BOHNERS LAKE INLET WATERSHED STUDY

Prepared for

BOHNERS LAKE IMPROVEMENT ASSOCIATION

Town of Burlington, Racine County, Wisconsin

March 1, 1993

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BOHNERS LAKE INLET WATERSHED STUDY
Town of Burlington, Racine County, WI

EXECUTIVE SUMMARY

The preparation of the Inlet Watershed Study for Bohners Lake was prepared with a Wisconsin Department of Natural Resources, Chapter NR 119 Lake Management Planning Grant and a cooperative effort by the Bohners Lake Improvement Association, Racine County, and R. A. SMITH & ASSOCIATES, INC. The study included the mapping of inlet watershed boundaries, mapping of land use and cover along with slopes and soils. Estimates of the volume of incoming sediment were made and recommendations were made to reduce erosion from high sediment producing areas. Also, general watershed and inlet management recommendations were made.

Bohners Lake is a drainage lake with an unnamed tributary feeding it from the west. Bohners Lake lies within the Town of Burlington, Racine County, Wisconsin. The Inlet Watershed (watershed area for unnamed tributary) which this study addressed, consists of approximately 578.5 acres, of which approximately 22% (or 125.8 acres) are in agricultural use. The soils are predominately Casco, Fox and Houghton soils at average slopes of 0 to 12%.

Soil erosion and delivery to the Lake were also estimated. Sediment delivery to the stream, wetland, and Lake system for all agricultural land in the Bohners Lake watershed averaged from 57.5 tons annually for a 15% delivery ratio of 115 tons annually for a 30% delivery ratio. Eroded soils, as defined by the USDA, Soil Survey and streambank erosion were identified as two areas of soil erosion to address.

The Bohners Lake Inlet Watershed is a relatively stable and controlled drainage area with numerous wetlands acting as buffers. While cropland is not a major land use in the watershed, it does contribute a major percentage of the sediment to the stream and ultimately to the Lake. Much of the soil erosion is preventable and should be directed to the landowners affecting water quality. Voluntary cooperation in non-point source pollution control would be the most beneficial to all parties. However, in the event that cooperation is not realized, the Lake Association should take their own measures to prevent the further degradation of Bohners Lake. The following recommendations are made in the order of importance. For all recommendations, the Bohners Lake Improvement Association will have to be the facilitator between the landowners, agencies, and lake residents.

Watershed management recommendations are made to encompass both short-term maintenance issues and long-term management problems. Priority 1 recommendations include: Land Use/Cropping Changes, Buffer Strips, Grassed Waterways, Construction Site Erosion Control, and Water Quality Monitoring. Priority 2 recommendations include: a Box Inlet Spillway and Maintenance Dredging. The Priority 3 recommendation is Wetland Preservation. Other recommendations have been made but have not been ranked as high a priority because of their cost, effectiveness at reducing pollutants, and the likelihood of implementation.

The implementation of management practices can be coordinated with the Racine County Land Conservation Department. There may be money available for the landowner which may improve participation in what would be a voluntary program. These projects could be done with no cost to the Lake Association. However, because these are voluntary programs, landowner participation must be encouraged by possibly having the Lake Association sponsor and fund a project where a landowner was unwilling to participate. This could be handled in a way such that the Lake Association could lease some of a farmer's land along a stream and plant it to native grasses. This way the farmer is getting paid for his loss of production and water quality is improved. These types of arrangements have other benefits. The buffer strip can provide additional wildlife habitat and helps foster a cooperative relationship between the Lake Association and the landowners.

It should be noted the Watershed and Lake Management Practices and their attendant priorities are based on several factors. One factor is the ease in which a particular recommendation can be implemented. Some solutions are more long term and may take years of planning, selling, and implementation before the results can be seen. Also, some recommendations are more costly and may take several years of planning just to obtain financing.

THE BOHNERS LAKE INLET WATERSHED STUDY
TOWN OF BURLINGTON, RACINE COUNTY, WISCONSIN

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1. Background

1.1 Bohners Lake

Bohners Lake is a small, moderately shallow Lake located in the Town of Burlington, Racine County, Wisconsin. It has a surface area of 135.4 acres and a water volume of 1,243 acre-feet at a surface elevation of 801.8 feet above mean sea level. Though it has limited surface area, its immediate environs are among the most intensively developed in the Fox River watershed. The many year-round dwellings near the Lake attest to its recreational and economic value to the region. To assure these values for the future; provisions for the protection, development, and wise use of this resource are necessary.[1]

1.2 Bohners Lake Improvement Association

The Bohners Lake Improvement Association was formed in the 1970s to act as a voice for the Lake and to make improvements on and around the Lake without raising taxes. To date, the Association has been very successful in implementing a weed harvesting program, an inlet clean-out project, and ongoing water quality sampling. This Lake Planning Grant project is just another of many projects the Lake Association is sponsoring.

1.3 Lake Planning Grant - The Bohners Lake Inlet Watershed Study

Reason for Project

The reason for this project is to evaluate the hydrology and sedimentology of the watershed and inlet to Bohners Lake. The inlet of the Lake is nearly full of sediment. Because the inlet has filled with sediment, its trap efficiency has been greatly reduced, sending new sediment into the Lake and decreasing water quality. Also, watershed erosion continues to provide sources of these new sediments.

Project Goals

The goals of this project are as follows:

1. Identify sources of sediment in the inlet watershed.
2. Determine soil parameters in the inlet watershed.
3. Determine trap efficiency of the existing inlet.
4. Determine sediment characteristics in the Lake at the inlet.
5. Determine the feasibility of a sediment basin at the inlet of Bohners Lake.

[1] Bohners Lake--Lake Use Report No. FX-25, Wisconsin Department of Natural Resources, 1969.

Project Description

The Lake Planning Grant has eight major components listed below:

1. The watershed boundary will be determined and delineated.
2. Land use and land cover will be mapped along with slopes, soils, and rainfall data.
3. Two upland soil samples and four lake sediment samples will be taken at times and locations described in the revised sampling program prepared by R. A. SMITH & ASSOC., INC. The sample analysis will include; grain-size analysis, percent solids, moisture content, total organic C, NO2, NH3, N, TKN, total P, K. As, Ca, Cl, Cu, Mg, Na, pH, and SO4.
4. Volume and characteristics of sediment entering the Lake will be estimated.
5. Recommendations for erosion reduction will be developed.
6. Trap efficiency of the inlet area will be developed.
7. The inlet will be analyzed through the CORPS of Engineers "SETTLE" computer program.
8. The final report summarizing the findings will be prepared and distributed. The data reporting format will be prepared and distributed.

2. Inlet Watershed Study Area

2.1 Lake Watershed

The entire Bohners Lake Watershed area covers 1,958 acres. See Figure 1. During the course of a year, the watershed receives 5,287 acre-feet of precipitation. Of this, 470 acre-feet is lost by evaporation from the Lake surface. Wetlands in the watershed might evaporate an additional 200 acre-feet. Presumably, seven inches of precipitation will leave the watershed as runoff, in this case, about 2,675 acre-feet or a sustained average discharge of 3.7 cfs. Since the measured discharge does not exceed this even during the spring, it can be assumed that considerable groundwater recharge and evapotranspiration occur in this watershed, lowering the average annual discharge. Since this water is returned through soil absorption treatment systems, pumpage is not a consumptive use.[1]

There are three basic classes of soils bordering Bohners Lake. North and south of the Lake, muck soils border the inlet and outlet and occupy all of the marshlands. Silt loams with moderate limitations for development border the east shore and occupy small pockets west of the Lake. In most instances, a high water table is the deterring factor in the evaluation of these soil areas. The remaining soils are loams and gravel loams with slight limitations except when occupying steep slopes. Since the area around Bohners Lake is hilly, this becomes a limiting factor. These soils are erosive on steep slopes, will not support sewage treatment systems, and may therefore contribute to groundwater contamination.[1]

[1] Bohners Lake--Lake Use Report No. FX-25, Wisconsin Department of Natural Resources, 1969.

