LAKE MAGNOR LAKE ASSOCIATION
LAKE WATERSHED MANAGEMENT PLAN

Prepared for:

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CHAPTER 1: INTRODUCTION

The Lake is located in the Town of Clayton in the southeast corner of Polk County and just southwest of the Village of Clayton immediately adjacent to State Highway 63. Less than 100 miles from the Minneapolis-St. Paul metroplex, it is on route to northern Wisconsin where many city residents have summer or weekend destinations and because of this is experiencing increasing development pressure. Although the Lake Magnor area is considered rural, the intensity of the development in the area led to the creation of a Sanitary District. A sanitary sewer extension from the Village of Clayton was installed in 1994 to replace existing septic systems. This project is considered to have improved the water quality by reducing the rate of lake water quality degradation as a result of seepage from septic systems surrounding the lake. However, water quality concerns continue and the Association and local residents have exhibited considerable interest in evaluating these issues and finding long term solutions.

The 230 acre Lake Magnor has experienced significant water quality degradation over the past few decades. This degradation includes decreasing water clarity and increasing algae content and has generated considerable concern in local residents and members of the Lake Magnor Lake Association. To evaluate the problem, the lake and surrounding watershed are being studied in order to determine the source of the problem. In 2003, the Polk County Land and Water Resource Department compiled the Lake Management Plan titled, "Lake Magnor Comprehensive Planning Report, 2003". Polk County continued to recognize the concerns of the lake property owners and the on going water quality degradation and prepared the Polk County Land and Water Management Plan in 2004. They also proposed and approved changes to their Storm Water Management and Erosion Control Ordinances in 2005. These reports are excellent information resources. The current project is an extension of this work and the information reported herein should be used in conjunction with this existing information as future planners consider the options for water quality improvements in this watershed.

During this planning grant project, existing documents such as Lake Magnor Comprehensive Planning Report, the Polk County Land and Water Management Plan, existing and future land use maps, FEMA Flood Rate Insurance Maps, zoning maps, aerial imagery, topographic maps, historic and archaeological databases, and soil surveys have been reviewed. These documents were used to delineate the local watersheds, categorize land use, identify existing soil conditions, and determine aspects of the runoff rates as well as make other evaluations and assumptions regarding the entire watershed. Field reconnaissance was also conducted to verify the accuracy of the collected data and to more accurately delineate the local sub-watersheds.

Internal phosphorous loading form the lake bottom sediments is also a concern. The collection and analysis of a lake bottom sediment core sample was completed by the WDNR took the sample in early August, 2005. The completed report is included as Appendix A and the sample analysis is to be used to guide the next phase of the project.

Both storm water runoff quality and quantity analysis have been completed for the Lake Magnor watershed under this project. The quantity analysis was completed to help size BMPs (Best

Management Practices) and identify existing and possible future problem areas. BMPs can be non-structural (ordinances, street sweeping) or structural (wet detention ponds, rain gardens, swales), and their purpose is to improve storm water quality and/or reduce storm water quantity before it is discharged to local streams and lakes by encouraging natural filtration and infiltration of runoff. The water quality analysis will provide the baseline in determining the internal and external nutrient loading. Water quality and water quantity improvement alternatives are considered and general recommendations, including the general location of structural BMPs are provided. More study and analysis will be necessary to determine specific recommendations for lake improvement projects.

Results have been communicated throughout this project through various presentations, reports, and press releases. A final presentation to closeout this project will be made at the next Lake Magnor Lake Association meeting which will be held in August 2006.

The water quality in Lake Magnor has been described as eutrophic. The mean Secchi disk average depth for lakes in this region is 9 feet. Lake Magnor has a mean depth of 3 feet. Eutrophic water quality status is typically assigned when the phosphorous concentrations reach over 60 ppb. The summer time concentrations of phosphorous in Lake Magnor were measured in 2005 to range from 126 to 157 ppb with water quality TSI levels of 66 and 67 very near hyper eutrophic values (greater than 70). Implementation of any of the water quality improvement or phosphorous reduction techniques discussed herein is an improvement over past practices.

Polk County has recently adopted a Storm Water Management and Erosion Control Ordinance that is more restrictive than the current DNR administrative code. This new ordinance coupled with other County ordinances that restrict manure spreading, are directly aimed at reducing the quantity of sediments and nutrient loading to storm runoff water. These ordinances are designed to reduce loading into lakes such as Lake Magnor. These are positive steps but everyone must be making contributions to address these issues. There is no question that long term protective measures will have to be considered to improve the water quality in this watershed, but it behooves all concerned – Association members, watershed residents, Town of Clayton residents and government, Polk County, and the State of Wisconsin to continue to assist and participate in the water quality improvements needed in this area.

CHAPTER 2: LAKE SEDIMENT CORING

Sediment core sampling was completed by Paul Garrison of the Wisconsin Department of Natural Resources (WDNR) in August 2005. Top sediment cores (10 cm) were taken at various locations on the lake including a historical core (70 cm) from the lake's deeper point (25 feet). The top 10 cm of each core was analyzed in 2 cm increments for sediment density. The purpose of this study was to determine if an alum treatment, which binds the phosphorus to the aluminum sulfate thus sealing it in the sediment, would be an effective alternative treatment to reduce internal phosphorus loading.

Results of the coring indicate a high density of water (>90%) in the top 10 cm of sediment. The results of the study are inconclusive:

"Other studies have found that this can be a reasonable estimate of the depth alum will settle. This analysis indicates that an alum treatment may not be appropriate for this lake since alum is likely to sink into the sediments. A more accurate test of the effectiveness of alum would be to extract cores from the lake and treat them with sequential amounts of alum. "

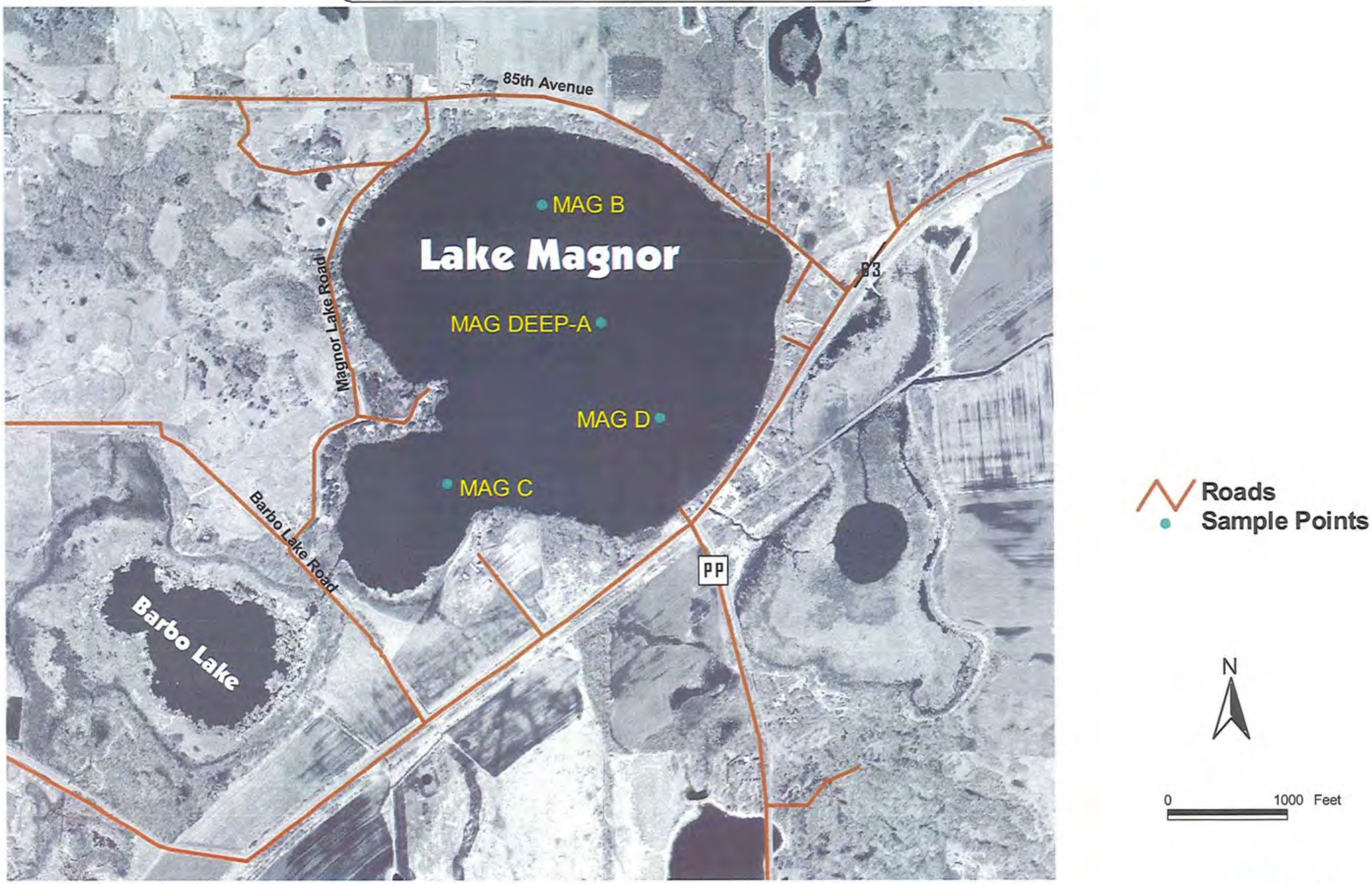
Recommendations from the WDNR include acquiring additional core samples and conduct sediment incubation studies with alum treatments. This will help to estimate the amount of alum necessary for an effective treatment and the costs associated with it. The full WDNR report is included in Appendix A.

The next phase in this water quality implementation method is to conduct lab incubation studies by the Army Corps of Engineers to better understand project costs and technical feasibility and effectiveness of an aluminum sulfate treatment.

Deep Hole Core Sample

Core Sample Up Close

LAKE MAGNOR
Polk & Barron Counties, Wisconsin
CORE SEDIMENT LOCATIONS



Source: Polk County, Tiger 2000 and Cedar Corporation

Cedar corporation

CHAPTER 3: WATERSHED WATER RUNOFF QUANTITY

The estimation of the quantity of storm water runoff that occurs within a watershed is dependent on several factors including physical, chemical, and anthropologic. The area and shape of the watershed, annual precipitation quantities, seasonal events, soil types and soil chemistry, and human influences all must be considered in this process. These factors are considered individually and then compiled into computer models that generate water quantity runoff estimates for the watershed.

