and 5 drain into the West basin, while Watersheds 1, 2 and 3 drain into the East basin. Watershed land use was not specifically addressed during this project; however, the watershed is generally agricultural in origin with a ring of seasonal and permanent homes immediately adjacent to the lake. A watershed map is also presented on Figure 1.

3.0 METHODS

3.1 Hydrologic (Water) Budget

A hydrologic (water) budget for Deer Lake was determined by measuring or estimating the important components of the budget. The important components of the budget include:

- Precipitation
- Surface Runoff
- Lake Outflow
- Evaporation
- Groundwater Flow

3.1.1 Precipitation

Rain gages accurate to within 1/100th of an inch were installed throughout Deer Lake's watershed and read daily by volunteers during the ice free period, to determine daily precipitation amounts. National Weather Service data was used during the winter months to determine total precipitation amounts for the unmonitored periods.

3.1.2 Surface Runoff

To determine the volume of surface runoff into Deer Lake from the lake's five watersheds, automated flowloggers were installed by Barr near culverts under Tipperary Road. Manning's equation was utilized to estimate the rates and volumes of water flow through each culvert. Each flowlogger was housed in an enclosure and placed on platforms constructed by the Deer Lake Association. Polk County Land Conservation Department personnel were trained by Barr in the operation of the flowloggers, and were responsible for bi-weekly downloading of flow data. Flow data was compiled for three periods during the summer of 1992:

May 5 - May 23, May 23 - July 1, July 1 - September 1. Unfortunately, the flow data for the period May 23 - July 1 was lost due to a field accident.

In order to estimate an annual yield of water from Deer Lake's watersheds, the measured watershed runoff volumes were divided by the watershed area of the respective watershed to compute a yield value expressed in inches of water. The runoff yield was divided by the total precipitation for the monitored period. The resultant number represents runoff coefficient for the particular watershed. Watershed runoff volumes for areas which were not monitored were estimated by using the average coefficient from the five monitored watersheds. The data and runoff volumes are presented in Table 3.

It should be noted that the summer of 1992 was relatively dry in the Deer Lake area and that Watersheds 4 and 5 have significant storage requirements which must be satisfied prior to the watershed discharging into Deer Lake. Therefore, the runoff coefficients, hydrologic budgets, and nutrient budgets computed for this study should be considered representative of dry or drought conditions.

3.1.3 Lake Outflow

A staff gage was installed at the lake outlet and a rating curve developed for the outlet structure to determine the quantity of water leaving the lake. Deer Lake's outlet structure consists of a concrete structure with a sheet pile crest. A survey was performed of the crest to determine its configuration in relation to the water surface profile. Discharge at the structure was measured on two occasions to assist in calibrating a standard weir equation for discharge. The appropriate headlosses were included in the equation following methods recommended by Henderson (1966) for weirs with small water depths. The staff gage was accurate to within 0.02 feet and read on a daily basis during the open water period and weekly during ice covered periods.

3.1.4 Evaporation

Evaporation was estimated using National Weather Service published evaporation rates for 1992 applied to the lake surface. The evaporation rates are for U.S Class A pans. A pan coefficient was applied to the rates to account for the additional evaporation which typically occurs from these pans. The evaporation rates were applied on a monthly basis to the surface area of Deer Lake to estimate the amount of evaporation from the lake's surface.

3.1.5 Groundwater

Groundwater appears to be a major component to the hydrologic budget of Deer Lake. The groundwater inflow to Deer Lake was determined by solving the water balance equation for Deer Lake as presented below.

$$\pm GW = P + RO - OF - EVAP$$

Where:

GW = groundwater inflow or outflow

P = Direct Precipitation on the lake's surface

RO = Watershed Runoff

OF = Lake Outflow

EVAP = Evaporation from the Lakes Surface

Figures 2 and 3 present the estimate of the hydrologic budget for Deer Lake for the period of May 1992 through May of 1993. The significance of these results will be discussed in subsequent sections.

3.2 Nutrient Monitoring

Nutrient monitoring involves collecting water samples to determine the concentrations of various pollutants within the water. The Deer Lake Planning Grant project involved collection of storm event, snowmelt and lake water quality samples. The method of collection of each type of samples is discussed in the following sections.

3.2.1 Storm Event Sampling

In order to compare the relative quality of the runoff following storm events in Deer Lake's five tributary watersheds, grab samples were proposed for two summer storm events. However, the dry conditions allowed for only one sample to be collected in 1992. Some additional sampling is occurring in 1993, but the data is not available for this report.

Deer Lake volunteers collected grab samples from four of the five main tributaries entering the lake on July 7, 1992. The volunteers attempted to collect the samples at the initial stages of the runoff event. Each of the four grab samples were analyzed at the Wisconsin Department of Hygiene Laboratory for total phosphorus, orthophosphorus, total Kjeldahl nitrogen, nitrate + nitrite nitrogen, ammonia nitrogen, and total suspended solids. This data is presented in Table 4 and Figures 4 through 9. The significance of the data will be discussed in latter sections.

3.2.2 Snowmelt Sampling

In order to compare the relative quality of snowmelt runoff, Deer Lake volunteers collected grab samples from the five tributaries on March 27 and March 29, 1993. The samples were analyzed at the Wisconsin Department of Hygiene Laboratory for the same parameters as the summer runoff sample. These data are also presented in Table 4 and Figures 4 through 9.

3.3 Water Quality Survey of Deer Lake

As part of the Self Help Lake Monitoring program, Deer Lake volunteers collected lake water samples during July - October during 1990 and 1991, and during June - October during 1992. Samples were collected from both the East and West Basins near the lake surface and at a depth of 1 to 2 feet above the lake bottom during 1990 and 1991. During 1992 the same sampling regime was followed, however samples from two additional hypolimnetic depths were also collected. Transparency was measured with a 20 cm white Secchi disc at the time of each sample collection.

Water quality samples were submitted to the Wisconsin Department of Hygiene Laboratory for analysis. Concentrations of total and dissolved phosphorus were measured on all lake water samples; concentration of chlorophyll *a* was measured on lake surface samples. These data are presented in Table 5 and presented on Figures 10 through 15.

3.4 Property Owners Survey

As part of the Deer Lake Improvement Association's effort to develop a management plan for Deer Lake and its watershed, a survey was distributed to lake shore residents and association members on May 1, 1992. The survey, similar to one developed by the University of Wisconsin - Stevens Point, was designed to collect information on topics such as lake use, user conflicts, and other related data. A copy of the survey results is included in the appendices of this report.

4.0 RESULTS AND DISCUSSION

4.1 Lake and Watershed Overview

Within a lake system, water quality problems and accelerated biological activity are often caused by sediments and nutrients deposited into the lake by tributary streams which drain the lake's watershed. The process of nutrient enrichment and sedimentation is termed eutrophication. During the process of eutrophication, a lake accumulates sediments and nutrients from its watershed. As the process progresses, a lake is converted from oligotrophic (nutrient poor) to eutrophic (nutrient rich) status.

It is important to note that the process of eutrophication is natural and results from the normal environmental forces. However, cultural eutrophication is a termed used to described the effect of human accelerating the natural process. This acceleration may result from point-source nutrient loadings, such as effluent from wastewater treatment plants and septic tanks. It may also be caused by diffuse (i.e., non-point) sources of nutrients and sediments, such as stormwater runoff from urban and agricultural areas. The accelerated rate of water quality degradation caused by these pollutants results in unpleasant consequences. These include profuse and unsightly growths of algae (algal blooms), and/or rooted aquatic weeds (macrophytes).

Because lake degradation occurs over a period of time and all lakes are not the same, lakes are not in the same stage of eutrophication. Therefore, criteria have been established to evaluate lakes, such as Deer Lake, to denote their nutrient status. Four "trophic" descriptions are frequently used to describe the effects of the nutrients on the general water quality water body. They are:

1. Oligotrophic
2. Mesotrophic
3. Eutrophic
4. Hypertrophic

Oligotrophic (Greek for "food-poor") describes a water body with few nutrients, and a clear or pristine appearance. Mesotrophic describes a water body that is moderately nourished, and has an appearance midway between an oligotrophic and eutrophic lake. Eutrophic (Greek for "food-rich") describes a water body that is rich in nutrients. Significant weed growth and green and/or murky colored water from algal blooms and suspended sediment are generally found in eutrophic water bodies. Hypereutrophic describes a water body extremely rich in nutrients. Such water bodies experience heavy algal blooms and/or very dense weed growths all summer.

The determination of the trophic status (stage of eutrophication/degradation) of Deer Lake is an important aspect of the diagnosis of its problem. The trophic status indicates the severity of a lake's algal problems and the degree of change needed to meet its recreational goals. However, it does not indicate the cause of the algal growth, or the means of reducing such growth.

The trophic states of a lake or pond is usually determined by the concentration of an essential element or dissolved nutrient, which is referred to as the "limiting nutrient". This nutrient will generally control the amount of algae a particular lake can produce. Aquatic weeds, on the other hand, derive most of their nutrients from lake or pond sediments. The limiting nutrient concept is a widely applied principle in the study of eutrophication. It is based on the concept that, in considering all of the substances needed for biological growth, one will be present in limited quantity. The availability of this limiting nutrient will, therefore, control the rate of algal growth. The identification of a lake's limiting nutrient may point the way toward possible solutions for its algal problems.

Algal growth is generally phosphorus-limited in most waters similar to Deer Lake. It has been amply demonstrated, in experiments ranging from laboratory bioassays to fertilization of in-situ enclosures to whole-lake experiments, that most often phosphorus is the nutrient that limits algal growth. Algal abundance is nearly always phosphorus-dependent. A reduction in the phosphorus concentration in a lake is therefore necessary in order to reduce algal abundance and improve water transparency. Failure to reduce phosphorus concentrations will allow the process of eutrophication to continue at an accelerated rate.

4.2 <u>Watershed Runoff Water Quality</u>

The results of the laboratory analyses of the storm runoff and snowmelt samples are presented in the sections below. The concentrations of several common contaminants found in runoff were monitored as part of the watershed study. It is important to understand the potential sources of each contaminant in order to interpret the results of the laboratory analyses. The sources are described below.

Phosphorus is the nutrient which limits algal growth in Deer lake and is present naturally in the environment. However, excess phosphorus added to a lake from the watershed may cause excessive, unpleasant algal growth. Potential sources of phosphorus include livestock feed lots, fertilizers, decaying plant matter (such as grasses and leaves), eroded soils, and malfunctioning septic systems. Two forms of phosphorus were measured during this study. Dissolved phosphorus, (also called "ortho-phosphorus"), is the only form of phosphorus which is immediately available for uptake by aquatic plants such as algae.

Total phosphorus provides an estimate of all the phosphorus forms present in a sample.

Nitrogen is also a naturally occurring nutrient important for aquatic plant growth. While phosphorus typically stimulates excess algal growth, in some cases nitrogen may play a part as well. Also, several forms of nitrogen will be present in runoff. These include: ammonia nitrogen, nitrate + nitrite nitrogen, and total Kjeldahl nitrogen. These nutrients were all measured as a part of this watershed study. A complex biological nitrogen cycle determines the form of nitrogen present in natural waters. For example, microbial decomposition of organic nitrogen waste will produce ammonia; however, over time another type of microbe may convert the ammonia to nitrate and nitrite. The relative concentrations of ammonia and nitrate + nitrite may give an indication of the nitrogen source and its proximity to the sampling site. Runoff from a nitrogen source in close proximity to the site may have high concentrations of ammonia relative to nitrate + nitrite; runoff from a more remote source may have higher concentrations of nitrate + nitrite relative to the concentration of ammonia (MPCA, 1989). Possible sources of nitrogen include fertilizers, malfunctioning septic systems, and animal wastes.

It is important to note that the concentration of contaminants in runoff will often vary throughout the runoff event. In some cases the runoff produced early in a storm or snow melt event will flush debris and other accumulated materials out of stream beds and culverts. This runoff may have much higher concentrations of contaminants than the runoff produced later in the storm event. In other cases, the runoff may have higher concentrations of contaminants later in the storm event, when water from non-point sources upstream reach the sampling site. Since only one sample was collected during each runoff event, it is not possible to ascertain the average concentration of the runoff. Therefore, the results presented below must be viewed in a relative sense to determine which watershed may have a pollution problem.

4.2.1 Storm Event Grab Sample

Grab samples were collected during a summer storm runoff event on July 7, 1992 from monitoring sites for Watersheds 1, 2, 3 and 4. Watershed 5 was not sampled during the summer storm event due to lack of flow. The results of the laboratory analyses performed on the samples are presented on Figures 4 through 9, and in Table 4.

Examination of the data for July 7, 1992 reveals that the concentrations of the various nutrients in the runoff from Watershed 1 were consistently higher than the other watersheds. The summer runoff from Watershed 2 also experienced elevated concentrations of many of the nutrients. The relatively high concentrations of ammonia nitrogen in the runoff from Watershed 1 indicates that the sampling station is in close proximity to a pollution source. The runoff from Watershed 4 has the consistently lowest concentration of nutrients.

The elevated concentrations of nutrients in the summer runoff samples are likely caused by the runoff from feedlots and pasture areas since most fields have been planted and have a cover crop prior to the sampled storm event. However, the study is not extensive enough to specify any particular location within the watershed which could be causing the pollution.

4.2.2 Snowmelt Event

Grab samples were collected during two snowmelt events on March 27 and March 29, 1993 from all five watersheds. As with the summer storm event samples, Watersheds 1 and 2 showed consistently high concentrations of nutrients. However, the second snowmelt sampling of Watershed 5 indicates that water quality on that particular day was significantly degraded from the previously sampling. These data point out the variability in collection of grab sample data. A significant number of data points needs to be collected to ascertain the exact loading of nutrients from each of these watersheds.

Since the watersheds of Deer Lake are primarily agricultural in origin, it is likely that the elevated concentrations observed in Watersheds 1, 2 and 5 have a agricultural source. The elevated concentrations observed in these watersheds could occur from several sources. These include: runoff from bare agricultural fields, application of manure to frozen fields, and runoff from feedlots and pasture areas.

4.3 Water Quality Survey of Deer Lake

As mentioned previously, phosphorus may enter lakes and ponds from both external and internal sources. A relative review of the water quality from one external nutrient sources, the five tributary watersheds, was described previously. Lakes can also receive phosphorus from an internal source, the lake's sediments. The lake sediments are an important source of phosphorus in many lakes because dead algae and weeds settle to the lake bottom and decompose. As they decompose nutrients are added to the lake sediments.

In many lakes, such as Deer Lake, the bottom waters of the lake become void of oxygen during the summer stratified period. The lack of oxygen results in a chemical/physical change to the bottom sediments which results in a release of phosphorus from the sediments. This process was observed to occur in Deer Lake and will be discussed in detail in the following paragraphs.

4.3.1 Deer Lake Water Quality

Deer Lake's mixing status is classified as dimictic, which means the water column is stratified during the summer months and circulates during the spring and fall overturn periods. However, from the temperature isopleths for the East and West basins presented on Figures 16 and 17, it is apparent that only the East basin is deep enough to stratify throughout the summer. The West basin appears to circulate freely from top to bottom throughout most portions of the summer and fall months. The fall circulation period in the East basin occurred in early September. Examination of the dissolved oxygen isopleths, presented on Figures 18 and 19, reveals the implications of the thermal structure in each basin. Circulation in the West basin ensures that the water column remains well-oxygenated throughout the summer. The dissolved oxygen concentration near the lake bottom was below 4 mg/L briefly during June; however, oxygen levels for the remainder of the summer were in excess of 6 mg/L. Stratification in the East basin implies that oxygen is not replenished into the lake hypolimnion (near-bottom layer) through wind mixing or photosynthesis. Therefore, oxygen is depleted by microbial decomposition and respiration. During July and August, the dissolved oxygen near the bottom of the basin was less than 1 mg/L. This level is unsuitable for fish and other aerobic (oxygen breathing) organisms.

As stated previously, at low dissolved oxygen concentrations, the chemical environment of the lake sediments will favor release of dissolved phosphorus into the water column.

An attempt was made to quantify the amount of dissolved phosphorus being released from the sediments of the East basin during 1992. Unfortunately, the phosphorus data gathered from near-sediment depths during July was not valid, and no surface sample was collected during August. Without these values, the a complete calculation could not be made.

However, examination of the near-sediment samples collected during August from the East basin shows that the total phosphorus concentration is high - 0.30 mg/L at 35 feet depth, and 1.21 mg/L at 40 feet depth. These high concentrations indicate that phosphorus release from the sediment is occurring in the East basin during the latter part of the summer. While the sediment-released phosphorus remains sequestered in the hypolimnion during the summer, some is transported to the lake surface during September as the lake mixes (see Figures 16 and 17). This is discussed further in the following paragraphs.

The near-surface total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disc transparency during 1990 - 1992 for the East and West basins of Deer Lake were compared to Carlson's Trophic State Index; the results are plotted on Figures 10 through 15. The Trophic State Index can be used to estimate the trophic state of a lake (i.e., whether a lake is eutrophic, mesotrophic, or oligotrophic) based on its total phosphorus, chlorophyll *a* concentration and transparency.