2.2 Inlet Watershed

The purpose of this study was not to evaluate the entire Lake watershed but rather the watershed of the principal tributary to the Lake. The focus on this inlet watershed is to analyze its hydrology and sedimentology. This 578-acre "subwatershed" begins at the outlet of Dyer Lake, approximately 1.25 miles to the southwest of the inlet to Bohners Lake. See Figure 1. The unnamed tributary flows through several wetland areas and has been ditched for approximately a one-quarter mile at one point. The final half mile flow to Bohners Lake is through wooded and open wetland areas. See Figure 2. The vertical drop between Dyer Lake and Bohners Lake is 26.19 feet. The stream flow distance between the two lakes is approximately 10,800 feet. This would give an average stream gradient of 0.0024 feet or 0.24 percent. The stream gradient is not erosive itself, but may be a factor when soils and storm runoff are considered. Applying the estimated 7 inches of runoff for the inlet watershed will yield 337 acre-feet or 0.46 cfs of runoff. This estimate appears on the high side based on 1991 periodic field observations.

"This intermittent stream connects Dyer Lake with Bohners Lake in Racine County. Most of its drainage area is wetland. The watershed is mainly agricultural and much of this stream's length has been straightened and ditched for better agricultural drainage. There is some housing development near its lower sections."[2]

For the purpose of this study, the inlet watershed has been broken down in two ways. One analysis compares land use within the subwatershed while another is a hydrological breakdown. The hydrological breakdown evaluates the subwatershed in "sub" subwatershed units and each unit is further broken down by land use. This methodology used on a small watershed such as the Bohners Lake inlet, allows for easier and more accurate determination of sediment sources. The next section of this report describes the various components of the inlet watershed as a whole and the subwatersheds.

3. Land Use In the Study Area

3.1 Land Use

The land use in the inlet watershed has been broken down into four major groups: Residential, Woodland, Wetland, and Agricultural. Figure 2 illustrates the land use in the watershed. Each land use category was delineated by using a 1990 aerial photograph then field verified and calculated for inlet "sub" watershed. These subwatersheds are categorized as follows: a) lands north of Dyer Lake, b) lands west of CTH "P," c) central area with farmed organic soils, d) narrow lower region, and e) bottom land area.

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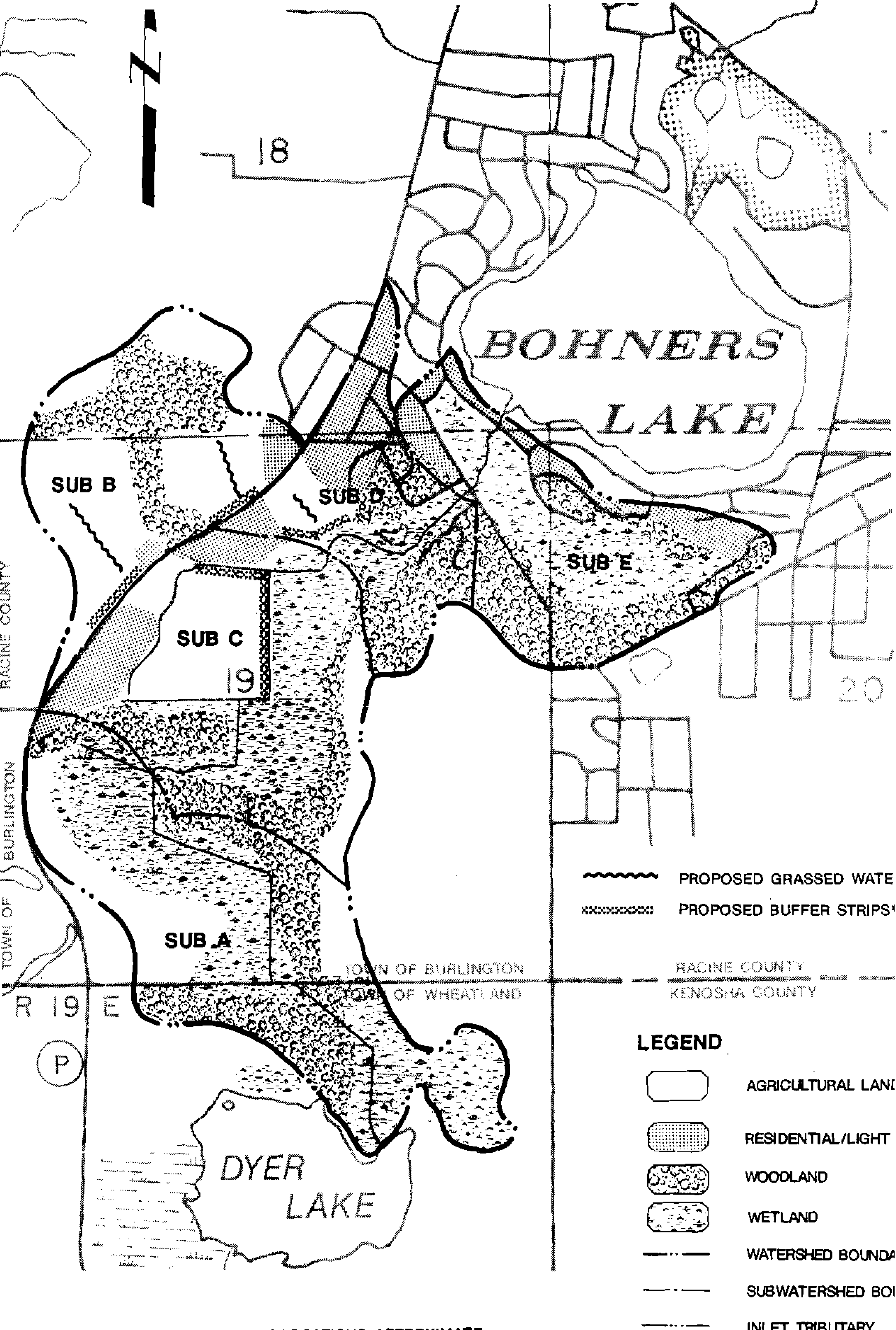
[1] Bohners Lake--Lake Use Report No. FX-25, Wisconsin Department of Natural Resources, 1969.

[2] Surface Waters of Kenosha County, Wisconsin Department of Natural Resources, 1982.



BASE MAP: SEWRPC

* LOCATIONS APPROXIMATE

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LAND USE

DRAWN BY	
CHECKED BY	
APPROVED BY	
SCALE 1"=1000'	FIG

TABLE 1
LAND USE BY SUBWATERSHED
BOHNERS LAKE INLET WATERSHED
(Acres)

LAND USE	Sub A	Sub B	Sub C	Sub D	Sub E	Total	Percent
Residential	27.5	5.2	19.9	21.4	22.3	96.3	17
Woodland	49.5	34.1	29.7	30.8	42.3	186.4	32
Wetland	69.2	0.0	47.2	9.5	44.1	170.0	29
Agricultural	8.2	60.1	49.4	8.1	0.0	125.8	22
Totals	154.4	99.4	146.2	69.8	108.7	578.5	100

From Table 1 it can be seen that the majority of the agricultural land is in Subwatersheds B and C. Also, the cropland in Subwatersheds B and C have more direct routes to the surface water system via the road or dug agricultural drainage ditches. With the exception of Subwatershed B, most of the subwatersheds have similar amounts of residential acreage. Wetland areas are most common in the upper(A), middle(B), and lower(E) subwatersheds. Woodlands are spread out through all the subwatersheds.

