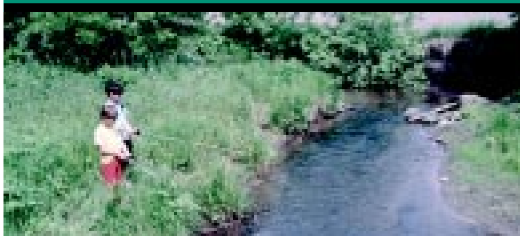
PHOSPHORUS IN RUNOFF POLLUTION IN WISCONSIN



KEY OMISSIONS IN THE DEPARTMENT OF NATURAL RESOURCES' PROPOSED RUNOFF MANAGEMENT RULES

WISPIRG Foundation

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Executive Summary

The runoff management rules recently proposed by the Wisconsin Department of Natural Resources and Department of Agriculture, Trade and Consumer Protection are a major step forward in the battle to curtail runoff pollution, but fall short in their ability to curb the two most important runoff pollutants, phosphorus and sediment. Phosphorus and sediment, both present in dangerous levels in Wisconsin streams, rivers, and lakes, are the main causes of eutrophication, a major water quality problem.

Phosphorus runoff is the main factor in nutrient over-enrichment of waterways resulting in eutrophication.

Eutrophication is the main cause of impaired surface water quality in the United States, and the single greatest factor in the decline of water quality conditions in Wisconsin. While nitrogen and other nutrients are also factors in eutrophication and cause other environmental problems, phosphorus is the key nutrient affecting eutrophication in more than eighty percent of Wisconsin's waterways. Eutrophication refers to the over-enrichment of waterways, the resulting explosive growth of harmful aquatic vegetation, and the negative impacts of those plants on water quality. Eutrophication restricts water use for fisheries, recreation, and industry.

Phosphorus is carried into waterways by sediment.

The most common form of phosphorus present in the environment is attached to soil or other organic particles. Sixty percent to ninety percent of phosphorus in runoff pollution is transported by sediment.

Agricultural practices are the number one source of sediment and phosphorus in Wisconsin due to high erosion rates and high phosphorus levels in agricultural soils.

Croplands supply 76 percent of the total sediment load and 65 percent of the phosphorus load in Wisconsin runoff. Phosphorus in fertilizer and manure on croplands, along with high erosion rates, make agricultural sources the largest contributors of sediment and phosphorus to runoff.

Urban sources, though significantly smaller contributors to the sediment and phosphorus loads overall, contribute almost as much per acre. Urban areas, with large impervious ground areas, deliver more runoff, faster, and with less filtration than other land use types. Construction sites are the number one source of sediment per acre of any land use type. A construction site of one acre can deliver thirty tons of sediment per year to downstream waterways, far above the cropland average of 1-10 tons per acre per year.

Phosphorus and sediment are present at dangerous levels in Wisconsin waterways.

Wisconsin streams and rivers exceeded EPA recommended phosphorus levels in 93 percent of tests over the past decade. Eighty percent of phosphorus tests in Wisconsin lakes exceeded recommended standards.

The state median phosphorus level for streams and rivers was five times the EPA recommended standard from 1990-2001. The median level in lakes was more than double the standard.

Sediment loading in Wisconsin waterways is increasing. A recent USGS study of eastern Wisconsin showed a continuous increase in suspended sediment concentrations from 1971-1990. Thirty percent of locations tested across the state in the past decade exceed healthy levels of suspended sediment.

The new DNR runoff management rules are a solid step in the right direction but do not adequately address phosphorus and sediment.

Policy Recommendations

- **Require vegetative buffers between agricultural land and adjacent waterways.**

  Croplands are the number one source of phosphorus and sediment in Wisconsin's waterways. Vegetative buffers are the best way of controlling these contaminants in runoff from croplands. It is imperative that buffers be wide enough to adequately trap sediment and nutrients and contribute to the health of aquatic ecosystems. Studies show that buffers must be at least 35 feet wide.

- **Make phosphorus a focus of nutrient management plans along with nitrogen.**

  Currently nutrient management planning focuses solely on nitrogen. Because manure and fertilizers have a much higher phosphorus content than nitrogen, and nutrient management regulates applications by nitrogen content, phosphorus is applied in amounts that greatly exceed crop needs. Nutrient management is a key provision of these rules but will be rendered ineffective if it does not clearly define "nutrient" to include phosphorus along with nitrogen. Federal guidelines expected in 2005 will likely make this switch, but there is no reason for Wisconsin to wait through four or more years of heavy pollution before effectively controlling phosphorus.

- **Include all construction sites in the performance standard requirements for construction sites.**

  The current performance standards for construction sites only regulate sites with "one or more land disturbing construction activities that in total will disturb 5 or more acres." New federal regulations will lower this threshold to one acre next year. But this still leaves many construction sites unregulated.

Introduction

Water quality is a major problem in Wisconsin, as it is throughout the United States. Thirty years after the landmark passage of the Clean Water Act, only a third of our streams, rivers, and lakes fully support aquatic life uses.[1]

After thirty years of focusing on curbing point-source water pollution, the state began the task of creating a comprehensive plan to deal with non-point-source runoff pollution three years ago. Three years of debate, drafts, revisions, lobbying, public comment, and politics have led us within arm's length of a solid set of policies to deal with the state's most pressing water quality issue.

Tackling runoff pollution will not be an easy battle. Whereas water policy has traditionally focused on easily identifiable pollution sources, often relying on technological improvements in a small number of major sources, conquering runoff will require much broader changes. Runoff, by nature, is ubiquitous, and occurs in both urban and rural areas. Solving the issue of runoff will mean changing how all Wisconsinites treat our land and our water.

Unique challenges face Wisconsin in the battle to conquer runoff pollution – most notably the large number of livestock operations. Poultry, hog, and dairy farming have proud histories in Wisconsin, but they also have serious impacts on water quality. Livestock operations in Wisconsin are responsible for 9.5 billion gallons of liquid manure on our fields and in our waterways each year, enough to cover 29,000 acres of land one foot deep in manure.[2]

If stored properly, manure presents no problem to our waterways. But most Wisconsin farmers cannot afford long-term storage costs for manure, forcing them to spread their manure on fields in excess of crop needs, sometimes up to a foot thick. Phosphorus from the manure and fertilizers is carried away by rainfall and snowmelt into our waterways. To make a significant impact in the runoff pollution problem, major changes will have to be made by farmers to reduce phosphorus and sediment runoff.

The Wisconsin Department of Natural Resources (DNR) and Department of Agriculture, Trade and Consumer Protection (DATCP) have created a plan to address the wide array of problems associated with non-point-source runoff. The Runoff Management Plan is a major step forward in Wisconsin's battle against runoff pollution. It sets new performance standards for farmers, agricultural facilities, large construction sites, and developed urban areas. It will have a major impact on our most pressing water quality issue.

But some of Wisconsin's worst runoff problems are not addressed adequately in the new program. A requirement for vegetative buffers below croplands, the single most effective policy to reduce concentrations of the most prevalent water contaminants, has been pulled from the plan. Fertilization standards meant to control excessive nutrients focus on nitrogen, while phosphorus is the key factor in nutrient over-enrichment. And many construction sites are exempted from requirements for best management practices.

It is up to the Natural Resources Board to do what's right for water quality in Wisconsin. With the plan in its court after the Legislature sent it back for improvement, the Natural Resources Board has no excuse not to reinstate provisions leading to mandatory buffers and to add requirements for the inclusion of phosphorus in nutrient management plans. At the same time, as the DNR makes rules based on new federal construction site regulations, they have the opportunity to remove the exemption of many constructions sites.

Phosphorus in the Environment

Runoff pollution, both urban and rural, is the leading cause of water quality degradation in Wisconsin. The EPA estimates that runoff has resulted in the impairment of forty percent of Wisconsin's streams and ninety percent of our lakes, and threatens many of our Great Lakes coastal waters, wetland areas, and groundwater resources.[3]

Rainfall and snowmelt travel across all different types of land on their way to Wisconsin's streams, rivers and lakes. Along the way, this runoff picks up a range of pollutants. Soil, fertilizer, pesticides, and nutrients are eroded from our croplands and livestock operations. Oil, rust particles, pieces of brake lining, and construction sediment are picked up in urban runoff. Even the soot and pollution from the smokestacks of our industrial areas makes its way into runoff. All of this pollution eventually ends up in our streams, rivers, and lakes.

The two most significant non-point-source runoff pollutants are phosphorus, a nutrient, and sediment, which carries phosphorus into waterways.

"Nutrient" is a loosely defined term that refers to a compound that is necessary for metabolism, including nitrogen and phosphorus. Nutrients are needed in large quantities by cells in order to grow.[4] Nutrients enter water bodies through atmospheric deposition and runoff, enriching the water and enabling growth of aquatic vegetation. Phosphorus enters our waterways mainly attached to soil and sediment particles eroded from our croplands and construction sites.

Phosphorus and Eutrophication

An Overview of Eutrophication

Eutrophication is the main cause of impaired surface water quality in the U.S., and the single greatest factor in the decline of water quality conditions in Wisconsin.[5]

Eutrophication refers to the over-enrichment of our rivers and lakes by nutrients, the consequential growth of harmful aquatic vegetation, and the resulting negative impacts on aquatic habitat. The process can best be described in three stages:

- Nutrients enter the waterway and spur growth of new algae and aquatic vegetation.
- The new plant life dies and decays, consuming high levels of oxygen.
- Low oxygen levels contribute to the death of local species of aquatic plants and fish.

Increased eutrophication is very harmful to water quality. Eutrophication restricts water use for fisheries, recreation, industry, and drinking.[6] Decreased oxygen levels can lead to fish kills and the destruction of aquatic habitat. Local aquatic communities that evolved over time to survive in unique aquatic conditions often die out in favor of blue-green algae and other aquatic weeds that are able to survive with high nutrient levels and low oxygen levels. In addition, algal blooms associated with eutrophication block much-needed light for submerged aquatic vegetation. These plant communities often die due to the loss of light, changing the habitat of the waterway and making it more difficult for other aquatic organisms to survive.

