LpL-647

Report

Phase I Lake Study Report

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Harmony Grove Lake District

August 2001

Foth & Van Dyke

consultants · engineers · scientists

Harmony Grove Lake District
Phase I Lake Study Report

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1 Executive Summary

Foth & Van Dyke was retained by the Harmony Grove Lake District (District) to conduct a water quality evaluation of the Harmony Grove lagoons. The District received a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) which provided funding up to $10,000 for this project with in-kind services and matching funds of 25% provided by the District.

This evaluation and report focused on the evaluation of the current trophic status, including water quality data generation, the recharge/discharge relationship of groundwater flowing into or out of the Harmony Grove lagoons, and the relationship to the land use practices in the Harmony Grove watershed to the water quality of the lake.

Water Quality

A water quality sampling program was implemented to determine the lake's water quality and trophic status. The Harmony Grove lagoons can be described as eutrophic based on the high nutrient concentrations of phosphorus and nitrogen and high levels of algae growth. Water quality in the lagoons was similar to water quality in Lake Wisconsin. Each lagoon is connected to Lake Wisconsin and the water quality in the lagoons is highly influenced by Lake Wisconsin.

Groundwater Recharge/Discharge

Piezometers (groundwater wells designed to evaluate flow direction) were installed in two of the five lagoons to determine the extent, if any, of groundwater contribution to the Harmony Grove lagoons. The data collected showed there is a small groundwater input to the lagoons. In spite of a groundwater input to the lagoons, water quality in the lagoons is similar to Lake Wisconsin and the exchange of water from Lake Wisconsin has a much greater impact on the lagoons than groundwater.

Watershed Analysis

Forested land use is the largest category in the watershed and makes up 47% of the total land use. Agricultural land use totals 39% of the total watershed. Residential land use makes up 6%. The watershed to Harmony Grove Lake District is small when compared to the Lake Wisconsin watershed. Because of the large impact Lake Wisconsin has on Harmony Grove Lake District, improvements to land use will not have a significant impact on water quality in the lagoons.

Recommendations

It is recommended that the Harmony Grove Lake District proceed with the following:

- Complete a Lake Management Plan directed toward maintaining and protecting the water quality of Harmony Grove Lake District.
- Evaluate methods of reducing phosphorus loading to the lake.
- Evaluate dredging to remove accumulated sediment and phosphorus, thereby reducing excessive weed growth

2 Introduction

Harmony Grove Lake District is located in southwest Columbia County. The Harmony Grove Lake District is a series of five long, narrow canals connected to Lake Wisconsin. The canals cover an area of 21 acres, has 3.9 miles of shoreline, a maximum depth of 8 feet, and an average depth of 5 feet. Development has occurred on most developable lots around the lake, and these areas currently are serviced by public sanitary sewer.

In May 2000 the District was awarded a Lake Management Planning Grant from the Wisconsin Department of Natural Resources (WDNR) to conduct a study of the water quality of the Harmony Grove Lake District. This study was completed in the summer of 2001.

2.1 Authorization

The District authorized the consulting firm of Foth & Van Dyke to complete Phase I of the lake study for the Harmony Grove Lake District, and to prepare a report identifying the results. The study resulted in a collaborative effort among Foth & Van Dyke, the District, and WDNR personnel.

2.2 Purpose

The purpose of the Phase I lake study was to address the following areas.

- Obtain water quality data to establish the existing water quality of Harmony Grove Lake District.
- Determine the extent to which groundwater is a feeding source for the lake.
- To complete an analysis of the land use and associated phosphorus runoff in the lake's immediate watershed.

The results of this study will be used to provide the District with a sound understanding of the water quality of Harmony Grove Lake District and potential sources of pollution to the lake. This report will also provide the District with alternatives to protect and preserve the water quality of Harmony Grove Lake District based on the findings of the studies.

2.3 Project Study Area

Figure 2-1 illustrates the project study area, including the water quality sampling locations and the locations where groundwater piezometers were installed.


4
Boat
Ramp 4
A
B-1
Harmony Grove
F
782
D-1

FIGURE 2-1
SAMPLING LOCATION
Harmony Grove
Columbia County, Wisconsin

● A Sampling Location

▲ B-1 Piezometer Location

Boat Ramp

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Source: U.S.G.S. 7.5 minute topographic quadrangles -- Duward's Glen, Lodi (1975), Arlington, Poynette (1984).

N

0 200 400 600 800 1000 Feet

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m:\99h011\apr\harmony.apr August 7, 2001 Drawn by: kpk1 Checked by: pak

3 Water Quality

The water quality of a lake is dependent upon a number of factors. Every lake possesses a unique set of physical and chemical characteristics that may change over time. The chemical changes occur on a daily basis, while physical changes (such as plant and algae growth) occur 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 the 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 Harmony Grove Lake District, a sampling program was devised which included testing numerous characteristics of the lake. The following section explains the sampling program and its components, presents the results and analysis of the sampling conducted, and provides conclusions about the water quality of Harmony Grove Lake District. First however, it is important to identify the natural aging process experienced by lakes (eutrophication), and the source of the lake's water supply as this contributes to the factors which effect 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.