The trophic state analysis of the East basin of Deer Lake is illustrated on Figure 10 through 12. The total phosphorus concentrations during June, July, and August were in the mesotrophic range. The total phosphorus concentration during September increased dramatically all three years. This increase was probably due to the transport of sediment-released phosphorus to the lake surface during the fall mixing period. The addition of phosphorus to the lake's surface water stimulates algal growth, which causes a decrease in water transparency and an increase in the chlorophyll *a* concentration (which indicates algal abundance). In general, the East basin of Deer Lake appears to be mesotrophic during the majority of the summer period and becomes characteristic of a eutrophic lake during September and October. The data collected as part of this study and the self help monitoring indicate that the cause of the annual degradation of late season water quality is the result of a internal load of phosphorus.

The trophic status of the West basin of Deer Lake is illustrated on Figures 13 through 15. Like the East basin, the West also appears to be mesotrophic.

4.2.2 Hydrologic and Nutrient Budgets

The collection of data for the hydrologic budget of Deer Lake was a valuable exercise. As mentioned previously, the hydrologic budget for Deer Lake is presented on Figures 2 and 3 and in Table 3. As the budget indicates, groundwater inflows and direct precipitation play and important role in providing water to Deer Lake, especially during dry years as occurred in 1992. The large inflow of groundwater into the lake indicates that effluent from leaking septic tanks and drain fields will likely reach Deer Lake. It underscores the importance of emphasizing the continued upgrade and maintenance of these systems.

The comparatively small amount of watershed runoff which reached the lake indicates that watershed runoff during 1992 had little impact on the water quality of Deer Lake. The majority of the storm event runoff which reached the lake came from the direct watershed and Watersheds 1, 2 and 3. These watersheds are relatively steep and have very few natural wetlands or depressions for storage of stormwater. The minor influence of the watershed runoff on the overall water budget of Deer Lake and the relatively good water quality of the lake are interrelated. Typically, lakes which receive a majority of this water from watershed runoff, experience significantly poorer water quality than groundwater controlled lakes.

The hydrologic budget is an important factor in determining the breakdown of nutrient loads into Deer Lake. Because phosphorus is the parameter of most concern, the discussion of nutrient budgets will be limited to phosphorus only.

The initial project plan was to collect sufficient hydrologic data from Deer Lake's tributary watershed to estimate the watershed loading of phosphorus into Deer Lake. This estimate was to be collaborated with published phosphorus export rates applied to the lakes watershed. However, the dry conditions and small runoff volumes generated by the tributary watersheds made estimates of phosphorus loads based on export rates difficult to make with any accuracy. Therefore, an alternative approach was used.

Numerous researchers have demonstrated the relationship between phosphorus loads, water loads and lake basin characteristics to the observed in-lake total phosphorus concentration. The relationship was used to predict the annual phosphorus load into Deer Lake based on mean summer surface phosphorus concentrations, the lake's hydrologic budget, and lake basin characteristics. The relationship has many forms, the equation used for Deer lake was one developed by Chapra (1975) and has the form of:

$$[P] = [L*(1-R)]/Qs$$

Where:

- P = is the mean phosphorus concentration
- L = amount of phosphorus added per unit surface area of lake
- R = the coefficient which describes the total amount of phosphorus retained by the sediments each year
- Qs = the outflow of the lake divided by its surface area

In the case of Deer Lake, all variables of the equation were measured or could be computed based on data collected during the study except for L, the loading term. Therefore, it was possible to determine the annual load of phosphorus into Deer Lake by solving for L. The computation reveals that the annual phosphorus load into Deer Lake is approximately 1,393 pounds per year, based on 1992 data.

Phosphorus export rates, published by the USEPA for septic systems, were used to estimate an annual load of 88 pounds per year from drain fields. An atmospheric wet and dry deposition rate published by Uttormark and Wall (1976) of 0.56 kg/ha/yr applied to the surface area of Deer Lake. The computation indicates that the atmospheric component of the load is approximately 405 pounds per year. The watershed component was estimated by computing the numeric average phosphorus concentration of all watershed grab samples. The numeric average was 1.1 mg/L. This value was applied to the estimate of water loading from the watershed. The result is an estimate of 152 pounds per year from Deer Lake's tributary watershed. Groundwater and internal loading comprise the remaining 748 pounds of phosphorus into the lake. Due to inconsistencies in the lab data and the limited scope of the project, there is insufficient information to differentiate between groundwater and internal loading of phosphorus. The results of the phosphorus budgets are presented on Figure 22 and in Table 6.

As the budgets indicate, phosphorus inputs into Deer Lake primarily result from groundwater, internal and atmospheric sources. The data suggest that the greatest potential for increased nutrient loads into Deer Lake will be from the lake's tributary watershed and drain fields.

4.4 <u>Property Owners Survey</u>

The survey was distributed by mail to members of the Deer Lake Improvement Association on May 1, 1992. Two hundred seventy surveys were distributed; 160 were returned, resulting in a response of 60 percent. The complete results of the survey are included in the appendices at the end of the report.

The intent of the survey was to collect information which would assist the Association in short and long range planning. The Association evaluated the responses to the survey and selected ten items which appeared to be the most important issues facility property owners around Deer Lake. The ten items were:

- Why did you buy property on Deer Lake
- How much property did you buy
- What type and number of watercraft are on the lake
- Will you make you property a future permanent residence
- Water quality and water clarity
- Shoreline structures
- Lake use conflicts
- Aquatic plant growth

- Enforcement of county and state regulations
- Boater safety

Why Did You Buy Property On Deer Lake

The overwhelming response centered around enjoying the peace, tranquility and beauty offered by the lake. Another major response indicated that the lake home offered a great opportunity for relatives and friends to enjoy the lake. The survey indicated that the Association should work towards maintaining a quiet peaceful environment, not by restrictions, but by educating all users regarding the desirability of such an environment.

How Much Property Did You Buy

The survey results indicated that 54 of the respondents owned less than 100 feet of lake shore. However, most were 100 to 200 feet wide. There is very little undeveloped shoreline remaining on Deer Lake. Therefore, new construction will likely be in the form of remodeling or construction of new housing on existing lots. This type of construction may posed problems for property owners with small lots. The Association will need to work with zoning officials to better educate lake shore residents regarding any potential restrictions.

What Type and Number of Watercraft are on the Lake

The numbers reported in the returned surveys were used to project the total number of watercraft owned by all 270 property owners. The estimated numbers are:

292 power boats with 25 h.p. motors and over
54 pontoon boats
189 canoes, fishing and sail boats

The survey indicates that if non-property owners are added to this count, there is the potential for significant user conflicts should all boats be on the water at one time. While this is not likely, high usage days such as Memorial, 4th of July and Labor Day could have a significant number of boats on the lake. The survey indicates that only 25 respondents indicated a significant amount of disturbance from noise and other activities. However, the majority did say they experience a moderate amount of disturbances. Therefore, the Association should consider investigating ways to address noise and safety issues on the lake.

Will You Make Your Property a Future Permanent Residence

The response to this question should be considered very important to the Association. The survey indicated that 50 percent of the respondents either have decided or are considering making Deer Lake their permanent residence. There are four main issues which the Association should consider in regards to this information.

1. The added population will result in more clout (votes) with the various governmental bodies.

2. Property values and property taxes may increase.

3. There may be more lake activity and traffic on week days.

4. The added population could result in water quality deterioration.

Water Quality and Water Clarity

The responses to the survey overwhelmingly consider the lake to be clear and have good water quality. The results of the water quality study indicate that this is generally true. However, the lake is at a point that it is very susceptible to additional nutrient inputs.

Shoreline Structures

The large majority of the respondents did not feel that shoreline structures were detracting from the scenic views of Deer Lake.

Lake Use Conflicts

The survey indicated that approximately 50 percent of the people had experienced a conflict with other lake users. The Association should increase its educational efforts and encourage safe and courteous boating.

Aquatic Plant Growth

The survey indicated that approximately 50 percent of the respondents thought the lake had the right amount of weed growth, while 50 percent thought it was to heavy. The results of the water quality study indicate that the lake is very clear which encourages weed growth. The Association should consider discussing whether the appropriate studies should be under taken to determine the best control program, should weed growth continue to be a issue with lake shore residents.

Enforcement of County and State Regulations

Most agreed some form of relations were good, however, many respondents indicated that they were not familiar with the current rules. Thirty-two responses indicated that they were not familiar with shoreland regulations, 49 were not familiar with sanitary ordinances, and 14 were not familiar with boating regulations. The Association should consider setting up a education program to communicate these regulations to the Association Members.

Boater Safety

Sixty-three respondents indicated that they would attend a Association sponsored boater safety program.

In addition, the survey indicated many persons would like to see a rest stop developed which would offer a scenic view of Deer lake, however, many did not want a public access on the lake. Additionally, over 100 responded that a long range management plan for the lake and its watershed is desirable. The majority of the lake shore residents felt that the lake property owners should take responsibility for managing the lake with the state and local agencies providing significant support.

The survey generally indicates that the property owners on Deer Lake will take the appropriate actions to maintain and improve the quality of the lake. Sixty-three of the respondents indicated a willingness to volunteer their services to Association activities.

5.0 RECOMMENDATIONS AND MANAGEMENT ACTIONS

The recommendations and management actions presented in this report are based on the evaluation of the Self Help Lake Monitoring Data, the Deer Lake Planning Grant Study and designation of the Deer Lake Watershed as a priority watershed. The Priority Watershed Program is a multi-year effort to categorize the watershed's of lakes in the Balsam Branch watershed. The priority watershed project is being managed through the Polk County Land Conservation Department. Representatives from the Deer Lake Improvement Association are members of a advisory committee which is overseeing the priority watershed project.

The management recommendations are broken down into four main categories. These include:

1. Urban Lake Shore Recommendations
2. Agricultural Watershed Recommendations
3. In-Lake Recommendations
4. Additional Work Tasks

5.1 Urban Lake Shore Recommendations

The immediate ring of cabins and roads surrounding the shoreline of Deer Lake is very typical of low to moderate density residential land use observed in many urban situations. This type of land use generally exports 2-5 times the phosphorus into a lake than does land in its natural state. The increase in pollutant load is primarily attributable to increases in impervious (paved) surfaces. The surfaces increase the amount of stormwater runoff. Additionally, land use practices such as fertilizing near the shoreline, grass clippings placed into the lake, failing septic systems etc.... all result in increased pollutant loads.

The results of the hydrologic and phosphorus budgets indicate that watershed and septic phosphorus loads into Deer Lake are relatively minor in comparison to other sources. However, it is important for Deer Lake property owners to recognize that their property represents a significant potential source of pollutants into Deer Lake. Therefore, in order to protect Deer Lake's water quality, the Deer Lake Association and other local units of government should adopt, as its management goal, a no-net increase in phosphorus load from the urban lake shore areas surrounding Deer Lake. It is therefore recommended that the Deer Lake Improvement Association implement the following actions;

1. Regularly educate Association members regarding their role in protecting Deer Lake's water quality. Activities such as using low phosphate fertilizers, regularly maintaining septic systems, and creation of shoreline buffer strips should be encouraged. Lake shore property owners should consider the regular maintenance and update of their septic systems as the "costs" associated with owning lake shore property.

2. Comprehensive land use planning should be enforced in the watershed of Deer Lake. Specifically, any new residential, commercial, or institutional development which will increases the amount of storm water runoff and hence pollutant loadings into Deer Lake should be directed to discharge stormwater through an appropriate treatment device. These devices can include grassed swales, wetlands or constructed wet detention ponds. This practice will assist in mitigating the eutrophication effects of the development.

3. As indicated by the property owners survey, the Deer Lake Improvement Association should begin a program to regularly update property owners regarding the most current regulations affecting zoning, boater safety, and sanitary ordinances. These ordinances, if enforced and followed, offer significant protection to Deer Lake's water quality.

5.2 Agricultural Watershed Recommendations

The hydrologic and nutrient budgets indicate that watershed and agricultural loadings of nutrients into Deer Lake were relatively minor. However, the runoff grab sampling indicates that there may be some significant pollutant sources within the watershed. Based on the runoff water quality data, water quality of Deer Lake's tributary streams could be considered poor. The potential increases in nutrient loadings from the agricultural watershed into Deer Lake is the single biggest threat to the long term health of Deer Lake. It is therefore imperative that the Deer Lake Improvement Association actively assist with the Priority Watershed Project. Specifically, the Deer Lake Improvement Association should focus its attention on the following issues related to the agricultural watershed of Deer Lake.

1. Promote the retention/detention of stormwater runoff within Deer Lake's watershed. This activity includes protection of any existing depressions and wetlands. Additionally, creations of new detention areas, especially within the direct watershed and Watersheds 2 and 3 should be encouraged.

2. Promote the stabilization and restoration of stream beds within Deer Lake's watershed. During the installation of the flow monitoring equipment, it was obvious that significant erosion was occurring at the outfalls of the stormwater culverts and in the stream channels tributary to Deer Creek. The Association should assist the Priority Watershed project in identifying areas for restoration and protection.

3. Work closely with the agricultural community through the Priority Watershed Project to identify cost effective management practices which lead to increased profitability for the farm operators and improved water quality in Deer Lake's tributary streams.

5.3 <u>In-Lake Recommendations</u>

This project resulted in two main issues being identified in regards to in-lake water quality of Deer Lake. The issues are weeds (aquatic macrophytes) and internal loading of phosphorus from the lakes sediments.

1. Aquatic Weeds

The weed issue is significant because a significant number of Deer Lake property owners identified weeds as a problem within the lake. It must be understood by the public that aquatic weeds generally do not derive their nourishment from phosphorus in the water column. Their nourishment typically comes from the lake's sediments, which typically have a large supply of nutrients. Generally, very little can be done to control weed growth other than harvesting and chemical treatment. One situation which may cause excessive weed growth in localized areas, is the presence of a failing septic system.

The relatively clear water of Deer Lake and sandy to silty substrate offer an excellent growth environment for weeds. An environmentally responsible position for the management of aquatic weeds is to first study the types, distribution, and density of weed growth prior to instituting a corrective action. The management activity, whether harvesting or chemical application, should be selected with a specific goal in mind. A random or uncontrolled treatment of aquatic weeds can result in detrimental consequences for the lake and its aquatic community. Therefore, the Deer Lake Improvement Association should institute a careful evaluation of the weed problem and then conduct the appropriate studies prior to instituting any specific management action.

2. Internal Phosphorus Loading

The water quality data of Deer Lake indicates that internal loading of phosphorus is greatly affecting late summer early fall phosphorus concentrations. The anaerobic (without oxygen) conditions in Deer Lake's bottom waters during the mid and late summer are resulting in release of phosphorus from the sediments. There is insufficient data to determine whether this release is also occurring over winter and affecting spring and early summer water quality.

The control of internal phosphorus load would likely require the application of a chemical precipitate such as alum (aluminum sulfate), which effectively prevents the release of phosphorus from anoxic sediments. Aeration is another technique which has been suggested as a means to reduce the internal load of phosphorus in lakes. However recent studies (Beduhn et al., 1993, in publication) have found that destratifying aeration systems actually increase the internal loading of phosphorus from lake sediments and typically result in degraded late summer water quality.

The management recommendation in regards to internal loading of phosphorus is to take a wait and see approach. Deer Lake's water quality is generally good. The internal component of the load is significant, but can be controlled and would not be expected to increase significantly in the near future. Therefore, the Association should focus its attention on the areas with the greatest potential to increase the phosphorus loads to Deer Lake. Specifically, the urban and agricultural watersheds of Deer Lake.

5.4 Additional Work Tasks

It is recommended that the Deer Lake Association follow three parallel tracks in the process of implementing the recommendations of this report these include:

1. Actively participate in the Priority Watershed Project.

2. Actively implement and pursue the educational activities and programs outline in this report.

3. Collect additional data on Deer Lake and its tributary watershed.

3. Collect Additional Data on Deer Lake and Its Tributary Watershed

In conjunction with the Priority Watershed Project, the Deer Lake Improvement Association is encourage to continue baseline data collection. This baseline data includes:

- Continued participation in the Self Help Monitoring Program
- Continued daily reading of the lake outlet gage
- Redistribute rain gages and continue collecting data
- Apply for a second Lake Planning Grant

The second study should focus on collecting the following information:

- Winter and spring lake water quality data
- Collect additional snowmelt runoff data from the lakes five main tributary watersheds.
- Continued collection of the rainfall and staff gage data
- Intensive storm event monitoring and continuous flow gaging on two of Deer Lake's five tributary watersheds. (Sample six storms during 1994, two spring, two summer and two fall.)

The second lake planning grant has two main goals, these are to further define the significance of the internal phosphorus loads on spring and early summer water quality, and with more precision, quantify the loading of nutrients and water from Deer Lake's tributary watersheds. The study will be completed by the end of 1994 and the results can be incorporated by the Priority Watershed Committee in recommending and prioritizing corrective actions in Deer Lakes tributary watershed. The second grant application should be submitted by August 1, 1993 to ensure funding for the winter sampling work.