While eutrophication is a naturally occurring process, human activity greatly speeds up the process by increasing the amount of nutrients released into our streams and rivers. The increase in nutrients elevates biological activity by causing the rapid growth of algae – microscopic floating plants. The green scum that covers Lake Mendota in Madison, one of the most studied lakes in the world, is a perfect example of the effect of human activity on our waterways. One hundred fifty years of local agricultural and urban activities have resulted in extremely high phosphorus levels that contribute to the eutrophication of the lake.[7]

Eutrophication can also lead to the increased production of toxins and cyanobacteria, and bacteria harmful to plants, animals, and humans. Blue-green algae, a naturally occurring species in inland waterways, produce low levels of toxins. Increased production of algae from eutrophication can result in dangerous levels of production of these toxins. Fishermen, boaters, swimmers, farmers, livestock, and others who come into contact with contaminated waters are at risk. These toxins can produce fevers, joint pain, vomiting, and liver disease in humans. They can even result in the death of livestock.[8]

An outbreak of Pfiesteria, a cyanobacteria, in the Chesapeake Bay and other eastern waters in 1997 has been linked to eutrophication. Pfiesteria outbreaks caused large fish kills and illnesses in humans exposed to the algae. Pfiesteria's toxins produce lesions in fish that may be fatal. As of October 1997, 146 people had reported possible *Pfiesteria*-related health problems, including researchers working with the toxins in the laboratory, commercial fishermen, a water-skier, and officials working in the field during a fish kill. Symptoms reported by these individuals include skin irritation; memory loss and other cognitive impairments; nausea and vomiting; and respiratory, kidney, liver, vision, and immune system problems.[9]

Phosphorus: The Leading Cause of Eutrophication

Phosphorus inputs are the biggest factor in the eutrophication of our streams, rivers, and lakes. Phosphorus is the key nutrient affecting algal growth in more than eighty percent of Wisconsin's waterways.[10] Other nutrients, including nitrogen and carbon, are the key nutrients affecting eutrophication only in areas where phosphorus and sediment runoff from agricultural and urban practices is minimal.

Phosphorus is necessary for the growth of plants and animals, and has long been recognized as necessary to maintain profitable crop and animal production.[11] Farmers throughout Wisconsin have applied fertilizers and manure containing large amounts of phosphorus to aide crop growth for many years. Too often, however, this application has been excessive, resulting in levels of phosphorus in agricultural soils higher than the soil or crops can absorb. This excess phosphorus makes its way into our waterways.

The advice and regulations of government and farm advisors have historically placed an emphasis on the control of nitrogen in fertilizers and agricultural production, ignoring phosphorus. But in recent years many researchers, policy makers, and farm advisors have come to realize that phosphorus is also a major contributor to the eutrophication of our waterways.

Although nitrogen and carbon are also essential to the growth of aquatic life, phosphorus is the most important element in controlling eutrophication because of our ability to control its presence in waterways through runoff management. Controls on phosphorus through runoff management can eliminate a large percentage of the phosphorus and the total nutrients available to waterways. Runoff management can only control a much smaller percentage of the total nitrogen and carbon entering our waterways, because the majority of nitrogen and carbon comes from sources other than runoff. Phosphorus is the place where we can make the most impact.[12]

Kerry Schumann

Forms of Phosphorus

Phosphorus can be found in runoff in two different forms, dissolved phosphorus and sediment-bound phosphorus. Dissolved phosphorus refers to phosphorus compounds dissolved in water. Sediment phosphorus, the most common form, refers to phosphorus associated with soil particles and organic material. Surface runoff gathers up both forms of phosphorus from soil and plant material and carries them into Wisconsin waterways.

Dissolved Phosphorus

Dissolved phosphorus occurs naturally from the release of phosphorus from organic material such as grass, leaves, and soil, but is greatly increased by human activities such as the application of fertilizers and manure, and the array of human activities that increase the exposure of soils and organic materials to runoff – agriculture, construction, lawn mowing, etc. When precipitation reacts with a thin soil layer with available dissolved phosphorus, the runoff picks up dissolved phosphorus and carries it into nearby streams, rivers, and lakes.

Dissolved phosphorus is a major factor in aquatic plant growth. Though dissolved phosphorus makes up only between ten and forty percent of the total amount of phosphorus entering our waterways, it is a major problem due to its immediate availability for biological uptake.[13] As soon as it enters a waterway it is in a chemical form that aquatic plants can ingest, spurring excess growth of biological material with a host of harmful effects.

Sediment Phosphorus

Sediment is the main mechanism by which phosphorus ends up in Wisconsin's waterways. Phosphorus attaches itself to soil and other small particles, which are then washed into our waterways and become suspended in the water.

Sediment phosphorus exists in three different forms

- Attached to soil particles.
- In mineral form as a compound in conjunction with aluminum, iron, or calcium.
- Incorporated in organic matter.

By volume, sediment is the number one pollutant in the United States.[14] Rainwater and snowmelt passing over land making their way toward our lakes, rivers, and streams pick up and carry with them large amounts of sediment and organic materials. While some amount of erosion is natural, a large amount of sediment in our waterways comes from human activity, both urban and rural. In Wisconsin, typically more than ninety percent of the sediment load comes from anthropogenic sources.[15]

Excessive sedimentation can create problems for plants, animals, and drinking water. The worst problem associated with sediment is its ability to transport phosphorus into a water body. Sediment is responsible for sixty percent to ninety percent of the phosphorus load entering Wisconsin waterways.[16]

Fortunately, sediment phosphorus, though more abundant than dissolved phosphorus, is not immediately available to aquatic life in surface waters. While dissolved phosphorus can be immediately used by plants, sediment phosphorus must break its tie with its host sediment particle and dissolve before it is biologically available. Not all sediment phosphorus results in plant growth and eutrophication, though a significant percentage can become available over time. If sediment phosphorus levels are high in a water body, such as in areas with high erosion levels, enough phosphorus will become available to spur eutrophication.

Other Water Quality Issues with Sediments

Besides harboring phosphorus, excessive sediment loads can create a number of different problems for streams, rivers, and lakes, both as suspended sediment in the water column and with accumulation.

Sediment erosion into waterways is a naturally occurring process, but a wide range of human activity makes sediment erosion a serious problem. Sediment comes from many different sources, urban and rural. Oil, rust particles, pieces of brake lining, and construction sediment are picked up in urban runoff. Soil from croplands, the largest source of sediment, and manure from livestock erode from agricultural areas. These particles are swept into our waterways, clogging up the water, choking out aquatic life, and drastically altering aquatic environments.

Large levels of suspended sediment – sediment floating in the water column – reduce water clarity, inhibit plant growth, and make it difficult for fish to find food. The productivity of many lakes and reservoirs is seasonally limited because suspended sediment inhibits light penetration.

Water bodies with large loads of suspended sediment also suffer from increases in temperature. Sediment traps heat in waterways – a greenhouse effect. Reduced clarity increases the solar heating of water, warming the temperature and reducing the ability of the water to hold oxygen, putting stress on fish.[17]

Sediment deposition also covers plant and animal habitat critical to healthy waterways, shortens useful reservoir life, reduces water storage capacity, increases flooding, elevates maintenance costs for harbors and navigation channels, and creates contaminant repositories. Sediment deposition has become such a central issue to the upper Mississippi River that today annual maintenance costs for dredging and the preservation of its banks exceed $100 million.[18] In Wisconsin, the cost of dredging Green Bay amounts to $1.6 million each year, mainly because of sediment from runoff reaching Green Bay through the Fox and East Rivers.[19]


Wisconsin Department of Natural Resources

Loss of habitat results in loss of biodiversity of aquatic environments. Sensitive and diverse aquatic habitats throughout Wisconsin are giving way to ecosystems with only a few plants and animals that can survive the new harsh environments associated with over-sedimentation. The U.S. Geological Survey (USGS) concludes that sediment is the number one water quality problem impacting trout populations in Wisconsin.[20]

Sources of Phosphorus in Runoff

Phosphorus pollution comes from a range of sources, point and non-point, urban and rural. Common point sources include wastewater treatment plants, failing septic systems, and industrial operations. Non-point-source runoff from urban areas can also be a significant source of phosphorus in local waterways. But by far the largest amount of anthropogenic phosphorus enters our waterways in runoff from a few agricultural sources.

Agricultural Sources

Like sediment, most of the excess phosphorus in surface water comes from agricultural practices, mainly croplands and livestock operations.[21] According to research by the Wisconsin DNR, agriculture was the main source of pollution for over ninety percent of the 1,400 Wisconsin streams polluted by non-point-source runoff pollution.[22]

Croplands

Croplands are the largest source of phosphorus in Wisconsin waterways for two reasons:

- Fertilizer and manure applications on croplands exceed the needs of crops.
- Croplands supply Wisconsin's waterways with a majority of the state's total sediment, providing a mode of transport for phosphorus.

The over-application of phosphorus-laden fertilizers and manure is the result of a historic lack of knowledge about nutrients and a lack of accountability of farmers for the use of these fertilizers and manures.

Fertilizer and manure contain both nitrogen and phosphorus. Farmers using nutrient management plans today apply fertilizer or manure at rates designed to meet nitrogen requirements. However, fertilizers and manure typically have a much higher phosphorus content than nitrogen content. This has often resulted in an over-application of phosphorus. Phosphorus is applied to land beyond crop needs, increasing phosphorus in surface soil and enriching runoff with enough phosphorus to accelerate eutrophication.[23]

To this day, nutrient management in Wisconsin and throughout the U.S. focuses on nitrogen instead of phosphorus. Wisconsin's standard regulating nutrient management only addresses nitrogen. The standard reads:

> *"Available nitrogen, including nitrogen from legumes, manure, sludge, organic byproducts, and commercial sources shall not exceed nonlegume crop needs, except that available nitrogen may exceed crop needs by up to 20%, if legumes, manures, and organic byproducts are the only sources of nitrogen."*[24]

Farmers, advocates, and decision makers now realize that nutrient management must focus on phosphorus along with nitrogen. The Wisconsin Department of Agriculture, Trade, and Consumer Protection acknowledges that nutrient management cannot be effective without including phosphorus. But the agency attempts to justify its reluctance to shift toward phosphorus-based nutrient management due to economic considerations. The agency's website displays the following points:

- Nutrient management planning for nitrogen alone often allows continued build-up of soil phosphorus.
- Current federal initiatives such as the Clean Water Action Plan and a proposed revision to the national NRCS Nutrient Management Policy intend to base nutrient management on soil phosphorus levels and/or on risk of phosphorus delivery to surface water.
- The economic impact of adopting a phosphorus-based nutrient management strategy could be significant and wide-ranging in Wisconsin.
- Federally proposed phosphorus limiting strategies will compound problems for this region by forcing manure to be stored or finding more cropland that is not already high in phosphorus.[25]

Phosphorus accumulation on Wisconsin croplands often exceeds the needs of crops. Seventy-seven percent of croplands in Wisconsin have high soil phosphorus levels. They require no fertilization. On average, only 30 percent of fertilizer and feed phosphorus input into croplands is actually output in crop produce. The remaining seventy percent stays in the soil or runs off. Without any additional fertilization the following year, phosphorus levels would be more than adequate for crop production. Depending on how much of a phosphorus surplus the soil has, a field could go years without needing any additional fertilizer or manure applications.

