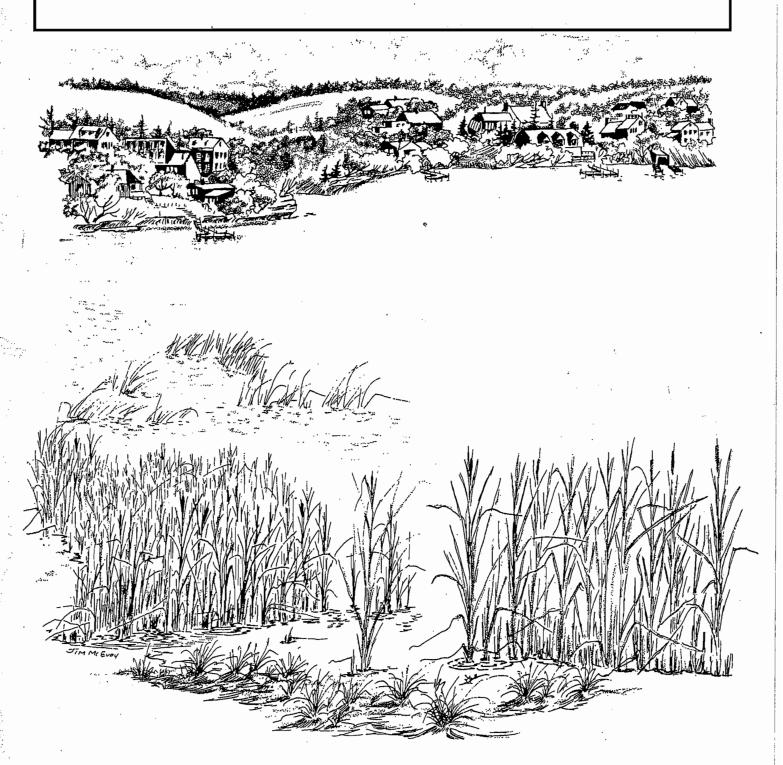
An Interim Evaluation of the Big Green Lake Nonpoint Source Control Project



Wisconsin Department of Natural Resources

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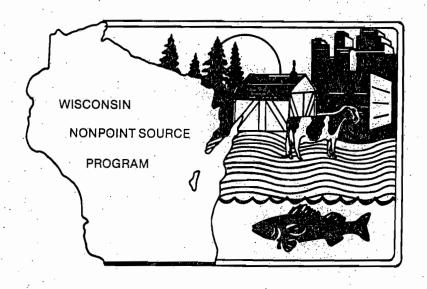
Dan Simonson of the Big Green Lake Sanitary District

AN INTERIM EVALUATION OF THE BIG GREEN LAKE NONPOINT SOURCE CONTROL PROJECT

SEPTEMBER 1988

Wisconsin Department of Natural Resources 101 S. Webster P.O. Box 7921 Madison, WI 53707

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BIG GREEN LAKE WATERSHED PROJECT INTERIM EVALUATION REPORT

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SUMMARY

This document reports the progress of the Big Green Lake Priority Watershed Project in meeting the goals as established in the project's watershed plan. Big Green Lake was selected as a priority watershed in In December of 1981 the watershed plan was approved by the counties and DNR. The watershed plan established a pollutant reduction goal to reduce the nutrient input to the lake from the various nonpoint sources by 40%.

The original period for landowners to sign cost share agreements for the funding of nonpoint source control practices ended in December of 1984. However, because of substantial local interest, the project's sign up period was reopened from January 1, 1988 to March 31, 1988 to allow for additional management practices to be installed. The evaluation is based on the status of the project at the completion of the second sign up period.

The potential pollution reduction used in this evaluation is based upon the management practices agreed to in the project's cost share agreements. Not all of these practices are currently installed because there are still two years for the installation period.

The reduction in pollutant loading was calculated for upland soil erosion, animal waste runoff from barnyards, and gully erosion. The upland soil loss control reached 41% of the watershed plan's goal. Within the subwatersheds of the project, the level of control ranged from 5% to 147% of the plan's goal. In the entire watershed, out of the 16,884 acres needing erosion control measures, 8,479 acres were managed for an overall 18% soil loss reduction.

On a watershed basis, the reduction in phosphorus loading from barnyard runoff was calculated as 75%. exceeds the 40% reduction qual established in the watershed plan. The phosphorus reduction in each subwatershed varied from 0% to 96%. This reduction is accomplished through control of 36 barnyards. There are 111 barnyards in the project area.

Streambank and gully erosion accounts for only a small fraction of the nutrient and sediment load to the It is estimated that the project will control 17% of the sediment coming from gully or streambank erosion.

The water quality goals in the plan included:

- 1. reduce the bacteria levels at the swimming beaches of the lake;
- increase the average summer secchi disc readings (the water's transparency); and 3. halt the trend of the increase in
- the lake's littoral zone.

It is still too soon for the lake to respond to any changes in land management practices that were installed through this program. the project began, variations in water quality that occurred are most likely due to year-to-year climatic variations.

Bacteria samples were taken at 6 beaches around the lake each summer. Although the data is variable, the violations of the bacteria standards declined from 15% in 1984 to 4% in 1987.

Lake transparency measurements over the past 20 years have not shown consistent trends. In 1970 and 1972, the average summer measurements were

about 6.5 meters. The lowest average summer secchi level was 2.5 meters in 1984.

A water quality goal to halt the lake's trend in littoral zone increases was not evaluated. Changes in the lake's littoral zone were not measured.

The evaluation concludes that although the project did not attain all of the goals in the plan, the opening of an additional sign up period resulted in significant improvement in the level of nonpoint source control.

The original goals of the watershed project were to improve the lake's water quality. However, the evaluation suggests the goals should be revised to project the lake's water quality. The lake is currently a high quality water resource, so the project's purpose should be to maintain this level of quality.

I. INTRODUCTION

The purposes of this interim evaluation are: 1) to determine the degree of the objectives being met in the Big Green Lake Priority Watershed Project as stated in the watershed plan, and 2) to assess if there is a need to revise the objectives based on current information. In addition, the evaluation will document the current water quality conditions in the project area. The evaluation is based on two approaches: 1) indicators of accomplishment; and 2) water quality measurements. The indicators of accomplishment are based on the calculated reduction in pollutant loads as a result of the various management practices on the cost share agreements. These indicators are necessary because the water quality changes from the management practices are not expected to be manifested for several years. The indicators of accomplishment for the various sources are explained later in this report. The water quality data is included in this report mainly to show the present conditions of the water resources -- in most cases it is premature to make statements about trends based on the monitored information.

In 1980, the Big Green Lake Watershed was selected as a priority watershed project under the Wisconsin Nonpoint Source Water Pollution Abatement Program. The program is administered by the Wisconsin Department of Natural Resources. The counties within the watershed (Green Lake and Fond du Lac Counties) are responsible for implementation of the project.

In the Big Green Lake Watershed, the Green Lake Land Conservation Committee (acting on behalf of the county board) is the lead management agency for the project. The Fond du Lac Land Conservation Committee is the

management agency for the Fond du Lac county portion of the watershed. The management agencies' responsibilities include: contacting landowners, entering into cost share agreements, designing best management practices, certifying the installation of the practices, and overall project and fiscal management at the county level.

The Department of Natural Resources has made cost share grants of \$680,000 to the project. In addition, the Department has made grants to Green Lake and Fond du Lac Counties since 1981 for support of additional staff, public education, and other activities to carry out the \$156,800 project.

As stated previously, the project was selected in 1980. The planning period was completed in December of 1981 and the implementation period began at The implementation schedthat time. ule called for a period of three years during which landowners could sign cost share agreements for the installation of management practices. There were 5 additional years allowed to complete the management installations. It became clear that there were a number of critical sources still existing in the watershed after the sign up period was completed. The counties requested the Department to open up the cost share sign up period to allow for additional participation of targeted landowners. The Department granted this additional sign up for the period of September 1, 1987 through March 31, 1988.

The information for this evaluation was collected and analyzed by staff from the Green Lake and Fond du Lac County Land Conservation Departments, the Green Lake Sanitary District, and the Wisconsin Department of Natural Resources.

II. WATERSHED DESCRIPTION

A. THE PHYSICAL SETTING

The Big Green Lake watershed is located in eastern Green Lake County, and western Fond du Lac County. About 60% of the watershed is in Green Lake County. It covers about 94 square miles and is largely rural and agricultural land use. The cities of Green Lake and Ripon are the only incorporated areas in the watershed.

Dairy farming is the dominate rural land use in the area south of Big Green Lake. This land is quite hilly with steep slopes. To the east of the lake and into Fond du Lac County the slopes become less severe and canning crops is the most common agricultural land use.

There are also extensive wetlands north and southeast of Ripon. Much of this land has been drained for cropping purposes. The entire shore of Big Green Lake is in residential and second home development land use. This land use, on the average, extends about one quarter mile from the shoreline, but on the western and northwestern side of the lake there are more extensive housing developments. The city of Green Lake is located at the outlet of the lake, and Ripon is located on Silver Creek in Fond du Lac County. Together these cities have about 1,685 acres of drainage into the watershed.

