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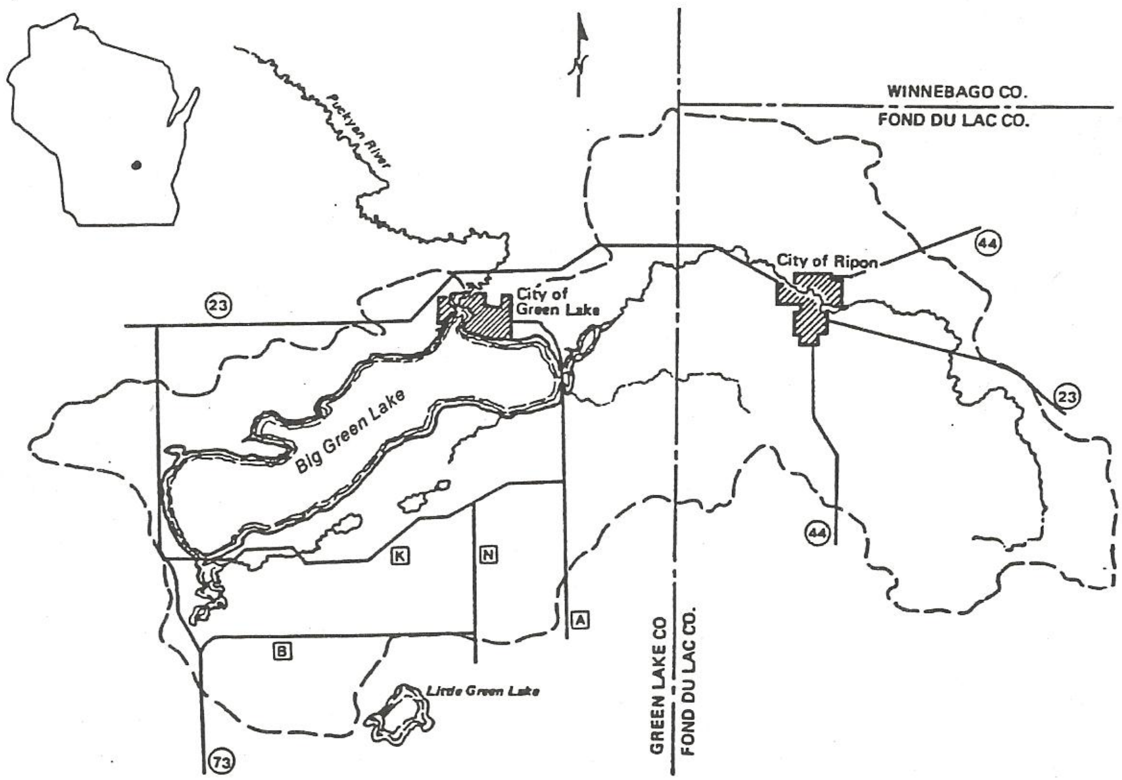
BIG GREEN LAKE PRIORITY WATERSHED PROJECT

Final Evaluation Monitoring Report



Prepared By:
Wisconsin Department of Natural Resources
Bureau of Water Resources

BIG GREEN LAKE
PRIORITY WATERSHED PROJECT

A Final Evaluation Monitoring Report

Wisconsin Nonpoint Source Pollution Abatement Program

by RON KRONER, JOE BALL, and MIKE MILLER

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SUMMARY

The nonpoint source pollution abatement program implemented in the Big Green Lake Watershed concludes in December, 1992. This program, which was implemented by the Wisconsin Department of Natural Resources (DNR) and the Green County Department of Land Conservation, installed best management practices (BMPs) throughout the watershed in an effort to control nonpoint source pollution impacts to Big Green Lake. The DNR conducted an evaluation monitoring study to evaluate the success of the Big Green Lake Priority Watershed Project. The evaluation monitoring team's focus is two-fold; first, the evaluation of water quality and habitat improvements resulting from the implementation of BMPs and secondly, determine to what extent the original objectives of the project were met.

Water quality analysis of Big Green Lake, indicated a slight trend toward improved water quality. Secchi disk readings and bacterial levels exceeding the recommended water quality standard have both shown improvement since 1984. Nutrient and chlorophyll concentrations have essentially remained stabile over the duration of the priority watershed project. Due to the long hydraulic residence time of Big Green Lake (21 years) and the nutrient sink associated with such a large body of water, consistent trends exhibiting water quality improvements may not manifest themselves in Big Green Lake for decades to come.

Habitat assessments indicate that best management practices have substantially reduced sediment and nutrient additions to Big Green Lake. The Big Green Lake Priority Watershed project experienced a high level of participation which has resulted in control of cropland soil erosion and a high reduction of nutrient runoff from barnyards. Habitat assessments also identified two prevailing sources of nonpoint source pollution: serious sheet, rill, and streambank erosion in densely wooded areas and gully erosion found in numerous roadside ditches.

Installation and implementation of BMPs throughout the watershed began in the spring of 1985. The completion date for installation of BMPs was readjusted to December, 1992, to accommodate added cost-share projects acquired through a second sign-up period offered in 1988.

This evaluation concludes that although some of the projects have yet to be completed, with the additional projects gained through the supplementary sign-up period in 1988, participation levels will be with-in the projected success rate of 75 percent. Water quality in Big Green Lake has been maintained throughout the duration of the project and BMPs have reduced sediment and nutrient loss associated with agricultural practices to tolerable levels. This evaluation also concludes that nonpoint sources of pollution associated with dense forests and roadside gullies, continue to significantly impact Big Green Lake and should be the focus of future nonpoint source reduction efforts.

INTRODUCTION

Agricultural nonpoint sources (NPS) of pollution are major contributors to water systems degradation. Agricultural runoff has been associated with unnatural algal blooms, fish kills, and accelerated eutrophication of lakes, rivers, and streams. Many agricultural practices cause disruption of stream systems by increasing suspended solids, siltation of pools and riffles, and degradation of instream and streambank habitat.

In 1980, the Big Green Lake Watershed was selected for participation in the Wisconsin Nonpoint Source (NPS) Pollution Abatement program. The primary role of this program is to provide cost-sharing and technical assistance to local agencies for the control of nonpoint source pollution. The planning period was completed in December 1984, and installation of BMPs began immediately after. As the program progressed, it became apparent that many nonpoint source problems had not been accounted for in the original plan. There was significant interest by the Green Lake and Fond du Lac County Land Conservation Departments and relevant landowners to address the remaining nonpoint source problems. As a result, the Wisconsin Department of Natural Resources (DNR) granted a three-month window (January 1, 1988 to March 31, 1988) for additional cost-share agreements to be made. The installation of all BMPs are scheduled for completion in December, 1992.

Traditionally, Big Green Lake was considered to have good water quality. However, long term trend monitoring of transparency, littoral zone expansion, and nutrients, indicated the lake was moving toward a more nutrient rich trophic state. The eutrophic trend of Big Green Lake was traced to high annual sediment loading from direct runoff and surrounding tributaries. The primary objective of this project was to reduce sediment and nutrient loading to Big Green Lake by installing and implementing best management practices.

In 1988, an interim report written by the DNR covered the Big Green Lake Priority Watershed Project's progress. At that time five subwatersheds had fully achieved or exceeded their nonpoint source pollution reduction goals (Bachhuber, 1988). The interim report also suggested, that the original project goals be revised to protect Big Green Lake's water quality and not an improvement effort. Given Big Green Lake's existing condition, maintenance of current water quality levels was regarded as a more realistic objective of the project (Bachhuber, 1988).

A priority watershed evaluation team from the DNR, Bureau of Water Resources Management, was organized in 1990. The team's objectives are to evaluate water quality improvements resulting from the implementation of BMPs and to determine to what extent the objectives of the individual watershed plans were met. This report covers the Big Green Lake Watershed evaluation monitoring study conducted from May, 1990 through January, 1992.

PROJECT GOALS AND OBJECTIVES

The goals of the Big Green Lake Priority Watershed Project were designed to protect existing high water quality areas, to rehabilitate areas degraded by nonpoint source pollution, and to halt or reverse (where possible) the declining water quality trend in Big Green Lake. This plan documents the available data and the proposed methodologies for collecting pre-implementation and post-implementation data concerning the Big Green Lake Priority Watershed Project. The data obtained will be used to assess to what extent the Big Green Lake Watershed goals have been met. The Big Green Lake Priority Watershed project's water quality goals as stated in the original plan are:

* Protect the areas that currently have good or excellent water quality.
* Improve the waterbodies that have been degraded by nonpoint sources of pollution.
* Halt and, where possible, reverse the trend in declining water quality.

These goals were further expanded to include:

* Reduce the concentration of coliform bacteria to "acceptable" levels (400 fecal coliform/100 milliliter (ml) sample) where ever this level is exceeded.
* Reduce nutrient loading (nitrogen and phosphorus) to tributaries by 40 percent on a yearly basis.
* Increase average secchi disk readings during open water times.
* Halt the trend of increasing lake littoral zones.

As stated previously, it was later recommended that the focus of the priority watershed project be that of lake protection rather than lake improvement.

The objective of this report is to evaluate water quality and habitat improvements resulting from the implementation of BMPs and to determine to what extent the objectives of the project were met. Two points, however, obscure this report's objectives:

* Because of the high number of additional projects attained during the second sign-up period, the end date for installation of cost-shared BMPs has been extended to December, 1992. It will take time for the BMPs to stabilized and for the nonpoint source pollution already in transport to essentially be "flushed out" of the watershed.

* Due to the large size and long hydraulic residence time of Big Green Lake (21 years), consistent measurable water quality responses from installed BMPs, are not expected to be manifested for several years.

This report assesses the existing water quality and habitat conditions as well as the degree too which the revised objectives were met. Although this report is titled "Final Evaluation Monitoring", in actuality it is better termed an interim evaluation monitoring study of the Big Green Lake Priority Watershed.

WATERSHED DESCRIPTION

Big Green Lake is located in mid-eastern Wisconsin, with 60 percent of the watershed in eastern Green Lake County, and 40 percent of the watershed in western Fond du Lac County (See Figure 1). The watershed spans approximately 100 square miles and is primarily used for agricultural purposes. Some residential development surrounds Big Green Lake. The cities of Ripon and Green Lake are the only two incorporated cities located within the watershed boundaries.

Big Green Lake is the deepest inland lake in Wisconsin with a maximum depth of 237 feet and a mean depth of 101 feet. The lake is situated in a large pre-glacial river valley. The Cary Glacier scoured this valley and deposited a large recessional moraine across the western end. The deposited material then flooded the valley and created the present day Big Green Lake and Puckyan-Fox drainage system. Big Green Lake covers 7,346 acres. Big Green Lake has a hydraulic residence time of 21 years and a dam has been constructed at the outlet (Puckyan River), which maintains the water level approximately five feet higher than the natural lake level (Donohue, 1978).

A rich prairie soil covers most of the watershed and supports a productive agricultural cash crop industry as well as dairy, beef, and hog farming.

BIG GREEN LAKE MONITORING STRATEGY

There is a large amount of background data characterizing the ecological condition of Big Green Lake prior to implementation of the priority watershed project. Lake monitoring efforts have been primarily performed by the Green Lake Sanitary District and the DNR. The monitoring efforts characterizing the ecological trends of Big Green Lake include: water clarity, bacteriological, littoral zone expansion, phosphorus, and chlorophyll. Data, including visible observations, indicated a gradual decline in the lake's water quality up until 1975. Since 1975, however, Big Green Lake's water quality appears to have stabilized.

Water Clarity

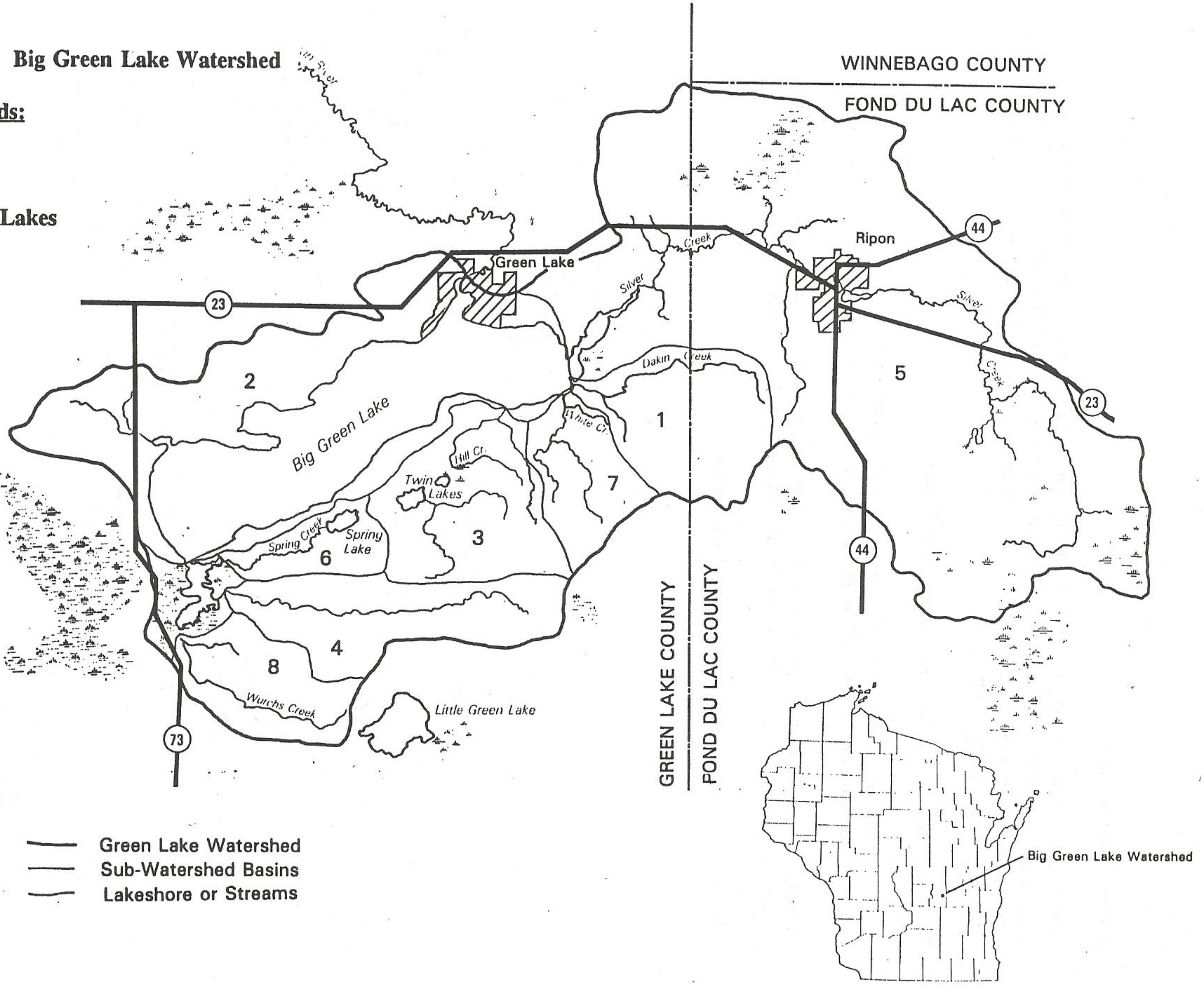
For over 20 years, the secchi disk has been used to measure water clarity on Big Green Lake. All secchi disk data shown in this report was acquired through the Green Lake Sanitary District. Currently, volunteers in the Self-Help Lake Monitoring Program take secchi disk measurements at least once every two weeks during the summer months (June, July, and August) and forward the data to the Big Green Lake Sanitary District.

