Report

Cedar Lake Management Plan

Scope ID: 00C036

Town of Schleswig Sanitary District No. 1
Manitowoc County, Wisconsin

August 2002

Foth & Van Dyke
consultants · engineers · scientists

Town of Schleswig Sanitary District No. 1
Cedar Lake Management Plan

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1 Executive Summary

A lake management plan is defined as a working document that describes the activities that have been undertaken and those that should be undertaken, which will result in the optimum use and enjoyment of the lake and surrounding land area without adverse impacts on that water body. This lake management plan was prepared at the request of the Town of Schleswig Sanitary District No. 1. The plan was developed in sequence, following the water quality study completed in 2001. The previous work was documented in the Lake Study Report, July 1998 and the Phase II Lake Study Report, July 2000. This study and plan focused on Cedar Lake's water quality and an evaluation to determine the potential impact that surrounding land uses may have on the lake's water quality. The initial reports evaluated private sanitary systems and their potential impact on the regions water quality. As part of the earlier study reports, a water quality sampling program was performed to determine the lake's trophic status (water quality indicator), a sanitary survey was distributed to all property owners within the Cedar Lake area to determine the potential impact of private sanitary systems on the water quality of the lake, and an analysis of the lake's watershed was completed. Since those reports were completed, a shoreline survey was completed, an analysis of the high capacity well that discharges water to the lake and its impact on the lake water quality was completed, and additional water quality data was accumulated. The following highlight the conclusions of the studies and the recommendations to the Town of Schleswig Sanitary District No. 1:

Conclusions

- Cedar Lake can be classified as a Mesotrophic lake based on the water quality sampling results.

- Based on the data collected from the sanitary survey, and water quality analysis, it is possible that some on-site sanitary systems within the Cedar Lake area are discharging wastewater to the groundwater which feeds into Cedar Lake and is potentially contributing to the accelerated eutrophication of the lake.

- The watershed model (WiLMS) indicates that Cedar Lake is not experiencing significant phosphorus loadings from the residential land use in the watershed. However, as increased development occurs there will likely be a greater negative impact on the lake's water quality if surface water runoff is not controlled. It does show that the primary land use of agricultural land poses the most risk to the water quality of Cedar Lake. Current non-point sources of pollution exist, including herbicides, pesticides, and fertilizer from these agricultural lands.

It is recommended that the Schleswig Sanitary District No. 1 proceed with the following:

- Establish a long-term water quality testing program to accurately determine if the lake is experiencing significant changes in water quality and evaluate the rate of that change.

- Implement one or more water quality improvement alternatives, including:
  - Educate property owners in the District.
  - Upgrade malfunctioning on-site sanitary systems.
  - Consider the benefits of installing public sanitary sewer and potable water.

2 Introduction

Cedar Lake is located in the east central portion of the Town of Schleswig in southwest Manitowoc County, Wisconsin. The largest lake in the county, it covers an area of 147 acres, has approximately 3.2 miles of shoreline, a maximum depth of approximately 33 feet (depth at sampling point was 21 feet), and an average depth of 9 feet. Development has occurred on all developable lots around the lake, and these areas currently are not serviced by public sanitary sewer or water. All developments adjacent to Cedar Lake have private, on-site septic systems or holding tanks which could potentially have a negative impact on the water quality of the lake and/or the local groundwater resources.

In May, 1997 the Town of Schleswig Sanitary District No. 1 was awarded a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) to conduct a study of the water quality of Cedar Lake. The study looked at existing conditions and potential impacts to the water quality of Cedar Lake.

A study report was completed by the consulting firm of Foth & Van Dyke in July of 1998 and that report detailed findings and recommendations of the Cedar Lake area.

A Phase II Study Report was completed by Foth & Van Dyke in July 2000 and that report included information from the 1998 report. Additional water quality testing was completed in areas throughout Cedar Lake and findings and recommendations documented.

The next phase of work included applying for a subsequent grant from the WDNR to complete a Lake Management Plan. That grant was awarded to the Town of Schleswig Sanitary District No. 1 in July of 2000.

2.1 Authorization

The Town of Schleswig Sanitary District No. 1 authorized Foth & Van Dyke to reevaluate the existing water quality and the potential impacts to lake water quality from private sanitary systems and surrounding land uses within the lake's watershed, and to prepare a lake management plan identifying the results and giving recommendations for improvements.

The local share of the lake management plan was to be funded by the Town of Schleswig Sanitary District No. 1. The Lake Planning Grant funded $10,000, while the local share, including in-kind services, provided the remaining 41% of the total project cost.

2.2 Purpose

The purpose of the 1998 and 2000 lake studies was to evaluate the water quality of Cedar Lake, and determine the potential impact of private on-site sanitary systems and surrounding land uses on the lake's water quality. This information was used to aid in assessing the feasibility of providing public sanitary sewer service to properties in the Cedar Lake area. The studies also included an exploration of alternatives to improve water quality. Recommendations, based on the 1998 and 2000 data presented in the reports were made to provide direction to the Sanitary District. This direction addressed the need for future technical studies, including the development of an overall lake management plan and an evaluation to determine the feasibility of installing public sewer service.

The 1998 and 2000 studies eventually lead to the development of this Lake Management Plan.

The development of this Lake Management Plan utilized data obtained from both the 1998 and 2000 studies. The work completed for the 2001/2002 phase also contained a data collection component. Much of the data collected in this phase was used to confirm or add information to the 1998 and 2000 data set. This process helped define recommendations for protection of the surface water and groundwater in and surrounding Cedar Lake. The Lake Management Plan is intended to provide direction for both corrective steps and preventative measures that can be taken to improve and/or sustain the existing Cedar Lake water quality.

2.3 Project Study Area

Map No. 1 illustrates Cedar Lake and surrounding parcels, and also identifies the location from which water quality samplings were performed for the study.

Map No. 1 Project Study Area

3 Water Quality Protection

3.1 Introduction

The water quality of a lake is dependent upon a number of factors and lake characteristics. Every lake possesses a unique set of physical and chemical characteristics that may change over time. The chemical changes may occur on a daily basis, while physical changes (such as plant and algae growth) are more likely to be seen on a seasonal basis. Seasonal changes in the physical characteristics of a lake are common because factors such as surface runoff, groundwater inflow, precipitation, temperature and sunlight are variable. A lake's water quality will vary with these seasonal changes, therefore data must be gathered over a period of time to accurately determine if a lake is experiencing significant changes in water quality and to distinguish between natural variability and human activity impacts.

To determine the water quality and trophic status of Cedar Lake, a sampling program was developed which included monitoring numerous characteristics of the lake. The following section explains the sampling program and its components and presents the results and analysis of the sampling conducted. First however, it is important to identify the source of the lake's water supply as this contributes to the factors which affect the quality of its water supply. In addition, identification of the water source allows for sound management practices to be selected which reflect the specific characteristics of the lake.

3.2 General Lake Characteristics

Cedar Lake is classified as a seepage lake: a seepage lake is a landlocked, natural lake where water levels are maintained by the groundwater table, precipitation, and limited runoff; Cedar Lake's water level is primarily maintained by groundwater, therefore septic systems or other groundwater contamination sources could cause problems. A high capacity well does discharge water to the lake. The high capacity well water quality was also investigated and will be discussed in a later section. It does appear, however, that the quality of water from the high capacity well is no worse than what exists in Cedar Lake today. In addition, because the lake is a seepage lake, runoff from various land applications can also cause problems, such as nuisance plant growth resulting from excess phosphorous. Because the lake has no natural outlet, chemicals which enter the lake stay in the lake for long periods of time. The lake district did construct an outlet during the mid-1980's to alleviate significantly high water levels but this outlet remains relatively dry throughout most of the year.

3.3 Watershed Characteristics

A watershed is an area of land in which water drains to a common point, such as a stream, lake or wetland. Managing the watershed to control nutrients and soil that enter the lake is essential to protecting water quality. Controlling the water that runs from the land's surface into the lake is especially important for drained lakes as their primary source of water is from direct drainage from the surrounding land (watershed) and precipitation. The watershed which drains into Cedar

Lake was delineated by Foth & Van Dyke along with input from District personnel and is illustrated on Map No. 2.

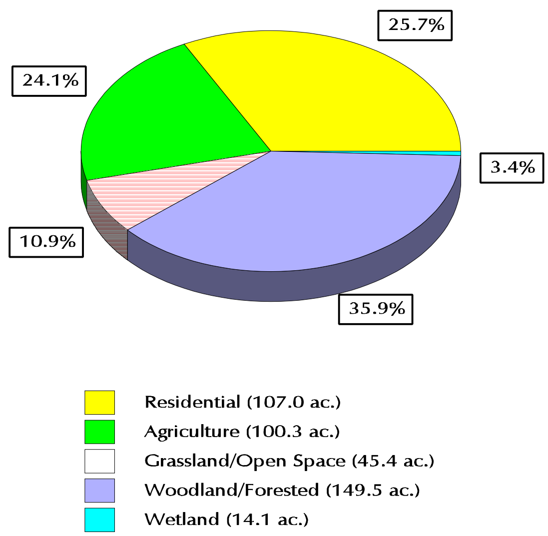
Cedar Lake drains approximately 417 acres of land, while Cedar Lake itself comprises approximately 147 acres of surface water. Therefore, the watershed to lake area ratio is about 3:1. The larger the ratio, the more the watershed will have an impact on the lake through nutrient, pesticide, and soil runoff. (Impoundment ratios usually average more than 100:1). However, low ratio lakes (small watershed and large lake area) have high retention times, in which instance nutrients are more likely to remain in the water for a longer time period before exiting the lake. Cedar Lake is a low-ratio lake. Reserve nutrients in lake sediments can continue to recirculate in lakes with high retention times, even after the source of the nutrients has been controlled. Therefore, effects of watershed protection may not be apparent for many years.

Map No. 2 illustrates the existing land use within the Cedar Lake watershed. The map was prepared using LandSat imagery which is made available by the WDNR. This map was also compared with the Manitowoc County Land Use Map and digital orthophotograph. Figure 3-2 summarizes the land use classifications within the watershed and the total acreage and percentage of land use each comprises.

Approximately one-third (149.5 acres) of the Cedar Lake watershed is comprised of woodland/forested land which is mostly privately-held.

The shoreland areas have been converted to residential lots, except for portions identified on Map No. 3 , which include the areas along west shore of the southeast bay and an area on the northeast shoreline. Residential uses comprise approximately 25 percent of the land within the watershed (107 acres). Some agricultural land exists within the watershed and comprises approximately 70 acres or 24 percent of the total land use within the watershed.

Figure 3-2
Existing Land Use
Cedar Lake Watershed



An estimation of sediment and nutrient (phosphorus) loading (utilizing past WDNR modeling methodology) to Cedar Lake was calculated based on the existing land uses illustrated in Map No. 2. The results of the calculation are identified in Table 3-1.

Table 3-1
Existing Sediment and Nutrient Loading (in lbs/yr)
Cedar Lake Watershed

Land Use Class	Acreage	Sediment (lbs/yr)	Phosphorus (lbs/yr)	Zinc (lbs/yr)	Lead (lbs/yr)
Residential	107.0	20,330.0	53.5	21.4	21.4
Agriculture	100.3	2,507.5	1.0	0.0	0.5
Grassland/Open Space	45.4	1,135.0	0.5	0.0	0.2
Woodland/Forested	149.5	3,737.5	1.5	0.0	0.7
Wetlands	14.1	352.5	0.1	0.0	0.1
Total*	**416.3**	**28,062.5**	**56.6**	**21.4**	**22.9**

*Lake Area = 147 acres.
Source: Foth & Van Dyke, 2002.

Table 3-1 identifies the estimated existing pollutant loadings for the Cedar Lake watershed. The level of the estimated pollutant loadings is very similar to that of a primarily undeveloped or open area. Therefore, if the land use within the Cedar Lake watershed remains relatively unchanged, the level of pollutant loadings would not be a major concern in the future. If however, the area experiences more development there could potentially be a threat to the existing water quality of Cedar Lake, and consideration should be given to managing the area to control runoff. If this is the case, there are some common "Best Management Practices" (BMP's) which can be used to help protect the lake's water quality from pollutants/nutrients. Such practices include wet and dry detention basins, wet ponds, porous pavement, swales and filter strips, and the many construction site BMP's available, as well as the general reduction in use, or protection from the use of fertilizers, pesticides, herbicides, illicit discharges and other public use controls.

It should be noted the Wisconsin Department of Natural Resources has recently been using new modeling software for determining phosphorous loadings for lakes than what has been applied on Cedar Lake in the past. This new software, called "WiLMS", has determined that the main contribution of phosphorous loading is the result of the agricultural lands. Regardless of whichever the main land use category contributes the most phosphorous, the recommendations remain the same.

Map No. 2 Land Cover and USGS Quadrangle

3.4 Water Quality Sampling Program

The Phase 1 July 1998 lake study report documented the sampling program for Cedar Lake. The program was conducted over approximately a one year time period, beginning in May of 1997, and concluding in April, 1998. Samples were taken from the deepest point in the lake (illustrated on Map No. 1) on six separate occasions including:

- May 8, 1997
- June 12, 1997
- July 15, 1997
- August 13, 1997
- February 10, 1998 (ice on)
- April 14, 1998 (ice off - spring turnover)

The Phase II Lake Study Report completed in July 2000 contained data from six more sampling events. Samples were taken at five locations including the sample point used in the Phase I Report. Those occasions included:

- April 1999
- June 1999
- July 1999
- August 1999
- October 1999
- February 2000

Finally, under Phase III in 2001, additional samples were taken at the original sampling point to show a comparison of the water quality over a certain time period. Those samples were taken on the following:

- February 13, 2001
- April 18, 2001
- June 24, 2001
- July 24, 2001
- August 15, 2001
- November 11, 2001

The samples were collected by staff from Foth & Van Dyke, the Town of Schleswig Sanitary District No. 1 and representatives from the Wisconsin Department of Natural Resources, while sample testing was completed by the State Laboratory of Hygiene. It was important to obtain samples with ice on, ice off, and in summer months to obtain data representative of the seasonal changes which affect water quality.

