LpL-658

Report

Phase II Lake Study Report

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Harmony Grove Lake District

August 2001

Foth & Van Dyke

consultants · engineers · scientists

Harmony Grove Lake District

Phase II 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 sediment quality and sediment removal evaluation of the sediment in the five lagoons in the District. 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 sediment quantity and quality. When the sediment quality and quantity were established, alternatives were developed and analyzed to remove the sediment and dispose of it. Costs for sediment removal were also developed.

Sediment Quality

A sediment quality sampling program was implemented to determine the lake's sediment quality. The sediment was found to contain significant concentrations of nutrients but the heavy metals in the sludge are at low levels and as such the sediment is not regulated in regard to heavy metals. Sediment disposal may be controlled by the amount of nitrogen in the sediment which averaged 0.74% of the total dry weight.

Sediment Quantity

Sediment depth was measured at several locations in each lagoon. The results showed increasing sediment thickness from north lagoon to south lagoon. The average sediment thickness is 2.5 feet. The total sediment quantity was calculated to be 84,700 cubic yards. On a dry weight basis this totals 3,110 tons of sediment.

Sediment Removal Evaluation

Hydraulic dredging is the best alternative for sediment removal at Harmony Grove Lake District. The use of a floating dredge and pump will fit in the long, narrow lagoons and not impact the residential areas adjacent to the lagoons. Complete sediment removal is not practical but the evaluation assumed the center one-third of the lagoon could be dredged effectively and this assumption was used for the cost analysis. Removal of a portion of the sediment will aid in navigation, reduce weed growth, and reduce nutrients in the lagoons.

Hydraulic dredging and liquid transport and disposal was evaluated as a feasible alternative. Sediment removed from the lagoons would be hauled as a liquid and spread on agricultural land. The cost for this alternative is estimated at $1,700,000.

Hydraulic dredging and sediment dewatering in a sedimentation basin was evaluated. This alternative assumed sediment could be pumped to a sedimentation basin where the sediment

would settle and the clear water would be pumped back to the lagoons. The dewatered sediment would be spread on adjacent land. The cost for this alternative is estimated at $600,000.

Hydraulic dredging and sediment dewatering with a mechanical dewatering system was the final alternative evaluated. This alternative assumes a mechanical dewatering device would be used near the dredging site and sediment would be hauled as a solid for application on farm fields. The cost for this alternative is estimated at $660,000.

Project financing was evaluated for the lowest cost alternative. General obligation borrowing can be used to finance a project of $600,000. The average annual cost for the 180 users is $278.

for how many years?

Recommendations

It is recommended that 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 the hydraulic dredging/sedimentation basin alternative in regard to available land, financing and schedule. The project scope should be limited to approximately 1/3 of the lagoon channel.

2 Introduction

Harmony Grove Lake District is located in south west Columbia County. The Harmony Grove Lake District is a series of five long, narrow lagoons connected to Lake Wisconsin. The lagoons cover an area of 21 acres, has 3.9 miles of shoreline, a maximum depth of 8 feet, and an average depth of 4 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 sediment and methods of sediment disposal. 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 II 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 II lake study was to address the following areas.

- Obtain information on the sediment quality and quantity of Harmony Grove Lake District.
- Develop alternatives for sediment removal from the lagoons.
- Evaluate the cost of various alternatives for sediment removal.
- Identify alternatives for reducing the sedimentation in the lagoons.

The results of this study will be used to provide the District with a sound understanding of the sediment quality and quantity of Harmony Grove Lake District and potential alternatives for sediment removal. This report will also provide the District with the cost to implement the alternatives to remove sediment.

2.3 Project Study Area

Figure 3-1 illustrates the project study area, including the sediment quality sampling locations and the locations.

3 Sediment Quality

The sediment quality of a lake is dependent upon a number of factors and lake characteristics. Sediments are deposits that are made as materials settle to the bottom of the lake. The source of the sediments will determine the quality. Some sediments are organic and are caused by plants and animals that die and settle to the bottom. Fecal material from animals can also add to the lake sediments. Inorganic sediments are typically caused by runoff that take fine particles from a watershed and carry them into the lake. Suspended particles in the lake may settle and form deposits in the sediment.

To determine the sediment quality of Harmony Grove Lake District, a sampling program was devised which included testing numerous characteristics of the lake sediments. The following section explains the sampling program and its components, presents the results and analysis of the sampling conducted, and provides conclusions about the sediment quality of Harmony Grove Lake District.