Yet with no regulation of phosphorus applications or impacts on individual farmers for over-application of fertilizers and manure, farmers continue to apply fertilizers and manure on soil that cannot absorb more phosphorus. The result is an annual average phosphorus surplus of 30 lb/acre. Crops do not suffer from over-fertilization, so farmers have no incentive to control phosphorus levels. The resulting excess of phosphorus in crop soils ends up in runoff. The higher the soil phosphorus, the greater the phosphorus runoff to surface waters.

Croplands are also the main source of sediment erosion in the state. Hundreds of thousands of acres of bare soil allow for massive erosion of sediment into waterways, carrying phosphorus with it. With no natural buffers and croplands often extending directly to the banks of streams, rivers, and lakes, sediment and phosphorus have easy access to Wisconsin waterways. Croplands provide an estimated 76 percent of the total sediment load in Wisconsin waterways, according to the DNR.[26]

Livestock Operations

Livestock operations where runoff can come into contact with large quantities of concentrated manure are another major source of phosphorus and sediment. Manure from livestock operations is extremely high in phosphorus, is spread widely on Wisconsin croplands, and is subject to disastrous spills. By fencing off adjacent waterways from livestock, sediment and phosphorus runoff could be reduced by 50 to 90 percent.[27]

Wisconsin is home to more dairy farms per square mile than anywhere in the country. At the start of 2000, Wisconsin had 70 facilities larger than 1,000 animal units and 25 waiting to be permitted, a 36 percent increase from 1999.[28] Livestock operations in Wisconsin are responsible for 9.5 billion gallons of liquid manure on our fields and in our waterways each year, enough to cover 29,000 acres of land one foot deep in manure.[29]

Livestock feed is extremely high in phosphorus. Consequently, livestock operations often have a higher phosphorus surplus than do crop-producing farms. The average phosphorus surplus at a livestock operation can be between 30 and 110 lb/acre/yr.[30] If the manure from these operations is either spread on fields or in contact with runoff during storage, it can be a greater source of phosphorus in runoff than excess phosphorus in fertilizer on croplands.

Only 17 percent of Wisconsin farmers have long-term storage capacity for manure, and frequently those few storage facilities release contaminants into waterways by overflowing, leaching into groundwater or being exposed to runoff.[31] Farmers spread manure directly on their fields as a means of waste disposal as much as for fertilizer, sometimes up to a foot thick, leaving the phosphorus-laden material vulnerable to runoff.

Spills from manure storage areas are also a major problem. Fish kills due to nutrient overloading from manure spills are frequent occurrences in Wisconsin.

- In 1991, an Iowa County feedlot operator accidentally spilled 620,000 gallons of liquid cattle waste into a nearby creek, killing tens of thousands of fish.
- In June of 1998, runoff from a large dairy farm near Cleveland in Manitowoc County created a plume of contaminated water that stretched a quarter mile into Lake Michigan and killed thousands of fish.
- In December of 2000, 1,200 trout were killed by a manure spill that ran into Bostwick Creek in La Crosse County.[32]
- In June 2001, over 5,000 trout died in Black Earth Creek in Dane County from polluted runoff following a heavy rainfall in the watershed. Up to 86 percent of the trout in certain stretches of the stream were lost.[33]

Urban Sources

Urban areas are another major source of phosphorus and sediment in runoff. Developed urban areas and developing urban areas (construction sites) contribute on average 11 percent and 13 percent of Wisconsin's phosphorus load, respectively.

The contribution of both types of urban areas to the overall phosphorus load is minor compared to that from rural runoff, but annual phosphorus loads per acre are comparable.[34] Several factors contribute to high phosphorus loadings per acre from urban areas. Though Wisconsin and the country as a whole have much less urban land than rural land, urban areas have little ability to filter runoff. Urban areas are largely impervious, and therefore most of the water turns into runoff.

Urban areas also have a high delivery rate, meaning that it takes less time for the rainwater or snowmelt to make it into our waterways. Precipitation falls on cemented urban areas and runs quickly through the watershed, picking up phosphorus and other pollutants on the way.

Developed Urban Areas

The most common sources of urban phosphorus include fertilized lawns and gardens and private waste treatment systems. Failing private waste treatment systems often discharge directly into a stream without a field to filter them, or a failing septic field will discharge the wastewater directly to the soil surface, allowing it to come into contact with runoff.

Developed urban areas, though they have less soil erosion than rural areas, have other sediment types that can play host to phosphorus molecules in runoff. Tiny pieces of asphalt and pavement, particles from vehicle exhaust, factories, and smokestacks, flakes of rusting metal, and bits of tires and brake linings all make up the sediment load of urban waterways.[35]

Construction Sites

With high erosion rates, construction sites are the largest urban contributor of phosphorus to runoff. Construction sites are the biggest source of urban soil erosion, providing 16 percent of the average annual sediment load statewide.[36]

The Wisconsin Department of Natural Resources estimates that an average construction site of one acre delivers thirty tons of sediment per year to downstream waterways, more than any other activity or land use, urban or rural. Some sites contribute upwards of 45 tons per acre per year. This far outstrips the erosion rule of croplands, which average between one and ten tons per acre per year.[37]

Construction sites are designed to stay as dry as possible. Early in the construction phase a drainage system is built and ditches and storm sewers are installed. The ditches are designed to carry away rainwater as quickly and efficiently as possible to keep projects moving despite precipitation events. This efficient drainage of water also means efficient runoff of sediment and phosphorus. Between 50 and 100 percent of all sediment eroded from a construction site will make it into downstream waters, as opposed to only three to ten percent of soil eroded from cropland.[38]

SEDIMENT AND PHOSPHORUS LEVELS IN WISCONSIN WATERWAYS

Phosphorus Monitoring Data

Phosphorus monitoring data in both streams and lakes illustrates an enormous water quality problem in the state of Wisconsin. Phosphorus levels throughout the state routinely exceed the recommended standards for healthy rivers and streams set by the EPA.

In December 2001 the EPA completed recommended standards for several nutrient indicators, including phosphorus. The EPA divided the country into 16 different ecoregions, eight for streams and rivers and eight for lakes. Each ecoregion has its own standard customized to local conditions. Wisconsin falls in ecoregion VII for streams and rivers, with a recommended standard of 0.033 milligrams/liter (mg/l). For lakes, Wisconsin falls into two separate categories, ecoregions VII and VIII. Ecoregion VII has a recommended standard of 0.01475 mg/l, nearly twice as high as the standard of 0.008 mg/l for region VIII. Because the data used in this report includes both ecoregions without distinguishing between the two, we used the less stringent lake standard to analyze all Wisconsin data. Thus, our analysis of Wisconsin lakes is conservative.

While there are areas of the state that stand out as regional problem areas and water bodies with consistent problems, the problem of excess phosphorus loading is visible statewide. Phosphorus levels exceeding EPA recommended standards have been detected in streams, rivers, or lakes in all but one of Wisconsin's 72 counties.

Streams and Rivers

Wisconsin streams and rivers exceeded recommended phosphorus levels in 93 percent of tests over the past decade. The mean phosphorus level measured in streams and rivers across the state is 0.64 mg/l, 19 times the EPA recommended standard of 0.033 mg/l.[39] The median concentration is 0.16 mg/l, more than five times the EPA recommended standard.

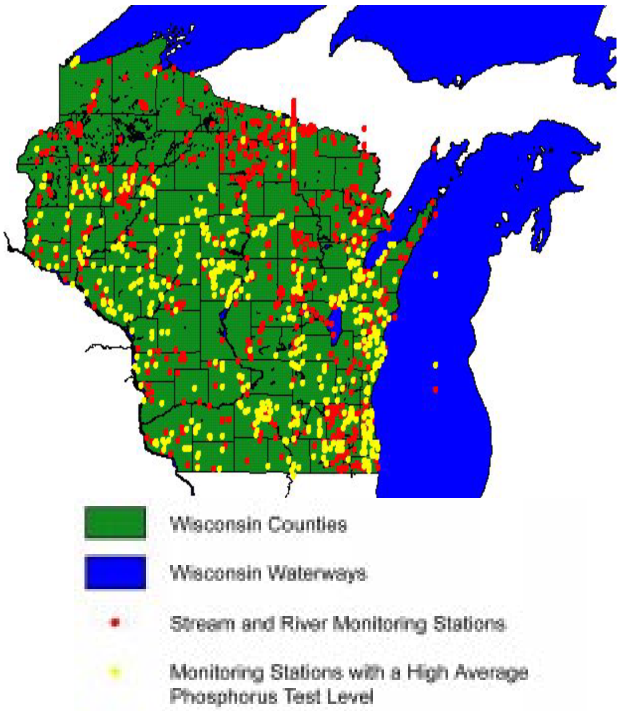
Though excess phosphorus appears to be a problem for streams and rivers throughout the entire state, there are several regions that stand out with extremely high average levels. Several areas had phosphorus averages at least three times the recommended standard.

- The area surrounding Milwaukee, Wisconsin's largest city, with both the Fox River and the Milwaukee River, had dozens of testing stations with phosphorus averages more than three times the recommended standard.
- Streams in the Madison area also had extremely high averages, with runoff coming from both urban and agricultural sources.
- The Fox River Valley, which runs from Green Bay to Appleton, is another area with destructive phosphorus levels.
- Agriculture has contributed to high phosphorus levels in the La Crosse and Chippewa Rivers, the southwest counties of Grant, Iowa, and Lafayette, and the northern sections of the Wisconsin River.

