Dane County
Water Body Classification Study
Phase I

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Prepared by the Staff of the
Dane County Regional Planning Commission

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EXECUTIVE SUMMARY

Background

Water body classification involves grouping water bodies based on their physical vulnerability to human impacts and the level of surrounding development. Classification systems are used to identify and target management strategies and techniques where they are needed most and have the greatest beneficial effect. The result of this study is a classification system that has been developed for all the navigable waters in Dane County using available scientific information and water resource survey data.

Lake and Pond Classification

For lakes and ponds, sensitivity criteria are based on physical attributes such as lake type and maximum depth. Development levels have been estimated using impervious cover percentages derived from existing land use information. Lakes are particularly sensitive to development along their shorelines and the associated impacts this has on lake ecology and habitat. Class I lakes and ponds possess high sensitivity and low development levels. Protection efforts are recommended for these ponds and lakes. Class II lakes and ponds possess medium sensitivity and development levels. Combined protection and restoration efforts are recommended for these ponds and lakes. Class III lakes and ponds possess low sensitivity and high development levels. The available menu of alternatives is more limited for these water bodies because of pre-existing development. Restoration and enhancement efforts are recommended in these cases to replace some of the lost shoreland functions and values.

Water Body Classification Matrix

Natural Sensitivity to Development	**Current Level of Development**		
	Low Level	**Medium Level**	**High Level**
High Sensitivity	Class I (Protection)	Class I (Protection)	Class II (Protection and Restoration)
Medium Sensitivity	Class I (Protection)	Class II (Protection and Restoration)	Class III (Restoration and Enhancement)
Low Sensitivity	Class II (Protection and Restoration)	Class III (Restoration and Enhancement)	Class III (Restoration and Enhancement)

River and Stream Classification

There is a considerable body of research correlating impervious cover with stream quality. A substantial decline in stream quality has been documented as impervious area increases. Streams are particularly sensitive to changes in the quantity and source of water as development and impervious area increase. By the time the water quality impacts become evident the damage has already largely been done. Class I streams are those having low development levels in their watershed. They are analogous to their lake counterparts in that protection efforts are recommended. Class II streams are those possessing intermediate development levels. Combined protection and restoration efforts are recommended for these transitional urbanizing streams. Class III streams are streams where the level of development has overwhelmed the biological integrity and function of the stream. Remedial strategies are directed more to the aesthetic and cultural amenities associated with these streams.

Natural Characteristics	Stream Classification Matrix		
	Class I (Sensitive Streams)	**Class II (Impacted Streams)**	**Class III (Degraded Streams)**
Warm and coldwater streams are equally sensitive	Protection	Protection and Restoration	Restoration and Enhancement

Process to Date

The focus for this study grew out of informal public meetings held by the Dane County Lakes and Watershed Commission regarding amendments to the county shoreland zoning ordinance. Public comments from those meetings prompted the submission and subsequent award of a DNR Lake Classification grant. Classification systems have been used by counties in Wisconsin to improve management of their surface water resources and tailor policies, plans, and programs accordingly. The project was initiated in June 2004 by the Dane County Planning and Development Department, with technical staff assistance provided by the former Dane County Regional Planning Commission (DCRPC). An introductory public meeting was also held August 26, 2004 to outline the approach and seek public comment. The DCRPC appointed a technical advisory committee of state and local experts to oversee the development of the study. The final report was presented to the Lakes and Watershed Commission March 10, 2005.

Next Steps

Completion of the Phase I Classification Study is expected to provide the basis for a Phase II Management Program coordinated by Dane County (not yet funded) working with the community to determine where its interests and priorities lie, and how current efforts may be best restructured and focused. The Phase II effort would include extensive public input, discussion of priorities, identifying limitations or gaps in existing programs, and how they might be enhanced or improved. The Phase I work provides the necessary background information and basis for Phase II community discussions and efforts. It is hoped the water body classification system and subsequent management program will provide a common understanding and framework by which the various partners can work together, combine technical, financial, and volunteer resources, and target them where they are needed most and have the greatest beneficial effect.

WATER BODY CLASSIFICATIONS

LAKE / POND	Class	Management Objective
AMES POND	I	Protection
ANDERSON POND	I	Protection
BARBIAN POND	I	Protection
BARNEY LAKE	I	Protection
BASS LAKE	I	Protection
BOWER POND	I	Protection
BRANDENBURG LAKE	I	Protection
BRUENIG POND	I	Protection
C. BUECHNER POND	I	Protection
CHRISTENSON POND	I	Protection
CRYSTAL LAKE	I	Protection
DAHMEN POND	I	Protection
DIEDRICH POND	I	Protection
DORN POND	I	Protection
DUNKIRK MILLPOND	I	Protection
EDGERTON POND	I	Protection
ESSER POND	I	Protection
FISH LAKE	I	Protection
FISHERS LAKE	I	Protection
FOX POND	I	Protection
GALLAGHER POND	I	Protection
GOOSE LAKE	I	Protection
GRABER/DREHER POND	I	Protection
GRASS LAKE (dunkirk)	I	Protection
GRASS LAKE (dunn)	I	Protection
HARRIETT LAKE	I	Protection
HOOK LAKE	I	Protection
INDIAN LAKE	I	Protection
ISLAND LAKE	I	Protection
KALSCHEUR POND	I	Protection
KRUTCHEN POND	I	Protection
L. BUECHNER POND	I	Protection
MAHER POND	I	Protection
MEIER POND	I	Protection
MENZEL POND	I	Protection
MORTENSON POND	I	Protection
MUD LAKE (MARX POND)	I	Protection
MUD LAKE T7N R12E S02	I	Protection
MUD LAKE, LOWER (MUD	I	Protection
MUD LAKE, UPPER	I	Protection
O'CONNELL POND	I	Protection
ORTMAN POND	I	Protection
PATRICK MARSH	I	Protection
POND 22-14	I	Protection
POND 7-11-34	I	Protection
POND 9-7-20	I	Protection
POND 9-9-13	I	Protection
RICE LAKE	I	Protection
SECTION 35 POND	I	Protection
SEMINOLE POND	I	Protection
STOUGHTON MILLPOND	I	Protection
SWEET LAKE	I	Protection
TURTLE LAKE	I	Protection
VIRGIN LAKE/HULL POND	I	Protection
BELLE VIEW LAKE	II	Protection / Restoration
GOOSE POND	II	Protection / Restoration
KOSHKONONG LAKE	II	Protection / Restoration
MARSHALL MILLPOND	II	Protection / Restoration
MORSE POND	II	Protection / Restoration
POND 7-10-10	II	Protection / Restoration
POND 7-9-25	II	Protection / Restoration
SECTION 26 POND	II	Protection / Restoration
SPRINGFIELD POND	II	Protection / Restoration
STEWART LAKE	II	Protection / Restoration
STRICKER POND	II	Protection / Restoration
TIEDEMAN POND	II	Protection / Restoration
WARNER PARK LAGOON	II	Protection / Restoration
WESTSIDE POND	II	Protection / Restoration
KEGONSA LAKE	III	Restoration / Enhancement
MARION LAKE	III	Restoration / Enhancement
MENDOTA LAKE	III	Restoration / Enhancement
MONONA LAKE	III	Restoration / Enhancement
SALMO POND	III	Restoration / Enhancement
TENNEY PARK LAGOON	III	Restoration / Enhancement
VERONA GRAVEL PIT	III	Restoration / Enhancement
WAUBESA LAKE	III	Restoration / Enhancement
WINDSOR LAKE	III	Restoration / Enhancement
WINGRA LAKE	III	Restoration / Enhancement

RIVER / STREAM / CREEK	Class	Management Management Objective
BADFISH CREEK	I	Protection
BLACK EARTH CREEK (LOWER)	I	Protection
BLUE MOUNDS BRANCH (GORDON)	I	Protection
BLUE MOUNDS CREEK, EAST BR.	I	Protection
DUNLAP CREEK	I	Protection
ELLA WHEELER WILCOX CREEK	I	Protection
ELVERS CREEK	I	Protection
FLYNN CREEK	I	Protection
FROG POND CREEK	I	Protection
GARFOOT CREEK	I	Protection
GERMAN VALLEY BRANCH	I	Protection
HALFWAY PRAIRIE CREEK	I	Protection
HENRY CREEK	I	Protection
JEGLUM VALLEY CREEK	I	Protection
KITTLESON VALLEY CREEK	I	Protection
LEUTENS CREEK	I	Protection
LITTLE DOOR CREEK	I	Protection
LITTLE NORWAY CREEK	I	Protection
LITTLE SUGAR RIVER	I	Protection
MARSH CREEK	I	Protection
MAUNESHA RIVER	I	Protection
MILUM CREEK	I	Protection
MUD CREEK T07N R12E S23	I	Protection
MUD CREEK T09N R12E S24	I	Protection
NOLAN CREEK	I	Protection
PLEASANT VALLEY BRANCH	I	Protection
PLEASANT VALLEY CREEK	I	Protection
PLEASURE VALLEY CREEK	I	Protection
PRIMROSE BRANCH	I	Protection
ROXBURY CREEK	I	Protection
RUTLAND BRANCH (ANTHONY)	I	Protection
RYAN CREEK	I	Protection
SAUNDERS CREEK	I	Protection
SPRING CREEK (DORN)	I	Protection
SPRING CREEK T08N R12E S15	I	Protection
SPRING CREEK(LODI)T9N R8E S4	I	Protection
SPRING VALLEY CREEK	I	Protection
STORY CREEK	I	Protection
STRANSKY CREEK	I	Protection
SYFTESTAD CREEK	I	Protection
VERMONT CREEK	I	Protection
WENDT CREEK	I	Protection
WEST BR. SUGAR RIVER	I	Protection
WEST BR. SUGAR RIVER TRIB.	I	Protection
WISCONSIN RIVER	I	Protection
YORK VALLEY CREEK	I	Protection
BLACK EARTH CREEK (MIDDLE)	II	Protection/Restoration
BLACK EARTH CREEK (UPPER)	II	Protection/Restoration
BOHN CREEK	II	Protection/Restoration
BREWERY CREEK	II	Protection/Restoration
DEER CREEK	II	Protection/Restoration
DOOR CREEK	II	Protection/Restoration
ELVERS CREEK (UPPER)	II	Protection/Restoration
FRYES FEEDER	II	Protection/Restoration
KEENANS CREEK	II	Protection/Restoration
KOSHKONONG CREEK	II	Protection/Restoration
MOEN CREEK	II	Protection/Restoration
MT VERNON CREEK	II	Protection/Restoration
MURPHYS CREEK	II	Protection/Restoration
OREGON BRANCH	II	Protection/Restoration
PHEASANT BRANCH CREEK TRIB.	II	Protection/Restoration
SCHALPBACH CREEK	II	Protection/Restoration
SCHUMACHER CREEK	II	Protection/Restoration
SIX MILE CREEK	II	Protection/Restoration
SIX MILE CREEK TRIBUTARY	II	Protection/Restoration
SUGAR RIVER (UPPER)	II	Protection/Restoration
SUGAR RIVER coldwater segment	II	Protection/Restoration
SUGAR RIVER warmwater segment	II	Protection/Restoration
SWAN CREEK	II	Protection/Restoration
TOKEN CREEK	II	Protection/Restoration
TOKEN CREEK TRIBUTARY 1	II	Protection/Restoration
WEST BR. SUGAR RIVER (UPPER)	II	Protection/Restoration
YAHARA RIVER (LOWER)	II	Protection/Restoration
YAHARA RIVER (MIDDLE)	II	Protection/Restoration
YAHARA RIVER (UPPER)	II	Protection/Restoration
BADGER MILL CREEK	III	Restoration/Enhancement
MURPHY CREEK (Wingra Cr)	III	Restoration/Enhancement
NINE SPRING CREEK	III	Restoration/Enhancement
PHEASANT BRANCH CREEK	III	Restoration/Enhancement
STARKWEATHER CREEK, EAST BR.	III	Restoration/Enhancement
STARKWEATHER CREEK, WEST BR.	III	Restoration/Enhancement

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I INTRODUCTION

A. Regional Setting

Dane County occupies 1,230 square miles in the heart of an agricultural state. Most of the land is productive farmland. In the center of this farmland is the City of Madison, the state capitol and the main campus of the state university. The total water surface area in Dane County is about 23,000 acres, or about 3% of the total area of the county. There are about 21,600 acres in 70 named lakes and ponds, and 69 named streams totaling 475 miles. Due to its location at a terminal glacial moraine, Dane County boasts a wide diversity of water bodies:

- large glacial lakes such as the Yahara Lake Chain (now almost entirely urbanized)
- small shallow landlocked lakes such as Fish and Crystal lakes
- warmwater streams with significant restoration potential, such as Door Creek and Koshkonong Creek, and
- coldwater streams such as Mt. Vernon Creek, Sugar River, and the nationally-recognized Black Earth Creek

This diversity is a reflection of its varied and unique geologic and physiographic setting (Map 1). The western part of the county, known as the Valley and Ridge or "Driftless" area, is the only part of the county that has not been affected by glaciers. The area is characterized by fast-flowing streams, generally without natural lakes or impoundments. Most of the streams are fed by springs and seeps flowing from groundwater and water-bearing layers of bedrock. Stream gradients, temperature, baseflow and habitat conditions are suitable for trout fisheries on many streams.

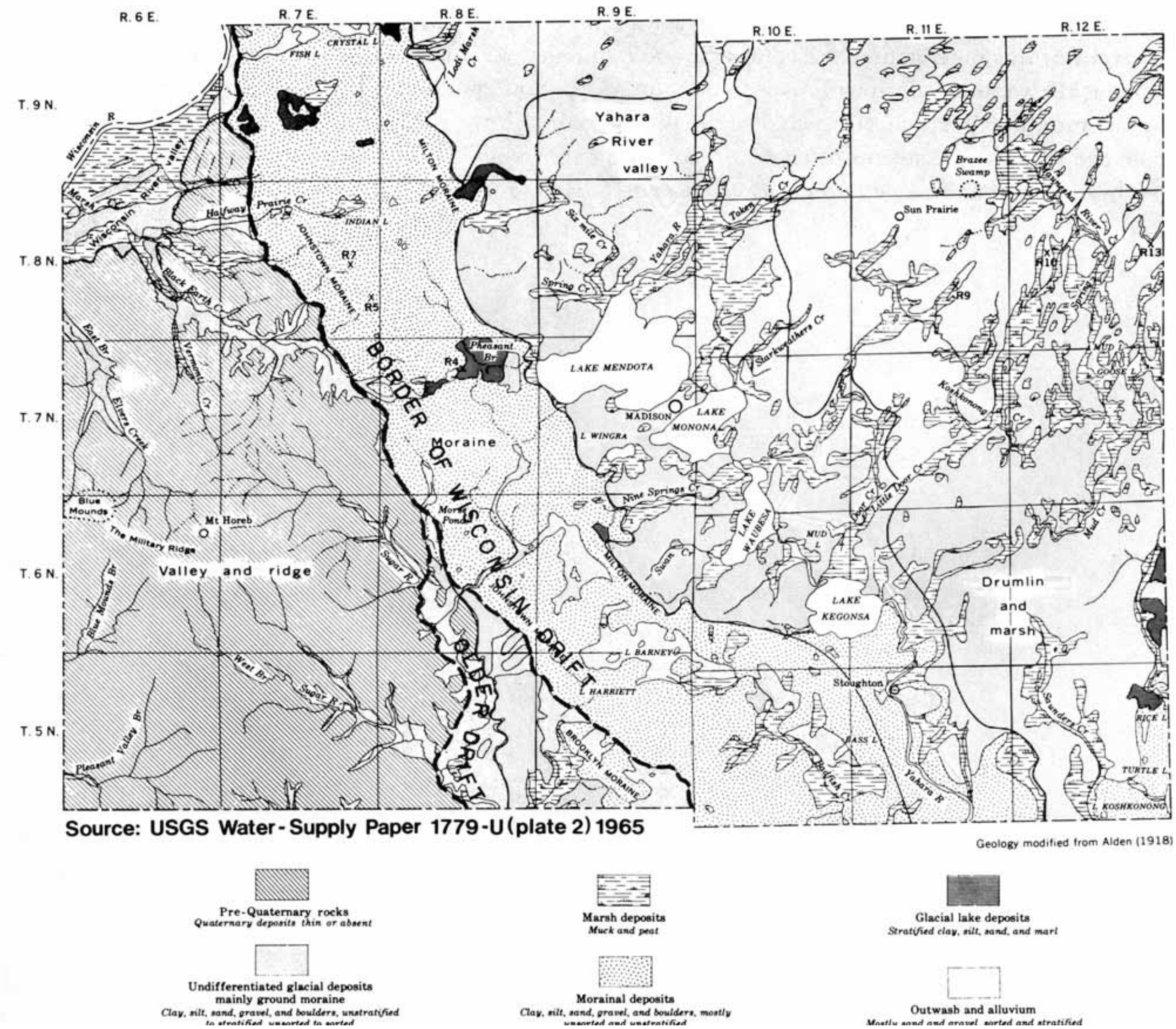
To the east of the driftless area is an area of glacial moraines, located at a major drainage divide where the headwater of many streams of the Wisconsin, the Sugar, and the Yahara River basins originate. The area includes kettle lakes and closed depression areas. These were formed as the glacier retreated and large blocks of ice buried under glacial till melted away.

East of the moraines, in the center of the county, is the Yahara River valley. Here deep glacial deposits dammed up large valleys, forming a chain of large lakes and wetlands. Streams in the Yahara River valley are generally flatter and more sluggish than those in the driftless area, and fewer are spring fed.

The eastern part of the county is known as the Drumlin and Marsh area and consists primarily of glacial deposits with extensive areas of marsh deposits. This creates an extensive system of interconnected wetlands with poorly defined drainage. Small streams wind slowly through the lowlands and there are only a few springs supplying streamflow. The only lakes in this area are small stream impoundments or shallow, marshy lakes.

Dane County is the fastest growing metropolitan area in the state. Land use patterns in the county are changing rapidly as each of the 61 local jurisdictions within the county experiences these growth pressures. As the population has grown, the City of Madison and other cities and villages have expanded into neighboring agricultural land. In addition, many individual houses and subdivisions have been built on unsewered lots scattered outside these urban areas. Both the pressures of urbanization and changes in the farm economy have pushed farmers to convert more land to cash crops such as corn. The expansion of urban areas and changes in farming have affected the region's lakes and streams. The primary problem has been "nonpoint source pollution" or diffuse sources of polluted runoff from urban and agricultural land. Some of the more gradual and subtle impacts to the resource result from groundwater withdrawals and reductions in groundwater recharge, vegetation removal and habitat loss associated with urban development.

MAP 1. Dane County, Wisconsin Showing Physiographic Areas and Deposits of Quaternary Age



B. Legislative Finding

Dane County Chapter 11.02 states:

> *The county Board does find that the uncontrolled use of the shorelands and pollution of the navigable waters of Dane County adversely affect the public health, safety, convenience, and general welfare and impairs the tax base. The legislature of Wisconsin has delegated responsibility to the counties to further the maintenance of safe and healthful conditions; prevent and control water pollution; protect spawning grounds, fish and aquatic life; control building sites, placement of structures and land uses; and preserve shore cover and natural beauty, and this responsibility is hereby recognized by Dane County.*

The Dane County Lakes and Watershed Commission also has unique legislative authority (Wisconsin Act 324). It can propose to the County Board regulatory standards for water quality that apply in both unincorporated and incorporated areas in Dane County. For example, the Commission recently used this authority to establish uniform countywide stormwater and erosion control standards, (enacted August 2002). The focus for this study grew out of informal public meetings held by the county Lakes and Watershed Commission regarding amendments to the county shoreland zoning ordinance. Public comment from those meetings raised a number of concerns, including the following:

- Tailoring policies to meet the differing needs and circumstances of various types of water bodies
- Treating city, village and town riparian landowners fairly, based on the sensitivity of the resource and level of development
- Providing a sound, scientific justification for new regulations or guidelines to help coordinate and focus existing programs and resources
- Ensuring that the burden on landowners with different land uses is proportional to the impacts of these uses
- Including voluntary, incentive and other non-regulatory approaches

C. Project Description

The Water Body Classification Study is the next step toward developing an equitable and consistent set of countywide standards and policies to help protect and restore the surface waters of the county. The following uses are anticipated for the Water Body Classification system:

- Tailor shoreland zoning standards to suit the sensitivity of the resource, surrounding land uses, and development pressures
- Provide a basis for setting cost-sharing priorities for environmental projects
- Identify gaps in the county's environmental protection strategies and suggest improvements
- Help direct information, education and volunteer resources where they can provide the greatest benefit
- Provide information and a framework for the county's comprehensive plan

D. Project Goals and Objectives

The following goals and objectives have been identified for the first phase of the Water Body Classification Study:

- Provide the scientific basis for developing a mix of regulations, incentives, education, cost-sharing, acquisition and other policy approaches appropriate for each water body type, quality of the resource, level of urbanization and potential land use impacts
- Provide basic information about the types, vulnerabilities, condition and restoration potential of the navigable waters in Dane County
- Coordinate with the county's Comprehensive Plan development
- Provide the basis for fair and consistent treatment of riparian landowners under different jurisdictions
- Promote a deeper understanding of the current condition of Dane County waters and provide for more effective management to improve water quality, natural habitat, the ecological health of Dane County waters, and shorelands

E. Project Area

The project area includes navigable lakes, ponds, rivers and streams within the territorial boundaries of Dane County. The classification study includes water bodies in both incorporated and unincorporated areas.

F. Phase II Protection Program

It is expected the Phase I study will provide the basis for a subsequent Phase II effort coordinated by Dane County to develop a water body management program. This could include updates to the county shoreland zoning ordinance and recommendations for new or existing water quality protection programs. The Phase II effort would involve extensive public input, discussion of priorities, identifying limitations or gaps in existing programs, and how they might be enhanced or improved. This may be similar to what was done in updating the countywide erosion control and stormwater management ordinance and supporting programs. The Phase I work provides the necessary background information and basis for supporting those discussions and efforts.

II. BACKGROUND

Wisconsin's shoreland zoning standards were originally developed in the late 1960s based on the best professional judgement at that time. Since then, there have been significant advances in our understanding of aquatic natural systems, and the public's knowledge and perceptions and the political landscape have also changed. Current and future development trends pose major challenges to the significant environmental, recreational and economic resources in Dane County. Options for improving the shoreland zoning program are also being evaluated and recommended at the state level, tied to regional classifications systems specifically tailored to local circumstances and priorities. It has been realized that a one-size-fits all approach may not be necessary or even appropriate in many cases, and that different strategies can be used for different situations. A classification system may also be used to guide program resources, promote cost-sharing opportunities and partnerships among various public agencies and private groups, as well as direct their efforts where they will do the most good and have the greatest beneficial impact.

In 2003, Dane County received a DNR Lake Classification Grant to conduct a Water Body Classification Study. The Phase I study will provide the technical basis and support for a subsequent Phase II protection program coordinated by Dane County (not yet funded) developed in cooperation with local units of government, private citizen groups and landowners, and incorporated into the county's Comprehensive Plan. At last count, twenty-seven counties in Wisconsin have adopted or are in the process of adopting classification systems. Almost all of them have chosen shoreline development as their primary management objective, and improvement of shoreland regulations as their primary management strategy. Dane County has chosen to expand the scope of alternatives to include non-regulatory and financial incentive approaches as well.

A classification system is based on the notion that water resources plans, policies and programs can be modified to suit local needs and circumstances. In other words, one strategy or set of standards may not be appropriate in all cases, and that these can be tailored to reflect local conditions. The purpose is to provide enhanced protection of lake and river shorelines, and water quality. The water body classification system and subsequent management program would be designed to provide varying degrees of protection and restoration based on a water body's sensitivity and level of surrounding development pressures. For example, classification systems have been used to control the pattern and density of development along shorelines, limit land disturbing activities, limit runoff from yards and impervious surfaces, provide greater and therefore more effective shoreland buffer widths, protect sensitive resource areas, and restore lost shoreland functions.

A. Imperviousness as an Environmental Indicator

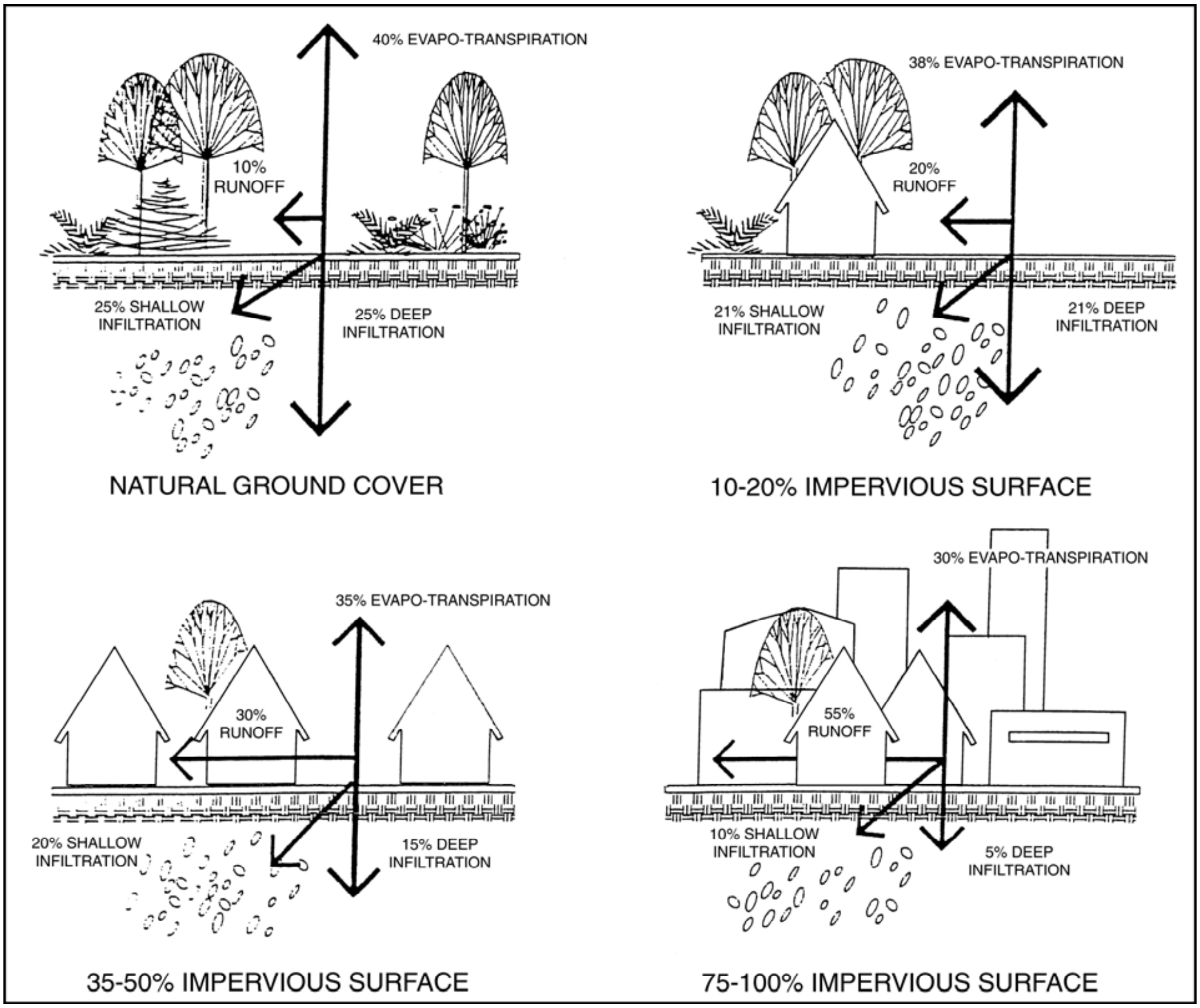
Impervious areas are hard surfaces such as roofs, concrete, asphalt, and compacted soil which prevent rain and snowmelt from soaking into the ground. Impervious areas increase the amount of runoff as well as its velocity and cause the following changes:

- Greater fluctuations in water levels
- Increased erosion
- More sediment and pollutants delivered to waterways
- Degraded habitat (e.g., gravel spawning areas filled with sediment, loss of vegetation and structure)
- Increased water temperature and loss of sensitive coldwater fish
- Decline in aquatic insect diversity
- Decline in fish diversity
- Reduced natural reproduction and numbers of species

In addition, impervious cover affects groundwater quality and quantity in the following ways:

- Prevents the physical filtration and natural biological processes that remove nutrients and other pollutants when water is allowed to soak into the ground
- Inhibits groundwater recharge through the soil, as well as subsequent groundwater discharge (baseflow) to surface waters

Figure 1. Water Cycle Changes Associated with Urbanization



Source: Environmental Protection Agency 1993

As development alters the natural landscape, the percentage of the land covered by impervious surface increases. Imperviousness has become synonymous with human presence. Studies have shown that population density in an area is correlated with the percentage of impervious cover.[1,2] Impervious cover not only indicates urbanization, but is also a major contributor to the environmental impact of urbanization. As the natural landscape is paved over, a chain of events is initiated that typically results in degraded water resources. The chain begins with alteration in the hydrologic cycle, or the way that water is transported and stored.