Appendices

Appendix A

Tables

Table 1
Deer Lake Physical Morphometry

Normal Elevation	1,109 feet (MSL)
Surface Area @ Normal	812 acres
Maximum Depth - East Basin	45 feet
- West Basin	26 feet
Volume @ Normal	20,762 acre-feet
Mean Depth (Volume/Surface Area)	25.6 feet
Watershed Area to Lake Area Ratio	7.1 : 1

Table 2
Deer Lake Watershed Areas

Direct (excluding lake)	1,157 acres
Watershed 1	222 acres
Watershed 2	145 acres
Watershed 3	350 acres
Watershed 4	2,241 acres
Watershed 5	1,649 acres
Total Watershed Area	5,764 acres

TABLE 3

TRIBUTARY RUNOFF VOLUME DATA

Watershed	Recorded Dates of Flow	Runoff Volume (ac-ft)	Runoff Yield (in)	Precipitation (in)	R.O. Coeff
1	May 5-May 23 July 1-Sept 1	0.50	0.027	5.9	0.005
2	May 5-June 4 June 19-Sept 1	3.80	0.314	7.02	0.045
3	May 5-June 5 June 19-Sept 1	0.12	0.004	7.02	0.0006
4	May 5-June 4 June 19-Sept 1	0.17	0.001	7.02	0.0001
5	May 5-June 4 June 19-Sept 1	0.84	0.006	7.02	0.0009

Average Coeff. = 0.010

ESTIMATE MAY 1992 - MAY 1993 RUNOFF VOLUMES

Watershed	Runoff Coeff	Total Precipitation (in)	Runoff Yield (in)	Runoff (ac-ft)
1	0.005	21.89	0.103	1.91
2	0.045	21.89	1.062	12.83
3	0.0006	21.89	0.10	2.88
4	0.0001	21.89	0.003	0.57
5	0.0009	21.89	0.033	4.53
6 Direct	0.010	21.89	0.26	25.06
			Total	47.78

TABLE 4c

DEER LAKE TRIBUTARY RUNOFF - SNOWMELT

WATER QUALITY DATA

DATE COLLECTED: 29-MAR-93

Parameter	Locations				
	W-2 NE¼ Sec. 30	W-3 NW¼ Sec. 30	W-4 E. Fork Rock Creek	W-1 Sec. 29	W-5 W. Fork Rock Creek
Stream Depth (ft)	1	1	1	1	1
Ammonia-N (mg/L)	0.025	0.463	0.273	0.978	4.87
Nitrate-Nitrite-N (mg/L)	0.129	0.493	0.428	0.237	0.854
Total Kjeldahl Nitrogen-N (mg/L)	0.4	1.6	1.7	2.6	11.0
Total Phosphorus (mg/L)	0.135	0.90	0.66	0.36	4.15
Dissolved Phosphorus (mg/L)	0.053	0.75	0.47	0.153	3.11
Total Suspended Solids (mg/L)	6	11	32	44	92
Sample Collection Time	13:30	13:45	14:00	13:15	13:00

TABLE 4b

DEER LAKE TRIBUTARY RUNOFF - SNOWMELT

WATER QUALITY DATA

DATE COLLECTED: 27-MAR-93

Parameter	Locations				
	W-2 NE¼ Sec. 30	W-3 NW¼ Sec. 30	W-4 E. Fork Rock Creek	W-1 Sec. 29	W-5 W. Fork Rock Creek
Stream Depth (ft)	3	3	3	3	3
Ammonia-N (mg/L)	0.202	0.054	0.051	3.60	1.46
Nitrate-Nitrite-N (mg/L)	0.340	0.293	0.243	0.609	0.274
Total Kjeldahl Nitrogen-N (mg/L)	1.8	1.1	0.8	6.5	3.3
Total Phosphorus (mg/L)	0.36	0.27	0.175	1.08	0.171
Dissolved Phosphorus (mg/L)	0.23	0.196	0.101	0.81	0.084
Total Suspended Solids (mg/L)	40	5	6	11	73
Sample Collection Time	14:45	10:15	10:30	10:00	10:45

TABLE 4a

DEER LAKE TRIBUTARY RUNOFF - STORM

WATER QUALITY DATA

DATE COLLECTED: 07-JUL-92

Parameter	Locations			
	W-2 NE¼ Sec. 30	W-3 NW¼ Sec. 30	W-4 E. Fork Rock Creek	W-1 Sec. 29
Stream Depth (ft)	0.25	0.5	0.75	0.6
Ammonia-N (mg/L)	0.390	0.114	0.059	4.05
Nitrate-Nitrite-N (mg/L)	1.43	1.0	0.238	1.16
Total Kjeldahl Nitrogen-N (mg/L)	3.0	1.0	1.70	21.0
Total Phosphorus (mg/L)	1.05	0.67	0.43	11.6
Dissolved Phosphorus (mg/L)	0.304	0.348	0.054	9.55
Total Suspended Solids (mg/L)	436	209	114	98
Sample Collection Time	5:15 a.m.	5:30 a.m.	5:45 a.m.	5:00 a.m.

TABLE 5a

DEER LAKE - EAST BASIN

1990 LAKE WATER QUALITY

Depth (ft)	Date	Total Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	pH	Secchi Disc (ft)
0.5	30-JUL-90	0.030	--	--	--	9.5
3			72.3	7.4	8.7	
9			72.3	7.6	8.9	
15			72.3	8.4	8.8	
20			70.3	5.4	7.9	
25			68.2	3.4	7.4	
30			63.2	2.9	7.2	
35			60.2	3.4	7.2	
38		0.840	--	--	--	
40			59.1	1.8	7.2	
42			58.1	0.6	7.2	
0.5	27-AUG-90	0.029	--	--	--	7.0
3			75.3	9.2	9.0	
9			73.3	8.1	9.0	
15			73.3	6.2	8.4	
20			71.3	5.6	7.9	
25			71.3	3.7	8.0	
30			65.2	3.5	7.3	
35			62.2	2.8	7.2	
40			61.0	2.6	7.3	
44		1.021	60.2	3.8	7.3	
1	25-SEP-90	0.101	--	--	--	6.0
3			63.1	5.4	7.7	
9			62.1	5.8	7.7	
15			62.1	5.8	7.7	
20			61.0	6.1	7.6	
25			61.0	6.0	7.6	
30			61.0	6.0	7.6	
35			61.0	5.2	7.6	
40			60.0	2.6	7.2	
44			58.9	2.3	7.1	

TABLE 5a (Cont.)

DEER LAKE - EAST BASIN

1990 LAKE WATER QUALITY

Depth (ft)	Date	Total Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	pH	Secchi Disc (ft)
1	15-OCT-90	0.082	--	--	--	7.0
3			55.8	7.9	8.1	
9			55.8	8.1	8.1	
15			54.8	8.1	8.0	
20			54.8	8.2	8.1	
25			54.8	8.9	8.0	
30			54.8	8.9	8.1	
35			54.8	8.9	8.2	
40			54.8	9.2	8.2	
43		0.091	54.8	9.2	8.1	

TABLE 5b

DEER LAKE - EAST AND WEST BASINS

1991 LAKE WATER QUALITY DATA

EAST BASIN

Depth (ft)	Date	Total Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	pH	Secchi Disc (ft)	Chla (μg/L)
3	31-JUL-91	0.013	73.5	10.2	8.3	13.0	3.68
9			73.5	9.4	8.3		
15			72.5	8.6	8.4		
20			71.4	8.8	8.4		
25			65.2	2.2	6.9		
30			57.9	3.8	6.7		
35			54.8	3.0	6.9		
40			53.7	1.4	7.0		
44		1.002	54.8	3.8	7.0		
3	26-AUG-91	0.014	75.6	8.8	8.9	10.5	8.95
9			74.5	9.4	9.1		
15			74.5	8.5	9.0		
20			72.5	7.2	7.9		
25			70.4	5.2	7.4		
30			60.0	1.8	7.5		
35			63.1	2.3	7.2		
40			54.8	3.6	7.2		
44		0.960	54.8	0.0	7.2		
3	24-SEP-91	0.046	58.9	8.0	8.7	8.5	16.4
9			58.9	8.0	8.5		
15			58.9	7.8	7.5		
20			58.9	7.8	7.7		
25			58.9	7.8	7.7		
30			58.9	7.4	8.0		
35			58.9	7.4	8.0		
40			55.8	4.0	7.6		
45		1.150	53.7	2.8	7.6		

TABLE 5b (Cont.)

DEER LAKE - EAST AND WEST BASINS

1991 LAKE WATER QUALITY DATA

EAST BASIN

Depth (ft)	Date	Total Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	pH	Secchi Disc (ft)	Chla (μg/L)
3	17-OCT-91	0.030	53.7	9.8	7.9	8.0	15.8
9			53.7	9.7	8.0		
15			52.7	9.9	7.9		
20			52.7	9.6	8.1		
25			52.7	9.4	8.0		
30			51.7	9.8	8.1		
35			51.7	9.5	8.0		
40			51.7	9.5	8.0		
45		0.031	52.7	9.6	8.1		

TABLE 5b

DEER LAKE - EAST AND WEST BASINS

1991 LAKE WATER QUALITY DATA

WEST BASIN

Depth (ft)	Date	Total Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	pH	Secchi Disc (ft)	Chla (μg/L)
3	01-AUG-91	0.016	73.5	9.2	8.9	10.5	5.71
9			72.5	9.4	8.9		
15			71.4	9.4	8.8		
20			64.1	3.0	7.3		
25		0.078	67.3	5.8	7.6		
3	26-AUG-91	0.017	75.6	8.8	9.2	9.0	8.66
9			74.5	8.8	9.1		
15			74.5	8.4	8.9		
20			72.5	6.3	8.4		
24		0.092	70.4	3.4	7.9		
3	24-SEP-91	0.025	58.9	8.8	8.9	9.0	17.61
9			58.9	8.8	8.9		
15			58.9	9.0	8.8		
20			58.9	8.9	8.9		
25		0.021	57.9	8.2	8.7		
3	17-OCT-91	0.019	53.7	9.7	8.0	8.5	10.25
9			52.7	8.8	7.9		
15			51.7	9.0	7.9		
20			51.7	8.8	7.7		
25		0.017	51.7	8.8	7.8		

TABLE 5c

DEER LAKE - EAST AND WEST BASINS

1992 LAKE WATER QUALITY DATA

EAST BASIN

Depth (ft)	Date	Total Phosphorus (mg/L)	Diss. Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	Secchi Disc (ft)	Chla (µg/L)
3	18-JUN-92	0.018		66.0	8.7	11.0	4.0
9				65.0	8.9		
15				65.0	8.9		
20				65.0	8.9		
25				65.0	8.6		
30				62.0	5.8		
35		0.088	0.031	58.0	5.2		
40		0.174	0.061	56.0	4.3		
45				56.0	3.7		
3	29-JUL-92	0.010		72.0	9.2	13.0	3.0
9				72.0	9.2		
15				70.0	9.0		
20				70.0	9.0		
25				67.0	6.0		
30				65.0	2.8		
35		0.027	0.125	64.0	2.6		
40				56.0	0.8		
45				54.0	0.7		
3	18-AUG-92			72.0	9.2	15.0	
9				70.0	9.1		
15				70.0	8.8		
20				70.0	8.4		
25				70.0	6.5		
30				66.0	1.2		
35		0.3	0.195	60.0	0.8		
40		1.21	0.32	58.0	0.5		
45				57.0	0.0		

TABLE 5c (Cont.)

DEER LAKE - EAST AND WEST BASINS

1992 LAKE WATER QUALITY DATA

EAST BASIN

Depth (ft)	Date	Total Phosphorus (mg/L)	Diss. Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	Secchi Disc (ft)	Chl<u>a</u> (µg/L)
3	08-SEP-92	0.054		63.0	8.6	11.0	7.72
9				65.0	8.4		
15				65.0	8.2		
20				65.0	8.1		
25				65.0	8.1		
30				65.0	7.8		
35		0.055	0.027	65.0	7.5		
40		0.83	0.32	62.0	3.4		
45				60.0	3.6		
3	13-OCT-92	0.026		54.0	9.0	9.0	8.87
9				55.0	8.8		
15				55.0	8.8		
20				55.0	8.8		
25				55.0	8.7		
30				55.0	8.8		
35		0.039	0.007	55.0	9.8		
40		0.027	0.006	55.0	9.0		
45				55.0	8.8		

TABLE 5c

DEER LAKE - EAST AND WEST BASINS

1992 LAKE WATER QUALITY DATA

WEST BASIN

Depth (ft)	Date	Total Phosphorus (mg/L)	Diss. Phosphorus (mg/L)	Temp (°F)	D.O. (mg/L)	Secchi Disc (ft)	Chla (μg/L)
3	18-JUN-92	0.017		66.0	8.8	11.5	3.43
9				66.0	7.7		
15		0.025	0.004	66.0	8.3		
20		0.03	0.003	65.0	7.4		
25				61.0	3.4		
3	29-JUL-92	0.011		72.0	9.2	12.5	2.86
9				70.0	9.2		
15		0.012	0.021	70.0	9.2		
20		0.014	0	70.0	9.2		
25				68.0	7.6		
3	18-AUG-92	0.017		70.0	8.7	13.0	5.0
9				70.0	8.8		
15		0.012	0.008	70.0	8.8		
20		0.013	0.004	70.0	8.5		
25				70.0	6.6		
3	08-SEP-92	0.026		63.0	8.8	12.0	8.29
9				65.0	8.2		
15		0.035	0.01	65.0	8.3		
20		0.034	0.009	65.0	8.6		
25				65.0	8.2		
3	13-OCT-92	0.022		53.0	9.8	9.0	6.87
9				54.0	9.6		
15		0.023	0.002	54.0	9.8		
20		0.022	0.002	54.0	9.6		
25				54.0	9.6		

TABLE 6

1992 DEER LAKE PHOSPHORUS BUDGETS

Phosphorus Sources	Load (lbs)
Drain Fields/Septic Systems	88
Atmospheric Deposition	405
Watershed Loading	152
Groundwater and Internal	748
Total Load	1,393