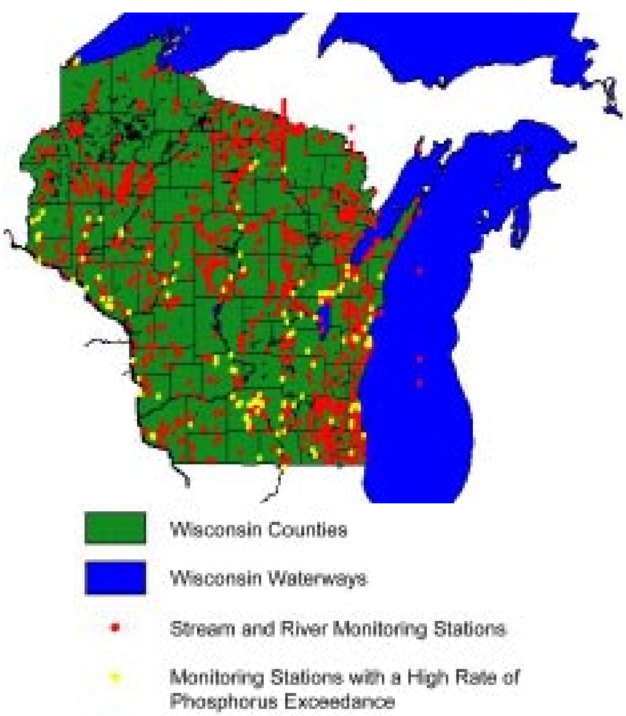
Most streams with high phosphorus levels exceed standards consistently. Monitoring stations on 441 of 471 separate water bodies identified as streams or rivers in water qual-

Kerry Schumann

Map 1- Stream and River Monitoring Stations with High Average Phosphorus Test Levels



Map 2- Stream and River Monitoring Stations with a High Percentage of Phosphorus Exceedances



ity monitoring databases (94 percent) had at least one test for phosphorus exceeding EPA recommended levels. Of those water bodies exceeding standards at least once, 88 percent exceeded standards more than fifty percent of the time they were tested. Sixty-three streams and rivers tested at least ten times over the past ten years exceeded standards in 100 percent of the tests. (See Appendix C.) The twenty streams with 100 percent exceedance rates and the highest average concentrations are show in Table 2.

Several regions stand out when looking at areas that have exceedance rates of at least 80 percent. (See Map 2.)

- Monitoring stations up and down the length of the Mississippi River along Wisconsin's western border consistently exceed recommended levels.
- The Willow River, north of Hastings in St. Croix County, is another trouble spot.
- The Fox River Valley, rivers and streams in the Madison area, the Milwaukee River, the upper Wisconsin River, and the Chippewa River near Eau Claire all are areas with extremely high average phosphorus levels and high exceedance percentages.

Lakes

Wisconsin lakes have an equally serious phosphorus problem. Average levels of phosphorus in Wisconsin's lakes are extremely high, a majority of lakes tested exceed healthy phosphorus levels, and those water bodies with high phosphorus levels test high on a regular basis. While overall phosphorus levels tend to be lower in lakes than streams and rivers, lakes and reservoirs are much more sensitive to phosphorus. The water cycle is much slower in lakes than rivers, as they do not flush annually. This results in lower dissolved oxygen concentrations, larger fluctuations in temperature, and sensitivity to algae growth.

Eighty percent of phosphorus tests in Wisconsin lakes over the past decade exceeded

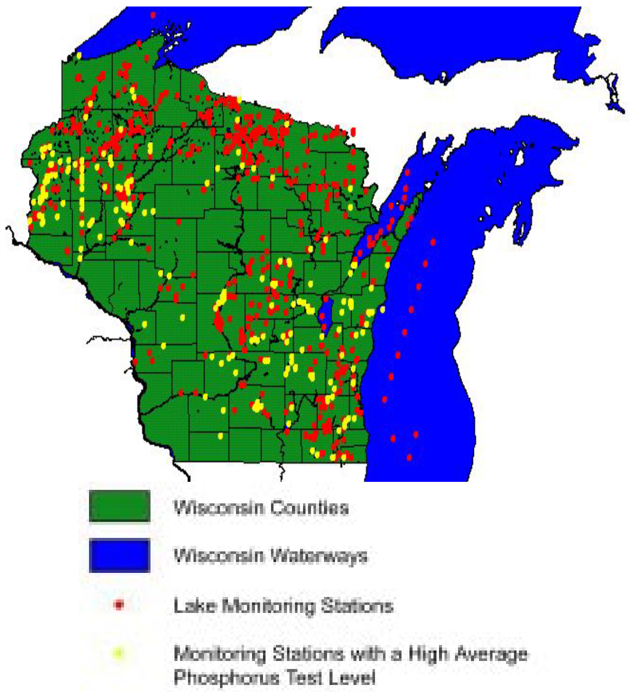
Table 1. Streams and Rivers with High Average Phosphorus Concentrations, 1990-2001

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Hutchinson Creek	Buffalo	91	91	100%	5.308
Joe's Valley Creek	Buffalo	455	434	95%	2.904
Kuenster Creek	Grant	418	408	98%	2.670
Eagle Creek	Buffalo	486	472	97%	2.654
Rattlesnake Creek	Grant	413	406	98%	2.602
Mill Creek	Wood	37	33	89%	1.897
Brewery Creek	Iowa	725	712	98%	1.851
Pecatonica River	Iowa	61	61	100%	1.391
Birch Creek	Walworth	60	47	78%	1.204
Garfoot Creek	Dane	515	508	99%	1.183
Parsons Creek	Fond Du Lac	707	694	98%	1.004
Belgium River	Sheboygan	22	22	100%	0.953
Kankapot Creek	Outagamie	25	24	96%	0.832
Bower Creek	Brown	670	668	100%	0.735
Sauk Creek	Ozaukee	32	32	100%	0.710
Yahara River	Rock	255	253	99%	0.681
Koshkonong Creek	Dane	55	55	100%	0.662
Halfway Prairie Creek	Dane	249	248	100%	0.661
Otter Creek	Sheboygan	2,021	1,901	94%	0.636
Barr Creek	Sheboygan	37	36	97%	0.634

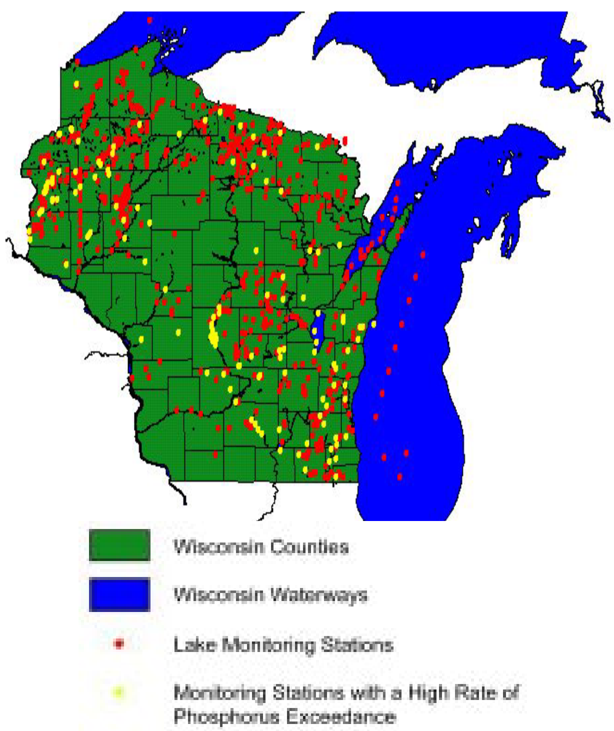
Table 2. Streams and Rivers with High Exceedance Rates,1990-2001

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Hutchinson Creek	Buffalo	91	91	100%	5.308
Pecatonica River	Iowa	61	61	100%	1.391
Belgium River	Sheboygan	22	22	100%	0.953
Sauk Creek	Ozaukee	32	32	100%	0.710
Koshkonong Creek	Dane	55	55	100%	0.662
Alto Creek	Dodge	15	15	100%	0.621
Trout Run Creek	Trempealeau	26	26	100%	0.618
Rock Creek Tributary	Polk	38	38	100%	0.569
Rock River	Dodge	82	82	100%	0.416
Townline Creek	Oneida	16	16	100%	0.378
Bohris Valley Creek	Buffalo	46	46	100%	0.361
Six Mile Creek	Dane	98	98	100%	0.357
Spring Creek	Rock	114	114	100%	0.355
Nine Springs Creek	Dane	92	92	100%	0.333
Drew Creek	Dodge	12	12	100%	0.331
Des Plaines River	Kenosha	25	25	100%	0.321
Trempealeau River	Jackson	47	47	100%	0.315
Suamico River	Brown	10	10	100%	0.292
Starkweather Creek	Dane	81	81	100%	0.292
Hay River	Dunn	90	90	100%	0.291

Map 3- Lake Monitoring Stations with High Average Phosphorus Test Levels



Map 4- Lake Monitoring Stations with a High Percentage of Phosphorus Exceedances



EPA recommended standards. The mean phosphorus level measured in Wisconsin lakes is 0.10 mg/l, seven times the EPA recommended standard of 0.01475. The median concentration is 0.034 mg/l, more than double the EPA recommended standard.

Lakes in several regions of Wisconsin show phosphorus levels more than three times the recommended standard.

- The lakes region of northwestern Wisconsin leads the way with high average phosphorus levels.
- Polk, St. Croix, Barron, and Dunn counties have especially high average phosphorus tests.
- Other areas with high phosphorus tests in lakes are the Peternell Flowage on the Wisconsin River, Lake Poygan near Lake Winnebago, Lake Mendota in the Madison Area, and Lake Tichgan on the Fox River in southeastern Wisconsin.

As with streams, lakes with phosphorus problems had high levels of phosphorus on a consistent basis. Of 657 lakes tested, 623 (93 percent) had at least one test that exceeded the phosphorus recommended standard. Of those 623 with exceedances, 522 (84 percent) tested above the phosphorus standard in more than half of all tests. Thus 79 percent of all lakes in the state exceeded phosphorus standards more than half the time they were tested.

This corresponds with research by the DNR on the eutrophication of lakes. A recent DNR study concluded that eighty percent of Wisconsin lakes have an accelerated eutrophic state.[40]

107 lakes that were tested at least ten times over the past ten years exceeded EPA recommended levels in every test. (See Appendix E.) The twenty lakes with 100 percent exceedance rates and the highest average phosphorus concentrations are shown in Table 4.