Watersheds

The FEMA maps indicate that the entire watershed is above the 500-year flood elevation for this area. Any flooding would be local and is considered to be unlikely as considerable storage ability is present in the wetlands and marshes that comprise 10% of the watershed area.

The watershed delineation is based on a USGS topographic map with 10 foot contours (Figure 3-1). The 10 foot contours are interpolated to a 2 foot contour interval. This means that smaller features in the landscape are not well defined, the modeling of features less than 10 foot in elevation difference is based on assumed contours, which provides generalized but adequate results for this survey.

The watershed delineation for Lake Magnor has determined that a much larger watershed is present than the 2003 Comprehensive Planning Report. The 2003 survey estimated the watershed at 1989 acres. The watershed delineated by Cedar Corporation is very similar to the 2003 watershed in the west but extends eastward to include another 1700 acres. The eastward extension is justified based on field observations and that it matches with the current delineation of the St. Croix River Basin boundary for the Beaver Brook Watershed.

The sub-watersheds are typically delineated by using ridges and other high points of topography as boundaries. A site reconnaissance of the watershed area was completed to further delineate the boundaries of the eighteen identified sub-watersheds. These watersheds are labeled alphabetically without any significance to the labeling and presented on Figure 3.1. The culverts under the roads, and the storage provided on the upstream side of the roads are considered in the modeling.

Land Use

Existing land use (Figure 3.2) is based on WiscLand 1992 which is 1992 satellite imagery analyzed to determine land cover in the State of Wisconsin. This base reference was compared with a survey of existing conditions and aerial photography. The Town of Clayton as well as the Village of Clayton's land use maps were considered in determining existing conditions.

Future land use conditions (Figure 3.3) are an important consideration and define potential future areas of concern fro storm water generation. Future land use maps for the Town of Clayton were used as a base starting point. Population projections as well as development estimates were referenced from the Town of Clayton's Comprehensive Plan. Population projections for the Town of Turtle Lake (east portion of the watershed) future land use estimates were incorporated. Existing population density (people per acre) was used in relation to the population projections for the area to determine future development densities. To evaluate the potential future storm water quantity and quality projections, the development was scattered throughout the east portion of the watershed in areas that are most likely to see development (good soils, existing land cover, and highway access).

A review of the State records for historic and archaeological places and/or items of interest in the watershed have determined only two items of note. Both are cemeteries – the St. Charles Cemetery in Section 27, Township 33 North, Range 14 West and the West Clayton Cemetery in Section 20 of Township 33 North, Range 15 West.

Soil Types

Each observed soil type as presented on Figure 3.4 is characterized to define its Hydrologic Soil Group (HSG) following the US Department of Agriculture definitions. The four basic HSG classifications are A, B, C and D. Where A represents sandy soils with high rates of infiltration and low runoff volume; B and C types have intermediate parameters; and, D types represent clay soils with low infiltration rates and high runoff volumes. The HSG soils distribution in the Lake Magnor watershed is presented on Figure 3.5 and is summarized in Table 3.1.

HSG	A	B	C	D
Percentage	0.5%	79.5%	9.6 %	10.4%

Table 3.1: HSG distribution for soils in the Lake Magnor watershed.

Curve Numbers

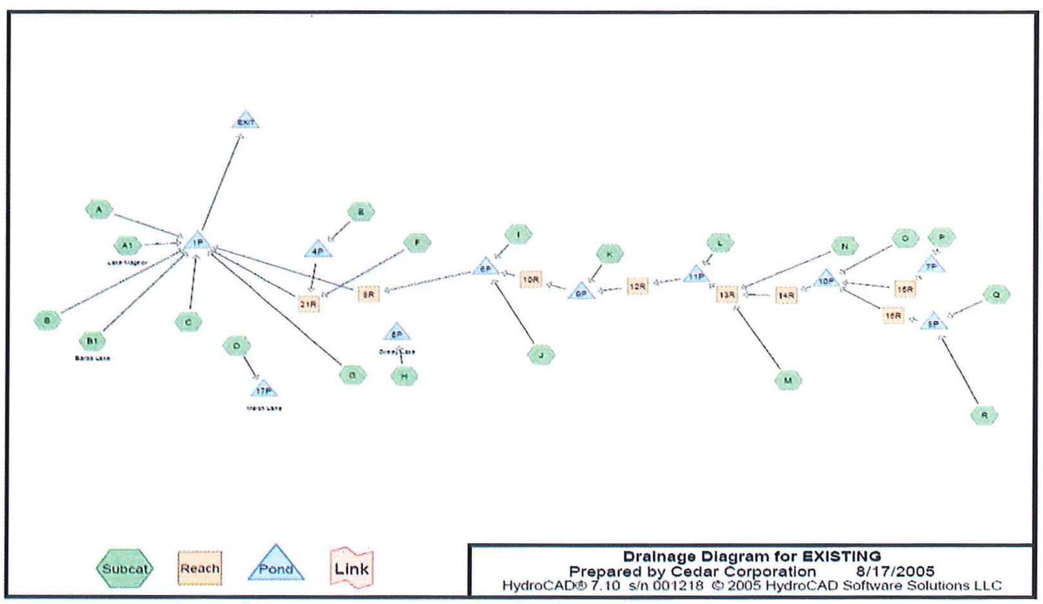
The Curve Number is a measure of the amount of runoff that will occur on a given land surface. This mathematical relationship has been given much interpretation by the USDA and storm water engineers to determine accurate runoff volume calculations to improve surface water runoff and minimize flooding. The selection of the Curve Number forms the basis for several different methods of calculating runoff quantities. The method has become even more refined with the introduction of computers that can handle the complex shapes and calculations. The Curve Number is dependent on land use and soil type. Each land use/soil type combination is evaluated and assigned a Curve Number. Here the Curve Number is used to evaluate the total runoff quantity under certain precipitation events such that the runoff to local streams and tributaries can be calculated and thus provide a measure of the impact to the watershed and the lake. The lower Curve Numbers generally indicate sandy soil types with little development and therefore low potential for runoff but a higher degree of water infiltration capacity. The higher CN values indicate a combination of less pervious soils and increasing development (which is proportional to increased impervious surface, hence greater runoff volumes.

Using Curve Numbers can be extended to predicting future areas of runoff water quantity concerns. By subtracting the Existing Curve Number from the Future Curve Number, the Development Intensity of a watershed can be estimated. Areas with potential development intensity will have values greater than 1 and these areas can be targeted for future Best Management Practices for Storm Water Management. Most areas within the Lake Magnor Watershed are predicted (Figure 3.8) to see low development intensity except the areas closest to the Lake and south of Clayton.

<u>Water Quantity Runoff Modeling</u>

To calculate the runoff quantity, all manmade and natural features are considered. The information gathered for the watershed and meteorological data, soil characteristics and hydrologic type, land use, storm sewers, overland drainage, wetlands, lakes, ponds, streams and channels are compiled and modeled in the HydroCAD Storm Water Modeling System (v7.1) to derive the runoff quantities. HydroCAD is a computer aided design program used for modeling surface hydrology and hydraulics of storm water runoff. It is based on hydrological techniques (namely TR-20) developed by the USDA Soil Conservation Service (now known as the Natural Resource Conservation Service). It facilitates creation of a working model of an entire drainage system by combining the hydrological analysis results with standard engineering hydraulic calculations.

Lake Magnor Drainage Diagram from HydroCAD



The procedure for calculating the storm water runoff quantity is as follows:

1. Delineate the overall lake watershed (Figure 3.1).
2. Delineate sub-watersheds within the lake watershed (Figure 3.1).
3. Identify existing and future land use within the watershed (Figures 3.2 and 3.3).
4. Identify the soils in the watershed (Figure 3.4 & 3.5).
5. Calculate Curve Numbers* based on land use and soils (Figure 3.5, 3.6 & 3.7).
6. Compile all data in the HydroCAD model, create the Drainage Diagram (below) and calibrate the model.
7. Run the model for the 2-, 10-, and 100-year rainfall events for existing and future land use conditions.

Two HydroCAD models were completed for the Lake Magnor Watershed: One for existing land use conditions and one for future land use conditions. The results from the stormwater quantity results are presented as HydroCAD printout sheets in Appendix B. Examples of information included on these sheets are: Subwatershed area in acres, runoff in cubic feet per second, runoff volume in acre-feet (1 acre-foot equals 325,851 gallons) and pond-, reach-, and outlet particulars.

The principal information that is derived from this model is presented in Table 3.2.

Existing Conditions					
24 hr storm events	Watershed Runoff Volume (ac-ft)	Runoff Average Depth (in)	Watershed Wide Impervious Area (ac)	Principal Volume Input Tributary (21R) to Lake Magnor (cu ft /sec)	Hours after Storm event begins that Peak Flow is reached in 21R
2 year	305.617	0.94	260.6	92	19.69
10 year	635.522	1.95	260.6	185.66	17.71
100 year	1086.94	3.35	260.6	310	16.88
Future Conditions					
24 hr storm events	Watershed Runoff Volume (ac-ft)	Runoff Average Depth (in)	Watershed Wide Impervious Area (ac)	Principal Volume Input Tributary (21R) to Lake Magnor (cu ft /sec)	Hours after Storm event begins that Peak Flow is reached in 21R
2 year	306.529	0.94	260.6	92	19.69
10 year	635.053	1.95	260.6	185.66	17.71
100 year	1089.07	3.35	260.6	310	16.88

Table 3.2 Existing and Future water volume discharges as determined by HydroCAD computer modeling.

1. There is little difference in impervious surface area and runoff volume from existing to future development conditions. This suggests that the anticipated future development will have minimal increases on current sediment loading to the Lake.
2. Significant water volume impacts Lake Magnor in a short time period at high velocities in the principal tributary to the lake. This indicates high sediment loading is occurring for even the smaller storm events.

CHAPTER 4: WATERSHED WATER QUALITY

To calculate the storm water pollutant loads generated in the Lake Magnor watershed, two different methods were used:

Method 1: Compare the Lake Magnor watershed to similar watersheds where water quality data already exists.

Method 2: Use the WiLMS software to calculate phosphorus loads to Lake Magnor.

Method 1:

The Lake Magnor watershed was compared to similar watersheds where water quality research has taken place to identify the most similar watershed available. Results from research at Wapogasset Lake, Polk County [1] indicate the two watersheds are very similar. The Wapogasset Lake data was used to estimate phosphorus and nitrogen loads to Lake Magnor. Similarly, research from Bruce Valley Creek near Pleasantville, Trempealeau County [2] was used to estimate the TSS loads to Lake Magnor. Similar land use was the most important factor when deciding which watershed to use for these calculations.