Appendix B

Figures

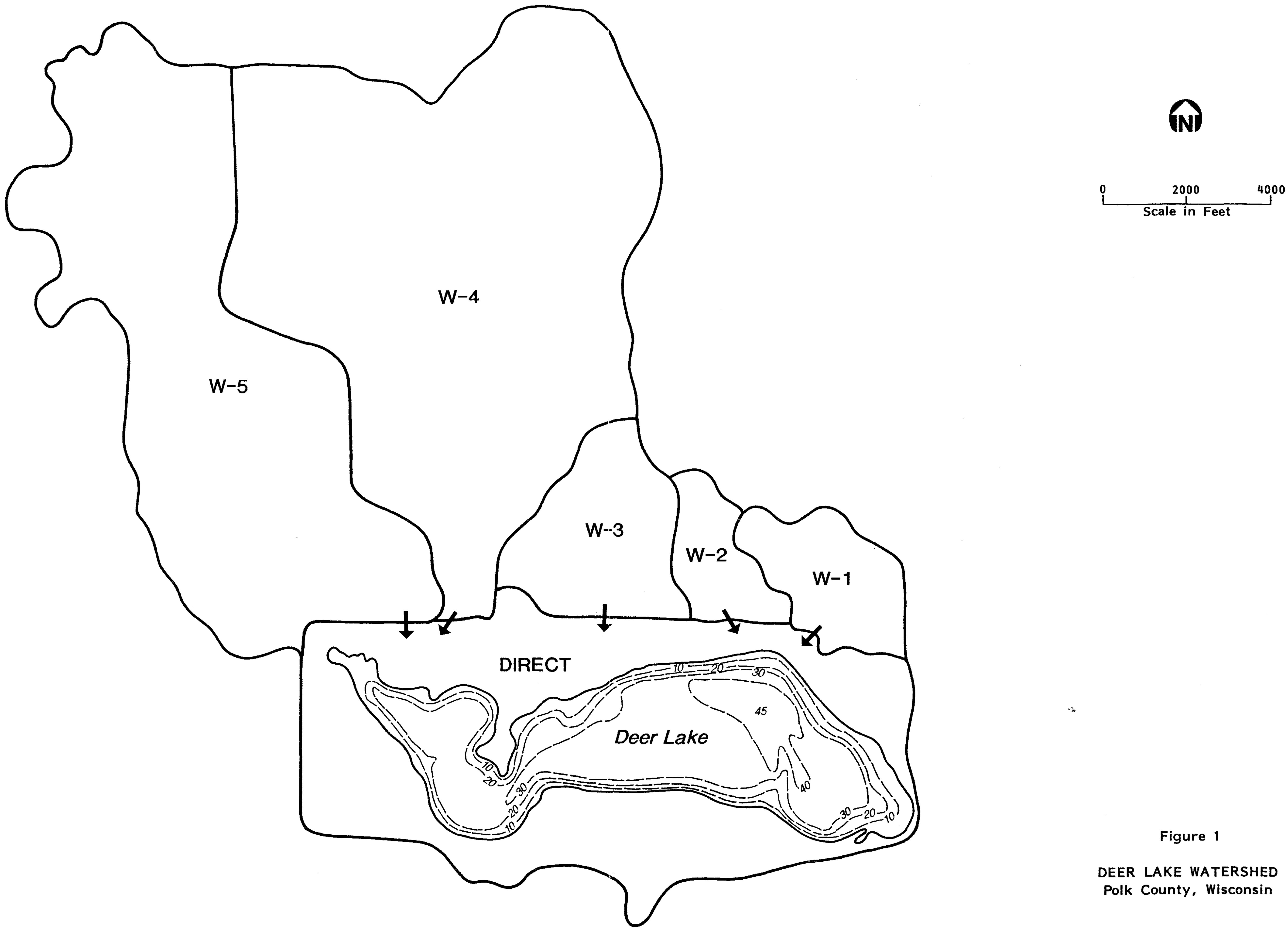


Figure 1

DEER LAKE WATERSHED
Polk County, Wisconsin

Deer Lake Hydrologic Budget
May, 1992 - May, 1993

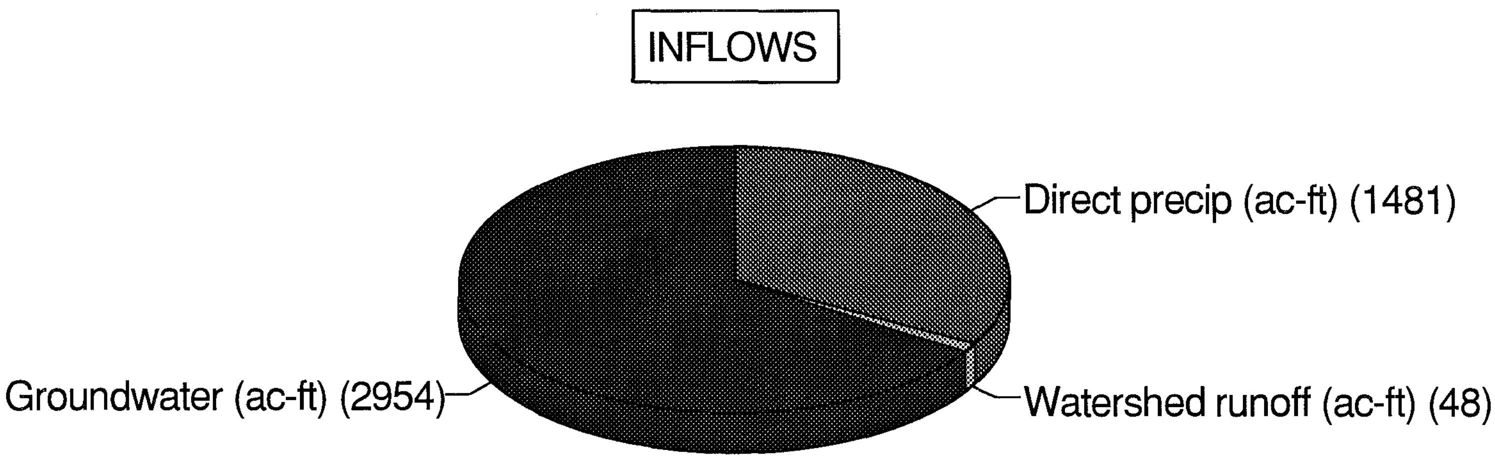


Figure 2

Deer Lake Hydrologic Budget
May, 1992 - May, 1993

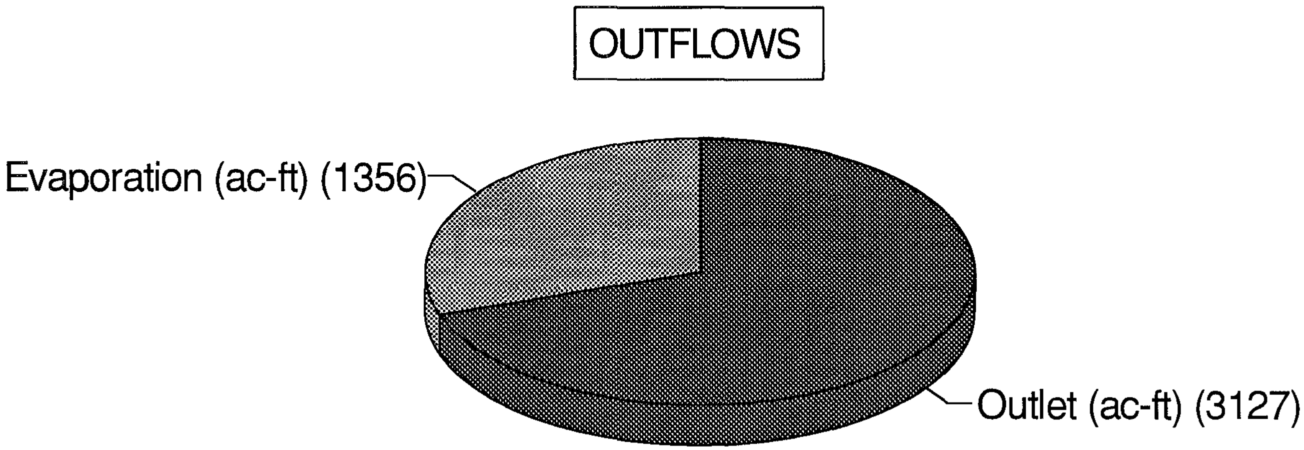


Figure 3

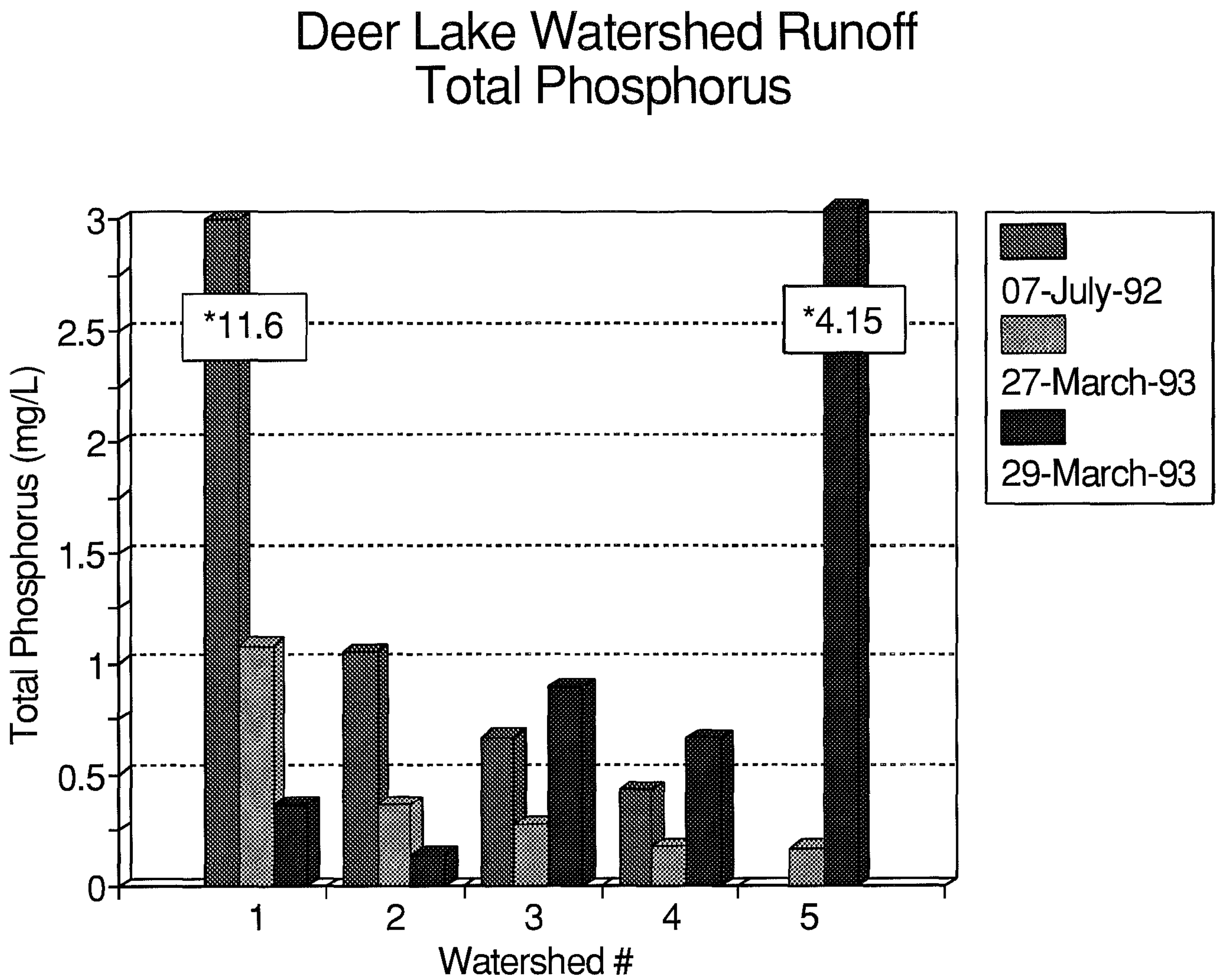

Deer Lake Watershed Runoff
Total Phosphorus
Total Phosphorus (mg/L)
3
2.5
2
1.5
1
0.5
0
*11.6
*4.15
1
2
3
4
5
Watershed #
07-July-92
27-March-93
29-March-93

Figure 4

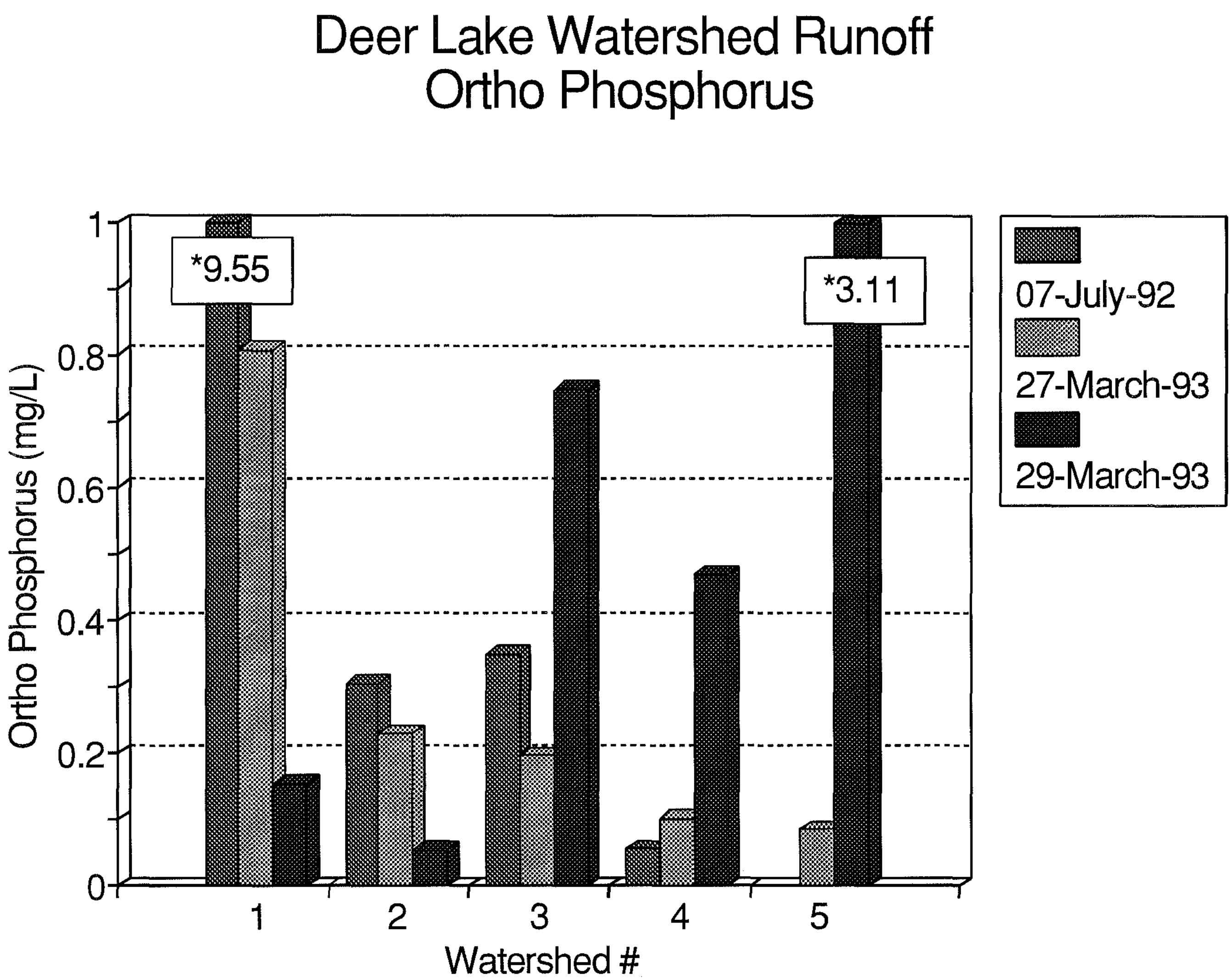
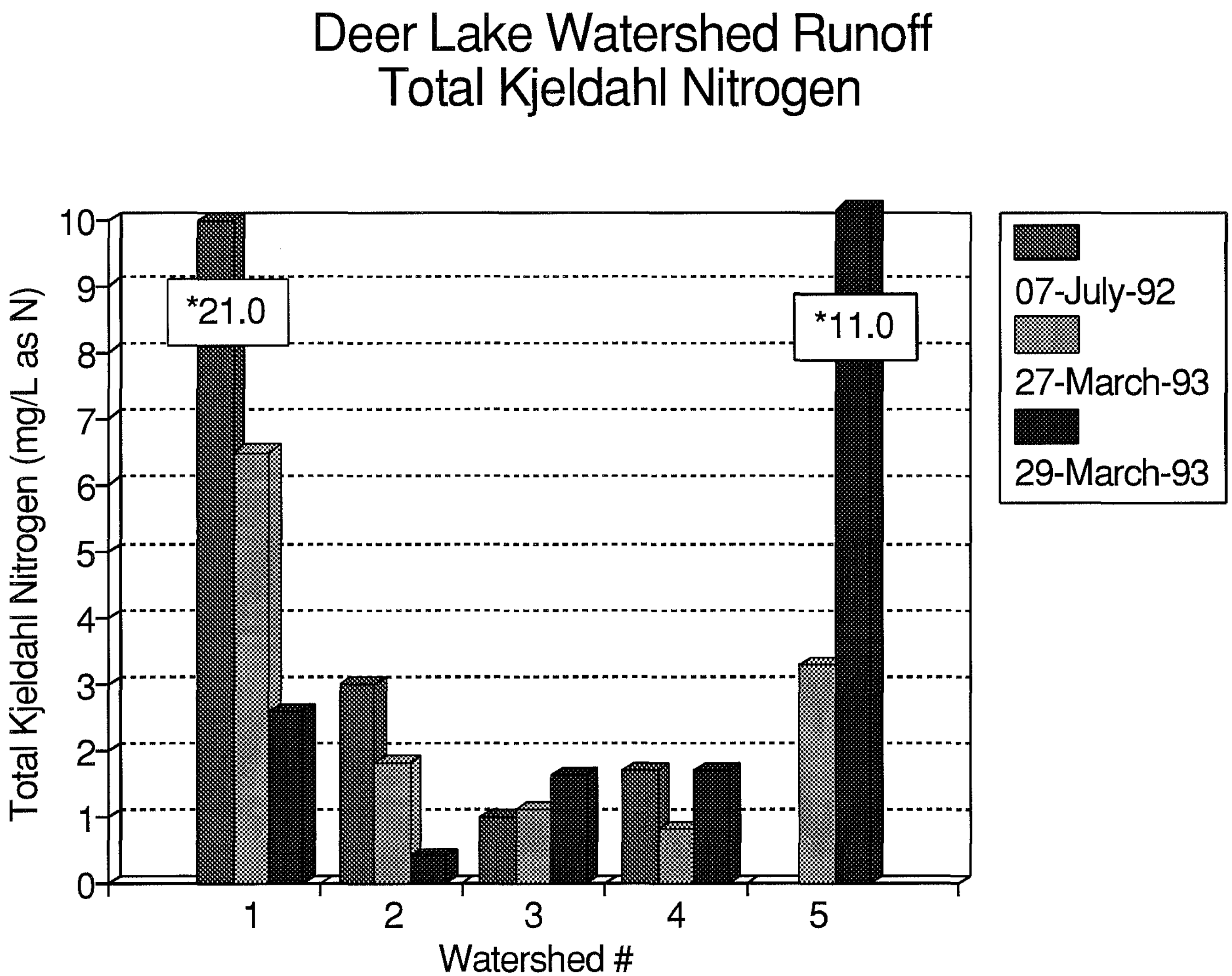

Deer Lake Watershed Runoff
Ortho Phosphorus
*9.55
*3.11
Ortho Phosphorus (mg/L)
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
Watershed #
07-July-92
27-March-93
29-March-93