Lakes in several regions stand out as those most consistently above recommended phosphorus levels. (See Map 4.)

Table 3. Lakes with High Average Phosphorus Concentrations, 1990-2001

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Benedict Lake	Kenosha	24	18	75%	3.915
Oliver Lake	Chippewa	13	13	100%	0.969
Green Lake	Green Lake	48	47	98%	0.751
Potato Lake	Rusk	26	25	96%	0.646
Deer Lake	Polk	159	137	86%	0.538
Squaw Lake	St Croix	131	131	100%	0.525
Twin Lake	Polk	40	39	98%	0.508
Finley Lake	Chippewa	13	13	100%	0.415
Desair Lake	Barron	26	25	96%	0.387
Little Gerber Lake	Sheboygan	58	58	100%	0.383
Black Otter Lake	Outagamie	31	31	100%	0.330
Kelly Lake	Oconto	10	9	90%	0.330
Carstens Lake	Manitowoc	17	16	94%	0.309
Lake Koshkonong	Jefferson	11	11	100%	0.296
Silver Birch Lake	Pepin	20	20	100%	0.265
Scout Lake	Milwaukee	33	32	97%	0.255
Hartlaub Lake	Manitowoc	25	23	92%	0.255
Como Lake	Chippewa	11	11	100%	0.250
Lake Redstone	Sauk	43	43	100%	0.238
Big Long Lake	Manitowoc	97	95	98%	0.226

Table 4. Lakes with High Exceedance Rates, 1990-2001

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Oliver Lake	Chippewa	13	13	100%	0.969
Squaw Lake	St Croix	131	131	100%	0.525
Finley Lake	Chippewa	13	13	100%	0.415
Little Gerber Lake	Sheboygan	58	58	100%	0.383
Black Otter Lake	Outagamie	31	31	100%	0.330
Lake Koshkonong	Jefferson	11	11	100%	0.296
Silver Birch Lake	Pepin	20	20	100%	0.265
Como Lake	Chippewa	11	11	100%	0.250
Lake Redstone	Sauk	43	43	100%	0.238
Tichigan Lake	Racine	44	44	100%	0.223
Largon Lake	Polk	27	27	100%	0.208
Lake Arbutus	Jackson	21	21	100%	0.203
English Lake	Manitowoc	36	36	100%	0.200
Harpts Lake	Manitowoc	10	10	100%	0.185
Virginia Lake	Sauk	11	11	100%	0.172
White Clay Lake	Shawano	108	108	100%	0.163
Tombeau Lake	Walworth	22	22	100%	0.154
Marsh-Miller Central Bay	Chippewa	17	17	100%	0.140
Tug Lake	Lincoln	13	13	100%	0.139
Pine Lake	St Croix	16	16	100%	0.134

- Lake Mendota in the Madison area, lakes in Polk County and Barron County, and Lake Michigan on the Fox River all have a large number of monitoring stations with exceedance percentages over 80 pecent.
- Lake Winnebago, and lakes in Oneida and Vilas counties in north central Wisconsin also have very high exceedance rates, with average phosphorus levels more than three times the recommended standards.

Sediment Studies

Suspended sediment concentrations in Wisconsin are increasing. A USGS study of the Western Lake Michigan drainages, including all of eastern Wisconsin, showed a continuous increase in suspended sediment concentrations from 1971-1990.[41]

Changes in land cover and land use affect rates of sediment erosion and sediment loading. Wisconsin waterways receive much more eroded sediment each year now than they did under pre-settlement conditions. A USGS study of North Fish Creek concluded that when local drainage changed from forest cover to agricultural uses, sediment loads increased by a factor of five.[42] The USGS study of Western Lake Michigan from 1971-1990 showed the same trends. The study found that urban areas had the highest median concentrations of suspended sediment. Agricultural areas had the second highest concentrations, and forested areas were a distant third.[43]

Analysis of recent water quality data suggests that sediment continues to be a major water quality problem in Wisconsin. The levels of phosphorus outlined in the previous section are secondhand evidence of heavy sediment erosion, and analysis of suspended sediment concentrations confirms the problem.

Evaluating suspended sediment is a subject of controversy. While much is understood about the effects of sediment buildup in reservoirs and sediment as a vehicle for phosphorus transport, little is understood about how much *suspended* sediment is too much. Different water bodies can handle and transport different sediment loads. Thus it is difficult to apply general standards to large groups of water bodies that have different characteristics.

Various national and state agencies are working to develop standards for suspended sediment. Wisconsin does not yet have a numerical standard for suspended sediment levels in streams and rivers. The U.S. EPA now uses a level of 100 mg/l as a general guideline for developing total maximum daily loads for suspended solids where detailed local analysis suggesting other levels is not available.[44] The USGS also used this standard in a study of sediment in Wisconsin.[45]

Of 356 water bodies analyzed, 109 of them (31 percent) had concentrations of suspended solids above 100 mg/l. Of the 109 locations that had tests exceeding healthy levels of suspended solids, 25 percent of locations exceeded healthy levels more than one third of the time they were tested.

WISCONSIN'S RUNOFF MANAGEMENT PLAN

The Runoff Management Plan (RMP) produced by the Wisconsin Depart ment of Natural Resources has the potential to establish Wisconsin as the country's leader in the battle against runoff pollution. These sweeping regulations aimed at reducing runoff's effect on Wisconsin's water quality are an attempt at a comprehensive statewide plan to alter a wide range of activities that are harmful to the health of Wisconsin's waterways.

Wisconsin's runoff pollution policies have evolved through the years from an emphasis on voluntary programs to mandatory policies, culminating in the proposed runoff management rules now being debated. In the late 1970s, Wisconsin created the Nonpoint Source Water Pollution Abatement (NPS) Program to implement "priority watershed projects." Between 1979 and 1995, priority projects were selected from water quality management plans that identified water quality concerns by river basin. These projects were funded with state money.

The program began a transition toward a more regulatory approach in the early 1990s after two Legislative Audit Bureau reports showed that the old program was not improving water quality significantly. New state laws required all watershed projects after 1993 to identify critical sites within their watershed where Best Management Practices (BMPs) must be implemented to protect water quality. The new laws also provided the DNR with the ability to enforce the new statutes. The state has noted that this enforcement ability is an "extremely effective approach to obtaining results at most heavily polluting sites."[46]

The BMP program never reached its full potential due to a lack of funding for the cost share program. The selection of new projects for the program was permanently suspended in 1995. By 1997 the state legislature in Wisconsin realized that efforts toward reducing runoff pollution in the state were stagnant, and enacted the law that has since resulted in the runoff management rules of today. These laws require the DNR to prescribe performance standards for agricultural and non-agricultural sources of non-point-source pollution.

A Major Step toward Curbing Runoff

The Runoff Management Plan proposes many completely new or altered regulations that comprise a major step in the right direction toward battling runoff pollution. The rules set performance standards for both agricultural practices and non-agricultural activities, including development and redevelopment, developed areas, and transportation.

The agricultural performance standards cover several areas. The standards will apply to a wide range of practices, including curbing agricultural soil erosion, manure management and storage, clean water diversions (runoff from agricultural buildings, feedlots, and manure storage areas), and nutrient management.

These new regulations are a major step in that they would affect farms of all sizes. Present regulations only affect large farms. Nutrient management plans are also a new attempt at managing runoff from agricultural fields as well as any lawn or field five acres or larger in the state, including playing fields, golf courses, and even private yards.

The urban performance standards are divided into three parts: new development and redevelopment, developed urban areas, and transportation performance standards. The regulations for new development and redevelopment require storm water management plans and practices for construction sites larger than five acres, a major source of sediment runoff. The plans for large construction sites will also require a vegetative buffer between sites and streams, rivers, and lakes.

The urban performance standards for developed areas will require all communities with average population densities of over 1,000 people per square mile to follow several new requirements. These cities will have to make information available to the public regarding "proper yard and garden care to minimize polluted runoff." Cities will also have to institute practices to collect leaves and grass clippings swept onto residential streets. Additional programs will be put in place to detect and eliminate illicit discharges to storm sewers.

Transportation facilities will also be required to meet performance standards. These standards will include education requirements for transportation staff on runoff. They will also include a requirement for total suspended solids reductions of twenty percent by 2008 and forty percent by 2013 for highways within certain municipalities. Most importantly, the rules require vegetative buffers between roads and road building projects and waterways.

The Runoff Management Plan shows that Wisconsin is moving in the right direction toward solving our most dangerous and most difficult water quality problems. But several important changes are needed to make this program much more effective.

Shortcomings in the Plan

Agricultural Runoff

The most significant problem with Wisconsin's proposed policies on runoff is their exclusion of mandatory cropland vegetative buffers. Agricultural runoff is both the largest source of sediment and the leading source of phosphorus in Wisconsin, providing 76 percent of the sediment and 65 percent of the phosphorus in the state. The Runoff Management Plan fails to fully address the problems of agricultural runoff.

Cropland buffers, vegetated strips of land between crops and waterways, were an original part of the Runoff Management Plan and are essential to its success. But buffers were pulled from the DNR's final proposals. Existing and proposed regulations addressing cropland soil loss are not enough to stop excess sediment runoff into our waterways without vegetative buffers. Implementing the Runoff Management Plan without buffers ignores the most effective solution to the largest source of both phosphorus and sediment in Wisconsin's waterways.

Neglecting Phosphorus

Nutrient management regulations are outdated and continue to focus solely on nitrogen, while research from the Wisconsin DNR clearly shows that phosphorus is the nutrient most responsible for eutrophication.

The plan itself is not necessarily at fault for overlooking phosphorus, as it calls for nutrient management plans in general, and is not chemical specific. But "nutrients" refer to nitrogen under Wisconsin NRCS 590, not phosphorus.

The rules do require nutrient management plans to follow the technical standards written by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS). The NRCS is revising the standards with the intention of basing nutrient management planning on phosphorus. Those revisions will be finalized by 2005. At that point, Wisconsin's NMPs are expected to become phosphorus based. However, until then, farmers will be basing their planning on nitrogen, allowing excess phosphorus to impact our waterways.

Small Construction Sites

Construction sites contribute more sediment per acre to waterways than any other land use. Because of such high rates of soil erosion, they are also the largest urban source of phosphorus into our waterways.