Eutrophication - The Aging Process

The process of eutrophication is a natural aging process which occurs in all lakes whereby a lake progresses from a more oligotrophic (young lake) to a more eutrophic (old age) state. When nutrients such as phosphorus and nitrogen wash into a lake with stormwater or by soil erosion, they fertilize the lake and encourage algae and larger plants to grow. As plants and the animals that feed on them die and decompose, they accumulate on the lake bottom as organic sediments. After hundreds or thousands of years of plant growth and decomposition, the character of a lake may more closely resemble a marsh or a bog.

However, lakes also obtain nutrients from various human activities which can literally make a lake old before its time. This accelerated transition is commonly termed "cultural eutrophication", whereby changes that would normally take centuries may occur over/within one person's lifetime. Nutrients from agriculture, stormwater runoff, urban development, lawn and garden fertilizers, failing septic systems, land clearing, construction site runoff, municipal and industrial wastewater, and recreational activities contribute to the accelerated eutrophication or enrichment of lakes.

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 - Young lakes with low productivity which are generally clear, cold, deep, and free of weeds or large algae blooms. Oligotrophic lakes are low in nutrients 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, 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 and support a large biomass are categorized as eutrophic. These old age lakes are usually weedy and/or experience large algae blooms. Most often they support large fish populations, however are also susceptible to oxygen depletion which limits fishery diversity. Rough fish are common in eutrophic 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 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.

General Characteristics of Harmony Grove Lake District

Harmony Grove Lake District is classified as an impoundment lake: an impoundment lake is a man made lake created by damming a stream. In this case, Harmony Grove Lake District is connected to Lake Wisconsin. Lake Wisconsin was created by damming the Wisconsin River. The river enters the lake on the northeast end and flows over a dam on the southwest end of the lake. Impoundment lakes have their water level primarily maintained by flow from the inlet stream. Groundwater and direct precipitation are minor water source to the lake when compared

to the stream flow. Water quality is most impacted by the inlet stream which is impacted by the drainage basin and the land use in that basin.

Harmony Grove Lake District has a surface area of 21 acres with an average depth of 5 feet and a maximum depth of 8 feet. It is a series of long, narrow inlets of Lake Wisconsin with a shoreline of 3.9 miles. There are three boat landings in the District. The watershed associated with Harmony Grove Lake District covers 4,200 acres, a relatively small watershed.

3.1 Sampling Program

The sampling program used to determine the water quality of Harmony Grove Lake District was conducted over approximately a one year time period, beginning in May of 2000, and concluding in March 2001. This sampling program provided information to evaluate the current water quality of the lake. Sampling was conducted on six separate occasions including:

- May 2000
- June 2000
- August 2000
- September 2000
- February 2001 (ice on)
- March 2001 (ice on)

Harmony Grove Lake District staff and Foth & Van Dyke personnel performed the water sampling, while laboratory analysis of the samples 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.

Numerous factors were considered in the sampling program, including:

Dissolved Oxygen (D.O.)	Temperature	Chlorophyll *a*
Total Phosphorus	Orthophosphate	pH
Ammonia Nitrogen	Nitrate plus Nitrite Nitrogen	
Total Kjeldahl Nitrogen	Secchi Disc readings	

These factors were measured at six sample locations. These locations are shown on Figure 1. Sample locations A through E were taken in each lagoon. Sample point F was taken in Lake Wisconsin outside of the sand bar with has formed at the mouth of the lagoons. The location for sample point F assumed that this water represented the lake quality rather than the lagoons. At each sample point, one sample was collected midway between surface and bottom of the lake. Temperature and D.O. were also measured at each sample point. Samples for the nitrogen compounds were taken on the May, September and March sampling dates. As the primary objective of this study was to determine the trophic status of Harmony Grove Lake District, the factors which contribute to making this determination were sampled more frequently than most other factors. These factors include total phosphorus (Total P), Chlorophyll *a*, and Secchi Disc

readings. For the purposes of this study, orthophosphate, dissolved oxygen, pH, and temperature were also sampled more frequently, including all sample dates.

The following section provides the results of the sampling program, highlighting those factors which contribute to the determination of the lake's trophic state,

3.2 Results and Analysis

The complete results of the sampling program conducted on Harmony Grove Lake District are displayed in Appendix A. The following section provides a more detailed discussion of the sampling results of temperature, dissolved oxygen levels, trophic status indicators including total phosphorous concentrations, Chlorophyll *a* concentrations, and Secchi disc readings.

Temperature

Temperature exerts a major influence on biological activity and growth. To a point, the higher the water temperature, the greater the biological activity. Temperature also governs the kinds of organisms that can live in a lake. Fish, insects, zooplankton, phytoplankton, and other aquatic species all have a preferred temperature range. As temperatures get too far above or below this preferred range, the survival of individual species may be limited or eliminated.