As mentioned previously, numerous factors were considered in the sampling program. On the dates provided above, samples were collected and analyzed for Total Phosphorus and Chlorophyll *a*, while field measurements for Dissolved Oxygen, Temperature, pH, Conductivity, Redox Potential, and Secchi Disc readings were also collected. These factors were sampled at various depths in the lake ranging from surface to subsurface.

During the spring turnover sampling (April 18, 2001), more extensive monitoring was conducted which included those items mentioned above, along with Chloride, Calcium, Potassium, Sulfate, Iron, Color, Total Dissolved Solids, Total Suspended Solids, Alkalinity, Magnesium, Dissolved Phosphorus, Ammonium Nitrogen, Nitrate plus Nitrite Nitrogen, Total Kjeldahl Nitrogen (organic plus ammonium), Organic Nitrogen (calculation), Manganese, Turbidity, and Total Volatile Solids. Samples for these parameters were collected at two depths, a surface sample was collected and one from near the bottom of the lake.

In order to accomplish the objective of identifying the water quality of the lake, some of the sampling data was used to make a determination of the lake's current trophic state. The trophic state of a lake is an indicator of water quality. The factors which contribute to making the determination of the lake's trophic status were therefore sampled more frequently than most other factors. These factors include Total Phosphorus (Total P), Chlorophyll *a*, and Secchi Disc readings.

Other factors that may indicate any problems in the water quality of Cedar Lake and their causes include analyzing for chlorides. Chlorides are found in septic tank effluents, animal waste, and road salts. High nitrogen concentrations may indicate that local land use impacts are greater than they should be and therefore need to be addressed. These include the presence of human and pet waste, and the excessive use of lawn and agricultural fertilizers being applied along the shoreline.

The following section provides the results of the sampling program, highlighting the dissolved oxygen levels, temperature, and those factors which contribute to the determination of the lake’s trophic state.

3.5 Water Quality Sampling Results and Analysis

The following section explains how a lake's trophic status is determined, and provides more detailed discussion of the sampling results of Dissolved Oxygen levels, temperature, Total Phosphorous concentrations, Chlorophyll *a* concentrations, and Secchi disc readings completed on Cedar Lake, as part of the July 1998 study report, the July 2000 study report and this plan.

3.5.1 Trophic Status Indicators

The trophic state of a water body is an indicator of the nutrient levels and water clarity in a lake. Lakes can be divided into three categories based on their trophic state which include Oligotrophic, Mesotrophic, and Eutrophic. The following provides a description of each trophic state:

> **Oligotrophic:** Generally clear, cold lakes which are deep and free of weeds or large algae blooms. Oligotrophic lakes are low in nutrients (nutrient-poor) and therefore do not support

plant growth or large fish populations, however are capable of sustaining a desirable fishery of large game fish.

Mesotrophic: These lakes are in an intermediate stage between the oligotrophic and eutrophic stages. They are moderately productive (contain excess nutrients), supporting a diverse community of native aquatic plants. The bottoms of Mesotrophic lakes lack oxygen in late summer months or winter periods which limits cold water fish and causes phosphorus cycling from sediments. Overall however, Mesotrophic lakes support good fisheries.

Eutrophic: Lakes which are high in nutrients (nutrient-rich), and support a large biomass are categorized as eutrophic. These lakes are usually weedy and/or frequently experience large algae blooms. Most often they support large fish populations, however they are also susceptible to oxygen depletion which limits fishery diversity. Rough fish are common in eutrophic lakes.

The process of eutrophication is a natural aging process which occurs in all lakes, however this process may be accelerated by allowing nutrients from soil erosion, lawn fertilizers, streets, septic systems, agriculture, and urban storm drains to enter lakes. The trophic state of a lake can be determined by observing three lake characteristics including Total Phosphorus concentration (Total-P) which indicates the amount of nutrients present in the lake which are necessary for algae growth, Chlorophyll *a* concentration which is a measure of the amount of algae actually present, and Secchi disc readings which is an indicator of water clarity. As expected, low levels of Total P are related to low levels of Chlorophyll *a*, which are related to high Secchi disc readings.

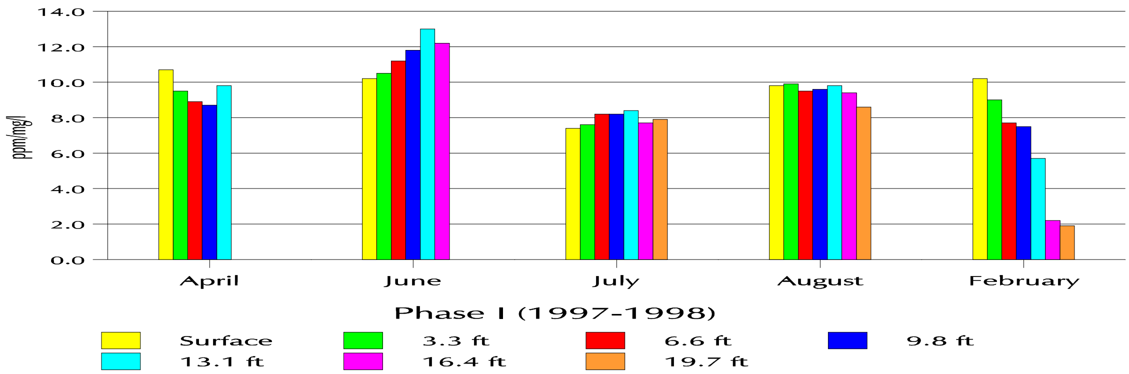
To determine the trophic state of the lake, the Wisconsin Trophic State Index (WTSI) can be applied to each of the above noted factors. The WTSI converts the actual measurement into a value which is representative of one of the trophic states. Values less than or equal to 39 indicate oligotrophic conditions, values from 40-49 indicate Mesotrophic conditions, and values equal to or greater than 50 represent eutrophic conditions.

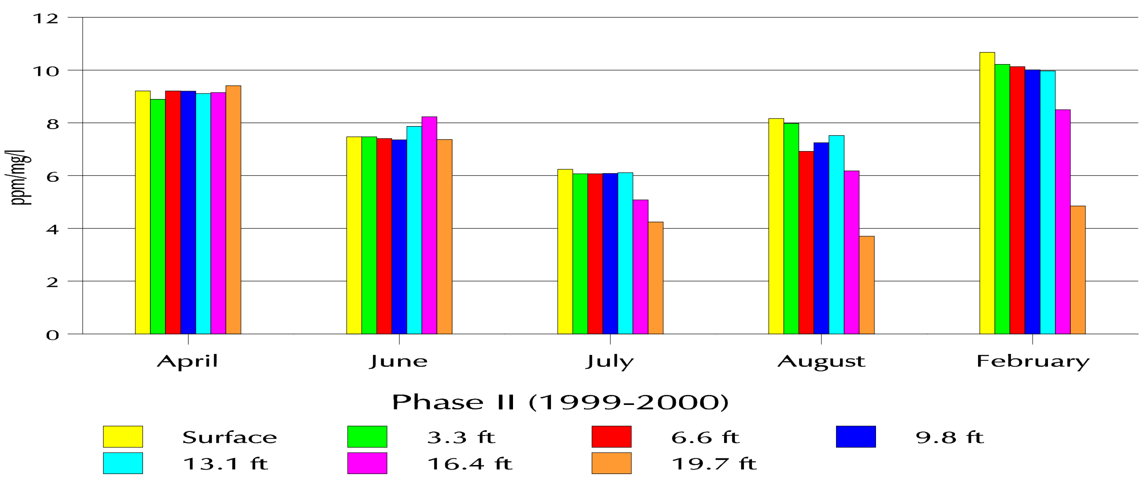
3.5.2 Dissolved Oxygen (D.O.) Concentration

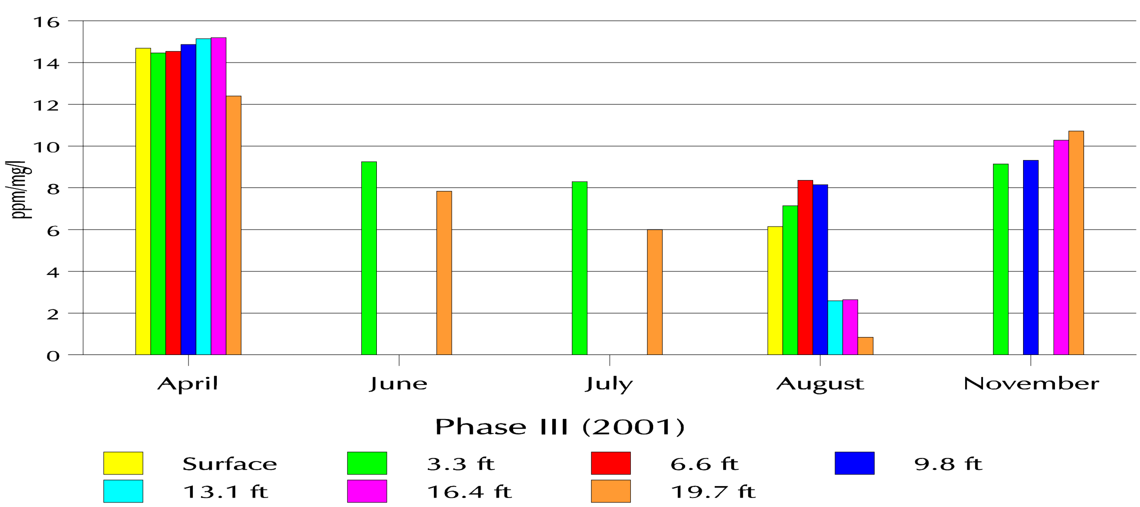
The concentration of Dissolved Oxygen present in a lake is important as it supports aquatic life. The solubility of oxygen depends on the temperature of the water - colder water holds more oxygen than warmer water. The amount of D.O. present in lakes at different times of the day, and at different depths, is largely determined by the processes of photosynthesis and respiration. Oxygen is produced when green plants grow (photosynthesis), and is consumed through respiration. Therefore, D.O. levels tend to be higher during daylight hours (when photosynthesis occurs), and lower at night/early morning. In addition, lake depths which are below the reach of sunlight may experience oxygen depletion. Oxygen depletion is especially apparent in winter months where snow cover prevents sunlight from penetrating the water, stopping photosynthesis and causing plants to die; this is termed "winterkill" and occurs in many eutrophic lakes.

The warm water sport fish water quality standard for D.O. is 5 mg/l, which represents the minimum amount of oxygen needed for the survival and growth of fish such as largemouth bass and perch. When a lake is very healthy, the D.O. levels will be near saturation. Saturated D.O. concentrations exist between 8.1 mg/l for an 80 F summer water temperature to greater than 14 mg/l when the water temperature approaches the freezing mark of 32 F. Figure 3-3 illustrates Dissolved Oxygen levels at varying depths in Cedar Lake on fifteen of the eighteen sampling dates.

Figure 3-3
Dissolved Oxygen Levels
Cedar Lake: Phases I, II & III







As indicated by Figure 3-3, D.O. levels in Cedar Lake have met or exceeded the water quality standard of 5 mg/l at varying depths on most sample dates. Also, levels at, near, or even exceeding saturation were experienced in most samples. Figures 3-1 and 3-2 show, however, that D.O. levels indicated a lack of oxygen at depths greater than 16.4 feet during the sampling taken during February, July and August. This lack of summertime oxygen, especially in the lower depths of the lake, is a critical indicator that water quality gradually deteriorated over the summer. The lack of oxygen in winter below approximately 16 feet is a symptom of the lake's aging process and is consistent with the Mesotrophic status of the lake's water chemistry. Despite oxygen depletion in this depth of the lake, fish are still able to survive by moving to more shallow areas where D.O. levels are high enough to support them.

As oxygen levels continue to decrease, phosphorus (an important nutrient for algae growth) in the sediments will become available for algae blooms in the fall. When sufficient oxygen is present in water, phosphorus is less soluble and remains in the sediment rather than being released into the lake.