The research has determined appropriate export coefficients (mass of pollutant per area per year) for the researched watersheds. These export coefficients are applied to the area of the Lake Magnor watershed/ sub-watersheds to estimate the annual pollutant load to the lake. This method does not take the pollutant travel distance into account. The results from Method 1 are presented in Table 4.1 and summarized for the watershed in Table 4.2.

Total Phosphorus	Total Nitrogen	Total Suspended Solids
627 [lb/yr]	11,000 [lb/yr]	2,444,000 [lb/yr]

Table 4.2: Storm water quality results from Method 1.

The majority of the pollutants that are generated in the most distant parts of the watershed will likely be removed or at least reduced from the storm water before it reaches the Lake. The watershed is not linear nor is the distribution of the pollutants. The watershed is long, narrow, and is quite flat and punctuated with wetlands along its axis. Lake Magnor is at the far west end of the watershed. It is likely that the above estimates of pollutants that reach the lake are overestimated. Using this assumption and attempting to establish a realistic trend in the deposition of sediment and nutrients in the lake, it is reasonable to make an assumption about the level of contribution from the sub-watersheds. One can assume that the sub-watersheds directly surrounding the lake contribute considerably more of the loading to the lake than those that are not directly related to the lake. This fact is even more pronounced as the eastern sub-watersheds

[1] "Nutrient Loads to Wisconsin Lakes: Part 1: Nitrogen and Phosphorus Export Coefficients". *Nicholas Clesceri, Sidney J. Curran, and Richard I. Sedlak.*

[2] "Unit-Area Loads of Suspended Sediment, Suspended Solids, and Total Phosphorus from Small Watersheds in Wisconsin". *Steven R. Corsi, David J. Graczyk, David W. Owens, and Roger T. Bannerman*

Pollutant Loading

TABLE 4.1

	soil						Residential							
Watershed	HSG	Agricultural	Commercial	Forestland	Grassland	Industrial	Rural	Single	Open water	Wetland	Total	Curve Number	Total Loading (lbs)	est. % contributing to lake
A	B	31.1	0.0	54.7	46.1	0.0	1.8	107.5	0.0	9.2	250.4	69	570	1
Phosphorus		7.3	0.0	5.5	7.2	0.0	0.3	16.9	0.0	1.4			39	39
Nitrogen		185.3	0.0	181.2	167.1	0.0	6.5	389.7	0.0	33.4			963	963
TSS		20895.3	0.0	36751.6	30973.4	0.0	1209.4	72226.6	0.0	6181.3			168,238	168,238
B	C	142.1	0.0	73.6	22.9	0.0	5.3	4.4	4.9	47.1	300.3	79	679	1
Phosphorus		33.2	0.0	7.3	3.6	0.0	0.8	0.7	0.0	7.4			53	53
Nitrogen		846.7	0.0	243.9	83.0	0.0	19.2	16.0	0.0	170.7			1,380	1,380
TSS		95473.4	0.0	49450.0	15385.9	0.0	3560.9	2956.3	3292.2	31645.3			201,764	201,764
C	D	28.1	0.0	11.0	7.9	0.0	2.8	1.2	0.0	0.0	51.0	82	184	1
Phosphorus		6.6	0.0	1.1	1.2	0.0	0.4	0.2	0.0	0.0			10	10
Nitrogen		167.4	0.0	36.4	28.6	0.0	10.2	4.4	0.0	0.0			247	247
TSS		18879.7	0.0	7390.6	5307.8	0.0	1881.3	806.3	0.0	0.0			34,266	34,266
D	D	60.0	3.6	51.4	32.9	0.0	0.0	3.7	14.2	10.5	176.3	84	436	1
Phosphorus		14.0	0.6	5.1	5.2	0.0	0.0	0.6	0.0	1.6			27	27
Nitrogen		357.5	13.1	170.3	119.3	0.0	0.0	13.4	0.0	38.1			712	712
TSS		40312.5	2418.8	34534.4	22104.7	0.0	0.0	2485.9	9540.6	7054.7			118,452	118,452
E	C	72.8	0.0	29.9	7.3	21.8	0.0	25.2	0.0	21.0	178.0	69	425	1
Phosphorus		17.0	0.0	3.0	1.1	3.4	0.0	4.0	0.0	3.3			32	32
Nitrogen		433.8	0.0	99.1	26.5	79.0	0.0	91.4	0.0	76.1			806	806
TSS		48912.5	0.0	20089.1	4904.7	14646.9	0.0	16931.3	0.0	14109.4			119,594	119,594
F	D	123.2	0.0	0.0	1.7	0.0	0.0	0.0	0.0	0.0	124.9	83	333	1
Phosphorus		28.7	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0			29	29
Nitrogen		734.1	0.0	0.0	6.2	0.0	0.0	0.0	0.0	0.0			740	740
TSS		82775.0	0.0	0.0	1142.2	0.0	0.0	0.0	0.0	0.0			83,917	83,917
G	C	184.6	0.9	73.8	43.2	0.0	5.7	2.7	7.2	57.1	375.2	79	830	1
Phosphorus		43.1	0.1	7.4	6.8	0.0	0.9	0.4	0.0	9.0			68	68
Nitrogen		1100.0	3.3	244.5	156.6	0.0	20.7	9.8	0.0	207.0			1,742	1,742
TSS		124028.1	604.7	49584.4	29025.0	0.0	3829.7	1814.1	4837.5	38364.1			252,088	252,088
H	C	6.9	0.0	40.7	26.0	0.0	1.0	0.0	21.5	0.0	96.1	81	273	1
Phosphorus		1.6	0.0	4.1	4.1	0.0	0.2	0.0	0.0	0.0			10	10
Nitrogen		41.1	0.0	134.9	94.3	0.0	3.6	0.0	0.0	0.0			274	274
TSS		4635.9	0.0	27345.3	17468.8	0.0	671.9	0.0	14445.3	0.0			64,567	64,567
I	C	44.3	21.5	4.1	0.0	0.0	4.1	37.5	0.0	0.0	111.5	82	305	0
Phosphorus		10.3	3.4	0.4	0.0	0.0	0.6	5.9	0.0	0.0			21	4
Nitrogen		264.0	77.9	13.6	0.0	0.0	14.9	135.9	0.0	0.0			506	101
TSS		29764.1	14445.3	2754.7	0.0	0.0	2754.7	25195.3	0.0	0.0			74,914	14,983
J	C	242.7	0.0	40.5	15.3	0.0	3.6	0.0	0.3	12.8	315.2	78	709	0
Phosphorus		56.6	0.0	4.0	2.4	0.0	0.6	0.0	0.0	2.0			66	13
Nitrogen		1446.2	0.0	134.2	55.5	0.0	13.1	0.0	0.0	46.4			1,695	339
TSS		163064.1	0.0	27210.9	10279.7	0.0	2418.8	0.0	201.6	8600.0			211,775	42,355
K	C	55.7	0.0	52.8	46.7	0.0	4.5	7.1	0.0	85.5	252.3	80	584	0
Phosphorus		13.0	0.0	5.3	7.3	0.0	0.7	1.1	0.0	13.4			41	8
Nitrogen		331.9	0.0	174.9	169.3	0.0	16.3	25.7	0.0	309.9			1,028	206
TSS		37423.4	0.0	35475.0	31376.6	0.0	3023.4	4770.3	0.0	57445.3			169,514	33,903
L	B	23.2	0.0	100.6	15.8	0.0	3.9	0.0	0.0	14.9	158.4	65	382	0
Phosphorus		2.3	0.0	10.0	2.5	0.0	0.6	0.0	0.0	2.3			18	4
Nitrogen		138.2	0.0	333.3	57.3	0.0	14.1	0.0	0.0	54.0			597	119
TSS		15587.5	0.0	67590.6	10615.6	0.0	2620.3	0.0	0.0	10010.9			106,425	21,285
M	C	202.7	0.0	233.4	8.2	0.0	7.4	0.0	0.0	17.4	469.1	76	1,014	0
Phosphorus		47.3	0.0	23.3	1.3	0.0	1.2	0.0	0.0	2.7			76	15
Nitrogen		1207.8	0.0	773.3	29.7	0.0	26.8	0.0	0.0	63.1			2,101	420
TSS		136189.1	0.0	156815.6	5509.4	0.0	4971.9	0.0	0.0	11690.6			315,177	63,035
N	B	22.7	0.0	66.0	39.6	0.0	0.0	0.0	0.0	5.4	133.7	65	333	0
Phosphorus		5.3	0.0	6.6	6.2	0.0	0.0	0.0	0.0	0.8			19	4
Nitrogen		135.3	0.0	218.7	143.6	0.0	0.0	0.0	0.0	19.6			517	103
TSS		15251.6	0.0	44343.8	26606.3	0.0	0.0	0.0	0.0	3628.1			89,830	17,966
O	B	70.9	0.0	23.3	0.0	0.0	0.0	0.0	0.0	11.5	105.7	69	281	0
Phosphorus		16.5	0.0	2.3	0.0	0.0	0.0	0.0	0.0	1.8			21	4
Nitrogen		422.5	0.0	77.2	0.0	0.0	0.0	0.0	0.0	41.7			541	108
TSS		47635.9	0.0	15654.7	0.0	0.0	0.0	0.0	0.0	7726.6			71,017	14,203
P	B	25.9	0.0	42.5	14.0	0.0	0.0	0.0	0.0	38.8	121.2	71	314	0
Phosphorus		6.0	0.0	4.2	2.2	0.0	0.0	0.0	0.0	6.1			19	4
Nitrogen		154.3	0.0	140.8	50.8	0.0	0.0	0.0	0.0	140.7			487	97
TSS		17401.6	0.0	28554.7	9406.3	0.0	0.0	0.0	0.0	26068.8			81,431	16,286
Q	C	140.4	0.0	31.8	0.0	0.0	0.0	0.0	0.0	4.6	176.8	78	432	0
Phosphorus		32.8	0.0	3.2	0.0	0.0	0.0	0.0	0.0	0.7			37	7
Nitrogen		836.6	0.0	105.4	0.0	0.0	0.0	0.0	0.0	16.7			959	192
TSS		94331.3	0.0	21365.6	0.0	0.0	0.0	0.0	0.0	3090.6			118,788	23,758
R	B	135.8	0.0	61.6	20.7	0.0	13.3	0.0	0.0	11.2	242.6	68	553	0
Phosphorus		31.7	0.0	6.1	3.2	0.0	2.1	0.0	0.0	1.8			45	9
Nitrogen		809.2	0.0	204.1	75.0	0.0	48.2	0.0	0.0	40.6			1,177	235
TSS		91240.6	0.0	41387.5	13907.8	0.0	8935.9	0.0	0.0	7525.0			162,997	32,599
										Total Phosphorus		lbs/yr	627	339
										Total Nitrogen		lbs/yr	16,471	8,785
										Total TSS		lbs/yr	2,444,752	1,323,258
Acreage		Agricultural	Commercial	Forestland	Grassland	Industrial	Rural	Single	Open water	Wetland	Total			
		1613.1	26.0	991.7	348.3	21.8	53.4	189.3	48.1	347.0	3638.7			
Lake Magnor											217.0			
Barbo Lake											43.0			
Total Watershed Acreage											3898.7			

drain into marshes which retard the pollutant load in streams and tributaries. To consider the effects of nutrient and sediment travel distance, the model combines 100% of the loading generated in the nearby watersheds A, B, C, D, E, F and G reaching the Lake with 20% of the loading generated in watersheds I, J, K, L, M, N, O, P, Q & R. Sub-watershed H is omitted as it is assumed the loading goes directly into Greely Lake.