Geologists and hydrologists have long understood these changes, depicted in Figure 1. This diagram shows how increases in impervious cover increases the amount of runoff that eventually ends up in our lakes and streams. In a non-urban setting, runoff is around 10% of total rainfall. As impervious coverage increases, the velocity and volume of surface runoff increases with a corresponding decrease in infiltration into the ground. The larger volumes of runoff and the increased efficiency of water conveyance through pipes, gutters, and artificially straightened channels result in increased severity of flooding, with storm flows that are greater in volume and rise or peak more rapidly than is the case in rural areas. The shift away from infiltration also reduces groundwater contribution to streamflow, which can result in the drying up of perennial streams during low flow or dry-weather periods.

[1] Arnold, C., and C.J. Gibbons. 1996. *Impervious Surface Coverage. The Emergence of a Key Environmental Indicator*. Journal of the American Planning Association 62(2):243-258.

[2] Center for Watershed Protection. 2000. *Housing Density and Urban Land Use as Stream Quality* Indicators. Watershed Protection Techniques 3(3):735-739.

Hydrologic disruption gives rise to physical and ecological impacts as well. Enhanced runoff causes increased erosion from construction sites, downstream areas, and stream banks. The increased volume of water and sediment, combined with the "flashiness" of these peak discharges, result in wider and straighter stream channels. There is substantial loss of both streamside (riparian) habitat through erosion, and in-stream habitat as the natural streambed of pebbles, rocks and deep pools are covered by a uniform blanket of eroded sand and silt. Loss of tree cover leads to greater water temperature fluctuations, making the water warmer in the summer and colder in the winter. Engineered responses to flooding such as stream diversion, channelization, and ditching destroy streambeds and associated habitats like ponds and wetlands even further. Also, with more intensive land uses come a corresponding increase in pollutants. Increased runoff transports these pollutants directly into waterways creating "nonpoint source pollution," or diffuse sources of polluted runoff from land surfaces (as opposed to "point source pollution" originating from a single point such as an industrial pipe).

Major categories of nonpoint source pollutants include nutrients, fertilizers, pesticides, oil and volatile organic compounds, heavy metals and other toxic contaminants, pathogens (disease-causing microorganisms), sediment and debris. Overabundance of nutrients such as phosphorus and nitrogen can lead to algal "blooms" in surface waters that decay and rob the waters of life-sustaining oxygen. Toxic contaminants like heavy metals and pesticides pose threats to the health of aquatic organisms, and their human consumers, and can persist in the environment. Pathogen contamination presents possible health hazards for recreational users. Sediment is a major nonpoint source pollutant, both for its effects on aquatic ecology and because many of the other pollutants tend to adhere to eroded soil particles. Debris detracts from the visual and aesthetic qualities of surface water bodies and can pose a hazard to wildlife through ingestion and entrapment.

Studies of water quality impacts of lakeshore development point to the importance of reducing the cumulative impacts of development, both in terms of the impacts to habitat and phosphorus loading. When shoreland vegetation is disturbed or removed by human activities, aquatic plants and animals are affected. Vegetated riparian zones along the shoreline help stabilize the banks by holding soil in place. By trapping sediment and removing nutrients from runoff, the natural shoreline helps maintain water clarity and prevents siltation of the lakebed, thus preserving spawning areas. When trees fall into the near-shore waters, they are another important part of habitat structure. Near-shore waters littered with exposed or submerged woody debris diversify the habitat for a variety of insects, fish, birds and mammals, which live along the water. Woody debris plays an important role in the aquatic food chain by providing colonization sites for insects. The insects and the structure created by branches and logs provides cover and forage opportunities for juvenile fish and larger adult species. Floating logs, leaning trees, and overhanging branches also provided basking sites for turtles and snakes, as well as perching sites for shorebirds and ambush sites for raccoons and other mammals that prey on aquatic life, thus supporting a very broad and diverse food-web or ecological pyramid. In comparison, the limited ecosystems associated with urban areas only support fewer numbers of only the most tolerant species.

When conducting community-level planning, or where detailed site information is not available, impervious coverage may be the most feasible and cost-effective way of assessing the impacts of development. Impervious cover can be used to estimate or predict cumulative water resource impacts without regard to specific factors – thereby helping to cut through much of the complexity surrounding nonpoint source pollution and habitat degradation. Although impervious surfaces do not generate pollution, they are (1) a critical contributor to the hydrologic changes that degrade waterways; (2) a major component of the intensive land uses that generate pollution; (3) prevent natural pollutant attenuation or removal in the soil by preventing infiltration; and (4) serve as an efficient conveyance system transporting pollutants into waterways.

Research over the last 20 years shows a strong correlation between the imperviousness of a drainage basin and the health of receiving streams.[3,4,5,6,7,8] In some cases, the impervious cover and indicator relationship is considered so

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[3] Wang, L., J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons. 2000. *Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams.* Journal of the American Water Resources Association 36(5):1173-1189.

[4] Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. *Influences of Watershed Land Use on Habitat Quality and Biotic Integrity in Wisconsin Streams*. Fisheries 22(6):6-12.

[5] Arnold, C., and C.J. Gibbons. 1996. *Impervious Surface Coverage. The Emergence of a Key Environmental Indicator*. Journal of the American Planning Association 62(2):243-258.

[6] Schueler, T. 1995. *Site Planning for Urban Stream Protection*. Center for Watershed Protection. Ellicot, MD

[7] Masterson, J.P., and R.T. Bannerman. 1994. *Impacts of Stormwater Runoff on Urban Streams in Milwaukee, Wisconsin*. In *National Symposium on Water Quality*. 1994. American Water Resources Association. Middelburg, VA.

[8] Schueler, T. 1994. *The Importance of Imperviousness*. Watershed Protection Techniques 1:100-111.

strong that it has been incorporated directly into accepted engineering models. This has been particularly true for hydrologic and water quality indicators. In terms of the degree of impact, for example, a modeling study by the Wisconsin DNR compared an undeveloped shoreland lot with the impacts from a large lake home on a lot entirely converted to lawn (approx. 4000 sq. ft. of impervious surface).[9] The study found up to a 500% increase in runoff volume, 700% increase in phosphorus loading and 900% increase in sediment flowing to the lake. Another monitoring study of pollutants in Wisconsin stormwater revealed that streets were the single most important source for urban pollution in residential, commercial and industrial areas.[10] Runoff from lawn areas yielded the highest overall phosphorus concentrations, which may be attributed to excessive lawn fertilization.

Another factor in favor of the use of imperviousness as an environmental indicator is that it is measurable. The percentage of land covered by impervious surfaces varies significantly with land use. The most frequently cited estimates come from the U.S. Department of Agriculture, Natural Resources Conservation Service (formerly the Soil Conservation Service) Technical Release No. 55 (TR-55). These estimates were used in this study as well.

Good site design begins with an analysis of the natural and environmental features and constraints. Applying this principle to water resources protection translates to maintaining the natural hydrologic function by retaining natural contours and vegetation to the maximum extent possible. Reducing impervious surface area is the other key element of the overall strategy. This also includes construction site erosion control practices and stormwater management measures to mitigate or reduce the effects of runoff from new development.

For example, large-lot subdivisions generally create more impervious cover and greater water resource impacts than cluster-style housing (Figure 2). This is true even though the large lots may have less impervious coverage per lot. Because the traditional design requires longer roads, driveways, and sidewalks, this makes the overall subdivision parcel more impervious.[11] A modeling study in South Carolina compared the water quality impacts of conventional versus clustered town subdivision design.[12] Total water quality impacts were significantly greater under the conventional design build out. The conventional design generated 43 percent more runoff and 3 times the amount of sediment loading. It also resulted in greater nitrogen and phosphorus inputs and greater chemical oxygen demand.

An important note about reducing imperviousness through planning and design is that it can save money.[13] Cluster development can reduce site imperviousness by 10-50%, depending on the lot size and the road network.[14] Savings to both the private and public sectors in reduced construction, infrastructure, and maintenance costs can be considerable.

The other advantage of using imperviousness as an environmental indicator is that it seems to make sense to the average citizen. Reduction of paved areas is one of the relatively few planning initiatives that resonates at all levels, from the suburban driveway to the big box parking lot. Impervious cover is characteristic of urban land uses and is an excellent integrative measure of the extent and intensity of urbanization. The use of impervious coverage as an environmental indicator is an important tool that can be used to help protect and restore a community's aquatic natural resources. Alternatively, the restoration and protection of naturally vegetated areas is an equally important management strategy.

Imperviousness is especially important with regard to stormwater management. "Best management practices" (BMPs) include a wide range of on-site options available to manage stormwater runoff. BMPs are often divided into two major types: those involving structures such as stormwater detention ponds or infiltration trenches, and "nonstructural" practices that usually involve the use of vegetated areas to buffer, direct, and otherwise break up large impervious areas.[15] Table 1 presents the comparative water *quantity* benefits provided by urban BMPs. Table 2 presents the water *quality* benefits or pollutant removal. Maintenance measures like sweeping sand from roads and storm drain cleaning are also included in BMPs, as are practices on individual homesites. These include directing downspouts to grassy

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[9] Panuska, J. 1994. Internal Memo on results of modeling study on phosphorus loading. Wisconsin Department of Natural Resources Bureau of Watershed Management.

[10] Bannerman, R., D. Owens, R. Dodds, and N. Hornewer. 1993. *Sources of Pollutants in Wisconsin Stormwater* in Water Science & Technology (28)3-5 pp.241-259.

[11] Arendt, Randall. 1994. *Designing Open Space Subdivision, A Practical Step by Step Approach*. Natural Lands Trust, Inc. Media, PA.

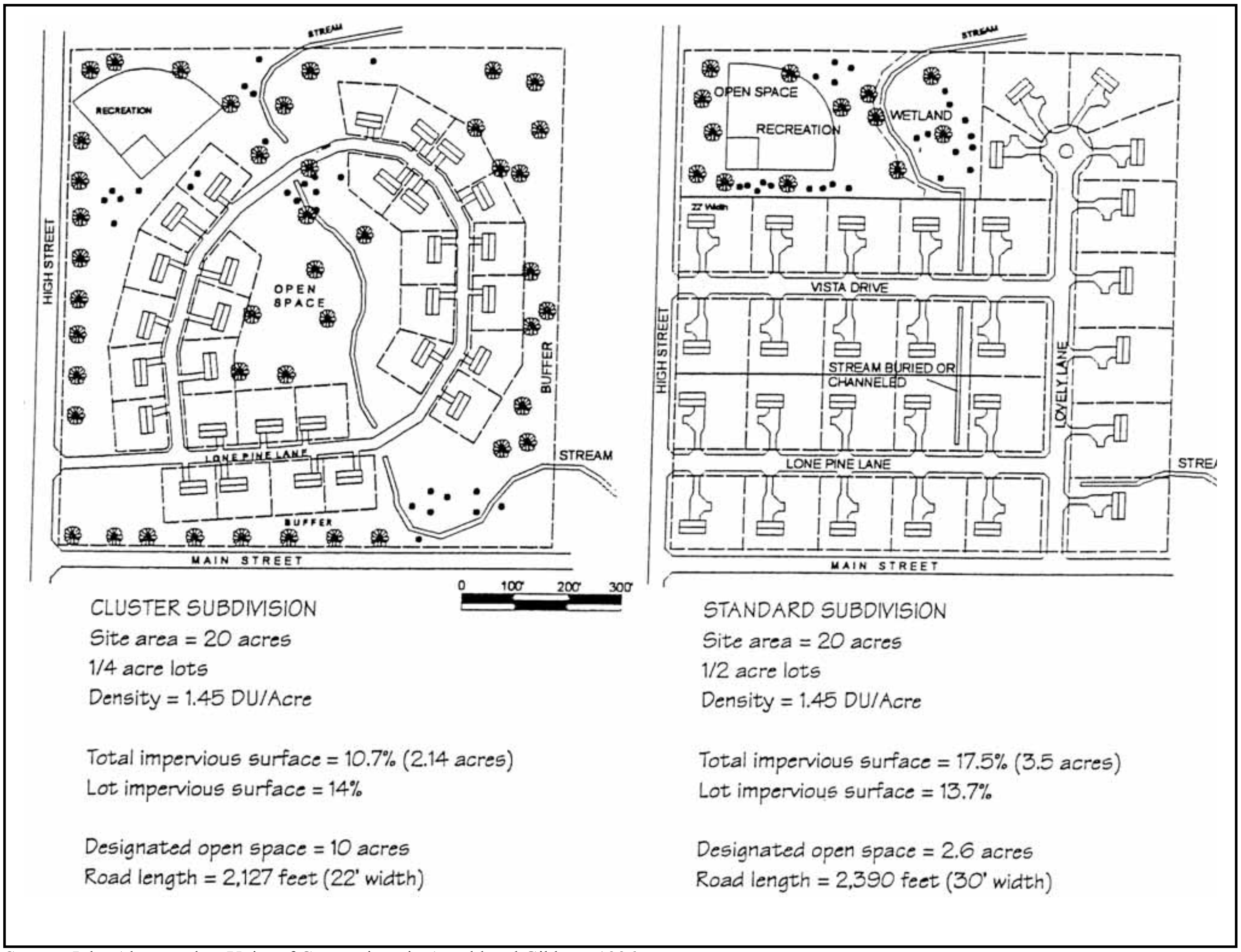
[12] South Carolina Coastal Conservation League. 1995. *Getting a Rein on Runoff: How Sprawl and the Traditional Town Compare*. South Carolina Coastal Conservation League Land Development Bulletin, No. 7.

[13] Arnold, C., and C.J. Gibbons. 1996. *Impervious Surface Coverage. The Emergence of a Key Environmental Indicator*. Journal of the American Planning Association 62(2):243-258.

[14] Schueler, T.R. 1994, *Use of Cluster Development to Protect Watersheds*. Watershed Protection Technuques 1,3:137-40.

[15] Dane County Regional Planning Commission. 2004. *Dane County Water Quality Summary Plan*. Madison, WI

Figure 2. Clustering Reduces Overall Site Imperviousness



Source: John Alexopoulos, Univ. of Connecticut, in Arnold and Gibbons 1996

areas away from pavement, rain gardens, limiting fertilizer and pesticide use, proper disposal of leaves, yard and garden waste, etc. There is another whole set of agricultural BMPs directed at rural nonpoint source runoff (Table 3).

Dane County has a long agricultural history and heritage. Not too surprisingly, whatever land isn't already developed, too steep, or too wet is very likely devoted to agriculture. While some farm operations may be more harmful than others, agriculture generally affects *all* surface waters in Dane County to one extent or another. For example, soil erosion from agricultural lands is the largest source of sediment and nutrients to the county's lakes and streams, with the most significant erosion occurring on sloping areas with exposed soils, especially those devoted to row crops.[16] In addition, the transition of agricultural land to urban development results in some of the highest concentrations of these same pollutants. Streambank erosion from overgrazing and in-stream livestock watering is another serious problem. Also, runoff from barnyards, feedlots, and croplands where manure is spread can contribute to high levels of nutrients and organic material. This material can cause bacterial contamination and dissolved oxygen problems in receiving streams and add nutrients to surface waters. Lastly, pesticides used to control weeds and insects can contribute potentially toxic materials.

In most cases, agricultural BMPs can be employed to help address these problems. These are usually site specific including, for example: cropping and tilling practices, nutrient, pesticide, and barnyard management, stream buffers, streambank fencing, wetland restoration, etc. These are largely implemented in cooperation with individual landowners as opportunity and available funding permit.

[16] Dane County Regional Planning Commission. 2004. *Dane County Water Quality Summary Plan*. Madison, WI

Table 1.

BMP	Peak Discharge Control					
	2 Year Storm	10 Year Storm	100 Year Storm	Volume Control	Groundwater Recharge	Streambank Erosion Control
Extended Detention						
Dry	●	●	●	⊘	⊘	●
Dry w/Marsh	●	●	●	○	⊘	●
Wet	●	●	●	⊘	⊘	●
Wet Pond	●	●	●	○	⊘	⊘
Infiltration Trench						
Full Exfiltration	●	○	⊘	●	●	●
Partial Exfiltration	●	●	⊘	●	●	●
Water Quality Trench	⊘	⊘	⊘	●	●	●
Infiltration Basin						
Full Exfiltration	●	○	⊘	●	●	●
Infiltration/Detention	●	●	●	●	●	○
Off-Line Basin	⊘	⊘	⊘	●	●	○
Porous Pavement						
Full Exfiltration	●	○	⊘	●	●	●
Partial Exfiltration	●	●	○	●	●	○
Water Quality	⊘	⊘	⊘	●	●	○
Water Quality Inlet	⊘	⊘	⊘	⊘	⊘	⊘
Grassed Swale	○	⊘	⊘	○	○	⊘
Filter Strip	○	⊘	⊘	○	○	⊘

⊘ Seldom or Never Provided ○ Sometimes Provided w/Careful Design ● Usually Provided

Derived from: Schueler, Thomas R. (1987). *Controlling Urban Runoff: A practical manual for plan and designing urban BMPs*

Table 2.

Comparison of Median Pollutant Removal Efficiencies Among Selected Practice Groups: Conventional Pollutants

		Median Removal Rate For Stormwater Pollutants (%)					
Practice Groups	N	TSS	TP	Sol P	Total N	Nitrate	Carbon
Detention Pond	2	7	10	2	5	3	(-1)
Dry ED Pond	6	61	19	(-9)	31	9	25
Wet Pond	30	77	47	51	30	24	45
Wet ED Pond	6	60	58	58	35	42	27
Ponds[a]	**36**	**67**	**48**	**52**	**31**	**24**	**41**
Shallow Marsh	14	84	38	37	24	78	21
ED Wetland	5	63	24	32	36	29	ND
Pond/Wetland	11	72	54	39	13	15	4
Wetlands	**35**	**78**	**51**	**39**	**21**	**67**	**28**
Surface Sand Filters	6	83	60	(-37)	32	(-9)	67
Filters[b]	**11**	**87**	**51**	**(-31)**	**44**	**(-13)**	**66**
Channels	**9**	**0**	**(-14)**	**(-15)**	**0**	**2**	**18**
Swales[c]	**9**	**81**	**29**	**34**	**ND**	**38**	**67**

N =Number of performance monitoring studies. The actual number for a given parameter is likely to be slightly less.
Sol P= Soluble phosphorus, as measured as ortho-p, soluble reactive phosphorus or biologically available phosphorus.
Total N = Total Nitrogen. Carbon = Measure of organic carbon (BOD, COD, or TOC).
[a] Excludes conventional and dry ED ponds.
[b] Excludes vertical sand filters and vegetated filter strips.
[c] Includes biofilters, wet swales and dry swales.

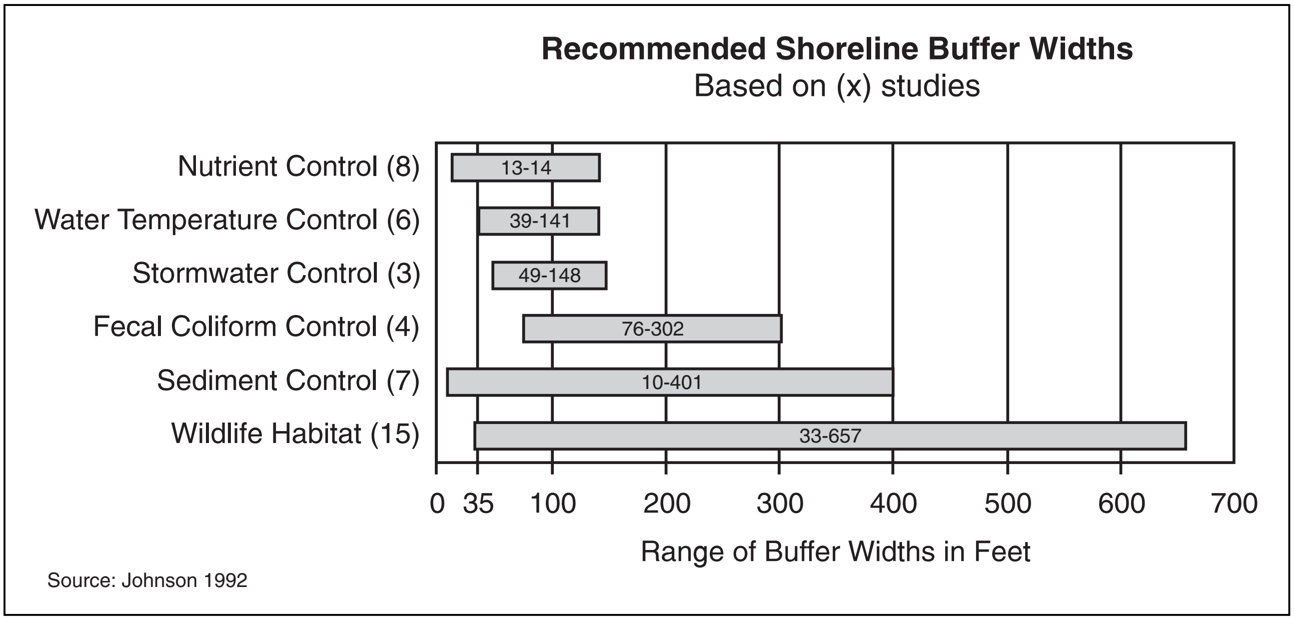
Table 3.

Agricultural Management Practices

Management Practice	Effectiveness	Capital Cost	On-Site Benefit
Contour Cropping	High	Low	Moderate
Strip Cropping	High	Low	Moderate
Field Diversions	High	Moderate	Moderate
Terraces	High	Moderate	Moderate
Waterways	High	Moderate	Moderate
Reduced Tillage	High	Low	Moderate
Critical-Area Stabilization	High	High	Low
Grade Stabilization Structure	High	High	Low
Shoreline Protection	High	High	Low
Barnyard Runoff Management	High	Moderate	Moderate
Long-term Manure Storage Facilities	High	High	Moderate
Short-term Manure Storage Facilities	High	Moderate	Moderate
Livestock Exclusion from Woodlot	High	Low	Low

Source: Wisconsin Department of Natural Resources, 1986

A review of studies on buffer widths shows the recommended shoreline buffer widths for many critical functions (Figure 3).[17,18] Under most circumstances, buffers necessary to protect streams, lakes, and wetlands should be a minimum 75 to 100 feet in width. Generally buffer widths toward the lower end of the range help maintain the physical and chemical characteristics of aquatic resources. For example, pollutant removal increases with increasing buffer width up to about 100 feet where a point of diminishing returns is reached. In other words, after about 70-80 percent removal is obtained, much greater widths are needed to gain the next increment of removal.[19] Buffer widths toward the upper end of the range appear to be the minimum necessary for maintaining the biological components of many streams, lakes, and wetlands.



Water pollution control continues to get more complex, while at the same time the responsibility for water resource protection is shifting toward local authorities. Given the limited technical and financial resources available to address both agricultural and urban runoff, the Water Body Classification System provides a very useful framework for targeting these efforts where they can have the greatest beneficial effect.

B. Lakes and Streams are Inherently Different

A water body classification system groups water bodies based on their vulnerability to human impacts and the extent of surrounding development. It is important to point out that the resulting classification does not identify certain water bodies as being more valuable than others. It is grouping water bodies in order to identify and target management techniques and strategies, which may then be tailored to their unique physical, chemical, and biological characteristics.

There are important ecological differences between streams and lakes. “Lotic” or flowing water aquatic communities flourish in rivers and streams. “Lentic” or still water aquatic communities flourish in lakes and ponds. In addition, retention time and water volume affect the rate at which silt, nutrients, and contaminants are distributed through and removed from the water column. In comparison to fish that are confined to a relatively narrow channel in streams, lake fish may be better able to find refuge from localized areas of highly polluted water. Likewise, many of the impacts on streams lead to rapid and direct response by the organisms living there. This is in contrast to lakes where the effects may be more gradual and less visible. The response time for reversing problems such as nonpoint pollution is also greater in lakes than in streams.

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[17] Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. *Wetland and Stream Buffer Size Requirements—A Review*. Journal of Environmental Quality 23:878-882.

[18] Johnson, A. W., and D. Ryba. 1992. *A Literature Review of Recommended Buffer Widths to Maintain Various Functions of Stream Riparian Areas*. King County Surface Water Management Div., Seattle, WA.

[19] Desbonnet, A. et. al. 1994. *Vegetated Buffers in the Coastal Zone: A Summary Review and Bibliography*. Coastal Resource Center, Rhode Island Sea Grant, Unversity of Rhode Island, ISBN 0-938-412-37-x.

Imperviousness also influences hydrology, including flooding and drought conditions. Streams are particularly sensitive to changes in water *quantity,* especially increased peak flows and scouring associated with high flow events, as well as reductions in "baseflow" or dry weather streamflow. This results from more water running off the land and less water infiltrating into the ground where it could resurface or discharge more gradually and naturally later on. These impacts occur at relatively low levels of development before water *quality* problems become apparent. By the time water quality impacts become evident, the stream ecosystem has usually already been degraded by these hydrologic changes.[20]

This is much less of a problem in lakes, which are not as susceptible to flooding and drought (from a biological standpoint – flooding and drought can cause property damage, however, this is beyond the scope of this study). In lakes, most of the impacts result from modification of habitat (loss of trees, shading, woody vegetation, vegetative clearing, sandy beaches, seawalls, piers, etc.). Changes in the near shore area have impacts on habitat, fish, the insects on which they feed, as well as top carnivores which feed on them. Cumulative development on the shoreline can affect the ecology of the entire lake.

Recognizing the difference between lakes and streams, they are treated separately in this classification study.

III. CLASSIFICATION CRITERIA: LAKES

A classification matrix for lakes has been used for this study, providing a two-tiered approach that accounts for a water body's sensitivity to development as well as the current level of surrounding development (Figure 4). This matrix or model has also been used by other Wisconsin counties. The matrix shows that management techniques for a lake with high sensitivity and a low surrounding development level will be different than the techniques used for a lake with low sensitivity and a high level of surrounding development.

Figure 4.

Water Body Classification Matrix (example)			
Sensitivity to Development	**Current Level of Development**		
	Low Level	**Medium level**	**High Level**
High Sensitivity	Protection	Protection	Protection and Restoration
Medium Sensitivity	Protection	Protection and Restoration	Restoration and Enhancement
Low Sensitivity	Protection and Restoration	Restoration and Enhancement	Restoration and Enhancement

For highly sensitive/low development water bodies (such as shallow rural landlocked ponds), protecting the remaining natural shoreline and other strategies would be recommended (upper left on the matrix). For less sensitive/highly developed water bodies (such as deep drainage lakes regularly flushed with flowing water, like the Yahara chain of lakes), the options are usually more limited. Strategies such as restoring the developed shoreline to a more natural condition would be recommended, as well as increased enhancement or maintenance of existing natural areas (lower right on the matrix). Figure 4 illustrates the other combinations of sensitivity and development.

[20] Personal communication with John Lyons, DNR Research Watershed Ecologist. August 2004. Madison, WI.

A. Data Collection

Laying the foundation for the Water Body Classification System began with the sensitivity parameters contained in the left-hand column of the matrix. Published surveys of water resources information were compiled to develop a database for individual lakes and ponds where physical, chemical, and biological data had been previously collected. The sources of published information included the following:

Surface Water Resources of Dane County (DNR)
Surface Water Inventory (DNR)
Register of Water Bodies (DNR)
DNR Basin Plans (Upper Rock, Lower Rock, Sugar-Pecatonica and Wisconsin Rivers)
Wisconsin Lakes (DNR)
Surface Water Index (Dane County RPC)
Dane County Water Quality Plan (Dane County RPC)
Dane County Water Resource Management Plan (Dane County LCD)

Inconsistencies were resolved by comparing information among sources. The database can easily be updated if more accurate or new information becomes available.