3.1 Sampling Program

The sampling program used to determine the sediment quality of Harmony Grove Lake District was conducted with a single sampling effort in April of 2000. This sampling program provided information to evaluate the current sediment quality of the lake and identify the limiting factors for sediment disposal.

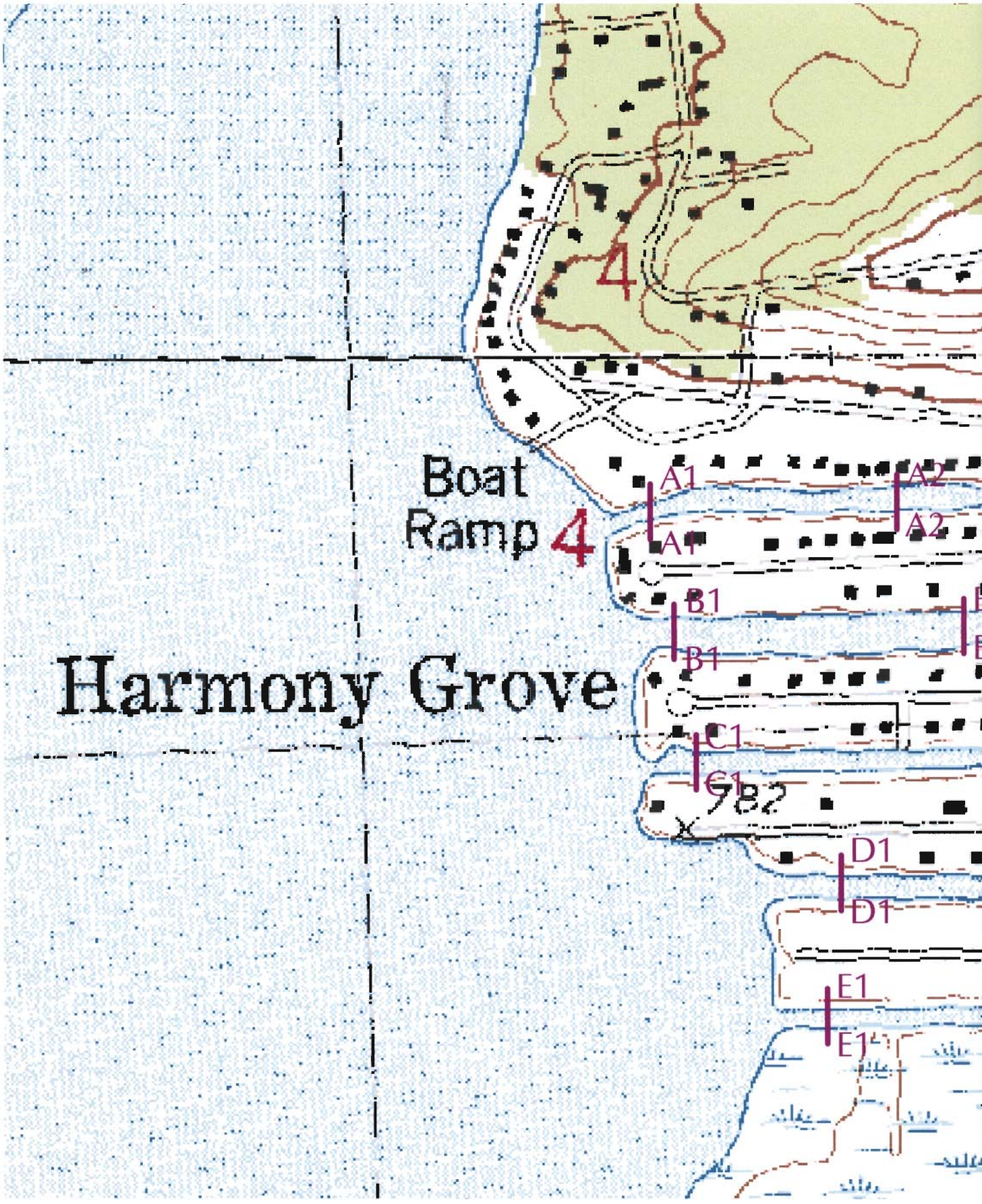
Harmony Grove Lake District staff and Foth & Van Dyke personnel performed the sediment sampling, while laboratory analysis of the samples was completed by the State Laboratory of Hygiene. It was important to obtain samples representative various areas of the lagoons.