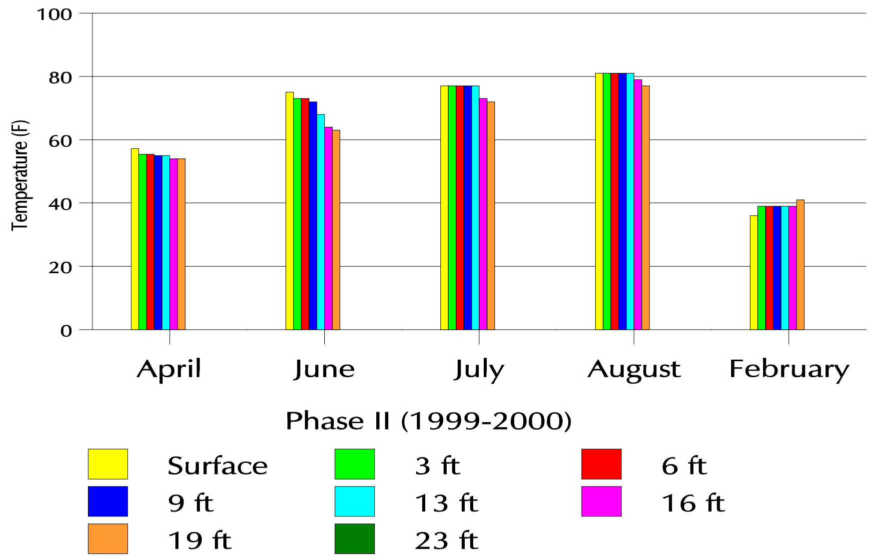
3.5.3 Temperature

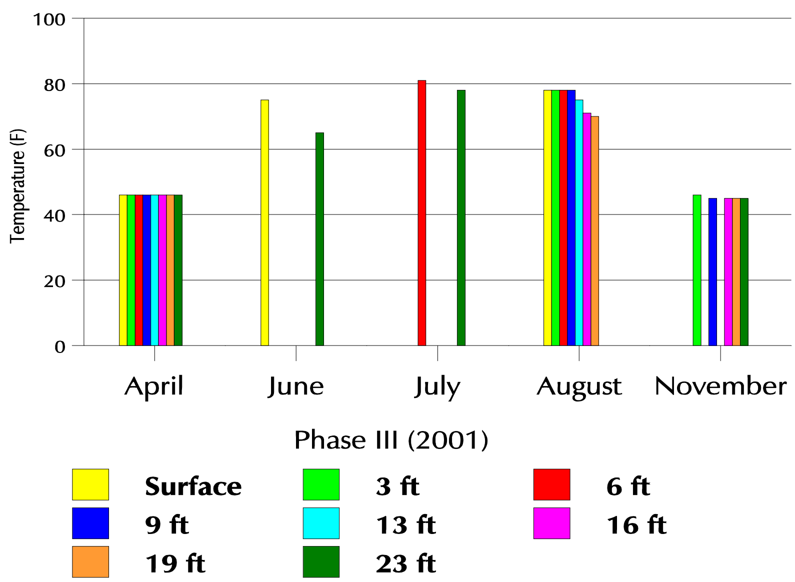
Temperature profiles at different depths were taken in Cedar Lake. Figure 3-4 shows that the lake did not stratify into thermal layers during the summer months, as was expected since the lake's maximum depth is only 33 feet. The water remained "mixed", or at approximately the same temperature from top to bottom, throughout the summer months.

As expected, the lake had the same temperature from top to bottom as it completely mixed in mid-April when the ice melted and then again in the fall before the ice formed. Insufficient sampling data contributed to not including February 2001 information.

Overall, the water in Cedar Lake remains mixed year-round, therefore distributing oxygen throughout the lake, which is consistent with the D.O. levels that do not experience much variation from the top of the lake to the bottom of the lake, except during the late summer and winter months.

Figure 3-4
Temperature Profile
Cedar Lake
Phase II and III





3.5.4 Total Phosphorus Concentration (Total P)

Phosphorus is the key nutrient which influences plant growth in over 80% of the lakes throughout Wisconsin, and promotes excessive aquatic plant growth. This chemical is generated from a number of sources including many human-related activities such as human and animal wastes, soil erosion, detergents, septic systems, and runoff from farms and/or lawns. Two types of phosphorus analyses can be conducted which include soluble reactive phosphorus and total phosphorus; total phosphorus is a better indicator of the nutrient status of a lake because its levels remain more stable. The concentrations of Total P detected at the surface (0 to 3.3 feet), and near the lake bottom (19 to 23 feet), in Cedar Lake are presented in Figures 3-5 and 3-6, respectively, while the corresponding WTSI values representing lake conditions are presented in Figures 3-7 and 3-8.

Figure 3-5
Total P Concentrations - Surface Samples
Cedar Lake
Phase I, II & III

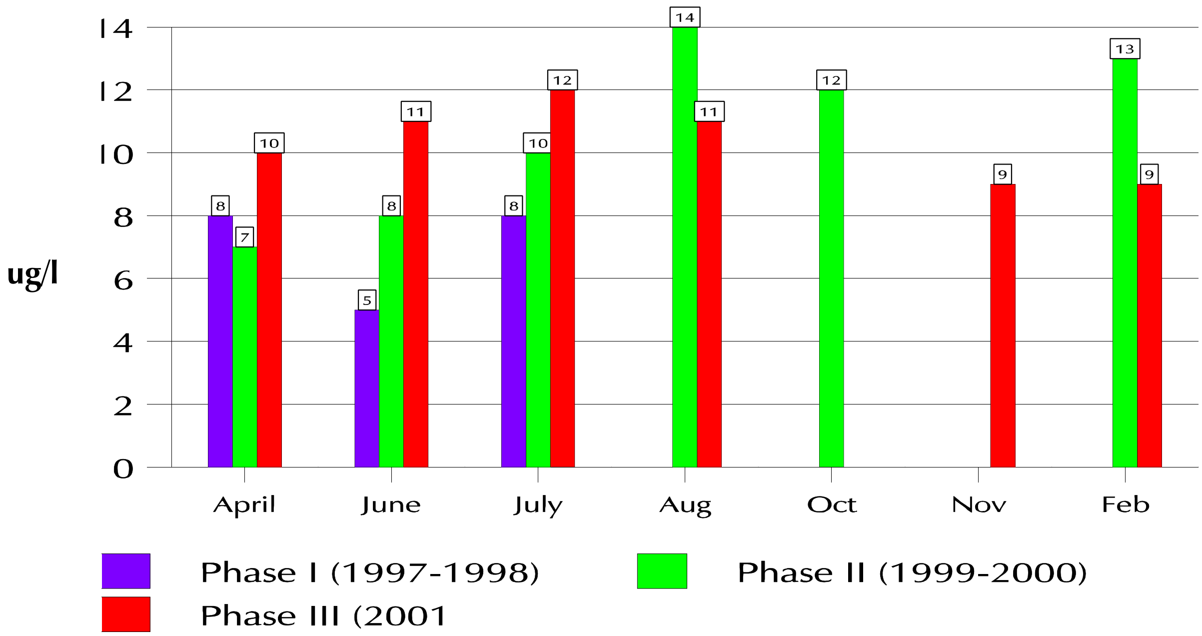
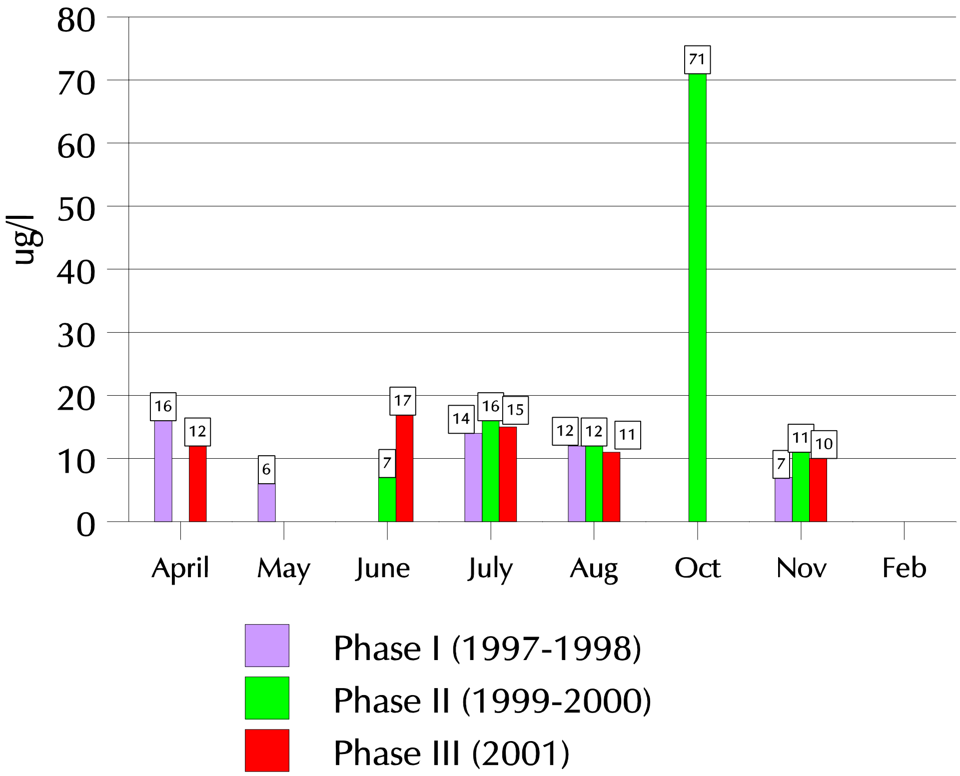


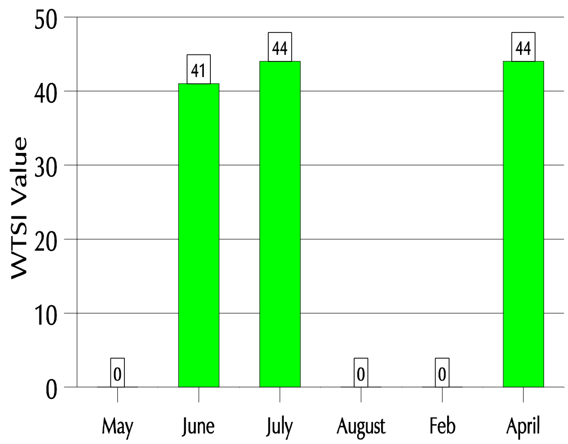
Figure 3-6
Total P Concentrations - Bottom Samples
Cedar Lake
Phase I, II & III



Total P concentrations should be maintained below 20 ug/l for natural lakes in order to prevent nuisance algae blooms (Understanding Lake Data). As indicated in Figure 3-5, the surface sample Total P concentrations in Cedar Lake remained below 20 ug/l for all samples taken with the highest detected concentration being 14 ug/l.

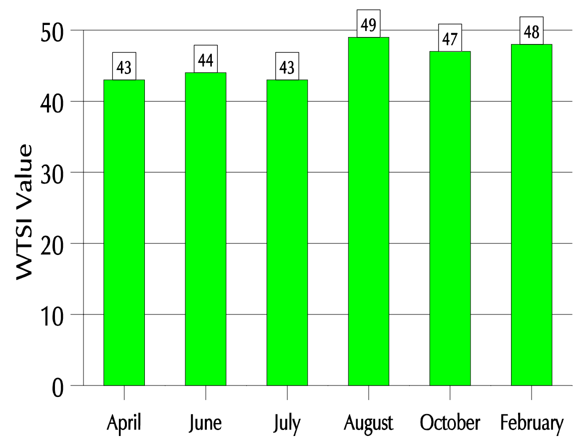
Total P concentrations near the lake bottom (Figure 3-6) were higher overall than those detected near the surface, being below 20 ug/l on almost all sample dates. Overall, the sample results indicate the water quality of Cedar Lake is at a Mesotrophic level.

Figure 3-7
Total P - Surface Sample WTSI Values
Cedar Lake
5/8/97 - 11/11/01



Phase I (1997-1998)

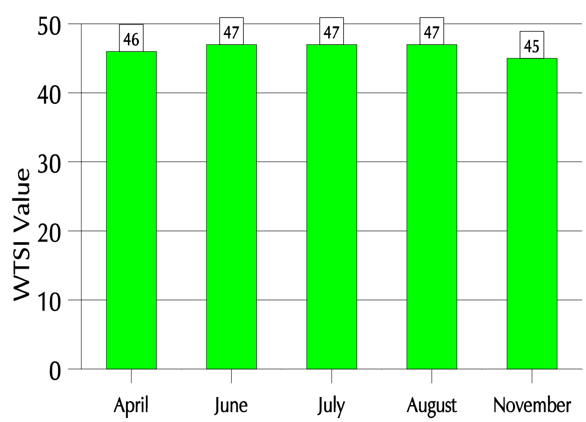
> 50 Eutrophic
40-49 Mesotrophic
< 39 Oligotrophic



Phase II (1999-2000)