Figure 5



Deer Lake Watershed Runoff
Total Kjeldahl Nitrogen
Total Kjeldahl Nitrogen (mg/L as N)
0
1
2
3
4
5
6
7
8
9
10
*21.0
*11.0
1
2
3
4
5
Watershed #
07-July-92
27-March-93
29-March-93

Figure 6

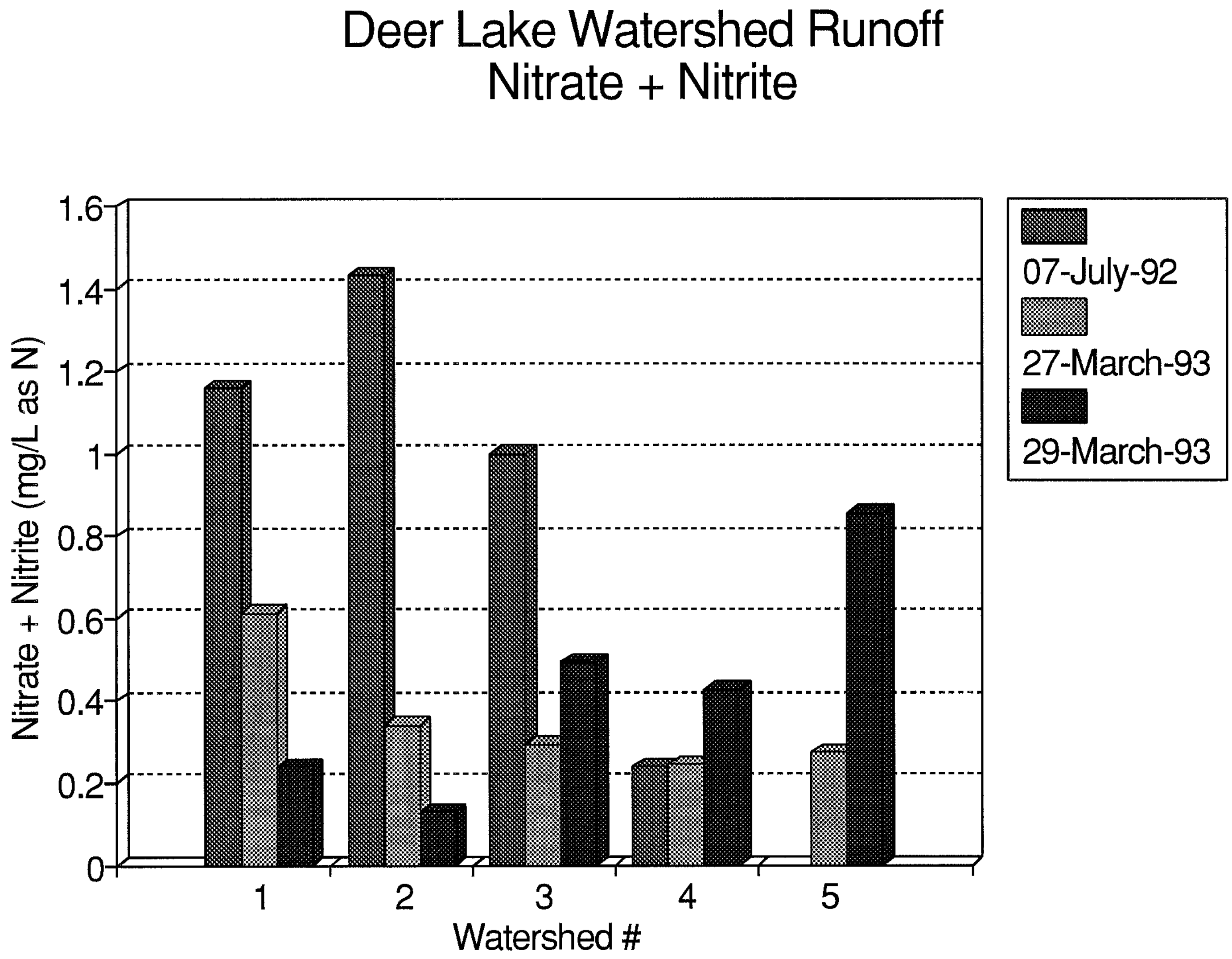
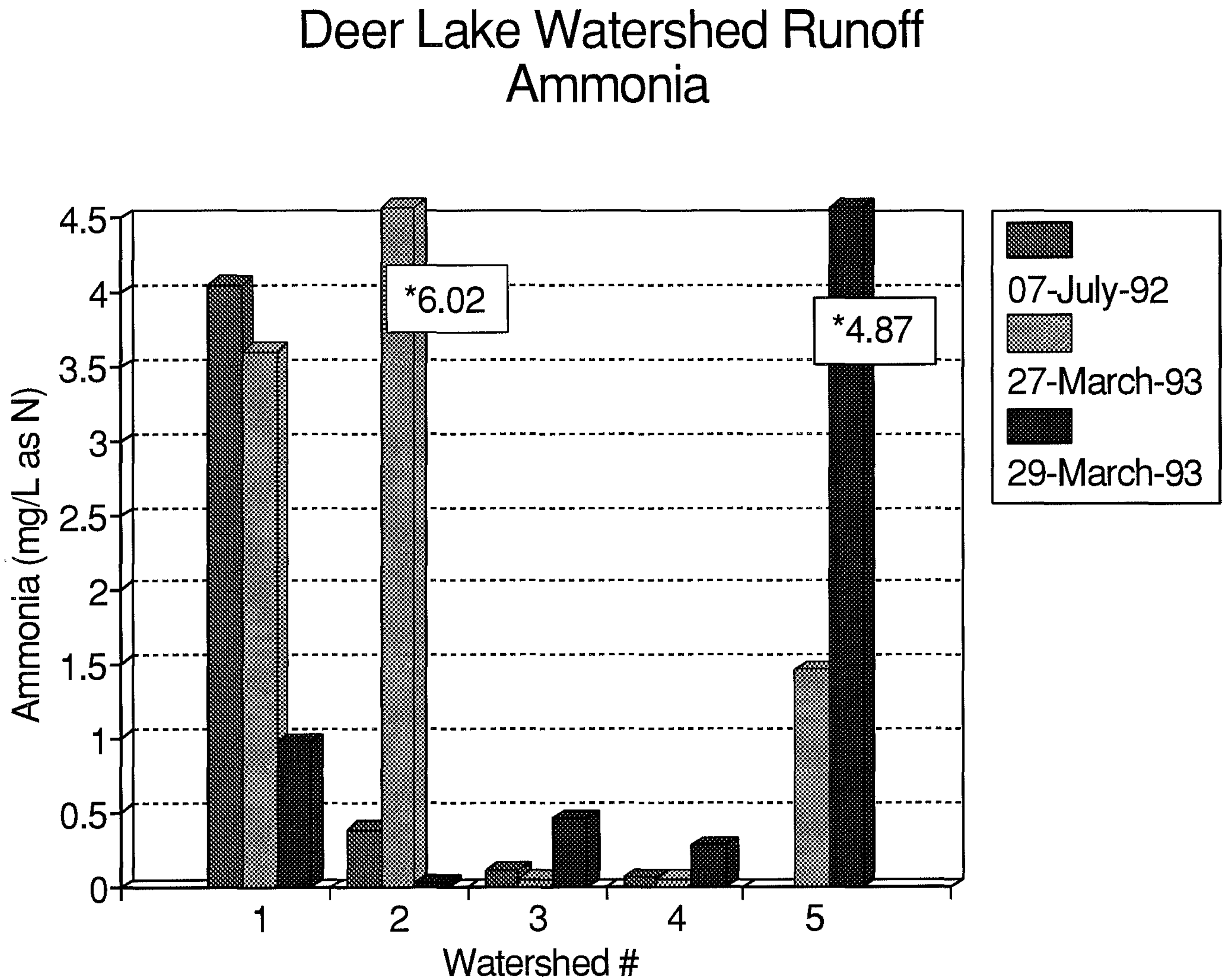

Deer Lake Watershed Runoff
Nitrate + Nitrite
Nitrate + Nitrite (mg/L as N)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1
2
3
4
5
Watershed #
07-July-92
27-March-93
29-March-93

Figure 7



Deer Lake Watershed Runoff
Ammonia
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Ammonia (mg/L as N)
*6.02
*4.87
1
2
3
4
5
Watershed #
07-July-92
27-March-93
29-March-93

Figure 8

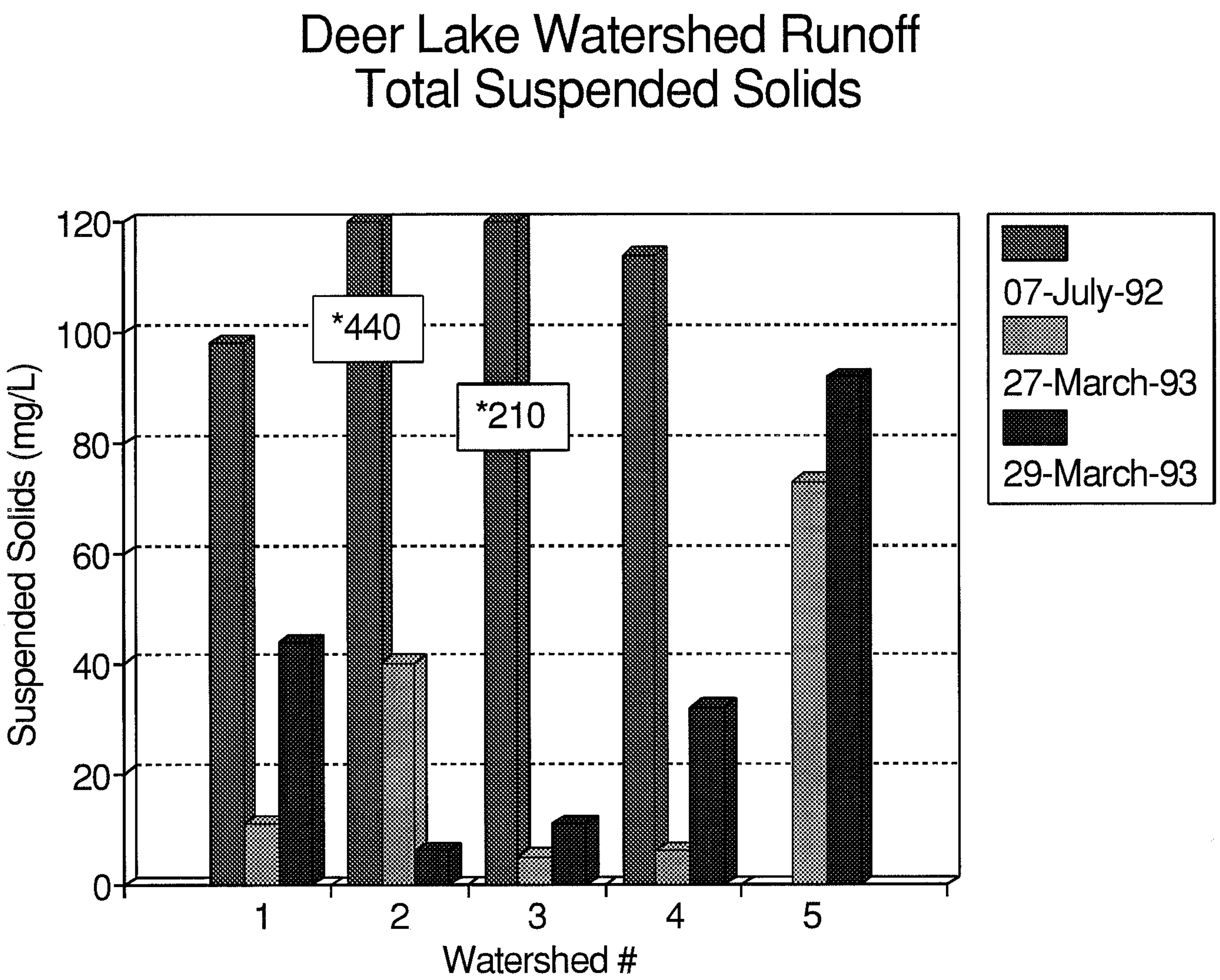

Deer Lake Watershed Runoff
Total Suspended Solids
Suspended Solids (mg/L)
120
100
80
60
40
20
0
*440
*210
1
2
3
4
5
Watershed #
07-July-92
27-March-93
29-March-93

Figure 9

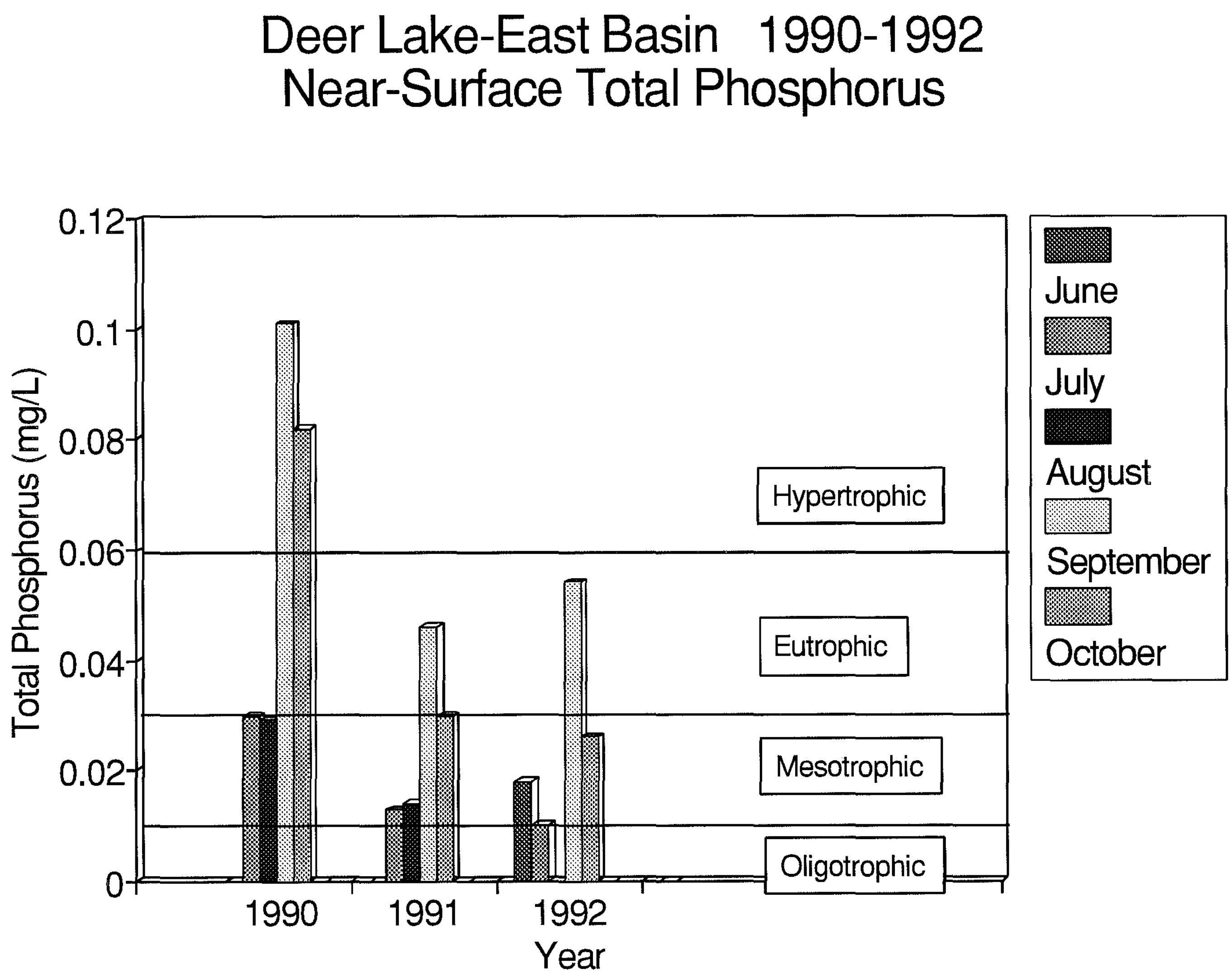

Deer Lake-East Basin 1990-1992
Near-Surface Total Phosphorus
Total Phosphorus (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
1990
1991
1992
Year
Hypertrophic
Eutrophic
Mesotrophic
Oligotrophic
June
July
August
September
October