The definitions of construction sites in NR216.002 only require the state to regulate construction sites with "one or more land disturbing construction activities that in total will disturb 5 or more acres." This means that only the largest of construction sites will be regulated – large housing developments, shopping malls, etc. This definition leaves a loophole large enough to compromise the effectiveness of the Runoff Management Plan.

The federal government is requiring states to regulate construction sites with land-disturbing activity of one acre or greater by March 2003. The Wisconsin DNR is currently drafting rules to comply with that regulation. However, even with a standard of one acre most home building projects and many business and industrial construction projects would not be covered.

Studies in Wisconsin show that small construction sites are a major source of sediment and phosphorus pollution, polluting as much as 10 times the amount of other urban and rural land uses.

POLICY RECOMMENDATIONS

***Require vegetative buffers of at least 35 feet between agricultural land and adjacent waterways*.**

Buffers are the best way to reduce agricultural runoff pollution in Wisconsin. They increase filtration, allowing rainfall, snowmelt, and other precipitation to filter into the groundwater system rather than running directly into waterways. They reduce the sediment load by trapping sediment before it reaches waterways and by slowing runoff, allowing particles to settle before reaching the water body.[47] Buffers also limit nutrient loading of waterways by utilizing the natural uptake of nutrients by plants. Of all the proposed policies to reduce runoff in Wisconsin, vegetative buffers give the most bang for the buck.

Buffers also contribute to the overall health of our aquatic ecosystems. They help stabilize stream banks and moderate stream temperatures by reducing solar radiation.[48] Buffers create wildlife corridors and provide habitat for aquatic creatures. Many aquatic species require the protection of vegetation along stream banks in order to survive.

Studies show that a 100-foot wide buffer is sufficiently wide to protect water quality and the minimum buffer width for most water bodies is 49 to 98 feet. Buffers less than 35 feet provide little protection of aquatic resources.[49]

Although the Runoff Management Plan originally required vegetative buffers – a provision that was agreed to by groups including environmentalists and the Wisconsin Farm Bureau – DNR staff removed the provision in the final draft. DNR staff is concerned that mandatory buffers could jeopardize Wisconsin's eligibility for the Conservation Reserve Enhancement Program (CREP), a federal program that provides money for states to install vegetative buffers on farmland. But this does not have to be a choice between federal money and mandatory buffers. Wisconsin can remain eligible for CREP money while ensuring that Wisconsin's waterways are being restored and protected for future generations simply by phasing in the mandatory buffer program after the completion of the federal CREP program.

With written support from the Farm Service Agency, Brown County has put a moratorium on their mandatory buffer program in order to participate in the CREP program. The Brown County mandatory buffer program will resume after the completion of CREP. The State of Wisconsin should replicate this approach statewide.

The Senate Committee on the Environment recently reviewed the Runoff Management Plan and sent the plan back to the DNR, requesting that they re-evaluate the decision to remove buffers from the plan. The agency should now reinstate mandatory buffers of at least 35 feet.

Make phosphorus the focus of nutrient management plans along with nitrogen.

Nutrient management is a key step in reducing the discharge of nutrients into our waterways, but nutrient management plans currently focus on only a small part of the problem. Although phosphorus is the most important factor in the eutrophication of Wisconsin's waterways, nutrient management still focuses solely on nitrogen. Because manure and fertilizers have a much higher phosphorus content than nitrogen and nutrient management regulates applications by nitrogen content, phosphorus is applied in amounts that greatly exceed crop needs.

The control of phosphorus is much more effective than the control of nitrogen through runoff management. Phosphorus enters our waterways almost entirely through runoff, whereas nitrogen comes from many sources. Thus runoff controls can eliminate a much larger percentage of phosphorus.

Wisconsin should not wait until the U.S. Department of Agriculture's new nutrient management regulations take effect – now expected to be 2005 at the earliest – to base nutrient management plans on phosphorus. The DNR has the perfect opportunity in the present policy debate to clarify the rule by specifying phosphorus as a nutrient of focus along with nitrogen.

Include all construction sites in the performance standard requirements for construction sites.

With unmatched erosion rates and sediment runoff, construction sites are the largest urban contributor to phosphorus runoff, providing 16 percent of the sediment load in Wisconsin. They are also the largest source of sediment per acre of any land use. The Wisconsin DNR estimates that an average construction site of one acre delivers 30 tons of sediment per year to downstream waterways.

The Runoff Management Plan addresses this problem by requiring best management practices for construction sites. However, the plan only requires the state to regulate construction sites with "one or more land disturbing construction activities that in total will disturb 5 or more acres." This means that only the largest of construction sites will be regulated – large housing developments, shopping malls, etc.

A federal rule set to take effect next year will lower this threshold to include sites that dig up at least one acre. But this still leaves a loophole large enough to compromise the effectiveness of the Runoff Management Plan.

If construction sites with less than one acre of total land disturbed are left unregulated, almost every residential construction project and many commercial projects will continue to pollute Wisconsin's waterways with high levels of sediment and phosphorus.

Controlling sediment erosion and runoff should be a priority for construction sites of all sizes, from major developments down to small additions on houses. During the rule-making process for the new federal regulations, the standard should be altered to require best management practices for all construction sites.

Appendix A: Test Results for Phosphorus in Streams and Rivers by County, 1990-2001

County	Number of Tests	Number of Exceedances	Exceedance Rate	Statewide Rank for Exceedance Rate	Average Concentration (mg/l)	Statewide Rank for Average Concentration
Adams	58	53	91%	44	0.100	49
Ashland	17	10	59%	65	0.039	69
Barron	218	164	75%	57	0.098	51
Bayfield	6	5	83%	52	0.082	54
Brown	974	963	99%	15	0.590	6
Buffalo	1320	1284	97%	27	2.390	2
Burnett	8	8	100%	1	0.073	56
Calumet	44	38	86%	51	0.254	16
Chippewa	161	127	79%	54	0.064	61
Clark	164	162	99%	16	0.176	30
Columbia	26	26	100%	1	0.134	41
Crawford	392	380	97%	28	0.155	36
Dane	3184	3156	99%	13	0.899	3
Dodge	448	445	99%	12	0.406	10
Door	37	32	87%	50	0.169	32
Douglas	58	38	66%	63	0.111	45
Dunn	388	387	100%	10	0.190	26
Eau Claire	127	125	98%	20	0.188	27
Florence	1	1	100%	1	0.060	63
Fond Du Lac	1551	1531	99%	18	0.717	4
Forest	12	8	67%	60	0.037	70
Grant	884	865	98%	22	2.495	1
Green	36	36	100%	1	0.175	31
Green Lake	768	730	95%	30	0.221	22
Iowa	158	149	94%	32	0.676	5
Iron	10	7	70%	58	0.043	68
Jackson	289	251	87%	49	0.110	47
Jefferson	269	245	91%	45	0.224	21
Juneau	2	2	100%	1	0.138	40
Kenosha	86	85	99%	17	0.193	25
Kewaunee	76	74	97%	26	0.146	38
La Crosse	33	33	100%	1	0.209	24
Lafayette	44	41	93%	40	0.218	23
Langlade	25	25	100%	1	0.320	15
Lincoln	102	96	94%	33	0.063	62
Manitowoc	403	378	94%	36	0.168	33

County	Number of Tests	Number of Exceedances	Exceedance Rate	Statewide Rank for Exceedance Rate	Average Concentration (mg/l)	Statewide Rank for Average Concentration
Marathon	110	109	99%	14	0.140	39
Marinette	129	57	44%	69	0.100	50
Marquette	13	3	23%	71	0.037	71
Menominee	0					
Milwaukee	496	466	94%	34	0.158	34
Monroe	97	97	100%	1	0.156	35
Oconto	189	105	56%	68	0.066	58
Oneida	385	225	58%	66	0.056	64
Outagamie	186	178	96%	29	0.235	18
Ozaukee	88	86	98%	24	0.360	12
Pepin	143	140	98%	23	0.110	46
Pierce	508	461	91%	46	0.154	37
Polk	143	110	77%	56	0.368	11
Portage	125	123	98%	21	0.133	42
Price	12	8	67%	61	0.051	65
Racine	107	100	94%	37	0.229	20
Richland	28	19	68%	59	0.084	52
Rock	199	196	99%	19	0.246	17
Rusk	120	114	95%	31	0.102	48
Sauk	206	201	98%	25	0.229	19
Sawyer	30	25	83%	53	0.065	59
Shawano	38	25	66%	62	0.048	67
Sheboygan	2532	2366	93%	38	0.563	8
St Croix	222	207	93%	41	0.132	43
Taylor	28	28	100%	1	0.341	13
Trempealeau	169	168	99%	11	0.334	14
Vernon	271	236	87%	48	0.119	44
Vilas	148	52	35%	70	0.049	66
Walworth	428	393	92%	42	0.578	7
Washburn	39	22	56%	67	0.065	60
Washington	420	392	93%	39	0.182	28
Waukesha	351	330	94%	35	0.181	29
Waupaca	309	239	77%	55	0.076	55
Waushara	38	23	61%	64	0.066	57
Winnebago	252	228	91%	47	0.083	53
Wood	216	198	92%	43	0.453	9

Appendix B: Test Results for Phosphorus in Lakes by County, 1990-2001

County	Number of Tests	Number of Exceedances	Exceedance Rate	Statewide Rank for Exceedance Rate	Average Concentration (mg/l)	Statewide Rank for Average Concentration
Adams	398	364	92%	32	0.073	38
Ashland	36	36	100%	1	0.036	59
Barron	472	385	82%	43	0.080	34
Bayfield	203	139	69%	58	0.039	56
Brown	28	28	100%	1	0.392	2
Buffalo	0					
Burnett	368	303	82%	42	0.055	46
Calumet	27	24	89%	36	0.387	3
Chippewa	661	573	87%	39	0.108	22
Clark	21	21	100%	1	0.065	42
Columbia	157	156	99%	13	0.123	19
Crawford	0					
Dane	816	787	96%	20	0.122	20
Dodge	265	255	96%	21	0.202	8
Door	243	79	33%	65	0.014	65
Douglas	336	267	80%	48	0.036	60
Dunn	161	161	100%	1	0.139	17
Eau Claire	67	67	100%	1	0.097	26
Florence	268	159	59%	62	0.047	52
Fond Du Lac	193	182	94%	25	0.099	25
Forest	133	47	35%	64	0.017	64
Grant	11	11	100%	1	0.061	43
Green	0					
Green Lake	354	311	88%	38	0.177	11
Iowa	25	24	96%	22	0.085	29
Iron	193	179	93%	30	0.032	61
Jackson	85	79	93%	28	0.126	18
Jefferson	342	266	78%	52	0.050	49
Juneau	139	139	100%	1	0.103	24
Kenosha	226	184	81%	45	0.457	1
Kewaunee	45	41	91%	33	0.071	40
La Crosse	52	51	98%	14	0.172	13
Lafayette	7	7	100%	1	0.107	23
Langlade	113	96	85%	40	0.038	57
Lincoln	113	85	75%	54	0.051	48
Manitowoc	396	377	95%	24	0.203	7
Marathon	122	119	98%	18	0.081	31