> 50 Eutrophic
40-49 Mesotrophic
< 39 Oligotrophic

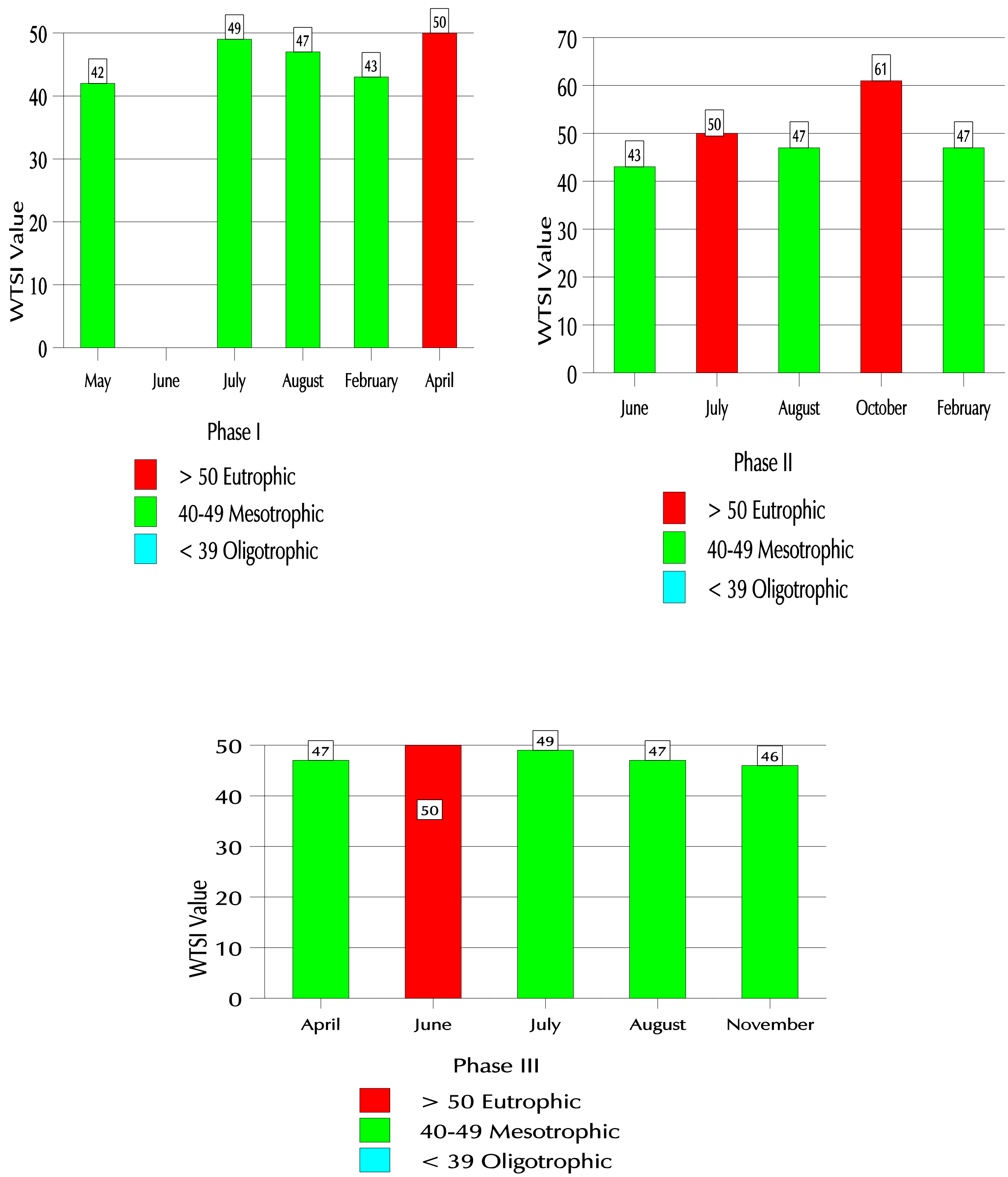
Note: "0" indicates no detection.



Phase III (2001)

> 50 Eutrophic
40-49 Mesotrophic
< 39 Oligotrophic

Figure 3-8
Total P - Bottom Sample WTSI Values
Cedar Lake
5/8/97 - 11/11/01



In terms of trophic status, the Total P concentrations found in Cedar Lake indicate that the lake's trophic status ranges from Oligotrophic to Mesotrophic at the surface (Figure 3-7), and is primarily in a Mesotrophic to slightly eutrophic state in the sub-surface (Figure 3-8). Based on the results of the Total P samples, Cedar Lake may be classified as being in the mesotrophic stage.

3.5.5 Chlorophyll *a* Concentration

Chlorophyll *a* is a green pigment which is present in all plant life and is necessary for photosynthesis. The amount of chlorophyll *a* present in a lake is dependent upon the amount of algae present, and is therefore used as a common indicator of water quality. It is also one of three characteristics used to determine the trophic state of a lake. Figure 3-9 identifies the concentration of Chlorophyll *a* detected in Cedar Lake, while Figure 3-10 illustrates the corresponding WTSI values.

Figure 3-9
Chlorophyll *a* Concentrations - ug/l
Cedar Lake
Phase I, II & III

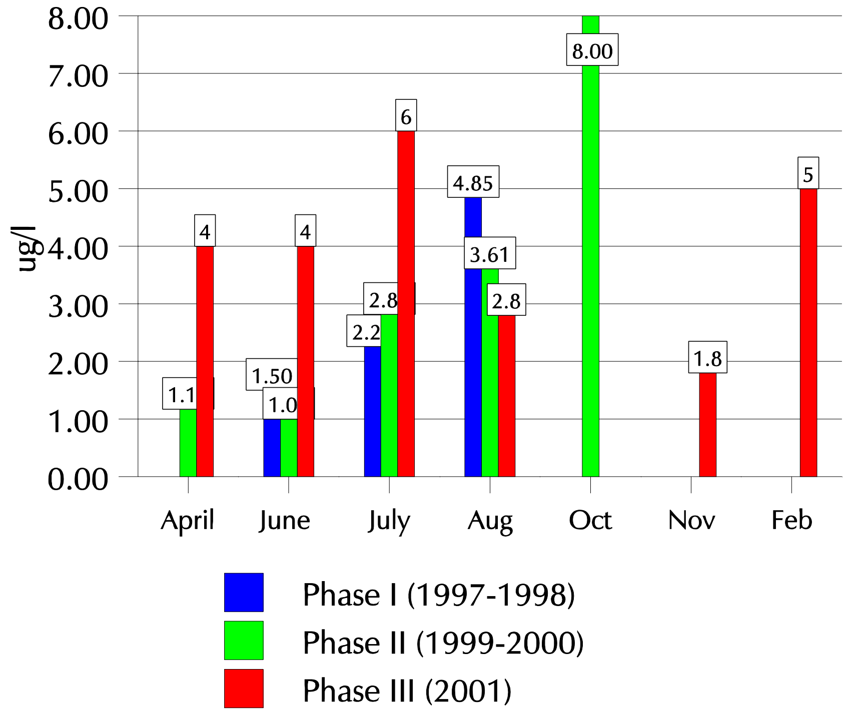
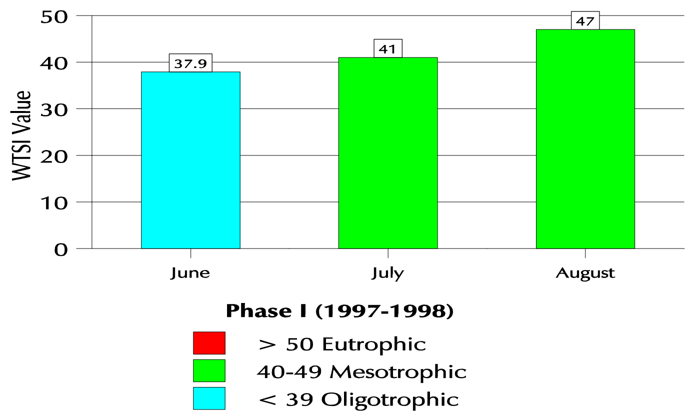
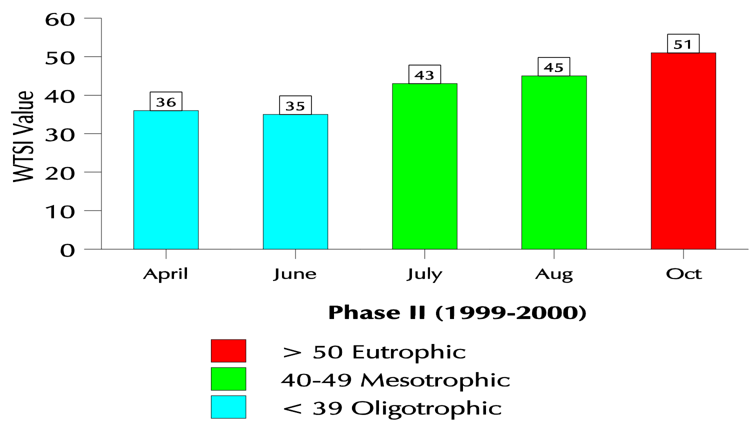
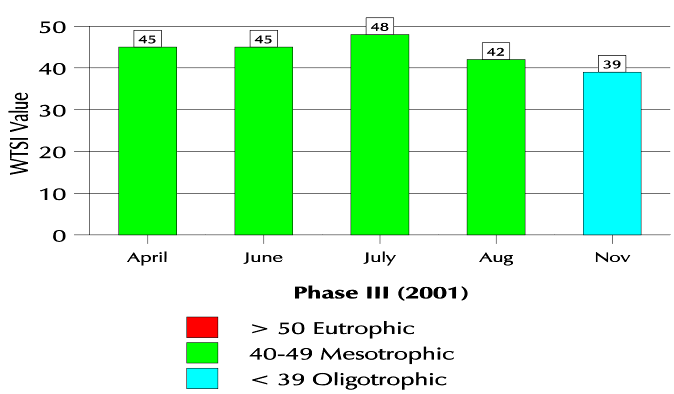


Figure 3-10
Chlorophyll *a* Concentrations - TSI Value
Cedar Lake
Phase I, II & III







Chlorophyll *a* concentrations were sampled on eight dates, including the summer months and during spring and fall turnover. Based on the results of the Chlorophyll *a* samples, the trophic status of Cedar Lake was identified as being near the high end of Oligotrophic in early summer and gradually changed to the Mesotrophic status near the end of summer, indicating an increase in the amount of algae in Cedar Lake throughout the summer months, than decreasing again in the fall.

3.5.6 Secchi Disc Reading

A Secchi disc reading is a measure of water clarity; it is not a direct measure of water quality related to chemical and physical properties. However, water clarity is often indicative of a lake's overall water quality, especially the amount of algae present. Secchi disc readings are taken by lowering an 8 inch disc into the water, and taking the average of the depth where the disc disappears from sight and where it becomes visible again when raised. The Secchi disc reading can be used to determine the trophic state of a lake. Figure 3-11 provides the Secchi disc readings from Cedar Lake on ten sampling dates, and Figure 3-12 displays the representative WTSI values for these readings.

Figure 3-11
Secchi Disk Readings
Cedar Lake
Phase I, II & III

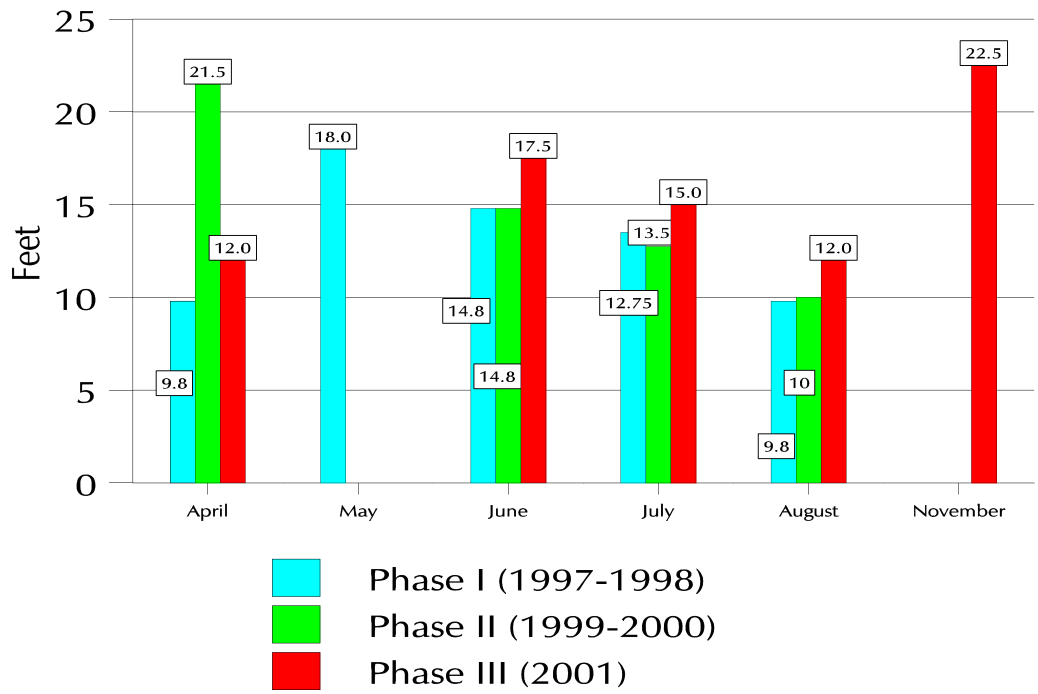
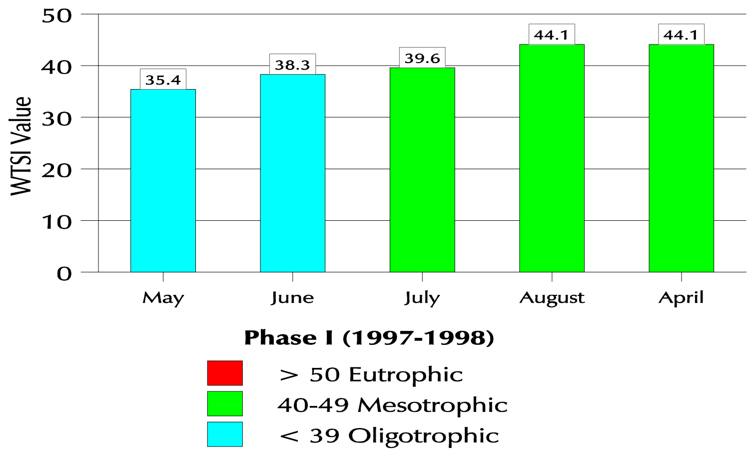
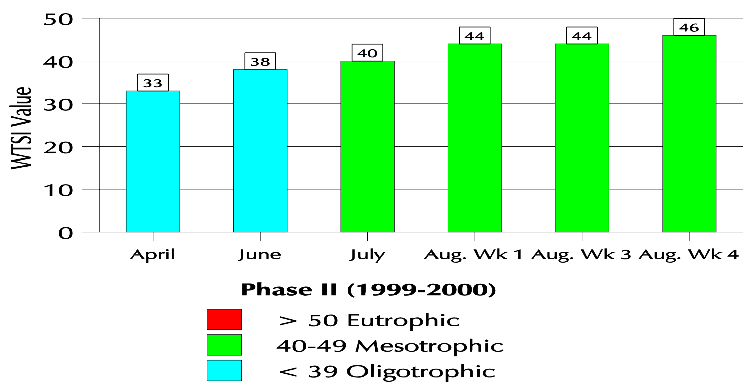


Figure 3-12
Secchi Disk - TSI Values
Cedar Lake
Phases I, II & III





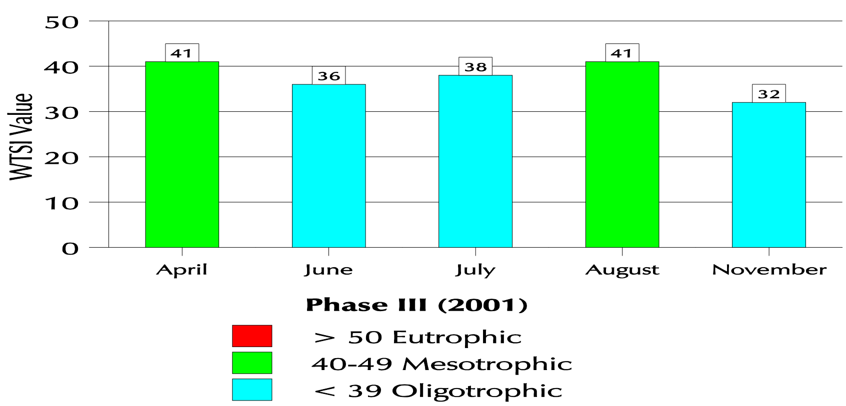


Figure 3-11 depicts that the water clarity of Cedar Lake experienced a slight decrease during the late summer months, however remained relatively stable overall during the sampling period. These readings indicate the lake's water quality ranges from good to very good.