Figure 10

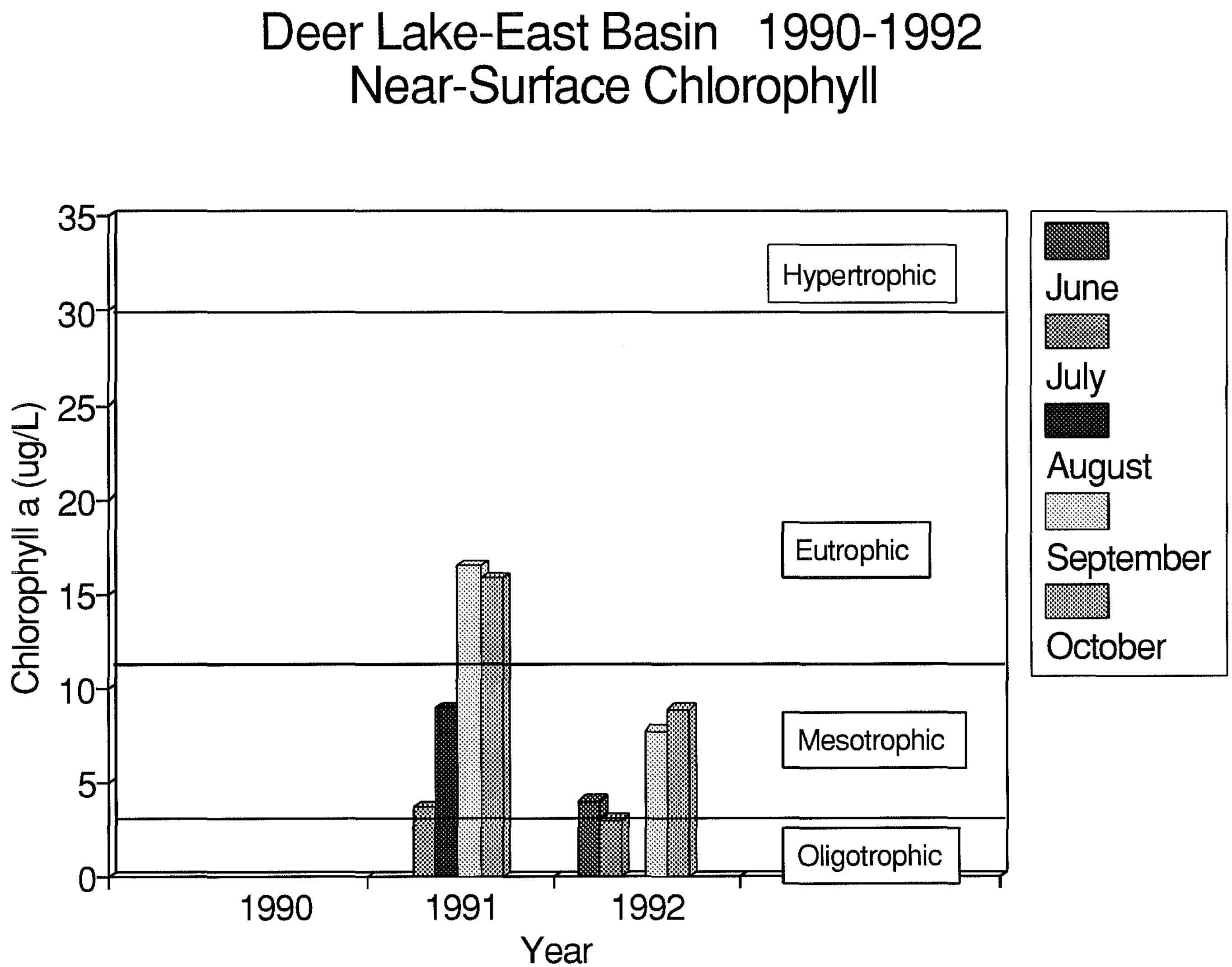
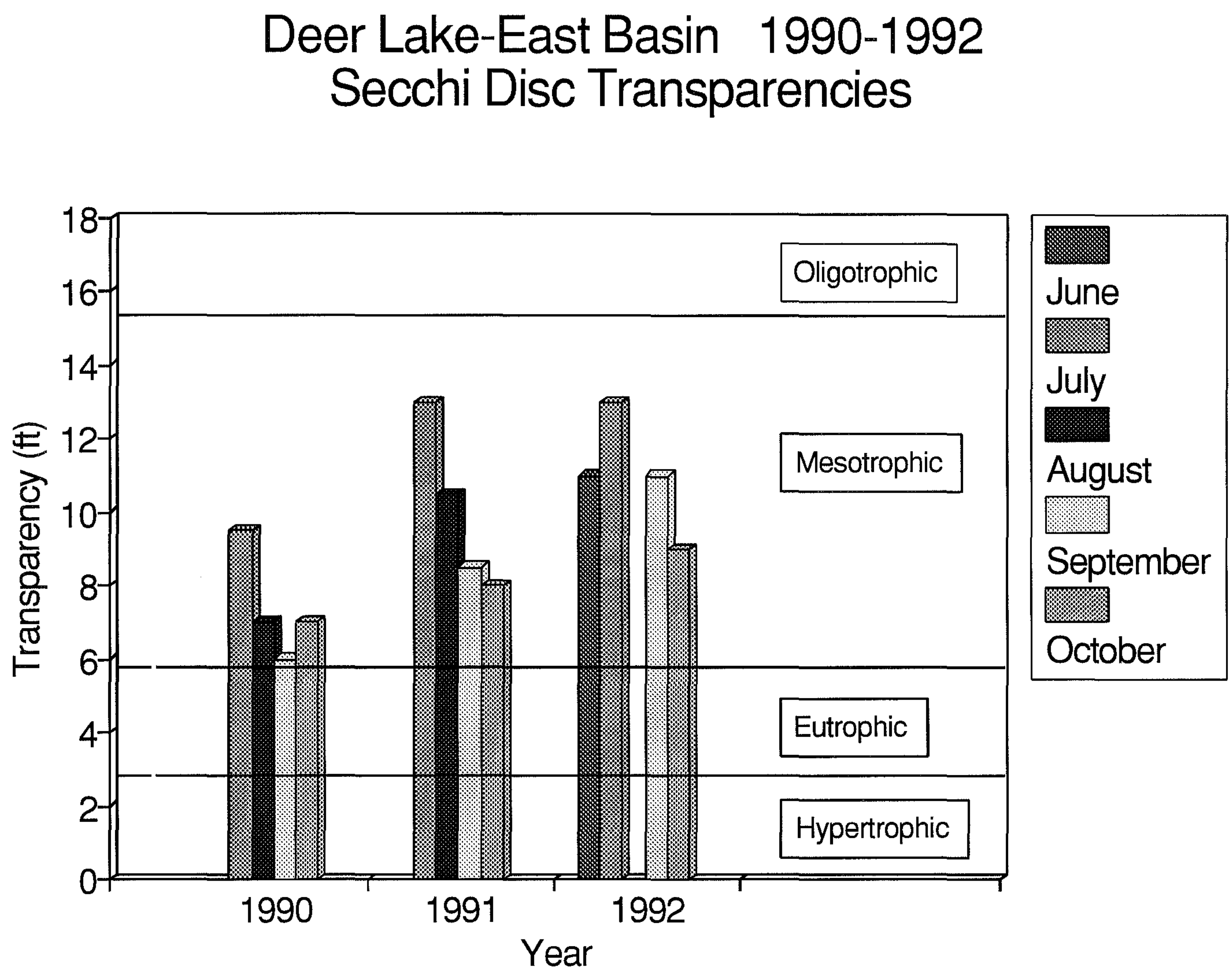
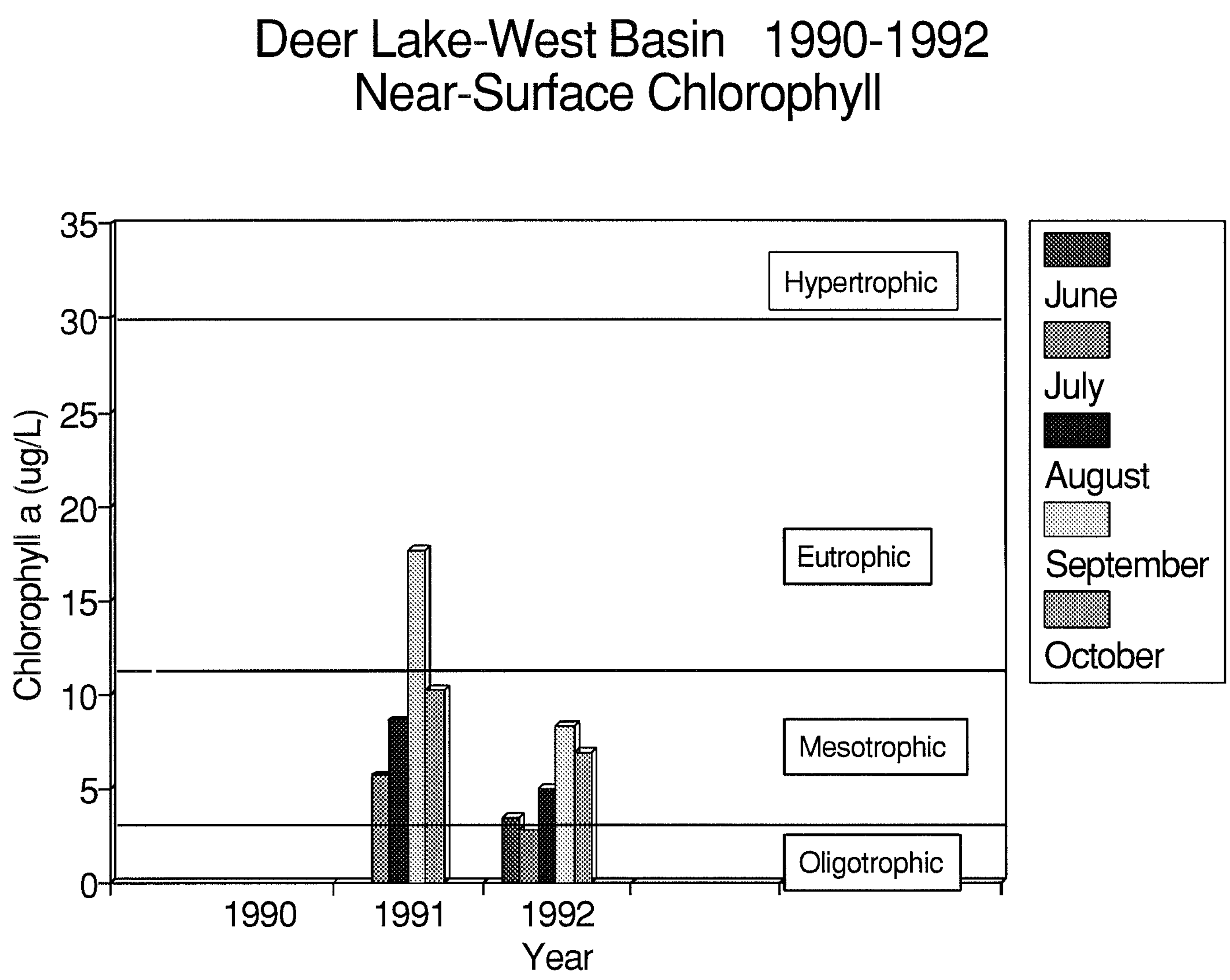

Deer Lake-East Basin 1990-1992
Near-Surface Chlorophyll
Chlorophyll a (ug/L)
35
30
25
20
15
10
5
0
Hypertrophic
Eutrophic
Mesotrophic
Oligotrophic
1990
1991
1992
Year
June
July
August
September
October

Figure 11



Deer Lake-East Basin 1990-1992
Secchi Disc Transparencies
18
16
14
12
10
8
6
4
2
0
Transparency (ft)
Oligotrophic
Mesotrophic
Eutrophic
Hypertrophic
1990
1991
1992
Year
June
July
August
September
October

Figure 12



Deer Lake-West Basin 1990-1992
Near-Surface Chlorophyll
Chlorophyll a (ug/L)
35
30
25
20
15
10
5
0
Hypertrophic
Eutrophic
Mesotrophic
Oligotrophic
1990
1991
1992
Year
June
July
August
September
October

Figure 13

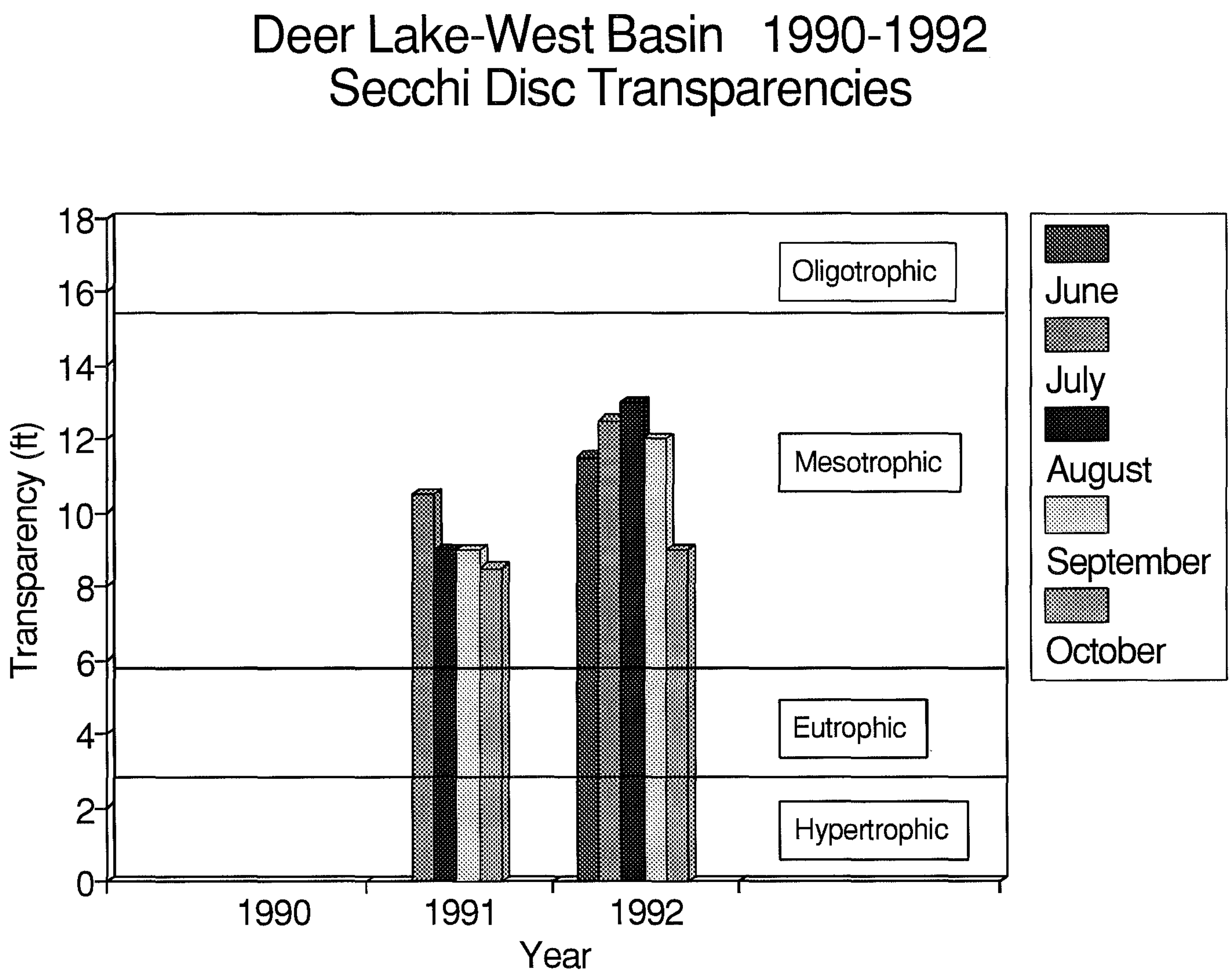

Deer Lake-West Basin 1990-1992
Secchi Disc Transparencies
Transparency (ft)
18
16
14
12
10
8
6
4
2
0
Oligotrophic
Mesotrophic
Eutrophic
Hypertrophic
1990
1991
1992
Year
June
July
August
September
October