Temperature is also important because of its influence on water chemistry. The rate of chemical reactions generally increases at higher temperature, which in turn affects biological activity. An important example of the effects of temperature on water chemistry is its impact on oxygen. Warm water holds less oxygen than cool water, so it is more difficult to maintain enough oxygen in warm water for survival of aquatic life.

Stratification: Layers of a Lake

Stratification is a layering effect produced by the warming of the surface waters in many lakes during summer, during which time lake water separates into layers of distinctly different temperature. Upper waters are progressively warmed by the sun and the deeper waters remain cold. Because the layers don't mix, they develop different physical and chemical characteristics, often resembling two different lakes. As a result, oxygen in the bottom waters may become depleted. In autumn, as the upper waters cool to about the same temperature as the lower water, stratification is lost and the whole lake mixes again. This process is called fall turnover. Many lakes experience stratification in winter because ice covers the lake surface. In spring, as ice melts, the water temperatures once again equalize and mixing occurs, a process called spring turnover. As summer progresses, the temperature difference (and density difference) between surface and bottom water becomes more distinct, as mentioned previously, and most lakes form three layers. The upper layer, the epilimnion, is characterized by warmer (less dense) water and is the zone of light penetration, where the bulk of productivity or biological growth occurs. The next layer, the metalimnion or thermocline, is a narrow band where the transition from warmer surface waters goes to the cooler bottom layer. This transition zone helps to prevent mixing

between the upper and lower layers. The bottom layer, the hypolimnion, has much colder water. Plant material either decays or sinks to the bottom and accumulates in this isolated layer. During fall turnover, surface waters cool until the waters from top to bottom have an equal temperature and density. Wind action then mixes the lake waters, balancing the lake's chemistry.

A shallow lake or an impoundment lake, however, is more likely to be homogeneous from top to bottom. The water is well-mixed by the wind and current, and physical characteristics such as temperature (and oxygen) vary little with depth. Because sunlight reaches all the way to the bottom, photosynthesis and growth occur throughout the water column. As in a deep lake, decomposition in a shallow lake is higher near the bottom than the top simply due to the fact that when plants and animals die they sink. It is also likely that a larger portion of the water in a shallow lake is influenced by sunlight, and that photosynthesis and plant growth are proportionately higher.

Temperature Profile of Harmony Grove Lake District

Temperature profiles of Harmony Grove Lake District were not taken due to the shallow depth. The water remains relatively "mixed", or at approximately the same temperature from top to bottom, throughout the year.

Dissolved Oxygen (D.O.) Concentration

The presence of oxygen in lake water determines where organisms such as fish and zooplankton are found. When water is well-mixed, oxygen is usually present at all depths, thus organisms may be distributed throughout the lake. Available oxygen is consumed through decomposition of plant and animal material, and oxygen levels become too low for fish which then must move to a zone of higher oxygen levels. If these conditions are prolonged and the waters become too warm, sensitive fish may become stressed and eventually die. The formation of ice in water reduces the supply of oxygen to the lake from the overlying air. If oxygen levels fall too low, fish and other aquatic life may die.

The concentration of dissolved oxygen (D.O.) present in a water body 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 surface water 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, water 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 "winter kill" and occurs in many eutrophic water bodies. oops

In warm water, the water quality standard for D.O. is 5 mg/l, which represents the minimum amount needed for the survival and growth of warm water fish species. D.O. concentrations between 8 mg/l and 10 mg/l indicate saturation.

The D.O. levels in Harmony Grove Lake District remained fairly consistent among the varying sample dates ranging from approximately 5 mg/l to 11 mg/l for all sampling events. This level of D.O. is adequate for warm water fish growth and survival.

Trophic Status Indicators

Total Phosphorus Concentration (Total P)

Phosphorus is the key nutrient which influences plant growth in over 80% of the lakes throughout Wisconsin. Excess phosphorus promotes excessive aquatic plant growth. In most lakes, phosphorus is the least available nutrient, so it's abundance, or scarcity, controls the extent of algae growth. For that reason, phosphorus is typically referred to as the limiting nutrient. If more phosphorus is added to the lake from septic tanks, urban or farmland runoff, lawn or garden fertilizers, sewage treatment plants, or other watershed or outside resources, or even if it is released from phosphorus-rich lake bottom sediments, that limitation is taken away and more weeds and algae will grow. Under certain conditions, especially when oxygen is absent from bottom waters, phosphorus is released from bottom sediments into the overlying water. In turn, algae clouds water clarity and decreases the depth of light penetration.

Algae and weeds are a source of food and energy for fish and other lake organisms, and are a vital part of all lakes. However, excessive amounts or nuisance types of algae or weeds can interfere with lake uses by inhibiting the growth of other plants by clouding the water so that it shades them, contributing - as the decay - to oxygen depletion and fish kills, and causing taste and odor problems in water and fish. In addition, it can interfere with the aesthetic environment of the lake causing unsightly algal blooms which float on the lake surface forming scums. The regular occurrence of visible algal blooms often indicates that nutrient levels, especially phosphorus, are too high.