Water clarity is reported as "average summer secchi disk depth" measured in feet. This is an average of all the discrete samples taken during the months of June, July, and August. Because Big Green Lake covers a large area, secchi disk measurements are taken on the east and the west ends of the lake. By measuring water clarity at both ends of the lake, the natural variability associated with depth, wind, and tributary input, is somewhat accounted for.

Figure 1. Big Green Lake Watershed

Subwatersheds:

1. Dakin
2. Direct
3. Hill-Twin Lakes
4. Roy
5. Silver
6. Spring
7. White
8. Wurches



Bacterial Monitoring

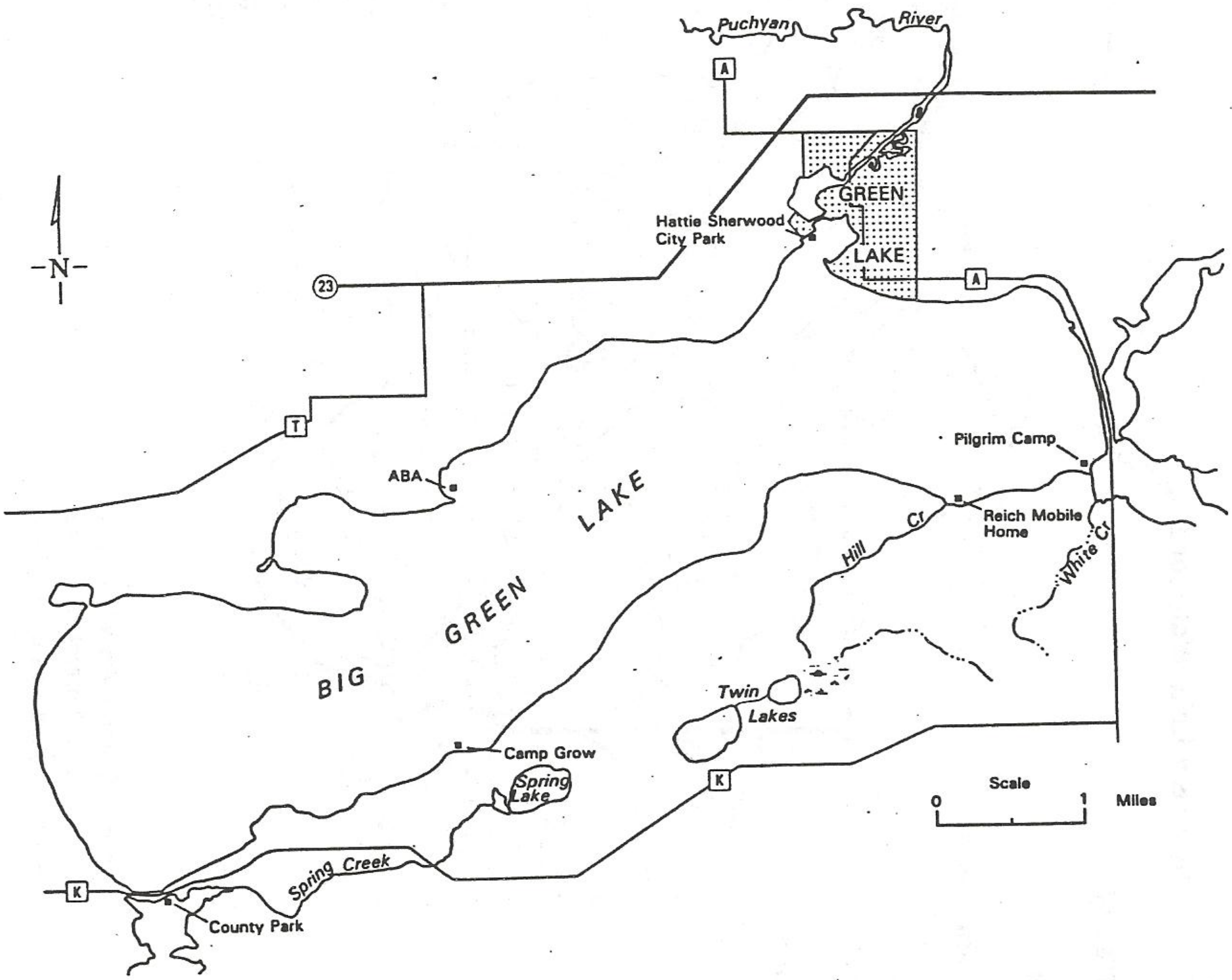
Weekly bacterial monitoring is conducted by the Green Lake Sanitary District from June to September. Fecal coliform samples were solely performed from 1978 to 1987. In 1987, bacterial monitoring was expanded to include enterococcus bacteria which have shown a more direct correlation to swimmer infections.

The five bacterial evaluation sites around Big Green include:

* Two public beaches (Hattie Sherwood and County Park).
* Three private beaches (Pilgrim Camp, Camp Grow, and Reich Mobile Home Park).

American Baptist Assembly (ABA) was also a bacterial evaluation site until 1988, when they closed their swimming area. See figure 2 for bacterial monitoring locations.

Figure 2. Bacteriological Monitoring Locations



Littoral Zone Expansion

The littoral zone expansion rate is defined by the increase in the distance between the shoreline and the 20 foot bottom contour over a given time period. A hydrographic survey done by Donohue & Associates in 1978, compared data from a 1968 survey conducted by the DNR. Donohue & Associates concluded that there was an increase in the littoral zone over the last ten years. The existing 20-foot contour was not measured during this study due to time and equipment constraints, but littoral zone expansion was evaluated by examining tributary sediment loading and direct loading associated with shoreline erosion.

Phosphorus and Chlorophyll Monitoring

Phosphorus and chlorophyll samples are routinely collected during the summer by the Green lake Sanitary District and the DNR.

Phosphorus occurs naturally in parent soil and bedrock, but human activities throughout the watershed have greatly increased phosphorus quantities introduced into Big Green Lake. Anthropogenic activities largely responsible for increased phosphorus loading to Big Green Lake include: agricultural runoff, lawn fertilization, soap and detergent, and sewage effluent.

Phosphorus is an essential element contributing to fertility and growth of plants in the lake. When phosphorus is found in excess, however, the productivity of the lake is accelerated to a rate higher than normally observed without outside phosphorus contributions.

Chlorophyll-a concentrations are periodically monitored by the DNR. The chlorophyll-a pigment is widely used as an estimation of phytoplankton biomass. Lakes which appear clear or blue to the eye generally have Chlorophyll-a concentrations less than 10 micrograms per liter (ug/l).

TRIBUTARY MONITORING STRATEGY

As previously stated, consistent water quality improvements in Big Green Lake are not expected to be observed for several more years. In fact, it may take decades before positive results are visible. Most of the best management practices have been installed in the subwatersheds. These practices will yield rapid, perhaps even immediate impacts on the tributaries. This explains why changes in water quality will be observed in the tributaries long before being observed in Big Green Lake. With regular stream monitoring, responses in stream water quality resulting from BMP implementation can be examined. Therefore, evaluation monitoring of the tributaries draining into Big Green Lake, is an essential interim step in determining the success of the priority watershed program.

There are eight subwatersheds draining into Big Green Lake. The tributaries are located on the south and southeast shores (See Figure 1). Evaluation monitoring of Big Green lake's tributaries include water gaging stations, habitat assessments, and macroinvertebrate analysis. Ideally, the locations and types of BMPs that are to be installed would be identified prior to pre-implementation monitoring. Pre-implementation and post-implementation monitoring data would then be collected at sites strategically located to monitor any change in water quality resulting from the installed practices. However, little pre-implementation data on watershed streams were collected that can be used for comparison with post-implementation data. Therefore, most of the monitoring results in this study are used to document existing conditions and problems, and can be used for comparison to future monitoring results.

Water Gaging Stations

The United States Geological Survey (USGS) installed water gaging stations on White and Silver Creeks. These stations record hydrologic, suspended sediment loading, and phosphorus loading data. Annual monitoring of sediment and phosphorus loadings to streams is of great significance because these parameters are indicators of nonpoint source pollution. Changes in these parameters may also reflect a reduction in nonpoint source pollution due to implementation of BMPs. Best management practices such as contour plowing, strip cropping, and creating buffer zones, may significantly reduce field sediment and phosphorus loss. Ideally, gaging stations would be installed prior to BMP installation and remain in operation for many years after BMP installations are complete.

The White Creek gaging station was installed in 1982 and was discontinued in 1987. Silver Creek's gaging station began operation in 1987 and continues to be used.

Habitat Assessments

Habitat assessments were conducted in July, 1991, in an effort to characterize existing stream system and watershed conditions, and identify any factors significantly affecting the water quality. Habitat assessments (Stream System Habitat Evaluation) evaluated the stream systems by examining the watershed, near-stream, and stream morphology characteristics. The evaluation methods used for habitat assessments followed "Stream Classification Guidelines For Wisconsin" (WDNR Tech. Bull. 1982) and used a modified stream habitat rating scale:

Excellent = <64	Fair = 113-176
Good = 65-112	Poor = > 177

The scale was adjusted because flows were not measured at the assessment sites.
Habitat assessments were conducted on the entire reaches of White Creek, Hill Creek, and Spring Creek and at the crossroad areas on Wurches Creek, Twin Lakes, and Roy Creek. Each stream was broken down into smaller sections. Then these sections were assessed and rated. Finally the ratings for each section were averaged together to characterize the overall stream condition.

Water Quality Analysis

* The water quality assessment strategy monitors water quality parameters above and below future cost-share projects, and during normal and event flow periods. An event flow period is defined as one or more inches of precipitation within a 24-hour period. Water chemistry samples were taken on Hill Creek above and below a barnyard in an attempt to identify nonpoint source contributions. The parameters selected for analysis include: total

identify nonpoint source contributions. The parameters selected for analysis include: total and suspended solids, 5-day biological oxygen demand (BOD), ammonia nitrogen, nitrate and nitrite, total kjeldahl nitrogen, total and dissolved oxygen, and fecal coliform bacteria. Water sample collection followed the Wisconsin State Lab of Hygiene (SLOH) established procedures. The samples were analyzed at SLOH.

Macroinvertebrate Analysis

The DNR periodically conducts macroinvertebrate community analysis on the tributaries around Big Green Lake. Macroinvertebrates are thought to be good indicators of water quality over several months. The Macroinvertebrate community will generally respond to periodic water quality problems that are not always detected during (grab) water quality sampling.

The DNR collected macroinvertebrate samples in Fall, 1990 and Spring, 1991. Using a D-frame net, the kick technique was employed (as described by Hilsenhoff, 1987). Samples were sent to University Wisconsin-Stevens Point for taxonomic analysis to species level. Finally the results were interpreted using the Hilsenhoff Biotic Index (developed by Hilsenhoff, 1987). Water quality is evaluated on a scale ranging from 0-10, with a value of 0 indicating excellent water quality and a biotic index value of 10 indicating very poor water quality.

EVALUATION MONITORING RESULTS

There is a substantial amount of pre-evaluation monitoring data for Big Green Lake, and somewhat limited pre-data available on the watershed tributaries. Water resource accomplishments have been interpreted in terms of transparency, bacteria levels, sedimentation, biotic index, habitat assessments, and nutrient concentrations.

LAKE MONITORING

Secchi Disk

Lake transparency readings performed on Big Green Lake indicate a trend toward improved water clarity. Average yearly secchi disk measurements prior to the mid-1970's averaged in the teens (feet). From the mid-1970's to 1984 the levels declined to a minimum yearly average of 8.8 feet in 1984. From 1984 to the present there has been a gradual increase in secchi disk depths. Secchi disk measurements over the past three years are now comparable to the levels commonly found before the mid-1970's (See Table 1 & Figure 3).

The secchi disk depth measurements tend to be slightly higher on the west end of Big Green Lake than the east end. This difference may be attributed to the deeper depth, and lack of sediment and nutrient input from tributaries on the west end. Unlike the east end, the west end has a large marsh area which acts as a sediment trap for all of the tributaries entering the lake at that end. Also, the prevailing winds tend to blow from west to east moving suspended material to the east. Because the east end of the lake is shallow, this promotes wave action and resuspension of bottom sediments (See Tables 2-3 & Figures 4 -5).

Phosphorus and Chlorophyll Analysis

Numerous sources contribute phosphorus to surface waters and stream and lake bottoms naturally release phosphorus over time. However, water quality has been shown to deteriorate as land is changed from its original state toward intensive uses. The activities associated with modern agriculture often increase runoff which can include sediment, nutrients, and pesticides. Phosphorus is considered the limiting nutrient in aquatic ecosystems, and when found in levels above .025 milligrams per liter (mg/l), can be conducive to algal blooms.

The highest phosphorus concentration over the last ten years occurred in 1984. The yearly total phosphorus concentration in 1984 was .038 mg/l. In 1984, implementation of BMPs began throughout the watershed. After 1984 there was a greater than .01 mg/l drop in yearly total phosphorus levels and has since fluctuated between .018 -.024 mg/l.

The chlorophyll-a pigment is widely used as an estimation of phytoplankton biomass in lakes. Phytoplankton have short life cycles and quickly respond to environmental changes which is why the standing crop and species composition indicate the quality of water in which they are found (Donohue, 1978). Chlorophyll-a concentrations over the last ten years have been slightly above or below 10.0 micrograms per liter (ug/l) and ranged between 5.0-6.5 ug/l the last three years. Generally, aesthetically pleasing lakes have chlorophyll-a concentrations below 10 ug/l.