B. THE WATER RESOURCES

There are seven named streams which are tributaries to Big Green Lake and there are three smaller lakes (in addition to Green Lake) within the watershed. Big Green Lake is the major water resource of concern in the project. The lake is 7,325 acres in size and with a maximum depth of 229

feet. It is the deepest lake in Wisconsin. The lake's reputation for clean water and proximity to the populations of southeastern Wisconsin and northeastern Illinois, have made this a highly used and valuable resource. The lake supports a cold water fishery along with walleye, northern pike, and other warmwater sport fish species. The lake is also intensively used for sailing, swimming, and boating.

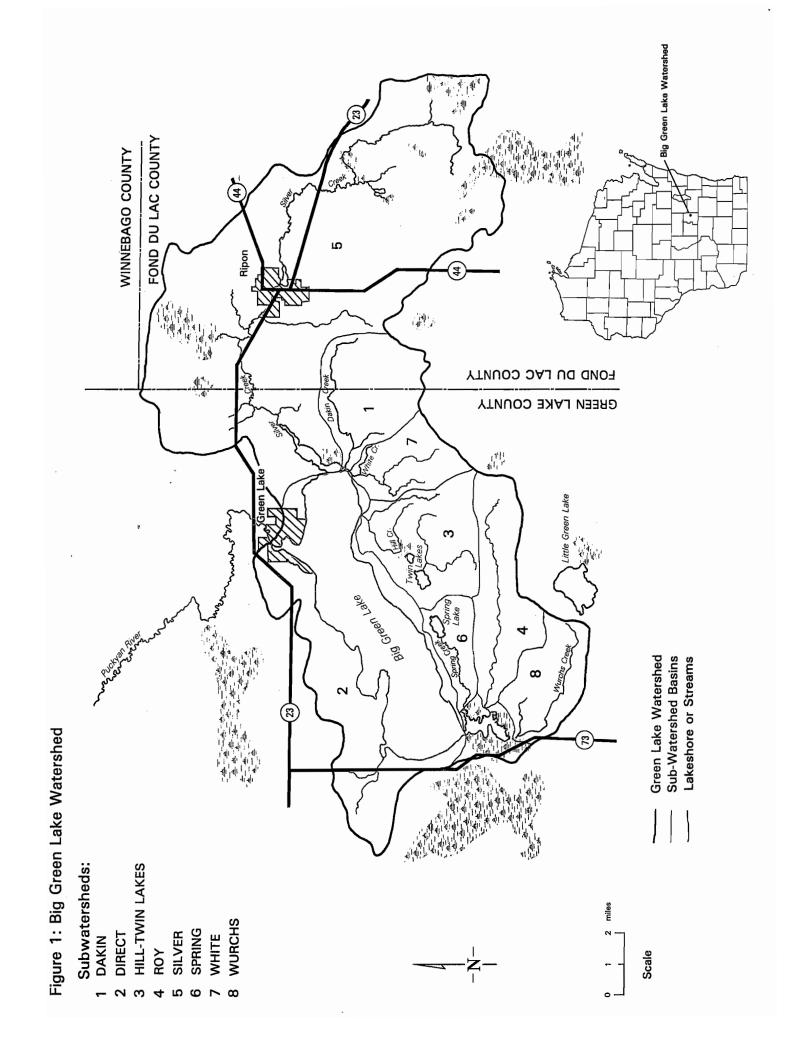
III. PROJECT OBJECTIVES

The original watershed plan set water resource objectives focused mainly on Big Green Lake. The value of the lake as a recreational resource is the major reason for the project. The overall objectives as stated in the watershed plan are to:

- protect the areas that currently have good or excellent water quality;
- improve the water bodies that have been degraded by nonpoint sources of pollution; and
- halt, and where possible, reverse the trend of declining water quality.

These objectives for Big Green Lake were further defined as follows:

- for the areas used for swimming in the lake, reduce the incidence of bacteriologically unsafe conditions.
- 2) reduce the duration and intensity of the lake's algal blooms and decrease the extent of the weed (macrophyte) growth through the reduction of nutrient input to the lake.
- 3) increase the average transparency readings during the lake's open water times. (The increase in transparency would be a result of a decrease of algal growth.)
- 4) halt the trend of the increase in the lake's littoral zone from the tributary sediment loading.



The plan recognized that, because of the lake's large volume and its long recycling period, changes in the lake's algae, macrophyte, and transparency levels may not be noticed for a long time-- perhaps for decades. Changes in the tributary streams to the lake would be measurable before quantifiable changes in the lake take place. Because of this, the plan recommended water quality monitoring for the parameters that would indicate progress of the four objectives to be done both in the lake and in the tributaries to the lake. monitoring that has taken place and the results are described later in this report.

The "indicators of accomplishment" that show a change in the nonpoint source loadings are discussed below. The pollutants of concern that relate to the above objectives are: sediment, nutrients, and bacteria.

IV. PROJECT EVALUATION

A. INDICATORS OF ACCOMPLISHMENT

The analysis conducted below for each pollutant source (upland erosion, gully erosion, and barnyard runoff) is based on the practices signed up on cost share agreements. The estimate of pollutant reduction assumes that the practices signed up on the cost share agreements will be installed.

At this point in the project, all of these practices have not yet been installed.

1. Practice Implementation

Table 1 summarizes the landowner participation and the practices on cost share agreements. This information does not directly measure

changes in pollutant loading or water quality. However, it does indicate a level of activity in the project and can be compared to the predicted practice needs as listed in the watershed plan. The effects these practices have had on pollutant load reductions is discussed by each pollutant source in the sections below.

2. Changes in Upland Erosion

<u>Methods</u>. One reason that upland erosion is a concern for water quality is that it can be the main contributor of sediment in the streams and lakes of a watershed. Sediment in streams and lakes adversely impacts the water resources in many ways. The suspended sediment can make it difficult for fish to feed, and it can abrade fish gills making the fish more susceptible to disease. The suspended sediment also causes the water to be warmer in the summer, and warm water cannot hold as much oxygen as cold water. Sediment that settles out to the stream or lake bottom can fill up pools in streams (destroying the fish habitat) and can fill up the bays in lakes (promoting excess aquatic weed growth).

Another major reason for concern of water quality impacts is that soil from cropland entering the water can also contain nutrients and pesticides. These pollutants can increase the algae and weed growth in lakes and harm the aquatic life. Upland erosion control is essential for meeting the objectives of reduced algal and macrophyte growth, increasing the transparency, and halting the littoral zone expansion in Big Green Lake.

Upland Erosion (for this project) is defined as the sheet and rill erosion from land areas and is commonly measured by soil loss in tons per acre per year. This class of erosion includes only the type that results

Table	1:	Summary of Practices	on	Cost Share Agreements	in	the
		Big Green Lake Priori	t٧	Watershed as of March	31,	1988

Practice	Units	Quantity of Both Sign Ups	State Share	Total Costs	Second Sign Up Quantity*
# of Cost Share Agreemen	ts:	137			+ 49
Contour Cropping	Acres	682	\$5,646	\$11,291	271
Contour Strip Cropping	Acres	563	7,950	15,902	2
Cropland Diversion	Feet	13,730	30,450	43,500	6,830
Terraces	Feet	25,525	48,333	69,048	14,100
Grassed Waterways	Acres	41.5	95,674	139,785	17.4
Reduced Tillage	Acres	1,975	45,744	91,389	1,003
Manure Storage	Units	10	50,000	175,171	3
Barnyard Runoff	Units	35	222,048	317,085	14
Stream Crossings	Units	5	6,800	10,000	3
Stream Fencing	Feet	8,874	3,582	5,245	8,000
Stream Rip Rap	Feet	2,444	24,044	42,009	60
Stream Shape & Seed.	Feet	120	420	600	120
Critical Area	Acres	808	21,918	72,391	757
Grade Stabe. Structures	Units	33	54,310	77,314	11
Woodlot Fencing	Feet	2,942	1,653	2,307	1,940
Settling Basins	Units	9	27,075	38,679	2
Leaf Collection	Units	1	3,890	7,780	0
Street Sweeping	Units	1	3,000	6,000	0

\$652,537 \$1,125,496

* Practices resulting from opening the sign up period for an additional 6 months and that are part of the total quantity. The cost during this period was \$276,622.

from the overland flow of water on fields. It does not include the gully and streambank types of erosion. The most common method of measuring upland erosion is with the Universal Soil Loss Equation (USLE). This method calculates the soil loss from a field in tons of soil lost from the field during an average year. The factors used to make this determination on a field are: rainfall runoff, soil erosivity, land cover, present management practices, slope, and slope length. calculated soil loss is not the amount of soil that enters the channel system of a watershed. of the soil will become trapped in depressions on the land before it reaches a channel. This "trapped"

soil may move into the channel system with subsequent rainfalls. (Once in the channel system, the sediment can become temporarily trapped in the pools of a stream before moving downstream.) The USLE calculation was used to determine which parcels potentially contribute the most sediment to the channel system, and what changes in sediment pollution could be expected from the installation of soil erosion control practices signed up under the watershed program.

All the rural lands in the watershed within the priority management area (as defined by the watershed plan) were inventoried for upland erosion potential. On a parcel-by-parcel

basis, USLE factors representing a "before" and "after" practice condition was collected. A parcel was defined as a field with homogenous individual USLE factors and was bounded by landowner property lines and watershed or subwatershed lines. A comparison was then made between the soil loss calculated from the "before" conditions and the "after" conditions. These are reported below.