Numerous factors were considered in the sampling program, including:

Cadmium	Copper	Zinc
Total Kjeldahl Nitrogen	Total Phosphorus	
Percent Solids	Percent Volatile Solids	

These factors were measured at five sample locations; one from each lagoon. Samples of sediment were composited from various sites in the lagoons to obtain representative samples. These locations are shown on Figure 3-1. Sample locations A through E were taken in each lagoon.

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


4
Boat
Ramp 4
A1
A1
A2
A2
B1
B1
Harmony Grove
C1
C1
D1
D1
E1
E1

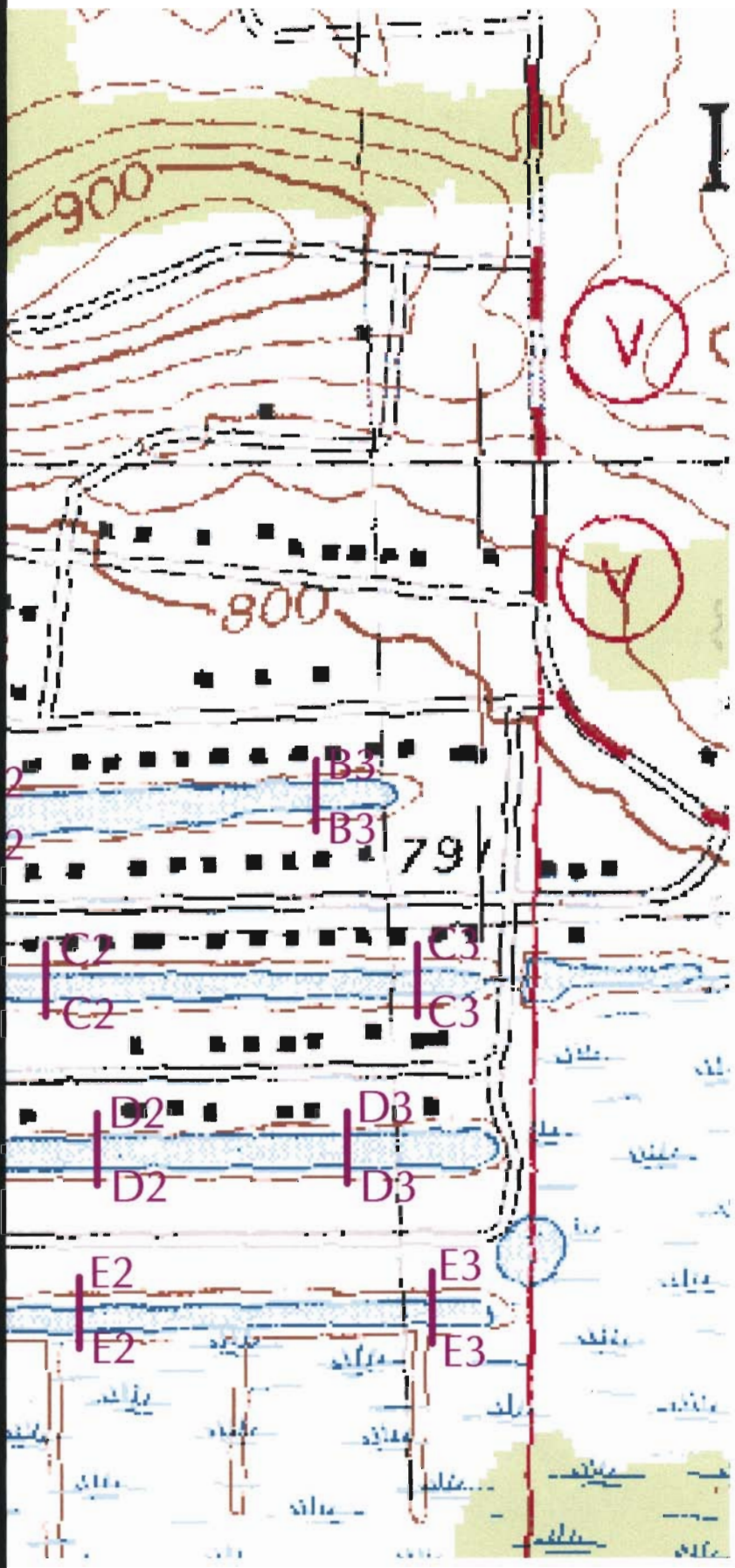


FIGURE 3-1
SEDIMENT SAMPLING LOCATION
Harmony Grove
Columbia County, Wisconsin

A1 — A1 Cross Section of Sediment Sample Location

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 June 15, 2001 Drawn by: kpk1 Checked by: pak

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 heavy metals, nitrogen, phosphorus, and total solids.