Table 1. Average summer secchi disk measurements *
Big Green Lake (East & West Basins)

Year	Summer Water Clarity Average (Feet)	Description	Minimum Reading (Feet)	Maximum Reading (Feet)
1972	14.70 Feet	Very Good	0.04	18.00
1977	15.87 Feet	Very Good	9.80	24.30
1980	10.63 Feet	Very Good	3.90	18.00
1981	11.93 Feet	Very Good	5.00	18.00
1982	11.10 Feet	Very Good	4.00	25.00
1983	11.93 Feet	Very Good	5.00	25.00
1984	7.30 Feet	Good	4.00	13.00
1985	9.70 Feet	Good	5.00	24.00
1986	9.40 Feet	Good	4.50	19.00
1987	9.47 Feet	Good	6.00	16.00
1988	9.60 Feet	Good	5.50	13.50
1989	12.30 Feet	Very Good	3.25	23.00
1990	11.40 Feet	Very Good	4.00	22.00
1991	15.53 Feet	Very Good	8.00	28.50

*** Summer average includes June, July, and August data only.**
*** Source: Green Lake Sanitary District**

Figure 3. Average summer secchi disk measurements *
Big Green Lake (East & West Basins)

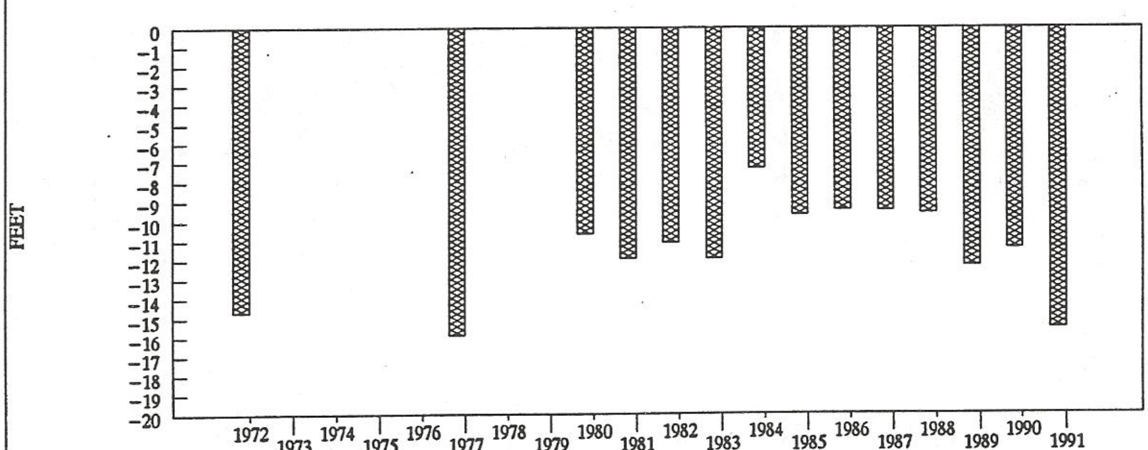


Table 2. **Average summer secchi disk measurements ***
Big Green Lake (East Basin)

Year	Summer Water Clarity Average (Feet)	Description	Minimum Reading (Feet)	Maximun Reading (Feet)
1972	12.77	Very Good	0.40	18.00
1977	15.27	Very Good	9.80	24.00
1980	10.50	Very Good	3.90	18.00
1981	12.43	Very Good	5.00	18.00
1982	11.73	Very Good	5.00	20.00
1983	11.60	Very Good	5.00	20.00
1984	7.17	Good	5.00	13.00
1985	9.10	Good	6.00	21.00
1986	8.13	Good	4.50	13.00
1987	9.40	Good	6.50	16.00
1988	9.17	Good	6.00	13.25
1989	11.27	Very Good	3.25	18.00
1990	10.90	Very Good	4.00	19.25
1991	14.73	Very Good	8.00	26.50

*** Summer is defined as: June, July, and August.**
*** Source: Green Lake Sanitary District**

Figure 4. Average summer secchi disk measurements (1972–1991) *
Big Green Lake (East Basin)

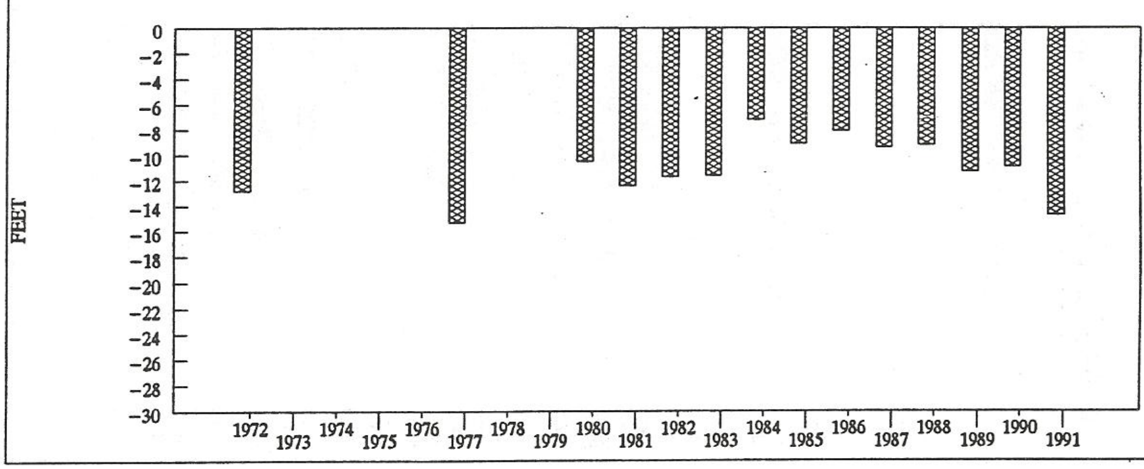
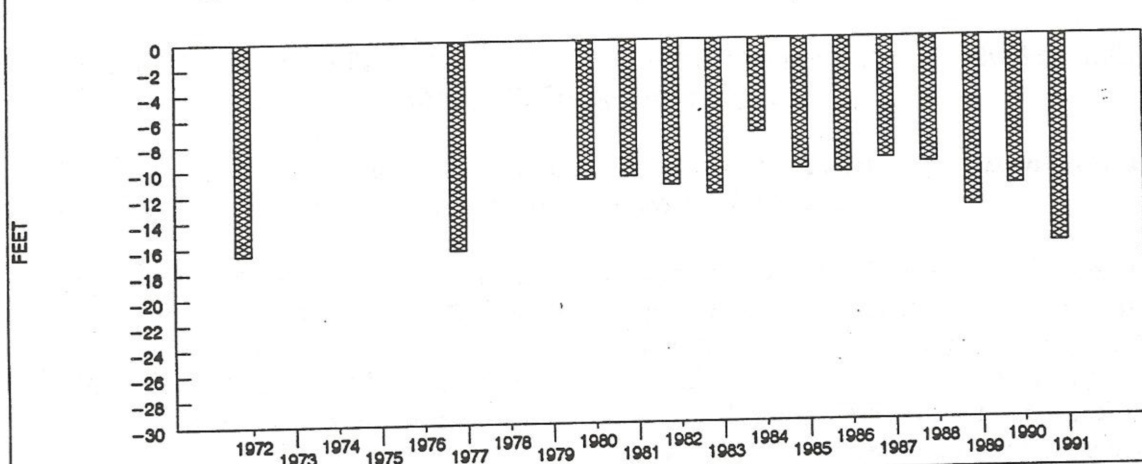


Table 3. Average summer secchi disk measurements *
Big Green Lake (West Basin)

Year	Summer Water Clarity Average (Feet)	Description	Minimum Reading (Feet)	Maximum Reading (Feet)
1972	16.63	Very Good	13.10	16.40
1977	16.40	Very Good	10.80	24.30
1980	11.00	Very Good	5.90	17.10
1981	10.77	Very Good	4.00	17.00
1982	11.50	Very Good	5.00	25.00
1983	12.20	Very Good	5.00	25.00
1984	7.43	Good	4.00	11.00
1985	10.40	Very Good	6.50	24.00
1986	10.73	Very Good	5.50	19.00
1987	9.57	Good	6.00	16.00
1988	9.97	Good	5.50	13.50
1989	13.37	Very Good	4.25	23.00
1990	11.83	Very Good	5.50	22.00
1991	16.30	Very Good	10.00	28.50

* Summer is defined as: June, July, and August.
* Source: Green Lake Sanitary District

Figure 5. Average summer secchi disk measurements *
Big Green Lake (West Basin)



Trophic State Index

Trophic state index (TSI) is a general classification system that uses water quality characteristics for Wisconsin lakes. The parameters used to describe the existing water quality state are total phosphorus, chlorophyll-a concentrations, and water clarity measurements (DNR Tech Bull. 138, 1983)(See Table 4). The summer averages of these parameters were used to develop the trophic state indices for Big Green Lake. The summer averages include all of the samples collected during June, July, and August.

Table 4. Trophic State Index for Wisconsin Lakes
Source: DNR Tech Bulletin 138

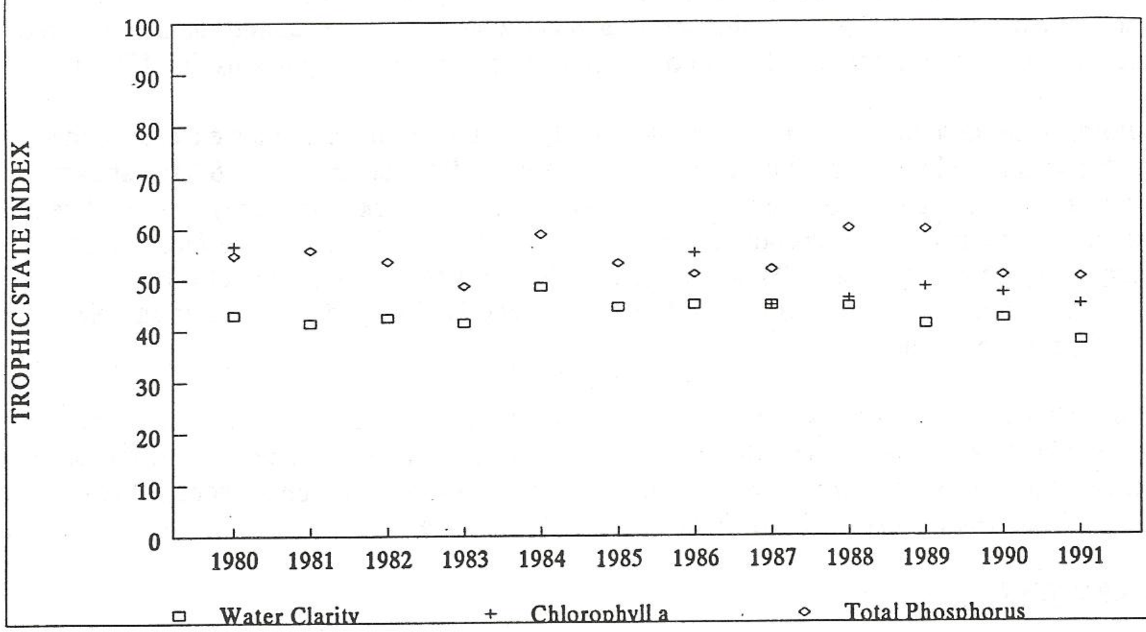
Water Quality	Total Phos. Surface (mg/l)	Water Clarity (Feet)	Chlorophyll a (ug/l)	Trophic State Index
Excellent	<.001	> 20	< 1	<34
Very Good	.001-.01	10-20	1-5	34-44
Good	.01-.03	6-10	5-10	44-50
Fair	.03-.05	5-6	10-15	50-54
Poor	.05-.15	3-5	15-30	54-60
Very Poor	>.15	< 3	> 30	> 60

The trophic state index (TSI) for Big Green Lake (1980-1991) can be broken down as follows:

- * **Water Clarity:** Had a maximum TSI of 49 in 1984, a minimum TSI of 37 in 1977, and an 11 year average of 43 (Very Good).
- * **Chlorophyll:** TSIs ranged from 57 (Max) in 1980 to 45 (Min) in 1987 and 1991, and an 11 year average of 49 (Good).
- * **Phosphorus:** Had a maximum TSI of 60 in 1988, a minimum TSI of 49 in 1983, and an 11-year average TSI of 54 (Fair-Poor).

The trophic state indices for Big Green Lake have varied over the last 11 years and for the most part ranged from 40-55 (See Figure 6). This trophic state index range reflects a lake in a mesotrophic state shifting toward a more eutrophic condition. By interrelating all three parameters, it appears that over the last 11 years Big Green Lake has become stabilized in this range/state (Carlson, 1977). Due to the 21-year hydrologic residence time, measurable improvements may not be observed for many years.

Figure 6. Trophic State Index (Summer Averages)
Big Green Lake



Littoral Zone Expansion

Shoreline erosion is a major contributor to littoral zone expansion and can be adequately controlled through shoreline rip-rap installation. On the southwest shore of Big Green Lake there is a collaboration of four landowners who rip-rapped 240 feet of shoreline. Adjacent lot owners declined the best management practice opportunity and have since lost valuable lake frontage; the shoreline has receded approximately 15 feet as a result of continued bank erosion. The shoreline rip-rap benefits are clearly exhibited (both ecologically and monetarily). This is not an isolated case and the same results can be observed at numerous locations around any lake.

Littoral currents flow from east to west along the north and south shores of Big Green Lake. These currents are formed by surface water movement caused by the prevailing winds. Since much of the sedimentation that is occurring is of silty composition, it is easily transported by these currents and deposited on the west shore were the two currents merge. Thus, it can be assumed that any reduction of sediment loading to tributaries on the east end of the lake will slow littoral zone expansion on the west end of Big Green Lake (Donohue, 1978).

Bacteriological Evaluation

The recommended water quality health standard used by the Green Lake Sanitary District for fecal coliform contamination is "the fecal coliform density of a single sample shall not exceed 1,000 organisms per 100 milliliters (ml)". In 1987 bacterial monitoring of Big Green Lake was expanded to include enterococcus organisms. Enterococcus organisms are thought to be a more reliable indicator of human fecal contamination in a waterbody. The water quality health standard for enterococcus is "a single sample should not exceed 61 enterococcus organisms per 100 ml".