Results. Most of the changes in the upland erosion soil losses shown below are a result of management practices and land use changes signed up under the watershed project. There are other state and federal programs which also account for some of the upland soil loss control in the watershed. Changes due to these other programs are included in table 2.

The upland erosion inventory conducted during the planning stage of the Green Lake Watershed Project did not determine a target soil loss control amount. Based on the evaluation effort, an estimated potential soil loss reduction was determined. This potential reduction is defined as the reduction that occurs if all lands eroding above 4 tons/acre/year were managed at an erosion level of 4 tons/acre/year. This level was chosen because it is the soil loss "tolerance" level for the soils in the project area; and it is the level that conservation staff normally attempt to attain with management practices. If this level were attained the result would be a 44% decrease in upland erosion. It is important to note that this reduction level is not based on a water quality objective. It is a level which represents keeping the current agricultural land use in the watershed with reasonable conservation practices.

Although upland erosion is not the same as sediment delivered to the lake it is assumed that a percentage reduction in upland erosion results in a similar percentage reduction in sediment delivery to the stream system and lake. For new projects, however, the program now uses a watershed sediment model which more accurately reflects the amount of sediment entering a water body under various land management conditions.

Table 2: Upland Soil Loss Changes in the Big Green Lake Watershed
Based on Cost Share Agreements as of March 31, 1988

		1	Acres 8 Needing		*	Soil Loss * Targeted	Soil Loss Controlled	% of Target Met	% Total Soil Loss
Subwatershed	Total Acres	"Before" (t/yr)	Management (>4 t/a/y)	Acres Managed	Acres Managed	for Control (t/yr)	to Date (t/yr)	(t/yr)	Reduced
Dakin Creek Direct	3,226	15,189	1,657	1,299	78	4,456	4,033	91	27
Subwatershed	3,800	13,675	1,047	1,138	109	4,952	5,574	113 +	+ 41
Hill Creek Marsh	3,472	13,111	1,240	996	80	3,579	4,436	124 ÷	34
Subwatershed	281	828	57	10	18	600	28	5	3
Roy Creek	3,256	11,571	1,140	1,406	123	2,812	4,147	147 +	- 36
Silver Creek	20,269	109,453	9,416	1,565	17	59,396	7,637	13	7
Spring Creek	933	4,139	351	226	64	1,554	1,544	99	37
White Creek	1,992	9,087	1,005	670	67	2,524	2,206	87	24
Wurchs Creek	2,455	10,159	971	1,169	120	3,065	4,117	134 +	+ 41
Totals	39,687	187,212	16,884	8,479	50	82,938	33,722	41	18

^{*} Soil loss targeted for control is that erosion that could be eliminated if all lands eroding above 4 tons/acre/year were brought down to a level of 4 tons/acre/year

3. Changes in Gully Erosion

Methods. Gully erosion occurs where water flow becomes channelized and where there is not sufficient vegetative cover to protect the soil from erosion. Although there is usually a low amount of nutrients contained in this nonpoint source, the sediment is a concern to water quality for the same reasons mentioned in the upland erosion discussion. This source of pollution directly affects the objective to halt the littoral zone expansion in the lake.

To estimate sediment loss from gullies, the county's soil survey sheets were used to identify the location and length of the gullies.

For all gullies draining directly to Big Green Lake, a standard channel configuration of 6 feet deep, 10 feet across the top, and 5 feet across the bottom was used. Using a standard age of 20 years for the gullies and the length measured from the soil survey, a sediment loss rate in tons/year was calculated for each gully. gullies not directly draining to the lake, a configuration of 4 feet deep, 8 feet across the top, and 3 feet across the bottom was used. length and recession rates were the same for both types of gullies. A soil density of 90 pounds per cubic foot was used to convert the volume of sediment to tons.

⁺ Percentages exceed 100 % when lands are brought down to an erosion rate less than 4 tons/acre/year

Table 3: Gully Erosion Sediment Loss Changes in the Big Green Lake Watershed Based on Cost Share Agreements Signed as of March 31, 1988

Subwatershed	Total Soil Loss "Before" (t/yr)	Total Controlled (t/yr)	% Soil Reduction
Dakin Creek Direct	361	139	39
Subwatershed	4,917	474	10
Hill Creek	416	244	59
Marsh			
Subwatershed	63	11	17
Roy Creek	1,112	223	20
Silver Creek	.569	103	18
Spring Creek	175	0	0
White Creek	399	88	22
Wurchs Creek	460	130	28
Totals	8,472	1,412	17

4. Changes in Barnyard Runoff

Dairy operations are a <u>Methods</u>. major type of agriculture in the western portion of the Big Green Lake Watershed. All of the barnyards were inventoried for their potential to impact water quality from their runoff. Runoff from these yards can carry manure to the streams and lakes of the watershed. The manure contains several components that can adversely affect the water quality and aquatic life. Manure contains nitrogen which can break down to ammonia in the streams and lakes. In high concentrations the ammonia can be toxic to fish and other aquatic life. the manure enters a water system the breakdown of the organic matter results in a depletion of the water oxygen which fish require to survive. Also, the nutrients in manure (including nitrogen and phosphorus) will promote nuisance algae and weed growth in the streams and lakes. Finally, the bacteria found in

livestock manure can be harmful to other livestock drinking the water and humans using the water for recreation. Control of barnyard runoff is necessary for the attainment of the objectives of reduced algal and macrophyte growth, increase in transparency, and reduction of bacteria levels in Big Green Lake.

The United States Department of Agriculture's Agricultural Research Service developed a computer model to estimate the amount of pollutants coming from a barnyard as a result of a rainstorm. This model was modified by the Wisconsin DNR - Nonpoint Source and Land Management Section and has been used to indicate which barnyards within a watershed have the greatest potential to impact water quality from a rainfall washing through a barnyard. The model does not assess any needs for manure storage or the impact from manure runoff from spread fields - it only assesses the barnyard runoff pollutant quantities from a runoff event.

This model was not available for use when the project began in 1980. At that time the identification of high priority barnyards was based on livestock numbers and distance of 107 yards to a creek. For this evaluation, information to run the barnyard runoff model was collected on all of the barnyards in the watershed. The data required by this model includes the types and numbers of livestock; the size of the yard; the physical characteristics of the area which contribute surface runoff waters to the yard; and the physical characteristics of the area through which the runoff waters leaving the barnyard flow before becoming channelized. A rainfall amount is assigned to the The 10-year, 24-hour rain model.

event (4.0 inches) was selected. this information the model calculates the pounds of phosphorus and pounds of Chemical Oxygen Demand (COD) for each barnyard as a result of the selected (Chemical Oxygen rainfall event. Demand is a measure of the amount of organic material in the barnyard runoff). The model was then rerun for each yard that was controlled using the new conditions of the yard. This second calculation is used to indicate the "current" phosphorus load from the yards. Although the model does not calculate a nitrogen or bacteria impact it is assumed that those yards with the highest phosphorus and COD loadings also had the most potential for water quality impacts from nitrogen and bacteria.

Results:

Table 4: Barnyard Runoff Control in the Big Green Lake Watershed
Based on Cost Share Agreements Signed as of March 31, 1988

Subwatershed	# of Barn- yards	# of Barnyards Controlled		horus Load "Current"	(1bs) Reduction	% Reduction
Dakin Creek	9	0	39.8	39.8	0.0	0
Direct						
Subwatershed	7	5	336.2	33.7	302.5	90
Hill Creek	15	10	274.7	82.8	191.9	70
Marsh					10110	, ,
Subwatershed	1	1	47.2	1.9	45.3	96
Roy Creek	. 8	7	132.8	27.2	105.6	80
Silver Creek	58	4	372.3	111.9	260.4	70
Spring Creek	2	i	15.4	2.1	13.3	86
White Creek	$\bar{1}$	ī	19.0	1.9	17.1	90
Wurchs Creek	10	7	440.7	115.2	325.5	74
Totals	111	36	1,678	416.5	1,262	75

It can be seen from the table above that controlling the runoff from a few key barnyards can greatly reduce the pollutant load from barnyard runoff within a subwatershed. For example, in the watershed as a whole,

only 32% of the barnyards are under cost share agreement but these yards account for 75% of the phosphorus load to streams and channels leading to the lake.

B. WATER QUALITY

1. Introduction

Recent water quality monitoring in the lake and in the watershed has been conducted largely through the efforts of the Big Green Lake Sanitary District. Numerous other agencies and groups have conducted studies on the lake in the past. Data from many of these sources will be presented in this report. As previously stated, it would not be expected that the lake's water quality would respond to any changes in pollutant input from the watershed project within the six years since the project's beginning. The data is included in this report only to document the conditions of the water resources. Monitoring will need to continue for many years before conclusions can be drawn on the changes in lake water quality as a result of the nonpoint source control project.

2. Lake Water Quality Conditions

a. Background Information

One indicator of the water quality conditions of a lake is the lake's "trophic status". In general, this refers to the nutrient level in the lake's waters. A lake with high levels of nutrients will support nuisance algae and weed growth and is termed "eutrophic". A lake low in nutrients that has clear water during the summer is called "oligotrophic". A level between these two classes is called "mesotrophic".