County	Number of Tests	Number of Exceedances	Exceedance Rate	Statewide Rank for Exceedance Rate	Average Concentration (mg/l)	Statewide Rank for Average Concentration
Marinette	204	154	76%	53	0.146	15
Marquette	198	168	85%	41	0.088	28
Menominee	0					
Milwaukee	51	50	98%	15	0.182	10
Monroe	24	23	96%	23	0.190	9
Oconto	201	99	49%	63	0.030	62
Oneida	1122	792	71%	57	0.040	54
Outagamie	31	31	100%	1	0.330	4
Ozaukee	18	5	28%	66	0.014	66
Pepin	21	21	100%	1	0.257	5
Pierce	45	44	98%	17	0.080	33
Polk	1029	955	93%	29	0.176	12
Portage	103	84	82%	44	0.038	58
Price	230	223	97%	19	0.082	30
Racine	264	236	89%	34	0.078	35
Richland	0					
Rock	36	33	92%	31	0.029	63
Rusk	237	190	80%	47	0.121	21
Sauk	540	507	94%	26	0.141	16
Sawyer	420	309	74%	55	0.045	53
Shawano	267	238	89%	35	0.094	27
Sheboygan	300	241	80%	46	0.172	14
St Croix	571	536	94%	27	0.211	6
Taylor	23	23	100%	1	0.074	37
Trempealeau	0					
Vernon	36	32	89%	37	0.077	36
Vilas	860	671	78%	51	0.053	47
Walworth	505	314	62%	60	0.050	50
Washburn	386	304	79%	50	0.058	44
Washington	615	489	80%	49	0.073	39
Waukesha	915	672	73%	56	0.056	45
Waupaca	720	464	64%	59	0.069	41
Waushara	175	105	60%	61	0.048	51
Winnebago	297	291	98%	16	0.080	32
Wood	25	25	100%	1	0.039	55

Appendix C: Streams and Rivers with 100% Phosphorus Exceedance Rates, 1990-2001

Location	County	Number of Tests	Number of Exceedances	Average Concentration (mg/l)
Hutchinson Creek	Buffalo	91	91	5.308
Pecatonica River	Iowa	61	61	1.391
Belgium River	Sheboygan	22	22	0.953
Sauk Creek	Ozaukee	32	32	0.710
Koshkonong Creek	Dane	55	55	0.662
Alto Creek	Dodge	15	15	0.621
Trout Run Creek	Trempealeau	26	26	0.618
Rock Creek Tributary	Polk	38	38	0.569
Rock River	Dodge	82	82	0.416
Townline Creek	Oneida	16	16	0.378
Bohris Valley Creek	Buffalo	46	46	0.361
Six Mile Creek	Dane	98	98	0.357
Spring Creek	Rock	114	114	0.355
Nine Springs Creek	Dane	92	92	0.333
Drew Creek	Dodge	12	12	0.331
Des Plaines River	Kenosha	25	25	0.321
Trempealeau River	Jackson	47	47	0.315
Suamico River	Brown	10	10	0.292
Starkweather Creek	Dane	81	81	0.292
Hay River	Dunn	90	90	0.291
Baird Creek	Brown	15	15	0.289
Yellow River	Wood	15	15	0.259
Renard Creek	Door	15	15	0.248
Shioc River	Outagamie	11	11	0.246
Root River	Racine	93	93	0.240
Weeden Creek	Sheboygan	79	79	0.231
Popple River	Clark	34	34	0.223
Buffalo River	Buffalo	93	93	0.219
Burns Creek	La Crosse	14	14	0.208
Pine Creek	Taylor	41	41	0.208

Location	County	Number of Tests	Number of Exceedances	Average Concentration (mg/l)
Baraboo River	Sauk	144	144	0.198
Sandy Creek	St Croix	13	13	0.197
Bass Creek	Rock	10	10	0.195
Nashota River	Manitowoc	15	15	0.188
Sheboygan River	Sheboygan	139	139	0.186
Pike River	Racine	11	11	0.157
Little Lax River	Monroe	12	12	0.149
Mc Dermott Creek	Rusk	14	14	0.146
Sugar River	Dane	186	186	0.134
Dutch Creek	La Crosse	12	12	0.134
Farmers Valley Creek	Monroe	12	12	0.133
Showen Creek	Monroe	10	10	0.125
Rush Creek	Crawford	43	43	0.123
Isabelle Creek	Pierce	20	20	0.123
Sussex Creek	Waukesha	10	10	0.121
Oak Creek Tributary	Milwaukee	12	12	0.120
Menomin Lake	Dunn	37	37	0.119
Eau Galle River	Dunn	32	32	0.114
Pike River	Kenosha	10	10	0.110
Devils Creek	Lincoln	11	11	0.105
Rice Lake	Oneida	19	19	0.101
Vermillion River	Barron	13	13	0.099
Irish Creek	Dodge	14	14	0.097
Alder Creek	Rusk	10	10	0.093
Gilbert Creek	Dunn	12	12	0.090
Black Creek	Manitowoc	37	37	0.087
Horse Creek	Polk	10	10	0.080
Joos Creek	Buffalo	12	12	0.074
Brush Creek	Monroe	13	13	0.058

Appendix D: Streams and Rivers with High Average Phosphorus Concentrations, 1990-2001

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Hutchinson Creek	Buffalo	91	91	100%	5.308
Joe's Valley Creek	Buffalo	455	434	95%	2.904
Kuenster Creek	Grant	418	408	98%	2.670
Eagle Creek	Buffalo	486	472	97%	2.654
Rattlesnake Creek	Grant	413	406	98%	2.602
Mill Creek	Wood	37	33	89%	1.897
Brewery Creek	Iowa	725	712	98%	1.851
Pecatonica River	Iowa	61	61	100%	1.391
Birch Creek	Walworth	60	47	78%	1.204
Garfoot Creek	Dane	515	508	99%	1.183
Parsons Creek	Fond Du Lac	707	694	98%	1.004
Belgium River	Sheboygan	22	22	100%	0.953
Kankapot Creek	Outagamie	25	24	96%	0.832
Bower Creek	Brown	670	668	100%	0.735
Sauk Creek	Ozaukee	32	32	100%	0.710
Yahara River	Rock	255	253	99%	0.681
Koshkonong Creek	Dane	55	55	100%	0.662
Halfway Prairie Creek	Dane	249	248	100%	0.661
Otter Creek	Sheboygan	2021	1901	94%	0.636
Barr Creek	Sheboygan	37	36	97%	0.634
Alto Creek	Dodge	15	15	100%	0.621
Trout Run Creek	Trempealeau	26	26	100%	0.618
Rock Creek Tributary	Polk	38	38	100%	0.569
Plum Creek	Pierce	55	53	96%	0.555
Apple Creek	Brown	27	26	96%	0.549
Rock River	Washington	547	543	99%	0.478
Rock River	Dodge	82	82	100%	0.416
Townline Creek	Oneida	16	16	100%	0.378
Southwick Creek	Walworth	65	62	95%	0.368
Ashwaubenon Creek	Brown	22	20	91%	0.368
Bohris Valley Creek	Buffalo	46	46	100%	0.361
Six Mile Creek	Dane	98	98	100%	0.357
Spring Creek	Rock	114	114	100%	0.355
Black Earth Tributary	Dane	142	141	99%	0.341
Nine Springs Creek	Dane	92	92	100%	0.333

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Drew Creek	Dodge	12	12	100%	0.331
Des Plaines River	Kenosha	25	25	100%	0.321
Silver Creek	Marathon	1201	1193	99%	0.316
Trempealeau River	Jackson	47	47	100%	0.315
Spring Brook	Langlade	32	31	97%	0.307
Rice Creek	Barron	17	16	94%	0.303
Cambra Creek	Dodge	36	35	97%	0.294
Starkweather Creek	Dane	81	81	100%	0.292
Pigeon Creek	Grant	18	10	56%	0.292
Suamico River	Brown	10	10	100%	0.292
Hay River	Dunn	90	90	100%	0.291
Beaver Dam River	Dodge	45	44	98%	0.289
Baird Creek	Brown	15	15	100%	0.289
Bloody Run	Wood	18	4	22%	0.283
Yellow River	Wood	15	15	100%	0.259
Cedar Creek	Manitowoc	57	56	98%	0.257
Crawfish River	Columbia	56	55	98%	0.249
Renard Creek	Door	15	15	100%	0.248
Shioc River	Outagamie	11	11	100%	0.246
Garners Creek	Outagamie	23	21	91%	0.245
Root River	Racine	93	93	100%	0.240
Galena River	Lafayette	40	39	98%	0.236
Turtle Creek	Barron	47	46	98%	0.234
Weeden Creek	Sheboygan	79	79	100%	0.231
Rock Lake Tributary	Jefferson	32	27	84%	0.230
Buffalo River	Buffalo	93	93	100%	0.219
Pine Creek	Taylor	41	41	100%	0.208
Burns Creek	La Crosse	14	14	100%	0.208
Badger Mill Creek	Dane	62	60	97%	0.207
Yahara River	Dane	186	185	100%	0.205
Lincoln Creek	Milwaukee	96	89	93%	0.203
Clear Creek	Rusk	48	47	98%	0.200
Branch River	Manitowoc	11	10	91%	0.200