Table 4.2 then is re-calculated to be:

Total Phosphorus	Total Nitrogen	Total Suspended Solids
339 [lb/yr]	8,785 [lb/yr]	1,323,258 [lb/yr]

Method 2:

WiLMS (Wisconsin Lake Modeling Suite), a lake water quality-planning tool, was used to calculate the phosphorus load to Lake Magnor from the surrounding watershed. The model uses an annual time step and predicts spring overturn, growing season mean, and annual average total phosphorus concentration in lakes. The model is suitable in rural settings as opposed to other programs such as P8 and WinSLAMM. Lake parameters, land use information, and WiLMS export coefficients are incorporated to calculate the phosphorus load to the Lake. But as no WiLMS export coefficient is available for urban land use to model the area surrounding the lake, this "most likely" value (1.91 kg/ha/yr or 1.70 lbs. per acre per year) is taken from existing research[3].

The "low" and "high" values required in WiLMS are assumed to be + or - 0.5 kg/ha/year from the "most likely" value. Figure 4.1 illustrates how different land uses contribute to the external phosphorus loading to the lake.

The model used to consider the effects of phosphorus travel distance also combines 100% of the phosphorus generated in watersheds A, B, C, D, E, F & G reaching the Lake with 20% of the pollutants that are generated in watersheds I, J, K, L, M, N, O, P, Q & R. The result is a summation of the output from these models or 879 pounds of phosphorus per year. The WiLMS data sheets are included in Appendix C.

The results from both models are combined to provide the total model loading parameters into Lake Magnor. It is assumed that the WiLMS program projection of phosphorus loading is more accurate than the method used in Model 1. And as WiLMS does not provide other nutrient loading, the nitrogen and suspended solids loading from Model 1 are recommended for future modeling efforts and are used here for the final estimating of loading into the Lake.

[3] "Modeling Phosphorus Loading and Lake Response under Uncertainty: A Manual and Compilation of Export Coefficients". *Reckhow et al. (1980)*

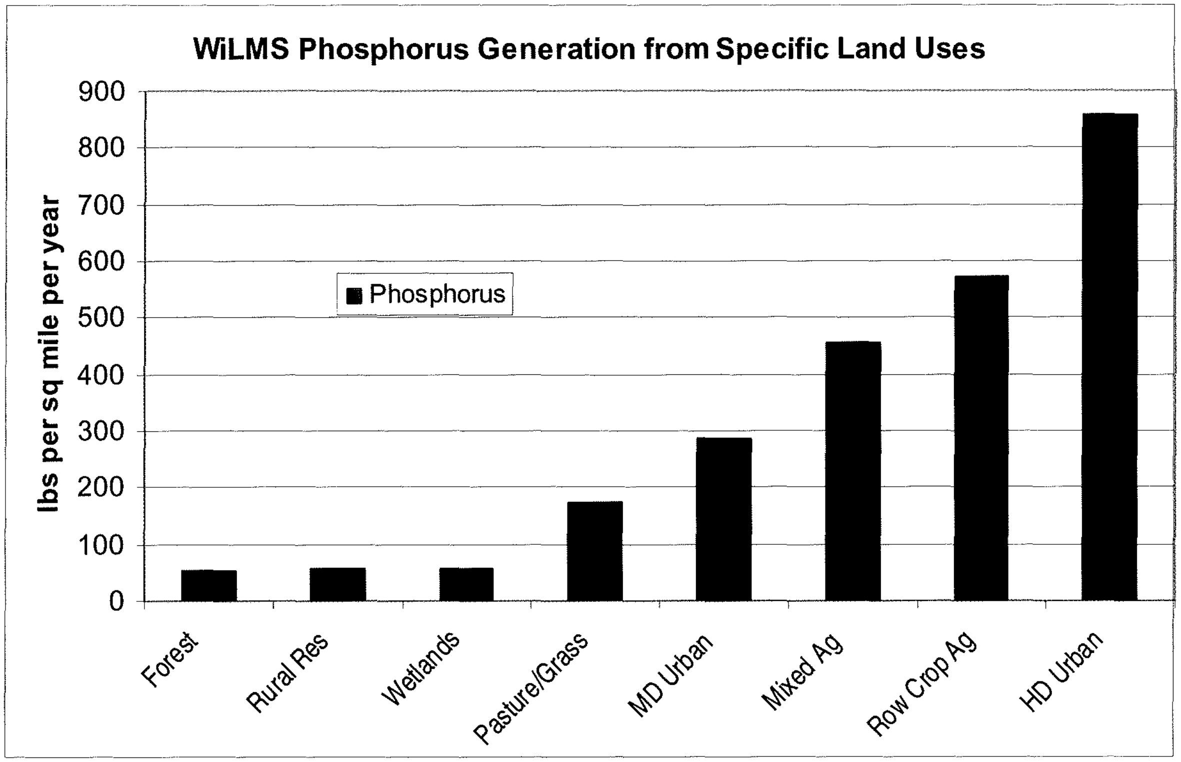


Figure 4.1: Phosphorus generation from various land use in pounds per square mile per year.

Water Quality Model Loading

Using the above modeling techniques the current estimated loading of nutrients and suspended solids to Lake Magnor is presented in Table 4.3.

Total Phosphorus	Total Nitrogen	Total Suspended Solids
879 [lb/yr]	8,785 [lb/yr]	1,323,258 [lb/yr]
0.44 [tons/yr]	4.39 [tons/yr]	662 [tons/yr]
		472 [cubic yards]
		32 [truck loads]

Table 4.3: Water quality modeling results for Lake Magnor.

CHAPTER 5: RECOMMENDATIONS

Water quality improvements must consider all aspects of nutrient controls. Reiteration of the water quality actions from the 2003 Comprehensive Planning Report is deliberate.

5-1 Short-Term Goals– Year 2006 - 2011

- Private Housekeeping Program. The County could encourage residents to implement local BMPs such as Rain Gardens, Swales, Filter Strips, Roof Runoff Diversions, etc. on their property by offering a tax credit for active BMPs that improve Lake Water quality.

- Control Residential Lawn Runoff. Direct runoff from well maintained and fertilized shoreland lawns is a key contributor to dissolved phosphorus concentrations in lakes. Development of runoff rain gardens, shoreland vegetation buffers, and redirecting storm water are important steps in residential runoff control.

- Street Sweeping. Target those parts of the watershed that contribute the most TSS (Total Suspended Solids) to the lake. In this case, street and parking lot sweeping would be effective along Highway 63 and Town-/residential roads around Lake Magnor. Studies show that street sweeping *once a month* is very effective at reducing pollutant levels in storm water runoff. Highways and commercial parking areas are targeted due high traffic counts and percentage of heavy vehicles. The Association could contract with the Village of Clayton to conduct this effort.

- Curb and Gutter. Petition the state to install curb and gutter to redirect the runoff from STH 63 to nearby wetland (not stream channel) areas to utilize the wetlands natural filtration and nutrient trapping abilities to improve stormwater quality. Install a sand trap if appropriate.

- Have Town of Clayton consider adopting a Storm Water Management Ordinance, and an Erosion Control Ordinance, and have Polk County consider adopting a Fertilizer Ordinance. The most effective actions that the Town of Clayton and Polk County can take in regards to storm water management are the adoption of these ordinances. Enforcement of these ordinances shares the burden of storm water management with developers. Example model ordinances are attached in Appendix D.

- Increase Frequency of Curbside Pickup of Lawn Debris. Curbside pickup reduces the amount of organic material in the curb line which has a high potential of being washed into the lake during runoff events. This increases the effectiveness of downstream structural BMPs and non-structural BMPs because the amount of large organic particles is drastically reduced.

- Consider Limitations on Phosphorus-Based Fertilizers. Many communities now require a soil test before allowing phosphorous-based fertilizers to be used. Most tests performed in such communities reveal that soil concentrations of phosphorus are already higher than are recommended by lawn keeping organizations. Phosphorous limiting fertilizer would apply only to lawn fertilizer on established lawns. Some communities in the Minneapolis-St. Paul metropolitan area and in Wisconsin (i.e., City of Amery, Dane County) have banned the sale of phosphorus-based fertilizer or require that phosphorus content does not exceed 1%.

- Provide Public Education and Information to Residents. Methods include pamphlets sent with water bills, stencils such as "Drains to Lake" at all storm sewer inlets, presentations at meetings, more frequent meetings to discuss proper storm water management techniques, appearances at Town and County meetings to voice concerns, invite Town and county staff and political leaders to local meetings.

- Lawn Debris Disposal. Encourage collection and off-site disposal of lawn debris. This reduces the quantity of organic debris that can be collected by storm water and transported to the lake. Ash and debris from camp fires, leaf burning, etc. contain concentrated amounts of phosphorous. These areas should be kept away from the lake and the cold ash collected for disposal.

5-2 Long Term Goals – Year 2011 - 2026

Implementation of Structural BMPs:
The numbering of each of the BMPs below corresponds to the numbering on Figure 5.1 (if any). Please note that the majority of the BMPs shown on Figure 5.1 are New Development BMPs that will be installed by future developers.