Heavy Metals

Heavy metals occur naturally in the environment. Some water bodies may have high metal concentrations caused by urban runoff and industrial discharges. Where heavy metal concentrations are high, the amount of metals may limit the application of the sediment to agricultural lands to avoid contamination of crops grown on the land.

The concentrations of heavy metals detected at the sample points are presented in Table 3-1.

Table 3-1
Heavy Metal Levels
Harmony Grove Lake District

Metal Parameter	Cadmium	Copper	Zinc
Average concentration mg/kg	0.5	22	62
Range mg/kg	0.4 - 0.8	16 - 27	39 - 95

The average concentrations for all metals are below the concentrations listed in NR 204 Table 3. Sediment with concentrations below those listed in NR 204 Table 3 is considered high quality and there are no annual or cumulative loading restrictions.

Nutrients

Nitrogen and phosphorus are the major nutrients that can affect both the water quality and the application of sediment to land. The nitrogen and phosphorus in the sediment are a source of nutrients that can contribute to plant and algae growth. Removing the sediments will reduce the potential source of nutrients available to plants. If the sediment is removed, the amount of nitrogen and phosphorus may limit the amount of sediment that can be land applied. If the amount of nutrients applied to an agricultural field exceeds the needs of the plants, the nutrients can migrate to groundwater or surface water resources and be a pollution problem.

Table 3-2 identifies the concentration of nitrogen and phosphorus in the sediment samples collected in Harmony Grove Lake District.

Table 3-2
Nutrient Concentrations in Sediment
Harmony Grove Lake District

Nutrient Parameter	Phosphorus	Nitrogen (TKN)
Average concentration mg/kg	623	7,362
Range mg/kg	255 - 974	2,670 - 13,400

Based on the results of the analysis, nitrogen will likely be the limiting nutrient when evaluating land application. The average dry weight of nitrogen in the sediment is 0.74% or about 14.8 pounds of nitrogen in each ton of sediment.

Total Solids

Total solids measurements were taken to determine the relative amount of solids in the sediment. The percent solids varied from 14.8% in sample E (the most southerly lagoon) to 51.4% in sample C (the middle lagoon). While these values were used in developing an estimate of total solids in the lagoon sediments, the sampling method using an Eckman dredge are not meant to provide an accurate value of sediment solids concentration in place. It should be noted that lagoon C has an inlet stream while other lagoons do not. Lagoon C may have more sand and silt deposits from stream runoff compared to the other lagoons which may lead to higher solids concentrations. Lagoon C also had lower concentrations of volatile solids and nitrogen than the other lagoons. This data also supports a higher sediment load from the stream than the other lagoons.

Table 3-3
Solids Concentrations
Harmony Grove Lake District

Sample Point - Lagoon ID	A	B	C	D	E
Total Solids - %	30.4	26.6	51.2	21.9	14.8
Volatile Solids - % of Total	7.8	8.8	3.7	14.3	33.2

4 Sediment Quantity

4.1 Sampling Procedure and Results

Sediment depth was measured in each lagoon. Figure 3-1 shows the sediment depth measurement locations. Appendix B contains the detailed sediment depth data. Each measurement was done with two sediment probes. The first probe contained a flat plate at the bottom of the probe. This identified the top of the sediment. A second probe with sharp point on the end was used to measure the bottom of the soft sediment. The difference in elevation was determined to be the sediment thickness. Table 4-1 summarizes the data collected.

Table 4-1
Sediment Thickness
Harmony Grove Lake District

Sample Point - Lagoon ID	A	B	C	D	E
Average Sediment Thickness - Ft.	1.90	1.96	2.51	2.84	3.05
Range of Sediment Thickness - Ft.	1.4 - 2.6	1.0 - 2.3	1.8 - 4	1.3 - 4.5	1.5 - 4.5

The testing showed an increase in sediment thickness from the most northern lagoon to the most southern lagoon. The reason for this is not known but may be due to the general lake currents in Lake Wisconsin. If the current flows from north to south on the east shore of the lake, more sediments could be pushed to the south and enter the more southerly lagoons.