Figure 14

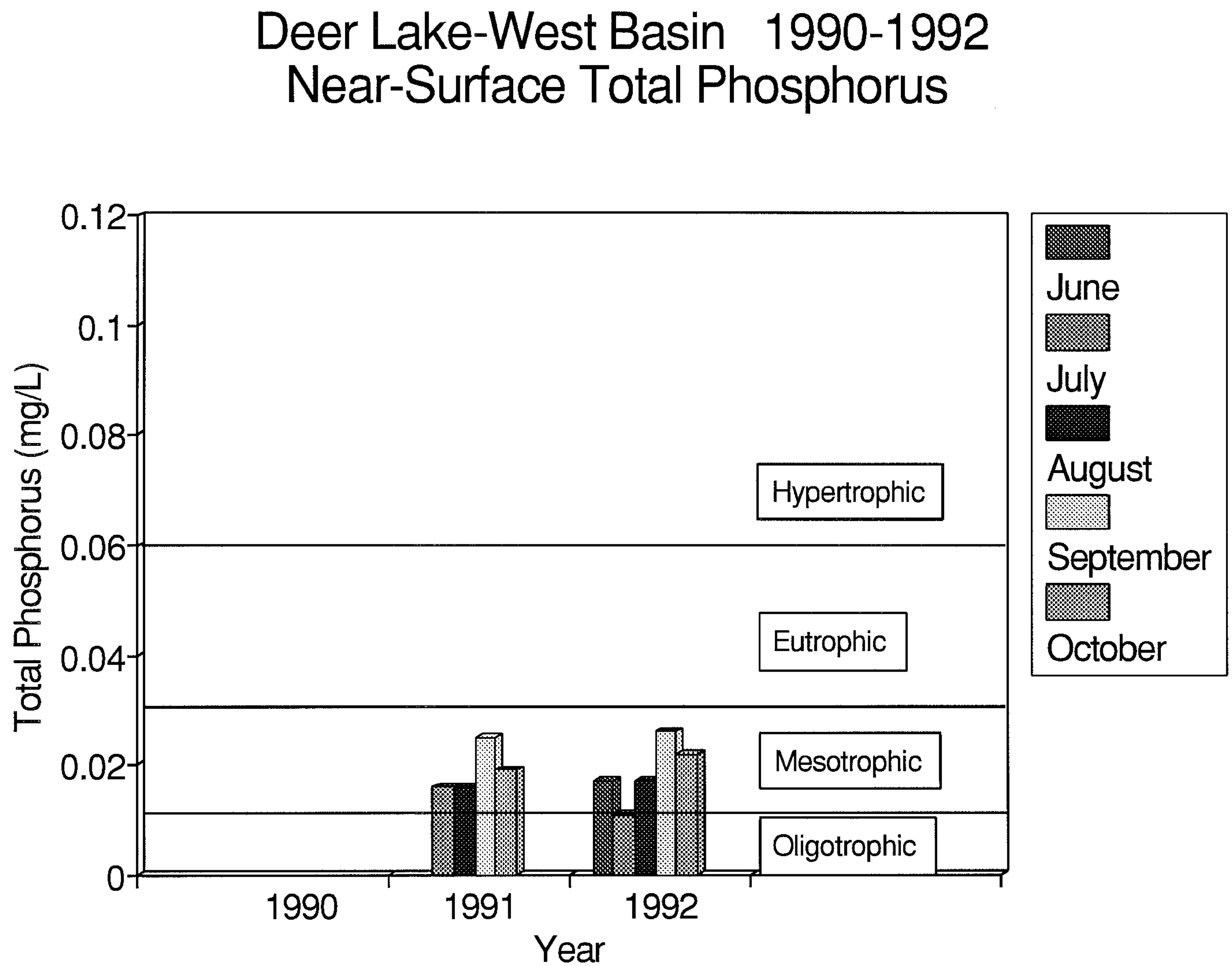

Deer Lake-West Basin 1990-1992
Near-Surface Total Phosphorus
Total Phosphorus (mg/L)
0.12
0.1
0.08
0.06
0.04
0.02
0
Hypertrophic
Eutrophic
Mesotrophic
Oligotrophic
1990
1991
1992
Year
June
July
August
September
October

Figure 15

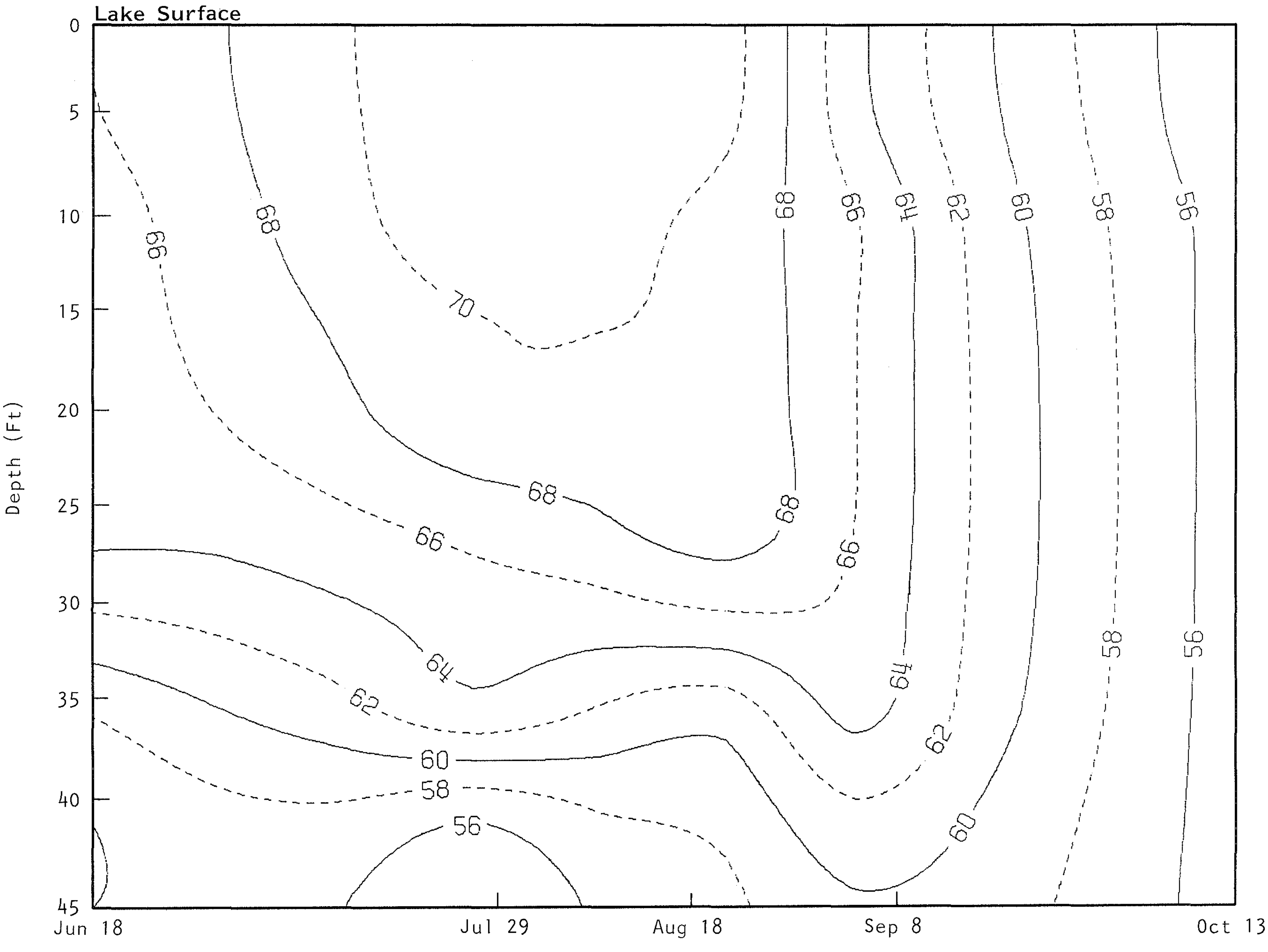
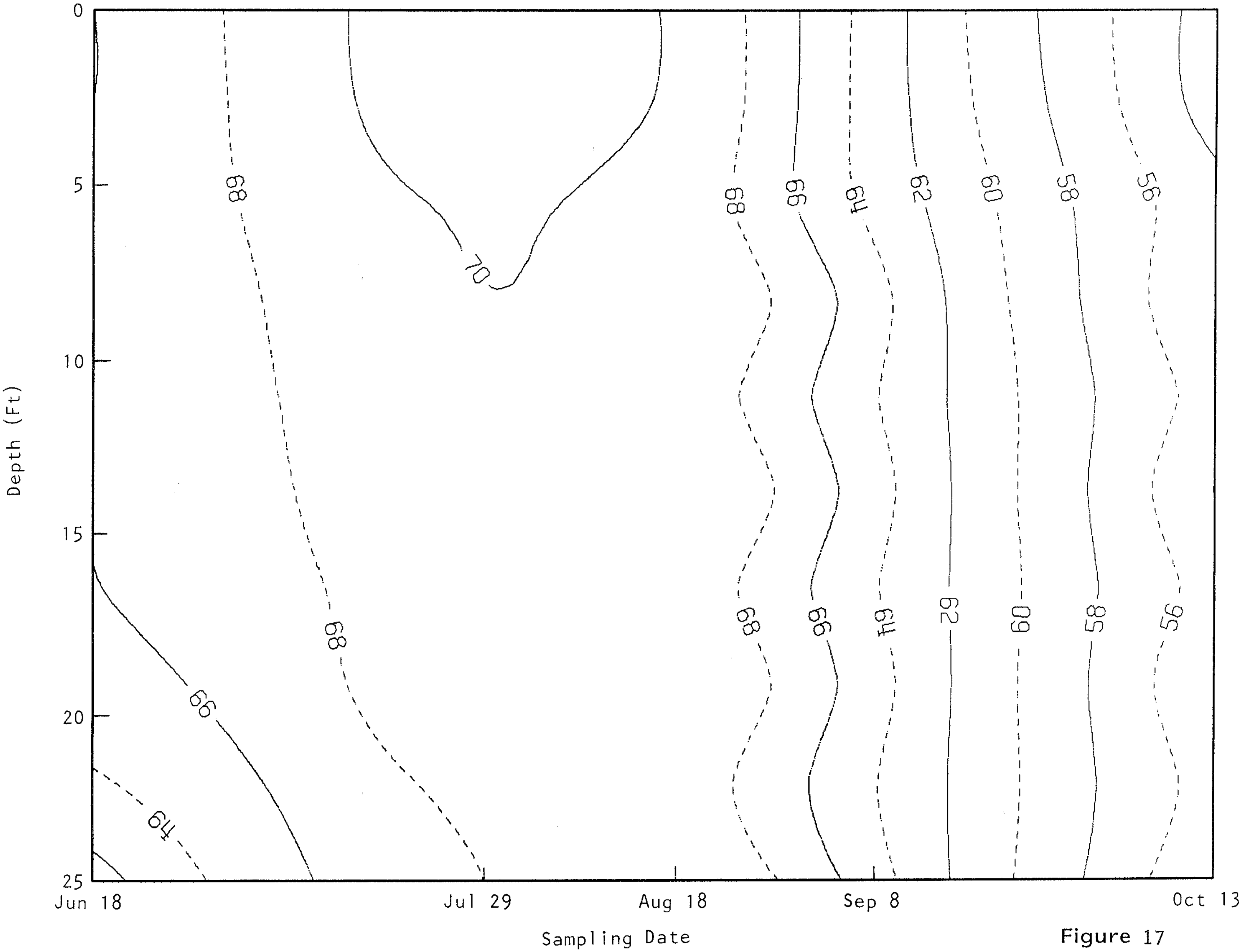