Aquatic plants may also limit many lake uses. Although aquatic plants (macrophytes) serve a vital function for the lake by providing cover, habitat, and even food for fish and other wildlife, an overabundance of rooted and floating plants can limit swimming, fishing, skiing, sailing, and boating activities, and aesthetic appreciation. Excessive plant growth can physically prevent mixing of oxygen through the water.

Two types of phosphorus analyses can be conducted which include soluble reactive phosphorus (orthophosphate) 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 sample points and the corresponding WTSI values are presented in Table 3-1.

Table 3-1
Total Phosphorus Levels
Harmony Grove Lake District

Sample Point	A	B	C	D	E	F
Average Total P ug/l	91	71	80	141	73	91
Range Total P ug/l	45 - 218	54 - 79	42 - 137	52 - 379	41 - 138	34 - 138
Average WTSI	63	61	62	67	61	63

The total phosphorus data indicates that Harmony Grove Lake District is in a eutrophic category for lakes. The phosphorus concentrations in the Harmony Grove lagoons are similar to the sample point outside the lagoons in Lake Wisconsin. This points out that Lake Wisconsin itself is the largest influence on water quality in the Harmony Grove Lake District lagoons.

The WDNR guide Understanding Lake Data shows that an average total phosphorus concentration for impoundments is 65 ug/l. This guide also states that total phosphorus should be maintained below 30 ug/l for impoundment lakes in order to prevent nuisance algae blooms. As indicated in Table 3-1, the total P concentrations in Harmony Grove Lake District exceeded 30 ug/l for all samples points at all times of the year. The total phosphorus concentrations in Harmony Grove Lake District are higher than the average impoundment.

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. Table 3-2 identifies the concentration of Chlorophyll *a* detected in Harmony Grove Lake District and the corresponding WTSI status.

Table 3-2
Chlorophyll *a* Levels
Harmony Grove Lake District

Sample Point	A	B	C	D	E	F
Average Chl. a - ug/l	30	34	9	29	17	34
Range Chl. a - ug/l	14 - 60	22 - 57	4 - 13	10 - 49	3 - 30	19 - 45
Average WTSI	60	61	51	60	56	62

Based on the results of the Chlorophyll *a* samples, the trophic status of Harmony Grove Lake District was identified as being eutrophic on average. Note that lagoon C has chlorophyll readings lower than the other lagoons. This lagoon has a creek enter on the east side of the lagoon. This creek may influence the algae growth by flushing algae out of the lagoon before they can grow to levels that match the other lagoons.

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. Table 3-3 shows the average Secchi disc readings in Harmony Grove Lake District and the corresponding WTSI status.

Table 3-3
Secchi Depth
Harmony Grove Lake District

Sample Point	A	B	C	D	E	F
Average Secchi Depth - Ft.	3.33	3.54	4.96	3.33	3.88	3.13
Range Secchi Depth - Ft.	2.5 -4	3 - 4	4 - 6	2.3 - 4	2.5 - 4.5	2 - 5
Average WTSI	60	59	54	60	58	61

Table 3-3 shows water clarity was consistently higher at sample point C compared to other sample points. All readings at all sample points indicate the lake's water quality is in the eutrophic range.

Non-Trophic Status Indicators

Orthophosphate

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 all samples.~~ at all sites The concentrations ranged from 22 ug/l to less than 2 ug/l. The highest concentrations occurred in March and the lowest concentrations occurred in May. The high concentrations in March correlate with lower algae growth in the winter.

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.

The data shows relatively high values for nitrogen compared to natural lakes. The value for nitrite/nitrate was 0.3 mg/l or higher for all samples with maximum values of 1.8 mg/l. Total nitrogen exceeded 1.0 mg/l for all samples with maximum values up to 2.5 mg/l. Most values for natural lakes are less than 1.0 mg/l. The data indicates that adequate nitrogen is present to allow algae to grow. The limiting nutrient for Harmony Grove Lake District is phosphorus.

3.3 Conclusions

Temperature

The lagoons do not have strong stratification characteristic due to the shallow depth. The water remains mixed throughout the year.

Dissolved Oxygen

The DO concentrations were adequate for fish and other aquatic organism survival.

Total Phosphorus

Concentrations of Total P were consistently in the eutrophic range. The average trophic status indicator value for the 5 lagoons was 63. The average trophic status indicator value for Lake

Wisconsin was also 63. This would indicate that the water quality is similar in the lagoons when compared to Lake Wisconsin.

Chlorophyll a

Measurements of chlorophyll a were in the eutrophic range for all samples. The average trophic status value in the lagoons was 58 while the average value in Lake Wisconsin was 62. This may be due to the shade provided by the trees along the narrow lagoons which will reduce the algae growth.

Secchi Disc

The Secchi disc measurements were also in the eutrophic range for all samples. Trophic status indicator values were lower in the lagoons when compared to the values for Lake Wisconsin. This correlates to decreased algae growth in the lagoons.