The total volume of sediment was calculated based on the measured depths and the area of the lagoons. Table 4-2 summarizes the sediment volume calculations.

The study also evaluated sediment distribution from west to east for all lagoons. The results show that the western sample site averaged 2.99 feet of sediment. The central sample site averaged 2.24 and the most easterly site averaged 1.70 feet. This shows greater sediment depth at the west end of the lagoons and a decreasing sediment depth going east from the mouth of the lagoon. This is likely the cause of prevailing westerly winds and wave action which bring sediment to the mouth of the lagoon where it settles.

5 Sediment Removal Analysis

Sediments are commonly removed from a water body. A hydraulic dredge is a popular mechanism for removing sediment. The dredge system combines an auger and a pump to direct sediment to a pump intake and pump the solids to a disposal system. Many options exist for handling the liquid sludge. The sediment can be hauled to a disposal site as a liquid with trucks. The sediment can be pumped to a sedimentation basin where the solids settle and the clear water is discharged. Final sediment disposal takes place after the sediment has dried and can be moved with earth moving equipment. Liquid sediment can also be dewatered with a mechanical device such as a belt filter press or a plate and frame press. With the mechanical devices located near the dredging source, the water removed from the sediment is discharged directly to the water body. The dewatered sediment can be moved by dump truck to the final disposal area. Liquid sediment removal is well suited for the Harmony Grove Lake District with its long, narrow lagoons and will be evaluated in detail. The mechanical dewatering alternative will be evaluated but space will be needed for placing the equipment and the truck loading area. Liquid disposal, mechanical dewatering, and a sedimentation basin will be evaluated in detail.

An alternative to liquid dredging is mechanical removal using a drag line or clam shell device. These devices are typically located on shore or a floating barge. The sediment is mechanically removed and deposited in a truck for transport and disposal as a dewatered product. This dredging alternative will be difficult to implement at Harmony Grove Lake District. The developed shoreline offers no opportunity to locate either the mechanical removal machine or the dump truck needed to haul away the sediment. For these reasons the mechanical removal device will not be evaluated in this report.

The hydraulic dredging alternatives assume a floating hydraulic dredge will be used for sediment removal in each lagoon. Removing sediment along the shoreline will be more difficult due to water depth, trees, and piers. The cost for sediment removal will increase as the difficulty in removing the sediment increases. Costs will be developed for dredging the middle third of each lagoon, dredging 2/3 of the lagoon, and dredging the entire lagoon. The sediment removed in the middle of the lagoon will also aid in boat navigation for all those who use the lagoon.

Sedimentation has also been a problem at the mouth of the lagoons. This has caused navigational problems for residents and those who use the public boat launches. Dredging to improve navigation to the main lake will be evaluated with dredging options for the lagoons. The dredging to the main lake will consist of a single 30 foot wide strip that would be marked for navigation.

5.1 Hydraulic Dredging - Liquid Sediment Transport and Disposal

This alternative assumes the sediment pumped from the lagoon will be transported to liquid hauling trucks. The trucks will take the liquid sediment and discharge it onto agricultural fields. The best time for this work is fall when the crops are off and before the ground is frozen. Approximately 60 acres are required for disposal assuming a corn crop the following year and nitrogen will limit the amount of sediment to be spread. See Appendix C for detailed calculations regarding land application of sediment.

The cost for this alternative is estimated at $1,700,000 for dredging approximately 1/3 of the lagoon sediment. Most of the cost is in the trucking of the liquid sediment. A solids concentration from the dredge of 5% was assumed. In some locations hydraulic dredging can produce solids concentrations of up to 10%. If that concentration was achievable at Harmony Grove, the project cost would be reduced to $1,000,000. It is more realistic to use the 5% solids concentration without further testing of the sediment by a dredging company.

5.2 Hydraulic Dredging - Sedimentation Pond and Dewatered Sediment Disposal

This alternative was evaluated for all dredging conditions up to complete removal of sediment. If the removal process is only 1/3 of the total sediment, the liquid sediment will be pumped approximately two miles to an agricultural area where the sediment will be dewatered in a sedimentation pond. A square pond with dimensions of 600 feet on each side was assumed for settling and storing the sediment. Sediment would be pumped through a pipeline and clear water in the sedimentation pond will be pumped back to the lagoon through the same pipe when the dredging equipment is not being used. By using flexible plastic pipe, the piping system can be laid on top of the ground. This will provide minimal disturbance to the ground and will be easily removed when the dredging is done.