1. **Installation of proposed BMPs for new development areas.**
   Location: Multiple
   Watershed: Multiple
   Target: Quantity Control and Water Quality

   Notes:

   - As developers or land owners approach the Towns for the various approvals necessary to develop, the Towns should continually address the need to set aside land for the construction of BMPs. Because it is unknown at this time the rate or sequence of development of these areas, the locations of these BMPs can not be exactly located on the map.

   - A Township Storm Water Management Ordinance would require developers to pay for storm water BMP implementations on their development property prior to acceptance and approval of the new development project by the Township. The Township does not intend to use general revenue funds to pay for any newly proposed BMPs for new developed areas. Thus, the proposed regional BMP sites may require creative developer agreements.

2. **Construct Wet Detention Facility next to 10th Street**
Location: West of 10th Street and North of the drainage way
Target: Control storm water quantity and improve water quality.
Notes: A Wet Detention Facility at this location will control storm water from existing Village of Clayton as well as from future expansion of the Village in this area.

3. **Construct Wet Detention Facility North of 85th Street**
Location: North of 85th Street, East of farm in front of the culvert.
Target: Control storm water quantity and improve water quality.
Notes: A Wet Detention Facility is proposed to treat runoff from the farm field located to the north of this BMP.

4. **Construct Wet Detention Facility in the NE ¼ of Section 26**
Location: South of railroad tracks, north of drainage way, NE ¼ Sec 26.
Target: Control storm water quantity and improve water quality.
Notes: This area has high future growth potential. A Wet Detention Facility in this area will reduce pollutants and storm water runoff peaks before reaching the drainage way and Lake Magnor.

5. **Implement Swale Easements in natural drainage ways.**
Location: As defined on Figure 5.1.
Target: Improve water quality.
Notes: The easement should prohibit development, limit the presence of grazing cows, and maintain mature vegetation.

6. **Implement BMPs around wetlands**
Location: As defined on Figure 5.1.
Target: Improve water quality.
Notes: Wetlands help remove pollutants from storm water and attenuates peak runoff rates. Therefore the wetlands should be protected. Protection can be provided by means of 20' wide buffers (undisturbed area) or ponds (wet-, dry-, or infiltration ponds). When new developments are proposed near wetlands, one should keep in mind that the developer is required to reduce TSS by 80% before reaching the wetland.

7. **Implement BMPs in Tributary.** Initiation of water quality improvement methods (primarily velocity and flow reduction) on the unnamed tributary that connects the eastern wetlands to Lake Magnor may be appropriate but requires land acquisition and construction.

CHAPTER 6: INFORMATION AND EDUCATION

Education is an important part of any planning process. There are a variety of ways to educate and inform the public about what is going on with the first phase of the Lake Magnor Lake Management Plan.

One way is to send out press releases. Cedar Corporation worked with the *Hometown Gazette* to provide press releases throughout the duration of the project. This method gets the information to the greatest number of people throughout the area, but doesn't guarantee readership. The following are the publication dates of the *Hometown Gazette* that included information about Lake Magnor Lake Management Planning Project:

- Prior to May, 2005 the entire Polk County report was published in several installments.
- September, 2004 – Extensive discussion of lake algae
- February 2005 – 2003 Lake Magnor Repot
- May 31, 2005 – 2003 Lake Magnor Repot
- October, 2005 - November 30, 2005 Status Report given at October Meeting of Association
- June through September 2006, the results of this study

This partnership will continue to be ongoing in order to educate the public about future lake projects.

It is also important to have direct interaction with the public. Cedar Corporation attended a number of meetings held by both the Magnor Lake Association and the Town of Clayton. These forums allowed us to present information regarding the project as well as interact with local residents. Both the DNR and Polk County were invited to attend the Town of Clayton meeting in August of 2005. Jeremy Williamson from the Land and Water Conservation Department of Polk County was in attendance and provided valuable feedback regarding the project. The final results of this part of the study will be presented at the fall meeting of the Association.

CHAPTER 7: CONCLUSIONS

Samples taken from Lake Magnor through the summer months of 2005 show phosphorus concentrations ranging from 66 – 157 micrograms per liter. Any concentration above 50 micrograms per liter is considered high. The presence of phosphorus in the Lake at these levels is due in part to the external loading of the estimated 1021 lb/yr and the high phosphorous content of the sediments. Recommendations for water quality improvements are presented in Chapter 5 and summarized below.

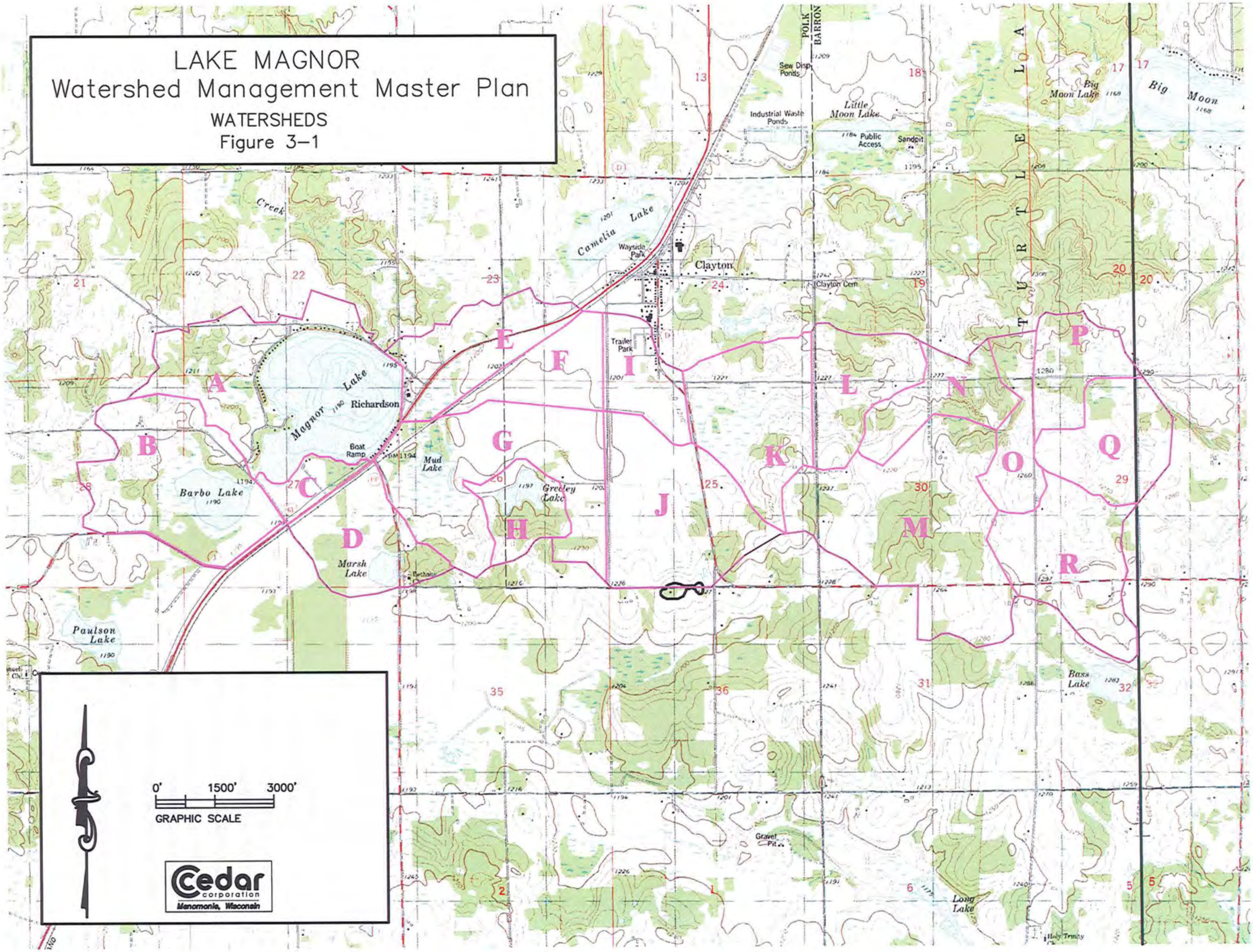
Short Term Practices that can have Immediate Effects to Improve Storm Water Quality

- Private Housekeeping Program.
- Control Residential Lawn Runoff.
- Street Sweeping.
- Have Town of Clayton consider adopting a Storm Water Management Ordinance, an Erosion Control Ordinance and have Polk County consider adopting a Fertilizer Ordinance.
- Increase Frequency of Curbside Pickup of Lawn Debris.
- Consider Limitations on Phosphorus-Based Fertilizers
- Provide Public Education and Information to Residents.
- Lawn Debris Disposal.

Implement Structural BMPs to Control sediment and Nutrient loading of the waterways that lead to Lake Magnor:

- Install BMPs in new development areas.
- Construct Wet Detention Facility West of 10th Street and North of the drainage way
- Construct Wet Detention Facility North of 85th Street
- Construct Wet Detention Facility in the NE ¼ of Section 26
- Implement Swale Easements in natural drainage ways as noted on Figure 5.1
- Implement BMPs around wetlands as noted on Figure 5.1
- Implement Storm Water Velocity Check Basin on unnamed tributary