Orthophosphate

Concentrations of orthophosphate were relatively low during open water and increased when the ice was on the lake.

Nitrogen

Inorganic and organic nitrogen compounds are relatively high in Harmony Grove Lake District. The values are consistent with a eutrophic lake and the high levels of nitrogen make phosphorus the limiting nutrient.

Summary

The water quality parameters showed Harmony Grove Lake District to be a eutrophic lake for all parameters. The water quality in the lagoons is similar to the water quality in Lake Wisconsin. This indicates that the main lake has a major impact on the water quality in the lagoons. Improvements made to the area immediately adjacent to the lagoons may have little impact on the water quality because of the influence of water from Lake Wisconsin. Adequate D.O. for fish and other aquatic life is available all year.

4 Groundwater Recharge/Discharge and Lake Level

4.1 Groundwater Recharge/Discharge

Most lakes are influenced to some degree by groundwater. Harmony Grove Lake District and Lake Wisconsin is classified as an impoundment lake in which water levels are maintained by an inlet stream (the Wisconsin River). The lake has a large tributary area and a relatively short detention time. Groundwater will typically have a minor impact on the lake water quality for an impoundment lake. The small lagoons may have a greater impact from groundwater than the larger Lake Wisconsin. This study collected data to determine the potential impact groundwater has on the lagoons in Harmony Grove Lake District.

Foth & Van Dyke installed groundwater piezometers along the lakeshore in four locations (See Figure 2-1). Two piezometers were installed in the second lagoon (Clar-Mar) and two piezometers in the fourth lagoon (Sunset). These piezometers were monitored weekly over the summer months in 2000. The results are shown in Appendix B. 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 no significant gradient at any location. All piezometers showed groundwater entering the lake with the highest gradient at the east end of lagoon 2.

The practical application for this data is that groundwater adds a small amount of flow to the lagoons. Based on the water quality analysis, there is presently little impact from groundwater on the lagoon water quality.

5 Watershed Analysis

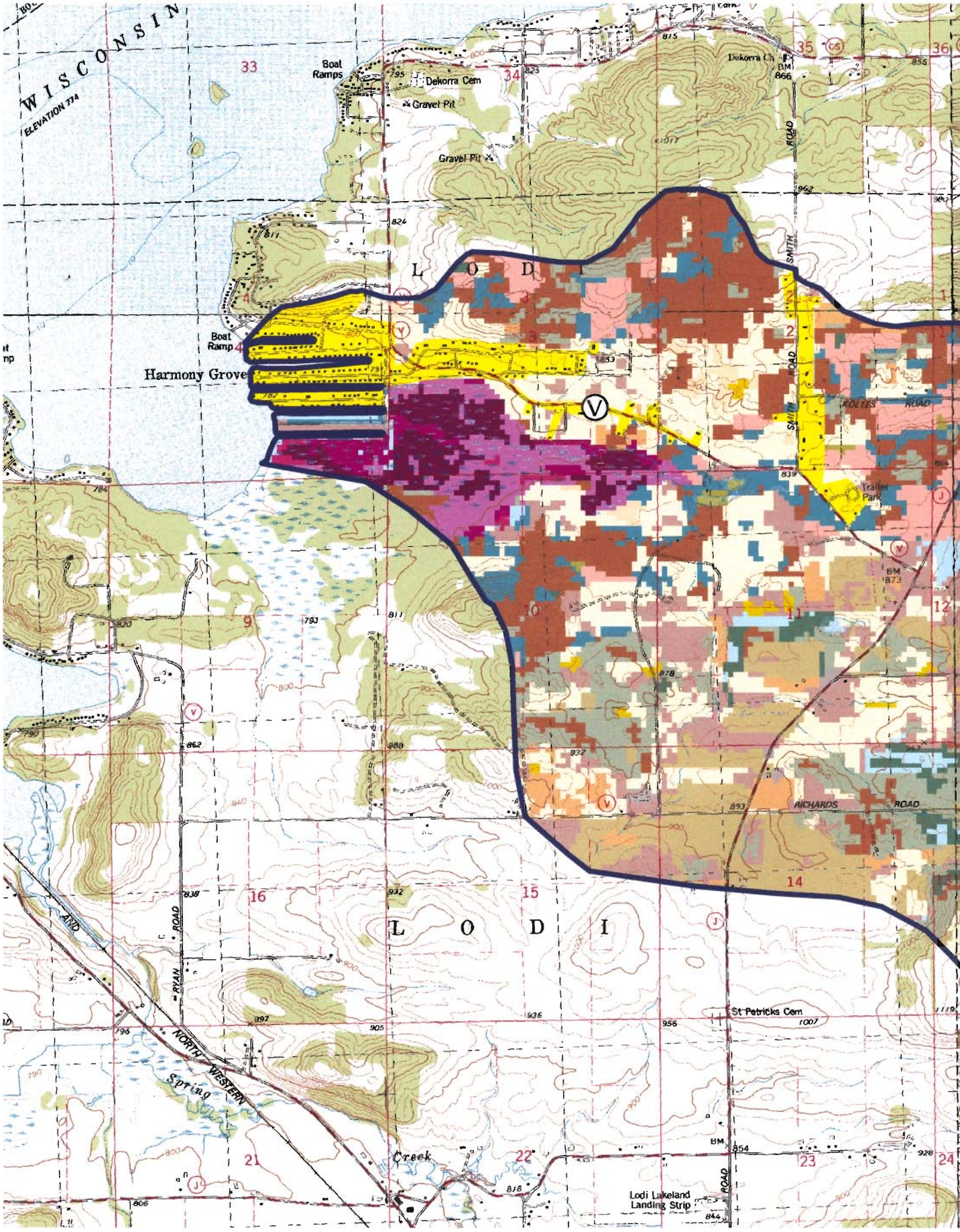
A watershed is an area of land in which water drains to a common point, such as a stream, lake or wetland. A lake reflects its watershed because the watershed contributes both the water required to maintain a lake, and the majority of pollutants which enter the lake. Therefore, effective lake management programs must include watershed management practices, as lake problems generally cannot be solved without controlling the sources in the watershed. Managing the watershed to control nonpoint pollutants such as nutrients, soil, and other substances which originate over a relatively broad area is essential to protecting water quality. Water running over the land picks up these materials and transports them to the lake, either directly in runoff or through a tributary stream, drainage system, or groundwater. Water running off a lawn or driveway during a heavy rain is an example of nonpoint source runoff. Land uses such as agriculture, construction, and roadways contribute higher nonpoint pollutant loads than other land uses such as forests. Controlling nonpoint pollution sources can usually be achieved by implementing best management practices. However, it must be noted that nonpoint pollution sources are harder to identify, isolate, and control than point sources (distinct sources such as a wastewater treatment plant or an industrial facility). Controlling the water that runs from the land's surface into the lake is important as lakes receive water directly from drainage of the surrounding land (watershed) and precipitation.