Individual water bodies were identified on a Geographic Information System (GIS) using the Dane County Land Information Office 2000 hydrography layer. This resulted in 70 named lakes and ponds for which published information was available. Other lakes and ponds were also identified and noted using 2000 orthophotography, as follows:

- 214 "unknown ponds" with areas greater than 2 acres (digitized on the 2000 hydrography layer where no published water resource data exists)

- 1870 "farmponds" and "other features" not previously digitized, identified from the orthophotographs (farm ponds are generally less than 2 acres, while other features are greater than 2 acres)

Additional work will be needed to field survey and digitize the ponds greater than 2 acres in order to incorporate them into the classification system. The parameters needed include hydrologic type, maximum depth, area, shoreline length, slope and septic suitability (explained below). Individual farmponds less than 2 acres may be treated as a single category or group since they are largely similar and require similar management. Farmponds are usually excavated and owned by a private landowner. The approach will be different with a landowner having sole ownership, compared to that what might be used for landowners living around a lake and sharing the resource.

B. Sensitivity Criteria

Sensitivity criteria (left side of the matrix) were developed to help determine and describe the assimilative capacity, or the ability of the resource to dilute or flush pollutants from its system. The following data were compiled based on classification systems developed by other counties in Wisconsin, as well as technical guidance provided by DNR, and provides the basis for the sensitivity criteria.[21,22] It is also important to focus on relatively static parameters (values that do not fluctuate on an annual, seasonal, or monthly basis). This lends greater stability to the classification system.

1. Lake Hydrologic Type

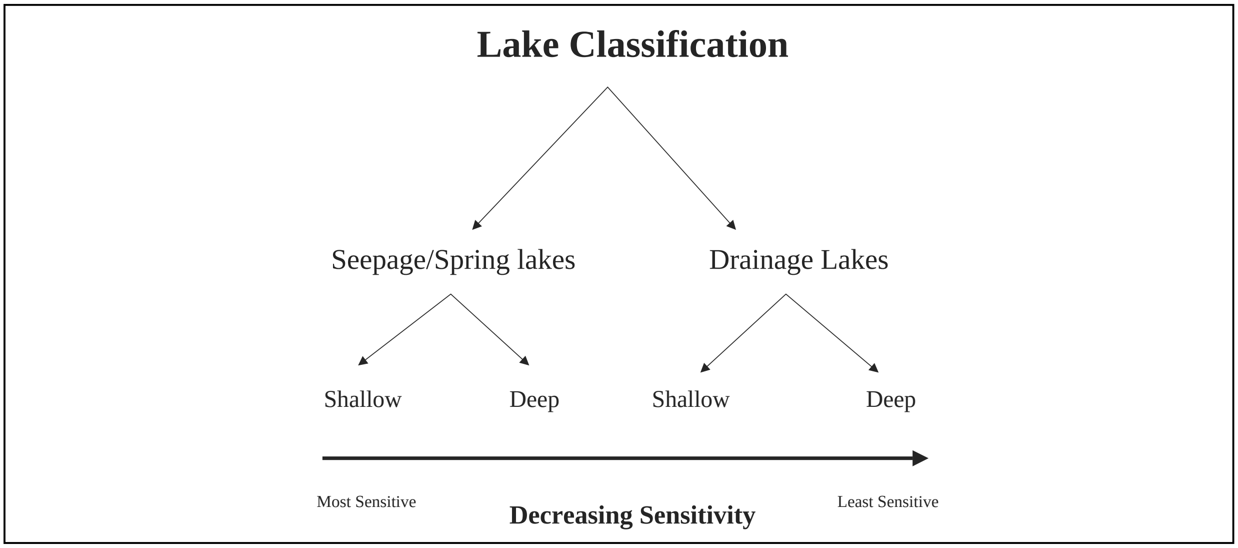
Lake type is determined by the primary source of water. Three different lake types are found in Dane County:

> *Seepage Lakes*: The primary sources of water are rainfall and groundwater. They have neither an inlet nor an outlet stream (land-locked). Small watersheds and very low flushing rates make seepage lakes the most sensitive to pollutants.
>
> *Spring Lakes*: The primary source of water is groundwater. They may have high flow outlet streams. The flushing that occurs in spring lakes make them less sensitive to pollutants.
>
> *Drainage Lakes*: The primary source of water is overland flow. They have permanent inlet and outlet streams. Their relatively large watersheds and high flushing rates make drainage lakes generally the least sensitive to pollutants.

2. Maximum Depth

This relates to a lake's ability to assimilate pollutants, having to do with the volume of water available for dilution. Shallow lakes are generally more sensitive to the effects of shoreland development than deeper lakes. Eighteen (18) feet was used as the break point distinguishing deep and shallow lakes and ponds typical for Wisconsin.[23] Using this information, water bodies were first separated based on their type: seepage/spring lakes or drainage lakes (Figure 5). Water bodies were further separated using maximum depth: either greater or less than 18 feet. This results in four distinct groups, with decreasing levels of sensitivity.[24] Within these four groups, additional parameters were used to define sensitivity even further, resulting in individual rankings described below. [25]

Figure 5.



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[21] Wisconsin Department of Natural Resources. 1999. *A Guide for County Lake Classification*. WDNR Lake Classification Advisory Committee.
[22] Young, R. 1998. *Lake Classification for Shoreland Development Impacts*. Wisconsin DNR, Rhinelander, WI.
[23] Personal communication with Edward Emmons. DNR Section Chief Fish and Habitat Research. July 2004. Madison, WI.
[24] Personal communication with Edward Emmons. DNR Section Chief Fish and Habitat Research. July 2004. Madison, WI.

3. Surface Area:

This is related to a lake's sensitivity to pollutants and shoreland habitat impacts. Smaller lakes are generally more sensitive to the effects of shoreland development than larger lakes.

4. Shoreline Development Factor:

This parameter captures how the shape of a lake can affect the potential amount of development along the shoreline. It is a ratio of the shoreline length to the circumference of a circle with the same area. An irregularly shaped lake has a greater amount of shoreline available for development than a circle-shaped lake of the same size. Therefore, irregularly shaped lakes will be exposed to a greater amount of shoreline development per acre of water.[26]

$$\text{SDF} = \text{Shoreline Length (mi)} / 0.14\sqrt{\text{Surface Area}}\ \text{(acres)}$$

5. Stratification Factor:

This factor estimates the degree of a lake's summer thermal stratification. Stratification is a temperature dependent condition that prevents the mixing of a lake's upper and lower layers due to differences in water density. Stratified lakes are more sensitive to the effects of shoreland-derived phosphorus. Lakes that do not stratify have a greater supply of nutrients recycling from the sediment, and therefore are less sensitive from outside inputs. Stratification factor is a function related to the lake's volume as a heat sink and is calculated using the maximum depth and area of the lake.[27]

$$\text{SF} = (\text{Maximum Depth (ft)} + 4.5) / \log_{10} \text{Surface Area (acres)}$$

6. Soil Erodibility:

Lakes with a higher proportion of steeply sloped shoreline areas are more vulnerable to erosion and resulting pollutants than lakes with relatively flat shorelines. Soil Erodibility is an indicator of the potential for shoreland development to cause erosion, adversely impacting water quality and near shore aquatic habitat with sediment and phosphorus. Erodibility is determined by calculating the percentage of a lake's shoreline within 300 feet of the water's edge having a slope of 12% or greater using USDA NRCS Dane County Soil Survey maps.[28]

7. Septic Suitability:

Septic suitability indicates how suitable the shoreland soils are for in-ground septic systems. Septic systems in unsuitable soils can result in water quality impacts through transport of phosphorus-rich wastewater to lakes. Lakes with a higher proportion of shorelands having unsuitable soils are more vulnerable to ground and lake water contamination than lakes with more suitable soils. Septic suitability is determined by the percentage of a lake's shoreline within 300 feet of the water using septic suitability ratings obtained from the USDA NRCS Dane County Soil Survey.[29] These are based on excessive permeability, shallow depth to groundwater, and other factors.

C. Breakpoints and Scoring

Appendix A provides a data summary of the individual values for each named lake and pond in Dane County listed for each parameter. Breakpoints were chosen using classification studies from other counties, as well as DNR technical guidance (Table 4).[30] Numerical scores were then assigned to values within each parameter, with the most sensitive receiving the least points. Appendix B lists the numerical scores and ranking for each lake and pond. Follow-up survey work is needed to confirm the estimated scores in the highlighted cells where the original data was not available. Total scores were tallied across the table for each water body and then ranked down through the four main groups with the most sensitive (lowest score) receiving the highest sensitivity ranking. Note that Lake Type and Maximum Depth were not included in the ranking totals because these two parameters were already used to define the four main groups. Also note that the two middle groups were then combined into a medium sensitivity category (since there were fewer of these), resulting in three sensitivity levels: (A) High, (B) Medium, and (C) Low, with the finer individual rankings shown in between, shown in Figure 6.

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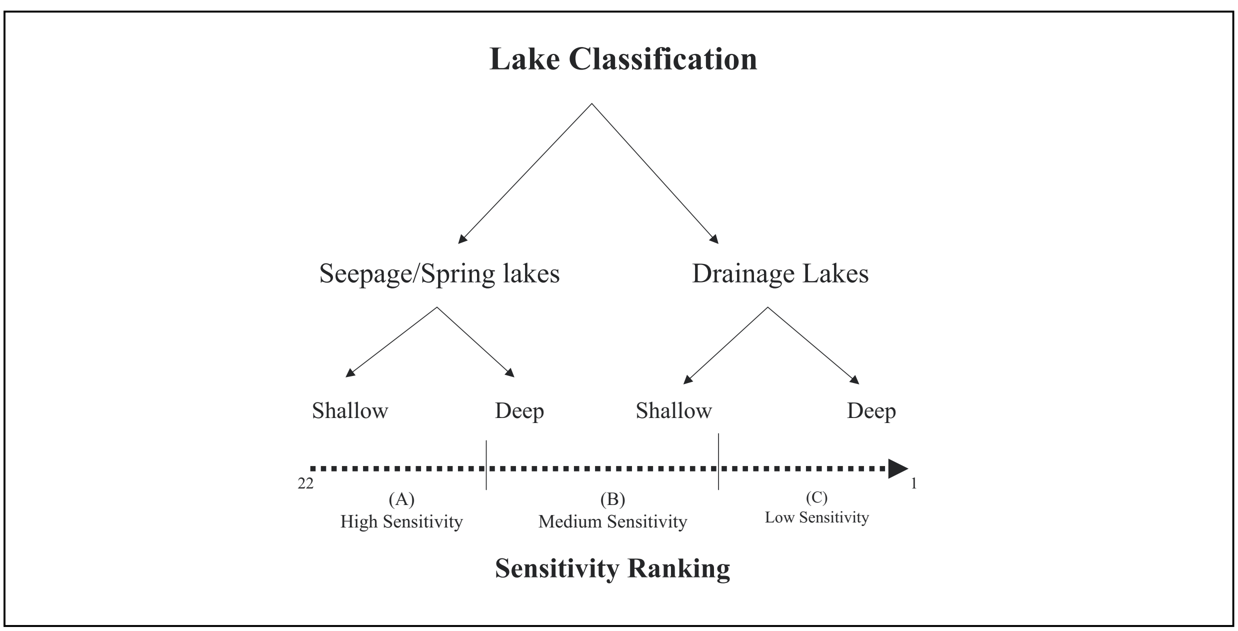
[25] Wisconsin Department of Natural Resources. 1999. *A Guide for County Lake Classification*. WDNR Lake Classification Advisory Committee.
[26] Young, R. 1998. *Lake Classification for Shoreland Development Impacts*. Wisconsin DNR, Rhinelander, WI
[27] Lathrop, R.C., and R.A. Lillie. 1980. *Thermal Stratification of Wisconsin Lakes*. Trans. Wis. Acad. Sci., Arts and Letters. 68:90-96.
[28] Wisconsin Department of Natural Resources. 1999. *A Guide for County Lake Classification*. WDNR Lake Classification Advisory Committee.
[29] Wisconsin Department of Natural Resources. 1999. *A Guide for County Lake Classification*. WDNR Lake Classification Advisory Committee.
[30] Wisconsin Department of Natural Resources. 1999. *A Guide for County Lake Classification*. WDNR Lake Classification Advisory Committee.

Table 4.

LAKE CLASSIFICATION Sensitivity Rating Factors					
Criterion	**Significance**	**Criterion Classes**	**Units of Measure**	**Points**	**Comments**
Lake Surface Area (size)	Smaller lakes are generally more vulnerable to water quality problems	1 - 10 10 - 100 100 - 500 500+	Acres	1 2 3 4	Very small lakes/ponds Small lakes Medium lakes Large lakes
Shoreline Development Factor (shape)	Lakes with irregular shorelines are more vulnerable to a higher density of development	3.0+ 2.0 - 3.0 1.5 - 2.0 1.0 - 1.5	Unitless	1 2 3 4	Very irregular shoreline Close to circular shoreline
Stratification Factor (nutrient sensitivity)	Lakes that strongly stratify are more sensitive to outside sources of phosphorus	30.0+ 13.5 - 30.0 11.5 - 13.5 0 - 11.5	Unitless	1 2 3 4	Strongly stratified Stratified Weakly Not stratified
Soil Erodibility (steep slopes)	Lakes with steep sloped shorelines are more vulnerable to erosion and surface water degradation	75 - 100% 50 - 75% 25 - 50% 0 - 25%	Percent of shoreline within 300'	1 2 3 4	Percent of shoreline with D slope (12% slope or greater)
Septic Suitability (severe soils)	Lakes having shorelines with high groundwater or soils posing severe limitation for septic systems are more vulnerable to ground and surface water contamination	1 - 1.5 1.5 - 2.5 2.5 - 3.5 3.5 - 4.0	Ave. soil factor within 300' of shoreline	1 2 3 4	Very severe limitations Severe Moderate Slight or sewered

Figure 6.



D. Other Criteria Not Used

Other sensitivity parameters were considered, but excluded from the classification system due to incomplete data availability or redundancy as an indicator. These included: surface acres less than three feet deep, watershed area, flushing index, winterkill, presence of carp or being a sport fishery, and lake condition index (LCI) or fertility level.

Information was also gathered on the percentage of wetlands and woodlands within a 300-foot buffer surrounding each lake or pond, representing natural areas or habitat. Comparing the 2000 Land Use with future Planned Land Use revealed relatively few reductions in acreage in this buffer area. This indicates that projected growth is largely being planned outside these areas. This makes sense since wetlands are already fairly well regulated and most forestland that is not too steep has, in most cases, already been cleared for agriculture. This parameter was not included in the classification because it is adequately represented in impervious cover, or shoreland development pressure covered in the next section.

E. Shoreland Development

Recognizing that lake ecosystems are inextricably linked to adjacent uplands, the level of shoreland development is also incorporated into classification systems (horizontal scale along the top of the matrix). Typically, the amount of development is measured by counting the number of dwelling units or structures along the shoreline. Obviously, this would be very difficult on a countywide basis. More recently, particularly with the advent of GIS, impervious surface coverage has emerged as a very useful and key indicator for measuring the impacts of development on aquatic ecosystems.

Shoreland development can have various impacts on aquatic and riparian systems. Water quality is degraded by the delivery of nutrients from construction sites, impervious surfaces, and excessive fertilizer and pesticide application from both urban and rural sources. These factors contribute to algal blooms, degraded fish habitat and the crowding out of native vegetation by monocultures of exotic or aggressive species. Fish habitat is threatened by sediment delivery, through burial of spawning areas and decreased water clarity. Complex fish habitat structure is altered by modifications of the littoral zone such as constructing piers, constructing seawalls, removing woody debris from the water, clearing out aquatic plants, placing sand blankets over existing substrate, and removing overhanging vegetation from the shoreline. The resulting simplified habitat results in lower fish abundance and diversity. While individual actions may occasionally cause serious impacts, it is the interaction of these factors and the cumulative effect of many small impacts adding up that degrades water quality and habitat for fish and aquatic life, particularly in the near shore area where the impacts are most pronounced. In this manner, development on the shoreline can have a cumulative effect on the ecology of the entire lake or pond.

As indicated earlier, impervious cover is any surface that stops rainwater or snowmelt from soaking into the ground, including roads, sidewalks, driveways, parking lots, and buildings. This rainwater or snowmelt then takes the form of runoff that flows into our lakes and streams, arriving more quickly and in greater volumes, with more pollutants and higher temperatures. Of the many different pollutants that can impact lakes, phosphorus is regarded as the primary lake management concern because it is the most limiting with respect to plant growth. Increases in phosphorus lead to increases in algae growth and accelerate the eutrophication process or natural aging of our lakes and ponds. People may be more familiar with the algal blooms in the summer, due to the overfertilization, as well as fish kills resulting from the oxygen depletion caused by decaying plants through the winter. Research has shown that the amount of phosphorus going into a lake steadily increases as more impervious cover is added to the watershed.

There are three scales to consider:

1) Site-specific scale – whether or not there is a house or structure; the configuration of the structure on the site; largely regulated through zoning.
2) Shoreland scale – the incremental and cumulative impact of development on aquatic habitat and water quality.
3) Watershed scale – which provides the larger context and background conditions.

Lake habitat has generally been managed at smaller scales. Also, much of regulatory framework is focused on the level of individual properties; for example, restricting cutting of riparian vegetation and regulating construction activity at the shoreline. However, development at the larger scales also affect the quality of our surface waters. Therefore, the focus of this study is on this next level of development, taking into account the shoreland or cumulative impacts with implications for similar efforts being expanded out into the watershed as well. As pointed out earlier, impervious cover is a qualifying characteristic of many land uses and provides an excellent measure of the extent and intensity of urbanization.

F. Methodology

In order to calculate the amount of impervious cover for a given water body, a 300-foot buffer was delineated around each lake and pond using GIS. The buffer area was then intersected with the 2000 Land Use Map.[31] Fig. 7 shows an example of this approach. The area of each land use within the buffer for each lake/pond was recorded in an excel spreadsheet. Average impervious cover percentages were assigned to each land use (Table 5). These percentages were taken from the latest version of the Natural Resources Conservation Service's hydrology manual, TR-55, shown in Appendix C. Multiplying the land use acres by the corresponding impervious cover percent area resulted in calculated impervious cover acres for each cover type within the buffer area. Totaling the impervious cover acres and dividing by the total acreage within the buffer resulted in a weighted average or composite impervious cover percentage for each named lake and pond. Appendix D lists the impervious cover results for each lake and pond. These values can be incorporated into the horizontal axis of the matrix, representing various levels of shoreland development. This procedure was also done using a Planned Land Use Map,[32] which is a compilation of adopted land use plans from each municipality in Dane County, for comparison. These results are also listed in Appendix D.

Table 5.

Percent Imperviousness Assigned to 2000 Land Use Categories Dane County, Wisconsin

Land Use	Ave. % Imperviousness
Commercial – Retail Sales	85
Commercial – Retail Services	85
Single Family	20
Two Family	65
Multi-Family	85
Industrial	72
Extractive	2
Institutional/Government	50
Transportation	75
Communication & Utilities	50
Vacant	2
Under Construction	2
Cemeteries	25
Agriculture	2
Outdoor Recreation	25
Commercial Forest	0
Woodland	0
Undeveloped (non-agriculture)	0

After considering both existing and planned development, the 2000 Land Use Map was selected as the foundation for the water body classification system. This is because it represents actual development information surveyed in April 2000. The 2000 Land Use Map thus provides a solid baseline for evaluating the impact of future growth and development. Planned land use values may be used to "red-flag" potentially threatened areas. Although, comparing the two columns (2000 Impervious Cover and Planned Impervious Cover in Appendix D) there is not a lot of

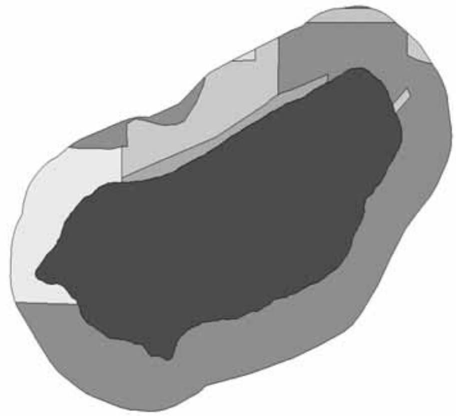
[31] Dane County Regional Planning Commission. 2002. *2000 Land Use Map, Dane County, Wisconsin*. Madison, WI

[32] Madison Area Metropolitan Planning Organization. 2004. *Existing and Planned Future Land Use Map*. Draft Map Based Upon Local Adopted Plans. Madison, WI.

Figure 7.

Impervious Cover Calculations:

- 300-foot buffer
- Determined acres of each land use present within buffer
- Assigned each land use an impervious cover percentage
- Calculated the average percent impervious cover for each named lake/pond



change being planned along the shoreline. Most future change is planned to occur on agricultural and vacant lands elsewhere in the county. It appears that most of the future growth is being directed adjacent to existing areas of development (Urban Service Areas, for example), which have themselves formed around lakes and ponds long ago – very likely as the nucleus or focal point for that development.

G. Other Analyses Not Used

It should be mentioned that prior to selecting the 300-foot buffer as the basic unit of analysis, other alternative analyses were also conducted. These alternatives used the same methodology as described above but, instead, intersected the land use map using a 1000-foot buffer area, as well as the contributing subwatershed area – for comparison purposes. The impervious cover results using a 1000-foot buffer were not significantly different than using a 300-foot buffer. This seems largely because of the relatively general land use categories available for the analysis, which do not change appreciably between 300 and 1000 feet of the shoreline. Greater resolution or more detailed spatial data could be incorporated into the classification system, as it becomes available. It should be pointed out, however, that most research and shoreland development standards are focused within 300 feet of the shoreline.

Alternatively, using the lake's contributing subwatershed area as the basis of analysis was found to be inconsistent and counter-intuitive in many cases. For example, impervious cover surrounding lakes in highly urbanized areas seemed to be decreased or diluted by incorporating agricultural lands located farther away in the watershed. This did not adequately reflect the level of development being seen along the shoreline – which is typically the focus of most classification studies. Conversely, the level of impervious cover surrounding highly buffered lakes was considerably higher than expected in some urban areas (e.g., Lake Wingra , Upper and Lower Mud Lakes, etc.), where this also did not seem representative. It was also very difficult accurately defining the subwatershed or contributing area for each lake and pond with the methods available. Keep in mind, this approach should not be confused with watershed pollutant modeling or loading studies that are often conducted for individual lakes. While these studies are usually very useful on an individual or site specific basis, this level of analysis is well beyond the scope of this study, conducted for every pond and lake. Considering these limitations, a subwatershed approach was not considered any further for lakes and ponds.

Given these results, the 300-foot buffer was thereby used as the basic analytical unit for estimating development levels in the lake classification portion of the study.

H. Lake Classification

Using the classification matrix (Figure 4), a graph was plotted using Sensitivity Ranking (from Appendix B) along the vertical scale and Impervious Cover (from Appendix D) representing development levels along the horizontal scale. This was done for each named lake and pond and plotted on (Figure 8). On the horizontal scale of the matrix, increasing levels of development are shown (0-50%). Natural breakpoints were determined using the Jenks Classification Method in ArcView GIS.[33] ArcView uses a rather complex statistical formula (Jenks Optimization) that minimizes variation within each class. The method identifies breakpoints by looking for groupings and patterns inherent in the data. Using this methodology, breakpoints were identified at 11.5% and 25.5% imperviousness thereby separating low, medium, and high levels of development. These levels correspond to the following land uses interpolated from the Natural Resources Conservation Service's hydrology manual, TR-55 (Appendix C):

(A) Low Development Level – Rural Residential (2 acre lots and greater)
(B) Medium Development Level – Single Family Residential (1 and 1-1/2 acre lots)
(C) High Development Level – Multi-family and greater (1/2 acre lots and less)

The high development level corresponds to the minimum lot size contained in the Dane County Shoreland Zoning ordinance for unsewered development. These development levels also correspond to the average lot sizes of other counties who have adopted Lake Classification systems in Wisconsin.[34] These groupings are listed for each lake and pond in the Development column of the Lake Classification table (Appendix E).

There is a similar distribution for low, medium, and high sensitivity along the vertical scale of the matrix. From Appendix B, these correspond to the following types of lakes:

(A) High Sensitivity – shallow seepage/spring lakes and ponds
(B) Medium Sensitivity – deep seepage/spring lakes and ponds, and shallow drainage lakes
(C) Low Sensitivity – deep drainage lakes

These groupings are listed for each lake and pond in the Sensitivity column of the Lake Classification table (Appendix E).

Referring back to the Water Body Classification matrix (Figure 4) and superimposing this on (Figure 8) highlights the 3 classifications (Class I, Class II, and Class III) displayed in each cell. This also corresponds to the different management approaches for each class:

Class I – Protection measures preferred
Class II – Combined protection and restoration
Class III – Restoration and enhancement

These are listed for each lake and pond in the Lake Classification table (Appendix E), which have also been sorted alphabetically for easy reference. The Lake Classifications are also presented on Map 2.

Looking back over the individual lakes and ponds in terms of a reality check, the classification system seems intuitive and fits quite well. This is by design; based on the experiences of many others who have done this sort of work. The classification system can be broken down further into five or even nine separate classes (corresponding to the arrangement of cells in the matrix); however, this was viewed as adding unnecessary complexity.

Note that there are 214 red dots and 1870 orange dots displayed on Map 2. The red dots represent unknown ponds greater than 2 acres that have been digitized on the GIS hydrography layer, but where relatively little published information exists. Follow-up work is needed to digitize and survey these water bodies to collect the necessary information. It is likely that these will fall into Class I, although this needs to be confirmed.