Fecal coliform bacteria levels have been variable over the last 11 years. Samples exceeding the recommended water quality standard decreased from 1984 to 1986, but since 1986 have shown variable increases (See Figure 7 & Table 5). Reich Mobile Home Park historically has had levels exceeding the water quality recommendation. Between 1980 and 1985 the average fecal coliform levels averaged 2,441 colonies per 100ml. Between 1986 and 1991 the average coliform concentration per sample was 365 colonies/100ml. This trend is observed at the other sample locations but not to the same degree.

Enterococcus standard exceedances have shown a slight increase over the last four years, but more importantly, have made up the majority of water quality violations. Percentage of bacterial samples exceeding the recommended water quality standard constituted by enterococcus bacteria was: 1988 = 77%, 1989 = 78%, 1990 = 71%, and 1991 = 94%.

TRIBUTARY RESULTS

White Creek

White Creek is a springfed creek, and was rated as a Class I trout stream in 1971. White Creek originates from a spring at the end of Craig Road and flows approximately .9 miles before it enters Big Green Lake (See Figure 8). An intermittent branch enters White Creek approximately 1/2 mile from it's mouth. White Creek receives drainage from woodlands, cash cropping, and animal concentration areas (Donohue, 1978).

Habitat Assessment

White Creek was found to have a stream system habitat rating of 166 (Fair). The habitat assessment identified three significant sources of soil erosion and are reflected in the final habitat rating: sparse forest floor vegetation, gully, and streambank erosion.

For the habitat assessment, White Creek was broken into four sections and each section was individually assessed (See Figure 8). White Creek initially flows through a very dense forest with sparse undergrowth (Section 1) and exits into a marsh area. After flowing through a small grass area, White Creek enters a 1/4 mile uncultivated stretch (Section 2). White Creek then enters another densely forested area (Section 3) and finally enters Big Green Lake below Spring Grove Road (Section 4). The individual stream habitat ratings for each section were: Section 1 (185 = Poor), Section 2 (149 = Fair), Section 3 (185 = Poor), and Section 4 (146 = Fair). The individual ratings were then averaged together to derive the stream rating of (166 = Fair).

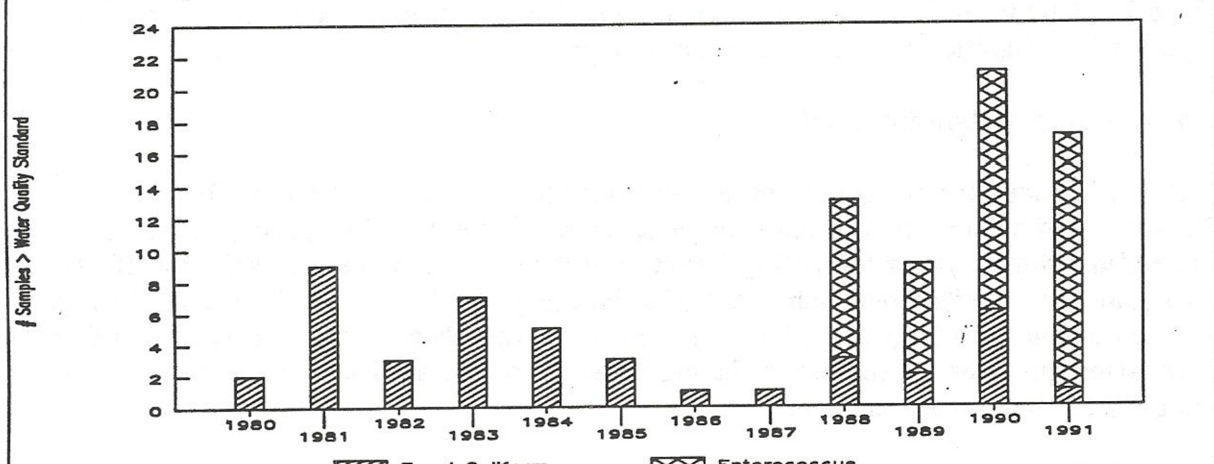
Table 5. **Bacterial beach monitoring (Yearly Averages)**
(Big Green Lake)

DATE	PILGRIM CAMP FC	PILGRIM CAMP E	COUNTY PARK FC	COUNTY PARK E	HATTIE SHERWOOD FC	HATTIE SHERWOOD E	REICH MOBILE FC	REICH MOBILE E	CAMP GROW FC	CAMP GROW E
1978	12	-	12	-	-	-	-	-	-	-
1979	24	-	29	-	4	-	208	-	5	-
1980	45	-	47	-	21	-	1717	-	55	-
1981	2850	-	915	-	12	-	4276	-	23	-
1982	155	-	52	-	14	-	710	-	26	-
1983	7	-	104	-	707	-	2039	-	8	-
1984	113	-	78	-	145	-	2164	-	92	-
1985	33	-	190	-	7	-	1302	-	21	-
1986	35	-	73	-	12	-	232	-	2	-
1987	15	40	210	14	11	10	167	320	6	10
1988	31	562	856	83	23	545	139	255	188	57
1989	104	10	126	44	58	10	486	111	17	6
1990	207	118	112	42	27	4	854	331	20	9
1991	233	52	68	34	25	37	309	110	27	44

* FC = Fecal Coliform   E = Enterococcus   Units = Coliform/100ml

Source: Green Lake Sanitary District

Figure 7. **Fecal Coliform & Enterococcus samples above the recommended water quality standard.**
Big Green Lake



The three main factors determining the habitat rating of "Fair" for White Creek are:

- **Insufficient forest floor vegetation:** has resulted in extensive sheet and rill erosion throughout Sections 1 and 3. A dense forest canopy has almost completely shaded the understory (70-80 percent) minimizing any vegetative growth. Debris dams commonly cause overflowing of the lower bank area and augment an already deleterious situation.

- **Bank erosion:** is common in open areas left fallow (Section 2). The topsoil composition of Section 2 is a silt loam with a depth ranging from three to four feet. White Creek has down-cut through this easily erodible silt loam top and this action has resulted in severely undercut sloughing banks.

- **Gully erosion:** is a problem throughout most of the White Creek Watershed but in variable degrees. A small intermittent tributary entering at the junction of Sections 3 and 4 has a significant impact on White Creek. A dendritic gully system connects gullies associated with small wooded lots, road ditches, and fields. Gullies reaching 10-feet wide and 4-feet deep are not uncommon.

The agricultural impacts to White Creek have been minimized through BMP implementation. Some soil loss through wind, sheet, and rill erosion is inevitable, but soil loss resulting from agricultural practices have been controlled to tolerable levels.

Macroinvertebrate Assessment

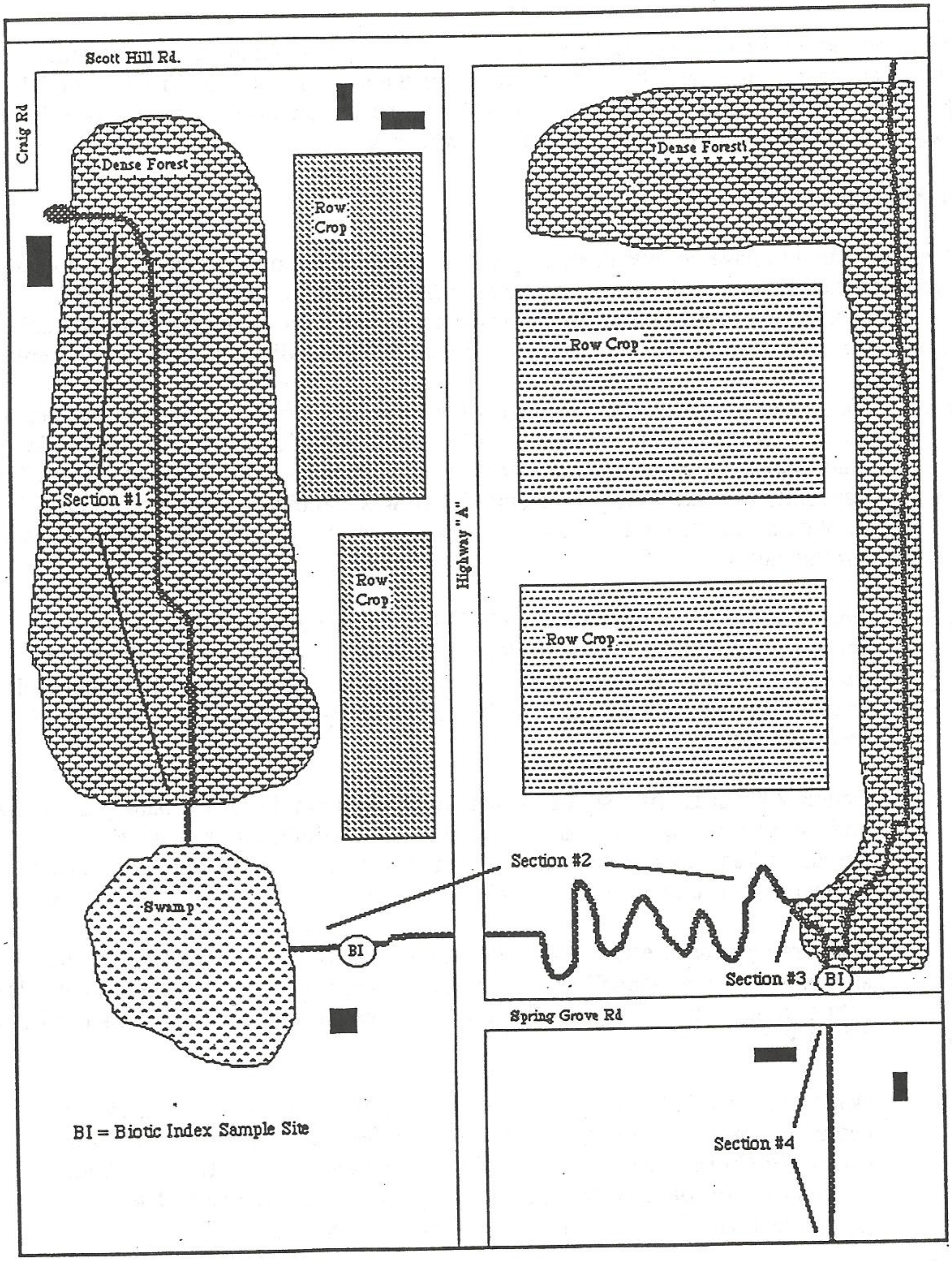
Macroinvertebrate samples were taken in duplicate at two locations on White Creek in the Spring, 1991. The two individual biotic indices from each site were then averaged together. The first sample site is located approximately 150 yards upstream of Highway "A" and the second site is located about 30 yards upstream of the intersection of White Creek and Spring Grove Road (See Figure 8).

The average biotic indices for Sample Sites 1 and 2 are 5.06 and 6.77, respectively.
The 5.06 biotic index found at Site 1 indicates good water quality with some organic pollution.
The 6.77 biotic index found at Site 2 is indicative of sites with very poor water quality and impacted by a significant source of organic pollution.

Water Gaging Station Information

A U.S.G.S. water gaging station was operated on White Creek from 1982 to 1988.
The monitored parameters included total phosphorus, ammonia, and suspended sediment.
Suspended sediment yields for the Big Green Lake Watershed have been estimated at 10-30 tons per square mile. White Creek Subwatershed sediments yields for 1982-1988, averaged 558 tons per square mile. This large deviation from the overall watershed average is best explained by the three factors previously identified by the habitat assessment; insufficient forest floor vegetation, and gully and streambank erosion.

Figure 8. **White Creek Watershed**
Big Green Lake



Hill Creek

Hill Creek, located on the southeast side of Big Green Lake, is a two-branched intermittent creek. The main branch originates from Twin Lakes and the second just south of Highway "K". The intermittent tributary joins Hill Creek approximately one quarter mile from Big Green Lake. Land uses include cash cropping, cattle pasture, and wetlands.

Habitat Assessment

Hill Creek was found to have an overall stream system habitat rating of 167 (Fair). The habitat assessment identified several sediment and nutrient loading sources including, sheet and rill erosion of farm fields and forest floors, streambank erosion, and degradation by pastured cattle. Hill Creek was broken down into six sections (See Figure 9). The individual assessments were:

Section 1. Originates at a small dam just below the Twin Lakes marsh area and continues to Lake View Road. The marsh areas filter out sediment and normalize hydraulic fluctuations; however, the marsh area is nearing its capacity which has reduced its capability to control these problems. There was significant filamentous and floating algae present indicating a source of excess nutrients. The habitat rating for this Section is 165 (Fair).