The watershed, or land area, which drains into Harmony Grove Lake District was delineated by the Wisconsin Department of Natural Resources (WDNR) and Foth & Van Dyke, and is illustrated on Figure 5-1. The map was prepared using LandSat imagery which is made available by the WDNR.

The watershed of Harmony Grove Lake District is relatively small, and is situated within Columbia county. The center lagoon is fed by a creek which runs through the northern portion of the Town of Lodi. Overall, the watershed of Harmony Grove Lake District comprises a land area of 4,220 acres.

According to the generalized land cover map of the watershed (see Figure 5-1), forested land uses comprise the greatest amount of acreage, totaling about 47% of the watershed. Agricultural areas comprise 39%. Wetland areas occupy nearly 8% of the watershed's total area and residential uses (or other "developed" land) comprise under 6% of the land uses in the watershed. Within the watershed, residential land uses are concentrated in the area immediately surrounding Harmony Grove Lake District. In fact, the majority of the lake shoreline is developed residentially, leaving little room for public access. There is a single boat launch on the southern most lagoon.

Not all areas of the watershed are equal pollutant contributors. By identifying those critical areas that contribute excessive amounts of soil and nutrients to the lake, the most effective controls can be developed. For example, agricultural runoff carrying animal wastes, soil, and nutrients can be a critical pollutant contributor. Urban runoff from lawns, gardens, streets, and rooftops may be significant sources of sediment, oils and greases, nutrients, and heavy metals to lakes.


WISCONSIN
ELEVATION 774
Boat Ramps
Dekorra Cem
Gravel Pit
Gravel Pit
Dekorra Ch
BM 866
ROAD
SMITH
ROAD
L O D
Boat Ramp
Harmony Grove
SMITH
ROAD
ROLFES
ROAD
Trailer Park
BM 873
RICHARDS
ROAD
L O D I
AND
ROAD
RYAN
NORTH WESTERN
Spring
Creek
St Patricks Cem
BM 854
Lodi Lakeland Landing Strip
ROAD