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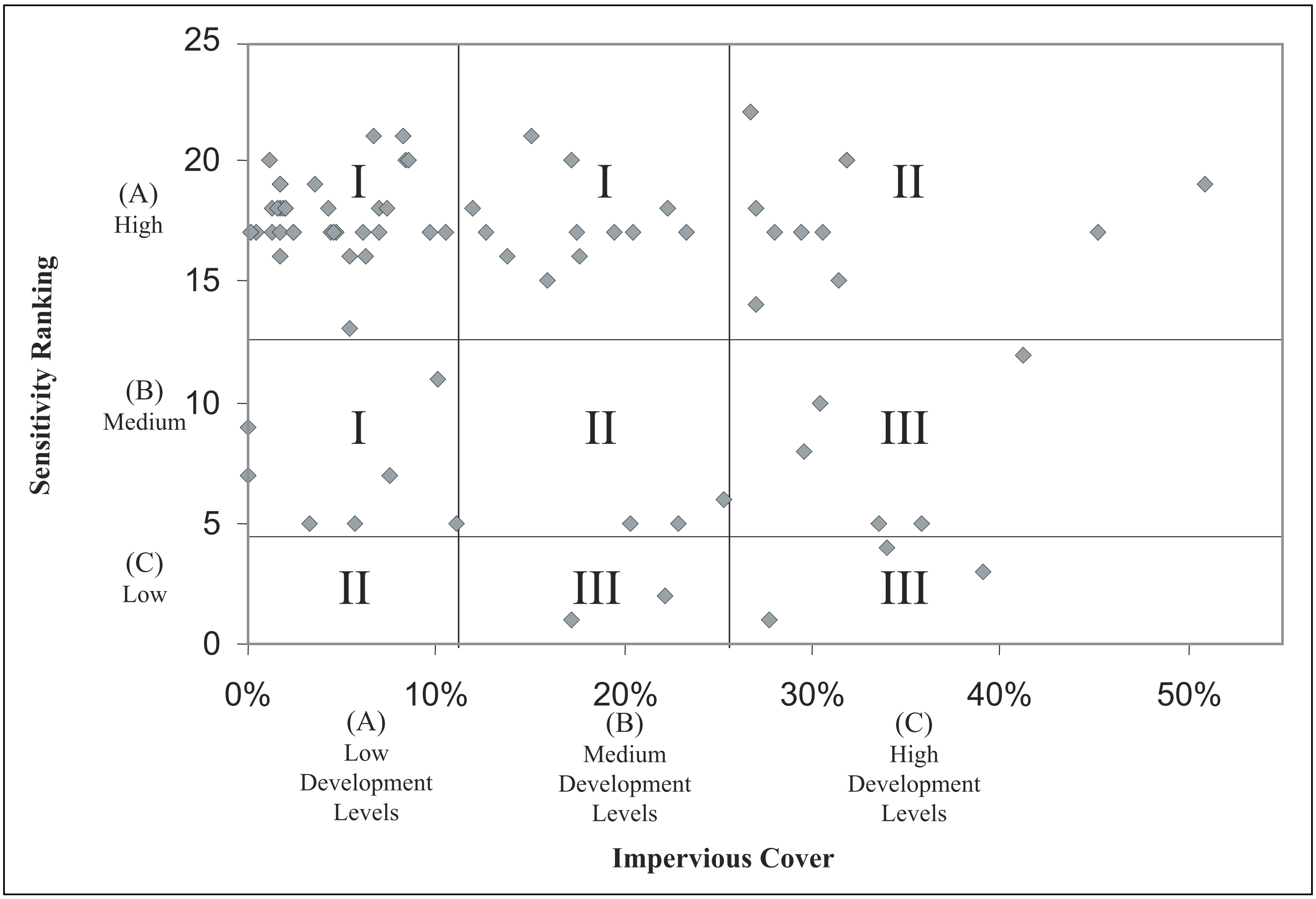
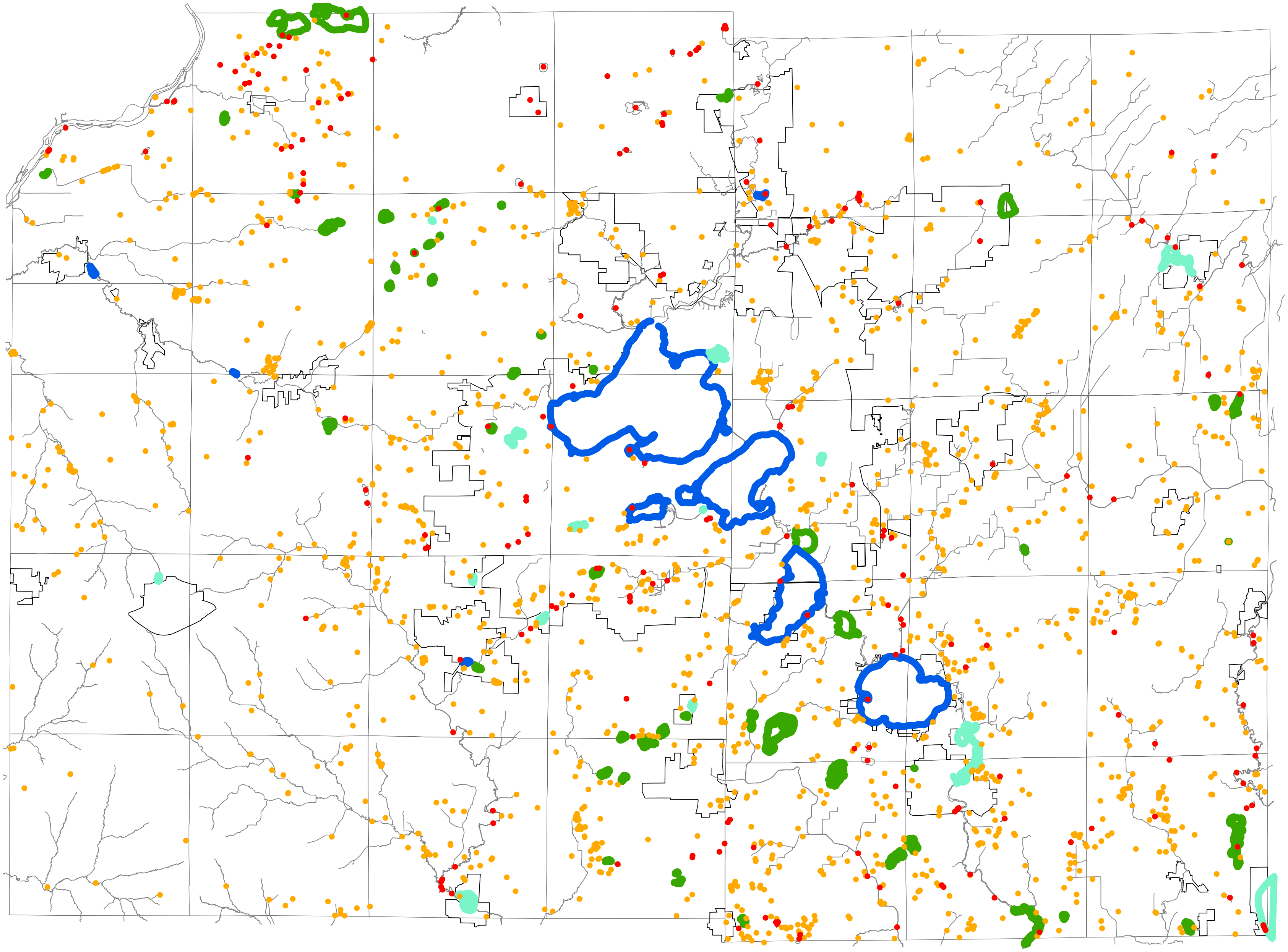
[33] Environmental Systems Research Institute, Inc (ESRI). 1996. *Using ArcView Geographic Information System*. Redlands, CA.
[34] Wisconsin Association of Lakes. 2002. *Water Classification in Wisconsin: Annual Report for 2002*. Madison, WI.

The orange dots represent farmponds generally smaller than 2 acres, or other water bodies larger than 2 acres identified from orthophotographs but missing from of the GIS hydrography layer. Farmponds smaller than 2 acres are usually privately owned, controlled by a single landowner, and may be treated similarly as a group. The recommended approach here would be to work with individual landowners. This is being accomplished through, for example, soil and water conservation plans and programs in cooperation with the Dane County Land Conservation Division, as well as possibly working with other private groups (e.g., Ducks Unlimited, Pheasants Forever, Natural Heritage Land Trust, American Farmland Trust, etc.). Water bodies greater than 2 acres identified from the orthophotos and also missing from the GIS database should be digitized and incorporated into the classification system, as above.

Figure 8. Water Body Classification Matrix – Lakes and Ponds





Map 2

Dane County Water Body Classification Study, Dane County WI.

Lake Classifications

- Class I - High Sensitivity/Low Development
- Class II - Medium Sensitivity/Development
- Class III - Low Sensitivity/High Development

- Unknown Ponds
- Farm Ponds
- Service Areas

Water Features are a revised 2000 DNR hydro data file. Revisions included the use of aerial photography and past land surveys.

March 2005

0 0.5 1 2 3 4 5 6 7 Miles

Created by the Staff at the Dane County Regional Planning Commission. All information is believed to be accurate but is NOT guaranteed to be without error. This map is intended for general reference use and not intended for detailed site-specific analysis.
Updated by the Community Analysis & Planning Division of Dane County Planning & Development.

I. Fish and Wildlife

It is interesting to note that a Surface Water Resources report published in 1962 for Dane County classified lakes and ponds simply by their ability to support fish and wildlife.[35] Those able to support fish populations were classified as "Fish Lakes." The smaller landlocked features undergoing succession from pothole to fresh meadow were classified as "Duck Lakes" or marsh ponds. Hunting, fishing and trapping were the primary considerations at that time. Although somewhat basic in regard to the science, these designations are still useful in characterizing the fish and wildlife communities these water bodies support, their ecological structure, and associated natural resource functions and values.

1. "Fish Lakes"

The lakes supporting fish populations in are listed in Table 6**.** Fishing is especially popular on the Yahara Chain of Lakes in central Dane County. The abundant fishery sustains a thriving local tourism industry. Other lakes and ponds throughout Dane County provide additional fishing and wildlife recreation opportunities. While Fish Lakes comprise a much larger acreage, there are many more Duck Lakes or marsh ponds scattered throughout Dane County.

2. "Duck Lakes" or marsh ponds

The establishment of fisheries is impractical and often impossible in many of these marsh lakes and ponds. Water level fluctuations can result in a pothole or deep marsh one year and a shallow marsh or dry one the next. The following helps characterize these aquatic habitats and communities:

Pothole Ponds

Small, shallow, landlocked basins were considered potholes in early Wisconsin Conservation Department Wetland Surveys. These are listed in Table 6. These ponds experience annual winterkill and quite frequently show severe fluctuations in water level. The fish population, if present, is comprised solely of minnow species. The ponds usually have very little cover or fringe vegetation and, therefore, are of marginal value for marsh fur-bearers and waterfowl. In years when emergent aquatics are more abundant they may be considered as deep marsh.

Deep Marsh Ponds

These are small, shallow, landlocked depressions typically vegetated with grassy marsh plants and commonly having scattered open water areas. These are listed in Table 6. Wildlife viewing opportunities are exceptional on these ponds where shorebirds, waterfowl and marsh nesting songbirds are abundant. In fall, the presence of marsh fur-bearers is evidenced by muskrat huts and newly-created open water areas where they have been harvesting cattails. Both migrant and nesting waterfowl find cover in the bulrushes and cattails.

Shallow Marsh Ponds

Shallow, landlocked depressions occupying poorly drained valleys were called shallow marsh ponds in early Wetland Surveys. These are listed in Table 6. Frequently there is very little open water and commonly there is at least one period of near dryness each year. Here as in deep marsh ponds, waterfowl and fur-bearers are common occupants. During prolonged periods of low precipitation many of the shallow marsh areas acquire the characteristics usually associated with wet meadows: bulrushes and cattails lose ground to encroaching wetland plants such as smartweed, sedge and bur reed.

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[35] Poff, R. J., and C.W. Threinen. 1962. *Surface Water Resources of Dane County*. Lake and Stream Classification Project. Wisconsin Conservation Department. Madison, WI.

Table 6.

Habitat Associated with Dane County Lakes and Ponds			
"Fish Lakes"	"Duck Lakes"		
	Pothole Ponds	Deep Marsh Ponds	Shallow Marsh Ponds
BARNEY LAKE*	AMES POND	BARBIAN POND	DORN POND
BELLE VIEW LAKE	ANDERSON POND	DAHMEN POND	GRABER/DREHER POND
BRANDENBURG LAKE*	BASS LAKE	ESSER POND	ISLAND LAKE
CRYSTAL LAKE	BOWER POND	FOX POND	KRUTCHEN POND
DUNKIRK MILLPOND	BRUENIG POND	GOOSE LAKE	MENZEL POND
FISH LAKE	C. BUECHNER POND	GRASS LAKE (Dunkirk)	SEMINOLE POND
FISHERS LAKE	CHRISTENSON POND	GRASS LAKE (Dunn)	TURTLE LAKE
GOOSE POND[1]	DIEDRICH POND	HOOK LAKE	VIRGIN LAKE/HULL POND
HARRIETT LAKE*	EDGERTON POND	PATRICK MARSH	
INDIAN LAKE[1]	GALLAGHER POND	RICE LAKE	
KEGONSA LAKE	KALSCHEUR POND	STRICKER POND	
KOSHKONONG LAKE	L. BUECHNER POND	SWEET LAKE	
MARION LAKE	MAHER POND	TIEDEMAN POND	
MARSHALL MILLPOND	MEIER POND	WESTSIDE POND	
MENDOTA LAKE	MORSE POND		
MONONA LAKE	MORTENSON POND		
MUD LAKE (MARX POND)*	O'CONNELL POND		
MUD LAKE T7N R12E*	ORTMAN POND		
MUD LAKE, LOWER	SECTION 26 POND		
MUD LAKE, UPPER	SECTION 35 POND		
SALMO POND	SPRINGFIELD POND		
STEWART LAKE			
STOUGHTON MILLPOND			
TENNEY PARK LAGOON			
VERONA GRAVEL PIT			
WARNER PARK LAGOON			
WAUBESA LAKE			
WINDSOR LAKE			
WINGRA LAKE			

* Winterkill occurs frequently on these lakes, eliminating all or part of the fish populations.
From: Poff, R., and C.W. Threinen. 1962. *Surface Water Resources of Dane County*. Wisconsin Conservation Department

Overall, these lakes and ponds provide significant water quality, wildlife, recreation, and aesthetic qualities and benefits. Combining this information with the lake class designations provides useful insight and guidelines for targeting management activities. It gives an indication of the resource sensitivity, development pressures, management approach and where these efforts may be best directed.

J. Lake Management

Although conservation approaches designed to manage habitat at the site-scale have clear application and benefit, protecting small pieces of habitat within lakes is unlikely to maintain ecological integrity because small impacts can accumulate. A comprehensive approach to lake management should include not only in-water and riparian zone management, but should also emphasize activities targeted in the watershed as well. Examples include maintaining and restoring wetlands, agricultural and forestry BMPs that reduce nonpoint source runoff, maintaining and restoring riparian vegetative buffers and native cover, and limiting the intensity of development in riparian zones.

The literature clearly describes the many ways in which the cumulative impacts of shoreland development can lead to the degradation of aquatic ecosystems and the loss of natural beauty along the shoreline.[36] However, it is

[36] Wisconsin Department of Natural Resources. 2001. *Shoreland Development Density and Impervious Surfaces*. Fact Sheet: FS-102-01

important to note that it is difficult to determine the thresholds at which these impacts become cumulatively significant. The difficulty of sorting out the complex interplay between habitat variables, the physical, chemical, and biological factors, and the effect of other land uses in the watershed make it difficult to set a threshold level at which shoreland development significantly degrades the integrity of our lakes and ponds. While it has not been possible to make conclusions regarding specific lot sizes and widths, for example, it is clear that limiting the overall intensity of development is essential to protecting, fish and aquatic habitat, water quality, and preserving natural beauty.[37]

It is also important to realize that impacts on a shoreline and in the watershed are the cumulative result of the interaction of many incremental changes over time. By their very nature, these incremental changes are likely to be in place for some time before their impacts become apparent in the water. Because of the time lags between impacts and detectable responses in lakes, management decisions cannot be based exclusively on in-lake indicators. Instead, they need to emphasize proactive conservation measures at the lake scale and in the watershed as well. In other words, by the time the impacts become evident it is usually too late. This is not to say we should abandon our efforts, but to try very hard to keep the problem from getting worse.

IV. CLASSIFICATION CRITERIA: STREAMS

Streams are primarily affected by the quantity and quality of the water flowing through them. As progress has been made in controlling the acute effects of point-source water pollution, it has become increasingly clear that nonpoint source pollution from agricultural and urban land uses has caused long-term cumulative harm to stream ecosystems.

Major nonpoint source pollution and habitat destruction began when land was converted from forest to agriculture during European settlement. Degradation intensified after the implementation of modern farming practices such as heavy applications of fertilizers, pesticides, and herbicides to improve crop yields; concentrations of greater numbers of livestock into barnyards and feedlots to increase production efficiency; and stream channelization, ditching, and wetland draining to expand agricultural acreage.

Urban development degrades streams even further by releasing toxic substances and excess amounts of nutrients, by increasing stormwater runoff which in turn leads to more frequent and severe flooding, accelerated channel erosion, and smothered streambeds and spawning areas. Research has linked stream degradation to increases in the extent of impervious cover in the watershed. This relationship has been observed for streams in Wisconsin as well as other parts of the United States.[38,39]

A study of Wisconsin streams clearly illustrates the strong effects of upstream land uses on stream ecosystems.[40] Generally, high levels of forest or wetland are associated with healthy streams, whereas high levels of agriculture are associated with degraded ecosystems. Urbanization impacts on biotic integrity (an index of stream health) are particularly severe and occur at a relatively low levels of land use. These findings are consistent with other studies.[41,42,43,44,45,46,47]

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[37] Bernthal, T. and J. Barrett. 1997. *Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives. A Literature Review with Policy Implications*. WDNR Bureau of Watershed Management Publ. WT-505-97.

[38] Wang, L., J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons. 2000. *Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams.* Journal of the American Water Resources Association 36(5):1173-1189.

[39] Center for Watershed Protection. 1994. *The Importance of Imperviousness*. Watershed Protection Techniques 1(3):100-111.

[40] Wang, L., J. Lyons, P. Kanehl, and R. Gatti. 1997. *Influences of Watershed Land Use on Habitat Quality and Biotic Integrity in Wisconsin Streams*. Fisheries 22(6):6-12.

[41] Roth, N.R., J.D. David, and D.L. Erickson. 1996. *Landscape Influences on Stream Biotic Integrity Assessed at Multiple Spatial Scales*. Landscape Ecol. 11:141-156.

[42] Benke, A.C., G.E. Willke, F.K. Parrish, and D.L. Stites. 1981. *Effects of Urbanization on Stream Ecosystems*. ERCo7-81. Georgia Institute of Technology, Atlanta

[43] Osborn, L.L., and M.J. Wiley. 1988. *Empirical Relationships Between Land Use/Cover and Stream Water Quality in an Agricultural Watershed*. J. Environ. Manage. 26:9-27.

[44] Smart, M.M, T.W. Barney, and J.R. Jones. 1981. *Watershed Impact on Stream Water Quality: A Technique for Regional Assessment*. J. Soil Water Conserv. 36:297-300.

[45] Omernik, J.M., A.R. Abernathy, and L.M. Male. 1981. *Stream Nutrient Levels and Proximity of Agricultural and Forest Land to Streams: Some Relationships*. J. Soil Water Conserv. 36:227-231.

[46] Omernik, J.M. 1977. *Nonpoint Source-Stream Nutrient Level Relationships: A Nationwide Study*. U.S. Environmental Protection Agency Publ. 600/3-77-105.

[47] Omernik, J.M.. 1976. *The Influence of Land Use on Stream Nutrient Levels*. U.S. Environmental Protection Agency Publ. 600/3-76-014.

Forest cover tends to reduce runoff of water, sediments, nutrients, and toxicants; maintain more stable flows, water temperatures, and stream channels; and supply coarse organic material and debris as food and habitat for aquatic life. Conversely, agriculture often increases runoff; destabilizes flow, temperature, and stream channels; and reduces the supply of coarse organic material. Urban land uses increase the impervious land area such as roads, parking lots, sidewalks, and rooftops, which substantially increases watershed runoff. The magnitude of land-use influences on stream fish communities also depends on watershed conditions such as slope, soil type, and riparian vegetation characteristics.

According to the study, the amount of forestland upstream is positively and linearly correlated with stream habitat quality and biotic integrity (Figure 9). That is to say, greater amounts of forestland reflect increased quality and integrity in the receiving stream.

Figure 9. Shows the relationships between watershed Forest land use and habitat scores and IBI scores. Open circles are considered outliers. Lines were fitted by eye.

Source: Wang, L. and J. Lyons, et. Al. 1997

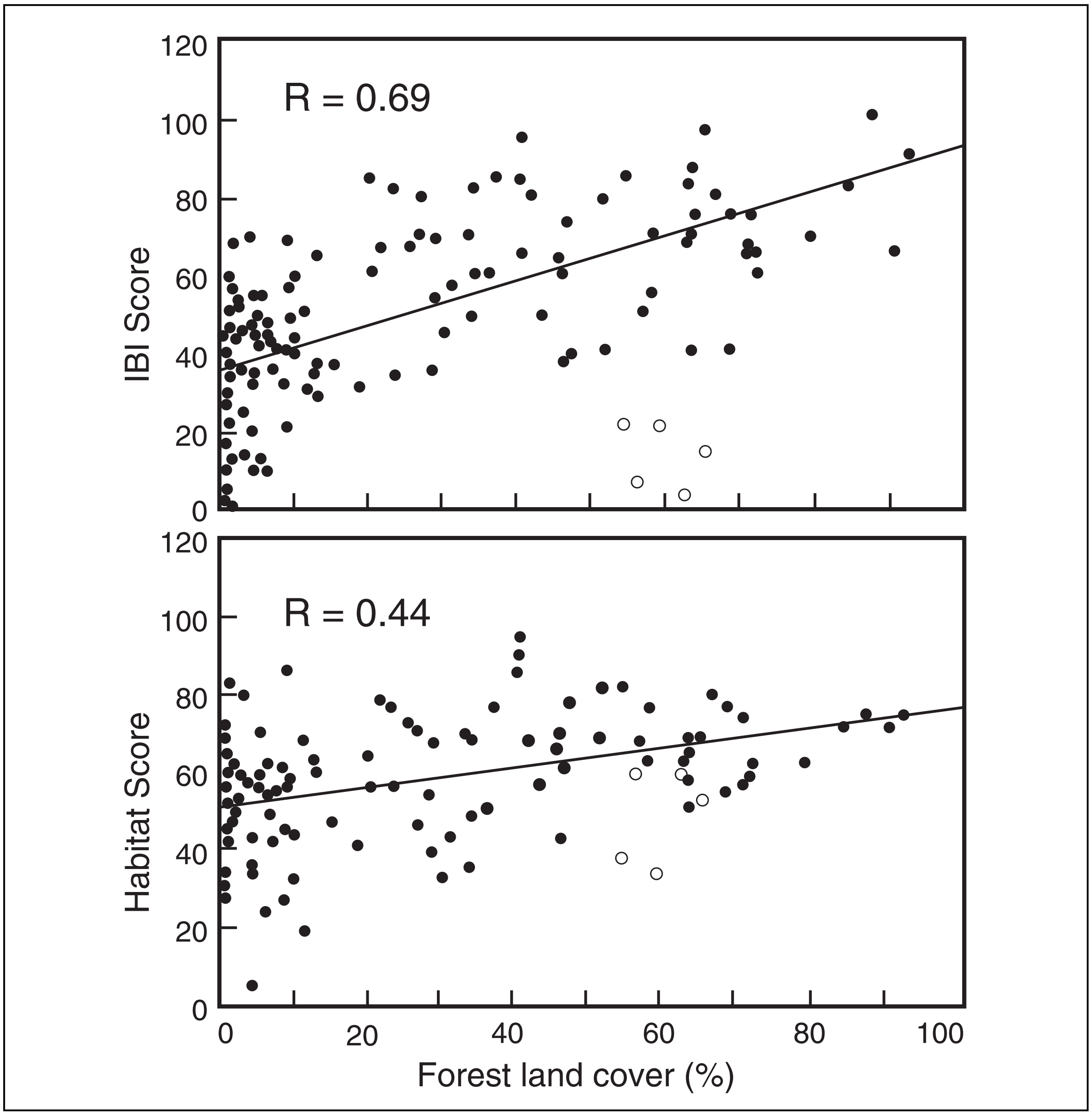
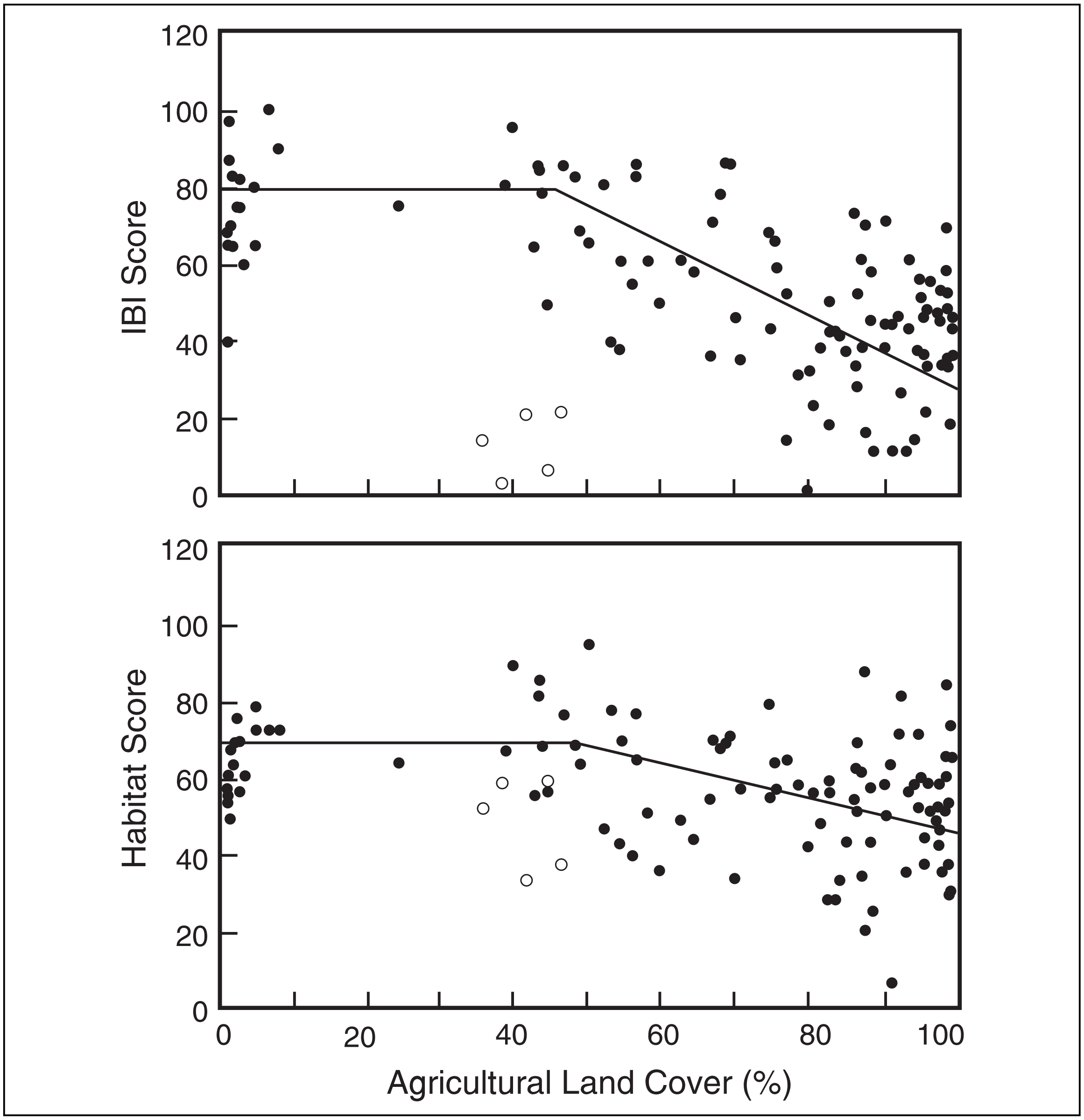
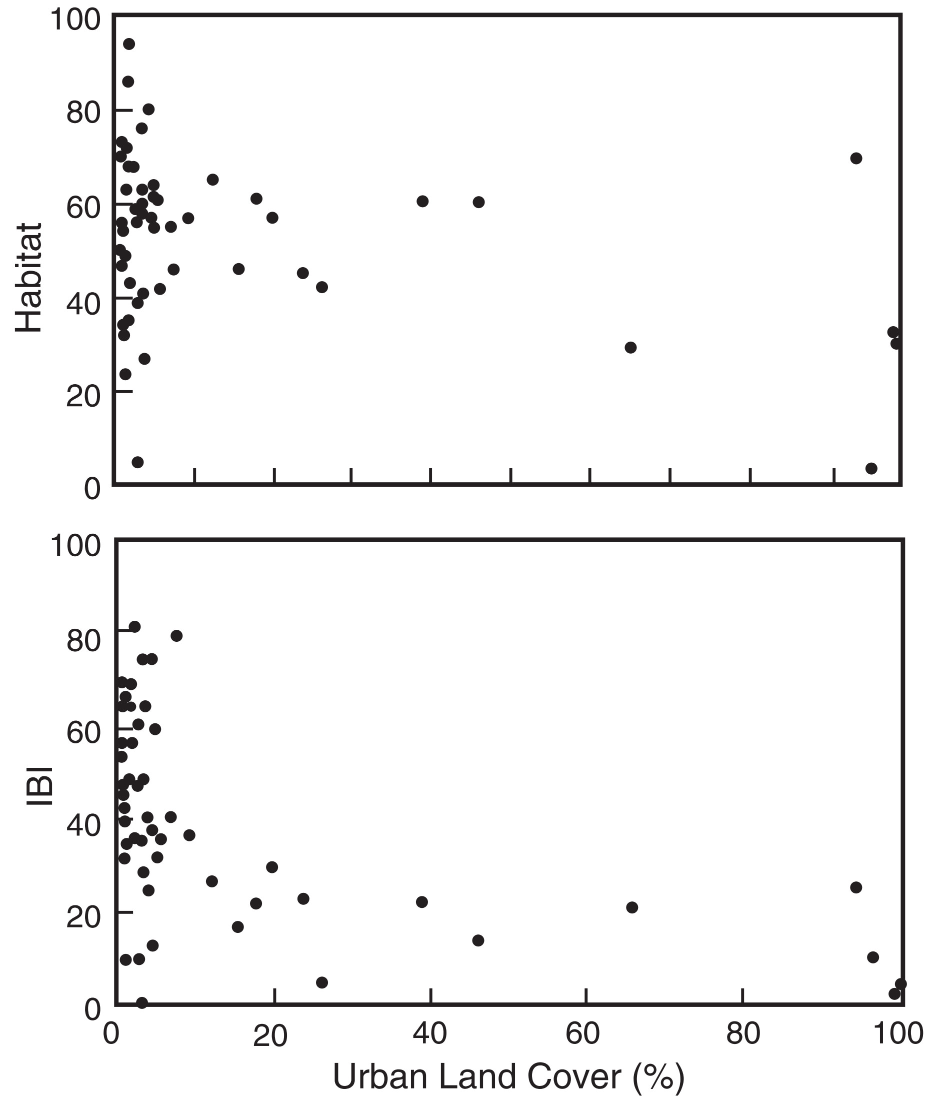


Figure 10. Shows the relationships between watershed Agricultural land use and habitat scores and IBI scores. Open circles are considered outliers. Lines were fitted by eye.
Source: Wang, L. and J. Lyons, et. Al. 1997



The amount of agricultural land use tends to be negatively correlated with stream habitat quality and biotic integrity, although the relationship was nonlinear (Figure 10). When upstream land use is less than about 50 percent, no apparent relationship existed between land use and biotic integrity or habitat. However, when agriculture exceeds 50 percent, biotic integrity and habitat scores decrease. This decreasing trend is stronger for biotic integrity than for habitat. This suggests that there may be a threshold level at which agricultural impacts begin to become apparent or overwhelm the assimilative capacity of the stream.