3.2 Soils

The predominate soils in the watershed are Casco, Fox, and Houghton muck. "The Casco series is made up of well-drained, loamy soils that are underlain by outwash sand and gravel. These soils are gently sloping on terraces and are sloping to moderately steep on morainic ridges. They generally are near the major streams in the survey area. The native vegetation is hardwood."[3] See Figure 3.

"The Fox series is made up of well-drained, loamy soils that are underlain by outwash, sand, and gravel. These nearly level to sloping soils occupy terraces near the major streams in the survey area and along the glacial beach lines that parallel the Lake Michigan shoreline. The native vegetation was hardwood forest."[3]

"The Houghton series consists of very poorly drained, deep, organic soils that developed from the remains of grasses and sedges. These nearly level soils are on flats and in broad depressions and basins. Most of the Houghton soils in this survey area are west of U.S. Highway 45. The native vegetation was water-tolerant grasses and sedges."[3]

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[3] Soil Survey, Kenosha and Racine Counties, Wisconsin, United States Department of Agriculture, Soil Conservation Service, University of Wisconsin, Wisconsin Geological and Natural History Survey, Soils Department and Wisconsin Agricultural Experiment Station.

"The first capital letter is the initial one of the soil name. A second capital letter A, B, C, D, or E, shows the slope. Most symbols without a slope letter are those of nearly level soils or land types, but some are for soils or land types that have a considerable range in slope. The final number, 2, or 3, in a symbol indicates that the soil is eroded or severely eroded."[3]

TABLE 2

LIMITATIONS OF MAJOR SOILS[3]

Soil Series	Residential Development	Onsite Sewage Disposal System
Casco	Slight on slopes of 2 to 12 percent, moderate on slopes of 12 to 20 percent, severe on slopes of more than 20 percent; slightly droughty; sloping soils are erodible.	Moderate on slopes of 2 to 12 percent and severe on slopes of more than 12 percent.
Fox "Fm" "Fo" "Fs"	Slight; sloping soils are erodible.	Moderate; danger of contaminating groundwater.
"Fs"	Moderate; sloping soils are erodible; clayey substratum has high shrink-swell potential and low bearing capacity.	Moderate; clayey substratum has slow permeability.
Houghton	Very severe; subject to shrinkage; very low bearing capacity; high water table.	Very severe; high water table.

These soils also dominate the cultivated land in the watershed. For the purpose of this study, the cultivated land is evaluated for erosion and sediment delivery. Therefore, the soil types of the agricultural land in the subwatershed become very important. Of the 125.8 acres of cropland in the watershed, 44.3 acres (35.2%) is a Casco soil, 42.0 acres (33.4%) is a Fox soil, and 34.7 acres (27.6%) is Houghton Muck. Most of the Casco soil cropland fields are smaller and steeper parcels under ten acres, while the Fox and Houghton soil fields are more concentrated into larger and more level fields. Figure 4 shows the soils distributed on cropland or agricultural fields.

[3] Soil Survey, Kenosha and Racine Counties, Wisconsin, United States Department of Agriculture, Soil Conservation Service, University of Wisconsin, Wisconsin Geological and Natural History Survey, Soils Department and Wisconsin Agricultural Experiment Station.

3.3 Slopes

The slopes of the watershed vary by land use, soil, and subwatershed. The only generalizations that could be made are that the woodland and the residential areas see the most variation in slope. While the cropland varies from 0- to 2-, 2- to 6-, and 6- to 12-percent slope ranges. Obviously, the wetland areas occupy level or nearly level lowlands. Figure 1 provides an overview of the watershed and its topography.

3.4 Hydrology

The hydrology of the watershed can best be described as having a base flow from Dyer Lake and drains wetlands and ditched crop fields along the way to Bohners Lake.

4. Soil and Sediment Analysis

4.1 Sampling Locations and Analysis

Two upland soil samples and four Lake sediment samples were taken. Four Lake samples came from within the inlet area, two samples came from the Lake side of the inlet, and two came from the west side of Shoreline Drive still within the backwater of the inlet (Figure 5). These four samples would be considered "sediment" because they are inundated 100 percent of the time. The other two samples came from upland soils (Figure 4). Sample No. 5, came from a wetland area in the lower third of the stream segment between Dyer and Bohners Lake. The wetland sample was taken because so much of the watershed is composed of wetlands. Sample No. 6 came from a cropland field located in approximately the middle of the stream segment between Dyer and Bohners Lake.

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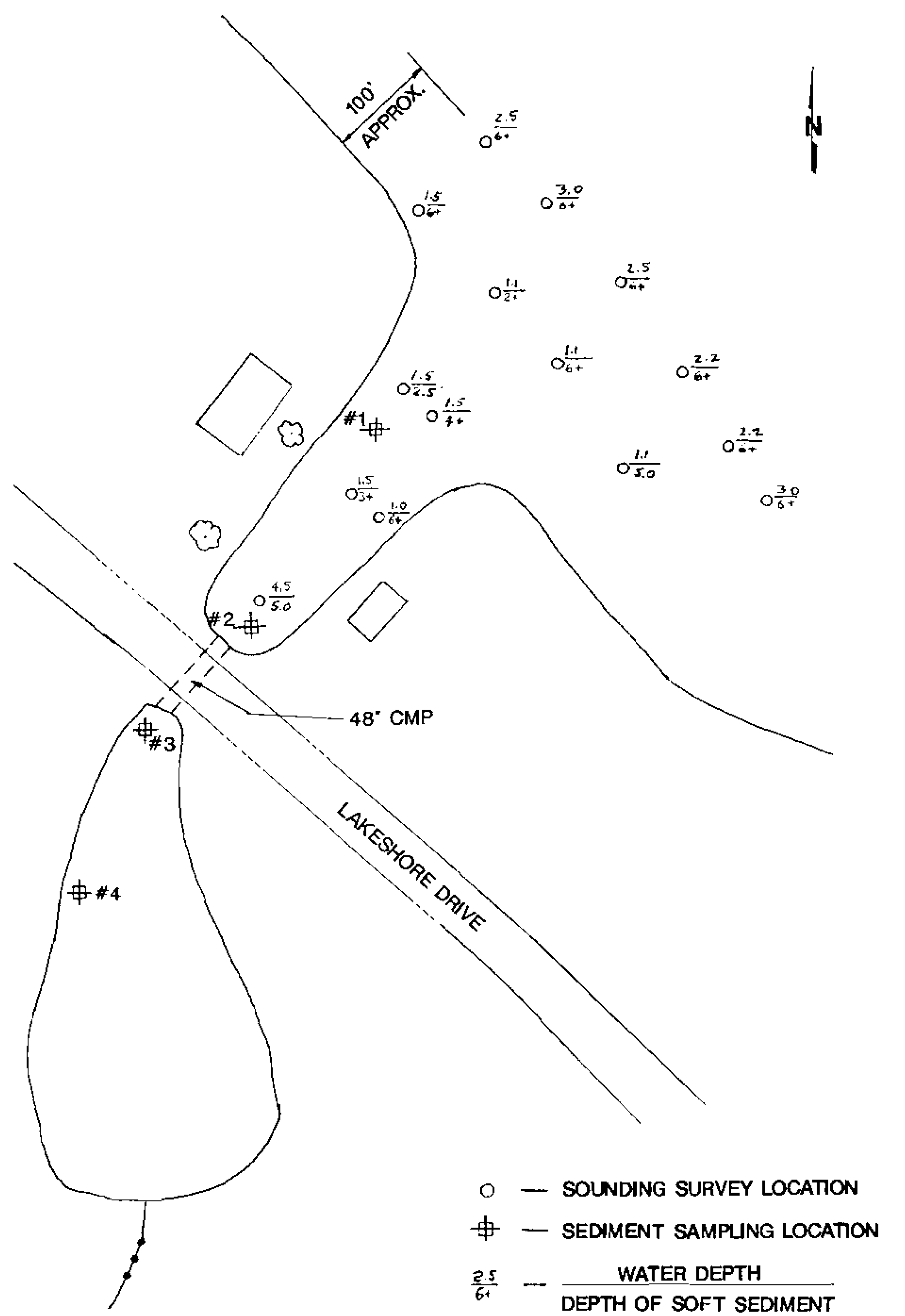
[3] Soil Survey, Kenosha and Racine Counties, Wisconsin, United States Department of Agriculture, Soil Conservation Service, University of Wisconsin, Wisconsin Geological and Natural History Survey, Soils Department and Wisconsin Agricultural Experiment Station.