There are three indicators commonly used to establish the "trophic status" of a lake. The first is the lake's phosphorus concentration. In Wisconsin lakes, phosphorus is usually the most significant nutrient limiting the growth of algae and weeds. The higher the concentration of phosphorus in the water, the

greater the potential for nuisand growth of algae and weeds. The leve of a substance called Chlorophyll a i a second indicator of the trophi status of a lake. Chlorophyll a is substance found in algae. The concen tration of Chlorophyll a in the wate can be correlated with the amount o algae in the water. The third indica tor is a measurement of the secch disc depth. A secchi disc is an inch diameter weighted plate wit black and white markings on it. Th depth to which the disc can be lowers and be seen in the lake's water i called the secchi depth. This dept can vary depending on the roughness (the water, the angle of the sun, and the technique of the observer However, it does measure the depth sunlight penetration, and the turbi ity of the water which could be due algae or other suspended material.

Using these three indicators, t trophic status of a lake can be detemined. Table 5 indicates the valuath that could be expected for the paraeters discussed above in various lawater quality situations. To relathis table back to the three troph status levels described above: index value at 46 and below is consered oligotrophic; 47-53 is mesotrophic, and above 53 is eutroph It must be emphasized that the valigiven on table 5 are only very geneguidelines.

Table 5: Water Quality Index for Wisconsin Lakes Based on Total Phosphorus, Chlorophyll a Concentrations, and Water Clarity

Water Quality	Approximate Total Phosphorus (mg/l)	Approximate Water Clarity (ft)	Approximate Chlorophyll <u>a</u> (ug/l)	Approximate Trophic Status Index *
Excellen V. Good Good Fair Poor V. Poor	t < .001 .00101 .0103 .0305 .0515 > .15	> 20 10 - 20 6 - 10 5 - 6 3 - 5 < 3	< 1 1 - 5 5 - 10 10 - 15 15 - 30 > 30	< 34 34 - 44 44 - 50 50 - 54 54 - 60 > 60
* Aften	Capleon (1077	1	II moans	"loce than"

* After Carlson (1977)

Source: DNR Tech. Bulletin 138 (1983)

"<" means "less than"</pre>

">" means "greater than"

Bacteria has also been monitored at several of the beaches around the lake. It is the major pollutant that causes the lake to be considered unsafe for human contact use. The test conducted is called a "Membrane Filtered Fecal Coliform Count" (MFFCC). In Wisconsin, a bacteria count of over 400 MFFCC/100 ml is considered a violation of the water quality standard and unsafe for contact recreational use.

Most of the recent monitoring of the lake has been done by the Green Lake Sanitary District and the Wisconsin Department of Natural Resources. The results of this monitoring for total phosphorus, transparency, and chlorophyll <u>a</u> are summarized below. Appendix A contains the detailed monitoring results for each of these parameters.

b. Monitoring Results

The water quality of Big Green Lake has been studied since the turn of the century by various researchers. In 1891 C. Dwight Marsh and E.F. Chandler conducted a lake depth survey for the Wisconsin Geological and Natural History Survey. They constructed a hydrographic map of the lake and found it to be the deepest inland lake in Wisconsin. In 1911, E.A. Birge and C. Juday from the University of Wisconsin collected and reported information on the chemical and biological characteristics for Big Green Lake.

Table 6: Total Phosphorus Surface Concentrations (mg/l) for the Stratified Period (June - Sept.) in Big Green Lake

Year	# of Samples	Range	Average	Standard Deviation	Data Source
1968	1	-	0.043	-	DNR
1969	1	-	0.030	-	DNR
1970	1	-	0.030	-	DNR
1972	5	.07-0.17	0.136	0.063	Ripon College
1977	1	-	0.042	-	Donahue & Assoc.
1980	8	.012045	0.026	0.013	Green Lake San. Dist
1981	7	.015065	0.027	0.016	Green Lake San. Dist
1981	4	.0204	0.030	0.010	DNR
1982	6	.011039	0.021	0.010	DNR
1983	4	.011029	0.017	0.007	DNR
1984	7.	.0213	0.056	0.036	Green Lake San. Dist
1985	14	.0112	0.023	0.029	Green Lake San. Dist
1986	2	.021022	0.022	0.000	DNR
1987	3	.011012	0.012	0.000	DNR

Figure 2: Average Surface Total Phosphorus Concentrations for the Stratified Period (June - Sept.) in Big Green Lake 1968-1987

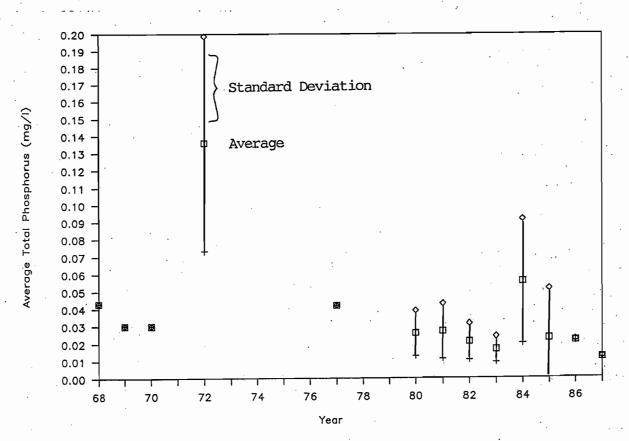


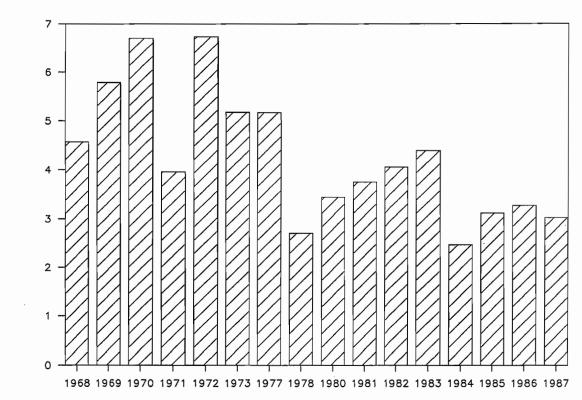
Table 7: Secchi Disk Measurements for the Stratified Period (June - Sept.) in Big Green Lake *

Year	# of Samples	Ŗange	Äverage (meters)	Standard Deviation
1968	1	-	4.57	-
1969	1	-	5.79	-
1970	1	- ·	6.71	-
1971	1	-	3.96	-
1972	5	5.50-10.00	6.74	1.65
1973	1	-	5.18	-
1977	9	3.3 - 7.4	5.17	1.12
1978	5	2.10-3.50	2.70	0.60
1980	14	1.8 - 5.2	3.44	0.89
1981	14	1.8 - 5.8	3.75	1.10
1982	13	1.2 - 5.8	4.06	1.35
1983	17	1.5 - 5.5	4.39	0.91
1984	12	1.2 - 3.0	2.46	0.56
1985	16	2.0 - 7.3	3.11	1.51
1986	16	2.1 - 5.8	3.27	0.97
1987	14	1.8 - 8.0	3.01	0.88

^{*} Source: Green Lake Sanitary District; Wisconsin DNR, and Stauffer (see appendix A for detailed information)

Meters

Figure 3: Average Secchi Depth Measurements on Big Green Lake for the Stratified Period 1968-1987



Year

Table 8: Chlorophyll <u>a</u> Measurements in Big Green Lake Surface Samples 1980 - 1987 *

Date	Chlorophyll (ug/l)	<u>a</u>
6/11/80 8/13/80 9/14/81 4/17/86 6/3/86 7/24/86	6.0 36.0 9.0 4.0 28.0 >5.0	
6/25/87 7/4/87	3.0 6.0	

* Source: Wisconsin DNR

In general, the data above indicates the lake's water quality is in the "Good" range according to table 5. The three parameters related to the lake's trophic status (phosphorus, secchi depth, and chlorophyll a) place the lake's trophic level between the meso- and eutrophic area according to the trophic status index values. The graphs of the phosphorus levels show little change in the lake's water quality over the monitoring period. The graph of the secchi depth shows a decline in the transparency since the early 1970's, and little change in the past six years. Although this data indicates that the lake is in generally good condition; it does show that there are nutrient levels sufficient to support nuisance levels of algal growth during some years.

In addition to the chemical data shown above, the Green Lake Sanitary District also collects samples for bacteria analysis at six beaches around the lake. These samples are taken once a week for the summer at two public beaches (Hattie Sherwood and the County Park) plus four other private beaches. The locations of these sites are shown on figure 4.

The results of sampling are shown table 9.

Both the number of water quality s dards violations, and the average teria count at the six beaches had a drop during the last two ye Although it is too early to make firm conclusions, the most signif change in bacteria levels has occ at the Reich Mobile Home Beach This beach is located near the ou of Hill and White Creeks. large animal lot operations have their runoff controlled or the a have been removed (through clos the farm) in the Hill and White subwatersheds which likely acc for significant sources of bacte this beach. Continued monitoria confirm if this trend continues.