Figure 11. Shows the relationships between watershed Urban land use and habitat scores and IBI scores.
Source: Wang, L. and J. Lyons, et. Al. 1997



The amount of urban land use upstream shows a strong negative relationship with biotic integrity and, to a lesser extent, with habitat quality (Figure 11). Watersheds with more than 20% urban land invariably have poor to very poor biotic index scores while their habitat scores vary from very poor to good. There appears to be a particularly sharp decline in biotic scores from 0% and 20% urban land use. On a per-unit-acre basis, urban land uses generally cause more damage to stream fish communities than agriculture.[48]

[48] Wang, L., J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons. 2000. *Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams.* Journal of the American Water Resources Association 36(5):1173-1189.

A. Sensitivity to Development

Studies of streams from around the country have identified a threshold of 10% impervious area in a watershed at which stream water quality and habitat begin to degrade.[49] A second threshold appears to be reached at around 25 to 30% impervious cover, where most stream quality indicators consistently shift to a poor condition (e.g., diminished aquatic diversity, water quality, and habitat scores). The mechanisms of the degradation process are well known. As impervious cover increases, surface runoff increases and infiltration and groundwater recharge decrease. The more rapid runoff results in higher peak flows in streams, and increased stream bank erosion and sediment loading to the streambed. The results are wider, straighter, sediment-choked streams, greater water temperature fluctuation, and loss of shoreland and stream habitat. The streambed is covered by sand and silt, and pollutant loading is increased. Engineering responses to flooding have increased the ecological damage by severely simplifying stream habitat.

Based on the research, it is possible to develop a simple stream classification system based on impervious cover and stream quality.[50] This classification system contains three stream categories based on the percentage of impervious cover. Figure 12 illustrates this model describing current and future stream quality based on changes in impervious cover. It is important to point out that while the impervious cover model does not predict precise values for individual stream quality indicators, it does represent the average behavior of a group of indicators over a range of impervious cover.

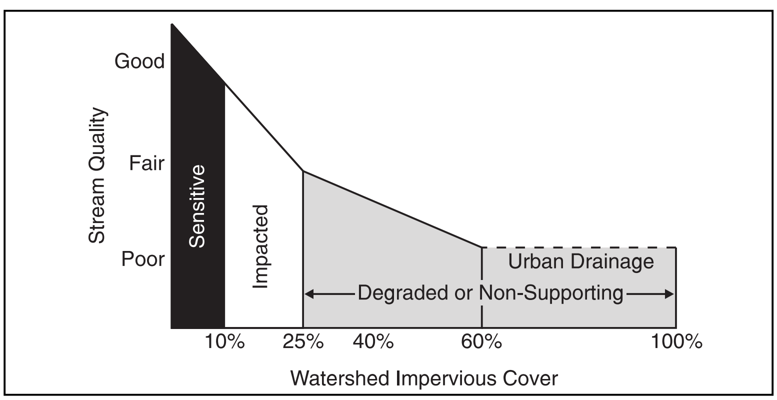
The model classifies streams into one of three categories: sensitive, impacted, and degraded or non-supporting streams. Each stream category can be expected to have unique or characterizing features as follows:

1. Sensitive Streams (0–10% Impervious Cover)

Sensitive streams exhibit high quality typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects. Because impervious cover is low, these streams do not experience frequent flooding and other hydrological changes that accompany urbanization. It should be noted that some sensitive streams located in rural areas may have been impacted by poor grazing and cropping practices that may have severely altered the riparian zone and, consequently, may not have all the properties of a high quality stream. Once riparian management improves, however, these streams often recover.

It is also important to note that research in Wisconsin indicates the threshold is slightly lower than those presented in the model. Thresholds set at 6% (coldwater) and 8% (warmwater) are probably more representative of the systems found in this area.[51]

Figure 12.



2. Impacted Streams (10–25% Impervious Cover)

Impacted streams show clear signs of degradation due to urbanization. The elevated storm flows begin to alter stream geometry. Erosion and channel widening are clearly evident. Stream banks become unstable, and physical habitat in the stream declines noticeably. Stream quality shifts from the good category to fair. Stream biodiversity also declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.

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[49] Schueler, T. 1994. *The Importance of Imperviousness*. Watershed Protection Techniques 1:100-111.
[50] Center for Watershed Protection. 2003. *Impacts of Impervious Cover on Aquatic Systems.* Ellicot City, MD
[51] Personal communication with John Lyons, DNR Research Watershed Ecologist, August 2004

3. Degraded or Non-Supporting Streams (25% or Greater Impervious Cover)

Once impervious cover exceeds 25% of the watershed area, stream quality crosses a second threshold. Streams in this category essentially become conduits for stormwater, and can no longer support a diverse stream community. The stream channel becomes highly unstable and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated, and the streambed or substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Water quality is consistently rated as fair to poor, and water recreation is no longer possible due to the presence of high bacterial contamination. Streams in the non-supporting category will also generally show increases in nutrient loads even with urban BMPs. The biological quality of non-supporting streams is generally considered poor, and is dominated by pollution tolerant insects and fish. While these streams may have other aesthetic or community values, the stream ecology has been significantly and usually permanently altered.

It should be reiterated that the impervious cover model does not predict the precise values of *individual* stream quality indicators but rather describes the average behavior of a *group* of indicators over a range of impervious cover. The essential habitat requirements for many sensitive or endangered species are best determined by the most sensitive stream quality indicators, rather than the average behavior of combined stream quality indicators (e.g., temperature, dissolved oxygen, substrate, habitat, etc.). It should also be expected that some individual stream reaches or segments will deviate from the predictions of the impervious cover model. For example, physical and biological monitoring may find poor quality in a stream classified as sensitive, or good diversity in a non-supporting stream. Rather than being a shortcoming, these "outliers" may help watershed managers identify and better understand the local watershed and stream dynamics, indicating where more investigation is needed. For example, an "outlier" stream may be the result of past human disturbance such as grazing, channelization, agricultural drainage, poor forestry practices, etc. which can be corrected.

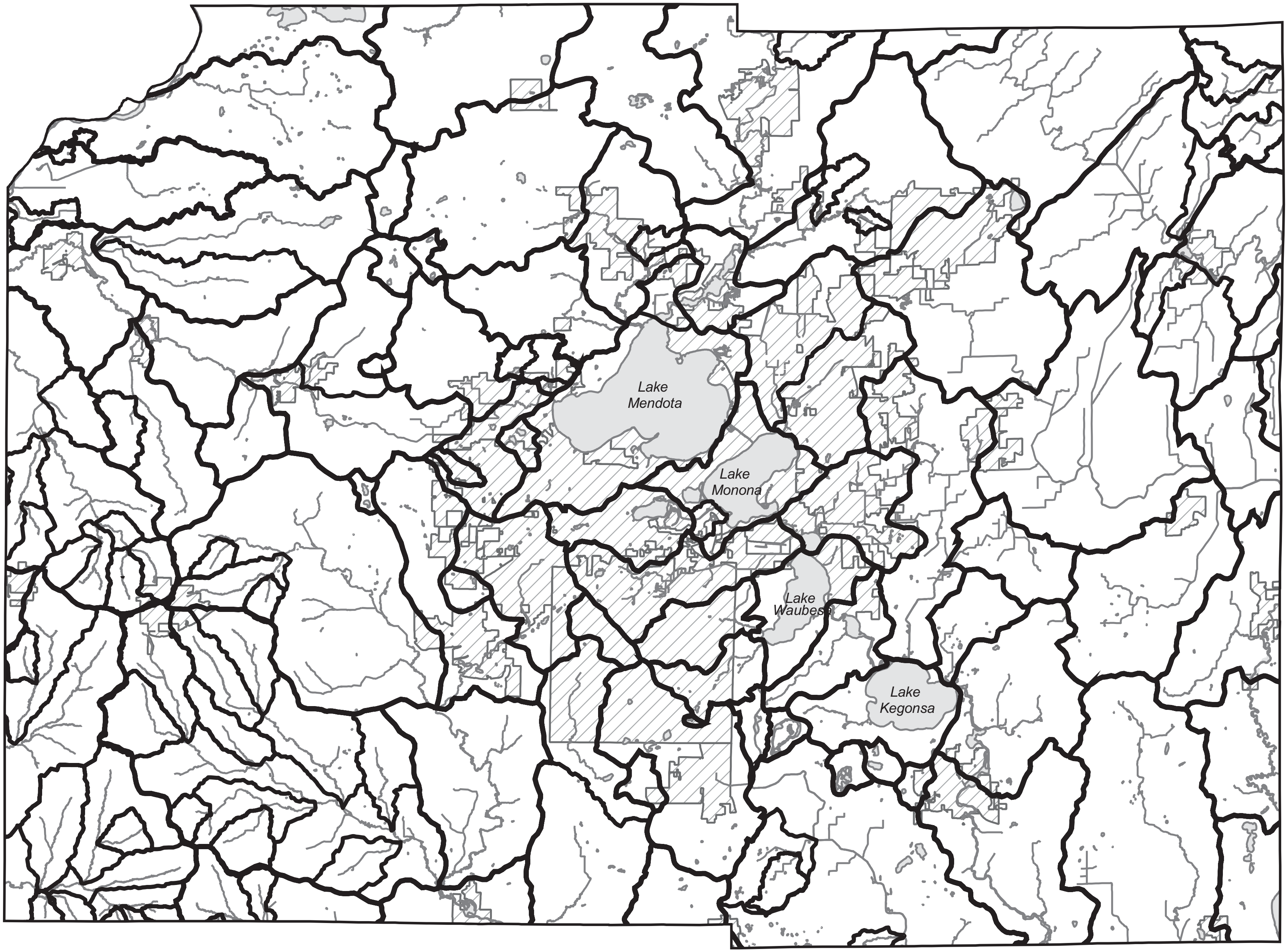
B. Stream Classification

Impervious cover was analyzed for streams using the same methodology as for lakes and ponds. However, the amount of impervious cover was collected at the subwatershed level for streams because streams are more affected by the amount and quality of water flowing through them than development on their immediate shorelines. A subwatershed, watershed, or drainage basin is defined as the contributing area that drains to a common body of water, whether it is a lake, river, or stream. Watersheds have an advantage in that they can be clearly defined as geographic units. In addition, the watershed can be used as a system of organization at any scale, from a major basin encompassing several states, to a regional watershed involving several municipalities, to a local subwatershed on a community or neighborhood scale. Furthermore, basins, watersheds, and subwatersheds are not constrained by jurisdictional boundaries. In this regard, they more accurately reflect the connection between water and the surrounding land.

With this in mind, the subwatershed for each stream was delineated using GIS (Map 3), which was then intersected with the 2000 Land Use Map. Figure 13 shows this procedure for Token Creek. The area of each land use category within the watershed for each stream was recorded in an excel spreadsheet. Average impervious cover percentages were assigned to each land use (Table 5), similar to what was done for the lakes. Multiplying the land use acreage by the corresponding impervious coverage percentage resulted in calculated impervious cover acreage for each cover type within the subwatershed area. Totaling the impervious cover acreage and dividing by the total acres within the subwateshed area results in a weighted average or composite impervious cover percent for each named stream (Appendix F). This procedure was also followed using the Planned Land Use Map to "red flag" potentially threatened streams, or those in danger of falling into a lower category because of future development.

The impervious cover percentages result in Class I (Sensitive), Class II (Impacted), and Class III (Degraded) stream classifications, listed in Appendix F**.** These have also been sorted alphabetically for easy reference. Note that 6% and 8% thresholds were used for cold and warm water streams, respectively; differentiating between Class I (Sensitive) and Class II (Impacted) streams found in Wisconsin. The respective stream classes are also on Map 4 for streams designated as being cold or warm sport fisheries.

The classification system could easily be broken down further into six separate classes, corresponding to cold and warm water streams, or even 12, corresponding to existing and potential cold and warm water stream segments. However, this was judged to add unnecessary complexity.



Map 3

Dane County Subwatersheds

Dane County, Wisconsin

Subwatershed

Incorporated Area

Subwatersheds were futher delineated using 4ft contours and 1995 digital elevation model.

Subwatersheds were chosen to be delineated based on DNR classified streams from the DNR fish and aquatic life dataset. Streams that were not classified did not have their watersheds further delineated.

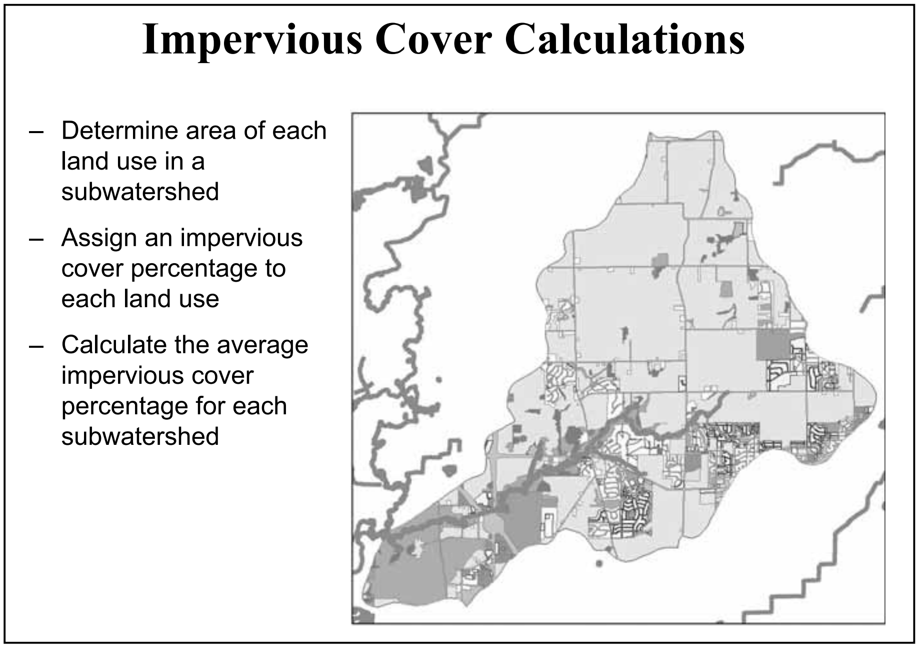
Projection:
Lambert Conformal Conic
Dane County Coordinates - NAD 83(91)

Prepared by: The Dane County Regional Planning Commission

N

0 0.5 1 2 3 4 5 Miles

Figure 13.



C. Fish and Aquatic Life

The Wisconsin DNR maintains Fish and Aquatic Life designations for stream segments throughout the state (Table 7). They are published for each stream segment in its respective DNR Basin Plan. In Dane County this includes the Wisconsin River Basin, the Sugar-Pecatonica River Basin, and both the Upper and Lower Rock River Basins. This information is listed in Appendix G. Individual stream segments begin at the mouth and progress upstream as lettered segments. Also included are special designations such as Exceptional Resource Waters (ERW), Outstanding Resource Waters (ORW), and Clean Water Act 303(d) impaired stream segments, and also whether or not a municipal wastewater treatment plant (WWTP) discharges to the stream.

Table 7.

DNR Fish and Aquatic Life Designations	
COLD	Cold Water community
WWSF	Warm Water Sport Fish community
WWFF	Warm Water Forage Fish community
LFF	Limited Forage Fishery
LAL	Limited Aquatic Life
Special Designations	
ORW	Outstanding Resource Water
ERW	Exceptional Resource Water
303(d)	Clean Water Act Section 303(d) impaired stream

The impervious cover thresholds provide useful insight and guidelines for targeting management activities. When used in conjunction with the DNR stream designations, they give an indication of stream quality, development pressures, management approach, and where these efforts may be best directed.

D. Stream Management

The response to urbanization is basically the same whether the stream is a warm or coldwater resource, although with slightly different thresholds and temperature requirements.[52] The changes are primarily hydrologic. Once water quality changes become apparent, the stream ecosystem is in an advanced state of deterioration. As can be seen from Figure 12**,** there is a steep decline with relatively small changes in imperviousness (generally, 6% for coldwater streams and 8% for warmwater systems in Wisconsin). Beyond 10% the streams are pretty much impacted. Beyond 25% streams become seriously degraded: low baseflow, stagnant water, flooding and water quality problems (e.g, sediment, low dissolved oxygen, ammonia, etc.)

It is important to note there is really no distinction between cold and warmwater systems in terms of sensitivity, although the management approach might vary – for example, temperature considerations for coldwater streams, while wetland restoration may more suitable for warmwater streams. Typically, coldwater streams receive more attention from environmental groups, conservation organizations, and resource management agencies. More attention should be paid to warmwater systems, which are equally important.

The results of the impervious cover analysis can be used to guide management plans and activities (Fig 14). For areas in the "sensitive" category (lower imperviousness), emphasis should be placed on protective measures that retain existing vegetation, using techniques like open space planning, stream buffers and conservation easements.

Figure 14. Stream Classification Matrix

Natural Characteristics	**Stream Classification**		
	Class I (Sensitive Streams)	**Class II (Impacted Streams)**	**Class III (Degraded Streams)**
Warm and coldwater streams equally sensitive	Protection	Protection and Restoration	Restoration and Enhancement

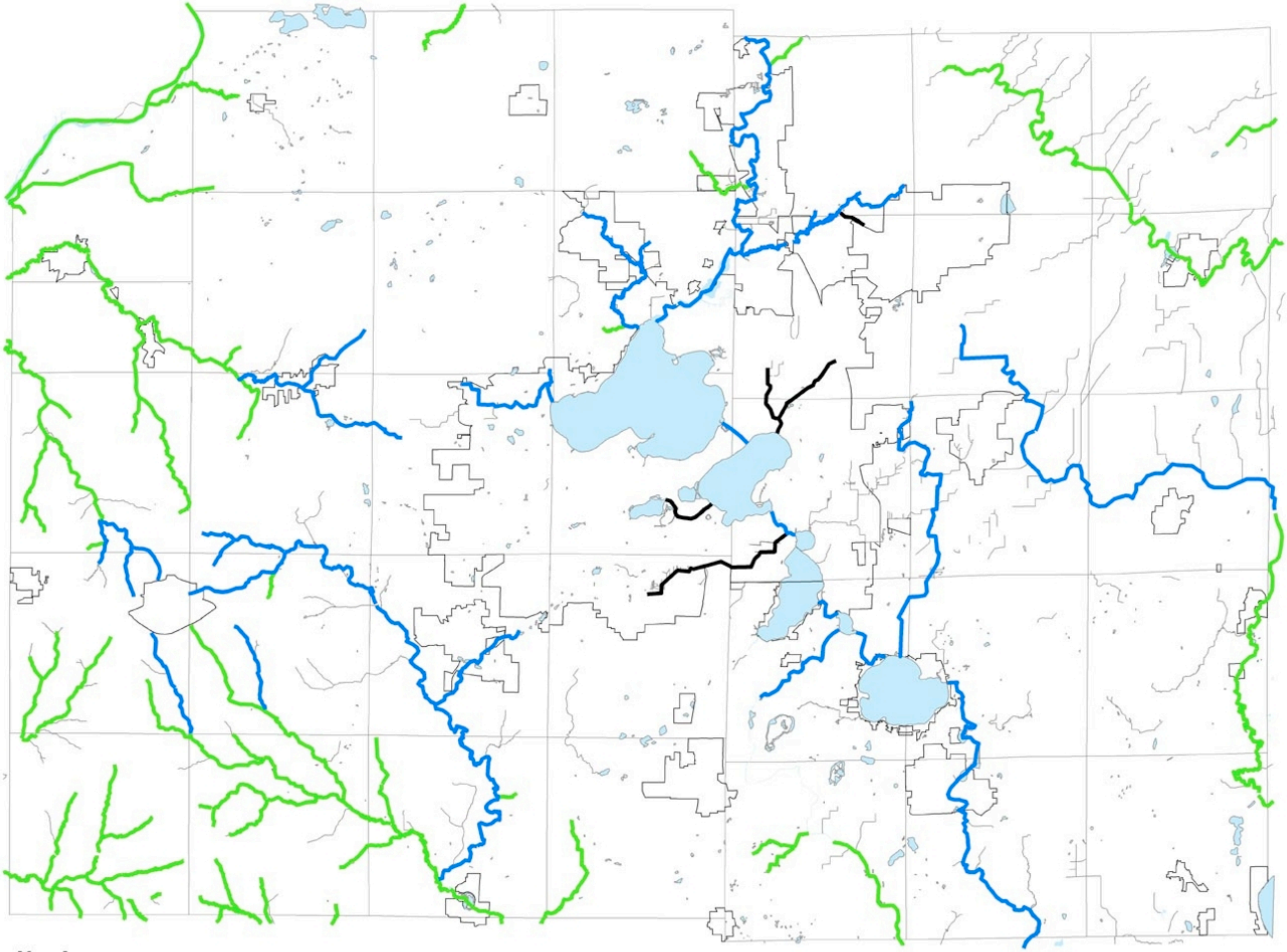
For areas in the "impacted" category, a combination of protection and restoration practices are needed, focusing more on site design considerations that reduce runoff and imperviousness. Finally, for areas in the "degraded" category, the focus shifts primarily to resource restoration and enhancement of existing practices and measures to help reduce pollutant loads, increase public amenities, and aesthetic qualities.

The management approach may also vary based on priorities and technique. A more aggressive strategy may be needed for the impacted streams located in the transitional areas to prevent further deterioration of the stream. For example, maximizing infiltration, BMPs, conservation design, etc.; focused more on urban design features, reviews, and approvals.

In the more rural areas a more personal approach may be more appropriate – working cooperatively with landowners. This approach can be incorporated in the resource conservation plans and programs, such as those implemented through the Dane County Land Conservation Division. These have more to do with agricultural BMPs, conservation easements, financial cost-sharing, barnyard and nutrient management, soil and water conservation plans, vegetative buffers, restoring native habitat and prior-converted wetlands, among other efforts. The right mix of practices can help protect, restore, or enhance healthy stream systems, both warm and cold. In the short-term, the most dramatic results could possibly be achieved through improvements in the riparian zone, restoring native cover, buffers, streambanks, and barnyard management – keeping dirty water out of the stream. In the long-term, improvements are needed throughout the watershed including soil and water conservation plans and practices, nutrient and pesticide management, increased groundcover and infiltration, and similar measures that replicate or restore natural processes and prevent pollution at its source.

There is an entirely different management focus for degraded streams – less on aquatic ecology and more on open space, recreation, trails, aesthetics, wildlife habitat and water quality. Degraded streams are valued differently and pose different constraints. In urban areas, BMPs are primarily geared toward water quality improvements and trying to reduce the property damage associated with flooding. These efforts may do very little for improving the biological community, largely because these impacts are irreversible. On the other hand, streams classified by their potential for restoration offer opportunities for improvements in water quality, stream stability, and the

[52] Center for Watershed Protection. 2003. *Impacts of Impervious Cover on Aquatic Systems.* Ellicot City, MD



Map 4

Dane County Water Body Classification Study, Dane County WI.

Stream Classifications

- Class I - Sensitive Streams
- Class II - Impacted Streams
- Class III - Degraded Streams
- Open Water
- Service Areas

Water Features are a revised 2000 DNR hydro data file. Revisions included the use of aerial photography and past land surveys.

July 2005

0 0.5 1 2 3 4 5 6 7 Miles

Created by the Staff at the Dane County Regional Planning Commission. All information is believed to be accurate but is NOT guaranteed to be without error. This map is intended for general reference use and not intended for detailed site-specific analysis.
Updated by the Community Analysis & Planning Division of Dane County Planning & Development.

storage/transport of water through the use of urban retrofit and other stream restoration techniques. It should be noted, however, that retrofitting existing urban development is usually very expensive. High property values, other urban constraints, and pre-existing impacts can result in a significant expenditure of resources without seeing much overall improvement in the ecology of a degraded stream. While urban BMPs may be able to shift the impervious cover thresholds higher, the ability of the current generation of BMPs to shift these thresholds appears to be very modest or limited.[53,54]

Limited financial resources may be better spent in the agricultural or transitional areas, achieving a better return on the investment where the same dollar amount can go significantly further. There are also fewer property owners to work with in these areas, increasing the prospects of agreement and facing less conflict among many competing interests.

Attention should also be focused on healthy streams and those that can reasonably be expected to be improved or restored. Conserving or restoring an intact and naturally vegetated riparian zone along streams appears to extend the impervious cover threshold to a modest degree. This is not surprising given the integral role the riparian zone plays in the form, structure and ecology of headwater streams. Indeed, the value of conserving and restoring riparian forests and native grasslands to protect stream ecosystems is being increasingly recognized as a critical management tool in both urban and rural areas.

In any event, the overall concept of impervious cover provides one of the best tools for evaluating the health of a subwatershed and its receiving stream. It captures the impacts of development on sensitive water resources and helps cut through much of the complexity that surrounds the issue. Not only does it serve as a useful indicator, but it is also a valuable tool in reducing the cumulative impacts of development. Since impervious cover is measurable, it is also appropriate for a wide range of other planning and regulatory applications as well. For example, as a feature that is a substantial component of many current trends in road, neighborhood, and landscape design, it can be used as a reinforcing connection between seemingly unrelated planning goals and objectives. Finally, the basic strategy of reducing imperviousness – retaining the natural landscape, minimizing pavement, promoting infiltration to the soil – are concepts that can be readily understood by most people. While impervious cover is rarely specifically identified or addressed in community goals, policies, or regulations – it probably should be.

V. PARKS AND RECREATION

A classification study would not be complete without giving some attention, of course, to parks and recreation. Dane County has a relatively large surface water acreage for a southern Wisconsin county. Opportunities for water-related recreation are many and are available to a large number of people. The county's waters provide a broad and diverse framework for outdoor recreational activities and experiences. The waterfowl, shorebirds, wildlife, and unique vegetation in these areas offer hours of discovery and enjoyment.

As the population increases, more outdoor recreation opportunities will be needed. Dane County plays a special role in partnership with state, county and local units of government, as well as private groups to meet the recreational and resource protection needs of Dane County's citizens. The *Dane County Parks and Open Space Plan* defines that role and also recommends how Dane County can work as a partner with other governmental units and also the private sector.