The trophic status of Cedar Lake, as illustrated in Figure 3-12, ranged from late Oligotrophic to early Mesotrophic during the sampling period which indicates the presence of algae in the lake, however it is highly unlikely that nuisance algae blooms are experienced in the lake as the water is rather clear.

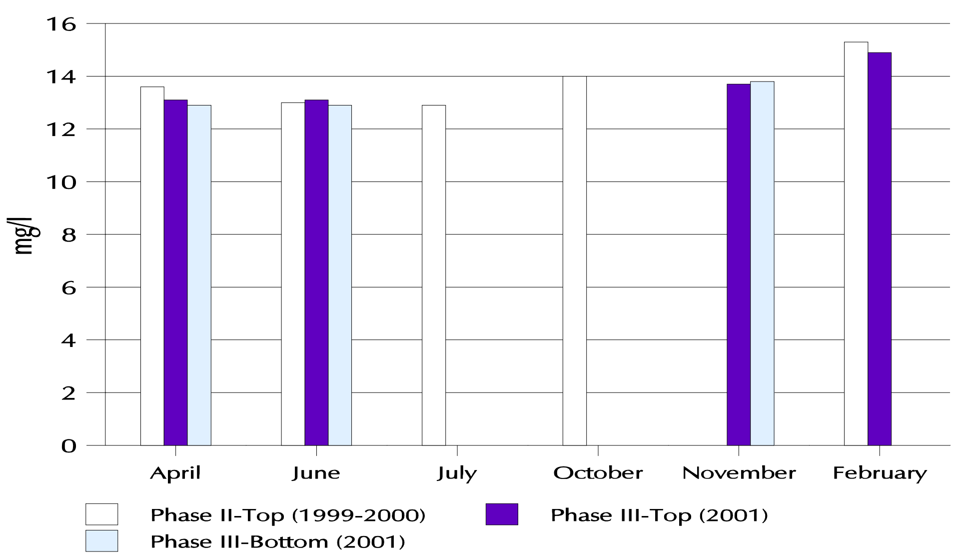
3.5.7 Non-Trophic Status Indicators

Chloride

Chloride is present in Wisconsin waters in small amounts naturally. The highest natural concentrations are found in southeastern Wisconsin with typical values of 10 mg/l or greater. Higher concentrations of chloride is an indicator of possible water pollution. Potential sources of chloride include septic systems, animal waste, fertilizers, and drainage from road salting chemicals.

The chloride values for Cedar Lake were consistently between 12mg/l and 16 mg/l. This is in the range of natural values. While the initial indication is that the potential pollutant chloride sources are not significantly impacting the lake, chloride concentrations can vary from year to year and chloride data should be included in a long term data collection program to track changes.

Figure 3-13
Chloride Concentrations
Cedar Lake

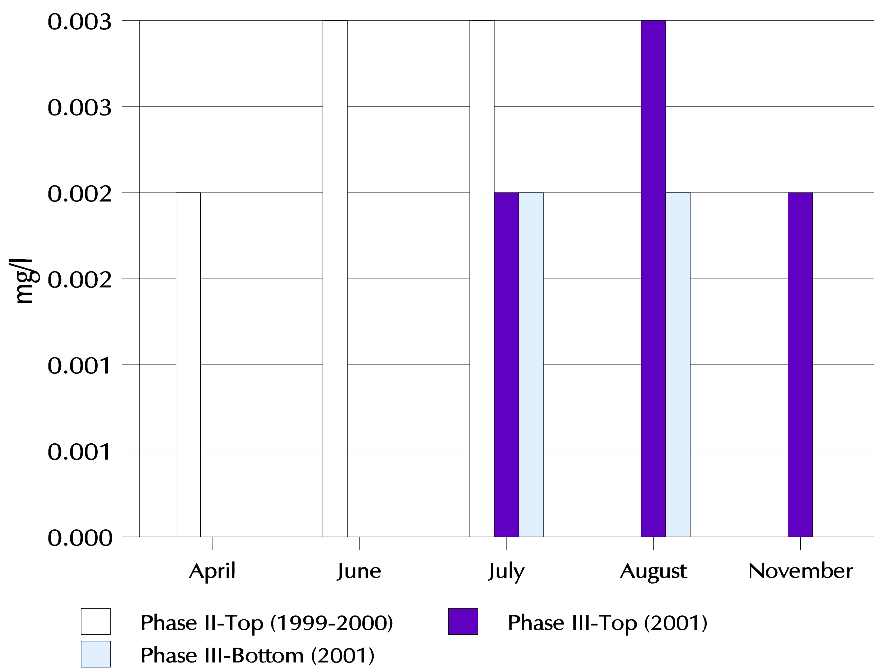


Ortho-phosphate

This chemical parameter is a measurement of the soluble phosphorus available for algae and weed growth. The concentration of ortho-phosphate will vary during the season in response to algae growth. When algae growth is at its peak, ortho-phosphate concentrations will be at a minimum.

Orthophosphate was measured in samples collected in April, June, July, August, November and February. The concentrations were relatively low in all samples and range from 4 ug/l to less than 2 ug/l. The highest concentrations occurred in August and the lowest concentrations occurred in November. This data corresponds to the chlorophyll *a* measurements which followed an opposite pattern. When chlorophyll a concentrations are at their peak, almost all the ortho-phosphate will be removed from the water and this is shown in the data from Cedar Lake.

Figure 3-14
Orthophosphate Concentrations
Cedar Lake



Nitrogen (Ammonia, NO2+NO3, and TKN)

Nitrogen is an important plant nutrient. While phosphorus is typically the limiting nutrient for algae growth, nitrogen can be limiting under some circumstances. Nitrogen compounds are present in lakes as inorganic or organic. The inorganic forms are ammonia and nitrite/nitrate ($NO_2 + NO_3$) and these forms are available to plants for growth. The organic form is included in Total Kjeldahl Nitrogen. This form is found in plant and animal tissues.

While ammonia, a source of nitrogen, is considered a macro nutrient, it is rarely a limiting nutrient. Therefore, it does not promote or restrict excessive macrophyte or algae growth. It can, however, reach toxicity levels harmful to fish at relatively low concentrations in pH-neutral or alkaline water. Under acid conditions, non-toxic ammonium ions (NH_4) form, but at high pH values the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for fish and aquatic life is 0.02 mg/l of NH_4OH. At a pH of 7 and a temperature of 68° F (20° C), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH 8, the ratio is 26:1. The highest value for ammonia (NH3) found in the water for Cedar Lake was 0.117 mg/l. Given the ratios noted above, the ammonia levels are below the toxic threshold.

The data shows a significant increase in nitrogen concentrations from 1997 to 1999. Possible nitrogen sources are lawn fertilizer, agricultural runoff, or domestic sewage from septic systems.

Figure 3-15
Ammonia & NO2+NO3 Concentrations
Cedar Lake

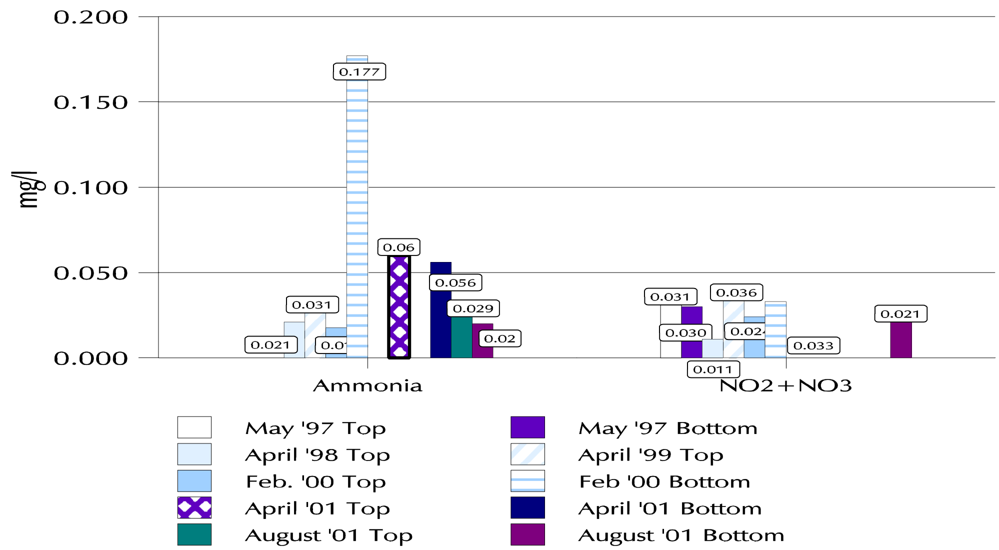
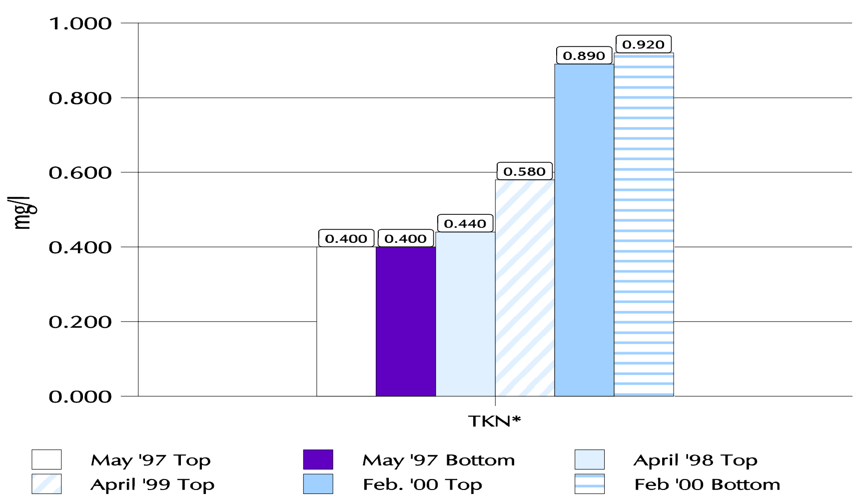


Figure 3-16
TKN* Concentrations
Cedar Lake

* TKN = Total Kjeldahl Nitrogen



3.5.8 High Capacity Well Water Quality

Water quality sampling was conducted for the high capacity well located along the northeast shoreline of Cedar Lake in April 2001. Chloride values were analyzed to be 15.1 mg/l. This value is higher than chloride values taken from the lake, but is within the 12-16 mg/l range of lake values for all Phases of study. Nitrate+Nitrite values were analyzed to be 39 ug/l. This value is higher than what was observed from the lake in 2000. However, values of chloride in Cedar Lake obtained in August were well below those taken from the well. A total phosphorus value of 12 ug/l was observed from the well water. This value is higher than the sample taken from Cedar Lake during April 2001. It is however the same as that taken from the bottom of Cedar Lake during April 2001. Orthophosphate was detected at 3 ug/l which is a low value.

It appears that the high capacity well does not have a substantial impact on the water quality of Cedar Lake. Analysis of water quality data taken during later periods of the 2001 year were actually lower in most instances than what was observed from the well.

3.5.9 Alkalinity and Hardness

Alkalinity is defined as a waters ability to neutralize acid. The minimum amount of alkalinity recommended for a water body is 20 mg/l. The higher the number the more the lake is able to buffer the fish and aquatic life from rapid pH changes. The alkalinity of Cedar Lake, for the years sampled (1997-2001), ranged from 146 to 179 mg/l. These numbers indicate that the alkalinity of Cedar Lake is such that it is well buffered for the impacts of acid rain, etc.