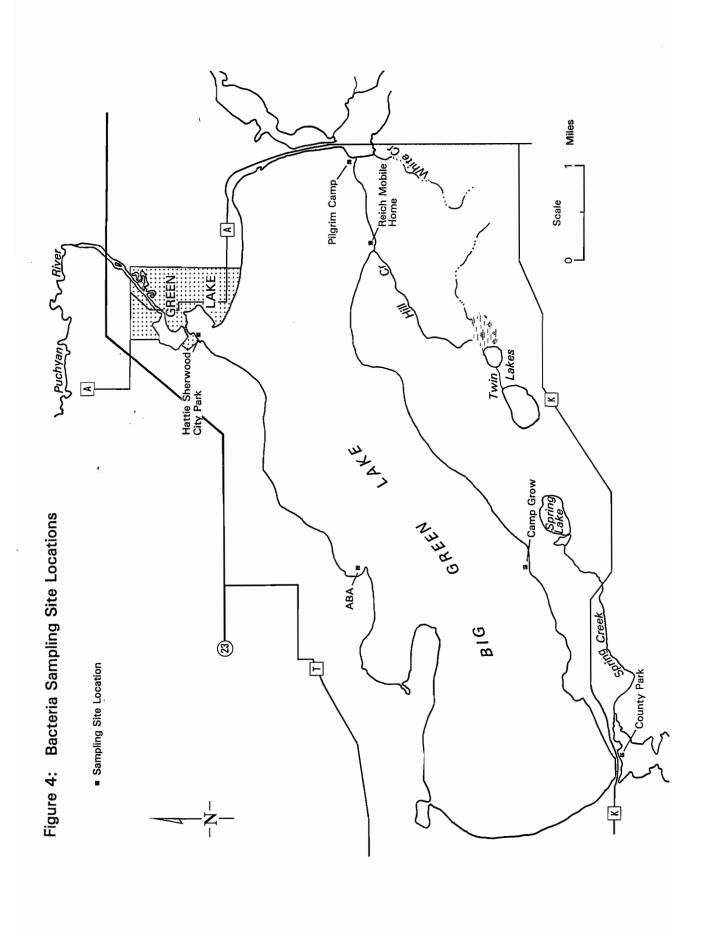


Table: 9: Big Green Lake Summer Beach Sampling for Fecal Coliform Bacteria (June - September; values in MFFCC/100ml) +

Year	ţ	Pilgrim Camp		-Sampling County Park	Hattie		Camp Grow
1979	# of Samples Range Avg. Value # > WQS **	9 0-70 24 0	- - - -	10 5-124 29 0	9 0-14 4 0	3-379 192 0	1 - 5 0
1980	<pre># of Samples Range Avg. Value # > WQS</pre>	10 0-111 45 0	0-55 15 0	0-169 47 0	12 1-150 21 0	0-TNTC * 1717 2	0-299 55 0
1981	# of Samples Range Avg. Value # > WQS	11 10-TNTC 2,850 4	11 1-150 29 0	12 1-TNTC 915 2	12 2-66 16 0	10 118-TNTC 4,276 6	0-104 25 0
	<pre># of Samples Range Avg. Value # > WQS</pre>	1-1070 154 1		10 0-230 52 0	10 0-96 14 0	9 0-3350 710 2	9 0÷112 26 0
1983	<pre># of Samples Range Avg. Value # > WQS</pre>	29 0-46 7 0	19 0-4 6 0	19 0-1300 104 1	0-9500 707 2	17 0-TNTC 2,039 5	19 0-63 8 0
1984	<pre># of Samples Range Avg. Value # > WQS</pre>	2-420 113 1	11 1-80 13 0	2-400 78 1	2-1200 145 1	30-13,000 2,164 6	11 1-510 92 1
1985	<pre># of Samples Range Avg. Value # > WQS</pre>	0-100 34 0	0-34 9 0	12 0-847 189 2	0-34 7 0	0-11,200 1,302 5	0-85 21 0
1986	<pre># of Samples Range Avg. Value # > WQS</pre>	13 0-250 35 0	0-180 20 0	0-391 73 0	0-100 12 0	13 10-1,157 232 2	13 0-7 2 0
1987	# of Samples Range Avg. Value # > WQS	12 0-42 15 0	2-77 22 0	12 20-1,050 210 2	2-30 10 0	12 5-740 167 1	12 0-20 6 0

^{*} to obtain the average, a value of 10,000 was used for samples reported as
 "Too Numerous to Count" (TNTC)
** Water Quality Standard = 400 MFFCC/100 ml; + Source: Green Lake San. Dist.

Figure 5: Percent of Bacteria Samples Violating State Water
Quality Standards at All Beach Sites

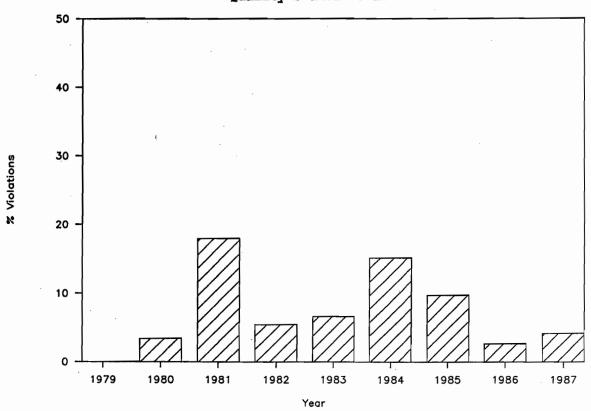
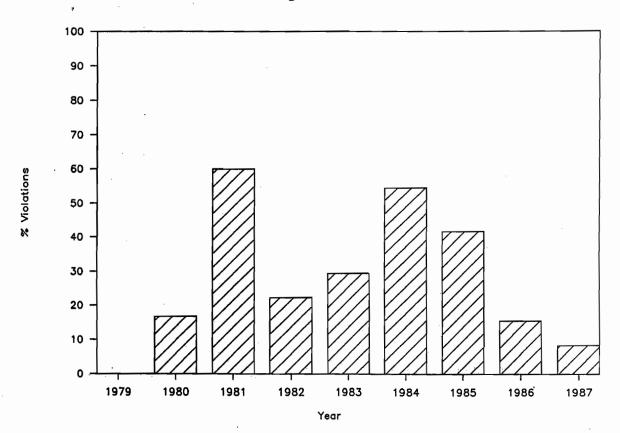


Figure 6: Percent of Samples Violating Bacteria Water Quality
Standards at Reich Home Beach,
Big Green Lake



2. Stream Water Quality Conditions

a. Background Information

Since 1982 the Green Lake Sanitary District has contracted with the United States Geologic Survey to conduct event related stream monitoring on a tributary to Green Lake. A station was established near the

mouth of White Creek which auto matically collects water qualit samples during high flow periods, an continuously measures the stream's discharge. With these measurements, th total volume of water and pollutant leaving this subwatershed can be calculated for each year. Below is summary of the data collected to date.

b. Monitoring Results

	itored Water Creek Subwat Units of 19	ershed	Stati	on *		oads 1986	I
	Measure						Average
DATA FOR BOTH BASE FI	LOW & STORM E	VENTS:					
Total Phosphorus	(lbs/yr)	2,168	1,397	1,086	1,443	4,269	2,073
Suspended Solids	(tons/yr)					5,208	2,347
Total Annual		00.0	170 6	151 6		050 0	160.0
Discharge Annual	ft./year)	89.0	1/3.6	151.6	155.1	250.3	163.9
Precipitation **	(inches)	18.58	32.88	31.80	32.71	42.57	31.71
Annual Runoff	(inches)						
% Runoff/Precip	%	68	75	67	67		73
P Load/" Runoff		173	57	51	66	121	
Sed. Load/" Runoff	(tons/in.)	239	39	72	47	147	109
DATA FOR STORM EVENTS	ONLY:						
Total Phosphorus	(lbs/yr)	665	708	616	1,133	3,403	1,305
Suspended Solids	(tons/yr)	416	756	1,398	889	4,994	1,691
Event Discharge	<pre>(million cu. ft./year)</pre>	18.6	24.9	30	39.1	73.6	37.24
Storm Runoff	(inches)	2.63	3.51	4.23	5.52	10.38	5.25
% Runoff/Precip	%	14	11		17		16
P Load/ " Runoff		253		146			227
Sed. Load/ " Runoff	(tons/in.)	158	215	330	161	481	269

^{*} All data is for the Water Year: October 1 - September 30 + Monitoring for Water Year 1982 began on December 1, 1981

^{**} Average water year precipitation from White Cr. Station and Ripon Wisconsin station.

The table above could be misleading if the information from the upland erosion control inventory (table 2) was not considered. The data on table 2 shows that, a 10% reduction in upland soil loss has occurred in the White Creek subwatershed. would result in a maximum reduction of the sediment load of 10%. table 10, it is evident that there were large changes in the sediment and phosphorus loads from the watershed during the period 1982 to 1986. Between 1984 and 1985 the storm event sediment load per inch of runoff decreased by about 50%. The following year (1986) the same parameter nearly tripled. These changes are due to factors other than the land management practices accounted for in the upland erosion inventory.

The volume of pollutants in the runoff from a watershed during year to year can vary depending upon several factors. Two of the major factors are:

 climatic factors (such as variation in precipitation amounts, intensity, and time of the year); and

2) cultural factors (such as changes in land use and land management from year to year).