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SEDIMENT SAMPLE SITES

BOHNERS LAKE INLET WATERSHED STUDY

DRAWN BY	KLS
CHECKED BY	MJD
APPROVED BY	
SCALE N.T.S.	FIGURE NO. 5
R.A.S. PROJECT NO. 91805-0-335-335	

Sediment samples were taken using a 2-inch outside diameter, stainless steel sediment corer. The corer is approximately 18 inches in length and attached to a 3/4-inch rod with one-foot increments. Samples are taken by forcing the corer into the sediment to the known depth. Samples are then recovered and extruded from the corer. The general appearance and location of the sample is noted. The samples are then placed in quart glass jars, labeled, and placed on ice at approximately 4° C. The soil samples were simple surficial grab samples also placed in glass jars and kept cool. The samples were taken to National Environmental Testing (NET) Midwest for analysis.

The sample analysis included; grain-size analysis, percent solids, moisture content, total organic C, NO2, NH3, N, TKN, total P, K. As, Ca, Cl, Cu, Mg, Na, pH, and SO4. The purpose of the sampling was to obtain the necessary data to input into computer models, to get actual soil and sediment data for comparison purposes, and to have a record of actual conditions of the sediment for future planning and assessments.

4.2 Soil and Sediment Analysis Results

All sediment and soil samples were taken by R. A. SMITH & ASSOC., INC. The samples were then sent to NET Watertown, Wisconsin, a state certified testing lab.

The test results showed that the sediment and soil were high in nutrients and very high in organic content. The analysis for the heavy metals shows no high levels that could cause concern for continued sediment removal. Some trends that were observed indicated that the pH appears to decrease in the samples tested as it travels towards the Lake. This may be explained by the possible acidic conditions that occur during plant decay under anaerobic conditions. Other nutrients and inorganic compounds vary in concentration from upland soil sites to inlet sediment locations. Table 3 is a complete listing of the analytical results. Figure 6 is a sieve analysis chart on all samples.

TABLE 3	BOHNERS LAKE INLET WATERSHED STUDY						
	Sediment Analysis Summary						
		Sample numbers					
PARAMETER	UNITS	1	2	3	4	5	6
Chloride	mg/kg	200	240	200	160	260	220
Moisture	%	82	81	86	86	27	66
N-Ammonia	mg/kg	940	500	750	690	49	760
N-Kehldahl	mg/kg	17000	14000	20000	19000	920	32000
N02 + N03	mg/kg	<2	<2	<2	<4	7.2	62
pH	units	6.89	6.93	6.86	7.05	7.41	7.56
Total Phos.	mg/kg	1100	860	310	1000	130	970
# 8 Sieve	%[1]	100	98.2	55	100	95.8	100
# 20 Sieve	%[1]	98.1	84.2	49.9	99.8	90	100
# 50 Sieve	%[1]	95.8	66.8	43.7	96.7	77.2	99.5
# 100 Sieve	%[1]	92.5	53.2	37.2	92.2	66.1	95.2
# 200 Sieve	%[1]	89.3	37.3	30.1	84.3	52.6	93.2
Total Solids	%[1]	18	22	16	16	76	38
Sulfate	mg/kg	130	7.3	80	<3	<3	<3
T. O. C.	%	>53	[2]	>53	[2]	2.6	>53
Arsenic	mg/kg	9.4	1.8	1.7	1.6	6.3	2.6
Calcium	mg/kg	8230	18600	7910	6120	5790	20900
Copper	mg/kg	14	2.6	1.9	1.6	7	3.4
Magnesium	mg/kg	13000	6840	2280	1830	3720	1460
Potassium	mg/kg	1300	182	149	142	341	444
Sodium	mg/kg	640	463	431	442	587	856

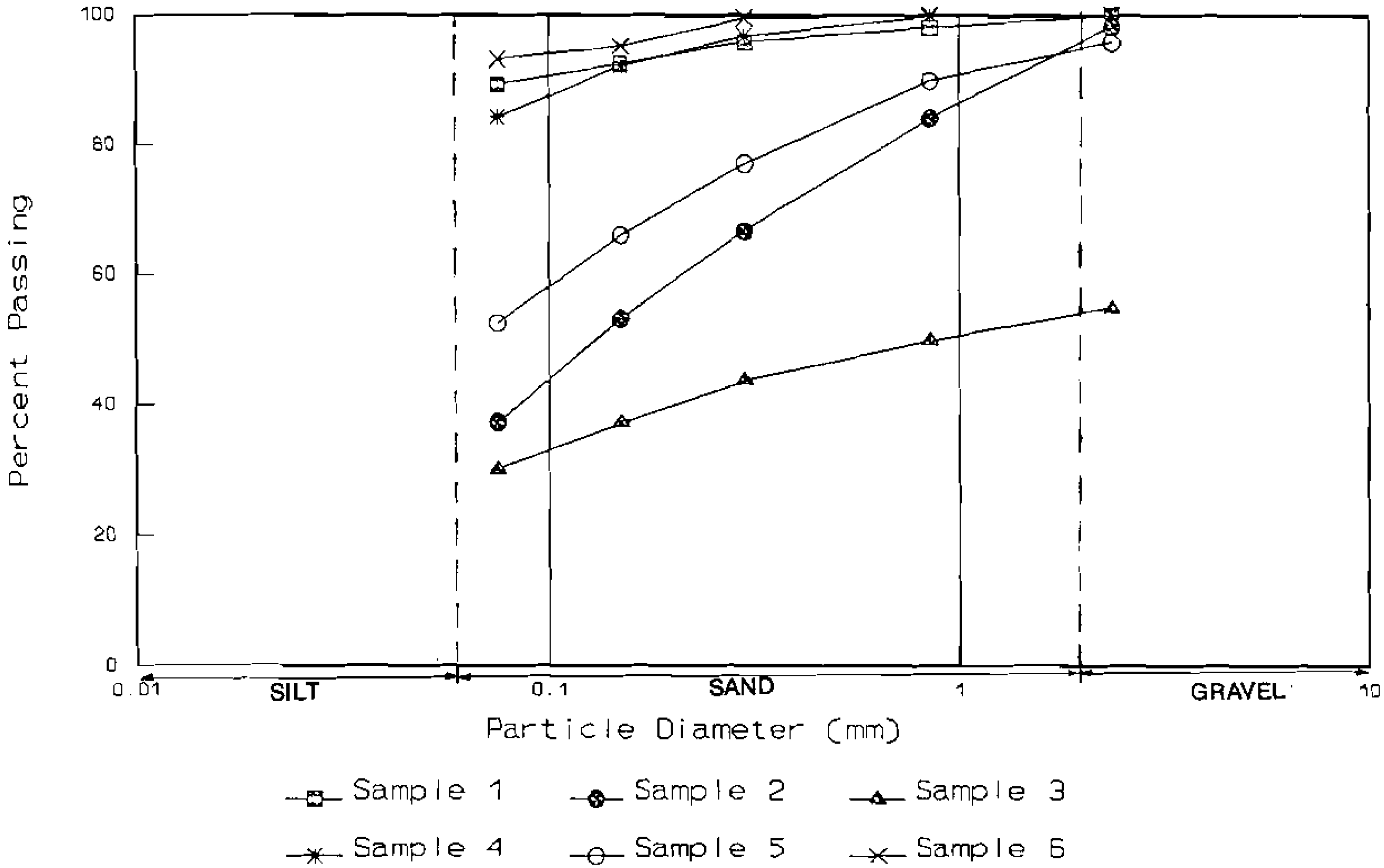
[1] Percent means percent smaller than or percent passing through sieve size shown.