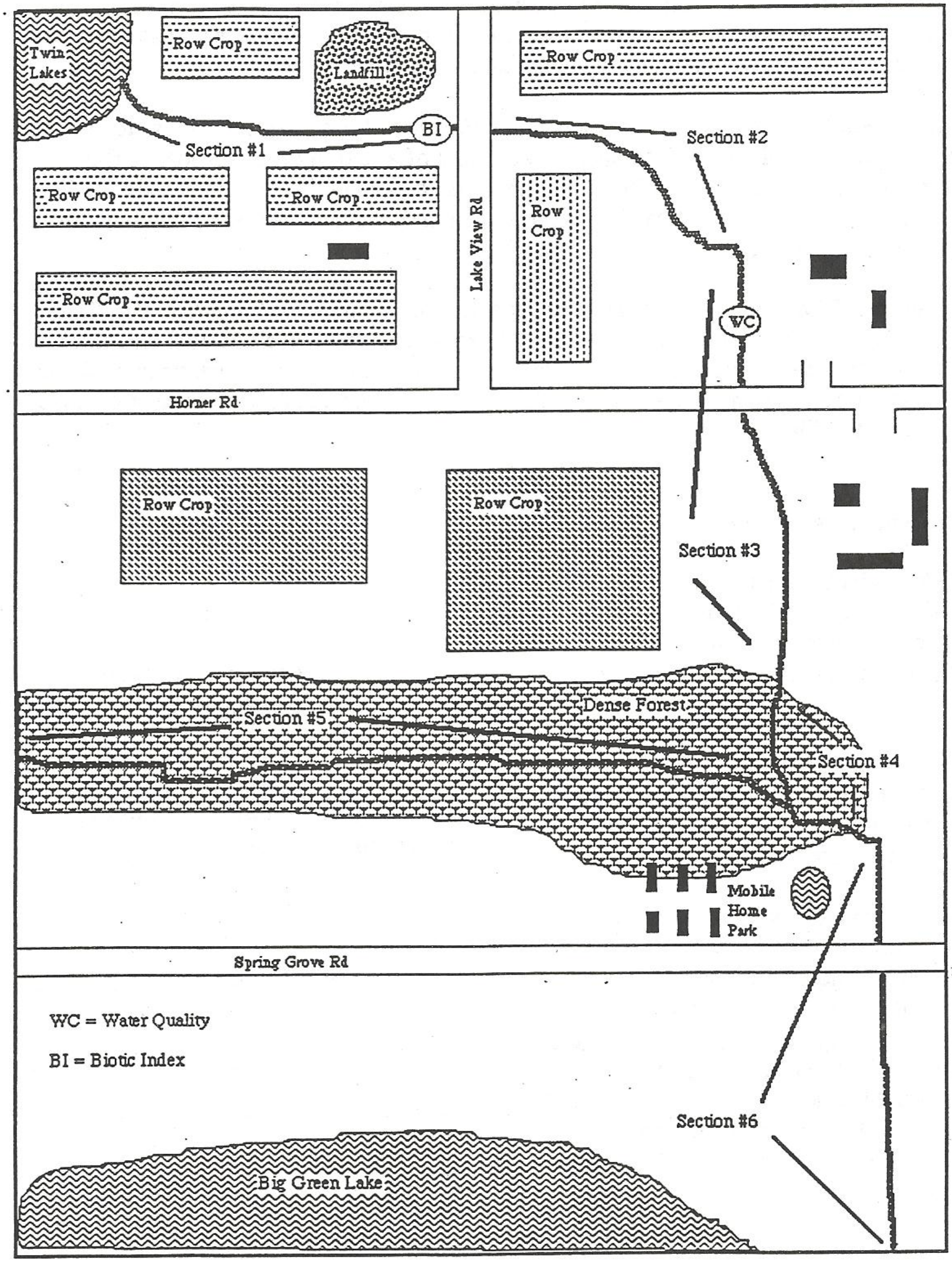
Section 2. Begins at Lake View Road and ends 200 yards upstream of Horner Road. This section is covered by a thick silt loam topsoil layer. Hill Creek has down-cut through this layer, resulting in hydraulic souring of streambanks throughout this section. The habitat rating for this Section is 157 (Fair). The silt accumulation levels average six inches.

Section 3. Begins 200 yards upstream of Horner Road and flows through a cattle pasture that ends at the wooded area. Pastured cattle result in additional nutrients to the stream system and streambank degradation. Heavy filamentous algae growth occurred throughout this entire section. The habitat rating for this Section is 201 (Poor).

Sections 4 & 5. Both are densely forested areas with minimal stabilizing undergrowth. Severe streambank, sheet, and rill erosion are the primary concerns in these sections. The habitat rating for Section 4 is 194 (Poor) and the habitat rating for Section 5 is 133 (Fair).

Section 6. Begins 50 yards below the confluence of the main stem and its tributary and continues downstream to Spring Grove Road. This section is where Hill Creek enters Big Green Lake and is primarily a backwater section. There is slight streambank erosion throughout this section and silt readily accumulates to depths greater than one foot. The habitat rating for this section is 156 (Fair).

Figure 9. **Hill Creek Watershed**
Big Green Lake



The nonpoint sources of pollution impacting Hill Creek include:

* **Insufficient forest floor vegetation:** has resulted in extensive sheet and rill erosion throughout Sections 4 and 5. A dense forest canopy has almost completely shaded the understory (70-80 percent) minimizing stabilizing vegetative growth.

* **Bank erosion:** is common in areas left fallow (Section 2 has been left fallow for many years). In Section 2 the topsoil composition consists of a nutrient rich silt loam. This depth ranges from three to four feet. Hill Creek has down-cut through this easily erodible silt loam topsoil layer. The streambanks have been undercut and in areas sloughing into the creek has occurred.

* **Agricultural impacts:** are evident in Section 1, mainly due to soil erosion. The fields are contour plowed, but there is no buffer strip separating the fields and Hill Creek. Hill Creek continues to be impacted by sheet and rill erosion. In Section 3, pastured cattle and a barnyard runoff system, contribute additional nutrients, sediment, and cause streambank degradation to Hill Creek.

Macroinvertebrate Assessment

The biotic index values for Hill Creek ranged from 6.04 (Fair) to 6.95 (Fairly Poor). The samples indicate that there is significant organic and nutrient pollution throughout the creek.

Macroinvertebrate samples were collected at three locations on Hill Creek: L-1 above Lake View road, H-1 above Horner road, and H-2 below Horner road (See Figure 9).

The macroinvertebrate analysis revealed that biotic indices decreased as they moved downstream. The farthest downstream macroinvertebrate sample location (H-2), was taken below a cattle pasture and was consistently lower (indicated lower levels of organic impact) than the samples taken above it. This data indicates this farm area is not the only major source of organics and nutrients impacting Hill Creek as was originally suspected.

Table 6. Macroinvertebrate Assessment
Hill Creek

Location	Fall 1990	Spring 1991
L−1		6.77
H−1	6.95	6.32
H−2	6.92	6.04

Water Chemistry

The original assessment strategy was to monitor water quality parameters above and below future cost-share projects, during normal and event flow periods. An event situation was defined as one or more inches of precipitation within a 24-hour period. Event peak concentrations were missed; however, because of the long collection time period (24 hours), quick responsiveness of the smaller watershed, and lengthy travel time. The data is still useful however, for above and below water quality analysis.

Water chemistry samples were collected at two evaluation sites on Hill Creek; one above and one below a future cost-share project (See Figure 9). Pastured cattle and a barnyard drainage field are the major agricultural practices impacting this stream.

The water quality analysis indicates that in general, all of the parameters (concentrations) were the same or slightly higher at the downstream evaluation site (See Table 7). This analysis indicates that there are upstream impacts associated with the Hill Creek Subwatershed. Periodically, suspended solids, fecal coliform, and streptococcus concentrations, were substantially higher at the downstream evaluation site. These parameters are commonly found in elevated concentrations in the presence of cattle. This appears to be the case at this evaluation site.

Table 7. Water Chemistry Data (Averages)
Hill Creek

	Sus. Solids	Total Soilds	Ammonia Nitrogen	Nitrate/ Nitrite	Total Phos.	Coliform	Strep.
10/2/90							
Above Horner	2.67	305.33	0.32	0.67	0.16	46.67	113.33
Below Horner	23.00	327.33	0.23	0.72	0.20	1666.67	450.00
10/15/90							
Above Horner	18.00	338.00	0.29	0.56	0.15	20.00	50.00
Below Horner	28.00	350.00	0.23	0.62	0.18	480.00	290.00
11/07/90							
Above Horner	14.67	332.00	0.06	0.50	0.13	130.00	74.67
Below Horner	18.00	280.67	0.06	0.50	0.13	105.00	170.00

*** BOD, TKN, and dissolved phosphorus data can be found in Appendix G.**

Spring Creek

Spring Creek originates at Spring Lake and flows through the County Park marshlands before it empties into the southwest end of Big Green Lake (See Figure 2). Spring Creek is 2.2 miles long and receives water from open meadows, gullies, and agricultural croplands.

Habitat Assessment

Spring Creek exhibited an average stream habitat rating of 180 (Poor). Spring Creek is impacted by heavy silt accumulation that has significantly reduced stream bottom habitat. For the habitat assessment, Spring Creek was divided into two sections. Section 1 is located upstream of Highway "K" and Section 2 is located downstream of Highway "K" (See Figure 2).

The stream habitat rating for Section 1 in Spring Creek is 195 (Poor). Heavy silt accumulation is the main factor for the "poor" rating. Silt depths greater than one foot are common throughout the entire section and silt has filled the pools and covered all beneficial bottom substrate.

The stream habitat rating for Section 2 is 165 (Fair). A steep grade in this stream allows for swift sediment transport to Big Green Lake. Silt accumulation throughout this stretch averages six inches. In some spots bottom substrate consists of sand and gravel. This section flows through a low-land swamp area. The vegetation is comprised mostly of wooded shrubs. A distinct stream channel disappears and at times transforms into sheet flow.

The sediment source is difficult to pinpoint, however, a watershed window survey revealed numerous gullies in road ditches and wooded areas. These gullies are undoubtedly major contributors to the sediment accumulation problem.

Roy and Wurches Creeks

Roy Creek is an intermittent tributary that enters the Green Lake County Park marsh area. Wurches Creek is a continually flowing stream that also enters at the marsh area. The primary land use in the Roy Creek Subwatershed is cash cropping. Croplands, wetlands, and some animal concentrations, comprise the land uses found in the Wurches Creek Subwatershed.

Habitat Assessment

The entire reaches of Roy and Wurches Creeks were not evaluated, but were assessed at their intersections with Highway "O" and Highway "B" respectively. These spot checks revealed nonpoint source pollution problems similar to those characterized in the previous subwatersheds. Because of this similarity, assessments of the entire streams were not performed. Roy Creek had a stream habitat rating of 177 (Poor) and Wurches Creek had a stream habitat rating of 201 (Poor).

Roy Creek

The Roy Creek assessment was conducted on approximately one quarter mile sections, upstream and downstream of its intersection with Highway "O". The upstream section was characterized by heavy silt accumulation and deposition. Roy Creek had cut through the silt loam top soil and hydraulic scour of streambanks was occurring in several areas. Severe bank sloughing was visible in many areas. Row crops (corn) were grown within 10 feet of the creek. The field was contour plowed, however, sediment erosion problems still existed. The field was not under cost-share agreement and soil erosion could easily be reduced by allowing for a buffer strip between the field and stream. Downstream of Highway "O", Roy Creek flows through a dense forest and exhibited many of the nonpoint source problems discussed previously (i.e. heavily shaded, debris dams, sheet and rill erosion).

Wurches Creek

The Wurches Creek assessment was conducted above and below its intersection with Highway "B". The visible upstream section of Wurches Creek is accompanied by a barnyard where cost-share BMPs have been installed. However, cattle are pastured in the immediate stream area and contribute to nutrient input and streambank degradation. Small sections of row cropping were observed near the stream course. A wetland area, dominated by small shrubs lies at the entrance of the Wurches Creek lower section. Most silt accumulation into the creek is a result of upstream impacts.

Silver and Dakin Creeks

Silver and Dakin Creeks were not included in this Big Green Lake Watershed assessment. Silver Creek was not assessed for the following reasons:

* The city of Ripon (specifically, the Ripon wastewater treatment plant and urban runoff) contributes a substantial amount of point and nonpoint source pollution.

* Silver Creek is Big Green Lake's largest subwatershed and has a very low level of participation.

* Due to the above points, any change in Silver Creek's water quality would be difficult to correlate to the Priority Watershed Program.

Dakin Creek was not assessed for the following reasons:

* There is limited access to Dakin Creek.

* Any change in Dakin's Creek water quality would be difficult to attribute to BMP installations, due to a low level of participation in the Priority Watershed Program.

CONCLUSIONS

This Big Green Lake Priority Watershed Project evaluation concludes that, although all of the cost-share projects are not completed, nonpoint source pollution derived from agricultural origin, has been adequately controlled by best management practices where they have been installed and properly maintained. With the additional projects gained through the supplementary sign-up period in 1988, participation levels will be within the projected 75 percent success rate.

The habitat assessments and soil analysis revealed additional sources of nutrients and sediment, including bare forest floors resulting from dense forest canopies, extensive intermittent gully systems, and downcuttting through the rich silt loam topsoil causing streambank erosion. These problems should be addressed in the future.

The Big Green Lake Priority Watershed Project original goals were to improve conditions which had been degraded and maintain areas with high water quality. Evidence that these goals were met included monitoring changes in transparency readings, bacterial levels, sedimentation, macroinvertebrate analysis, and nutrient analysis. Specifically, these changes were:

* Transparency readings in Big Green Lake have gradually increased since 1984. Average summer secchi disk readings have increased from 7.30 feet in 1984 to 15.53 feet in 1991. This indicates a change in water quality from "Good" to "Very Good" when measured by the TSI for Wisconsin lakes.

* Bacteriological samples which have exceeded the recommended water quality standard decreased from 1984 to 1986 and have since shown variable increases to date. Fecal coliform levels have been variable over the last 11 years. Enterococcus bacteria concentrations have been sampled since 1987 and levels have been variable during this time.

* Sediment additions to Big Green Lake have been reduced by BMP installation and implementation throughout the watershed. Shoreline erosion was successfully reduced by rip-rapping areas along the shoreline. Based on soil erosion models, upland best management practices reduced sediment delivery to watershed streams.

* Lake nutrient data has been highly variable over the last ten years and has not exhibited any consistent trends. Trophic state index evaluation for phosphorus indicates that water quality levels have fluctuated between "Fair" and "Poor" over the last 10 years.

* Habitat assessments indicated that installed BMPs have substantially reduced agricultural soil and nutrient additions to Big Green Lake. The assessments also identified forests, gullies, and streambank erosion as significant sediment and nutrient contributors to Big Green Lake and associated tributaries.

* Both spring and fall macroinvertebrate samples taken in 1991, indicate a fairly significant amount of organic pollution throughout the watershed.

While this report is intended to be a final examination of the Green Lake Priority Watershed Project, in actuality, it should be viewed as an interim evaluation. All BMPs will be installed by Fall, 1992. However, it will take time for the installed practices to become stabilized and for the sediment already in transport toward Big Green Lake (i.e. gullies, ditches, and streams) to be "flushed out" of the system. Another factor which must be considered is that Big Green Lake has a 21-year hydrologic residence period. Confident trends may not be available for at least twenty years. Climatic and anthropogenic variability also can have dramatic effects on water quality and must be considered in the overall evaluation. Any change in water quality will be affected by these and perhaps additional factors, making it very difficult to accurately assess water quality trends. Long term trend monitoring such as secchi disk, chlorophyll, phosphorus, coliform, etc., should continue to be monitored.

FUTURE EFFORTS

* Continue monitoring Big Green Lake using secchi disks.

* Remeasurement of Big Green Lake's Littoral Zone. Although not directly influential in improving the lake's water quality, it is a valuable tool in the evaluation of long term trends.

* Bacterial monitoring efforts exhibited that a higher percentage of the water quality violations have been due to high enterococcus counts which are indicative of human origin. The majority of the dwellings around Big Green Lake use soil absorption beds for domestic waste removal. If this trend continues (majority of violations resulting from high enterococcus counts), a study associating the impacts of seepage system waste systems and high enterococcus bacteria counts would be a worthwhile effort.

* Gully erosion continues to be a problem in the Big Green Lake Watershed primarily in areas shielded by dense forest.