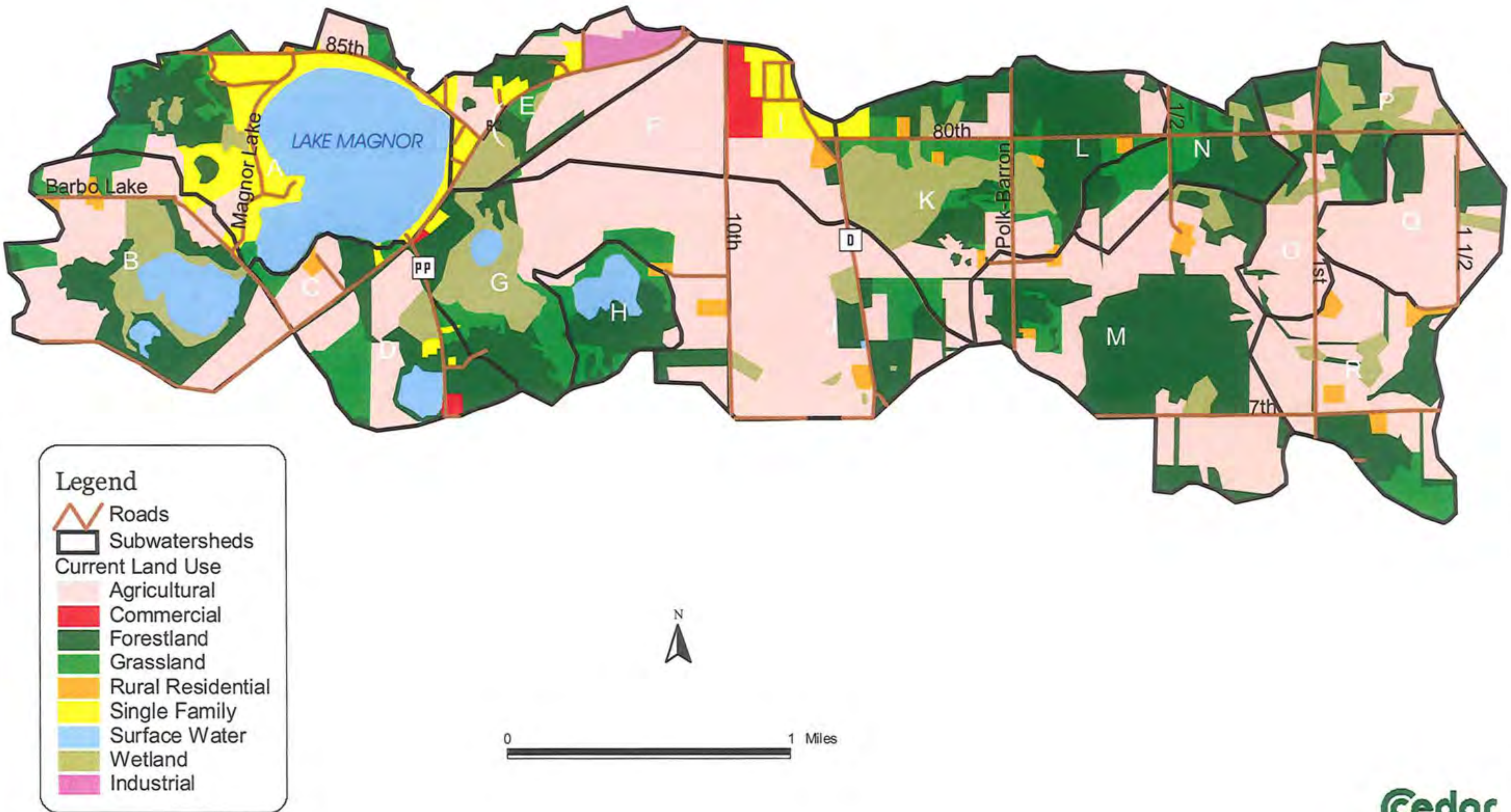
FIGURES



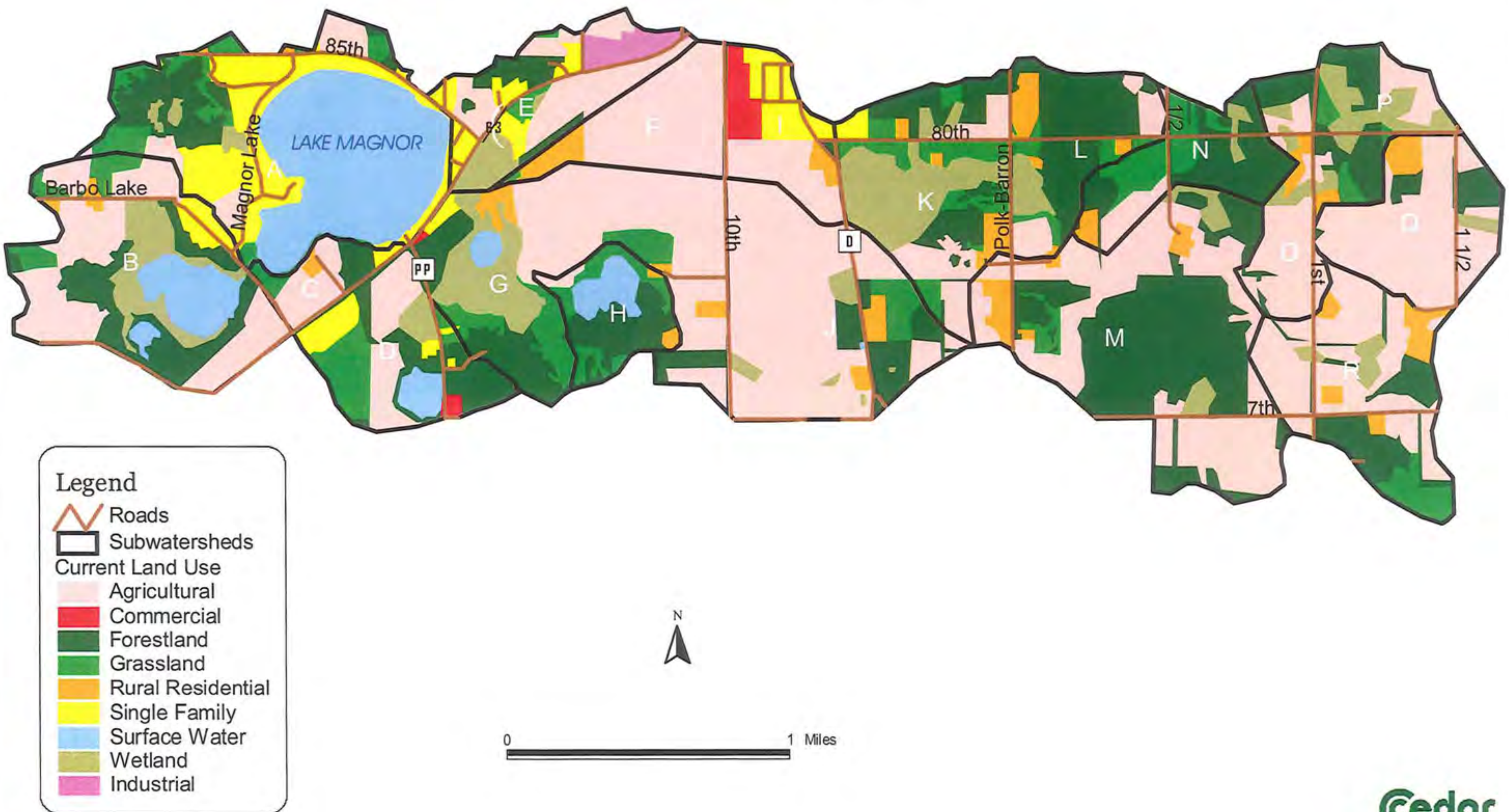
LAKE MAGNOR
Watershed Management Master Plan
WATERSHEDS

Figure 3–1

LAKE MAGNOR WATERSHED
Polk & Barron Counties, Wisconsin
CURRENT LAND USE
Figure 3.2



LAKE MAGNOR WATERSHED
Polk & Barron Counties, Wisconsin
FUTURE LAND USE
Figure 3.3