Appendix E: Lakes with 100% Phosphorus Exceedance Rates, 1990-2001

Location	County	Number of Tests	Number of Exceedances	Average Concentration (mg/l)
Oliver Lake	Chippewa	13	13	0.969
Squaw Lake	St Croix	131	131	0.525
Finley Lake	Chippewa	13	13	0.415
Little Gerber Lake	Sheboygan	58	58	0.383
Black Otter Lake	Outagamie	31	31	0.330
Lake Koshkonong	Jefferson	11	11	0.296
Silver Birch Lake	Pepin	20	20	0.265
Como Lake	Chippewa	11	11	0.250
Lake Redstone	Sauk	43	43	0.238
Tichigan Lake	Racine	44	44	0.223
Largon Lake	Polk	27	27	0.208
Lake Arbutus	Jackson	21	21	0.203
English Lake	Manitowoc	36	36	0.200
Harpts Lake	Manitowoc	10	10	0.185
Virginia Lake	Sauk	11	11	0.172
White Clay Lake	Shawano	108	108	0.163
Tombeau Lake	Walworth	22	22	0.154
Marsh-Miller Central Bay	Chippewa	17	17	0.140
Tug Lake	Lincoln	13	13	0.139
Pine Lake	St Croix	16	16	0.134
Tainter Lake	Dunn	143	143	0.130
Delavan Lake	Walworth	31	31	0.127
Lake Delton	Sauk	19	19	0.127
Petenwell Flowage	Juneau	117	117	0.124
Mallalieu Lake	St Croix	16	16	0.121
Paulsen Lake	Polk	12	12	0.118
Hemlock Lake	Barron	32	32	0.116
North Pipe Lake	Polk	16	16	0.113
Spence Lake Middle	Chippewa	13	13	0.112
North Spirit Lake	Price	13	13	0.110
Little Wood Lake	Burnett	21	21	0.108
Elk Lake	Price	10	10	0.108
Dunham Lake	Burnett	14	14	0.105
Mirror Lake	Sauk	37	37	0.102
Prairie Lake	Barron	29	29	0.102
Center Lake	Kenosha	20	20	0.099
Mounds Pond	St Croix	11	11	0.096

Location	County	Number of Tests	Number of Exceedances	Average Concentration (mg/l)
Chetac Lake	Sawyer	34	34	0.095
Black River Flowage	Jackson	10	10	0.094
Harmony Grove Lake	Columbia	36	36	0.091
Montana Lake	Marinette	10	10	0.091
Mud Lake	Jefferson	20	20	0.090
Sheas Lake	Kewaunee	10	10	0.089
Castle Rock Flowage	Juneau	154	154	0.085
Lake Butte	Winnebago	38	38	0.085
Montello Lake	Marquette	13	13	0.085
Lake Poygan	Winnebago	21	21	0.084
Lotus Lake	Polk	11	11	0.084
Birch Lake	Iowa	12	12	0.082
Kegonsa Lake	Dane	52	52	0.081
Bone Lake	Polk	21	21	0.081
Amacoy Lake	Rusk	36	36	0.078
Big Butternut Lake	Polk	22	22	0.075
Avoca Lake	Iowa	11	11	0.074
Mason Lake	Adams	144	144	0.073
Waubesa Lake	Dane	53	53	0.070
Wissota Lake	Chippewa	51	51	0.065
Coon Fork Lake	Eau Claire	47	47	0.064
Duroy Lake	Price	10	10	0.064
Jones Lake	Grant	11	11	0.061
Turtle Lake	Barron	53	53	0.059
Island Lake	Iron	19	19	0.057
Lake St. Croix	St Croix	84	84	0.056
Lac Sault Dore	Price	20	20	0.055
Falk Lake	Burnett	22	22	0.054
Heidmann Lake	Kewaunee	17	17	0.054
Potter Flowage	Jackson	52	52	0.053
Hallie Lake	Chippewa	11	11	0.053
Hooker Lake	Kenosha	15	15	0.052
Tree Lake	Portage	14	14	0.052
Road Lake	Lincoln	11	11	0.052
Shingle Mill Lake	Oneida	18	18	0.051
Musser Flowage	Price	15	15	0.050

Appendix F: Lakes with High Average Phosphorus Concentrations, 1990-2001

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Benedict Lake	Kenosha	24	18	75%	3.915
Oliver Lake	Chippewa	13	13	100%	0.969
Green Lake	Green Lake	48	47	98%	0.751
Potato Lake	Rusk	26	25	96%	0.646
Deer Lake	Polk	159	137	86%	0.538
Squaw Lake	St Croix	131	131	100%	0.525
Twin Lake	Polk	40	39	98%	0.508
Finley Lake	Chippewa	13	13	100%	0.415
Desair Lake	Barron	26	25	96%	0.387
Little Gerber Lake	Sheboygan	58	58	100%	0.383
Black Otter Lake	Outagamie	31	31	100%	0.330
Kelly Lake	Oconto	10	9	90%	0.330
Carstens Lake	Manitowoc	17	16	94%	0.309
Lake Koshkonong	Jefferson	11	11	100%	0.296
Silver Birch Lake	Pepin	20	20	100%	0.265
Scout Lake	Milwaukee	33	32	97%	0.255
Hartlaub Lake	Manitowoc	25	23	92%	0.255
Como Lake	Chippewa	11	11	100%	0.250
Lake Redstone	Sauk	43	43	100%	0.238
Big Long Lake	Manitowoc	97	95	98%	0.226
Tichigan Lake	Racine	44	44	100%	0.223
Little Bearskin Lake	Oneida	21	20	95%	0.217
Largon Lake	Polk	27	27	100%	0.208
Lake Arbutus	Jackson	21	21	100%	0.203
English Lake	Manitowoc	36	36	100%	0.200
Big Gerber Lake	Sheboygan	60	42	70%	0.199
Otter Lake	Chippewa	100	91	91%	0.193
Tomah Lake	Monroe	24	23	96%	0.190
Redstone Lake	Sauk	153	150	98%	0.189
Fox Lake	Dodge	220	213	97%	0.187
Harpts Lake	Manitowoc	10	10	100%	0.185
Monona Lake	Dane	213	211	99%	0.176
Neshonoc Lake	La Crosse	52	51	98%	0.172
Virginia Lake	Sauk	11	11	100%	0.172
Little Green Lake	Green Lake	114	113	99%	0.170
Bullhead Lake	Manitowoc	45	44	98%	0.168
Lake Mendota	Dane	237	235	99%	0.165
White Clay Lake	Shawano	108	108	100%	0.163
School Section Lake	Waupaca	84	81	96%	0.160
Stone Lake	Washburn	16	15	94%	0.160
Kentuck Lake	Vilas	109	107	98%	0.159

Location	County	Number of Tests	Number of Exceedances	Exceedance Rate	Average Concentration (mg/l)
Tombeau Lake	Walworth	22	22	100%	0.154
Ward Lake	Polk	30	27	90%	0.150
Jersey Valley Lake	Vernon	13	12	92%	0.145
Mccrossen Lake	Waupaca	18	9	50%	0.140
Marsh-Miller Central Bay	Chippewa	17	17	100%	0.140
Keesus Lake	Waukesha	17	12	71%	0.139
Tug Lake	Lincoln	13	13	100%	0.139
Manson Lake	Oneida	11	5	46%	0.137
Devils Lake	Sauk	168	158	94%	0.136
Pine Lake	St Croix	16	16	100%	0.134
Tainter Lake	Dunn	143	143	100%	0.130
Friess Lake	Washington	120	116	97%	0.127
Delavan Lake	Walworth	31	31	100%	0.127
Lake Delton	Sauk	19	19	100%	0.127
Mount Morris Lake	Waushara	16	14	88%	0.127
Buck Lake	Rusk	23	19	83%	0.126
Arbutus Lake	Jackson	32	26	81%	0.125
Petenwell Flowage	Juneau	117	117	100%	0.124
Buffalo Lake	Marquette	116	114	98%	0.122
North Lake	Walworth	39	32	82%	0.122
Balsam Lake	Polk	24	20	83%	0.121
Mallalieu Lake	St Croix	16	16	100%	0.121
Miner Lake	Waupaca	25	14	56%	0.119
Paulsen Lake	Polk	12	12	100%	0.118
Cedar Lake	Polk	200	178	89%	0.117
Hemlock Lake	Barron	32	32	100%	0.116
Orlando Lake	Waupaca	26	17	65%	0.114
North Pipe Lake	Polk	16	16	100%	0.113
Spence Lake	Chippewa	13	13	100%	0.112
North Spirit Lake	Price	13	13	100%	0.110
Camp Lake	Kenosha	25	24	96%	0.109
Little Wood Lake	Burnett	21	21	100%	0.108
North Twin Lake	Vilas	12	10	83%	0.108
Elk Lake	Price	10	10	100%	0.108
Crooked Lake	Oconto	71	58	82%	0.107
Dunham Lake	Burnett	14	14	100%	0.105
Mirror Lake	Sauk	37	37	100%	0.102
Prairie Lake	Barron	29	29	100%	0.102
Cornell Lake	Chippewa	21	20	95%	0.101

METHODOLOGY

Data from 1990-1998 is from the U.S. EPA's STORET database. This data contains records from all agencies that have uploaded data to STORET for Wisconsin waterways. 99% of all data came from the Wisconsin DNR; the other 1% came from several different agencies, including the U.S. EPA Region 5 and the National Park Service. Three records for Lake Michigan came from the Michigan Department of Environmental Quality.

Data from 1999-2001 was obtained directly from the Wisconsin DNR.

This analysis used only records from ambient streams and ambient lakes.

Phosphorus

Analysis of phosphorus data used only records of "total phosphorus" tests. Orthophosphate tests and other phosphorus measurements were not included. Records with estimated values or non-quantitative values were not included.

Each individual record was compared to the appropriate EPA recommended ecoregional criteria to determine whether it exceeded the levels recommended for a healthy lake or stream.

Records were then aggregated by monitoring station, by water body, and by county. The aggregation by monitoring station and county was done automatically using monitoring station and county codes attached to the data. The aggregation by water body was done manually using the described location of each record to assign it to the correct water body.

Stations identified as having "high exceedance rates" for the GIS maps were stations where at least 80% of tests exceeded the appropriate EPA criteria with a minimum of twenty tests from 1990-2001. Stations identified as having a "high average" had an average phosphorus value above 0.1 mg/l with a minimum of twenty tests over the study period.

Sediment

Analysis of sediment data used records of tests for total suspended solids. Records with estimated values or non-quantitative values were not included.

Test values were compared to recommended criteria for suspended sediment to identify those test values that exceeded the criteria for healthy waterways.

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