[2] Lab error, unable to compute.

All results except pH and Total Solids are reported on a 100% dry weight basis.

SIEVE ANALYSIS

Bohners Lake Inlet Watershed Study



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SIEVE ANALYSIS

BOHNERS LAKE INLET WATERSHED STUDY

DRAWN BY	DJC
CHECKED BY	MJD
APPROVED BY	
SCALE N.T.S.	FIGURE NO. 6
R.A.S. PROJECT NO. 91805-0-335-335	

5. Soil Erosion and Sediment Yield

5.1 Predicting and Estimating Soil Erosion

The prediction of soil erosion has been studied for years. One of the first soil erosion prediction methods developed was the Universal Soil Loss Equation (USLE). This equation uses five environmental factors multiplied together to give an average annual soil erosion rate(A). The five factors are: rainfall (R), soil erodibility(K), slope steepness and length(LS), land cover(C), and conservation practices(P). The USLE equation then looks like this: $\mathbf{A = R * K * LS * C * P}$

Table 3 and Appendix A show what typical input values were used and where they originate.

It is important to note that the USLE was developed for disturbed or farmed soils and was intended as a planning tool and a predictor of soil erosion. Since the original equation was developed, modifications have been made to more accurately predict soil loss. One such modification was dividing the slope into segments for the prediction of sediment deposition. Because the USLE only predicts gross erosion, the prediction of sediment yield is necessary so that a sediment delivery can be determined. Sediment yield is the amount of soil that erodes and actually reaches water bodies such as lakes or rivers. Sediment yield is a difference between gross erosion calculated by the USLE and in-field deposition.

Table 4 shows the application of a modified USLE with a sediment delivery ratio applied to the average annual tons per year generated.

The purpose of this analysis is to show that even though the agricultural land comprises only 22 percent of the watershed, it contributes approximately 70 percent of the sediment. Even if the factors used are reliable within an accuracy of 10 percent, the agricultural land would still be the primary non-point source pollution. The acreage for the different land uses comes from Table 1.

5.2 Sediment Delivery Prediction

Even though the numbers in Table 4 reflect a sediment delivery ratio, they still appear to be higher than would be expected. To compare sediment delivery rates, a computer model developed by the University of Kentucky was used. This program is entitled SEDIMOT, and has its origins in disturbed land soil erosion prediction. SEDIMOT has a stormwater hydrology component built into it so that different storm events can be analyzed.

The SEDIMOT program predicted four different sediment rates for four different storms. These storm events were selected because of the available rainfall data and they are the most common, reoccurring storm events. Table 5 shows these storms and sediment rates reaching Bohners Lake. Figure 7 illustrates the nomenclature used in the SEDIMOT program.

TABLE 4
Sediment Delivery to Bohners Lake by Empirical Calculation

Bohners Lake Soil Erosion and Sediment Delivery Results												
	USLE Factors					Soil Loss RXKXLSXCXP	Land Use	Land Use	Soil Movement (Erosion)	Soil Delivery Ratio	Sediment Delivery	Sediment Delivery
LAND USE (Predominate Soil Type)[1]	R	K[1]	LS[1]	C	P	(Tons/Ac/Yr)	(Acres)	(%)	(Tons)	(%)	(Tons)	(%)
Residential (CrC)	130	0.32	1.31	.003	1	0.16	96.3	17	16	85%	13	8
Woodland (CrD)	130	0.32	2.41	.009	1	0.90	186.4	32	168	15%	25	15
Wetland (Ht)	130	0.37	0.25	.009	1	0.11	170	29	18	65%	12	7
Ag. Land (FsB)	130	0.37	0.53	0.12	1	3.05	125.8	22	383	30%	115	70
Totals							578.5	100	585		165	100

[1] Soil type used in USLE equation.

TABLE 5
Sediment Delivery to Bohners Lake by Modeling

Event - Return Time	10 Year	2 Year	2 Year	1 Year
Time Interval	24 Hour	24 Hour	6 Hour	1 Hour
Rainfall	3.95 Inches	2.7 Inches	2 Inches	1.25 Inches
Total Sediment Reaching Bohners Lake (Tons)	275	90	37	4

Once the sediment rates were calculated, the program could be used to route stormwater through the detention pond at different size increments to determine settling efficiency.

The existing pond area upstream of the road culvert under Lakeshore Drive is approximately 0.2 acres and is more or less rectangular in shape. It has an average depth of two feet. The trap efficiency of the existing pond is in the range of 60 to 65 percent.

Table 6 shows each of the different stages of the detention pond, each storm interval, resulting efficiency, and tonnage of sediment reaching the Lake. The data shows that sediment basins of the size of one to two acres can provide 80 to 90 percent efficiency in removing sediment from one- and two-year storm events. The ten-year storm requires at least a 3-acre basin to provide an 80 percent efficiency rating. It is important to note that like the size, the volume has a proportional effect on the settling efficiency of the pond.

TABLE 6
Bohners Lake Possible Detention Pond Efficiencies by Size and Storm Event

Bohners Lake			
Lakeshore Drive Detention Pond Design			
Event	Surface Area	Efficiency	Sediment*
	(Acre)	(%)	(Tons)
10 Yr. 24 Hr., 3.95"	0.5	71	78
	0.8	75	67
	1	77	62
	3	82	47
	4	84	41
	8	88	32
	12	91	23
2 Yr. 24 Hr. 2.70"	0.5	74	23
	0.8	78	18
	1.8	84	13
	2.8	89	9
2 Yr. 6 Hr 2.00"	0.5	72	10
	0.6	71	10
	0.8	78	9
	1.1	75	98
	1.8	91	3
	2	94	2
1 Yr. 1 Hr. 1.25"	0.5	89	0.5
* Note: Total Sediment Reaching Bohners Lake			

6. CONCLUSIONS

The Bohners Lake Inlet Watershed is a relatively stable and controlled drainage area with numerous wetlands acting as buffers. While cropland is not a major land use in the watershed, it does contribute a major percentage of the sediment to the stream and ultimately to the Lake. Much of the soil erosion is preventable and should be directed to the landowners affecting water quality. Voluntary cooperation in non-point source pollution control would be the most beneficial to all parties. However, in the event that cooperation is not realized, the Lake Association should take their own measures to prevent the further degradation of Bohners Lake. The following recommendations are made in the order of importance. For all recommendations, the Bohners Lake Improvement Association will have to be the facilitator between the landowners, agencies, and lake residents.

7.0 WATERSHED AND INLET MANAGEMENT RECOMMENDATIONS

7.1 Watershed Management Recommendations

The most effective Watershed Management is stopping problems from occurring. In the case of soil erosion, keeping soil in place is the best solution. If this cannot be accomplished, the next best alternative is to keep the sediment from leaving the areas from which it originates. Once the sediment has left the site, it becomes a sediment control problem which is always more complicated and expensive to solve.

7.1.1 Land Use/Cropping Changes

Land Use changes or even cropping changes can have one of the biggest impacts on the erosion of a site and are usually the most cost effective; however, they can be the most difficult to implement. For the sites involved in this project, land use changes or cropping changes may not be feasible. The sites producing erosion are not suited for anything but agriculture. The current cropping patterns are also the result of specific economics and how the farmers operate these fields. This means that the conversion of land to a less erosive crop may not be economically or agrinomically feasible. Converting cropland to pasture, for example, may not be possible because that landowner may not have cattle to graze.