The Green Lake County Department of Land Conservation has developed a pilot project which addresses this problem and should be continued. The project was initiated on Roy Creek with the objective to stabilize eroding streambanks, characteristic of many areas throughout the watershed. The project area was heavily overgrown with undesirable species of trees (mainly box elder). The stream reach that was treated was 400 feet in length. A selective cutting of box elders was done in an effort to reduce the forest canopy and expose the understory to more sunlight. Debris dams were removed and steep streambanks were graded back where possible. Red Fescue was then seeded into the bank areas and has since overwhelmingly taken hold. This effort has resulted in excellent stabilized streambanks, and reduced sheet and rill erosion.

The Roy Creek project was a cooperative effort between the Green Lake County Land Conservation Department and Wisconsin Conservation Corps. Future efforts on Roy Creek include riprapping of two steep banks on the stretch that could not be graded by hand, and maintenance of the stream section through the "Adopt-A-Stream Program". This program needs to be expanded to other problem areas in the watershed to reduce this significant source of sediment.

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APPENDICES
(Bulk Data)

Appendix A.

Secchi Disk Measurements: 1972–1991
Big Green Lake (East and West Basins)

1972	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
13–Jun–72	2.90	—
21–Jun–72	11.50	13.10
27–Jun–72	16.40	—
03–Jul–72	18.00	14.80
11–Jul–72	10.70	—
18–Jul–72	16.40	16.40
25–Jul–72	0.40	16.40
08–Aug–72	11.48	16.40
# Samples	11	8
Range	0.40–18.00	13.10–25.00
Average Depth	10.97	15.42

1977	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
13–May–77	6.89	10.17
02–Jun–77	9.84	14.11
09–Jun–77	24.61	24.28
27–Jun–77	10.50	10.83
14–Jul–77	13.78	14.76
25–Jul–77	14.44	14.76
15–Aug–77	16.73	16.73
25–Aug–77	16.73	19.36
22–Sep–77	13.45	18.37
28–Sep–77	19.69	19.36
12–Oct–77	12.14	15.09
26–Oct–77	19.03	22.64
31–Oct–77	16.40	21.33
# Samples	13	13
Range	6.90–24.61	10.02–24.28
Average Depth	14.94	17.06

1980	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
16–Apr–80	13.12	13.12
30–Apr–80	9.84	15.09
21–May–80	4.92	3.94
29–May–80	5.91	4.92
10–Jun–80	3.94	5.91
24–Jun–80	18.04	17.06
01–Jul–80	14.11	11.15
08–Jul–80	12.14	13.12
15–Jul–80	12.14	13.12
22–Jul–80	8.86	11.15
29–Jul–80	12.14	12.14
02–Aug–80	12.14	—
06–Aug–80	7.87	9.84
26–Aug–80	5.91	8.86
03–Sep–80	5.91	6.89
09–Sep–80	7.87	8.86
10–Sep–80	8.86	9.84
17–Sep–80	12.14	14.11
23–Sep–80	9.84	15.09
07–Oct–80	14.11	18.04
# Samples	20	19
Range	6.90–24.61	3.94–18.04
Average Depth	9.99	11.17

1981	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
15–Apr–81	7.00	7.00
21–Apr–81	7.00	11.00
27–Apr–81	7.00	11.00
12–May–81	14.00	8.00
27–May–81	4.00	5.00
03–Jun–81	4.00	6.00
10–Jun–81	6.00	7.00
16–Jun–81	—	7.00
22–Jun–81	13.00	12.00
29–Jun–81	15.00	14.00
06–Jul–81	14.00	16.00
13–Jul–81	14.00	15.00
30–Jul–81	—	13.00
03–Aug–81	18.00	19.00
10–Aug–81	13.00	15.50
17–Aug–81	14.00	12.50
31–Aug–81	10.00	12.00
16–Sep–81	10.00	11.00
29–Sep–81	10.00	13.00
07–Oct–81	12.00	17.00
21–Oct–81	12.00	18.50
27–Oct–81	16.00	21.00
03–Nov–81	25.00	30.00
# Samples	21	23
Range	4.00–25.00	5.00–30.00
Average Depth	11.67	13.11

1982	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
27–Apr–82	12.00	14.50
11–May–82	—	10.00
18–May–82	5.00	5.00
26–May–82	5.00	—
03–Jun–82	5.00	—
07–Jun–82	—	4.00
11–Jun–82	—	6.00
28–Jun–82	18.00	17.00
07–Jul–82	—	13.00
16–Jul–82	13.00	13.00
23–Jul–82	12.00	14.00
30–Jul–82	10.00	10.00
06–Aug–82	11.00	12.00
13–Aug–82	13.00	14.00

Secchi Disk Measurements: 1972–1991
Big Green Lake (East and West Basins)

1982	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
07–Sep–82	13.00	14.00
16–Sep–82	18.00	19.00
24–Sep–82	18.00	18.00
30–Sep–82	15.00	19.00
08–Oct–82	16.00	16.00
15–Oct–82	13.00	19.00
26–Oct–82	17.00	16.00
# Samples	17	19
Range	5.00–18.00	4.00–19.00
Average Depth	12.59	13.34

1983	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
08–Apr–83	16.00	20.00
19–Apr–83	14.00	16.00
28–Apr–83	14.00	17.00
06–May–83	12.00	16.00
10–May–83	12.00	12.00
20–May–83	14.00	6.00
26–May–83	6.00	6.00
02–Jun–83	5.00	5.00
09–Jun–83	7.00	—
14–Jun–83	—	5.00
22–Jun–83	11.00	9.00
01–Jul–83	20.00	25.00
06–Jul–83	16.00	16.00
13–Jul–83	—	10.00
20–Jul–83	8.00	10.00
27–Jul–83	7.00	9.00
05–Aug–83	12.00	13.00
08–Aug–83	16.00	17.00
10–Aug–83	15.00	—
12–Aug–83	15.00	16.00
19–Aug–83	14.00	17.00
23–Aug–83	16.00	17.00
31–Aug–83	12.00	18.00
08–Sep–83	12.00	14.00
14–Sep–83	14.00	16.00
21–Sep–83	—	14.00
13–Oct–83	14.00	18.00
31–Oct–83	11.00	16.00
# Samples	25	26
Range	5.00–20.00	5.00–25.00
Average Depth	12.52	13.77

1984	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
02–May–84	10.00	12.00
11–May–84	6.00	8.00
18–May–84	5.00	6.00
25–May–84	4.00	4.00
15–Jun–84	5.00	4.00

1984	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
25–Jun–84	6.00	7.00
03–Jul–84	11.00	10.00
11–Jul–84	13.00	11.00
18–Jul–84	6.00	8.00
25–Jul–84	6.00	8.00
02–Aug–84	8.00	8.00
08–Aug–84	7.00	7.00
15–Aug–84	7.00	7.00
23–Aug–84	6.00	8.00
05–Sep–84	8.00	10.00
14–Sep–84	8.00	10.00
19–Sep–84	8.00	—
03–Oct–84	9.00	10.00
26–Oct–84	12.00	14.00
14–Nov–84	15.00	16.00
20–Dec–84	—	16.00
# Samples	20	20
Range	4.00–15.00	4.00–16.00
Average Depth	8.00	9.20

1985	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
19–Apr–85	12.00	16.00
13–May–85	4.50	4.50
24–May–85	4.50	5.00
05–Jun–85	7.00	8.00
14–Jun–85	21.00	21.00
19–Jun–85	15.00	24.00
26–Jun–85	9.50	11.50
02–Jul–85	9.00	8.50
10–Jul–85	7.50	8.50
17–Jul–85	6.50	6.50
31–Jul–85	8.00	—
07–Aug–85	6.50	7.00
14–Aug–85	7.00	7.50
21–Aug–85	6.00	7.50
28–Aug–85	6.00	7.00
03–Sep–85	6.50	6.50
11–Sep–85	7.50	8.00
13–Sep–85	9.00	9.00
18–Sep–85	10.00	11.00
25–Sep–85	11.00	12.00
02–Oct–85	12.00	21.00
09–Oct–85	14.00	23.00
16–Oct–85	12.50	24.00
25–Oct–85	13.00	18.00
30–Oct–85	14.00	19.00
# Samples	25	24
Range	4.50–21.00	4.50–24.00
Average Depth	9.58	12.25

Secchi Disk Measurements: 1972–1991
Big Green Lake (East and West Basins)

1986	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
02–May–86	9.00	12.50
07–May–86	4.00	9.00
14–May–86	8.00	5.00
21–May–86	8.00	7.00
28–May–86	6.00	7.50
04–Jun–86	4.50	5.50
11–Jun–86	7.00	—
17–Jun–86	13.00	19.00
26–Jun–86	12.00	14.00
02–Jul–86	6.00	7.00
08–Jul–86	6.00	9.00
16–Jul–86	8.00	10.00
23–Jul–86	7.00	8.00
31–Jul–86	8.00	9.00
05–Aug–86	8.00	9.50
12–Aug–86	10.00	13.00
20–Aug–86	8.00	11.00
27–Aug–86	7.00	9.50
03–Sep–86	10.50	11.50
12–Sep–86	3.00	12.00
19–Sep–86	8.00	10.00
24–Sep–86	5.00	9.00
01–Oct–86	12.00	14.00
15–Oct–86	16.00	18.00
# Samples	24	23
Range	3.00–16.00	5.00–19.00
Average Depth	8.08	10.43

1987	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
08–Apr–87	13.00	16.00
29–Apr–87	7.50	10.00
13–May–87	6.50	6.50
20–May–87	5.50	6.00
28–May–87	5.00	5.00
03–Jun–87	8.00	8.00
10–Jun–87	12.00	10.00
17–Jun–87	16.00	16.00
24–Jun–87	14.00	14.00
30–Jun–87	8.00	7.00
08–Jul–87	7.00	7.00
15–Jul–87	6.50	6.00
22–Jul–87	8.00	8.00
28–Jul–87	8.00	8.00
05–Aug–87	7.75	8.00
12–Aug–87	10.00	10.00
21–Aug–87	10.00	11.50
27–Aug–87	9.00	12.00
02–Sep–87	9.00	13.00
09–Sep–87	11.00	13.00
18–Sep–87	12.00	13.00
23–Sep–87	10.00	13.00
30–Sep–87	12.00	13.00
07–Oct–87	10.50	12.00
14–Oct–87	12.00	14.50
# Samples	25	25
Range	5.00–16.00	5.00–16.00
Average Depth	9.53	10.42

1988	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
29–Apr–88	15.00	17.00
05–May–88	10.00	5.00
12–May–88	6.00	9.50
18–May–88	6.50	8.00
25–May–88	5.75	6.00
01–Jun–88	6.00	5.50
14–Jun–88	13.25	12.50
21–Jun–88	11.50	13.50
28–Jun–88	9.00	9.50
12–Jul–88	6.50	7.00
19–Jul–88	8.00	9.00
26–Jul–88	9.75	9.75
02–Aug–88	7.50	9.00
16–Aug–88	11.50	11.75
30–Aug–88	9.50	12.25
09–Sep–88	12.00	12.25
15–Sep–88	12.25	13.50
24–Sep–88	11.00	13.50
30–Sep–88	13.25	14.00
12–Oct–88	12.25	14.75
# Samples	20	20
Range	5.75–15.00	5.00–17.00
Average Depth	9.83	10.66

1989	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
11–May–89	13.50	14.25
02–Jun–89	4.00	7.25
08–Jun–89	3.25	4.25
16–Jun–89	7.50	9.25
21–Jun–89	14.00	15.25
29–Jun–89	18.00	23.00
05–Jul–89	14.25	18.75
17–Jul–89	13.25	13.00
28–Jul–89	10.50	11.50
02–Aug–89	9.50	9.00
10–Aug–89	10.25	12.00
18–Aug–89	12.25	16.50
30–Aug–89	14.75	18.00
07–Sep–89	13.00	18.00
22–Sep–89	17.50	21.00
29–Sep–89	15.50	19.00
04–Oct–89	15.75	20.25
23–Oct–89	17.50	19.75
# Samples	18	18
Range	3.25–18.00	4.25–23.00
Average Depth	12.46	15.00

Secchi Disk Measurements: 1972–1991
Big Green Lake (East and West Basins)

1990	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
21-Mar-90	7.50	22.00
23-May-90	11.75	7.75
30-May-90	5.50	5.00
07-Jun-90	4.00	5.50
14-Jun-90	6.00	5.75
21-Jun-90	7.00	7.50
27-Jun-90	10.00	11.25
05-Jul-90	19.25	22.00
11-Jul-90	11.00	12.00
19-Jul-90	11.75	11.50
24-Jul-90	9.75	10.50
01-Aug-90	13.75	13.00
09-Aug-90	10.75	11.75
16-Aug-90	11.50	12.50
22-Aug-90	14.00	15.00
30-Aug-90	14.75	17.75
06-Sep-90	15.50	17.25
13-Sep-90	17.00	21.50
20-Sep-90	16.00	24.00
26-Sep-90	21.50	23.50
11-Oct-90	22.00	22.25
19-Oct-90	14.75	22.50
24-Oct-90	18.25	26.00
# Samples	23	23
Range	4.00-22.00	5.00-26.00
Average Depth	12.75	15.12

1991	EAST BASIN Secchi Depth (Feet)	WEST BASIN Secchi Depth (Feet)
14-May-91	4.50	4.75
24-May-91	5.25	5.50
31-May-91	5.10	5.00
06-Jun-91	8.50	12.00
13-Jun-91	25.00	29.50
20-Jun-91	26.50	30.50
27-Jun-91	9.00	10.00
02-Jul-91	11.50	11.00
09-Jul-91	8.00	10.00
19-Jul-91	12.00	13.00
23-Jul-91	8.50	14.25
30-Jul-91	14.00	12.00
06-Aug-91	12.50	13.25
13-Aug-91	15.50	16.00
21-Aug-91	16.50	17.00
28-Aug-91	20.00	19.00
04-Sep-91	18.00	18.00
20-Sep-91	18.00	22.25
10-Oct-91	16.00	25.00
# Samples	19	19
Range	4.50-26.50	4.75-30.50
Average Depth	13.39	15.16

APPENDIX B.