The type of monitoring done in White Creek measures changes in the pollutant load from the watershed from year to year. It does not show the cause of these changes. In order to determine if the changes in the monitored pollutant is a result of cultural factors, the variation in climatic factors must be "normalized". Once the variability of the climatic factors is eliminated, then the data can be used to indicate pollutant load changes over the monitoring period due to changes in land management practices. Presenting the pollutant loads in terms of pounds (or tons) per inches of runoff is one way

to attempt to normalize the climatic factors. Another factor that affects the ability to make this determination is the precision of pollutant load measurements. A certain amount of variability of the monitored values can be explained simply because of the accuracy level of measuring stream flow and pollutant concentration. According to the upland erosion inventory conducted as part of this evaluation, the expected reduction in erosion in the White Creek subwatershed is only 10% from the total erosion (see table 2). This predicted change is well within the expected error term of the monitoring conducted at White Creek. Thus, even if the variability in the climatic factors were eliminated, the small predicted change in upland erosion could not be measured with the monitoring If there are large reductions in the erosion levels either through the watershed project or other programs, then there is the possibility that the change in pollutant levels could be confirmed through continued monitoring at the White Creek site.

V. DISCUSSION AND CONCLUSIONS

A. THE WATERSHED PLAN OBJECTIVES

A significant factor missing in the original watershed plan is the determination of the nutrient reduction levels necessary to meet the lake's water quality goals. As stated in the watershed plan, the goals are to: "reduce intensity and duration of the lake's algae blooms" and "increase the summer transparency levels." Because of the lake's great depth and long hydraulic residence time, conventional trophic models are not applicable for the determination of nutrient reduction goals.

The watershed plan calls for a reduction in nutrients and sediment of 40% (page 14 of the watershed plan). This level represents what was predicted and what could be reasonably achieved given the conventional management practices in use at the time.

It is not known if this level of reduction corresponds to a measurable improvement in the lake's nuisance algae growth or transparency levels. Recent information indicates that the objectives listed above may have been unrealistic for the project. In an article by Stauffer (1985) "Nutrient internal cycling and trophic regulation of Green Lake, Wisconsin", the author investigates the water quality of Green Lake between 1971 and 1979 and compares it to the studies done by Birge and Juday in the early 1900's. Stauffer concluded: "Comparative studies...suggest that the lake's nutrient economy must have been similar in the first decade of this century." The author further stated: "Green Lake is a highly pro-Nevertheless, it is ductive lake. not a highly degraded ecosystem; in fact, just the opposite." These conclusions indicate that the objective of the project should be revised to be a protection effort, not an improvement effort. Thus, the objective should be to maintain the lake's current high water quality as measured by the nutrient level in the epilimnion (or photic zone) and the summer transparency levels.

B. COMMENTS ON THE NONPOINT SOURCE CONTROL LEVELS

The level of management achieved for upland control as of July 1, 1987 was rather low. At that point in time, only 1 subwatershed had achieved its goal of a 40% reduction in the "controllable" soil loss (the soil loss which can be controlled above the acceptable rate of 4

tons/acre/year). And overall, only 19% of the soil loss goal was A major reason for this is achieved. that the project did not have adequate staff for a large implementation effort during the early stages of the Until the fall of 1986, project. neither county had brought on any additional staff. However, there were several reasons that this level of control was significantly improved by the spring of 1988. First, Green Lake County contracted with the Green Lake Sanitary District for two full-time staff to work in the watershed project. These additional staff have been working in both counties since November of 1986. Initially, these staff were hired to collect information for this evaluation. Since the watershed project was granted an additional landowner sign up period (from September 1 to March 31) these staff have been working on obtaining the additional sign ups, completing the farm plans, and the designing and installing of practices. A second reason for the change is the instigation of state and federal programs requirin compliance with a farm conservatio The state's Farmland Preserva tion Program requires those farms re ceiving farmland tax credits to be i compliance with an approved far plan. Also the federal Croplan Reserve Program, along with the cros compliance requirements of the Foc Securities Act, have greatly increase the incentives for landowners i install and maintain cropland best ma agement practices on their field These state and federal programs we just beginning to have a major impa on the landowners in the watersh during the spring and summer of 198 and they have influenced the particit tion rate in the watershed project.

As a result of the additional sign period, table 2 on page 7 shows the five subwatersheds fully achieved 40% reduction goal. Overall, 41% the reduction goal was reached this pollutant source.

There has been more success in the control of barnvard runoff within the watershed. It has been reported that farmers, in general, perceive this practice to have a more direct benefit to farm operations and production than some of the other practices. The success of this practice is the likely reason for the significant reduction of bacteria levels at certain beaches on Big Green Lake. Table 4 on page 9 shows that, overall, 75% of the phosphorus from this source will be controlled when all of the practices have been installed.

Finally, a great deal of credit for the level of control that has been achieved in the project must go to the Green Lake Sanitary District. The sanitary district was instrumental in getting the project selected in 1980 as a priority watershed. Also, during the implementation phase, the district has provided additional cost sharing funds (above the state level) as a further incentive for landowner participation. working with the county, the sanitary district has managed to break down many of the barriers that often exist between the lake shore property owners and the agricultural landowners of the lake's watershed. effort should be used as an example for other lake districts that are looking to improve or protect a lake's water quality through control of nonpoint source pollution.

C. COMMENTS ON FUTURE MONITORING EFFORTS

1. White Creek Monitoring

Event monitoring, of the type done at the White Creek site, is expensive and requires much maintenance time. However, it is the only monitoring that has the potential of demonstrating a pollutant loading rate from a portion of the watershed. The concern arises in that, as discussed above, there are several factors that can mask a change in the loading rates so that only very large changes can be measured with this effort.

If the monitoring is to continue at the White Creek station, steps can be taken to reduce the variability found in the climatic factors and to determine if this monitoring should continue.

- a) A statistical evaluation needs to be developed which will determine the minimum level of change that the monitoring will be able to detect. This, along with a projected loading change in the watershed will help determine if the monitoring effort should continue.
- b) At least two more continuous recording rain gauges should be installed in the watershed. Rainfall amounts and intensities can change dramatically and the additional gauges will help to better quantify the rainfall (which is the driving force for nonpoint source pollution).
- c) Annual nonpoint source inventories (including streambank, gully, and upland erosion, and barnyard runoff) should be conducted in the White Creek subwatershed to locate new sources of pollutants and to track the level of pollutant control achieved each year.
- d) A determination should be made by the DNR, Green Lake LCD, and the Green Lake Sanitary District on the feasibility of using the Wisconsin Nonpoint (WIN) Model as a predictive tool in estimating the reduction of nonpoint source pollution in the White Creek subwatershed and in other parts of the Big Green Lake Watershed.

2. Other Monitoring Efforts

Bacteria monitoring at the beaches should continue at the same level as in the past.

It is recommended that the lake monitoring effort also be continued. The Sanitary District has been able to obtain more frequent samples of the lake's total phosphorus, and secchi depth than is possible for the DNR. These more frequent samples give a much better characterization of the lake and this sampling level should be encouraged to continue.

The DNR will continue to monitor Big Green Lake through its Long Term Trend Monitoring Program. The lake is sampled five times over the year for a series of nutrient parameters, temperature, dissolved oxygen, and secchi disk measurements. This effort is scheduled to continue for seven more years.

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APPENDIX A DETAILED WATER QUALITY MONITORING DATA

SECCHI DISK MONITORING 1968 - 1987
TOTAL PHOSPHORUS MONITORING 1968 - 1987
FECAL COLIFORM MONITORING 1979 - 1987

Table A-1: Secchi Disk Measurements in Big Green Lake

	Secchi			Std.		ı	Secchi			Std.	
Date	Depth	Range * '	 v *		Source	l I Date		Range	x		Source
Date	(meters)	_	^	DCV.	Jour CC	l	(meters)	Kunge	^		000.00
7/15/68	4.57					6/10/80	1.80				
10/24/68			4.57			6/24/80					
, ,						7/1/80	3.40				
2/23/69	6.48					7/8/80	4.00				
5/5/69	7.62					7/15/80					
7/29/69	5.79					7/22/80					
10/28/69	10.67		5.79			7/29/80					
						8/6/80	3.00				
3/3/70	7.01					8/26/80	2.70				
4/28/70	4.27					9/3/80	2.40				
7/21/70	6.71					9/9/80	2.70				
11/17/70	7.01	•	6.71	-	DNR	9/10/80	3.00				
						9/17/80	4.30				
2/5/71	12.80					9/23/80	4.60	1.8-5.2	3.44	0.9	GLSD
4/28/71	5.79										
8/24/71	3.96					6/3/81	1.80				
11/10/71	6.40	-	3.96	-	DNR	6/10/81	2.10				
						6/16/81					
2/21/72	12.20					6/22/81					
4/27/72	7.32					6/29/81					
7/18/72	5.79					7/6/81	4.90				
11/20/72						7/13/81					
6/8/72	10.00				Stauffer	•					
6/24/72	6.00				Stauffer	•	5.80				
7/25/72	5.50	E E 10 00	4 7/	1 /5	Stauffer						
8/4/72	0.40	5.5-10.00	0.74	1.00							
2/22/73	11.89					8/31/81 9/16/81					
5/10/73	5.18		5.18			9/29/81		1.8-5.8	3.75	1 1	GUSC
37 107 13	3.10		J. 10		DAK	<i>//2/</i> /01 	4.00	1.0 5.0	3.75		0.55
6/2/77	4.30					 6/7/82	1.22				
6/9/77	7.40					6/11/82					
6/27/77	3.30					6/28/82					
7/14/77	4.50					7/7/82	3.96				
7/25/77	4.50				j	7/16/82	3.96				
8/15/77	5.10				j	7/23/82	4.27				
8/25/77	5.90				ĺ	7/30/82	3.05				
9/22/77	5.60				İ	8/6/82	3.66				
9/28/77	5.90	3.30-7.40	5.17	1.1	GLSD	8/13/82	4.27				
					I	9/7/82	4.27				
6/8/78	2.1					9/16/82	5.79				
7/15/78	3.3					9/24/82	5.49				
7/31/78	2.1					9/30/82	5.79 1	.22.5.79	4.06	1.3	GL SC
8/14/78	2.4										
9/10/78	3.5	2.1-3.5	2.7	0.60	Stauffer						

^{*} Statistics applied only to summer measurements (June - Sept.)