Hardness is an indicator of the mineralized character of a lake and the effect that groundwater may have on the lake. Hardness is not considered as a parameter that is neither good nor bad. The biological community of a lake may vary based on the hardness of a lake but this variance is not outside of natural balance. It is, as noted, an indicator of the lakes water budget system. Values for hardness of Cedar Lake range from 158 to 190 mg/l. Lakes with values of 150 mg/l or greater are considered "hard" lakes. Soft water lakes typically receive their water from precipitation. Rain water has little to no measurable hardness. Therefore, Cedar Lake’s hardness is a strong indication that there is a significant groundwater effect on Cedar Lake and its water budget.

4 Existing Private Sanitary System Evaluation

An evaluation of the potential for existing private sanitary systems to negatively affect the water quality of Cedar Lake was conducted for the 1998 study report through a collaborative effort by the Town of Schleswig Sanitary District No. 1 and Foth & Van Dyke staff. The evaluation included conducting a sanitary system survey in the Cedar Lake area.

4.1 Sanitary Sewer

A sanitary survey was distributed to all property owners within the Town of Schleswig Sanitary District No. 1 in July, 1997. The purpose of the survey was to collect input regarding private wastewater and water supply systems to aid in evaluating the potential impact of private sanitary systems on the water quality of Cedar Lake.

Currently, all residences are equipped with private, on-site septic systems, including septic tanks and fields, holding tanks, mound systems and other systems. Private septic systems can potentially have a negative impact on the water quality of the lake if they are improperly installed (including poor location selection) or maintained. The waste products of these systems contain nutrients which promote nuisance plant and algae growth. If these waste products enter the lake, the process of eutrophication can be accelerated and water quality may decrease.

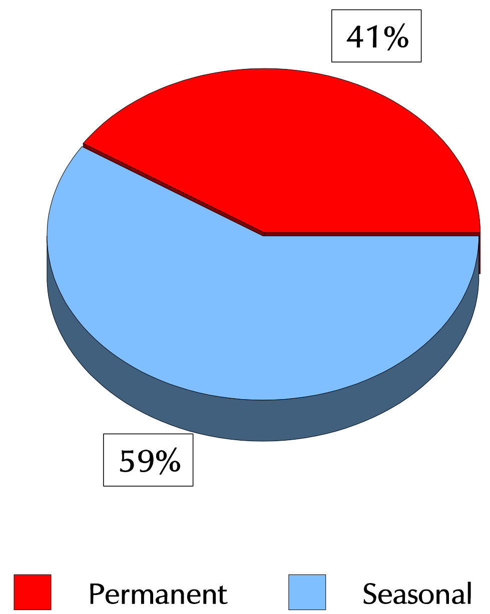
4.2 Survey Results and Analysis (July 1998 Study)

The following identifies the results of the majority of the survey responses which were received from 68 of the 141 property owners along Cedar Lake for a response rate of 48.2 percent. The survey results are categorized into data concerning occupancy status, wastewater disposal systems, and water supply systems. The complete results of the Sanitary Survey are included in Appendix 4-1.

Occupancy Status

Figure 4-1 displays the occupancy status of the dwellings along Cedar Lake, including Permanent and Seasonal residency. The majority of respondents, 59%, indicated that their dwellings are for seasonal use, while the remaining 41% of the respondents use their dwelling as a permanent residence.

Figure 4-1
Occupancy Status
Town of Schleswig Sanitary District No. 1



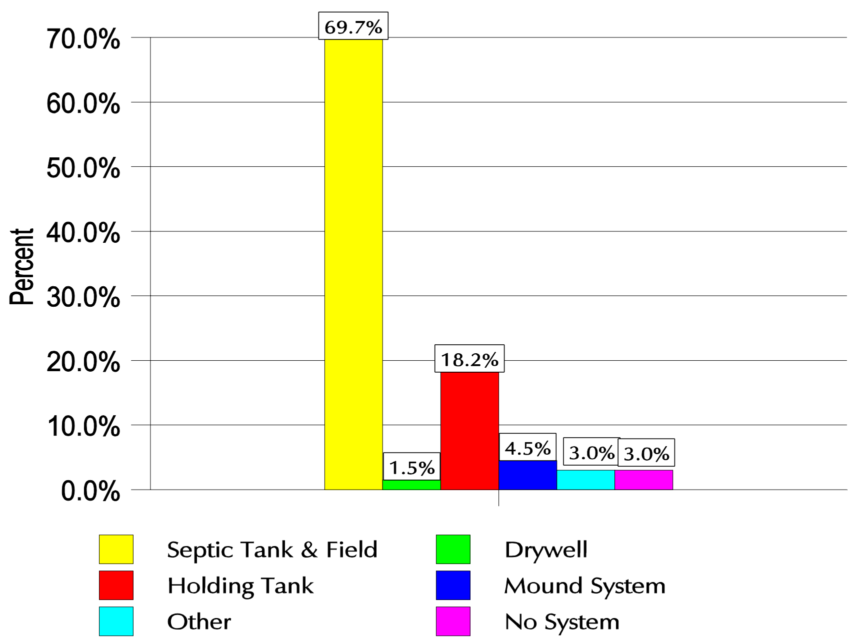
Wastewater Disposal Systems

The following identifies the characteristics of the respondent's wastewater disposal systems along Cedar Lake, including type of system, age of system, time from last maintenance, location of system from Cedar Lake, and problems experienced with the systems.

4.3 Type of System

The distribution of the various types of wastewater disposal systems along Cedar Lake is presented in Figure 4-2. Approximately two-thirds of the respondents (69.7 %) have a septic tank and field for their sanitary system. Holding tanks comprised 18.2 percent of the systems, while the remaining approximately 10 percent of sanitary systems are distributed among mound systems, drywells, other systems and no systems.

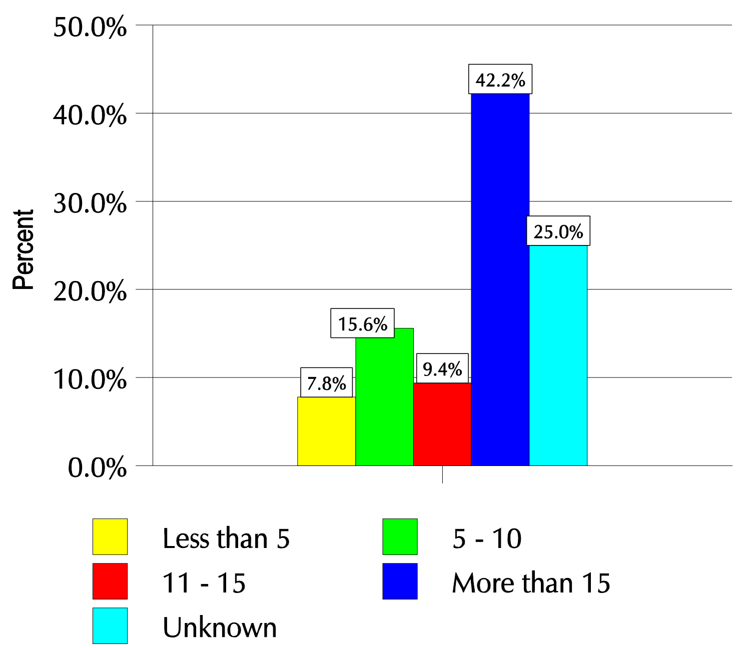
Figure 4-2
Type of Wastewater Disposal Systems
Town of Schleswig Sanitary District No. 1



4.4 Age of System

Figure 4-3 displays the ages of the private sanitary systems as indicated by survey respondents. The majority of these systems (42.2%) are more than 15 years old, and another 15.6 percent are 5-10 years of age. Systems less than 5 years old and 11 to 15 years old comprised less than 10 percent of all sanitary system. One quarter of the respondents were uncertain as to the age of their system. The older systems are more susceptible to experience failure if not replaced or properly maintained which indicates a rather high potential exists for these systems to leak nutrients into Cedar Lake, thus negatively impacting the water quality of the lake.

Figure 4-3
Age of Wastewater Disposal Systems
Town of Schleswig Sanitary District No. 1

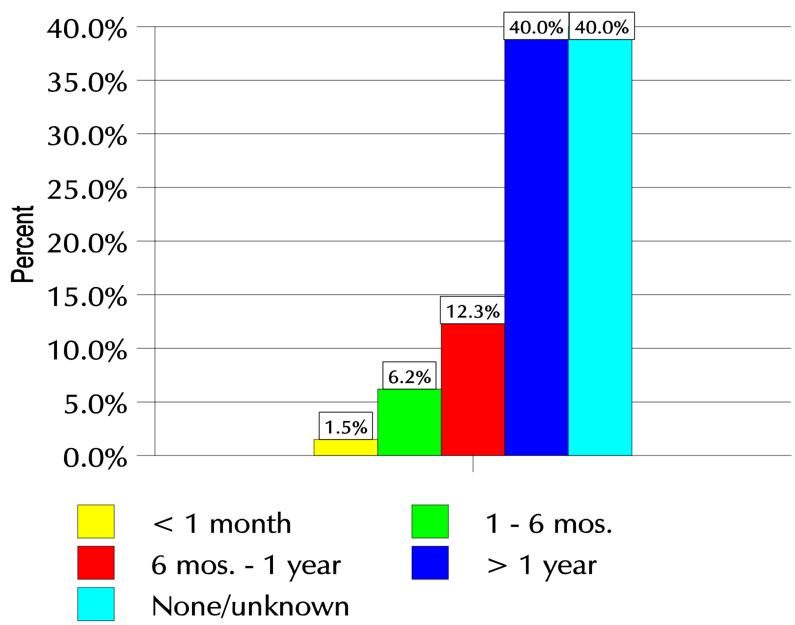


4.5 Time from Last Maintenance

The time period since the last maintenance was performed on the wastewater disposal systems along Cedar Lake is presented in Figure 4-4. Forty percent of respondents indicated it has been longer than one year since the last time their sanitary system was maintained, while another 40 percent did not know when the last maintenance was performed on their system. Approximately 20 percent responded that their systems had been maintained within the last year.

Maintenance (pumping) should be performed at least once every year or every other year for conventional and mound systems, and should occur frequently (upon alarm) for holding tanks. Pumping conventional and mound system septic tanks will prevent clogging of the drain field; it does not, however, impact the nutrient discharge to the groundwater.

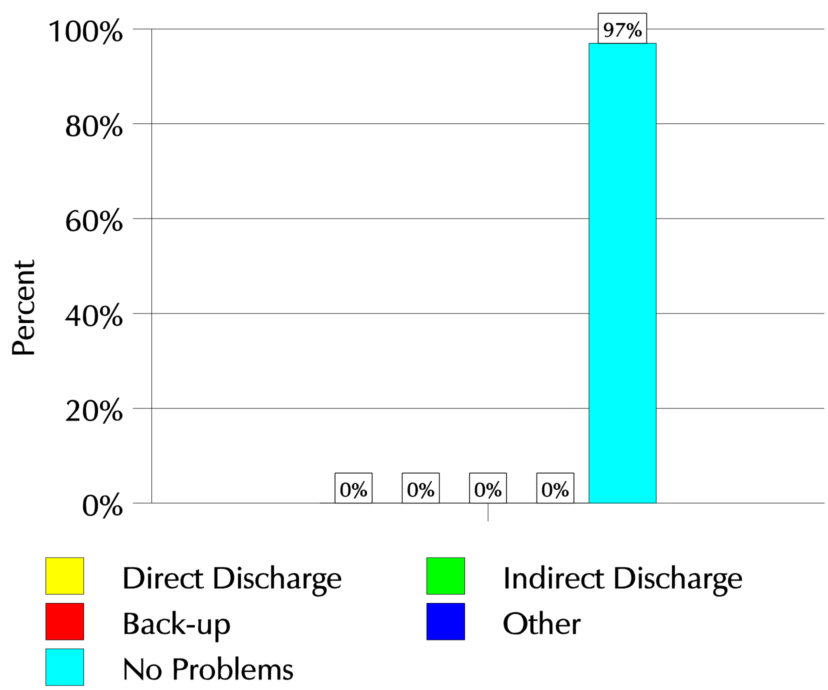
Figure 4-4
Time From Last Maintenance
Town of Schleswig Sanitary District No. 1



4.6 Problems with Wastewater Disposal Systems

Respondents were asked to identify any problems which were experienced from their wastewater disposal systems. Problems include direct discharge to the surface, indirect discharge (seepage), back-up into the house, other problems, and no problems experienced. Ninety-seven percent of respondents indicated they had not experienced any problems with their wastewater disposal systems (see Figure 4-5).

Figure 4-5
Problems with Wastewater Disposal Systems
Town of Schleswig Sanitary District No. 1



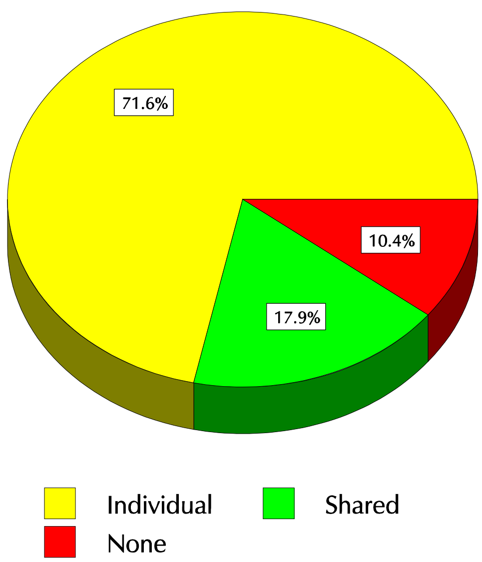
Water Supply Systems

The following identifies the characteristics of the water supply systems along Cedar Lake, including the types of wells, ages of wells, location of wells (in relation to sanitary systems), and problems experienced with these systems.