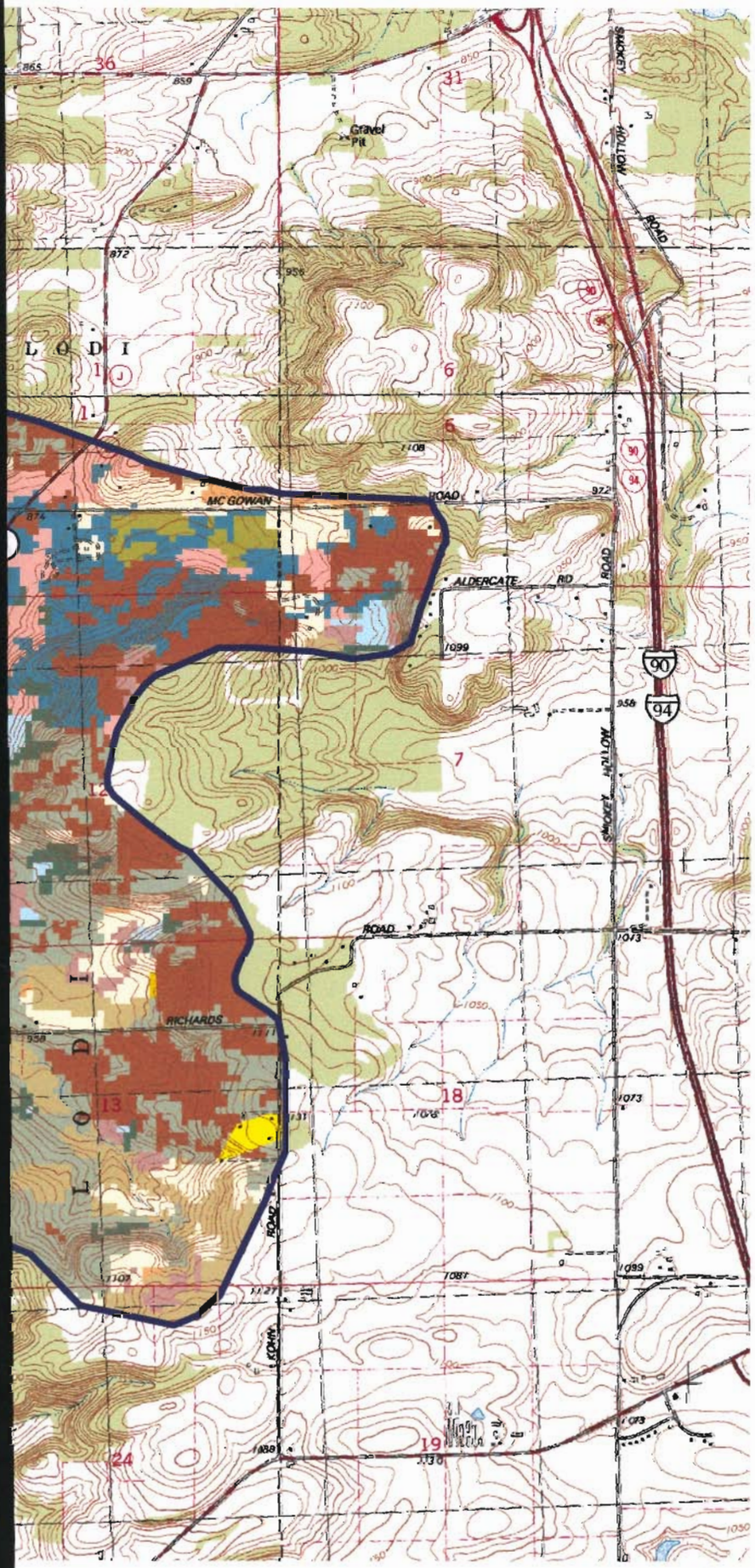


FIGURE 5-1
HARMONY GROVE LAKE DISTRICT WATERSHED
Harmony Grove
Columbia County, Wisconsin

State of Wisconsin

- Harmony Grove Lake District Watershed

Agriculture
- General Agriculture
- Primary Row Crops
- Other Row Crops
- Forage Crops
- Grassland

Forested
- Jack Pine
- Red Pine
- Mixed/Other Coniferous
- Oak

Wetland
- Mixed/Other Broad Leaved Deciduous
- Mixed Deciduous/Coniferous
- Emergent/Wet Meadow
- Lowland Shrub: Broad Leaved Deciduous
- Forested: Broad Leaved Deciduous
- Forested: Coniferous

Other
- Residential/Built-Up
- Surface Water
- Barren
- Shrubland
- Other Forested Areas

This drawing is neither a legally recorded map nor a survey and is not intended to be used as one. This drawing is a compilation of records, information and data used for reference purposes only.

Source: U.S.G.S. 7.5 minute topographic quadrangles – Duward's Glen, Lodi (1975), Arlington, Poynette (1984).

N

0 700 1400 2100 2800 3500 Feet

Foth & Van Dyke
consultants. engineers. scientists

m:\99h011\apr\harmony.apr June 14, 2001 Drawn by: kpk1 Checked by: pak

Construction and forestry activities can provide significant quantities of sediments, especially during rainstorms. In small watersheds, lakeside residential activities may be more critical pollutant contributors. However, in large watersheds, the contributions from urban, forestry, and agricultural areas are generally more significant than those from lakeshore homes.

An estimation of phosphorus loading to Harmony Grove Lake District was calculated based on the existing land uses illustrated in Figure 5-1. Unit area loads by land use type in lbs/acre/year for phosphorus were provided by the WDNR. The unit area load by land use type was then multiplied by the total acreage The results of the calculation are identified in Table 5-1.

Table 5-1
Existing Phosphorus Loading (in lbs/yr)
Harmony Grove Lake District Watershed

Land Use Class	Acreage	Phosphorus (lbs/yr)	% of Total
Residential/Built-Up	245	22	5.8%
Agriculture	1648	148	39.1%
Open Space	27	1	0.6%
Woodlands	1981	59	46.9%
Wetlands	319	10	7.6%
Total	**4220**	**240**	**100.0%**

Source: Wisconsin Department of Natural Resources, Bureau of Watershed Management, Unit Area Loads by Land Use (lbs/acre/year); Foth & Van Dyke, 2000.