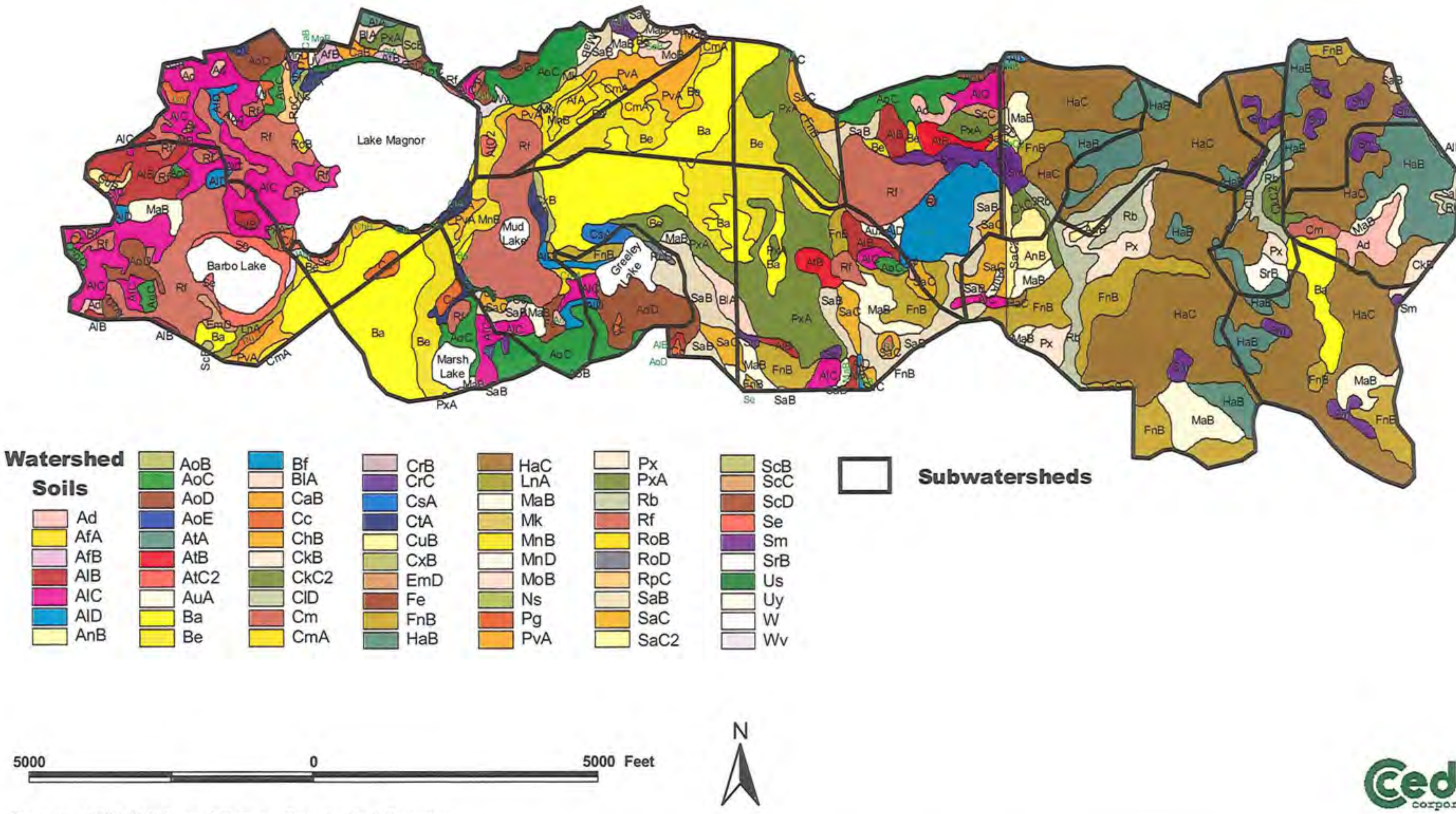


LAKE MAGNOR WATERSHED

Polk & Barron Counties, Wisconsin

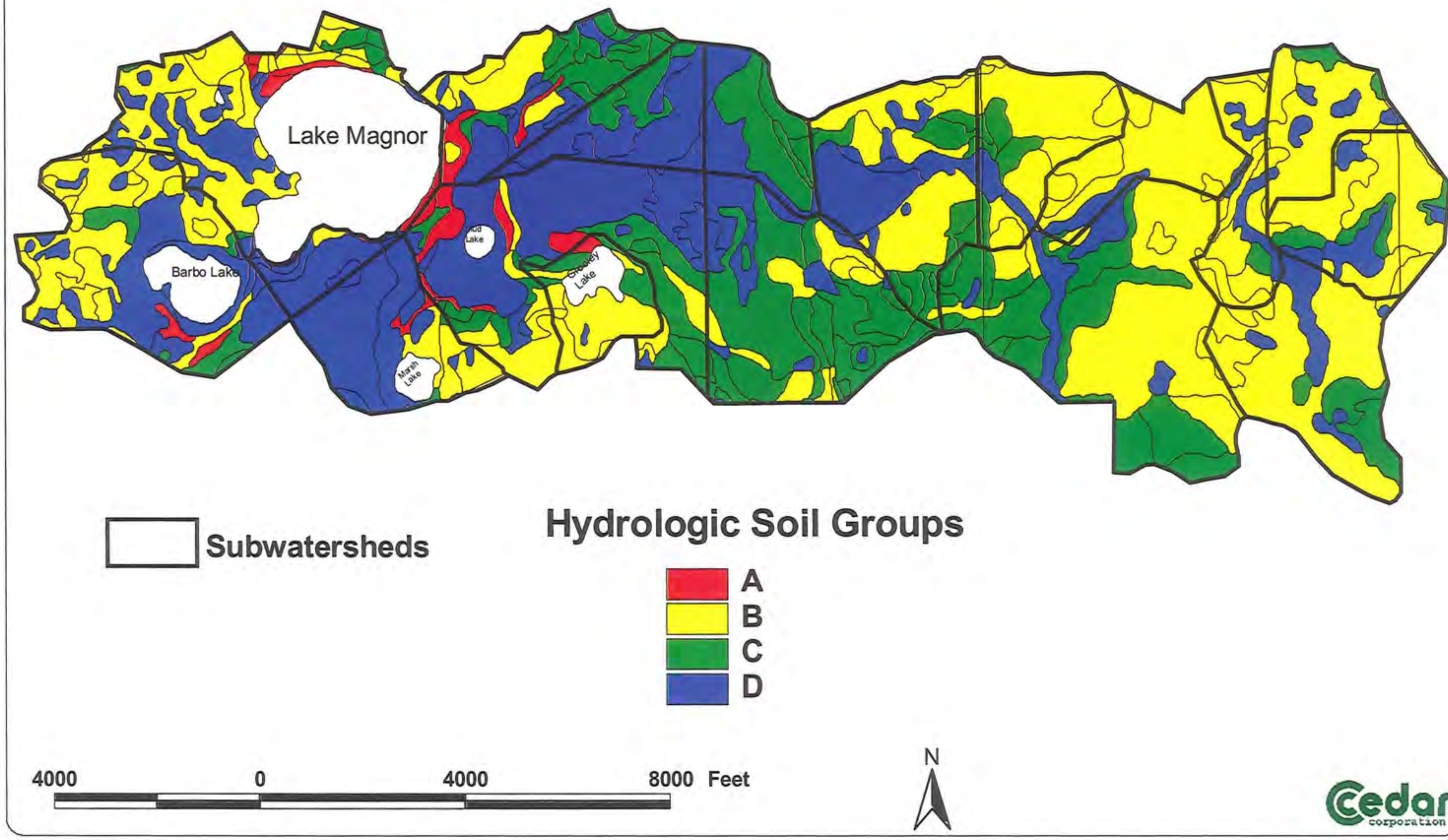
SOILS

Figure 3.4

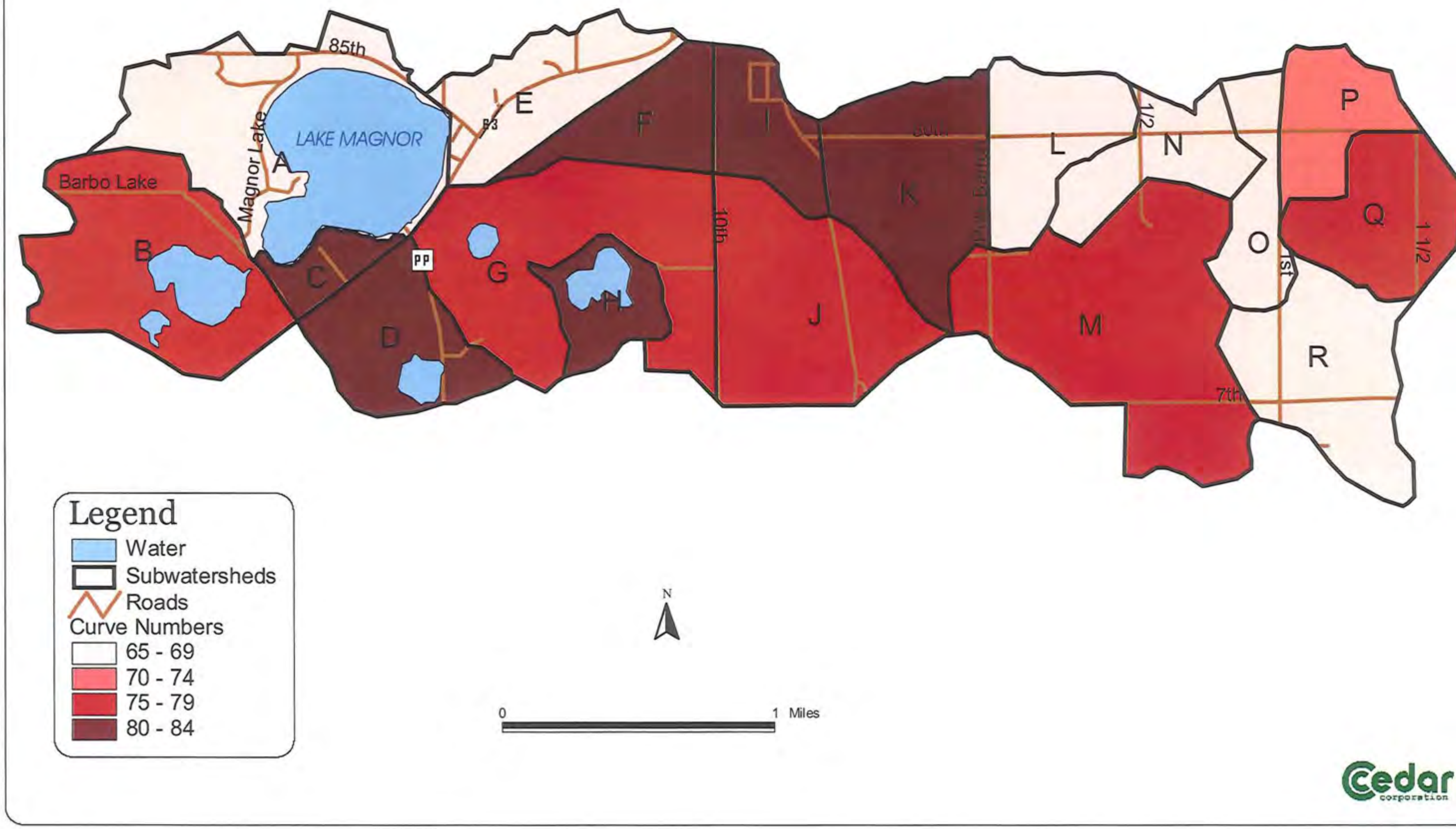


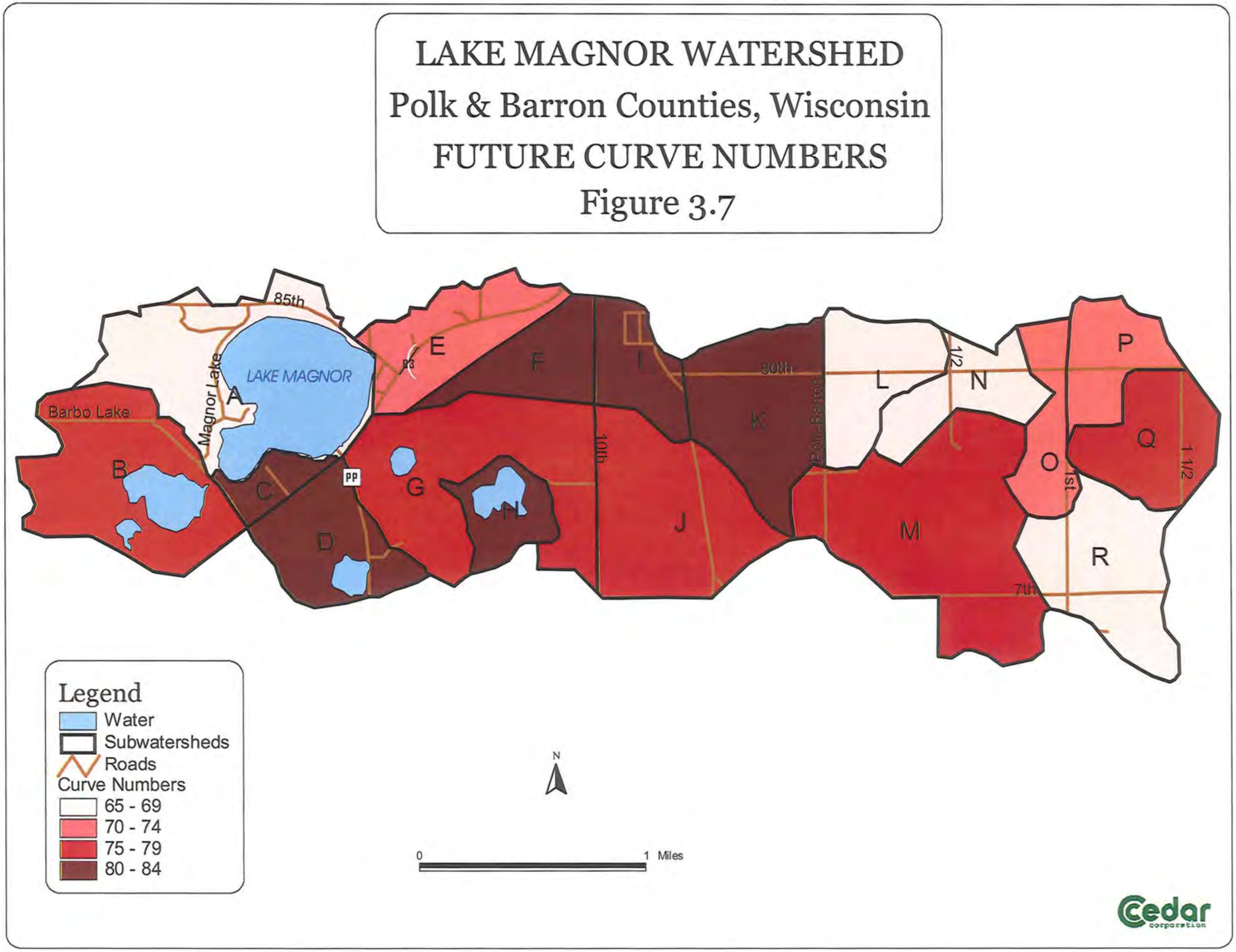
Source: NRCS Polk and Barron County Soil Surveys