4.7 Types of Wells

Figure 4-6 displays the types of wells (i.e. individual, shared, none) in operation along Cedar Lake. Based on the survey responses, over 71 percent of the wells in the Town of Schleswig Sanitary District No. 1 are individual wells, while the remaining 18 percent are shared, and approximately 10 percent do not have a well.

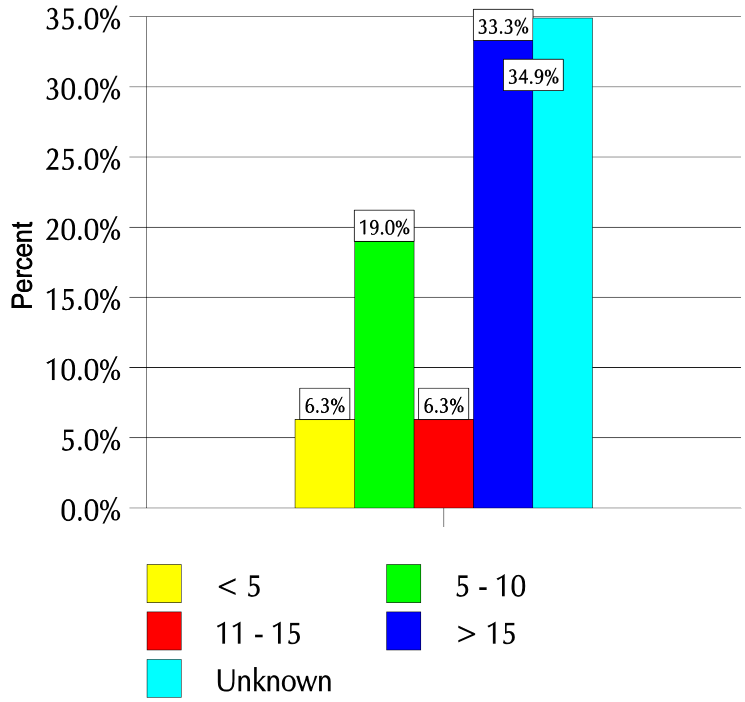
Figure 4-6
Well Types
Town of Schleswig Sanitary District No. 1



4.8 Age of Wells

The ages of the wells in the Cedar Lake area are illustrated in Figure 4-7. According to the results of the survey, approximately one-third of the wells in the area are more than 15 years old, and another one-third are less than 15 years old.

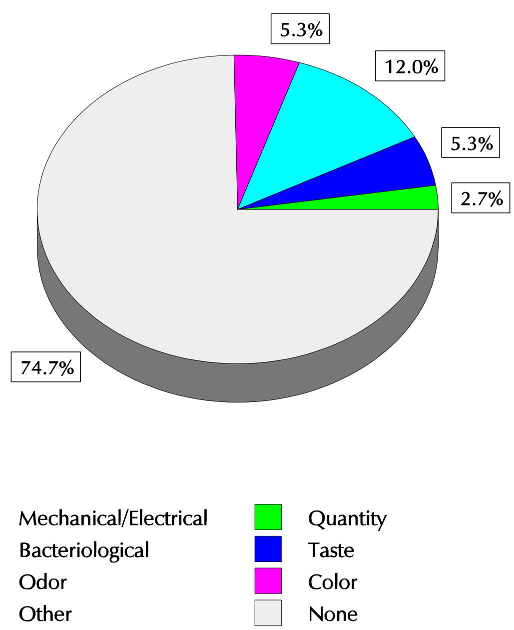
Figure 4-7
Ages of Wells
Town of Schleswig Sanitary District No. 1



4.9 Problems Experienced with Wells

Survey respondents were asked to identify any problems experienced with their water supply systems, including mechanical/electrical, quantity (volume/pressure), and quality such as bacteriological, taste, odor, color, nitrates, or other, or to indicate if no problems were experienced. Figure 4-8 displays that approximately 75 percent of all respondents do not have any problems with their wells. The remaining 25 percent, however, did indicate some problems. Approximately 22 percent experienced problems with well water quality, including 12 percent having odor problems, while taste and color problems were each experienced by approximately 5 percent of respondents. Problems with well water quantity were indicated by approximately 3 percent of respondents, while mechanical/electrical, bacteriological, and nitrate problems were not experienced at all.

Figure 4-8
Problems with Water Supply Systems
Town of Schleswig Sanitary District No. 1



5 Groundwater Recharge/Discharge and Lake Level

5.1 Groundwater Recharge/Discharge

Cedar Lake is influenced by groundwater. The lake is classified as a seepage lake in which water levels are maintained by groundwater, precipitation and limited runoff. The lake has a small tributary area and an intermittent outlet. The water level in the lake is primarily determined by groundwater. The groundwater elevation influences the lake levels from two perspectives, on the east end of the lake, the groundwater flows into the lake, acting as a source of water for the system. On the west end of the lake the water typically flows out of the lake into the groundwater. The groundwater elevation at the west end controls the rate at which the surface water will discharge to the groundwater, therefore controlling the lake levels in a second manner. The major water input to the lake is a high capacity well that pumps groundwater into the lake.

Foth & Van Dyke installed groundwater piezometers along the lakeshore in six locations. These piezometers were monitored weekly over the summer months in 1999. The purpose of the piezometers was to determine groundwater flow direction. If the piezometer has a water level in the well lower than the adjacent lake level, then groundwater is flowing out of the lake at that point. If the piezometer has a higher water level than the adjacent lake level, then groundwater is flowing into the lake at that point.

The piezometer measurements showed a significant seasonal variation in water level in the piezometers. In general, the water levels were highest in June, July and August. The water levels were lower in the spring and fall. These water levels correspond to the rainfall in 1999. Precipitation was below normal in early spring, above normal in May, June and July, and well below normal in late summer and fall. The piezometers on the east end of the lake had significant periods of time where the water level in the piezometers was higher than the adjacent lake. This showed groundwater flowing into the lake and corresponded to the higher groundwater and rainfall periods. The piezometers on the west side of the lake had almost all readings showing lower water levels in the piezometers than in the lake. This data showed water from the lake discharging to groundwater.

The piezometer measurements show that on the average, lake water is discharged to groundwater. This condition may be exaggerated by the high capacity well which raises the lake level when in operation. Without the well, the lake level would be lower but the level would tend to seek the level of the groundwater and less water would be discharged to groundwater.

The groundwater quality around the lake will affect the lake water quality. This is particularly true on the east side of the lake where groundwater discharges to the lake seasonally during higher groundwater periods. On the west side of the lake, groundwater will have an impact on water quality less frequently. Adequate groundwater elevation to have groundwater discharge into the lake occurred briefly during the 1999 study period.

The practical application for this data is that septic systems around the lake do not necessarily discharge to the lake. On the west side of the lake, groundwater generally moves away from the lake and septic systems have little impact on the lake water quality. On the east side of the lake, groundwater moves into the lake when groundwater is high as evidenced by the data collected during 1999. Improvements to septic systems should focus on the east side of the lake.

Many residences have septic systems between the lake and their drinking water well. Since the groundwater flows away from the lake in most conditions, it is likely that the septic system effluent travels toward the well. This situation may contribute to nitrate and/or coliform bacteria in drinking water wells.

5.2 Lake Level

The water level in Cedar Lake varied in 1999 by 0.81 feet. The highest level was in June during a period of high precipitation and high groundwater. The lowest level was in fall when precipitation and groundwater levels were low. The lake normally has no surface discharge. If water levels are extremely high, there is an overflow pipe on the west end of the lake to drain excess water. The lake level is less prone to wide fluctuations than other lakes due to the high capacity well that is located on the northeast lake shore. This groundwater source adds water to the lake to prevent water levels from getting too low. If water levels get high, water is discharged from the lake to the groundwater or through the overflow pipe at the west end of the lake.

6 Existing Regulations/Planning Efforts

Chapter 6 summarizes some of the local regulatory requirements that pertain to activities conducted near Cedar Lake. The Town of Schleswig, Manitowoc County, and the Wisconsin Department of Natural Resources all have jurisdiction when dealing with certain aspects of activities surrounding Cedar Lake. The following summarizes what those jurisdictional rules are. It should be noted that all landowners should contact the appropriate agency and possibly all if there are any questions before undertaking any activity directly linked to Cedar Lake.

6.1 Town of Schleswig

The Town of Schleswig has enacted a "slow no wake speed limit" on Cedar Lake with signs posted at the boat landing on the south side of the lake. The ordinance requires that no motorized boat shall produce a wake between the hours of 6:00 p.m. to 11:00 a.m., Monday through Saturday, and 2:00 p.m. to 11:00 a.m. on Sundays. Vehicular boat traffic should proceed in a counter-clockwise manner when traveling around the lake during the high speed times.

6.2 Manitowoc County

The Manitowoc County Planning and Zoning office is working on county wide initiatives for proposed water resource protection. Cedar Lake has been classified as a "Highly Developed Lake" which will have certain criteria that will need to be met for future development. Standards pertaining to highly developed waters strive for restoration and watershed management. A shoreline buffer area of 50 feet landward from the ordinary high water mark (OHWM) and a shoreline setback for building locations of 75 feet are part of that management plan. Minimum future lot widths shall be 150 feet at the OHWM and lot size shall not be less than 0.75 acres.

6.3 Wisconsin Department of Natural Resources

Under the "Aquatic Plant Protection Law", lake associations or towns can apply for harvest permits to remove nuisance weeds and plant growth. The 75 foot setback for new construction is also a state regulation. Other WDNR enforceable regulations include lake bank stabilization activities, fish crib placement, boat house and pier construction, and grading in excess of 10,000 square feet that is within 500 feet of a lake. If any of these activities are planned to be undertaken, the Wisconsin Department of Natural Resources Water Management Specialist for Manitowoc County should be contacted (At this time, Mr. Mike Hanaway located in the Mishicot office, can be reached at 920-755-4942).

7 Shoreline Survey Evaluation

A shoreline survey was performed for Cedar Lake by Foth & Van Dyke in July of 2001. The intent of the shoreline survey was to identify sensitive areas such as highly erodible land, critical habitat, buffer zones, wetlands and any areas that may pose a threat to the water quality of the lake such as roads, structures, etc. Map No. 3 illustrates some of the more important features found on Cedar Lake that should be kept an eye on. They include sensitive areas along the lake, such as the northeast lake area in close proximity to Rokilo Road, the sandy beach of the resort located on the north side of the lake that slopes to the lake, various dwellings that are located immediately adjacent to the lake on the north side of the lake, and the boat landing on the south side of the lake that gives access to the lake to many non-property owners unaware of the sensitivity of the lake. Also illustrated on Map No. 3 are undeveloped areas that need to be kept undeveloped because of their shading, filtering, and habitat aspects, and the location of the high capacity well and lake outlet pipe. The survey concluded that the existing developed lots have homes built close to the lake and that most properties have rock riprap protection along the shoreline. Where no protection exists, there is visible erosion and erosion potential. An excellent example of a property that demonstrates correct building setback from the lake and utilizing existing vegetative buffer zones to help filter runoff before it reaches the lake is located along the west shore of the southeast bay of Cedar Lake. Future development or re-development should strive to match this design and layout. Other areas that act as a buffer for runoff impacts to the lake are the wetlands and woodlands shown on Map No. 2, Existing Land Use, Cedar Lake Watershed. Other areas that play an important role for Cedar Lake include nesting areas for birds and lake structure for fish habitat. These areas should be continually monitored and protected so that they are left undisturbed.

Map No. 3 Shoreland Survey Information

8 Conclusions

Results from the sampling program indicate that D.O. concentrations in Cedar Lake were below saturation during the summer months, indicating a lack of summertime oxygen. This low amount/lack of oxygen in the summer months allows phosphorus to be released from the sediments which could cause algae blooms in the fall. In addition, oxygen depletion was experienced in the winter at depths of approximately 16 feet or greater.

The lake remains mixed year-round, meaning that the temperature of the water remains stable from the top to the bottom of the lake. This is expected as the maximum depth of the lake is approximately 20 feet. Because the lake remains mixed, oxygen is distributed rather evenly throughout the lake, as concluded from the D.O. concentrations. This may also be impacted by the addition of water to the system from the high capacity well. A source of water that maintains a consistent water temperature.

During the sampling period, the overall water quality of Cedar Lake as indicated by WTSI values is of good quality. In general, Cedar Lake can be classified as a Mesotrophic lake based on a combination of Total P concentrations, Chlorophyll *a* concentrations, and Secchi disc readings which were collected from May, 1997 through November, 2001.

In terms of trophic status indicators, it was mentioned that levels of Total P are related to levels of Chlorophyll *a*, which are in turn related to Secchi disc readings. The sample results for Cedar Lake were somewhat inconsistent with this, whereby the lake experienced relatively high Total P concentrations which should be associated with higher levels of algae and therefore low Secchi disc readings. However, Chlorophyll *a* concentrations were not as high as would be expected based on the Total P levels, and Secchi disc readings were indicative of very good water clarity and quality. However, there was consistency when relating these readings to the trophic status of the lake. The majority of the data indicated a mesotrophic status for Cedar Lake. This data may indicate that there is another limiting nutrient in Cedar Lake, keeping the algae production in check. This may be a macro-nutrient, such as nitrogen or it could be a micro-nutrient such as zinc or copper.