7.1.2 Buffer Strips

Buffer Strips are permanently vegetated grass areas placed between sediment-producing areas and streams or lakes. These strips vary in width from 30 to 100 feet. These strips are typically placed on the cropland field areas because of access and maintenance concerns. Buffer strips should be used where the runoff from cropland fields can directly enter the stream or a intermittent stream or ditch that connects to the main branch. Buffer strips can effectively remove 50 percent or more of the sediment in runoff water. The best location for buffer strips in the Bohners Lake watershed are those cropland areas that drain directly into ditches or waterways. Here unfiltered runoff flows directly into the wetland ditches and then into Bohners Lake with no treatment. See Figure 2 for locations of possible buffer strips.

7.1.3 Grassed Waterways

A grassed waterway is a natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff. Their purpose is to convey runoff water from fields without causing erosion and to improve water quality. Grassed waterways are typically located towards the lower ends of fields and are usually placed in natural drainage ways. The locations for grassed waterways are shown in Figure 2.

7.1.4 Construction Site Erosion Control

The nonpoint source pollution today may be agricultural runoff, however, tomorrow the likely problem will be construction site erosion. Because of location to Burlington, Milwaukee, and Chicago, development pressures are likely to continue to grow. The Lake Association, the Town of Burlington, and Racine County need to work cooperatively to administer and enforce a Construction Site Erosion Control Ordinance.

7.1.5 Water Quality Monitoring

One of the findings of this report is that there is no real long term water quality monitoring data available for Bohners Lake. Because of this, management recommendations have to be based on field observations, personnel communication of district officials, and experience with similar watersheds to get the perceived water quality problems. Years of water quality data could not only confirm suspected problem areas, it could be a way to monitor improvements of continued degradation of the resource. For Bohners Lake, a water quality program consisting of at least two samples a year of nutrients, suspended solids, chlorophyll a, dissolved oxygen, temperature, pH, and secchi disk readings should be obtained. More extensive sampling would provide additional information. However, the long-term commitment to continue a modest sampling program is more useful than an extensive program that cannot be sustained because of a lack of funds or volunteers.

7.2 Inlet Maintenance and Management Recommendations

Because of the documented sediment entering the Lake, maintenance of the Lake and pond will be necessary. These areas could be cleaned out on an annual basis. Volunteers could be coordinated to probe the depth of the water at the inlet of the Lake and the pond. When sediment thickness increases to the point where it becomes visible from the surface or it is susceptible to scour from incoming stream flows, dredging should be scheduled. Lake dredging permits in general are not freely approved by the DNR; however, the expired permit for maintenance dredging for Bohners Lake should be reapplied for. This permit could be for an extended period of five years. In this way, the Association could be "pre-approved" and then proceed with a maintenance program that is subject to funding and the need.

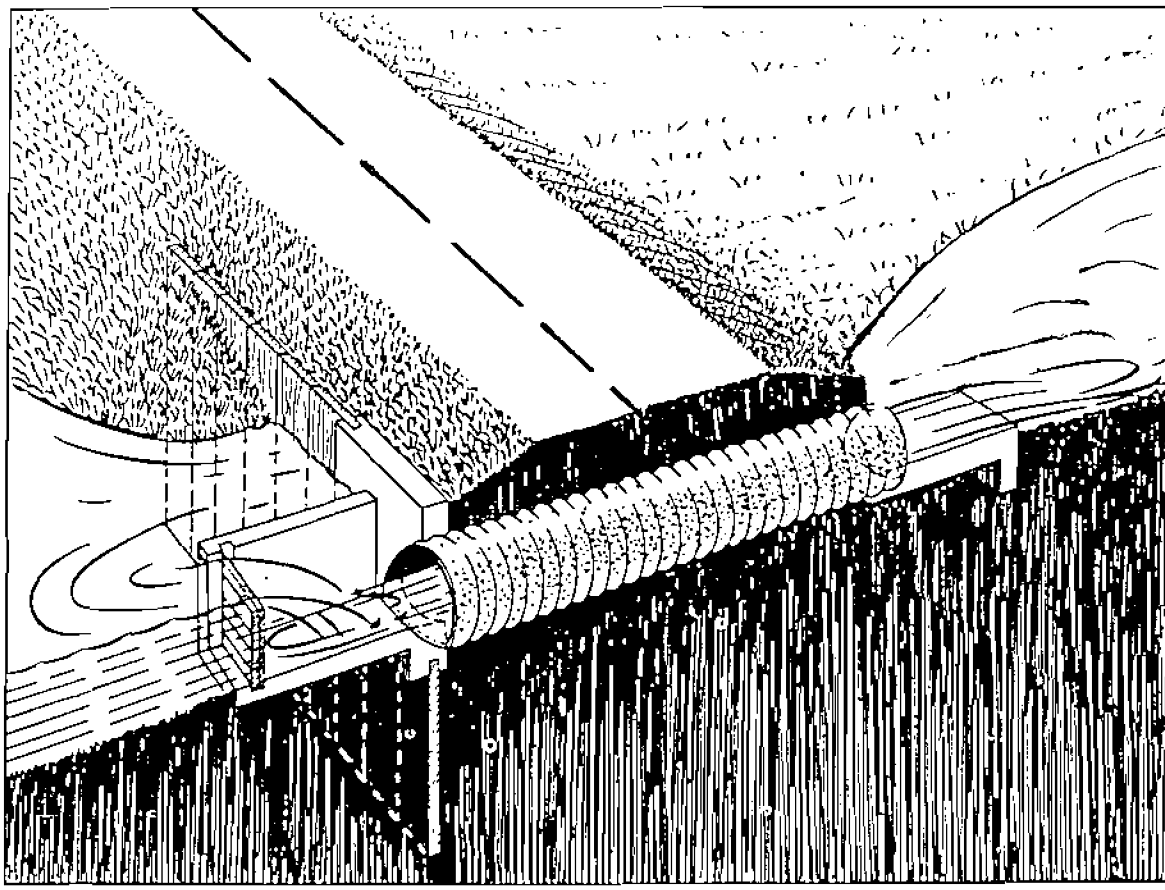
7.2.1 Box Inlet Spillway

As discussed earlier, if sediment cannot be stopped in its source, then it has to be removed somewhere else in the system. In the case of the Bohners Lake Watershed, the Lakeshore Drive stream constriction is the best location to remove the sediment from the system (See Figure 11). The current system of periodic dredging of the inlet upstream removes only the sediment that drops out of suspension at those locations under the existing hydraulics. In Table 6, the different efficiency ratings were given for various storm events and sizes of sediment basins. Also, it was discussed that a sediment basin 3 acres in size would have a removal efficiency in excess of 80 percent. The problem becomes creating a basin of this size. The first and most common approach is to excavate an area of the size required that will have standing water. In the Bohners Lake inlet area, this would be a problem because of the existing wetland. Wetland regulations today are much more restrictive than they have been in the past when filling of wetlands was a primary concern.

The proposal on this inlet would be to utilize the existing wetland area as a sediment basin by backing up water onto the wetland. The water would be backed up by constructing a Drop Inlet Spillway on the upstream side of the culvert that goes under Lakeshore Drive, See Figure 8 and 9. The top of the road elevation is approximately 806.5, the average water level in the Lake is 803. Based on existing Racine County topographic maps, a fixed spillway elevation of 805 could back up water over approximately 3 acres. See Figure 10.