Dane County's parks system actually began in 1935 when the county acquired Stewart Park, its first park. In 1990 the Dane County Park Commission broadened its scope to focus on resource protection and providing connections among communities and natural resource sites. The *Parks and Open Space Plan* contains a map showing local, state, and federal lands, natural resource sites and study areas, existing and proposed land and water based trails, among other features. As one would expect, many of these are closely associated with surface waters. Overall, public lands provide about 107 miles of frontage on Dane County Lakes and streams.[55] Access to the county's streams is good, with about 75 miles of public frontage. Access to the county's lakes is very good, with about 32 miles of public frontage. Additional maps indicating the public recreation facilities associated along the Yahara Chain of Lakes are available from the County Parks Department, as is information about many other sites around the county.

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[53] Center for Watershed Protection. 2003. *Impacts of Impervious Cover on Aquatic Systems.* Ellicot City, MD
[54] Personal communication with John Lyons, DNR Research Watershed Ecologist, August 2004
[55] Day, E. A., G. P. Grzebieniak, K. M. Osterby, and C. L. Brynildson. 1985. *Surface Water Resources of Dane County*. Wisconsin Department of Natural Resources. Madison, WI.
[56] Day, E. A., G. P. Grzebieniak, K. M. Osterby, and C. L. Brynildson. 1985. *Surface Water Resources of Dane County*. Wisconsin Department of Natural Resources. Madison, WI.

In planning for future park and open space acquisitions and capital improvements, the demand for specific types of recreational activities must be gauged. This demand is determined in different ways, depending on the type of recreational activity. The recommendations in the plan are also reviewed annually in order to determine how well the county is doing in achieving its goals.

A. Relative Importance of Summertime Water Recreation Activities

A Wisconsin Recreation Survey conducted in 1986[57] contains estimated participation rates by state residents in various outdoor recreational activities. A fairly high percentage of respondents (approx. 40-55%) indicated they took part in water-oriented activities such as swimming, fishing and/or pleasure boating (Table 8**)**. These activities had higher participation rates than many other outdoor recreational choices (e.g., hiking, hunting and camping). A 1990 survey done for Dane County Park Commission[58] showed similar local participation rates for water recreation activities.

Table 8. Recreation Activity Participation

Activity	% of Respondents Participating	
	1986 State Survey	1990 Dane Co. Survey
Swimming	54%	48%
Fishing	51%	41%
Other Boating	40%	24%
Canoeing, Kayaking	21%	22%
Water-skiing	15%	27%
Sailing	7%	12%
Jetskiing	—	10%

Source: WDNR, 1989; and Gardner, 1990

1. Swimming

Swimming is the most popular recreational activity. There are numerous beaches located on many of the larger lakes in urban areas, as well as various other opportunities in state and local parks elsewhere in the county. Swimming is also a popular activity at many private waterfront residences and resorts. However, sediment deposits, algal blooms, and weed growth can limit the enjoyment of swimming activities. Some species of blue-green algae produce toxins that in large enough concentrations can cause illness in animals and humans, including possibly seizures or death. A review of City of Madison swimming beach attendance indicates there has been a substantial decline in beach use since 1980. Average annual attendance for 2000 to 2004 (43,000 people) was over 50 percent lower than 1990 to1995 (102,000 people) which was over 50 percent lower than the 1980 to 1989 average (234,000 people). There may be numerous reasons contributing to this decline, although public perceptions of poor water quality is suspected as being a leading factor.

2. Fishing

Fishing has increased in popularity. There were 45,634 resident fishing licenses sold in Dane County in 2003. This is a 22% increase from 1999, approximately 4% per year. The fisheries in Dane County are limited by both natural and human factors. The trout fishery is generally limited to the western portion of the county, since the eastern half is generally low gradient and somewhat marshy, with low baseflow streams and silting problems resulting from agricultural and residential development. Trout need cold, fast flowing streams with high oxygen content and gravel substrate. Some of the best trout fishing in the area is within the Sugar, Wisconsin, and Pecatonica river basins, but without good soil conservation practices and costly habitat rehabilitation many of these streams are in danger of losing their trout populations. There are also many potentially good trout streams that have suitable flow characteristics, but require control of agricultural runoff and erosion before they can support trout populations.

Most lakes in Dane County are too shallow to support a cold water fishery. Brown and rainbow trout are stocked and released to Salmo Pond and Stewart Lake, respectively. Some of the deeper lakes such as Mendota, Monona, and

[57] Wisconsin Department of Natural Resources. 1989. *Wisconsin Recreation Survey—1986*. Technical Bull. 167.
[58] Gardner, Jeff. 1990. *Summary of Results, Dane County Park Commission Recreation Participation and Need Survey for Dane County*. Conducted by Madison Area Technical College Spring 1989-90 Marketing Research Class.

Fish Lakes have such high oxygen demands that their hypolimnia or bottom layers become oxygen-depleted, threatening their cisco populations (another cold water species). Some of the more popular warmwater species include true muskies (Lake Wingra), hybrid "tiger" muskies, northern pike, walleye, smallmouth bass, largemouth bass, catfish, sturgeon, and assorted varieties of panfish.

In some of the already shallow seepage lakes, soil erosion and the subsequent accumulation of sediment and organic material is causing winterkill problems for the more intolerant warmwater species. This reduction in species diversity can be difficult and costly to correct. In eastern portions of the county, the continuing destruction of wetland spawning habitat is threatening northern pike populations.

3. Boating

Dane County has a significantly greater number of lakes than any of its neighboring counties and, therefore, offers a greater diversity of recreational boating activities for more people. In 1981 there were 19,498 motorboats registered in the county. In 2003 this number increased 41% to 27,607, approximately 2% per year. Boating activities include fishing, water skiing, cruising, speed boating, and sailing. Boating is regulated on certain waters in the county by local ordinances (e.g,, Lake Wingra and Fish Lake) to insure safety and to minimize activity conflicts. Other restrictions such as a 200 foot slow-no-wake zone on the Yahara Lakes helps to address safety issues and resolve conflicts among multiple user groups, particularly along the shoreline.

Due to size and depth limitations, most boating activities are confined to a small number of lakes and two rivers – the Wisconsin and the Yahara Rivers. The most popular lakes are Mendota, Monona, Wingra, Waubesa, Kegonsa, Fish, Marshall Millpond, and Lake Belle View, which collectively provide over 19,000 acres of surface area. Although the latter two are less than 7 feet deep, they are popular because they are large and located near population centers. Sailing is also very popular on the larger lakes. All of these lakes and rivers have at least one public boat ramp, with multiple ramps located on the lakes subject to more use.

Many Dane County lakes are naturally shallow and others impassable to power boats because of dense weeds. Power boating in Dane County is generally limited to lakes with a surface area of 50 acres or more. This causes a crowding problem on some of the lakes, especially the Yahara Lakes which support a wide range of water recreation activities. Conflicts occur between speed boaters, water skiers, anglers, and nonpowered boat users. Crowding is a particular problem on weekend afternoons during the summertime.

Canoes, rowboats, kayaks, and other small, nonmotorized craft, on the other hand, can be used with a fair degree of isolation on some of the smallest lakes and streams. That has significant appeal for many folks. Of the smaller Dane County streams, the Sugar River and the lower reaches of Black Earth Creek are among those most extensively used for recreational boating.

4. Camping, Hiking, and Hunting

Dane County has many campgrounds offering a wide variety of recreational activities. A majority of the campgrounds are situated near lakes or streams. Likewise, many of the best hiking and hunting spots are located near water.

B. Yahara Lakes Water Recreation Study[59]

The Yahara Lakes are the most popular and heavily used water bodies in Dane County. Results from a public opinion questionnaire conducted as part of the 1995 Yahara Lakes Water Recreation the Study indicate that poor water quality and weedy conditions are the top-rated problems interfering with the recreational use and enjoyment of the lakes. In addressing the needs and concerns of the lake users, the study recommends that the highest priority be placed on water quality issues. Various efforts to control nonpoint source pollution to the lakes are taking place through the State's Nonpoint Source Pollution Control Program, in cooperation with local units of government; various agricultural conservation compliance programs; as well as urban construction site erosion control and stormwater management ordinances and programs. These management efforts need to be continued and expanded in order to protect and improve water quality conditions.

[59] Dane County Regional Planning Commission. 1995. *Yahara River Lakes Water Recreation Study*. Madison, WI.

In comparison to results from previous surveys, concerns about overcrowding of boaters on the lakes seem to be increasing, particularly for Lake Monona. A majority of the respondents indicated that large motorboats and high speeds are a moderate to serious recreational problem and that speeds should be limited. A majority of the respondents also view personal watercraft/jet skis to be a moderate to serious recreational problem. The average horsepower of all motorboats recorded during a July Saturday survey of major public and private access sites was 123 HP. About 15 percent had 200 HP or higher engines. Approximately 10 percent of the boats had out-of-state registrations. Parking spaces at most major public access sites were filled to capacity by early afternoon, which is a common occurrence on pleasant summer weekends. There is a concern that trends to larger or more powerful motorboats could eventually lead to significant safety or nuisance problems. Many of the respondents felt water safety patrols should be increased. Aggressive education and enforcement efforts are also viewed as being needed to limit use conflicts, control boat speeds, and maintain safety. Respondents appeared to be fairly well satisfied with recreational support facilities and services provided by local and state agencies (e.g., restrooms, storm warning systems, waterway markers, fishing piers, lake levels, etc.).

For most lake recreational activities (e.g., swimming, fishing, sailing, motorboating), respondents indicated they spend an average of $15 to $22 per outing for supplies and fuel. They generally average 15 to 23 outings per summer; thus their direct seasonal expenditure is about $225 to $500 for each activity. Lake Mendota was cited as the most frequented water body for all recreational activities. Overall, these activities provide a substantial base for tourism, recreation, and quality of life for people living and visiting here, which is very difficult to quantify. This is because of the multiplier effects through the economy where the same dollar can turn over numerous times through stimulated economic activity, increased property values, and overall personal enjoyment.

VI. MANAGEMENT IMPLICATIONS AND PHASE II PROGRAM

The best way to protect the water resources from the impacts of human activity is to protect the remaining natural areas and to restore or enhance those areas where human activity has already occurred. The focus of these activities should begin at the water's edge and expand up into the watershed or out into the water body as needed. The overall focus on minimizing impervious cover or (conversely) maximizing natural vegetation applies to both urban and rural areas alike. By keeping this in mind, considerable progress can be made in improving the quantity and quality of water being discharged to our lakes and streams, along with associated wildlife and human benefits. It also provides the basis for planning, prioritizing, and targeting various management strategies and activities given the available resources. While these efforts are not the only ones that can or should be taken, focusing on them would actually accomplish quite a lot.

This section of the report outlines water resources management topic areas or issues that need to be considered by local units of government in tailoring their own specific policies, plans, programs and activities. It begins with site-specific considerations and then broadens out to the more general planning and policy objectives. It provides the conceptual framework for further needed discussions to develop a Phase II water body management program (not yet funded). This could include updates to the county shoreland zoning ordinance as well as recommendations for new or existing water resource management programs. The Phase II effort would involve extensive public input, discussion of priorities, identifying limitations or gaps in existing programs, and ways to enhance or improve these programs.

A. Shoreland Vegetation

Shoreland vegetation can significantly reduce the amount of sediment, nutrients, and toxic substances entering surface waters, thereby reducing their impact on aquatic species. Shoreland vegetation also provides food and habitat for wildlife, moderates water temperatures, and protects shorelines and streambanks. Buffer areas provide other important amenities as well, including aesthetic beauty, open space, and natural corridors for the movement of wildlife. While effective buffer width is dependent on various factors including topography, shoreline vegetation type, adjacent land use and habitat, etc.; the literature provides some general guidance:[60,61,62]

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[60] Bernthal, T. and J. Barrett. 1997. *Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives. A Literature Review with Policy Implications*. WDNR Bureau of Watershed Management Publ. WT-505-97.

[61] Bernthal, T., S. Jones, and J. Barrett. 1997. *Shoreland Management Program Assessment*. WDNR Bureau of Watershed Management Publ. WT-508-97.

[62] Castelle, A.J., A.W. Johnson, and C. Conolly. 1994. *Wetland and Stream Buffer Size Requirements—A Review*. Journal of Environmental Quality 23:878-882.

1. Buffer Size

- Buffers less than 35 feet provide minimal water quality protection from sediment and nutrients and do not provide adequate wildlife habitat, water temperature attenuation, or protection from fecal coliform and stormwater runoff.
- If properly maintained, a 35 to 75 foot buffer can provide moderate levels of some important ecological and aesthetic functions such as visual screening, shoreline stabilization, shading, and some habitat.
- Water quality benefits can generally be expected to increase with increasing buffer widths up to about 100 feet, beyond which a point of diminishing returns is reached.
- Increasing buffer widths beyond 100 feet will be primarily beneficial for shoreland wildlife.
- Under most circumstances, buffers necessary to protect streams, lakes, and wetlands should be a minimum 75 to 100 feet in width.

2. Buffer Quality

- Drastic alteration such as conversion of natural ground cover to manicured lawns can reduce buffer effectiveness to near zero.
- Overuse of fertilizers and pesticides can eliminate the nutrient retention and assimilation function of buffers.
- Removal of dead or dying trees or shrubbery can result in long-term impacts on fish and aquatic habitat in lakes and streams and reduce habitat for many shoreland wildlife species.
- A vegetated buffer with a natural diversity of vegetation will have greater aesthetic or natural beauty.
- Efforts should be taken to encourage landowners to re-establish natural shoreland vegetation in areas where lawns extend to the water's edge.

Vegetated shoreland buffers alone cannot be expected to adequately protect aquatic ecosystems in urban and urbanizing areas. The duration and frequency of storm events and bypass of storm sewers require additional nonpoint source pollution Best Management Practices. (See below)

B. Wetlands

Wetlands provide important water quality filtering, nutrient and flood storage benefits for lakes and streams, but can themselves be overwhelmed and degraded. Wetlands cannot maintain their protection and functional values when they are impacted by polluted runoff, hydrologic alteration, or habitat loss such as ditching, draining or filling. The following provides useful guidance:[63]

- Since wetlands are degraded by the same processes that affect streams and lakes and greatly contribute to their overall health and well-being, they too should be afforded the same level of protection and emphasis.
- Even wetlands smaller than 2 acres play important roles, individually and cumulatively. Protection should be based on field delineation, working around these areas or incorporating them into the design.
- Prior-converted wetlands and others that have been ditched or drained should be restored and enhanced.

C. Shoreland Development

Fragmentation and simplification of shoreline areas are inevitable as shoreland property is developed. Lot width and size standards provide a way of limiting the cumulative impacts of shoreland development by reducing the density of settlement along the shoreline, thereby reducing the intensity of use. State minimum requirements have remained largely unchanged since the 1960s, while our knowledge and understanding of these systems have evolved significantly. Many other Wisconsin counties have decided to re-evaluate their shoreland policies, programs and ordinances and make necessary changes or upgrades. This has implications for the following areas:

[63] Bernthal, T. and J. Barrett. 1997. *Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives. A Literature Review with Policy Implications*. WDNR Bureau of Watershed Management Publ. WT-505-97.

- Lot size, width, and setbacks.
- Shoreline frontage.
- Shoreland buffers and maintenance.
- Shoreland wetlands.
- Land disturbance.
- Impervious surface area.
- On-site wastewater systems and public sanitary sewerage.
- Accessory structures.
- Non-conforming structures.
- Mitigation and restoration of natural shoreland functions and values.

D. Floodplain Management

When buildings are constructed in the floodplain they reduce the floodplain storage capacity, causing the next flood of equal intensity to crest even higher than the last. This results in increased property and infrastructure damage, crop losses, and environmental degradation of the stream. Because each encroachment is treated separately, the cumulative impact of development is usually not taken into account. While floodplain zoning is intended to minimize or avoid property damage due to flooding, it does not restrict development or other activities in the floodplain if the only concern is adverse habitat or stream quality impact.

As the name implies, floodplains possess significant water quantity benefits, reducing flood velocities and peak volumes of water through increased storage and more gradual release. Floodplains also provide important water quality benefits filtering sediments, nutrients and other impurities from runoff. In addition, they promote infiltration and recharge of the aquifer, helping moderate temperature fluctuations as well as increasing groundwater discharge or baseflow to area waters. This is especially important during dry weather or drought conditions. They also provide important breeding and feeding grounds for fish and wildlife, as well as habitat for rare and endangered species.

The *Dane County Flood Mitigation Plan*[66] recognizes that flooding is only a single element of an otherwise highly variable and complex hydrologic system including many of the other management areas outlined in this section of the report. (For example, floods may become more frequent and reach higher levels in watersheds where wetlands have been drained, streams channelized, and large impervious areas developed without concern for stormwater management.)

The five basic elements to the county's strategy to reduce flood losses include:

- Minimizing the impact of flooding on existing structures.
- Improving the ability to respond to flooding and minimize the impact when it does occur.
- Minimizing the potential for increasing flooding and flood-related problems.
- Facilitating and coordinating solutions to multi-jurisdictional issues that involve government, citizens, and policy-makers at all levels.
- Gathering and disseminating information about issues and processes associated with flood management in Dane County.

While the focus of floodplain management has been primarily directed at protecting people and property, these efforts should be expanded to protect and improve the natural resource functions and values as well.

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[64] Arnold, C., and C.J. Gibbons. 1996. *Impervious Surface Coverage. The Emergence of a Key Environmental Indicator*. Journal of the American Planning Association 62(2):243-258.

[65] South Carolina Coastal Conservation League. 1995. *Getting a Rein on Runoff: How Sprawl and the Traditional Town Compare*. South Carolina Coastal Conservation League Land Development Bulletin, No. 7.

[66] Dane County Department of Emergency Management. 2003. *Dane County Flood Mitigation Plan*. Madison, WI.

E. Land Disturbance and Construction Site Erosion Control

Sediment delivery from construction site erosion can be a major source of nonpoint pollution with rates as much as 30 to 200 tons/acre/year.[67] Sediment is also a significant source of phosphorus. Shoreland buffers do not adequately prevent sediment and phosphorus delivery to lakes, streams, and wetlands during construction. The following considerations should be taken into account:[68]

- Sediment delivery from construction sites can be controlled through proper erosion control and stormwater management practices.
- Success is dependent on aggressive and proper implementation of control measures as well as adequate maintenance and inspection.
- Technical assistance from state and local agencies can promote more effective erosion and sediment control

F. Stormwater Management and Urban Best Management Practices

Stormwater runoff can have significant adverse impact on water quality in urban and urbanizing areas. Reducing impervious area and increasing infiltration are important management considerations in addressing these impacts. It is also critically important to take a pro-active approach *before* a problem develops – before it becomes either too difficult or too expensive to remedy. There are many structural and non-structural BMPs available from which to choose, based on site specific requirements and circumstances. Additional progress is being made in the research and development of new practices and techniques. Landowner education is also needed on the proper use of fertilizers and pesticides, keeping leaves, yard waste, and other potentially polluting substances off of streets and paved surfaces. These measures are more fully described in the *Dane County Water Quality Plan*[69] and the *Dane County Erosion Control and Stormwater Management Manual*[70], among other publications. The following measures provide a general outline of possible approaches to urban stormwater management:

- Promoting land use patterns and practices which preserve the integrity of the natural hydrologic system, including the balance between ground and surface water.
- Implementing infiltration measures, wherever practical, as a means of reducing stormwater impacts and increasing groundwater recharge.
- Preparing specific watershed plans incorporating flow and water quality management practices for all existing and developing urban drainage basins.
- Applying for funding to develop stormwater management plans, and to install specific practices.
- Promoting open drainage systems and natural greenways in developing areas.
- Promoting Low Impact Development (LID) design techniques to help mimic natural hydrology. Examples of such techniques include homeowner raingardens, redirecting downspouts to pervious grassed areas, infiltration basins, porous pavement, grassed swales, etc.
- Conducting aggressive public education and information programs on controlling pollutants at their source, more frequent and effective street-sweeping, reduced road salt usage, etc.
- Working cooperatively with state and local units of government, private watershed and conservation groups, and the business community.

From a watershed perspective, "cluster design" features a return to a traditional town layout – as opposed to conventional large-lot development. By incorporating smaller lot sizes, smaller street widths, different parking configurations and development patterns, a developer can offer the same amount of urban development as conventional design, while also preserving natural features, providing generous buffer areas, open space, and greatly reducing overall impervious area.[71,72] This has benefit in previously degraded areas as well. While less important from a biological standpoint, there are important physical and chemical aspects that need to be managed effectively such as the quantity and quality of stormwater being discharged to surface waters.

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[67] Wisconsin Land Conservation Board. 1984. *Erosion in Wisconsin*. Madison, WI.

[68] Bernthal, T. and J. Barrett. 1997. *Effectiveness of Shoreland Zoning Standards to Meet Statutory Objectives. A Literature Review with Policy Implications*. WDNR Bureau of Watershed Management Publ. WT-505-97.

[69] Dane County Regional Planning Commission. 2004. *Dane County Water Quality Summary Plan*. Madison, WI

[70] Dane County Land Conservation Department. 2002. *Dane County Erosion Control and Stormwater Management Manual*. Madison, WI.

[71] Arnold, C., and C.J. Gibbons. 1996. *Impervious Surface Coverage. The Emergence of a Key Environmental Indicator*. Journal of the American Planning Association 62(2):243-258.

[72] South Carolina Coastal Conservation League. 1995. *Getting a Rein on Runoff: How Sprawl and the Traditional Town Compare*. South Carolina Coastal Conservation League Land Development Bulletin, No. 7.

G. Rural Runoff and Agricultural Best Management Practices

Agricultural BMPs reduce soil loss and excessive nutrient inputs especially from barnyards, feedlots, and croplands. The Dane County Land Conservation Division plays a significant role in coordinating federal, state, and local resource management programs, plans and activities. These are more fully described in the *Dane County Land and Water Resources Plan*. The following are a few examples:

- Protecting, restoring and enhancing in-stream, riparian, wetland and upland habitats.
- Preparing and implementing soil and water conservation plans with federal and state cross-compliance requirements.
- Agricultural and transitional area nonpoint source pollution control.
- Nutrient and pesticide management.
- Technical assistance and cost-sharing.
- Groundwater protection.
- Partnering with and promoting watershed groups, involving citizens in water resource management initiatives in both rural and urban areas.

H. Comprehensive Land Use Planning

It is clear that a comprehensive watershed planning approach is needed to help coordinate and direct efforts to address water resource management issues. Coordination among federal, state, and local units of government is especially critical. Comprehensive land use plans, policies and programs are currently being developed by individual municipalities as required by the "Smart Growth" legislation. It is expected the *Dane County Comprehensive Plan* will incorporate the Phase I Water Body Classification system study and the subsequent Phase II Protection Program. Additional effort will also be needed to work with the community at large to integrate the Water Body Classification System with existing policies, programs, and activities – coming up with new ideas, revisions, and upgrades. By working with the community it is also hoped that other municipalities will incorporate similar changes in their own plans and programs. These changes can occur in the following areas:

- Natural resources protection and management.
- Parks and open space planning and implementation.
- Farmland preservation.
- Growth and development management.
- Land use and siting requirements.
- Flood mitigation and prevention.
- Financial incentives and alternative approaches such as PDRs, TDRs, conservation easements, and cost-sharing opportunities through federal, state, and local programs.
- Partnerships with private watershed organizations, conservation groups, and landowners.
- Information and education efforts aimed at many different audiences and sectors of the community, demonstration projects, etc.

The *Dane County Water Quality Plan*[73] and its technical appendices provide significant detail on surface and groundwater conditions in Dane County; point and nonpoint source pollution problems; stream, lake and groundwater management strategies; the institutional framework of government agencies, their roles and responsibilities; and recommendations for addressing these issues. The *Dane County Land and Water Resources Management Plan*[74] is the companion plan for addressing soil and water quality concerns primarily focused on the rural and urbanizing areas of Dane County. DNR Basin Plans provide additional detail and field results. Various other plans such as the *Dane County Parks and Open Space Plan*[75] and the *Dane County Flood Mitigation Plan*[76]

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[73] Dane County Regional Planning Commission. 2004. *Dane County Water Quality Summary Plan*. Madison, WI

[74] Dane County Land Conservation Committee. 2003. *Dane County Land and Water Resources Management Plan*. Madison, WI.

[75] Dane County Parks Department. 2001. *Dane County Parks and Open Space Plan 2001-2005*. Madison, WI.

[76] Dane County Department of Emergency Management. 2003. *Dane County Flood Mitigation Plan*. Madison, WI.

provide similar guidance with respect to those topics. Finally, the *Dane County Land Use and Transportation Plan*[77] as well as individual town plans provide the overall context for growth and development patterns. These plans as well as individual reports should be consulted for more specific information and detail surrounding water resource management issues, concerns, and activities throughout Dane County.

The following table provides an example of how this might be integrated with the Water Body Classification System. There are, of course, many other programs and activities with considerable overlap among categories. Follow-up efforts will be needed to involve the respective resource management agencies and associated community groups, very likely as the basis or framework leading into Phase II.

Potential Management Tools by Classification
(examples)

Classification	Program Area		
	Education & Technical Assistance Programs	**Public Investment, Incentives & Acquisition Programs**	**Plan Approval & Regulatory Programs**
Class I (Protection)	- Farm conservation plans - Agricultural runoff practices design - Agricultural performance standards - Agricultural buffers - Nutrient and pesticide management - Safe handling / use of chemicals - Workshops and field demonstrations - Landowner and citizen education	- Parks & Open Space Plan and County Conservation Fund - State Stewardship Fund - Lake / River Planning and Protection Grants - Cost-share programs - Conservation Reserve (CRP) and other easement programs - Streambank buffer programs - Wetland / habitat restoration - Purchase of Development Rights (PDRs) and Transfer of Development Rights (TDRs)	- Shoreland / wetland zoning - Floodplain zoning - Conservancy zoning - Site plan approval - Erosion control and stormwater management (focus on new development) - Open space corridors - Comprehensive planning
Class II (Protection & Restoration)	- Agricultural buffers - Stormwater practices design - Regional stormwater facility planning - Wetland / habitat restoration assistance - Watershed group support - Adult conservation volunteers - Workshops and field demonstrations - Landowner and citizen education	- Streambank buffer programs - Wetland / habitat restoration - Lake / River Planning and Protection Grants - Cost-share programs - PDR / TDR programs - Wastewater treatment facilities - Regional stormwater facilities planning - Water quality monitoring - Public land stewardship - Floodplain hazard mitigation	- Shoreland / wetland zoning - Floodplain zoning - Sewer services planning - Environmental corridor mapping - Erosion control - Stormwater management (both new and redevelopment; quality and quantity) - High capacity well withdrawals and permitting - Comprehensive planning
Class III (Restoration & Enhancement)	- Neighborhood / watershed group support - Volunteer clean-up programs such as "Take a Stake in the Lakes" - Nonpoint runoff education - Citizen monitoring - Pollution prevention - Invasive and exotic species control - Landowner and citizen education	- Streambank buffer programs - Wetland / habitat restoration - Lake / River Planning and Protection Grants - Cost-share programs - Regional stormwater facilities - Recreational access / trails - Floodplain hazard mitigation - Weed harvesting, dredging, lake level management (Yahara Lakes)	- Nutrient / pollution control and removal - Shoreland redevelopment - Erosion control - Stormwater management (focus on redevelopment / retrofit) - Lake use regulations - Boater safety / enforcement

[77] Dane County Regional Planning Commission. 1997. *Dane County Land Use and Transportation Plan*. Madison, WI.

VII. SUMMARY

A water body classification system is based on the notion that water resource plans, policies and programs can be specifically tailored and targeted to the needs of the resource as well as priorities of the community. In other words, a “one-size-fits-all” approach may not be necessary or even appropriate in many cases. The principle emphasis of the Phase I Water Body Classification Study was to develop a classification system that is intuitive, relatively simple, and is supported by current science and resource information. It has also been designed so that it can be easily updated as new or better information becomes available. The classification system provides the basis and framework for guiding program resources, promoting cost-sharing opportunities, and also partnerships among the various agencies and groups.