The dewatered sediment will be allowed to be remain in the sedimentation pond until the sediment is dry and can be spread on adjacent agricultural fields. Approximately 60 acres are required for land spreading of the sediment. See Appendix C for detailed calculations regarding land disposal of the sediment. Figure 5-1 shows the sedimentation pond which was assumed to be located near the junction of CTH J and CTH V. The pipeline could be laid along the creek that enters the middle lagoon and by using the same culvert under the road, there would be no roads to cross the entire length of the pipeline.

If the amount of sediment to be removed is increased, the sedimentation pond will not be adequate for the greater sediment amounts. Additional land will be required for sedimentation basins and for sediment disposal. For purposes of this report, it was assumed that an additional site could be found for each 1/3 increase in sediment amount and the site would be about 2 miles farther from the District.

The cost for this alternative is estimated at $565,000 for 1/3 of the sediment volume and up to $1,800,000 for the total sediment volume. An additional $35,000 would be added for providing a navigation channel to the main lake.

5.3 Hydraulic Dredging - Mechanical Dewatering and Dewatered Sediment Disposal

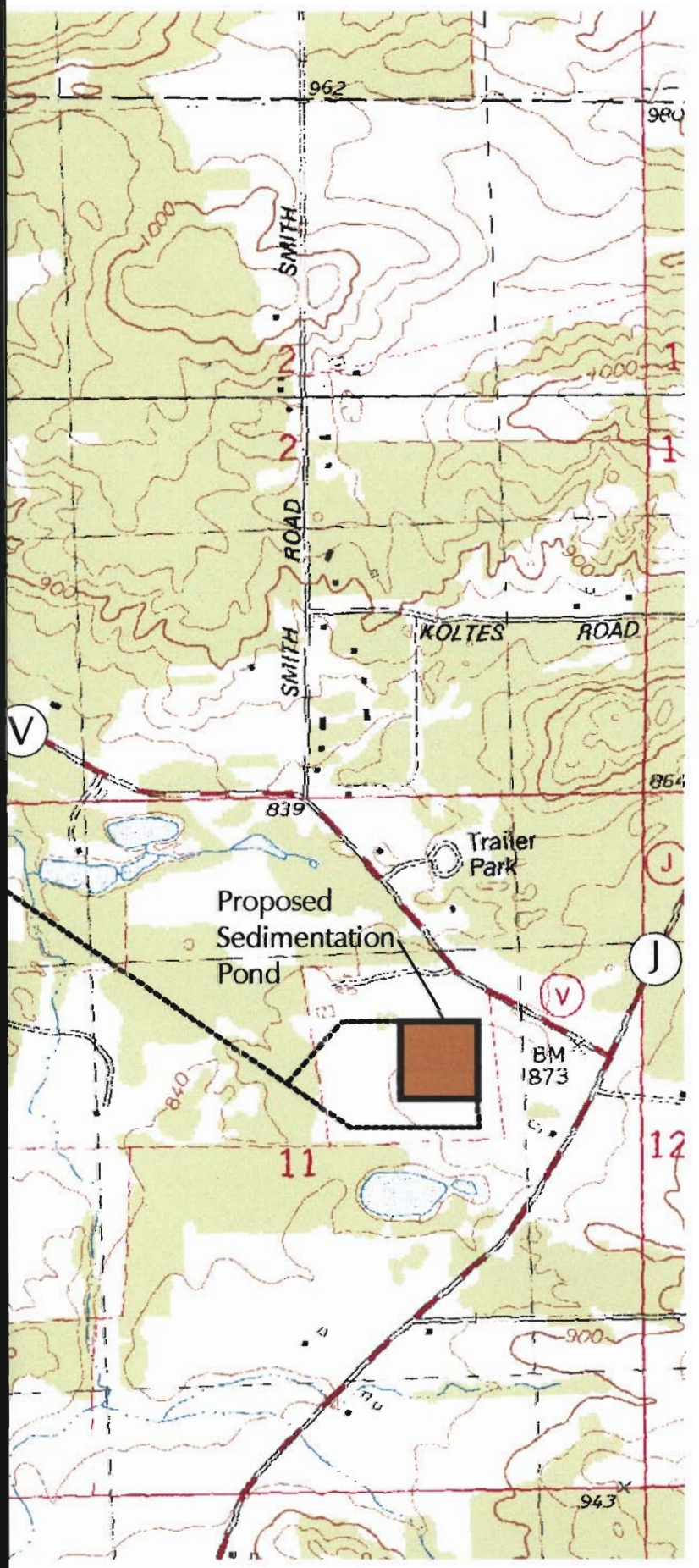
This alternative also includes hydraulic dredging but the sediment is dewatered near the source and the solids are trucked to a disposal site. A mechanical dewatering system is set up near the dredging site. Liquid sediment is pumped to the dewatering system where the sediment is reduced to a cake solid and the liquid is drained back to the lagoons. The sediment is loaded onto trucks for hauling and disposal.