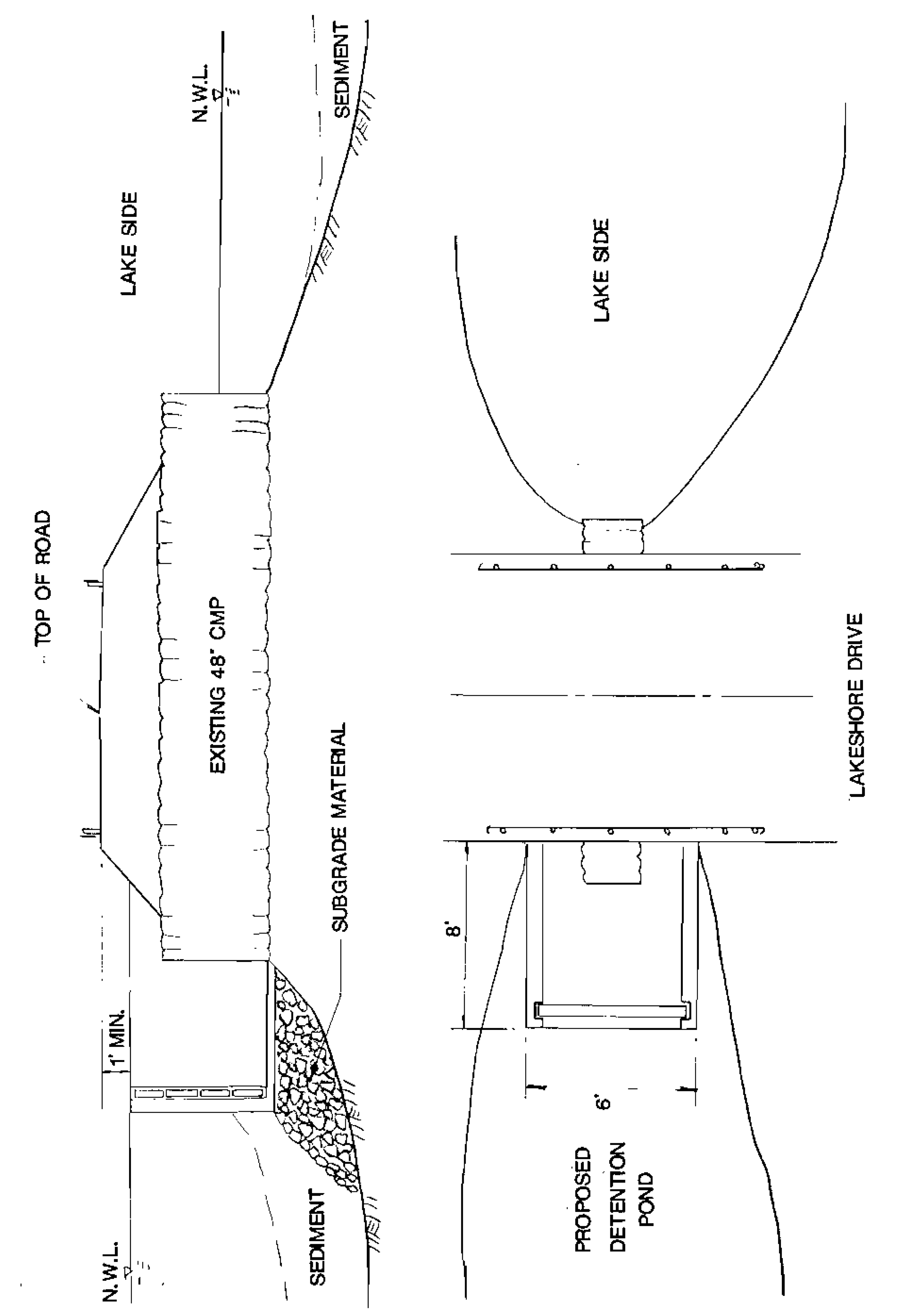
The construction of this spillway could cost $10,000. In addition, a Chapter 30 permit from the Wisconsin Department of Natural Resources would be required. The precise elevation of the spillway would have to be verified through an analysis of the 100-year flood plain. This would be done to ensure that the 100-year storm event could pass over the spillway and under Lakeshore Drive without causing flooding. The area has been studied for the 100-year flood as evidenced by the delineation of the flood plain boundary on the Racine County Topographic maps.

Finally, this proposal is just now being proposed to the Bohners Lake Improvement Association. It has not been presented to the public for comment; therefore, the reaction and support for this type of project is not known.



Corrugated metal culvert water control structures
with concrete box inlet and stoplogs

R.A. Smith & Assoc. Inc. ENGINEERS PLANNERS SURVEYORS INSPECTORS 17400 W. NORTH AVE. BROOKFIELD, WI. 53045 (414) 786-1777	PROJECT/CLIENT BOHNERS LAKE IMPROVEMENT ASSOCIATION **DROP INLET SPILLWAY** BOHNERS LAKE INLET WATERSHED STUDY	DRAWN BY KLS CHECKED BY MJD APPROVED BY SCALE N.T.S. FIGURE NO. 8 R.A.S. PROJECT NO. 91805-0-335-335



R.A. Smith & Assoc. Inc. ENGINEERS PLANNERS SURVEYORS INSPECTORS 17400 W. NORTH AVE. BROOKFIELD, WI 53045 (414) 786 1777	PROJECT/CLIENT BOHNERS LAKE IMPROVEMENT ASSOCIATION	DRAWN BY	KLS
		CHECKED BY	MJD
	DROP INLET SPILLWAY	APPROVED BY	
		SCALE N.T.S.	FIGURE NO. 9
	BOHNERS LAKE INLET WATERSHED STUDY	R.A.S. PROJECT NO. 91805-0-335-335	

7.2.2 Inlet Dredging

Regardless of whether the drop inlet spillway would be constructed, the existing inlet area on both sides of Lakeshore Drive are heavily silted. The upstream side of the inlet is periodically cleaned out under an existing permit so the effects are not as apparent as the downstream side. The existing program of removing sediment from the upstream side should be continued and the lake side of the culvert should be included in a clean dredging project. If the Lake side of the inlet were to be dredged to a depth of 5 feet with 3 to 1 side slopes, this would result in the removal of approximately 1,710 cubic yards or 2,275 tons of sediment (See Figure 11). Using the conservative sedimentation rate of 165 tons per year, and not considering the sediment removal effectiveness, this would last approximately 13 years before needing more maintenance dredging. If the upstream side is also cleaned out, but to a 5-foot depth with 3 to 1 side slopes, this would result in the removal of 800 cubic yards or 1,065 tons. This could add another six years to the entire inlet improvement project.

The current inlet dredging is approved under a Department of Natural Resources (DNR) permit. As recommended, this should continue with the same construction methods using a backhoe or dragline. The lake side of the inlet may require a hydraulic dredge because of access needs. Recent hydraulic dredging projects of a similar size project have cost $11/cubic yard. These costs included the disposal site preparation. If the BLIA proceeded with the inlet dredging and bids were received at $11/cubic yard, the total project cost would be approximately $19,000. However, this project will require a separate permit from the existing one; therefore, you could expect to spend upwards of $25,000 to clean out the lake side of the inlet. The timeline for such a project could easily span the course of one year to obtain all the necessary approvals. The coordination between the requirements of the disposal site landowner, Town, County, and DNR can be very difficult and may take a long period of time. These projects can be done; they just take time, planning, patience, and commitment from the sponsors.