The data presented here, however, does not completely reflect the health of Cedar Lake. A lake's aging process naturally transitions from Oligotrophic through Mesotrophic to Eutrophic. However, it is the rate of this aging process that is very important. Data from several years is needed to accurately show whether a lake is experiencing significant changes in water quality as year-to-year changes in lakes are an indication of the rate of change. As a Mesotrophic lake, Cedar Lake's aging process *is* progressing towards a Eutrophic condition. Human activity can accelerate this aging process. Therefore, continued water quality monitoring will be needed to follow and better predict the aging process of Cedar Lake. The sampling conducted for this study provides a baseline for future water quality monitoring efforts to be compared with to gauge the rate of change experienced by Cedar Lake through this aging process.

Based on the data collected from the sanitary survey, the following conclusions can be drawn:

- Approximately three-fourths of the on-site sanitary systems within the Cedar Lake area are conventional septic systems.

- Over 60 percent of sanitary systems in the Cedar Lake area are more than 15 years old. Codes may have been more lenient at the time these systems were constructed, therefore they may not be ideally located or constructed by today's standards.

- The vast majority of survey respondents (97%) indicated that no problems were experienced with their sanitary systems, however they may not be educated on how to detect wastewater discharging to the surface or discharging indirectly. Bacterial sampling by individual homeowners may indicate a local impact but lake-wide sampling will not pinpoint problem areas.

9 Lake Management Objectives and Techniques for Water Quality Improvements

The following presents some alternatives which may be implemented to improve the water quality of Cedar Lake, and to slow the process of eutrophication. Alternatives include educating Cedar Lake area landowners, and improving the sanitary systems. Additional materials are attached in Appendix A.

9.1 Education

There are numerous ways individual landowners can contribute to maintaining or improving the water quality of Cedar Lake through various land practices. Landowners should continue to be provided with educational material explaining proper land practices and the benefits of them.

A number of human activities add nutrients to the water which promote excessive plant growth. The best long-term solution to control/prevent excessive plant and algae growth and improve water quality then is to prevent surplus nutrients and sediments from entering the water. Surface water runoff is a major source of nutrients and sediments in lakes. It should be noted, however, that variations in the natural environment (i.e. temperature, weather conditions, etc..) can also cause excessive plant growth.

This section identifies the ways in which private landowners can help to improve the lake's water quality by reducing surface water runoff and controlling soil erosion:

Landscaping Along the Waterfront

Landscaping along the shoreline is best kept in its natural state and provides several benefits which include:

- ♦ Protecting the water quality of the lake by filtering nutrients and pollutants from runoff before reaching the lake.
- ♦ Preserving the beauty of the shoreline by preserving the natural appearance and screening development from view.
- ♦ Providing wildlife habitat.
- ♦ Protecting the shoreline from erosion.
- ♦ Shading lakeshore water minimizing aquatic plant growth near shore
- ♦ low-maintenance care.

These benefits can be achieved by doing the following:

- ♦ Preserve Natural Shoreline Buffers: Leave the shoreline in a natural state if it has not yet been altered. In areas where the land slopes to the water, construct a berm back from the shore to detain runoff, allowing time for infiltration and evaporation of water.(local zoning regulations restrict shoreline vegetation removal).

- Restore Shoreline Buffer Areas: Leave a strip of unmowed grass, preferably 20 feet wide or more, along the shoreline; native flowers, shrubs and grasses will naturally grow in this area. Native species, including trees, may also be planted in these areas to add variety and provide more immediate results without requiring the use of fertilizers. The wider the buffer area, the greater the benefits.

- Shoreline Paths: Create pathways to the shoreline which follow natural contours rather than descend straight downslope to minimize erosion. Use wood chips or gravel for paving so runoff is not directed into the lake.

- Limit paved or impermeable areas. Dominating the landscape with driveways, patios, decks, and roofs increases the amount and velocity of runoff, carrying sediments and nutrients which cause nuisance plant growth, damage aquatic habitat, hinder recreational activities, and speed the eutrophication of the lake. Reduce the amount of runoff from driveways and patios by constructing them with porous paving bricks, and diverting water to areas where it can evaporate or soak into the soil.

- Minimize land slopes. Keeping the land as flat as possible reduces erosion. Terracing should be used to flatten areas of steep slope, such as those along the east shore of Cedar Lake.

Lawn/Garden Care

It was observed during the field study that much of the lake is surrounded by well-kept lawns. The fertilizers and pesticides frequently used to maintain these laws and gardens can reach the water and negatively affect the water quality of the lake. A minimal amount of lawn area is recommended to maintain good water quality; ideally, native, low-maintenance ground covers should be planted in place of lawn. There are ways however, to care for lawns and gardens which will preserve the water quality of the lake, including:

- Proper use of fertilizers and pesticides, including the use of no- or low-phosphorus containing fertilizers. Use fertilizer only if there is a nutrient deficiency present as shown by a soil test. For pesticides, avoid application 1) if rain is likely, 2) near the shoreline, and 3) near a well, do not dispose of them down a toilet or drain, do not mix different pesticides, and carefully follow the directions on the label.

- Choose a grass type or groundcover that is appropriate for your site and soils which requires minimal maintenance, fertilizer and pesticide application.

- Leave grass clippings on the lawn. This will provide up to one-half of the nitrogen the lawn needs. Do not burn grass clippings and leaves near the shore or rake them into the water.

- Do not mow more than ⅓ of the height of grass blades. Set the mower blade to 2-2½".

- Locate gardens away from the shoreline.

- Control garden pests by using natural controls and pest predators rather than pesticides.

- Add nutrients to gardens by composting aquatic weeds.

- Divert runoff from waterways. Downspouts should be directed to areas where infiltration can occur and not to areas of steep slope. Planting beds are a good location to direct downspout runoff.

- During construction, minimize soil disturbance and revegetate bare areas as soon as possible.

Other ways that Cedar Lake area users can help protect the water quality of the lake are to abide by all local regulations. These regulations are in-place to help everyone live in harmony with the environment and to protect the environment from careless misuse. The Cedar Lake Sanitary District No. 1 in conjunction with the Wisconsin Department of Natural Resources and town and county representatives have established some regulations. Among them include shoreland zoning regulations and boating regulations. These boating regulations prevent undue stress upon the lake shore from wave action and prevents excessive turbidity from propeller spin.

9.2 Sanitary System Improvements

Properly functioning sanitary systems are designed to remove the majority of disease-causing organisms and some nutrients and chemicals from household water and wastewater, keeping them from entering surface water and groundwater. However, these systems are not designed to treat many water-soluble pollutants. It is necessary, therefore, to take extra care in the maintenance of private sanitary systems, especially those located near surface waters or where groundwater is close to the surface. Malfunctioning, unmaintained, or improperly installed sanitary systems can result in the release of nutrients such as phosphorus which encourage nuisance weed and algae growth in the lake.

The following provides improvements that can be made to upgrade malfunctioning or improperly installed/located sanitary systems, and also identifies ways in which property owners can reduce the risk of a malfunctioning sanitary system through proper maintenance and waste reduction practices.

Based on the sanitary survey results presented in Section 4, there are sanitary system improvements which can and should be made to failing systems, to reduce the risk of malfunctioning systems discharging wastewater into Cedar Lake. These improvements include:

- Relocate drainage fields on sites away from the lake and private wells, especially in areas of steep slope (i.e. uphill/across street from property if possible).

- Construct a cluster system with a number of other residents whereby one sanitary system has the capacity to be shared by multiple households. This is especially encouraged in areas where many small lots are grouped together and sufficient room is not available for individual systems.

- Change from conventional septic systems to holding tanks in areas of steep slope, where small lots are grouped together, and in low areas. Holding tanks can be successful if properly maintained.

- The Cedar Lake Sanitary District No. 1 could develop ordinances allowing them to keep records of septic, mound and holding tank pumping frequencies for all systems in the area. This would encourage proper system maintenance.

In addition to sanitary system improvements, several recommendations are identified for properly maintaining private sanitary systems, whereby increasing the life of the system, reducing the chances of system malfunction, and more importantly reducing the incidence of allowing pollutants and nutrients to enter the lake (and groundwater):

- Decrease the amount of water used. There are several ways this can be achieved including using water-efficient appliances and flow restrictors, not letting faucets run unnecessarily, do dishes/laundry only when needed (full loads), etc.

- Use no- or low-phosphate laundry detergents and minimize the use of fabric softeners and water additives which contain phosphates. Detergents with less than 0.5% phosphate are considered low phosphate; usually liquid detergents are free of phosphates. Do not use detergents which contain fillers.

- Do not dump/pour products which contain contaminants, including pesticides, household chemicals, and solvents, or oil or grease down drains, on the ground, or down the driveway. Try to use products that are non-hazardous or less-hazardous.

- Divert discharge from wash water and water softeners from the lake; direct this water to the sanitary system.

- Avoid the use of garbage disposals.

- Don't drain sump pump water into the sanitary system, as this could increase the chance of a system overload.

- Have conventional and mound system tanks pumped at least once every year or every other year. Have holding tanks pumped upon alarm.

Malfunctioning sanitary systems can be detected by the following:

- Backup of sewage in drains or basement.
- Wet areas or ponded water over the drain field.
- Grass over the drain field is bright green (indicates effluent at the surface).
- An increase in aquatic plant growth along property's shoreline.
- Drains or toilets drain slowly.
- Sewage odors.
- Bacteria or nitrates detected in a nearby well water test.
- Biodegradable dye flushed through the system is detectable in the lake.

9.3 Future Water Quality Testing

Water quality testing is recommended to be continued in the future. The testing completed as part of the report and this plan, even over the four to five year period, provides only a snapshot of Cedar Lake's water quality. In order to accurately determine if the lake is experiencing significant changes in water quality, and the rate of that change, data from several years needs to be collected and analyzed.

A long-term sampling program should be established, specifically including the testing of the trophic status indicators - Total P, Chlorophyll *a*, and Secchi disc readings. Testing should be completed on a quarterly basis and include samples from both spring and fall overturn. Secchi disc readings should be taken on a weekly or bi-weekly basis from April through November. Other critical parameters that should also be monitored include D.O., pH, and the nitrogen compounds; Ammonia, Nitrate plus Nitrite and Total Kjeldahl Nitrogen.

In addition to water quality testing, it is recommended that the flow rate of water entering the lake, via the well and leaving the lake be continually monitored. The discharge from the lake should be monitored with the staff gauge to obtain a better understanding of the rate at which the lake discharges. Calibration of the stage/discharge relationship will need to be completed approximately every two to three years.

Also, as part of this additional testing, a Lake Management Planning Grant may be applied for that will help defray the costs associated with such an effort. As part of that grant application, additional testing should be included that will look for chlorides and sulfates that may indicate pollution causing agents exist from the private sanitary systems.

All private wells should be tested for the presence of fecal coliform and nitrate on a regular basis due to the threat of contamination from failed and at risk on-site systems.

9.4 Water Quality Improvements

It is recommended that alternatives for water quality improvement be implemented. Alternatives may include educating the public, upgrading on-site sanitary sewer systems, and/or the installation of a public sanitary sewer system and possibly a water system.

The installation of a public sanitary sewer system should be considered for the long term maintenance and protection of Cedar Lake's water quality and the local groundwater. Cedar Lake is very sensitive to pollution due to its low watershed to lake area ratio, therefore pollutants which enter the lake remain in the lake for a longer period of time before exiting. In addition, the lake's primary source of water is from the surrounding land uses in the watershed which, if significant development occurs, may have a tremendous impact on the lake's water quality. Both of these may cause the lake to progress to eutrophic status more rapidly. It would be more feasible to spend less money now to ensure protection of the lake's water quality rather than spend more money later to clean up the lake and then ensure protection.

There are numerous advantages to proceeding with the installation of a public sanitary sewer system, including:

- Eliminates contamination of lake waters.
- Improves drinking water quality.
- Eliminates waste trucks in the area.
- Improves the value of properties.
- Eliminates the need for replacement systems.
- Improves overall environmental impact.
- Eliminates maintenance of on-site systems.

There are however, a few disadvantages to installing public sanitary sewer. The first disadvantage is the cost and associated unit assessments per Residential User Equivalent (RUE), taking into account the different land use development and calculating correct assessments for residential, commercial or industrial sites. Second is the inconvenience created due to construction of the system, however this occurs only initially for a limited time. Third, the installation of public sanitary sewer may promote growth within the district.

As part of looking into the feasibility of installing public sanitary sewer and the fact that private wells are at risk of being contaminated, the Town of Schleswig Sanitary District No. 1 and the Cedar Lake Association should also look at the need and feasibility for public water via the installation of water main. Installing water main at the same time as sewer saves time and dollars that would otherwise occur down the road. At a minimum, it is recommended that a public sewer system be evaluated to protect the on-site wells from contamination.

10 Implementation

The Town of Schleswig Sanitary District No. 1 can begin the process of implementing the recommendations provided in Section 9 by applying for grants from Rural Development and others to fund a public project and sending out educational flyers to the property owners throughout the area.

The development of local regulations and ordinances, and lake improvement activities may be funded through these Lake Management Grants. Applications are accepted on May 1 of every year.

Educational flyers should be distributed to all property owners within the Cedar Lake area, identifying ways they can contribute to the protection of Cedar Lake's water quality.
The Town of Schleswig Sanitary District No. 1 should investigate the feasibility of extending public sewer and water service to the Cedar Lake area in the future to ensure the protection of the groundwater and the water quality of Cedar Lake. On-site systems, even if upgraded, still pose the threat of nutrients and contaminants discharging into the lake and nearby wells.