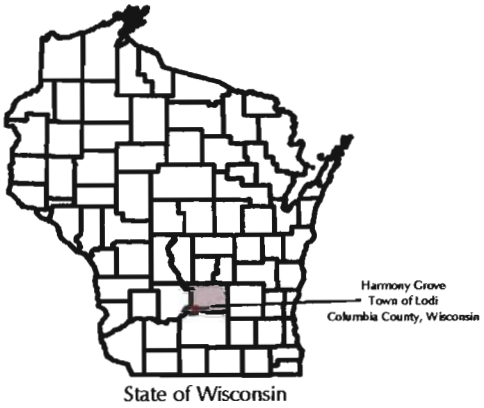
The advantage of this alternative is the smaller site needed for dewatering and the elimination of the sedimentation lagoon. The disadvantage is trucking the solids rather than pumping them to the disposal site. Disposal of dewatered solids onto agricultural fields may be easier than finding sites for constructing a sedimentation lagoon. The dewatered solids can be applied between crop cycles without interfering with normal agricultural practices.

The cost for this alternative is estimated at $610,000 for 1/3 of the sediment volume and up to $1,580,000 for the total sediment volume. An additional $49,000 would be added for providing a navigation channel to the main lake.


824
811
900
L O D I
4
3
Boat
Ramp 4
853
ny Grove
791
782
9
793
811
10
800
862
888
932

FIGURE 5-1
HYDRAULIC DREDGING SEDIMENTATION POND ALTERNATIVE
Harmony Grove
Columbia County, Wisconsin





Proposed Dredging Pipeline

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

0 400 800 1200 1600 2000 Feet

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6 Recommendations

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

6.1 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

6.2 Lake Dredging

This study showed a significant amount of sedimentation has occurred in the lagoons. The sediments have decreased navigability and promoted excessive weed growth. The sediments are also rich in nutrients which promote weed and algae growth in the lagoons. Removing sediment from the center of each lagoon will improve navigability, eliminate the rich substrate for weeds to grow on, and reduce the nutrients contained in each lagoon. The most practical and effective dredging alternative is to dredge approximately the center 1/3 of the lagoons. The hydraulic dredging/sedimentation basin alternative was found to be the most cost-effective. Sites should be evaluated to construct a temporary sedimentation basin. The information collected should be used to determine a final plan for sediment removal and proceed with project implementation.

7 Implementation

The Harmony Grove Lake District can begin the process of implementing the recommendations provided in Section 6 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. Dredging projects are specifically excluded from the Lake Management Protection Grant program.

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.

7.1 Project Financing

Large capital projects such as dredging require special financing. The Harmony Grove Lake District has the ability to borrow money to finance a project such as dredging. There are two financing methods available to the District; general obligation and special assessment.

General obligation borrowing can be done for up to 20 years. The maximum amount of money that can be borrowed is 5% of the assessed valuation of the District. The current assessed valuation of the District is $24,000,000 and the maximum amount that can be borrowed is $1,200,000. Current interest rates for a general obligation loan are 5.5% or less.

Special assessments are levied against a property for improvements made to the property. Dredging would be an eligible improvement for special assessment financing. Each property would receive a special assessment that could be paid at once or over a time period up to 20 years with the District financing the assessment loan.

The recommended project is to dredge approximately 1/3 of the lagoon sediment at a total project cost of approximately $600,000. A project of this size can be financed by either financing method but the preferred method of financing is through a general obligation loan due to better interest rates and lower administrative costs. An example of the general obligation financing is shown below.

Harmony Grove Lake District
Project Financing - General Obligation Loan

Project Cost	$600,000
Annual Principal and Interest (20 yr., 5.5%)	$50,100
Number of Residents	180
Average Annual Cost per Resident	$278