Completion of the Phase I classification system is expected to provide the basis for a Phase II management program coordinated by Dane County (not yet funded) working with the community to determine where its interests and priorities lie and how our current efforts may be best restructured or focused. The Phase II effort would involve extensive public input, discussion of priorities, identifying limitations or gaps in existing programs, and how they might be enhanced or improved. The Phase I work provides the necessary background information and basis for Phase II community discussions and efforts. For example, a particular management strategy or activity will vary depending on whether it is a lake or stream; focused on protection, restoration or enhancement (based on the classification); leaning more toward a regulatory, incentive or educational approach; leading to specific urban or rural designs, practices, or activities. In this manner, agencies, groups, and individuals can focus their activities on the projects that hold the most promise taking into account their available skills, resources, and support base. It is hoped the water body classification system and subsequent management program will provide a common understanding and framework by which the various partners can work together, combine technical, financial, and volunteer resources, and target them where they are needed most and have the greatest beneficial effect.

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APPENDICES

APPENDIX A. Data Summary for Dane County Lakes and Ponds

NAME	Town	Range	Section	Area	Maximum Depth	Shoreline Length	Stratification Factor	SDF	Lake Type	Soil Erodability	Septic Suitability
AMES POND	5	10	31	6.1	4	0.51	10.82	1.47	Seepage	3.2%	1.98
ANDERSON POND	6	9	33	16	—	0.60	—	1.07	Seepage	0.0%	1.88
BARBIAN POND	8	8	2	6.6	3	0.56	9.15	1.56	Seepage	0.0%	1.59
BARNEY LAKE	6	9	34	27	6	0.84	7.34	1.15	Seepage	7.4%	1.85
BASS LAKE	5	10	4	69	9	1.67	7.34	1.43	Seepage	10.3%	2.28
BELLE VIEW LAKE	5	8	34	100	7	3.43	5.75	2.45	Drainage	11.0%	1.96
BOWER POND	5	11	36	12.5	15	0.58	17.78	1.17	Seepage	21.4%	2.53
BRANDENBURG LAKE	8	8	6	38	6	0.99	6.65	1.15	Seepage	13.6%	2.19
BRUENIG POND	8	7	3	8.1	10	0.51	15.96	1.28	Seepage	19.0%	2.34
C. BUECHNER POND	8	8	19	11.7	3	0.68	7.02	1.41	Seepage	33.9%	2.16
CHRISTENSON POND	5	9	28	2.5	—	0.52	—	2.35	Seepage	5.8%	3.23
CRYSTAL LAKE	9	7	1	516	9	5.30	4.98	1.69	Seepage	28.6%	2.59
DAHMEN POND	8	8	16	17	4	0.70	6.91	1.21	Seepage	15.1%	1.60
DIEDRICH POND	8	8	4	19	6	0.98	8.21	1.57	Seepage	17.1%	1.67
DORN POND	8	8	25	8.1	4	0.51	9.36	1.28	Seepage	14.3%	2.50
DUNKIRK MILLPOND	5	11	20	70	12	5.06	8.94	4.32	Drainage	16.3%	2.06
EDGERTON POND	5	12	34	5.1	5	0.38	13.43	1.2	Seepage	33.3%	2.17
ESSER POND	7	8	10	15	4	0.66	7.23	1.22	Seepage	7.3%	1.30
FISH LAKE	9	7	3	216	62	3.30	28.49	1.6	Seepage	21.7%	2.69
FISHERS LAKE	9	6	32	5.2	8	0.53	17.46	1.66	Drainage	0.0%	1.19
FOX POND	5	9	3	53	—	1.20	—	1.18	Seepage	4.9%	1.49
GALLAGHER POND	7	7	11	34.14	—	0.94	—	1.15	Spring	47.4%	2.84
GOOSE LAKE	7	12	2	32	3	2.20	4.98	2.77	Drainage	4.8%	1.08
GOOSE POND	6	8	13	11	10	0.68	13.92	1.46	Seepage	12.9%	2.51
GRABER/DREHER POI	7	8	2	13	4	0.78	7.63	1.56	Seepage	23.2%	2.14
GRASS LAKE (dunkirk)	5	11	18	10.2	5	0.53	9.42	1.18	Seepage	21.1%	2.29
GRASS LAKE (dunn)	5	10	30	48	9	1.74	8.03	1.79	Seepage	8.7%	1.75
HARRIETT LAKE	5	9	9	32	12	1.03	10.96	1.3	Seepage	1.0%	2.78
HOOK LAKE	6	10	29	9.2	3	0.79	7.78	1.86	Seepage	6.7%	1.70
INDIAN LAKE	8	7	2	66	6	1.30	5.77	1.14	Seepage	25.6%	1.88
ISLAND LAKE	5	10	3	9.8	5	0.53	9.58	1.21	Seepage	5.8%	1.88
KALSCHEUR POND	8	8	8	11	—	0.50	—	1.08	Seepage	34.3%	2.10
KEGONSA LAKE	6	11	16	3209	31	9.50	10.12	1.2	Drainage	16.2%	2.11
KOSHKONONG LAKE	5	12	36	10460	7	46.11	2.86	3.22	Drainage	8.7%	1.53
KRUTCHEN POND	8	8	9	1.8	5	0.28	37.22	1.49	Seepage	28.7%	2.68
L. BUECHNER POND	8	8	8	9.3	8	0.61	12.91	1.42	Seepage	20.9%	1.92
MAHER POND	5	9	9	6.2	4	0.38	10.73	1.09	Seepage	22.7%	2.55
MARION LAKE	8	6	16	16.7	10	0.85	11.86	1.48	Drainage	43.1%	1.27
MARSHALL MILLPOND	5	12	9	185	5	4.90	4.19	2.57	Drainage	3.7%	2.43
MEIER POND	8	8	18	8.4	6	0.87	11.36	2.14	Seepage	4.3%	1.87
MENDOTA LAKE	7	9	10	9842	82	22.9	21.66	1.66	Drainage	25.9%	1.95
MENZEL POND	7	12	35	0.5	—	0.14	—	1.41	Seepage	2.4%	1.96
MONONA LAKE	7	10	18	3274	64	14.4	19.49	1.78	Drainage	13.5%	2.48
MORSE POND	6	8	3	11.6	4	0.69	7.99	1.45	Seepage	24.2%	2.13
MORTENSON POND	5	9	26	11	3	0.65	7.20	1.38	Seepage	6.7%	2.01
MUD LAKE (MARX POI	9	7	4	54	8	1.22	7.22	1.18	Seepage	27.1%	2.82
MUD LAKE T7N R12E S	7	12	2	34	8	0.98	8.16	1.2	Seepage	12.1%	1.56
MUD LAKE, LOWER (M	6	10	10	195	15	2.40	8.52	1.23	Drainage	1.2%	1.24
MUD LAKE, UPPER	7	10	28	223	8	2.80	5.32	1.34	Drainage	0.0%	1.05
O'CONNELL POND	8	9	32	5.3	6	0.42	14.50	1.3	Seepage	8.4%	2.09
ORTMAN POND	5	9	26	4.6	4	0.38	12.83	1.26	Seepage	0.3%	2.24
PATRICK MARSH	9	11	34	160	9	2.30	6.12	1.3	Seepage	4.0%	2.25
POND 22-14	6	8	22	4.6	—	0.32	—	1.07	Seepage	34.6%	3.35
POND 7-10-10	7	10	10	10	6	0.75	10.50	1.69	Seepage	0.0%	3.06
POND 7-11-34	7	11	34	3	6	0.48	22.01	1.98	Seepage	2.2%	2.13
POND 7-9-25	7	9	25	2.1	12	0.23	27.41	1.13	Seepage	0.4%	1.63
POND 9-7-20	9	7	20	5	8	0.77	17.88	2.46	Seepage	8.8%	2.05
POND 9-9-13	9	9	13	11.28	10	1.28	20.74	2.72	Seepage	0.6%	1.15
RICE LAKE	5	12	14	170	8	2.67	5.60	1.92	Seepage	43.8%	2.15
SALMO POND	8	7	32	3.7	20	0.38	43.12	1.41	Spring	8.5%	2.00
SECTION 26 POND	6	9	26	4.4	8	0.42	19.43	1.43	Seepage	68.1%	2.22
SECTION 35 POND	6	9	35	12.4	4	0.64	7.77	1.3	Seepage	40.6%	2.04
SEMINOLE POND	6	9	5	28.6	4	0.91	5.84	1.22	Seepage	1.0%	1.33
SPRINGFIELD POND	8	8	5	3	12	0.44	34.58	1.84	Seepage	6.7%	2.60
STEWART LAKE	6	6	2	6.8	13	0.50	21.02	1.37	Spring	87.1%	1.14
STOUGHTON MILLPOI	5	11	5	82	5	2.44	4.96	1.92	Drainage	3.6%	1.84
STRICKER POND	7	8	23	25	4.5	0.90	6.44	1.29	Seepage	5.0%	2.51
SWEET LAKE	5	12	23	14.8	5	0.80	8.12	1.48	Seepage	37.6%	2.07
TENNEY PARK LAGOC	7	9	12	25	—	0.89	—	1.27	Drainage	0.5%	1.28
TIEDEMAN POND	7	8	13	15	6	0.94	8.93	1.73	Seepage	11.4%	2.28
TURTLE LAKE	5	12	24	15	4	0.70	7.23	1.29	Seepage	30.3%	1.69
VERONA GRAVEL PIT	6	8	22	8	20	0.60	27.13	1.52	Seepage	27.2%	3.57
VIRGIN LAKE/HULL PC	5	11	6	10	—	0.50	—	1.13	Seepage	13.6%	1.61
WARNER PARK LAGO	8	9	36	31	—	1.22	—	1.56	Seepage	3.2%	1.63
WAUBESA LAKE	6	10	32	2080	34	9.90	11.60	1.54	Drainage	13.7%	1.64
WESTSIDE POND	7	9	31	14.9	6	1.70	8.95	3.14	Seepage	3.4%	1.34
WINDSOR LAKE	9	10	31	9	6	0.70	11.00	1.67	Drainage	1.2%	3.05
WINGRA LAKE	7	9	27	345	21	4.20	10.05	1.61	Drainage	4.3%	1.25

APPENDIX B. Numerical Scores and Ranking

NAME	Town	Range	Section	Area	Max. Depth	Strat. Factor	SDF	Lake Type	Soil Erodability	Septic Suitability	*Total Score	Rank
(A) High Sensitivity												
Shallow Seepage Lakes												
SECTION 26 POND	6	9	26	1	1	2	3	1	2	2	10	22
KRUTCHEN POND	8	8	9	1	1	1	3	1	3	3	11	21
POND 9-7-20	9	7	20	1	1	2	2	1	4	2	11	21
POND 9-9-13	9	9	13	2	1	2	2	1	4	1	11	21
BRUENIG POND	8	7	3	1	1	2	3	1	4	2	12	20
EDGERTON POND	5	12	34	1	1	3	3	1	3	2	12	20
O'CONNELL POND	8	9	32	1	1	2	3	1	4	2	12	20
POND 7-11-34	7	11	34	1	1	2	3	1	4	2	12	20
SPRINGFIELD POND	8	8	5	1	1	1	3	1	4	3	12	20
WESTSIDE POND	7	9	31	2	1	4	1	1	4	1	12	20
L. BUECHNER POND	8	8	8	1	1	3	3	1	4	2	13	19
MEIER POND	8	8	18	1	1	4	2	1	4	2	13	19
ORTMAN POND	5	9	26	1	1	3	3	1	4	2	13	19
POND 7-9-25	7	9	25	1	1	2	4	1	4	2	13	19
AMES POND	5	10	31	1	1	4	3	1	4	2	14	18
BARBIAN POND	8	8	2	1	1	4	3	1	4	2	14	18
BOWER POND	5	11	36	2	1	2	3	1	4	3	14	18
C. BUECHNER POND	8	8	19	2	1	4	3	1	3	2	14	18
CHRISTENSON POND	5	9	28	1	**1	**4	2	1	4	3	14	18
DORN POND	8	8	25	1	1	4	3	1	4	2	14	18
GOOSE POND	6	8	13	2	1	2	3	1	4	3	14	18
HOOK LAKE	6	10	29	1	1	4	3	1	4	2	14	18
ISLAND LAKE	5	10	3	1	1	4	3	1	4	2	14	18
SECTION 35 POND	6	9	35	2	1	4	3	1	3	2	14	18
SWEET LAKE	5	12	23	2	1	4	3	1	3	2	14	18
BARNEY LAKE	6	9	34	2	1	4	3	1	4	2	15	17
BASS LAKE	5	10	4	2	1	4	3	1	4	2	15	17
DAHMEN POND	8	8	16	2	1	4	3	1	4	2	15	17
DIEDRICH POND	8	8	4	2	1	4	3	1	4	2	15	17
ESSER POND	7	8	10	2	1	4	4	1	4	1	15	17
FOX POND	5	9	3	2	**1	**4	4	1	4	1	15	17
GRABER/DREHER POND	7	8	2	2	1	4	3	1	4	2	15	17
GRASS LAKE (dunkirk)	5	11	18	2	1	4	3	1	4	2	15	17
GRASS LAKE (dunn)	5	10	30	2	1	4	3	1	4	2	15	17
INDIAN LAKE	8	7	2	2	1	4	4	1	3	2	15	17
KALSCHEUR POND	8	8	8	2	**1	**4	4	1	3	2	15	17
MENZEL POND	7	12	35	1	**1	**4	4	1	4	2	15	17
MORSE POND	6	8	3	2	1	4	3	1	4	2	15	17
MORTENSON POND	5	9	26	2	1	4	3	1	4	2	15	17
MUD LAKE (MARX POND)	9	7	4	2	1	4	3	1	3	3	15	17
MUD LAKE T7N R12E S02	7	12	2	2	1	4	3	1	4	2	15	17
POND 22-14	6	8	22	1	**1	**4	4	1	3	3	15	17
POND 7-10-10	7	10	10	1	1	4	3	1	4	3	15	17
RICE LAKE	5	12	14	3	1	4	3	1	3	2	15	17
SEMINOLE POND	6	9	5	2	1	4	4	1	4	1	15	17
TIEDEMAN POND	7	8	13	2	1	4	3	1	4	2	15	17
TURTLE LAKE	5	12	24	2	1	4	4	1	3	2	15	17
VIRGIN LAKE/HULL POND	5	11	6	1	**1	**4	4	1	4	2	15	17
WARNER PARK LAGOON	8	9	36	2	**1	**4	3	1	4	2	15	17
ANDERSON POND	6	9	33	2	**1	**4	4	1	4	2	16	16
BRANDENBURG LAKE	8	8	6	2	1	4	4	1	4	2	16	16
CRYSTAL LAKE	9	7	1	4	1	4	3	1	3	2	16	16
HARRIETT LAKE	5	9	9	2	1	4	3	1	4	3	16	16
MAHER POND	5	9	9	1	1	4	4	1	4	3	16	16
PATRICK MARSH	9	11	34	3	1	4	4	1	4	2	17	15
STRICKER POND	7	8	23	2	1	4	4	1	4	3	17	15
Shallow Spring Lakes												
STEWART LAKE	6	6	2	1	1	2	3	2	1	1	8	14
GALLAGHER POND	7	7	11	1	**1	**4	4	2	3	3	15	13
(B) Medium Sensitivity												
Deep Seepage Lakes												
VERONA GRAVEL PIT	6	8	22	1	2	2	3	1	3	4	13	12
FISH LAKE	9	7	3	3	2	2	3	1	4	3	15	11
Deep Spring lakes												
SALMO POND	8	7	32	1	2	1	3	2	4	2	11	10
Shallow Drainage Lakes												
FISHERS LAKE	9	6	32	1	1	2	3	3	4	1	11	9
MARION LAKE	8	6	16	2	1	3	3	3	3	1	12	8
DUNKIRK MILLPOND	5	11	20	2	1	4	1	3	4	2	13	7
GOOSE LAKE	7	12	2	2	1	4	2	3	4	1	13	7
BELLE VIEW LAKE	5	8	34	2	1	4	2	3	4	2	14	6
KOSHKONONG LAKE	5	12	36	4	1	4	1	3	4	2	15	5
MARSHALL MILLPOND	5	12	9	3	1	4	2	3	4	2	15	5
MUD LAKE, LOWER (MUD)	6	10	10	3	1	4	3	3	4	1	15	5
MUD LAKE, UPPER	7	10	28	3	1	4	3	3	4	1	15	5
STOUGHTON MILLPOND	5	11	5	2	1	4	3	3	4	2	15	5
TENNEY PARK LAGOON	7	9	12	2	**1	**4	4	3	4	1	15	5
WINDSOR LAKE	9	10	31	1	1	4	3	3	4	3	15	5
(C) Low Sensitivity												
Deep Drainage Lakes												
MENDOTA LAKE	7	9	10	4	2	2	3	3	3	2	14	4
MONONA LAKE	7	10	18	4	2	2	3	3	4	2	15	3
WAUBESA LAKE	6	10	32	4	2	3	3	3	4	2	16	2
KEGONSA LAKE	6	11	16	4	2	4	3	3	4	2	17	1
WINGRA LAKE	7	9	27	3	2	4	3	3	4	3	17	1

* Total Score does not include Maximum Depth and Lake type since these are already accounted for in the groupings (A, B, and C).

** Estimated score because of missing data, also shown in Appendix A

APPENDIX C. Average Percent Imperviousness and Composite Curve Numbers By Hydrologic Group and Land Use

Land-Use	Description	Average % Impervious	Assumed Previous Type	Hydrologic Soil Group			
				A (low runoff potential)	B (low- moderate runoff potential)	C (high-moderate runoff potential)	D (high runoff potential)
RES-SF 1/8)	Single-family residential, 1/8 acre or less	65	lawn, good	77	85	90	92
RES-SF (1/4)	Single-family residential, 1/4 acre	38	lawn, good	61	75	83	87
RES-SF (1/3)	Single-family residential, 1/3 acre	30	lawn, good	57	72	81	85
RES-SF (1/2	Single-family residential, 1/2 acre	25	lawn, good	54	70	80	85
RES-SF (1)	Single-family residential, 1 acre	20	lawn, good	51	68	79	84
RES-SF (+)	Single-family residential, more than 1 acre	12	lawn, good	46	65	77	82
RES-MOHM	Mobile home park	65	lawn, good	77	85	90	92
RES-MFMOD	Multi-family residential, moderate density	85	lawn, good	89	92	94	95
RES-MFHI	Multi-family residential, high density	85	lawn, good	89	92	94	95
RES-OTHER	Other residential	85	lawn, good	89	92	94	95
COM-OFF	Commercial, office	85	lawn, good	89	92	94	95
COM-GEN	Commercial, retail or service	85	lawn, good	89	92	94	95
MIX-ALL	Commercial/office/residential mix	85	lawn, good	89	92	94	95
MIX-COMRES	Commercial/residential mix	85	lawn, good	89	92	94	95
MIX-COM	Commercial/office mix	85	lawn, good	89	92	94	95
MIXSHPCTR	Shopping center	85	lawn, good	89	92	94	95
IND-LT	Light industrial	72	lawn, good	81	88	91	93
IND-HVY	Heavy industrial	72	lawn, good	81	88	91	93
INS-WARE	Warehouse/storage	72	lawn, good	81	88	91	93
PUB-ASSEM.	Public assembly	50 (a)	lawn, good	69	80	86	89
INST	Institutional	50 (a)	lawn, good	69	80	86	89
SCHOOL	School	50 (a)	lawn, good	69	80	86	89
PARK	Park	25	lawn, good	54	70	80	85
OPENSPACE	Open space	0	brush, good (b)	30	48	65	73
AG-GEN	Agricultural, general	0	farmsteads	59	74	82	86
AG-DAIRY	Agricultural, livestock	0	pasture, good	39	61	74	80
AG-CROP	Agricultural, crops	0	row crops, good	64	75	82	85
ROW	Rights-of-way	75 (c)	lawn, good (b)	83	89	92	94
PARKING	Parking	95 (c)	lawn, good (b)	95	96	97	97
VACANT	Vacant	0	gravel (c)	30	48	65	73
OTHER	Other/miscellaneous	50 (d)	gravel (d)	87	92	94	95

(a) 0 – 100 depending on size of structures
(b) Depending on previous surface type
(c) Depends on ground treatment type
(d) Arbitrary

Source: 210-VI-TR-55, Second Ed., USDA, NSCS, 1986
in *Dane Index* .2002.Criteriaon Planners Engineers, Inc. Portland, OR

February 2002

APPENDIX D. Impervious Cover Results

NAME	2000 Land Use Imperv. Cover	Planned Land Use Imperv. Cover
(A) Low Development Levels		
FISHERS LAKE	0.00%	0.00%
GOOSE LAKE	0.02%	0.02%
MUD LAKE T7N R12E S02	0.11%	0.11%
FOX POND	0.12%	1.82%
BARNEY LAKE	0.48%	0.48%
POND 7-11-34	1.11%	1.11%
DAHMEN POND	1.22%	1.22%
BOWER POND	1.22%	1.22%
ISLAND LAKE	1.62%	1.71%
BARBIAN POND	1.65%	1.65%
L. BUECHNER POND	1.71%	1.71%
MEIER POND	1.72%	1.93%
MAHER POND	1.75%	1.75%
GRASS LAKE (dunn)	1.75%	1.75%
HOOK LAKE	1.83%	1.83%
SWEET LAKE	1.99%	1.99%
C. BUECHNER POND	2.00%	2.00%
KALSCHEUR POND	2.38%	2.38%
GRASS LAKE (dunkirk)	2.45%	2.45%
MUD LAKE, LOWER (MUD)	3.26%	3.26%
ORTMAN POND	3.60%	3.60%
CHRISTENSON POND	4.27%	4.27%
RICE LAKE	4.44%	4.83%
TURTLE LAKE	4.49%	4.89%
MORTENSON POND	4.65%	4.65%
HARRIETT LAKE	5.37%	5.37%
GALLAGHER POND	5.45%	5.45%
MUD LAKE, UPPER	5.64%	5.64%
BASS LAKE	6.17%	6.17%
ANDERSON POND	6.30%	6.30%
POND 9-9-13	6.63%	34.22%
MUD LAKE (MARX POND)	6.99%	7.91%
AMES POND	7.02%	7.86%
DORN POND	7.42%	7.42%
DUNKIRK MILLPOND	7.56%	7.56%
POND 9-7-20	8.24%	8.24%
BRUENIG POND	8.43%	8.43%
EDGERTON POND	8.57%	7.75%
INDIAN LAKE	9.70%	9.70%
FISH LAKE	10.04%	10.49%
MENZEL POND	10.51%	10.51%
WINGRA WETLANDS	10.89%	11.56%
STOUGHTON MILLPOND	11.13%	12.65%
(B) Medium Development Levels		
SEMINOLE POND	11.87%	16.43%
DIEDRICH POND	12.70%	14.28%
CRYSTAL LAKE	13.79%	14.65%
KRUTCHEN POND	15.09%	24.42%
PATRICK MARSH	15.87%	17.48%
WINGRA LAKE	17.17%	17.39%
O'CONNELL POND	17.19%	18.02%
POND 22-14	17.55%	40.88%
BRANDENBURG LAKE	17.56%	18.07%
GRABER/DREHER POND	19.50%	27.23%
MARSHALL MILLPOND	20.29%	24.82%
VIRGIN LAKE/HULL POND	20.45%	26.38%
WAUBESA LAKE	22.18%	26.08%
SECTION 35 POND	22.27%	22.27%
KOSHKONONG LAKE	22.86%	30.03%
ESSER POND	23.25%	40.38%
BELLE VIEW LAKE	25.24%	27.97%
(C) High Development Levels		
SECTION 26 POND	26.73%	26.73%
GOOSE POND	27.06%	30.67%
STEWART LAKE	27.06%	27.06%
KEGONSA LAKE	27.74%	34.36%
POND 7-10-10	27.96%	29.90%
MORSE POND	29.48%	28.85%
MARION LAKE	29.62%	31.71%
SALMO POND	30.43%	30.43%
WARNER PARK LAGOON	30.50%	30.65%
STRICKER POND	31.45%	35.63%
WESTSIDE POND	31.77%	31.80%
SPRINGFIELD POND	31.86%	32.52%
WINDSOR LAKE	33.52%	46.13%
MENDOTA LAKE	33.98%	38.51%
TENNEY PARK LAGOON	35.83%	36.82%
MONONA LAKE	39.01%	43.62%
VERONA GRAVEL PIT	41.14%	42.48%
TIEDEMAN POND	45.25%	47.20%
POND 7-9-25	50.87%	52.62%

APPENDIX E. Lake Classification Table

NAME	Town	Range	Section	Rank	Sensitivity	Development	Class	Management Objective
Shallow Seepage Lakes								
SECTION 26 POND	6	9	26	22	A	C	II	Protection / Restoration
KRUTCHEN POND	8	8	9	21	A	B	I	Protection
POND 9-7-20	9	7	20	21	A	A	I	Protection
POND 9-9-13	9	9	13	21	A	A	I	Protection
BRUENIG POND	8	7	3	20	A	A	I	Protection
EDGERTON POND	5	12	34	20	A	A	I	Protection
O'CONNELL POND	8	9	32	20	A	B	I	Protection
POND 7-11-34	7	11	34	20	A	A	I	Protection
SPRINGFIELD POND	8	8	5	20	A	C	II	Protection / Restoration
WESTSIDE POND	7	9	31	20	A	C	II	Protection / Restoration
L. BUECHNER POND	8	8	8	19	A	A	I	Protection
MEIER POND	8	8	18	19	A	A	I	Protection
ORTMAN POND	5	9	26	19	A	A	I	Protection
POND 7-9-25	7	9	25	19	A	C	II	Protection / Restoration
AMES POND	5	10	31	18	A	A	I	Protection
BARBIAN POND	8	8	2	18	A	A	I	Protection
BOWER POND	5	11	36	18	A	A	I	Protection
C. BUECHNER POND	8	8	19	18	A	A	I	Protection
CHRISTENSON POND	5	9	28	18	A	A	I	Protection
DORN POND	8	8	25	18	A	A	I	Protection
GOOSE POND	6	8	13	18	A	C	II	Protection / Restoration
HOOK LAKE	6	10	29	18	A	A	I	Protection
ISLAND LAKE	5	10	3	18	A	A	I	Protection
SECTION 35 POND	6	9	35	18	A	B	I	Protection
SWEET LAKE	5	12	23	18	A	A	I	Protection
BARNEY LAKE	6	9	34	17	A	A	I	Protection
BASS LAKE	5	10	4	17	A	A	I	Protection
DAHMEN POND	8	8	16	17	A	A	I	Protection
DIEDRICH POND	8	8	4	17	A	B	I	Protection
ESSER POND	7	8	10	17	A	B	I	Protection
FOX POND	5	9	3	17	A	A	I	Protection
GRABER/DREHER POND	7	8	2	17	A	B	I	Protection
GRASS LAKE (dunkirk)	5	11	18	17	A	A	I	Protection
GRASS LAKE (dunn)	5	10	30	17	A	A	I	Protection
INDIAN LAKE	8	7	2	17	A	A	I	Protection
KALSCHEUR POND	8	8	8	17	A	A	I	Protection
MENZEL POND	7	12	35	17	A	A	I	Protection
MORSE POND	6	8	3	17	A	C	II	Protection / Restoration
MORTENSON POND	5	9	26	17	A	A	I	Protection
MUD LAKE (MARX POND)	9	7	4	17	A	A	I	Protection
MUD LAKE T7N R12E S02	7	12	2	17	A	A	I	Protection
POND 22-14	6	8	22	17	A	B	I	Protection
POND 7-10-10	7	10	10	17	A	C	II	Protection / Restoration
RICE LAKE	5	12	14	17	A	A	I	Protection
SEMINOLE POND	6	9	5	17	A	A	I	Protection
TIEDEMAN POND	7	8	13	17	A	C	II	Protection / Restoration
TURTLE LAKE	5	12	24	17	A	A	I	Protection
VIRGIN LAKE/HULL POND	5	11	6	17	A	B	I	Protection
WARNER PARK LAGOON	8	9	36	17	A	C	II	Protection / Restoration
ANDERSON POND	6	9	33	16	A	A	I	Protection
BRANDENBURG LAKE	8	8	6	16	A	B	I	Protection
CRYSTAL LAKE	9	7	1	16	A	B	I	Protection
HARRIETT LAKE	5	9	9	16	A	A	I	Protection
MAHER POND	5	9	9	16	A	A	I	Protection
PATRICK MARSH	9	11	34	15	A	B	I	Protection
STRICKER POND	7	8	23	15	A	C	II	Protection / Restoration
Shallow Spring Lakes								
STEWART LAKE	6	6	2	14	A	C	II	Protection / Restoration
GALLAGHER POND	7	7	11	13	A	A	I	Protection
Deep Seepage Lakes								
VERONA GRAVEL PIT	6	8	22	12	B	C	III	Restoration / Enhancement
FISH LAKE	9	7	3	11	B	A	I	Protection
Deep Spring lakes								
SALMO POND	8	7	32	10	B	C	III	Restoration / Enhancement
Shallow Drainage Lakes								
FISHERS LAKE	9	6	32	9	B	A	I	Protection
MARION LAKE	8	6	16	8	B	C	III	Restoration / Enhancement
DUNKIRK MILLPOND	5	11	20	7	B	A	I	Protection
GOOSE LAKE	7	12	2	7	B	A	I	Protection
BELLE VIEW LAKE	5	8	34	6	B	B	II	Protection / Restoration
KOSHKONONG LAKE	5	12	36	5	B	B	II	Protection / Restoration
MARSHALL MILLPOND	5	12	9	5	B	B	II	Protection / Restoration
MUD LAKE, LOWER (MUD)	6	10	10	5	B	A	I	Protection
MUD LAKE, UPPER	7	10	28	5	B	A	I	Protection
STOUGHTON MILLPOND	5	11	5	5	B	A	I	Protection
TENNEY PARK LAGOON	7	9	12	5	B	C	III	Restoration / Enhancement
WINDSOR LAKE	9	10	31	5	B	C	III	Restoration / Enhancement
Deep Drainage Lakes								
MENDOTA LAKE	7	9	10	4	C	C	III	Restoration / Enhancement
MONONA LAKE	7	10	18	3	C	C	III	Restoration / Enhancement
WAUBESA LAKE	6	10	32	2	C	B	III	Restoration / Enhancement
KEGONSA LAKE	6	11	16	1	C	C	III	Restoration / Enhancement
WINGRA LAKE	7	9	27	1	C	B	III	Restoration / Enhancement