Table A-1 (continued): Secchi Disk Measurements in Big Green Lake

				6 4.4			Conchi			Std.	
	Secchi			Std.		l Dodo	Secchi	Donas			Source
Date	Depth	Range *	х *	Dev.*	Source	Date	Depth	Range	X	Dev.	Source
	(meters)					 	(meters)				
6/2/83	1.50					6/4/86	1.70				
6/14/83	1.50		,			6/17/8					
6/22/83	2.70		·.			6/26/8					
7/1/83	7.60					7/2/86					
7/6/83	4.90					7/8/86					
7/13/83	3.00					7/16/86					
7/20/83	3.00					7/23/8					
7/27/83	2.70					7/31/8					
8/5/83	4.00					8/5/86					
8/8/83	5.20					8/12/8					
8/12/83	4.90					8/20/8		•			
8/19/83	5.20					8/27/8					
8/23/83	5.20					9/3/86					
8/31/83	5.50					9/12/80	3.70				
9/8/83	4.30		· .			9/19/8	3.00				
9/14/83	4.90	1				9/24/86	4.30	2.1-5.8	3.27	1.0	GLSD
9/21/83	4.30	1.5-5.5	4.39	0.9	GLSD	1					
						6/3/87	2.40				
6/15/84	1.20	,				6/10/87	7 3.05				
6/25/84	2.10					6/17/87	7 4.88				
7/3/84	3.00		*			6/24/87	7 4.27				
7/11/84	3.40					6/30/87					
7/18/84	2.40					7/8/87					
7/25/84	2.40					7/15/87					
8/2/84	2.40					7/22/87					
8/8/84	2.10					7/28/87					
8/15/84	2.10	٠.				8/5/87					
8/23/84	2.40					8/12/87		•			
9/5/84	3.00					8/21/87					
9/14/84	3.00	1.2-3.0	2.46	0.6		8/27/87		1 0 0 0	7 01		C1 CD
	2 (2					9/2/87	3.96	1.8-8.0	3.01	0.9	GLSD
6/5/85	2.40	•				1					•
6/14/85	6.40					!					
6/19/85 6/26/85	7.30 3.50					! ·			• •		
7/2/85	2.60					<u> </u>					
7/10/85	2.60					i					:
7/17/85	2.00					i					
8/7/85	2.10				•	İ					
8/14/85						i					
8/21/85	2.30					i					
8/28/85	2.10					i					
9/3/85	2.00					i .					
9/11/85	2.40					i					
9/13/85	2.70					i					
9/18/85	3.40					i				•	
9/25/85	3.70	2.0-7.3	3.11	1.5	GLSD	i					
,, 25,05	2					•					

^{*} Statistics applied only to summer measurements (June - Sept.)

Table A-2: Total Phosphorus Surface Concentrations for the Stratified Period (June - Sept.) in Big Green Lake

		T.Phos.			Standard	
Year	Date	(mg/l)	Range /	Average	Deviation	Data Source
			•••••	• • • • • • • •	• • • • • • • • • • • • • • • • • • • •	•••••
1968	July 15	0.043	_	-	-	DNR
1060	July 29	0.030	,			DNR
1707	July 29	0.030	-	-	-	DAK
1970	July 21	0.030		_	_	DNR
			_	_	-	
1972	June 19	0.120				
	July 3	0.170				
	July 24	0.240				
	July 31	0.080				
	Aug 7	0.070	0.07-0.17	0.136	0.063	Ripon College
1977	July 26	0.042	-	_,	_	Donahue & Assoc. Project
1980	June 11	0.045				
.,,	June 14					
	July 2					
	July 8					
	July 16					
	Sept. 4					
	Sept. 1					
			.012045	0.026	0.013	Green Lake Sanitary Dist
1981	June 4	0.065				
	tiune 11	0.022				
	June 30	0.024				
	July 7	0.021				
	July 21	0.025				
	Aug. 4	0.015				
	Sept. 1	0.017	.015065	0.027	0.016	Green Lake Sanitary Dist
1001	June 29	0.040				
1701	July 21					
	Aug 19				·	
	Sept 14		.0204	0.030	0.010	DNR
	sept 14	0.020	106-104	0.030	0.010	DIN
1982	June 1	0.039				
	June 14					
	July 19					
	Aug 16					
	Sept. 1					
	•		.011039	0.021	0.010	DNR
		,				
1983	June 20	0.029				
	July 21	0.015				
	Aug. 22	0.011				
	Sept. 2	0.011	.011029	0.017	0.007	DNR

Table A-2 (continued) Total Phosphorus Surface Concentrations for the Stratified Period (June - Sept.) in Big Green Lake

	•	T.Phos.		.,	Standard	,
Year	Date	(mg/l)	Range	Average	Deviation	Data Source
• • • •		• • • • • • • • •			• • • • • • • • • • • • • • • • • • • •	
1984	July 3				• • •	·
	July 11					
	July 18					•
	July 25			•	,	
	Aug. 8		,			,
	Aug. 15					
	Sept. 5	0.04	.0213	0.056	0.036	Green Lake Sanitary Dist
1985	June 19	0.12				
	June 26					•
	July 2					
	July 10					
	July 17					
	July 31					
	Aug. 7	0.03				
	Aug. 14					
	Aug. 21			·.		
•	Aug. 28					
	Sept. 4					
	Sept. 1					•
	Sept. 1					· .
	Sept. 2		.01 .12	0.023	0.029	Green Lake Sanitary Dist
1094	June 3					
1700			021- 022	0.022	0.000	DND
	July 24	U.U21	.021022	0.022	0.000	DNR
1987	June 25	0.012				
	July 23	0.012				
	Sept. 2	0.011	.011012	0.012	0.000	DNR

Table: A-3: Fecal Coliform Bacteria Measurements in Big Green Lake (MFFCC/100 ml)

			Sample S	ites		
Sample	Pilgrim		County	Hattie	Reich	Camp
Date	•				Mobile Home	Grow
	• • • • • • • • • • • • • • • • • • • •		••••••		• • • • • • • • • • • • • • • • • • • •	
1979						
Jun 13	4	••	16	••	211	••
Jun 20	70	•.•	36	••	••	••
Jun 27	••	••	. 16	1	80	••
July 11 July 18	3	••	45	5	••	••
July 16 July 26	0 52	••	15 124	1	3	
Aug 1	7		10	2	238	
Aúg 8	33		19	14	379	
Aug 15	1	••	5	0		••
Aug 22	43	••	20	8	••	5
nug LL	75		20	·		,
Average:	24		29	4	182	5
1980						
Jun 4	0	••	0	0	0	••
Jun 11	••	••	6	6	20	••
Jun 17 ,	8	6	80	10	27	••
Jun 25	69	8	169	4	199	••
July 2	18	10	36	6	26	1
July 9	5	8	13	19	32	0
July 16	101	55	64	150	TNTC	45
July 23	111	0	44	3	79	• •
July 30	24	18	2	••	10	• •
Aug 12	19	17	5	5	134	229
Aug 21	92		14	••	THTC	••
Aug 27	••	••	130	2	82	••
Average	45	15	47	21	1,717	55
1981						
Jun 11	10	3	1	8	••	42
Jun 16	780	20	15	8	TNTC	30
Jun 25	2	0	TNTC	2	118	1
Jun 30	TNTC	3	38	3	138	25
July 7	13	3	178	11	TNTC	0
July 14	TNTC	40	54	3	TNTC	15
July 21	TNTC	1	35	1	TNTC	9
July 29	100	2	6	2	300	2
Aug 4	200	••	570	2	••	2
Aug 11	90	12	10	34	1,800	28
Aug 18	154	150	70	6	203	104
Aug 26		44	. 12	66	206	••
Average:	2,850	25	916	12	4,277	23

Table: A-3 (continued): Fecal Coliform Bacteria Measurements in Big Green Lake (MFFCC/100 ml)