Bacterial Beach Sampling: 1979–1991
Fecal Coliform

1979	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
13–Jun–79	4	16	—	211	—	—
20–Jun–79	70	36	—	—	—	—
11–Jul–79	3	—	5	—	—	—
18–Jul–79	0	15	1	3	—	—
26–Jul–79	52	124	1	238	—	—
01–Aug–79	7	10	2	—	—	—
08–Aug–79	33	19	14	379	—	—
15–Aug–79	1	5	0	—	—	—
22–Aug–79	43	20	8	—	5	—
# of Samples	9	8	7	4	1	—
Range	0–70	5–124	0–14	3–379	—	—
Yearly Avg.	24	29	4	208	5	—
# > WQS *	0	0	0	0	0	—

1980	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
04–Jun–80	0	0	0	0	—	—
11–Jun–80	—	6	6	20	—	—
17–Jun–80	8	80	10	27	—	6
25–Jun–80	69	169	4	199	—	8
02–Jul–80	18	36	6	26	1	10
09–Jul–80	5	13	19	32	0	8
16–Jul–80	101	64	150	TNTC	45	55
23–Jul–80	111	44	3	79	—	0
30–Jul–80	24	2	—	10	—	18
12–Jul–80	19	5	5	134	229	17
21–Jul–80	92	14	—	TNTC	—	—
27–Jul–80	—	130	2	82	—	—
# of Samples	10	12	10	12	4	8
Range	0–11	0–169	0–150	0–TNTC	0–229	0–55
Yearly Avg.	45	47	21	1717	55	15
# > WQS *	0	0	0	2	0	0

* Water Quality Standard (Fecal Coliform) = 1,000 colonies/100ml

Bacterial Beach Sampling: 1979–1991
Fecal Coliform

1981	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
11-Jun-81	10	1	8	—	42	3
16-Jun-81	780	15	8	TNTC	30	20
25-Jun-81	2	TNTC	2	118	1	0
30-Jun-81	TNTC	38	3	138	25	3
07-Jul-81	13	178	11	TNTC	0	3
14-Jul-81	TNTC	54	3	TNTC	15	40
21-Jul-81	TNTC	35	1	TNTC	9	1
29-Jul-81	100	6	2	300	2	2
04-Jul-81	200	570	2	—	2	—
11-Jul-81	90	10	34	1800	28	12
18-Jul-81	154	70	6	203	104	150
26-Jul-81	—	12	66	206	—	44
# of Samples	11	12	12	10	11	11
Range	2-TNTC	1-TNTC	2-66	18-TNTC	0-104	1-150
Yearly Avg.	2850	915	12	4226	23	25
# > WQS *	3	1	0	5	0	0

1982	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
09-Jun-82	3	12	1	150	—	—
26-Jun-82	1	50	1	320	2	1
07-Jul-82	1070	100	4	3350	0	0
14-Jul-82	100	38	96	0	112	2
21-Jul-82	20	230	20	140	20	20
27-Jul-82	32	72	2	150	12	0
04-Aug-82	—	4	4	—	80	2
11-Aug-82	—	0	0	60	3	0
17-Aug-82	4	4	8	24	0	12
25-Aug-82	6	6	0	2200	1	0
# of Samples	8	10	10	9	9	9
Range	1-1070	0-230	0-96	0-3350	0-112	0-20
Yearly Avg.	155	52	14	710	26	4
# > WQS *	1	0	0	2	0	0

* Water Quality Standard (Fecal Coliform) = 1,000 colonies/100ml

Bacterial Beach Sampling: 1979–1991
Fecal Coliform

1983	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
01-Jun-83	0	36	—	400	0	0
08-Jun-83	10	0	—	—	0	0
15-Jun-83	2	20	130	0	1	3
23-Jun-83	5	15	4	1100	11	0
27-Jun-83	19	—	—	—	—	—
29-Jun-83	5	47	7	45	1	1
30-Jun-83	3	—	—	—	—	—
05-Jul-83	0	—	—	—	—	—
06-Jul-83	4	4	17	130	0	0
07-Jul-83	0	—	—	—	—	—
11-Jul-83	2	—	—	—	—	—
12-Jul-83	0	—	—	—	—	—
14-Jul-83	1	0	0	31	0	0
18-Jul-83	2	—	—	—	—	—
21-Jul-83	3	3	1	TNTC	0	3
25-Jul-83	1	—	—	—	—	—
28-Jul-83	0	5	6	300	0	7
27-Jul-83	0	—	—	—	—	—
29-Jul-29	8	—	—	—	—	—
04-Aug-83	2	1300	13	—	3	4
11-Aug-83	3	4	0	50	1	0
17-Aug-83	46	370	9500	13000	63	40
18-Aug-83	40	105	2200	8400	43	27
24-Aug-83	6	12	32	200	1	6
25-Aug-83	6	4	32	170	0	4
31-Aug-83	10	31	66	130	10	6
01-Sep-83	7	14	6	56	5	3
07-Sep-83	15	9	4	115	1	3
08-Sep-83	3	6	3	46	5	2
# of Samples	29	19	17	17	19	19
Range	0-46	0-1300	0-9500	0-TNTC	0-63	0-40
Yearly Avg.	7	104	707	2039	8	6
# > WQS *	0	1	2	4	0	0

* Water Quality Standard (Fecal Coliform) = 1,000 colonies/100ml

Bacterial Beach Sampling: 1979–1991
Fecal Coliform

1984	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
14–Jun–84	60	25	20	1500	40	80
21–Jun–84	25	2	250	740	0	24
27–Jun–84	110	120	22	700	150	10
05–Jul–84	0	22	0	30	11	2
12–Jul–84	150	21	22	3800	31	14
18–Jul–84	4	18	28	160	80	0
25–Jul–84	420	80	26	3300	30	4
02–Aug–84	4	12	12	200	10	4
08–Aug–84	250	400	1200	13000	510	6
15–Aug–84	2	10	10	180	9	2
23–Aug–84	220	150	4	190	140	0
# of Samples	11	11	11	11	11	11
Range	0–420	2–400	0–1200	30–13000	0–510	1–80
Yearly Avg.	113	78	145	2164	92	13
# > WQS *	0	0	1	4	0	0

1985	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
12–Jun–85	20	31	8	785	55	10
19–Jun–85	28	80	10	70	85	15
26–Jun–85	0	110	0	400	0	34
02–Jul–85	6	70	0	1220	10	0
10–Jul–85	40	30	34	350	8	4
17–Jul–85	4	187	3	145	0	6
24–Jul–85	0	0	2	20	0	0
31–Jul–85	96	540	2	63	11	24
07–Aug–85	100	847	8	11200	26	0
14–Jul–85	96	147	3	0	0	11
21–Jul–85	5	73	9	0	4	2
28–Jul–85	6	160	5	1367	50	2
# of Samples	12	12	12	12	12	12
Range	0–100	0–847	0–34	0–11200	0–85	0–34
Yearly Avg.	33	190	7	1302	21	9
# > WQS *	0	0	0	3	0	0

* Water Quality Standard (Fecal Coliform) = 1,000 colonies/100ml

Bacterial Beach Sampling: 1979–1991
Fecal Coliform

1986	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
05-Jun-86	0	20	0	443	0	0
11-Jun-86	0	0	0	1157	0	180
18-Jun-86	2	170	6	55	0	10
25-Jun-86	0	0	100	60	2	15
02-Jul-86	1	30	10	210	2	3
09-Jul-86	250	391	5	285	2	—
16-Jul-86	10	84	4	315	2	—
23-Jul-86	0	150	4	20	2	3
30-Jul-86	37	51	1	77	4	4
06-Aug-86	15	12	4	10	2	2
13-Aug-86	0	10	4	15	1	0
20-Aug-86	93	3	3	78	4	0
27-Aug-86	45	30	10	290	7	0
# of Samples	13	13	13	13	13	11
Range	0-250	0-391	0-100	10-1157	0-7	0-180
Yearly Avg.	35	73	12	232	2	20
# > WQS *	0	0	0	1	0	0

1987	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
03-Jun-87	10	1050	15	5	6	11
16-Jun-87	10	20	20	57	0	2
24-Jun-87	5	25	4	358	5	2
01-Jul-87	42	87	5	150	0	62
06-Jul-87	7	22	2	10	0	10
13-Jul-87	10	353	6	126	8	4
20-Jul-87	10	73	2	36	4	4
27-Jul-87	0	180	30	740	20	10
03-Aug-87	6	36	17	80	0	2
17-Aug-87	51	468	16	278	17	77
24-Aug-87	2	13	2	12	2	15
31-Aug-87	32	193	7	152	8	70
# of Samples	12	12	12	12	12	12
Range	0-42	13-1050	2-30	5-740	0-20	2-77
Yearly Avg.	15	210	11	167	6	22
# > WQS *	0	1	0	0	0	0

* Water Quality Standard (Fecal Coliform) = 1,000 colonies/100ml

Bacterial Beach Sampling: 1979–1991
Fecal Coliform

1988	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC	ABA FC
07–Jun–88	7	88	4	12	12	23
13–Jun–88	11	4	17	58	2	152
20–Jun–88	14	28	22	32	1	6
27–Jun–88	32	813	8	30	20	17
05–Jul–88	1	10	166	30	1133	107
11–Jul–88	79	128	5	92	90	15
18–Jul–88	181	9250	26	1120	230	4
25–Jul–88	30	300	1	230	120	6
01–Aug–88	10	45	9	27	5	2
08–Aug–88	30	340	5	40	790	34
15–Aug–88	1	80	30	120	17	26
22–Aug–88	10	15	4	10	9	8
29–Aug–88	3	28	1	5	9	10
29–Aug–88	2	5	2	5	4	2
# of Samples	14	14	14	14	14	14
Range	1–181	4–9250	1–166	5–1120	1–1133	2–152
Yearly Avg.	29	795	21	129	174	29
# > WQS *	0	1	0	1	1	0

1989	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC
01–Jun–89	>200	>200	>200	>200	>200
07–Jun–89	>200	6	13	>200	6
14–Jun–89	200	900	10	18	4
21–Jun–89	100	2	300	500	2
26–Jun–89	300	100	100	2800	4
05–Jul–89	2	12	6	24	2
10–Jul–89	14	6	16	2800	6
17–Jul–89	2	64	8	22	2
24–Jul–89	4	2	2	100	4
31–Jul–89	6	200	6	70	2
07–Aug–89	4	100	2	100	4
14–Aug–89	4	100	2	60	4
21–Aug–89	100	100	2	100	6
28–Aug–89	400	<100	100	200	10
05–Sep–89	20	<2	100	100	4
# of Samples	15	15	15	15	15
Range	2–400	2–900	2–300	18–2800	2–200
Yearly Avg.	104	126	58	486	17
# > WQS *	0	0	0	2	0

* Water Quality Standard (Fecal Coliform) = 1,000 colonies/100ml

Bacterial Beach Sampling: 1979–1991
Fecal Coliform

1990	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC
04–Jun–90	8	4	100	2600	16
11–Jun–90	1	100	1	100	2
18–Jun–90	1400	1	1	1700	100
25–Jun–90	300	1	1	300	1
02–Jul–90	12	1	1	600	2
09–Jul–90	100	12	20	200	6
14–Jul–90	200	1	1	400	1
21–Jul–90	22	200	100	100	20
28–Jul–90	10	44	6	600	4
06–Aug–90	600	18	1	3100	20
08–Aug–90	40	32	14	88	22
20–Aug–90	120	1100	34	1300	26
27–Aug–90	18	46	64	800	38
04–Sep–90	60	10	28	70	22
# of Samples	15	15	15	15	15
Range	1–1400	1–1100	1–100	70–3100	1–100
Yearly Avg.	207	112	27	854	20
# > WQS *	1	1	0	4	0

1991	Pilgrim Camp FC	County Park FC	Hattie Sherwood FC	Reich Mobile FC	Camp Grow FC
04–Jun–91	2	120	80	400	2
11–Jun–91	28	50	8	148	2
18–Jun–91	300	12	14	600	75
25–Jun–91	300	18	22	430	2
02–Jul–91	20	20	12	125	4
09–Jul–91	100	22	20	40	8
18–Jul–91	1200	18	58	130	10
23–Jul–91	600	70	20	800	80
30–Jul–91	150	180	10	650	16
06–Aug–91	140	57	14	310	34
13–Aug–91	96	22	36	100	8
20–Aug–91	80	58	50	58	26
27–Aug–91	145	300	4	36	100
04–Sep–91	100	6	6	500	8
# of Samples	14	14	14	14	14
Range	2–1200	6–300	4–80	36–800	2–100
Yearly Avg.	233	68	25	309	27
# > WQS *	1	0	0	0	0

* Water Quality Standard (Fecal Coliform) = 1,000 colonies/100ml

APPENDIX C.

Bacterial Beach Sampling: 1988–1991
Enterococcus

1988	Pilgrim Camp E	County Park E	Hattie Sherwood E	Reich Mobile E	Camp Grow E
08–Aug–88	32	180	36	100	
15–Aug–88	132	52	78	236	100
22–Aug–88	2080	50	66		10
29–Aug–88	2	50	2000	430	60
29–Aug–88	3	6	4	10	20
# of Samples	5	5	5	5	5
Range	2–2080	6–180	36–2000	10–430	10–100
Yearly Avg.	450	68	437	194	48
# > WQS *	2	1	3	3	1

1989	Pilgrim Camp E	County Park E	Hattie Sherwood E	Reich Mobile E	Camp Grow E
07–Jun–89	16	3	1	50	1
14–Jun–89	18	200	5	36	10
21–Jun–89	2	8	8	240	2
26–Jun–89	20	80	20	740	16
05–Jul–89	18	8	20	4	2
10–Jul–89	6	20	20	340	8
17–Jul–89	12	20	18	24	6
24–Jul–89	4	20	14	40	4
31–Jul–89	6	80	4	14	2
07–Aug–89	4	20	2	4	2
14–Aug–89	6	80	2	6	2
21–Aug–89	4	60	20	6	4
28–Aug–89	20	12	2	40	20
05–Sep–89	2	4	4	6	2
# of Samples	14	14	14	14	14
Range	2–20	3–200	0–20	4–740	1–20
Yearly Avg.	10	44	10	111	6
# > WQS *	0	4	0	3	0

* Water Quality Standard (Enterococcus) 61 colonies/100ml

Bacterial Beach Sampling: 1988–1991
Enterococcus

1990	Pilgrim Camp E	County Park E	Hattie Sherwood E	Reich Mobile E	Camp Grow E
04–Jun–90	2	4	12	580	4
11–Jun–90	2	6	1	140	1
18–Jun–90	1040	12	1	2560	20
25–Jun–90	20	1	1	20	1
02–Jul–90	4	4	1	160	1
09–Jul–90	8	4	1	18	8
14–Jul–90	1	4	2	26	2
21–Jul–90	1	112	1	29	2
28–Jul–90	1	140	1	64	19
06–Aug–90	120	38	2	400	24
08–Aug–90	1	62	4	30	12
20–Aug–90	440	192	6	480	6
27–Aug–90	8	1	10	116	12
04–Sep–90	6	10	8	14	12
# of Samples	14	14	14	14	14
Range	1-1040	1–192	1–12	14–2560	1–24
Yearly Avg.	118	42	4	331	9
# > WQS *	3	4	0	8	0

1991	Pilgrim Camp E	County Park E	Hattie Sherwood E	Reich Mobile E	Camp Grow E
04–Jun–91	2	75	4	40	1
11–Jun–91	32	1	28	20	6
18–Jun–91	15	30	20	62	2
25–Jun–91	18	16	10	90	4
02–Jul–91	8	21	16	60	1
09–Jul–91	42	22	20	29	4
18–Jul–91	98	70	8	23	46
23–Jul–91	114	12	18	146	30
30–Jul–91	35	19	30	78	1
06–Aug–91	80	6	50	34	32
13–Aug–91	30	16	220	15	60
20–Aug–91	50	35	40	75	25
27–Aug–91	105	150	50	710	400
04–Sep–91	100	8	4	155	10
# of Samples	14	14	14	14	14
Range	2–114	1–150	4–220	15–710	1–400
Yearly Avg.	52	34	37	110	44
# > WQS *	5	2	1	7	1

APPENDIX D.