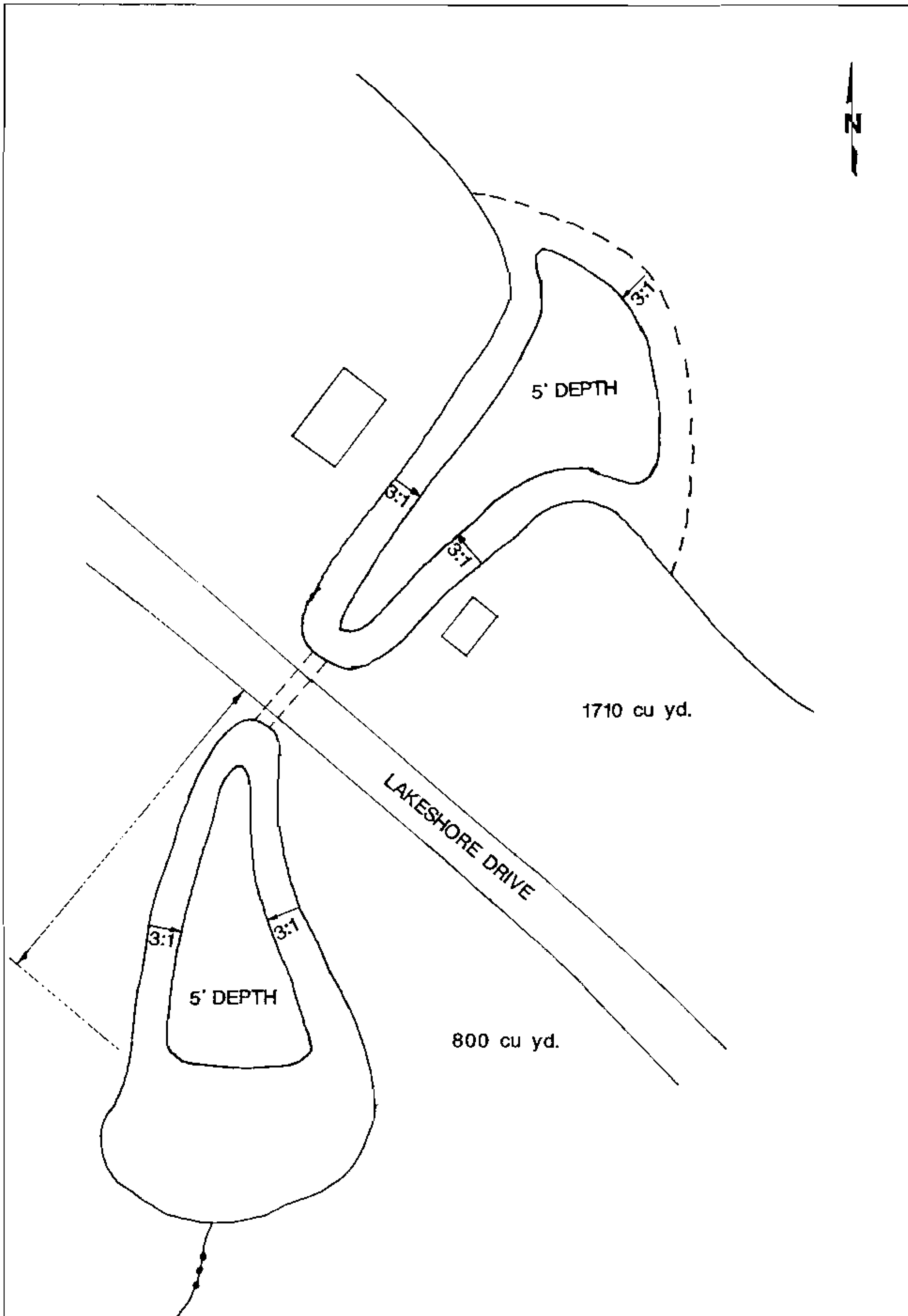
7.3 Other Management Recommendations

7.3.1 Wetland Preservation

The wetland complex west of Bohners Lake is a vital link to the well being of the Lake. In field observations, measures should be taken to preserve and protect these natural areas. Some management techniques that may enhance the wetlands would include species diversification and buffer strips on adjacent cropland (discussed earlier).

7.4 Watershed and Inlet Management Implementation

The implementation of management practices can be coordinated with the Racine County Land Conservation Department. Mr. Charles Seeger, County Conservationist, could be of great assistance in working with landowners in planning and installing conservation practices. Another advantage of working through Mr. Seeger is that he is fully up-to-



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PROJECT/CLIENT
BOHNERS LAKE IMPROVEMENT ASSOCIATION

INLET DREDGING AREAS

BOHNERS LAKE INLET WATERSHED STUDY

DRAWN BY	KLS
CHECKED BY	MJD
APPROVED BY	
SCALE N.T.S.	FIGURE NO. 11
R.A.S. PROJECT NO 91805-0-335-335	

date on any cost-share funding for these practices. There may be money available for the landowner which may improve participation in what would be a voluntary program. These projects could be done with no cost to the Lake Association. However, because these are voluntary programs, landowner participation must be encouraged by possibly having the Lake Association sponsor and fund a project where a landowner was unwilling to participate. This could be handled in a way such that the Lake Association could lease some of a farmer's land along a stream and plant it to native grasses. This way the farmer is getting paid for his loss of production and the Association has cleaner water. These types of arrangements have other benefits. The buffer strip can provide additional wildlife habitat and helps foster a cooperative relationship between the Lake Association and the landowners.

If a lease or rent arrangement had to be established with a landowner, the following costs could be expected. For example, if a 30-foot wide by 800-foot long buffer strip was needed, this would be 24,000 square feet or 0.55 acres. If the landowner needed $100 per acre per year not to plant this strip to crops, it would cost the Lake Association $55 per year (0.55 acres X $100/acre) for this buffer strip. The initial seeding of the buffer strip could cost $500 up front in addition to the $55 per year cost.

It should be noted the Watershed and Lake Management Practices and there attendant priorities are based on several factors. One factor is the ease in which a particular recommendation can be implemented. Table 7 lists the watershed and Inlet Management Recommendations. Some solutions are more long term and may take years of planning, selling, and implementation before the results can be seen. Also, some recommendations are more costly and may take several years of planning just to obtain financing. At the request of the Wisconsin Department of Natural Resources and the Lake Association, Table 8 has been included to show the generalized effectiveness of selected nonpoint source pollution abatement management measures.

BOHNERS LAKE
WATERSHED AND INLET MANAGEMENT PRACTICES

Organization Involved In Implementation

Management Practice	Priority	Unit Cost	Units	Practice/ Priority Costs	Lake Assoc.	Landowner/ Renter/ Lessee	DNR	LCD SCS	UW-EX	Town of Burlington	Racine County
Land Use Changes Cropping Changes Reduced Tillage	1a	N/A	300 Ac	N/A	✓	✓		✓	✓		
Buffer Strips (50' Wide)	1b	$0.20/Ft	2,500 Ft	$500[1]	✓	✓	✓	✓	✓		
Grassed Waterways	1c	$7/Ft	1500 Ft	$10,500[1]	✓	✓		✓	✓		
Construction Site Erosion Control	1d	N/A	N/A	N/A	✓	✓	✓	✓	✓	✓	✓
Water Quality Monitoring	1e	$500/Yr	5 Years	$2,500[1]	✓		✓				
PRIORITY 1 COSTS				$13,500							
Box Inlet Spillway	2a	$10,000	Ea	$20,000							
Maintenance Dredging	2b	$5,000	Ea	$5,000	✓	✓	✓			✓	✓
PRIORITY 2 COSTS				$25,000							
Wetland Protection	3a	$500	40 Ac.	$20,000[1]	✓	✓	✓		✓		
PRIORITY 3 COSTS				$20,000							
TOTAL COSTS FOR ALL MANAGEMENT PRACTICES				$58,500							

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[1] Cost Share Funds Available

Table 8 - Generalized Effectiveness of Selected Nonpoint Source Pollution Abatement and Management Measures

Control Measure	Approximate Percent of Reduction of Released Pollutants to the Inlet Stream System [1]	Approximate Percent of Reduction of In Stream Pollutants Entering Bohners Lake [2]
Buffer Strips	50 %	n/a
Feedlot and Pasture Management	50 - 75 %	n/a
Construction Site Erosion Control	20 -40 %	n/a
Cropping Changes, Conservation Tillage	50 %	n/a
Grassed Waterways	50 %	n/a
Inlet Spillway	n/a	80 %
Inlet/Maintenance Dredging	n/a	40 %

[1] Sediment delivery reduction to the inlet tributary.
Source: Southeastern Wisconsin Regional Planning Commission

[2] In-lake deposition of sediment already in tributary.
Source: R. A. SMITH & ASSOC., INC.

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