APPENDIX E. Lake Classification Table -- alphabetical

NAME	Town	Range	Section	Sensitivity	Development	Class	Management Objective
AMES POND	5	10	31	A	A	I	Protection
ANDERSON POND	6	9	33	A	A	I	Protection
BARBIAN POND	8	8	2	A	A	I	Protection
BARNEY LAKE	6	9	34	A	A	I	Protection
BASS LAKE	5	10	4	A	A	I	Protection
BELLE VIEW LAKE	5	8	34	B	B	II	Protection / Restoration
BOWER POND	5	11	36	A	A	I	Protection
BRANDENBURG LAKE	8	8	6	A	B	I	Protection
BRUENIG POND	8	7	3	A	A	I	Protection
C. BUECHNER POND	8	8	19	A	A	I	Protection
CHRISTENSON POND	5	9	28	A	A	I	Protection
CRYSTAL LAKE	9	7	1	A	B	I	Protection
DAHMEN POND	8	8	16	A	A	I	Protection
DIEDRICH POND	8	8	4	A	B	I	Protection
DORN POND	8	8	25	A	A	I	Protection
DUNKIRK MILLPOND	5	11	20	B	A	I	Protection
EDGERTON POND	5	12	34	A	A	I	Protection
ESSER POND	7	8	10	A	B	I	Protection
FISH LAKE	9	7	3	B	A	I	Protection
FISHERS LAKE	9	6	32	B	A	I	Protection
FOX POND	5	9	3	A	A	I	Protection
GALLAGHER POND	7	7	11	A	A	I	Protection
GOOSE LAKE	7	12	2	B	A	I	Protection
GOOSE POND	6	8	13	A	C	II	Protection / Restoration
GRABER/DREHER PO	7	8	2	A	B	I	Protection
GRASS LAKE (dunkirk)	5	11	18	A	A	I	Protection
GRASS LAKE (dunn)	5	10	30	A	A	I	Protection
HARRIETT LAKE	5	9	9	A	A	I	Protection
HOOK LAKE	6	10	29	A	A	I	Protection
INDIAN LAKE	8	7	2	A	A	I	Protection
ISLAND LAKE	5	10	3	A	A	I	Protection
KALSCHEUR POND	8	8	8	A	A	I	Protection
KEGONSA LAKE	6	11	16	C	C	III	Restoration / Enhancement
KOSHKONONG LAKE	5	12	36	B	B	II	Protection / Restoration
KRUTCHEN POND	8	8	9	A	B	I	Protection
L. BUECHNER POND	8	8	8	A	A	I	Protection
MAHER POND	5	9	9	A	A	I	Protection
MARION LAKE	8	6	16	B	C	III	Restoration / Enhancement
MARSHALL MILLPONI	5	12	9	B	B	II	Protection / Restoration
MEIER POND	8	8	18	A	A	I	Protection
MENDOTA LAKE	7	9	10	C	C	III	Restoration / Enhancement
MENZEL POND	7	12	35	A	A	I	Protection
MONONA LAKE	7	10	18	C	C	III	Restoration / Enhancement
MORSE POND	6	8	3	A	C	II	Protection / Restoration
MORTENSON POND	5	9	26	A	A	I	Protection
MUD LAKE (MARX POI	9	7	4	A	A	I	Protection
MUD LAKE T7N R12E :	7	12	2	A	A	I	Protection
MUD LAKE, LOWER (N	6	10	10	B	A	I	Protection
MUD LAKE, UPPER	7	10	28	B	A	I	Protection
O'CONNELL POND	8	9	32	A	B	I	Protection
ORTMAN POND	5	9	26	A	A	I	Protection
PATRICK MARSH	9	11	34	A	B	I	Protection
POND 22-14	6	8	22	A	B	I	Protection
POND 7-10-10	7	10	10	A	C	II	Protection / Restoration
POND 7-11-34	7	11	34	A	A	I	Protection
POND 7-9-25	7	9	25	A	C	II	Protection / Restoration
POND 9-7-20	9	7	20	A	A	I	Protection
POND 9-9-13	9	9	13	A	A	I	Protection
RICE LAKE	5	12	14	A	A	I	Protection
SALMO POND	8	7	32	B	C	III	Restoration / Enhancement
SECTION 26 POND	6	9	26	A	C	II	Protection / Restoration
SECTION 35 POND	6	9	35	A	B	I	Protection
SEMINOLE POND	6	9	5	A	A	I	Protection
SPRINGFIELD POND	8	8	5	A	C	II	Protection / Restoration
STEWART LAKE	6	6	2	A	C	II	Protection / Restoration
STOUGHTON MILLPOI	5	11	5	B	A	I	Protection
STRICKER POND	7	8	23	A	C	II	Protection / Restoration
SWEET LAKE	5	12	23	A	A	I	Protection
TENNEY PARK LAGO(	7	9	12	B	C	III	Restoration / Enhancement
TIEDEMAN POND	7	8	13	A	C	II	Protection / Restoration
TURTLE LAKE	5	12	24	A	A	I	Protection
VERONA GRAVEL PIT	6	8	22	B	C	III	Restoration / Enhancement
VIRGIN LAKE/HULL PC	5	11	6	A	B	I	Protection
WARNER PARK LAGO	8	9	36	A	C	II	Protection / Restoration
WAUBESA LAKE	6	10	32	C	B	III	Restoration / Enhancement
WESTSIDE POND	7	9	31	A	C	II	Protection / Restoration
WINDSOR LAKE	9	10	31	B	C	III	Restoration / Enhancement
WINGRA LAKE	7	9	27	C	B	III	Restoration / Enhancement

APPENDIX F: Stream Classification Table

7.18.05

NAME	2000 Land Use Imperv. Cover	Planned Land Use Imperv.Cover	Class	Management Objective
PLEASANT VALLEY CREEK	2.81%	2.81%	I	Protection
JEGLUM VALLEY CREEK	2.94%	2.94%	I	Protection
GARFOOT CREEK	2.99%	2.99%	I	Protection
YORK VALLEY CREEK	3.07%	3.07%	I	Protection
MUD CREEK T09N R12E S24	3.08%	3.08%	I	Protection
STRANSKY CREEK	3.29%	3.20%	I	Protection
WENDT CREEK	3.32%	3.32%	I	Protection
KITTLESON VALLEY CREEK	3.38%	3.38%	I	Protection
DUNLAP CREEK	3.43%	3.48%	I	Protection
FLYNN CREEK	3.43%	3.43%	I	Protection
SYFTESTAD CREEK	3.47%	3.47%	I	Protection
VERMONT CREEK	3.57%	3.90%	I	Protection
PLEASANT VALLEY BRANCH	3.62%	3.62%	I	Protection
BLUE MOUNDS CREEK, EAST BR.	3.71%	3.83%	I	Protection
RYAN CREEK	3.75%	3.81%	I	Protection
PRIMROSE BRANCH	3.80%	3.97%	I	Protection
MILUM CREEK	3.81%	3.79%	I	Protection
NOLAN CREEK	3.85%	3.85%	I	Protection
WEST BR. SUGAR RIVER TRIB.	3.86%	3.88%	I	Protection
HALFWAY PRAIRIE CREEK	3.99%	4.07%	I	Protection
RUTLAND BRANCH (ANTHONY)	4.02%	6.18%	I	Protection
LITTLE SUGAR RIVER	4.06%	4.35%	I	Protection
SPRING VALLEY CREEK	4.06%	4.35%	I	Protection
STORY CREEK	4.20%	4.56%	I	Protection
ROXBURY CREEK	4.26%	4.69%	I	Protection
GERMAN VALLEY BRANCH	4.33%	4.48%	I	Protection
SPRING CREEK(LODI)T9N R8E S4	4.33%	4.58%	I	Protection
LITTLE NORWAY CREEK	4.46%	4.46%	I	Protection
ELVERS CREEK	4.51%	4.72%	I	Protection
WISCONSIN RIVER	4.59%	5.03%	I	Protection
WEST BR. SUGAR RIVER	4.79%	5.19%	I	Protection
BADFISH CREEK	4.87%	5.49%	I	Protection
HENRY CREEK	4.93%	5.01%	I	Protection
BLUE MOUNDS BRANCH (GORDON)	5.11%	5.46%	I	Protection
ELLA WHEELER WILCOX CREEK	5.12%	5.62%	I	Protection
BLACK EARTH CREEK (LOWER)	5.19%	5.83%	I	Protection
MARSH CREEK	5.42%	5.42%	I	Protection
MAUNESHA RIVER	5.57%	6.78%	I	Protection
BLACK EARTH CREEK (MIDDLE)	5.68%	6.47%	I	Protection
PLEASURE VALLEY CREEK	5.72%	5.87%	I	Protection
SAUNDERS CREEK	5.75%	6.96%	I	Protection
SPRING CREEK T08N R12E S15	5.85%	6.45%	I	Protection
SPRING CREEK (DORN)	5.88%	8.40%	I	Protection
MT VERNON CREEK	5.93%	6.76%	I	Protection
DEER CREEK	5.94%	6.89%	I	Protection
FROG POND CREEK	6.14%	6.14%	I	Protection
SUGAR RIVER (UPPER)	6.15%	7.32%	II	Protection/Restoration
BREWERY CREEK	6.24%	7.42%	II	Protection/Restoration
BOHN CREEK	6.51%	6.51%	II	Protection/Restoration
MUD CREEK T07N R12E S23	6.57%	7.71%	I	Protection
LITTLE DOOR CREEK	6.64%	10.19%	I	Protection
LEUTENS CREEK	6.69%	7.75%	I	Protection
BLACK EARTH CREEK (UPPER)	7.06%	8.53%	II	Protection/Restoration
FRYES FEEDER	7.17%	8.37%	II	Protection/Restoration
ELVERS CREEK (UPPER)	7.61%	8.84%	II	Protection/Restoration
SCHUMACHER CREEK	7.75%	8.50%	I	Protection
KOSHKONONG CREEK (LOWER)	7.76%	11.84%	I	Protection
KEENANS CREEK	8.04%	12.50%	II	Protection/Restoration
SIX MILE CREEK	8.04%	11.26%	II	Protection/Restoration
MURPHYS CREEK	8.07%	8.71%	II	Protection/Restoration
MOEN CREEK	8.08%	9.39%	II	Protection/Restoration
KOSHKONONG CREEK (MIDDLE)	8.28%	13.17%	II	Protection/Restoration
SIX MILE CREEK TRIBUTARY	8.97%	38.14%	II	Protection/Restoration
SWAN CREEK	9.27%	13.35%	II	Protection/Restoration
TOKEN CREEK TRIBUTARY 1	9.99%	20.06%	II	Protection/Restoration
SUGAR RIVER coldwater segment	10.06%	14.17%	II	Protection/Restoration
SUGAR RIVER warmwater segment	10.06%	14.17%	II	Protection/Restoration
DOOR CREEK	10.26%	23.48%	II	Protection/Restoration
TOKEN CREEK	10.59%	18.61%	II	Protection/Restoration
SCHALPBACH CREEK	10.62%	14.40%	II	Protection/Restoration
WEST BR. SUGAR RIVER (UPPER)	10.66%	11.17%	II	Protection/Restoration
PHEASANT BRANCH CREEK TRIB.	10.80%	16.93%	II	Protection/Restoration
OREGON BRANCH	10.84%	23.19%	II	Protection/Restoration
YAHARA RIVER (UPPER)	12.01%	16.64%	II	Protection/Restoration
KOSHKONONG CREEK (UPPER)	13.72%	23.07%	II	Protection/Restoration
YAHARA RIVER (LOWER)	14.79%	19.52%	II	Protection/Restoration
YAHARA RIVER (MIDDLE)	16.97%	21.90%	II	Protection/Restoration
PHEASANT BRANCH CREEK	18.05%	26.23%	II	Protection/Restoration
BADGER MILL CREEK	19.58%	30.96%	II	Protection/Restoration
NINE SPRING CREEK	28.83%	35.27%	III	Restoration/Enhancement
MURPHY CREEK (Wingra Cr)	34.81%	35.57%	III	Restoration/Enhancement
STARKWEATHER CREEK, EAST BR.	37.50%	48.09%	III	Restoration/Enhancement
STARKWEATHER CREEK, WEST BR.	37.70%	49.64%	III	Restoration/Enhancement

APPENDIX F: Stream Classification Table -- alphabetical

7.18.05

NAME	2000 Land Use Imperv. Cover	Planned Land Use Imperv.Cover	Class	Management Objective
BADFISH CREEK	4.87%	5.49%	I	Protection
BADGER MILL CREEK	19.58%	30.96%	II	Protection/Restoration
BLACK EARTH CREEK (UPPER)	7.06%	8.53%	II	Protection/Restoration
BLACK EARTH CREEK (MIDDLE)	5.68%	6.47%	I	Protection
BLACK EARTH CREEK (LOWER)	5.19%	5.83%	I	Protection
BLUE MOUNDS BRANCH (GORDON)	5.11%	5.46%	I	Protection
BLUE MOUNDS CREEK, EAST BR.	3.71%	3.83%	I	Protection
BOHN CREEK	6.51%	6.51%	II	Protection/Restoration
BREWERY CREEK	6.24%	7.42%	II	Protection/Restoration
DEER CREEK	5.94%	6.89%	I	Protection
DOOR CREEK	10.26%	23.48%	II	Protection/Restoration
DUNLAP CREEK	3.43%	3.48%	I	Protection
ELLA WHEELER WILCOX CREEK	5.12%	5.62%	I	Protection
ELVERS CREEK	4.51%	4.72%	I	Protection
ELVERS CREEK (UPPER)	7.61%	8.84%	II	Protection/Restoration
FLYNN CREEK	3.43%	3.43%	I	Protection
FROG POND CREEK	6.14%	6.14%	I	Protection
FRYES FEEDER	7.17%	8.37%	II	Protection/Restoration
GARFOOT CREEK	2.99%	2.99%	I	Protection
GERMAN VALLEY BRANCH	4.33%	4.48%	I	Protection
HALFWAY PRAIRIE CREEK	3.99%	4.07%	I	Protection
HENRY CREEK	4.93%	5.01%	I	Protection
JEGLUM VALLEY CREEK	2.94%	2.94%	I	Protection
KEENANS CREEK	8.04%	12.50%	II	Protection/Restoration
KITTLESON VALLEY CREEK	3.38%	3.38%	I	Protection
KOSHKONONG CREEK (UPPER)	13.72%	23.07%	II	Protection/Restoration
KOSHKONONG CREEK (MIDDLE)	8.28%	13.17%	II	Protection/Restoration
KOSHKONONG CREEK (LOWER)	7.76%	11.84%	I	Protection
LEUTENS CREEK	6.69%	7.75%	I	Protection
LITTLE DOOR CREEK	6.64%	10.19%	I	Protection
LITTLE NORWAY CREEK	4.46%	4.46%	I	Protection
LITTLE SUGAR RIVER	4.06%	4.35%	I	Protection
MARSH CREEK	5.42%	5.42%	I	Protection
MAUNESHA RIVER	5.57%	6.78%	I	Protection
MILUM CREEK	3.81%	3.79%	I	Protection
MOEN CREEK	8.08%	9.39%	II	Protection/Restoration
MT VERNON CREEK	5.93%	6.76%	I	Protection
MUD CREEK T07N R12E S23	6.57%	7.71%	I	Protection
MUD CREEK T09N R12E S24	3.08%	3.08%	I	Protection
MURPHY CREEK (Wingra Cr)	34.81%	35.57%	III	Restoration/Enhancement
MURPHYS CREEK	8.07%	8.71%	II	Protection/Restoration
NINE SPRING CREEK	28.83%	35.27%	III	Restoration/Enhancement
NOLAN CREEK	3.85%	3.85%	I	Protection
OREGON BRANCH	10.84%	23.19%	II	Protection/Restoration
PHEASANT BRANCH CREEK	18.05%	26.23%	II	Protection/Restoration
PHEASANT BRANCH CREEK TRIB.	10.80%	16.93%	II	Protection/Restoration
PLEASANT VALLEY BRANCH	3.62%	3.62%	I	Protection
PLEASANT VALLEY CREEK	2.81%	2.81%	I	Protection
PLEASURE VALLEY CREEK	5.72%	5.87%	I	Protection
PRIMROSE BRANCH	3.80%	3.97%	I	Protection
ROXBURY CREEK	4.26%	4.69%	I	Protection
RUTLAND BRANCH (ANTHONY)	4.02%	6.18%	I	Protection
RYAN CREEK	3.75%	3.81%	I	Protection
SAUNDERS CREEK	5.75%	6.96%	I	Protection
SCHALPBACH CREEK	10.62%	14.40%	II	Protection/Restoration
SCHUMACHER CREEK	7.75%	8.50%	I	Protection
SIX MILE CREEK	8.04%	11.26%	II	Protection/Restoration
SIX MILE CREEK TRIBUTARY	8.97%	38.14%	II	Protection/Restoration
SPRING CREEK (DORN)	5.88%	8.40%	I	Protection
SPRING CREEK T08N R12E S15	5.85%	6.45%	I	Protection
SPRING CREEK(LODI)T9N R8E S4	4.33%	4.58%	I	Protection
SPRING VALLEY CREEK	4.06%	4.35%	I	Protection
STARKWEATHER CREEK, EAST BR.	37.50%	48.09%	III	Restoration/Enhancement
STARKWEATHER CREEK, WEST BR.	37.70%	49.64%	III	Restoration/Enhancement
STORY CREEK	4.20%	4.56%	I	Protection
STRANSKY CREEK	3.29%	3.20%	I	Protection
SUGAR RIVER (UPPER)	6.15%	7.32%	II	Protection/Restoration
SUGAR RIVER coldwater segment	10.06%	14.17%	II	Protection/Restoration
SUGAR RIVER warmwater segment	10.06%	14.17%	II	Protection/Restoration
SWAN CREEK	9.27%	13.35%	II	Protection/Restoration
SYFTESTAD CREEK	3.47%	3.47%	I	Protection
TOKEN CREEK	10.59%	18.61%	II	Protection/Restoration
TOKEN CREEK TRIBUTARY 1	9.99%	20.06%	II	Protection/Restoration
VERMONT CREEK	3.57%	3.90%	I	Protection
WENDT CREEK	3.32%	3.32%	I	Protection
WEST BR. SUGAR RIVER (UPPER)	10.66%	11.17%	II	Protection/Restoration
WEST BR. SUGAR RIVER	4.79%	5.19%	I	Protection
WEST BR. SUGAR RIVER TRIB.	3.86%	3.88%	I	Protection
WISCONSIN RIVER	4.59%	5.03%	I	Protection
YAHARA RIVER (UPPER)	12.01%	16.64%	II	Protection/Restoration
YAHARA RIVER (MIDDLE)	16.97%	21.90%	II	Protection/Restoration
YAHARA RIVER (LOWER)	14.79%	19.52%	II	Protection/Restoration
YORK VALLEY CREEK	3.07%	3.07%	I	Protection

APPENDIX G: DNR Fish and Aquatic Life Designations

7.18.05

Unique No.	NAME	2000 Land Use Imper. Cover	Planned Land Use Imper. Cover	Existing Use	Potential Use	Codified Use
362	BADFISH CREEK	4.87%	5.49%	wwsf		WWTP, 303(d)
362a				lff		WWTP, lff
362b				lal		WWTP, lal
353	BADGER MILL CREEK	19.58%	30.96%	cold		lff
353a				wwff		
324	BLACK EARTH CREEK (LOWER)	5.19%	5.83%	wwsf	potential cold	
324a	BLACK EARTH CREEK (MIDDLE)	5.68%	6.47%	cold		
324b	BLACK EARTH CREEK (UPPER)	7.06%	8.53%	cold		ERW, ORW
311	BLUE MOUNDS BRANCH (GORD	5.11%	5.46%	cold		
315	BLUE MOUNDS CREEK, EAST B	3.71%	3.83%	cold		
322	BOHN CREEK	6.51%	6.51%	cold		
328	BREWERY CREEK	6.24%	7.42%	wwff	potential cold	
328a				lff	potential cold	
342	DEER CREEK	5.94%	6.89%	cold		ERW
382	DOOR CREEK	10.26%	23.48%	wwff	potential wwsf	lff
332	DUNLAP CREEK	3.43%	3.48%	wwsf		ERW
332a				cold		ERW
	ELLA WHEELER WILCOX CREEI	5.12%	5.62%	wwff		
312	ELVERS CREEK	4.51%	4.72%	cold		ERW
	ELVERS CREEK (UPPER)	7.61%	8.84%	cold		ERW
349	FLYNN CREEK	3.43%	3.43%	cold		ERW
375	FROG POND CREEK	6.14%	6.14%	wwff		
343	FRYES FEEDER	7.17%	8.37%	cold		ERW
326	GARFOOT CREEK	2.99%	2.99%	cold		ERW
308	GERMAN VALLEY BRANCH	4.33%	4.48%	cold		303(d)
330	HALFWAY PRAIRIE CREEK	3.99%	4.07%	wwff		303(d)
352	HENRY CREEK	4.93%	5.01%	wwff	potential cold	303(d)
305	JEGLUM VALLEY CREEK	2.94%	2.94%	cold		
377	KEENANS CREEK	8.04%	12.50%	wwff	potential cold	
300	KITTLESON VALLEY CREEK	3.38%	3.38%	cold		
401	KOSHKONONG CREEK (LOWER	7.76%	11.84%	wwsf		
401a	KOSHKONONG CREEK (MIDDLE	8.28%	13.17%	wwsf		
401b	KOSHKONONG CREEK (UPPER)	13.72%	23.07%	lal		WWTP, lal
380	LEUTENS CREEK	6.69%	7.75%	lff		
383	LITTLE DOOR CREEK	6.64%	10.19%	lff		
323	LITTLE NORWAY CREEK	4.46%	4.46%	cold		
337	LITTLE SUGAR RIVER	4.06%	4.35%	wwff		ERW
331	MARSH CREEK	5.42%	5.42%	wwsf		
331a				wwff		
390	MAUNESHA RIVER	5.57%	6.78%	wwsf		303(d)
350	MILUM CREEK	3.81%	3.79%	wwff	potential cold	ERW
321	MOEN CREEK	8.08%	9.39%	cold		
344	MT VERNON CREEK	5.93%	6.76%	cold		ERW
344a				cold		ORW
404	MUD CREEK T07N R12E S23	6.57%	7.71%	wwff		WWTP, lff
400	MUD CREEK T09N R12E S24	3.08%	3.08%	wwff	potential wwsf	
389	MURPHY CREEK (Wingra Cr)	34.81%	35.57%	wwsf		303(d)
376	MURPHYS CREEK	8.07%	8.71%	wwff		
371	NINE SPRING CREEK	28.83%	35.27%	wwsf		303(d)
399	NOLAN CREEK	3.85%	3.85%	lff		
363	OREGON BRANCH	10.84%	23.19%	lal		WWTP, lal
370	PHEASANT BRANCH CREEK	18.05%	26.23%	wwsf		303(d)
370a				lff		303(d)
	PHEASANT BRANCH CREEK TR	10.80%	16.93%		potential cold	
303	PLEASANT VALLEY BRANCH	3.62%	3.62%	wwff	potential cold	303(d)
316	PLEASANT VALLEY CREEK	2.81%	2.81%	wwff		
314	PLEASURE VALLEY CREEK	5.72%	5.87%	wwff		
346	PRIMROSE BRANCH	3.80%	3.97%	cold		
346a				wwsf	potential cold	
333	ROXBURY CREEK	4.26%	4.69%	wwsf		
333a				lff		
364	RUTLAND BRANCH (ANTHONY)	4.02%	6.18%	cold		ERW
313	RYAN CREEK	3.75%	3.81%	cold		ERW
408	SAUNDERS CREEK	5.75%	6.96%	wwff		303(d)
355	SCHALPBACH CREEK	10.62%	14.40%	cold		ERW
396	SCHUMACHER CREEK	7.75%	8.50%	lff		
366	SIX MILE CREEK	8.04%	11.26%	wwsf		ERW
366a				lff		ERW
	SIX MILE CREEK TRIBUTARY	8.97%	38.14%		potential cold	
367	SPRING CREEK (DORN)	5.88%	8.40%	wwsf		303(d)
367a				lff		303(d)
398	SPRING CREEK T08N R12E S15	5.85%	6.45%	wwff		
335	SPRING CREEK(LODI)T9N R8E S	4.33%	4.58%	cold		ERW
336	SPRING VALLEY CREEK	4.06%	4.35%	wwff		
369	STARKWEATHER CREEK, EAST	37.50%	48.09%	lff	potential wwsf	303(d)
368	STARKWEATHER CREEK, WEST	37.70%	49.64%	lff	potential wwsf	
368a				lff		
356	STORY CREEK	4.20%	4.56%	cold		
356a					potential cold	
395	STRANSKY CREEK	3.29%	3.20%	lff		
351	SUGAR RIVER (UPPER)	6.15%	7.32%	cold		ERW
351	SUGAR RIVER (MIDDLE)	10.06%	14.17%	cold		ERW
351a				wwsf		ERW
372	SWAN CREEK	9.27%	13.35%	wwff		
301	SYFTESTAD CREEK	3.47%	3.47%	wwff	potential cold	303(d)
365	TOKEN CREEK	10.59%	18.61%	wwsf	potential cold	
365a				cold		303(d)
365b					potential cold	
	TOKEN CREEK TRIBUTARY 1	9.99%	20.06%		potential cold	
325	VERMONT CREEK	3.57%	3.90%	cold		
329	WENDT CREEK	3.32%	3.32%	wwff		303(d)
340	WEST BR. SUGAR RIVER	4.79%	5.19%	wwsf		
340a				cold		
340b	WEST BR. SUGAR RIVER (UPPE	9.46%	11.17%		potential cold	lff (3)
	WEST BR. SUGAR RIVER TRIB.	3.86%	3.88%		potential cold	
358	WISCONSIN RIVER	4.59%	5.03%	wwsf		ERW
358a				wwsf		
361	YAHARA RIVER (LOWER)	14.79%	19.52%	wwsf		303(d)
361a	YAHARA RIVER (MIDDLE)	16.97%	21.90%	wwsf		
361b	YAHARA RIVER (UPPER	12.01%	16.64%	wwsf	potential cold	
306	YORK VALLEY CREEK	3.07%	3.07%	cold		