Total Phosphorus Concentrations: 1980–1991
Big Green Lake

1980	Tot. Phos. (mg/l)
11-Jun-80	0.045
14-Jun-80	0.045
02-Jul-80	0.035
08-Jul-80	0.015
16-Jul-80	0.015
04-Aug-80	0.015
01-Sep-80	0.025
02-Sep-80	0.012
# Samples	8
Range	.012-.045
Yearly Avg.	0.026
Source	GLSD

1981	Tot. Phos. (mg/l)
04-Jun-81	0.065
11-Jun-81	0.022
29-Jun-81	0.040
30-Jun-81	0.024
07-Jul-81	0.021
21-Jul-81	0.040
21-Jul-81	0.025
04-Aug-81	0.015
19-Aug-81	0.020
01-Sep-81	0.017
14-Sep-81	0.020
# Samples	11
Range	.015-.065
Yearly Avg.	0.028
Source	GLSD & DNR

1982	Tot. Phos. (mg/l)
01-Jun-82	0.039
14-Jun-82	0.031
19-Jul-82	0.018
16-Aug-82	0.015
01-Sep-82	0.012
03-Sep-82	0.011
# Samples	6
Range	.011-.039
Yearly Avg	0.021
Source	DNR

1983	Tot. Phos. (mg/l)
20-Jun-83	0.029
21-Jul-83	0.015
22-Aug-83	0.011
02-Sep-83	0.011
# Samples	4
Range	.011-.029
Yearly Avg	0.017
Source	DNR

1984	Tot. Phos. (mg/l)
03-Jul-84	0.013
11-Jul-84	0.060
18-Jul-84	0.080
25-Jul-84	0.030
08-Aug-84	0.020
15-Aug-84	0.020
05-Sep-84	0.040
# Samples	7
Range	.020-.130
Yearly Avg	0.038
Source	GLSD

Total Phosphorus Concentrations: 1980–1991
Big Green Lake

1985	Tot. Phos. (mg/l)
19-Jun-85	0.120
26-Jun-85	0.010
02-Jul-85	0.010
10-Jul-85	0.010
17-Jul-85	0.010
31-Jul-85	0.010
07-Aug-85	0.030
14-Aug-85	0.030
21-Aug-85	0.010
28-Aug-85	0.010
01-Sep-85	0.010
02-Sep-85	0.010
04-Sep-85	0.040
# Samples	13
Range	.010–.120
Yearly Avg.	0.024
Source	GLSD

1986	Tot. Phos. (mg/l)
17-Apr-86	0.034
03-Jun-86	0.022
24-Jul-86	0.021
# Samples	3
Range	.021–.034
Yearly Avg.	0.026
Source	DNR

1987	Tot. Phos. (mg/l)
02-Mar-87	0.020
07-Apr-87	0.021
07-Apr-87	0.023
25-Jun-87	0.012
25-Jun-87	0.027
25-Jun-87	0.063
22-Jul-87	0.012
22-Jul-87	0.010
22-Jul-87	0.013
02-Sep-87	0.011
02-Sep-87	0.009
02-Sep-87	0.095
# Samples	12
Range	.009–.063
Yearly Avg	0.026
Source	DNR

1988	Tot. Phos. (mg/l)
26-Feb-88	0.046
26-Feb-88	0.133
28-Apr-88	0.030
28-Apr-88	0.030
22-Jun-88	0.012
22-Jun-88	0.020
22-Jun-88	0.061
19-Jul-88	0.010
19-Jul-88	0.027
19-Jul-88	0.087
30-Aug-88	0.007
30-Aug-88	0.008
30-Aug-88	0.127
# Samples	13
Range	.007–.133
Yearly Avg	0.046
Source	DNR

Total Phosphorus Concentrations: 1980–1991
Big Green Lake

1989	Tot. Phos. (mg/l)
06–Mar–89	0.033
06–Mar–89	0.046
19–Apr–89	0.030
19–Apr–89	0.031
22–Jun–89	0.025
22–Jun–89	0.023
22–Jun–89	0.051
26–Jul–89	0.017
26–Jul–89	0.013
26–Jul–89	0.107
07–Sep–89	0.010
07–Sep–89	0.010
07–Sep–89	0.131
# Samples	**13**
Range	**.010–.131**
Yearly Avg.	**0.041**
Source	**DNR**

1990	Tot. Phos. (mg/l)
22–Feb–90	0.040
22–Feb–90	0.095
28–Feb–90	0.036
28–Feb–90	0.043
20–Jun–90	0.028
20–Jun–90	0.020
23–Jul–90	0.012
23–Jul–90	0.015
23–Jul–90	0.025
14–Aug–90	0.008
14–Aug–90	0.009
14–Aug–90	0.016
14–Aug–90	0.056
24–Oct–90	0.011
24–Oct–90	0.071
# Samples	**15**
Range	**.008–.095**
Yearly Avg.	**0.032**
Source	**DNR**

1991	Tot. Phos. (mg/l)
19–Feb–91	0.032
19–Feb–91	0.06
24–Apr–91	0.033
24–Apr–91	0.03
06–Jun–91	0.02
06–Jun–91	0.01
06–Jun–91	0.034
09–Jul–91	0.013
09–Jul–91	0.015
09–Jul–91	0.048
09–Jul–91	0.008
09–Jul–91	0.031
20–Aug–91	0.004
20–Aug–91	0.02
# Samples	**14**
Range	**.010–.048**
Yearly Avg	**0.026**
Source	**DNR**

APPENDIX E.

Chlorophyll a Measurements: 1980–1991
Big Green Lake

Date	Chlorophyll a (ug/l)
11-Jun-80	6.0
13-Aug-80	36.0
14-Sep-81	9.0
17-Apr-86	4.0
03-Jun-86	28.0
24-Jul-86	5.0
07-Apr-87	6.0
25-Jun-87	3.0
22-Jul-87	4.0
02-Sep-87	5.0
26-Feb-88	37.0
28-Apr-88	9.0
22-Jun-88	5.0
22-Jun-88	4.0
30-Aug-88	4.0
30-Aug-88	4.0
06-Mar-89	6.0
26-Jul-89	6.0
07-Sep-89	3.0
22-Feb-90	15.0
28-Mar-90	3.0
20-Jun-90	7.0
23-Jul-90	3.0
19-Feb-91	13.0
24-Apr-91	6.0
06-Jun-91	3.0
09-Jul-91	4.0

Year	Avg. Con (ug/l)	# Samples
1980	21.0	2
1981	9.0	1
1982	-	-
1983	-	-
1984	-	-
1985	-	-
1986	12.3	3
1987	4.5	4
1988	10.5	5
1989	5.0	3
1990	7.0	4
1991	6.5	4

Stream System Habitat Rating
Hill Creek

Rating Item	Sec. #1	Sec. #2	Sec. #3	Sec. #4	Sec. #5
Watershed Erosion	14	10	14	10	10
Watershed Nonpoint Source	14	10	16	10	10
Bank Erosion	20	8	16	20	16
Bank Vegetative Protectioin	15	9	15	18	15
Lower Bank Channel Capacity	10	10	14	10	10
Lower Bank Deposition	15	15	15	15	15
Embededness	16	16	16	16	8
Bottom Substrate Available Cover	7	7	17	17	7
Average Depth Riffles & Runs	6	18	24	24	6
Average Depth Pools	18	24	24	24	18
Ratio Pool\Riffle/run	16	16	16	16	8
Aesthetics	14	14	14	14	10
Total	165	157	201	194	133
Stream Rating	168 (Fair)				

* <64 = Excellent, 65–112 = Good, 113–175 = Fair, >176 = Poor

Stream System Habitat Rating

Rating Item	Roy	Wurches	Spring #1	Spring #2
Watershed Erosion	14	14	14	14
Watershed Nonpoint Source	14	14	14	14
Bank Erosion	16	16	16	16
Bank Vegetative Protectioin	15	18	18	15
Lower Bank Channel Capacity	14	16	16	16
Lower Bank Deposition	15	18	18	15
Embededness	16	16	16	16
Bottom Substrate Available Cover	17	17	17	7
Average Depth Riffles & Runs	6	18	18	6
Average Depth Pools	24	24	18	24
Ratio Pool\Riffle/run	16	16	16	8
Aesthetics	10	14	14	14
Total	177	201	195	165
Stream Rating	Roy (Poor)	Wurches (Poor)		Spring (Poor)

* <64 = Excellent, 65–112 = Good, 113–175 = Fair, >176 = Poor

APPENDIX I.

STREAM SYSTEM HABITAT RATING FORM

RATING ITEM	CATEGORY			
	EXCELLENT	GOOD	FAIR	POOR
Watershed Erosion	No evident of significant erosion. Stable forest or grass land. Little potential for future erosion. 8	Some erosion evident. No significant "raw" areas. Good land mgmt. practices in area. Low potential for significant erosion. 10	Moderate erosion evident. Erosion from heavy storm events obvious. Some "raw" areas. Potential for significant erosion. 14	Heavy erosion evident. Probably erosion from any run off. 16
Watershed Nonpoint Source	No evidence of significant source. Little potential for future problem. 8	Some potential sources (roads, urban area, farm fields). 10	Moderate sources (small wetlands, tile fields, urban area, intense agriculture). 14	Obvious sources (major wetland drainage, high use urban or industrial area, feed lots, impoundment). 16
Bank Erosion, Failure	No evidence of significant erosion or bank failure. Little potential for future problem. 8	Infrequent, small areas, mostly healed over. Some potential in extreme floods. 8	Moderate frequency and size. Some "raw" spots. Erosion potential during high flow. 16	Many eroded areas. "Raw" areas frequent along straight sections and bends. 20
Bank Vegetative Protection	90% plant density. Diverse trees, shrubs, grass. Plants healthy with apparently good root system. 6	70-90% density. Fewer plant species. A few barren or thin areas. Vegetation appears generally healthy. 9	50-70% density. Dominated by grass, sparse trees and shrubs. Plant types and conditions suggest poorer soil binding. 15	<50% density. Many raw areas. Thin grass, few if any trees and shrubs. 18
Lower Bank Channel Capacity	Ample for present peak flow plus some increase. Peak flow contained. W/D ration <7. 8	Adequate. Overbank flows rare. W/D ration 8-15 10	Barely contains present peaks. Occasional overbank flow. W/D ration 15-25. 14	Inadequate. Overbank flow common. W/D ration >25. 16
Lower Bank Deposition	Little or no enlargement of channel or point bars. 6	Some new increase in bar formation. Mostly from coarse gravel. 9	Moderate deposition of new gravel and coarse sand on old and some new bars. 15	Heavy deposits of fine material, increased bar development. 18
Bottom Scouring and Deposition	Less than 5% of the bottom affected by scouring and deposition. 4	5-30% affected. Scour at constructions and where grades steepen. Some deposition in pools. 8	30-50% affected. Deposits and scour at obstructions, constrictions and bends. Some filling of pools. 16	More than 50% of the bottom changing nearly year long. Pools almost absent due to deposition. 20

RATING ITEM	CATEGORY			
	EXCELLENT	GOOD	FAIR	POOR
Bottom Substrate/Available Cover	Greater than 50% rubble, gravel or other stable habitat. 2	30-50% rubble, gravel or other stable habitat. Adequate habitat. 7	10-30% rubble, gravel or other stable habitat. Habitat availability less than desirable 17	Less than 10% rubble gravel or other stable habitat. Lack of habitat is obvious. 22
Avg. Depth Riffles and Runs	Cold >1' 0 Warm >1.5' 0	6" to 1' 6 10" to 1.5' 6	3" to 6" 18 6" to 10" 18	<3" 24 <6" 24
Avg. Depth of Pools	Cold >4' 0 Warm >5' 0	3' to 4' 6 4' to 5' 6	2' to 3' 18 3' to 4' 18	<2' 24 <3' 24
Pool/Riffle, Run/Bend Ration (distance between riffles ÷ stream width)	5-7. Variety of habitat. Deep riffles and pools. 4	7-15. Adequate depth in pools and riffles. Bends provides habitat. 8	15-25. Occasional riffle or bend. Bottom contours provide some habitat. 16	>25. Essentially a straight stream. Generally all flat water or shallow riffle. Poor habitat. 20
Aesthetics	Wilderness characteristics, outstanding natural beauty. Usually wooded or unpastured corridor. 8	High natural beauty. Trees, historic site. Some development may be visible. 10	Common setting, not offensive. Developed but uncluttered area. 14	Stream does not enhance aesthetics. Condition of stream is offensive. 16
Column Totals:	_______	_______	_______	_______

Column Scores E _______ +G _______ +F _______ +P _______ = _______ = Score

<64 = Excellent, 65-112 = Good, 113-176 = Fair, >177 = Poor

OUR MISSION:

To protect and enhance our Natural Resources —
our air, land and water;
our wildlife, fish and forests.

To provide a clean environment
and a full range of outdoor opportunities.

To insure the right of all Wisconsin citizens
to use and enjoy these resources in
their work and leisure.

And in cooperation with all our citizens
to consider the future
and those who will follow us.

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