Sample	Pilgrim			ites ····· Hattie		Camp
Date	Camp	ABA	Park	•	Mobile Home	•
		••••••		• • • • • • • • •		•••••
1982						
Jun 9	3	• • •	12	1	150	••
Jun 26	1	1	50	1	320	2
July 7	1,070	0	100	4	3,350	0
July 14	100	2	38	96	0	112
July 21	20	20	230	20	140	20
July 27	32	0	. 72	2	150	12
Aug 4		2	4	4	•-	80
Aug 11	••	0	0	. 0	60.	3
Aug 17	. 4	12	.4.	8	24	0
Aug 25	6	0	6	. 0	2,200	1
Average:	155	4	52	14	. 710	26
1983						
Jun 1	. 0	0	36	••	400	0
Jun 8	10	0	0.	••		0.
Jun 15	2	3	. 20	130	0	1
Jun 23	5,	0	15	4	1,100	11
Jun 27	19	••	••	••		••
Jun 29	5	- 1	47	7	45	1
Jun. 30	3	••	••	••	••	••
July 5	" O		••	••	••	
July 6	4	0	4	. 17	130	. 0
July 7	0	••	••	••	••	
July 11	2	••	• •	••	••	
July 12	. 0		••	• • .	••	
July 14	1	0	. 0	0	31	0
July 18	2	••	• •	••	••	
July 21	3	3	3	1	TNTC	0
July 25	.1	••.	••	••		• •
July 28	0	7	5	6	300	0
July 27	0	••		••	••	••
July 29	8	••	••	••	••	••
Aug 4	2	4	1,300	. 13	••	3
Aug 11	3	0	4	0	50	1
Aug 17	46	40	370	9,500	13,000	63
Aug 18	40	27	105	2,200	8,400	43
Aug 24	6	6	12	32	200	1
Aug 25	6	4	4	32	170	0
Aug 31	10	6	31	66	130	10
Sept 1	· 7	3	14	6	56	5
Sept 7	15	3	9	4	115	1
Sept 8	3	2	6	3	. 46	5
verage:	7	. 6	104	707	2,010	8

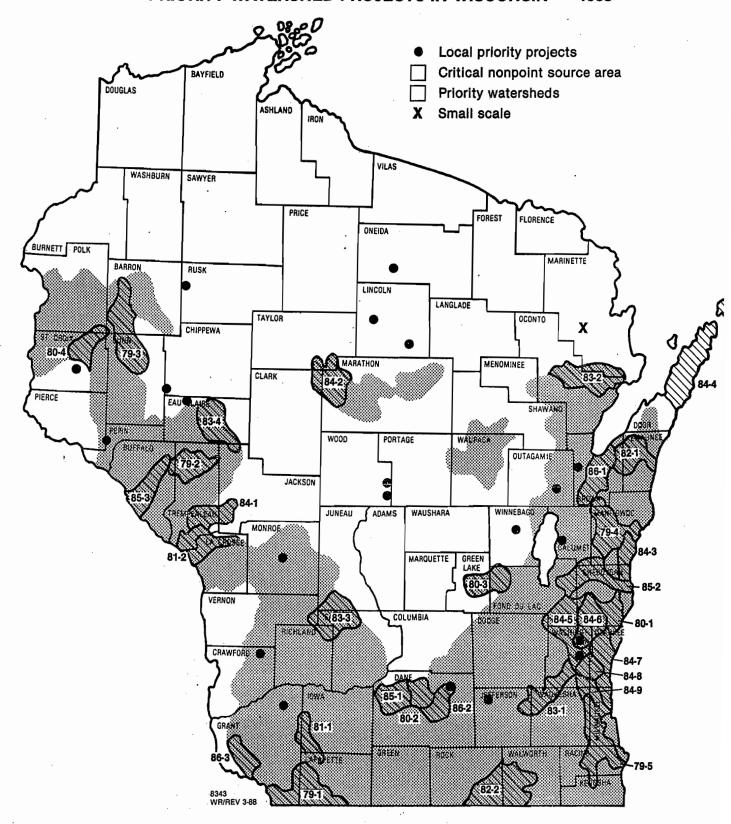
Table: A-3 (continued): Fecal Coliform Bacteria Measurements in Big Green Lake (MFFCC/100 ml)

			Sample S	ites		
Sample	Pilgrim				Reich	•
Date	Camp	ABA	Park	Sherwood	Mobile Home	Grow
•••••	•••••	• • • • • • •		• • • • • • • •	• • • • • • • • • • • • • • • • • • • •	•••••
1984						
Jun 14	60	80	25	20	•	40
Jun 21	25	24	2			0
Jun 27	110	10	120		700	150
July 5	0	2	22	0	30	11
July 12	150	14	21	22	3,800	31
July 18	4	0	18	28	160	80
July 25	420	4	80	26	3,300	30
Aug 2	4	4	12	12	200	10
Aug 8	250	6	400	1,200	•	510
Aug 15	2	2	10	10		9
Aug 23	220	0	150	4	190	140
Average:	113	13	78	145	2,164	92
1985						
Jun 12	20	10	31	8	785	55
Jun 19	- 28	15	80	10	70	85
Jun 26	. 0	34	110	0	400	0
July 2	6	0	70	0	1,220	10
July 10	40	4	30	34	350	8
July 17	4	6	187	3	145	0
July 24	0	0	0	2	20	0
July 31	96	24	540	2	63	11
Aug 7	100	0	847	8	11,200	26
Aug 14	96	11	147	3	0	0
Aug 21	5	2	73	9	0	4
Aug 28	6	2	160	5	1,367	50
Average:	33	9	190	7	1,302	21
1986						
Jun 5	0	0	20	0	443	0
Jun 11	8	180	0	0	1,157	0
Jun 18	2	10	170	6	55	0
Jun 25	0	15	. 0	100	60	2
July 2	1	3	30	10	210	2
July 9	250	••	391	5	285	. 2
July 16	10	• •	84	4	315	2:
July 23	0	3	150	4	20	2
July 30	37	4	51	1	. 77	4
Aug 6	15	2	12	4	. 10	2
Aug 13	0	0	10	4	15	1
Aug 20	93	0	3	3	78	4
Aug 27	45	0	30	10	290	7
Average:	35	20	73	12	232	2

Table: A-3 (continued): Fecal Coliform Bacteria Measurements in Big Green Lake (MFFCC/100 ml)

	Sample Sites							
Sample	Pilgrim		County	Hattie	Reich	Camp		
Date	Camp	ABA	Park	Sherwood	Mobile Home	Grow		
1987				••••••	• • • • • • • • • • • • • • • • • • • •	•••••		
Jun 3	10	11	1,050	15	5	6		
Jun 16	10	2	20	20	57	0		
Jun 24	5	2	25	4	358	5		
July 1	42	62	87	5	150	0		
July 6	7.	10	22	2	· 10	. 0		
July 13	10	4	353	6	126	8		
July 20	10	4	73	2	36	4		
July 27	0	10	¹ 180	30	740	20		
Aug 3	6	2.	36	. 17	80	. 0		
Aug 17	51	. 77	468	16	278	17		
Aug 24	2	15	13	2	12	2		
Aug 31	32	70	193	7	152	8		
Average:	15	22	210	11	167	6		

PRIORITY WATERSHED PROJECTS IN WISCONSIN — 1988



PRIORITY WATERSHED PROJECTS IN WISCONSIN

Map Number	Project	County(ies)	Year Project Selected
79-1	Galena River	Grant, Lafayette	1979
79-2	Elk Creek	Trempealeau	1979
79-3	Hay River	Barron, Dunn	1979
79-4	Lower Manitowoc River	Manitowoc, Brown	1979
79-5	Root River	Racine, Milwaukee, Waukesha	1979
80-1	Onion River	Sheboygan, Ozaukee	1980
80-2	Sixmile-Pheasant Branch Creek	Dane	1980
80-3	Green Lake	Green Lake, Fond du Lac	1980
80-4	Upper Willow River	Polk, St. Croix	1980
81-1	Upper West Branch Pecatonica River	lowa, Lafayette	1981
81-2	Lower Black River	La Crosse, Trempealeau	1981
82-1	Kewaunee River	Kewaunee, Brown	1982
82-2	Turtle Creek	Walworth, Rock	1982
83-1	Oconomowoc River	Waukesha, Washington, Jefferson	1983
83-2	Little River	Oconto	1983
83-3	Crossman Creek/Little Baraboo River	Sauk, Juneau, Richland	1983
83-4	Lower Eau Claire River	Eau Claire	1983
84-1	Beaver Creek .	Trempealeau, Jackson	1984
84-2	Upper Big Eau Pleine River	Marathon, Taylor, Clark	1984
84-3	Seven Mile-Şilver Creeks	Manitowoc, Sheboygan	1984
84-4	Upper Door Peninsula	Door	1984
84-5	East & West Branch Milwaukee River	Fond du Lac, Washington, Sheboygan, Dodge	1984
84-6	North Branch Milwaukee River	Sheboygan, Washington, Ozaukee	1984
84-7	Cedar Creek	Washington, Ozaukee	1984
84-8	Milwaukee River South	Ozaukee, Milwaukee	1984
84-9	Menomonee River	Milwaukee, Waukesha, Ozaukee, Washington	1984
85-1	Black Earth Creek	Dane	1985
85-2	Sheboygan River	Sheboygan, Fond du Lac, Manitowoc, Calumet	1985
85-3	Waumandee Creek	Buffalo	1985
86-1	East River	Brown	1986
86-2	Yahara River — Lake Monona	Dane	1986
86-3	Lower Grant River	Grant	1986