LAKE MAGNOR WATERSHED
Polk & Barron Counties, Wisconsin
HYDROLOGIC SOIL GROUPS
Figure 3.5



LAKE MAGNOR WATERSHED
Polk & Barron Counties, Wisconsin
CURRENT CURVE NUMBERS
Figure 3.6





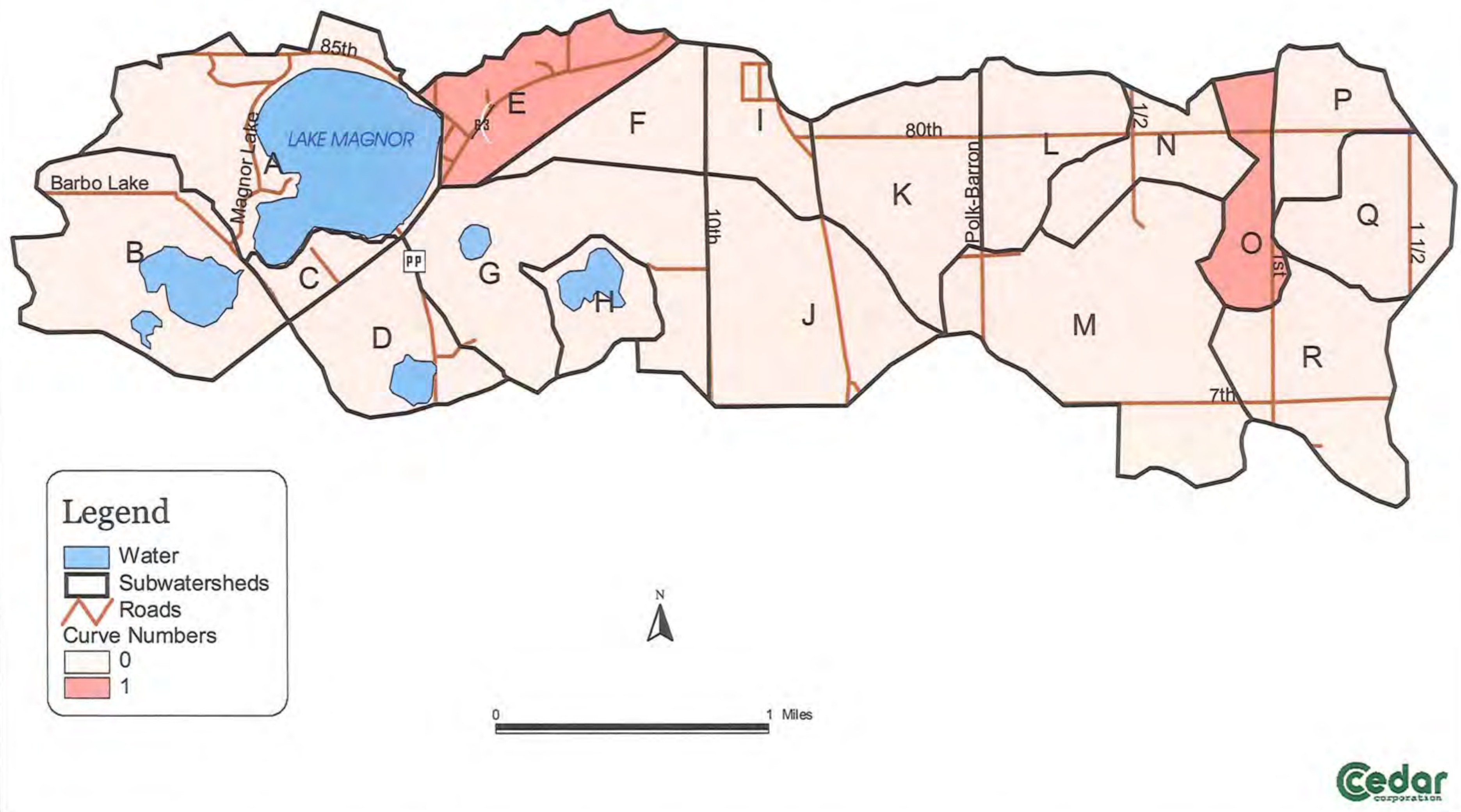
LAKE MAGNOR WATERSHED
Polk & Barron Counties, Wisconsin
FUTURE CURVE NUMBERS
Figure 3.7
LAKE MAGNOR
85th
Magnor Lake
Barbo Lake
80th
10th
Polk-Barron
1/2
1st
1 1/2
7th
PP
A
B
C
D
E
F
G
H
I
J
K
L
M
N
O
P
Q
R
Legend
Water
Subwatersheds
Roads
Curve Numbers
65 - 69
70 - 74
75 - 79
80 - 84
N
0
1 Miles
Cedar corporation

LAKE MAGNOR WATERSHED

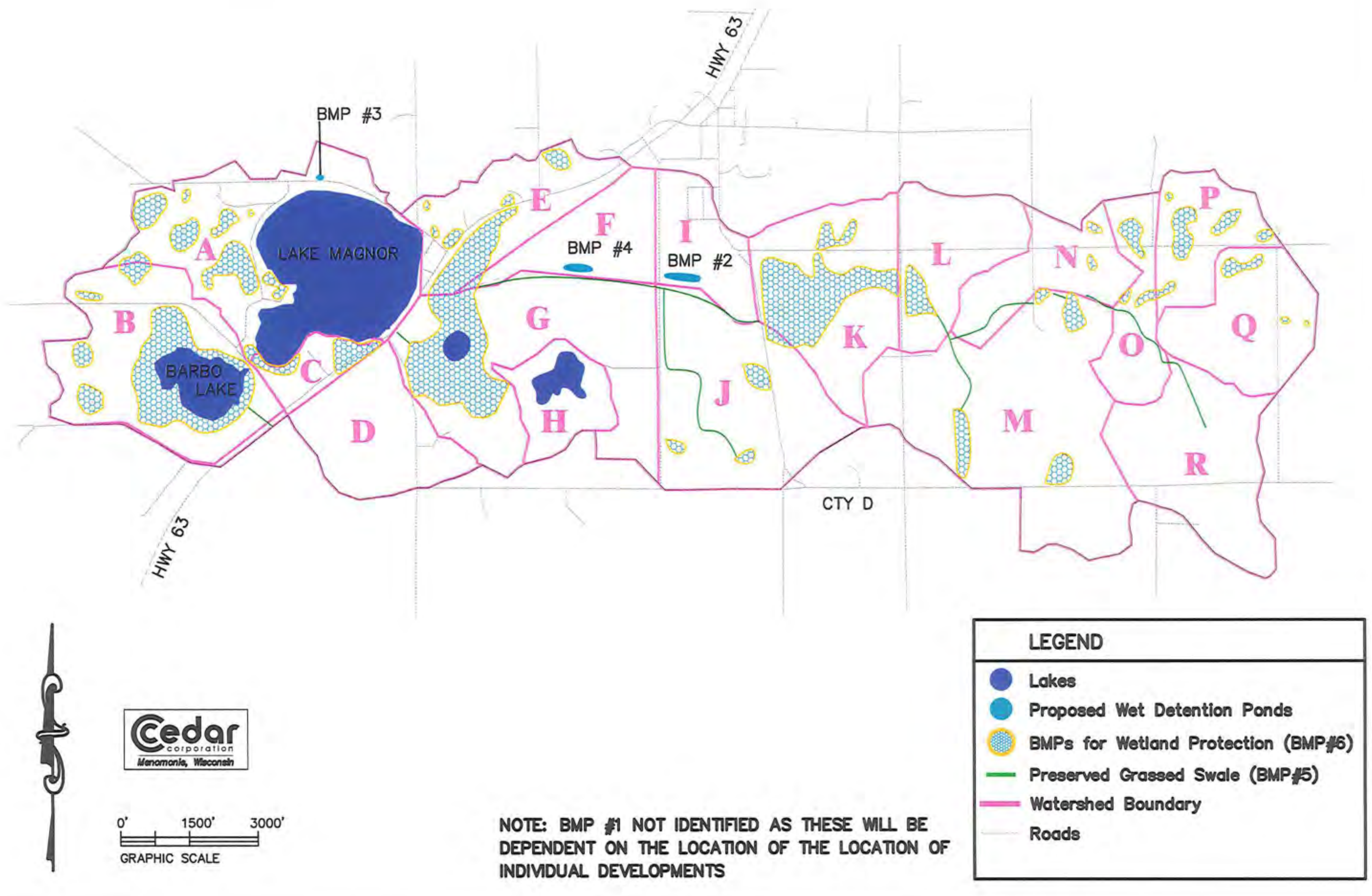
Polk & Barron Counties, Wisconsin

DEVELOPMENT INTENSITY
(Change in Curve Number)

Figure 3.8



LAKE MAGNOR
Watershed Management Master Plan
PROPOSED BEST MANAGEMENT PRACTICES
Figure 5-1



APPENDIX A

WDNR SEDIMENT CORING REPORT

APPENDIX B-1

STORM WATER QUANTITY – HYDROCAD SHEETS

EXISTING CONDITIONS

APPENDIX B-2

STORM WATER QUANTITY – HYDROCAD SHEETS

FUTURE CONDITIONS

APPENDIX C

WiLMS REPORT

APPENDIX D

MODEL ORDINANCES