Figure 16

1992 DEER LAKE EAST BASIN
Temperature Isopleth °F



----- Value + 0.5

Figure 17

1992 DEER LAKE WEST BASIN
Temperature Isopleth °F

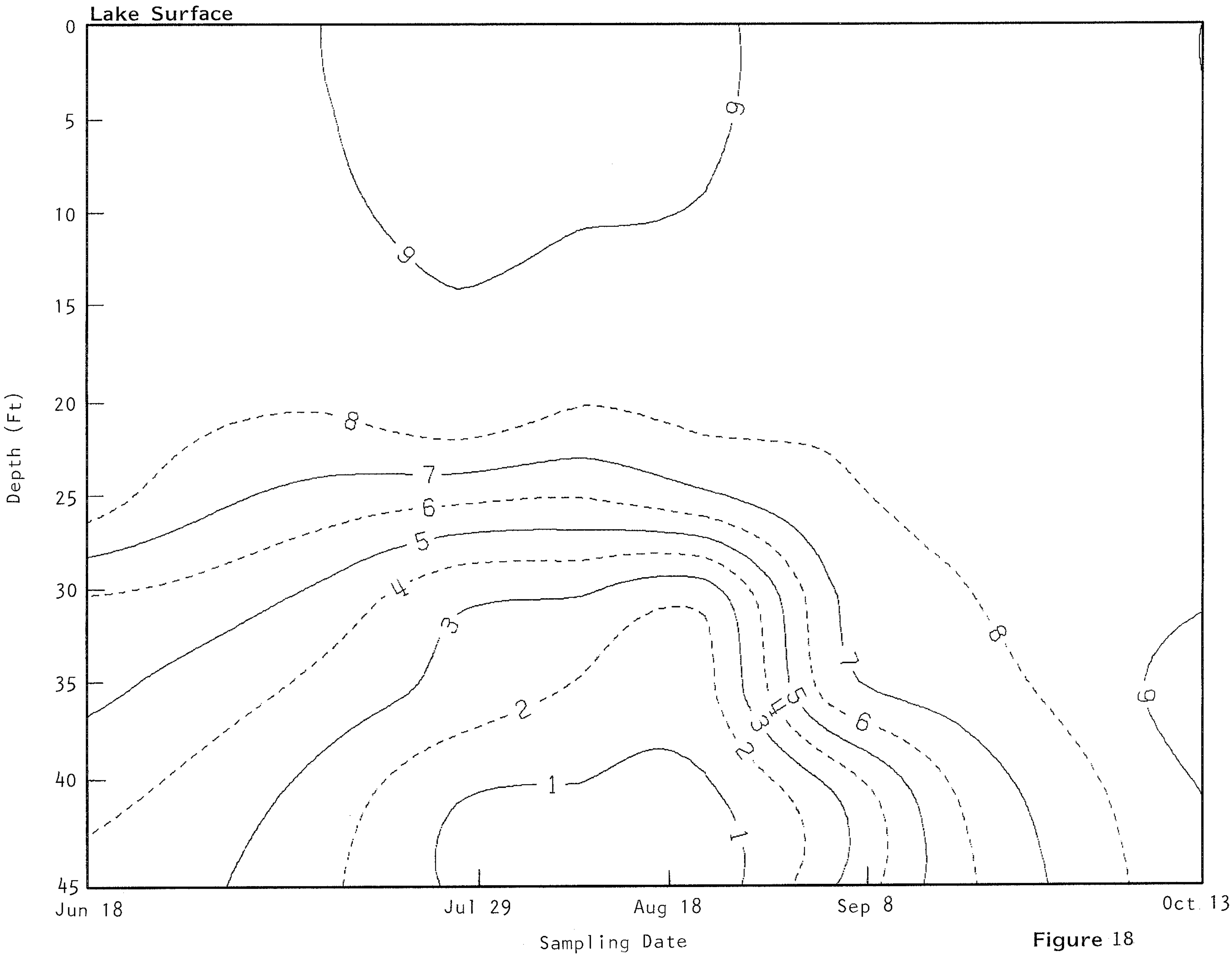


Figure 18

1992 DEER LAKE EAST BASIN
Dissolved Oxygen Isopleth (mg/l)

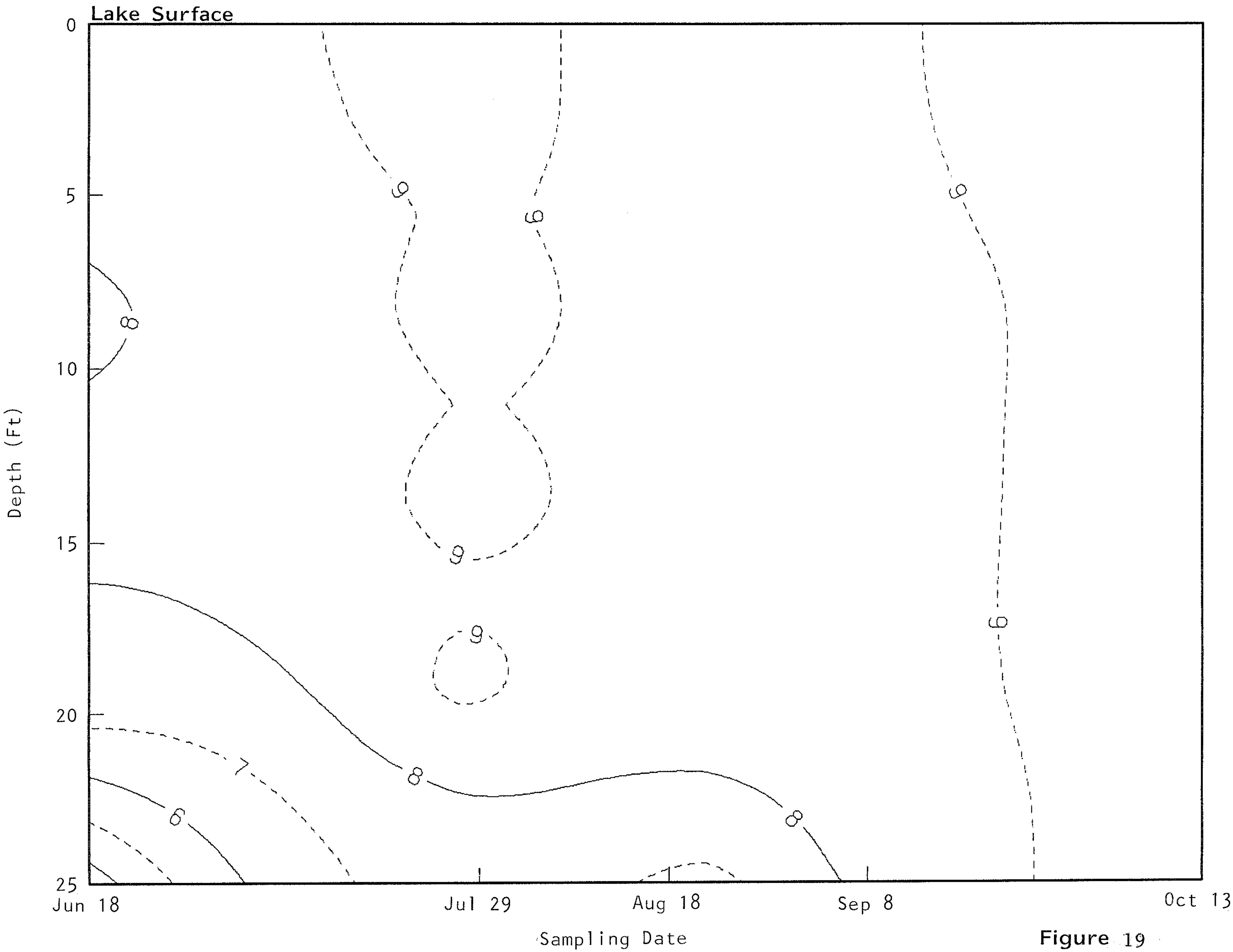


Figure 19

1992 DEER LAKE WEST BASIN
Dissolved Oxygen Isopleth (mg/l)

1992 Deer Lake Phosphorus Budget

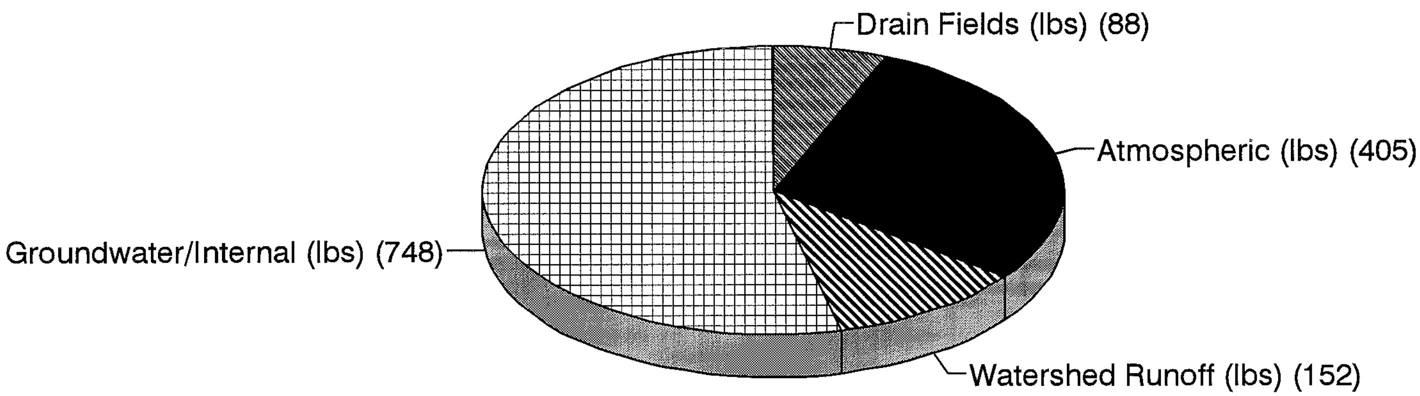


Figure 20

Appendix C

Property Owners Survey

Membership Survey

For Deer Lake

Improvement Association

Summer 1992

Date prepared:
8/25/92

MEMBERSHIP SURVEY FOR DEER LAKE IMPROVEMENT ASSOCIATION

1. Why did you buy property on a lake? (List the letter of your top three choices in order of importance.) 1st_____ 2nd_____ 3rd_____

		1st	2nd	3rd
A.	Entertaining friends and relatives	25	27	22
B.	Investment	8	13	16
C.	Fishing/ice fishing	9	16	15
D.	Observing wildlife	2	9	6
E.	Swimming/scuba diving, snorkeling	6	7	10
F.	Appreciating peace and tranquility	74	25	13
G.	Enjoying the view	10	28	22
H.	Water skiing	2	4	7
I.	Jet skiing			1
J.	Motorized boating		8	14
K.	Non-motorized canoeing, rowing		1	3
L.	Sailing, wind surfing		7	9
M.	Other (please state)			
M.	Grew up on/near a lake	2		
M.	Weekend getaway	1	1	
M.	Weekend and summer recreation	1		
M.	Inherited land	5		
M.	Land given as a gift	1		
M.	Vacation home	2	1	
M.	Lakefront home	2		
M.	Bought a farm, it had lakeshore	1		
M.	Place to raise children	2		
M.	Outdoor life and lake surroundings	1	1	1
M.	Retirement home	1		2

2. Why did you choose property on Deer Lake? (List the letter of your top three reasons in order of importance.) 1st_____ 2nd_____ 3rd_____

		1st	2nd	3rd
A.	Distance from home	67	49	10
B.	Family tradition	24	14	3
C.	Cost of property	4	13	19
D.	Low number of people using the lake	5	13	27
E.	Because of neighbors	5	10	13
F.	Ability to meet your needs from Question 1	35	38	39
G.	Other (please state)			
G.	Water quality	4	2	2
G.	Loved a particular property	3		1
G.	Size of property available		1	
G.	Bought farm	1		
G.	Distance from Twin Cities	2	2	2
G.	Grew up near/on lake	1	1	
G.	Friends on lake	1	1	
G.	Land given as gift	1		
G.	Work nearby	1		
G.	Value of the property			1
G.	Close to family/relatives		1	
G.	Inherited property	1		

3. Approximately how many feet of lake frontage do you own?________

0-99 ft	100-199 ft	200-399 ft	400+ ft
54	79	18	4

4. Which of the following best describes your lake frontage? (Check one)

3	Masonry retaining wall	28	Lawn
10	Wood retaining wall	78	Natural vegetation
56	Rocks added for stabilization	5	Planted trees or shrubs

5. How many of the following watercraft are kept at your property?

58	Canoes		Other (please list)
70	Rowboats	32	Pontoon boats
58	Motor boats under 25 Hp	8	Peddle boats
28	Rafts	3	Windsurfers
60	Sailboats	1	Fishing boats
2	Jet Skis	3	Water bikes
115	Motor boats over 25 Hp	1	Kayak

6. What structures exist on your property? (Check all that apply)

94	Winterized house	36	Boathouse	125	Dock/pier
67	Summer Cottage	104	Detached garage/storage shed		

7. How many persons normally (on average) use your lake property?________

The average number from all of the responses is 3.9

8. How do you actually use your property? (List the letter of your top three uses in order of time spent.) 1st_____ 2nd_____ 3rd_____

		1st	2nd	3rd
A.	Permanent year around home	38	2	1
B.	Entertaining friends and relatives	27	44	16
C.	Holding property for appreciation in value	1	1	8
D.	Fishing/ice fishing	3	9	14

8. (continued)		1st	2nd	3rd
E.	Observing wildlife	1	7	8
F.	Swimming/scuba/snorkeling	4	4	7
G.	Appreciating peace and tranquility	58	28	20
H.	Enjoying the view	5	28	20
I.	Water skiing	2	1	8
J.	Jet skiing			1
K.	Motorized boating	2	10	11
L.	Non-motorized boating/canoeing/rowing			
M.	Sailing/wind surfing		5	5
N.	Working on the property	8	8	24
O.	Other (please list)			
O.	Snowmobiling			1
O.	Vacation home	1		
O.	Summer residence	1		
O.	Other activities	1		
O.	Retirement			1
O.	All forms of recreation		1	
O.	Relaxing	1		
O.	Summer camp for children	1		

9. Which of the following best describes when you would be most likely to use the lake property?

48	Weekends	49	Year round
23	3-4 day weekends		Other
16	Vacations/Holidays	2	Weekdays
52	Most of the summer	1	Whenever the spirit moves
14	Spring - Fall	1	May - October

10. If your lake home is not now your permanent residence, are your future plans to make it your permanent residence?

Yes	No	Undecided	Now permanent
9	61	49	36

11. Which term best defines what you consider the water "clarity" of the lake to be: (Please check one)

Crystal Clear	Clear	Cloudy	Murky
9	130	19	3

12. Which term best defines what you consider the water "quality" of the lake to be: (Please check one)

Very Good	Good	Fair	Poor	Seriously Polluted
27	100	24	5	3

What factors prompted your answer? Explain_________

No.	Factor	No.	Factor
8	Observation	5	Depends on time of year
3	Swimming	2	Lake is spring-fed
11	Deteriorated over the years	1	Reports at annual meeting
21	Abundant plant growth	2	Many snails
31	Good clarity	2	Swimmer's itch
13	Comparison to other lakes	1	Lack of algae
3	Knowledgeable	3	Mucky bottom
1	Old septic tanks	1	Lack of debris
1	Many dead fish	1	O.K. depth
1	We use too many chemicals	1	Private analysis
1	Many fish	1	O.K. odor
1	Muskies	1	Farm-runoff is significant
1	Abundance of healthy fish	1	Too much trash in lake

13. Which statement best describes the peace and tranquility at the lake? (Please check one)

19	Few disturbances - Rarely see and hear another person.
114	Moderate disturbances - It is easy to share the lake.
22	Heavily Used - Sometimes the noise and activities of others disturb me.
3	Over used - I have to regularly plan around the noise and activities of others.
1	Unusable - There is so much noise and activity that I normally can't use my lake property for peace and tranquility.

14. Which statement best describes the natural beauty of the shoreline? (Please check one)

41	Lightly developed - Shoreline structures do not spoil my view.
81	Moderately developed - Shoreline structures do not spoil my view of only part of the shoreline.
28	Heavily developed - Shoreline structures are detracting from the natural beauty of much of the shoreline.
5	Over developed - Shoreline structures are detracting from the natural beauty of most of the shoreline.
0	Unusable - Shoreline structures have replaced the natural beauty of the shoreline.

15. Which statement best describes the boat traffic the lake receives? (Please check one)

1	Lightly used - Rarely see another boat.
121	Moderately used - Not enough to bother my use.
32	Heavily used - On occasion I have to modify my plans because of boat traffic.
4	Over used - I have to regularly change my plans because of the boat traffic on the lake.
0	Unusable - There is so much boat traffic that I don't use the lake much any more.

16. Which statement best describes your experience with other boaters while on the water? (Please check one)

80	Little conflict - Boaters have been courteous and law abiding.
66	Moderate conflict - A few boaters have been discourteous and broken rules.
3	Heavy conflict - Significant number of boaters have been discourteous and broken rules.
2	Overt conflict - Some boaters intimidate and harass other boaters.
0	Displacement - I have generally quit boating because of the behavior of other boaters.

17. Which statement best describes the level of aquatic plant growth in the lake? (Please check one)

3	Light growth - Very little, less than optimum for fish and wildlife.
75	Moderate growth - Just the right amount for fish and wildlife.
74	Heavy growth - The plants limit my use of some parts of the lake and diminish attractiveness.
5	Dense growth - The plants limit my use of much of the lake and are unattractive.
1	Choked with growth - The plants ruin my ability to enjoy the lake.

18. How would you rate the enforcement of the following existing regulations? (Please check one for each regulation)

	Excellent	Good	Fair	Poor	Not familiar with the regulations
Shoreland zoning	15	67	28	13	32
Sanitary ordinances for septics	10	50	33	13	49
Wisconsin boating regulations	21	93	20	6	14

19. If you are not familiar with the boating regulations, would you attend a boat safety course put on by your Lake Association?

Yes	No
63	53

20. When having guests that may operate your watercraft, do you familiarize them with Wisconsin Boating Regulations?

Yes	No
112	27

21. Which statement best describes current public access to the lake? (Please check one)

0	No access - Public access not available.
36	Some access - Public access is available but limited.
99	Adequate access - The number of sites and parking spaces are appropriate to the size of the lake.
18	Excessive access - The number of public access sites and parking spaces contributes to crowding and user conflict on the lake.
3	Overwhelming access - Over development of public access causing severe use conflicts and damage to the ecosystem.

YOUR IDEAS

22. Which of the following best describes the type of public access you would like to see on the lake? (List the letters of your top three choices in order) 1st_____ 2nd_____ 3rd_____

		1st	2nd	3rd
A.	Vista for viewing lake from a road or park	10	18	10
B.	Privately run access	30	25	13
C.	Boat landings with ramps	33	16	11
D.	Carry-in landings for non-motorized boats		20	10
E.	Boat rental service		6	

22. (continued)		1st	2nd	3rd
F.	Fishing pier	1	2	9
G.	Beach/park	1	2	4
H.	Trails near lake	4	12	8
I.	None	71	8	16

23. List in order of importance the actions which you feel need to be taken to deal with your concerns for the lake. 1st_____ 2nd_____ 3rd_____

		1st	2nd	3rd
A.	Form a lake district	11	3	5
B.	Develop a long-term management plan for the lake	65	27	13
C.	Conduct a study of land uses in the watershed	7	23	13
D.	Conduct a study of water chemistry	6	9	23
E.	Stock fish	10	8	9
F.	Stabilize water levels	3	4	2
G.	Boat safety program	1	4	3
H.	Inspect septic tanks	15	16	9
I.	Pump septic tanks		1	1
J.	Harvest aquatic weeds	10	9	9
K.	Chemically treat weeds	4	17	10
L.	Chemically treat algae	3	11	15
M.	Aerate the lake		2	3
N.	Other (please list)			
N.	Milfoil prevention		1	1
N.	Need protection from zoning board's poor behavior	1		
N.	Control farm and other runoff	1	1	1
N.	No muskies	3	1	2
N.	Reduce taxes	1		

23. (continued)

		1st	2nd	3rd
N.	Water patrol		1	
N.	Reroute highway 8			1
N.	Work in conjunction with biologist			1
N.	Install a sewer system	1		1
N.	Control swimmer's itch		1	
N.	Avoid DNR	1		

Please discuss the reasons for your answers.______________________

No.	Reason	No.	Reason
7	Old septics need attention	9	Too many weeds
1	DNR is not a homeowner advocate	19	Need to preserve lake for future use
1	Need to educate lake users	1	Many dead fish this year
10	Don't stock muskies	1	Boat traffic is heavy
8	Need more pan fish	1	Lake district gets everyone involved
3	Stock walleye and other fish	1	Cut weeds float away and are messy
2	Harvest weeds, don't use chemicals	1	Must know lake's chemical makeup
1	Need good lake management	1	Need to study and identify runoff
1	Lake is too high - erodes shoreline	3	Too many muskie fishermen

24. List in order of importance who you think is responsible for managing the lake.
1st_____ 2nd_____ 3rd_____

		1st	2nd	3rd
A.	Federal government	2	3	8
B.	State government	43	24	52
C.	Local government	14	63	32
D.	Lake property owners	90	32	20
E.	The general public that uses the lake	6	16	14

25. List in order of importance who you think is responsible for <u>paying</u> for the managing of the lake. 1st_____ 2nd_____ 3rd_____

		1st	2nd	3rd
A.	Federal government	4	4	11
B.	State government	49	26	38
C.	Local government	25	50	18
D.	Lake property owners	54	31	36
E.	The general public that uses the lake (user fees)	14	27	24

YOUR BACKGROUND

26. What is your gender?

Male	Female
117	51

27. What is your age on your next birthday?

20 - 29	30 - 39	40 - 49	50 - 59	60 - 69	70 - 79	80 - 89	90 - 99
0	12	21	29	47	28	10	2

28. What is your present occupation?

The respones from this question are not included in this report.

29. Do you have special skills that could assist your Association in providing better lake management use?

The responses from this question are not included in this report.

30. Would you be willing to volunteer your skills for association projects?

Yes	Not available
63	90

31. Have you attended an annual or special meeting of the Deer Lake Improvement Association in the past two years?

Yes	No
100	53

32. Have you ever served as an officer of the organization?

Yes	No
22	131

33. What is the best way for the organization to communicate with its members? (please check one)

34	Meetings	128	Newsletters
5	Articles in local paper	4	Informal discussions

34. What do you like about the current policies and activities of the lake organization?

15	Good job communicating	2	Watch dog activities
11	All been good	2	Newsletters/surveys
19	Water quality concern	2	Good work!
13	Vitality	3	Meetings
11	Social events and activities	10	Priorities and direction
3	People care and are involved	1	Government grant opportunity

35. What would you like to see changed?

2	Public trash	1	More taxing authority
4	Install sewer	1	More meetings
3	Control runoff (farms,lawns,etc...)	1	Eliminate algae
1	Harassment from zoning board	1	More septic concern
3	More action	1	Less social event planning
3	More lake quality concern	1	Collect garbage
1	More activities	1	Lake education programs
4	Muskie fisherman conflicts	1	"Junk" yards on highway 8
9	Muskie stocking	1	Fisherman too close to dock
2	Less weeds	2	Annual parties in summertime
1	Increase dues	4	Reduce taxes
1	Relationship with DNR	2	Join lake district
1	Boating rules	1	Trees along highway 8
1	Allow a lake restaurant	2	Compliance with water rules
6	More people involved	1	A more comprehensive newsletter
2	Good use of grant	1	More experts involved
2	More newsletters	1	More government funding
1	Monitored boat access	1	Limit number of boats at access
2	Building codes	1	Have non-smoking section
1	Less liquor with boating	2	No 4th of July fireworks