The table identifies the estimated existing phosphorus loadings for the Harmony Grove Lake District watershed. Clearly, agricultural land use has the greatest phosphorus contribution to the lake. The watershed tributary to Harmony Grove Lake District is tiny in comparison to the watershed of Lake Wisconsin and the Wisconsin River. The Wisconsin River headwaters are at the Wisconsin/Michigan border and the river drains much of northern and central Wisconsin.

Harmony Grove Lake District lagoons contains about 27 million gallons of water. With an average total phosphorus concentration of 85 ug/l, the average amount of phosphorus in the water is 19 pounds. The watershed evaluation identified an annual phosphorus load of 240 pounds. Each year phosphorus is removed by plant uptake, weed removal, sedimentation, and discharge to Lake Wisconsin. Due to the large impact of the inlet stream and the impact of Lake Wisconsin on water quality in the lagoons, any phosphorus removal measures done in the lagoons itself will have little impact on the phosphorus concentration in the lagoons.

6 Alternatives for Water Quality Improvements

The following presents some alternatives which may be implemented to improve the water quality of Harmony Grove Lake District and to slow the process of eutrophication. Alternatives include educating District property owners on ways they can contribute to improving the lake's water quality, controlling pollution from runoff, and dredging.

6.1 Education

There are numerous ways individual landowners can contribute to maintaining or improving the water quality of Harmony Grove Lake District through various land practices. Land owners should be provided with educational material explaining proper land practices and the benefits of them. While residential land use contributes minor amounts of nutrients to the lake, any improvements will be beneficial.

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.

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 one-third 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.

6.2 Dredging

Sedimentation is caused by a variety of activities. Sedimentation in the lagoons can be caused by particulate matter from Lake Wisconsin entering the lagoons and settling in the relatively quiet environment. Biological activity in the lagoons such as weed algae growth can also cause sedimentation. Erosion along the shoreline and from upstream areas can also bring particulate matter into the lagoons where it will settle. The long, narrow lagoons are a unique environment which will promote settling and sedimentation.

The amount of sedimentation and the alternatives for removing sediment are discussed in the Phase 2 report.

6.3 Agricultural Runoff Reduction

This effort must involve state and local agencies. County land conservation agents and WDNR staff should be contacted to develop a strategy for runoff reduction.

7 Recommendations

This section provides recommendations which the District should implement to maintain and protect the water quality of Harmony Grove Lake District.

7.1 Lake Management Plan

It is recommended that the District prepare a Lake Management Plan. A Lake Management Plan identifies the plan of action to be taken towards maintaining and protecting the water quality of a lake, including determining needs, setting goals, gathering and analyzing information, and developing alternative courses of action. Activities which could be included in the plan are:

- Water Testing
- Educational Programs for Lake Residents
- Develop Management and Implementation Plans for Lake Protection

7.2 Evaluate Methods of Reducing Phosphorus Loading to the Lake

Phosphorus concentrations are consistent with other impoundment lakes and can potentially cause excessive weed growth. Methods of reducing phosphorus loading to the lake, or removing phosphorus from the lake, should be considered and included in the Lake Management Plan. Some methods include:

- Land use planning to minimize land use impacts on the lagoons.
- Cooperative efforts with agricultural land owners in the watershed reduce agricultural runoff and phosphorus loading to the lagoons.

The significant sediment deposits in the lagoons are also sources of sediment phosphorus. This source is available to water weeds during the growing season. Removing sediment will reduce this phosphorus source.

Alternatives to reduce phosphorus are limited because of the impact of Lake Wisconsin on the water quality. Extensive efforts to improve water quality in the Harmony Grove lagoons may provide little benefit when the water quality of Lake Wisconsin is the most important factor affecting water quality in the lagoons.

7.3 Dredging

Dredging is an option to remove sediment and reduce weed growth. This option should be studied thoroughly before considering implementation. This option should be considered as part of a Lake Management Plan.

8 Implementation

The Harmony Grove Lake District can begin the process of implementing the recommendations provided in Section 7 by applying for grants to assist with costs, sending out educational flyers to the property owners throughout the District, and proceeding with development of a lake management plan.

Lake Management Planning Grants are available from the Wisconsin Department of Natural Resources which provide cost sharing for the development of lake management plans and related activities. There are two application cycles to apply for these grants which include February 1 and August 1 of each year.

In addition, Lake Management Protection Grants are also available to assist in with the costs of implementing the recommendations of a lake management plan. The development of local regulations and ordinances, and lake improvement activities may be funded through these grants. Applications are accepted on May 1 of every year.

Educational flyers should be distributed to all property owners within the Harmony Grove Lake District, identifying ways they can contribute to the protection of Harmony Grove Lake District and improving water quality.